FICHTNER

Consulting Engineers Limited

Killoch ERP

Barr Environmental Ltd

Appendix 8.4 – Process Emissions Modelling

ENGINEERING CONSULTING

Document approval

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Contents

1 Introduction

This Appendix has been produced to set out the approach taken to modelling emissions from the Energy Recovery Park (ERP) (the Proposed Development) at Killoch, East Ayrshire. The operation of the Proposed Development would include the release of emissions from a single point source, the stack. This appendix refers only to these process emissions.

This Appendix sets out the approach taken to modelling the emissions from the stack. This includes all model inputs and justifications where appropriate. Finally, this Appendix presents the results of the modelling.

When considering the impact of the operation of the Proposed Development on human health, the predicted atmospheric concentrations have been compared to the Air Quality Assessment Levels (AQALs) for the protection of human health. When considering the impact on ecosystems, the predicted atmospheric concentrations have been compared to the Critical Levels for the protection of ecosystems. It is noted that deposition of emissions over a prolonged period can have nitrification and acidification impacts. An assessment of the long-term deposition of pollutants has been undertaken and the results compared to the habitat specific Critical Loads.

It should be noted that this assessment does not consider the air quality impacts resulting from the abnormal operation of the Proposed Development; nor does it consider the impact from pollutants accumulating within the environment, both of which are considered separately

2 Air Quality Standards, Objectives and Guidelines

Limits and targets related to ambient air are set in European legislation namely the Air Quality Directive (Directive 2008/50/EC), the fourth daughter Directive (Directive 2004/107/EC). In Scotland these are described in the Air Quality Standards (Scotland) Regulations (2010) and subsequent amendments.

The UK Government and the devolved administrations are required under the Environment Act (1995) to produce a national air quality strategy. This was last reviewed and published in 2007. The Air Quality Strategy (AQS) sets out the UK's air quality objectives and recognises that action at national, regional and local level may be needed, depending on the scale and nature of the air quality problem. This includes additional targets and limits for 15-minute sulphur dioxide and 1,3-butadiene and more stringent requirements for benzene and PAHs, known as AQS Objectives. In 2015 the Scottish Government produced "Cleaner Air for Scotland – the Road to a Healthier Future" (CAFS Strategy). This sets out how the Scottish Government proposed to reduce air pollution further to protect human health and fulfil Scotland's legal responsibilities. This included a commitment to include in legislation World Health Organisation (WHO) guideline values as Scottish objectives for PM_{10} and $PM_{2.5}$. For other pollutants SEPA set Environmental Assessment Levels (EALs) in the IPPC H1 (2003) document. On other projects SEPA has requested that those EALs set out in the Environment Agency's environmental management guidance 'Air Emissions Risk Assessment for your Environmental Permit'[1] ("Air Emissions Guidance") are also considered. The long-term and short-term EALs from these documents have been used when the AQS does not contain relevant objectives. Standards and objectives for the protection of sensitive ecosystems and habitats are also contained within IPPC H1, the Air Emissions Guidance and the Air Pollution Information System (APIS).

2.1.1 Regulated pollutants

2.1.2 Nitrogen dioxide

All combustion processes produce nitric oxide and nitrogen dioxide, known by the general term of nitrogen oxides. In general, the majority of the nitrogen oxides released is in the form of NO, which then reacts with ozone in the atmosphere to form nitrogen dioxide. Of the two compounds, nitrogen dioxide is associated with adverse effects on human health, principally relating to respiratory illness. The World Health Organisation has stated that "many chemical species of nitrogen oxides exist, but the air pollutant species of most interest from the point of view of human health is nitrogen dioxide".

The single greatest source of nitrogen oxides in Scotland is road transport. According to the most recent annual report from the National Atmospheric Emissions Inventory (NAIE)[2], in 2018 road transport accounted for 48% of Scottish emissions. High levels of nitrogen oxides in urban areas are almost always associated with high traffic densities.

The AQS includes two objectives, which are also included in the Air Quality Standards (Scotland) Regulations.

1 https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air-emissions

2 NAIE Air Pollution Inventories for England, Scotland, Wales and Northern Ireland: 1990-2018, DEFRA.

- A limit for the one-hour mean of 200 µg/m³, not to be exceeded more than 18 times a year (equivalent to the 99.79th percentile).
- A limit for the annual mean of 40 µg/m³.

The AQS includes objectives for the protection of sensitive vegetation and ecosystems of 30 µg/m³ for the annual mean nitrogen oxides. This is also included in the Air Quality Standards (Scotland) Regulations. The APIS also defines the daily mean Critical Level as 75 µg/m³ for nitrogen oxides.

2.1.3 Sulphur dioxide

Sulphur dioxide is predominantly released by the combustion of fuels containing sulphur. Emissions of sulphur dioxide in Scotland have reduced by 96% since 1990, due to a reduction in the number of coal-fired combustion plants, the installation of flue gas desulphurisation plants on a number of large coal-fired power stations and the reduction in sulphur content of liquid fuels. The AQS contains three objectives for the control of sulphur dioxide:

- A limit for the 15-minute mean of 266 µg/m³, not to be exceeded more than 35 times a year (the 99.9th percentile).
- A limit for the one hour mean of 350 µg/m³, not to be exceeded more than 24 times a year (the 99.73rd percentile).
- A limit for the daily mean of 125 µg/m³, not to be exceeded more than 3 times a year (the 99.2nd percentile).

The hourly and daily objectives are included in the Air Quality Standards (Scotland) Regulations.

The Air Quality Standards (Scotland) Regulations includes a Critical Level for the protection of vegetation and ecosystems of 20 µg/m³ as an annual mean and as a winter average. This is also set out in the AQS. In addition, APIS defines the long-term Critical Level as 10 µg/m³ where lichens or bryophytes are present.

2.1.4 Particulate matter

Concerns over the health impact of solid matter suspended in the atmosphere tend to focus on particles with a diameter of less than 10 µm, known as PM_{10}. These particles have the ability to enter and remain in the lungs. Various epidemiological studies have shown increases in mortality associated with high levels of PM_{10}, although the underlying mechanism for this effect is not yet understood. According to the NAIE, significant sources of PM_{10} include industrial processes (28%), residential, commercial and public sector combustion (25%), agriculture (17% and transport (15%). The most significant sources of $PM_{2.5}$s differs slightly with residential, commercial and public sector combustion the greatest (44%).

The AQS includes two objectives for PM_{10} specific to Scotland which go beyond those set out in European legislation and are transposed into Scottish legislation in the Air Quality (Scotland) Amendment Regulations (2002).

- A limit for the annual mean of 18 µg/m³.
- A daily limit of 50 µg/m³, not to be exceeded more than 7 times a year (the 98.1st percentile) in Scotland.

The annual mean objective set in the Air Quality (Scotland) Amendment Regulations (2002) is more stringent than the WHO guideline value. Therefore, there was no reason to further amend the objective to comply with the commitment set out in the CAFS Strategy.

The AQS included some provisional objectives for particulate matter with a diameter less than 2.5 µm ($PM_{2.5}$). These have been replaced by an objective based on the WHO guideline values for $PM_{2.5}$ of 10 µg/m³ as an annual mean.

2.1.5 Carbon monoxide

Carbon monoxide is produced by the incomplete combustion of fuels containing carbon. By far the most significant sources are residential, commercial public sector combustion (43%), industrial combustion (27%) and transport (23%). Carbon monoxide can interfere with the processes that transport oxygen around the body, which can prove fatal at very high levels.

Concentrations in the Scotland and indeed the UK are well below levels at which health effects can occur. The AQS includes the following objective for the control of carbon monoxide, which is also included in the Air Quality Standards (Scotland) Regulations:

- A limit for the 8-hour running mean of 10 mg/m³.

The Environment Agency's Air Emissions Guidance also defines the hourly EAL as 30 mg/m³.

2.1.6 Hydrogen chloride

There are no objectives for hydrogen chloride contained within the AQS or Air Quality Standards (Scotland) Regulations. However, IPPC H1 (2003) defines the long-term EAL of 20 µg/m³ and the short-term EAL of 800 µg/m³. The Environment Agency's Air Emissions Guidance also defines the short-term EAL as 750 µg/m³, but provides no long-term EAL. For the purpose of this analysis the most conservative of the IPPC H1 (2003) or Air Emissions Guidance limit has been applied.

2.1.7 Hydrogen fluoride

There are no objectives for hydrogen fluoride contained within the AQS or Air Quality Standards (Scotland) Regulations. However, IPPC H1 (2003) defines the short term EAL of 250 µg/m³. No long term EAL is provided in IPPC H1.

The Environment Agency's Air Emissions Guidance defines the short-term EAL as 160 µg/m³ and the long-term EAL as 16 µg/m³. In addition, Critical Levels for the protection of vegetation and ecosystems of 5 µg/m³ as a daily mean and 0.5 µg/m³ as a weekly mean concentration are set for hydrogen fluoride, these have not been derived from a European Directive and are not contained in IPPC H1 (2003).

For the purpose of this analysis the most conservative of the IPPC H1 (2003) or Air Emissions Guidance limit has been applied.

2.1.8 Ammonia

There are no objectives for ammonia contained within the AQS or Air Quality Standards (Scotland) Regulations. However, IPPC H1 (2003) defines the short term EAL as 2,500 µg/m³ and the long term EAL as 180 µg/m³. These are the same as those set in the Environment Agency's Air Emissions Guidance.

APIS also provides Critical Levels for the protection of vegetation and ecosystems. This level is 3 µg/m³ as an annual mean, reduced to 1 µg/m³ where lichens or bryophytes are present.

For the purpose of this analysis the most conservative of the IPPC H1 (2003) or Air Emissions Guidance limit has been applied.

2.1.9 Volatile Organic Compounds (VOCs)

A variety of VOCs could be released from the stacks, of which benzene and 1,3-butadiene are included in the AQS and monitored at various stations around the UK. The AQS includes the following objectives for Scotland for the running annual mean:

- Benzene – 3.25 µg/m³; and
- 1,3-butadiene – 2.25 µg/m³.

The Environment Agency's Air Emissions Guidance includes a short-term EAL for benzene, calculated from occupational exposure. This is a limit of 195 µg/m³ for an hourly mean. There are no short-term EALs for 1,3-butadiene.

2.1.10 Metals

Lead is the only metal included in the AQS or Air Quality Standards (Scotland) Regulations. Lead can have many health effects, including effects on the synthesis of haemoglobin, the nervous system and the kidneys. Emissions of lead in the UK have declined by 97% since 1990, due principally to the virtual elimination of leaded petrol.

The AQS includes objectives to limit the annual mean to 0.5 µg/m³ by the end of 2004 and to 0.25 µg/m³ by the end of 2008. Only the first objective is included in the Air Quality Standards (Scotland) Regulations.

The fourth Daughter Directive on air quality (Commission Decision 2004/107/EC) includes target values for arsenic, cadmium and nickel. However, the preamble to the Directive makes it clear that the use of these target values is relatively limited. Paragraph (5) states:

"The target values would not require any measures entailing disproportionate costs. Regarding industrial installations, they would not involve measures beyond the application of best available techniques (BAT) as required by Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (5) and in particular would not lead to the closure of installations. However, they would require Member States to take all cost-effective abatement measures in the relevant sectors."

And paragraph (6) states:

"In particular, the target values of this Directive are not to be considered as environmental quality standards as defined in Article 2(7) of Directive 96/61/EC and which, according to Article 10 of that Directive, require stricter conditions than those achievable by the use of BAT."

Although these target values have been included in the assessment, it is important to note that the application of the target values would not have an effect on the design or operation of the Proposed Development. The Proposed Development will be designed in accordance with BAT and will include cost effective methods for the abatement of arsenic, cadmium and nickel, including the injection of activated carbon and a fabric filter.

Emissions limits have been set in permits for similar facilities for a number of heavy metals which do not have air quality standards associated with them. The EALs for these metals, and lead, are summarised in Table 1. The Environment Agency published updated EALs in its Air Emissions Guidance. These take into account the guidelines for metals and metalloids in ambient air for the protection of human health produced by EPAQS in 2009, after the publication of IPPC H1. Some metals included in this assessment do not have EALs.

Table 1: Environmental Assessment Levels (EALs) for Metals

Metal	AAD Limit / Target (ng/m³)	EALs (ng/m³) – IPPC H1 (2003)		EALs (ng/m³) – EA 2016	
		Long-term	Short-term	Long-term	Short-term
Arsenic	6	200	15,000	3	-
Antimony	-	5,000	150,000	5,000	150,000
Cadmium	5	5	1,500	5	-
Chromium (II & III)	-	5,000	150,000	5,000	150
Chromium (VI)	-	100	3,000	0.0002	-
Cobalt	-	200	6,000	-	-
Copper	-	10,000	200,000	10,000	200
Lead	500 (250 AQS Target)	500	-	250	-
Manganese	-	1,000	1,500,000	150	1500
Mercury	-	250	7,500	250	7.5
Nickel (total nickel compounds in the PM_{10} fraction)	20	-	-	20	-
Nickel and inorganic compounds (as Ni)	-	1,000	30,000	-	-
Nickel, organic compounds (as Ni)		10,000	300,000	-	-
Thallium	-	1,000	30,000	-	-
Vanadium	-	5,000	1,000	5	1

2.1.11 Dioxins and furans

Dioxins and furans are a group of organic compounds with similar structures, which are formed as a result of combustion in the presence of chlorine. Principal sources include steel production, power generation, coal combustion and uncontrolled combustion, such as bonfires. The Municipal Waste Incineration Directive and UK legislation imposed strict limits on dioxin emissions in 1995, with the result that current emissions from incineration of municipal solid waste in the UK in 1999 were less than 1% of the emissions from waste incinerators in 1995. The Waste Incineration Directive, now included in the IED, imposed even lower limits, reducing the limit to one tenth of the previously permitted level and the BAT-AELs in the Waste Incineration BREF reduce the limits even more.

One dioxin, 2,3,7,8-TCDD, is a definite carcinogen and a number of other dioxins and furans and dioxin-like PCBs are considered to be possible carcinogens. A tolerable daily intake for dioxins, furans and dioxin-like PCBs of 2 pg I-TEQ per kg bodyweight per day has been recommended by the Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment. This is expressed as the total intake from inhalation and ingestion. The Human Health Risk Assessment (Appendix 8.5 of the EIAR) considers the intake from inhalation and ingestion and compares this to the tolerable daily intake.

2.1.12 Polychlorinated biphenyl (PCBs)

PCBs have high thermal, chemical and electrical stability and were manufactured in large quantities in the UK between the 1950s and mid 1970s. Commercial PCB mixtures, which contained a range of dioxin-like and non-dioxin like congeners, were sold under a variety of trade names, the most common in the UK being the Aroclor mixtures. UK legislative restrictions on the use of PCBs were first introduced in the early 1970s.

Although now banned from production current atmospheric levels of PCBs are due to the ongoing primary anthropogenic emissions (e.g. accidental release of products or materials containing PCBs), volatilisation from environmental reservoirs which have previously received PCBs (e.g. sea and soil) or incidental formation of some congeners during the combustion process.

There are no objectives for PCBs contained within the AQS. However, IPPC H1 (2003) defines the short-term EAL as 6 µg/m³ and the long-term EAL as 0.2 µg/m³. These are the same as those set in the Environment Agency's Air Emissions Guidance.

A number of PCBs are considered to possess dioxin like toxicity and are known as dioxin-like PCBs. The effect of emissions of dioxins, furans and dioxin-like PCBs has been assessed within the Human Health Risk Assessment (Appendix 8.5 of the EIAR). .

2.1.13 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are members of a large group of organic compounds widely distributed in the atmosphere. The best known PAH is benzo[a]pyrene (B[a]P). The AQS included an objective to limit the annual mean of B[a]P to 0.25 ng/m³. This goes beyond the requirements of European Directives, since the fourth Daughter Directive on air quality (Commission Decision 2004/107/EC) includes a target value for B[a]P of 1 ng/m³ as an annual mean which was transposed in to Scottish legislation via the Air Quality Standards (Scotland) Regulations .

2.1.14 Summary

AAD Target and Limit Values, AQS Objectives, and EALs are set at levels well below those at which significant adverse health effects have been observed in the general population and in particularly sensitive groups. For the remainder of this report these are collectively referred to as AQALs. Table 2 to Table 4 summarise the air quality objectives and guidelines used in this assessment. The sources for each of the values can be found in the preceding sections.

Table 2: Air Quality Assessment Levels (AQALs)

Pollutant	AQAL ($\mu g/m^3$)	Averaging period	Frequency of exceedances	Source
Nitrogen dioxide	200	1 hour	18 times per year (99.79th percentile)	AAD Limit Value
	40	Annual	-	AAD Limit Value
Sulphur dioxide	266	15 minutes	35 times per year (99.9th percentile)	AQS Objective
	350	1 hour	24 times per year (99.73rd percentile)	AAD Limit Value
	125	24 hours	3 times per year (99.18th percentile)	AAD Limit Value
Particulate matter (PM10)	50	24 hours	7 times per year (98.1stpercentile)	AQS Objective (Scotland)
	18	Annual	-	AQS Objective (Scotland)
Particulate matter (PM2.5)	10	Annual	-	AQS Objective (Scotland)
Carbon monoxide	10,000	8 hours, running	-	AAD Limit Value
	30,000	1 hour	-	EA (2016)
Hydrogen chloride	750	1 hour		EA (2016)
	20	Annual	-	IPPC H1 (2003)
Hydrogen fluoride	160	1 hour	-	EA (2016)
	16	Annual	-	EA (2016)
Ammonia	2,500	1 hour	-	IPPC H1 (2003)
	180	Annual	-	IPPC H1 (2003)
Benzene	3.25	Annual	-	EA (2016)
	195	1 hour	-	IPPC H1 (2003)
1,3-butadiene	2.25	Annual, running	-	AQS Objective
PCBs	6	1-hour	-	IPPC H1 (2003)
	0.2	Annual	-	IPPC H1 (2003)
PAHs	0.00025	Annual	-	AQS Objective

Table 3: Air Quality Assessment Levels for Metals

Pollutant	AQAL (ng/m^3)	Averaging Period	Source
Cadmium	1,500	1 hour	IPPC H1 (2003)
	5	Annual	AAD Target Value
Thallium	30,000	1 hour	IPPC H1 (2003)

Pollutant	AQAL (ng/m³)	Averaging Period	Source
	1,000	Annual	IPPC H1 (2003)
Mercury	7,500	1 hour	IPPC H1 (2003)
	250	Annual	IPPC H1 (2003)
Antimony	150,000	1 hour	IPPC H1 (2003)
	5,000	Annual	IPPC H1 (2003)
Arsenic	15,000	1 hour	IPPC H1 (2003)
	3	Annual	EA (2016)
Cadmium	1,500	1 hour	IPPC H1 (2003)
	5	Annual	IPPC H1 (2003)
Chromium (II & III)	150,000	1 hour	IPPC H1 (2003)
	5,000	Annual	IPPC H1 (2003)
Chromium (VI)	3,000	1 hour	IPPC H1 (2003)
	0.2	Annual	EA (2016)
Cobalt	6,000	1 hour	IPPC H1 (2003)
	200	Annual	IPPC H1 (2003)
Copper	200,000	1 hour	IPPC H1 (2003)
	10,000	Annual	IPPC H1 (2003)
Lead	-	1 hour	-
	250	Annual	AQS Target
Manganese	1,500,000	1 hour	IPPC H1 (2003)
	150	Annual	EA (2016)
Nickel	30,000	1 hour	IPPC H1 (2003)
	20	Annual	AAD Limit
Vanadium	1,000	1 hour	IPPC H1 (2003)
	5,000	Annual	IPPC H1 (2003)

Table 4: Critical Levels for the Protection of Vegetation and Ecosystems

Pollutant	Concentration (µg/m³)	Measured as	Source
Nitrogen oxides (as nitrogen dioxide)	75	Daily mean	APIS
	30	Annual mean	AAD Critical Level
Sulphur dioxide	10	Annual mean for sensitive lichen communities and bryophytes and ecosystems where lichens and bryophytes are an important part of the ecosystems integrity	IPPC H1 / APIS
	20	Annual mean	AAD Critical Level

Pollutant	Concentration (µg/m³)	Measured as	Source
		for all higher plants	
Hydrogen fluoride	5	Daily mean	Air Emissions Guidance / APIS
	0.5	Weekly mean	Air Emissions Guidance / APIS
Ammonia	1	Annual mean for sensitive lichen communities and bryophytes and ecosystems where lichens and bryophytes are an important part of the ecosystems integrity	APIS
	3	Annual mean for all higher plants	APIS

2.2 Areas of relevant exposure

The AQALs apply only at areas of exposure relevant to the assessment level. The following table extracted from Local Authority Air Quality Technical Guidance (2016) (LAQM.TG(16))[3] explains where the AQALs apply.

Table 5: Guidance on Where AQALs Apply

Averaging period	AQALs should apply at:	AQALs should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short-term.
24-hour mean and 8-hour mean	All locations where the annual mean AQAL would apply, together with hotels. Gardens of residential properties.	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short-term.

[3] Department for Environment, Food and Rural Affairs, Local Air Quality Management Technical Guidance (TG16), February 2018, available at: https://laqm.defra.gov.uk/documents/LAQM-TG16-February-18-v1.pdf

Averaging period	AQALs should apply at:	AQALs should generally not apply at:
1-hour mean	All locations where the annual mean and 24 and 8-hour mean AQALs apply. Kerbside sites (for example, pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.

Source: Box 1.1 LAQM.TG(16)

3 Sensitive Receptors

As part of this assessment, the predicted Process Contribution (PC) at the point of maximum impact and a number of sensitive receptors has been evaluated.

3.1 Human sensitive receptors

The human sensitive receptors identified for assessment are displayed in Figure 1 of Annex E and listed in Table 6. These have been identified to represent residential properties, farms and schools within 3 km of the application site.

Table 6: Human Sensitive Receptors

ID	Name	Location		Distance from the stack (m)
		X (m)	Y (m)	
R1	Pennymore	248884	621862	1,986
R2	Findlayston	250156	620463	2,447
R3	Holehouse	249570	619960	1,876
R4	Bardarroch Farm	247095	618531	1,833
R5	Hunterston	246279	621583	1,958
R6	Creoch House	247623	620969	720
R7	Ardmhor	247622	621096	847
R8	The Bungalow	248878	621553	1,741
R9	Knowe View	249895	620966	2,290
R10	Gallowlee Avenue	250241	620991	2,628
R11	Torview	248903	620814	1,311
R12	Mote Toll	249057	620619	1,388
R13	Netherton	250498	620708	2,817
R14	North Palmerston	250712	620043	3,002
R15	The Bungalow	250697	619775	3,018
R16	Hilltop	249337	619489	1,791
R17	Auchness Cottage	248554	619646	1,034
R18	Lessnessock Bungalows	248306	619658	838
R19	Provost Mount	247711	619866	389
R20	Clydenoch	247290	619272	1,072
R21	Oakmount	246933	618100	2,293
R22	The Cottage	246426	619844	1,355
R23	Shield	245279	619923	2,461
R24	Briardene Cottage	245108	621159	2,762
R25	Alpbach	245396	621344	2,564
R26	House Fox Hollow	246050	621589	2,136

ID	Name	Location		Distance from the stack (m)
		X (m)	Y (m)	
R27	Gowanpark House	247977	622321	2,082
R28	Gargowan	247489	622329	2,087
R29	Steelpark	248503	622454	2,335
R30	Corselet	248450	621650	1,576
R31	Cawhillan	249237	621552	1,998
R32	Slatehole	249078	623077	3,133
R33	Barturk	249516	622088	2,568
R34	Low Carston	249945	621752	2,684
R35	Hill of Ochiltree	250016	621331	2,538
R36	High Tarbeg	248610	620713	1,003
R37	Back o'Hill	250217	619821	2,537
R38	South Palmerston	250786	619544	3,150
R39	Glenconner	249470	619350	1,972
R40	Barquharrie	250259	619079	2,800
R41	Burnockstone	250123	618685	2,872
R42	Lessnessock	248181	619633	776
R43	Barlosh Court	248066	618199	2,085
R44	High Plyde	248906	617702	2,816
R45	Burnton	249367	617985	2,806
R46	Bardarroch	247373	618715	1,578
R47	Killochside	247386	620184	339
R48	Treesmax	246082	618570	2,348
R49	East Tarelgin	246665	619857	1,125
R50	Macquittiston	246068	619250	1,932
R51	Lochmark Farm	245065	619639	2,723
R52	West Tarelgin	246137	620014	1,599
R53	Chipperlaigan	245629	620735	2,143
R54	Hoodston	245937	620972	1,920
R55	Speirston	246330	621261	1,714
R56	Braehead	246828	621708	1,704
R57	Trabbochburn	246676	621872	1,924
R58	Laigh Tarbeg	248730	620437	1,029
R59	Tarelgin Smokehouse	246115	619720	1,690
R60	Gemmell's Garden Centre	245656	621496	2,406
R61	Ochiltree Primary School	250523	621047	2,915
R62	Watson	249647	621013	2,073

ID	Name	Location		Distance from the stack (m)
		X (m)	Y (m)	
R63	Ochiltree Corner - Ayr Road	250682	621117	3,087
R64	Ochiltree Corner - Main Street 1	250727.5	621184	3,150
R65	Ochiltree Corner - Main Street 2	250744	621172.7	3,162
R66	Ochiltree Corner - Main Street 3	250768	621191	3,191
R67	Ochiltree Corner - Main Street 4	250795	621180	3,213
R68	Ochiltree Corner - Mill Street	250797.5	621197.5	3,221
R69	Ochiltree Corner - Burnock Street 1	250829	621179	3,246
R70	Ochiltree Corner - Burnock Street 2	250839	621151	3,247

3.2 Ecological sensitive receptors

A study was undertaken to identify the following sites of ecological importance in accordance with the following screening distances laid out in IPPC H1:

- Special Protection Areas (SPAs), Special Areas of Conservation (SACs), or Ramsar sites within 15 km of the site;
- Sites of Special Scientific Interest (SSSIs) within 15 km of the site; and
- National Nature Reserves (NNR), Local Nature Reserves (LNRs), local wildlife sites and ancient woodlands within 2 km of the site.

Where habitats are found to cover a large area, multiple receptor points have been selected along the boundary of the ecological site closest to the Proposed Development. The sensitive ecological receptors identified as a result of the study are displayed in Figure 2 of Annex E and are listed in Table 7.

There are multiple sites which have been designated for geological reasons, rather than ecological reasons. These sites are included within Table 7 but do not require further assessment because they are not home to any sensitive habitats or species which could potentially be impacted by emissions from the Proposed Development.

A review of the citation, APIS website and discussions with the project ecologist has been undertaken to determine if lichens or bryophytes are an important part of the ecosystem's integrity at each site. If lichens or bryophytes are present, the more stringent Critical Level has been applied as part of the assessment.

Table 7: Ecological Sensitive Receptors

ID	Site	Designation	Closest point to site		Distance from stack at closest point (km)	Lichens/ bryo-phytes present
			X (m)	Y (m)		
European designated sites						
E1	Airds Moss (A)	SAC	257461	624709	10.7	Yes
E2	Airds Moss (B)		259302	622825	11.9	Yes
E3	Muirkirk and North Lowther Uplands (A)	SPA	257418	624779	10.7	Yes

ID	Site	Designation	Closest point to site		Distance from stack at closest point (km)	Lichens/ bryo-phytes present
			X (m)	Y (m)		
E4	Muirkirk and North Lowther Uplands (B)		258148	623668	11.0	Yes
E5	Muirkirk and North Lowther Uplands (C)		254645	633055	14.6	Yes
E6	Muirkirk and North Lowther Uplands (D)		256052	628981	12.1	Yes
E7	Muirkirk and North Lowther Uplands (E)		263344	620377	15.6	Yes
UK designated sites						
E8	River Ayr Gorge	SSSI	245808	624721	4.9	Yes[(1)]
E9	Muirkirk Uplands (A)	SSSI	256110	628851	12.0	Yes
E10	Muirkirk Uplands (B)	SSSI	255179	631719	13.7	Yes
E11	Barlosh Moss (A)	SSSI	248300	618674	1.7	Yes
E12	Barlosh Moss (B)	SSSI	249141	618711	2.1	Yes
E13	Dalmellington Moss	SSSI	246342	606588	13.7	Yes
E14	Bogton Loch	SSSI	246565	605778	14.5	Yes
E15	Martnaham Loch and Wood	SSSI	240321	617764	7.8	Yes
Locally designated sites						
E16	Burnock Water	LWS	249957	620139	2.2	No
E17	Ancient woodland 1	AW	247689	620602	0.3	Yes*
E18	Ancient woodland 2	AW	248241	620679	0.7	Yes*
E19	Ancient woodland 3	AW	248648	620755	1.1	Yes*
E20	Ancient woodland 4	AW	248260	621326	1.2	Yes*
E21	Ancient woodland 5	AW	245905	620304	1.8	Yes*
UK designated sites – geological reasons						
E22	Afton Lodge	SSSI	241591	625802	8.3	No
E23	Stairhill	SSSI	245153	624132	4.6	No
E24	Howford Bridge	SSSI	251274	625107	6.0	No
E25	Greenock Mains	SSSI	263280	627653	17.2	No
E26	Lugar Sill	SSSI	259823	621527	12.2	No
E27	Nith Bridge	SSSI	259294	614130	13.1	No
E28	Benbeoch	SSSI	248945	608874	11.4	No
E29	Dunaskin Glen	SSSI	245597	609165	11.3	No
Notes: AW = ancient woodland						

ID	Site	Designation	Closest point to site		Distance from stack at closest point (km)	Lichens/ bryo-phytes present
			X (m)	Y (m)		

(1) Lichens not listed as a site feature but considered likely- conservatively have assumed 'yes'.

(*) For the ancient woodland sites, there is no botanical data available. It is likely that there are some lichen and bryophyte species present, but they are unlikely to be a key part of the system integrity. To be conservative, their presence has been assumed and this has been further assessed by the ecologist if necessary.

4 Dispersion Modelling Methodology

4.1 Selection of model

Detailed dispersion modelling was undertaken using the model ADMS 5.2, developed and supplied by Cambridge Environmental Research Consultants (CERC) This is a new generation dispersion model, which characterises the atmospheric boundary layer in terms of the atmospheric stability and the boundary layer height. In addition, the model uses a skewed Gaussian distribution for dispersion under convective conditions, to take into account the skewed nature of turbulence. The model also includes modules to take account of the effect of buildings and complex terrain.

ADMS is routinely used for modelling of emissions for planning and permitting purposes to the satisfaction of the SEPA and local authorities. In line with the SEPA's requirements, a sensitivity study has also been undertaken using the USEPA AERMOD model. AERMOD has been run through ADMS 5.2 to ensure that the model inputs are consistent. This prevents variances between model inputs as a result of using the two different models.

4.2 Emission limits

The IED (Directive 2010/75/EU), adopted on 7th January 2013, is the key European Directive which covers almost all regulation of industrial processes in the EU. Within the IED, the requirements of the relevant sector BREF become binding as BAT guidance, as follows.

- Article 15, paragraph 2, of the IED requires that Emission Limit Values (ELVs) are based on best available techniques, referred to as BAT.
- Article 13 of the IED, requires that 'the Commission' develops BAT guidance documents (referred to as BREFs).
- Article 21, paragraph 3, of the IED, requires that when updated BAT conclusions are published, the Competent Authority (in England this is the Environment Agency) has up to four years to revise permits for facilities covered by that activity to comply with the requirements of the sector specific BREF.

The Waste incineration BREF was adopted by the European IPPC Bureau in December 2019. The BREF introduces BAT-Associated Emission Limits (BAT-AELs) which are more stringent than the ELVs currently set out in the IED. It has been assumed that stack emissions from the Proposed Development will comply with the BAT-AELs, or the emission limits from Annex VI Part 3 of the IED for waste incineration plants where BAT-AELs are not applicable.

4.3 Source and emissions data

The principal inputs to the model with respect to the process emissions to air from the Proposed Development are presented in Table 8 and Table 9. This data is based a thermal input capacity of approximately 54.7 MWth, assuming the combustion of 18.2 tonnes per hour of residual waste with a net calorific value of 10.5 MJ/kg

Table 8: Stack Source Data

Item	Unit	Value
Stack Data		
Height	m	75

Item	Unit	Value
Internal diameter	m	1.8
Location	m, m	247717.7, 620254.9
Flue Gas Conditions		
Temperature	°C	130
Exit moisture content	% v/v	16.22%
	kg/kg	0.116
Exit oxygen content	% v/v dry	7.39%
Reference oxygen content	% v/v dry	11%
Volume at reference conditions (dry, ref O_2)	Nm^3/s	30.53
Volume at actual conditions	Am^3/s	39.46
Exit velocity	m/s	15.51

Table 9: Stack Emissions Data

Pollutant	Conc. (mg/Nm^3)		Release rate (g/s)	
	Daily or periodic	Half-hourly	Daily or periodic	Half-hourly
Oxides of nitrogen (as NO_2)	120	400	3.663	12.210
Sulphur dioxide	30	200	0.916	6.105
Carbon monoxide	50	100(1)	1.526	3.053
Fine Particulate Matter (PM)(2)	5	30	0.153	0.916
Hydrogen chloride	6	60	0.183	1.832
Volatile organic compounds (as TOC)	10	20	0.305	0.611
Hydrogen fluoride	1	4	0.031	0.122
Ammonia	10	-	0.305	-
Cadmium and thallium	0.02	-	0. 611 (mg/s)	-
Mercury	0.02	0.035	0. 611 mg/s	1.068 (mg/s)
Other metals(3)	0.3	-	9.158 (mg/s)	-
Dioxins and furans	0.06 ngITEQ/Nm3	-	1.831 (ng/s	-
Benzo(a)pyrene (PaHs) (4)	0.0002	-	6.1051 µg/s	-
PCBs(5)	0.005	-	0.153 (mg/s)	-

Notes:

All emissions are expressed at reference conditions of dry gas, 11% oxygen, 273.15K.

(1) Averaging period for carbon monoxide is 95% of all 10-minute averages in any 24-hour period.

Pollutant	Conc. (mg/Nm³)		Release rate (g/s)	
	Daily or periodic	Half-hourly	Daily or periodic	Half-hourly
(2) As a worst-case it has been assumed that the entire PM emissions consist of either PM10 or PM2.5 for comparison with the relevant AQALs. (3) Other metals consist of antimony (Sb), arsenic (As), lead (Pb), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni) and vanadium (V). (4) Figure 8.121 of the Waste Incineration BREF shows that the maximum B[a]P concentration from an ERF was 0.4 µg/Nm3 (dry, 11% oxygen, 273K). However, this was an outliner, being twice as high as the next highest concentration, and was recorded at a German plant. The maximum monitored concentration of B[a]P for a UK plant was 0.2 µg/m^3. In lieu of any specific limit, this has been assumed to be the emission concentration for the ERP. (5) The 2006 Waste Incineration BREF provided a range of values for PCB emissions to air from European municipal waste incineration plants. This stated that the annual average total PCBs is less than 0.005 mg/Nm³ (dry, 11% oxygen, 273K). The latest version of the BREF (2019) does not include any data on the emissions of total PCBs. In lieu of any specific limit, the data from 2006 Waste Incineration BREF has been assumed to be the emission concentration for the Proposed Development.				

The Proposed Development will be designed to operate at full capacity and is not anticipated to have significant changes in loading. Therefore, it is appropriate to base the assessment on the design point of the system. If the Proposed Development continually operated at the half-hourly limits, the daily limits would be exceeded. The Proposed Development is designed to achieve the daily limits and as such will only operate at the short-term limits for short periods on rare occasions.

4.4 Other Inputs

4.4.1 Modelling domain

Various model runs have been undertaken at various grid sizes and spatial resolutions. To assess the impact at human receptors, a grid size of 7.5 km x 7.5 km has been used with a spatial resolution of 75 m. This covers the extent of all chosen human receptors and uses a spatial resolution of less than 1.5 times the stack height, which is the widely accepted method. To improve accuracy of emissions closer to the stack, and surrounding the point of maximum impact, a nested grid approach has been used for the smaller area of 2 km x 2 km at a spatial resolution of 20 m.

Reference should be made to Figure 3 of Annex E for a graphical representation of the modelling domain used. The extent of the modelling domain is detailed in Table 10.

Table 10: Modelling Domain

Grid Quantity	Value
Human receptor grid	
Grid spacing (m)	75
Grid points	101
Grid Start X (m)	243950
Grid Finish X (m)	251450

Grid Quantity	Value
Grid Start Y (m)	616550
Grid Finish Y (m)	624050
Human receptor nested grid	
Grid spacing (m)	20
Grid points	101
Grid Start X (m)	246700
Grid Finish X (m)	248700
Grid Start Y (m)	619300
Grid Finish Y (m)	621300

4.4.2 Meteorological data and surface characteristics

The impact of meteorological data was taken into account by using weather data from Prestwick meteorological station for the years 2015 – 2019. The data was obtained from ADM Limited. Prestwick airport is approximately 13 km to the north west of the Proposed Development and is the closest and most representative meteorological recording station available. Prestwick meteorological station is located at an elevation of 20 metres above sea level, compared to approximately 156 m at the Proposed Development. However, this is not expected to significantly affect the meteorological parameters used for dispersion modelling. Five years of data have been used to take into account inter-annual fluctuations in weather conditions. Wind roses from Prestwick Airport for each year can be found in

Figure 4 of Annex E.

The minimum Monin-Obukhov length can be selected in ADMS for both the dispersion site and the meteorological site. This is a measure of the minimum stability of the atmosphere and can be adjusted to account for urban heat island effects which prevent the atmosphere in urban areas from ever becoming completely stable. The minimum Monin-Obukhov length has been set to 1 m, the model default, for the dispersion site. This is deemed most representative of the surrounding rural area of the site. The meteorological site uses a minimum Monin-Obukhov length of 10 m, appropriate for 'small towns' due to the business park and residential areas of Prestwick to the south and west but predominantly rural landscapes to the north and east.

The surface roughness length can be selected in ADMS for both the dispersion site and the meteorological site. The surface roughness has been set to 0.3 m (agricultural areas max) for both the dispersion site and meteorological site. This is deemed most appropriate for the open fields and rural surroundings of the dispersion site and the large areas of open space to the north and east of the meteorological site. The sensitivity of the modelling to the choice of surface roughness has been considered in Section 6.1.

Table 11: Meteorological parameters summary

Parameter	Dispersion site	Meteorological site
Minimum Monin-Obukhov length	1 m	10 m
Surface roughness	0.3 m	0.3 m

4.4.3 Buildings

The presence of adjacent buildings can significantly affect the dispersion of the atmospheric emissions in various ways:

- Wind blowing around a building distorts the flow and creates zones of turbulence. The increased turbulence can cause greater plume mixing.
- The rise and trajectory of the plume may be depressed slightly by the flow distortion. This downwash leads to higher ground level concentrations closer to the stack than those which would be present without the building.

The IPPC H1 recommends that buildings should be included in the modelling if they are both:

- Within 5L of the stack (where L is the smaller of the building height and maximum projected width of the building); and
- Taller than 40% of the stack.

The ADMS 5.2 user guide also states that buildings less than one third of the stack height will not have any effect on dispersion.

A review of the site layout has been undertaken and the details of the applicable buildings are presented in Table 12. The buildings have been modelled at the height of the highest point of the structure. A site plan showing which buildings have been included in the model is presented in Figure 5 of Annex E. The main building has been selected as the boiler hall.

Table 12: Building Details

Buildings	Centre point		Height (m)	Width (m)	Length (m)	Angle (°)
	X (m)	Y (m)				
Boiler Hall	247799.2	620290.5	45	28	55	68
ACC, Turbine hall and technical building	247765	620301	21	16.7	110.5	68
Bunker	247836	620309.4	33.5	53.8	27.6	68
Tipping hall	247870.6	620313	16	35.5	40	68
FGT	247747.5	620270.5	30	27.5	55	68
Visitor centre	247806	620273.5	12	9	55	68

4.4.4 Terrain

CERC recommends that, where gradients within 500 m of the modelling domain are greater than 1 in 10, the complex terrain module within ADMS (FLOWSTAR) should be used. A review of the local area has deemed that the effect of terrain should be taken into account in the modelling.

A terrain file large enough to cover the output grid of points was created using Ordnance Survey Terrain 50 data. Due to the use of two modelling domains for human receptors and to cover all of the ecological receptors, three sizes of terrain files have been used. The parameters of the terrain files used are outlined in Table 13. Reference should be made to Figure 3 of Annex E for a graphical representation of the modelling domain and terrain files used. The sensitivity of the modelling to the use of terrain has been considered in Section 6.1

Table 13: Terrain File Parameters

Parameter	Value
Terrain file used with human receptor grid	
Grid Start X	243400
Grid Finish X	252000
Grid Start Y	616000
Grid Finish Y	624600
Resolution	64 x 64
Terrain file used with human receptor nested grid	
Grid Start X	246000
Grid Finish X	249500
Grid Start Y	618400
Grid Finish Y	621900
Resolution	64 x 64
Terrain file used with ecological receptor grid	
Grid Start X	230000
Grid Finish X	268000
Grid Start Y	600000
Grid Finish Y	638000
Resolution	64 x 64

4.5 Chemistry

The Proposed Development will release nitric oxide (NO) and nitrogen dioxide (NO_2) which are collectively referred to as NOx. In the atmosphere, nitric oxide will be converted to nitrogen dioxide in a reaction with ozone which is influenced by solar radiation. Since the AQALs are expressed in terms of nitrogen dioxide, it is important to be able to assess the conversion rate of nitric oxide to nitrogen dioxide.

Ground level NOx concentrations have been predicted through dispersion modelling. Nitrogen dioxide concentrations reported in the results section assume 70% conversion from NOx to nitrogen dioxide for annual means and a 35% conversion for short term (hourly) concentrations, based upon the worst-case scenario in the Environment Agency methodology, which is accepted for use by SEPA. Given the short travel time to the areas of maximum concentrations, this approach is considered conservative.

4.6 Baseline concentrations

Background concentrations for the assessment have been derived from monitoring and national mapping as presented in Appendix 8.1 - Baseline Analysis. For short term averaging periods, the background concentration has been assumed to be twice the long-term ambient concentration following the methodology set out in IPPC H1.

5 Stack Height Assessment

When determining a suitable stack height, it is best practice to identify the stack height where the rate of reduction in maximum ground level concentration with increased height slows down. This can be identified on a graph as a step change in the slope. This analysis has been carried out for the emissions from the stack of the Proposed Development.

The following parameters were kept constant:

- model – ADMS 5.2
- buildings – included;
- dispersion site surface roughness value – 0.3 m;
- meteorological site surface roughness – 0.3 m;
- dispersion site Monin-Obukhov length – model default;
- meteorological site Monin-Obukhov length – 10 m;
- terrain – included at 64 x 64 resolution; and
- meteorological data used – Prestwick 2015 to 2019.

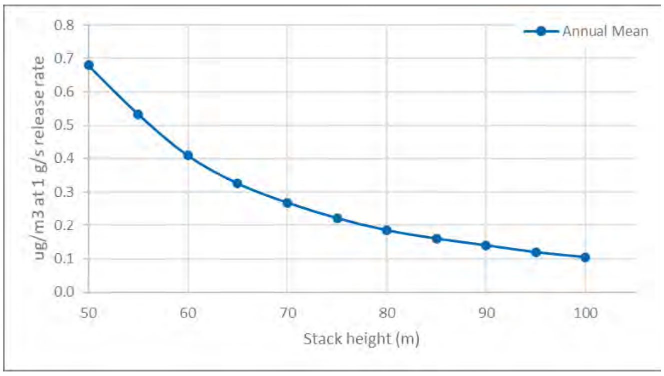
The stack height modelling has been analysed to take into consideration the following key pollutants and averaging periods which align with the AQALs for the protection of human health:

- Annual mean nitrogen dioxide impacts;
- Annual mean particulate matter (as PM_{10}) impacts;
- Annual mean particulate matter (as $PM_{2.5}$) impacts;
- Annual mean chromium VI impacts;
- 99.79th percentile of 1-hour nitrogen dioxide impacts;
- 99.9th percentile of 15-minute mean sulphur dioxide impacts.

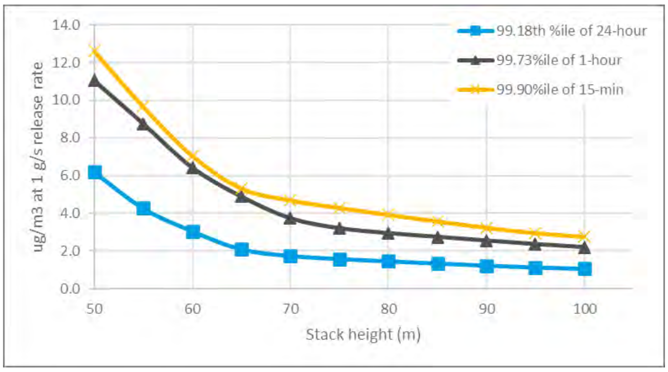
5.1 Analysis

The following graphs show the annual mean (Graph 1) and short term mean (Graph 2) ground level concentration based on an emission rate of 1 g/s from the Proposed Development.

Graph 1: Stack height analysis – annual mean at 1 g/s emission rate



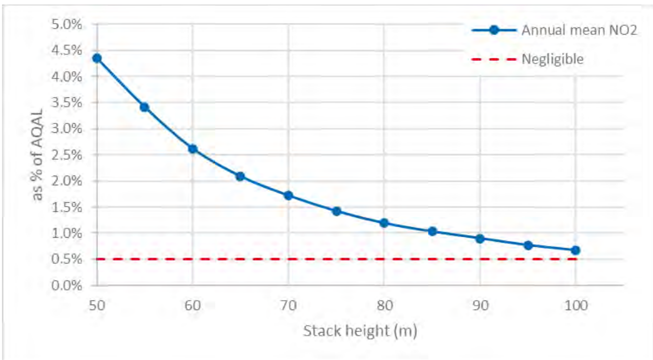
Graph 2: Stack height analysis – short term at 1 g/s emission rate



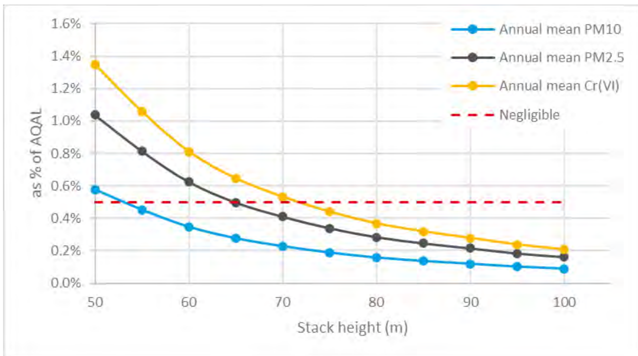
As shown, for annual mean results the change is gradual with height and there is not an obvious step change in slope. However, the results of the short term percentiles clearly show that the rate of reduction in concentration with increased stack height slow down at 65 m. This would therefore be the minimum suggested stack height. However, further assessment of the impacts of pollutants in comparison to the relevant AQALs is required, as follows.

The following graphs shows the predicted impact of the Proposed Development at the point of maximum impact for the range of stack heights considered.

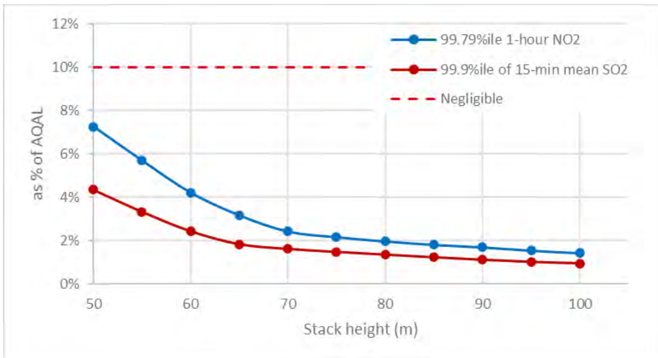
Graph 3: Annual mean at daily ELV - nitrogen dioxide



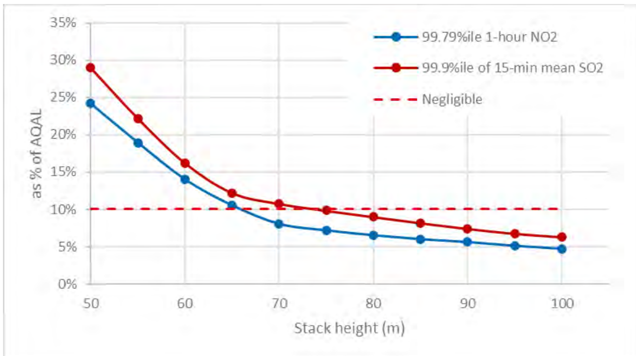
Graph 4: Annual means at daily ELVs – other pollutants



Graph 5: Short term means at daily ELVs



Graph 6: Short term means at half hourly ELVs



Graphs 4 to 6 show that at a stack height of 75 m, at the point of maximum impact:

- all annual mean impacts of particulate matter and chromium VI are less than 0.5% of the AQAL and can be described as 'negligible', 'insignificant' or 'not significant' irrespective of background conditions; and
- all short term impacts are less than 10% of the AQAL and can be described as 'negligible' or 'insignificant' if it is assumed that the plant operates at the daily BAT-AELs.

However, at a 75 m stack height annual mean nitrogen dioxide is greater than 0.5% of the AQAL and cannot screen out as negligible irrespective of background levels. This would be the case even at higher stack heights up to 100 m, higher than which was not considered in this assessment. Further analysis shows that when the low background conditions are considered, the PC at the point of maximum impact is well below 5% of the AQAL and the PEC is well below 75%. Therefore, for planning purposes, the impact would still be described as negligible. For permitting, the PEC at the point of maximum impact is well below 70% of the AQAL and so the impact can be described as not significant.

At a stack height of 75 m, 99.9%ile of 15 minute means sulphur dioxide just exceeds the 10% of the AQAL screening criteria when it is assumed the Proposed Development operates at half-hourly ELVs as set out in the IED (i.e. 200 mg/Nm^3). This is four times the daily ELV set in the IED (50 mg/Nm^3). The Waste Incineration BREF introduces a more stringent limit of 30 mg/Nm^3. If the same ratio is applied the maximum process contribution is predicted to be 7% of the AQAL. It is unlikely that the plant would operate at the half-hourly ELV during the worst-case weather conditions for dispersion. Therefore, there is little risk that the impact would exceed 10% of the AQAL.

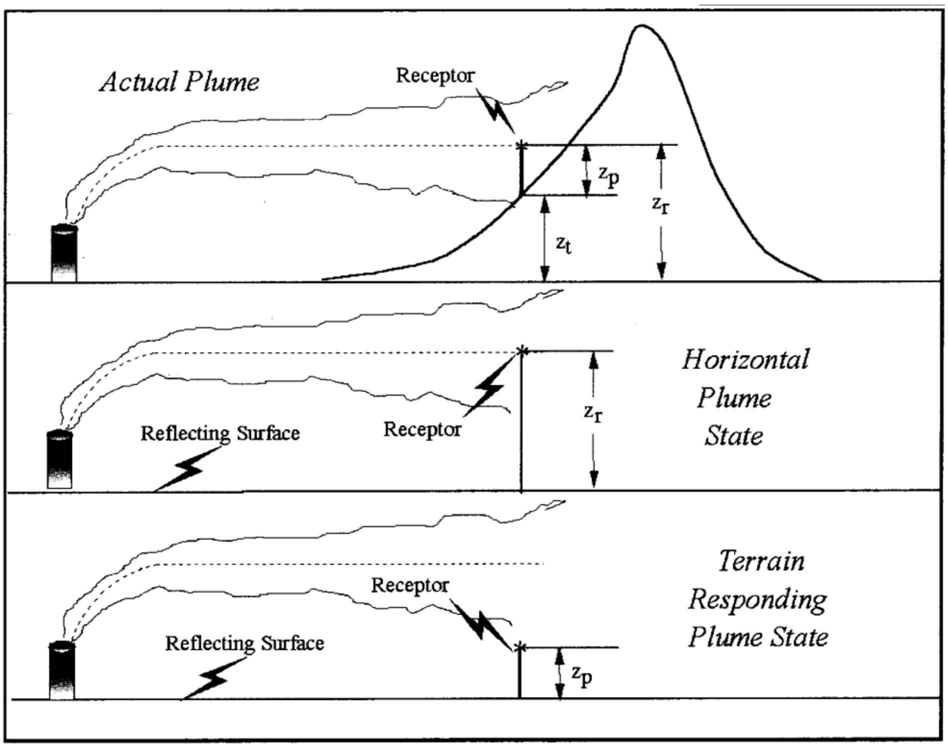
Therefore, a stack height of 75 m provides adequate dispersion of pollutants from the Proposed Development, and the remainder of this assessment has been undertaken for a stack height of 75 m.

6 Sensitivity Analysis

6.1 Choice of model

Within ADMS, the FLOWSTAR module is used to generate a new flow and turbulence field based on the terrain. This simulates the changes to the movement of air in the horizontal and vertical direction as a result of the terrain features in that the air flow is simulated flowing above and around raised ground. This modified flow field is then used by the model to predict the dispersion of the pollutants.

Within AERMOD, the effect of terrain is modelled by scaling the sum of two possible extreme plume states as shown in the following figure.



The terrain data is used by the AERMAP processor to determine the hill height scale for each receptor. This is then used to calculate the dividing streamline height and consequently the fraction of the plume mass which is below this height. This is used as the basis of the scaling of the two extreme plume states. AERMOD therefore does not take into account changes in wind flow patterns as a result of presence of terrain features. As such, in areas of complex terrain, ADMS is considered to be the most suitable model and so it has been used as the main model for this application.

To investigate whether the models (including and excluding) are simulating the dispersion of pollutants in a similar way, we have compared the ADMS and AERMOD model outputs. The latest release of the ADMS model, ADMS 5.2, allows the user to run the model with the US EPA developed AERMOD executable. The standard ADMS conversion tool has been used to generate and run the AERMOD version of the model.

The following parameters were kept constant:

- buildings – included;
- dispersion site surface roughness value – 0.3 m;

- meteorological site surface roughness – 0.3 m;
- dispersion site Monin-Obukhov length – model default;
- meteorological site Monin-Obukhov length – 10 m;
- meteorological data used – Prestwick 2019.

The following table outlines the results at the point of maximum impact for nitrogen dioxide using both ADMS and AERMOD assuming a 75 m stack for the Proposed Development.

Table 14: Sensitivity - Choice of Model

Model	Nitrogen dioxide process contribution (µg/m³)		
	Excluding terrain	Including terrain	% Difference
Annual Mean			
ADMS 5.2	0.65	0.54	17%
AERMOD	0.30	0.30	2%
% Difference	53%	45%	
Max 1-hour			
ADMS 5.2	41.04	40.36	2%
AERMOD	7.57	9.38	-24%
% Difference	82%	77%	
99.79%ile 1-hour			
ADMS 5.2	10.98	10.61	3.3%
AERMOD	5.75	5.53	3.7%
% Difference	48%	48%	

As shown in Table 22 and presented in Figure 6 of Annex E, the greatest annual mean and short-term impacts are predicted using ADMS 5.2, regardless of whether the effect of terrain is considered or not. The impact of terrain is minimal at the point of maximum impact, but due to the topography of the area terrain effects are considered likely to affect concentrations at receptor locations. As explained previously, in areas of complex terrain, ADMS is considered to be the most suitable model. In addition, ADMS predicts a higher maximum ground-level concentration than AERMOD. Therefore, as a conservative approach, ADMS has been used as the model for this application.

As shown, for both long term and short term nitrogen dioxide impacts, AERMOD predicts lower impacts. The results excluding terrain are more similar, demonstrating the different ways which ADMS and AERMOD process terrain; AERMOD does not take into account changes in wind flow patterns as a result of presence of terrain features, and therefore can underestimate ground level concentrations and is not considered to be representative of the likely ground level concentrations.

6.2 Surface roughness

The sensitivity of the results to using spatially varying surface roughness length has been considered by running the model with a variety of surface roughness lengths for the dispersion site. For all sensitivity analysis the impact of changing model parameters on the maximum annual mean and short-term concentrations of oxides of nitrogen have been considered.

The following parameters were kept constant:

- Stack height – 75 m
- Buildings – included;
- Terrain file – included at 64 x 64 resolution;
- Meteorological site surface roughness – 0.3 m;
- Dispersion site Monin-Obukhov length – model default;
- Meteorological site Monin-Obukhov length – 10 m; and
- Meteorological data used – Prestwick 2019.

The contribution of the Proposed Development to the ground level concentration of the emissions of oxides of nitrogen at the point of maximum predicted concentration is presented in Table 15.

Table 15: Surface Roughness Sensitivity Analysis

Surface roughness (m)	Oxides of nitrogen PC (µg/m³)			
	Point of maximum impact		Maximum impacted receptor	
	Annual mean	Max 1-hour mean	Annual mean	Max 1-hour mean
0.1	0.51	22.94	0.42	14.75
0.2	0.54	42.89	0.42	14.31
0.3	0.54	40.36	0.42	14.01
0.5	0.60	37.25	0.43	13.58
0.7	0.63	35.27	0.44	13.46

As shown, increasing the surface roughness value leads to greater annual mean concentrations but generally lower short-term concentrations. A surface roughness value of 0.3 m was selected for the model as this was deemed the most appropriate for the surrounding landscape which mainly comprises open fields, copses and isolated buildings.

6.3 Building parameters

ADMS 5.2 has a buildings effects module to account for the impact of buildings when it calculates the air flow and dispersion of pollutants from a source. The model works by combining the inputted individual buildings into a single effective building for each wind direction.

The sensitivity of the results to the effect of buildings has been considered by running the model with the buildings presented in Table 12 and with no buildings at all.

The following parameters were kept constant:

- Stack height – 75 m;
- Terrain file – included at 64 x 64 resolution;
- Dispersion site surface roughness value – 0.3 m;
- Meteorological site surface roughness value – 0.3 m;
- Dispersion site Monin-Obukhov length – model default;
- Meteorological site Monin-Obukhov length – 10 m; and
- Meteorological data used – Prestwick 2019.

Table 16 presents the ground level concentration of oxides of nitrogen at the point of maximum predicted concentration for each building scenario.

Table 16: Effect of Buildings

Scenario used in model	Oxides of nitrogen PC (µg/m³)			
	Point of maximum impact		Maximum impacted receptor	
	Annual mean	Max 1-hour mean	Annual mean	Max 1-hour mean
Including buildings presented in Table 12	0.54	40.36	0.42	14.01
Excluding buildings	0.35	17.99	0.32	13.35

As shown, modelling the presence of buildings results in higher annual mean and short-term concentrations. Buildings have been included in the dispersion model as this represents a realistic approach.

6.4 Terrain

The sensitivity of the results to the effect of terrain has been considered by running the model with and without the main human receptor terrain file (at 64 x 64 resolution).

The following parameters were kept constant:

- Stack height – 75 m
- Buildings – included
- Dispersion site surface roughness value – 0.3 m;
- Meteorological site surface roughness – 0.3 m;
- Dispersion site Monin-Obukhov length – model default;
- Meteorological site Monin-Obukhov length – 10 m; and
- Meteorological data used – Prestwick 2019.

Table 16 presents the ground level concentration of oxides of nitrogen at the point of maximum predicted concentration for each terrain scenario.

Table 17: Effect of Terrain

Scenario used in model	Oxides of nitrogen PC (µg/m³)			
	Point of maximum impact		Maximum impacted receptor	
	Annual mean	Max 1-hour mean	Annual mean	Max 1-hour mean
Including terrain	0.54	40.36	0.42	14.01
Excluding terrain	0.65	41.04	0.46	14.27

As shown, including modelling the effect of terrain has minimal effect on the annual mean and maximum 1-hour concentrations. The terrain file has been included in the dispersion model as this represents a realistic approach.

6.5 Sensitivity analysis – operating below the design point

Dispersion modelling has been undertaken based on the emission parameters based on the design point for the Proposed Development. The Proposed Development is to be operated as a commercial plant, so it is beneficial to operate at full capacity. If loading does fall below the design point the volumetric flow rate and the exit velocity of the exhaust gases would reduce. The effect on this would decrease the quantity of pollutants emitted but also reduce the buoyancy of the plume due to momentum. The reduction in buoyancy, which would lead to reduced dispersion, would be more than offset by the decrease in the amount of pollutants being emitted, so that the impact of the plant when running below the design point would be reduced.

7 Impact on Human Health

7.1 At the point of maximum impact

Table 18 and Table 19 present the results of the dispersion modelling of process emissions from the Proposed Development at the point of maximum impact. This is the maximum predicted concentration based on the following:

- The smaller modelling domain size – 2 km by 2 km at 20 m resolution;
- Buildings – included;
- Terrain – included at 64 x 64 resolution;
- Stack height – 75 m;
- 5 years of weather data 2015 to 2019 from Prestwick meteorological recording station;
- Operation at the long term ELVs for 100% of the year;
- Operation at the short term ELVs (Table 19 only);
- Environment Agency's worst case conversion of NOx to nitrogen dioxide;
- The entire VOC emissions are assumed to consist of either benzene or 1,3-butadiene; and
- Cadmium is released at the combined emission limit for cadmium and thallium.

The baseline concentration is taken from the review of baseline monitoring contained in Appendix 8.3 of the EIAR.

Impacts that cannot be described as 'negligible' irrespective of the total concentration in accordance with the IAQM 2017 criteria are highlighted. Where the impact cannot be screened out 'as 'negligible' irrespective of the total concentration, further analysis has been undertaken.

Table 18: Dispersion Modelling Results – Point of Maximum Impact - Daily ELVs

Pollutant	Quantity	Units	AQAL	Bg conc.	PC at point of maximum impact						Max as % of AQAL	PEC (PC +Bg)	PEC as % of AQAL
					2015	2016	2017	2018	2019	Max			
Nitrogen dioxide	Annual mean	µg/m³	40	4.79	0.60	0.55	0.63	0.62	0.45	0.63	1.57%	5.42	13.54%
	99.79th%ile of hourly means	µg/m³	200	9.58	4.03	4.12	3.59	4.46	3.97	4.46	2.23%	14.04	7.02%
Sulphur dioxide	99.18th%ile of daily means	µg/m³	125	6.76	1.08	1.19	1.26	1.50	1.01	1.50	1.20%	8.26	6.61%
	99.73rd%ile of hourly means	µg/m³	350	6.76	2.69	2.85	2.49	3.05	2.62	3.05	0.87%	9.81	2.80%
	99.9th%ile of 15 min. means	µg/m³	266	6.76	3.26	3.57	3.15	4.52	4.28	4.52	1.70%	11.28	4.24%
PM_{10}	Annual mean	µg/m³	18	11.08	0.04	0.03	0.04	0.04	0.03	0.04	0.21%	11.12	61.76%
	98.1st %ile of daily means	µg/m³	50	22.16	0.16	0.17	0.18	0.20	0.14	0.20	0.40%	22.36	44.72%
$PM_{2.5}$	Annual mean	µg/m³	10	5.81	0.04	0.03	0.04	0.04	0.03	0.04	0.37%	5.85	58.47%
Carbon monoxide	8 hour running mean	µg/m³	10000	354	13.62	7.28	11.17	9.23	5.92	13.62	0.14%	367.62	3.68%
	Hourly mean	µg/m³	30000	354	13.62	7.28	11.17	9.23	5.92	13.62	0.05%	367.62	1.23%
Hydrogen chloride	Annual mean	µg/m³	20	0.71	0.04	0.04	0.04	0.04	0.03	0.04	0.22%	0.75	3.77%
	Hourly mean	µg/m³	750	1.42	1.63	2.15	1.49	1.78	1.91	2.15	0.29%	3.57	0.48%
Hydrogen fluoride	Annual mean	µg/m³	16	2.35	0.01	0.01	0.01	0.01	0.01	0.01	0.05%	2.36	14.73%
	Hourly mean	µg/m³	160	4.7	0.27	0.36	0.25	0.30	0.32	0.36	0.22%	5.06	3.16%
Ammonia	Annual mean	µg/m³	180	3.18	0.07	0.07	0.07	0.07	0.05	0.07	0.04%	3.25	1.81%
	Hourly mean	µg/m³	2500	6.36	2.72	3.59	2.48	2.97	3.18	3.59	0.14%	9.95	0.40%

Pollutant	Quantity	Units	AQAL	Bg conc.	PC at point of maximum impact						Max as % of AQAL	PEC (PC +Bg)	PEC as % of AQAL
					2015	2016	2017	2018	2019	Max			
VOCs (as benzene)	Annual mean	µg/m³	3.25	0.23	0.07	0.07	0.07	0.07	0.05	0.07	2.30%	0.30	9.38%
	Hourly mean	µg/m³	195	0.46	2.73	3.60	2.49	2.98	3.19	3.60	1.85%	4.06	2.08%
VOCs (as 1,3-butadiene)	Annual mean	µg/m³	2.25	0.08	0.07	0.07	0.07	0.07	0.05	0.07	3.33%	0.15	6.88%
Mercury	Annual mean	ng/m³	250	2.8	0.14	0.13	0.15	0.15	0.11	0.15	0.06%	2.95	1.18%
	Hourly mean	ng/m³	7500	5.6	5.46	7.20	4.97	5.96	6.38	7.20	0.10%	12.80	0.17%
Cadmium	Annual mean	ng/m³	5	0.57	0.14	0.13	0.15	0.15	0.11	0.15	2.99%	0.72	14.39%
	Hourly mean	ng/m³	1500	1.14	5.46	7.20	4.97	5.96	6.38	7.20	0.48%	8.34	0.56%
Thallium	Annual mean	ng/m³	1000	-	0.14	0.13	0.15	0.15	0.11	0.15	0.01%	-	-
	Hourly mean	ng/m³	30000	-	5.46	7.20	4.97	5.96	6.38	7.20	0.02%	-	-
PAHs	Annual mean	pg/m³	250	980	1.44	1.32	1.50	1.48	1.07	1.50	0.60%	981.50	392.60%
Dioxins	Annual mean	fg/m³	-	32.99	0.43	0.40	0.45	0.44	0.32	0.45	-	33.44	-
PCBs	Annual mean	ng/m³	200	0.12893	0.04	0.03	0.04	0.04	0.03	0.04	0.02%	0.17	0.08%
	Hourly mean	ng/m³	6000	0.25786	1.37	1.80	1.24	1.49	1.60	1.80	0.03%	2.06	0.03%
Other metals	Annual mean	ng/m³	-	-	2.16	1.99	2.25	2.22	1.61	2.25	See metals assessment – Section 7.2.4		
	Hourly mean	ng/m³	-	-	81.93	107.97	74.58	89.35	95.72	107.97			

Note:
All assessment is based on the maximum PC using all 5 years of weather data.

Table 19: Dispersion Modelling Results – Point of Maximum Impact - Short-Term ELVs

Pollutant	Quantity	Units	AQAL	Bg conc.	PC at point of maximum impact						Max as % of AQAL	PEC (PC +Bg)	PEC as % of AQAL
					2014	2015	2016	2017	2018	Max			
Nitrogen dioxide	99.79th%ile of hourly means	µg/m³	200	9.58	13.43	13.73	11.95	14.87	13.23	14.87	7.44%	24.45	12.23%
Sulphur dioxide	99.73rd%ile of hourly means	µg/m³	350	6.76	17.94	18.98	16.58	20.33	17.45	20.33	5.81%	27.09	7.74%
	99.9th%ile of 15 min. means	µg/m³	266	6.76	21.71	23.81	21.02	30.16	28.56	30.16	11.34%	36.92	13.88%
Carbon monoxide	8 hour running mean	µg/m³	10000	354	27.24	14.56	22.34	18.45	11.84	27.24	0.27%	381.24	3.81%
	Hourly mean	µg/m³	30000	354	27.24	14.56	22.34	18.45	11.84	27.24	0.09%	381.24	1.27%
Hydrogen chloride	Hourly mean	µg/m³	750	1.42	16.33	21.52	14.87	17.81	19.08	21.52	2.87%	22.94	3.06%
Hydrogen fluoride	Hourly mean	µg/m³	160	4.7	1.09	1.43	0.99	1.19	1.27	1.43	0.90%	6.13	3.83%
VOCs (as benzene)	Hourly mean	µg/m³	195	0.46	5.46	7.20	4.97	5.96	6.38	7.20	3.69%	7.66	3.93%
Mercury	Hourly mean	ng/m³	7500	5.6	9.56	12.60	8.70	10.42	11.17	12.60	0.17%	18.20	0.24%

Note:
All assessment is based on the maximum PC using all 5 years of weather data and operation at the short-term ELVs.

As shown, at the point of maximum impact all of the PCs are less than 10% of the short-term AQAL when operating at the daily ELVs and less than 0.5% of the annual mean AQAL and can be screened out as 'negligible' irrespective of the total concentration in accordance with the IAQM 2017 guidance, with the exception of the following :

- annual mean nitrogen dioxide impacts;
- annual mean VOCs impacts;
- annual mean cadmium impacts; and
- annual mean PAHs impact.

At the point of maximum impact all of the PCs are less than 10% of the short-term AQAL when operating at the half-hourly ELVs and can be screened out as 'negligible' irrespective of the total concentration in accordance with the IAQM 2017 guidance, with the exception of short term (99.9th%ile of 15 min. means) sulphur dioxide impacts.

Further analysis of the likely future baseline concentrations has been undertaken to define the magnitude of change for annual mean impacts for, and the extent of relevant exposure has been undertaken to determine the magnitude of change for short-term impacts.

7.2 Further assessment

7.2.1 Annual mean nitrogen dioxide

The annual mean nitrogen dioxide PC from the Proposed Development is predicted to be 1.57% of the AQAL at the point of maximum impact. Table 20 details the impact of annual mean nitrogen dioxide contributions from process emissions at the identified sensitive human receptor locations. PCs greater than 0.5% of the AQAL are highlighted. Figure 7 of Annex E shows the spatial distribution of emissions.

Table 20: Annual Mean Nitrogen Dioxide Impact at Identified Sensitive Receptors

Receptor	PC		PEC	
	µg/m³	as % of AQAL	µg/m³	as % of AQAL
R1	0.12	0.29%	4.91	12.26%
R2	0.12	0.30%	4.91	12.28%
R3	0.17	0.42%	4.96	12.39%
R4	0.03	0.06%	4.82	12.04%
R5	0.05	0.13%	4.84	12.11%
R6	0.16	0.41%	4.95	12.38%
R7	0.17	0.42%	4.96	12.40%
R8	0.15	0.38%	4.94	12.36%
R9	0.14	0.35%	4.93	12.32%
R10	0.11	0.29%	4.90	12.26%
R11	0.30	0.75%	5.09	12.72%
R12	0.27	0.68%	5.06	12.66%
R13	0.10	0.25%	4.89	12.23%
R14	0.09	0.23%	4.88	12.20%

Receptor	PC		PEC	
	µg/m³	as % of AQAL	µg/m³	as % of AQAL
R15	0.09	0.21%	4.88	12.19%
R16	0.12	0.31%	4.91	12.28%
R17	0.22	0.54%	5.01	12.52%
R18	0.19	0.48%	4.98	12.46%
R19	0.03	0.08%	4.82	12.05%
R20	0.05	0.13%	4.84	12.10%
R21	0.02	0.05%	4.81	12.03%
R22	0.08	0.21%	4.87	12.18%
R23	0.04	0.11%	4.83	12.09%
R24	0.04	0.11%	4.83	12.08%
R25	0.04	0.11%	4.83	12.08%
R26	0.05	0.12%	4.84	12.09%
R27	0.11	0.28%	4.90	12.25%
R28	0.09	0.22%	4.88	12.19%
R29	0.09	0.22%	4.88	12.19%
R30	0.14	0.35%	4.93	12.32%
R31	0.14	0.36%	4.93	12.33%
R32	0.06	0.14%	4.85	12.12%
R33	0.09	0.23%	4.88	12.21%
R34	0.11	0.27%	4.90	12.25%
R35	0.13	0.32%	4.92	12.29%
R36	0.40	1.00%	5.19	12.98%
R37	0.11	0.27%	4.90	12.25%
R38	0.07	0.19%	4.86	12.16%
R39	0.11	0.26%	4.90	12.24%
R40	0.07	0.16%	4.86	12.14%
R41	0.06	0.16%	4.85	12.13%
R42	0.13	0.32%	4.92	12.30%
R43	0.01	0.03%	4.80	12.01%
R44	0.02	0.06%	4.81	12.04%
R45	0.05	0.13%	4.84	12.10%
R46	0.02	0.06%	4.81	12.04%
R47	0.10	0.26%	4.89	12.23%
R48	0.05	0.13%	4.84	12.11%
R49	0.11	0.28%	4.90	12.26%
R50	0.08	0.21%	4.87	12.18%

Receptor	PC		PEC	
	µg/m³	as % of AQAL	µg/m³	as % of AQAL
R51	0.04	0.10%	4.83	12.07%
R52	0.06	0.15%	4.85	12.13%
R53	0.06	0.14%	4.85	12.11%
R54	0.06	0.14%	4.85	12.12%
R55	0.06	0.14%	4.85	12.11%
R56	0.06	0.16%	4.85	12.14%
R57	0.06	0.14%	4.85	12.12%
R58	0.37	0.92%	5.16	12.90%
R59	0.07	0.18%	4.86	12.15%
R60	0.04	0.11%	4.83	12.08%
R61	0.10	0.25%	4.89	12.22%
R62	0.16	0.41%	4.95	12.39%
R63	0.09	0.23%	4.88	12.21%
R64	0.09	0.23%	4.88	12.20%
R65	0.09	0.22%	4.88	12.20%
R66	0.09	0.22%	4.88	12.20%
R67	0.09	0.22%	4.88	12.19%
R68	0.09	0.22%	4.88	12.19%
R69	0.09	0.22%	4.88	12.19%
R70	0.09	0.21%	4.88	12.19%

7.2.2 Annual mean VOCs

There are two VOCs for which an AQAL has been set: benzene and 1,3-butadiene. For the purpose of this analysis it has been assumed that the entire VOC emissions consist of only benzene or 1,3-butadiene. This is a highly conservative assumption as it does not take into account the speciation of VOCs in the emissions and the modelling does not take into account the volatile nature of the compounds.

The PC from the Proposed Development is predicted to be 2.30% of the AQAL for benzene and 3.33% of the AQAL for 1,3-butadiene at the point of maximum impact. Table 21 and Table 22 detail the impact of annual mean benzene and 1,3-butadiene contributions from process emissions at the identified sensitive human receptor locations. PCs greater than 0.5% of the AQAL are highlighted. Figure 8 and Figure 9 of Annex E show the spatial distribution of emissions.

Table 21: Annual Mean VOCs (as Benzene) Impact at Identified Sensitive Receptors

Receptor	PC		PEC	
	ng/m³	as % of AQAL	ng/m³	as % of AQAL
R1	13.74	0.42%	243.74	7.50%
R2	14.42	0.44%	244.42	7.52%
R3	19.91	0.61%	249.91	7.69%

Receptor	PC		PEC	
	ng/m³	as % of AQAL	ng/m³	as % of AQAL
R4	3.08	0.09%	233.08	7.17%
R5	6.27	0.19%	236.27	7.27%
R6	19.52	0.60%	249.52	7.68%
R7	20.25	0.62%	250.25	7.70%
R8	18.15	0.56%	248.15	7.64%
R9	16.68	0.51%	246.68	7.59%
R10	13.68	0.42%	243.68	7.50%
R11	35.70	1.10%	265.70	8.18%
R12	32.61	1.00%	262.61	8.08%
R13	12.01	0.37%	242.01	7.45%
R14	10.75	0.33%	240.75	7.41%
R15	10.21	0.31%	240.21	7.39%
R16	14.70	0.45%	244.70	7.53%
R17	26.00	0.80%	256.00	7.88%
R18	23.04	0.71%	253.04	7.79%
R19	3.80	0.12%	233.80	7.19%
R20	6.08	0.19%	236.08	7.26%
R21	2.49	0.08%	232.49	7.15%
R22	9.99	0.31%	239.99	7.38%
R23	5.33	0.16%	235.33	7.24%
R24	5.14	0.16%	235.14	7.24%
R25	5.09	0.16%	235.09	7.23%
R26	5.70	0.18%	235.70	7.25%
R27	13.22	0.41%	243.22	7.48%
R28	10.34	0.32%	240.34	7.40%
R29	10.44	0.32%	240.44	7.40%
R30	16.62	0.51%	246.62	7.59%
R31	17.14	0.53%	247.14	7.60%
R32	6.70	0.21%	236.70	7.28%
R33	11.22	0.35%	241.22	7.42%
R34	13.05	0.40%	243.05	7.48%
R35	15.24	0.47%	245.24	7.55%
R36	47.78	1.47%	277.78	8.55%
R37	12.97	0.40%	242.97	7.48%
R38	8.86	0.27%	238.86	7.35%
R39	12.63	0.39%	242.63	7.47%

Receptor	PC		PEC	
	ng/m³	as % of AQAL	ng/m³	as % of AQAL
R40	7.82	0.24%	237.82	7.32%
R41	7.61	0.23%	237.61	7.31%
R42	15.32	0.47%	245.32	7.55%
R43	1.46	0.04%	231.46	7.12%
R44	2.88	0.09%	232.88	7.17%
R45	6.04	0.19%	236.04	7.26%
R46	2.92	0.09%	232.92	7.17%
R47	12.27	0.38%	242.27	7.45%
R48	6.25	0.19%	236.25	7.27%
R49	13.37	0.41%	243.37	7.49%
R50	9.95	0.31%	239.95	7.38%
R51	4.77	0.15%	234.77	7.22%
R52	7.29	0.22%	237.29	7.30%
R53	6.59	0.20%	236.59	7.28%
R54	6.89	0.21%	236.89	7.29%
R55	6.58	0.20%	236.58	7.28%
R56	7.68	0.24%	237.68	7.31%
R57	6.73	0.21%	236.73	7.28%
R58	44.09	1.36%	274.09	8.43%
R59	8.43	0.26%	238.43	7.34%
R60	5.13	0.16%	235.13	7.23%
R61	11.88	0.37%	241.88	7.44%
R62	19.67	0.61%	249.67	7.68%
R63	11.01	0.34%	241.01	7.42%
R64	10.80	0.33%	240.80	7.41%
R65	10.71	0.33%	240.71	7.41%
R66	10.60	0.33%	240.60	7.40%
R67	10.47	0.32%	240.47	7.40%
R68	10.47	0.32%	240.47	7.40%
R69	10.32	0.32%	240.32	7.39%
R70	10.26	0.32%	240.26	7.39%

Table 22: Annual Mean VOCs (as 1,3-Butadiene) Impact at Identified Sensitive Receptors

Receptor	PC		PEC	
	ng/m³	as % of AQAL	ng/m³	as % of AQAL
R1	13.74	0.61%	93.74	4.17%

Receptor	PC		PEC	
	ng/m³	as % of AQAL	ng/m³	as % of AQAL
R2	14.42	0.64%	94.42	4.20%
R3	19.91	0.89%	99.91	4.44%
R4	3.08	0.14%	83.08	3.69%
R5	6.27	0.28%	86.27	3.83%
R6	19.52	0.87%	99.52	4.42%
R7	20.25	0.90%	100.25	4.46%
R8	18.15	0.81%	98.15	4.36%
R9	16.68	0.74%	96.68	4.30%
R10	13.68	0.61%	93.68	4.16%
R11	35.70	1.59%	115.70	5.14%
R12	32.61	1.45%	112.61	5.00%
R13	12.01	0.53%	92.01	4.09%
R14	10.75	0.48%	90.75	4.03%
R15	10.21	0.45%	90.21	4.01%
R16	14.70	0.65%	94.70	4.21%
R17	26.00	1.16%	106.00	4.71%
R18	23.04	1.02%	103.04	4.58%
R19	3.80	0.17%	83.80	3.72%
R20	6.08	0.27%	86.08	3.83%
R21	2.49	0.11%	82.49	3.67%
R22	9.99	0.44%	89.99	4.00%
R23	5.33	0.24%	85.33	3.79%
R24	5.14	0.23%	85.14	3.78%
R25	5.09	0.23%	85.09	3.78%
R26	5.70	0.25%	85.70	3.81%
R27	13.22	0.59%	93.22	4.14%
R28	10.34	0.46%	90.34	4.02%
R29	10.44	0.46%	90.44	4.02%
R30	16.62	0.74%	96.62	4.29%
R31	17.14	0.76%	97.14	4.32%
R32	6.70	0.30%	86.70	3.85%
R33	11.22	0.50%	91.22	4.05%
R34	13.05	0.58%	93.05	4.14%
R35	15.24	0.68%	95.24	4.23%
R36	47.78	2.12%	127.78	5.68%
R37	12.97	0.58%	92.97	4.13%

Receptor	PC		PEC	
	ng/m³	as % of AQAL	ng/m³	as % of AQAL
R38	8.86	0.39%	88.86	3.95%
R39	12.63	0.56%	92.63	4.12%
R40	7.82	0.35%	87.82	3.90%
R41	7.61	0.34%	87.61	3.89%
R42	15.32	0.68%	95.32	4.24%
R43	1.46	0.06%	81.46	3.62%
R44	2.88	0.13%	82.88	3.68%
R45	6.04	0.27%	86.04	3.82%
R46	2.92	0.13%	82.92	3.69%
R47	12.27	0.55%	92.27	4.10%
R48	6.25	0.28%	86.25	3.83%
R49	13.37	0.59%	93.37	4.15%
R50	9.95	0.44%	89.95	4.00%
R51	4.77	0.21%	84.77	3.77%
R52	7.29	0.32%	87.29	3.88%
R53	6.59	0.29%	86.59	3.85%
R54	6.89	0.31%	86.89	3.86%
R55	6.58	0.29%	86.58	3.85%
R56	7.68	0.34%	87.68	3.90%
R57	6.73	0.30%	86.73	3.85%
R58	44.09	1.96%	124.09	5.51%
R59	8.43	0.37%	88.43	3.93%
R60	5.13	0.23%	85.13	3.78%
R61	11.88	0.53%	91.88	4.08%
R62	19.67	0.87%	99.67	4.43%
R63	11.01	0.49%	91.01	4.05%
R64	10.80	0.48%	90.80	4.04%
R65	10.71	0.48%	90.71	4.03%
R66	10.60	0.47%	90.60	4.03%
R67	10.47	0.47%	90.47	4.02%
R68	10.47	0.47%	90.47	4.02%
R69	10.32	0.46%	90.32	4.01%
R70	10.26	0.46%	90.26	4.01%

7.2.3 Annual mean cadmium

The annual mean cadmium PC from the Proposed Development is predicted to be 3.07% of the AQAL. However, this assumes that the entire cadmium and thallium emissions consist of only cadmium. The Waste Incineration BREF shows that the average concentration recorded from UK plants equipped with bag filters was 1.6 µg/Nm^3 (or 8% of the ELV of 0.02 mg/Nm^3), the highest recorded concentration of cadmium and thallium was 14 µg/Nm^3 (or 70% of the ELV of 0.02 mg/Nm^3) and only three lines recorded concentrations higher than 10 µg/Nm^3 (or 50% of the ELV of 0.02 mg/Nm^3).

Table 23 shows the annual mean cadmium PC at the identified sensitive human receptor locations, for cadmium emitted at 100%, 50% and 8% of the ELV, referred to as the 'screening', 'worst case' and 'typical' scenarios. PCs greater than 0.5% of the AQAL are highlighted. Figure 10 of Annex E shows the spatial distribution of emissions for all three scenarios.

Table 23: Annual Mean Cadmium Impact at Identified Sensitive Receptors

Receptor	PC (as % of AQAL)					
	Screening		Worst-case		Typical	
	ng/m³	% AQAL	ng/m³	% AQAL	ng/m³	% AQAL
R1	27.49	0.55%	13.74	0.27%	2.20	0.04%
R2	28.83	0.58%	14.42	0.29%	2.31	0.05%
R3	39.83	0.80%	19.91	0.40%	3.19	0.06%
R4	6.16	0.12%	3.08	0.06%	0.49	0.01%
R5	12.54	0.25%	6.27	0.13%	1.00	0.02%
R6	39.03	0.78%	19.52	0.39%	3.12	0.06%
R7	40.49	0.81%	20.25	0.40%	3.24	0.06%
R8	36.31	0.73%	18.15	0.36%	2.90	0.06%
R9	33.36	0.67%	16.68	0.33%	2.67	0.05%
R10	27.35	0.55%	13.68	0.27%	2.19	0.04%
R11	71.41	1.43%	35.70	0.71%	5.71	0.11%
R12	65.21	1.30%	32.61	0.65%	5.22	0.10%
R13	24.03	0.48%	12.01	0.24%	1.92	0.04%
R14	21.50	0.43%	10.75	0.21%	1.72	0.03%
R15	20.43	0.41%	10.21	0.20%	1.63	0.03%
R16	29.40	0.59%	14.70	0.29%	2.35	0.05%
R17	52.00	1.04%	26.00	0.52%	4.16	0.08%
R18	46.08	0.92%	23.04	0.46%	3.69	0.07%
R19	7.60	0.15%	3.80	0.08%	0.61	0.01%
R20	12.16	0.24%	6.08	0.12%	0.97	0.02%
R21	4.97	0.10%	2.49	0.05%	0.40	0.01%
R22	19.98	0.40%	9.99	0.20%	1.60	0.03%
R23	10.65	0.21%	5.33	0.11%	0.85	0.02%
R24	10.28	0.21%	5.14	0.10%	0.82	0.02%

Receptor	PC (as % of AQAL)					
	Screening		Worst-case		Typical	
	ng/m³	% AQAL	ng/m³	% AQAL	ng/m³	% AQAL
R25	10.17	0.20%	5.09	0.10%	0.81	0.02%
R26	11.39	0.23%	5.70	0.11%	0.91	0.02%
R27	26.43	0.53%	13.22	0.26%	2.11	0.04%
R28	20.68	0.41%	10.34	0.21%	1.65	0.03%
R29	20.88	0.42%	10.44	0.21%	1.67	0.03%
R30	33.25	0.66%	16.62	0.33%	2.66	0.05%
R31	34.28	0.69%	17.14	0.34%	2.74	0.05%
R32	13.40	0.27%	6.70	0.13%	1.07	0.02%
R33	22.43	0.45%	11.22	0.22%	1.79	0.04%
R34	26.10	0.52%	13.05	0.26%	2.09	0.04%
R35	30.48	0.61%	15.24	0.30%	2.44	0.05%
R36	95.57	1.91%	47.78	0.96%	7.65	0.15%
R37	25.95	0.52%	12.97	0.26%	2.08	0.04%
R38	17.73	0.35%	8.86	0.18%	1.42	0.03%
R39	25.26	0.51%	12.63	0.25%	2.02	0.04%
R40	15.65	0.31%	7.82	0.16%	1.25	0.03%
R41	15.22	0.30%	7.61	0.15%	1.22	0.02%
R42	30.63	0.61%	15.32	0.31%	2.45	0.05%
R43	2.92	0.06%	1.46	0.03%	0.23	0.00%
R44	5.75	0.12%	2.88	0.06%	0.46	0.01%
R45	12.09	0.24%	6.04	0.12%	0.97	0.02%
R46	5.84	0.12%	2.92	0.06%	0.47	0.01%
R47	24.54	0.49%	12.27	0.25%	1.96	0.04%
R48	12.50	0.25%	6.25	0.12%	1.00	0.02%
R49	26.74	0.53%	13.37	0.27%	2.14	0.04%
R50	19.90	0.40%	9.95	0.20%	1.59	0.03%
R51	9.53	0.19%	4.77	0.10%	0.76	0.02%
R52	14.58	0.29%	7.29	0.15%	1.17	0.02%
R53	13.18	0.26%	6.59	0.13%	1.05	0.02%
R54	13.77	0.28%	6.89	0.14%	1.10	0.02%
R55	13.16	0.26%	6.58	0.13%	1.05	0.02%
R56	15.37	0.31%	7.68	0.15%	1.23	0.02%
R57	13.47	0.27%	6.73	0.13%	1.08	0.02%
R58	88.17	1.76%	44.09	0.88%	7.05	0.14%
R59	16.86	0.34%	8.43	0.17%	1.35	0.03%

Receptor	PC (as % of AQAL)					
	Screening		Worst-case		Typical	
	ng/m³	% AQAL	ng/m³	% AQAL	ng/m³	% AQAL
R60	10.27	0.21%	5.13	0.10%	0.82	0.02%
R61	23.75	0.48%	11.88	0.24%	1.90	0.04%
R62	39.35	0.79%	19.67	0.39%	3.15	0.06%
R63	22.03	0.44%	11.01	0.22%	1.76	0.04%
R64	21.61	0.43%	10.80	0.22%	1.73	0.03%
R65	21.43	0.43%	10.71	0.21%	1.71	0.03%
R66	21.20	0.42%	10.60	0.21%	1.70	0.03%
R67	20.94	0.42%	10.47	0.21%	1.68	0.03%
R68	20.94	0.42%	10.47	0.21%	1.67	0.03%
R69	20.64	0.41%	10.32	0.21%	1.65	0.03%
R70	20.53	0.41%	10.26	0.21%	1.64	0.03%

7.2.4 Annual mean PAHs

The annual mean cadmium PC from the Proposed Development is predicted to be 0.60% of the AQAL. Figure 11 of Annex E shows the spatial distribution of emissions as shown the area where impacts are predicted to exceed 0.5% of the AQAL is restricted to a small area to the north-east of the Proposed Development where there is no area of relevant exposure.

7.2.5 15-minute sulphur dioxide

The 99.9th percentile of 15-minute sulphur dioxide process emissions is predicted to be 11.34% of the AQAL at the point of maximum impact if it assumed that the plant continually operates at the half-hourly ELV as set out in the IED (i.e. 200 mg/Nm^3) and this coincides with the worst-case weather conditions for dispersion. Figure 12 shows the distribution of emissions and the areas where the impact is greater than 10% of the AQAL.

The half-hourly ELV assumed is four times the daily ELV set in the IED (50 mg/Nm^3). The Waste Incineration BREF introduces a more stringent limit of 30 mg/Nm^3 as a daily average. If the same ratio of daily to half-hourly ELV is applied the maximum process contribution is predicted to be 7% of the AQAL. It is unlikely that the plant would operate at the half-hourly ELV during the worst-case weather conditions for dispersion. Therefore, there is little risk that the impact would exceed 10% of the AQAL at any area of relevant exposure.

7.2.6 Heavy metals – at the point of maximum impact

Table 24 and Table 25 detail the PC and PEC assuming that each metal is released at the combined long and short term metal ELVs respectively. If the PC is greater than 0.5% of the AQAL when it is assumed that each metal is emitted at the total metal ELV, further analysis has been undertaken assuming the release is no greater than the maximum monitored at an existing waste facility. The Environment Agency's metals guidance details the maximum monitored concentrations of group 3 metals emitted by Municipal Waste Incinerators and Waste Wood Co-Incinerators as a percentage of the group ELV. The maximum monitored emission presented in the Environment Agency's analysis has been used as a conservative assumption.

Table 24: Long-Term Metals Results – Point of Maximum Impact

Metal	AQAL	Background conc.	Metals emitted at combined metal limit				Metal as % of ELV [1]	Metals emitted no worse than a currently permitted facility			
			PC		PEC			PC		PEC	
	ng/m³	ng/m³	ng/m³	as % AQAL	ng/m³	as % AQAL		ng/m³	as % AQAL	ng/m³	as % AQAL
Arsenic	3	1.10	2.25	74.87%	3.35	111.53%	8.3%	0.19	6.24%	1.29	42.91%
Antimony	5,000	-	2.25	0.04%	-	-	3.8%	0.09	0.00%	-	-
Chromium	5,000	39.00	2.25	0.04%	41.25	0.82%	30.7%	0.69	0.01%	39.69	0.79%
Chromium (VI)	0.2	7.80	2.25	1123.0%	10.05	5023.0%	0.043%	0.00	0.49%	7.80	3900.49%
Cobalt	200	0.92	2.25	1.12%	3.17	1.58%	1.9%	0.04	0.02%	0.96	0.48%
Copper	10,000	33.00	2.25	0.02%	35.25	0.35%	9.7%	0.22	0.002%	33.22	0.33%
Lead	250	20.00	2.25	0.90%	22.25	8.90%	16.8%	0.38	0.15%	20.38	8.15%
Manganese	150	36.00	2.25	1.50%	38.25	25.50%	20.0%	0.45	0.30%	36.45	24.30%
Nickel	20	2.70	2.25	11.23%	4.95	24.73%	73.3%	1.65	8.24%	4.35	21.74%
Vanadium	5,000	1.70	2.25	0.04%	3.95	0.08%	2.0%	0.04	0.001%	1.74	0.03%

Notes:

(1) Metal as maximum percentage of the group 3 BAT-AEL, calculated from the data presented in Environment Agency metals guidance document (V.4) Table A1.