City of Edinburgh Council

Review and Assessment of Air Quality

Stage 3

2000

Contents

Executive Summary

The Environment Act 1995 requires all Local Authorities to undertake a review and assessment of air quality in their areas in order to determine whether the objectives set out in the Air Quality (Scotland) Regulations 2000 are likely to be achieved. The achievement of these objectives is by reference to the quality of air outside buildings or other natural or man-made structures; **and** where members of the public are regularly present, i.e. housing, schools, hospitals etc.

An air quality review and assessment is a three-stage process. This report constitutes a third stage and concentrates on two objectives, nitrogen dioxide (annual) and Particles. The other atmospheric pollutants covered in the Regulations have been shown, at the previous stages of this process, as being ones that will comply with the objectives and be achieved by the relevant dates.

The Government, since the start of this process, has undertaken a review of the national air quality strategy. This has resulted in revised objectives for Particles. This report concludes that these objectives are currently being met for that pollutant.

The two objectives for nitrogen dioxide currently remain provisional. However, these are set out in the Regulation and require to be met. The previous stages of this process indicated that the Hourly objective was already being achieved. This report concludes, however, that the Annual objective is unlikely to be met at eight locations:

1. **George Street**
2. **Gorgie Road / Ardmillan**
3. **Leith Walk / McDonald Road**
4. **North Bridge**
5. **Princes Street**
6. **Queen Street**
7. **Roseburn Terrace**
8. **West Maitland Street**

At each of these locations vehicular traffic is the principal source of emissions and analysis shows that nitrogen dioxide levels will continue to exceed the limits set out in Regulation. There are dwelling houses at these locations in buildings adjacent to the roads and it is reasonable to assume that the residents will be present in their houses or in the immediate vicinity for significant periods of time throughout the averaging period (twelve months). It will therefore be necessary to designate an Air Quality Management Area(s) to ensure that the air quality objective for the nitrogen dioxide (annual standard) is achieved by the required date of 31 December 2005.

An action plan covering the designated area will then have to be prepared within 12 months setting out how the authority intends to exercise its powers to ensure the objectives are achieved.

By the end of 2003 a further review and assessment of air quality must be carried out in order to measure progress towards achieving all the objectives.

1.0 Introduction

1.1 Statutory Requirements

Part IV of the Environment Act 1995 requires each local authority periodically to review air quality in its area. The Air Quality (Scotland) Regulations 2000 prescribe air quality objectives and the dates by when they must be achieved. Local authorities have to consider the present and likely future air quality in their areas, and assess whether the objectives are likely to be achieved by the relevant deadline.

Review of air quality means consideration of the levels of air pollutants for which objectives have been set, and the estimation of the likely future levels. Assessment of air quality is the consideration of whether those levels estimated for the future are likely to exceed the levels set down in the objectives.

The objectives to be included in Regulations for the purposes of Local Air Quality Management (LAQM) are: -

Pollutant	Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 $\mu g/m^3$	Running annual mean	31 December 2003
1,3-Butadiene	2.25 $\mu g/m^3$	Running annual mean	31 December 2003
Carbon Monoxide	11.6 mg/m^3	Running 8-hour mean	31 December 2003
Lead	0.5 $\mu g/m^3$	Annual mean	31 December 2004
	0.25 $\mu g/m^3$	Annual mean	31 December 2008
Nitrogen Dioxide [1]	200 $\mu g/m^3$ not to be exceeded more than 18 times a year	1-hour mean	31 December 2005
	40 $\mu g/m^3$	Annual mean	31 December 2005
Particles (PM10) [2]	50 $\mu g/m^3$ not to be exceeded more than 35 times a year	24-hour mean	31 December 2004
	40 $\mu g/m^3$	Annual mean	31 December 2004
Sulphur dioxide	350 $\mu g/m^3$ not to be exceeded more than 24 times a year	1-hour mean	31 December 2004
	125 $\mu g/m^3$ not to be exceeded more than 3 times a year	24-hour mean	31 December 2004
	266 $\mu g/m^3$ not to be exceeded more than 35 times a year	15-minute mean	31 December 2005

1. The objectives for nitrogen dioxide are provisional.
2. The Scottish Executive sees this new objective for particles as a staging post, not a final outcome. Work has begun on assessing the prospects for strengthening the new objective and the SE expects to make an announcement by the end of 2000.

Note: $\mu g/m^3$ = microgrammes per cubic metre

1.2 Air Quality Management

A review and assessment of air quality is the first, and key step in the LAQM regime. The main objective is to identify those areas where national policies and instruments, together with other anticipated changes, appear unlikely, of themselves, to deliver the national air quality objectives by the end of the relevant period. A review and assessment provides the benchmark for action by local authorities and the mechanism by which its success can be measured. It can also ensure that air quality considerations are incorporated into decision-making processes, particularly in related areas such as land use planning and traffic management.

The most significant judgement local authorities will be required to make is whether the air quality objectives are likely to be achieved in their area by the relevant deadline. Where, in the local authority's judgement, they are not likely to be achieved in any relevant locations, a local authority must designate those areas as Air Quality Management Area's (AQMA's).

The complexity and detail of a review and assessment should be consistent with the risk of failing to achieve air quality objectives by the end of the relevant period. This is done using a phased approach involving three stages. All local authorities should complete the first stage. The results of the first stage will indicate whether it is necessary to go on to the second stage. Similarly the results of the second stage will indicate whether it is necessary to go on to the third stage. By their design, the first two stages should be precautionary in nature, while the third stage should aim to provide an accurate assessment.

This report constitutes a third stage review and assessment and focuses on nitrogen dioxide and Particles. The first and second stage report, published in January 1999, concluded that the objectives would be met for the other pollutants listed above and that further work was not required at that time.

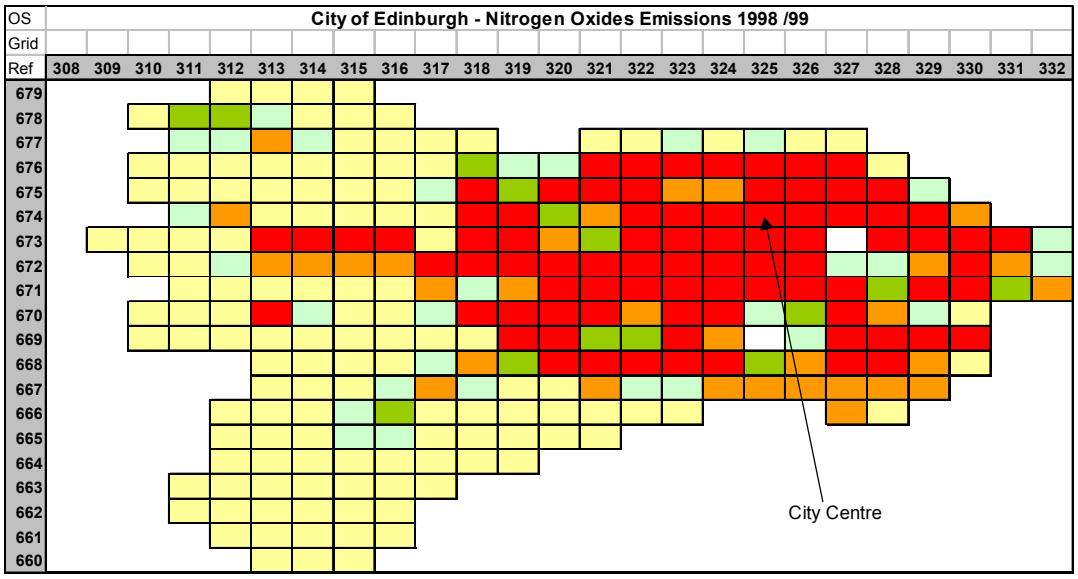
The primary objective of the Strategy and the Regulations is to ensure that everyone is able to enjoy a level of ambient air quality in public places which poses no significant risk to his or her health and quality of life, without imposing unacceptable social or economic costs. The degree of human exposure to pollutants is therefore a key element in determining relevant locations at which air quality needs to be reviewed and assessed. The Regulations provide that compliance with the objectives is to be determined by reference to the quality of air at outdoor locations where members of the public are regularly present.

For the PM10 and annual objective for nitrogen dioxide, reviews and assessments should be focused on the following non-occupational, near ground level outdoor locations: background locations; roadside locations; and other areas of elevated pollutant concentrations where members of the public might reasonably be expected to be regularly exposed to outdoor air for a substantial part of the day (e.g. in the vicinity of housing, schools or hospitals etc). Exposure at these locations should be regular over a year. There is a link between indoor and outdoor air quality, however, and as people spend most of their time indoors, the building façade is considered to be an appropriate location at which to assess concentrations. Where a building is set alongside a road, this would be the building façade closest to the road.

1.3 Review and Assessment

For the previous stage of the review and assessment process an emissions inventory was compiled on a 1km X 1km grid square. This identified road transport as the most significant source of nitrogen oxides and Particles within Edinburgh. Mobile sources accounted for up to 96% nitrogen oxide emissions. Chart 1 displays a graphical representation of nitrogen oxides emissions across the City of Edinburgh Council area. It can seen that the highest emissions occur mainly in and around the city centre.

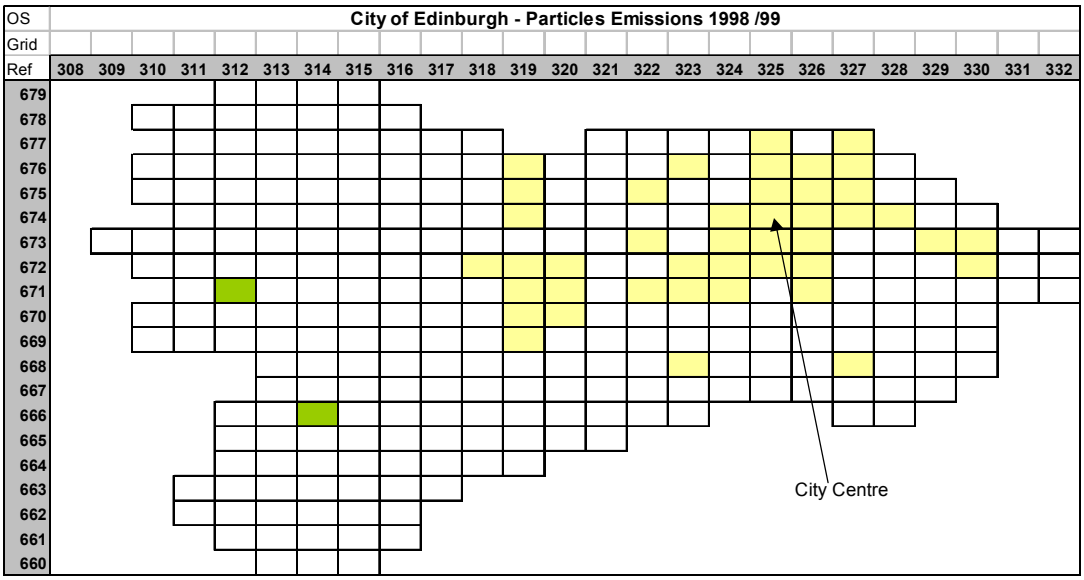
Chart 1



Tonnes / sq.km / annum	
	More than 50
	30 to 50
	20 to 30
	5 to 20
	less than 5

Similarly, Chart 2 displays a graphical representation of Particles emissions

Chart 2



Tonnes / sq.km / annum	
	More than 50
	30 to 50
	20 to 30
	5 to 20
	less than 5

1.4 Areas of Potential exceedences

The areas identified as having the highest emissions levels typically have high traffic volumes on the radial routes (main roads) leading to and through the city centre. Additionally many of these roads have tenement properties, typically of four storeys, within two to five metres of the kerbside. The area of tenements extends approximately two kilometres from the city centre. Such buildings often have commercial properties at ground level with the first to third floors usually occupied by dwelling houses. This layout of roads and buildings creates “canyons” which inhibit dispersal of pollutants. Clearly, the close proximity of housing to busy roads at these locations may lead to a risk of exposure to nitrogen dioxide and Particles concentrations that exceed the National Air Quality Strategy objectives. Table 1 below shows 1999 traffic flow data on various roads in and around the city centre.

Table 1

Road Link	24-hr annual average flow
Haymarket Ter	37151
Queen Street	35516
Leith Walk	33000
Lothian Road	31025
Slateford Road	22936
London Road	22203
Calder Road (A)	22000

Calder Road (B)	21823
Pleasance	21575
Ferry Road	20431
Deanhaugh Street	19000
Nicolson St	17752
South Bridge	17752
Cowgate	17273
North Bridge	17000
Lanark Road	17000
Holyrood Road	17000
Queensferry Road	16087
Grassmarket	15925
Morningside Road	15590
Dundas St	14346
Lauriston Place	14125
Inverleith Row	14081
Morrison St	13723
Brougham St	12616
Dalry Road	11777
Charterhall Road	11709
George IV Bridge	11159
Queensferry St	11000
Hanover St	10895

The adjacent table shows known traffic flow data and gives an indication of areas where it might be appropriate to measure or model pollutant concentrations.

Traffic counts including vehicle type (i.e. motorcycle, car, LGV, HGV and bus) and speeds were undertaken by automatic monitoring equipment at three real-time pollution monitoring sites (Castle St, Cowgate and Haymarket). The measurement period was for 12 months and gave the annual 24-hr average daily flow.

2.0 Nitrogen Dioxide (NO_2)

2.1 Introduction

Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen and are collectively referred to as NOx. All combustion processes produce some NOx emissions, largely in the form of nitric oxide, which is then converted to nitrogen dioxide, mainly as a result of reaction with ozone in the atmosphere. Only nitrogen dioxide is associated with adverse effects upon human health.

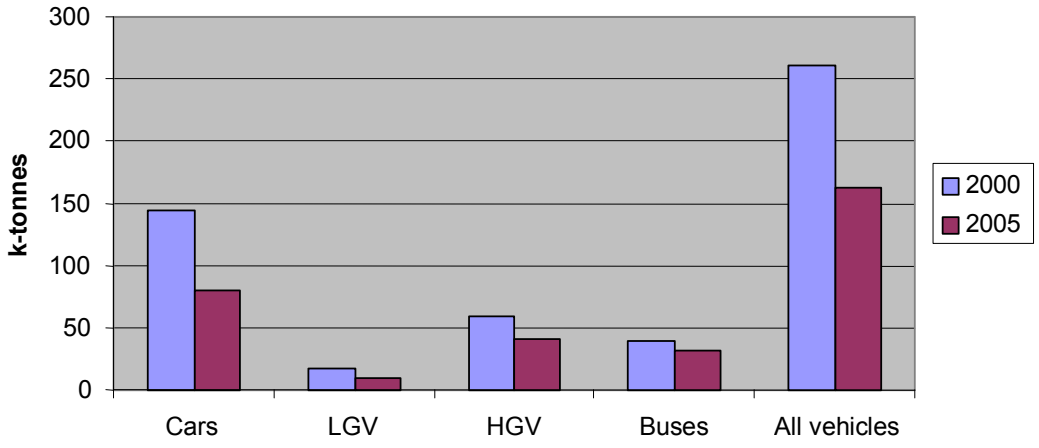
2.2 National Perspective

The national perspective is that policies currently in place, or to take effect before 2005, will lead to the annual average objective being achieved at all background locations, (except inner London), and at most roadside locations by the end of 2005. They are unlikely in themselves, however, to lead to the objective being met at all busy roadside locations. Traffic management measures are therefore likely to be needed in some heavily trafficked urban areas for the annual objective to be achieved in all locations.

Chart 3 details the predicted decline in emissions of nitrogen oxides from urban road transport between 2000 and 2005.

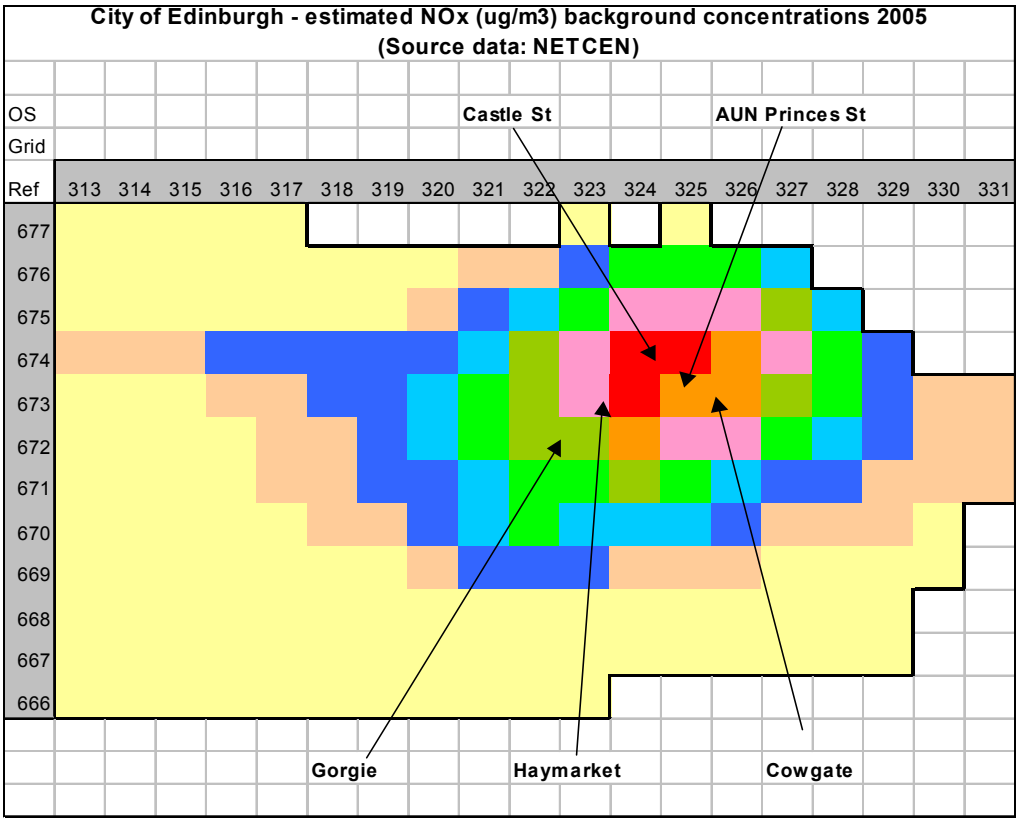
Chart 3

UK urban road transport emissions of NOx (2000 - 2005)
Source - National Air Quality Strategy



Data giving the estimated NOx background concentrations for 2005 were obtained from the National Environmental Technology Centre (NETCEN). These have been plotted against OS grid references and are displayed graphically in the chart 4 below. It can be seen that the highest predicted concentrations are in and around the city centre.

Chart 4



Key	
ug/m3	
55-58	
50-54	
45-49	
40-44	
35-39	
30-34	
25-29	
20-24	
<20	

Each of the locations shown on the chart are automatic real-time monitoring sites for Nitrogen dioxide.

2.3 Methodology

LAQM Guidance note TG4 states that if chemiluminescent or diffusion tube monitoring data are available in the authority's area, and the measurements are representative of roadside or kerbside locations relevant to public exposure then these data may be used in preference to, or in conjunction with, modelling predictions. This Third Stage review and assessment was based upon the use of chemiluminescent analysers at five locations, with monitoring carried out for a full period of 1 year

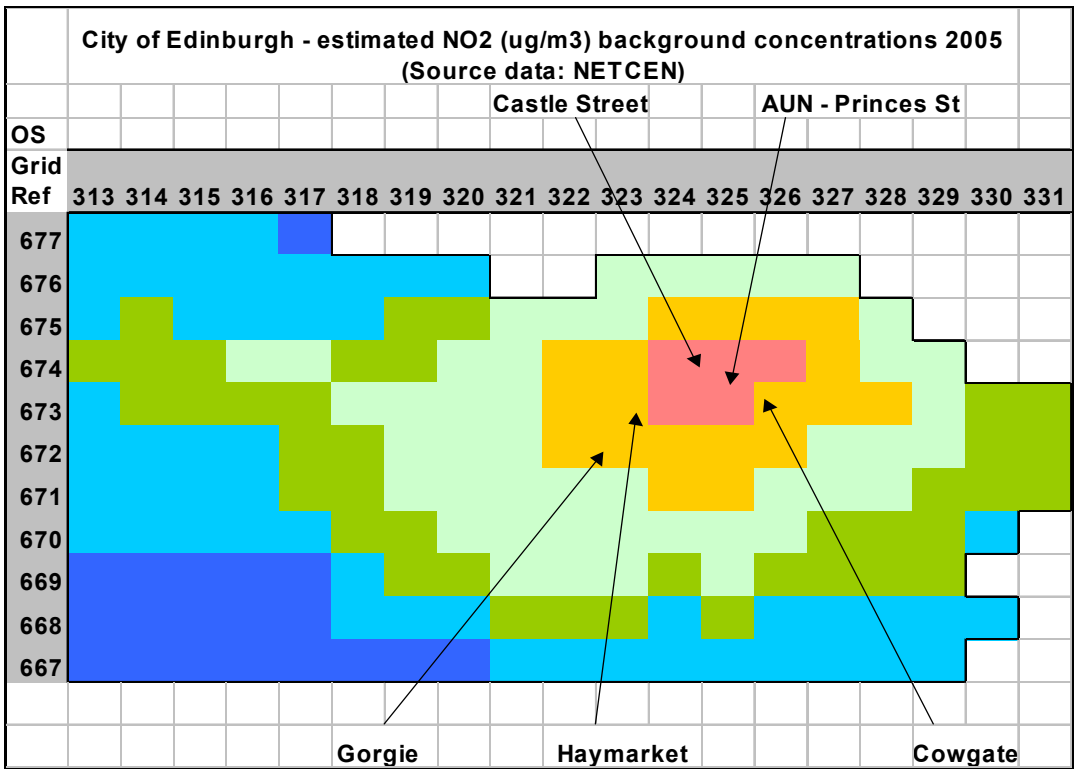
(1 March 1999 – 28 February 2000). Data capture at all sites exceeded 90%. Further monitoring with a chemiluminescent analyser was undertaken for a 3-month period in Leith Walk and data capture was 96%. Diffusion tubes were sited at 49 other locations for the same period to assist in determining the spatial variability of concentrations. Two diffusion tubes were co-located at each analyser-sampling head to determine the equivalence of diffusion tube results against a chemiluminescent analyser. The location of all monitoring sites is set out in Section 6 Maps.

Where actual traffic data (volume, speed and type) is available this has been input into the DMRB screening model and the resulting nitrogen dioxide concentration compared with the current concentration and that predicted for 2005.

NOTE:
Modelling traffic emissions is a delicate issue. Such emissions are highly related to vehicle operating modes such as idle, steady-state cruise, various levels of acceleration and deceleration. These models must therefore, be able to account for complex changes in traffic patterns. The highest emission rates of CO and HC are generally associated with low average speeds. Frequent stops and starts, acceleration and decelerations in response to traffic congestion or other disruptions to vehicle progress typify a journey of low average speed. These conditions lead to high fuel consumption and inefficient operation of emissions control systems. As average speed increases, the operation of the vehicle becomes more efficient and so less fuel is used per kilometre and pollutant emission rates decrease. At higher speeds there is a tendency for emissions and fuel consumption to increase again as the engine struggles to provide the additional power required to overcome aerodynamic drag. Oxides of nitrogen display an almost inverse behaviour because, in general, high engine temperatures reached during combustion increase their rate of formation. As temperatures are highest when an engine operates under high speed and load conditions, NOx emission rates are highest at high average vehicle speeds. Furthermore it has been noted that models can provide significantly different results to each other. The Design Manual for Roads and Bridges model (DMRB) has been used as part of this review and assessment. It is known to be a conservative model which tends to over-predict concentrations. Accordingly, its use has been restricted to comparing results with the recorded monitoring values (adjusted for 2005)to give further confidence in the data sets.

Chart 5 shows the predicted background nitrogen dioxide concentrations for 2005. Obtaining numerical data from NETCEN and plotting against the relevant Ordnance Survey grid square references has produced this chart. The real-time monitoring locations are also shown. It can be seen that the real-time monitoring sites are within the areas predicted to have the highest concentrations.

Chart 5



Values	
ug/m3	Key
>=40	
35-39	
30-34	
25-29	
20-24	
15-19	
10-14	
<10	

This chart shows that background concentrations in the central area are predicted to be approximately 15% lower than the maximum imposed by the standard. However the contribution to nitrogen dioxide concentrations from traffic still requires to be added. A number of factors such as traffic volumes, topology, meteorology and season will influence NO_x to NO_2 conversion rates and dispersal.

Details of the monitoring locations can be found in Section 6 Maps. These sites have been chosen for a number reasons including the availability of space for the monitoring units so that they do not cause an obstruction to traffic. In the case of North Castle Street, Haymarket Terrace and Gorgie Road these locations are representative of roads with high traffic volumes that have tenements, and thus dwelling houses, which form canyons. Canyons are known to inhibit rapid dispersal of pollution. The Cowgate site was chosen because of its proximity to a busy road junction near the city centre, housing, nursery school and the fact that a higher level road crosses the road nearby. The AUN Princes Street site provides comparative data.

2.4 Measurements

Table 2 shows the concentrations recorded at the national automatic urban network site since 1992. Simple linear trend has been used to indicate probable values up till 2005.

Table 2

AUN values		µg/m^3
Actual	1992	54
	1993	52
	1994	50
	1995	50
	1996	48
	1997	48
	1998	48
	1999	42
Simple linear trend prediction	2000	43
	2001	42
	2002	40
	2003	39
	2004	38
	2005	**37**

Note:
The NAQS strategy documents estimates that 2005 concentration at Edinburgh centre will be 34 µg/m^3

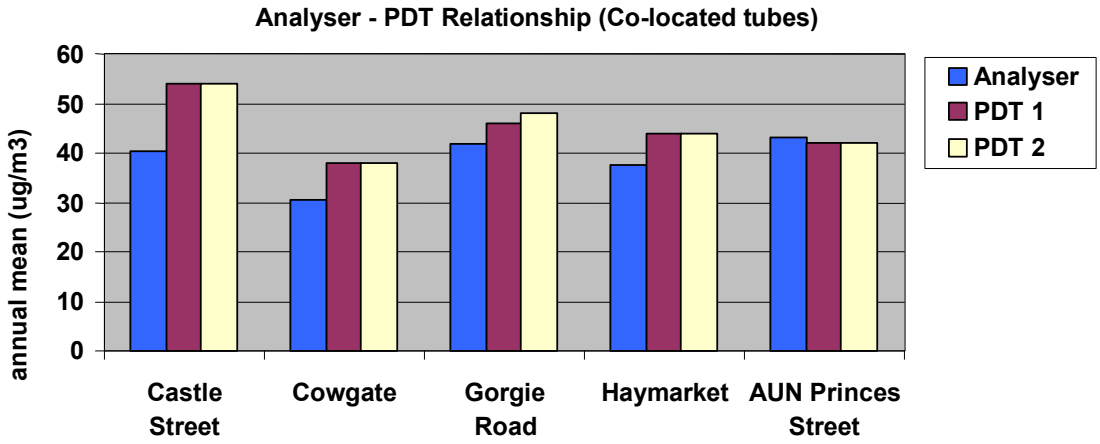
Table 3 shows the nitrogen dioxide annual average values recorded at the real-time monitoring sites by the chemiluminescent analysers and the two co-located passive diffusion tubes.

Table 3

Co-located NO_2 Analyser / PDT Tubes values (µg/m^3)						
	Analyser	**PDT 1**	**PDT 2**	**PDT mean**	**PDT % variation**	**Site Type**
Castle Street	40.3	53.2	53.4	53.3	32.2	Roadside
Cowgate	30.6	39.1	39.1	39.1	27.7	Roadside
Gorgie Road	41.8	46.6	47.7	47.2	12.7	Roadside
Haymarket	37.6	43.7	42.8	43.3	15.1	Roadside
AUN Princes Street	43.2	42.7	42.1	42.4	**-1.9**	Background
Mean	38.71	45.06	45.02	45.04	**17.20**	**All % variation**
Note: PDT% Variation is the variation between the analyser value and the mean of the PDT values.					**21.90**	**Roadside % variation**

The real-time analysers provide the most accurate and precise values. Each of these sites, except Princes St, is at a busy roadside location close to dwelling houses. These values indicate that current concentrations are close to the standard to be met by 2005. The co-located passive diffusion tubes show an average 17.2% variation from the analyser values. The average variation at the roadside sites being 21.9%. These values are displayed in graphical form below.

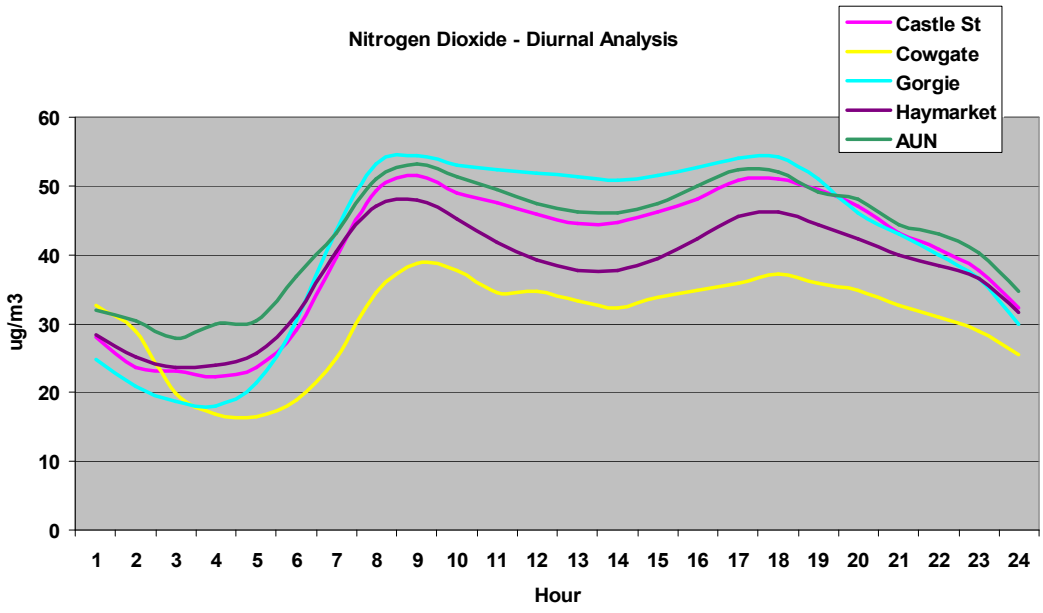
Chart 6



The standard to be met by 2005 is 40μg/m^3 and it can be seen that concentrations at these locations are currently below or close to achieving that. It is worth noting that the highest value is at the AUN Princes Street site; although it is furthest from the roadside, the sheltered location and significantly higher bus traffic volumes on Princes Street may account for this.

A diurnal analysis (chart 7) has been undertaken for each of the automatic monitoring sites. This shows the variations in levels during an average day.

Chart 7



As expected this displays a strong relationship to traffic flows during the day with the highest concentrations occurring at the rush hour peaks.

Predictions of concentrations for 2005 have been made using 1999/2000 data and applying the correction factor detailed in Guidance note TG4. See example below.

Correction factors to estimate annual mean roadside/kerbside NO2 concentrations for future years. (Source TG4)

Year	Correction factor to be applied
1996	1.00
1997	0.97
1998	0.94
1999	**0.92**
2000	0.90
2001	0.87
2002	0.85
2003	0.83
2004	0.81
2005	**0.79**

Example:

To correct measurement data to 2005. Assume the 1999 measured NO2 concentration is 30 $\mu g/m^3$. The estimated 2005 concentration is then:

30 x (0.79/0.92) = 25.8 $\mu g/m^3$

A further correction is then made for the distance between the sampling point and the nearest building façade. The assistance of the Governments review and assessment helpdesk was sought in relation to this. The following factors were used (0-2 metres x 0.95, 2-5 metres x 0.9, >5 metres x 0.75). A final correction is made to compensate for the recorded variance of diffusion tubes from the four real-time automatic analysers sited at the roadside (see Table 3). Accordingly, it was decided to use the demonstrated average variation of passive diffusion tube values from chemiluminescent analyser values at all locations, this being +17.2%. This value is used to reduce the kerb to façade value by 17.2% to provide a final corrected estimated value for the year 2005.

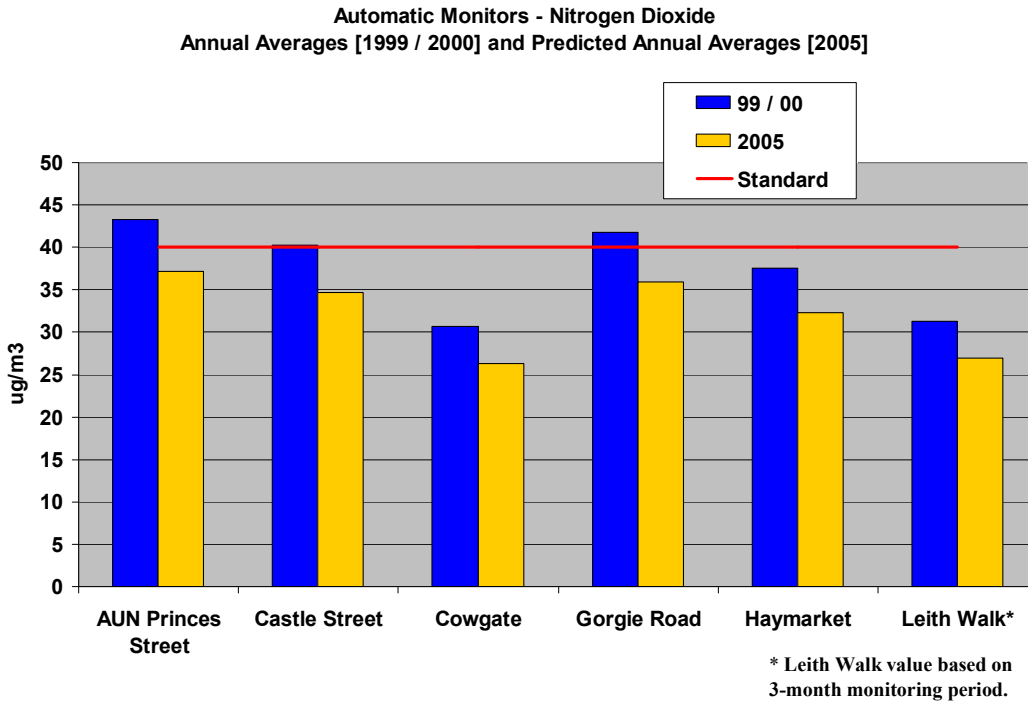
Table 4

Nitrogen Dioxide Passive Diffusion Tube Network ($\mu g/m^3$)					
Site	Site No	1999 value	2005 estimated value	Kerb / Façade distance correction	2005 Final **estimated** value
West Maitland Street	2	82.26	70.74	67.21	57.34
Roseburn Terrace	20	78.43	67.45	64.08	54.68
North Bridge	23	76.52	65.81	59.23	50.53
Princes Street	22	68.87	59.23	56.27	48.01
Queen Street	32	66.96	57.58	51.82	44.22
George Street	30	61.22	52.65	50.01	42.67
Princes Street	21	76.52	65.81	49.36	42.11
Gorgie Road	4	59.30	51.00	48.45	41.34
Leith Walk-McDonald Road	19	61.22	52.65	47.38	40.43
George Street	31	57.39	49.36	44.42	37.90

North Castle Street	44A	53.56	46.07	41.46	35.37
North Castle Street	44B	53.56	46.07	41.46	35.37
Charlotte Street	26	63.13	54.29	40.72	34.74
St Johns Road	1	49.74	42.77	40.64	34.67
Morningside Road	6	49.74	42.77	40.64	34.67
Leith Walk	10	49.74	42.77	40.64	34.67
York Place	38	51.65	44.42	39.98	34.11
Leith Walk	5	47.83	41.13	39.07	33.34
Gorgie Road	45B	47.83	41.13	39.07	33.34
Lothian Road	25	49.74	42.77	38.50	32.85
Deanhaugh Street	11	45.91	39.48	37.51	32.01
Gorgie Road	45A	45.91	39.48	37.51	32.01
St Andrews Square	39	57.39	49.36	37.02	31.58
Grassmarket	42	57.39	49.36	37.02	31.58
Home Street	8	44.00	37.84	35.95	30.67
Clerk Street	15	44.00	37.84	35.95	30.67
Inverleith Row	16	44.00	37.84	35.95	30.67
Howe Street	34	44.00	37.84	35.95	30.67
St Combe Street	29	45.91	39.48	35.54	30.32
Lauriston Street	24	53.56	46.07	34.55	29.48
Dundas Street	36	42.09	36.19	34.38	29.34
Waverley Bridge	12	51.65	44.42	33.31	28.43
Great Stuart Street	28	40.17	34.55	32.82	28.00
Portobello High Street	40	40.17	34.55	32.82	28.00
Slateford Road	9	42.09	36.19	32.57	27.79
Cowgate	13	47.83	41.13	30.85	26.32
Calder Road	3	45.91	39.48	29.61	25.27
Charlotte Street	27	45.91	39.48	29.61	25.27
Melville Drive	41	44.00	37.84	28.38	24.21
Haymarket Terrace	46A	44.00	37.84	28.38	24.21
Haymarket Terrace	46B	44.00	37.84	28.38	24.21
Princes Street Gardens East	18	42.09	36.19	27.15	23.16
Princes Street Gardens East	18A	42.09	36.19	27.15	23.16
Princes Street Gardens East	18B	42.09	36.19	27.15	23.16
Melville Drive	41A	42.09	36.19	27.15	23.16
Melville Drive	41B	42.09	36.19	27.15	23.16
Great King Street	37	32.52	27.97	26.57	22.67
India Street	33	30.61	26.32	25.01	21.34
Heriot Row	35	30.61	26.32	25.01	21.34
High Street	14	38.26	32.90	24.68	21.06
Cowgate	43A	38.26	32.90	24.68	21.06
Cowgate	43B	38.26	32.90	24.68	21.06
Queensferry Road	17	36.35	31.26	23.44	20.00
Lanark Road	7	30.61	26.32	19.74	16.84

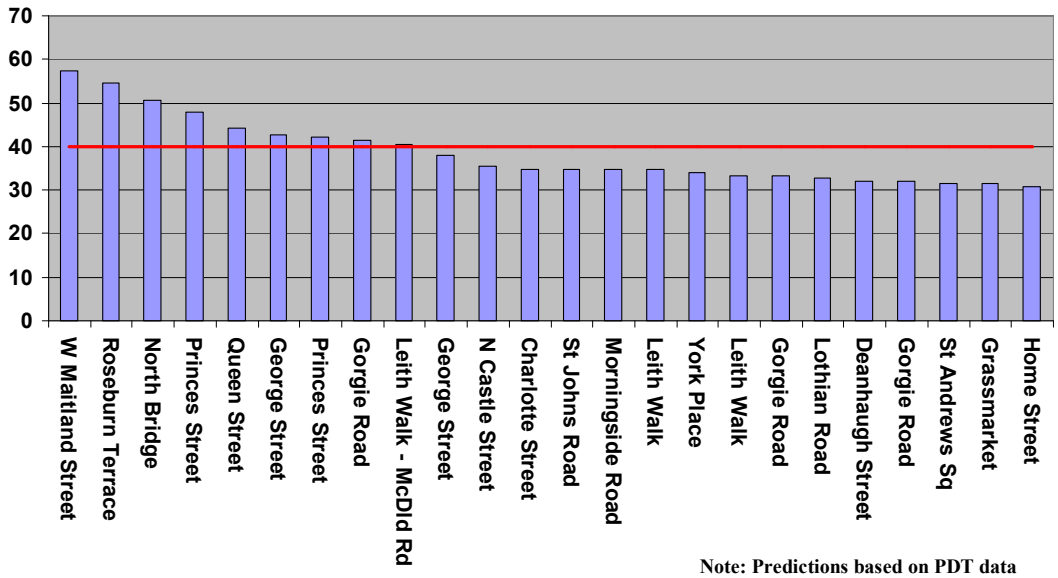
It should be noted that concentrations predicted using PDT values are not as accurate and precise as data produced by real-time automatic analysers. The overall bias for all sites is set out in Table 3 but there may be significant variations from site to site. Corrections (as set out in TG4) have been applied to the values recorded at the real-time monitoring sites. The predicted values at all sites for 2005 are shown in Charts 8 (automatic monitors), 9 and 10 (passive diffusion tubes).

Chart 8



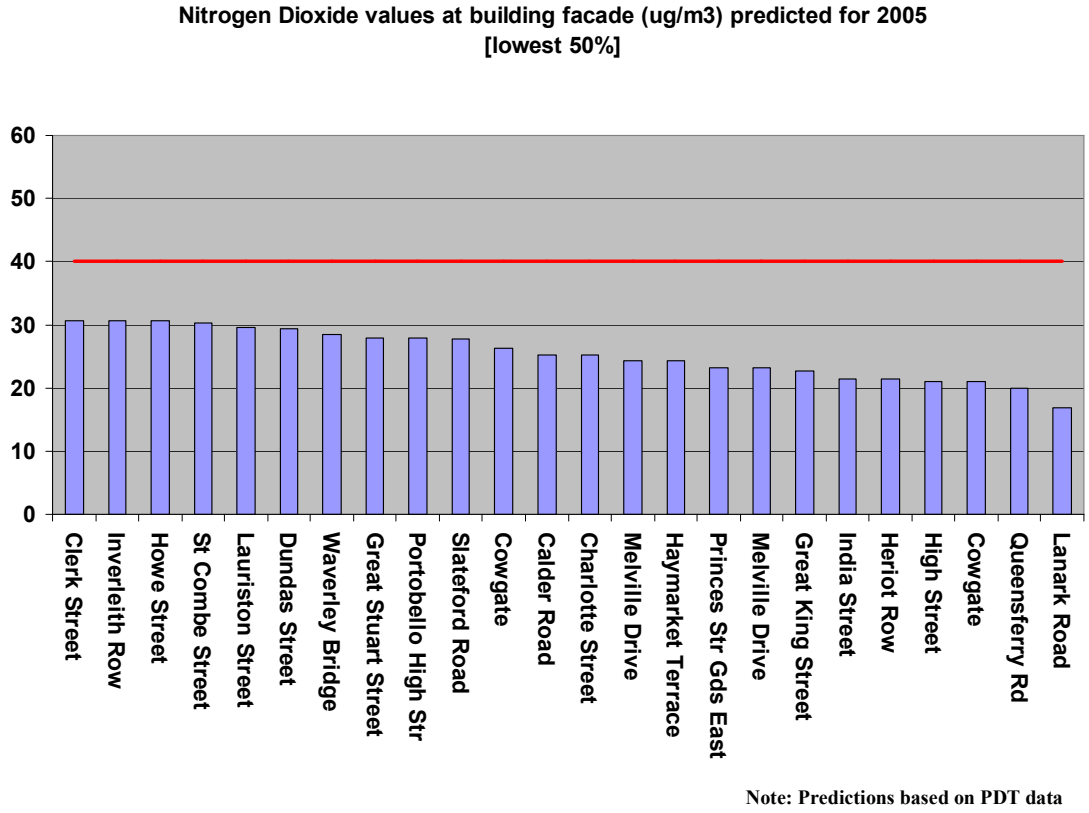
* Leith Walk value based on 3-month monitoring period.

Chart 9



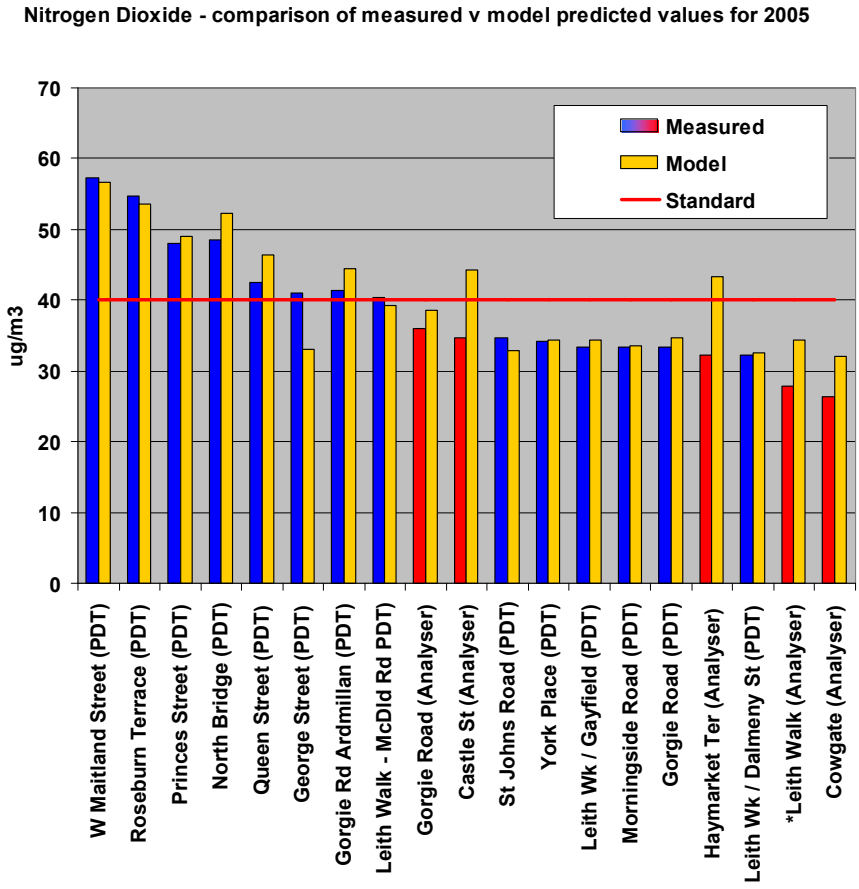
Note: Predictions based on PDT data

Chart 10



As further confirmation of predicted values for 2005, the DMRB model (Stanger version) was used for predictions at those locations with the highest recorded current values. Chart 11 displays all locations where measured **or** modelled values exceeded 30μg/m^3. Sites with predictions based on real-time analyser values are coloured red.

Chart 11



2.5 Assessment

The predicted values detailed in charts 8,9,10 and 11 indicate that the annual standard for nitrogen dioxide could potentially be exceeded at eight locations. These are:

1. West Maitland Street
2. Roseburn Terrace
3. North Bridge
4. Princes Street
5. Queen Street
6. George Street
7. Gorgie Road / Ardmillan
8. Leith Walk / McDonald Road

Crucial to the assessment is the requirement in the Air Quality (Scotland) Regulations 2000 for the achievement of the objectives to be determined by reference to the quality of the air at locations which are situated outside of buildings, **and where members of the public are regularly present**. Statutory

guidance states that local authorities should have regard to those locations where members of the public are **likely** to be regularly present and are **likely** to be exposed over the averaging period of the pollutant and that exceedances of the objectives should not be considered **where relevant public exposure would not be realistic.**

In the case of West Maitland Street, Roseburn Terrace, North Bridge, Gorgie Road / Ardmillan and Leith Walk / McDonald Road there are significant numbers of dwelling houses in tenements within 2 – 5 metres of the roadside. Research shows that there two buildings containing dwellings in Princes Street, six buildings containing dwellings in George Street and eleven buildings containing dwellings in Queen Street.

It is reasonable to assume that residents at these locations could be present in their houses or in the immediate vicinity for significant periods of time throughout the averaging period (twelve months). Accordingly, it is considered that at **all** the locations listed above the air quality objectives for the nitrogen dioxide annual standard are unlikely to be achieved.

3.0 Particles (PM10)

3.1 Introduction

Atmospheric levels of particles can be categorised into three sources. One, primary particles emitted directly by combustion sources. Two, secondary particles formed in the atmosphere by chemical reaction. Three, so-called coarse particles formed from a variety of primarily non-combustion sources such as wind-blown dust, mining, quarrying, construction, re-suspended road dust and brake and tyre debris.

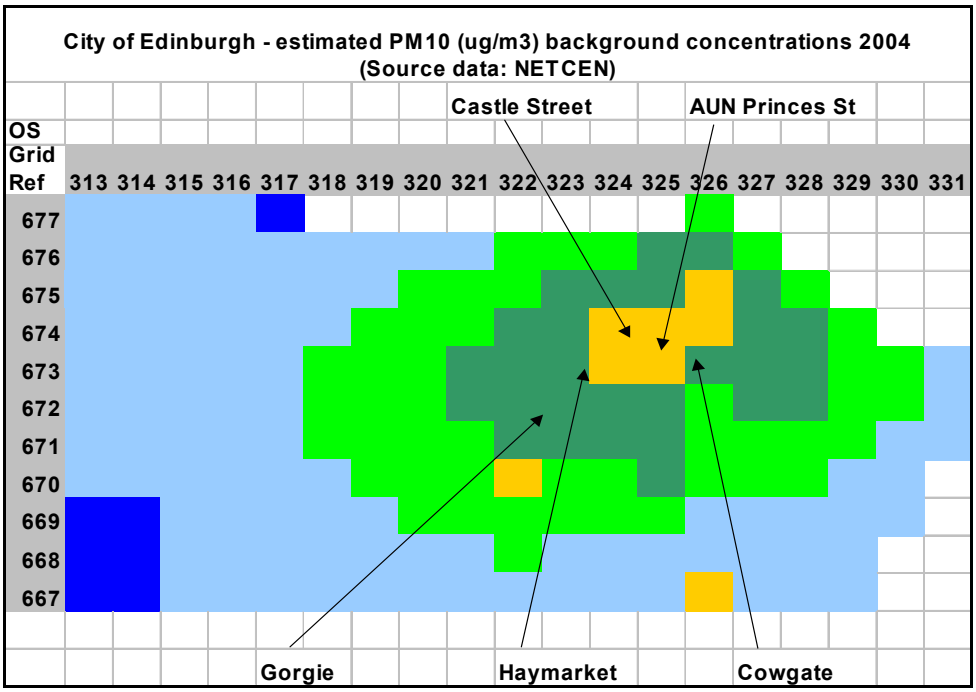
3.2 National Perspective

The national perspective is that in years of typical meteorology, policies already in place should lead to compliance with the objectives (50μg/m3 as a 24-hour mean, not to be exceeded more than 35 times a year, and 40μg/m3 as an annual mean) in all urban background locations. There are, however, likely to be exceedances of the 24 hour objective at busy roadsides in some large urban areas and also, possibly, in the vicinity of some industrial plant. In years when there are prolonged periods of air movements from mainland Europe, which occur about once every five to ten years, the objectives are likely to be achieved at urban background locations across most of the UK, with the exception of central London. There is also the potential for exceedances of the 24-hour objective at busy roadsides in some large urban areas and in the vicinity of some industrial plant and/or fugitive emissions sources.

3.3 Methodology

Four real-time analysers were used for measurements of Particles. Three of these were located at the same sites as nitrogen dioxide analysers (North Castle St, Haymarket Terrace and Cowgate). The fourth analyser is located at the AUN Princes St site. Three of the analysers are Tapered Element Oscillating Microbalance (TEOM's) with the Cowgate site having a Beta Attenuation Monitor (BAM). For the purposes of comparison with the revised UK standard the TEOM data have been multiplied by a factor of 1.4 and should be viewed as equivalent of gravimetric measurements. (Note: Guidance Note TG4 suggests a factor of 1.3 is used, however, as a precautionary approach a factor of 1.4 was chosen to ensure concentrations were not under measured).

Chart 12



Values	
ug/m3	Key
>=40	
22	
21	
20	
19	
18	
17	
<16	

Chart 13 shows the predicted background Particles concentrations for 2004. Obtaining numerical data from NETCEN and plotting against the relevant Ordnance Survey grid square references has produced this chart. The locations of real-time monitoring locations are also shown. It can be seen that the monitoring sites are within the areas predicted to have the highest concentrations.

The National Air Quality Strategy document details predicted PM10 concentrations for 2005 at Edinburgh centre. (Note: these are based on both 1995 and 1996 years meteorology).

Table 5

Predicted PM10 concentrations for 2005 based on 1995 and 1996 analysis µg/m^3 (grav)	
Annual Mean	
2005 estimate based on 1996	22
2005 estimate based on 1995	23
Fixed daily means above 50µg/m^3 (grav)	
2005 estimate based on 1996	8
2005 estimate based on 1995	12

3.4 Measurements

Table 6 contains a summary of the annual mean values and the number of fixed daily means when concentrations exceeded 50μg/m^3

Table 6

Particles (PM10) Annual Mean values				
Site	**AUN Princes St**	**Cowgate**	**Castle St**	**Haymarket**
Annual mean 40μg/m^3 (grav)	**20.81**	**26.38**	**23.30**	**22.62**
Number of days greater than 50μg/m^3 (grav)	**4**	**10**	**6**	**7**

In comparison with the annual mean standard of 40μg/m^3 (grav) all sites recorded significantly lower values. The number of fixed daily means greater than 50μg/m^3 (grav) was also significantly lower than the permitted maximum of 35.

Charts 14 – 17 display the daily mean concentrations recorded at each site throughout the monitoring period.

Chart 13

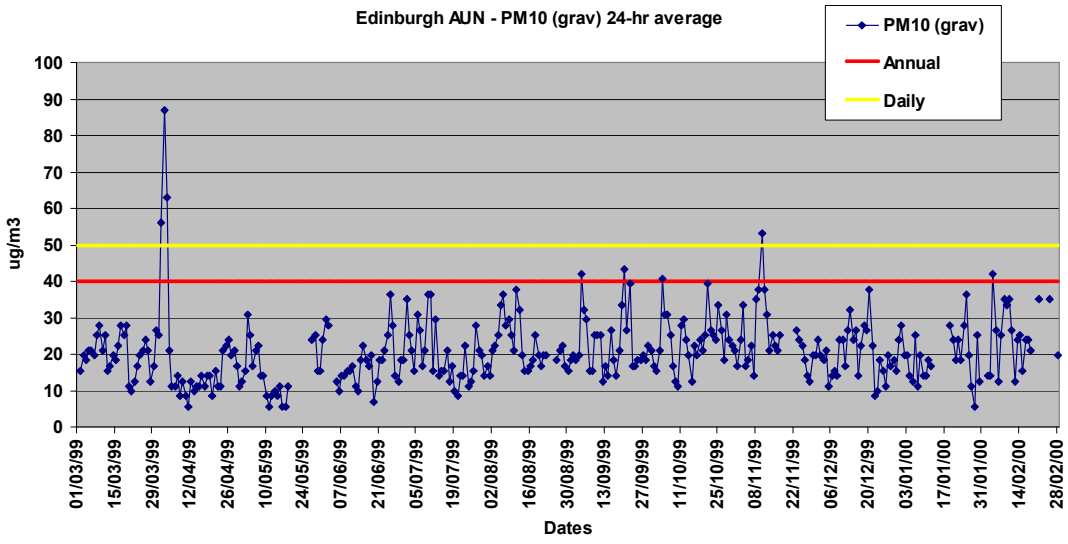


Chart 14

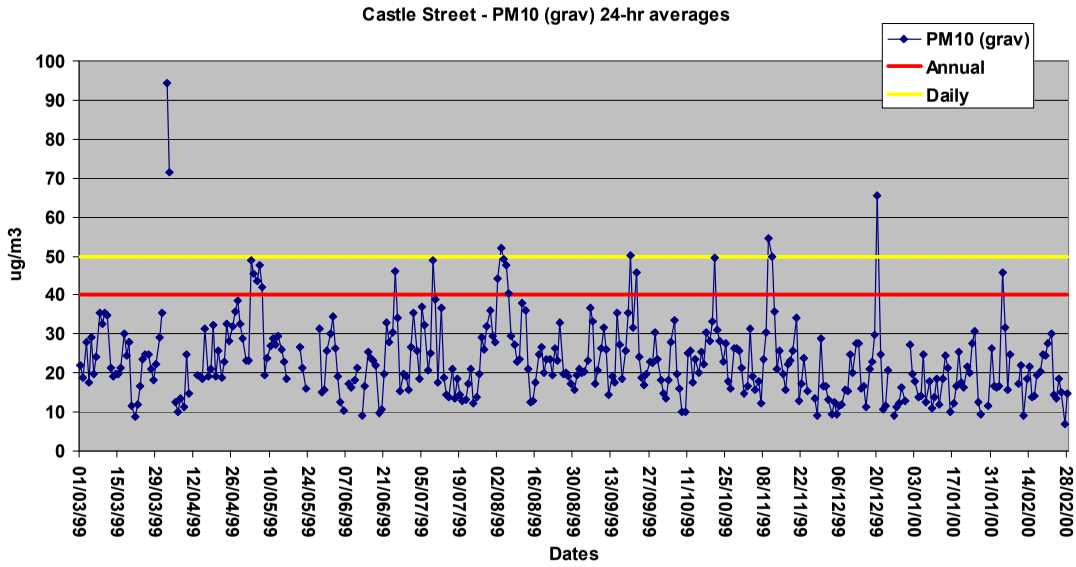


Chart 15

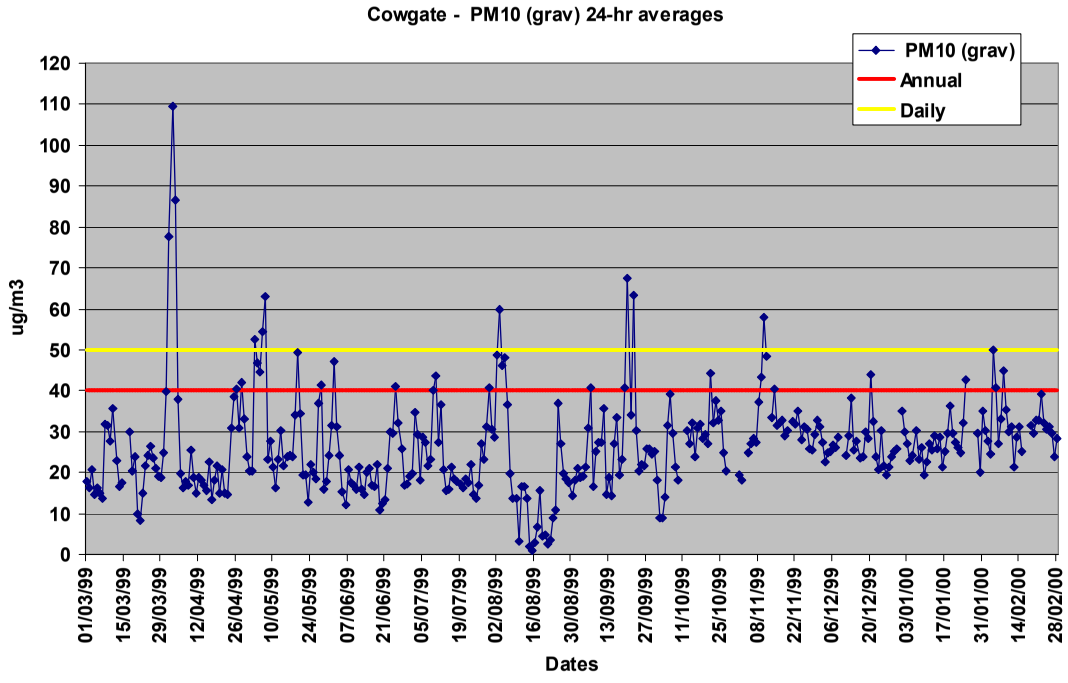
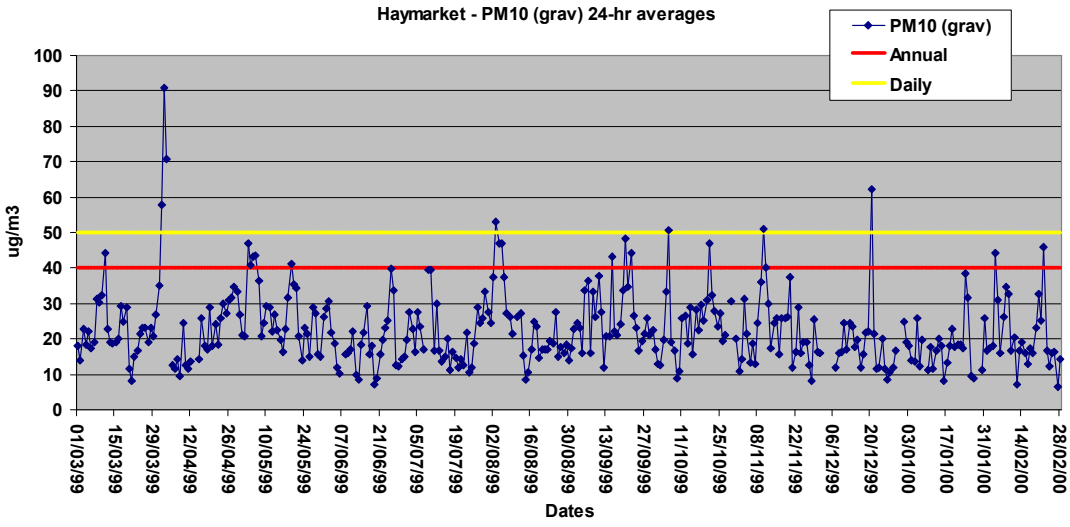


Chart 16



3.5 Modelling Results

As further confirmation of likely concentrations in 2005 the DMRB was used to model at various locations where traffic volumes are high and close to dwelling houses. These results are given in Table 7.

Table 7

Particles – Results from DMRB model **Predicted annual mean concentrations for 2005 μg/m^3 (grav)**	
Location	**Concentration**
Castle Street	23.56
Gorgie Road – White Park	21.62
Gorgie Road	21.62
Ardmillan	22.26
Haymarket Terrace	22.38
Gayfield	22.49
McDonald Road	22.16
Morningside Road	19.67
North Bridge	23.45
Roseburn Terrace	23.31
St Johns Road	20.60
York Place	22.89
West Maitland Street	25.22

4.0 Conclusions

4.1 Nitrogen Dioxide

Extensive monitoring has been undertaken throughout the areas most at risk of failing to meet the nitrogen dioxide annual mean objective. Using methods, set out in technical guidance, to predict future concentrations at the nearest building facades has shown that there are eight locations where the objective is not likely to be met. These are:

1. George Street
2. Gorgie Road / Ardmillan
3. Leith Walk / McDonald Road
4. North Bridge
5. Princes Street
6. Queen Street
7. Roseburn Terrace
8. West Maitland Street

In each case these are heavily trafficked roads or junctions which have dwelling houses in buildings situated within 2 – 5 metres of the kerbside. The relevant exposure criterion is thus fulfilled and it will be necessary to declare air quality management areas at these locations.

4.2 Particles

A detailed investigation of Particles concentrations was made as part of this third stage review and assessment. However, since the start of the process, a review of the national air quality strategy has revised the objective to be met. It may be concluded that the new objective will be met.

4.3 Other Pollutants

For the other pollutants listed in the regulations:

- 1,3-Butadiene
- Carbon Monoxide
- Lead
- Nitrogen Dioxide (hourly)
- Sulphur Dioxide

It may be concluded that the objectives will be met.

5.0 Proposed Air Quality Management Area

It is clear from this review and assessment that the locations at which the nitrogen dioxide annual standard is not likely to be met are congested road junctions on main radial routes to the city centre and the main vehicular traffic routes within the first New Town. However, analysis of data shows that even at short distances away from these locations there is a rapid decline in concentrations of nitrogen dioxide to levels that meet the standard. Examples of this are:

- On the short main traffic link (Haymarket Terrace) between two areas of likely exceedance at Roseburn Terrace and West Maitland St, levels of nitrogen dioxide currently meet the standard.

- At the North Bridge, concentrations of nitrogen dioxide decline within 40 metres to levels that currently meet the standard.

- Within the city centre, levels of nitrogen dioxide in the links between Princes Street, George Street and Queen Street are currently meeting or are close to meeting the standard.

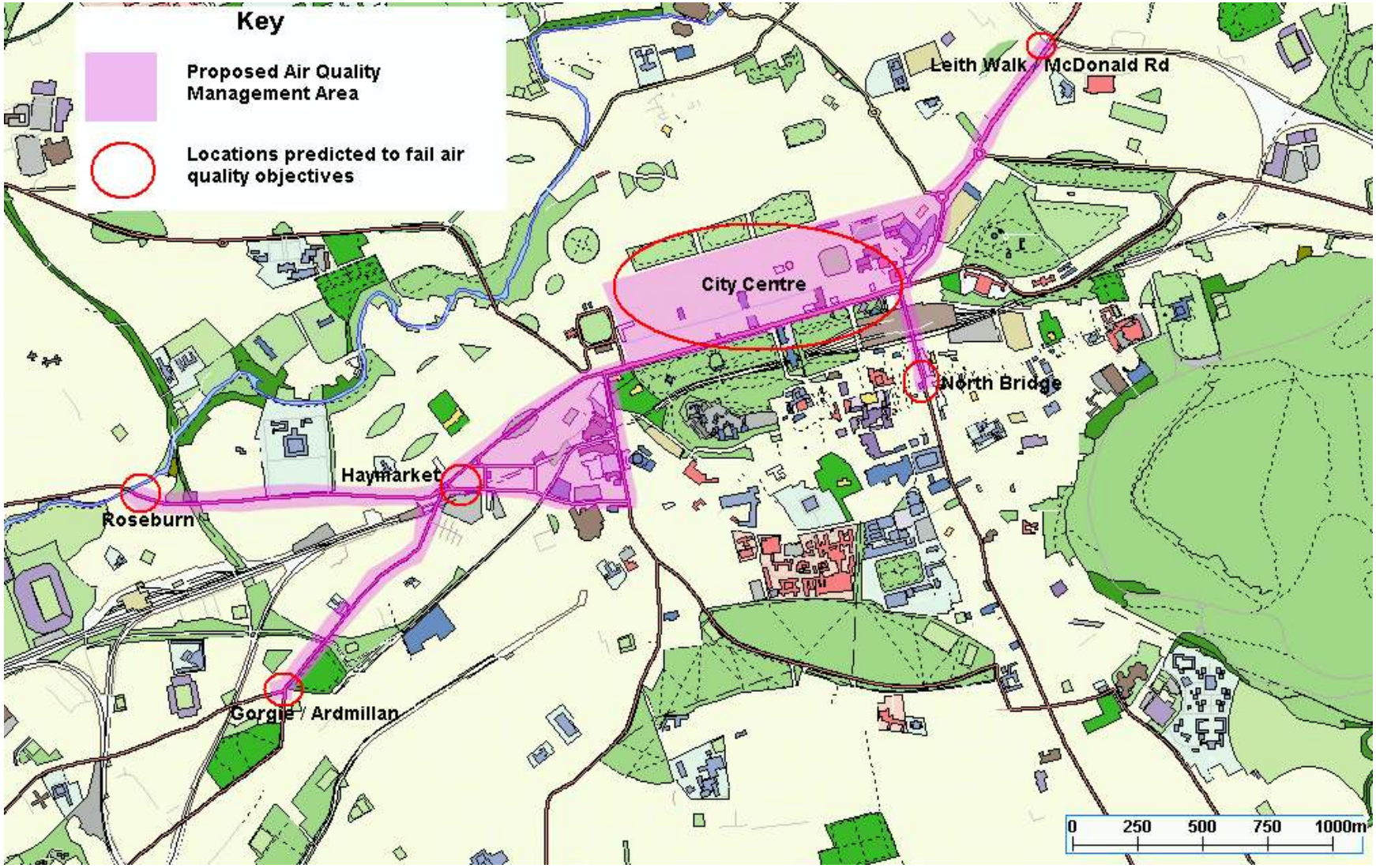
- At other sections of Leith Walk, either sides of the McDonald road junction, levels of nitrogen dioxide currently meet the standard or are predicted to comfortably meet it by 2005.

- At Gorgie Road, predictions based on real-time and passive monitoring at other locations close to the Gorgie Road / Ardmillan junction indicate that levels of nitrogen dioxide should comfortably meet the standard by 2005.

It is also clear that vehicular traffic is the main source of emissions at these locations and that traffic management is likely to be the principal tool in ensuring that the air quality objectives are met.

Accordingly, it is proposed that a single Air Quality Management Area (AQMA) which centres on the New Town and links directly to the other locations be designated in order that an integrated action plan can be prepared.

The areas of likely exceedance and the proposed AQMA are shown on the following map.


Key
Proposed Air Quality Management Area
Locations predicted to fail air quality objectives
Leith Walk / McDonald Rd
City Centre
North Bridge
Haymarket
Roseburn
Gorgie / Ardmillan
0
250
500
750
1000m

6.0 Quality Assurance / Quality Control

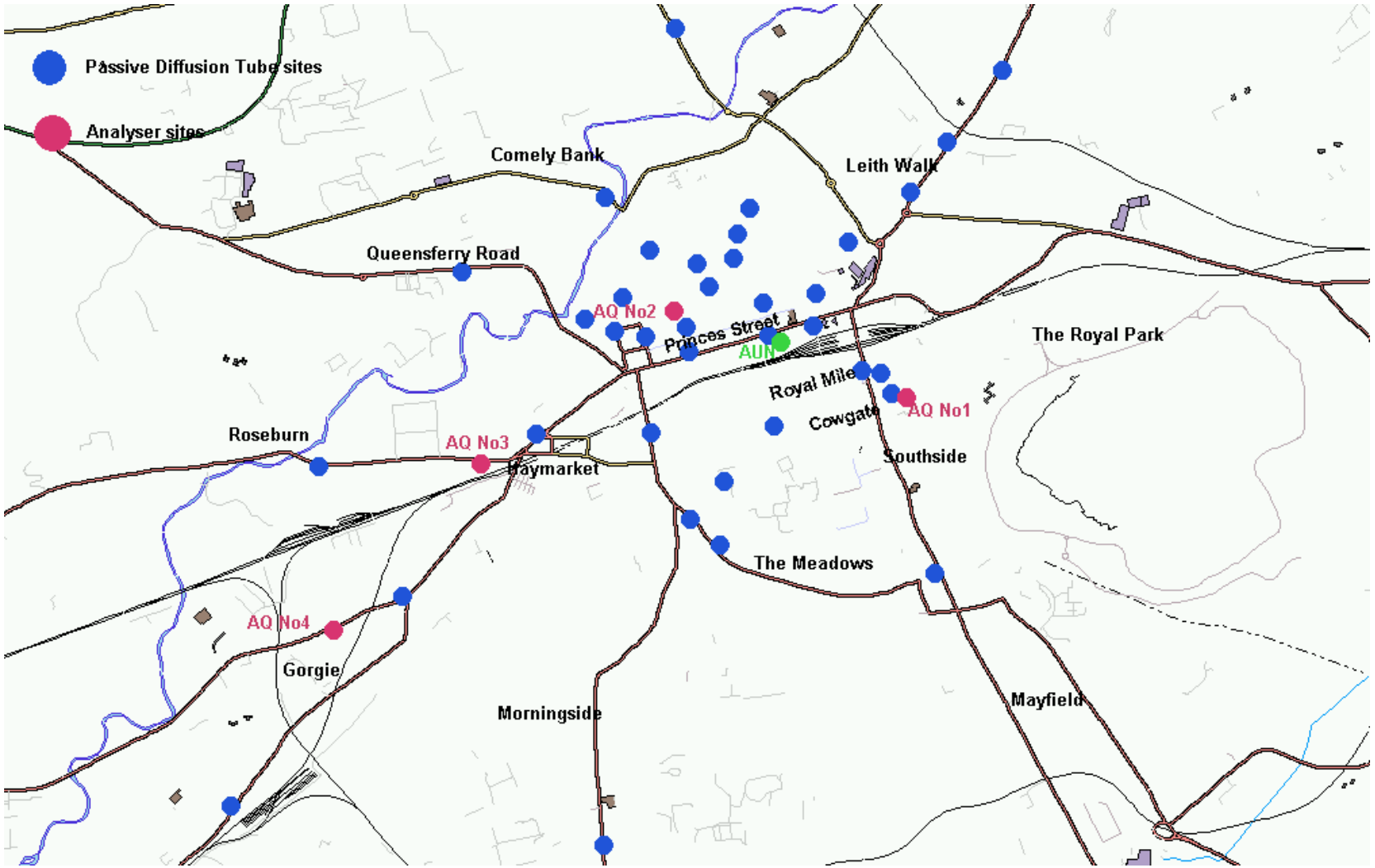
Details of all quality assurance and quality control undertaken in relation to:

- analytical measurement,
- equipment calibration,
- data verification,
- data management and
- staff competencies

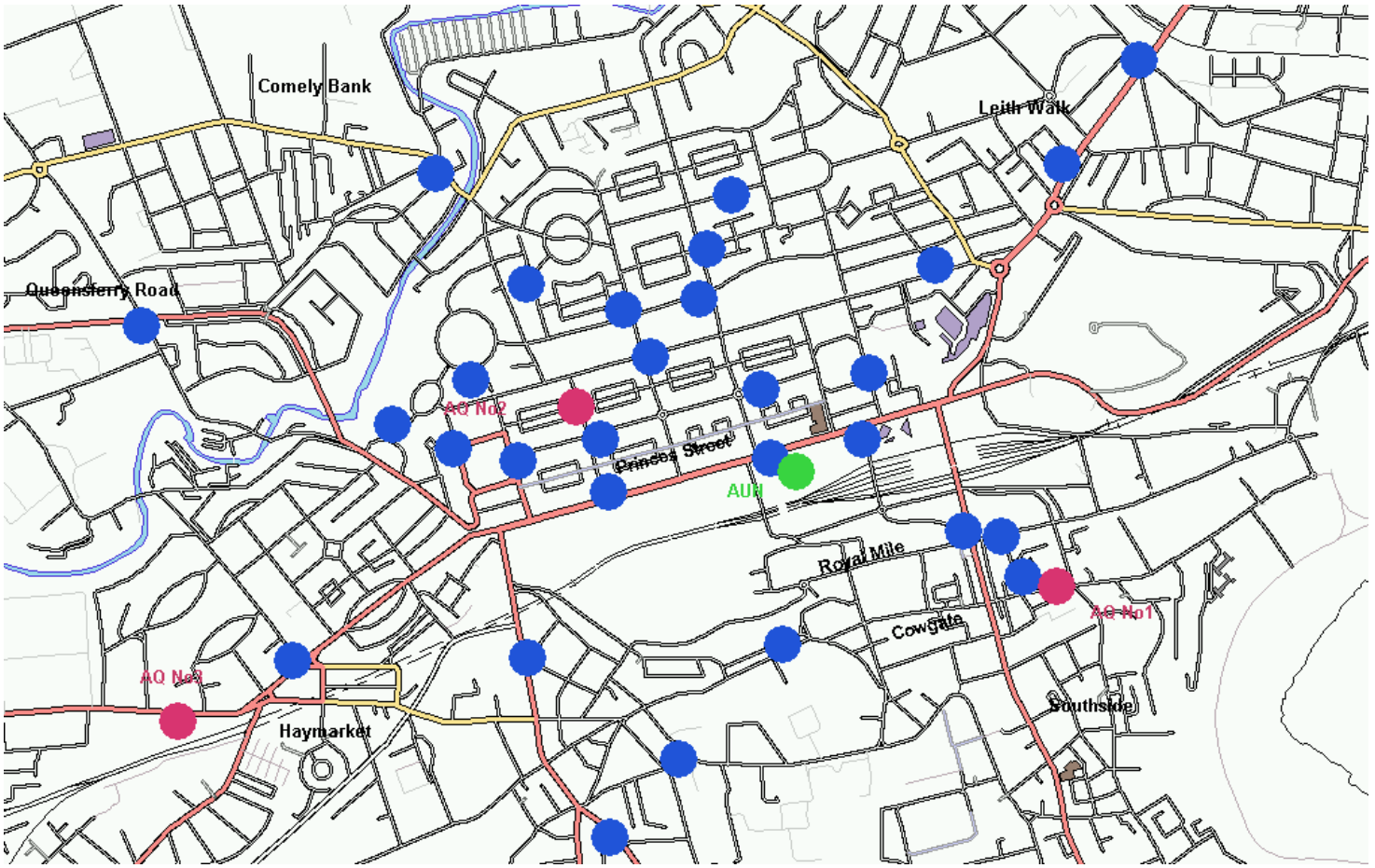
is contained in a separate appendix to this document. It is available on request in either paper or electronic format (MS Word 97).

7.0 Maps and Site Locations

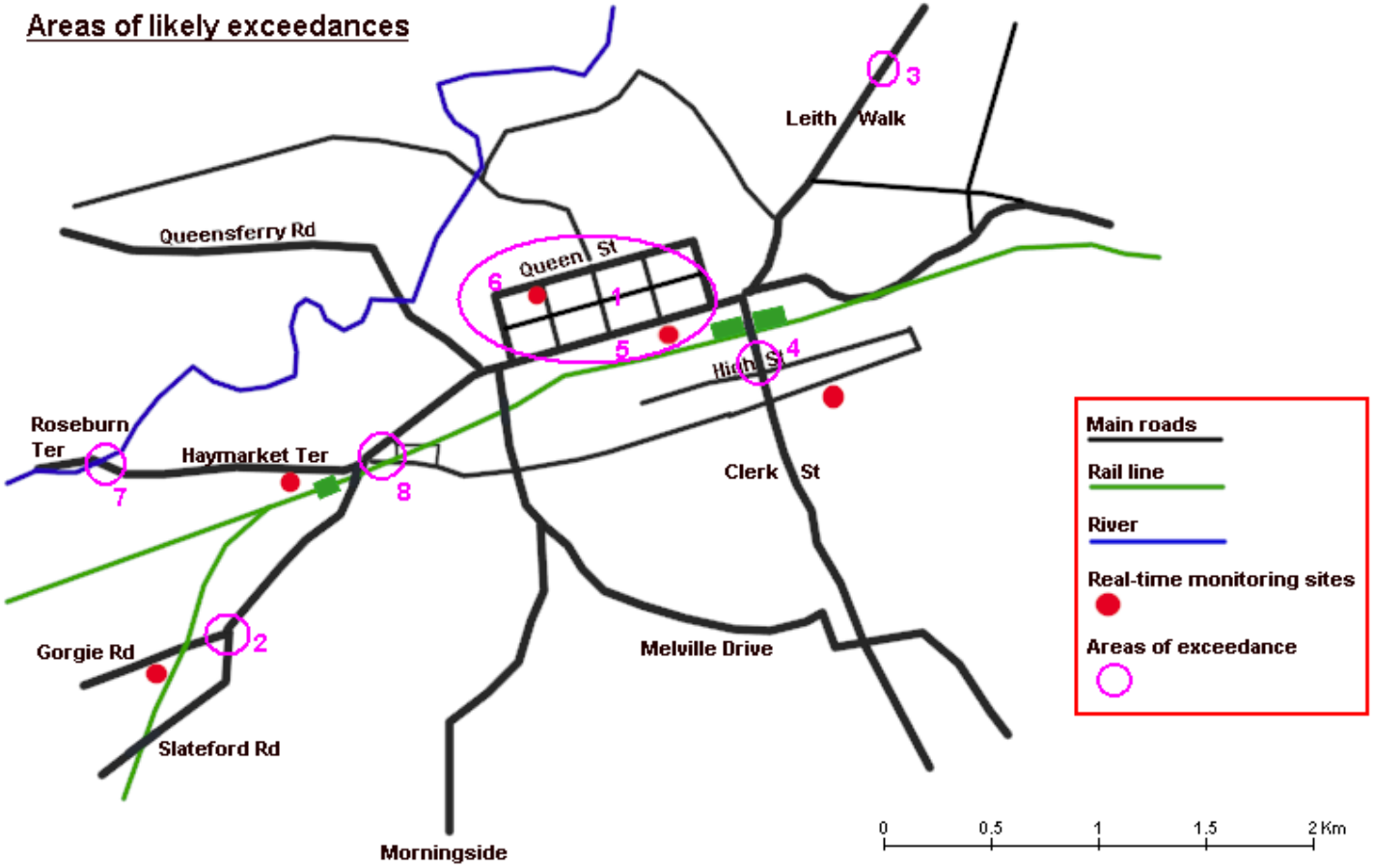
Map 1. Monitoring site locations


Passive Diffusion Tube sites
Analyser sites
Comely Bank
Leith Walk
Queensferry Road
AQ No2
Princes Street
AUN
The Royal Park
Royal Mile
Cowgate
AQ No1
Roseburn
AQ No3
Haymarket
Southside
The Meadows
AQ No4
Gorgie
Morningside
Mayfield

Map 2. City Centre monitoring locations


Comely Bank
Leith Walk
Queensferry Road
AQ No2
Princes Street
AUN
Royal Mile
Cowgate
AQ No1
AQ No3
Haymarket
Southside

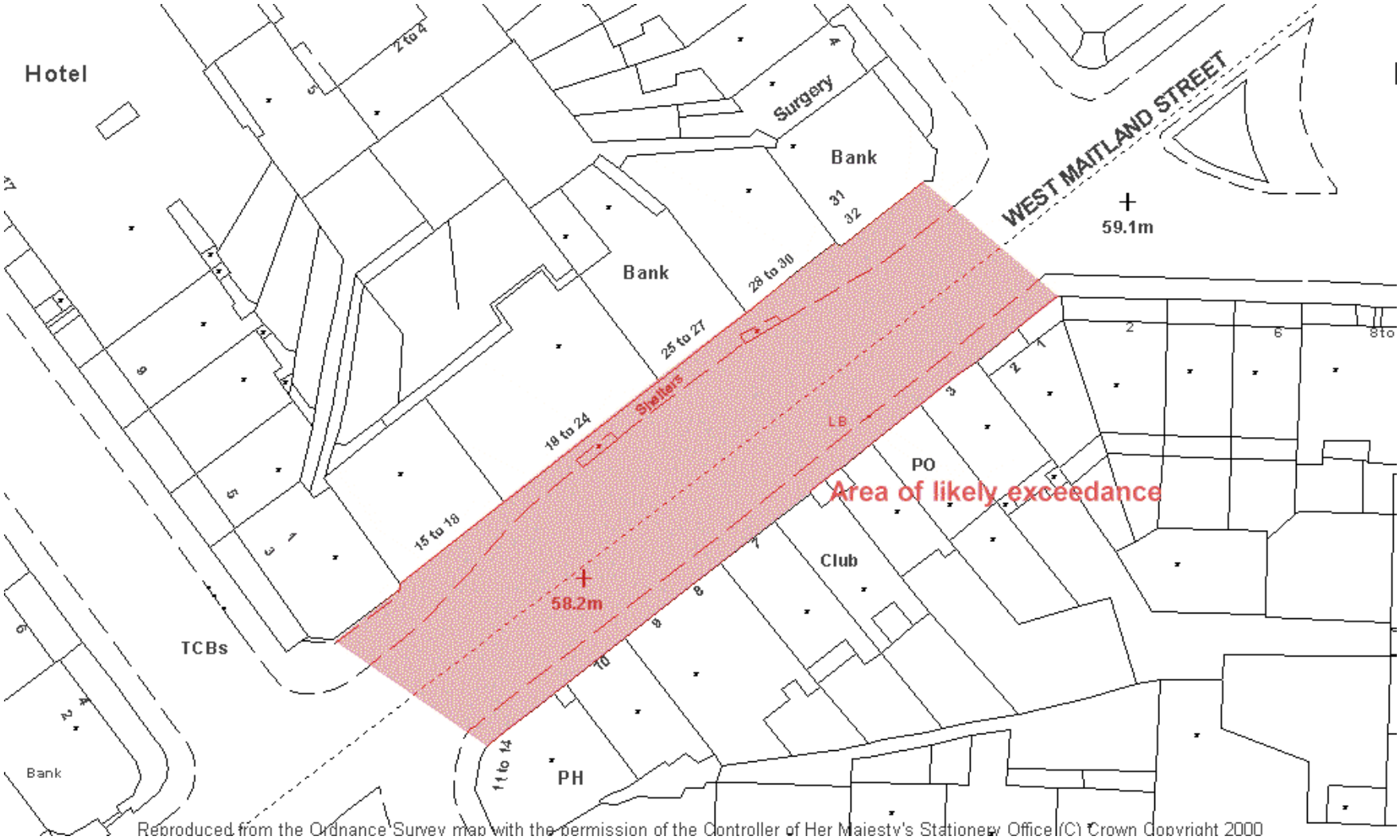
Map 3. Area of Likely Exceedances (meeting exposure criteria)


Areas of likely exceedances
Leith Walk
3
Queensferry Rd
Queen St
6
1
5
4
High St
Roseburn Ter
Haymarket Ter
7
8
Clerk St
Gorgie Rd
2
Melville Drive
Slateford Rd
Morningside
Main roads
Rail line
River
Real-time monitoring sites
Areas of exceedance
0
0.5
1
1.5
2 Km

Map 4. West Maitland Street

This location has four storey tenements on the north side of the road and three storeys on the south. All ground floor premises are commercial. Premises above ground floor are mainly residential. The roadway consists of four lanes with two bus stop lay-bys. The 24-hr average annual traffic flow is approximately 50,000 at the junction to the east. The area of likely exceedance that is shown on the site map (shaded in red) is a conservative estimate based on current information. A more detailed assessment of nitrogen dioxide concentrations will be undertaken during the next 6 months to more fully define the area of likely exceedance.

OS ref. 324186 : 673315


Hotel
2 to 4
Surgery
Bank
WEST MAITLAND STREET
59.1m
31
32
Bank
28 to 30
25 to 27
19 to 24
Shelters
LB
15 to 18
58.2m
PO
Area of likely exceedance
Club
TCBs
11 to 14
PH
Bank
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Map 5. Roseburn Terrace

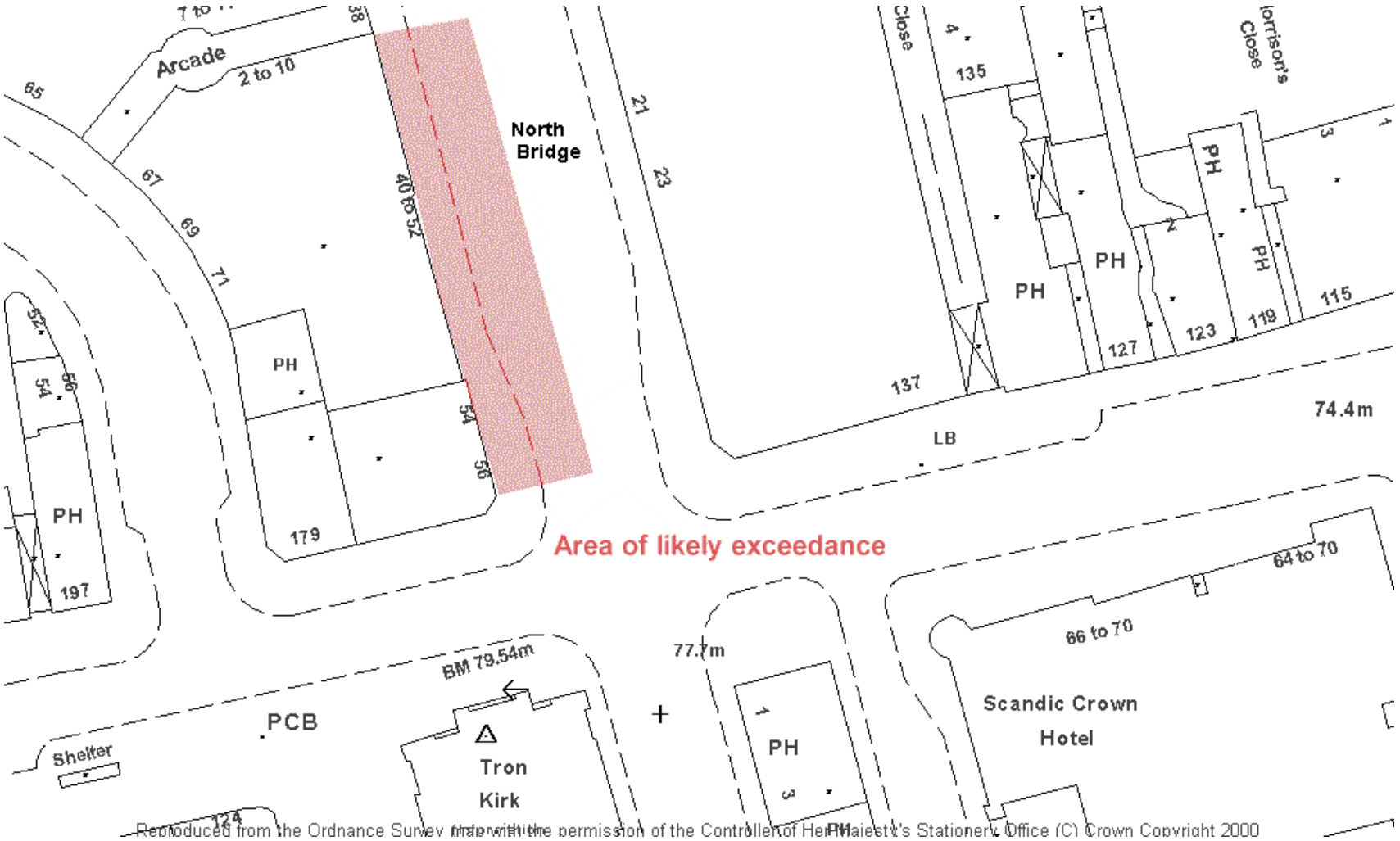
This road is a major route into the city centre. It has four storey tenements on each side with the building facades approximately two to three metres from the kerb. The first to third storeys all contain dwelling houses. The annual average 24-hr traffic flow is approximately 37,000. There is a major traffic junction at the east of the site. The area of likely exceedance that is shown on the site map (shaded in red) is a conservative estimate based on current information. A more detailed assessment of nitrogen dioxide concentrations will be undertaken during the next 6 months to more fully define the area of likely exceedance.

OS ref. 323043 : 673166

Map 6. North Bridge

This street forms a major road junction with the High Street. On the west side of the road there is a four storey building which contains dwelling houses. The roadway adjacent to the building façade is four lanes wide and contains several bus stops that are heavily used. Traffic at the furthest point from the houses is often queuing for the traffic lights, whilst traffic in the nearest lanes is accelerating away. Available traffic counts indicate a 24-hr annual average flow of 17,000 vehicles, although it likely that this figure is being exceeded. Future traffic management plans for Princes Street are likely to result in additional private vehicles being diverted onto the North Bridge. The next nearest monitoring location in the High Street indicates significantly lower NO_2 concentrations, which strongly suggest that the likely area of exceedance is very localised. The area of likely exceedance that is shown on the site map (shaded in red) is a conservative estimate based on current information. A more detailed assessment of nitrogen dioxide concentrations will be undertaken during the next 6 months to more fully define the area of likely exceedance.

OS ref. 325931 : 673668


Arcade
2 to 10
North Bridge
40 to 52
PH
179
PH
197
PH
PH
PH
PH
135
137
127
123
119
115
74.4m
LB
Area of likely exceedance
64 to 70
66 to 70
Scandic Crown Hotel
77.7m
BM 79.54m
PCB
Shelter
Tron Kirk
PH
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Map 7. City Centre locations

- George Street
- Princes Street
- Queen Street

Princes Street and George Street form the main retail and commercial thoroughfares within the city centre. Princes Street has a very high level of bus vehicle traffic. Queen Street contains principally commercial premises and acts the main vehicular route through the city centre due to an eastbound prohibition on non-bus/taxi vehicles in Princes Street.

Within Princes Street there are live-in staff at a members club and four flats within another building which directly faces the road. Within George Street there are six buildings containing single homes or flats that directly face the road. Within Queen Street there are eleven buildings containing either single dwellings or multiple flats. Forty persons are registered on the voter's roll as living within these dwellings. It is not know how many non-registered adults or children are resident.

Traffic flows on Queen Street may increase if a planned westbound prohibition on non-bus/taxi vehicles in Princes Street is implemented. Current annual average 24-hr flow is 35,516

OS ref. 325139 : 673978


Areas of likely exceedance
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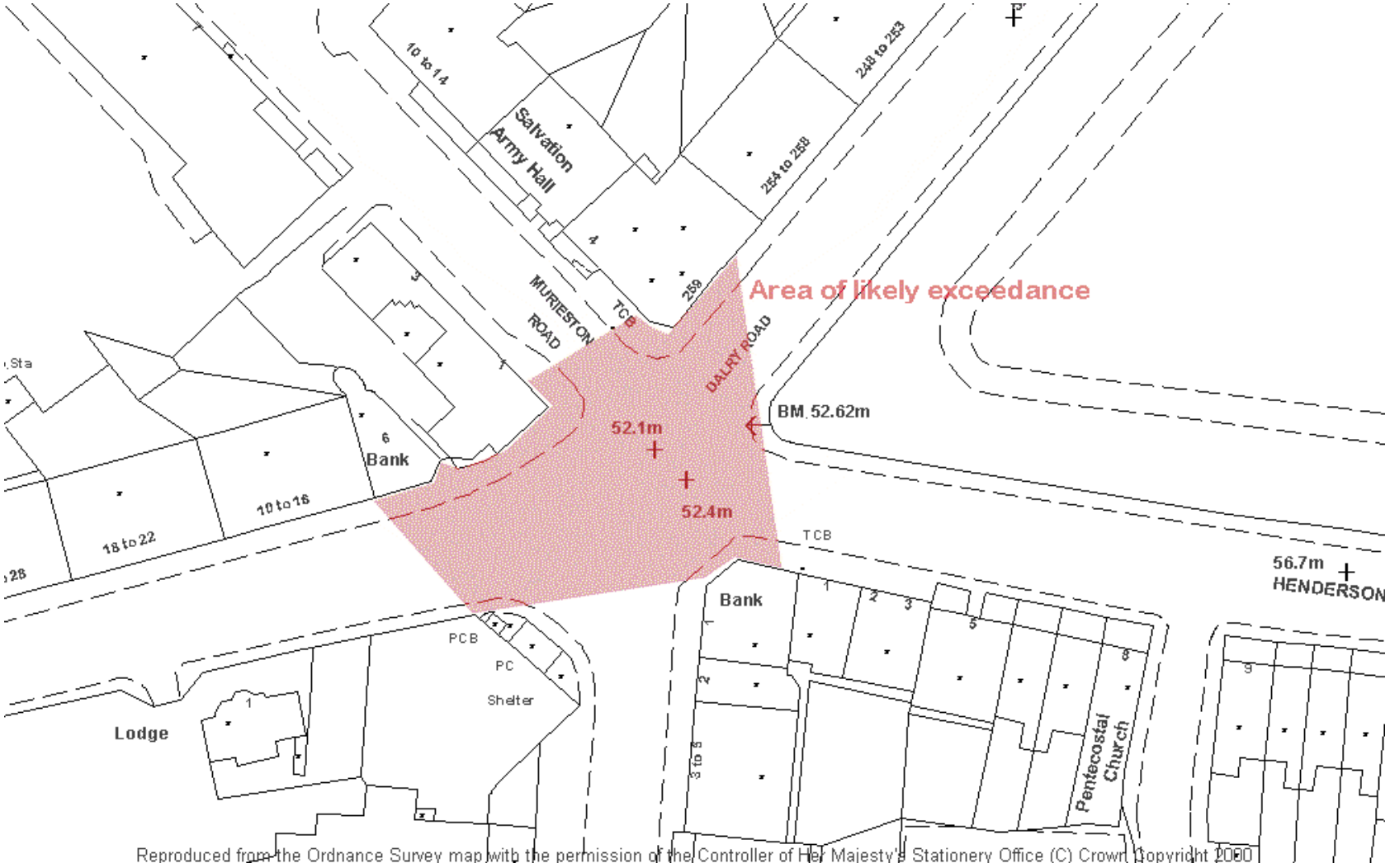
Map 8. Gorgie / Ardmillan junction

This is a major road junction close to the city centre. Five roads converge with traffic controlled by signals. Of the ten roadsides, six have buildings within 2 - 3 metres of the road that contain dwelling houses. All the buildings are tenements that are three or four storeys in height. The annual average 24-hr traffic flow is approximately 40,000. The area of likely exceedance that is shown on the site map (shaded in red) is a conservative estimate based on current information. A more detailed assessment of nitrogen dioxide concentrations will be undertaken during the next 6 months to more fully define the area of likely exceedance.

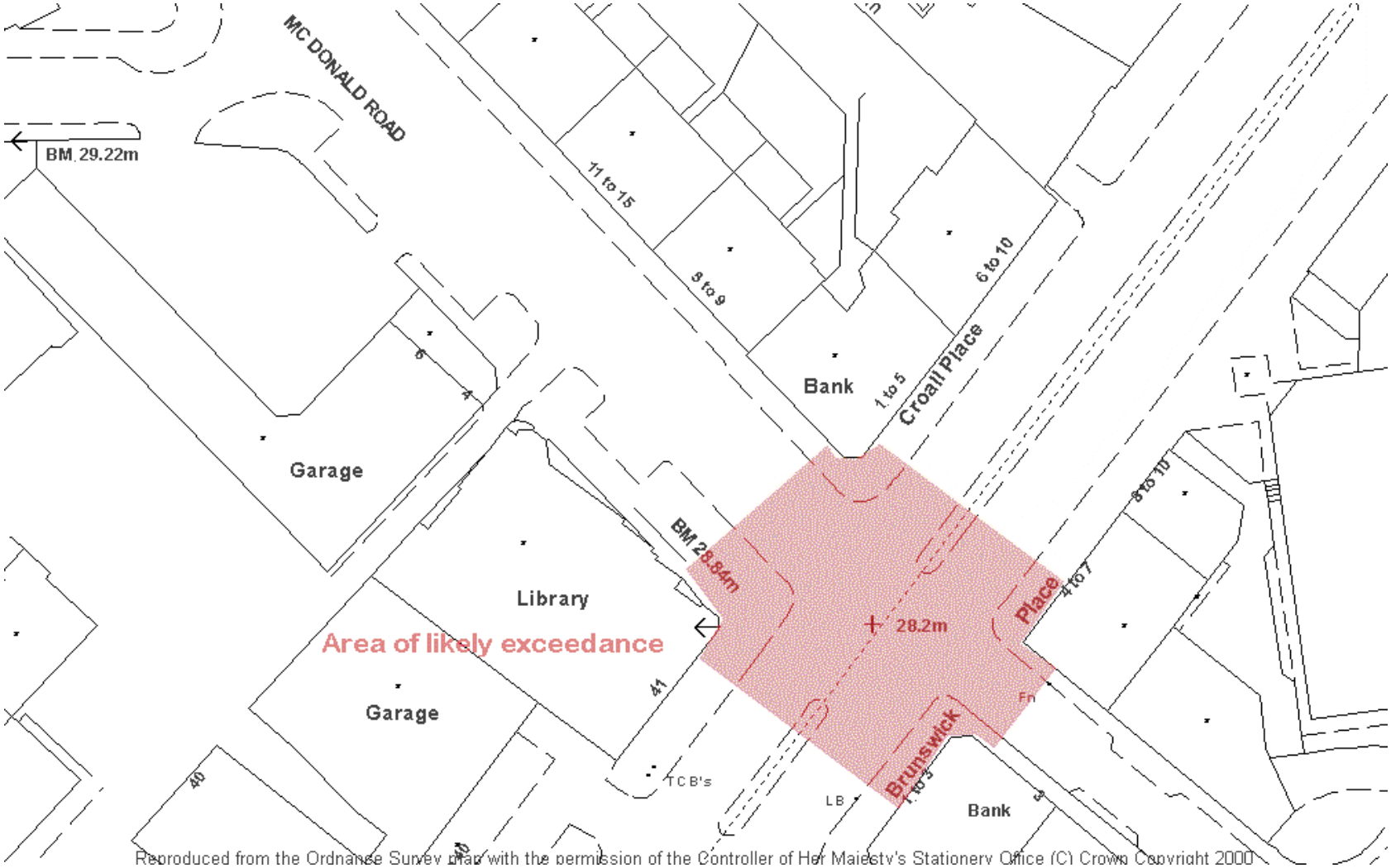
OS ref. 323497 : 672477



Map 9. Leith Walk/ McDonald Road junction

This road is a major route into the city centre. It has four storey tenements on each side with the building facades approximately two to three metres from the kerb. The first to third storeys all contain dwelling houses. The annual average 24-hr traffic flow is approximately 33,000. The area of likely exceedance that is shown on the site map (shaded in red) is a conservative estimate based on current information. A more detailed assessment of nitrogen dioxide concentrations will be undertaken during the next 6 months to more fully define the area of likely exceedance.

OS ref. 326386 : 674888


MC DONALD ROAD
BM 29.22m
11 to 15
8 to 9
6 to 10
Bank
1 to 5
Croall Place
Garage
Library
Area of likely exceedance
BM 28.84m
28.2m
Place
4 to 7
8 to 10
Garage
41
40
TCB's
LB
Brunswick
1 to 3
Bank
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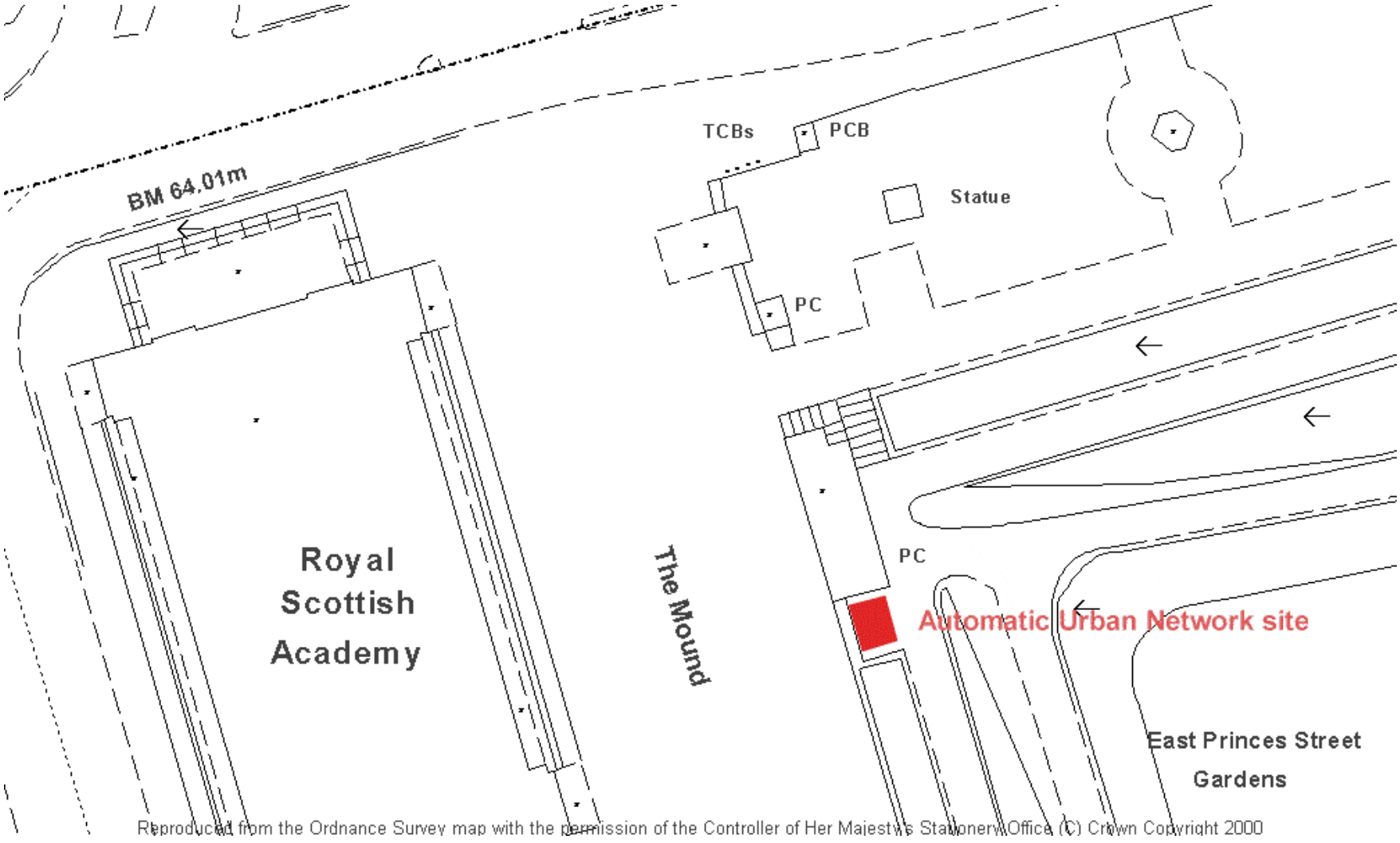
Map 10. AUN Princes Street Monitoring Site

This monitoring site operates as part of the UK Government national air quality monitoring network. It is currently operated under contract by Council staff who also undertook the monitoring for this review and assessment. The site has been operational since 1992 and data from it has been used as a reference for comparing other data sets produced for this report.

The site is classified as Urban Centre and is situated in a park, which is bordered on three sides by heavily trafficked routes, and on the fourth by a railway main-line with a station close by. The traffic flows on the nearest road have changed significantly since the inception of the site. Private vehicles are prohibited from the eastbound lanes and priority is given to buses. It is considered to be the road with the highest bus volumes and there are several heavily used bus stops at the kerbside nearest to the monitoring site. There are no dwelling houses in the vicinity.

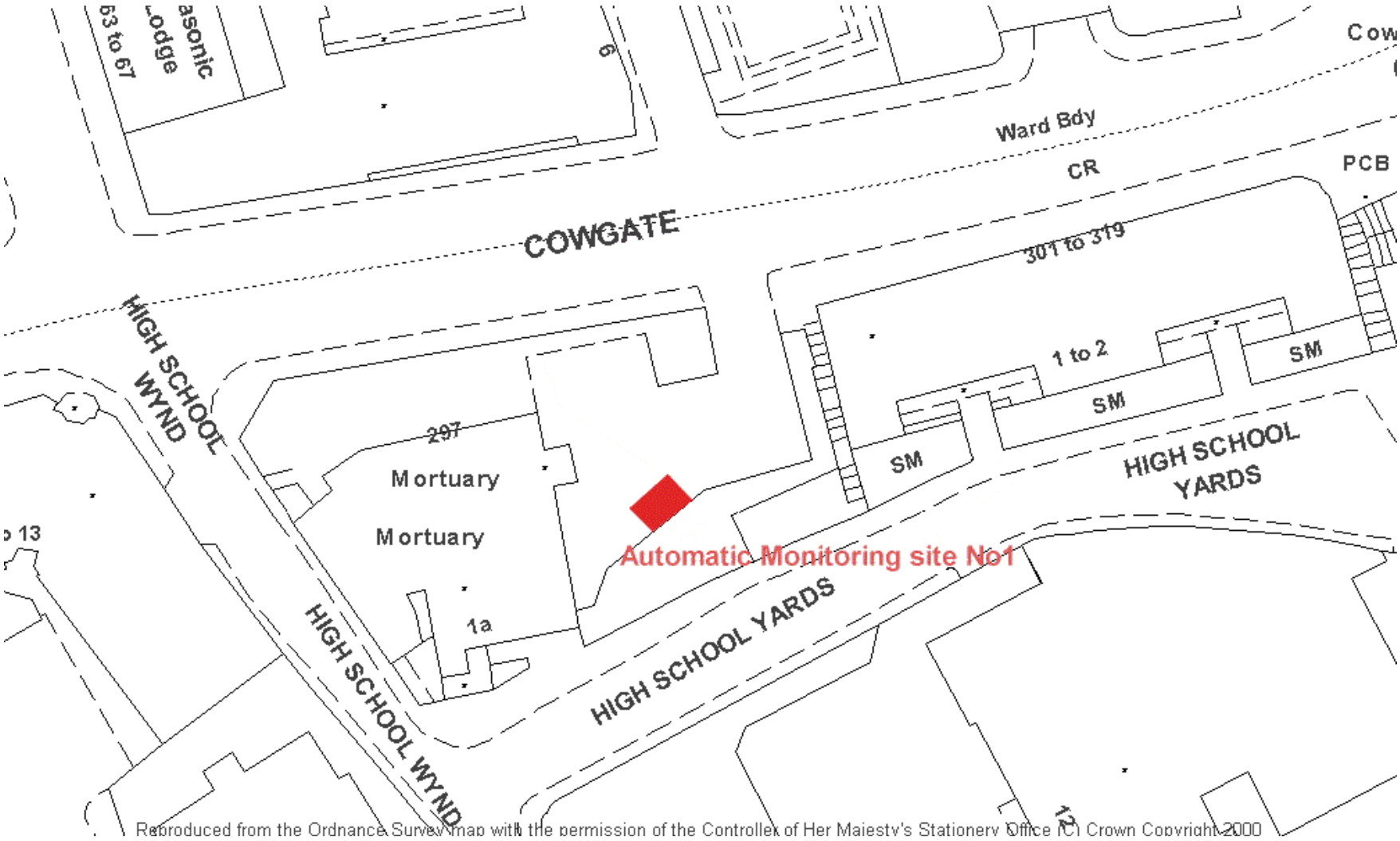
OS ref. 325477 : 673828



Map 11. Cowgate – Monitoring Site

This site is located in the Mortuary car park close to the kerbside. There are a significant number of dwelling houses surrounding the site. The nearest building facades are 2 metres from the roadside. An unusual feature of this location is that a heavily trafficked road (South Bridge) passes over the Cowgate approximately 150 metres from the monitoring site. The buildings at this point are up to 8 storeys high creating a very deep street “canyon” in the Cowgate.

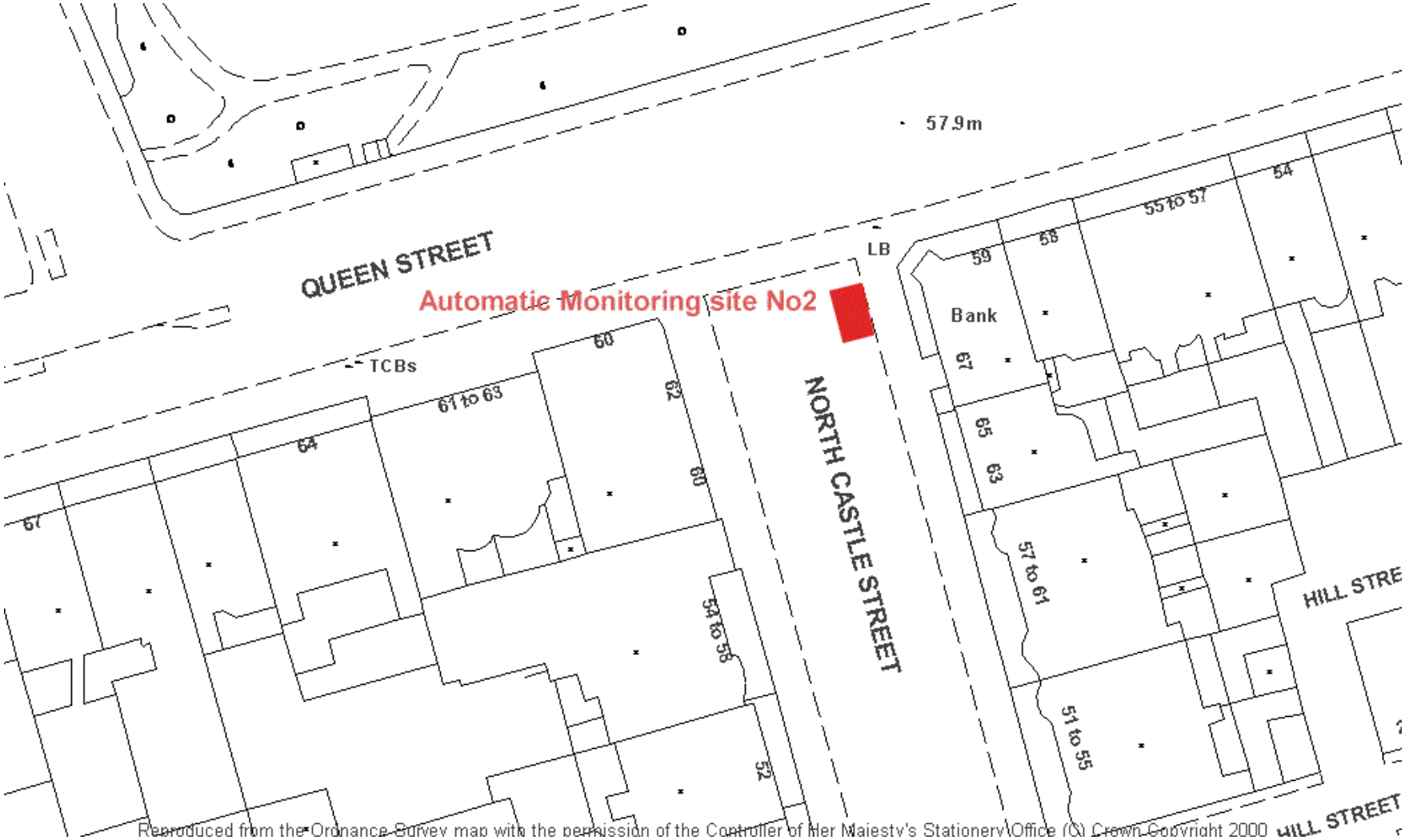
OS ref. 326158 : 673523



Map 12. Castle Street North – Monitoring Site

This site can be classified as Urban Roadside. It is located adjacent to the road with the highest traffic volumes through the city centre. Traffic counts indicate that the annual average 24-hr flow is greater than 35,000. There are a small number of dwelling houses in the immediate vicinity.

OS ref. 324195 : 674052


57.9m
QUEEN STREET
Automatic Monitoring site No2
LB
TCBs
Bank
NORTH CASTLE STREET
HILL STREET
67 to 63
64
62
60
54 to 58
52
59
58
55 to 57
54
67
65
63
57 to 61
51 to 55
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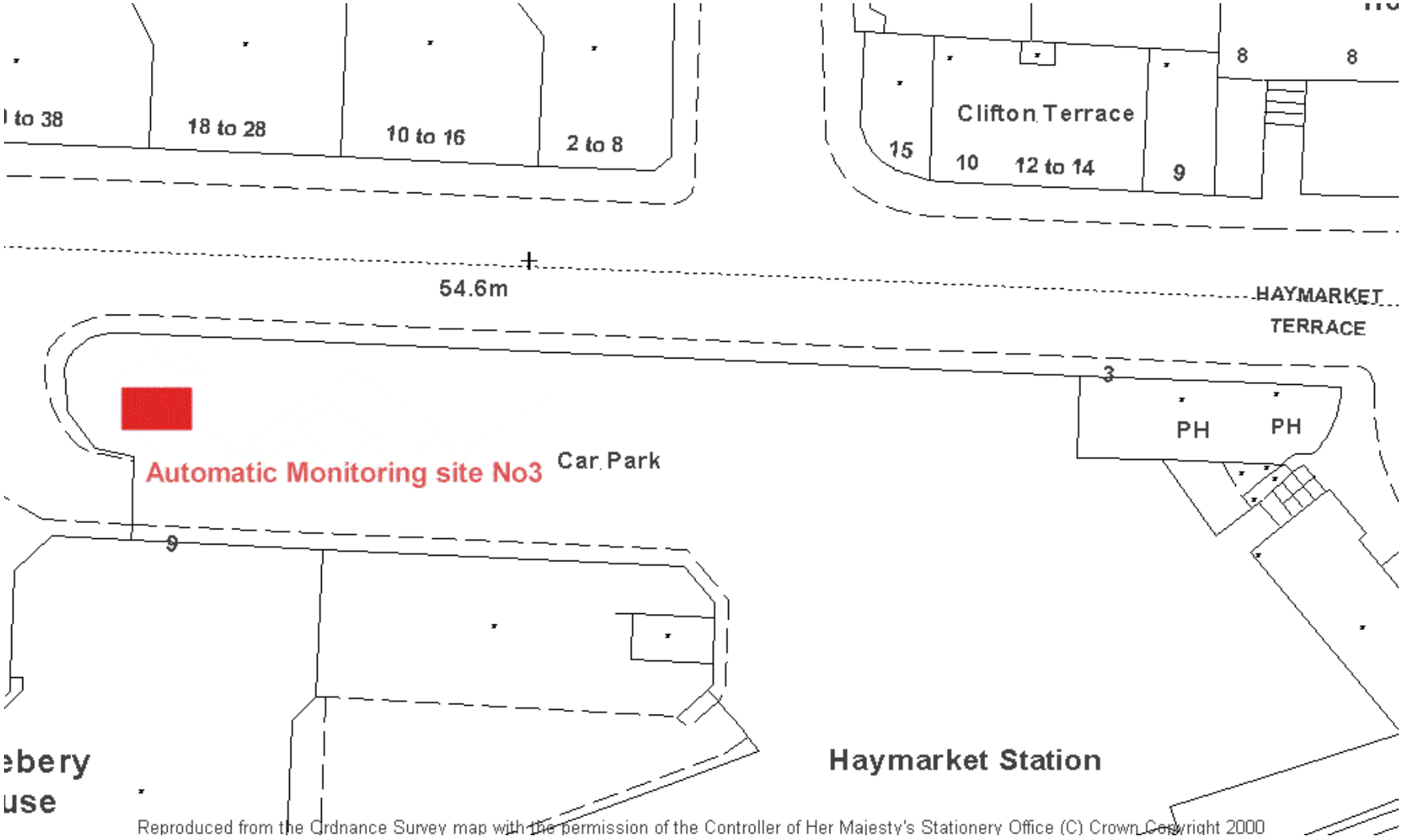
Map 13. Haymarket Terrace – Monitoring Site

This site can be classified as Urban Roadside. The monitoring site is located in a railway station car park adjacent to a heavily trafficked main road. The tenement bulidings on the opposite side of the road contain a high number of dwelling houses at first to third storey. The building façade is approximately 2.5 metres from the kerb. Traffic counts indicate that the annual average 24-hr flow is 37,000.

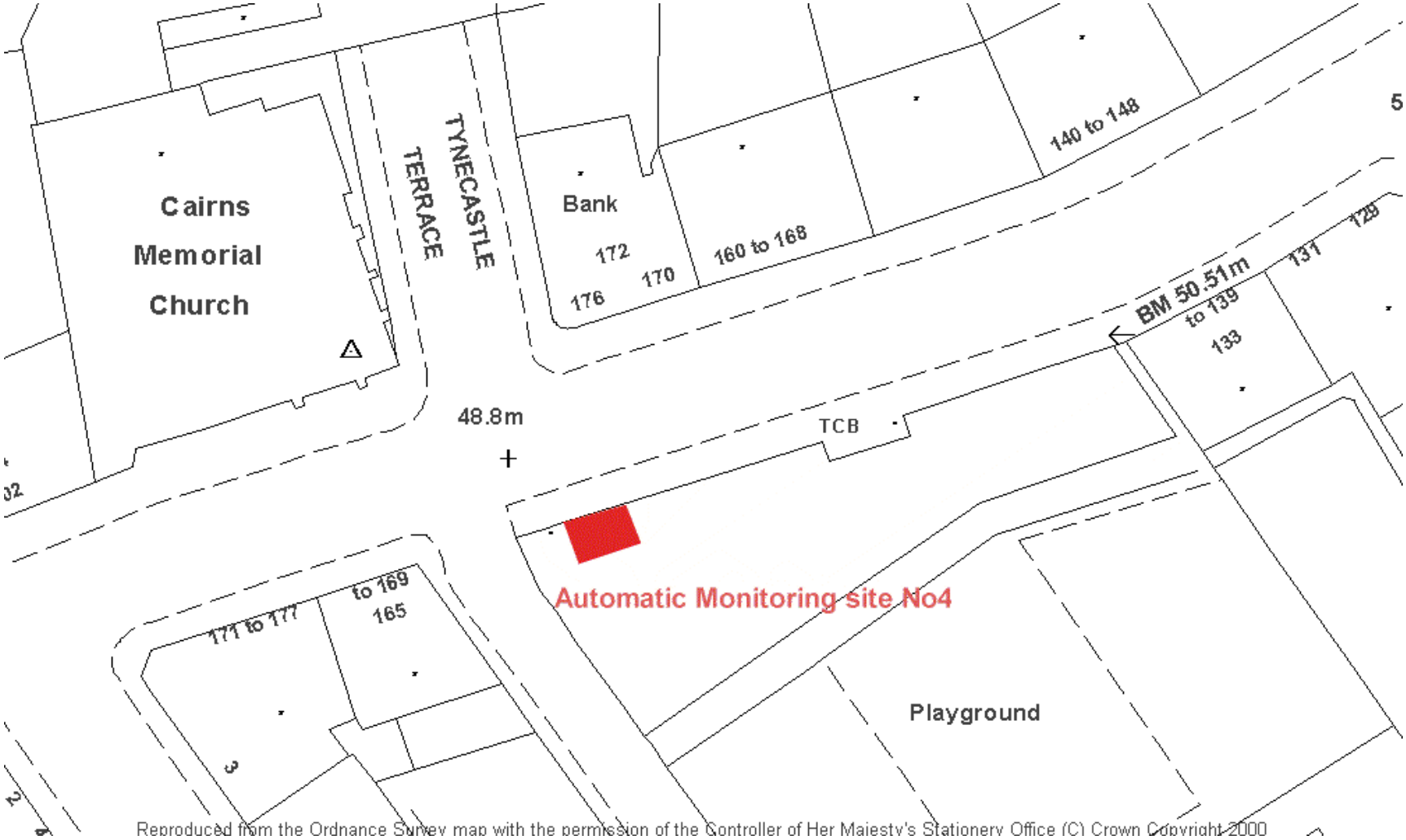
OS ref. 323880 : 673203



Map 14. Gorgie Road - Monitoring Site

The monitoring unit is contained within a Police Box. This is located adjacent to the pavement within a children's play area. Adjacent buildings are all tenements and there are significant numbers of dwellings at first to third storeys. The building facades are approximately 2.5 metres from the kerbside with the road being heavily trafficked for much of the day.

OS ref. 323121 : 672314


Cairns
Memorial
Church
TYNECASTLE
TERRACE
Bank
172
176
170
160 to 168
140 to 148
5
BM 50.51m
131
129
to 139
133
48.8m
TCB
Automatic Monitoring site No4
171 to 177
to 169
165
Playground
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Notes