Air Quality Assessment of Emissions to Atmosphere from BAe Systems Samlesbury, Lancashire

P2303

A Report Prepared for
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1 INTRODUCTION

Earth & Marine Environmental Consultants Ltd (EAME) has commissioned Atmospheric Dispersion Modelling Ltd (ADM Ltd) to undertake an air quality assessment of emissions to the atmosphere from the BAe Systems facility in Samlesbury, Lancashire.

BAe Systems, Samlesbury, are installing a new surface treatment line to replace an existing anodising process. The process occurs within the central treatment facility (CTF); see **Figure 1.1**.

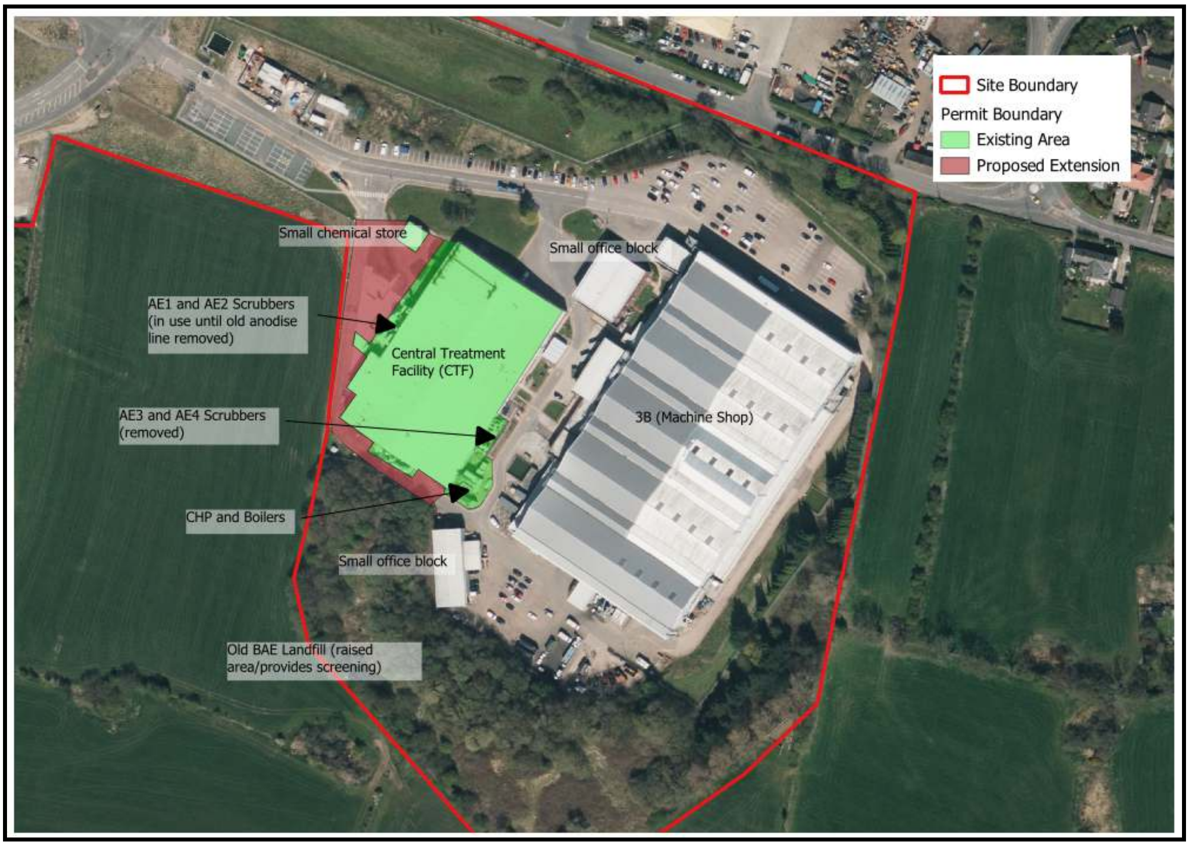
This air quality assessment is required to support the application for a variation to the existing environmental permit (EP) to accommodate the new surface treatment line and removal of existing permitted processes.

Details of the proposal are as follows:

- The clean and pickle line and associated scrubbers (AE3 and AE4) were removed at the end of 2022 and are discounted from the assessment.
- The existing anodise line emission points AE1 and AE2 will be removed once the new anodise line is fully commissioned and, therefore, can be discounted.
- The Penetrant Flaw Detect (PFD) scrubber (AE5) is the only other source requiring assessment alongside the new anodise scrubber (A10/AE26).

Figure 1.1 shows the location of the BAe Systems, Samlesbury.

Figure 1.1 Location of BAe Systems Samlesbury



The ADMS 6.0 dispersion model has been used to make predictions of ground-level concentrations of the following pollutants released to the atmosphere from the two scrubbers.

- Oxides of nitrogen (NO_x)
- Hydrogen fluoride (HF)
- Chromium (VI) and total chromium (chromium (III) and its compounds)

The remainder of this report is structured as follows:

- Section 2: Describes the assessment criteria
- Section 3: Presents and assesses the existing air quality
- Section 4: Describes the modelling methodology
- Section 5: Assessment of Impacts
- Section 6: Sensitivity analysis
- Section 7: Provides a summary and conclusions

About the Author

This air quality assessment and report was prepared by David Harvey, MBA BSc FIAQM, who has 30 years of experience in air quality. Mr Harvey is a Director of ADM Ltd, a company he founded in 1997 and is a Fellow of the Institute of Air Quality Management (FIAQM). Fellowship is for '*professionals who have had a distinguished career in the field of air quality*'.

2 ASSESSMENT AND SIGNIFICANCE CRITERIA

2.1 INTRODUCTION

This section presents the relevant air quality legislation and guidance together with significance levels. Also presented is a description of the pollutants assessed.

2.2 LEGISLATION

2.2.1 European Legislation

The Air Quality (England) Regulations 2000 (SI 2000 No. 928) and Air Quality (England) (Amendment) Regulations 2002 (SI 2002 No. 3043) include national air quality objectives, which, in most cases, are numerically synonymous with the European limit values. However, they may have different compliance target dates and apply to different locations. The air quality objectives are for specific use by local authorities when undertaking their Local Air Quality Management (LAQM) duties in pursuit of Part IV of the Environment Act 1995.

2.2.2 National Legislation And Guidance

The Government's policy on air quality within the UK is set out in the Air Quality Strategy for England, Scotland, Wales & Northern Ireland Strategy (AQS), published in July 2007, following the requirements of Part IV of the Environment Act 1995. The Air Quality Strategy (AQS) sets out a framework to reduce adverse health effects from air pollution and ensures that international commitments are met. The AQS sets standards and objectives for pollutants to protect human health, vegetation and ecosystems.

Many of the objectives in the Air Quality Strategy (AQS) were made statutory in England with the Air Quality (England) (Amendment) Regulations 2002 for Local Air Quality Management (LAQM).

2.2.3 Review And Assessment

Under Part IV of the Environment Act 1995, local planning authorities must review and assess the air quality within their area through staged appraisals to meet the objectives by target dates defined in the Air Quality (England) (Amendment) Regulations. Where the air quality objectives have not been achieved, the local planning authority must designate an AQMA and draw up an air quality action plan (AQAP) to achieve future air quality objectives.

2.2.4 Development Control: Planning For Air Quality

In January 2017, the Institute of Air Quality Management (IAQM) and Environmental Protection UK (EPUK) published an update to its guidance document, which contains a framework for air quality to be accounted for in local development control [(1)]. The IAQM/EPUK guidance has been considered when undertaking this assessment.

(1) IAQM (2017) Land-Use Planning & Development Control: Planning for Air Quality.

2.3 INDUSTRIAL POLLUTION REGULATION

Atmospheric emissions from industrial processes are controlled in the UK through the Environmental Permitting (England and Wales) Regulations (2016) and subsequent amendments. These regulations implement the European Union's Industrial Emissions Directive (2010/75/EU) in England and Wales.

2.4 DESCRIPTION OF POLLUTANTS

This section describes the principal pollutants considered in this assessment, which are:

- Oxides of nitrogen (NO_x)
- Hydrogen fluoride (HF)
- Chromium (VI) and total chromium

2.4.1 Nitrogen Dioxide (NO_2)

Where road traffic is the dominant source of air pollution, which is usually the case in urban environments, Local Authorities have found that the objectives for nitrogen dioxide (NO_2) and particulate matter (PM_{10}) are the most difficult to achieve. It is also generally the case that where annual average concentrations of nitrogen dioxide (NO_2) and particulate matter (PM_{10}) meet their respective objectives and where there are no significant local sources of air pollution, concentrations of all other pollutants in the air quality strategy will also be achieved.

Nitrogen dioxide (NO_2) is a reddish-brown gas (at sufficiently high concentrations). It occurs as a result of the oxidation of nitric oxide (NO), which in turn originates from the combination of atmospheric nitrogen (N_2) and oxygen (O_2) during combustion processes. In terms of ground-level concentrations in many parts of the United Kingdom, nitrogen dioxide (NO_2) concentrations are dominated by emissions from road transport.

2.4.2 Hydrogen Fluoride (HF)

Hydrogen fluoride (HF) is a highly corrosive and toxic chemical compound. Exposure to hydrogen fluoride (HF) can lead to various health effects. Hydrogen fluoride gas or vapour can cause respiratory tract irritation, coughing, shortness of breath, and chest tightness. Prolonged or high-level exposure can lead to severe lung damage, including pulmonary edema (fluid buildup in the lungs).

Hydrogen fluoride (HF) can be released into the environment through industrial processes, such as metal production, glass etching, semiconductor manufacturing, and certain chemical manufacturing processes. It may also be present in some consumer products, including cleaning agents and rust removers.

2.4.3 Chromium and Chromium (VI)

Chromium is a metallic element that exists in different oxidation states, including chromium (III) and chromium (VI). While chromium (III) is an essential nutrient for the human body in small amounts, chromium (VI) and its compounds are highly toxic and can have detrimental health effects.

Breathing in chromium (VI), especially in fine particles or fumes, can lead to respiratory problems such as nose, throat, and lung irritation. Prolonged exposure to high levels may cause lung cancer.

Chromium (III) is considered an essential nutrient and is generally not associated with significant health risks at normal dietary levels.

Chromium (VI) can be released into the air and water through various industrial activities, such as metal plating, leather tanning, stainless steel production, and chemical manufacturing. Chromium can also occur naturally in soil and rocks, but human activities tend to be the primary sources of elevated chromium levels.

2.5 WORLD HEALTH ORGANIZATION (WHO) GUIDELINES

In September 2021, the World Health Organization (WHO) updated its 2005 Air Quality Guidelines (1). The WHO's 2021 Air Quality Guidelines (AQG) for nitrogen dioxide (NO_2) are below.

Nitrogen dioxide (NO_2):

- 10 $\mu g\ m^{-3}$ annual mean
- 25 $\mu g\ m^{-3}$ 24-hour mean

A spokesperson for the Department for Environment, Food and Rural Affairs (Defra) said in response to the publication of the WHO guidelines (2).

'Air pollution has reduced significantly since 2010 – at a national level emissions of fine particulate matter have fallen by 11%, while emissions of nitrogen oxides are at their lowest level since records began.

To continue to drive forward tangible and long-lasting improvements to the air we breathe, we will set stretching and ambitious targets on air quality through our Environment Bill. We will consider the updated WHO guidelines on PM2.5 to inform the development of air quality targets but we must not underestimate the challenges these would bring particularly in large cities and for people's daily lives.

We must all understand the impact of the choices we need to make, which is why we will be running a public consultation on the proposed targets early next year which will inform the target setting process alongside independent expert advice and analysis on a range of factors.'

(1) World Health Organization (2021) WHO global air quality guidelines.
(2) https://deframedia.blog.gov.uk/2021/09/23/who-updates-guideline-levels-for-air-pollutants.

2.6 ASSESSMENT CRITERIA

Table 2.1 shows the assessment criteria used to assess the impacts on human health, and **Table 2.2** for protected conservation areas.

The criteria (Air Quality Assessment Levels, AQAL) used in this assessment are drawn from:

- Air Quality Standards Regulations 2010 Limit Values and Target Values
- UK Air Quality Strategy Objectives
- Environmental Assessment Levels set by the Environment Agency (EA)

Table 2.1 Air Quality Assessment Levels (AQAL) for the Protection of Human Health

Substance	Averaging time	Assessment Criteria ($\mu g\ m^{-3}$)
Nitrogen dioxide (NO_2)	Annual mean	40
	99.8th percentile of hourly means	200
Hydrogen fluoride (HF)	Monthly mean	16
	Hourly mean	160
Chromium (III) and chromium (III) compounds (as chromium)	Annual mean	5
	Hourly mean	150
Chromium (VI)	Annual mean	0.00025 (0.25 ng m^{-3})

Table 2.2 Air Quality Assessment Levels (AQAL) for the Protection of Conservation Areas

Substance	Averaging time	Assessment Criteria ($\mu g\ m^{-3}$)
Hydrogen fluoride (HF)	Weekly mean	0.5
	Daily mean	5.0
Oxides of nitrogen (NO_x)	Annual mean	30
	Daily mean	75

2.7 SIGNIFICANCE CRITERIA

The impact refers to the predicted change to the prevailing environment due to emissions from the proposed scrubber. Significance criteria are available from both the Institute of Air Quality Management (IAQM) and the Environment Agency (EA).

2.7.1 IAQM Criteria

The significance of an impact is generally determined by the combination of the sensitivity and/or 'value' of the affected environmental receptor and the predicted 'extent' and/or 'magnitude' of the impact or change. The impact descriptors in this assessment are taken from the IAQM/EPUK guidance for planning and air quality [1]. The assessment of significance ultimately relies on professional judgement, although comparing the extent of the impact with criteria and standards specific to each environmental topic can guide this judgement.

Details of impact descriptors used in this assessment are shown in **Table 2.3.** It should be noted that the IAQM/EPUK impact descriptors refer to permanent changes in air quality brought about by a development and not short-term or temporary changes. They also refer to locations with relevant exposure and not necessarily the location of the maximum impact. The criteria, therefore, are only appropriate for changes to annual average concentrations at locations where there is relevant exposure, ie not generally the point of maximum impact.

Table 2.3 IAQM/EPUK Air Quality Impact Descriptors for Individual Receptors

Long-term Average Concentration at Receptor in Assessment Year	% Change in Concentration Relative to Air Quality Assessment Level (AQAL)			
	1	2-5	6-10	>10
75% or less of AQAL [a]	Negligible	Negligible	Slight	Moderate
76-94% of AQAL	Negligible	Slight	Moderate	Moderate
95-102% of AQAL	Slight	Moderate	Moderate	Substantial
102%-109% of AQAL	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Moderate	Substantial	Substantial	Substantial

Note: Changes less than 0.5% are Negligible.
(a) Air Quality Assessment Level (AQAL).

The IAQM guidance on significance shown in **Table 2.3** only applies to long-term/annual average impacts with relevant exposure.

For short-term impacts, the IAQM guidance states:

'Where such peak short-term concentrations from an elevated source are in the range 11-20% of the relevant AQAL, then their magnitude can be described as small, those in the range 21-50% medium and those above 51% as large. These are the maximum concentrations experienced in any year and the severity of this impact can be described as slight, moderate and substantial respectively.'

2.7.2 Environment Agency (EA)

The Environment Agency's (EA) risk assessment guidance includes a two-stage test to screen insignificant impacts [2].

The impacts are defined in terms of:

- Process Contribution (PC)
- Predicted Environmental Concentration (PEC)

(1) IAQM (May 2017) Land-Use Planning & Development Control: Planning for Air Quality.
(2) www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit.

The process contribution (PC) is the contribution from the installation. The PEC is the PC added to the prevailing background concentration.

Stage 1:

The EA guidance states that the process contribution (PC) can be considered as insignificant if both of the following are achieved:

- The long-term PC is <1% of the long-term Environmental Assessment Level (EAL)

- The short-term PC is < 10% of the short-term Environmental Assessment Level (EAL)

The EA guidance states:

If you meet both of these criteria you don't need to do any further assessment of the substance. If you don't meet them you need to carry out a second stage of screening to determine the impact of the PEC.

Stage 2:

The EA guidance states that detailed modelling of emissions is needed for emissions that do not meet both of the following requirements:

- The long-term PEC is less than 70% of the long-term EAL

- The short-term PC is less than 20% of the short-term EAL minus twice the long-term background concentration.

3 AMBIENT AIR QUALITY DATA

3.1 INTRODUCTION

This section describes the ambient air quality in the BAe Systems, Samlesbury region.

The criteria used throughout this assessment are compared to the contribution to ambient pollutant concentrations occurring due to emissions to the atmosphere from the stacks. Therefore, an accurate determination of the prevailing concentration is not necessary. However, estimates of the overall background concentrations are presented for completeness.

3.2 SOURCES OF POLLUTION

The prevailing air quality at the BAe Systems, Samlesbury, will result from emissions from local and distant sources of pollution. Away from the impact of local sources of pollution, such as roads and industry, pollutant levels will reflect the prevailing background concentrations.

These sources of pollution will include:

- **Road Traffic:** Vehicle emissions, particularly from diesel-powered vehicles, release pollutants such as nitrogen oxides (NO_x), particulate matter (PM_{10}), and volatile organic compounds (VOCs).

- **Industrial Activities:** Industrial facilities near the BAe Systems, Samlesbury, may contribute to pollution.

- **Residential Heating and Energy Consumption:** Residential areas near the BAe Systems, Samlesbury, may contribute to air pollution by burning fossil fuels for heating and energy consumption.

It is important to note that the specific contribution and impact of these pollution sources near the BAe Systems, Samlesbury, will vary depending on weather conditions, traffic patterns, and the proximity of sensitive receptors like residential areas, schools, and healthcare facilities.

3.3 AIR QUALITY MANAGEMENT AREAS (AQMA)

Under Part IV of the Environment Act 1995, Local Planning Authorities (LPA) must review and assess the air quality within their area through staged appraisals to meet the objectives by target dates defined in the Air Quality (England) (Amendment) Regulations. Where the air quality objectives have not been achieved, the local planning authority must designate an AQMA and draw up an air quality action plan (AQAP) to achieve future air quality objectives.

Declaring an AQMA does not necessarily mean that all locations within the AQMA exceed the Air Quality Strategy (AQS) objective. Also, if a location is not within an AQMA, it does not necessarily follow that the prevailing air quality achieves the AQS objectives. For example, if no 'relevant exposure' exists, an AQMA may not have been declared, or the Local Planning Authority (LPA) may be unaware of exceedences.

For Local Air Quality Management (LAQM), the Air Quality Strategy Objectives (AQS) only apply where there is 'relevant exposure'. This is defined as being where members of the public are regularly present and are likely to be exposed for a period of time appropriate to the averaging period of the objective. For the annual average objective, locations of relevant exposure include residential properties, schools and hospitals.

The site is in South Ribble Borough Council, which has five Air Quality Management Areas (AQMAs), none relevant to this assessment, given their distances from the site.

The closest AQMA is AQMA No 7, declared in February 2012 by Blackburn and Darwin Borough Council. This AQMA is in Four Lane Ends (4.5 km) and is irrelevant to this assessment, given its distance.

3.4 NITROGEN DIOIXDE (NO_2)

3.4.1 Measured Data

The closest locations to BAe Systems, Samlesbury, where air quality monitoring data are available, are the nitrogen dioxide (NO_2) diffusion tube monitoring sites operated by South Ribble Borough Council in Walton-le-Dale. However, given that these are road site monitoring locations and more than 8 km from the site, there are not representative of the prevailing air quality at the site.

3.4.2 Estimated Background Concentrations

The Department for Environment, Food and Rural Affairs (Defra) provide estimates of the background concentrations for several pollutants for many years on a 1 km grid resolution for the whole of the UK. The OS grid reference closest to the BAe Systems, Samlesbury location, is 363500, 431500.

Table 3.1 summarises all the relevant annual average background pollutant concentrations of the oxides of nitrogen (NO_x) and nitrogen dioxide (NO_2) used in this assessment.

Table 3.1 Estimated Annual Average Background Pollutant Concentrations

Pollutant	Background Concentration	Unit	Data Source
Nitrogen dioxide (NO_2)	9.1	$\mu g\ m^{-3}$	Defra 2023 estimate
Oxides of nitrogen (NO_x)	11.8	$\mu g\ m^{-3}$	Defra 2023 estimate

Table 3.2 shows the estimated annual average background pollutant concentrations as a percentage of the assessment quality assessment level (AQAL) for impacts on human health and ecological sites.

Table 3.2 Estimated Annual Average Background Pollutant Concentrations Compared to the Assessment Criteria

Pollutant	Background Concentration	Assessment Criteria	Unit	Percentage of Assessment Criteria (%)
Nitrogen dioxide (NO_2)	9.1	40	$\mu g\ m^{-3}$	23%
Oxides of nitrogen (NO_x)	11.8	30 [(a)]	$\mu g\ m^{-3}$	39%
(a) Assessment criteria for vegetation and ecosystems.				

Table 3.2 shows that all the estimated background annual average concentrations of the oxides of nitrogen (NO_x) and nitrogen dioxide (NO_2) are less than the assessment criteria and not of concern.

3.5 CHROMIUM (III) AND COMPOUNDS

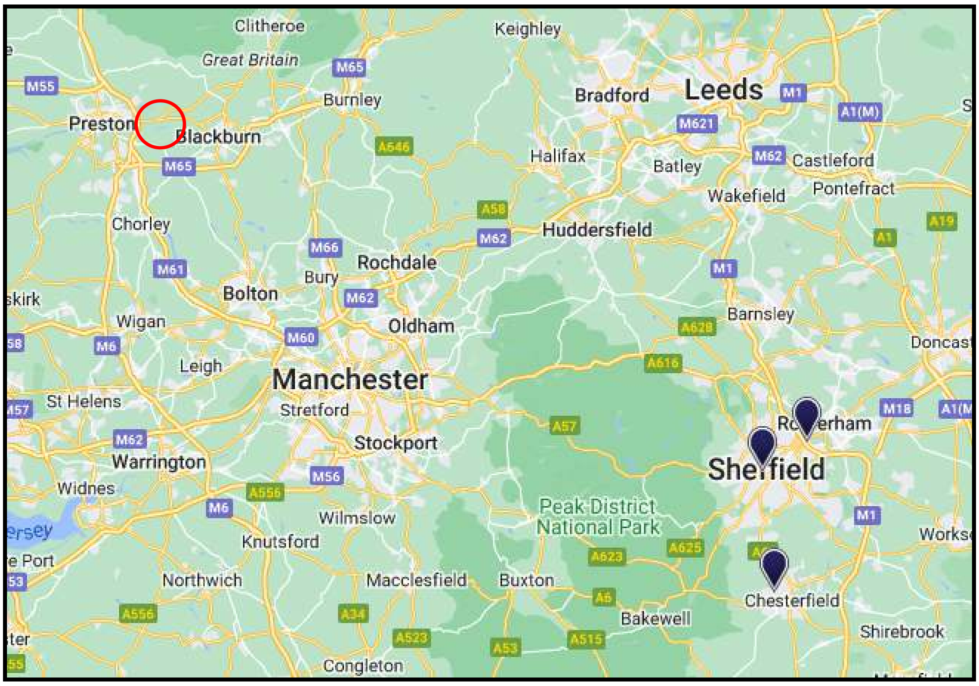
Local Authorities do not monitor chromium (Cr) and other heavy metals, as it is not part of Local Air Quality Management (LAQM).

The Environment Agency (EA) manage the UK's national monitoring sites on behalf of Defra and the Devolved Administrations.

The heavy metals network of monitors was expanded to 24 sites in 2008. Each site monitors Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Mercury (Hg), Manganese (Mn), Nickel (Ni), Lead (Pb), Platinum (Pt), Vanadium (V) and Zinc (Zn). There is no routine monitoring of Chromium (VI).

Figure 3.1 shows the location of the three closest heavy metal monitoring sites to BAe Samlesbury.

Figure 3.1 Location of BAe Samlesbury (Red Circle) and three Closest Heavy Metal Monitoring Sites



Source: https://uk-air.defra.gov.uk/interactive-map?network=metals

Table 3.3 shows the details of the three closest heavy metal monitoring sites.

Table 3.3 Details of Heavy Metal Monitoring Sites

Monitoring Site	Environment Type	OS Grid Reference	Start Date (Chromium)
Sheffield Devonshire	Urban Background	434816, 386990	November 2013
Sheffield Tinsley	Urban Background	440238, 390588	February 2013
Chesterfield Loundsley Green	Urban Background	436470, 372039	August 2015

Table 3.4 shows the measured annual average concentrations of total chromium for 2014 to 2022 for each of the three closest monitoring locations.

Table 3.4 Estimated Annual Average Concentration of Total Chromium (Cr, ng m^{-3})

Year	Sheffield Devonshire	Sheffield Tinsley	Chesterfield Loundsley Green	Average of Monitoring Sites
2014	3.2	35.0	-	**-**
2015	3.2	29.0	-	**-**
2016	4.6	31.0	2.0	**12.5**
2017	3.6	34.0	1.3	**13.0**
2018	5.8	39.0	3.3	**16.0**
2019	4.2	25.0	2.1	**10.4**
2020	3.7	21.0	1.4	**8.7**
2021	4.8	33.0	2.0	**13.3**
2022	4.6	33.0	2.0	**13.2**
2014 to 2022	**4.2**	**31.1**	**2.0**	**12.4**
Air Quality Assessment Level		**5,000**		

It is evident from the data presented in **Table 3.4** that there are local sources of chromium (Cr) affecting the measured data at Sheffield Tinsley. Sheffield has a history of heavy industry, including steel manufacturing and other metal-related industries. Chromium (Cr) is commonly used in these industries, and emissions from industrial processes can contribute to elevated chromium concentrations in the air.

It is considered that the average for these three sites (12.4 ng m^{-3}) provides a conservative estimate of the background concentration in the vicinity of BAe Samlesbury. It is recognised that the actual concentration of chromium (Cr) could be significantly lower in the absence of local sources of emissions.

The expected background concentration of total chromium (Cr) is less than 1% of the Air Quality Assessment Level (AQEL) of 5,000 ng m^{-3}.

3.6 CHROMIUM (VI)

Ambient concentrations of chromium (VI) are not available.

Text Box 3.1 provides background on the likely percentage of chromium (VI) in total chromium (Cr).

Text Box 3.1 Percentage of Chromium VI in Total Chromium (Cr (III) and Compounds)

> Estimates of the comparative concentrations in air of Cr(III) and Cr(VI) are uncertain, in part because the ratio is variable and dependent on the source of chromium. In the UK it is likely that less than 20% of emissions are of Cr(VI), those with the higher proportions from chromium-using industries (Passant, 2006). The proportion of Cr(VI) in ambient air may be lower than that measured in emissions. Data from Canada, quoted by Rowbotham ***et al.*** (2000), suggest that Cr(VI) constitutes between 3 and 8% of total airborne chromium in that country. Keiber ***et al.*** (2002) found that about half of the chromium in rainwater in the USA was in water soluble form and of this there were approximately equal concentrations of Cr(VI) and Cr(III). As most of the insoluble chromium is likely to be present as Cr(III), this implies that the Cr(III)/Cr(VI) ratio in air was about 3:1.

Source: Consultation on guidelines for metal and metalloids in ambient air for the protection of human health.

The Environment Agency (EA) suggest that for screening purposes, it should be assumed that chromium (VI) is 20% of the total background chromium (Cr) [(1)].

Assuming that chromium (VI) is 20% of the total chromium in ambient air, this would suggest an ambient chromium (VI) concentration of 2.5 ng m^{-3} compared to the Air Quality Assessment Level (AQAL) of 0.25 ng m^{-3}. However, for the following reasons, it is impossible to conclude with any confidence that the assessment level is exceeding:

- No measured data are available for chromium (VI)
- Uncertainty over the chromium (VI) percentage in total chromium (Cr)
- Concerns about how representative the chromium (Cr) data are

3.7 HYDROGEN FLUORIDE (HF)

Ambient measurements of hydrogen fluoride (HF) are not routinely made.

The EPAQS report '*Guidelines for halogens and hydrogen halides in ambient air for protecting human health against acute irritancy effects'* contains some estimates of baseline levels, reporting that measured concentrations have been in the range of 0.036 μg m^{-3} to 2.35 μg m^{-3} [(2)]. A background concentration of hydrogen fluoride (HF) is assumed to be 2.0 μg m^{-3} which is considered conservative.

(1) Environment Agency (EA, September 2012) Guidance for applicants on the Impacts Assessment for Group 3 Metals Version 3.

(2) EPAQS (February 2006) Guidelines for Halogen and Hydrogen Halides in Ambient Air for Protecting Human Health.

4 METHODOLOGY

4.1 INTRODUCTION

This section describes the methodology and assumptions made for the air quality assessment. Also described are the emissions data used.

4.2 EMISSIONS DATA

The two stacks modelled in this assessment are:

- Existing Penetrant Flaw Detect (PFD) scrubber (A5/AE5)
- New anodise scrubber (A10/AE26)

The existing PFD/A5 stack is assumed to operate continuously. The new anodise scrubber stack (A10/AE26) has three modes of operation:

- Lip extraction will run for 48 hours a week, over the weekend
- One transporter is active for 108 hours per week
- Two transporters are active for 12 hours per week

Table 4.1 shows the parameters which describe the physical properties of emissions from the two stacks.

Table 4.1 Emissions and Physical Properties

Stack	Existing PFD Scrubber (A5)	Proposed Anodise Scrubber (A10/AE26)		
Number of flues in each stack	1	1		
OS Grid Reference (m)	363603,431120	363606,431121		
Release height level (m)	15.0	15.0		
Diameter (m)	0.9	1.1		
Flue gas emission temp (deg C)	20	20		
Mode of Operation	-	Lip Extraction	1 Transporter	2 Transporters
Hours per week (hours)	168	48	108	12
Percentage operation (%)	100	29	64	12
Actual vol. flow rate ($Am^3\ hr^{-1}$)	37,864	27,300	42,030	50,850
Actual vol. ($Am^3\ s^{-1}$)	10.5	7.6	11.7	14.13
Exit velocity ($m\ s^{-1}$)	16.5	8.0	12.3	14.9
Emission Conc. (mg Nm^{-3}) (a)				
Oxides of Nitrogen (NO_x)	10	10	10	10
Hydrogen fluoride (HF)	1.0	1.0	1.0	1.0
Total chromium (Cr)	-	0.010	0.010	0.010
Chromium (VI) (b)	-	0.0020	0.0020	0.0020
Emission Rate (mg s^{-1})				
Oxides of Nitrogen (NO_x)	98	71	109	132
Hydrogen fluoride (HF)	9.8	7.1	10.9	13.2
Total chromium (Cr)	-	0.07	0.11	0.13
Chromium (VI)	-	0.0014	0.0022	0.0026

(a) Reference conditions: Temp: 0 deg C, pressure 101.3 kPa, no correction for H_2O or O_2.
(b) Assumes chromium (VI) is 20% of total chromium (Cr).

4.3 RECEPTORS

Predictions are made of ground-level concentrations using a grid of receptors. The receptor grid is 1,000 m by 1,000 m with a grid spacing of 10 m. Making predictions using a grid of receptors allows the maximum impact to be determined and the predicted ground-level concentrations to be presented as contour plots.

In addition to predictions using a grid of receptors, predictions are made at 20 specific receptors.

Table 4.2 presents details of the specific receptors included in the modelling selected because of their potential for '*relevant exposure*'.

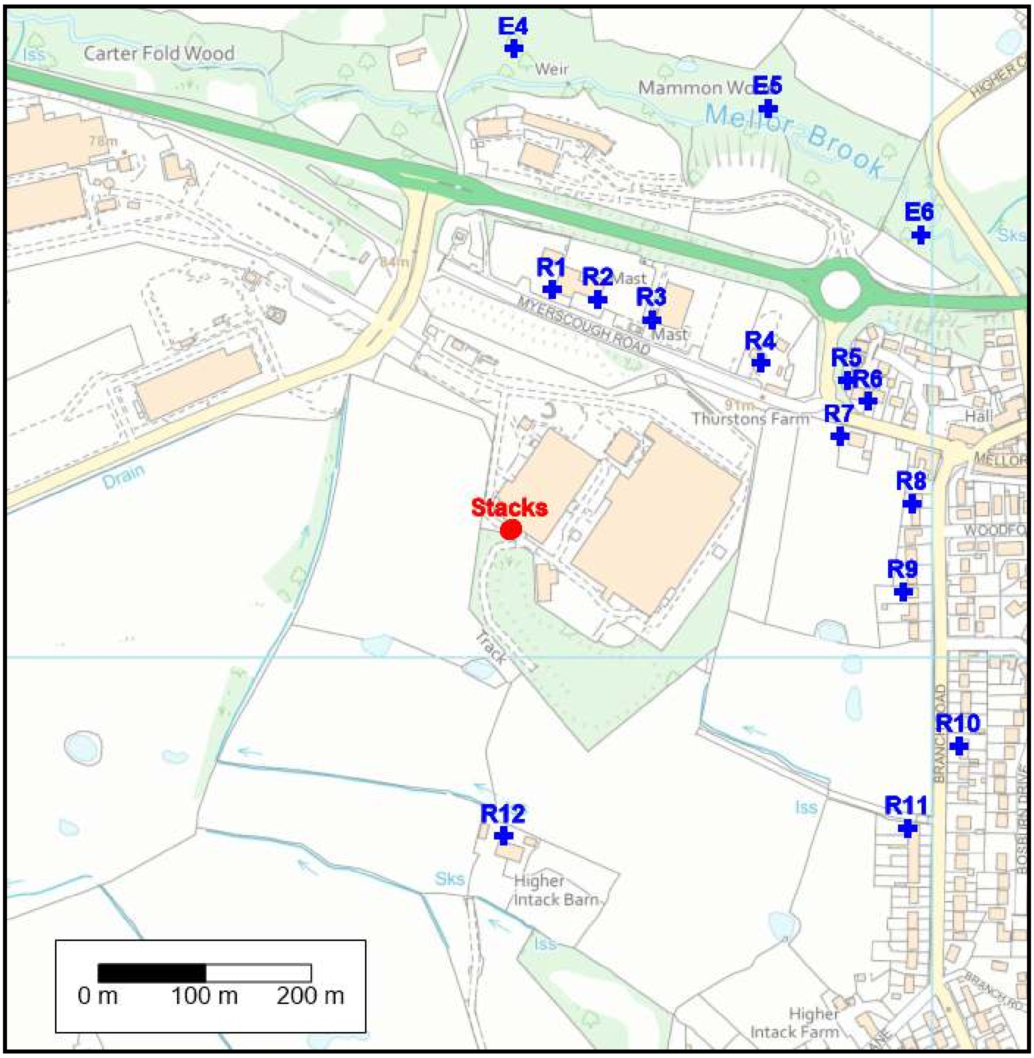
Also shown are the Ecological sites within 5 km.

Table 4.2 Receptor Locations

No.	Description	Distance from Stack (km)	OS Grid Reference (m)
R1	Industrial	0.2	363643 431346
R2	Industrial	0.2	363686 431337
R3	Industrial	0.2	363737 431318
R4	Industrial	0.3	363839 431277
R5	Residential	0.3	363920 431261
R6	Residential	0.4	363940 431241
R7	Residential	0.3	363913 431208
R8	Residential	0.4	363981 431145
R9	Residential	0.4	363973 431062
R10	Residential	0.5	364025 430917
R11	Residential	0.5	363977 430840
R12	Residential	0.3	363597 430832
E1	Darwen River (SSSI)	2.6	361803 429290
E2	Red Car and Tun (SSSI)	4.4	359311 431997
E3	Pleasington Old Hall (LNR)	4.1	364675 427174
E4	Mammon Wood	0.5	363607 431573
E5	Mammon Wood	0.5	363846 431517
E6	Mammon Wood	0.5	363989 431398
E7	Jeffery Woos	2.0	363941 429182
E8	Holster Wood	1.3	362926 430003

Figure 4.1 shows the locations of the receptors.

Figure 4.1 Location of Receptors within 1 km of the installation



The selected receptors are representative of locations where there is relevant exposure, such as residential properties. For Local Air Quality Management (LAQM), the Air Quality Strategy Objectives (AQS) only apply where there is '*relevant exposure'*. This is defined as being where members of the public are regularly present and are likely to be exposed for a period of time appropriate to the averaging period of the objective. For the annual average objective, locations of relevant exposure include residential properties, schools and hospitals.

In addition to the receptors shown in **Table 4.2,** predictions are made at the location of the closest public access, which is any off-site location.

4.4 FACTORS AFFECTING DISPERSION

Several factors will affect how emissions disperse once released into the atmosphere. The four factors having the most significant effect on dispersion are:

- Physical characteristics of the emissions
- Climate

- Terrain
- Building downwash

4.4.1 Physical Characteristics Of The Emissions

Provided that the exhaust gases have sufficient velocity to overcome the effects of stack tip downwash, which is almost certainly the case for velocities of 15 m s^{-1} or more, the physical characteristics of the flue gases will determine the amount of plume rise and hence the effect on ground-level pollutant concentrations. The degree of plume rise depends on the greater of the thermal buoyancy or momentum effects and not necessarily a combination of the two effects.

4.4.2 Climate

The most important meteorological parameters governing the atmospheric dispersion of pollutants are wind speed, wind direction and atmospheric stability.

- **Wind direction** determines the broad transport of the plume and the sector of the compass into which the plume is dispersed.

- **Wind speed** can affect plume dispersion by increasing the initial dilution of pollutants and inhibiting plume rise.

- **Atmospheric stability** is a measure of the turbulence of the air, particularly of the vertical motions present. For dispersion modelling purposes, one method of classifying stability is by using Pasquill Stability categories, A to F. Dispersion models, such as ADMS and AERMOD, do not allocate the degree of atmospheric turbulence into six discrete categories (A-F). These models use a parameter known as the Monin-Obukhov length, which, together with the wind speed, describes the atmosphere's stability.

4.4.3 Building Downwash

The presence of buildings can significantly affect the dispersion of atmospheric emissions. Wind blowing around a building distorts the flow and creates greater turbulence zones than if the building were absent. Increased turbulence causes greater plume mixing; the rise and trajectory of the plume may be depressed generally by the flow distortion. For elevated releases such as from stacks, building downwash leads to higher ground-level concentrations closer to the stack than those present if a building was not there. The effects of building downwash are usually only significant where the buildings are more than 40% of the stack height.

Table 4.3 shows the dimensions of the buildings included in the modelling.

Table 4.3 Dimensions of Buildings Included in the Modelling

Building	Centre (m)	Height (m) [a]	Length (m)	Width (m)	Angle (deg) [b]
CTF	363634 431163	11.85	100	60	34
3B	363740 431126	16.9	164	84	34

(a) Height above ground-level (at the location of the stack).
(b) Angle building length makes to the north.

4.4.4 Nature Of The Surface

Terrain

The effects of elevated terrain can affect dispersion and have been included in the modelling.

Roughness

The surface's nature can significantly influence dispersion by affecting the vertical velocity profile (ie the rate of increase in wind speed for increasing heights above ground level). The amount of atmospheric turbulence also affects dispersion.

The site is in a rural area with some properties and trees, which will affect dispersion by increasing turbulence and reducing the wind speed close to the ground.

Considering the site's surrounding nature, a surface roughness length of 0.3 m has been assumed for the dispersion modelling.

4.5 SELECTION OF SUITABLE DISPERSION MODEL

The dispersion models widely used to predict ground-level pollutant concentrations are based on the time-averaged lateral and vertical concentration of pollutants in a plume characterised by a Gaussian [(1)] distribution. Older models, such as ISC, characterise the atmosphere into several discrete stability classes. So-called 'new generation' dispersion models such as ADMS and AERMOD have been developed, which replace the description of the atmospheric boundary layer as being composed of discrete stability classes with an infinitely variable measure of the surface heat flux, which in turn influences the turbulent structure of the atmosphere and hence the dispersion of a plume.

Two commercially available dispersion models which have been described by the Environment Agency (EA) as being 'new generation' are:

- AERMOD: The US **A**merican Meteorological Society and **E**nvironmental Protection Agency **R**egulatory Model Improvement Committee developed

(1) A Gaussian distribution has the appearance of a bell-shaped curve. The maximum concentration occurs on the centre line.

the dispersion **MOD**del called AERMOD, which incorporates the latest understanding of the atmospheric boundary layer.

- Atmospheric Dispersion Modelling System (ADMS): This dispersion model was developed by the UK consultancy CERC. The model allows for the skewed nature of turbulence within the atmospheric boundary layer.

In many respects, the models are quite similar and generate comparable predictions of ground-level concentrations in many situations.

The ADMS 6.0 dispersion model was selected for use in this assessment because it has been extensively validated and widely used for assessment work of this nature.

4.6 METEOROLOGICAL DATA

An essential input to the dispersion model is the meteorological data.

The three closest observing stations with usable data are

- Blackpool (31 m, 10 m elevation)
- Bingley (45 km, 267 m elevation)
- Crosby (46 km, 9 m elevation)

The elevation of the installation site is about 90 m.

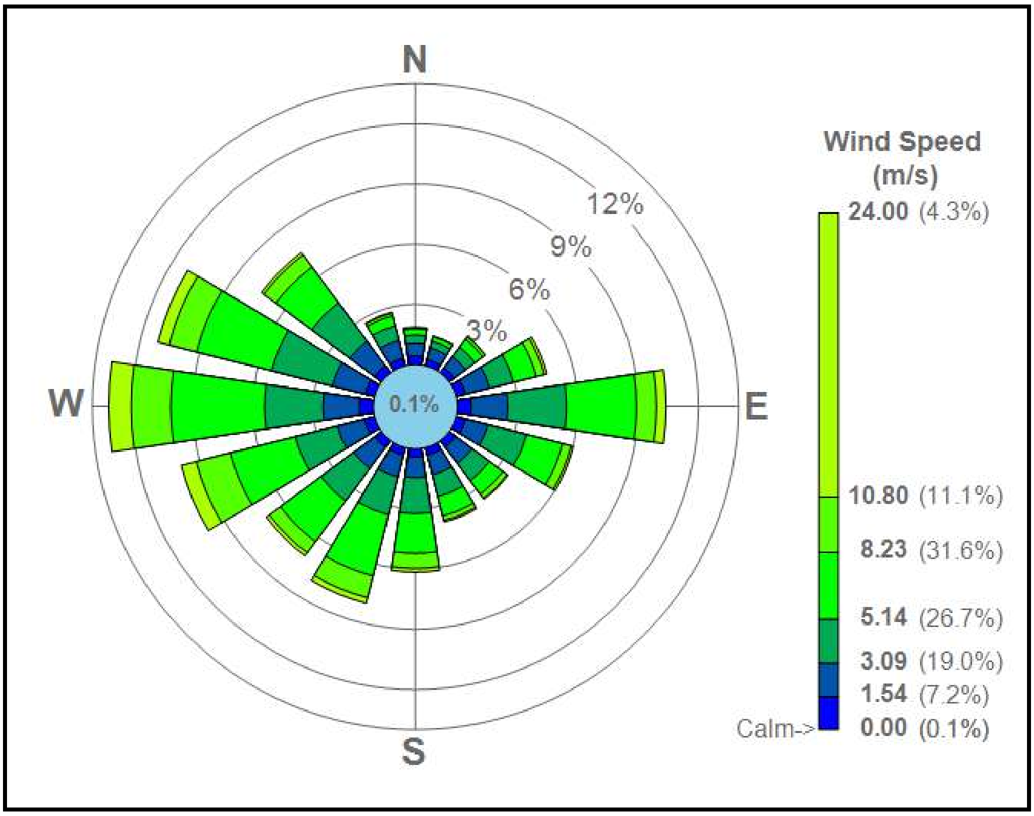
Given the separation distance between these observing stations and the differences in elevation to that of the site, it is considered that data from none of these observing stations will represent conditions at the site.

Therefore, this assessment uses five years (2018 to 2022) of site-specific NPW data. Numerical Weather Prediction (NWP) models calculate weather conditions across a network of grid cells in a 3-dimensional space and have been extensively validated and are increasingly used for assessment and permitting dispersion modelling.

The sensitivity analysis presented in this report (**Section 6**) shows details of the model sensitivity to the choice of meteorological data, including predictions using both Blackpool, Bingley, and Crosby observed meteorological data.

Figure 4.2 shows the wind rose for NWP data for the site for 2018-2022.

Figure 4.2 Wind Rose from Site-Specific NWP Meteorological Data (2018-2022)



4.7 PERCENTAGE OXIDATION OF NITRIC OXIDE (NO) TO NITROGEN DIOXIDE (NO_2)

Oxides of nitrogen (NO_x) emitted to the atmosphere due to gas combustion will consist largely of nitric oxide (NO), a relatively innocuous substance. Once released into the atmosphere, nitric oxide (NO) is oxidised to nitrogen dioxide (NO_2), which concerns human health and other environmental impacts. The proportion of nitric oxide oxidised to nitrogen dioxide depends on several factors, and oxidation is limited by the availability of oxidants, such as ozone (O_3).

Oxidation of 50% has been assumed for nitric oxide (NO) oxidation to nitrogen dioxide (NO_2) for short-term concentrations. For predictions of annual averages, it is assumed that 100% of nitrogen (NO_x) oxides are in the form of nitrogen dioxide (NO_2). These assumptions are recommended by the Environment Agency (EA) and are considered to be conservative [1].

(1) https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#detailed-modelling.

5 PREDICTIONS AND ASSESSMENT OF IMPACTS

5.1 INTRODUCTION

This section presents the contribution to ground-level concentrations predicted due to atmospheric emissions from BAe Systems, Samlesbury. Predictions of the routine emissions to the atmosphere from the existing Penetrant Flaw Detect (PFD) and the proposed scrubber (AE5) are presented.

The modelling assumes two transporter operation for the proposed anodise scrubber as this results in the largest pollutant emission rates. **Section 6** provides details of the sensitivity of the model-predicted concentrations to modes of operation.

5.2 MODELLING AND ASSESSMENT OF EMISSIONS – IMPACTS ON HUMAN HEALTH

5.2.1 Nitrogen Dioxide (NO_2)

The principal pollutant released into the atmosphere from the proposed anodise scrubber is the oxides of nitrogen (NO_x) which will progressively oxidise to nitrogen dioxide (NO_2) in the atmosphere.

Table 5.1 shows the predicted annual average ground-level process contribution (PC) of nitrogen dioxide (NO_2) at the specific receptors and at the point of maximum impact for each of the five years of meteorological data. Also shown are the total concentrations, known as the Predicted Environmental Concentration (PEC).

Table 5.1 ADMS 6.0 Predicted Annual Average Ground Level Concentrations of Nitrogen Dioxide (NO_2, $\mu g\ m^{-3}$) [(a)]

Location	Process Contribution (PC)						Max PC + Background (Predicted Environmental Conc. PEC)	Max PC as Percentage of AQAL (%) [(b)]
	2018	2019	2020	2021	2022	Max.		
R1	0.66	0.68	0.60	0.61	0.78	**0.78**	9.9	2.0%
R2	0.71	0.69	0.72	0.66	0.83	**0.83**	9.9	2.1%
R3	0.67	0.65	0.76	0.67	0.76	**0.76**	9.9	1.9%
R4	0.58	0.59	0.70	0.60	0.62	**0.70**	9.8	1.7%
R5	0.50	0.54	0.60	0.53	0.55	**0.60**	9.7	1.5%
R6	0.53	0.58	0.62	0.55	0.57	**0.62**	9.7	1.5%
R7	0.71	0.76	0.79	0.69	0.73	**0.79**	9.9	2.0%
R8	0.70	0.70	0.71	0.65	0.65	**0.71**	9.8	1.8%
R9	0.68	0.70	0.65	0.68	0.63	**0.70**	9.8	1.8%
R10	0.37	0.38	0.33	0.43	0.37	**0.43**	9.5	1.1%
R11	0.32	0.32	0.29	0.38	0.35	**0.38**	9.5	1.0%
R12	0.10	0.12	0.11	0.15	0.11	**0.15**	9.2	0.4%
Public Access	**1.78**	**1.69**	**1.74**	**1.57**	**1.59**	**1.78**	**10.9**	**4.4%**
Grid Maximum	**4.14**	**4.17**	**4.06**	**4.17**	**4.01**	**4.17**	**13.3**	**10.4%**
Air Quality Assessment Level (AQAL)						**40**		
(a) Assumes 100% oxidation. (b) Air Quality Assessment Level (AQAL).								

Table 5.1 shows that the maximum predicted off-site annual average ground-level concentrations of nitrogen dioxide (NO_2) is 1.78 μg m^{-3} which is 4.4% of the Air Quality Assessment Level (AQAL) of 40 μg m^{-3}. The maximum grid concentration occurs on the BAe Systems, Samlesbury work site, where there is no public access and therefore is not of concern to public health.

The IAQM/EPUK significance criteria apply to locations with relevant exposure and only apply to annual average concentrations. Defra's TG16 guidance gives the following examples of where there is relevant exposure to annual average objectives.

- Building facades of residential properties
- Schools
- Hospitals
- Care homes

Examples of where there is no relevant exposure to annual average objectives include; gardens of residential properties, hotels, and kerbside sites.

Table 5.2 shows the IAQM/EPUK significance criteria based on the year of meteorological data that gives rise to the highest impact, which varies for the receptors.

Table 5.2 IAQM/EPUK Significance Criteria; Nitrogen Dioxide (NO_2, μg m^{-3})

No.	Process Contribution (PC)	Increase as %age of AQAL (%)	PEC [(a)]	PEC as %age of AQAL	IAQM Impact Descriptor
R5	0.60	1.5%	9.70	24.2%	Negligible
R6	0.62	1.5%	9.72	24.3%	Negligible
R7	0.79	2.0%	9.89	24.7%	Negligible
R8	0.71	1.8%	9.81	24.5%	Negligible
R9	0.70	1.8%	9.80	24.5%	Negligible
R10	0.43	1.1%	9.53	23.8%	Negligible
R11	0.38	1.0%	9.48	23.7%	Negligible
R12	0.15	0.4%	9.25	23.1%	Negligible

(a) Predicted Environmental Concentration (PEC).

Table 5.2 shows that the impact description is '*negligible*' at all the receptor locations with relevant exposure to annual average concentrations (eg residential properties).

Table 5.3 shows the predicted 99.8th percentile concentration at the specific receptors and at the point of maximum impact for each of the five years of meteorological data.

Table 5.3 ADMS 6.0 Predicted 99.8th Percentile of Hourly Average Ground-Level Concentrations of Nitrogen Dioxide (NO_2, $\mu g\ m^{-3}$) (a)

No.	Process Contribution (PC)						Max PC + Background (Predicted Environmental Conc. PEC) (b)	Max. PC as Percentage of AQAL (%) (c)
	2018	2019	2020	2021	2022	Max.		
R1	4.8	4.8	4.8	5.0	5.1	**5.1**	23.3	2.5%
R2	4.9	5.0	4.8	5.3	4.9	**5.3**	23.5	2.6%
R3	5.5	5.5	5.4	5.4	5.4	**5.5**	23.7	2.7%
R4	5.0	4.8	5.2	5.2	5.1	**5.2**	23.4	2.6%
R5	3.8	3.7	4.2	4.1	4.2	**4.2**	22.4	2.1%
R6	4.0	3.8	4.4	4.4	4.4	**4.4**	22.6	2.2%
R7	4.8	4.6	4.9	5.1	5.0	**5.1**	23.3	2.6%
R8	6.5	5.2	5.8	6.4	4.9	**6.5**	24.7	3.2%
R9	5.9	4.9	4.4	6.1	5.6	**6.1**	24.3	3.0%
R10	4.1	3.6	3.3	4.5	4.1	**4.5**	22.7	2.2%
R11	3.8	3.2	3.6	3.8	3.5	**3.8**	22.0	1.9%
R12	3.8	4.2	3.9	4.3	4.0	**4.3**	22.5	2.1%
Public Access	**16.7**	**14.2**	**14.1**	**15.5**	**15.7**	**16.7**	**34.9**	**8.3%**
Grid Maximum	**17.2**	**15.2**	**14.1**	**18.4**	**17.5**	**18.4**	**36.6**	**9.2%**
Air Quality Assessment Level (AQAL)						**200**		

(a) Assumes 50% oxidation.
(b) Defra guidance TG4(00) & EA H1 Annex F; NO_2 99.8th + 2 x annual average NO_2 background.
(c) Air Quality Assessment Level (AQAL).

Table 5.3 shows that the maximum predicted 99.8th percentile of hourly average nitrogen dioxide (NO_2) concentrations with public access is 16.7 $\mu g\ m^{-3}$ which is 8.3% of the Air Quality Assessment Level (AQAL) of 200 $\mu g\ m^{-3}$. The IAQM guidance describes the range of 11% to 20% of the AQAL as being 'small'; therefore, an impact of 8.3% is considered negligible.

Tables 5.2 and 5.3 show that at the specific receptors, the predicted incremental increase in concentrations of nitrogen dioxide (NO_2) occurring due to emissions from the installation is not of concern to human health.

Table 5.4 shows the predicted ground-level nitrogen dioxide (NO_2) concentration for the existing PFD stack and the proposed AE5 scrubber. Predictions are presented for the year of meteorological data that gives rise to the largest impact.

Table 5.4 ADMS 6.0 Predicted Annual Average and 99.8th %ile of Hourly Average Ground Level Concentrations of Nitrogen Dioxide (NO_2, $\mu g\ m^{-3}$) (a)

No.	Process Contribution (PC)					
	Annual Average (a)			99.8th Percentiles of Hourly Averages (b)		
	PFD	PFD+A5	Increase	PFD	PFD+A5	Increase
R1	0.34	0.78	**0.45**	2.2	5.1	**2.9**
R2	0.36	0.83	**0.47**	2.3	5.3	**3.0**
R3	0.33	0.76	**0.44**	2.4	5.5	**3.1**
R4	0.30	0.70	**0.40**	2.3	5.2	**2.9**
R5	0.26	0.60	**0.34**	1.9	4.2	**2.3**
R6	0.27	0.62	**0.35**	2.0	4.4	**2.4**
R7	0.34	0.79	**0.45**	2.3	5.1	**2.9**
R8	0.31	0.71	**0.40**	2.9	6.5	**3.6**
R9	0.30	0.70	**0.40**	2.7	6.1	**3.4**
R10	0.19	0.43	**0.25**	1.9	4.5	**2.6**
R11	0.17	0.38	**0.22**	1.6	3.8	**2.1**
R12	0.06	0.15	**0.08**	1.9	4.3	**2.4**
Public Access	**0.77**	**1.78**	**1.01**	**7.2**	**16.7**	**9.5**
Grid Maximum	**1.68**	**4.17**	**2.50**	**8.2**	**18.4**	**10.2**
Air Quality Assessment Level (AQAL)						
		40			**200**	

(a) Assumes 100% oxidation.
(b) Assumes 50% oxidation.

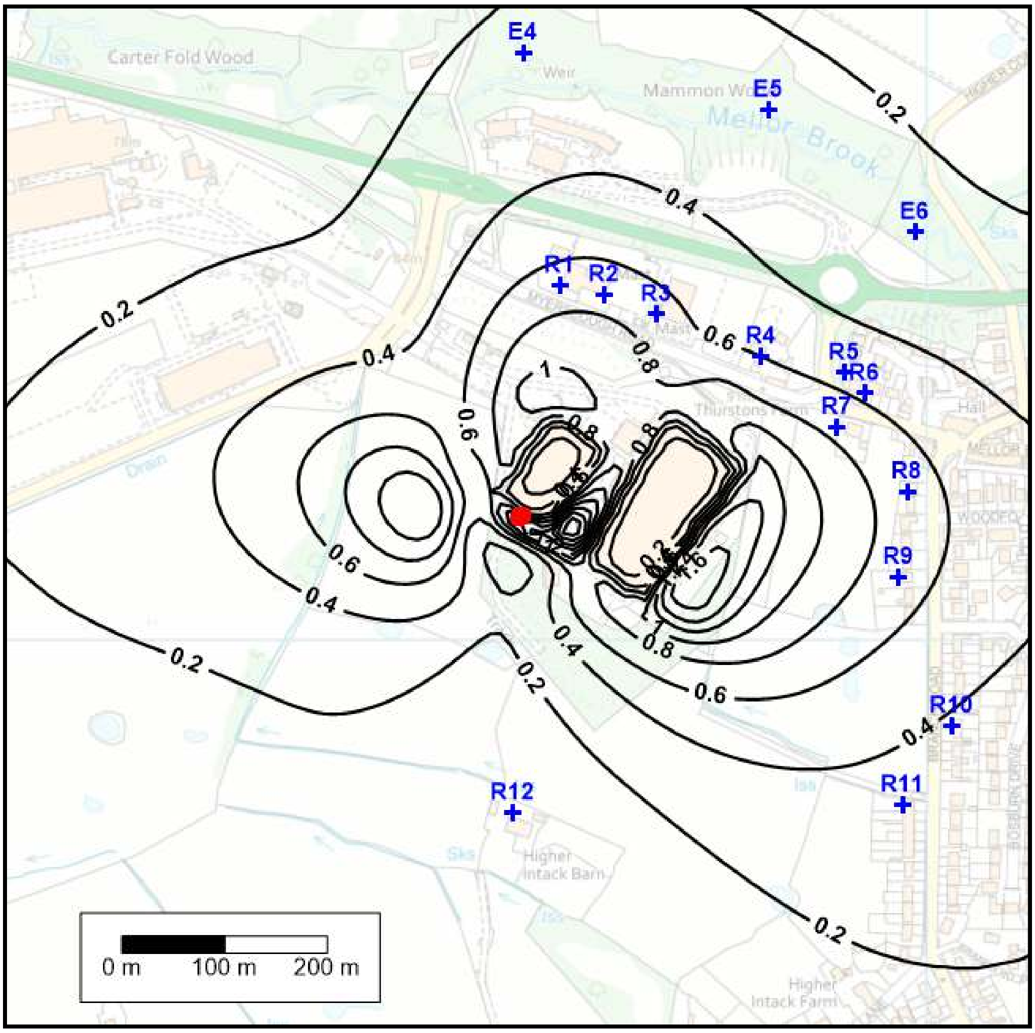
Table 5.4 shows that the increase predicted to occur due to emissions from the proposed anodise scrubber is about 50% of the total impacts shown in **Table 5.1**, **Table 5.2** and **Table 5.3**.

The following figures are presented to illustrate the distribution of concentrations of nitrogen dioxide (NO_2). The figures are for 2019 meteorological data, as this year gives rise to the highest process contribution (PC).

- **Figure 5.1:** Annual Average
- **Figure 5.2:** 99.8th percentile of hourly averages

The figures show that peak predicted increments to ground-level concentrations (process contribution PC) occur within 100 m of the installation.

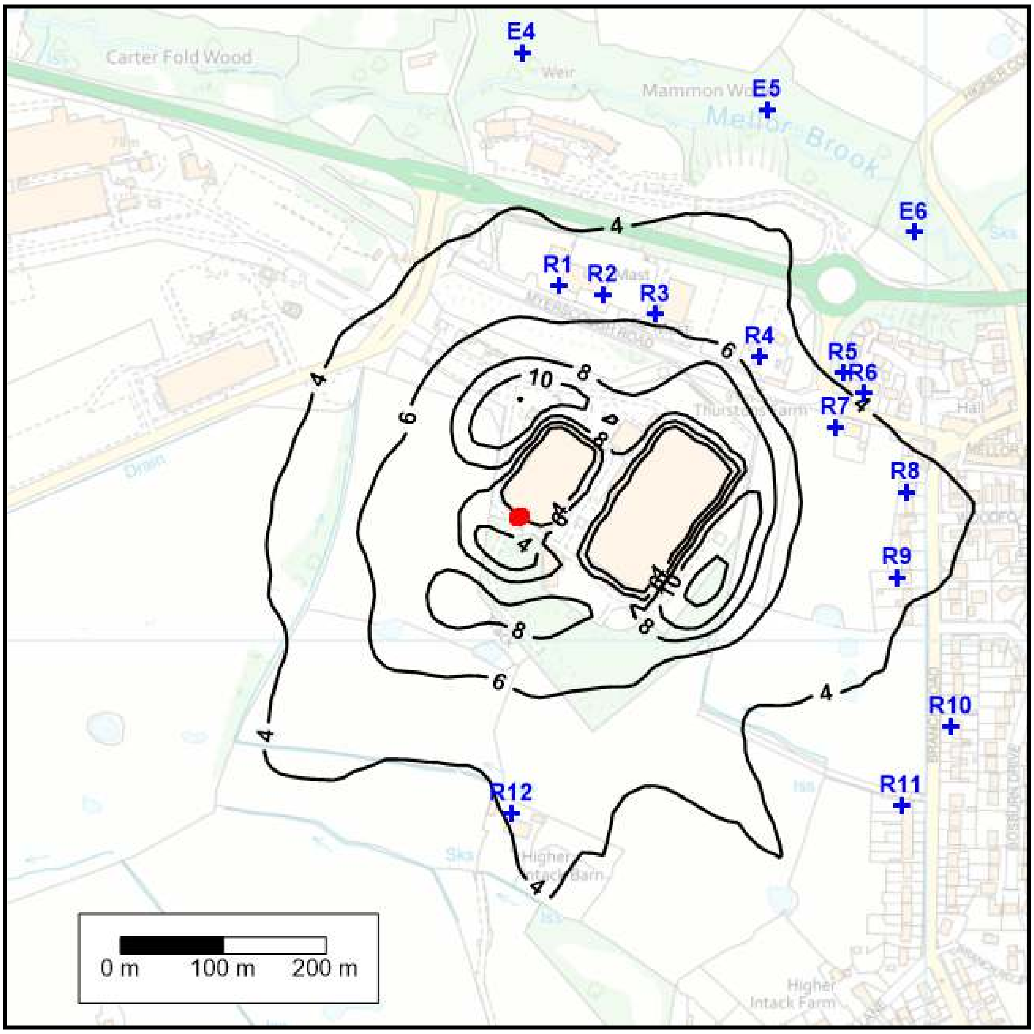
Figure 5.1 ADMS 6.0 Predicted Annual Average Ground-Level Concentration of the Nitrogen Dioxide (NO_2); 2019 Meteorological Data (μg m^{-3}); Assuming 100% Oxidation



AQAL: 40 μg m^{-3}

Figure 5.1 shows that the maximum predicted impact (process contribution, PC) occurs close to the source and reduces with distance from the stacks.

Figure 5.2 ADMS 6.0 Predicted 99.8th Percentile of Hourly Average Ground-Level Concentrations of Nitrogen Dioxide (NO_2); 2019 Meteorological Data ($\mu g\ m^{-3}$); Assuming 50% Oxidation



AQAL: 200 $\mu g\ m^{-3}$

5.2.2 Hydrogen Fluoride (HF)

Table 5.5 shows the maximum predicted increment to ground-level concentrations (process contribution, PC) of hydrogen fluoride (HF) for any of the five years of meteorological data. Also shown is the Predicted Environmental Concentrations (PEC).

Table 5.5 ADMS 6.0 Maximum Predicted Ground Level Concentration of Hydrogen Fluoride (HF) Concentrations due to Emissions to Atmosphere (2018 - 2022 Meteorological Data)

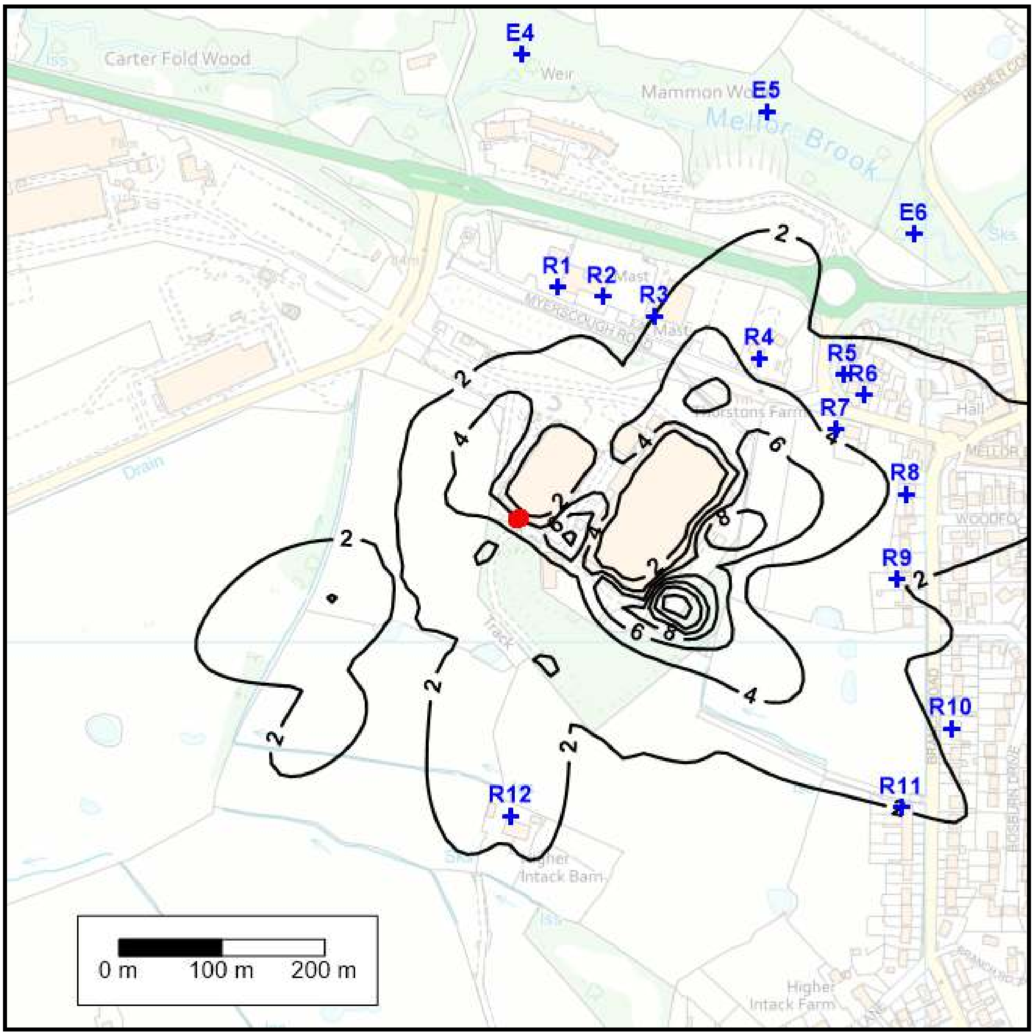
Averaging Period	Grid Maximum PC ($\mu g\ m^{-3}$)	Public Access PC ($\mu g\ m^{-3}$)	Baseline ($\mu g\ m^{-3}$)	PEC ($\mu g\ m^{-3}$)	AQAL ($\mu g\ m^{-3}$)	PC (public access) as %age of AQAL (%)	PEC (public access) as %age of AQAL (%)
Monthly Mean [(a)]	0.42	0.18	2.0	2.2	16	1.1	13.6
Hourly Mean	21.1	12.6	-	16.6 [(b)]	160	7.9	10.4

(a) A monthly mean is assumed to be equivalent to an annual mean.
(b) Defra guidance TG4(00) & EA H1 Annex F; Max 1 Hour + 2 x annual average background.

Table 5.5 shows that at the point of maximum impact (and therefore all other locations), the predicted impacts of hydrogen fluoride (HF) are negligible.

Figure 5.3 shows the predicted maximum hourly average process contribution (PC) for hydrogen fluoride (HF). Predictions are presented for 2022 meteorological data, as this is the year that gives rise to the largest impacts.

Figure 5.3 ADMS 6.0 Predicted Maximum Hourly Average Ground-Level Conc. of Hydrogen Fluoride (HF); 2022 Meteorological Data ($\mu g\ m^{-3}$)



AQAL: 160 $\mu g\ m^{-3}$

5.2.3 Total Chromium (Cr)

Table 5.6 shows the maximum predicted increments to ground-level concentrations (process contribution, PC) for any of the five years of meteorological data for chromium (III) and its compounds, total chromium (Cr). Also shown are the Predicted Environmental Concentrations (PEC).

Table 5.6 ADMS 6.0 Maximum Predicted Ground-Level Concentrations of Chromium (III and its Compounds, total Chromium) due to Emissions to Atmosphere (2018 - 2022 Meteorological Data)

Averaging Period	Grid Maximum PC ($\mu g\ m^{-3}$)	Public Access PC ($\mu g\ m^{-3}$)	Baseline ($\mu g\ m^{-3}$)	PEC ($\mu g\ m^{-3}$)	AQAL ($\mu g\ m^{-3}$)	PC (public access) as %age of AQAL (%)	PEC (public access) as %age of AQAL (%)
Annual Mean	0.0025	0.0010	0.0124	0.013	5	0.0%	0.3%
Hourly Mean	0.13	0.07	-	0.15 [(a)]	150	0.0%	0.1%
(a) Defra guidance TG4(00) & EA H1 Annex F; Max 1 Hour + 2 x annual average background.							

Table 5.6 shows that at the point of maximum impact (and therefore all other locations), the predicted impacts of chromium (III) and its compounds (total chromium, Cr) are negligible.

5.2.4 Chromium (VI)

Table 5.7 shows the maximum predicted increments to ground-level concentrations (process contribution, PC) of chromium (VI) for any of the five years of meteorological data. Also shown is the Predicted Environmental Concentration (PEC). Given that it is only annual average concentrations of chromium (VI) for which there is an air quality assessment level (AQAL), the locations of relevant exposure will be the residential receptors; these are also in **Table 5.7**.

Table 5.7 ADMS 6.0 Maximum Predicted Annual Average Ground Level Concentrations of Chromium (VI) due to Emissions to Atmosphere (ng m^{-3}, 2018 - 2022 Meteorological Data) [(a)]

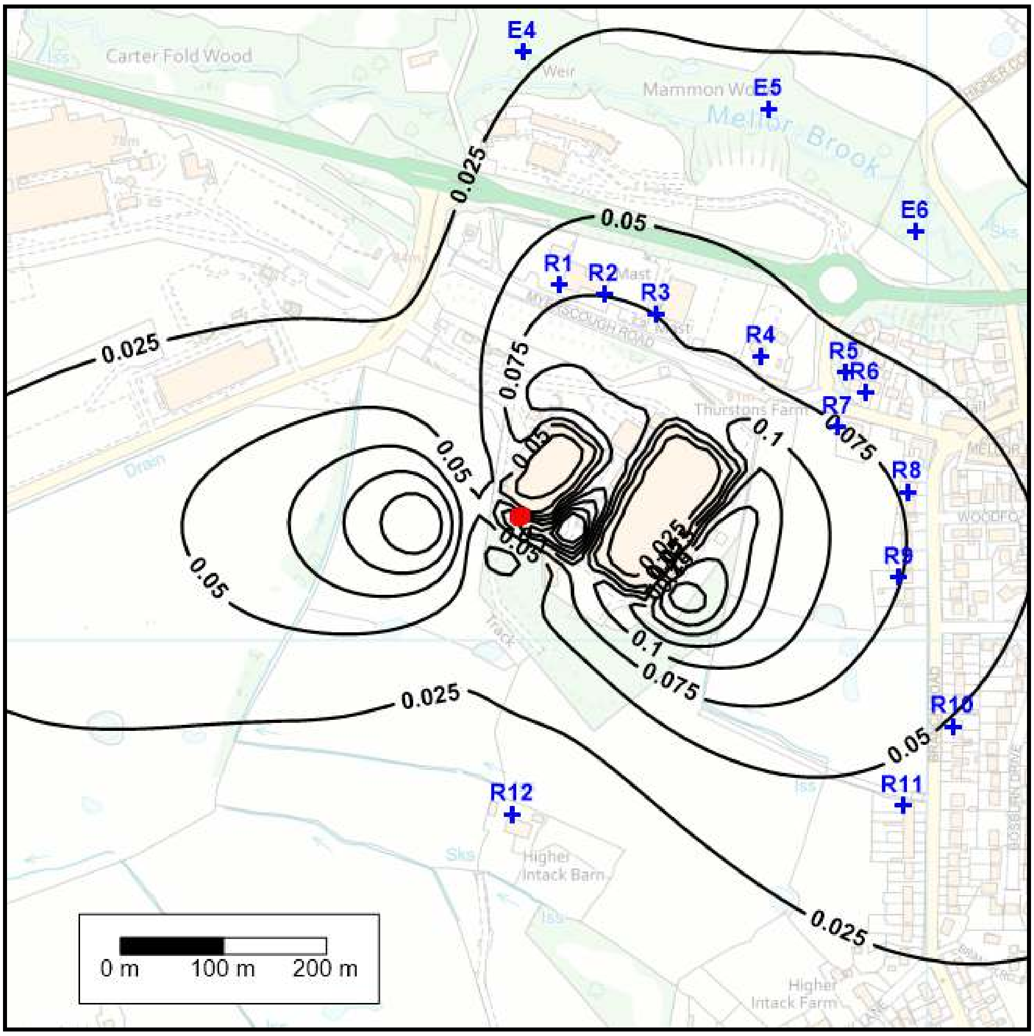
Location	Process Contribution (PC)	Predicted Environmental Conc. PEC	PC as %age of AQAL (%)
R5	0.067	2.55	27%
R6	0.069	2.55	28%
R7	0.088	2.57	35%
R8	0.079	2.56	32%
R9	0.079	2.56	31%
R10	0.049	2.53	19%
R11	0.043	2.52	17%
R12	0.016	2.50	6%
Public Access	**0.20**	**2.68**	**80%**
Grid Maximum	**0.50**	**2.98**	**198%**
Air Quality Assessment Level (AQAL)	**0.25**		
(a) Assuming 20% of total Cr is Chromium (VI).			

Table 5.7 shows that if the assumption is made that chromium (VI) is 20% of total chromium, then at locations where there is relevant exposure (eg properties) the process contribution (PC) is no more than 35% of the Air Quality Assessment level (AQAL). Given that the assumption of 20% has been suggested by the Environment Agency (EA) for screening purposes and that the process contribution is less than the assessment level, it is considered that the impact of emissions of chromium (VI) is not of concern to human health.

The PEC (Predicted Environmental Concentration) exceeds the AQAL due to the baseline concentration. There is little confidence in the baseline concentration, given that no measured ambient chromium (VI) concentrations are available.

Figure 5.4 shows the process contribution (PC) of chromium (VI) for 2021, which is the year that gives rise to the largest impact.

Figure 5.4 ADMS 6.0 Predicted Maximum Annual Average Ground-Level Concentrations of Chromium (VI); 2021 Meteorological (ng m^{-3})



AQAL: 0.25 ng m^{-3}

5.3 MODELLING AND ASSESSMENT OF EMISSIONS – ECOSYSTEMS

Table 5.8 shows the predicted impacts at the closest ecological sites.

Table 5.8 Predicted Impacts (Process Contribution, PC) at Closest Ecological Sites Receptor Locations ($\mu g\ m^{-3}$)

No.	Description	Distance from Stack (km)	Hydrogen Fluoride (HF)		Oxides of Nitrogen (NO_x)	
			Weekly	Daily	Annual	Daily
E1	Darwen River (SSSI)	2.6	0.0017	0.069	0.02	0.69
E2	Red Car & Tun (SSSI)	4.4	0.0014	0.024	0.01	0.24
E3	Pleasington Hall (LNR)	4.1	0.0008	0.023	0.01	0.23
E4	Mammon Wood	0.5	0.0236	0.256	0.24	2.56
E5	Mammon Wood	0.5	0.0284	0.257	0.29	2.57
E6	Mammon Wood	0.5	0.0305	0.256	0.30	2.56
E7	Jeffery Wood	2.0	0.0021	0.052	0.02	0.52
E8	Holster Wood	1.3	0.0027	0.080	0.03	0.80
Maximum as Percentage of AQAL			**6.1%**	**5.1%**	**1.0%**	**3.4%**
Air Quality Assessment Level (AQAL)			**0.5**	**5.0**	**30**	**75**

Given that the maximum short-term (weekly and daily) impacts are less than 10% of the AQAL and the annual average is less than 1%, the predicted impacts of emissions on ecological sites are negligible, and no further consideration is necessary.

Hydrogen fluoride (HF) will directly affect vegetation at high concentrations, but fluorides can also induce injury to plants at very low concentrations over time.

The Environment Agency (EA) suggest a maximum deposition rate for fluoride of 2.1 mg m^{-2} day^{-1}. **Table 5.9** shows the deposition rates calculated from the process contribution (PC) at each ecological receptor and as a percentage of the maximum deposition rate.

Table 5.9 Hydrogen Fluoride (HF) Deposition at Ecological Sites Receptor Locations

No.	Description	Annual Average Process Contribution (PC, $\mu g\ m^{-3}$)	Deposition Rate (mg m^{-2} day^{-1}) [(a)]	Deposition Rate (Percentage of Maximum, %)
E1	Darwen River (SSSI)	0.0017	0.00044	0.0%
E2	Red Car & Tun (SSSI)	0.0014	0.00035	0.0%
E3	Pleasington Hall (LNR)	0.0007	0.00019	0.0%
E4	Mammon Wood	0.0237	0.00613	0.3%
E5	Mammon Wood	0.0286	0.00741	0.4%
E6	Mammon Wood	0.0304	0.00788	0.4%
E7	Jeffery Wood	0.0021	0.00053	0.0%
E8	Holster Wood	0.0026	0.00068	0.0%
Maximum Deposition Rate			**2.1**	

(a) Fluoride (F) as Hydrogen Fluoride (HF) assumes a deposition velocity of 0.01 m s^{-1} and a factor of 3 to convert from dry deposition to total deposition.

Table 5.9 shows that the calculated deposition rates are less than 1% of the maximum rate of 2.1 mg m^{-2} day^{-1} and are, therefore, insignificant.

6 SENSITIVITY ANALYSIS

6.1 INTRODUCTION

This section considers the sensitivity of model-predicted concentrations to the following:

- Mode of operation
- Meteorological data
- Roughness length
- Terrain
- Buildings
- Stack height
- Grid receptor spacing

Predictions are for the maximum predicted process contribution (PC) of nitrogen dioxide (NO_2) with public access (ie off-site locations).

6.2 MODE OF OPERATION

The predictions presented in **Section 5** are for two transporter operation, as this results in the maximum pollutant emission rates. However, for one transporter operation and lip extraction, it is possible that even though emission rates are lower, the impacts may be higher due to lower exit velocity resulting in poorer dispersion.

Table 6.1 shows the maximum predicted process contribution (PC) for nitrogen dioxide (NO_2) where there is public access for each of the three modes of operation using 2022 meteorological data.

Table 6.1 Mode of Operation: ADMS 6.0 Predicted Annual Average and 99.8th Percentile of Hourly Average Concentrations of Nitrogen Dioxide (NO_2), Maximum where there is Public Access ($\mu g\ m^{-3}$)

Model of Operation	Annual Average	99.8th Percentile of Hourly Averages
Two Transporter	**1.59**	**15.7**
One Transporter	1.51	15.4
Lip Extraction	1.32	13.6
Air Quality Assessment Level (AQAL)	**40**	**200**

Table 6.1 shows two transporter operation gives rise to the largest predicted concentrations.

6.3 METEOROLOGICAL DATA

The assessment presented in this report is based on predictions made using five years (2018-2022) of NWP meteorological data.

To illustrate the year-to-year variation in meteorological data and sensitivity to meteorological data selection, **Table 6.2** shows the maximum concentration of nitrogen dioxide (NO_2) where there is public access for each of the five years of meteorological data using 2018 to 2022 NWP data and 2018 data from Blackpool, Bingley and Crosby.

Table 6.2 Meteorological Data: ADMS 6.0 Predicted Annual Average and 99.8th Percentile of Hourly Average Concentrations of Nitrogen Dioxide (NO_2), Maximum where there is Public Access ($\mu g\ m^{-3}$)

Source	Year	Annual Average	99.8^{th} Percentile of Hourly Averages
NWP	2018	1.78	16.7
NWP	2019	1.69	14.2
NWP	2020	1.74	14.1
NWP	2021	1.57	15.5
NWP	2022	1.59	15.7
Blackpool	2018	1.63	12.7
Bingley	2018	2.27	21.5
Crosby	2018	1.93	12.4
Air Quality Assessment Level (AQAL)		**40**	**200**

Table 6.2 shows some year-to-year variation in the predicted concentration for NWP data for 2018 to 2022, although the variation is insignificant. For 2018 meteorological data, predictions from Blackpool, Bingley and Crosby vary from those using NWP data. There is no indication from the predicted concentrations that using NWP data is not the most representative for the location of the installation.

6.4 ROUGHNESS LENGTH

The roughness length of 0.3 m used in this assessment was selected using professional judgement. Roughness length cannot be directly measured. In practice, there is no one unique roughness that fits a given wind speed profile. Roughness length will also vary depending on wind direction and other factors, such as the season of the year.

Therefore, it is interesting to see how sensitive the model predictions are to roughness length.

Table 6.3 shows the maximum concentration of nitrogen dioxide (NO_2) where there is public access for roughness lengths in the range of 0.1 m to 0.5 m using the most recent year of NWP meteorological data (2022).

Table 6.3 Roughness Length: ADMS 6.0 Predicted Annual Average and 99.8th Percentile of Hourly Average Concentrations of Nitrogen Dioxide (NO_2), Maximum where there is Public Access ($\mu g\ m^{-3}$)

Roughness Length (m)	Annual Average	99.8th Percentile of Hourly Averages
0.2	1.59	15.0
0.3	**1.59**	**15.7**
0.5	1.53	14.9
Air Quality Assessment Level (AQAL)	**40**	**200**

Table 6.3 shows only a slight variation in the predicted concentration for roughness lengths in the 0.2 m to 0.5 m range in this modelling situation.

6.5 TERRAIN AND BUILDINGS

The modelling presented in this assessment included the effects of buildings and terrain. **Table 6.4** shows the maximum predicted ground level concentration of nitrogen dioxide (NO_2) where there is public access concentration both with and without the effects of terrain and buildings using 2022 NWP meteorological data.

Table 6.4 Terrain and Buildings: ADMS 6.0 Predicted Annual Average and 99.8th Percentile of Hourly Average Concentrations of Nitrogen Dioxide (NO_2), Maximum where there is Public Access ($\mu g\ m^{-3}$)

Terrain Effects	Building Effects	Annual Average	99.8th Percentile of Hourly Averages
Yes	**Yes**	**1.59**	**15.7**
Yes	No	1.00	6.6
No	Yes	1.37	10.9
No	No	0.85	6.6
Air Quality Assessment Level (AQAL)		**40**	**200**

Table 6.4 shows the effects of terrain and buildings both significantly impact the maximum process contribution (PC) where there is public access.

6.6 GRID RECEPTOR SPACING

The assessment assumed a grid receptor spacing of 10 m. **Table 6.5** shows the grid maximum predicted ground-level concentration of nitrogen dioxide (NO_2) concentrations for the grid maximum for receptor spacings of 5 m, 10 m and 20 m.

Predictions are made for 2022 NWP meteorological data.

Table 6.4 **Grid Receptor Spacing: ADMS 6.0 Predicted Annual Average and 99.8th Percentile of Hourly Average Concentrations of Nitrogen Dioxide (NO_2), Grid Maximum Concentrations (μg m^{-3})**

Grid Receptor Spacing (m)	Annual Average	98th Percentile of Hourly Averages
5	4.44	17.5
10	**4.01**	**17.5**
20	2.43	16.9
Air Quality Assessment Level (AQAL)	**40**	**200**

Table 6.4 shows that reducing the receptor spacing from 10 m to 5 m increases the maximum predicted annual average concentration by about 10% but does not affect the 99.8th percentile. The reason for this is evident from **Figure 5.1**, which shows the maximum annual average impact occurring over a small area on site between the two modelled buildings. The off-site predicted concentration would not show that same sensitivity to receptor spacing.

6.7 STACK HEIGHT

The stack heights modelled were both 15 m. **Table 6.5** shows the predicted ground-level concentration of nitrogen dioxide (NO_2) concentration for stack heights in the 13 m to 17 m range. Predictions are made for 2022 NWP meteorological data where there is public access.

Table 6.5 **Stack Height: ADMS 6.0 Predicted Annual Average and 99.8th Percentile of Hourly Average Concentrations of Nitrogen Dioxide (NO_2), where there is Public Access Grid Maximum Concentrations (μg m^{-3})**

Stack Height (m) [(a)]	Annual Average	98th Percentile of Hourly Averages
13	1.79	17.8
14	1.69	16.7
15	**1.59**	**15.7**
16	1.50	14.8
17	1.41	13.9
Assessment Level	**40**	**200**
(a) Stack height for both the PFD and AE5 (anodise scrubber stack).		

Table 6.5 shows that an increase in the stack height reduces the maximum predicted concentration and that the benefit is minimal above the proposed height of 15 m.

7 SUMMARY AND CONCLUSIONS

Earth & Marine Environmental Consultants Ltd (EAME) has commissioned Atmospheric Dispersion Modelling Ltd (ADM Ltd) to undertake an air quality assessment of emissions to the atmosphere from the BAe Systems, Samlesbury, Lancashire.

BAe Systems, Samlesbury, are installing a new surface treatment line to replace an existing anodising process. The process occurs within the central treatment facility (CTF).

This air quality assessment is required to support the application for a variation to the existing environmental permit (EP) to accommodate the new surface treatment line and removal of existing permitted processes.

Details of the proposal are as follows:

- The clean and pickle line and associated scrubbers (AE3 and AE4) were removed at the end of 2022 and are discounted from the assessment.
- The existing anodise line emission points AE1 and AE2 will be removed once the new anodise line is fully commissioned and, therefore, can be discounted from the assessment.
- The Penetrant Flaw Detect (PFD) scrubber (AE5) is the only other source requiring assessment alongside the new anodise scrubber (A10/AE26).

The ADMS 6.0 dispersion model has been used to make predictions of ground-level concentrations of the following pollutants released to the atmosphere from the two scrubbers.

- Oxides of nitrogen (NO_x)
- Hydrogen fluoride (HF)
- Chromium (VI) and total chromium (Cr)

Predictions are made for each of five years of meteorological data. The predicted impacts have been compared against air quality assessment level and guidance to determine the significance of the predicted impacts.

A detailed analysis of the sensitivity of the model-predicted concentration to assumptions made has been undertaken.

The principal conclusions of this assessment are:

- The impacts of emissions of the oxides of nitrogen (NO_x), hydrogen fluoride (HF) and total chromium (Cr) are determined not to be of concern to human health or ecology.

- Conservatively assuming that 20% of total chromium (Cr) is chromium (VI), the process contribution (PC) is no more than 35% of the Air Quality Assessment level (AQAL) and locations where there is relevant exposure (eg residential properties). Given that the assumption of 20% has been suggested by the Environment Agency (EA) for screening purposes and that the process contribution is less than the assessment level, it is considered that the impact of emissions of chromium (VI) is not of concern to human health.