BUROHAPPOLD ENGINEERING

St Giles Circus

Environmental Statement – Air Quality

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1 Air Quality

1.1 Introduction

This report has been prepared in order to discharge conditions 37 and 38 of planning permission 2012/1697/P which was granted permission on the 31st March 2015 and should be read in conjunction with Chapter 11 of the ES which was submitted in support of the original application.

The report provides an assessment of the proposed use of a 200kW gas-fired combined heat and power (CHP) unit and two 300kW gas-fired boilers. The impacts from these plants are assessed using the dispersion model ADMS-Roads (Atmospheric Dispersion Modelling System).

1.2 Construction effects and significance

No changes to construction effects are likely to be caused by the final design.

1.3 Operational effects and significance

The potential impacts of the proposed CHP and boilers upon local air quality have been assessed. These plants will give rise to emissions of nitrogen oxides (NOx), which will have the potential to impact upon local air quality in the vicinity of the development. This report details the dispersion modelling undertaken in order to predict the impacts of the CHP and boilers on local air quality

1.3.1 Assessment methodology

1.3.1.1 Dispersion modelling

The contribution of emissions from the CHP and boilers to NO_2 concentrations has been predicted using the ADMS-Roads Extra dispersion model. This model is widely used in the UK by regulators, government departments, industrial companies and consultancies to assess environmental impacts of air emissions from road and industrial sources.

The model has been used to predict the likely increments to annual mean and hourly mean NO_2 concentrations as a result of the CHP and boiler emissions.

1.3.1.2 Emission characteristics

The proposed plants are one gas-fired CHP unit and two gas-fired boilers. The flues from each plant will be discharged through three stacks located in Area A, Block D (York & Clifton Mansions) of the development. These three stacks will be contained in the existing Victorian chimney (3m above the roof level, see Figure 1—1.. A stack with the same effective cross-sectional area as the sum of the individual flue cross-sectional area of the two gas-fired boilers has been used in the model in order to take into account the effect of enhanced plume buoyancy. Accordingly, emissions from the two boilers have been modelled as one source. Emissions from the CHP stack have been modelled as a separate source. The emission characteristics of the CHP and boilers are presented in Table 1—1, whilst model input parameters are listed in Table 1—2 Diurnal and seasonal changes in emissions were accounted for by using time varying emission factors. Daily and Yearly profiles used are shown in Table 1—3 and Table 1—4.

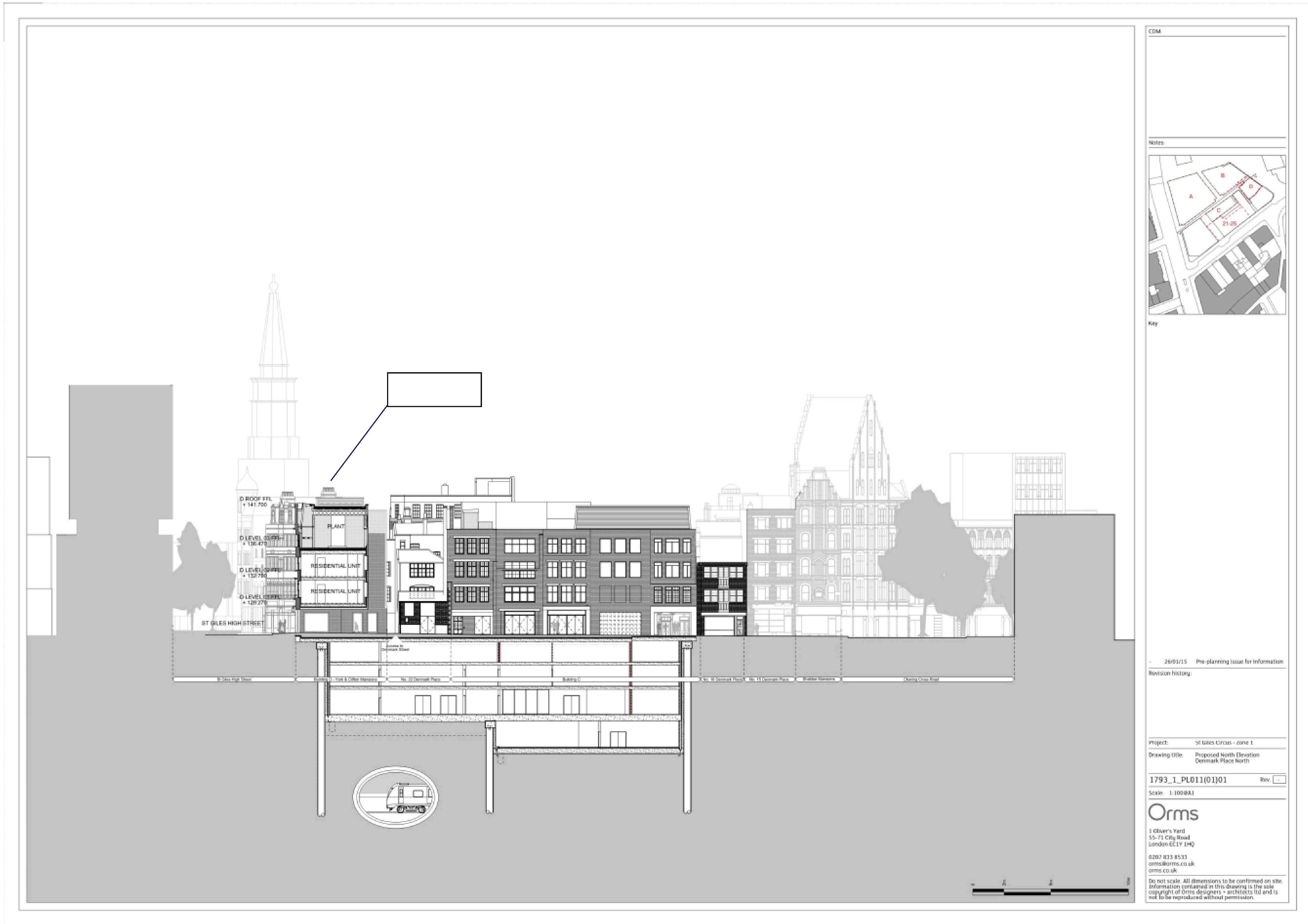

Figure 1—1 Location of proposed stack in relation to nearby buildings

Table 1—1 Emission characteristics of energy plant

Appliance (size)	Flue gas temperature (°C)	NOx emission rate (gs^{-1})	Efflux velocity (ms^{-1})	Stack diameter (m)
Gas-fired CHP (200kW)	120	0.023	6	0.125
Gas-fired boilers (300kW each)	80	0.04	6	0.25

Table 1—2 Emission modelling input parameters

Source	Grid reference (X,Y)	Height (m)	Diameter (m)	Velocity (m/s)	Temperature (°C)	NOx emission rate (g/s)
CHP	529917.4, 181293.4	18.8	0.125	6	120	0.023
Boilers	529917.6, 181293.7	18.8	0.35	6	80	0.08

Table 1—3 Daily profile of CHP and boiler emissions

Daily	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
CHP	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gas boilers	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.2	0.2	0.6	0.6	0.6	0.6	0.8	0.8	0.2	0.2	0.2	0.2	0.2

Table 1—4 Yearly profile of CHP and boiler emissions

Yearly	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CHP	1	1	1	1	1	0	0	0	0	1	1	1
Gas boilers	1	0.9	0.8	0.7	0.4	0.7	0.8	0.7	0.7	0.6	0.7	0.9

1.3.1.3 Building downwash

The building where the stack is located and other adjacent buildings have been included in the assessment as building downwash will have a significant effect on the dispersion of the resulting plumes. The ADMS-roads extra package allows for the inclusion of buildings which can impact upon the dispersion of stack emissions. The buildings where modelled stacks are located have been included as well as a number of buildings within the vicinity. Guidance suggests that only buildings that are taller than 1/3 of the height of the stack should be included. Building locations and measurements included in the model are presented in Table 1—5. The dispersion model requires a building to be designated as the "main building" to affect the dispersion of the plume for each stack, in this instance, the building upon which the stack is located has been designated the main building. Visualisation of building inputs is shown in Figure 1—2.

Table 1—5 Parameters used for building inputs into model

Building	Central point grid ref. (X,Y)	Height (m)	Length (m)	Width (m)	Angle from N (°)
Onsite*	529892, 181288	15.6	50	43	38
Centre point	529870, 181354	117	21	38	73
Centre point house	529925.9, 181341.9	40	17	46	70
Central St Giles	530015, 181333	50	108	60	60

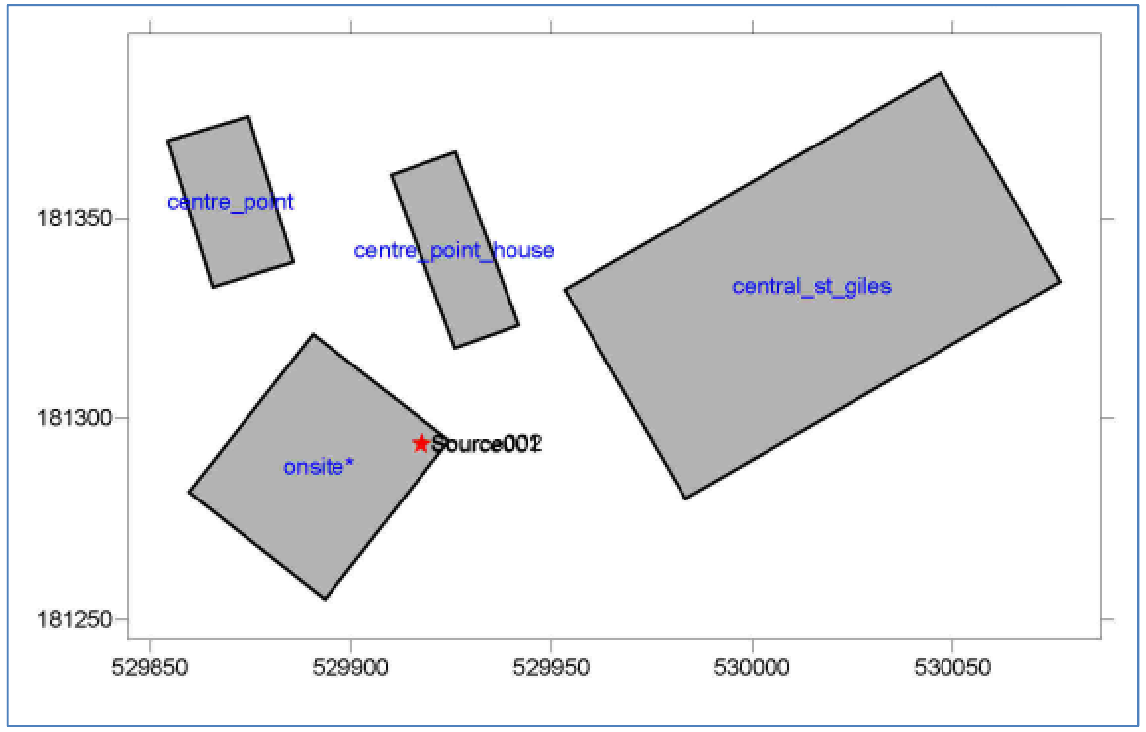

Figure 1—2 Visualisation of building inputs used in model

1.3.1.4 Meteorological data

Hourly sequential meteorological data were used from Heathrow Airport station. A model sensitivity analysis was undertaken using data from 2008-2012 in order to identify the year which led to the prediction of the highest annual mean ground level NO_2 concentrations. Results from this analysis (see Table 1—6) indicated that the maximum annual mean NO_2 concentration was predicted using 2010 meteorological data. Wind roses showing meteorological data from Heathrow for 2008 to 2012 are presented in Figure 1—3. The 2010 meteorological data set was subsequently used for all remaining modelling runs.

The extent of mechanical turbulence in the atmosphere is affected by the roughness of the surface over which the air passes. Typical surface roughness values range from 1.5m (large urban areas) to.001 m (for water or sandy deserts). A surface roughness of 1.5m has been used in this instance.

Table 1—6 Results from met year sensitivity analysis

Meteorological Year	Maximum annual mean NO_2 concentration, $\mu g/m^3$
2008	1.33
2009	1.34
2010	1.48
2011	1.31
2012	1.36

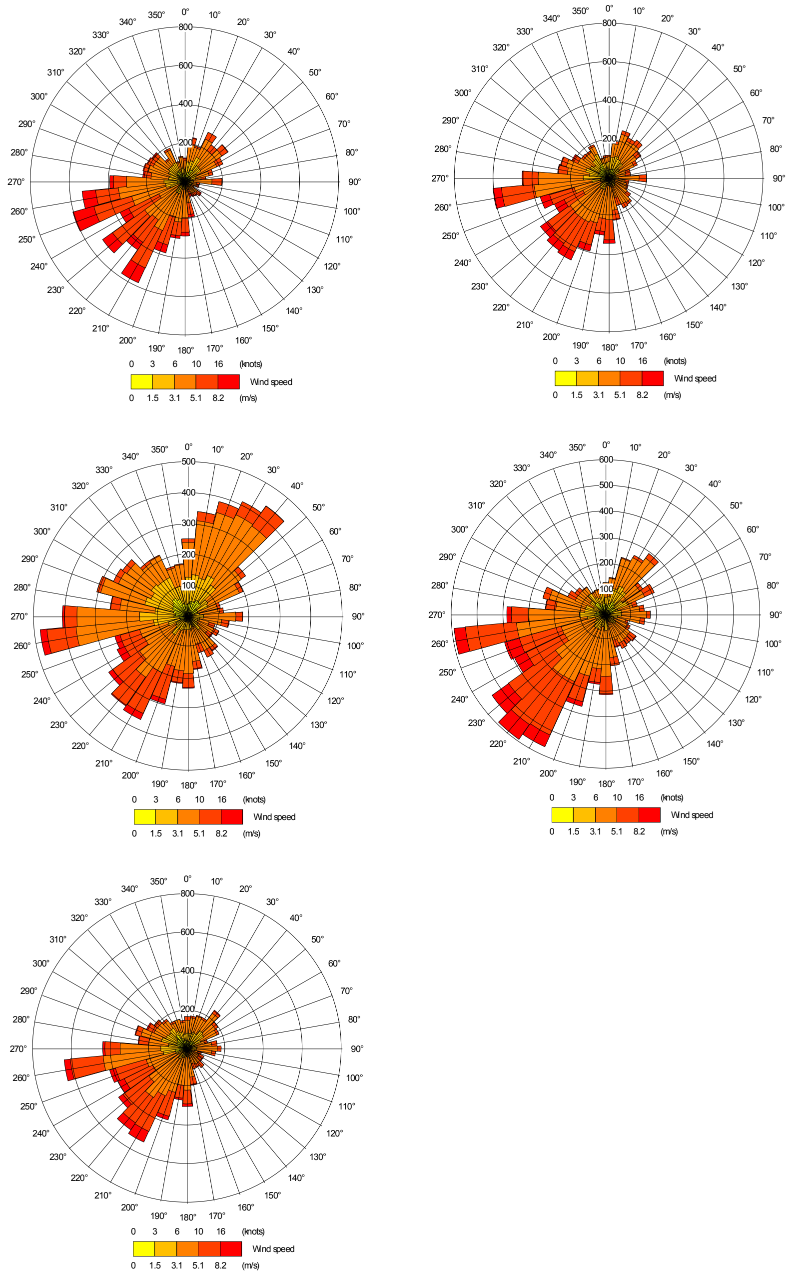

Figure 1—3 Wind rose for Heathrow, 2010

1.3.1.5 NOx - NO_2 conversion

The ADMS-Roads model predicts NOx concentrations, which are comprised principally of nitric oxide (NO) and a small percentage of NO_2. The emitted NO reacts with oxidants in the air, mainly ozone, to form more NO_2. Air quality standards for the protection of human health are based on NO_2 concentrations, and therefore a suitable NOx:NO_2 conversion ratio needs to be applied to the modelled NOx concentrations. Research indicates that when the oxidation reaction is dominated by ozone, NO_2/NOx ratio is a function of the distance from the source. In order to convert NOx into NO_2, a 35% ratio for short term concentrations, and 50% for long term concentrations have been used. These are considered to be conservative assumptions, particularly due to the short distance between stack and receptors.

1.3.1.6 Receptors

A grid of 380m by 420m, with a spacing of 5m was used to predict ground level pollutant concentrations. Additional discrete receptor points were included to model the impact of emissions on the nearest residential property façades at different heights. These receptor locations are shown in Table 1—7 and Figure 1—4 Location of receptor points.

Table 1—7 Location of receptor points

Receptor number	Location	Grid Ref (X, Y)		Height (m)
1	Onsite (25 Denmark Street-nearest residential receptor)	529905.3	181283.93	15.8
2	Central St Giles (N) fifth floor	529954.99	181333.76	17.5
3	Central St Giles (N) sixth floor	529954.99	181333.76	21
4	Central St Giles (N) seventh floor	529954.99	181333.76	24.5
5	Central St Giles (N) eighth floor	529954.99	181333.76	28
6	Central St Giles (N) ninth floor	529954.99	181333.76	31.5
7	Central St Giles (N) tenth floor	529954.99	181333.76	35
8	Central St Giles (S) fifth floor	529972.19	181297.08	17.5
9	Central St Giles (S)sixth floor	529972.19	181297.08	21
10	Central St Giles (S) seventh floor	529972.19	181297.08	24.5
11	Central St Giles (S) eighth floor	529972.19	181297.08	28
12	Central St Giles (S) ninth floor	529972.19	181297.08	31.5
13	Central St Giles (S) tenth floor	529972.19	181297.08	35
14	Centre Point House fifth floor	529923.36	181321.59	17.5
15	Centre Point House sixth floor	529923.36	181321.59	21
16	Centre Point House seventh floor	529923.36	181321.59	24.5
17	Centre Point House eighth floor	529923.36	181321.59	28
18	Centre Point House ninth floor	529923.36	181321.59	31.5
19	Centre Point House tenth floor	529923.36	181321.59	35

[1] L. H. M. Janssen, J. H. A. Van Wakeren, H. Van Duuren and A. J. Elshout (1988). A classification of NO oxidation rates in power plant plumes based on atmospheric conditions. Atmospheric Environment. Vol. 22. No 1. pp. 43-53.

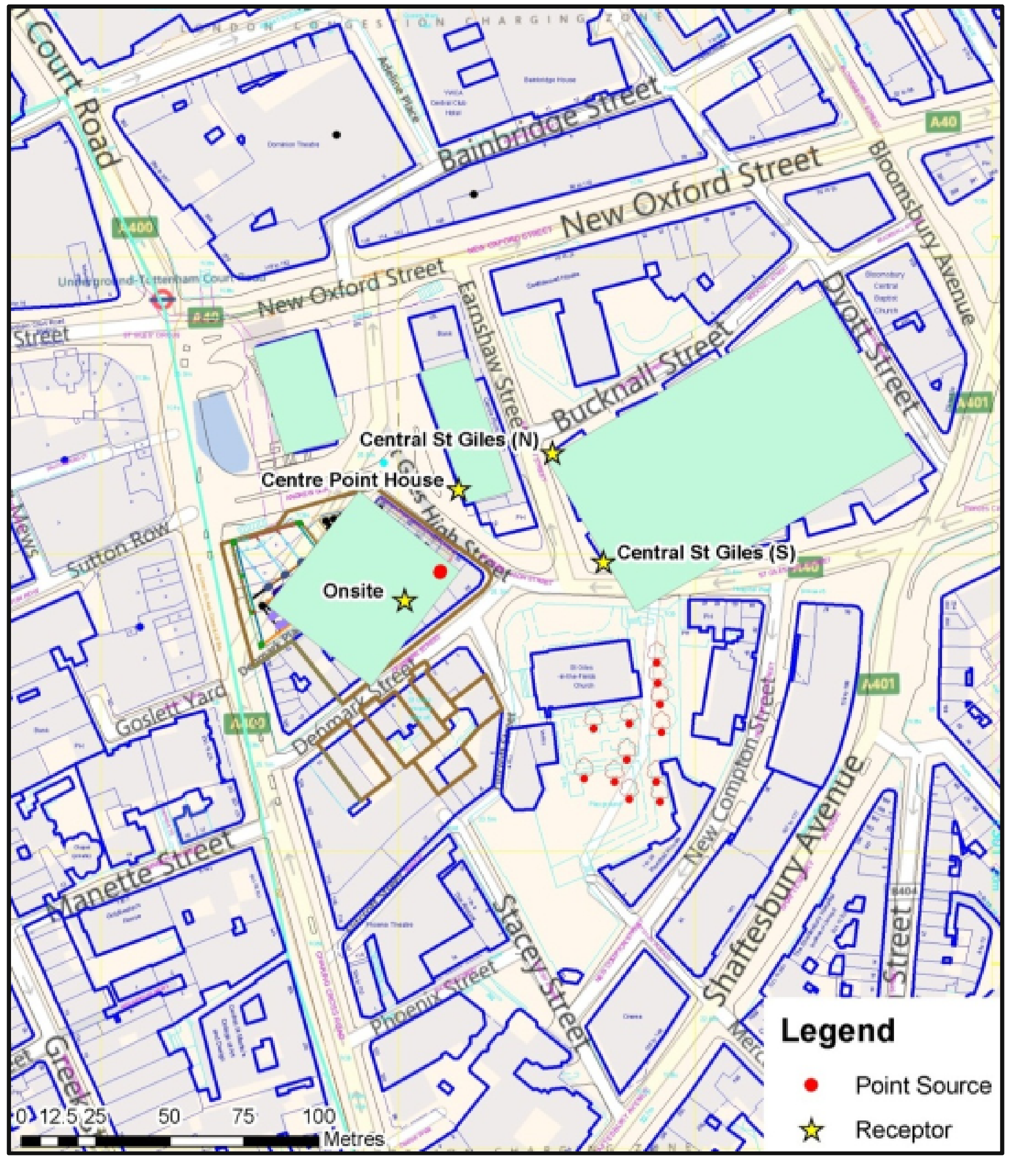

Figure 1—4 Location of receptor points

1.3.1.7 Background pollutant concentrations

Background pollutant concentrations were added to predicted model results in order to determine if air quality objectives are likely to be met or exceeded. For the assessment of annual mean NO_2 concentrations, the annual mean contribution of the CHP and boilers were added to the annual mean estimate of the background. For the assessment of the hourly mean NO_2 concentrations an approach described by the environment agency was taken which involves doubling the annual mean background concentration in order to give a suitable hourly mean background concentration.

According to Defra's background maps[1], the background NO_2 concentration for the site for the year 2013 is 54.7µg/m^3.

1.3.1.8 Assessment criteria

The Environmental Protection UK (EPUK) Guidance[2] provides an approach to describing the significance of the impacts predicted from the air quality modelling. The guidance sets out examples of descriptors for magnitude of change and significance. The descriptors for magnitude of change and significance for NO_2 are shown in Table 1—8 and Table 1—9.

Table 1—8 Descriptors for Changes in Ambient Concentrations of NO_2 *

Magnitude of Change	Absolute Change in NO_2 Concentrations (µg/m^3)
Large	Increase/decrease > 4
Medium	Increase/decrease 4 – 2
Small	Increase/decrease 2 – 0.4
Imperceptible	Increase/decrease < 0.4

* Taken from the EPUK 2010 guidance

Table 1—9 Descriptors for Impact Significance for annual mean NO_2 *

Absolute Concentration in Relation to Objective/Limit Value	Change in Concentration		
	Small	Medium	Large
Increase with Scheme			
Above Objective/Limit Value with Scheme (> 40 µg/m^3)	Slight Adverse	Moderate Adverse	Substantial Adverse
Just Below Objective/Limit Value with Scheme (36-40 µg/m^3)	Slight Adverse	Moderate Adverse	Moderate Adverse
Below Objective/Limit Value with Scheme (30-36 µg/m^3)	Negligible	Slight Adverse	Slight Adverse
Well Below Objective/Limit Value with Scheme (<30 µg/m^3)	Negligible	Negligible	Slight Adverse
Decrease with Scheme			
Above Objective/Limit Value without Scheme (40 µg/m^3)	Slight Beneficial	Moderate Beneficial	Substantial Beneficial
Just Below Objective/Limit Value without Scheme (36-40 µg/m^3)	Slight Beneficial	Moderate Beneficial	Moderate Beneficial
Below Objective/Limit Value without Scheme (30-36 µg/m^3)	Negligible	Slight Beneficial	Slight Beneficial
Well Below Objective/Limit Value without Scheme (<30 µg/m^3)	Negligible	Negligible	Slight Beneficial

* Taken from the EPUK 2010 guidance

In terms of overall operational impact, the EPUK Guidance provides an approach for assessing the significance of air quality impacts associated with a given development. This approach suggests factors which should be considered before a suitably qualified professional can determine, with sufficient justification, whether the overall impact of a potential development should be termed 'insignificant', 'minor', 'moderate' or 'major'. These factors are the following:

- Number of people affected by slight, moderate or major air quality impacts and a judgement on the overall balance;
- Where new exposure is being introduced into an existing area of poor air quality, then the number of people exposed to levels above the objective or limit value will be relevant;
- The magnitudes of the changes and the descriptions of the impacts at the receptors;
- Whether or not an exceedence of an objective or limit value is predicted to arise in the study area where none existed before or an exceedence area is substantially increased;

[2] Defra (2012a) Air quality background maps: http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

[2] Environmental Protection UK. Development Control: Planning for air quality (2010 update).

- Whether or not the study area exceeds an objective or limit value and this exceedence is removed or the exceedence area is reduced;
- Uncertainty, including the extent to which worst-case assumptions have been made; and
- The extent to which an objective or limit value is exceeded e.g. an annual mean NO_2 of 41 µg/m3 should attract less significance than an annual mean of 51 µg/m^3.

1.3.2 Results

The predicted process contribution and total NO_2 concentrations at receptors are presented in Table 1—10 Predicted process contribution and total contribution were highest at receptors 1 and 15, which both have a predicted concentration of 55.8µg/m^3; this is above the 40µg/m^3 objective. The highest hourly mean concentration is predicted at receptor 15 with a total 99.79th percentile hourly mean of 132.8µg/m^3; this is well below the 200µg/m^3 objective.

Table 1—10 Predicted process contributions and total concentrations

Receptor number	Location	NO_2 process contribution, µg/m^3		Total concentrations, µg/m^3 (process contribution + background)	
		Annual mean	99.79th percentile of hourly mean	Annual mean	99.79th percentile of hourly mean
1	Onsite (25 Denmark Street)	1.1	20.6	55.8	130.0
2	Central St Giles (N) fifth floor	0.3	6.6	55.0	116.0
3	Central St Giles (N) sixth floor	0.3	7.5	55.0	116.9
4	Central St Giles (N) seventh floor	0.3	6.9	55.0	116.3
5	Central St Giles (N) eighth floor	0.2	5.3	54.9	114.7
6	Central St Giles (N) ninth floor	0.1	3.4	54.8	112.8
7	Central St Giles (N) tenth floor	0.1	2.2	54.8	111.6
8	Central St Giles (S) fifth floor	0.4	9.8	55.1	119.2
9	Central St Giles (S)sixth floor	0.4	13.0	55.1	122.4
10	Central St Giles (S) seventh floor	0.4	12.2	55.1	121.6
11	Central St Giles (S) eighth floor	0.3	8.9	55.0	118.3
12	Central St Giles (S) ninth floor	0.2	4.8	54.9	114.2
13	Central St Giles (S) tenth floor	0.1	2.8	54.8	112.2
14	Centre Point House fifth floor	0.9	17.8	55.6	127.2
15	Centre Point House sixth floor	1.1	23.4	55.8	132.8
16	Centre Point House seventh floor	0.7	17.5	55.4	126.9
17	Centre Point House eighth floor	0.3	8.4	55.0	117.8
18	Centre Point House ninth floor	0.1	4.4	54.8	113.8
19	Centre Point House tenth floor	0.0	2.7	54.7	112.1

According to the criteria described in section 1.3.1.8 , the magnitudes of change in annual mean NO_2 concentrations at receptors 1, 14, 15 and 16 are considered **small**, which will result in a **slight adverse** impact at these receptors. All other receptors are predicted to have **imperceptible** magnitudes of change, and therefore **negligible** impacts.

Figure 1—5 to Figure 1—8 show contour maps of the modelled NOx process contribution at ground level and at 15.8m height (the same height as the nearest residential receptor). The maximum process contributions at both levels are presented in Table 1—11. The maximum impacts are considered to be small.

Table 1—11 Maximum process contribution NO2 concentrations at ground level and at 15.8m

Height	Maximum 99.79th percentile hourly NO_2 concentration, µg/m^3	Maximum annual mean NO_2 concentration, µg/m^3
Ground level (0m)	3.94	0.74
15.8m	25.54	1.50

With regards to EPUK factors for judging significance, the following conclusions can be made:

- The predicted change in NO_2 concentrations is small;
- The proposal will not lead to any new air quality objective exceedences;
- The main cause of the predicted slight adverse impact is due to an existing high background NO_2 concentration;
- Although air quality objectives are already being exceeded at ground level in the vicinity of the site, the worst case receptors (1 and 15) were modelled at heights of 15.8m and 21m, where background concentrations are likely to be significantly lower than those at ground level. It could therefore be assumed that NO_2 concentrations at these heights are below the objective, which would result in a negligible impact from the process contribution. Such an assumption would mean that no sensitive receptors will be exposed to adverse impacts; and
- This assessment has considered pessimistic assumptions including the use of worst case meteorological data and conservative NOx-NO_2 conversion ratios.

In conclusion, modelling results indicate that a **small** increase in pollutant concentrations are predicted to occur at the following locations: onsite (25 Denmark Street), and on the fifth, sixth and seventh floors of Centre Point House. Total NO_2 concentrations (process contribution + background) have been calculated using ground level background concentrations and other worst-case assumptions. The predicted impact of the increase in concentration at these receptors is **slight adverse**. All other receptors are predicted to have a **negligible** impact.

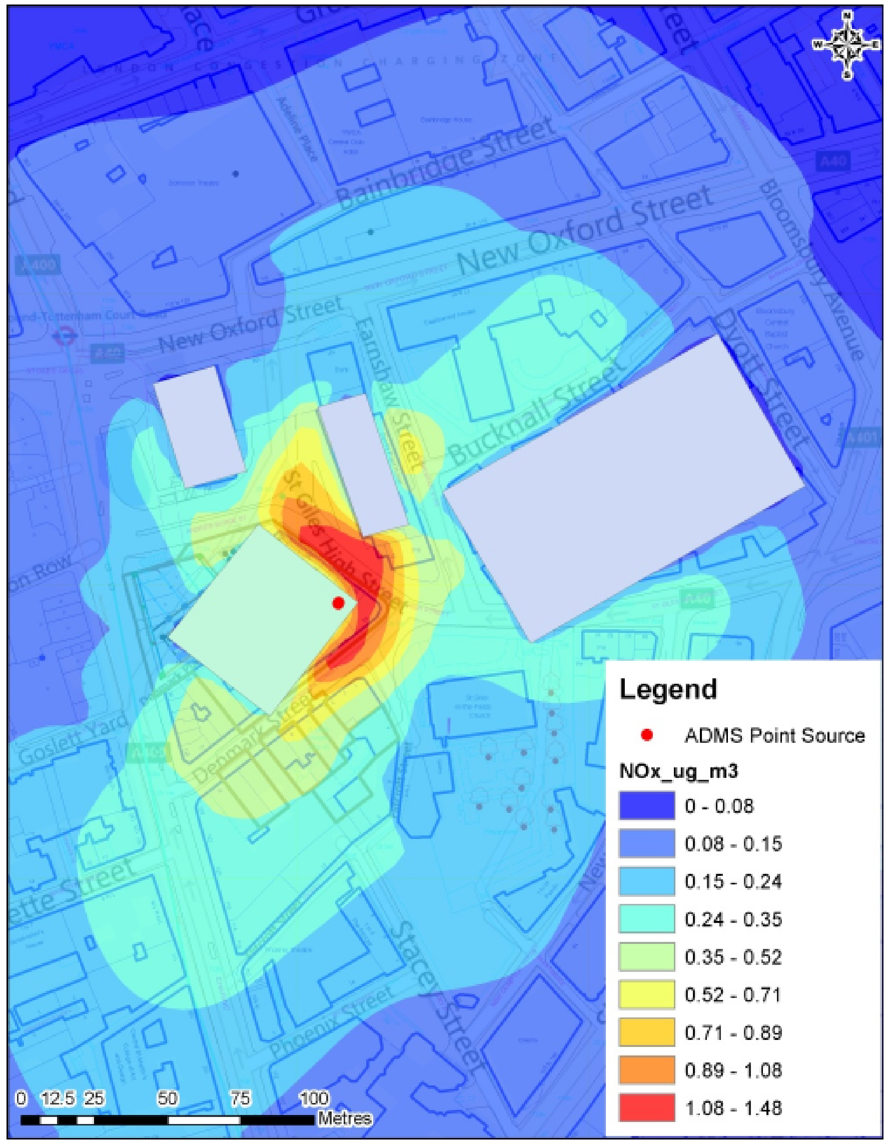

Figure 1—5 Ground level NOx annual mean contribution

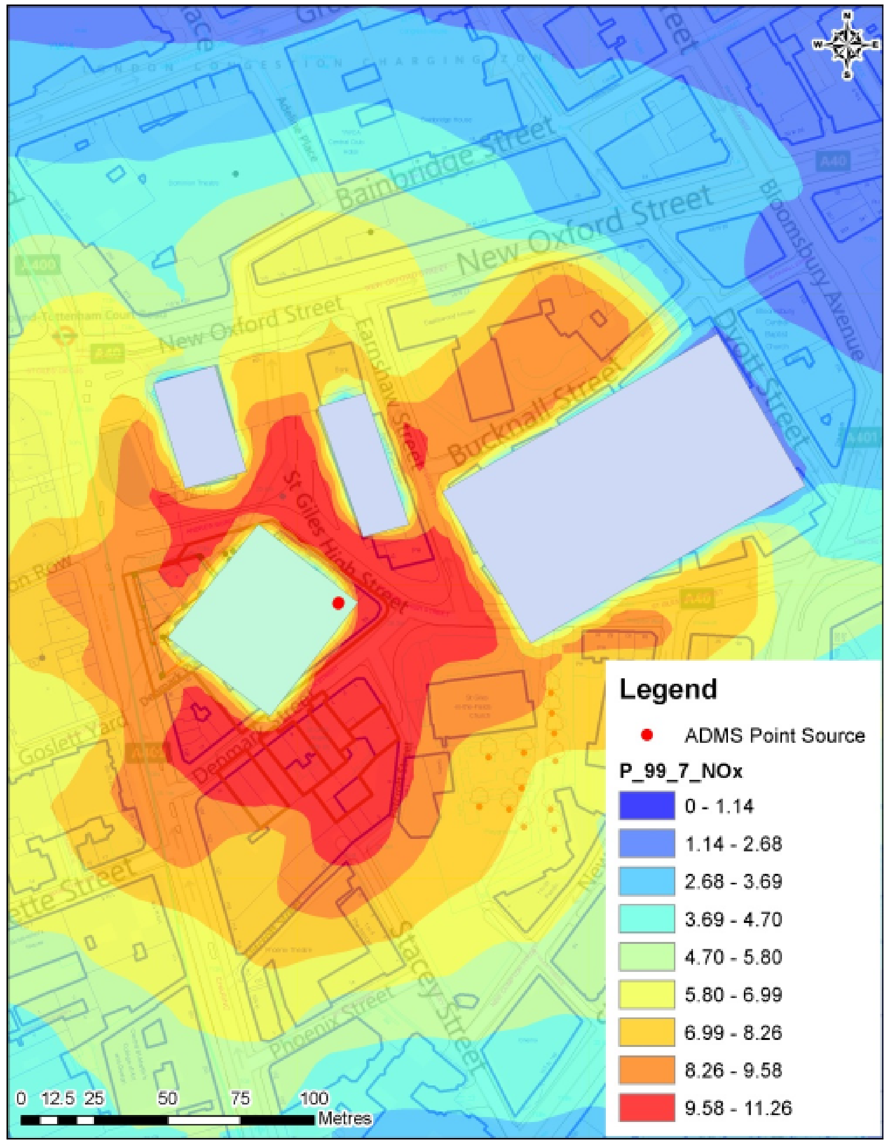

Figure 1—6 Ground level 99.79th percentile hourly mean NOx contribution

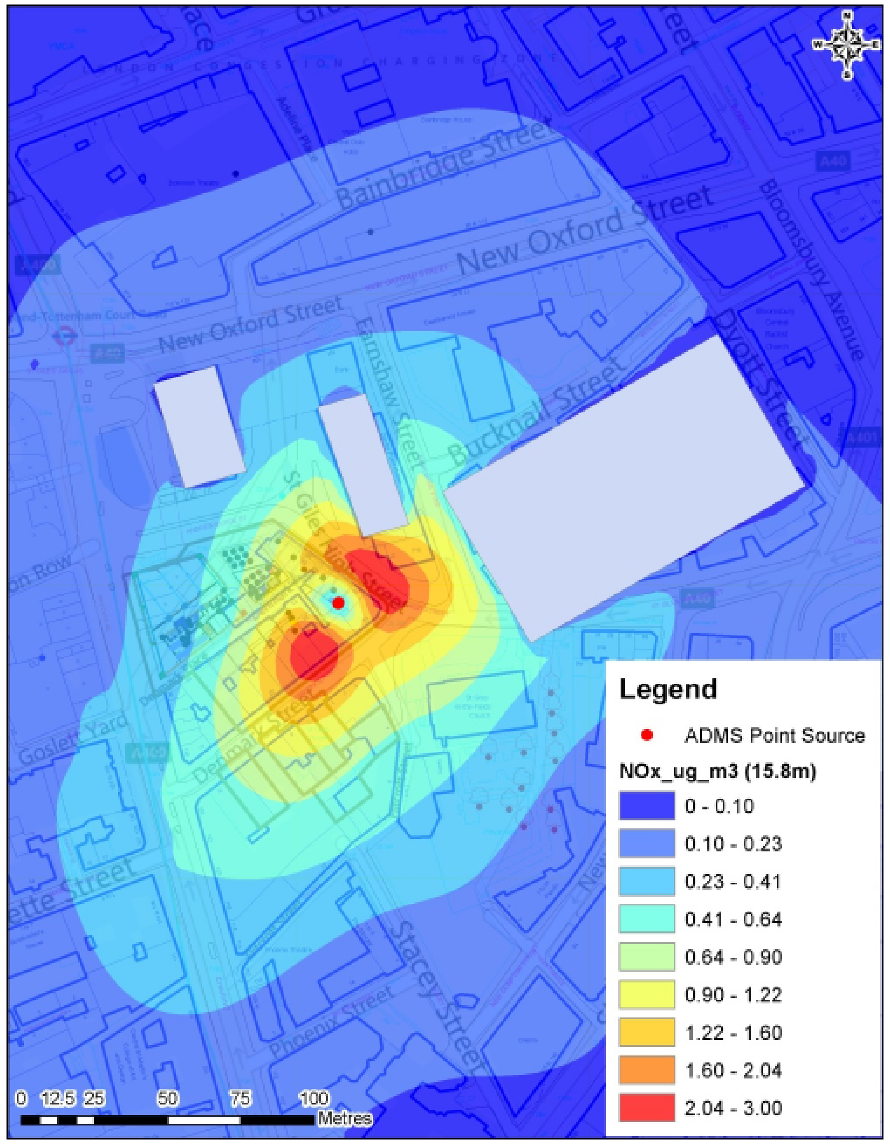

Figure 1—7 15.8m NOx annual mean contribution

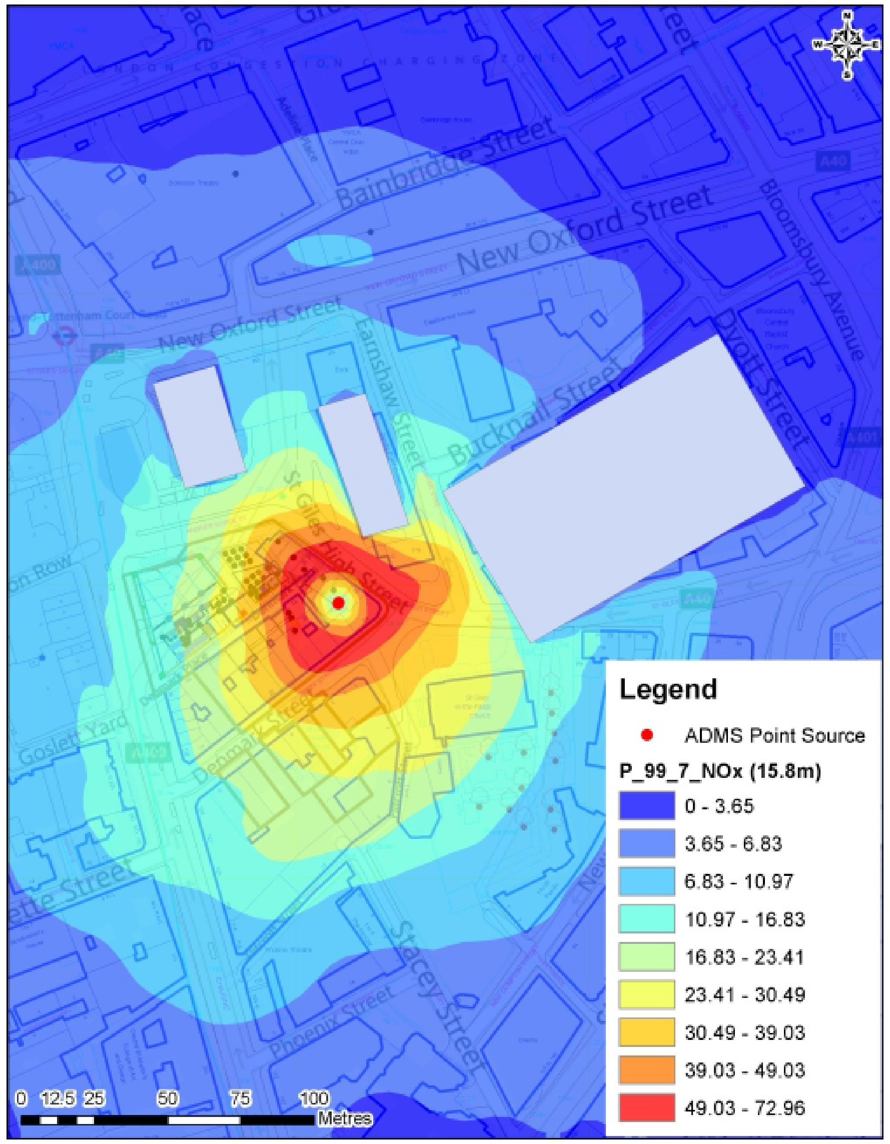

Figure 1—8 15.8m 99.79th percentile hourly mean NOx contribution

1.4 Further mitigation measures

Further mitigation measures are incorporated into the abatement technology utilised by the CHP.

An extra low NOx catalytic converter will be incorporated into the CHP exhaust flue to reduce the NOx and CO emissions of the unit to meet required standards. The specification for a proposed CHP unit for the project, including filters, is outlined in section 2 of this report to demonstrate compliance with the relevant emissions targets. It is not anticipated that any further activated carbon filtration will be required in addition to the equipment outlined in chapter 2.

Impacts from local air quality on residential receptors will be minimised by having ensured that ventilation intakes are placed away from the busy Charing Cross Road, and are now located in Denmark Place so as to avoid the direct ingress of pollutants into the building.

1.5 Residual effects and conclusions

The residual impacts of the submitted ES remain unchanged, and there is a slight adverse impact to nearby residential receptors from the CHP emissions as outlined below.

Table 1—12 Summary of residual effects

Effect	Significance before mitigation	Mitigation	Residual effect significance
Dust and other emissions during the construction phase have the potential to have air quality impacts on sensitive receptors located at St Giles High Street	Moderate adverse	Application of the measures detailed in section 11.4.3 of ES	Minor to indiscernible adverse
Impacts from boiler and CHP emissions upon nearby residential receptors	Slight adverse	Use of suitable abatement technology	Slight adverse

2 Proposed CHP Equipment

2.1 Executive Summary

This document has been written in response to the pre-commencement planning clause:

'Prior to commencement of development full details of the location and height of the proposed CHP flue, including full modelling calculations of NO_2 emissions, necessity of carbon filters and mitigation measures shall be submitted and approved in writing by the Local Planning Authority.'

- The CHP unit size has been sized at 200kWth (thermal).
- The target emissions for the CHP is **95 mg/Nm.**
- A typical CHP manufacturer can achieve emissions **< 27 mg/Nm^3.**

2.2 GLA Requirement

The emissions target is set by Sustainable Design and Construction Supplementary Planning Guidance, April 2014 http://www.london.gov.uk/

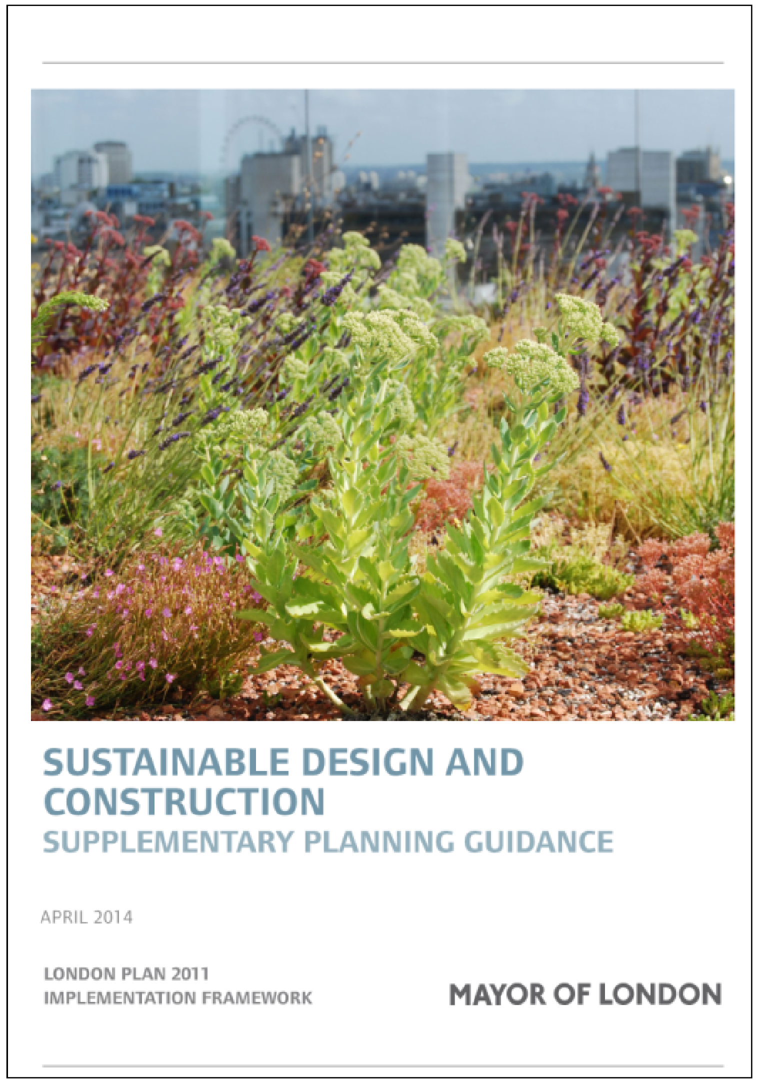

Figure 2—1 Emissions standards for solid biomass and CHP plant

Combustion Appliance[A]	Pollutant/ Parameter	Emission Standard at Reference O_2 (mg Nm^{-3})	Equivalent Concentration at 0% O_2 (mg Nm^{-3})	Likely Technique Required to Meet Emission Standard
Spark ignition engine (natural gas/biogas)[B]	NO_x	95	125	SCR (lean burn engines) NSCR (rich burn engines)

Figure 2—2 The target for Band B is 95 mg/Nm^3

2.3 Manufacturers Data

The following is a copy of a manufacturer's proposal for a CHP unit to meet the required emissions criteria:

- The data on page 2 indicates an the emissions can be reduced to **<27mg/Nm.**
- This is achieved using a high performance MINE-X catalytic converter.

Manufacturers that maybe approached to provide the CHP include:

- Helec
- EnerG
- Hoval

Super low CAT with PB138SNG CHP

Cat info:

General information (Three Way Catalytic Converters):
MINE-X® catalytic converters are metallic elements contained in a stainless steel mantle. The catalyst material is coated on a metal honeycomb substrate containing a series of alternating flat and corrugated FeCrAlloy foils, wound together and contained within a stainless steel outer shell. The ultra-thin foils increase the interior void space and provide low backpressure values. The foils are brazed, both to each other, as to the steel mantle, to provide added stability and prevent substrate telescoping.
A variety of standard and customized housing designs, equipped with monitoring ports, clamps and flanges are offered to ensure optimal fit in existing or new exhaust systems. The overall length and connection sizes of each system are to be built according to customer specifications.
MINE-X® Industrial designs feature either a welded or clamped body connected to reducing cones and, optionally, flanges, diffuser, or additional ports.
The MINE-X® QUICK-LID® and Mini QUICK-LID® series feature a reactor-style housing with a quick-release lid, providing easy access to the catalytic elements for servicing and maintenance.
This structure, coupled with the flexibility in design and coating choice, make MINE-X® catalytic converters a perfect choice for emission reduction in industrial engines worldwide.

CHP with extra low NOx Cat from Helec Ltd

CHP operation	Mains parallel Synchronous
CHP make	PB138SNG
Electrical Power modulation	55 kWe – 138 kWe
Thermal Output	207 kWt
Overall efficiency	89%
Power factor	cos phi 0.98
Fuel consumption	392 kW
Flow temperature max	90^{0}C
Return temperature max	78^{0}C
Upgraded insulated enclosure	65 dBA @ 1 metre
Engine Make and Model	MAN E2876 E312
Engine Power (hp or kW) at Speed (RPM)	150 kW at 1500 RPM / 50 Hz
Exhaust Temperature (°C)	590
Exhaust Gas Flow/Volume (Nm_3/h, kg/h)	503 kg/h
Lambda (λ) / AFRC Quality	1.0 / Good

Lye Cross Road, Redhill, Bristol BD40 5RH 01934 862264

Max. allowable backpressure (kPa)	10 mbar
Fuel used	Natural Gas
Three way extra low NOx Cat inside unit	MINE-X® catalytic converter
Emission Levels: (mg/Nm_3 at 5% O_2)	CO: <60 NOx: <27
CHP unit Overall Dimensions	3600mm(Length) 1200mm (Width) 1900mm (Height) + Separate secondary silencer – horizontal or vertical outside of unit

Lye Cross Road, Redhill, Bristol BD40 5RH 01934 862264

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