Odour Impact Assessment – Integrated Pig Farm at Annakisha, Co. Cork

Prepared for:

Mr Michael Monagle

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Final

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Glossary

Term	Definition
g/s	gram per second
kg	kilogram
kg/m³	Kilogram per cubic meter
km	kilometre
km/hr	kilometre per hour
m	metre
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/s	cubic metres per second
m³/hr	cubic metres per hour
mg	milligram
Z_0	roughness length
ou_E/m^3	European odour unit per cubic meter
ou_E/s	European odour unit per second
$\mu g/m^3$	micrograms per cubic meter

Abbreviations	Definition
AG4	Air Guidance 4
BAT	Best available techniques
EPA	Environmental Protection Agency
EF	Emission factor
EU	European Union

EXECUTIVE SUMMARY

Mr Michael Monagle commissioned Katestone to complete an odour impact assessment for a pig farm located at Annakisha North, Doneraile Co. Cork.

The pig farm has an Industrial Emissions Directive (IED) licence (Licence registration number P0446-01) issued by the Environment Protection Agency (EPA) in 1999.

According to its license, total stocking capacity for the Site is 7,462 pigs (131 suckling sows, 649 dry sows, 20 boars, 94 maiden gilts, 2,668 weaners and 3,900 finishers).

The most recent planning application to Cork County Council for the Site was in 2014 (application number 14/5815). Cork County Council issued conditional approval in June 2015 to construct a pig fattening house, associated feed mixing room and a pig walkway. The planning application 14/5815 was for a stocking capacity of 10,174 pigs (164 suckling sows, 690 dry sows, 120 maiden gilts, 4,400 weaners and 4,800 finishers).

The OIA is required to determine the potential impact of odorous emissions from the pig farm on nearby residential locations. The assessment will be submitted as part of a license review application for the pig farm.

The odour assessment was conducted in accordance with recognised techniques for dispersion modelling specified in EPA's Air Dispersion Modelling Guidance Note (AG4). The dispersion model, CALPUFF, was used to predict ground-level concentrations of odour across the model domain due to the pig farm. The assessment of odour has also been conducted in accordance with EPA's instruction note for the assessment of odour emissions from intensive agriculture pig installations (EPA, 2022).

The odour modelling assessment found that the predicted concentrations of odour at all sensitive receptors **comply** with odour criterion recommended by EPA for existing pig farms (that were licensed before 2001 with no licence review since that time) of $6.0ou_E/m^3$ at all modelled sensitive receptor locations.

Final Report Findings

The odour modelling assessment found that the predicted concentrations of odour at all sensitive receptors **comply** with odour criterion recommended by EPA for existing pig farms (that were licensed before 2001 with no licence review since that time) of $6.0ou_E/m^3$ at all modelled sensitive receptor locations. Consequently, the pig farm will not cause adverse odour impacts if it is appropriately managed and operated.

1. INTRODUCTION

Katestone Environmental Pty Ltd (Katestone) was commissioned by Mr Michael Monagle of Monagle Pig Farms Limited (Monagle Pig Farms) to complete an odour impact assessment of a pig farm located at Annakisha North, Co. Cork (site).

The pig farm has an Industrial Emissions Directive (IED) licence (Licence registration number P0446-01) issued by the Environment Protection Agency (EPA) in 1999.

Monagle Pig Farms submitted a planning application to Cork County Council for the pig farm in 2014 (application number 14/5815) to facilitate the construction of a pig fattening house, associated feed mixing room and a pig walkway. Council issued conditional approval in June 2015.

Monagle Pig Farms intends to submit an EPA licence review application to facilitate the increased pig numbers associated with the conditional approval for application number 14/5815.

This odour impact assessment will form part of the supporting documentation for the licence review application.

This odour impact assessment was undertaken using dispersion modelling techniques. The dispersion modelling has been completed in accordance with the requirements of EPA's Air Dispersion Modelling Guidance Note (AG4). The assessment of odour has also been conducted in accordance with EPA's instruction note for the assessment of odour emissions from intensive agriculture pig installations (EPA, 2022).

2. OVERVIEW OF THE PIG FARM

The pig farm is located approximately 3.6 km south of the village of Doneraile, Co. Cork and approximately 6.7 km northeast of the town of Mallow, Co. Cork. The licence boundary of the Site and its environs are presented in Figure 1. All proposed pig housing units will be located within the proposed licence boundary of the Site.

A site plan illustrating the layout of the proposed housing units is presented in Figure 2.

According to its license, total stocking capacity for the Site is 7,462 pigs (131 suckling sows, 649 dry sows, 20 boars, 94 maiden gilts, 2,668 weaners and 3,900 finishers).

The most recent planning application that was submitted to Council for the Site was in 2014 (application number 14/5815). Council issued conditional approval in June 2015 to construct a pig fattening house, associated feed mixing room and a pig walkway. Monagle Pig Farms intends to submit an EPA licence review application to facilitate the increased pig numbers that are allowed under the conditional approval.

The planning application 14/5815 specifies the following maximum stocking capacities:

- 164 farrowing sows
- 690 dry sows
- 120 Maiden gilts
- 4,400 weaners
- 4,800 fattener pigs (growers and finishers).

All of the housing units at the Site including those identified in the planning application 14/5815 are mechanically ventilated.

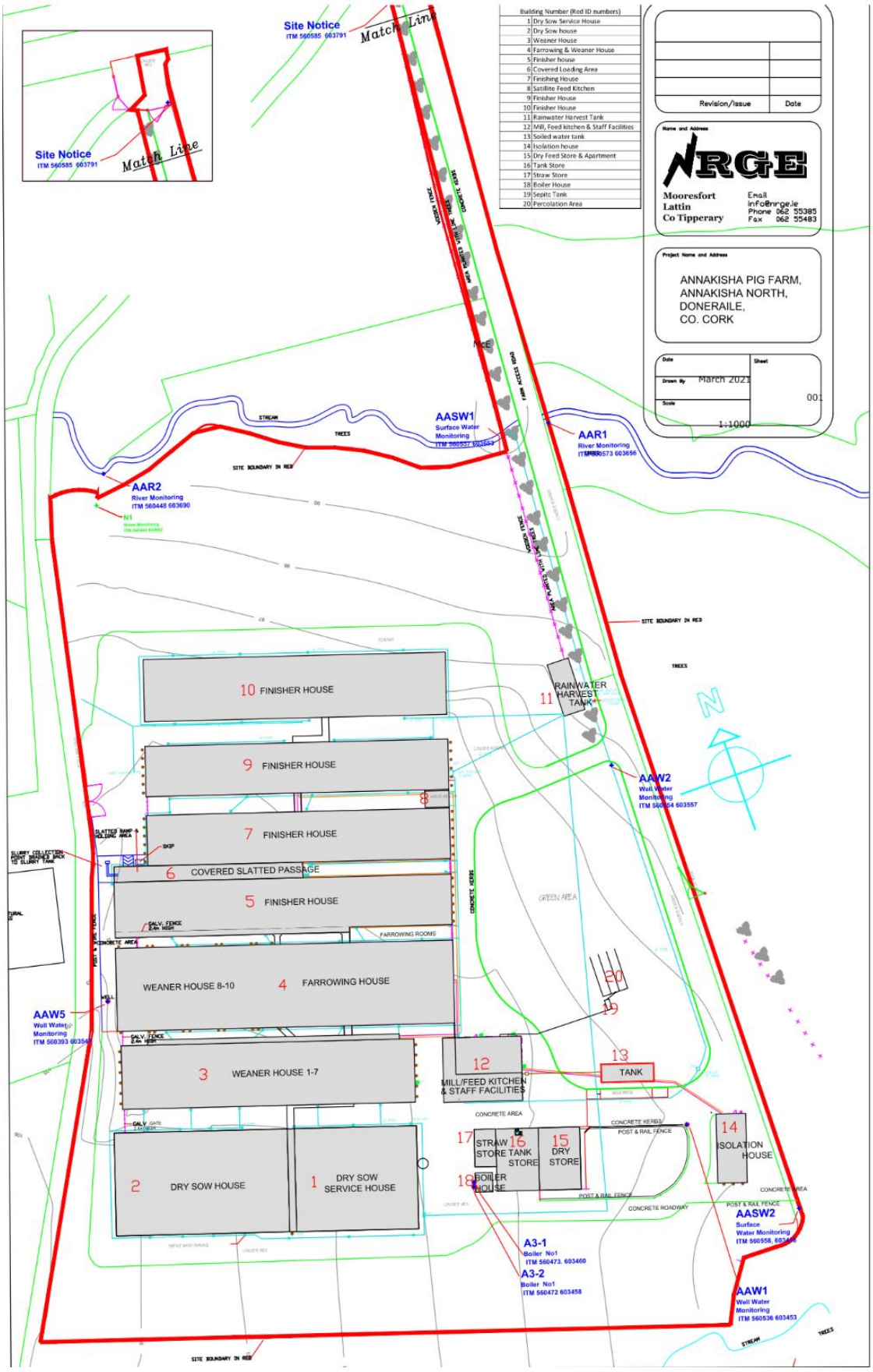

Figure 1 **Monagle pig farm proposed Site boundary (red line) and site layout**

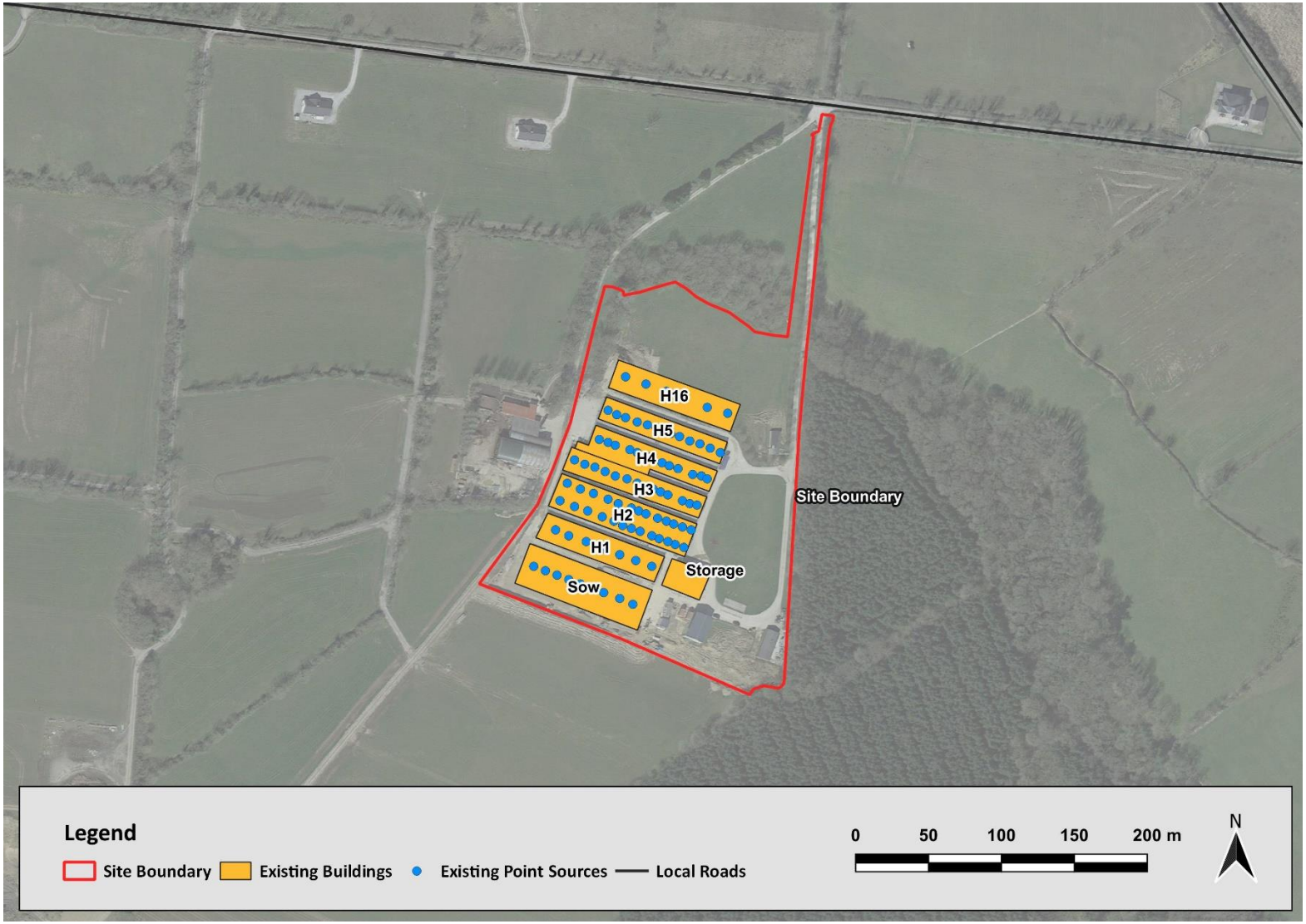

Figure 2 **Monagle pig farm Site plan – existing and proposed housing units and existing volume sources and proposed chimney stacks**

3. REGULATORY FRAMEWORK AND ASSESSMENT CRITERIA

3.1 *Environmental Protection Agency Acts 1992 and 2003*

The *Environmental Protection Agency Act 1992 (EPA Act)* and Part 2 of the *Protection of the Environment Act 2003* are collectively referred to as the *Environmental Protection Agency Acts 1992 and 2003*. These Acts provide for the management of air emissions from activities (meaning any process, development or operation) that are listed in the First Schedule of the Acts.

Section 4 (2) of the *Environmental Protection Agency Acts 1992 and 2003* defines Air Pollution as follows:

> *"…the direct or indirect introduction to an environmental medium, as a result of human activity, of substances, heat or noise which may be harmful to human health or the quality of the environment, result in damage to material property, or impair or interfere with amenities and other legitimate uses of the environment, and includes -*
>
> *(a) 'air pollution' for the purposes of the Air Pollution Act 1987,*
>
> *(b) ……..*
>
> *(c) ……..."*

The *Air Pollution Act 1987* (AP Act) provides for the control of air pollution and other matters connected with air pollution. Under the AP Act 'pollutant' means any substance that is specified in the First Schedule or any other substance (including a substance which gives rise to odour) or energy which, when emitted into the atmosphere either by itself or in combination with any other substance, may cause air pollution.

Section 4 of the AP Act defines air pollution as follows:

> *"Air pollution" in this Act means a condition of the atmosphere in which a pollutant is present in such a quantity as to be liable to —*
>
> *(i) be injurious to public health, or*
>
> *(ii) have a deleterious effect on flora or fauna or damage property, or*
>
> *(iii) impair or interfere with amenities or with the environment."*

Section 24 of the AP Act details the obligations of the occupier of a premises in respect to preventing emissions, nuisance and what constitutes defences against prosecution:

> *(1) The occupier of any premises, other than a private dwelling, shall use the best practicable means to limit and, if possible, to prevent an emission from such premises.*
>
> *(2) The occupier of any premises shall not cause or permit an emission from such premises in such a quantity, or in such a manner, as to be a nuisance.*
>
> *(3) In any prosecution for a contravention of this section, it shall be a good defence to establish that—*
>
> *(a) the best practicable means have been used to prevent or limit the emission concerned, or*
>
> *(b) the emission concerned was in accordance with a licence under this Act, or*
>
> *(c) the emission concerned was in accordance with an emission limit value, or*

(d) the emission concerned was in accordance with a special control area order in operation in relation to the area concerned, or

(e) in the case of an emission of smoke, the emission concerned was in accordance with regulations under section 25, or

(f) the emission did not cause air pollution.

Section 75 (1) of the *Environmental Protection Agency Acts 1992 and 2003* requires the EPA to publish reasonable and desirable quality objectives to protect the environment, namely:

"The Agency shall, in relation to any environmental medium and without prejudice to its functions under section 103, specify and publish quality objectives which the Agency considers reasonable and desirable for the purposes of environmental protection."

3.2 Odour

In 2001, the EPA issued an assessment framework that "*aims to define a set of criteria for odour exposure to achieve a common environmental quality objective in licencing procedures"* (EPA, 2001). This framework is specific to intensive pig units; however, in the absence of other environmental quality objectives specified by EPA, the criterion for odour exposure to intensive pig units has been adopted for this assessment. The Environmental Quality criteria are:

- *Target value:* $C_{98,\ 1\text{-}hour} \leq 1.5\ ou_E/m^3$
    - *The target value provides a general level of protection against odour annoyance for the general public, aiming to limit the percentage of people experiencing some form of odour-induced annoyance to 10% or less. The target value is to be used as an environmental quality target for all situations.*
    - *The target value is achieved when the calculated odour exposure for all locations of odour sensitive receptors is less than an hourly average odour concentration of 1.5* ou_E/m^3 *in 98% of all hours in an average meteorological year.*
- *Limit value for new pig production units:* $C_{98,\ 1\text{-}hour} \leq 3.0\ ou_E/m^3$
    - *The limit value for new pig production units provides a minimum level of protection against odour annoyance, aiming to limit the percentage of those experiencing some form of odour-induced annoyance to 10% or less in the general public, assuming some degree of acceptance of the rural nature of their living environment.*
    - *The limit value for new pig production units shall not be exceeded in the vicinity of new pig production units to ensure a minimum environmental quality. The limit value for new pig production units is complied with when for all locations of odour sensitive receptors the calculated odour exposure is less than an hourly average odour concentration of 3.0* ou_E/m^3 *in 98% of all hours in an average meteorological year.*
- *Limit value for existing pig production units:* $C_{98,\ 1\text{-}hour} \leq 6.0\ ou_E/m^3$
    - *The limit value for existing pig production units provides a minimum level of protection against odour annoyance, aiming to limit the percentage of people experiencing some form of odour-induced annoyance to 10% or less*
    - *The limit value for existing pig production units shall not be exceeded in the vicinity of existing pig production units to ensure the minimum environmental quality in an agricultural setting. A phased plan must be made to reduce the odour impact, with time, to the limit value for new pig production units and, eventually, the target value. The limit value for existing production units is complied with when for all locations of odour sensitive receptors the calculated odour exposure*

is less than an hourly average odour concentration of 6.0 ou_E/m^3 in 98% of all hours in an average meteorological year.

In 2020, EPA released an updated version of its dispersion modelling guidance titled Air Dispersion Modelling from Industrial Installations Guidance Note (AG4) (EPA, 2020a). AG4 includes an appendix that describes *Relevant Odour Standards*. It states:

Currently there is no general statutory odour standard in Ireland relating to industrial installations. The EPA(53) has issued guidance specific to intensive agriculture which has outlined the following standards:

- *Target value for new pig-production units of 1.5 OUE/m3 as a 98th%ile of one hour averaging periods,*
- *Limit value for new pig-production units of 3.0 OUE/m3 as a 98th%ile of one hour averaging periods,*
- *Limit value for existing pig-production units of 6.0 OUE/m3 as a 98th%ile of one hour averaging periods.*

Guidance from the UK (EA, 2011, and adapted for Irish EPA use) recommends that odour standards should vary from 1.5 – 6.0 OUE/m3 as a 98th%ile of one hour averaging periods at the worst-case sensitive receptor based on the offensiveness of the odour and with adjustments for local factors such as population density(54). A summary of the indicative criterion is given below in Table A4:

In 2022, EPA issued a document titled "Instruction note for the assessment of odour emissions from Intensive Agriculture pig installations" (EPA, 2022) which is referred to here as the EPA 2022 Pig Instruction Note. Its stated objective is to:

"provide applicants with a methodology on how to screen for and assess odour impacts from the licensable intensive agriculture pig sector, as well as assisting in how applicants can demonstrate compliance with BAT 13 (to reduce odour emissions and / or odour impact) of the Commission Implementing Decision (CID) 2017/302. This instruction note replaces the EPA's 2001 'Odour Impacts and Odour Emission Control Measures for Intensive Agriculture' guidance document and screening methodology.".

The EPA 2022 Pig Instruction Note sets out acceptable odour levels, below which licenced Sites can operate without generating unacceptable odour pollution at sensitive receptors. According to the EPA 2022 Pig Instruction Note, the acceptable odour levels specific to intensive agriculture are defined as follows:

- 3.0 ou_E/m^3 for new pig-production units
- 5.0 ou_E/m^3 for existing pig-production units (includes Sites licensed by the EPA between 2001 and 15th February 2017 only)
- 6.0 ou_E/m^3 for existing pig-production units (includes sites licensed by the EPA prior to 2001 and not reviewed since this date only).

The acceptable odour levels are based on the 98th percentile of hourly mean concentrations of odour modelled over a year at the odour-sensitive locations.

The EPA 2022 Pig Instruction Note states that applicability of the above levels will be at odour-sensitive locations only. Note, for the purposes of this instruction note, the applicant's dwelling and farmyard are not considered to be odour sensitive locations. Where there are no third-party odour-sensitive receptors present, a higher odour level may be considered acceptable e.g., at the applicant's dwelling, farmyard, or countryside.

The odour level that is applicable to the pig farm is 6.0 ou_E/m^3 reported at the 98th percentile of hourly mean concentrations of odour modelled over a year at the odour-sensitive locations.

4. EXISTING ENVIRONMENT

This section presents information on the existing environment in the vicinity of the Site, within the dispersion modelling domain and within the meteorological modelling domain. The meteorological modelling domain has been generated using geophysical data (terrain and land use) and meteorological data.

The extents of the dispersion modelling domain were determined based on the locations of the nearest sensitive receptors in all directions from the Site.

4.1 Local terrain and land-use

The pig farm is located in a wide valley that runs from west to east that is bound by the Nagles Mountains that rise to over 420 m south of the site and the Ballyhoura Mountains that rise to over 520 m north of the site.

The River Blackwater Runs from southwest to northeast, 3.8 km south of the site. The River Awbeg, a tributary of the River Blackwater, runs from west to east approximately 3.0 km north of the Site. The River Awbeg flows south approximately 7.7 km northwest of the Site and it merges with the River Blackwater at a point approximately 9.3 km southeast of the Site.

The complexities of the Site in terms of local terrain and proximity to river systems are likely to have an important effect on dispersion conditions near the Site and across the modelling domain.

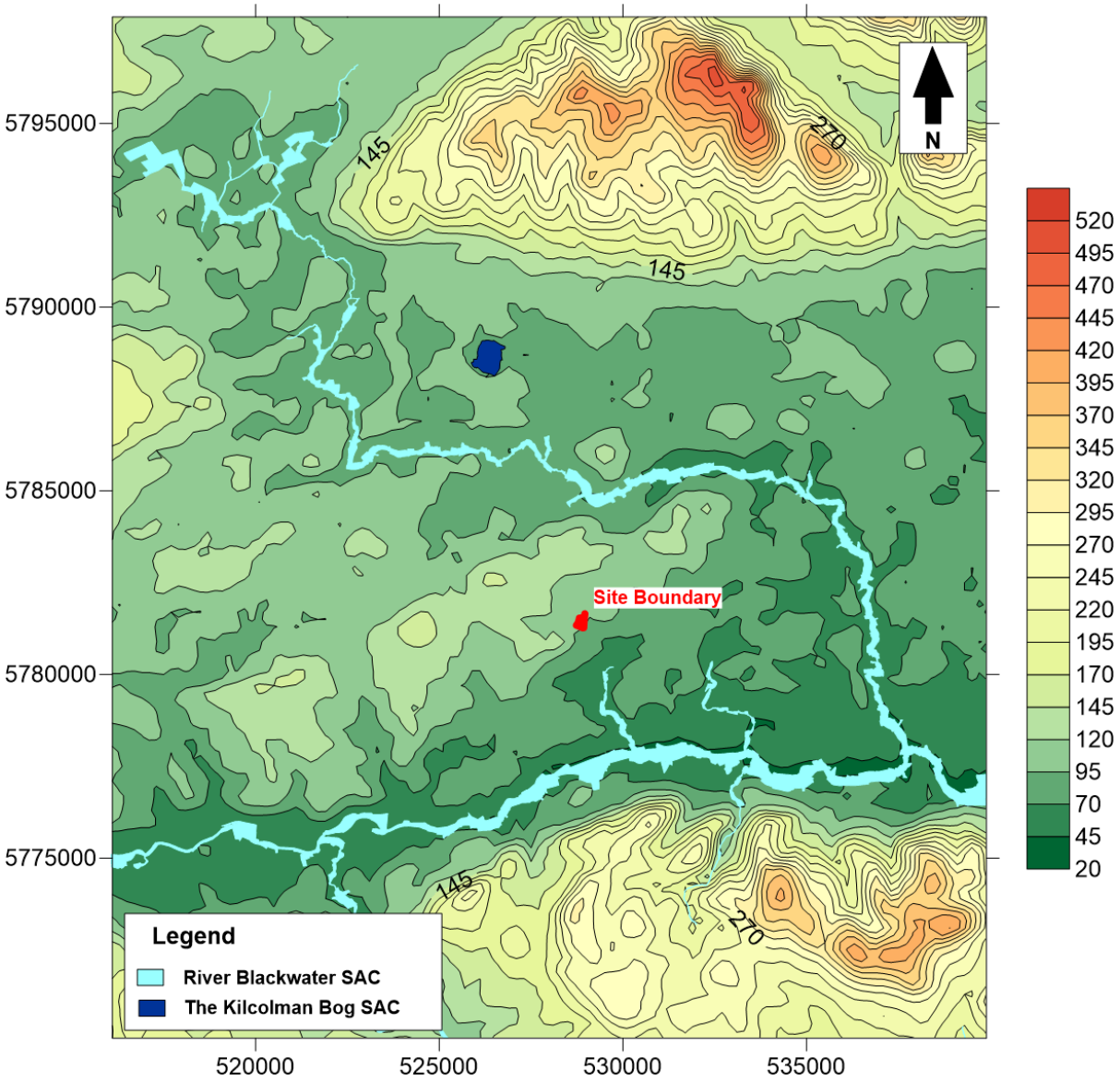

Figure 3 Two-dimensional characterisation of terrain in the modelled domain

4.2 Meteorology

Wind speed and wind direction are important parameters for the transport and dispersion of air pollutants from a source. The winds in the vicinity of the Site have been characterised using a three-dimensional meteorological model called CALMET. The 1-hour average wind speed for the modelling period is 4.97 m/s. This compares to a 1-hour average wind speed of 4.3 m/s at Gurteen between 2008 and 2018 (EPA, 2020). A wind rose representing the annual distribution of 1-hour average winds is presented in Figure 4.

The prevailing wind direction in Ireland is between south and west. It is clear from Figure 4 that these winds influence wind patterns at the Site; however, due to the elevated terrain the modelling indicates that the south-westerly winds are channelled in a predominant southerly direction at the Site. Daytime winds between 6 am and 6 pm are heavily influenced by the prevailing winds and channelling due to local terrain. During late evening and early morning, prevailing winds also dominate; however, there is also a substantial proportion of winds from the northwest as indicated in the diurnal wind roses (Figure 5).

The seasonal distribution of wind speed and wind direction is presented in Figure 6. The strongest winds at the Site occur most frequently from the south during the winter months. The greatest proportion of light winds occur

during summer. There is a distinct north-westerly component to the wind rose in all seasons. A significant proportion of light north westerly winds occur during spring months.

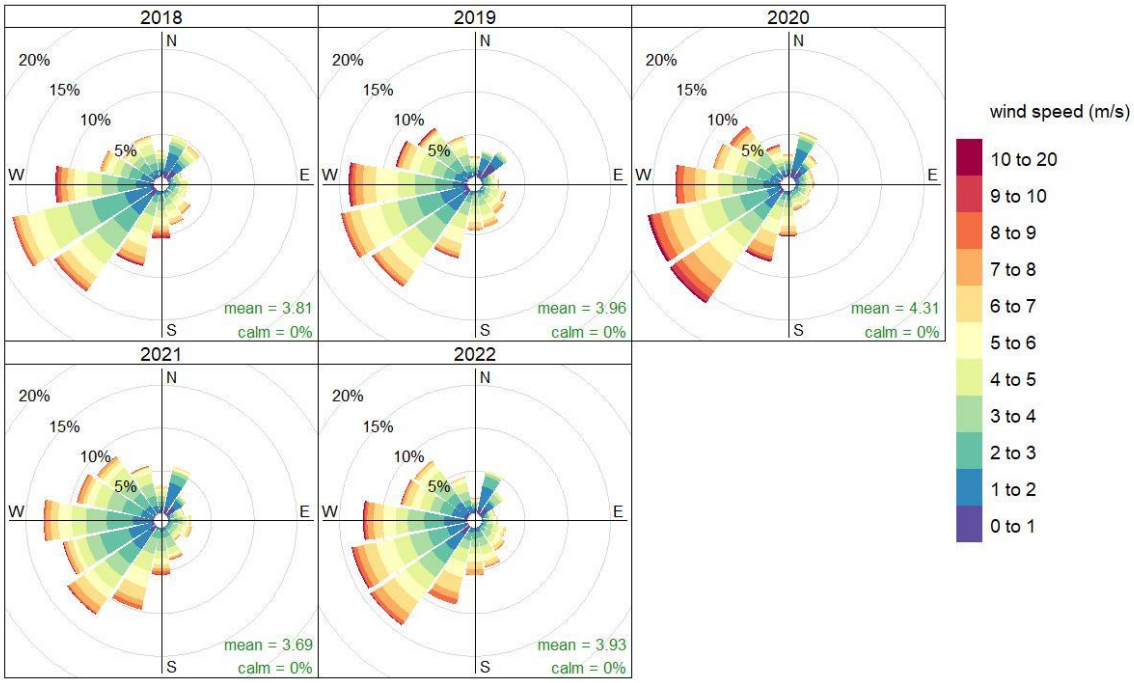

Figure 4 **Annual wind distribution predicted at the Site using CALMET for 2018 (top-left), 2019 (top-middle), 2020 (top-right), 2021 (bottom-left) and 2022 (bottom-right)**

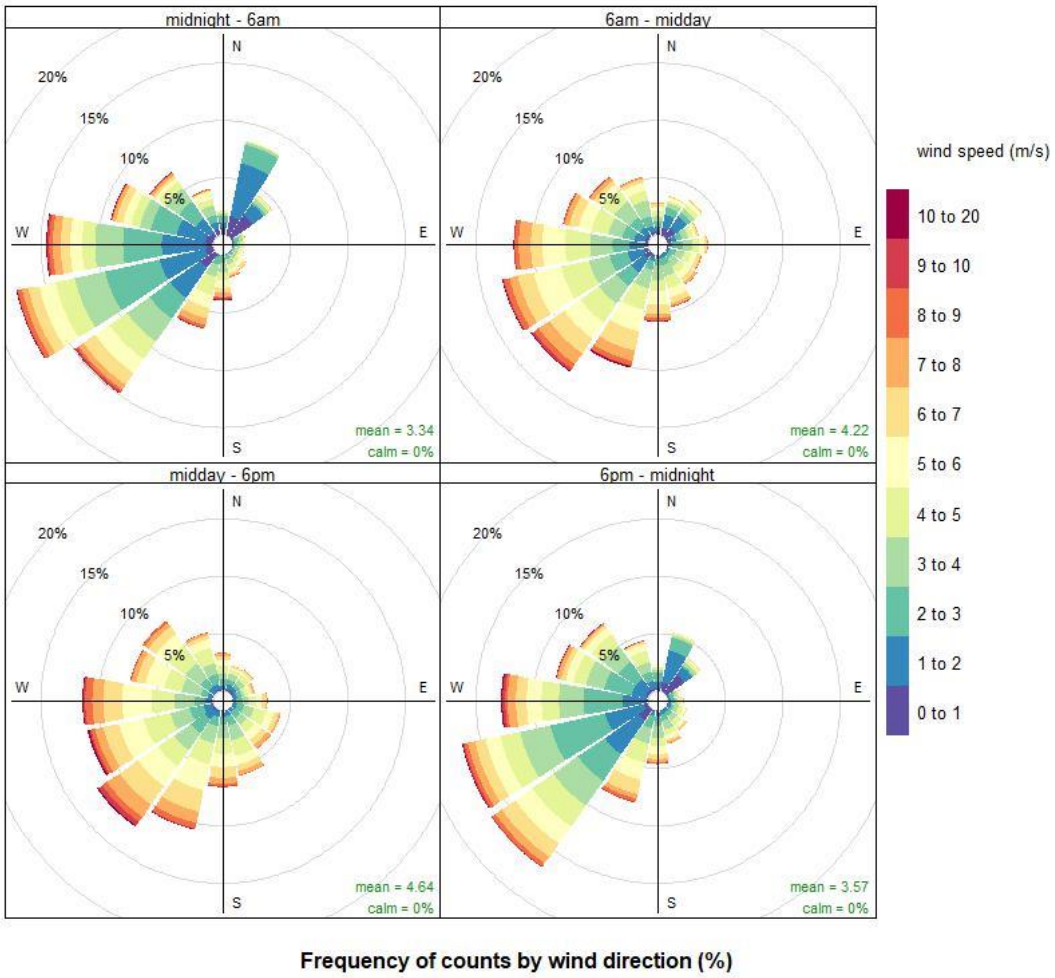

Figure 5 Diurnal wind distribution predicted at the Site using CALMET

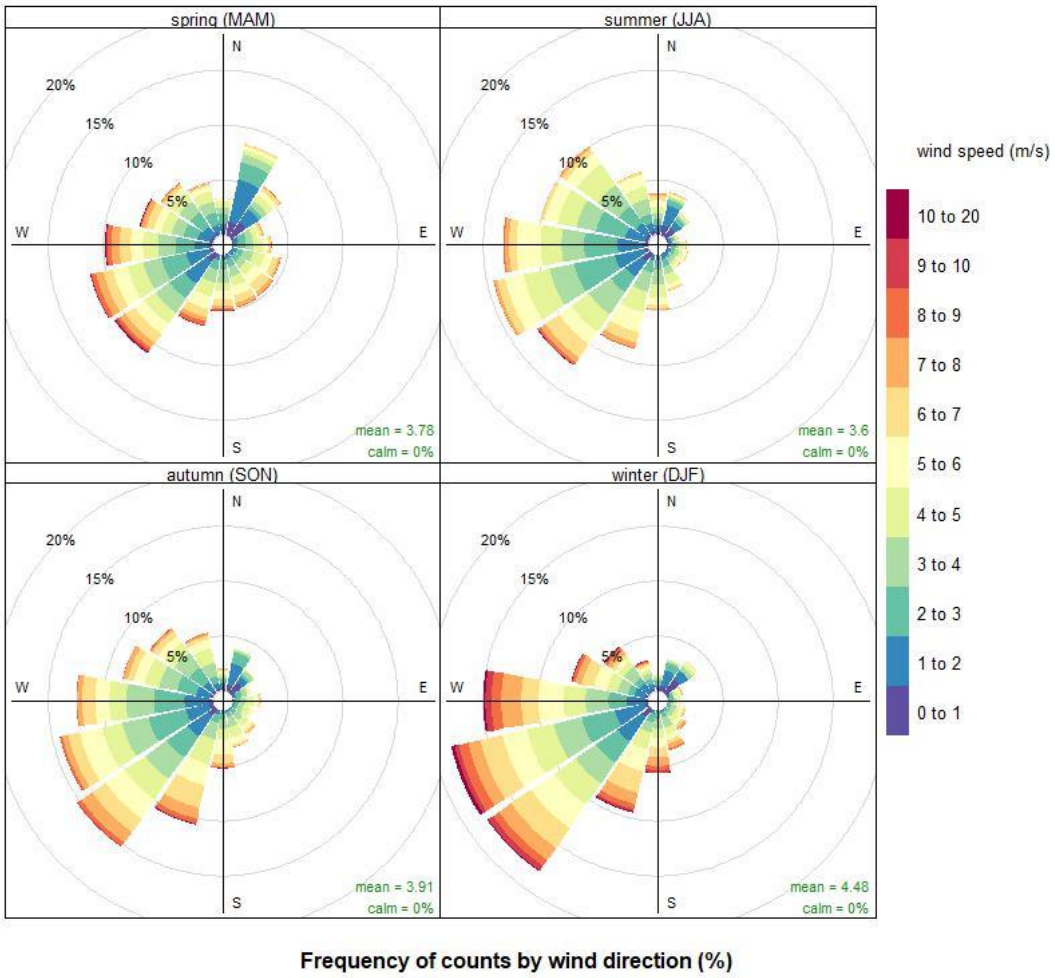

Figure 6 Seasonal wind distribution predicted at the Site using CALMET

4.3 Sensitive receptors

The sensitive receptors that are nearest to the Site are presented in Figure 7. Of these, the closest sensitive receptor is 90 m northwest of the Site boundary and 180 m northwest of the closest pig housing unit. This receptor and other sensitive receptors that are located further away to the north, northeast, east, and southeast were included as discrete receptors in the modelling assessment.

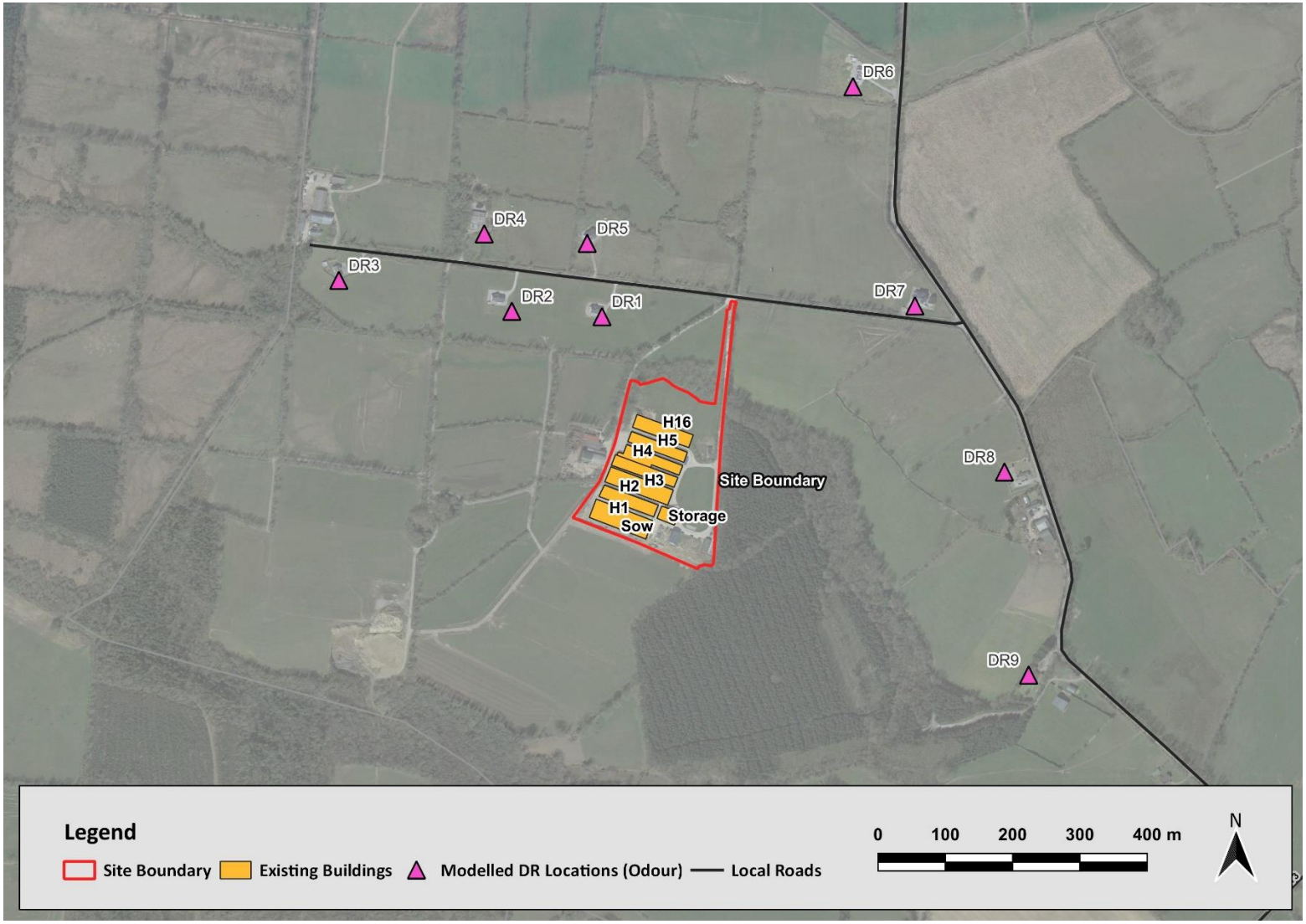

Figure 7 **Nearest sensitive odour receptors to the pig farm**

5. ODOUR IMAPCT ASSESSMENT

5.1 Methodology

The following section describes the modelling methodology that was adopted to assess the potential impacts of odour from the pig farm. The methodology is based on a dispersion modelling study incorporating source characteristics and operational activity data with meteorological data that is representative of the Site and surrounding region. The assessment has been prepared in accordance with industry standards, regulatory requirements and best practice approaches.

The assessment methodology has included:

- Selection of odour assessment criteria from Irish guidance.
- Derivation of an emissions inventory for the pig farm based on:
    - The layout and design of the housing units and sources
    - Emission factors from the EPA 2022 Pig Instruction Note.
- Generation of a representative meteorological dataset using prognostic meteorological modelling techniques.
- Characterisation of meteorological conditions in the region using prognostic meteorological data
- Dispersion modelling using the regulatory dispersion model, CALPUFF, to predict ground-level concentrations of odour across a Cartesian grid that covers the study area.
- Comparison of the predicted ground-level concentrations of odour against the odour assessment criteria.

5.2 Meteorological modelling

5.2.1 Overview

EPA's Air Dispersion Modelling Guidance Note (AG4) states that the dispersion process is dependent on the underlying meteorological conditions and ensuring that the air dispersion model includes representative meteorological data is critical. In the absence of Site-specific meteorological data, AG4 requires the use of representative data observed at a Met Eireann monitoring location. AG4 states:

> *The USEPA (24) has defined meteorological representativeness as:*
>
> > *"the extent to which a set of {meteorological} measurements taken in a space-time domain reflects the actual conditions in the same or different space-time domain taken on a scale appropriate for a specific application"*
>
> *and has expanded on this definition by outlining the factors to consider in the selection of appropriate meteorological data:*
>
> - *Proximity of the meteorological station to the modelling domain;*
> - *The complexity of the terrain;*
> - *The exposure of the meteorological monitoring Site;*
> - *The period of time during which data is collected."*

The modelling domain includes areas of complex terrain. The meteorological parameters that affect dispersion are likely to vary spatially and temporally across the modelling domain due to the complexity of the terrain.

The closest Met Eireann monitoring location to the Site is at Moore Park, Co. Cork, which is 22 km east of the pig farm. This monitoring station is in a narrow valley. It sits at a low point in the local terrain and is close to the Blackwater River. Meteorological data at Moore Park is characterised by frequent easterly and westerly winds that occur due to the east-west orientation of the valley in which the monitoring station is located. The meteorological station at Moore Park is not likely to be representative of meteorological conditions at the Site as the narrow valley results in a high level of wind channelling that is not likely to be observed at the site.

A review by Katestone indicates that there are no other meteorological observation stations on the Met Eireann Network that meet the requirements specified in AG4 to be considered representative of the modelling domain.

Where site-specific or representative meteorological data is not available, AG4 provides the following alternatives:

> *Prognostic meteorological data should be considered in locations where there is no comparable representative Met Eireann station particularly in areas of complex terrain or at a land / sea interface.*

and

> *Prognostic meteorological data may be useful in locations where there is no comparable representative Met Eireann station. Locations where prognostic meteorological data may be required include regions of complex terrain and at a land/sea interface in circumstances where the nearest meteorological stations are outside of the modelling domain. As outlined by the USEPA, meteorological data should be spatially representative of the modelling domain and in particular of the pathway from the source to the most impacted receptor.*

Accordingly, prognostic meteorological data was generated for the Site due to the complexity of the terrain. The approach adopted to generate representative site-specific data used a numerical model to generate a 3-dimensional grid of spatially varying meteorological parameters to represent conditions surrounding the Site. The approach is described in Appendix A1.

5.2.2 Meteorology

The prognostic model TAPM (developed in Australia by the Commonwealth Scientific and Industrial Research Organisation [CSIRO], version 4.0.5) and the diagnostic meteorological model CALMET (developed by EarthTec, version 6.5) were used to generate the three-dimensional meteorological dataset for the region.

The CALMET simulation was initialised with the gridded TAPM 3D wind field data from the innermost nest. CALMET treats the prognostic model output as the initial guess field for the CALMET diagnostic model wind fields. The initial guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

The three-dimensional wind field produced by TAPM/CALMET was then used to create a meteorological file suitable for us with the CALPUFF dispersion model.

Details of the model configuration and evaluation are presented in Appendix A.

The TAPM/CALMET approach has been used in jurisdictions like Australia to generate suitable meteorological data for modelling odour impacts for over 15 years. It has been adopted in for the assessment of a number of proposed projects in Ireland in the last 5 years. There is significant experience using these approaches in jurisdictions such as Australia. Industry specific guidance on modelling odour dispersion from sources such as intensive poultry farms and cattle feedlots recommend the use of TAPM/CALMET to generate representative site-specific data. Research in Europe indicates that meteorological data generated using a numerical model provided a better indication of locations where odour nuisance occurred (Feliubadaló et al, 2008). In that study, locations of

likely odour nuisance were determined using the German VDI grid assessment approach. The correlation between observed and modelled odour concentrations was significantly better using the TAPM/CALMET approach compared to traditional steady state gaussian models such as AERMOD.

5.3 Emissions of odour

5.3.1 Overview

The derivation of an odour emissions inventory for the Site is presented in this section.

There is no emissions monitoring data available for the pig farm. Odour emission rates from the pig housing units at pig farms vary considerably depending on factors such as:

- The ventilation rate which is heavily influenced by:
    - The target temperature of the pigs in the unit, which is influenced by:
        - Type of pig (sow, weaner, finisher)
        - The age of the pigs.
    - The ambient temperature outside the pig unit.
- The design of the housing system including but not limited to the following:
    - Depth of manure holding pits
    - Frequency on manure removal
    - Ventilation design
    - Surface area of manure exposed beneath the slats.
- The depth of manure in the house, which varies considerably with season.

There is no external slurry storage at the site.

The odour emission rates for the housing units at the pig farm were derived from EPA recommended emission factors published in the EPA 2022 Pig Instruction Note. Whilst a site-specific odour emissions inventory could be developed by sampling the subject Site, it would require a significant amount of sampling to be conducted over different seasons and farm operating conditions, which is not economically viable.

5.3.2 Odour Emission Rates

The EPA 2022 Pig Instruction Note presents recommended approaches for the assessment of odour impact from pig farms in Ireland using:

- A screening tool approach (Screening Approach)
- A detailed modelling for odour assessment approach (detailed modelling approach).

The screening tool approach defined in the EPA 2022 Pig Instruction Note mandates the use of screening odour emission rates to determine if a pig farm is compliant with the relevant odour impact criterion.

The detailed modelling approach described in the EPA 2022 Pig Instruction Note presents lower emission factors that may be used in a detailed modelling assessment. Lower emission factors may be used when applicable emission reduction techniques are adopted on a pig farm.

The odour emission rates adopted in this assessment are based on screening odour emission rates presented in EPA 2022 Pig Instruction Note, which are reproduced in Table 1 below.

5.3.2.1 Screening odour emission rates

The EPA 2022 Pig Instruction Note requires the calculation of a baseline odour emission rate by pig type based on the odour emission rates presented in Table 1.

Table 1 Odour emission factors for the different pig types used in the screening tool described in the EPA 2022 Pig Instruction Note

Type of Pig	Recommended odour emission Factor
	OU_E/s/pig
Dry Sow	21.0
Farrowing Sows	20.0
Weaners	6.0
Growers	12.0
Finishers	20.0
Fatteners[1]	17.3
Maiden Gilts	20.0

[1] In this document fatteners refer to the combined number of growers and finishers, which are defined in the EPA 2022 Pig Instruction Note. Growers and finisher are reared in the same housing units on pig farms. The emission rates for growers and finishers are therefore modelled using a single emission factor, presented for fatteners, which is calculated as a weighted average odour emission rate based on the proportion of growers/finishers on a pig farm and the odour emission rate specified in the EPA 2022 Pig Instruction Note for each category of pig

The typical pig weights by animal category are defined in the EPA 2022 Pig Instruction Note as:

- Between 8 kg and 30 kg for weaners
- Between 30 kg and 60 kg for growers
- Between 60 kg and 120 kg for finishers.

The typical pig weights by animal category defined in the EPA 2022 Pig Instruction Note indicate that in relation to pigs between 30 kg and 120 kg:

- 33.3% are growers weighing between 30 kg and 60 kg for
- 66.6% are finishers weighing between 60 kg and 120 kg.

Pig farms in Ireland generally separate pigs in dedicated houses for weaners (8 kg and 30 kg) and pigs above 30 kg classified as fatteners, which includes growers and finishers.

Considering that growers and finishers are housed in the same housing units at the subject pig farm, a weighted average odour emission rate has been determined for fatteners based on:

- The odour emission rates for growers and finishers defined in the EPA 2022 Pig Instruction Note
- The proportion of fatteners made up of growers and finishers as per the EPA 2022 Pig Instruction Note.

A screening odour emission rate of 17.33 ou_E/s/pig has been determined for fatteners at the pig farm.

The odour emission rate for slurry storage as presented in the EPA 2022 Pig Instruction Note is 20 $ou_E/m^2/s$. This odour emission rate applies to slurry storage without mitigation.

5.3.2.2 Detailed dispersion modelling odour emission rate

On 15 February 2017, the European Commission adopted Commission Implementing Decision (EU) 2017/302 (2017 CID). The 2017 CID establishes best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the intensive rearing of poultry or pigs. The 2017 CID and its

associated BAT Reference document (BREF document) include the theory behind the sources of odour and possible odour control techniques available for the intensive agriculture (poultry and pigs) sector.

The EPA 2022 Pig Instruction Note states:

> *The 2017 CID and BREF note include techniques to reduce emissions of odour (BAT 13) from the whole farm and to reduce ammonia (BAT 30) from animal housing. Whilst BAT 30 is specific to reducing ammonia emissions, the BREF outlines how odour emissions can also be reduced by implementing various BAT 30 techniques*
>
> *The BREF note describes how emissions associated with standard housing with a deep pit can be reduced for existing animal housing through their use in combination with other techniques (e.g., nutritional management, an air cleaning system, pH reduction of slurry, or slurry cooling).*

Further detail of pig housing types and housing systems to reduce emissions of odour are presented in the EPA 2022 Pig Instruction Note (EPA, 2022).

The EPA 2022 Pig Instruction Note presents recommended levels of mitigation (odour emission reduction factors) that can be applied to the screening odour emission rates presented for the screening approach.

The existing housing units are operated as traditional deep pit housing units. The pig diets at the existing housing units are formulated with reduced protein content to limit emissions. The pig diets at the existing housing units will continue to be formulated with reduced protein content to limit emissions.

In relation to the manipulation of dietary protein and supplements, the EPA 2022 Pig Instruction Note states:

> *Manipulating animal feed by reducing dietary protein will reduce the amount of unused protein that passes through a pig's digestive system. Fewer precursor compounds present in the slurry will reduce potential odour.*
>
> *For detailed modelling, it would be reasonable to apply a reduction factor of 10% on the basis of a reduction of 1% crude protein in the diet. The maximum reduction factor that can be applied is 30% linked to a reduction of 3% crude protein in the diet.*

If dietary crude protein exceeds the dietary requirements of a pig it will be excreted resulting in higher levels of nitrogen in slurry. It is therefore desirable to optimise the level of crude protein in diets to meet the pig's nutritional requirements for growth while minimising nitrogen levels in excrement. Excess nitrogen For weaner and finisher pigs, the level of crude protein required in the diet declines with age and as growth slows. Younger pigs therefore require more crude protein than older pigs in each of the weaner (8kg to 30kg) and finisher (30kg to 120kg) categories.

The site will adopt low protein diets as a BAT technique to reduce ammonia emissions to the atmosphere. The level of protein in diets at the pig farm will be limited (as a weighted average) to:

- 14.5% for sows
- 17.5% for weaners
- 15% for fatteners.

The crude protein levels stated here are weighted average levels across the diets fed to sows, weaners and finishers because the overall level of nitrogen that ends up in the slurry tanks of pig housing units is correlated with the average level of crude protein in the diets fed to pigs in the housing unit.

The diets of younger pigs in each of the weaner and fattener categories will be above the levels specified and the diets of older pigs in each of these categories will be below the levels specified overall. However, the weighted average crude protein levels for the categories of pigs will be maintained below the levels specified above.

Monagle Pig Farms has worked with animal nutritionists to reduce crude protein and supplements in the pigs' diet. The levels of crude protein and supplements has been optimised at levels that minimise the amount of unused protein that passes through the pig's digestive system. This approach has reduced dietary crude protein by levels that surpass 3%. Consequently, the maximum odour reduction factor of 30%, is justified according to the EPA 2022 Pig Instruction Note has, therefore, been applied to all pig types.

The existing housing units that will be kept at the Site will continue to operate as deep pit housing systems.

The odour emission rates adopted for the existing housing units at the pig farm were determined as the screening odour emission factors specified in the EPA 2022 Pig Instruction Note reduced by 30% to account for dietary manipulation, which will be adopted by Monagle Pig Farms.

The odour emission rates adopted for the proposed housing units at the pig farm were determined as the screening odour emission factors specified in the EPA 2022 Pig Instruction Note reduced by 30% to account for dietary manipulation adopted by Monagle Pig Farms.

The odour emission rates adopted in the detailed dispersion modelling assessment for the existing housing units are presented in Table 2.

Table 2 The odour emission rates adopted for each category of pig in the existing housing units at the pig farm

Type of Pig	Recommended odour emission Factor
	OU_E/s/pig
Dry Sow (and Gilts)	14.0
Weaners	4.2
Fatteners[1]	12.1
Maiden Gilts	14.0

[1] In this document fatteners refer to the combined number of growers and finishers, which are defined in the EPA 2022 Pig Instruction Note. Growers and finisher are reared in the same housing units on pig farms. The emission rates for growers and finishers are therefore modelled using a single emission factor, presented for fatteners, which is calculated as a weighted average odour emission rate based on the proportion of growers/finishers on a pig farm and the odour emission rate specified in the EPA 2022 Pig Instruction Note for each category of pig

5.4 Dispersion modelling

The assessment was conducted in accordance with recognised techniques for dispersion modelling specified in EPA's Air Dispersion Modelling Guidance Note (AG4). CALPUFF was used to predict ground-level concentrations of odour across the modelling domain and at sensitive receptor locations due to sources at the pig farm.

The details of source characterisation utilised for the pig farm in the modelling assessment are provided in Section 5.7.

5.5 Building downwash

When modelling emissions from an industrial installation it should be borne in mind that stacks that are relatively short can be subjected to additional turbulence due to the presence of nearby buildings. Buildings are considered nearby if they are within five times the lesser of the building height or maximum projected building width (but not greater than 800m) (EPA, 2020).

A plume of a short stack is likely to be downwashed if its height is less than two and a half times the height of nearby buildings within a distance of 10 x L from each source, where L is the lesser of the height or width of the building. A Building Profile Input Program (BPIP) was used to determine the effects of buildings at the Site on the point sources of emissions at the pig farm. The Plume Rise Model Enhancements (PRIME) algorithm is

recommended in EPA Guidance for use with AERMOD. PRIME was used in the dispersion modelling assessment to determine the effect of building induced turbulence on plumes from point sources at the pig farm.

The PRIME algorithm takes into account the position of each stack relative to each relevant building and the projected shape of each building for 36 wind directions (at 10º intervals). The model determines the change in plume centreline location with downwind distance based on the slope of the mean streamlines and coupled to a numerical plume rise model.

There were eight onsite buildings/structures included in the BPIP program to represent pig housing units and other onsite buildings. The coordinates used in the configuration of the pig housing units and onsite buildings in the PRIME BPIP model for this assessment are presented in Table 3.

Table 3 Pig housing units included and configuration of the pig housing units in BPIP

Building	Easting	Northing	Height (m)
	UTM (m)	UTM (m)	
H16	528899.8	5781444	4.884
	528906.7	5781463	
	528823.1	5781493	
	528816.3	5781474	
H5	528897.8	5781437	4.31
	528815	5781468	
	528809.3	5781453	
	528892.6	5781422	
H3	528784.8	5781418	4.31
	528878	5781385	
	528883.7	5781399	
	528791.1	5781433	
H2	528775.2	5781393	5.331
	528868.5	5781358	
	528877	5781381	
	528784.3	5781415	
H1	528766.5	5781371	4.7
	528847.6	5781341	
	528854.7	5781358	
	528774.6	5781388	
Sow	528836.1	5781308	4.766
	528846.3	5781335	
	528762.4	5781367	
	528752.1	5781340	
Store	528852.7	5781339	8
	528878.5	5781328	
	528886.4	5781347	
	528859.9	5781357	
H4	528795.1	5781437	4.31
	528793.3	5781432	
	528843.2	5781414	
	528844.7	5781418	
	528807.7	5781448	
	528802.6	5781434	
	528795.1	5781437	
	528795.1	5781437	

5.6 Sources of Emissions

The pig housing units included in the dispersion modelling assessment are presented in Table 4, which specifies:

- The housing unit at the pig farm
- The type of pigs housed
- The type of ventilation
- The number of pigs housed in the building
- The number of sources used to represent the mechanical ventilation points in the modelling assessment.

The pig housing units at the Site will be mechanically ventilated as indicated in Table 4 and were configured as point sources in the modelling assessment.

The point sources representing mechanically ventilated housing units included in the modelling assessment, the number of pigs per source and the odour emission rate per source included in the modeling assessment are presented in Table 5.

Table 4 Pig housing units included in the dispersion modelling assessment

Building	Type of Ventilation	Type of Pig	Number of Pigs	Sources per shed
House 1/2	Mechanical	Dry Sow (Maiden Gilts)	670 (120)	8
House 3	Mechanical	2nd	2933	6
House 3	Mechanical	1st	567	1
House 4	Mechanical	1st	900	6
House 4	Mechanical	Farrowing	164	19
House 4	Mechanical	Dry Sow	20	1
House 5	Mechanical	Fattener	1120	13
House 7	Mechanical	Fattener	1120	12
House 9	Mechanical	Fattener	1120	12
House 10	Mechanical	Fattener	1440	6

Table 5 Sources and odour emission rate of point sources representing mechanically ventilated housing units included in the modelling assessment

Housing Unit	Source Number	Number of pigs per source	Ammonia Emission rate (g/s)
House 1/2	S_DS_1	99	1,452
	S_DS_2	99	1,452
	S_DS_3	99	1,452
	S_DS_4	99	1,452
	S_DS_5	99	1,452
	S_SS_1	99	1,452
	S_SS_2	99	1,452
	S_SS_3	99	1,452
House 3	H3_W1	489	2,053
	H3_W2	489	2,053
	H3_W3	489	2,053

Housing Unit	Source Number	Number of pigs per source	Ammonia Emission rate (g/s)
	H3_W4	489	2,053
	H3_W5	489	2,053
	H3_W6	489	2,053
	H3_W7	567	2,380
	H4_W1	150	630
House 4	H4_W2	150	630
	H4_W3	150	630
	H4_W4	150	630
	H4_W5	150	630
	H4_W6	150	630
	H4_Far1	9	121
	H4_Far2	9	121
	H4_Far3	9	121
	H4_Far4	9	121
	H4_Far5	9	121
	H4_Far6	9	121
	H4_Far7	9	121
	H4_Far8	9	121
	H4_Far9	9	121
	H4_Sow10	20	294
	H4_Far11	9	121
	H4_Far12	9	121
	H4_Far13	9	121
	H4_Far14	9	121
	H4_Far15	9	121
	H4_Far16	9	121
	H4_Far17	9	121
	H4_Far18	9	121
	H4_Far19	9	121
	H4_Far20	9	121
House 5	H5_F1	86	1,045
	H5_F10	86	1,045
	H5_F11	86	1,045
	H5_F12	86	1,045
	H5_F13	86	1,045
	H5_F2	86	1,045
	H5_F3	86	1,045
	H5_F4	86	1,045
	H5_F5	86	1,045
	H5_F6	86	1,045

Housing Unit	Source Number	Number of pigs per source	Ammonia Emission rate (g/s)
	H5_F7	86	1,045
	H5_F8	86	1,045
	H5_F9	86	1,045
House 7	H7_F1	93	1,132
	H7_F2	93	1,132
	H7_F3	93	1,132
	H7_F4	93	1,132
	H7_F5	93	1,132
	H7_F6	93	1,132
	H7_F7	93	1,132
	H7_F8	93	1,132
	H7_F9	93	1,132
	H7_F10	93	1,132
	H7_F11	93	1,132
	H7_F12	93	1,132
House 9	H9_F1	93	1,132
	H9_F10	93	1,132
	H9_F11	93	1,132
	H9_F12	93	1,132
	H9_F2	93	1,132
	H9_F3	93	1,132
	H9_F4	93	1,132
	H9_F5	93	1,132
	H9_F6	93	1,132
	H9_F7	93	1,132
	H9_F8	93	1,132
	H9_F9	93	1,132
House 10	H10_F1	240	2,912
	H10_F2	240	2,912
	H10_F3	240	2,912
	H10_F4	240	2,912
	H10_F5	240	2,912
	H10_F6	240	2,912

5.7 Source configuration

The pig housing units at the pig farm are mechanically ventilated and were, therefore, modelled as point sources in the modelling assessment. This section describes the configuration of the sources included in the CALPUFF modelling assessment.

Table 6 lists the point sources included in the modelling assessment and relevant modelling parameters including:

- The source coordinates

- The base elevations
- Stack height
- Stack diameter
- Exhaust temperature
- Exhaust velocity.

The building locations, configuration and heights were determined from Site plans provided by Monagle Pig Farms, correspondence between Katestone and Monagle Pig Farms and from satellite imagery.

Table 6 Source parameters for the point sources at the pig farm

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Velocity
	km	km	m	m	m	°C	m/s
S_DS_1	528.765	5781.352	101.2	6.046	0.71	21	6.0
S_DS_2	528.773	5781.349	101.0	6.046	0.71	21	6.0
S_DS_3	528.781	5781.346	100.7	6.046	0.71	21	6.0
S_DS_4	528.789	5781.343	100.4	6.046	0.71	21	6.0
S_DS_5	528.797	5781.34	100.1	6.046	0.71	21	6.0
S_SS_1	528.813	5781.334	99.6	6.046	0.71	21	6.0
S_SS_2	528.824	5781.33	99.2	6.046	0.71	21	6.0
S_SS_3	528.833	5781.326	98.9	6.046	0.71	21	6.0
H1_W1	528.78	5781.377	101.3	6.03	0.91	25	5.1
H1_W2	528.789	5781.373	101.0	6.03	0.91	25	5.1
H1_W3	528.801	5781.369	100.5	6.03	0.91	25	5.1
H1_W4	528.813	5781.364	100.1	6.03	0.91	25	5.1
H1_W5	528.824	5781.36	99.7	6.03	0.91	25	5.1
H1_W6	528.835	5781.356	99.3	6.03	0.91	25	5.1
H1_W7	528.846	5781.352	98.9	6.03	0.91	25	5.1
H2_W1	528.783	5781.397	101.6	5.131	0.56	25	5.4
H2_W2	528.793	5781.393	101.2	5.131	0.56	25	5.4
H2_W3	528.802	5781.39	100.9	5.131	0.56	25	5.4
H2_W4	528.788	5781.409	101.7	5.131	0.56	25	5.4
H2_W5	528.812	5781.386	100.5	5.131	0.56	25	5.4
H2_W6	528.816	5781.398	100.6	5.131	0.56	25	5.4
H2_Far1	528.797	5781.405	101.3	5.131	0.45	25	4.7
H2_Far2	528.862	5781.367	98.7	5.131	0.45	25	4.7
H2_Far3	528.857	5781.369	98.9	5.131	0.45	25	4.7
H2_Far4	528.851	5781.371	99.1	5.131	0.45	25	4.7
H2_Far5	528.846	5781.373	99.3	5.131	0.45	25	4.7
H2_Far6	528.838	5781.376	99.5	5.131	0.45	25	4.7
H2_Far7	528.832	5781.378	99.8	5.131	0.45	25	4.7
H2_Far8	528.826	5781.38	100.0	5.131	0.45	25	4.7
H2_Far9	528.82	5781.383	100.2	5.131	0.45	25	4.7
H2_Far10	528.806	5781.402	101.0	5.131	0.45	21	4.7
H2_Far11	528.856	5781.383	99.1	5.131	0.45	25	4.7
H2_Far12	528.868	5781.365	98.5	5.131	0.45	25	4.7
H2_Far13	528.823	5781.395	100.3	5.131	0.45	25	4.7
H2_Far14	528.832	5781.392	100.0	5.131	0.45	25	4.7
H2_Far15	528.837	5781.39	99.8	5.131	0.45	25	4.7
H2_Far16	528.842	5781.388	99.6	5.131	0.45	25	4.7

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Velocity
	km	km	m	m	m	°C	m/s
H2_Far17	528.85	5781.385	99.3	5.131	0.45	25	4.7
H2_Far18	528.861	5781.381	98.9	5.131	0.45	25	4.7
H2_Far19	528.867	5781.379	98.7	5.131	0.45	25	4.7
H2_Far20	528.873	5781.377	98.5	5.131	0.45	25	4.7
H3_F1	528.793	5781.425	101.8	5.14	0.56	21	5.4
H3_F10	528.857	5781.401	99.4	5.14	0.56	21	5.4
H3_F11	528.867	5781.397	99.0	5.14	0.56	21	5.4
H3_F12	528.872	5781.395	98.8	5.14	0.56	21	5.4
H3_F13	528.877	5781.394	98.6	5.14	0.56	21	5.4
H3_F2	528.8	5781.422	101.5	5.14	0.56	21	5.4
H3_F3	528.807	5781.42	101.3	5.14	0.56	21	5.4
H3_F4	528.814	5781.417	101.0	5.14	0.56	21	5.4
H3_F5	528.821	5781.414	100.7	5.14	0.56	21	5.4
H3_F6	528.829	5781.412	100.4	5.14	0.56	21	5.4
H3_F7	528.836	5781.409	100.1	5.14	0.56	21	5.4
H3_F8	528.847	5781.405	99.7	5.14	0.56	21	5.4
H3_F9	528.852	5781.403	99.5	5.14	0.56	21	5.4
H4_F1	528.81	5781.439	101.5	5.14	0.56	21	5.4
H4_F2	528.816	5781.437	101.3	5.14	0.56	21	5.4
H4_F3	528.821	5781.435	101.1	5.14	0.56	21	5.4
H4_F4	528.831	5781.432	100.7	5.14	0.56	21	5.4
H4_F5	528.836	5781.43	100.5	5.14	0.56	21	5.4
H4_F6	528.842	5781.428	100.3	5.14	0.56	21	5.4
H4_F7	528.853	5781.423	99.8	5.14	0.56	21	5.4
H4_F8	528.858	5781.421	99.6	5.14	0.56	21	5.4
H4_F9	528.864	5781.419	99.4	5.14	0.56	21	5.4
H4_F10	528.874	5781.415	99.0	5.14	0.56	21	5.4
H4_F11	528.88	5781.414	98.8	5.14	0.56	21	5.4
H4_F12	528.884	5781.412	98.7	5.14	0.56	21	5.4
H5_F1	528.816	5781.459	101.6	5.14	0.56	21	5.4
H5_F10	528.879	5781.436	99.2	5.14	0.56	21	5.4
H5_F11	528.886	5781.433	98.9	5.14	0.56	21	5.4
H5_F12	528.893	5781.43	98.6	5.14	0.56	21	5.4
H5_F2	528.822	5781.456	101.4	5.14	0.56	21	5.4
H5_F3	528.828	5781.454	101.1	5.14	0.56	21	5.4
H5_F4	528.836	5781.451	100.8	5.14	0.56	21	5.4
H5_F5	528.843	5781.449	100.6	5.14	0.56	21	5.4
H5_F6	528.849	5781.447	100.3	5.14	0.56	21	5.4
H5_F7	528.859	5781.443	99.9	5.14	0.56	21	5.4

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Velocity
	km	km	m	m	m	°C	m/s
H5_F8	528.865	5781.441	99.7	5.14	0.56	21	5.4
H5_F9	528.872	5781.438	99.4	5.14	0.56	21	5.4
H16_F1	528.828	5781.482	101.6	6.124	0.91	21	5.1
H16_F2	528.842	5781.477	101.0	6.124	0.91	21	5.1
H16_F3	528.856	5781.472	100.5	6.124	0.91	21	5.1
H16_F4	528.869	5781.467	99.9	6.124	0.91	21	5.1
H16_F5	528.884	5781.461	99.3	6.124	0.91	21	5.1
H16_F6	528.898	5781.457	98.8	6.124	0.91	21	5.1

6. ASSESSMENT RESULTS

Dispersion modelling has been conducted for five years of meteorological data. The following sections present the highest concentrations across the five-year modelled period.

Predicted ground-level concentrations of odour (1-hour average, 98th percentile) at the nearest sensitive receptors due to the pig farm are presented in Table 7. Plate 1 is a contour plot that presents the highest ground-level concentrations (1-hour average, 98th percentile) across the model domain during the five-year period.

The results show that predicted concentrations **comply** with the odour criterion recommended by EPA for pig farms (that were licensed before 2001 with no licence review since that time) that have of 6.0ou$_E$/m^3 at all sensitive receptors included in the modelling assessment.

Table 7 Predicted ground-level concentrations of odour (1-hour average, 98th percentile) at the nearest sensitive receptors due to the pig farm

Year	DR1	DR2	DR3	DR4	DR5	DR6	DR7	DR8	DR9
	Concentration of odour								
2018	3.5	2.2	0.9	1.4	2.1	3.9	4.5	3.6	1.0
2019	3.3	2.3	0.9	1.6	2.0	2.9	4.2	3.1	1.1
2020	3.3	2.0	0.8	1.3	1.9	1.9	3.0	3.4	1.1
2021	3.8	1.8	0.8	1.2	2.3	4.3	4.4	4.2	1.2
2022	3.9	2.3	0.9	1.5	2.4	3.5	3.2	4.9	1.2
Predicted Concentration	3.9	2.3	0.9	1.6	2.4	4.3	4.5	4.9	1.2
Odour Criteria Limit	**6.0**								

7. CONCLUSIONS

Monagle Pig Farms commissioned Katestone to complete an odour impact assessment for a pig farm located at Annakisha North, Doneraile Co. Cork.

The pig farm has an Industrial Emissions Directive (IED) licence (Licence registration number P0446-01) issued by the Environment Protection Agency (EPA) in 1999.

According to its license, total stocking capacity for the Site is 7,462 pigs (131 suckling sows, 649 dry sows, 20 boars, 94 maiden gilts, 2,668 weaners and 3,900 finishers).

The most recent planning application to Cork County Council for the Site was in 2014 (application number 14/5815). Cork County Council issued conditional approval in June 2015 to construct a pig fattening house, associated feed mixing room and a pig walkway. The planning application 14/5815 was for a stocking capacity of 10,174 pigs (164 suckling sows, 690 dry sows, 120 maiden gilts, 4,400 weaners and 4,800 finishers).

The OIA is required to determine the potential impact of odorous emissions from the pig farm on nearby residential locations. The assessment will be submitted as part of a license review application for the pig farm.

The odour assessment was conducted in accordance with recognised techniques for dispersion modelling specified in EPA's Air Dispersion Modelling Guidance Note (AG4). The dispersion model, CALPUFF, was used to predict ground-level concentrations of odour across the model domain due to the pig farm. The assessment of odour has also been conducted in accordance with EPA's instruction note for the assessment of odour emissions from intensive agriculture pig installations (EPA, 2022).

The odour modelling assessment found that the predicted concentrations of odour at all sensitive receptors **comply** with odour criterion recommended by EPA for existing pig farms (that were licensed before 2001 with no licence review since that time) of 6.0ou_E/m^3 at all modelled sensitive receptor locations.

8. REFERENCES

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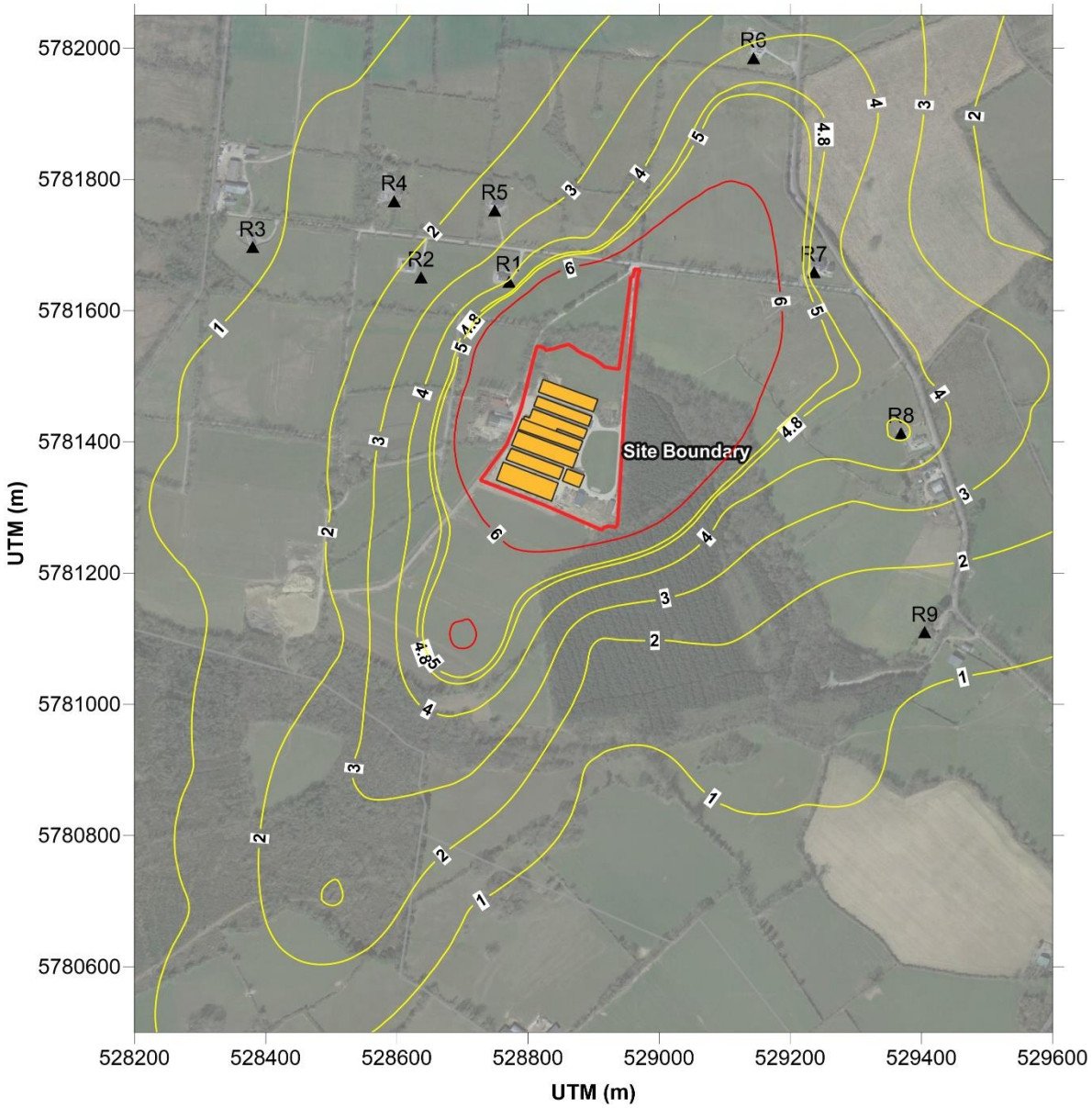

Plate 1 **Highest predicted 98th percentile 1-hour average ground-level concentrations of odour of five modelled years due to the pig farm**

Location:	**Averaging period:**	**Data source:**	**Units:**
Annakisha North, Co Cork	1-hour	CALPUFF	ou_E/m^3
Type:	**Criterion level:**	**Prepared by:**	**Date:**
98th percentile	6 ou (Red Line)	P McDowell	Oct 2023

APPENDIX A MODELLING METHODOLOGY

A1 METEOROLOGICAL MODELLING

A1.1 TAPM

The meteorological model, TAPM (The Air Pollution Model) Version 4.0.5, was developed by the CSIRO and has been validated by the CSIRO, Katestone and others for many locations in Australia, southeast Asia, North America and Ireland. Katestone has used the TAPM model throughout Australia and has performed well for simulating regional winds patterns. Katestone has recently used the TAPM model to generate gridded data over Cork city and Harbour. The data generated correlated well with observed data at Cork Airport. TAPM has proven to be a useful model for simulating meteorology in locations where monitoring data is unavailable.

TAPM requires synoptic meteorological information for the region surrounding the project. This information is generated by a global model similar to the large-scale models used to forecast the weather. The data are supplied on a grid resolution of approximately 75 km, and at elevations of 100 metres to five kilometres above the ground. TAPM uses this synoptic information, along with specific details of the location such as surrounding terrain, land-use, soil moisture content and soil type to simulate the meteorology of a region as well as at a specific location.

TAPM resolves local terrain and land-use features that may influence local meteorology and generates a meteorological dataset that is representative of Site-specific geographic conditions. A year of synoptic data must be selected as input for TAPM. The selection of this year should be such that the year is representative of typical meteorological conditions (and therefore is not necessarily the most recent year of available data) and whether monitoring data is available for the time period to validate the output dataset. In addition, Katestone's experience elsewhere suggests that variability of dispersion meteorological conditions from year to year are unlikely to change the outcome of the air quality assessment.

TAPM was configured as follows:

- 41 x 41 grid point domain with an outer grid resolution of 30 kilometres and nesting grids of 10, 3.0 and 1.0 kilometres.
- 5 modelled years (1 January 2018 to 31 December 2022)
- Grid centered near the Project Site at latitude 52°12’30 and longitude -8°35’0
- US Geological Survey EROS global terrain height database
- TAPM default land use database, modified to be consistent with aerial imagery in the innermost grid
- 25 vertical grid levels
- No data assimilation.

A1.2 CALMET meteorological modelling

CALMET is an advanced non-steady-state diagnostic 3D meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF modelling system. CALMET is capable of reading hourly meteorological data as data assimilation from multiple Sites within the modelling domain; it can also be initialised with the gridded three-dimensional prognostic output from other meteorological models such as TAPM. This can improve dispersion model output, particularly over complex terrain as the near surface meteorological conditions are calculated for each grid point.

CALMET (version 6.5.0) was used to simulate meteorological conditions in the region. The CALMET simulation was initialised with the gridded TAPM 3D wind field data from the 1 km grid. CALMET treats the prognostic model

output as the initial guess field for the CALMET diagnostic model wind fields. The initial guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

CALMET was configured with twelve vertical levels with heights at 20, 60, 100, 150, 200, 250, 350, 500, 800, 1600, 2600 and 4600 metres at each grid point.

All options and factors were selected in accordance with NSW EPA CALPUFF Guidance released by TRC Environmental in 2011 except where noted below.

Key features of CALMET used to generate the wind fields are as follows:

- Domain area of 120 x 140 grid cells at 200m spacing
- 5 years modelled (1 January 2018 to 31 December 2022)
- Prognostic wind fields input as MM5/3D.dat for “initial guess” field (as generated by TAPM)
- Gridded cloud cover from prognostic relative humidity at all levels
- No extrapolation of surface wind observations to upper layers (not used in no-obs mode)
- Terrain radius of influence set to 5 km
- Maximum search radius of 10 grid cells in averaging process
- Use prognostic relative humidity
- Land use data modified to be consistent with aerial imagery.

All other options set to default.

A2 CALPUFF DISPERSION MODELLING

CALPUFF simulates the dispersion of air pollutants to predict ground-level concentration and deposition rates across a network of receptors spaced at regular intervals, and at identified discrete locations. CALPUFF is a non-steady-state Lagrangian Gaussian puff model containing parameterisations for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation. CALPUFF employs the 3D meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. CALPUFF takes into account the geophysical features of the study area that affects dispersion of pollutants and ground-level concentrations of those pollutants in identified regions of interest. CALPUFF contains algorithms that can resolve near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub-grid scale terrain interactions, as well as the long-range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions. Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

Key features of CALPUFF used to simulate dispersion:

- Domain area of 20 x 20 grid cells at 200m spacing, which is a sub-set of the CALMET domain centred on the Site
- 5 years modelled (1 January 2018 to 31 December 2022)
- Gridded 3D hourly-varying meteorological conditions generated by CALMET
- Partial plume path adjustment for terrain modelled
- Dispersion coefficients calculated internally from sigma v and sigma w using micrometeorological variables.

All other options set to default.