1 AIR QUALITY AND ODOUR IMPACT ASSESSMENT

1.1 INTRODUCTION

A secondary wastewater treatment plant is proposed for Newport, Co. Mayo. The plant will be designed to cater for a population equivalent (PE) of 2,501. This chapter outlines the appropriate odour compliance criterion, which will ensure that no odour nuisance occurs from the proposed facility. The impact of the proposed facility on the general air quality will also be considered.

As the proposed facility is to be built as part of a Design Build Operate contract (DBO), the Contractor chooses the appropriate plant to meet the specified design criteria. Thus, the current assessment outlined in this report is based on the specimen design available at this time. The conclusions drawn from this assessment are thus limited to the specified design.

1.2 ASSESSMENT METHODOLOGY

1.2.1 Air Dispersion Modelling Methodology

The United States Environmental Protection Agency (USEPA) developed AERMOD(1) dispersion model has been used to predict the ground level odour concentrations (GLC) from the proposed Newport WWTP (further details in Appendix 1.2). The modelling incorporated the following features:

- Seventeen discrete receptors were identified near the proposed facility. In addition, boundary receptors locations were placed at the site boundary giving a total of 31 calculation points for each model case.
- All on-site buildings and significant process structures were mapped into the computer to create a three dimensional visualisation of the site and its emission point.
- AERMOD incorporates a meteorological pre-processor AERMET PRO(2). The AERMET PRO meteorological preprocessor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature (see Appendix 1.2). The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use type was carried out to a distance of 3km from the source location in line with USEPA recommendations(3).
- The source and emission data, including area source dimensions, gas volumes and emission temperatures have been incorporated into the model.
- Terrain has been included in the modelling. The immediate area on-site is relatively flat but has some slight changes in terrain to the northeast and southwest of the site.

The selection of the appropriate meteorological data has followed the guidance issued by the USEPA(4). A primary requirement is that the data used should have a data capture of greater than 90% for all parameters. The nearest representative meteorological station to the site is Belmullet. Real meteorological data collected at Belmullet Meteorological Station from 1993,95-97 has been used as input to the model. Belmullet is located approximately 40km northwest of the site. The worst-case year (i.e the year which gives the highest ground level pollutant concentration relative to its limit value) has been used throughout this study (Year 1997). This will lead to higher concentrations than would be experienced in an average year.

1.2.2 Odour Standards & Guidelines

The exposure of the population to a particular odour consists of two factors; the concentration and the length of time that the population may perceive the odour. By definition, 1 ou/m^3 is the detection threshold of 50% of a qualified panel of observers working in an odour-free laboratory using odour-free air as the zero reference.

In the absence of specific Irish EPA guidance on odour, available guidance from the UK has historically been adopted(5-7). During the 1990's in the UK, it was generally accepted that odour concentrations of between 5 and 10 ou/m^3 would give rise to a faint odour only, and that only a distinct odour (concentration of >10 ou/m^3) could give rise to a nuisance(7). In 1990, a survey of the populations surrounding 200 industrial odour sources in the Netherlands showed that there were no justifiable complaints when 98%ile compliance with an odour exposure standard of a "faint odour" (5-10 ou/m^3) was achieved(7).

Recent approaches to odour compliance criteria are moving away from a purely arithmetic approach to odour, based on odour concentration, to one where the dose-effect relationship is investigated (further details in Appendix 1.1). This dose-response relationship will depend on factors such as on the offensiveness of odour, the Peak/Mean (P/M) ratio and the sensitivity of the surrounding environment(8).

As part of the dose-response approach to odour assessment, the odour concentration is corrected to reflect the offensiveness and nature of the odour. Hangartner(8) has produced a table (Table 1.1) which shows the concentration of various sources of odour that would need to be present to extract the same hedonic response as that from pure hydrogen sulphide. Assuming that the baseline annoyance threshold of 5 ou/m^3 is appropriate for hydrogen sulphide (as is likely), this data can be used to determine the annoyance threshold for other sources of odour:

Odour Type	Value on Hangartner Scale	Value Relative to H_2S
Hydrogen Sulphide	8	1
Rendering Plant	5	0.6
Biofilter	40	5
Bakery	500	62

Table 1.1 Annoyance Threshold Corrections (Hangartner 1988).

An uncontrolled rendering plant is particularly offensive (see Table 1.1) and thus a correction would be applied over and above the detected odour concentration in order to reflect the nauseous nature of these odours. In contrast, biofilters should be corrected downwards to reflect the generally inoffensive nature of their odour. In this regard, an odour concentration measurement of 25 odour units from a biofilter should in fact lead to an odour intensity as perceived at the receptor of 5 odour units or alternatively the corrected annoyance threshold for a biofilter should be 25 ou/m^3(8). In the current context, the odour will be untreated WWTP odours (H_2S, mercaptans, amines etc).

It is also appropriate to apply a correction to the concentration component for land use, location and population intensity. The current location is in a relatively low population, rural environment. The sensitivity of the current environment would be viewed as relatively low both due to medium to high existing background odours (odours associated with coastal locations (sea weed etc), and agricultural odours) and because the opportunities for people to be affected by the odours are reduced due to the relatively low population density (relative to high density urban areas). The recommended corrected annoyance threshold for a low sensitivity environment is 10 ou/m^3 (compared to the standard annoyance threshold of 5 ou/m^3) which is the same as for a moderately sensitive environment(8). In addition, the rural nature of the site may lead to the masking of the odour by the existing background odour and thus reduce the impact of the facility beyond the site boundary.

A further factor which needs to be considered in the assessment procedure is the P/M ratio likely due to emissions from the facility. Due to the averaging period of standard air dispersion models (1-hour means), much higher levels may be detected over short periods although the mean hourly value may be below the annoyance threshold. In order to account for this, a peak to mean ratio has been derived which incorporates the ratio of that odour peak sensed by the nose over a very short period and the average result of a dispersion model over 1-hour. In respect to the current scenario, which involves area sources, volume sources and wake-effected point sources a P/M ratio (based on a 1-hour averaging period) of 2.3 for both the near and far field is recommended(8).

In terms of selection of the appropriate percentile, the 98th%ile has been most commonly applied in odour thresholds and standards. This represents a compromise between the use of very high percentiles which corresponds with the particular conditions which cause most odour complaints and the fact that the uncertainty of the model increases significantly at very high percentiles(9).

Several European countries have recently set standards for odour. The Netherlands has set differentiated target values between 0.5 – 3.5 ou/m^3 as a 98th%ile for industrial sources. The UK in it's recent guidance documents(10-11) has set an indicative odour exposure criteria for waste water treatment works of 1.5 ou/m^3 as a 98th%ile. This indicative criterion can then be adjusted to allow for relevant local factors. In the current case, the rural nature of the facility would allow a more lenient exposure criteria to be applied. Recently, the EPA has set a target value and two limit values for use in pig production units(9). The target value is 1.5 ou/m^3 as a 98th%ile at all sensitive locations. In relation to limit values, a value of 3.0 ou/m^3 as a 98th%ile has been set for new pig production units whilst for existing facilities a value of 6.0 ou/m^3 as a 98th%ile has been set.

In summary, an appropriate assessment criteria for Newport waste water odour emissions in a rural setting taking into account the P/M ratio, annoyance threshold correction factor and the land-use correction factor, has been detailed below:

Odour annoyance threshold for Newport WWTP:

= 5.0 ou/m^3 (default based on a 98th%ile for H_2S)

x 1 (no annoyance threshold correction factor relative to H_2S)

x 2 (correction factor for low or medium sensitivity environment)

x 1/ (2.3) (P/M ratio for wake-affected point sources, area sources, volume sources)

= 4.3 ou/m^3 (based on a 98th%ile of hourly concentrations)

= 4 ou/m^3 (based on a 98th%ile of hourly concentrations) at the nearest sensitive receptor.

1.2.3 Air Quality Standards

Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values. The applicable standards in Ireland are the EU Air Quality Directives 1999/30/EC and 2000/69/EC, which have recently been adopted into Irish

Legislation (S.I. No. 271 of 2002) and which supersede existing ambient air quality standards (see Tables 1.2 – 1.3).

Pollutant	Regulation	Limit Type	Margin of Tolerance	Value
Nitrogen Dioxide	1999/30/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	50% until 2001 reducing linearly to 0% by 2010	200 $\mu g/m^3$ NO_2
		Annual limit for protection of human health	50% until 2001 reducing linearly to 0% by 2010	40 $\mu g/m^3$ NO_2
		Annual limit for protection of vegetation	None	30 $\mu g/m^3$ NO + NO_2
Lead	1999/30/EC	Annual limit for protection of human health	100% until 2001 reducing linearly to 0% by 2005	0.5 $\mu g/m^3$
Sulphur dioxide	1999/30/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	43% until 2001 reducing linearly until 0% by 2005	350 $\mu g/m^3$
		Daily limit for protection of human health - not to be exceeded more than 3 times/year	None	125 $\mu g/m^3$
		Annual & Winter limit for the protection of ecosystems	None	20 $\mu g/m^3$
Particulate Matter Stage 1	1999/30/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	50% until 2001 reducing linearly to 0% by 2005	50 $\mu g/m^3$ PM_{10}
		Annual limit for protection of human health	20% until 2001 reducing linearly to 0% by 2005	40 $\mu g/m^3$ PM_{10}
Particulate Matter Stage 2[1]	1999/30/EC	24-hour limit for protection of human health - not to be exceeded more than 7 times/year	To be derived from data and to be equivalent to Stage 1 limit value	50 $\mu g/m^3$ PM_{10}
		Annual limit for protection of human health	50% until 2005 reducing linearly to 0% by 2010	20 $\mu g/m^3$ PM_{10}

[1] Indicative limit values to be reviewed in the light of further information on health and environmental effects, technical feasibility and experience in the application of Stage 1 limit values in the Member States

Table 1.2 EU Ambient Air Standard - Council Directive 1999/30/EC (S.I. 271 of 2002)

Pollutant	Regulation	Limit Type	Margin of Tolerance	Value
Benzene	2000/69/EC	Annual limit for protection of human health	100% until 2006 reducing linearly to 0% by 2010	5 $\mu g/m^3$
Carbon Monoxide	2000/69/EC	8-hour limit (on a rolling basis) for protection of human health	60% until 2003 reducing linearly to 0% by 2006	10 mg/m^3

Table 1.3 EU Ambient Air Standard - Council Directive 2000/69/EC (S.I. 271 of 2002)

1.3 EXISTING ENVIRONMENT

The proposed facility is located in a rural location approximately 500m from Newport village and 200m from the coastline. The closest residential receptors are a number of properties 400m to the north-west of the site, a property 350m directly south of the site and several properties at the edge of Newport village, 250m southeast of the site boundary.

Rural Ireland, of which the current region is typical, (which in the context of ambient air legislation is defined as rural areas and all towns with populations less than 15,000) is defined under ambient air quality legislation as a "Zone D" region. Zone D regions are considered areas of good air quality which is reflected in the absence of a requirement for continuous air monitoring(12). The current region in which the treatment plant is proposed has no significant air emission sources with the prevailing westerly wind from the Atlantic ensuring that the area experiences low background air concentrations. Existing levels of NO_2, CO and benzene are likely to be very low. PM_{10} may be higher due to sea spray and other natural sources but will be significantly below the ambient air quality standards. In terms of odour, the existing background will be dominated by the influence of the coastal location with sea spray and seaweed imparting a characteristic coastal odour. Although an existing background odour is present, odours are not generally additive i.e. a "new" odour cannot be added to an existing background odour to give a "total" odour. This is a result of the brain's ability to screen out existing odours and detecting a much lower "new" odour against this background. Thus, the existing odour is effectively ignored in the olfactometry assessment(10).

1.3.1 Meteorological Environment

Wind speed is of key importance in dispersing both air and odour pollutants and for low level sources, such as sedimentation tanks and aeration basins, pollutant concentrations are inversely related to wind speed. Thus, odour levels will be greatest under very calm conditions and low wind speeds when movement of air is restricted. The frequency of these conditions is low. Data from the nearest appropriate meteorological station (Belmullet) has been examined to identify the wind field pattern which will be indicative of conditions likely at Newport. For data collated during four representative years (1993, 95-97), the worst-case conditions occurred for approximately 1-2% of the time. The predominant wind directions in the worst-case year (1997) are south-westerly with average wind speeds of approximately 3-5 m/s.

Temperature is an important factor in terms of the rate of chemical and biochemical reactions. As the temperatures increases, oxygen becomes less soluble in water while the rate of biochemical reactions increases (rate of biological uptake and thus oxygen utilization doubles for every 10°C in temperature(13)). Both of these factors lead to faster depletion of dissolved oxygen in summer months. The 30-year average temperatures at Belmullet vary from a low of 5.6°C in February to a high of 14.1°C in August with a long-term mean of 9.6°C.

1.4 CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

Source of Odours in Wastewater Treatment Plants(13-15)

Wastewater has a discernible odour as does its degradation products. The degree to which the odour will cause a problem will depend on:

- The original components,
- The treatment and handling of the wastewater and products, and

- Extent to which they are exposed to the atmosphere.

Fresh Wastewater

The smell of wastewater results from its components which in the present case will generally be domestic sources (toilets, baths, sinks, dishwashers and washing machines). The mixture of odorous chemicals contains a range of aliphatic, aromatic and chlorinated hydrocarbons, derived from cleaning agents used in the home, solvents and odours associated with human waste (urea, ammonia, skatole and indole).

Fresh wastewater has usually sufficient dissolved oxygen (DO) to prevent the generation of anaerobic compounds although oxidation of volatile organic compounds to alcohols, and in turn to aldehydes (which can be further oxidised to carboxylic acid and eventually carbon dioxide and water) and ketones may lead to the formation of odours under even aerobic conditions.

However, fresh wastewater generally does not cause an odour problem unless potential complainants are located very close to discharge points (typically less than 50 metres from the site boundary) or where industrial discharges are important (both of which are not relevant in this case).

Development of Odour At WWTPs

The majority of chemicals associated with odour problems develop in wastewater and waste sludges when they become anaerobic or septic (i.e when all the DO and nitrates have been used). Under anaerobic conditions, various reactions will occur:

- Fermentation of fats, polysaccharides and proteins to produce fatty acids, alcohols, aldehydes, ketones, ammonia, amines, mercaptans and suphides – particularly important in stored sludges and sludge liquors where they may be main source of odours.
- Reduction of sulphates by sulphate-reducing bacteria (SRB) with the production of hydrogen sulphide. Generally sulphate levels may be in the region of 10 - 20 mg/l. Examples where sulphate reduction takes place include rising main sewers, sediments and slimes within tanks, grit channels, primary sedimentation tanks, slimes in high rate or overloaded biological filters, sludge storage tanks and gravity thickeners(14).

A complex range of factors are important in the rate of the two sets of reactions including retention time, temperature, pH value, redox potential, concentration of substrates and nutrients and the concentration of wastewater and sludges.

Potential Releases of Odours at WWTP

The presence of odorous substances in wastewater does not necessarily mean that they will contribute to odour problems because the conditions under which they are transformed from liquid to gas are complicated. The factors which affect the amount of odorous gases released to atmosphere are(13-14):

- The solubility of the dissolved gases,
- Concentration of compounds in the gas and liquid phases,
- Overall volumetric mass-transfer coefficient which is related to the mass transfer coefficient and the interfacial area - the rate of release at points of turbulence is very much greater than from quiescent surfaces,
- Temperature - solubility decreases and the rate of transfer increases with increasing temperature,

- pH – low pH values favour the emission of H_2S, mercaptans and volatile fatty acids, while high pH values favour the emission of ammonia and reduced nitrogeneous compounds.

Examples of locations where there may be significant potential for release of odours are discharge point of rising main sewers, primary tank weirs, free drops of sludge into open holding tanks or over weirs, mechanical sludge thickening and dewatering plant, discharge points of septage sludges and discharge point of sludge liquors(13-14).

Newport Wastewater Treatment Plant

The Newport WWTP is likely to consist of an inlet works prior to aeration in an activated sludge aeration basin. Following secondary sedimentation, sludge may be thickened using a picket fence thickening tank and then dewatered in an enclosed building prior to disposal offsite.

Sewer Network

In rising main sewers, respiration of wastewater and slimes rapidly depletes any dissolved oxygen and nitrates. Thus, sulphate reduction and fermentation may take place within the body of wastewater and on the slimes in the submerged sewer walls leading to odour releases at the discharge points. Designs to minimise odours should minimise the length of pumped sewers and ensure odours cannot escape outside the sewerage system. Design velocities of at least 1.0 m/s in conjunction with the short length of the rising main sewer in Newport (600m) will ensure that solids and grit accumulation in the sewer is reduced and that odour formation will not be a significant issue (13).

Inlet Works

Raw wastewater inlet channels can be a source of odour problems. Odours can be released from the discharge points, channels, screenings and grit removal. Screenings and grit will be odorous during storage and transfer, particularly if not washed after separation. Designs to minimize odours should avoid accumulation of grit and minimize height of discharge points.

Flow Balancing Tank

The flow balancing tank will be used for stormwater flows and thus will not be in operation continually. Provided that the flow balancing tank is clean after discharge of influent, odour emissions should not be significant.

Aeration

Odours are removed from wastewater by adsorption of anaerobic compounds onto sludge floc and through biochemical oxidation. However, the aeration system will also strip odours from the mixed liquor with the off-gases having a characteristic musty odour. Greater stripping of odour is likely with a mechanically aerated plant than a fine bubble diffused air plant. Designs to minimize odours should:

- Ensure adequate aeration and mixing – An adequate concentration of DO must be maintained especially at the point of fresh wastewater entry. Poor mixing can result in organic solids deposition in corners and along edges of the tank.

Secondary Sedimentation Tank

The secondary sedimentation tank is generally low in odour due to the low BOD load in the influent. However, odours can develop faster than primary sedimentation tanks due to the more biologically active, settled mixed liquor. Housekeeping to prevent accumulation of scum on water surface, sludge accumulation on walls and organic matter on effluent weir troughs will minimise odour formation. Withdrawal rates should provide for residence times not exceeding 1.5 – 2 hours to avoid septic conditions in the settled sludge(13).

Sludge Thickening & Dewatering

The amount of hydrogen sulphide and fermentation products generated will increase significantly with time of storage during sludge thickening. Depletion of residual DO occurs very rapidly because the number of micro-organisms in the sludge is several orders of magnitude higher than in wastewater whilst the availability of substrate per unit volume is much greater. The strength of sludge liquors will also increase with time. In order to reduce odour release, the dewatering unit will be contained within an enclosed building with the dewatered sludge transferred to a cover skip.

1.5 PREDICTED IMPACT OF THE PROPOSED DEVELOPMENT

An odour modelling assessment has been carried out based on the specified design. Indicative plant specifications and layout have been assumed based on the specified design and based on similar plants and engineering calculations. Although based on the specified design with assumptions in regard to emission heights (assumed to be at 1.5m) and incorporating worst-case emission factors as outlined in Table 1.4, the modelling will give an estimation of the likely impact of the facility in the surrounding environment.

Indicative Emission Rates

In the absence of specific plant and operational details, accurate emission rates cannot be derived. However, typical emission rates from a wide range of WWTPs are available in the literature and will give an order of magnitude estimate of likely levels at the Newport WWTP. A recent review of over one hundred measurements (Frechen, 2000)(14) is shown in Table 1.4:

WWTP Source	Specific odorant flow rate	
	From (ou/m^{2}h)	To (ou/m^{2}h)
Aerated Grit Chamber	500	20,000
Screenings	1,000	5,000
Sand From Grit Chamber	1,000	6,500
Primary Sedimentation Tank: surface	500	4,000
Primary Sedimentation Tank: weir area	500	5,000
Aeration tank: Anaerobic part	850	3,000
Aeration tank: Aerobic part	300	1,700
Final sedimentation tank	150	500
Primary sludge thickener	12,000	35,000
Stabilised Sludge thickener	500	5,000
Stabilised Sludge, dewatered	600	16,000

Table 1.4 ***Overview of specific odorant flow rates from WWTP sources.***

The range of emission factors above assumes normal conditions at a well operated plant without major industrial influent. However, values outside of this range will occur where poor site management and overloading leads to septic conditions. In addition, some emission sources are particularly difficult to measure accurately. Area source (sedimentation tanks, aeration basins etc) emission factors are generally measured using wind tunnel systems by sweeping air across the surface at a sweep rate of approximately 1800 l/min. However, some literature studies have been sampled using isolation chambers (flux hoods) which have a significantly lower sweep rate (5 – 24 l/min). Comparisons between total odour emission rates using both sampling apparatuses show under-predictions of isolation chambers of up to 300 times in some cases(14).

Process Emissions

Emission sources for the model were based on the specified design supplied by design engineers. Odour emission rates used the highest of the range of values outlined for the specific odorant flow rate in Table 1.4. This is likely to significantly over-estimate the impact of the facility in the surrounding environment. The details of the input parameters are given in Table 1.5.

Emission Source Reference	**Estimated Cross-section area (m^2)**	**Odour Emission Rate ($ou/m^2.s$)**
Aerated Grit Chamber	12	7.4
Screenings	12	1.4
Flow Balancing Tank	110	1.1
Aeration tanks	200	0.47
Final sedimentation tanks	55	0.14
Sludge thickener	25	9.7
Stabilised Sludge, dewatered	200	4.4

Table 1.5 Source Emission Details

Odour Modelling Results

For all averaging periods, the predicted odour concentration is the maximum concentration predicted either at the nearest residential receptor at ground level. Odour emissions have been modelled for several different emission sources on-site which represents the main sources of odour from a well-operated WWTP (see Table 1.6). Emissions from these sources were modelled using the specified design for the proposed sources (as outlined in Table 1.5) and using worst-case estimated emission data (see Table 1.4). Details of the 98th%ile 1-hour mean odour concentrations at the nearest residential receptor and the contribution of each type of source to the overall concentrations are given in Table 1.6. The 98th%ile of 1-hour mean odour concentrations at the nearest residential receptors are listed in Table 1.7.

Stack Reference	**Averaging Period**	**Predicted Odour Concentration (ou/m^3) – Worst-case Receptor**
All Sources	98th%ile of 1-hour means	**0.37**
Grit Channel	98th%ile of 1-hour means	0.02
Screenings	98th%ile of 1-hour means	0.004
Flow Balancing Tank(1)	98th%ile of 1-hour means	0.07
Aeration tanks	98th%ile of 1-hour means	0.05
Final sedimentation tanks	98th%ile of 1-hour means	0.007
Sludge thickener	98th%ile of 1-hour means	0.04
Stabilised Sludge, dewatered	98th%ile of 1-hour means	0.17

(1) Assumed to have an emission rate of a primary sedimentation tank and as a worst-case to be filled[14].

Table 1.6 Dispersion model results – Contributions of each emission source to worst-case odour concentration.

Receptor	**Location**	**Predicted Odour Concentration (ou/m^3)**
		98th %ile of 1-hour Means
1	SE of Site (E 97995 N 294136)	0.36
2	SE of Site (E 97989 N 294128)	0.37
3	SE of Site (E 98184 N 294155)	0.18
4	NW of Site (E 97269 N 294544)	0.08
5	S of Site (E 97657 N 293886)	0.11
6	NW of Site (E 97223 N 294456)	0.13

Table 1.7 Dispersion model results – Predicted odour concentration at worst-case receptors.

The dispersion modelling results presented in Tables 1.6 and 1.7 show that the 98th%ile of mean hourly concentrations is 0.37 ou/m^3 at the worst-case residential receptor, which is located to the southeast of the site. The greatest contribution to the overall odour emissions from the Newport WWTP at the worst-case residential receptor occurs from the sludge thickener and dewatering unit, aeration basin and flow balancing tank, with relatively minor contributions from the other sources. As the overall 98th%ile of 1-hour mean concentrations is significantly below the 4 ou/m^3 assessment criteria which would give rise to nuisance(9), it is unlikely that odour emissions from the facility will cause a nuisance at the nearest residential receptor.

Concentration Contours

The geographical variation in ground level odour concentrations is illustrated as concentration contour in Figure 1.2 below:

Figure 1.2 Predicted 98th Percentile of Mean Hourly Odour Concentrations.

The concentrations listed in Table 1.6 and 1.7 are for the maximum odour concentrations to be predicted at any of the nearest residential receptors off-site. All other residential receptors are below these values. The maximum concentrations are generally observed to the southeast of the site. The concentration contours show where the maximum concentrations are predicted to occur and the reduction in concentration with distance away from the maximum.

Impact On General Air Quality

The primary impact on air quality will be the release of odour from the WWTP process and NO_2, PM_{10} and benzene emissions from vehicles travelling to and from the facility. The existing baseline concentration of these pollutants is significantly below the ambient air quality limit values (as the site is located in a "Zone D" region). The additional impact of site traffic will lead to an insignificant increase in the levels of NO_2, PM_{10} and benzene emissions. Thus, the cumulative impact of the baseline concentration and the additional concentration due to site traffic will lead to levels which are still significantly below the ambient air quality limit values as outlined in S.I. 271 of 2002. Thus, the impact of the scheme in terms of general air quality is not significant.

1.6 REMEDIAL OR REDUCTIVE MEASURES

In general, odour control is accomplished in a sewage disposal works by proper operation of the various processes to ensure that the sewage is maintained in a fresh, aerobic condition throughout the treatment system. Some specific measures which can be implemented to ensure odour nuisance does not occur, are outlined below:

- Preliminary treatment processes should be cleaned frequently to remove any accumulated organic debris.
- Velocities of greater than 0.2m/s through grit chambers should be maintained to avoid deposition of organic solids with the grit(13).
- Regular cleaning of channels and general maintenance should be carried out.
- Flow balancing tank should be cleaned after discharge of influent.
- A scraper to remove scum on the surface of the sedimentation tanks should be incorporated into the design.
- The retention time in the sludge thickening tank should be minimised to prevent odour formation.
- A significant reduction in odour release can be achieved by minimising the height of drops over weirs and into tanks and channels or by selective covering at these locations. Installing a cover over weirs allows gaseous contaminants to accumulate in the headspace and thus retard emissions by reducing the concentration driving force. This can account for a reduction of three fold in primary sedimentation tanks(13).

1.7 RESIDUAL IMPACTS

No residual impacts are envisaged.

1.8 IMPACTS AND MITIGATION DURING THE CONSTRUCTION PHASE

Predicted Impacts of Construction

Construction activities are likely to generate some dust emissions in the vicinity of the proposed development. Construction vehicles, generators etc., may also give rise to NO_2, PM_{10}, CO_2 and N_2O emissions. However, the implementation of the dust minimisation plan in addition to the absence of nearby receptors (the distance to the nearest receptor is greater than 250m) should lead to no significant impact on sensitive receptors during the construction phase of the project.

Construction Mitigation Measures

A dust minimisation plan should be formulated for the construction phase of the project (detailed in Appendix 1.3).

Residual Impacts

Once the dust minimisation plan is implemented, the residual impact of construction on air quality will not be significant.

1.9 CONCLUSION

Provided that the proposed wastewater treatment plant is designed and operated as specified the development should not have a significant impact on the environment with respect to odour emissions.

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APPENDIX 1.1

Odour Perception & Characterisation

Odours are sensations resulting from the reception of a stimulus by the olfactory sensory system, which consists of two separate subsystems: the olfactory epithelium and the trigeminal nerve. The olfactory epithelium, located in the nose, is capable of detecting and discriminating between many thousands of different odours and can detect some of them in concentrations lower than those detectable by currently available analytical instruments(13). The function of the trigeminal nerve is to trigger a reflex action that produces a painful sensation. It can initiate protective reflexes such as sneezing to interrupt inhalation. The olfactory system is extremely complex and peoples' responses to odours can be variable. This variability is the result of differences in the ability to detect odour; subjective acceptance or rejection of an odour due to past experience; circumstances under which the odour is detected; and the age, health and attitudes of the human receptor. The perception of odour is complex and a number of properties of odour need to be considered including:

- the intensity of the odour,
- the odour character,
- the hedonic tone and
- the frequency of occurrence of the odour.

Odour intensity is a measure of the strength of the odour sensation and is related to the odour concentration. However, this relationship is logarithmic in nature. Thus, if the concentration of the odour increases tenfold, the perceived increase in intensity will be by a much smaller amount. The odour threshold refers to the minimum concentration of an odorant that produces an olfactory response or sensation. This threshold is normally determined by an odour panel consisting of a specified number of people, and the numerical result is typically expressed as occurring when 50% of the panel correctly detect the odour. The odour threshold is not a precisely determined value, but depends on the sensitivity of the odour panellists and the method of presenting the odour stimulus to the panellists. An odour detection threshold relates to the minimum odorant concentration required to perceive the existence of the stimulus, whereas an odour recognition threshold relates to the minimum odorant concentration required to recognise the character of the stimulus. Typically, the recognition threshold exceeds the detection threshold by a factor of 2 to 10(13,16).

The character of an odour distinguishes it from another odour of equal intensity whereas the hedonic tone of an odour relates to its pleasantness or unpleasantness. Odours are characterised on the basis of odour descriptor terms (e.g. putrid, fishy, fruity etc.). Odour character is evaluated by comparison with other odours, either directly or through the use of descriptor words. When an odour is evaluated in the laboratory for its hedonic tone in the neutral context of an olfactometric presentation, the panellist is exposed to a stimulus of controlled intensity and duration. The degree of pleasantness or unpleasantness is determined by each panellist's experience and emotional associations. The responses among panellists may vary depending on odour character; an odour pleasant to many may be declared highly unpleasant by some.

In terms of frequency of occurrence of the odour, several time-dependent characteristics are of importance:

- Total duration of impact,
- Rhythm of impact,
- Frequency of impact,

- Time of day / week / year.

Adaptation, or olfactory fatigue, is a phenomenon that occurs when people with a normal sense of smell experience a decrease in perceived intensity of an odour if the stimulus is received continually. Adaptation to a specific odorant typically does not interfere with the ability of a person to detect other odours. Another phenomenon known as habituation or occupational anosmia occurs when a worker in an industrial situation experiences a long-term exposure and develops a higher threshold tolerance to the odour.

APPENDIX 1.2

Description of the AERMOD Model

The AERMOD dispersion model has been recently developed in part by the U.S. Environmental Protection Agency (USEPA)(11). The model is a steady-state Gaussian model used to assess pollutant concentrations associated with industrial sources. The model is an enhancement on the Industrial Source Complex-Short Term 3 (ISCST3) model which has been widely used for emissions from industrial sources. The Proposed Determination 2000 Federal Register Part II (Guidelines on Air Quality Models) has proposed that AERMOD (earlier version of AERMOD without the PRIME algorithm) become the preferred model for a refined analysis from industrial sources, in all terrains(1). A ruling by the USEPA on this proposal is due shortly.

Improvements over the ISCST3 model include the treatment of the vertical distribution of concentration within the plume. ISCST3 assumes a Gaussian distribution in both the horizontal and vertical direction under all weather conditions. AERMOD with PRIME, however, treats the vertical distribution as non-Gaussian under convective (unstable) conditions while maintaining a Gaussian distribution in both the horizontal and vertical direction during stable conditions. This treatment reflects the fact that the plume is skewed upwards under convective conditions due to the greater intensity of turbulence above the plume than below. The result is a more accurate portrayal of actual conditions using the AERMOD model. AERMOD also enhances the turbulence of night-time urban boundary layers thus simulating the influence of the urban heat island.

In contrast to ISCST3, AERMOD is widely applicable in all types of terrain. Differentiation of the simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions. In the dividing-streamline concept, flow below this height remains horizontal, and flow above this height tends to rise up and over terrain. Extensive validation studies have found that AERMOD (precursor to AERMOD with PRIME) performs better than ISCST3 for many applications and as well or better than CTDMPLUS for several complex terrain data sets(17).

Due to the proximity to surrounding buildings, the PRIME (Plume Rise Model Enhancements) building downwash algorithm has been incorporated into the model to determine the influence (wake effects) of these buildings on dispersion in each direction considered. The PRIME algorithm takes into account the position of the stack relative to the building in calculating building downwash. In the absence of the building, the plume from the stack will rise due to momentum and/or buoyancy forces. Wind streamlines act on the plume leads to the bending over of the plume as it disperses. However, due to the presence of the building, wind streamlines are disrupted leading to a lowering of the plume centreline.

When there are multiple buildings, the building tier leading to the largest cavity height is used to determine building downwash. The cavity height calculation is an empirical formula based on building height, the length scale (which is a factor of building height & width) and the cavity length (which is based on building width, length and height). As the direction of the wind will lead to the identification of differing dominant tiers, calculations are carried out in intervals of 10 degrees.

In PRIME, the nature of the wind streamline disruption as it passes over the dominant building tier is a function of the exact dimensions of the building and the angle at which the wind approaches the building. Once the streamline encounters the zone of influence of the building, two forces act on the plume. Firstly, the disruption caused by the building leads to increased turbulence and enhances horizontal and vertical dispersion. Secondly, the streamline descends in the lee of the building due to the reduced pressure and drags the plume (or part of) nearer to the ground, leading to higher ground level concentrations. The model calculates the descent of the plume as a function of the building shape and, using a numerical plume rise model, calculates the change in the plume centreline location with distance downwind.

The immediate zone in the lee of the building is termed the cavity or near wake and is characterised by high intensity turbulence and an area of uniform low pressure. Plume mass captured by the cavity region is re-emitted to the far wake as a ground-level volume source. The volume source is located at the base of the lee wall of the building, but is only evaluated near the end of the near wake and beyond. In this region, the disruption caused by the building downwash gradually fades with distance to ambient values downwind of the building.

AERMOD has made substantial improvements in the area of plume growth rates in comparison to ISCST3(1). ISCST3 approximates turbulence using six Pasquill-Gifford-Turner Stability Classes and bases the resulting dispersion curves upon surface release experiments. This treatment, however, cannot explicitly account for turbulence in the formulation. AERMOD is based on the more realistic modern planetary boundary layer (PBL) theory which allows turbulence to vary with height. This use of turbulence-based plume growth with height leads to a substantial advancement over the ISCST3 treatment.

Improvements have also been made in relation to mixing height(1). The treatment of mixing height by ISCST3 is based on a single morning upper air sounding each day. AERMOD, however, calculates mixing height on an hourly basis based on the morning upper air sounding and the surface energy balance, accounting for the solar radiation, cloud cover, reflectivity of the ground and the latent heat due to evaporation from the ground cover. This more advanced formulation provides a more realistic sequence of the diurnal mixing height changes.

AERMOD also contains improved algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed may be less than 1 m/s, but still greater than the instrument threshold.

Meteorological Data - AERMET Pro

AERMOD incorporates a meteorological pre-processor AERMET PRO(2). AERMET PRO allows AERMOD to account for changes in the plume behaviour with height. AERMET PRO calculates hourly boundary layer parameters for use by AERMOD, including friction velocity, Monin-Obukhov length, convective velocity scale, convective (CBL) and stable boundary layer (SBL) height and surface heat flux. AERMOD uses this information to calculate concentrations in a manner that accounts for changes in dispersion rate with height, allows for a non-Gaussian plume in convective conditions, and accounts for a dispersion rate that is a continuous function of meteorology.

The AERMET PRO meteorological pre-processor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. A morning sounding from a representative upper air station, latitude, longitude, time zone, and wind speed threshold are also required.

Two files are produced by AERMET PRO for input to the AERMOD dispersion model. The surface file contains observed and calculated surface variables, one record per hour. The profile file contains the observations made at each level of a meteorological tower, if available, or the one-level observations taken from other representative data, one record level per hour.

From the surface characteristics (i.e. surface roughness, albedo and amount of moisture available (Bowen Ratio)) AERMET PRO calculates several boundary layer parameters that are important in the evolution of the boundary layer, which, in turn, influences the dispersion of pollutants. These parameters include the surface friction velocity, which is a measure of the vertical transport of horizontal momentum; the sensible heat flux, which is the vertical transport of heat to/from the surface; the Monin-Obukhov length which is a stability parameter relating the surface friction velocity to the sensible heat flux; the daytime mixed layer height; the nocturnal surface layer height and the convective velocity scale which combines the daytime mixed layer height and the sensible heat flux. These parameters all depend on the underlying surface.

The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use type was carried out to a distance of 3km from the source location in line with USEPA recommendations(13). In relation to wind direction, a minimum sector arc of 30 degrees is recommended. In the current model, the surface characteristics for the site were assessed and two sectors identified with distinctly varying land use characteristics.

Surface roughness

Surface roughness length is the height above the ground at which the wind speed goes to zero. Surface roughness length is defined by the individual elements on the landscape such as trees and buildings. In order to determine surface roughness length, the USEPA recommends that a representative length be defined for each sector, based on an area-weighted average of the land use within the sector, by using the eight land use categories outlined by the USEPA. The area-weighted surface roughness length derived from the land use classification within a radius of 3km from the site is shown in Table A1.

Sector	**Area Weighted Land Use Classification**	**Spring**	**Summer**	**Autumn**	**Winter(1)**
310 - 90	1.0 (grassland)	0.05	0.10	0.01	0.01
90 - 140	0.7 (grassland) + 0.3 (urban)	0.307	0.37	0.35	0.35
140 - 220	1.0 (grassland)	0.05	0.10	0.01	0.01
220 - 310	0.5 (grassland) + 0.5 (water)	0.025	0.05	0.005	0.005

(1) Winter defined as periods when surfaces covered permanently by snow whereas autumn is defined as periods when freezing conditions are common, deciduous trees are leafless and no snow is present (Iqbal (1983))(3). Thus for the current location autumn more accurately defines "winter" conditions at Newport.

Table A1 Surface Roughness based on an area-weighted average of the land use within a 3 km radius of Newport, Co. Mayo.

ALBEDO

Noon-time Albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. Albedo is used in calculating the hourly net heat balance at the surface for calculating hourly values of Monin-Obuklov length. The area-weighted albedo derived from the land use classification within a radius of 3km from the site is shown in Table A2.

Sector	**Area Weighted Land Use Classification**	**Spring**	**Summer**	**Autumn**	**Winter(1)**
310 - 90	1.0 (grassland)	0.18	0.18	0.20	0.20
90 - 140	0.7 (grassland) + 0.3 (urban)	0.168	0.175	0.194	0.194
140 - 220	1.0 (grassland)	0.18	0.18	0.20	0.20
220 - 310	0.5 (grassland) + 0.5 (water)	0.15	0.14	0.17	0.17

(1) Winter defined as periods when surfaces covered permanently by snow whereas autumn is defined as periods when freezing conditions are common, deciduous trees are leafless and no snow is present (Iqbal (1983))(3). Thus for the current location autumn more accurately defines "winter" conditions at Newport.

Table A2 Surface Roughness based on an area-weighted average of the land use within a 3 km radius of Newport, Co. Mayo.

BOWEN RATIO

The Bowen ratio is a measure of the amount of moisture at the surface of the earth. The presence of moisture affects the heat balance resulting from evaporative cooling which, in turn, affects the Monin-Obukhov length which is used in the formulation of the boundary layer. The area-weighted Bowen ratio (wet) derived from the land use classification within a radius of 3km from the site is shown in Table A3.

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[1]
310 - 90	1.0 (grassland)	0.30	0.40	0.50	0.50
90 - 140	0.7 (grassland) + 0.3 (urban)	0.36	0.58	0.65	0.65
140 - 220	1.0 (grassland)	0.30	0.40	0.50	0.50
220 - 310	0.5 (grassland) + 0.5 (water)	0.20	0.25	0.30	0.30

(1) Winter defined as periods when surfaces covered permanently by snow whereas autumn is defined as periods when freezing conditions are common, deciduous trees are leafless and no snow is present (Iqbal (1983))[3]. Thus for the current location autumn more accurately defines "winter" conditions at Newport.

Table A3 Surface Roughness based on an area-weighted average of the land use within a 3 km radius of Newport, Co. Mayo.

APPENDIX 1.3

Dust Minimisation Plan

A dust minimisation plan will be formulated for the construction phase of the project, as construction activities are likely to generate some dust emissions. The potential for dust to be emitted depends on the type of construction activity being carried out in conjunction with environmental factors including levels of rainfall, wind speeds and wind direction. The potential for impact from dust depends on the distance to potentially sensitive locations and whether the wind can carry the dust to these locations. The majority of any dust produced will be deposited close to the potential source and any impacts from dust deposition will typically be within several hundred metres of the construction area.

In order to ensure that no dust nuisance occurs, a series of measures will be implemented. Site roads shall be regularly cleaned and maintained as appropriate. Hard surface roads shall be swept to remove mud and aggregate materials from their surface while any un-surfaced roads shall be restricted to essential site traffic only. Furthermore, any road that has the potential to give rise to fugitive dust must be regularly watered, as appropriate, during dry and/or windy conditions.

Vehicles using site roads shall have their speed restricted, and this speed restriction must be enforced rigidly. Indeed, on any un-surfaced site road, this shall be 20 km per hour, and on hard surfaced roads as site management dictates.

All vehicles exiting the site shall make use of a wheel wash facility, preferably automatic, prior to entering onto public roads, to ensure mud and other wastes are not tracked onto public roads. Public roads outside the site shall be regularly inspected for cleanliness, and cleaned as necessary.

Material handling systems and site stockpiling of materials shall be designed and laid out to minimise exposure to wind. Water misting or sprays shall be used as required if particularly dusty activities are necessary during dry or windy periods.

At all times, the procedures put in place will be strictly monitored and assessed. In the event of dust emissions occurring outside the site boundary, movement of these soils will be immediately terminated and satisfactory procedures implemented to rectify the problem before the resumption of the operations.

The dust minimisation plan shall be reviewed at regular intervals during the construction phase to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust through the use of best practise and procedures.