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Air Quality Impact Assessment to Support a Bespoke Permit Application for Three Maids Anaerobic Digestion Plant (AD), Three Maids Farm, Three Maids Hill, Winchester, SO21 2QG

On behalf of: Acorn Bioenergy Operations Limited

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Abbreviations

AAD	Ambient Air Quality Directive (2008/50/EC)
AADT	Annual average daily traffic
AEL	Associated Emissions Level
AcidDep	Acid deposition
acph	Air changes per hour
AD	Anaerobic Digester
AOD	Above Ordnance Datum
APIS	Air Pollution Information System
AQMA	Air Quality Management Area
AQIA	Air Quality Impact Assessment
AQS	Air Quality Standards
AQSR	Air Quality Standards Regulations 2010
AW	Ancient Woodland
BAT	Best Available Techniques
BLD	Boundary layer depth
BUP	Biogas upgrading plant
CH_4	Methane
CHP	Combined heat and power (engine)
CLe	Critical level (concentration)
CLo	Critical load (deposition)
CO_2	Carbon dioxide
Defra	Department for the Environment, Food and Rural Affairs
EA	Environment Agency
EAL	Environmental Assessment Level
EC	European Commission
ELV	Emission Limit Value
EPR	Environmental Permitting Regulations
EPUK	Environmental Protection UK
ETL	Earthcare Technical Ltd
EU	European Union
GFS	Global Forecast System
h/day	hours per day
H1	Environment Agency Horizontal Guidance Note H1
H_2S	Hydrogen sulphide
HGV	Heavy goods vehicle
IAQM	Institute of Air Quality Management

IED Industrial Emissions Directive

kWe Kilowatts electrical output

kWthi Kilowatts thermal input

kWtho Kilowatts thermal output

LAQM Local Air Quality Management

LWS Local wildlife site

MCP Medium Combustion Plant

MCPD Medium Combustion Plant Directive

MWth Megawatts thermal input

n/a Not applicable

N Nitrogen

NDep Nutrient nitrogen deposition

NGR National Grid Reference

O_2 Oxygen

PC Process Contribution

PEC Predicted environmental concentration

PRV Pressure relief valve

PVRV Pressure and vacuum relief valve

PST Pre-storage tank

S Sulphur

SO_2 Sulphur dioxide

SAC Special Area of Conservation

SPA Special Protection Area

SSSI Site of Special Scientific Interest

TG Technical Guidance

TPA Tonnes per annum

TVOC Total gaseous and vaporous organic substances, expressed as total organic carbon

VOC Volatile organic compounds

WCC Winchester City Council

%v/v Percent by volume (v/v)

1 Introduction

1.1 Background

Earthcare Technical Ltd (ETL) has been commissioned on behalf of Acorn Bioenergy Operations Limited, hereafter referred to as 'the Client,' in respect of a bespoke permit application for the operation of an anaerobic digestion plant at Three Maids, Three Maids Farm, Three Maids Hill, Winchester, SO21 2QG hereafter referred to as 'the AD Plant.'

An H1 risk assessment, following H1 methodology set out in Environment Agency (EA) guidance[1] and using the EA H1 Assessment Tool has been carried out to determine whether any pollutants can be screened out from further consideration. The H1 tool is a conservative tool and the H1 assessment is reported in a document submitted alongside this AQIA.[2] It concluded that the following pollutants, (and averaging time), required detailed modelling for comparison with Environmental Assessment Levels (EALs):

- Nitrogen Dioxide (Annual and 1 Hour Mean)
- Nitrogen Dioxide (Ecological - Daily Mean)
- Ammonia (Ecological - Sensitive Lichens)
- Carbon monoxide (8 Hour mean)
- Benzene (Annual and 24 Hour mean)
- Sulphur Dioxide (15 Min Mean)
- Sulphur Dioxide (1 Hour Mean)
- Sulphur Dioxide (24 Hour Mean)
- Sulphur Dioxide (Ecological - Sensitive Lichens)

1.2 Site description

Figure 1 shows the proposed green line boundary for the AD Plant, Figure 2 shows the emission points of the AD Plant. The area enclosed by the Three Maids Anaerobic Digestion Plant permit boundary is referred to herein as 'the Site.'

The National Grid Reference of the approximate centre of the AD Plant site lies at SU 46094 33959 (446094, 133959). The Site sits within the northwest section of the intersection between the A34 dual carriageway and the A272. It's gradient slopes downwards in a north easterly direction towards the A34 from approximately 93.5m AOD to approximately 87.8m AOD. The Site is located approximately 4 km north northwest of the city of Winchester.

The surrounding area is used principally for arable farming and grassland with pockets of protected Ancient Woodland. Other land uses within 1 km of the Site include: a solar farm, an area used for muck-away, recycling and aggregates processing, and a pig farm. The nearest

[1] Environment Agency and Department for Environment, Food & Rural Affairs, Air emissions risk assessment for your environmental permit, Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit [Accessed 12 March 2024]

[2] Earthcare Technical Ltd (8 March 2024) H1 Assessment to Support a Permit Application for Three Maids Anaerobic Digestion Plant (AD), Three Maids Farm, Three Maids Hill, Winchester, SO21 2QG. Document reference: ETL724/H1/V1.0.

residential premises, Three Maids Bungalow, is situated approximately 250m southwest of the Site. The village of Littleton lies over 1 km southwest of the proposed Site.

Within 2 km of the proposed Site, there are nine locally designated conservation sites, the closest of which is Worthy Copse situated 157m northwest of the Site and is designated as Ancient Woodland (AW), a Local Wildlife Site (LWS) and Site of Importance for Nature Conservation (SINC). The eight additional local sites include: South Worthy Grove (AW, SINC), Worthy Grove (LWS, AW, SINC), The Gallops, Worthy Down (LWS, SINC), Long Wood (AW, SINC), Northwood Park Woods (Cradle Copse) (LWS, SINC), Flowerdown, Littleton (LWS, SINC), Worthy Camp Grassland (LWS, SINC), and Worthy Down Railway Halt (LWS). There is one statutory designation within 10 km; the River Itchen Special Area of Conservation (SAC), that is also coincident with areas designated as Site of Special Scientific Interest (SSSI), located at its nearest point approximately 3.6 km southeast of Site.

1.3 Scope of report

This AQIA assesses the impact on human and ecological receptors of emissions to air from the proposed AD Plant. Emissions to air have been modelled in normal operation at the specified ELVs if ELVs exist for the sources; if there are no ELVs, the emission concentrations have been taken from indicative monitoring data from similar plant at other sites.

The ADMS 6 dispersion model has been used to calculate concentrations of the pollutants, from which dry deposition to sensitive conservation sites has been calculated.

While ELVs and the air quality standards for ecological receptors are specified for NOx, standards for human health are for nitrogen dioxide (NO_2) which is emitted as a by-product of combustion and is formed (and consumed) in chemical reactions including NOx and other species.

Predicted concentrations have been compared with relevant air quality standards (AQS) (limits, targets, objectives, and assessment levels) in order to assess their significance, considering background concentration data where relevant. There are no AQS for Total volatile organic compounds (TVOC) but there is an AQS for benzene which is one of the emitted. Benzene emissions from the CHPs has been modelled as 10% of TVOC (or 10% of non-methane VOCs if this data is available) as a conservative estimate for the combustion sources.[3]

The pollutants considered in this AQIA are, therefore:

- Oxides of nitrogen (NOx)/Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Carbon monoxide (CO)
- TVOCs/Benzene
- Ammonia
- Odour

[3] N R Passant (2002) Speciation of UK emissions of non-methane volatile organic compounds. Reference: AEAT/ENV/R/0545 Issue 1

Predicted deposition fluxes have been compared with critical loads for nutrient nitrogen deposition and acid deposition at sensitive conservation sites.

This report describes the: proposed AD Plant processes on Site (Section 2); relevant legislation and guidance for industrial emissions, ambient air quality and modelling of emissions to air (Section 3); the assessment methodology used to model concentrations of pollutants and odour (Section 4); assessment criteria including air quality limit values, objectives and Environmental Assessment Levels and significance criteria (Section 5); background concentrations (Section 6); and results of the dispersion modelling (Sections 7, 8 and 9); before Section 10 provides conclusions.

2 Process description and emissions to air

2.1 Process description

This section provides a summary of the process which should be read in conjunction with the Process Flow Diagram provided in Appendix A, and Drainage Process Flow Diagram in Appendix B.

The facility will treat around 94,000 tonnes per annum (TPA) of liquid and solid feedstock comprising: livestock waste (poultry and farmyard manures and dairy and pig slurry); energy crops and crop residues; and dirty water, to produce heat and power using biogas produced by the process.

With specific regard to emissions to air, supporting infrastructure includes the following, where numbering A1-A22 refer to point source emissions, as shown on the emission point plan (Figure 2):

- 2 No. CHP engines with 7 m stacks (TEDOM Quanto 1200 1.2 MWe) (**A1, A2**)
- Emergency flare – 8.7 m stack height (**A3**)
- 1 No. 550 kWtho emergency biogas boiler (**A4**)
- 1 No. diesel emergency generator (770 kVA) (**A5**)
- Manure reception building incorporating: fast acting roller shutter doors; air handling and emissions abatement system ('Centri-Air AB') (**A6**); dedicated manure conveyor feed hopper (44 m^3); and pre-mix system
- Biogas upgrade unit (BUU) PRV (**A7**)
- BUU Carbon dioxide (CO_2) vent (**A8**)
- 2No. CO_2 recovery plant PRVs (**A9, A10**)
- 2No. Compressor PRVs (**A11, A12**)
- 1 No. underground leachate tank (1 x 50 m^3) with 1No. vent (**A13**)
- 5 No. digesters: 2No. Primary digesters (5,840 m^3 each) each with 1No. PVRV (**A14, A15**); 2No. Secondary digesters (6,430 m^3 each) each with 1No. PVRV (**A16, A17**); and 1 No. Tertiary digester (6,430 m^3) with 1No. PVRV (**A18**)
- 1 No. Digestate storage bag with leak detection (7,344 m^3) with 3No. vents (**A19 – A21**)
- 1 No. Digestate off-take bay with sump (3 m^3) and carbon filter abatement system on liquid digestate tanker dispatch point (**A22**)
- Straw treatment building containing: bale conveyor; destringer; bale breaker; Straw mill with water injection; storage bay for crushed wet straw; 2No. straw extruders with 1No. feed hopper; and 1No. set down bay for prepared straw
- 2 No. silage clamps: Clamp 1 (28,534 m^3); Clamp 2 (25,080 m^3)
- 2 No. feed hoppers (external) (150 m^3 each)
- Process tanks including, 3No. pasteurisation tanks (35 m^3 each), 2No. Buffer water tanks (400 m^3 each), 1No. Process water buffer tank (100 m^3), Suspension buffer tank (400 m^3)
- Covered Separator bunker including: 2No. Separators, fibre storage bay.

All solid manure feedstock is received and processed within an enclosed Manure reception building which benefits from the continuous operation of an air extraction and emissions abatement system (emission point **A6**).

There will be five digesters (two primary (PD1 & PD2), two secondary (SD1 & SD2) and one tertiary or 'post' digester (TD1)). Each digester will have a Pressure and vacuum relief valve (PVRV) (emission points A15 to A19) to emit biogas or take in air if there is an over-pressure or under-pressure event respectively. PVRVs will not operate during normal operation, over-pressure is managed by operation of the flare (emission point **A3**) before the PVRVs. The operation of the digester PVRVs is therefore not considered within the H1 assessment.

Emissions will be released from the combustion of biogas (BG) in CHP1 (SO_2, TVOC, NOx and CO) and natural gas (NG) in CHP2 (TVOC, NOx and CO) from 7m stacks (emission points **A1** and **A2**). The 2 No. 1200kWe CHPs are required to meet the Medium Combustion Plant (MCP) Directive Emission Limit Values (ELVs) for sulphur dioxide (SO_2) and nitrogen oxides (NOx) for new plant.[4] The emissions and monitoring standards that apply to total volatile organic compounds (TVOC) and carbon monoxide (CO) from biogas fuelled engines are the same as those applied to landfill gas engines.[5]

- 107 mg/Nm^3 for SO_2 (5% O_2), MCP ELV
- 500 mg/Nm^3 for NOx (5% O_2), MCP ELV
- 1,000 mg/Nm^3 for TVOC (5% O_2), LFTGN08
- 1,400 mg/Nm^3 for CO (5% O_2), LFTGN08

Biogas may be burnt under abnormal operating conditions such as during extended periods of maintenance of the CHPs and/or malfunction of the BUU by the emergency flare (emission point **A3**). The flare should operate for a limited number of hours per year (<10% or <876 hours) as it is only used under abnormal operating conditions. Guidance for monitoring enclosed landfill gas flares (LFTGN 05[6]) sets out the emission standards for enclosed gas flares:

- 150 mg/Nm^3 for NOx (3% O_2), LFTGN 05
- 50 mg/Nm^3 for CO (3% O_2), LFTGN 05
- 10 mg/Nm^3 for TVOC (3% O_2), LFTGN 05

The emergency biogas boiler (emission point **A4**) will be used to generate heat for the AD plant when the CHPs are unavailable and/or cannot provide sufficient heat to the AD Plant, for instance in the event of extreme cold weather, CHP breakdown or prolonged unscheduled maintenance. It has been conservatively assumed that the emergency boiler could potentially operate approximately 15% of the time (i.e. approximately two months) but it is expected it will operate less than 5% of the time. The emergency boiler will not be used in normal operation.

[4] DIRECTIVE (EU) 2015/2193 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants
[5] Environment Agency (2010) LFTGN08 v2 2010: guidance for monitoring landfill gas engine emissions (https://assets.publishing.service.gov.uk/media/5a7d87c140f0b64fe6c24434/LFTGN08.pdf)
[6] Environment Agency (2010) Guidance for monitoring enclosed landfill gas flares LFTGN05 v2 2010 (https://www.gov.uk/government/publications/monitoring-enclosed-landfill-gas-flares-lftgn-05)

The boiler will release emissions to air of NOx, SO_2 and CO from the 7m stack. The 647kWthi (thermal input) biogas-fired emergency standby boiler will meet the MCP Directive ELVs for new plant fired by biogas although it is not an MCP as its thermal input is less than 1MW. There are no BAT-AELs for TVOC and CO, emissions of which will be negligible from the emergency boiler:

- 100mg/Nm^3 for SO_2 (3% O_2), MCP ELV
- 200mg/Nm^3 for NOx (3% O_2), MCP ELV
- No limit set for CO (3% O_2)

An emergency standby diesel generator (770 kVA, 616 kWe, 1,867 kWthi) (emission point **A5**) will provide power when the CHPs are not operational and if power is not available from the grid. Therefore, it would be used only as an emergency backup operating typically less than 50 hours per year and operating less than 500 hours per year as a 3-year rolling average. It would be exempt from meeting MCPD ELVs and as such is not part of the H1 quantitative assessment.

Biogas (60% CH_4 by volume) will enter the Biogas Upgrade Unit (BUU) where it will be treated to create biomethane (97.5% CH_4 by volume) which leaves the BUU. Biogas from the gas holders will be pass through a series of gas treatment steps including cooling, filtration (2 No. carbon filters to remove H_2S and 1 No. filter for VOCs, compression prior to three-stage membrane filtration which separates the biogas into methane (CH_4) and carbon dioxide (CO_2).

Biogas will be released from the Pressure Relief Valve (PRV) on the BUU in over-pressure scenarios only (emission point **A7**). In the event that the CO_2 recovery plant is not operational, during abnormal conditions, residual CO_2 emissions will be released from the BUU via a stack ('CO_2 vent', emissions point **A8**). The cleaned gas that is vented must comply with Gas Safety Management Regulations for hydrogen sulphide (H_2S) and total sulphur, and TVOC at minimal level of detection. The release of CO_2 due to the abnormal operation of the BUU PRV has therefore not been considered within the H1 assessment.

The BUU will be fitted with CO_2 recovery equipment so the remaining CO_2 output stream will not be released to air but captured prior to liquefaction of the CO_2. The CO_2 is compressed in a two-stage process compressor and passed through an automatic molecular sieve dryer to completely remove moisture. The CO_2 then passes through a fine filter to remove any remaining odorant compounds or impurities, as well as any remaining powders. The gas treatment technology is designed specifically to remove contaminants and ensure a high level of CO_2 purity.

The gas (99.9 % v/v CO_2 purity) is sent to a CO_2 liquefier; traces of non-condensable gases still contained in the CO_2 gas remain gaseous when the CO_2 transforms to liquid in the liquefier. Any entrained non-condensables, such as oxygen, methane, and nitrogen are effectively removed in a stripping tower. These non-condensable gases are used for regeneration of the dryer; the pure liquid CO_2 flows to a storage tank. When both the BUU and CO_2 recovery plant are operational, cleaned gas may be released from the PRVs in over-pressure scenarios only (emission points A7, A9 and A10). Emissions from the CO_2 recovery plant have therefore not been included in this assessment.

Silage leachate is produced from storage of silage. The leachate runs forwards within the clamps into drainage channels, then to an underground leachate storage tank, from where it is pumped into the Process water tanks and then used in the AD process. The leachate storage tank will be fitted with one vent (emissions point **A13**).

Whole digestate from the Tertiary digester will be screened and pasteurised before being cooled and pumped to the Suspension buffer tank (400m^3). Any displaced air during the pasteurisation process is recycled back to into the gas system.

Whole digestate from the Suspension buffer tank (400 m^3) is pumped to the 2 No. Borger type mechanical separators. The digestate separators and the resulting fibre digestate are situated within a covered bunker. The bunker has a roof which forms a sealed join with the bunker base and a roller shutter door opening. Separated fibre collects in the concrete storage bay below the separators. The digestate fibre will be removed periodically during the day from site to destination field heaps. The front roller shutter door is only open for 20 minutes whilst loading and closed thereafter.

Separated liquor is pumped from the separator to either: the 7,344 m^3 Digestate storage bag where residual emissions are released via three vents (emission points **A19 to A21** inclusive); or the sealed 100m^3 Process water buffer tank. Tankers will be filled with liquid digestate at a tanker loading point fitted with a carbon filter emissions abatement system (emission point **A22**).

2.2 Pressure and Vacuum Relief Valves

Pressure and Vacuum Relief Valves (PVRVs) are fitted on the 5No. digester tanks, in addition to Pressure relief Valves (PRVs) on the biomethane upgrading and injection unit, the CO_2 recovery plant and compressors.

PVRVs are a necessary safety feature for an AD Plant but will only be used as a contingency to maintain the integrity of the infrastructure and/or equipment. The PVRVs are only activated in the event of an over or under pressure within the AD tanks. Biogas will be burnt via an emergency flare in preference to release to atmosphere via the PVRVs. The supervisory control and data acquisition system (SCADA) for the AD Plant ensures that biogas is controlled in this manner.

Activation of the PVRVs represents an abnormal operating scenario and therefore the frequency of PVRV activation is not possible to predict for any plant in any given year albeit it is monitored when it occurs. The operator will seek to minimise PVRV activation through diligent optimised operation of the AD Plant. Therefore, the nature of these releases, typically very short-term sporadic events, would be difficult to represent accurately. PVRVs have therefore been neglected as a source of pollutants.

2.3 Summary of emissions to air

Table 1 lists the sources of emissions to air at the AD Plant that have been considered in this impact assessment.

Table 1 AD Plant sources of emissions to air to be assessed

Emission point reference	Source	Emissions	Operation profile
Point Sources			
A1	CHP1 stack (BG)	NOx, SO_2, TVOC, CO	Continuous
A2	CHP2 stack (NG)	NOx, TVOC, CO	Continuous
A3	Emergency flare stack	NOx, TVOC, CO	Emergency back-up[1]
A5	Emergency biogas boiler stack	NOx, SO_2	Emergency back-up[2]
A6	Emissions abatement stack	NH_3, odour	Continuous
A13	Leachate tank vent	NH_3, odour	Continuous
A19	Digestate storage bag vent 1	NH_3, odour	Continuous
A20	Digestate storage bag vent 2	NH_3, odour	Continuous
A21	Digestate storage bag vent 3	NH_3, odour	Continuous
A22	Digestate off-take vent	NH_3, odour	Intermittent, factored for operational hours [3]
Other sources			
n/a	Separator bunker	NH_3, odour	Continuous
n/a	Feed hoppers	Odour	Continuous
n/a	Clamp	Odour	Continuous

Notes: [1]assumed conservatively, to operate for 10% of the year (876 hours) for comparison with long-term AQS
[2]assumed to operate for 15% of the year (approximately 2 months) for comparison with long-term AQS
[3] Intermittent emissions are modelled as equivalent total emissions continuous across operational hours.

2.4 Operational scenarios

This assessment considers the impact on receptors of emissions to air from combustion plant; the CHPs, emergency boiler, emergency flare, alone and when added to background concentrations.

The following scenarios have been modelled:

- **Modelled Long-term Scenario**, **normal operation**, all sources
    - CHP1, CHP2, operating continuously, emergency boiler (15%), emergency flare (10%)
- **Modelled Short-term Scenario**, **abnormal operation**, all sources
    - CHP1, CHP2, emergency boiler, emergency flare, all operating continuously.

For long-term impacts (annual means), the emergency boiler and emergency flare have been modelled with annual emissions equivalent to operating at full load for 15% and 10% of the year respectively.

The assessment of short-term impacts pessimistically assumes that the CHPs, emergency boiler and emergency flare will operate at full load continuously and simultaneously, which would be very unlikely to occur; it is worst case as it assumes that emissions from the operation of the emergency boiler and flare might coincide with all worst-case meteorological conditions during the year.

The proposed standby generator at the AD Plant site, A5 on the emissions point plan, Figure , has not been included in any of the scenarios as it will typically operate for fewer than 50 hours per year, if required to provide emergency power.

3 Legislation and guidance

3.1 Overview

This section describes the relevant legislation, policy, and guidance relevant to this assessment which is summarised in Table 2 and described further in Sections 3.2 to 0.

Table 2 Summary of legislation, policy and guidance

Short name	Name	Body	Scope
Legislation			
1995 Act	Environment Act 1995[7]	UK Parliament	Establishes the framework for managing air quality to achieve compliance with air quality objectives.
4th Daughter Directive	Directive 2004/107/EC[8]	European Commission, now EU	Sets limit values for arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air
AAD	Ambient Air Quality Directive 2008/50/EC[9]	EU	Ambient air quality, sets limit and target values
IED	Industrial Emissions Directive, 2010/75/EU[10]	EU	Industrial emissions
MCPD	Medium Combustion Plant Directive, EU/2015/2193[11]	EU	Emission limit values for pollutants from combustion plant greater than 1MWth and less than 50MWth
AQSR	Air Quality (Standards) Regulations 2010[12] as amended in 2016[13]	UK Parliament	Ambient air quality, standards for pollutant concentrations. Transposed EU limit values defined in AAD into law in England and Wales

[7] Environment Act 1995, 1995 Chapter 25, Part IV Air Quality
[8] 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.
[9] 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 comment on amendment
[10] DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions (integrated pollution prevention and control)
[11] DIRECTIVE (EU) 2015/2193 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants.
[12] Statutory Instrument: 2010 No. 1001, ENVIRONMENTAL PROTECTION, The Air Quality (Standards) Regulations 2010 comment on amendment
[13] The Air Quality Standards (Amendment) Regulations 2016, Statutory Instrument 2016 No, 1184, Made 6th December 2016

Short name	Name	Body	Scope
EPR	Environmental Permitting Regulations 2018[14]	UK Parliament	Industrial emissions. Transposed IED into law in England and Wales
Guidance			
Defra permit guidance	Air emissions risk assessment for your environmental permit[15]	Department for Environment, Food & Rural Affairs and Environment Agency	How to undertake an air quality assessment for a permit
Waste Treatment BREF	BAT Reference Document Waste Treatment[16]	European IPPC Bureau,	Indicative BAT for waste treatment including Associated Emission Levels
Appropriate Measures	Biological waste treatment: appropriate measures for permitted facilities[17]	Environment Agency	Sets out appropriate measures for the treatment of organic materials
EA H4	Technical Guidance Note H4 – Odour Management[18]	Environment Agency	Guidance on assessing odour impact, includes benchmark values
Defra SWIP	Specified generators: dispersion modelling assessment[19]	Environment Agency and Natural Resources Wales	Includes reference for conversion of NOx to NO_2
AQTAG06	AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air[20]	Air Quality Advisory Group	Guidance on calculating deposition
LAQM.TG16	Local Air Quality Management, Technical Guidance (TG16)[21]	Department for Environment, Food & Rural Affairs and the Devolved Authorities	Includes general guidance on dispersion modelling

[14] The Environmental Permitting (England and Wales) (Amendment) Regulations 2018, Statutory Instrument 2010 No, 675
[15] Department for Environment, Food & Rural Affairs and Environment Agency, Air emissions risk assessment for your environmental permit, Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit [Accessed March 2024].
[16] Best Available Techniques (BAT) Reference Document for Waste Treatment, European IPPC Bureau, 2018
[17] Environment Agency (21 September 2022) Biological waste treatment: appropriate measures for permitted facilities. Available at: (https://www.gov.uk/guidance/biological-waste-treatment-appropriate-measures-for-permitted-facilities/1-when-appropriate-measures-apply).
[18] Environment Agency (March 2011) Technical Guidance Note H4 - Odour Management. How to comply with your environmental permit
[19] Environment Agency and Natural Resources Wales, Specified generators: dispersion modelling assessment, Available at: https://www.gov.uk/guidance/specified-generators-dispersion-modelling-assessment#nosubxsub-to-nosub2sub-conversion-ratios-to-use [Accessed March 2024].
[20] Air Quality Advisory Group, 2014, AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air
[21] Department for Environment, Food & Rural Affairs and the Devolved Authorities, Local Air Quality Management Technical Guidance (TG16), February 2018

3.2 Legislation and policy

3.2.1 Environment Act

The Environment Act, which established the Environment Agency for England and Wales with functions including the control of pollution. Part IV of the Environment Act 1995 establishes the framework for managing air quality to achieve compliance with air quality objectives and for local air quality management (LAQM). Under LAQM local authorities (district councils) are required to monitor, review, assess and improve air quality in their areas; if exceedances are monitored or predicted, they must consider establishing an AQMA. Part IV requires the Secretary of State to prepare a National Air Quality Strategy.

3.2.2 Ambient Air Quality Directive and 4th Daughter Directive

The Ambient Air Quality Directive and 4th Daughter Directive contain **Limit Values** and **Target Values** with which the UK must comply. The Ambient Air Quality Directive also addresses common methods and criteria; information on ambient air quality to help combat air pollution and nuisance, to monitor long-term trends; and making information and pollution alerts available to the public.

3.2.3 Air Quality Standards Regulations

The Air Quality (Standards) Regulations 2010 is the instrument by which the Ambient Air Quality Direction and the 4th Daughter Directive were transposed into English law.

3.2.4 Industrial Emissions Directive

The IED is the main EU instrument by which pollutant emissions from industrial installations are regulated. It consolidated seven earlier directives including, in particular, the Integrated Pollution Prevention and Control Directive and the Waste Incineration Directive. It defines emissions limit values (ELVs) for some process-fuel combinations but there are no ELVs relevant to the Biogas upgrading stack.

3.2.5 Medium Combustion Plant Directive

The MCPD regulates emissions of SO_2, NOx and dust to air and requires monitoring of carbon monoxide (CO) emissions in order to reduce emissions and risks to human and ecological receptors. MCPD ELVs apply from 2025 or 2030 for existing plants, depending on their size.

The relevant ELVs for proposed engines using biogas, which have been used in this assessment, are those defined in Part 2 of Annex II of the MCPD.

3.2.6 Environmental Permitting Regulations

The Environmental Permitting (England and Wales) (Amendment) Regulations 2023 is the latest consolidated version of instrument by which the IED was transposed into national legislation.

Guidance

3.2.7 Air emissions risk assessment for your environmental permit

The webpage provides Department for Environment, Food & Rural Affairs and Environment Agency guidance on how to carry an air emissions risk assessment.[22] It includes guidance on the ecological receptors to be assessed, tests on significance on results, relevant air quality Limit Values (from the Ambient Air Directory), objectives from the National Air Quality Strategy and it lists short-term (hourly) and long-term (annual mean) **Environmental Assessment Levels (EALs)** for human health.

3.2.8 Biological waste treatment: appropriate measures for permitted facilities.

This guidance applies to aerobic and anaerobic processes including AD including the combustion or upgrading of the resulting biogas and treating the digestate (AD can include wet, dry, and dry-batch digestion). There is overlap between BAT and necessary measures for waste operations. The EA uses the term 'appropriate measures' to cover both sets of requirements.

3.2.9 Technical Guidance Note H4 – Odour Management

The guidance from EA is intended for permit holders and applicants, to advise them on how to comply with odour conditions set by the permit. It covers, assessing odour pollution, measures to reduce pollution, control measures and monitoring. It contains advice on odour thresholds or benchmarks for assessment.

3.2.10 Specified generators: dispersion modelling assessment

The webpage provides Defra and Environment Agency guidance on how to do detailed air quality modelling for specified generators. This includes the use environmental standards for air, the use of NOx to NO_2 conversion ratios, and guidance on impact assessment.

3.2.11 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air

This document (AQTAG06) provides guidance on how to carry out a quantitative assessment (Stage 3 appropriate assessment) including guidance on calculating deposition for emissions to air in order to fulfil the requirements of the Habitats Regulations.

3.2.12 Local Air Quality Management, Technical Guidance

This technical guidance (LAQM.TG16) is published to support local authorities in carrying out their duties under the Environment Act 1995, which established the LAQM process. It provides guidance on monitoring and assessing air quality, action planning and reporting. While aimed at local authorities the advice in used more widely by those working in the field, and not just for LAQM.

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[22] Environment Agency (EA) and Department for Environment, Food & Rural Affairs (Defra) Air emissions risk assessment for your environmental permit (last updated 21 December 2023) (https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit). Accessed March 2024.

4 Assessment Methodology

4.1 Introduction

The methodology comprised three parts which are described in more detail in Sections 4 to 6:

1. Baseline conditions assessment at the Site and the surrounding area:
    - AQMAs and designated conservation areas; background concentration and deposition (section 6).
2. Modelling of impacts:
    - Assessment of the likely changes in concentration and deposition due to emissions from the sources listed in Table 1. Operation of the plant under normal and abnormal operating conditions. The assessment was undertaken using the ADMS 6 dispersion model (section 4.2).
    - The modelling assessment included an assessment of the sensitivity of model results and hence, the impacts, to changes in model input.
3. Assessment of significance. Sections 5.2, 5.3 and 5.4 describe the significance criteria.

If the impacts are significant then further investigation would be required.

4.2 Modelling of air quality impacts

4.2.1 Model

The dispersion model used to predict ambient concentrations due to the stack emissions was ADMS 6 (version 6.0.0.1). The model is termed a 'new generation' model and is commonly used in the UK for industrial permit applications to the Environment Agency.

It requires as input: data on the source of emissions and the mass emission rates of each pollutant (Table 3 to Table 5), meteorological data and associated parameters, buildings data, terrain data, and receptor locations. Full details of the meteorological, buildings and receptor data are described in Appendix C.

The outputs calculated by the model are the air concentrations of pollutants from the sources modelled for the relevant averaging times and statistics. The contribution from the modelled sources on the Site to air concentration and to deposition rates are referred to the Process Contribution (PC), which is then compared with the relevant AQS. When background concentrations or deposition rates are added to the PC, the totals are referred to as Predicted Environmental Concentration (PEC) and Predicted Environmental Deposition Rate (PEDR) respectively, which are also compared with the relevant AQS.

From air concentrations of NO_2 the deposition rate of nitrogen can be calculated and the acid deposition due to nitrogen; from the air concentration of SO_2 the contribution of sulphur to acid deposition can be calculated.

4.2.2 Model scenarios

In section 2.4 the modelled scenarios are summarised as:

- **Modelled Long-term Scenario**, **normal operation**, all sources
    - CHP1, CHP2 operating continuously, emergency boiler (15% of the time), emergency flare (10% of the time)
- **Modelled Short-term Scenario**, **abnormal operation**, all sources
    - CHP1, CHP2, emergency boiler, emergency flare, all operating continuously.

Both scenarios have been modelled as occurring all year in order to capture the impacts if the scenario were to coincide with the worst-case meteorological data that gives rise to the greatest impacts.

It is a very conservative assumption in terms of the abnormal scenarios to assume that their occurrence, which will persist for a short period, will coincide with all the worst-case meteorological conditions.

4.2.3 Model options and sensitivity

The model was run for each of the five years of meteorological data (2018-2022) for three combinations of model option scenarios:

- Flat terrain: no buildings and no terrain (hills)
- Buildings: with buildings and no terrain (hills)
- Terrain (hills): with buildings

Results at the receptors were calculated as the maximum value at each receptor from these 15 models runs and are therefore worst-case values across all five years and the three model options scenarios. Use of five years' meteorological data in the modelling is to account for intra-annual variation.

The impact of buildings, terrain and meteorological data year were assessed, and the results are given in Appendix D.

For human and ecological receptors, modelling buildings led to higher model prediction than for flat terrain. Modelling terrain as well as buildings generally led to a further increase. The variation due to meteorological data year is generally less significant than the impact of modelling buildings.

The results presented in this report are the worst case across 15 model runs: flat terrain, with buildings, with buildings and terrain, each modelled with five years of meteorological data. The assessment is therefore conservative (pessimistic) is this respect.

4.2.4 Sources and emissions

The source geometry, parameters, ELVs, design emission limits and calculated emissions are given in Table 3 for the CHPs, emergency boiler and emergency flare, Table 4 summarises the input parameters for the Manure reception building emissions abatement stack (A6), the underground leachate tank (A13), 3No. Digestate storage bag vents (A19 – A21) and the Digestate offtake point (A22).

Table 5 sets out the parameters for volume sources including the clamps, Feedstock hoppers, and Separation bunker.

There are changes in ground level across the site. In the Flat terrain and Buildings model scenarios (section 4.2.3) stack and building heights were modified to account for changes in ground level as described in Appendix C, section C.3. In the Terrain (hills) model scenario such an adjustment is not required as the ADMS model accounts for changes in terrain height. The heights of emission sources given in Table 3, Table 4 and Table 5 are the unadjusted heights.

The CHPs and emergency boiler have been modelled using MCP ELVs. While the exact plant has not been finalised at this stage, representative data have been used in this assessment (Appendix E and Appendix F). Emissions from the emergency flare, a Uniflare ground flare, were modelled at the permit ELVs; it can burn up to 2,500m^3/h of biogas. The efflux parameters have been provided by the manufacturer (Appendix G). Benzene emissions have been represented as 10%[3] of TVOC emissions from the combustion plant.

For the assessment of short-term impacts, all combustion plant are assumed to operate continuously at full load. Assuming the continuous operation of these sources provides a pessimistic prediction of impacts as no account has been taken of planned outages for maintenance.

Key design details of the proposed system are based on advice provided by the technology provider. Table 4.4 details the input parameters for the **Manure building emissions abatement system** point source (**A6**). The system is expected to achieve the Best Available Techniques (BAT) associated emission levels (AELs) for the waste treatment sector, BAT-AEL[16] of 1,000 ou_E/m^3 for odour. Exhaust concentrations of NH_3 are based on the predicted outlet concentrations provided in the manufacturer's specification (Appendix H). The NH_3 concentration of 5ppm (3.5mg/m^3) meets the BAT-AEL of 0.3-20mg/m^3 for channelled emissions.

The 50m^3 **underground leachate tank** will be fitted with a vent (**A13**) that will enable the release of displaced air during filling. The tank will have a maximum cross-sectional area of 36.8m^2 (3.2m x 11.5m) and will passively vent at ground level via a vent assumed to be 0.1m in diameter, which has been modelled as a point source with a low emission velocity (0.1m/s). The odour and NH_3 emission rates have been calculated on the same basis as those from the digestate storage bag, with an 55% reduction for dilution of the silage clamp leachate on the basis that the tank will provide storage for run-off from the secondary containment area including the Clamp apron.

The 7,344m^3 **Digestate storage bag** will have 3No. surface vents (**A19 – A21**) that will enable the release of displaced air during filling of the bag. The vents have been assumed to have a height of 0.5m, diameter of 0.1m and exit velocity of 0.1m/s; modelled as a point source. Emission rates from the vents have been calculated based on an odour concentration of 10,000ou_E/m^3.[23] Emissions of NH_3 from the stored liquid digestate have been calculated using the estimated total

[23] A S Modelling & Data (2017) A Dispersion Modelling Study of the Impact of Odour from the Proposed Biofertilizer Storage Lagoon at land west of Hangman Stone Lane, near High Melton in South Yorkshire.

nitrogen content of the feedstock material, 7.1kg total nitrogen per tonne (kg/N/t) and an emission rate of 0.0266 kg NH_3-N per kg N in feedstock from EMEP/EEA.[24] An emissions reduction of 95% was applied to account for containment within the storage bag.

Approximately 40,388 TPA of digestate liquor will be produced that will be transferred for spreading and/or to dedicated offsite storage on destination farms. The liquid digestate will be pumped from the Digestate storage bag via a sealed connection to the liquid **Digestate offtake point** including a carbon filter and associated ductwork on the liquid digestate off-take point to treat displaced air during off-take (emission point **A22**).

It is expected that liquid digestate will be removed from site up to 6 times per day during key spreading campaigns in spring and autumn (a 4-month period in total), and up to 5 times per day otherwise, based on 60% of the liquor removed daily via an HGV vehicle (capacity 27 m^3) and 40% via tractor and trailer/ slurry tanker (capacity 14 m^3). This equates to approximately 2,051 removals per year, taking into account the mix of vehicle types used.

The storage and transfer process will be undertaken through sealed pipework into sealed vessels. It will take approximately 20 minutes to fill a 27m^3 tanker during which time there will be an emission of displaced air from within the tanker via the tanker 'breather' valve connected to a carbon filtration system.

Emissions of NH_3 and odour from the digestate tanker off-take emission point have been calculated on the same principles as that for the Digestate storage bag. Intermittent emissions were modelled as equivalent total emissions continuous across operational hours. That is, calculated NH_3 and odour emission rates for a 20-minute filling period (as a worst-case for a 27m^3 tanker) were factored as an hourly emission rate, adjusted for the total number of hours annually during which offtake movements may occur (3,285 hours), and the total number of tankers per annum (2,051). Tankers will connect to the carbon filtration system at the off-take point prior to filling. A reduction factor of 95% has been applied to account for emissions abatement.

The **working face of the clamp** will be uncovered to enable the loader to remove silage and transfer to the external solid feeders. The clamps hold approximately 32,168 tonnes (53,614m^3) of silage. Based on current feedstock quantities, approximately 119 tonnes of silage and 55 tonnes of straw may be processed per day (that is, 60 tonnes of silage and 27 tonnes of straw every 12 hours).

It has been assumed that 50% of the width of both clamps (i.e. one clamp face, 42.5m in width) would be exposed at any one time. Ensiled material is removed from the working face only using equipment that cuts 'cleanly' such that the clamp face remains compacted and intact to minimise disturbance and the generation of odour and to avoid deterioration of ensiled material. It is further assumed that the average height of the clamp is 5m, and that 1m of the top of the clamps is exposed at any time. This corresponds to approximately 213m^3 (128 tonnes). Measured odour emission rates within the literature for silage (stored within clamps) have been reported

[24] European Monitoring and Evaluation Programme and European Environment Agency (EMEP/EEA) (2023) Air pollutant emission inventory guidebook 2023 Emissions Guidebook, NFR 5.B.2, Biological treatment of waste – anaerobic digestion at biogas facilities. (https://www.eea.europa.eu//publications/emep-eea-guidebook-2023)

between <1.0 and 22 $ou_E/m^2/s$.[25,26] The odour emission rate of $20ou_E/m^2/s$[27] for silage was applied, and it is assumed that odour is emitted continuously from this source.

Twice daily loading of the external **Feed hoppers** ($150m^3$ each or 90 tonnes at maximum filling weight compacted) will take approximately 1 hour on each occasion; ensiled material will take approximately 30 minutes to load in the morning and 30 minutes in the evening, depending on the location of the working clamp face. A large loading bucket will be used for transfer and drop heights kept to a minimum. The feed hoppers will operate continuously, transferring feedstock to the digesters within a closed system.

Odour emissions from material handling, agitation and loading within the hoppers is based on the estimated odour emission rate of $50ou_E/m^2/s$ as a continuous emission from the surface of the material contained within the hopper. Emissions from the feedstock material within each feed hopper were estimated by multiplying the surface area of materials ($42.75m^2$) within each hopper by the estimated odour emission rate of $50ou_E/m^2/s$. The calculated modelled emission rate for the volume of material exposed/ agitated, based on a surface layer depth of 0.5m within the hopper, was $100ou_E/m^3/s$. Emissions have been assumed to occur continuously and have been modelled as an elevated volume source, 0.5m in depth, at the top of the feed hoppers to represent the fugitive nature of the emissions.

Approximately 69,218 TPA of solid fibre digestate will be produced. Emissions from the **Separator bunker** have been modelled as a volume source for the size of the bunker (575 m^3 or 302 tonnes). NH_3 emissions have been calculated as for NH_3 emissions from the digestate. An odour emission rate of $2.8ou_E/m^2/s$ has been applied based on similar assessment and has been used here.[28] A reduction factor has been applied to account for the covering of the separator by concrete push walls to the sides and rear, and a tarpaulin cover over the bunker fixed with battens to achieve a sealed join to the bunker. The front of the bunker will be fitted with a roller shutter door; only the door will be opened for access during loading, the tarpaulin will not be rolled back. The bunker doors will be open for 20 mins only during loading and thereafter closed.

Approximately 190 tonnes of solid fibre digestate (one days' worth of production), will be removed from site via 11 vehicle movements per working shift based on 50% of the digestate removed via 27 tonne HGVs, and 50% via 13 tonne farm tractor and trailer. The relative proportions of vehicle types used represents an average, and the loading duration is a conservative estimate; both will vary according to the destination of the fibre.

Emissions have been modelled as continuous from the bunker. During periods when the bunker is closed, a reduction factor of 0.2 has been applied in the model to allow for some residual emission from the bunker (i.e. 80% containment afforded by the closed bunker).[29] For a 9-hour period 7 days per week, the release rate was increased to represent periods when the bunker is

[25] Ricardo (2018) Odour impact assessment West Fen Farm AD development.
[26] Odournet (2008) Odour impact assessment for a proposed Crop CHP Plant at Stoke Bardolph.
[27] Redmore Environmental, Odour Assessment, Herriard Anaerobic Digestion Plant, Herriard, Reference: 2256-4r1, 16th December 2021r
[28] Odournet UK Ltd (October 2013) Odour Impact Assessment for a proposed Anaerobic Digestion facility in Chatteris, Cambridgeshire.
[29] Equivalent to SCAIL Agriculture emissions reduction of 80% for a circular store with a rigid cover.

opened for loading; emission rates were reduced by 60% (a reduction factor of 0.4) to account for the containment of the bunker,[30] and a factored by 0.3 to account for the time the access door will remain open during loading (i.e., 5.4 hours closed, 3.6 hours open) based on 11 loads removed per day.

[30] Equivalent to SCAIL Agriculture emissions reduction of 60% for a circular store with a floating cover.

Table 3 CHP, flare and boiler emission parameters (points A1, A2, A3, A4)

Parameter	Units	CHP A1 (BG)[1]	CHP A2 (NG)[2]	Emergency flare (A3)[3]	Emergency boiler (A4)[4]
Location	Easting, Northing	446014, 134088	446010, 134097	445988, 134142	445996, 134080
Fuel	-	Biogas	Natural gas	Biogas	Biogas
Electrical output	kWe	1,200	1,200	-	-
Thermal output	kWtho	n/a	n/a	-	560
Stack height	m	7	7	8.7	7
Internal diameter at exit	m	0.4	0.4	2.645	0.25
Volume flow rate (dry)	Nm^3/s	1.04	1.19	5.48	0.16
Volume flow rate (wet)	Am^3/s	2.21	2.51	63.19	0.33
Velocity	m/s	17.6	20.0	11.5	6.73
Temperature	°C	150	150	1,000	180
Exit concentration SO_2	mg/Nm^3	107 (ELV, 5% O_2)	n/a	n/a	100 (ELV, 3% O_2)
Exit concentration TVOC	mg/Nm^3	1,000 (ELV, 5% O_2)	1,000 (ELV, 5% O_2)	10 (ELV, 3% O_2)	n/a
Exit concentration NOx	mg/Nm^3	500 (Tech spec, 5% O_2)	250 (Tech spec, 5% O_2)	150 (ELV, 3% O_2)	200 (ELV, 3% O_2)
Exit concentration CO	mg/Nm^3	1,400 (ELV, 5% O_2)	1,400 (ELV, 5% O_2)	50 (ELV, 3% O_2)	n/a
Emission rate SO_2	g/s	0.11	-	-	0.016
Emission rate TVOC	g/s	1.04	1.19	0.05	-
Emission rate NOx	g/s	0.52	0.30	0.82	0.031
Emission rate CO	g/s	1.46	1.66	0.27	-

Notes:

[1] CHP1, TEDOM Quanto 1200 TCG2020V12, fuelled by biogas (Appendix E). ELVs are the MCP Directive values for new plant (Annex II, Part 2, Table 2: gaseous fuels other than natural gas). Flue gas diameter and height were advised by ABL based on similar plant The exhaust gas volume flow rate (wet) is from the manufacturer's datasheet; the oxygen (8%) and moisture content (10%) were estimated based on monitoring data from comparable engines.

[2] CHP2, TEDOM Quanto 1200 TCG2020V12, fuelled by natural gas (Appendix E). ELVs are the MCP Directive values for new plant (Annex II, Part 2, Table 2: natural gas). Flue gas diameter and height were advised by ABL. The exhaust gas volume flow rate (wet) was taken from the manufacturer's datasheet; the oxygen (8%) and moisture content (10%) were estimated based on monitoring data from comparable engines.

[3] Based on Uniflare UF10-2500 High Temperature Enclosed Flare Stack (Appendix G) with maximum biogas flow rate of 2,500 Nm^3/h. Data on ELVs, temperature and volume flow rate were supplied by the manufacturer, Uniflare. Emission rates shown are for continuous operation; for long-term impact it has been assumed the flare will operate for a maximum of 10% of the time.

[4] Boiler parameters based on example specification for 560 kW, Veissmann Vitoplex 200, Type SX2A, Dual fuel: oil/gas boiler (Appendix F). ELVs for SO_2 and NOx are the MCP Directive values for new plant (Annex II, Part 2, Table 1). The specification was used to reference volumetric flow rates; the oxygen (4.3%) and moisture (15.2%) content of the exhaust gas have been referenced from monitoring data from the same boiler at Wardley Biogas AD Facility (16 November 2020). Emission rates shown are for continuous operation; for long-term impact it has been assumed the emergency boiler will operate for a maximum of 15% of the time.

Table 4 Other point source emission parameters (A6, A13, A19- A21, and A22)

Parameter	Units	(A6) OCU stack[1]	(A13) Leachate tank vent[2]	(A19 – A21) Digestate storage bag vents 1 - 3[3]	(A22) Liquid digestate offtake[4]
Location	NGR (X,Y) m	446049, 134061	446028, 133948	445960, 134129 445977, 134095 445968, 134112	446011, 134078
Stack height	m	15.5	0.1	0.5	2.5
Internal diameter at stack exit	m	0.55	0.1	0.1	0.1
Volume flow rate (dry)	Nm^3/s	-	-	-	-
Volume flow rate (wet)	Am^3/s	5.14	0.009	0.001	0.02
Velocity	m/s	21.6	0.1	0.1	2.86
Temperature	°C	22.5	Modelled as 'Ambient'	Modelled as 'Ambient'	Modelled as 'Ambient'
Exit concentration NH_3	mg/Nm^3	3.5	17.9	22,571 (1,129) [5]	0.9 (0.04)[6]
Exit concentration Odour	ou_E/Nm^3	1,000	10,000	10,000 (500) [5]	10,000 (500)[6]
Emission rate NH_3	g/s	0.018	0.00016	0.0177 (0.0009) [5]	0.00002 (0.000001)[6]
Emission rate Odour	ou_E/s	5,139	40.5	7.85 (0.39) [5]	225 (11.3) [6]

Notes:

[1] Emissions abatement system designed and supplied by Centri-Air AB. Data on the extraction system flow rates and design parameters taken from the data sheet (Appendix H). NH_3 concentrations (5ppm or 3.5mg/m^3 at 22.5°C) based on technical specification; odour concentrations are based on BAT-AEL for channelled emissions (1,000 ou_E/Nm^3). The BAT-AEL for NH_3 and odour is not necessarily applicable where waste is derived principally from manure.

[2] Underground leachate tank vent: stack height, diameter and volume flow rates based on assumptions. Exit concentrations of NH_3 have been calculated based on the nitrogen content of fresh matter in the feedstock (7.1kg total N/tonne) derived from the feedstocks used within the process. Odour concentrations based on measured odour concentrations for a digestate storage bag (AS Modelling & Data, 2017[31]). A 55% reduction to emissions has been applied to account for dilution of the leachate by surface water run-off.

[3] 3No. Lagoon vents: stack height, diameter and volume flow rates based on assumptions. NH_3 concentrations have been calculated based on the nitrogen content of fresh matter in the feedstock (7.1kg total N/tonne) derived from the feedstocks used within the process. Odour concentrations based on measured odour concentrations for a digestate storage bag (AS Modelling & Data, 2017).

[4] Digestate off-take point with carbon filter abatement system. Stack height, diameter and volume flow rates from carbon filter based on assumptions. NH_3 and odour concentrations have been calculated based on the nitrogen content of fresh matter in the feedstock (7.1kg total N/tonne) derived from the feedstocks to be used within the process. Emission rates have been factored to account for intermittent tanker filling, assuming constant rate Monday to Sunday, 9 hours per day (3,285 hours/ year).

[5] Brackets indicate values used for modelling, factored to account for 95% reduction in emissions due to containment within a digestate storage bag.

[6] Brackets indicate values used for modelling, factored to account for 95% reduction in emissions through the carbon filter.

[31] A S Modelling & Data (2017) A Dispersion Modelling Study of the Impact of Odour from the Proposed Biofertilizer Storage Lagoon at land west of Hangman Stone Lane, near High Melton in South Yorkshire.

Table 5 Volume sources Clamps, Hoppers, Separation bunker

Parameter	Units	Working face of clamp exposed	2No. Feed hoppers	Separator bunker [7]
Depth, width, length	Each in m	5, 42.5, 1	0.5[3], 14.25, 3	4.5, 11, 12[8]
Emitting surface area	m^2	213 (cutting face)	42.75	414 [9]
Emission mid-height	m	2.5	3	2.25
Total emission of NH_3	kg/yr	n/a	n/a	68 [10]
Exit concentration Odour	$ou_E/m^2/s$	20[1]	50[4]	2.8 [11]
Emission rate NH_3	$g/m^3/s$	n/a	n/a	0.0000038 (0.0000057) [12]
Emission rate Odour	$ou_E/m^3/s$	10 (14.65)[2]	100 (121)[5] (116)[6]	2.02 (3.06) [12]

Notes:
n/a = not applicable
[1] Redmore Environmental, Odour Assessment, Herriard Anaerobic Digestion Plant, Herriard, Reference: 2256-4r1, 16th December 2021.
[2] Brackets indicate mission rate adjusted for the dimensions of the source as represented within the model
[3] Depth of the modelled, elevated volume source.
[4] Odour concentration increased from $20ou_E/m^2/s$ to $50ou_E/m^2/s$ to account for agitation within the hopper.
[5] Brackets indicate Feed hopper 1 emission rate, adjusted for the dimensions of the source as represented within the model
[6] Brackets indicate Feed hopper 2 emission rate, adjusted for the dimensions of the source as represented within the model
[7] Time varying emissions profile used within the model: a reduction factor of 0.3 (a weighted average) was used for a 9-hour period each day, 7 days per week, to account for the impact of opening of the separator cover to allow for loading (duration approximately 20 minutes per hour), otherwise a reduction factor of 0.2 was used to account for residual emission when separator bunker door closed (Section 4.2.4).
[8] Dimensions of a cone, in terms of: height, radius and hypotenuse.
[9] Surface area calculated based on the shape of a cone to account for pile of digestate on the floor within Separation bunker.
[10] Calculated assuming 7.1kg total N/t of fibre digestate and an emission rate of 0.0266kg NH_3/kg N from EMEP/EEA.[24]
[11] Odournet UK Ltd (October 2013) Odour Impact Assessment for a proposed Anaerobic Digestion facility in Chatteris, Cambridgeshire.
[12] Brackets indicate emission rate adjusted for the dimensions of the source as represented within the model

5 Assessment criteria

5.1 Air Quality Standards

European and national legislation, policy, and guidance, as described in Section 3.2 to Section 0, set various limit values, target values, objectives and environmental assessment levels (EALs) that may apply to human or ecological receptors. These will be collectively referred to throughout this report as air quality standards (AQS).

The AQS are defined with respect to an averaging time and a statistic. Annual mean AQS are an example of a long-term AQS, which is defined over a long period of time as the effects of the pollutant on human health or the environment are chronic, that is, due to long-term exposure. Pollutants may also have acute impacts, that is, the effects become apparent after short period of exposure to high values. For these pollutants short-term AQS are defined, for instance the 24-hour limit for benzene and 1-hour limit for H_2S are a maximum hourly average that must not be exceeded.

5.2 AQS for human health

Table 6 sets out the AQS for human health for the pollutants relevant to this assessment. The standards which apply at human receptor locations apply where people will be exposed to a pollutant for a period relevant to the standard such as at residential locations, hospitals, and schools for annual mean values. Emissions are specified for TVOC for which there are no AQS; there is an AQS for benzene, one component of TVOC.

Table 6 Air Quality Standards for human health

Substance	Emission period	Limit (average)	Standard	Exceedances[1]
Benzene	24 hour	30 μg/m^3	EAL	None
Benzene	Annual	5 μg/m^3	AAD Limit Value and AQS Objective	None
Carbon monoxide	8 hour running average across a 24-hour period	10,000 μg/m^3	AAD Limit Value	None
Nitrogen dioxide	1 hour	200 μg/m^3	AAD Limit Value	Up to 18 1-hour periods
Nitrogen dioxide	Annual	40 μg/m^3	AAD Limit Value	None
Sulphur dioxide	15 minutes	266 μg/m^3	UK AQS Objective	Up to 35 15-minute periods
Sulphur dioxide	1 hour	350 μg/m^3	AAD Limit Value	Up to 24 1-hour periods
Sulphur dioxide	24 hour	125 μg/m^3	AAD Limit Value	Up to 3 24-hour periods

Notes: AQS taken from https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit
[1]number of times a year that you can exceed the limit

5.2.1 Significance of results

The Defra permit guidance[15] addresses when impacts can be considered insignificant. The guidance considers initial screening and then detailed modelling.

At the initial screening stage, a PC can be screened out from further assessment if:

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

The second stage of screening considers the background concentration as well as the PC. The Predicted Environmental Concentration (PEC) is the sum of the PC and background concentration. A further assessment is not needed if:

- the short-term PC is less than 20% of the 'headroom,' where headroom is defined as the short-term environmental standards minus twice the long-term background concentration, and
- the long-term PEC is less than 70% of the long-term environmental standards.

If the PC cannot be screened out on that basis, following detailed modelling, two tests are applied:

- the proposed emissions must comply with BAT associated emission levels (AELs) or the equivalent requirements where there is no BAT AEL
- the resulting PECs will not exceed environmental standards.

If those tests are not satisfied it is necessary to consider whether: the PCs could cause the PEC to exceed an AQS; the PEC already exceeds an AQS; or the activity on site is not covered by a BAT reference document. Further action is not required if the following both apply:

- your proposed emissions comply with BAT associated emission levels (AELs) or the equivalent requirements where there is no BAT AEL
- the resulting PECs will not exceed environmental standards.

5.3 AQS for sensitive conservation sites

The Defra/Environment Agency guidance[15] specifies that SACs, SPAs and Ramsar site within 10 km should be considered and SSSIs, AWs, LWSs, Local Nature Reserves and National Nature Reserves within 2 km should also be considered.

Data supplied by Hampshire Biodiversity Information Centre (Appendix I) confirmed the presence of 9 No. LWS and/or AW, some of which are coincident with Site of Importance for Nature Conservation (SINC) within 2 km of the permit boundary and provided information on the habitats at those sites. The closest site is Worthy Copse an area designated as AW, LWS and SINC located 157m northwest of the site.

The EA in their Screening Report for Nature and Heritage Conservation identified the River Itchen SAC, located at its nearest point approximately 3.6 km southeast of site, as a feature to be considered; in addition to 7 No. LWS (including Worthy Copse, Worthy Grove, Worthy Camp

Grassland, The Gallops - Worthy Down, Flowerdown – Littleton, Northwood Park Woods, and Worthy Down Railway Halt) and 3 No. areas of AW coincident with the LWS (including Worthy Copse, South Worthy Grove and Long Wood) (Appendix I).

For modelling purposes, discrete ecological receptors were placed in each designated area at the nearest locations to the Site and additional locations. The EA Screening Report identifies Worthy Down Railway Halt as a feature to be considered although the nearest part of the LWS lies over 2 km from the Site. It has, nonetheless, been included in this assessment.

Table 7 presents the sensitive conservation sites, receptors, and habitats in each area. AQS for concentrations of pollutants are referred to as critical levels (CLes) and those for deposition flux of nutrient nitrogen (NDep) and acid deposition due to nitrogen (N) and sulphur (S) (AcidDep) are referred to as critical loads (CLos). In Table 8 the CLes for the pollutants relevant to this assessment for designated ecological site receptors are summarised, in Table 9 the CLos for NDep are given and in Table 10 the CLos for AcidDep. CLos for AcidDep vary with habitat and location.

Table 7 Sensitive conservation sites

Site	Designation	Receptors	Habitat
Worthy Copse 1	LWS, AW, SINC	E1(a), E1(b), E1(c)	Broadleaved, Mixed and Yew Woodland
South Worthy Grove 1	AW, SINC	E2(a), E2(b)	Broadleaved, Mixed and Yew Woodland
Worthy Grove	LWS, AW, SINC	E3	Broadleaved, Mixed and Yew Woodland
The Gallops, Worthy Down	LWS, SINC	E4	Calcareous grassland
Long Wood	AW, SINC	E5(a), E5(b)	Broadleaved, Mixed and Yew Woodland
Northwood Park Woods (Cradle Copse)	LWS, SINC	E6	Coniferous woodland
Flowerdown, Littleton	LWS, SINC	E7(a), E7(b)	Neutral grassland
Worthy Camp Grassland	LWS, SINC	E8(a), E8(b)	Improved grassland
Worthy Camp Grassland	LWS, SINC	E8(c)	Broadleaved, Mixed and Yew Woodland
Worthy Down Railway Halt	LWS	E9	Broadleaved, Mixed and Yew Woodland
River Itchen	SAC	E10(a), E10(b), E10(c)	Dwarf shrub heath

Table 8 Environmental standards for protected conservation areas

Substance	Target	Emission period
Sulphur dioxide[1]	10 µg/m^3 where lichens or bryophytes are present. 20 µg/m^3 where they are not present	Annual
Nitrogen oxide (expressed as nitrogen dioxide)[2]	30 µg/m^3	Annual

Nitrogen oxide (expressed as nitrogen dioxide)[3]	75 µg/m³ 200 µg/m³ for detailed assessments where the ozone is below the AOT40 critical level and sulphur dioxide is below the lower critical level of 10 µg/m³	Daily
Nutrient nitrogen deposition	Depends on location, use www.apis.ac.uk[32]	Annual
Acidity deposition	Depends on location, use www.apis.ac.uk	Annual
Notes: Environmental standards taken from https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit [1]20 µg/m³ is an AAD Limit Value if you have nature or conservation sites in the area; [2]30 µg/m³ is an AAD Limit Value [3]The lower (stricter) value of 75 µg/m³ has been used throughout this assessment.		

Table 9 shows whether sites were modelled as grass or forest for the calculation of deposition flux. The River Itchen SAC was modelled as 'grass' as the most sensitive habitats for NDep and AcidDep at the SAC are wet heath.

Table 9 Nutrient nitrogen deposition critical loads

Site	Nitrogen critical load class	Critical load (kg/ha/yr)	Forest / Grass
Worthy Copse	Broadleaved deciduous woodland	10 - 15	Forest
South Worthy Grove	Broadleaved deciduous woodland	10 - 15	Forest
Worthy Grove	Broadleaved deciduous woodland	10 - 15	Forest
The Gallops, Worthy Down	Arctic-alpine calcareous grassland	5 - 10	Grass
Long Wood	Broadleaved deciduous woodland	10 - 15	Forest
Northwood Park Woods (Cradle Copse)	Coniferous woodland	3 - 15	Forest
Flowerdown, Littleton	Low and medium altitude hay meadows	10 - 20	Grass
Worthy Camp Grassland	Improved grassland habitat is not sensitive	n/a	Grass
Worthy Camp Grassland	Broadleaved deciduous woodland	10 - 15	Forest
Worthy Down Railway Halt	Broadleaved deciduous woodland	10 - 15	Forest
River Itchen	Northern wet heath: Erica tetralix dominated wet heath (lowland)	5 - 15	Grass
Note: Values from www.apis.ac.uk			

Table 10 Acid deposition critical loads

Site	Acidity critical load class	Critical loads (keq/ha/yr)
Worthy Copse	Broadleafed/Coniferous unmanaged woodland	CLminN: 11.027 / CLmaxS: 0.142 / CLmaxN: 11.169
South Worthy Grove	Broadleafed/Coniferous unmanaged woodland	(E2a) CLminN: 11.027 / CLmaxS: 0.142 / CLmaxN: 11.169 (E2c) CLminN: 11.037 / CLmaxS: 0.142 / CLmaxN: 11.179
Worthy Grove	Broadleafed/Coniferous unmanaged woodland	CLminN: 11.037 / CLmaxS: 0.142 / CLmaxN: 11.179
The Gallops, Worthy Down	Calcareous grassland (using base cation)	CLminN: 4 / CLmaxS: 0.856 / CLmaxN: 4.856

[32] UK Air Pollution Information System (APIS) (http://www.apis.ac.uk/) Accessed March 2024.

Long Wood	Broadleafed/Coniferous unmanaged woodland	(E4a) CLminN: 11.033 / CLmaxS: 0.142 / CLmaxN: 11.175 (E4b) CLminN: 2.749 / CLmaxS: 0.142 / CLmaxN: 2.891
Northwood Park Woods (Cradle Copse)	Broadleafed/Coniferous unmanaged woodland	CLminN: 11.033 / CLmaxS: 0.142 / CLmaxN: 11.175
Flowerdown, Littleton	Calcareous grassland (using base cation)	CLminN: 4 / CLmaxS: 0.856 / CLmaxN: 4.856
Worthy Camp Grassland	This habitat is not sensitive to acidity	n/a
Worthy Camp Grassland	Broadleafed/Coniferous unmanaged woodland	(E7c) CLminN: 11.027 / CLmaxS: 0.142 / CLmaxN: 11.169
Worthy Down Railway Halt	Broadleafed/Coniferous unmanaged woodland	CLminN: 11.037 / CLmaxS: 0.142 / CLmaxN: 11.179
River Itchen	Dwarf shrub heath (Coenagrion mercuriale)	CLminN: 0.267 / CLmaxS: 0.499 / CLmaxN: 0.922
Note: Values from www.apis.ac.uk		

5.3.1 Significance of results

For nationally designated sites (River Itchen SAC) tests on significance are the same as for human receptors (as given in section 5.2) with the exception that PC as a percentage of Headroom is not assessed for short-term impacts (daily NOx).

For locally designated sites such as AW and LWS, impacts can be screened out as insignificant if the short-term and long-term PCs are less than 100% of the relevant AQS.

5.4 Odour benchmarks

Most odours arise from mixtures of pollutants and the odour threshold is judged subjectively.

Environment Agency H4 Odour Management guidance17 sets out benchmark odour criteria based on the 98th percentile of hourly mean concentrations of odour modelled over a year at a site boundary, that is, the benchmarks are odour concentrations that may be exceeded during 2% of hours.

The benchmarks, to which predicted odour impacts have been compared are:

- 1.5ou_E/m^3 for “most offensive” odours e.g., processes involving septic effluent or sludge, processes involving decaying animal or fish remains, biological landfill odours.
- 3.0 ou_E/m^3 for “moderately offensive” odours e.g., intensive livestock rearing, well-aerated green composting, sugar beet processing. Odours from poultry rearing and Wastewater Treatment Works operating normally i.e., non-septic conditions, are usually placed in the “moderately offensive” category.
- 6.0 ou_E/m^3 for “less offensive” odours e.g., brewery, bakery, coffee roasting.

Odours from the normal operation of the AD plant are considered to fall within the “moderately offensive” category for which 3ou_E/m^3 is the appropriate benchmark.

6 Background concentrations and deposition fluxes

6.1 District Council air quality monitoring

Winchester City Council (WCC) have declared an Air Quality Management Area (AQMA) for NO_2 and particulate matter (PM_{10}) in Winchester City Centre following the one-way travel system in the city, situated approximately 3.8 km to the southeast of the site. The 24-hour PM_{10} AQMA was revoked in 2013 after measured concentrations demonstrated consistent compliance with the objective. [33]

In 2022, the latest year for which results are published,[33] WCC undertook NO_2 monitoring via a network of automatic (continuous) monitoring units, and non-automatic (passive) diffusion tubes. WCC does not operate any rural or urban background monitoring sites.

Monitoring results across the network, for sites classified as either 'roadside' or 'other' (other areas of potentially elevated concentrations across the wider district), demonstrated compliance with the annual mean objective for NO_2 both within the AQMA and within the wider district.

The highest concentration in the wider district was 23.7 µg/m^3, that is almost half of the national objective, at 'District 3' (Martyr Worth Roads, Kings Worthy/Martyr Worthy). District 3 roadside monitoring location is also the closest monitoring point to the site, situated approximately 3.6 km to the southeast. Table 11 details the most recent 5-year monitoring results at locations closest to the site.

Table 11 WCC Annual Mean NO_2 Monitoring Results: Non-Automatic Monitoring (µg/m^3)

Diffusion Tube ID	X NGR	Y NGR	Site Type	Distance from site (m)	2018	2019	2020 [(a)]	2021	2022
District 3	449647	132669	Roadside	3,673	40.5	34.6	25.0	25.0	**23.7**
City 18	447534	130006	Roadside	4,035	20.0	18.7	13.1	13.2	13.7
City 27	447898	130065	Roadside	4,137	30.6	26.5	20.8	22.0	21.1

Notes: Data source: Winchester City Council, 2023 Air Quality Annual Status Report (ASR) (May 2023).
(a) The decrease observed in some instances in 2020 is attributed largely to the COVID-19 pandemic and the associated lockdowns.

6.2 Defra modelled background concentrations

Defra provides maps of 2024 background concentrations of NOx and NO_2 that have been projected from a base year of 2018, benzene projected to 2010 from a base year of 2001 and SO_2 and CO for 2001. Factors are provided to project the concentrations of benzene, CO and SO_2 to future years.[34] The maps and factors have been used to determine 2024 background

[33] Winchester City Council, 2023 Air Quality Annual Status Report (ASR) (May 2023)
[34] Defra, Background Maps, Available at: https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html [Accessed March 2024].

concentrations at each of the receptors which are shown in Table 12. Background concentrations of NH_3 are not part of the Defra mapped data and have been obtained from APIS.[35]

The 2024 Defra spatially varying background concentrations (7.49 – 9.94 µg/m^3) are lower than the 2022 roadside background concentrations (section 6.1) monitored in WCC. The site and nearby receptors are situated within 200m of the A272 and/or A34, and therefore the 2022 monitored NO2 background concentration (23.7 µg/m^3) has been applied in this assessment. For other relevant pollutants, the Defra spatially varying background concentrations are applied.

Table 12 2024 Annual mean background concentrations (µg/m^3)

ID	Annual mean concentration (µg/m^3)				
	NOx	NO_2	SO_2	Benzene	CO
R1 (a)	13.0	9.94	2.28	0.21	0.12
R1 (b)	13.0	9.94	2.28	0.21	0.12
R2	13.0	9.94	2.28	0.21	0.12
R3	13.0	9.94	2.28	0.21	0.12
R4	9.62	7.49	2.26	0.20	0.12
R5 (a)	11.1	8.60	2.47	0.20	0.12
R6	13.0	9.94	2.28	0.21	0.12
R7	13.0	9.94	2.28	0.21	0.12
R5 (b)	11.1	8.60	2.47	0.20	0.12
R8	13.0	9.94	2.28	0.21	0.12
R5 (c)	11.1	8.60	2.47	0.20	0.12
R9	9.62	7.49	2.26	0.20	0.12
R10	9.62	7.49	2.26	0.20	0.12
R11	9.62	7.49	2.26	0.20	0.12
R5 (d)	11.1	8.60	2.47	0.20	0.12
R12	10.3	7.96	2.31	0.24	0.13

6.3 Background concentration and deposition at sensitive conservation sites

Background concentrations of NOx, SO_2 and deposition of NDep at all the ecological receptors have been obtained from APIS maps which provide the data on a 1 km grid cell basis. The NDep values depend on whether the habitat is forest (woodland) or grass (moorland) as deposition rates vary according to the nature of the vegetation. Table 9 shows which receptors have been modelled as forest and which as grass. The background values are the latest available and are an average for the years 2019-2021 and are shown in Table 13.

[35] Air Pollution Information System, Available at www.apis.ac.uk, [Accessed March 2024].

Table 13 Background concentrations and deposition at ecological receptors

Receptor ID	NOx (µg/m^3)	SO_2 (µg/m^3)	NH_3 (µg/m^3)	NDep (kgN/ha/yr)	AcidSDep (keqS/ha/yr)	AcidNDep (keqN/ha/yr)
E1 (a)	10.6	0.73	1.68	28.43	2.03	0.17
E1 (b)	10.6	0.73	1.68	28.43	2.03	0.17
E1 (c)	10.6	0.73	1.68	28.43	2.03	0.17
E2 (a)	10.6	0.73	1.68	28.43	2.03	0.17
E2 (b)	11.6	0.70	1.67	28.34	2.02	0.16
E3	11.6	0.70	1.67	28.34	2.02	0.16
E4	11.6	0.70	1.67	16.93	1.21	0.13
E5 (a)	9.14	0.70	1.62	28.20	2.01	0.17
E5 (b)	9.31	0.73	1.58	28.23	2.02	0.17
E6	9.14	0.70	1.62	28.20	2.01	0.17
E7 (a)	10.7	0.93	1.66	17.42	1.24	0.15
E7 (b)	11.4	1.34	1.63	17.16	1.23	0.15
E8 (a)	10.3	0.78	1.77	17.33	1.24	0.14
E8 (b)	10.3	0.78	1.77	17.33	1.24	0.14
E8 (c)	10.3	0.78	1.77	28.95	2.07	0.18
E9	10.2	0.85	1.75	28.75	2.05	0.17
E10 (a)	13.8	1.02	1.72	16.94	1.21	0.14
E10 (b)	13.8	1.02	1.72	16.94	1.18	0.14
E10 (c)	13.8	1.02	1.72	16.94	1.13	0.12

7 Impact assessment of air quality on human health

Predicted impacts of each pollutant at each human receptor are given in Appendix J. In this section the highest results are presented, that is, the impacts at the worst-case receptor. Impacts have been compared to the screening thresholds given in section 5.2.1.

Table 14 shows the maximum annual mean (long-term) concentration and Table 15 shows the maximum predicted short-term impacts, from 15 minutes to 24 hours. The predicted concentrations, with and without background concentrations, have been compared with the AQS. Long-term AQS are not applicable at the workplaces nor recreational locations where the public are unlikely to spend long periods of time.

7.1 Long-term AQS

Maximum long-term impacts for all pollutants are predicted at the residential receptor, R3, 'Three Maids Bungalow', which is located 250m southwest of the site boundary.

The PCs exceed 1% of the AQS (1.3% for NO_2, 3.9% for benzene) although the PECs are much less than 70% of AQS. The long-term impacts at all receptors can therefore be screened out as **not significant** and there is no need for further assessment.

Table 14 Results, long-term AQS

Pollutant	AQS (μg/m^3)	PC (μg/m^3)	PC/AQS (%)	PEC (μg/m^3)	PEC/AQS (%)	Receptor
NO_2	40	0.53	**1.3%**	24.2	61%	R3
NH_3	180	0.04	0.02%	1.81	1.0%	R3
Benzene	5	0.20	**3.9%**	0.41	8.2%	R3
Notes: bold font indicates an exceedance of the screening threshold. Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest.						

7.2 Short-term AQS

The maximum short-term concentrations for each AQS, across all receptors and all meteorological years, and the worst of with and without buildings and terrain, are given in Table 15.

The maximum short-term impacts, with the exception of predicted short-term NH_3 concentrations, are predicted at receptor R2 that is representative of 'The Pringle Group/ Concrete 247' recycling and aggregates processing operation, situated approximately 245m to the east of the site boundary. For short-term concentrations of NH_3, the maximum impacts are predicted at R1(b), approximately 125m to the south of the site boundary, selected as representative of the proposed Instavolt playground.

Calculated PCs have been compared with the AQS and to the 'Headroom' as defined in section 5.2. It is a measure used by the Environment Agency in assessing air quality impacts for an environmental permit.

The short-term PCs do not exceed 10% of the AQS or the screening threshold of 20% for PC/Headroom, with the exception of short-term predicted concentrations of TVOCs as 10% benzene. The maximum PC for benzene exceeds the screening threshold of 20% for PC/Headroom (28% benzene PC/Headroom). All PECs are well below the respective AQS however, including that for benzene (29% benzene PEC/AQS). A very conservative approach has been taken to the short-term modelling of combustion emissions, assuming that operation of both CHPs, emergency flare and emergency boiler are operating simultaneously, and of which might coincide with all the worst-case meteorological conditions.

There is therefore no need for further assessment of any pollutant. The short-term impacts at all receptors can therefore be screened out as **not significant**.

Table 15 Results, short-term AQS

Pollutant	Statistic	AQS ($\mu g/m^3$)	PC ($\mu g/m^3$)	PC/AQS (%)	Headroom ($\mu g/m^3$)	PC/ Headroom (%)	PEC/ AQS (%)	Receptor
NO_2	99.79th 1h	200	17.9	8.9%	153	11.7%	33%	R2
SO_2	99.9th 15min	266	18.6	7.0%	261	7.1%	8.7%	R2
SO_2	99.73rd 1h	350	7.74	2.2%	345	2.2%	3.5%	R2
SO_2	99.18th 24h	125	2.46	2.0%	120	2.0%	5.6%	R2
CO*	Max daily 8h*	10,000	255	2.5%	9,759	2.6%	5.0%	R2
NH_3	Max 1h	2,500	6.36	0.25%	2,496	0.25%	0.4%	R1(b)
Benzene	Max 24h	30	8.29	**27.6%**	29.6	**28%**	29%	R2

Notes: *Maximum daily 8h running.
Bold font indicates an exceedance of the screening threshold.
Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest.

8 Impact assessment of air quality on ecological receptors

Predicted impacts of each pollutant at each ecological receptor are given in Appendix K. In this section the highest results are presented, that is, the impacts at the worst-case receptor across all meteorological years, and the worst with and without buildings and terrain. Impacts have been compared to the screening thresholds given in section 0.

8.1 Nationally designated sites

Considering the closest area of the nationally designated site, represented as receptor E10(a), River Itchen SAC, Table 16 shows that the predicted long-term and short-term concentration PCs are below the respective 1% and 10% screening thresholds; Table 18 and Table 19 show that the predicted contributions to NDep and AcidDep are below 1%.

Impacts at E10, River Itchen SAC can therefore be screened out as **not significant**.

8.2 Locally designated sites

Considering the locally designated sites, AWs and LWSs, Table 17 shows that predicted PCs do not exceed any of the screening thresholds (section 5.3.1). Maximum long-term and short-term concentrations were predicted at E1(a), Worthy Copse LWS, AW and SINC.

Table 18 and Table 19 show that the maximum impacts are predicted at E1, Worthy Copse. Predicted contributions to NDep and AcidNDep less than 100% of the relevant Clos.

Impacts at LWSs, AW and SINCs can therefore be screened out as **not significant**.

Table 16 Results at SAC, long-term and short-term AQS, worst case impact

Pollutant	AQS ($\mu g/m^3$)	Averaging time	Statistic	LT or ST AQS*	PC ($\mu g/m^3$)	PC/AQS (%)	PEC ($\mu g/m^3$)	PEC/AQS (%)	Receptor
NOx	30	Annual	mean	LT	0.06	0.21%	19.0	63%	E10(a)
SO_2	20	Annual	mean	LT	0.008	0.04%	1.01	5.0%	E10(a)
SO_2	10	Annual	mean	LT	0.008	0.08%	1.01	10%	E10(a)
NH_3	**1 ****	Annual	mean	LT	0.002	0.19%	1.70	170%	E10(a)
Pollutant	**AQS ($\mu g/m^3$)**	**Averaging time**	**Statistic**	**LT or ST AQS***	**PC ($\mu g/m^3$)**	**PC/AQS (%)**	**PEC ($\mu g/m^3$)**	**PEC/ AQS (%)**	**Receptor**
NOx	75	24-hour	100th percentile	ST	2.82	3.8%	-	-	E10(a)

Notes: *LT= long-term, ST = short-term; Bold font indicates an exceedance of the screening threshold (long-term PC/AQS = 1%, short-term PC/AQS = 10%).
Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest.
** Lower NH_3 CLe adopted as a conservative approach although lichens and bryophytes are not cited as integral to the SAC habitat (www.apis.co.uk).

Table 17 Results at AW, LWS and SINCs - long-term and short-term AQS, worst case impact

Pollutant	AQS ($\mu g/m^3$)	Averaging time	Statistic	LT or ST AQS*	PC ($\mu g/m^3$)	PC/AQS (%)	Receptor
NOx	30	Annual	mean	LT	1.31	4.4%	E1(a)
SO_2	20	Annual	mean	LT	0.18	0.9%	E1(a)
SO_2	10	Annual	mean	LT	0.18	1.8%	E1(a)
NH_3	**1 ****	Annual	mean	LT	0.08	8.2%	E1(a)
Pollutant	**AQS ($\mu g/m^3$)**	**Averaging time**	**Statistic**	**LT or ST AQS***	**PC ($\mu g/m^3$)**	**PC/AQS (%)**	**Receptor**
NOx	75	24-hour	100th percentile	ST	27.7	37%	E1(a)

Notes: *LT= long-term, ST = short-term; Bold font indicates an exceedance of the screening threshold (long and short-term PC/AQS = 100%).
Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest.
** Lower NH_3 CLe adopted as a conservative approach although lichens and bryophytes were not cited as integral to the habitats (www.apis.co.uk).

Table 18 Worst-case nutrient nitrogen deposition

Habitat	PC (kg/ha/y)	CLomin (ka/ha/y)	CLomax (ka/ha/y)	PC/CLomin (%)	PC/CLomax (%)	PEDR/CLomin (%)	PEDR/CLomax (%)	Receptor
SAC	0.016	5	15	0.32%	0.11%	338%	113%	E10(a)
AW, LWS, SINC	0.907	10	15	9.1%	6.0%	293%	196%	E1(a)

Notes: Bold font indicates an exceedance of the screening threshold; data on each row is for one receptor, the receptor at which the percentage of PC/CLo is greatest.

Table 19 Worst-case acid deposition

Habitat	PC_N (keqN/ha/yr)	PC_S (keqN/ha/yr)	PC/CLo (%)	Background/CLo (%)	PEDR/CLo (%)	Receptor
SAC[1]	0.001	0.001	0%	146%	146%	E10(a)
AW, LWS, SINC	0.065	0.041	0.6% (N only)	18% (N only)	25% (N only)	E1(a)

Notes: Bold font indicates an exceedance of the screening threshold; data on each row is for one receptor, the receptor at which the percentage of PC/CLo is greatest.

[1] %PC of minimum critical load determined using the Critical Load Function tool, available at www.apis.co.uk.

9 Impact assessment of odour

Table 20 shows the predicted 98th percentile of 1-hour mean odour concentrations at the modelled discrete receptor locations. The values given are the worst case for each year (with or without buildings and terrain), the maximum at each receptor and the year for which it was predicted are given in the final two columns.

The maximum predicted, 2.69ou_E/m^3, is at one of the nearest receptors, R1(a), a location selected as representative of the proposed Instavolt Restaurant, to be situated approximately 120m south of the site boundary. Receptor R3, Three Maids Bungalow situated 250m to the southwest is the closest *residential* receptor, at which the maximum odour impact is predicted (1.73ou_E/m^3).

The maximum predicted odour concentration at R1(a) is below the adopted criterion of 3ou_E/m^3 for 'moderately offensive' odours. Maximum predicted odour concentrations at the nearest residential receptor, R3, where high levels of amenity may be expected, are also below this threshold. On this basis, the site operation is not likely to cause odour impact at human receptors.

Table 20 98th percentile hour mean odour concentration (ou_E/m^3)

ID	2018	2019	2020	2021	2022	Maximum	Worst case year
R1 (a)	2.19	2.54	2.26	2.27	2.69	2.69	2022
R1 (b)	1.98	2.35	2.30	2.25	2.58	2.58	2022
R2	1.68	1.96	1.96	2.45	1.96	2.45	2021
R3	0.87	1.22	1.71	1.73	1.48	1.73	2021
R4	0.42	0.56	0.56	0.57	0.61	0.61	2022
R5 (a)	0.17	0.25	0.25	0.25	0.31	0.31	2022
R6	0.30	0.30	0.31	0.43	0.30	0.43	2021
R7	0.30	0.30	0.30	0.41	0.30	0.41	2021
R5 (b)	0.22	0.23	0.26	0.24	0.29	0.29	2022
R8	0.26	0.26	0.26	0.36	0.26	0.36	2021
R5 (c)	0.22	0.22	0.22	0.31	0.31	0.31	2021
R9	0.26	0.32	0.26	0.26	0.30	0.32	2019
R10	0.16	0.19	0.24	0.24	0.24	0.24	2022
R11	0.22	0.22	0.22	0.24	0.28	0.28	2022
R5 (d)	0.20	0.21	0.19	0.27	0.26	0.27	2021
R12	0.14	0.17	0.17	0.17	0.20	0.20	2022

10 Conclusion

This AQIA has been prepared to support a permit application for the operation of an anaerobic digestion plant at Three Maids, Three Maids Farm, Three Maids Hill, Winchester, SO21 2QG.

An H1 risk assessment concluded that the following pollutants and averaging time required detailed modelling for comparison with the following EALs (or AQS):

- Nitrogen Dioxide (Annual and 1 Hour Mean)
- Nitrogen Dioxide (Ecological - Daily Mean)
- Ammonia (Ecological - Sensitive Lichens)
- Carbon monoxide (8h mean)
- Benzene (Annual and 24 Hour mean)
- Sulphur Dioxide (15 Min Mean)
- Sulphur Dioxide (1 Hour Mean)
- Sulphur Dioxide (24 Hour Mean)
- Sulphur Dioxide (Ecological - Sensitive Lichens)

The proposed Site is not in an AQMA, the nearest of which is approximately 3.7 km away.

Within 2 km of the proposed site, there are nine locally designated conservation sites, the closest of which is Worthy Copse situated 157m northwest of the site and is designated as Ancient Woodland (AW), a Local Wildlife Site (LWS) and Site of Importance for Nature Conservation (SINC). There is one statutory designation within 10 km; the River Itchen Special Area of Conservation (SAC), that is also coincident with areas designated as Site of Special Scientific Interest (SSSI), located at its nearest point approximately 3.6 km southeast of site.

Baseline conditions of sensitive receptors, current background concentrations and deposition rates have been established. Detailed modelling has been carried out using the ADMS 6 dispersion model and numerical modelled meteorological data for the Site location. Conservative assumptions have been made throughout the assessment.

The proposed point source and fugitive emissions to air at the Site were taken into account in assessing impacts at human and ecological receptors.

Two modelling scenarios were considered for the assessment of long and short-term impacts (section 2.4). Long-term impacts of the proposed sources were calculated assuming the proposed CHPs operate continuously at full load, the emergency boiler for 15% of the year (approximately two months) at full load, and the emergency flare 10% of the time (i.e., 876 hours per year).

Short-term impacts were calculated on the basis of both CHPs, the emergency boiler and emergency flare operating at full load, all year. This is a conservative approach as it assumes that the emergency boiler and flare may be operating at full load during all the worst-case meteorological conditions, whereas the boiler is expected to operate for no more than 15% of the year, and the emergency flare no more than 10% and therefore their infrequent hours of operation are unlikely to coincide with all the worst-case conditions.

10.1 Human health receptors

The long-term and short-term impacts at all receptors can be screened out as **not significant** and there is no need for further assessment.

10.2 Ecological receptors

Impacts at the nationally designated site, E10, River Itchen SAC, can be screened out as **not significant**.

Impacts at locally designated sites, AWs and LWSs, can be screened out as **not significant**.

10.3 Odour impact

Predicted odour concentrations are below the adopted criterion of $3ou_E/m^3$ for 'moderately offensive' odours. On this basis, the site operation is not likely to cause odour impact at human receptors.

Figures

Figure 1 Site location

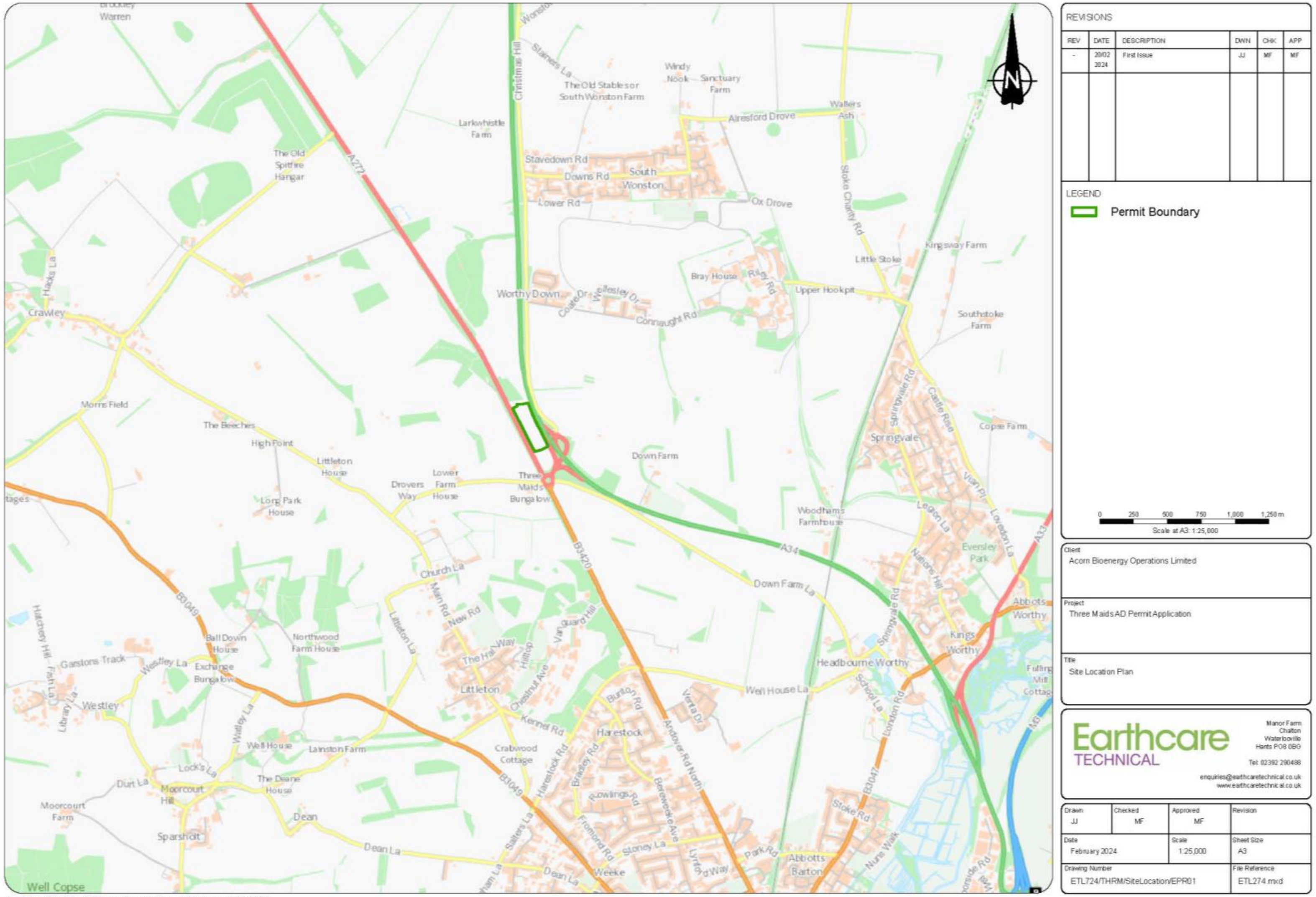
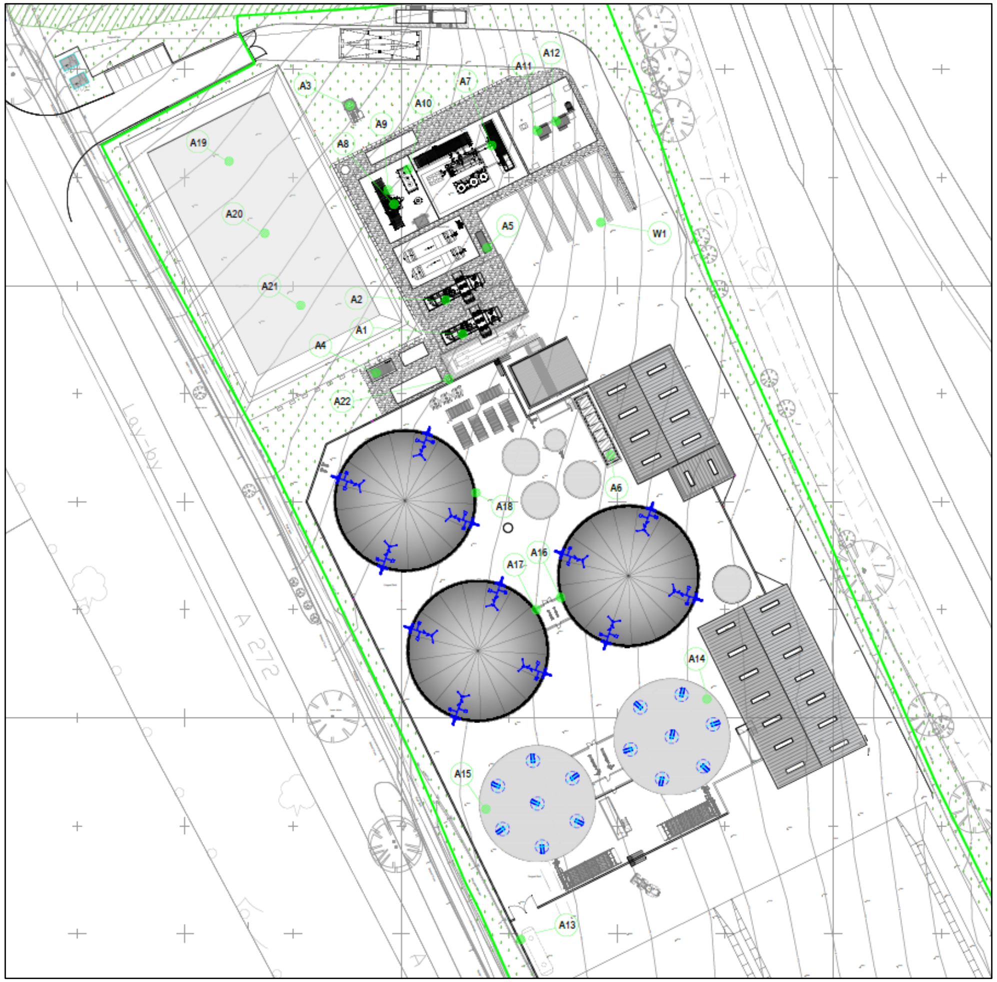


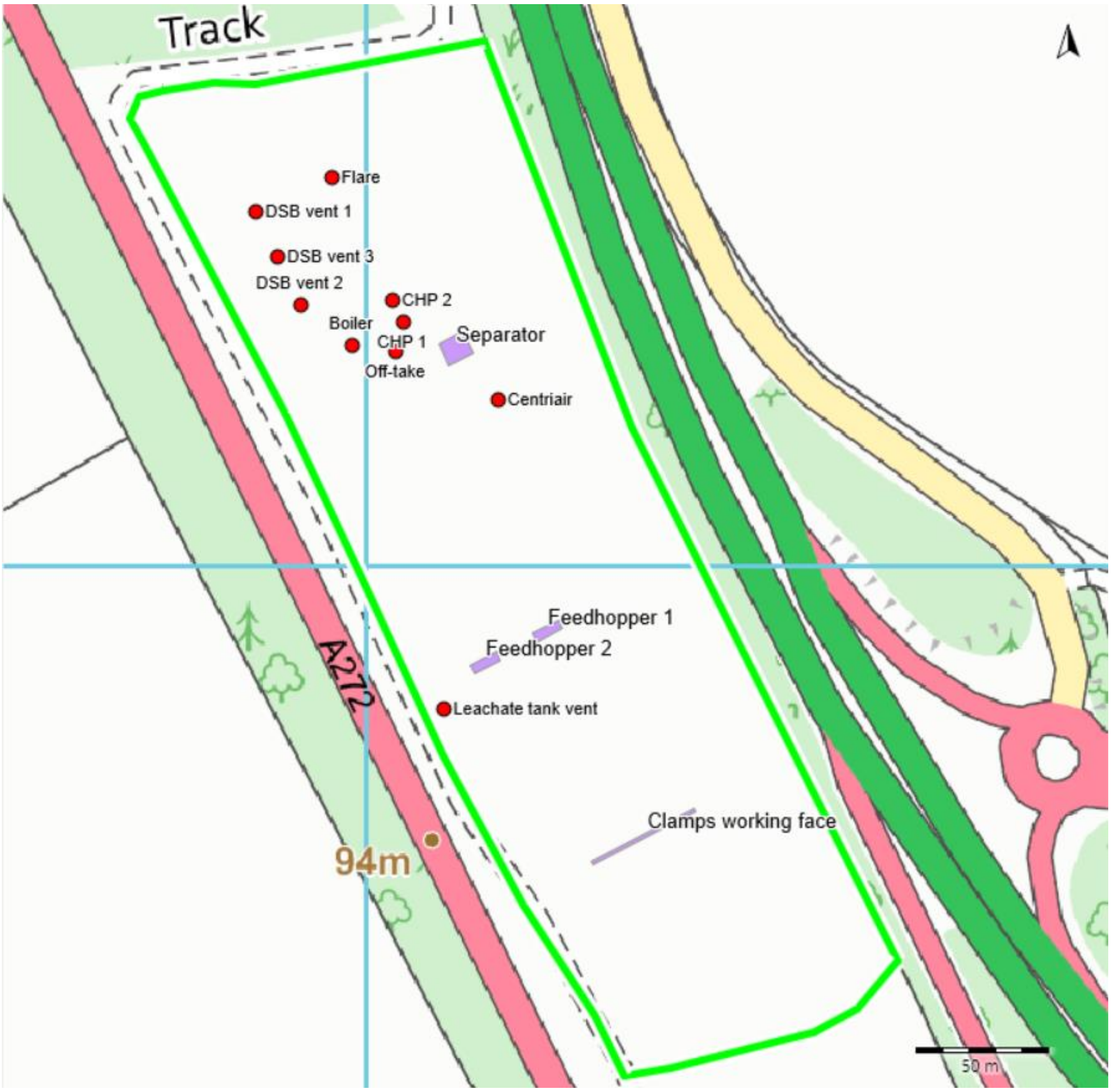
Figure 2 Permit boundary and emission point plan



Reference Table	
A1	Combined heat and power engine stack 1
A2	Combined heat and power engine stack 2
A3	Emergency flare stack
A4	Emergency boiler stack
A5	Emergency generator stack
A6	Emissions abatement plant stack (manure reception building)
A7	Biogas upgrade unit PRV
A8	Biogas upgrade unit CO_2 vent
A9	Carbon dioxide recovery plant PRV 1
A10	Carbon dioxide recovery plant PRV 2
A11	Compressor PRV 1
A12	Compressor PRV 2
A13	Underground leachate tank vent
A14	PVRV on Primary digester 1
A15	PVRV on Primary digester 2
A16	PVRV on Secondary digester 1
A17	PVRV on Secondary digester 2
A18	PVRV on Tertiary digester
A19	Digestate storage bag vent 1
A20	Digestate storage bag vent 2
A21	Digestate storage bag vent 3
A22	Liquid Digestate off-take point
W1	Clean surface water from underground storage system

Base plan produced by GGP Reference: Acorn-29348-C-202-E Site Emissions Plan. Edited by Earthcare Technical Ltd March 2024.

Figure 3 Modelled point and volume sources



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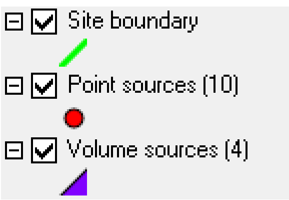
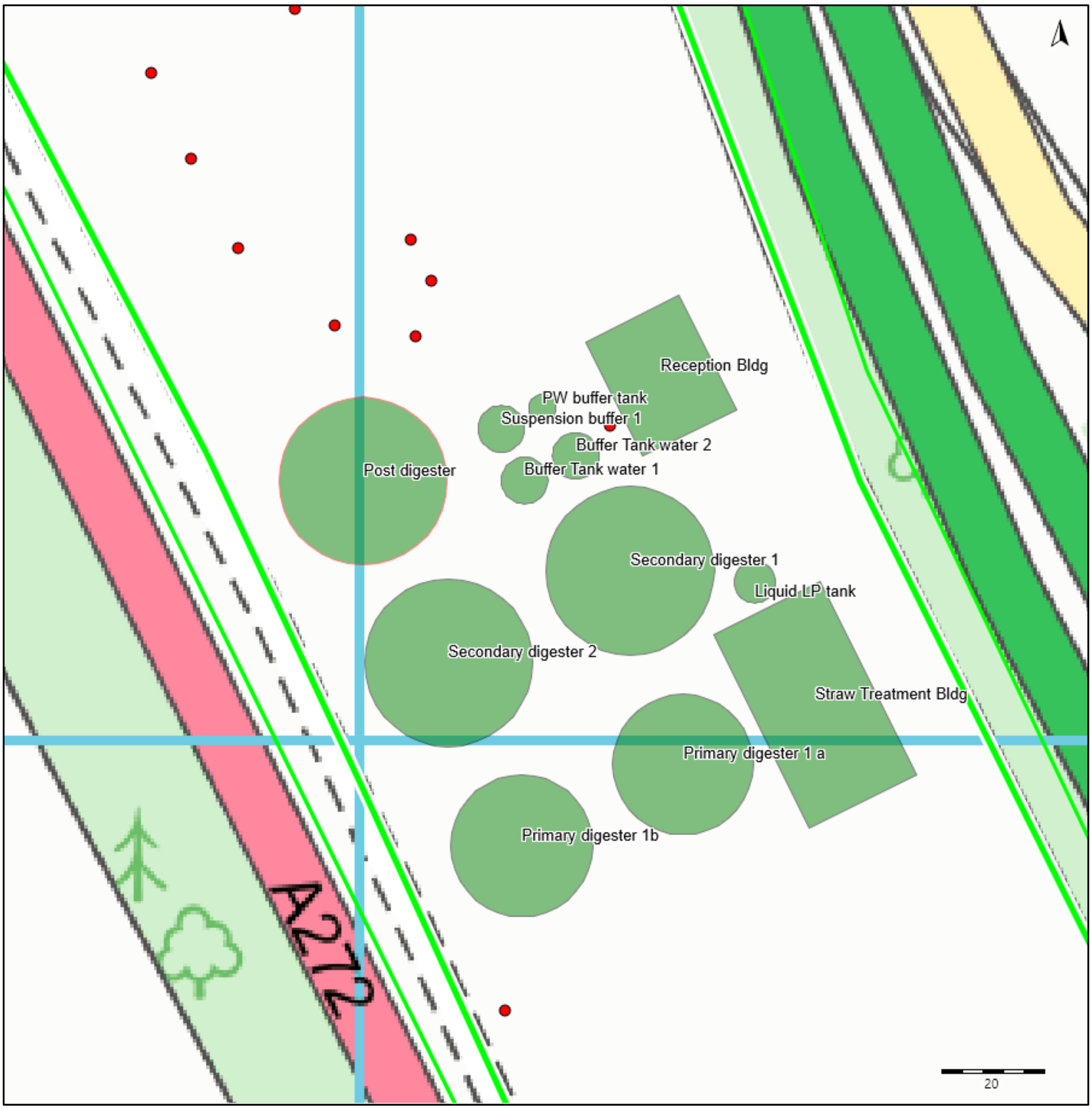


Figure 4 Modelled buildings



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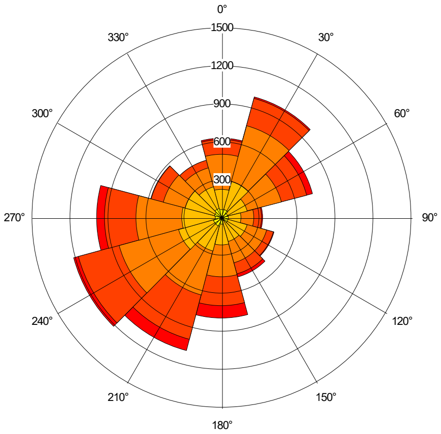
Legend

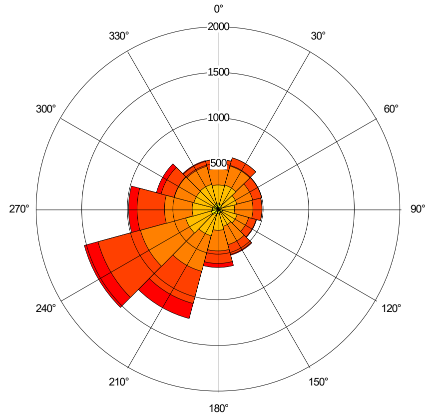
- Site boundary
- Point sources (10)
- Buildings (12)

Figure 5 GFS meteorological data (51.102°, -1.342°), windroses 2018-2022

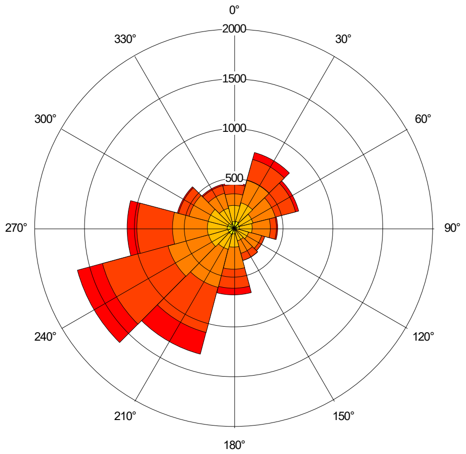
2018



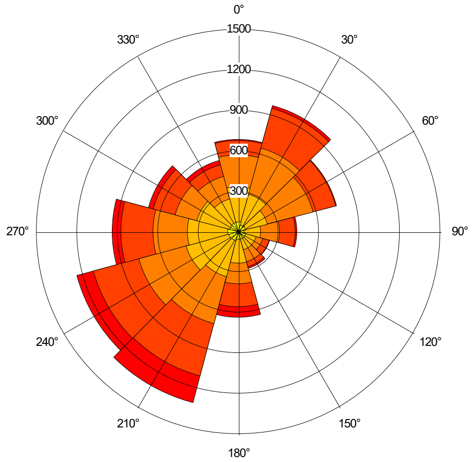
2019



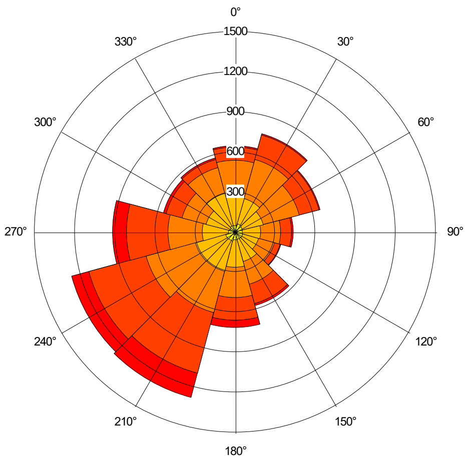
2020



2021



2022



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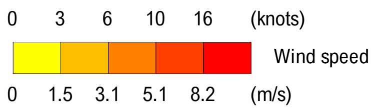


Figure 6 Terrain data

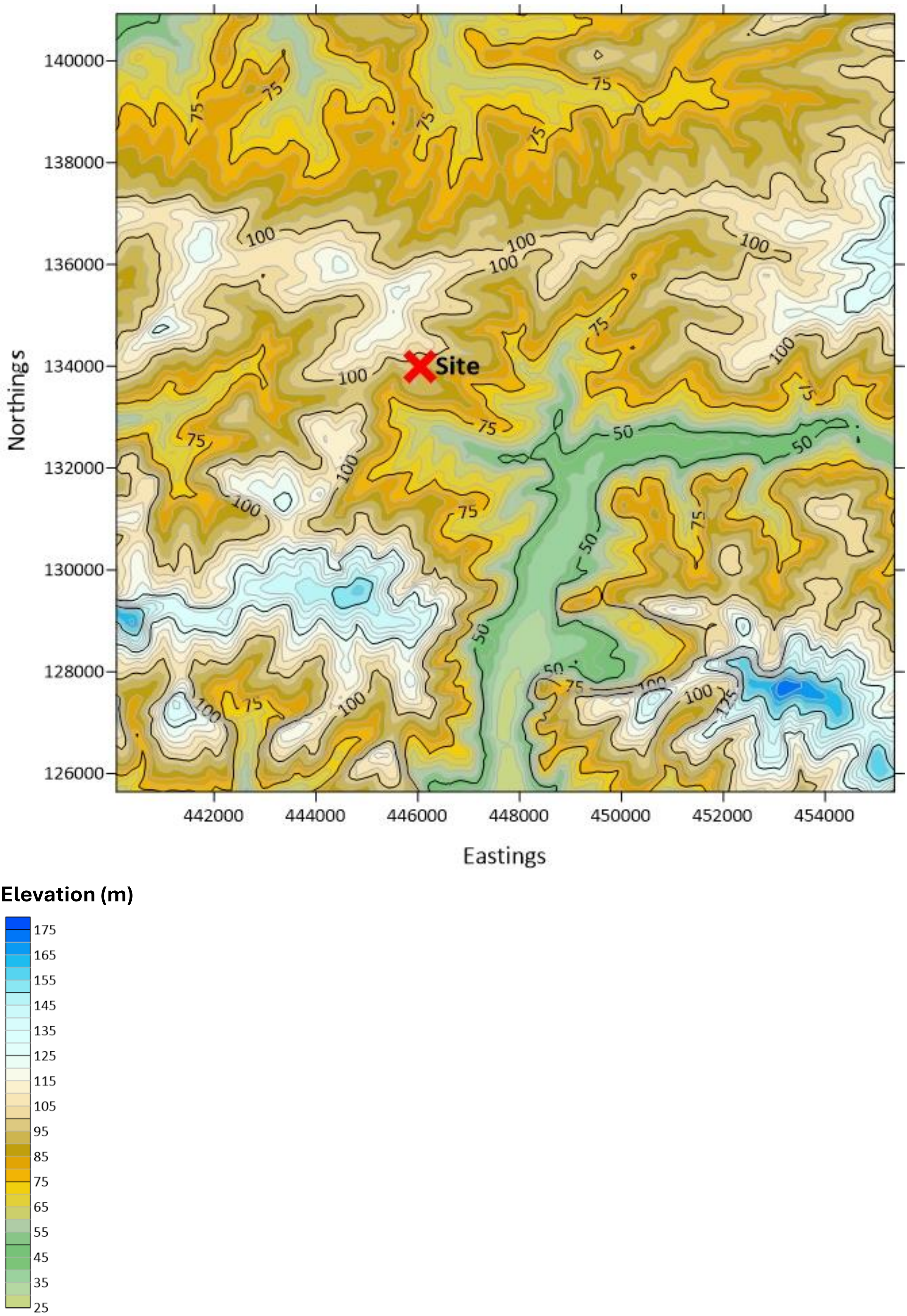
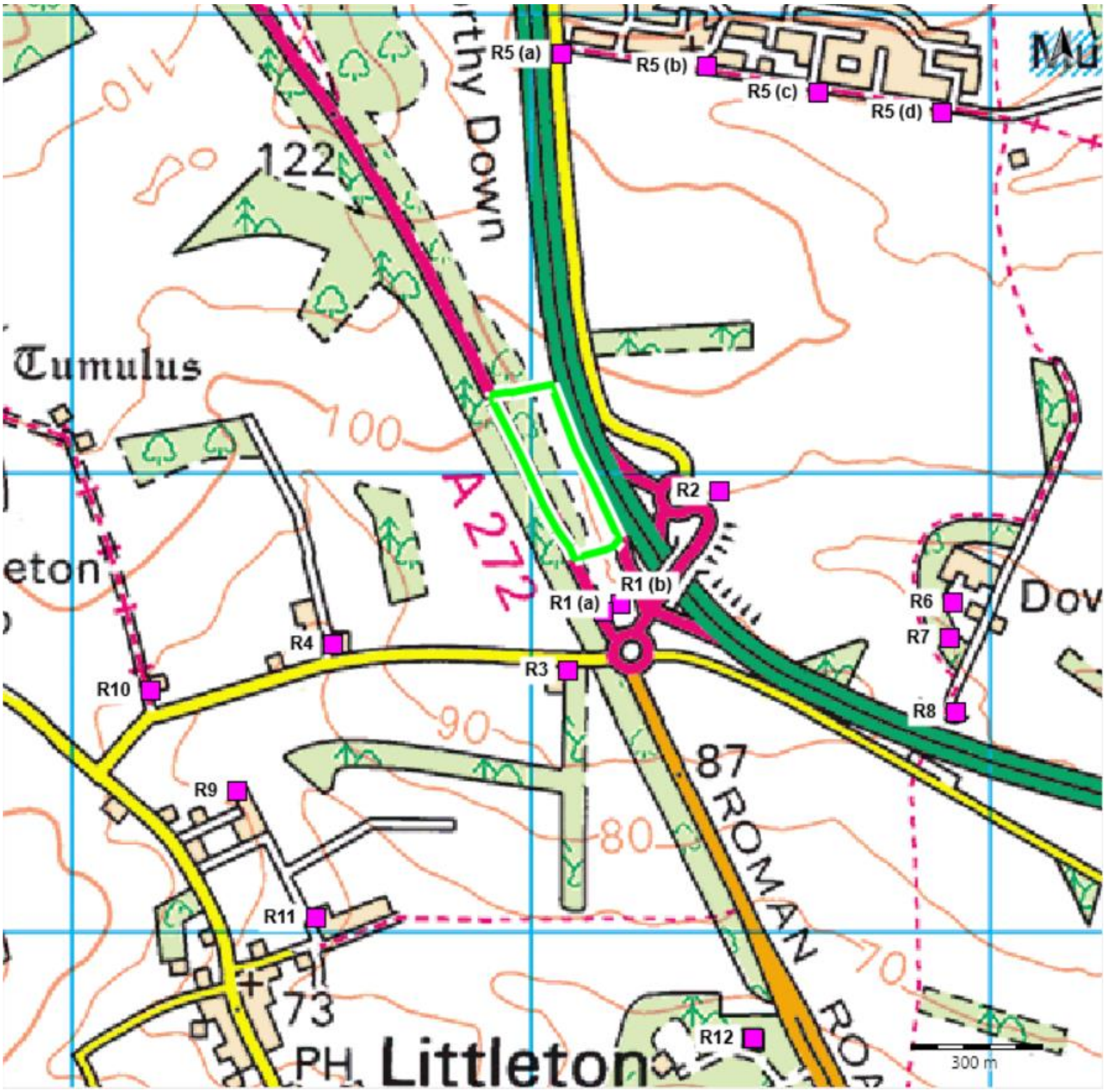


Figure 7 Modelled human receptors



Legend

Figure 8 Ecological receptors (+/-2 km)

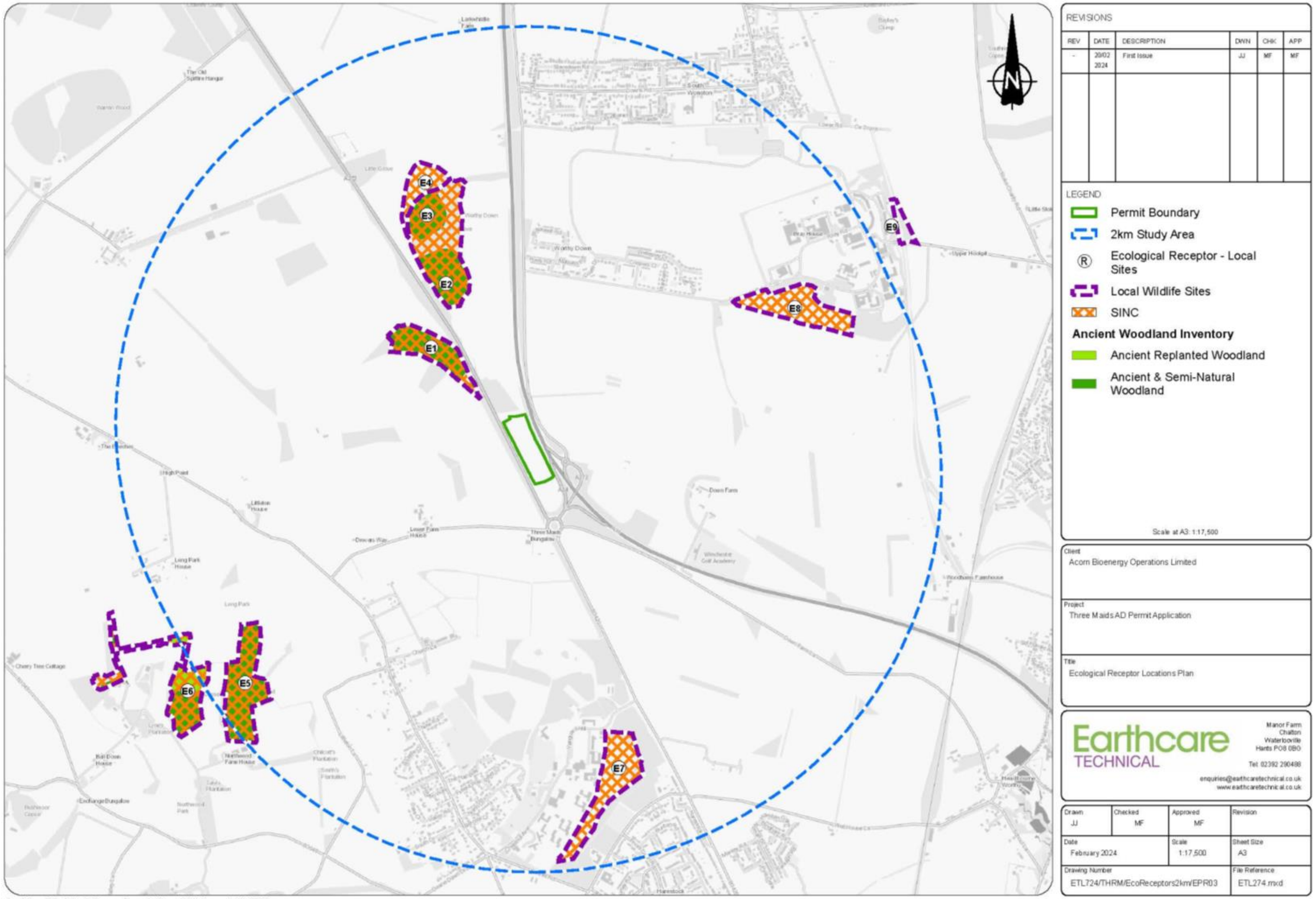
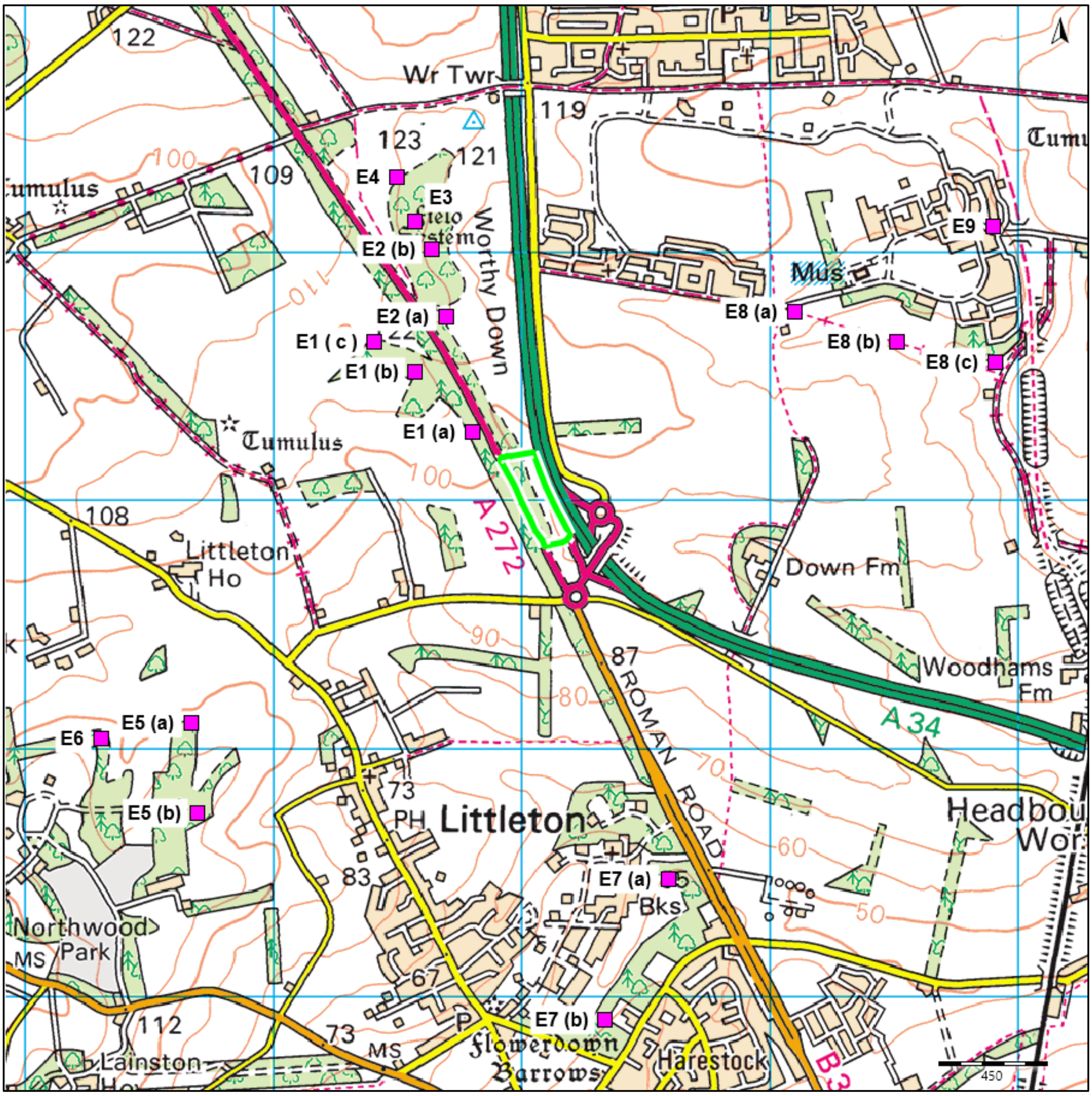


Figure 9 Modelled ecological receptors (+/-2 km)



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Legend

Figure 10 Ecological receptors (+/-10 km)

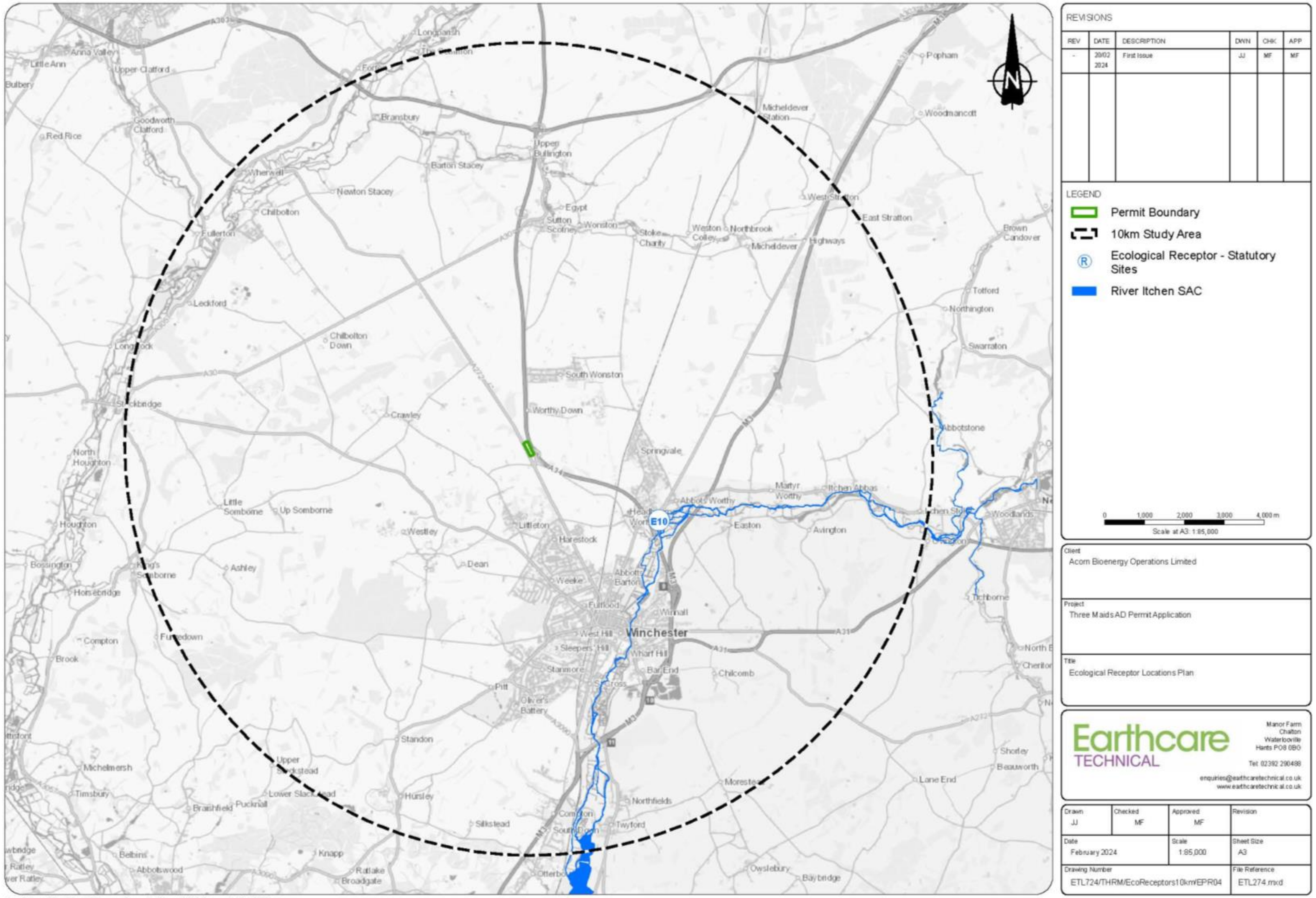

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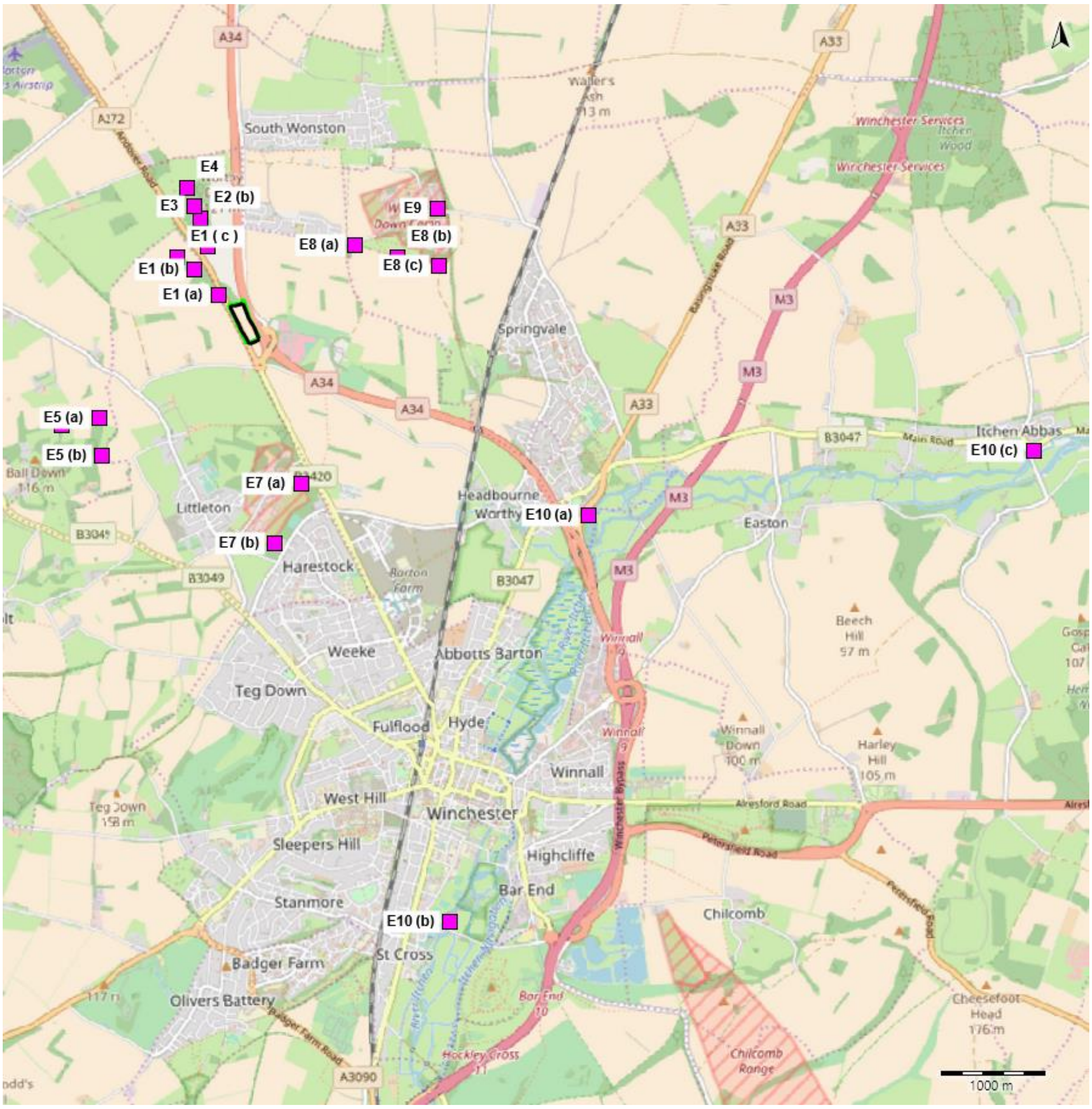
Figure 11 Modelled ecological receptors (+/-10 km)



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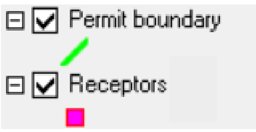
Legend



Appendix A AD Plant process flow diagram

CONFIDENTIAL

PRELIMINARY

REV.	DATE	REVISION DETAILS	DRAWN	CH'K	APP'D
A	-	-	-	-	-

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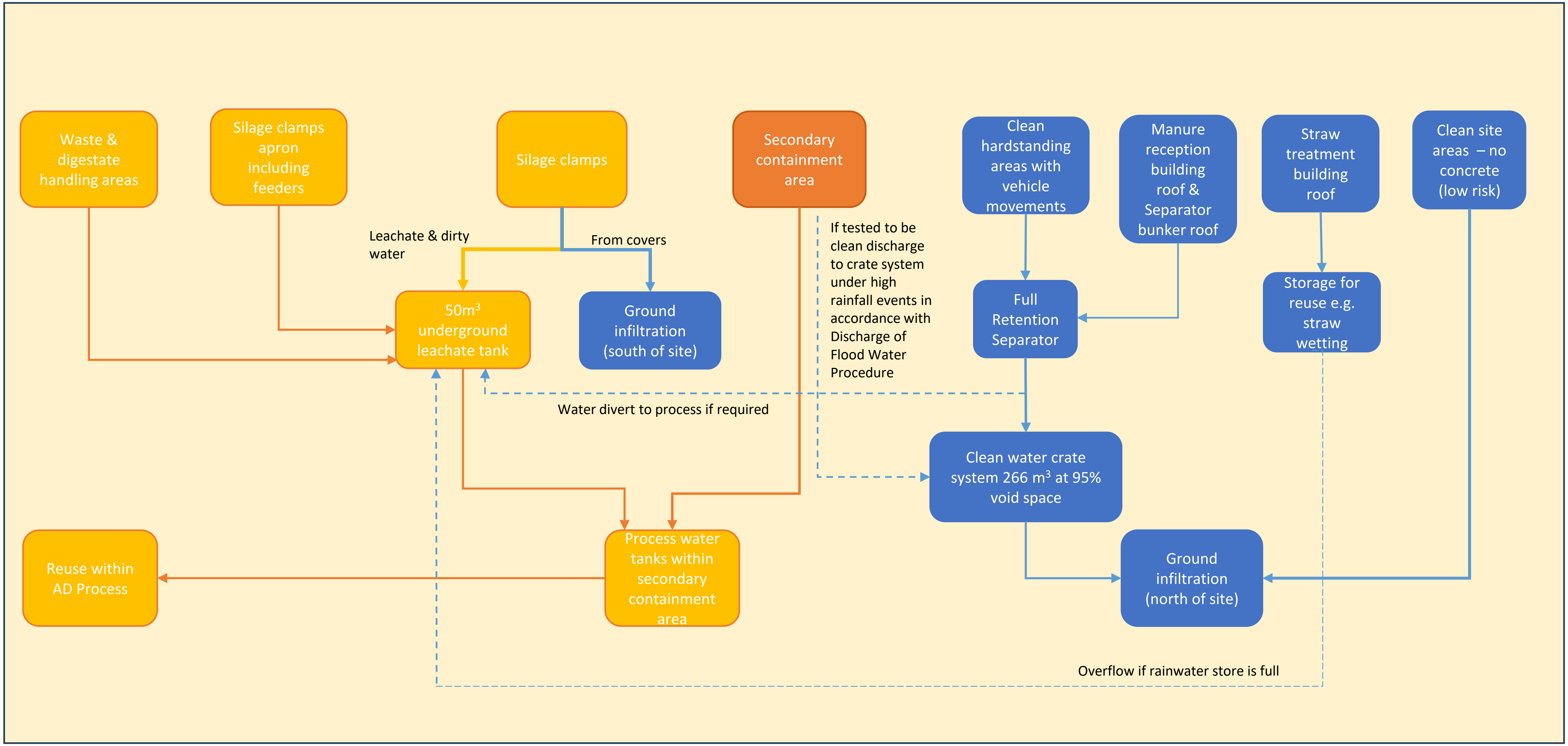
PROJECT	Three Maids
ORDER NO.	A2878UK
TITLE	Process Flow Diagram
DATE	09.01.2024
DRAWN	SKa
CH'K	-
APP'D	-
REVISION	-
VERSION	01
SHEET	A1
SCALE	-
PAGE	-
SOURCE	A2878UK Three Maids_PFD.dwg

Appendix B Drainage process flow diagram

THR-OD-04 Three Maids AD, Drainage Process Flow Diagram V1.0, March 2024



Appendix C Model and model set-up

C.1 Meteorology and associated parameters

C.1.1 Hourly meteorological data

The model uses hourly data of surface meteorology parameters that are typically measured at a synoptic station or are generated by a numerical model. In this assessment, five years' meteorological data were obtained for the period 2018-2022 for the area surrounding the Site location (Latitude 51.102°, Longitude -1.342°), from a Numerical Weather Prediction system known as the Global Forecast System (GFS).

The GFS is a spectral model and data are archived at a horizontal resolution of 0.5 degrees longitude, or approximately 50 km over the UK (latterly 0.25 degrees, or approximately 25 km). The GFS resolution captures major topographical features and the broad-scale characteristics of the weather over the UK. The use of NWP data has advantages over traditional meteorological records as:

- Calm periods in traditional records may be over-represented.
- Traditional records may include local deviations from the broad-scale wind flow that would not necessarily be representative of the site being modelled
- Information on the state of the atmosphere above ground level which would otherwise be estimated by the meteorological pre-processor may be included explicitly.

Figure 5 shows windroses for each year of data. The prevailing wind direction is southwesterly (southwesterly and south-southwesterly) although with an additional component from the northeast. The data were used with the ADMS 6 calms option with default values. Table 21 shows the number of lines of usable data each year with and without calms option. Without the calms options the lowest percentage of usable lines was 99.73% and with the calms option 100%.

Defra's LAQM TG16[21] contains cautionary guidance on use of data with less than 85% usable data in calculating for comparison with short-term AQS. The minimum values of usable data were far above this threshold.

Table 21 Meteorological station data for calm conditions

Year of data	Number of hours modelled with calm conditions	Number of hours with inadequate data (excluding calms)	Hours used
2018	0	0.21%	8760
2019	0	0.13%	8760
2020	0	0.17%	8784
2021	0	0.25%	8760
2022	0	0.27%	8760
Notes: Meteorological parameters supplied are: wind speed, wind direction, near-ground air temperature, cloud cover			

C.1.2 Meteorological parameters

The ADMS model uses various meteorological parameters to represent the area at the meteorological station and the site of the Site. The key parameters that have been defined are the surface roughness and minimum Monin-Obuhkov length which are defined at the site of the meteorological data measurement and the Site.

- Surface roughness: this is related to land-use and the height of obstacles on the ground which give rise to mechanically generated turbulence; and
- Minimum Monin-Obuhkov length: this is used to model the extent to which the urban heat island effect limits the most stable atmospheric conditions. Heat released from the urban area prevents the atmospheric boundary layer becoming very stable.

Table 22 shows the values of the parameters that can be selected in the model from a drop-down menu. Other, intermediate, values can be entered directly. The values selected for the meteorological data site and the Site are given Table 23. A value of 2m for minimum Monin-Obuhkov length reflects the rural nature of the surrounding area; values of 0.3m for surface roughness across the wider area reflect the mixed arable, grassland and woodland, while a value of 0.5m close to the Site reflects the proximity of woodland.

ADMS sets a higher value of minimum turbulence when modelling terrain, therefore, a value of 0.01m/s was set in the ADMS additional input file (.aai) so that the value used when modelling terrain would be the same as that calculated by the model for flat terrain as a function of Monin-Obuhkov length (ADMS 6 User Guide, section 4.15.3).

Table 22 ADMS 6 meteorological parameter values

Surface roughness	
Descriptor	**Value (m)**
Large urban areas	1.5
Cities, woodland	1.0
Parkland, open suburbia	0.5
Agricultural areas (max)	0.3
Agricultural areas (min)	0.2
Root crops	0.1
Open grassland	0.02
Short grass	0.005
Sea	0.0001

Minimum Monin-Obuhkov length	
Descriptor	**Value (m)**
Large conurbations >1million	100m
Cities and large towns	30m
Mixed urban/industrial	30m
Rural areas (max) [1]	20m
Small towns < 50,000	10m
Rural areas (min)[1]	2m

Notes: [1] Not available from the ADMS drop-down menu

Table 23 Meteorological site and Site met parameters

Parameter	**Meteorological data site**	**Site**
Surface roughness	0.3m	0.5m
Minimum Monin-Obhukov length	2m	2m

C.2 Buildings

The presence of buildings close to an emission point can affect the dispersion from a source, bringing the plume centreline down towards the ground in the lee of a building and entraining pollutant into the cavity (or, recirculation) region in the lee of a building. In the cavity, concentrations are assumed to be uniform, and it may be a region of high concentrations depending on the amount of pollutant entrained. The presence of buildings may increase or decrease concentrations at a location compared with the no buildings scenario.

ADMS allows up to 25 buildings to be included as input and the model combines the relevant input buildings into one effective building; the effective building is calculated for each line of meteorological data. Buildings can only be circular or rectangular in cross-section, so the buildings entered are simplified geometries. Buildings less than one third of the height of the stack will be ignored by the ADMS 6 model. Smaller Site structures such as the CHP containers and tanks with smaller diameters than the digesters have been neglected as their effect will be limited compared with the larger structures: digesters, buildings.

The building height entered into the model is the height to the eaves plus a proportion (50%) of roof height. The roof height is the height to the apex minus the height to the eaves. Table 24 shows the (simplified) parameters of the buildings on site used as input to the model; they are shown in Figure 4. In ADMS, for each stack a 'main' building must be specified; the option to allow ADMS to automatically select the main building for each source was selected.

Table 24 Modelled buildings

Building name	Building centre X	Building centre Y	Height to eaves (m)	Height to apex (m)	Height modelled (m)	Length/ Diameter (m)	Width (m)	Orientation (°)
Post (tertiary) digester	446001	134050	8.00	16.5	12.25	32.3	-	-
Secondary digester 1	446053	134033	8.00	16.5	12.25	32.4	-	-
Secondary digester 2	446018	134015	8.00	16.5	12.25	32.4	-	-
Straw Treatment Bldg	446088	134007	7.00	8.20	7.600	23.0	41.6	63.6
Reception Bldg	446059	134071	12.2	13.5	12.89	20.2	24.6	63.4
Primary digester 1a	446063	133996	11.0	11.3	11.25	27.0	-	-
Primary digester 1b	446032	133980	11.0	11.3	11.25	27.4	-	-
Liquid LP tank	446077	134031	8.00	8.20	8.20	8.00	-	-
Buffer Tank water 1	446032	134050	8.00	8.00	8.00	9.00	-	-
Buffer Tank water 2	446042	134055	8.00	8.00	8.00	9.00	-	-
Suspension buffer 1	446028	134060	8.00	8.20	8.10	9.00	-	-
PW buffer tank	446036	134064	8.00	8.00	8.00	5.30	-	-
Notes: Buildings with circular cross-section, such as the digesters, do not have a width and orientation specified								

C.3 Terrain

The effect of terrain is not usually modelled when terrain gradients in the modelled domain are below the 1:10 threshold usually applied. However, when using numerical weather data, it is recommended to consider the dispersion model predictions with and without terrain.

The Site locale is characterised by undulating topography of the Crawley Downs to the west of the site, and the Wonston Downs to the east. Terrain rises from an elevation of 40m Above Ordnance Datum (AOD) in the lower reaches of the Itchen valley approximately 3.7 km southeast of the site to over 176m approximately 9.5 km to the southeast.

Figure Figure 6 shows the terrain data used. The terrain data file covered a domain 15.4 km x 15.4 km, with a total of 36,864 data points, with a grid spacing of 80m. In ADMS 6 a calculation grid of resolution 128x128 was used.

C.3.1 Local changes in ground level

There will be changes in ground level across the site and in the Flat terrain and Buildings model scenarios (section 4.2.3) stack and building heights were modified to account for changes in ground level. In the Terrain (hills) model scenario such an adjustment is not required as the ADMS model accounts for changes in terrain height.

Based on the proposed site levels, a datum was established for the lowest point on-site (m Above Ordnance Datum (AOD) at the location of the feed hoppers), and adjustment made to buildings and emission sources in accordance with that datum. Table 25 shows the base elevation, unadjusted and adjusted height of each source and building.

Table 25 Actual and modified stack and building heights

Building or stack	Name	AOD of base (m)	Unadjusted height (m) (a)	Adjusted height (m)
Building	Post digester	92.15	16.5	13.35
Building	Secondary digester 1	91.90	16.5	13.10
Building	Secondary digester 2	91.90	16.5	13.10
Building	Straw Treatment Bldg	91.65	8.20	8.20
Building	Reception Bldg	92.90	13.5	14.74
Building	Primary digester 1 a	91.75	11.3	11.95
Building	Primary digester 1b	91.75	11.3	11.95
Building	Liquid LP tank	91.85	8.20	9.00
Building	Buffer Tank water 1	92.15	8.00	9.10
Building	Buffer Tank water 2	92.15	8.00	9.10
Building	Suspension buffer 1	92.15	8.20	9.20
Building	PW buffer tank	92.15	8.00	9.10
Stack	CHP 2 NG	93.70	7.00	9.65
Stack	CHP 1 BG	93.70	7.00	9.65
Stack	Boiler	93.60	7.00	9.55
Stack	Flare	96.20	8.70	13.85
Stack	Centriair	91.90	15.5	16.35
Stack	Digestate storage bag vents 1 - 2	97.45	0.50	6.90
Stack	Underground leachate tank vent 1	97.45	0.50	6.90
Stack	Off-take	97.45	0.50	6.90
Volume source	Feedhopper 2	91.05	3.00	3.00
Volume source	Feedhopper 1	91.05	3.00	3.00
Volume source	Clamps working face	91.85	2.50	3.30
Volume source	Separator bunker	93.00	2.25	4.20

Notes: Lowest site datum 91.05m

(a) Height to ridge where applicable

C.4 Receptors

The impact of stack emissions at relevant human and ecological receptors has been modelled. A relevant receptor is defined in Defra's LAQM TG16[21] as:

> '*A location representative of human (or ecological) exposure to a pollutant, over a time period relevant to the objective that is being assessed against, where the Air Quality Strategy objectives are considered to apply*.'

C.4.1 Human receptors

For long-term AQS the relevant receptors are residences (including care homes), schools and hospitals. For short-term AQS additional receptors may also need to be considered: outdoor spaces such as balconies, gardens, leisure sites and public space where human populations may spend the relevant time period. As most short-term AQS allow for a number of exceedances per annum, the human exposure may need to be repeated in order to be relevant. Workplaces are usually excluded from consideration as air quality in workplaces is covered by Health and Safety legislation.[36]

Table 26 shows the locations and type of the receptors selected to be representative of the relevant human receptors. All the receptors have been modelled at a height of 1.5m, representative of inhalation height (nose level) at ground level. Their locations are shown in Figure 7.

Table 26 Human receptors

ID	Location	Type	NGR X	NGR Y	Distance and direction from main AD Plant site boundary	
					Distance (m)	Direction
R1 (a)	Proposed Instavolt Restaurant (a)	Commercial/ Recreational	446194	133714	265	S
R1 (b)	Proposed Instavolt Playground (b)	Recreational	446160	133699	268	S
R2	The Pringle Group/ Concrete 247	Aggregate/ recycling	446412	133961	245	E
R3	Three Maids Bungalow	Residential	446081	133569	390	SW
R4	Lower Farm Cottages	Residential	445570	133626	621	WSW
R5 (a)	Worthy Down (a)	Residential	446068	134913	954	NE
R6	Down Farm	Residential	446920	133716	861	SE
R7	Off Down Farm Lane (Static caravans)	Residential	446911	133640	877	SE
R5 (b)	Worthy Down (b)	Residential	446385	134884	970	NE
R8	Winchester Golf Academy	Recreational	446926	133479	961	SE
R5 (c)	Worthy Down (c)	Residential	446626	134829	1,020	NE
R9	Littleton Stud	Residential	445362	133307	980	SW
R10	Drovers Way	Residential	445172	133525	1,019	WSW
R11	Church Lane, St Catherines (Littleton)	Residential	445532	133031	1,085	SW

[36] Health and Safety Executive EH40/2005 Workplace Exposure Limits (Fourth Edition 2020)

ID	Location	Type	NGR X	NGR Y	Distance and direction from main AD Plant site boundary	
					Distance (m)	Direction
R5 (d)	Worthy Down (d)	Residential	446894	134786	1,151	NE
R12	Flowerdown Barracks	MOD Recreational	446484	132768	1,253	S

C.4.2 Ecological receptors

The Defra/Environment Agency guidance[21] specifies that SACs, SPAs and Ramsar site within 10 km should be considered and SSSIs, AWs, LWSs, Local Nature Reserves and National Nature Reserves within 2 km should also be considered.

Ecological receptors were placed in the designated areas at the nearest locations to the Site and additional locations. Table 7 in section 5.3 lists the sensitive conservation sites identified within the specified distance, their designation and main habitat. Table 27 lists the ecological receptors modelled which are illustrated in Figures 9 to 11. All the ecological receptors have been modelled at a height of 1.5m. Their locations are shown in Figure 8 to Figure 11 inclusive.

Table 27 Ecological receptors

ID	Location	Type	NGR X	NGR Y	Distance and direction from main AD Plant site boundary	
					Distance (m)	Direction
E1 (a)	Worthy Copse 1	LWS, AW, SINC	445804	134276	157	NW
E1 (b)	Worthy Copse 2	LWS, AW, SINC	445572	134517	493	NW
E1 (c)	Worthy Copse 3	LWS, AW, SINC	445406	134638	695	NW
E2 (a)	South Worthy Grove 1	AW, SINC	445696	134738	610	NNW
E2 (c)	South Worthy Grove 2	AW, SINC	445637	135010	890	NNW
E3	Worthy Grove (LWS)	LWS, AW, SINC	445570	135119	1,012	NNW
E4	The Gallops, Worthy Down (LWS)	LWS, SINC	445500	135300	1,200	NNW
E5 (a)	Long Wood 1	AW, SINC	444673	133104	1,590	WSW
E5 (b)	Long Wood 2	AW, SINC	444697	132742	1,770	WSW
E6	Northwood Park Woods (Cradle Copse)	LWS, SINC	444308	133040	1,950	SW
E7 (a)	Flowerdown, Littleton 1	LWS, SINC	446593	132474	1,430	SSW
E7 (b)	Flowerdown, Littleton 2	LWS, SINC	446336	131908	1,930	SSW
E8 (a)	Worthy Camp Grassland 1	LWS, SINC	447102	134757	1,235	NE
E8 (b)	Worthy Camp Grassland 2	LWS, SINC	447510	134638	1,530	NE
E8 (c)	Worthy Camp Grassland 3	LWS, SINC	447909	134556	1,880	NE
E9	Worthy Down Railway Halt	LWS	447900	135100	2,090	ENE
E10 (a)	River Itchen 1	SAC	449335	132180	3,575	SE
E10 (b)	River Itchen 2	SAC	448014	128298	5,840	SSE
E10 (c)	River Itchen 3	SAC	453581	132788	7,480	ESE

C.5 Post-processing

C.5.1 Use of background data

Considering long-term AQS, it is a straightforward matter to add the annual mean contribution from the source, (annual mean PC) to the annual mean background concentration to predict the total concentration (annual mean PEC).

For comparison with short-term AQS the addition of background is not so straightforward. The ADMS model allows for the calculation of percentiles from hourly background and process concentrations, but hourly background concentrations are not commonly available, and not for all pollutants. The approach used was that described in the Defra permit guidance:[15]

> '*When you calculate background concentration, you can assume that the short-term background concentration of a substance is twice its long-term concentration*.'

This has been used for all for short-term AQS for averaging times for 15 minutes to 24 hours.

C.5.2 Conversion of NOx to NO_2

The ADMS model includes a NOx chemistry model, but the conversion of primary NOx emissions to NO_2 is usually undertaken as a post-processing step for industrial permitting applications. For primary NO_2 to NO_x ratios of 10% or less, which is likely to be the case for the stack emissions, the Environment Agency and Natural Resources Wales[37] recommend use of the following conversion ratios:

- 35% for short term assessment
- 70% for long term assessment.

These ratios have been used in main part of this assessment. In fact, combustion sources emit NOx with approximately 5% NO_2 by volume,[38] and conversion from nitric oxide (NO) to NO_2 proceeds relatively slowly, depending on temperature. Assuming a temperature of 15°C and a wind speed of 3m/s, in the 50 seconds taken for emissions to travel 150m, 19% of a mole of NO would have been converted to NO_2.[39] The prediction of short-term NO_2 impacts at the nearest human receptor (H1) is therefore conservative.

C.5.3 Conversion of TVOC to benzene

Emissions are specified as TVOC for which there are no AQS. There is an AQS for benzene, one component of TVOC. An AEA Technology report on the Speciation of UK emissions of non-methane volatile organic compounds (2002)[3] reported on a series of VOC species profiles available for stationary combustion sources, covering a range of both fuel types and scale of combustion. The benzene fraction in industrial and commercial combustion of natural gas was

[37] Environment Agency and Natural Resources Wales (Last updated 27 March 2023) (https://www.gov.uk/guidance/specified-generators-dispersion-modelling-assessment#nosubxsub-to-nosub2sub-conversion-ratios-to-use)
[38] CERC Ltd (2023) ADMS 6 Atmospheric Dispersion Modelling System, user Guide, Version 6.0, March 2023
[39] CERC Ltd (2023) NOx Chemistry Model in ADMS 6, P18/02K/23, March 2023

reported to be less than 10%, therefore the TVOC concentrations at receptors has been modelled as 10% benzene (or non-methyl VOCs) for the other combustion sources.

C.5.4 Deposition to ecological receptors

The ADMS model includes the ability to calculate the deposition flux rate (deposition) of pollutants, but the Environment Agency recommends deposition be calculated as a post-processing step in order to give conservative estimates of both ground level concentration and deposition, by assuming no loss of pollutant from air concentration to ground deposition.

Deposition may be 'dry' or 'wet'. Dry deposition of gases occurs due to diffusive motions and removal at surfaces, primarily the ground. It is characterised by a deposition velocity that depends on the pollutant and the nature of the surface. Table 28 gives the deposition velocities for grassland and forest for the pollutants included in this assessment which are the values recommended by AQTAG 06.[20] The values for grassland, which are lower than those for forest, have been used to represent deposition at all receptors.

Wet deposition occurs when precipitation washes pollutants out of the air. Some pollutants have a low solubility, and in addition, wet deposition is considered to be of limited importance close to the source. Wet deposition has been neglected.

Table 28 Dry deposition velocities

Pollutant	Deposition velocity (m/s)	
	Grassland	Forest
NO_2	0.0015	0.003
SO_2	0.012	0.024
NH_3	0.020	0.030

Deposition (µg/m^2/s) is calculated by multiplying the near ground air concentration (µg/m^3) by deposition velocity. Ecological receptors are sensitive to deposition of nitrogen (nutrient nitrogen) and to deposition of acid species including nitrogen (N), sulphur (S) and HCl. To convert from deposition of a pollutant to deposition of a species, the conversion factors given in

Table 29 were used. Nutrient nitrogen deposition is calculated as the total deposition of N in kg/ha/year, due to NO_2 and NH_3. To convert from deposition of N or S deposited to equivalent acidification units, a measure of how acidifying the chemical species can be, (keq/ha/year), the conversion factors given in Table 30 were used. Acid deposition is calculated taking into account the acidifying nitrogen and sulphur deposition, both expressed as keq/ha/year.

Table 29 Conversion factors for deposition of species N, S

Pollutant	Species deposited	Conversion factor from deposition of pollutant (µg/m^2/s) to deposition of species (kg/ha/year)
NO_2	N	96

SO_2	S	157.7
NH_3	N	259.7

Table 30 Conversion factors from deposition of species to deposition of acid equivalent

Species	Conversion factor from deposition of species (kg/ha/year) to deposition of equivalent acidification units (keq/ha/year)
N	0.071428
S	0.0625

Appendix D Results of sensitivity tests

The impact of buildings, terrain and meteorological data year have been assessed. The eight cases modelled, A-G, are shown in Table 31. They are for the impacts of the proposed CHP and back-up boiler. Long-term impacts have been predicted assuming the proposed CHP operates continuously at full load and the emergency boiler emissions are equivalent to operating 15% of the year. Short-term impacts have been predicted assume both sources operate continuously at full load.

Results of the sensitivity tests were the maximum concentration predicted at any human receptor and any ecological receptor. For each AQS, the predicted maximum was divided by (normalised) the AQS value, or if the AQS is expressed as a number of exceedances of threshold value, by the threshold value. These normalised values have been expressed as a percentage and are shown in Table 32. The comparison is expressed this way to show the relative importance of the change in terms of exceedance of the AQS. If all the results are a very small percentage of the AQS, the variation in results is unlikely to affect the conclusions of the study.

For human and ecological receptors, comparing the results for tests A, B and C, it can be seen that modelling buildings led to higher model prediction than for flat terrain. Modelling terrain as well buildings generally led to a further increase at human receptor locations. Comparing the results for tests A, D, E, F and G shows that the variation due to meteorological data year is generally less significant than the impact of modelling buildings for human receptors, whereas for ecological receptors the variation due to the meteorological year is of greater significant.

Table 31 Sensitivity tests

Sensitivity test	Flat/Buildings/Terrain model options	Meteorological data year
A	Flat	2018
B	Buildings	2018
C	Terrain & buildings	2018
A	Flat	2018
D	Flat	2019
E	Flat	2020
F	Flat	2021
G	Flat	2022

Table 32 Sensitivity tests: results as a percentage of the AQS or threshold

Pollutant	Long-term (LT) or Short-term (ST)	Value, EAL or threshold, (mg/m^3)	A	B	C	A	D	E	F	G
Human receptors										
SO_2	ST	350	1.0%	2.1%	2.2%	1.0%	1.0%	0.9%	1.0%	1.0%
SO_2	ST	266	1.8%	5.8%	7.0%	1.8%	1.8%	1.8%	1.8%	1.8%
SO_2	ST	125	1.5%	2.0%	1.9%	1.5%	1.3%	1.3%	1.2%	1.3%
NH_3	LT	180	0.02%	0.02%	0.03%	0.02%	0.02%	0.02%	0.02%	0.02%
NH_3	ST	2,500	0.1%	0.1%	0.3%	0.1%	0.1%	0.1%	0.1%	0.1%
NOx	LT	40	1.8%	2.4%	2.4%	1.8%	1.9%	1.8%	1.8%	1.5%
VOC	LT	5	5.3%	7.0%	7.1%	5.3%	5.8%	5.4%	5.3%	4.5%
VOC	ST	30	10%	17%	16%	10%	10%	12%	12%	12%
NOx	ST	200	3.9%	8.0%	8.9%	3.9%	3.8%	3.9%	3.8%	3.9%
CO	ST	10,000	0.8%	1.3%	1.5%	0.8%	0.8%	0.7%	0.7%	0.7%
Ecological receptors										
SO_2	LT	20	0.8%	0.9%	0.9%	0.8%	0.7%	0.5%	0.4%	0.7%
SO_2	LT	10	1.6%	1.8%	1.7%	1.6%	1.4%	1.0%	0.7%	1.3%
NH_3	LT	1	4.1%	4.3%	6.5%	4.1%	4.0%	3.1%	2.7%	4.3%
NOx	ST	75	31%	32%	32%	31%	25%	24%	19%	35%
NOx	LT	30	3.8%	4.4%	4.4%	3.8%	3.3%	2.6%	1.7%	3.2%

Appendix E Proposed CHP, representative technical specification

Technical specification - datasheet

TEDOM
Combined Heat & Power

Quanto 1200

Basic technical data

Electrical output	1200	kW	Voltage	400	V
Heat output nominal/max.	1238/-	kW	Frequency	50	Hz
electrical efficiency	42,4	%	secondary circuit temperature inlet/outlet	70/90	°C
heat efficiency nominal/max.	43,8/-	%	Service weight of complete CHPU		
total efficiency nominal/max.	86,2/-	%	- container (C)	38	t
fuel input	2828	kW			

Emission	lean mixture	
NOx emission at 5% O2 in exhaust gas standard/option	500/-	mg/Nm^3
CO emission at 5% O2 in exhaust gas standard/option	1100/-	mg/Nm^3

Noise parameters		standard	
C	- CHPU at 10m	66	dB(A)

Notes

The Basic Technical Data are applicable for the standard conditions pursuant to the "Technical instructions" document. The minimum permanent electrical output must not drop below 50 % of the nominal output. Gas consumption is expressed under the normal conditions (0°C, 101.325 kPa) and gas LHV according to the section Fuel. Gas consumption tolerance, or fuel input tolerance, at 100% load is +5%. Tolerances of other parameters are mentioned in "Technical Instructions-Validity of Technical Data" document.

The manufacturer reserves the right to change this document and related documents.

Quanto 1200

Extended technical data

Standard design	100%	75%	50%	
electrical output	1200	900	600	kW
heat output	1238	976	725	kW
gas consumption	569	439	310	m^3/h
fuel input	2828	2183	1543	kW
electrical efficiency	42,4	41,2	38,9	%
heat efficiency	43,8	44,7	47,0	%
total efficiency	86,2	85,9	85,9	%

1) Heat output is formed of a secondary circuit heat output with exhaust gas cooled to 150°C.

Guaranteed parameters		
electrical output	1200	kW
electrical efficiency	40,4	%
heat efficiency	45,8	%
total efficiency	86,2	%
fuel input	2969	kW
NOx emission at 5% O2 in exhaust gas	500	mg/Nm^3
CO emission at 5% O2 in exhaust gas	1100	mg/Nm^3
CHPU at 10m	70	dB(A)

Electrical parameters

voltage	400	V
frequency	50	Hz
nominal current	2000	A
nominal power factor (GCB settings)	0,87	

operational current at cos φ=0,9	1925	A
short circuit resistance of the switchboard	40	kA
contribution of the actual source to the short-circuit current	< 20	kA
cos φ regulation range (underexcited/overexcited) [1]	0,9÷1÷0,9	

1) Operation of generator with power factor lower than 0,98 decreaes generator efficiency, what can cause reduction of the CHPU active power.

Engine / Generator

Engine	TCG2020V12	
manufacturer	MWM	
oil consumption	0,15	g/kWh
quantity of oil in the engine	715	dm^3
volume of oil tank for refilling	350	dm^3

Generator	MJB 500 MB4
manufacturer	MARELLI

TEDOM
Combined Heat & Power

Quanto 1200

Heat system

Secondary circuit

heat carrier: water		
heat output	1238	kW
inlet/outlet temperature	70/90	°C
min./max. inlet temperature	50/70	°C
nominal flow	14,8	kg/s
max. allowed pressure in circuit	600	kPa
volume (OM/SE/C)	-/-/145	dm^3
pressure drop at nominal flow (OM/SE/C)	-/-/45	kPa

Aftercooler circuit

heat carrier: antifreeze		
ethylene glycol concentration	35	%
heat output	91	kW
max. coolant inlet temperature into CHPU	50	°C
nominal flow	7,7	kg/s
expansion vessel volume (OM/SE/C)	/-/35	dm^3
min. inlet pressure into CHPU	100	kPa
max. inlet pressure into CHPU	300	kPa
max. outlet pressure from CHPU	450	kPa
volume (OM/SE/C)	-/-/45	dm^3
dry cooler volume	*tbd	dm^3

Primary circuit

heat carrier: antifreeze		
ethylene glycol concentration	35	%
heat output (OM, C)	1238	kW
max. allowed pressure in circuit	300	kPa
volume (OM/SE/C)	-/-/980	dm^3
dry cooler volume	*tbd	dm^3
**tbd - to be defined*		

Exhaust gas

quantity	6254	kg/h
temperature at the engine outet	466	°C
temperature at the CHPU outlet nominal/max.	150/180	°C
max. allowed back-pressure	1	kPa

Fuel

biogas		
low heat value	17,9	MJ/m^3
min. methane content	45	%
nominal methane content	50	%
pressure (C)	10 - 15	kPa
max. temperature	35	°C

Combustion and ventilation air

Combustion air

ambient temperature min./max. (C)	-20/35	°C
combustion air temperature min./max.	10/35	°C
quantity	5490	kg/h

Ventilation

	C	
unused heat removed by the ventilation	76	kW

Quanto 1200

Related documents

dimensional drawing C	R0550

TEDOM
Combined Heat & Power

Quanto 1200

Basic technical data

Electrical output	1200	kW
Heat output nominal/max.	1220/-	kW
electrical efficiency	42,0	%
heat efficiency nominal/max.	42,7/-	%
total efficiency nominal/max.	84,7/-	%
fuel input	2854	kW

Voltage	400	V
Frequency	50	Hz
secondary circuit temperature inlet/outlet	70/90	°C
Service weight of complete CHPU		
- container (C)	38	t

Emission	lean mixture	
NOx emission at 5% O2 in exhaust gas standard/option	250/-	mg/Nm³
CO emission at 5% O2 in exhaust gas standard/option	1100/-	mg/Nm³

Noise parameters		standard	
C	- CHPU at 10m	66	dB(A)

Notes

The Basic Technical Data are applicable for the standard conditions pursuant to the "Technical instructions" document. The minimum permanent electrical output must not drop below 50 % of the nominal output. Gas consumption is expressed under the invoicing conditions (15°C, 101.325 kPa) and gas LHV according to the section Fuel. Gas consumption tolerance, or fuel input tolerance, at 100% load is +5%. Tolerances of other parameters are mentioned in "Technical Instructions-Validity of Technical Data" document.

The manufacturer reserves the right to change this document and related documents.

Quanto 1200

Extended technical data

Standard design	100%	75%	50%	
electrical output	1200	900	600	kW
heat output	1220	962	714	kW
gas consumption	302	233	165	m^3/h
fuel input	2854	2203	1558	kW
electrical efficiency	42,0	40,8	38,5	%
heat efficiency	42,7	43,7	45,8	%
total efficiency	84,7	84,5	84,3	%

1) Heat output is formed of a secondary circuit heat output with exhaust gas cooled to 150°C.

Guaranteed parameters		
electrical output	1200	kW
electrical efficiency	40,0	%
heat efficiency	44,7	%
total efficiency	84,7	%
fuel input	2997	kW
NOx emission at 5% O2 in exhaust gas	250	mg/Nm^3
CO emission at 5% O2 in exhaust gas	1100	mg/Nm^3
CHPU at 10m	70	dB(A)

Electrical parameters

voltage	400	V
frequency	50	Hz
nominal current	2000	A
nominal power factor (GCB settings)	0,87	

operational current at cos φ=0,9	1925	A
short circuit resistance of the switchboard	40	kA
contribution of the actual source to the short-circuit current	< 20	kA
cos φ regulation range (underexcited/overexcited) [1)]	0,9÷1÷0,9	

1) Operation of generator with power factor lower than 0,98 decreaes generator efficiency, what can cause reduction of the CHPU active power.

Engine / Generator

Engine	TCG2020V12	
manufacturer	MWM	
oil consumption	0,15	g/kWh
quantity of oil in the engine	715	dm^3
volume of oil tank for refilling	350	dm^3

Generator	MJB 500 MB4
manufacturer	MARELLI

Quanto 1200

Heat system

Secondary circuit

heat carrier: water		
heat output	1220	kW
inlet/outlet temperature	70/90	°C
min./max. inlet temperature	50/70	°C
nominal flow	14,6	kg/s
max. allowed pressure in circuit	600	kPa
volume (OM/SE/C)	-/-/145	dm^3
pressure drop at nominal flow (OM/SE/C)	-/-/45	kPa

Aftercooler circuit

heat carrier: antifreeze		
ethylene glycol concentration	35	%
heat output	95	kW
max. coolant inlet temperature into CHPU	47	°C
nominal flow	9,7	kg/s
expansion vessel volume (OM/SE/C)	/-/35	dm^3
min. inlet pressure into CHPU	100	kPa
max. inlet pressure into CHPU	300	kPa
max. outlet pressure from CHPU	450	kPa
volume (OM/SE/C)	-/-/45	dm^3
dry cooler volume	*tbd	dm^3

Primary circuit

heat carrier: antifreeze		
ethylene glycol concentration	35	%
heat output (OM, C)	1220	kW
max. allowed pressure in circuit	300	kPa
volume (OM/SE/C)	-/-/980	dm^3
dry cooler volume	*tbd	dm^3

**tbd - to be defined*

Exhaust gas

quantity	7114	kg/h
temperature at the engine outet	402	°C
temperature at the CHPU outlet nominal/max.	150/180	°C
max. allowed back-pressure	1	kPa

Fuel

natural gas		
low heat value	34	MJ/m^3
min. methane number	101	
pressure (C)	10 - 15	kPa
max. temperature	35	°C

Combustion and ventilation air

Combustion air

ambient temperature min./max. (C)	-20/35	°C
combustion air temperature min./max.	10/35	°C
quantity	6896	kg/h

Ventilation

	C	
unused heat removed by the ventilation	77	kW

TEDOM
Combined Heat & Power

Quanto 1200

Related documents

dimensional drawing C	R0550

Appendix F Emergency boiler, example technical specification

VIESSMANN

VITOPLEX 200

Low temperature oil/gas boiler
90 to 560 kW

Datasheet

Part no. and prices: See pricelist

VITOPLEX 200 Type SX2A

Low temperature oil/gas boiler

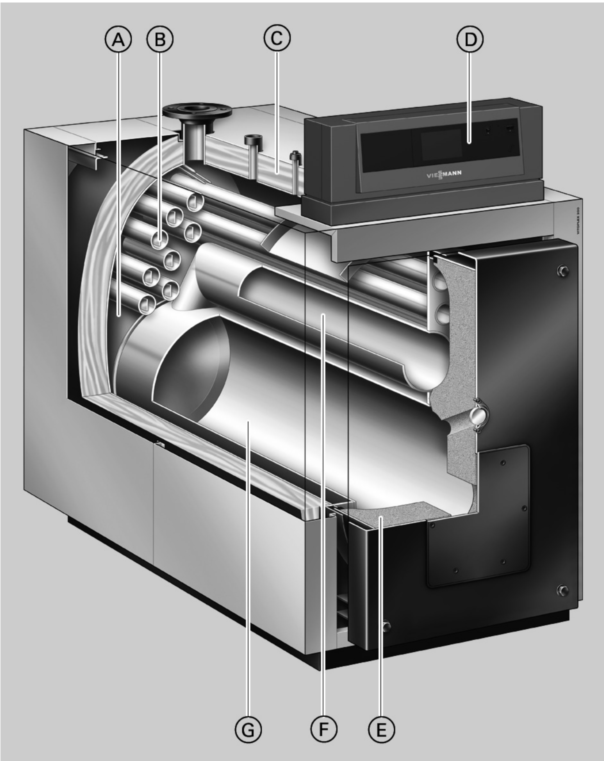
- Three-pass boiler
- For operation with modulating boiler water temperature
- With Vitotrans 300 as condensing unit

Information for type SX2A, 90 to 350 kW:
In accordance with the Ecodesign Directive for Heating Appliances and Water Heaters (Dir. 2009/125/EC), Implementing Regulation (EU) No. 813/2013 and (EU) No. 814/2013, these boilers may not be sold and used within the EU for the purpose of generating space heating and domestic hot water. A sale is subject to the proviso of exclusive use for purposes not included in the regulations stated above.

5797332 GB 4/2020

Benefits at a glance

- Economical and environmentally responsible due to modulating boiler water temperature.
- Standard seasonal efficiency [to DIN] for operation with fuel oil: 89 % (H_s) [gross cv].
- Optional stainless steel flue gas/water heat exchanger enables the utilisation of condensing technology for higher standard seasonal efficiency [to DIN].
- Three-pass boiler with low combustion chamber loading, resulting in clean combustion with low emissions.
- Wide water galleries and large water content provide excellent natural circulation and reliable heat transfer.
- Integral Therm-Control start-up system for easy hydraulic connection – no shunt pump or return temperature raising facility are required.
- No low water indicator required for boilers up to 300 kW.
- Compact design for easy transport into boiler rooms and economical use of space – important for modernisation projects.
- Fastfix assembly system for control unit and thermal insulation.
- Easy to use Vitotronic control unit with colour touchscreen.
- Integral WiFi for service interface.
- Economical and safe operation of the heating system through the Vitotronic control system with communication capability which, in conjunction with Vitogate 300 (accessories), enables integration into building management systems.
- Vitocontrol control panel can be supplied on request.



Ⓐ Wide water galleries and large water content ensure excellent natural circulation and easy hydraulic connection
Ⓑ Third hot gas flue
Ⓒ Highly effective thermal insulation
Ⓓ Vitotronic control unit with colour touchscreen
Ⓔ Thermal insulation on boiler door
Ⓕ Hot gas flue (second pass)
Ⓖ Combustion chamber

5797332

Boiler specification

Specification

Rated heating output	kW	90	120	150	200	270	350	440	560
Rated heat input	kW	98	130	163	217	293	380	478	609
CE designation									
– According to Efficiency Directive		CE-0085BQ0020						—	—
– According to Gas Appliances Directive		CE-0085BQ0020							
Permiss. flow temperature (= safety temperature)	°C	110 (up to 120 °C on request)							
Permiss. operating temperature	°C	95							
Permiss. operating pressure	bar	4							
	kPa	400							
Pressure drop on the hot gas side	Pa	60	80	100	200	180	310	280	400
	mbar	0.6	0.8	1.0	2.0	1.8	3.1	2.8	4.0
Boiler body dimensions									
Length (dim. q)[*1]	mm	1195	1400	1385	1580	1600	1800	1825	1970
Width (dim. d)	mm	575	575	650	650	730	730	865	865
Height (incl. connectors) (dim. t)	mm	1145	1145	1180	1180	1285	1285	1455	1455
Total dimensions									
Total length (dim. r)	mm	1260	1460	1445	1640	1660	1860	1885	2030
Total length incl. burner and hood, depending on burner make (dim. s)	mm	1660	1860	1865	2060	2085	–	–	–
Total width (dim. e)	mm	755	755	825	825	905	905	1040	1040
Total height (dim. b)	mm	1315	1315	1350	1350	1460	1460	1625	1625
Service height (control unit) (dim. a)	mm	1485	1485	1520	1520	1630	1630	1795	1795
Height									
– Adjustable anti-vibration feet	mm	28	28	28	28	28	28	28	28
– Anti-vibration boiler supports (under load)	mm	–	–	–	–	–	37	37	37
Foundation									
Length	mm	1000	1200	1200	1400	1400	1650	1650	1800
Width	mm	760	760	830	830	900	900	1040	1040
Combustion chamber diameter	mm	380	380	400	400	480	480	570	570
Combustion chamber length	mm	800	1000	1000	1200	1200	1400	1400	1550
Weight boiler body	kg	315	365	415	460	585	700	895	1100
Total weight Boiler incl. thermal insulation and boiler control unit	kg	360	410	465	510	635	760	960	1170
Capacity boiler water	litres	180	210	255	300	400	445	600	635
Boiler connections									
Boiler flow and return	PN 6 DN	65	65	65	65	65	80	100	100
Safety connection (safety valve) (male thread)	R	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
Drain (male thread)	R	1¼							
Flue gas parameters[*2]									
Temperature (at 60 °C boiler water temperature)									
– At rated heating output	°C	180							
– At partial load	°C	125							
Temperature (at 80 °C boiler water temperature)	°C	195							
Flue gas mass flow rate									
– For natural gas	kg/h	1.5225 x combustion output in kW							
– For fuel oil EL	kg/h	1.5 x combustion output in kW							
Flue gas connection	Ø mm	180	180	200	200	200	200	250	250
Standard seasonal efficiency [to DIN] (for operation with fuel oil) For heating system temperature 75/60 °C	%	89 (H_s) [gross cv]							
Standby loss $q_{B,70}$	%	0.40	0.35	0.30	0.30	0.25	0.25	0.22	0.20

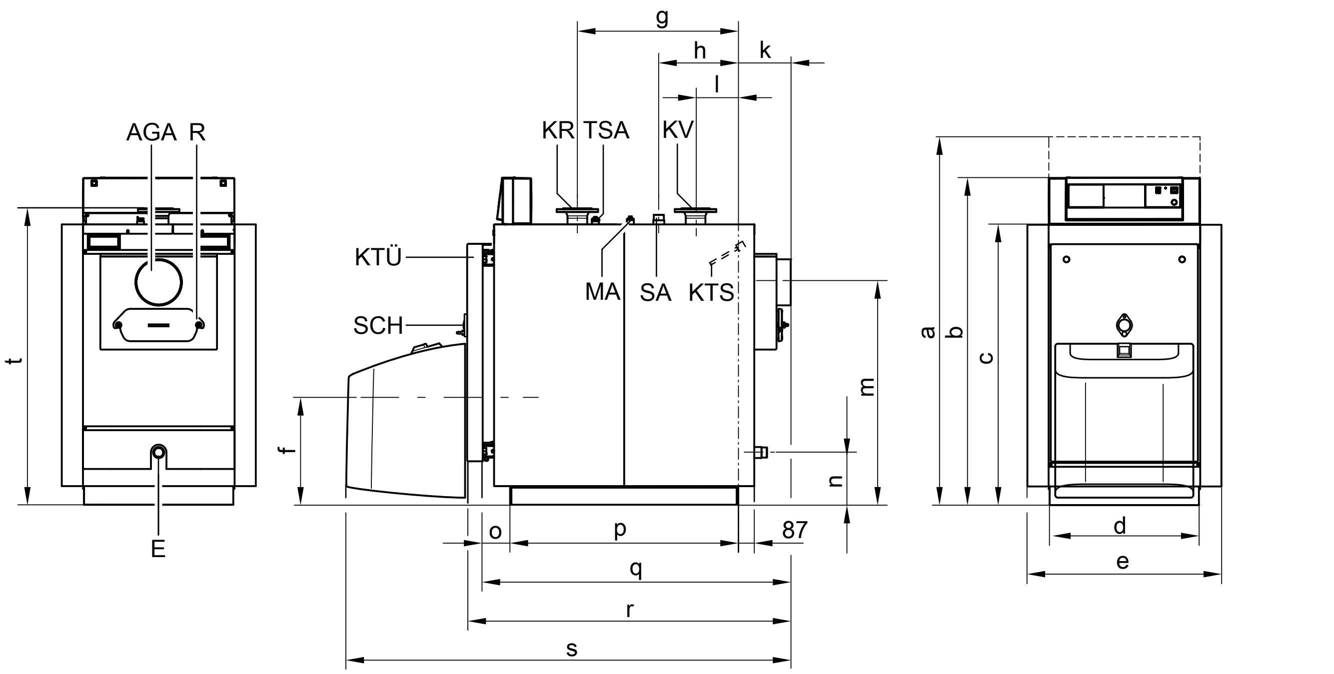
*1 *Boiler door removed.*

*2 *Values for calculating the size of the flue system to EN 13384, relative to 13.2 % CO_2 for fuel oil EL and 10 % CO_2 for natural gas.*
Flue gas temperatures as actual gross values at 20 °C combustion air temperature.
The details for partial load refer to an output of 60 % of rated heating output. If the partial load differs (depending on operating mode), calculate the flue gas mass flow rate accordingly.

5797332

Rated heating output	kW	90	120	150	200	270	350	440	560
Sound pressure level[*3]									
1 m in front of the boiler (1st/2nd stage)	dB(A)	<68/<69					–		
In the flue pipe (1st/2nd stage)	dB(A)	<96/<103					–		
Matching Vitotrans 300									
– Gas operation	Part no.	Z010326		Z010327		Z010328		Z010329	
– Oil operation	Part no.	Z010330		Z010331		Z010332		Z010333	
Rated heating output Boiler with Vitotrans 300									
– Gas operation	kW	98.7	131.4	164.3	219.0	295.6	383.3	478.7	608.9
– Oil operation	kW	95.8	127.8	159.8	213.0	287.5	372.7	466.4	593.5
CE designation Vitotrans 300 in conjunction with boiler as a condensing unit		CE-0085BS0287							
Pressure drop on the hot gas side	Pa	125	145	185	285	280	410	385	505
Boiler with Vitotrans 300	mbar	1.25	1.45	1.85	2.85	2.80	4.10	3.85	5.05
Total length Boiler with Vitotrans 300 excl. burner	mm	1990		2290		2570		2950	

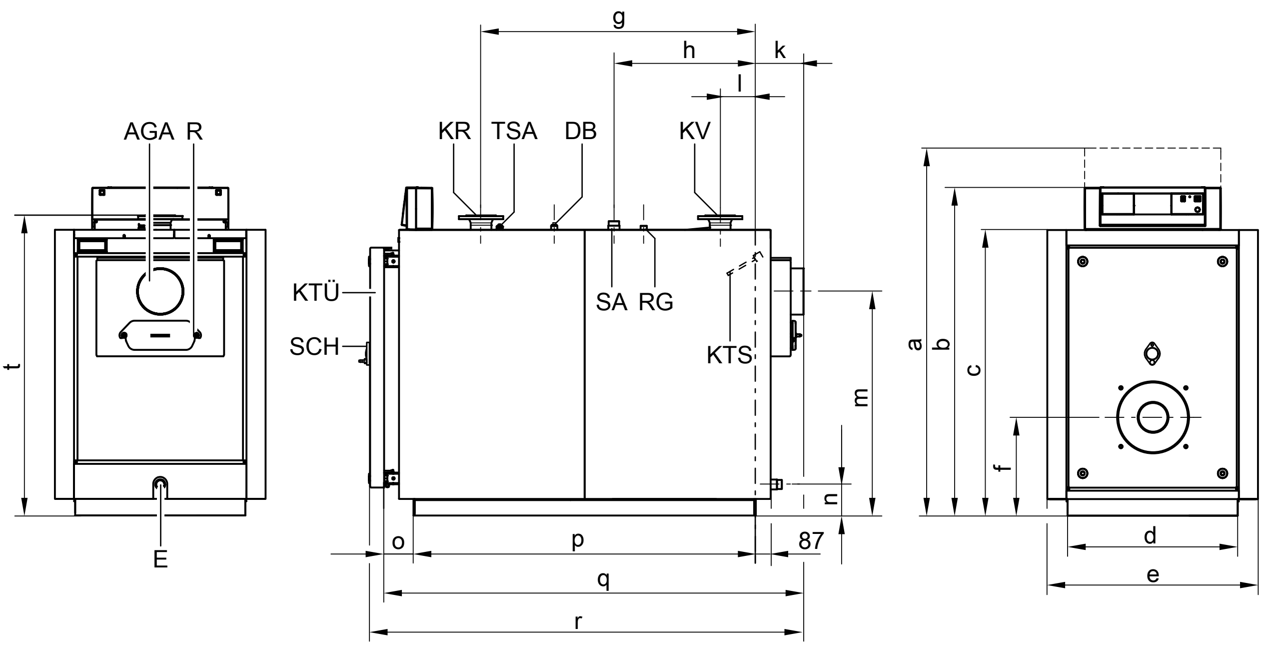
Dimensions



90 to 270 kW

AGA Flue outlet
E Drain
KR Boiler return
KTS Boiler water temperature sensor
KTÜ Boiler door
KV Boiler flow
MA Female connection R ½ (male thread) for pressure gauge
R Cleaning aperture
SA Safety connection (safety valve)
SCH Inspection port
TSA Female connection R ½ (male thread) for Therm-Control temperature sensor

*3 *Standard values resulting from sound pressure level testing cannot be guaranteed, as sound pressure level tests are always dependent on the specific system. The data provided here refers to Viessmann Vitoflame 100 pressure-jet oil/gas burners.*



350 to 560 kW

AGA	Flue outlet
DB	Female connection R ½ (male thread) for maximum pressure limiter
E	Drain
KR	Boiler return
KTS	Boiler water temperature sensor
KTÜ	Boiler door
KV	Boiler flow
R	Cleaning aperture
RG	Female connection R ½ (male thread) for additional control equipment
SA	Safety connection (safety valve)
SCH	Inspection port
TSA	Female connection R ½ (male thread) for Therm-Control temperature sensor

Dimensions

Rated heating output	**kW**	**90**	**120**	**150**	**200**	**270**	**350**	**440**	**560**
a	mm	1485	1485	1520	1520	1630	1630	1795	1795
b	mm	1315	1315	1350	1350	1460	1460	1625	1625
c	mm	1085	1085	1115	1115	1225	1225	1395	1395
d	mm	575	575	650	650	730	730	865	865
e	mm	755	755	825	825	905	905	1040	1040
f	mm	440	440	440	440	420	420	470	470
g	mm	622	825	811	1009	979	1179	1146	1292
h	mm	307	395	324	423	409	609	710	783
k	mm	203	203	203	203	203	203	224	224
l	mm	165	165	151	151	153	153	166	166
m	mm	860	860	885	885	960	960	1110	1110
n	mm	200	200	190	190	135	135	135	135
o	mm	110	110	110	110	130	130	130	130
p (length of base rails)	mm	882	1085	1071	1268	1269	1469	1471	1617
q (transport dimension)	mm	1195	1400	1385	1580	1600	1800	1825	1970
r	mm	1260	1460	1445	1640	1660	1860	1885	2030
s (depending on burner make)	mm	1670	1875	1880	2075	2095	–	–	–
t	mm	1145	1145	1180	1180	1285	1285	1455	1455

Where access to the boiler room is difficult the boiler door can be removed.

Dim. f: Observe the installed burner height.

Dim. q: With boiler door removed

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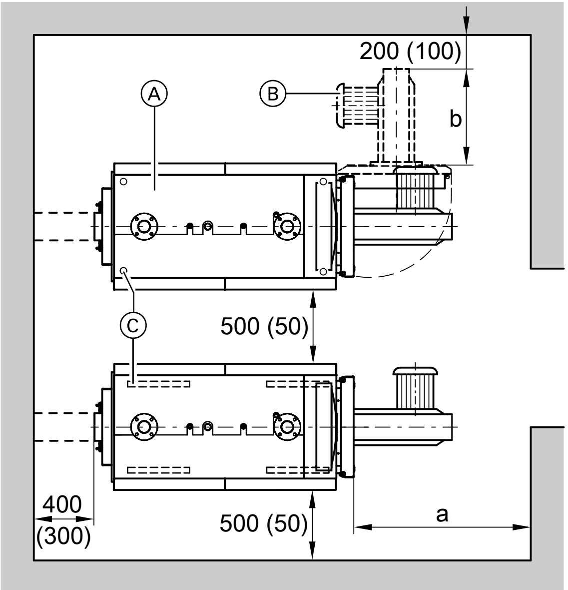
Siting

Minimum clearances



Observe the stated dimensions to ensure easy installation and maintenance. Where space is tight, only the minimum clearances (dimensions in brackets) need to be maintained. In the delivered condition, the boiler door is fitted so it opens to the left. The hinge pins can be repositioned so the door opens to the right.

Ⓐ Boiler
Ⓑ Burner
Ⓒ Adjustable anti-vibration feet (90 to 560 kW) or anti-vibration boiler supports (350 to 560 kW)

Rated heating output	**kW**	**90**	**120**	**150**	**200**	**270**	**350**	**440**	**560**
a	mm	1100			1400		1600		

Dim. a: Maintain this space in front of the boiler to enable removal of the turbulators and cleaning of the hot gas flues.
Dim. b: Observe the installed burner length.

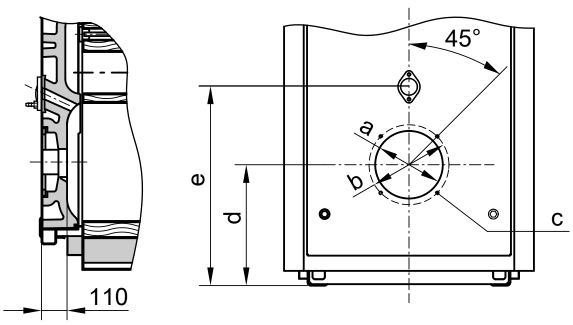
Siting conditions

- Prevent air contamination by halogenated hydrocarbons (e.g. as contained in sprays, paints, solvents and cleaning agents)
- Prevent very dusty conditions
- Prevent high levels of humidity
- Prevent frost and ensure good ventilation

Otherwise the system may suffer faults and damage.
In rooms where air contamination through **halogenated hydrocarbons** may occur, install the boiler only if adequate measures can be taken to provide a supply of uncontaminated combustion air.

Burner installation

Boilers up to 120 kW:
The burner fixing hole circle, burner fixing holes and flame tube aperture comply with EN 226.
Boilers from 150 kW:
The burner fixing hole circle, burner fixing holes and flame tube aperture are as detailed in the table below.
The burner may be mounted directly on the hinged boiler door. If the burner dimensions deviate from those stated in the table below, use the burner plate included in the standard delivery.
Burner tiles can be prepared at the factory on request (chargeable option). If this is required, state the burner make and type when ordering. The flame tube must protrude from the thermal insulation of the boiler door.



Rated heating output	**kW**	**90**	**120**	**150**	**200**	**270**	**350**	**440**	**560**
a	Ø mm	135	135	240	240	240	240	290	290
b	Ø mm	170	170	270	270	270	270	330	330
c	Number/thread	4/M 8	4/M 8	4/M 10	4/M 10	4/M 10	4/M 10	4/M 12	4/M 12

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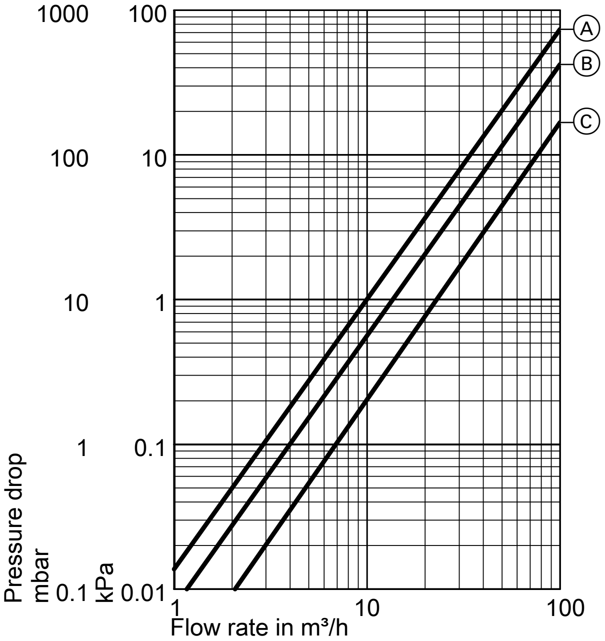
Rated heating output	kW	90	120	150	200	270	350	440	560
d	mm	440	440	440	440	420	420	470	470
e	mm	650	650	650	650	670	670	780	780

Pressure drop on the heating water side



Ⓐ Rated heating output 90 to 270 kW
Ⓑ Rated heating output 350 kW
Ⓒ Rated heating output 440 and 560 kW

The Vitoplex 200 is only suitable for fully pumped hot water heating systems.

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Vitotrans 300 specification

Specification

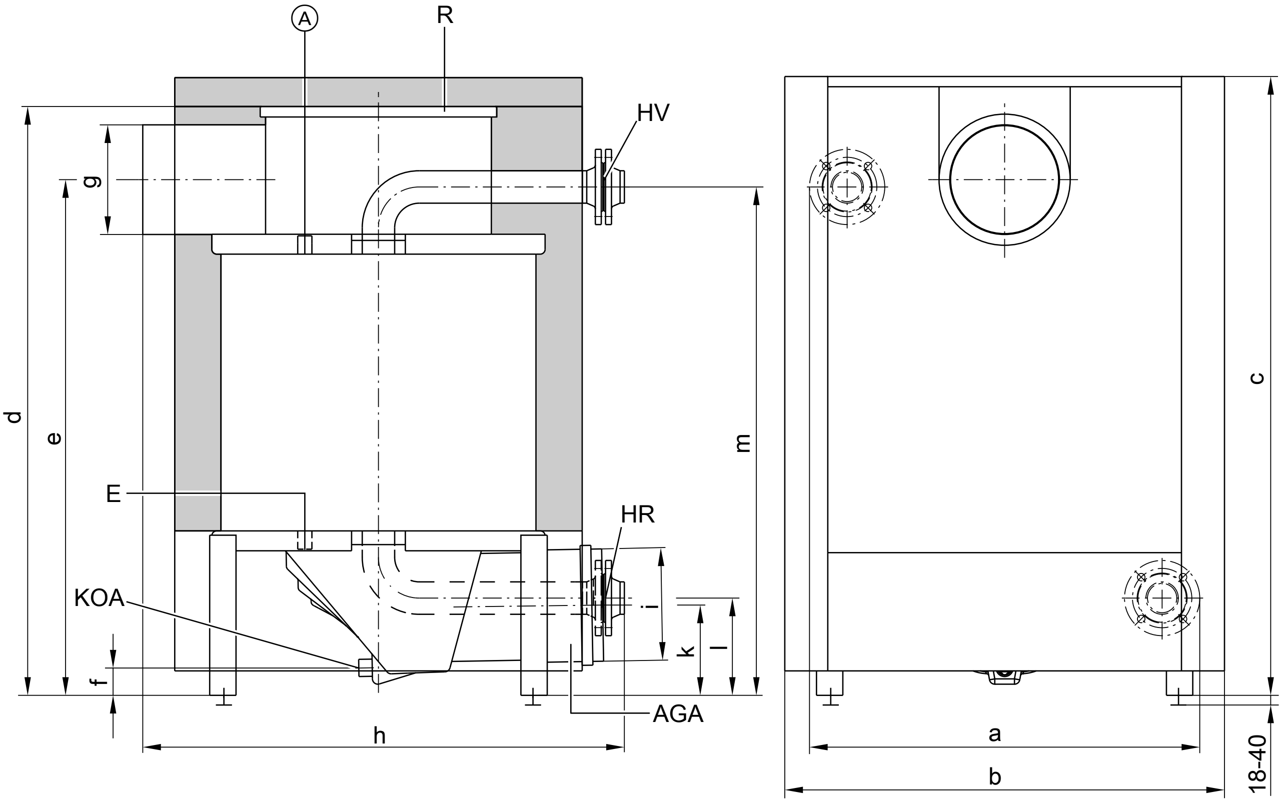
Vitotrans 300 – Gas operation – Oil operation	 Part no. Part no.	 Z010326 Z010330	 Z010327 Z010331	 Z010328 Z010332	 Z010329 Z010333
Rated boiler heating output	kW	90-125	140-200	230-350	380-560
Rated heating output range of the Vitotrans 300 for					
– Gas operation	from kW	8.7	12.7	21.8	33.3
	to kW	11.9	19.0	33.3	48.9
– Oil operation	from kW	5.8	8.8	14.9	22.9
	to kW	8.1	13.0	22.7	33.5
Permiss. operating pressure	bar	4	4	4	6
	MPa	0.4	0.4	0.4	0.6
Permiss. flow temperature (= safety temperature)	°C	110	110	110	110
Pressure drop on the hot gas side	mbar	0.65	0.85	1.00	1.05
	Pa	65	85	100	105
Flue gas temperature					
– Gas operation	°C	65	65	65	65
– Oil operation	°C	70	70	70	70
Flue gas mass flow rate	from kg/h	136	213	383	546
	to kg/h	213	341	596	954
Total dimensions					
Total length (dim. h) incl. mating flanges	mm	666	777	856	967
Total width (dim. b)	mm	714	760	837	928
Total height (dim. c)	mm	1037	1152	1167	1350
Transport dimensions					
Length excl. mating flanges	mm	648	760	837	928
Width (dim. a)	mm	618	636	706	839
Height (dim. d)	mm	1081	1098	1172	1296
Heat exchanger weight	kg	94	119	144	234
Total weight Heat exchanger incl. thermal insulation	kg	125	150	188	284
Capacity					
Heating water	litres	70	97	134	181
Flue gas	m^3	0.055	0.096	0.133	0.223
Connections					
Heating water flow and return	DN	40	50	50	65
Condensate drain (male thread)	R	½	½	½	½
Flue gas connection					
– To the boiler	DN	180	200	200	250
– To the flue system	DN	150	200	200	250

Rated heating output range of the Vitotrans 300 and flue gas temperature
Heating output of the Vitotrans 300 with flue gas cooling of 200/65 °C for gas operation and 200/70 °C for oil operation, with a heating water temperature rise in the Vitotrans 300 from 40 °C to 42.5 °C.
For conversion to other temperatures, see chapter "Output data".

Pressure drop on the hot gas side
Pressure drop on the hot gas side at rated heating output. The burner must overcome the hot gas pressure drop of the boiler, the Vitotrans 300 and the flue pipe.

Tested quality
CE designation according to current EC Directives at a permissible flow temperature (safety temperature) of up to 110 °C to EN 12828.

Dimensions



Ⓐ Additional female connection R ½ (male thread)
AGA Flue outlet
E Drain R ½ (male thread)
HR Heating water return (inlet)
HV Heating water flow (outlet)
KOA Condensate drain ∅ 32
R Cleaning aperture

Dimensions

Part no.		Z010326 Z010330	Z010327 Z010331	Z010328 Z010332	Z010329 Z010333
a	mm	628	656	726	839
b	mm	714	746	818	912
c	mm	1022	1098	1151	1308
d	mm	965	1043	1096	1245
e	mm	851	907	960	1080
f	mm	73	53	51	88
g (internal)	∅ mm	181	201	201	251
h	mm	707	818	896	1015
i (internal)	∅ mm	151	201	201	251
k	mm	165	170	168	230
l	mm	170	172	181	232
m	mm	851	899	946	1075

Delivered condition

Heat exchanger body with fitted flue gas collector. Mating flanges are fitted to all connectors

1 box with thermal insulation

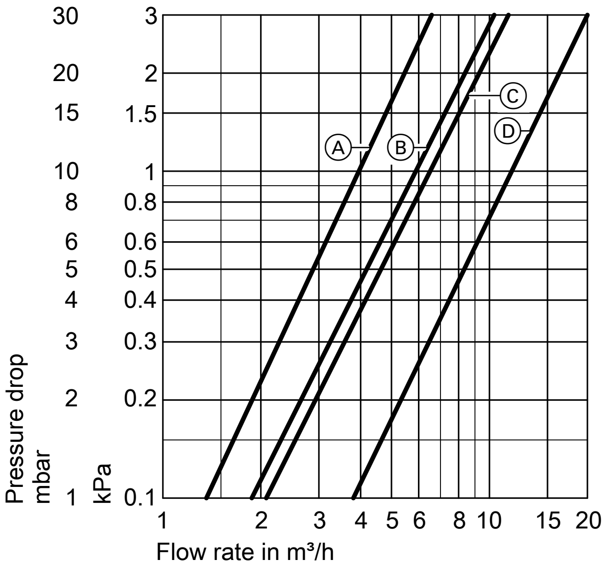
Connection on the flue gas side

Connect the boiler flue outlet and offset flue adaptor of the flue gas/water heat exchanger through a connection collar (accessories) (do not weld).

Height compensation:
- Vitoplex boiler through adjusting screws
- Vitorond boiler through on-site adaptor

Pressure drop on the heating water side

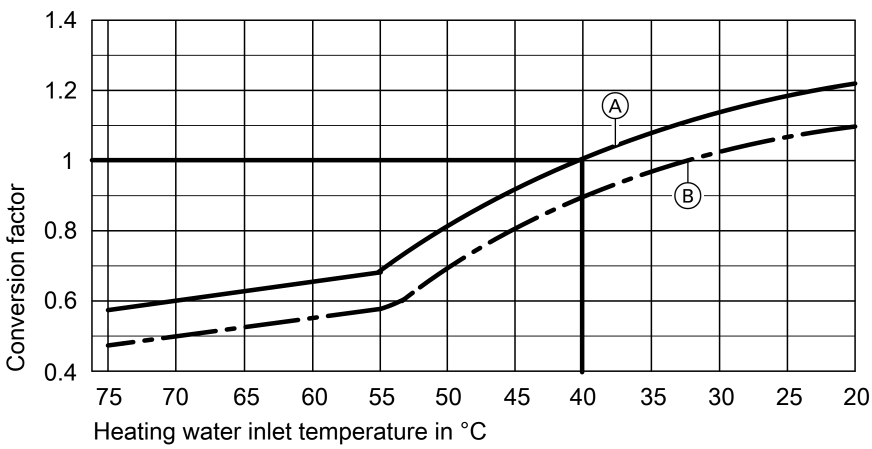
Part no. Z010326 to Z010333



Part no.	Curve
Z010326 Z010330	Ⓐ
Z010327 Z010331	Ⓑ
Z010328 Z010332	Ⓒ
Z010329 Z010333	Ⓓ

Output data

Vitotrans 300 for gas operation



Ⓐ Flue gas inlet temperature 200 °C
Ⓑ Flue gas inlet temperature 180 °C

Conversion of the output data
The heating output data of the Vitotrans 300 flue gas/water heat exchanger refers to a flue gas inlet temperature of 200 °C and a heating water inlet temperature into the heat exchanger of 40 °C.

For different conditions the heating output can be calculated by multiplying the specified rated heating output by the conversion factor established from the diagram.

Delivered condition of the boiler

Boiler body with fitted boiler door and cleaning cover.
Mating flanges are fitted to all connectors.
The adjusting screws are supplied in the combustion chamber.
Cleaning equipment can be found on top of the boiler.

2 boxes with thermal insulation
1 box with boiler control unit and 1 bag with technical documentation
1 Therm-Control
1 coding card and technical documentation for Vitoplex 200
1 burner plate (from 150 kW)

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Control unit versions

For a single boiler system

- **Vitotronic 100, type CC1E**
  For the control unit with a constant boiler water temperature.
  For weather-compensated or room temperature-dependent operation in conjunction with an external control unit.
- **Vitotronic 200, type CO1E**
  For weather-compensated operation and mixer control for up to 2 heating circuits with mixer. For the 2 heating circuits with mixer, the accessory "Extension for heating circuits 2 and 3" is required.

For a multi boiler system (up to 8 boilers)

- **Vitotronic 300, type CM1E**
  For weather-compensated operation of a multi boiler system. This Vitotronic control unit also handles control of the boiler water temperature of a boiler within this multi boiler system.
  Vitotronic 100, type CC1E and LON communication module
  To control the boiler water temperature for each additional boiler in the multi boiler system.
- **Vitocontrol 100-M/200-M multi mode system controller**
  For weather-compensated cascade control of boilers with Vitotronic 100 control unit and a Vitobloc 200 CHP unit or other heat generators.

Multi mode system controller in the control panel

For single and multi boiler systems

Vitocontrol 100-M

- For operation of multi mode heating systems with up to 4 heat generators, with various combinations of oil/gas boilers, heat pumps, CHP units and solid fuel boilers. The Vitocontrol 100-M can operate a range of defined standard schemes. The schemes are available via the Viessmann Schematic Browser. For the compatibility of the Vitocontrol 100-M in conjunction with Viessmann control units, see the compatibility list. Connection to Vitoscada for web-based system visualisation is available as an option. This requires an internet connection.
  Viessmann Schematic Browser: **www.viessmann-schemes.com**
  Compatibility list: **www.vitocontrol.info**

Vitocontrol 200-M

- For the operation of customer-specific multi mode energy systems with any number of heat generators in various combinations, as well as cooling, solar, ventilation and electricity components. Solutions are based on a modular system and can be flexibly extended with new functions and process applications. Connection to Vitoscada for web-based system visualisation is available as an option. This requires an internet connection.

Boiler accessories

See pricelist.

Operating conditions for systems with Vitotronic boiler protection

Vitotronic boiler protection, e.g. Therm-Control.

		Requirements	
Operation with burner load		**≥ 60 %**	**< 60 %**
1.	Heating water flow rate	None	
2.	Boiler return temperature (minimum value)*4	None*5	
3.	Lower boiler water temperature	– Oil operation 50 °C – Gas operation 60 °C	– Oil operation 60 °C – Gas operation 65 °C
4.	Two-stage burner operation	Stage 1: 60 % of rated heating output	No minimum load required
5.	Modulating burner operation	Between 60 and 100 % of rated heating output	No minimum load required
6.	Reduced mode	Single boiler systems and the lead boiler in multi boiler systems – Operation with lower boiler water temperature	

*4 *The technical guide "System examples" contains relevant sample systems for use of the Therm-Control start-up system.*
*5 *No requirements; only in conjunction with Therm-Control.*

	Requirements	
Operation with burner load	**≥ 60 %**	**< 60 %**
	Lag boilers in multi boiler systems – Can be shut down	
7. Weekend setback	As per reduced mode	

For water quality requirements see the technical guide to this boiler.

Operating conditions for systems with on-site boiler protection

	Requirements	
Operation with burner load	**≥ 60 %**	**< 60 %**
1. Heating water flow rate	None	
2. Boiler return temperature (minimum value)	– Oil operation 40 °C – Gas operation 53 °C	– Oil operation 53 °C – Gas operation 58 °C
3. Lower boiler water temperature	– Oil operation 50 °C – Gas operation 60 °C	– Oil operation 60 °C – Gas operation 65 °C
4. 2-stage burner operation	1st stage 60 % of rated heating output	No minimum load required
5. Modulating burner operation	Between 60 and 100 % of rated heating output	No minimum load required
6. Reduced mode	Single boiler systems and lead boiler in multi boiler systems – Operation with lower boiler water temperature Lag boilers in multi boiler systems – Can be shut down	
7. Weekend setback	As per reduced mode	

For water quality requirements see the technical guide to this boiler.

Design/engineering information

Mounting a suitable burner

The burner must be suitable for the relevant rated heating output and the pressure drop on the hot gas side of the boiler (see burner manufacturer's specification).
The material of the burner head must be suitable for operating temperatures of at least 500 °C.

Pressure-jet oil burner
The burner must be tested and designated to EN 267.

Pressure-jet gas burner
The burner must be tested to EN 676 and CE-designated in accordance with Directive 2009/142/EC.

Burner adjustment
Adjust the oil or gas throughput of the burner to suit the rated boiler heating output.

Low water indicator

If the standard boiler control unit is connected in accordance with the installation instructions, the Vitoplex 200 up to 300 kW (except in attic heating centres) does not require a low water indicator to EN 12828.

In the event of a water shortage due to a leak in the heating system and simultaneous burner operation, the control unit will automatically shut down the burner before the boiler and/or flue system reach impermissible high temperatures.

Permissible flow temperatures

Hot water boiler for permissible flow temperatures (= safety temperatures)

Up to 110 °C

- **CE designation:**
  CE-0085 (90 to 350 kW) compliant with Efficiency Directive
  and
  CE-0085 compliant with the Gas Appliances Directive

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Above 110 °C (up to 120 °C) (with individual test certification on request)

- **CE designation:**
  CE-0035 in compliance with the Pressure Equipment Directive
  For operation with safety temperatures in excess of 110 °C additional safety equipment is required.
  Boilers with a safety temperature **above 110 °C** require supervision, according to the Health & Safety at Work Act [Germany]. In accordance with the conformity assessment diagram no. 5 of the EU Pressure Equipment Directive, these boilers must be classed as category III.
  The system must be tested prior to commissioning.
  – Annually: External inspection, inspection of the safety equipment and water quality.
  – Every 3 years: Internal inspection (or water pressure test as an alternative).
  – Every 9 years: Water pressure test (for max. test pressure see type plate).
  An approved inspection body (e.g. TÜV [in Germany]) must carry out the test.

Further information on design/engineering

See the technical guide to this boiler.

Tested quality

CE designation according to current EC Directives

Subject to technical modifications.

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Appendix G Emergency flare technical specification

UNIFLARE™
GLOBAL ENVIRONMENTAL TECHNOLOGY

UF10 2500 Emissions Page EA Compliant Biogas Flare Stack

Customer	**ACORN BIOENERGY**			
Our Reference No.				
Machine type	**UF10-2500** High Temperature Enclosed Flare Stack			
Turndown Ratio	**5:1**			
Design Flow – Biogas	**500 - 2500**	**Nm3hr (Variable)**		
Pilot System	Uniflare Fire Blaster Optional Propane ZAI ionisation pilot			
Use environment	Site in open air with restricted access.			
Hazardous area classification in compliance with ATEX requirements.	Zone 2 in sphere 200 mm radius around all positive gas pipe connections and 100 mm radius around all negative pressure gas pipe connections			
Maximum design emissions Normalised at 0°C, 101.3 k Pa and 3% O2:	Carbon monoxide (CO)	50 mg Nm-3		
	Oxides of nitrogen (NOx)	150 mg Nm-3		
	Total volatile organic carbon as carbon	10 mg Nm-3		
	Non-methane volatile organic carbon	5 mg Nm-3		
Operation	Unattended Intermittent use			
Design Media	65%	Methane CH^4		
Design Burner Pressure	Minimum Burner inlet Pressure	70	mbarg	
Thermal Rating	16.20	MW		
Design Destruction Efficiency	>99.7%			
Design Combustion temperature	Combustion >1000°C Fully refractory line with automated combustion control			
Minimum retention time	> 0.3 seconds			
Control system	PLC controlled with Hardwired interface. Remote Start Stop. Status and Information available for Remote and site SCADA system.			
Safety systems	CE marked equipment Piltz PNOZ monitoring e-stop circuit Gas pressure protection IS barriers Local Isolators Flash back protected Flame arrestor Pressure and Temperature monitoring DSEAR and ATEX compliant			

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Registered in England Number 05689034

UF10 2500 Emissions Page EA Compliant Biogas Flare Stack

Design Calculation Page

UF10-2500 High Temperature Flare @ 65%CH4

CALCULATION OF RETENTION TIME					
CALCULATION OF COMPOSITION OF COMBUSTION PRODUCTS BS 5854					
per one volume of fuel @ 15° C and 1013 mbar					
Constitituent	Percentage	rel den	rel den fuel		
	in fuel		to air		
CH_4	65%	0.554	0.3601		
CO_2	35%	1.5198	0.53193		
	1	OK	0.89203		
STOICHIOMETRIC AIR PER UNIT VOLUME OF METHANE IS 9.55					
	biogas flow rate	2500	m3h-1 >	1625	m3h-1 CH4
	min air required	15518.75	m3h-1		
	excess air	200%			
	specific volume of air	0.819	m3 kg-1		
	mass flow rate of air	56845	kg h-1		
	mass flow rate of biogas	2723	kg h-1		
	total mass flow rate	59568	kg h-1		
fuel gases above their dew point have a specific volume similar to air at the relevant temperature					
	the volume of 1 kg of				
	flue gases at	1000	° C is		
		4	m3 kg-1		
	therefore the volume flow rate	227491	m3 h-1		
		63	m3 s-1		
	hot face diameter	2.645	m		
	area	5.49	m2		
	velocity	11.5	m s-1		
	height above flame	5.5	m		
	retention time	0.48	s		
	Retention time at sample port	0.39	s	Port 1m down from top	
	Heat release turn down ratio	5	:1		
	Combustion heat release full load	16.20	MW		
	Minimum heat release	3.24	MW	**Created**	RPB
EA Guidance on Landfill Gas Flaring 4.8.7 Page 24				**Checked**	MIJ

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Appendix H Manure reception building emissions abatement system

Quotation no:	Ver3.1119	Valid through:	2024-01-22	Customer:	Acorn Bioenergy
Date	2023-12-22	Our ref:	Emanuel Andersson	Your ref:	Roger Hammett

Quotation for Odour removal

Centriair develops and offers technology leading solutions for abatement of industrial airborne emissions. We provide solutions with proven environmental and economic benefits. Our systems typically have higher performance and lower energy consumption than prevailing solutions. We help the industry solve a broad range of emission problems while increasing the productivity and reducing operations and maintenance costs.

These benefits are achieved through higher performance, lower energy consumption and by recovering energy from the process. We work across a broad range of industry sectors, however most of our customers are in the food processing and waste processing industries.

Centriair AB
Ögärdesvägen 4A
433 30 Partille
Tel. 46 (0)31 263500
E-mail info@centriair.com
Reg. number 556737-9374

Introduction

Centriair is pleased to offer this quotation for odour removal at the client site based on the ColdOx™ system.

The following design is suggested to be designed for the application. The outlet gas will meet the following criteria:

- Odour concentration less than 1 000 OU/m3 from the chimney.

No	Component
1	Packed Acid Scrubber – treating 18 500 Nm3/h.
1	UV reactor of model Frej with 10 lamp frames – treating 18 500 Nm3/h.
1	Carbon filter 2x6 - treating 18 500 Nm3/h.
1	Main fan - treating 18 500 Nm3/h.
1	Standalone Chimney 16.5 meters high – treating 18 500 Nm3/h.
1	Ducting supply and installation.
1	Piping between equipment
1	Drainpipes with water trap
1	Instrumentation for control and monitoring

Centriair AB
Ögärdesvägen 4A
433 30 Partille
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E-mail info@centriair.com
Reg. number 556737-9374

Planned feedstock

Chicken manure and farm yard manure (poultry litter) from the table below:

Feedstock (Inputs)	Category	Mass Required (T/yr)	Dry Matter (%)	Volatile Solids (%)
Wholecrop	Energy Crop/Product	17,500	35.00%	95.00%
Maize Silage	Energy Crop/Product	26,000	32.00%	97.00%
Straw	Residue/Waste	20,000	86.88%	91.56%
Farm Yard Manure	Residue/Waste	9,000	25.00%	80.00%
Dairy Slurry (south lynch spec.)	Residue/Waste	6,000	11.00%	90.00%
Pig Slurry	Residue/Waste	4,500	6.00%	80.00%
Botanical waste	Residue/Waste	-	78.72%	95.34%
Poultry Litter (three maids av spec.)	Residue/Waste	11,000	68.00%	72.00%
Water	Dilution	42,000	0.00%	0.00%
		94,000	45.19%	

Process description

The expected performance from the ColdOx system is illustrated below.

Inlet air streams		
source no. 1	air from chicken shed	
air flow	18,500	m³/h
temperature min.	10	°C
temperature max.	35	°C
humidity	80-90	%rH
O2 content	21	Vol%
dust content	TBD	mg/m³
pressure at connection point	500	Pa

Inlet air pollutants		
source no. 1	air from chicken shed	
odour	< 20,000	OU/m³
NH3	<100	ppm
H2S	2	ppm
VOC	not defined	ppm
other	not defined	

Target values for exhaust air		
odour	<1000	OU/m³
NH3	<5	ppm
H2S	0	ppm

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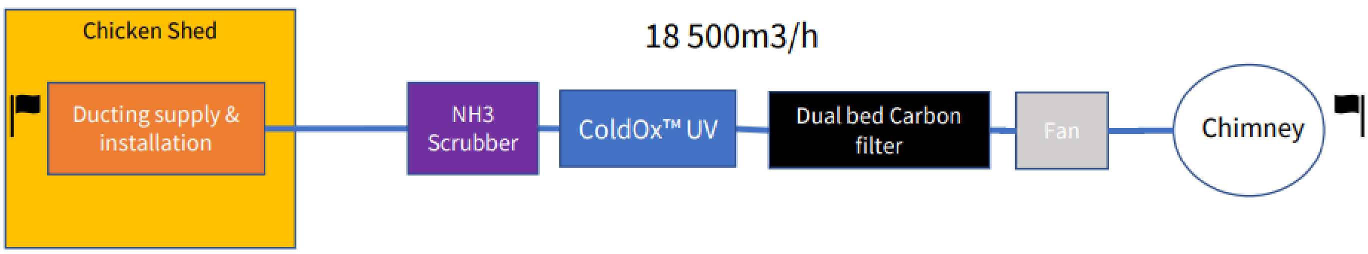
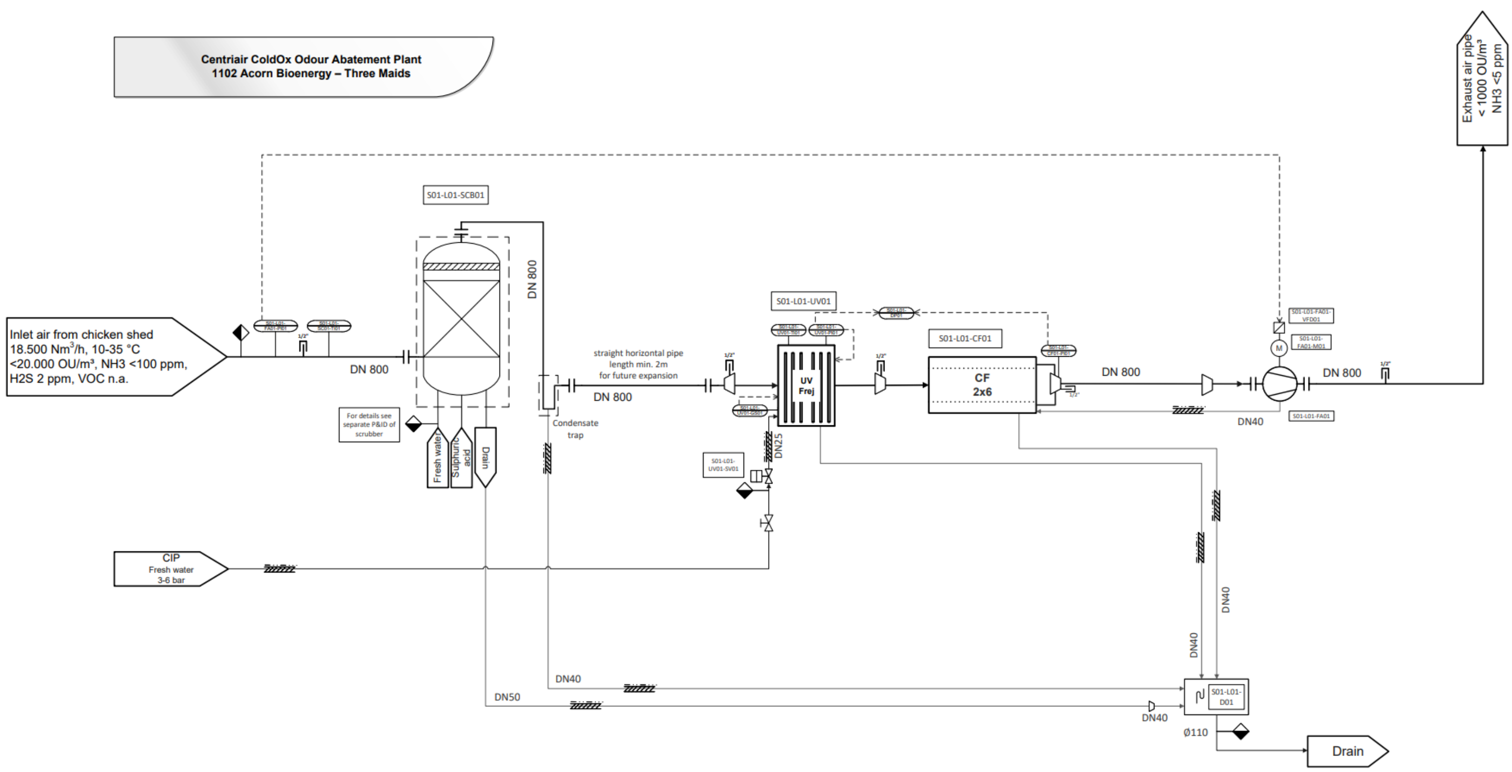
Odour mapping & Conceptual design



P&ID Odour treatment system



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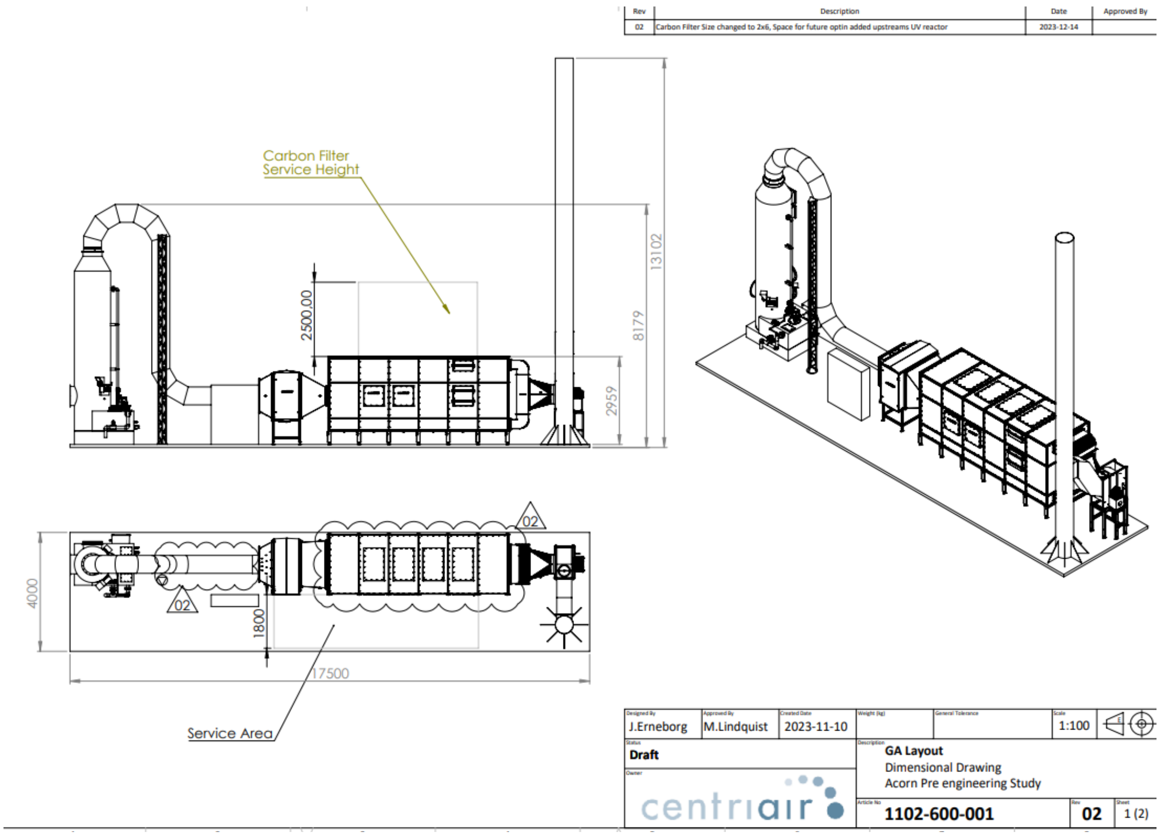
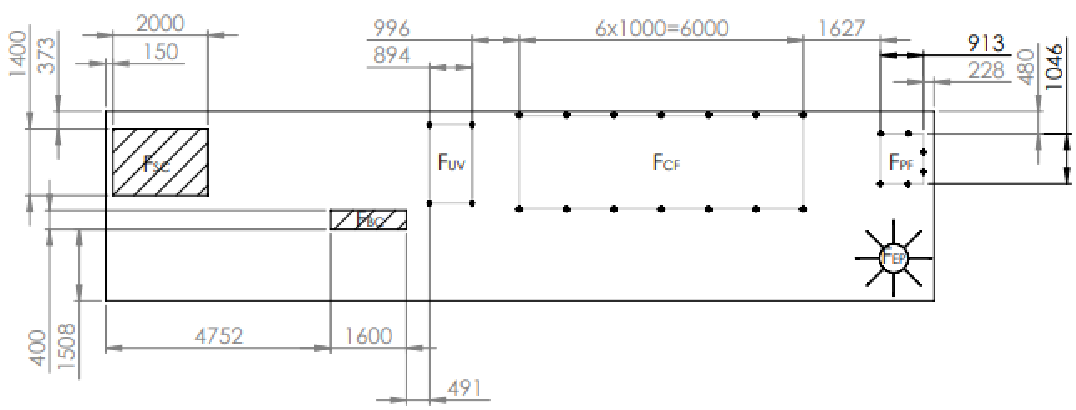
Overall footprint

Below is the preliminary footprint of the odour treatment system.





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Equipment Loads

Equipment Loads		
Equipment	**Tag**	**App. Weight [kg]**
Scrubber	F_{SC}	2500
UV Reactor	F_{UV}	450
Carbon Filter	F_{CF}	9600
Process Fan	F_{PF}	300
Exhaust Pipe	F_{EP}	750
Ballast Cabinet	F_{BC}	300

Overall consumptions

The information about the consumption is conservative.

Total power consumption

Fans come with VFD system to regulate the airflow changes. Thus, the fan can be set to run at a lower frequency, (e.g., 50 %) during less active periods to save power.

Main fan ColdOx :	15.0 kW
UV reactors system:	13,5 kW
Packed Cross-flow scrubber	approx. 5 kW
Summary	33,5 kW

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Detailed system specification

UV Specification:

Description :	The UV reactors is in the first treatment stage, built together with the active carbon filter. Lamp life is approximately 16 000 hours. Basic control setup is start/stop signal from your system and running and error signal back to your system. Control and safety solution includes pressure guard for the UV as well as door switches. Equipment prewired with “plug and play” to minimize site wiring. Automatic flushing system of lamps, CIP (Clean in Place). Safety switches with alarm system in case of lamp failure. Controls and signaling see Appendix D.
Note:	The ballast panel should be positioned within 20 meter cable length from the UV reactor.
Electrical connection:	380-400 V/50 A three phase + Neutral 50 Hz
Weight:	Total weight of one reactor including support and lamp frames is 580 kg.
Process gas flow:	18 500 m^3/h
Maximal operating temp:	45 °C.
Control system:	PLC Siemens S7 1200

Active Carbon Specification:

Description:	Active Carbon filter with medium residence time due to the initial treatment and combination effects from oxidation + carbon. Dual carbon beds to minimize pressure drop.
Material:	Stainless steel AISI 304
Disposal of Carbon	For the disposal of spent media, we recommend following the guidelines of the European Waste Catalogue EWC and use the waste code number 19 09 04 or 15 02 03 – non hazard waste. Numerous landfills containing household trash and building materials will accept the loaded gas purification product, which is totally harmless to the environment, after submitting a declaration of analysis.
Other:	Centriair has the right to decide which type of activated carbon that operates.

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Main Fan Specification:

Description:	Industrial centrifugal fan (1) from stainless steel driven by frequency inverter. Fans come with VFD system to regulate the airflow changes. The exact pressure drops in the ducts to our system must be specified before ordering the final fan. This will have to be done already at the detailed design stage. **Please revert if additional pressure capacity is needed.** For more detailed specification see appendix.
Capacity:	18 500 m^3/h
Electrical connection:	380-400 V
Installed Power:	**18,5 kW**

Packed Acid Scrubber:

Description:	Scrubber stage for an efficient NH3 removal consisting of a reaction vessel with packing and distributor. Exit from the packed column includes a demister. Water conditioned with sulphuric acid is used in the system. The water reacts with the NH3 to form ammonium sulphate. The process water is drained when concentration reaches for instance 25% and the chemical should be possible to reuse in the customer's process.
Material:	FRP
Capacity:	18 500 m^3/h
Pressure drop:	App. 500 Pa

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Chimney:

Description:	Steel Chimney System
	Single flue Stack Height: 12m manufactured in 2No flanged sections. Structural Shell Diameter: 700mm. Flanged Inlet Dimensions: 550mm wide x 700 deep complete with necessary compensation bars. Inspection Hatch 400mm x 300mm at base level complete with necessary compensation bars. Sample Ports: 2No 125mm dia flanged sample ports. 1No internal drain plate 1No 50N/B drain connection. 2NO Earthing Bosses welded to base plate 1 set of steeplejack access points @ 1.5m centres. 1no drilled base plate complete with gussets to suit foundation bolts. 2No lifting points at the top of each chimney section.
Material.	According to EN10025 grade 304 stainless steel as a minimum

Ducting supply and installation:

Description:	See appendix for detailed information

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Centriairs responsibilities, Centriair reserves the right to invoice additional travel costs and time separately.

Centriair expects a safe and healthy workplace in compliance with international standards and national regulations. To prevent incidents and injuries, all Centriair employees are authorized to stop any work or behavior deemed unsafe to themselves or other personnel on site.

The delivery time will start after these clarifications are received and confirmed. Changes from specification may result in increased price or delivery time:

- If nothing else is stated, fan size is based on an assumption of 500Pa pressure drop total for ducting leading to, and from Centriairs equipment.

- Approval of Layout is required including:
  Positioning of fan, ballast cabinet, electrical cabinet, drain system and CIP connections, positioning of drain outlet, Service hatch directions (Service area)

- Signal exchange to supervising system must be defined. External signals from control panel include only Start/Stop/Summary alarm as a standard.

- Droplet separators, filter and other equipment before Centriair's equipment must be specified, including pressure drop.

- Project specific P&ID from Centriair shall be supplied and confirmed.

- The customer holds the responsibility to control the airflow between the low and medium concentration lines.

Terms of delivery

- General delivery terms: Orgalime SI 14
- Warranty 12 months from Hand-over, maximally 15 months from delivery from supplier (extended with preventive maintenance contract)
- INCOTERM 2020 FCA, Sweden, Poland
- Delivery time: Normally 24-28 weeks from approved drawings (typically 6-8 weeks)

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Terms of payment

- 40 % on contract signature
- 50 % when equipment is ready for delivery
- 10 % at plant start up but no more than 1 month after commissioning.
- Net 20 days payment term
- Payment with Bank transfer to our IBAN account, checks are never accepted

Warranty Terms

Standard mechanical warranty (according to Orgalime SI 14) of 12 months. It is extended when preventive maintenance contract is signed, with up to 5 years.

We trust this proposal meets your requirements and we look forward to working together with you to reduce the odour emissions.

Emanuel Andersson
Centriair AB
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Appendix E Fan specification

Specification, Fan
Project reference: 1102
2023-12-14
Page 1/1

Project:	1102 Acorn Bioenergy
Fan ID:	**Main Fan S01-L01-FA01**

Description of function and process

A frequency controlled fan used to keep a constant pressure upstream in the system. Fan will be used in an odour treatment process. Low concentrations of residual ozone may be present in the exhaust air. Fan is operated without stopping all year.

Design data, gas

Type of gas	Ventilation air
Dust content inlet	Low (normal outdoor air)
ATEX	No Ex-Zone

Mode of operation	**Normal**
Gas flow inlet, Nm3/h	18.500 Nm^3/h
Gas density inlet, kg/m3	1,1
Gas temperature inlet, °C	10 to +35 °C
Static Pressure increase over fan, Pa	2.100 Pa

Design data, surroundings

Environment	Outdoor
Temperature	-20 to +40 °C
Corrosion protection (for painted surfaces)	C3-M (ISO 12944)

Fan Specification and scope

Maximum fan speed, rpm and Hz	*Specified by supplier*
Materials, in gas contact	AISI 304 (1.4301)
Materials, not in gas contact	AISI 304 (1.4301)
Drainage	2"
Inspection hatch	Placed in outer radius of housing
Outlet direction	ISO LG-315
Drive type	Direct driven
Fan wheel type	*Specified by supplier*
Sound level limits, surroundings	<65 dB(A), at 1m distance from fan (while inlet/outlet pipes are connected)

Motor Specification and scope

Motor voltage, V	400
Net frequency, Hz	50
No of Poles, motor	*Specified by supplier*
Motor efficiency class	IE3 or higher
Insulation class	F
Protection class	IP55
Frequency converter driven	Yes

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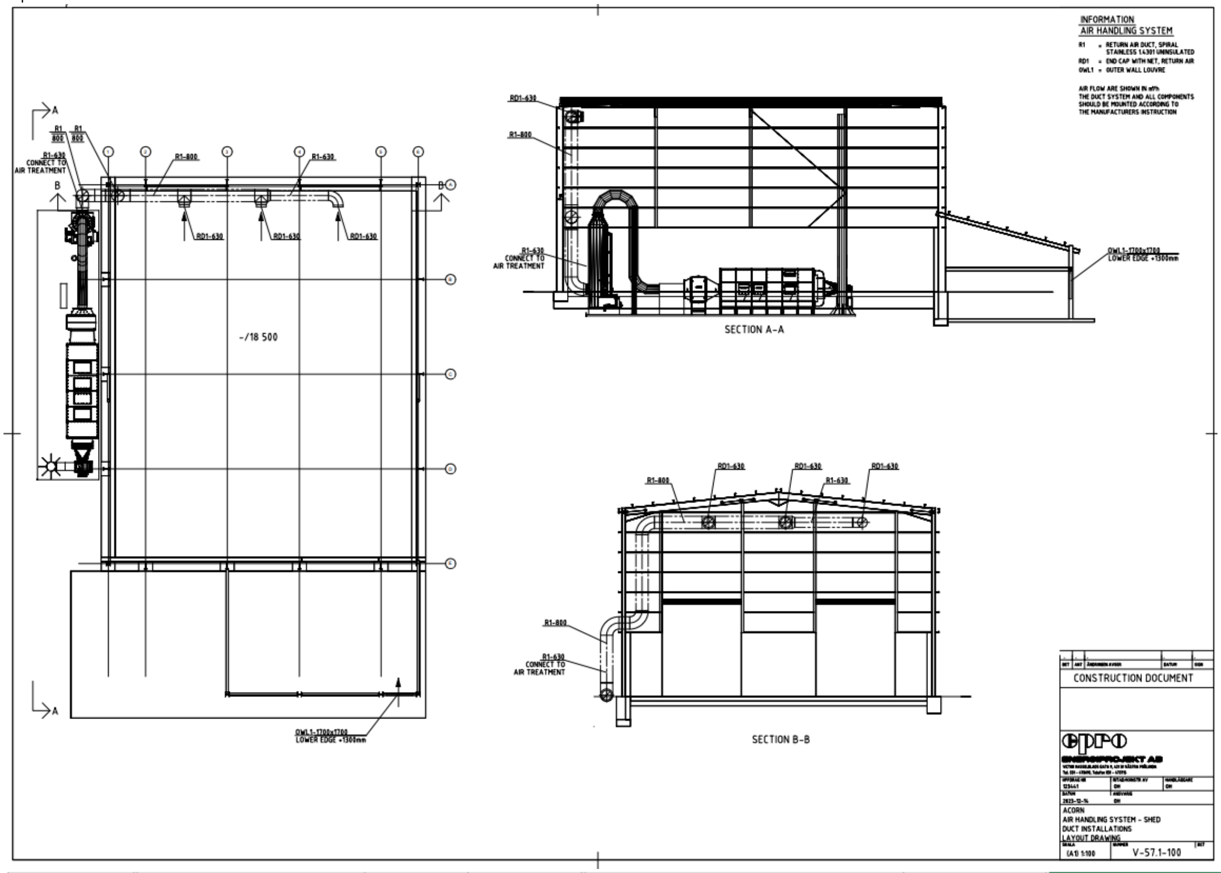
Appendix F Ducting supply and installation

Specification ductwork from shed.



COMPONENT NR.	COMPONENT DESCRIPTION	QUANTITY NO.	CONNECTION SIZE	REMARK 1	REMARK 2	MATERIAL
AIR DUCT SYSTEM						
RETURN AIR			**Ø (mm)**			
RD1-630	END CAP WITH NET	3	630	BIRD SCREEN		STAINLESS STEEL(1.4301)
FRESH AIR			**BxH(mm)**			
OWL1-1700x1700	FRESH AIR LOUVRE	1	1700 x 1700			STAINLESS STEEL(1.4301)
AIR DUCT SYSTEM						
R1-800	Straight duct	20 meters	800	DUCT SIZING ACCORDNING TO DRAWING	SPIRAL TUBE	STAINLESS STEEL(1.4301)
R1-800	Elbow 90 deg	4 pieces	800	DUCT SIZING ACCORDNING TO DRAWING	SPIRAL TUBE	STAINLESS STEEL(1.4301)
R1-800	T-piece	2 pieces	800	DUCT SIZING ACCORDNING TO DRAWING	SPIRAL TUBE	STAINLESS STEEL(1.4301)
R1-800	Reduction 800-630	4 pieces	800/630	DUCT SIZING ACCORDNING TO DRAWING	SPIRAL TUBE	STAINLESS STEEL(1.4301)
R1-630	Straight duct	6 meters	630	DUCT SIZING ACCORDNING TO DRAWING	SPIRAL TUBE	STAINLESS STEEL(1.4301)
R1-630	Elbow 90 deg	1 pieces	630	DUCT SIZING ACCORDNING TO DRAWING	SPIRAL TUBE	STAINLESS STEEL(1.4301)

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Appendix I Ecological data

Hampshire Biodiversity Information Centre data

Environment Agency Screening Report for Nature and Heritage Conservation

Hampshire Biodiversity Information Centre

HBIC Ref: 11370

Broad habitats within 2km of Three Maids:

Some Habitats may overlap. Please see 'UK Broad Habitats Legend' for full Legend, there is a link to this within your covering letter

(see explanatory note for details of the origin and accuracy of this data)

Legend

2km Search Area

Three Maids

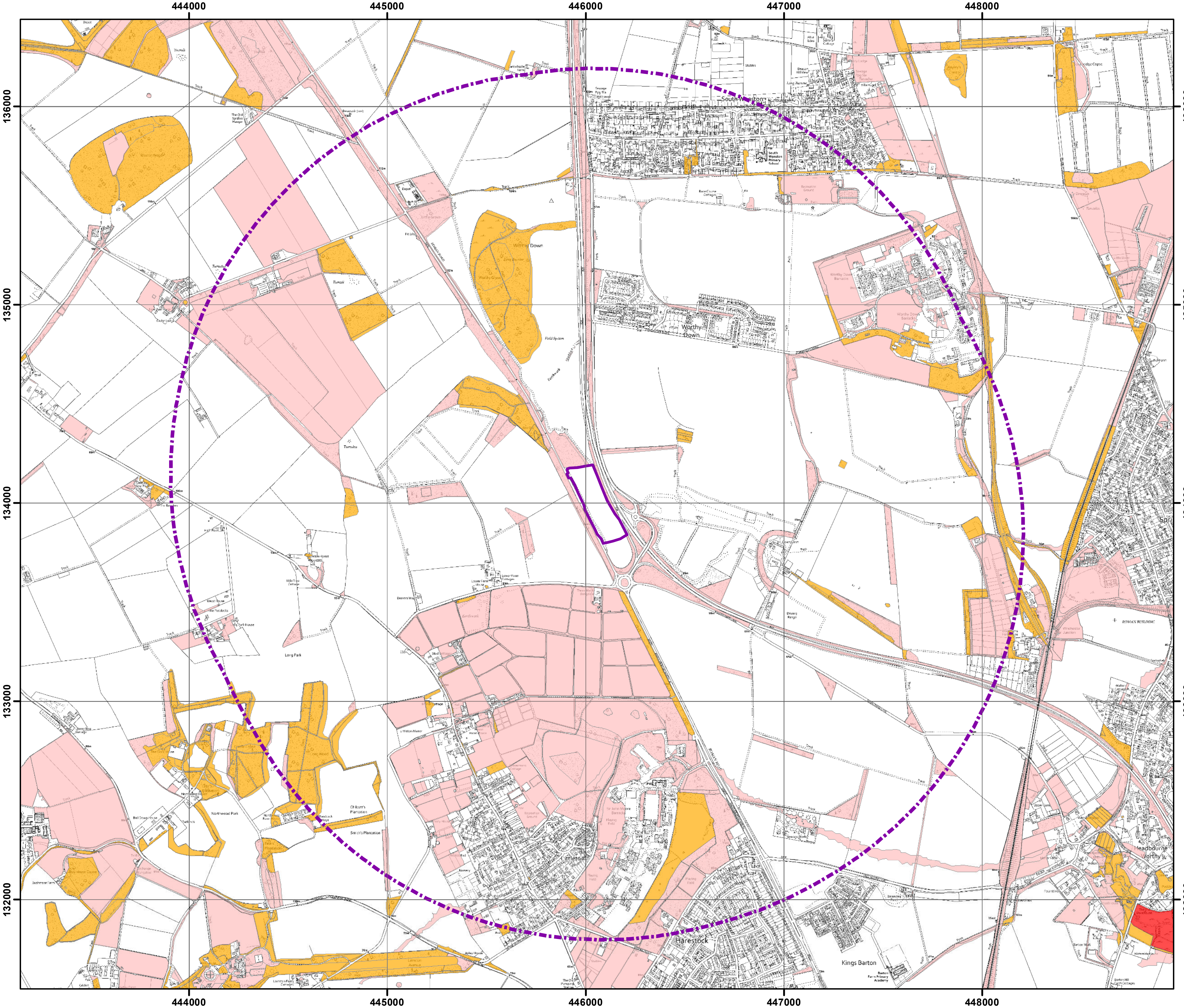
Created: 07/03/2023

Scale at A3: 1:18,000

Your licence to re-use expires on 07/03/2024

N

0 100 200 400 600 800 1,000 1,200 Meters



Hampshire Biodiversity Information Centre

HBIC Ref: 11370

Ecological Network Mapping within 2km of Three Maids:

Legend

- 2km Search Area
- Three Maids
- Core Statutory
- Core Non-statutory
- Network Opportunities

Created: 07/03/2023
Scale at A3: 1:18,000

N

Your licence to re-use expires on 07/03/2024

0 100 200 400 600 800 1,000 1,200 Meters

Hampshire Biodiversity Information Centre

HBIC Ref: 11370

Priority habitats within 2km of Three Maids:

Some Habitats may overlap. Please see 'UK Priority Habitats Legend' for full Legend, there is a link to this within your covering letter

(see explanatory note for details of the origin and accuracy of this data)

Legend

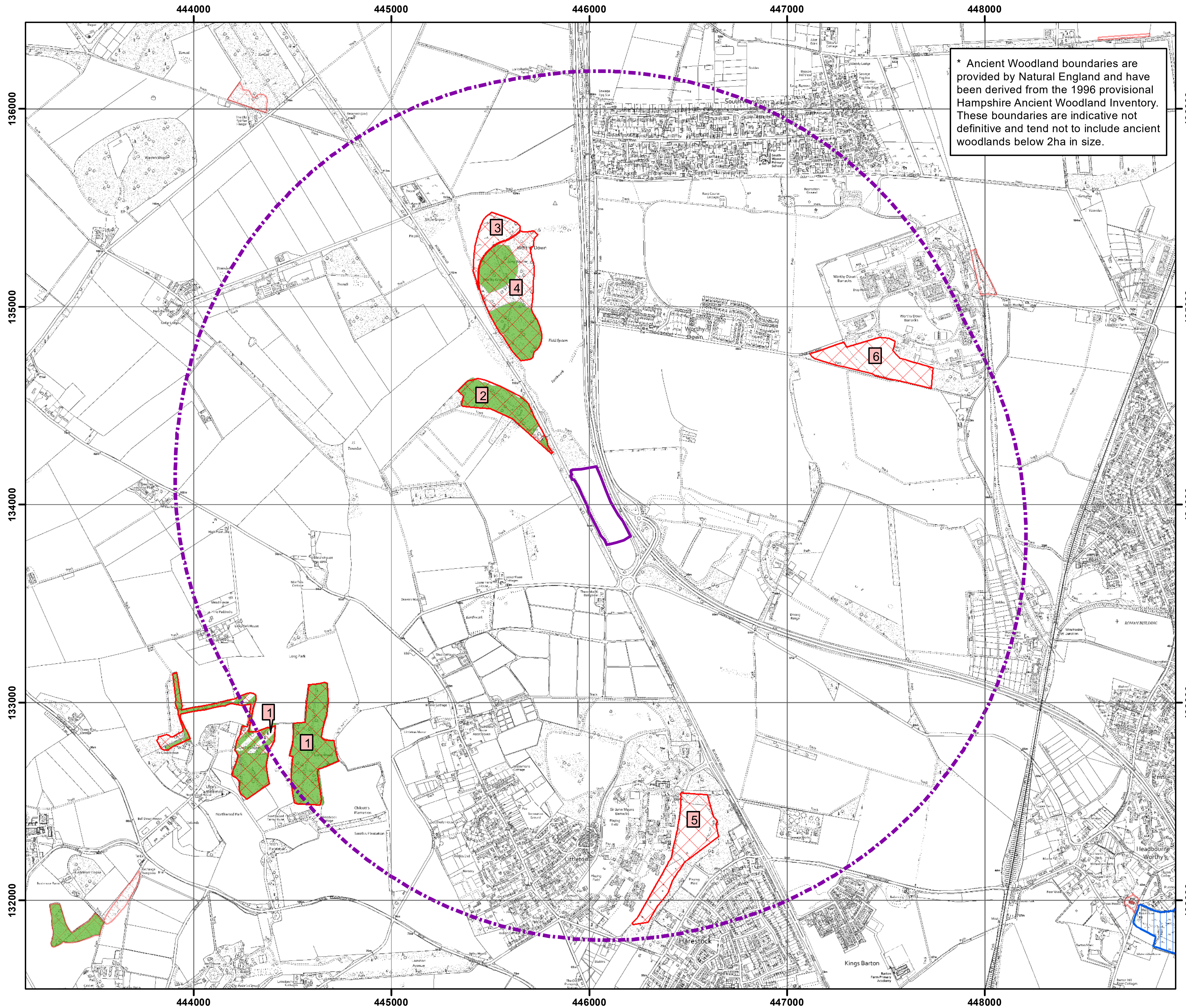
2km Search Area

Three Maids

Created: 07/03/2023
Scale at A3: 1:18,000

Your licence to re-use expires on 07/03/2024

0 100 200 400 600 800 1,000 1,200 Meters



Hampshire Biodiversity Information Centre

HBIC Ref: 11370

Statutory and non-statutory designated sites within 2km of Three Maids:

Legend

- 2km Search Area
- Three Maids
- SSSI
- SINCs (Labelled pink)
- Surrounding SINCs

Ancient Woodland Inventory

- Semi-Natural
- Replanted

Created: 07/03/2023

Scale at A3: 1:18,000

Your licence to re-use expires on 07/03/2024

N

0 100 200 400 600 800 1,000 1,200 Meters

Please note: The boundaries for statutory sites have been provided as digital data from Natural England (NE); this digital data is indicative not definitive. Paper maps produced by NE at the time the sites were designated show the official site boundaries.

Habitat Legend

BAP Priority Habitats

- Arable Field Margins
- Coastal Saltmarsh
- Coastal Sand Dunes
- Coastal Vegetated Shingle
- Coastal and Floodplain Grazing Marsh
- Eutrophic Standing Waters
- Hedgerows
- Intertidal Mudflats
- Intertidal chalk
- Lowland Beech and Yew Woodland
- Lowland Calcareous Grassland
- Lowland Dry Acid Grassland
- Lowland Fens
- Lowland Heathland
- Lowland Meadows
- Lowland Mixed Deciduous Woodland
- Maritime Cliff and Slopes
- Lowland Raised Bog
- Open Mosaic Habitats on Previously Developed L
- Ponds
- Purple Moor Grass and Rush Pastures
- Reedbeds
- Rivers
- Saline Lagoons
- Seagrass Beds
- Traditional Orchards
- Wet Woodland
- Wood-Pasture and Parkland

BAP Broad Habitats

- Acid grassland
- Arable and horticulture
- Bog
- Boundary and linear features
- Bracken
- Dense scrub
- Broadleaved, mixed, and yew woodland
- Built-up areas and gardens
- Post-industrial sites
- Calcareous grassland
- Coniferous woodland
- Dwarf shrub heath
- Fen, marsh and swamp
- Improved grassland
- Neutral grassland
- Rivers and streams
- Standing open water and canals
- Inland rock
- Inshore sublittoral rock
- Inshore sublittoral sediment
- Littoral Rock
- Littoral Sediment
- Supralittoral Rock
- Supralittoral Sediment

Unknown Habitats

- Unknown terrestrial vegetation
- Unidentified habitat
- Unidentified water

Hampshire Biodiversity Information Centre

Nature and Heritage Conservation

Screening Report: Bespoke installation

Reference	**EPR/BP3326SD/P001**
NGR	**SU 46094 33959**
Buffer (m)	**205**
Date report produced	**06/02/2024**
Number of maps enclosed	**1**

This nature and heritage conservation report

The nature and heritage conservation sites, protected species and habitats, and other features identified in the table below **must be considered in your application**.

In the further information column, there are links which give more information about the site or feature type and indicate where you are able to self-serve to get the most accurate site boundaries or feature locations.

Most designated site boundaries are available on Magic map. Using Magic map allows you to zoom in and see the site boundary or feature location in detail, Magic map also allows you to measure the distance from these sites and features to your proposed boundary. Help videos are available on Magic map to guide you through.

Where information is not publicly available, or is only available to those with GIS access, we have provided a map at the end of this report.

Sites and Features within screening distance	Screening distance (km)	Further Information
Special Areas of Conservation (cSAC or SAC)	5	Joint Nature Conservation Committee and Magic map
River Itchen		
Local Wildlife Sites (LWS) (see map below)	2	Appropriate Wildlife Trust
Worthy Copse		

Worthy Grove		
Worthy Camp Grassland		
The Gallops, Worthy Down		
Flowerdown, Littleton		
Northwood Park Woods		
Worthy Down Railway Halt		
Ancient Woodland	2	Woodland Trust Forestry Commission Natural England and Magic map
WORTHY COPSE		
SOUTH WORTHY GROVE		
LONG WOOD		

Where protected species are present, a licence may be required from Natural England to handle the species or undertake the proposed works.

The relevant Local Records Centre must be contacted for information on the features within local wildlife sites. A small administration charge may also be incurred for this service.

The following nature and heritage conservation sites, protected species and habitats, and other features have been checked for, where they are relevant for the permit type requested, but have not been found within screening distance of your site unless included in the list above.

Special Areas of Conservation (cSAC or SAC), Special Protection Area (pSPA or SPA), Marine Conservation Zone (MCZ), Ramsar, Sites of Special Scientific Interest (SSSI), National Nature Reserve (NNR), Local Nature Reserve (LNR), Local Wildlife Sites (LWS), Ancient Woodland, relevant species and habitats.

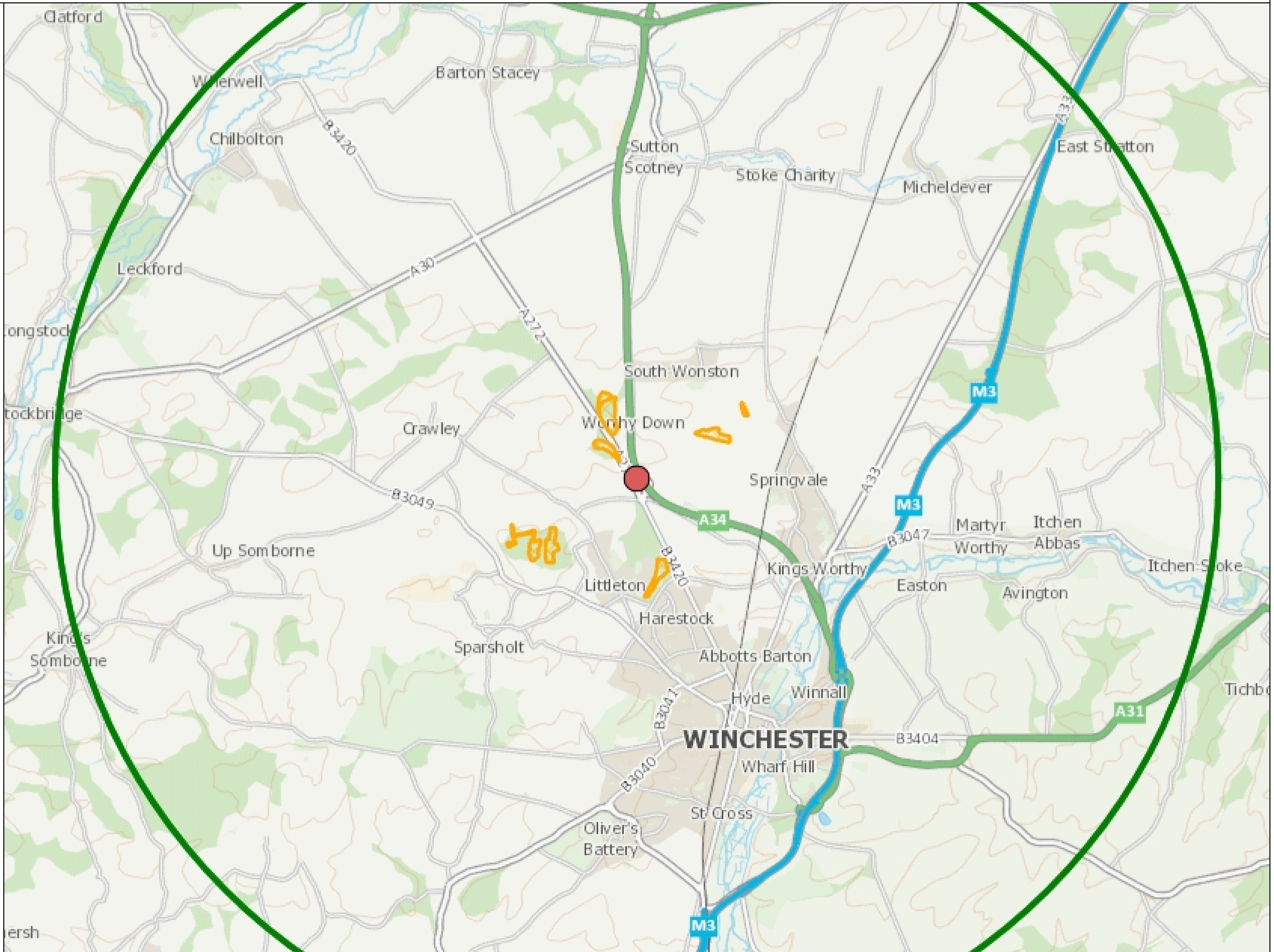
Please note we have screened this application for features for which we have information. It is however your responsibility to comply with all environmental and planning legislation, this information does not imply that no other checks or permissions will be required.

The nature and heritage screening we have conducted as part of this report is subject to change as it is based on data we hold at the time it is generated. We cannot guarantee there will be no changes to our screening data between the date of this report and the submission of the permit application, which could result in the return of an application or requesting further information

LWS

Legend

Local Wildlife Sites



1: 100,000

0 2,500

Metres

N W E S

Appendix J Human receptor results

Table 33 Long-term and short-term results NO_2

ID	Receptors	Comparison with annual mean AQS: 40 µg/m³				Comparison with 99.79th percentile 1-hour threshold 200 µg/m³			
		PC (µg/m³)	PC/AQS (%)	PEC (mg/m³)	PEC/AQS (%)	PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/Headroom (%)
R1 (a)	Proposed Instavolt Restaurant (a)	n/a	n/a	n/a	n/a	8.74	4.4%	153	5.7%
R1 (b)	Proposed Instavolt Playground (b)	n/a	n/a	n/a	n/a	8.29	4.1%	153	5.4%
R2	The Pringle Group/ Concrete 247	n/a	n/a	n/a	n/a	17.9	8.9%	153	12%
R3	Three Maids Bungalow	0.53	1.3%	24.2	61%	8.60	4.3%	153	5.6%
R4	Lower Farm Cottages	0.50	1.2%	24.2	60%	6.27	3.1%	153	4.1%
R5 (a)	Worthy Down (a)	0.29	0.7%	24.0	60%	7.11	3.6%	153	4.7%
R6	Down Farm	0.27	0.7%	24.0	60%	7.01	3.5%	153	4.6%
R7	Off Down Farm Lane (Static caravans)	0.25	0.6%	24.0	60%	6.69	3.3%	153	4.4%
R5 (b)	Worthy Down (b)	0.38	0.9%	24.1	60%	6.56	3.3%	153	4.3%
R8	Winchester Golf Academy	n/a	n/a	n/a	n/a	5.28	2.6%	153	3.5%
R5 (c)	Worthy Down (c)	0.36	0.9%	24.1	60%	4.11	2.1%	153	2.7%
R9	Littleton Stud	0.24	0.6%	23.9	60%	4.41	2.2%	153	2.9%
R10	Drovers Way	0.20	0.5%	23.9	60%	3.33	1.7%	153	2.2%
R11	Church Lane, St Catherines (Littleton)	0.22	0.6%	23.9	60%	4.38	2.2%	153	2.9%
R5 (d)	Worthy Down (d)	0.32	0.8%	24.0	60%	3.72	1.9%	153	2.4%
R12	Flowerdown Barracks	0.11	0.3%	23.8	60%	2.62	1.3%	153	1.7%
Notes: n/a = long-term AQS are not applicable at workplaces									

Table 34 Short-term results, 15-minute and 1-hour, SO_2

ID	Receptors	Comparison with 99.9th percentile 15-min threshold: 266 µg/m³				Comparison with 99.73rd percentile 1-hour threshold: 350 µg/m³			
		PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/Headroom (%)	PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/Headroom (%)
R1 (a)	Proposed Instavolt Restaurant (a)	7.04	2.6%	261	2.7%	4.00	1.1%	345	1.2%
R1 (b)	Proposed Instavolt Playground (b)	5.39	2.0%	261	2.1%	3.63	1.0%	345	1.1%
R2	The Pringle Group/ Concrete 247	18.6	7.0%	261	7.1%	7.74	2.2%	345	2.2%
R3	Three Maids Bungalow	7.93	3.0%	261	3.0%	3.80	1.1%	345	1.1%
R4	Lower Farm Cottages	4.88	1.8%	261	1.9%	2.75	0.8%	345	0.8%
R5 (a)	Worthy Down (a)	8.15	3.1%	261	3.1%	2.39	0.7%	345	0.7%
R6	Down Farm	6.68	2.5%	261	2.6%	2.97	0.8%	345	0.9%
R7	Off Down Farm Lane (Static caravans)	6.36	2.4%	261	2.4%	2.80	0.8%	345	0.8%
R5 (b)	Worthy Down (b)	7.42	2.8%	261	2.8%	3.01	0.9%	345	0.9%
R8	Winchester Golf Academy	4.69	1.8%	261	1.8%	2.16	0.6%	345	0.6%
R5 (c)	Worthy Down (c)	4.17	1.6%	261	1.6%	1.88	0.5%	345	0.5%
R9	Littleton Stud	3.68	1.4%	261	1.4%	1.89	0.5%	345	0.5%
R10	Drovers Way	2.67	1.0%	261	1.0%	1.40	0.4%	345	0.4%
R11	Church Lane, St Catherines (Littleton)	5.04	1.9%	261	1.9%	1.73	0.5%	345	0.5%
R5 (d)	Worthy Down (d)	2.99	1.1%	261	1.1%	1.47	0.4%	345	0.4%
R12	Flowerdown Barracks	2.07	0.8%	261	0.8%	1.10	0.3%	345	0.3%

Table 35 Short-term results, 24-hours, SO_2

ID	Receptors	Comparison with maximum 24h average AQS: 125 µg/m³			
		PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/Headroom (%)
R1 (a)	Proposed Instavolt Restaurant (a)	1.71	1.4%	120	1.4%
R1 (b)	Proposed Instavolt Playground (b)	1.73	1.4%	120	1.4%
R2	The Pringle Group/ Concrete 247	2.46	2.0%	120	2.0%
R3	Three Maids Bungalow	1.62	1.3%	120	1.3%
R4	Lower Farm Cottages	1.06	0.8%	120	0.9%
R5 (a)	Worthy Down (a)	0.68	0.5%	120	0.6%
R6	Down Farm	0.86	0.7%	120	0.7%
R7	Off Down Farm Lane (Static caravans)	0.82	0.7%	120	0.7%
R5 (b)	Worthy Down (b)	0.91	0.7%	120	0.8%
R8	Winchester Golf Academy	0.51	0.4%	120	0.4%
R5 (c)	Worthy Down (c)	0.60	0.5%	120	0.5%
R9	Littleton Stud	0.58	0.5%	120	0.5%
R10	Drovers Way	0.63	0.5%	120	0.5%
R11	Church Lane, St Catherines (Littleton)	0.60	0.5%	120	0.5%
R5 (d)	Worthy Down (d)	0.53	0.4%	120	0.4%
R12	Flowerdown Barracks	0.35	0.3%	120	0.3%

Table 36 Short-term results, CO

ID	Receptors	Comparison with maximum 8-hour running AQS: 10,000µg/m³			
		PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/Headroom (%)
R1 (a)	Proposed Instavolt Restaurant (a)	88.7	0.9%	9,759	0.9%
R1 (b)	Proposed Instavolt Playground (b)	82.5	0.8%	9,759	0.8%
R2	The Pringle Group/ Concrete 247	255	2.5%	9,759	2.6%
R3	Three Maids Bungalow	96.1	1.0%	9,759	1.0%
R4	Lower Farm Cottages	66.4	0.7%	9,768	0.7%
R5 (a)	Worthy Down (a)	62.0	0.6%	9,766	0.6%
R6	Down Farm	92.4	0.9%	9,759	0.9%
R7	Off Down Farm Lane (Static caravans)	78.3	0.8%	9,759	0.8%
R5 (b)	Worthy Down (b)	73.7	0.7%	9,766	0.8%
R8	Winchester Golf Academy	64.7	0.6%	9,759	0.7%
R5 (c)	Worthy Down (c)	36.6	0.4%	9,766	0.4%
R9	Littleton Stud	39.4	0.4%	9,768	0.4%
R10	Drovers Way	34.9	0.3%	9,768	0.4%
R11	Church Lane, St Catherines (Littleton)	48.1	0.5%	9,768	0.5%
R5 (d)	Worthy Down (d)	44.4	0.4%	9,766	0.5%
R12	Flowerdown Barracks	25.4	0.3%	9,749	0.3%

Table 37 Short-term results, annual mean and 24h benzene

ID	Receptors	Comparison with annual mean AQS: 5μg/m³				Comparison with 100th percentile 24-hour threshold 30μg/m³			
		PC (μg/m³)	PC/AQS (%)	PC (μg/m³)	PC/AQS (%)	PC (μg/m³)	PC/AQS (%)	Headroom (μg/m³)	PC/Headroom (%)
R1 (a)	Proposed Instavolt Restaurant (a)	n/a	n/a	n/a	n/a	3.73	12.4%	29.6	13%
R1 (b)	Proposed Instavolt Playground (b)	n/a	n/a	n/a	n/a	3.74	12%	29.6	13%
R2	The Pringle Group/ Concrete 247	n/a	n/a	n/a	n/a	8.29	27.6%	29.6	28%
R3	Three Maids Bungalow	0.20	3.9%	0.41	8.2%	3.66	12.2%	29.6	12%
R4	Lower Farm Cottages	0.19	3.7%	0.39	7.7%	2.23	7.4%	29.6	7.5%
R5 (a)	Worthy Down (a)	0.11	2.2%	0.31	6.2%	1.79	6.0%	29.6	6.0%
R6	Down Farm	0.10	2.0%	0.32	6.3%	2.66	8.9%	29.6	9.0%
R7	Off Down Farm Lane (Static caravans)	0.10	1.9%	0.31	6.2%	2.10	7.0%	29.6	7.1%
R5 (b)	Worthy Down (b)	0.14	2.8%	0.34	6.9%	1.96	6.5%	29.6	6.6%
R8	Winchester Golf Academy	n/a	n/a	n/a	n/a	1.94	6.5%	29.6	6.5%
R5 (c)	Worthy Down (c)	0.14	2.7%	0.34	6.8%	1.46	4.9%	29.6	4.9%
R9	Littleton Stud	0.09	1.8%	0.29	5.8%	1.23	4.1%	29.6	4.2%
R10	Drovers Way	0.08	1.5%	0.28	5.5%	1.25	4.2%	29.6	4.2%
R11	Church Lane, St Catherines (Littleton)	0.08	1.7%	0.28	5.7%	2.28	7.6%	29.6	7.7%
R5 (d)	Worthy Down (d)	0.12	2.4%	0.32	6.4%	1.32	4.4%	29.6	4.5%
R12	Flowerdown Barracks	0.04	0.9%	0.28	5.6%	0.76	2.5%	29.5	2.6%
Notes: n/a = long-term AQS are not applicable at workplaces									

Table 38 Short-term results, annual mean and 1h NH_3

ID	Receptors	Comparison with annual mean AQS: 180µg/m³				Comparison with 100th percentile 1-hour threshold 2,500µg/m³			
		PC (µg/m³)	PC/AQS (%)	PC (µg/m³)	PC/AQS (%)	PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/Headroom (%)
R1 (a)	Proposed Instavolt Restaurant (a)	n/a	n/a	n/a	n/a	6.18	0.25%	2,496	0.25%
R1 (b)	Proposed Instavolt Playground (b)	n/a	n/a	n/a	n/a	6.36	0.25%	2,496	0.25%
R2	The Pringle Group/ Concrete 247	n/a	n/a	n/a	n/a	6.12	0.24%	2,496	0.25%
R3	Three Maids Bungalow	0.04	0.02%	1.81	1.0%	3.66	0.15%	2,496	0.15%
R4	Lower Farm Cottages	0.03	0.02%	1.80	1.0%	3.01	0.12%	2,496	0.12%
R5 (a)	Worthy Down (a)	0.02	0.01%	1.79	1.0%	2.01	0.08%	2,496	0.08%
R6	Down Farm	0.01	0.01%	1.78	1.0%	1.22	0.05%	2,496	0.05%
R7	Off Down Farm Lane (Static caravans)	0.01	0.01%	1.78	1.0%	1.23	0.05%	2,496	0.05%
R5 (b)	Worthy Down (b)	0.02	0.01%	1.79	1.0%	1.71	0.07%	2,496	0.07%
R8	Winchester Golf Academy	n/a	n/a	n/a	n/a	1.01	0.04%	2,496	0.04%
R5 (c)	Worthy Down (c)	0.02	0.01%	1.79	1.0%	1.41	0.06%	2,496	0.06%
R9	Littleton Stud	0.01	0.01%	1.78	1.0%	1.39	0.06%	2,496	0.06%
R10	Drovers Way	0.01	0.01%	1.78	1.0%	1.41	0.06%	2,496	0.06%
R11	Church Lane, St Catherines (Littleton)	0.01	0.01%	1.78	1.0%	1.02	0.04%	2,496	0.04%
R5 (d)	Worthy Down (d)	0.02	0.01%	1.79	1.0%	1.06	0.04%	2,496	0.04%
R12	Flowerdown Barracks	0.01	0.00%	1.78	1.0%	0.74	0.03%	2,496	0.03%
Notes: n/a = long-term AQS are not applicable at workplaces									

Appendix K Ecological receptor results

Table 39 Results: Ecological receptors, long-term and short-term AQS for NOx

ID	Receptors	Comparison with annual mean AQS: 30 µg/m³				Comparison with maximum daily AQS: 75 µg/m³	
		PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PC/AQS (%)	PC (µg/m³)	PC/AQS (%)
E1 (a)	Worthy Copse 1 (a)	1.31	4.4%	11.9	40%	27.7	37%
E1 (b)	Worthy Copse 2 (b)	0.42	1.4%	11.0	37%	9.87	13%
E1 (c)	Worthy Copse 3 (c)	0.28	0.9%	10.9	36%	7.20	9.6%
E2 (a)	South Worthy Grove 1 (a)	0.44	1.5%	11.0	37%	8.97	12.0%
E2 (b)	South Worthy Grove 2 (b)	0.31	1.0%	11.9	40%	6.72	9.0%
E3	Worthy Grove (LWS)	0.27	0.9%	11.8	39%	5.70	7.6%
E4	The Gallops, Worthy Down (LWS)	0.23	0.8%	11.8	39%	4.68	6.2%
E5 (a)	Long Wood (a)	0.14	0.5%	9.28	31%	2.73	3.6%
E5 (b)	Long Wood (b)	0.12	0.4%	9.43	31%	2.36	3.1%
E6	Northwood Park Woods (Cradle Copse)	0.10	0.3%	9.24	31%	2.01	2.7%
E7 (a)	Flowerdown, Littleton (a)	0.13	0.4%	10.8	36%	2.42	3.2%
E7 (b)	Flowerdown, Littleton (b)	0.10	0.3%	11.5	38%	2.59	3.4%
E8 (a)	Worthy Camp Grassland (a)	0.36	1.2%	10.7	36%	4.16	5.5%
E8 (b)	Worthy Camp Grassland (b)	0.28	0.9%	10.6	35%	3.33	4.4%
E8 (c)	Worthy Camp Grassland (c)	0.20	0.7%	10.5	35%	2.58	3.4%
E9	Worthy Down Railway Halt	0.17	0.6%	10.3	34%	1.81	2.4%
E10 (a)	River Itchen (a)	0.06	0.21%	19.0	63%	2.82	3.8%
E10 (b)	River Itchen (b)	0.03	0.08%	13.9	46%	0.96	1.3%
E10 (c)	River Itchen (c)	0.03	0.11%	9.93	33%	0.79	1.0%
Notes: No further analysis required for LWS/ AW/ SINCs if PC/AQS < 100%							

Table 40 Results: Ecological receptors, long-term AQS for SO_2

ID	Receptors	Comparison with annual mean AQS: 20μg/m³				Comparison with annual mean AQS: 10μg/m³			
		PC (μg/m³)	PC/AQS (%)	PEC (μg/m³)	PEC/AQS (%)	PC (μg/m³)	PC/AQS (%)	PEC (μg/m³)	PEC/AQS (%)
E1 (a)	Worthy Copse 1 (a)	0.176	0.88%	0.91	4.5%	0.176	1.76%	0.91	9.1%
E1 (b)	Worthy Copse 2 (b)	0.055	0.28%	0.79	3.9%	0.055	0.55%	0.79	7.9%
E1 (c)	Worthy Copse 3 (c)	0.036	0.18%	0.77	3.8%	0.036	0.36%	0.77	7.7%
E2 (a)	South Worthy Grove 1 (a)	0.059	0.30%	0.79	3.9%	0.059	0.59%	0.79	7.9%
E2 (b)	South Worthy Grove 2 (b)	0.042	0.21%	0.74	3.7%	0.042	0.42%	0.74	7.4%
E3	Worthy Grove (LWS)	0.036	0.18%	0.74	3.7%	0.036	0.36%	0.74	7.4%
E4	The Gallops, Worthy Down (LWS)	0.031	0.15%	0.73	3.7%	0.031	0.31%	0.73	7.3%
E5 (a)	Long Wood (a)	0.019	0.09%	0.72	3.6%	0.019	0.19%	0.72	7.2%
E5 (b)	Long Wood (b)	0.016	0.08%	0.75	3.7%	0.016	0.16%	0.75	7.5%
E6	Northwood Park Woods (Cradle Copse)	0.013	0.07%	0.71	3.6%	0.013	0.13%	0.71	7.1%
E7 (a)	Flowerdown, Littleton (a)	0.017	0.09%	0.95	4.7%	0.017	0.17%	0.95	9.5%
E7 (b)	Flowerdown, Littleton (b)	0.014	0.07%	1.35	6.8%	0.014	0.14%	1.35	14%
E8 (a)	Worthy Camp Grassland (a)	0.049	0.24%	0.83	4.1%	0.049	0.49%	0.83	8.3%
E8 (b)	Worthy Camp Grassland (b)	0.038	0.19%	0.82	4.1%	0.038	0.38%	0.82	8.2%
E8 (c)	Worthy Camp Grassland (c)	0.027	0.14%	0.81	4.0%	0.027	0.27%	0.81	8.1%
E9	Worthy Down Railway Halt	0.023	0.11%	0.87	4.4%	0.023	0.23%	0.87	8.7%
E10 (a)	River Itchen (a)	0.008	0.04%	1.01	5.0%	0.008	0.08%	1.01	10%
E10 (b)	River Itchen (b)	0.003	0.02%	1.30	6.5%	0.003	0.03%	1.30	13%
E10 (c)	River Itchen (c)	0.004	0.02%	0.70	3.5%	0.004	0.04%	0.70	7.0%
Notes: No further analysis required for LWS/ AW/ SINCs if PC/AQS < 100%									

Table 41 Results: Ecological receptors, long-term AQS for NH_3

ID	Receptors	Comparison with annual mean AQS: 1 µg/m³ *			
		PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PEC/AQS (%)
E1 (a)	Worthy Copse 1 (a)	0.082	8.24%	1.76	176%
E1 (b)	Worthy Copse 2 (b)	0.021	2.05%	1.70	170%
E1 (c)	Worthy Copse 3 (c)	0.013	1.27%	1.69	169%
E2 (a)	South Worthy Grove 1 (a)	0.021	2.14%	1.70	170%
E2 (b)	South Worthy Grove 2 (b)	0.014	1.45%	1.68	168%
E3	Worthy Grove (LWS)	0.012	1.22%	1.68	168%
E4	The Gallops, Worthy Down (LWS)	0.010	1.00%	1.68	168%
E5 (a)	Long Wood (a)	0.006	0.55%	1.63	163%
E5 (b)	Long Wood (b)	0.005	0.47%	1.58	158%
E6	Northwood Park Woods (Cradle Copse)	0.004	0.40%	1.62	162%
E7 (a)	Flowerdown, Littleton (a)	0.006	0.60%	1.67	167%
E7 (b)	Flowerdown, Littleton (b)	0.005	0.46%	1.63	163%
E8 (a)	Worthy Camp Grassland (a)	0.014	1.38%	1.78	178%
E8 (b)	Worthy Camp Grassland (b)	0.010	1.02%	1.78	178%
E8 (c)	Worthy Camp Grassland (c)	0.007	0.72%	1.78	178%
E9	Worthy Down Railway Halt	0.006	0.61%	1.76	176%
E10 (a)	River Itchen (a)	0.002	0.19%	1.70	170%
E10 (b)	River Itchen (b)	0.001	0.11%	1.70	170%
E10 (c)	River Itchen (c)	0.001	0.10%	1.50	150%

Notes: No further analysis required for LWS/ AW/ SINCs if PC/AQS < 100%

* Lower NH3 CLe adopted as a conservative approach although lichens and bryophytes were not cited as integral to the habitats (www.apis.co.uk)

Table 42 Results: Ecological receptors, nutrient nitrogen deposition, nationally designated sites

Receptors	Comparison with nutrient nitrogen critical loads								
	Deposition velocity type	PC (kgN/ha/yr)	CLmin (kgN/ha/yr)	CLmax (kgN/ha/yr)	PC/CLmin (%)	PC/CLmax (%)	Background (kgN/ha/yr)	PEDR/CLmin (%)	PEDR/CLmax (%)
E1 (a)	forest	0.907	10	15	9.07%	6.05%	28.43	293%	196%
E1 (b)	forest	0.244	10	15	2.44%	1.63%	28.43	287%	191%
E1 (c)	forest	0.155	10	15	1.55%	1.03%	28.43	286%	191%
E2 (a)	forest	0.255	10	15	2.55%	1.70%	28.43	287%	191%
E2 (b)	forest	0.175	10	15	1.75%	1.16%	28.34	285%	190%
E3	forest	0.149	10	15	1.49%	0.99%	28.34	285%	190%
E4	grass	0.075	5	10	1.49%	0.75%	16.93	340%	170%
E5 (a)	forest	0.071	10	15	0.71%	0.47%	28.20	283%	188%
E5 (b)	forest	0.061	10	15	0.61%	0.41%	28.23	283%	189%
E6	forest	0.051	3	15	1.70%	0.34%	28.20	942%	188%
E7 (a)	grass	0.044	10	20	0.44%	0.22%	17.42	175%	87.3%
E7 (b)	grass	0.034	10	20	0.34%	0.17%	17.16	172%	86.0%
E8 (a)	grass	0.108	n/a	n/a	n/a	n/a	17.33	n/a	n/a
E8 (b)	grass	0.081	n/a	n/a	n/a	n/a	17.33	n/a	n/a
E8 (c)	forest	0.096	10	15	0.96%	0.64%	28.95	290%	194%
E9	forest	0.082	10	15	0.82%	0.55%	28.75	288%	192%
E10 (a)	grass	0.016	5	15	0.32%	0.11%	16.90	338%	113%
E10 (b)	grass	0.008	5	15	0.16%	0.05%	16.50	330%	110%
E10 (c)	grass	0.008	5	15	0.17%	0.06%	15.80	316%	105%
Notes: No further analysis required for LWS/ AW/ SINCs if PC/AQS < 100%									

Table 43 Results: Ecological receptors, acid deposition

Receptors	PC (keqS/ha/yr)	PC (keqN/ha/yr)	Background (keqS/ha/yr)	Background (keqN/ha/yr)	Minimum critical loads		
					PC (%)	Background (%)	PEC (%)
E1 (a)	0.0415	0.0646	0.17	2.03	0.58%	18%	19%
E1 (b)	0.0130	0.0174	0.17	2.03	0.16%	18%	18%
E1 (c)	0.0086	0.0110	0.17	2.03	0.10%	18%	18%
E2 (a)	0.0140	0.0182	0.17	2.03	0.16%	18%	18%
E2 (b)	0.0099	0.0124	0.16	2.02	0.11%	18%	18%
E3	0.0086	0.0106	0.16	2.02	0.09%	18%	18%
E4	0.0036	0.0053	0.13	1.21	0.11%	25%	25%
E5 (a)	0.0044	0.0051	0.17	2.01	0.05%	18%	18%
E5 (b)	0.0038	0.0043	0.17	2.02	0.15%	70%	70%
E6	0.0031	0.0036	0.17	2.01	0.03%	18%	18%
E7 (a)	0.0020	0.0031	0.15	1.24	0.06%	26%	26%
E7 (b)	0.0017	0.0024	0.15	1.23	0.05%	25%	25%
E8 (a)	0.0057	0.0077	0.14	1.24	n/a	n/a	n/a
E8 (b)	0.0045	0.0058	0.14	1.24	n/a	n/a	n/a
E8 (c)	0.0064	0.0068	0.18	2.07	0.06%	19%	19%
E9	0.0054	0.0058	0.17	2.05	0.05%	18%	18%
E10 (a) [1]	0.0010	0.0011	0.14	1.21	0%	146%	146%
E10 (b) [1]	0.0004	0.0006	0.14	1.18	0%	143%	143%
E10 (c) [1]	0.0005	0.0006	0.12	1.13	0%	136%	136%
Note: [1] %PC of minimum critical load determined using the Critical Load Function tool, available at www.apis.co.uk.							