TECHNICAL NOTE

Penguins AQIA

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ABBREVIATIONS

g/s	Grams per second
m	Metre
mg/m³	Milligrams per cubic metre
m/s	Meters per second
MW	Megawatts
μg/m³	Micrograms per cubic metre
km	Kilometres
ADMS	Atmospheric Dispersion Modelling System
AQS	Air Quality Standard
CERC	Cambridge Environmental Research Consultants
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CO	Carbon Monoxide
DLE	Dry Low Emission
EA	Environment Agency
FPSO	Floating Production, Storage and Offloading
GTG	Gas Turbine Generator
HP	High Pressure
IGG	Inert Gas Generator
LP	Low Pressure
NNS	Northern North Sea
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
PAH	Polycyclic Aromatic Hydrocarbons
PC	Process Contributions
PEC	Predicted Environmental Concentration

PPC	Pollution Prevention and Control
SO_2	Sulphur Dioxide
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
WHRU	Waste Heat Recovery Units

1.0 INTRODUCTION

1.1 Background

The Penguins Field is located in the United Kingdom Continental Shelf (UKCS) Blocks 211/13 (Penguins West) and 211/14 (Penguins East), in the northern North Sea (NNS). The field is located approximately 150 km from the Scottish coastline (Northern Shetland) and runs adjacent to the UK/Norway median line, as shown in Figure 1-1.

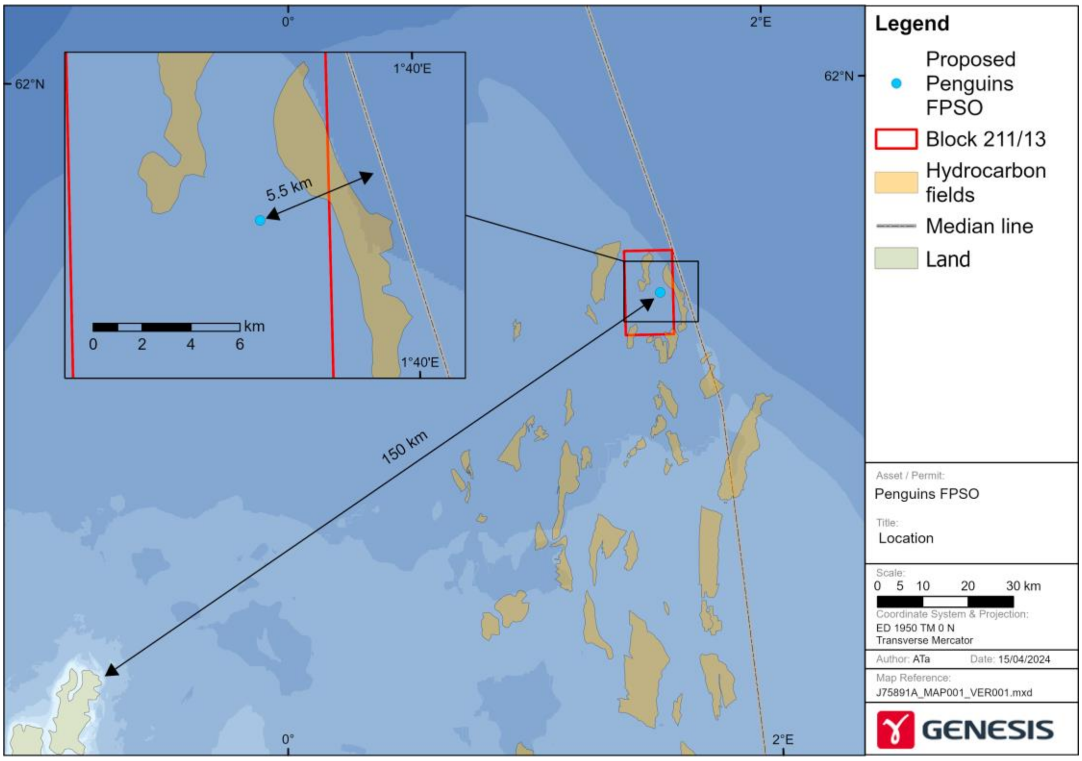

Figure 1-1 Location of the Penguins FPSO

The existing and new developments will be produced via additional subsea infrastructure to the Penguins Sevan Floating, Production, Storage and Offloading (FPSO) facility (Latitude WGS84: N 61 34 59.269; Longitude WGS84: E 001 32 47.707). The closest protected area is some 60 km from the FPSO, as shown in Figure 1-2.

Oil will be temporarily stored and exported via tanker offload. Gas is compressed, dehydrated and exported through the gas export pipeline tied into the existing FLAGS pipeline system. Gas will also be used for gas lift, fuel gas and cargo tank blanketing. When the FPSO becomes gas deficient or is shutdown, gas can be imported from the FLAGS system.

The main power supply is obtained from the three Taurus 70 Gas Turbine Generators in a 3 x 50% configuration. Normally two machines are running with the load shared. Gas compression is supplied via a Titan 130 HP gas fired compression turbine (1 x 100% configuration). Both the power generation and gas compression turbines are fitted with Solar's SoLoNOx^{TM} Dry Low-Emission (DLE) combustion technology, which is optimised to reduce emissions by tightly controlling the combustion temperature inside the turbine.

The FPSO also has an inert gas generator (IGG) to provide a low oxygen atmosphere in the cargo tanks of the FPSO to minimise the risk of explosion. The IGG operates on diesel/gas oil and is expected to operate for around 1500 hours per year.

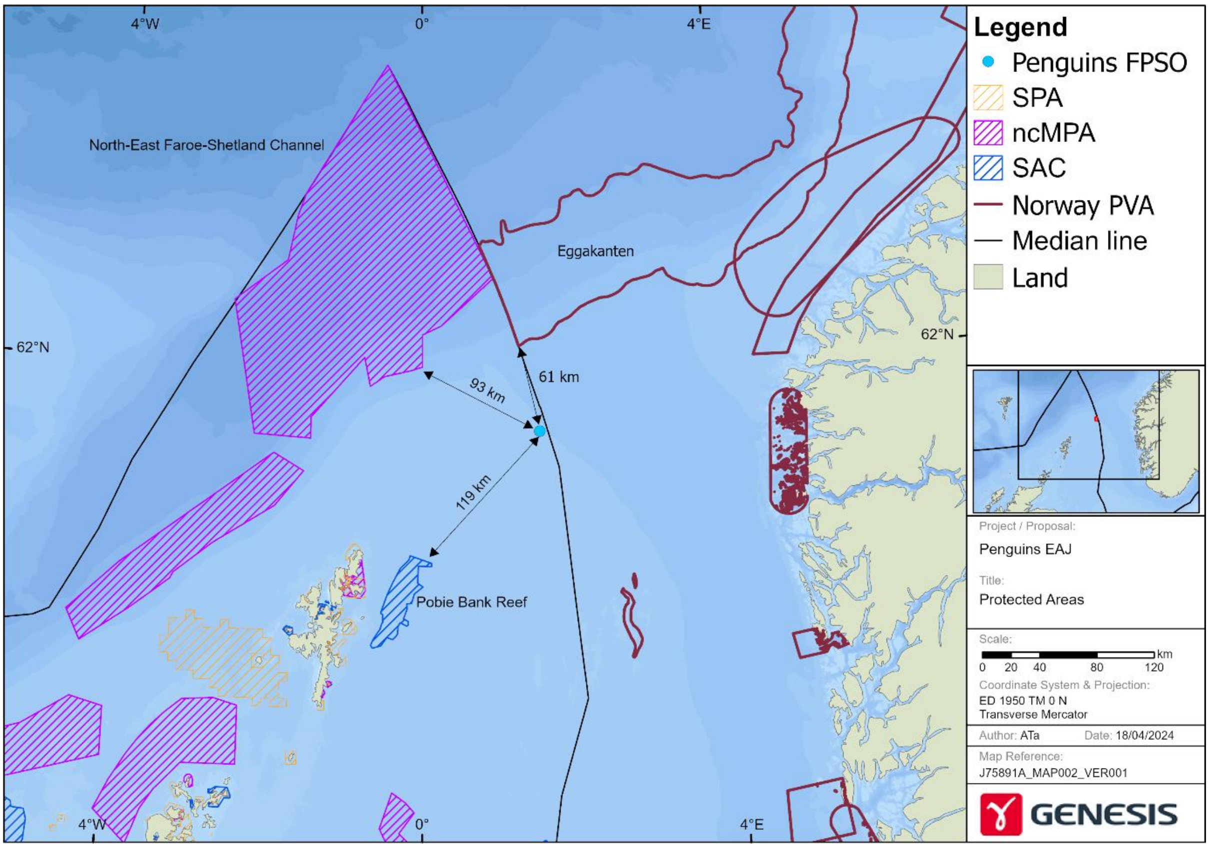

Figure 1-2 Proximity of the Penguins FPSO to Protected Areas

The Penguins FPSO also has a safety flare gas system. In the event of an installation upset or process shutdown, the flare gas flows are routed to conventional flare tips and ignited, as per a conventional system. During normal operations the flare system is continuously purged with Nitrogen. To reduce the emissions from the asset, a Vapour Recovery Unit (VRU) has been installed to recycle waste streams which would otherwise historically have been routed to flare. The Vapour Recovery Unit (VRU) compresses fuel gas which has been used for purging the vapour space in the oil cargo tanks and as stripping gas in the TEG regeneration unit and feeds it into the gas compression train. No routine flaring is anticipated from the FPSO during normal operations.

Emissions of oxides of sulphur from the combustion equipment at the installation are a function of the Sulphur content of the fuels burnt. All the gas turbines normally operate on gas minimising the emissions of SO_2 from this combustion equipment. Low Sulphur diesel (< 0.1 wt.%) is also used as a back-up fuel source for gas turbines infrequent events where enough fuel gas is not available. Emergency equipment such as firewater pumps and an emergency generator consume diesel and are a potential source of pollutants but they are expected to run for less than 500 hours per year.

1.2 Scope

Shell U.K. Ltd engaged Genesis Energies to undertake an Air Quality Impact Assessment (AQIA) to supplement the Penguins FPSO PPC permit application (Ref 1).

The main objective of the dispersion modelling assessment is to determine the potential environmental impact of emissions from the FPSO by comparing the predicted atmospheric concentrations of nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO) to onshore air quality standards. It should be noted that there are no applicable air quality standards for the offshore UKCS. This technical note presents the results of atmospheric emission modelling undertaken for the FPSO facility operating under four different scenarios.

2.0 EMISSIONS AND AIR QUALITY GUIDELINES

2.1 PPC Requirements

The Offshore Combustion Installations (Pollution Prevention and Control) (Amendment) Regulations 2018 transpose the relevant provisions of the IED 2010/75/EU with respect to specific atmospheric pollutants from offshore combustion installations with aggregated thermal input capacities greater than 50 megawatts (MW). Installations with combustion equipment exceeding 50 MWth must apply for a PPC permit. As part of the application process, atmospheric dispersion modelling of pollutants should be carried out, and updates completed if significant combustion plant operational changes have occurred.

2.2 Air Quality Standards

The significance of the concentrations of pollutants in the environment is generally compared against published environmental Air Quality Standards (AQS) (Ref 2). However, there are no prescribed air quality standards for the offshore environment. Therefore, for comparison purposes and in order to assess the impacts of emissions to air in this assessment, the terrestrial UK AQS will be used.

The AQS are based on standards from expert recommendations representing levels below which no significant health effects would be expected in the population as a whole. The standards are based on assessment of the effects of each pollutant on human health including the effects on sensitive subgroups or on ecosystems.

The Air Quality Standards (Scotland) Regulations 2010 (“the Regulations”) implement Directive 2008/50/EC of the European Parliament and of the Council on ambient air quality and cleaner air for Europe (“the Directive”), together with Directive 2004/107/EC of the European Parliament and of the Council relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons (PAHs) in ambient air (“the Fourth Daughter Directive”), which flows from the Air Quality Framework Directive1996/62/EC (“the Framework Directive”). The Regulations replace and revoke the Air Quality Standards (Scotland) Regulations 2007 (SSI 2007/182). The principal aim of both the Directive and the Fourth Daughter Directive is to achieve a high degree of protection for human health and the environment against the effects of ambient air emissions.

The objective of the modelling is to determine the potential environmental impact of emissions of NO_2, SO_2 and CO from the FPSO. Table 2-A outlines the ‘permitted exceedance’ thresholds for these pollutants.

Table 2-A Air Quality Standards (Ref 2)

Pollutant	Standard (µg/m^3)	Reference period and permitted exceedance
SO_2	266 µg/m^3	15-minute mean not to be exceeded more than 35 times/year (99.9th percentile)
	350 µg/m^3	1-hour mean not to be exceeded more than 24 times/year (99.73rd percentile)
	125 µg/m^3	24-hour mean not to be exceeded more than 3 times/year (99.18th percentile)
NO_2	200 µg/m^3	1-hour mean not to be exceeded more than 18 times/year (99.79th percentile)
	40 µg/m^3	Annual mean
CO	10,000 µg/m^3	Maximum daily rolling 8-hour mean

Model results will be considered in terms of their relevant percentile, as set by the AQS. For example, where the benchmark allows for 24 exceedances of the hourly mean per year, this equates to the 99.73rd percentile; in this case the maximum value occurring in the model domain or at a relevant receptor at the 99.73rd percentile is reported.

Environment Agency (EA) guidance (Ref 3) sets out criteria for determining the significance of emissions from industrial sources. Emissions from a source are termed insignificant if the Process Contribution (PC) comprises:

- Less than 1% of the long-term environmental standard (e.g. annual mean AQS)
- Less than 10% of the short-term environmental standard (e.g. hourly mean AQS)

However, even if the PC does not meet these criteria, the emission may still be judged as having an acceptable level of environmental risk if the total concentration of the pollutant (i.e., the Predicted Environmental Concentration (PEC) including the existing background contribution from other sources) falls below the benchmark.

3.0 METHODOLOGY

3.1 Dispersion Model

The Cambridge Environmental Research Consultants (CERC) ADMS (Ref 4) is an atmospheric pollution dispersion model used to estimate dispersion of gaseous pollutants from sources of various types (point, volume, area and others). Gaussian plume air dispersion is modelled, and the atmospheric boundary layer is characterised by the boundary layer depth and the Monin-Obukhov length.

The latest version of ADMS used in this study, ADMS 6, models the air quality impact of emissions from industrial installations to the atmosphere. The model calculates long and short-term concentrations and deposition fluxes from various types of emission sources such as continuous point, jet, line, area and volume sources. It uses hourly data for the relevant location, taking many factors into account (e.g., meteorological data and background concentrations), allowing complex and realistic model outputs to be generated.

Emissions sources are modelled as a Gaussian plume and the dispersion of the plume is modelled mathematically across the grid. The concentrations of pollutants can then be exported from the model for any point in the model domain and assessed against relevant thresholds.

3.2 Modelling Basis

3.2.1 Combustion Equipment

The air modelling study focused on the impacts of the FPSO's combustion equipment, The following combustion equipment was included in the model:

- HP Compressor (GTC)
- 3 x Gas Turbine Generators (GTGs)
- Inert Gas Generator (IGG)
- HP Flare; and
- LP Flare.

The combustion equipment included in the modelling are expected to cause the greatest pollutant emissions of all the combustion plant on the FPSO. It is anticipated that following the commissioning period, the diesel engines associated with the firewater pumps and emergency generators will only be used in emergencies and furthermore, will normally operate for less than 500 hours per annum and hence have been excluded from the scope of this study.

The turbines are fitted with Solar's SoLoNOx™ Dry Low-Emission (DLE) combustion technology which is optimised to reduce emissions by tightly controlling the combustion temperature inside the turbine. When operating above 50% load the GTGs operate in SoLoNOx mode. When below 50% load the GTGs do not operate in in SoLoNOx mode and pollutant rates are higher than when operating in SoLoNOx mode. For providing vessel power during normal operations one GT is expecting to be in SoLoNOx mode with the remaining GT operating around 30% load. However, during cargo offloading operations power demand is expected to increase such that both GTGs will be operating in SoLoNOx mode.

3.2.2 Modelling Scenarios

Air dispersion modelling was carried out for four difference scenarios:

- Scenario 1: Normal Operations – max fuel use case. 2 GTGs operating on fuel gas at 100% load, HP compressor operating at 100% load, and the IGG operating at maximum capacity.
- Scenario 2: Normal operations – max fuel use case, with emergency flaring. 2 GTGs operating on fuel gas at 100% load, HP and LP flares operating on an emergency blowdown case, and the IGG operating at maximum capacity.
- Scenario 3: Upset conditions with emergency flaring. 2 GTGs operating on gas oil/diesel at 100% load, HP and LP flares operating on a full flow relief case, and the IGG operating at maximum capacity.
- Scenario 4: Normal operations – realistic case. 2 GTGs operating on fuel gas (one at 50% load and the other at 30% load), HP compressor operating at 100% load and the IGG operating at maximum capacity.

Scenario 1 represents a case where maximum fuel is being consumed and allows for future optionality on the FPSO should extra power demand be needed. Scenario 2 represents a case where the HP compressor is offline and the FPSO is flaring. And Scenario 3 models a case where the FPSO has experienced a full emergency shutdown with the topside inventory being disposed via the flare system and the GTGs running on diesel/gas oil.

Scenario 4 represents a more realistic case of turbine loading. For this scenario, it has been assumed that 1 GTG will be operating in SoLoNO$_x$ mode all year and 1 GTG will be operating out of SoLoNOx mode all year at 30% load. NO_x and CO concentrations are larger at the 30% load, so assuming a full year at 30% load represents a conservative approach to modelling normal operations because at regular intervals both GTGs will be operating in SoLoNOx mode during cargo offloads.

3.3 ADMS Modelling Inputs

Specific model inputs, based on calculations and data provided by Shell, which are entered into the model interface are illustrated in Table 3-A. Full details of the flare gas compositions used in the modelling can be found in Appendix C.

3.3.1 Emissions Calculations

Data for each individual source was supplied by Shell (Ref 10 to 15). The data was used to determine the emission rates, stack geometries and physical parameters for each emissions source. ADMS cannot be applied to the flaming region of a flare but can be used to model the dispersion of the combustion products from the start of the buoyant plume of the flare. This is achieved by estimating an ‘effective height’, ‘effective diameter’ and ‘effective velocity’ of the flare (Ref 9) which are then entered as flare height, diameter and velocity in the model input parameters. The following assumptions were made during the calculation of the model inputs:

- The molecular weight of the HP Compressor exhaust gas was assumed to be similar to that of the GTGs;
- For the equipment operating on fuel gas, the gas itself was assumed to be an ideal gas and therefore ideal gas laws were used to determine certain parameters of the combustion plant, such as the emission rates and velocities of the exhaust gases. Exhaust gases were also assumed to be ideal gases.
- Ambient temperature was used to calculate the effective velocity. The ambient temperature was assumed to be the average temperature in the meteorological data file, which was 9°C.
- The flare temperature was assumed to be 1000°C as per Ontario modelling guidance (Ref. 9).
- All sources were assumed to be point sources, apart from the IGG which was modelled as a jet source at 90°. The IGG gases are released to atmosphere from a goose-neck vent, part-way up the flare boom on the vessel. Modelling the IGG as a jet source at 90° to the horizontal is a simplifying assumption to accommodate limitations in the ADMS software, i.e. that downward sources cannot be modelled.
- The flaring scenarios are aligned with data provided in Flare and Vent Cargo Tank Vent Gas Dispersion Study (Ref. 10). Emissions rates have been estimated using emissions factors from EEMS (Ref 16).
- The concentrations applied to the exhaust gases of the GTGs and the GTC were provided by the vendor and referenced to 15% O_2. No conversion has been made to convert to actual O_2 levels as this data was not available. Using pollutant concentrations referenced to 15% O_2 is likely to result in a conservative estimate of pollutant rates.

3.3.2 Emission Source Parameters

The source parameters used in the model are outlined in Table 3-A.

Table 3-A: Source Input Data

Source	HP compressor	GTG A	GTG B	HP Flare	LP Flare	IGG
Source Type	Point	Point	Point	Point	Point	Jet
Coordinate System	ED50 UTM Zone 31N					
Coordinates	(422813, 6828796)	(422805, 6828790)	(422808, 6828790)	(422898, 6828825)	(422897, 6828826)	(422879, 6828810)
Scenario 1: 2 GTGs operating on fuel gas at 100% load, HP compressor operating at 100% load, and the IGG operating at maximum capacity						
Height (m)	60.5	60.5	60.5	-	-	79.5
Diameter (m)	2.4	1.7	1.7	-	-	0.21
Exit velocity (m/s)	26.1	28.8	28.8	-	-	23.5
Exit Temperature (°C)	487	493	493	-	-	45
SO_2 Emission Rate	0.0123	0.0002	0.0002	-	-	0.11
NO_x Emission Rate	3.53	1.06	1.06	-	-	3.17
CO Emission Rate	5.12	0.64	0.64	-	-	0.84
Scenario 2: 2 GTGs operating on fuel gas at 100% load, HP and LP flares operating on an emergency blowdown case, and the IGG operating at maximum capacity						

Source	HP compressor	GTG A	GTG B	HP Flare	LP Flare	IGG
Height (m)	-	60.5	60.5	188.6[(1)]	131.4[(1)]	79.5
Diameter (m)	-	1.7	1.7	24.0[(1)]	4.2[(1)]	0.2
Exit velocity (m/s)	-	28.8	28.8	20.0[(1)]	20.0[(1)]	23.5
Exit Temperature (°C)	-	493	493	1000[(2)]	1000[(2)]	45
SO_2 Emission Rate	-	0.0002	0.0002	0.0000	0.0000	0.1065
NO_x Emission Rate	-	1.06	1.06	23.31	0.76	3.17
CO Emission Rate	-	0.64	0.64	130.16	4.26	0.84
Scenario 3: 2 GTGs operating on gas oil/diesel at 100% load, HP and LP flares operating on a full flow relief case, and the IGG operating at maximum capacity.						
Height (m)	-	60.5	60.5	203.4[(1)]	152.4[(1)]	79.5
Diameter (m)	-	1.7	1.7	81.3[(1)]	26.0[(1)]	0.2
Exit velocity (m/s)	-	28.84	28.84	2.59[(1)]	3.76[(1)]	23.51
Exit Temperature (°C)	-	493	493	1000[(2)]	1000[(2)]	45
SO_2 Emission Rate	-	10.57	10.57	0.0000	0.0000	0.11
NO_x Emission Rate	-	4.24	4.24	34.55	5.48	34.55

Source	HP compressor	GTG A	GTG B	HP Flare	LP Flare	IGG
CO Emission Rate	-	1.34	1.34	192.91	30.58	0.84
Scenario 4: 2 GTGs operating on fuel gas (one at 50% load and the other at 30% load), HP compressor operating at 100% load and the IGG operating at maximum capacity.						
Height (m)	60.5	60.5	60.5	-	-	79.5
Diameter (m)	2.4	1.7	1.7	-	-	0.21
Exit velocity (m/s)	26.1	18.2	28.8	-	-	23.5
Exit Temperature (°C)	487	493	493	-	-	45
SO_2 Emission Rate	0.0123	0.0001	0.0002	-	-	0.11
NO_x Emission Rate	3.53	0.70	3.88	-	-	3.17
CO Emission Rate	5.12	0.43	236.6	-	-	0.84
(1) These parameters are pseudo-parameters calculated in line with the Ontario flare guidance (Ref. 9). See section 3.3.1 for more information. (2) Flare tip temperature used in the modelling is in line with Ontario flare guidance (Ref. 9)						

3.3.3 Meteorology and Surface Characteristics

Recent hourly meteorological data was acquired from a third-party supplier, ADM Ltd (Ref 5), for Magnus Oil Platform for the years of 2021 and 2022. Meteorological variables included were time (year, day and hour), air temperature, wind speed and direction, precipitation, cloud coverage and relative humidity.

ADMS includes an option to model the surface roughness and heat fluxes which occur over the sea, called the marine boundary layer. In order to run this model option, sea surface temperature should be included in the meteorological input data, and it is not recommended to run the marine boundary layer option without this data. Sea surface temperature is not recorded at the Magnus Oil Platform and hence the model option has not been used. Further, it is not anticipated that changes in surface roughness or heat flux would lead to changes to the conclusions of the modelling.

The wind roses for the 2021 and 2022 meteorological data are shown in Figure 3-1. The figures show that there was no clear predominant wind direction in 2021 and that the predominant wind direction was from the South and South-west in 2022.

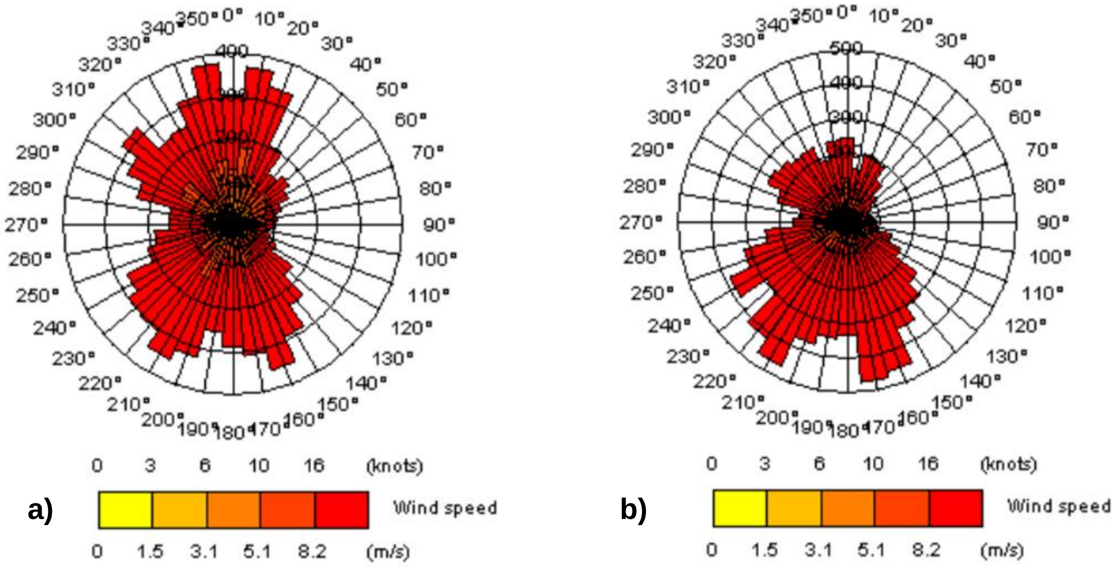

Figure 3-1 Wind roses for the Magnus Oil platform meteorological data for a) 2021 b) 2022

3.3.4 Background Pollutant Concentrations

When predicting pollutant concentrations, background concentrations should be taken into account where relevant. Ambient levels of pollution are incorporated into model outputs for analysis in context of AQS. Ambient air quality data is not gathered offshore therefore, available information for remote onshore locations is considered appropriate. Modelled background SO_2 and CO concentrations for the Shetlands have been applied (Ref 6).

Background NO_2 concentrations were obtained from the Stratchvaich monitoring station near Loch Vaich (Ref 7). The ambient pollutant concentrations are presented in Table 3-B.

Table 3-B: Background Concentrations

Averaging Time	CO (mg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)
Long-Term	0.11	1.65	4.0
Short Term	0.22	3.30	8.0

As per EA guidelines, the long-term ambient concentrations have been doubled to approximate a short-term background concentration (Ref 3).

3.3.5 Receptors

Receptor locations for the modelling study have been selected based on the locations of the nearest offshore installation and 4 points along the transboundary line (Norway/UK). A coarse grid (4 along the median line, each at 4 heights) of points along the median line to minimise model runtime was used to identify the order of magnitude of the emission concentrations at these points. As the concentrations were so low at all of these points and on the modelled grid itself, there was no value to be gained in increasing the number of points along the median line. Thus 4 points were considered sufficient to determine that the transboundary impact on air quality was negligible. Details of the receptors for each study are outlined in Table 3-C.

Table 3-C Modelled Sensitive Receptor Locations

Receptor Name		Location (m)	Distance from FPSO (km)	Direction from FPSO	Height Above Sea Level (m)
Magnus		(410246, 6833190)	13.0	West	0, 50 100,150
Norwegian Transboundary	Location 1	(426826, 6835026)	7.4	East	0, 50 100,150
	Location 2	(427713, 6831798)	5.7	East	0, 50 100,150
	Location 3	(428425, 6829065)	5.5	East	0, 50 100,150
	Location 4	(429186, 6826156)	6.8	East	0, 50 100,150

3.3.6 Grids

A 160 km^2 grid has been used in the model to estimate the pollutant concentrations from the FPSO combustion plant. The grid has been used to model concentrations at a range of heights. A grid spacing on 160 m was used.

3.3.7 Output Processing

A variety of output data according to run configuration is produced by running a model in ADMS. For the model, the 15-minute, 1-hour, 24-hour average concentrations of SO_2 were calculated at each receptor and for each point in the modelled grid. For NO_x the 1-hour average and annual mean was modelled, and for CO the 8-hour average was modelled. For each averaging time, the maximum concentration at each receptor and within 40 km of the FPSO was recorded.

3.3.8 Treatment of Nitrogen Oxides

The AQS objectives for the protection of human health relate to the concentrations of the NO_2 component of NO_X. Once released, NO can be converted to NO_2 by reaction with low level ozone in the atmosphere. The process is also reversible in sunlight and the net rate of conversion of NO to NO_2 in the plume is therefore a function of the rate of dilution of the plume by ambient air, trace gas concentrations in the air and meteorology.

As per the original AQIA and EA guidance (Ref 8), 35% of the modelled short-term NO_2 values and 70% of the modelled long-term NO_2 values should be used for comparison with the relevant air quality standards and limits.

3.3.9 Norwegian Transboundary

Due to the close proximity of the FPSO to the Norwegian median line, pollutants could be dispersed across the median line and impact Norway's air quality.

Norway's offshore petroleum industry is regulated by the Pollution Control Act which aims to reduce pollution. It is implemented by the Norwegian Environment Agency and the Act lays down a general prohibition against pollution. Pollution is prohibited unless an operator has specific permits to do so. There are numerous regulatory acts which govern the emissions to air including the Petroleum Act, the CO_2 Tax Act on Petroleum Activities, the Sales Tax Act, the Greenhouse Gas Emission Trading Act and the Pollution Control Act.

The UK and Norway are both parties to the Convention on Long-Range Transboundary Air Pollution (CLRTAP), which aims to reduce air pollution across national boundaries. The convention has several protocols and agreements that set emission reduction targets and air quality standards for various pollutants. Examples of regulations that apply to transboundary offshore air emissions between the UK and Norway include:

- Gothenburg Protocol: Sets out emission reduction targets for several air pollutants.
- The OSPAR Convention: Has measures to reduce emissions of air pollutants such as SO_2 and NO_x.

No specific air quality limits have been identified for offshore installations operating in the Norwegian continental shelf. No Norwegian installations were identified as being within a 30 km radius from the proposed location of the Penguins FPSO.

4.0 RESULTS

The key results from the assessment of pollutant concentrations in the vicinity of the FPSO and at selected sensitive receptors, over the range of meteorological conditions are presented in this section. If pollutant concentrations are below 1% of the long-term (annual mean) or 10% of the short term AQS limits shown in Table 2-A, then they can be screened out as insignificant according to the EA screening criteria (Ref 3). This section summaries which pollutant concentrations have been screened out as insignificant and discusses in more detail those results that exceed the screening criteria. The full results for all modelled scenarios can be found in Appendix A and B.

4.1 Gridded Output Concentrations

The maximum concentrations of the modelled grid are shown in Appendix A. The gridded outputs are all at sea-level. The results for scenarios 1 and 2 show that none of the pollutant concentrations are deemed significant and hence can be screened out.

For scenario 3 the 1-hour and the 24-hour averages for SO_2 are below the screening criteria and can be screened out. All other pollutant concentrations in scenario 3 are above the screening criteria but are still well below the relevant AQS. Further, the concentrations of the pollutants are driven by the emission rates from the flare systems assuming full flow relief which are not representative of the annual release rates – the release rates will be significantly lower during normal operations. The topside inventory is designed to be depressurised within 15 mins so the associated emissions rates will peak during that 15-minute window. The flare has been modelled at a constant flow-rate, operating all year. The results show that even at these rates the AQS are not exceeded. Emissions from the flare are conservatively based on the flare being operational at full flow for 3 hrs per year. For scenario 4 the 1-hour average for NO_2 exceeds the screening criteria. All other pollutant concentrations are deemed insignificant and can be screened out. The NO_2 emissions are driven by the emission rates from the GTGs, in particular the assumptions related to the emissions when the GTGs are not in SoLoNOx mode. Whilst the PC values for NO_2 exceed the 1% screening threshold, the PEC values are at 10% of the 1-hour NO_2 standard indicating that the pollutant AQS are very unlikely to be breached at sea level.

Contour plots of the PC for each of the relevant AQS are presented in Figures 4-1 to 4-5. The plots are shown for scenario 3 as this was scenario resulted in the highest concentration of pollutants on the modelled grid. The contour plots illustrate that the highest concentrations occur in proximity to the FPSO with concentration decreasing with distance from the emission sources. For the SO_2 15-minute average pollutant concentrations (266 µg/m^3), the limits on the contour plots relate to the screening criteria. As the 15-min average is a short-term measure, the screening criteria is 1%. Therefore, the chart is illustrating that the receptors are in contours that are well below the screening criteria.

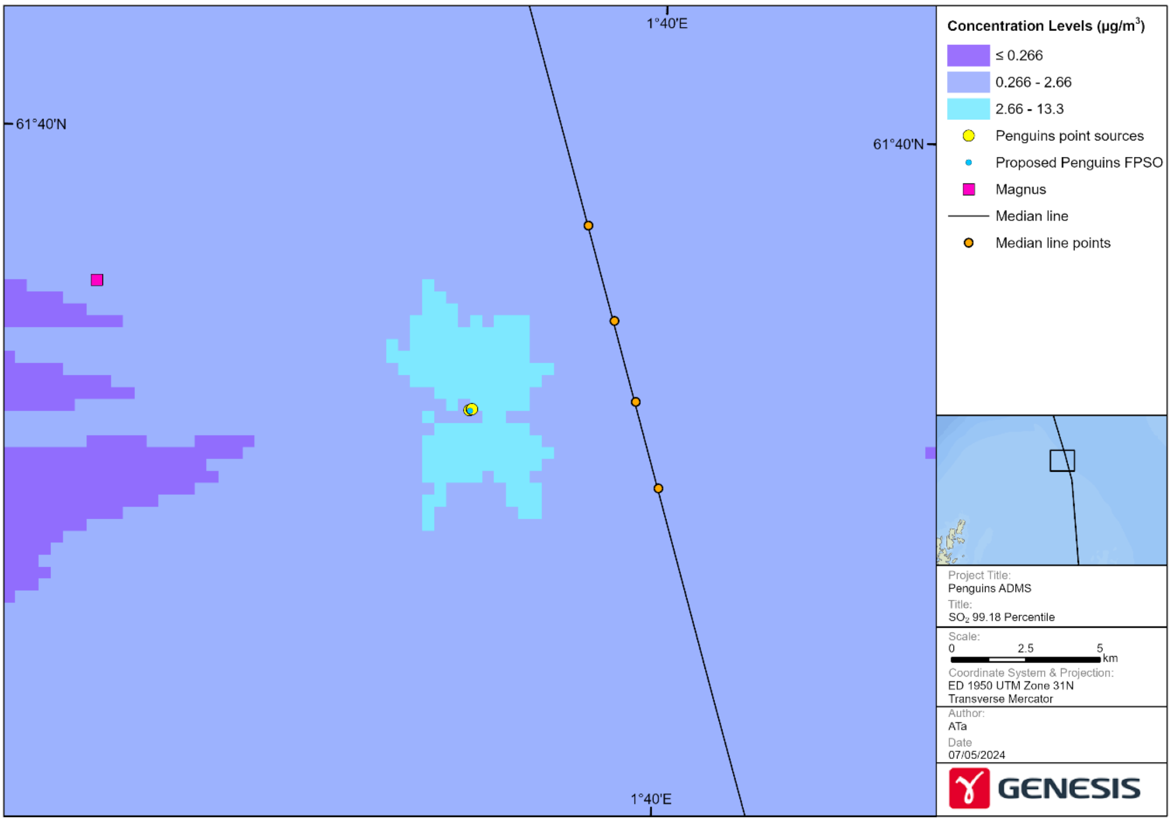

Figure 4-1: 15-minute average PC SO_2 concentrations on site in scenario 3.

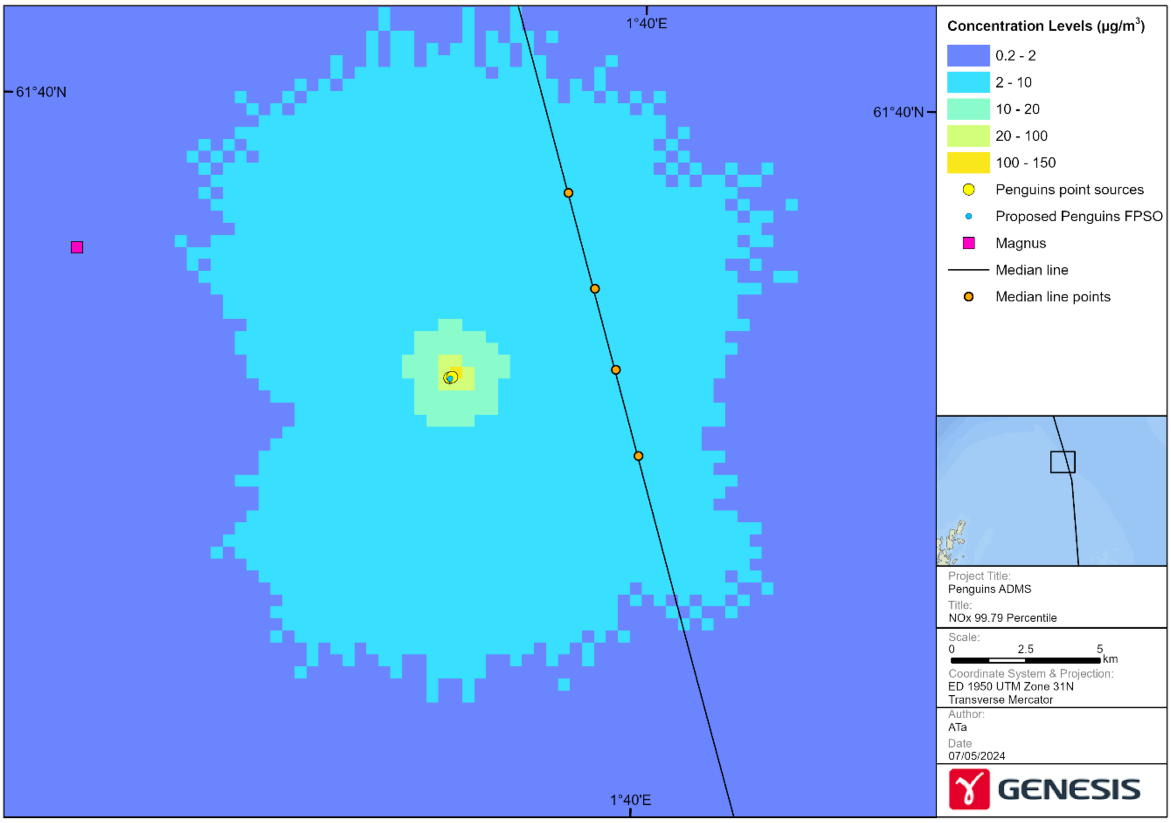

Figure 4-2: 1-hour average PC NO_x concentrations on site in scenario 3.

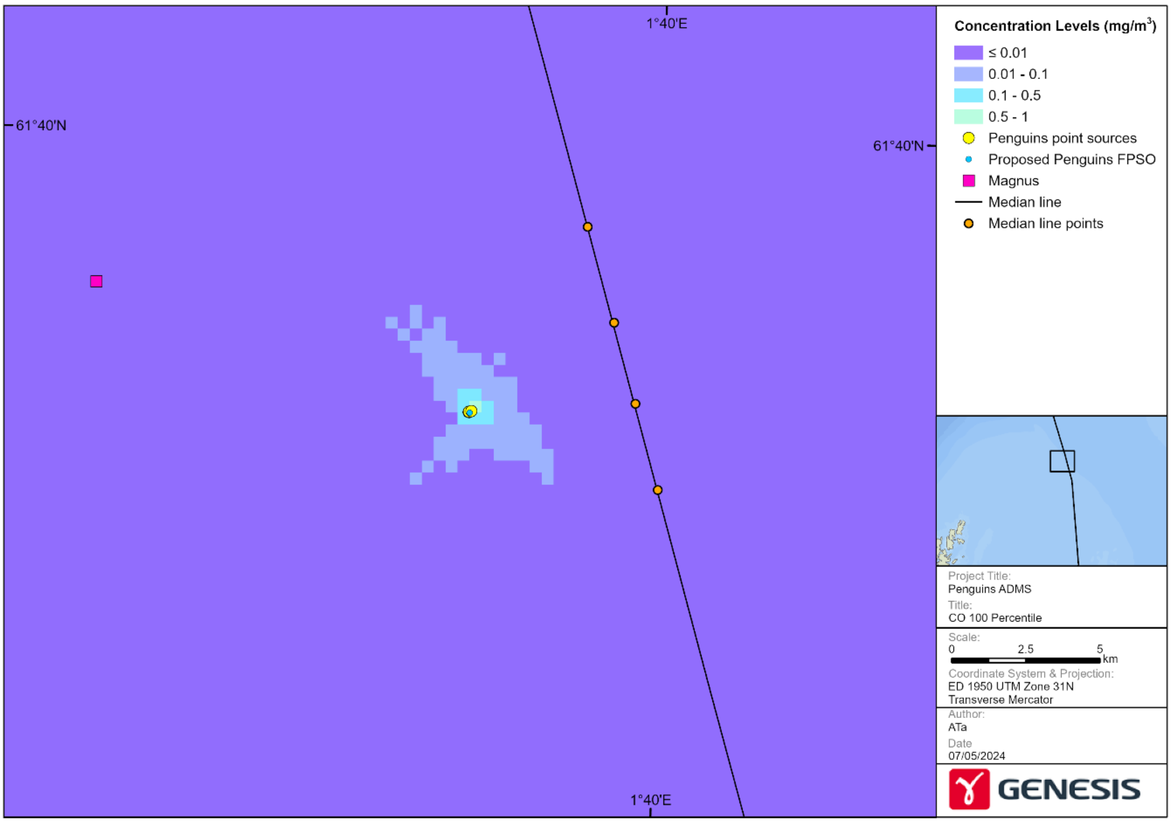

Figure 4-3: 8-hour average PC CO concentrations on site in scenario 3.

4.2 Receptors

The maximum process contribution (PC) for each pollutant has been compared to the exceedance thresholds of the AQS for the receptors of interest. This section summaries the results. The full results are presented in Appendix B.

4.2.1 Magnus Installation

For scenario 1 and 2 all pollutant concentrations are below the screening criteria and can be classed as insignificant.

For scenario 3 the 15-minute and 1-hour averages for SO_2 exceed the screening criteria. However, the concentrations are still well below the relevant AQS. The SO_2 emissions are driven by the diesel use in the GTGs. The GTGs should seldom be run at 100% load on diesel. All other pollutant concentrations can be classed as insignificant.

For scenario 4 all pollutant concentrations are below the screening criteria and can be classed as insignificant.

Where the PC values for SO_2 have exceeded the 1% screening threshold, the PEC values do not reach 15% of relevant standards indicating that the pollutant AQS are very unlikely to be breached at the Magnus Installation.

4.2.2 Median Line

For scenario 1 and 2, the 1-hour average for NO_2 exceeds the screening criteria at the 100 m and 150 m height. However, the exceedances are still well below the relevant AQS. All other pollutant concentrations can be classed as insignificant.

For scenario 3, CO and NO_2 annual mean emissions are below the screening criteria and can be classed as insignificant. NO_2 and SO_2 emissions are largest at the 100m height receptor but all concentrations are below the AQS. The SO_2 emissions are driven by the diesel use in the GTGs. The GTGs should seldom be run at 100% load on diesel. The full flow relief events modelled in the flare system which drive the NO_2 emissions are also likely to be in frequent. Hence it can be concluded that the relevant pollutant AQS are very unlikely to be breached.

For scenario 4, SO_2 and NO_2 annual mean emissions are below the screening criteria and can be classed as insignificant. Short-term NO_2 and CO emissions are largest at the 100 m receptor but all concentrations are below the AQS. These emissions are driven by the GTG at low load where the SoLoNOx technology is not active. The second GTG is not going to be running at low load all year as has been assumed in the modelling. Hence it can be concluded that the relevant pollutant AQS are very unlikely to be breached.

The UK Government also provides guidance (Ref 3) on how to screen for protected areas. Whilst the Penguins FPSO lies outwith the 15 km threshold indicated by the guidance, the screening limits presented in the guidance are a useful comparator. The guidance states that where a long-term PC is greater than 1% and the PEC is less than 70% of the long-term environmental standard then the emissions are deemed insignificant. At all points at all receptors along the median the PEC is less than 70%.

4.3 Model Limitations

A limitation of ADMS 6 is that it does not model meteorological conditions where wind speed is lower than 0.75 m/s. The proportion of time steps within the simulation where the wind speed was below 0.75 m/s was less than 0.6% for 2021 and less than 1% for 2022 meteorological data. Incidentally, conditions of low wind are the conditions which yield the highest concentrations of pollutants at the receptors of interest in this study, due to less dispersion. However, the low proportion of time steps where the wind speed is less than 0.75 m/s shows that the results are unlikely to be affected by low wind speeds.

Modelling of flares is also limited in ADMS and relies upon pre-processing of data to estimate parameters needed to determine the effective height and diameter of the flare as well as the velocity of the combusted flare gas. The pre-processing applied in this study follows guidance (Ref 9) recommended by CERC. This guidance applies a conservative approach to prevent stack tip downwash during calm and low wind speed events to ensure that dispersion can be modelled. In this approach if the calculated flare gas velocity is less than 1.5 m/s then it is replaced by a conservative value of 20 m/s. This conservative approach was relevant to scenario 2 flaring rates.

5.0 CONCLUSIONS

Modelling was carried out to predict the Process Contribution (PC) to the concentrations of each pollutant from the FPSO combustion equipment. The model output was calculated on a 40 km x40 km grid in the proximity of the FPSO and also at the nearby Magnus Oil facility and at four points along the UK/Norway median line to estimate the transboundary impact of emissions from the FPSO.

The significance of modelled concentrations was assessed by comparison of the PC to the relevant AQS. EA Guidance considers long-term concentrations insignificant if the PC is less that 1% of the AQS and short-term concentrations insignificant if the PC is less than 10% of the AQS. For scenarios 1,2, and 3, CO emissions at all receptors were screened out and for scenario 4, SO_2 emissions at all receptors were screened out.

Where a release is not screened out as insignificant, the Predicted Environmental Concentration (PEC) is calculated. For long-term objectives, the PEC is calculated by adding the PC to the ambient background pollutant concentration. For short-term objectives, the PEC is calculated by adding the PC to twice the ambient background pollutant concentration.

For those results not screened out as insignificant, all are well below the AQS. Scenario 3 presents the highest levels of NO_2 and SO_2 concentrations. The NO_2 emissions are driven by the full flow relief flare rates which are likely to be in frequent. The SO_2 emissions are driven by the diesel use in the GTGs which should seldom be run at 100% load on diesel. Given the conservative nature of the scenario it can be concluded that the relevant pollutant AQS are very unlikely to be breached and the impact on air quality is likely to be negligible.

For scenario 4, NO_2 and CO emissions are driven by the GTG at low load where the SoLoNOx technology is not active. The modelling approach used is considered to be a conservative approximation and hence is likely to overestimate the pollutant rates and it can be concluded that the relevant pollutant AQS are very unlikely to be breached.

With the prevailing wind direction being broadly parallel to the median line and the relatively low pollutant concentrations that have been estimated from conservative modelling scenarios, the expected trans-boundary impacts from the Penguins FPSO is likely to be negligible.

The UK Government also provides guidance (Ref 3) on how to screen for protected areas. Whilst the Penguins FPSO lies outwith the 15km threshold indicated by the guidance, the screening limits presented are a useful comparator. The guidance states that where a long term PC is greater than 1% and the PEC is less than 70% of the long term environmental standard then the emissions are deemed insignificant. At all points on the model grid and at all receptors the PEC is less than 70%.

6.0 REFERENCES

REFERENCES	
Ref 1	Penguins PPC Permit Application (PPC/113)
Ref 2	Defra (2010). National Air Quality Objectives. Available at: https://uk-air.defra.gov.uk/assets/documents/National_air_quality_objectives.pdf
Ref 3	Environment Agency (2023). Guidance: Air emissions risk assessment for your environmental permit. [online] Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit
Ref 4	Cambridge Environmental Research Consultants (CERC) (2023). ADMS 6. Available at: http://www.cerc.co.uk/environmental-software/ADMS-model.html
Ref 5	ADM Ltd (2023). Magnus Oil Platform 2021 and 2022 ADMS Meteorological data. [purchased online] Available at: https://www.aboutair.com/met-data-search/
Ref 6	Background concentrations of CO and SO_2 in the Shetlands, available from https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2001
Ref 7	Scottish Air Quality (2024). Site Data – Strath Vaich [online] Available at: https://www.scottishairquality.scot/latest/site-info/SV
Ref 8	Environment Agency, Air Quality Modelling and Assessment Unit, 'Conversion Ratios for NOx and NO2' (no date).
Ref 9	Lakes Environmental Consultants Inc., 2003: Flare Sources. In Proposed guidance for air dispersion modelling, Ontario Ministry of the environment.
Ref 10	Flare and Vent Cargo Tank Vent Gas Dispersion Study - PRD-PT-GEN-00-E-HX-6874-00001_A02
Ref 11	Inert Gas Generator Data Sheet - P3NG-4-0303-01-F02-00001-4_A.pdf
Ref 12	Gas Turbine Generator Package Data Sheet - P3NG-4-0306-01-C08-00001-5
Ref 13	GTG SoloNOx Emissions in Non-SoLoNOx mode - P3NG-4-0306-01-C17-000017_02
Ref 14	GTG Performance Curves - P3NG-4-0306-01-F29-00001-3A_A
Ref 15	HP Gas compressor datasheet - P3NG-4-0304-01-K04-00007
Ref 16	EEMS Atmospherics Emissions Calculations, DECC. 2008

Appendix A Max Concentrations on the Modelled Grid

Pollutant	Averaging Time	Exceedance Threshold	Percentile	Background	Scenario 1 - 2021				Scenario 2 - 2021				Scenario 3 - 2021				Scenario 4 - 2021			
					PC (mg/m3 for CO, ug/m3 else)	% of PC limit	PEC	% of PEC limit	PC (mg/m3 for CO, ug/m3 else)	% of PC limit	PEC	% of PEC limit	PC (mg/m3 for CO, ug/m3 else)	% of PC limit	PEC	% of PEC limit	PC (mg/m3 for CO, ug/m3 else)	% of PC limit	PEC	% of PEC limit
NO_2	1 Hour	200	99.79	8	11.83	5.9%	19.83	9.92	11.29	5.6%	19.29	9.64	91.05	45.5%	99.05	49.52	12.84	6.4%	20.84	10.42
	Annual Mean	40	100	4	0.20	0.5%	4.20	10.50	0.17	0.4%	4.17	10.42	20.03	50.1%	24.03	60.08	0.22	0.6%	4.22	10.56
SO_2	15 min	266	99.9	3.3	1.49	0.6%	4.80	1.80	1.49	0.6%	4.80	1.80	44.79	16.8%	48.09	18.08	1.49	0.6%	4.80	1.80
	1 Hour	350	99.73	3.3	0.96	0.3%	4.27	1.22	0.95	0.3%	4.26	1.22	29.43	8.4%	32.74	9.36	0.96	0.3%	4.27	1.22
	24 Hour	125	99.18	3.3	0.19	0.2%	3.50	2.80	0.19	0.2%	3.50	2.80	8.21	6.6%	11.52	9.21	0.19	0.2%	3.50	2.80
CO	8 Hour rolling average	10	100	0.2	0.0105	0.1%	0.2323	2.3229	0.0065	0.1%	0.23	2.28	1.394	13.9%	1.616	16.158	0.27	2.7%	0.50	4.96

Pollutant	Averaging Time	Exceedance Threshold	Percentile	Background	Scenario 1 - 2022				Scenario 2 - 2022				Scenario 3 - 2022				Scenario 4 - 2022			
					PC (mg/m3 for CO, ug/m3 else)	% of PC limit	PEC	% of PEC limit	PC (mg/m3 for CO, ug/m3 else)	% of PC limit	PEC	% of PEC limit	PC (mg/m3 for CO, ug/m3 else)	% of PC limit	PEC	% of PEC limit	PC (mg/m3 for CO, ug/m3 else)	% of PC limit	PEC	% of PEC limit
NO_2	1 Hour	200	99.79	8	9.00	4.50%	17.00	9%	8.77	4.38%	16.77	8%	92.37	46%	100.37	50%	10.32	5.2%	18.32	9%
	Annual Mean	40	100	4	0.18	0.46%	4.18	10%	0.14	0.36%	4.14	10%	22.75	57%	26.75	67%	0.25	0.6%	4.25	11%
SO_2	15 min	266	99.9	3.3	1.13	0.43%	4.44	2%	1.12	0.42%	4.43	2%	41.08	15%	44.39	17%	1.13	0.4%	4.44	2%
	1 Hour	350	99.73	3.3	0.54	0.15%	3.85	1%	0.54	0.15%	3.85	1%	24.73	7%	28.04	8%	0.54	0.2%	3.85	1%
	24 Hour	125	99.18	3.3	0.23	0.19%	3.54	3%	0.23	0.18%	3.54	3%	9.05	7%	12.36	10%	0.23	0.2%	3.54	3%
CO	8 Hour rolling average	10	100	0.2	0.0115	0.12%	0.23	2%	0.0092	0.09%	0.2311	2%	1.49	15%	1.71	17%	0.52	5.2%	0.74	7%

Appendix B Full Results

- Red shading indicates PC limit above 1%. Orange Shading indicates PC limit above 10%
- Exceedance thresholds are in units of ug/m3 for all pollutants except CO which has units of mg/m3

Receptors	Pollutant	Averaging Time	Exceedance Threshold	Percentile	Background Concentration	Scenario 1 - 2021				Scenario 1 - 2022				Scenario 2 - 2021				Scenario 2 - 2022				Scenario 3 - 2021				Scenario 3 - 2022				Scenario 4 - 2021				Scenario 4 - 2022			
						PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit
Median Line 1 @ 0m Height	NO_2	1 Hour	200	99.79	8	0.69	0.34	8.69	4.34	0.68	0.34	8.68	4.34	0.51	0.26	8.51	4.26	0.50	0.25	8.50	4.25	0.98	0.49	8.98	4.49	0.96	0.48	8.96	4.48	0.94	0.47	8.94	4.47	0.92	0.46	8.92	4.46
		Annual Mean	40	100	4	0.04	0.09	4.04	10.09	0.04	0.11	4.04	10.11	0.03	0.07	4.03	10.07	0.03	0.08	4.03	10.08	0.05	0.12	4.05	10.12	0.06	0.16	4.06	10.16	0.05	0.12	4.05	10.12	0.06	0.15	4.06	10.15
	SO_2	15 min	266	99.9	3.3	0.09	0.03	3.40	1.28	0.06	0.02	3.37	1.27	0.08	0.03	3.39	1.28	0.06	0.02	3.37	1.27	2.43	0.91	5.74	2.16	6.92	2.60	10.23	3.85	0.09	0.03	3.40	1.28	0.06	0.02	3.37	1.27
		1 Hour	350	99.73	3.3	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.03	0.01	3.34	0.96	1.45	0.41	4.76	1.36	4.29	1.23	7.60	2.17	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.66	0.36	0.29	3.67	2.93	1.31	1.05	4.62	3.70	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.66
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.01	0.22	2.23	0.00	0.04	0.23	2.25	0.02	0.19	0.24	2.41	0.04	0.37	0.26	2.59
Median Line 2 @ 0m Height	NO_2	1 Hour	200	99.79	8	0.73	0.36	8.73	4.36	0.78	0.39	8.78	4.39	0.56	0.28	8.56	4.28	0.60	0.30	8.60	4.30	1.02	0.51	9.02	4.51	1.05	0.53	9.05	4.53	0.84	0.42	8.84	4.42	1.01	0.51	9.01	4.51
		Annual Mean	40	100	4	0.04	0.10	4.04	10.10	0.05	0.11	4.05	10.11	0.03	0.07	4.03	10.07	0.04	0.09	4.04	10.09	0.05	0.13	4.05	10.13	0.06	0.16	4.06	10.16	0.04	0.11	4.04	10.11	0.06	0.15	4.06	10.15
	SO_2	15 min	266	99.9	3.3	0.07	0.03	3.38	1.27	0.09	0.03	3.40	1.28	0.07	0.02	3.38	1.27	0.09	0.03	3.40	1.28	2.13	0.80	5.44	2.05	6.66	2.50	9.97	3.75	0.07	0.03	3.38	1.27	0.09	0.03	3.40	1.28
		1 Hour	350	99.73	3.3	0.04	0.01	3.35	0.96	0.05	0.01	3.36	0.96	0.04	0.01	3.35	0.96	0.05	0.01	3.36	0.96	1.64	0.47	4.95	1.42	4.75	1.36	8.06	2.30	0.04	0.01	3.35	0.96	0.05	0.01	3.36	0.96
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.39	0.31	3.70	2.96	1.37	1.09	4.68	3.74	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.01	0.22	2.23	0.00	0.04	0.23	2.26	0.02	0.21	0.24	2.43	0.04	0.43	0.26	2.65
Median Line 3 @ 0m Height	NO_2	1 Hour	200	99.79	8	0.79	0.39	8.79	4.39	0.82	0.41	8.82	4.41	0.61	0.30	8.61	4.30	0.58	0.29	8.58	4.29	1.09	0.54	9.09	4.54	1.14	0.57	9.14	4.57	0.88	0.44	8.88	4.44	1.09	0.54	9.09	4.54
		Annual Mean	40	100	4	0.02	0.05	4.02	10.05	0.02	0.06	4.02	10.06	0.02	0.04	4.02	10.04	0.02	0.04	4.02	10.04	0.03	0.07	4.03	10.07	0.03	0.09	4.03	10.09	0.02	0.06	4.02	10.06	0.03	0.08	4.03	10.08
	SO_2	15 min	266	99.9	3.3	0.09	0.03	3.39	1.28	0.07	0.02	3.37	1.27	0.09	0.03	3.39	1.28	0.06	0.02	3.37	1.27	2.63	0.99	5.94	2.23	7.70	2.89	11.01	4.14	0.09	0.03	3.39	1.28	0.07	0.02	3.37	1.27
		1 Hour	350	99.73	3.3	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	1.54	0.44	4.85	1.39	4.85	1.39	8.16	2.33	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.27	0.22	3.58	2.87	0.90	0.72	4.21	3.37	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.03	0.22	2.25	0.02	0.19	0.24	2.40	0.04	0.36	0.26	2.58
Median Line 4 @ 0m Height	NO_2	1 Hour	200	99.79	8	0.69	0.35	8.69	4.35	0.68	0.34	8.68	4.34	0.54	0.27	8.54	4.27	0.53	0.26	8.53	4.26	0.97	0.48	8.97	4.48	0.95	0.47	8.95	4.47	0.80	0.40	8.80	4.40	0.92	0.46	8.92	4.46
		Annual Mean	40	100	4	0.03	0.06	4.03	10.06	0.02	0.06	4.02	10.06	0.02	0.05	4.02	10.05	0.02	0.05	4.02	10.05	0.04	0.09	4.04	10.09	0.03	0.09	4.03	10.09	0.03	0.07	4.03	10.07	0.03	0.08	4.03	10.08
	SO_2	15 min	266	99.9	3.3	0.07	0.03	3.38	1.27	0.06	0.02	3.37	1.27	0.07	0.03	3.38	1.27	0.06	0.02	3.37	1.27	2.24	0.84	5.55	2.09	6.49	2.44	9.80	3.68	0.07	0.03	3.38	1.27	0.06	0.02	3.37	1.27
		1 Hour	350	99.73	3.3	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	1.40	0.40	4.71	1.34	4.11	1.17	7.42	2.12	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.65	0.33	0.27	3.64	2.91	0.88	0.70	4.19	3.35	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.03	0.22	2.25	0.02	0.20	0.24	2.42	0.04	0.36	0.26	2.57
Median Line 1 @ 50m Height	NO_2	1 Hour	200	99.79	8	0.78	0.39	8.78	4.39	0.73	0.37	8.73	4.37	0.60	0.30	8.60	4.30	0.58	0.29	8.58	4.29	1.10	0.55	9.10	4.55	1.03	0.52	9.03	4.52	0.89	0.44	8.89	4.44	0.99	0.50	8.99	4.50
		Annual Mean	40	100	4	0.04	0.10	4.04	10.10	0.05	0.12	4.05	10.12	0.03	0.08	4.03	10.08	0.04	0.09	4.04	10.09	0.06	0.14	4.06	10.14	0.07	0.17	4.07	10.17	0.05	0.11	4.05	10.11	0.06	0.16	4.06	10.16
	SO_2	15 min	266	99.9	3.3	0.09	0.03	3.40	1.28	0.09	0.03	3.40	1.28	0.09	0.03	3.40	1.28	0.09	0.03	3.39	1.28	3.12	1.17	6.43	2.42	8.06	3.03	11.37	4.28	0.09	0.03	3.40	1.28	0.09	0.03	3.40	1.28
		1 Hour	350	99.73	3.3	0.05	0.01	3.36	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	1.63	0.46	4.94	1.41	4.65	1.33	7.96	2.27	0.05	0.01	3.36	0.96	0.04	0.01	3.35	0.96
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.36	0.28	3.67	2.93	1.28	1.02	4.59	3.67	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.01	0.22	2.23	0.00	0.04	0.23	2.25	0.02	0.19	0.24	2.41	0.04	0.38	0.26	2.60
Median Line 2 @ 50m Height	NO_2	1 Hour	200	99.79	8	0.83	0.41	8.83	4.41	0.85	0.43	8.85	4.43	0.67	0.34	8.67	4.34	0.71	0.35	8.71	4.35	1.16	0.58	9.16	4.58	1.21	0.60	9.21	4.60	0.98	0.49	8.98	4.49	1.18	0.59	9.18	4.59
		Annual Mean	40	100	4	0.04	0.11	4.04	10.11	0.05	0.13	4.05	10.13	0.03	0.08	4.03	10.08	0.04	0.10	4.04	10.10	0.06	0.16	4.06	10.16	0.08	0.19	4.08	10.19	0.05	0.13	4.05	10.13	0.07	0.18	4.07	10.18
	SO_2	15 min	266	99.9	3.3	0.08	0.03	3.39	1.28	0.10	0.04	3.41	1.28	0.08	0.03	3.39	1.28	0.10	0.04	3.41	1.28	2.42	0.91	5.73	2.16	7.23	2.72	10.54	3.96	0.08	0.03	3.39	1.28	0.10	0.04	3.41	1.28
		1 Hour	350	99.73	3.3	0.06	0.02	3.37	0.96	0.06	0.02	3.37	0.96	0.05	0.02	3.36	0.96	0.06	0.02	3.37	0.96	1.76	0.50	5.07	1.45	5.11	1.46	8.42	2.41	0.06	0.02	3.37	0.96	0.06	0.02	3.37	0.96
		24 Hour	125	99.18	3.3	0.02	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.44	0.35	3.75	3.00	1.42	1.14	4.73	3.78	0.02	0.01	3.32	2.66	0.01	0.01	3.32	2.66
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.01	0.22	2.23	0.00	0.05	0.23	2.26	0.03	0.28	0.25	2.50	0.05	0.52	0.27	2.74
Median Line 3 @ 50m Height	NO_2	1 Hour	200	99.79	8	0.81	0.41	8.81	4.41	0.84	0.42	8.84	4.42	0.64	0.32	8.64	4.32	0.61	0.31	8.61	4.31	1.15	0.57	9.15	4.57	1.18	0.59	9.18	4.59	0.95	0.47	8.95	4.47	1.13	0.56	9.13	4.56
		Annual Mean	40	100	4	0.02	0.06	4.02	10.06	0.03	0.07	4.03	10.07	0.02	0.05	4.02	10.05	0.02	0.05	4.02	10.05	0.03	0.08	4.03	10.08	0.04	0.10	4.04	10.10	0.03	0.07	4.03	10.07	0.04	0.09	4.04	10.09
	SO_2	15 min	266	99.9	3.3	0.10	0.04	3.41	1.28	0.08	0.03	3.39	1.27	0.10	0.04	3.40	1.28	0.07	0.03	3.38	1.27	2.85	1.07	6.16	2.32	8.33	3.13	11.64	4.38	0.10	0.04	3.41	1.28	0.08	0.03	3.39	1.27
		1 Hour	350	99.73	3.3	0.05	0.01	3.36	0.96	0.04	0.01	3.35	0.96	0.05	0.01	3.36	0.96	0.04	0.01	3.35	0.96	1.64	0.47	4.95	1.41	5.13	1.47	8.44	2.41	0.05	0.01	3.36	0.96	0.04	0.01	3.35	0.96
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.32	0.26	3.63	2.90	0.96	0.77	4.27	3.42	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65

Receptors	Pollutant	Averaging Time	Exceedance Threshold	Percentile	Background Concentration	Scenario 1 - 2021				Scenario 1 - 2022				Scenario 2 - 2021				Scenario 2 - 2022				Scenario 3 - 2021				Scenario 3 - 2022				Scenario 4 - 2021				Scenario 4 - 2022			
						PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.23	0.00	0.04	0.23	2.25	0.02	0.18	0.24	2.40	0.04	0.39	0.26	2.61
Median Line 4 @ 50m Height	NO_2	1 Hour	200	99.79	8	0.82	0.41	8.82	4.41	0.72	0.36	8.72	4.36	0.63	0.31	8.63	4.31	0.57	0.28	8.57	4.28	1.14	0.57	9.14	4.57	1.00	0.50	9.00	4.50	0.93	0.46	8.93	4.46	0.96	0.48	8.96	4.48
		Annual Mean	40	100	4	0.03	0.07	4.03	10.07	0.03	0.07	4.03	10.07	0.02	0.06	4.02	10.06	0.02	0.05	4.02	10.05	0.04	0.10	4.04	10.10	0.04	0.10	4.04	10.10	0.03	0.08	4.03	10.08	0.04	0.09	4.04	10.09
	SO_2	15 min	266	99.9	3.3	0.10	0.04	3.41	1.28	0.07	0.03	3.38	1.27	0.10	0.04	3.41	1.28	0.07	0.03	3.38	1.27	2.81	1.06	6.12	2.30	7.14	2.69	10.45	3.93	0.10	0.04	3.41	1.28	0.07	0.03	3.38	1.27
		1 Hour	350	99.73	3.3	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	1.62	0.46	4.93	1.41	4.39	1.25	7.69	2.20	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.65	0.38	0.30	3.68	2.95	1.20	0.96	4.51	3.61	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.04	0.23	2.25	0.02	0.21	0.24	2.43	0.03	0.34	0.26	2.56
Median Line 1 @ 100m Height	NO_2	1 Hour	200	99.79	8	4.89	2.45	12.89	6.45	4.51	2.25	12.51	6.25	4.79	2.40	12.79	6.40	4.37	2.19	12.37	6.19	5.10	2.55	13.10	6.55	4.92	2.46	12.92	6.46	5.03	2.51	13.03	6.51	4.88	2.44	12.88	6.44
		Annual Mean	40	100	4	0.10	0.25	4.10	10.25	0.10	0.24	4.10	10.24	0.08	0.21	4.08	10.21	0.08	0.20	4.08	10.20	0.13	0.32	4.13	10.32	0.13	0.32	4.13	10.32	0.11	0.27	4.11	10.27	0.12	0.30	4.12	10.30
	SO_2	15 min	266	99.9	3.3	0.94	0.35	4.25	1.60	0.65	0.24	3.96	1.49	0.93	0.35	4.24	1.59	0.65	0.24	3.96	1.49	6.80	2.56	10.11	3.80	23.96	9.01	27.27	10.25	0.94	0.35	4.25	1.60	0.65	0.24	3.96	1.49
		1 Hour	350	99.73	3.3	0.29	0.08	3.60	1.03	0.32	0.09	3.63	1.04	0.29	0.08	3.60	1.03	0.32	0.09	3.62	1.04	2.97	0.85	6.28	1.79	7.34	2.10	10.65	3.04	0.29	0.08	3.60	1.03	0.32	0.09	3.63	1.04
		24 Hour	125	99.18	3.3	0.05	0.04	3.36	2.69	0.05	0.04	3.36	2.68	0.05	0.04	3.36	2.69	0.05	0.04	3.36	2.68	0.70	0.56	4.01	3.21	1.88	1.50	5.18	4.15	0.05	0.04	3.36	2.69	0.05	0.04	3.36	2.68
	CO	8 Hour rolling average	10	100	0.2	0.00	0.02	0.22	2.24	0.00	0.02	0.22	2.24	0.00	0.02	0.22	2.24	0.00	0.02	0.22	2.24	0.00	0.02	0.22	2.23	0.00	0.04	0.23	2.26	0.06	0.55	0.28	2.77	0.06	0.56	0.28	2.78
Median Line 2 @ 100m Height	NO_2	1 Hour	200	99.79	8	5.43	2.71	13.43	6.71	4.23	2.12	12.23	6.12	5.33	2.66	13.33	6.66	4.13	2.07	12.13	6.07	5.66	2.83	13.66	6.83	4.76	2.38	12.76	6.38	5.58	2.79	13.58	6.79	4.76	2.38	12.76	6.38
		Annual Mean	40	100	4	0.10	0.25	4.10	10.25	0.11	0.28	4.11	10.28	0.08	0.21	4.08	10.21	0.09	0.22	4.09	10.22	0.13	0.32	4.13	10.32	0.15	0.37	4.15	10.37	0.11	0.27	4.11	10.27	0.14	0.35	4.14	10.35
	SO_2	15 min	266	99.9	3.3	0.83	0.31	4.14	1.56	0.77	0.29	4.08	1.53	0.83	0.31	4.14	1.56	0.77	0.29	4.08	1.53	6.50	2.44	9.81	3.69	20.20	7.59	23.51	8.84	0.83	0.31	4.14	1.56	0.77	0.29	4.08	1.53
		1 Hour	350	99.73	3.3	0.36	0.10	3.67	1.05	0.28	0.08	3.59	1.02	0.36	0.10	3.66	1.05	0.28	0.08	3.59	1.02	3.47	0.99	6.78	1.94	11.62	3.32	14.93	4.26	0.36	0.10	3.67	1.05	0.28	0.08	3.59	1.02
		24 Hour	125	99.18	3.3	0.07	0.05	3.38	2.70	0.07	0.05	3.38	2.70	0.07	0.05	3.38	2.70	0.07	0.05	3.38	2.70	0.87	0.70	4.18	3.34	2.35	1.88	5.66	4.52	0.07	0.05	3.38	2.70	0.07	0.05	3.38	2.70
	CO	8 Hour rolling average	10	100	0.2	0.00	0.03	0.22	2.25	0.00	0.03	0.22	2.25	0.00	0.03	0.22	2.25	0.00	0.03	0.22	2.24	0.00	0.01	0.22	2.23	0.01	0.06	0.23	2.28	0.06	0.56	0.28	2.78	0.14	1.38	0.36	3.60
Median Line 3 @ 100m Height	NO_2	1 Hour	200	99.79	8	5.70	2.85	13.70	6.85	3.53	1.77	11.53	5.77	5.57	2.79	13.57	6.79	3.49	1.75	11.49	5.75	6.05	3.03	14.05	7.03	4.20	2.10	12.20	6.10	5.90	2.95	13.90	6.95	4.08	2.04	12.08	6.04
		Annual Mean	40	100	4	0.09	0.21	4.09	10.21	0.07	0.17	4.07	10.17	0.08	0.19	4.08	10.19	0.06	0.14	4.06	10.14	0.10	0.25	4.10	10.25	0.08	0.21	4.08	10.21	0.09	0.23	4.09	10.23	0.08	0.20	4.08	10.20
	SO_2	15 min	266	99.9	3.3	0.83	0.31	4.14	1.56	0.73	0.27	4.04	1.52	0.83	0.31	4.13	1.55	0.73	0.27	4.04	1.52	5.53	2.08	8.84	3.32	15.05	5.66	18.36	6.90	0.83	0.31	4.14	1.56	0.73	0.27	4.04	1.52
		1 Hour	350	99.73	3.3	0.43	0.12	3.74	1.07	0.13	0.04	3.44	0.98	0.43	0.12	3.74	1.07	0.13	0.04	3.44	0.98	2.56	0.73	5.86	1.68	6.83	1.95	10.14	2.90	0.43	0.12	3.74	1.07	0.13	0.04	3.44	0.98
		24 Hour	125	99.18	3.3	0.09	0.07	3.40	2.72	0.06	0.05	3.37	2.70	0.09	0.07	3.40	2.72	0.06	0.05	3.37	2.70	0.47	0.37	3.78	3.02	1.62	1.30	4.93	3.95	0.09	0.07	3.40	2.72	0.06	0.05	3.37	2.70
	CO	8 Hour rolling average	10	100	0.2	0.00	0.04	0.23	2.26	0.00	0.03	0.23	2.25	0.00	0.04	0.23	2.26	0.00	0.02	0.22	2.24	0.00	0.02	0.22	2.23	0.01	0.05	0.23	2.27	0.04	0.45	0.27	2.67	0.18	1.83	0.40	4.05
Median Line 4 @ 100m Height	NO_2	1 Hour	200	99.79	8	5.59	2.79	13.59	6.79	3.35	1.68	11.35	5.68	5.49	2.74	13.49	6.74	3.26	1.63	11.26	5.63	5.92	2.96	13.92	6.96	3.79	1.90	11.79	5.90	5.79	2.89	13.79	6.89	3.63	1.81	11.63	5.81
		Annual Mean	40	100	4	0.11	0.27	4.11	10.27	0.06	0.16	4.06	10.16	0.09	0.24	4.09	10.24	0.05	0.13	4.05	10.13	0.13	0.32	4.13	10.32	0.08	0.20	4.08	10.20	0.11	0.28	4.11	10.28	0.08	0.19	4.08	10.19
	SO_2	15 min	266	99.9	3.3	1.17	0.44	4.48	1.69	0.56	0.21	3.87	1.45	1.17	0.44	4.48	1.68	0.55	0.21	3.86	1.45	4.97	1.87	8.28	3.11	13.09	4.92	16.40	6.16	1.17	0.44	4.48	1.69	0.56	0.21	3.87	1.45
		1 Hour	350	99.73	3.3	0.43	0.12	3.74	1.07	0.17	0.05	3.48	0.99	0.43	0.12	3.74	1.07	0.17	0.05	3.48	0.99	2.58	0.74	5.89	1.68	6.63	1.89	9.94	2.84	0.43	0.12	3.74	1.07	0.17	0.05	3.48	0.99
		24 Hour	125	99.18	3.3	0.06	0.05	3.37	2.69	0.05	0.04	3.36	2.69	0.06	0.05	3.37	2.69	0.05	0.04	3.36	2.69	0.69	0.55	4.00	3.20	1.41	1.13	4.72	3.77	0.06	0.05	3.37	2.69	0.05	0.04	3.36	2.69
	CO	8 Hour rolling average	10	100	0.2	0.00	0.02	0.22	2.24	0.00	0.02	0.22	2.23	0.00	0.02	0.22	2.24	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.05	0.23	2.27	0.04	0.43	0.26	2.64	0.06	0.61	0.28	2.83
Median Line 1 @ 150m Height	NO_2	1 Hour	200	99.79	8	1.61	0.81	9.61	4.81	1.43	0.71	9.43	4.71	0.86	0.43	8.86	4.43	0.69	0.34	8.69	4.34	3.02	1.51	11.02	5.51	2.56	1.28	10.56	5.28	2.00	1.00	10.00	5.00	2.36	1.18	10.36	5.18
		Annual Mean	40	100	4	0.06	0.15	4.06	10.15	0.06	0.16	4.06	10.16	0.03	0.09	4.03	10.09	0.04	0.09	4.04	10.09	0.10	0.25	4.10	10.25	0.10	0.26	4.10	10.26	0.07	0.17	4.07	10.17	0.09	0.22	4.09	10.22
	SO_2	15 min	266	99.9	3.3	0.07	0.03	3.38	1.27	0.05	0.02	3.36	1.26	0.07	0.03	3.38	1.27	0.04	0.02	3.35	1.26	15.67	5.89	18.98	7.14	41.00	15.41	44.31	16.66	0.07	0.03	3.38	1.27	0.05	0.02	3.36	1.26
		1 Hour	350	99.73	3.3	0.03	0.01	3.34	0.95	0.03	0.01	3.34	0.95	0.03	0.01	3.34	0.95	0.02	0.01	3.33	0.95	6.24	1.78	9.55	2.73	16.33	4.67	19.64	5.61	0.03	0.01	3.34	0.95	0.03	0.01	3.34	0.95
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.01	0.00	3.32	2.65	0.01	0.00	3.32	2.65	1.11	0.88	4.42	3.53	2.85	2.28	6.16	4.93	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.03	0.23	2.25	0.00	0.02	0.22	2.24	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.02	0.22	2.24	0.01	0.05	0.23	2.27	0.08	0.83	0.30	3.05	0.16	1.64	0.39	3.85
Median Line 2 @ 150m Height	NO_2	1 Hour	200	99.79	8	1.87	0.94	9.87	4.94	2.06	1.03	10.06	5.03	0.87	0.44	8.87	4.44	0.99	0.50	8.99	4.50	3.20	1.60	11.20	5.60	3.87	1.94	11.87	5.94	2.28	1.14	10.28	5.14	3.30	1.65	11.30	5.65
		Annual Mean	40	100	4	0.06	0.16	4.06	10.16	0.08	0.19	4.08	10.19	0.04	0.09	4.04	10.09	0.04	0.11	4.04	10.11	0.10	0.25	4.10	10.25	0.13	0.32	4.13	10.32	0.07	0.18	4.07	10.18	0.11	0.26	4.11	10.26
	SO_2	15 min	266	99.9	3.3	0.06	0.02	3.37	1.27	0.07	0.03	3.38	1.27	0.05	0.02	3.36	1.26	0.06	0.02	3.37	1.27	12.40	4.66	15.71	5.91	38.33	14.41	41.64	15.65	0.06	0.02	3.37	1.27	0.07	0.03	3.38	1.27
		1 Hour	350	99.73	3.3	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96	0.03	0.01	3.34	0.95	0.03	0.01	3.34	0.96	5.91	1.69	9.22	2.63	24.22	6.92	27.53	7.86	0.04	0.01	3.35	0.96	0.04	0.01	3.35	0.96
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66	1.42	1.14	4.73	3.78	3.27	2.62	6.58	5.27	0.01	0.01	3.32	2.66	0.01	0.01	3.32	2.66
	CO	8 Hour rolling average	10	100	0.2	0.00	0.04	0.23	2.25	0.00	0.04	0.23	2.26	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.02	0.22	2.24	0.01	0.11	0.23	2.33	0.09	0.88	0.31	3.09	0.23	2.28	0.45	4.50
	NO_2	1 Hour	200	99.79	8	1.56	0.78	9.56	4.78	1.31	0.66	9.31	4.66	0.82	0.41	8.82	4.41	0.63	0.32	8.63	4.32	3.11	1.55	11.11	5.55	2.53	1.27	10.53	5.27	2.17	1.09	10.17	5.09	2.40	1.20	10.40	5.20

Receptors	Pollutant	Averaging Time	Exceedance Threshold	Percentile	Background Concentration	Scenario 1 - 2021				Scenario 1 - 2022				Scenario 2 - 2021				Scenario 2 - 2022				Scenario 3 - 2021				Scenario 3 - 2022				Scenario 4 - 2021				Scenario 4 - 2022			
						PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit	PC	% of limit	PEC	% of limit
Median Line 3 @ 150m Height		Annual Mean	40	100	4	0.04	0.10	4.04	10.10	0.04	0.10	4.04	10.10	0.02	0.06	4.02	10.06	0.02	0.06	4.02	10.06	0.07	0.17	4.07	10.17	0.06	0.16	4.06	10.16	0.05	0.12	4.05	10.12	0.05	0.13	4.05	10.13
	SO_2	15 min	266	99.9	3.3	0.07	0.03	3.38	1.27	0.05	0.02	3.36	1.26	0.06	0.02	3.37	1.27	0.04	0.02	3.35	1.26	10.94	4.11	14.24	5.36	24.13	9.07	27.44	10.32	0.07	0.03	3.38	1.27	0.05	0.02	3.36	1.26
		1 Hour	350	99.73	3.3	0.03	0.01	3.34	0.96	0.03	0.01	3.34	0.95	0.03	0.01	3.34	0.95	0.02	0.01	3.33	0.95	6.11	1.75	9.42	2.69	14.05	4.01	17.36	4.96	0.03	0.01	3.34	0.96	0.03	0.01	3.34	0.95
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.65	0.01	0.00	3.32	2.65	0.01	0.00	3.32	2.65	0.01	0.00	3.31	2.65	1.08	0.86	4.39	3.51	2.24	1.80	5.55	4.44	0.01	0.01	3.32	2.65	0.01	0.00	3.32	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.03	0.22	2.24	0.00	0.04	0.23	2.26	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.01	0.08	0.23	2.29	0.13	1.25	0.35	3.47	0.12	1.20	0.34	3.41
Median Line 4 @ 150m Height	NO_2	1 Hour	200	99.79	8	1.52	0.76	9.52	4.76	1.42	0.71	9.42	4.71	0.79	0.39	8.79	4.39	0.69	0.34	8.69	4.34	2.85	1.43	10.85	5.43	2.82	1.41	10.82	5.41	1.95	0.97	9.95	4.97	2.36	1.18	10.36	5.18
		Annual Mean	40	100	4	0.05	0.13	4.05	10.13	0.04	0.10	4.04	10.10	0.03	0.07	4.03	10.07	0.02	0.06	4.02	10.06	0.09	0.22	4.09	10.22	0.07	0.17	4.07	10.17	0.06	0.15	4.06	10.15	0.06	0.14	4.06	10.14
	SO_2	15 min	266	99.9	3.3	0.06	0.02	3.37	1.27	0.05	0.02	3.36	1.26	0.05	0.02	3.36	1.26	0.04	0.02	3.35	1.26	14.36	5.40	17.67	6.64	41.08	15.44	44.39	16.69	0.06	0.02	3.37	1.27	0.05	0.02	3.36	1.26
		1 Hour	350	99.73	3.3	0.03	0.01	3.34	0.95	0.03	0.01	3.34	0.95	0.03	0.01	3.34	0.95	0.02	0.01	3.33	0.95	6.53	1.87	9.84	2.81	13.19	3.77	16.50	4.72	0.03	0.01	3.34	0.95	0.03	0.01	3.34	0.95
		24 Hour	125	99.18	3.3	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65	0.01	0.00	3.32	2.65	0.92	0.74	4.23	3.39	2.70	2.16	6.01	4.81	0.01	0.01	3.32	2.65	0.01	0.01	3.32	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.02	0.22	2.24	0.00	0.02	0.22	2.24	0.00	0.01	0.22	2.22	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.01	0.07	0.23	2.28	0.07	0.67	0.29	2.89	0.13	1.35	0.36	3.56
Magnus Platform @ 0m Height	NO_2	1 Hour	200	99.79	8	0.27	0.14	8.27	4.14	0.37	0.18	8.37	4.18	0.20	0.10	8.20	4.10	0.27	0.13	8.27	4.13	0.41	0.20	8.41	4.20	0.55	0.27	8.55	4.27	0.29	0.15	8.29	4.15	0.48	0.24	8.48	4.24
		Annual Mean	40	100	4	0.00	0.01	4.00	10.01	0.01	0.02	4.01	10.02	0.00	0.01	4.00	10.01	0.01	0.01	4.01	10.01	0.01	0.02	4.01	10.02	0.01	0.03	4.01	10.03	0.01	0.01	4.01	10.01	0.01	0.03	4.01	10.03
	SO_2	15 min	266	99.9	3.3	0.02	0.01	3.33	1.25	0.04	0.02	3.35	1.26	0.02	0.01	3.33	1.25	0.04	0.02	3.35	1.26	1.02	0.38	4.32	1.63	4.42	1.66	7.73	2.91	0.02	0.01	3.33	1.25	0.04	0.02	3.35	1.26
		1 Hour	350	99.73	3.3	0.01	0.00	3.32	0.95	0.02	0.01	3.33	0.95	0.01	0.00	3.32	0.95	0.02	0.00	3.33	0.95	0.52	0.15	3.83	1.09	2.06	0.59	5.37	1.53	0.01	0.00	3.32	0.95	0.02	0.01	3.33	0.95
		24 Hour	125	99.18	3.3	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.08	0.07	3.39	2.71	0.41	0.33	3.72	2.97	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.23	0.01	0.08	0.23	2.29	0.03	0.25	0.25	2.47
Magnus Platform @ 50m Height	NO_2	1 Hour	200	99.79	8	1.75	0.88	9.75	4.88	1.29	0.65	9.29	4.65	1.66	0.83	9.66	4.83	1.24	0.62	9.24	4.62	1.96	0.98	9.96	4.98	1.71	0.86	9.71	4.86	1.84	0.92	9.84	4.92	1.61	0.81	9.61	4.81
		Annual Mean	40	100	4	0.02	0.06	4.02	10.06	0.02	0.06	4.02	10.06	0.02	0.05	4.02	10.05	0.02	0.05	4.02	10.05	0.03	0.07	4.03	10.07	0.03	0.07	4.03	10.07	0.02	0.06	4.02	10.06	0.03	0.07	4.03	10.07
	SO_2	15 min	266	99.9	3.3	0.36	0.14	3.67	1.38	0.31	0.12	3.62	1.36	0.36	0.14	3.67	1.38	0.31	0.12	3.62	1.36	2.17	0.82	5.48	2.06	8.31	3.13	11.62	4.37	0.36	0.14	3.67	1.38	0.31	0.12	3.62	1.36
		1 Hour	350	99.73	3.3	0.11	0.03	3.42	0.98	0.08	0.02	3.39	0.97	0.11	0.03	3.42	0.98	0.08	0.02	3.39	0.97	0.97	0.28	4.28	1.22	2.73	0.78	6.04	1.73	0.11	0.03	3.42	0.98	0.08	0.02	3.39	0.97
		24 Hour	125	99.18	3.3	0.02	0.02	3.33	2.66	0.02	0.02	3.33	2.67	0.02	0.02	3.33	2.66	0.02	0.02	3.33	2.67	0.17	0.14	3.48	2.79	0.59	0.47	3.90	3.12	0.02	0.02	3.33	2.66	0.02	0.02	3.33	2.67
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.22	0.00	0.02	0.22	2.23	0.02	0.16	0.24	2.38	0.04	0.42	0.26	2.64
Magnus Platform @ 100m Height	NO_2	1 Hour	200	99.79	8	0.68	0.34	8.68	4.34	0.60	0.30	8.60	4.30	0.34	0.17	8.34	4.17	0.33	0.17	8.33	4.17	1.29	0.65	9.29	4.65	1.06	0.53	9.06	4.53	0.90	0.45	8.90	4.45	1.09	0.54	9.09	4.54
		Annual Mean	40	100	4	0.01	0.03	4.01	10.03	0.01	0.03	4.01	10.03	0.01	0.02	4.01	10.02	0.01	0.02	4.01	10.02	0.02	0.05	4.02	10.05	0.02	0.05	4.02	10.05	0.01	0.03	4.01	10.03	0.02	0.05	4.02	10.05
	SO_2	15 min	266	99.9	3.3	0.02	0.01	3.33	1.25	0.03	0.01	3.34	1.26	0.01	0.01	3.32	1.25	0.03	0.01	3.33	1.25	6.21	2.34	9.52	3.58	11.50	4.32	14.81	5.57	0.02	0.01	3.33	1.25	0.03	0.01	3.34	1.26
		1 Hour	350	99.73	3.3	0.01	0.00	3.32	0.95	0.01	0.00	3.32	0.95	0.01	0.00	3.32	0.95	0.01	0.00	3.32	0.95	2.50	0.71	5.81	1.66	5.76	1.65	9.07	2.59	0.01	0.00	3.32	0.95	0.01	0.00	3.32	0.95
		24 Hour	125	99.18	3.3	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.40	0.32	3.71	2.97	1.07	0.86	4.38	3.50	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.01	0.22	2.23	0.00	0.01	0.22	2.23	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.23	0.00	0.02	0.22	2.24	0.04	0.36	0.26	2.58	0.05	0.47	0.27	2.69
Magnus Platform @ 150m Height	NO_2	1 Hour	200	99.79	8	0.27	0.14	8.27	4.14	0.37	0.18	8.37	4.18	0.20	0.10	8.20	4.10	0.27	0.13	8.27	4.13	0.41	0.20	8.41	4.20	0.55	0.27	8.55	4.27	0.29	0.15	8.29	4.15	0.48	0.24	8.48	4.24
		Annual Mean	40	100	4	0.00	0.01	4.00	10.01	0.01	0.02	4.01	10.02	0.00	0.01	4.00	10.01	0.01	0.01	4.01	10.01	0.01	0.02	4.01	10.02	0.01	0.03	4.01	10.03	0.01	0.01	4.01	10.01	0.01	0.03	4.01	10.03
	SO_2	15 min	266	99.9	3.3	0.02	0.01	3.33	1.25	0.04	0.02	3.35	1.26	0.02	0.01	3.33	1.25	0.04	0.02	3.35	1.26	1.02	0.38	4.32	1.63	4.42	1.66	7.73	2.91	0.02	0.01	3.33	1.25	0.04	0.02	3.35	1.26
		1 Hour	350	99.73	3.3	0.01	0.00	3.32	0.95	0.02	0.01	3.33	0.95	0.01	0.00	3.32	0.95	0.02	0.00	3.33	0.95	0.52	0.15	3.83	1.09	2.06	0.59	5.37	1.53	0.01	0.00	3.32	0.95	0.02	0.01	3.33	0.95
		24 Hour	125	99.18	3.3	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65	0.08	0.07	3.39	2.71	0.41	0.33	3.72	2.97	0.00	0.00	3.31	2.65	0.00	0.00	3.31	2.65
	CO	8 Hour rolling average	10	100	0.2	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.00	0.22	2.22	0.00	0.01	0.22	2.23	0.01	0.08	0.23	2.29	0.03	0.25	0.25	2.47

Appendix C Flare Gas Composition

Table C-1: Flare gas composition

Component	Scenario 2	Scenario 3
HP Flare Component Molar Fraction		
H_2S	0.000008	0.000008
H_2O	0.009387	0.000223
Nitrogen	0.007352	0.007945
CO_2	0.032193	0.031779
Methane	0.600366	0.713061
Ethane	0.132377	0.126781
Propane	0.120235	0.079056
Butane	0.064103	0.027252
Pentane	0.021729	0.008477
Hexane	0.004645	0.003184
Benzene	0.003743	0.000477
Heptane	0.002702	0.00125
Toluene	0.001158	0.000507
LP Flare Component Molar Fraction		
H_2S	0.000011	0.00001
H_2O	0.031128	0.029551
Nitrogen	0.002803	0.000869
CO_2	0.021419	0.013081
Methane	0.312019	0.192648
Ethane	0.133252	0.134535
Propane	0.232208	0.235882

Butane	0.189069	0.221995
Pentane	0.058251	0.116541
Hexane	0.008628	0.037268
Benzene	0.006246	0.005053
Heptane	0.003488	0.009641
Toluene	0.001477	0.002926