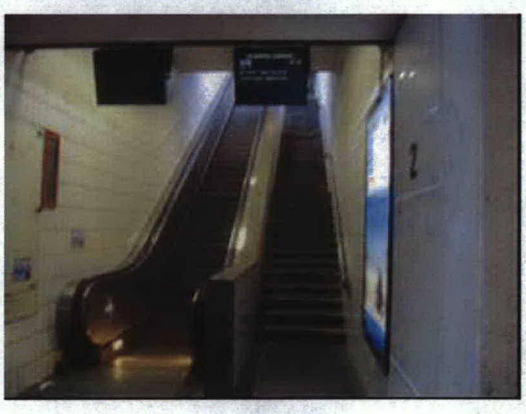
Figure 27 - Ghent Railway Station - Tram Tunnel

Figure 28 - Ghent Railway Station - Tram Interchange Under Station Platforms

Figure 29 - Ghent Railway Station - Escalators To Platforms From Tram Tunnel



8 Air Quality

8.1 Introduction

This section presents the air quality assessment for the proposed York Central Development. It predicts the potential impact of the proposed development on the air quality in York. Concentrations of two pollutants, nitrogen dioxide and fine particulate matter, are predicted for a base year (2004) and for two future years (2011 and 2021). Pollutant concentrations are predicted for the two future years for two scenarios: the do-minimum scenario assumes that the development does not proceed; and the do-something scenario assumes that the development does proceed.

8.2 Air Quality in York

Like many cities in the UK, traffic congestion is a problem in York, and this can lead to elevated concentrations of pollutants. Nitrogen oxides and particulate matter are the key emissions from traffic that have the greatest potential to impact upon health. There are national air quality objectives for these pollutants, which every local authority with in the UK has to work towards within the review and assessment framework.

The City of York Council (CoYC) have, on the basis of their review and assessment work, designated a large area within the city centre as an Air Quality Management Area (AQMA) for nitrogen dioxide. This is in recognition of the fact that within this area the annual mean national air quality objective for nitrogen dioxide is unlikely to be met. The site of the proposed York Central Development lies in close proximity to the AQMA.

8.3 Pollutants of Concern

8.3.1 Nitrogen Dioxide

In an attempt to reduce ambient NO2 levels, the UK Government and the Devolved Administrations have adopted two Air Quality Objectives for NO2, to be achieved by the end of 2005 [Ref 1&2]:

- An annual mean concentration of less than 40 µg/m3 (21 ppb); and
- A 1-hour mean concentration of 200 µg/m3 (105 ppb) not to be exceeded more than 18 times per year (equivalent to a 99.8th percentile).

These objectives are included in full in **Appendix E**, together with EU objectives for 2010. In practice, meeting the annual mean objective in 2005 is expected to be considerably more demanding than achieving the 1-hour objective. Therefore, if the annual mean objective is not exceeded, it can be reasonably assumed that the 1-hour objective will be met.

8.3.2 Background

Oxides of nitrogen (NOX) are primarily comprised of nitric oxide (NO) and nitrogen dioxide (NO2). A major source of NOX is from motor vehicles, as it is formed as a by-product of fuel combustion in the high temperatures of the engine. NO and NO2 are grouped together in the term NOX, and the majority of NOX emitted from vehicles is in the form of NO, with a smaller proportion of NO2.

The health effects of NO2 exposure can be chronic and/or acute. Studies of artificial exposure have shown that chronic effects of the upper range of possible exposure concentrations might include changes in lung structure, metabolism and reduced resistance of the lungs to bacterial infection. No clear link has been established between these effects and exposure to NO2 from ambient air. Acute effects, including increased airway resistance and associated reduced pulmonary function, are experienced by some asthmatics, but there is no clear dose-response relationship. Exposure to NO2 may also increase reactivity to natural allergens.

NOX gases are also recognised as indirect greenhouse gases, and are one of the main contributors to acid deposition. Direct exposure of vegetation to NOX may result in leaf damage or make plants more susceptible to attack by pests and disease. The effects of NOX can be greatly influenced by the presence of other pollutants. In particular, NOX and sulphur dioxide can significantly reduce vegetation growth rates at higher concentrations.

As shown in **Figure 30** [Ref 3], estimates for 2002 show that road transport accounts for around 45% of total UK emissions of NOX with the energy industry accounting for a further 28%. The contribution of road transport to nitrogen oxides emissions has declined significantly in recent years as a result of various policy measures, and further reductions are expected up until 2010 and beyond. For example, urban traffic nitrogen oxides emissions are estimated to fall by about 46% between 2000 and 2010.

8.3.3 *Atmospheric Chemistry of Nitrogen Oxides*

Once released into the atmosphere nitric oxide (NO) is oxidised to form nitrogen dioxide (NO2) in a reaction with ozone (O3), and other hydrocarbon based oxidants. The availability of O3 directly affects the ratio of NO to NO2. Although motor vehicles are regarded as the primary source of NO, the diurnal variation of the NO2 formed does not always vary in accordance with local traffic patterns. Nevertheless, measurements of NO2 taken at kerbside and roadside monitoring sites typically show higher concentrations than those observed at background monitoring sites.

The Advisory Group on the Medical Aspects of Air Pollution Episodes[Ref 9] described NOX chemistry in the following way:

During its atmospheric lifetime, the dominant oxide of nitrogen, NO, is progressively oxidised to NO2, largely by reaction with O3.

$$NO + O3 \rightarrow NO2 + O2$$

The consequence of this reaction is that the amount of the total NOX emitted which is oxidised to NO2 is often limited by the availability of O3. Close to NOX sources, the fraction of NOX present as NO2 will generally be low. Further from the sources, in conditions of vigorous atmospheric mixing, the initial NOX plume will be diluted with more O3, and the proportion of NO2 will be higher. The relationship between NO, NO2 and O3 is complicated by the photolytic reaction which occurs during daylight as NO2 is photolysed by short wavelength light (> 400 nm), to reform NO and O3.

$$NO2 + h\square \rightarrow NO + O$$

$$O + O2 \rightarrow O3$$

The Quality of Urban Air Research Group[Ref10] add that "In polluted atmospheres other reactions take place involving hydrocarbons, aldehydes, CO and other compounds".

Understanding the mechanisms that are responsible for the elevated levels of NO2 that occur during the winter months is an ongoing topic of air quality research. Although NO2 levels increased nationally by around 30% between 1986 and 1991, followed by a decrease to 2000, future trends associated with NO2 remain unclear at present.

8.4 Particles (PM10)

In an attempt to reduce ambient PM10 levels, the Government and the Devolved Administrations have adopted two Air Quality Objectives for PM10, to be achieved by the end of 2004 [Ref 1]:

An annual mean concentration of less than 40 µg/m3 (gravimetric) -

A 24-hour mean concentration of 50 µg/m3 (gravimetric) not to be exceeded more than 35 times per year.

Further objectives have been proposed for 2010 for PM10 [Ref 2]. These objectives are a 24-hour mean of less than 50 µg/m3, with a maximum of 7 exceedences per year (equivalent to a 98.1th percentile) and an annual mean of less than 20 µg/m3. The objectives for 2010 are considerably more stringent than those for 2004, and it is likely that they will not be achieved throughout many urban areas in England. This is expected to be the case mainly due to typical predicted background concentrations being only slightly lower than the annual mean standard.

8.4.1 *Background*

Particulate matter is composed of a wide range of materials arising from a variety of sources, and is typically assessed as total suspended particulates, or as a mass size fraction. The

European air quality standards have adopted the PM10 standard for the assessment of fine particulate matter. This expresses particulate levels as the total mass size fraction at or below an aerodynamic diameter of 10 µm. Particles of this size have the greatest likelihood of reaching the lung. Health effects of PM10 are largely linked with the worsening of pre-existing conditions. For instance, there is no evidence that exposure can cause asthma but its effects can lead to periods of excess deaths during periods of high particulate concentrations. Increases in mortality rates from heart and lung disease on exposure to different levels of PM10 have been measured to be 1.4% and 3.4% per 10 µg/m3, respectively. However, the impact on heart disease-related fatalities has a greater impact on the population as heart disease accounts for 45% of deaths while lung disorders cause only 5% of deaths. There is some concern that fine particles from diesel exhaust may have a carcinogenic effect. This may be due to air-stream entrained particles carrying adsorbed carcinogens into the respiratory system. The true effects are difficult to determine as they are masked by other parameters often associated with different exposure levels such as weather and lifestyle.

Road transport accounts for a contribution of 24% to the annual UK emissions of particulates in 2002. Other major sources include residential combustion at 17%, quarrying at 16% and power stations at 6%. **Figure 31** shows that total national emissions of PM10 have decreased since 1986. This reduction is due to legislation and emission control technology both for road traffic and industrial sources.

8.5 Pollutant Monitoring

There are several continuous monitoring sites in York that measure NO2 and PM10, and there is also a comprehensive network of NO2 diffusion tubes throughout the city. This section provides an overview of recent monitoring results.

8.5.1 Continuous NO2 Monitoring

Measured NO2 concentrations are shown in **Table 21,** for the year 2004. Dunnington is a background site to the east of York; Bootham Hospital is an urban background site near the centre of York; the remaining sites are roadside sites within, or near to, the centre of York. The data shown have been collected and ratified according to guidelines used in the UK Automatic Urban and Rural Network (AURN) and those outlined in Technical Guidance Note LAQM.TG(03) [Ref 1]. A map showing the locations of the central monitoring sites is presented in **Appendix F**.

Table 21 – Continuous Monitoring Summary for NO_2, 2004

Site	Grid Reference		Mean / µg/m^3	No. of Exceedences of Hourly Mean	Data Capture
	X	Y			
Rawcliffe	457701	454803	27.4	0	65%
Holgate	459513	451282	42.0	7	76%
Bootham Hospital	460023	452778	19.8	0	90%
Nunnery Lane	460069	451199	32.6	0	94%
Gillygate	460149	452344	30.2	0	83%
City Centre	460427	451769	32.1	0	79%
Fishergate	460746	451039	33.4	0	89%
Lawrence Street	461257	451341	39.4	0	87%
Dunnington	467276	452355	16.0	0	65%

The annual mean measured concentrations at the monitoring stations were below the 2005 annual mean objective level of 40 µg/m3, except at Holgate (42.0 µg/m3). There were seven exceedences of the 200 µg/m3 hourly mean standard at Holgate (eighteen are permitted in any one year).

8.5.2 NO2 Diffusion Tube Monitoring

CoYC maintains a comprehensive network of NO2 diffusion tubes throughout the city. Diffusion tube results within the Air Quality Management Area (AQMA), and near to the York Central Development, are shown in **Table 22** overleaf. The 12-month averaging period used by CoYC is from April-March. The data have been ratified and corrected for bias, according to the procedure detailed in 'Technical Guidance' (LAQM.TG(03)) [Ref 1].

Table 22 - CoYC NO_2 Diffusion Tube Results Summary (µg/m³)

Receptor	X	Y	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004
A1	460088	452263	-	-	43	47	45
A64	460029	452327	-	-	36	63	45
A2	459917	452405	-	-	41	48	42
A3	459822	452492	-	-	32	47	30
A4	459699	452638	-	32	23	27	25
A5	459594	452708	44	48	52	65	52
A6	459536	452811	35	41	33	41	33
A7	459441	452892	-	34	30	45	34
A13	459335	452931	19	28	28	32	24
A14	459335	452931	-	30	27	30	25
A14a	459335	452931	-	-	-	-	28
A15	459309	452962	28	33	30	33	30
A16	459060	452857	-	31	33	34	26
A12	459251	453008	27	34	31	37	29
A9	459295	453067	30	40	38	41	41
A87	459324	453048	27	29	30	40	29
A11	459341	453043	23	30	23	21	24
A85	459363	453010	24	29	28	34	24
A58	459258	453135	20	27	24	28	24
A59	459160	453165	27	34	36	43	35
A60	458907	453276	28	31	25	29	28
A61	458917	453295	23	27	19	24	19
40	459054	452106	21	24	26	25	26
D43	459919	451836	23	27	30	33	25
17	459646	451500	20	25	23	30	26
6	459777	451406	29	33	32	34	32
D40	460069	451196	30	40	35	45	31
D33	460075	451174	32	29	23	28	25
D34	460139	451105	38	39	32	35	28
D35	460134	451169	30	35	26	42	37
16	460160	451152	-	36	32	35	22
15	461105	451458	25	29	30	27	24
D9	460483	452357	25	34	29	37	27
D41	460286	452487	25	27	20	27	21
A30	457060	452888	19	31	26	34	29
A31	457137	452862	19	35	27	44	28
A36	457625	452446	32	38	36	33	30
A17	458578	452472	-	-	21	36	24
A20	458760	452404	-	-	-	30	30
A23	458835	452301	-	29	33	41	32
A25	458706	452225	-	39	40	45	36
A27	458675	452363	-	38	36	33	27
A41	458172	452109	-	38	30	35	27
A49	458634	451510	-	31	31	36	27
A51	458827	451348	-	54	30	48	26
A52	458945	451254	-	51	40	57	38
A54	459255	451223	-	38	31	41	27
D1	460088	452183	-	63	52	71	55
D22	460028	452011	-	38	36	50	25

Receptor	X	Y	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004
D25	459690	451747	-	37	37	40	31
D13	460234	451422	-	40	34	37	28
D16	460708	451231	-	-	42	-	-
D11	460677	452204	-	-	29	42	28
D4	460556	452302	-	-	41	61	45
D3	460464	451782	-	-	43	43	37
D8	460575	451617	-	42	31	39	32
D12	460567	451740	-	-	24	39	30
D18	460395	451503	-	-	46	52	33
D19	460041	451626	-	-	-	-	40
D14	461076	451350	-	43	29	38	31
D26	460671	451385	-	39	31	51	40
D7	460725	451927	-	51	41	56	-

8.6 PM10 Monitoring

Measured PM10 concentrations, using TEOM instruments are shown in **Table 23**, for 2004. The data shown have been collected and ratified according to guidelines used in the UK Automatic Urban and Rural Network (AURN) and those outlined in Technical Guidance Note LAQM.TG(03).

Table 23 – Monitoring summary for PM_{10}, 2004

Site	Grid Reference		Mean / µg/m^3	No. of Exceedences of Daily Mean	Data Capture
	X	Y			
Rawcliffe	457701	454803	22.9	0	65%
Holgate	459513	451282	24.6	6	82%
Bootham Hospital	460023	452778	19.0	0	87%
Fishergate	460746	451039	24.1	7	89%

There have been no breaches of the 2004 annual mean objective at any of the monitoring sites. There were seven recorded exceedences of the 50 µg/m3 daily mean standard at Fishergate and six at Holgate (35 are permitted in a year).

8.7 Modelling Methodology

8.7.1 *Overview*

The AAQuIRE 6.1.1 regional air quality dispersion modelling software was used to predict concentrations of nitrogen dioxide and PM10 from road traffic and industrial sources. Concentrations were predicted for a base year (2004), and two future years (2011 and 2021). For the future years, concentrations were predicted for a do-minimum scenario, and a do-something scenario. The do-minimum scenario assumes that the York Central Development does not proceed, and the do-something scenario assumes that it does proceed. Therefore, the difference between the do-minimum and do-something scenarios can be considered to be the impact of the development.

The AAQuIRE regional dispersion model was developed by Faber Maunsell and has been used widely for the past 12 years. The model uses the dispersion algorithms CALINE4 (for line sources) and AERMOD (for point, area and volume sources), which have both been independently and extensively validated. A more detailed description of the AAQuIRE dispersion model is included in **Appendix G**.

There are 4 main categories of air pollutant sources: road traffic sources, industrial sources (Part A and B processes), diffuse sources (e.g. domestic heating), and mobile sources (e.g. airports, rail and shipping). For the purposes of this study, an assessment was performed on all major roads in York. The impact of emissions from industrial sources is also modelled.

Contributions from the remaining sources were amalgamated into the background concentration (see Section 4.4).

8.7.2 *Modelling Study Area*

For the purposes of this study, pollutant concentrations were predicted at a number of sensitive locations. These locations were chosen based on the positions of the existing continuous monitoring sites and nitrogen dioxide diffusion tube sites.

8.7.3 *Meteorological Data*

A meteorological dataset was compiled using data from Leeds weather centre, and Church Fenton. The data set from 2004 was of poor quality and could not be used, and therefore it was decided, in consultation with CoYC, to use data from 2002. Wind speed and direction data from Church Fenton were used, together with cloud cover and other required parameters from Leeds Weather Centre. This procedure retains consistency with previous modelling studies carried out by CoYC.

The windrose for this location for 2002 is shown in **Appendix H** along with further details about the methodology used to compile the meteorological data.

8.7.4 *Background Concentrations*

A large number of small sources of air pollutants exist which individually may not be significant, but collectively, over a large area, need to be considered. These sources are accounted for by including background concentrations, which are given in **Table 24**. These concentrations were based on 2004 annual mean data from the background monitoring site, at Dunnington. It is important to note that these background concentrations, as they are based on actual monitoring data, will potentially include contributions from the emissions sources being modelled. The background concentrations for 2011 and 2021 were determined from the 2004 monitoring data by applying a scaling factor as outlined in 'Technical Guidance' (LAQM.TG4(03)) [Ref 1].

Table 24 – Background Concentrations for Study Area (μg/m^3)

Pollutant	Base Year 2004	Future Year 2011	Future Year 2021
NO_x	23.6	17.7	15.7
PM_{10}	19.0	17.2	17.2

As the local authority has some control over emissions of NOX but little or no control over the atmospheric oxidants that oxidise NO to NO2, it is more appropriate to review NO2 by first modelling NOX. It is for this reason that a NOX background is applied to the modelled NOX concentration before being converted to NO2 (see Section 4.6).

8.7.5 *Traffic Data*

The traffic data required for the modelling were provided by Faber Maunsell Transportation. AM peak flows, average speeds and HGV proportions were provided for the three years and the scenarios. Average speeds were adjusted to 15 km/hr near to junctions.

Road transport represents the major source of pollution in the study area and it was therefore imperative that the emission data were as accurate as possible. Speed related emission factors for the two pollutants were derived from the latest factors supplied on the National Atmospheric Emissions Inventory website [Ref 3].

Emissions of some pollutants are higher when the engine is cold. Cars take about 3 minutes or 1.6 km before the engine 'is hot'. The engine warming was accounted for by using a variable vehicle composition profile for each road, and for each year. This information was taken from the QUARG Report [Ref 10]. Enhancement of pollutant emissions due to cold starts is given in **Table 25** overleaf. This table summarises vehicle emissions testing, which has demonstrated, for example, that a Light Duty Vehicle (LDV) with a cold catalyst will emit 1.3 times the quantity of NOX as the same LDV once the catalyst has warmed up.

Table 25 – Ratio of Emissions of Cold Engines Relative to Hot Engines

LDV Category	NO_x	PM_{10}
Non catalyst petrol	1.0	1.0
Catalyst petrol	1.3	2.0
Diesel	1.2	1.0

8.7.6 *Diurnal Traffic Profiles*

The AAQuIRE model requires peak hour flows; a diurnal traffic flow variation is then used to factor the concentrations for the other hours of the day. One diurnal profile was used for all road links, provided by CoYC, and shown in **Figure 32** (on page 65).

8.8 Conversion of NOX to NO2

As explained in Section 8.7.4, the proportion of NO2 in NOX varies greatly with location and time according to a number of factors including the amount of ozone available and the distance from the emission source.

The variable NO2/NOX relationship that has been used to convert annual average NOX to annual average NO2 is given in **Table 26**. It is based on all of the hourly data collected at the roadside continuous monitoring sites in York, during 2004. This relationship was used for both the existing and objective case years as the best representation of the NO2/ NOX relationship in York.

Table 26 – NO_2/NO_x Relationship

NO_x (µg/m³)	NO_2 (µg/m³)	NO_x (µg/m³)	NO_2 (µg/m³)
0	0	260	75.0
10	7.4	270	76.2
20	14.1	280	77.4
30	19.9	290	78.6
40	24.9	300	79.7
50	29.4	310	80.9
60	33.5	320	82.0
70	37.2	330	83.1
80	40.5	340	84.2
90	43.6	350	85.3
100	46.5	360	86.4
110	49.1	370	87.5
120	51.6	380	88.5
130	53.9	390	89.6
140	56.0	400	90.7
150	58.1	410	91.8
160	60.0	420	92.9
170	61.8	430	94.0
180	63.5	440	95.1
190	65.2	450	96.2
200	66.7	460	97.3
210	68.2	470	98.5
220	69.7	480	99.6
230	71.1	490	100.8
240	72.4	500	102.0
250	73.7		

It should also be noted that as NOX concentrations are expected to decline in future years, NO2 concentrations will not be limited as much by ozone. This means it is possible that the future year NO2/ NOX ratio may increase.

8.8.1 *Industrial Emissions Data*

Details required by AAQuIRE regarding industrial pollutant emissions were provided by CoYC, and are presented in **Table 27**.

Table 27 – Industrial Emissions Data

Source	X	Y	Emissions rates g/s		Stack Height / m	Exit Temp / k	Exit Velocity m/s	Stack Diameter /m
			NO_x	PM_{10}				
Barbican Pool	460935	451233	0.01219	0	13.1	473	15	0.45
British Sugar York	457600	452900	5.06	0.02	52	375	10.6	1.98
Drax	466400	426400	1870.88	38.0518	259	364	23	19
Eggborough	457500	424500	541.128	72.2983	199	403	28	13
Ferrybridge	446700	424800	546.296	99.0614	198	403	23	13
Monkhill Confect	457052	453163	0.18035	0	15	493	25.46	0.5
Nestle Rowntree	460900	453600	1.331	0	40	473	20	3.12
Terrys Suchard	459800	449800	0.12936	0	41	473	15	1.52
York Crematorium	459632	448172	0.01017	0	12.19	473	20	2.11
York Hospital	460199	453250	0.153	0	16	473	20	0.6
York University	462700	450700	0.237	0	58.4	473	20	0.55

8.8.2 *Model Error and Verification*

The results from the modelling study will be subject to error due to uncertainties in modelling dispersion algorithms and the input data. Therefore, it is imperative that the performance of any modelling study is verified by comparison with local monitoring data. The modelling results for NO2 and PM10 have been verified against the roadside continuous monitoring data within the study area.

8.9 Results

8.9.1 *Modelling Verification*

As discussed in Section 8.8.2, when undertaking a dispersion modelling study, it is standard practice to make a comparison between the modelling results and the monitoring data, to ensure that the model is reproducing actual observations. The accuracy of the future year modelling results are related to the accuracy of the base year results, therefore greater confidence can be placed in the future year concentrations, if good agreement is found for the base year.

Modelling results are subject to systematic and random error; systematic error arises due to many factors, such as uncertainty in the traffic data and the composition of the vehicle fleet, and uncertainty in the meteorological dataset. This can be addressed and, if necessary, adjusted for by comparison with monitoring data. **Table 28** compares the modelling and continuous monitoring results for NO2 and PM10 for 2004. The background monitoring sites have been excluded from the verification. The adjusted modelled concentrations are also shown; the method to calculate these is explained below.

Table 28 – Monitored and Modelled Results used for Model Verification ($\mu g/m^3$)

Site	Grid Reference		Pollutant	Monitored mean *	Modelled Mean	
	X	Y			Unadjusted	Adjusted
Rawcliffe	457701	454803	NO_2	27.4	23.6	28.8
			PM_{10}	22.9	20.4	22.7
Holgate	459513	451282	NO_2	42.0	26.9	33.9
			PM_{10}	24.6	20.9	24.0
Nunnery Lane	460069	451199	NO_2	32.6	28.3	36.0
Gillygate	460149	452344	NO_2	30.2	27.3	34.6
City Centre	460427	451769	NO_2	32.1	23.8	29.1
Fishergate	460746	451039	NO_2	33.4	28.7	26.6

Site	Grid Reference		Pollutant	Monitored mean *	Modelled Mean	
	X	Y			Unadjusted	Adjusted
			PM_{10}	24.1	21.4	25.3
Lawrence Street	461257	451341	NO_2	39.4	32.2	41.8

The model shows fairly good agreement with the monitoring results. However, for both NO2 and PM10 the model did under-predict concentrations, and it was therefore necessary to calculate and apply an adjustment factor to the modelled results. The final column of the table shows the adjusted modelled results.

The steps in the adjustment procedure for NO2 are described below. Firstly the monitored and modelled NOX contributions from traffic emissions were calculated for each site:

NOX [monitored, traffic contribution] = NOX [monitored] – NOX [background]

NOX [modelled, traffic contribution] = NOX [modelled] – NOX [background]

These two parameters were averaged over all the sites, and the adjustment factor calculated:

Adjustment Factor = NOX [monitored, traffic contribution] / NOX [modelled, traffic contribution]

The adjusted modelled NOX was then calculated by multiplication of the modelled NOX traffic contribution, by the adjustment factor, and addition of the background:

NOX [model adjusted, traffic contribution] = NOX [modelled, traffic contribution] x Adjustment Factor

NOX [model adjusted] = NOX [model adjusted, traffic contribution] + NOX [background]

The adjusted NO2 concentrations were calculated using the NOX/NO2 ratio as detailed previously.

The adjustment procedure for PM10 was identical in principle.

This procedure is in accordance with that detailed in technical guidance note LAQM.TG(03)[Ref 1].

8.9.2 *Random Error of the Model*

In addition to the systematic errors, as described above, the model is still likely to predict concentrations slightly different to actual ambient values. This is termed random error, and must be considered. It is possible to account for the degree of random error, according to guidance provided by the NSCA.

By comparison of the modelled and monitored results at the continuous monitoring locations, a 'U value' can be determined for the data set. This then allows the standard deviation of the model (SDM) to be calculated:

SDM = U x Co

where Co is the air quality objective (40 µg/m3 for the NO2 annual mean objective). The U value was calculated to be 0.07. Therefore:

SDM = 0.07 x 40 = 2.8 µg/m3

This introduces an uncertainty of ±2.8 µg/m3, which should be considered when analysing the modelled results.

8.9.3 *Nitrogen Dioxide Modelled Results*

Modelled results are presented in Table 28 for 2004, 2011 and 2021, for both the do-minimum (DM) and do-something (DS) scenarios. The impact of the development is shown for the years 2011 and 2021, and is equal to the difference between the do-something and do-minimum concentrations. A positive impact denotes an increase in NO2 as a result of the development. An impact of greater then ± 0.5 µg/m3 is shown in bold in **Table 29** overleaf. More detail is provided on the contour plots in **Appendix I**.

Table 29 - Nitrogen Dioxide Modelled Results (µg/m³)

Receptor	Base 2004	DM 2011	DS 2011	2011 impact	DM 2021	DS 2021	2021 impact
Rawcliffe	28.8	21.2	21.3	0.0	18.6	18.7	0.1
Holgate	33.9	26.0	26.2	0.1	21.5	22.4	0.9
Bootham Hospital	22.8	17.4	17.4	0.0	15.0	15.0	0.0
Nunnery Lane	36.0	26.3	26.5	0.2	21.9	23.0	1.1
Gillygate	34.6	25.3	25.2	0.0	21.0	20.9	-0.1
City Centre	29.1	22.0	21.9	0.0	18.3	18.3	0.1
Fishergate	36.6	28.4	28.5	0.1	23.3	22.7	-0.7
Lawrence Street	41.8	31.2	31.1	-0.1	25.7	25.5	-0.2
A1	37.0	27.2	27.2	0.0	22.6	22.5	-0.1
A64	34.8	25.5	25.5	0.0	21.3	21.0	-0.3
A2	29.7	21.8	21.8	0.0	18.7	18.7	0.0
A3	28.6	21.1	21.2	0.0	18.2	18.3	0.0
A4	27.3	20.3	20.3	0.0	17.4	17.4	0.0
A5	34.7	25.3	25.4	0.1	21.3	21.5	0.1
A6	28.5	21.0	21.0	0.0	18.2	18.3	0.1
A7	32.3	23.7	23.8	0.0	20.0	20.1	0.1
A13	26.2	19.6	19.8	0.2	16.9	16.9	0.1
A14	26.2	19.6	19.8	0.2	16.9	16.9	0.1
A14a	26.2	19.6	19.8	0.2	16.9	16.9	0.1
A15	28.5	21.4	21.4	0.0	18.2	18.4	0.2
A16	28.0	21.2	21.1	-0.1	18.2	18.3	0.1
A12	35.7	26.7	26.9	0.2	22.6	22.8	0.2
A9	42.1	31.1	31.3	0.1	26.0	26.6	0.6
A87	38.6	28.4	28.6	0.2	23.6	23.9	0.3
A11	34.9	25.6	25.6	0.0	21.3	21.6	0.3
A85	30.4	22.6	22.6	0.0	19.2	19.3	0.1
A58	40.7	30.0	30.1	0.2	25.0	25.6	0.6
A59	29.2	21.6	21.6	0.0	18.4	18.6	0.2
A60	25.3	19.1	19.1	0.0	16.5	16.6	0.1
A61	29.0	21.4	21.4	0.0	18.4	18.5	0.1
40	32.2	24.4	24.4	0.0	20.4	20.5	0.1
D43	48.4	36.8	37.0	0.2	29.0	30.1	1.1
17	34.6	25.8	25.9	0.1	21.0	21.3	0.3
6	35.3	26.2	26.5	0.2	21.8	22.2	0.4
D40	36.2	26.4	26.7	0.2	22.0	23.0	1.0
D33	34.9	25.5	25.7	0.2	21.4	22.1	0.6
D34	35.3	26.0	26.1	0.1	21.6	22.1	0.5
D35	33.9	25.4	25.7	0.2	21.3	23.5	2.2
16	34.9	26.2	26.4	0.2	22.0	24.4	2.3
15	39.1	29.0	29.0	0.0	24.4	24.5	0.1
D9	34.4	26.2	26.4	0.1	22.8	23.0	0.2
D41	33.7	25.7	25.8	0.1	21.9	22.1	0.2
A30	25.9	20.5	20.4	-0.1	17.6	17.7	0.1
A31	25.5	20.2	20.1	-0.1	17.6	17.6	0.1
A36	28.0	22.2	22.1	-0.1	18.9	19.2	0.2
A17	36.5	27.7	27.7	0.0	22.9	23.2	0.3

Receptor	Base 2004	DM 2011	DS 2011	2011 impact	DM 2021	DS 2021	2021 impact
A20	33.7	24.9	24.8	-0.1	21.2	20.8	-0.4
A23	27.3	20.6	20.6	0.0	17.6	17.5	-0.1
A25	28.9	22.1	22.2	0.0	18.8	19.3	0.5
A27	30.2	22.9	22.9	0.1	19.3	19.9	0.6
A41	31.4	24.4	24.3	-0.1	20.8	20.8	0.0
A49	29.9	23.3	23.3	0.0	19.6	20.4	0.8
A51	30.6	23.5	23.5	0.0	19.6	19.7	0.1
A52	38.3	29.2	29.1	-0.1	24.1	24.1	0.0
A54	37.4	28.9	28.8	-0.1	23.6	23.5	0.0
D1	39.3	28.9	28.8	-0.1	23.6	23.8	0.2
D22	36.0	26.3	26.3	0.0	21.3	21.6	0.2
D25	36.4	27.0	27.0	0.0	21.8	22.2	0.4
D13	29.3	22.0	22.1	0.0	18.3	18.7	0.4
D16	42.9	32.2	32.3	0.0	26.5	26.5	0.0
D11	32.2	24.9	24.9	0.0	20.7	21.0	0.4
D4	34.7	26.3	26.5	0.1	22.6	22.9	0.3
D3	32.5	24.9	24.9	0.0	20.2	20.2	0.0
D8	33.7	24.9	24.8	-0.1	20.4	20.4	0.0
D12	26.3	20.0	20.0	0.0	16.7	16.7	0.0
D18	38.7	28.7	28.8	0.1	23.7	24.1	0.4
D19	43.8	33.4	33.8	0.5	26.4	27.3	1.0
D14	45.3	34.3	34.4	0.1	28.8	29.1	0.3
D26	31.9	23.7	23.7	0.0	20.1	20.1	0.0
D7	33.0	25.2	25.2	0.0	20.6	20.6	0.0

For all receptors the concentrations decreased significantly between 2004 and future years, irrespective of whether the development were to proceed or not.

At one receptor (D19) in 2011, an impact of greater then ± 0.5 μg/m3 was predicted as a result of the development (+0.5 μg/m3). This is most likely to be due to an increase in the traffic flow on the road adjacent to the receptor. For all other receptors, the impact of the development ranged from –0.1 to +0.3 μg/m3.

Greater impacts were observed in 2021. Impacts of greater then ± 0.5 μg/m3 were predicted at 13 of the receptors. At one of these a reduction in NO2 was predicted (Fishergate, -0.7 μg/m3), but at the remaining twelve receptors increases in NO2 were predicted. At six of the receptors (D40, D33, D34, D35, 16 & Nunnery Lane) the most probable reason for the increased concentrations are reductions in speed on adjacent roads. At the remaining six, the most probable reason for the increased concentrations are increases in traffic flow on adjacent roads. The greatest increases in concentration were observed in the Nunnery Lane / Price's Lane area (receptor 16, +2.3 μg/m3), due to reduced speeds.

The increases predicted at Holgate (+0.8 μg/m3) are as a result of the proposed site access road.

8.9.4 *PM10 Modelled Results*

Modelled results are presented in **Table 30** for 2004, 2011 and 2021, for both the do-minimum (DM) and do-something (DS) scenarios. The impact of the development is shown for the years 2011 and 2021, and is equal to the difference between the DS and DM concentrations. A positive impact denotes an increase in PM10 as a result of the development. An impact of greater then ± 0.5 μg/m3 is shown in bold. More detail is provided on the contour plots in **Appendix I**.

Table 30 – PM_{10} Modelled Results (µg/m³)

Receptor	Base 2004	DM 2011	DS 2011	2011 impact	DM 2021	DS 2021	2021 impact
Rawcliffe	28.8	20.4	20.4	0.0	20.2	20.3	0.1
Holgate	33.9	21.6	21.7	0.1	21.2	21.9	**0.7**
Bootham Hospital	22.8	18.8	18.8	0.0	18.7	18.7	0.0
Nunnery Lane	36.0	22.8	22.8	0.0	22.3	22.6	0.3
Gillygate	34.6	21.6	21.7	0.0	21.3	21.3	0.0
City Centre	29.1	19.5	19.5	0.0	19.2	19.3	0.0
Fishergate	36.6	22.6	22.6	0.0	22.0	21.7	-0.4
Lawrence Street	41.8	23.3	23.3	0.0	22.8	22.9	0.1
A1	37.0	21.9	21.9	0.0	21.5	21.5	0.0
A64	34.8	21.5	21.5	0.0	21.1	21.1	-0.1
A2	29.7	20.4	20.4	0.0	20.2	20.3	0.0
A3	28.6	20.1	20.2	0.0	20.0	20.0	0.0
A4	27.3	19.8	19.8	0.0	19.7	19.7	0.0
A5	34.7	21.7	21.8	0.0	21.4	21.5	0.1
A6	28.5	20.3	20.3	0.0	20.1	20.1	0.0
A7	32.3	21.4	21.4	0.0	21.1	21.2	0.0
A13	26.2	19.6	19.7	0.0	19.5	19.5	0.1
A14	26.2	19.6	19.7	0.0	19.5	19.5	0.1
A14a	26.2	19.6	19.7	0.0	19.5	19.5	0.1
A15	28.5	20.4	20.4	0.0	20.2	20.2	0.0
A16	28.0	20.3	20.4	0.0	20.2	20.2	0.1
A12	35.7	22.6	22.7	0.0	22.3	22.5	0.2
A9	42.1	23.9	24.0	0.1	23.5	23.8	0.2
A87	38.6	22.8	22.9	0.1	22.5	22.7	0.1
A11	34.9	21.8	21.9	0.0	21.6	21.7	0.1
A85	30.4	20.6	20.6	0.0	20.4	20.5	0.1
A58	40.7	23.3	23.4	0.1	22.9	23.2	0.3
A59	29.2	20.2	20.2	0.0	20.0	20.1	0.1
A60	25.3	19.3	19.3	0.0	19.2	19.3	0.0
A61	29.0	20.3	20.3	0.0	20.2	20.3	0.1
40	32.2	21.5	21.5	0.0	21.2	21.2	0.1
D43	48.4	23.7	23.8	0.1	22.7	23.1	0.4
17	34.6	20.9	21.0	0.1	20.5	20.8	0.3
6	35.3	21.9	22.0	0.1	21.6	21.9	0.3
D40	36.2	22.8	22.9	0.0	22.4	22.6	0.2
D33	34.9	22.4	22.5	0.1	22.0	22.2	0.2
D34	35.3	22.6	22.6	0.0	22.2	22.3	0.1
D35	33.9	22.3	22.4	0.1	22.0	22.5	**0.5**
16	34.9	22.7	22.8	0.1	22.3	22.9	**0.6**
15	39.1	23.8	23.8	0.0	23.4	23.5	0.1
D9	34.4	22.7	22.8	0.1	22.5	22.8	0.2
D41	33.7	22.1	22.1	0.0	21.9	22.0	0.2
A30	25.9	19.8	19.7	0.0	19.6	19.7	0.1
A31	25.5	19.6	19.6	0.0	19.4	19.5	0.0
A36	28.0	20.3	20.3	0.0	20.1	20.2	0.1
A17	36.5	22.2	22.3	0.0	21.8	21.9	0.1

Receptor	Base 2004	DM 2011	DS 2011	2011 impact	DM 2021	DS 2021	2021 impact
A20	33.7	21.4	21.4	0.0	21.1	21.0	-0.1
A23	27.3	19.8	19.8	0.0	19.6	19.6	0.0
A25	28.9	20.3	20.3	0.0	20.0	20.3	0.3
A27	30.2	20.6	20.7	0.1	20.4	20.6	0.2
A41	31.4	21.6	21.5	0.0	21.4	21.4	-0.1
A49	29.9	20.9	21.0	0.1	20.7	21.1	0.4
A51	30.6	20.8	20.8	0.0	20.5	20.6	0.0
A52	38.3	23.0	23.0	0.0	22.5	22.5	0.0
A54	37.4	23.0	23.0	0.0	22.5	22.4	0.0
D1	39.3	21.8	21.9	0.0	21.2	21.4	0.1
D22	36.0	20.9	21.0	0.0	20.4	20.5	0.1
D25	36.4	21.2	21.2	0.0	20.7	20.9	0.2
D13	29.3	20.3	20.3	0.0	20.0	20.1	0.2
D16	42.9	24.9	25.0	0.1	24.3	24.4	0.1
D11	32.2	21.3	21.3	0.0	21.0	21.1	0.1
D4	34.7	22.5	22.6	0.1	22.3	22.5	0.2
D3	32.5	19.8	19.8	0.0	19.4	19.5	0.0
D8	33.7	20.7	20.7	0.0	20.2	20.3	0.0
D12	26.3	19.2	19.2	0.0	19.0	19.1	0.0
D18	38.7	22.5	22.6	0.0	22.1	22.3	0.2
D19	43.8	22.8	23.0	0.1	22.0	22.4	0.4
D14	45.3	25.7	25.7	0.1	25.0	25.3	0.2
D26	31.9	21.0	21.0	0.0	20.8	20.8	0.0
D7	33.0	20.7	20.7	0.0	20.3	20.3	0.0

As was the case for NO2, for all receptors PM10 concentrations decreased significantly between 2004 and the future years, irrespective of whether the development were to proceed or not.

For all receptors, the impact of the development in 2011 ranged from 0.0 to +0.1 µg/m3.

Greater impacts were observed in 2021, but the impacts were not so great as those predicted for NO2. Impacts of greater then ± 0.5 µg/m3 were predicted at two receptors in the Nunnery Lane area, D35 (+0.5 µg/m3), and receptor 16 (+0.5 µg/m3), most likely as a result of reduced speeds predicted on Price's Lane.

8.10 Conclusions

8.10.1 Nitrogen Dioxide

It is predicted that at the receptors modelled, the impacts of the development in 2011 will range from -0.1 to +0.5 µg/m3. A negative concentration indicates an improvement in air quality as a result of the development. However, the impacts are predicted to be greater in 2021. For 12 of the 70 receptors modelled NO2 concentrations were predicted to increase by more than 0.5 µg/m3. In the Nunnery Lane area (within the AQMA) increases of up to 2.3 µg/m3 were predicted. It should however be noted that between 2004 and 2021, NO2 concentrations at roadside locations in the same area are predicted to fall by approximately 10-13 µg/m3 (well below the EU limit value for the 2010 annual mean). These reductions are due primarily to decreasing background pollutant levels and improvements in vehicle emissions.

The impacts at the receptors studied are deemed to be of medium priority for the year 2011. This conclusion is based upon guidance issued by the National Society for Clean Air and Environmental Protection (NSCA)[Ref 11], (regarding developments and planning for air quality), and also upon transport and environment guidance issued by the Association of London Government[Ref 12] (on assessing the significance of air quality impacts). However for the year 2021, the impacts are deemed to be of greater significance, especially as the greatest impact is within the present AQMA. However, it should be noted that it is predicted that by

2021, NO_2 concentrations will be below the EU limit value for the 2010 annual mean. On this basis, with regard to NO_2, air quality is of medium priority with regard to the development.

8.10.2 *PM10*

It is predicted that at the receptors modelled, the impacts of the development in 2011 will range from 0 to +0.1 µg/m3. As is the case for NO_2 however, the impacts are predicted to be greater in 2021. For two of the receptors modelled PM10 concentrations were predicted to increase by more than 0.5 µg/m3. The maximum increases (0.5 to 0.6 µg/m3) were again predicted in the Nunnery Lane area. As is discussed above, it should be noted that between 2004 and 2021, PM10 concentrations at roadside locations in the same area are predicted to fall by approximately 3 µg/m3.

The impacts at the receptors studied are deemed to be of low priority for the year 2011. The impacts are greater in 2021, and are deemed to be of medium priority. This conclusion is based upon guidance issued by the NSCA [Ref 11], and the ALG [Ref 12]. On this basis, with regard to PM10, air quality is of medium priority with regard to the development.

8.11 References

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(10)Department of the Environment, Quality of Urban Air Research Group (QUARG), Urban Air Quality in the UK, 1993).
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(12)Association of London Government, Transport and Environment Committee, Air Quality Assessments for Planning applications - Technical Guidance Note, 2001.

Figure 30 : National Trend of Oxides of Nitrogen Emissions (MT/yr) (1970 – 2002)

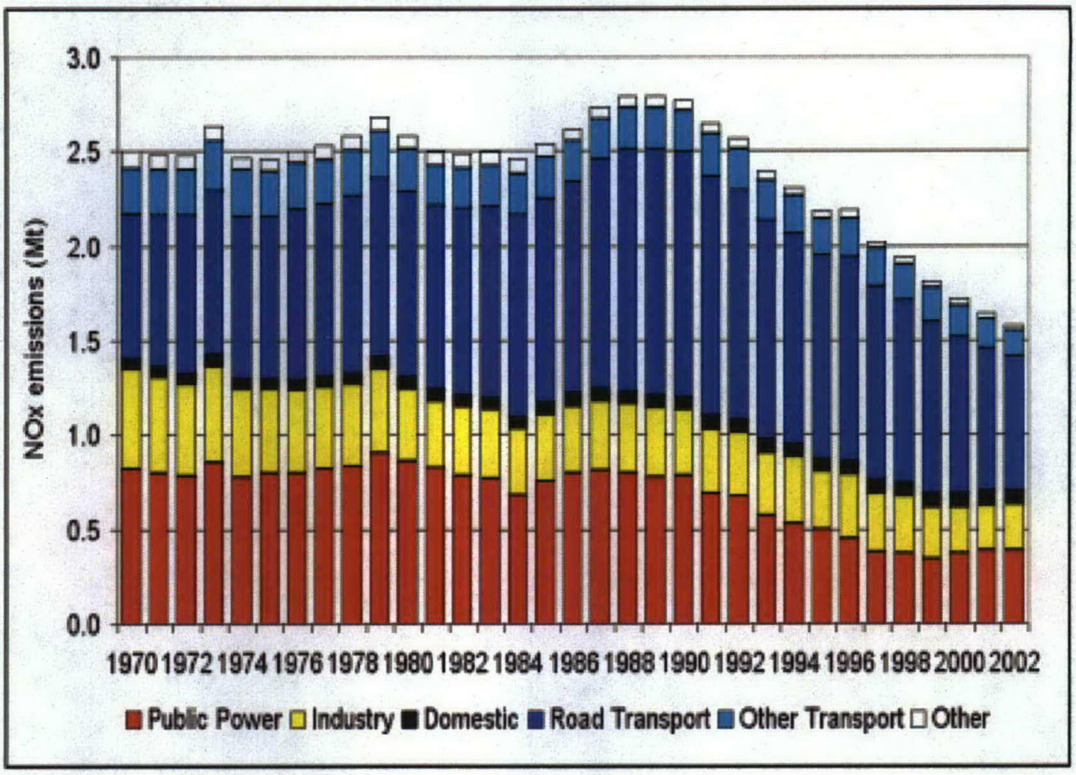


Figure 31 – National Trend of PM_{10} Emissions (kT/yr) (1970 – 2002)

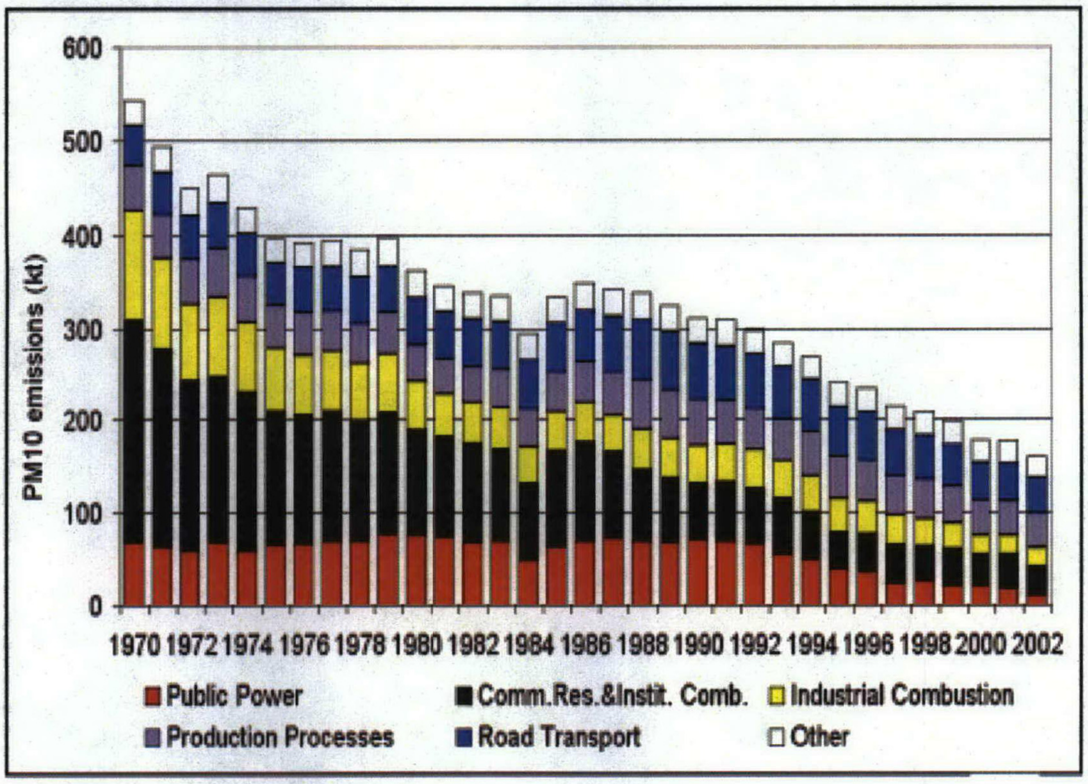
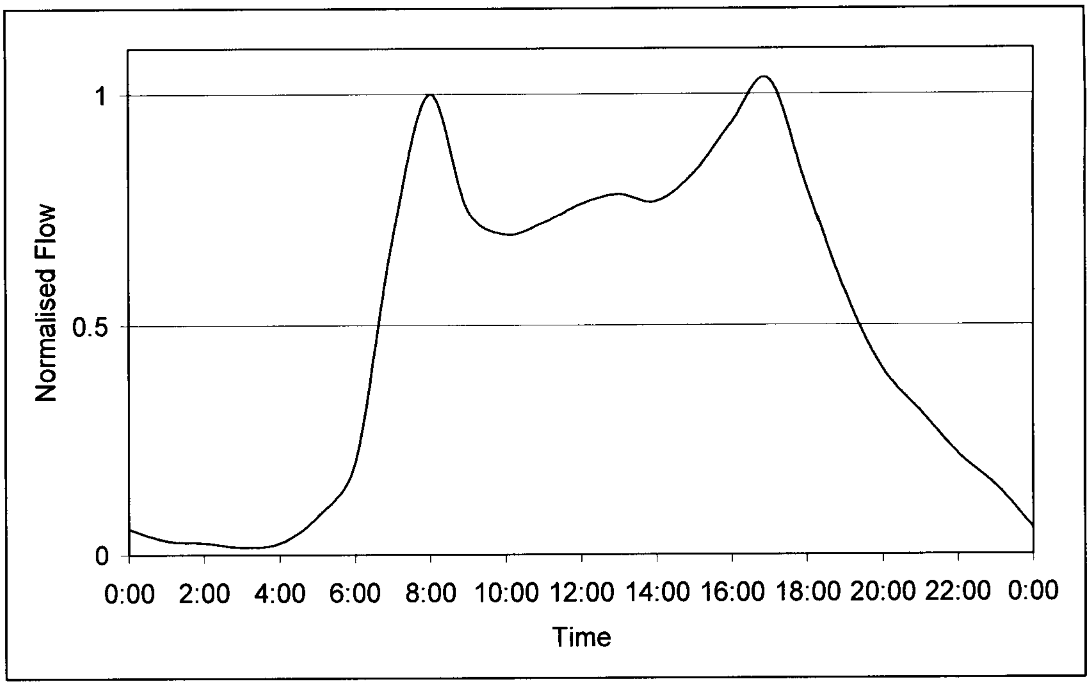


Figure 32 : Diurnal Traffic Profile



9 Option Appraisal

9.1 Introduction

Appraisal and funding bids for major public transport and highway schemes ('major schemes') as part of the Local Transport Plan (LTP) process should follow the guidance set out in GOMMMS and provide Appraisal Summary Tables (ASTs) for the preferred option and alternatives.

Major schemes are currently defined as those whose gross capital cost are greater than £5m and where clear additional benefits accrue from the proposal being treated as a single scheme and implemented as such.

In this section we present a high level, largely qualitative appraisal of the main York Central public transport and highway options considered in the study, based on the Appraisal Summary Table process. It should be noted that the level of analysis in this chapter, and indeed the level of analysis in this entire masterplan report, is not compliant with the full Government requirements for a Major Scheme Appraisal.

The appraisal sets out:

- The components of each options;
- A first order estimate of capital; and operating costs for these components; and
- The impact that each option will have on the objectives and sub-objectives set out in an appraisal summary table.

We will then suggest a recommended package of options to go forward for further consideration alongside the development master plan for York Central.

9.2 Options Considered

As explained in previous chapters, there is a wide range of highway and public transport access options that have been considered during the development of this master plan. In order to make the appraisal process manageable we have assumed that all options will adopt the preferred highway access strategy for York Central, namely the provision of two new accesses at Holgate Park and Queen Street, plus the removal of general traffic from Leeman Road west of the NRM and Queen Street at the station entrance. The differences between options in this appraisal are therefore the public transport components of each package.

The options considered in this chapter are therefore:

- Option A – preferred highway access strategy plus: an enhanced on-street bus-based public transport route between the A59 P&R site, York Central and the City Centre; and a new bus-rail interchange on Queen Street.
- Option B – preferred highway access strategy plus: an off-street segregated guided bus link between the A59 P&R site, York Central, the City Centre and the University; and a new bus-rail interchange on Queen Street.
- Option C – preferred highway access strategy plus: an off-street segregated tram link between the A59 P&R site and York Central, with service continuing on-street to the City Centre; and a new bus-rail interchange at Marble Arch.

9.3 Treatment of AST Objectives

The appraisal that we have performed is based on the objectives and sub-objectives set out in the Appraisal Summary Table. The way in which we have assessed options against these sub-objectives is set out below.

It is noted that the appraisal compares each option with the Do-Minimum, not the options with each other. This is an important consideration because the demand and supply assumptions for the Do-Minimum and the options are not the same, as the options include transport demands associated with the York Central development and the Do-Minimum does not.

9.3.1 *Environment*
The analysis undertaken has used air quality as the main analytical indication of environmental impacts that will arise as a result of development of York Central. This is the primary indicator that has been used to assess environmental impacts in the ASTs. We have also added a qualitative assessment of townscape as this is a potentially important issue in the central area of the city and the vicinity of the railway station.

9.3.2 *Safety*
The main safety issue related to this appraisal is the potential exposure to road traffic accidents. This is related at the highest level to the amount of vehicle kilometres in the network with each option. We have therefore taken the total number of vehicle kilometres in the SATURN highway network for 2021 as an indication of exposure to road traffic accident risk.

9.3.3 *Economy*
The economy objective is typically assessed through a cost:benefit analysis of the options considered. However, for a cost:benefit analysis to accurately assess the impacts of options, a common set of demand assumptions between the Do-Minimum and the Do-Something scenarios is required. In this study the addition of development traffic to York Central is included in the Do-Something but excluded in the Do-Minimum – as a result a formal cost:benefit analysis is neither possible to perform nor appropriate to the level of assessment that has been conducted to date.

As a result we have sought to use simple indicators of costs and benefits of each option, namely:

- First order estimates of capital costs in 2004 prices – note that this is not based on any detailed engineering assessment, it is simply based on an estimate of the likely order of costs based on capital costs of similar schemes elsewhere in the UK;
- The likely additional operating costs in 2004 prices associated with the addition of the public transport interventions included in each option;
- The likely fare box revenue in 2004 prices associated with each public transport option; and
- The number of vehicle kilometres and passenger kilometres on the highway and public transport networks for each option.

9.3.4 *Accessibility*
The core purpose of the study is to provide a suitable level of accessibility to the York Central site, which currently suffers from poor accessibility due to the constraints that arise from the site being surrounded by live railway lines. In this respect the enhancement of accessibility in all options is significantly positive, and while each option provides subtly different benefits to the site the core purpose of achieving improved accessibility at York Central remains the same.

As a result we have not compared accessibility improvements directly in this analysis.

9.3.5 *Integration*
The way in which each option contributes to improving bus-rail and bus-bus integration is assessed qualitatively. The integration in transport terms of York Central to the rest of the transport network and York City Centre is also considered.

9.4 Capital and Operating Costs

During this master plan study we have not undertaken a detailed design exercise for the highway and public transport schemes, our analysis has been focussed on establishing the feasibility of options. As a consequence we have not produced detailed design costings for the various components of each option described above.

Consequently, for this analysis we have used existing operations across the UK to establish current capital and operating costs for new schemes associated with York Central.

9.4.1 *Capital Costs*
The capital cost for the provision of bus priority measures on the A59 corridor has been estimated by Atkins as part of their work on the park and ride case for the route, and amounts to around £500,000 in total.

For a guided bus system, recent detailed work on capital costs has been undertaken for the proposed busway between St Ives and Cambridge. This work is reported on the

Cambridgeshire County Council website and suggests a capital cost of £4 million per route kilometre for guided sections. The capital cost for the guided busway from the A59 to the city centre is therefore assumed to be £22.0m (assuming a 5.5km route length), with an extended route from the A59 to the University costing £34.0 million.

Recent tram systems been constructed in Nottingham, Croydon and the West Midlands. All have their own mix of on-street and segregated running, this mix can strongly influences overall costs. The approximate costs are £13m per kilometre for Nottingham and £7m per kilometre for both Croydon and West Midlands. For robustness we have adopted a tram system cost of £10m per route kilometre to allow for one-off exceptional items such as signalling centres and a vehicle depot. The overall cost of a tram route between the A59 and the city centre is therefore assumed to cost £55.0 million.

The costs of highway schemes have been estimated with reference to similar major bridge schemes elsewhere in the UK. The Holgate Park bridge is assumed to cost £10 million, the Queen Street bridge is assumed to cost £15 million.

The two interchange options are likely to attract greatly different capital costs. The Queen Street interchange is to be provided on established highway that already caters for intensive bus use. We therefore assume that this interchange would cost £5 million. This is based on a similar facility currently being constructed in Warrington.

The Marble Arch interchange would be far more costly in terms of construction requirements and disruption. We have not been able to identify a comparable interchange scheme that has the level of complexity associated with the Marble Arch option. We have assumed a capital cost of £30 million, but accept that this could be exceeded once detailed design is undertaken.

Finally, we have recommended a series of pedestrian and cycling improvements in the vicinity of York Central that will cost in the order of £500,000. This does not allow for any new bridges across the Ouse that have been suggested as being beneficial.

9.4.2 *Operating Costs*

A number of sources have been examined for vehicle operating costs including DfT statistics, the TAS Bus and Rail Industry Monitor and the Annex E major scheme submission for the Cambridgeshire Guided Busway. From this we have assumed that vehicle operating costs will be:

- On-street bus £1.25 per veh.km
- Guided bus £1.35 per veh.km
- Tram £4.00 per veh.km

Assuming an 18 hour operating day and a service frequency of six services per hour, this leads to the following annual vehicle operating cost estimates:

- On-street bus £0.5 million p.a.
- Guided bus £0.9 million p.a.
- Tram £1.7 million p.a.

We have also assumed additional operating costs associated with the segregated systems. Additional maintenance of the guided bus system is assumed to cost £0.3 million per annum. For the tram option similar additional track maintenance costs plus the extra cost of operating and depot have been included and amount to £0.5 million per annum.

Overall operating costs are therefore assumed to be:

- On-street bus £0.5 million p.a.
- Guided bus £1.2 million p.a.
- Tram £2.2 million p.a.

9.4.3 *Fare Revenues*

Outputs from the public transport model with respect to additional passenger kilometres and fare levels per kilometre have been used to develop forecasts of additional fare revenues for the three options. However this is additional fare revenue across the whole public transport network, not just the new transit service serving York Central. As a result only a proportion of the fare revenue estimated below is directly attributable to the new service.

The fare revenue estimates are provided below:

- On-street bus £1.3 million p.a.
- Guided bus £1.7 million p.a.
- Tram £2.2 million p.a.

For the on-street bus and guided bus options the estimates of additional fares exceed the operating costs. However, as previously noted not all of these revenues are directly attributable to the new service, other additional revenues will accrue to existing routes and operators as a result of the wider mode share changes that will benefit public transport across the City as a result of the highway strategy for York Central.

The estimated fare revenues for the tram option are similar to the operating costs. However the same consideration regarding the allocation of fare revenues to other services still applies, therefore we conclude that the tram system cannot generate sufficient revenue to cover its operational costs.

9.5 Appraisal Findings

The summary appraisal sheets are included in **Tables 31, 32 and 33** overleaf.

For Option A the impacts are generally positive with the exception of environmental indicators. Air quality is degraded in the Do-Something because there is more traffic demand in the network as a result of the introduction of York Central travel demand, this outweighs the impact of modal shift to public transport.

This option appears to be viable as a system to serve York Central and the city centre alone from the A59, subject to their being a sufficient cost:benefit case to justify the £31.0 million estimated capital expenditure.

For Option B the impacts are also generally positive with the exception of environmental indicators. Air quality is degraded in the Do-Something because there is more traffic demand in the network as a result of the introduction of York Central travel demand, this outweighs the impact of modal shift to public transport.

The benefits of this option are farther reaching and more significant against several indicators, and demonstrate the additional benefits that could accrue by incorporating a public transport system serving York Central with a wider system that serves other corridors in the City.

Finally for Option C the impacts are also generally positive with the exception of environmental indicators. Air quality is degraded in the Do-Something because there is more traffic demand in the network as a result of the introduction of York Central travel demand, this outweighs the impact of modal shift to public transport.

The benefits of this option are significant in some aspects but the consideration of operating costs and revenues shows a slight negative. It is questionable whether a sufficient cost:benefit case can be constructed to justify the substantial capital cost requirements associated with this option.

9.6 Conclusions

Overall we conclude that, subject to there being a suitable benefit to cost ratio, Options A and B are worthy of further consideration but that the tram element of Option C should be rejected due to its high capital cost. Option A is more likely to be fundable if a new system is put in place that serves the A59 P&R, York Central and the City Centre alone. Option B is favoured if the York Central proposals are combined with similar public transport enhancements in other busy transport corridors in the City.

Table 31 – Appraisal Summary Table – Option A

Description On-Street bus diverted through York Central Site, highway access via Holgate Park and Queen Street, bus-rail interchange at Queen Street			**Estimated Costs:** £31.0million
Objective	**Sub-Objective**	**Assessment**	**Impact**
Environment	Local Air Quality	Some minor increases in air quality indicators on certain streets.	Slight Negative
	Townscape Impacts	Impact on listed buildings in vicinity of Queen Street.	Slight Negative
Safety	Road Safety	Vehicle kilometres in the morning peak hour decreased from 295,350 in Do Minimum to 295,150 in Do Something	Neutral
Economy	Operating Costs and Operating Revenues	Costs £0.5 million per annum, revenues £1.3 million per annum	Slight Benefit
	Veh.km on highway	Vehicle kilometres in the morning peak hour decreased from 295,350 in Do Minimum to 295,150 in Do Something	Slight Benefit
	Pax.km on public transport	Passenger kilometres increased by 2.6 million per annum in Do Something	Moderate Benefit
Integration	Interchange Impacts	Enhanced interchange at Queen Street for bus and rail movements.	Moderate Benefit
	Network integration	Provides improvements to movement of pedestrians and cyclists along existing and future desire lines.	Moderate Benefit

Table 32 - Appraisal Summary Table, Option B

Description Off-Street guided bus provided between A59 P&R, York Central, City Centre and University, highway access via Holgate Park and Queen Street, bus-rail interchange at Queen Street			**Estimated Costs :** £64.5 million
Objective	**Sub-Objective**	**Assessment**	**Impact**
Environment	Local Air Quality	Some minor increases in air quality indicators on certain streets.	Slight Negative
	Townscape Impacts	Impact on listed buildings in vicinity of Queen Street.	Slight Negative
Safety	Road Safety	Vehicle kilometres in the morning peak hour decreased from 295,350 in Do Minimum to 294,000 in Do Something	Moderate Benefit
Economy	Operating Costs and Operating Revenues	Costs £1.2 million per annum, revenues £7.1 million per annum	Moderate Benefit
	Veh.km on highway	Vehicle kilometres in the morning peak hour decreased from 295,350 in Do Minimum to 294,000 in Do Something	Slight Benefit
	Pax.km on public transport	Passenger kilometres increased by 14.3 million per annum in Do Something	Moderate Benefit
Integration	Interchange Impacts	Enhanced interchange at Queen Street for bus and rail movements.	Moderate Benefit
	Network integration	Provides improvements to movement of pedestrians and cyclists along existing and future desire lines.	Moderate Benefit

Table 33 - Appraisal Summary Table, Option C

Description			
Off-Street tram provided between A59 P&R and York Central, on-street running from there to City Centre, highway access via Holgate Park and Queen Street, bus-rail interchange at Marble Arch			**Estimated Costs** : £110.5 million
Objective	**Sub-Objective**	**Assessment**	**Impact**
Environment	Local Air Quality	Some minor increases in air quality indicators on certain streets.	Slight Negative
	Townscape Impacts	Impact on listed buildings in vicinity of Queen Street.	Slight Negative
Safety	Road Safety	Vehicle kilometres in the morning peak hour decreased from 295,350 in Do Minimum to 294,450 in Do Something	Slight Benefit
Economy	Operating Costs and Operating Revenues	Costs £2.2 million per annum, revenues £2.2 million per annum	Slight Negative
	Veh.km on highway	Vehicle kilometres in the morning peak hour decreased from 295,350 in Do Minimum to 294,450 in Do Something	Slight Benefit
	Pax.km on public transport	Passenger kilometres increased by 4.3 million per annum in Do Something	Moderate Benefit
Integration	Interchange Impacts	Significantly enhanced interchange at Marble Arch for bus and rail movements.	Significant Benefit
	Network integration	Provides significant improvements to movement of pedestrians and cyclists along existing and future desire lines.	Moderate Benefit

10 Summary and Conclusions

10.1 Introduction

This report provides a comprehensive assessment of the transport implications of a major new edge-of-centre development at York Central. The development will offer residential, commercial, retail and leisure facilities as part of a mixed-use development pattern, and will be of regional and sub-regional significance.

A development of this scale will inevitably bring forward a range of transport challenges. While the site's proximity to the railway lines and railway station of York presents a significant public transport opportunity, the encircling of the site by operational railway infrastructure also presents particular problems of highway, bus, cycling and pedestrian access. The transport master plan that has been developed to tackle these challenges is set out graphically in **Figure 33**.

The Council has set out the objectives for York Central in the development-planning brief published in March 2004. These objectives, set out in Chapter 2, relate to the Council's vision for the site:

> "The Council's vision for the development of York Central is that it will provide high quality of life opportunities for future generations, through the creation of a modern, central business district, attractive, exciting, sustainable in its design, mix of activity and transport system, complementary to the city's Historic Core, expanding and diversifying the City's urban economy, housing choice and cultural life."

From this a series of transport related objectives have been developed alongside wider development and environmental objectives:

- Meet a 20% modal share limit for drivers arriving to work at the York Central site by car;
- Promote connectivity between York Central and the walled city, with particular emphasis on cycling and walking, to contain trip generation and traffic congestion;
- Promote connections between York Central, the Railway Station and the proposed transport interchange to take advantage of suitable public transport connections to the site;
- Protect the rail infrastructure for both present and future uses including station car parking, taxi facilities, drop-off points and short stay parking;
- Promote connectivity between York Central and the riverside area, with links to the riverside walk into the City Centre;
- Serve the site in ways that will minimise the impact on the highway network and air quality beyond the immediate vicinity of the development;
- Reduce reliance on the car;
- Provide opportunities for dedicated public transport corridors to serve the city centre and wider city; and
- Promote connectivity to the surrounding areas by foot and cycle.

The initial task was to understand the quantum of additional travel that will be generated by the development elements proposed for York Central. Traffic and public transport models were then used to develop future year scenarios for 2011 and 2021 with and without the York Central development in place. The role that various highway and public transport interventions could play in accommodating these extra travel demands – in the context of providing wider improvements to the transport system of the whole city – was then examined and a series of recommended transport schemes suggested.

10.2 Highway Access

In respect of highways, the York Central site presently has poor road access, which impacts upon cars, goods vehicles, buses, cycles and pedestrians alike. The site is surrounded by operational railways, the only significant current access points being the western and eastern ends of Leeman Road, which are both constrained by low and unattractive bridges beneath the railway.

A number of options have been considered to provide improved highway access to York Central. Three main options have been examined that will bridge between York Central and the surrounding highway network at Water End, Holgate Park and Queen Street/Holgate Road. The Council's traffic model, which has been upgraded as part of the work develop this master plan, has been used to assess the best combination of accesses that meets the highway needs of the site, while at the same time not encouraging excessive use of car as an access mode or drawing significant levels of through traffic to roads within the York Central site. Our conclusions are that the following package of highway measures will best meet the objectives for York Central:

- A new bridge access over the Freight Avoiding Line (FAL) at Holgate Park, feeding directly into the signalised junction (which may need to be revised) on A59 Poppleton Road;
- A new bridge access over the southern throat of the East Coast Main Line (ECML) at Queen Street, forming a new junction with the Inner Ring Road just south of the main station entrance;
- Restrictions on the Inner Ring Road immediately north of the Queen Street for general traffic, allowing improvements to the station entrance environment to be made, possibly in association with a new bus-rail interchange in that location; and
- Restrictions on Leeman Road for general traffic, and possibly the removal of the Marble Arch highway access for general traffic should the bus-rail interchange be provided at this location.

10.3 Cycling and Walking

Further improvements to the cycling and walking networks have been considered to ensure that these important transport modes are well catered for, to encourage their use for local journeys. In this regard, and in addition to the new highway accesses at Holgate Park and Queen Street described above, we recommend that significant access and environmental improvements to Marble Arch and links from the eastern extremity of Marble Arch to the Ouse River front are required. These improvements should proceed whether or not Marble Arch is the chosen site for the new bus-rail interchange (see below). We further recommend that improvements to cycling and walking links across the River Ouse, either at Scarborough Bridge or in that vicinity, be made to further improve slow mode connectivity to York Central.

10.4 Public Transport

In respect of public transport, we have considered the requirements of the York Central development itself and also the wider requirements of the City's transport network. There have been two key considerations: the provision of a new public transport route between the proposed A59 park & ride site at Boroughbridge Road, the York Central development, the railway station and the city centre; and the provision of a new bus-rail transport interchange that will be a new focus for public transport for both York Central and the City Centre.

The conclusions drawn from the detailed analysis of public transport are as follows:

- If a link between the A59 P&R, York Central and the city centre is considered alone then the most cost-effective means of providing public transport access is an on-street bus-based service that provides the maximum level of bus priority on the A59 route before entering the York Central at the Holgate Park access. Neither a segregated guided busway nor the tram services between A59 and the city centre alone attract enough patronage to justify the cost of construction and subsequent operation.
- The aspiration to achieve a 20% modal share for car drivers will only be met with the implementation of significant traffic restraint measures across the City. With an improved public transport link in place to directly serve York Central and the city centre, the car driver modal share is estimated to be around 45%. Even the provision of a tram system, or a guided bus system extended to the University area from the city centre, fails to significantly affect this mode share. Only a substantial imposition of car parking charges at York Central, or the introduction of a congestion charge across the City, would provide the transport conditions to achieve this mode share target. It is questionable whether the imposition of such car access charges could impact adversely on the marketability of the York Central proposals – and perhaps other retail, leisure and commercial facilities across the City Centre – in the future.

- The development of a public transport system for York Central must be seen in the context of wider network improvements in the city. Our preliminary work, which extended the segregated guided bus proposal across the City Centre to the University area of the city (please note that no specific guided bus corridor has been identified east of the City centre as part of this work), suggests that while non-car mode share to York Central is not affected significantly, total ridership on such a mass transit system is significantly enhanced. In the event that a network of guided bus corridors can be identified that serve most or all major transport corridors in the City, a level of ridership growth could be achieved that may start to match the capital and operational costs of installing such a system.
- Our work has highlighted that problems of congestion on the A1237 Outer Ring Road means that York Central trips originating on the A64 are choosing to use Askham Bar Park and Ride as opposed to the new A59 Park and Ride facility. If the Outer Ring Road were improved then this could increase usage of the A59 corridor
- Our work in relation to York Central suggests that the cost and disruption of a fixed wheel tram system could not be justified to serve the A59-York Central-City Centre corridor. It is suggested that the feasibility of providing a more comprehensive tram network in the City would need to be considered alongside an examination of the case for a guided bus network in York as described above.

In respect of bus-rail interchange, a number of locational choices have been examined in the vicinity of the railway station and two clearly favoured options have emerged. A new transport interchange east of the current station on the area currently occupied by Station Road would provide a facility that is well related to bus-rail interchange requirements and has the potential to serve as a fulcrum for city centre bus services. This site would however require improvements to pedestrian access through the station in order to best serve York Central. The new mass transit route could serve this new interchange by crossing from York Central to the interchange at the proposed Queen Street bridge over the ECML.

A further option would be comprehensively reconstruct the Marble Arch area beneath the northern throat of the railway station and provide an underground bus interchange with direct escalator links from the bus interchange to the station platforms above. This facility would provide the optimal balance between the access to the City Centre, the railway station and York Central. This option would however be significantly more expensive than the eastern interchange and would potentially disrupt railway operations through the station during the construction period.

It is recommended that the eastern interchange be adopted as the preferred option, but that further work is undertaken to establish the cost and feasibility of what would be an optimal solution in terms solely of transport access at Marble Arch.

10.5 Air Quality

This work concludes that the impact of development at York Central, which will inevitably bring new travel demands to the city by a range of modes, will have a small adverse impact on air quality in the immediate environs of the site. The level of this impact is not significantly influenced by the choice of public transport system selected for York Central. It is possible that a comprehensive transit system for the City may start to reverse these adverse impacts, although this possibility has not been analysed as part of this master plan work.

10.6 Conclusions

Overall, our conclusions are:

- Two new highway accesses into York Central at Holgate Park and Queen Street along with various improvements to Leeman Road and pedestrian links around Marble Arch should be provided to meet the highway, cycling and pedestrian needs of York Central;
- To provide a new public transport link that would only serve the A59 corridor between the Park & Ride site, York Central, the railway station and the city centre, a on-street bus-based system along Poppleton Road with significant bus priority measures in place is the most feasible solution;
- If a new public transport link in the A59 corridor is to be provided as part of a more comprehensive investment in guided bus corridors in other main transport corridors in the city, a business case for this investment may emerge. This possibility should be the subject of further analytical work.

- A mass transit system based on fixed wheel trams would be very costly and would not be feasible for the York Central corridor alone. The Council will need to establish whether there is a case for a comprehensive tram system in the City, alongside the suggested study of guided bus corridors.
- A new interchange at the railway station could be provided at the current station entrance or at Marble Arch. While the Marble Arch location would best meet the transport objectives of the city and York Central, it is a far more costly and disruptive option that the Eastern Interchange. On balance the eastern interchange is recommended as a preferred option, but further work to establish the feasibility of a Marble Arch interchange is recommended.

Appendix A - SATURN Model Validation

AM Peak Model Validation
In order to achieve the required level of validation of the AM peak model, minor amendments were made to the network as follows:

- Update of signal timings;
- Amendment of saturation flows;
- Amendment of free flow speeds on certain links; and
- Amendments of the Saturn GAP parameter to more accurately reflect the observed delays on the roundabouts of the A1237 York Outer Ring Road.

In order to introduce the observed queuing and delay to the model, flows were increased on certain key corridors until a better match was achieved with the observed journey times while ensuring that the flow validation was maintained.

Implementation of the network and matrix amendments as described above led to a significant improvement in the model journey time validation. This can be seen in **Table A1** and shows that 19 of the 22 journey time routes fall within the criteria set by the Department for Transport (DfT).

Table A1 – Summary of Observed and Modelled Journey Times (AM Peak)

Route	Observed Journey Time (Sec)	Modelled Journey Time Sec)	Error (Observed – Modelled)	% Error	Ok Dtp
Boroughbridge Road (In)	1125	1016.6	-108.4	9.6	Y
Boroughbridge Road (Out)	709	787.5	78.5	11.1	Y
Shipton Road (In)	923	799.6	-123.4	13.4	Y
Shipton Road (Out)	424	375.7	-48.3	11.4	Y
Tadcaster Road (In)	1433	1408.4	-24.6	1.7	Y
Tadcaster Road (Out)	438	394	-44	10	Y
Outer Ring Road (Clockwise)	1226	1264.5	38.5	3.1	Y
Outer Ring Road (Anti-clockwise)	1135	1136.9	1.9	0.2	Y
Inner Ring Road (Clockwise)	1306	1491.3	185.3	14.2	Y
Inner Ring Road (Anti-clockwise)	1184	1454.2	270.2	22.8	N
Fulford Road (In)	933	977	44	4.7	Y
Fulford Road (Out)	449	422.7	-26.3	5.9	Y
Hull Road (In)	617	558.5	-58.5	9.5	Y
Hull Road (Out)	482	500.4	18.4	3.8	Y
Malton Road (In)	570	646.6	76.6	13.4	Y
Malton Road (Out)	477	514.5	37.5	7.9	Y
Wigginton Road (In)	643	778.8	135.8	21.1	N
Wigginton Road (Out)	384	434.3	50.3	13.1	Y
Wetherby Road (In)	437	529.1	92.1	21.1	N
Wetherby Road (Out)	255	264.5	9.5	3.7	Y
Water End to Shipton Road	684	619.9	-64.1	9.4	Y

Route	Observed Journey Time (Sec)	Modelled Journey Time Sec)	Error (Observed – Modelled)	% Error	Ok Dtp
Shipton Road to Water End	453	478	25	5.5	Y

Source: F:\PROJECTS\37670TYT York Central\CYC Supplied Data\Saturn\am2004 Amended\AM_2004_10.ufs

Table A2 below gives a comparison of the flow validation statistics between the original 2004 validated model and the amended model discussed in this section. As can be seen from the table, the amendments to the network and matrix have adversely impacted on the flow validation, with two of the parameters falling below the 85% threshold as recommended by the DfT. However, the flow validation has not reduced significantly and the greatly improved journey time statistics as summarised in **Table A1** suggest that overall the model has achieved a more balanced level of validation.

Table A2 – Summary of Flow Validation Statistics (AM Peak)

	AM 2004 (Original)	AM 2004 (Amended)
Flow > 700: Modelled within 15% of observed	87.06%	80.00%
Flow < 700: Modelled within 15% of observed	90.24%	84.99%
All Links – GEH Statistic > 5.0	81.39%	75.40%

Off Peak Validation

In order to achieve the required level of validation of the Off-peak model, minor amendments were made to the network as follows:

- Amendments of free flow speeds on certain links.

These amendments were carried out on the Off-peak model and the journey time validation was checked. This can be seen in **Table A3** and shows that 19 of the 22 journey time routes fall within the criteria set by the DfT.

Table A4 below gives a comparison of the flow validation statistics between the original 2004 validated model and the amended model discussed in this section. As can be seen from the table, the amendments to the network have have had a minimal impact on the flow validation with all criteria falling above the 85% threshold as set by the DfT.

Table A4 – Summary of Flow Validation Statistics (Off-Peak)

	Off-Peak 2004 (Original)	Off-Peak 2004 (Amended)
Flow > 700: Modelled within 15% of observed	95.56%	95.56%
Flow < 700: Modelled within 15% of observed	98.11%	97.35%
All Links – GEH Statistic > 5.0	91.64%	90.59%

Table A3 — Summary Of Observed And Modelled Journey Times (Off Peak)

Route	Observed Journey Time (sec)	Modelled Journey Time (sec)	Error (Observed – Modelled)	% Err or	OK DTp
Boroughbridge Road (In)	554	488	-66.0	11.9	Y
Boroughbridge Road (Out)	462	478	15.6	3.4	Y
Shipton Road (In)	730	411	-318.6	43.6	N
Shipton Road (Out)	409	357	-52.3	12.8	Y
Tadcaster Road (In)	676	404	-272.0	40.2	N
Tadcaster Road (Out)	327	314	-13.1	4.0	Y
Outer Ring Road (Clockwise)	893	815	-78.2	8.8	Y
Outer Ring Road (Anti-clockwise)	982	844	-137.6	14.0	Y
Inner Ring Road (Clockwise)	1106	949	-156.7	14.2	Y
Inner Ring Road (Anti-clockwise)	1299	847	-452.0	34.8	N
Fulford Road (In)	414	392	-22.3	5.4	Y
Fulford Road (Out)	421	406	-15.5	3.7	Y
Hull Road (In)	564	511	-52.8	9.4	Y
Hull Road (Out)	497	479	-17.9	3.6	Y
Malton Road (In)	468	469	1.3	0.3	Y
Malton Road (Out)	498	512	14.2	2.9	Y
Wigginton Road (In)	534	465	-68.8	12.9	Y
Wigginton Road (Out)	413	390	-22.6	5.5	Y
Wetherby Road (In)	288	283	-4.8	1.7	Y
Wetherby Road (Out)	254	256	2.1	0.8	Y
Water End to Shipton Road	348	392	43.5	12.5	Y
Shipton Road to Water End	367	398	30.8	8.4	Y

Source: F:\PROJECTS\37670TYT York Central\CYC Supplied Data\Saturn\OP2004 Amended\OP_2004A.ufs

Appendix B – Future Year Forecasts

Introduction
Future year highway and public transport models are required to produce transport flows and to provide inputs to any financial and economic appraisal. Two forecast years have been developed to facilitate the assessment of public transport scheme options. The first forecast year theoretically reflects the scheme opening year, which in the case of York Central is assumed to be 2011. The development of a second forecast year reduces the level of uncertainty particularly with respect to the effects of traffic congestion and the level of car transfer. It is assumed the second forecast year would be 2021, 10 years after the assumed opening year. Future year forecasting models have been developed for a do minimum scenario and will incorporate assumptions on:

- Employment and population growth in York;
- Future growth in underlying travel demand by mode; and
- Changes in the highway network and travel costs.

Future Year Developments
A list of future employment developments in the city and an estimate of their site area have been provided by CoYC. In terms of estimating the trip generation of these employment sites, each site has been assigned to three distinct categories:

1. York Central – where the Gross Floor Area (GFA), employee numbers and trip generation have been previously calculated by Faber Maunsell and agreed with CoYC;
2. Employment sites where developer aspirations with regard to predicted employee numbers are known (e.g. A59 Site, Monks Cross South, and University of York Campus 3); and
3. Other sites where only the estimated site area is known.

The sites identified in category 2 above were used to calculate a factor of employees per hectare. This factor (117 employees per ha.) is then applied to the remaining sites where only the estimated site area is known.

This resulted in a predicted total employee generation of 27,401 employees (11,320 by 2011 and a further 16,081 by 2021).

The adopted trip rates can be seen in **Tables B1 and B2** below. TRICS rates have been disaggregated by size of development.

Table B1 – TRICS Rates for B1 Office Use (Sites with less than 400 predicted employees)

	ARRIVALS	DEPARTURES
AM Peak (0800-0900)	0.25	0.03
Off Peak (1100-1200)	0.07	0.06
PM Peak (1700-1800)	0.04	0.20

Source: TRICS ver. 2004b

Table B2 – TRICS Rates for B1 Office Use (Sites with more than 400 predicted employees)

	ARRIVALS	DEPARTURES
AM Peak (0800-0900)	0.30	0.04
Off Peak (1100-1200)	0.02	0.03
PM Peak (1700-1800)	0.04	0.24

Source: TRICS ver. 2004b

Other Proposed Residential Sites
CoYC also provided a list of future residential developments in the city. The predicted number of residential units within each development was reduced by 10% to take account of difficult site layouts.

The adopted trip rates can be seen in **Tables B3 and B4** below. TRICS rates have been disaggregated by location.

Table B3 – TRICS Rates for Residential Sites (Sites outside of Inner Ring Road)

	Arrivals	Departures
AM Peak (0800-0900)	0.09	0.45
Off Peak (1100-1200)	0.10	0.10
PM Peak (1700-1800)	0.40	0.21

Source: CoYC – Traffic Generation from Housing Devs.
Note: No Off Peak data available – 0.10 assumed.

Table B4 – TRICS Rates for Residential Sites (Sites within Inner Ring Road)

	Arrivals	Departures
AM Peak (0800-0900)	0.04	0.23
Off Peak (1100-1200)	0.09	0.07
PM Peak (1700-1800)	0.11	0.04

Source: TRICS ver. 2004a

A complete list of development sites, their estimated size and trip generation can be seen in **Table B5** overleaf.

Matrix Development
The estimate of trip generation was subsequently added to the base matrix using the following assumptions:

- As the trips are peak hour office employment trips, an HGV percentage of 0% has been assumed;
- For employment sites outside the city centre it has been assumed that parking will be available on site, therefore, these employment trips have been assigned to User Class 1;
- For city centre employment developments e.g. York Central and Hungate, trips have been assigned to all user classes based on the proportional split between user classes in other city centre employment zones;
- For employment sites external to the model e.g. Elvington Airfield Business Park and Wheldrake Industrial Estate, it has been assumed that only 50% of trips to these sites will come from the modelled network;
- Trips have been distributed across the network using either the distribution from the same zone if trips exist in that zone in the base situation or an adjacent equivalent zone; and
- NRTF central growth has been applied to all external-external trips. A factor of 1.116 has been calculated from 2004 to 2011 and 1.274 from 2004 to 2021.

The predicted total employee generation of 27,401 employees is greater than the 19,000 employees agreed with the CoYC as a more realistic assumption. In order to achieve a net increase of 19,000 employees by 2021, a reduction has been applied to all employment zones across the model. The percentage reduction for 2011 and 2021 has been calculated as a proportion of the total employee forecasts for 2011 and 2021. This results in a reduction of 3,471 employees by 2011 and a further 4,930 employees by 2021 creating the net increase of 19,000 employees across new and existing employment zones by 2021.

The residential AM peak departures were then added to the equivalent row totals with the windfall sites proportioned across all residential zones. This allowed for a singly constrained matrix furness procedure to be carried out on User Class 1. The matrix was constrained to the new row totals including the residential departures.

The updated User Class 1 matrix can then be restacked with User Classes 2-5 with the resulting 2011 and 2021 base matrices being assigned to the updated base network. The 2011 AM peak base matrix shows a 17% increase from 35,139 trips in 2004 to 41,139 trips in 2011.

For the PM peak matrix, the residential arrivals were added to the equivalent column totals with the windfall sites proportioned across all residential zones. The matrix was furnessed to the new column totals including the residential arrivals.

The methodology for the off-peak matrix can be summarised as follows:

- York Central employment trips have been added to the matrix as per the AM and PM peak methodology; and
- TEMPRO growth has been applied to the remainder of the matrix for 2004-2011 (1.16) and 2004 to 2021 (1.33). These factors take account of fuel costs and income adjustment.

YORK CENTRAL - EMPLOYMENT AND RESIDENTIAL TRIP GENERATTION FORECASTS

Site Number	Employment Site (York Central)	Opening Year	Saturn Zone	Max Size (Ha)*	Max Size (m²)	Employee Numbers	Zone Equivalent for Distribution	AM Arrivals	AM Departures	Off-Peak Arrivals	Off-Peak Departures	PM Arrivals	PM Departures
1	York Central	2011	205	6	60,000	1311	Various	122	20	9	12	14	112
2	York Central Employment	2021	205	30	300,000	8299	Various	774	127	54	77	92	710
						9610		896	147	63	90	106	822

Site Number	Employment Site (Where Developer Aspirations are Known)	Opening Year	Saturn Zone	Max Size (Ha)*	Max Size (m²)	Employee Numbers	Zone Equivalent for Distribution	AM Arrivals	AM Departures	Off-Peak Arrivals	Off-Peak Departures	PM Arrivals	PM Departures
3	A59 Site	2011	218	14	140,000	1204	208	361	48	24	36	48	289
4	South of Monks Cross	2011	203	13	130,000	2000	98/87	600	80	40	60	80	480
5	Campus 3	2011	187	12.5	125,000	2000	107	600	80	40	60	80	480
6	Campus 3	2021	187	12.5	125,000	2000	107	600	80	40	60	80	480
7	North Minster	2021	218	36	360,000	3096	208	929	124	62	93	124	743
				88		10300		3090	412	206	309	412	2472
					Employees per Ha.	117							

Site Number	Employment Site	Opening Year	Saturn Zone	Max Size (Ha)*		Employee Numbers	Zone Equivalent for Distribution	AM Arrivals	AM Departures	Off-Peak Arrivals	Off-Peak Departures	PM Arrivals	PM Departures
8	North of Monks Cross	2011	98	10.95		1282	98/87	384	51	26	38	51	308
9	University Science Park	2011	184	1.7		199	184	50	6	14	12	8	40
10	Hungate	2011	24	1		117	Various	29	4	8	7	5	23
11	Clifton Park (Laundry Building)	2011	71	0.6		70	71	18	2	5	4	3	14
12	Varvills Warehouse	2011	37	0.1		12	37	3	0	1	1	0	2
13	York Business Park	2011	208	8.2		960	208	288	38	19	29	38	230
14	Elvington Airfield Business Park (Areas a,b,c,e)	2011	178	4		468	178	140	19	9	14	19	112
15	Wheldrake Industrial Estate (Sites a,c,d,e)	2011	160	2.5		293	160	73	9	20	18	12	59
16	Centurion Park	2011	197	2.6		304	197	76	9	21	18	12	61
17	Holgate Park	2011	206	2.2		258	206	64	8	18	15	10	52
18	Heworth Green	2011	12	0.7		82	12	20	2	6	5	3	16
19	Murton Industrial Estate	2011	180	0.5		59	153	15	2	4	4	2	12
20	Link Business Park	2011	153	0.4		47	153	12	1	3	3	2	9
21	Green Lane	2011	76	0.4		47	197	12	1	3	3	2	9
22	Audax Road	2011	196	0.3		35	196	9	1	2	2	1	7
23	Towton House	2011	28	0.1		12	25	3	0	1	1	0	2
24	Land at Stirling Road, Clifton Moor	2011	196	1		117	196	29	4	8	7	5	23
25	Land at Green Lane/Water Lane	2011	76	3.8		445	197	133	18	9	13	18	107
26	North of Monks Cross	2021	98	10.95		1282	98/87	384	51	26	38	51	308
27	York Business Park	2021	208	8.2		960	208	288	38	19	29	38	230
28	Land at Green Lane/Water Lane	2021	76	3.8		445	197	133	18	9	13	18	107
				64		7491		2165	283	232	274	300	1732
					Total Employment	27401		6151	842	501	673	818	5026

14	70	9	5	7	9	56
15	37	4	10	9	6	29

Employee Total 2011	11320
Employee Total 2021	16081

Site Number	Residential Development	Opening Year	Saturn Zone	Max Dwellings	10% Reduction	Location	Residential Units	Zone Equivalent for Distribution	AM Arrivals	AM Departures	Off-Peak Arrivals	Off-Peak Departures	PM Arrivals	PM Departures
29	Metcalfe Lane. Osbaldwick	2011	186	520	468		468	-	42	211	47	47	187	98
30	Hungate	2011	24	600	540	City Centre	540	-	22	124	49	38	59	22
31	Castle-Picadilly	2011	27	27	24	City Centre	24	-	1	6	2	2	3	1
32	N. of Trinity Lane, Micklegate	2011	39	27	24	City Centre	24	-	1	6	2	2	3	1
33	NCP Skeldergate, Bishophill	2011	174	145	131	City Centre	131	-	5	30	12	9	14	5
34	Kennings Garage, Bishophill	2011	39	30	27	City Centre	27	-	1	6	2	2	3	1
35	Peel St/Margaret St, Guildhall	2011	171	30	27	City Centre	27	-	1	6	2	2	3	1
36	Germany Beck, Fulford	2011	181	700	630		630	-	57	284	63	63	252	132
37	Bonding Warehouse, Skeldergate	2011	37	20	18	City Centre	18	-	1	4	2	1	2	1
38	Bramham Road, Chapelfields	2011	141	19	17		17	-	2	8	2	2	7	4
39	Burnholme WMC, Burnholme Drive	2011	94	16	14		14	-	1	6	1	1	6	3
40	Rosedale,Clifton Park	2011	71	8	7		7	-	1	3	1	1	3	2
41	DC Cooke, Lawrence Street	2011	30	91	82		82	-	7	37	8	8	33	17
42	Heworth Green	2011	12	148	133		133	-	12	60	13	13	53	28
43	Hospital Fields Road	2011	116	91	82		82	-	7	37	8	8	33	17
44	MOD Land, Fulford	2011	110	72	65		65	-	6	29	6	6	26	14
45	Monk Bar Garage	2011	20	10	9	City Centre	9	-	0	2	1	1	1	0
46	Former Bus Depot, Navigation Road	2011	210	69	62		62	-	6	28	6	6	25	13
47	Osbaldwick Lane, Murton Way	2011	152	25	23		23	-	2	10	2	2	9	5
48	Tedder Road, Acomb	2011	128	128	115		115	-	10	52	12	12	46	24
49	Reynards Garage	2011	69	10	9	City Centre	9	-	0	2	1	1	1	0
50	Tenneco	2011	72	225	203		203	-	18	91	20	20	81	43
51	Minster Engineering	2011	6	17	15		15	-	1	7	2	2	6	3
52	Donnelly's	2011	148	250	225		225	-	20	101	23	23	90	47
53	Land at Birch Park	2011	86	182	164		164	-	15	74	16	16	66	34
54	The Croft Campus, Heworth Grn	2011	11	53	48		48	-	4	21	5	5	19	10
55	15A-C Haxby Road	2011	8	10	9		9	-	1	4	1	1	4	2
56	6-19 Hull Road	2011	111	17	15		15	-	1	7	2	2	6	3
57	Land at lea Way, Huntington	2011	85	17	15		15	-	1	7	2	2	6	3
58	York College, Tech. Site	2011	179	350	315		315	-	28	142	32	32	126	66
59	York Central	2011	219			City Centre	584	-	23	134	53	41	64	23
60	Windfalls	2011	Various	1428	1285		1285	-	116	578	129	129	514	270
61	Windfalls	2021	Various	1600	1440		1440	-	130	648	144	144	576	302
62	Strensall	2021	156	240	216		216	-	19	97	22	22	86	45
63	Naburn	2021	182	360	324		324	-	29	146	32	32	130	68
64	West of Grimston Bar P&R	2021	220	400	360		360	-	32	162	36	36	144	76
65	York Central Housing	2021	219			City Centre	2441	-	98	561	220	171	269	98
						Total Residential	10167		723	3731	978	902	2955	1483

Appendix C – Highway Access Drawings

Appendix D – Public Transport Model Validation

Table D1 : 2004 Passenger Bus Validation

Link	2004 Observed AM Peak Hour Flow	2004 Modelled AM Peak Flow	GEH
Huntington Road	37	78	5
Heworth Green	145	80	6
Layerthorpe	374	176	**12**
Lawrence Street	518	232	**15**
Heslington Road	118	125	1
Fulford Road	495	128	**21**
Bishopthorpe Road	19	12	2
Blossom Street	643	570	3
Leeman Road	287	241	3
Bootham	0	0	0
Clarence Street	641	578	3
TOTAL (Corridor)	**1571**	**1389**	**5**
TOTAL (All radials)	**3278**	**2220**	**20**

Table D2 : 2004 Cycle Matrix Validation

Link	2004 Observed AM Peak Hour Flow	2004 Modelled AM Peak Flow	GEH
Huntington Road	44	55	2
Heworth Green	96	87	1
Layerthorpe	73	65	1
Lawrence Street	78	69	1
Heslington Road	6	28	5
Fulford Road	30	66	5
New Walk Terrace	49	0	10
Terry Avenue	44	13	6
Bishopthorpe Road	51	65	2
Blossom Street	90	188	8
Leeman Road	5	73	**11**
Cinder Lane	146	71	7
Riverside Walk	69	31	5
Bootham	160	114	4
Clarence Street	56	103	5
TOTAL (Corridor)	**526**	**580**	**2**
TOTAL (All radials)	**997**	**1028**	**1**

Table D3 : 2004 Walk Matrix Validation

Link	2004 Observed AM Peak Hour Flow	2004 Modelled AM Peak Flow	GEH
Huntington Road	113	364	16
Heworth Green	141	236	7
Layerthorpe	170	220	4
Lawrence Street	203	312	7
Heslington Road	48	236	16
Fulford Road	131	122	1
New Walk Terrace	143	0	17
Terry Avenue	23	0	7
Bishopthorpe Road	189	441	14
Blossom Street	869	642	8
Leeman Road	320	220	6
Cinder Lane	146	168	2
Riverside Walk	174	2	**18**
Bootham	396	502	5
Clarence Street	216	523	**16**
TOTAL (Corridor)	**2121**	**2057**	**1**
TOTAL (All radials)	**3282**	**3988**	**12**

Appendix E – UK Air Quality Objectives

Table E1 : UK Air Quality Objectives Set in Regulations

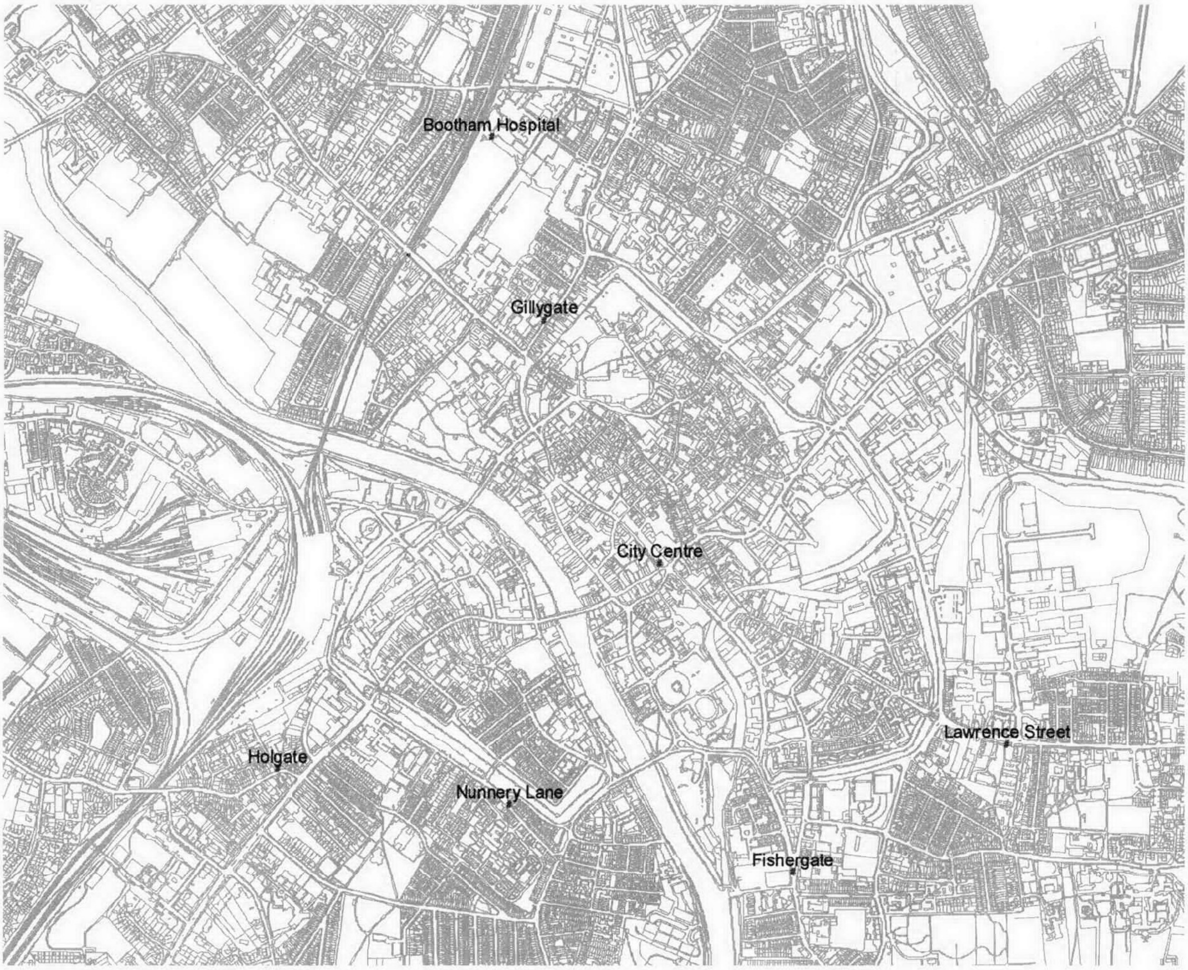
Pollutant	Applies	Objective			EU Objectives	
		Concentration	Measured as	Compliance	Concentration	Date
Benzene	All UK	16.25 $\mu g/m^3$ (5 ppb)	running annual mean	Dec 31, 2003	5 $\mu g/m^3$	2010
	Eng & Wales	5 $\mu g/m^3$ (1.5 ppb)	annual mean	Dec 31, 2003		
	Scotland	3.25 $\mu g/m^3$ (1 ppb)		Dec 31, 2010		
1,3-Butadiene	All UK	2.25 $\mu g/m^3$ (1 ppb)	running annual mean	Dec 31, 2010	n/a	n/a
Carbon monoxide	All UK	10 mg/m^3 (8.6 ppm)	maximum daily running 8 hour mean	Dec 31, 2003	10 mg/m^3	2005
Lead	All UK	0.5 $\mu g/m^3$	annual mean	Dec 31, 2004	0.5 $\mu g/m^3$	2005
		0.25 $\mu g/m^3$	annual mean	Dec 31, 2008		
Nitrogen dioxide	All UK	200 $\mu g/m^3$ (105 ppb)	1 hour, 18 exceedences	Dec 31, 2005	200 $\mu g/m^3$ (18 exceedences)	2010
		40 $\mu g/m^3$ (21 ppb)	annual mean	Dec 31, 2005	40 $\mu g/m^3$	2010
Particles(PM_{10}) (gravimetric)	All UK	50 $\mu g/m^3$	24hr mean, 35 exceedences	Dec 31, 2004	50 $\mu g/m^3$	2005
		40 $\mu g/m^3$	annual mean	Dec 31, 2004	40 $\mu g/m^3$	2005
	Scotland	50 $\mu g/m^3$	24hr mean, 7 exceedences	Dec 31, 2010	40 $\mu g/m^3$	2010
		18 $\mu g/m^3$	annual mean	Dec 31, 2010	20 $\mu g/m^3$	2010
Sulphur dioxide	All UK	350 $\mu g/m^3$ (132 ppb)	1 hour, 24 exceedences	Dec 31, 2004	350 $\mu g/m^3$ (24 exceedences)	2005
		125 $\mu g/m^3$ (47 ppb)	24 hour mean, 3 exceedences	Dec 31, 2004	125 $\mu g/m^3$ (18 exceedences)	2005
		266 $\mu g/m^3$ (100 ppb)	15 min mean, 35 exceedences	Dec 31, 2005		

Table E2 : UK Air Quality Objectives not set in Regulations

Pollutant	Applies	Objective		Compliance	Notes
		Concentration	Measured as		
Polycyclic aromatic hydrocarbons (PAHs)	All UK	0.25 ng/m^3	annual mean	Dec 31, 2010	To be set in future regs, 2005
Ozone	All UK	100 µg/m^3	8 hour mean, 10 exceedences	Dec 31, 2005	Ozone is a national rather then local authority problem
Particles(PM_{10}) (gravimetric)	London	50 µg/m^3 (provisional)	24 hour mean, 10 exceedences	Dec 31, 2010	These particle objectives may be set in regs once the EU has decided its new limit value.
		23 µg/m^3 (provisional)	annual mean	Dec 31, 2010	
		20 µg/m^3 (provisional)	annual mean	Dec 31, 2015	
	Rest of Eng & Wales	50 µg/m^3 (provisional)	24 hour mean, 7 exceedences	Dec 31, 2010	
		20 µg/m^3 (provisional)	annual mean	Dec 31 2010	
Nitrogen oxides	All UK	30 µg/m^3	annual mean	Dec 31, 2000	Vegetative based directives kept out of regulations as national problem. Targets have been met.
Sulphur dioxide	All UK	20 µg/m^3 (8 ppb)	annual mean	Dec 31 2000	
		20 µg/m^3 (8 ppb)	Winter mean (October – March)	Dec 31 2000	

Appendix F - Maps

Figure F1 : Map of Central Continuous Monitoring Locations



Appendix G – Aaquire Description

The AAQuIRE 6.1.1 software is a system to predict Ambient Air Quality in Regional Environments and comprises a regional air quality model and statistical package.

AAQuIRE was developed by Faber Maunsell Ltd to meet three requirements in predictive air quality studies. The first requirement was an immediate need for a system which produced results which could be interpreted easily by non-air quality specialists, to allow for proper informed inclusion of air quality issues for a range of topics; the main example being to allow consideration of air quality issues in planning processes.. This was achieved by allowing results to be generated over a sufficiently large study area, and at an appropriate resolution, for the issue being considered. The results are also presented in a relevant format, which is normally a statistic directly comparable with an air quality criterion or set of measured data being considered. For example, the UKNAQS PM10 24-hour objective level of 50 µg/m3 is expressed as a 90th percentile of hourly means. AAQuIRE can also produce results directly comparable with all ambient air quality standards, including:

- the annual average objective for nitrogen dioxide of 40 µg/m3;
- the 90th percentile of 24 hour means for PM10 of 50 µg/m3;
- the 99.9th percentile of 15 minute means for sulphur dioxide of 266 µg/m3; and
- the nitrogen dioxide 1-hour mean objective of 200 µg/m3, not to be exceeded more than 18 times a year.

The second requirement was for a system to be based, initially, on existing and well-accepted and validated dispersion models. This has two advantages. The primary one is that it avoids the need to prove a new model against the accepted models and therefore enhances acceptability. The second advantage is that when appropriate new models are developed they can be included in AAQuIRE and be compared directly with the existing models, and sets of measured data, using the most appropriate statistics.

The final primary requirement for AAQuIRE was a consideration of quality assurance and control. An important aspect of modelling is proper record keeping ensuring repeatability of results. This is achieved within AAQuIRE by a set of log files, which record all aspects of a study and allow model runs to be easily repeated.

The ways in which AAQuIRE and the models currently available within it operate are discussed below.

The operation of AAQuIRE can be divided into five main stages. These are:

- the preparation of the input data;
- the generation of model input files;
- dispersion modelling;
- the statistical treatment of dispersion modelling results; and
- the presentation of results.

The first step in operating AAQuIRE is to prepare the input data. For the year and pollutant to be modelled, data are needed on:

- meteorological data expressed as occurrence frequencies for specified combinations of wind speed, direction, stability and boundary layer height;
- road system layout and associated traffic data within and immediately surrounding the study area;
- industrial stack locations and parameters; and
- grid of model prediction locations (receptors).

The modelling is always carried out to give annual average results from which appropriate shorter period concentrations can be derived.

The second stage is the generation of the model input files required for the study. All the data collated in the first stage can be easily input into AAQuIRE, using the worksheets, drop down boxes and click boxes in the Data Manager section of the software. Data from spreadsheets can be easily pasted into worksheets, so that any complicated procedures required for data manipulation can be achieved before entry into AAQuIRE. Several diurnal and seasonal profiles can be defined for each separate source. The relevant meteorological data can also be specified at this stage.

The third stage is executing the models. The study area will usually be divided up into manageable grids and run separately using the Run Manager in AAQuIRE. The results from the separate files can be combined at a later stage. Pollutant concentrations are determined for each receptor point and each meteorological category and are subsequently combined.

The fourth stage is the statistical processing of the raw dispersion results to produce results in the relevant averaging period. Traffic sources and industrial sources can be combined at this stage provided the same receptor grid has been used for both. Background concentrations should also be incorporated at this stage.

The final stage is the presentation of results. Currently the result files from the statistical interpretation are formatted to be used directly by the SURFER package produced by Golden Software Inc. Alternative formats are available to permit interfacing with other software packages. On previous projects the results have been imported into a GIS (e.g. ArcView and Map Info).

Currently AAQuIRE uses the CALINE4 model for the dispersion of road-traffic emissions and AERMOD for all other sources. Both these models are fully validated and have been extensively used worldwide. These are relatively complex models designed for detailed studies of local areas, which are used within AAQuIRE for both local and larger scale studies. This is considered necessary because of the frequent importance of local effects, such as traffic junctions, in properly assessing 'regional' effects. The modelling uncertainty for AAQuIRE is approximately ±20%, which is well within the recommendations in technical guidance note LAQM.TG3(00).

Appendix H – Meteorological Parameters

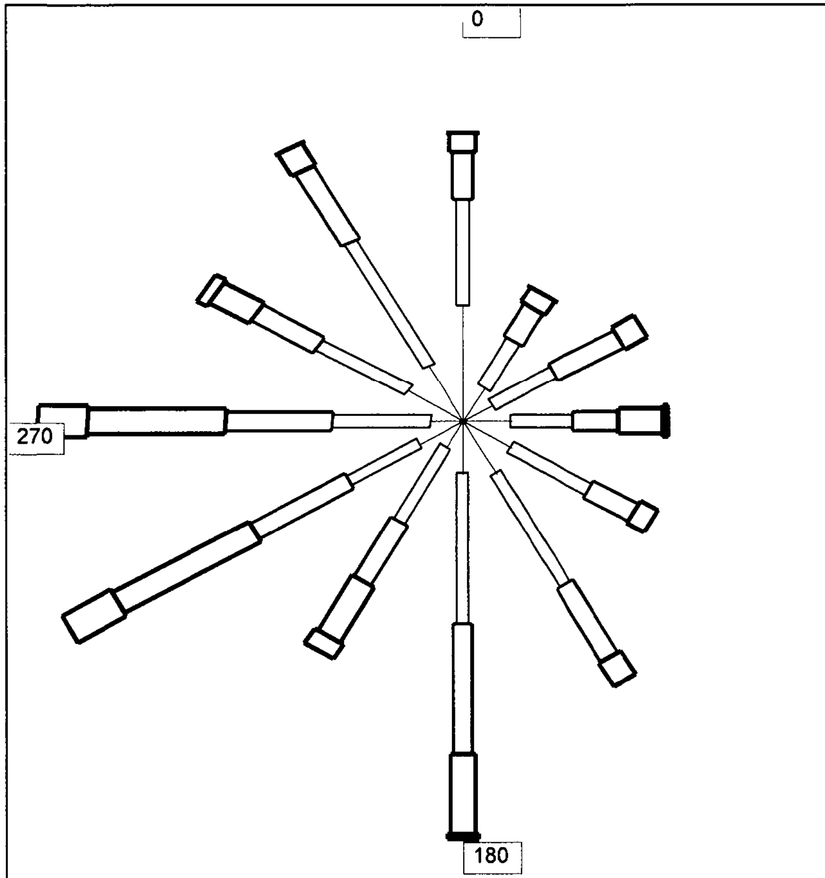
A meteorological dataset (2002) was compiled using data from Leeds weather centre and Church Fenton for this modelling study. Wind speed and direction data from Church Fenton were used, together with cloud cover and other required parameters from Leeds Weather Centre. The data consisted of the frequencies of occurrence of wind speed (0-2, 3-4, 6-10, 10+ m/s), wind direction (30° resolution) and Pasquill stability classes. Pasquill stability classes categorise the stability of the atmosphere from A (very unstable) through D (neutral) to G (very stable).

The meteorological data were used to produce a wind/stability rose. The rose consisted of 12 wind direction sectors of 30°, 4 wind speed bands and 3 stability classes.

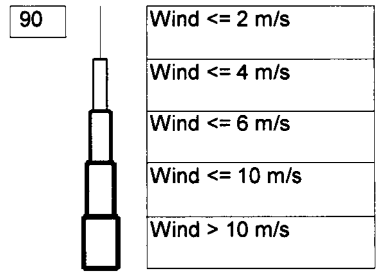
Calm winds were distributed evenly between the wind direction sectors in the 1 m/s category. The stability classes used were C, D and E where all of the unstable classes were grouped in C and all of the stable classes in E. The windrose is shown on the following page.

Each windrose bar is designed to illustrate three wind properties: the direction the wind is coming from; the relative number of hours the wind is from this direction; and the magnitude of the wind speeds and their occurrence from each wind direction. These data are also tabulated to show the total number of hours and the wind speed split for each wind direction sector.

Figure H1 : Windrose for Church Fenton, 2002



	Wind <= 2 m/s	Wind <= 4 m/s	Wind <= 6 m/s	Wind <= 10
D >= 345 or D < 15	303	273	123	
15 <= D < 45	100	142	99	
45 <= D < 75	81	169	181	
75 <= D < 105	115	150	110	
105 <= D < 135	133	217	123	
135 <= D < 165	157	330	216	
165 <= D < 195	136	387	337	
195 <= D < 225	80	222	177	
225 <= D < 255	120	193	256	
255 <= D < 285	77	236	248	
285 <= D < 315	151	247	168	
315 <= D < 345	162	373	215	
Total	1615	2939	2253	



Appendix I – Air Quality Plots

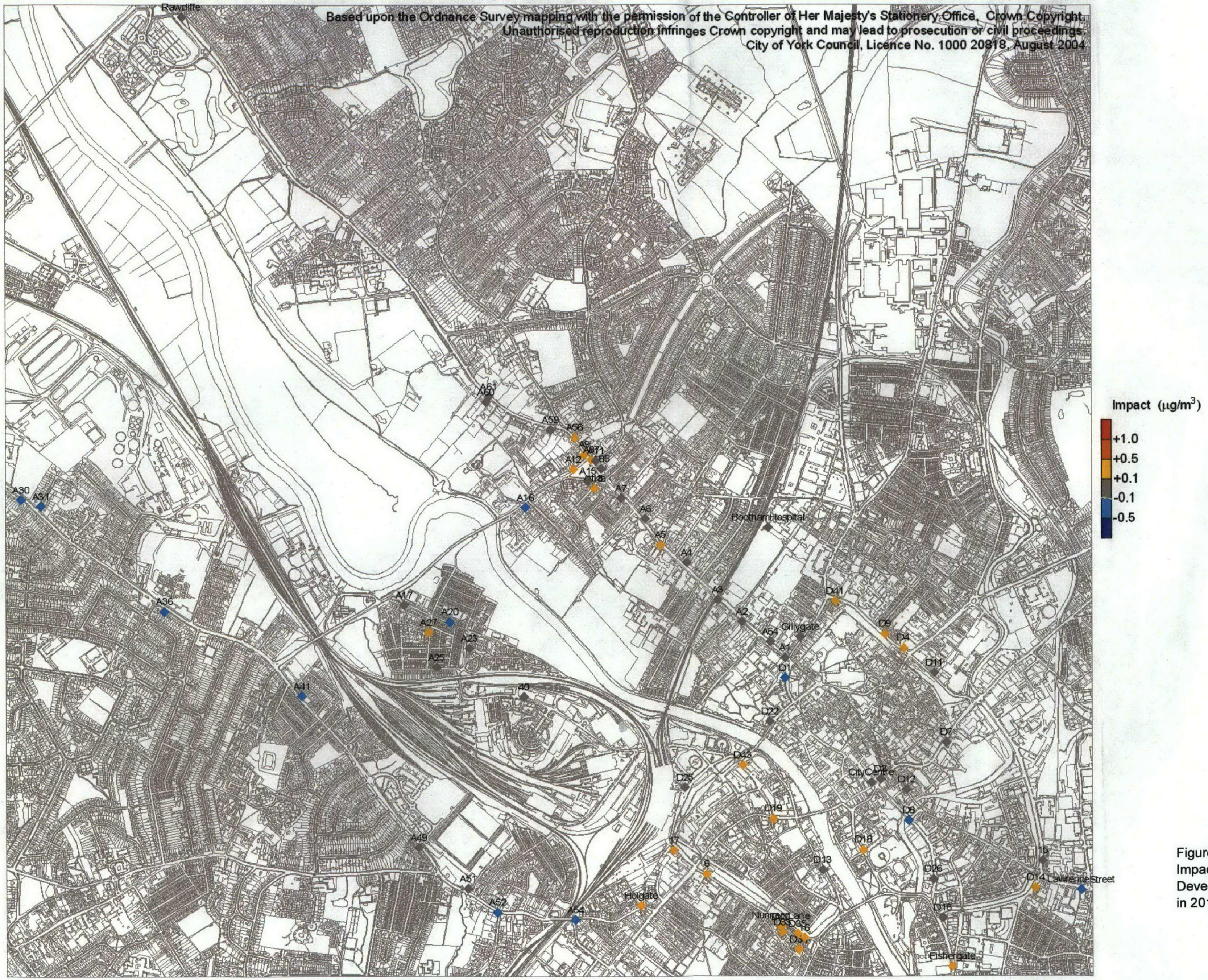


Figure A:
Impact of the York Central Development on NO_2 concentrations in 2011

FABER MAUNSELL | AECOM

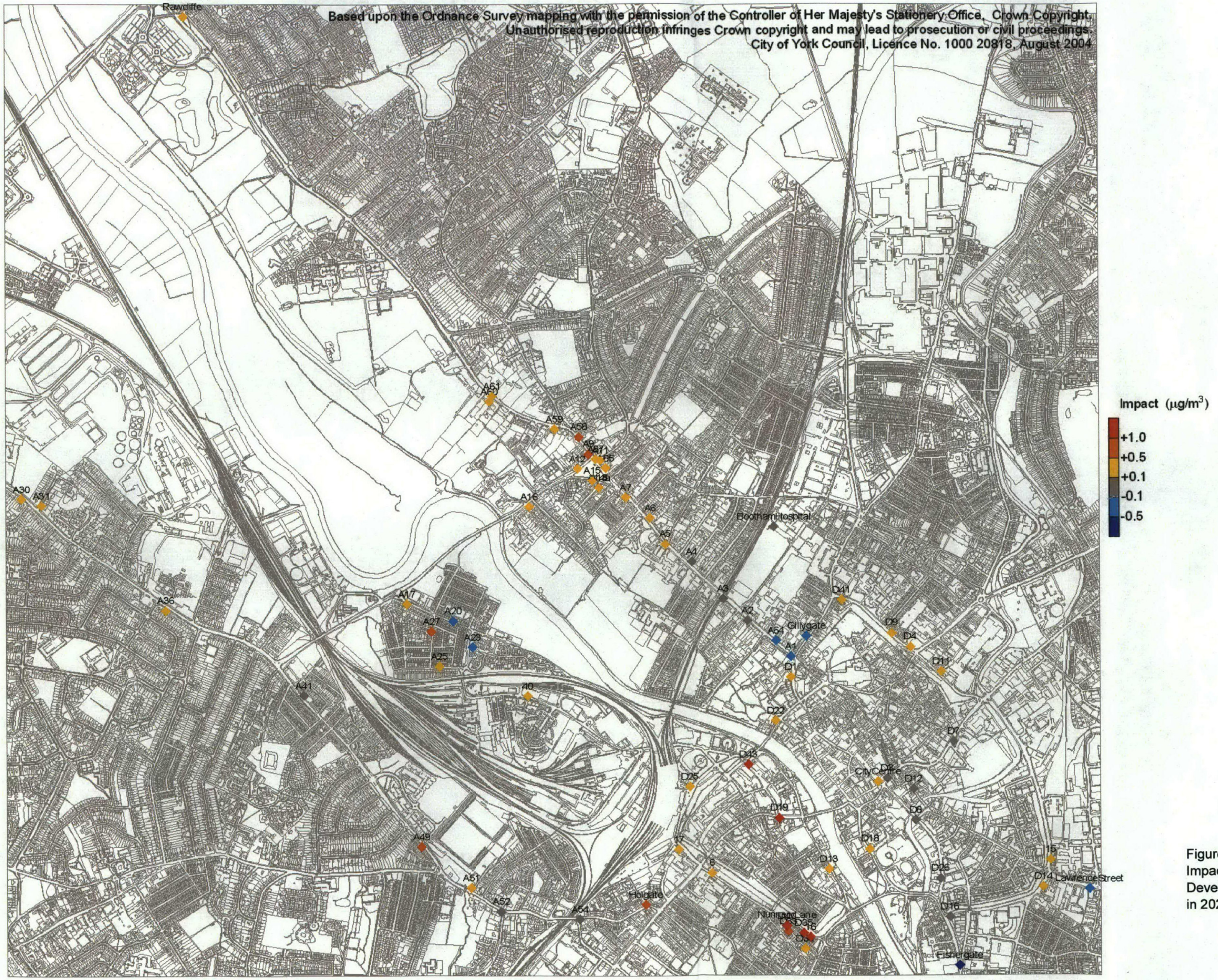


Figure B:
Impact of the York Central Development on NO_2 concentrations in 2021

FABER MAUNSELL | AECOM

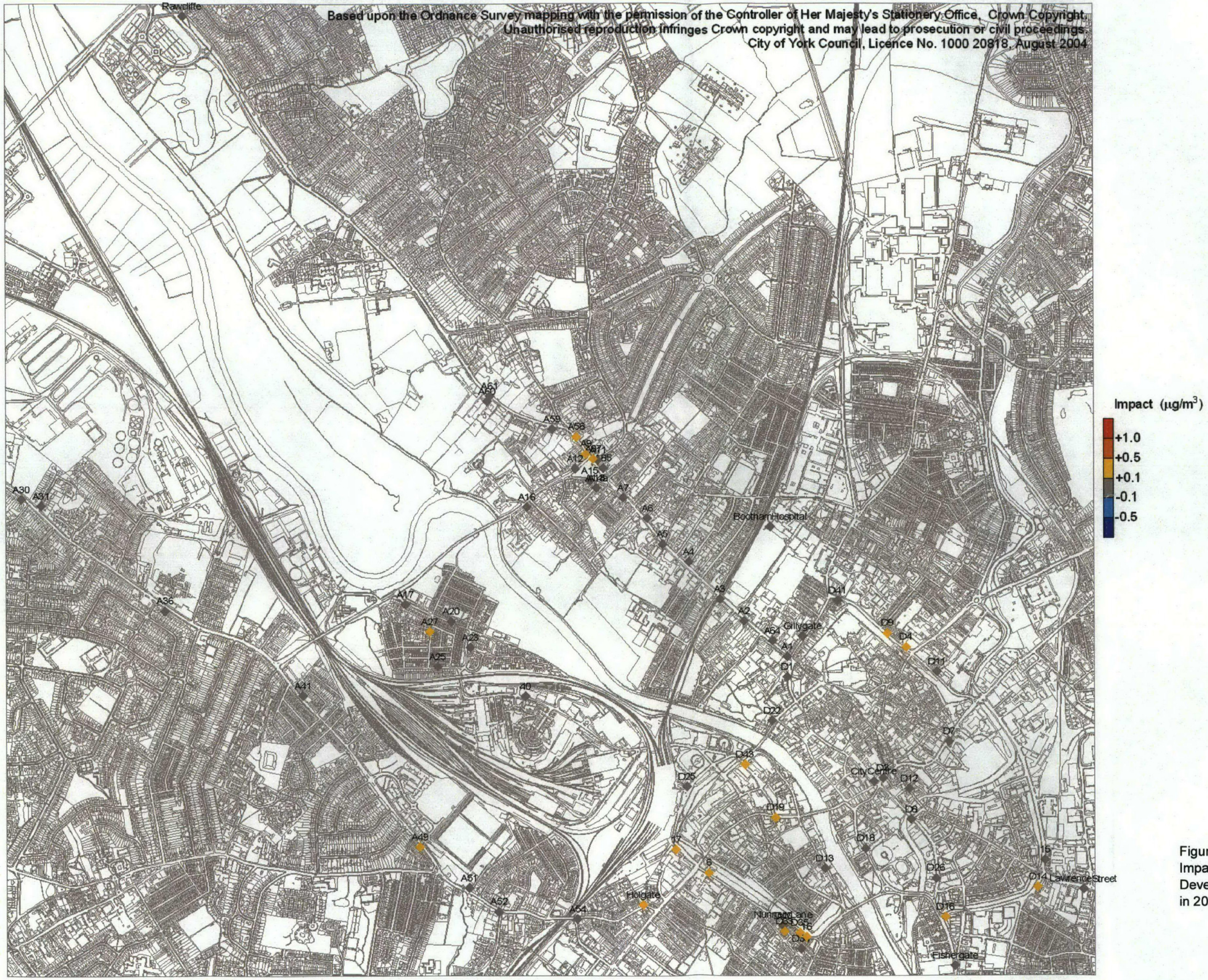


Figure C:
Impact of the York Central Development on PM_{10} concentrations in 2011

FABER MAUNSELL | AECOM

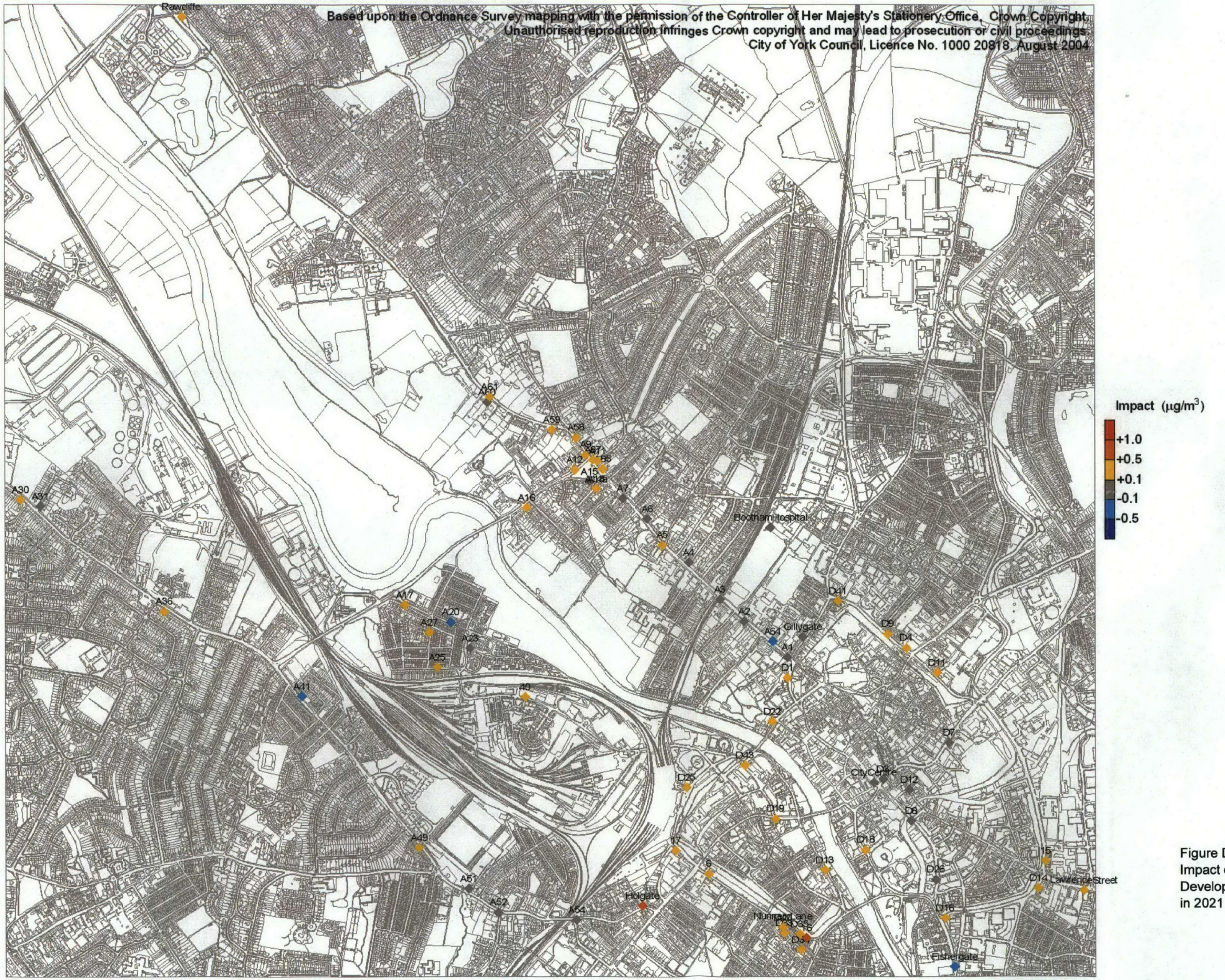


Figure D:
Impact of the York Central Development on PM_{10} concentrations in 2021

FABER MAUNSELL | AECOM

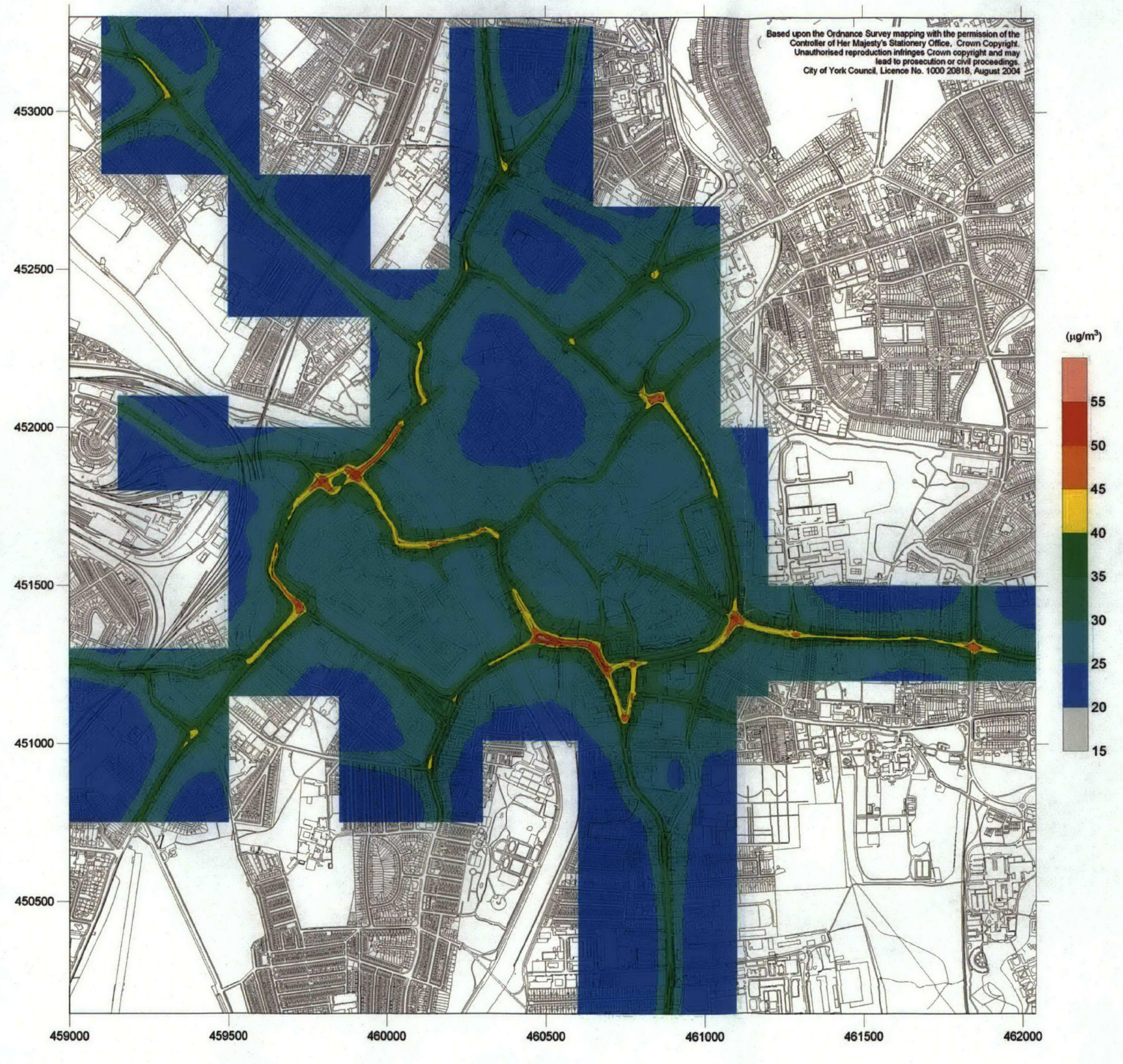


Figure E:
York AQMA NO_2 Contour Plot, 2004

FABER MAUNSELL | AECOM

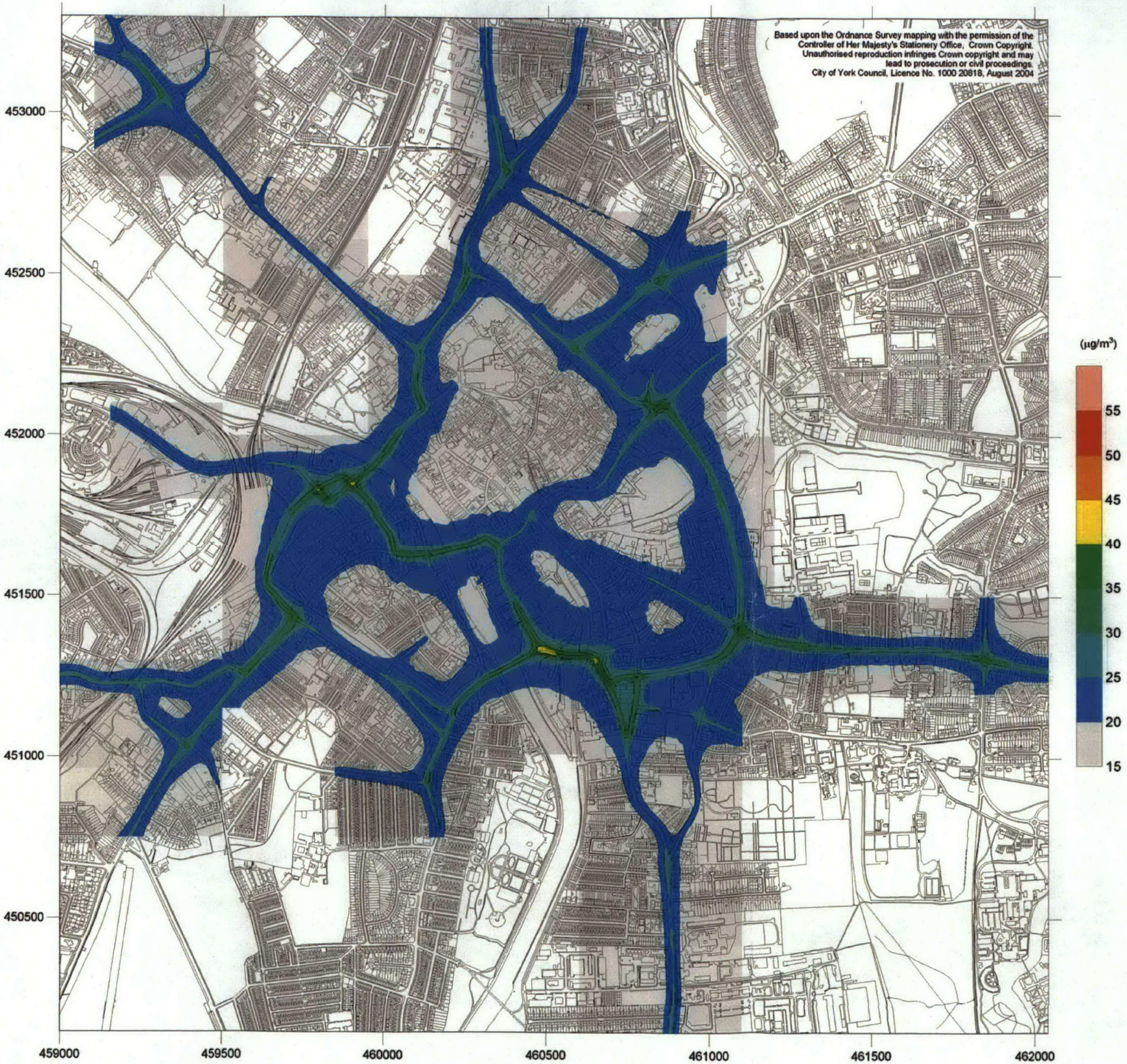


Figure F:
York AQMA NO_2 Contour Plot,
2011, Do-Minimum

FABER MAUNSELL | AECOM

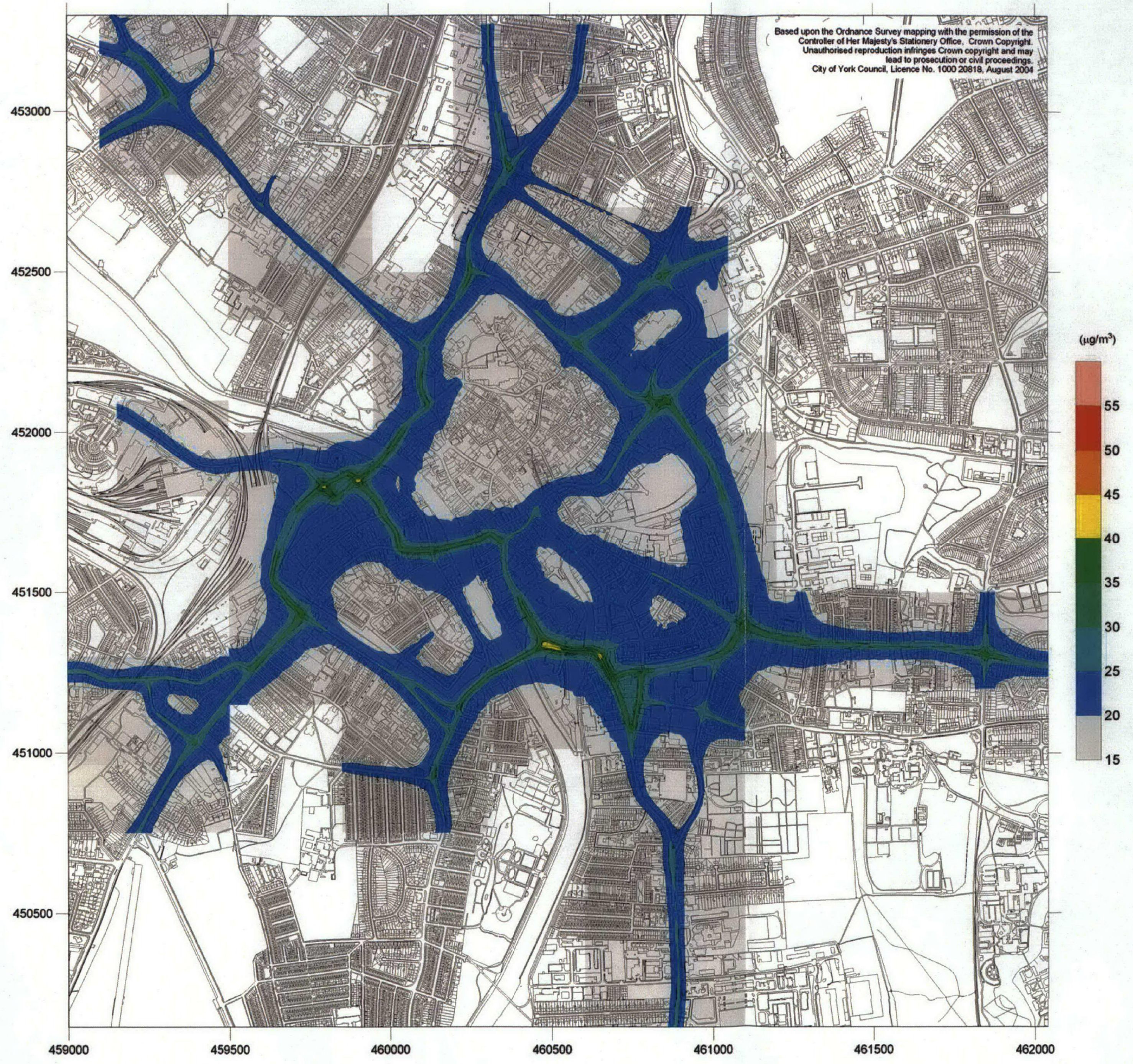


Figure G:
York AQMA NO_2 Contour Plot, 2011, Do-Something

FABER MAUNSELL | AECOM

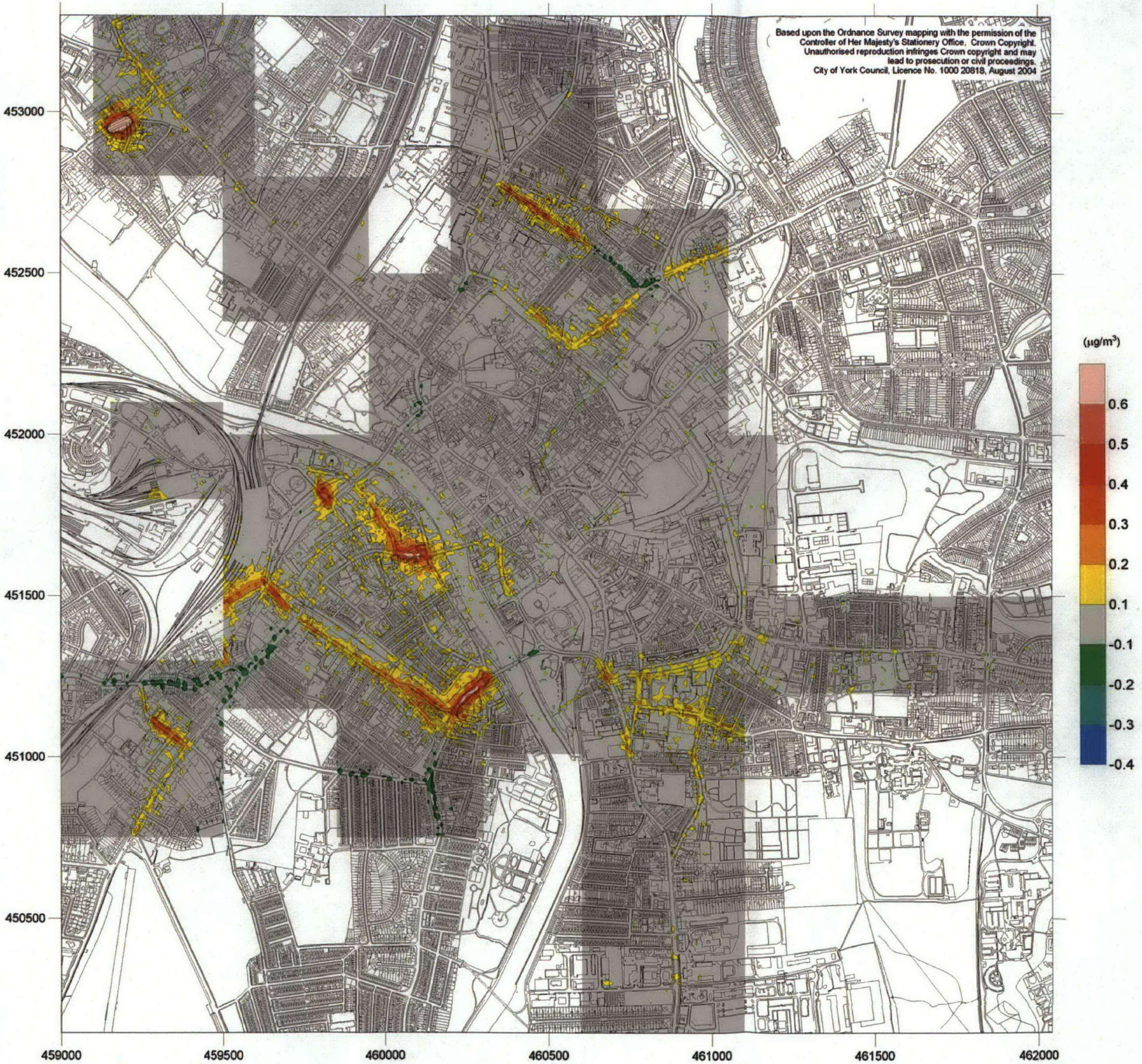


Figure H:
York AQMA NO_2 Contour Plot, 2011, Impact of the York Central Development

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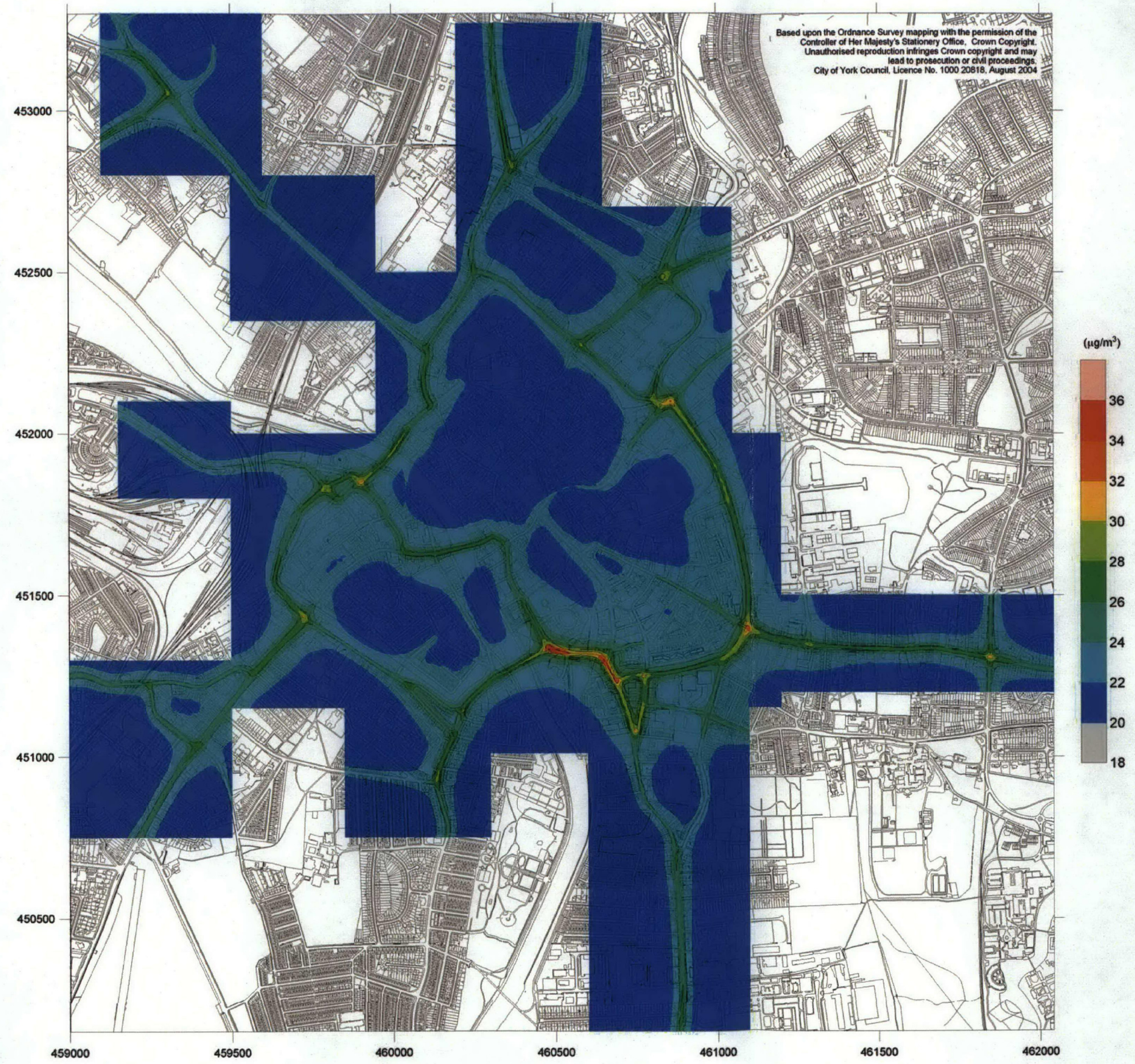

Figure I:
York AQMA PM_{10} Contour Plot, 2004

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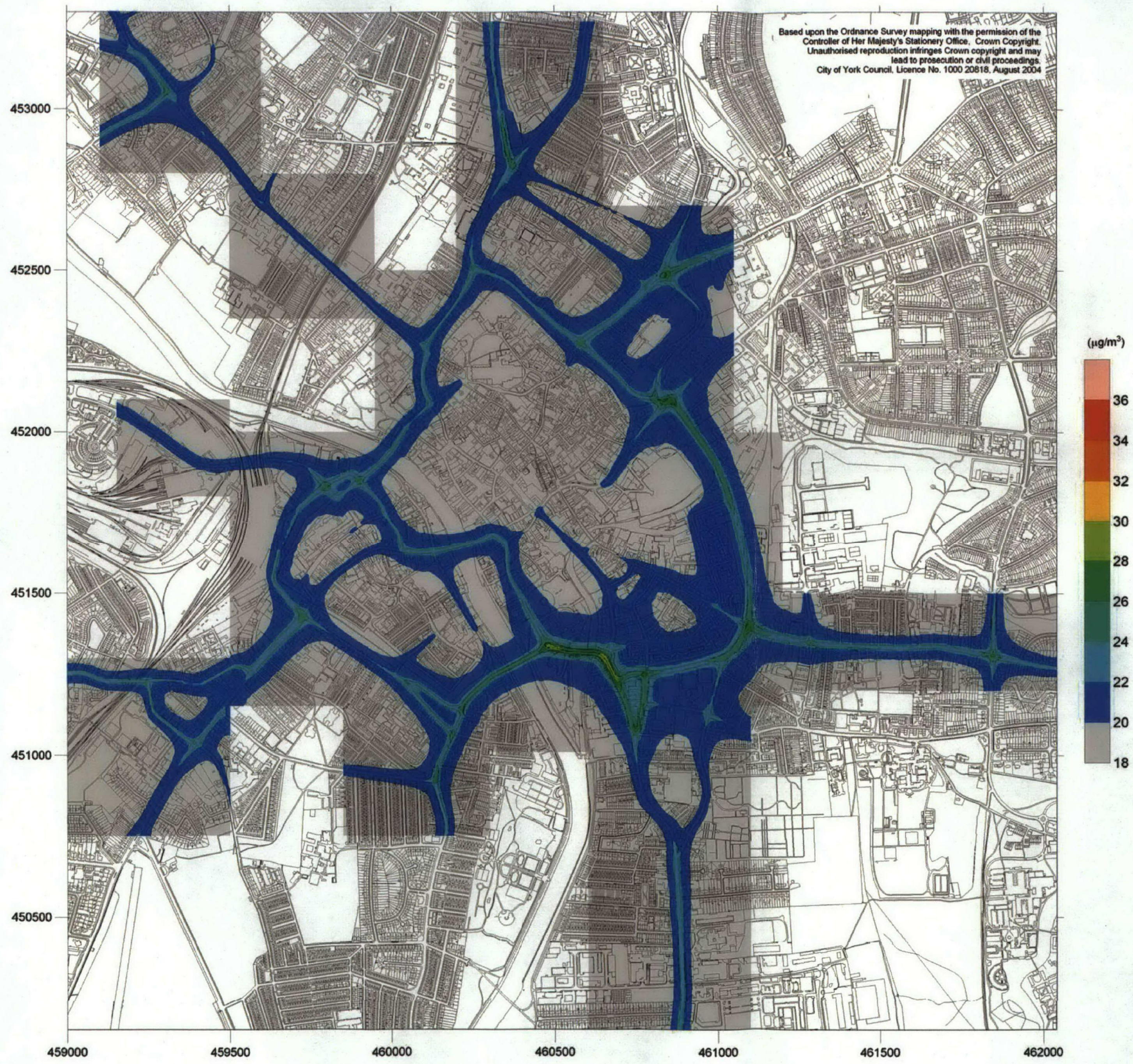

Figure J:
York AQMA PM_{10} Contour Plot,
2011, Do-Minimum

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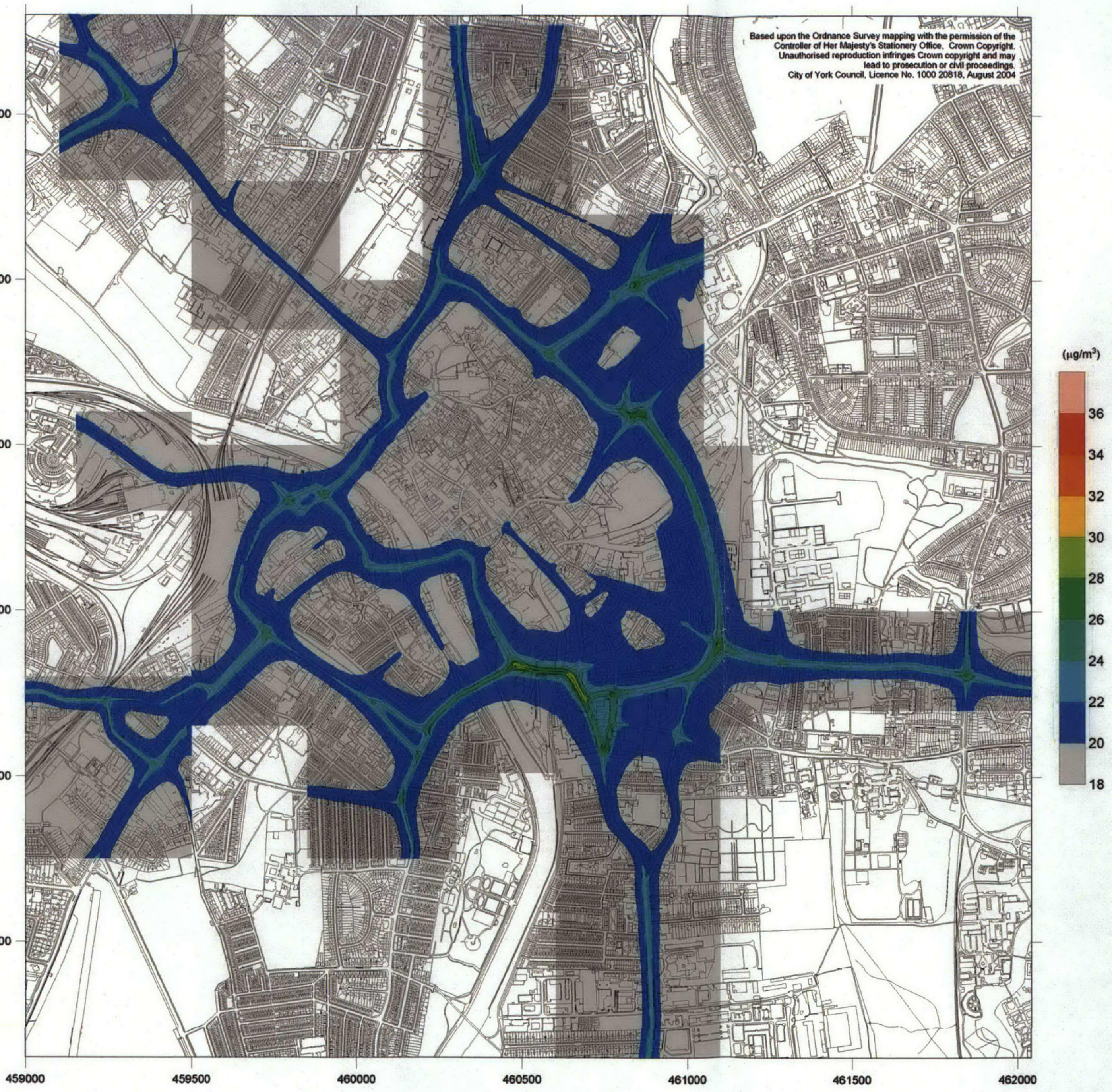

Figure K:
York AQMA PM_{10} Contour Plot,
2011, Do-Something

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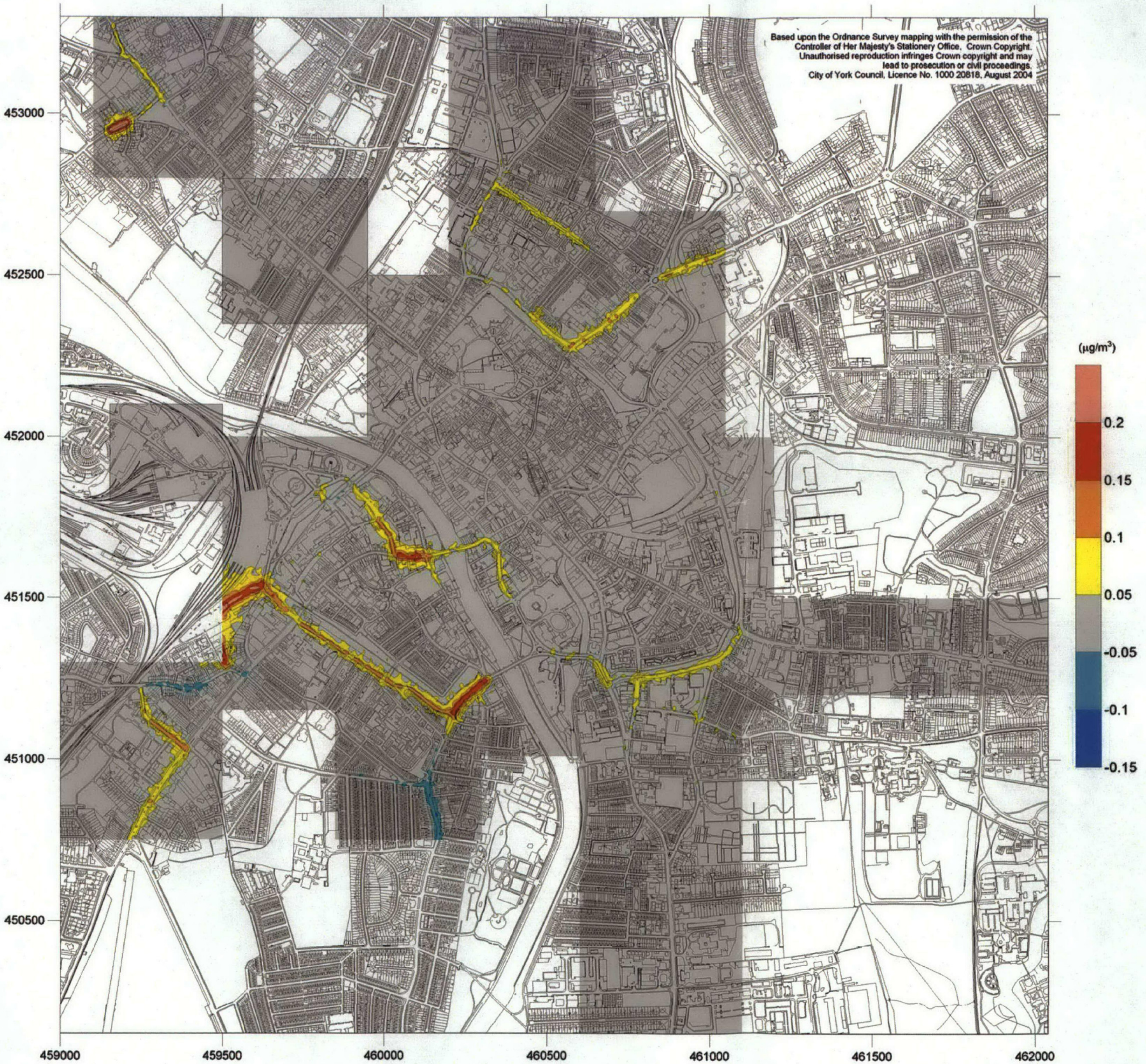

Figure L:
York AQMA PM_{10} Contour Plot, 2011, Impact of the York Central Development

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York Central – Transport MasterPlan Study

Rev No	Comments	Date
1	Incorporating comments from CYC	July 05
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