Attachment 7.1.3.2 – Impact Assessment of Emissions/Discharges

1.0 INTRODUCTION

AWN Consulting Ltd. (AWN) was appointed by AbbVie Ireland NL B.V. to complete a Receiving Environment Report for their proposed Industrial Emissions (IE) licenced facility in Ballytivnan Sligo. This report is to accompany an application for a new IE licence.

This report was completed in accordance with the *Environmental Protection Agency's (EPA) Licence Application Form Guidance – Industrial Emissions (IE), Integrated Pollution Control (IPC) and Waste.*

1.1 Description of Site

The facility at Ballytivnan is located approximately 1.7 km north east of Sligo town centre. The site is also located approximately 1 km from another AbbVie facility on the Manorhamilton Road established in 2002. The locations of both facilities are shown on Drawing 001.

The purpose of this development is to design a facility to manufacture special medicines for treating illnesses (like cancer) in a highly controlled and contained environment. The main process includes the linking of a bio-pharmaceutical molecule to a cytotoxic molecule providing effective delivery of the medicine within the patient.

The project will consist of internal demolition of part of the existing redundant manufacturing facility which is located to the west of the new Warehouse to make way for the proposed bio-chemical pharmaceutical suite.

1.2 Limitations of the Report

The conclusions presented in this report are professional opinions based solely on the tasks outlined herein and the information made available to AWN. They are intended for the purpose outlined herein and for the indicated site and project. Furthermore, this report is produced solely for the benefit of AbbVie Ireland NL B.V. to address an Environmental Protection Agency (EPA) requirement for their licence.

This report may not be relied upon by any other party without explicit agreement from AWN. Opinions and recommendations presented herein apply to the site conditions existing at the time of the recently completed field work and subsequent assessment. They cannot apply to changes at the site of which AWN is not aware and has not had the opportunity to evaluate. This report is intended for use in its entirety; no excerpt may be taken to be representative of this baseline assessment. All work carried out in preparing this report has utilized and is based on AWN professional knowledge and understanding of the current relevant Irish and European Community standards, codes and legislation.

2.0 IMPACT TO SURFACE WATER

2.1 Surface Water Environment

The proposed development site is located within the Western River Basin District (WRBD) in Hydrometric Area No. 35 of the Irish River Network. The First Cycle WRBD Management Plan (2009-2015) is to be superseded by Second Cycle River Basin Management Plan (2018-2021) and has recently completed public consultation in August 2017. The new River Basin Management Plan defines a single national river basin district. This has been broken down into 46 catchment management units, which are further sub-divided into 583 sub-catchments. These 583 sub-catchments contain a total of 4,832 water bodies ranging from 3 to 15 water bodies in each sub-catchment. The Western River Management Plan defines that the area of the proposed development is within the Sligo Bay & Drowse catchment and the Bonet sub-catchment.

The Willsborough Stream is located close to the north western boundary of the AbbVie site. The Lisnalurg Stream, a tributary of the Willsborough is 280m to the west. The largely culverted Shannon Eighter Stream is >50m to the south of the site.

The site is not located within a Special Area of Conservation (cSAC) or Specially Protected Area (SPA). The nearest SAC and SPA is Cummeen Strand/Drumcliff Bay (Sligo Bay) located approximately 0.7 km away from the proposed development

There are no natural watercourses occurring within the proposed development site as shown in Figure 1 below. The nearest watercourse is the Willsborough Stream and Shannon Eighter. The Shannon Eighter flows along half of the eastern site boundary and then enters a culvert located at the south-eastern corner of the site which is located less than 50m away from the subject site.

Figure 1 *Hydrological Environment Map (source www.gsi.ie, 2018)*

2.1.1 Ecologically Designated Sites

The Geological Society of Ireland (GSI) and National Parks and Wildlife Service (NPWS) on-line databases presently list no ecological designated areas within or immediately adjacent to the proposed development site. The Lough Gill (site code: 0001976 SAC & site code: 004035 SPA) SAC (Special Area of Conservation) & SPA (Special Protection Area) is located approx. 1 km to the west and southwest of the proposed development site. This area is also a proposed Natural Heritage Areas (pNHA), with a site code 000627 - Cummeen Strand/Drumcliff Bay (Sligo Bay).

2.1.2 Regional Surface Water Quality

The proposed development is located within the WRBD, as defined under the European Communities Directive 2000/60/EC, establishing a framework for community action in the field of water policy, (commonly known as the Water Framework Directive [WFD]). The WFD requires ‘Good Water Status’ for all European waters by 2015, to be achieved through a system of river basin management planning and extensive monitoring. ‘Good status’ means both ‘Good Ecological Status’ and ‘Good Chemical Status’. In 2009, the ERBD River Management Plan (RMP) 2009-2015 was published. In the WRBD RMP, the impacts of a range of pressures were assessed including diffuse and point pollution, water abstraction and morphological pressures (e.g. water regulation structures). The purpose of this exercise was to identify water bodies at risk of failing to meet the objectives of the WFD by 2015 and include a programme of measures to address and alleviate these pressures by 2015.

The strategies and objectives of the WFD in Ireland have influenced a range of national legislation and regulations. These include the following:

- Statutory Instrument (SI) No. 293 of 1988 European Communities (Quality of Salmonid Waters) Regulations 1988;
- Local Government (Water Pollution) Acts 1977-1990;
- SI No. 258 of 1988 Water Quality Standards for Phosphorus Regulations 1998; and
- SI No. 272 of 2009 European Communities Environmental Objectives (Surface Waters) Regulations 2009.

In accordance with the WFD, each river catchment within the WRBD was assessed and a water management plan detailing the programme of measures was put in place.

Q-Values are used by the EPA to express biological water quality, based on changes in the macro invertebrate communities of riffle areas brought about by organic pollution. Table 1 below summarises an explanation of the ratings; for example, Q1 indicates a seriously polluted water body while Q5 indicates unpolluted water of high quality.

Quality Ratings (Q)	Status	Water Quality	Key
Q5, Q4-5	High	Unpolluted	
Q4	Good	Unpolluted	
Q3-4	Moderate	Slightly Polluted	
Q3, Q2-3	Poor	Moderately Polluted	
Q2, Q1-2, Q1	Bad	Seriously Polluted	

Table 1 *EPA Biological Q Ratings & Key*

Entity Name	Willsborough Stream		
Station Name:	Bridge W of Willsborough	1.5 km W.S.W. of Willsborough	Bridge on Sligo-Bundoran Road
Station ID:	RS35W010150	RS35W010200	RS35W010300
WFD CODE:	IE_EA_35W010150	IE_EA_35W010200	IE_EA_35W010300
Type of water monitored:	River Water	River Water	River Water
River Basin District:	WRBD	WRBD	WRBD
Station Type (WFD):	Operational	Operational	Operational
Easting:	171207.22	169972	169258.31
Northing:	338306.55	337947	337375.33
Last Q Year:	2015	1990	2015
Last Q Value:	4	4	4
Q Legend:	Good	Good	Good
Q Linear Value:	4	4	4

Table 2 *EPA sampling locations for the Willsborough Stream*

Available data for 2015 from the EPA on-line mapping database EPA Maps is presented in Table 2 together with the most recent Q-Value for the watercourse at the locations closest to the site. Figure 2 presents the river catchment map and water quality status (including current EPA monitoring stations).

Figure 2 *River Catchment Map & Quality (EPA, 2018) (Site Location Red Cross).*

The values listed above are for monitoring stations located both upstream and downstream of the subject site. The downstream monitoring location (RS35W010300) has a Q Linear Value of 4 (*'Good Status'*), this is similar to the upstream monitoring location (RS35W010150) which also has a Q Linear Value of 4 (*'Good Status'*). The linear value takes into account the current and previous Q-values to determine the expected Q-value for next year. The Willsborough Stream is classified as being 'Not At Risk of Achieving Good Status". The WFD status (2010-2015) is designated as Good.

EPA's *Envision* Database was also consulted to determine if any designated salmonid waters (S.I. 293/1988-European Communities (Quality of Salmonid Waters) Regulations, 1988) existed close to the site or are located so that they may be adversely impacted by the proposed development or operation of the facility. The Willsborough Stream was previously not included in the register of salmonid waters included in those regulations.

2.1.3 Flooding

In accordance with the guidelines produced by the Department of the Environment, Heritage and Local Government (DoEHLG) - The Planning System and Flood Risk Management (FRM) Guidelines for Planning Authorities, November 2009, a Stage 1 assessment has been carried out and is submitted as part of this planning application.

No historic flooding of the site has been identified from the Office of Public Works (OPW) floodmaps.ie website. Soil maps were researched and indicated that the site was not underlain by alluvium soils therefore indicating that, historically flooding has not occurred onsite. Catchment Flood Risk Assessment and Management Preliminary Flood Risk Assessment (CFRAM PFRA) and Fluvial Flood Extent maps conclusively indicate that the site majority resides within Flood Zone C and is not at risk of flooding from any modelled flood event. A small proportion of the north-eastern and eastern boundary is modelled as having an impact by the 1 in 10 (10% AEP) year flood event which indicates that some of the existing development resides in Flood Zone A. This is due to the partly culverted Shannon Eighter watercourse located at the south-eastern boundary. The Shannon Eighter is susceptible to flooding due to the capacity of the culvert during periods of heavy rainfall and high tides. No flooding has been recorded on the site since the facility has been built in 1970's.

In keeping with the Stage 1 assessment, the review of available information has identified no flood hazards for the proposed works at the proposed development site therefore; in accordance with The Planning System and Flood Risk Management Guidelines for Planning Authorities, there is no requirement to proceed to the Stage 2 or 3 assessments. The proposed redevelopment is found within Flood Zone C, with a small proportion residing within existing development area in Flood Zone A. The development is considered a "Less Vulnerable Development" due to the nature of the development, e.g. buildings used for industrial and non-residential institutions. The proposed development is primarily within the envelope of the existing development. There is no increase in hardstanding (0%). The proposed development works are located within Flood Zone C and are suitable development for this flood zonation. As a result, there is no expected measurable increase in run-off as a result of this development. During the reworking for the temporary contractor car park, a soil berm will be moved to the southern boundary of the site which is located within Flood Zone C.

The existing drainage systems along with those proposed ensures appropriate drainage for the site. There is inconsequential increase in hardstanding area, therefore no resultant measurable increase in surface run-off.

2.2 Potential Impacts to Surface Water Environment

The proposed development is an internal conversion within the existing AbbVie facility which has been in operation since early 2013 and was previously (1970's) the site of an Abbott Nutrition manufacturing plant. Stormwater discharges via 4 no. hydrocarbon interceptors at 3 no. discharge points into a drainage ditch along the eastern and southern boundary of the site. Each of the discharge points has a manhole to allow for visual inspection on a weekly basis. The locations of these discharge points are shown on Drawing 008.

The existing on-site stormwater drainage network currently covers the entire site (including the proposed location of the development) and collects rainwater runoff from three distinct catchment areas;

- Site roads;
- Car Park areas;
- Building roofs.

Mostly internal modification will be undertaken for the proposed development, so the overall discharge will be similar to the current stormwater discharge in terms of flow and quality.

A Class 1 full retention interceptor will be installed on the stormwater drainage line draining the area around the bulk diesel storage tank as is required.

2.2.1 Management of Fuels, Chemicals and Wastes

A full list of chemicals and their hazard statements is compiled and is presented in Attachment 4-6-2 in Section 4 of this IE licence application.

The majority of the hazardous chemicals that are or will be stored on site are stored in small quantities in drums and bottles. These will be stored in designated areas within the Warehouse or in the existing self-bunded external chemstores.

Table 3 presents the bulk hazardous chemicals to be stored on site which have potential to impact on water quality. Whilst the high high strength wastewater does not carry an H400+ hazard statement it will contain cytotoxins which are highly toxic and mutagenic. As such, the high high strength wastewater has been included in this assessment.

Chemical	Units	Maximum Storage Quantity	Storage Container	Storage Location	Hazard Statements
Diesel	Litres	10,000	Double skinned belly tank	Under Reserve Generator	H351, H304, H332, H315, H373, H226, H411,
High High Strength Waste Water	Litres	60,000	Sunken bunded bulk tank	Beside Main Building	Cyto-toxins (H300, H301, H311, H331, H341, H351, H361)
High High Strength Waste Water	Litres	7,000	Sunken bunded sump tank	Beside Main Building	Cyto-toxins (H300, H301, H311, H331, H341, H351, H361)

Table 3 *Bulk Materials and Corresponding Hazard Statements*

Bulk storage of diesel will be stored within a 10m^3 double skinned belly tank integrated with the back-up generator. The tank will be equipped with leak detection.

The high high strength wastewater will also be stored in a 7m^3 stainless steel, sunken bunded sump tank and a 60m^3 stainless steel, bunded bulk tank located beside the main building. Details of the bunds are provided in Attachment 4.8.1 Operational Report. In the event of a spill into the bund, the wastewater would be tested and pumped out into the appropriate tank.

All process materials, product and chemicals will be delivered to the site in tamper proof and/or lockable containers or tankers, which are approved for transport use.

Trolleys and carts will be used for all material movements within the facility. Separate trolleys/ carts will be used for the general circulation areas as opposed to the individual processing rooms. Each individual processing room will have dedicated trolleys/ carts which will stay within the relevant rooms and will only travel to the individual room material air locks (MAL) to receive materials. Single use mixers (SUM) and totes will also be used for movement of materials and single use components around the process areas.

Diesel fuel oil will be delivered to the site by HGV road tankers approximately every 6 months. A dedicated tanker set-down area will be provided for use during deliveries. All deliveries will be supervised, and any spill will be addressed using designated spill kits by trained personnel.

Bulk chemical storage at the new facility including the external diesel tank and the high and low strength wastewater tanks will be bunded (wastewater tanks) or double lined (diesel belly tank). In the event of a spillage, drainage from bunded areas shall be inspected and diverted for collection and safe disposal if required. Drainage from unloading facility for diesel trucks and for transfer area for wastewater tanker is also diverted for collection and safe disposal.

Liquid Nitrogen and LPG will also be stored in bulk tanks external to the buildings however these do not require bunding and will vaporise in the event of a leak.

All proposed tanks, bunded storage and pipelines have been designed for their specific purpose and their contents. As required the structures will be rendered impervious to the materials stored therein. Tanks will be stored in bunds meeting the requirements of Agency guidelines on the “Storage and Transfer of Materials for Scheduled Activities”.

With respect to integrity testing all bulk tanks, bunds and pipelines are new structures. As such no integrity testing of these structures has been carried out to date. It is anticipated that all bunds will be tested in accordance with standard licence requirements (testing is required typically every 3 years). Integrity testing will be completed in accordance with BS8007 “Code of Practice for design of concrete structures for retaining aqueous liquids” i.e. bunds will be demonstrated to be capable of holding 110% of the capacity of the largest tank or drum within the bunded area or 25% of the total volume of substances stored within the bund (whichever the larger).

Individual chemical type storage details are provided in Attachment 4.8.1 Operational Report.

As such, it is very unlikely that any of the chemicals stored onsite will become entrained in the stormwater run-off. Hydrocarbons and sediment from road run-off will be managed through the use of hydrocarbon interceptors as described in Section 2.2.2 below.

2.2.2 Management of Run-off

Stormwater from the site arises from buildings run-off, car-parks, roadways, service yards and other developed areas of the site. There are 3 no. discharge locations which drain to the east (2 no.) and south (1 no.) of the site i.e. SW1, SW2, and SW3. These discharge points drain via hydrocarbon interceptors before combining in the outfall of the plant to the Shannon Eighter watercourse. Drawing no. 008 shows the drainage layout.

The proposed facility will be served by the current stormwater drainage network. There is no increase in hardstanding area (0% change), therefore there is no measurable increase in stormwater run-off.

The existing hydrocarbon interceptors will prevent discharge of oils/fuels which may potentially be present in stormwater run-off from the car park and main building areas. A Class 1 full retention interceptor will be installed on the stormwater drainage line draining the area around the bulk diesel storage tank as is required.

A proposed dedicated fire water system will collect fire water arising within the new biochemical manufacturing area.

2.2.3 Impact to Surface Water Environment

The proposed development will not have a significant impact on the quality of the receiving surface water bodies as further discussed in Attachment 7.1.3.3 Receiving Environment Report. There is a very low risk of Principle Pollution Substances being discharged from the facility via the stormwater network due to the stringent controls and procedures in place to prevent and minimize spills.

3.0 IMPACT TO SEWER

3.1 Emissions to Sewer

The emissions to sewer from the current facility are primarily sanitary, domestic foul and canteen wastewater (32.6m^3/day).

The proposed development will include the addition of Low Strength wastewater to the emissions to sewer. Low Strength wastewater is process specific waste including reject water from water purification systems, boilers and cooling towers blowdown, and wastewater from non-product contact equipment. The anticipated maximum daily volume of low strength wastewater will be 180m^3/day.

The proposed development will also produce high high strength wastewater which is waste from high containment areas or waste which has been identified that may contain some toxin or other harmful substances. This waste is considered hazardous and is not suitable for treatment by conventional WWT (Waste Water Treatment) technology. As such, it will be stored separately in the high high strength wastewater tank and will be tankered offsite for incineration. There will be no discharge of high high strength wastewater to sewer.

Low Strength wastewater will initially be routed, primarily by gravity, to a bunded $10m^3$ sump tank, from where it will be pumped to a bunded $30m^3$ tank, both within a sunken bund.

The Low Strength wastewater will be sampled and will generally be sent to the foul sewer (municipal waste water treatment). The facility includes for pH and temperature adjustment should there be a need for this before discharge. The waste can also be pumped into the high high strength wastewater tank or to a road tanker if there is ever a concern about the possibility of contamination of the waste. The locations of all low strength and high high strength sumps and tanks are shown on Drawing 007.

The main characteristics of the wastewater are presented in Table 4.

Description	Max values per day (kg unless otherwise noted)	Max Concentration (mg/l unless otherwise stated)
Flow	180 (m^3/day)	-
BOD	61	377
COD	97	599
Total phosphorous	11	68
Total Nitrogen	2	12
Chlorides	18	6000

Table 4. *Wastewater Characteristics*

Due to the nature of the process there will be very infrequent high concentrations of chloride in the wastewater stream. These peaks will occur only during re-generation of the water conditioning skids and the total contribution to the sewer will be minimal.

Small quantities of sulphate, detergents, and oils fats and greases (OFG) may also be present.

It is not anticipated that any significant concentrations of List I or List II substances, as listed in the Annex to European Union (EU) Directive 2006/11/EC (as amended) will be contained in any emission to sewer from the site.

3.1.1 Wastewater Monitoring

Treated wastewater from the low strength wastewater tank will be routed to a wastewater monitoring cabinet. Continuous monitoring of certain wastewater discharge parameters (e.g. pH, temperature) will be performed at this wastewater monitoring station. This station will also be equipped with a composite grab sampler to allow for collection of compliance-related samples.

3.1.2 Shut-off Valve

There is a shutoff valve located downstream from the monitoring cabinet for potential breaches of the licence limits. If the licence limits are breached, the wastewater is recirculated back to the 30m^3 tank. It should be noted that the shut-off valve can recirculate the low strength wastewater only and is located downstream of the monitoring cabinet before the wastewater combines with the domestic sanitary wastewater for discharge to SE1. The location of SE1 is shown on Drawing 006.

3.1.3 Domestic Waste

Wastewater from welfare facilities and the canteen (c. 32.6 m^3/day) will join with the treated low strength wastewater and discharge to the public sewer at SE1. This will be within the prescribed flow velocities range of 0.8 – 3.0 m/s as outlined in the Department of the Environment and Local Government document 'Recommendations for Site Development Works for Housing Areas'.

A grease trap is in place for the kitchen wastewater and grab samples will be taken periodically from an external manhole to ensure the grease trap is working effectively.

3.1.4 Off-site Waste Water Treatment

The existing wastewater treatment works at Sligo Wastewater Treatment Plant (WWTP) at Sligo Harbour has a capacity of 50,000 population equivalent (PE) and is currently receiving and treating a daily load of approximately 28,158 PE according to the 2017 AER. The maximum discharge volumes from the installation represent about 0.96 % of wastewater discharge volumes from the Sligo Wastewater Treatment Plant.

3.2 Impact to Sewer

Operation of the plant will be according to BAT principles and in compliance with the licence conditions to ensure that inputs to, and subsequent contamination of, soil and water environments does not occur during normal and / or emergency conditions (material spillage or fire event situations).

Wastewater will be discharged after flow balancing and pH neutralisation to ensure no impacts on the sewer network. The main issue at the Sligo WWTP as identified in the 2017 AER for the facility is Total Phosphorus as the facility is not in compliance with the discharge limits for Total Phosphorous. The Total Phosphorous concentration of the wastewater discharge from the AbbVie facility is anticipated to be 68 mg/L which, once diluted with the rest of the hydraulic load of the Sligo WWTP (at a dilution factor of 0.0096) will contribute 0.019 mg /L to the total influent to the facility. Irish Water have advised that the receiving wastewater system will have the capacity to accept the proposed discharge.

S.I. No. 283/2013 - Environmental Protection Agency (Integrated Pollution Control) (Licensing) Regulations 2013, lists a number of Principle Pollution Substance including:

- Substances which contribute to eutrophication (in particular, nitrates and phosphates).
- Substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), etc.).

As such, these parameters will be monitored in accordance with the licence conditions. Mitigation measures were included in the design of the facility to limit the contributions of these parameters as discussed in the BAT Conclusions document for wastewater and waste gas (Attachment 4.7.1).

Other Principle Pollution Substances such as heavy metals are not relevant for this facility as there will be no direct contributions of metals to the wastewater streams. Trace quantities from cleaning of metal equipment may be present in the wastewater only.

Wastewater to be discharged is relatively low strength and has similar characteristics to domestic wastewater. The loading associated with the proposed discharge, as a percentage of Sligo WWTP is insignificant when compared with the overall plant loading. Table 5 shows the percentage of the total influent to the facility based on the 2017 AER.

Description	Proposed Discharge	Quantity of Influent to Sligo (Annual Mean)	Quantity of Influent to Sligo (Annual Max)	Percentage of Sligo Influent
Max wastewater flow per day (m^3 / day)	180	18740.10	51,236	0.96 % (0.35% at Max)

Table 5 *AbbVie wastewater as a % of overall influent to Sligo WWTP*

The impact on the receiving environment is discussed in Attachment 7.1.3.3 Receiving Environment.

4.0 IMPACT TO AIR

4.1 Major and Minor Air Emissions

The primary air emissions from the facility will be from the 2 no. high efficiency LPG fired steam boilers i.e. A1-1 and A1-2. The locations of these boilers are shown on Drawing 004.

The minor air emissions from the facility will include solvent store and pad printing extracts from the existing facility, the new and existing low pressure hot water boilers and domestic hot water boiler, tank and process vents, Lyo vents, autoclave vents, and the Vaporized hydrogen peroxide (VHP) vents (from sterilization).

Potential emissions will include process safety vents emissions and emissions from the new emergency generator (emergency and testing only). The locations of minor and potential emissions are shown on Drawing 005.

4.2 Impact on Air Quality

There is the potential for a number of emissions to the atmosphere during the operational phase of the development. In particular, boiler related air emissions may generate quantities of air pollutants such as NO_2. Oxides of nitrogen are listed as a Principle Pollution Substance (S.I. No. 283/2013) and as such these have been modelled to assess the impact. The air model report is provided in Appendix A of this attachment.

4.2.1 NO_2 Modelling and Boiler Emissions

The purpose of the modelling study was to determine whether the emissions from the site will lead to ambient concentrations which are in compliance with the relevant ambient air quality standards for NO_2. There is a second AbbVie facility located approximately 1km to the east which holds a valid IE licence (Licence No. P0643-03), emissions from both facilities have been included in a cumulative assessment to ensure compliance with the ambient air quality standards for NO_2.

Air dispersion modelling was carried out using the United States Environmental Protection Agency's regulatory model AERMOD (Version 16216r) and the report is provided as Appendix A to this report. The air dispersion modelling input data consisted of information on the physical environment (including building dimensions and terrain features), design details from all emission points on-site and five full years of appropriate meteorological data. Using this input data, the model predicted ambient ground level concentrations beyond the site boundary for each hour of the modelled meteorological year. The model post-processed the data to identify the location and maximum of the worst-case ground level concentration. This worst-case concentration was then added to the background concentration to give the worst-case predicted environmental concentration (PEC). The PEC was then compared with the relevant ambient air quality standard to assess the significance of the releases from the site.

Throughout this study a worst-case approach was taken. This will most likely lead to an over-estimation of the levels that will arise in practice. The worst-case assumptions are outlined below:

- Maximum predicted concentrations were reported in this study, even if no residential receptors were near the location of this maximum;
- The effects of building downwash, due to on-site buildings, has been included in the model;
- Emission points were assumed to run continuously, every hour of the day, 365 days per year.

In order to reduce the risk to health from poor air quality, national and European statutory bodies have set limit values in ambient air for a range of air pollutants. These limit values or "Air Quality Standards" are health- or environmental-based levels for which additional factors may be considered. Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values. The applicable standards in Ireland include the Air Quality Standards Regulations 2011, which incorporate EU Directive 2008/50/EC which combines the previous air quality framework and subsequent daughter directives (see Table 4.1). Although the EU Air Quality Limit Values are the basis of legislation, other thresholds outlined by the EU Directives are used which are triggers for particular actions.

The ambient air quality standards applicable for NO_2 are outlined in Directive 2008/50/EC (see Table 6). These standards have been used in the current assessment to determine the potential impact of NO_2 emissions from the facility on air quality.

Pollutant	Regulation Note 1	Limit Type	Value
Nitrogen Dioxide (NO_2)	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	200 μg/m^3 NO_2
		Annual limit for protection of human health	40 μg/m^3 NO_2
		Critical level for the protection of vegetation	30 μg/m^3 NO + NO_2

Note 1 EU 2008/50/EC – Clean Air For Europe (CAFÉ) Directive replaces the previous Air Framework Directive (1996/30/EC) and daughter directives 1999/30/EC and 2000/69/EC

Table 6 Air Quality Standards Regulations 2011 (Based on Directive 2008/50/EC and S.I. 180 of 2011)

The results indicate that the ambient ground level concentrations of nitrogen oxides (as NO_2) are below the annual and 1-hour ambient air quality standards. Emissions from the facility lead to an ambient NO_2 concentration (including background) which is 24% of the maximum 1-hour limit and 38% of the annual limit at the worst-case off-site location for the worst-case years modelled (2014 and 2015).

The cumulative assessment with the neighbouring AbbVie facility also found results to be in compliance with the relevant ambient air quality limit values. Emissions from both facilities lead to an ambient NO_2 concentration (including background) which is 25% of the maximum ambient 1-hour limit value and 39% of the annual mean limit value at the worst-case off-site receptor for the worst-case years modelled (2014 and 2016).

Ambient levels of nitrogen oxides (as NO_2) from the facility are well below the air quality limit values for the protection of human health and it is predicted that air emissions from the installation will not have a significant impact on the local environment.

No abatement is proposed for boiler emissions or emergency generators. The proposed boiler and emergency generator technology have been selected with minimisation of environmental emissions as a key criterion. The boilers will run on liquid petroleum gas (during normal operations) which will minimise pollutant concentrations in comparison to oil/diesel fired alternatives.

4.2.2 Impact from Minor Process Emissions

New minor emissions from preparatory and production vessels, emissions from fume hoods, autoclave vents, Lyo vents, production room vents, and low pressure hot water boilers are not considered to be significant and appropriate abatement (i.e. HEPA filters and 2 um filters as appropriate) will be employed to remove trace contaminants. Dual catalytic converters in series will be in place on the Isolator lines to convert H_2O2 to H_20 and O_2.

Existing process emissions include extracts from the pad printer and the solvent store. These contain small amounts of Volatile Organic Compounds (VOCs); however, the quantities of emissions are not considered significant and abatement systems are not required.

4.2.3 Impact from Potential Emissions – Emergency Generators

A diesel generator will provide emergency power to critical and essential manufacturing and utility equipment and systems. Emissions of NO_x, SO_x and particulate matter from the emergency generator will be inconsequential as the generator is small in size and will normally only be used during very short duration operability test every month.

4.2.4 Fugitive Emissions

Fugitive emissions are defined as low level diffuse emissions, mainly of volatile organic compounds, that occur when either gaseous or liquid process fluids escape from plant equipment. There are very minor fugitive emissions anticipated from the use of Isopropyl Alcohol (IPA) impregnated wipes and spray for cleaning internal work surfaces. Losses due to displacement of vapour and dilution are anticipated internally within the production areas only.

5.0 NOISE IMPACTS

5.1 Noise Emissions

The primary sources of outward noise in the operational context are deemed long term and will involve:

- Building Services and Process Plant including provision of Emergency Diesel Generators and;
- Additional vehicular traffic on public roads.

The main operational noise sources associated with building services and factory process plant will include cooling towers, air handling units (AHU's), condenser units and various rooftop mounted fan and exhaust units. For the purposes of this assessment we have assumed that all items of plant will operate continuously 24/7.

In addition to the factory process plant, it is proposed to install 1 no. emergency diesel generator on site. It is expected that this generator will only run occasionally for example, when grid power fails and intermittently during daytime hours for testing purposes.

5.2 Impact on Noise Environment

An environmental noise survey was conducted to quantify the existing noise environment in the vicinity of the nearest noise sensitive locations (NSL's) around the site. The surveys were conducted in accordance with guidance contained within the EPA NG4 publication and ISO 1996: 2007: *Acoustics – Description, measurement and assessment of environmental noise*. Further details of the baseline noise survey are provided in Appendix B to this report.

The results of the baseline noise survey were then used in a noise model to assess whether the addition of the development would cause noise levels at the nearest sensitive receptors to exceed the following restrictions:

- Daytime (07:00 to 19:00hrs) 55dB $L_{Ar,15min}$
- Evening (19:00 to 23:00hrs) 50dB $L_{Ar,15min}$
- Night time (23:00 to 07:00hrs) 45dB $L_{Aeq,15min}$

5.2.1 Noise Modelling

To assess the potential noise impact of the proposed plant items an industrial noise prediction model incorporating the new plant items associated with the proposed development has been prepared.

Noise levels were predicted at the three nearest Noise Sensitive Locations (NSL), the locations of which are shown in the modelling report. Please see Appendix B of this attachment.

A noise survey was undertaken in April 2018 to assess the level of the existing noise emissions. The existing AbbVie facility was operational during the noise survey. Plant noise emissions that were measured during the survey were then used to determine the expected cumulative noise emissions at the nearest noise sensitive locations for both the existing and new mechanical plant items.

Some of the noise sources at the existing facility at the time of the surveys were from operational Abbott equipment including the Steriliser installation. These were decommissioned between January 2018 and May 2018 and as such the existing operational noise levels are anticipated to be lower than those measured.

There are several items of noise generating equipment proposed for the new development. The plant items identified as major or minor noise sources with the potential to emit noise beyond the site boundary were considered, and the details and location of all noise emission points and associated noise source data were provided by Jacobs Engineering.

The computer-based noise model was prepared using a proprietary noise modelling software package, *iNoise V2017 Enterprise*. All noise prediction calculations were carried out in accordance with ISO 9613-2:1996 *Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*. This is the preferred calculation methodology as stated in the NG4 Guidance and in this instance, due to the number of noise sources and distances to the nearest NSL's, it is considered the most appropriate assessment method. This method has the scope to consider a range of factors affecting sound propagation, including:

- the magnitude of the noise source in terms of sound power;
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;
- attenuation due to atmospheric absorption, and;
- meteorological effects such as wind gradient, temperature gradient, humidity (these can have significant impact at distances greater than approximately 400m).

Control of noise has been considered as part of the design of the new facility. Where practical, external plant layout has utilised barrier screening of on-site buildings, low noise generating plant items such as attenuated cooling towers have been selected and noisy plant items have been located within buildings.

As a worst case it was assumed that the plant (except emergency items) are operating continuously during daytime, evening and night periods. From the modelled values, the predicted noise levels at all NSL's are below the day, evening and night-time noise criteria that are applicable to the site operations (see the noise modelling report in Appendix 2).

In the event of a failure in electricity supply from the national grid, the standby generator will operate in order to maintain the sites key operations. Otherwise, testing of emergency plant is likely to be scheduled on an agreed frequency and would typically involve operation of plant consecutively over a short time during a scheduled daytime period. The predicted operational and emergency noise levels at the nearest modelled locations were also within both the relevant emergency operations limits, as well as and normal operational limits.

A follow up noise survey will be undertaken in 2019 following installation of the new plant to confirm compliance with the relevant limits.

6.0 IMPACTS TO GROUND

6.1 Soil and Groundwater Environment

The current condition of the AbbVie Ireland NL B.V. facility located at Ballytivnan, Co. Sligo is covered in Sections 6.0 *Stage 5 – Environmental Setting* an 8.0 *Stage 7 – Site Investigation and Baseline Soil & Water Quality Assessment* of the Screening & Baseline report submitted as part of this application.

Soil Type and Quality
Reference to the GSI (2018) on-line mapping indicates the predominant subsoil type in the general area at the AbbVie site is Made Ground and limestone tills. The Teagasc subsoil map of Ireland illustrates the natural soil covering the site to be predominantly Tills derived chiefly from limestone rocks (TNSSs). The soils distribution across the study area is provided on the EPA/Teagasc Soils Map. The map identified podzolics, gleys and alluvium as the distinct soil types that exist in the general area.

Results of baseline soil testing carried out in July 2018 can be seen in Section 8.2 *Baseline Soil Analysis* of the Soil & Water Baseline Report. Overall, this indicated that the soil is relatively clean and there is no contamination present on site.

Groundwater Characteristics
The GSI (2018) currently classifies the bedrock aquifer underlying the site as a (Ll) Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones. According to the GSI National Draft Gravel Aquifer Map for the region, the subject site is not underlain by a gravel aquifer.

The GSI well search for the area surrounding the site does not identify any groundwater abstraction wells within 1.5 km of the subject site. It should be noted that the area is serviced by public water supply however agricultural wells may be present.

During the site investigation carried out in 2018, groundwater was only encountered at one out of four boreholes at 4.70 metres below ground level (mbgl) and at one out of three trial pits at 2.05mbgl in a thin layer of gravel.

The underlying bedrock of interbedded limestone and shale by nature has a low fracture index with little connectivity and therefore there is no likely hydrogeological connectivity with Lough Gill SAC located 1 km from the proposed development site or Cummeen Strand/Drumcliff Bay (Sligo Bay) pNHA.

As part of a groundwater monitoring round carried out by TMS Environment on behalf of AbbVie Ireland NL B.V., it was concluded that the water table in the limestone beneath the site is shallow and the groundwater flow direction is not uniform across the site. It is likely that a groundwater divide exists across the site, where groundwater in the west of the site flows to the west/southwest and groundwater in the east flows to the southeast, with some local groundwater drainage along the southern site boundary into the drainage ditch.

Groundwater Quality

The European Communities Directive 2000/60/EC established a framework for community action in the field of water policy, (commonly known as the Water Framework Directive [WFD]). The WFD required *'Good Water Status'* for all European waters by December 2015, to be achieved through a system of river basin management planning and extensive monitoring. 'Good status' means both *'Good Ecological Status'* and *'Good Chemical Status'.*

The Groundwater Body (GWB) regionally underlying the site is the Drumcliff Strandhill GWB (EU Groundwater Body Code: IE_WE_0044). Currently, the EPA (2018) on-line mapping classifies the GWB as "under review" meaning it may or may not achieve good status.

Results of baseline groundwater sampling and comparison with Groundwater Regulations 2010, S.I. No. 9 of 2010 are included in Section 8 *Stage 7 – Site investigation, Baseline Soil & Water Quality Assessment* of the Baseline Report. The results are compared with Drinking Water Parametric Values (PVs) provided in the European Union (Drinking Water) Regulations 2014 (S.I. No. 122 of 2014), and Groundwater Threshold Values (GTVs) from the European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016 (S.I. No. 366 of 2016). GTVs are trigger values ('threshold' values) which warn of potential breaches of water quality standards, but not water quality standards themselves.

Overall, the groundwater quality is good with no major noticeable contamination across the AbbVie site apart from minor exceedances of some inorganics. Volatile Organic Compounds (VOCs), Semi Volatile Organic Compounds (SVOCs), Polycyclic Aromatic Hydrocarbons (PAHs) and most inorganic parameters were not detected above statutory or guideline levels during groundwater monitoring.

Levels of chloride were elevated compared to the GTVs however not compared to the Drinking Water PVs and may have been related to a leaking sewer in the vicinity. Integrity testing of the AbbVie sewer lines was last undertaken in April 2017.

Elevated aluminium, iron, arsenic and manganese was detected in groundwater samples at concentrations above the GTVs. However, these levels are considered to be a reflection of filtering practices in the laboratory.

6.2 Impact to Ground and Groundwater

There will be no direct discharges of contaminated water to groundwater or soil environment during operation. As such, the only impact that could only occur is due to accidental emissions such as localised accidental leakages from cars/vehicles in the car park areas/ on site or accidental leakage from the bunded diesel storage tank and/ or chemical releases during refueling or transport.

During operation, an environmental management plan (EMP) will be in place to ensure compliance with licencing requirements. This will include full and adequate containment and management of potential contaminants. Site-specific emergency response measures will be in place and all relevant personnel will be trained accordingly.

Fuel and Chemical Handling

In order to minimise any impact on the underlying sunken strata from material spillages, chemical storage tanks will be fully bunded in designated areas with an impervious loading area. Bunding will be to a volume in compliance with EPA standards.

Drainage from the diesel storage area will be to a Class 1 full retention interceptor which will be inspected and properly managed. All tanks, bunding and transfer pipelines will be tested regularly to confirm integrity as per the site EMP and licencing requirements.

As such, it is considered that other than those parameters that are natural elevated in the local groundwater body, there will be no impact on the quality of the groundwater. As such, it is anticipated that there will be no additional exceedances of the European Communities Environmental Objectives (Groundwater) Regulations 2010 (S.I. No. 9 of 2010) and the EPA (2003) Interim guidelines.

Groundwater Recharge

As there will be no increase in hardstanding, the proposed development will not have a significant impact on the recharge of the groundwater body. The aquifer is classified as Moderately Productive only in Local Zones, with the site naturally underlain by natural gravelly and sandy firm Clays ranging in thickness from 5 m to 10 mbgl.

Groundwater Monitoring

Operation of the plant will be according to BAT (Best Available Technology) principles and in compliance with the licence for the site to ensure that inputs to, and any subsequent contamination of, soil and water environments does not occur during normal and/ or emergency conditions (material spillage or fire event situations).

Groundwater monitoring will be undertaken at the following points: MW1, MW2 and MW3. The locations of these wells are shown on Drawing 009. It is proposed that monitoring results are compared with current regulatory limits and guidelines, including the European Communities Environmental Objectives (Groundwater) Regulations 2010 (S.I. No. 9 of 2010) and the EPA (2003) Interim guidelines.

7.0 COMPLIANCE WITH BEST AVAILABLE TECHNIQUES

The proposed facility is intended to replicate successful and proven technologies and processes already developed and in manufacture and use in existing facilities in the USA. With that in mind and with Good Management Practice (GMP) requirements and other bio-pharmaceutical manufacturing constraints, much of the proposed technology and techniques to be applied at the facility had already been pre-determined from the outset of this project.

Nevertheless, as part of the detailed design currently being completed, the design team have assessed BAT and ensured compliance with the relevant BAT as a minimum requirement.

In terms of the document referred to regarding Economic and Cross-Media Effects, it is our understanding that the process described in the document facilitates applicants in determining whether an alternative technique or techniques that might be implemented under IPPC (replaced by IE) offers the highest level of protection for the environment as a whole. This is achieved by following a methodology for balancing the trade-offs that may have to be made in determining which is the best environmental option.

It is anticipated that in many cases, the technique that offers the highest level of protection to the environment will be BAT, but the Directive also requires that the likely costs and benefits of implementing a technique are considered.

7.1 Relevant Decisions on BAT

The following documents are considered potentially relevant in terms of BAT conclusions, BREF and BAT guidance:

- EU Conclusions on Best Available Techniques in Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector, June 2016;
- BREF document on Best Available Techniques for the Manufacture of Organic Fine Chemicals, August 2006;
- BREF document on Best Available Techniques for Energy Efficiency, February 2009;
- BREF document on Best Available Techniques for Emissions from Storage, July 2006.

Please refer to Attachments 4-7-1 to 4-7-4 for detailed assessments of compliance with BAT for each of the above listed BAT Reference (BREF) and BAT guidance documents. It is concluded from this assessment that the facility when completed will comply with the required best available techniques.

7.2 Emerging Techniques

An ‘Emerging technique’ is defined as a novel technique for an industrial emissions directive activity that, if commercially developed, could provide either a higher general level of protection of the environment or at least the same level of protection of the environment and higher cost savings than existing best available techniques.

It is concluded that the proposed technology, based on successful and proven technologies and processes already developed and in manufacture and use in existing facilities in the USA, is not novel and no specific aspect is considered to represent an “Emerging technique”.

7.3 Cleaner Technologies, Waste Minimization and Raw Material Substitution

Please refer to Section 8 of the application for details regarding Waste Minimization.

There are limited opportunities for the substitution of raw materials in the proposed process. The raw materials used have been developed carefully, with due respect to minimizing potential environmental nuisances or other consequences of their use**.**

Cleaner technologies are addressed in Section 9 under Energy Efficiency.

7.4 General Environmental Measures

Unlike traditional chemical based pharmaceutical facilities, the proposed facility will be a lower risk, cleaner, water-based bio-chemical manufacturing process using limited quantities of solvents or hazardous substances.

The facility will be managed by an experienced team of bio-chemical specialists. All operatives will be trained for their specific duties and work will be carried out in line with standard operating procedures. In the event of an accident or other malfunction staff will be trained to address the accident as efficiently and effectively as possible thereby minimizing pollution arising therefrom.

Following grant of the revised licence, AbbVie will be required to comply with the conditions of its licence. All emissions from the facility will be abated and monitored to ensure compliance. For further details of the controls in place, including accident prevention and management of liabilities, see Section 9.

8.0 CONCLUSIONS

From an assessment of both the direct and indirect emission sources, the proposed development is unlikely to have a significant impact on the air, noise, water and ground environments within the vicinity of the site. Monitoring of the emissions will be in accordance with the licence requirements. Diffuse discharges will be controlled through the use of sealed systems and standard operating procedures for control and maintenance.

A further discussion on the impact from the direct emissions (i.e. air, sewer and stormwater emissions) to their respective receiving environment is provided in Attachment 7.1.3.3.

9.0 REFERENCES

EIAR (2018) Environmental Impact Assessment Report for Internal Works & Change in Activity at AbbVie Ireland, NL B.V., Ballytivnan, Sligo. Environmental Impact Services; May 2018.

Annual Environmental Report (2017), D0014-01, Sligo (Sligo Wastewater Treatment Plant).

Appendix 7.1.3.2-A

Air Dispersion Modelling

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AIR DISPERSION MODELLING OF EMISSIONS TO ATMOSPHERE FROM ABBVIE, BALLYTIVNAN, CO. SLIGO

Technical Report Prepared For

AbbVie,
Ballytivnan,
Co. Sligo

Technical Report Prepared By

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EXECUTIVE SUMMARY

Air dispersion modelling was carried out using the United States Environmental Protection Agency's regulatory model AERMOD (Version 16216r). The purpose of this modelling study is to determine whether the emissions from the AbbVie facility, Ballytivnan, Co. Sligo will lead to ambient concentrations which are in compliance with the relevant ambient air quality standards for NO_2. There is a second AbbVie facility located approximately 1km to the east which holds a valid Industrial Emissions (IE) licence (Licence No. P0643-03), emissions from both facilities have been included in a cumulative assessment to ensure compliance with the ambient air quality standards for NO_2.

The study consists of the following components:

- Review of emission data and other relevant information needed for the modelling study;
- Summary of background NO_2 levels;
- Dispersion modelling of released substances under a worst-case emission scenario;
- Presentation of predicted ground level concentrations of released substances;
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the relevant ambient air quality limit values.

Assessment Summary

The results indicate that the ambient ground level concentrations of nitrogen oxides (as NO_2) are below the annual mean and maximum 1-hour (measured as a 99.8th percentile) ambient air quality standards. Emissions from the facility lead to an ambient NO_2 concentration (including background) which is 24% of the maximum 1-hour limit (measured as a 99.8th percentile) and 38% of the annual mean limit at the worst-case off-site location for the worst-case years modelled (2014 and 2015).

The cumulative assessment with the neighbouring AbbVie facility also found results to be in compliance with the relevant ambient air quality limit values. Emissions from both facilities lead to an ambient NO_2 concentration (including background) which is 25% of the maximum ambient 1-hour limit value (measured as a 99.8th%ile) and 39% of the annual mean limit value at the worst-case off-site receptor for the worst-case years modelled (2014 and 2016).

Ambient levels of nitrogen oxides (as NO_2) from the facility are well below the air quality limit values for the protection of human health and it is predicted that air emissions from the installation will not have a significant impact on the local environment

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1.0 INTRODUCTION

AWN Consulting Ltd. were commissioned to carry out an air dispersion modelling study of emissions from the AbbVie facility, Ballytivnan, Co. Sligo for their IE Licence application. The purpose of this modelling study is to determine whether the emissions from the site will lead to ambient concentrations which are in compliance with the relevant ambient air quality standards for NO_2. There is a second AbbVie facility located approximately 1km to the east which holds a valid IE licence (Licence No. P0643-03), emissions from both facilities have been included in a cumulative assessment to ensure compliance with the ambient air quality standards for NO_2.

This report describes the outcome of this study. The study consists of the following components:

- Review of emission data and other relevant information needed for the modelling study;
- Summary of background NO_2 levels;
- Dispersion modelling of released substances under a worst-case emission scenario;
- Presentation of predicted ground level concentrations of released substances;
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the relevant ambient air quality limit values.

Information supporting the conclusions has been detailed in the following sections. The assessment methodology and study inputs are presented in Section 2. The dispersion modelling results and assessment summaries are presented in Section 3. The model formulation is detailed in Appendix I and a review of the meteorological data used is detailed in Appendix II.

2.0 MODELLING METHODOLOGY

Emissions from the proposed facility have been modelled using the AERMOD dispersion model (Version 16216r) which has been developed by the U.S. Environmental Protection Agency (USEPA)[1] and following guidance issued by the EPA[2]. The model is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources and has replaced ISCST3[3] as the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and rolling terrain[4-6]. The model has more advanced algorithms and gives better agreement with monitoring data in extensive validation studies[7-11]. An overview of the AERMOD dispersion model is outlined in Appendix I.

The air dispersion modelling input data consisted of information on the physical environment (including building dimensions and terrain features), design details from all emission points on-site and five full years of appropriate meteorological data. Using this input data the model predicted ambient ground level concentrations beyond the site boundary for each hour of the modelled meteorological year. The model post-processed the data to identify the location and maximum of the worst-case ground level concentration. This worst-case concentration was then added to the background concentration to give the worst-case predicted environmental concentration (PEC). The PEC was then compared with the relevant ambient air quality standard to assess the significance of the releases from the site.

Throughout this study a worst-case approach was taken. This will most likely lead to an over-estimation of the levels that will arise in practice. The worst-case assumptions are outlined below:

- Maximum predicted concentrations were reported in this study, even if no residential receptors were near the location of this maximum;
- The effects of building downwash, due to on-site buildings, have been included in the model;
- All emission points were assumed to run continuously, every hour of the day, 365 days per year.

The Ozone Limiting Method (OLM) was used to model NO_2 concentrations. The OLM is a regulatory option in AERMOD which calculates ambient NO_2 concentrations by applying a background ozone concentration and an in-stack NO_2/NOx ratio to predicted NOx concentrations. An in-stack NO_2/NOx ratio of 0.1 and a background ozone concentration of 60 μg/m^3 were used for modelling.

2.1 Background Concentrations

Air quality monitoring programs have been undertaken in recent years by the EPA and Local Authorities(12,13). The most recent annual report on air quality "Air Quality Monitoring Annual Report 2016"(13), details the range and scope of monitoring undertaken throughout Ireland.

As part of the implementation of the Framework Directive on Air Quality (1996/62/EC), four air quality zones have been defined in Ireland for air quality management and assessment purposes(13). Dublin is defined as Zone A and Cork as Zone B. Zone C is composed of 23 towns with a population of greater than 15,000. The remainder of the country, which represents rural Ireland but also includes all towns with a population of less than 15,000 is defined as Zone D. In terms of air monitoring, Ballytivnan is categorised as Zone C due to its proximity to Sligo town(13).

NO_2 monitoring was carried out at the Zone C monitoring stations of Kilkenny, Portlaoise and Mullingar in 2016(12). The NO_2 annual average in 2016 for the locations of Kilkenny and Portlaoise were 7 and 11 μg/m^3, respectively. This is significantly lower than the annual average limit value of 40 μg/m^3. The average results over the last five years at a range of Zone C locations suggests an upper average of no more than 13 μg/m^3 as a background concentration as shown in Table 1. Based on the above information, a conservative estimate of the current background NO_2 concentration in the region of the AbbVie facility is 13 μg/m^3.

Year	Kilkenny	Portlaoise	Mullingar
2012	4	-	7
2013	4	-	6
2014	5	16	4
2015	5	10	-
2016	7	11	-
Average	**5.0**	**12.3**	**5.7**

Table 1 Annual Average NO_2 Concentrations – Zone C(13)

In relation to the annual average background, the ambient background concentration was added directly to the process concentration with the short-term peaks assumed to have an ambient background concentration of twice the annual mean background concentration.

2.2 Ambient Air Quality Standards

In order to reduce the risk to health from poor air quality, national and European statutory bodies have set limit values in ambient air for a range of air pollutants. These limit values or "Air Quality Standards" are health- or environmental-based levels for which additional factors may be considered. Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values. The applicable standards in Ireland include the Air Quality Standards Regulations 2011, which incorporate EU Directive 2008/50/EC which combines the previous air quality framework and subsequent daughter directives (see Table 2). Although the EU Air Quality Limit Values are the basis of legislation, other thresholds outlined by the EU Directives are used which are triggers for particular actions.

The ambient air quality standards applicable for NO_2 are outlined in Directive 2008/50/EC (see Table 2). These standards have been used in the current assessment to determine the potential impact of NO_2 emissions from the facility on air quality.

Pollutant	Regulation Note 1	Limit Type	Value
Nitrogen Dioxide (NO_2)	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	200 µg/m^3 NO_2
		Annual limit for protection of human health	40 µg/m^3 NO_2
		Critical level for the protection of vegetation	30 µg/m^3 NO + NO_2

Note 1 EU 2008/50/EC – Clean Air For Europe (CAFÉ) Directive replaces the previous Air Framework Directive (1996/30/EC) and daughter directives 1999/30/EC and 2000/69/EC

Table 2 Air Quality Standards Regulations 2011 (Based on Directive 2008/50/EC and S.I. 180 of 2011)

2.3 Air Dispersion Modelling Methodology

The United States Environmental Protection Agency (USEPA) approved AERMOD dispersion model has been used to predict the ground level concentrations (GLC) of compounds emitted from the principal emission sources on-site.

The modelling incorporated the following features:

- Two receptor grids were created at which concentrations would be modelled. Receptors were mapped with sufficient resolution to ensure all localised "hot-spots" were identified without adding unduly to processing time. The receptor grids were based on Cartesian grids with the site at the centre. An outer grid measured 8 x 8 km with concentrations calculated at 400 m intervals. A smaller grid measured 2 x 2 km with concentrations calculated at 50 m intervals. Boundary receptor locations were also placed along the boundary of the site at 50 m intervals giving a total of 2,236 calculation points for the model.

- Hourly-sequenced meteorological information has been used in the model. The 2012 - 2016 meteorological data from Shannon Airport has been used in the assessment.

- AERMOD incorporates a meteorological pre-processor AERMET[14]. The AERMET 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. 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 10km from the meteorological station for Bowen Ratio and albedo and to a distance of 1km for surface roughness in line with USEPA recommendations[15].

- The source and emissions data, including stack dimensions, gas volumes and emission temperatures have been incorporated into the model.

- Detailed terrain has been mapped into the model using SRTM (Shuttle Radar Topography Mission) data with 30 m resolution. The site is located in relatively flat terrain. All terrain features have been mapped in detail into the model using the terrain pre-processor AERMAP.

Modelling for NO_2 was undertaken in detail. However, emissions of carbon monoxide (CO) may also be present in the exhaust gases. In relation to CO, no detailed modelling was undertaken. Emissions of CO are significantly lower than the NO_X emissions from the boilers relative to the ambient air quality standards. The CO ambient air quality standard is 10,000 µg/m^3 compared to the 1-hour NO_2 standard of 200 µg/m^3. Thus ensuring compliance with the NO_2 ambient limit value will ensure compliance for any other pollutants.

2.4 Terrain

The AERMOD air dispersion model has a terrain pre-processor AERMAP which was used to map the physical environment over the receptor grid. The digital terrain input data used in the AERMAP pre-processor was SRTM data. This data was run to obtain for each receptor point the terrain height and the terrain height scale. The terrain height scale is used in AERMOD to calculate the critical dividing streamline height, H_{crit}, for each receptor. The terrain height scale is derived from the Digital Elevation Model (DEM) files in AERMAP by computing the relief height of the DEM point relative to the height of the receptor and determining the slope. If the slope is less than 10%, the program goes to the next DEM point. If the slope is 10% or greater, the controlling hill height is updated if it is higher than the stored hill height.

In areas of complex terrain, AERMOD models the impact of terrain using the concept of the dividing streamline (H_c). As outlined in the AERMOD model formulation[1] a plume embedded in the flow below H_c tends to remain horizontal; it might go around the hill or impact on it. A plume above H_c will ride over the hill. Associated with this is a tendency for the plume to be depressed toward the terrain surface, for the flow to speed up, and for vertical turbulent intensities to increase.

AERMOD model formulation states that the model “captures the effect of flow above and below the dividing streamline by weighting the plume concentration associated with two possible extreme states of the boundary layer (horizontal plume and terrain-following). The relative weighting of the two states depends on: 1) the degree of atmospheric stability; 2) the wind speed; and 3) the plume height relative to terrain. In stable conditions, the horizontal plume "dominates" and is given greater weight while in neutral and unstable conditions, the plume traveling over the terrain is more heavily weighted”[1].

AERMOD also has the capability of modelling both unstable (convective) conditions and stable (inversion) conditions. The stability of the atmosphere is defined by the sign of the sensible heat flux. Where the sensible heat flux is positive, the atmosphere is unstable whereas when the sensible heat flux is negative the atmosphere is defined as stable. The sensible heat flux is dependent on the net radiation and the available surface moisture (Bowen Ratio). Under stable (inversion) conditions, AERMOD has specific algorithms to account for plume rise under stable conditions, mechanical mixing heights under stable conditions and vertical and lateral dispersion in the stable boundary layer.

2.5 Meteorological Data

The selection of the appropriate meteorological data has followed the guidance issued by the USEPA[3] and EPA[2]. A primary requirement is that the data used should have a data capture of greater than 90% for all parameters. Shannon Airport meteorological station, which is located approximately 178 km south of the site, collects data in the correct format and has a data collection of greater than 90%. Shannon Airport is the most representative meteorological station for the region of the AbbVie facility.

Hourly observations at Shannon Airport meteorological station provide an indication of the prevailing wind conditions for the region. Results indicate that the prevailing wind direction is from south-westerly to westerly in direction (see Figure 1).

2.6 Process Emissions

The AbbVie facility will have two new boiler stacks which will have a height of 17.4 m above ground level. The two boilers will operate in a standby/duty mode, with only one boiler in operation at any one time. However, for the purposes of this modelling assessment, both boilers have been modelled as running simultaneously as a conservative approach and to allow for any potential future need to increase capacity.

There are also a number of existing LPHW boilers (3 no.) and proposed LPHW boilers (4 no.) which emit via a common flue (1 no for existing, 1 no. for proposed). Separately these emission points are all less than 1 MW, however, as advised under the Medium Combustion Plant Directive, when these emission points are aggregated they are greater than 1 MW and as such have been included in the modelling assessment. These sources have been modelled as one single emission point for the existing 3 no. LPHW boilers and one single emission point for the proposed 4 no. LPHW boilers. For the purposes of this assessment it has been assumed that all 7 the LPHW boilers are operating continuously, whereas in reality these operate in a standby/duty mode with only 5 in operation at any one time.

A cumulative assessment with the neighbouring AbbVie site has also been undertaken. The relevant source parameters for the neighbouring AbbVie site (emission points A1-1, A1-2 and A2-1c) are based on actual monitoring data over the past two years. The source information for the modelled emission points can be seen in Table 3.

There are a number of other emission points on site, however as these have an output below 1MW there were not included in the air dispersion model as their emissions were deemed insignificant.

Stack Reference	Location (Irish Grid Coordinates)		Height Above Ground Level (m)	Exit Diameter (m)	Temp (K)Note 1	Max Volume Flow (Nm^3/hr) Note 2	Exit Velocity (m/sec actual)	NO_2 Note 3	
								NO_X Concentration (mg/Nm^3)	Mass Emission (g/s)Note 3
New Boiler 1	E169867	N337606	17.4	0.355	403.2	837	4.07	200	0.048
New Boiler 2	E169868	N337605	17.4	0.355	403.2	837	4.07	200	0.048
New LPHW Boilers Combined Flue	E169861	N337604	12.5	0.25	366.2	1,187	9.30	40	0.013
Existing LPHW Boilers Combined Flue	E169775	N337488	12.5	0.25	366.2	1,542	12.08	40	0.017
A1_1	E170604	N337494	26	0.75	358	1,137	0.94	166	0.052
A1_2	E170604	N337494	26	0.75	366	1,518	1.28	148	0.062
A2-1c	E170674	N337478	15	0.3	413	1,477	8.77	200	0.082

Note 1 Kelvin (K) SI Unit for Temperature

Note 2 (Nm^3/hr) Cubic Metres per Hour measured under normal temperature and pressure conditions, 3% O_2 and 0% moisture

Note 3 (g/s) Grams per Second

Table 3 AbbVie, Ballytivnan, Co. Sligo - Process Emissions Details

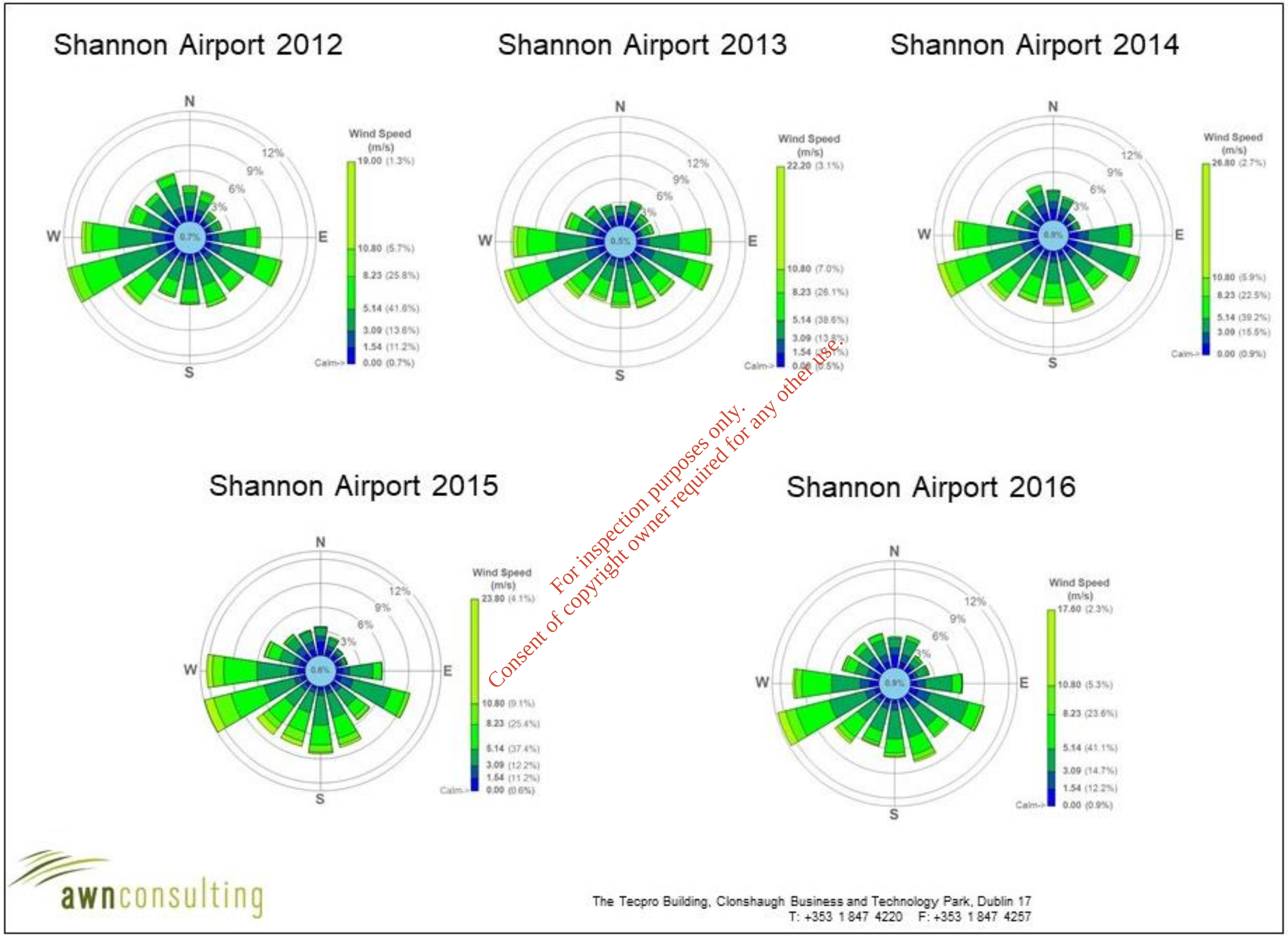

Figure 1 Shannon Airport Windrose 2012 - 2016

3.0 RESULTS & DISCUSSION

3.1 Proposed Development

The nitrogen oxide modelling results are detailed in Table 4. The results indicate that the ambient ground level concentrations are below the annual and 1-hour ambient air quality standards. Emissions from the facility lead to an ambient NO_2 concentration (including background) which is 24% of the maximum 1-hour limit (measured as a 99.8th percentile) and 38% of the annual limit at the worst-case off-site location for the worst-case years modelled (2014 and 2015).

The geographical variations in ground level NO_2 concentrations beyond the facility boundary for the worst-case years modelled are illustrated as concentration contours in Figures 2 and 3. The locations of the maximum concentrations for NO_2 are close to the boundary of the site with concentrations decreasing with distance from the facility.

Pollutant / Meteorological Year	Background (µg/m^3)	Averaging Period	Process Contribution NO_2 (µg/m^3)	Predicted Emission Concentration NO_2 (µg/m^3)	Standard (µg/m^3) Note 1
NO_2 / 2012	13	Annual Mean	2.09	15.09	40
	26	99.8th%ile of 1-hr means	21.11	47.11	200
NO_2 / 2013	13	Annual Mean	2.20	15.20	40
	26	99.8th%ile of 1-hr means	22.35	48.35	200
NO_2 / 2014	13	Annual Mean	2.31	15.31	40
	26	99.8th%ile of 1-hr means	21.16	47.16	200
NO_2 / 2015	13	Annual Mean	2.10	15.10	40
	26	99.8th%ile of 1-hr means	22.39	48.39	200
NO_2 / 2016	13	Annual Mean	2.18	15.18	40
	26	99.8th%ile of 1-hr means	20.77	46.77	200

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC and S.I. 180 of 2011)

Table 4 Dispersion Model Results for Nitrogen Oxides (as NO_2) – Proposed Development

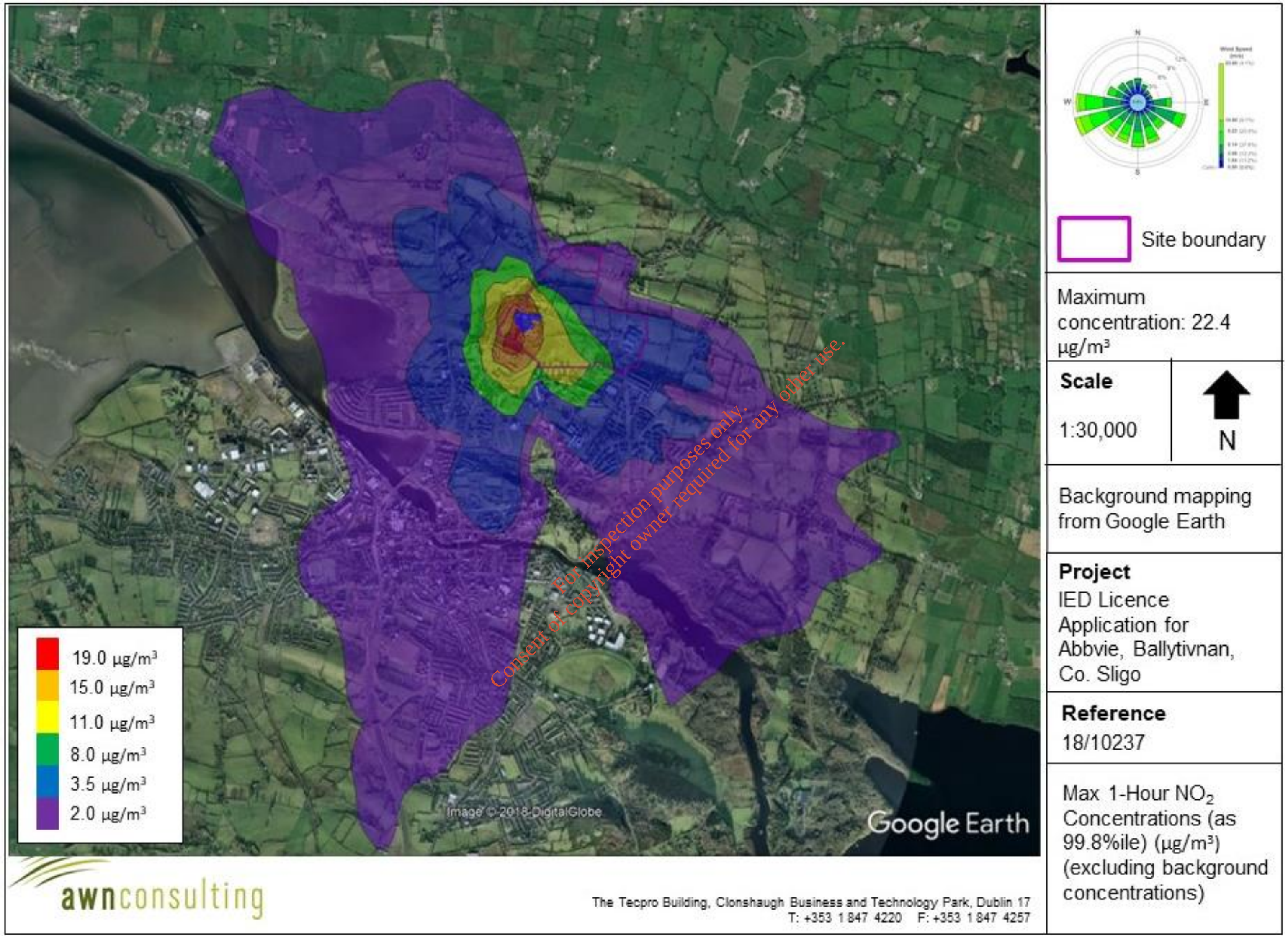

Figure 2 Maximum 1-Hour NO_2 Concentrations (as 99.8th percentile) (Year 2015)

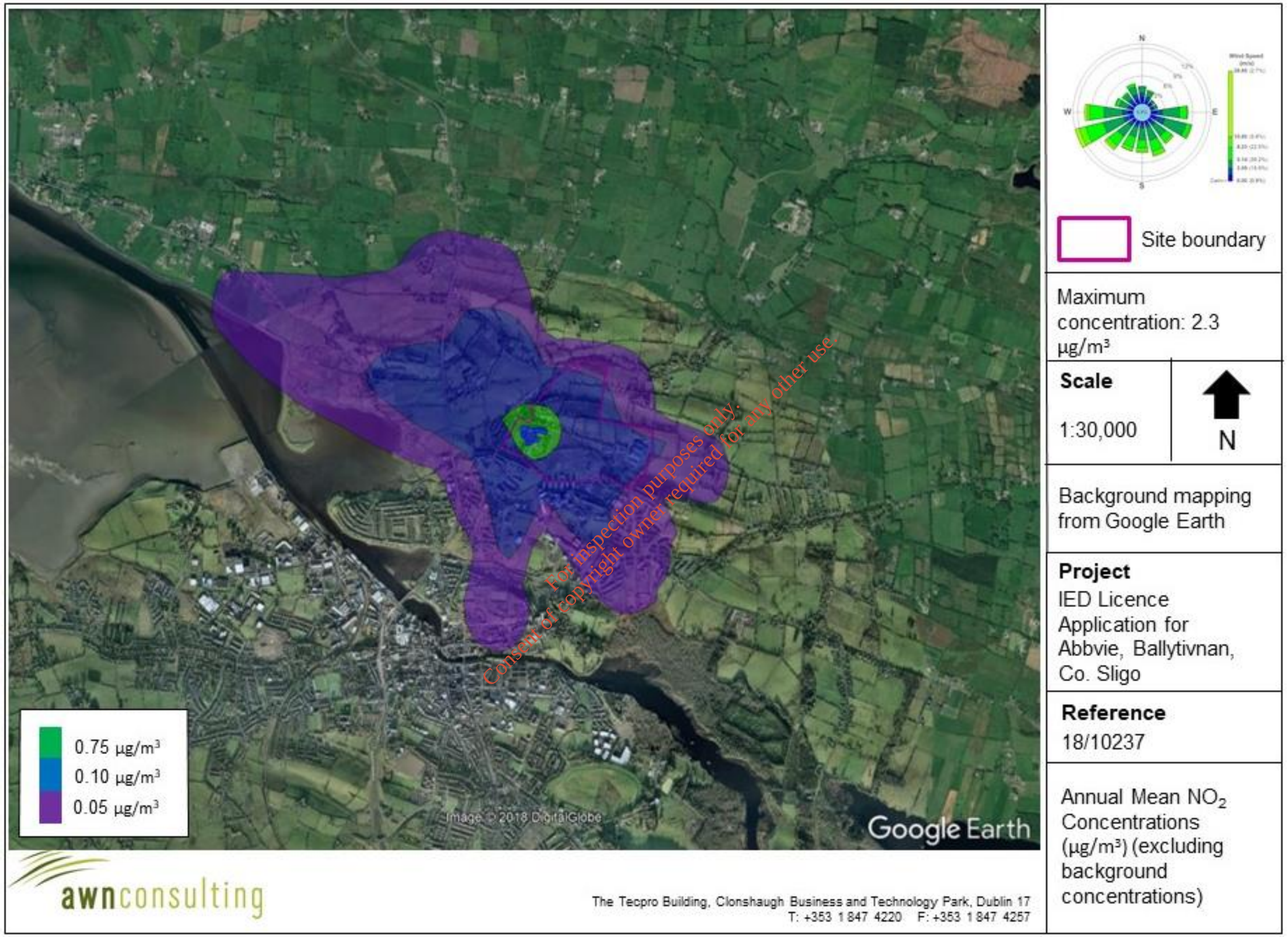

Figure 3 Annual Mean NO_2 Concentrations (Year 2014)

3.2 Cumulative Assessment

The cumulative impact of process emissions of NO_2 from the proposed development and the neighbouring AbbVie facility are detailed in Table 5 below. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for NO_2. For the worst-case year, emissions from the sites lead to an ambient NO_2 concentration (including background) which is 25% of the maximum ambient 1-hour limit value (measured as a 99.8th%ile) and 39% of the annual limit value at the worst-case off-site receptor for the worst-case years modelled (2014 and 2016).

Pollutant / Meteorological Year	Background (µg/m^3)	Averaging Period	Process Contribution NO_2 (µg/m^3)	Predicted Emission Concentration NO_2 (µg/m^3)	Standard (µg/m^3) Note 1
NO_2 / 2012	13	Annual Mean	2.18	15.18	40
	26	99.8th%ile of 1-hr means	22.23	48.23	200
NO_2 / 2013	13	Annual Mean	2.33	15.33	40
	26	99.8th%ile of 1-hr means	24.07	50.07	200
NO_2 / 2014	13	Annual Mean	2.43	15.43	40
	26	99.8th%ile of 1-hr means	23.48	49.48	200
NO_2 / 2015	13	Annual Mean	2.20	15.20	40
	26	99.8th%ile of 1-hr means	22.39	48.39	200
NO_2 / 2016	13	Annual Mean	2.27	15.27	40
	26	99.8th%ile of 1-hr means	24.08	50.08	200

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC and S.I. 180 of 2011)

Table 5 Dispersion Model Results for Nitrogen Oxides (as NO_2) – Cumulative Assessment

3.3 Assessment Summary

In conclusion, ambient levels of nitrogen oxides (as NO_2) from the proposed development as well as the cumulative assessment with the neighbouring AbbVie facility are well below the air quality limit values for the protection of human health and it is predicted that air emissions from the installation will not have a significant impact on the local environment.

References

(1) USEPA (2017) AERMOD Description of Model Formulation and Evaluation

(2) EPA (2010) Air Dispersion Modelling from Industrial Installations Guidance Note (AG4)

(3) USEPA (1995) User's Guide for the Industrial Source Complex (ISC3) Dispersion Model Vol I & II

(4) USEPA (2016) Guidelines on Air Quality Models, Appendix W to Part 51, 40 CFR Ch.1

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(8) Schulman et al "Development and evaluation of the PRIME Plume Rise and Building Downwash Model" Air & Waste Management Association, 1998.

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(11) USEPA (2000) Estimating Exposure to Dioxin-Like Compounds Volume IV, Chapter 3 Evaluating Atmospheric Releases of Dioxin-Like Compounds from Combustion Sources (Draft)

(12) EPA (2018) http://www.epa.ie/air/quality/data/

(13) EPA (2017) Air Quality Monitoring Report 2016 (and previous reports)

(14) USEPA (2004) User's Guide to the AERMOD Meteorological Preprocessor (AERMET)

(15) Hanrahan, P (1999a) The Plume Volume Molar Ratio Method for Determining NO_2/NO_X Ratios in Modeling – Part 1: Methodology J. Air & Waste Management Assoc. 49 1324-1331.

(16) Hanrahan, P (1999b).The Plume Volume Molar Ratio Method for Determining NO_2/NO_X Ratios in Modeling – Part 21: Evaluation Studies J. Air & Waste Management Assoc. 49 1332-1338.

APPENDIX I

Description of the AERMOD Model

The AERMOD dispersion model has been recently developed in part by the U.S. Environmental Protection Agency (USEPA)[(1)]. 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.

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[(7)].

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.

APPENDIX II

Meteorological Data - AERMET

AERMOD incorporates a meteorological pre-processor AERMET (version 16216)(15). AERMET allows AERMOD to account for changes in the plume behaviour with height. AERMET 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 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. 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 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 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 types was carried out in line with USEPA recommendations(4) and using the detailed methodology outlined by the Alaska Department of Environmental Conservation(17). AERMET has also been updated to allow for an adjustment of the surface friction velocity (u*) for low wind speed stable conditions based on the work of Qian and Venkatram (BLM, 2011). Previously, the model had a tendency to over-predict concentrations produced by near-ground sources in stable conditions.

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 upwind area-weighted average of the land use within the sector, by using the eight land use categories outlined by the USEPA. The inverse-distance weighted surface roughness length derived from the land use classification within a radius of 1km from Shannon Airport Meteorological Station is shown in Table A1.

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
270-180	100% Grassland	0.05	0.10	0.01	0.01
180-270	100% Urban	1	1	1	1

(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))[19]. Thus for the current location autumn more accurately defines "winter" conditions in Ireland.

Table A1 Surface Roughness based on an inverse distance weighted average of the land use within a 1km radius of Shannon Airport Meteorological Station.

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. A 10km x 10km square area is drawn around the meteorological station to determine the albedo based on a simple average for the land use types within the area independent of both distance from the station and the near-field sector. The classification within 10km from Shannon Airport Meteorological Station is shown in Table A2.

Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
6% Urban, 49% Grassland, 45% Water	0.151	0.143	0.172	0.172

(1) For the current location autumn more accurately defines "winter" conditions in Ireland.

Table A2 Albedo based on a simple average of the land use within a 10km × 10km grid centred on Shannon Airport Meteorological Station.

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. A 10km x 10km square area is drawn around the meteorological station to determine the Bowen Ratio based on geometric mean of the land use types within the area independent of both distance from the station and the near-field sector. The classification within 10km from Shannon Airport Meteorological Station is shown in Table A3.

Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
19% Urban, 81% Grassland	0.301	0.557	0.655	0.655

(1) For the current location autumn more accurately defines "winter" conditions in Ireland.

Table A3 Bowen Ratio based on a geometric mean of the land use within a 10km × 10km grid centred on Shannon Airport Meteorological Station.

APPENDIX III

Detailed Meteorological Data – Shannon Airport 2012 - 2016

Shannon Airport 2012

Dir \ Spd	<= 1.54	<= 3.09	<= 5.14	<= 8.23	<= 10.80	> 10.80	Total
0.0	106	51	141	40	27	4	369
22.5	70	59	100	76	21	2	328
45.0	42	22	65	29	9	0	167
67.5	40	24	79	23	8	0	174
90.0	57	68	284	130	25	2	566
112.5	60	110	404	194	40	12	820
135.0	47	71	244	141	19	1	523
157.5	34	57	253	188	39	3	574
180.0	54	58	251	138	16	5	522
202.5	38	47	214	148	20	6	473
225.0	62	89	241	237	52	17	698
247.5	79	117	440	360	118	27	1,141
270.0	86	130	357	277	72	36	958
292.5	68	91	178	126	23	1	487
315.0	76	119	150	63	1	0	409
337.5	66	85	256	92	15	0	514
Total	985	1,198	3,657	2,262	505	116	8,723
Calms							61
Missing							0
Total							8,784

Shannon Airport 2013

Dir \ Spd	<= 1.54	<= 3.09	<= 5.14	<= 8.23	<= 10.80	> 10.80	Total
0.0	106	42	65	9	0	0	222
22.5	91	57	111	27	2	0	288
45.0	57	33	74	33	9	1	207
67.5	38	30	88	48	2	0	206
90.0	56	83	339	305	42	18	843
112.5	64	148	390	209	61	14	886
135.0	58	74	223	164	50	10	579
157.5	36	52	221	193	75	12	589
180.0	32	77	265	128	27	28	557
202.5	23	77	170	179	26	32	507
225.0	42	77	237	161	60	36	613
247.5	72	146	461	330	96	59	1,164
270.0	97	99	349	324	112	47	1,028
292.5	68	79	173	91	41	10	462
315.0	69	77	112	58	5	1	322
337.5	61	58	99	27	2	0	247
Total	970	1,209	3,377	2,286	610	268	8,720
Calms							40
Missing							0
Total							8,760

Shannon Airport 2014

Dir \ Spd	<= 1.54	<= 3.09	<= 5.14	<= 8.23	<= 10.80	> 10.80	Total
0.0	118	84	112	12	2	0	328
22.5	66	80	98	25	0	0	269
45.0	56	21	44	9	0	0	130
67.5	44	23	53	14	0	1	135
90.0	102	111	332	132	18	2	697
112.5	96	181	418	81	26	5	807
135.0	65	77	250	135	34	15	576
157.5	56	71	257	222	64	27	697
180.0	58	68	229	159	62	22	598
202.5	60	52	203	207	61	10	593
225.0	62	100	250	211	64	39	726
247.5	68	126	402	335	133	74	1,138
270.0	91	113	352	271	49	45	921
292.5	58	61	166	67	6	0	358
315.0	61	92	118	35	1	0	307
337.5	87	100	153	60	0	0	400
Total	1,148	1,360	3,437	1,975	520	240	8,680
Calms							80
Missing							0
Total							8,760

Shannon Airport 2015

Dir \ Spd	<= 1.54	<= 3.09	<= 5.14	<= 8.23	<= 10.80	> 10.80	Total
0.0	146	66	93	10	0	0	315
22.5	68	49	79	19	0	0	215
45.0	52	33	45	5	0	0	135
67.5	48	29	43	8	0	0	128
90.0	70	73	256	96	4	0	499
112.5	64	130	426	159	49	2	830
135.0	48	64	198	130	49	9	498
157.5	47	40	268	233	72	29	689
180.0	36	58	327	216	79	18	734
202.5	25	51	223	216	107	55	677
225.0	39	61	212	224	77	81	694
247.5	50	77	337	372	195	102	1,133
270.0	76	94	355	361	123	59	1,068
292.5	66	67	162	127	38	6	466
315.0	71	94	129	34	4	0	332
337.5	74	85	120	13	0	0	292
Total	980	1,071	3,273	2,223	797	361	8,705
Calms							55
Missing							0
Total							8,760

Shannon Airport 2016

Dir \ Spd	<= 1.54	<= 3.09	<= 5.14	<= 8.23	<= 10.80	> 10.80	Total
0.0	137	75	100	18	0	0	330
22.5	68	86	162	42	0	0	358
45.0	57	38	76	27	4	1	203
67.5	40	43	106	17	5	1	212
90.0	65	93	288	102	6	4	558
112.5	89	131	423	138	35	5	821
135.0	70	97	236	115	27	1	546
157.5	47	64	313	191	57	23	695
180.0	38	76	308	150	35	13	620
202.5	43	68	245	126	27	11	520
225.0	43	65	219	213	57	31	628
247.5	50	104	397	371	113	87	1,122
270.0	97	102	309	319	70	22	919
292.5	64	75	128	113	27	7	414
315.0	90	93	132	61	2	0	378
337.5	70	79	164	67	4	0	384
Total	1,068	1,289	3,606	2,070	469	206	8,708
Calms							76
Missing							0
Total							8,784

Appendix 7.1.3.2-B

Noise Modelling Report

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AbbVie IRELAND

PRELIMINARY NOISE IMPACT ASSESSMENT FOR EPA LICENCE APPLICATION

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DB/18/10237NR01

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Date	31 August 2018	31 August 2018

EXECUTIVE SUMMARY

AbbVie Ireland are currently progressing detailed design of a proposed extension to develop an integrated bio-chemical suite at their existing facility at Ballytivnan, Sligo. As part of the Licence application to the EPA (required to operate the development) an initial noise impact assessment must be undertaken and details in relation to noise emissions associate with the operation of the site submitted.

This technical report has been prepared to provide full details in relation to the noise impact assessment for the licence application. The assessment is based on the most up-to-date design details available for development and has been prepared with due consideration of the guidance contained within the Environmental Protection Agency (EPA) document *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) 2016*.

Section 6 of the EPA's NG4 Guidance outlines the following assessment stages for the noise impact assessment for licence applications.

- Stage 1 – Baseline Noise Survey / Monitoring Locations;
- Stage 2 – Derivation of Noise Criteria;
- Stage 3 – Assessment of Noise Impact; and,
- Stage 4 – Reporting / Licence Application Form.

This report has been prepared with consideration of the four assessment stages outlined above.

An environmental noise survey was conducted to quantify the existing noise environment in the vicinity of nearest Noise Sensitive Receivers (NSL's) to the site. The survey was conducted in accordance with the EPA's NG4 Guidance.

Appropriate operational noise criteria have been derived for the site following review of noise survey data and receiving environment, in accordance with the relevant NG4 Guidance. The applicable noise criteria identified are in line with the typical limit values for noise from licensed sites.

To assess the impact of noise from new mechanical plant at nearby NSL's, a detailed computer-based noise model has been prepared using proprietary noise modelling software package, *iNoise V2018 Enterprise*. Noise prediction calculations have carried out in accordance with ISO 9613-2:1996 *Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*. The predicted noise levels at all NSL's for new mechanical plant and the levels of existing plant noise from the facility are considerably the day, evening and night-time noise criteria for site operations.

It should be noted that noise impact assessment has been completed using information obtained from the design team for significant items of plant which are currently being procured from vendors. It is anticipated that where there is any substantial variation in the noise emission level of plant when installed on site (i.e. that has not been accounted for in the data used for this assessment), additional noise control measures such as, acoustic barriers or attenuator systems will be employed where necessary, to ensure that the operation of the facility will comply with the required noise criteria set out in this report or defined in the Licence issued to the operator.

CONTENTS

1.0 INTRODUCTION

AbbVie Ireland are currently progressing detailed design of a proposed extension to develop an integrated bio-chemical suite at their existing facility at Ballytivnan, Sligo. AWN Consulting has been commissioned to prepare a noise impact assessment for the operation of the facility to be compiled and submitted as part of the Industrial Emissions (IE) licence application process.

This preliminary assessment is based on the existing noise emissions from the facility and the most up-to-date design details available for the development and has been prepared with due consideration to the guidance contained within the Environmental Protection Agency *in Relation to Scheduled Activities (NG4)".*

This report has been prepared in accordance with the four noise impact assessment stages outlined in Section 6 of NG4, which are as follows:

- Stage 1 – Baseline Noise Survey / Monitoring Locations;
- Stage 2 – Derivation of Noise Criteria;
- Stage 3 – Assessment of Noise Impact; and,
- Stage 4 – Reporting / Licence Application Form.

Figure 1 illustrates the proposed site location in the context of the surrounding environment with the approximate site boundary outlined in red.

Figure 1 Site Location & Context (Background Imagery Source: Google Earth)

The site is situated just off the Old Bundoran Road and approximately 500m east of the N15 national road.

Appendix A presents a glossary of the acoustic terminology referred to in this document.

2.0 FUNDAMENTALS OF ACOUSTICS

In order to provide a broader understanding of some of the technical discussion in this report, this section provides a brief overview of the fundamentals of acoustics and the basis for the preparation of this noise assessment.

A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. In order to take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

The audible range of sounds expressed in terms of Sound Pressure Levels is 0dB (for the threshold of hearing) to 120dB (for the threshold of pain). In general, a subjective impression of doubling of loudness corresponds to a tenfold increase in sound energy which conveniently equates to a 10dB increase in SPL. It should be noted that a doubling in sound energy (such as may be caused by a doubling of traffic flows) increases the SPL by 3dB.

The frequency of sound is the rate at which a sound wave oscillates and is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity decreases markedly as frequency falls below 250Hz. In order to rank the SPL of various noise sources, the measured level has to be adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. Several weighting mechanisms have been proposed but the 'A-weighting' system has been found to provide one of the best correlations with perceived loudness. SPL's measured using 'A-weighting' are expressed in terms of dB(A). An indication of the level of some common sounds on the dB(A) scale is presented in Figure 2.

The established prediction and measurement techniques for the dB(A) parameter are well developed and widely applied. For a more detailed introduction to the basic principles of acoustics, reference should be made to an appropriate standard text[1].

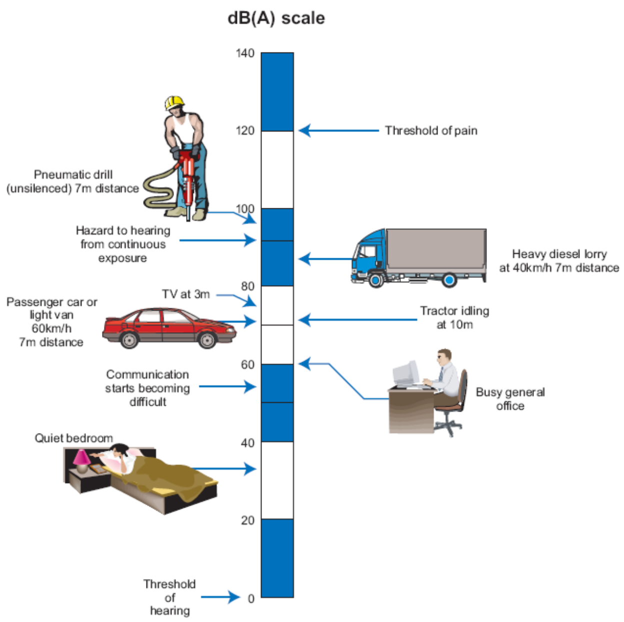

Figure 2
Level of Typical Sounds on the dB(A) Scale – (*NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004*)

[1] For example, *Woods Practical Guide to Noise Control* by Ian Sharland.

3.0 RECEIVING ENVIRONMENT

This section deals with 'Stage 1' of the noise impact assessment as outlined in the EPA's NG4 Guidance.

An environmental noise survey was conducted by AWN in support the planning application for the proposed extension in April 2018 (Sligo County Council planning application reference 18185). The purpose of the survey was to quantify the existing noise environment at nearby noise sensitive locations. The surveys were conducted in accordance with guidance contained in the EPA NG4 publication and ISO 1996: 2007: *Acoustics – Description, measurement and assessment of environmental noise*. Details of this survey are presented in the following Section.

It should be noted that the existing noise surveys take account of noise from the existing facility. It is understood that some of the noise sources that were in operation at the time of the surveys are due to be decommissioned as part of the proposed development.

The nearest NSL's to the site are the residential properties located the west of the site boundary along the old Bundoran Road, an isolated property situated to the north of the site and to the south of the site at the Glendallon housing estate.

3.1 Choice of Measurement Locations

Following a review of the neighbouring environment and nearest NSL's, it was considered that three noise monitoring locations is appropriate for this assessment. Figure 3 illustrates the proposed site boundary in the context of the three nearest noise sensitive locations identified. Figure 3 also indicates the Noise Monitoring Locations (N1, N2 & N3) that were selected for the noise survey and deemed to be representative of the noise environment at NSL's. Each of the monitoring locations are described in turn below.

N1 Situated to the south of the facility in the Glendallon housing estate close to NSL1 and approximately 80m south of the site boundary. The SLM was position on a grass mound tin order to provide a clearer line of site to the facility.

N2 Situated to the west of the facility outside houses along the old Bundoran Road close NSL2 and approximately 20m west of the site boundary.

N3 Situated to the north west of the facility, just off the old Bundoran Road at Shannon Eighter housing estate. The monitoring location is considered representative of the noise environment at NSL3. The monitoring position is approximately 75m northwest of the site boundary.

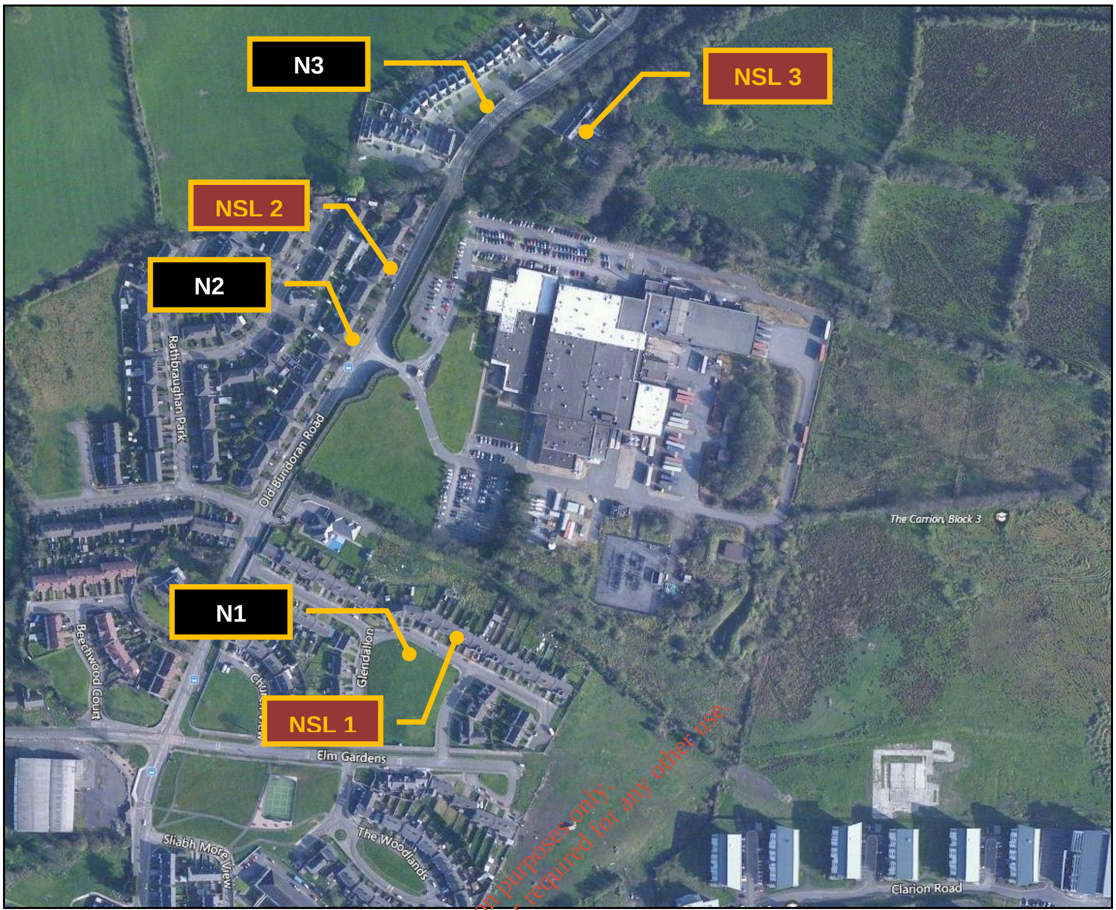

Figure 3 Noise Sensitive Locations (NSL's) and Noise Monitoring Locations (N1-N3)

3.2 Survey Periods

Noise measurements were conducted over the course of three survey periods as follows:

- Daytime 10:30hrs to 14:30hrs on 11 April 2018;
- Evening 21:00hrs to 23:00hrs on 11 April 2018, and;
- Night 23:00hrs to 00:40hrs 11/12 April 2018.

3.3 Personnel & Instrumentation

AWN conducted the noise measurements during all survey periods. The attended noise measurements were performed using a Brüel & Kjaer Type 2250 Sound Level Meter (SN. 2818080). Before and after the survey the instrument was check calibrated using a Brüel & Kjær Type 4231 Sound Level Calibrator (SN. 2263026).

3.4 Procedure

Measurements were conducted at each location on a cyclical basis. Sample periods for the noise measurements were 15 minutes during all periods. The results were noted onto a Survey Record Sheet immediately following each sample and were also saved to the instrument memory for post analysis where appropriate. Survey personnel noted all primary noise sources contributing to noise build-up.

3.5 Measurement Parameters

The noise survey results are presented in terms of the following three parameters:

L_{Aeq} is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period.

L_{AF10} is the sound level that is exceeded for 10% of the sample period. It is typically used as a descriptor for road traffic noise.

L_{A90} is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.

The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the non-linear nature of human hearing. All sound levels in this report are expressed in terms of decibels (dB) relative to 2×10^{-5} Pa.

3.6 Survey Results

N1

The survey results for Location N1 are summarised in Table 1 below.

Period	Start Time	Measured Noise Levels (dB re. 2×10^{-5} Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Day	11:19	46	47	40
	12:25	51	51	40
Evening / Night	21:40	56	53	37
	22:39	38	40	35
	00:04	42	44	37

Table 1 Summary of Measured Noise Levels at N1

During daytime survey periods, steady plant noise from the existing AbbVie Ballytivnan facility was audible in the background throughout along with steady distant road traffic noise, intermittent noise from local anthropological sources were noted throughout the survey periods.

During the evening and night-time survey periods, the main source of noise was steady plant noise from the existing AbbVie Ballytivnan facility audible in the background along with distant road traffic. During the first evening measurement the measured L_{Aeq} level was elevated due to the presence of a dog barking in the vicinity.

No significant source of vibration was noted during the survey periods.

N2

The survey results for Location N2 are summarised in Table 2 below.

Period	Start Time	Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Day	10:58	63	65	48
	12:04	64	66	46
	13:08	64	69	45
Evening / Night	21:19	59	58	43
	22:19	56	47	43
	23:44	58	52	44

Table 2 Summary of Measured Noise Levels at N2

During daytime survey periods, the ambient noise in the vicinity were dominated by intermittent road traffic movements along the Old Bundoran Road and intermittent activity from the AbbVie site, noise from truck movements and the use of reverse alarms. The background noise was dominated by steady noise from the existing AbbVie Ballytivnan facility.

During the evening and night-time survey periods, the dominant source of noise was steady plant noise from the existing AbbVie Ballytivnan facility interrupted by intermittent road traffic movements along the Old Bundoran Road.

No significant source of vibration was noted during the survey periods.

N3

The survey results for Location N3 are summarised in Table 3 below.

Period	Start Time	Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Day	10:36	52	56	42
	11:39	53	57	42
	12:49	50	54	41
Evening / Night	21:00	48	52	41
	22:00	44	42	40
	23:24	45	48	40

Table 3 Summary of Measured Noise Levels at N3

During daytime survey periods, the ambient noise levels in the vicinity were dominated by intermittent road traffic movements along the Old Bundoran Road and birdsong. The background noise was dominated by steady and intermittent noise from the existing AbbVie Ballytivnan facility.

During the evening and night-time survey periods, steady plant noise from the existing AbbVie Ballytivnan was audible facility interrupted by intermittent road traffic movements along the Old Bundoran Road and occasionally dogs barking in the area.

4.0 REVIEW OF RELEVANT GUIDANCE

This section deals with 'Stage 2' of the noise impact assessment as outlined in the EPA's NG4 Guidance.

The derivation of appropriate IE Licence noise emission criteria for the proposed facility will be conducted in accordance with the NG4 document. This approach is summarised below in accordance with guidance detailed in Section 4 of the NG4 document.

4.1 Quiet Area Screening

The proposed development is not considered a quiet area in this instance as it fails to meet all the criteria outlined in EPA's Guidance. The most stringent of these criteria are noted in bullet point and commented on below.

- At least 3km from urban area with a population >1,000 people;

The town of Sligo is located less than 3km from the site and has a population of greater significantly greater than 1000.

- At least 3km away from any local industry;

The current facility is operational, in addition to this there are numerous facilities with 3km of the site.

- At least 5km away from any National Primary Route;

The site is located approximately 500m from the N15 national road.

4.2 Low Background Noise Area Screening

In order to establish whether the noise sensitive locations in the vicinity of the site would be considered 'low background noise' areas, the noise levels measured during the environmental noise survey need to satisfy all three of the following criteria:

- Arithmetic Average of L_{A90} During Daytime Period ≤40dB L_{A90}, and;
- Arithmetic Average of L_{A90} During Evening Period ≤35dB L_{A90}, and;
- Arithmetic Average of L_{A90} During Night-time Period ≤30dB L_{A90}.

The arithmetic average L_{A90} results at each location are compared against the criteria in Table 4.

Location	Period	Average $L_{A90,15iin}$ (dB)	NG4 Screening (dB $L_{A90,15min}$)	Satisfies All Criteria for Low Background Noise Area?
N1	Daytime	40	≤40	No
	Evening	36	≤35	
	Night-time	35	≤30	
N2	Daytime	46	≤40	No
	Evening	43	≤35	
	Night-time	43	≤30	
N3	Daytime	42	≤40	No
	Evening	41	≤35	
	Night-time	40	≤30	

Table 4 Comparison of Measurement Results with NG4 Low Background Noise Area Criteria

As outlined in Table 4, none of the locations would be considered 'Areas of Low Background Noise' as the measured noise levels do not satisfy the criteria.

4.3 Determining Appropriate Noise Criteria

Based on the EPA NG4 guidance the following noise criteria are appropriate at the nearest NSL's to the facility:

- Daytime (07:00 to 19:00hrs) 55dB $L_{Ar,15min}$
- Evening (19:00 to 23:00hrs) 50dB $L_{Ar,15min}$
- Night time (23:00 to 07:00hrs) 45dB $L_{Aeq,15min}$

During the night period, no tonal or impulsive noise from the facility should be clearly audible or measurable at any NSL. The applicable noise criteria identified are in line with the typical limit values for noise from licensed sites.

There are some plant items proposed for the development site that are designed to be used in emergency situations, for example, when grid power supplies fail. It is common practice to allow a relaxation of noise limits associated with emergency plant operations. Section 4.4.1 of EPA NG4 contains the following comments in relation to emergency plant items:

> *"In some instances, licensed sites will have certain items of emergency equipment (e.g. standby generators) that will only operate in urgent situations (e.g. grid power failure). Depending upon the context, it may be deemed permissible for such items of equipment to give rise to exceedances in the noise criteria/limits during limited testing and emergency operation only. If such equipment is in regular use for any purposes other than intermittent testing, it is subject to the standard limit values for the site".*

It is therefore considered that the proposed noise criterion of 55dB $L_{Aeq,(15mins)}$ is appropriate in emergency scenarios for daytime, evening and night-time periods.

4.4 Compliance Noise Monitoring

See Attachment 7.5 of the Licence application for further details on the noise sensitive locations.

Given there may be potential access constraints at some noise sensitive locations and the presence of extraneous noise sources in the vicinity, it is may be necessary to undertake compliance noise monitoring (if required) at the site boundary or at a suitable proxy location and assess to the nearest NSL's. Any such assessment should be undertaken in accordance with the guidance outlined in the EPA NG4 document and supported by a sufficiently detailed noise report outlining the calculation methods used to determine the noise emission levels at the NSL's. Simultaneous monitoring may be required initially to set appropriate limit values at alternative locations.

5.0 ASSESSMENT

This section deals with 'Stage 3' of the noise impact assessment as outlined in the EPA's NG4 Guidance.

The noise levels expected at nearest NSL's, due to the operation of the facility, must be considered and presented as part of the licence application.

The following sections present details of the assessment and the preliminary findings. Further information in relation to the noise prediction model, inputs, calculation settings and assessment assumptions are provided in Appendix B.

It should be noted that noise impact assessment has been completed using information obtained from the design team for significant items of plant which are currently being procured from vendors.

5.1 Noise Sensitive Locations

Noise prediction calculations have been carried out at the three nearest noise sensitive locations (NSL's) surrounding the site as previously identified, details of the NSL's used for the prediction calculations are presented in Table 5. Free field noise emission levels have been predicted at a height of 4m.

Noise Sensitive Location	Calculation Height	National Grid Reference (ITM)	
		North	East
NSL1	4m	569,655	837,378
NSL2	4m	569,627	837,634
NSL3	4m	569,772	837,732

Table 5 Coordinates of Noise Sensitive Recievers

5.2 Noise Source Data

The main new sources of noise on the site are listed in Appendix B of this document and location of all these items and existing items will remain operational on the site are shown in Drawing Ref. No. 0011 of the Licence application.

5.2.1 Existing Operational Noise

As outlined in Section 3.0, the existing AbbVie facility was operational during the noise survey. For this assessment, reference is made to the plant noise emissions that were measured during the survey to determine the expected cumulative noise emissions at the nearest noise sensitive locations for both the existing and new mechanical plant items.

As previously stated, it is understood that some of the noise sources operational at the existing facility at the time of the surveys are due to be decommissioned as part of the proposed development.

5.2.2 New Mechanical Plant

There are several items of noise generating equipment proposed for the new development. It has been assumed for this assessment that all plant items will operate 24 hours a day as a worst case and that all plant items have omni-directional noise emissions (apart from AHU penthouse louvres and boiler stacks). The assessment considers all the major and minor noise sources of plant items that have been identified as having the potential to emit noise beyond the site boundary.

The details and location of all noise emission points and associated noise source data has been provided by Jacobs Engineering. Details on any assumptions made in relation to this data are outlined in Appendix B.

Confirmation will be sought from the relevant suppliers at the detailed design stage that any significant noise producing plant items shall not emit total or impulsive characteristics to such a degree, that these characteristics could be audible at the noise sensitive locations.

5.2.3 Details of Noise Control Measures

Control of noise has been considered as part of the design of the new facility. Where possible, external plant layout has utilised barrier screening of on-site buildings, low noise generating plant items such as attenuated cooling towers have been selected, and noisy plant items have been located within buildings.

The rooftop AHU's are likely to have acoustic attenuators fitted, however, for the purposes of this assessment we have assumed a nominal attenuation that would typically be provided for 2.5m of duct with 1 no. 90° bend and standard weather louvres at the atmosphere side.

We have assumed that the penthouse louvres for AHU's NE-2, NE-6 and NE-8 will be closed on the two sides that face to the north and west such most of the noise form the louvre will propagate to the south and east and away from the nearest noise sensitive receivers.

This action may not be required if a higher level of attenuation can be provided for the AHU's e.g. fitting acoustic attenuators, increased the duct lengths, duct linings or increasing the number of duct bend.

5.3 Calculation Methodology

This assessment has been completed using a detailed computer-based noise model that has been prepared by AWN using proprietary noise modelling software package, *iNoise V2018 Enterprise*. All noise prediction calculations have been carried out in accordance with ISO 9613-2:1996 *Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*. This is the preferred calculation methodology as stated in the NG4 Guidance and in this instance, due to the number of noise sources and distances to the nearest NSL's, it is considered the most appropriate assessment method. This method has the scope to consider a range of factors affecting sound propagation, including:

- the magnitude of the noise source in terms of sound power;
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;
- attenuation due to atmospheric absorption, and;
- meteorological effects such as wind gradient, temperature gradient, humidity (these can have significant impact at distances greater than approximately 400m).

5.4 Predicted Noise Levels

This section presents the predicted noise levels at the nearest noise sensitive locations. It should be noted that as a worst case it is assumed that the new plant (except emergency items) are operating continuously during daytime, evening and night periods for normal operation.

Figure 4 presents the predicted noise contour plot for mechanical services and factory process plant associate with the development at a calculation height of 4m above ground level.

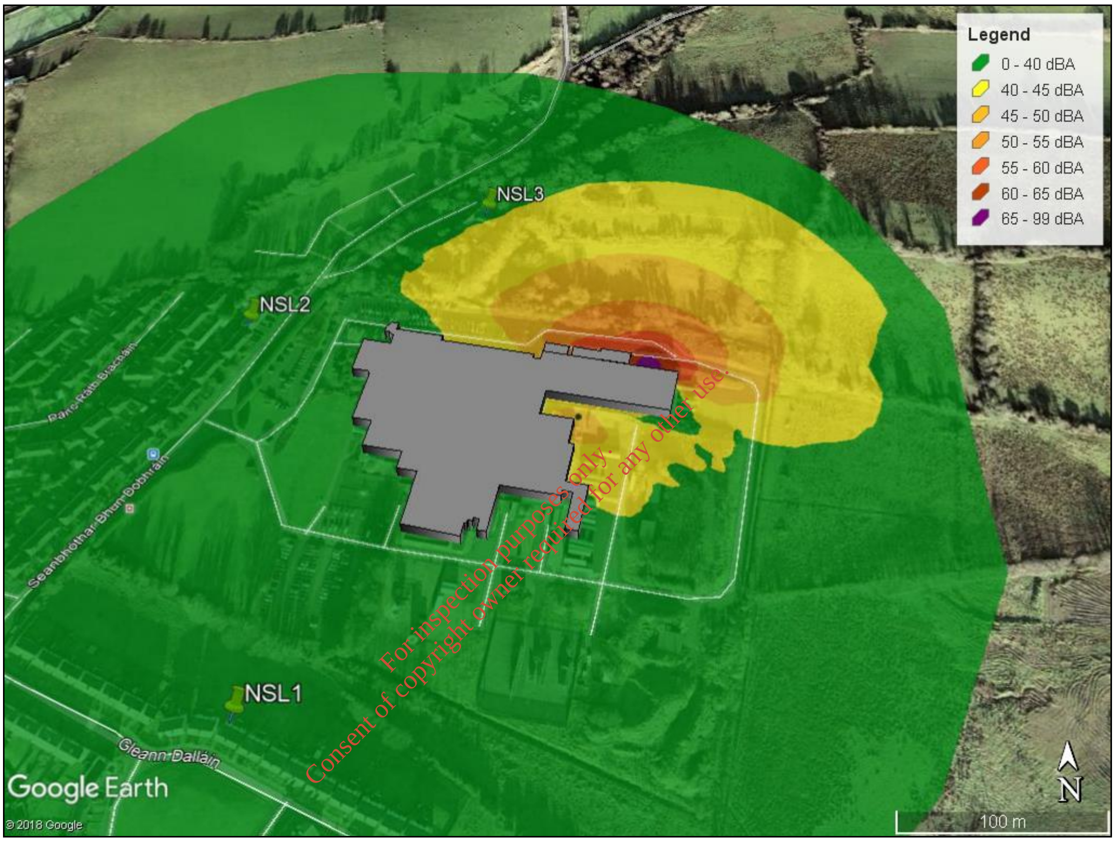

Figure 4 Predicted Operational Noise Contours dB $L_{Aeq,T}$ for New Mechanical Plant

The predicted noise levels from new mechanical plant at each NSL are tabulated in Table 6.

Location	New Plant Predicted Level (dB)
NSL 1	32
NSL 2	33
NSL 3	40

Table 6 Predicted Operational Noise Levels at NSL's for New Mechanical Plant Items

Table 7 presents an assessment of the resultant noise emissions predicted from the site considering the operation of both new and existing plant items. The existing plant noise levels have been calculated with due consideration of the guidance set out in Section 7.8 & 7.9 of the EPA NG4 guidance document and review of the noise survey data presented in Section 3.0 of this report. The measured L_{AF90} parameter from noise survey has been judged to be an appropriate indicator for existing plant noise emissions in this instance. It is noted, that the measured levels encompass all noise sources in the vicinity of the site and that a number of plant items will be decommissioned as part of the development therefore, the approach can be considered to be worst case.

Location	New Plant Predicted Level (dB)	Existing Plant Noise Level (dB)	Total Operational Plant Noise Level (dB)
NSL 1	32	35	37
NSL 2	33	43	43
NSL 3	40	40	43

Table 7 Predicted Operational Plant Noise Levels at NSL's

Table 8 present the predicted plant noise emission levels at the nearest NSL's and compares the results against the relevant criteria that have been derived for the site.

Receptor	Predicted $L_{Aeq,15minute}$	Day (07:00 – 19:00hrs)		Evening (19:00 – 23:00hrs)		Night (23:00 – 07:00hrs)	
		Criterion dB $L_{Ar,T}$	Complies?	Criterion dB $L_{Ar,T}$	Complies?	Criterion dB $L_{Aeq,T}$	Complies?
NSL1	37	55	Yes	50	Yes	45	Yes
NSL2	43		Yes		Yes		Yes
NSL3	43		Yes		Yes		Yes

Table 8 Predicted Operational Noise Levels vs Criteria

An emergency generator will operate in emergency situations and for periodic testing during daytime hours. To reiterate, the NG4 document allows for relaxed noise emission criteria for emergency use equipment. Regardless of this fact, the worst case predicted noise emissions from the operation of the generators are below the normal day, evening and night time noise criteria and any predicted increase in the noise emissions is expected to be not significant.

6.0 CONCLUSION

A detailed noise survey has been completed at three noise sensitive locations surrounding the site to establish the existing noise environment. This work has demonstrated that the existing noise environment is dictated by steady plant noise emissions from the operation of the existing facility and road traffic noise.

In accordance with the relevant NG4 Guidance, appropriate operational noise criteria have been derived for the site which are based on the existing noise environment at the nearest NSL's.

A noise impact assessment has been completed using information obtained from the design team for significant items of new mechanical plant. A detailed computer-based noise model has been prepared using proprietary noise modelling software in accordance with the calculation method outlined in ISO 9613-2:1996.

The predicted noise levels at all NSL's are below the day, evening and night-time noise criteria that are applicable to the site operations.

Confirmation will be sought from the relevant suppliers at the detailed design stage that any significant noise producing plant items shall not emit tonal or impulsive characteristics to such a degree, that these characteristics could be audible at the noise sensitive locations.

It should be noted that this preliminary noise impact assessment has been completed using information obtained from the design team for significant items of plant which are currently being procured from vendors. It is anticipated that where there is any substantial variation in the noise emission level of plant when installed on site (i.e. that has not been accounted for in the data used for this assessment), additional noise control measures such as, acoustic barriers or attenuator systems will be employed where necessary, to ensure that the operation of the facility will comply with the required noise criteria set out in this report or defined in the Licence issued to the operator.

APPENDIX A
GLOSSARY OF ACOUSTIC TERMINOLOGY

ambient noise The totally encompassing sound in a given situation at a given time, usually composed of sound from many sources, near and far.

background noise The steady existing noise level present without contribution from any intermittent sources. The A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 per cent of a given time interval, T ($L_{AF90,T}$).

broadband Sounds that contain energy distributed across a wide range of frequencies.

dB Decibel - The scale in which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the RMS pressure of the sound field and the reference pressure of 20 micro-pascals (20 μPa).

dB L_{pA} An 'A-weighted decibel' - a measure of the overall noise level of sound across the audible frequency range (20 Hz – 20 kHz) with A-frequency weighting (i.e. 'A'–weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.

Hertz (Hz) The unit of sound frequency in cycles per second.

impulsive noise A noise that is of short duration (typically less than one second), the sound pressure level of which is significantly higher than the background.

$L_{Aeq,T}$ This is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period (T).The closer the L_{Aeq} value is to either the L_{AF10} or L_{AF90} value indicates the relative impact of the intermittent sources and their contribution. The relative spread between the values determines the impact of intermittent sources such as traffic on the background.

L_{AFN} The A-weighted noise level exceeded for N% of the sampling interval. Measured using the "Fast" time weighting.

L_{AFmax} is the instantaneous slow time weighted maximum sound level measured during the sample period (usually referred to in relation to construction noise levels).

$L_{Ar,T}$ The Rated Noise Level, equal to the L_{Aeq} during a specified time interval (T), plus specified adjustments for tonal character and impulsiveness of the sound.

L_{AF90} Refers to those A-weighted noise levels in the lower 90 percentile of the sampling interval; it is the level which is exceeded for 90% of the measurement period. It will therefore exclude the intermittent features of traffic and is used to estimate a background level. Measured using the "Fast" time weighting.

APPENDIX A
GLOSSARY OF ACOUSTIC TERMINOLOGY (Continued)

L_{AT}(DW) equivalent continuous downwind sound pressure level.

L_{fT}(DW) equivalent continuous downwind octave-band sound pressure level.

low frequency noise LFN - noise which is dominated by frequency components towards the lower end of the frequency spectrum.

noise Any sound, that has the potential to cause disturbance, discomfort or psychological stress to a person exposed to it, or any sound that could cause actual physiological harm to a person exposed to it, or physical damage to any structure exposed to it, is known as noise.

noise sensitive location NSL – Any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels.

octave band A frequency interval, the upper limit of which is twice that of the lower limit. For example, the 1,000Hz octave band contains acoustical energy between 707Hz and 1,414Hz. The centre frequencies used for the designation of octave bands are defined in ISO and ANSI standards.

rating level See $L_{Ar,T}$.

sound power level The logarithmic measure of sound power in comparison to a referenced sound intensity level of one picowatt (1pW) per m^2 where:

$$Lw = 10 Log \frac{P}{P_0} \text{ dB}$$

Where: p is the rms value of sound power in pascals; and
P_0 is 1 pW.

sound pressure level The sound pressure level at a point is defined as:

$$Lp = 20 Log \frac{P}{P_0} \text{ dB}$$

specific noise level A component of the ambient noise which can be specifically identified by acoustical means and may be associated with a specific source. In BS 4142, there is a more precise definition as follows: 'the equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source over a given reference time interval ($L_{Aeq, T}$)'.

APPENDIX A
GLOSSARY OF ACOUSTIC TERMINOLOGY (Continued)

tonal Sounds which cover a range of only a few Hz which contains a clearly audible tone i.e. distinguishable, discrete or continuous noise (whine, hiss, screech, or hum etc.) are referred to as being 'tonal'.

$^{1}/_{3}$ octave analysis Frequency analysis of sound such that the frequency spectrum is subdivided into bands of one–third of an octave each.

APPENDIX B
NOISE MODEL AND IMPACT ASSESSMENT DETAILS

B.1.1 Noise Sensitive Locations

Table B.1 presents the location of the various noise sensitive locations (NSL's) identified for the noise impact assessment.

Receptor	Co-ordinates (ITM)	
	N	E
NSL1	569,655	837,378
NSL2	569,627	837,634
NSL3	569,772	837,732

Table B.1 Details of Noise Sensitive Locations

B.1.2 Noise Model

A 3D computer-based prediction model has been prepared to quantify the operational noise emission levels from proposed development. This section discusses the methodology behind the noise modelling and noise impact assessment process.

B.1.3 dGmR iNoise V2018 Enterprise

Proprietary noise calculation software has been used for the purposes of this modelling exercise. The selected software package was dGmR iNoise V2018 Enterprise, this package calculates noise levels in accordance with ISO 9613: *Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation, 1996*.

iNoise V2018 is a proprietary noise calculation package for computing noise level propagation from a range of noise source types. iNoise calculates noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated considering a range of factors affecting the propagation of sound, including:

- the magnitude of the noise source in terms of A weighted sound power levels (LWA);
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;
- Attenuation due to atmospheric absorption; and
- Meteorological effects such as wind gradient, temperature gradient and humidity (these have significant impact at distances greater than approximately 400m).

B.1.4 Brief Description of ISO9613-2: 1996

ISO 9613-2:1996 calculates the noise level based on each of the factors discussed previously. However, the effect of meteorological conditions is significantly simplified by calculating the average downwind sound pressure level, $L_{AT(DW)}$, for the following conditions:

- wind direction at an angle of ±45° to the direction connecting the centre of the dominant sound source and the centre of the specified receiver region with the wind blowing from source to receiver, and;

- wind speed between approximately 1ms-1 and 5ms-1, measured at a height of 3m to 11m above the ground.

The equations and calculations also hold for average propagation under a well-developed moderate ground based temperature inversion, such as commonly occurs on clear calm nights.

The basic formula for calculating $L_{AT(DW)}$ from any point source at any receiver location is given by:

$$L_{fT(DW)} = L_W + D_c - A \qquad \textbf{Equation A}$$

Where:

$L_{fT(DW)}$ is an octave band centre frequency component of $L_{AT(DW)}$ in dB relative to $2x10^{-5}$Pa;
L_W is the octave band sound power of the point source;
D_c is the directivity correction for the point source;
A is the octave band attenuation that occurs during propagation, namely attenuation due to geometric divergence, atmospheric absorption, ground effect, barriers and miscellaneous other effects.

The estimated accuracy associated with this methodology is shown in Table B.2 below:

Height, h*	Distance, d†	
	0 < d < 100m	100m < d < 1,000m
0<h<5m	±3dB	±3dB
5m<h<30m	±1dB	±3dB

Table B.2 Estimated Accuracy for Broadband Noise of $L_{AT(DW)}$

* h is the mean height of the source and receiver.
† d is the mean distance between the source and receiver.
N.B. These estimates have been made from situations where there are no effects due to reflections or attenuation due to screening.

B.1.5 Input Data and Assumptions

The noise model has been compiled using data from various sources as follows:

Site Layout The general site layout has been obtained from the drawings forwarded by Jacobs Engineering.

Local Area The Location of noise sensitive locations has been obtained from review of Ordinance Survey Ireland (OSI) maps and online mapping applications (e.g. Google Earth) and on-site observations.

Heights Onsite building heights have been obtained from the drawings forwarded from Jacobs Engineering.

The assessment considers all the major and minor noise sources of plant items that have been identified as having the potential to emit noise beyond the site boundary.

The details and location of all noise emission points and associated noise source data has been provided by Jacobs Engineering. Details of the noise source data used for this assessment are provided and section B.1.7 and Drawing Ref. No. 0011.

It should be noted that noise impact assessment has been completed using information obtained from the design team for significant items of plant which are currently being procured from vendors. The noise data used in the assessment is considered worst case based on data provided by a range of vendors. In order to present a conservative assessment, the following assumptions have been made for noise sources in the noise model:

- omni-directional directivity, i.e. 360° propagation for all noise sources (apart from AHU penthouse louvres and boiler stacks);
- continuous 24/7 operation for all operational plant items;
- rooftop AHU's are likely to have acoustic attenuators fitted as standard, however, for the purposes of this assessment we have assumed no attenuators on the AHU's as a worst-case.

B.1.6 Modelling Calculation Parameters

The atmospheric attenuation outlined in Table B.3 has been assumed for all calculations.

Temp (ºC)	% Humidity	Octave Band Centre Frequencies (Hz)							
		63	125	250	500	1k	2k	4k	8k
10	80	0.11	0.38	1.02	1.97	3.57	8.76	28.72	103.21

Table B.3 Atmospheric Attenuation Assumed for Noise Calculations (dB per km)

Prediction calculations for noise emissions have been conducted in accordance with ISO 9613: *Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation, 1996*. The following are the main aspects that have been considered in terms of the noise predictions presented in this instance.

Directivity Factor: The directivity factor (D) allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. In this case the sound power level is calculated in a down wind direction, corresponding to the worst-case propagation conditions and needs no further adjustment. All noise sources have been assumed omni directional as a worst case with the exception of AHU penthouse louvres and boiler stack where a realistic directivity factor has been incorporated into the calculations.

Ground Effect: Ground effect is the result of sound reflected by the ground interfering with the sound propagating directly from source to receiver. The prediction of ground effects are inherently complex and depend on source height receiver height propagation height between the source and receiver and the ground conditions. The ground conditions are described according to a variable defined as G, which varies between 0.0 for hard ground (including paving and concrete) and 1.0 for soft ground (includes ground covered by grass

	trees or other vegetation) Our predictions have been carried out using various source height specific to each plant item, a receiver height of 4m for a two-story development. A ground factor of G = 0.3 has been applied in general in the noise prediction model.
Geometrical Divergence:	This term relates to the spherical spreading in the free-field from a point sound source resulting in attenuation depending on distance according to the following equation: A_{geo} = 20 x Log(distance from source in meters) + 11
Atmospheric Absorption:	Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation is dependent on the temperature and relative humidity of the air through which the sound is travelling and is frequency dependent with increasing attenuation towards higher frequencies. In these predictions a temperature of 10°C and a relative humidity of 80% have been used, which give relativity low levels of atmosphere attenuation and corresponding worst case noise predictions.
Barrier Attenuation:	The effect of any barrier (or building) between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise.

B.1.7 Source Sound Power Data

The source data that has been assumed for this preliminary assessment is outlined in Table B.4. Each noise source was input as sound power in octave bands. iNoise accepts sound power levels in octave bands from 63Hz to 8kHz. Overall sound power levels have been provided by Jacobs Engineering and the source locations have been obtained from the supplied drawings.

The list of noise sources included in the model are presented in Table B.4 this list includes all new operational mechanical plant items proposed for the site.

The noise source emissions table (previously IE Licence application Table E.5(i)) is presented in Appendix C.

Location	Emission Ref.	Name	Description	Coordinates		Sound Power Data (dBA re 10^{-12} W)								
				N	E	L_{WA}	63	125	250	500	1	2	4	8
							Hz				kHz			
Rooftop	NE-1	AHU 531_01 IN	Penthouse Louvre	569783	837602	67	37	51	60	64	60	56	43	33
Rooftop	NE-2	AHU 531_01 EX	Penthouse Louvre	569823	837598	89	46	51	67	77	88	81	77	71
Rooftop	NE-3	AHU 532_01 IN	Penthouse Louvre	569772	837577	65	33	45	58	61	58	56	44	34
Rooftop	NE-4	AHU 532_01 EX	Penthouse Louvre	569769	837587	87	43	53	65	76	84	81	78	71
Rooftop	NE-5	AHU 533_01 IN	Penthouse Louvre	569751	837581	66	36	50	59	63	59	56	43	33
Rooftop	NE-6	AHU 533_01 EX	Penthouse Louvre	569757	837587	89	45	50	67	77	88	81	77	71
Rooftop	NE-7	AHU 534_01 IN	Penthouse Louvre	569822	837592	63	31	45	56	59	56	54	41	31
Rooftop	NE-8	AHU 534_01 EX	Penthouse Louvre	569784	837577	89	43	49	66	76	87	81	76	70
Rooftop	NE-9	AHU 535_01 IN	Penthouse Louvre	569836	837578	67	37	52	58	63	61	58	47	38
Rooftop	NE-10	AHU 535_01 EX	Penthouse Louvre	569761	837587	81	55	38	62	71	75	76	76	71
Rooftop	NE-11	LYO AHU - IN	Penthouse Louvre	569803	837605	58	33	34	46	56	52	47	43	33
Rooftop	NE-12	LYO AHU - EX	Penthouse Louvre	569811	837607	72	31	32	51	62	67	67	67	57
Rooftop	NE-13	WH AHU - IN	Penthouse Louvre	569840	837577	63	33	51	56	59	56	53	40	31
Rooftop	NE-14	WH AHU - EX	Penthouse Louvre	569840	837580	87	47	57	67	76	85	81	75	70
Rooftop	NE-15	PROCESS SUPPLY AHU	Penthouse Louvre	569778	837581	63	33	44	56	60	54	49	34	23
Rooftop	NE-28	Cooling Unit	Condenser	569842	837607	81	44	54	60	69	75	76	74	69
Rooftop	NE-29	Cooling Unit	Condenser	569841	837605	81	44	54	60	69	75	76	74	69
Rooftop	NE-37	Cooling Unit	Condenser	569742	837591	81	44	54	60	69	75	76	74	69
Stack	NE-50	BOILER EXHAUST	Flue	569813	837610	79	--	--	--	79	--	--	--	--
Stack	NE-54	BOILER EXHAUST	Flue	569812	837610	72	--	--	--	72	--	--	--	--
Stack	NE-55	BOILER EXHAUST	Flue	569814	837609	72	--	--	--	72	--	--	--	--
Stack	NE-56	BOILER EXHAUST	Flue	569816	837609	72	--	--	--	72	--	--	--	--
Stack	NE-60	EXHAUST FLUE	Flue	569816	837611	69	--	--	--	69	--	--	--	--
Yard	NE-74	PUMP	Cooling Tower Pump	569873	837607	85	48	58	64	73	79	80	78	73
Yard	NE-75	PUMP	Cooling Tower Pump	569877	837606	85	48	58	64	73	79	80	78	73
Yard	NE-77	PUMP	Cooling Tower Pump	569889	837601	81	44	54	60	69	75	76	74	69
Rooftop	NE-79	AHU - INLET LOUVRE	Intake Louvre	569828	837584	76	42	65	71	70	68	66	54	44
Rooftop	NE-80	AHU - EXHAUST LOUVRE	Extract Louvre	569832	837584	76	42	65	71	70	68	66	54	44

Location	Emission Ref.	Name	Description	Coordinates		Sound Power Data (dBA re 10^{-12} W)								
				N	E	L_{WA}	63	125	250	500	1	2	4	8
							Hz				kHz			
Yard	NE-62	Chiller Louvre	Chiller Room Louvre	569836	837615	78	--	--	--	78	--	--	--	--
Yard	NE-70	COOLING TOWER	Cooling tower	569871	837601	84	71	73	75	78	79	77	72	66
Yard	NE-71	COOLING TOWER	Cooling tower	569875	837600	84	71	73	75	78	79	77	72	66
Yard	n/a	Diesel Generator	Emergency Generator	569867	837617	83	58	65	70	75	80	75	68	58

Table B.4 Noise Model Input Sound Power Data for New Operational Noise Sources

APPENDIX C
NOISE EMISSIONS TABLE (PREVIOUSLY TABLE E.5(i))

NOISE EMISSIONS – Normal Duty Significant Noise Sources – Preliminary Noise Emission Summary

Source[1]	Emission point Ref. No[2]	Equipment Ref. No	Sound Power Level dB L_{WA}[3]	Octave bands (Hz) Sound Power Levels dB(A) per band									Impulsive or tonal qualities[4]	Periods of Emission
				31.5	63	125	250	500	1K	2K	4K	8K		
AHU 531_01 IN	NE-1	n/a	67	--	37	51	60	64	60	56	43	33	n/a	Continuous
AHU 531_01 EX	NE-2	n/a	89	--	46	51	67	77	88	81	77	71	n/a	Continuous
AHU 532_01 IN	NE-3	n/a	65	--	33	45	58	61	58	56	44	34	n/a	Continuous
AHU 532_01 EX	NE-4	n/a	87	--	43	53	65	76	84	81	78	71	n/a	Continuous
AHU 533_01 IN	NE-5	n/a	66	--	36	50	59	63	59	56	43	33	n/a	Continuous
AHU 533_01 EX	NE-6	n/a	89	--	45	50	67	77	88	81	77	71	n/a	Continuous
AHU 534_01 IN	NE-7	n/a	63	--	31	45	56	59	56	54	41	31	n/a	Continuous
AHU 534_01 EX	NE-8	n/a	89	--	43	49	66	76	87	81	76	70	n/a	Continuous
AHU 535_01 IN	NE-9	n/a	67	--	37	52	58	63	61	58	47	38	n/a	Continuous
AHU 535_01 EX	NE-10	n/a	81	--	55	38	62	71	75	76	76	71	n/a	Continuous
LYO AHU - IN	NE-11	n/a	58	--	33	34	46	56	52	47	43	33	n/a	Continuous
LYO AHU - EX	NE-12	n/a	72	--	31	32	51	62	67	67	67	57	n/a	Continuous
WH AHU - IN	NE-13	n/a	63	--	33	51	56	59	56	53	40	31	n/a	Continuous
WH AHU - EX	NE-14	n/a	87	--	47	57	67	76	85	81	75	70	n/a	Continuous
PROCESS SUPPLY AHU	NE-15	n/a	63	--	33	44	56	60	54	49	34	23	n/a	Continuous
Cooling Unit	NE-28	n/a	81	--	44	54	60	69	75	76	74	69	n/a	Continuous
Cooling Unit	NE-29	n/a	81	--	44	54	60	69	75	76	74	69	n/a	Continuous
Cooling Unit	NE-37	n/a	81	--	44	54	60	69	75	76	74	69	n/a	Continuous
BOILER EXHAUST	NE-50	n/a	79	--	--	--	--	79	--	--	--	--	n/a	Continuous
BOILER EXHAUST	NE-54	n/a	72	--	--	--	--	72	--	--	--	--	n/a	Continuous
BOILER EXHAUST	NE-55	n/a	72	--	--	--	--	72	--	--	--	--	n/a	Continuous
BOILER EXHAUST	NE-56	n/a	72	--	--	--	--	72	--	--	--	--	n/a	Continuous
EXHAUST FLUE	NE-60	n/a	69	--	--	--	--	69	--	--	--	--	n/a	Continuous
PUMP	NE-74	n/a	85	--	48	58	64	73	79	80	78	73	n/a	Continuous
PUMP	NE-75	n/a	85	--	48	58	64	73	79	80	78	73	n/a	Continuous

Source[1]	Emission point Ref. No[2]	Equipment Ref. No	Sound Power Level dB L_{wA}[3]	Octave bands (Hz) Sound Power Levels dB(A) per band									Impulsive or tonal qualities[4]	Periods of Emission
				31.5	63	125	250	500	1K	2K	4K	8K		
PUMP	NE-77	n/a	81	--	44	54	60	69	75	76	74	69	n/a	Continuous
AHU - INLET LOUVRE	NE-79	n/a	76	--	42	65	71	70	68	66	54	44	n/a	Continuous
AHU - EXHAUST LOUVRE	NE-80	n/a	76	--	42	65	71	70	68	66	54	44	n/a	Continuous
Chiller Louvre	NE-62	n/a	78	--	--	--	--	78	--	--	--	--	n/a	Continuous
COOLING TOWER	NE-70	n/a	84	--	71	73	75	78	79	77	72	66	n/a	Continuous
COOLING TOWER	NE-71	n/a	84	--	71	73	75	78	79	77	72	66	n/a	Continuous

1. See Drawing No. 0011 for location of all main noise sources on site.
2. Noise source emissions have been assumed from the preliminary noise impact assessments submitted as part of the IE Licence Application. See technical note ref. DB/18/10237NR01 (Preliminary Noise Impact assessment for IE Application).
3. Preliminary noise emission data, as part of the detailed design process, acoustic attenuators, enclosures, silencers and louvres and barriers will be utilised where appropriate to ensure that the noise emissions will not exceed the operational noise limits stipulated in the facilities EPA Licence.
4. It is understood that all noise sources will be continuous and broadband in nature. A tonal assessment has not been undertaken.