Air Quality Assessment for a Proposed Crematorium at Long Lane, Bradford

Prepared for

City of Bradford Metropolitan District Council

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acilia

ACILIA LTD
HEART Centre
Bennett Road, Leeds, LS6 3HN

Tel: +44 7437 041871
Website: www.aciliaglobal.com
Environmental Solutions

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Executive Summary

Acilia Limited (Acilia) was commissioned by the City of Bradford Metropolitan District Council (CBMDC) to prepare an air quality impact assessment for a planning application for a crematorium and memorial gardens to be built on a parcel of land located at Long Lane near Shipley in Bradford, West Yorkshire.

The aim of the assessment was to determine the potential air quality impacts in the surrounding community associated with emissions to air from the proposed cremator. The emissions from the proposed cremator have been assessed in this report on a quantitative basis using the AERMOD atmospheric dispersion model. The ambient air quality concentrations predicted by the model at discrete sensitive receptor locations have been compared against the relevant UK ambient air quality standards and objectives set for the protection of human health.

The principal emissions to air from the proposed cremator will include particulate matter (as PM_{10} and $PM_{2.5}$), mercury (Hg), hydrogen chloride (HCl) and carbon monoxide (CO). The total predicted PM_{10}, $PM_{2.5}$, Hg, HCl and CO concentrations indicate that were will be no exceedances of the relevant UK ambient air quality objectives and standards at any location beyond the site boundary, including sensitive receptor locations.

The predicted short-term and long-term concentrations indicate that there will be no adverse (human health) impacts as a result of the operation of the proposed cremator and that the impacts at these locations will be *'negligible'*, providing that the cremator is operated and maintained in accordance with the manufacturer's specifications and instructions and the environmental permit conditions. The short-term and long-term air quality impacts predicted by the model were, therefore, not considered to be significant. Furthermore, there are no apparent conflicts with local or national planning policy.

Based on the Transport Assessment prepared by Pell Frischmann in October 2019, it is anticipated that the additional number of light- and heavy-duty vehicles travelling to and from the proposed crematorium will not be significant. A qualitative (screening) assessment for operational phase road traffic emissions was undertaken and indicated that the potential impacts associated with these emissions will be *'negligible'*.

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1.0 Introduction

1.1 Project Overview

Acilia Limited (Acilia) was commissioned by the City of Bradford Metropolitan District Council (CBMDC) to prepare an air quality impact assessment for a planning application for a crematorium and memorial gardens to be built on a parcel of land located at Long Lane near Shipley in Bradford, West Yorkshire (the 'project site' or the 'proposed development site').

The aim of the assessment was to determine the potential air quality impacts associated with emissions to air from the proposed cremator. The emissions have been assessed in this report on a quantitative basis using the AERMOD atmospheric dispersion model. The ambient air quality concentrations predicted by the model at discrete sensitive receptor locations have been compared against the relevant UK ambient air quality standards and objectives set for the protection of human health.

1.2 Study Overview

This report sought to quantify the potential air quality impacts at the nearest identified sensitive receptors during the operation of the proposed cremator and to make recommendations regarding the control of emissions at the site, if required.

The purpose of this air quality impact assessment is to accompany the planning application prepared by Stride Treglown Limited (Stride Treglown), on behalf of CBMDC. This air quality assessment is distinct from any subsequent assessment(s) undertaken under the Environmental Permitting Regulations .[1] This report should be read in conjunction with the planning application and supporting information.

In order to determine the potential air quality impacts in the surrounding community due to emissions to air from the proposed cremator, Acilia used the AERMOD atmospheric dispersion model. The principal emissions to air from the cremator are likely to include particulate matter, mercury, hydrogen chloride and carbon monoxide.

This report has taken into consideration the following sources of information:

- Site layout drawings prepared by Stride Treglown showing the proposed Roasting Centre (dated February 2020); and,
- Process Guidance Note PG5/2(12), Statutory Guidance for Crematoria, Department for Food, Environment and Rural Affairs (Defra), 2012.

[1] The Environmental Permitting Regulations (England and Wales) 2016, Part B Regulated Activity (Cremation of Human Remains), Section 5.1.

The air quality impact assessment undertaken in this report was carried out in accordance with the following 'best practice' guidance documents:

- IAQM, 2017. Land-Use Planning and Development Control: Planning for Air Quality. Institute of Air Quality Management (IAQM) and Environmental Protection UK (EPUK), January 2017; and
- Defra and Environment Agency, 2016. Guidance on Air Emissions Risk Assessment for your Environmental Permit, first published online on 1 February 2016 and last updated on 2 August 2016.[2]

Acilia consulted with CBMDC's Environmental Health Service in March 2020 regarding the scope of the assessment.

1.3 Study Location

The proposed development site is located at Long Lane, Shipley at Ordnance Survey National Grid Reference (also known as the British National Grid or 'BNG') 413050 metres East and 436300 metres North, or latitude 53.822811 °South, longitude 1.8032429 °West.

The proposed development site is located within the Bradford district and is approximately 4.5 km north-west of Bradford city centre. The location of the site is shown in Figure 1, and is situated on the northern side of Long Lane, between Northcliffe Golf Club (to the north) and the Express Golf driving range (to the south).

The site boundary is shown in Figure 1 by a solid red line and the proposed location of the crematorium is shown by a red dot. The figure was produced for a 2 km by 2 km basemap centred on the project site using OpenStreetMap (OSM) under the Open Database License. OSM has been used throughout this report and Acilia has acknowledged OSM and its contributors, where relevant. The Open Database License can be read in full on the OSM website[3].

2 UK Government website: www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

3 OpenStreetMap website (http://opendatacommons.org/licenses/odbl/1.0/).

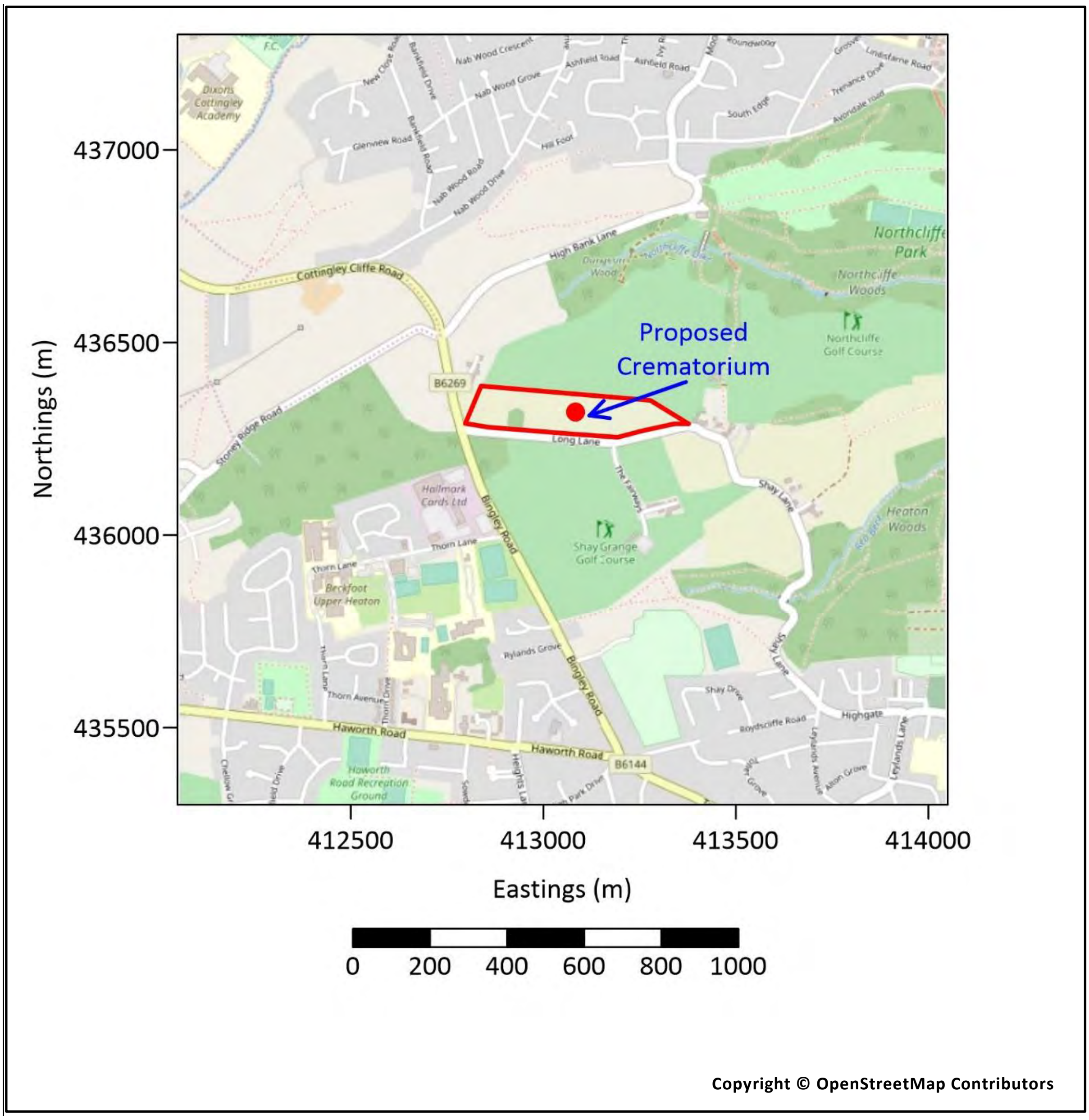

Figure 1: Proposed Location of the Crematorium on an OpenStreetMap Basemap

A Google Earth aerial photograph of the project site is shown in Figure 2 (image date 15 July 2015). The boundary of the site is shown by a solid yellow line. The figure was produced for the same 2 km by 2 km area shown in Figure 1 and the proposed location of the crematorium is shown by a yellow dot.

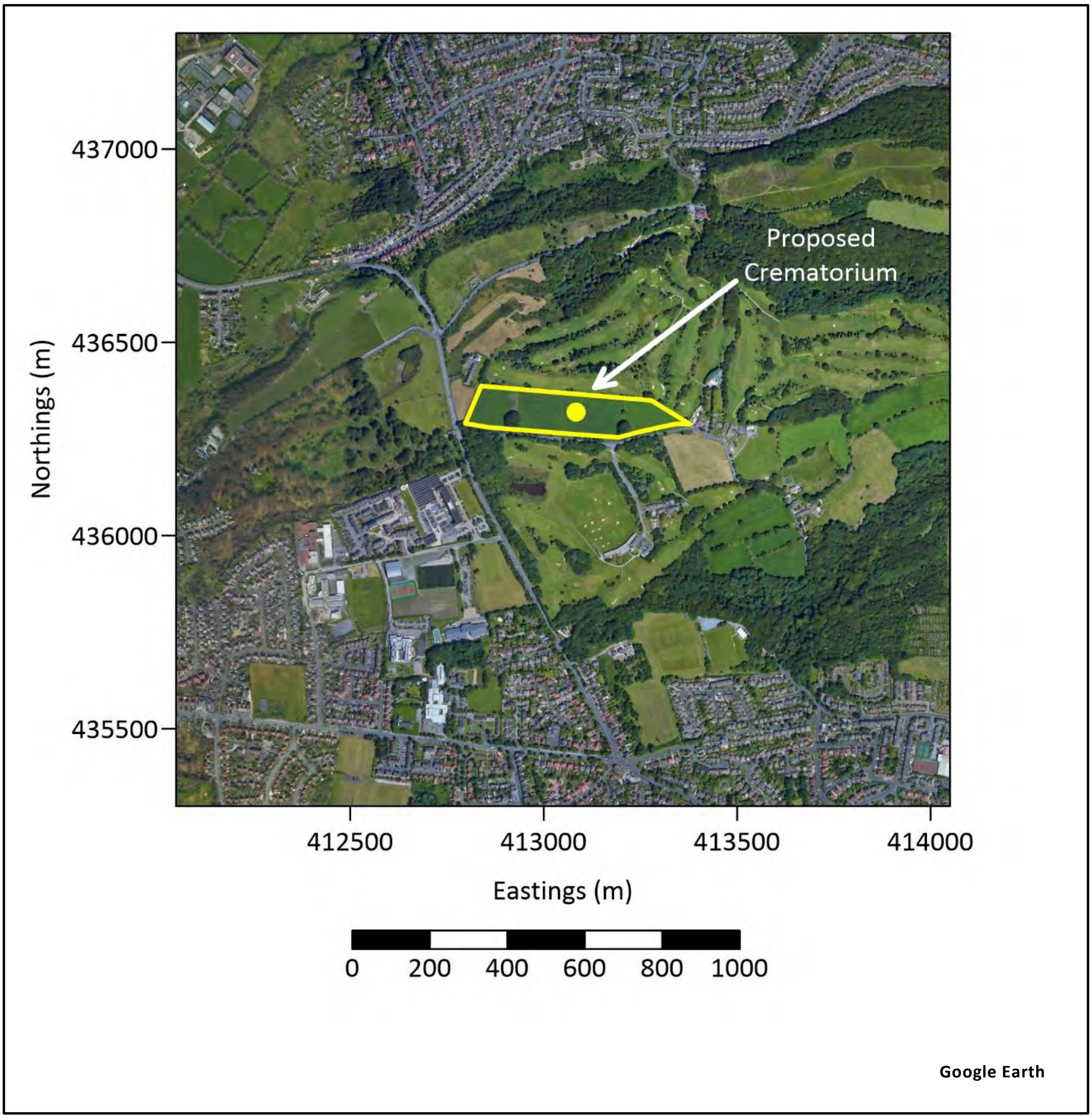

Figure 2: Proposed Location of the Crematorium on a Google Earth Aerial Basemap

1.4 Proposed Development and Emissions to Air

1.4.1 Proposed Crematorium

The indicative site layout (landscape design dated February 2020) for the proposed crematorium and memorial gardens is shown in Figure 3 and was provided by Stride Treglown.

Figure 3: Proposed Location of the Crematorium and Memorial Gardens

1.4.2 Emissions to Air

Construction Dust Emissions

As with any construction site, there is the potential for the release of dust and particulate matter to air during the preparation of the land (e.g. demolition, land clearing, and earth moving) and during construction of the proposed crematory and chapel. Emissions may vary substantially from day to day during the construction phase, depending on the level of activity, the specific operations being undertaken, and the weather conditions. A large proportion of the emissions are likely to result from site plant (e.g. non-road mobile machinery) and road vehicles moving over temporary roads and open ground. If mud is tracked-out by site vehicles onto local roads, dust emissions could occur some distance away from the construction site. The scale of these impacts depends on the dust suppression and other mitigation measures applied.

In the IAQM semi-quantitative risk assessment methodology (IAQM, 2016)[4], the dust emission magnitude is combined with the sensitivity of the area to determine the risk of impacts prior to mitigation (see Section 6 for further details). Once appropriate mitigation measures have been identified, the significance of construction phase impacts can be determined. The aim is to prevent significant effects at receptors due to the implementation of effective mitigation.

With the implementation of effective mitigation measures (see Section 6), the generation of dust and particulate matter emissions onsite will be minimised such that the residual impacts are not considered to be significant, in accordance with IAQM (2016).

Operational Phase Traffic Emissions

There is the potential for a small number of vehicle movements to be generated on the local road network during the construction phase and once the cremator has been built and is fully operational.

The proposed scheme is considered to be ‘medium’ development in terms of the West Yorkshire Low Emission Strategy (WYLES) for 2016 to 2021 as 300 parking spaces are proposed to be created (i.e. more than 100 parking spaces will be provided), and for the reasons set-out below.

According to the Transport Assessment prepared by Pell Frischmann in October 2019, it is anticipated that the additional number of light- and heavy-duty vehicles travelling to and from the proposed crematorium will not be significant. The Transport Assessment indicates that the proposed crematorium is likely to generate between 200 and 400 daily trips (two-way). In other words, the total (two-way) annual average daily traffic

4 IAQM, 2016. Guidance on the Assessment of Dust from Demolition and Construction, Institute of Air Quality Management (IAQM), Version 1.1, 2016 (originally published in 2014).

flow (AADT) on the local road network (i.e. vehicle movements to and from the crematorium) is anticipated to be more than 100 AADT but less than 500 AADT.

It is also anticipated that there could be 37 arrivals and 37 departures in the highway network peak (i.e. more than 30 two-way vehicle movements in any hour).

It is also noted that the local transport infrastructure is unlikely to be considered as being 'inadequate' and the development site is not adjacent to an Air Quality Management Area. Nor does the proposal trigger any of the 'major' development criteria and it is not an Environmental Impact Assessment (EIA) development.

A qualitative (screening) assessment for operational phase road traffic emissions was undertaken (see Section 5) and indicated that the potential impacts associated with these traffic-related emissions will be '*negligible'*.

Cremator Emissions

The principal source of emissions to air at the development site during the operation of the proposed 650 kW gas-fired cremator will be from its single stack (point source) located on the roof of the proposed crematory building. The principal emissions will include particulate matter, mercury, acid gases such as hydrogen chloride, carbon monoxide, in addition to relatively minor emissions of oxides of nitrogen and volatile organic compounds (VOCs). According to the joint European Monitoring and Evaluation Programme and European Environment Agency (EMEP/EEA) Air Pollutant Emission Inventory Guidebook 2019,[5] nitrogen oxide emissions from crematories are *"low and are not of major concern"* and the emissions can be minimised through temperature control and burner design.

The principal emissions from the cremator were assessed in this report using AERMOD (see Section 5). Whilst the cremator will not be used 24 hours a day, 7 days a week, it was conservatively assumed in the dispersion modelling assessment that the emissions from the cremator will be continuous (i.e. every hour of the day, all year round).

An environmental permit will be required from CBMDC, in addition to planning permission, to discharge contaminants into air as the cremation of human remains is a Part B activity under the Environmental Permitting Regulations.[6]

It is understood that the cremator selected for the site will meet the emission limit values and operating provisions stated in Defra's Process Guidance Note PG5/2(12).[7] The particulate emissions will be controlled by means of fabric filtration (e.g. bag filter

[5] EEA, 2019. Air Pollutant Emission Inventory Guidebook 2019, European Monitoring and Evaluation Programme and European Environment Agency (EMEP/EEA), Part 5.C.1.b.v Cremation, Guidebook 2019.

[6] The Environmental Permitting Regulations (England and Wales) 2016, Part B Regulated Activity (Cremation of Human Remains), Section 5.1.

[7] Process Guidance Note PG5/2(12), Statutory Guidance for Crematoria, Department for Food, Environment and Rural Affairs (Defra), 2012.

fitted with a filter leak detector), while an activated carbon filter will be used to control to control mercury and VOC emissions from the stack. Alkali compounds will also be employed to control hydrogen chloride emissions.

The combustion provisions stated in PG5/2(12) and to be measured at the exit the secondary combustion chamber include a minimum temperature of 1,123 K (850°C), an oxygen (O_2) concentration wet or dry of 6% (average) and 3% (minimum), and a residence time of two (2) seconds in the secondary combustion chamber.

2.0 Legislative Context

2.1 National Legislation and Policy Guidance

2.1.1 The Air Quality Strategy

European Union (EU) legislation forms the basis for UK air quality policy. The EU Air Quality Framework Directive 96/62/EC on Ambient Air Quality Assessment and Management entered into force in September 1996.[8] This was a framework for tackling air quality through setting European-wide air quality limit values in a series of Daughter Directives, prescribing how air quality should be assessed and managed by the Member States. Directive 96/62/EC and the first three Daughter Directives were combined to form the new EU Directive 2008/50/EC[9] on Ambient Air Quality and Cleaner Air for Europe, which came into force in June 2008.

The 1995 Environment Act[10] required the preparation of a national Air Quality Strategy (AQS) which set air quality standards and objectives for specified pollutants. The Act also outlined measures to be taken by local planning authorities in relation to meeting these standards and objectives (the Local Air Quality Management (LAQM) system).

The UK AQS was originally adopted in 1997[11] and has been reviewed and updated in order to take account of the evolving EU Legislation, technical and policy developments and the latest information on the health effects of air pollution. The strategy was revised and reissued in 2000 as the AQS for England, Scotland, Wales and Northern Ireland.[12] This was subsequently amended in 2003[13] and was last updated in July 2007.[14]

The standards and objectives relevant to the LAQM framework have been prescribed through the Air Quality (England) Regulations (2000)[15] and the Air Quality (England) (Amendment) Regulations 2002.[16] The Air Quality Standards Regulations 2010 set out the combined Daughter Directive limit values and interim targets for Member State compliance.[17]

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8 European Parliament (1996) Council Directive 96/62/EC on Ambient Air Quality Assessment and Management.
9 European Parliament (2008) Council Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe.
10 HMSO (1995) 'The Environment Act 1995 (c.25)', London:TSO.
11 Department of the Environment (DoE) (1997) 'The UK National Air Quality Strategy', London: HMSO.
12 Department of the Environment, Transport & the Regions (DETR) (2000) 'UK Air Quality Strategy'. London:HMSO.
13 DETR (2003) 'UK Air Quality Strategy- Addendum'. London:HMSO.
14 Department for Environment, Food and Rural Affairs (Defra) (2007) 'The Air Quality Strategy for England, Scotland, Wales and Northern Ireland', London:HMSO.
15 HMSO (2000) 'Statutory Instrument 2000 No. 928, The Air Quality (England) Regulations 2000', London:HMSO.
16 HMSO (2002) 'Statutory Instrument 2002 No. 3043, The Air Quality (England) (Amendment) Regulations 2002', London:HMSO.
17 HMSO (2010) 'Statutory Instrument 2010 No. 1001, Air Quality Standards (England) Regulations, 2010'. London:HMSO.

2.1.2 National Planning Policy Framework

The revised National Planning Policy Framework (NPPF)[18] was adopted in July 2018 and refers to the LAQM process by recognising that:

> *"Planning policies and decisions should sustain and contribute towards compliance with relevant limit values or national objectives for pollutants, taking into account the presence of Air Quality Management Areas and Clean Air Zones, and the cumulative impacts from individual sites in local areas."*

The NPPF identifies that local planning authorities should maintain consistency within the LAQM process and states that:

> *"Planning decisions should ensure that any new development within Air Quality Management Areas and clean air zones is consistent with the local Air Quality Action Plan."*

2.1.3 Planning Practice Guidance

The UK Government Planning Practice Guidance provides guidance on how the planning process can take account of the impact a new development may have on air quality.

The guidance states that air quality may be relevant to a planning application where:

- Traffic in the vicinity of the development may be affected by increasing volume or congestion or altering the fleet composition on local roads;
- New point sources of air pollution are to be introduced;
- People may be exposed to existing sources of pollution;
- Potentially unacceptable impacts (such as dust) may arise during construction; and
- Biodiversity may be affected.

2.2 Local Planning Policy Guidance

CBMDC's Core Strategy Development Plan Document (Core Strategy)[19] was adopted in July 2017 and is the Local Plan and is used to determine planning applications for proposed developments in the Bradford district.

[18] Department for Communities and Local Government (DCLG) (2018), Revised National Planning Policy Framework.
[19] City of Bradford Metropolitan District Council (2017) Core Strategy Development Plan Document, adopted July 2017.

Policy EN8 of the Core Strategy concerns environmental protection and, with regards to air quality, states:

> *"In liaison with partner organisations, the Council will take a proactive approach to maintaining and improving air quality within the District in line with both National Air Quality Standards, the European Union limit values and the principles of best practice. Through a range of actions, it will seek to secure a reduction in emissions from sources which contribute to poor air quality.*
>
> *Development proposals that have the potential to adversely impact on air quality will be required to incorporate measures to mitigate or offset their emissions and impacts, in accordance with the Low Emission Strategy for Bradford and associated guidance documents.*
>
> *In areas where air quality is a matter of concern, development proposals will be required to deliver a positive impact on air quality in the district.*
>
> *Development proposals must not exacerbate air quality beyond acceptable levels; either through poor design or as a consequence of site selection."*

Paragraphs 5.4.166 and 5.4.167 of the Core Strategy also refer to CBMDC's Air Quality Strategy (adopted in April 2011) and Low Emission Strategy (adopted in November 2013), which state:

> *"5.4.166 Bradford Council has produced a District Air Quality Strategy, which was adopted in April 2011. The Strategy aims to take a proactive approach to help maintain and improve air quality within the District. A district-wide approach is needed due to the fact that air quality in Bradford is worse than in many other parts of the UK. Air quality problems in the district are mainly attributable to transport, in order to mitigate against this Bradford Council adopted a Low Emission Strategy in November 2013.*
>
> *5.4.167 Addressing air quality issues is recognised to be complementary to the aim of achieving a reduction in transport emissions, reflected in the transport theme and which forms an important element in the District's overall approach to climate change. It also recognised that the impact of transport is a cross boundary issue and Bradford Council are working with the four other West Yorkshire Local Authorities to develop a West Yorkshire Low Emission Strategy which will (amongst other measures) provide consistent air quality and development control policy across West Yorkshire."*

Policy DS5 of the Core Strategy also states:

> *"**Policy DS5: Safe and Inclusive Places***
>
> *Plans and development proposals should make a positive contribution to people's lives through high quality, inclusive design. In particular they should:*
>
> *A. Be designed to ensure a safe and secure environment and reduce the opportunities for crime.*
>
> *B. Allow flexibility to adapt to changing needs and circumstances.*
>
> *C. Be designed to ensure buildings and places provide easy access for all, including those with physical disabilities.*
>
> *D. Encourage social interaction and where appropriate provide opportunities for members of the community to meet and come into contact with each other.*
>
> *E. Include appropriate design arrangements for servicing, waste handling, recycling and storage.*
>
> *F. Not harm the amenity of existing or prospective users and residents."*

The requirements of Policies DS5 and EN8 were considered in this air quality assessment.

The Air Quality Action Plan for Bradford (2019) indicates that the key pollutant of concern within the district is nitrogen dioxide (NO_2) and that exceedances of the annual mean air quality objective for NO_2 were still being recorded at some locations. The Air Quality Action Plan also indicated that road transport was the dominant local source of NO_2 emissions in the district.

Of particular relevance to the management of transport emissions and local air quality within the Bradford district, in addition to the Air Quality Action Plan, are:

- Bradford Air Quality Strategy 2011;
- West Yorkshire Low Emission Strategy 2016 to 2021; and,
- Bradford Low Emission Strategy 2013.

These documents focus on the measures to reduce road traffic vehicle emissions.

2.3 Assessment Criteria

The key pollutants of concern associated with the proposed cremator emissions will include particulate matter, as particles of less than 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$) in size, mercury (Hg), hydrogen chloride (HCl) and carbon monoxide (CO). Whilst the cremator emissions will also include NO_2 and VOCs, these pollutants were not explicitly input into AERMOD as the emission rates and resulting contributions to local ambient air quality are expected to be negligible (see Section 1).

The modelling results were assessed against the following ambient air quality standards:

- EU Ambient Air Directive Limit Values;
- EU Ambient Air Directive and 4th Daughter Directive Target Values;
- UK Air Quality Strategy Objectives; and
- Environment Agency (EA) Environmental Assessment Levels.

The UK Air Quality Strategy (AQS) Objectives, EU Ambient Air Directive (AAD) limit and target values and Environmental Assessment Levels (EALs) set for the protection of human health (as short-term and long-term or annual mean concentrations) for PM_{10}, $PM_{2.5}$, Hg, HCl and CO are shown in Table 1. Note that the units shown in the table for all pollutants are in micrograms per cubic metre of air (µg/m^3).

Table 1: Assessment Criteria used in this Report

Pollutant	AQS Objective / Limit Value / EAL (µg/m3)	Averaging Period	Number of permitted exceedances per year
PM_{10}	50 40	24-hour Annual	Not to be exceeded >35 times a year [1] None [1]
$PM_{2.5}$	25	Annual	Limit Value to be achieved by 2020 [1]
Hg	7.5 0.25	1-hour Annual	None [2] None [2]
HCl	750 N/A	1-hour Annual	None [2]
CO	10,000	8-hour	Maximum daily running 8-hour mean [1]

Notes:
1. UK Air Quality Strategy (AQS) Objective and EU Ambient Air Directive (AAD) Limit Value.
2. Environmental Assessment Level (EAL).

Examples of the scientific notation used in this assessment, including the conversion factors between various concentration values, are shown in Appendix A.

3.0 Local Ambient Air Quality and Meteorology

3.1 Background Air Quality

The concentration of an air pollutant that is already present in the environment is known as the 'background concentration'. The background concentration, in this context, is therefore representative of the baseline air quality conditions at the proposed development site i.e. *without* any incremental change associated with the operation of the proposed cremator.

3.1.1 Particulate Matter, Oxides of Nitrogen and Carbon Monoxide

A set of background concentration maps have been produced by the Department for Food, Environment and Rural Affairs (Defra) and the devolved administrations to assist local authorities in carrying out Review and Assessment of local air quality as part of their duties under the Environmental Act 1995.[20] The background maps are updated by Defra periodically due to updates to underlying data, including emission factors.

The annual mean background concentrations of oxides of nitrogen (NO_x), NO_2, PM_{10} and $PM_{2.5}$ for 2017 are shown in Table 2, which is the most recent reference year for these pollutants. The annual mean background concentration shown in the table for CO is for 2001, which is the most recent reference year for that pollutant. The background concentrations shown in the table are for the closest 1 km by 1 km grid coordinate on the database to the proposed development site. Note that the background concentrations for NO_x, NO_2, PM_{10} and $PM_{2.5}$ are shown in µg/m^3, while the background concentration for CO is shown in milligrams per cubic metre of air (mg/m^3).

Table 2: Background Ambient Air Quality at the Project Site

Grid Co-ordinate (BNG) (X, Y in metres)	Annual Mean Background Concentration and Year				
	NO_x 2017 (µg/m^3)	NO_2 2017 (µg/m^3)	PM_{10} 2017 (µg/m^3)	$PM_{2.5}$ 2017 (µg/m^3)	CO 2001 (mg/m^3)
413500, 436500	32.0	21.2	12.1	8.35	0.374

The 2001 background concentration for CO and the 2017 concentrations for NO_2, PM_{10} and $PM_{2.5}$ shown in Table 2 for the proposed development site are well below the relevant assessment criteria shown in Table 1. This approach is considered to be conservative as in reality there is the potential for the background concentrations of some or all of these pollutants to decrease in future years as emissions from new

20 Defra website: https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html.

vehicles are reduced by the progressive introduction of higher emission standards, and by the implementation of tighter standards and controls for industrial and domestic (wood burning) emissions. Although somewhat speculative, it is likely that given the strong focus on local and national policies and efforts to reduce road traffic emissions and the increasing emphasis to encourage people to shift to low or zero emission vehicles, active transport modes (e.g. walking and cycles) and public transport, emissions from vehicles, in particular, will decline in future years.

CBMDC has been monitoring real-time air pollution levels since 1999 at four locations within the Bradford district and declared AQMAs in each location on 1 September 2006 for an exceedance of the annual mean AQS Objective for NO_2.

The four AQMAs located in the Bradford district are as follows:

- Mayo Avenue / Manchester Road ('AQMA No.1') located 6 km south-east of the proposed development site;
- Manningham Lane ('AQMA No.2'), located 2.8 km south-east of the proposed development site;
- Thornton Road ('AQMA No.3') located 4 km south-east of the proposed development site; and
- Shipley Airedale Road ('AQMA No.4'), located 4.6 km south-east of the proposed development site.

As indicated above, all four AQMAs are located some distance away from the proposed development site and are unlikely to be impacted by the proposed development for the following reasons:

1. NO_x emissions generated by operational-phase ('with development') road traffic are anticipated to be negligible and any incremental increase in the ambient NO_x concentration is likely to be localised to within approximately 200 m of the road;
2. NO_x emissions generated during the operation of the proposed cremator located at the development site are anticipated to be negligible and providing there is adequate dispersion and dilution of the emissions from the proposed cremator stack it is unlikely that there will be any discernible increase in the 1-hour mean and annual mean ambient NO_2 concentrations measured in the AQMAs.

3.1.2 Mercury

The Environment Agency (EA) currently manages the UK's national monitoring sites on behalf of Defra and the devolved administrations. There are currently approximately 300 ambient air quality monitoring sites located across the UK, which are organised into a particular network depending on the measurement method.

The ambient air quality monitoring data for mercury measured in 2013 at the Tinsley Community Centre and at the Sheffield Devonshire Green as part of Defra's Heavy Metals Network were analysed. The Tinsley Community Centre monitoring site (UK Air reference 'UKA00181') is located at 440238 m E, 390588 m N, while the Sheffield Devonshire Green site (reference 'UKA00575') is located at 434816 m E, 386990 m N, which are both 53 km south-east of the proposed development site. Both of these sites are 'urban background' monitoring locations and are the closest such monitoring sites to the proposed crematorium.

Analysis of the monitoring data from the weekly sampling undertaken at the Tinsley Community Centre monitoring site over the period 28 February to 31 December 2013 indicated that the average Hg concentration measured over this period was 0.0429 nanograms per cubic metre (ng/m^3), while the minimum and maximum weekly Hg concentrations were 0.0133 ng/m^3 and 0.101 ng/m^3, respectively. The 25th, 50th and 75th percentiles of the weekly Hg concentrations were 0.0287 ng/m^3, 0.0378 ng/m^3 and 0.0462 ng/m^3, respectively.

Unfortunately, there were only two samples collected at the Sheffield Devonshire Green site: one was for the period 20 November to 18 December 2013 and the other was for the period 18 December to 31 December 2013. The average of these two concentration values was 0.0118 ng/m^3 (i.e. lower than the period-average concentration measured at the Tinsley Community Centre).

Therefore, in the absence of site-specific ambient air quality monitoring data, it was conservatively assumed in this assessment that the annual mean background Hg concentration at the proposed development site was 0.0429 ng/m^3 (i.e. the same as the period-average concentration measured at the Tinsley Community Centre).

3.1.3 Gaseous Hydrochloric Acid

Gaseous hydrochloric acid (HCl) ambient air quality data collected at the Ladybower Reservoir 'rural background' monitoring site (reference'UKA00171'), which is part of Defra's Acid Gas and Aerosol Network (AGANET), for the period 10 January 2011 to 11 January 2016 were analysed. The Ladybower site is the closest AGANET monitoring location to the proposed development site and is situated in the Peak District (East Midlands), approximately 46 km south of the development site (at 416585 m E, 389645 m N).

The 5-year mean HCl concentration measured at Ladybower was 0.33 µg/m^3 (2011 to 2016), while the minimum and maximum monthly HCl concentrations over this period were 0.02 µg/m^{3}and 1.87 µg/m^3, respectively. The 25th, 50th and 75th percentiles of the monthly HCl concentrations measured over the 5-year period were 0.16 µg/m^3, 0.24 µg/m^3 and 0.34 µg/m^3, respectively.

Therefore, in the absence of site-specific ambient air quality monitoring data, it was conservatively assumed in this assessment that the annual mean background HCl concentration at the proposed development site was 0.33 μg/m^3 (i.e. the same as the period-average concentration measured at Ladybower).

3.1.4 Background Concentrations Assumed in this Assessment

It was assumed in the dispersion modelling assessment that the short-term background pollutant concentration was twice the long-term concentration for that compound, in accordance with Defra's '*Guidance on Air Emissions Risk Assessment for your Environmental Permit*'.[21]

The background concentrations used in the modelling assessment are shown in Table 3. Note the units are shown in μg/m^3 for all pollutants, including Hg and CO.

Table 3: Background Air Pollution Concentrations used in this Assessment

Pollutant	Air Quality Objective/ Limit Value (μg/m^3)	Averaging Period	Background Pollutant Concentration (μg/m^3)	Background Concentration Against Air Quality Criterion (%)
PM_{10}	50 40	24-hour Annual	20.6 10.3	41.2 25.8
$PM_{2.5}$	25	Annual	7.1	28.4
Hg [1]	7.5 0.25	1-hour Annual	8.58e-5 4.29e-5	<0.01 <0.1
HCl	750 N/A	1-hour Annual	0.66 N/A	0.09 N/A
CO [2]	10,000	8-hour	748	7.5

Notes:
1. To convert the mass value from μg/m^3 to ng/m^3 multiply the value by 1,000. Therefore, 8.58e-5 μg/m^3 is 0.0858 ng/m^3, while 4.29e-5 μg/m^3 is 0.0429 ng/m^3.
2. To convert the mass value from μg/m^3 to mg/m^3 divide the value by 1,000. Therefore, 748 μg/m^3 is 0.748 mg/m^3.

21 Defra and Environment Agency, 2016. *Guidance on Air Emissions Risk Assessment for your Environmental Permit*, first published online on 1 February 2016 and last updated on 2 August 2016: www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit.

Based on a simple 'head-room' analysis of the data shown in the table (by comparing the background concentration against the relevant air quality criterion value), the key pollutant of concern in this dispersion modelling assessment is likely to be PM_{10} (at 41% of the 24-hour mean Air Quality Objective), whereas the pollutants of least concern are likely to be Hg and HCl (at <0.1% of the relevant EAL criteria).

3.2 Dispersion Meteorology

3.2.1 Wind Speed and Direction

Meteorological data were analysed from the Met Office's automatic weather station located in Bingley (WMO site reference '03344'), which is the nearest weather station to the proposed development site.

The Bingley weather station is located approximately 4 km to the west of the proposed development site at latitude 53.817°N, longitude 1.867° W (at an elevation of 267 m), which is considered to be representative of the project site.[22] Parameters analysed for 1 January 2014 to 31 December 2018 included wind speed, wind direction, air temperature, atmospheric pressure, relative humidity, cloud cover (amount) and ceiling height (the height of the base of the lowest clouds).

The hourly wind speed and wind direction data measured at the Bingley weather station between 1 January 2014 (Hour 1) and 31 December 2018 (Hour 24) were analysed. The data capture for the five-year period was excellent at 96.86% (or 42,448 data hours out of a possible 43,824 hours). In other words, there were only 1,376 missing hours over the five-year period. The five-year mean wind speed was 3.9 m/s, which corresponds to 'light breeze' conditions or Beaufort 2. The minimum and maximum hourly wind speeds were 0 m/s and 17.5 m/s, respectively. The total number of calm wind conditions (or wind speeds <0.5 m/s) was very low at only 0.01% (or 6 calm hours over the five-year period).

The wind speed and direction frequencies measured at the Bingley weather station over the five-year period and for each calendar year are shown in the wind roses presented in Figure 4. The wind roses show 16 compass point directions (N, NNE, NE etc.)[23] from which the wind blew.

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22 Data are considered representative if they are obtained from a site that is *"similar in land use, geographic location and terrain to the emission site,"* according to EA (2008), Integration of Air Quality Modelling and Monitoring Methods: Review and Applications, Science Report SC060037/SRI, Environment Agency (EA), 2008.

23 The 16 compass point directions (clockwise from north) are: north (N), north-north-east (NNE), north-east (NE), east-north-east (ENE), east (E), east-south-east (ESE), south-east (SE), south-south-east (SSE), south (S), south-south-west (SSW), south-west (SW), west-south-west (WSW), west (W), west-north-west (WNW), north-west (NW) and north-north-west (NNW).

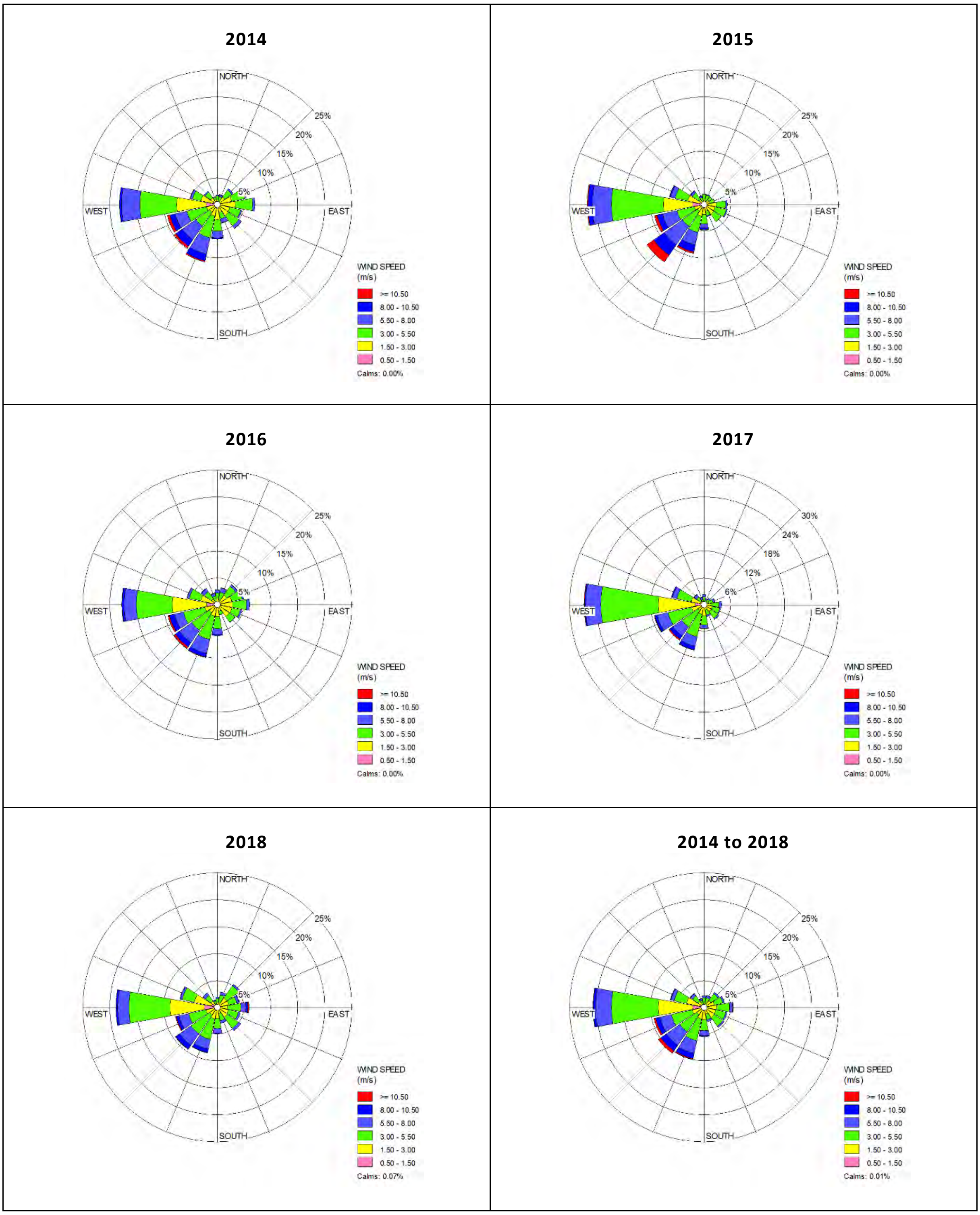

Figure 4: Wind Roses for the Bingley Weather Station: 2014 to 2018

The wind roses indicate that winds from all directions were measured at the Bingley weather station. However, the wind directions were predominantly (at 57% in total) from the following directions:

- West (W; 20.6%);
- South-west (SW; 10.4%);
- South-south-west (SSW; 9.9%);
- West-south-west (WSW; 9.6%); and
- West-north-west (WNW; 6.5%).

In other words, winds measured at the Bingley weather station tend to flow from the west and south-west. Winds were very infrequent from the north-north-west (NNW; 1.8%), north (N; 2.2%) and north-north-east (NNE; 2.3%) over the five-year period. The wind roses shown in Figure 4 indicate that there was generally very little interannual variability in wind direction, however, a slightly higher frequency of westerlies was measured in 2017 compared to other years.

The hourly wind speed frequency distribution for the Bingley weather station over the five-year period is shown in Figure 5. Note, as mentioned above, that there were 0.01% calms and 3.1% missing data recorded over the period.

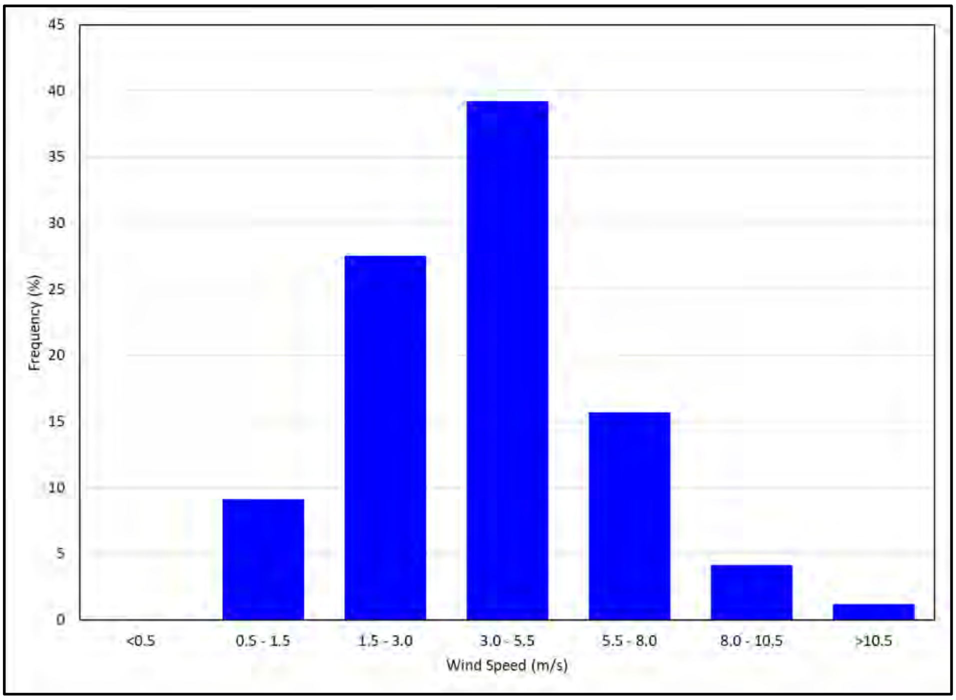

Figure 5: Wind Speed Frequency Distribution for Bingley: 2014 to 2018

Figure 5 indicates that the 1-hour mean wind speeds were predominately between 3.0 m/s and 5.5 m/s (i.e. Beaufort 3 or 'gentle breeze' conditions) at 39.2% of the total.

The figure also indicates that 'light air' (Beaufort 1; wind speeds of between 0.5 m/s and 1.5 m/s) and 'light breeze' (Beaufort 2; wind speeds of between 1.5 m/s and 3.0 m/s) occurred 9.1% and 27.5% of the time, respectively. The figure indicates that the wind speeds were greater than 8 m/s ('moderate breeze' or Beaufort 4 and above) for only 5.3% of the time.

The annual mean wind speeds were slightly below the five-year average (3.9 m/s) in 2016 and 2018 (at 3.7 m/s) and the annual mean wind speed in 2015 was slightly above the five-year average (at 4.2 m/s).

Generally, there was very little interannual variability in wind speed and direction over the five-year period. The hourly wind speed and direction measurements were also within the typical range.

3.2.2 Air Temperature

The hourly air temperature data measured at the Bingley weather station over the five-year period were analysed.

A time-series plot of the hourly air temperature data is shown in Figure 6. As expected, the highest temperatures were measured in summer (June to August), while the lowest temperatures generally occurred in winter (December to February). The minimum and maximum hourly temperatures were -7.9°C (winter) and 30.6°C (summer), respectively. These values are within the typical range.

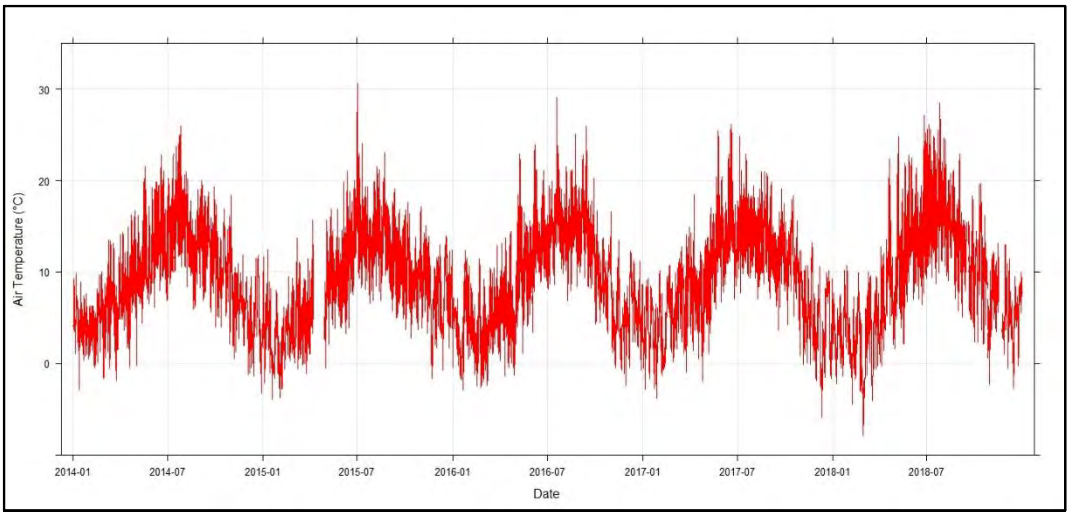

Figure 6: Time-series Plot of Air Temperature at Bingley: 2014 to 2018

Diurnal variations in mean air temperature measured over the five-year period are shown in Figure 7. It can be seen that an increase in temperature occurred during the morning following sunrise, and that the maximum temperature occurred between 1:00 and 3:00 pm.

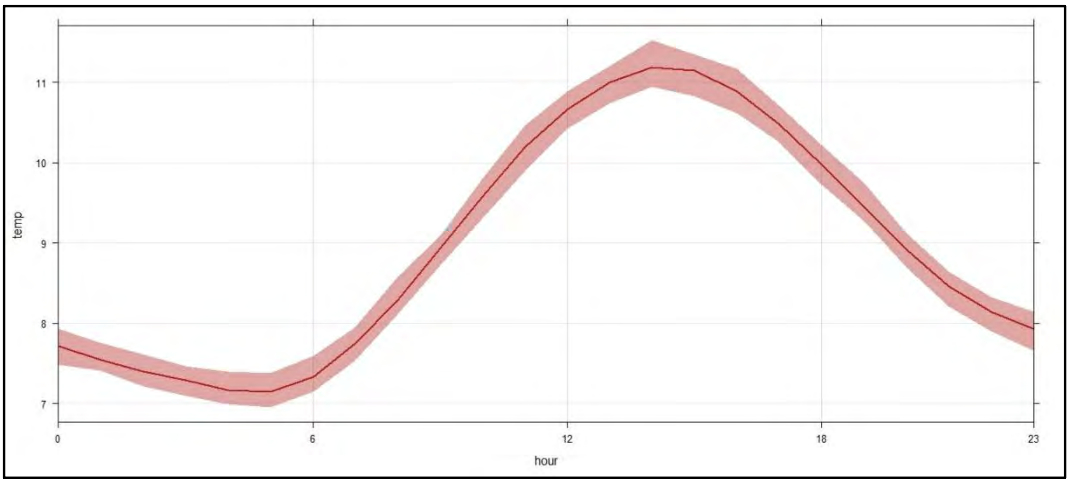

Figure 7: Diurnal Variation in Air Temperature at Bingley: 2014 to 2018

3.2.3 Atmospheric Pressure and Relative Humidity

The minimum and maximum hourly atmospheric pressure measured over the five-year period in Bingley were 962 hPa and 1,044 hPa, respectively. These values are within the typical range.

The minimum and maximum hourly relative humidity measured over the five-year period in Bingley were 20% and 100%, respectively. These values are within the typical range.

3.2.4 Ceiling Height and Cloud Cover

The minimum and maximum hourly ceiling height measured over the five-year period in Bingley were 30 m and 7,500 m, respectively. These values are within the typical range.

The minimum and maximum hourly cloud cover (amount) measured over the five-year period in Bingley were 1 octa and 8 octas, respectively. These values are within the typical range.

4.0 Assessment Methodology

4.1 Modelling Approach

An assessment was undertaken using the AERMOD (Version 19191) Gaussian plume atmospheric dispersion model, which is the latest version of the model (released on 10 July 2019).

AERMOD was developed by the American Meteorological Society (AMS) and the US Environmental Protection Agency (US EPA) Regulatory Model Improvement Committee (AERMIC). AERMOD is a US EPA regulatory model.

The AERMOD steady-state plume model incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

Given the proposed development site's location and local meteorology (see Section 3), it was considered that the AERMOD model would adequately represent the dispersion of pollutants from the cremator stack (point emission source) located at the proposed development site. Furthermore, the model has been used extensively in the UK and worldwide for similar sites.

Gaussian plume dispersion models such as AERMOD assume that the meteorological conditions are uniform spatially over the entire modelling domain for any given hour, and this model was considered appropriate for the purposes of this assessment.

4.2 Modelling Grid and Terrain Data

A surface elevation (digital terrain data) file was extracted from Lakes Environmental Software's website (www.webGIS.com).

The terrain data were imported into AERMOD using the terrain pre-processor AERMAP (Version 19191) for a 2 km by 2 km modelling area centred on the project site at UK Map Grid 413050 m E, 436300 m N at the following spatial resolutions:

- 0.5 km by 0.5 km innermost grid 20 m spacing;
- 1.0 km by 1.0 km middle grid 40 m spacing; and,
- 2.0 km by 2.0 km outermost grid 80 m spacing.

A total of 1,796 grid receptors were created using the above method. In addition, 'fenceline' receptors were input along the site boundary at a 10 m resolution, making a total of 134 fenceline receptors. The grid and fenceline receptors (1,930 receptors in total) were then converted to discrete receptors and were input into the model at ground level.

The terrain data were applied to the grid and fenceline receptors and sixteen sensitive receptors (i.e. a total of 1,946 receptors were input into the model).

The grid and fenceline receptor locations input into the model are shown in Figure 8 and are overlain on top of an OSM basemap, while the site boundary is shown by a solid yellow line.

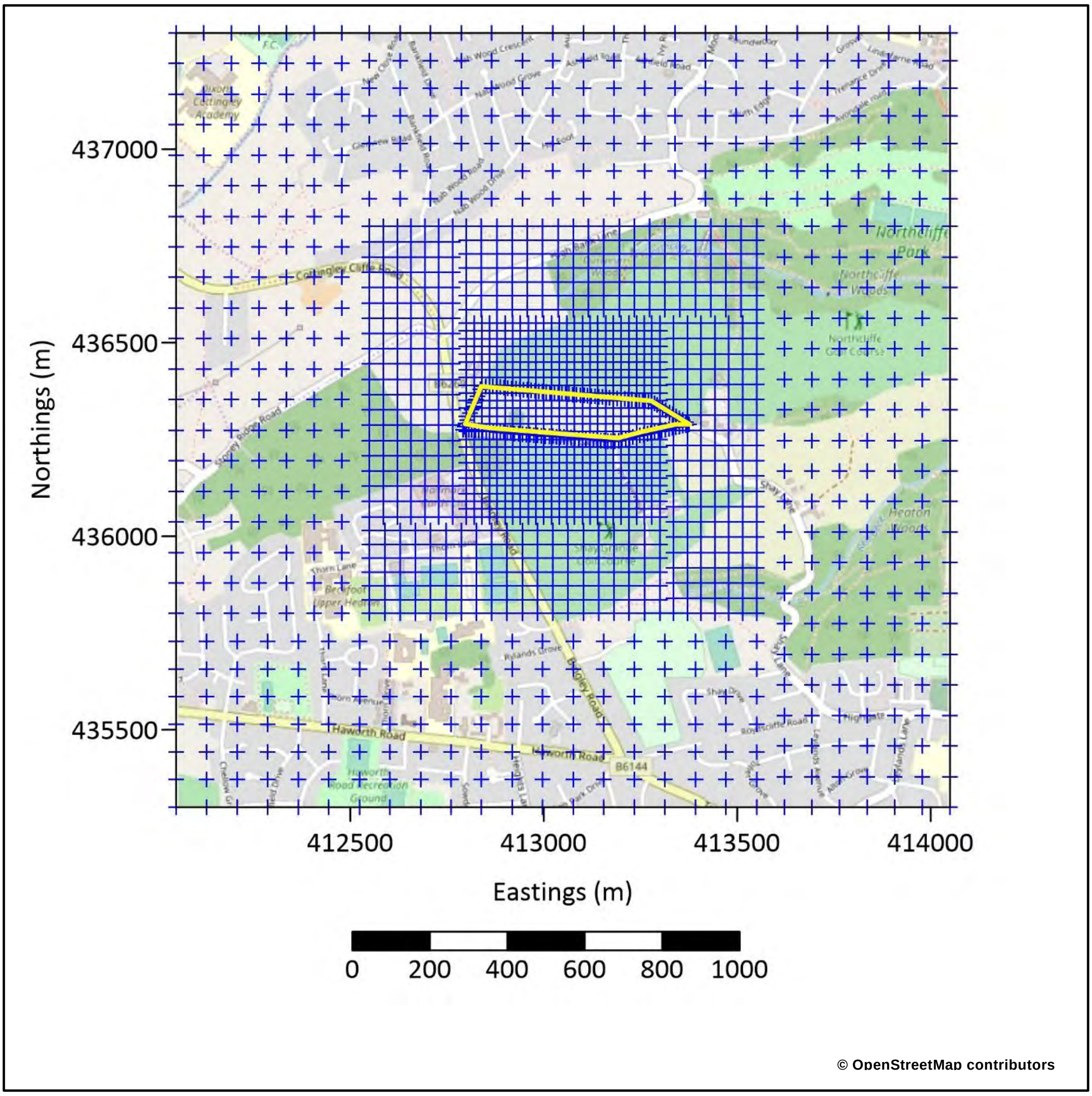

Figure 8: Basemap Showing the Nested Grid Receptor Locations

4.3 Discrete Receptors and Sensitivity of the Receiving Environment

The sensitivity of the receiving environment must be considered in an air quality impact assessment. The degree of sensitivity in a particular location is based on characteristics of the land use, including the time of day and the reason why people are at the particular location (e.g. for work or recreation). Furthermore, different locations have different sensitivities to airborne pollutants and can be classified as having 'high', 'medium' or 'low' sensitivity.

Typical locations for sensitive receptors (based on potential human health effects) include:

- Residential properties;
- Retirement villages;
- Hospitals or medical centres;
- Schools and day-care centres;
- Libraries; and,
- Public outdoor locations (e.g. parks).

A desk-study was undertaken to identify 'human-health' sensitive receptor locations within a 1 km radius of the proposed development site that have the potential to be adversely affected by the proposed development. The nearest receptors deemed sensitive to potential changes in ambient air quality and, therefore, adverse (human health) effects, include residential properties, schools, parks and sports grounds, a golf course and a golf driving range. Sixteen discrete sensitive receptors (referred to herein as receptors R1 to R16) were input into the dispersion model. The locations of the sensitive receptors are shown in Table 4.

Two of the closest residential properties are located at Chak Gardens (receptors R1 and R2), which are situated <10 m and 60 m to the north-west of the site boundary, respectively. There are four residential properties (receptors R4 to R7), which are situated between 20 m and 100 m to the east of the site boundary on Long Lane. There is also a residential property located on the B6269 Bingley Road (receptor R15), which is 20 m to the south-west of the site boundary. These seven residences are the closest properties to the site boundary and are, therefore, considered to be representative of 'worst-case' sensitive receptor locations for the purposes of this assessment. The residential properties are also considered to be of 'high' sensitivity to emissions to air from the proposed cremator as people have the potential to be present in their homes continuously or regularly (e.g. up to 24 hours a day, every day) and can reasonably expect enjoyment of a high level of amenity.

Receptors R3 and R16 represent locations at the Northcliffe Golf Club (greenkeepers buildings and clubhouse, respectively), while receptor R9 is a golf driving range. Receptors R11 and R12 are schools situated to the south-west of the site boundary, while receptor R13 is a sports centre with open-air playing fields (i.e. locations of public open space) also located to the south-west of the site. The remaining receptors (R8, R10 and R14) are residences.

Table 4: Sensitive Receptor Locations

Ref.	Receptor Type & Description	Distance (m) and Direction from Site Boundary		Location (BNG)	
				Easting (m)	Northing (m)
R1	Residence at Chak Gardens (No.1)	<10	NW	412827	436387
R2	Residence at Chak Gardens (No.2)	60	N	412853	436451
R3	Northcliffe Golf Club (No.1) [1]	10	E	413387	436307
R4	Residence on Long Lane (No.1)	20	E	413399	436293
R5	Residence on Long Lane (No.2)	70	E	413443	436287
R6	Residence on Long Lane (No.3)	90	E	413462	436270
R7	Residence on Long Lane (No.4)	100	E	413472	436261
R8	Residence on Shay Grange	180	S	413279	436088
R9	Express Golf Centre - driving range	270	S	413207	435981
R10	Residence off B6269 Bingley Road	480	SW	412923	435795
R11	High Park School (Thorn Lane)	490	SW	412826	435779
R12	Thorn Park School (Thorn Lane)	340	SW	412811	435947
R13	Zara Sports Centre (Thorn Lane)	400	SW	412770	435901
R14	Residence on Plantation Drive	260	SW	412643	436092
R15	Residence on B6269 Bingley Road	20	SW	412774	436273
R16	Northcliffe Golf Club (No.2) [2]	500	NE	413406	436826

Notes:
1. Northcliffe Golf Club greenkeepers' buildings located on Long Lane.
2. Northcliffe Golf Club clubhouse located on High Bank Lane.

Sensitive receptors may also include ecological and culturally important sites, such as European, national and local designated sites, such as Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Ramsar sites and Sites of Special Scientific Interest (SSSIs), local and national nature reserves, local wildlife sites, and ancient woodland (collectively 'designated sites'). Whether they are to be included in an air quality assessment will depend on which of the two regulatory systems (the planning or environmental permitting systems) the application is made, and the type of project. There are no SSSIs or local nature reserves situated within a 2 km radius of the site, and the closest SPA/SAC is the South Pennine Moor SPA/SAC at Thornton Moor and Ilkley Moor, which are 6.1 km north and 8.2 km south-west of the site, respectively.

The sensitive receptor locations (R1 to R16) are shown in Figure 9 on a Google Earth aerial basemap, which covers a 2 km by 2 km area. The site boundary is shown by a solid yellow line and the proposed cremator stack location is shown by a light blue dot.

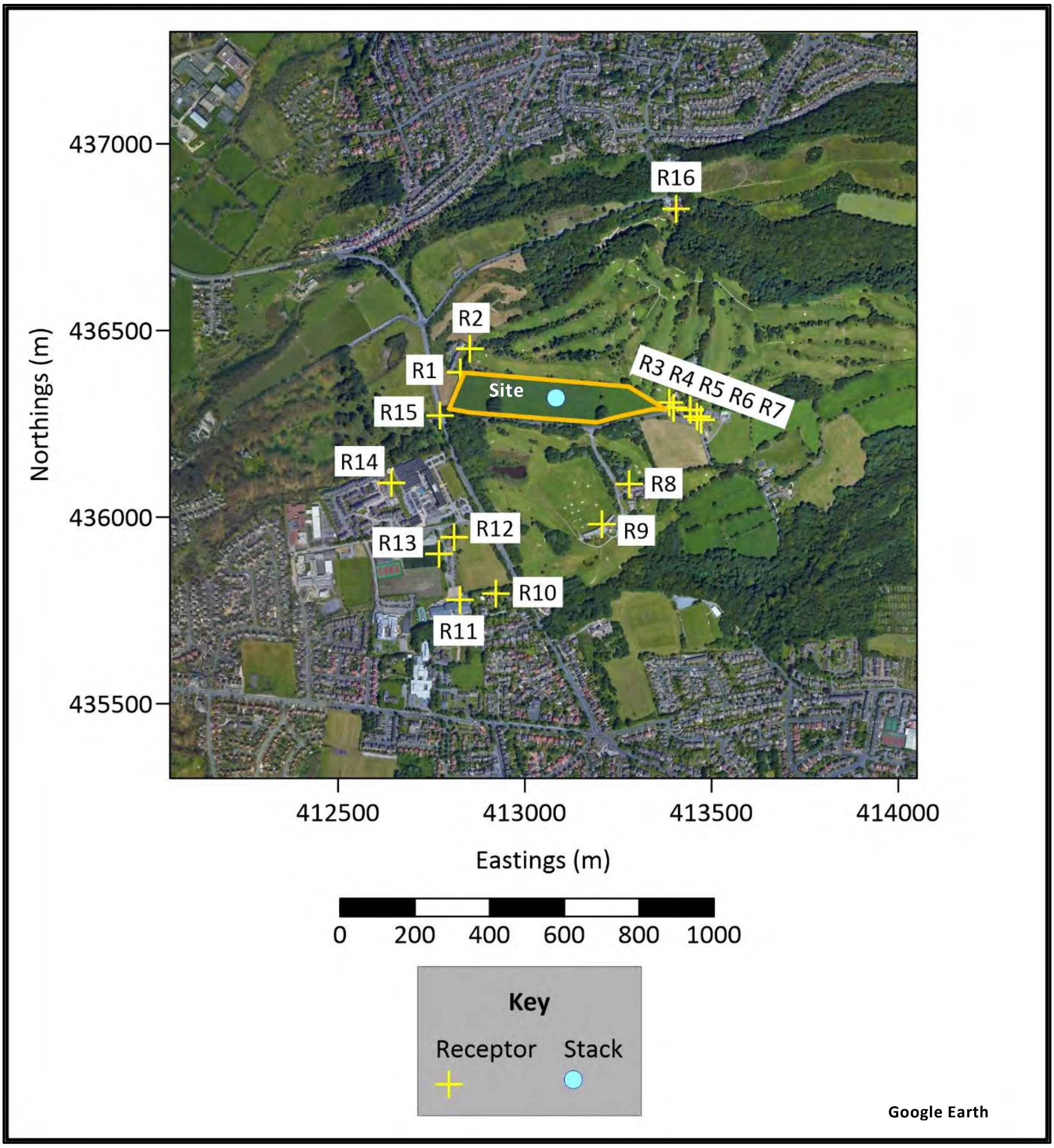

Figure 9: Sensitive Receptor Locations on a Google Earth Aerial Basemap

The sensitive receptor locations (R1 to R16) are shown in Figure 10 on an OSM basemap. The site boundary is shown by a solid red line and the proposed cremator stack location is shown by a red dot.

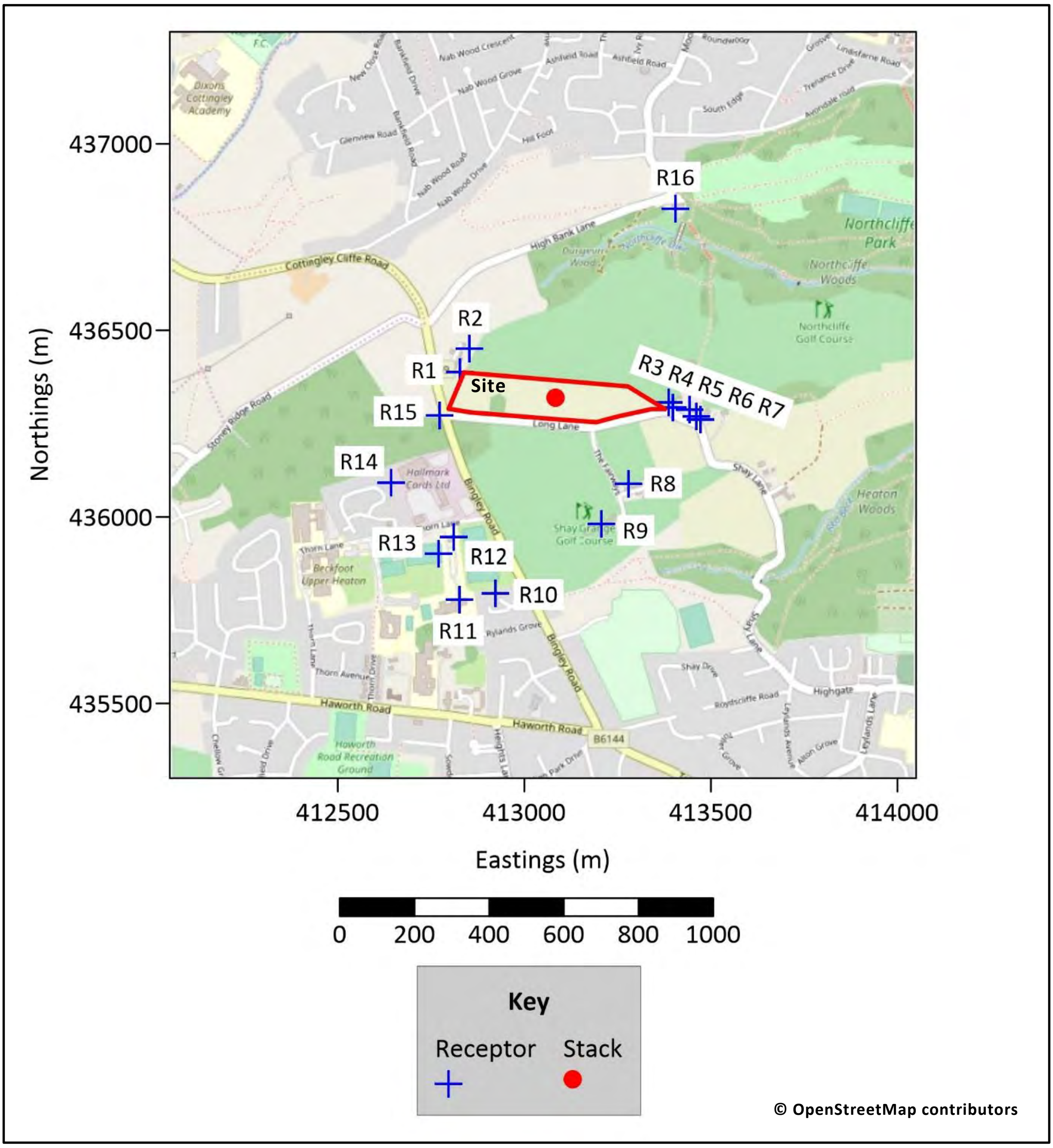

Figure 10: Sensitive Receptor Locations on an OpenStreetMap Basemap

4.4 Building Data

BPIP-PRIME (Building Profile Input Program – Plume Rise Model Enhancements) was used in this assessment to account for enhanced plume dispersion in the turbulent wake, and reduced plume rise due to a combination of descending streamlines and increased entrainment in the wake.

The proposed chapel and crematory buildings located on the project site were input into the model to account for building downwash effects.

4.5 Meteorological Data

The meteorological pre-processor AERMET (Version 18081) was used to generate the surface and profile meteorological data files for input into AERMOD, which were created using local meteorological data taken from the Bingley weather station for the five-year period from 1 January 2014 to 31 December 2018 (see Section 3).

The land use surrounding the Bingley weather station was assumed to be 'urban' (90°N to 910°N) and 'grassland' (190°N to 90°N) and the US EPA's default monthly values for albedo (r), Bowen ratio (B_0) and surface roughness (z_0) were applied.

4.6 Emission Rates, Scenarios and Assumptions

The emission rates input into the dispersion model were based on the emission limit values stated in PG5/2(12). Emission limit values were available for total particulate matter, total volatile organic compounds (VOCs) and Hg, HCl and CO but not NO_x. However, the NO_x emissions from the cremator stack are anticipated to be negligible (see Section 1). The results of a sensitivity assessment (see Section 5) indicate that there are unlikely to be any exceedances of the relevant AQS Objectives for NO_2 and, therefore, the air quality impacts at any sensitive receptor location were predicted to be *'negligible'*. The PM_{10} and $PM_{2.5}$ emission rates were both assumed to be as 100% of the total particulate matter emissions, in the absence of size fraction data.

In order to undertake a worst-case assessment, it was assumed that the actual volumetric flow rate at the cremator stack will be 3 m^3/s, whereas in reality it is likely to be much lower than this, based on Acilia's experience at other project sites. Furthermore, as the minimum stack exit velocity recommended in PG5/2(12) is 15 m/s, it was also conservatively assumed that the stack exit diameter will be 0.5 m to give a stack exit velocity of 15.3 m/s. Again, in reality it is possible that the stack could be designed to give a much higher exit velocity (e.g. by fitting a cone or by installing a smaller diameter stack), which would create much better dispersion conditions than was considered in the model. The stack exit temperature was assumed to be 90°C.

It was also assumed that the cremator will be fitted with a single stack and that the emissions to air will be controlled by an abatement system, as per PG5/2(12), which is likely to comprise of fabric filtration (e.g. bag filter fitted with a filter leak detector) to control particulate emissions, activated carbon filter to control mercury and VOC emissions, and alkali compounds to control acid gases, such as HCl.

The parameters input into the model for the proposed cremator stack, including the stack emission concentrations, are shown in Table 5.

Table 5: Emission Parameters Input into the Model for the Proposed Cremator Stack

Parameter	Value input into Model
Stack height (m) [1]	9
Stack exit temperature (K)	363
Stack exit diameter (m)	0.5
Stack exit velocity (m/s)	15.3
Emission Concentration (mg/Nm^3) [2,3]	
PM_{10}	20
$PM_{2.5}$	20
Hg	0.05
HCl	30
CO	100
Emission Rate (g/s) [4]	
PM_{10}	0.038
$PM_{2.5}$	0.038
Hg	0.0001
HCl	0.057
CO	0.191

Notes:

1. The height of the proposed cremator stack was assumed to be 9 m above ground level (3 m above roof-level) to promote adequate dispersion. The stack was located at 413084 m E, 436320 m N.
2. At reference conditions of 273.1 K, 101.3 kPa and 11% O_2 v/v on a dry gas basis.
3. It was conservatively assumed in the modelling assessment that the PM_{10} and $PM_{2.5}$ emission rates were as per total particulate matter, in the absence of particle size fraction data.
4. It was assumed that the stack discharges will be vertical and unimpeded, and continuous (24/7).

4.7 Dispersion Options and Model Run Period

It was conservatively assumed in the modelling assessment that the cremator stack emissions will be continuous throughout the model run period (i.e. the emissions will occur 24 hours a day and 7 days a week), whereas in reality the cremator will be used much less frequently.

The model was run for the complete five-year meteorological data period for Bingley (i.e. 1 January 2014 hour 1 to 31 December 2018 hour 24) using the urban dispersion coefficients and the following US EPA regulatory defaults options:

- Stack-tip downwash (except for building downwash cases);
- Elevated terrain effects;
- Calms processing routine;
- Missing data processing routine; and
- No exponential decay.

In the 2014 model run, a total of 8,760 hours were processed, there were 3 missing hours (0.03%) and zero calm hours. There were no fatal error or warning messages.

In the 2015 model run, a total of 8,760 hours were processed, there were 4 missing hours (0.05%) and zero calm hours. There were no fatal error or warning messages.

In the 2016 model run, a total of 8,784 hours were processed, there were 4 missing hours (0.05%) and zero calm hours. There were no fatal error or warning messages.

In the 2017 model run, a total of 8,760 hours were processed, there were 2 missing hours (0.02%) and zero calm hours. There were no fatal error or warning messages.

In the 2018 model run, a total of 8,760 hours were processed, there were 4 missing hours (0.05%) and zero calm hours. There were no fatal error or warning messages.

Over the five-year period (2014 to 2018), 43,824 hours were processed in total and there were 17 missing hours (0.04%), zero calm hours and no fatal error or warning messages.

The terms 'background concentration' (BC), 'process contribution' (PC) and 'predicted environmental concentration' (PEC) are used in this report and are defined as follows:

- BC: The existing ambient air pollutant concentration (e.g. from background map);
- PC: The incremental change in air pollutant concentration (model prediction); and
- PEC: The predicted change in concentration (PC) plus background concentration.

5.0 Air Quality Impact Assessment

5.1 Particulate Matter as PM_{10}

Table 6 shows the predicted 24-hour mean PM_{10} concentrations at 90.41 percentile.

Table 6: 24-hour Mean PM_{10} Process Contribution and Total Concentration

Ref.	24-hr Mean PM_{10} Concentration (at the 90.41 %ile) (µg/m^3)							Max PC Against AQAL (%)	Max PEC Against AQAL (%)
	PC 2014	PC 2015	PC 2016	PC 2017	PC 2018	BC	Max PEC		
R1	0.38	0.39	0.43	0.29	0.36	20.6	21.0	0.9	42.1
R2	0.45	0.38	0.45	0.43	0.47	20.6	21.1	0.9	42.1
R3	0.41	0.45	0.37	0.50	0.40	20.6	21.1	1.0	42.2
R4	0.36	0.40	0.31	0.44	0.36	20.6	21.0	0.9	42.1
R5	0.29	0.35	0.26	0.35	0.29	20.6	21.0	0.7	41.9
R6	0.26	0.39	0.23	0.30	0.26	20.6	21.0	0.8	42.0
R7	0.24	0.38	0.21	0.29	0.25	20.6	21.0	0.8	42.0
R8	0.12	0.12	0.14	0.11	0.14	20.6	20.7	0.3	41.5
R9	0.06	0.06	0.08	0.05	0.05	20.6	20.7	0.2	41.4
R10	0.04	0.04	0.09	0.04	0.06	20.6	20.7	0.2	41.4
R11	0.05	0.04	0.08	0.03	0.07	20.6	20.7	0.2	41.4
R12	0.08	0.06	0.13	0.04	0.17	20.6	20.8	0.3	41.5
R13	0.07	0.05	0.11	0.04	0.16	20.6	20.8	0.3	41.5
R14	0.19	0.07	0.18	0.06	0.17	20.6	20.8	0.4	41.6
R15	0.47	0.17	0.34	0.18	0.31	20.6	21.1	0.9	42.1
R16	0.19	0.19	0.18	0.18	0.17	20.6	20.8	0.4	41.6

Notes:
PC: process contribution (without background concentration and for the year shown)
BC: background concentration (based on the Defra 1km by 1km background map for 2017)
PEC: predicted environmental concentration (i.e. PEC = PC + BC)
AQAL: air quality assessment level (i.e. the AQS Objective for PM_{10} of 50 µg/m^3 as 24-hour mean)

Table 6 shows the total 24-hour mean PM_{10} concentrations at the 90.41 percentile (or '%ile') predicted at ground-level at each sensitive receptor location (R1 to R16). The 'total concentration' is also known as the 'predicted environmental concentration' (or 'PEC'), which includes the contribution from the cremator stack emissions (the 'process contribution' or 'PC') and from existing background emission sources, such as home heating, transport and industry (i.e. PEC = process contribution + background concentration). The background concentration was assumed to be 20.6 $\mu g/m^3$.

The results shown in the table indicate that there were predicted to be no exceedances of the 24-hour mean AQS Objective for PM_{10} of 50 $\mu g/m^3$ at any sensitive receptor location. The highest total 24-hour mean PM_{10} 90.41 percentile concentration shown in the table of 21.1 $\mu g/m^3$ was predicted at receptors R2, R3 and R15. Receptors R2 and R15 are residential properties situated 60 m N and 20 m SW of the site boundary, respectively, while receptor R3 is the Northcliffe Golf Club (greenkeepers buildings) situated 10 m to the E of the site boundary. This highest predicted 24-hour mean concentration (PEC) represents 42% of the AQS Objective. In other words, the highest 24-hour mean process contribution at the 90.41 percentile (i.e. excluding background) was only predicted to be 0.5 $\mu g/m^3$ (at R3 in 2017).

The total maximum predicted 24-hour mean 90.41 percentile PM_{10} concentrations (PECs) for 2014 to 2018 are shown in Figure 11 to Figure 15 and include a background concentration of 20.6 $\mu g/m^3$. The figures also show the discrete receptor locations (white circles with a plus sign in the centre), the site boundary (solid blue line) and the 50 $\mu g/m^3$ AQS Objective contour line (red with solid fill). Note that the scale used is non-linear.

The figures indicate that no exceedances of the AQS Objective were predicted at any discrete sensitive receptor location (receptors R1 to R16), or at any location at or beyond the site boundary. The highest total 24-hour mean PM_{10} (90.41 percentile) concentration predicted at any grid receptor location (including on the proposed development site) was 33.4 $\mu g/m^3$.

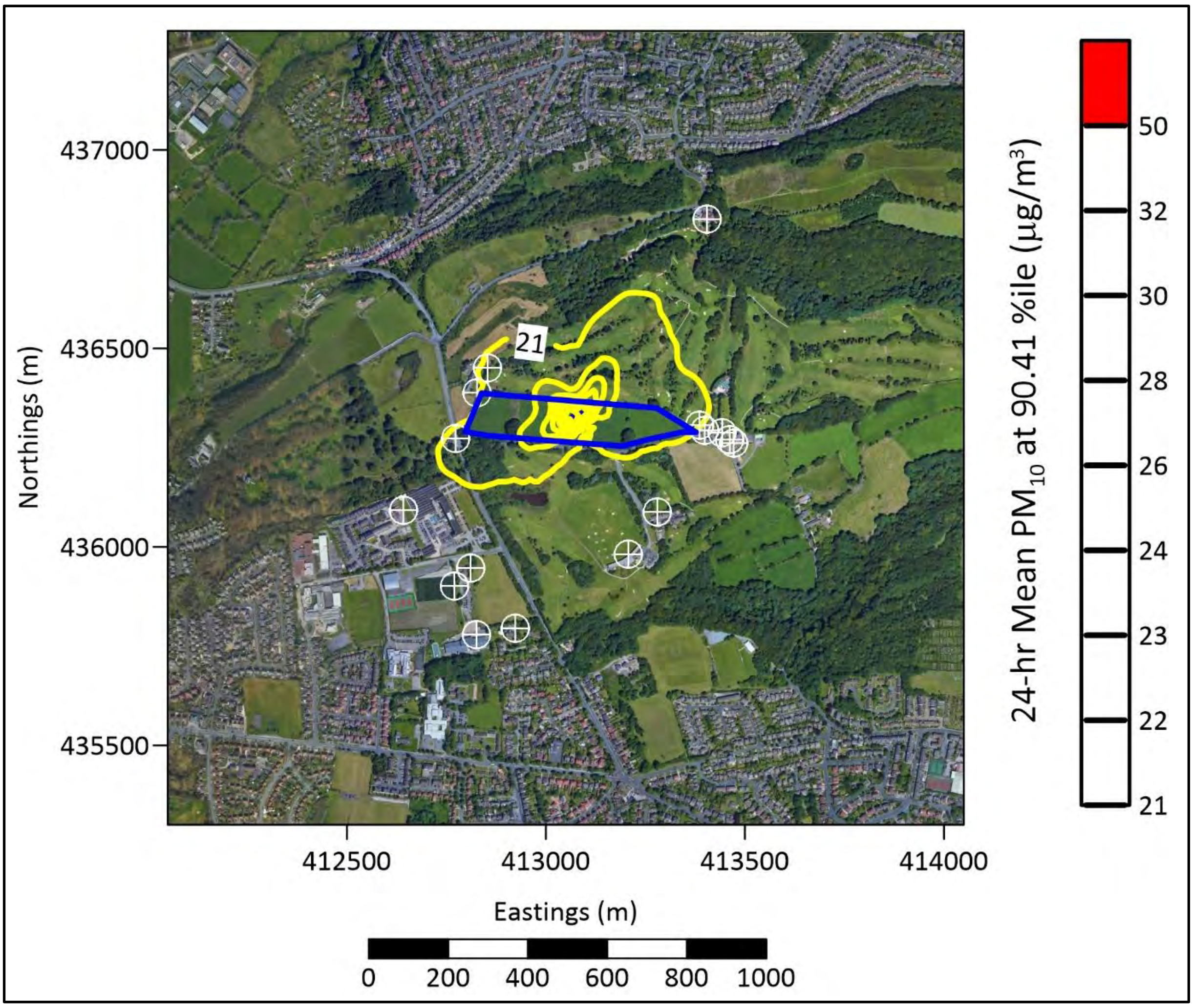

Figure 11: Total 24-hour Mean PM_{10} Concentration (µg/m³) at 90.41 %ile for 2014

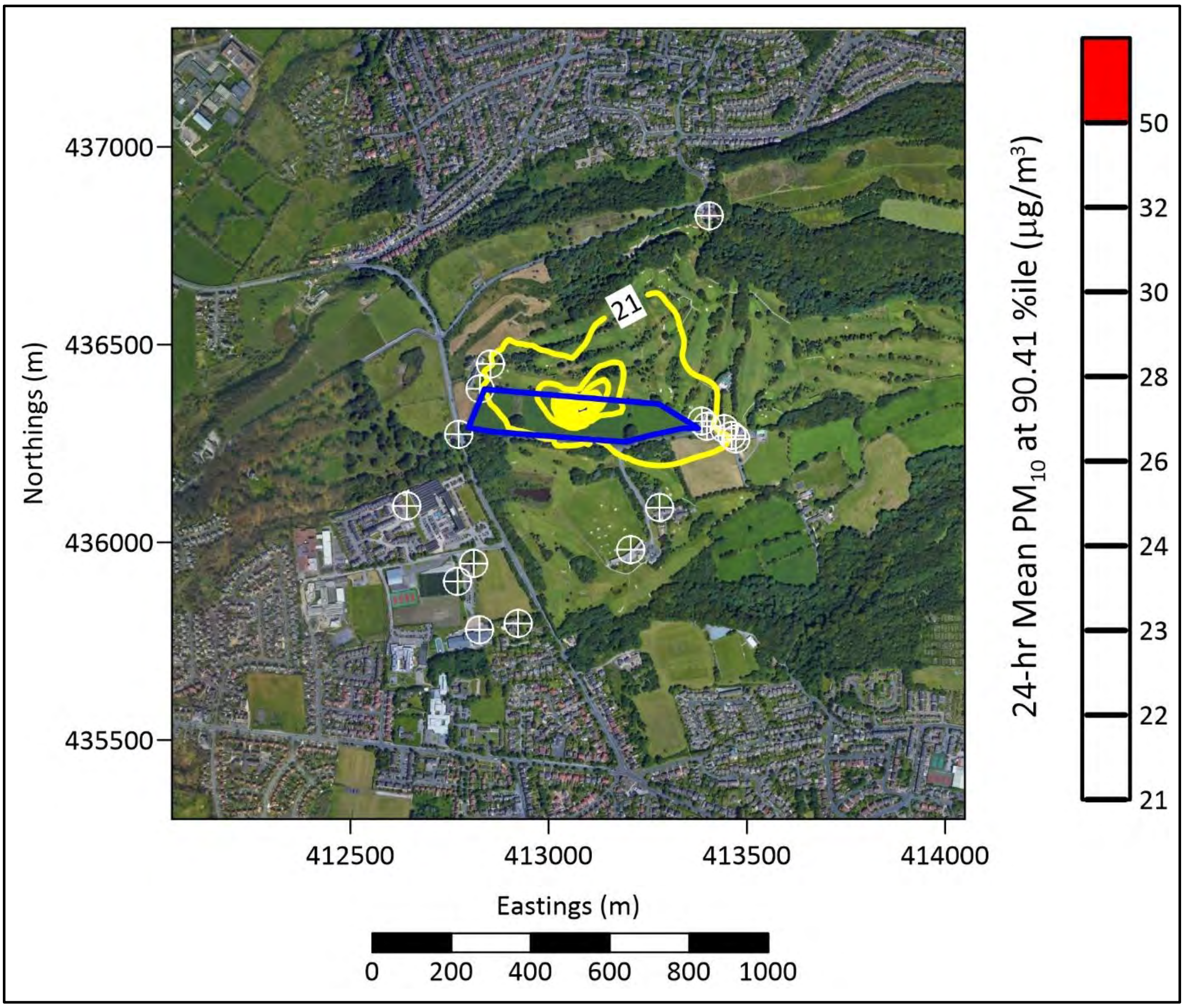

Figure 12: Total 24-hour Mean PM_{10} Concentration (µg/m³) at 90.41 %ile for 2015

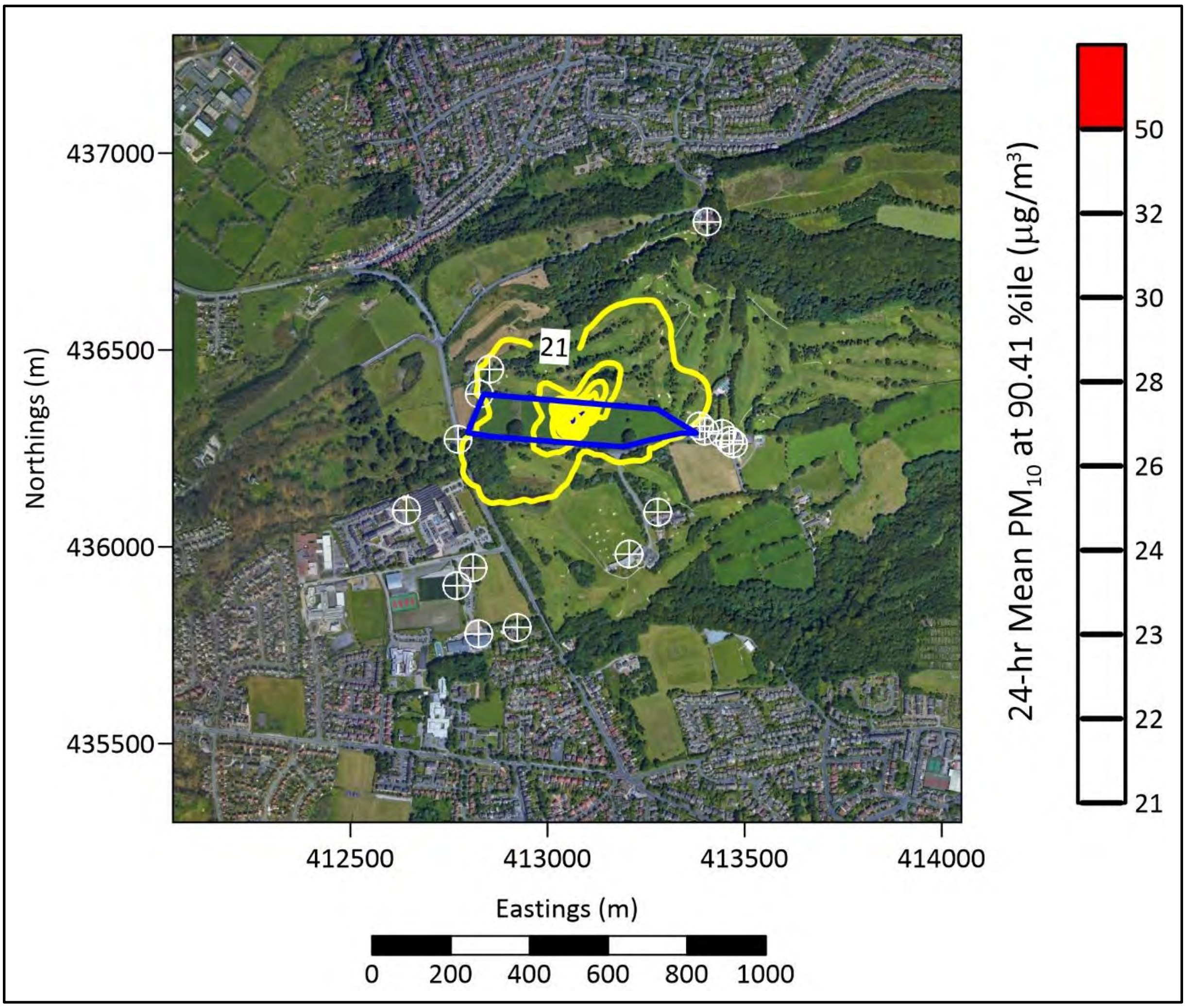

Figure 13: Total 24-hour Mean PM_{10} Concentration (µg/m³) at 90.41 %ile for 2016

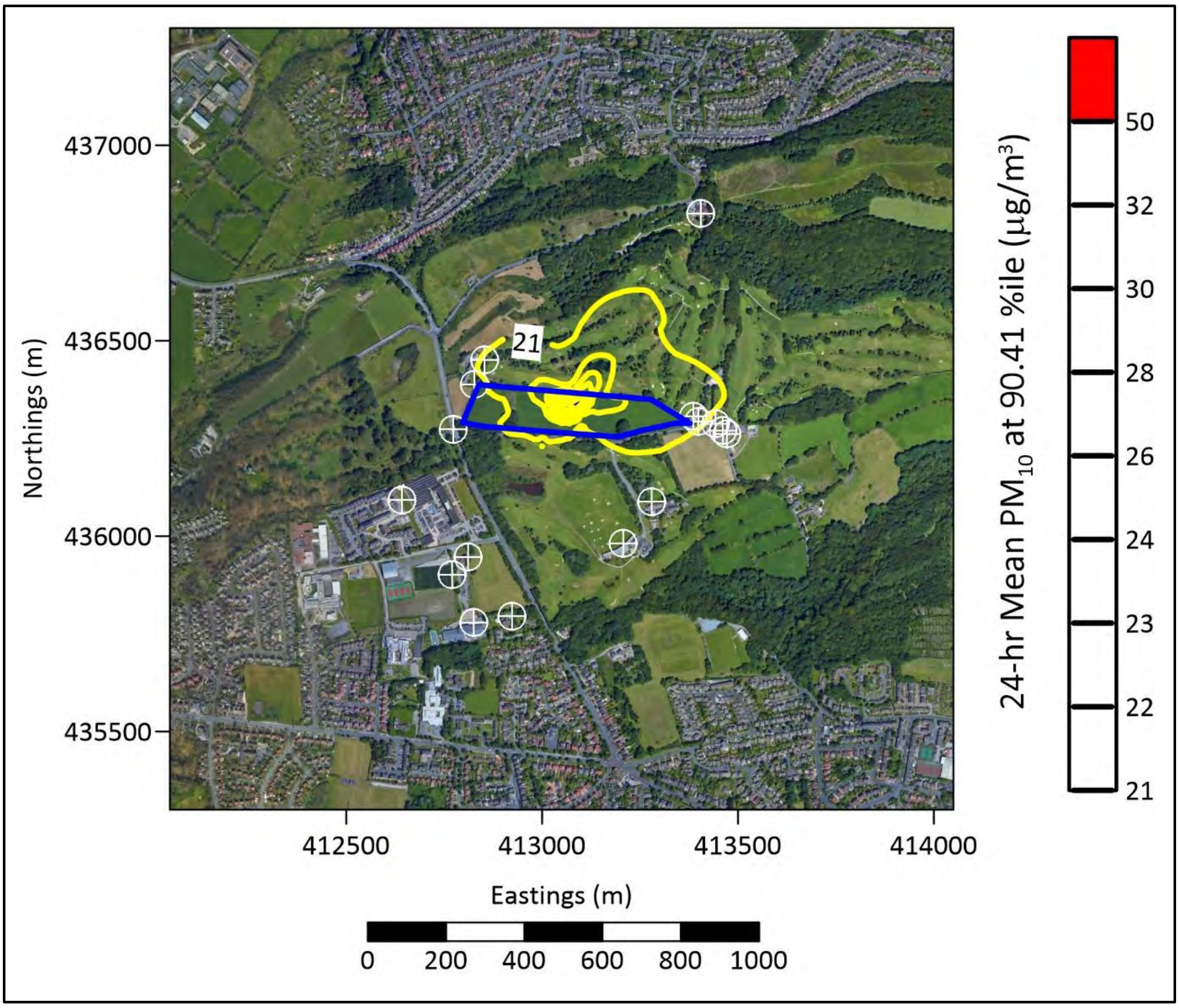

Figure 14: Total 24-hour Mean PM_{10} Concentration (µg/m³) at 90.41 %ile for 2017

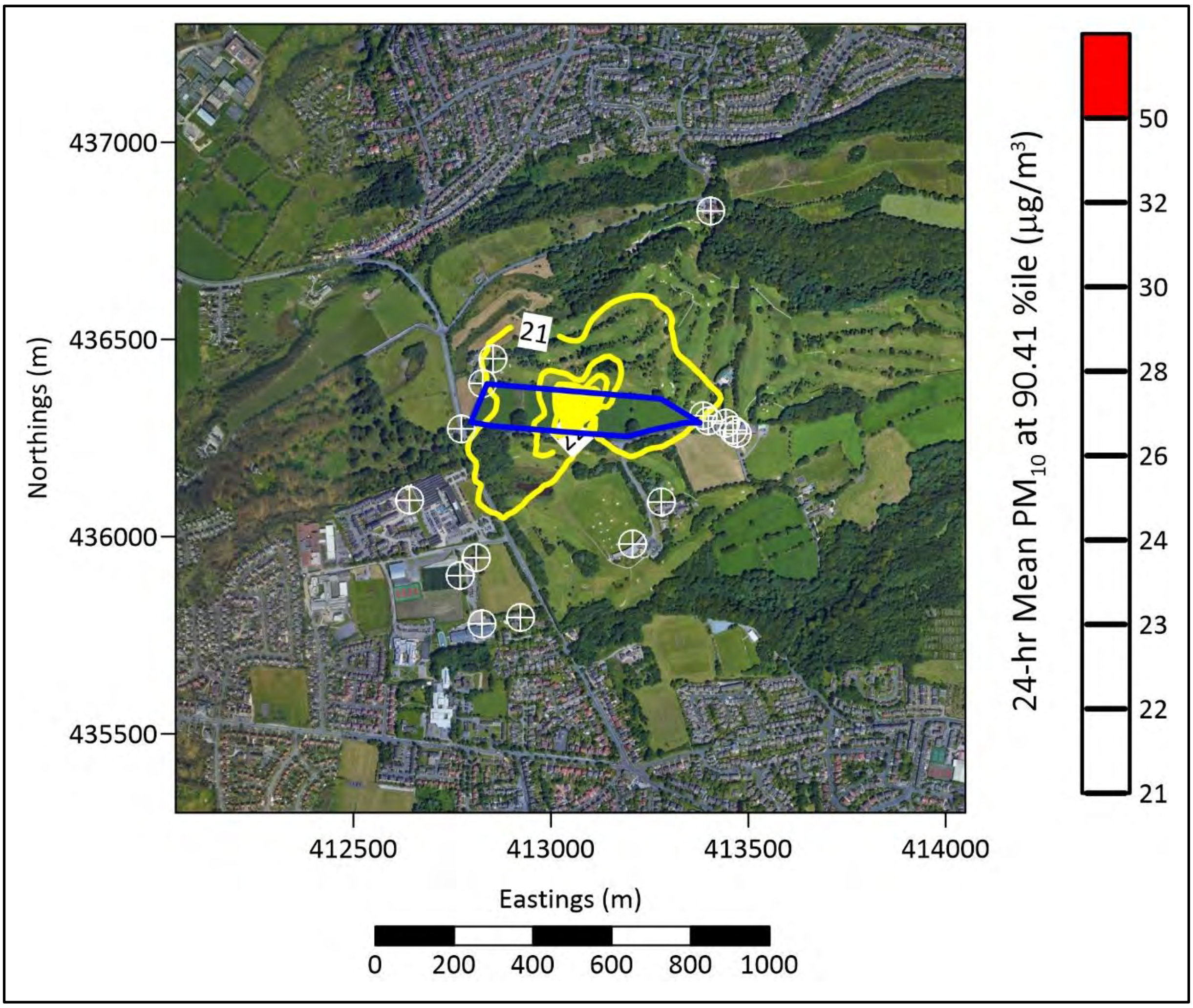

Figure 15: Total 24-hour Mean PM_{10} Concentration (µg/m³) at 90.41 %ile for 2018

Table 7 shows the annual mean PM_{10} concentrations predicted by the model at each sensitive receptor location (R1 to R16).

Table 7: Annual Mean PM_{10} Process Contribution and Total Concentration

Ref.	Annual Mean PM_{10} Concentration (µg/m³)							Max PC Against AQAL (%)	Max PEC Against AQAL (%)
	PC 2014	PC 2015	PC 2016	PC 2017	PC 2018	BC	Max PEC		
R1	0.11	0.10	0.12	0.09	0.11	10.3	10.4	0.3	26.0
R2	0.13	0.11	0.12	0.11	0.13	10.3	10.4	0.3	26.1
R3	0.14	0.17	0.12	0.19	0.15	10.3	10.5	0.5	26.2
R4	0.12	0.16	0.11	0.17	0.13	10.3	10.5	0.4	26.2
R5	0.10	0.13	0.09	0.14	0.11	10.3	10.4	0.3	26.1
R6	0.09	0.12	0.08	0.12	0.09	10.3	10.4	0.3	26.1
R7	0.08	0.12	0.07	0.11	0.09	10.3	10.4	0.3	26.0
R8	0.04	0.04	0.05	0.04	0.05	10.3	10.3	0.1	25.9
R9	0.02	0.02	0.03	0.02	0.02	10.3	10.3	0.1	25.8
R10	0.02	0.02	0.03	0.02	0.02	10.3	10.3	0.1	25.8
R11	0.02	0.02	0.03	0.01	0.02	10.3	10.3	0.1	25.8
R12	0.03	0.02	0.04	0.02	0.05	10.3	10.3	0.1	25.9
R13	0.03	0.02	0.04	0.02	0.04	10.3	10.3	0.1	25.8
R14	0.05	0.02	0.05	0.03	0.04	10.3	10.4	0.1	25.9
R15	0.14	0.06	0.11	0.06	0.09	10.3	10.4	0.4	26.1
R16	0.06	0.07	0.06	0.06	0.06	10.3	10.4	0.2	25.9

Notes:
PC: process contribution (without background concentration and for the year shown)
BC: background concentration (based on the Defra 1km by 1km background map for 2017)
PEC: predicted environmental concentration (i.e. PEC = PC + BC)
AQAL: air quality assessment level (i.e. the AQS Objective for PM_{10} of 40 µg/m³ as annual mean)

The results shown in the table indicate that there were predicted to be no exceedances of the annual mean AQS Objective for PM_{10} of 40 µg/m^3 at any sensitive receptor location. The highest total annual mean PM_{10} concentration shown in the table of 10.5 µg/m^3 was predicted at receptors R3 and R4. Receptor R4 is a residential property situated 20 m to the E of the site boundary. This highest predicted annual mean concentration (PEC) represents 26% of the AQS Objective. In other words, the highest annual mean process contribution (excluding background) was only predicted to be 0.19 µg/m^3 (at R3 in 2017).

The total predicted annual mean PM_{10} concentrations (PECs) for 2014 to 2018 are shown in Figure 16 to Figure 20 and include a background concentration of 10.3 µg/m^3. The figures also show the discrete receptor locations, the site boundary and the 40 µg/m^3 AQS Objective contour line. Note that the scale used is non-linear.

The figures indicate that no exceedances of the AQS Objective were predicted at any discrete sensitive receptor location (receptors R1 to R16), or at any location at or beyond the site boundary. The highest total annual mean PM_{10} concentration predicted at any grid receptor location (including on the proposed development site) was 14.7 µg/m^3.

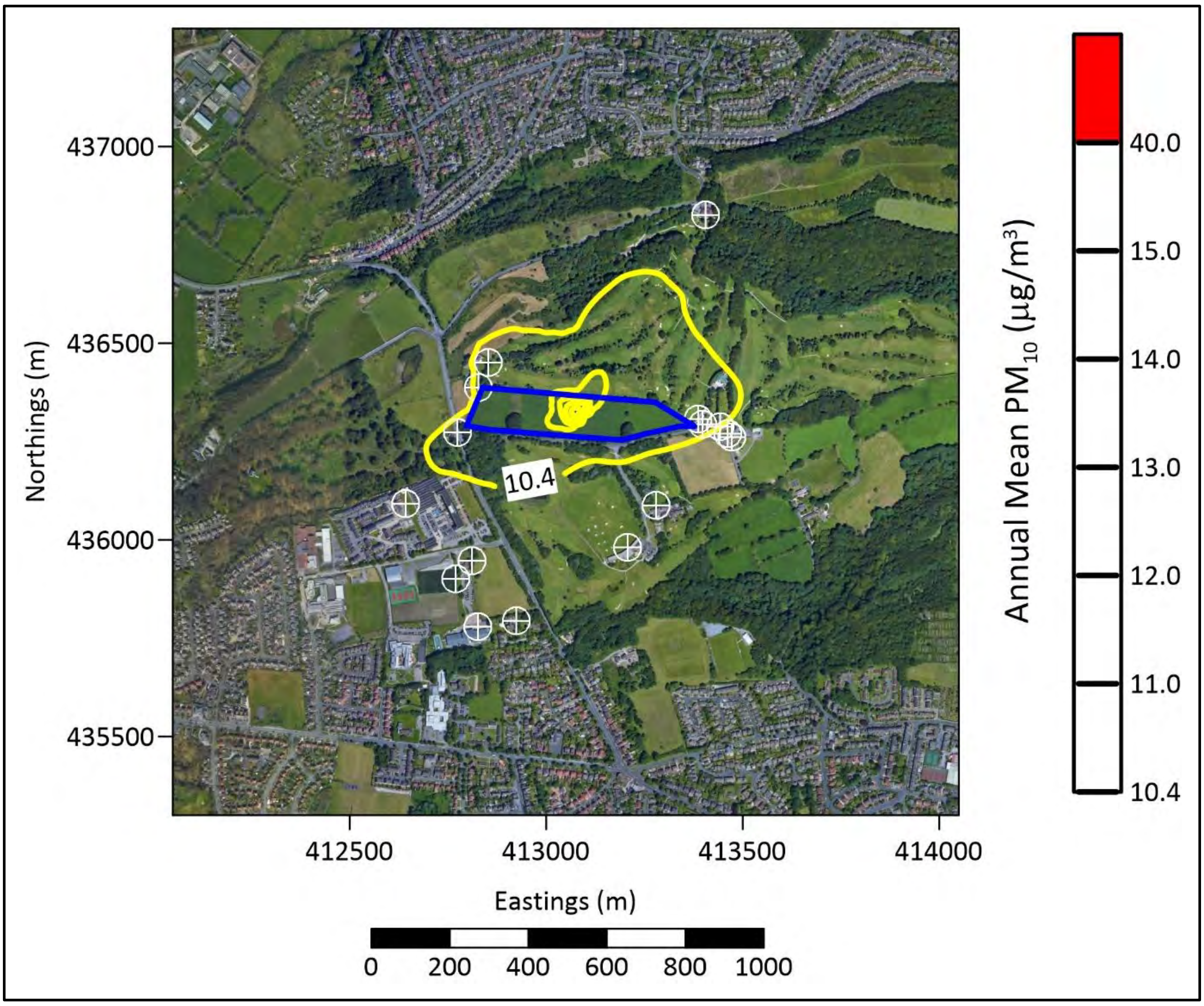

Figure 16: Total Annual Mean PM_{10} Concentration ($\mu g/m^3$) for 2014

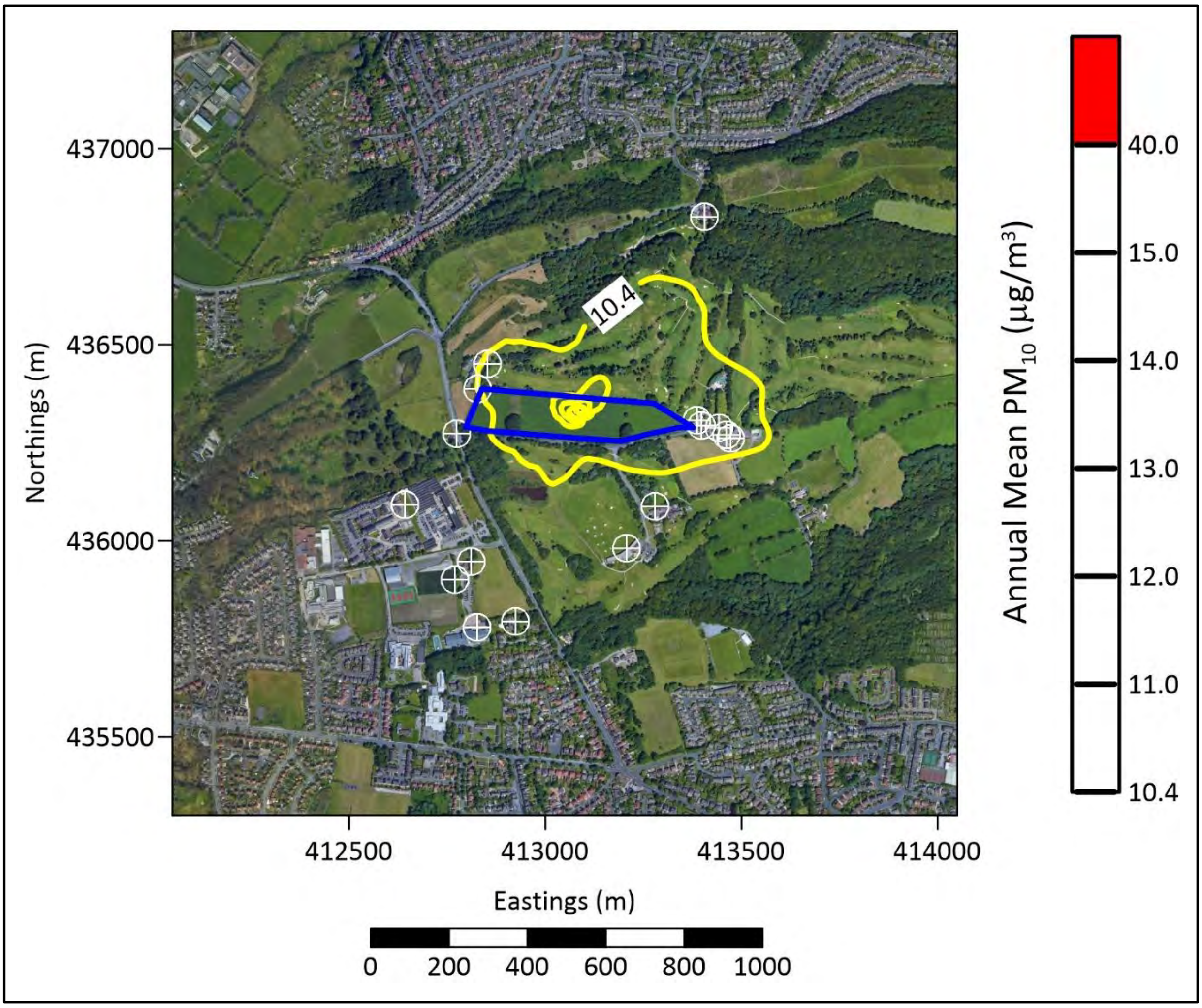

Figure 17: Total Annual Mean PM_{10} Concentration (µg/m³) for 2015

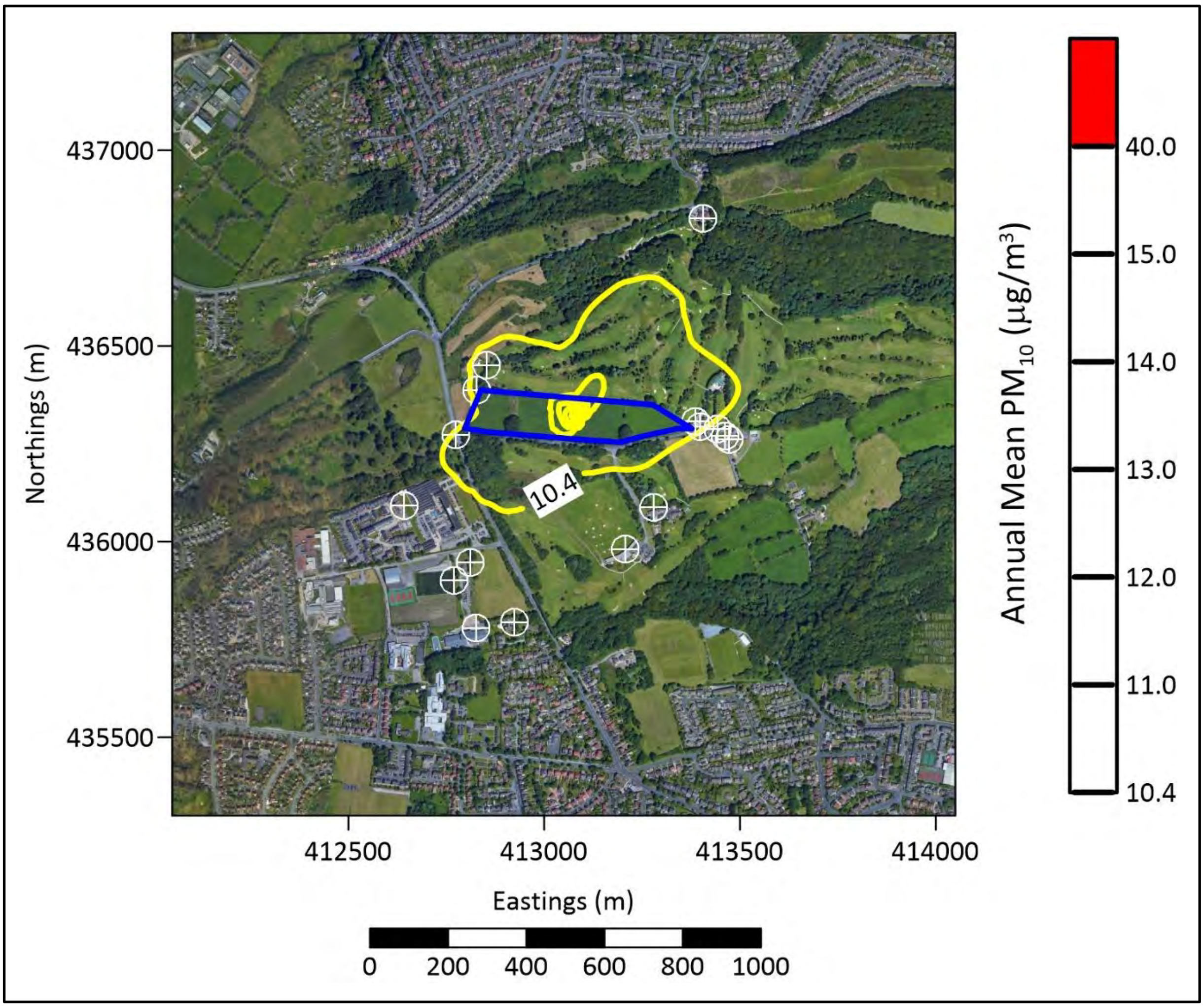

Figure 18: Total Annual Mean PM_{10} Concentration ($\mu g/m^3$) for 2016

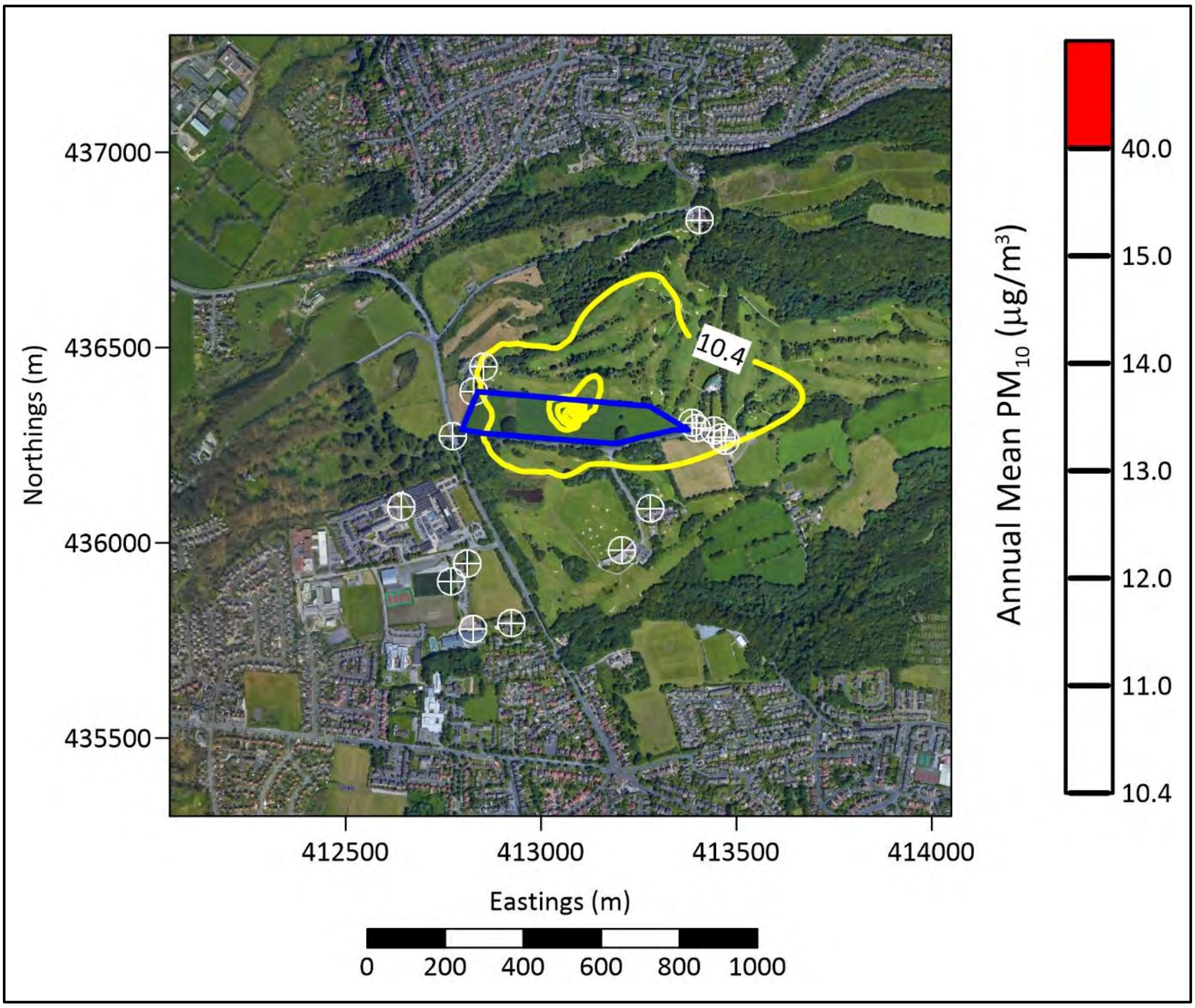

Figure 19: Total Annual Mean PM_{10} Concentration (µg/m³) for 2017

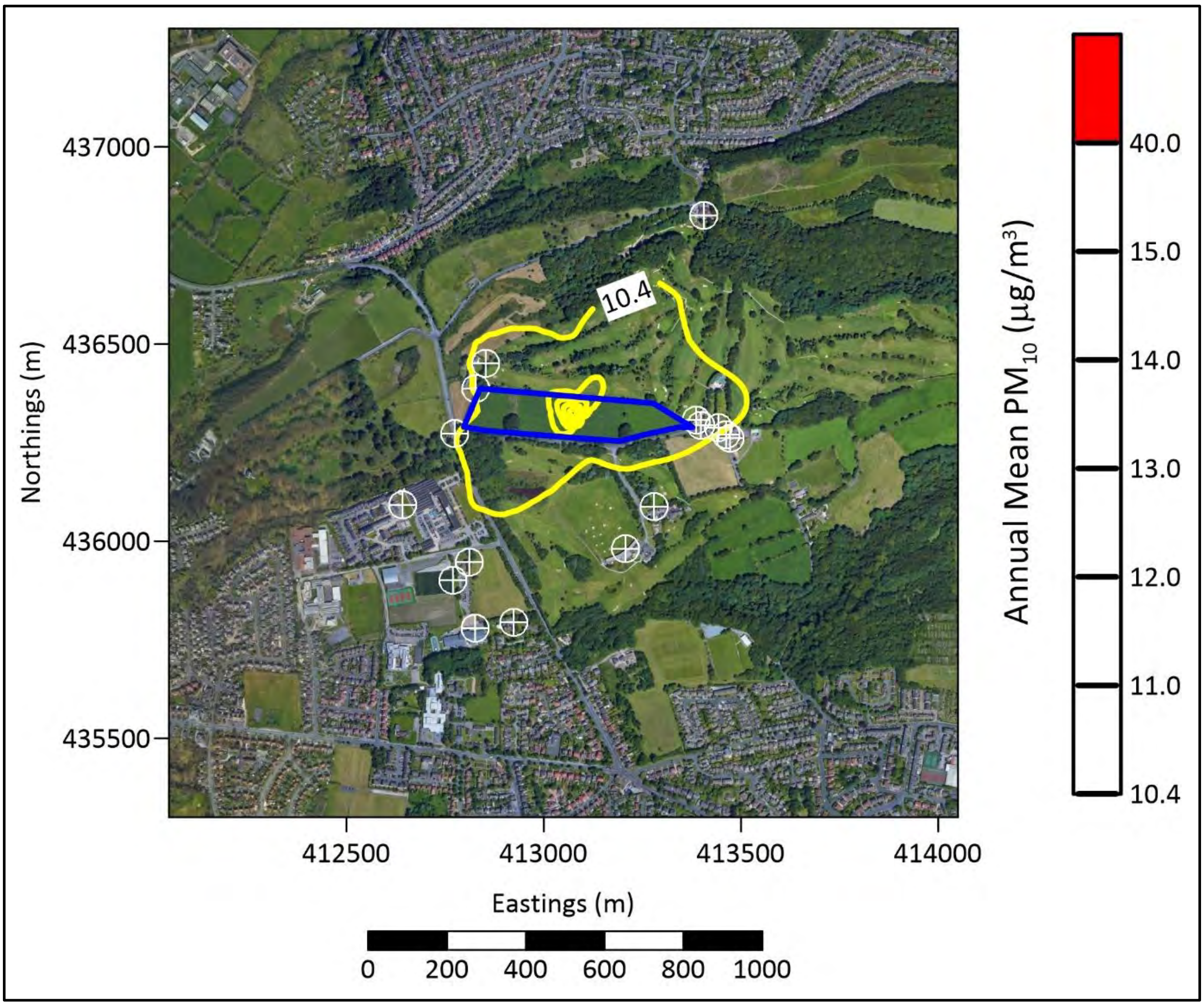

Figure 20: Total Annual Mean PM_{10} Concentration (µg/m³) for 2018

5.2 Particulate Matter as $PM_{2.5}$

Table 8 shows the annual mean $PM_{2.5}$ concentrations predicted by the model at each sensitive receptor location.

Table 8: Annual Mean $PM_{2.5}$ Process Contribution and Total Concentration

Ref.	Annual Mean $PM_{2.5}$ Concentration (µg/m^3)							Max PC Against AQAL (%)	Max PEC Against AQAL (%)
	PC 2014	PC 2015	PC 2016	PC 2017	PC 2018	BC	Max PEC		
R1	0.11	0.10	0.12	0.09	0.11	7.10	7.22	0.5	28.9
R2	0.13	0.11	0.12	0.11	0.13	7.10	7.23	0.5	28.9
R3	0.14	0.17	0.12	0.19	0.15	7.10	7.29	0.8	29.2
R4	0.12	0.16	0.11	0.17	0.13	7.10	7.27	0.7	29.1
R5	0.10	0.13	0.09	0.14	0.11	7.10	7.24	0.5	28.9
R6	0.09	0.12	0.08	0.12	0.09	7.10	7.22	0.5	28.9
R7	0.08	0.12	0.07	0.11	0.09	7.10	7.22	0.5	28.9
R8	0.04	0.04	0.05	0.04	0.05	7.10	7.15	0.2	28.6
R9	0.02	0.02	0.03	0.02	0.02	7.10	7.13	0.1	28.5
R10	0.02	0.02	0.03	0.02	0.02	7.10	7.13	0.1	28.5
R11	0.02	0.02	0.03	0.01	0.02	7.10	7.13	0.1	28.5
R12	0.03	0.02	0.04	0.02	0.05	7.10	7.15	0.2	28.6
R13	0.03	0.02	0.04	0.02	0.04	7.10	7.14	0.2	28.6
R14	0.05	0.02	0.05	0.03	0.04	7.10	7.15	0.2	28.6
R15	0.14	0.06	0.11	0.06	0.09	7.10	7.24	0.6	29.0
R16	0.06	0.07	0.06	0.06	0.06	7.10	7.17	0.3	28.7

Notes:
PC: process contribution (without background concentration and for the year shown)
BC: background concentration (based on the Defra 1km by 1km background map for 2017)
PEC: predicted environmental concentration (i.e. PEC = PC + BC)
AQAL: air quality assessment level (i.e. the annual mean AQS Objective for $PM_{2.5}$ of 25 µg/m^3)

The results shown in the table indicate that there were predicted to be no exceedances of the annual mean AQS Objective for $PM_{2.5}$ of 25 µg/m^3 at any sensitive receptor location. The highest total annual mean $PM_{2.5}$ concentration shown in the table of 7.29 µg/m^3 was predicted at receptor R3. This highest predicted annual mean concentration (PEC) represents 29% of the AQS Objective. In other words, the highest annual mean process contribution (excluding background) was only predicted to be 0.19 µg/m^3 (at R3 in 2017).

The total predicted annual mean $PM_{2.5}$ concentrations (PECs) for 2014 to 2018 are shown in Figure 21 to Figure 25 and include a background concentration of 7.1 µg/m^3. The figures also show the discrete receptor locations, the site boundary and the 25 µg/m^3 AQS Objective contour line. Note that the scale used is non-linear.

The figures indicate that no exceedances of the AQS Objective were predicted at any discrete sensitive receptor location (receptors R1 to R16), or at any location at or beyond the site boundary. The highest total annual mean $PM_{2.5}$ concentration predicted at any grid receptor location (including on the proposed development site) was 11.5 µg/m^3.

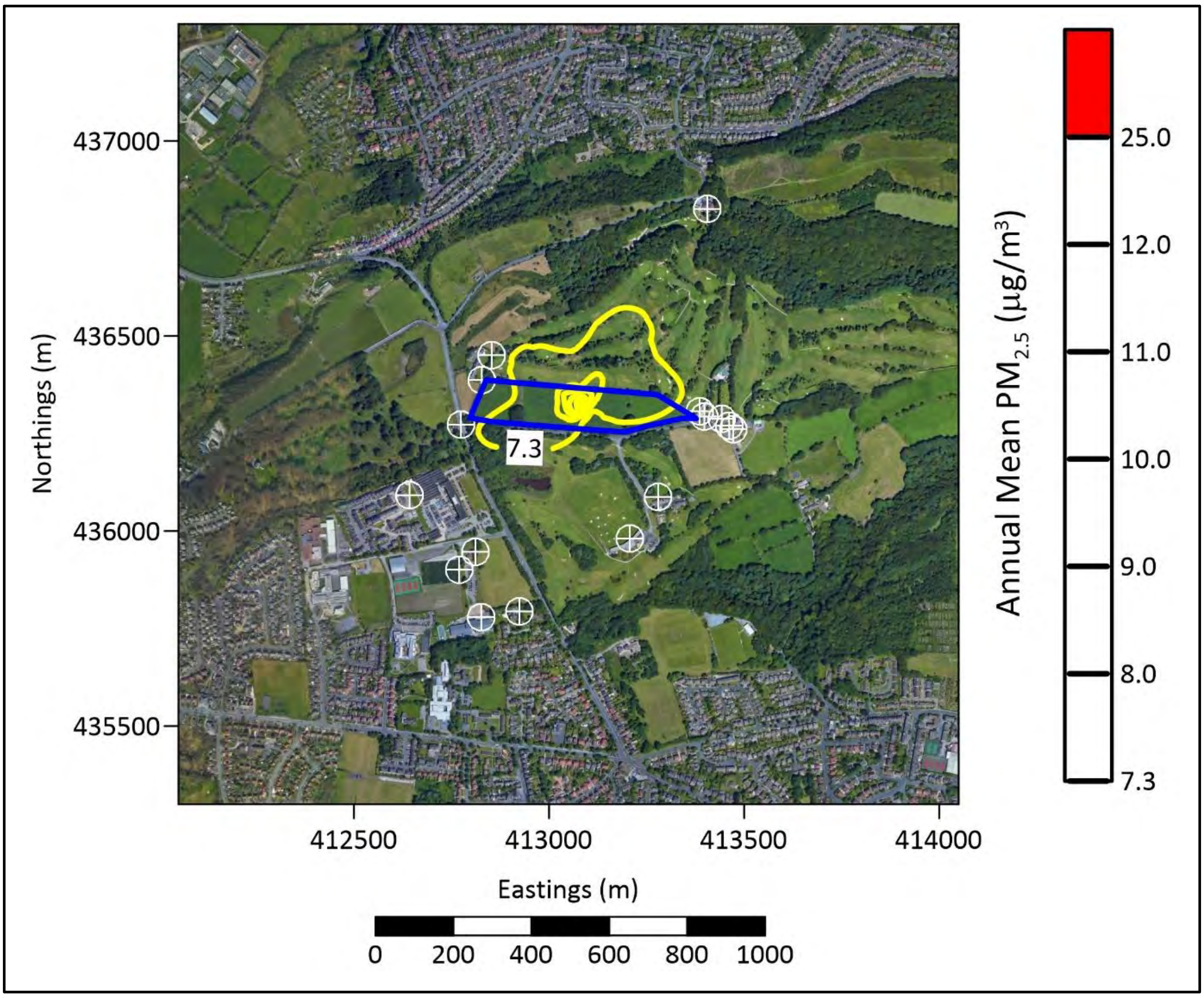

Figure 21: Total Annual Mean $PM_{2.5}$ Concentration (µg/m^3) for 2014

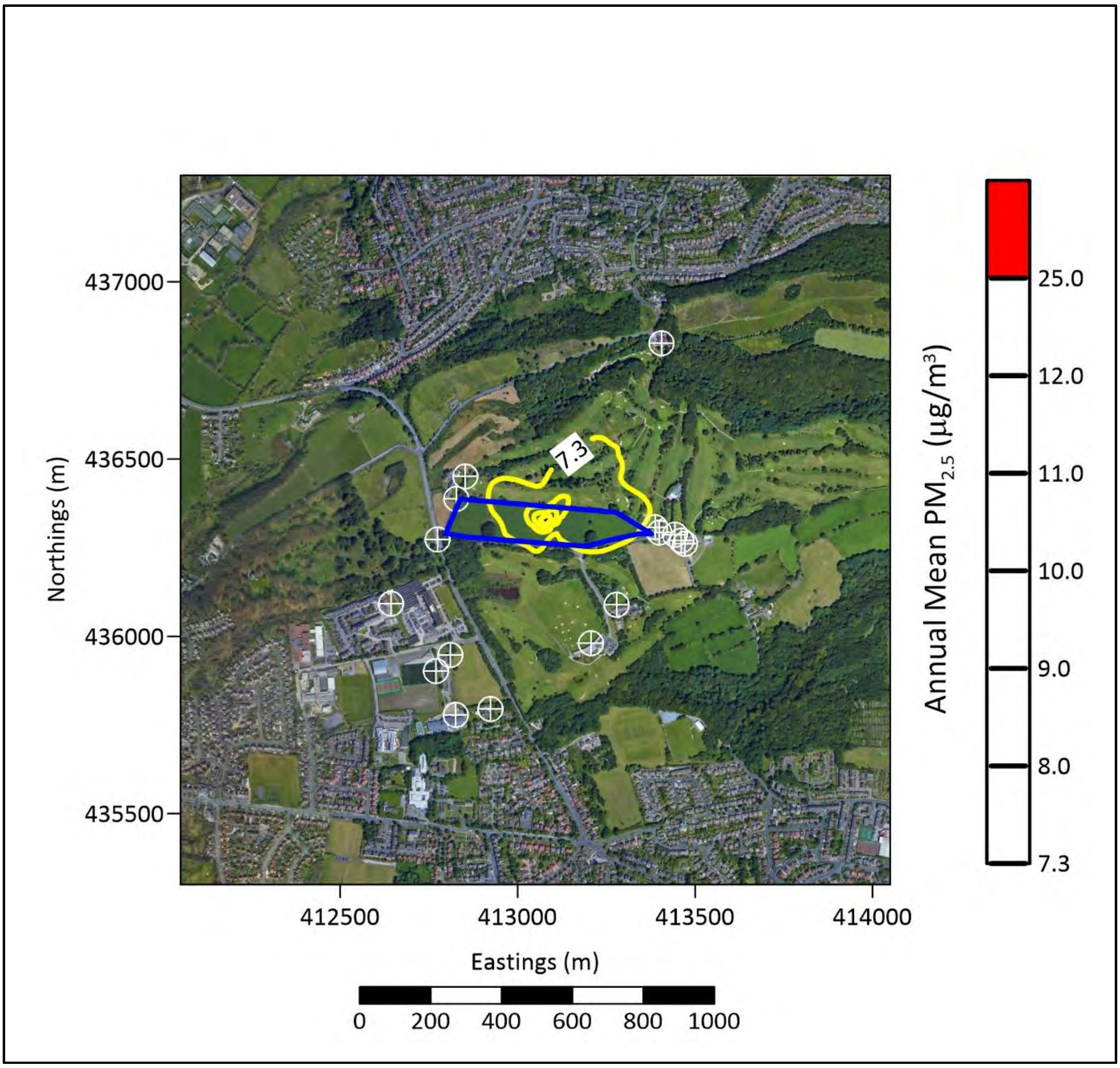

Figure 22: Total Annual Mean $PM_{2.5}$ Concentration (µg/m³) for 2015

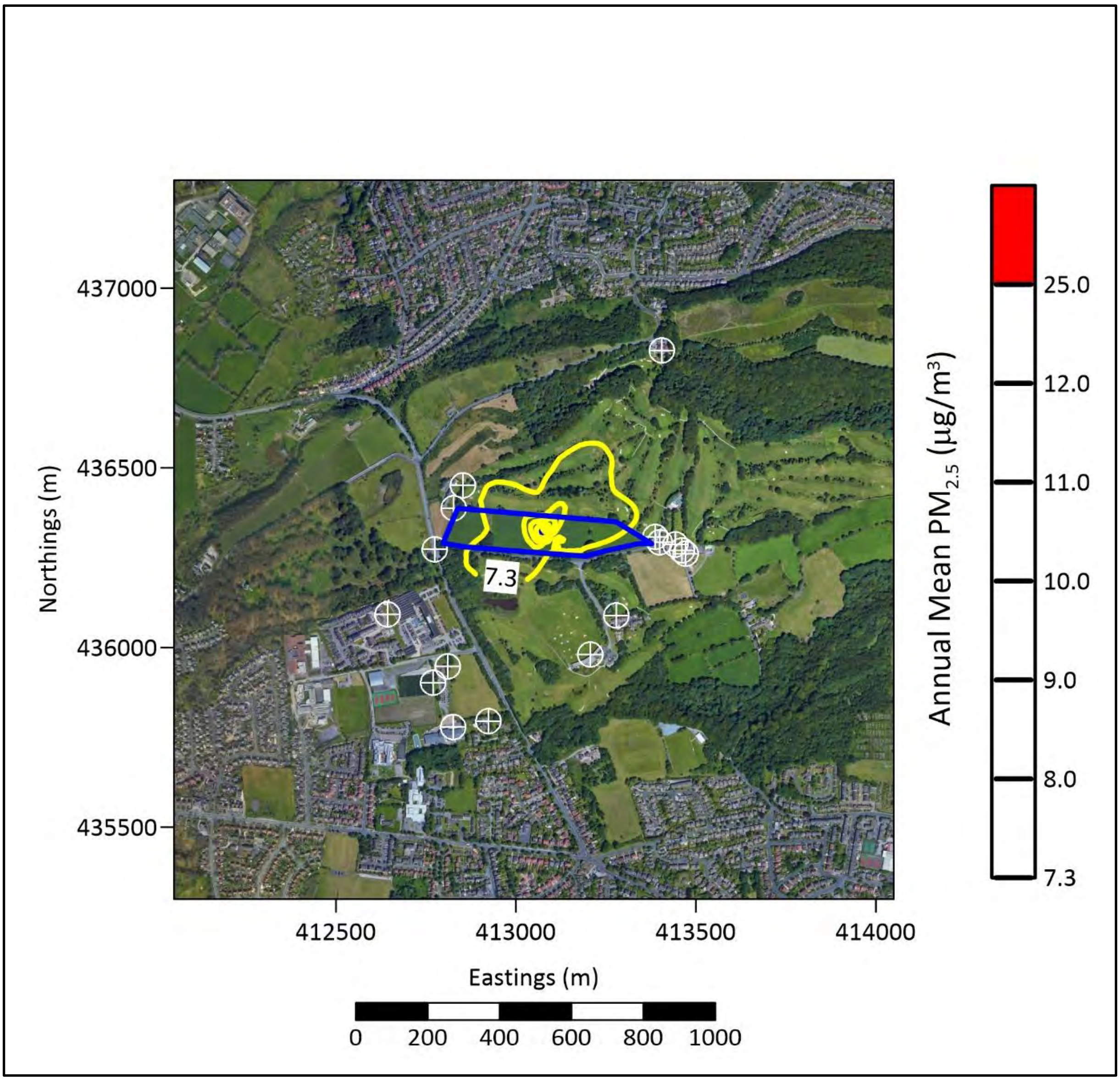

Figure 23: Total Annual Mean $PM_{2.5}$ Concentration (µg/m³) for 2016

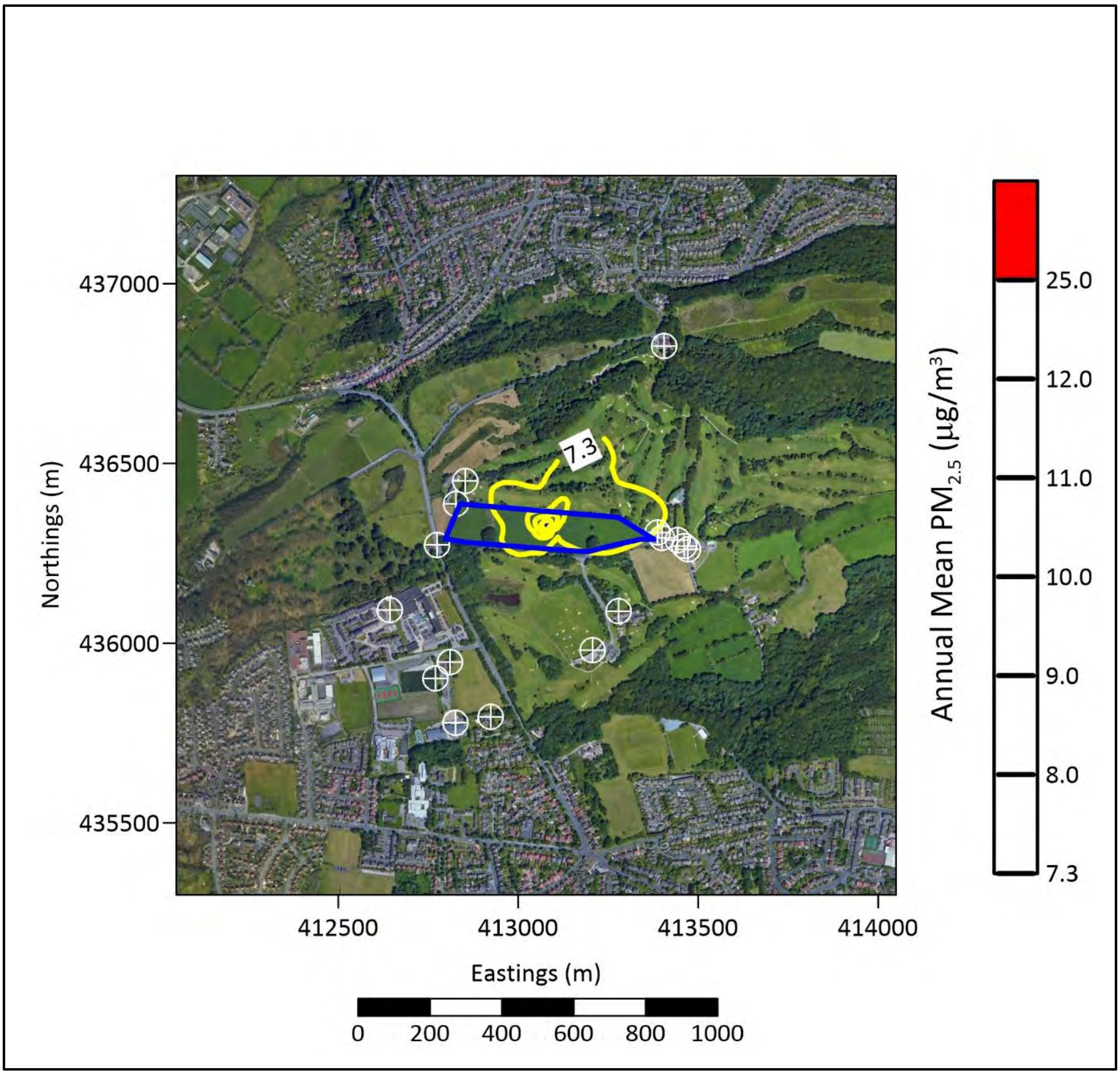

Figure 24: Total Annual Mean $PM_{2.5}$ Concentration (µg/m^3) for 2017

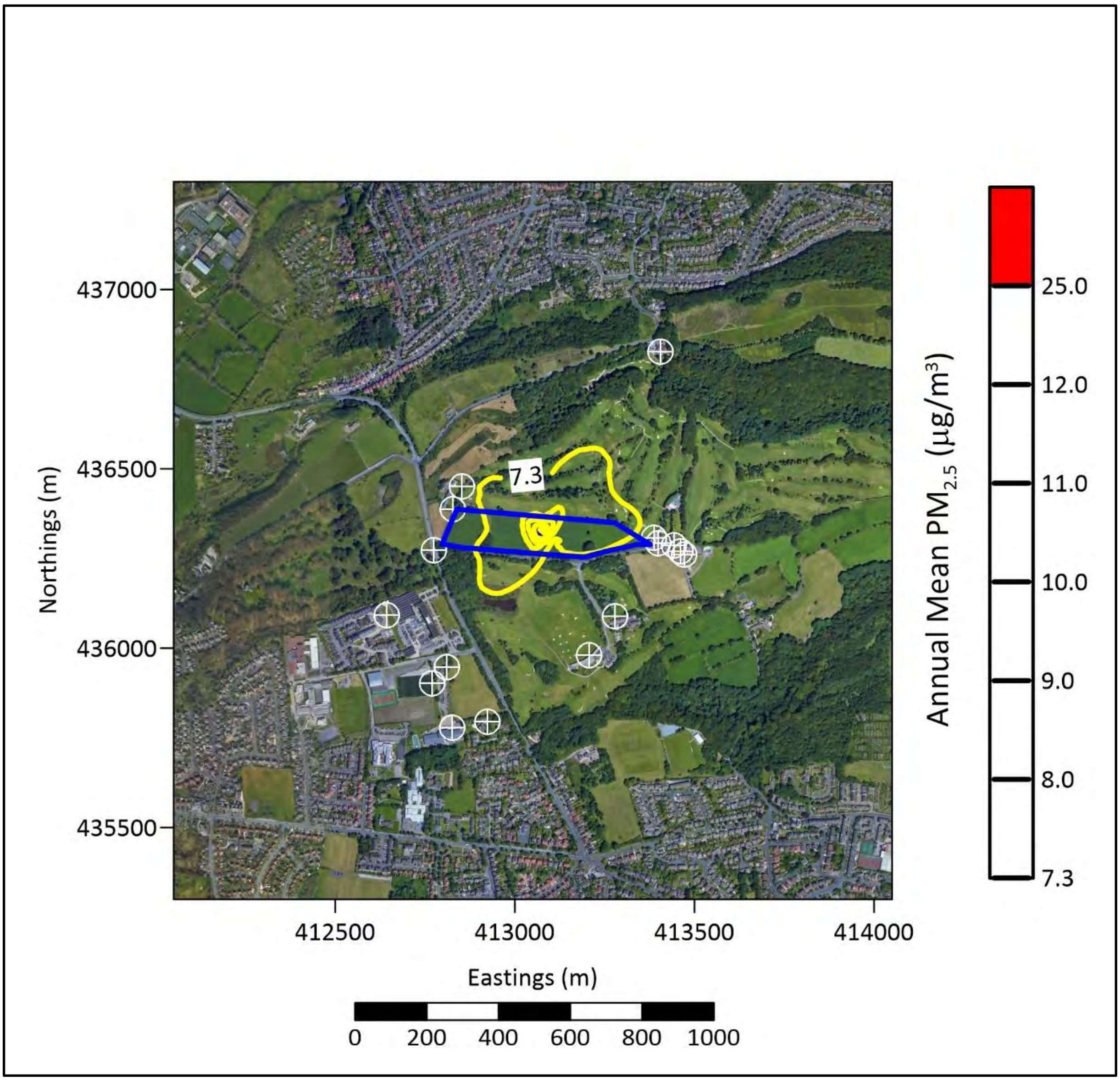

Figure 25: Total Annual Mean $PM_{2.5}$ Concentration (µg/m³) for 2018

5.3 Mercury

Table 9 shows the maximum 1-hour mean mercury concentrations predicted by the model at each sensitive receptor location. Note that the units are in ng/m^3.

Table 9: 1-hour Mean Mercury Process Contribution and Total Concentration

Ref.	1-hour Mean Mercury Concentration (ng/m^3)							Max PC Against AQAL (%)	Max PEC Against AQAL (%)
	PC 2014	PC 2015	PC 2016	PC 2017	PC 2018	BC	Max PEC		
R1	10.5	10.3	10.4	10.3	10.8	0.09	10.9	0.14	0.15
R2	15.7	15.6	15.8	15.0	15.5	0.09	15.9	0.21	0.21
R3	6.50	6.44	6.53	6.53	6.57	0.09	6.66	0.09	0.09
R4	4.05	3.66	3.78	3.99	3.71	0.09	4.14	0.05	0.06
R5	2.93	2.90	2.90	2.90	2.85	0.09	3.02	0.04	0.04
R6	3.38	3.32	3.34	3.25	3.36	0.09	3.47	0.05	0.05
R7	3.48	3.40	3.42	3.32	3.43	0.09	3.56	0.05	0.05
R8	5.49	6.36	5.30	4.92	6.33	0.09	6.45	0.08	0.09
R9	3.71	3.85	3.73	3.19	2.87	0.09	3.94	0.05	0.05
R10	3.30	3.20	3.20	3.60	3.14	0.09	3.68	0.05	0.05
R11	3.16	3.06	3.06	2.65	3.04	0.09	3.24	0.04	0.04
R12	3.75	3.53	3.61	3.57	3.67	0.09	3.83	0.05	0.05
R13	3.72	3.44	3.48	3.45	3.67	0.09	3.81	0.05	0.05
R14	5.37	5.22	5.41	5.14	5.24	0.09	5.50	0.07	0.07
R15	16.1	15.5	16.4	16.1	15.2	0.09	16.5	0.22	0.22
R16	2.88	2.88	2.84	2.77	2.92	0.09	3.01	0.04	0.04

Notes:
PC: process contribution (without background concentration and for the year shown)
BC: background concentration (based on ambient air quality monitoring data for Tinsley)
PEC: predicted environmental concentration (i.e. PEC = PC + BC)
AQAL: air quality assessment level (i.e. the EAL for Hg of 7,500 ng/m^3 (7.5 µg/m^3) as a 1-hour mean)

The results shown in the table indicate that there were predicted to be no exceedances of the 1-hour mean EAL for Hg of 7,500 ng/m^3 (7.5 µg/m^3) at any sensitive receptor location. The highest total 1-hour mean Hg concentration shown in the table of 16.5 ng/m^3 was predicted at receptor R15. This highest predicted 1-hour mean concentration (PEC) represents 0.2% of the EAL. In other words, the highest 1-hour mean process contribution (excluding background) was predicted to be 16.4 ng/m^3 (at R15 in 2016).

The total predicted 1-hour mean Hg concentrations (PECs) for 2014 to 2018 are shown in Figure 26 to Figure 30 and include a background concentration of 0.086 ng/m^3. The figures also show the discrete receptor locations, the site boundary and the 7,500 ng/m^3 EAL contour line. Note that the scale used is non-linear.

The figures indicate that no exceedances of the 1-hour mean EAL were predicted at any discrete sensitive receptor location (receptors R1 to R16), or at any location at or beyond the site boundary. The highest total 1-hour mean Hg concentration predicted at any grid receptor location (including on the proposed development site) was 93.5 ng/m^3.

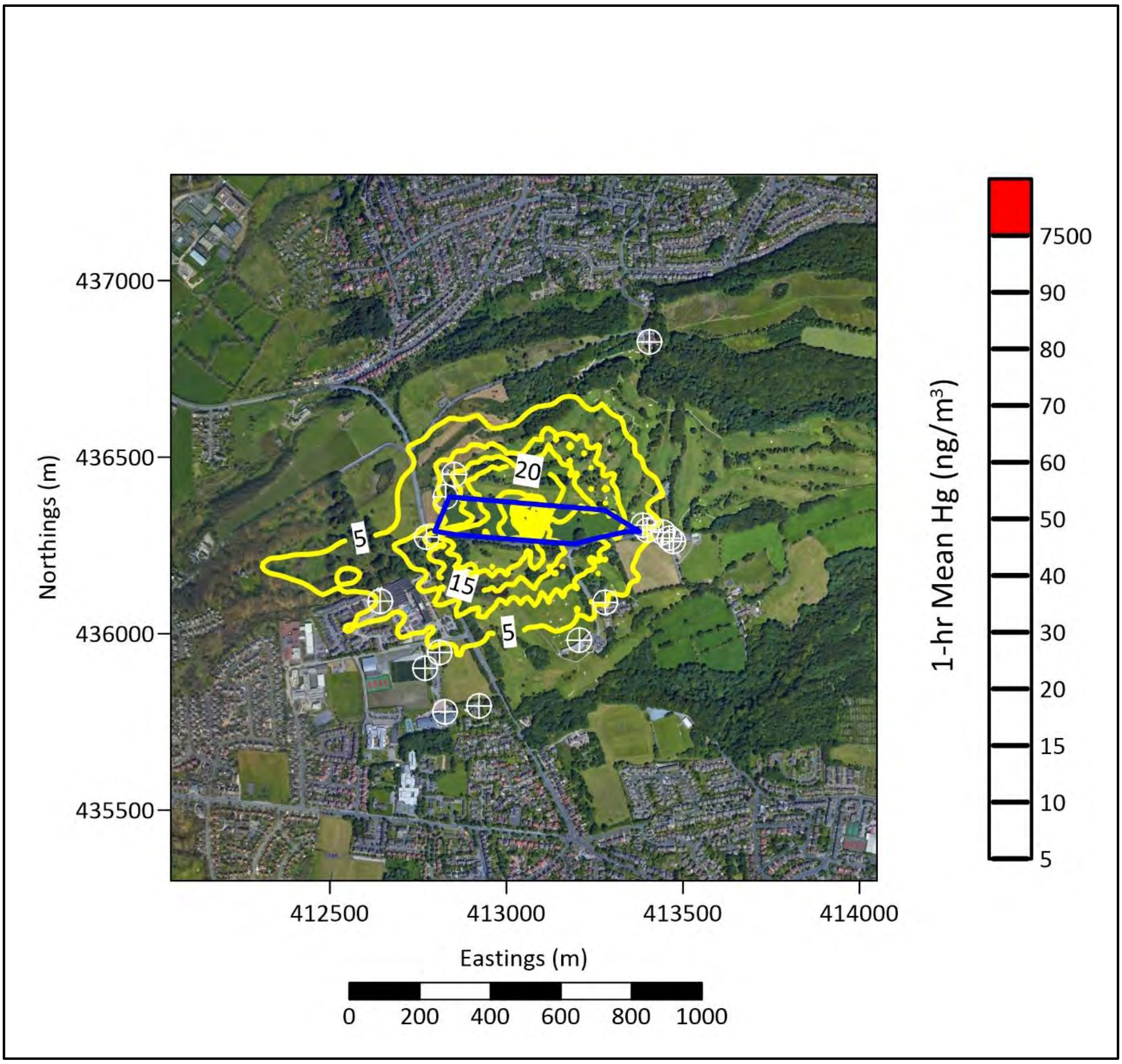

Figure 26: Total Maximum 1-hour Mean Hg Concentration (ng/m^3) for 2014

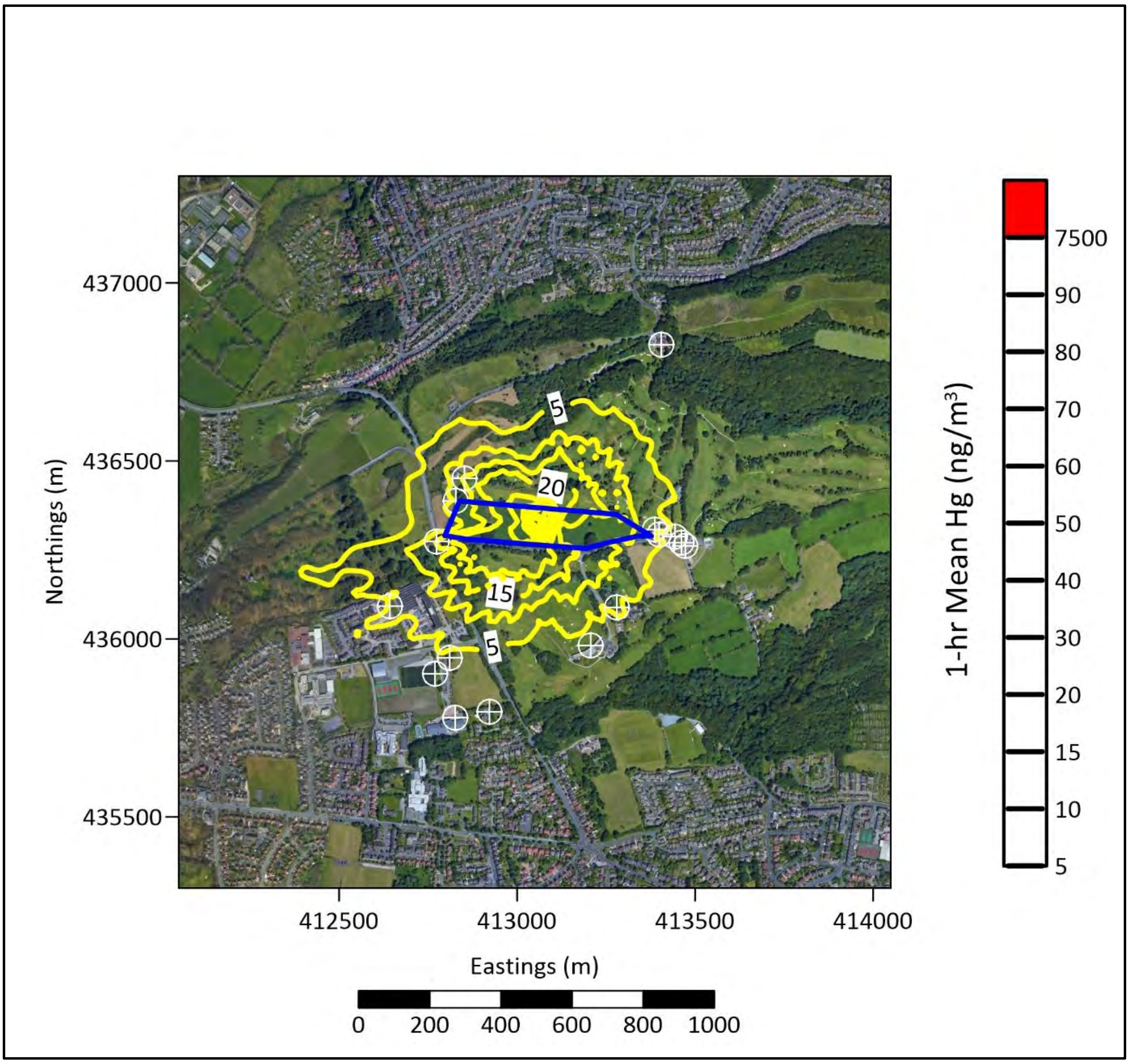

Figure 27: Total Maximum 1-hour Mean Hg Concentration (ng/m^3) for 2015

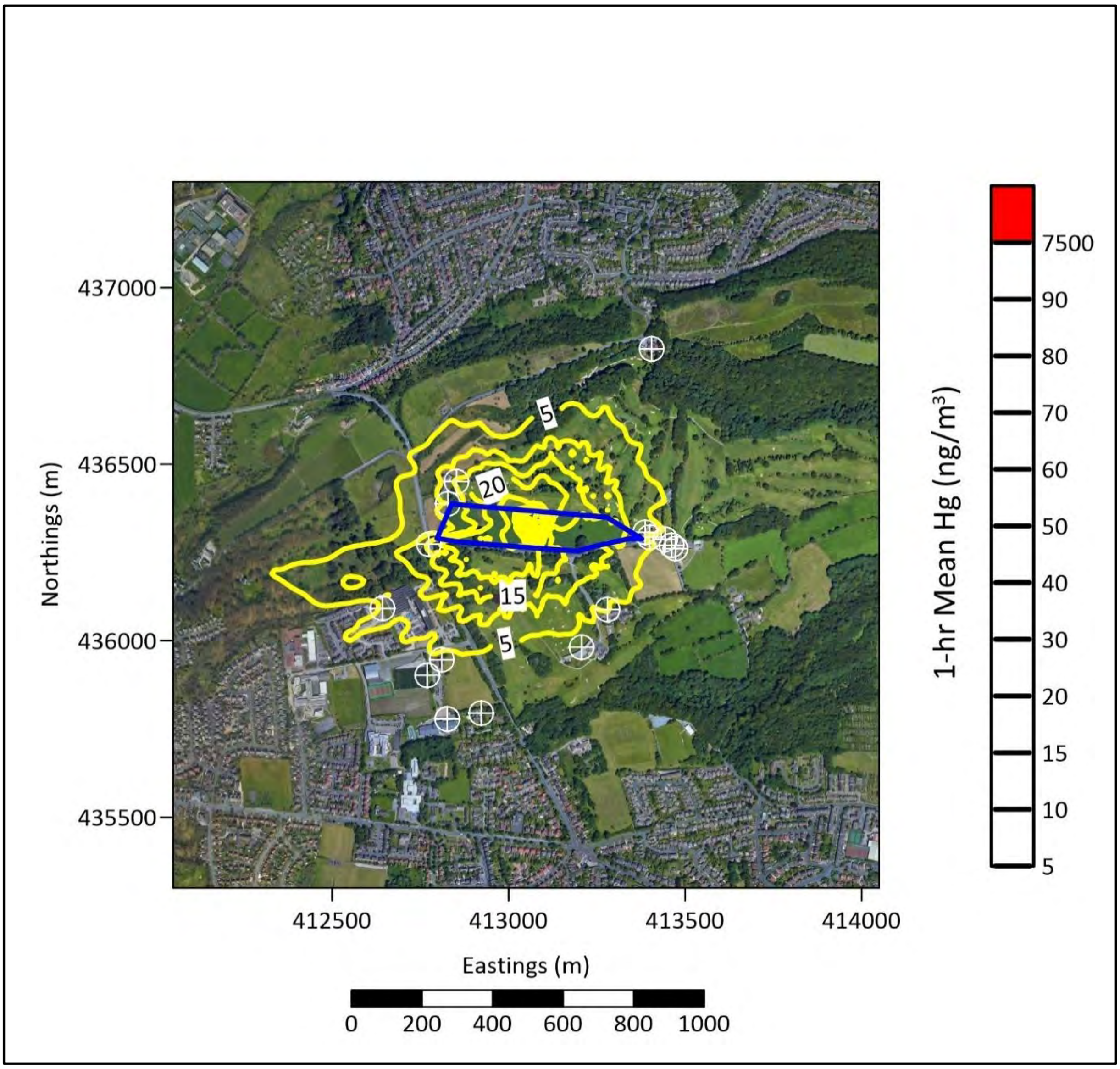

Figure 28: Total Maximum 1-hour Mean Hg Concentration (ng/m^3) for 2016

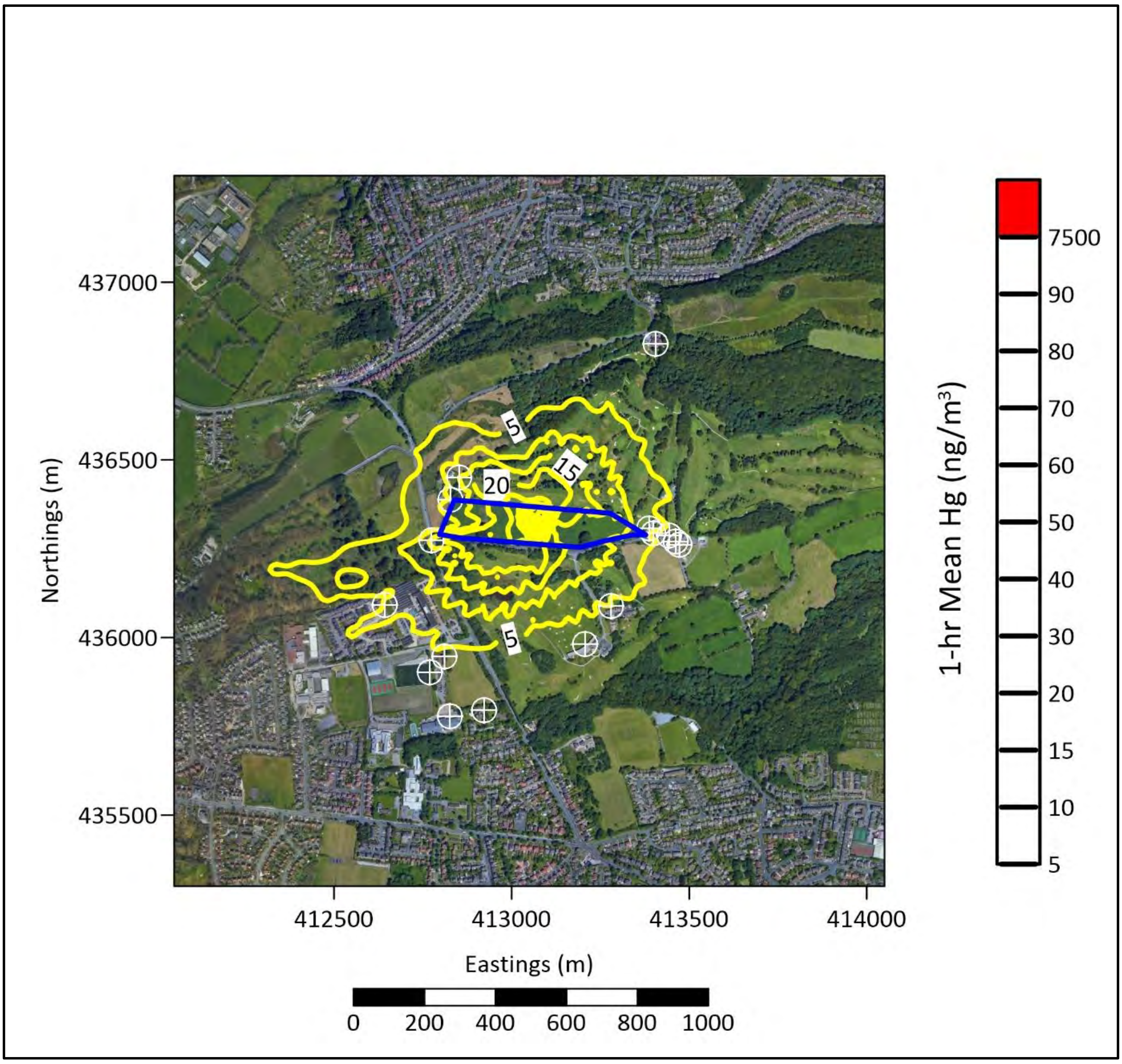

Figure 29: Total Maximum 1-hour Mean Hg Concentration (ng/m^3) for 2017

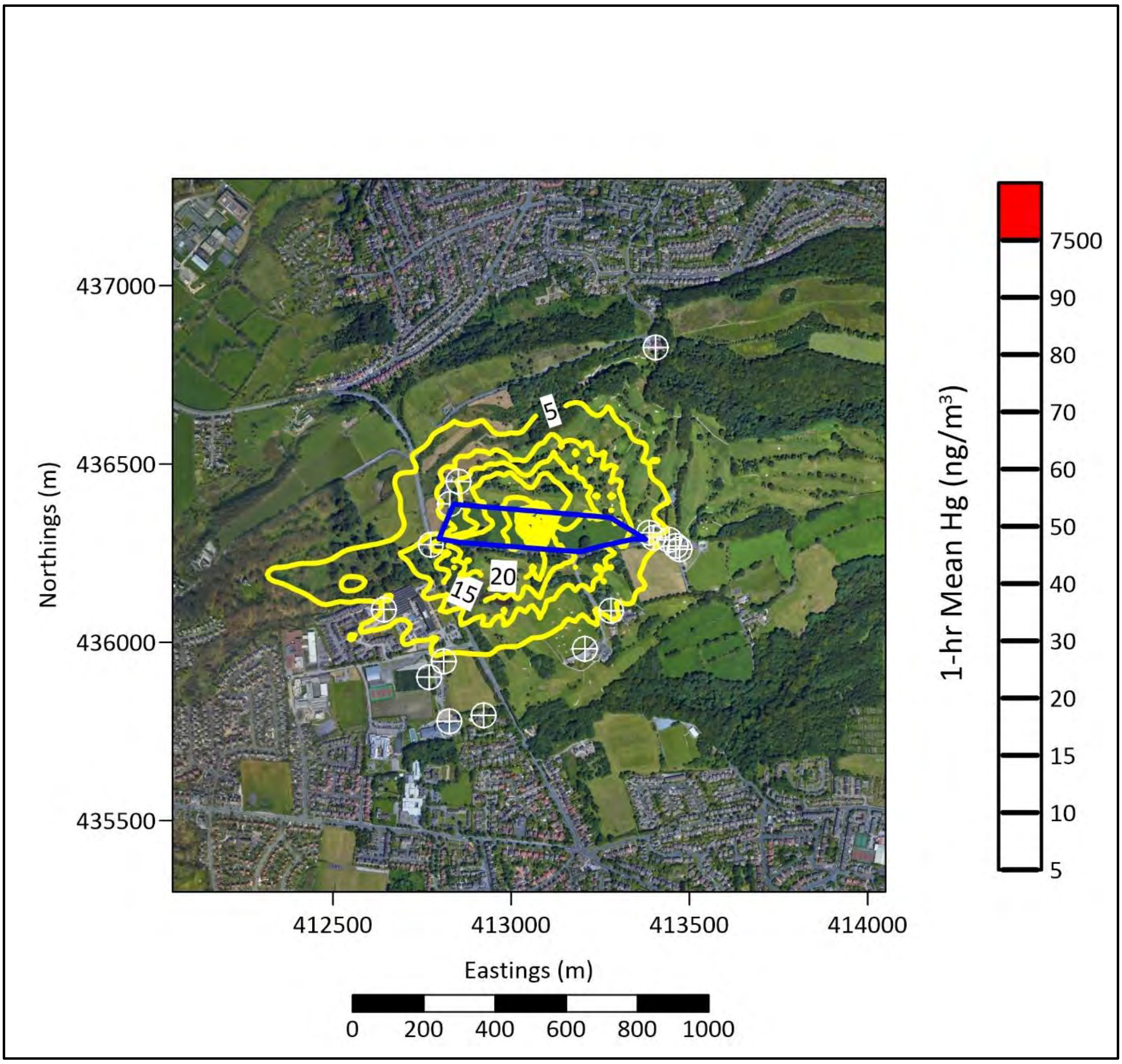

Figure 30: Total Maximum 1-hour Mean Hg Concentration (ng/m^3) for 2018

Table 10 shows the annual mean mercury concentrations predicted by the model at each sensitive receptor location. Note that the units are in ng/m^3.

Table 10: Annual Mean Mercury Process Contribution and Total Concentration

Ref.	Annual Mean Mercury Concentration (ng/m^3)							Max PC Against AQAL (%)	Max PEC Against AQAL (%)
	PC 2014	PC 2015	PC 2016	PC 2017	PC 2018	BC	Max PEC		
R1	0.29	0.26	0.30	0.23	0.28	0.04	0.35	0.12	0.14
R2	0.34	0.29	0.33	0.28	0.34	0.04	0.39	0.14	0.15
R3	0.36	0.45	0.32	0.50	0.39	0.04	0.55	0.20	0.22
R4	0.32	0.42	0.28	0.44	0.34	0.04	0.48	0.18	0.19
R5	0.26	0.35	0.23	0.36	0.28	0.04	0.40	0.14	0.16
R6	0.23	0.32	0.21	0.31	0.24	0.04	0.37	0.13	0.15
R7	0.21	0.31	0.19	0.28	0.23	0.04	0.35	0.12	0.14
R8	0.11	0.12	0.12	0.10	0.12	0.04	0.16	0.05	0.07
R9	0.06	0.06	0.07	0.06	0.06	0.04	0.12	0.03	0.05
R10	0.05	0.05	0.07	0.04	0.06	0.04	0.11	0.03	0.04
R11	0.05	0.05	0.07	0.04	0.07	0.04	0.11	0.03	0.05
R12	0.08	0.05	0.11	0.05	0.12	0.04	0.16	0.05	0.06
R13	0.07	0.05	0.10	0.04	0.10	0.04	0.15	0.04	0.06
R14	0.14	0.06	0.14	0.07	0.11	0.04	0.18	0.06	0.07
R15	0.37	0.16	0.28	0.16	0.25	0.04	0.42	0.15	0.17
R16	0.17	0.17	0.16	0.17	0.15	0.04	0.22	0.07	0.09

Notes:
PC: process contribution (without background concentration and for the year shown)
BC: background concentration (based on ambient air quality monitoring data for Tinsley)
PEC: predicted environmental concentration (i.e. PEC = PC + BC)
AQAL: air quality assessment level (i.e. the EAL for Hg of 250 ng/m^3 (0.25 µg/m^3) as an annual mean)

The results shown in the table indicate that there were predicted to be no exceedances of the annual mean EAL for Hg of 250 ng/m^3 (0.25 µg/m^3) at any sensitive receptor location. The highest total annual mean Hg concentration shown in the table of 0.55 ng/m^3 was predicted at receptor R3. This highest predicted annual mean concentration (PEC) represents 0.2% of the EAL. In other words, the highest annual mean process contribution (excluding background) was predicted to be 0.5 ng/m^3 (at R3 in 2017).

The total predicted annual mean Hg concentrations (PECs) for 2014 to 2018 are shown in Figure 31 to Figure 35 and include a background concentration of 0.043 ng/m^3. The figures also show the discrete receptor locations, the site boundary and the 250 ng/m^3 EAL contour line. Note that the scale used is non-linear.

The figures indicate that no exceedances of the annual mean EAL were predicted at any discrete sensitive receptor location (receptors R1 to R16), or at any location at or beyond the site boundary. The highest total annual mean Hg concentration predicted at any grid receptor location (including on the proposed development site) was 11.6 ng/m^3.

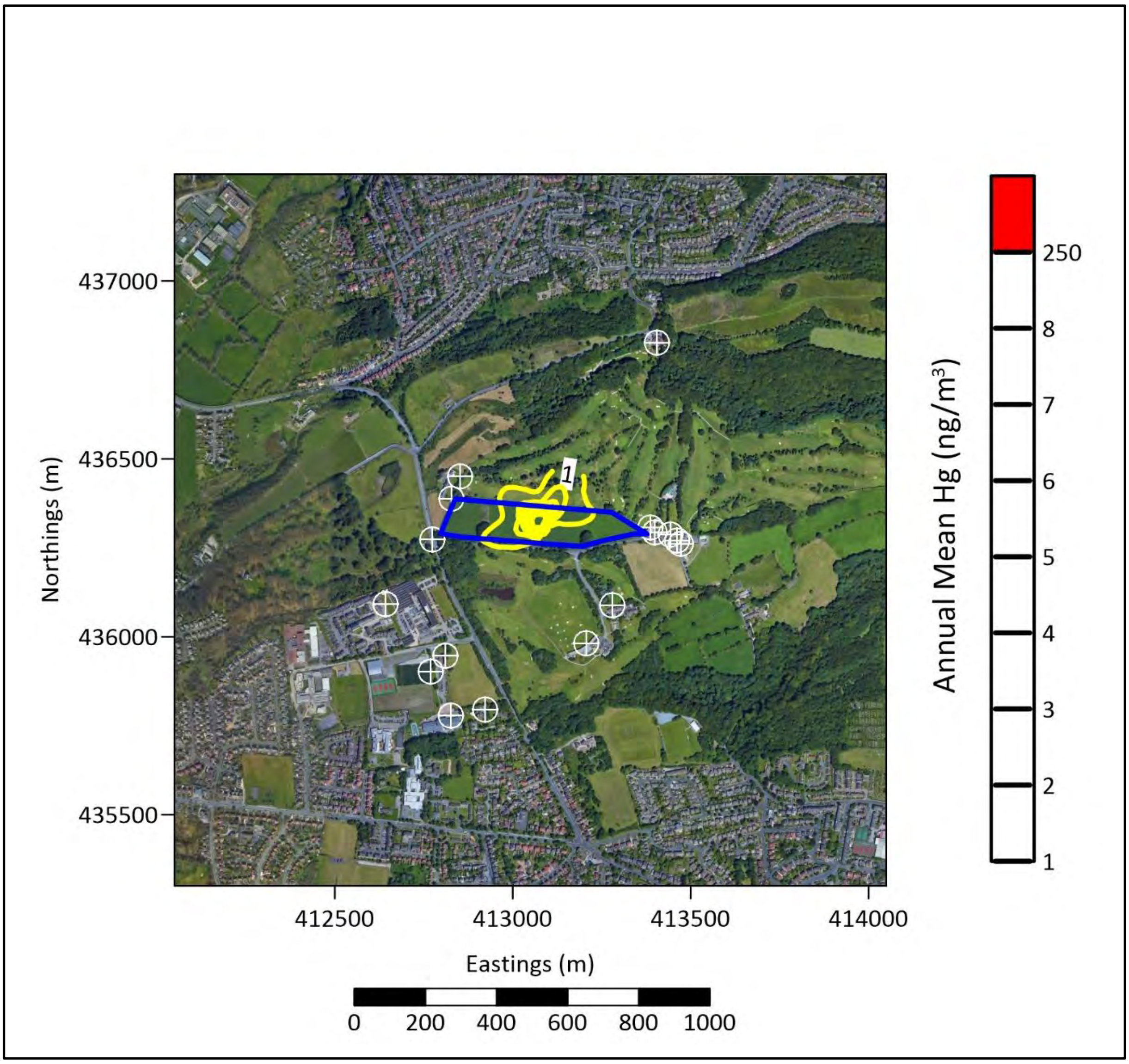

Figure 31: Total Annual Mean Hg Concentration (ng/m³) for 2014

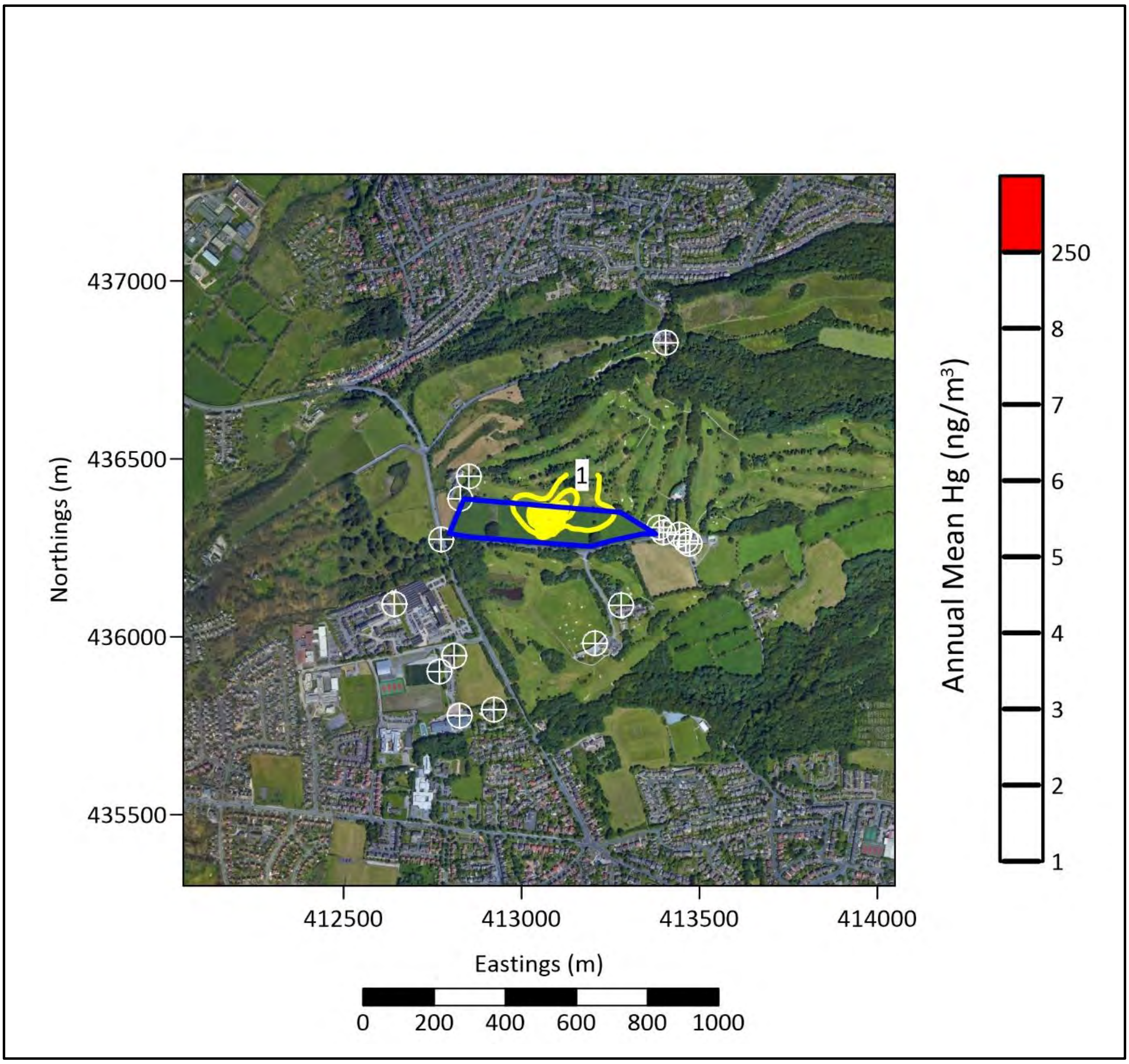

Figure 32: Total Annual Mean Hg Concentration (ng/m^3) for 2015

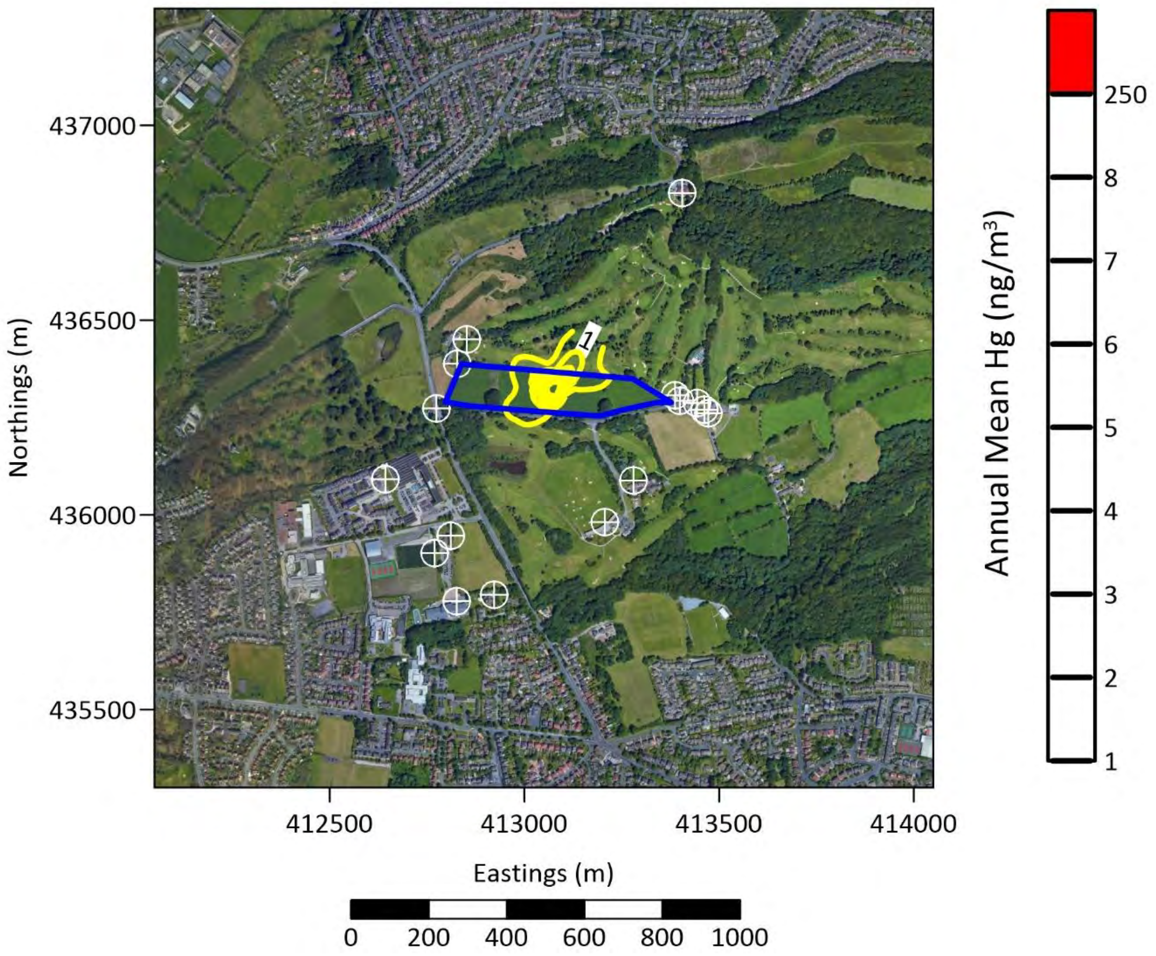

Figure 33: Total Annual Mean Hg Concentration (ng/m^3) for 2016

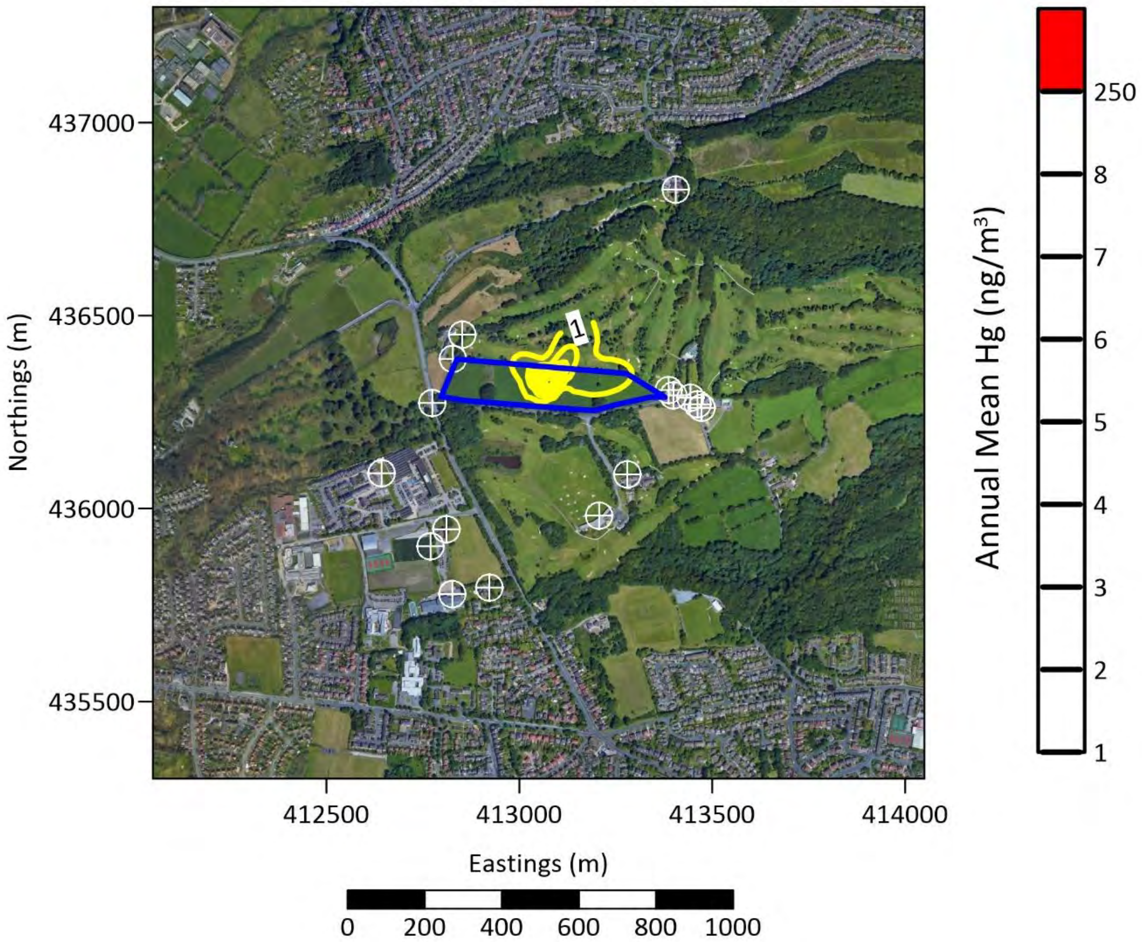

Figure 34: Total Annual Mean Hg Concentration (ng/m^3) for 2017

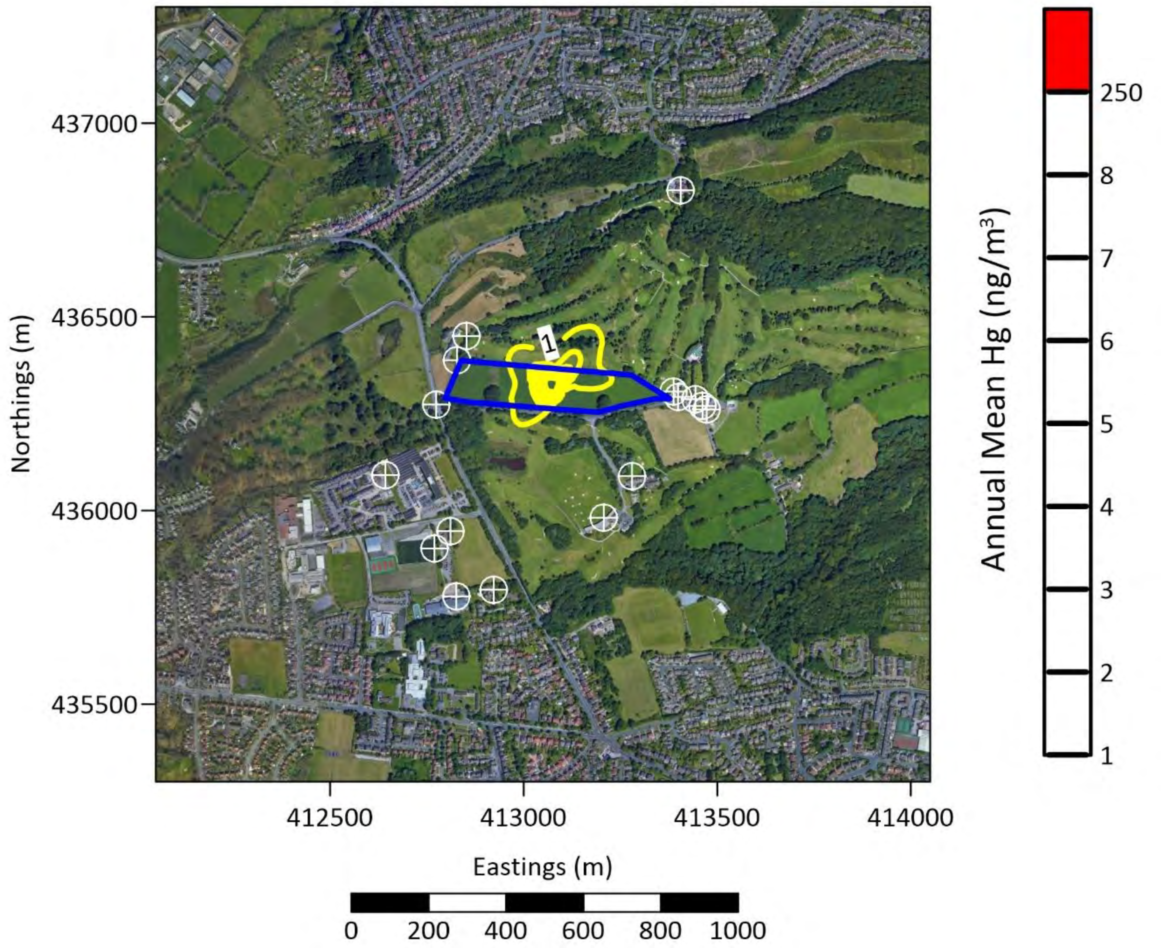

Figure 35: Total Annual Mean Hg Concentration (ng/m³) for 2018

5.4 Hydrogen Chloride

Table 11 shows the maximum 1-hour mean hydrogen chloride concentrations predicted by the model at each sensitive receptor location.

Table 11: Maximum 1-hour Mean HCl Process Contribution and Total Concentration

Ref.	Maximum 1-hour Mean HCl Concentration ($\mu g/m^3$)							Max PC Against AQAL (%)	Max PEC Against AQAL (%)
	PC 2014	PC 2015	PC 2016	PC 2017	PC 2018	BC	Max PEC		
R1	5.98	5.88	5.91	5.86	6.17	0.66	6.83	0.8	0.9
R2	8.95	8.92	9.00	8.55	8.86	0.66	9.66	1.2	1.3
R3	3.70	3.67	3.72	3.72	3.75	0.66	4.41	0.5	0.6
R4	2.31	2.08	2.16	2.27	2.12	0.66	2.97	0.3	0.4
R5	1.67	1.65	1.65	1.65	1.62	0.66	2.33	0.2	0.3
R6	1.93	1.89	1.91	1.85	1.91	0.66	2.59	0.3	0.3
R7	1.98	1.94	1.95	1.89	1.96	0.66	2.64	0.3	0.4
R8	3.13	3.63	3.02	2.80	3.61	0.66	4.29	0.5	0.6
R9	2.12	2.20	2.13	1.82	1.64	0.66	2.86	0.3	0.4
R10	1.88	1.83	1.82	2.05	1.79	0.66	2.71	0.3	0.4
R11	1.80	1.74	1.74	1.51	1.74	0.66	2.46	0.2	0.3
R12	2.14	2.01	2.06	2.04	2.09	0.66	2.80	0.3	0.4
R13	2.12	1.96	1.98	1.97	2.09	0.66	2.78	0.3	0.4
R14	3.06	2.97	3.09	2.93	2.99	0.66	3.75	0.4	0.5
R15	9.15	8.82	9.36	9.16	8.66	0.66	10.0	1.2	1.3
R16	1.64	1.64	1.62	1.58	1.67	0.66	2.33	0.2	0.3

Notes:
PC: process contribution (without background concentration and for the year shown)
BC: background concentration (based on ambient air quality monitoring data for Ladybower)
PEC: predicted environmental concentration (i.e. PEC = PC + BC)
AQAL: air quality assessment level (i.e. the EAL for HCl of 750 $\mu g/m^3$ as a 1-hour mean concentration)

The results shown in the table indicate that there were predicted to be no exceedances of the 1-hour mean EAL for HCl of 750 µg/m^3 at any sensitive receptor location. The highest total 1-hour mean HCl concentration shown in the table of 10 µg/m^3 was predicted at receptor R15. This highest predicted 1-hour mean concentration (PEC) represents 1.3% of the EAL. In other words, the highest 1-hour mean process contribution (excluding background) was predicted to be 9.36 µg/m^3 (at R15 in 2016).

The total predicted 1-hour mean HCl concentrations (PECs) for 2014 to 2018 are shown in Figure 36 to Figure 40 and include a background concentration of 0.66 µg/m^3. The figures also show the discrete receptor locations, the site boundary and the 750 µg/m^3 EAL contour line. Note that the scale used is non-linear.

The figures indicate that no exceedances of the 1-hour mean EAL were predicted at any discrete sensitive receptor location (receptors R1 to R16), or at any location at or beyond the site boundary. The highest total 1-hour mean HCl concentration predicted at any grid receptor location (including on the proposed development site) was 53.9 µg/m^3.

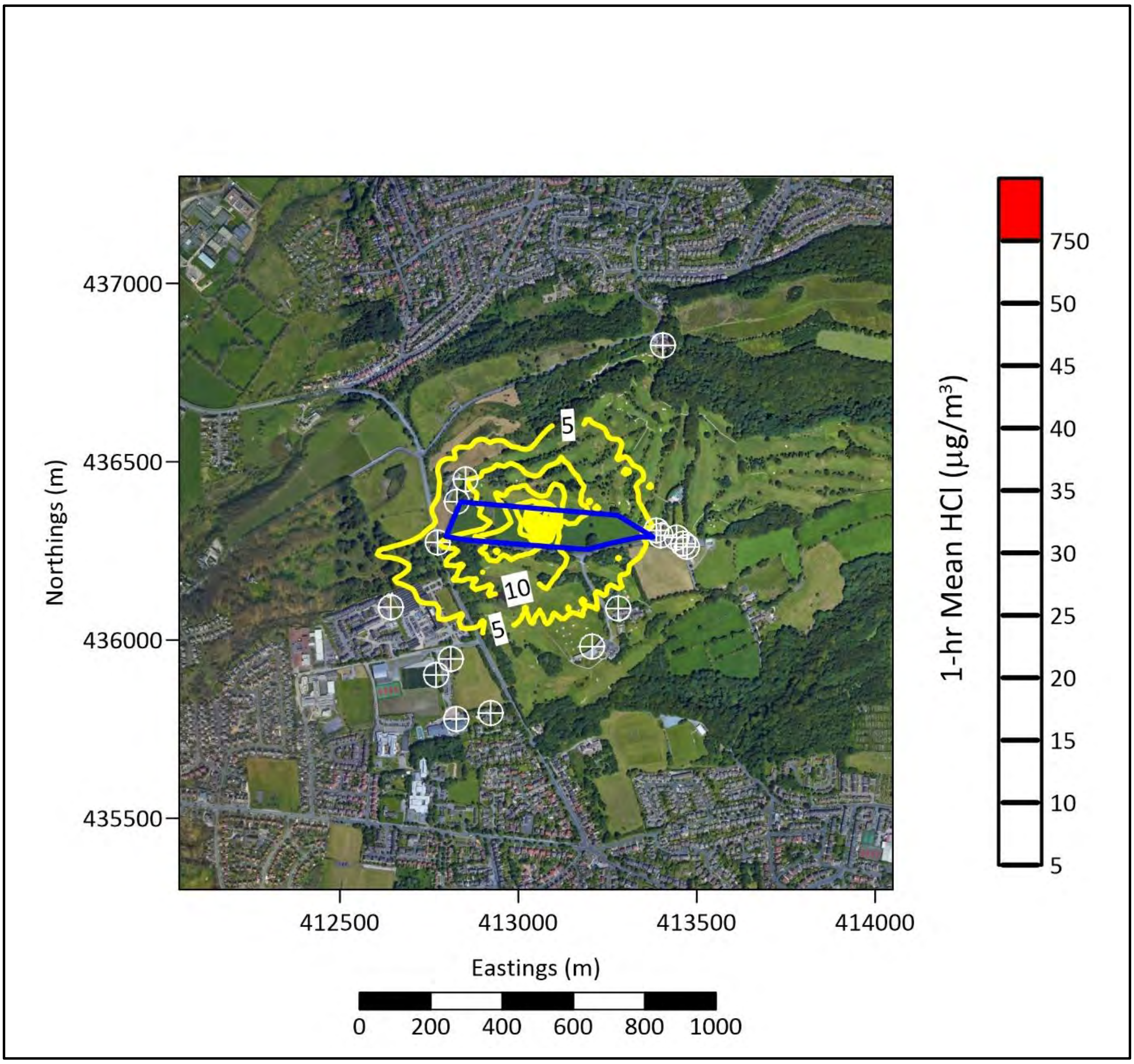

Figure 36: Total Maximum 1-hour Mean HCl Concentration (µg/m^3) for 2014

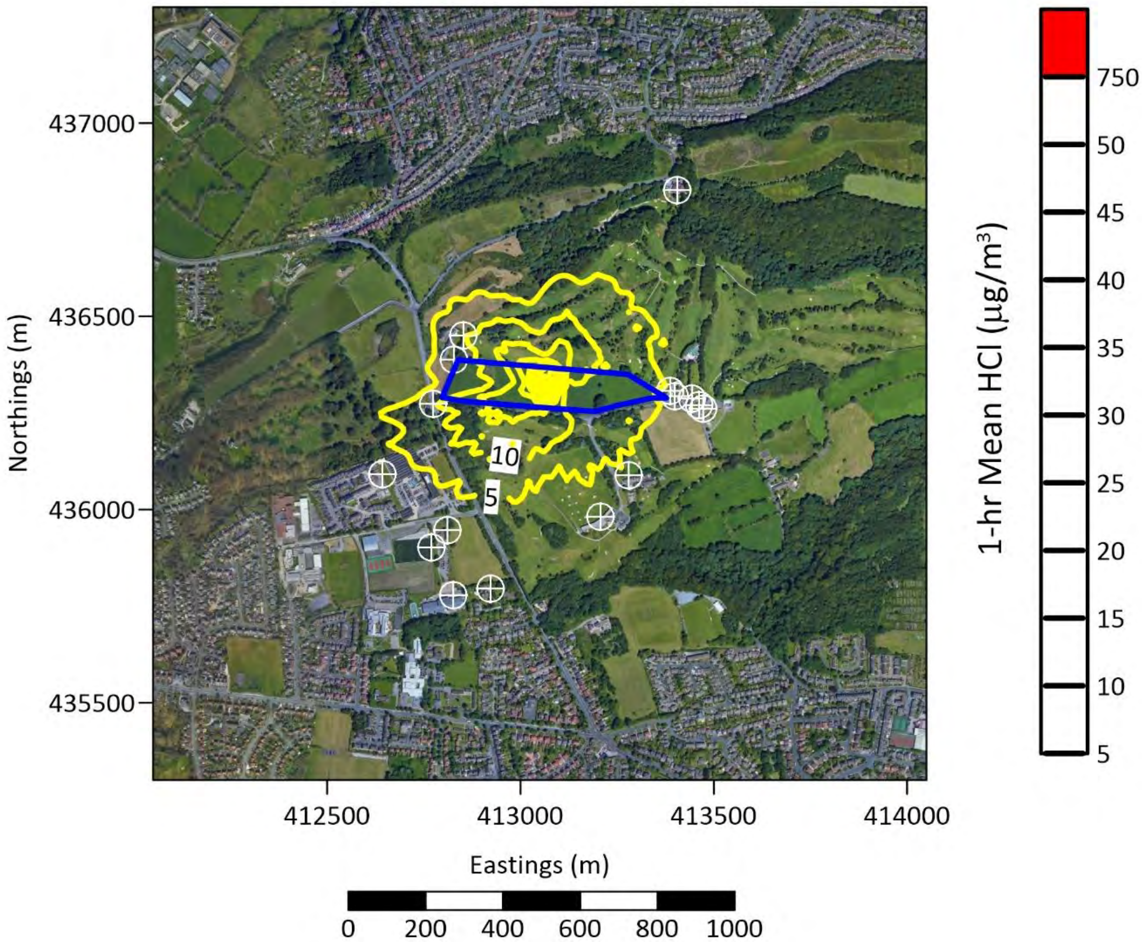

Figure 37: Total Maximum 1-hour Mean HCl Concentration (µg/m³) for 2015

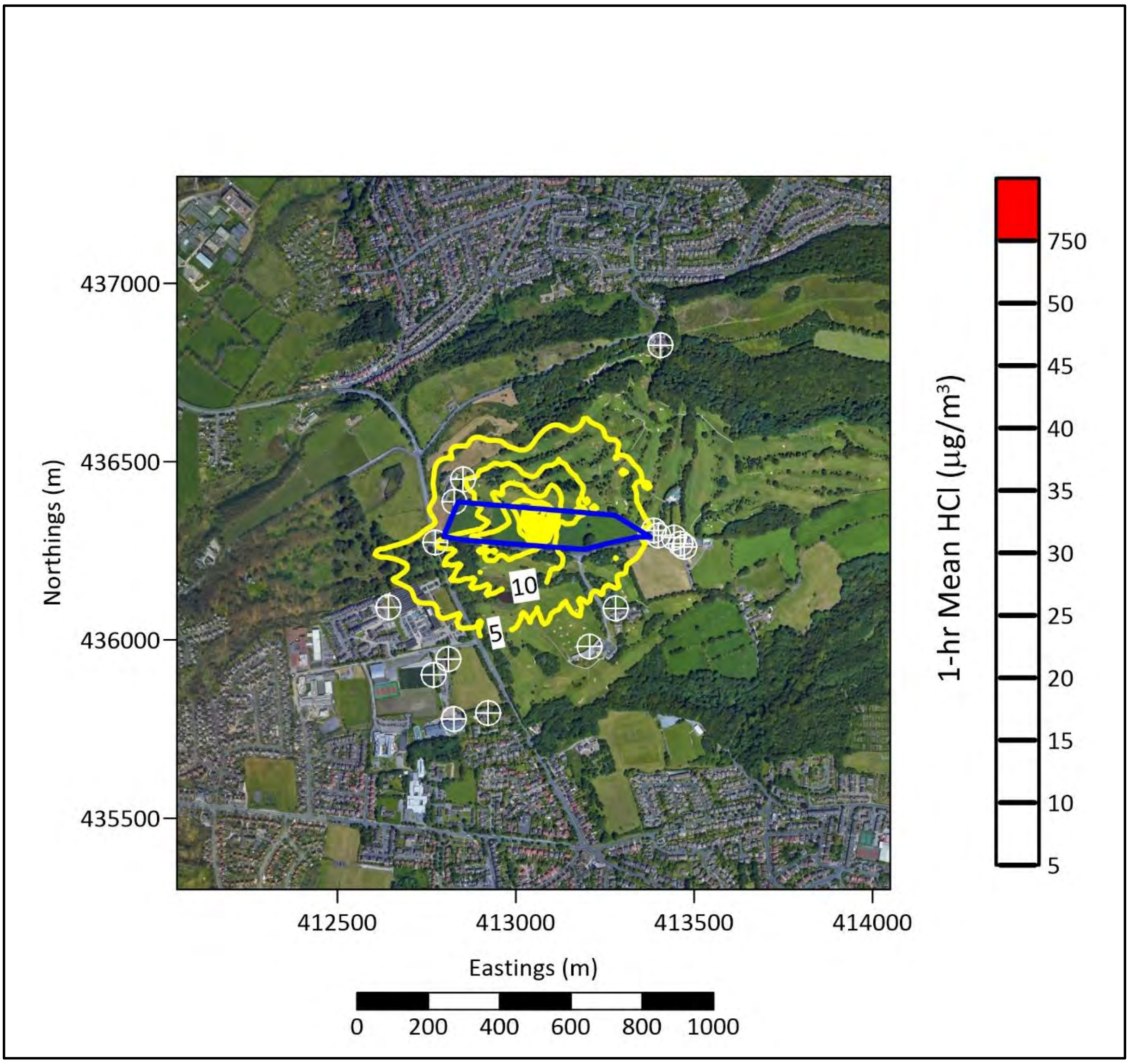

Figure 38: Total Maximum 1-hour Mean HCl Concentration (µg/m³) for 2016

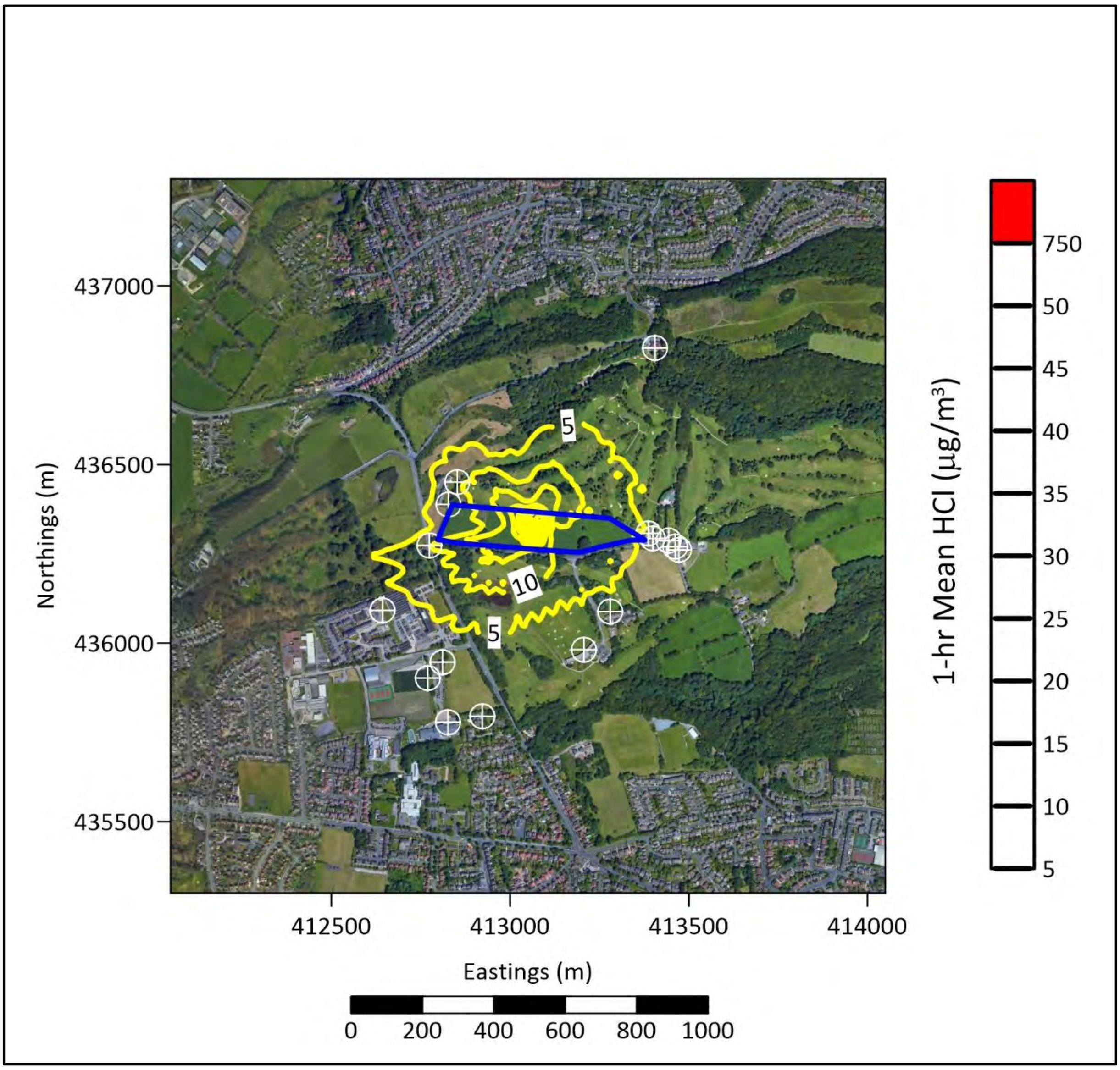

Figure 39: Total Maximum 1-hour Mean HCl Concentration (µg/m³) for 2017

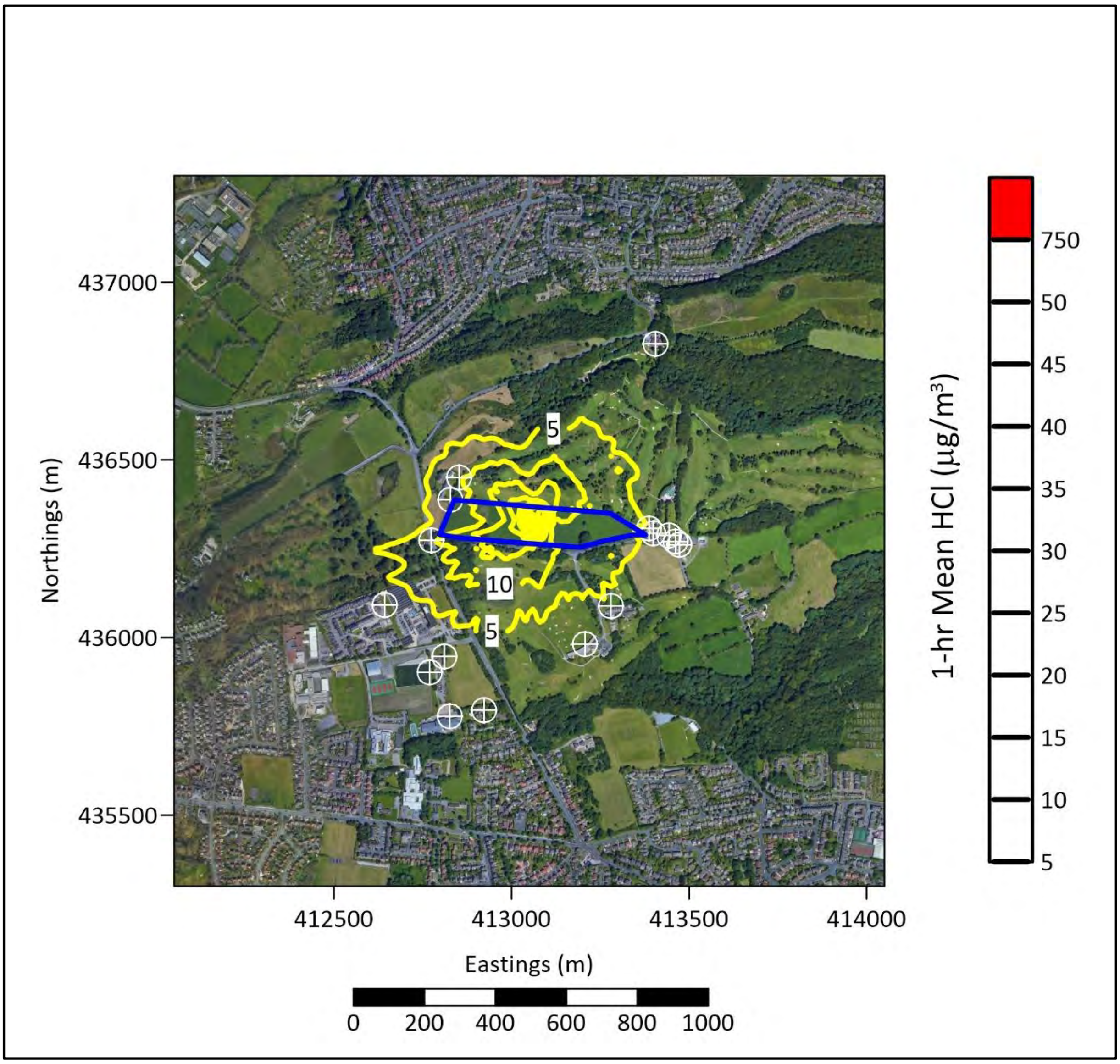

Figure 40: Total Maximum 1-hour Mean HCl Concentration (µg/m³) for 2018

5.5 Carbon Monoxide

Table 12 shows the maximum 8-hour rolling mean CO concentrations predicted by the model at each sensitive receptor location. Note that the concentrations are in mg/m^3.

Table 12: Maximum 8-hour Mean CO Process Contribution and Total Concentration

Ref.	Maximum 8-hour Rolling Mean CO Concentration (mg/m^3)							Max PC Against AQAL (%)	Max PEC Against AQAL (%)
	PC 2014	PC 2015	PC 2016	PC 2017	PC 2018	BC	Max PEC		
R1	0.011	0.015	0.014	0.011	0.010	0.748	0.763	0.15	7.63
R2	0.011	0.011	0.011	0.012	0.013	0.748	0.761	0.13	7.61
R3	0.010	0.007	0.007	0.008	0.008	0.748	0.758	0.10	7.58
R4	0.006	0.006	0.006	0.006	0.006	0.748	0.754	0.06	7.54
R5	0.005	0.005	0.004	0.005	0.005	0.748	0.753	0.05	7.53
R6	0.005	0.005	0.004	0.005	0.005	0.748	0.753	0.05	7.53
R7	0.005	0.005	0.004	0.005	0.004	0.748	0.753	0.05	7.53
R8	0.004	0.004	0.004	0.005	0.008	0.748	0.756	0.08	7.56
R9	0.002	0.003	0.005	0.003	0.003	0.748	0.753	0.05	7.53
R10	0.005	0.004	0.003	0.003	0.004	0.748	0.753	0.05	7.53
R11	0.003	0.003	0.003	0.002	0.003	0.748	0.751	0.03	7.51
R12	0.005	0.003	0.005	0.004	0.004	0.748	0.753	0.05	7.53
R13	0.004	0.002	0.005	0.003	0.004	0.748	0.753	0.05	7.53
R14	0.005	0.006	0.007	0.006	0.005	0.748	0.755	0.07	7.55
R15	0.017	0.012	0.020	0.011	0.017	0.748	0.768	0.20	7.68
R16	0.003	0.003	0.003	0.003	0.003	0.748	0.751	0.03	7.51

Notes:
PC: process contribution (without background concentration and for the year shown)
BC: background concentration (based on the Defra 1km by 1km background map for 2001)
PEC: predicted environmental concentration (i.e. PEC = PC + BC)
AQAL: air quality assessment criterion (i.e. the 8-hr CO Air Quality Strategy Objective of 10 mg/m^3)

The results shown in the table indicate that there were predicted to be no exceedances of the 8-hour mean AQS Objective for CO of 10 mg/m^3 (10,000 µg/m^3) at any sensitive receptor location. The highest total 8-hour mean CO concentration shown in the table of 0.768 mg/m^3 was predicted at receptor R15. This highest predicted 8-hour mean concentration (PEC) represents 7.7% of the AQS Objective. In other words, the highest 8-hour mean process contribution (excluding background) was predicted to be 0.02 mg/m^3 (at R15 in 2016).

The total predicted 8-hour mean CO concentrations (PECs) for 2014 to 2018 are shown in Figure 41 to Figure 45 and include a background concentration of 0.748 mg/m^3. The figures also show the discrete receptor locations, the site boundary and the 10 mg/m^3 AQS Objective contour line. Note that the scale used is non-linear.

The figures indicate that no exceedances of the 8-hour mean AQS Objective were predicted at any discrete sensitive receptor location (receptors R1 to R16), or at any location at or beyond the site boundary. The highest total 8-hour mean CO concentration predicted at any grid receptor location (including on the proposed development site) was 0.912 mg/m^3.

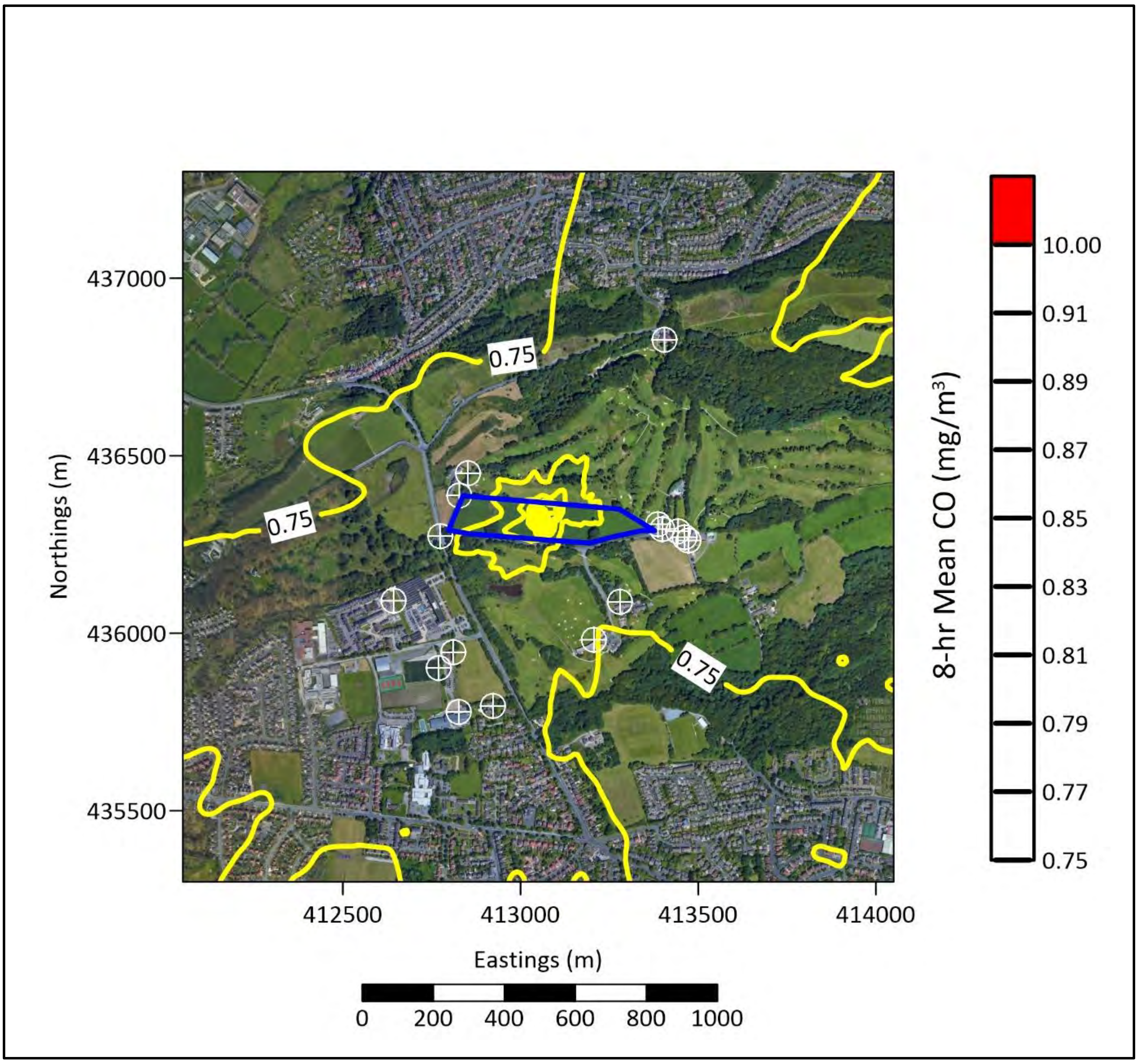

Figure 41: Total Maximum 8-hour Mean CO Concentration (mg/m^3) for 2014

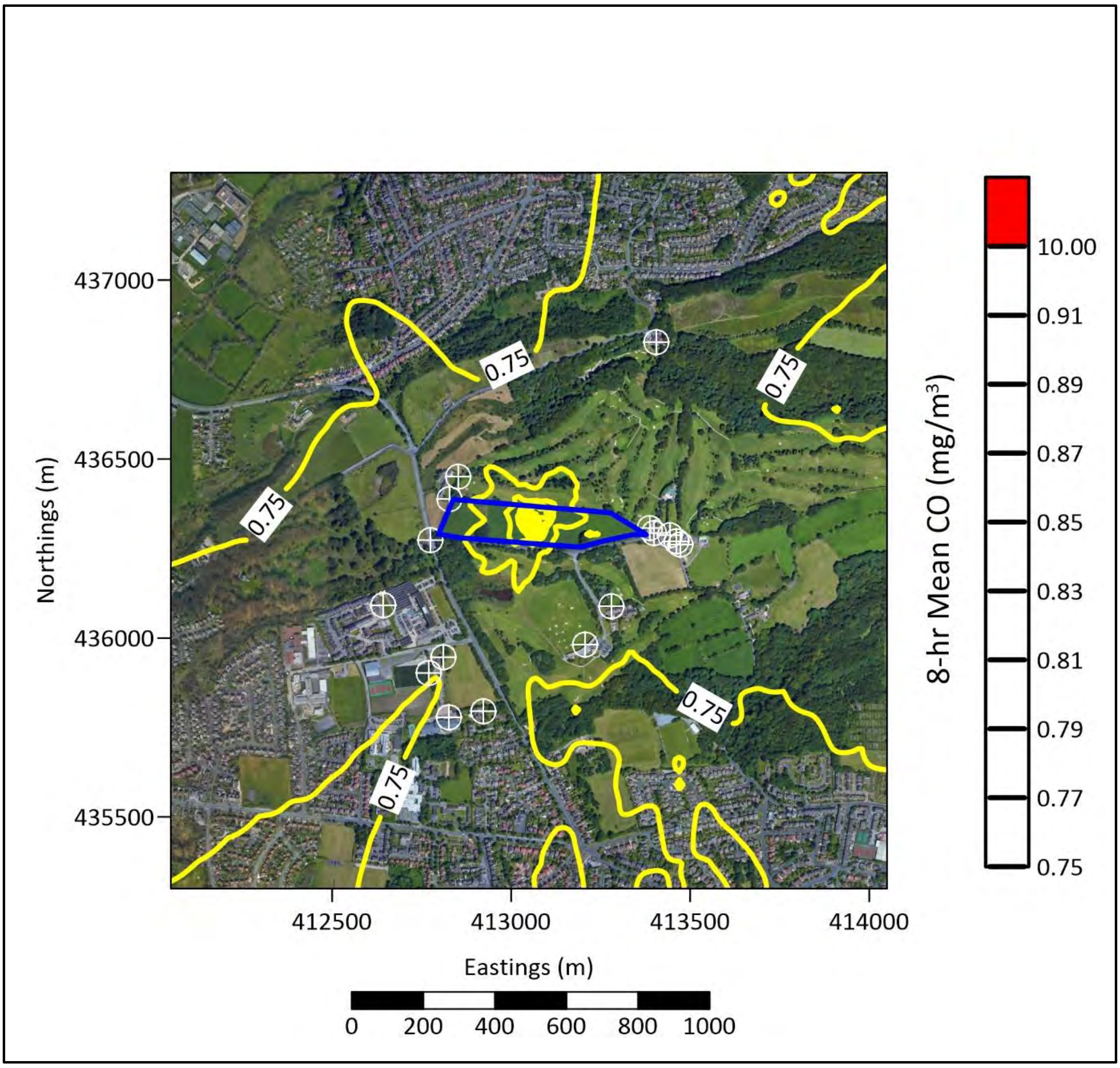

Figure 42: Total Maximum 8-hour Mean CO Concentration (mg/m^3) for 2015

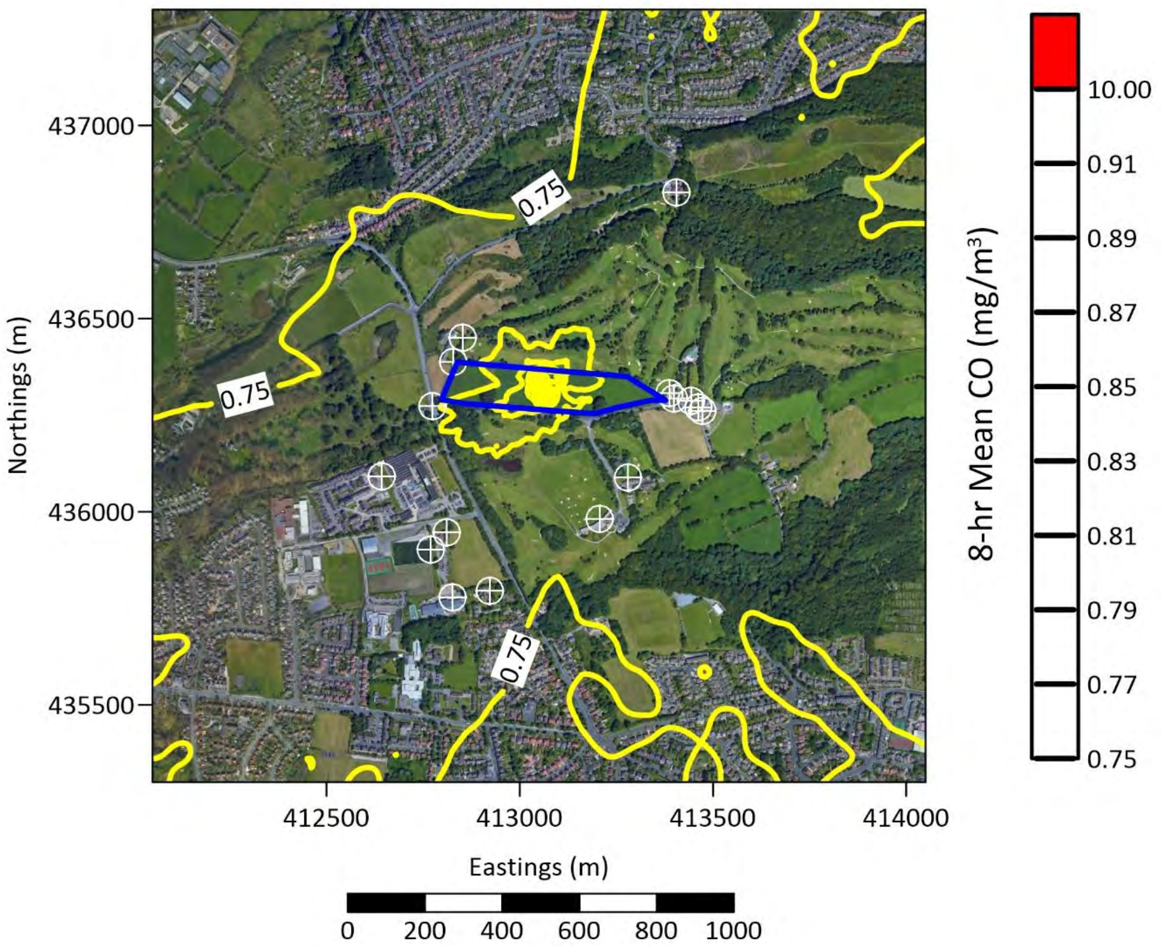

Figure 43: Total Maximum 8-hour Mean CO Concentration (mg/m³) for 2016

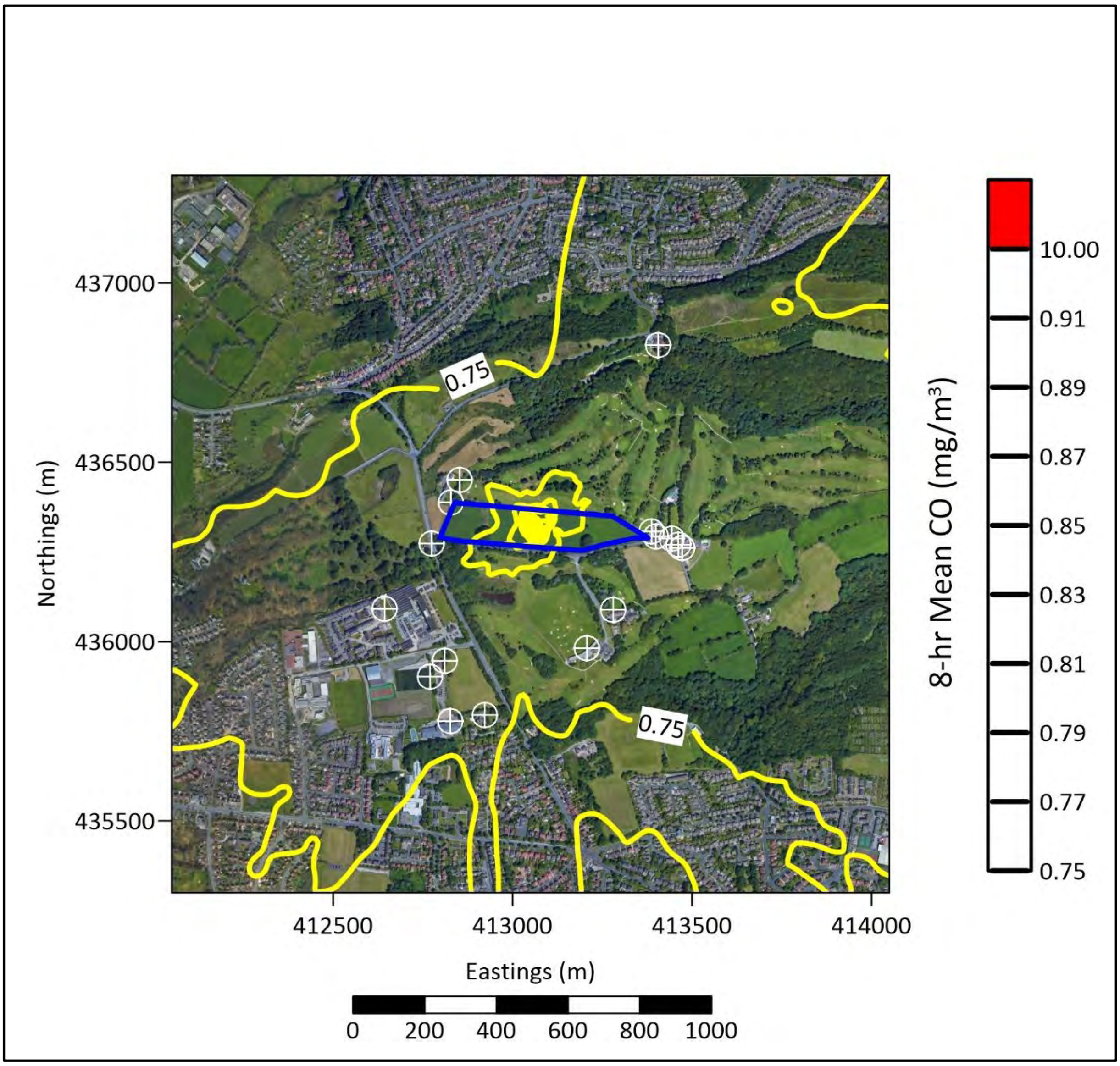

Figure 44: Total Maximum 8-hour Mean CO Concentration (mg/m^3) for 2017

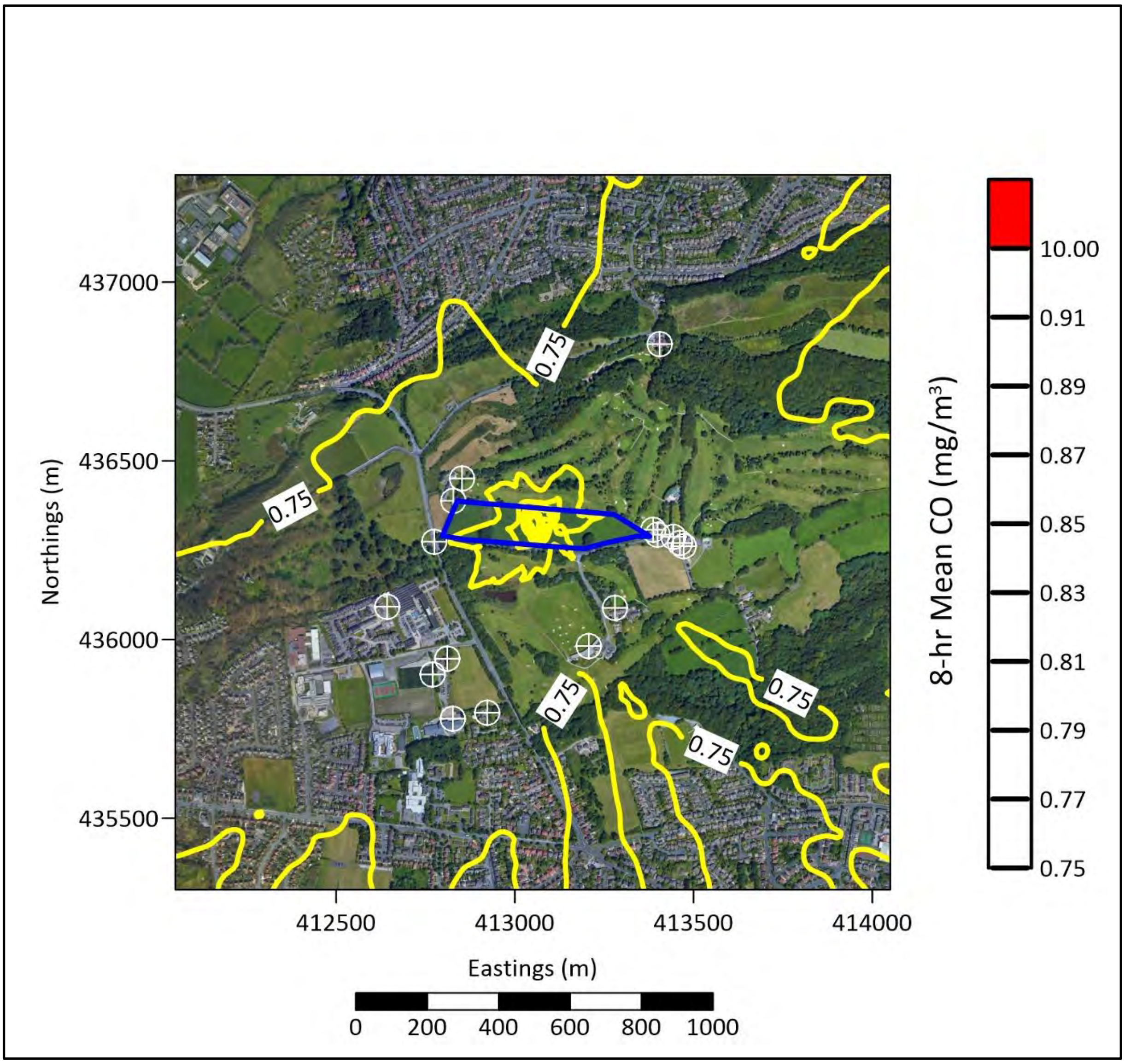

Figure 45: Total Maximum 8-hour Mean CO Concentration (mg/m^3) for 2018

5.6 Potential Air Quality Impacts from Other Sources and Pollutants

5.6.1 Oxides of Nitrogen Emissions from the Proposed Cremator

A screening (or sensitivity) assessment was undertaken to assess the potential worst-case impacts associated with public exposure to NO_x and VOC emissions to air from the proposed cremator stack.

Although PG5/2(12) does not contain an emission limit value for NO_x, it was conservatively assumed for the purposes of this screening and sensitivity assessment that the in-stack NO_x emission concentration will not exceed 350 mg/Nm^3 at reference conditions of 273.1 K, 101.3 kPa and 11% O_2 v/v on a dry gas basis. Based on the stack emission parameters stated in Section 4 and used as input into the model, the theoretical worst-case NO_x emission rate would be 0.668 g/s.

Assuming a background 1-hour mean NO_2 concentration of 42.4 µg/m^3, which is double the annual man background from Defra's 1 km by 1 km background map for 2017 and that 50% of the NO_x emissions from the cremator stack will be converted to NO_2 in the atmosphere over a 1-hour period (in accordance with the Defra H1 guidance),[24] the total maximum 1-hour mean ground-level NO_2 concentrations (PECs) predicted in 2014 at sensitive receptors R1 to R16 will range from 52 µg/m^3 (at R16) to 96 µg/m^3 (at R15). Note that these 1-hour mean NO_2 concentrations are total predicted *maximum* values and not at the 99.79th percentile, therefore the predictions are even more conservative. The total maximum 1-hour mean NO_2 concentration of 96 µg/m^3 predicted at receptor R15 is only 48% of the 1-hour mean NO_2 AQS Objective of 200 µg/m^3, and the maximum 1-hour mean PC at this location was predicted to be 53.6 µg/m^3. In other words, there were predicted to be no exceedances of the 1-hour mean NO_2 AQS Objective at any sensitive receptor location, based on the results of this sensitivity study.

Assuming a background annual mean NO_2 concentration of 21.2 µg/m^3 (based on Defra's 1 km by 1 km background map for 2017) and that 100% of the NO_x emissions from the cremator stack will be converted to NO_2 in the atmosphere over a 1-year period (in accordance with the Defra H1 guidance), the annual mean ground-level NO_2 concentration (PECs) predicted for 2014 at sensitive receptors R1 to R16 will range from 21.5 µg/m^3 (at R10 and R11) to 23.7 µg/m^3 (at R15). The total annual mean NO_2 concentration of 23.7 µg/m^3 predicted at receptor R15 is 59% of the annual mean NO_2 AQS Objective of 40 µg/m^3, and the annual mean PC at this location was predicted to be only 2.49 µg/m^3 (6% of the annual mean NO_2 AQS Objective). In other words, there were predicted to be no exceedances of the annual mean NO_2 AQS Objective at any sensitive receptor location, based on the results of this sensitivity study.

[24] UK Government website for Guidance on 'Air emissions risk assessment for your environmental permit': https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

5.6.2 Operational Phase Road Traffic Emissions

The indicative (screening) criteria stated in IAQM (2017) for proposed developments requiring an air quality assessment that are relevant to this application are summarised below:

1. A change in the annual average daily traffic (AADT) flow in light-duty vehicles (LDVs) on local roads with relevant sensitive receptors of:
    - More than 100 AADT within or adjacent to an AQMA;
    - More than 500 AADT elsewhere.
2. A change in the AADT flow in heavy-duty vehicles (HDVs) on local roads with relevant sensitive receptors of:
    - More than 25 AADT within or adjacent to an AQMA;
    - More than 100 AADT elsewhere.
3. A change in the road alignment of more than 5 m and within an AQMA (i.e. changing the proximity of relevant sensitive receptors to traffic lanes);
4. A change in road configuration (e.g. introducing or removing a junction and creating a roundabout or traffic lights), which could impact on local road traffic emissions (due to acceleration, deceleration, breaking and engine idling);
5. A change in a bus station (e.g. introducing or removing a bus station), where bus flows will change by:
    - More than 25 AADT within or adjacent to an AQMA;
    - More than 100 AADT elsewhere.
6. A change in car parking configuration (e.g. introducing an underground car park with a mechanical ventilation and extraction system), where the ventilation extract is located within 20 m of a relevant sensitive receptor and the proposed car park will have more than 100 movements per day (total in and out);
7. If the proposed development has one or more combustion processes where there is a risk of impacts at relevant sensitive receptors (e.g. emissions of NOx of more than 5 mg/s or from a stack or vent without adequate dispersion).

In light of the IAQM (2017) screening assessment criteria shown above, it is considered that it is unlikely that there will be a change in the local LDV and HDV flows of more than 500 AADT and 100 AADT, respectively, as a result of the operation of the proposed development (see the Transport Assessment prepared by Pell Frischmann dated October 2019). Furthermore, the proposed scheme is considered to be a 'medium' development (not major) in terms of the West Yorkshire Low Emission

Strategy (see Section 1). Therefore, a detailed dispersion modelling assessment of the potential impacts at receptors locations associated with operational phase road traffic movements has not been undertaken in this report. It is anticipated that the potential adverse air quality impacts associated with these vehicle movements will be *negligible*.

5.7 Summary of Potential Air Quality Impacts and their Significance

The principal emissions to air from the proposed cremator will include PM_{10}, $PM_{2.5}$, Hg, HCl and CO and the potential adverse impacts were assessed by using the AERMOD atmospheric dispersion model. The results of the modelling assessment indicate that there will be no adverse air quality impacts at any sensitive receptor location.

The total predicted ground-level PM_{10}, $PM_{2.5}$, Hg, HCl and CO concentrations indicate that were will be no exceedances of the relevant air quality assessment levels (AQALs), including AQS Objectives, at any location on or beyond the site boundary, including sensitive receptor locations.

5.7.1 Long-Term Impacts

The impact descriptors and significance criteria recommended in IAQM (2017) apply to long-term (annual mean) concentrations predicted by a dispersion model. Predicted changes in ambient concentrations (PCs) of less than 1% relative to the AQAL are considered to be 'negligible', according to the IAQM (2017) criteria, if the total long-term concentration (PEC) is less than 94% of the AQAL.

The highest total annual mean PM_{10} concentration (PEC) predicted at a sensitive receptor location (receptors R1 to R16) was 10.5 $\mu g/m^3$ (at R3 in 2017), which represents 26% of the AQAL (AQS Objective of 40 $\mu g/m^3$) and a PC of only 0.19 $\mu g/m^3$, which is 0.5% of the AQAL. Therefore, the annual mean PM_{10} impacts were predicted to be 'negligible.'

The highest total annual mean $PM_{2.5}$ concentration (PEC) predicted at a sensitive receptor location was 7.29 $\mu g/m^3$ (at R3 in 2017), which represents 29% of the AQAL (AQS Objective of 25 $\mu g/m^3$) and a PC of only 0.19 $\mu g/m^3$, which is 0.8% of the AQAL. Therefore, the annual mean $PM_{2.5}$ impacts were predicted to be 'negligible.'

The highest total annual mean Hg concentration (PEC) predicted at a sensitive receptor location was 0.55 ng/m^3 (at R3 in 2017), which represents 0.2% of the AQAL (EAL of 250 ng/m^3) and a PC of only 0.5 ng/m^3, which is also only 0.2% of the AQAL. Therefore, the annual mean Hg impacts were predicted to be 'negligible.'

The long-term concentrations predicted at ground-level by the dispersion model indicate that there will be no adverse (human health) impacts as a result of the operation of the proposed cremator. The long-term air quality impacts are not considered to be significant, providing that the cremator is operated and maintained in accordance with the permit and the manufacturer's specifications and instructions.

5.7.2 Short-Term Impacts

For the purposes of this assessment and in the absence of any short-term significance criteria being stated in IAQM (2017), a predicted change in short-term ambient concentration (PC) of less than 10% relative to the AQAL is considered to be 'negligible'.

The highest total 24-hour mean PM_{10} concentration (PEC) predicted at a sensitive receptor location was 21.1 µg/m^3 (at receptor R3 in 2017), which represents 42% of the AQAL (AQS Objective of 50 µg/m^3) and a PC of only 0.5 µg/m^3, which is 1% of the AQAL. Therefore, the 24-hour mean PM_{10} impacts were predicted to be 'negligible.'

The highest total 1-hour mean Hg concentration (PEC) predicted at a sensitive receptor location was 16.5 ng/m^3 (at receptor R15), which represents 0.2% of the AQAL (EAL of 7,500 ng/m^3) and a PC of only 16.4 ng/m^3, which is also only 0.2% of the AQAL. Therefore, the 1-hour mean Hg impacts were predicted to be 'negligible.'

The highest total 1-hour mean HCl concentration (PEC) predicted at a sensitive receptor location was 10.0 µg/m^3 (at receptor R15), which represents 1.3% of the AQAL (EAL of 750 µg/m^3) and a PC of only 9.4 µg/m^3, which is also only 1.2% of the AQAL. Therefore, the 1-hour mean HCl impacts were predicted to be 'negligible.'

The highest total 8-hour mean CO concentration (PEC) predicted at a sensitive receptor location was 0.77 mg/m^3 (at receptor R15), which represents 7.7% of the AQAL (AQS Objective of 10 mg/m^3) and a PC of only 0.02 mg/m^3, which is also only 0.2% of the AQAL. Therefore, the 8-hour mean CO impacts were predicted to be 'negligible.'

The short-term concentrations predicted at ground-level by the dispersion model indicate that there will be no adverse (human health) impacts as a result of the operation of the proposed cremator. The short-term air quality impacts are not considered to be significant, providing that the cremator is operated and maintained in accordance with the permit and the manufacturer's specifications and instructions.

6.0 Air Pollution Control Measures

6.1 Construction Dust Mitigation Measures

The onsite construction activities have the potential to release dust and particulate matter to air. Considering the relatively small size of the proposed construction site (including the likely short duration of the construction works) and the source-pathway-receptor concept, human and ecological receptors in the vicinity of the site were considered to be of 'low' risk to construction dust emissions.[25] The impact magnitude was therefore predicted to be 'slight, adverse', which was not considered to be significant.[26] However, Acilia recommends that the following best practice mitigation measures are implemented to reduce construction dust emissions to a practicable minimum.

Site Management

- Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.
- Make the complaint's log available to the local authority when asked.
- Record any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation in the logbook.

Monitoring

- Develop a Dust Management Plan (DMP), which may form part of an overall Environmental Management Plan (EMP), and may include measures to control dust emissions and to respond to complaints.
- Carry out regular site inspections to monitor compliance with the DMP, record inspection results, and make an inspection log available to the local authority when asked.
- Increase the frequency of site inspections by the person accountable for air quality and dust issues onsite when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.

[25] Other factors considered in the risk assessment included local wind speed and direction as they influence the dispersion of dust. Furthermore, the potential for a dust impact will also depend on the frequency that a sensitive receptor is downwind and the distance of the receptor from the construction activities (including any terrain and vegetation effects). Dust impacts are more likely to occur during drier periods, as rainfall acts as a natural dust suppressant. Overall, it was considered that there is a 'medium' dust release potential, a 'moderately' effective source-receptor pathway and a 'low' risk of dust impact at the nearest receptors. Therefore, for a 'high' sensitive receptor (e.g. residential property) the magnitude of a potential dust effect was predicted to be 'slight, adverse'.

[26] For a 'high' sensitive receptor (e.g. residential property) with a 'low' risk, the magnitude of a potential dust effect was predicted to be 'slight, adverse'.

Preparing and Maintaining the Site

- Plan site layout so that machinery and dust causing activities are located away from sensitive receptors, as far as is possible and practicable.
- Erect solid screens or barriers around dusty activities or the site boundary that are at least as high as any stockpiles onsite.
- Fully enclose site or specific operations where there is a high potential for dust production and the site is actives for an extensive period.
- Avoid site runoff of water or mud.

Operating Vehicles

- Ensure all vehicles switch off engines when stationary (i.e. no idling vehicles).
- Avoid the use of diesel or petrol-powered generators and use mains electricity or battery powered equipment where practicable.
- Impose and signpost a maximum-speed-limit of 15 mph on surfaced and 10 mph on unsurfaced haul roads and work areas.

Operations

- Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction (e.g. suitable local exhaust ventilation systems).
- Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.
- Use enclosed chutes and conveyors and covered skips.
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate
- Avoid bonfires and burning of waste materials.

6.2 Emission Control Measures for the Proposed Cremator

It is understood that particulate emissions from the proposed cremator will be controlled by means of fabric filtration (e.g. bag filter fitted with a filter leak detector), while an activated carbon filter will be used to control to control Hg and VOC emissions from the stack. Alkali compounds will also be employed to control HCl.

The cremator should be operated and maintained in accordance with the permit conditions and the manufacturer’s instructions such that emissions to air are kept to a minimum, and in accordance with the emission limit values set-out in PG5/2(12) at reference conditions of 273.1 K, 101.3 kPa and 11% O_2 v/v (dry gas basis), which are:

- Particulate matter 20 mg/Nm^3;
- Total organic compounds 20 mg/Nm^3;
- HCl 30 mg/Nm^3;
- CO 100 mg/Nm^3;
- Hg 0.05 mg/Nm^3.

6.3 Further Recommendations for the Proposed Cremator

As the ground-level air quality impacts were not predicted to be significant, no specific mitigation measures, other than those set-out above, have been considered. However, Acilia recommends that an Air Quality Management Plan (AQMP) should be prepared for the proposed crematorium.

The AQMP should be treated as a 'living document' and should include details of all emission control measures implemented onsite. It should also include, but not be limited to, the following:

- A site layout plan showing the location of the cremator and associated stack and ductwork, including the abatement plant (emission control equipment);
- Details of the complaint response procedures and investigations;
- Procedures to minimise emissions to air from the stack, including the inspection and maintenance procedures, ductwork and emission control equipment;
- The manufacturer's instructions including the inspection and maintenance requirements (including a log of maintenance undertaken) and operating parameters for the emission control equipment;
- Procedures for undertaking stack emissions monitoring, where required; and,
- The identification of staff responsibilities.

6.4 Further Recommendations for the Proposed Development

As the proposed scheme is considered to be a 'medium' development in terms of the West Yorkshire Low Emission Strategy (WYLES), the proposed development should give early consideration to including:

- Proposals for electric vehicle charging on the site; and,
- Low emission travel plan arrangements.

7.0 Conclusions

Acilia was commissioned by CBMDC to prepare an air quality impact assessment for a planning application for a proposed crematorium and memorial gardens located on a parcel of land at Long Lane near Shipley in Bradford, West Yorkshire.

The aim of the impact assessment is to determine the potential air quality impacts associated with discharges to air from the proposed cremator stack. The principal emissions to air from the proposed cremator will include particulate matter (as PM_{10} and $PM_{2.5}$), mercury (Hg), hydrogen chloride (HCl) and carbon monoxide (CO).

The potential impacts associated with these emissions were assessed on a quantitative basis using the AERMOD atmospheric dispersion model. The air quality concentrations predicted by the model at ground-level at discrete sensitive receptor locations were compared against the relevant UK ambient air quality standards and objectives set for the protection of human health.

7.1 Potential PM_{10} and $PM_{2.5}$ Impacts

Based on the results of the dispersion modelling assessment for 24-hour and annual mean PM_{10}, it is considered unlikely that there will be any significant, adverse air quality impacts at any sensitive receptor location as a result of PM_{10} emissions from the proposed cremator. The total predicted 24-hour mean and annual mean PM_{10} concentrations indicated that were will be no exceedances of the 24-hour mean and annual mean UK ambient air quality objectives for PM_{10} at any location beyond the site boundary.

Based on the results of the dispersion modelling assessment for annual mean $PM_{2.5}$, it is considered unlikely that there will be any significant, adverse air quality impacts at any sensitive receptor location as a result of $PM_{2.5}$ emissions from the proposed cremator. The total predicted annual mean $PM_{2.5}$ concentrations indicated that were will be no exceedances of the annual mean UK ambient air quality objective for $PM_{2.5}$ at any location beyond the site boundary.

7.2 Potential Hg and HCl Impacts

Based on the results of the dispersion modelling assessment for 1-hour and annual mean Hg, it is considered unlikely that there will be any significant, adverse air quality impacts at any sensitive receptor location as a result of Hg emissions from the proposed cremator. The total predicted 1-hour mean and annual mean Hg concentrations indicated that were will be no exceedances of the 1-hour mean and annual mean Environmental Assessment Levels (EALs) for Hg at any location beyond the site boundary.

Based on the results of the dispersion modelling assessment for 1-hour mean HCl, it is considered unlikely that there will be any significant, adverse air quality impacts at any sensitive receptor location as a result of HCl emissions from the proposed cremator. The total predicted 1-hour mean HCl concentrations indicated that were will be no exceedances of the 1-hour mean EAL for HCl at any location beyond the site boundary.

7.3 Potential CO Impacts

Based on the results of the dispersion modelling assessment for 8-hour mean CO, it is considered unlikely that there will be any significant, adverse air quality impacts at any sensitive receptor location as a result of CO emissions from the proposed cremator. The total predicted 8-hour mean CO concentrations indicated that were will be no exceedances of the 8-hour mean UK ambient air quality objective for CO at any location beyond the site boundary.

7.4 Summary of Potential Impacts

7.4.1 Construction Phase Dust Emissions

Considering the relatively small size of the proposed construction site (including the likely short duration of the construction works) and the source-pathway-receptor concept, human and ecological receptors in the vicinity of the site were considered to be of *'low'* risk to construction dust emissions. The impact magnitude was therefore predicted to be *'slight, adverse'*, which was not considered to be significant.

7.4.2 Operational Phase Traffic Emissions

Based on the Transport Assessment prepared by Pell Frischmann in October 2019, it is anticipated that the additional number of light- and heavy-duty vehicles travelling to and from the proposed crematorium will not be significant. A qualitative (screening) assessment for operational phase road traffic emissions was undertaken and indicated that the potential impacts associated with these emissions will be '*negligible'*.

7.4.3 Cremator Emissions

The short-term and long-term concentrations predicted by AERMOD indicate that there will be no adverse (human health) impacts as a result of the operation of the proposed cremator and that the impacts at these locations will be *'negligible'*, providing that the cremator is operated and maintained in accordance with the manufacturer's specifications and instructions, and the environmental permit conditions.

Therefore, the short-term and long-term air quality impacts predicted by the dispersion model were not considered to be significant and there are no apparent conflicts with local or national planning policy.

Appendix A: Examples of Scientific Notation

Table A-1: Examples of Scientific Notation used in the Assessment

Value	Scientific Notation	
0.000000001	1.0e-9	1×10^{-9}
0.000001	1.0e-6	1×10^{-6}
0.001	1.0e-3	1×10^{-3}
1	1.0e+0	1×10^{0}
1,000	1.0e+3	1×10^{3}
1,000,000	1.0e+6	1×10^{6}
1,000,000,000	1.0e+9	1×10^{9}

1 gram = 1,000 milligrams (mg) or 1.0e+3 mg

= 1,000,000 micrograms (µg) or 1.0e+6 µg

= 1,000,000,000 nanograms (ng) or 1.0e+9 ng

1 microgram = 0.001 milligrams (mg)

= 1,000 nanograms (ng)