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Variation to Operate Carbon Capture and Directly Associated Activities to on Unit 2 and/or Unit 1 at Drax Power Station (VP3530LS)

Contents

Glossary

AGL	Above Ground Level
AQAL	Air Quality Assessment Level
AQMA	Air Quality Management Areas
ASR	Air Quality Annual Status Report
Baseline	The core model scenario for air quality assessment as set out in Section 7.14.2
BAT	Best Available Techniques
BREf	Large Combustion Plant Best Available Techniques Conclusion Reference document
CEM	Continuous Emission Monitors
CERC	Cambridge Environmental Research Consultants
DCO	Development Consent Order
EA	Environment Agency
EAL	Environmental Assessment Levels
ELV	Emission Limit Values
EQS	Environmental Quality Standards
ESP	Electrostatic Precipitators
FGD	Flue Gas Desulphurisation
HSS	Heat Stable Salts
IED	Industrial Emissions Directive
KM-CDR	Kansai Mitsubishi Carbon Dioxide Recovery Process
LCP	Large Combustion plant
Main Stack	The main stack at the Site
MHI	Mitsubishi Heavy Industries
PCC	Post-combustion carbon dioxide capture
PC	Process Contribution
PEC	Predicted Environmental Concentration
PFA	Pulverised Fly Ash
REACh	Registration Evaluation and Authorisation of Chemicals

SDC	Selby District Council
Site	Drax Power Station
SNCR	Selective Non-Catalytic Reduction

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1.0 Executive Summary

The history of Drax Power Station is very much enshrined in utilisation of fossil fuels, but as a company Drax has recognised and put the climate challenge at the centre of the site's transformation. This led to the largest fossil fuelled generator in the United Kingdom becoming the largest single site renewable generator, a transformation that remains Europe's largest single site decarbonisation project and that was significant in scale, both technologically and environmentally.

Once again Drax and the Drax Power Station are standing on the precipice of change. A change with the goal to start indirectly sequestering carbon dioxide through use of sustainable forestry from the biosphere, when coupled with the carbon dioxide transportation and storage facilities also being developed.

This aligns with the UK Government's 'The Ten Point Plan for a Green Industrial Revolution', point 8 of which supports the investment in carbon capture, usage and storage which targets the capture of 10Mt of carbon dioxide per year by 2030. This work has commenced with the announcement of the first two carbon capture clusters, one of which, the East Coast Cluster, is in the locality of Drax Power Station. Separately the UK Government has an ambition to achieve 5Mt of engineered carbon dioxide removals by 2030.

This UK Government's direction is influence by the independent Climate Change Committee (CCC) in its capacity as adviser to the UK and devolved administration on emissions targets. The CCC's Sixth Carbon Budget supports the utilisation of bioenergy with carbon dioxide capture, as a significant contributor to the greenhouse gas removals sector.

Aligned to this policy intent, Drax is seeking a variation to its environmental permit for Drax Power Station to retrofit and operate post-combustion carbon dioxide capture as an activity on up to two of our current biomass fuelled generating units. This would enable the capture of over approximately 8 million tonnes of carbon dioxide per annum from sustainable biomass sources, the largest bioenergy carbon capture project at any material stage of development in the UK. Drax is planning to transport and store carbon dioxide captured by the post-combustion carbon dioxide capture (PCC) system via the East Coast Cluster.

The technology that has been selected to enable Drax to take this step is being developed around industry leading amine-based carbon capture processes, the Kansai Mitsubishi Carbon Dioxide Recovery Process (KM-CDR©) process, utilising the very latest in amine solvents, namely KS21™ solvent. This package of technology and solvent was selected following an internal assessment which found it to be the best technology available in terms of efficiency, capture and environmental performance.

In terms of environmental performance, the assessments Drax has undertaken clearly indicate that air emissions released from the operation of the process should not have any significant impact on human or ecological receptors at the proposed operating limits. In addition, the discharges to water in terms of quality and quantity are not expected to deteriorate.

Engineering design has optimised heat and electrical demand from the process without reducing capture efficiency or solvent life cycle. The water cycle of the site and the process have been integrated to optimise utilisation of this key resource within the process with the aim of optimising our abstraction requirements.

In our view the KM-CDR process together with the associated KS21^{TM} solvent is the best available carbon capture technique. This, coupled with the integrated engineering ethos that has been applied to the retrofit post-combustion carbon dioxide capture at Drax Power Station. This will ensure that the proposed technological solution applied to our existing host units will be done in the most energy and resource efficient way available within the physical and engineering constraints of the existing site.

2.0 Introduction

The post-combustion capture involves the installation of post-combustion carbon dioxide capture (PCC) technology to capture carbon dioxide from up to two of the existing 660 megawatt electrical (‘MWe’) permitted biomass power generating units at the Drax Power Station (planned to be Unit 1 and Unit 2) (“the New Activity”).

The installation of the PCC technology is a separately identified activity under the Environmental Permitting (England and Wales) Regulations 2016 and is separate although directly linked to the host combustion activity of biomass Units 1 and 2. The PCC is designed to target the removal of approximately 95% of the carbon dioxide from the flue gas from these two Units over the course of their operation (based on 12-month averaging period).

Drax is therefore seeking a variation to its existing environmental permit for Drax Power Station under the Environmental Permitting (England and Wales) Regulations 2016, to enable it to operate the New Activity (“the Variation Application”). This document sets out information required to enable the Environment Agency (EA) to consider the Variation Application.

The New Activity is a novel and complex installation. The EA has indicated that it accepts that the New Activity falls under that description and that it is, in principle, therefore willing to accept a staged Variation Application being made, consistent with paragraph 5.15 of the EA’s Environmental Permitting: Core Guidance for the Environmental Permitting (England and Wales) Regulations 2016. The proposed approach to the staged application, including timescales for providing further information, is set out in Section 3.0.

It should be noted that the Project is the subject of an application for a development consent order (DCO) under the Planning Act 2008, and the information in this Variation Application is consistent with the information provided in support of the DCO application.

The carbon dioxide captured will undergo processing and compression before being transferred to the operator of a carbon dioxide pipeline (expected to be National Grid Carbon Limited) for onward transportation and subsequent storage. This interface is critical, and the future rules and requirements attributed to this carbon dioxide transport network will have direct implications for the operations of the PCC activity.

It is intended that core items of the existing infrastructure at the Drax Power Station will be re-used by installing and integrating the Carbon Capture Plant with existing infrastructure including existing power generating units (Units 1 and 2) for extraction of steam, and re-using the cooling water systems, Main Stack and electrical connections where feasible.

The New Activity will involve the installation and operation of up to two Carbon Capture Plants (one associated with Unit 1 and one associated with Unit 2) each consisting of:-

- Flue gas pre-treatment (quench column)
- One Absorber Column
- Solvent Regeneration Systems (two regenerator units)
- Rich Solvent / Lean Solvent Heat Exchangers

Additional common plant infrastructure and modification works to the Drax Power Station that are required to support and integrate with one or both Carbon Capture Plants include:-

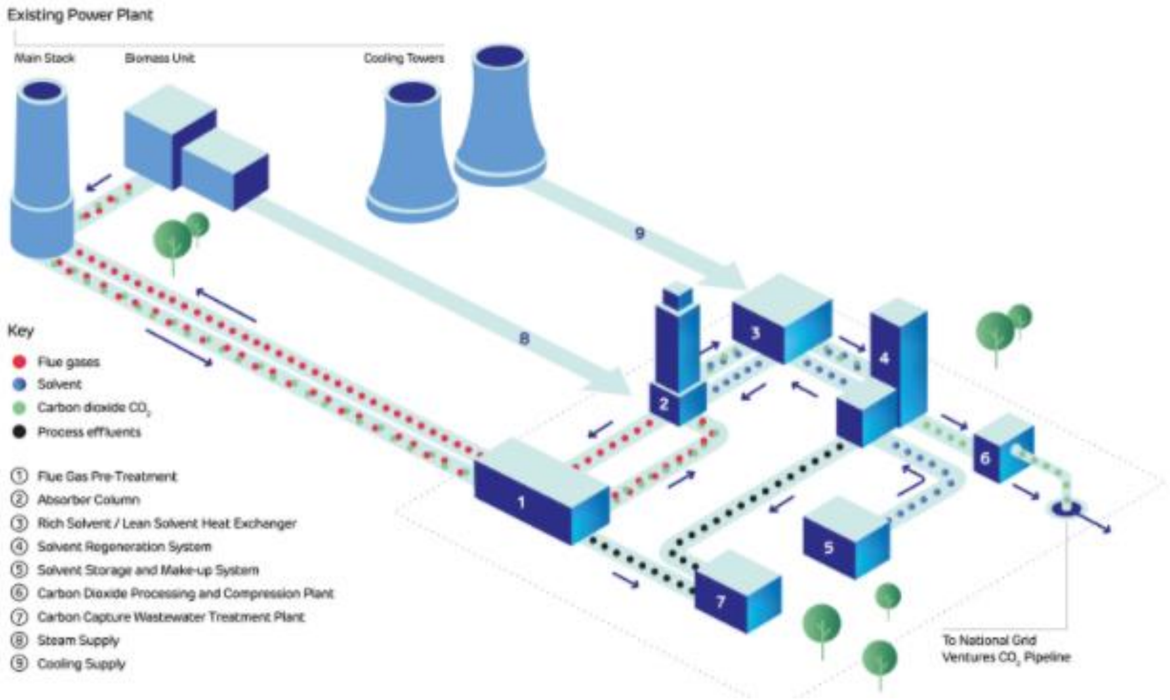
- Solvent Storage and Make-up System
- Carbon Capture Wastewater Treatment Plant
- Carbon Dioxide Processing and Compression Plant
- Modification of the existing cooling system and distribution of cooling water to the PCC
- Modifications to existing power generating units for steam extraction and new steam processing infrastructure for distribution of process steam and electricity supply to the PCC including combined heat and power train for each PCC system

- Alterations to the surface water collection infrastructure to enable utilisation of the resource
- Upgrades to the existing electrical infrastructure and new electrical infrastructure for the secondary electrical supply to the PCC

The captured carbon dioxide would ultimately be transported via new National Grid Transport and Storage Infrastructure for permanent storage in naturally occurring aquifers under the North Sea. This infrastructure would be developed by National Grid Carbon Limited.

The process block flow diagram showing a schematic layout of the PCC system is provide in **Diagram 1**. This is an illustrative schematic only to provide an indication of the systems and there a various interfaces and interactions.

Diagram 1 – Process Block Flow Diagram for Post-combustion Carbon Capture System



3.0 Environmental Risk Assessment

As part of the initial Project review the environment risks were thoroughly considered and the mitigation options identified and fed into the pre-FEED and FEED processes. This resulted in a number of innovations, design requirements and specific mitigations being embedded as FEED requirements within the Project early in the process. For example:-

- No deterioration of discharge quality
- No potential for solvent release to cooling water
- Increased recovery of waste waters for use in the cooling circuit
- Recovery and utilisation of rainwater as cooling water
- Maximising process heat utilisation

These were all done in parallel with the development of the "*Post-combustion carbon dioxide capture: best available techniques (BAT)*" guidance document. The development of the site to include up to two units of PCC as an additional activity on the power station site will have numerous environmental aspects associated with its operation from releases to air to potential fugitive emissions such as noise.

All of the environmental aspects associated with the operation of the PCC are addressed in this document, to enable consideration and determination of the Variation Application.

3.1 Release to Air Impact Screening

To support the development of the Variation Application Drax has utilised the EA H1 risk assessment tool. This considered a baseline and one additional scenario as detailed below.

1. Baseline Scenario:- four biomass units operating at full load (expected operation profile post 2027 without conversion of unit 5 and 6 - see Section7.14.2).
2. PCC Scenario:- Two biomass units with PCC at full load and two biomass units operating without PCC within the merchant electricity market.

The resulting output shows a reasonable level of consistency between the baseline and the PCC scenario for common species released such as NO_x, SO_2 and particulates (see **Tables 1 and 2** below). The baseline, as previously undertaken, identified that the majority of major emission to air species would require further air quality modelling to enable determination, as was the case with H1 assessments undertaken for permitting the original conversation to biomass.

Table 1 H1 assessment mass emission data

Species	Baseline (t)	PCC Scenario		
		PCC releases (t)	LCP releases (t)	Total (t)
Nitrogen dioxide	5782	2241	2891	5132
Sulphur dioxide	3614	1401	1807	3208
$PM_{2.5}$	217	84	108	192
PM_{10}	325	126	163	289
Hydrogen Chloride	903	350	452	802
Ammonia	365	140	181	321
Hydrogen Fluoride	36	14	18	32
Primary Amine (MEA EAL)	NA	14	NA	14
Secondary Amine (NDMA EAL)	NA	6	NA	6
Secondary Amine (OEM derived EAL)	NA	6	NA	6
Formaldehyde	NA	98	NA	98

Table 2 H1 Air Emission Screening Stage One Baseline Scenario

Species	Long Term EAL ($\mu g/m^3$)	Short Term EAL ($\mu g/m^3$)	Long Term			Short Term		
			PC	% PC of EAL	>1%	PC	% PC of EAL	>10%
Ammonia (Ecological)	1		0.264	26.4	Yes			
Ammonia (Human Health)	180	2500	0.264	0.147	No	26.4	1.06	No
Hydrogen Chloride		750				65.9	8.79	No

Species	**Long Term EAL ($\mu g/m^3$)**	**Short Term EAL ($\mu g/m^3$)**	**Long Term**			**Short Term**		
			PC	**% PC of EAL**	**>1%**	**PC**	**% PC of EAL**	**>10%**
Hydrogen Fluoride	16	160	0.0298	0.187	No	2.64	1.65	Yes
Nitrogen Dioxide (Ecological)	30	75	4.22	14.1	Yes	527	703	Yes
Nitrogen Dioxide	40	200	4.22	10.6	Yes	527	264	Yes
Particulates ($PM_{2.5}$)	25		0.159	0.633	No			
Particulates (PM_{10} 24 hour mean)		50	0.238			38	76.0	Yes
Particulate (PM_{10} annual mean)	40		0.238	0.594	No			
Sulphur Dioxide (15 Minute)		266	0.159			435	163	Yes
Sulphur Dioxide (1 Hour)		350	0.238			435	124	Yes
Sulphur Dioxide (Ecological)	10		0.238	26.4	Yes			
Sulphur Dioxide (24 Hour)		125				435	348	Yes

Under the PCC scenario the assessment shows that in addition to those species already modelled; more detailed modelling would be required for Aldehydes (as formaldehyde) and secondary amine releases when assessed against the N-Nitrosodimethylamine (NDMA) Environmental Assessment Level (EAL).

The H1 screening assessment clearly indicated that direct releases of nitrosamines substances were well below the 1% Process Contribution (PC) significance threshold based on the NDMA EAL at 0.512% of the EAL.

The H1 tool output tables are included in Appendix A. H1 risk assessment tool output tables

Table 3 Air Impact Modelling Screening Stage One PCC Scenario

Species	**Long Term EAL ($\mu g/m^3$)**	**Short Term EAL ($\mu g/m^3$)**	**Long Term**			**Short Term**		
			PC	**% PC of EAL**	**>1%**	**PC**	**% PC of EAL**	**>10%**
Formaldehyde	5	100	0.0716	1.44	Yes	7.16	7.16	No

Species	**Long Term EAL ($\mu g/m^3$)**	**Short Term EAL ($\mu g/m^3$)**	**Long Term**			**Short Term**		
			PC	**% PC of EAL**	**>1%**	**PC**	**% PC of EAL**	**>10%**
Ammonia (Ecological)	1		0.235	23.5	Yes			
Ammonia (Human Health)	180	2500	0.235	0.131	No	23.5	0.937	No
Hydrogen Chloride		750				58.6	7.81	No
Hydrogen Fluoride	16	160	0.0265	0.166	No	2.35	1.47	No
Nitrogen Dioxide (Ecological)	30	75	3.75	12.5	Yes	468	624	Yes
Nitrogen Dioxide	40	200	3.75	9.37	Yes	468	234	Yes
Particulates ($PM_{2.5}$)	25		0.141	0.562	No			
Particulates (PM_{10} 24 hour mean)		50	0.211			33.7	67.4	Yes
Particulate (PM_{10} annual mean)	40		0.211	0.527	No			
Sulphur Dioxide (15 Minute)		266	2.35			3863	145	Yes
Sulphur Dioxide (1 Hour)		350	2.35			386	110	Yes
Sulphur Dioxide (Ecological)	10		2.35	23.5	Yes	386		
Sulphur Dioxide (24 Hour)		125	2.35			386	309	Yes
Primary Amine (MEA EAL)	100	400	0.0103	0.0103	No	1.54	0.384	No
Nitrosamine		0.000201	0.00000102	0.512	No			
Nitramine		0.000201	0.00000102	0.512	No			
Secondary Amine (NDMA EAL)	0.000201		0.00409	2045	Yes			
Secondary Amine (OEM derived EAL)	13	53	0.00409	0.0315	No	1.03	1.93	No

Due to the limited large-scale experience of PCC activities in the UK, specifically where paired with bioenergy generation, Drax has provided additional transparency within the Variation Application with regard to releases to air, through undertaking air quality modelling on a broader range of species than required by the H1 screening assessment process. The modelling (Section 7.14) considers primary and secondary amines (including direct nitrosamine releases) as well as aldehydes (as formaldehyde) - substances specifically associated with the operation of the PCC process.

3.2 Release to water screening assessment

The release to water H1 screening assessment is based on a design principle of no deterioration to the current permitted discharged water quality. This position was taken on the basis that the PCC activity will include a significant wastewater treatment facility to process the excess water from the quencher systems managing influent gas quality.

To ensure that any potential treatment solution achieves the required design principle, a minimum performance criterion was embedded within FEED specification for the water treatment process, with the outputs based on the BAT conclusions for Flue Gas Desulphurisation (FGD) water treatment effluent limits due to the similarities between the two activities.

This design principle has a secondary benefit of ensuring the water is of a suitable quality to allow its further utilisation through recirculation within the main cooling circuit prior to discharge. This supports an optimised operational abstraction requirement.

The risk screening for water discharges was undertaken based on this principle, utilising an appropriate conservative worst-case position. This was based on utilising the maximum permitted output from the treatment plant for concentration and volume to be discharged and applying this to the conservative cooling water receiving volume (a single unit flume) and applying these concentrations to the current river background data, where available. This concentration was then assumed to discharge to river via discharge point W1, using the current flow data as required within the H1 screen assessment tool.

The output from the H1 screen assessment (**Table 4**) shows that the treatment plant output concentrations for the appropriate species to be discharged into the cooling circuit are all lower than the current influent background concentrations for everything but sulphate, and those species for which background data is not available. The design required treatment output concentrations for the screened species discharged into the cooling circuit are all lower than the current influent river background concentrations.

Table 4 Future Discharge Concentration Modelling

Species	As	SO_4	Cd	Cr	Cu	Hg	Ni	Pb	Z	NH_3
	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Max Estimated Concentration wastewater treatment	50	2000000	10	50	50	5	50	20	200	500
Discharge volume from wastewater treatment (m3)	350	350	350	350	350	350	350	350	350	350

Species	As	SO_4	Cd	Cr	Cu	Hg	Ni	Pb	Z	NH_3
	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Receiving Volume (single unit flume volume) (m3)	116000	116000	116000	116000	116000	116000	116000	116000	116000	116000
New Concentration	0.15	6016	0.030	0.150	0.150	0.015	0.15	0.06	0.60	1.50
Max Background concentration		269.1	0.094	1.97	9.02	0.1	2.94		6.53	0.095
Ave Background concentration		115.3	0.04	0.585	5.565	0.03	1.86		3.78	0.02
Overall, Max potential concentration	0.15	6285	0.12	2.12	9.17	0.12	3.09	0.06	7.13	1.60
Overall Average Potential Concentration	0.15	6131	0.07	0.74	5.72	0.045	2.01	0.06	4.38	1.52

The H1 impact screening undertaken using the tool indicated that additional modelling would be required for Chromium VI, Nickel and Zinc when the background influent concentrations are considered (see **Table 5**), whereas all parameters screen out when the background concentrations are excluded (see **Table 6**).

This clearly demonstrates that the source of the substance's concentrations triggering the modelling requirement are influent to site from the river Ouse and not the direct effect of the proposed PCC Activity. Copies of the output tables are located in Appendix A. H1 risk assessment tool output tables

The other relevant element for assessing discharges to water for the PCC is the mitigation of potential cross-contamination of the cooling circuit though cooling interfaces. Drax are confident that there are several engineering solutions able to prevent this, and there are tried and tested solutions that are already available to the market that could be utilised. Drax has therefore stipulated this as a term within the FEED specification with its FEED contractor.

Table 5 Water discharge screening assessment test 1 including background concentrations

Substance	Annual Ave Environmental Quality Standards (EQS)			MAC EQS		
	Release (µg/l)	EQS (µg/l)	Release Conc <10% EQS	Release (µg/l)	EQS (µg/l)	Release Conc <10% EQS
Ammonia >50mg/l (90%ile)	1.52	200	Yes			
Arsenic	0.15	200	Yes			
Chromium VI (95%ile) dissolved	0.73	3.4	No			
Copper	0.15	1	No			

Substance	Annual Ave Environmental Quality Standards (EQS)			MAC EQS		
	Release (µg/l)	EQS (µg/l)	Release Conc <10% EQS	Release (µg/l)	EQS (µg/l)	Release Conc <10% EQS
Lead and its compounds	0.06	1.2	Yes	0.06	14	Yes
Nickel and its compounds	2.01	4	No	3.09	34	Yes
Sulphate	6131		Yes			
Zinc	4.38	10.9	No			

Table 6 Water discharge impact screening assessment process contribution only

Substance	Annual Ave EQS			MAC EQS		
	Release (µg/l)	EQS (µg/l)	Release Conc <10% EQS	Release (µg/l)	EQS (µg/l)	Release Conc <10% EQS
Ammonia >50mg/l (90%ile)	1.5	200	Yes			
Arsenic	0.15	200	Yes			
Chromium VI (95%ile) dissolved	0.15	3.4	Yes			
Copper	0.15	1	No			
Lead and its compounds	0.6	1.2	Yes	0.6	14	Yes
Nickel and its compounds	0.15	4	Yes	0.15	34	Yes
Sulphate	6016		Yes			
Zinc	0.6	10.9	Yes			

In conclusion, the environmental risk assessment has identified the environmental aspects associated with the operation of the PCC activity at Drax Power Station. The use of the H1 assessment tool has enabled Drax to understand the required modelling in relation to emissions to air and water. This assessment underpins the permit variation application document in conjunction with the guidance provided within the *"Post-combustion carbon dioxide capture: best available techniques (BAT)"* guidance document.

4.0 Unit 5 & 6

4.1 Overview

Unit 5 and 6 are currently operated as coal-fired units operated to support energy security on the behalf of National Grid. Drax expects to cease all coal operations pertaining to the units on 31 March 2023 (the "**Coal Closure Date**") when existing contractual commitments in respect of the units cease.

Should one or more of the existing biomass units be retrofitted with PCC equipment then this activity and associated infrastructure will utilise space on the Drax Power Station site that is currently utilised by Units 5 and 6 and related equipment. Accordingly, PCC activity and Units 5 and 6 cannot operate simultaneously and the current Units 5 and 6 would permanently close once construction of the PCC activity commences.

The development of the PCC activity as set out in this Variation Application is a key strategic objective of the Drax Group. However, the extent to which the project can proceed is conditional on a number of factors, most notably the development by the UK Government of a business model for BECCS and the agreement of an appropriate form of revenue support to underpin the economics of the project. Should these not be forthcoming, and PCC not be built on the site, then Drax may wish to consider alternative, non-coal, generating options for Units 5 and 6 and so intends to maintain Units 5 and 6 in the intervening period with appropriate systems and controls put in place to preserve existing flexibility within the permit. To reiterate, these alternative options could only be actively pursued in the event that the PCC activity installation project does not progress to construction.

4.2 Particulate matter abatement

The physical layout of the flue arrangements for Units 5 and 6 will be altered to enable development of the PCC activity. Drax will notify the EA of the periods that the units will be unavailable as a result of these changes, as required by clause 3.5 of the current environmental permit.

Separately, the current 'end of life' SO3 injection system and the electrostatic precipitators that are both utilised by Units 5 and 6 will be removed to enable development of the site. In the event that construction of the PCC activity was not to proceed then these systems would need to be reinstated in a BAT-compliant form to support of any future non-coal utilisation of Units 5 and 6.

4.3 Flue Gas Desulphurisation (FGD)

While the Units are operating on coal the FGD technique will be maintained and operated in line with current Environmental Management System (EMS) and Environment Permit requirements. Once coal operations come to an end as expected in March 2023, then the FGD in its current form will no longer be required.

As there are currently no identified new biomass fuels that could require an increase to the fuel sulphur limitations in the near term and the PCC as an activity is only currently planned to be installed on Units 1 and 2. The current FGD absorber towers on Units 4, 5, and 6 are no longer required for sulphur control and will be demolished along with the majority of the current common FGD infrastructure. The current gypsum and limestone storage building will be retained but only as building structures to be utilised as stores and workshops during the PCC construction phase.

5.0 Biomass Furnace Bottom Ash Handling

Drax is looking to improve ash handling and recovery for the future operation. To do this the current ash system will be changed in two phases:

1. The first phase will see the current furnace bottom ash pits consolidated to enable multiple Units to fill the pits current associated specifically with Units 1 and 2. The other four pits will then be demolished to open space for the PCC construction; and
2. The second phase will result in a change to both the FBA and ash water management system. This will be a technology-based solution to improve the separation of ash from the transport water. The solution and onsite location are still being developed but will be consistent with the current directly associated activities and discharges. Drax would look to provide a pre-operational report detailing the design and location along with an environmental risk assessment prior to construction and operation.

The construction of the new system will be developed in a way that ensures that current operations can continue with no change to their associated environment aspects. Although the final engineered solution is still in the front-end engineering design stage the expectation is the new solution will provide several benefits over the current systems, in term of recovery and water use.

6.0 Ouse Renewable Energy Plant

The permit currently includes the AR1 activity for the operation of the Ouse Renewable Energy Plant, a dedicated 300MW generator, located to the north of the primary activities. This project no longer forms part of the strategic plans for the Drax Power Station site, and we request the removal of this specific AR1 activity and all associate pre-operational and improvement conditions from the permit under this Variation Application.

7.0 Best Available Techniques for the Control of Emissions to Air form PCC

Drax recognises that the management of point source emissions to air is key to the control, operation and environmental footprint of carbon capture as an activity and that the identification of BAT, controls and monitoring equipment is key to the credibility, reliability and acceptance of the technology as a key technique in the control of atmospheric carbon dioxide.

The capture system requires effective operation and application of control techniques in the management of the influent and exiting flue gas stream to control constituents whose presence can affect the formation of reaction by-products and/or the solvent life cycle.

7.1 Sulphur Dioxide and Sulphur Trioxide

The presence of acid gases such as the oxides of sulphur have the potential to impact on the operation of post-combustion carbon capture. Their presence can have a role in the formation of substance that can be emitted to air and affect the solvents longevity. It is therefore important that these substances are understood, mitigated and controlled from the design through to the operation.

7.1.1 Influent Flue Gas Controls

The combustion activity at Drax Power Station is a mature and well understood process that is already operating within the emission limits set by the Industrial Emissions Directive- (IED) *Large Combustion Plant Best Available Technique Conclusions* document (BREf). The oxides of Sulphur are controlled within the combustion activity through primary means, specifically fuel selection.

7.1.1.1 Fuel and Mitigant Selection

The majority of biomass fuels available as fuels in the global marketplace are all very low in sulphur content. **Table 7** shows the average fuel sulphur levels of the Drax fuel basket from 2013 to 2021. This clearly shows that the average fuel sulphur over this period was 0.033mg/kg, which is significantly lower than that associated with coal combustion and effective operational limits of the current FGD plant.

The naturally low sulphur levels within the fuel are a benefit to the operation of post-combustion carbon capture as they result in less degradation of the solvent and the formation of heat stable salts (HSS) and minimise any vapour carry over.

The fuel sulphur requirements form part of the fuel selection criteria of all purchased fuels and permit compliance. This is always examined and complied with as part of Drax's fuel management system.

Table 7 Annual Average Biomass Fuel Sulphur Delivered to Site

Year	Average biomass fuel sulphur (mg/kg)
2013	0.024
2014	0.057
2015	0.045
2016	0.040
2017	0.030
2018	0.029
2019	0.027
2020	0.027
2021	0.022
Average	0.033

In addition to the sulphur found in the biomass fuel, there is a proportion of sulphur found in the additive used to control corrosion within the combustion zone. The level of sulphur within the mitigant is monitored and controlled to ensure that it is in line with the operational and compliance parameters required.

7.1.1.2 Influent Flue Gas Treatment

Further to the primary controls currently in place, the PCC system will also include a front-end quench tower designed as a secondary technique to further improve the influent gas quality in relation to particulate and sulphur content.

7.1.1.2.1 Gas/Gas heater

The PCC system will also include a gas/gas heater. The primary purpose of the heater is to reduce the influent gas temperature from the combustion unit while heating the gas stream exiting the PCC process prior to release.

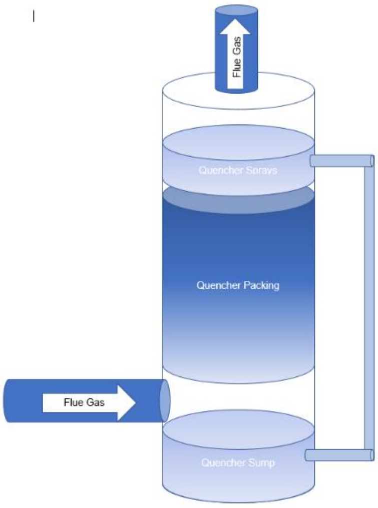
However, a secondary consequence of the heater is the mitigation of SO_3 mist formation.

7.1.1.2.2 Quencher Tower

The technique will be designed to effectively manage a broad operational envelope of gas conditions designed around expected future fuel and operating conditions.

In relation to the control of sulphur emissions the tower is designed to operate utilising an alkali solution. The system will include a variable dosing system to enable the alkalinity to be adjusted to match the incoming sulphur levels to mitigate the associated impacts such as HSS formation, while optimising the usage of the alkali solution.

The tower removes the vast majority of the incoming sulphur dioxide to limit HSS formation to a level that can be effectively controlled within the solvent regeneration process and therefore maximising the life of the KS21^{TM} solvent.



7.2 Oxides of Nitrogen

The control of Oxides of Nitrogen (NO_x) is important to reduce the potential formation of nitramine and nitrosamine-based degradation products. These can potentially form within the PCC process and in the wider environment. This can be mitigated through the reduction of the amount of available NO_2 critical in the formation of nitramine and nitrosamine-based degradation products once released.

7.2.1 Influent Flue Gas control

Drax Power Station utilises a mixed technique approach in the control of NO_x with primary techniques being the principal controls used, but with the secondary technique of Selective Non-Catalytic Reduction (SNCR) being available as required. This approach ensures that the Drax Power Station complies with its environment permit whilst optimising the use of the SNCR system and its associated ammonia emissions.

7.2.1.1 Combustion control

Drax has a long history of utilising combustion control to mitigate the emission of NO_x. The site is currently employing the fourth generation of low NO_x burners with the current burner specifically designed for biomass combustion. This early adoption of low NO_x burners has enabled our design and combustion engineers to work with the various manufacturers to find and refine the best burner for the station’s boiler configuration.

This evolutionary approach has ensured that the site has been able to meet the tightening emission requirements of both the Large Combustion Plant (LCP) Directive and the IED and the subsequent limit changes implement by the BREf.

In addition to the application of low NO_x burners, Drax has also invested in combustion zone monitoring and control systems. The station operates two differing systems each with their own advantages. Units 1, 2 and 3 utilise a laser-based combustion zone monitoring system coupled with a computerised combustion control system. Unit 4 utilises the Multiple Variable Control (MVC) combustion control system which is preferable due to the difference in fuel system to that of Units 1-3.

Both systems support the unit operator in refining the combustion conditions within the boiler to optimise the performance in relation to efficiency, emission level and safety related operational parameters. Their control ethos considers the ability of the units to utilise various air staging techniques, the primary technique of which is Boosted Over Fire Air (BOFA).

7.2.1.2 Air Staging

Drax also has differing options for air staging, which are incorporated within the combustion control systems to provide further primary control options to mitigate the formation of NO_x. Generally, with fuel combustion most of the NO_x formed is due to thermal reactions between the oxygen and nitrogen within the air. This generally occurs above 800C. To minimise the formation of thermal NO_x the aim is to utilise a long cool flame and it is in this process that air staging performs an important function. Where air staging is available the amount of air used in the initial firing zone can be reduced, cooling the flame and reducing NO_x formation before additional control of combustion air is added.

Drax has three options available to manage air within the boiler.

1. Low NO_x burners initially provide air control to reduce air within the firing zone;
2. Boosted over fire air enables efficient complete combustion and heat transfer to the steam system while controlling NO_x formation.
3. Mill over fired air (where the fuel and plant conditions allow), further supporting temperature control and NO_x reduction.

Drax has operated air staging as a key NO_x control for a long period of time and has a solid and mature understanding of how to utilise this technique to optimise emissions control while balancing the safety of the unit through the control of carbon monoxide (CO) formation. This is one of the key control parameters when controlling flame and thermal NO_x formation; high level of CO brings with them safety challenges and it very much requires a balanced approach.

7.2.1.3 Selective Non-Catalytic Reduction

In addition to the primary control techniques, Drax has also invested in a secondary abatement technique on the biomass units. The technique installed is SNCR. The reason SNCR was chosen was that Specific Catalytic Reduction control as a technique has significant challenges when coupled with biomass combustion. Specific Catalytic Reduction catalysts suffer significant degradation and fouling when paired with biomass combustion systems, significantly increasing operational costs for limited reduction improvement. This issue, when coupled with the lower flame temperatures and fuel nitrogen level inherent with biomass combustion makes SNCR a far more effective system overall for biomass-based generation assets.

However, both of the systems come with a downside in the form of ammonia slip. This therefore has to be factored into the operation of SNCR on the biomass units. It is important to note that ammonia slip control is more important where PCC is fitted. Although NO_x control is more critical in terms of solvent life and the formation of degradation products, ammonia can play a lesser (but significant) role in this, in addition to the impact of its release on the surrounding environment. Given that the operation of the PCC can also result in the formation of ammonia, it is critical that Drax balances the operation of both techniques to work in tandem for the best environmental outcome.

Effective primary control systems enable Drax to operate within the BREf emission limits for the majority of the time and therefore within the design parameters of the PCC unit. This allows Drax the choice of when to deploy SNCR in support of periods where additional control is required, i.e. operating at low load, returning units to service, or if a primary system out of service due to defects.

7.3 Particulate Emissions

The control of particulate emissions is key to the operational effectiveness and environment optimisation of the PCC unit. Their presence can have an impact in a number of ways.

- The availability of $PM_{2.5}$ material with its potential to increase solvent vapour release.
- The presence of certain metals and carbon can result in degradation product formation and the particulates themselves can cause fouling of the solvent and its management system.

7.3.1 Influent Flue Gas control

The control of particulates within the influent flue gas stream is critical to the operation of the PCC. Drax operates electrostatic precipitators as a secondary control technique to manage particulates, with further techniques to be introduced as part of the PCC activity which are outlined in Sections7.3.1.1, 7.3.1.2and7.3.1.3.

7.3.1.1 Electrostatic Precipitators

The units at Drax are all fitted with Electrostatic Precipitators (ESP) as a secondary control technique, designed to remove ~ 90% of the particulate matter from the flue gas. Significant work has been undertaken on the ESP systems over the last few years, for example Unit 1 saw significant maintenance during its last outage, including rewiring.

This work has put the units in a compliant position under IED BREf, with the annual average emission for 2021 of 7mg/Nm^3. Drax is undertaking a longer-term review of the system and interlinked process to identify further incremental improvements suitable to support the life extension that PCC would bring.

7.3.1.2 Influent Flue Gas Treatment

Further to the secondary control technique (ESP) in place on the host Unit, the PCC system will also include a front-end quencher tower designed as a further secondary control technique to improve the influent gas quality in relation to particulate content.

7.3.1.2.1 Quencher Tower

The technique will be designed to effectively manage a broad operational envelope of gas conditions designed around expected future fuels and operating conditions.

The Quencher Tower is designed to operate as a wet scrubber in order to control particular emissions. The system will effectively mitigate the current operational range of particulate emissions reducing the incoming particulate levels down to <5mg/Nm^3 to palliate absorber fouling, vapour formation and degradation impacts associated with its presence in the gas stream.

7.3.1.3 Post Absorber Gas Treatment

The PCC system will also incorporate a post absorber wash system within the carbon capture absorber tower. Although the primary purpose of this technique is the control of the releases of solvent vapour and other degradation products it will have a secondary effect of also controlling any particulates that have passed through the other control systems.

7.4 Ammonia

The primary source of ammonia in the flue gas stream exiting the combustion activity will be as a result of the utilisation of selective non-catalytic reduction used for the control of NO_x. This technique is not employed regularly on Drax Power Station’s biomass units and is only employed on an “as required” basis as part of Drax’s mixed techniques approach for NO_x emissions.

7.4.1 SNCR

The SNCR was designed with an advance control system. The system uses plant information along with predefined tables developed for each fuel basket to control the urea injection ensuring the Optimum maximum utilization of ammonia and minimal slip. These tables require development during operational running where there is a significant change in the biomass fuels to be utilised on site. Although Drax uses a wider variety of biomass fuels, the majority are white wood pellets which generally have a similar NO_x potential. These pellets are currently supplemented with various agricultural residues and on occasion biogenic end of waste materials from historic industrial processes. Where the percentage burn for these products is significant enough and fuel testing has shown a NO_x impact a specific table would be design within the SNCR for these fuels.

7.4.2 Quencher Tower

The quencher is expected to remove the majority of the ammonia within the incoming gas stream prior to the absorber. This means the already very low levels of ammonia will be further reduced so that any associated solvent interactions will be minimised.

7.5 Mercury

Biomass fuel has very low levels of mercury and all the mercury found within the combustion zone is fuel based. This means that biomass has a lower emission rate for mercury when compared to other solid fuels. However, mercury is one of a few metals that vaporises and therefore is in the vapor of the flue gas stream. Mercury is known to interact with solvents in relation to the formation of HSS.

7.5.1 Fuel Selection

Drax has a defined fuel envelope that is used in the purchase of fuel. This envelope is based on several operational and compliance factors. The level of mercury within the fuel is part of the suite of analysis and data we collect on the fuel to undertake a suitability assessment.

7.5.2 Quencher Tower

The quencher is expected to remove the majority of the vapor mercury within the incoming gas stream prior to the absorber. This means the already very low levels of mercury will be further reduced so the associated interaction with the solvent will be minimal.

7.6 Aldehydes

Aldehydes can be formed within the absorber tower as a by-product of oxidative degradation of the amines within the solvent. There, formation is limited by the control of the influent gas composition, solvent selection and maintenance of the solvent. The oxidation generally occurs within the absorber or the rich/lean transfer lines for the reaction of oxygen in the presence of certain metals.

The presence of substances that can support oxidative reaction is also minimised by regeneration of the solvent.

7.6.1 Solvent Selection

The KS21^{TM} solvent has been developed to be resistant to oxidative reactions through the choice of constituent components. This minimises the formation of aldehydes within the solvent and the potential entrainment of such substances within the gas stream.

7.6.2 Quencher Tower

The metals that can support oxidation that can carry over from the combustion of the biomass would generally be found within the pulverised fly ash (PFA), with the exception of mercury and selenium. As the majority of the PFA will be removed in the quencher tower this also minimises the quantity of metals within the absorber that support the oxidation of the solvent and the resulting formation of aldehydes. Additionally, mercury vapour is soluble and removed within the quenching tower, further reducing the presence of those metals of interest in the oxidation of the amine solvent.

7.7 KS21^{TM} Solvent Vapours and Associated Releases

7.7.1 Disclosure

KS21^{TM} is a solvent which is based on 30 years of intellectual development to design an efficient solvent that is significantly more stable both thermally and oxidatively, with reduced volatility than other primary amine solvents such as MEA. These are all key factors in the environmental performance of the solvent.

In terms of chemical safety under the Registration, Evaluation and Authorisation of Chemicals (REACh) KS21^{TM} will be recognised as a mixture and is being assessed as such under REACh in such a way as enables the ingredients to be identified in a way that ensures commercial confidence is maintained.

In terms of emissions, the EA has deemed that it can be foreseen that the emission of constituent amines from the proprietary solvents as individual substances could occur, rather than the release being deemed a mixture as registered under REACh. This is challenging for the solvent owners, since those constituent substances in the solvent are commercially confidential, resulting from a significant development process, and as such have a high value as a propriety product.

In response to the findings of the air dispersion modelling, a set of air emission limits have been developed and proposed for determination, agreement, and approval within Section 7.12 of the Variation Application. These are based on the associated impacts and accounting available control and monitoring techniques to support operational control of the process.

7.7.1.1 Commercial in Confidence

As stated above, those substance within the solvent with a foreseeable release and which have potential associate impacts will be provided and assessed as part of the air quality modelling in Section 7.14 and the attach modelling files. The other constituents of the KS21^{TM} solvent that do not meet this criterion will be subject to a commercial in confidence application by the Mitsubishi Heavy Industries (MHI). the application for which is included separately as part of this variation submission (Appendix G – Application for commercial in confidence retaining to KS21TM composition.) and has also been provided directly to the EA referencing the Variation Application and permit number of the Drax Power Station site.

7.7.2 Emissions Associated with Solvents

The KS21^{TM} solvent utilised with the KM-CDR process can form vapours that could be carried by the gas stream out of the absorber. This can be mitigated through primary and secondary techniques. The primary control techniques are based on managing the presence of SO_3, fine particulate ($PM_{2.5}$) and temperature within the absorber. The secondary control techniques are based on utilising the physiochemical properties of the KS21^{TM} solvent vapours to capture and recover the solvent and return it to the system.

In addition to the solvent, reaction by-products and degradation products can be formed. These can also be captured within the gas stream and be carried out of the absorber. These again have several methods of mitigation with both primary and secondary techniques utilised. The primary control technique lies in principle with the solvent development in relation to its resistance to form vapours or form reaction and degradation by-products. These are coupled with system design in controlling the incoming gas composition and absorber temperatures to further minimise the formation of these substances. The secondary control techniques are based on the design of the post absorber wash system and the inclusion of specially designed proprietary demister systems.

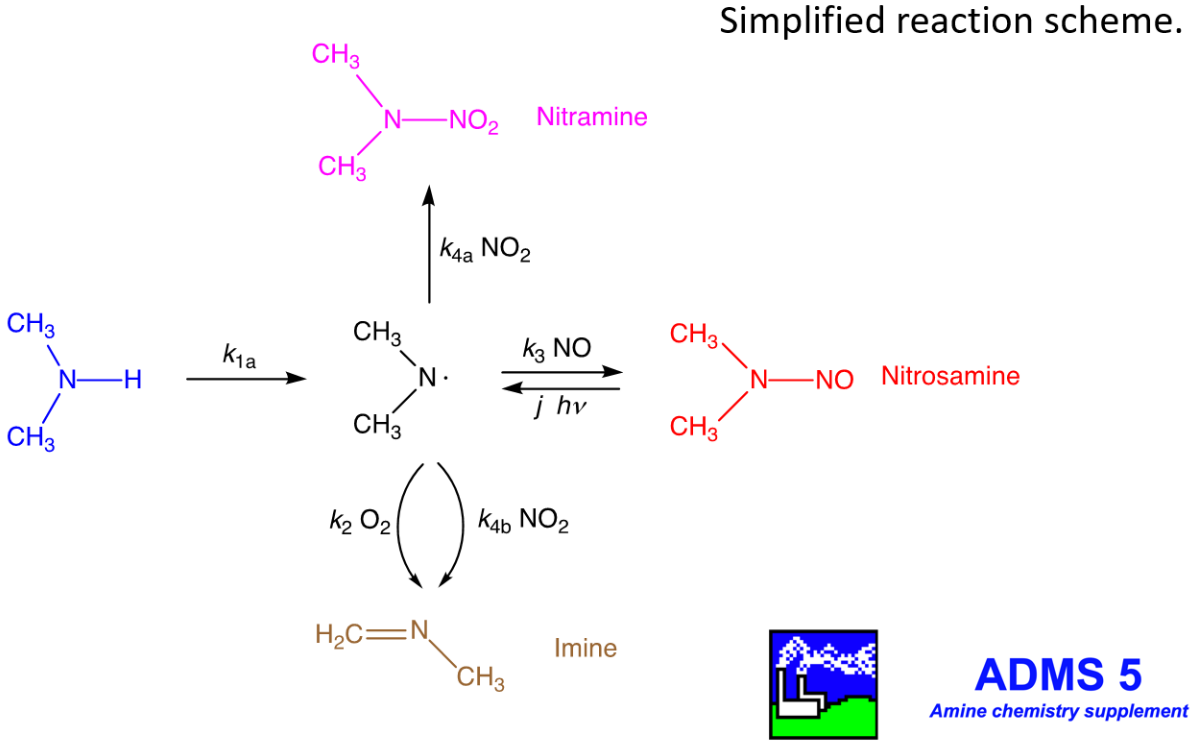
MHI has spent nearly three decades developing the solvent to maximise CO_2 absorption and optimising its life cycle by minimising the formation of degradation by-products. They have partnered this with their advanced KM-CDR process developed to support maximising the solvent life cycle by managing the incoming gas composition and maximises solvent recovery and by-product substance capture.

7.7.3 Solvent Vapour Releases

The nature of the PCC process means there is potential for very small quantities of the KS21^{TM} solvent to escape the absorber within the gas stream. It is important to minimise these releases for both environmental and commercial reasons.

On the environmental front the release of KS21^{TM} solvent into the atmosphere could result in the formation of degradation products such as nitrosamine and nitramines. These generally form as a result of oxidation of the solvents as shown in the photo-oxidation scheme in **Figure 1**.

Figure 1 Example of photo-oxidation scheme of generic amines solvents in the atmosphere



Source: Prof. Claus Nielsen/CERC

The reaction initially starts with the reaction of the solvent with OH radicals, although it can also involve several other substances such as ozone. This initial step also limits the rate of formation of the nitrosamine and nitramines in the atmosphere. Primary amines cannot form nitrosamine as these degrade rapidly to release nitrogen gas, however, they can form nitramines. Both secondary and tertiary amines can form both nitrosamine and nitramine substances within the atmosphere. However, even though these substances can be formed within the atmosphere they can also be destroyed, with photolysis reactions being a major reaction in their destruction.

It is for these reasons that the KM-CDR process has been developed to minimise the potential escape and loss of solvent vapour from the process.

7.7.3.1 Influent Gas Control

There are a number of substances in the post combustion gas stream that can increase the volume of solvent vapour formed and therefore increase the risk of vapour escape from the absorber. Principally these are SO_3 and $PM_{2.5}$. The KM-CDR process is designed to condition the incoming gas stream to minimise the vapour formation potential and therefore any release from the absorber. The primary control here is the quenching tower described in Section 7.1.1.2.1, which removes a large percentage of the particulates from the flue gas.

In terms of SO_3, the mitigation is the nature of the fuel, coupled with the use of a gas/gas heater. Biomass by its very nature has a very low sulphur content and therefore a low level of SO_3 is formed. Additionally, there is evidence that gas/gas heaters, which will be installed as part of the project, help mitigate the formation of SO_3 and further reduce the vapour formation risk from SO_3. Further to the controls on the influent gas stream the KM-CDR process also includes secondary controls, using a water wash system post the absorber.

7.7.3.2 Post Absorber Gas Treatment

As stated, the KS21^{TM} solvent has been developed to maximise its lifetime within the system. This is a key aspect to the commercial viability of PCC systems. The solvents have a significant associated cost, so their life cycle is a critical commercial and operational consideration. However, the nature of the process means that some of the KS21^{TM} can be vapourised and entrained in the gas stream.

The KM-CDR process has been designed to minimise these releases though the exploitation of the physiochemical properties of amines. Amines as a family are generally very soluble, so the process uses this solubility to control any potential releases through the inclusion of post absorber wash systems. This is a multiple level process with MHI- developed proprietary demister systems included. In the Drax system a multi-level wash will be designed to include up to four demister systems and three levels of structured packing.

This will also include an acidic solution wash as part of the secondary control system. This will further capture the small quantities of amine-based substances that pass through the main water wash levels. The inclusion of acid to the system further supports capture, as well as targeting other related substances potentially released, such as ammonia.

7.7.4 Degradation process

The degradation of the amine generally occurs in three different ways; oxidative degradation, thermal degradation, and acid gas reactions. As highlighted in other sections oxidative degradation is key in the formation of ammonia (Section 7.4) and aldehydes (Section7.6). Thermal degradation is key to the long life of the solvent (Section 9.1.1). Acid gas reactions are the key reaction in relation to the formation of nitrosamine and nitramines. It is the control of these acid gases that is key to minimising the formation and release of nitramine and nitrosamines directly from the process.

7.7.5 Nitrosamines

These substances are a wide range of chemicals known as N-Nitrosamines. Specifically, nitros compounds of the original alkanolamines within the solvents, and nitros compounds of short chain aldehydes and primary and secondary amines. These substances are of interest due to their potential toxicity and potential environmental effects. It is these attributes that mean their formation and control are key aspects in the operation of PCC as a technique.

These substances are principally formed through the degradation of the amine solvent when in contact with acid gases specifically nitrogen dioxide. The control of these substances is detailed in Sections 7.1and 7.2 respectively. As shown, significant mitigations are in place to minimise the level of acid gases within the flue gas stream and therefore reduce the formation of nitrosamines within the PCC process.

Further secondary controls are also in place within the KM-CDR process to minimise the direct release of nitrosamines though exploitation of the solubility of these substances.

7.7.5.1 Post Absorber Gas Treatment

The KM-CDR process has been designed to minimise this release of nitrosamines though exploitation of the physiochemical properties of these products. These substances a generally very soluble so the process uses this to minimise the release through the inclusion of post absorber wash system. This is a multiple level process with additional proprietary demister systems developed to maximise the collection of the substances prior to release. This is a multiple level process with original manufacturer developed proprietary demister systems included. In the Drax system a multi-level wash will be designed to include up to four demister systems and three levels of structured packing.

In addition, an acidic solution level will also form part of the secondary control system. This will capture the small quantities of amine-based substances that pass through the initial levels, the inclusion of the acid further mitigate release, and supports the capture of associated substances.

7.7.6 Nitramines

These substances are a wide range of chemicals known as nitramines. Specifically, nitra compounds of the original alkanolamines within the solvents, nitra compounds of short chain aldehydes and primary and secondary amines. These substances are of interest due to their potential toxicity and potential environmental effects.

It is these attributes that mean their formation and controls are key aspects in the operation of PCC systems as a technique.

These substances are principally formed through the degradation of the amine solvent when in contact with acid gases specifically nitrogen dioxide. The control of these substances is detailed in 7.1and 7.2 respectively. As shown, significant mitigations are in place to minimise the level of acid gases within the flue gas stream and therefore reduce the formation of nitramines within the PCC process. Further secondary controls are also in place within the KM-CDR process to minimise the direct release of nitramines though exploitation of the solubility of some of these substances.

7.7.6.1 Post Absorber Gas Treatment

The KM-CDR process has been designed to minimise this release of nitramines though exploitation of the physiochemical properties of these products. Some of these substances are soluble, so the process uses this solubility to minimise the release through the inclusion of post absorber water wash systems. This is a multiple level process with an original manufacturer developed proprietary demister systems included. In the Drax system a multi-level wash will be designed to include up to four demister systems and three levels of structured packing.

In addition, an acidic solution level will also form part of the secondary control system. This will capture the small quantities of amine-based substances that pass through the initial levels, the inclusion of the acid further mitigates release, and supports the capture of associated substances.

7.8 Ammonia

Ammonia is formed within the absorber through the oxidation of the amines. There, formation is limited by the control of the influent gas composition, solvent selection and maintenance of the solvent. The oxidation generally occurs within the sump or the rich/lean transfer lines for the reaction of oxygen in the presence of certain metals.

7.8.1 Solvent Selection

The KS21^{TM} solvent has been developed to be resistant to oxidative reactions through the choice of amines. This minimises the formation of ammonia within the solvent and the potential entrainment of such materials within the gas stream.

7.8.2 Quencher Tower

The metals that can support oxidation are carried over from the combustion of the biomass and would generally be found within the PFA, with the exception of mercury and selenium. As the majority of the PFA will be removed in the quencher tower, this also minimises the quantity of metals within the absorber that support the oxidation of the solvent and results in the formation of aldehydes. Additionally, mercury vapour is soluble and so is removed within the quenching tower, further reducing the presence of those metals of interest in the oxidation of the amine solvent.

7.8.3 Post Absorber Gas Treatment

The KM-CDR process also controls the ammonia release through the use of an acidic final stage water wash, as per the amine related BAT positions within the large volume organic chemical BREf 2017. This is designed to capture a proportion of the ammonia prior to release to atmosphere.

7.9 Chlorides

The control of chlorides in relation to PCC operations is important to avoid HSS and to mitigate foaming and corrosion within various elements of PCC system. This needs to be balanced with the needs of the boiler, as certain forms of chlorine here also cause corrosion and slagging of the boiler systems.

To control the negative traits of chlorine within the boiler, the chlorine needs to be kept within the vapour phase. To do this, Drax utilise an alkali chloride-converting additive in the form of historical coal combustion by-products. The alkali chloride-converting additive reacts with the various potassium compounds as well as other alkali-based compounds, reducing the formation of corrosion compounds and moving much of the chlorine and some sulphur into the gas phase.

7.9.1 Quencher Tower

Although the primary design of the quencher Tower is not for the removal of chlorides, as with particulates it will remove a proportion of the chlorides from the incoming gas stream. This will support the mitigation of the associated affects caused by the presence of the chlorides within the gas stream. In addition, the solvent reclaiming process has been sized to accommodate higher level of chlorides than are expected within the incoming cooled flue gas.

7.10 Hydrogen Fluoride

The control of fluorides in relation to PCC operations is important to avoid HSS and to mitigate foaming and corrosion within various elements of PCC system.

7.10.1 Quencher Tower

Although the primary design of the quencher tower is for not the removal of fluorides, as with particulates it will have remove a proportion of the fluorides from the incoming gas stream. This will support the mitigation of the associated affects caused by the presence of the fluorides within the gas stream. In addition, the solvent reclaiming process has been sized to accommodate higher level of fluorides than are expected within the incoming cooled flue gas.

7.11 Metals

Metals support the oxidation of the amine solvents and the formation of the associated oxidation products such as aldehydes and ammonia. The majority of species of concern are found in the PFA, with only mercury and selenium having reasonable presence in the gas phase. The primary control on metals entering the absorber in the quencher tower. As discussed in Section7.3, this will remove a large percentage of the particulate within the gas stream and therefore the metal. It will also remove the mercury due to it solubility. These controls are key in reducing the oxidation potential from the metals in the post combustion gas stream.

7.12 Proposed Air Emission Limit Values

Drax has analysed a range of associate industries' emission limits identified including as set out in the IED, and the associated BREf for LCPs and large volume organics and inorganics, in order to identify and build an appropriate suite of proposed emissions limits for the New Activity. Where a suitable regulatory or BREf emission limit has not been defined, Drax have reviewed the EAL and the associated modelling data in conjunction with the equipment design specialists in putting forward these proposals.

The proposed point source emissions to air from the PCC process are based on the defined normal operating parameters (between 60 and 100% of flue gas volume from the host unit). These are shown in **Table 8**. The amine limits are proposed on the basis of continuous emission monitoring being available. Where this is not available periodic monitoring will be used and the proposed limits are provided in **Table 9**.

The host biomass units (IED, chapter 3 regarding LCPs) will continue to operate to the BREf based best available technique limits as agreed in variation 18 to the environment permit and shown in **Table 10**.

Table 8 – Proposed point source emission to air limits for the Carbon Capture process

Species	Method	Monitoring Type	Proposed ELV			Units	Confidence internal (%)
			Daily	**Monthly**	**AEL**		
SO_2		Continuous	100	200	60	mg/Nm^3	20
Total Particulates		Continuous	16	20	10	mg/Nm^3	30
HCl		Continuous	25			mg/Nm^3	40
NH_3		Continuous			10	mg/Nm^3	40
Aldehyde		Continuous	10		7	mg/Nm^3	40
Total Primary Amine (MEA)		Continuous[#]	2		1	mg/Nm^3	40
Total Secondary Amine (DMA)		Continuous[#]	1		0.3	mg/Nm^3	40
HF		Periodic			1	mg/Nm^3	40
Notes # the table assumes appropriate continuous emission monitors (CEMs) can be identified and certified for the monitoring of amines prior to operation. Where CEMs are not available periodic monitoring will be utilised.							

Table 9 – Proposed periodic amine point source emission to air limits for the Carbon Capture process

Species	Method	Monitoring Type		Proposed ELV			Units	Confidence internal (%)
			Daily	**Monthly**	**Average over sampling period**	**AEL**		
Aldehyde		Periodic			7		mg/Nm^3	
Total Primary Amine (MEA)		Periodic			1.5		mg/Nm^3	
Total Secondary Amine (DMA)		Periodic			1		mg/Nm^3	

Table 10 – Current point source emission to air limits for biomass combustion activity

Species	Method	Monitoring Type	Proposed ELV			Units	Confidence internal (%)
			Daily	**Monthly**	**AEL**		
NO_x		Continuous	200	200	160	mg/Nm^3	20
SO_2		Continuous	165	200	100	mg/Nm^3	20
Total Particulates		Continuous	16	20	10	mg/Nm^3	30
HCl		Continuous	25			mg/Nm^3	40
Carbon Monoxide		Continuous			400	mg/Nm^3	10
HF		Periodic			1	mg/Nm^3	40

7.13 Mass Emissions Releases

Based on the modelling and the air emission limit proposals (Tables 8 to 10), Drax has calculated a set of mass emissions based on the proposed emission limit concentrations in conjunction with a conservative operational position in relation to mass release. This provides a very conservative total release for each substance from the activities for an operational year.

These calculations used to develop these estimates do not align with the more precise concentrations used in the deposition modelling presented in Section 7.14.

The data in **Table 11** shows the mass emissions for the current permitted baseline and for the inclusion of PCC. This clearly shows that all primary combustion emissions are either maintained or reduced in terms of mass emissions, with the installation and operation of the PCC system outlined in this Variation Application. This clearly shows environmental benefits of the PCC activity outside those associated with the capture and long-term storage of carbon dioxide.

However, the inclusion of PCC as an activity does add several additional substances that could be potentially released through its installation and operation. These are primarily based on the utilisation of an amine-based solvent and the potential associated releases from the activity.

Table 11 Estimated worst case mass emissions for Station operation with PCC in service

Species	**4 Biomass units, 2 with plus PCC**	**4 Biomass Units, no PCC**	**6 Biomass Unit, no PCC**

NO_x	10314	11570	17355
SO_2	7413	8316	12474
Particulate	644	723	1084
Ammonia	644	723	1084
HCl	1611	1807	2711
HF	64.5	72	108
Primary Amine	28		
Secondary Amine	8		
Aldehyde	198		
Based on 100% load and 100% availability			

7.14 Air Dispersion Modelling

Air dispersion modelling was undertaken based on the outcome of the H1 environmental risk assessment. However, a decision was made by Drax to undertake a wider, more comprehensive modelling scope than was required by the environmental risk assessment, on the basis that in Drax's view this is appropriate in order to build confidence in the carbon capture technology.

For the purposes of modelling the amines within the solvent will be referred to as Amine 1 and Amine 2 with associated nitrosamines reference using the proxies of Nitrosamine 1 and Nitrosamine 2.

7.14.1 Modelling Approach

The approach to the assessment of the New Activity is based on the outcomes of consultation with both the Environmental Health Officer at Selby District Council (SDC) and the EA.

The scope of the assessment is a quantitative assessment of point source emissions to air from the operation of the PCC.

The assessment of point source emissions from the PCC is based on a dispersion modelling exercise undertaken using the ADMS model (v5.2) published by Cambridge Environmental Research Consultants (CERC). The model has been validated against both field studies and wind tunnel studies of dispersion and is widely used for air quality impact assessment in the UK.

The atmospheric dispersion model considers the effects of terrain, roughness length and buildings (as appropriate for the location), together with, and in accordance with EA guidance, five years of recent meteorological data from RAF Waddington.

The air pollutants assessed as part of the operational phase air quality assessment comprise:

- Oxides of nitrogen, NO_x
- Ammonia, NH_3
- Particulate matter (capturing both PM_{10} and $PM_{2.5}$)
- Hydrogen chloride, HCl
- Sulphur dioxide, SO_2
- Aldehydes
- Amine and nitrosamine compounds associated with the use of a proprietary solvent as part of the PCC process. For the purposes of this assessment, all modelled amine concentration outputs are treated as secondary amine (OEM derived EAL) and all

nitrosamine concentration outputs as N-Nitrosodimethylamine (NDMA) for comparison with the associated non-statutory EALs (see **Table 12**). As shown in Section7.14.4.

Table 12 Air Quality Statutory and Non-Statutory EALs relevant to the Assessment of Impacts from the PCC

Pollutant	Objective/ Limit value (µg/m³)	Target Value	Measured as	Set for protection of:
Nitrogen dioxides, NO_2	200	-	1 hour mean, not to be exceeded more than 18 times per year.	Human Health
	40	-	Annual Average	
Particulate matter, PM_{10}	40	-	Annual Average	
	50	-	24-hour mean, not to be exceeded more than 35 times per year	
Particulate matter, $PM_{2.5}$	20	-	Annual Mean	
Sulphur dioxide, SO_2	266	-	15-minute mean not to be exceeded more than 35 times per year	
	350	-	1-hour mean not to be exceeded more than 24 times per year	
	125	-	24-hour mean not to be exceeded more than 3 times per year	
Ammonia, NH_3		180	Annual mean	
		2500	1-hour mean	
Hydrogen chloride, HCl		750	1-hour mean	
Secondary Amine (OEM derived EAL)		13	24-hour mean	
		53	1-hour mean	
N-Nitrosodimethylamine		0.0002	Annual mean	
Nitrogen oxides, NO_x	30	-	Annual mean	
	-	75	24-hour mean	
Sulphur dioxide, SO_2		20 / 10(3)	Annual mean	
			Annual mean	
Ammonia, NH_3		1(3) /3		

1) Air Quality (England) Regulations 2000; Air Quality Standards Regulations 2010
(2) EA Guidance – targets for protected conservation areas and EALs for human health
(3) Applicable where lichens or bryophytes are present

Details of the adopted atmospheric dispersion modelling approach, including the treatment and assessment of amine and nitrosamine emissions, are provided in Appendix B Modelling of amine compounds.. However, key information relating to the dispersion modelling methodology is summarised in the subsections below.

7.14.2 Modelled Scenarios

The air quality assessment for the operational phase has focussed on the following core model scenarios:

- **Baseline**:
    - Operation of existing four biomass units (4 x 660 MW output) from Main Stack (259 m above ground level (agl));
    - All units assumed to be running at full load for 4,000 hours per year, representing a reasonably likely operating profile based on a 'mid-merit' operating regime.
    - The two coal-fired units are not included in the Baseline (or PCC scenario) because have ceased to operate as commercial generating in March 2021 and the future of these units is undetermined before the PCC plant commences operation.
- **With PCC**:
    - Operation of two biomass units with PCC (Unit 1 & Unit 2; 660 MWe equivalent output per unit) from the Main Stack (259 m agl), assumed to be running continuously at full load (8,760 hours per year), representing a reasonable worst-case operating profile;
    - Operation of two biomass units without PCC (Unit 3 & Unit 4; 600 MWe equivalent output per unit) from the Main Stack (259 m agl) assumed to be running at full load for 4,000 hours per year, representing a reasonable operating profile based on a 'mid-merit' operating regime[Error! Bookmark not defined.];
- **With PCC and Other Projects (Cumulative Impacts)**:
    - Operation of PCC as per above With PCC scenario;
    - Emissions sources associated with relevant other projects, for which development has been approved or approval is being sought, have been sourced from the respective project planning documents and, where possible, emission sources have been included in the atmospheric dispersion model as part of this scenario;
    - The 'other projects' included in this scenario are provided below (see Section 7.14.5).

Sensitivity Test: Worst Case Emissions Profile

Further sensitivity modelling was undertaken for the same scenarios as above, but assuming that all four biomass units in the Baseline scenario and non-CCS Units 3 & 4 in the ‘With PCC’ scenario would be operating at full load for all hours of the year (8,760 hours). This represents a worst-case emissions profile for both the Baseline and the With PCC scenario. Model results relating to these sensitivity scenarios are reported in Appendix C Operational Air Quality Assessment Result Tables: Human Receptors. (human receptors) and Appendix D Operational Air Quality Assessment Result Tables: Ecological Receptors. (ecological receptors).

The core and sensitivity test model scenarios have been undertaken for assessment purposes so that emissions from the consented biomass plant with PCC applied can be understood. As such, it is important to note that the effects identified cannot be considered to be simply due to the impacts of the operation of the PCC’s alone – the impacts presented are a combination of the changes to dispersion from the Main Stack caused by the installation of PCC, the consequences of the use of an amine solvent as part of the PCC process, and an assumed change in load profile to Units 1 and 2.

7.14.3 Modelled Stack parameters

The stack parameters for the Baseline and With PCC scenarios are provided in **Table 13** below. The flue discharge conditions for the four biomass units represent baseload operation (i.e. full load) for any given hour of operation, both in the Baseline and With PCC scenarios. Therefore, in a mid-merit operating profile (i.e. as per core model scenarios for Baseline & With PCC), the respective units are assumed to operate at full load for 4,000 hours per annum. In continuous baseload operation (i.e. as per sensitivity test scenarios for Baseline & With PCC), all four units are assumed to operate at full load for 8,760 hours (i.e. all hours of year).

Unless stated otherwise in the below tables, all pollutant emission concentrations are based on the respective emission limit values (ELVs) as per the EU Best Available Techniques (BAT) associated emission levels (BAT-AELs) as per BREf (European Commission, 2017).

Table 13 - Emission Parameters for the Baseline and With PCC Scenarios

Parameter	Baseline (per Unit)	With PCC	
		With Scheme Scenario (per Unit *with* PCC)*	With Scheme Scenario (per Unit *without* PCC)**
No. Biomass Units	4	2	2
No. flues	2	1	1
Stack height (m agl)	259	259	259
Flue diameter (m)	8	8	8
Discharge Temp (°C)	144.2	80.0	144.2
Vol. flow (Nm^3/s) (1)	573.0	444.5	573.0
Vol. flow (Am^3/s) (2)	992.5	686.4	992.5

NO_x exit concentration (mg/Nm^3) (3)	160	160	160
NH_3 exit concentration (mg/Nm^3)	10	10	10
Dust (PM_{10}/$PM_{2.5}$) exit concentration (mg/Nm^3) (3)	10	10	10
HCl exit concentration (mg/Nm^3) (3)	5	5	5
SO_2 exit concentration (mg/Nm^3) (3)	100	100	100
Amine 1 (mg/Nm^3) (3), (4)	-	0.5	-
Amine 2 (mg/Nm^3) (4)	-	0.3	-

Notes:

*** Applicable to Unit 1 & Unit 2 only (with CCS)**

**** Applicable to Units 3 & Unit 4 only (without CCS)**

(1) – Calculated at 273.15 Kelvin (0°C), pressure of 101.3 kPa, dry, 6% O_2.

(2) – Actual discharge conditions, 4.9% H_2O, 7.4% O_2.

(3) – Representative of yearly average BAT-AELs. Corresponding daily average BAT-AELs provided in Appendix 6.3.

(4) – Representative of proposed yearly average ELVs. Corresponding proposed daily average ELVs for amines provided in Appendix C. The proposed ELVs exceed the reasonable worst-case design emissions concentrations provided by the technology supplier (MHI).

Given that there will be multiple flues within the Main Stack (i.e. one flue per two biomass units) in both the Baseline and With PCC scenarios, emissions from these flues will in effect act as a single plume with combined source characteristics. The combined source characteristics modelled within ADMS 5.2, are presented in **Table 14** and associated details provided in Appendices Appendix B Modelling of amine compounds., Appendix C Operational Air Quality Assessment Result Tables: Human Receptors. and Appendix D Operational Air Quality Assessment Result Tables: Ecological Receptors..

Table 14 - Combined Flue Emissions Parameters used in Dispersion Modelling

Parameter	Baseline Scenario	With PCC Scenario
Emission Source	Biomass Units	Biomass Units
No. Units	4	4 (1)
Stack height (m agl)	259	259
Stack location X, Y (m)	466124, 427224	466124, 427224
No. flues	2	2 (1)
Effective Flue diameter (m)	11.3	11.3
Discharge Temp (°C)	144.2	116.8

Exit velocity (m/s)	39.5	33.5
Vol. flow (Am^3/s)	3,970	3,370
NO_x emission rate (g/s)	366.7	325.5
NH_3 emission rate (g/s)	22.9	20.3
$PM_{10}/PM_{2.5}$ emission rate (g/s)	22.9	20.3
HCl emission rate (g/s)	11.5	10.2
SO_2 emission rate (g/s)	229.2	203.4
Amine 1 emission rate (g/s)	-	0.3
Amine 2 emission rate (g/s)	-	0.2

(1) – Units 1 & 2 with CCS and Units 3 & 4 without CCS. One flue will serve the units with CCS and second flue will serve the units without CCS

7.14.4 Amine Chemistry Modelling

For the assessment of amines and nitrosamines from the PCC activity, the ADMS Amine Chemistry Module (CERC, 2016) has been utilised to model the chemical reactions associated with the formation of nitrosamines and nitramines in the atmosphere. Reaction rate coefficients specific to the amines associated with the proprietary amine solvent proposed for use in the PCC process have been provided by the PCC technology supplier for use in the atmospheric dispersion modelling.

Given that the specified reactivity data for the proprietary amine and nitrosamine compounds remain confidential, additional model sensitivity testing has been completed based on applying amine reaction rate coefficients equivalent to primary amine and nitrosamine compounds, for which published data in the public domain are available. KS21™ is in the process of being REACh registered and as such is undergoing various assessments as requirement by this Regulation in relation to human health and environmental consequence of use of the substance. This data has been used to review and develop EAL for potential emission releases. This review has identified that the secondary amine potentially has a greater risk to human health than that posed by MEA and therefore requires a lower EAL. This secondary amine EAL has been used to assess the potential impacts related to the release of both emissions amines associated with KS21™. This review also found the NDMA is the best and most suitable substance assessing the nitrosamines against.

The proxy compound for ‘Amine 1’ is MEA and the proxy for ‘Amine 2’ is dimethylamine (DMA), which is a precursor to the formation of NDMA. NDMA has also been used as a proxy for directly emitted nitrosamines (i.e., ‘Nitrosamine 1’ and ‘Nitrosamine 2’).

The use of MEA as a proxy compound supports the use of provided rate coefficients which are suitable in relation to the air quality modelling and associated sensitivity analysis and comparison to the secondary amine EAL. The use of DMA ensures that any predicted atmospheric formation of nitrosamine, in addition to directly emitted nitrosamines, will be as NDMA, which also allows for direct comparison with the Agency’s EAL for NDMA (see **Table 12**).

The MEA and NDMA reaction rate coefficients applied in the amine sensitivity testing have covered low, mid, and high range values based on literature research for these compounds. The equivalent reaction rate coefficients for the amine compounds fall within the tested range of values applicable to MEA and DMA, thereby addressing uncertainty in key parameters used in modelling amine chemistry within ADMS. Furthermore, the dispersion modelling results for amines and nitrosamines reported in this Chapter have incorporated a number of conservative assumptions, as summarised in Section7.14.5.

See Appendix B Modelling of amine compounds. for further details on the atmospheric dispersion model input parameters, assumptions and limitations, post-processing of model outputs and associated sensitivity testing that has been completed.

7.14.5 Cumulative Impacts

The following projects have been identified for inclusion in the operation phase cumulative impacts assessment, for which development has been approved or approval is being sought:

- **Eggborough Combined Cycle Gas Turbine (CCGT) Power Station**, proposed opening year of 2022 (*not operational at time of writing*);
- **Keadby 2 CCGT Power Station**, proposed opening year of 2022 (*not operational at time of writing*);
- **Keadby 3 CCGT with Carbon Capture Power Station**, proposed opening year of 2026;
- **Energy from Waste (EfW) Plant, Kirk Sandall**, proposed opening year not known.

The equivalent point sources of emissions from each of the above projects were modelled using ADMS v5.2 as part of the assessment. The associated stack emissions parameters are presented in **Table 15**, with data obtained from the respective air quality assessment reports/ES chapters published with each of the above development applications.

The emissions from each source were modelled for each hour of the year (8,760 hours), thus providing a worst-case assessment of long-term (annual mean) impacts. Given the extremely low likelihood of peak operating conditions coinciding across all different emissions sources at any given time, assessment of cumulative short-term air quality impacts (e.g. hourly, daily) has not been undertaken.

Table 15 - Flue Emissions Parameters for Other Projects included in Cumulative Impacts Dispersion Modelling

Parameter	Eggborough		Keadby 2	Keadby 3	Kirk Sandall
	CCGT (per unit)	Peaking plant (1) (per unit)	HRSG (2) stack	CCP (3) Absorber Stack	EfW Plant Stack
No. Units	3	10	1	1	1
No. flues	3	10	1	1	1

Stack location X, Y (m)	457600, 423934	457520, 423950	482670, 411606	481820, 412158	460707, 407179
Stack height (m agl)	90	45	75	105	95
Flue diameter (m)	8.1	1.2	8.0	6.8	2.6
Effective stack diameter (m agl)	17.2 (4)	8.5 (4)	8.0	6.8	2.6
Discharge Temp (°C)	75	355	74.1	60	135
Vol. flow (Am^3/s)	3600 (5)	305 (5)	1030	856.4	81.2
Exit velocity (m/s)	15.5 (5)	5.4 (5)	20.5	24.3	15.0
NO_x emission rate (g/s)	172.5 (5)	17.9 (5)	39.5	32.4	8.1
NH_3 emission rate (g/s)	-	-	4.4	1.1	0.7
$PM_{10}/PM_{2.5}$ emission rate (g/s)	-	-	-	-	0.3

Sources:

Eggborough – Data taken from Table 8.10 based on worst-case modelled scenario described in paragraph 8.6.17 and Table 8.9 of Chapter 8 – Air Quality, ES Volume 1 (Eggborough Power Ltd, 2017)

Keadby 2 and Keadby 3 – Data for both sources taken from Table 2 and Table 3 of Appendix 8B: Air Quality – Operational Phase, Keadby 3 ES Volume 2 (Keadby Generation Ltd, May 2021)

EfW Kirk Sandall – Data taken from Table 20 and Table 21 of the Air Quality Assessment Report published with the planning application (BH EnergyGap (Doncaster) Limited, June 2020)

Notes:

(1) Reciprocating gas engines
(2) Heat Recovery Steam Generator
(3) Carbon Capture Plant
(4) Effective stack diameter combines all flues for the respective source
(5) Values based on all units for the respective source

The Keadby 3 air quality assessment included amines chemistry modelling (Keadby Generation Ltd, May 2021) which was based on sensitivity testing of a range of reaction parameters for proxy amine compounds, with results treated as MEA and NDMA for comparison with the relevant EALs. Given the complexity and uncertainty in the amine chemistry methodology, conservatism applied to both the PCC modelling and Keadby 3 modelling (Keadby Generation Ltd, May 2021), and specifically the use of proxy compounds where the precise chemical make-up of the proprietary amine solvent is unknown or cannot be disclosed[i], it was not considered appropriate to undertake modelling of cumulative impacts associated with amine compounds.

Instead, for the purposes of providing a qualitative judgement on potential cumulative impacts, a conservative approach was taken whereby the maximum predicted amine (MEA) and nitrosamine (NDMA) concentrations from both the PCC and Keadby 3 assessments were summed and compared to the respective EALs (refer to Section 7.14.10).

7.14.6 Model Outputs

The processed model outputs comprise concentration data for each pollutant and the respective short term (e.g. hourly, daily) and long term (annual) averaging periods at each modelled discrete and gridded receptor location (see Section 7.14.8.2). These outputs were provided for each of the modelled five years (2016-2020 inclusive), thereby allowing the maximum value at each receptor to be reported over this period. The relevant averaging periods specific to each assessed pollutant are provided in **Table 12**.

The model output concentrations for all pollutants, except PM_{10} and $PM_{2.5}$, have been used in the assessment of nutrient nitrogen deposition and acid deposition at identified sensitive habitats (see Section 7.14.8.2), which has adhered to EA guidance (Environment Agency, 2014). For nitrogen-containing pollutants not included within this guidance (i.e. amines, nitrosamines, nitramines), a deposition velocity equivalent to that for ammonia has been used which, based on relevant research (Matthias Karl, 2009), is considered to be conservative (see Appendix B).

Background pollution and nitrogen/acid deposition levels for each relevant compound, where available, have been obtained from national mapping data provided by Defra (Defra, 2022) and APIS (UK Centre for Ecology & Hydrology, 2021) for human and ecological receptors respectively. These are reported in Section 7.14.8.1.5below.

The quantified impacts associated with the PC (i.e. the pollutant concentration/deposition resulting from the Baseline scenario and the With PCC scenario, respectively) and the Predicted Environmental Concentration (PEC) (i.e. the PC plus background concentration/deposition for each scenario) have been assessed in relation to the following standards:

- Statutory ambient air quality standards for both human and ecological receptors (see **Table 12**);
- Non-statutory EALs set by the EA (see **Table 12**);
- Non-statutory critical levels and critical loads for ecological receptors, taken from the APIS website (UK Centre for Ecology & Hydrology, 2021) .

This assessment has accounted for the PC and Predicted Environmental Concentration (PEC) relating to the With PCC scenario in isolation and cumulatively with other projects. The PC impact of the With PCC scenario represents the change in concentration/deposition between the Baseline scenario and the With PCC scenario. For the assessment of cumulative impacts, the PC from the With PCC scenario is added to relevant PCs from the qualifying developments identified.

The assessment of potential effects has taken into account the approach provided in the EPUK/IAQM guidance (EPUK & IAQM, 2017), which assists in describing the air quality effects of emissions, in line with best practice for assessing air quality effects relating to planning applications. In addition, EA guidance and IAQM guidance is referenced with respect to establishing the potential for significant effects on the assessed sensitive ecological receptors.

7.14.7 Potential effects on Human Receptors

For long term (annual mean) pollutant concentrations, the EPUK/IAQM guidance recommends that the degree of an impact is described by expressing the magnitude of incremental change in pollution concentration as a proportion of the relevant air quality assessment level (AQAL). This change is then examined in the context of the new total concentration and its relationship with the assessment criterion. This is summarised in **Table 16**.

Table 16 - Air Quality Impact Descriptors Relating to Individual Receptors (Human)

Long term average concentration at receptors in assessment year	**% Change in concentration relative to AQAL**			
	1	2-5	6-10	>10
75% or less of AQAL	Negligible	Negligible	Slight	Moderate
76 – 94% AQAL	Negligible	Slight	Moderate	Moderate
95 – 102 of AQAL	Slight	Moderate	Moderate	Substantial
103 – 109 % of AQAL	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Moderate	Substantial	Substantial	Substantial

Notes:

AQAL = Air Quality Assessment Level, which for this assessment relates to the UK Air Quality Strategy objectives and non-statutory EALs for human health as presented in Table 6.1.

Where the %change in concentrations is <0.5%, the change is described as 'Negligible' regardless of the concentration.

When defining the concentration as a percentage of the AQAL, 'without scheme' (Baseline) concentration should be used where there is a decrease in pollutant concentration and the 'with scheme' (PCC) concentration where there is an increase.

Where concentrations increase, the impact is described as adverse, and where it decreases as beneficial.

The EPUK/IAQM impact descriptors (**Table 16**) are used as the starting point to make a judgement on significance of effects, since other impacts/effects may be important. The EPUK/IAQM guidance states that the assessment of overall significance should be based on professional judgement, considering several factors, including:

- The existing and future air quality in the absence of the development.
- The extent of current and future population exposure to the impacts; and
- The influence and validity of any assumptions adopted when undertaking the prediction of impacts.

The EPUK/IAQM guidance states that for most road transport related emissions, long-term average concentrations are the most useful for evaluating the severity of impacts. For short term (sub-hourly, hourly and daily averages) pollutant concentrations from sources such as the PCC ('point' sources), the EPUK/IAQM guidance recommends that the impact is described with reference to the magnitude of the impact from the process without consideration of the background concentrations. This assumes that the background concentrations will be smaller than the peak concentrations caused by a substantial plume. Where the impact is ≤10% of an AQAL, it is negligible; impacts in the range 11-20% are slight, 21-50% are moderate and those ≥51% are substantial.

As a precautionary approach, both long-term and short-term average concentrations have been considered with respect to judging likely significant effects as part of this assessment.

For the purposes of assessing cumulative impacts associated with the New Activity and other projects (as per Section 7.14.5), all named 'other projects' are treated as committed developments. As such, the contributions of these committed developments have been added to the Baseline scenario when assessing impacts at human receptors within the operational phase study area. This approach aligns with EPUK/IAQM guidance.

7.14.8 Potential Effects on Ecological Receptors

Following EA guidance (Environment Agency, 2021), if the change in PC derived from the 'With PCC scenario' meets both of the following criteria, impacts are considered to be insignificant and further assessment is not required:

- the short-term PC is less than 10% of the short-term environmental standard for the ecological receptor; and
- the long-term PC is less than 1% of the long-term environmental standard for the ecological.

If the above criteria are not met, additional criteria are applied as follows:

- If the short-term PC exceeds the above screening criteria, significant effects cannot be screened out and further assessment is needed; and
- If the long-term PC is greater than 1% and the PEC is less than 70% of the long-term environmental standard, the emissions are insignificant, and no further assessment is required; or
- If the PEC is greater than 70% of the long-term environmental standard, significant effects cannot be screened out and further assessment is needed.

Where it is determined that the impact of the With PCC scenario 'alone' is sufficiently large that significant effects cannot be screened out, based on the above criteria, the results of the air quality assessment will be passed to the PCC ecologist to use their expertise in determining whether or not there is, in fact, a likely significant effect. This approach aligns with IAQM guidance (IAQM, 2019).

The above criteria are also applied to the assessment of cumulative impacts (i.e. those arising as a result of the with PCC scenario with other relevant projects). Unlike the assessment of cumulative impacts at human receptors where all contributions from 'other projects' are treated as committed and part of the 'future baseline', the same projects in the ecological receptor modelling are treated as 'in-combination' for the purposes of assessing cumulative impacts. This means that contributions from the 'other projects' are added to the PCC impacts only, with no contributions from these projects being included in the Baseline scenario.

The following baseline data sources have been used in the preparation of this section:

- National pollutant concentration mapping for NO_x and particulate matter, available from the Defra website (Defra, 2022);
- National pollutant concentration data for ammonia and sulphur dioxide, and deposition mapping for nitrogen and acid, available from the Air Pollution Information System (APIS) (UK Centre for Ecology & Hydrology, 2021);
- The most recent Local Air Quality Management reporting (2020 and 2021) from Local Authorities including Selby District Council, Doncaster Council, East Riding of Yorkshire Council, North Lincolnshire District Council and Wakefield District Council, including

2019 air quality monitoring from these authorities (pre-COVID travel restrictions), where applicable;

- UK's national monitoring networks, managed by the EA on behalf of Defra and the Devolved Administrations, with data available from Defra's UK Air Information Resource website (Defra UK AIR, 2022); and

The following guidance documents and data sources have been used during the preparation of this Section:

- Local Air Quality Management Review and Assessment Technical Guidance (Defra, 2018)
- Guidance on the Assessment of Dust from Demolition and Construction (IAQM, 2016)
- Land-use Planning & Development Control: Planning for Air Quality (EPUK & IAQM, 2017)
- Guidance on the assessment of air quality impacts on designated nature conservation sites (IAQM, 2019)
- Air Pollution Information Service website (UK Centre for Ecology & Hydrology, 2021)
- Environment Agency: Risk assessments for specific activities, Environmental permits (Environment Agency, 2021)
- Selby Air Quality: Planning Guidance Note (Selby District Council, 2014)
- AQMAU recommendations for the assessment and regulation of impacts to air quality from amine-based post-combustion Carbon Capture plants (Environment Agency, 2021)
- CERC (2016) ADMS 5 Amine Chemistry User Guide Supplement (CERC, 2016)
- AQTAG06 Technical guidance on detailed modelled approach for an appropriate assessment for emissions to air (Environment Agency, 2014)

7.14.8.1 Assessment Assumptions and Limitations

This section outlines the limitations, uncertainties, and assumptions that apply to the air quality assessment.

7.14.8.1.1 Baseline Conditions

a) The baseline information that has been collated and used in the assessment has been based on the most up to date information currently available. Where Defra background mapped pollutant-data were not available for the operational phase study area, specifically for SO_2, HCl, and NH_3, ambient monitored data were obtained from suitable monitoring sites, operated by Defra (Defra UK AIR, 2022), for use in the assessment of impacts at human receptors.

b) The assessment of impacts at the identified human and ecological receptors has assumed that there will be no improvement in baseline levels of pollutant concentrations and deposition rates by the proposed opening year (2027), which is a conservative approach as detailed in Section 7.14.8.1.6, 'Future Baseline.'.

c) No additional, project-specific, air quality surveys have been undertaken to inform the assessment given the availability of existing data holdings as outlined above.

d) There are currently no data relating to ambient levels of amines and nitrosamines within the UK, a position acknowledged by the EA (Environment Agency, 2021), with the Scottish Environment Protection Agency's review of amine emissions from Carbon Capture stating that further work is required to develop a reliable method(s) for measurement (Scottish

Environment Protection Agency, 2015). Although the absence of background data for these compounds represents a limitation to the assessment of operational phase impacts at human receptors, there are no known sources of amine and/or nitrosamine emissions currently operating within the operational phase study area.

7.14.8.1.2 Operational Conditions

The operational phase air quality assessment has, where possible, adopted a conservative approach by applying the following assumptions to the atmospheric dispersion modelling study:

a) In the core mode scenarios, the non-PCC Biomass Units at Drax Power Station are assumed to operate at full load for up to 4,000 hours per annum (i.e., a 'mid-merit' operating regime), representing a robust and realistic projection for future baseline operation. The PCC units are assumed to operate continuously at baseload for all hours of the year. However, further sensitivity model scenarios have been completed, as reported in Appendix B Modelling of amine compounds., whereby the non-BECCS units also operate continuously at baseload for all hours of the year. This provides an assessment of the 'worst case' emissions profile from the PCC;

b) Emissions of pollutants from the Main Stack that are subject to ELVs/BAT-AELs were modelled at the associated emission limit with all operational 'dust' emissions assumed to be in the $PM_{2.5}$ size fraction for particulate matter and therefore included, in total, in both the assessment of PM_{10} and $PM_{2.5}$. All reported modelled concentrations for short-term averaging periods (daily, hourly, sub-hourly) are based on the respective daily average BAT-AELs for each relevant pollutant (see Appendix B Modelling of amine compounds.);

c) Mass emissions of amines ('Amine 1' and 'Amine 2') in the With PCC scenario were modelled at proposed annual and daily average ELVs for all hours of the year (see **Table 13**. These proposed ELVs represent emission concentrations that are higher than the reasonable worst-case design emissions given for each amine compound from the technology supplier (MHI).

d) Mass emissions of nitrosamines ('Nitrosamine 1' and 'Nitrosamine 2') in the With PCC scenario were modelled based on nominal emission concentrations at baseload operation, as provided by MHI, and represent reasonable worst-case direct emissions. As evidenced in Appendix C, the PC to ground level concentrations of direct nitrosamine emissions is insignificant (<0.1% of the EAL for NDMA). Given the negligible emissions under baseload operation and the associated insignificant impacts, there is no requirement to propose an annual average ELV for direct nitrosamine emissions.

e) A 70% conversion ratio of NO_x to NO_2 in the atmosphere was assumed, based on EA guidance (Environment Agency, 2006);

f) Deposition of amines, nitrosamines, and nitramines from the atmosphere were modelled using a deposition velocity equivalent to that for ammonia (see Appendix B Modelling of amine compounds. for details), which based on relevant research (Karl, 2009), is considered to be conservative.

g) The significance screening of maximum impacts at each designated site was undertaken against minimum recommended critical levels/critical loads, unless otherwise informed by the project ecologist (see **Table 18**);

h) Assessment of maximum impacts for both human and ecological receptors has been undertaken across five years of hourly meteorological data; and

i) In the assessment of cumulative emissions sources, emissions from each source were modelled for each hour of the year, thus providing a worst-case assessment of potential short (sub-hourly, hourly, daily) and long-term (annual) cumulative impacts.

7.14.8.1.3 Amine Chemistry Modelling

In addition to the above, all amine concentration outputs from the core dispersion model scenarios, which are based on the proprietary amine solvent proposed for use in the PCC process, have been treated as MEA for comparison with other projects and are suitable in comparison to the derived EAL. The modelled maximum hourly mean and daily mean amine (as MEA) concentrations have been derived based on the sum of 'Amine 1' and 'Amine 2' maximum ground level concentrations at each receptor and grid point. This approach is potentially conservative because the 'Amine 1' maximum concentration might occur at a different time (day or hour) to the corresponding 'Amine 2' concentration.

Furthermore, the sum of all nitrosamine and nitramine concentration outputs have been treated as NDMA for comparison with the relevant EAL. This is conservative given that NDMA is considered to be one of the most toxic nitrosamines that has been tested, with nitramines being considered notably less toxic based on preliminary toxicity studies (Gjernes, 2013).

Due to the proprietary nature and limited availability data in general for amine solvents, it is not possible to present the equivalent toxicity data relating to the assessed amine and nitrosamine compounds, thus representing a limitation to the assessment. However, further sensitivity testing of the amine chemistry modelling has been undertaken to address and reduce uncertainty, as detailed in Appendix B Modelling of amine compounds. and below.

There are a number of input variables that are required to model atmospheric amine chemistry using the ADMS model. The modelling undertaken has utilised specific reaction rate coefficients for the relevant amine compounds, as provided by MHI for the proprietary amine solvent, along with appropriate regional ambient concentration data for NO_2 and ozone over a five-year period, and published background hydroxyl radical data for the UK. However, as acknowledged by the EA there is inherent uncertainty in the amines modelling process, meaning further sensitivity testing of the aforementioned variables was needed as part of the ES.

The sensitivity testing relating to amine chemistry (see Appendix B Modelling of amine compounds.) comprises extensive testing of a range of published reaction rate coefficients relevant to MEA, DMA and NDMA, acting as proxy compounds to 'Amine 1', 'Amine 2' and 'Nitrosamine 1 and 2', respectively. The equivalent reaction rate coefficients for the confidential amine compounds fall within, or are of the same order of magnitude as, the tested range of values applicable to MEA and DMA, therefore reducing the uncertainty in how the proprietary solvent compounds might behave in the atmosphere relative to MEA and DMA. The use of MEA and DMA (NDMA) as proxy compounds has allowed for a direct assessment against the EA's health based EALs for MEA and NDMA.

7.14.8.1.4 Areas to be considered

The areas to be considered for air quality extend 15 km in all directions from the Main Stack located at Drax Power Station. The Main Stack currently releases emissions associated with the existing four biomass units and two coal units. The operation of the two current coal units will have paused subject to engineering assessment, with the other four continuing to release emissions associated with two biomass units without PCC and two units with PCC as part of the variation. The extent of the study area aligns with EA guidance (Environment Agency, 2021) for larger emitters (i.e. over 50 MW output)

7.14.8.1.5 Baseline Conditions

The PCC is located in an area where air quality is influenced by emissions from the Drax Power Station, emissions from traffic on the local road network including the M62 motorway, other major power plants including Ferrybridge waste to energy plant (located approximately 18 km to the west), and agricultural practices within the operational phase study area. Whilst air quality is influenced by these local sources, local pollutant concentrations will approach background levels throughout the operational phase study area.

According to the latest Air Quality Annual Status Report (ASR) from SDC (Selby District Council, 2021), based on annual mean 2020 monitoring results, the respective air quality objectives (see **Table 12**) were met throughout the District, including the annual mean NO_2 objective within the existing Air Quality Management Areas (AQMA) along New Street in Selby Town. However, compliance with the NO_2 objective within the AQMA in 2020 was likely to be a consequence of travel restrictions imposed due to the Covid-19 pandemic. As such, SDC has not proposed to amend the size of existing AQMA at this time. The PCC lies approximately 6 km to the southeast of the AQMA. SDC does not monitor air quality in the vicinity of the site.

SDC published an Air Quality Action Plan (AQAP) in 2018 (Selby District Council, 2018) to address air quality issues within its area of jurisdiction. The AQAP identifies the measures intended to result in the '…greatest and most immediate improvements…' in Selby's air quality. The main actions of the AQAP under which measures are set, place an emphasis on reducing emissions from road transport, such as alternatives to private vehicle use; freight and delivery management; promoting low emission transport; traffic management; and transport planning and infrastructure.

The operational phase study area also encompasses parts of neighbouring Council areas, namely Doncaster, Wakefield, East Riding of Yorkshire, and North Lincolnshire. A summary of the latest ASR from each of these Councils is provided below:

According to the 2021 ASR published by Doncaster Council (Doncaster Council, 2021), there are currently seven AQMAs designated due to exceedances of the annual mean NO_2 objective, all of which relate to traffic emissions. None of these AQMAs are located within the operational phase study area. However, monitoring within Thorne, located in the southeast of the study area, recorded an annual mean NO_2 concentration (38 µg/m3) close to the objective (40 µg/m3) in 2019 (before the introduction of COVID-19 restrictions). Again, elevated levels of NO_2 in this area are attributed to traffic emissions.

The 2020 ASR published by Wakefield Council (Wakefield Council, 2020) reports the presence of ten AQMAs designated due to exceedances of the annual mean NO_2 objective, all of which relate to local road traffic emissions. None of these AQMAs are located within the operational phase study area. Wakefield Council does not undertake any monitoring within the study area.

The 2021 ASR published by East Riding of Yorkshire Council (East Riding of Yorkshire Council, 2021) confirms that there are no AQMAs designated within East Riding, with air quality reported to be good. The Council does undertake monitoring of NO_2 at some locations within the operational phase study area, such as in Goole, Snaith, and Rawcliffe, but 2019 monitoring (pre-COVID-19 restrictions) shows that annual mean NO_2 concentrations remained below the respective air quality objective at all locations.

The 2020 ASR published by North Lincolnshire Council (North Lincolnshire Council, 2020) confirms that monitoring is ongoing within the Scunthorpe AQMA, which was designated due to exceedances of the 24-hour PM_{10} objective, attributed to the integrated iron and steel works within Scunthorpe. This AQMA is not located within the study area and North Lincolnshire does not undertake any monitoring within the study area.

Background pollutant concentrations are available from the national maps provided on the Defra website (Defra, 2022), where background concentrations of those pollutants included within the Air Quality Strategy (see Section 7.14.8.1.5) have been mapped at a grid resolution of 1x1 km for the whole of the UK. Projected concentrations are available for all years between 2018 and 2030.

Given the low population density, absence of urban centres, and prevalence of agricultural land within the area surrounding the Order Limits, existing air quality within the context of Air Quality Strategy statutory objectives can be characterised based on background air pollution data published by Defra. As such, no site-specific air quality monitoring was undertaken.

The background mapped concentrations for NO_x, NO_2, and PM_{10} and other pollutants are summarised in **Table 17** for a base year of 2021, which account for the contribution of existing industrial processes in the vicinity of the PCC, including the Drax Power Station itself. The data, therefore, are conservative for use as background concentrations for the assessment of impacts on human health, given that the operational phase assessment will effectively result in 'double-counting' of background contributions from the Site.

The background concentrations for each pollutant are modelled to be demonstrably below the respective air quality standards in 2021.

Table 17 - Defra Background Annual Mean Pollutant Concentrations Based on Study Area for 2021 Baseline Year

Statistic	**2021 annual mean background ($\mu g/m^3$)**						
	NO_x	NO_2	SO_2(1)	PM_{10}	$PM_{2.5}$(2)	HCl(3)	NH_3(3)
Minimum	7.0	5.5	-	11.0	6.7	-	-
Maximum	18.2	13.5	20.5	17.6	10.6	2.4	1.6
Average	9.6	7.5	1.8	14.1	7.8	1.3	0.8
Air Quality Standard / EAL	30	40	350	40	25	750	180

Notes:

(1) In the absence of Defra background data for 2021, data based on 2018 hourly monitored data at Defra's AURN site at Hull Freetown has been used. Maximum value corresponds to maximum hourly observation. Compared to 1-hour mean Objective. Year 2018 chosen based on comparison of data from years 2017-2020 inclusive, with 2018 representing year with highest maximum hourly concentration.

(2) Emissions of $PM_{2.5}$ and PM_{10} are included in assessment at the same emission rate, based on the ELV for 'dust'.

(3) Based on maximum monthly measured data in 2020 at Defra's UK eutrophying and acidifying network (UKEAP) monitoring site at Ladybower, Peak District (EAL for HCL based on hourly limit, EAL for NH_3 based on annual mean). Monitored values were shown to

be comparable to equivalent data available for earlier years (2017-2019 inclusive), indicating no discernible impact of the Covid-19 pandemic on data from this monitoring station.

Background annual mean concentrations of NO_x, SO_2, and NH_3 at ecological receptors (**Table 18**), in addition to annual mean acid and nitrogen (N) deposition rates, were taken from the APIS website (UK Centre for Ecology & Hydrology, 2021) and are based on a three year mean (2017-2019), which represents the latest available data at the time of writing. A summary of the background concentrations and deposition levels at the identified ecological receptors, along with the respective critical levels (concentration) and critical loads (deposition), is presented in **Table 18.**

Both NO_X and SO_2 concentrations are within the relevant critical levels across all sites, noting that the maximum background levels for NO_x within the Humber Estuary SAC/SPA are reported by APIS (UK Centre for Ecology & Hydrology, 2021) to exceed the 30 µg/m^3 benchmark. However, there are no areas of exceedance within the portion of the Humber Estuary located inside the operational phase study area. The maximum background annual mean NO_x concentration applicable to the Humber Estuary SAC/SPA within the study area, as given by Defra background maps data (Defra, 2022), is 12.2 µg/m^3, which is well below the critical level.

Background NH_3 concentrations are more likely to exceed the critical level where lower plants (e.g. bryophytes and lichens, with a critical level of 1µg/m^3) are present, such as over Thorne Moore, Lower Derwent Valley and Skipwith Common designated sites, compared to where higher plants are present (i.e. plants having vascular tissues, with a critical level of 3 µg/m^3).

The relevant background nitrogen and acid deposition levels within the operational phase study area exceed the respective critical loads stated in **Table 18** for all identified designated sites with the exception of Eskamhorn Meadows SSSI (nitrogen and acid deposition) and Went Ings Meadows SSSI (acid deposition only).

Table 18 - Background Annual Mean Pollutant Concentrations and Deposition Levels at Ecological Receptors included in Assessment

Ecological Receptor	**NO_x ($\mu g/m^3$)**	**SO_2 ($\mu g/m^3$)**	**NH_3 ($\mu g/m^3$)**	**N Deposition (kgN/ha/yr)(1)**		**Acid Deposition (Keq/ha/yr)(2)**	
				Background	**Critical Load**	**Background**	**Critical Load**
Thorne Moor SAC	13.2	1.3	2.6	21.3	5	1.73	0.462
Thorne & Hatfield Moors SPA	13.2	1.3	2.6	21.3	10	*Species within broad habitat not sensitive to acid deposition* (3)	
Thorne, Crowle and Goole Moors SSSI	13.2	1.3	2.6	21.3	5	1.73	0.462
Lower Derwent Valley SAC	8.2 – 9.9	1.1 – 1.7	4.6	30.2	20	2.40	0.643
Lower Derwent Valley SPA					20	*No expected negative impact on species due to impacts on the species' broad habitat* (3)	
Lower Derwent Valley Ramsar					20		
River Derwent SAC	11.9	3.9	4.6	14.8	n/a	*No sensitive habitats* (3)	
Skipwith Common SAC	9.8	1.4	2.6	21.1	10	1.73	0.802

Ecological Receptor	**NO_x ($\mu g/m^3$)**	**SO_2 ($\mu g/m^3$)**	**NH_3 ($\mu g/m^3$)**	**N Deposition (kgN/ha/yr)(1)**		**Acid Deposition (Keq/ha/yr)(2)**	
				Background	**Critical Load**	**Background**	**Critical Load**
Skipwith Common SSSI					10		
Humber Estuary SAC	12.2	7.5	3.6	28.9	20	*No expected negative impact on species due to impacts on the species' broad habitat (SPA) (3)* *No sensitive habitats (SAC & SSSI) (3)*	
Humber Estuary SPA					20		
Humber Estuary SSSI					20		
Breighton Meadows SSSI	9.9	1.7	3.1	23.5	20	1.92	0.643
Eskamhorn Meadows SSSI	11.4	1.3	2.4	20.0	20	1.64	2.00
Derwent Ings SSSI	9.8	1.7	4.6	30.2	20	2.40	0.643
Barn Hill Meadows SSSI	12.9	1.8	2.3	20.4	20	1.69	0.633
Burr Closes SSSI	10.5	1.2	2.5	20.6	20	1.68	1.248

Ecological Receptor	NO$_x$ (µg/m^3)	SO$_2$ (µg/m^3)	NH$_3$ (µg/m^3)	N Deposition (kgN/ha/yr)(1)		Acid Deposition (Keq/ha/yr)(2)	
				Background	Critical Load	Background	Critical Load
Went Ings Meadows SSSI	12.1	1.3	2.4	19.4	15	1.59	2.008
Critical Level (µg/m^3)	30	20	1-3				

Notes:

(1) – Nitrogen (N) deposition presented as average mass deposition (kgN) per hectare (ha) per year (yr). Critical load represents the lower limit of the respective critical load range for the most sensitive feature within the designated site regardless of if it exists within the operational study area, which represents a precautionary approach with reference to IAQM guidance (IAQM, 2019). However, where applicable, an appropriate critical load and/or critical level has been provided by the PCC ecologist based on specialist knowledge of the relevant sensitive features located within the designated site inside the operational study area. This also aligns with IAQM guidance, which states that specialist knowledge can be applied to provide a critical load in place of the precautionary lower limit based on all sensitive features within the designated site.

(2) – Acidification caused by deposition of nitrogen (N) and sulphur (S) presented as kilo equivalents of H+ ions (keq) per hectare per year. Background and critical load values presented based on sum of N and S. Critical load represents the lower limit of the respective critical load range for the most sensitive feature within the designated site.

(3) – Applicable to all areas of respective designated sites within operational phase study area. See Appendix 5 (document reference 6.8.3.5) of the Habitats Regulations Assessment (HRA).

7.14.8.1.6 Operational PCC Modelling

It is expected that, should the PCC not proceed, the baseline local air quality conditions within the study area in relation to local air quality would likely remain unchanged or would slightly improve (i.e. ambient pollutant concentrations would reduce). Any improvement would be predominantly related to the expected reduction in vehicle emissions as older, more polluting vehicles are replaced by cleaner vehicles.

Table 19 presents future modelled pollutant concentrations in 2027 and 2029, which represent the respective opening years for Biomass Unit 2 and Unit 1 with PCC. These data demonstrate an expected improvement in pollutant concentrations compared to existing (2021) baseline concentrations as reported in **Table 17**.

The mapped reductions in pollutant concentrations have not been applied within the air quality assessment. Whilst this approach assumes no improvement in future baseline air quality, thereby providing a conservative assessment, it has limited material impact on the outcome of the assessment since both current and future pollutant concentrations are well within the air quality standards.

With respect to future baseline conditions at ecological receptors, IAQM (IAQM, 2019) guidance states that '…the air quality specialist may choose to assume no change in future baseline concentrations or deposition rates, where there is no evidence to indicate that they may decrease in value…'. The latest forecasts produced by the Joint Nature Conservation Council, under the Nitrogen Futures project (Joint Nature Conservation Council, October 2020), include multiple scenarios for future emissions including a 'Business As Usual' scenario, in which only policies that have already been adopted or implemented are considered. This was the most conservative scenario assessed and the conclusion was that total nitrogen deposition over the UK is expected to decrease by 13.6% between 2017 and 2030, with emissions of NO_x reducing by 34% over the same period, and emissions of NH_3 remaining near-unchanged (a 1% increase).

Although ambient levels of NO_x and rates of nitrogen deposition are expected to reduce throughout the study area, a conservative approach has been adopted for the assessment whereby no change in baseline conditions has been assumed for all ecological receptors.

Table 19 - Defra Background Annual Mean Pollutant Concentrations Based on Study Area for Future Baseline 2027 and 2029

Statistic	**NO_x (µg/m^3)**		**NO_2 (µg/m^3)**		**PM_{10} (µg/m^3)**		**$PM_{2.5}$ (µg/m^3)**	
	2027	2029	2027	2029	2027	2029	2027	2029
Minimum	6.0	5.9	4.8	4.7	10.6	10.6	6.4	6.4
Maximum	14.5	14.0	10.9	10.5	17.0	17.0	10.1	10.0
Average	8.1	7.9	6.4	6.2	13.6	13.6	7.4	7.4
AQ Standard	**30**		**40**		**40**		**25**	

7.14.8.2 Sensitive Receptors

The operational phase study area, encompassing 15 km in all directions from the Main Stack (see Section 7.14.8.1.4), is largely under agricultural use, sensitive human receptors are ubiquitous and the assessment of operational impacts assumes that the potential for exposure to impacts, at human receptors of high sensitivity, exists throughout the area and impacts on health will be assessed with reference to the maximum concentrations anywhere within the 30 km x 30 km study area.

As such and given the scale of the operational phase study area, it is not necessary to list all potential human receptors for air quality impacts. However, for illustrative purposes, properties representing sensitive human receptors have been included in proximity to the Order Limits, as per the DCO and further afield within the operational study area, including areas where the UK's Air Quality Strategy statutory objectives are being exceeded (e.g. Selby AQMA) or are close to exceeding (e.g. Thorne, Doncaster) and villages downwind of the Main Stack on the prevailing wind direction (south-westerly).

Human receptors in proximity to the Site will be largely unaffected by operational impacts. This is because, given the height of the Main Stack (259 m agl), the emitted pollutants will not mix down to ground level in the immediate vicinity of the PCC and impacts will be negligible. Rather, maximum ground level impacts will occur at distances over 7 km from the PCC.

The locations of the illustrative discrete receptors included in the assessment of operational phase impacts are summarised in **Table 20** and depicted in **Figure 2**. All receptors were modelled at 1.5 m agl to be representative of breathing height.

Figure 2 Modelled discrete human receptors

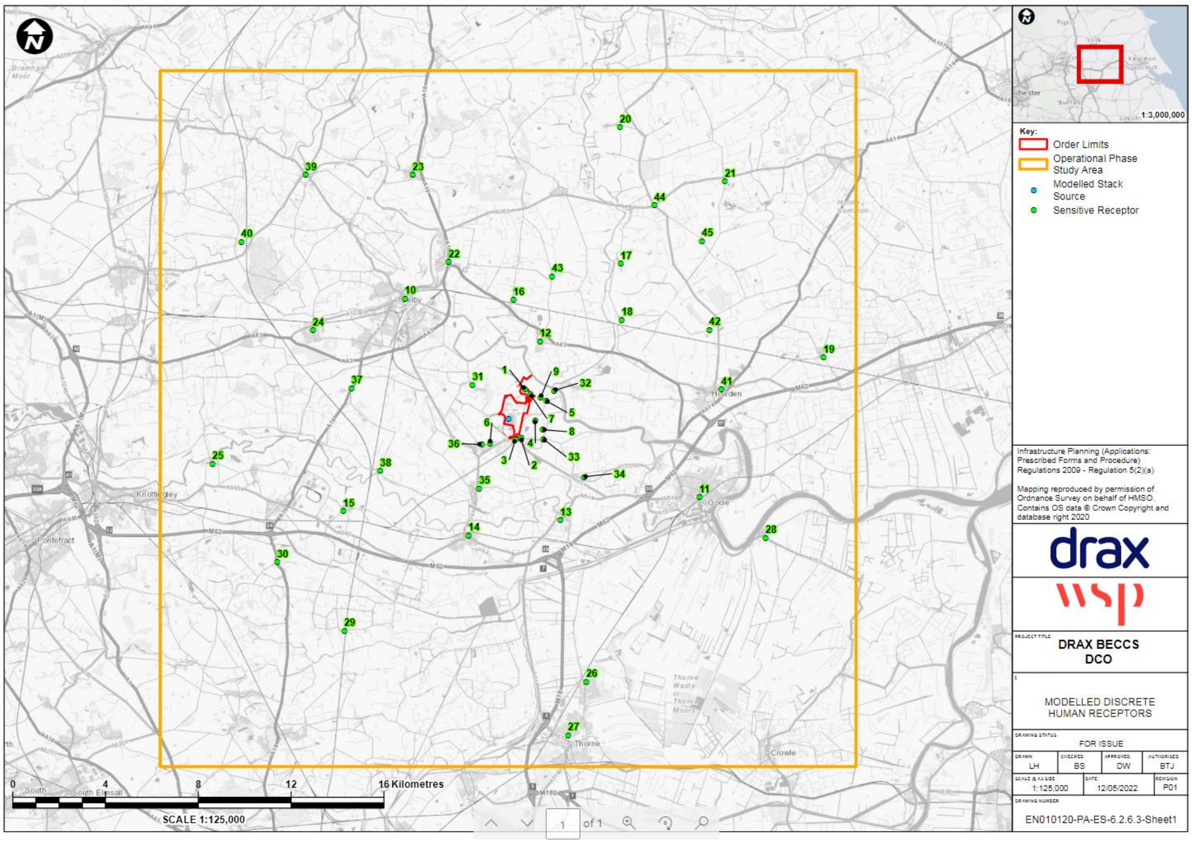


Table 20 - Discrete Sensitive Human Receptor Locations Included in Operational Phase Air Quality Assessment

Receptor ID	X, Y Grid Reference (m)	Location
1	466848, 428488	Foreman's Cottage
2	466681, 426392	East Yorkshire Caravan Salvage
3	466440, 426327	Drax Sport's and Social Club
4	467290, 427162	Wren Hall
5	467759, 428000	3 Pear Tree Ave
6	465346, 426160	Crange Cottages
7	467077, 428276	Drax Abbey Farm
8	467609, 426745	Read School
9	467524, 428124	Old Lodge
10	461665, 432401	Selby AQMA
11	474370, 423841	Goole
12	467492, 430550	Hemingbrough
13	468367, 422845	Rawcliffe
14	464405, 422188	Snaith
15	459008, 423234	Hensall
16	466349, 432349	Cliffe
17	470967, 433904	Breighton
18	471016, 431474	Wressle
19	479718, 429869	Eastrington
20	470943, 439787	Ellerton
21	475464, 437453	Foggathorpe
22	463554, 433977	Barlby
23	461998, 437720	Riccall

Receptor ID	X, Y Grid Reference (m)	Location
24	457696, 431036	Thorpe Willoughby
25	453369, 425275	Kellingley
26	469485, 415893	Moorends
27	468707, 413584	Thorne
28	477214, 422091	Swine Fleet
29	459057, 418081	Balne
30	456165, 421046	Whitley
31	464575, 428678	Barlow
32	468099, 428435	Long Drax
33	467637, 426345	Drax
34	469387, 424716	Newland
35	464866, 424206	Carlton
36	464976, 426107	Camblesforth
37	459362, 428539	Burn
38	460601, 424975	Temple Hirst
39	457380, 437726	Cawood
40	454617, 434848	Biggin
41	475309, 428488	Howden
42	474791, 431049	Brind
43	468012, 433355	South Duffield
44	472425, 436425	Highfield
45	474472, 434890	Willitoft

With reference to EA guidance (Environment Agency, 2021), the following ecological receptors were identified within the operational phase study area:

- SPAs, SACs, Ramsar Sites (protected wetlands) and SSSIs within a 15 km radius of the Main Stack.
- Local nature sites within 2 km of the Main Stack (National and Local Nature Reserves, Ancient Woodland).

The sensitive ecological receptors identified in **Table 21** meet these EA criteria within the operational study area and were modelled at 0.5 m agl at a resolution of between 100 m to 200 m to capture the maximum modelled impacts for the purposes of the ES.

In assessing potential air quality impacts at each of the identified sensitive ecological receptors (see Sections 7.14.8.3–7.14.10), the whole of the part of each designated site that is within the operational phase study area has been considered, thereby assuming that the relevant sensitive feature(s) could be present anywhere within the area of the Site that falls within the study area.

All key sensitive ecological receptor locations are shown on **Figure 3** below (Environmental Constraints).

Figure 3 - Environmental Constraints Plan

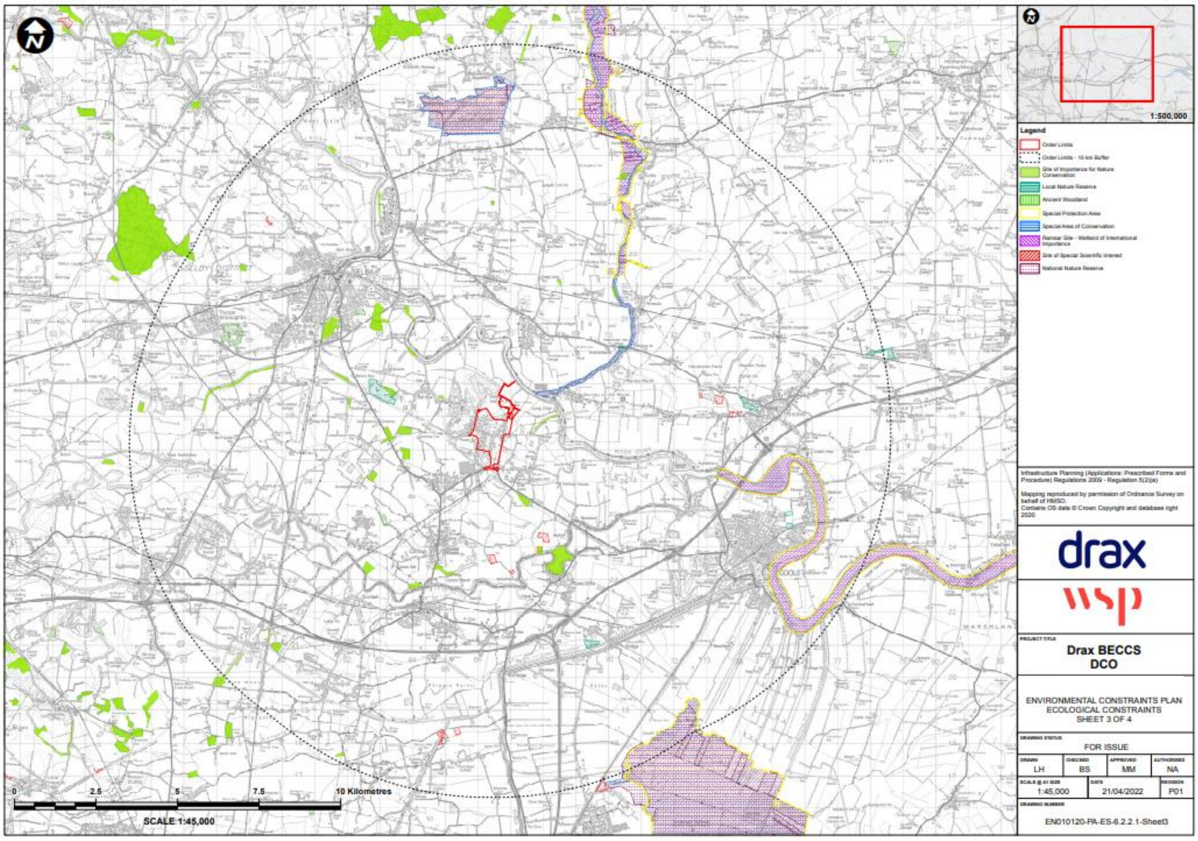


Table 21 Sensitive Ecological Receptor Locations Included in Operational Phase Air Quality Assessment

Site Name	Designation	Distance and Orientation from Main Stack (km)
River Derwent	SAC and SSSI	2.2 km northeast
Lower Derwent Valley	SAC, SPA, Ramsar, NNR (1)	6.4 km northeast
Humber Estuary	SAC, SPA, SSSI	7.2 km east
Skipwith Common	SAC and SSSI	9.4 km north
Thorne Moor	SAC	10.1 km southeast
Thorne and Hatfield Moors	SPA	10.1 km southeast
Thorne, Crowle and Goole Moors	SSSI	10.1 km southeast
Eskamhorn Meadows	SSSI	3.3 km south-southeast
Breighton Meadows	SSSI	6.4 km northeast

Site Name	Designation	Distance and Orientation from Main Stack (km)
Barn Hill Meadows	SSSI	6.8 km east
Derwent Ings	SSSI	8.6 km north-northeast
Went Ings Meadows	SSSI	8.8 km south
Burr Closes	SSSI	9.3 km northwest
Disused Railway Embankment	SINC (2)	0.6 km east
Brockholes	SINC	0.7 km southeast
Meadow East of Orchard Farm	SINC	1.2 km west
Cobble Croft Wood	SINC	1.4 km west
Common Plantation	SINC	1.4 km west
Hagg Green Lane	SINC	1.7 km north
Sand Pitt Wood and Barffs Close Plantation	SINC	1.9 km west
Barmby-on-the-Marsh	LWS (3)	1.3 km east
Barmby Pond	LWS	1.9 km northwest
Notes: **(1) Results reported for Lower Derwent Valley SAC in this Chapter are equally applicable to the Lower Derwent Valley National Nature Reserve (NNR)** **(2) Site of Importance for Nature Conservation (SINC)** **(3) Local Wildlife Site (LWS)**		

7.14.8.3 Assessment of Likely Impacts and Effects

The likely significant effects for air quality for the operational phase are set out below and focus on the results of core model scenarios (Baseline and With PCC, as detailed in Section 7.14.2).

The air quality impacts of the installation of PCC on a combustion unit are as follows:

a. Emissions of small quantities of amines and nitrosamines;
b. A potential decrease in emissions of all other pollutants (NO_X, SO_2, NH_3, HCl) due to a reduction in the volume of exhaust gas (without a change in emission limit); and
c. A reduction in the temperature of the exhaust gases due to heat extracted during the PCC process and subsequent reduction in plume buoyancy.

The combined impact of these changes results in a net low level of increase in ground level concentrations of the emitted pollutants and a net low level of increase in the deposition of nitrogen and acid to ecological receptors. These impacts are illustrated by the sensitivity test undertaken based on the worst-case emissions profile (as per Section 7.14.2), with the results set out in Appendix C Operational Air Quality Assessment Result Tables: Human Receptors. (human receptors) and Appendix D Operational Air Quality Assessment Result Tables: Ecological Receptors. (ecological receptors) which, in essence, directly compares the current, permitted operations against the proposed future permitted operations with PCC installed on the basis of the same operational load profile.

However, it should be noted that in the With PCC scenario, it is likely that the PCC equipped units would be brought into operation more frequently than non-PCC units; with such a load profile being within what is already consented at Drax Power Station. To fully reflect this possibility, the core modelled scenarios (as per Section 7.14.2) completed for this assessment have additionally considered the impact of that increased load profile.

The effect of the increased load for the PCC-enabled units increases the potential adverse impacts to receptors over and above those which result purely from the changed emissions characteristics. Therefore, to ensure a conservative assessment, the focus of the results presented in this section is the mid-merit scenario in which the likely future load profiles of the various combustion units on Site are appropriately represented as:

- Baseline: 4 x non-PCC units operating at baseload for 4,000 hours per year;
- With PCC: 2 x PCC units operating at baseload for 8,760 hours (all year) 2 x non-PCC units operating at baseload for 4,000 hours per year.

The core model scenario results, presented in this Chapter and in Appendices C and D, therefore represent the worst likely impacts, and reflect the combined effects of load profile change and PCC-driven emissions changes. The impacts of the installation of PCC alone, without a load change, are covered by the results of the worst-case emissions profile sensitivity test (Appendices C and D) and show lower impacts.

The results of the cumulative impact assessment are analysed in Section 7.14.10below.

7.14.8.4 Potential Effects on Human Receptors

Detailed atmospheric dispersion modelling has been undertaken to model the air quality impacts associated with the With PCC scenario at a number of discrete sensitive receptors and across a defined receptor grid (as outlined in Section 7.14.1).

The modelled grid maximum concentrations for each pollutant and relevant averaging period, based on modelling across five years of meteorological data (2016-2020), are presented in **Table 22**.

The results of the assessment at each discrete receptor and for each pollutant are presented in Tables C1 to C22 in Appendix C Operational Air Quality Assessment Result Tables: Human Receptors**.**. Pollutant contour plots, depicting the spatial distribution of modelled With PCC maximum impacts across the operational phase study area, are presented for NO_2, amine (as MEA), and nitrosamine (as NDMA) concentrations in **Figures 4 to 6** (below) inclusive for the respective averaging periods.

Figure 4 – Maximum impact on hourly mean Amine Concentrations (µg/m^3) with PCC; **Stack shown as red circle.**

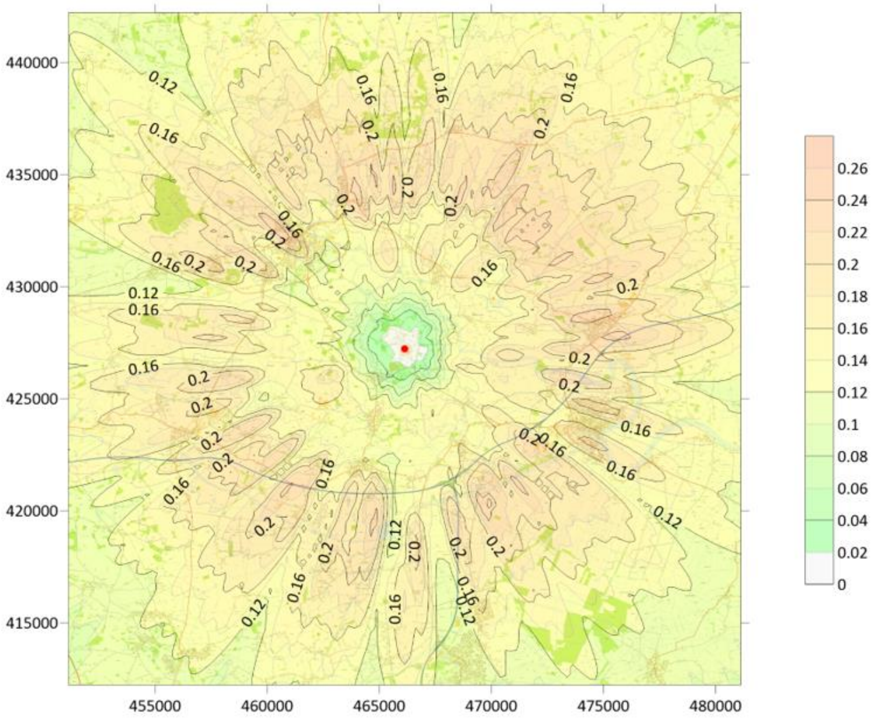


Figure 5 Maximum impact Daily Amine Concentrations (µg/m^3)

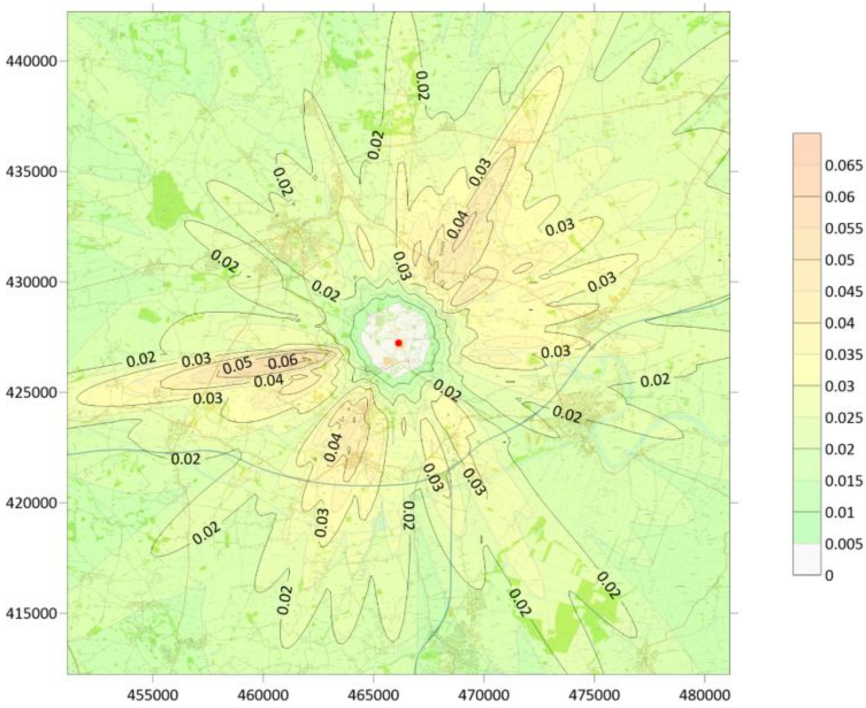


Figure 6 – Maximum impact Annual Mean Nitrosamine concentrations (ng/m^3)

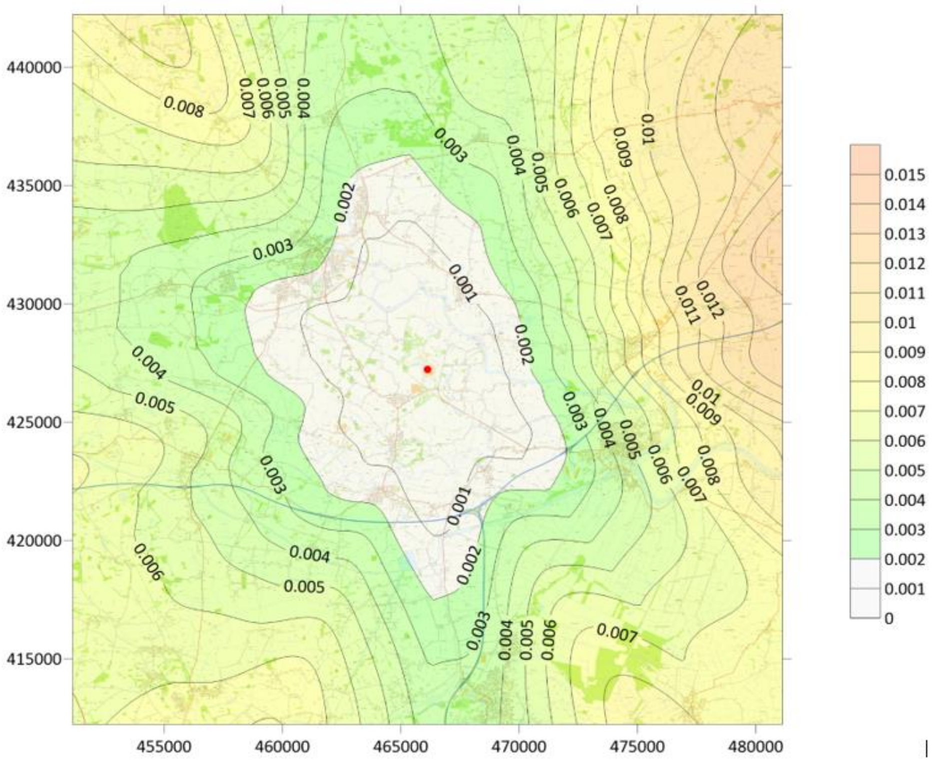


Figure 7 – Maximum impact PCC on Hourly Mean HCl Concentrations (µg/m3)

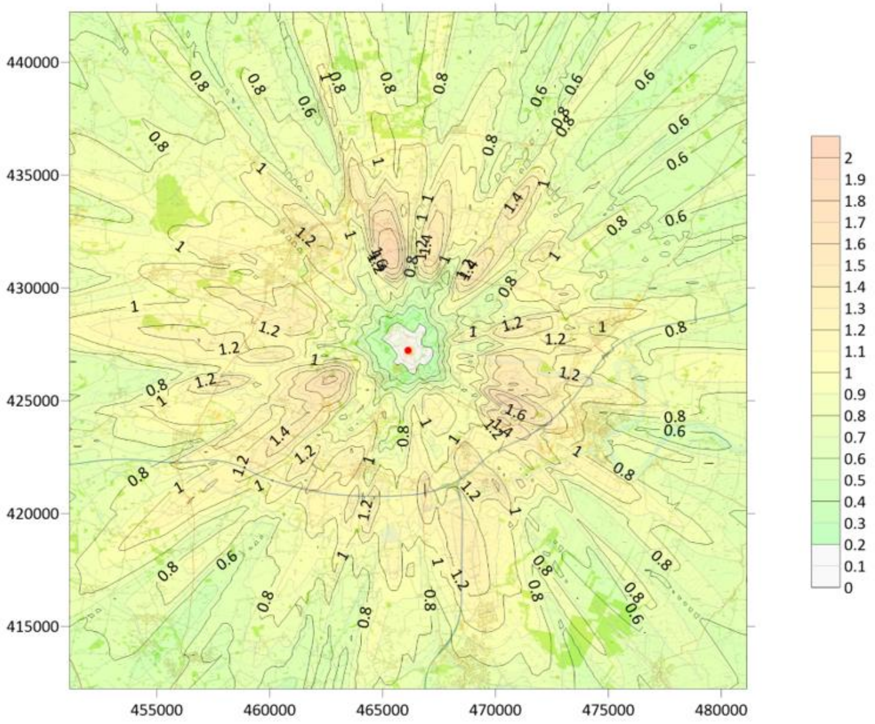


Figure 8 – Maximum impact of PCC on Hourly Mean Aldehyde Concentrations (µg/m^3).

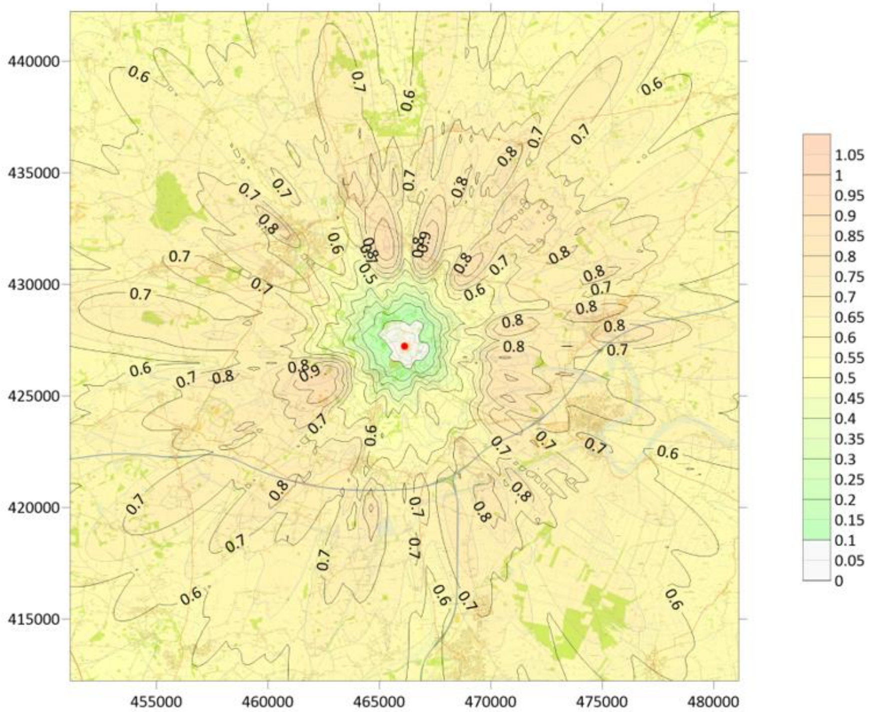


Figure 9 – Maximum impact of PCC on Annual Mean Aldehyde Concentrations (µg/m^3).

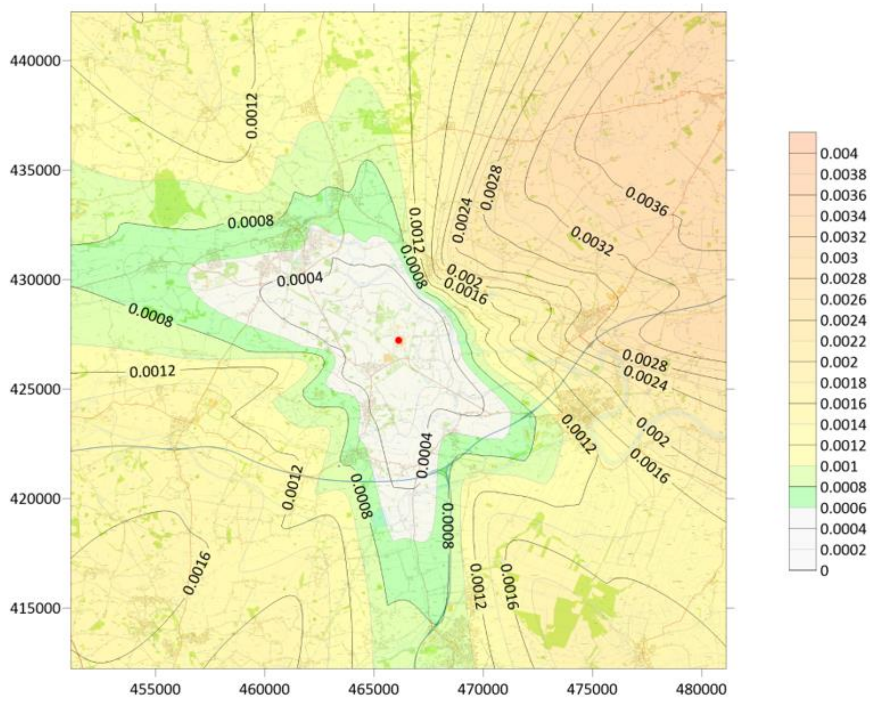


Table 22 - Modelled Maximum Pollutant Concentrations within Study Area presented as Percentage of Relevant AQALs

Pollutant	**Averaging Period**	**Maximum Concentration (µg/m^3)**			**Impact as % of AQAL**
		Baseline(1)	With Scheme(2)	Max Impact(3)	
NO_2	Annual	0.135	0.139	0.02	0.0
	Hourly	4.05	4.06	1.80	4.5
PM_{10}	Annual	0.012	0.012	0.002	0.0
	Daily (5)	0.079	0.076	0.035	0.1
$PM_{2.5}$	Annual				
SO_2 (5)	15-minute	26.81	25.23	10.03	3.8
	Hourly	10.96	10.83	5.36	
	Daily	3.2	3.48	1.33	
HCl	Hourly (5)	1.68	2.42	1.99	0.3
NH_3	Annual	0.012	0.012	0.002	0.0
	Hourly (5)	1.402	1.349	0.645	0.0
Aldehydes	Hourly		0.004	0.004	0.1
	Daily		0.97	0.97	1.1
Amine	Hourly (5)		0.258	0.258	0.5
	Daily (5)		0.063	0.63	0.5
NDMA	Annual		0.015	0.015	7.4

(1) Baseline scenario (mid-merit operating regime)

(2) With PCC scenario (2 x PCC Units at continuous baseload operation; 2 x non-PCC Units at mid-merit operating regime)

*(3) The maximum impact is the maximum difference between Baseline and With PCC **concentrations and** may not coincide with the specific geographic point at which the maximum value occurs in each modelled scenario.*

(4) The maximum PC in the 'With Scheme' scenario has decreased relative to 'Baseline'. However, because of the change in location of point of maximum impact between the two scenarios, some locations experience an increase in concentrations, and this is the maximum increase at any point within the study area.

(5) Results scaled (increased) according to corresponding daily average BAT-AEL / proposed permit daily average ELVs for amines.

The modelled impacts for all assessed pollutants are below 1% of the relevant AQALs, with the exception of the hourly mean NO_2, hourly mean SO_2, amine and annual mean nitrosamine (as NDMA), where the maximum modelled impacts equate to 4.5% (NO_2), 3.8% (SO_2), amines (0.5%) and 7.4% (NDMA) of the respective AQALs. For hourly mean NO_2 and SO_2, the maximum impact corresponds to a 'negligible' magnitude of change and for secondary amine and NDMA, the maximum impact corresponds to a 'slight adverse' magnitude of change within the context of the significance criteria presented in **Table 16**. For all other assessed pollutants and averaging periods, the maximum modelled impacts are classified as 'negligible' .

As such, emissions in the With PCC scenario will not result in significant air quality effects at human receptors.

7.14.8.4.1 Sensitivity Testing: Worst Case Emission Profile

The sensitivity testing completed and detailed in Appendix B Modelling of amine compounds. (technical approach) and Appendix C Operational Air Quality Assessment Result Tables: Human Receptors.(results in **Tables C13 to C20**), which considers the worst-case emissions profile for both the Baseline and With PCC scenarios (as per paragraph7.14.2), does not affect the outcome of the results reported above, such that emissions in the With PCC scenario would still not result in significant air quality effects at human receptors.

For instance, the maximum annual mean NO_2 PC in the Baseline scenario (0.14 µg/m^3) notably increases under a worst-case operating profile relative to the core modelling Baseline scenario (0.06 µg/m^3), with only a marginal increase in the With PCC scenario (0.15 µg/m^3) compared to the core modelling (0.13 µg/m^3). This is a function of all four biomass units in the Baseline scenario switching from 'mid-merit' operation (full load for 4,000 hours per year) to continuous operation (full load for 8,760 hours per year), resulting in more pollutants being emitted and thus more pronounced changes in annual mean concentrations relative to the With PCC scenario, where operation changes from 'mid-merit' to continuous full load at the two non-PCC biomass units only (PCC units already assumed to operate at continuous full load in core modelling scenario).

As a consequence, the maximum annual mean NO_2 impact in the PCC (0.03 µg/m^3) scenario decreases slightly under the worst-case emissions profile scenario relative to the core modelling (0.09 µg/m^3). This is evident for all modelled pollutants in the sensitivity test results, whereby the majority of modelled Baseline concentrations increase, whilst the With PCC scenario concentrations remain largely unchanged or reduce slightly. Therefore, the maximum impacts are reported to decrease at the majority of receptors relative to the core modelling equivalents.

7.14.8.4.2 Sensitivity Testing: Amine Chemistry Modelling

The sensitivity testing completed in relation to amine chemistry modelling for the With PCC scenario is detailed in Appendix B Modelling of amine compounds. (technical approach) and Appendix C Operational Air Quality Assessment Result Tables: Human Receptors.(results in **Tables C21 and C22**).

The maximum hourly (0.10 µg/m^3) and daily mean (0.02 µg/m^3) MEA concentrations from the sensitivity tests were modelled to be equivalent to the concentrations reported for the proprietary amine solvent (0.10 µg/m^3 and 0.02 µg/m^3 respectively), when modelling an identical mass emission rate for amines in all tests.

The maximum annual mean NDMA concentrations reported from the sensitivity tests (0.03 ng/m^3) was modelled to be 67% higher than the equivalent concentration reported for the proprietary amine solvent (0.02 ng/m^3). However, the maximum concentration from the sensitivity tests still remains well below the annual mean EAL for NDMA, equating to 14% of the EAL.

Therefore, the results of the sensitivity testing do not affect the outcome of the core assessment results, such that emissions in the With PCC scenario would still not result in significant air quality effects at human receptors in terms of amine (MEA) and nitrosamine (NDMA) concentrations.

7.14.8.5 Potential Effect on Ecological Receptors

The contributions in the With PCC scenario to air pollution are presented as maximum ground level concentrations and deposition levels at the identified designated sites. The PC of the With PCC scenario represents the change in concentration/deposition between the Baseline scenario and With PCC scenario.

The below sub-sections focus on the results associated with internationally and nationally designated habitat sites, where relevant. Detailed tables of results relating to each ecological receptor in the Baseline and With PCC scenarios, including locally designated habitat sites, are presented in Appendix D.

7.14.8.5.1 Oxides of Nitrogen(NO_x), Ammonia (NH_3) and Sulphur Dioxide (SO_2)

The modelled maximum PC and PEC concentrations relating to the relevant averaging periods for NO_x, NH_3, and SO_2 at each designated site, based on five years of meteorological data (2016-2020), are presented in Tables D1 to D4 of Appendix D Operational Air Quality Assessment Result Tables: Ecological Receptors.. Concentrations are presented for both the Baseline and With PCC scenarios.

The spatial distributions of the modelled With PCC scenario maximum concentration impacts for NO_x, NH_3, and SO_2 across the operational phase study area are depicted in **Figures 10 to 12**, respectively.

Figure 10 – Annual Nitrogen Deposition Maximum Impacts with PCC

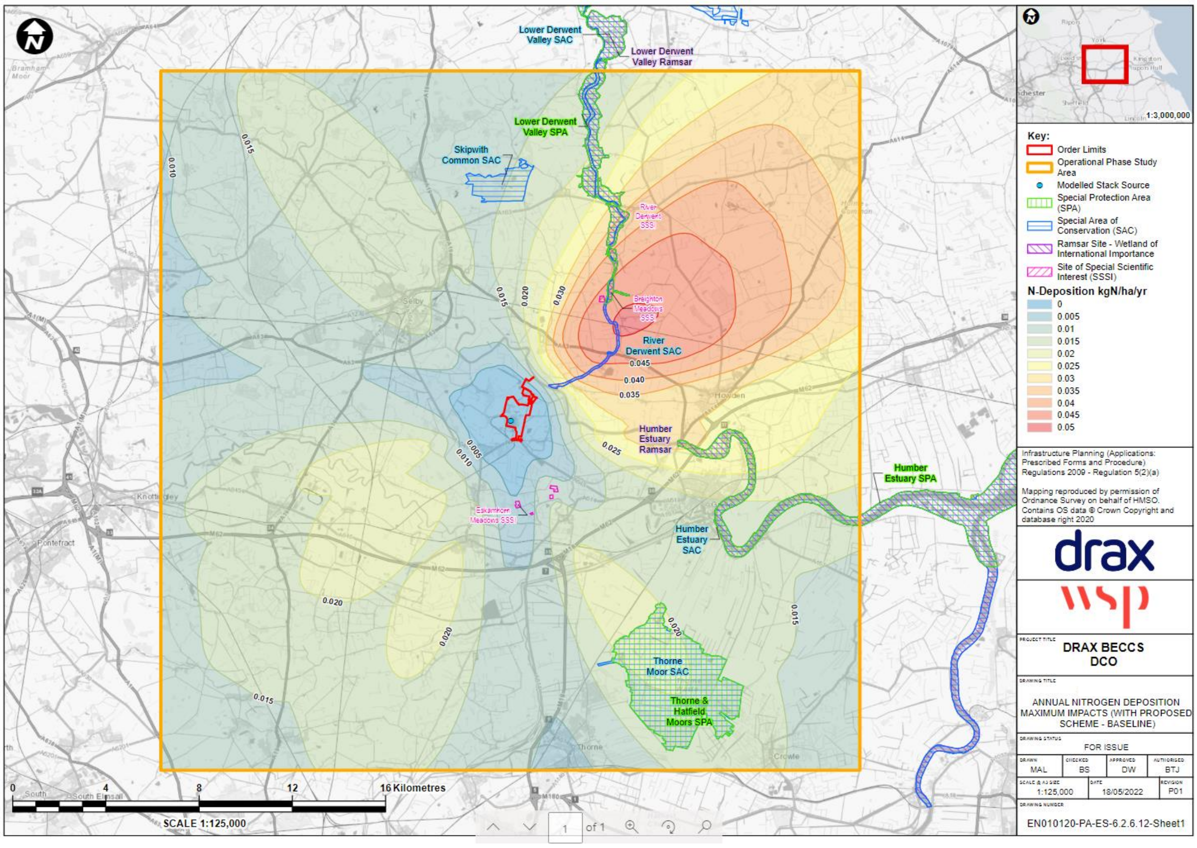


Figure 11 – Annual Mean NH_3 Concentration Maximum Impacts with PCC

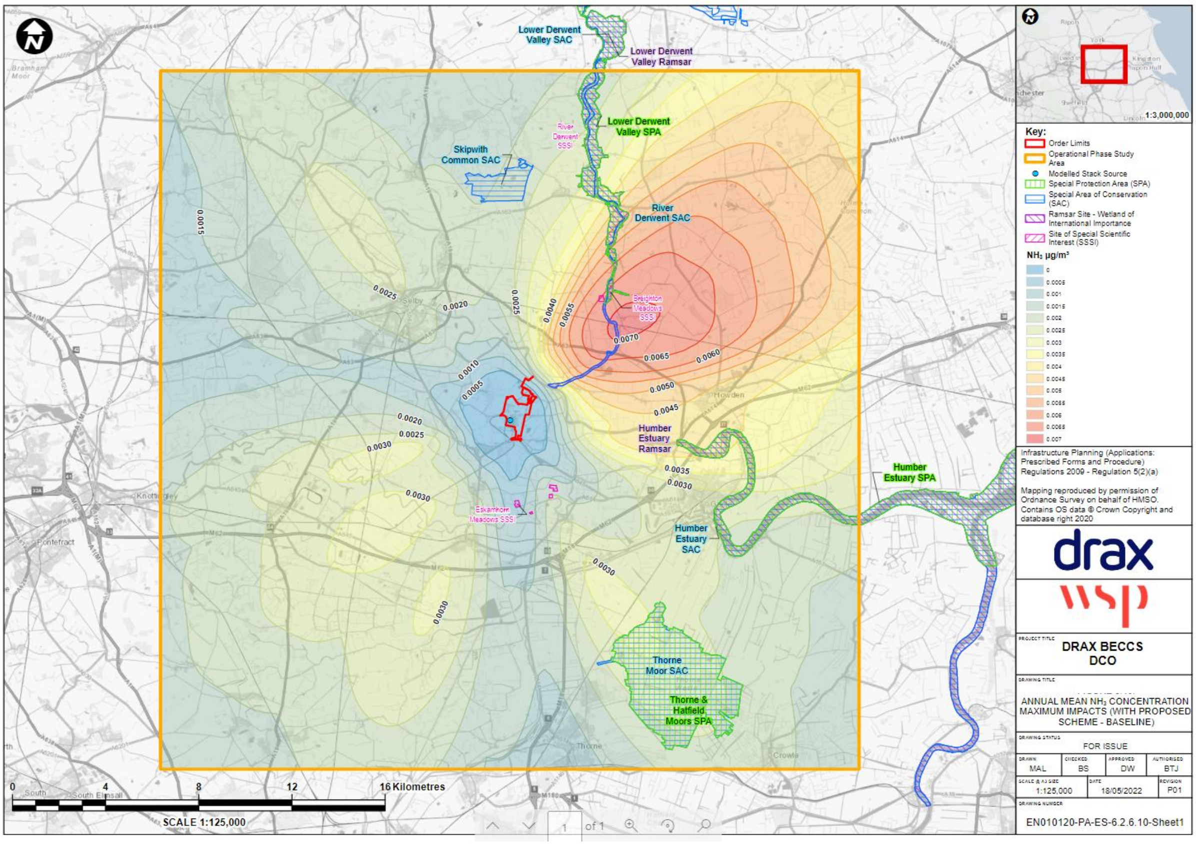
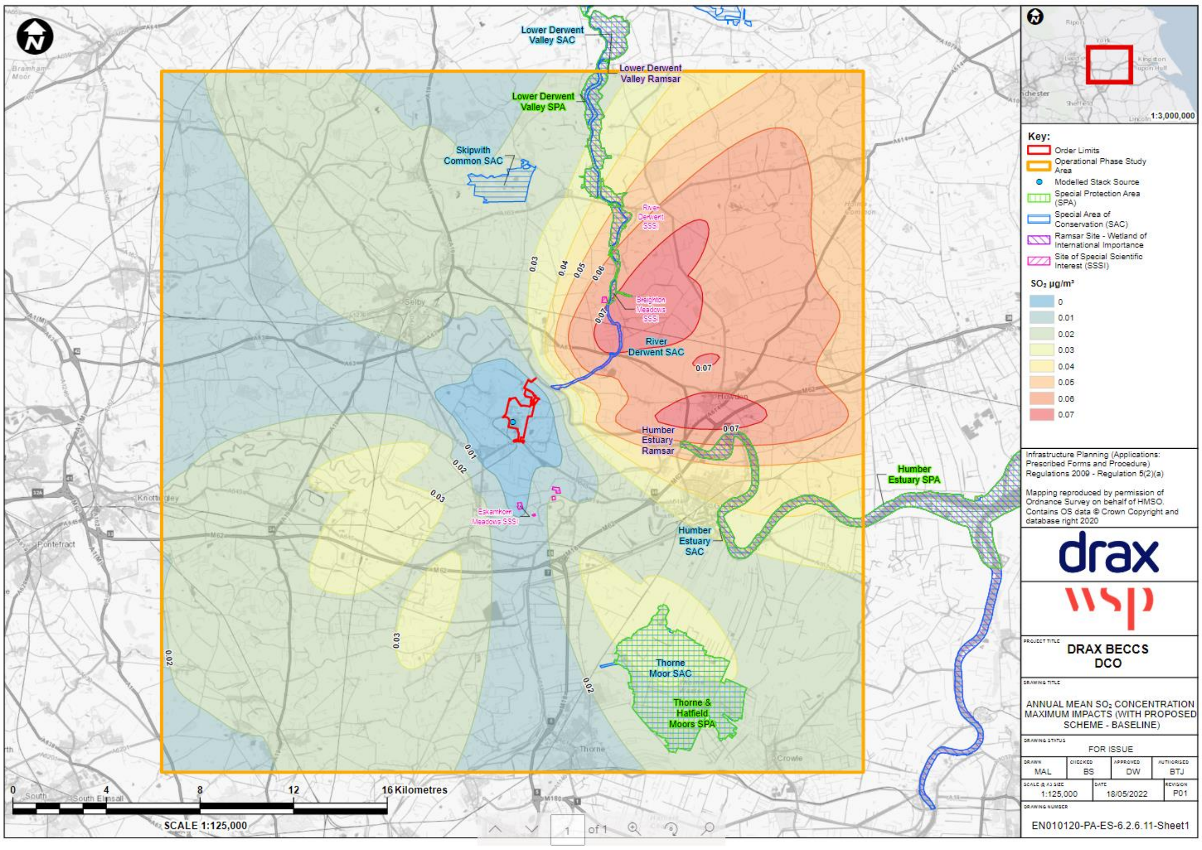


Figure 12 – Annual Mean SO_2Concentration Maximum impact with PCC



Using the significance screening criteria presented in Section 7.14.8for ecological receptors, the impacts of operation in the With PCC scenario alone on annual mean NO_x, annual mean NH_3, and annual mean SO_2 concentrations are classified as insignificant (≤1% of the critical level) at all designated sites. Similarly, the modelled maximum daily mean NO_x concentration impacts are well below 10% of the critical level, meaning the modelled impacts are classified as insignificant.

Therefore, emissions of NO_x, NH_3, and SO_2 in the With PCC scenario alone will not result in significant air quality effects at the assessed ecological receptors.

7.14.8.5.2 Nitrogen Disposition

The modelled maximum PC and PEC annual nitrogen deposition rates at each designated site, based on five years of meteorological data (2016-2020), are presented in Table D5 of Appendix D Operational Air Quality Assessment Result Tables: Ecological Receptors. The spatial distribution of modelled With PCC scenario maximum impacts for annual nitrogen deposition rates across the operational phase study area is depicted in **Figure 7**.

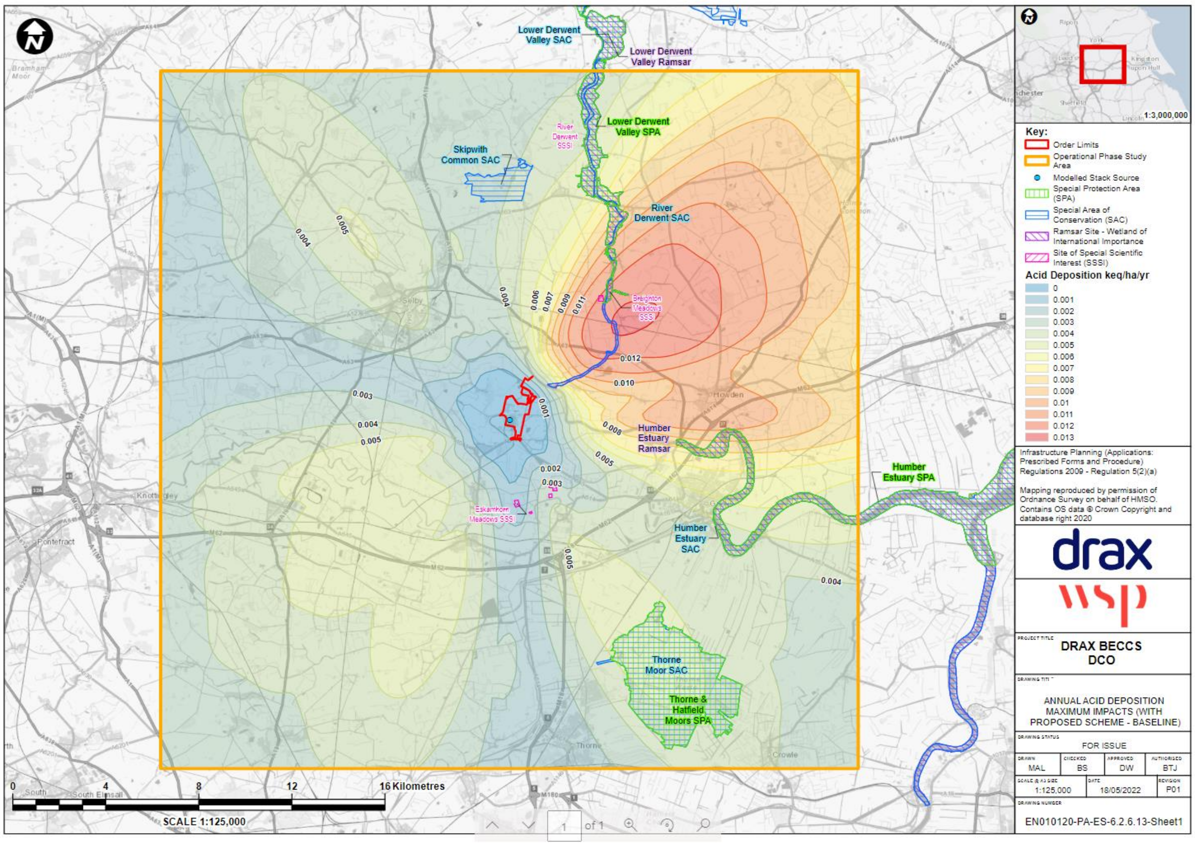
Using the significance screening criteria presented in Section 7.14.8for ecological receptors, the impacts of operation in the With PCC scenario alone on annual nitrogen deposition rates are classified as insignificant (≤1% of the critical level) at all designated sites.

Therefore, contributions to nitrogen deposition associated with emissions in the With PCC scenario alone will not result in significant air quality effects at the assessed ecological receptors

7.14.8.5.3 Acid Deposition

The modelled maximum PC and PEC annual acid deposition rates at each designated site, based on five years of meteorological data (2016-2020), are presented in **Table 23**. The spatial distribution of modelled With PCC scenario maximum impacts for annual acid deposition rates across the operational phase study area is depicted in **Figure 13**.

Figure 13 – Annual Acid Deposition Concentration Maximum impact with PCC



The modelled PC from the With PCC scenario operation is above 1% of the respective critical load at sensitive habitats within the Lower Derwent Valley SAC (2.0%), Thorne Moor SAC and Thorne, Crowle, and Goole Moors SSSI (1.3%), as well as at sensitive habitats within SSSI designations at Breighton Meadows (2.0%), Derwent Ings (1.6%), and Barn Hill Meadows (1.6%). Given that background levels of acid deposition at the relevant sensitive habitats within these designated sites already exceed their respective critical loads, the associated PCC related PECs exceed the screening criterion (i.e. PEC >70% of critical level).

Therefore, significant effects relating to acid deposition at the aforementioned designated sites cannot be screened out when considering the impacts of emissions from the With PCC scenario alone. For acid deposition, contributions attributed to the With PCC scenario are a small proportion of the existing background levels of deposition at the affected designated sites. That is to say that the risk of exceedance of critical loads or the level of exceedance of the critical load, is wholly dependent on the existing deposition levels and would not be affected by the operation of the PCC.

The PC annual acid deposition rates at all other international, national, and local designated sites included in the assessment are below the 1% criterion and, therefore, emissions from the With PCC scenario alone will not result in significant air quality effects at those sites.

Table 23 - Modelled Maximum Operational Phase Impacts at Ecological Receptors for Annual Acid Deposition

Receptor	**Critical Load (keq/ha/yr)**	**Max *Baseline* PEC(1) (keq/ha/yr)**	**Max *With Scheme* PEC(1) (keq/ha/yr)**	**Max PC (Impact) (keq/ha/yr)**	**Max PC as % of CL**	**Max *With Scheme* PEC as % of CL**
Thorne Moor SAC	0.462	1.74	1.74	0.01	**1.3%**	376.9%
Thorne Moor SSSI(2)	0.462	1.74	1.74	0.01	**1.3%**	376.9%
Lower Derwent Valley SAC	0.643	2.41	2.42	0.01	**2.0%**	376.8%
Skipwith Common SAC	0.802	1.73	1.73	0.00	0.5%	216.0%
Skipwith Common SSSI	0.802	1.73	1.73	0.00	0.5%	216.0%
Breighton Meadows SSSI	0.643	1.93	1.94	0.01	**2.0%**	302.2%
Eskamhorn Meadows SSSI	1.998	1.64	1.64	0.00	0.2%	82.2%
Derwent Ings SSSI	0.643	2.41	2.42	0.01	**1.6%**	376.4%
Went Ings SSSI	2.008	1.59	1.60	0.00	0.2%	79.6%
Barn Hill Meadows SSSI	0.633	1.69	1.70	0.01	**1.6%**	269.3%
Burr Closes SSSI	1.248	1.68	1.69	0.00	0.4%	135.2%

Notes: All deposition rates rounded to two decimal places (2 d.p.). Maximum values based on results modelled using five years of meteorological data (2016-2020). Results presented only for the sites that are assigned an acid deposition critical load.

(1) Including maximum background acid deposition (N+S) as reported by APIS (see Table 6.11).

(2) Thorne, Crowle, and Goole Moors SSSI

7.14.9 Sensitivity Testing: Worst Case Emission Profile

The sensitivity testing completed and detailed in Appendix B Modelling of amine compounds. (technical approach) and Appendix D Operational Air Quality Assessment Result Tables: Ecological Receptors. (results in Tables D12 to D17), which considers the worst-case emissions profile for both the Baseline and With PCC scenarios (as per Section 7.14.2), does not affect the outcome of the results reported above.

For all pollutant concentrations and deposition rates, it is evident that the modelled maximum PC impacts attributed to the With PCC scenario are lower at all receptors relative to the core model scenarios. This is a function of all four biomass units in the Baseline scenario switching from mid-merit operation (full load for 4,000 hours per year) to continuous operation (full load for 8,760 hours per year), resulting in more pollutants being emitted and thus more pronounced changes (increases) in concentrations/deposition rates relative to the With PCC scenario. In the With PCC scenario, operation changes from mid-merit to continuous full load at the two non-PCC biomass units only (PCC units already assumed to operate at continuous full load in core modelling scenario), meaning the changes (increases and decreases) in concentrations/deposition rates are relatively small compared to the Baseline.

As a consequence, the maximum modelled impacts of the activity decrease at all receptors under the worst-case emissions profile scenario relative to the core modelling. Whilst some modelled maximum PEC concentrations do increase under worst case emissions in both the Baseline and With PCC scenarios, there are no material changes relative to the core modelling equivalents, meaning that the respective assessment significance criteria are not exceeded.

7.14.10 Potential Cumulative Effects

The potential for significant cumulative effects has been assessed in relation to the operational phase of the PCC (relevant other projects identified in Section 7.14.5).

7.14.10.1Potential Effects on Human Receptors

Detailed atmospheric dispersion modelling has been undertaken to model the cumulative air quality impacts associated with the operational phase of the activity and other projects as outlined in Section 7.14.5.

The modelled grid maximum annual mean concentrations for each pollutant (NO_2, NH_3, and PM_{10}/$PM_{2.5}$), based on modelling across five years of meteorological data (2016-2020), are presented in **Table 24**.

Results relating to all relevant pollutants and modelled discrete receptors are presented in Tables C10 to C12 of Appendix C Operational Air Quality Assessment Result Tables: Human Receptors.. The spatial distribution of modelled With PCC maximum cumulative impacts across the operational phase study area for annual mean NO_2 is presented in **Figure 14**.

Figure 14 – Annual Mean NO_2 Concentration Maximum Cumulative Impacts with PCC

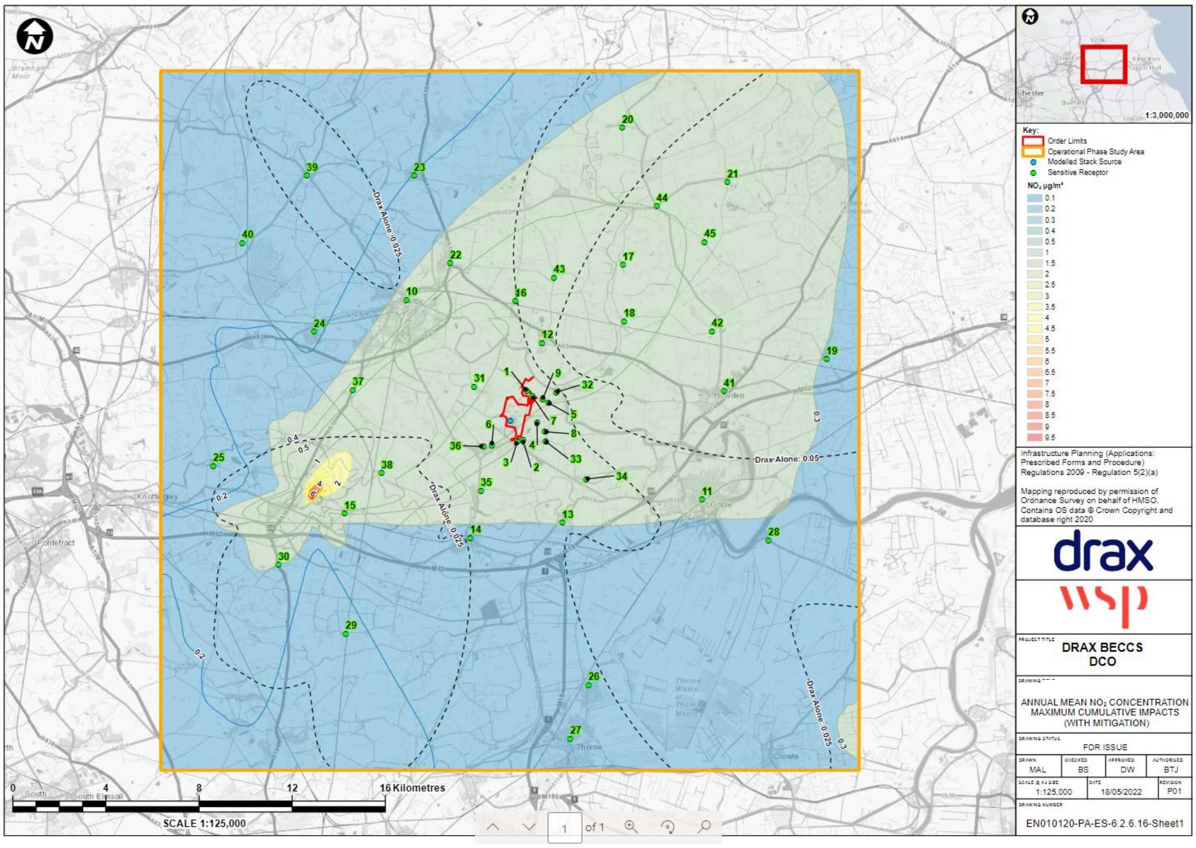


Table 24 Modelled Maximum Cumulative Pollutant Concentrations within Study Area presented as Percentage of Relevant AQALs

Pollutant	Averaging Period	Maximum Concentration (µg/m³)			Impact as % of AQAL
		Baseline[1]	Cumulative	Max Impact [2]	
NO_2	Annual	9.96	10.01	0.05	0.32%
PM_{10}	Annual	0.006	0.012	0.006	0.03%
$PM_{2.5}$	Annual	0.006	0.012	0.006	0.06%
NH_3	Annual	0.026	0.030	0.004	0.01%

(1) Baseline for Drax Power Station represented by 'mid-merit' operating regime.

(2) The maximum impact is the maximum difference between Baseline & Other Projects and Cumulative (Baseline & Other Projects & PCC) concentrations and may not coincide with the specific geographic point at which the maximum value occurs in each modelled scenario.

The modelled maximum cumulative impacts for all assessed pollutants are below 1% of the relevant AQALs, equating to negligible air quality impacts at all receptors within the operational phase study area. As such, cumulative emissions from the With PCC scenario and other projects would have no significant effect on local air quality with respect to human health.

7.14.10.1.1 Amines & Nitrosamines

As detailed in Section 7.14.5, a quantitative modelling assessment of cumulative impacts for amine and nitrosamine concentrations was not considered appropriate. However, to provide a qualitative and conservative judgement on potential cumulative impacts, the maximum modelled PC concentrations from both the PCC activity and Keadby 3 (Keadby Generation Ltd, May 2021) project were summed, as follows:

- Amine (as MEA) cumulative maximum 1-hour mean PC (µg/m3)
  = 0.24 (PCC) + 25.2 (Keadby 3) = 25.44 µg/m3
- Amine (as MEA) cumulative maximum 24-hour mean PC (µg/m3)
  = 0.06 (PCC) + 0.22 (Keadby 3) = 0.28 µg/m3
- Nitrosamine (as NDMA) cumulative maximum annual mean PC (ng/m3)
  = 0.017 (PCC) + 0.064 (Keadby 3) = 0.081 ng/m3

The EALs for primary amine and NDMA are not exceeded, with the maximum cumulative values representing 6.4% of the 1-hour mean EAL for primary amine (53 µg/m^3), 0.3% of the 24-hour mean EAL for primary amine (13 µg/m3), and 40.5% of the annual mean EAL for NDMA (0.2 ng/m^3), respectively.

Within the context of the significance criteria presented in Table 16, these maximum cumulative impacts equate to ‘slight adverse’ for secondary amine 1-hour averaging period, ‘negligible’ for the primary 24-hour averaging period, and ‘moderate adverse’ for annual mean NDMA.

However, given the conservatism applicable to the above values, including the worst-case assumption that maximum concentrations from both schemes would occur at the same location and time anywhere within the operational phase study area, and that values from both schemes represent the sum of nitramine and nitrosamine concentrations (see Section 7.14.8.1.1), the cumulative impact on amines and nitrosamines is considered to be not significant.

7.14.10.1.2 Potential Effects on Ecological Receptors

The cumulative contributions in the With PCC scenario alongside other projects to air pollution are presented as maximum ground level concentrations and deposition levels at the identified designated sites. The cumulative PC of the With PCC scenario and other projects represents the change in concentration/deposition between the Baseline scenario and With PCC and Other Projects scenario.

The below sub-sections focus on the results associated with internationally and nationally designated habitat sites, specifically where the assessment significance criteria are exceeded. Detailed tables of results relating to each ecological receptor in the Baseline and With PCC & Other Projects scenarios, including locally designated habitat sites, are presented in Appendix D Operational Air Quality Assessment Result Tables: Ecological Receptors.

7.14.10.1.3 Oxides of Nitrogen (NO_x) and Sulphur Dioxide (SO_2)

The modelled maximum cumulative PC and PEC concentrations relating to annual mean NO_x and SO_2 at each designated site, based on five years of meteorological data (2016-2020), are presented in Appendix D Operational Air Quality Assessment Result Tables: Ecological

Receptors.. The spatial distributions of the modelled With PCC scenario maximum cumulative concentration impacts for NO_x and SO_2 are depicted in **Figures 15 and 17** respectively.

Using the significance screening criteria set out in Section 7.14.8, the cumulative operational impacts on annual mean SO_2 are classified as insignificant (≤1% of the critical level) at all designated sites. Similarly, whilst the maximum cumulative NOx PC impacts are predicted to be above 1% of the annual mean critical level at all receptors, the maximum PECs at all designated sites are below 70% of the critical level. As such, the modelled cumulative impacts are classified as not significant.

Figure 15 – Annual Mean NO_2 Concentration Maximum Cumulative Impacts with PCC

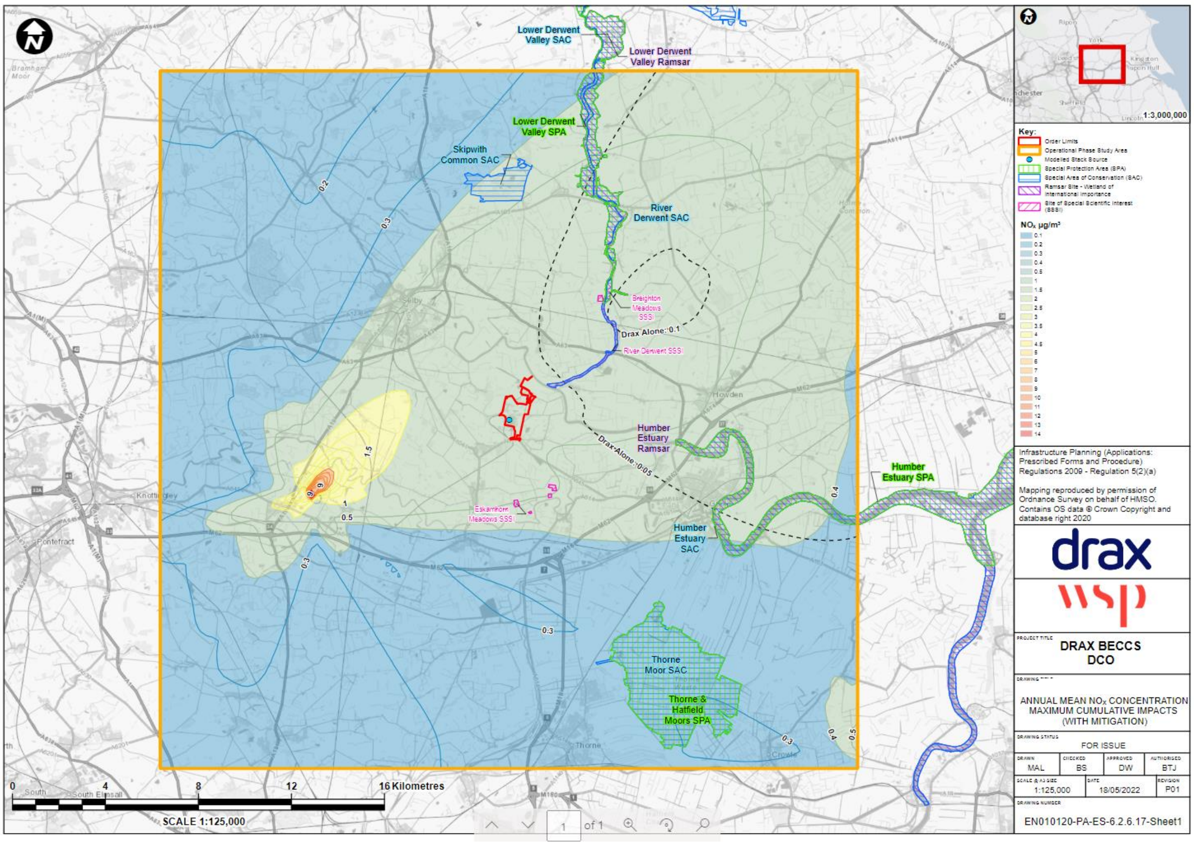


Figure 16 – Annual Mean NH_3 Concentration Maximum Cumulative Impacts with PCC

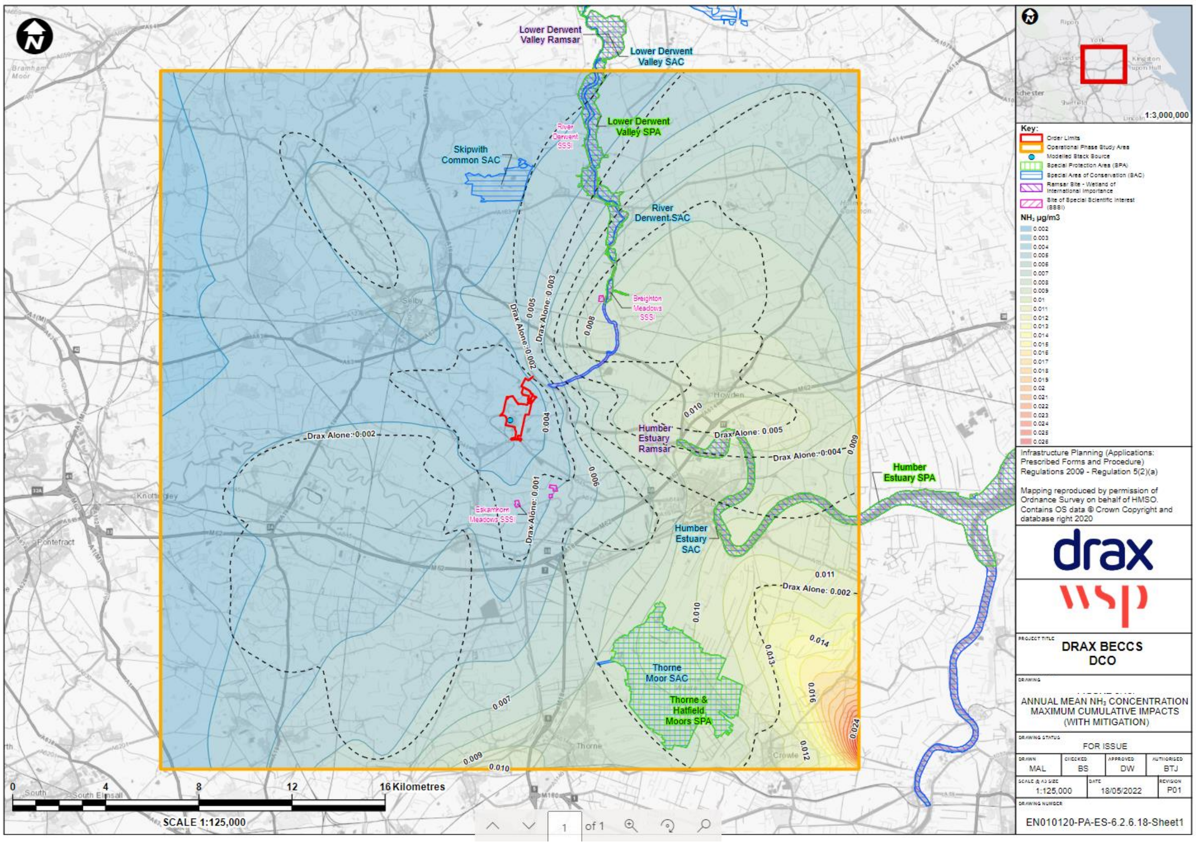
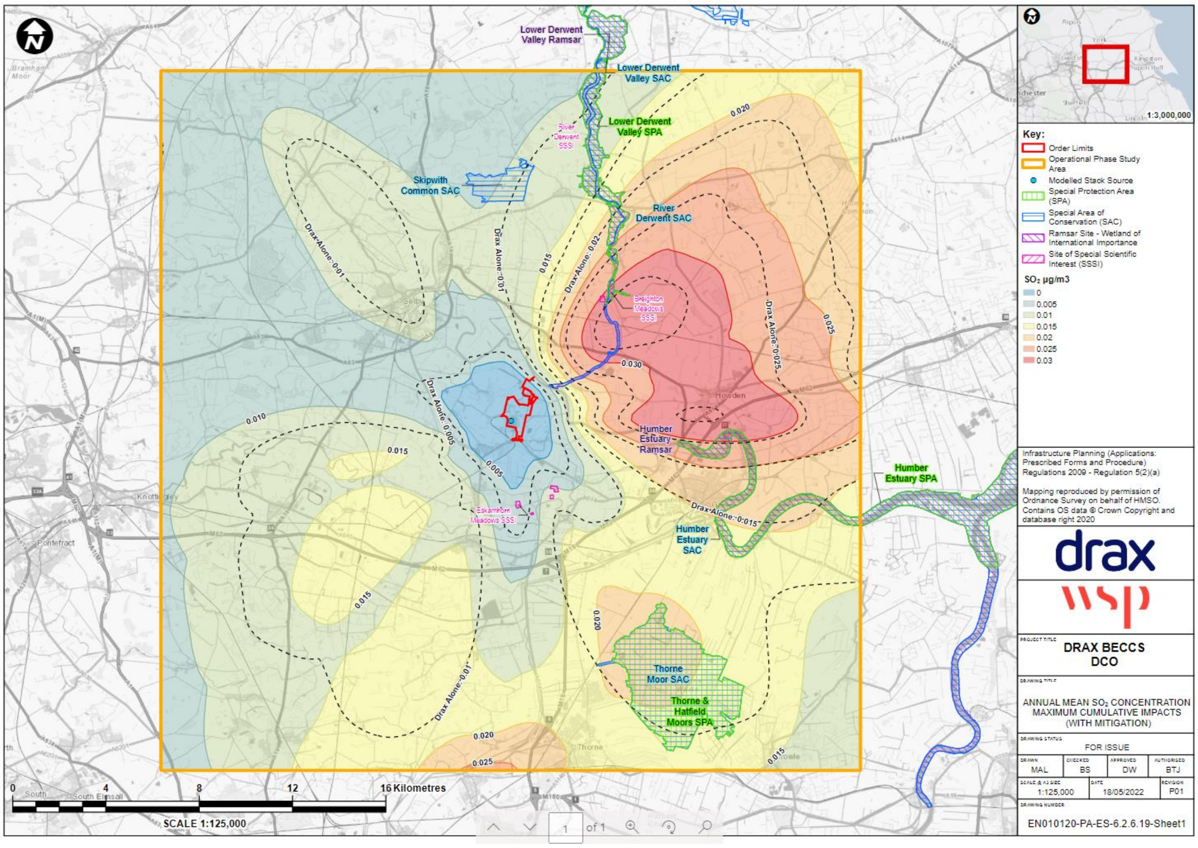


Figure 17 – Annual Mean SO_2 Concentration Maximum Cumulative Impacts with PCC



The maximum cumulative impacts on daily mean NO_x concentrations do not exceed the 10% significance screening criterion within any of the identified designated sites, except for the Humber Estuary SAC/SPA/SSSI, where the maximum impact equates to 22% of the critical level. However, the contribution from the PCC to this impact equates to 0.5% of the critical level and the corresponding maximum cumulative PEC remains well below the critical level. Therefore, the modelled cumulative impacts are classified as insignificant at all receptors in terms of daily mean NO_x concentrations.

Therefore, cumulative emissions of NO_x and SO_2 from the With PCC scenario & Other Projects scenario will have no significant effect on air quality at all assessed designated sites.

7.14.10.1.4 Ammonia (NH_3)

The modelled maximum cumulative PC and PEC concentrations relating to annual mean NH_3 at each designated site, based on five years of meteorological data (2016-2020), are presented in **Table 25**. Concentrations are presented for both the Baseline and With PCC and Other Projects scenarios. The spatial distribution of the modelled With PCC scenario maximum cumulative concentration impacts for NH_3 is depicted in **Figure 13**.

Using the significance screening criteria, the cumulative operational impacts on annual mean NH_3 are classified as insignificant (≤1% of the critical level) at all designated sites except for Thorne Moor SAC, Thorne & Hatfield Moors SPA, Thorne, Crowle, and Goole Moors SSSI. At these designated sites, the modelled maximum cumulative PC impact, which equates to 1.1% of the respective critical level, marginally exceeds the 1% significance screening criterion and the maximum PEC exceeds the critical level.

Therefore, the results of the NH_3 cumulative impact assessment at the above designated sites were passed to the project ecologist to determine whether or not there is a likely significant effect.

The cumulative emissions of NH_3 from the With PCC & Other Projects scenario will have no significant effect on air quality at all of the other assessed designated sites.

Table 25 - Modelled Maximum Cumulative Impacts at Ecological Receptors for Annual Mean NH_3 (Without Mitigation applied to PCC)

Receptor	Critical Level (µg/m³)	Max *Baseline* PEC[(1)] (µg/m³)	Max *Cumulative* PEC[(1)] (µg/m³)	Max PC (Impact) (µg/m³)[(2)]	Max PC as % of CL[(2)]	Max *Cumulative* PEC as % of CL[(2)]
River Derwent SAC	3	4.57	4.58	0.01	0.3%	152.8%
Thorne Moor SAC/SPA/SSSI[(3)]	1	2.59	2.60	0.01	**1.1%**	260.3%
Lower Derwent Valley SAC/SPA	3	4.57	4.58	0.01	0.3%	152.8%
Skipwith Common SAC/SSSI	1	2.58	2.59	0.00	0.4%	258.6%
Humber Estuary SAC/SPA/SSSI	3	3.58	3.59	0.01	0.4%	119.8%
Breighton Meadows SSSI	3	3.08	3.09	0.01	0.3%	103.1%
Eskamhorn Meadows SSSI	3	2.40	2.41	0.01	0.2%	80.2%
Derwent Ings SSSI	3	4.57	4.58	0.01	0.3%	152.7%
Went Ings SSSI	3	2.35	2.36	0.01	0.2%	78.6%
Barn Hill Meadows SSSI	3	2.32	2.33	0.01	0.3%	77.7%
Burr Closes SSSI	3	2.50	2.51	0.00	0.2%	83.5%

Notes: All concentrations rounded to two decimal places (2 d.p.). Maximum values based on results modelled using five years of meteorological data (2016-2020).

(1) Including maximum background concentration as reported by APIS (see Table 6.11)

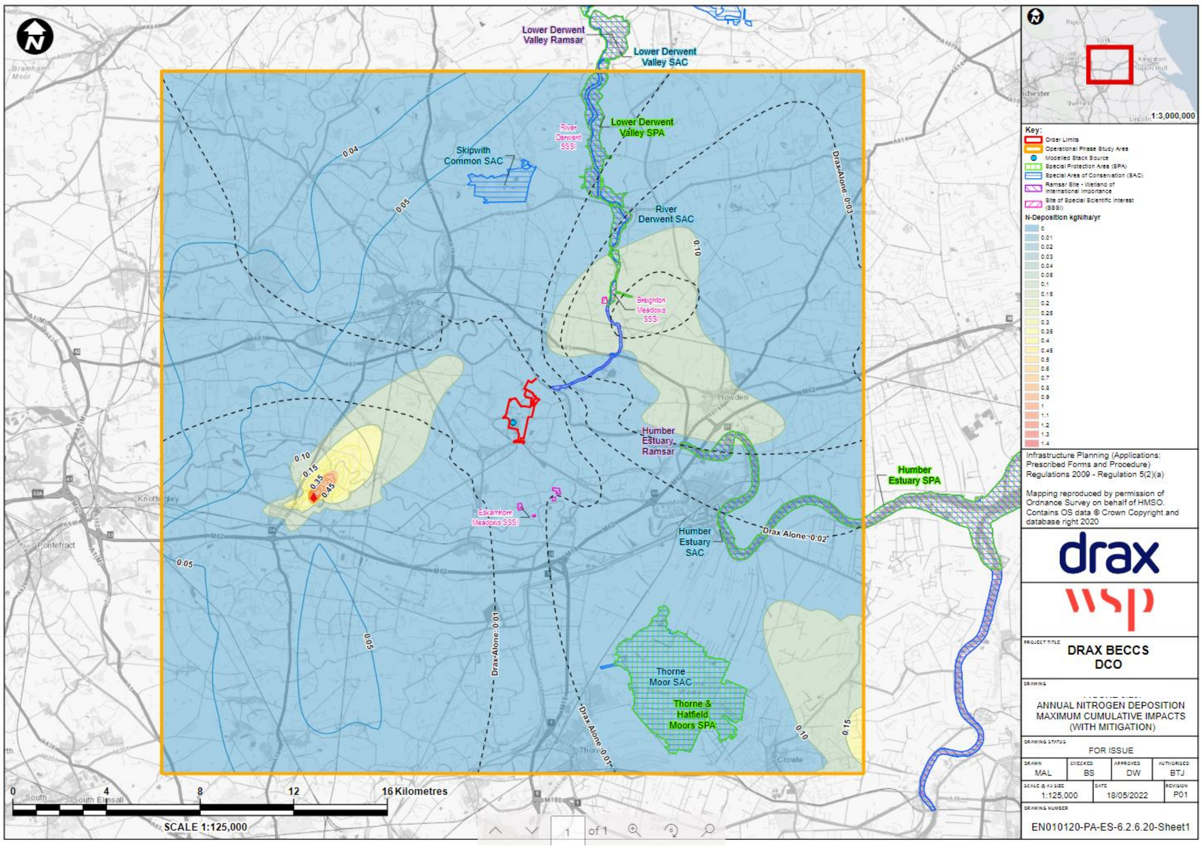
(2) No material changes to modelled results when mitigation (as per Section 6.10) applied to PCC

(3) Thorne Moor SAC, Thorne & Hatfield Moors SPA, Thorne, Crowle, and Goole Moors SSSI

7.14.10.1.5 Nitrogen Deposition

The modelled maximum cumulative PC and PEC annual nitrogen deposition rates at each designated site, based on five years of meteorological data (2016-2020), are presented in **Table 26**. Deposition rates are presented for both the Baseline and With PCC & Other Projects scenarios. The spatial distribution of the modelled With PCC scenario maximum cumulative nitrogen deposition impacts is depicted in **Figure 18**.

Figure 18 – Annual Nitrogen Deposition Maximum Cumulative Impacts with PCC



Using the significance screening criteria, the cumulative operational impacts on annual nitrogen deposition are classified as insignificant (≤1% of the critical level) at all designated sites except for Thorne Moor SAC and Thorne, Crowle, and Goole Moors SSSI. At these sites, the modelled maximum cumulative PC impact, which equates to 1.7% of the respective critical level, exceeds the 1% significance screening criterion the maximum PEC exceeds the relevant critical load.

The results of the cumulative impacts modelling at the locally designated sites has identified that the 1% significance criterion is exceeded at six of the nine sites included in the assessment (see Appendix C Operational Air Quality Assessment Result Tables: Human Receptors.). Furthermore, nitrogen deposition at each of these local sites already exceeds the critical load.

Therefore, the results of the nitrogen deposition cumulative impact assessment at Thorne Moor SAC and Thorne, Crowle, and Goole Moors SSSI, and at the identified locally designated sites, were passed to the project ecologist to determine whether or not there is a likely significant effect. The cumulative emissions of nitrogen deposition from the With PCC & Other Projects scenario will have no significant effect on air quality at all of the other assessed designated sites.

Table 26 Modelled Maximum Cumulative Impacts at Ecological Receptors for Annual Nitrogen Deposition (Without Mitigation applied to PCC)

Receptor	**Critical Load (µg/m^3)**	**Max *Baseline* PEC$^{(1)}$ (kgN/ha/yr)**	**Max *Cumulative* PEC$^{(1)}$ (kgN/ha/yr)**	**Max PC (Impact) (kgN/ha/yr)$^{(2)}$**	**Max PC as % of CL$^{(2)}$**	**Max *Cumulative* PEC as % of CL$^{(2)}$**
Thorne Moor SAC/SSSI$^{(3)}$	5	21.32	21.41	0.09	**1.8%**	428.1%
Thorne Moor SPA$^{(3)}$	10	21.32	21.41	0.09	0.9%	214.1%
Lower Derwent Valley SAC/SPA	20	30.25	30.36	0.11	0.6%	151.8%
Skipwith Common SAC/SSSI	10	21.13	21.20	0.07	0.7%	212.0%
Humber Estuary SAC/SPA/SSSI	20	28.89	28.98	0.09	0.5%	144.9%
Breighton Meadows SSSI	20	23.53	23.64	0.11	0.6%	118.2%
Eskamhorn Meadows SSSI	10	19.96	20.03	0.07	0.7%	200.3%
Derwent Ings SSSI	20	30.25	30.35	0.10	0.5%	151.7%
Went Ings SSSI	15	19.39	19.45	0.06	0.4%	129.7%
Barn Hill Meadows SSSI	20	20.45	20.54	0.09	0.5%	102.7%
Burr Closes SSSI	20	20.65	20.70	0.05	0.3%	103.5%

Notes:

All depositions rounded to two decimal places (2 d.p.). Maximum values based on results modelled using five years of meteorological data (2016-2020). Results presented only for the sites that are assigned a nitrogen deposition critical load.

(1) Including maximum background deposition as reported by APIS (see Table 6.11)

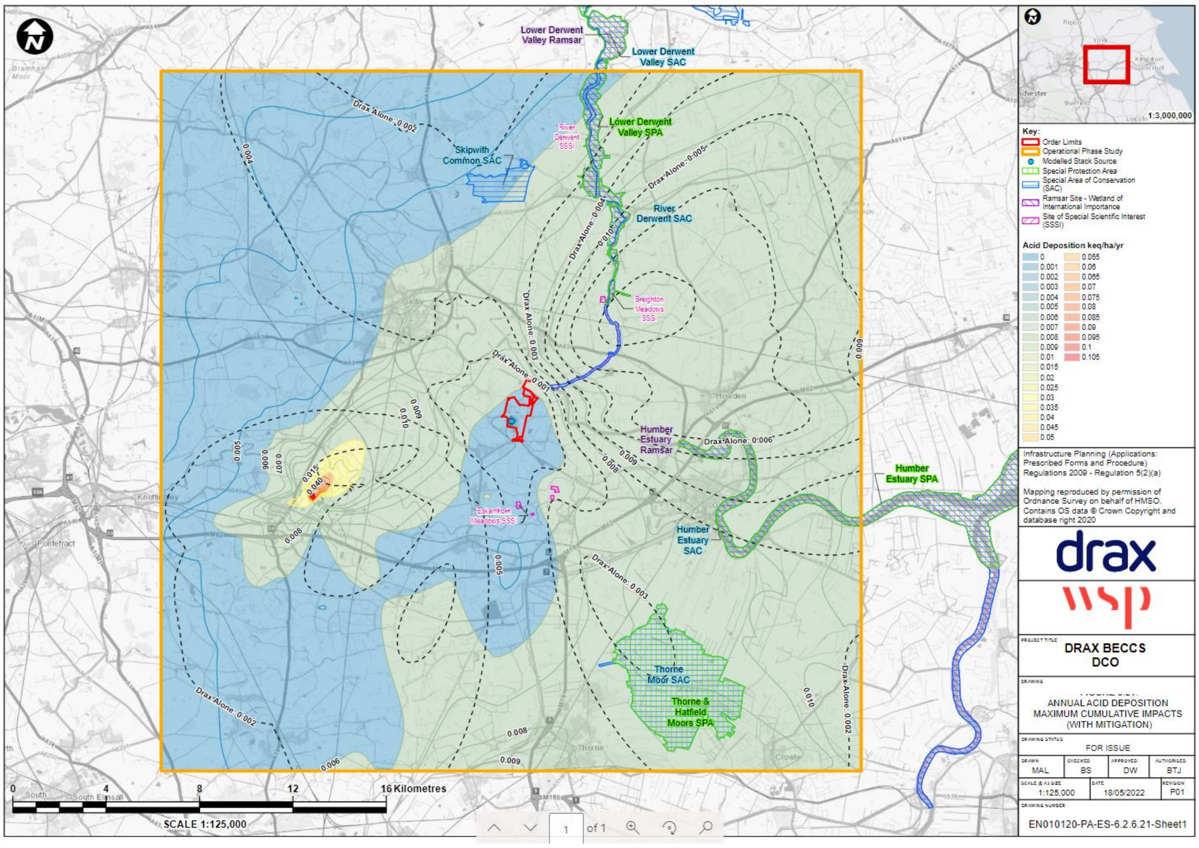
(2) No material changes to modelled results when mitigation (as per Section 6.10) applied to PCC. Max PC as % of CL at Thorne Moor SAC/SSSI reduces to 1.7%.

(3) Thorne Moor SAC, Thorne, Crowle, and Goole Moors SSSI, Thorne & Hatfield Moors SPA

7.14.10.2 Acid Deposition

The modelled maximum cumulative PC and PEC annual acid deposition rates at each designated site, based on five years of meteorological data (2016-2020), are presented in **Table 27**. Deposition rates are presented for both the Baseline and With PCC scenario & Other Projects scenarios (pre- and post-mitigation). The spatial distribution of the modelled With PCC scenario maximum cumulative acid deposition impacts is depicted in **Figure 19**.

Figure 19 – Annual Acid Deposition Maximum Cumulative Impacts with PCC



Using the significance screening criteria, the maximum cumulative PC impacts on annual acid deposition, without mitigation applied, exceed the 1% criterion at Thorne Moor SAC, Thorne, Crowle, and Goole Moors SSSI, Lower Derwent Valley SAC, Skipwith Common SAC and SSSI, and at the SSSIs designated at Breighton Meadows, Derwent Ings, and Barn Hill Meadows. Given the level of existing levels of depositions at these sites, the maximum PEC exceeds the respective critical loads.

With mitigation applied, the maximum cumulative PC impacts reduce to below the 1% criterion at Skipwith Common SAC and SSSI, but remain above 1% of the relevant critical loads at all other sites that exceeded the criterion in the pre-mitigation scenario.

Therefore, the results of the acid deposition cumulative impact assessment were passed to the project ecologist to determine whether or not there is a likely significant effect.

The cumulative emissions of nitrogen deposition from the With PCC & Other Projects scenario will have no significant effect on air quality at the SSSIs designated at Eskamhorn Meadows, Went Ings, and Burr Closes, in addition to all locally designated sites.

Overall, emissions from the PCC and other assessed projects have the potential to lead to a cumulative deterioration in air quality within a number of designated sites in terms of NH_3 concentration, nitrogen deposition, and acid deposition impacts. In all cases, the respective critical level for NH_3 and critical loads for nitrogen and acid deposition are already exceeded without the modelled PCC and other projects contributions.

For all other assessed pollutants and relevant designated sites, no substantial changes in air quality levels are expected within the operational phase study area and emissions from the PCC and other projects would not result in any new exceedances of relevant critical levels or critical loads.

Table 27 Modelled Maximum Cumulative Impacts at Ecological Receptors for Annual Acid Deposition (Without and With Mitigation applied to PCC)

Receptor	**Critical Load (keq/ha/yr)**	**Max *Baseline* PEC(1) (keq/ha/yr)**	**Max *Cumulative* PEC(1) (keq/ha/yr)**		**Max PC (Impact) (keq/ha/yr)**		**Max PC as % of CL**		**Max *Cumulative* PEC as % of CL**	
			Pre (2)	**Post (3)**	**Pre (2)**	**Post (3)**	**Pre (2)**	**Post(3)**	**Pre (2)**	**Post (3)**
Thorne Moor SAC	0.462	1.74	1.75	1.75	0.01	0.01	**2.3**	**1.9**	378.0	377.5
Thorne Moor SSSI (4)	0.462	1.74	1.75	1.75	0.01	0.01	**2.3**	**1.9**	378.0	377.5
Lower Derwent Valley SAC	0.643	2.41	2.43	2.42	0.02	0.01	**2.7**	**1.8**	377.5	376.7
Skipwith Common SAC	0.802	1.73	1.74	1.73	0.01	0.01	**1.1**	0.8	216.5	216.2
Skipwith Common SSSI	0.802	1.73	1.74	1.73	0.01	0.01	**1.1**	0.8	216.5	216.2
Breighton Meadows SSSI	0.643	1.93	1.95	1.94	0.02	0.01	**2.7**	**1.8**	302.9	302.0
Eskamhorn Meadows SSSI	1.998	1.64	1.65	1.64	0.01	0.01	0.4	0.3	82.4	82.3
Derwent Ings SSSI	0.643	2.41	2.43	2.42	0.01	0.01	**2.3**	**1.6**	377.1	376.4
Went Ings SSSI	2.008	1.59	1.60	1.60	0.01	0.01	0.4	0.3	79.8	79.7
Barn Hill Meadows SSSI	0.633	1.69	1.71	1.71	0.02	0.01	**2.4**	**1.9**	270.1	269.6
Burr Closes SSSI	1.248	1.68	1.69	1.69	0.01	0.01	0.6	0.4	135.4	135.2

Notes: All deposition rates rounded to two decimal places (2 d.p.). Maximum values based on results modelled using five years of meteorological data (2016-2020). Results presented only for the sites that are assigned an acid deposition critical load.

(1) Including maximum background acid deposition (N+S) as reported by APIS

(2) Modelled results before any mitigation applied to PCC Main Stack

(3) Modelled results after mitigation applied to PCC Main Stack

(4) Thorne, Crowle, and Goole Moors SSSI

8.0 Monitoring

The monitoring of emissions to air is well-defined and governed by several key standards, requirements and underpinning principles. Drax is designing its monitoring proposals around these requirements underpinned by the existing mature systems it uses to comply with the industry and regulatory standards.

Any new compliance monitoring locations and associated platform and port requirements will be developed around the requirements of BS EN15259 and the EA M1; sampling requirements for stack emission monitoring technical guidance notes and based on the derogations in place in relation to the retrofit of activities to the existing site.

The continuous emission monitor selection and operation will be developed in line with technical guidance note M20; quality assurance of continuous emission monitoring systems and BS EN 14181.

This will all be operated and managed within the site EMS and in line with the JEP; Electricity supply industry – IED compliance protocol for utility boilers and gas turbines (LCP BREf Update).

8.1 Continuous Emission Monitors

To effectively monitor both the combustion and the PCC activity in the various normal and other than normal operational scenarios, Drax are expecting to use multiple monitoring locations. These consist of both current and new reference monitoring locations.

The combustion operation will continue to utilise the continuous emission monitors (CEMs) at the precipitator outlets and the ID fan outlets. Both locations were selected based on the best available, in terms of ducting infrastructure layout, flow and concentration requirements. The locations predated the current requirements detailed in M1, M20, BS EN 14181 and BS EN 15259 and are the current reference monitoring locations. The precipitator outlets are used to monitor total particulate matter and the ID fan outlet is used to monitor gases.

The PCC activity design will also include new duct work and the monitoring location and associate sampling ports, and platforms will be selected and designed based on BS EN15259 and technical guidance note M1, but could be constrained due to the retrofit nature of the build and the space constraints involved. The finalised ducting design has not been completed at this time preventing the precise location to be identified and associated drawing to be shared. This will be available post FEED and Drax would be happy to provide this in response to a pre-operational condition.

This location, once identified, will be utilised to monitor the flue gas composition post the PCC activity and will include a suite of CEMs to monitor the emission release associated with the activity which is shown in **Table 28**.

Table 28 Continuous Monitored Emission to Air and Associate Units

Continuously Monitored Species Release to Air	Units
Oxides of nitrogen	mg/Nm3
Sulphur Dioxide	mg/Nm3
Total Particulate Mater	mg/Nm3
Hydrogen Chloride	mg/Nm3
Carbon Monoxide	mg/Nm3
Ammonia	mg/Nm3
Aldehydes	mg/Nm3

Primary Amines (reported as MEA)	mg/Nm3
Secondary Amines (reported and DMA)	mg/Nm3
Oxygen	%
Moisture	%
Stack Flow	m/s
Stack pressure	bar absolute

These CEMs will be selected utilising technical guidance note M20, BS EN 14181, site experience and original equipment manufacturers support to select the best instruments for each species. The instrument and the associate ranges will also be based on the ELV see7.12, expected operational concentrations, flue gas flow, flue gas temperature, instrument uncertainty and limit of detection. In relation to some of the species and the associated ELV this may require Drax to identify the most suitable instrument and work with the equipment manufacture to achieve a QAL1 certification or equivalent regulatory approval. Species where this may be required will be identified with the species-specific BAT detailed below.

8.1.1 Installation

The instruments will be installed as directed by the original equipment manufacturer and associated standards. Once completed functional checks will be undertaken by the original equipment manufacturer.

8.1.2 OEM Post Installation Testing

Where required by the original equipment manufacturer, any post installation instrument verification tests will be undertaken by MCert certified testing teams. These tests will then be used to refine the instrument setting prior to any initial QAL2 test being undertaken

8.1.3 QAL2

All new instruments will undergo a full QAL2 testing program in compliance with the relevant protocols and standards. These will be carried out within 6 months of the end of the PCC’s commissioning. They will then be included within the station current instrument management governance system which forms part of the environmental management system.

Once incorporated within the system they will then be retested in line with guidance but at least every five years.

8.1.4 QAL3

The site has a mature and robust system for managing our current instruments. The new instruments will be embedded within this system and the associate electronic maintenance systems as soon as we are able and the QAL3 requirements will start from that point.

As part of the QAL3 process currently in place all calibration gases that are selected and used are certified by the manufacture in line with the relevant standards.

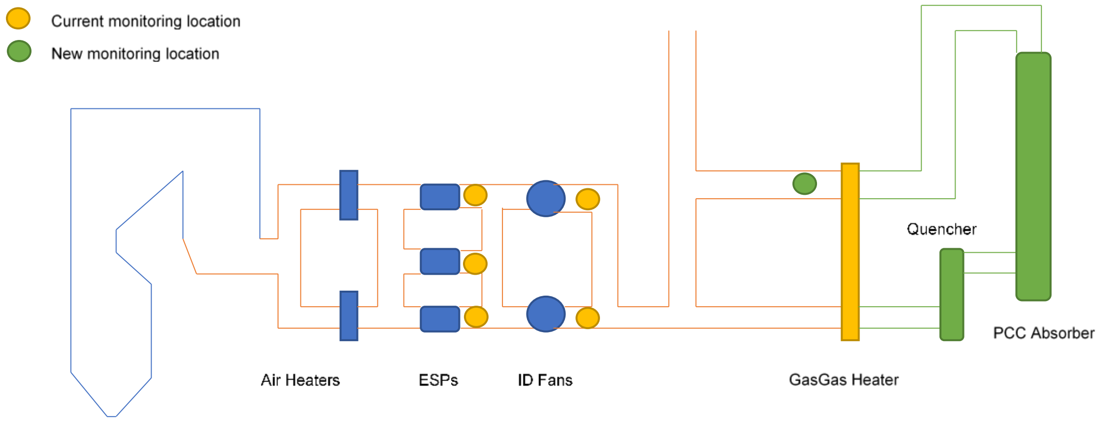
8.1.4.1 Calibration gases

The calibration gases utilised by the analysers for the purposes of QAL3 will be selected on the basis of the required range and certified to the appropriate national standard. All gases currently used on site are managed to this principle and it is our desire to continue to maintain this standard forward. However, it should be noted that for the new monitoring species the analysers and associated ranges are unknow and as such the availability of calibration gases is also unknown. Once instruments are selected, Drax will work with our current gas suppliers to identify and source appropriate calibration gases ready for insulation and operation.

8.1.5 Locations

The locations of the emission monitoring associated with the PCC for the continuous and periodic monitoring and additionally the associate calibration reference ports will be selected on the basis of compliance with Technical Guidance Note M1 and BS EN 15259. The monitoring locations will be developed on the principle of five hydraulic heads upstream and two hydraulic heads downstream of any bends, flue reductions or obstructions within the gas stream. Each PCC and combustion unit pair will have their own monitoring location prior to entering the main windshield.

Diagram 2 Block Flow Schematic of LCP PCC unit Gas flow configuration



The port locations will ensure suitable access to the relevant plains for both the instruments and parallel calibration testing, with the calibration port being parallel and as close to the instruments ports as possible within the same plane.

8.1.6 Access and Platforms

The platforms, access requirements and lifting facilities associated with the new reference monitoring points will be fully compliant with the requirements of the relevant standards and guidance.

8.1.7 Homogeneity assessment

Once the plant is completed and has achieved an operational status a suitable BS EN14181 velocity and concentration assessment will be undertaken for each of the monitoring locations. Following this testing, analysis of the results will be undertaken, and any findings will be implemented to ensure that all reference monitoring is of the required quality standard.

8.1.8 Instrument Operational Philosophy

All analysers engaged in compliance monitoring will transfer data to the control screens via the data acquisition and handling software (DAHS). With the displays positioned to allow suitable control and timely response by the unit operator on the basis of priority. This visibility element is supported by alarms for both faults and emission compliance.

The compliance alarms use a two-stage alarm principle of an approaching HI alarm and an exceedance HIHI alarm signal. Each alarm has a specific priority level and associated actions response document incorporated within the management system to ensure the correct and most appropriate response is taken.

The fault alarms are similarly prioritised in terms of action on receipt of alarm and governance document to be followed. All compliance monitoring instruments are managed as priority one instruments, the highest level available within the site systems.

8.1.9 Instrument Maintenance Philosophy

Drax utilises an electronic maintenance planning system to control all maintenance activities. This system will be used to ensure that all instruments are maintained in line with the original equipment manufacturers requirements. This system will also be used in conjunction with other systems to ensure that cylinders associated with the instruments are managed to an equivalent level.

In addition, the maintenance team are also responsible for the QAL3 management system and which identifies any drift or issues. Where this occurs a review of the instruments is carried to identify the cause and associated actions are carried out to bring the instrument back in line with expected performance.

These are mature and well-defined processes currently embedded within the site governance systems, which will be expanded to include all the compliance instrument involved with the monitoring of the PCC system

8.1.10 Data Acquisition and Handling System (DAHS)

Drax operates a MCert certified data acquisition and handling system. As an operator Drax has invested significantly to further improve its data handling systems with the majority of data now feeding directly from the CEMs to the system directly.

Where possible this will be the primary design ethos for all analysers associated with compliance monitoring for releases to air for the PCC.

8.1.11 Governance Philosophy

As part of the instrument management system, Drax uses several different meetings to ensure that the required level of monitoring quality is maintained. These meetings are used to review and develop actions plans as required in relation to specific instruments or the system. These meetings review for example QAL3 trends, Instrument downtime, valid calibration exceedances, incidents, testing dates, QAL2 reports, and other elements associated with the management of the CEMs.

8.1.12 Oxides of Nitrogen

The reference monitoring location for Oxides of Nitrogen for compliance monitoring will remain at their current location. These CEMs will remain unchanged. This is on the basis that NO_x is unaffected by operation of the PCC activity itself and retaining this CEM location enables a consistent measurement approach in both LCP and PCC modes of operation.

8.1.13 Sulphur Dioxide

Sulphur Dioxide for compliance purposes will be measured at two locations. To monitor PCC operation the analysers will be located at a yet to be defined reference monitoring location within the outlet ducting prior to entering the stack. The flue gas ducting and by association the CEM location are yet to be finalised at the point of submission but will comply with Technical Guidance Note M1 and BS EN 15259.

The second location is the current reference monitoring location which consists of pair analysers on the A and B ID fan discharge ducting. The existing CEMs and locations will remain unchanged.

8.1.14 Particulate Matter

Particulate matter for compliance purposes will be measured at two locations. To monitor PCC operation the analysers will be located at a yet to be defined reference monitoring location within the outlet ducting prior to entering the stack. The flue gas ducting and by association the CEM location are yet to be finalised at the point of submission but will comply with Technical Guidance Note M1 and BS EN 15259.

The second location is the current reference monitoring location which consists of three analysers on the A, B and C flow ESP discharge ducting. The existing CEMs and locations will remain unchanged.

8.1.15 Ammonia

Ammonia for compliance purposes will be measured at two locations. To monitor PCC operation the analysers will be located at a yet to be defined reference monitoring location within the outlet ducting prior to entering the stack. The flue gas ducting and by association the CEM location are yet to be finalised at the point of submission but will comply with Technical Guidance Note M1 and BS EN 15259.

The second location is the current reference monitoring location which consists of pair analysers on the A and B ID fan discharge ducting. The existing CEMs and locations will remain unchanged.

8.1.16 Hydrogen Chloride

Hydrogen Chloride for compliance purposes will be measured at two locations. To monitor PCC operation the analysers will be located at a yet to be defined reference monitoring location within the outlet ducting prior to entering the stack. The flue gas ducting and by association the CEM location are yet to be finalised at the point of submission but will comply with Technical Guidance Note M1 and BS EN 15259.

The second location is the current reference monitoring location which consists of pair analysers on the A and B ID fan discharge ducting. The existing CEMs and locations will remain unchanged.

8.1.17 Carbon Monoxide

Carbon Monoxide for compliance purposes will be measured at two locations. To monitor PCC operation the analysers will be located at a yet to be defined reference monitoring location within the outlet ducting prior to entering the stack. The flue gas ducting and by association the CEM location are yet to be finalised at the point of submission but will comply with Technical Guidance Note M1 and BS EN 15259.

The second location is the current reference monitoring location which consists of pair analysers on the A and B ID fan discharge ducting. The existing CEMs and locations will remain unchanged.

8.1.18 Amine Species

The monitoring of amines can be provided by both continuous and periodic means. The challenge with continuous monitoring is that the expected emission limits and the associated granularity needed for monitoring are very precise with a number of potential interference species also present.

Drax are proposing emission limits of 1mg/Nm^3 Annual Emission Limit (AEL) for primary amines (reported as MEA) and for secondary amines (reported as DMA) AEL of 0.3mg/Nm^3. Based on these limits the instrumentation to be utilised for monitoring would require an equivalent limit of detection for primary amines in the region of 0.01mg/Nm^3 and in the region of 0.003mg/Nm^3 for the secondary amines. These are challenging quantification levels when factoring interference species, speciation, and the limited analysers available within the current marketplace.

8.1.18.1 Monitoring approach

Drax's preference is to identify a suitable instrument that can enable us to achieve continuous monitoring of the emissions at the required level. In that regard both Drax and its contractor are searching for a suitable instrument that can or has the potential to achieve the desired levels. Should the instrument not have a QAL1 M-Certification then we would be looking to the supplier to work either towards this or equivalent through the standards available.

If a suitable continuous emissions monitoring instrument cannot be identified periodic monitoring will be used to monitor amines as required.

8.1.18.2 Instrument/techniques

Drax and our partners are looking to the industry to find a suitable instrument to allow the monitoring of the key amine species or family of species these being primary and secondary in nature. The instruments will be certified to or seeking to be certified of M20 and ISO14181 or an alternative regulatory standard agreed with the EA.

8.1.18.3 Location

Amines will be monitored at a single location on each unit. This location will be downstream of the gas/gas heater and CO2 vent inlet. It will be designed to meet the requirements of Technical Guidance Note M1 and BS 15259as stated in Section8.0.

8.1.19 Aldehydes

The monitoring of Aldehydes can be monitored by both continuous and periodic means.

8.1.19.1 Monitoring approach

Drax's preference is to identify a suitable instrument that can enable us to achieve continuous monitoring of the emissions at the required level. To that regard both ourselves and our contractor are searching for a suitable instrument that can or has the potential to achieve the desired levels. Should the instrument not have a QAL1 M-Certification then we would be looking to the supplier to work either towards this or equivalent through the standards available.

If a suitable instrument cannot be identified periodic monitoring will be used to monitor aldehydes as required.

8.1.19.2 Instrument/techniques

Drax and our partners are looking to the industry to find a suitable instrument to allow the monitoring of the aldehydes. The instruments will be certified to or seeking to be certified of M20 and ISO14181 or an alternative regulatory standard agreed with the EA.

8.1.19.3 Location

Aldehydes will be monitored at a single location on each unit. This location will be downstream of the gas heater and low pressure (LP) CO_2 vent inlet. It will be designed to meet the requirements of Technical Guidance Note M1 and BS 15259 as stated in Section 8.1.5.

8.1.20 Oxygen

Oxygen will be measured at two locations for compliance purposes. To monitor PCC operation the analysers will be located at a yet to be defined reference monitoring location within the outlet ducting prior to entering the stack. The flue gas ducting and by association the CEM location are yet to be finalised at the point of submission but will comply with Technical Guidance Note M1 and BS EN 15259. The second location is the current reference monitoring location which consists of pair analysers on the A and B ID fan discharge ducting.

The existing CEMs and locations will remain unchanged.

8.1.21 Moisture

Moisture for compliance purposes will be measured at two locations. To monitor PCC operation the analysers will be located at a yet to be defined reference monitoring location within the outlet ducting prior to entering the stack. The flue gas ducting and by association the CEM location are yet to be finalised at the point of submission but will comply with Technical Guidance Note M1 and BS EN 15259. The second location is the current reference monitoring location which consists of pair analysers on the A and B ID fan discharge ducting.

The existing CEMs and locations will remain unchanged.

8.1.22 Stack Pressure

Stack pressure will be measured at two locations for compliance purposes. To monitor PCC operation the analysers will be located at a yet to be defined reference monitoring location within the outlet ducting prior to entering the stack. The flue gas ducting and by association the CEM location are yet to be finalised at the point of submission but will comply with Technical Guidance Note M1 and BS EN 15259. The second location is the current reference monitoring location which consists of pair analysers on the A and B ID fan discharge ducting.

The existing CEMs and locations will remain unchanged.

8.1.23 Stack Flow

The stack flow is currently managed in accordance with the standards utilising generation in conjunction with an agreed calculation to determine the flow. This is then verified via a QAL2 test. This will continue to be our approach for stack flow for operation of the generating units without the PCC system in service. However, where the PCC is in service an alternative approach will be required.

The current position of Drax is that we will identify a suitable flow metering or alternative calculation basis on which to utilise with the PCC emission monitoring instrumentation. On this basis the system will be designed with a flow measurement instrument that complies with the required instrumentation and locational requirements and standards.

Should a suitable calculation methodology identified Drax will approach the EA with the approach and seek approval. The process and means by which this would be done will be dependent on the position of this variation at the time the approach is to be sought.

8.2 Periodic Monitoring

There will be a requirement for some periodic monitoring to be undertaken on the outlet ducting of the PCC system to comply with current permit considerations relating to mercury and HF. This will be facilitated by the installation of additional monitoring locations to the standards required by Technical Guidance Note M1 and BS 15259.

The ports will be identified with an appropriate label to clearly identify them as the periodic monitoring ports.

Where periodic monitoring is required it will be undertaken by M-Cert certified monitoring technicians to an agreed sampling standard approved by the EA with all analysis undertaken by a ISO17025 certified laboratory.

8.3 Reference Monitoring Conditions Post PCC

The nature of the PCC activity is unique in that the removal of the carbon dioxide reduces the volume of the flue gas by up to 13%. This results in an increase in concentration of all the present species within the flue gas without any associate mass change. On this basis Drax are proposing that this is accounted for, specifically in relation to the reference monitoring conditions for oxygen within the gas flow.

In a review of the level of carbon dioxide within the gas stream Drax have identified the 95th percentile as being 13.1% (wet). Using this as the basis of setting the associated oxygen level the reference monitoring condition for oxygen post PCC should be 6.9% to account for the volumetric change.

9.0 Carbon Capture Process

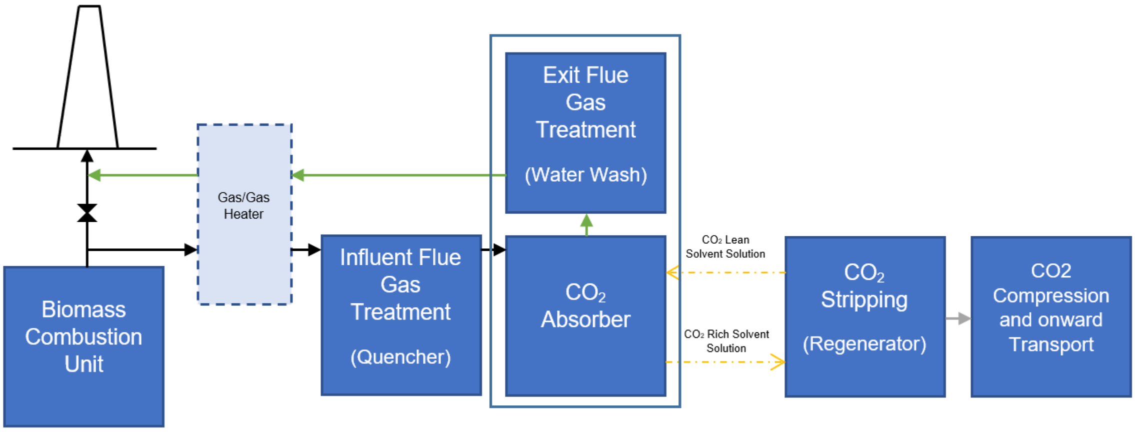
The capture of carbon post combustion can be done in various means but very few of the techniques have achieved a commercially scalable operation. At Drax Power Station we have now trialled three different techniques.

Of these the only one that has commercial potential is the amine-based PCC system. Amine based PCC systems are operating at an equivalent to commercial scale in various location across the globe with a small utilisation system in operation within the UK.

Drax has thoroughly reviewed the various technology options and solvents available and has identified the MHI post carbon capture technology and associated solvent as the best available technology to support the carbon capture ambitions at Drax Power Station. MHI have a long history in carbon capture technologies with a number of commercial industrial application plants in operation as well as one of the world’s largest PCC systems supporting power generation at Petra Nova in Texas. They have developed a proprietary PCC system that embraces the need to maximise efficiency while reducing the environment aspects of the plants operation.

The plant consists of five key activities as shown in **Diagram 3**. These are flue gas pre-treatment, CO2 absorption, solvent regeneration, flue gas emission treatment and CO2 processing and compression.

Diagram 3 Key post-combustion carbon capture activities



9.1 Post Combustion Carbon Capture Technology Selection

Once Drax had determined that an amine-based PCC was optimal, a further review of the various amine solvents and associated capture systems was undertaken. This further narrowed the options based on a number of key characteristics such as thermal efficiency, emissions, capture efficiency, solvent cost etc. This resulted in a pre-FEED process of, in Drax's mind, the best amine based solvent capture systems available. This pre-FEED involved a comprehensive design and, in the case of one system, a solvent trial. This process resulted in the selection of the KS21^{TM} solvent and KM-CDR process due to its lower capital cost (**Table 29**), per kilojoules per kg of CO_2 captured than the other processes and in parallel with lower emission impact due to a number of proprietary design systems and techniques.

Table 29 estimated % capital cost reduction of KM CDR design against industry standard MEA based PCC process

Purchase	Percentage benefit
Pumps	~40
Heat Exchangers	~10
Tower Internals	~20
Filtration Systems	~30
Tanks	~20

9.1.1 Solvent Selection

The solvent selection was based on commercial, technical, and environmental performance. These factors are key to the long-term credibility and viability of PCC in terms of supporting the net zero agenda and for bioenergy energy carbon capture negative emission technology.

A thorough review of the available solvents was undertaken considering single solvent options through to the cutting-edge proprietary solvent blends. This review considered the maturity of the systems and associated real world operation, the related energy demand to capture a kg of CO_2, the lifecycle of the solvent and the environmental impact of the operation.

The review identified that proprietary solvents offered significant benefit over the mature single solvent option of MEA across all aspects of the selection criteria as shown in **Table 30**. This then focused the selection on the proprietary solvents with two taken forward into a pre-FEED process.

Table 30 Comparison of KS21^{TM} to MEA where KS1^{TM} is the baseline

Parameter relative to KS1^{TM}	MEA	KS1^{TM}	KS21^{TM}
Volatility	100	100	50-60
Thermal degradation rate	200	100	30-50
Oxidation rate	500-1000	100	70
Heat Absorption	120	100	85

In terms of emissions, **Table 30** shows significant benefit in terms of volatility, thermal degradation and oxidative rates compared to other reviewed solvents. All key aspects in mitigating the formation and release of reaction by-product and vapour release.

The process also considered total thermal heat demand, electrical output penalty, water demand, solvent consumption, and efficiency. Out of the pre-FEED process, the MHI KM-CDR process was selected utilising their latest solvent technology in KS21^{TM}. The process showed that there was significant life cycle benefit of the process and solvent pairing from a resource, efficiency and emission perspective (**Table 31**).

Table 31 Resource demand of KM-CDR post-combustion carbon dioxide capture technology for Drax Power Station

Parameter	
Capture energy (kJ/kg$_{CO2}$)	2560
Water demand (m3/kg$_{CO2}$)	0.03
Cooling demand (MW$_{th}$/kg$_{CO2}$)	4.14

9.1.2 Environmental Assessment Level Considerations

The EA has published two EALs associated with post composition carbon capture utilising amines. It has also provided guidance in relation to companies providing chemical specific EALs.

Drax's work with MHI has considered all the options available and has determined that the most conservative approach is to use of the published EALs for NDMA. In relation to the secondary amine MHI have provided a EAL based on literature review and identified a substance specific EAL that is lower than that of MEA. To ensure a conservative approach the EAL for secondary amine has been utilised for the assessment. The details relating to this position are identified in **Error! Reference source not found.**.

KS21^{TM} is currently being assessed in relation to REACh in terms of its associated hazards to human health and the environment.

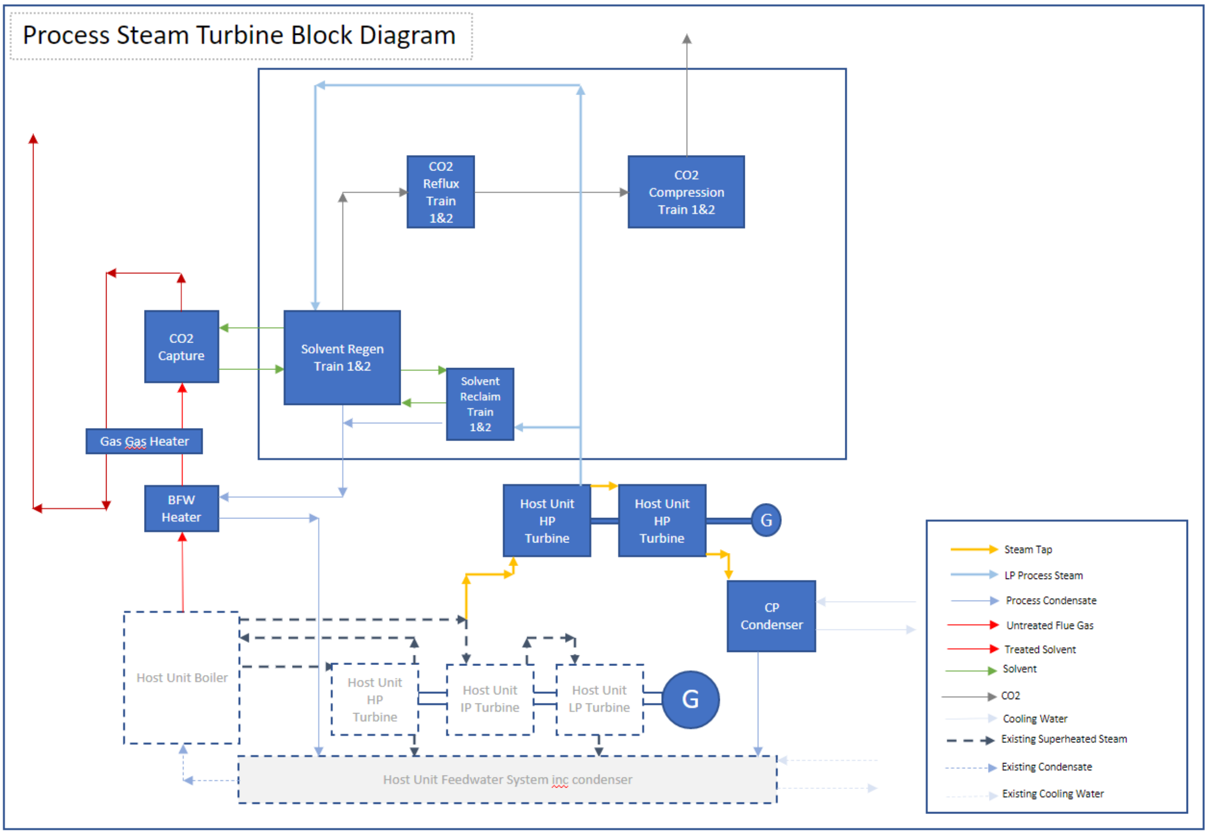
9.1.3 Thermal Integration

Drax, in combination with the PCC provider, have worked to identify and develop a proposal that endeavours to minimise the heat demand requirements of the PCC from the station, while at the same time maximising the utilisation of useful heat within the PCC process.

9.1.3.1 Steam Demand

The layout and plans have developed around the utilisation of hot reheat steam tapped off prior to the intermediate pressure turbine, as shown on **Diagram 4**. This steam will then be transported to the regeneration boiler via a small turbine that will generate ~90MWe required by the PCC unit and to provide process steam at the desired temperature and pressure for the PCC activity.

Diagram 4 Process Steam Turbine Block Flow Diagram



The regenerator boilers and reclaim heaters require around 380MWth of low-pressure steam. The regenerator boiler provides the required heat for the desorption process and is used to heat the dedicated water supply embedded within the solvent.

This is used in each of the regenerators to heat the rich solvent, breaking the bonds between the CO_2 and the solvent releasing the CO_2. This demand has been optimised through the effective holistic heat utilisation across the process where possible. The process Drax have selected is unique in terms of this offering due to the way it utilises the process heat difference between the rich and lean solvents within the process. This includes additional proprietary heat exchangers to interchange and utilises the heat to the best effect, reducing the overall steam and cooling demand of the system.

The reclaim boiler is a batch-based process that supports the quality and longevity of the solvent. The heat here is used to raise the temperature of the lean solvent to separate it from the unwanted HSS and other reaction by-products before the extracted lean solvent is then returned to the lean supply to the absorber.

9.1.3.2 Process Heat Utilisation

The design of the overall process has been developed to maximise the use of inherent heat where suitable due to quality, location and need. The heat is used in three different systems, which are outlined below.

9.1.3.2.1 Solvent Heat Utilisation

To maximise inherent heat utilised, the process has been designed to effectively utilise 150MWth of heat transferred using several significant heat exchangers, maximising the efficiency of the absorption/desorption cycle through the optimal heat transfer.

The majority of this heat is related to the heat transfer from hot lean solvent to the rich cool solvent in preparation for entry into the regeneration towers for desorption. This includes a series of proprietary heat exchangers engineered to support the desorption process maximising the CO_2 removal efficiency by reducing the associated steam demand of each regenerator train.

The primary heat transfer process for amine-based PCC systems is well understood and clearly identified with the BAT guidance as the use of cross flow heat exchangers. These transfer the heat within the lean solvent returning to the absorber to the rich solvent ready for the desorption. This serves a dual purpose through also cooling of the lean solvent and reducing the cooling demand required to optimise the absorption efficiency.

9.1.3.2.2 Process Condensate Heat Utilisation

The design of the process also maximises the utilisation of the heat remaining within the low-pressure steam system. This allows over 10MWth of heat to be fed back into the boiler feed system. This is another example of how the holistic approach to the process has been utilised to optimise the efficiency of the activity.

9.1.3.2.3 Compression Waste Heat

A review was also carried out in relation to the utilisation of the heat resulting from compression. This identified several differing heat sources the majority of which were low grade. There are other challenges associated with the recovery of heat from the compression system. These are available space for siting a heat exchanger of a suitable size, availability of activities requiring the heat, the power to heat recovery balance, and location.

A review of suitability of the heat utilisation from compression undertaken for the site identified that there was a very limited amount of high-grade available heat, around 1.5MW, and up to 20MW of low-grade heat. The report concluded that any benefits in recovering the heat were outweighed due to the limited heat available and the engineering difficulties and expense associated with its recovery.

9.1.3.3 Electrical Demand

As previously mentioned, each PCC system will require in the region of 90MWe for its operation. This will be supplied through the installation of a dedicated turbine for each unit. This will utilise the energy within the steam diverted from the main turbine train prior to the intermediate pressure turbine cylinder. The lower pressure steam fed from the combine power system which then enters the regenerator boiler and heats the solvent solution with the water vapour released, supporting the CO_2 desorption in the regenerator. Each host unit and PCC pairing will have its own dedicated combined power system.

Although this approach is the most effective and efficient way of providing both the heat and electrical load for the PCC system, it does result in an electrical output penalty. The reduced steam flow into the intermediate pressure turbine and subsequently the three low pressure turbines results in around a 200MW electrical output penalty. This reduces the unit output with the PCC in operation to in the region of 475MW_{gen} down from 675MW_{gen}. This is even with the significant benefits in terms of lower heat demand that the KM-CDR when coupled with the KS21^{TM} solvent.

9.2 Operational Control

The KM-CDR process as a PCC system has a well understood operational control ethos. The challenge in the design of the units at Drax is the scale of the system and the interfaces needed with the host unit. The final design of the KM-CDR process as it pertains to the units at Drax is currently on-going with completion of the final design estimated in the first half of 2023, which will include the majority of the final and detailed process control interfaces.

9.2.1 Key Control principle

The selection and subsequent development of the KM-CDR process in partnership with the supplier has been based on the principles of efficiency and minimising environmental impact. The KM-CDR process was identified as having significant operational and environmental benefits over other systems considered.

The system has been developed to minimise heat demand, solvent loss, solvent degradation, water consumption, release to the environment and electrical demand, while maximising the capture rate and overall life of the solvent. The key processes involved in achieving these principles are detailed below.

9.2.1.1 Start up and Shut down

Starting a post-carbon capture plant is not a straightforward process, with the initialisation phase requiring careful balancing between the various system aspects and the host combustion unit. This ensures that the best capture conditions can be achieved and stabilised promptly.

This requires the start-up and shutdown approach to be a parameter-based approach to identify the point of where stable operation achieved. Given that the advanced KM-CDR system is still undergoing final design within FEED, there are still aspects to be finalised preventing the full description of the parameters and or their associated start-up points at this time. It is expected that these will be available post the competition of FEED in the first quarter of 2023.

9.2.1.2 Influent Flue Gas Wet Scrubbing

Flue gas from the Drax PCC operating units first enters the gas gas heater followed by the flue gas quencher tower (wet scrubber). The flue gas quencher is a rectangular tower with structured packing, the primary function of which is the cooling of the incoming flue gas and removal of sulphur dioxide. However, the nature of the quencher also results in a number of secondary improvements in the flue gas quality in relation to the plant operation.

The design principle of the technique relates to the increasing efficiency of CO_2 absorption at lower temperatures and the reduction in the formation of degradation products and HSS associated with the presence of sulphur dioxide and other constituent components of the incoming gas stream.

The flue gas is cooled through direct contact with quench water on the surface of the structured packing. The circulating water is fed to the top of the packing and recirculated through the system. The quench water temperature is controlled within operational design parameter through the application of cooling systems on the return water lines.

Sulphur dioxide is removed from the flue gas stream though the quench water due to solubility and control of alkalinity, with pH controlled via the use of monitoring and make-up pump controls.

In addition to its primary purpose, the quencher tower will also reduce the volume of particulate matter carried into the absorber, as well as reducing other species of concern such as halides and metals. Metals tend to be in either vapour form i.e., mercury, or attached to the particulates such as Iron. These secondary consequences have positive impacts in terms of PCC operation. For example, particulates can support vapour formation and impact the transfer of rich and lean solvents between the two processes. Particulates can also introduce metals that can increase the rate of solvent degradation. Halides such as chlorine have the potential to form HSS and can increase corrosion risks within the plant.

9.2.1.3 Maximising Absorption

The CO_2 absorber is designed to maximise the absorption of CO_2 from the incoming gas stream. The absorber tower itself undertakes two functions, with the lower section being that focused on CO_2 absorption. The tower is a rectangular structure with dimensionally configured structured packaging.

The conditioned flue gas from the quencher tower enters the bottom of the tower and moves up through the structure packing, while lean solvent is supplied at the top of the absorption section. The absorption section of the tower is further split into an upper and lower section. This split is designed to enable additional management of the lean solvent temperature within the absorber. The flue gas time and surface areas are maximised by the packaging design with a view to removing approximately ~95% of the CO_2.

The reaction between the CO_2 and the solvent is exothermic. This heat reduces the efficiency of the reaction, so to overcome this inherent temperature increase the KM-CDR system uses proprietary coolers. These are designed to utilise process conditions within the absorption process to optimise the temperature of the solvent as it transitions through the tower. This ensures that the solvent interactions are optimised within the absorber and CO_2 capture is maximised.

Heat control and utilisation is a key design choice of managing the rich solvent into and out of the regenerator (combination stripping and regeneration system). The purpose of this is to exchange the heat between the rich solvent heading to the regenerator and lean solvent returning to the absorber. This, along with the use of the lean solvent cooling, ensures that the lean solvent is at the optimum available (air and wet bulb related) temperature prior to introduction to the absorber.

9.2.1.4 Solvent Regeneration

The design of the regenerator technique selected by Drax undertakes both the desorption of the CO_2 and regeneration of the solvent used to maximise the life and utilisation of the solvent. Each absorber is supported by two regenerator systems operating in parallel.

The regenerator for desorption utilises steam to release the CO_2 from the solvent. The CO_2 rich solvent is removed from the bottom of the absorber and transferred to regenerator via the crossflow (solution) heat exchanger. This utilises the inherent heat within the lean solvent to further warm the rich solvent prior to entry into the top of the regenerator. This reduces the heat demand required within the regenerator to desorb the CO_2 maximising the overall efficiency of the activity.

Upon entry into the regenerator the rich solvent moves down through the structurally design contact packaging through the heated environment (water vapour and CO_2), releasing CO_2 into the regenerator. Once the solvent reaches the bottom of each regenerator the majority of the CO_2 has been released leaving it depleted/lean. This is aided within the regenerator through the inclusion of further heat exchangers. These use the heat of the lean solvent returning to the absorber to transfer the heat to semi-lean solvent at various stages within the regenerator. The hot lean solvent is then transferred back to the absorber via the crossflow solution heat exchanger and lean solvent cooler to achieve the optimum temperature before once again cycling around the process.

On the return leg to the absorber a specified batch of the lean solvent can be diverted to a reclaiming unit. The purpose of this system is the removal of unwanted elements that can form in the solvent, these being heat stable solids, degradation products, soluble metals, and suspended solids. This process is conducted under a negative pressure environment with heat used to boil off the water and solvent leaving behind the unwanted materials which have higher boiling points. The water and solvent vapours are drawn off and condensed in the reclaim condenser and discharged to the reclaimer vapor drum. The condensed water is transferred to the CO_2 absorber. The solvent element is then circulated between the reclaim heater and the drum.

The remaining materials are then treated with caustic soda which is injected to into the drum. This breaks down the HSS, recovering the solvents bound to them. Over time the impurities reach a concentration that allows their removal via the reclaim waste tank.

The released CO_2 and associated water vapour exit from the top of the desorption tower (regenerator) and enter the regenerator reflux system. Here the gas is cooled within the lower section of the regenerator reflux drum though the use of circulation water, passed over structured packaging. The condensate collects in the drum bottom where it is transferred to the reflux cooler, from here it is then separated, with a proportion transferred to the top of the regenerator and a proportion transferred to the washing section of the absorber.

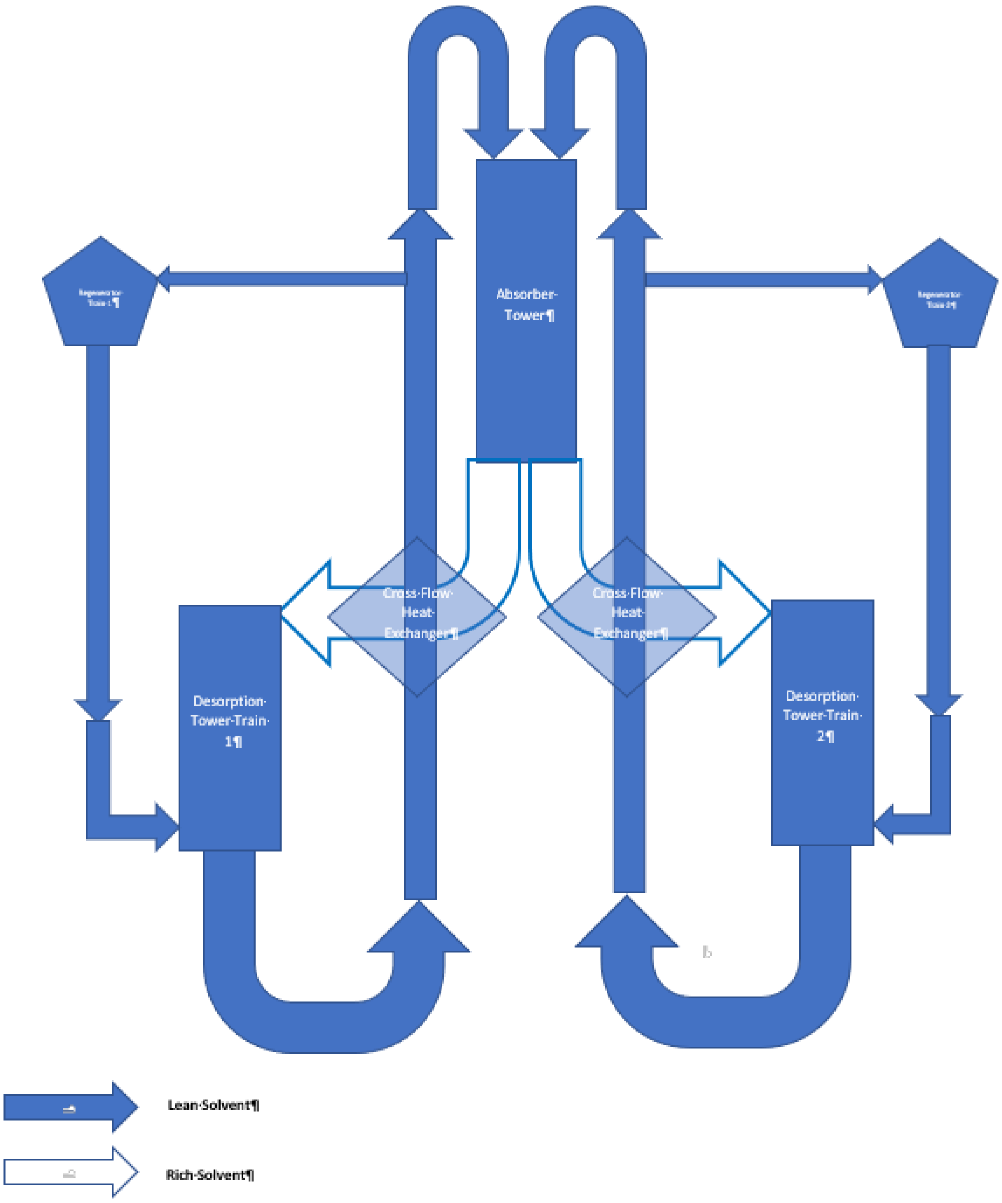
The condensate transfer to the regenerator is undertaken to maximise solvent recovery and the associated life of the solvent, and to minimise virgin solvent usage across the operational life of the plant. The condensate utilised in the absorber wash supports the management of solvent concentration within the in the circulation water. The management of this water stream is addressed in Section 9.2.1.8of this Variation Application.

The CO_2 passes through the lower section of the regenerator drum into the upper CO_2 gas wash section, where packaging and wash water are used to clean the CO_2. This clean CO_2 is then transferred for initial compression before being transferred to the final high-pressure compressors and entry to the transport and storage grid.

Another element of the regeneration process is the control of particulate matter collected within the solvent via the absorber. Although the quencher removes the majority of the particulate, some does carry over and is entrained within the solvent. This can result in fouling, flooding, or erosion within the system. To manage any entrained particulate the system uses a two-stage filtration system. This is designed to manage the maximum expected particulate entrainment, and mitigate the associated negative traits embedded with particulate entrainment.

Each absorber unit at Drax will have two desorption/stripper towers operating in parallel supporting the operations to ensure flexibility in the desorption process within the defined design envelope.

Diagram 5 – Lean Rich Solvent Process Flow



9.2.1.5 Carbon Capture Efficiency

The KM-CDR process when used in combination with the latest reiteration of the solvent in KS21^{TM} is designed to be the most efficient available in terms of carbon capture. The design is guaranteed to deliver 95% capture within the normal operating envelope when operating stably.

Although Drax expect the units to operate in a base load capacity the balance of operation between the host unit and PCC system will cause operational fluctuations that have the potential to impact capture efficiency for periods while systems stabilise or are recovered. It is due to these short duration events that Drax propose that the BAT position of 95% capture efficiency is measured as an annual average of all operational hours above the stable operating threshold.

This will be measured through the use of continuous emission monitors prior to and post the absorber coupled with either a volumetric flow measurement or calculation, the basis of which will be agreed with the EA once the finalised design and instrument details are determined.

9.2.1.6 Post Absorber Flue Gas Treatment

As indicated in Section 7.7.3.2 the absorber tower has two functions. The first of these is the removal of CO_2, whilst the second is the quality control of the CO_2 depleted flue gas that exits the absorber. The quality control system uses several consecutive stages to condition the gas prior to release to the environment via the main stack. The exact number of which will be based on detailed testing and modelling of the influent flue gas composition. The multi-stage process is explained below.

The initial stage is a standard demister system.

The middle stages of the process utilise proprietary demisters in conjunction with structure packing to remove amine solvent vapor, degradation by-products and mists that may have escaped the lower absorber section and to cool the flue gas down to maintain the water balance in the system. The solution within these sections is continuously cooled and recirculated with a proportion removed for treatment and additional make-up solution added as required to maintain levels.

The last stage is designed to be a final reduction system to maximise the reduction of the solvent vapour, mists or degradation by-products. This stage utilises a proprietary demister using an acidic solution to maximise the reduction of amine constituents and additionally some of the ammonia by-product that can be formed in the absorber.

9.2.1.7 CO_2 quality control and venting

The CO_2 quality is controlled prior to it being transported to the compressor and onward to the transportation and storage network. There are periods within the process, specifically around start, up, shut down and some other than normal operating conditions where the CO_2 is not suitable for compression and it will be returned to the stack upstream of the emission monitoring system.

9.2.1.8 Water Demand

The KM-CDR process has been developed to optimise the utilisation of water resource required for its operation. Water demand has long been identified as one of the challenges relating to the operation of a PCC system.

For this reason, MHI has worked to optimise the water needs of the operation and has developed a process that utilises recirculation and reutilisation where possible. A key example of this design principle is the way that water is maintained within the solvent system. The KM-CDR process utilises a self-contained absorption/desorption process which aims to maximise the retention of water, through recovery, reuse, and recirculation within the system.

Additionally, the quench tower is also designed to recirculate the water as much as possible with any effluent processed and returned to the cooling circuit for further recirculation and utilisation.

9.2.1.8.1 Self-contained solvent system

The solvent system has been designed to recover and reuse the demineralised water in several different locations. This results in a low water utilisation requirement for the actual absorption/desorption process of 0.03m^3 per tonne of CO_2 captured.

The water is recovered and utilised in four different locations within the system:

1. The first is the reflux drum which separates out the desorption steam and solvent from the captured CO_2 and returns this back to the system either directly to the process after solvent separation or the absorber tower water wash as make up.
2. The second is the solvent regeneration process, where the water and solvent are separated from the contaminates and returned to the system for recirculation.
3. The third is when the condensate from the high-pressure compression is returned via the reflux drum for reutilisation.
4. The fourth is when the associated waste solvent materials undergo a concentration process which removes as much water as possible, returning the water back to the process.

These recovery processes are effective at maintaining the water within the system and minimising any additional water required across the year.

9.2.1.8.2 Quench Water Recirculation

The quench system is unique in that after the initial fill it generally generates water from the moisture retained within the incoming flue gas. This is then purged from the system periodically to maintain a suitable level. The water from the quench is then treated and added to the station cooling circuit. Although the volume of water is low in volume terms, ~1Mm^3 per annum is still material in relation to supporting sustainable abstraction.

9.2.1.9 Control Monitoring

Drax is working with MHI to finalise the process control systems that will be involved in the operational control of the PCC systems. This includes the key systems to be utilised in maintaining the operational and chemical conditions that could affect the environmental aspects of the operation of the system. The key data associated with parameters, monitors, monitoring locations, operational alarms and actions will not be available until the design is completed in the first quarter of 2023.

9.2.1.9.1 CO_2 Monitoring

The precise location and details of the monitors are not yet available. Given the key nature of this monitoring in relation to the system control and monitoring of CO_2 level, it is expected the M-Cert certified instruments will be employed. The location of the instruments will be selected on the basis of need in relation to process control and not emissions compliance.

These instruments will be used to determine the capture efficiency of the process and the subsequent reporting of this in relation to any reporting obligations.

9.2.1.9.2 Temperature

The control of the solvent temperature is key in relation to a number of aspects of process control and solvent effectiveness. The actual location of the monitoring and associated parameters will not be available until completion of the design.

9.2.1.10 Dispatchable Operation

The generation of electricity from sustainable biomass with post-combustion carbon capture has not been undertaken commercially in the UK before. The primary benefit to adding the PCC to the existing generation units is to generate the negative carbon dioxide emissions across the full biomass supply chain, which is required in order for the UK to meet its future net zero targets and the sixth carbon budget. Accordingly whilst the effect of the addition of the PCC is that the units will produce two valuable products (electricity and negative emissions), the project is being designed with the expectation that it will generally aim to operate baseload to maximise negative emissions. Whilst a subsidy scheme for BECCS is not yet in place to support the development of power BECCS projects in the UK, Drax expects that any future scheme will be designed such that the units will generally be placed in the merit order such that they operate on a baseload basis.

Whilst the units will be able to flex power generation output and associated carbon dioxide capture within defined limits such that Drax can turn down the units in the balancing market where economic to do so or else to support system security, any decision to do so would need to price in and take account of the foregone revenue opportunity from the captured carbon dioxide. Accordingly, it is expected that the units would generally flex generation less frequently than other assets on the Grid.

It was for the reasons above that any additional capital, environmental impact and operational costs required to develop a more flexible and dispatchable system were not appropriate and could not be justified.

The design of the system means that where the PCC is not operating or should an emergency request be made to shut down the PCC activity, the electrical output that can be exported to the electricity grid can be increased to 645MWe. However, again, the expectation is that the project will be generally incentivised to maximise the capture of carbon dioxide except in circumstances where there is insignificant margin on the electricity grid.

10.0 Carbon Dioxide Compression

The design of the compression process is highly dependent on the requirements and associated rules that National Grid Carbon Limited will introduce in relation to the transportation and storge infrastructure. National Grid Carbon Limited are currently in the process of developing and finalising their own DCO and FEED processes, so a significant level of detail is not yet finalised as at the date of this Variation Application.

It is Drax’s intention to design and develop a compression system that is sympathetic to the needs of both the PCC activity and the carbon grid operational parameters and rules. Due to the level of available information, there are several options currently being pursued from an engineering basis. Although this means that several elements are still flexible from an environment release perspective. It is currently envisioned that there will be two potential release activities associate with compression, namely. the high-pressure venting facility and the management of the compression condensate.

10.1 High Pressure CO_2 Venting

There is a need for the high-pressure compression system to have a downstream vent to atmosphere to safety purge to support the operation. This will allow the high-pressure gases to be released safely in a number of circumstances. It is expected that during normal operations these will be of short duration (<1 hour).

However, no operator has any experience of the operation and associated challenges that potentially could arise through feeding CO_2 into transportation and storage grid. This may bring about a number of unforeseen abnormal operating conditions that may result in longer duration venting.

The vent gas stream will contain some trace impurities including solvent and associated impurities of less than 10ppm based on the quality criteria laid down by the transport system operator. Although this criterion is still to be completely finalised and as such further development and change could occur. Until this is finalised a final view of the CO_2 stream and any substance contained within this stream is somewhat variable.

10.2 Condensate

The design of the system has been developed to treat this as a continuation of the solvent system and therefore a resource to be utilised and maximised. This design decision means that this stream will be rooted back to the PCC and processed to allow the continued use of the water and the very small level of KS21^{TM} within the stream. This mean there is no direct pathway to the environment and therefore no environmental release and therefore there is no requirement for any additional treatment or release points.

11.0 Chemical and Solvent Storage, Load and Filling Systems

The PCC requires the support of several different chemicals in its operation as well as some liquid wastes. Several of these are of a volume that will require the installation of associated tanks, delivery and or loading points. The tanks’ location and associated infrastructure has not been finalised, but their design parameter is designed to ensure a BAT position is achieved.

11.1 Tank Storage

The main storage tanks will be located at ground level within an impermeable bund sized to contain either 110% of the largest tank or 125% of the total volume of all tanks within the bund whichever is largest. There will be no drains from these bunds and no penetrations through the bund walls. Any rainwater or spill (should they occur) will be removed by manually started pumps suitable for the chemical substance involved which will transfer the liquids to the appropriate drainage treatment and or storage system.

The storage facilities will comply with all statutory requirements and relevant codes and standards. They will be signed in line with statutory guidance and managed under the environmental management system.

11.2 Small Hazardous/Pollution Risk Materials Container Storage

Storage areas for small container storage such as intermediate bulk carrier, drums, bottles, shall be designed to mitigate the risks to the environment using the following design requirements.

- Storage areas will have appropriately sized bunds or containment systems to prevent uncontrolled release designed to BS8007(BS EN 1992) or equivalent.
- The storage areas will be correctly signed including providing the maximum storage capacity.
- Storage areas will be designed to comply with HSE chemical warehousing requirements in relation to hazard separation and fire prevention.
- Any rainwater and spillages will move to a collection point where they can be manually pumped via an appropriate drainage system.

11.3 Delivery Facilities

Tanks will be filled from tankers. The delivery points will be contained within a bunded area. This will be sized to provide containment for accidental spillages during the unloading process.

11.4 Loading facilities

Tanks containing liquid wastes will be loaded into road tankers. The collection point will be contained within a bunds area. This will be sized to provide containment for accidental spillages during the unloading process.

11.5 Emergency Response

The site has a comprehensive emergency response system underpinned by procedures already in place. This will be updated to reflect the changes and additional risks posed from the new storage and delivery facilities. The site also has a strong working relationship with North Yorkshire Fire and Rescue Service including an embedded officer to help train and develop the onsite fire response team and build the information and working relationships that would come into play during an incident.

Another element to consider which underpins our emergency responses from an environmental perspective is that the site is isolated from the surrounding water bodies and all liquids to be moved offsite have to be pumped.

12.0 Noise

A noise assessment has been undertaken in line with guidance described in BS4142:2014+A1:2019. The method in this standard uses outdoor sound levels to assess the likely effects of sound on people due to the operation of industrial or commercial premises.

The method described in BS 4142 compares the rating level of the sound source with the background sound level. The standard refers to the rating level, which describes the specific source level corrected by acoustic features, where appropriate. The difference in levels established is taken as an initial estimate of the magnitude of the impact:

a. Typically, the greater this difference, the greater the magnitude of the impact;
b. A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context;
c. A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context;
d. The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level,

this is an indication of the specific sound source having a low impact, depending on the context.

Certain acoustic features can increase the significance of the impact over that expected from a direct comparison between the specific sound level of the source and the background sound level. Acoustic features of the source include characteristics that may attract attention such as tonality, impulsivity and intermittency. Acoustic features added to the specific sound level form the rating noise level.

The significance is dependent on both the margin by which the rating level of the specific sound source exceeds the background sound level and also the context in which the sound occurs. Factors taken into consideration for context may include:

a. The absolute sound level at the individual receptor;
b. The character and level of the residual sound compared to the character and level of the specific sound; and
c. The sensitivity of the receptor and whether dwellings already incorporate noise mitigation measures.

For residential receptors, indoor ambient noise criteria for dwellings BS8233:2014 can be used to provide absolute sound level context as a part of the assessment. These levels have been derived from exposure response studies involving transportation noise, however they serve as a useful means of providing context to assessments of similar broad band noise sources.

12.1 Study Area

The study area used in the operational noise assessment is a 2 km radius from the DCO Order Limits, which is based on professional judgement. Noise and vibration effects as a result of the PCC activity would not be significant beyond this point based on the absolute noise levels expected at this distance. At this distance, rating levels arising from the PCC would not exceed the existing background noise levels. Therefore, effects would not be significant outside of this study area.

12.2 Existing Baseline Data

Table 32 presents the representative background sound level (L90) and ambient (Leq) level at each location, selected based on a statistical analysis of the measured sound levels during the monitoring period. The selection process aimed to choose low background sound level events which occurred for 30% of the measurement period.

The locations in **Table 33** and **Diagram 6** (Baseline Noise Survey and Sensitive Receptor Locations) are representative of residential noise sensitive receptors surrounding the PCC activity focusing on Camblesforth, Barlow, Drax and isolated properties in the immediate vicinity. The table includes an indication of the area.

During analysis of the data it was noted that the sound level generally increased after 0400 due to birds singing at the start of the day known as the dawn chorus. While this is a naturally occurring phenomenon, it raises the baseline sound level over the night-time period and has therefore been excluded in order to provide a baseline sound level that reflects the quieter periods during the night.

Table 32 Summary of Short-Term Sound Measurement Results

	Representative Background Sound Level (L_{A90}) dB	Ambient Sound Level (L_{Aeq}) dB

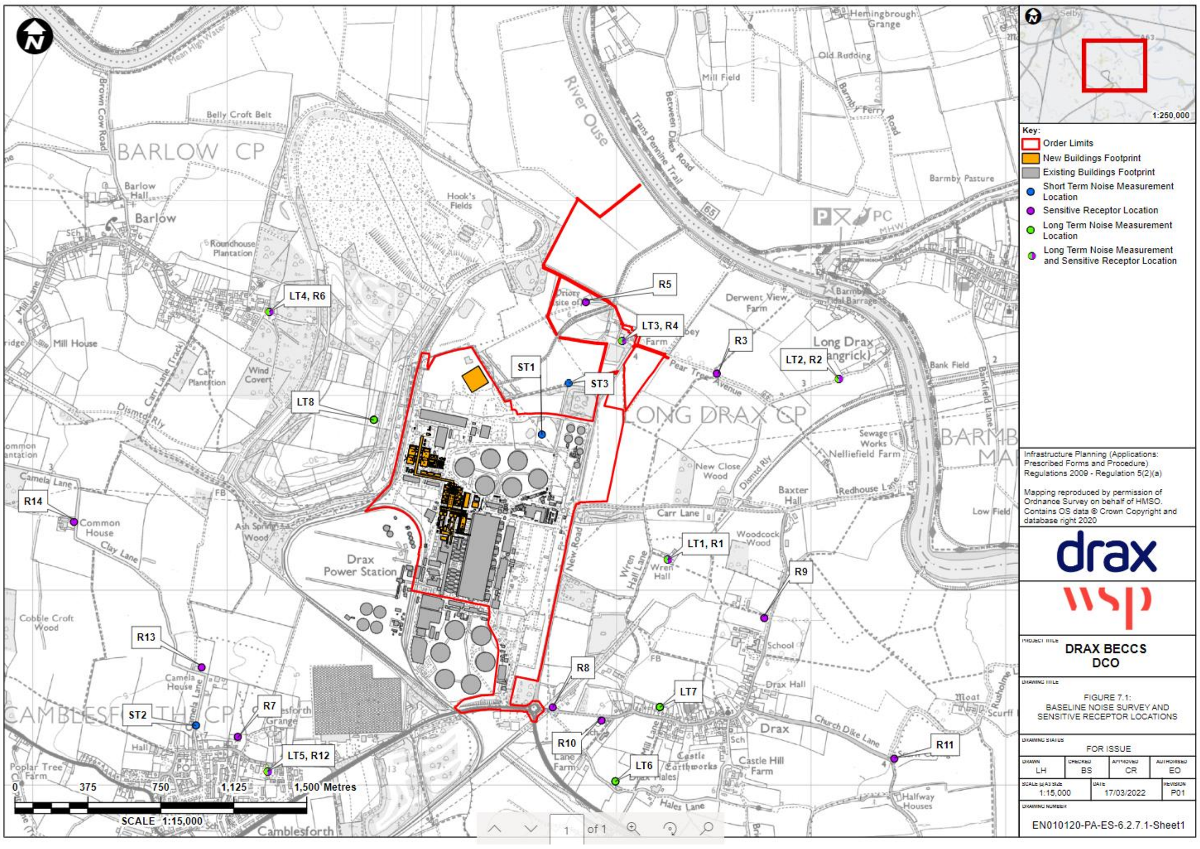
ID	Day	Day
ST1 (north of the PCC)	65	70
ST2 (south-west of the PCC)	35	50
ST3 (north of the PCC)	39	51

Table 33 List of Sensitive Receptor Locations

ID	X	Y	Location Description
R1, Wren Hall (LT1)	467261.9	427158.7	Isolated residential receptor, east of Drax Power Station
R2, Long Drax (LT2)	468142	428087.1	Isolated residential receptor, north-east of Drax Power Station
R3, Old Lodge (LT3)	467515.79	428113.3	Isolated residential receptor, north-east of Drax Power Station
R4, Drax Abbey Farm (LT3)	467028.1	428280.2	Isolated residential receptor, north-east of Drax Power Station
R5, Foreman's Cottage (LT3)	466842.78	428479.71	Isolated residential receptor, north of Drax Power Station
R6, 2 Forest Grove Barlow (LT4)	465215.3	428431.9	Sensitive residential receptors within the village of Barlow, north-west of Drax Power Station
R7, (Permanent Camblesforth)	465054.10	426248.03	Sensitive residential receptors within the village of Camblesforth, south-west of Drax Power Station
R8, Station Cottage, Hales Lane (LT6)	466994.3	426019.2	Isolated residential receptor, south-east of Drax Power Station
R9, Briden Bungalow (LT7)	467759.36	426857.68	Isolated residential receptor, east of Drax Power Station
R10, Weston House (LT7)	466922.76	426331.14	Sensitive residential receptors within the village of Drax, south-east of Drax Power Station
R11, Rose Cottage, Church Dike Lane (LT7)	468427.48	426135.35	Sensitive residential receptors in the vicinity (south) of Rose cottage, south-west of Drax Power Station

R12, Brigg Farm Court (LT5)	465206.3	426071.8	Sensitive residential receptors within the village of Camblesforth, south-west of Drax Power Station
R13, Camela House (Permanent Camblesforth)	464868.23	426604.69	Sensitive residential receptors in the vicinity (east) of Camela House, south-west of Drax Power Station
R14, Low Farm (LT4)	464211.46	427351.12	Sensitive residential receptors receptor, west of Drax Power Station

Diagram 6 Baseline Noise Sensitive Receptors



12.3 Sensitive Receptors

Locations have been selected to assess the likely noise and vibration effects at sensitive receptors over the 2 km operational study area.

Table 33 presents the list of representative assessment receptors, with a description and their OS coordinates. Sensitive receptor locations are shown in **Diagram 6** (Baseline Noise Survey and Sensitive Receptor Locations). The table also shows the associated long term noise monitoring, location in brackets.

Table 33 - Daytime Construction and Decommissioning Noise Levels at Sensitive Receptors

ID	Predicted All Construction Activities Noise Level dB $L_{Aeq,T}$	Measured Ambient Noise Level Day dB $L_{Aeq,T}$	ABC Category - Day
R1, Wren Hall (LT1)	28	63	B
R2, Long Drax (LT2)	25	55	A
R3, Old Lodge (LT3)	28	55	A
R4, Drax Abbey Farm (LT3)	31	49	A
R5, Foreman's Cottage (LT3)	31	49	A
R6, 2 Forest Grove Barlow (LT4)	32	51	A
R7, (Permanent Camblesforth)	29	54	A
R8, Station Cottage, Hales Lane (LT6)	22	54	A
R9, Briden Bungalow (LT7)	27	61	A
R10, Weston House (LT7)	20	61	A
R11, Rose Cottage, Church Dike Lane (LT7)	21	61	A
R12, Brigg Farm Court (LT5)	26	55	A
R13, Camela House (Permanent Camblesforth)	31	54	A
R14, Low Farm (LT4)	32	51	A

12.4 Conclusions

Based on the initial estimate described in BS4142:2014+A1:2019, it is considered that the specific sound source has a low impact, depending on the context, at most noise sensitive receptors. Using **Table 33**, this equates to negligible or minor and low magnitude of noise impact. Results at noise sensitive receptors R6 (Barlow) and R14 (Low Farm) show that there is an indication of an adverse impact of moderate magnitude, depending on the context which is described below.

Contextual considerations have been taken into account include information relating to the likely change in ambient noise levels and further analysis on absolute noise levels and background noise levels.

Table 34 and **Table 36** present the likely change in ambient noise levels expected when the PCC is in operation. This is derived by logarithmically adding the measured noise levels to the specific sound source of the PCC and then comparing the resulting value against the measured noise levels. It can be seen from both daytime and night-time comparisons, that the ambient noise levels would be dominated by the existing sound climate. Therefore, no change in ambient noise levels is expected due to the operation of the PCC at any sensitive receptor.

Secondly, absolute noise levels have been assessed against guidance in Section 7.7 Specific Types of Buildings in BS8233:2014. Predicted noise levels at R13 are the highest noise modelling results, therefore, these levels have been used as a worst-case assessment against BS8233 internal night-time guideline values within bedrooms described in **Table 35**. Results have also been compared against NR25 curve, in **Table 36**, also representative of guideline values for night-time within bedrooms across octave bands frequencies, based on the approximation described in BS8233 Annex B (Informative). The tables assume a noise reduction through a partially open window of 15 dB accordance with advice in BS8233.

Results in **Table 35** and **Table 36** show that internal noise levels at R13 are predicted to be below guideline values during the night-time. For instance, the internal noise level in **Table 35** is predicted to be lower than the guideline value for bedrooms of 30 dB LAeq,8h. Similarly, the internal noise levels presented in **Table 37** are lower than the noise levels on Noise Rating 25 curve at any octave frequency band.

Table 34 - Ambient Night-time Noise Assessment

ID	**Predicted Noise Level, $L_{Aeq,T}$ dB**	**Measured Noise Level, $L_{Aeq,8h}$ dB**	**Predicted Noise Level + Measured Noise Level, $L_{Aeq,8h}$ dB**	**Difference dB**
R1, Wren Hall (LT1)	25	57	57	0
R2, Long Drax (LT2)	20	48	48	0
R3, Old Lodge (LT3)	19	48	48	0
R4, Drax Abbey Farm (LT3)	21	48	48	0
R5, Foreman's Cottage (LT3)	21	48	48	0
R6, 2 Forest Grove Barlow (LT4)	29	43	43	0
R7, (Permanent Camblesforth)	28	47	47	0
R8, Station Cottage, Hales Lane (LT6)	18	48	48	0
R9, Briden Bungalow (LT7)	22	44	44	0
R10, Weston House (LT7)	19	44	44	0
R11, Rose Cottage, Church Dike Lane (LT7)	19	44	44	0
R12, Brigg Farm Court (LT5)	19	44	44	0
R13, Camela House (Permanent Camblesforth)	31	47	47	0
R14, Low Farm (LT4)	30	43	43	0

Table 35 – R13 Night-time Internal Noise Level Assessment

Predicted Noise Level, $L_{Aeq,T}$ dB	**Open Window Attenuation dB**	**Internal Noise Level $L_{Aeq,8h}$ dB**	**BS8233 Night Bedroom $L_{Aeq,8h}$ dB**

31	15	16	30

Table 36 R13 NR 25 Curve Night-time Noise Level Assessment

	Octave Band Frequency $L_{eq,8h}$ dB							
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Outdoor Noise Levels	39	37	38	26	17	3	0	0
Open Window Attenuation	15	15	15	15	10	15	15	15
Internal Noise Level	22	22	22	8	5	5	5	5
Noise Rating 25 Curve	55	44	35	29	25	22	20	18

Table 37 - Summary of Noise Effects

Receptor	Potential Effects	Additional Mitigation	Residual Effects
Noise sensitive receptors surrounding the Order Limits, including isolated properties and the villages Camblesforth, Barlow and Drax.	Likely noise effects arising from the PCC construction traffic	No additional mitigation measures other than those considered as primary mitigation.	**Not significant** T / I / ST
Noise sensitive receptors surrounding the Order Limits, including isolated properties and the villages Camblesforth, Barlow and Drax.	Likely noise effects arising from the construction and decommissioning activities	No additional mitigation measures other than those considered as primary mitigation.	**Not significant** T / I / ST
Noise sensitive receptors surrounding the Order Limits, including isolated properties and the villages Camblesforth, Barlow and Drax.	Likely noise effects arising from the PCC operational traffic	No additional mitigation measures other than those considered as primary mitigation.	**Not significant** P / I / LT
Noise sensitive receptors surrounding the Order Limits, including isolated properties and the	Likely noise effects arising from the PCC operation of the post	No additional mitigation measures other than those	**Not significant** P / I / LT

villages Camblesforth, Barlow and Drax.	combustion carbon capture technology	considered as primary mitigation.	

Key to table:

P/T = Permanent or Temporary, D/I = Direct or Indirect, ST/MT/LT = Short Term, Medium Term or Long Term, N/A = Not Applicabl

Finally, further analysis has been undertaken on the background noise monitoring undertaken by the Applicant. The conclusions of this analysis are summarised below:

a. The initial estimate for the operational noise assessment is based on the background noise levels recorded during 30% of the measurement period. This means that, approximately 70% of the time, the background noise levels are likely to be higher than those selected for this assessment. The conclusions related to operational noise in this chapter are based on a reasonably worst-case assessment; and
b. Permanent noise monitoring undertaken by the Applicant during three months in 2020 indicate that the background noise levels are generally higher than those selected for this assessment. Statistical analysis for the data collected in 2020 at Camblesforth and Barlow is presented in Appendix E - Noise Assessment Charts. (Baseline Noise Statistical Analysis)

The initial estimate combined with the contextual considerations demonstrates that the operational noise effect due to operation of the post combustion carbon capture technology would not be significant.

13.0 Cooling

The PCC activity along with the generation of electricity requires significant levels of cooling. Where possible the system has been designed to utilise as much of the various heat sources as possible. Although this has reduced the level of cooling required there is still a need for around 560MW_{th} in cooling to maximise the efficiency of each PCC activity.

This cooling will be provided principally in two ways. Where cooling is required between specific process activities this will be undertaken by engineered systems, designed to achieve the required level of cooling in the most efficient way accounting for the environment and space available. Whereas the cooling needs to supply cooled water for these activities will be provided by the reutilisation of the current natural draft cooling towers located at the north of the site.

13.1 System coolers

These will be designed and developed to optimise the cooling requirement based on the location and space available. They will generally be a liquid and plate cooled system where possible, but the section of cooling type will be based on the most efficient available based on space and cooling levels required.

These are generally positioned to provide cooling to various solvent systems, such as lean solvent prior to the absorber, quenching water cooling, fan and equipment cooling and steam systems. The design of the coolers will account for the environmental risk associated with potential leak/failure.

This is especially key in relation to the management of solvent cooling water interfaces. The design of the system is based on the principle that the coolers to be used will ensure that solvent cannot transfer to the cooling water system by nature of the design. However, this finalised design is currently subject to FEED and not fully developed, with more detailed information expected to be available by close of March 2023.

13.2 Natural Draft Cooling

Natural draft cooling is classified as BAT for non-coastal stations where once through cooling is not a viable option. This is due to the high degree of cooling that natural draft cooling offers though the nature of the design to cool the water. This maximises the cooling for minimal additional energy demand. In terms of the station operation, it also negates the need for the installation of additional cooling in the most anticipated, four-unit operating position beyond 2027.

14.0 Discharges to Water

The carbon capture system has several key activities in which water comes in to contact with potential pollutants. This is a position that is recognised and mitigated within the design of the KM-CDR process and the wider process design. This includes compartmentalisation of areas based on potential pollution/substances manage within each area. This in its most basic form means that area managing acid, caustic and solvents will be independent of each other and will managed in a way specific for each of these substances based on hazards and concentrations etc.

Additionally, the process has been developed to maximise the utilisation and maintenance of water within the PCC system, reducing the volume of water requiring treatment prior to discharge. This is a concept which has significant relevance where the water directly interfaces with the solvent, with the KM-CDR process underpinned by the concept of maximising solvent life within the system and minimising water utilisation.

It is due to these inherent design features that Drax is confident that the installed system will mitigate the risk of deterioration in the quality of the discharges of water from the site. The whole FEED design principles are based on this premise and although the designs are not finalised, process reviews undertaken have identified the treatment process required maintains the status quo. Drax will therefore provide the detail design, including operational control information and discharge qualities, by the end of March 2023.

14.1 Potential discharges and associated controls

Throughout the development process the issue of discharges to water has been a principal consideration of the project team. This approach has ensured that areas and processes that had a potential risk in relation to polluting substances and discharges to water were identified early. This allowed for a strategic review of the processes and associated risk to be undertaken and clear mitigation objectives to be identified and incorporated with the FEED process.

14.1.1 Solvent and water wash

The whole process encompassing the capture and release of CO_2 incorporates an inherent need for water and its direct interaction with the KS21^{TM} solvent. An interaction that has to be carefully managed both in terms of maximising the use of a key process resource but also in terms of solvent life cycle.

One of the key ways of maximising the solvent life cycle is to manage the water within the system. To do this the KM-CDR process is based on a sealed system approach. The design basis is to retain as much of the water and solvent within the PCC system as possible, with losses limited to vapour releases, degradation and unwanted reaction by-product removal, and solvent waste.

In terms of discharges to water, the current engineering design would ensure there is no source of solvent contaminated water that would be released to either surface or ground water from the PCC process. All materials other than the vapour element are managed as waste streams and are covered in Section 15.0.

14.1.2 Quencher Tower

The purpose of the quencher tower is to manage the influent gas quality and temperature prior to entry into the absorber. This is done by the utilisation of a wet scrubber utilising an alkali water-based solution. This removes a number of unwanted constituents from the gas stream such as sulphur dioxide as well as further reducing the overall flue gas temperature.

The nature of the process means that water comes into direct contact with the flue gas with the purpose of specifically removing several constituents. Due to this, the wastewater stream from this process will contain various pollutants. For this reason, this effluent stream will undergo specific treatment before being returned to the cooling system for recirculation. The nature of the interaction has identified trace metals such as mercury, chromium, cadmium as potential contaminant associate with particulate and gas contact and ammonia, chlorides and sulphur compounds relating to the general gas contact.

Given that the technology that Drax is going to employ is the first of its kind in terms of size and scale, there is limited information in relation to BAT for these effluents. On that basis a review of a number of related BAT reference documents was undertaken including the large combustion and large volume organics sectors.

On this basis the types of treatment techniques that are considered BAT were reviewed these alongside the pre-FEED documents. This clearly shows that the contaminated effluent can be treated to a level to allow its return to the cooling system for further recirculation.

14.1.3 Chemical storage areas

The chemical storage areas will be bunded and any build-up of liquids within the bunds do have potential to contain small quantities of the stored substances. This is why these are tested prior to discharge and either treated as rainwater or contaminated and therefore a waste stream as detailed in Section 15.0.

This means that there is no potential source in terms of discharges to surface or ground water during normal operations.

14.1.4 Plant drainage

The ethos of the plant drainage associated with the PCC system is one of segregation based on substance. This will ensure if there were to be leaks of potentially incompatible substances that mixing would be prevented. However, it also means that the drainage in these areas can be managed in the most applicable way.

This mitigates any risk of these potentially contaminated water being a source of pollution in relation to ground or surfaces waters.

14.1.5 System Cooling

The process has numerous system coolers that are cooling solvent or solvent containing liquids. This creates a potential risk of cross contamination should a leak occur if direct interface cooling systems are used. Due to this risk a number of engineered alternative options have been investigated. This work determined that coolers systems are available that provide a designed solution preventing direct cross contamination of the either system.

On the basis that these types of cooler are available and suitable for the application, the FEED design has been updated to require a cooler design that prevents cross contamination where cooling water is used to cool solvent or solvent bearing liquids

14.2 Compressor condensate

Due to its nature, the condensate from the compressors has the potential to contain solvent. For this reason, any condensate from the compressors will be returned back to the PCC system for reincorporation within the process.

This approach negates the discharge of this stream and maintains the solvent and water within the closed system.

14.3 Treatment plant design

The treatment plant for the industrial effluents will be designed on the basis of no deterioration to the current effluent discharges from the power station, based on the maximum expected effluent concentrations provided by the system designer once finalised and a conservative dilution capacity of the receiving cooling circuit.

The treatment plant will use a combination of but not limited to pH control, chemical coagulation, flocculation, settling and filtration to achieve the required output concentrations. These concentrations are shown in **Table 38** and are based on the current requirements for the site and research related to various sector best available technique conclusion reviews.

Table 38 treatment plant effluent discharge concentration requirements

Species	Units	Effluent discharge maximum level
Total Organic Carbon (TOC)	mg/l	50
Total Suspended Solids	mg/l	30
Fluoride	mg/l	25
Arsenic	µg/l	50
Sulphate	g/s	2
Cadmium	µg/l	5
Chromium	µg/l	50
Copper	µg/l	50
Mercury	µg/l	3
Nickel	µg/l	50
Lead	µg/l	20
Zinc	µg/l	200

14.4 W1 discharge to river

The site currently returns the cooling water, rainwater, river sludge and FGD effluents back to the River Ouse at permitted discharge point W1 [SE685275]. This discharge point is currently subject to discharge limits for the parameter shown in **Table 39**. Given that the PCC and associated activities will be designed to either manage effluents as a waste stream or treat them to ensure they will maintain the quality of the discharges in line with the current permit requirements it is our view that these limits continue to be applicable in relation to the discharge.

Table 39 Current Permit Discharge Parameters

Parameter	Units	Limit	Reference Period	Frequency
Flow	m^3/day	302,400	Day	Continuous
pH		6-9	Instantaneous	Continuous
Temperature	°C	30	Instantaneous	Continuous
Total ammonia (as nitrogen)	mg/l	0.5	Monthly Average of weekly spot sample	Weekly Sample
Mercury	mg/l	0.005	Monthly spot sample	Monthly
Cadmium (Total cadmium)	mg/l	0.01	Monthly spot sample	Monthly

It is on the basis of no deterioration The associate environmental consequence of the discharge remains unchanged, as shown by the H1 assessment. On the basis of conservatism, those applicable additional species identified as having limits for discharge location W2 were added to the H1 assessment with a conservative dilution factor applied to account for the discharge to cooling for recirculation prior to discharge to the river was not applied.

In relation to the discharge flow requirements for the station, the current pumps that govern the discharge flow will not be altered as part of the PCC installation so the flow levels form the station will remain unchanged.

14.5 Sampling regime

As an operator we currently utilise in house resource to undertake periodic sampling, analysis and the operate and maintain our continuous emission monitors. This is expected to continue in relation to the environmental monitoring.

14.5.1 Continuous Monitoring

Drax currently have a robust and mature system in place for the management of our water continuous emission monitors. This has been subject to Operator Assessment Audits by the EA and scored in the high 90% for overall compliance with the audit requirements.

14.5.1.1 Temperature

The temperature is currently measured using a resistance thermometer fitted in a tube just before the discharge location. This instrument, maintenance, calibration and alarms will remain unchanged should the current discharge limits be retained through the determination process. Any changes made during determination will be managed by the management of change process defined within the environmental management system.

14.5.1.2 pH

The current pH measurement is undertaken using a potentiometric measurement between a measuring electrode (glass) and a potential stable reference electrode. With the potential difference changes being used to determine change in pH of the outfall.

This probe along with the maintenance, calibration and alarm systems will be retained should the limits remain unchanged through determination. Any changes made during determination will be manage by the management of change defined within the environmental management system.

14.5.1.3 Flow

The current meter is two pairs of identically matched ultrasonic transducers clamped to the pipe and connected to a transmitter. The transmitter measures the difference of the transit time of ultrasonic pulses propagating with and against flow direction. This time difference is a measure for the average velocity of the fluid along the path of the ultrasonic beam. The meter will remain unchanged as the flow characteristic of the discharge will remain unaltered.

14.5.1.4 M-Certs

Both the pH and flow monitoring are carried out in accordance with M-Certs. The pH probe is a M-Cert instrument which is maintain and calibrated in line with the requirements of M-Cert and the OEM. Calibration standards used are traceable to national standards.

The flow meters are all M-Cert certified, and the system is operated and maintain in line with its own quality management system, audited by an approved third party to ensure it complies with the required EA standard.

14.5.2 Periodic Monitoring

Periodic sampling is currently undertaken directly by Drax. The schedule is managed through the use of an electronic system, currently Laboratory Information Management System. The frequency of sampling is derived from the permit requirements and operator knowledge.

The sample collection method and any associated stabilisation requirements are determined to suit the required species and the media the substance may be contained within, in line with the method being used as defined by laboratories ISO17025 certification requirements.

Where a sample has to be sent to third party test houses to allow a ISO17025 certified test to be undertaken, the sampling and associated media will be managed to those required by the third-party laboratory.

All of this is subject to our internal ISO17025 certification quality management system and detailed in an internal client contract reviewed annually.

14.6 Discharge Limit Proposals

Given the design of the PCC system and the associated risks Drax are proposing the limits for discharging to W1 remain unchanged as shown in **Table 40**.

Table 40 Proposed discharge limits for W1

Parameter	**Units**	**Limit**	**Reference Period**	**Frequency**
Flow	m^3/day	302,400	Day	Continuous

pH		6-9	Instantaneous	Continuous
Temperature	°C	30	Instantaneous	Continuous
Total ammonia (as nitrogen)	mg/l	0.5	Monthly Average of weekly spot sample	Weekly Sample
Mercury	mg/l	0.005	Monthly spot sample	Monthly
Cadmium (Total cadmium)	mg/l	0.01	Monthly spot sample	Monthly

It is recognised that the current proposal is based on the development of a water treatment system designed to ensure no deterioration in the current quality of the cooling waters on site. On this basis Drax are proposing operational trigger levels on the discharges of the treatment facility to the cooling system as shown in **Table 41**

Table 41 proposed operational trigger levels for water treatment effluent discharges

Species	**Units**	**Effluent trigger level**	**Reference Period**	**Frequency**
Total Organic Carbon (TOC)	mg/l	50	Monthly spot sample	Monthly
Total Suspended Solids	mg/l	30	Monthly spot sample	Monthly
Fluoride	mg/l	25	Monthly spot sample	Monthly
Chloride	mg/l			
Arsenic	µg/l	50	Monthly spot sample	Monthly
Cadmium	µg/l	5	Monthly spot sample	Monthly
Chromium	µg/l	50	Monthly spot sample	Monthly
Copper	µg/l	50	Monthly spot sample	Monthly
Mercury	µg/l	3	Monthly spot sample	Monthly
Nickel	µg/l	50	Monthly spot sample	Monthly
Lead	µg/l	20	Monthly spot sample	Monthly
Zinc	µg/l	200	Monthly spot sample	Monthly

14.7 Site rainwater drainage

As part of the retrofit of the PCC system several of the current rainwater gullies will need to be diverted. This diversion has been designed to maximise the utilisation of the water within the site boundary, with the collected rainwater in these areas routed to the Drax cooling system to support cooling and provide a small but important reduction in our make-up abstraction needs. As a secondary option the drainage will still be able to be transferred direct to purge to allow for continued operation where cooling systems they feed are on outage or drained.

The current route onsite is a direct pumped operation to purge. The new system retains the control pumps but allows the collected rainwater to be utilised as cooling water improving the sustainable position of the station, recognising the importance of water as a resource and trying to offset (even in small ways) abstraction where we can.

15.0 Waste Disposal

The site has a mature and effective waste management system in place to achieve the requirements of the current permitted activities. This system forms part of the site environmental management system. This system achieves circa 80% recycling and less than 5% going to landfill.

Drax continually looks to improve on our current systems by examining the wider industry for examples of best practice in parallel with partnership working with embedded contractors to identify innovative solutions to manage our waste streams.

The operational waste from the PCC activity will be incorporated within this system with activity specific waste stream disposal solutions identified at the earliest opportunity depending upon the composition and physiochemical properties.

15.1 Carbon Capture Specific Process Waste Streams

Several PCC specific waste streams have been identified, with the projected production volume as shown in **Table 42**. These streams are from the operational management of the various liquids involved in the process and their associated treatment wastes. The majority of these materials are expected to be hazardous in nature, but the precise composition and hazardous properties required to make an assessment under the EA WM3 guidance is not available.

Table 42 PCC specific wastes and projected volumes

Waste Stream	**Proposed EWC**	**Generation t/annum**
Concentrated Sludge from Quencher column	07 07 11 sludges from on-site effluent treatment containing dangerous substance	<1500
Regeneration waste	07 07 04 other organic solvents, washing liquids and mother liquids	3435
Amine Solvent Wastes	07 07 04 other organic solvents, washing liquids and mother liquids	2102
Precoat filter cake	07 07 10 other filter cake and spent absorbents	37
Dehydration catalyst	16 08 07 spent catalysts contaminated with dangerous substances	54

15.2 Minimisation approach

Where possible the New Activity will look to minimise the production of waste through processes or techniques suitable for the associated application. As an example of this the process is designed to minimise the production of solvents waste through influent gas conditioning, solvent filtration, and online solvent treatment to maximise the solvents life cycle. These processes are effective at minimising the level of new solvent required.

15.3 Segregation

The waste management system on-site already has a facility to segregate waste into over 40 different waste streams to maximise the recycling, treatment and recovery over landfill. These segregation principles will be incorporated within the PCC plant based on the types, quantities and location of the various wastes being produced.

15.4 Hazardous waste and WM3 approach

The site operates a hazardous waste separation system on site with a dedicated facility used to manage hazardous waste produced in relatively small quantities on-site i.e. drums, IBC etc. This system will continue to be used and embedded within the new plant facilities based on need.

These materials along with those hazardous waste streams produced in reasonably significant volumes will then be accessed for transport and disposal utilising where appropriate with the EA's technical Guidance WM3: Waste Classification – Guidance on the classification and assessment of waste. Once assessed these details will be shared with potential treatment partners to identify the available options and their position on the waste hierarchy to allow an informed decision on treatment/recovery/disposal route to be made.

16.0 Environmental Management System

Drax Power Station has operated a certified environmental management system since before the introduction of ISO14001. This provides a mature and well-established site management on which to build those new and additional elements that are needed to operate the PCC system.

16.1 Integrated Management system and ISO14001 certification

Drax Group now operate an integrated management system within the generation side of the business. This incorporates the overarching documents and system management elements of the management system as required by the ISO14001 certification. The main compliance system documents remain within the station specific governance system.

16.2 Site-specific Management System Philosophy

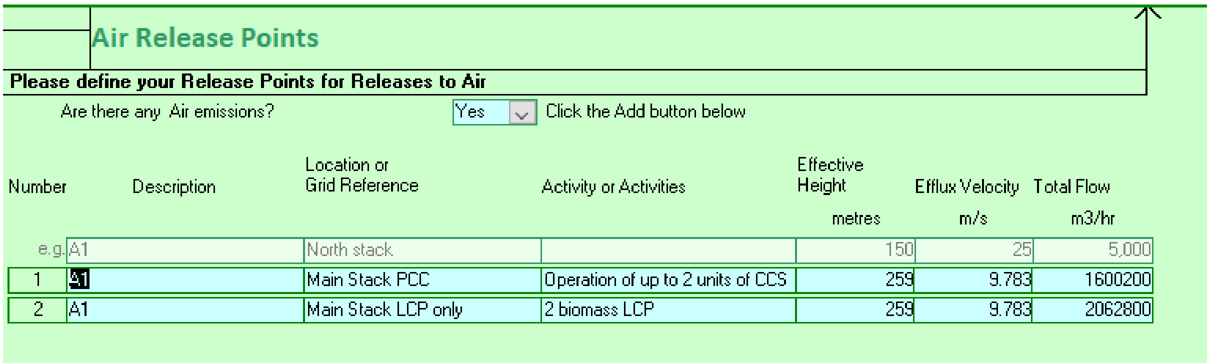
The site operates three different document types. The highest of these are management instructions. These documents provide the key activity management requirements of the associated aspect/activity they are related. They provide the specific requirements, responsibilities and training needs that are required to appropriately control/mange the process and associated aspects.

The next level of documents is work instruction. These provide the job/task related instructions at a doing level. They generally manage the majority of routine tasks undertaken to operate and maintain the power station.

The third set of documents are information notes. They provide specific detail or information relating to a specific activity or regulatory need. They support the other two documents by providing more detail on specific elements or regulations.

Appendix A. H1 risk assessment tool output tables

Table A1 Air Release point data



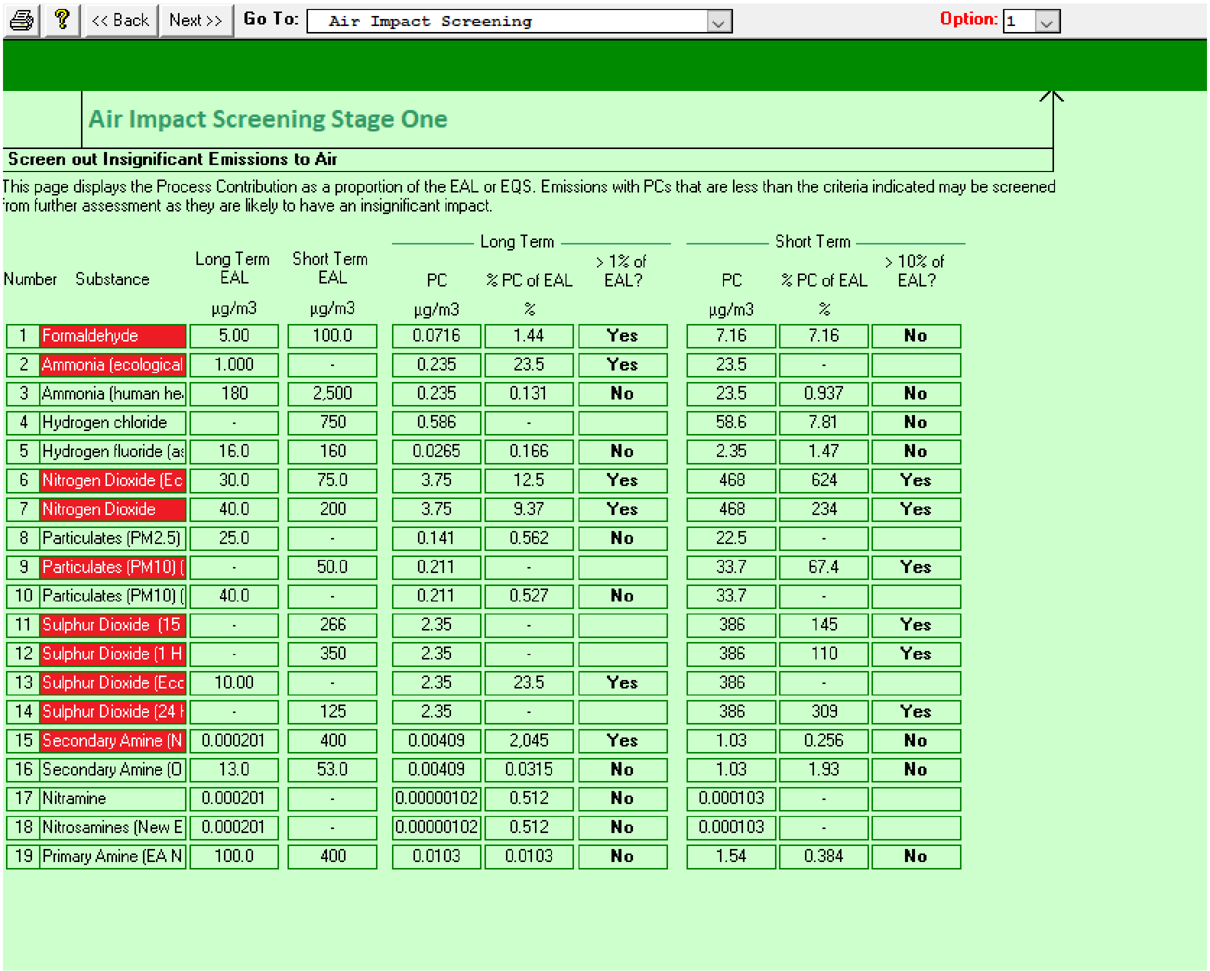
Air Release Points

Please define your Release Points for Releases to Air

Are there any Air emissions? Yes

Number	Description	Location or Grid Reference	Activity or Activities	Effective Height metres	Efflux Velocity m/s	Total Flow m3/hr
e.g.	A1	North stack		150	25	5,000
1	A1	Main Stack PCC	Operation of up to 2 units of CCS	259	9.783	1600200
2	A1	Main Stack LCP only	2 biomass LCP	259	9.783	2062800

Table A2 Air Impact Screening stage one PCC scenario



Go To: Air Impact Screening

Option: 1

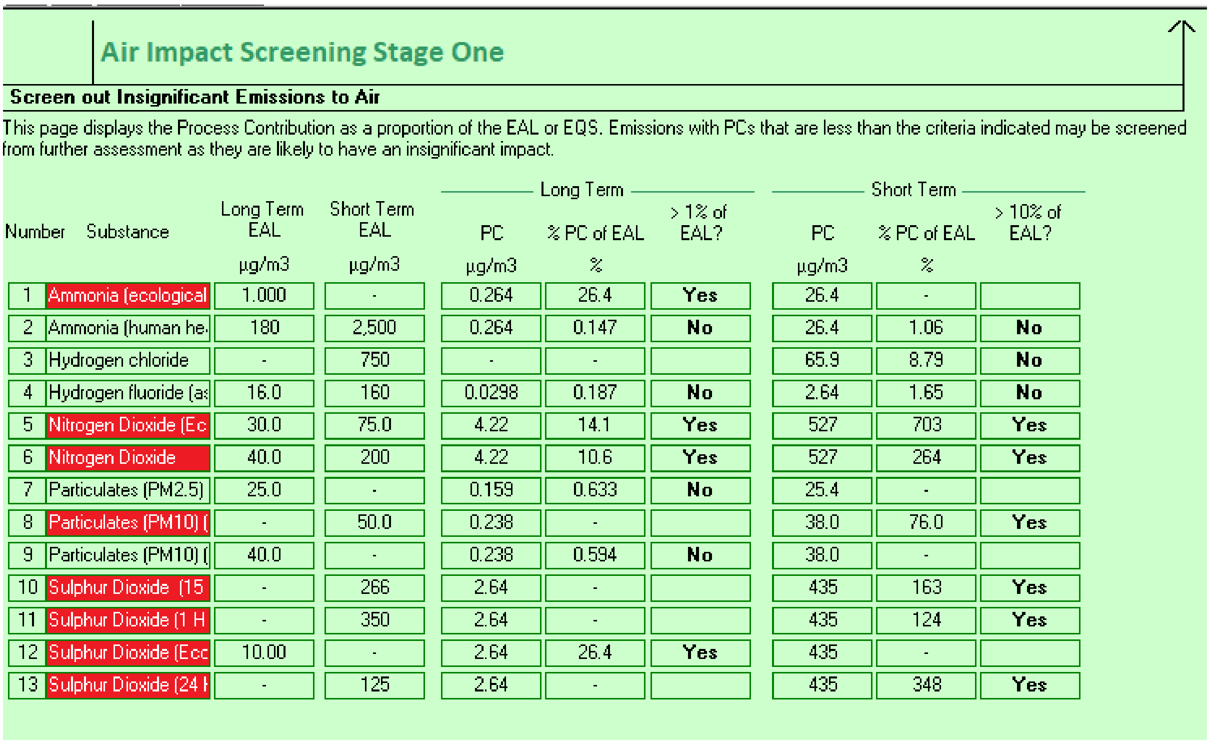
Air Impact Screening Stage One

Screen out Insignificant Emissions to Air

This page displays the Process Contribution as a proportion of the EAL or EQS. Emissions with PCs that are less than the criteria indicated may be screened rom further assessment as they are likely to have an insignificant impact.

				Long Term			Short Term		
Number	Substance	Long Term EAL µg/m3	Short Term EAL µg/m3	PC µg/m3	% PC of EAL %	> 1% of EAL?	PC µg/m3	% PC of EAL %	> 10% of EAL?
1	Formaldehyde	5.00	100.0	0.0716	1.44	**Yes**	7.16	7.16	**No**
2	Ammonia (ecological	1.000	-	0.235	23.5	**Yes**	23.5	-	
3	Ammonia (human he	180	2,500	0.235	0.131	**No**	23.5	0.937	**No**
4	Hydrogen chloride	-	750	0.586	-		58.6	7.81	**No**
5	Hydrogen fluoride (as	16.0	160	0.0265	0.166	**No**	2.35	1.47	**No**
6	Nitrogen Dioxide (Ec	30.0	75.0	3.75	12.5	**Yes**	468	624	**Yes**
7	Nitrogen Dioxide	40.0	200	3.75	9.37	**Yes**	468	234	**Yes**
8	Particulates (PM2.5)	25.0	-	0.141	0.562	**No**	22.5	-	
9	Particulates (PM10) (	-	50.0	0.211	-		33.7	67.4	**Yes**
10	Particulates (PM10) (	40.0	-	0.211	0.527	**No**	33.7	-	
11	Sulphur Dioxide (15	-	266	2.35	-		386	145	**Yes**
12	Sulphur Dioxide (1 H	-	350	2.35	-		386	110	**Yes**
13	Sulphur Dioxide (Ecc	10.00	-	2.35	23.5	**Yes**	386	-	
14	Sulphur Dioxide (24 I	-	125	2.35	-		386	309	**Yes**
15	Secondary Amine (N	0.000201	400	0.00409	2,045	**Yes**	1.03	0.256	**No**
16	Secondary Amine (O	13.0	53.0	0.00409	0.0315	**No**	1.03	1.93	**No**
17	Nitramine	0.000201	-	0.00000102	0.512	**No**	0.000103	-	
18	Nitrosamines (New E	0.000201	-	0.00000102	0.512	**No**	0.000103	-	
19	Primary Amine (EA N	100.0	400	0.0103	0.0103	**No**	1.54	0.384	**No**

Table A3 Air Impact Screening stage one Baseline



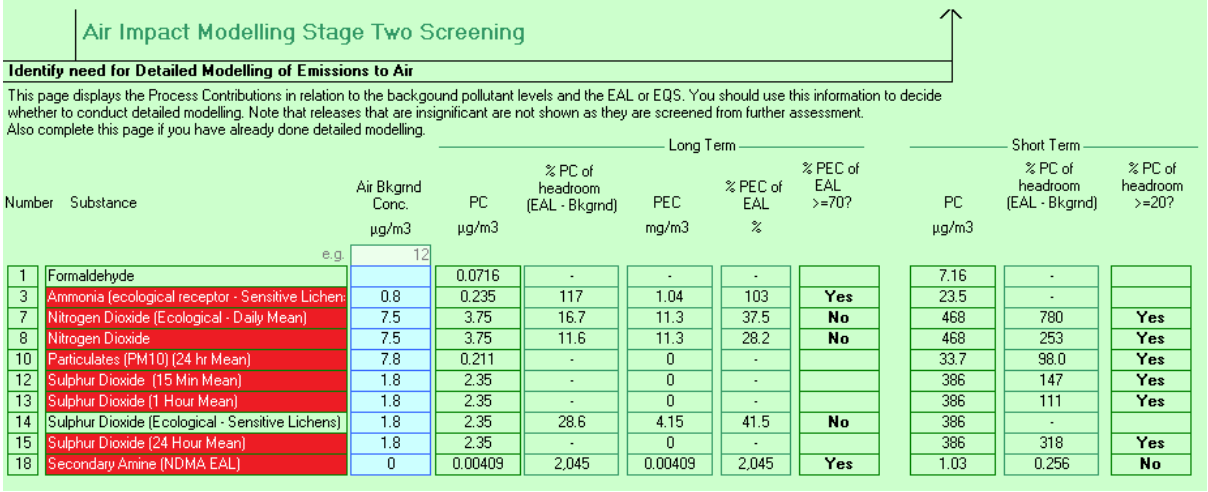
Air Impact Screening Stage One

Screen out Insignificant Emissions to Air

This page displays the Process Contribution as a proportion of the EAL or EQS. Emissions with PCs that are less than the criteria indicated may be screened from further assessment as they are likely to have an insignificant impact.

Number	Substance	Long Term EAL µg/m3	Short Term EAL µg/m3	Long Term PC µg/m3	Long Term % PC of EAL %	Long Term > 1% of EAL?	Short Term PC µg/m3	Short Term % PC of EAL %	Short Term > 10% of EAL?
1	Ammonia (ecological	1.000	-	0.264	26.4	**Yes**	26.4	-	
2	Ammonia (human he	180	2,500	0.264	0.147	**No**	26.4	1.06	**No**
3	Hydrogen chloride	-	750	-	-		65.9	8.79	**No**
4	Hydrogen fluoride (as	16.0	160	0.0298	0.187	**No**	2.64	1.65	**No**
5	Nitrogen Dioxide (Ec	30.0	75.0	4.22	14.1	**Yes**	527	703	**Yes**
6	Nitrogen Dioxide	40.0	200	4.22	10.6	**Yes**	527	264	**Yes**
7	Particulates (PM2.5)	25.0	-	0.159	0.633	**No**	25.4	-	
8	Particulates (PM10) (	-	50.0	0.238	-		38.0	76.0	**Yes**
9	Particulates (PM10) (	40.0	-	0.238	0.594	**No**	38.0	-	
10	Sulphur Dioxide (15	-	266	2.64	-		435	163	**Yes**
11	Sulphur Dioxide (1 H	-	350	2.64	-		435	124	**Yes**
12	Sulphur Dioxide (Ec	10.00	-	2.64	26.4	**Yes**	435	-	
13	Sulphur Dioxide (24	-	125	2.64	-		435	348	**Yes**

Table A4 Air impact modelling stage two screening PCC scenario



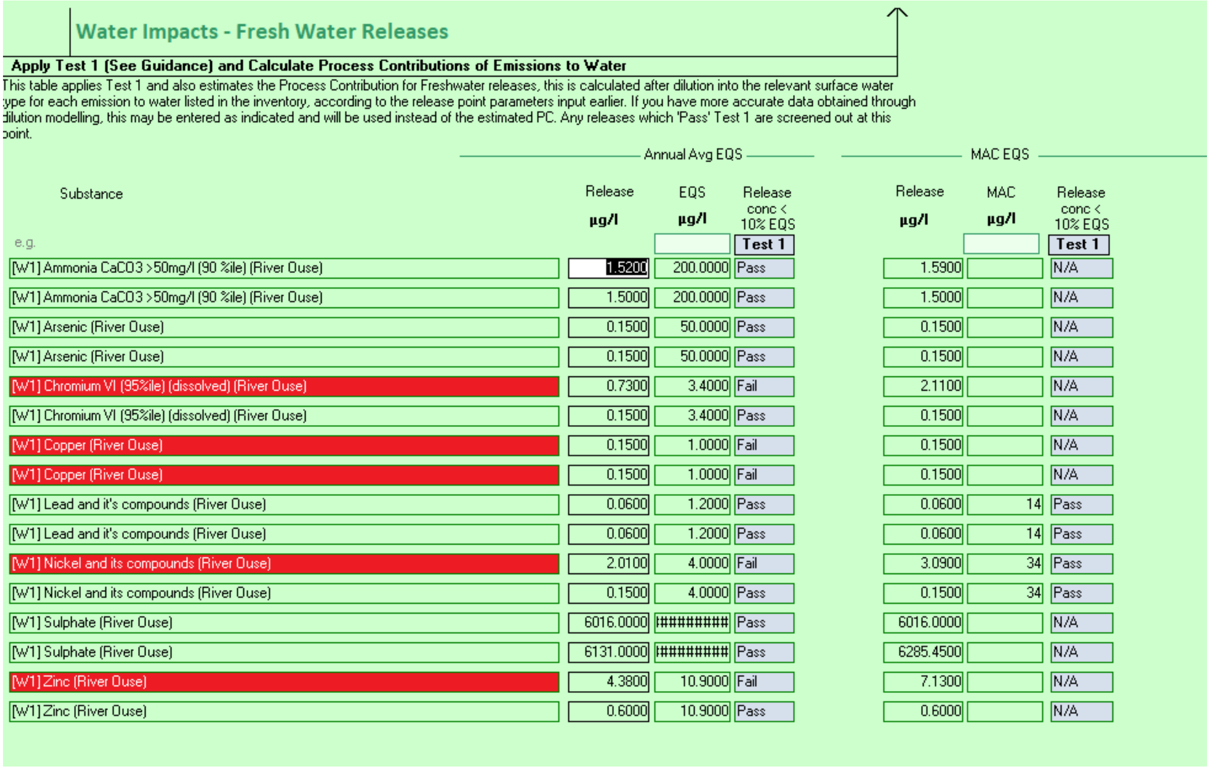
Air Impact Modelling Stage Two Screening

Identify need for Detailed Modelling of Emissions to Air

This page displays the Process Contributions in relation to the backgound pollutant levels and the EAL or EQS. You should use this information to decide whether to conduct detailed modelling. Note that releases that are insignificant are not shown as they are screened from further assessment.
Also complete this page if you have already done detailed modelling.

Number	Substance	Air Bkgrnd Conc. µg/m3	Long Term PC µg/m3	Long Term % PC of headroom (EAL - Bkgrnd)	Long Term PEC mg/m3	Long Term % PEC of EAL %	Long Term % PEC of EAL >=70?	Short Term PC µg/m3	Short Term % PC of headroom (EAL - Bkgrnd)	Short Term % PC of headroom >=20?
	e.g.	12								
1	Formaldehyde		0.0716	-	-	-		7.16	-	
3	Ammonia (ecological receptor - Sensitive Lichen	0.8	0.235	117	1.04	103	**Yes**	23.5	-	
7	Nitrogen Dioxide (Ecological - Daily Mean)	7.5	3.75	16.7	11.3	37.5	**No**	468	780	**Yes**
8	Nitrogen Dioxide	7.5	3.75	11.6	11.3	28.2	**No**	468	253	**Yes**
10	Particulates (PM10) (24 hr Mean)	7.8	0.211	-	0	-		33.7	98.0	**Yes**
12	Sulphur Dioxide (15 Min Mean)	1.8	2.35	-	0	-		386	147	**Yes**
13	Sulphur Dioxide (1 Hour Mean)	1.8	2.35	-	0	-		386	111	**Yes**
14	Sulphur Dioxide (Ecological - Sensitive Lichens)	1.8	2.35	28.6	4.15	41.5	**No**	386	-	
15	Sulphur Dioxide (24 Hour Mean)	1.8	2.35	-	0	-		386	318	**Yes**
18	Secondary Amine (NDMA EAL)	0	0.00409	2,045	0.00409	2,045	**Yes**	1.03	0.256	**No**

Table A5 Water Impacts freshwater screening test 1

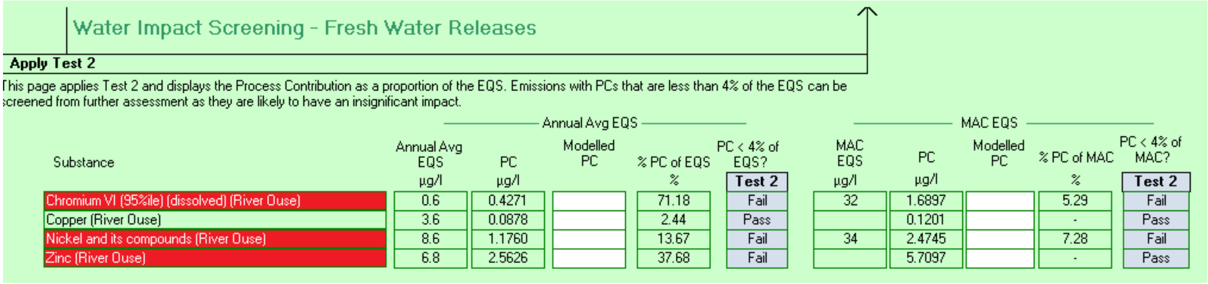

Water Impacts - Fresh Water Releases

Apply Test 1 (See Guidance) and Calculate Process Contributions of Emissions to Water

This table applies Test 1 and also estimates the Process Contribution for Freshwater releases, this is calculated after dilution into the relevant surface water ype for each emission to water listed in the inventory, according to the release point parameters input earlier. If you have more accurate data obtained through ilution modelling, this may be entered as indicated and will be used instead of the estimated PC. Any releases which 'Pass' Test 1 are screened out at this oint.

Substance	Annual Avg EQS Release µg/l	EQS µg/l	Release conc < 10% EQS	MAC EQS Release µg/l	MAC µg/l	Release conc < 10% EQS
e.g.			Test 1			Test 1
[W1] Ammonia CaCO3 >50mg/l (90 %ile) (River Ouse)	1.5200	200.0000	Pass	1.5900		N/A
[W1] Ammonia CaCO3 >50mg/l (90 %ile) (River Ouse)	1.5000	200.0000	Pass	1.5000		N/A
[W1] Arsenic (River Ouse)	0.1500	50.0000	Pass	0.1500		N/A
[W1] Arsenic (River Ouse)	0.1500	50.0000	Pass	0.1500		N/A
[W1] Chromium VI (95%ile) (dissolved) (River Ouse)	0.7300	3.4000	Fail	2.1100		N/A
[W1] Chromium VI (95%ile) (dissolved) (River Ouse)	0.1500	3.4000	Pass	0.1500		N/A
[W1] Copper (River Ouse)	0.1500	1.0000	Fail	0.1500		N/A
[W1] Copper (River Ouse)	0.1500	1.0000	Fail	0.1500		N/A
[W1] Lead and it's compounds (River Ouse)	0.0600	1.2000	Pass	0.0600	14	Pass
[W1] Lead and it's compounds (River Ouse)	0.0600	1.2000	Pass	0.0600	14	Pass
[W1] Nickel and its compounds (River Ouse)	2.0100	4.0000	Fail	3.0900	34	Pass
[W1] Nickel and its compounds (River Ouse)	0.1500	4.0000	Pass	0.1500	34	Pass
[W1] Sulphate (River Ouse)	6016.0000	#########	Pass	6016.0000		N/A
[W1] Sulphate (River Ouse)	6131.0000	#########	Pass	6285.4500		N/A
[W1] Zinc (River Ouse)	4.3800	10.9000	Fail	7.1300		N/A
[W1] Zinc (River Ouse)	0.6000	10.9000	Pass	0.6000		N/A

Table A6 Water impact freshwater screening test 2 PC and background scenario

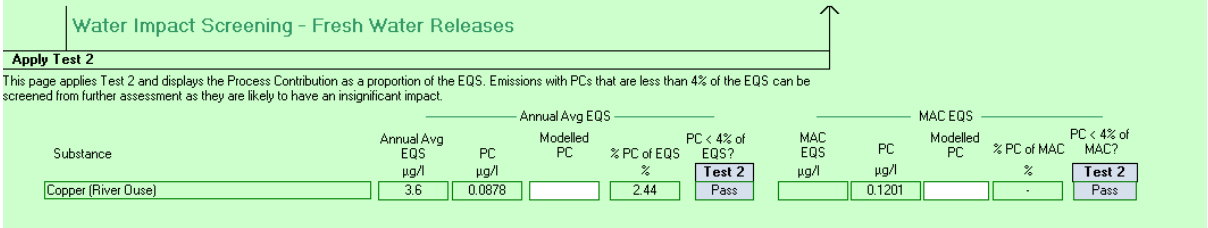

Water Impact Screening - Fresh Water Releases

Apply Test 2

his page applies Test 2 and displays the Process Contribution as a proportion of the EQS. Emissions with PCs that are less than 4% of the EQS can be creened from further assessment as they are likely to have an insignificant impact.

Substance	Annual Avg EQS Annual Avg EQS µg/l	PC µg/l	Modelled PC	% PC of EQS %	PC < 4% of EQS? Test 2	MAC EQS MAC EQS µg/l	PC µg/l	Modelled PC	% PC of MAC %	PC < 4% of MAC? Test 2
Chromium VI (95%ile) (dissolved) (River Ouse)	0.6	0.4271		71.18	Fail	32	1.6897		5.29	Fail
Copper (River Ouse)	3.6	0.0878		2.44	Pass		0.1201		-	Pass
Nickel and its compounds (River Ouse)	8.6	1.1760		13.67	Fail	34	2.4745		7.28	Fail
Zinc (River Ouse)	6.8	2.5626		37.68	Fail		5.7097		-	Pass

Table A7 Water impact freshwater screening test 2 PC scenario


Water Impact Screening - Fresh Water Releases

Apply Test 2

This page applies Test 2 and displays the Process Contribution as a proportion of the EQS. Emissions with PCs that are less than 4% of the EQS can be screened from further assessment as they are likely to have an insignificant impact.

Substance	Annual Avg EQS Annual Avg EQS µg/l	PC µg/l	Modelled PC	% PC of EQS %	PC < 4% of EQS? Test 2	MAC EQS MAC EQS µg/l	PC µg/l	Modelled PC	% PC of MAC %	PC < 4% of MAC? Test 2
Copper (River Ouse)	3.6	0.0878		2.44	Pass		0.1201		-	Pass

Appendix B Modelling of amine compounds.

OVERVIEW OF AMINES, NITROSAMINES & NITRAMINES

Amines are organic derivatives of ammonia (NH_3), wherein one or more of the hydrogens (H) atoms are replaced by a substituent organic group (R). The type of amine can be defined as primary, secondary, or tertiary, based on the number of H atoms that are replaced:

Primary amine (R-NH2) where 1 H-atom is replaced .eg, Monoethanolamine, MEA

Secondary amine (R2-NH) where 2 H-atoms are replaced .eg, Dimethylamine, DMA

Tertiary amine(R3-N) where 3 H-atoms are replaced eg, Trimethylamine, TMA

Amine-based solvents are used in the carbon capture process to remove carbon dioxide (CO_2) from combustion flue gases (i.e., for the PCC, removal of CO_2 from post-combustion gases associated with two biomass units prior to flue gas release via the Main Stack). However, the amine compounds included within the solvent make-up can react with substances other than CO_2 to create new, potentially harmful compounds (e.g. nitrosamines and nitramines), both within the carbon capture process and in the atmosphere following release of the treated post-combustion flue gases. Therefore, it is important that emissions to atmosphere, associated chemical transformations, and dispersion and deposition within the study area are represented within the air quality model.

Direct emissions of nitrosamines from the Main Stack, associated with potential solvent degradation within the PCC process and entrainment within the flue gas, are expected to be negligible. Nevertheless, direct mass emissions of nitrosamines from the PCC process in the assessment of the PCC have been modelled based on reasonable worst-case nominal emissions provided by the technology supplier (MHI), as per Table B1, for all hours of the year. However, the majority of nitrosamine and nitramine compounds associated with the PCC will form in the atmosphere as a result of the complex reactions outlined below (i.e., ‘indirect’ emissions).

Table B1

Parameter	**Baseline per Unit**	**With PCC – per unit ***	**Biomass LCP Unit ****
No. of Units	4	2	2
No Flues	2^	1	1
Stack height (m al)	259	259	259
Flue Diameter (m)	8	8	8
Discharge Temperature (°C)	144.2		144.2
Vol. flow (Nm^3/s)	573		573
Vol Flow (Am^3/s)	992.5		992.5
NO_x (mg/Nm^3) (3)			
NH_3 (mg/Nm^3) (3)	10	10	10
PM_{10} (mg/Nm^3) (3)	10 (16)	10 (16)	10 (16)
HCl (mg/Nm^3) (3)	5 (12)	5 (12)	5 (12)
SO_2 (mg/Nm^3) (3)	100 (215)	100 (215)	100 (215)
Amine 1 (mg/Nm^3) (4)		1 (2)	
Amine 2 (mg/Nm^3) (4)		0.3 (1)	
Nitrosamine 1 (mg/Nm^3) (5)		0.0001	

Nitrosamine 2 (mg/Nm^3) (5)		0.0001	

Notes
* Applicable to Unit 1 & Unit 2 only. These units have CCS.
*** Applicable to Units 3 & Unit 4 only. These units to not have CCS*
^ One flue serving two Biomass Units
(1)–Calculated at 273.15 Kelvin (0°C), pressure of 101.3 kPa, dry, 6% O2
(2)–Actual discharge conditions, 4.9% H2O,7.4% O2
(3)–Values in parentheses represent daily average emission BAT-AELs used for modelling short-term averaging periods (i.e. daily, hourly, sub-hourly concentrations)
(4)–Representative of proposed yearly average ELVs (values in parentheses represent proposed daily average ELVs for 'Amine 1' and 'Amine 2').The proposed ELVs exceed the reasonable worst-case design emissions concentrations provided by the technology supplier (MHI).
(5)–These are not proposed ELVs, but represent nominal emission concentrations provided by MHI based on expected baseload operation, representing reasonable worst-case direct emissions. Contributions to ground level nitrosamine concentrations from direct emissions are shown to be insignificant (<0.2% of EAL for NDMA; see Appendix 6.4).

As reported in Table B1 of this Variation Application the EA recommends that the contributions of directly emitted nitrosamines from those formed through atmospheric reactions are differentiated. The respective direct and indirect contributions of nitrosamines for the relevant model scenarios are presented in **Table 22** profile sensitivity test) in Appendix C (Operational Phase Air Quality Assessment Results Tables: Human Receptors).As evidenced in Appendix C (Operational Phase Air Quality Assessment Results Tables: Human Receptors), the PC to ground level concentrations of direct nitrosamine emissions is insignificant (<0.1% of the EAL for NDMA). Given the negligible emissions under baseload operation and the associated insignificant impacts, there is no requirement to propose an annual average ELV for direct nitrosamine emissions.

Nitrosamines and nitramines are organic compounds, formed by reactions with nitrogen monoxide (NO) and nitrogen dioxide (NO_2), respectively. The chemical structure of nitrosamines is R2N-NOand the structure of nitramines is R2N- NO_2, formed from the original amine, where R is usually an alkyl group. Nitrosamines are susceptible to photodegradation and therefore generally short-lived in the atmosphere (~5 min). In contrast, nitramines are more stable and will have longer atmospheric residence times (~2 days)(Sørensen, 2013). As such, the stability of nitramines indicates an increased potential for accumulation in the atmosphere relative to nitrosamines.

Existing toxicological data indicates that most nitrosamines are carcinogenic, with the most widely researched nitrosamine being N-Nitrosodimethylamine (NDMA), formed from DMA, due to its toxicity. Accordingly, the EAL established by the EA for the assessment of nitrosamines is derived for NDMA. Less is known about nitramines, but they have the potential to be mutagenic and carcinogenic although typically less potent than nitrosamines, with some research studies indicating that nitramines are at least six times less toxic (Gjernes, 2013) and fifteen times less mutagenic (Wagner, 2014)than nitrosamines.

To ensure a conservative approach to the assessment of nitrosamines and nitramines relating to the PCC, the modelled concentrations of each compound in this study have been summed (i.e. nitrosamines + nitramines) at each receptor/grid point and compared to the EAL for NDMA.

MODELLING AMINE CHEMISTRY IN ADMS

For the assessment of amines and associated degradation products relating to the proprietary amine-based solvent proposed for use with the PCC, the ADMS Amine Chemistry Module (CERC, 2016) has been utilised to model the chemical reactions associated with the release of specified amine compounds and formation of associated nitrosamines and nitramines in the atmosphere.

Whilst the EA acknowledge that the uncertainty associated with modelling of amines is likely to be very high, the EA's latest guidance(Environment Agency, 2021) on the assessment of impacts to air quality from amine-based post-combustion carbon capture plants states "...the only commercially available modelling software to evaluate the potential impacts from amines and amine degradation products releases is the amines module within ADMS. The amines chemistry module is based on established science considering published research on mechanisms of formation of toxic compounds. Although the validation of the module is not possible at the moment, the ADMS air dispersion modelling algorithms are continually validated against real world situations, field campaigns and wind tunnel experiments."

The mechanisms for the formation of nitrosamines and nitramines in the atmosphere are complex. However, the main initial reaction of amines in the atmosphere is with hydroxyl (OH) radicals and it is this reaction on which the ADMS amine chemistry scheme is based (CERC, 2016). As described above, the subsequent formation of nitrosamines and nitramines are attributed to reactions with NO and NO_2. However, they can further degrade in the atmosphere (eg, through photo-oxidation and subsequent reaction with oxygen molecules to form imines, which are relatively stable and non-toxic compounds (Manzoor, 2015)).

Primary amines do not form stable nitrosamines, meaning that any such nitrosamines would be rapidly isomerised to the respective imine. However, secondary and tertiary amines do form stable nitrosamines. The ADMS module includes an option to allow only unstable nitrosamines to be created (ie, assuming emissions of primary amines only), if selected by the model user, meaning all nitrosamine concentration outputs are set to zero and only nitramines will form. This option was not selected for the PCC modelling assessment, regardless of the amine compound being emitted (ie, primary, secondary, and/or tertiary).

The general reaction scheme simulated by the ADMS amines module is as follows:

AMINE + hydroxyl radical (•OH)	→	amino RADICAL + H2O	(1a)
	→	non-amine radical (RN(H)C•H2) + H2O	(1b)
amino RADICAL + O2	→	imine + hydroperoxyl (HO2)	(2)
amino RADICAL + NO	→	NITROSAMINE	(3)
amino RADICAL + NO2	→	NITRAMINE	(4a)
	→	imine + nitrous acid (HONO)	(4b)
NITROSAMINE	hυ →	amino RADICAL	(5)

Notes:

R represents an alkyl group.

Terms in capitals are the generic names given the respective compounds for which input data are required for modelling in ADMS v5.2.4.

The amount of nitrosamine and nitramine formed in the atmosphere is dependent on the initial reaction of the amine with the OH radical – specifically the branching ratio of the abstraction of an H atom from the amino group (N-H) (i.e. forming the amino RADICAL) to the abstraction from the methyl group (C-H) (i.e. forming the non-amine radical) – where a lower branching ratio will result in fewer amino radicals being made available and thus fewer nitrosamine/nitramine compounds being formed. However, a number of other variables play an essential role in the potential formation of nitrosamines and nitramines in the atmosphere and are required for the ADMS amine chemistry module to run, including:

A. Ambient concentrations of the OH radical;
    a. A representative annual average OH radical concentration for the UK was sourced from published research (Walker, 2015), based on measurements taken from a series of daytime and night-time flights over the UK in summer 2010 and winter 2011 using the fluorescence assay by gas expansion (FAGE) technique. In the absence of sunlight, OH is not formed at night and therefore OH was not detected above the instrument's limit of detection during any of the night-time or winter daytime flights.
    b. An upper limit OH concentration of 1.8 x 106 molecules cm-3 is reported, which is calculated based on summer daytime flights only.
    c. This is the value used to feed into the amine chemistry modelling and is likely to be conservative (skewed high) as an annual average due to there being more daylight hours in summer relative to winter (i.e. if more OH radicals are available in the atmosphere, daytime amine degradation increases, resulting in increased production of nitrosamine/nitramine compounds).
B. Photolysis rates applicable to the region of study;
    a. The ADMS meteorological pre-processor provides hourly information with respect to incoming solar radiation (K) specific to the meteorological year data and latitude. A subsequent calculation is completed using the K values to derive hourly photolysis rates, which are then used to calculate an annual average rate constant for NO_2 (jNO2)(CERC, 2016).
    b. The meteorological data used in the amine chemistry module aligns with that used for modelling of all other non-amine related pollutants, comprising hourly data for years 2016-2020 inclusive from RAF Waddington.
C. Ambient concentrations of ozone (O3) and NO_x (i.e. NO and NO_2);
    a. The amine reaction scheme requires hourly background levels of NO_x and O3equivalent to the year of meteorological data. Hourly data for these species were sourced from Defra's Hull Freetown AURN monitoring site, representing urban background levels, for the years 2016-2020 inclusive.
    b. Background NO_x concentrations are used to dictate the availability of NO and NO_2 in the formation of nitrosamines and nitramines, respectively, on an hourly basis.
    c. The hydroxyl radical concentration varies based on a number of factors, including solar radiation, latitude, and background levels of O3. The ADMS amine module requires a constant, 'c', which is used to calculate hourly varying OH radical concentrations for the region of study. The value for cis derived based on the relationship between annual average values for jNO_2, O3 and OH radical concentrations as described above.

The reaction rates and associated kinetic parameters input to ADMS v5.2.4 for the 'AMINE', 'amine RADICAL', 'NITROSAMINE', and 'NITRAMINE' species need to be defined by the model user. Reaction rate coefficients and kinetic parameters specific to these species associated with the proprietary amine solvent proposed for use in the PCC process, have been provided by the PCC technology supplier (MHI) for use in the atmospheric dispersion modelling. These data remain confidential and, as such, are not published in this Chapter. However, further sensitivity testing in relation to modelling amine atmospheric chemistry has been completed to address this (see ‘Amine Chemistry Sensitivity Testing’ below).

The general description of the ADMS amine chemistry scheme can be summarised in five steps:

1. On an hourly basis, ADMS uses the above input parameters to model concentrations of the species of interest as well as the age of the primary pollutants (eg, amines) at each receptor/grid point using the standard ADMS dispersion algorithms.
2. Using the ‘dilution and entrainment’ scheme within the ADMS amines module, the primary pollutant concentrations are adjusted to removed dilution effects (i.e. becoming increasingly conservative with distance from stack exit).
3. The chemistry reaction scheme requires consideration of timescales, so that after each hourly dispersion calculation, the 'age' of the pollutants is calculated based on the plume travel time. The chemical reaction equations are applied over a time (dt) to all pollutants from the source.
4. At this point, the ‘dilution and entrainment’ scheme is used to dilute all pollutants as ambient air, containing the background pollutants, is entrained into the plume.
5. Steps 3 and 4 are repeated for each time step until time becomes equal to the pollutant ‘age’.

An overview of the input variables required by the amine chemistry module in ADMS is provided in Table B1. Where possible, the respective input data have been presented relative to the PCC scenario modelling completed and reported in main variation text.

MODELLING DEPOSITION OF AMINES IN ADMS

The method for calculating deposition of amines and associated products (nitrosamines, nitramines) in ADMS was undertaken based on the following approach:

1. Run the respective amine chemistry model runs with amine chemistry switched on and deposition switched off (i.e. as detailed above).
2. Run the same model set up as in Step 1, but with the amine chemistry switched off and deposition switched on.
3. Run the same model set up as in Steps 1/2, but with both amine chemistry and deposition switched off.

Based on the outputs from step 2 (deposition switched on) and step 3 (deposition switched off), the ratio of the concentration to deposition flux was calculated for each amine and at each receptor / grid location. This ratio was then multiplied by the concentration output from step 1 (amine chemistry switched on) to derive the amine deposition fluxes at all receptor and grid locations. In summary, the approach can be viewed as:

$$D = C_1 \times \left(\frac{D_2}{C_3}\right)$$

Where:

D **is the deposition flux for the respective amine compound**

C_1 is the output concentration from Step 1

D_2 is the output deposition flux from Step 2

C_3 is the output concentration from Step 3

Research published by Karl et al. (Karl, 2009), which reports on worst-case studies for assessing deposition of amines from carbon capture plants, adopted a deposition velocity of 10 mm/s for amines and 30mm/s for nitrosamines and nitramines. This reflects that the solubility of amines is relatively lower than that of nitrosamines and nitramines. However, in the absence of recommended deposition velocities for these compounds, a conservative approach has been adopted for the PCC activity assessment, whereby the deposition velocity for all amine, nitrosamine, and nitramine compounds is assumed to be equivalent to that for ammonia (30 mm/s) (ie, all gaseous amine compounds assumed to be highly soluble). Furthermore, the deposition of amines was only taken into account in the modelling of impacts on ecological receptors.

AMINE CHEMISTRY SENSITIVITY TESTING

Given that the specified reactivity data for the proprietary amine and nitrosamine compounds remain confidential, additional model sensitivity testing has been completed based on applying amine reaction rate coefficients equivalent to proxy amine and nitrosamine compounds, for which published data in the public domain are available.

Namely, the proxy compound for ‘Amine 1’ is MEA and the proxy for ‘Amine 2’ is DMA, which is a precursor to the formation of NDMA. NDMA has also been used as a proxy for directly emitted nitrosamines (ie, ‘Nitrosamine 1’ and ‘Nitrosamine 2’)5

The use of MEA as a proxy compound is comparable in reaction rates and will be compared to the derived primary amine EAL. The use of DMA ensures that any predicted atmospheric formation of nitrosamine, in addition to directly emitted nitrosamines, will be as NDMA, which also allows for direct comparison with the Agency’s EAL for NDMA Section 5.

The MEA and NDMA reaction rate coefficients applied in the amine sensitivity testing have covered low, mid, and high range values based on literature research for these compounds and are reported in Table B1. The equivalent reaction rate coefficients for the confidential amine compounds fall within the tested range of values applicable to MEA and DMA, thereby addressing uncertainty in key parameters used in modelling amine chemistry within ADMS.

The results and analysis relating to the amine chemistry sensitivity tests are reported in Tables C21 (MEA) and C22 (NDMA) Appendix C Operational Air Quality Assessment Result Tables: Human Receptors.

Appendix C Operational Air Quality Assessment Result Tables: Human Receptors.

BACKGROUND POLLUTANT VALUES USED IN MODELLING: HUMAN RECEPTORS

The respective pollutant background concentrations applied to the post-processing of the dispersion model outputs, for each averaging period and discrete human receptor, are presented in Table C1.

Details of the sources of the pollutant background data are provided in Section 5. For background levels of NH_3, SO_2, and HCl, monitored data were used in the absence of spatially varying background data across the operation phase Study Area. For SO_2, the monitored maximum hourly value is used as the background level across the Study Area based on 2020 data. For NH_3 and HCl, the monitored maximum monthly value is used based on 2020 data.

For aldehydes, amines and nitrosamines, there are currently no published background data for the UK.

Table C1 - Modelled Background Pollutant Concentrations – Human Receptors

Receptor	**Pollutant Background Concentration (µg/m^3)**				
	Annual Mean NO$_2$	**Annual Mean PM$_{10}$**	**Hourly Max SO$_2$ ***	**Monthly Max NH$_3$ ****	**Monthly Max HCl *****
Foreman's Cottage	6.67	12.14	20.48	1.60	2.43
East Yorkshire Caravan Park	9.83	12.49	20.48	1.60	2.43
Drax S&C Club	9.83	12.49	20.48	1.60	2.43
Wren Hall	7.01	13.57	20.48	1.60	2.43
3 Pear Tree Ave	6.78	14.40	20.48	1.60	2.43
Crange Cottages	7.43	12.26	20.48	1.60	2.43
Drax Abbey Farm	6.78	14.40	20.48	1.60	2.43
Read School	7.27	12.50	20.48	1.60	2.43
Old Lodge	6.78	14.40	20.48	1.60	2.43
Selby AQMA	46.5 (1)	13.50	20.48	1.60	2.43
Goole	28.0 (2)	13.30	20.48	1.60	2.43
Hemingbrough	6.94	13.22	20.48	1.60	2.43
Rawcliffe	8.64	14.51	20.48	1.60	2.43
Snaith	8.40	13.45	20.48	1.60	2.43
Hensall	8.52	13.54	20.48	1.60	2.43
Cliffe	6.96	13.99	20.48	1.60	2.43
Breighton	6.51	13.44	20.48	1.60	2.43
Wressle	6.74	14.15	20.48	1.60	2.43
Eastrington	7.73	14.43	20.48	1.60	2.43
Ellerton	5.96	13.74	20.48	1.60	2.43
Fogathorpe	6.65	13.81	20.48	1.60	2.43
Barlby	10.18	14.41	20.48	1.60	2.43
Riccall	6.71	13.98	20.48	1.60	2.43
Thorpe Willoughby	7.77	13.93	20.48	1.60	2.43
Kellingley	8.41	14.18	20.48	1.60	2.43
Moorends	9.29	13.45	20.48	1.60	2.43
Thorne	38.0 (3)	13.27	20.48	1.60	2.43
Swinefleet	7.36	14.18	20.48	1.60	2.43
Balne	7.73	14.77	20.48	1.60	2.43
Whitley	8.87	13.83	20.48	1.60	2.43
Barlow	7.07	13.14	20.48	1.60	2.43

Receptor	**Pollutant Background Concentration (µg/m³)**				
	Annual Mean NO_2	**Annual Mean PM_{10}**	**Hourly Max SO_2 ***	**Monthly Max NH_3 ****	**Monthly Max HCl *****
Long Drax	6.86	13.92	20.48	1.60	2.43
Drax	7.27	12.50	20.48	1.60	2.43
Newland	7.53	13.98	20.48	1.60	2.43
Carlton	8.14	13.95	20.48	1.60	2.43
Camblesforth	7.40	13.60	20.48	1.60	2.43
Burn	7.76	14.08	20.48	1.60	2.43
Temple Hirst	8.29	14.31	20.48	1.60	2.43
Cawood	7.32	13.24	20.48	1.60	2.43
Biggin	7.76	12.93	20.48	1.60	2.43
Howden	9.11	14.93	20.48	1.60	2.43
Brind	6.58	14.37	20.48	1.60	2.43
South Duffield	6.33	14.55	20.48	1.60	2.43
Highfield	6.33	13.98	20.48	1.60	2.43
Willitoft	6.27	14.12	20.48	1.60	2.43
Receptor Grid Max	13.53	17.56	20.48	1.60	2.43

Notes:

(1) *For purposes of providing a conservative assessment within the Selby AQMA, the 2019 annual mean monitored concentration from diffusion tube site ID S7 (21 New Street) was used as the background for this receptor (Source: Selby District Council (June 2021)* 2021 Air Quality Annual Status Report*)*

(2) *For purposes of providing a conservative assessment of impacts in Goole, the 2019 annual mean monitored concentration from diffusion tube site ID S5 (Boothferry Rd/Airmyn Rd, Goole) was used as the background for this receptor (Source: East Riding of Yorkshire Council (June 2021)* 2021 Air Quality Annual Status Report*)*

(3) *For purposes of providing a conservative assessment of impacts in Thorne, the 2019 annual mean monitored concentration from diffusion tube site ID DT50 (King Street, Thorne) was used as the background for this receptor (Source: Doncaster Council (June 2021)* 2021 Air Quality Annual Status Report*)*

* *Maximum hourly monitored SO_2 used to represent short-term averaging period background level*

** *Maximum monthly monitored NH_3 used to represent annual mean level, with each concentration doubled to represent short-term averaging period background level*

*** *Maximum monthly monitored HCl doubled to represent short-term averaging period background level*

Impacts on Human Receptors

The results of the modelling assessment at each modelled discrete human receptor are presented in the below tables for each relevant pollutant and averaging period applicable to the study. For each receptor, the maximum modelled concentration is presented, which is based on modelling over all five years of meteorological data (2016-2020). In addition, the maximum modelled concentration from across the entire 30 km x 30km grid is provided.

Both the PC and PEC, which comprises the PC in addition to the receptor-specific background concentration, are presented for each receptor. For PEC's relating to short-term averaging periods (i.e. sub-hourly, hourly, daily means), the respective annual mean background concentration has been doubled in line with EA guidance (Environment Agency, 2021) and is a conservative approach where background concentrations are taken from short averaging period observations..

For SO_2, PM_{10} (dust), NH_3, HCl and aldehydes only the maximum PC impacts are presented given that they represent an insignificant contribution relative to the air quality objective/EAL.

It is important to note that the maximum PC impact is the maximum difference between Baseline and With PCC concentrations, and may not coincide with the specific geographic point at which either the maximum Baseline or maximum With PCC value occurs.

The human receptor results are presented in sub-sections relating to:

a) Continuous Full Load Operation of:
b) Baseline (4 x Biomass Units, no PCC)
c) With PCC (2 x Biomass Units without PCC, 2 x PCC Biomass Units) Amine sensitivity testing (With PCC).

Table C1 - Modelled Maximum Operational Impacts at Human Receptors – Annual Mean NO_2 Concentrations

Receptor	**Annual mean NO_2 Concentration ($\mu g/m^3$)**					
	Max Baseline PC	**Max Baseline PEC**	**Max PCC PC**	**Max PCC PEC**	**Max PC Impact**	**% of Objective**
Foreman's Cottage	0.001	6.67	0.001	6.67	0.00	0.0%
East Yorkshire Caravan Park	0.000	9.83	0.000	9.83	0.00	0.0%
Drax S&C Club	0.000	9.83	0.000	9.83	0.00	0.0%
Wren Hall	0.001	7.01	0.001	7.01	0.00	0.0%
3 Pear Tree Ave	0.005	6.79	0.006	6.79	0.00	0.0%
Crange Cottages	0.001	7.44	0.001	7.44	0.00	0.0%
Drax Abbey Farm	0.001	6.78	0.001	6.78	0.00	0.0%
Read School	0.002	7.27	0.002	7.27	0.00	0.0%
Old Lodge	0.003	6.78	0.004	6.78	0.00	0.0%
Selby_AQMA	0.019	46.52	0.024	46.52	0.01	0.0%
Goole	0.043	28.04	0.052	28.05	0.01	0.0%

Receptor	**Annual mean NO_2 Concentration (µg/m^3)**					
	Max Baseline PC	**Max Baseline PEC**	**Max PCC PC**	**Max PCC PEC**	**Max PC Impact**	**% of Objective**
Hemingbrough	0.043	6.98	0.045	6.98	0.01	0.0%
Rawcliffe	0.017	8.66	0.023	8.67	0.01	0.0%
Snaith	0.019	8.41	0.024	8.42	0.01	0.0%
Hensall	0.037	8.55	0.036	8.55	0.01	0.0%
Cliffe	0.026	6.98	0.030	6.99	0.00	0.0%
Breighton	0.096	6.61	0.091	6.60	0.01	0.0%
Wressle	0.084	6.82	0.079	6.82	0.01	0.0%
Eastrington	0.110	7.84	0.120	7.85	0.01	0.0%
Ellerton	0.073	6.03	0.078	6.03	0.01	0.0%
Fogathorpe	0.127	6.77	0.130	6.78	0.01	0.0%
Barlby	0.025	10.21	0.029	10.21	0.00	0.0%
Riccall	0.034	6.75	0.038	6.75	0.00	0.0%

Receptor	**Annual mean NO_2 Concentration (µg/m^3)**					
	Max Baseline PC	**Max Baseline PEC**	**Max PCC PC**	**Max PCC PEC**	**Max PC Impact**	**% of Objective**
Thorpe Willoughby	0.019	7.79	0.023	7.80	0.00	0.0%
Kellingley	0.044	8.45	0.048	8.46	0.00	0.0%
Moorends	0.036	9.33	0.040	9.33	0.02	0.0%
Thorne	0.029	38.03	0.032	38.03	0.01	0.0%
Swinefleet	0.054	7.42	0.061	7.42	0.01	0.0%
Balne	0.048	7.78	0.047	7.78	0.01	0.0%
Whitley	0.048	8.92	0.042	8.92	0.01	0.0%
Barlow	0.002	7.07	0.003	7.07	0.00	0.0%
Long Drax	0.014	6.87	0.014	6.87	0.00	0.0%
Drax	0.002	7.27	0.002	7.27	0.00	0.0%
Newland	0.009	7.54	0.010	7.54	0.00	0.0%
Carlton	0.011	8.15	0.012	8.15	0.00	0.0%

Receptor	**Annual mean NO_2 Concentration (µg/m^3)**					
	Max Baseline PC	**Max Baseline PEC**	**Max PCC PC**	**Max PCC PEC**	**Max PC Impact**	**% of Objective**
Camblesforth	0.002	7.40	0.002	7.40	0.00	0.0%
Burn	0.014	7.78	0.018	7.78	0.00	0.0%
Temple Hirst	0.034	8.32	0.040	8.33	0.01	0.0%
Cawood	0.048	7.37	0.053	7.37	0.00	0.0%
Biggin	0.034	7.80	0.037	7.80	0.00	0.0%
Howden	0.080	9.19	0.097	9.20	0.02	0.0%
Brind	0.099	6.68	0.101	6.68	0.01	0.0%
South Duffield	0.054	6.38	0.057	6.38	0.01	0.0%
Highfield	0.104	6.43	0.103	6.43	0.01	0.0%
Willitoft	0.116	6.38	0.118	6.38	0.01	0.0%
Receptor Grid Max	0.135	11.58	0.139	11.58	0.02	0.0%
AQ Objective	**40**					

Table C2 - Modelled Maximum Operational Impacts at Human Receptors – Hourly Mean NO_2 Concentrations

Receptor	Hourly mean NO2 Concentration (µg/m3) (Based on 99.79th %ile of hourly values)					
	Max Baseline PC	**Max Baseline PEC**	**Max PCC PC**	**Max PCC PEC**	**Max PC Impact**	**% of Objective**
Foreman's Cottage	0.11	13.45	0.20	13.54	0.13	0.1%
East Yorkshire Carav	0.02	19.68	0.06	19.72	0.05	0.0%
Drax S&C Club	0.01	19.67	0.04	19.70	0.03	0.0%
Wren Hall	0.08	14.10	0.13	14.15	0.07	0.0%
3 Pear Tree Ave	0.30	13.86	0.75	14.32	0.46	0.2%
Crange Cottages	0.08	14.95	0.13	15.00	0.10	0.0%
Drax Abbey Farm	0.08	13.64	0.19	13.75	0.12	0.1%
Read School	0.18	14.72	0.36	14.90	0.26	0.1%
Old Lodge	0.20	13.77	0.50	14.06	0.32	0.2%
Selby_AQMA	1.72	94.72	2.51	95.51	1.17	0.6%
Goole	2.52	58.52	2.99	58.99	0.83	0.4%
Hemingbrough	2.72	16.60	2.98	16.86	0.48	0.2%

	Hourly mean NO2 Concentration (µg/m3) (Based on 99.79th %ile of hourly values)					
Receptor	**Max Baseline PC**	**Max Baseline PEC**	**Max PCC PC**	**Max PCC PEC**	**Max PC Impact**	**% of Objective**
Rawcliffe	1.54	18.83	2.55	19.84	1.51	0.8%
Snaith	1.47	18.26	2.68	19.47	1.27	0.6%
Hensall	2.55	19.58	2.82	19.85	0.83	0.4%
Cliffe	2.37	16.28	2.82	16.73	0.83	0.4%
Breighton	3.07	16.09	3.13	16.15	0.20	0.1%
Wressle	3.25	16.72	3.46	16.93	0.39	0.2%
Eastrington	3.39	18.84	3.58	19.03	0.25	0.1%
Ellerton	2.84	14.75	3.05	14.96	0.29	0.1%
Fogathorpe	3.63	16.93	3.80	17.09	0.49	0.2%
Barlby	2.29	22.65	2.44	22.80	0.99	0.5%
Riccall	2.40	15.83	2.53	15.96	0.39	0.2%
Thorpe Willoughby	1.59	17.14	2.45	18.00	1.14	0.6%

	Hourly mean NO2 Concentration (µg/m3) (Based on 99.79th %ile of hourly values)					
Receptor	**Max Baseline PC**	**Max Baseline PEC**	**Max PCC PC**	**Max PCC PEC**	**Max PC Impact**	**% of Objective**
Kellingley	2.89	19.71	2.93	19.75	0.21	0.1%
Moorends	2.69	21.28	3.00	21.58	0.47	0.2%
Thorne	2.56	78.56	2.77	78.77	0.40	0.2%
Swinefleet	3.02	17.74	3.44	18.17	0.51	0.3%
Balne	2.79	18.25	3.14	18.60	0.35	0.2%
Whitley	2.72	20.47	2.95	20.70	0.43	0.2%
Barlow	0.20	14.33	0.76	14.89	0.56	0.3%
Long Drax	0.78	14.50	1.49	15.20	0.97	0.5%
Drax	0.21	14.75	0.44	14.97	0.32	0.2%
Newland	0.65	15.71	1.81	16.87	1.23	0.6%
Carlton	0.94	17.21	1.90	18.18	1.15	0.6%
Camblesforth	0.14	14.94	0.34	15.14	0.28	0.1%

	Hourly mean NO2 Concentration (µg/m3) (Based on 99.79th %ile of hourly values)					
Receptor	**Max Baseline PC**	**Max Baseline PEC**	**Max PCC PC**	**Max PCC PEC**	**Max PC Impact**	**% of Objective**
Burn	1.24	16.77	2.15	17.68	1.10	0.5%
Temple Hirst	2.77	19.34	2.95	19.53	1.22	0.6%
Cawood	3.06	17.70	3.31	17.95	0.38	0.2%
Biggin	2.52	18.04	2.89	18.42	0.37	0.2%
Howden	3.09	21.30	3.17	21.38	0.33	0.2%
Brind	3.04	16.21	3.38	16.55	0.37	0.2%
South Duffield	3.33	15.98	3.44	16.10	0.29	0.1%
Highfield	2.93	15.59	3.19	15.85	0.32	0.2%
Willitoft	3.41	15.94	3.45	15.98	0.42	0.2%
Receptor Grid Max	4.05	26.93	4.06	26.94	1.80	0.9%
AQ Objective	**200**					

Table C3 - Modelled Maximum Operational Impacts at Human Receptors – SO_2 Concentrations

SO_2 Concentration (µg/m^3) (15-min/Hourly/Daily mean)

Receptor	**Back-ground**	**Max Baseline PC**			**Max PCC PC**			**Max PC Impact**			**Max % of Objective (all periods)**
		15-min	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	
Foreman's Cottage	20.48	0.59	0.27	0.06	1.07	0.50	0.14	0.61	0.32	0.09	0.2%
East Yorkshire Caravan Park	20.48	0.21	0.05	0.02	0.60	0.14	0.05	0.53	0.08	0.04	0.2%
Drax S&C Club	20.48	0.16	0.02	0.02	0.55	0.08	0.04	0.39	0.06	0.03	0.1%
Wren Hall	20.48	0.65	0.16	0.06	1.21	0.34	0.11	0.56	0.21	0.05	0.2%
3 Pear Tree Ave	20.48	1.96	0.77	0.18	4.25	1.86	0.40	2.29	1.11	0.28	0.9%
Crange Cottages	20.48	0.54	0.19	0.06	1.07	0.30	0.11	0.85	0.24	0.09	0.3%
Drax Abbey Farm	20.48	0.50	0.17	0.05	1.26	0.48	0.10	0.76	0.34	0.06	0.3%
Read School	20.48	1.18	0.38	0.09	2.53	0.87	0.19	1.59	0.56	0.11	0.6%

SO_2 Concentration (µg/m^3) (15-min/Hourly/Daily mean)

Receptor	**Back-ground**	**Max Baseline PC**			**Max PCC PC**			**Max PC Impact**			**Max % of Objective (all periods)**
		15-min	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	
Old Lodge	20.48	1.33	0.51	0.11	3.22	1.32	0.29	2.00	0.92	0.19	0.8%
Selby_AQMA	20.48	9.95	4.40	1.08	13.54	6.98	1.59	5.51	3.03	0.56	2.1%
Goole	20.48	15.49	6.95	1.72	16.48	7.93	1.69	5.44	2.10	0.40	2.0%
Hemingbrough	20.48	15.41	7.07	2.17	16.48	7.95	2.53	1.80	1.54	0.54	0.7%
Rawcliffe	20.48	9.55	3.33	0.82	14.04	6.87	1.54	8.21	3.84	0.78	3.1%
Snaith	20.48	9.92	3.81	1.01	14.18	7.11	1.88	5.34	3.82	0.91	2.0%
Hensall	20.48	14.42	6.50	1.33	16.18	7.92	1.52	5.13	2.73	0.49	1.9%
Cliffe	20.48	15.16	5.80	1.82	16.20	6.86	2.05	2.30	2.54	0.90	0.9%
Breighton	20.48	15.90	8.49	2.18	17.49	8.90	2.13	2.75	0.63	0.19	1.0%
Wressle	20.48	17.82	9.27	2.57	17.66	9.94	2.91	2.07	1.35	0.35	0.8%
Eastrington	20.48	19.65	9.53	2.14	21.55	10.14	2.49	1.90	0.72	0.35	0.7%
Ellerton	20.48	17.52	7.68	1.89	19.10	8.15	1.96	3.97	0.77	0.16	1.5%

SO_2 Concentration (µg/m^3) (15-min/Hourly/Daily mean)

Receptor	**Back-ground**	**Max Baseline PC**			**Max PCC PC**			**Max PC Impact**			**Max % of Objective (all periods)**
		15-min	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	
Fogathorpe	20.48	25.47	9.93	2.02	24.93	9.85	2.10	3.29	1.13	0.11	1.2%
Barlby	20.48	14.81	5.53	1.35	15.08	6.36	1.40	7.32	2.74	0.52	2.8%
Riccall	20.48	14.06	6.46	1.26	16.11	6.88	1.40	3.74	1.21	0.28	1.4%
Thorpe Willoughby	20.48	10.50	4.15	1.19	16.03	5.72	1.31	6.12	3.20	0.26	2.3%
Kellingley	20.48	17.68	7.27	2.28	19.42	7.93	2.18	3.45	0.66	0.19	1.3%
Moorends	20.48	16.88	7.10	1.28	18.87	7.51	1.52	1.98	0.99	0.27	0.7%
Thorne	20.48	15.13	6.19	1.10	16.39	6.62	1.14	2.51	0.61	0.13	0.9%
Swinefleet	20.48	18.13	8.14	1.31	19.65	9.25	1.58	2.45	1.10	0.28	0.9%
Balne	20.48	18.83	7.83	1.67	20.55	8.37	1.77	2.04	1.34	0.18	0.8%
Whitley	20.48	15.29	7.62	1.46	16.68	8.15	1.67	1.58	1.12	0.21	0.6%
Barlow	20.48	1.59	0.40	0.15	4.59	1.87	0.47	3.25	1.47	0.32	1.2%

SO_2 Concentration ($\mu g/m^3$) (15-min/Hourly/Daily mean)

Receptor	**Back-ground**	**Max Baseline PC**			**Max PCC PC**			**Max PC Impact**			**Max % of Objective (all periods)**
		15-min	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	
Long Drax	20.48	4.57	2.06	0.48	8.01	4.12	0.89	4.38	2.58	0.51	1.6%
Drax	20.48	1.34	0.49	0.10	3.31	1.09	0.35	1.97	0.80	0.27	0.7%
Newland	20.48	5.14	1.66	0.43	11.51	5.12	1.02	7.89	3.51	0.60	3.0%
Carlton	20.48	8.28	2.03	0.57	10.97	5.33	1.28	6.23	3.75	0.77	2.3%
Camblesforth	20.48	0.95	0.30	0.11	2.31	0.92	0.25	1.67	0.66	0.14	0.6%
Burn	20.48	9.52	3.30	1.00	12.16	5.99	1.31	5.21	3.32	0.44	2.0%
Temple Hirst	20.48	16.58	6.93	2.36	17.21	7.99	2.62	5.82	3.58	0.76	2.2%
Cawood	20.48	16.90	7.83	1.61	18.27	8.70	1.93	2.00	0.87	0.32	0.8%
Biggin	20.48	17.95	6.76	1.50	18.66	7.20	1.49	2.84	1.25	0.09	1.1%
Howden	20.48	16.79	8.82	1.75	18.23	8.98	2.12	3.36	1.30	0.38	1.3%
Brind	20.48	18.55	8.44	1.97	23.25	9.22	2.05	4.71	1.15	0.28	1.8%
South Duffield	20.48	17.98	9.41	2.83	17.63	9.55	2.81	0.12	1.21	0.10	0.3%

Receptor	**SO$_2$ Concentration (µg/m^3) (15-min/Hourly/Daily mean)**										
	Back-ground	**Max Baseline PC**			**Max PCC PC**			**Max PC Impact**			**Max % of Objective (all periods)**
		15-min	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	**15-min**	**Hourly**	**Daily**	
Highfield	20.48	15.91	8.16	1.74	18.20	8.84	1.76	2.29	0.74	0.11	0.9%
Willitoft	20.48	18.64	9.29	2.04	21.06	9.25	2.19	3.32	0.84	0.23	1.2%
Receptor Grid Max	20.48	26.81	10.96	3.20	25.23	10.83	3.48	10.03	5.36	1.33	3.8%
AQ Objective		**266**	**350**	**125**	**266**	**350**	**125**	**266**	**350**	**125**	

Table C4 - Modelled Maximum Operational Impacts at Human Receptors – Dust (as PM$_{10}$) Concentrations

Receptor	**PM$_{10}$ Concentration (µg/m^3) (Annual & Daily mean)**									
	Background		**Max Baseline PC**		**Max PCC PC**		**Max PC Impact**			
	Annual	**Daily**	**Annual**	**Daily**	**Annual**	**Daily**	**Annual**	**As % of Obj**	**Daily**	**As % of Obj**
Foreman's Cottage	12.14	24.28	0.00	0.00	0.00	0.00	0.000	0.0%	0.001	0.0%
East Yorkshire Carav	12.49	24.97	0.00	0.00	0.00	0.00	0.000	0.0%	0.000	0.0%

Receptor	**PM_{10} Concentration ($\mu g/m^3$) (Annual & Daily mean)**									
	Background		**Max Baseline PC**		**Max PCC PC**		**Max PC Impact**			
	Annual	**Daily**	**Annual**	**Daily**	**Annual**	**Daily**	**Annual**	**As % of Obj**	**Daily**	**As % of Obj**
Drax S&C Club	12.49	24.97	0.00	0.00	0.00	0.00	0.000	0.0%	0.000	0.0%
Wren Hall	13.57	27.14	0.00	0.00	0.00	0.00	0.000	0.0%	0.000	0.0%
3 Pear Tree Ave	14.40	28.79	0.00	0.00	0.00	0.01	0.000	0.0%	0.004	0.0%
Crange Cottages	12.26	24.52	0.00	0.00	0.00	0.00	0.000	0.0%	0.000	0.0%
Drax Abbey Farm	14.40	28.79	0.00	0.00	0.00	0.00	0.000	0.0%	0.001	0.0%
Read School	12.50	25.00	0.00	0.00	0.00	0.00	0.000	0.0%	0.002	0.0%
Old Lodge	14.40	28.79	0.00	0.00	0.00	0.01	0.000	0.0%	0.003	0.0%
Selby_AQMA	13.50	26.99	0.00	0.00	0.00	0.02	0.000	0.0%	0.010	0.0%
Goole	13.30	26.60	0.00	0.02	0.01	0.03	0.001	0.0%	0.017	0.0%
Hemingbrough	13.22	26.45	0.00	0.01	0.01	0.04	0.001	0.0%	0.017	0.0%
Rawcliffe	14.51	29.02	0.00	0.00	0.00	0.02	0.000	0.0%	0.010	0.0%

Receptor	**PM_{10} Concentration (µg/m^3) (Annual & Daily mean)**									
	Background		**Max Baseline PC**		**Max PCC PC**		**Max PC Impact**			
	Annual	**Daily**	**Annual**	**Daily**	**Annual**	**Daily**	**Annual**	**As % of Obj**	**Daily**	**As % of Obj**
Snaith	13.45	26.90	0.00	0.00	0.00	0.01	0.000	0.0%	0.005	0.0%
Hensall	13.54	27.08	0.00	0.01	0.00	0.03	0.001	0.0%	0.013	0.0%
Cliffe	13.99	27.99	0.00	0.01	0.00	0.02	0.001	0.0%	0.010	0.0%
Breighton	13.44	26.89	0.00	0.05	0.01	0.06	0.001	0.0%	0.016	0.0%
Wressle	14.15	28.30	0.00	0.04	0.01	0.07	0.001	0.0%	0.023	0.0%
Eastrington	14.43	28.85	0.00	0.06	0.01	0.07	0.001	0.0%	0.007	0.0%
Ellerton	13.74	27.48	0.00	0.05	0.01	0.05	0.001	0.0%	0.007	0.0%
Fogathorpe	13.81	27.62	0.01	0.07	0.01	0.08	0.001	0.0%	0.006	0.0%
Barlby	14.41	28.82	0.00	0.01	0.00	0.02	0.000	0.0%	0.012	0.0%
Riccall	13.98	27.97	0.00	0.01	0.00	0.03	0.000	0.0%	0.011	0.0%
Thorpe Willoughby	13.93	27.87	0.00	0.00	0.00	0.01	0.000	0.0%	0.005	0.0%

Receptor	**PM10 Concentration (µg/m³) (Annual & Daily mean)**									
	Background		**Max Baseline PC**		**Max PCC PC**		**Max PC Impact**			
	Annual	**Daily**	**Annual**	**Daily**	**Annual**	**Daily**	**Annual**	**As % of Obj**	**Daily**	**As % of Obj**
Kellingley	14.18	28.36	0.00	0.01	0.00	0.01	0.000	0.0%	0.005	0.0%
Moorends	13.45	26.89	0.00	0.01	0.00	0.02	0.000	0.0%	0.007	0.0%
Thorne	13.27	26.53	0.00	0.01	0.00	0.01	0.000	0.0%	0.004	0.0%
Swinefleet	14.18	28.37	0.00	0.03	0.01	0.04	0.001	0.0%	0.009	0.0%
Balne	14.77	29.54	0.00	0.02	0.00	0.03	0.001	0.0%	0.009	0.0%
Whitley	13.83	27.66	0.00	0.03	0.00	0.03	0.001	0.0%	0.006	0.0%
Barlow	13.14	26.29	0.00	0.00	0.00	0.00	0.000	0.0%	0.000	0.0%
Long Drax	13.92	27.84	0.00	0.01	0.00	0.03	0.000	0.0%	0.012	0.0%
Drax	12.50	25.00	0.00	0.00	0.00	0.00	0.000	0.0%	0.002	0.0%
Newland	13.98	27.95	0.00	0.00	0.00	0.01	0.000	0.0%	0.007	0.0%
Carlton	13.95	27.89	0.00	0.00	0.00	0.01	0.000	0.0%	0.002	0.0%
Camblesforth	13.60	27.20	0.00	0.00	0.00	0.00	0.000	0.0%	0.000	0.0%

Receptor	**PM$_{10}$ Concentration (µg/m^3) (Annual & Daily mean)**									
	Background		**Max Baseline PC**		**Max PCC PC**		**Max PC Impact**			
	Annual	**Daily**	**Annual**	**Daily**	**Annual**	**Daily**	**Annual**	**As % of Obj**	**Daily**	**As % of Obj**
Burn	14.08	28.17	0.00	0.00	0.00	0.01	0.000	0.0%	0.005	0.0%
Temple Hirst	14.31	28.61	0.00	0.00	0.00	0.02	0.001	0.0%	0.013	0.0%
Cawood	13.24	26.48	0.00	0.03	0.00	0.03	0.000	0.0%	0.002	0.0%
Biggin	12.93	25.87	0.00	0.01	0.00	0.01	0.000	0.0%	0.003	0.0%
Howden	14.93	29.86	0.00	0.05	0.01	0.06	0.001	0.0%	0.017	0.0%
Brind	14.37	28.73	0.00	0.06	0.01	0.08	0.001	0.0%	0.014	0.0%
South Duffield	14.55	29.11	0.00	0.02	0.01	0.04	0.001	0.0%	0.017	0.0%
Highfield	13.98	27.95	0.00	0.06	0.01	0.07	0.001	0.0%	0.008	0.0%
Willitoft	14.12	28.23	0.00	0.06	0.01	0.07	0.001	0.0%	0.012	0.0%
Receptor Grid Max	17.56	35.11	0.01	0.08	0.01	0.08	0.002	0.0%	0.035	0.1%
AQ Objective	**40**	**50**	**40**	**50**	**40**	**50**	**40**		**50**	

Table C5 - Modelled Maximum Operational Impacts at Human Receptors – NH_3 Concentrations

Receptor	**NH_3 Concentration (µg/m^3) (Annual & Hourly mean)**									
	Background		Max Baseline PC		Max Proposed Scheme PC		Max PC Impact			
	Annual	Hourly	Annual	Hourly	Annual	Hourly	Annual	As % of EAL	Hourly	As % of EAL
Foreman's Cottage	1.6	3.2	0.000	0.051	0.000	0.126	0.000	0.0%	0.079	0.0%
East Yorkshire Caravan Park	1.6	3.2	0.000	0.060	0.000	0.141	0.000	0.0%	0.086	0.0%
Drax S&C Club	1.6	3.2	0.000	0.111	0.000	0.072	0.000	0.0%	0.034	0.0%
Wren Hall	1.6	3.2	0.000	0.084	0.000	0.109	0.000	0.0%	0.078	0.0%
3 Pear Tree Ave	1.6	3.2	0.000	0.171	0.001	0.295	0.000	0.0%	0.138	0.0%
Crange Cottages	1.6	3.2	0.000	0.119	0.000	0.169	0.000	0.0%	0.144	0.0%
Drax Abbey Farm	1.6	3.2	0.000	0.046	0.000	0.133	0.000	0.0%	0.096	0.0%
Read School	1.6	3.2	0.000	0.098	0.000	0.285	0.000	0.0%	0.190	0.0%
Old Lodge	1.6	3.2	0.000	0.119	0.000	0.196	0.000	0.0%	0.116	0.0%

Selby_AQMA	1.6	3.2	0.002	0.542	0.002	0.679	0.000	0.0%	0.402	0.0%
Goole	1.6	3.2	0.004	0.810	0.005	0.795	0.001	0.0%	0.130	0.0%
Hemingbrough	1.6	3.2	0.004	0.741	0.005	0.737	0.001	0.0%	0.037	0.0%
Rawcliffe	1.6	3.2	0.002	0.607	0.002	0.700	0.000	0.0%	0.302	0.0%
Snaith	1.6	3.2	0.002	0.580	0.002	0.626	0.000	0.0%	0.115	0.0%
Hensall	1.6	3.2	0.003	0.789	0.004	0.816	0.001	0.0%	0.205	0.0%
Cliffe	1.6	3.2	0.002	0.687	0.003	0.677	0.001	0.0%	0.133	0.0%
Breighton	1.6	3.2	0.009	1.203	0.010	1.165	0.001	0.0%	0.322	0.0%
Wressle	1.6	3.2	0.008	0.798	0.009	0.806	0.001	0.0%	0.039	0.0%
Eastrington	1.6	3.2	0.010	1.034	0.011	0.960	0.001	0.0%	0.096	0.0%
Ellerton	1.6	3.2	0.007	0.995	0.007	0.961	0.001	0.0%	0.066	0.0%
Fogathorpe	1.6	3.2	0.011	1.017	0.012	0.932	0.001	0.0%	-0.035	0.0%
Barlby	1.6	3.2	0.002	0.943	0.003	0.985	0.000	0.0%	0.269	0.0%
Riccall	1.6	3.2	0.003	1.144	0.003	1.104	0.000	0.0%	-0.038	0.0%
Thorpe Willoughby	1.6	3.2	0.002	1.165	0.002	1.117	0.000	0.0%	0.148	0.0%

Kellingley	1.6	3.2	0.004	0.954	0.004	0.919	0.000	0.0%	0.104	0.0%
Moorends	1.6	3.2	0.003	0.811	0.004	0.760	0.000	0.0%	0.208	0.0%
Thorne	1.6	3.2	0.003	0.756	0.003	0.801	0.000	0.0%	0.159	0.0%
Swinefleet	1.6	3.2	0.005	1.023	0.005	1.004	0.001	0.0%	0.185	0.0%
Balne	1.6	3.2	0.004	1.026	0.005	0.996	0.001	0.0%	0.016	0.0%
Whitley	1.6	3.2	0.004	0.980	0.005	1.013	0.001	0.0%	0.079	0.0%
Barlow	1.6	3.2	0.000	0.151	0.000	0.243	0.000	0.0%	0.189	0.0%
Long Drax	1.6	3.2	0.001	0.267	0.002	0.428	0.000	0.0%	0.193	0.0%
Drax	1.6	3.2	0.000	0.210	0.000	0.273	0.000	0.0%	0.116	0.0%
Newland	1.6	3.2	0.001	0.632	0.001	0.678	0.000	0.0%	0.344	0.0%
Carlton	1.6	3.2	0.001	0.628	0.001	0.682	0.000	0.0%	0.224	0.0%
Camblesforth	1.6	3.2	0.000	0.156	0.000	0.304	0.000	0.0%	0.204	0.0%
Burn	1.6	3.2	0.001	0.594	0.002	0.710	0.000	0.0%	0.272	0.0%
Temple Hirst	1.6	3.2	0.003	0.633	0.004	0.821	0.001	0.0%	0.294	0.0%
Cawood	1.6	3.2	0.004	0.765	0.005	0.773	0.000	0.0%	0.200	0.0%

Biggin	1.6	3.2	0.003	0.688	0.003	0.768	0.000	0.0%	0.111	0.0%
Howden	1.6	3.2	0.007	1.220	0.009	1.205	0.001	0.0%	0.099	0.0%
Brind	1.6	3.2	0.009	1.376	0.010	1.291	0.001	0.0%	0.043	0.0%
South Duffield	1.6	3.2	0.005	0.664	0.006	0.795	0.001	0.0%	0.154	0.0%
Highfield	1.6	3.2	0.009	1.191	0.010	1.137	0.001	0.0%	0.029	0.0%
Willitoft	1.6	3.2	0.010	1.245	0.012	1.214	0.001	0.0%	0.038	0.0%
Receptor Grid Max	1.6	3.2	0.012	1.402	0.012	1.349	0.002	0.0%	0.645	0.0%
Env. Agency EAL	**180**	**2,500**	**180**	**2,500**	**180**	**2,500**	**180**		**2,500**	

Table C6 - Modelled Maximum Operational Impacts at Human Receptors – Hourly Mean HCl Concentrations

Receptor	**HCl Hourly Mean Concentration (µg/m^3)**				
	Background	**Max Baseline PC**	**Max PCC PC**	**Max PC Impact**	**As % of EAL**
Foreman's Cottage	4.86	0.02	0.05	0.03	0.0%
East Yorkshire Carav	4.86	0.00	0.01	0.01	0.0%
Drax S&C Club	4.86	0.00	0.01	0.01	0.0%
Wren Hall	4.86	0.01	0.04	0.02	0.0%
3 Pear Tree Ave	4.86	0.05	0.18	0.13	0.1%
Crange Cottages	4.86	0.01	0.04	0.03	0.1%
Drax Abbey Farm	4.86	0.01	0.06	0.04	0.0%
Read School	4.86	0.03	0.11	0.08	0.1%
Old Lodge	4.86	0.03	0.13	0.10	0.1%
Selby_AQMA	4.86	0.30	0.54	0.26	0.2%
Goole	4.86	0.43	0.59	0.21	0.1%

Receptor	**HCl Hourly Mean Concentration (µg/m^3)**				
	Background	**Max Baseline PC**	**Max PCC PC**	**Max PC Impact**	**As % of EAL**
Hemingbrough	4.86	0.47	0.54	0.15	0.1%
Rawcliffe	4.86	0.26	0.53	0.41	0.2%
Snaith	4.86	0.25	0.53	0.30	0.1%
Hensall	4.86	0.44	0.55	0.20	0.2%
Cliffe	4.86	0.41	0.52	0.20	0.1%
Breighton	4.86	0.53	0.63	0.12	0.2%
Wressle	4.86	0.56	0.63	0.12	0.1%
Eastrington	4.86	0.58	0.66	0.08	0.1%
Ellerton	4.86	0.49	0.56	0.11	0.1%
Fogathorpe	4.86	0.62	0.68	0.11	0.1%
Barlby	4.86	0.39	0.46	0.25	0.2%
Riccall	4.86	0.41	0.45	0.15	0.1%
Thorpe Willoughby	4.86	0.27	0.50	0.28	0.1%

Receptor	**HCl Hourly Mean Concentration (µg/m^3)**				
	Background	**Max Baseline PC**	**Max PCC PC**	**Max PC Impact**	**As % of EAL**
Kellingley	4.86	0.50	0.57	0.08	0.1%
Moorends	4.86	0.46	0.54	0.13	0.2%
Thorne	4.86	0.44	0.49	0.10	0.1%
Swinefleet	4.86	0.52	0.63	0.11	0.1%
Balne	4.86	0.48	0.58	0.10	0.1%
Whitley	4.86	0.47	0.54	0.10	0.1%
Barlow	4.86	0.03	0.19	0.15	0.1%
Long Drax	4.86	0.13	0.34	0.24	0.1%
Drax	4.86	0.04	0.13	0.11	0.1%
Newland	4.86	0.11	0.42	0.33	0.2%
Carlton	4.86	0.16	0.44	0.31	0.1%
Camblesforth	4.86	0.02	0.09	0.07	0.1%
Burn	4.86	0.21	0.43	0.29	0.2%

Receptor	**HCl Hourly Mean Concentration (µg/m^3)**				
	Background	**Max Baseline PC**	**Max PCC PC**	**Max PC Impact**	**As % of EAL**
Temple Hirst	4.86	0.48	0.54	0.29	0.2%
Cawood	4.86	0.52	0.59	0.10	0.1%
Biggin	4.86	0.43	0.55	0.12	0.1%
Howden	4.86	0.53	0.62	0.14	0.1%
Brind	4.86	0.52	0.60	0.11	0.1%
South Duffield	4.86	0.57	0.62	0.07	0.2%
Highfield	4.86	0.50	0.57	0.09	0.1%
Willitoft	4.86	0.58	0.63	0.10	0.1%
Receptor Grid Max	4.86	0.69	0.74	0.42	0.3%
EAL	**750**				

Table C7 - Modelled Maximum Operational Impacts at Human Receptors – Amines (as MEA) Concentrations

Receptor	**Amine Concentration (µg/m^3) (Hourly & Daily mean) – Results presented to 3 d.p.**			
	Max PCC PC Impact			
	Hourly (1)	**As % of EAL**	**Daily (1)**	**As % of EAL**
Foreman's Cottage	0.035	0.1%	0.002	0.0%
East Yorkshire Caravan	0.039	0.1%	0.002	0.0%
Drax S&C Club	0.020	0.0%	0.002	0.0%
Wren Hall	0.030	0.1%	0.002	0.0%
3 Pear Tree Ave	0.079	0.1%	0.011	0.1%
Crange Cottages	0.041	0.1%	0.003	0.0%
Drax Abbey Farm	0.029	0.1%	0.003	0.0%
Read School	0.080	0.2%	0.007	0.1%
Old Lodge	0.054	0.1%	0.007	0.1%
Selby_AQMA	0.150	0.3%	0.024	0.2%
Goole	0.155	0.3%	0.020	0.2%
Hemingbrough	0.142	0.3%	0.039	0.3%
Rawcliffe	0.153	0.3%	0.028	0.2%

Snaith	0.116	0.2%	0.042	0.3%
Hensall	0.198	0.4%	0.027	0.2%
Cliffe	0.123	0.2%	0.031	0.2%
Breighton	0.254	0.5%	0.034	0.3%
Wressle	0.198	0.4%	0.035	0.3%
Eastrington	0.153	0.3%	0.024	0.2%
Ellerton	0.157	0.3%	0.019	0.1%
Fogathorpe	0.157	0.3%	0.022	0.2%
Barlby	0.235	0.4%	0.029	0.2%
Riccall	0.187	0.4%	0.020	0.2%
Thorpe Willoughby	0.204	0.4%	0.018	0.1%
Kellingley	0.160	0.3%	0.034	0.3%
Moorends	0.168	0.3%	0.019	0.1%
Thorne	0.119	0.2%	0.014	0.1%
Swinefleet	0.160	0.3%	0.015	0.1%
Balne	0.177	0.3%	0.017	0.1%
Whitley	0.170	0.3%	0.017	0.1%
Barlow	0.056	0.1%	0.008	0.1%
Long Drax	0.117	0.2%	0.024	0.2%
Drax	0.076	0.1%	0.010	0.1%
Newland	0.148	0.3%	0.017	0.1%
Carlton	0.150	0.3%	0.034	0.3%
Camblesforth	0.078	0.1%	0.006	0.0%
Burn	0.200	0.4%	0.020	0.2%
Temple Hirst	0.130	0.2%	0.040	0.3%
Cawood	0.116	0.2%	0.016	0.1%

Biggin	0.163	0.3%	0.015	0.1%
Howden	0.224	0.4%	0.028	0.2%
Brind	0.223	0.4%	0.028	0.2%
South Duffield	0.188	0.4%	0.033	0.3%
Highfield	0.180	0.3%	0.031	0.2%
Willitoft	0.201	0.4%	0.028	0.2%
Receptor Grid Max	0.258	0.5%	0.063	0.5%
EAL	**53**		**13**	

Notes:

(1) Maximum modelled amine concentrations based on sum of 'Amine 1' + 'Amine 2' maxima, which is potentially conservative because the 'Amine 1' maximum concentration could occur at a different time (hour/day) to the 'Amine 2' maximum concentration at any given receptor or grid point. Results based on proposed daily average AELs for 'Amine 1' and 'Amine 2'

Table C8 - Modelled Maximum Operational Impacts at Human Receptors – Annual Mean Nitrosamine (as NDMA) Concentrations

Receptor	Max PCC PC			As % of EAL
	Direct (1)	**Indirect** (2)	**Total** (3)	
Foreman's Cottage	0.0000	0.0001	0.000	0.0%
East Yorkshire Caravan Park	0.0000	0.0000	0.000	0.0%
Drax S&C Club	0.0000	0.0000	0.000	0.0%
Wren Hall	0.0000	0.0001	0.000	0.0%
3 Pear Tree Ave	0.0000	0.0008	0.001	0.1%
Crange Cottages	0.0000	0.0001	0.000	0.0%
Drax Abbey Farm	0.0000	0.0002	0.000	0.0%
Read School	0.0000	0.0003	0.000	0.0%
Old Lodge	0.0000	0.0005	0.000	0.0%
Selby AQMA	0.0001	0.0069	0.007	1.1%
Goole	0.0001	0.0089	0.009	2.3%

Hemingbrough	0.0001	0.0025	0.003	0.4%
Rawcliffe	0.0001	0.0037	0.004	0.6%
Snaith	0.0001	0.0046	0.005	0.7%
Hensall	0.0001	0.0070	0.007	1.6%
Cliffe	0.0001	0.0029	0.003	0.4%
Breighton	0.0001	0.0094	0.010	2.3%
Wressle	0.0002	0.0090	0.009	1.8%
Eastrington	0.0001	0.0166	0.017	6.5%
Ellerton	0.0001	0.0075	0.008	2.7%
Fogathorpe	0.0001	0.0132	0.013	5.0%
Barlby	0.0000	0.0039	0.004	0.7%
Riccall	0.0000	0.0055	0.006	1.5%
Thorpe Willoughby	0.0000	0.0053	0.005	1.3%
Kellingley	0.0001	0.0076	0.008	2.9%
Moorends	0.0000	0.0058	0.006	2.0%

Thorne	0.0000	0.0048	0.005	1.8%
Swinefleet	0.0001	0.0098	0.010	3.4%
Balne	0.0001	0.0078	0.008	2.6%
Whitley	0.0001	0.0079	0.008	2.5%
Barlow	0.0000	0.0007	0.001	0.0%
Long Drax	0.0000	0.0017	0.002	0.2%
Drax	0.0000	0.0003	0.000	0.0%
Newland	0.0000	0.0026	0.003	0.2%
Carlton	0.0000	0.0022	0.002	0.2%
Camblesforth	0.0000	0.0003	0.000	0.0%
Burn	0.0000	0.0041	0.004	0.8%
Temple Hirst	0.0001	0.0059	0.006	1.1%
Cawood	0.0001	0.0111	0.011	3.9%
Biggin	0.0000	0.0075	0.008	2.7%
Howden	0.0001	0.0146	0.015	4.1%

Brind	0.0002	0.0141	0.014	4.2%
South Duffield	0.0001	0.0044	0.004	0.9%
Highfield	0.0001	0.0109	0.011	3.6%
Willitoft	0.0002	0.0132	0.013	4.3%
Receptor Grid Max	0.0002	0.0171	0.017	7.4%
EAL	**0.2**			

Table C9 - Modelled Maximum Operational Impacts at Human Receptors - Aldehydes (as Formaldehyde) Concentrations

Aldehydes Concentration (µg/m^3) (Hourly & Annual mean) – Results presented to 3 d.p.

Receptor	Max PC Impact			
	Hourly	As % of EAL(1)	Daily	As % of EAL(1)
Foreman's Cottage	0.000	0.0%	0.13	0.1%
East Yorkshire Caravan Park	0.000	0.0%	0.14	0.2%
Drax S&C Club	0.000	0.0%	0.07	0.1%
Wren Hall	0.000	0.0%	0.11	0.1%
3 Pear Tree Ave	0.000	0.0%	0.29	0.3%
Crange Cottages	0.000	0.0%	0.17	0.2%
Drax Abbey Farm	0.000	0.0%	0.13	0.2%
Read School	0.000	0.0%	0.28	0.3%
Old Lodge	0.000	0.0%	0.20	0.2%
Selby_AQMA	0.001	0.0%	0.68	0.8%
Goole	0.001	0.0%	0.67	0.8%

Hemingbrough	0.001	0.0%	0.59	0.7%
Rawcliffe	0.001	0.0%	0.70	0.8%
Snaith	0.001	0.0%	0.62	0.7%
Hensall	0.001	0.0%	0.69	0.8%
Cliffe	0.001	0.0%	0.63	0.7%
Breighton	0.003	0.1%	0.85	1.0%
Wressle	0.003	0.1%	0.70	0.8%
Eastrington	0.003	0.1%	0.59	0.7%
Ellerton	0.002	0.0%	0.56	0.6%
Fogathorpe	0.004	0.1%	0.61	0.7%
Barlby	0.001	0.0%	0.80	0.9%
Riccall	0.001	0.0%	0.67	0.8%
Thorpe Willoughby	0.001	0.0%	0.69	0.8%
Kellingley	0.001	0.0%	0.63	0.7%
Moorends	0.001	0.0%	0.72	0.8%

Thorne	0.001	0.0%	0.63	0.7%
Swinefleet	0.002	0.0%	0.60	0.7%
Balne	0.001	0.0%	0.65	0.7%
Whitley	0.001	0.0%	0.75	0.9%
Barlow	0.000	0.0%	0.24	0.3%
Long Drax	0.000	0.0%	0.43	0.5%
Drax	0.000	0.0%	0.27	0.3%
Newland	0.000	0.0%	0.66	0.8%
Carlton	0.000	0.0%	0.59	0.7%
Camblesforth	0.000	0.0%	0.30	0.3%
Burn	0.000	0.0%	0.71	0.8%
Temple Hirst	0.001	0.0%	0.82	0.9%
Cawood	0.001	0.0%	0.61	0.7%
Biggin	0.001	0.0%	0.64	0.7%
Howden	0.003	0.1%	0.79	0.9%

Brind	0.003	0.1%	0.75	0.9%
South Duffield	0.002	0.0%	0.80	0.9%
Highfield	0.003	0.1%	0.71	0.8%
Willitoft	0.004	0.1%	0.69	0.8%
Receptor Grid Max	0.004	0.1%	0.97	1.1%
EAL	**5**		**87(2)**	

Notes:

(1) All aldehydes assumed in the form of formaldehyde. This is a conservative assumption

(2) 30min EAL for Formaldehyde converted to 1 hour concentration using power law relationship

Cumulative Impacts (With PCC & Other Projects)

Results pertaining to the cumulative impacts are presented in Tables C10 to C12.

Table C10 - Modelled Maximum Cumulative Impacts at Human Receptors – Annual Mean NO_2 Concentrations

Annual mean NO_2 Concentration ($\mu g/m^3$)

Receptor	Baseline + Other Projects		Baseline + Other Projects + With Scheme		Max Cumulative PC Impact	IAQM Impact Descriptor
	Max PC	**Max PEC**	**Max PC**	**Max PEC**		
Foreman's Cottage	0.62	7.29	0.62	7.30	0.00	Negligible
East Yorkshire Caravan Park	0.54	10.37	0.54	10.37	0.00	Negligible
Drax S&C Club	0.55	10.38	0.55	10.38	0.00	Negligible
Wren Hall	0.55	7.56	0.56	7.57	0.00	Negligible
3 Pear Tree Ave	0.56	7.34	0.58	7.36	0.01	Negligible
Crange Cottages	0.57	8.01	0.57	8.01	0.00	Negligible
Drax Abbey Farm	0.60	7.38	0.61	7.39	0.00	Negligible
Read School	0.53	7.80	0.53	7.80	0.01	Negligible
Old Lodge	0.58	7.36	0.59	7.37	0.01	Negligible
Selby_AQMA	0.45	46.95	0.49	46.99	0.04	Negligible

Goole	0.39	28.39	0.46	28.46	0.06	Negligible
Hemingbrough	0.63	7.57	0.69	7.63	0.06	Negligible
Rawcliffe	0.40	9.04	0.44	9.08	0.04	Negligible
Snaith	0.34	8.74	0.38	8.78	0.04	Negligible
Hensall	0.48	9.00	0.53	9.04	0.05	Negligible
Cliffe	0.64	7.60	0.68	7.63	0.04	Negligible
Breighton	0.52	7.03	0.63	7.14	0.11	Negligible
Wressle	0.51	7.25	0.62	7.36	0.11	Negligible
Eastrington	0.32	8.05	0.44	8.17	0.12	Negligible
Ellerton	0.41	6.37	0.49	6.45	0.07	Negligible
Fogathorpe	0.42	7.06	0.55	7.19	0.13	Negligible
Barlby	0.49	10.67	0.53	10.71	0.04	Negligible
Riccall	0.23	6.94	0.27	6.99	0.04	Negligible
Thorpe Willoughby	0.19	7.96	0.22	7.99	0.03	Negligible
Kellingley	0.15	8.55	0.19	8.60	0.05	Negligible

Moorends	0.25	9.54	0.29	9.59	0.04	Negligible
Thorne	0.28	38.28	0.31	38.31	0.03	Negligible
Swinefleet	0.35	7.71	0.41	7.78	0.06	Negligible
Balne	0.13	7.86	0.18	7.91	0.05	Negligible
Whitley	0.27	9.15	0.32	9.19	0.04	Negligible
Barlow	0.73	7.79	0.74	7.80	0.01	Negligible
Long Drax	0.56	7.42	0.59	7.45	0.03	Negligible
Drax	0.51	7.78	0.52	7.79	0.01	Negligible
Newland	0.47	7.99	0.49	8.02	0.02	Negligible
Carlton	0.53	8.67	0.56	8.70	0.03	Negligible
Camblesforth	0.58	7.98	0.58	7.98	0.00	Negligible
Burn	0.54	8.30	0.56	8.33	0.03	Negligible
Temple Hirst	0.80	9.09	0.85	9.14	0.05	Negligible
Cawood	0.12	7.44	0.18	7.50	0.06	Negligible
Biggin	0.18	7.94	0.21	7.98	0.04	Negligible

Howden	0.39	9.49	0.50	9.61	0.12	Negligible
Brind	0.42	7.00	0.53	7.12	0.12	Negligible
South Duffield	0.59	6.92	0.66	6.99	0.07	Negligible
Highfield	0.47	6.80	0.58	6.91	0.11	Negligible
Willitoft	0.44	6.71	0.57	6.84	0.13	Negligible
Receptor Grid Max	9.96	23.44	10.01	23.46	0.05	Negligible
AQ Objective	**40**					

Table C11 - Modelled Maximum Cumulative Impacts at Human Receptors – PM$_{10}$ Concentrations

Annual mean PM$_{10}$ Concentration ($\mu g/m^3$)

Receptor	Baseline + Other Projects		Baseline + Other Projects + With Scheme		Max Cumulative PC Impact	IAQM Impact Descriptor
	Max PC	**Max PEC**	**Max PC**	**Max PEC**		
Foreman's Cottage	0.00	12.14	0.00	12.14	0.00	Negligible
East Yorkshire Caravan Park	0.00	12.49	0.00	12.49	0.00	Negligible
Drax S&C Club	0.00	12.49	0.00	12.49	0.00	Negligible
Wren Hall	0.00	13.57	0.00	13.57	0.00	Negligible
3 Pear Tree Ave	0.00	14.40	0.00	14.40	0.00	Negligible
Crange Cottages	0.00	12.26	0.00	12.26	0.00	Negligible
Drax Abbey Farm	0.00	14.40	0.00	14.40	0.00	Negligible
Read School	0.00	12.50	0.00	12.50	0.00	Negligible
Old Lodge	0.00	14.40	0.00	14.40	0.00	Negligible
Selby_AQMA	0.00	13.50	0.00	13.50	0.00	Negligible

Goole	0.00	13.30	0.01	13.30	0.01	Negligible
Hemingbrough	0.00	13.22	0.01	13.23	0.01	Negligible
Rawcliffe	0.00	14.51	0.00	14.51	0.00	Negligible
Snaith	0.00	13.45	0.00	13.45	0.00	Negligible
Hensall	0.00	13.54	0.01	13.54	0.00	Negligible
Cliffe	0.00	13.99	0.00	14.00	0.00	Negligible
Breighton	0.00	13.44	0.01	13.45	0.01	Negligible
Wressle	0.00	14.15	0.01	14.16	0.01	Negligible
Eastrington	0.00	14.43	0.01	14.44	0.01	Negligible
Ellerton	0.00	13.74	0.01	13.75	0.01	Negligible
Fogathorpe	0.00	13.81	0.01	13.82	0.01	Negligible
Barlby	0.00	14.41	0.00	14.41	0.00	Negligible
Riccall	0.00	13.98	0.00	13.99	0.00	Negligible
Thorpe Willoughby	0.00	13.93	0.00	13.94	0.00	Negligible
Kellingley	0.00	14.18	0.00	14.19	0.00	Negligible

Moorends	0.00	13.45	0.01	13.45	0.00	Negligible
Thorne	0.00	13.27	0.01	13.27	0.00	Negligible
Swinefleet	0.00	14.19	0.01	14.19	0.01	Negligible
Balne	0.00	14.77	0.01	14.77	0.00	Negligible
Whitley	0.00	13.83	0.01	13.83	0.00	Negligible
Barlow	0.00	13.14	0.00	13.14	0.00	Negligible
Long Drax	0.00	13.92	0.00	13.92	0.00	Negligible
Drax	0.00	12.50	0.00	12.50	0.00	Negligible
Newland	0.00	13.98	0.00	13.98	0.00	Negligible
Carlton	0.00	13.95	0.00	13.95	0.00	Negligible
Camblesforth	0.00	13.60	0.00	13.60	0.00	Negligible
Burn	0.00	14.08	0.00	14.09	0.00	Negligible
Temple Hirst	0.00	14.31	0.01	14.31	0.00	Negligible
Cawood	0.00	13.24	0.01	13.25	0.00	Negligible
Biggin	0.00	12.94	0.00	12.94	0.00	Negligible

Howden	0.00	14.93	0.01	14.94	0.01	Negligible
Brind	0.00	14.37	0.01	14.38	0.01	Negligible
South Duffield	0.00	14.55	0.01	14.56	0.01	Negligible
Highfield	0.00	13.98	0.01	13.99	0.01	Negligible
Willitoft	0.00	14.12	0.01	14.13	0.01	Negligible
Receptor Grid Max	0.00	17.56	0.01	17.57	0.01	Negligible
AQ Objective	**40**					

Table C12 - Modelled Maximum Cumulative Impacts at Human Receptors – NH_3 Concentrations

Annual mean NH_3 Concentration (µg/m^3)

Receptor	Baseline + Other Projects	Baseline + Other Projects + With Scheme	Max Cumulative PC Impact	IAQM Impact Descriptor
	Max PC	**Max PC**		
Foreman's Cottage	0.00	0.00	0.00	Negligible
East Yorkshire Caravan Park	0.00	0.00	0.00	Negligible
Drax S&C Club	0.00	0.00	0.00	Negligible
Wren Hall	0.00	0.00	0.00	Negligible
3 Pear Tree Ave	0.00	0.00	0.00	Negligible
Crange Cottages	0.00	0.00	0.00	Negligible
Drax Abbey Farm	0.00	0.00	0.00	Negligible
Read School	0.00	0.00	0.00	Negligible
Old Lodge	0.00	0.00	0.00	Negligible
Selby_AQMA	0.00	0.01	0.00	Negligible

Goole	0.00	0.01	0.01	Negligible
Hemingbrough	0.00	0.01	0.01	Negligible
Rawcliffe	0.00	0.01	0.00	Negligible
Snaith	0.00	0.01	0.00	Negligible
Hensall	0.00	0.01	0.00	Negligible
Cliffe	0.00	0.00	0.00	Negligible
Breighton	0.00	0.01	0.01	Negligible
Wressle	0.00	0.01	0.01	Negligible
Eastrington	0.00	0.01	0.01	Negligible
Ellerton	0.00	0.01	0.01	Negligible
Fogathorpe	0.00	0.01	0.01	Negligible
Barlby	0.00	0.00	0.00	Negligible
Riccall	0.00	0.00	0.00	Negligible
Thorpe Willoughby	0.00	0.00	0.00	Negligible
Kellingley	0.00	0.00	0.00	Negligible

Moorends	0.00	0.01	0.00	Negligible
Thorne	0.01	0.01	0.00	Negligible
Swinefleet	0.01	0.01	0.01	Negligible
Balne	0.00	0.01	0.00	Negligible
Whitley	0.00	0.00	0.00	Negligible
Barlow	0.00	0.00	0.00	Negligible
Long Drax	0.00	0.01	0.00	Negligible
Drax	0.00	0.00	0.00	Negligible
Newland	0.00	0.01	0.00	Negligible
Carlton	0.00	0.01	0.00	Negligible
Camblesforth	0.00	0.00	0.00	Negligible
Burn	0.00	0.00	0.00	Negligible
Temple Hirst	0.00	0.01	0.00	Negligible
Cawood	0.00	0.00	0.00	Negligible
Biggin	0.00	0.00	0.00	Negligible

Howden	0.00	0.01	0.01	Negligible
Brind	0.00	0.01	0.01	Negligible
South Duffield	0.00	0.01	0.01	Negligible
Highfield	0.00	0.01	0.01	Negligible
Willitoft	0.00	0.01	0.01	Negligible
Receptor Grid Max	0.03	0.03	0.00	Negligible
EAL	**180**			

Sensitivity Test: Worst Case Emissions Profile

Results pertaining to the worst-case emissions profile sensitivity test are presented in Tables C13 to C20.

It is evident that, for the annual mean averaging period, modelled maximum PC concentrations increase in the Baseline scenario under worst case emission conditions, relative to the core modelling scenario equivalents (see Table C2 for NO_2 annual mean). Whereas, in the With PCC scenario, there is no or very small change in modelled annual mean concentrations when comparing the core and worst-case emissions modelling.

This is a function of all four biomass units in the Baseline scenario switching from 'mid-merit' operation (full load for 4,000 hours per year) to continuous operation (full load for 8,760 hours per year), resulting in more pollutants being emitted and thus more pronounced changes in annual mean concentrations relative to the With PCC, where operation changes from 'mid-merit' to continuous full load at the two non-PCC biomass units only (PCC units already assumed to operate at continuous full load in core modelling scenario). As the non-PCC units emit flue gas at a higher temperature relative to the PCC units, there is enhanced plume buoyancy when all units operate continuously, resulting in some minor reductions in maximum PC annual mean concentrations.

The net outcome of the above effects, under worst case emissions conditions, is that the majority of modelled Baseline annual mean concentrations increase, whilst With PCC concentrations remain largely unchanged or reduce slightly. Therefore, the maximum impacts on annual mean concentrations are reported to decrease at the majority of receptors relative to the core modelling equivalents.

For short-term averaging periods, under worst case emissions conditions, the modelled maximum PC concentrations in the Baseline scenario are shown to be identical to the core modelling equivalents (see Table C3 for NO_2 hourly mean). This is because modelling was undertaken with all biomass units at full load for all hours in the year in both core and worst-case Baseline scenarios, to capture all potential meteorological conditions in any given hour or day.

In the With PCC scenario, under worst case conditions, the maximum short-term PC concentrations are lower at receptors closer to the Main Stack relative to the core modelling results. This is due to the effect of enhanced plume buoyancy when the non-PCC units operate continuously with the PCC units (as discussed above). At distances further from the Main Stack, the effect of enhanced buoyancy on short-term maxima diminishes, resulting in no or very small changes in maximum PC concentrations relative to the core modelling.

The net outcome of the above, under worst case emissions conditions, is that the majority of modelled Baseline short-term averaged concentrations are unchanged, whilst With PCC maximum concentrations are largely unchanged or reduce slightly.

Therefore, the maximum impacts on short-term averaged concentrations are reported to decrease at the majority of receptors relative to the core modelling equivalents.

Whilst the maximum short-term grid PC concentrations do not change in the worst case modelling relative to the core modelling (excluding amines), in both the Baseline and With PCC scenarios, the maximum modelled impacts are lower. This is a function of the location of the maximum impact shifting under worst case emissions, again due to the change in Main Stack plume buoyancy (i.e. the maximum impact does not occur at the same location as the maximum PC concentration in the With PCC scenario).

Given that the results of the core scenario modelling represent the highest modelled impacts associated with the PCC operation, there was no need to repeat this sensitivity test in relation to ecological receptors.

Table C13 - Modelled Maximum Operational Impacts at Human Receptors – Annual Mean NO_2 Concentrations (Worst Case Emissions Profile)

Receptor	Annual mean NO_2 Concentration (µg/m^3)					
	Max Baseline PC	Max Baseline PEC	Max PCC PC	Max PCC PEC	Max PC Impact	IAQM Impact Descriptor
Foreman's Cottage	0.00	6.67	0.00	6.67	0.00	Negligible
East Yorkshire Caravan Park	0.00	9.83	0.00	9.83	0.00	Negligible
Drax S&C Club	0.00	9.83	0.00	9.83	0.00	Negligible
Wren Hall	0.00	7.01	0.00	7.01	0.00	Negligible
3 Pear Tree Ave	0.00	6.79	0.01	6.79	0.00	Negligible
Crange Cottages	0.00	7.44	0.00	7.44	0.00	Negligible
Drax Abbey Farm	0.00	6.78	0.00	6.78	0.00	Negligible
Read School	0.00	7.27	0.00	7.27	0.00	Negligible
Old Lodge	0.00	6.78	0.00	6.79	0.00	Negligible
Selby_AQMA	0.02	46.52	0.03	46.53	0.01	Negligible
Goole	0.04	28.04	0.06	28.06	0.01	Negligible

Hemingbrough	0.04	6.98	0.05	6.99	0.01	Negligible
Rawcliffe	0.02	8.66	0.03	8.67	0.01	Negligible
Snaith	0.02	8.41	0.03	8.42	0.01	Negligible
Hensall	0.04	8.55	0.04	8.56	0.01	Negligible
Cliffe	0.03	6.98	0.03	6.99	0.01	Negligible
Breighton	0.10	6.61	0.10	6.61	0.02	Negligible
Wressle	0.08	6.82	0.09	6.82	0.02	Negligible
Eastrington	0.11	7.84	0.13	7.85	0.02	Negligible
Ellerton	0.07	6.03	0.08	6.04	0.01	Negligible
Fogathorpe	0.13	6.77	0.14	6.78	0.02	Negligible
Barlby	0.02	10.21	0.03	10.21	0.01	Negligible
Riccall	0.03	6.75	0.04	6.75	0.01	Negligible
Thorpe Willoughby	0.02	7.79	0.02	7.80	0.01	Negligible
Kellingley	0.04	8.45	0.05	8.46	0.01	Negligible
Moorends	0.04	9.33	0.04	9.34	0.02	Negligible

Thorne	0.03	38.03	0.03	38.03	0.02	Negligible
Swinefleet	0.05	7.42	0.06	7.43	0.01	Negligible
Balne	0.05	7.78	0.05	7.78	0.01	Negligible
Whitley	0.05	8.92	0.05	8.92	0.01	Negligible
Barlow	0.00	7.07	0.00	7.07	0.00	Negligible
Long Drax	0.01	6.87	0.02	6.87	0.01	Negligible
Drax	0.00	7.27	0.00	7.27	0.00	Negligible
Newland	0.01	7.54	0.01	7.54	0.00	Negligible
Carlton	0.01	8.15	0.01	8.15	0.00	Negligible
Camblesforth	0.00	7.40	0.00	7.40	0.00	Negligible
Burn	0.01	7.78	0.02	7.78	0.01	Negligible
Temple Hirst	0.03	8.32	0.04	8.33	0.01	Negligible
Cawood	0.05	7.37	0.06	7.38	0.01	Negligible
Biggin	0.03	7.80	0.04	7.80	0.01	Negligible
Howden	0.08	9.19	0.11	9.21	0.03	Negligible

Brind	0.10	6.68	0.11	6.69	0.02	Negligible
South Duffield	0.05	6.38	0.06	6.39	0.01	Negligible
Highfield	0.10	6.43	0.11	6.44	0.02	Negligible
Willitoft	0.12	6.38	0.13	6.39	0.02	Negligible
Receptor Grid Max	0.14	13.67	0.15	13.68	0.03	Negligible
AQ Objective	**40**					

Table C14 - Modelled Maximum Operational Impacts at Human Receptors – Hourly Mean NO_2 Concentrations (Worst Case Emissions Profile)

Receptor	Hourly mean NO_2 Concentration ($\mu g/m^3$) (Based on 99.79th %ile of hourly values)					
	Max Baseline PC	Max Baseline PEC	Max PCC PC	Max PCC PEC	Max PC Impact	IAQM Impact Descriptor
Foreman's Cottage	0.11	13.45	0.15	13.50	0.05	Negligible
East Yorkshire Caravan Park	0.02	19.68	0.05	19.71	0.02	Negligible
Drax S&C Club	0.01	19.67	0.03	19.68	0.02	Negligible
Wren Hall	0.08	14.10	0.13	14.15	0.05	Negligible
3 Pear Tree Ave	0.30	13.86	0.42	13.98	0.15	Negligible
Crange Cottages	0.08	14.95	0.11	14.98	0.03	Negligible
Drax Abbey Farm	0.08	13.64	0.11	13.67	0.04	Negligible
Read School	0.18	14.72	0.23	14.77	0.08	Negligible
Old Lodge	0.20	13.77	0.27	13.83	0.09	Negligible
Selby_AQMA	1.72	94.72	2.23	95.23	0.61	Negligible
Goole	2.52	58.52	3.15	59.15	0.76	Negligible

Hemingbrough	2.73	16.60	3.14	17.02	0.68	Negligible
Rawcliffe	1.54	18.83	2.06	19.34	0.62	Negligible
Snaith	1.47	18.26	2.04	18.83	0.64	Negligible
Hensall	2.55	19.58	3.08	20.11	0.62	Negligible
Cliffe	2.37	16.28	3.05	16.97	0.68	Negligible
Breighton	3.07	16.09	3.26	16.28	0.31	Negligible
Wressle	3.25	16.72	3.65	17.12	0.60	Negligible
Eastrington	3.39	18.84	3.88	19.33	0.49	Negligible
Ellerton	2.84	14.75	3.27	15.18	0.62	Negligible
Fogathorpe	3.64	16.93	3.97	17.26	0.64	Negligible
Barlby	2.29	22.65	2.71	23.07	0.43	Negligible
Riccall	2.41	15.83	2.64	16.06	0.49	Negligible
Thorpe Willoughby	1.59	17.14	2.10	17.65	0.76	Negligible
Kellingley	2.89	19.71	3.32	20.14	0.45	Negligible
Moorends	2.70	21.28	3.13	21.72	0.73	Negligible

Thorne	2.56	78.56	2.84	78.84	0.60	Negligible
Swinefleet	3.02	17.75	3.68	18.41	0.66	Negligible
Balne	2.79	18.25	3.38	18.84	0.59	Negligible
Whitley	2.73	20.47	3.14	20.89	0.61	Negligible
Barlow	0.20	14.33	0.33	14.46	0.13	Negligible
Long Drax	0.78	14.50	1.05	14.77	0.34	Negligible
Drax	0.21	14.75	0.27	14.81	0.07	Negligible
Newland	0.65	15.71	0.99	16.05	0.41	Negligible
Carlton	0.94	17.21	1.30	17.58	0.39	Negligible
Camblesforth	0.14	14.94	0.19	14.99	0.07	Negligible
Burn	1.24	16.77	1.82	17.35	0.58	Negligible
Temple Hirst	2.77	19.34	3.14	19.72	0.74	Negligible
Cawood	3.06	17.70	3.43	18.07	0.59	Negligible
Biggin	2.52	18.05	3.22	18.74	0.70	Negligible
Howden	3.09	21.30	3.54	21.75	0.72	Negligible

Brind	3.04	16.21	3.52	16.69	0.63	Negligible
South Duffield	3.33	15.98	3.62	16.28	0.39	Negligible
Highfield	2.93	15.59	3.35	16.01	0.44	Negligible
Willitoft	3.41	15.94	3.67	16.21	0.59	Negligible
Receptor Grid Max	4.05	31.11	4.31	31.37	1.30	Negligible
AQ Objective	**200**					

Table C15 - Modelled Maximum Operational Impacts at Human Receptors – SO_2 Concentrations (Worst Case Emissions Profile)

Receptor	**SO_2 Concentration (µg/m^3) (15-min/Hourly/Daily mean)**										
	Background	Max Baseline PC			Max PCC PC			Max PC Impact			IAQM Impact Descriptor (applicable to all averaging periods)
		15-min	Hourly	Daily	15-min	Hourly	Daily	15-min	Hourly	Daily	
Foreman's Cottage	20.48	0.59	0.27	0.06	0.99	0.37	0.09	0.40	0.09	0.02	Negligible
East Yorkshire Caravan Park	20.48	0.21	0.05	0.02	0.38	0.10	0.03	0.19	0.05	0.01	Negligible
Drax S&C Club	20.48	0.16	0.02	0.02	0.33	0.04	0.02	0.17	0.03	0.01	Negligible
Wren Hall	20.48	0.65	0.16	0.06	0.81	0.28	0.12	0.36	0.12	0.06	Negligible
3 Pear Tree Ave	20.48	1.96	0.77	0.18	2.72	1.03	0.21	0.90	0.40	0.07	Negligible
Crange Cottages	20.48	0.54	0.19	0.06	0.90	0.22	0.09	0.36	0.06	0.03	Negligible
Drax Abbey Farm	20.48	0.50	0.17	0.05	0.91	0.26	0.08	0.41	0.12	0.03	Negligible
Read School	20.48	1.18	0.38	0.09	1.93	0.54	0.17	0.74	0.23	0.08	Negligible
Old Lodge	20.48	1.33	0.51	0.11	1.71	0.73	0.16	0.51	0.25	0.06	Negligible

Selby_AQMA	20.48	9.95	4.40	1.08	12.53	5.85	1.66	3.43	1.45	0.58	Negligible
Goole	20.48	15.49	6.95	1.72	17.96	8.51	1.74	4.24	2.05	0.29	Negligible
Hemingbrough	20.48	15.42	7.07	2.18	17.22	8.42	2.73	2.88	1.98	0.56	Negligible
Rawcliffe	20.48	9.56	3.34	0.82	12.14	5.24	1.21	3.82	1.90	0.41	Negligible
Snaith	20.48	9.93	3.81	1.01	14.08	5.57	1.32	4.51	1.95	0.36	Negligible
Hensall	20.48	14.43	6.51	1.33	16.41	8.46	1.49	4.01	1.96	0.32	Negligible
Cliffe	20.48	15.17	5.80	1.82	17.32	7.40	2.18	3.30	1.66	0.38	Negligible
Breighton	20.48	15.91	8.49	2.18	16.67	9.29	2.19	1.92	1.04	0.29	Negligible
Wressle	20.48	17.83	9.27	2.57	18.18	10.36	3.11	2.83	1.74	0.55	Negligible
Eastrington	20.48	19.66	9.54	2.14	23.22	10.57	2.59	3.56	1.18	0.45	Negligible
Ellerton	20.48	17.53	7.68	1.89	20.71	8.59	2.00	5.67	1.21	0.20	Negligible
Fogathorpe	20.48	25.48	9.94	2.02	25.04	10.33	2.17	4.85	1.59	0.18	Negligible
Barlby	20.48	14.81	5.53	1.35	15.44	6.65	1.46	3.70	2.02	0.39	Negligible
Riccall	20.48	14.07	6.47	1.27	16.66	7.39	1.46	3.55	1.59	0.30	Negligible
Thorpe Willoughby	20.48	10.50	4.15	1.19	14.79	5.41	1.39	4.48	1.85	0.36	Negligible

Kellingley	20.48	17.69	7.27	2.29	20.24	8.54	2.22	4.99	1.27	0.27	Negligible
Moorends	20.48	16.89	7.11	1.28	19.31	7.83	1.59	4.24	1.68	0.31	Negligible
Thorne	20.48	15.14	6.20	1.10	17.39	7.15	1.18	3.31	1.14	0.21	Negligible
Swinefleet	20.48	18.14	8.15	1.31	20.98	9.78	1.62	5.22	1.86	0.31	Negligible
Balne	20.48	18.84	7.84	1.67	21.24	8.77	1.81	2.42	1.67	0.22	Negligible
Whitley	20.48	15.30	7.63	1.46	18.16	8.53	1.76	2.95	1.66	0.44	Negligible
Barlow	20.48	1.59	0.40	0.15	2.40	0.79	0.27	1.06	0.39	0.11	Negligible
Long Drax	20.48	4.57	2.07	0.48	6.38	2.79	0.69	1.81	0.91	0.23	Negligible
Drax	20.48	1.34	0.49	0.10	1.84	0.69	0.17	0.74	0.22	0.08	Negligible
Newland	20.48	5.14	1.66	0.43	7.68	2.52	0.69	2.99	1.03	0.27	Negligible
Carlton	20.48	8.29	2.03	0.57	10.03	2.94	0.82	2.80	0.95	0.26	Negligible
Camblesforth	20.48	0.95	0.30	0.11	1.44	0.41	0.12	0.69	0.11	0.04	Negligible
Burn	20.48	9.52	3.30	1.00	11.19	4.50	1.34	3.40	1.93	0.34	Negligible
Temple Hirst	20.48	16.58	6.93	2.36	17.80	8.56	2.83	4.52	2.38	0.47	Negligible
Cawood	20.48	16.91	7.84	1.61	19.61	8.98	1.98	2.70	1.54	0.37	Negligible

Biggin	20.48	17.96	6.77	1.50	18.96	8.01	1.54	3.30	1.52	0.12	Negligible
Howden	20.48	16.80	8.82	1.75	20.93	9.48	2.12	6.06	1.82	0.37	Negligible
Brind	20.48	18.56	8.45	1.97	25.58	9.64	2.13	7.02	1.79	0.39	Negligible
South Duffield	20.48	17.98	9.42	2.84	18.50	9.94	2.90	0.95	1.90	0.15	Negligible
Highfield	20.48	15.92	8.16	1.75	20.22	9.46	1.84	4.30	1.37	0.21	Negligible
Willitoft	20.48	18.65	9.29	2.04	23.69	9.63	2.31	6.03	1.17	0.44	Negligible
Receptor Grid Max	20.48	26.83	10.97	3.20	26.28	11.61	3.69	8.91	3.18	0.81	Negligible
AQ Objective		**266**	**350**	**125**	**266**	**350**	**125**	**266**	**350**	**125**	

Table C16 - Modelled Maximum Operational Impacts at Human Receptors – Dust (as PM_{10}) Concentrations (Worst Case Emissions Profile)

PM_{10} Concentration (µg/m^3) (Annual & Daily mean)

Receptor	Background		Max Baseline PC		Max PCC PC		Max PC Impact		IAQM Impact Descriptor (applicable to all averaging periods)
	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	
Foreman's Cottage	12.14	24.28	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
East Yorkshire Caravan Park	12.49	24.97	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Drax S&C Club	12.49	24.97	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Wren Hall	13.57	27.14	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
3 Pear Tree Ave	14.40	28.79	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Crange Cottages	12.26	24.52	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Drax Abbey Farm	14.40	28.79	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Read School	12.50	25.00	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Old Lodge	14.40	28.79	0.00	0.00	0.00	0.00	0.00	0.00	Negligible

Selby AQMA	13.50	26.99	0.00	0.00	0.00	0.01	0.00	0.00	Negligible
Goole	13.30	26.60	0.00	0.02	0.01	0.03	0.00	0.01	Negligible
Hemingbrough	13.22	26.45	0.00	0.01	0.01	0.02	0.00	0.01	Negligible
Rawcliffe	14.51	29.02	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Snaith	13.45	26.90	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Hensall	13.54	27.08	0.00	0.01	0.00	0.02	0.00	0.01	Negligible
Cliffe	13.99	27.99	0.00	0.01	0.00	0.01	0.00	0.01	Negligible
Breighton	13.44	26.89	0.01	0.05	0.01	0.06	0.00	0.01	Negligible
Wressle	14.15	28.30	0.01	0.04	0.01	0.05	0.00	0.01	Negligible
Eastrington	14.43	28.85	0.01	0.06	0.01	0.07	0.00	0.01	Negligible
Ellerton	13.74	27.48	0.01	0.05	0.01	0.05	0.00	0.01	Negligible
Fogathorpe	13.81	27.62	0.01	0.07	0.01	0.08	0.00	0.01	Negligible
Barlby	14.41	28.82	0.00	0.01	0.00	0.01	0.00	0.00	Negligible
Riccall	13.98	27.97	0.00	0.01	0.00	0.02	0.00	0.01	Negligible
Thorpe Willoughby	13.93	27.87	0.00	0.00	0.00	0.00	0.00	0.00	Negligible

Kellingley	14.18	28.36	0.00	0.01	0.00	0.01	0.00	0.01	Negligible
Moorends	13.45	26.89	0.00	0.01	0.00	0.02	0.00	0.00	Negligible
Thorne	13.27	26.53	0.00	0.01	0.00	0.01	0.00	0.00	Negligible
Swinefleet	14.18	28.37	0.00	0.03	0.01	0.04	0.00	0.01	Negligible
Balne	14.77	29.54	0.00	0.02	0.01	0.03	0.00	0.01	Negligible
Whitley	13.83	27.66	0.00	0.03	0.01	0.03	0.00	0.01	Negligible
Barlow	13.14	26.29	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Long Drax	13.92	27.84	0.00	0.01	0.00	0.01	0.00	0.00	Negligible
Drax	12.50	25.00	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Newland	13.98	27.95	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Carlton	13.95	27.89	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Camblesforth	13.60	27.20	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Burn	14.08	28.17	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Temple Hirst	14.31	28.61	0.00	0.00	0.00	0.01	0.00	0.00	Negligible
Cawood	13.24	26.48	0.00	0.03	0.01	0.03	0.00	0.00	Negligible

Biggin	12.93	25.87	0.00	0.01	0.00	0.01	0.00	0.00	Negligible
Howden	14.93	29.86	0.01	0.05	0.01	0.06	0.00	0.01	Negligible
Brind	14.37	28.73	0.01	0.06	0.01	0.08	0.00	0.02	Negligible
South Duffield	14.55	29.11	0.00	0.02	0.01	0.03	0.00	0.01	Negligible
Highfield	13.98	27.95	0.01	0.06	0.01	0.07	0.00	0.01	Negligible
Willitoft	14.12	28.23	0.01	0.06	0.01	0.07	0.00	0.02	Negligible
Receptor Grid Max	17.56	35.11	0.01	0.08	0.01	0.08	0.00	0.02	Negligible
AQ Objective	**40**	**50**	**40**	**50**	**40**	**50**	**40**	**50**	

Table C17 - Modelled Maximum Operational Impacts at Human Receptors – NH_3 Concentrations (Worst Case Emissions Profile)

NH_3 Concentration (µg/m^3) (Annual & Hourly mean)

Receptor	Background		Max Baseline PC		Max PCC PC		Max PC Impact		IAQM Impact Descriptor (applicable to all averaging periods)
	Annual	Hourly	Annual	Hourly	Annual	Hourly	Annual	Hourly	
Foreman's Cottage	1.6	3.2	0.00	0.02	0.00	0.02	0.00	0.01	Negligible
East Yorkshire Caravan Park	1.6	3.2	0.00	0.00	0.00	0.01	0.00	0.00	Negligible
Drax S&C Club	1.6	3.2	0.00	0.00	0.00	0.00	0.00	0.00	Negligible
Wren Hall	1.6	3.2	0.00	0.01	0.00	0.02	0.00	0.01	Negligible
3 Pear Tree Ave	1.6	3.2	0.00	0.04	0.00	0.06	0.00	0.02	Negligible
Crange Cottages	1.6	3.2	0.00	0.01	0.00	0.02	0.00	0.00	Negligible
Drax Abbey Farm	1.6	3.2	0.00	0.01	0.00	0.02	0.00	0.01	Negligible
Read School	1.6	3.2	0.00	0.03	0.00	0.03	0.00	0.01	Negligible
Old Lodge	1.6	3.2	0.00	0.03	0.00	0.04	0.00	0.01	Negligible

Selby_AQMA	1.6	3.2	0.00	0.25	0.00	0.32	0.00	0.09	Negligible
Goole	1.6	3.2	0.00	0.36	0.01	0.45	0.00	0.11	Negligible
Hemingbrough	1.6	3.2	0.00	0.39	0.01	0.45	0.00	0.10	Negligible
Rawcliffe	1.6	3.2	0.00	0.22	0.00	0.29	0.00	0.09	Negligible
Snaith	1.6	3.2	0.00	0.21	0.00	0.29	0.00	0.09	Negligible
Hensall	1.6	3.2	0.00	0.36	0.00	0.44	0.00	0.09	Negligible
Cliffe	1.6	3.2	0.00	0.34	0.00	0.44	0.00	0.10	Negligible
Breighton	1.6	3.2	0.01	0.44	0.01	0.47	0.00	0.04	Negligible
Wressle	1.6	3.2	0.01	0.46	0.01	0.52	0.00	0.09	Negligible
Eastrington	1.6	3.2	0.01	0.48	0.01	0.55	0.00	0.07	Negligible
Ellerton	1.6	3.2	0.01	0.41	0.01	0.47	0.00	0.09	Negligible
Fogathorpe	1.6	3.2	0.01	0.52	0.01	0.57	0.00	0.09	Negligible
Barlby	1.6	3.2	0.00	0.33	0.00	0.39	0.00	0.06	Negligible
Riccall	1.6	3.2	0.00	0.34	0.00	0.38	0.00	0.07	Negligible
Thorpe Willoughby	1.6	3.2	0.00	0.23	0.00	0.30	0.00	0.11	Negligible

Kellingley	1.6	3.2	0.00	0.41	0.00	0.47	0.00	0.06	Negligible
Moorends	1.6	3.2	0.00	0.39	0.00	0.45	0.00	0.10	Negligible
Thorne	1.6	3.2	0.00	0.37	0.00	0.41	0.00	0.09	Negligible
Swinefleet	1.6	3.2	0.00	0.43	0.01	0.53	0.00	0.09	Negligible
Balne	1.6	3.2	0.00	0.40	0.01	0.48	0.00	0.08	Negligible
Whitley	1.6	3.2	0.00	0.39	0.01	0.45	0.00	0.09	Negligible
Barlow	1.6	3.2	0.00	0.03	0.00	0.05	0.00	0.02	Negligible
Long Drax	1.6	3.2	0.00	0.11	0.00	0.15	0.00	0.05	Negligible
Drax	1.6	3.2	0.00	0.03	0.00	0.04	0.00	0.01	Negligible
Newland	1.6	3.2	0.00	0.09	0.00	0.14	0.00	0.06	Negligible
Carlton	1.6	3.2	0.00	0.13	0.00	0.19	0.00	0.06	Negligible
Camblesforth	1.6	3.2	0.00	0.02	0.00	0.03	0.00	0.01	Negligible
Burn	1.6	3.2	0.00	0.18	0.00	0.26	0.00	0.08	Negligible
Temple Hirst	1.6	3.2	0.00	0.40	0.00	0.45	0.00	0.11	Negligible
Cawood	1.6	3.2	0.00	0.44	0.01	0.49	0.00	0.08	Negligible

Biggin	1.6	3.2	0.00	0.36	0.00	0.46	0.00	0.10	Negligible
Howden	1.6	3.2	0.01	0.44	0.01	0.51	0.00	0.10	Negligible
Brind	1.6	3.2	0.01	0.43	0.01	0.50	0.00	0.09	Negligible
South Duffield	1.6	3.2	0.00	0.48	0.01	0.52	0.00	0.06	Negligible
Highfield	1.6	3.2	0.01	0.42	0.01	0.48	0.00	0.06	Negligible
Willitoft	1.6	3.2	0.01	0.49	0.01	0.52	0.00	0.08	Negligible
Receptor Grid Max	1.6	3.2	0.01	0.58	0.01	0.62	0.00	0.19	Negligible
Env. Agency EAL	**180**	**2,500**	**180**	**2,500**	**180**	**2,500**	**180**	**2,500**	

Table C18 - Modelled Maximum Operational Impacts at Human Receptors – Hourly Mean HCl Concentrations (Worst Case Emissions Profile)

Receptor	**HCl Concentration (µg/m³)**				
	Background	Max Baseline PC	Max PCC PC	Max PC Impact	IAQM Impact Descriptor
Foreman's Cottage	4.86	0.02	0.03	0.01	Negligible
East Yorkshire Caravan Park	4.86	0.00	0.01	0.00	Negligible
Drax S&C Club	4.86	0.00	0.00	0.00	Negligible
Wren Hall	4.86	0.01	0.02	0.01	Negligible
3 Pear Tree Ave	4.86	0.05	0.07	0.03	Negligible
Crange Cottages	4.86	0.01	0.02	0.01	Negligible
Drax Abbey Farm	4.86	0.01	0.02	0.01	Negligible
Read School	4.86	0.03	0.04	0.01	Negligible
Old Lodge	4.86	0.03	0.05	0.02	Negligible
Selby_AQMA	4.86	0.30	0.38	0.11	Negligible
Goole	4.86	0.43	0.54	0.13	Negligible

Hemingbrough	4.86	0.47	0.54	0.12	Negligible
Rawcliffe	4.86	0.26	0.35	0.11	Negligible
Snaith	4.86	0.25	0.35	0.11	Negligible
Hensall	4.86	0.44	0.53	0.11	Negligible
Cliffe	4.86	0.41	0.52	0.12	Negligible
Breighton	4.86	0.53	0.56	0.05	Negligible
Wressle	4.86	0.56	0.63	0.10	Negligible
Eastrington	4.86	0.58	0.66	0.08	Negligible
Ellerton	4.86	0.49	0.56	0.11	Negligible
Fogathorpe	4.86	0.62	0.68	0.11	Negligible
Barlby	4.86	0.39	0.46	0.07	Negligible
Riccall	4.86	0.41	0.45	0.08	Negligible
Thorpe Willoughby	4.86	0.27	0.36	0.13	Negligible
Kellingley	4.86	0.50	0.57	0.08	Negligible
Moorends	4.86	0.46	0.54	0.13	Negligible

Thorne	4.86	0.44	0.49	0.10	Negligible
Swinefleet	4.86	0.52	0.63	0.11	Negligible
Balne	4.86	0.48	0.58	0.10	Negligible
Whitley	4.86	0.47	0.54	0.10	Negligible
Barlow	4.86	0.03	0.06	0.02	Negligible
Long Drax	4.86	0.13	0.18	0.06	Negligible
Drax	4.86	0.04	0.05	0.01	Negligible
Newland	4.86	0.11	0.17	0.07	Negligible
Carlton	4.86	0.16	0.22	0.07	Negligible
Camblesforth	4.86	0.02	0.03	0.01	Negligible
Burn	4.86	0.21	0.31	0.10	Negligible
Temple Hirst	4.86	0.48	0.54	0.13	Negligible
Cawood	4.86	0.52	0.59	0.10	Negligible
Biggin	4.86	0.43	0.55	0.12	Negligible
Howden	4.86	0.53	0.61	0.12	Negligible

Brind	4.86	0.52	0.60	0.11	Negligible
South Duffield	4.86	0.57	0.62	0.07	Negligible
Highfield	4.86	0.50	0.57	0.07	Negligible
Willitoft	4.86	0.58	0.63	0.10	Negligible
Receptor Grid Max	4.86	0.69	0.74	0.22	Negligible
EAL	**750**				

Table C19 - Modelled Maximum Operational Impacts at Human Receptors – Amines (as MEA) Concentrations (Worst Case Emissions Profile)

MEA Concentration (µg/m^3) (Hourly & Daily mean) – Results presented to 3 d.p.

Receptor	Max PCC PC Impact		IAQM Impact Descriptor (applicable to all averaging periods)
	Hourly	Daily	
Foreman's Cottage	0.009	0.001	Negligible
East Yorkshire Caravan Park	0.009	0.001	Negligible
Drax S&C Club	0.006	0.001	Negligible
Wren Hall	0.010	0.001	Negligible
3 Pear Tree Ave	0.016	0.002	Negligible
Crange Cottages	0.008	0.001	Negligible
Drax Abbey Farm	0.009	0.001	Negligible
Read School	0.017	0.001	Negligible
Old Lodge	0.014	0.002	Negligible
Selby AQMA	0.057	0.013	Negligible

Goole	0.086	0.011	Negligible
Hemingbrough	0.081	0.019	Negligible
Rawcliffe	0.066	0.012	Negligible
Snaith	0.066	0.019	Negligible
Hensall	0.090	0.014	Negligible
Cliffe	0.074	0.016	Negligible
Breighton	0.130	0.018	Negligible
Wressle	0.090	0.019	Negligible
Eastrington	0.105	0.015	Negligible
Ellerton	0.104	0.011	Negligible
Fogathorpe	0.103	0.012	Negligible
Barlby	0.111	0.017	Negligible
Riccall	0.123	0.014	Negligible
Thorpe Willoughby	0.123	0.010	Negligible
Kellingley	0.101	0.020	Negligible

Moorends	0.075	0.010	Negligible
Thorne	0.069	0.006	Negligible
Swinefleet	0.107	0.009	Negligible
Balne	0.109	0.011	Negligible
Whitley	0.110	0.009	Negligible
Barlow	0.021	0.003	Negligible
Long Drax	0.037	0.009	Negligible
Drax	0.015	0.001	Negligible
Newland	0.068	0.006	Negligible
Carlton	0.071	0.012	Negligible
Camblesforth	0.013	0.001	Negligible
Burn	0.058	0.008	Negligible
Temple Hirst	0.063	0.020	Negligible
Cawood	0.077	0.008	Negligible
Biggin	0.068	0.008	Negligible

Howden	0.136	0.013	Negligible
Brind	0.144	0.013	Negligible
South Duffield	0.069	0.020	Negligible
Highfield	0.121	0.016	Negligible
Willitoft	0.135	0.013	Negligible
Receptor Grid Max	0.150	0.032	Negligible
EAL	**400**	**100**	

Table C20 - Modelled Maximum Operational Impacts at Human Receptors – Annual Mean Nitrosamine (as NDMA) Concentrations (Worst Case Emissions Profile)

NDMA Concentration (ng/m^3)

Receptor	Max PCC PC			Max PC Impact	IAQM Impact Descriptor
	Direct (1)	**Indirect (2)**	**Total (3)**		
Foreman's Cottage	0.0000	0.0000	0.000	0.000	Negligible
East Yorkshire Caravan Park	0.0000	0.0000	0.000	0.000	Negligible
Drax S&C Club	0.0000	0.0000	0.000	0.000	Negligible
Wren Hall	0.0000	0.0000	0.000	0.000	Negligible
3 Pear Tree Ave	0.0000	0.0001	0.000	0.000	Negligible
Crange Cottages	0.0000	0.0000	0.000	0.000	Negligible
Drax Abbey Farm	0.0000	0.0000	0.000	0.000	Negligible
Read School	0.0000	0.0001	0.000	0.000	Negligible
Old Lodge	0.0000	0.0001	0.000	0.000	Negligible
Selby_AQMA	0.0000	0.0022	0.002	0.002	Negligible

Goole	0.0000	0.0042	0.004	0.004	Negligible
Hemingbrough	0.0000	0.0007	0.001	0.001	Negligible
Rawcliffe	0.0000	0.0012	0.001	0.001	Negligible
Snaith	0.0000	0.0014	0.001	0.001	Negligible
Hensall	0.0000	0.0030	0.003	0.003	Negligible
Cliffe	0.0000	0.0009	0.001	0.001	Negligible
Breighton	0.0001	0.0044	0.004	0.004	Negligible
Wressle	0.0001	0.0035	0.004	0.004	Negligible
Eastrington	0.0001	0.0117	0.012	0.012	Slight adverse (5.9% of EAL)
Ellerton	0.0001	0.0049	0.005	0.005	Negligible
Fogathorpe	0.0001	0.0090	0.009	0.009	Negligible
Barlby	0.0000	0.0013	0.001	0.001	Negligible
Riccall	0.0000	0.0028	0.003	0.003	Negligible
Thorpe Willoughby	0.0000	0.0024	0.002	0.002	Negligible
Kellingley	0.0000	0.0053	0.005	0.005	Negligible

Moorends	0.0000	0.0037	0.004	0.004	Negligible
Thorne	0.0000	0.0033	0.003	0.003	Negligible
Swinefleet	0.0000	0.0061	0.006	0.006	Negligible
Balne	0.0000	0.0047	0.005	0.005	Negligible
Whitley	0.0000	0.0047	0.005	0.005	Negligible
Barlow	0.0000	0.0001	0.000	0.000	Negligible
Long Drax	0.0000	0.0003	0.000	0.000	Negligible
Drax	0.0000	0.0001	0.000	0.000	Negligible
Newland	0.0000	0.0005	0.000	0.000	Negligible
Carlton	0.0000	0.0005	0.000	0.000	Negligible
Camblesforth	0.0000	0.0000	0.000	0.000	Negligible
Burn	0.0000	0.0016	0.002	0.002	Negligible
Temple Hirst	0.0000	0.0021	0.002	0.002	Negligible
Cawood	0.0000	0.0069	0.007	0.007	Negligible
Biggin	0.0000	0.0049	0.005	0.005	Negligible

Howden	0.0001	0.0077	0.008	0.008	Negligible
Brind	0.0001	0.0078	0.008	0.008	Negligible
South Duffield	0.0000	0.0018	0.002	0.002	Negligible
Highfield	0.0001	0.0065	0.007	0.007	Negligible
Willitoft	0.0001	0.0079	0.008	0.008	Negligible
Receptor Grid Max	0.0001	0.0132	0.013	0.013	Slight adverse (6.6% of EAL)
EAL	**0.2**				

(1) Based on direct mass emissions of 'Nitrosamine 1' and 'Nitrosamine 2' from Main Stack only.

(2) Accounts for application of ADMS Amine Chemistry Module and relates to indirect formation of nitrosamines and nitramines through atmospheric reactions.

(3) Equal to sum of modelled direct and indirect nitrosamine + nitramine concentrations.

Sensitivity Testing: Amine Chemistry

Results pertaining to the amine chemistry sensitivity testing are presented in Tables C21 (MEA) and C22 (NDMA). The grid receptor reporting the maximum modelled PCs are presented, based on the results of modelling completed for low and high range values relating to the atmospheric reaction kinetics detailed in Table C8 for the proxy compounds.

As stated in Table C8, amine sensitivity modelling was based on initial design mass emission data that is no longer representative of the proposed PCC plant. However, the initial design emissions represent higher mass emissions of the amine compounds relative to the proposed permit ELVs used in the core scenario modelling. As such, the initial design emission rates were used and also applied to the proprietary solvent (confidential) data as part of the sensitivity testing to allow a direct comparison with the proxy compound modelling results, whilst also providing a conservative assessment of amine mass emissions from the Main Stack. The maximum modelled PCs for the proprietary amine compounds are also presented in the below tables alongside the proxy compound results.

Therefore, the results of the amine sensitivity modelling are self-contained and should not be compared to the core scenario modelling results.

The maximum hourly (0.10 µg/m^3) and daily mean (0.02 µg/m^3) MEA concentrations from the sensitivity tests were modelled to be equivalent to the concentrations reported for the proprietary amine solvent (0.10 µg/m^3 and 0.02 µg/m^3 respectively), when modelling an identical mass emission rate for amines in all tests.

The maximum annual mean NDMA concentrations reported from the sensitivity tests (0.03 ng/m^3) was modelled to be 67% higher than the equivalent concentration reported for the proprietary amine solvent (0.02 ng/m^3). However, the maximum concentration from the sensitivity tests still remains well below the annual mean EAL for NDMA, equating to 14% of the EAL.

Therefore, the results of the sensitivity testing do not affect the outcome of the core assessment results, such that emissions in the With PCC scenario would still not result in significant air quality effects at human receptors in terms of amine (MEA) and nitrosamine (NDMA) concentrations.

Table C21 - Modelled Minimum and Maximum Operational Impacts at Human Receptors – Amines (as MEA) Concentrations (based on sensitivity testing)

Receptor	**MEA Concentration (µg/m^3) (Hourly & Daily mean)**					
	Maximum PC Impact (Proxy Data; Lower Range Reaction Rate Values)		Maximum PC Impact (Proxy Data; Upper Range Reaction Rate Values)		Maximum PC Impact (Proprietary Solvent)	
	Hourly	Daily	Hourly	Daily	Hourly	Daily
Grid Max	0.101	0.0215	0.101	0.0214	0.103	0.0218
EAL	**400**	**100**	**400**	**100**	**400**	**100**

Table C12 – Modelled Minimum and Maximum Operational Impacts at Human Receptors – Annual Mean Nitrosamine (as NDMA) Concentrations (based on sensitivity testing)

Receptor	**NDMA Concentration (ng/m^3) – Results presented to 4 d.p.**		
	Maximum PC Impact (Proxy Data; Lower Range Reaction Rate Values)	Maximum PC Impact (Proxy Data; Upper Range Reaction Rate Values)	Maximum PC Impact (Proprietary Solvent)
Grid Max	0.0005	0.0282	0.0169
EAL	**0.2**		

Appendix D Operational Air Quality Assessment Result Tables: Ecological Receptors.

IMPACTS ON ECOLOGICAL RECEPTORS

The results of the modelling assessment at each modelled ecological receptor are presented in the below tables for each relevant pollutant and averaging period applicable to the study. The maximum modelled concentration and deposition values are presented, which is based on modelling over all five years of meteorological data (2016-2020). The change in PC and PEC, as a percentage of the relevant critical level/load, is presented for each receptor.

The PC impact in the with PCC scenario represents the change in concentration/deposition between the Baseline scenario and PCC scenario.

All results are presented to two decimal places, unless otherwise stated.

CORE MODEL SCENARIOS

Results pertaining to the core model scenarios are presented in Tables D1 to D6.

Table D1 Modelled Maximum Operational Impacts at Ecological Receptors – Annual Mean NO_x (Including Mitigation)

Receptor	**Annual Mean NO_x concentration ($\mu g/m^3$)**				
	Critical Level	Max PC Impact – No Mitigation	Max PC Impact – With Mitigation	Max PC Impact as % of CL – No Mitigation	Max PC Impact as % of CL – With Mitigation
River Derwent SAC	30	0.123	0.100	0.4%	0.3%
Thorne Moor SAC/SPA/SSSI	30	0.057	0.047	0.2%	0.2%
Lower Derwent SAC	30	0.125	0.102	0.4%	0.3%
Lower Derwent SPA	30	0.125	0.102	0.4%	0.3%
Skipwith Common SAC	30	0.043	0.036	0.1%	0.1%
Skipwith Common SSSI	30	0.043	0.036	0.1%	0.1%
Humber Estuary SAC	30	0.111	0.093	0.4%	0.3%
Humber Estuary SPA/SSSI	30	0.111	0.093	0.4%	0.3%
Breighton Moors SSSI	30	0.125	0.102	0.4%	0.3%
Eskamhorn Meadows SSSI	30	0.035	0.026	0.1%	0.1%
Derwent Ings SSSI	30	0.100	0.084	0.3%	0.3%

Went Ings SSSI	30	0.039	0.032	0.1%	0.1%
Barn Hill Meadows SSSI	30	0.116	0.093	0.4%	0.3%
Burr Closes SSSI	30	0.047	0.038	0.2%	0.1%
Common Plantation SINC	30	0.013	0.009	0.0%	0.0%
Disused Railway Embankment SINC	30	0.031	0.022	0.1%	0.1%
Barmby-on-the-Marsh LWS	30	0.058	0.043	0.2%	0.1%
Brockholes SINC	30	0.015	0.010	0.0%	0.0%
Meadow East of Orchard Farm SINC	30	0.007	0.005	0.0%	0.0%
Barmby Pond LWS	30	0.097	0.074	0.3%	0.2%
Cobble Croft Wood SINC	30	0.021	0.015	0.1%	0.1%
Hagg Green Lane SINC	30	0.078	0.062	0.3%	0.2%
Sand Pitt Wood & Barffs Close Plantation SINC	30	0.021	0.015	0.1%	0.1%
Env. Agency Screening Criterion (as % of CL)				**1%**	

Table D2 - Modelled Maximum Operational Impacts at Ecological Receptors – Daily Mean NO_x (Including Mitigation)

Receptor	**Daily Mean NO_x concentration ($\mu g/m^3$)**				
	Critical Level	Max PC Impact – No Mitigation	Max PC Impact – With Mitigation	Max PC Impact as % of CL – No Mitigation	Max PC Impact as % of CL – With Mitigation
River Derwent SAC	75	1.165	0.793	1.6%	1.1%
Thorne Moor SAC/SPA/SSSI	75	0.534	0.446	0.7%	0.6%
Lower Derwent SAC	75	0.501	0.308	0.7%	0.4%
Lower Derwent SPA	75	0.501	0.308	0.7%	0.4%
Skipwith Common SAC	75	0.337	0.253	0.4%	0.3%
Skipwith Common SSSI	75	0.337	0.253	0.4%	0.3%
Humber Estuary SAC	75	0.741	0.469	1.0%	0.6%
Humber Estuary SPA/SSSI	75	0.741	0.469	1.0%	0.6%
Breighton Moors SSSI	75	0.501	0.306	0.7%	0.4%
Eskamhorn Meadows SSSI	75	1.417	0.983	1.9%	1.3%
Derwent Ings SSSI	75	0.416	0.308	0.6%	0.4%

Went Ings SSSI	75	0.535	0.245	0.7%	0.3%
Barn Hill Meadows SSSI	75	0.626	0.691	0.8%	0.9%
Burr Closes SSSI	75	0.500	0.346	0.7%	0.5%
Common Plantation SINC	75	0.759	0.485	1.0%	0.6%
Disused Railway Embankment SINC	75	0.835	0.753	1.1%	1.0%
Barmby-on-the-Marsh LWS	75	1.065	0.978	1.4%	1.3%
Brockholes SINC	75	1.175	0.824	1.6%	1.1%
Meadow East of Orchard Farm SINC	75	0.404	0.279	0.5%	0.4%
Barmby Pond LWS	75	1.029	0.698	1.4%	0.9%
Cobble Croft Wood SINC	75	0.828	0.430	1.1%	0.6%
Hagg Green Lane SINC	75	0.533	0.342	0.7%	0.5%
Sand Pitt Wood & Barffs Close Plantation SINC	75	1.158	0.733	1.5%	1.0%
	Env. Agency Screening Criterion (as % of CL)			**10%**	

Table D3 - Modelled Maximum Operational Impacts at Ecological Receptors – Annual Mean SO_2 (Including Mitigation)

Receptor	**Annual Mean SO_2 concentration (µg/m^3)**				
	Critical Level	Max PC Impact – No Mitigation	Max PC Impact – With Mitigation	Max PC Impact as % of CL – No Mitigation	Max PC Impact as % of CL – With Mitigation
River Derwent SAC	20	0.072	0.031	0.4%	0.2%
Thorne Moor SAC/SPA/SSSI	20	0.033	0.014	0.2%	0.1%
Lower Derwent SAC	20	0.073	0.031	0.4%	0.2%
Lower Derwent SPA	20	0.073	0.031	0.4%	0.2%
Skipwith Common SAC	20	0.025	0.011	0.1%	0.1%
Skipwith Common SSSI	20	0.025	0.011	0.1%	0.1%
Humber Estuary SAC	20	0.069	0.028	0.3%	0.1%
Humber Estuary SPA/SSSI	20	0.069	0.028	0.3%	0.1%
Breighton Moors SSSI	20	0.073	0.031	0.4%	0.2%
Eskamhorn Meadows SSSI	20	0.021	0.009	0.1%	0.0%
Derwent Ings SSSI	20	0.059	0.024	0.3%	0.1%

Went Ings SSSI	20	0.023	0.010	0.1%	0.0%
Barn Hill Meadows SSSI	20	0.072	0.029	0.4%	0.1%
Burr Closes SSSI	20	0.027	0.012	0.1%	0.1%
Common Plantation SINC	20	0.008	0.003	0.0%	0.0%
Disused Railway Embankment SINC	20	0.019	0.008	0.1%	0.0%
Barmby-on-the-Marsh LWS	20	0.036	0.015	0.2%	0.1%
Brockholes SINC	20	0.009	0.003	0.0%	0.0%
Meadow East of Orchard Farm SINC	20	0.004	0.002	0.0%	0.0%
Barmby Pond LWS	20	0.058	0.024	0.3%	0.1%
Cobble Croft Wood SINC	20	0.013	0.005	0.1%	0.0%
Hagg Green Lane SINC	20	0.047	0.019	0.2%	0.1%
Sand Pitt Wood & Barffs Close Plantation SINC	20	0.013	0.005	0.1%	0.0%
	Env. Agency Screening Criterion (as % of CL)				

Table D4 - Modelled Maximum Operational Impacts at Ecological Receptors – Annual Nitrogen Deposition Rate (Including Mitigation)

Receptor	**Annual Nitrogen Deposition Rate (kgN/ha/yr)**				
	Critical Load	Max PC Impact – No Mitigation	Max PC Impact – With Mitigation	Max PC Impact as % of CL – No Mitigation	Max PC Impact as % of CL – With Mitigation
Thorne Moor SAC	5	0.022	0.019	0.4%	0.4%
Thorne Moor SPA	10	0.022	0.019	0.2%	0.2%
Thorne Moor SSSI	5	0.022	0.019	0.4%	0.4%
Lower Derwent SAC	20	0.050	0.041	0.2%	0.2%
Lower Derwent SPA	20	0.050	0.041	0.2%	0.2%
Skipwith Common SAC	10	0.017	0.014	0.2%	0.1%
Skipwith Common SSSI	10	0.017	0.014	0.2%	0.1%
Humber Estuary SAC	20	0.031	0.037	0.2%	0.2%
Humber Estuary SPA/SSSI	20	0.031	0.037	0.2%	0.2%
Breighton Moors SSSI	20	0.050	0.041	0.2%	0.2%
Eskamhorn Meadows SSSI	10	0.014	0.011	0.1%	0.1%

Derwent Ings SSSI	20	0.039	0.033	0.2%	0.2%
Went Ings SSSI	15	0.015	0.012	0.1%	0.1%
Barn Hill Meadows SSSI	20	0.036	0.037	0.2%	0.2%
Burr Closes SSSI	20	0.018	0.015	0.1%	0.1%
Common Plantation SINC	10	0.009	0.006	0.1%	0.1%
Disused Railway Embankment SINC	10	0.020	0.015	0.2%	0.1%
Barmby-on-the-Marsh LWS	10	0.039	0.029	0.4%	0.3%
Brockholes SINC	10	0.006	0.004	0.1%	0.0%
Meadow East of Orchard Farm SINC	20	0.003	0.002	0.0%	0.0%
Barmby Pond LWS	10	0.040	0.030	0.4%	0.3%
Cobble Croft Wood SINC	10	0.014	0.010	0.1%	0.1%
Hagg Green Lane SINC	10	0.052	0.041	0.5%	0.4%
Sand Pitt Wood & Barffs Close Plantation SINC	10	0.014	0.010	0.1%	0.1%
	Env. Agency Screening Criterion (as % of CL)			**1%**	

Table D5 - Modelled Maximum Operational Impacts at Ecological Receptors – Annual Acid Deposition Rate (Including Mitigation)

Receptor	**Annual Acid Deposition Rate (keq/ha/yr)**				
	Critical Load	Max PC Impact – No Mitigation	Max PC Impact – With Mitigation	Max PC Impact as % of CL – No Mitigation	Max PC Impact as % of CL – With Mitigation
Thorne Moor SAC	0.462	0.006	0.003	**1.3%**	0.7%
Thorne Moor SSSI	0.462	0.006	0.003	**1.3%**	0.7%
Lower Derwent SAC	0.643	0.013	0.007	**2.0%**	**1.1%**
Skipwith Common SAC	0.802	0.004	0.002	0.5%	0.3%
Skipwith Common SSSI	0.802	0.004	0.002	0.5%	0.3%
Breighton Moors SSSI	0.643	0.013	0.007	**2.0%**	**1.1%**
Eskamhorn Meadows SSSI	1.998	0.004	0.002	0.2%	0.1%
Derwent Ings SSSI	0.643	0.010	0.006	**1.6%**	0.9%
Went Ings SSSI	2.008	0.004	0.002	0.2%	0.1%
Barn Hill Meadows SSSI	0.633	0.010	0.007	**1.6%**	**1.1%**
Burr Closes SSSI	1.248	0.005	0.003	0.4%	0.2%

Env. Agency Screening Criterion (as % of CL)	**1%**

CUMULATIVE IMPACTS (WITH PCC & OTHER PROJECTS)

Results pertaining to the cumulative impacts = associated With PCC Tables D6 to D11.

Table D6- Modelled Maximum Cumulative Impacts at Ecological Receptors – Annual Mean NO_x

Receptor	**Annual Mean NO_x concentration ($\mu g/m^3$)**				
	Critical Level	Max Cumulative PC Impact	Max PC Impact as % of CL	Max Cumulative PEC	Max PEC as % of CL
River Derwent SAC	30	0.645	2.2%	12.60	42.0%
Thorne Moor SAC/SPA/SSSI	30	0.365	1.2%	13.60	45.3%
Lower Derwent SAC	30	0.652	2.2%	10.61	35.4%
Lower Derwent SPA	30	0.652	2.2%	10.61	35.4%
Skipwith Common SAC	30	0.502	1.7%	10.29	34.3%
Skipwith Common SSSI	30	0.502	1.7%	10.29	34.3%
Humber Estuary SAC	30	0.487	1.6%	12.20	40.7%
Humber Estuary SPA/SSSI	30	0.487	1.6%	12.20	40.7%
Breighton Moors SSSI	30	0.652	2.2%	10.61	35.4%

Eskamhorn Meadows SSSI	30	0.508	1.7%	11.86	39.5%
Derwent Ings SSSI	30	0.618	2.1%	10.47	34.9%
Went Ings SSSI	30	0.316	1.1%	12.42	41.4%
Barn Hill Meadows SSSI	30	0.534	1.8%	13.46	44.9%
Burr Closes SSSI	30	0.290	1.0%	10.84	36.1%
Common Plantation SINC	30	0.741	2.5%	12.17	40.6%
Disused Railway Embankment SINC	30	0.569	1.9%	11.33	37.8%
Barmby-on-the-Marsh LWS	30	0.571	1.9%	11.06	36.9%
Brockholes SINC	30	0.505	1.7%	11.73	39.1%
Meadow East of Orchard Farm SINC	30	0.724	2.4%	11.55	38.5%
Barmby Pond LWS	30	0.596	2.0%	10.58	35.3%
Cobble Croft Wood SINC	30	0.700	2.3%	12.32	41.1%

Hagg Green Lane SINC	30	0.690	2.3%	11.65	38.8%
Sand Pitt Wood & Barffs Close Plantation SINC	30	0.800	2.7%	12.23	40.8%

Table D7 - Modelled Maximum Cumulative Impacts at Ecological Receptors – Daily Mean NO_x

Receptor	**Daily Mean NO_x concentration ($\mu g/m^3$)**				
	Critical Level	Max Cumulative PC Impact	Max PC Impact as % of CL	Max Cumulative PEC	Max PEC as % of CL
River Derwent SAC	75	3.975	5.3%	30.13	40.2%
Thorne Moor SAC/SPA/SSSI	75	3.726	5.0%	31.68	42.2%
Lower Derwent SAC	75	3.428	4.6%	26.13	34.8%
Lower Derwent SPA	75	3.428	4.6%	26.13	34.8%
Skipwith Common SAC	75	3.086	4.1%	24.08	32.1%
Skipwith Common SSSI	75	3.086	4.1%	24.08	32.1%
Humber Estuary SAC	75	16.173	21.6%	24.40	32.5%
Humber Estuary SPA/SSSI	75	16.173	21.6%	24.40	32.5%
Breighton Moors SSSI	75	3.428	4.6%	26.11	34.8%
Eskamhorn Meadows SSSI	75	5.066	6.8%	28.67	38.2%
Derwent Ings SSSI	75	3.416	4.6%	25.73	34.3%
Went Ings SSSI	75	3.800	5.1%	29.35	39.1%
Barn Hill Meadows SSSI	75	3.673	4.9%	31.34	41.8%

Burr Closes SSSI	75	2.912	3.9%	25.36	33.8%
Common Plantation SINC	75	6.849	9.1%	29.91	39.9%
Disused Railway Embankment SINC	75	5.087	6.8%	26.78	35.7%
Barmby-on-the-Marsh LWS	75	4.838	6.5%	26.84	35.8%
Brockholes SINC	75	4.382	5.8%	27.20	36.3%
Meadow East of Orchard Farm SINC	75	5.094	6.8%	26.84	35.8%
Barmby Pond LWS	75	3.829	5.1%	26.04	34.7%
Cobble Croft Wood SINC	75	5.899	7.9%	29.81	39.7%
Hagg Green Lane SINC	75	3.928	5.2%	28.12	37.5%
Sand Pitt Wood & Barffs Close Plantation SINC	75	7.223	9.6%	30.30	40.4%
Env. Agency Screening Criterion (as % of CL)			10%		70%

Table D8 - Modelled Maximum Cumulative Impacts at Ecological Receptors – Annual Mean NH_3

Receptor	Annual Mean NH_3 concentration (µg/m^3)				
	Critical Level	Max Cumulative PC Impact	Max PC Impact as % of CL	Max Cumulative PEC	Max PEC as % of CL
River Derwent SAC	3	0.008	0.3%	4.58	152.7%
Thorne Moor SAC/SPA/SSSI	1	0.011	**1.1%**	2.60	260.2%
Lower Derwent SAC	3	0.008	0.3%	4.58	152.7%
Lower Derwent SPA	3	0.008	0.3%	4.58	152.7%
Skipwith Common SAC	1	0.004	0.4%	2.59	258.5%
Skipwith Common SSSI	1	0.004	0.4%	2.59	258.5%
Humber Estuary SAC	3	0.011	0.4%	3.59	119.8%
Humber Estuary SPA/SSSI	3	0.011	0.4%	3.59	119.8%
Breighton Moors SSSI	3	0.008	0.3%	3.09	103.1%
Eskamhorn Meadows SSSI	3	0.005	0.2%	2.41	80.2%
Derwent Ings SSSI	3	0.007	0.2%	4.58	152.7%
Went Ings SSSI	3	0.006	0.2%	2.36	78.6%

Barn Hill Meadows SSSI	3	0.010	0.3%	2.33	77.7%
Burr Closes SSSI	3	0.004	0.1%	2.51	83.5%
Common Plantation SINC	3	0.003	0.1%	2.33	77.8%
Disused Railway Embankment SINC	3	0.005	0.2%	2.29	76.2%
Barmby-on-the-Marsh LWS	3	0.006	0.2%	2.29	76.2%
Brockholes SINC	3	0.004	0.1%	2.28	76.1%
Meadow East of Orchard Farm SINC	3	0.003	0.1%	2.33	77.8%
Barmby Pond LWS	3	0.008	0.3%	2.29	76.3%
Cobble Croft Wood SINC	3	0.004	0.1%	2.33	77.8%
Hagg Green Lane SINC	3	0.006	0.2%	3.10	103.3%
Sand Pitt Wood & Barffs Close Plantation SINC	3	0.004	0.1%	2.33	77.8%
Env. Agency Screening Criterion (as % of CL)			1%		70%

Table D9 - Modelled Maximum Cumulative Impacts at Ecological Receptors – Annual Mean SO_2

Receptor	**Annual Mean SO_2 concentration ($\mu g/m^3$)**				
	Critical Level	Max Cumulative PC Impact	Max PC Impact as % of CL	Max Cumulative PEC	Max PEC as % of CL
River Derwent SAC	20	0.005	0.0%	4.00	20.0%
Thorne Moor SAC/SPA/SSSI	20	0.010	0.0%	1.39	7.0%
Lower Derwent SAC	20	0.002	0.0%	1.78	8.9%
Lower Derwent SPA	20	0.002	0.0%	1.78	8.9%
Skipwith Common SAC	20	0.001	0.0%	1.45	7.3%
Skipwith Common SSSI	20	0.001	0.0%	1.45	7.3%
Humber Estuary SAC	20	0.006	0.0%	7.56	37.8%
Humber Estuary SPA/SSSI	20	0.006	0.0%	7.56	37.8%
Breighton Moors SSSI	20	0.002	0.0%	1.78	8.9%
Eskamhorn Meadows SSSI	20	0.005	0.0%	1.30	6.5%
Derwent Ings SSSI	20	-0.001	0.0%	1.76	8.8%
Went Ings SSSI	20	0.006	0.0%	1.34	6.7%
Barn Hill Meadows SSSI	20	0.006	0.0%	1.87	9.4%

Burr Closes SSSI	20	0.002	0.0%	1.26	6.3%
Common Plantation SINC	20	0.004	0.0%	1.45	7.2%
Disused Railway Embankment SINC	20	0.010	0.0%	1.33	6.7%
Barmby-on-the-Marsh LWS	20	0.017	0.1%	1.35	6.7%
Brockholes SINC	20	0.006	0.0%	1.33	6.6%
Meadow East of Orchard Farm SINC	20	0.003	0.0%	1.44	7.2%
Barmby Pond LWS	20	0.026	0.1%	1.36	6.8%
Cobble Croft Wood SINC	20	0.007	0.0%	1.45	7.2%
Hagg Green Lane SINC	20	0.021	0.1%	1.47	7.4%
Sand Pitt Wood & Barffs Close Plantation SINC	20	0.007	0.0%	1.45	7.2%
Env. Agency Screening Criterion (as % of CL)			1%		70%

Table D10 - Modelled Maximum Cumulative Impacts at Ecological Receptors – Annual Nitrogen Deposition Rate

Receptor	**Annual Nitrogen Deposition Rate (kgN/ha/yr)**				
	Critical Level	Max Cumulative PC Impact	Max PC Impact as % of CL	Max Cumulative PEC	Max PEC as % of CL
Thorne Moor SAC	5	0.086	**1.7%**	21.40	428.1%
Thorne Moor SPA	10	0.086	0.9%	21.40	214.0%
Thorne Moor SSSI	5	0.086	**1.7%**	21.40	428.1%
Lower Derwent SAC	20	0.107	0.5%	30.35	151.7%
Lower Derwent SPA	20	0.107	0.5%	30.35	151.7%
Skipwith Common SAC	10	0.071	0.7%	21.19	211.9%
Skipwith Common SSSI	10	0.071	0.7%	21.19	211.9%
Humber Estuary SAC	20	0.103	0.5%	28.99	145.0%
Humber Estuary SPA/SSSI	20	0.103	0.5%	28.99	145.0%
Breighton Moors SSSI	20	0.107	0.5%	23.63	118.2%
Eskamhorn Meadows SSSI	10	0.075	0.8%	20.03	200.3%
Derwent Ings SSSI	20	0.099	0.5%	30.34	151.7%
Went Ings SSSI	15	0.058	0.4%	19.45	129.6%

Barn Hill Meadows SSSI	20	0.103	0.5%	20.55	102.8%
Burr Closes SSSI	20	0.050	0.2%	20.70	103.5%
Common Plantation SINC	10	0.171	**1.7%**	33.91	339.1%
Disused Railway Embankment SINC	10	0.150	**1.5%**	33.47	334.7%
Barmby-on-the-Marsh LWS	10	0.160	**1.6%**	33.49	334.9%
Brockholes SINC	10	0.070	0.7%	19.81	198.1%
Meadow East of Orchard Farm SINC	20	0.087	0.4%	19.97	99.8%
Barmby Pond LWS	10	0.095	1.0%	19.85	198.5%
Cobble Croft Wood SINC	10	0.161	**1.6%**	33.90	339.0%
Hagg Green Lane SINC	10	0.188	**1.9%**	40.95	409.5%
Sand Pitt Wood & Barffs Close Plantation SINC	10	0.180	**1.8%**	33.92	339.2%
Env. Agency Screening Criterion (as % of CL)			**1%**		70%

Table D11 - Modelled Maximum Cumulative Impacts at Ecological Receptors – Annual Acid Deposition Rate

Receptor	**Annual Acid Deposition Rate (keq/ha/yr)**				
	Critical Level	Max Cumulative PC Impact	Max PC Impact as % of CL	Max Cumulative PEC	Max PEC as % of CL
Thorne Moor SAC	0.462	0.009	**1.9%**	1.75	377.5%
Thorne Moor SSSI	0.462	0.009	**1.9%**	1.75	377.5%
Lower Derwent SAC	0.643	0.012	**1.8%**	2.42	376.7%
Skipwith Common SAC	0.802	0.007	0.8%	1.73	216.2%
Skipwith Common SSSI	0.802	0.007	0.8%	1.73	216.2%
Breighton Meadows SSSI	0.643	0.012	**1.8%**	1.94	302.0%
Eskamhorn Meadows SSSI	1.998	0.007	0.3%	1.64	82.3%
Derwent Ings SSSI	0.643	0.011	**1.6%**	2.42	376.4%
Went Ings SSSI	2.008	0.006	0.3%	1.60	79.7%
Barn Hill Meadows SSSI	0.633	0.012	**1.9%**	1.71	269.6%
Burr Closes SSSI	1.248	0.005	0.4%	1.69	135.2%
Env. Agency Screening Criterion (as % of CL)			***1%***		**70%**

SENSITIVITY TEST: WORST CASE EMISSIONS PROFILE

Results pertaining to the worst-case emissions profile sensitivity test are presented in Tables D12 to D17, based on emissions from the PCC alone.

For all pollutant concentrations and deposition rates, it is evident that the modelled maximum PC impacts attributed to the with PCC scenario are lower at all receptors relative to the core model scenarios. This is a function of all four biomass units in the Baseline scenario switching from 'mid-merit' operation (full load for 4,000 hours per year) to continuous operation (full load for 8,760 hours per year), resulting in more pollutants being emitted and thus more pronounced changes (increases) in concentrations/deposition rates relative to the With PCC scenario. In the With PCC scenario, operation changes from 'mid-merit' to continuous full load at the two non-PCC biomass units only (PCC units already assumed to operate at continuous full load in core modelling scenario), meaning the changes (increases and decreases) in concentrations/deposition rates are relatively small compared to the Baseline.

As a consequence, the maximum modelled impacts of the PCC decrease at all receptors under the worst-case emissions profile scenario relative to the core modelling. Whilst some modelled maximum PEC concentrations do increase under worst case emissions in both the Baseline and With PCC scenarios, there are no material changes relative to the core modelling equivalents, meaning that the respective assessment significance criteria are not exceeded.

The results confirm that the assessment of likely significant effects reported in Section 5 is not affected when considering the worst-case emissions profiles in both the Baseline and With PCC. Given that the modelled maximum impacts are lower under a worst-case emissions profile, there was no need to repeat the test in relation to cumulative impacts, as the core modelling results for the cumulative scenarios represent the most conservative results in terms of potential impacts.

Table D12 - Modelled Maximum Operational Impacts at Ecological Receptors – Annual Mean NO_x (Worst Case Emissions Profile)

Receptor	**Annual Mean NO_x concentration ($\mu g/m^3$)**					
	Critical Level	Background	Max PC Impact	Max PC Impact as % of CL	PCC Max PEC	Max PEC as % of CL
River Derwent SAC	30	11.91	0.035	0.1%	12.08	40.3%
Thorne Moor SAC/SPA/SSSI	30	13.21	0.016	0.1%	13.32	44.4%
Lower Derwent SAC	30	9.92	0.036	0.1%	10.09	33.6%
Lower Derwent SPA	30	9.92	0.036	0.1%	10.09	33.6%
Skipwith Common SAC	30	9.76	0.014	0.0%	9.83	32.8%
Skipwith Common SSSI	30	9.76	0.014	0.0%	9.83	32.8%
Humber Estuary SAC	30	12.20	0.036	0.1%	12.36	41.2%
Humber Estuary SPA/SSSI	30	12.20	0.036	0.1%	12.36	41.2%
Breighton Moors SSSI	30	9.92	0.036	0.1%	10.09	33.6%
Eskamhorn Meadows SSSI	30	11.35	0.009	0.0%	11.38	37.9%

Derwent Ings SSSI	30	9.80	0.028	0.1%	9.96	33.2%
Went Ings SSSI	30	12.09	0.012	0.0%	12.14	40.5%
Barn Hill Meadows SSSI	30	12.89	0.038	0.1%	13.03	43.4%
Burr Closes SSSI	30	10.53	0.013	0.0%	10.59	35.3%
Common Plantation SINC	30	11.43	0.003	0.0%	11.44	38.1%
Disused Railway Embankment SINC	30	10.76	0.007	0.0%	10.78	35.9%
Barmby-on-the-Marsh LWS	30	10.48	0.015	0.0%	10.53	35.1%
Brockholes SINC	30	11.22	0.003	0.0%	11.23	37.4%
Meadow East of Orchard Farm SINC	30	10.83	0.001	0.0%	10.83	36.1%
Barmby Pond LWS	30	9.96	0.025	0.1%	10.05	33.5%
Cobble Croft Wood SINC	30	11.62	0.005	0.0%	11.64	38.8%
Hagg Green Lane SINC	30	10.93	0.021	0.1%	11.03	36.8%
Sand Pitt Wood & Barffs Close Plantation SINC	30	11.43	0.005	0.0%	11.44	38.1%

Env. Agency Screening Criterion (as % of CL)	**1%**		**70%**

Table D13 - Modelled Maximum Operational Impacts at Ecological Receptors – Daily Mean NO$_x$ (Worst Case Emissions Profile)

Receptor	**Daily Mean NO$_x$ concentration (µg/m^3)**					
	Critical Level	Background	Max PC Impact	Max PC Impact as % of CL	PCC Max PEC	Max PEC as % of CL
River Derwent SAC	75	23.82	0.503	0.7%	27.50	36.7%
Thorne Moor SAC/SPA/SSSI	75	26.42	0.534	0.7%	28.87	38.5%
Lower Derwent SAC	75	19.84	0.501	0.7%	23.31	31.1%
Lower Derwent SPA	75	19.84	0.501	0.7%	23.31	31.1%
Skipwith Common SAC	75	19.52	0.337	0.4%	21.40	28.5%
Skipwith Common SSSI	75	19.52	0.337	0.4%	21.40	28.5%
Humber Estuary SAC	75	24.40	0.469	0.6%	27.08	36.1%
Humber Estuary SPA/SSSI	75	24.40	0.469	0.6%	27.08	36.1%
Breighton Moors SSSI	75	24.40	0.501	0.7%	23.31	31.1%
Eskamhorn Meadows SSSI	75	22.70	0.508	0.7%	24.82	33.1%

Derwent Ings SSSI	75	19.60	0.416	0.6%	22.94	30.6%
Went Ings SSSI	75	24.18	0.371	0.5%	26.33	35.1%
Barn Hill Meadows SSSI	75	25.78	0.626	0.8%	27.87	37.2%
Burr Closes SSSI	75	21.06	0.291	0.4%	22.67	30.2%
Common Plantation SINC	75	22.86	0.132	0.2%	23.30	31.1%
Disused Railway Embankment SINC	75	21.53	0.225	0.3%	22.13	29.5%
Barmby-on-the-Marsh LWS	75	20.99	0.377	0.5%	22.38	29.8%
Brockholes SINC	75	22.44	0.287	0.4%	23.16	30.9%
Meadow East of Orchard Farm SINC	75	21.66	0.092	0.1%	21.95	29.3%
Barmby Pond LWS	75	19.98	0.368	0.5%	22.89	30.5%
Cobble Croft Wood SINC	75	23.25	0.308	0.4%	24.50	32.7%
Hagg Green Lane SINC	75	21.93	0.533	0.7%	24.81	33.1%
Sand Pitt Wood & Barffs Close Plantation SINC	75	22.87	0.256	0.3%	23.59	31.5%

Env. Agency Screening Criterion (as % of CL)	**10%**		**70%**

Table D14 - Modelled Maximum Operational Impacts at Ecological Receptors – Annual Mean NH_3 (Worst Case Emissions Profile)

Receptor	**Annual Mean NH_3 concentration (µg/m^3)**					
	Critical Level	Background	Max PC Impact	Max PC Impact as % of CL	PCC Max PEC	Max PEC as % of CL
River Derwent SAC	3	4.57	0.002	0.1%	4.58	152.6%
Thorne Moor SAC/SPA/SSSI	1	2.59	0.001	0.1%	2.60	259.6%
Lower Derwent SAC	3	4.57	0.002	0.1%	4.58	152.6%
Lower Derwent SPA	3	4.57	0.002	0.1%	4.58	152.6%
Skipwith Common SAC	1	2.58	0.001	0.1%	2.58	258.4%
Skipwith Common SSSI	1	2.58	0.001	0.1%	2.58	258.4%
Humber Estuary SAC	3	3.58	0.002	0.1%	3.59	119.6%
Humber Estuary SPA/SSSI	3	3.58	0.002	0.1%	3.59	119.6%
Breighton Moors SSSI	3	3.08	0.002	0.1%	3.09	103.0%

Eskamhorn Meadows SSSI	3	2.40	0.001	0.0%	2.40	80.1%
Derwent Ings SSSI	3	4.57	0.002	0.1%	4.58	152.6%
Went Ings SSSI	3	2.35	0.001	0.0%	2.35	78.4%
Barn Hill Meadows SSSI	3	2.32	0.002	0.1%	2.33	77.6%
Burr Closes SSSI	3	2.50	0.001	0.0%	2.50	83.4%
Common Plantation SINC	3	2.33	0.000	0.0%	2.33	77.7%
Disused Railway Embankment SINC	1	2.28	0.000	0.0%	2.28	76.0%
Barmby-on-the-Marsh LWS	3	2.28	0.001	0.0%	2.28	76.1%
Brockholes SINC	3	2.28	0.000	0.0%	2.28	76.0%
Meadow East of Orchard Farm SINC	1	2.33	0.000	0.0%	2.33	77.7%
Barmby Pond LWS	1	2.28	0.001	0.0%	2.29	76.2%
Cobble Croft Wood SINC	3	2.33	0.000	0.0%	2.33	77.7%
Hagg Green Lane SINC	3	3.09	0.001	0.0%	3.10	103.2%

Sand Pitt Wood & Barffs Close Plantation SINC	3	2.33	0.000	0.0%	2.33	77.7%
Env. Agency Screening Criterion (as % of CL)				**1%**		**70%**

Table D15 - Modelled Maximum Operational Impacts at Ecological Receptors – Annual Mean SO_2 (Worst Case Emissions Profile)

Receptor	**Annual Mean SO_2 concentration ($\mu g/m^3$)**					
	Critical Level	Background	Max PC Impact	Max PC Impact as % of CL	PCC Max PEC	Max PEC as % of CL
River Derwent SAC	20	3.93	0.021	0.1%	4.03	20.1%
Thorne Moor SAC/SPA/SSSI	20	1.34	0.009	0.0%	1.40	7.0%
Lower Derwent SAC	20	1.70	0.021	0.1%	1.80	9.0%
Lower Derwent SPA	20	1.70	0.021	0.1%	1.80	9.0%
Skipwith Common SAC	20	1.42	0.008	0.0%	1.46	7.3%
Skipwith Common SSSI	20	1.42	0.008	0.0%	1.46	7.3%
Humber Estuary SAC	20	7.49	0.021	0.1%	7.58	37.9%
Humber Estuary SPA/SSSI	20	7.49	0.021	0.1%	7.58	37.9%
Breighton Moors SSSI	20	1.70	0.021	0.1%	1.80	9.0%
Eskamhorn Meadows SSSI	20	1.29	0.005	0.0%	1.31	6.5%

Derwent Ings SSSI	20	1.69	0.016	0.1%	1.78	8.9%
Went Ings SSSI	20	1.31	0.007	0.0%	1.34	6.7%
Barn Hill Meadows SSSI	20	1.81	0.022	0.1%	1.89	9.4%
Burr Closes SSSI	20	1.23	0.008	0.0%	1.26	6.3%
Common Plantation SINC	20	1.44	0.002	0.0%	1.44	7.2%
Disused Railway Embankment SINC	20	1.32	0.004	0.0%	1.33	6.7%
Barmby-on-the-Marsh LWS	20	1.32	0.009	0.0%	1.35	6.7%
Brockholes SINC	20	1.32	0.002	0.0%	1.32	6.6%
Meadow East of Orchard Farm SINC	20	1.44	0.001	0.0%	1.44	7.2%
Barmby Pond LWS	20	1.32	0.015	0.1%	1.37	6.9%
Cobble Croft Wood SINC	20	1.44	0.003	0.0%	1.45	7.2%
Hagg Green Lane SINC	20	1.43	0.013	0.1%	1.49	7.5%
Sand Pitt Wood & Barffs Close Plantation SINC	20	1.44	0.003	0.0%	1.45	7.2%

Env. Agency Screening Criterion (as % of CL)	**1%**		**70%**

Table D16 - Modelled Maximum Operational Impacts at Ecological Receptors – Annual Nitrogen Deposition Rate (Worst Case Emissions Profile)

Receptor	**Annual Nitrogen Deposition Rate (kgN/ha/yr)**					
	Critical Load	Background	Max PC Impact	Max PC Impact as % of CL	PCC Max PEC	Max PEC as % of CL
Thorne Moor SAC	5	21.31	0.006	0.1%	21.35	426.9%
Thorne Moor SPA	10	21.31	0.006	0.1%	21.35	213.5%
Thorne Moor SSSI	5	21.31	0.006	0.1%	21.35	426.9%
Lower Derwent SAC	20	30.22	0.015	0.1%	30.29	151.5%
Lower Derwent SPA	20	30.22	0.015	0.1%	30.29	151.5%
Skipwith Common SAC	10	21.12	0.006	0.1%	21.14	211.4%
Skipwith Common SSSI	10	21.12	0.006	0.1%	21.14	211.4%
Humber Estuary SAC	20	28.87	0.015	0.1%	28.93	144.6%
Humber Estuary SPA/SSSI	20	28.87	0.015	0.1%	28.93	144.6%
Breighton Moors SSSI	20	23.51	0.015	0.1%	23.57	117.9%

Eskamhorn Meadows SSSI	10	19.95	0.004	0.0%	19.96	199.6%
Derwent Ings SSSI	20	30.22	0.011	0.1%	30.29	151.4%
Went Ings SSSI	15	19.38	0.005	0.0%	19.40	129.3%
Barn Hill Meadows SSSI	20	20.43	0.015	0.1%	20.48	102.4%
Burr Closes SSSI	20	20.64	0.005	0.0%	20.66	103.3%
Common Plantation SINC	10	33.74	0.002	0.0%	33.74	337.4%
Disused Railway Embankment SINC	10	33.32	0.005	0.0%	33.33	333.3%
Barmby-on-the-Marsh LWS	10	33.32	0.010	0.1%	33.35	333.5%
Brockholes SINC	10	19.74	0.001	0.0%	19.74	197.4%
Meadow East of Orchard Farm SINC	20	19.88	0.001	0.0%	19.88	99.4%
Barmby Pond LWS	10	19.74	0.010	0.1%	19.78	197.8%
Cobble Croft Wood SINC	10	33.74	0.003	0.0%	33.75	337.5%
Hagg Green Lane SINC	10	40.74	0.014	0.1%	40.81	408.1%

Sand Pitt Wood & Barffs Close Plantation SINC	10	33.74	0.003	0.0%	33.75	337.5%
Env. Agency Screening Criterion (as % of CL)				**1%**		**70%**

Table D17 - Modelled Maximum Operational Impacts at Ecological Receptors – Annual Acid Deposition Rate (Worst Case Emissions Profile)

Receptor	**Annual Acid Deposition Rate (keq/ha/yr)**					
	Critical Load	Background	Max PC Impact	Max PC Impact as % of CL	PCC Max PEC	Max PEC as % of CL
Thorne Moor SAC	0.462	1.73	0.002	0.4%	1.74	377.2%
Thorne Moor SSSI	0.462	1.73	0.002	0.4%	1.74	377.2%
Lower Derwent SAC	0.643	2.40	0.004	0.6%	2.42	376.6%
Skipwith Common SAC	0.802	1.73	0.001	0.2%	1.73	216.0%
Skipwith Common SSSI	0.802	1.73	0.001	0.2%	1.73	216.0%
Breighton Meadows SSSI	0.643	1.92	0.004	0.6%	1.94	301.9%
Eskamhorn Meadows SSSI	1.998	1.64	0.001	0.0%	1.64	82.1%
Derwent Ings SSSI	0.643	2.40	0.003	0.4%	2.42	376.4%
Went Ings SSSI	2.008	1.59	0.001	0.1%	1.60	79.5%
Barn Hill Meadows SSSI	0.633	1.69	0.004	0.6%	1.70	269.2%

Burr Closes SSSI	1.248	1.68	0.001	0.1%	1.69	135.1%
Env. Agency Screening Criterion (as % of CL)				**1%**		**70%**

Appendix E - Noise Assessment Charts.

BACKGROUND NOISE LEVELS

DAYTIME HISTOGRAM AND CUMULATIVE PERCENTAGE

The following figures are daytime (07:00 – 23:00) background noise levels surveyed by WSP during May and June 2021:

Plate 1 LT1 Daytime Histogram

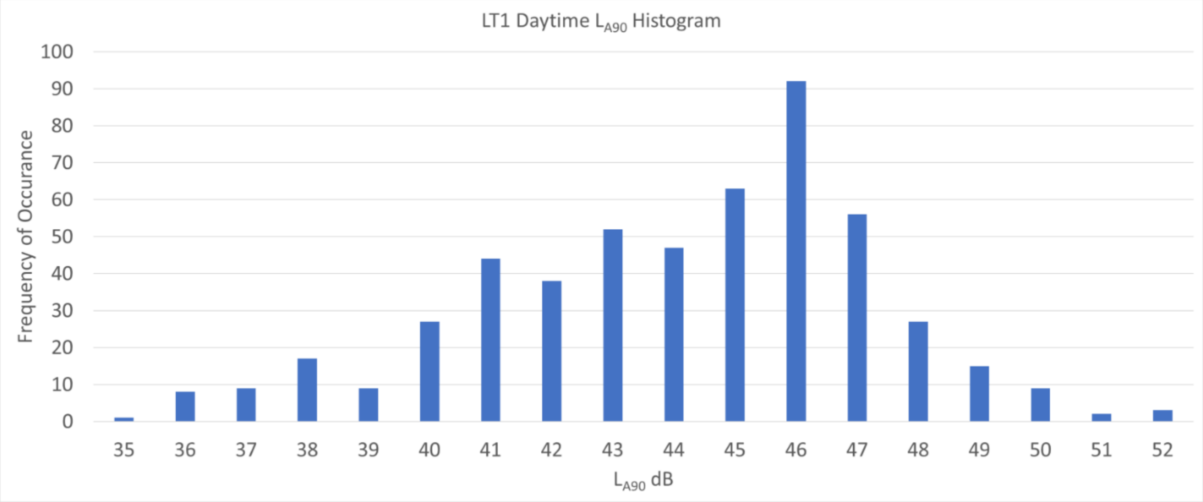


Plate 2 LT1 Daytime Cumulative Percentage

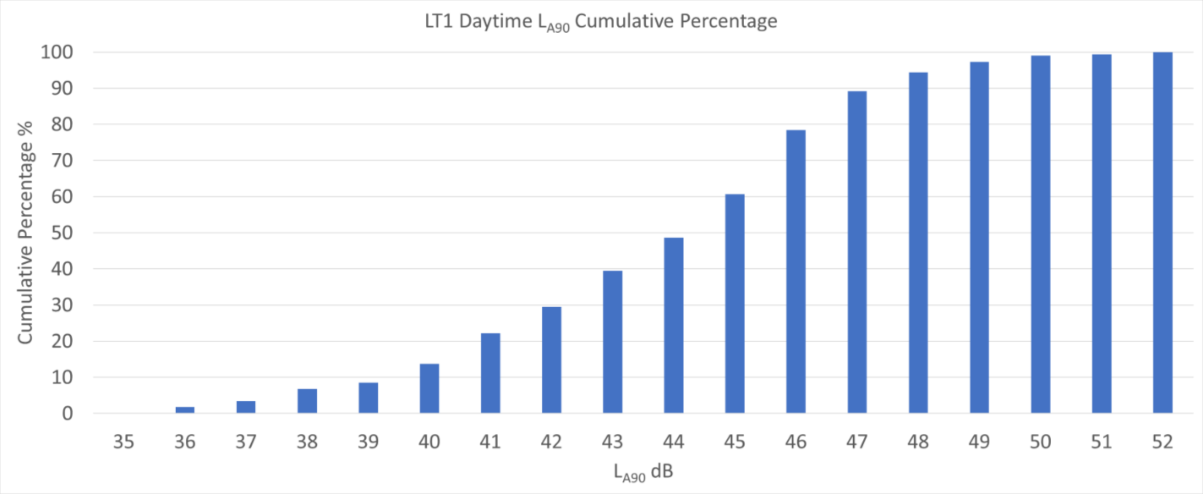


Plate 3 LT2 Daytime Histogram

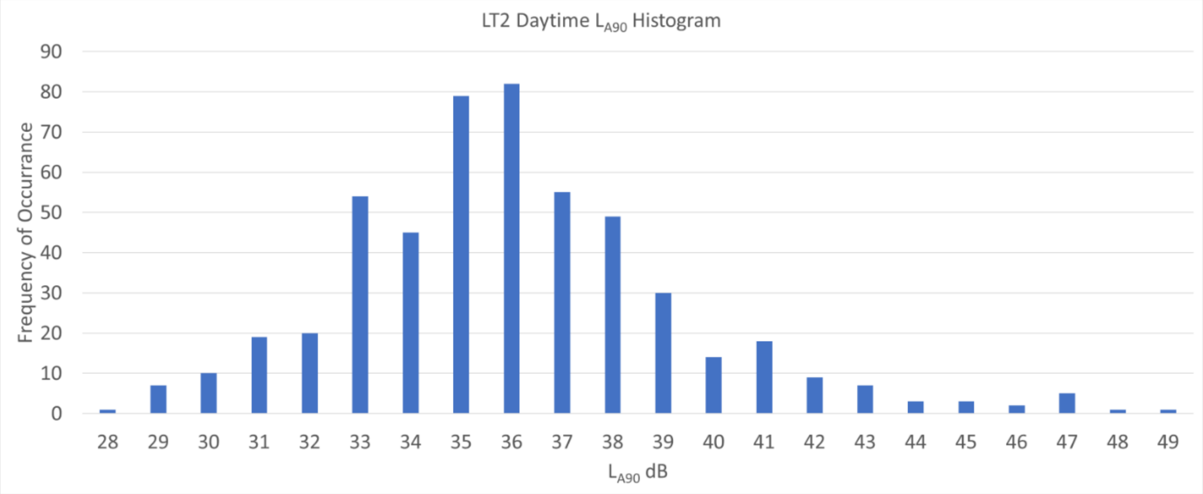


Plate 4 LT2 Daytime Cumulative Percentage

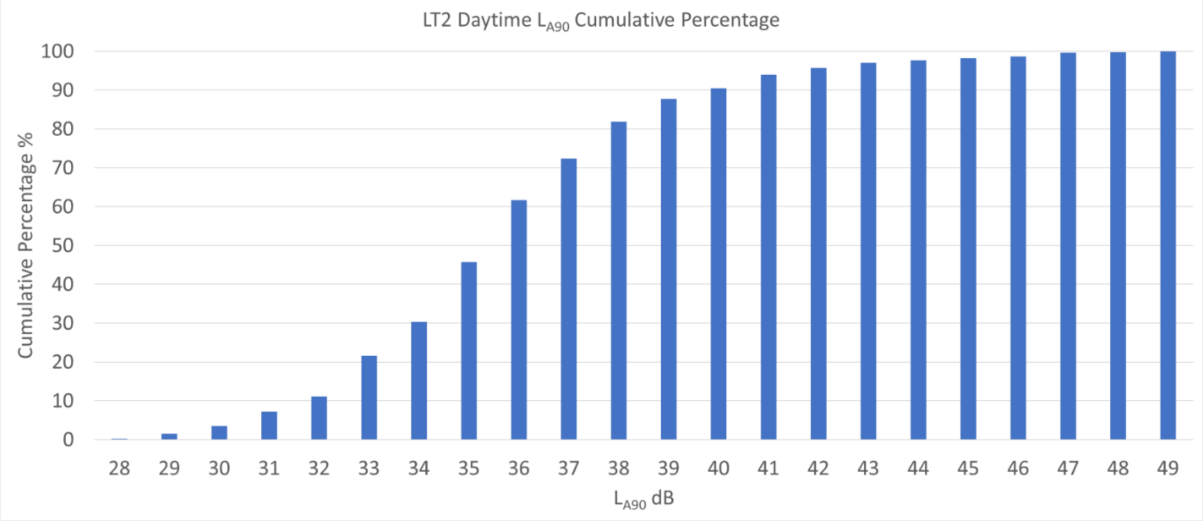


Plate 5 LT3 Daytime Histogram

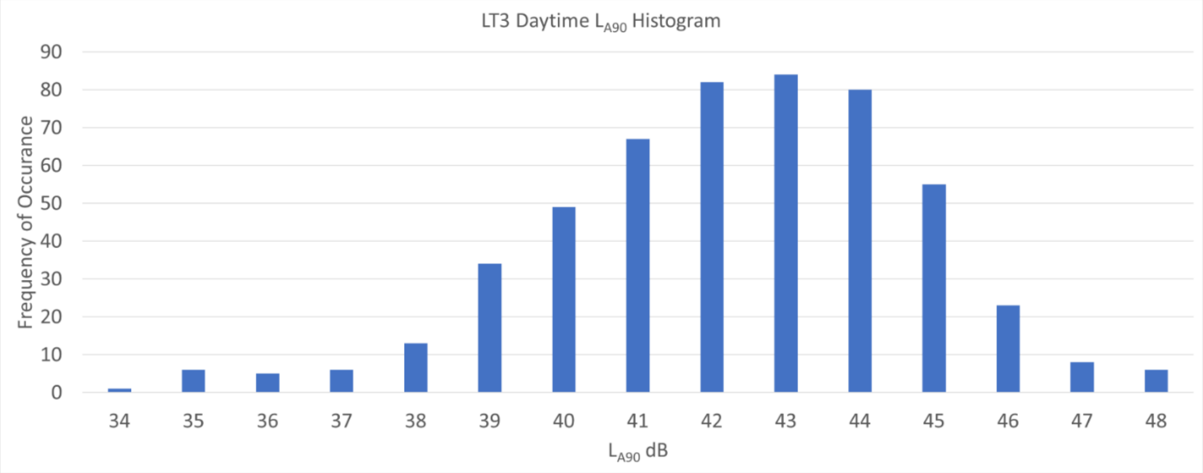


Plate 6 LT3 Daytime Cumulative Percentage

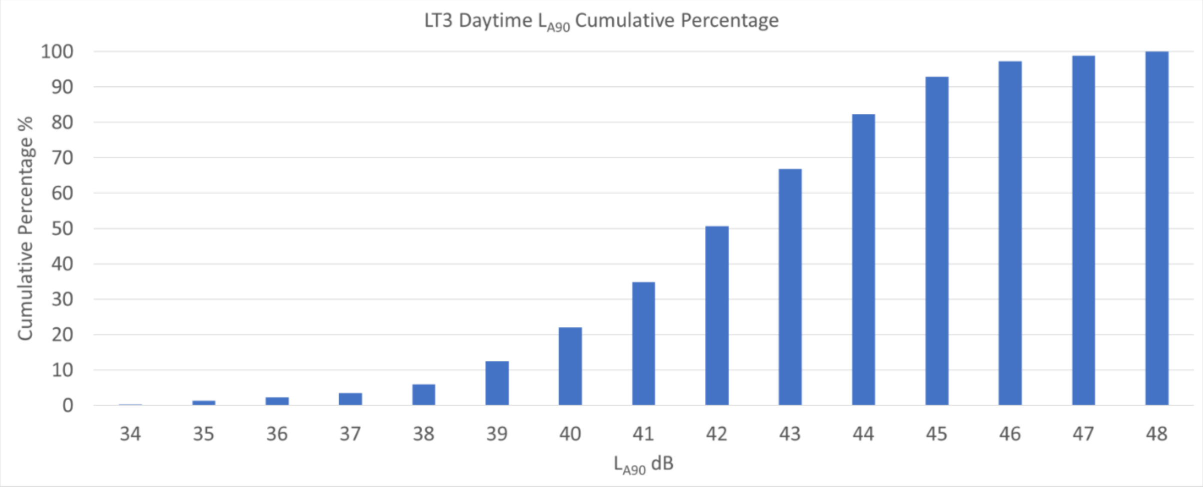


Plate 7 LT4 Daytime Histogram

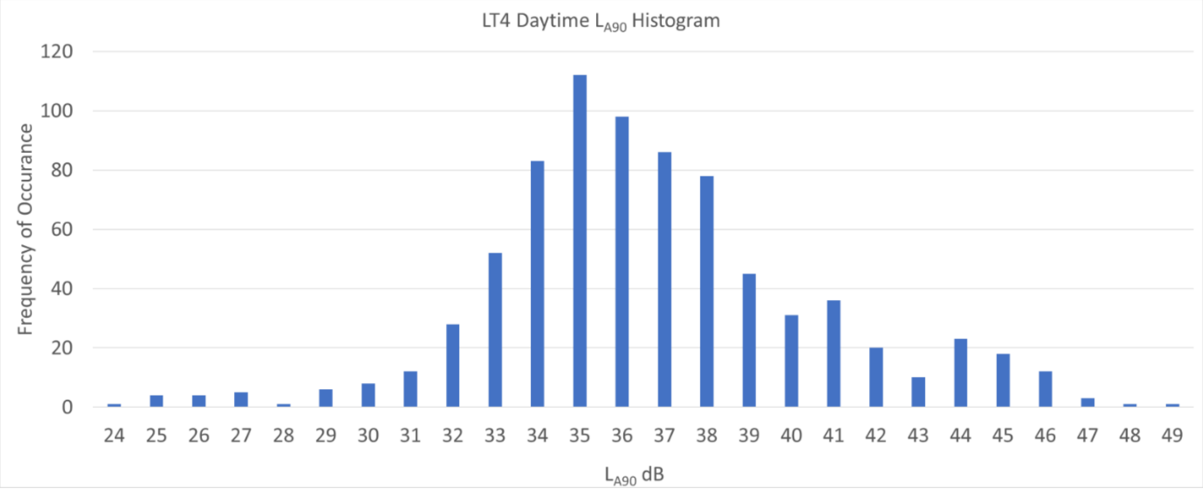


Plate 8 LT4 Daytime Cumulative Percentage

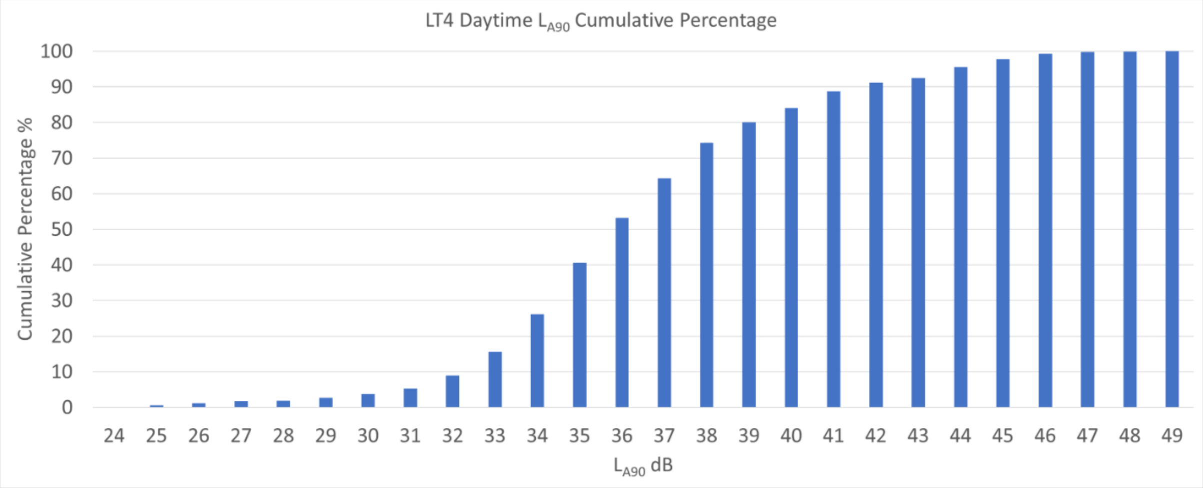


Plate 9 LT5 Daytime Histogram

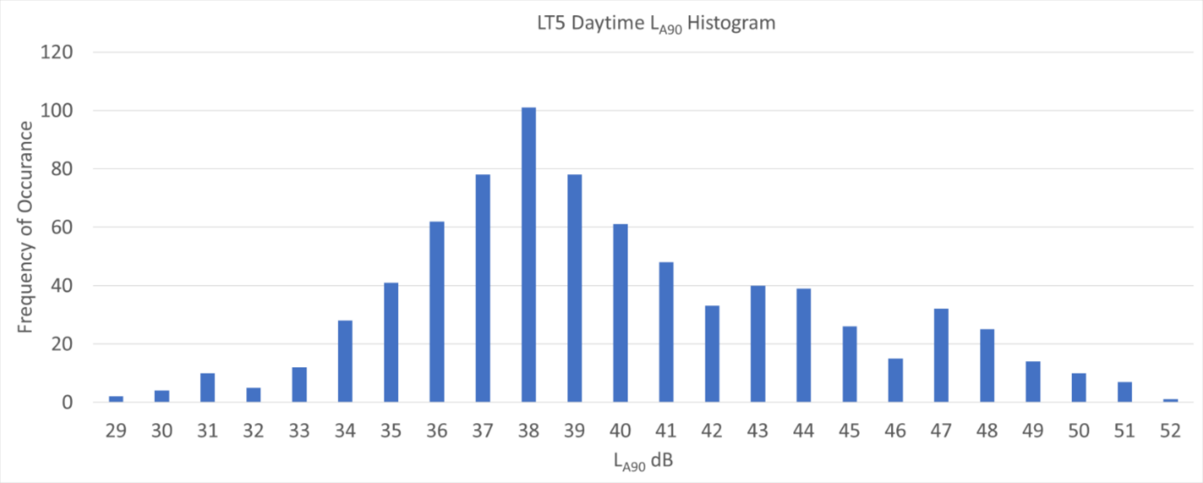


Plate 10 LT5 Daytime Cumulative Percentage

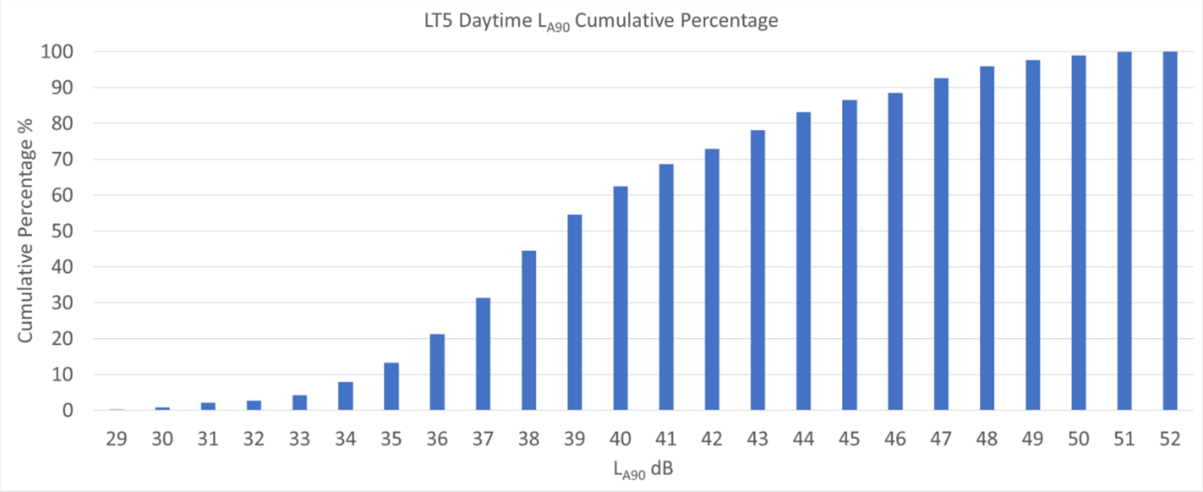


Plate 11 LT6 Daytime Histogram

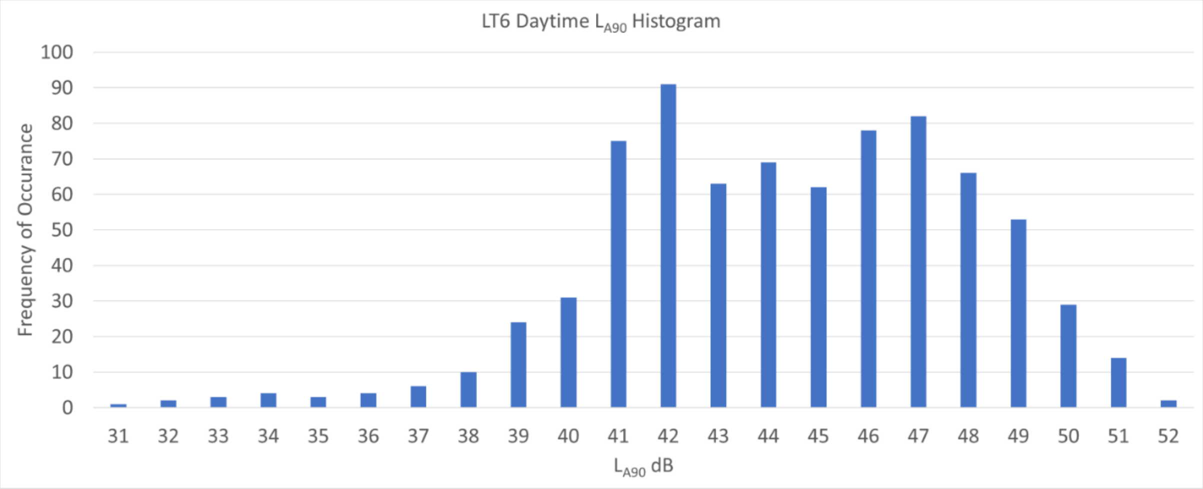


Plate 12 LT6 Daytime Cumulative Percentage

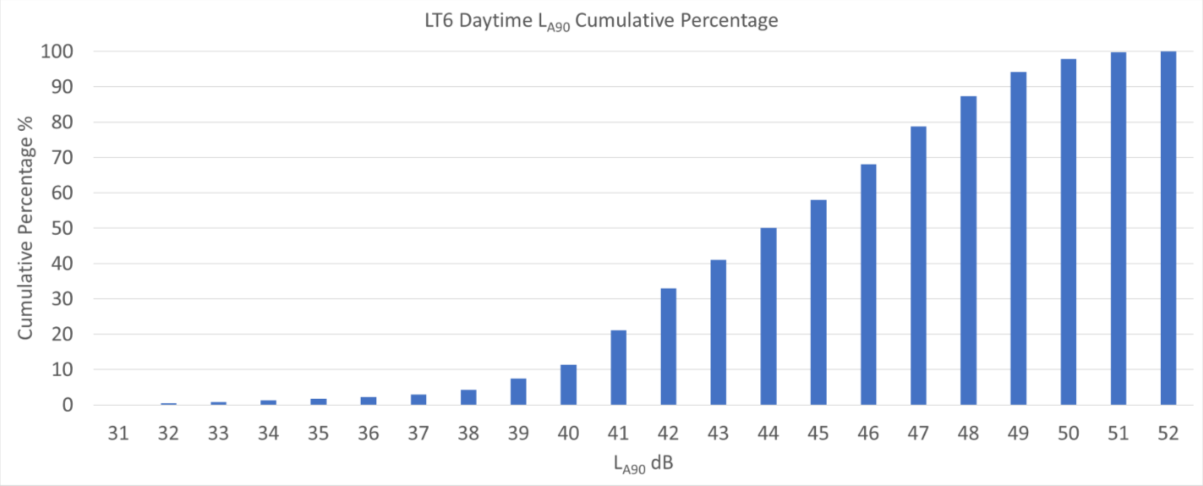


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Plate 13 LT7 Daytime Histogram

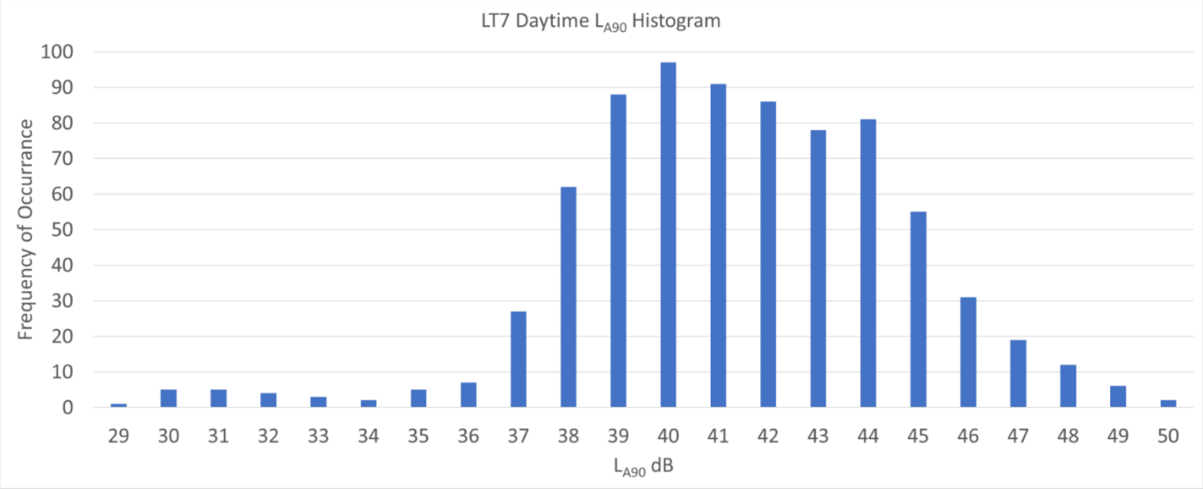
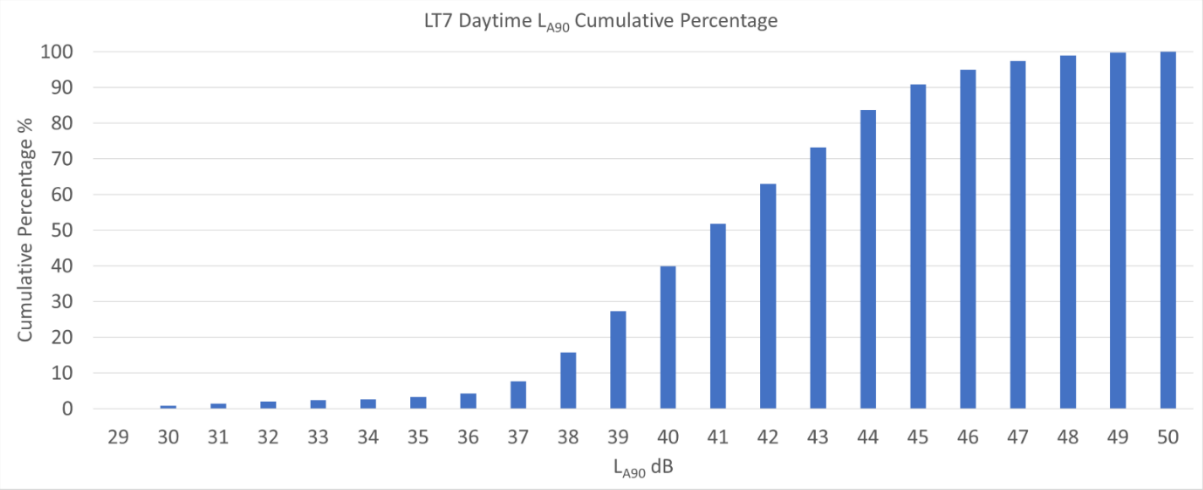


Plate 14 LT7 Daytime Cumulative Percentage



NIGHT-TIME HISTOGRAM AND CUMULATIVE PERCENTAGE

The following figures are night-time (23:00 – 04:00) background noise levels filtered for the dawn chorus, surveyed by WSP during May and June 2021:

Plate 15 LT1 Night-time Histogram

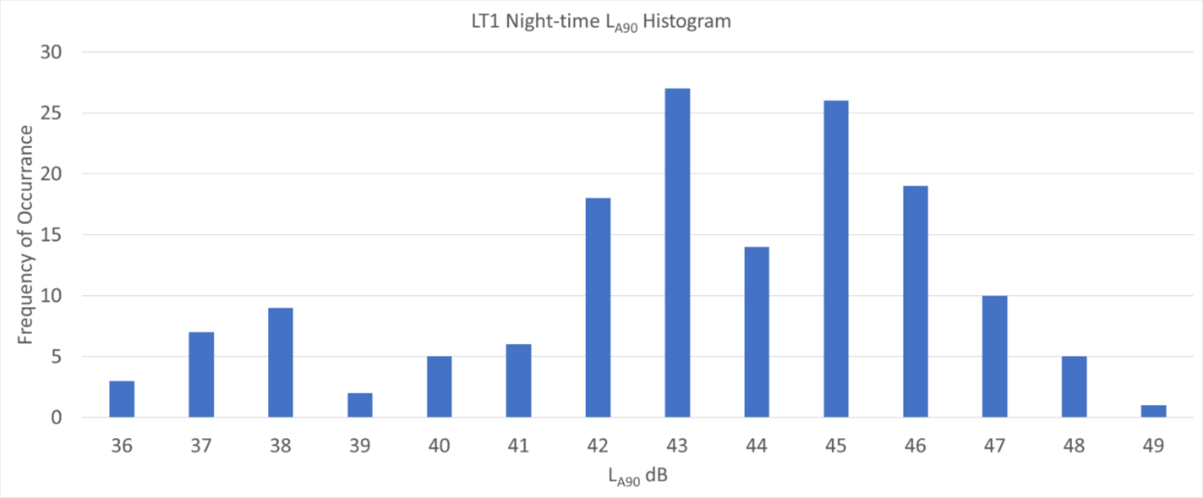


Plate 16 LT1 Night-time Cumulative Percentage

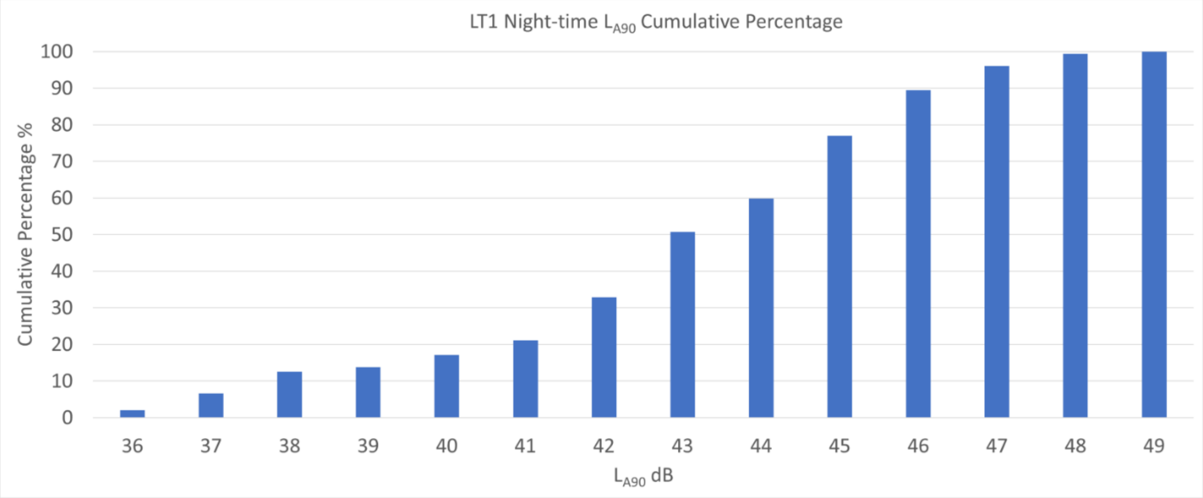


Plate 17 LT2 Night-time Histogram

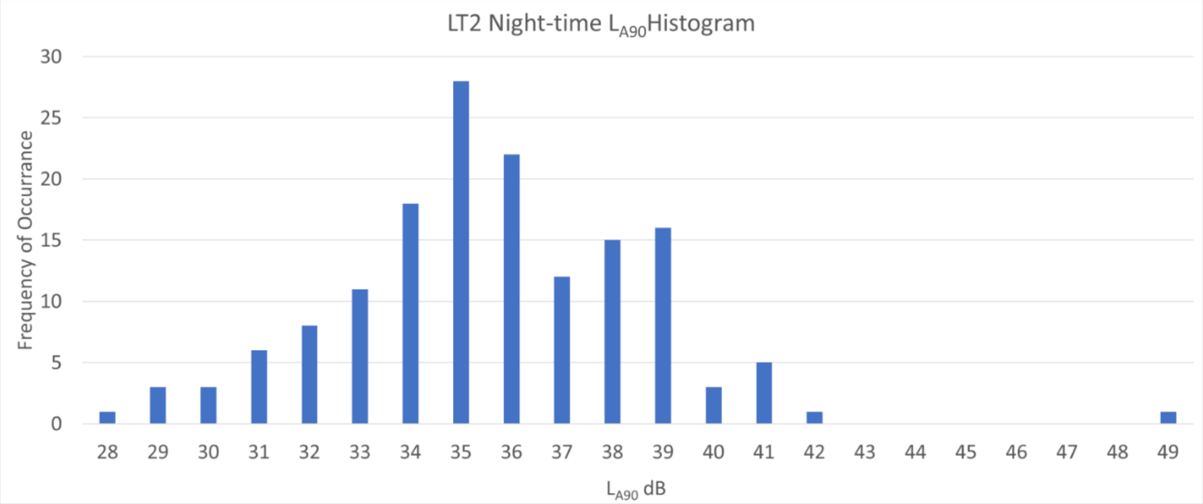


Plate 18 LT2 Night-time Cumulative Percentage

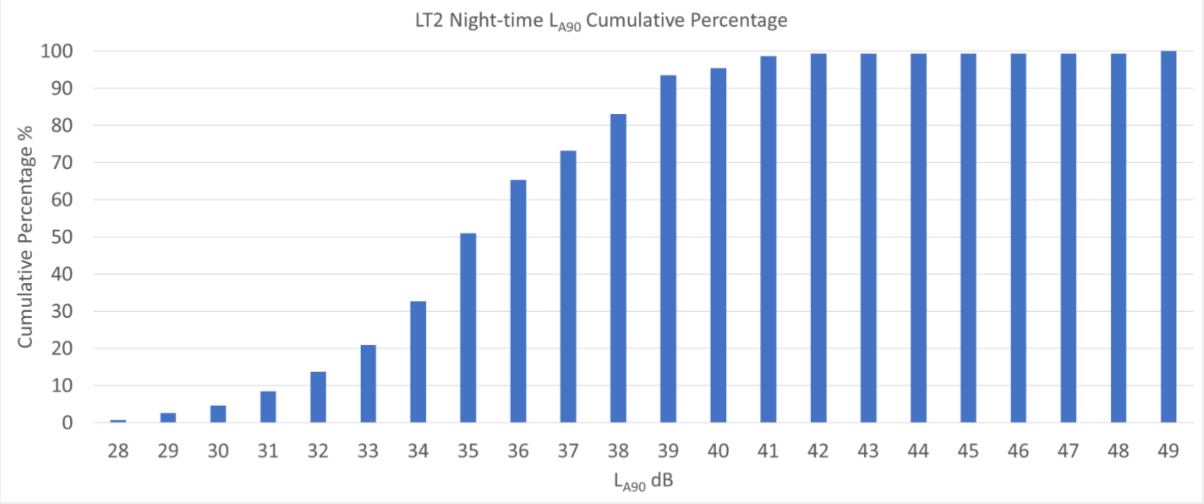


Plate 19 LT3 Night-time Histogram

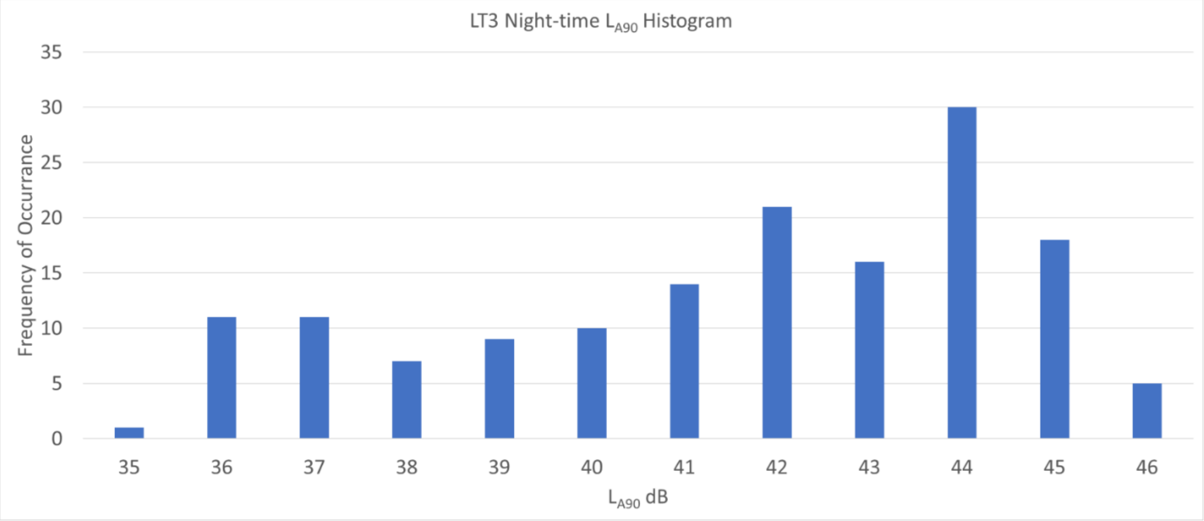


Plate 20 LT3 Night-time Cumulative Percentage

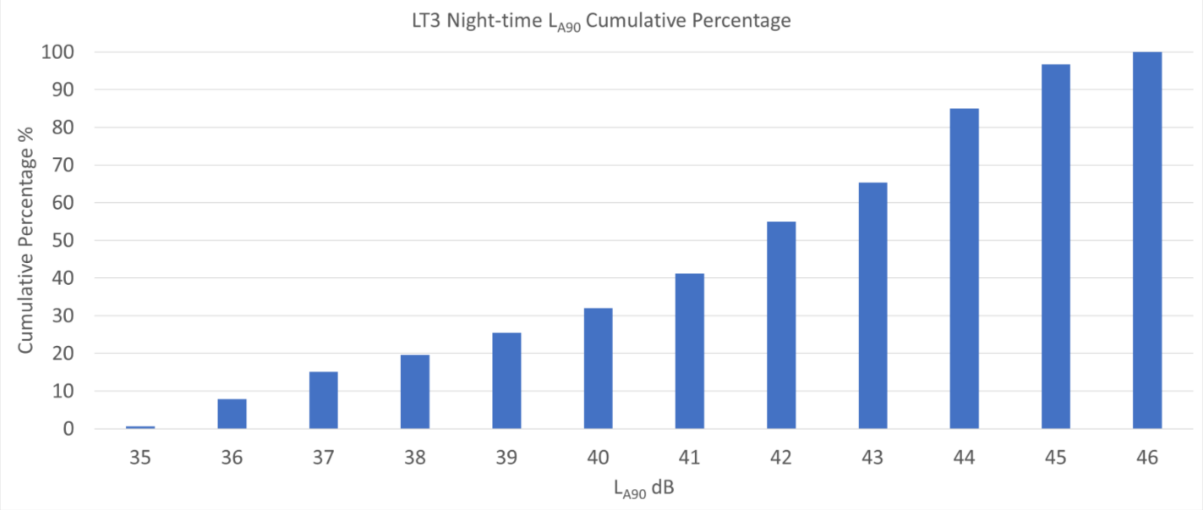


Plate 21 LT4 Night-time Histogram

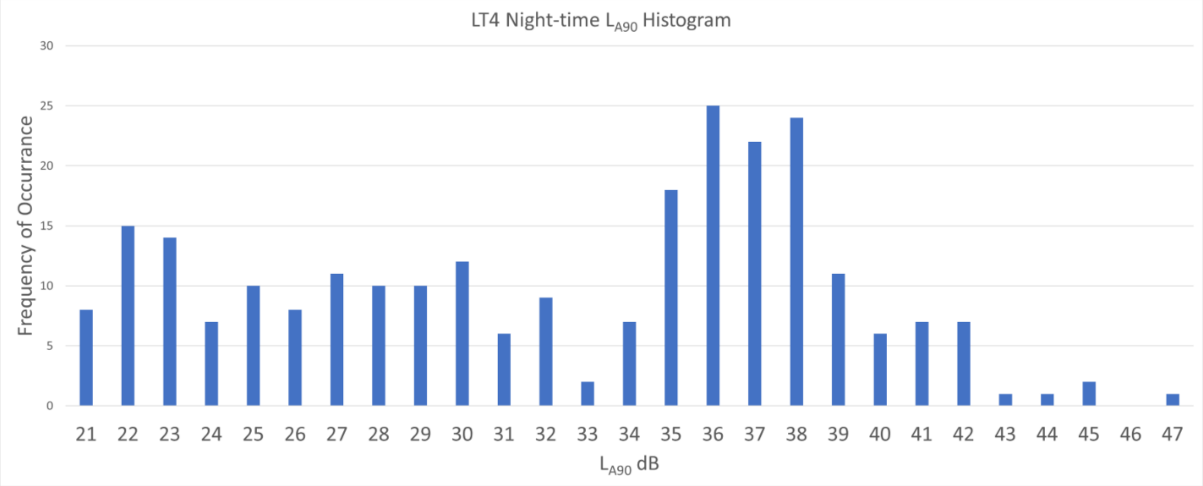


Plate 22 LT4 Night-time Cumulative Percentage

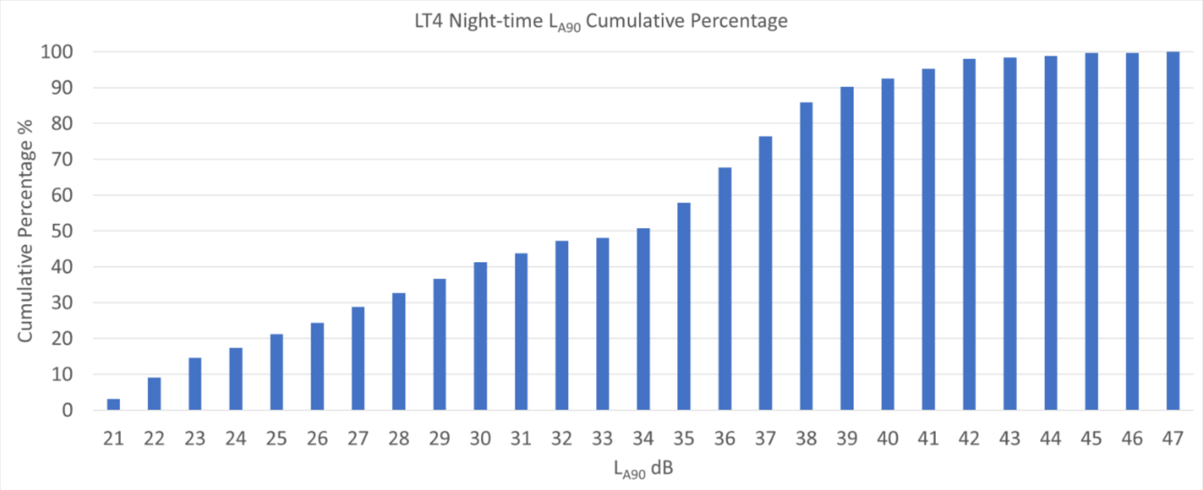


Plate 23 LT5 Night-time Histogram

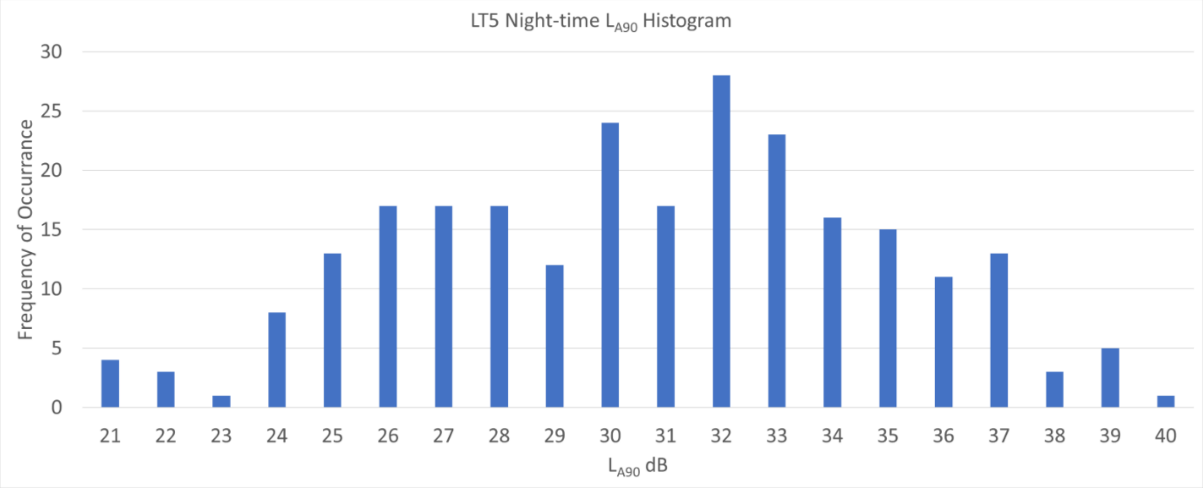


Plate 24 LT5 Night-time Cumulative Percentage

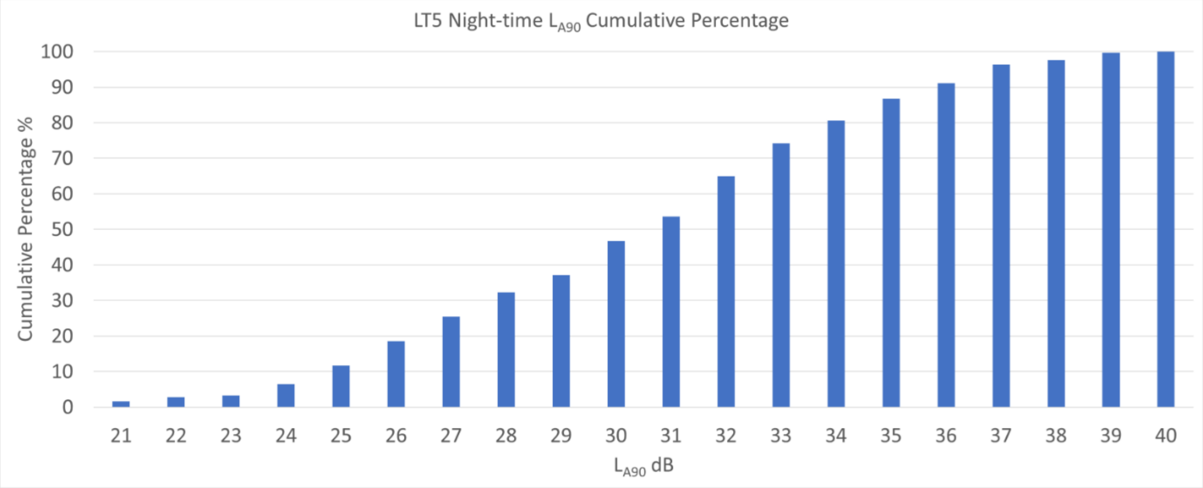


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Plate 25 LT6 Night-time Histogram

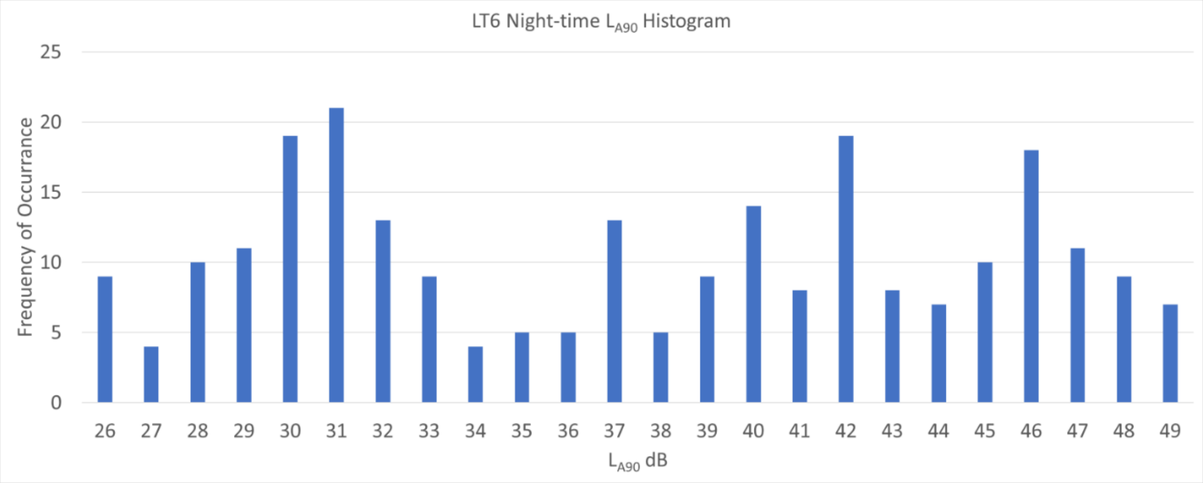


Plate 26 LT6 Night-time Cumulative Percentage

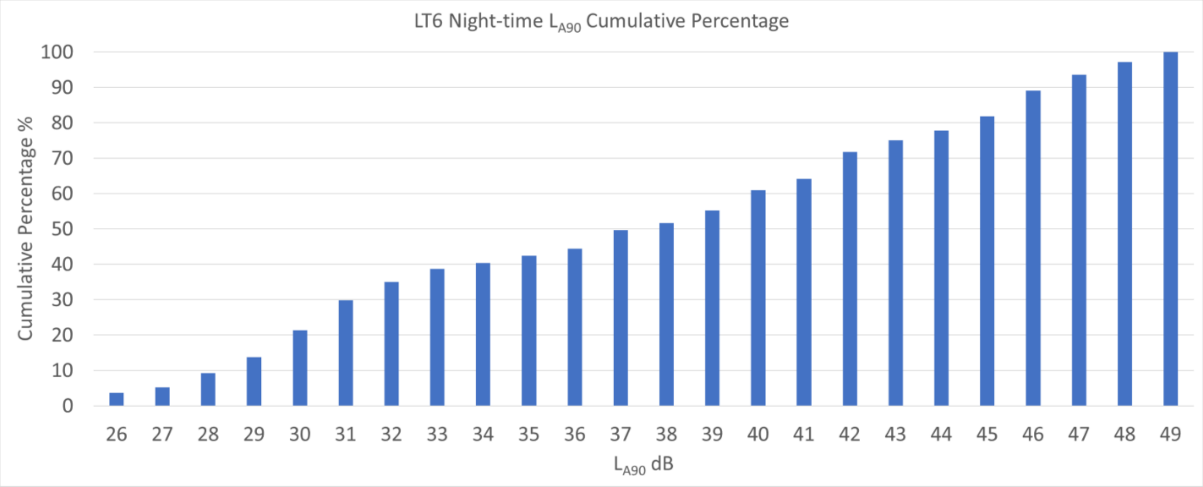


Plate 27 LT7 Night-time Histogram

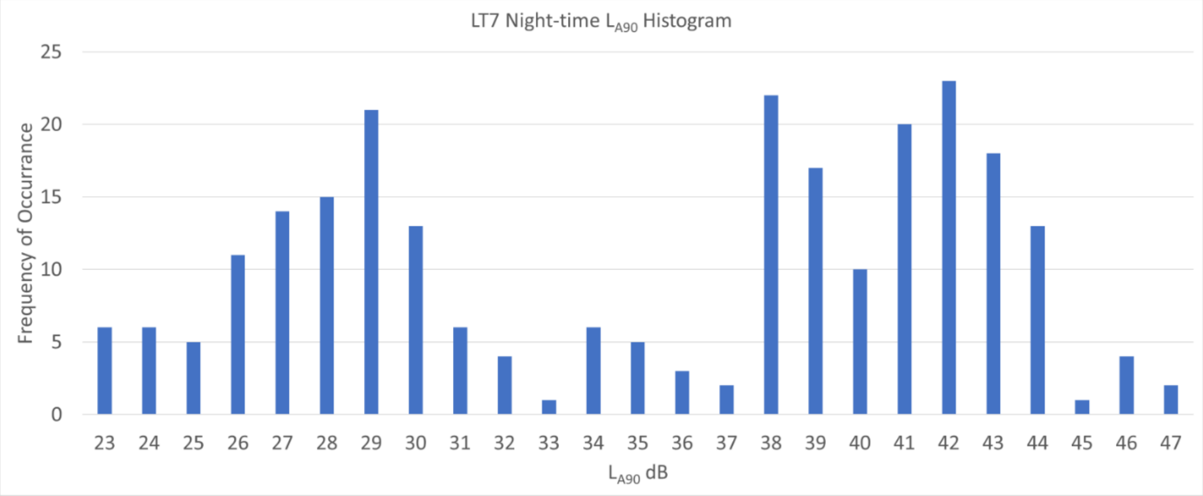
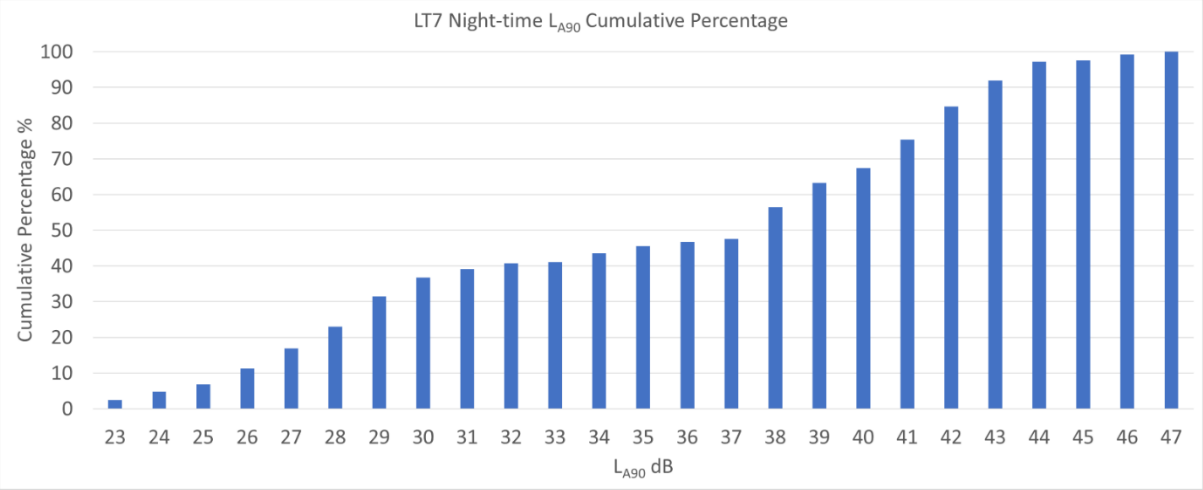


Plate 28 LT7 Night-time Cumulative Percentage



PERMANENT 2021 BACKGROUND NOISE LEVELS

DAYTIME HISTOGRAM AND CUMULATIVE PERCENTAGE

The following figures are daytime (07:00 – 23:00) background noise levels surveyed by Drax during May and June 2021:

Plate 29 Barlow 2021 Daytime Histogram

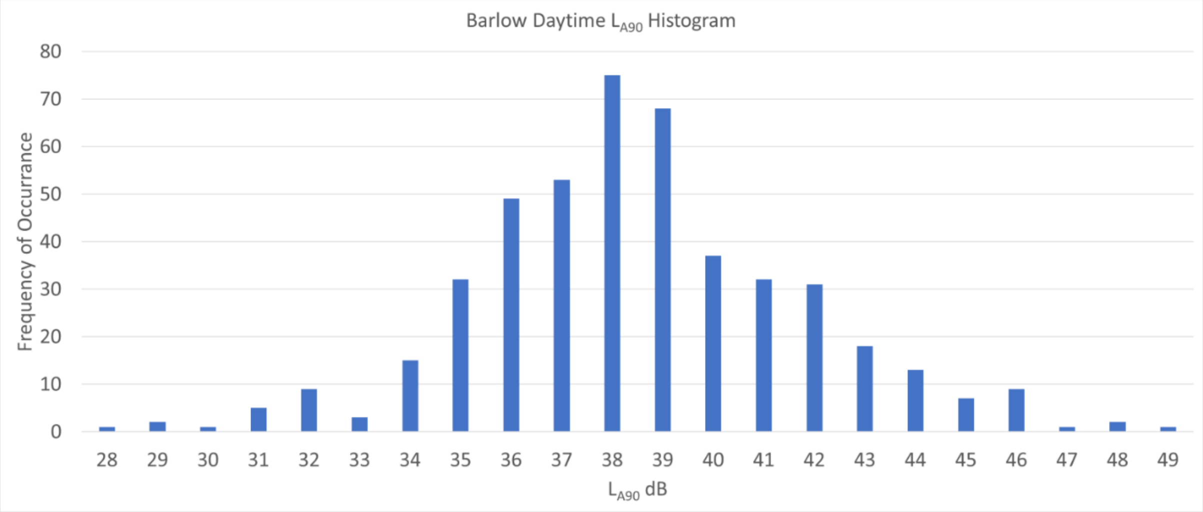


Plate 30 Barlow 2021 Daytime Cumulative Percentage

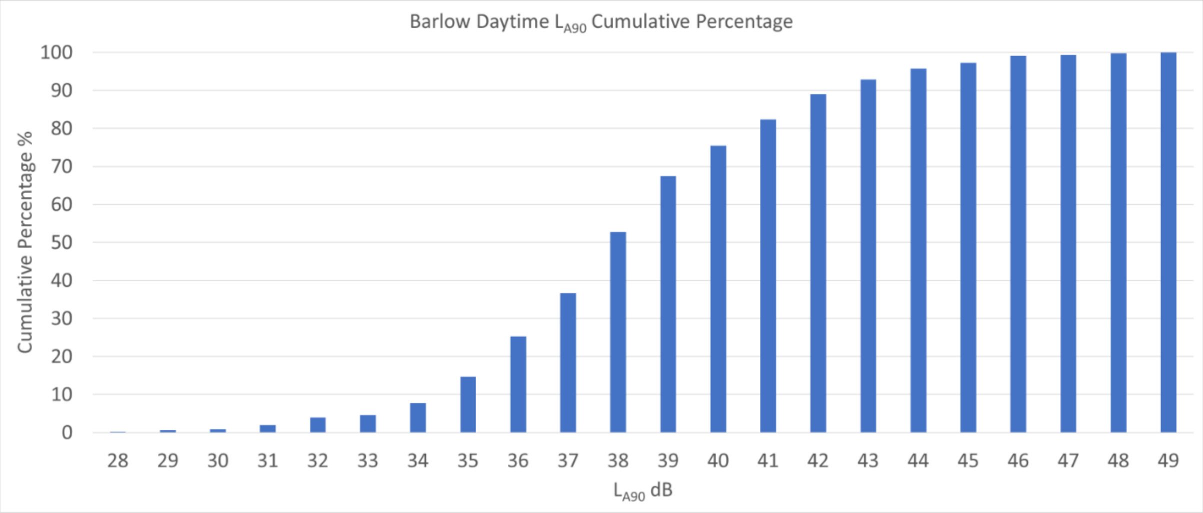


Plate 31 Camblesforth 2021 Daytime Histogram

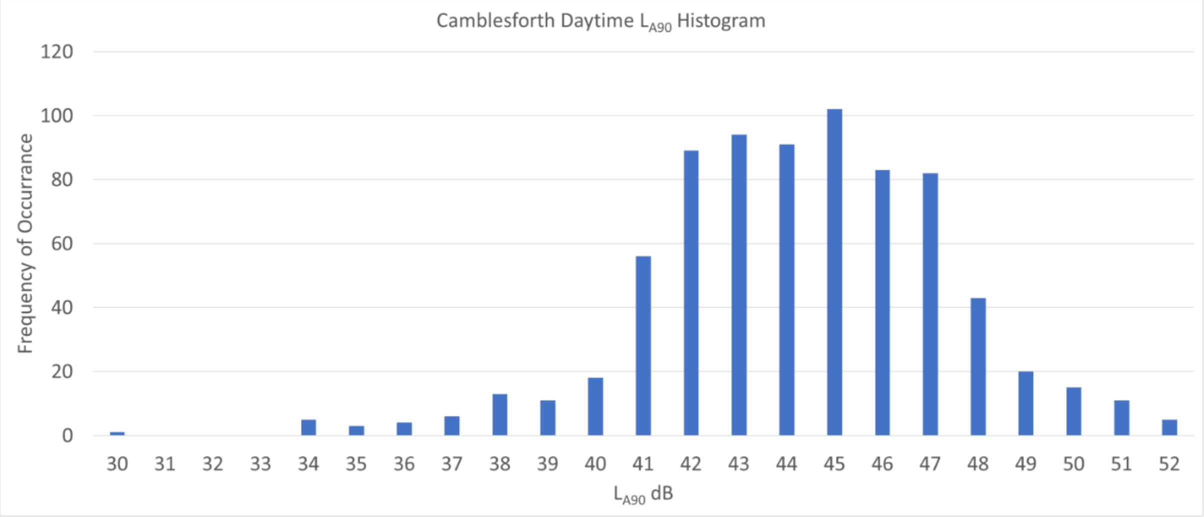
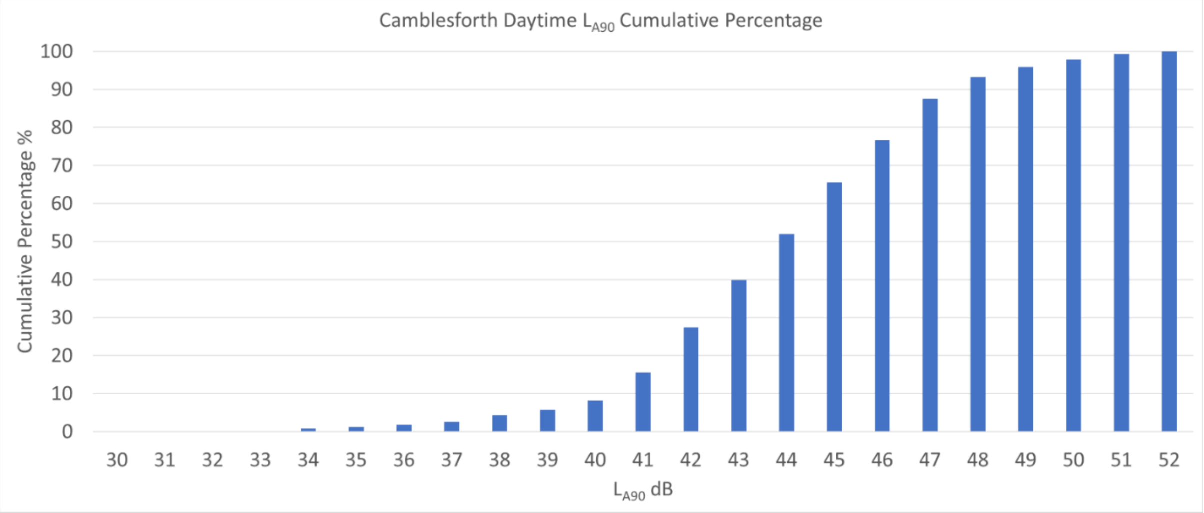


Plate 32 Camblesforth 2021 Daytime Cumulative Percentage



NIGHT-TIME HISTOGRAM AND CUMULATIVE PERCENTAGE

The following figures are night-time (23:00 – 04:00) background noise levels filtered for the dawn chorus, surveyed by Drax during May and June 2021:

Plate 33 Barlow 2021 Night-time Histogram

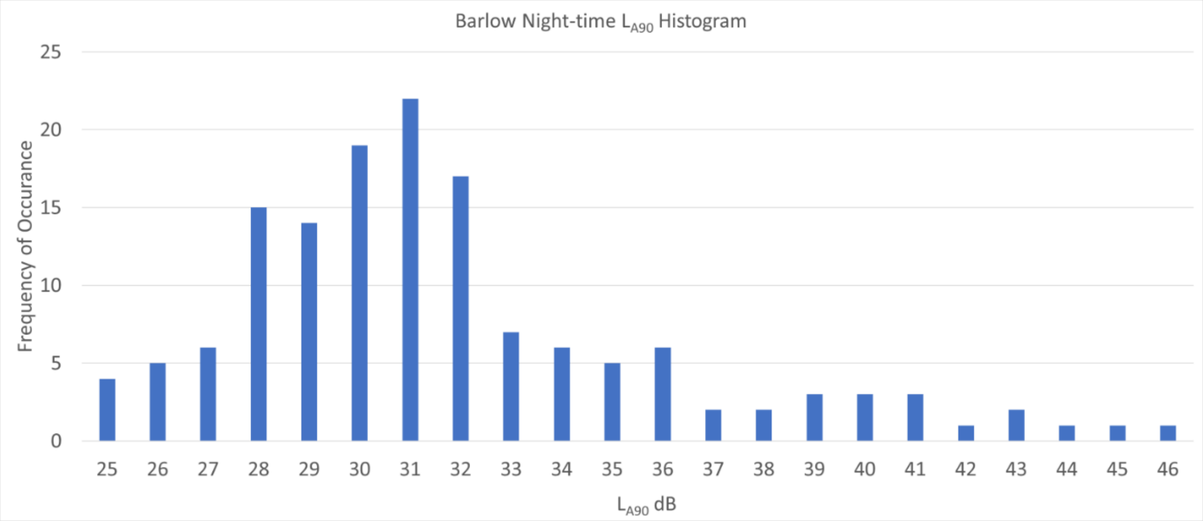


Plate 34 Barlow 2021 Night-time Cumulative Percentage

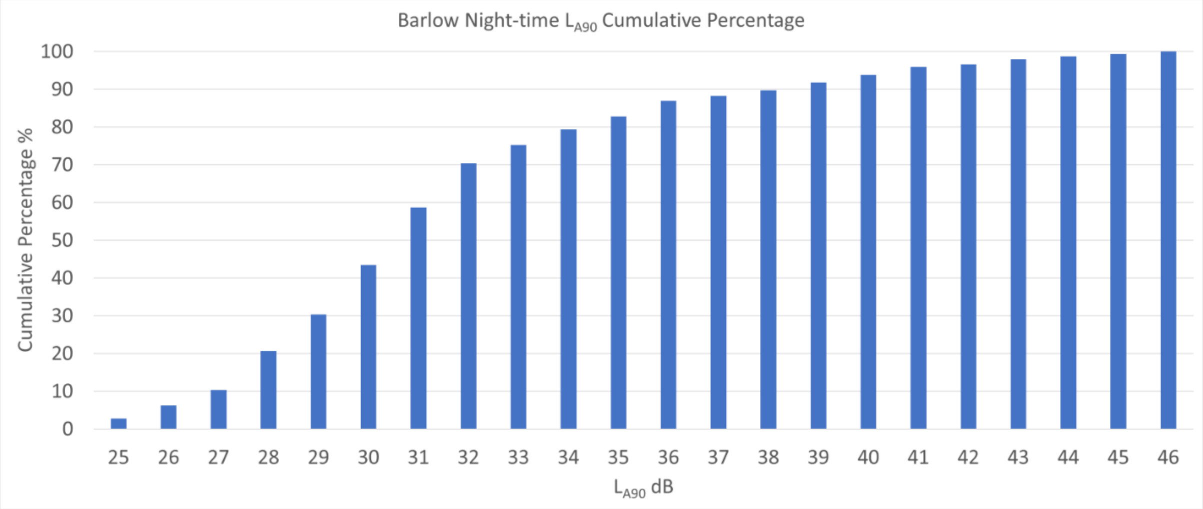


Plate 35 Camblesforth 2021 Night-time Histogram

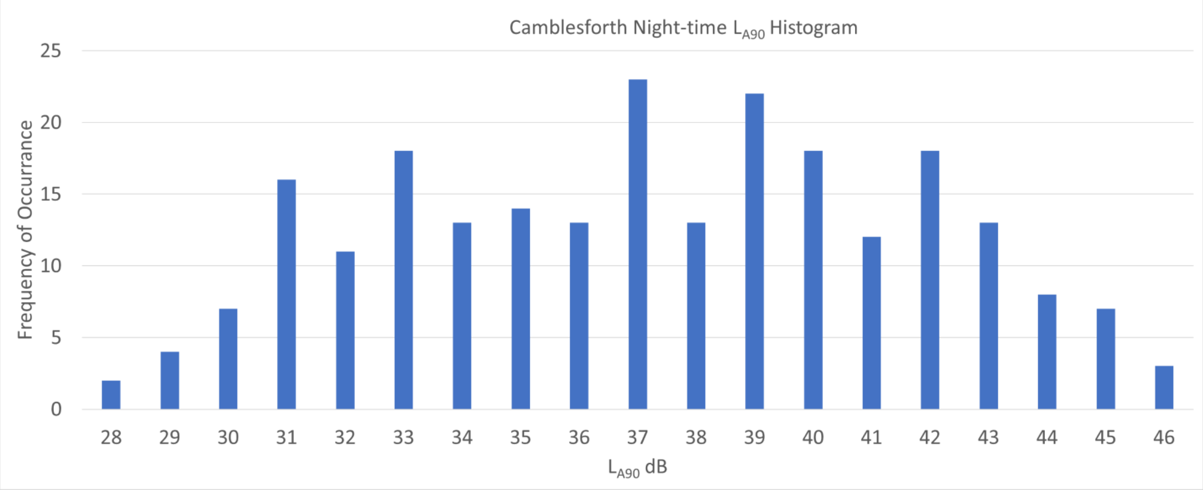
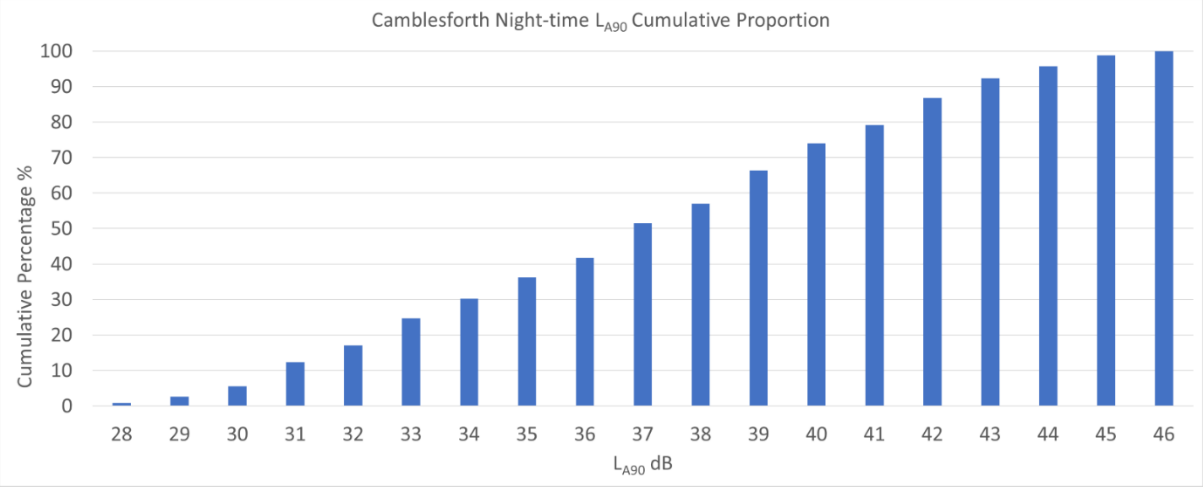


Plate 36 Camblesforth 2021 Night-time Cumulative Percentage



PERMANENT 2020 BACKGROUND NOISE LEVELS

NIGHT-TIME HISTOGRAM AND CUMULATIVE PERCENTAGE

The following figures are night-time (23:00 – 07:00) background noise levels surveyed by Drax between February to December 2020:

Plate 37 Barlow 2020 Night-time Histogram

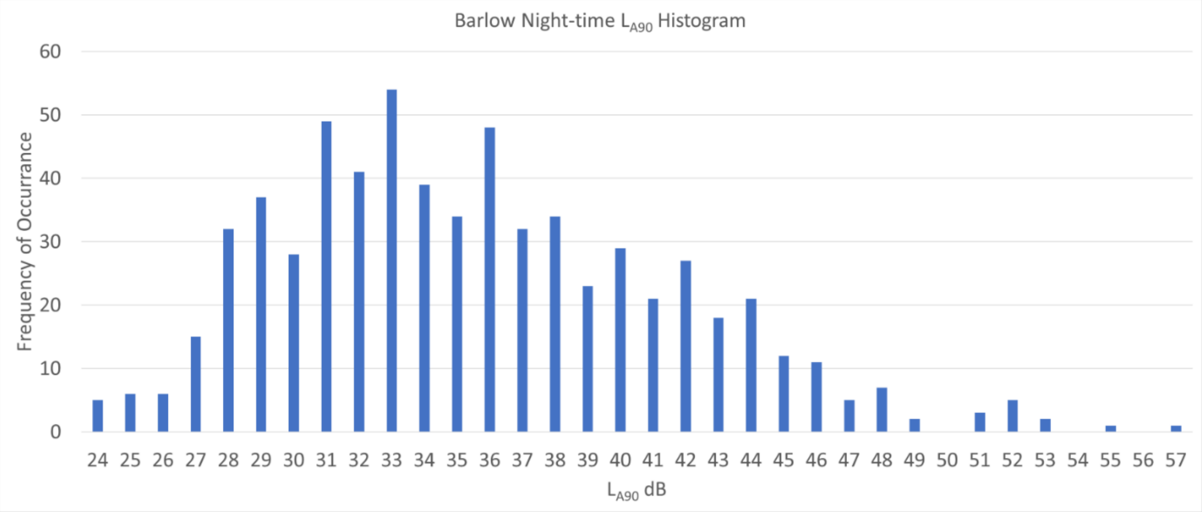


Plate 38 Barlow 2020 Night-time Cumulative Percentage

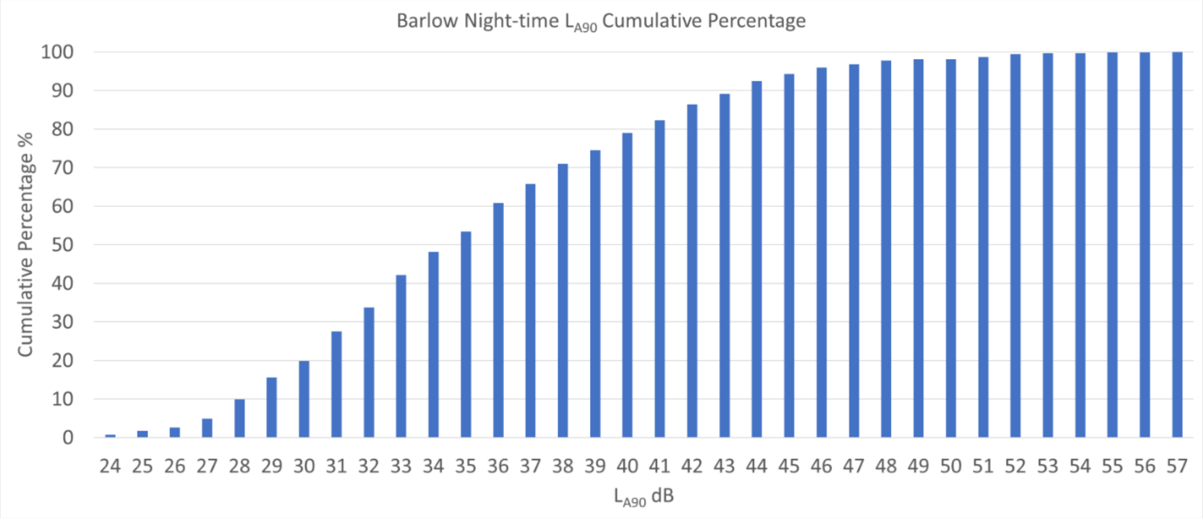


Plate 39 Camblesforth 2020 Night-time Histogram

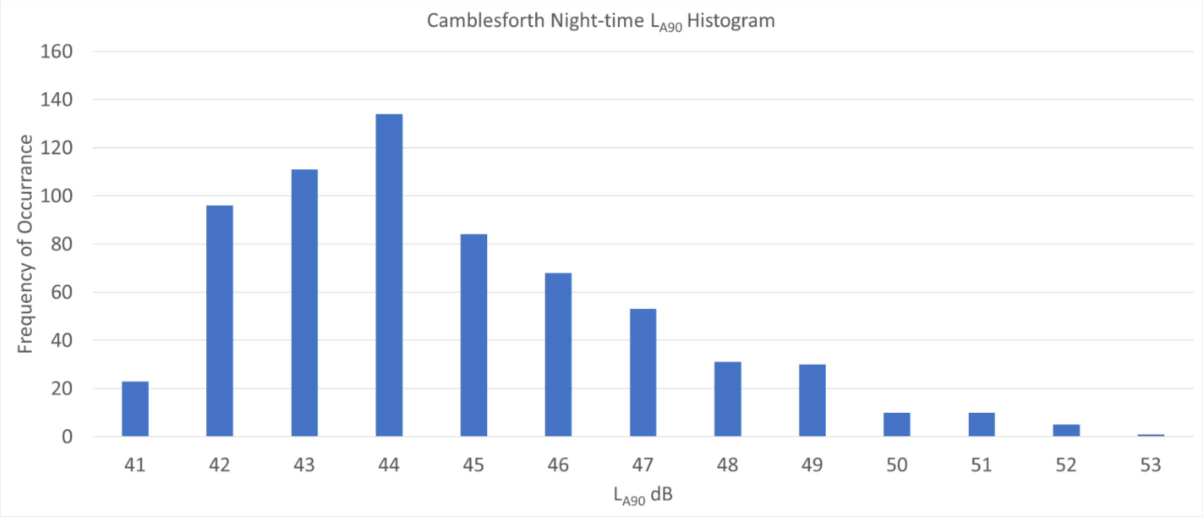
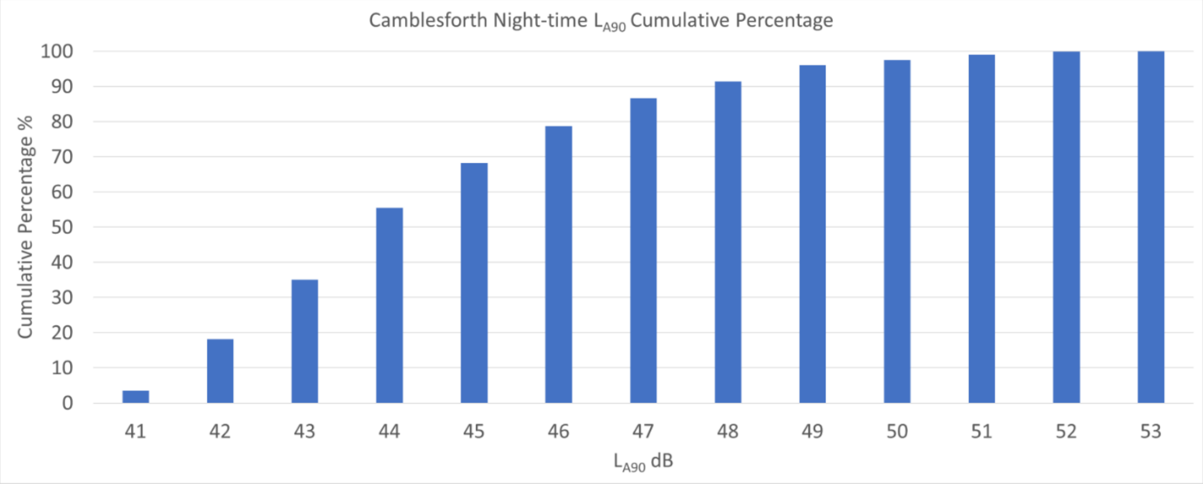
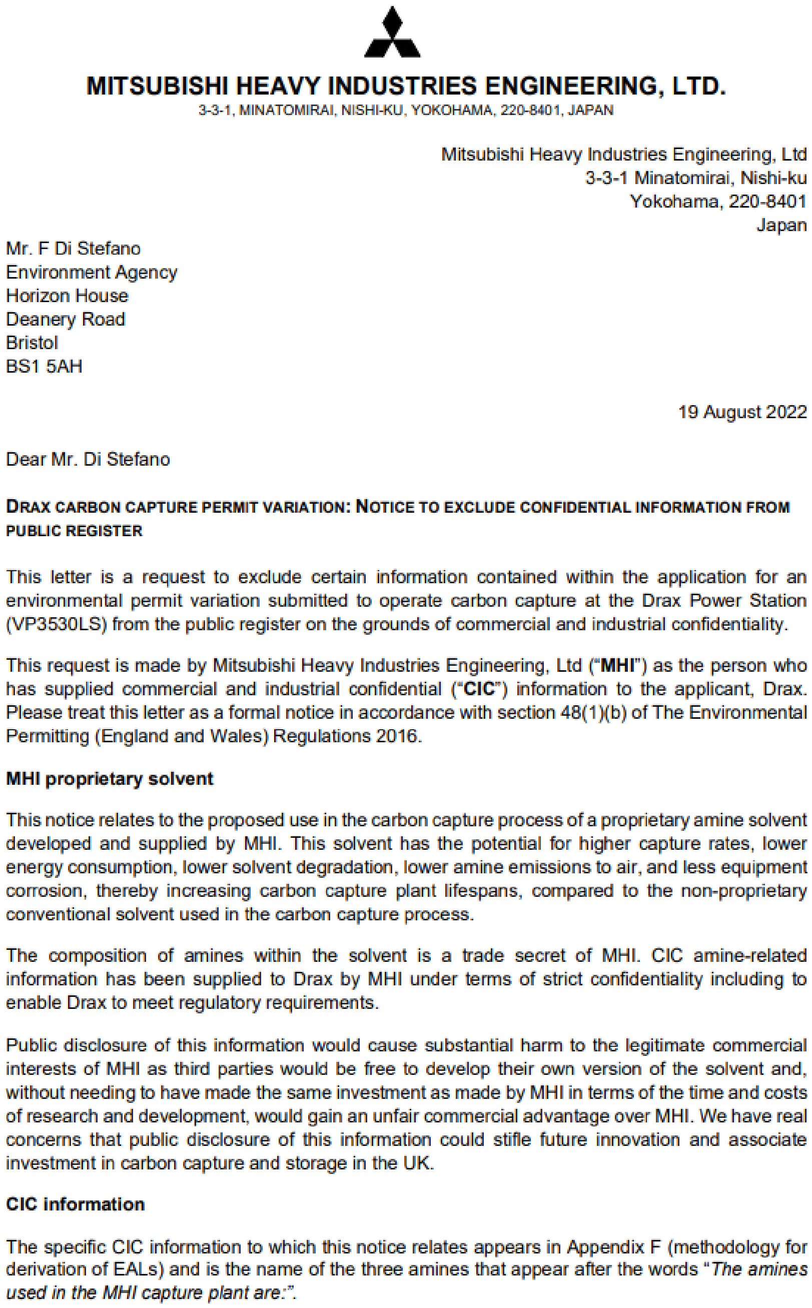


Plate 40 Camblesforth 2020 Night-time Cumulative Percentage



Appendix G – Application for commercial in confidence retaining to KS21^{TM} composition.



MITSUBISHI HEAVY INDUSTRIES ENGINEERING, LTD.
3-3-1, MINATOMIRAI, NISHI-KU, YOKOHAMA, 220-8401, JAPAN

Mitsubishi Heavy Industries Engineering, Ltd
3-3-1 Minatomirai, Nishi-ku
Yokohama, 220-8401
Japan

Mr. F Di Stefano
Environment Agency
Horizon House
Deanery Road
Bristol
BS1 5AH

19 August 2022

Dear Mr. Di Stefano

DRAX CARBON CAPTURE PERMIT VARIATION: NOTICE TO EXCLUDE CONFIDENTIAL INFORMATION FROM PUBLIC REGISTER

This letter is a request to exclude certain information contained within the application for an environmental permit variation submitted to operate carbon capture at the Drax Power Station (VP3530LS) from the public register on the grounds of commercial and industrial confidentiality.

This request is made by Mitsubishi Heavy Industries Engineering, Ltd ("**MHI**") as the person who has supplied commercial and industrial confidential ("**CIC**") information to the applicant, Drax. Please treat this letter as a formal notice in accordance with section 48(1)(b) of The Environmental Permitting (England and Wales) Regulations 2016.

MHI proprietary solvent

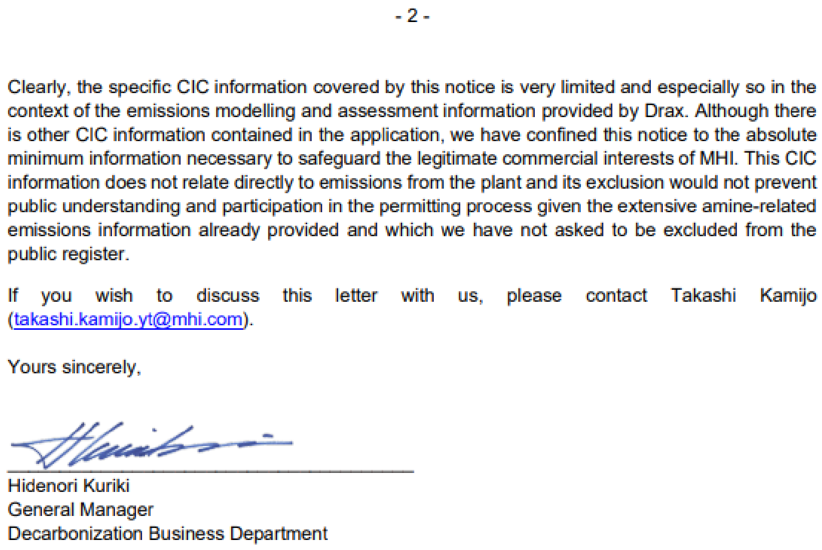
This notice relates to the proposed use in the carbon capture process of a proprietary amine solvent developed and supplied by MHI. This solvent has the potential for higher capture rates, lower energy consumption, lower solvent degradation, lower amine emissions to air, and less equipment corrosion, thereby increasing carbon capture plant lifespans, compared to the non-proprietary conventional solvent used in the carbon capture process.

The composition of amines within the solvent is a trade secret of MHI. CIC amine-related information has been supplied to Drax by MHI under terms of strict confidentiality including to enable Drax to meet regulatory requirements.

Public disclosure of this information would cause substantial harm to the legitimate commercial interests of MHI as third parties would be free to develop their own version of the solvent and, without needing to have made the same investment as made by MHI in terms of the time and costs of research and development, would gain an unfair commercial advantage over MHI. We have real concerns that public disclosure of this information could stifle future innovation and associate investment in carbon capture and storage in the UK.

CIC information

The specific CIC information to which this notice relates appears in Appendix F (methodology for derivation of EALs) and is the name of the three amines that appear after the words "*The amines used in the MHI capture plant are:*".



Clearly, the specific CIC information covered by this notice is very limited and especially so in the context of the emissions modelling and assessment information provided by Drax. Although there is other CIC information contained in the application, we have confined this notice to the absolute minimum information necessary to safeguard the legitimate commercial interests of MHI. This CIC information does not relate directly to emissions from the plant and its exclusion would not prevent public understanding and participation in the permitting process given the extensive amine-related emissions information already provided and which we have not asked to be excluded from the public register.

If you wish to discuss this letter with us, please contact Takashi Kamijo (takashi.kamijo.yt@mhi.com).

Yours sincerely,

Hidenori Kuriki
General Manager
Decarbonization Business Department