Detailed Assessment of Sulphur Dioxide for the Bedford Borough Council

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Executive Summary

This is the Detailed Assessment of sulphur dioxide for the Bedford Borough Council ("the Council"), which fulfils the Council's next step, of the Local Air Quality Management (LAQM) process.

The Council's earlier Updating and Screening Assessment report identified the Stewartby area as one where sulphur dioxide measured as a 15 minute mean was at risk of exceeding the government objective as laid down in the Air Quality (England) Regulations 2002. The basis for these conclusions were monitored results from two sites located close to the Stewartby brickworks and a screening exercise of sulphur dioxide emissions from the brickworks.

The Council has previously invested in a monitoring site in the village of Stewartby. The understanding of air quality is also greatly assisted by additional monitoring undertaken by Hanson Bricks in Kempston Hardwick (whose data were provided by the Environment Agency). The sulphur dioxide measurements from both sites have benefited the understanding of air quality in this area by providing a robust and accurate assessment of the sulphur dioxide pollution. Furthermore these sites have permitted an excellent opportunity to compare dispersion model results and thus gain confidence in the use of these tools in the decision making process.

The monitoring undertaken is very important in aiding understanding of peak concentrations over the period of a year. The monitoring to date continues to indicate that the objective may still be exceeded at the Council's site. (Data for the same monitoring period at Kempston Hardwick site have not been obtained to enable further comment on that site).

In addition to the latest monitoring data, modelling predictions have been made for this detailed assessment. The assumptions made in estimating emissions are given in the main report and its appendices, as is the modelling approach. The nature of the process and the actual objective however make the modelling process highly uncertain. It is therefore fortunate that two high quality monitoring sites are available to aid the process.

The detailed assessment modelling predictions confirm the earlier findings that the 15-minute mean SO2 objective will be exceeded. This is the case for all the scenarios modelled, including a base case for 2001 and possible future scenarios.

Comparisons of the modelled base case results with measurements for 2001 indicate a range of agreement. The modelling appears to predict the BF1 site much better than the KH site. However investigation based on an analysis of monitored data, indicates that episodes arise at the two monitoring sites under different wind conditions. This analysis suggests that the modelling of the KH site should be more robust and therefore in better agreement than the BF1 site.

Pollution plots based on the modelled results are shown for the scenarios, these indicate varying emissions and a plot factored to the KH monitoring results. The plots show a large variation in the area predicted to exceed, this highlights a high degree of model sensitivity to both changing emissions and factoring, thus making robust estimations of the area predicted to exceed problematical.

In the absence of additional information concerning emissions and monitoring it is recommended that the yellow line of exceedence (from Figure 15) be used to designate the boundary of an AQMA. This is based on robust monitoring and reflects that the monitoring results for the site easily exceed the 15-minute mean objective.

Further modelling of both the one-hour and 24 hour objective are presented. The results of this modelling highlight that the one-hour objective is not exceeded, however there is a small area of exceedence of 24-hour objective. The modelling for these objectives is based on the 2001 base case and therefore may underestimate emissions; the results also have not been factored.

As a result of the findings in this report the Council is recommended to undertake the following actions, in respect of the findings for the statutory sulphur dioxide objectives:

Undertake consultation on the findings arising from this report with the statutory and other consultees as required.

Following the outcome of the consultation process designate an Air Quality Management Area based on the findings in the report.

Undertake a further assessment under s.84 of the Environment Act 1995 and prepare its action plan, to allow it to work towards meeting the statutory objectives, including determining the cost effectiveness of the different measures proposed.

Continue its SO_2 monitoring programme as part of its LAQM actions.

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1 Introduction to Detailed Assessment of Sulphur Dioxide

1.1 Overview to the Detailed Assessment

This is the Detailed Assessment of sulphur dioxide (SO_2) for the Bedford Borough Council. This report is intended to fulfil the statutory requirement for this, the Council's next step, of the Local Air Quality Management (LAQM) process. The aim of which is to determine whether or not the Council needs to declare an Air Quality Management Area (AQMA) in its area for this pollutant.

It should be noted that the Council has produced a separate report for nitrogen dioxide.

1.2 Background – national perspective

New technical guidance (LAQM.TG03) was produced last year by DEFRA to aid local authorities with their duties (DEFRA, 2003). This replaces earlier versions produced in 1998 and 2000. The revised guidance is designed to support local authorities in carrying out their duties under the Environment Act 1995. It confirms that LAQM forms a key part of the government's strategies to achieve the air quality objectives.

The guidance provides advice to local authorities for the purposes of undertaking their statutory review and assessments and on factors that need to be taken into account when assessing exposure. The standards from which the objectives derive are based on a potential risk to health, thus a single exposure of an individual above the standards is to be avoided. The objectives however allow a number of occurrences where the standards might be exceeded for reasons of feasibility and practicality.

Short-term objectives, such as the 15-minute mean SO_2 objective, include all locations where members of the public are regularly present. The guidance confirms that this latter phrase does not imply that the same persons need to be regularly present at that location (paragraph 1.20). A relevant location is one where a member of the public might be exposed, in the case of the 15-minute objective it can apply to a single 15-minute period, as long as members of the public are regularly present.

The TG03 guidance advises that for the detailed assessment of SO_2 a combination of monitoring and modelling studies is required. This is due to the uncertainty associated with estimating emissions. The guidance also advises that monitoring should be carried out at locations of maximum public exposure with dispersion modelling being used to inform where monitoring equipment is to be sited and subsequently to determine the geographic boundary of any exceedences.

The aim of the detailed assessment is thus to identify with reasonable certainty whether or not a likely exceedence of an AQS objective will arise. The assumptions used need to be considered in depth and the data used should of high standard. This is to ensure confidence in the decisions that need to be made. Where a likely exceedence is identified the detailed assessment shall provide detail of both its magnitude and geographical extent.

The Council is also required to confirm that there is the likelihood of relevant public exposure in the identified area. The Air Quality (England) Regulations as amended, refer to "the quality of air at locations which are situated outside of buildings or other natural or man made structures, above or below ground, and where members of the public are regularly present."

1.3 Background – Bedford Borough Council perspective

The Council has undertaken the earlier stage of review and assessment of the Local Air Quality Management (LAQM) process within its area (see the Updating and Screening Assessment (USA) prepared in 2003). This report presented a staged approach whereby the seven air pollutants in the Government's Air Quality Strategy related to LAQM, were assessed and screened as to their relative importance to air quality within the Council's area.

The screening assessment examined air quality across the whole of the Council's area in accordance with DEFRA guidance. Five AQS pollutants (benzene, 1,3 butadiene, carbon monoxide, lead and PM_{10}) considered were found not to need detailed assessment. These pollutants will therefore be reported on in the Council's subsequent regular Air Quality Progress reports. Nitrogen dioxide however needed a detailed assessment and is reported on separately.

The screening assessment for SO_2 provided:

1. The results of SO_2 monitoring by the Council close to the Hanson Brickworks in Stewartby and this showed that the statutory objective for the 15-minute mean objective (see Table 1) had been exceeded recently.

2. An emission screening exercise for the Stewartby Brickworks and this indicated that the maximum emission exceeded the threshold in the guidance.

In view of these findings the Council were required to undertake a Detailed Assessment with a view to determining whether or not to declare an AQMA for SO_2.

Table 1 Air quality objectives relevant to the Detailed Assessment of sulphur dioxide

	Concentration	Measured as	Date to be achieved by
Sulphur dioxide (SO_2)	266µg/m^3 (100ppb) not be exceeded more than 35 times a year	15 minute mean	31-Dec-05
	350µg/m^3 (131ppb) not be exceeded more than 24 times a year	1 hour mean	31-Dec-04
	125µg/m^3 (47ppb) not be exceeded more than 3 times a year	24 hour mean	31-Dec-04

1.4 Stewartby brickworks

The Stewartby Brickworks are one of three brickworks still operating that produce Fletton bricks: the other two brickworks are south of Peterborough. These brickworks all produce bricks using Hoffman kilns.

Hoffman kilns were first developed in the mid 1850's and the main reason for their early success was the major fuel saving of over previous methods. Hoffman kilns were first introduced at the Fletton works more than 100 years ago.

The brickworks at Stewartby are regulated by the Environment Agency and when authorisations were first required about ten years ago there were 13 chimneys discharging from the 8 kilns operating. Only two kilns are operating now, ck1 and ck3. In recent years up to 2002, the kilns in operation were ck3 and ck22.

The present kilns at Stewartby still follow the basic Hoffman principle, being a large kiln built with a series of chambers. The flues built within the kiln allow up to two fires to move gradually around the chambers. This allows the most efficient use of the heat to first dry, then fire and finally cool the bricks.

The kilns are natural draught multi-chamber Hoffmann kilns designed for producing Fletton bricks in a continuous process. The kilns are large permanent structures built entirely from ordinary building brick with a chimney, approximately 70m high, connected to a main flue running the length of the kiln. On either side of the main flue there are up to 24 barrel-arched firing chambers, each linked to the main flue via damper controlled flues.

The clay used is found locally and comes from the lower Oxford Clay beds. The clay is shaped prior to firing; this is called a 'green brick'. The 'green' bricks are loaded into the chambers by forklift trucks. Each chamber holds about 64000 bricks. Once loaded in and dried the bricks are sealed into the chamber.

The flues control the fire within the kiln and it moves progressively from chamber to chamber until it approaches the dried bricks. Once the temperature of the bricks reaches approximately 400°C the bricks ignite and fire themselves. When the combustible elements with the bricks are burnt off a small amount of coal is added via the bungholes on the top of the kiln to keep the bricks at the correct temperature. Once it is decided the bricks are fired correctly the fire is moved into the next chamber. When the chamber has cooled the chamber is opened, with the bricks then being removed, prior to refilling to continue the cycle.

This method of production requires careful management of the kiln and so once it is lit the kiln is not allowed go out. The whole process is controlled manually by manipulating dampers and sliders. To assist the operator in controlling the process, chamber temperatures are now monitored using a number of thermocouples linked to a PC. The whole process takes approximately 11 days. Despite size of the kiln, the heat within it can be affected by the weather. For example, continual heavy rain can penetrate the brickwork of the kiln itself affecting the firing and the quality of the bricks within.

Emissions of SO_2 typically arise from combustion sources can usually be directly related to the sulphur (S) content of the fuel, as the S in the fuel is oxidised during the combustion process. In the case of the brickworks emissions arise from both the additional fuel and the Oxford clay.

The Stewartby brickworks uses coal as a supplementary fuel in the brick making process, whereas the other brickworks use natural gas. The coal is added in small quantities through openings in the top of the kiln to maintain the temperature of the firing process. Precise details of the S content of the coal are not known, nor is the exact quantity used. However estimates from other sources suggest that up to 0.5 tonne is used per chamber.

Sulphur is also a natural constituent of the Oxford clay that is used as the raw material for the Fletton bricks at the brickworks. The clay itself contains approximately 5% by weight of organic material and this minimises the support fuel needed. The S content of the clay is not known.

Further details regarding the emissions of SO_2 are given in the appendices.

2 Air Pollution Measurements in Bedford B.C

2.1 Monitoring Update

This section of the report provides an important update on recent air pollution monitoring undertaken by both the Council and Hanson Bricks, close to the Stewartby Brickworks.

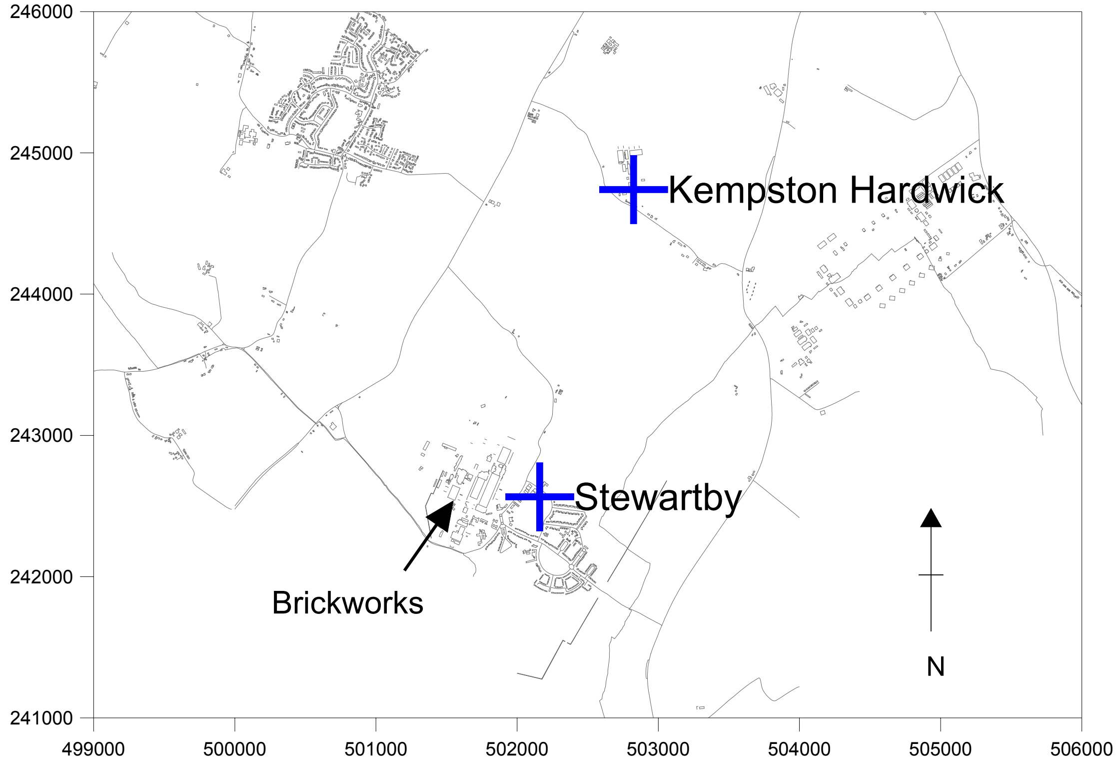
The monitoring of air quality in a local authority's area provides a valuable source of information for understanding air quality. This is particularly so in respect of significant pollution sources. The monitoring provides important information on atmospheric concentrations and can permit an understanding to be developed of the conditions when episodes arise.

The Council undertakes continuous monitoring of SO_2 as part of the Herts and Beds Air Pollution Monitoring Network (HBAPMN). This network operates in accordance with QA/QC procedures that meet those given in LAQM.TG (03). Further specific information is given in Appendix A. The monitoring undertaken by Hanson Bricks is in association with requirements of the Environment Agency, who supplied the data. It is therefore assumed that the QA/QC procedures adopted in relation to the monitoring also meet the requirements of TG03.

The two sites are indicated in Figure 1 overleaf. The Council's site (BF1) is in the village of Stewartby and Hanson's site (KH) is close to the village of Kempston Hardwick. The BF1 site began operating on the 1st November 2000 and is situated adjacent to a sports field directly east of the Stewartby Brickworks. The KH site has been operating longer than the BF1 site, although the monitoring data are only reported from the 1st January 2000. This site is located approximately 2km northeast of the brickworks. Both locations represent sites where there is relevant public exposure as defined earlier.

The following section supplements the earlier Updating and Screening Assessment report with recent results for SO_2. Data are provided up to the end of September 2003 for the KH site and mid-April 2004 for the BF1 site. It should be noted however that the BF1 data provided in this report for 2003 and 2004 are currently not fully ratified.

Figure 1 Location of the continuous air quality monitoring sites in the Bedford B.C area



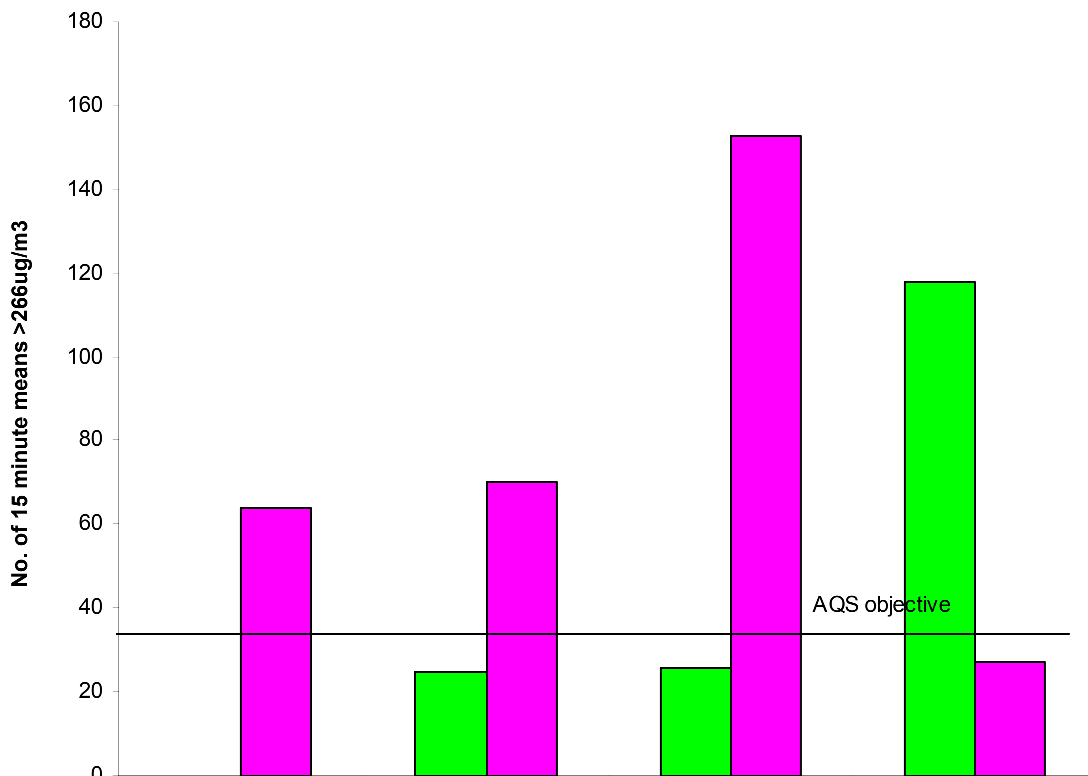
2.2 Summary of sulphur dioxide measurements

The figures below expand and update the information provided in the Council's earlier screening report. It should be noted that the data are summarised for calendar years in line with normal reporting practice. The data are also reported for the three SO_2 objectives (see Table 1 above).

The figures show that the 15-minute objective has been exceeded at the two monitoring sites. Figure 2 indicates that the 15-minute objective was exceeded in each year of monitoring. During this time period the objective was exceeded at the KH site only for 2000 to 2002 and at the BF1 site only for 2003. In each year where the objective was exceeded for the individual sites, it was far in excess of the objective threshold of 35 periods and for both the most recent years for which there are full years worth of data i.e. 2002 and 2003, the number of periods exceeding was more than 100 periods.

The one-hour and 24-hour mean objectives were not exceeded at either site during the period 2000 to 2003. The 24-hour mean objective however was approached in both 2000 and 2002 at the KH site only, with 2 periods exceeding the 24 hour standard for each of these years.

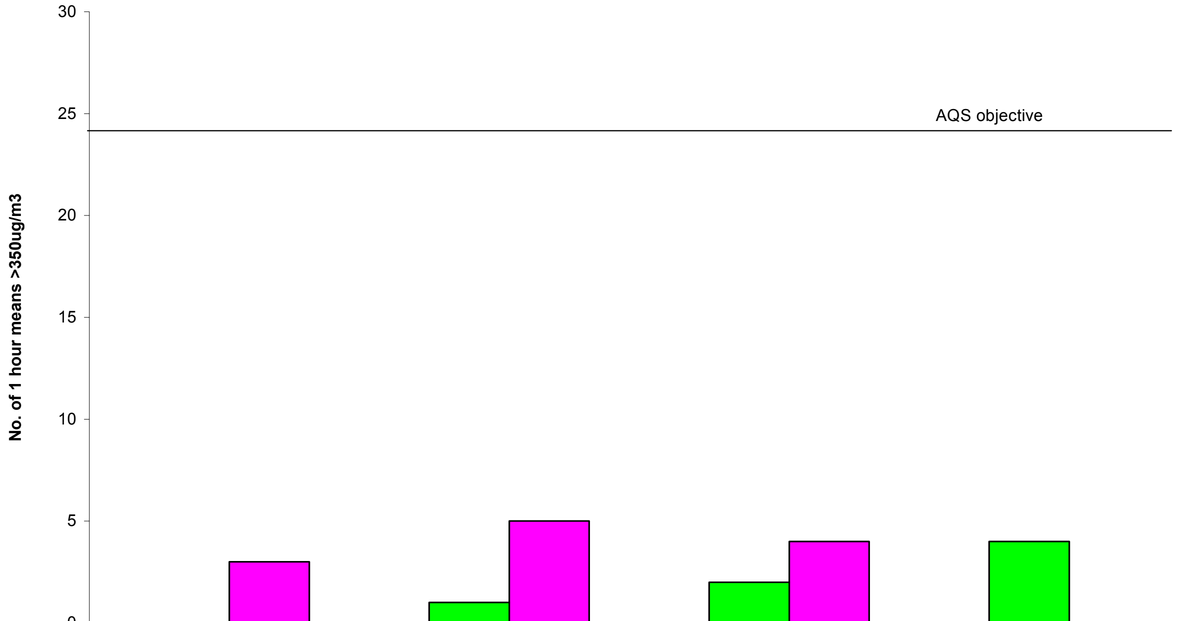
Figure 2 SO_2 monitoring at the sites in the Bedford area (15 minute mean objective)



	2000	2001	2002	2003
BF1	0	25	26	118
KH	64	70	153	27

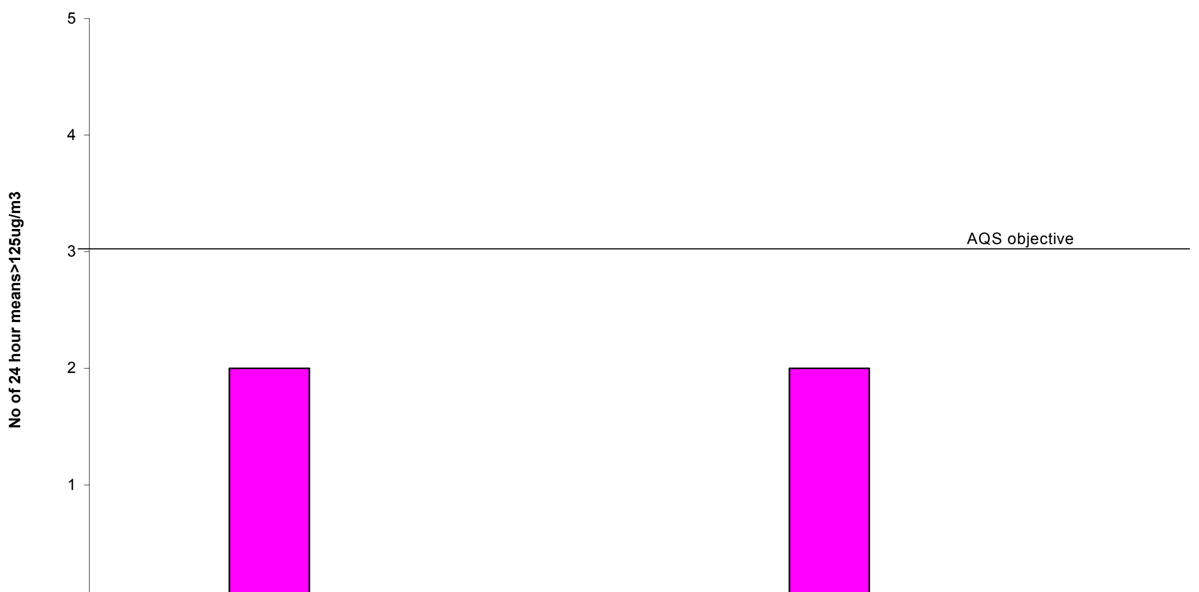
Note – the 2003 monitoring reported above at the KH site was for the period January to September only.

Figure 3 SO_2 monitoring at the sites in the Bedford area (1 hour mean objective)



	2000	2001	2002	2003
BF1	0	1	2	4
KH	3	5	4	0

Figure 4 SO_2 monitoring at the sites in the Bedford area (24 hour mean objective)



	2000	2001	2002	2003
BF1	0	0	0	0
KH	2	0	2	0

The following table indicates the maximum concentrations monitored for each year at each site. Thus it confirms that the peak 15-minute concentrations easily exceeded the 266 µg/m^3 standard for all years other than 2000 at BF1 (as monitoring at the site only started in November of that year).

The maximum one-hour standard of 350µg/m^3 was exceeded during each other, apart from 2000 at the BF1 site and 2003 at the KH site. To date it has not been exceeded at the BF1 site this year.

The 24-hour standard of 125 µg/m^3 was exceeded only at the KH site during 2000 and 2003.

Table 2 Maximum data (µg/m^3) relating to AQS objective periods and data capture

	Max 15 minute	Max 1 hour	Max 24 hourly
BF1			
2000 (part)	45.5	28.7	9.3
2001	763.2	418.7	47.9
2002	836.0	567.6	71.8
2003	1622.3	1095.4	100.3
2004 (part)*	599.8	329.3	72.1
KH			
2000	736.6	516.6	130.6
2001	684.4	520.3	108.3
2002 (part)	616.6	535.2	139.1
2003	476.9	308.8	97.1

(Note - * indicates that monitoring is still in progress, thus these data are provisional)

Previous reports for the HBAPMN (HBAPMN 1997 to 2000) indicate a 10% uncertainty in measuring peak concentrations of SO_2. The number of 15-minute peaks exceeding 239.4 µg/m^3 (i.e. 10% less than 266 µg/m^3) at the sites provides an indication of the number of such periods where the objective was approached for those years where the objective was not specifically exceeded.

The BF1 site did not record an exceedence of the objective in either 2001 or 2002, although an examination of the measurements reveals that it still recorded a high number of peak concentrations close to the objective and within the area of monitoring uncertainty. Similarly, the KH site in 2003 also measured a high number of peak concentrations close to the objective and within the area of monitoring uncertainty.

Table 3 Number of episodes at 90% of AQ standard

	No of 15 minute episodes >239.4µg/m^3	No of hourly episodes >315µg/m^3
BF1		
2000 (part)	0	0
2001	30	1
2002	43	3
2003	155	8
*2004 (part)**	*14*	*1*
KH		
2000	123	4
2001	119	7
2002 (part)	205	9
2003	41	0

(Note - * indicates that monitoring is still in progress, thus these data are provisional)

The table below indicates the data capture for the sites. The TG03 guidance indicates that 90% data capture is ideally required for short-term objective comparison, except in cases where the objective is exceeded with a lower data capture rate. For both sites the data capture exceeded 90% for 2001, with BF1 exceeding 90% also in 2002 and KH in 2000. The 15-minute objective was exceeded in 2003 and 2002 at the BF1 and KH sites respectively despite the data capture being less than 90%.

Table 4 Data capture for the monitoring sites (2000 to 2004 inclusive)

Site	% Data capture
BF1	
2000 (part)	4.2
2001	90.4
2002	93.4
2003	88.9
*2004**	*25.8*
KH	
2000	97.7
2001	95.3
2002 (part)	56.8
2003 (part)	73.1

(Note - * indicates that monitoring is still in progress)

For further comparison purposes the results for the background site in St. Albans (SA1) are given below in Table 5. This site is also part of the HBAPMN and can be considered representative of the background conditions that might exist in the Bedford area. From these results it can be seen that there have been no periods where the objective has been exceeded. (Further information on this site is given in Appendix D).

Table 5 Background monitoring results (2001-2003)

SA1	2001	2002	2003
Data capture	92.0%	93.1%	88.7%
Periods > 266µgm^3	0	0	0
99.9th %ile (µgm^3)	66.8	55.1	63.6

2.3 Monthly distribution of episodes at BF1 and KH

This section focuses on the distribution of 15-minute mean episodes, rather than hourly or 24 hour periods of high concentrations because the monitoring shows that the 15 minute mean objective is being exceeded.

The monitoring results from the two sites have been further examined to show the distribution of episodes during the year (i.e. based on the date and time of episodes where the 15 minute mean was greater than 266 µg/m^3). The individual details of episodes are given in Appendix B, and the distributions are shown below in Figure 5 and Figure 6 for each site.

Details of operations at the brickworks however are not known; hence it is not possible to confirm whether or not the variation in episodes over the respective years was due to any specific changes undertaken at the brickworks. It is however known that use of kiln ck22 ended in November 2002 and that there was a period around this time when production at kiln ck1was started. Monitoring at the KH site was also disrupted in 2002.

Figure 5 Distribution of SO_2 episodes for BF1 (January 2001 – December 2003)

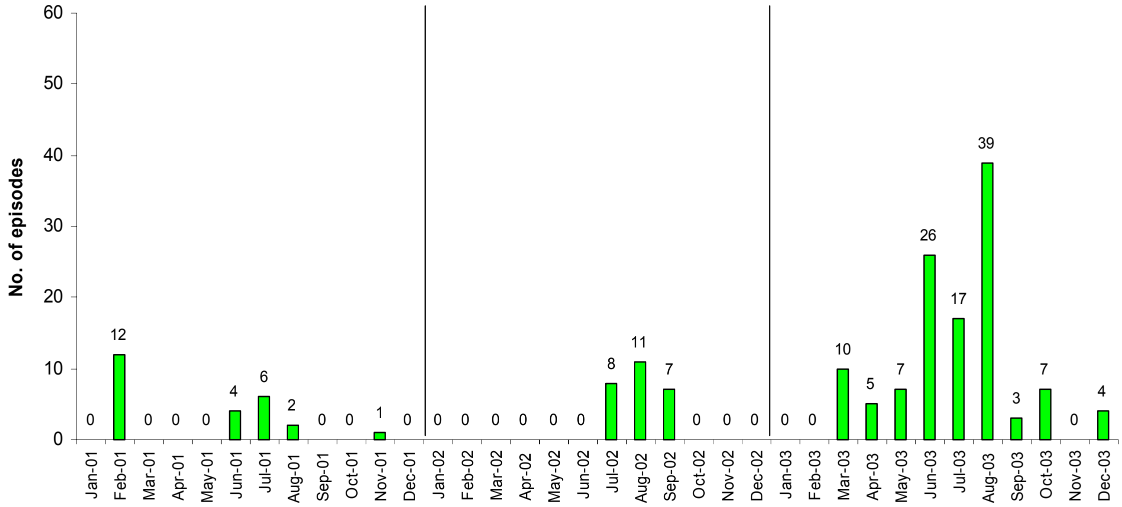


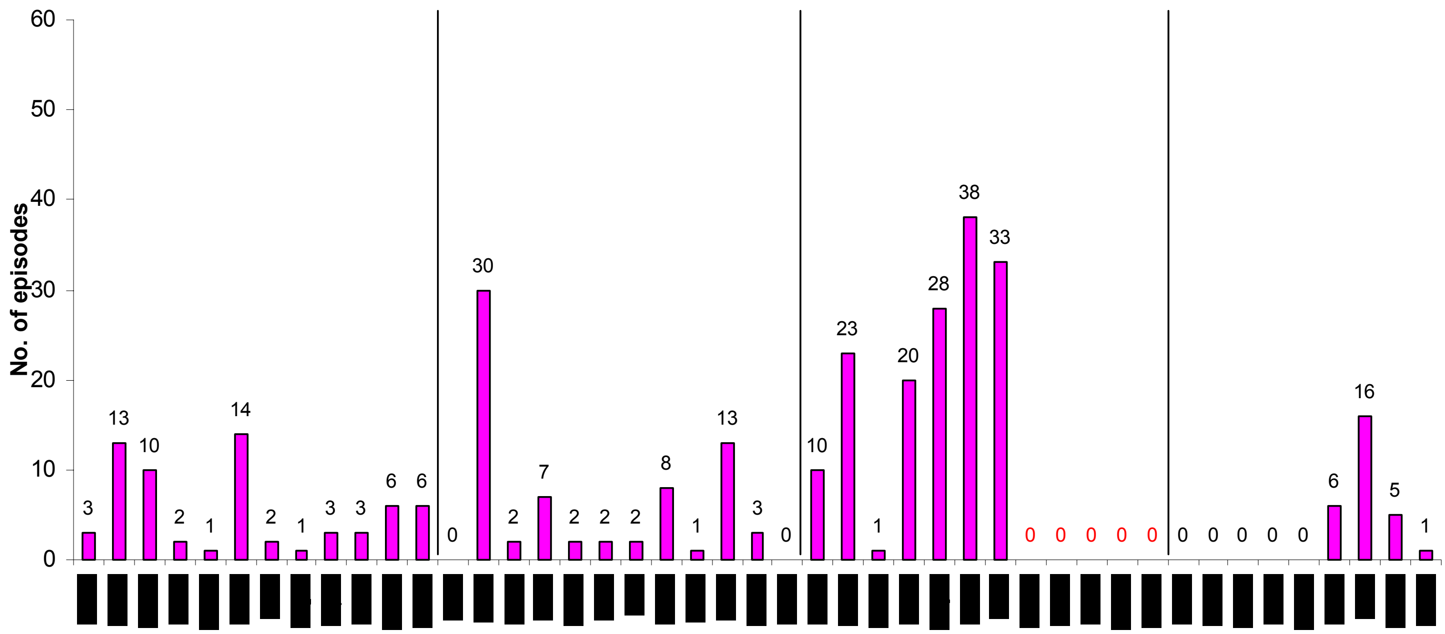
Figure 5 indicates that there have been episodes during many months of the year when the site has been operating, with the peak of 12 episodes in February 2001, 11 in August 2002 and 39 in August 2003. For each year there is clearly a preponderance of episodes during the summer and in 2002 episodes only occurred at this time. This suggests that summer conditions with warm calm periods are an important factor leading to the episodes arising at BF1. The BF1 monitoring site is close to the brickworks (less than 500m).

The above figure also clearly highlights the substantial increase in the numbers of episodes between the first two years (2001 and 2002) and 2003. The reason for this large increase cannot be determined from this analysis alone and is therefore discussed later.

The data presented below for the KH site represent a longer monitoring period, from 2000 to 2003. It should be noted that for 2002 the period from August to December is marked in red. This represents the period when the site was closed following vandalism. For 2003 no data were obtained for the period beyond September.

The assessment for this site clearly shows a higher number of episodes with 15-minute mean concentrations exceeding 266 µg/m^3 than BF1 for all years other than 2003. The KH site is located further from the brickworks than the BF1, being approximately 2km north east of Stewartby.

Figure 6 Distribution of SO_2 episodes for ZD4 (August 2002 – September 2003)



The distribution of episodes is different from that at the BF1 site, with episodes arising during most months of each year, apart from 2003. The peak number of episodes also varies with higher numbers in 2000 in February and March, as well as June. For 2001, the months with peak numbers were February and October. For 2002 the monitoring was limited to the end of July, although there were high numbers of episodes in every month other than March.

The KH results for 2003 show a lower number of episodes than previous years, with no episodes at all during the period January to May. Episodes did arise during the following months, with July being the peak month.

2.4 Analysis of episodes at BF1

To further understand the SO_2 episodes it is necessary to examine concurrent meteorological factors. To aid this wind speed and direction data have been used from the KH site. These data were not available for 2003 so data from the background monitoring site in nearby Luton (LN) has been used. This analysis assumes that there is no variation in meteorological conditions between the sites. The wind roses for these sites are provided in Appendix C.

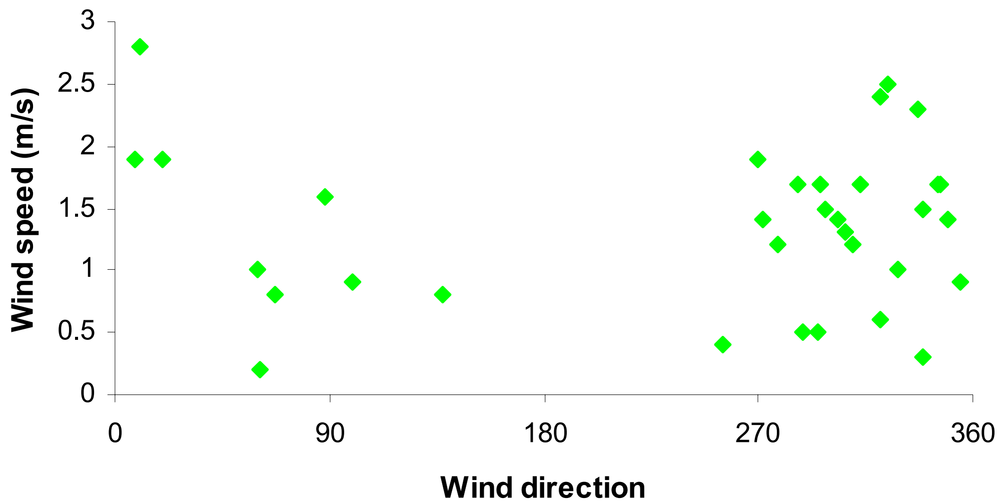
The monitoring data have been examined for a series of episodes. Table 6 and Table 7 provide details of these factors in summary form for 2001 - 2002 and for 2003 for the BF1 site.

Table 6 Wind speed and direction of peak 15-minute mean SO_2 episodes at BF1 for 2001 - 2002

Date	Time	SO_2 µg/m^3	KH W.Dir (°)	KH W.Sp (m/s)
01/02/2001	04:30:00	272.4	329	1
01/02/2001	04:45:00	516.8	321	0.6
01/02/2001	05:00:00	267.6	295	0.5
01/02/2001	05:30:00	303.5	289	0.5
09/02/2001	12:30:00	277.4	355	0.9
09/02/2001	13:00:00	332.0	339	0.3
15/02/2001	12:00:00	300.3	61	0.2
15/02/2001	12:15:00	763.2	100	0.9
15/02/2001	12:30:00	311.8	138	0.8
15/02/2001	12:45:00	299.3	67	0.8
15/02/2001	13:00:00	375.6	60	1
15/02/2001	14:30:00	267.9	8	1.9
18/06/2001	12:15:00	664.5	20	1.9
18/06/2001	13:00:00	362.6	306	1.3
18/06/2001	14:00:00	296.9	303	1.4
24/06/2001	09:00:00	323.7	88	1.6
15/07/2001	16:00:00	286.2	321	2.4
20/07/2001	09:15:00	327.4	272	1.4
20/07/2001	09:45:00	403.5	298	1.5
27/07/2001	14:15:00	594.2	313	1.7
28/07/2001	11:45:00	578.0	350	1.4
28/07/2001	13:00:00	414.7	339	1.5
20/08/2001	16:00:00	302.4	270	1.9
31/08/2001	08:30:00	305.4	324	2.5
23/11/2001	04:45:00	330.4	255	0.4
06/07/2002	11:45:00	341.8	287	1.7
06/07/2002	13:15:00	504.1	310	1.2
06/07/2002	13:30:00	297.4	346	1.7
13/07/2002	13:45:00	309.4	10	2.8
14/07/2002	12:45:00	318.9	345	1.7
14/07/2002	15:30:00	353.2	337	2.3
28/07/2002	13:15:00	354.8	278	1.2
28/07/2002	13:30:00	299.3	296	1.7

The above table represents peaks greater than 266 µg/m^3, up to the end of July 2002 due to the vandalism at the KH site. The wind direction and wind speed of episodes is shown in Figure 7, this indicates that episodes arose in two clusters with the majority in the sector from the 270 to 360°. The other cluster is more widely spread around 90°. The BF1 monitoring site is to the east of the brickworks, specifically east of stack ck22 and roughly south east of ck3 and this position coincides with the wind direction of the majority of episodes.

Figure 7 Analysis episodes at BF1 during 2001 and 2002



From wind speed data, the average wind speed when episodes arose was 1.35m/s, with a range from 0.2 to 2.8m/s. This indicates that episodes arose at fairly low wind speeds. The average wind speed for the whole period was just over 3m/s. Thus the episodes tended to occur when the wind speeds were slightly lower than the average (based on 2001 and 2002 measurements).

The following table gives meteorological information for those episodes arising in 2003, based on wind data from the Luton site. The pollution data for 2003 indicates a far greater number of episodes than previous years. Brick production at the brickworks also changed in 2002 with kiln ck22 being closed, being replaced by new production at kiln ck1. This kiln uses stacks ck1b and ck1c. Both of these stacks are closer to BF1 by approximately 50m although they still have approximately the same orientation as ck22 (i.e. they are to the west of BF1).

Table 7 Wind speed and direction of peak 15-minute mean SO_2 episodes at BF1 for 2003

Date	Time	SO_2 µg/m^3	LN W.Dir (°)	LN W.Sp. (m/s)
19/03/2003	12:45:00	348.7	271.1	0.9
19/03/2003	13:30:00	281.7	257.4	0.6
19/03/2003	14:00:00	339.2	145	0.6
19/03/2003	15:00:00	307.5	226.2	0.5
19/03/2003	16:15:00	306.4	253.8	0.8
19/03/2003	16:30:00	394.2	112.1	0.4
25/03/2003	09:45:00	327.7	276.6	1.4
25/03/2003	10:00:00	342.1	258.4	1.1
25/03/2003	11:30:00	342.3	244.4	0.9
25/03/2003	13:00:00	278.5	243.4	0.9
22/04/2003	10:45:00	548.5	240.5	1.8
22/04/2003	11:00:00	489.2	260.3	2
22/04/2003	11:15:00	328.2	235.3	1.8
22/04/2003	12:00:00	299.8	233.3	1.2
22/04/2003	17:30:00	286.0	295.1	0.8
06/05/2003	11:30:00	304.8	279.8	2.1
06/05/2003	11:45:00	335.4	263.9	2.1
06/05/2003	12:00:00	335.4	261.3	2.4
08/05/2003	11:15:00	412.3	271.1	1.5
08/05/2003	14:00:00	274.0	268.4	0.8
08/05/2003	16:00:00	287.5	255.5	1
09/05/2003	10:30:00	334.1	257.7	1.5
13/06/2003	08:30:00	377.2	247	1.1
13/06/2003	08:45:00	290.2	266.2	1.5
13/06/2003	09:00:00	287.3	263.3	1.2
13/06/2003	10:15:00	387.0	271.4	1.6
13/06/2003	11:15:00	266.8	272	1.6
13/06/2003	11:30:00	480.4	210.9	1.1
13/06/2003	11:45:00	385.4	255.5	1.1
13/06/2003	12:15:00	366.5	242.5	1.7
13/06/2003	12:30:00	464.2	235	1.5
13/06/2003	13:15:00	484.4	228.5	1
13/06/2003	14:00:00	436.8	274.9	1.7
13/06/2003	14:15:00	426.9	195.3	1.2
13/06/2003	15:15:00	450.3	223.9	1.1
13/06/2003	16:15:00	271.6	267.2	1.3
13/06/2003	16:30:00	311.8	261.9	1.5
15/06/2003	15:45:00	283.6	229.8	1.2
16/06/2003	10:15:00	292.9	184.6	0.8
24/06/2003	09:45:00	320.3	258.7	1.6
24/06/2003	10:45:00	359.1	267.8	1.6
24/06/2003	11:15:00	372.9	208.3	1.4

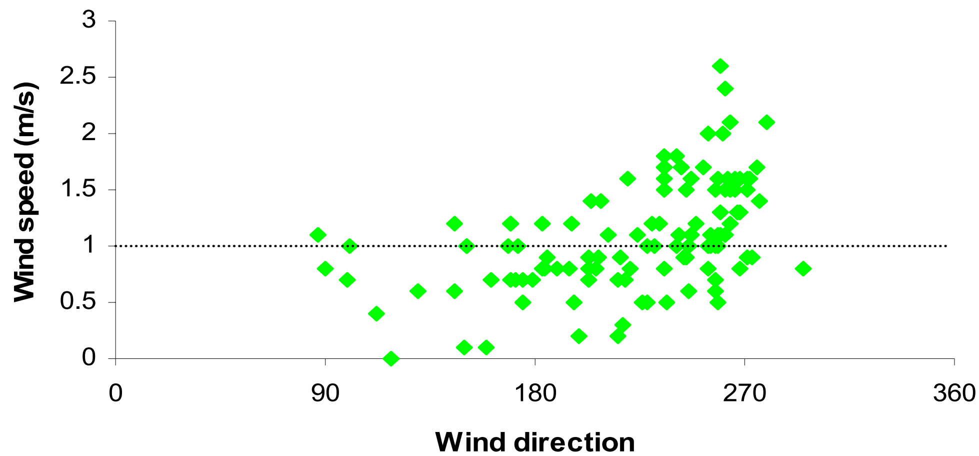
28/06/2003	13:00:00	374.3	171.6	0.7
28/06/2003	13:15:00	320.8	172.9	1
28/06/2003	13:45:00	314.7	217.1	0.9
28/06/2003	15:45:00	345.8	246.3	0.6
28/06/2003	16:00:00	414.7	219.1	0.7
28/06/2003	16:45:00	339.9	175.2	0.5
06/07/2003	09:30:00	475.1	266.2	1.6
06/07/2003	10:45:00	306.4	247.3	1.6
07/07/2003	07:45:00	377.5	261.6	1.1
07/07/2003	08:00:00	315.2	231.4	1
07/07/2003	08:30:00	366.5	245.4	1.5
12/07/2003	07:45:00	308.0	198.9	0.2
12/07/2003	08:00:00	311.0	189.5	0.8
12/07/2003	13:30:00	440.0	179.1	0.7
12/07/2003	14:00:00	499.5	248.6	1.2
12/07/2003	14:45:00	297.9	257.7	1
12/07/2003	16:00:00	456.7	259.7	1.1
12/07/2003	16:15:00	375.3	203.5	0.8
12/07/2003	17:00:00	283.0	202.8	0.9
16/07/2003	12:15:00	310.7	170	1.2
27/07/2003	11:15:00	275.3	259.4	2.6
27/07/2003	11:45:00	299.8	254.8	2
27/07/2003	12:00:00	288.9	235.3	1.7
03/08/2003	10:30:00	514.2	87.1	1.1
03/08/2003	10:45:00	294.5	99.5	0.7
03/08/2003	11:00:00	330.9	89.7	0.8
03/08/2003	11:45:00	355.9	175.2	0.7
03/08/2003	12:00:00	449.3	150.5	1
03/08/2003	12:15:00	375.3	185.6	0.9
03/08/2003	14:15:00	366.8	149.2	0.1
03/08/2003	14:45:00	287.3	183	0.8
03/08/2003	15:00:00	366.8	218.1	0.3
03/08/2003	16:30:00	342.6	161.2	0.7
07/08/2003	15:00:00	274.8	262.9	1.6
08/08/2003	10:45:00	303.5	259.7	1.3
08/08/2003	11:15:00	341.8	169.3	0.7
08/08/2003	11:30:00	732.6	235.6	0.8
08/08/2003	11:45:00	355.6	246	1
08/08/2003	12:00:00	437.6	246.7	1.1
08/08/2003	12:15:00	281.7	100.8	1
08/08/2003	13:00:00	275.0	203.8	1.4
08/08/2003	15:00:00	353.5	215.2	0.7
09/08/2003	08:30:00	481.7	245.4	0.9
09/08/2003	08:45:00	818.7	257.7	0.7
09/08/2003	09:00:00	1622.3	246	1
09/08/2003	09:15:00	1175.2	268.1	1.3

09/08/2003	09:30:00	1056.8	261.6	1.1
09/08/2003	09:45:00	527.7	240.5	1
09/08/2003	10:00:00	270.5	258.1	1
09/08/2003	11:00:00	415.2	221	0.8
09/08/2003	13:30:00	332.0	203.1	0.7
09/08/2003	15:00:00	280.6	207.7	0.9
09/08/2003	15:15:00	332.5	195	0.8
10/08/2003	11:15:00	329.8	170	1.2
10/08/2003	11:30:00	794.0	183.6	1.2
10/08/2003	11:45:00	313.9	169	1
13/08/2003	11:00:00	287.8	252.5	1.7
20/08/2003	09:45:00	411.2	235.6	1.6
20/08/2003	10:00:00	314.7	241.8	1.1
20/08/2003	13:30:00	274.8	219.4	1.6
20/08/2003	13:45:00	289.7	235	1.7
23/08/2003	10:45:00	417.6	264.2	1.5
07/09/2003	12:00:00	397.4	150.8	1
07/09/2003	12:15:00	476.7	145	1.2
16/09/2003	10:30:00	391.6	206.1	0.8
11/10/2003	12:15:00	491.3	236.3	0.5
11/10/2003	13:00:00	387.8	197	0.5
11/10/2003	13:15:00	286.5	216.1	0.2
11/10/2003	13:45:00	482.0	228.2	0.5
21/10/2003	10:30:00	293.9	258.1	0.5
21/10/2003	11:30:00	376.4	273	0.9
21/10/2003	11:45:00	462.0	254.5	1
10/12/2003	04:30:00	276.6	118	0
10/12/2003	05:00:00	405.7	130	0.6
10/12/2003	05:15:00	568.4	127.1	-0.1
10/12/2003	05:30:00	288.3	159.3	0.1

The data for 2003 (i.e. episodes greater than 266 $\mu g/m^3$) are given in Table 7 above for the 118 episodes during 2003.

A cursory examination of the wind direction for these episodes suggests that the range of wind directions is as great as that for the previous years. The range of the wind directions is shown in Figure 8, and this indicates that episodes arose when the wind was from the 90 to 300° sector.

Figure 8 Analysis episodes at BF1 during 2003



It should however be noted that many episodes arose during calm periods i.e. when the wind speed was less than 1 m/s. In these instances it is extremely difficult to accurately determine wind direction as it can vary hugely, thus allowing plumes to meander and re-circulate.

From the wind speed data, the average wind speed when episodes arose was 1.1m/s, with a range from 0 to 2.6m/s. The average for whole of 2003 was 1.6m/s. Thus the episodes again tend to arise when the wind speeds are slightly lower than average. It is important to note however that compared to the previous years the average wind speed for the whole year was much less.

A key point arising from this analysis of the episodes at BF1 is that whilst both wind direction and wind speed are important factors, it is low wind speed that is more important, since no episodes have arisen at speeds greater than 2.8m/s. The low wind speeds of 2003 are likely to have therefore contributed to the higher number of episodes at the site during this year compared to the previous two years.

2.5 Analysis of episodes at KH

The location of the KH monitoring site is shown in Figure 1 earlier; it is approximately 2km to the northeast of the brickworks.

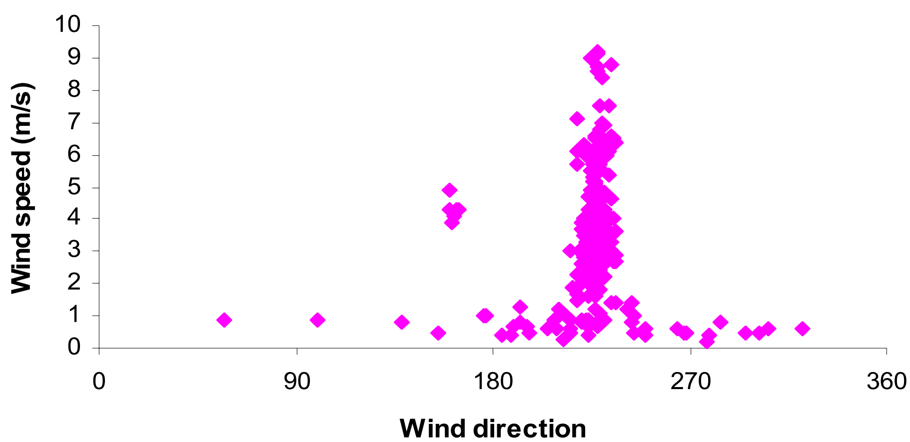
A summary of wind direction and speed data for each year is given in Table 8. Details of the episodes for 2000 to 2003 are also given in the following figures, with full details for 2003 only in Table 9.

Figure 9 highlights that the vast majority of episodes arose when the wind direction was close to 225°. Over 70% of the episodes also arose when the wind speed exceeded 2.5 m/s, which is close to the annual average wind speed. Compared to the BF1 site the wind direction for episodes was strongly directional with greater wind speeds for all years 2000 to 2002.

Table 8 Summary wind data of episodes for the KH site (2000 to 2003)

2000	Ave	Max	Min
Wind direction (°)	219	278	160
Wind speed (m/s)	3.9	9	0.2
2001			
Wind direction (°)	226	321	100
Wind speed (m/s)	2.2	6	0.3
2002			
Wind direction (°)	228	267	57
Wind speed (m/s)	3.9	9.2	0.5
2003			
Wind direction (°)	175	232	101
Wind speed (m/s)	1.5	3.2	0

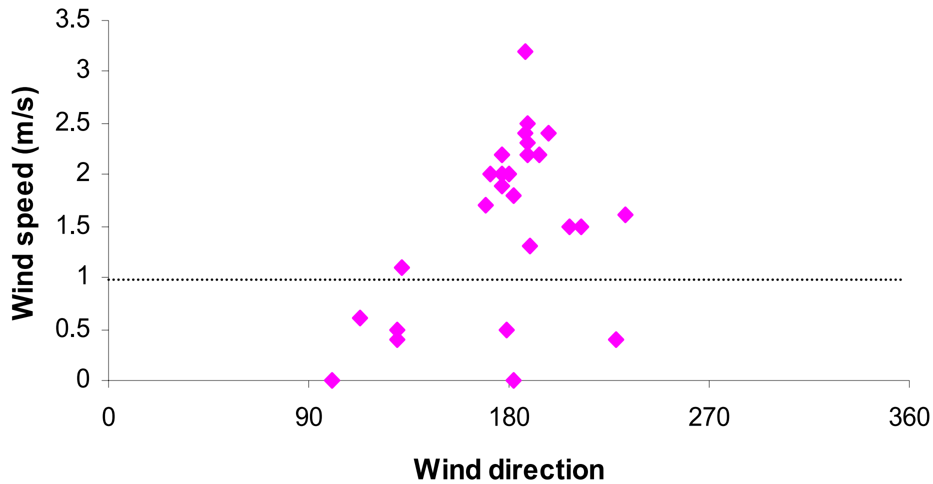
Figure 9 Analysis episodes at KH during 2000 to 2002



As for BF1, the monitoring results changed dramatically between the period from 2000 - 2002 inclusive and pollution year 2003. However unlike BF1, the numbers of episodes dramatically reduce with far less episodes; for 2003 there are 27 episodes compared to between 64 and 153 for the preceding years.

Figure 10 below provides equivalent information for 2003 to that given in Figure 9 using wind data from Luton rather than KH.

Figure 10 Analysis episodes at KH during 2003



The above figure shows that the average wind direction at the time of the episodes was approximately 180° with an average wind speed of about 1.5 m/s. In addition approximately 30% of the episodes arose with wind speeds of less than 1 m/s, i.e. during calm conditions. As discussed earlier it becomes extremely difficult to ascertain the direction of an emission source in these conditions due to plume meander.

Table 9 Wind speed and direction of peak 15-minute mean SO_2 episodes at KH for 2003

Date	Time	SO_2 µg/m^3	LN W.Dir (°)	LN W.Sp. (m/s)
05/06/2003	17:45	313.9	212.9	1.5
05/06/2003	18:00	379.6	197.3	2.4
10/06/2003	12:30	273.4	132.3	1.1
15/06/2003	08:30	339.4	112.8	0.6
15/06/2003	09:00	422.7	129.3	0.4
15/06/2003	09:15	294.5	129.7	0.5
18/07/2003	20:15	302.7	207	1.5
18/07/2003	20:30	329.6	193.1	2.2
19/07/2003	18:30	290.7	171.6	2
19/07/2003	19:00	297.4	187.2	2.4
20/07/2003	08:30	278.5	189.5	1.3
20/07/2003	19:15	305.4	176.5	2.2
20/07/2003	19:45	415.5	176.5	2
23/07/2003	13:30	334.6	178.8	0.5
23/07/2003	20:15	284.1	180.1	2
23/07/2003	22:00	338.6	188.2	2.5
23/07/2003	22:15	362.6	188.2	2.3
23/07/2003	22:45	368.1	187.2	3.2

28/07/2003	17:45	276.4	176.5	1.9
28/07/2003	20:00	323.2	232.1	1.6
29/07/2003	11:30	275.6	169.3	1.7
29/07/2003	14:30	364.7	182	1.8
01/08/2003	02:00	284.9	188.8	2.2
10/08/2003	09:30	320.8	100.8	0
10/08/2003	09:45	476.9	124.5	-0.2
10/08/2003	10:00	319.5	182	0
17/09/2003	08:30	296.3	228.5	0.4

2.6 Summary of episode analysis

By examining periods when high concentrations arise at both monitoring sites it becomes possible to develop an understanding of the wind conditions under which such occurrences might arise. It can be seen for both BF1 and KH monitoring sites wind data are clearly important.

The KH site is directly downwind of the brickworks in the direction of the prevailing wind, hence typically episodes arise when there is a wind speed of about 2.5 m/s.

The BF1 site is much closer and to the east of the brickworks, episodes typically arise at this site when wind speeds are low, approximately 1 m/s. At low wind speeds the wind direction is less certain however most episodes arise when the wind comes from the general direction of the brickworks.

For pollution years 2001 and 2002 the number of episodes arising at the KH site is much greater than the number at BF1. During pollution year 2003 however the monitoring at the two sites provided different results from previous years, with far less episodes at the KH site than the BF1 site. The analysis of wind data again provides useful information, indicating in this instance, that average winds speeds were less than previous years during the episodes at the KH site. Thus it is assumed that the plumes were more likely to meander away from the KH site due to the greater travel distance from the brickworks.

3 Predictions of Sulphur Dioxide (SO_2)

3.1 Outline of modelling developments

The detailed assessment represents significant progress beyond the Updating and Screening Assessment report. As a summary the developments include:

- Detailed modelling of the releases of SO_2 over the area of interest to allow an improved assessment of exposure;
- Predictions plotted on OS base maps;
- Additional monitoring data for assisting the modelling;
- Use of local meteorological data over two years to take into account year to year variation

A detailed explanation of the methods used, including the assumptions used are given in the appendices.

The overall aim of the air pollution modelling is to produce a sound method whereby concentrations of SO_2 can be determined and in conjunction with the continuous monitoring results be used to produce percentile values that can be compared with the AQS objectives.

The area of interest in the report was limited to the southwest corner of the Bedford B.C area. The area is based on the Stewartby Brickworks that was identified in the earlier Updating and Screening Assessment. No other potential sources of SO_2 that might lead to a risk of exceedence were identified in the study area in that report.

3.2 Verification of model performance with BF1 and KH monitoring sites

2001 is the only year with a full dataset (i.e. more than 90 % data capture) for the two monitoring sites. From the information received concerning the brickworks it is understood that only two kilns were operating during this year (ck3 and ck22 and details of the emissions used for the modelling of these sources are given in Appendices E and F).

Modelling was therefore undertaken to check the performance of the model for 2001 using meteorological data from Cardington, which is approximately 8km northeast of Stewartby. The results of the modelling at the monitoring sites are given in the following table.

Table 10 Comparison of modelled and monitored results at the BF1 and KH sites (for 2001)

AQS objective	% ile	Monitored	Modelled	Mod/ Mon Factor
BF1				
24 hour	99.18th%ile	39.9	50.1	0.80
1hour	99.7th%ile	131.2	189.2	0.69
15 min	99.9th%ile	237.2	230.1	1.03
KH				
24 hour	99.18th%ile	98.6	53.8	1.8
1hour	99.7th%ile	222.4	98.3	2.26
15 min	99.9th%ile	326.0	140.1	2.33

Upon initial examination of the above 2001 results it appears that the modelling at BF1 agrees well with monitoring results for the equivalent percentiles for each of the three SO_2 objectives.

The equivalent modelling for the KH site however under predicts significantly and is only about 50% of that monitored for each objective for the same year.

This difference between the two sites highlights the difficulties of modelling peak concentrations, representing the equivalent of less than 3 days in any one year. The limitations of modelling such periods are discussed further in the Appendices. In this instance the presence of two monitoring sites, whilst beneficial to gaining a robust understanding of air quality, greatly complicates understanding of the modelling, further highlighting its limitations.

The previous chapter provided an understanding of the monitoring of peak concentrations at the sites. This indicated for BF1 that episodes tend to arise when the wind direction is from the west (in broad terms) and when the wind speed is lower than the average. Low winds speeds however are the precise times when dispersion models typically perform least well. Hence this suggests that whilst the modelling agrees well with the monitoring, it is not necessarily representing accurately what is happening.

Conversely episodes at the KH monitoring site occur, in the majority of circumstances, when the wind is strongly directional (from the direction of the brickworks) and blowing at the average or greater than average wind speed. In such conditions it might be expected that the modelling would perform better than the BF1 site (which is closest to the brickworks (see Figure1)).

The implication from this assessment is that the modelling can most easily represent the monitoring at KH and therefore to produce a factor based on this site could provide a more robust answer than that based on using the modelling results based on BF1.

The intention of the modelling however is to produce an understanding of peak concentrations for a large area, not just two points. It can therefore be seen from the above comments that it is an extremely difficult task to produce robust modelling upon which the Council can base its decision making process for air quality.

The following figures present the best estimations for the area using the available emissions information and an approved dispersion model. It should however come as no surprise that the areas predicted to exceed vary widely with both increased emissions and use of factoring techniques as outlined in the TG03 guidance.

3.3 Figures showing model predictions

The following pages provide isopleths of the modelled predictions for SO_2 for the Bedford B.C area[1]. The modelling relates to the 15-minute objective since it is this objective that has been exceeded as outlined in the above section on monitoring. The areas coloured yellow to red indicate areas predicted to exceed the objective

It should be noted that the objective relates to the number of occasions, which the 15-minute standard of 266 $\mu g/m^3$ is exceeded over a year. This statistic can only be fully determined using measurements. The government's guidance however permits an approximate equivalent percentile to be used to assess pollution levels where modelling is necessary. For the 15 minute objective the equivalent percentile is the 99.9th percentile. This relates to the 36th highest 15-minute mean concentration arising over a year.

3.4 Scenarios examined in the detailed assessment

The scenarios tested in this section are intended to represent emissions arising from the Stewartby brickworks for the years 2001 and 2005. The scenarios tested are as follows:

1) Kilns ck3 and ck22 have been modelled for 2001 – as outlined above.

2) Kilns ck1 and ck3 have been modelled for 2005; this assumes that there will be no changes to the level of emissions from the brickworks. Kiln ck1 is assumed to discharge from stack ck1b only.

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3) Kilns ck1 and ck3 have been modelled for 2005; this also assumes that there will be no changes to the level of emissions from the brickworks. Kiln ck1 however is assumed to discharge from both stack ck1b and ck1c at the same emission rate.

4) Kilns ck3 and ck22 have been modelled for 2001 and factored to the KH monitoring site.

Further explanation on the inputs modelled and the approach taken are given in the appendices.

3.5 Predicted exceedences of the SO_2 15 minute mean in 2005

The predicted exceedences of the 15-minute mean of 266 μg/m^3 (100ppb) for the 2005 base case, assuming that the meteorology for 2001 is repeated, are shown in Figure 11 to Figure 14 below. The areas coloured yellow to red represent those areas that are predicted to exceed the air quality objective.

The predictions confirm that the air quality objective will be exceeded in areas close to and around the Stewartby brickworks for all the scenarios presented. An outline of the areas predicted to exceed for each scenario is given in Figure 15 to permit easy comparison.

The effect of using different years of meteorology is discussed in the appendices. Due to the very small difference between the two years examined i.e. 2001 and 2002, only scenarios based on 2001 meteorology are presented.

The main difference between the predictions is that the area predicted to exceed increases from Scenario 1) to Scenario 2). The area predicted to exceed for Figure 12 is slightly greater than that for Figure 11, reflecting that the stacks for kilns ck1 and ck3 are closer together than ck3 and ck22.

Figure 13 has an increased predicted to exceed area over that of Figure 12; this is due to increased emissions from ck1 based on similar discharges from stacks ck1b and ck1c.

The area predicted to exceed in Figure 14 is much larger than that predicted in Figure 11. The scenario in Figure 14 is based on that of scenario 1, i.e. for kilns ck22 and ck3 only. The factoring has been derived from the monitoring results obtained from the KH site for 2001. For this monitoring site, the model predictions under predict the monitored results, with the modelled results representing approximately 40% of those monitored. Further explanation of how the factoring was obtained is given in the Appendix D on modelling methodology.

Figure 11 Predicted 99.9th percentile SO_2 15-minute mean concentration ($\mu g/m^3$) for the southwest Bedford B.C area for 2001 (based on kilns ck3 and ck22)

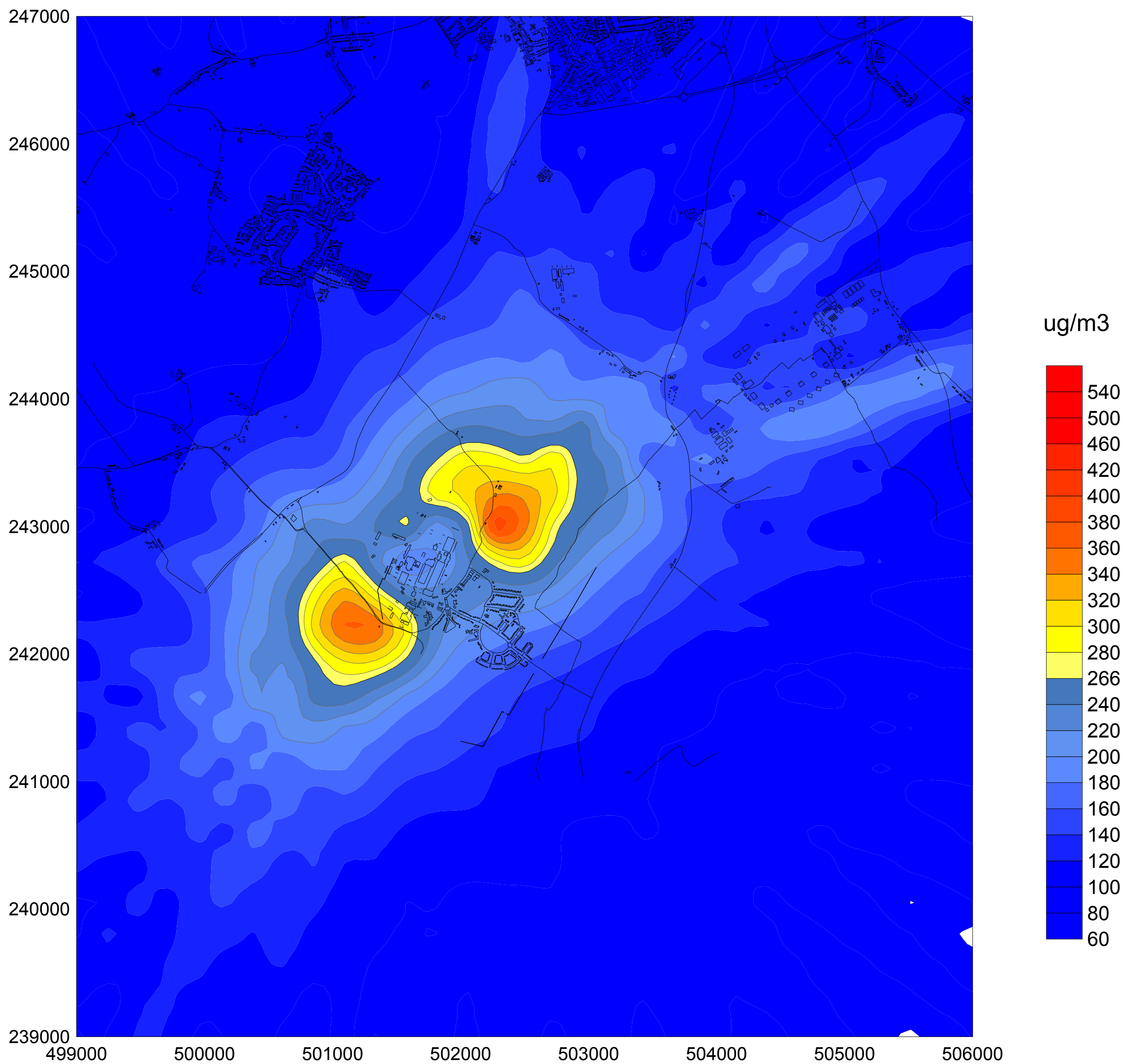

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Figure 12 Predicted 99.9th percentile SO_2 15-minute mean concentration ($\mu g/m^3$) for the southwest Bedford B.C area for 2005 (based on kilns ck1 and ck3 using 2001 meteorology)

(Note – emissions of 100g/s from ck1b and ck3 only)

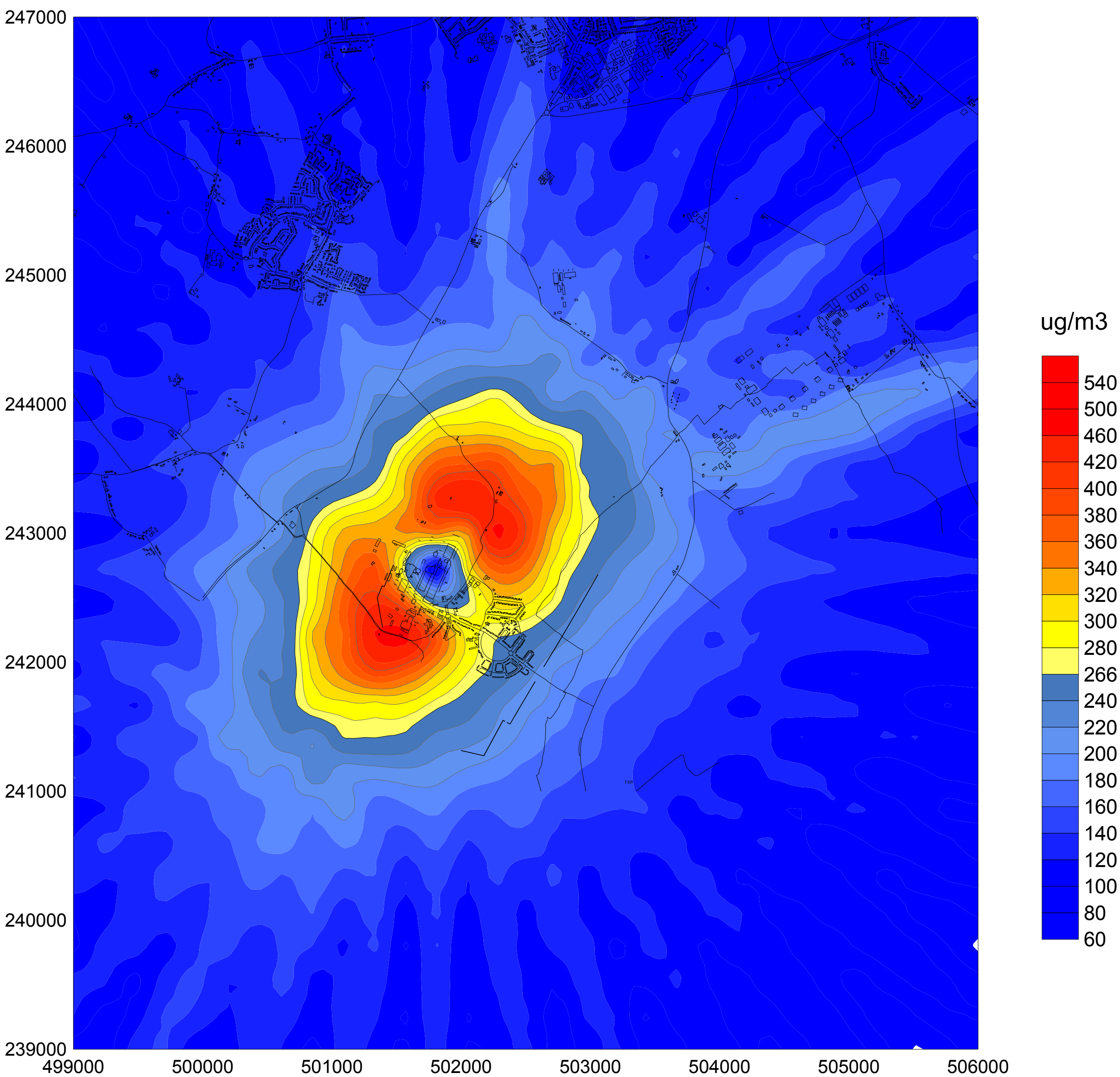

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Figure 13 Predicted 99.9th percentile SO_2 15-minute mean concentration (µg/m^3) for the southwest Bedford B.C area in 2005 (for kilns ck1 and ck3 using 2001 meteorology)

(Note – emissions of 100g/s from ck1b, ck1c and ck3 only)

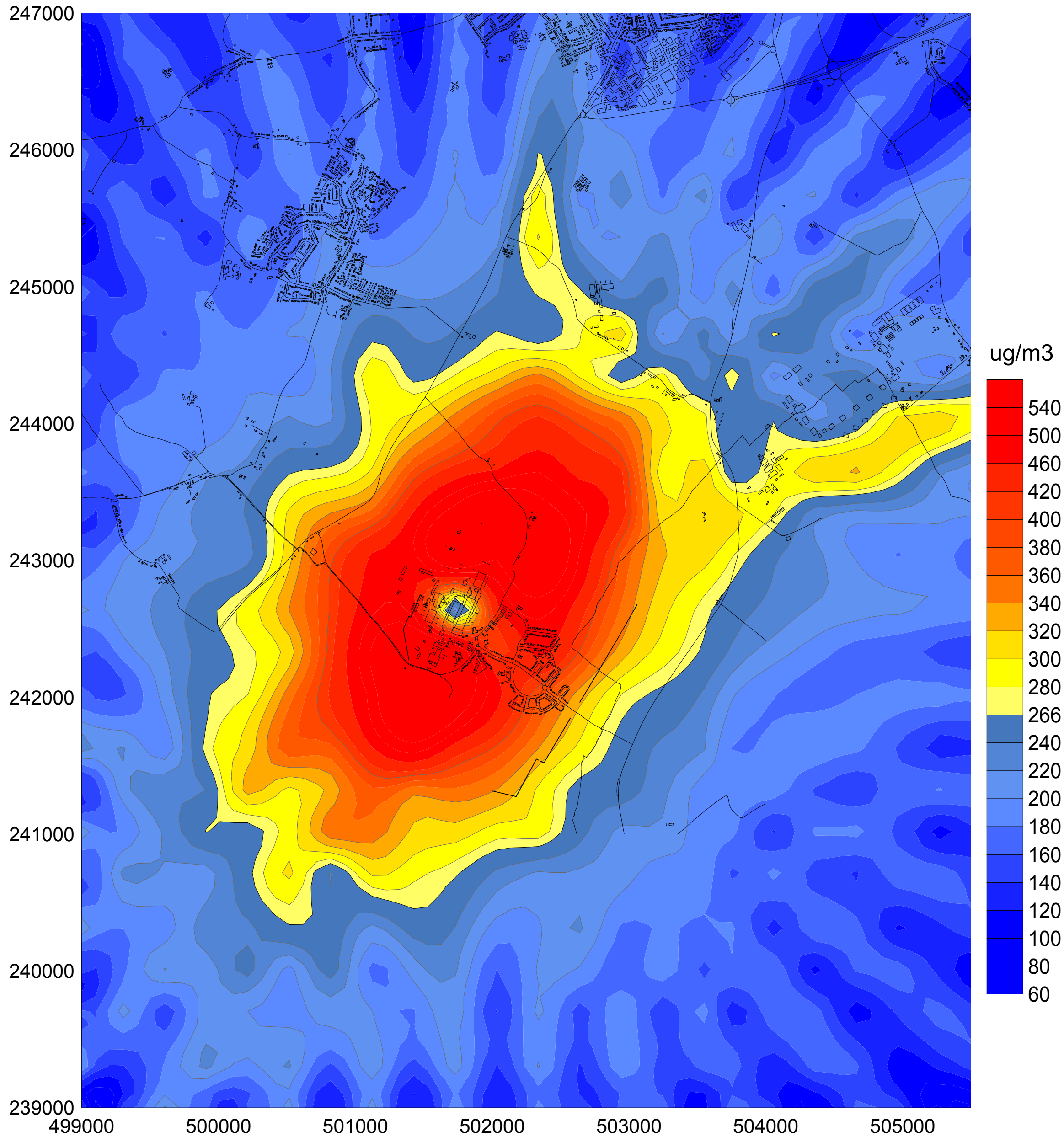

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Figure 14 Predicted 99.9th percentile SO_2 15-minute mean concentration (µg/m^3) for the southwest Bedford B.C area for 2001 - based on kilns ck3 and ck22 and factored using KH monitoring data

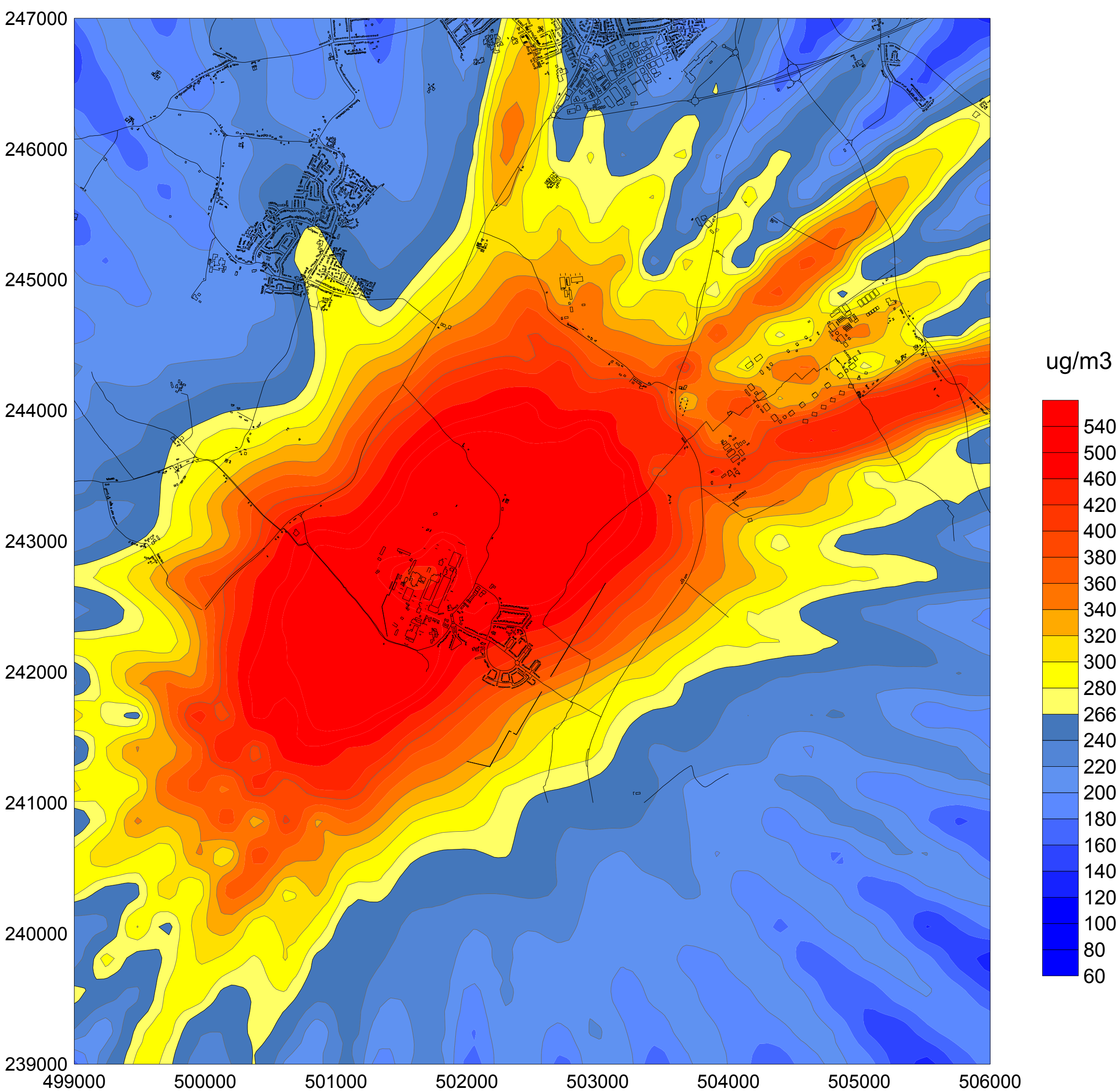

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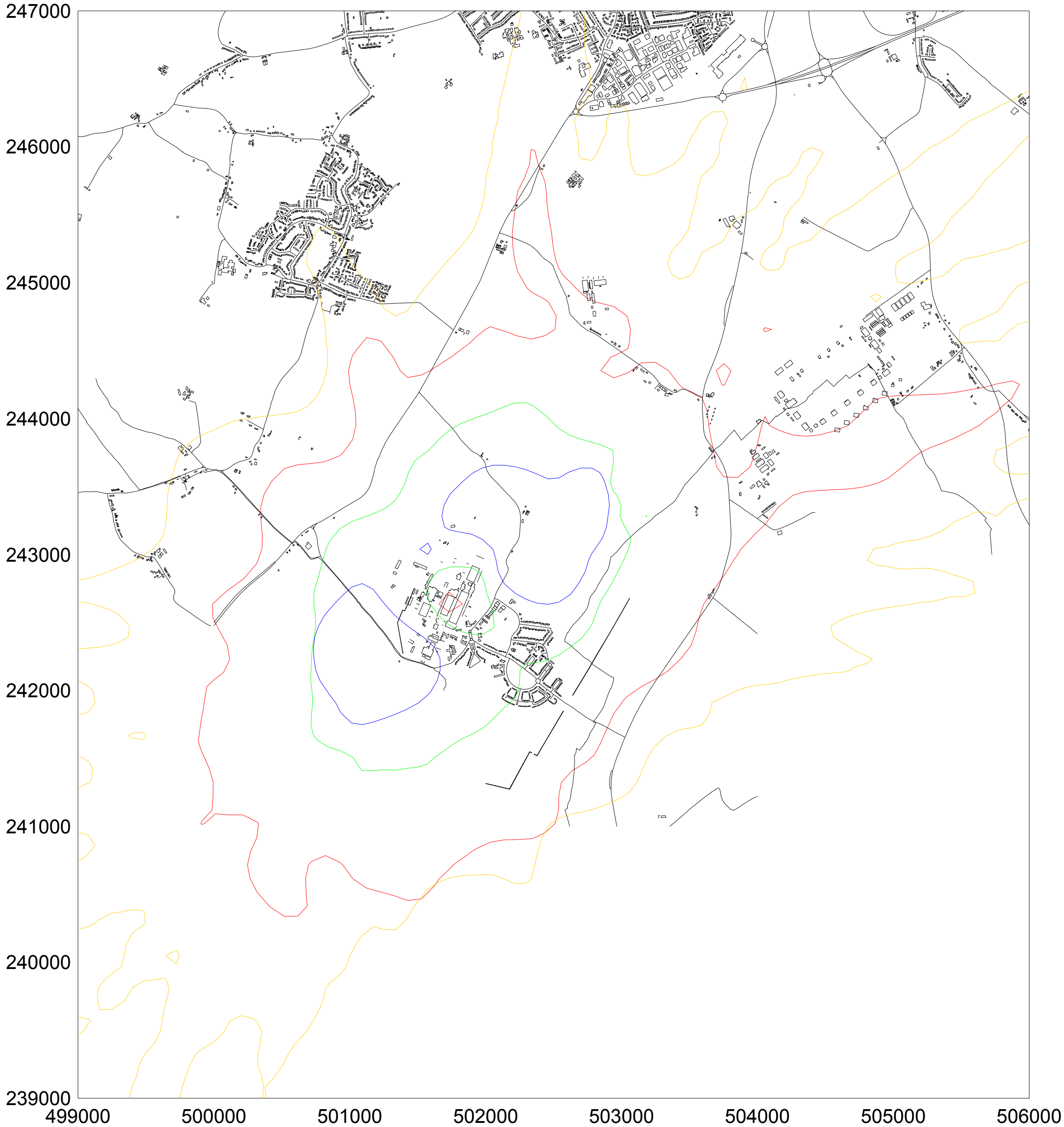
Figure 15 Comparison of areas of exceedence for the 15-minute mean modelled results



Notes:

Blue line area of exceedence from Figure 11
Green line area of exceedence from Figure 12
Red line area of exceedence from Figure 13
Yellow line area of exceedence from Figure 14

3.6 Commentary on areas predicted to exceed 15 minute mean SO2 objective

The monitoring results in the previous chapter confirmed that both monitoring sites are subject to high peak concentrations that exceed the 15-minute objective. As a result the model results for the scenarios tested should all include an area that is predicted to exceed the objective.

In fact all the model results indicate areas where there is potential public access and as a result the Council is required to designate an Air Quality Management Area. Identifying the boundary of the AQMA based on predicted area likely to exceed the objective however is more problematic. This can be seen from the above figure, which demonstrates the sensitive nature of the threshold of this objective to both increased emissions and factoring based on monitoring results.

It should also be noted that should the same factoring based on the KH monitoring site is applied to the base 2001 scenario only. If other scenarios were also similarly factored then the area predicted to exceed would increase greatly.

In the absence of additional information concerning emissions and monitoring it is recommended that the yellow line of exceedence (from Figure 15) be used to designate the boundary of an AQMA. This is based on robust monitoring and reflects that the monitoring results for the site easily exceed the 15-minute mean objective.

3.7 Predicted 1 hour and 24 hour mean SO_2 concentrations for 2005

The following pages provide isopleths of the one-hour and 24 hour mean modelled predictions for SO_2 for the Bedford B.C area. These objectives have not been exceeded (see above section on monitoring), although for the standard has been exceeded. The areas coloured yellow to red in the following figures indicate areas predicted to exceed the objective.

The scenario modelled is the 2001 base case scenario and the results for both figures have not been factored.

Figure 16 indicates that the one-hour objective will not be exceeded based on the modelling results. However Figure 17 does indicate a small area to the north east of the brickworks where the 24hour mean objective will be exceeded.

It should be noted that there is uncertainty associated with this prediction as discussed above for the 15-minute predictions. The previous monitoring data for the KH site in both 2000 and 2002 indicate exceedences of the standard approaching the objective indicating the potential for exceeding this objective. It should be noted that the area predicted to exceed would increase with increased emissions from the brickworks and/ or factoring.

Figure 16 Predicted 99.7th percentile SO_2 1 hour mean concentration ($\mu g/m^3$) for the southwest Bedford B.C area for 2001 (based on kilns ck3 and ck22)

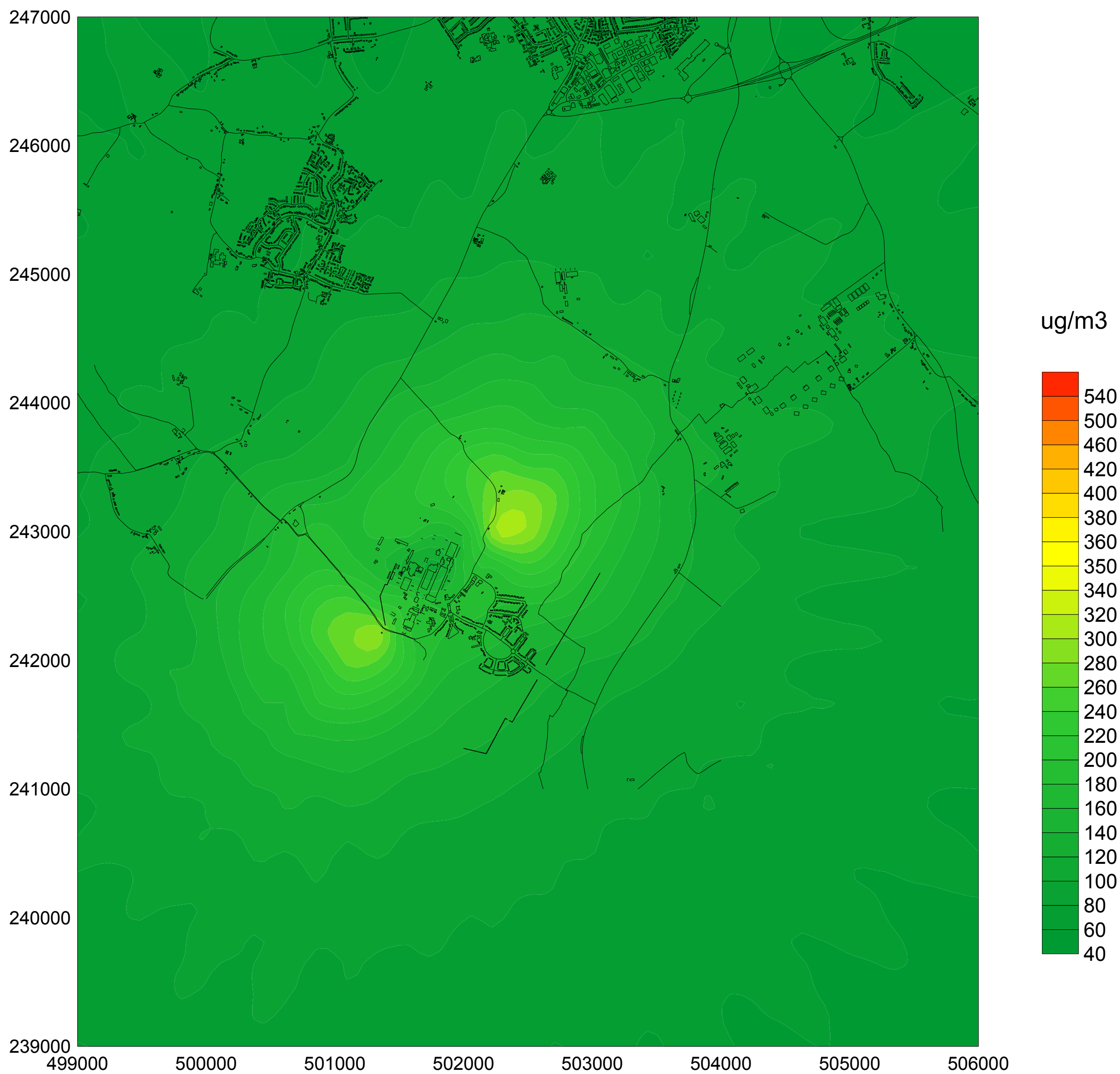


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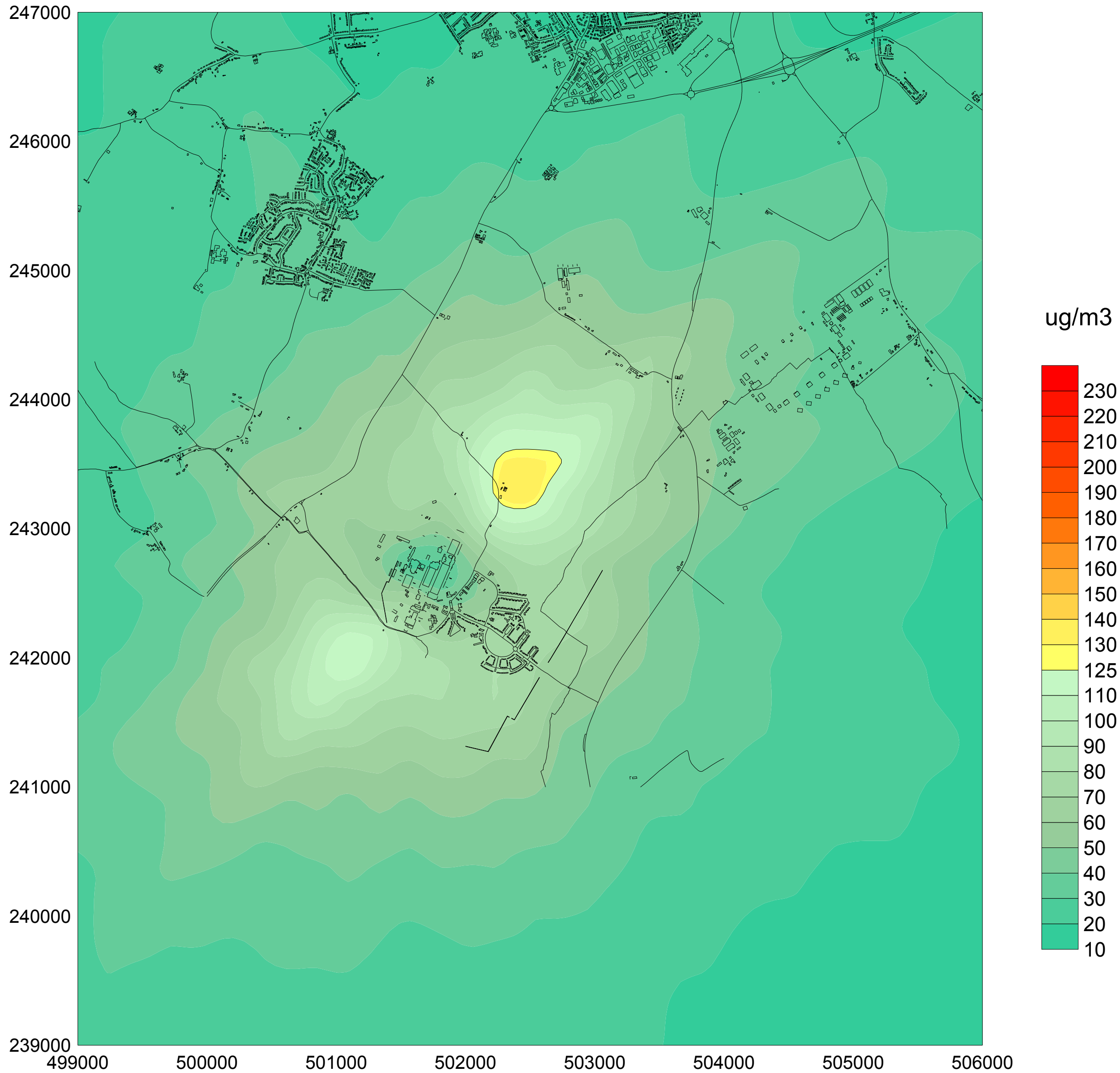
Figure 17 Predicted 99.2th percentile SO_2 24 hour mean concentration (µg/m^3) for the southwest Bedford B.C area for 2001 (based on kilns ck3 and ck22)



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Conclusion

This report fulfils the requirements of the DEFRA guidance for the Detailed Assessment of sulphur dioxide and seeks to permit the Council to identify with reasonable certainty whether or not a likely exceedence of an AQS objective will arise. The report has used updated monitoring results and detailed modelling techniques.

The Council has previously invested in a new monitoring site in the village of Stewartby (site BF1). This monitoring is also supplemented by the high quality continuous monitoring undertaken by Hanson Bricks in Kempston Hardwick (KH). The monitoring undertaken is important for understanding the objectives for SO_2, which require the identification of short-term peak mean measurements over the period of a year.

The monitoring to date continues to indicate that the 15-minute mean objective only will be exceeded at both sites, although monitoring for the same period has also exceeded the one hour and 24 hour standards for SO_2.

A number of scenarios have been modelled to try to represent the emissions arising from the brickworks; these include both a scenario for a base year in 2001 to compare with the monitored results and scenarios based on future changes for 2005. The emissions information for the process have only permitted average emissions to be modelled, hence they underestimate the peak emissions that arise. Many assumptions for the brickworks are based on information for stack ck3.

A comparison of modelled results and measurements has been undertaken and these indicate a range of agreement. Based on the analysis of episodes arising at the individual monitoring sites it is considered that the model under predicts the base case. This has been subsequently factored and the result indicates a large area of exceedence of the 15-minute objective.

The Council is required to estimate both the area predicted to exceed and the extent of the exceedence. Both of these are highly problematical. However in the absence of further emissions and monitoring information the extent of the area of exceedence should be based on the yellow line in Figure 15.

Further modelling has been undertaken for the one hour and 24 hour objectives based on the 2001 base case. The predictions for the one-hour objective do not indicate any area likely to exceed the objective. However unlike the one-hour objective there is a small area, which is predicted to exceed for the 24-hour mean modelling. This modelling is considered conservative based on the emissions information used.

Recommendations

The Council is recommended to undertake the following actions, in respect of the findings for the sulphur dioxide statutory objectives:

1. Undertake consultation on the findings arising from this report with the statutory and other consultees as required.

2. To use the outcome of the consultation process to determine the need for remedial measures, which the Environment Agency will enforce, regarding exceedences from the sources at Hanson Building Products Limited, Stewartby. In doing so, to consider whether or not designation of an AQMA, based on the findings of this report, is still appropriate.

3. To require the Environment Agency to confirm that it will insist, as a minimum, upon full compliance with the EU Limit Values on or before 1st January 2005.

4. Continue its SO_2 monitoring programme as part of its LAQM actions.

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Appendix A

Monitoring information

QA/QC of Bedford monitoring site (BF1)

The Council's operates the Stewartby (BF1) site as part of the Herts and Beds Air Pollution Monitoring Network (HBAPMN). The QA/QC procedure for the site is therefore equivalent to the government's UK Automatic and Rural Network.

SO_2 span gas is used at fortnightly calibrations at the site. Under the maintenance contract full equipment service and recalibration is carried out every 6 months. The main differences between the AURN and Bedford site is that the latter are not subject annual independent intercalibrations and do not use chart recorders.

The analysers retain measurements as 15-minute averages and the Environmental Research Group (ERG) polls the analysers every 12 hours to a secure database via telemetry. Calibration factors are applied to scale the raw 15-minute average pollutant concentrations. At each polling automatic validity checks are undertaken to flag any suspect measurements for future scrutiny. In addition every 24 hours trained ERG staff inspect the data each for suspicious data. The resultant provisional data sets are then reported.

Data are further scrutinised each year to provide a final ratified dataset of definitive results. This process requires the examination of site, calibration, servicing and equipment records.

QA/QC of Kempston Hardwick monitoring site (KH)

Full details of the site operation are not available, although the monitoring site is run on behalf of the brickwork operator as part of the Environment Agency's regulation of the process. It is therefore assumed that the requirements of TG03 are met. The data are reported as 15-minute averages.

Appendix B

Monitoring results (2000 to 2004)

The following tables provide the dates, times and measurements for the peak 15-minute mean periods of SO_2 concentrations when the 266 µg/m^3 standard has been exceeded for the BF1 and KH sites. It should be noted that the 2003 and 2004 results at BF1 are yet to be fully ratified.

Table 11 Number of 15 minute mean SO_2 concentrations > 266 µg/m^3 at BF1 (2001-2004)

Date	Time	SO_2 µg/m^3
01/02/2001	04:30:00	272.4
01/02/2001	04:45:00	516.8
01/02/2001	05:00:00	267.6
01/02/2001	05:30:00	303.5
09/02/2001	12:30:00	277.4
09/02/2001	13:00:00	332.0
15/02/2001	12:00:00	300.3
15/02/2001	12:15:00	763.2
15/02/2001	12:30:00	311.8
15/02/2001	12:45:00	299.3
15/02/2001	13:00:00	375.6
15/02/2001	14:30:00	267.9
18/06/2001	12:15:00	664.5
18/06/2001	13:00:00	362.6
18/06/2001	14:00:00	296.9
24/06/2001	09:00:00	323.7
15/07/2001	16:00:00	286.2
20/07/2001	09:15:00	327.4
20/07/2001	09:45:00	403.5
27/07/2001	14:15:00	594.2
28/07/2001	11:45:00	578.0
28/07/2001	13:00:00	414.7
20/08/2001	16:00:00	302.4
31/08/2001	08:30:00	305.4
23/11/2001	04:45:00	330.4
06/07/2002	11:45:00	341.8
06/07/2002	13:15:00	504.1
06/07/2002	13:30:00	297.4
13/07/2002	13:45:00	309.4
14/07/2002	12:45:00	318.9
14/07/2002	15:30:00	353.2
28/07/2002	13:15:00	354.8
28/07/2002	13:30:00	299.3

01/08/2002	15:30:00	441.0
01/08/2002	16:45:00	336.2
03/08/2002	09:45:00	647.2
03/08/2002	10:00:00	791.9
03/08/2002	10:15:00	462.3
03/08/2002	10:30:00	665.8
03/08/2002	10:45:00	350.9
03/08/2002	12:30:00	454.3
03/08/2002	12:45:00	836.0
03/08/2002	13:00:00	665.0
07/08/2002	09:45:00	277.7
04/09/2002	13:00:00	300.6
04/09/2002	13:15:00	385.7
04/09/2002	13:30:00	366.3
04/09/2002	13:45:00	271.9
04/09/2002	14:15:00	328.5
04/09/2002	14:30:00	336.2
26/09/2002	15:30:00	313.1
19/03/2003	12:45:00	348.7
19/03/2003	13:30:00	281.7
19/03/2003	14:00:00	339.2
19/03/2003	15:00:00	307.5
19/03/2003	16:15:00	306.4
19/03/2003	16:30:00	394.2
25/03/2003	09:45:00	327.7
25/03/2003	10:00:00	342.1
25/03/2003	11:30:00	342.3
25/03/2003	13:00:00	278.5
22/04/2003	10:45:00	548.5
22/04/2003	11:00:00	489.2
22/04/2003	11:15:00	328.2
22/04/2003	12:00:00	299.8
22/04/2003	17:30:00	286.0
06/05/2003	11:30:00	304.8
06/05/2003	11:45:00	335.4
06/05/2003	12:00:00	335.4
08/05/2003	11:15:00	412.3
08/05/2003	14:00:00	274.0
08/05/2003	16:00:00	287.5
09/05/2003	10:30:00	334.1
13/06/2003	08:30:00	377.2
13/06/2003	08:45:00	290.2
13/06/2003	09:00:00	287.3
13/06/2003	10:15:00	387.0
13/06/2003	11:15:00	266.8
13/06/2003	11:30:00	480.4
13/06/2003	11:45:00	385.4

13/06/2003	12:15:00	366.5
13/06/2003	12:30:00	464.2
13/06/2003	13:15:00	484.4
13/06/2003	14:00:00	436.8
13/06/2003	14:15:00	426.9
13/06/2003	15:15:00	450.3
13/06/2003	16:15:00	271.6
13/06/2003	16:30:00	311.8
15/06/2003	15:45:00	283.6
16/06/2003	10:15:00	292.9
24/06/2003	09:45:00	320.3
24/06/2003	10:45:00	359.1
24/06/2003	11:15:00	372.9
28/06/2003	13:00:00	374.3
28/06/2003	13:15:00	320.8
28/06/2003	13:45:00	314.7
28/06/2003	15:45:00	345.8
28/06/2003	16:00:00	414.7
28/06/2003	16:45:00	339.9
06/07/2003	09:30:00	475.1
06/07/2003	10:45:00	306.4
07/07/2003	07:45:00	377.5
07/07/2003	08:00:00	315.2
07/07/2003	08:30:00	366.5
12/07/2003	07:45:00	308.0
12/07/2003	08:00:00	311.0
12/07/2003	13:30:00	440.0
12/07/2003	14:00:00	499.5
12/07/2003	14:45:00	297.9
12/07/2003	16:00:00	456.7
12/07/2003	16:15:00	375.3
12/07/2003	17:00:00	283.0
16/07/2003	12:15:00	310.7
27/07/2003	11:15:00	275.3
27/07/2003	11:45:00	299.8
27/07/2003	12:00:00	288.9
03/08/2003	10:30:00	514.2
03/08/2003	10:45:00	294.5
03/08/2003	11:00:00	330.9
03/08/2003	11:45:00	355.9
03/08/2003	12:00:00	449.3
03/08/2003	12:15:00	375.3
03/08/2003	14:15:00	366.8
03/08/2003	14:45:00	287.3
03/08/2003	15:00:00	366.8
03/08/2003	16:30:00	342.6
07/08/2003	15:00:00	274.8

08/08/2003	10:45:00	303.5
08/08/2003	11:15:00	341.8
08/08/2003	11:30:00	732.6
08/08/2003	11:45:00	355.6
08/08/2003	12:00:00	437.6
08/08/2003	12:15:00	281.7
08/08/2003	13:00:00	275.0
08/08/2003	15:00:00	353.5
09/08/2003	08:30:00	481.7
09/08/2003	08:45:00	818.7
09/08/2003	09:00:00	1622.3
09/08/2003	09:15:00	1175.2
09/08/2003	09:30:00	1056.8
09/08/2003	09:45:00	527.7
09/08/2003	10:00:00	270.5
09/08/2003	11:00:00	415.2
09/08/2003	13:30:00	332.0
09/08/2003	15:00:00	280.6
09/08/2003	15:15:00	332.5
10/08/2003	11:15:00	329.8
10/08/2003	11:30:00	794.0
10/08/2003	11:45:00	313.9
13/08/2003	11:00:00	287.8
20/08/2003	09:45:00	411.2
20/08/2003	10:00:00	314.7
20/08/2003	13:30:00	274.8
20/08/2003	13:45:00	289.7
23/08/2003	10:45:00	417.6
07/09/2003	12:00:00	397.4
07/09/2003	12:15:00	476.7
16/09/2003	10:30:00	391.6
11/10/2003	12:15:00	491.3
11/10/2003	13:00:00	387.8
11/10/2003	13:15:00	286.5
11/10/2003	13:45:00	482.0
21/10/2003	10:30:00	293.9
21/10/2003	11:30:00	376.4
21/10/2003	11:45:00	462.0
10/12/2003	04:30:00	276.6
10/12/2003	05:00:00	405.7
10/12/2003	05:15:00	568.4
10/12/2003	05:30:00	288.3
09/04/2004	09:00:00	351.9
09/04/2004	09:30:00	388.1
09/04/2004	11:00:00	599.8
09/04/2004	11:30:00	464.4
09/04/2004	12:00:00	394.2

09/04/2004	12:15:00	347.7
09/04/2004	12:30:00	282.8
09/04/2004	13:45:00	466.8
09/04/2004	14:45:00	441.0
11/04/2004	11:45:00	282.2
11/04/2004	12:30:00	316.5
11/04/2004	12:45:00	515.0
11/04/2004	13:00:00	385.2
11/04/2004	13:15:00	273.2

Table 12 Number of 15 minute mean SO_2 concentrations > 266 µg/m^3 at KH (2000-2003)

Date	Time	SO_2 µg/m^3
11/01/2000	23:00:00	295.0
11/01/2000	23:15:00	277.7
11/01/2000	23:30:00	301.6
06/02/2000	14:30:00	274.8
06/02/2000	19:30:00	303.2
07/02/2000	13:30:00	303.2
08/02/2000	07:45:00	295.3
08/02/2000	08:00:00	274.0
09/02/2000	21:00:00	289.9
09/02/2000	21:30:00	304.0
09/02/2000	22:00:00	311.5
09/02/2000	23:30:00	284.9
27/02/2000	23:45:00	308.0
29/02/2000	01:30:00	358.0
29/02/2000	01:45:00	303.2
29/02/2000	02:15:00	284.1
22/03/2000	06:15:00	450.3
22/03/2000	06:30:00	272.7
22/03/2000	07:15:00	348.5
22/03/2000	07:30:00	610.5
22/03/2000	07:45:00	529.3
22/03/2000	08:00:00	275.6
22/03/2000	09:45:00	553.3
22/03/2000	10:00:00	736.6
22/03/2000	10:15:00	705.4
22/03/2000	10:30:00	504.1
18/04/2000	02:00:00	313.1
19/04/2000	15:15:00	269.7
31/05/2000	17:15:00	271.9
03/06/2000	09:15:00	279.0
10/06/2000	23:30:00	271.1
19/06/2000	08:00:00	291.5

19/06/2000	08:15:00	311.0
19/06/2000	08:45:00	299.8
19/06/2000	09:30:00	290.5
22/06/2000	02:30:00	408.8
22/06/2000	02:45:00	353.5
22/06/2000	03:00:00	279.6
22/06/2000	03:15:00	324.5
22/06/2000	03:30:00	395.8
22/06/2000	03:45:00	427.5
22/06/2000	04:00:00	266.8
22/06/2000	05:30:00	293.7
31/07/2000	17:45:00	277.7
31/07/2000	18:15:00	268.4
09/08/2000	08:00:00	289.1
14/09/2000	08:30:00	283.8
27/09/2000	08:00:00	282.2
27/09/2000	08:15:00	270.5
23/10/2000	08:45:00	271.9
23/10/2000	09:15:00	361.5
23/10/2000	09:30:00	296.6
29/11/2000	16:45:00	309.4
29/11/2000	17:00:00	299.5
29/11/2000	17:15:00	316.8
29/11/2000	17:30:00	298.5
29/11/2000	17:45:00	343.1
29/11/2000	18:00:00	313.6
04/12/2000	17:45:00	275.6
09/12/2000	11:45:00	278.5
09/12/2000	12:00:00	281.7
09/12/2000	15:00:00	272.9
09/12/2000	18:15:00	266.8
12/12/2000	09:15:00	274.5
01/02/2001	03:15:00	271.9
01/02/2001	03:30:00	427.2
01/02/2001	03:45:00	325.3
01/02/2001	04:30:00	427.2
01/02/2001	04:45:00	684.4
01/02/2001	05:00:00	441.8
01/02/2001	05:30:00	449.3
01/02/2001	05:45:00	288.3
01/02/2001	06:00:00	658.6
01/02/2001	06:15:00	293.4
01/02/2001	06:30:00	458.1
01/02/2001	06:45:00	279.8
01/02/2001	07:15:00	355.4
01/02/2001	07:30:00	499.8
01/02/2001	07:45:00	491.0

01/02/2001	11:15:00	307.5
06/02/2001	23:30:00	277.2
07/02/2001	05:45:00	326.4
07/02/2001	06:00:00	272.4
07/02/2001	06:15:00	332.5
07/02/2001	07:00:00	391.6
07/02/2001	07:15:00	411.8
07/02/2001	07:30:00	357.8
10/02/2001	22:45:00	321.9
10/02/2001	23:30:00	285.4
15/02/2001	10:15:00	304.0
15/02/2001	10:30:00	316.8
15/02/2001	12:00:00	443.2
15/02/2001	12:15:00	437.3
18/02/2001	11:30:00	484.9
22/03/2001	15:15:00	372.4
22/03/2001	15:30:00	298.5
27/04/2001	08:00:00	480.7
27/04/2001	08:15:00	673.0
27/04/2001	08:30:00	517.4
27/04/2001	08:45:00	410.2
27/04/2001	09:00:00	361.0
27/04/2001	09:15:00	373.2
27/04/2001	09:30:00	307.0
16/05/2001	11:45:00	303.5
16/05/2001	12:00:00	268.7
09/06/2001	12:15:00	302.7
29/06/2001	09:45:00	380.4
06/07/2001	08:00:00	306.2
09/07/2001	15:15:00	339.7
17/08/2001	15:15:00	325.3
17/08/2001	15:30:00	319.5
17/08/2001	15:45:00	358.8
24/08/2001	09:00:00	406.7
24/08/2001	09:15:00	417.6
24/08/2001	09:45:00	274.2
28/08/2001	08:15:00	375.1
28/08/2001	08:30:00	279.0
25/09/2001	12:30:00	350.1
02/10/2001	01:15:00	312.8
02/10/2001	01:30:00	327.4
02/10/2001	02:00:00	266.8
04/10/2001	15:45:00	280.1
08/10/2001	04:30:00	295.5
08/10/2001	04:45:00	300.8
08/10/2001	05:00:00	281.7
08/10/2001	05:30:00	294.7

23/10/2001	22:30:00	311.5
25/10/2001	14:15:00	324.3
25/10/2001	14:30:00	291.3
30/10/2001	07:15:00	332.2
30/10/2001	10:15:00	278.2
27/11/2001	08:30:00	302.4
27/11/2001	09:15:00	266.5
28/11/2001	18:30:00	271.6
14/01/2002	13:30:00	272.9
14/01/2002	17:15:00	276.1
14/01/2002	17:45:00	330.1
14/01/2002	18:00:00	387.3
18/01/2002	12:30:00	373.2
18/01/2002	12:45:00	320.0
18/01/2002	13:00:00	301.9
20/01/2002	04:00:00	402.2
20/01/2002	04:15:00	315.2
20/01/2002	04:45:00	287.3
02/02/2002	06:00:00	291.5
02/02/2002	06:15:00	272.1
02/02/2002	06:30:00	278.0
02/02/2002	06:45:00	306.4
02/02/2002	16:00:00	317.1
03/02/2002	12:00:00	297.9
03/02/2002	12:15:00	326.6
03/02/2002	12:30:00	273.4
05/02/2002	02:45:00	271.3
05/02/2002	03:15:00	296.9
05/02/2002	04:00:00	277.4
05/02/2002	04:15:00	270.0
05/02/2002	05:15:00	296.9
05/02/2002	17:30:00	271.9
05/02/2002	18:15:00	300.0
05/02/2002	19:00:00	327.7
21/02/2002	16:45:00	336.5
21/02/2002	17:00:00	289.4
21/02/2002	17:45:00	278.0
25/02/2002	23:15:00	316.5
25/02/2002	23:30:00	313.6
26/02/2002	01:15:00	301.4
26/02/2002	01:30:00	268.9
09/03/2002	08:45:00	294.5
16/04/2002	08:45:00	318.7
16/04/2002	09:00:00	344.7
16/04/2002	09:15:00	318.9
21/04/2002	17:00:00	284.6
21/04/2002	17:15:00	323.7

26/04/2002	05:45:00	275.3
26/04/2002	06:00:00	292.9
26/04/2002	06:15:00	322.7
26/04/2002	07:00:00	271.1
26/04/2002	08:15:00	340.2
26/04/2002	08:30:00	330.1
26/04/2002	08:45:00	276.1
26/04/2002	09:00:00	350.3
26/04/2002	09:15:00	277.7
28/04/2002	23:45:00	334.4
29/04/2002	00:00:00	332.0
29/04/2002	00:15:00	307.0
29/04/2002	00:30:00	266.3
30/04/2002	08:30:00	279.6
30/04/2002	08:45:00	281.4
14/05/2002	02:15:00	381.2
14/05/2002	02:30:00	273.4
15/05/2002	02:30:00	328.8
15/05/2002	02:45:00	298.7
15/05/2002	03:00:00	298.5
18/05/2002	21:15:00	291.8
18/05/2002	22:15:00	380.9
19/05/2002	01:15:00	292.3
19/05/2002	18:15:00	309.4
19/05/2002	19:15:00	312.8
23/05/2002	01:45:00	323.7
23/05/2002	04:45:00	431.5
23/05/2002	05:00:00	361.0
23/05/2002	05:15:00	360.7
25/05/2002	16:15:00	321.9
25/05/2002	16:45:00	355.1
25/05/2002	17:00:00	290.7
26/05/2002	12:00:00	273.7
27/05/2002	06:00:00	339.7
27/05/2002	06:30:00	310.7
29/05/2002	00:15:00	362.3
29/05/2002	00:30:00	377.2
29/05/2002	01:15:00	448.5
29/05/2002	01:45:00	404.1
29/05/2002	02:00:00	593.7
29/05/2002	02:15:00	387.6
30/05/2002	05:30:00	335.2
30/05/2002	05:45:00	391.3
07/06/2002	17:30:00	345.5
07/06/2002	18:45:00	281.2
09/06/2002	09:15:00	304.6
09/06/2002	10:15:00	325.1

10/06/2002	00:30:00	318.1
10/06/2002	01:15:00	298.2
10/06/2002	01:30:00	373.5
10/06/2002	01:45:00	359.9
10/06/2002	05:45:00	322.1
11/06/2002	20:00:00	478.0
11/06/2002	20:15:00	434.6
11/06/2002	20:30:00	472.7
11/06/2002	20:45:00	318.1
16/06/2002	02:30:00	284.4
16/06/2002	02:45:00	320.0
16/06/2002	03:00:00	337.0
16/06/2002	03:15:00	288.1
16/06/2002	03:30:00	347.1
16/06/2002	04:00:00	313.6
16/06/2002	04:15:00	347.9
17/06/2002	05:15:00	286.2
20/06/2002	09:15:00	344.5
20/06/2002	13:30:00	427.5
21/06/2002	19:45:00	441.8
21/06/2002	20:00:00	375.9
21/06/2002	20:15:00	319.5
21/06/2002	20:45:00	341.5
21/06/2002	21:00:00	312.3
21/06/2002	21:15:00	514.4
21/06/2002	21:30:00	278.8
21/06/2002	23:45:00	306.7
22/06/2002	00:00:00	358.8
22/06/2002	00:15:00	448.7
22/06/2002	00:30:00	469.8
22/06/2002	01:15:00	434.6
22/06/2002	02:15:00	315.2
22/06/2002	03:15:00	287.0
22/06/2002	04:00:00	299.3
04/07/2002	18:45:00	308.8
07/07/2002	10:00:00	420.3
07/07/2002	11:15:00	302.7
07/07/2002	12:15:00	325.1
07/07/2002	12:30:00	308.0
07/07/2002	13:30:00	313.1
07/07/2002	17:00:00	310.7
07/07/2002	18:45:00	383.6
07/07/2002	19:00:00	340.2
07/07/2002	19:30:00	324.3
07/07/2002	20:15:00	330.6
07/07/2002	20:30:00	362.0
07/07/2002	20:45:00	351.7

07/07/2002	21:00:00	283.3
07/07/2002	22:30:00	296.1
08/07/2002	02:00:00	559.4
08/07/2002	02:15:00	616.6
08/07/2002	02:30:00	484.4
08/07/2002	02:45:00	480.4
08/07/2002	06:15:00	347.9
08/07/2002	06:45:00	354.0
08/07/2002	07:00:00	289.7
08/07/2002	07:15:00	355.6
08/07/2002	07:30:00	327.2
08/07/2002	07:45:00	303.5
08/07/2002	08:00:00	338.6
08/07/2002	08:15:00	278.2
08/07/2002	08:45:00	279.0
08/07/2002	09:30:00	292.1
08/07/2002	09:45:00	318.1
08/07/2002	10:00:00	276.9
08/07/2002	17:15:00	347.4
08/07/2002	17:30:00	356.4
05/06/2003	17:30:00	313.9
05/06/2003	17:45:00	379.6
10/06/2003	12:15:00	273.4
15/06/2003	08:15:00	339.4
15/06/2003	08:45:00	422.7
15/06/2003	09:00:00	294.5
18/07/2003	20:00:00	302.7
18/07/2003	20:15:00	329.6
19/07/2003	18:15:00	290.7
19/07/2003	18:45:00	297.4
20/07/2003	08:15:00	278.5
20/07/2003	19:00:00	305.4
20/07/2003	19:30:00	415.5
23/07/2003	13:15:00	334.6
23/07/2003	20:00:00	284.1
23/07/2003	21:45:00	338.6
23/07/2003	22:00:00	362.6
23/07/2003	22:30:00	368.1
28/07/2003	17:30:00	276.4
28/07/2003	19:45:00	323.2
29/07/2003	11:15:00	275.6
29/07/2003	14:15:00	364.7
01/08/2003	01:45:00	284.9
10/08/2003	09:15:00	320.8
10/08/2003	09:30:00	476.9
10/08/2003	09:45:00	319.5
17/09/2003	08:15:00	296.3

Appendix C

Meteorology information used in the report

The report uses meteorological information from a number of sites in and close to the Bedford area for the period 2001 to 2003 inclusive. These include:

1) Kempston Hardwick (KH) operated by Hanson Brickworks (2001 and 2002)

2) Bedford site at Cardington – data provided by the Met. Office (2001 and 2002)

3) Luton (LN) site operated by Luton B.C (2003)

Wind roses for KH and LN sites

The KH and LN sites were used in chapter 2 to provide information on both wind speed and episodes at the BF1 and KH air pollution monitoring sites.

Figure 18 Kempston Hardwick wind data 2001

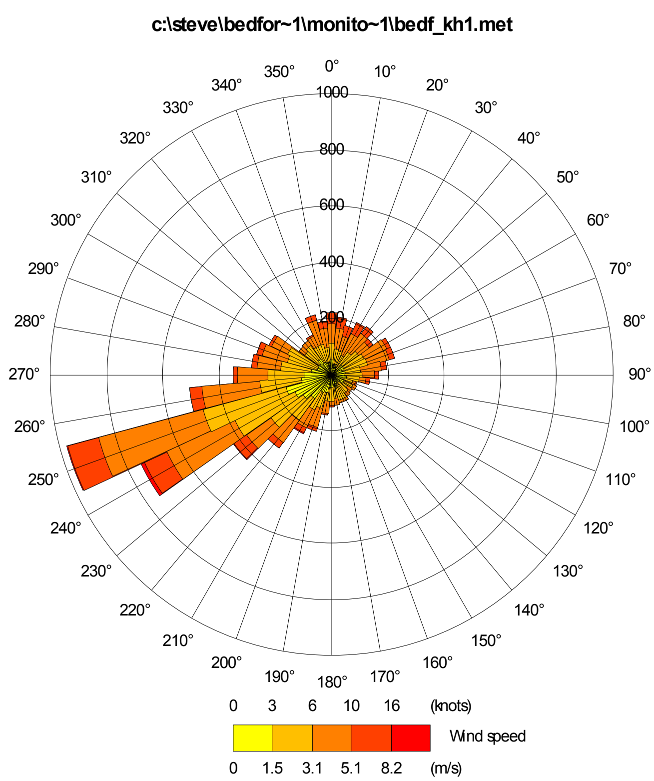


Figure 19 Kempston Hardwick wind data 2002

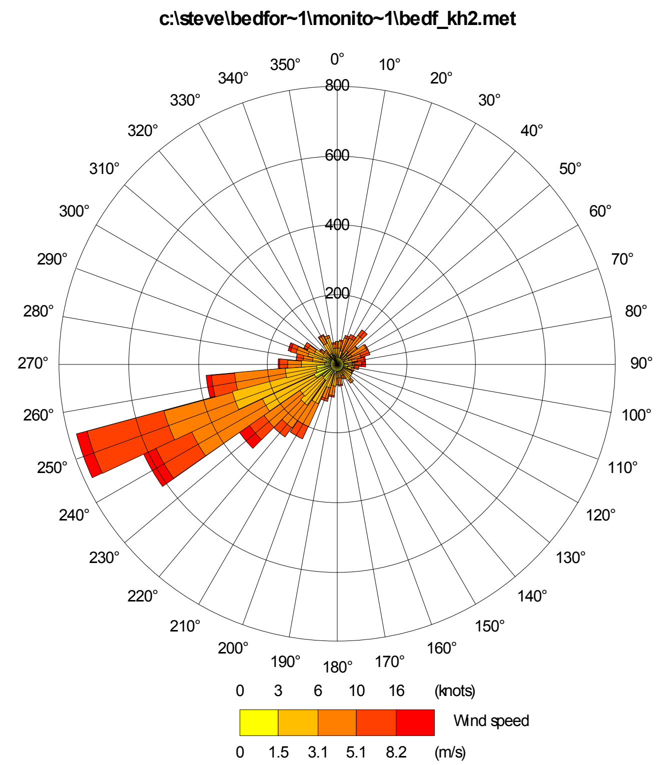
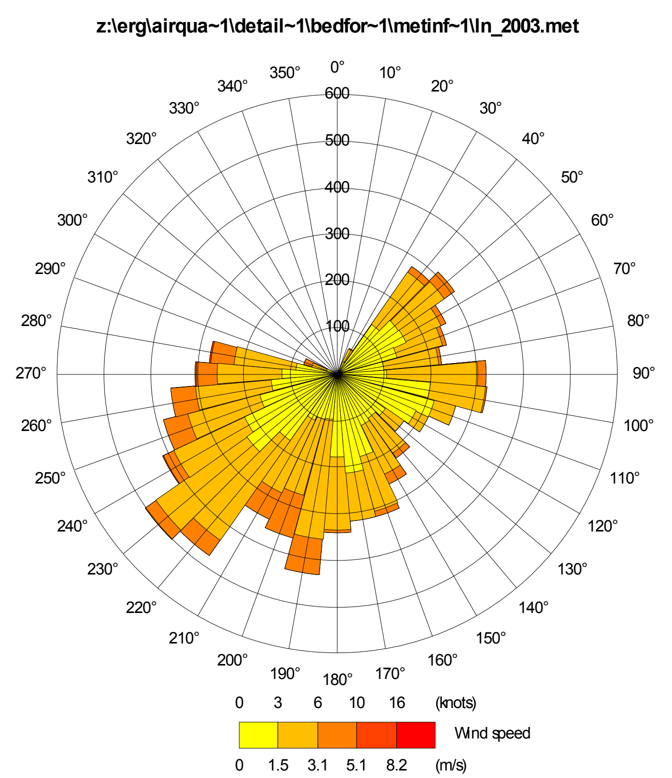


Figure 20 Luton wind data 2002



Meteorology used for modelling

The modelling has been undertaken using hourly sequential meteorological data from the Bedford (Cardington) site, which is also within the Council's area. These data were obtained from the Met Office in ADMS compatible format for the years 2001 and 2002. These years are the most recent for which data are available and they also make possible a comparison between different years.

For 2001 the number of hours that wind data are lacking is 175 (representing just under 2% of the years measurements) and for 2002 it is 252 hours (about 3%). The wind roses for the two years are given in the figures below.

Figure 21 Wind rose for Bedford 2001

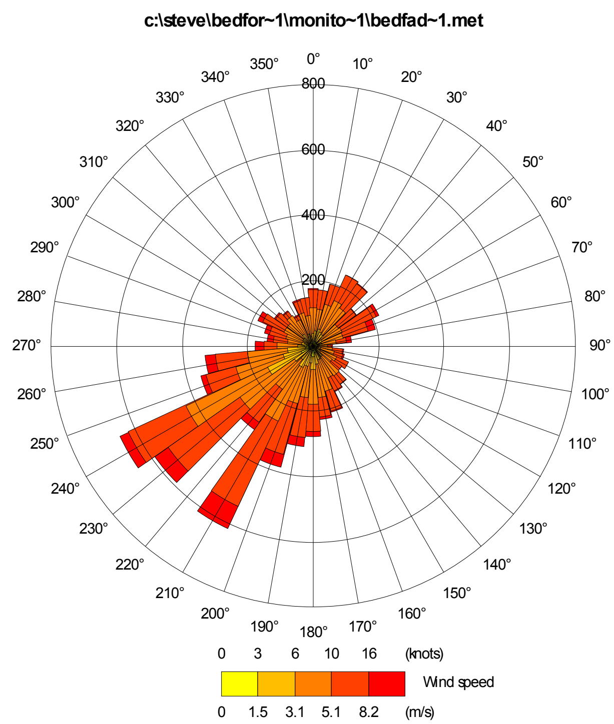
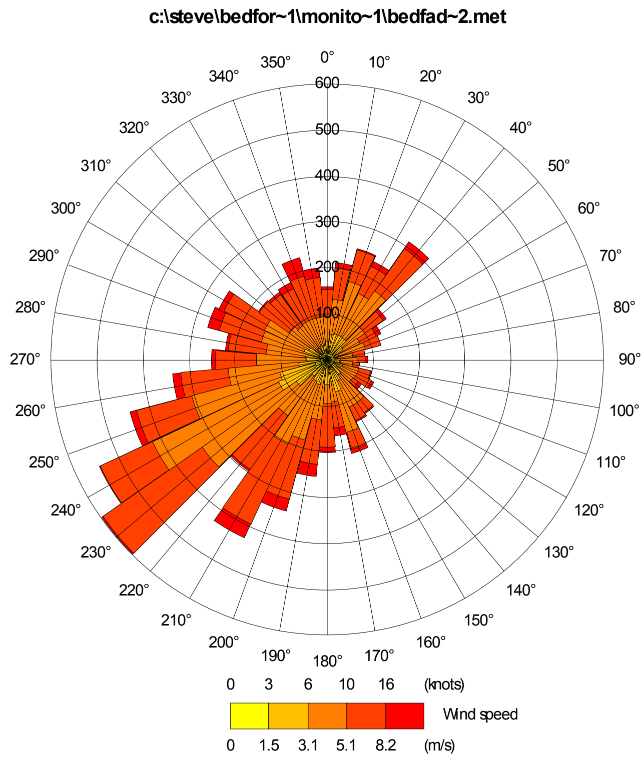


Figure 22 Wind rose for Bedford 2002



A comparison of the wind roses confirms an overall similarity, with the wind from the southwest dominant for both years. The following table presents a comparison of the winds from identified sectors for both years, based on the number of hours for each wind sector. The sectors have been derived from the analysis of episodes in the monitoring chapter of the report.

Table 13 Analysis of wind sectors based on the monitoring sites

Wind sector (°)	2001 (hours)		2002 (hours)	
220-230	896	10.4%	903	10.6%
270-360	2144	25.0%	1517	17.8%
Total (hours)	8585		8508	

From the above table it can be seen that the frequency of winds from the southwest are approximately 10% of the total measurements based on the narrow sector in line with the KH site for each year. As shown in the section on analysis of episodes the sector identified for the BF1 is less directional than that for the KH site and therefore a broader band is used. This sector indicates more variation with a slightly greater proportion of westerly winds in 2001 than 2002.

Appendix D

Modelling Approach

The overall objective of the air pollution dispersion modelling in this report is to produce a sound method whereby concentrations of SO_2 can be determined and developed in conjunction with the continuous monitoring results to produce percentile values that can be compared to the AQS objectives. In summary the main aims are to:

1) Use a dispersion model to make predictions of SO_2 over the time scales relevant to the AQS objectives
2) Undertake modelling of the releases of SO_2 over the area of interest and compare the model performance against air pollution measurements.
3) To make predictions of the possible future releases for the AQS objectives.
4) To use locally available meteorological data over recent years to take into account year to year variation.

Area of interest

The area of interest was limited to the southwest corner of the Council's area and the immediate surrounding area surrounding the Stewartby brickworks. This was based on the findings of Council's earlier Updating and Screening Assessment.

Dispersion model and parameters used

The dispersion model used was ADMS 3.1. This is a well-established dispersion model that meets the requirements of TG03 for point sources. It has also been well validated for use with point sources.

The surface roughness (s.r) length of 0.5m used was in the study. Sensitivity tests showed that a higher roughness length produced higher concentrations. As the area studied is predominantly rural it was considered that this s.r length was appropriate.

The development of emissions information used for the modelling the area is dealt with separately in Appendices D and E.

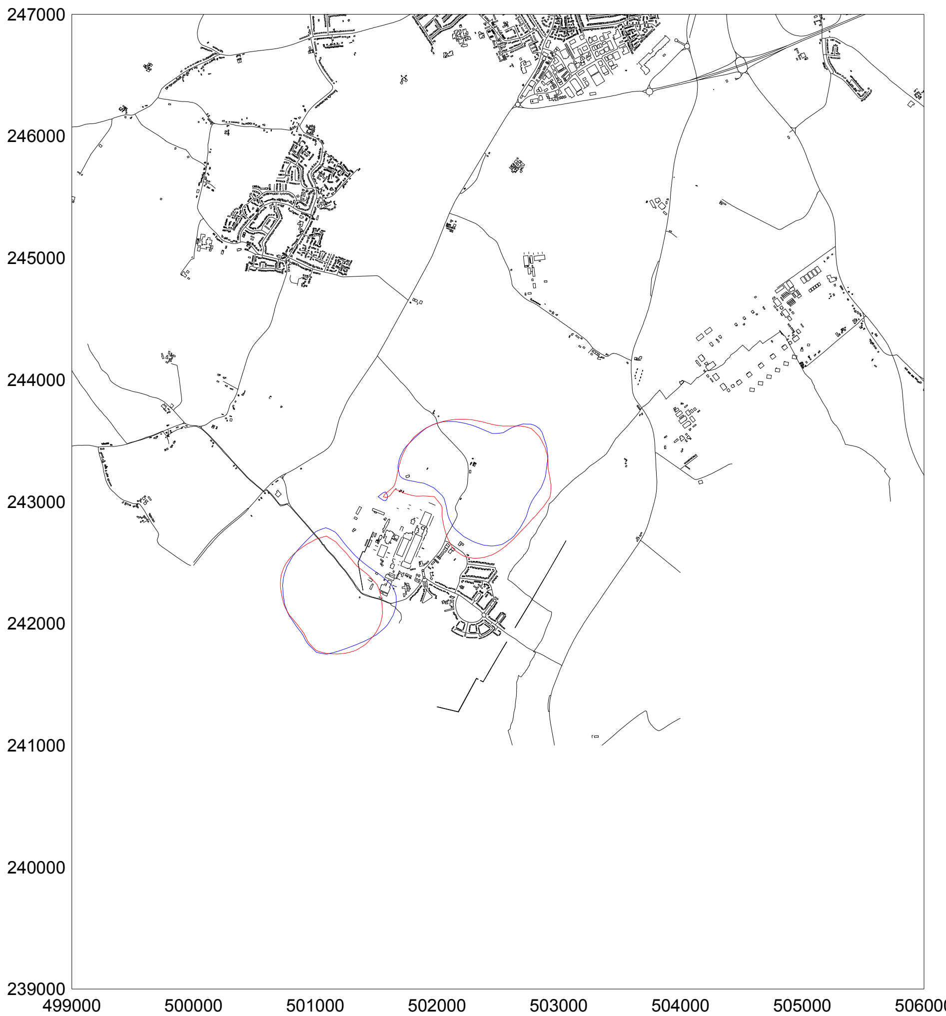
The model was set up to produce percentile values in long term mode, since these are output required. For comparison purposes between monitored and modelled data some short term modes were also run, these produce outputs every hour and hence for the growth of the boundary layer height throughout the day.

No consideration was given to the effects of buildings, or terrain effects within the model set up.

Comparison of modelled results for different meteorological years

The model was run for both 2001 and 2002 using the same input information to ascertain the extent of any inter annual variation between the two years. The results are shown below for the 99.9th percentile of 15-minute mean concentrations, no factoring of these results has been undertaken. The two concentration plots indicate that for these two years there was little variation. In view of the similarity between years, 2001 only is used for the subsequent modelling in the report.

Figure 23 Comparison of base case for 2001 and 2002



Blue line indicates 2001 met. Year
Red line indicates 2002 met. Year

Limitations in predicting 15 minute means

It is very important to note that the AQS objective considered in this report presents difficulties for dispersion models. The 99.9th percentile for SO_2 poses a particular challenge since all models are limited in their ability to predict over such short time scales of 15 minutes and this should be borne in mind when considering the results.

It should also be noted that the ADMS formatted files give wind direction by 10° sectors. The data are also hourly sequential, which means that they are averaged for each hour of the year.

The conditions that can lead to the highest pollutant concentrations i.e. very low wind speeds are also the very conditions that dispersion modelling start to break down. When wind speeds are less than 1m/s, conditions are considered calm and thus cannot be robustly modelled. It is therefore extremely beneficial that high quality measurements are being made since these will be used to ultimately determine whether or not the AQS objective is met.

This is most relevant for the BF1 site as it is closest to the brickworks and the analysis of monitoring data highlights that many episodes arose during low wind speeds. For the KH site however the analysis of episodes earlier showed that over 70% of episodes arose when the wind speed is greater than 2.5m/s.

Use of factor to adjust model results

The use of a model provides the opportunity to produce a deterministic approach to understanding air pollution concentrations. Thus in an ideal situation specific emissions from sources are quantified and related to their location and any variance over time. These are then modelled to represent physical dispersion from the source within the surrounding atmosphere, taking into account the changes within that atmosphere. Thus the results from the model can then be checked against measurements taken in the real world and in the ideal situation the results will agree. (There are however very few instances where this is true).

The situation at Stewartby however as in many instances, represents a far from ideal case. Some of the limitations have already been referred to and these can be summarised as follows:

1) Input data – including the estimation of emissions and their release, further compounded by production changes at the brickworks (see Appendices D and E)

2) Model limitations including representing short time changes in emissions and meteorological data

To help overcome these the high quality continuous monitoring at two fixed sites (described in the monitoring chapter of the report) is used. The use of such monitoring provides the most robust understanding of air quality available at a given location. This information is however still limited to the immediate geographic area of the monitoring site locations and the duration of the monitoring. In this instance the monitoring itself also provides challenges due to the vandalism at the KH site, changes at the brickworks and the effect of 2003 meteorology.

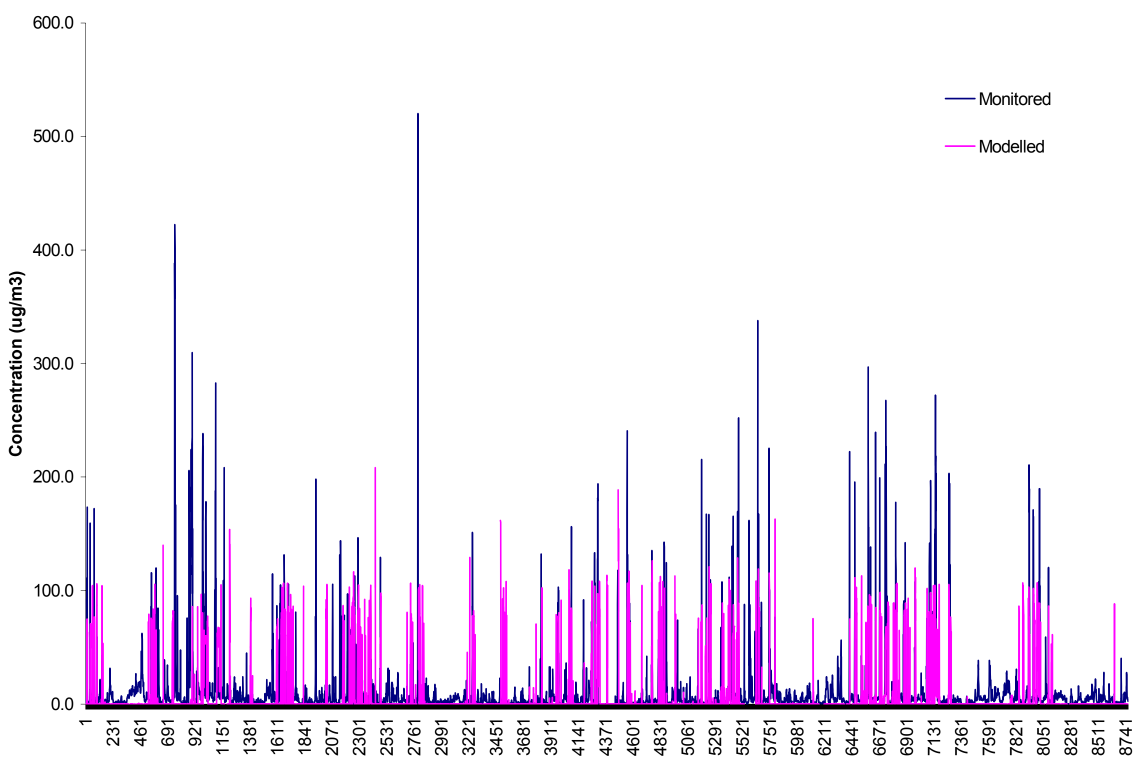
Despite these factors, the data can aid the modelling through the production of an adjustment factor to correct for systematic error. This is undertaken by verifying the model results against the measurement sites. The adjustment factor used in the report is based on a comparison of the results for KH in 2001. This was for two reasons:

1) The monitoring data were available for all this year (this represents 95.3% data capture for the year) and

2) The modelling can be based on 2001 meteorological data.

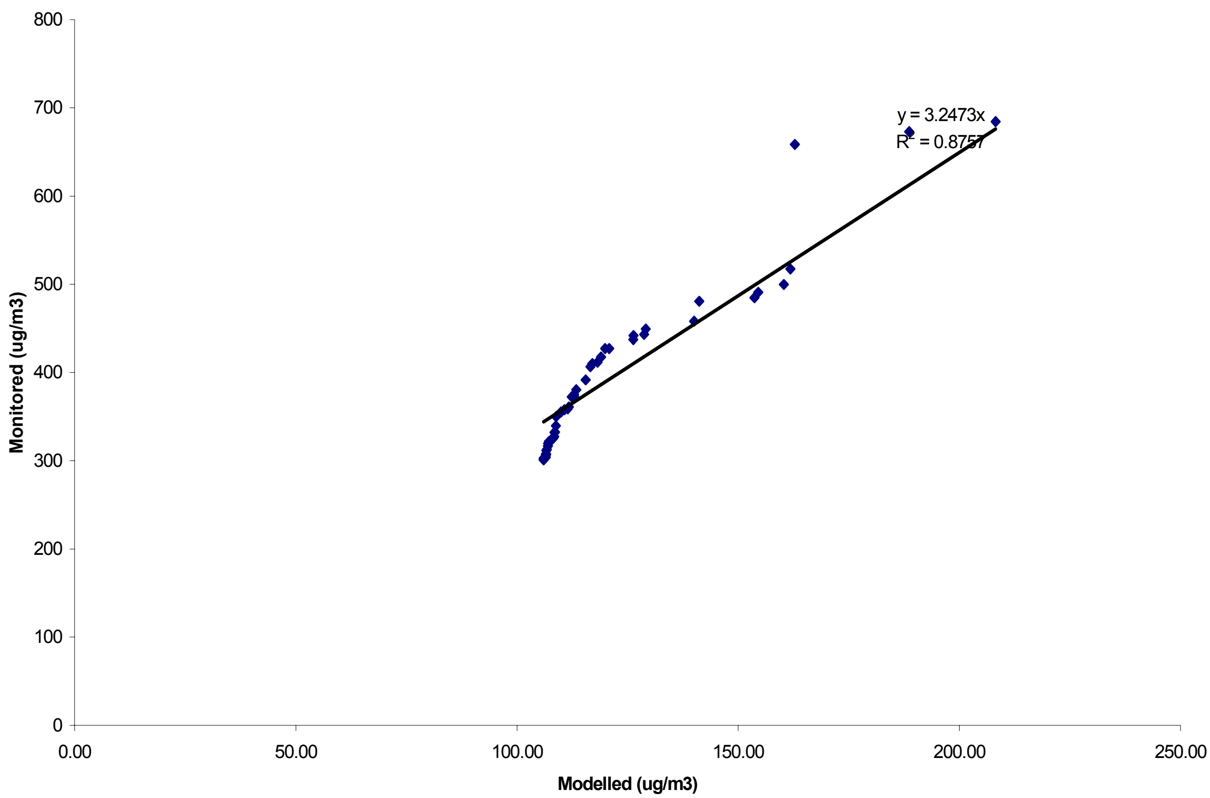
A separate model run for the KH site was undertaken. The direct comparison of results from this with the monitored results can be seen in Figure 24 below. This shows the variation in both monitored and modelled hourly averaged predictions throughout the year. (It should be noted that periods when no meteorological data were available have been treated as zero). This figure indicates that the highest modelled predictions underestimate the highest monitored data. It also demonstrates a reasonable agreement as to when the highest concentrations arise.

Figure 24 Comparison of monitored and modelled results at KH (2001)



As observed previously the AQS objective is difficult to model in view of its very short duration and the fact that only peaks are being sought. The effect of this means that deriving an average based on the data is not appropriate (see Table 18 for percentile values of monitored data); hence a method is required to adjust the peak concentrations. A methodology derived from TG03 was therefore been applied. This is based on the comparison of the top 50 measurements and predictions. These data are presented in Figure 25 below and a trend line has been added (based on an intercept at 0). The equation of the trend line indicates that the modelled concentration is approximately 30% of that monitored.

Figure 25 Comparison of top 50 measurements at KH (2001)



The modelled 99.9th percentile for the modelled case and monitoring location were also compared and this broadly agrees with the trend line method. The table overleaf gives the modelled 99.9th percentile concentration with the monitored result at KH for 2001.

Table 14 Predicted and measured 99.9[th] percentile at KH for 2001

	99.9th %ile concentration (µg/m³)
Monitored	326
Modelled	140

The final adjustment factor for the modelling was therefore derived from the above table.

An adjustment factor has not been derived for the BF1 site in view of the examination of episode analysis, which confirmed that most episodes arise at this site during low wind speeds, i.e. precisely the conditions when dispersion models work least well.

Treatment of background SO_2

The background concentrations of SO_2 can be determined from an examination of the measurements at the adjoining HBAPMN site at St. Albans. The results for the years 2001 to 2003 are presented in the figures below. The data capture rates were given earlier in Table 3.

The following table gives the percentile results for the St. Albans site (SA1) and also the two sites in the Council's area.

Table 15 Percentile results based on 15-minute mean SO_2 data for the SA1, KH and BF1 sites (µg/m³)

	SA1 2001	SA1 2002	*SA1 2003*	KH 2001	*KH 2002*	*KH 2003*	BF1 2001	BF1 2002	*BF1 2003*
10th%ile	0.0	0.0	*0.0*	0.8	*0.8*	*0.0*	2.7	2.4	*0.3*
20th%ile	2.4	2.1	*2.4*	1.3	*1.3*	*0.8*	4.3	3.7	*2.1*
30th%ile	2.4	2.4	*2.7*	1.9	*1.6*	*1.6*	5.6	4.8	*4.3*
40th%ile	2.4	2.7	*2.7*	2.4	*2.1*	*2.1*	6.9	5.9	*5.6*
50th%ile	2.4	4.3	*4.8*	3.2	*2.9*	*2.9*	8.2	6.9	*6.9*
60th%ile	4.8	5.3	*5.6*	4.3	*3.7*	*3.5*	9.6	8.2	*8.5*
70th%ile	4.8	6.7	*7.4*	5.9	*5.1*	*4.5*	11.4	9.6	*10.4*
80th%ile	7.2	8.5	*9.8*	8.5	*8.0*	*5.9*	13.8	11.7	*12.8*
90th%ile	11.2	12.8	*14.1*	16.5	*22.3*	*9.8*	19.2	17.0	*17.8*
99.9th%ile	47.3	41.2	*63.6*	326.0	*387.9*	*274.3*	237.2	255.9	*412.1*
Maximum	111.2	64.6	*111.7*	684.4	*616.6*	*476.9*	763.2	836.0	*1622.3*

(Italicised results indicate that the data capture is below 90% and / or the data are not ratified; for 2003 both SA1 and BF1 exceed 88% data capture)

It can be seen from this table that for all sites the 10 to 40 percentiles are low with the BF1 site tending to have slightly higher concentrations than the other corresponding sites. Using the 50% to represent the background it can be seen that the BF1 results are still higher by between 2 to 6 $\mu g/m^3$. However this is not particularly important as the objective relates to the 99.9th percentile and thus only to the very highest concentrations. In comparison with the 99.9th percentile it can be seen that background (50%ile) represents approximately 1% of the total concentration for the BF1 and KH sites. Using the assumption that the SA1 represents a typical background for the Bedford area then it can be seen this proportion still remains very small.

This report requires the prediction of concentrations for the end of 2005 in line with the AQS objective. From the above results it can be seen that there is little variation in concentrations over the period of monitoring. The TG03 guidance however suggests that the background will be 75% of the 2001 concentration and this has been assumed for the modelling.

Examination of the results for the SA1 site for the years 2001 to 2003 shows that there are occasional small peaks in concentration, however none exceed 140 $\mu g/m^3$.

Appendix D

Emissions from Stewartby brickworks

Introduction

The aim of this part of the study is to try to represent activity from the brickworks and thus develop an understanding of the SO_2 emissions created. To do this a series of assumptions have been made and these are explained fully below. These have been based on discussions with the Environment Agency (see also Appendix F).

Assumptions used in the report

1) All SO_2 emissions are calculated on the basis of grammes emitted per second (g/s), as required by dispersion models.

2) The emissions are discharged from the 4 different chimneystacks at different times at the brickworks (see Figure 26 below). Specific details of the stacks were provided and these are given in the table below.

Table 16 Details of Stewartby stacks

Stacks	Easting	Northing	Height (m)	Diameter (m)
ck22	501550	242596	70	3.27
ck3	501909	242858	67.85	3.33
ck1b	501726	242642	67.67	2.35
ck1c	501673	242514	69.8	2.67

3) The above kilns and stacks at Stewartby are understood not to have been operating concurrently in recent years. Based on advice obtained, it is assumed that operations were as follows:

- 2000 – ck22 and ck 3 only
- 2001 – as above
- 2002 – as above
- 2003 – ck3 and ck1
- 2004 – ck3 and ck1
- 2005 – ck3 and ck1

This is recognised to be a simplification due to production changes at the brickworks. For example kiln ck22 was closed in November 2002 as a result of structural problems to its stack (which was subsequently demolished). As a result general production was moved kiln ck1. The details of any testing (if any) prior to commissioning during an overlapping period were not available.

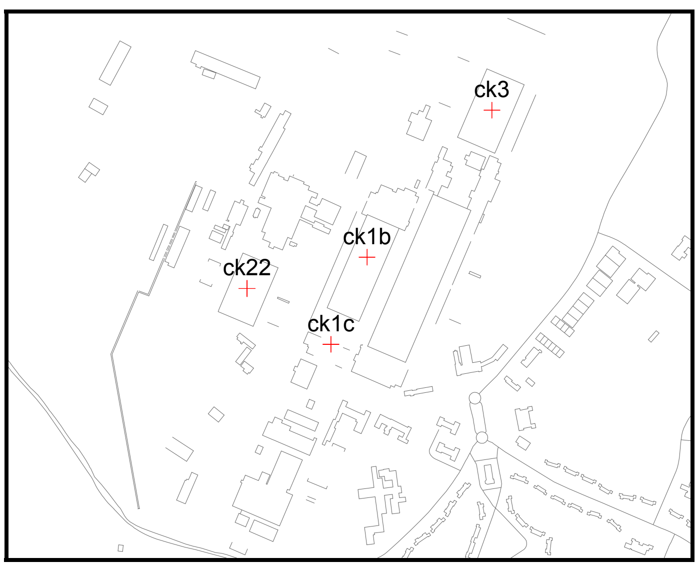
In view of the need to maintain fires within the kilns at all times it is also assumed that other short term changes in operation e.g. due to Christmas closures and maintenance practices were minimal and thus they have been ignored.

4) The emission rate for all stacks are based on the average emission rate for ck3, for which monitoring details were provided (seeFigure 27 below). This was determined using continuous monitoring equipment in line with Environment Agency requirements. The 50%ile emission rate is 100 g/s s. The range of emissions reported varied widely between 0 and 250g/s. The use of average emissions means that peak emissions are not reproduced in the modelling, which consequently means that the modelling results are likely to be underestimated

5) The flue gas exit temperature was assumed to be 150°C (ITC, 1999). This considered reasonable for such a process and recognises that the minimisation of heat loss is a key requirement for the process.

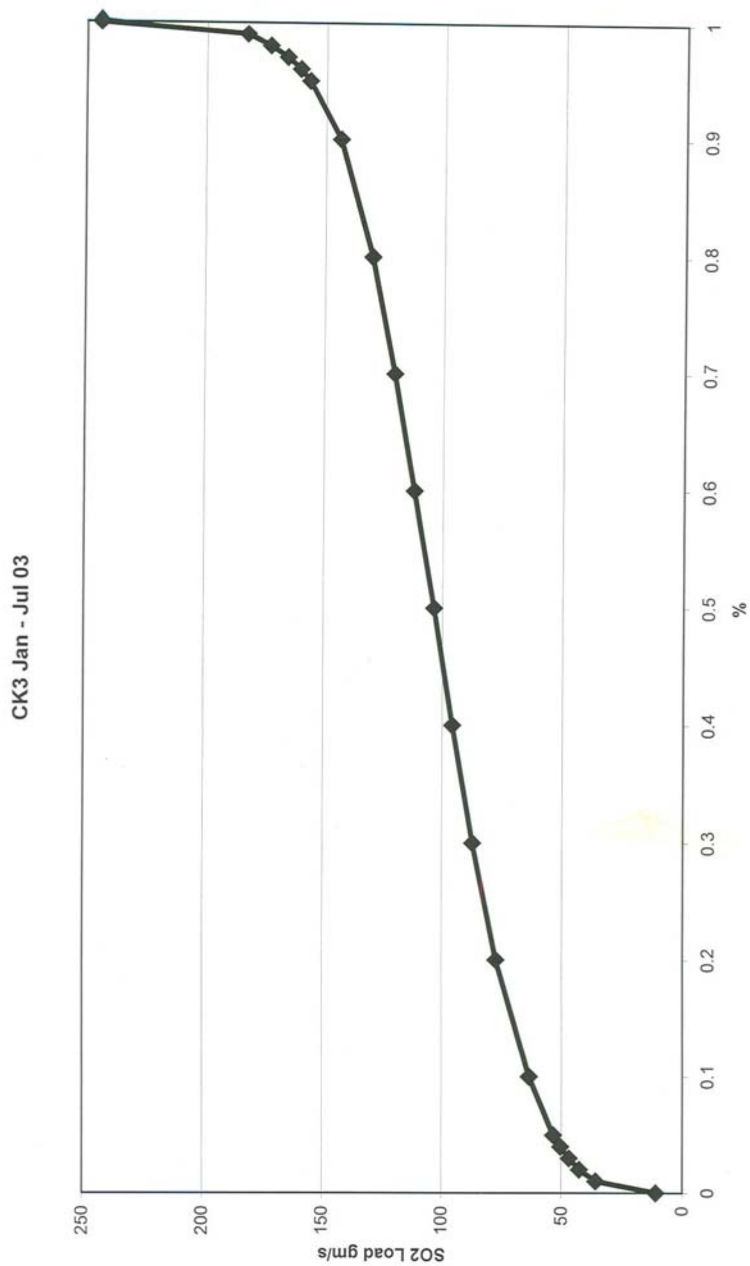
6) The efflux velocity used was 5m/s and again this is considered typical for a natural draught process.

Figure 26 Location of the chimneys to the kilns used at the Stewartby brickworks (2000 to 2005)



(Notes: the points are marked to represent the approximate position of the chimneystacks)

Figure 27 Emissions monitoring from kiln ck3



Emissions modelled

The model runs carried out relate to:

Base case 2001 – ck3 and ck22 only

Base case 2002 – ck3 and ck22 only

All future scenarios are based on ck3 operating with ck1 in the place of ck22. It also assumes business as usual i.e. that there is no change in emissions.

Limitations to estimating emissions

1) The above method to estimate emissions is based on the use of average emissions only. The use of the Hoffman kiln permits the brick making process to be continuous, albeit for batches only. No attempt has been made to quantify specific peak emissions arising from the kilns during the normal course of operations. Nor replicate actual process patterns, e.g. the practice of slowing the rate of transfer of the fire between chambers at weekends or works holidays. It can be further seen from the emissions information provided in the next Appendix that peak emissions arise on two occasions from the process.

2) The estimation of the emission rate is based on the use of two fires in the ck3 kiln. It is assumed that the same emission rate applies to ck1.

3) The estimation of emissions has not taken into account any recent process changes tested as a result of the requirements of the Environment Agency or the process operator.

Effect of limitations

The above limitations and other limitations referred to earlier in the report are thought likely to lead to an underestimate of emissions arising from the brickworks.

The 15-minute mean SO_2 objective also as noted previously requires the 266 $\mu g/m^3$ standard not to be exceeded more than 35 times in a year. Thus the objective requires the peak episodes of pollution to be highlighted. The estimation of emissions however has been based on average emissions and therefore the peak periods of emissions are smoothed out over a year. This is partly inevitable in view of the information available regarding emissions. The resultant model outputs are therefore considered also to represent an underestimate, which is the case prior to the application of the factor based on the Council's monitoring results.

Appendix E

Process information for Stewartby Brickworks

The following notes relating to brickworks were kindly provided by the Environment Agency in relation to the brickworks.

STEWARTBY BRICKWORK'S

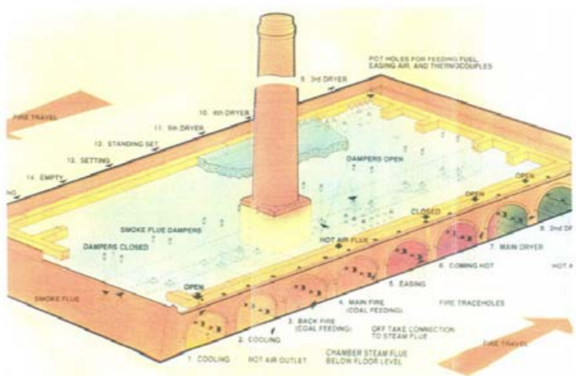
The Fletton brick industry has three works remaining; Stewartby near Bedford; and Saxon & Kings Dyke south of Peterborough. These still operate the brick making process using lower Oxford Clay fired in Hoffmann Kilns. The Fletton process has a characteristic odour associated with it from mercaptans present in the clay, which can be detected by sensitive people some twenty miles away in appropriate meteorological conditions. The process at Bedford uses coal as the supplemental fuel where as the Peterborough works use natural gas.

In February 1993 these processes came within the IPC Regulations from the air legislation and London Brick Company, as it was known then, applied for authorisation to operate several Fletton Brick making works. At that time the application for Stewartby consisted of thirteen chimneys discharging from eight Hoffman kilns. Today only two kilns remain working and discharge through three chimneys. They are kilns CK1 and CK3 that use chimneys CK1b, CK1c and CK3 as shown on the accompanying site drawing. Until November 2002 kiln 22 was used rather than kiln CK1 for general production. Kiln Ck1 and stack CK1b was used on an intermittent basis, but the chimney on kiln 22 became dangerous and had to be demolished, hence production was moved to kiln CK1.

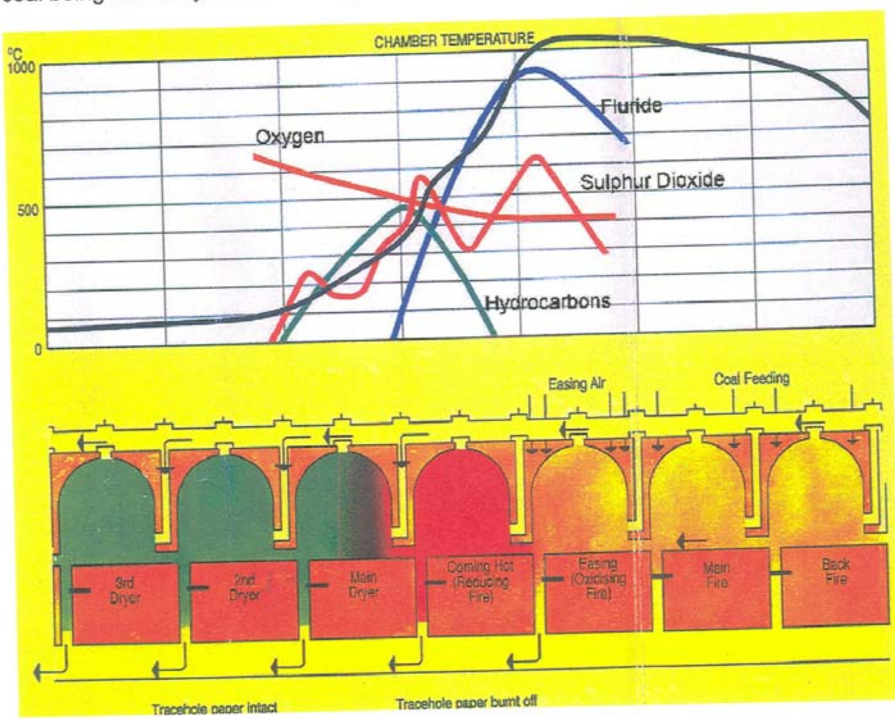
Thus the table below gives the basic information for the three operational chimneys.

Stewartby Chimney Details			
Chimney Number	CK1b	CK1c	CK3
Height (m)	69.80	67.67	67.85
Diameter at top (ID m)	2.35	2.67	3.33
Number of Chambers in Kiln	48		36
Number of Fires	2	1	2
Area of stack at measurement point (sq.m.) (ie. Position of CEMS kit)	9.348	10.18	13.494
Stack NGR easting	501726	501673	501909
Stack NGR northing	242642	242514	242858

The process consists of one or more fires to a kiln and each fire spreads its effect over several chambers as shown in the diagram below.



This means that various emissions come off in various chambers during the firing cycle, from the drying through coming hot (a reducing atmosphere) to easing, main fire and back fire (all oxidising atmospheres) to the cooling stage of the fired product. The art/skill in the operation is that the kiln operator must route the various gas flows through the correct flues and feed the right amount of supplementary fuel at the correct stage and in the correct volume. Remember at Stewartby all of this is by hand and experience, there is no automation available to assist. Small quantities of coal being added by the hand scoop.



Typically the time it takes the process to move forward one chamber is between 15 hours and 30 hours. During the working week (Monday - Friday) it would be expected that the fire would move forward in an interval of between 18 and 24 hours, being slower at weekends and works holidays.

Emissions Monitoring

Until very recent time the only continuous monitoring of the kilns were the temperatures within key chambers. Monitoring of the kilns was undertaken by extractive techniques 3 times a year. Twice by the company, once for check monitoring. Results were averaged over a kiln cycle, i.e. the fire had moved on one chamber. The typical release levels were:

SUBSTANCE	CONCENTRATION ❋
total particulate matter	100 mg/m^3
sulphur dioxide	2000 mg/m^3
total fluorides (as hydrogen fluoride)	25 mg/m^3

❋ The reference conditions for concentration of substances in air is:
temperature of 273K, pressure of 101.3 kPa absolute, dry with no correction for oxygen content.

N.B. There is no correction for oxygen as the kilns run at circa 18→20% Oxygen

It is generally thought that the peak of these releases may approximate to twice the cycle average figure, but with the complexities of multiple fires and are they in phase or out of phase with each other.

The company had always argued that continuos monitoring equipment was unavailable for such an aggressive plume, which is often below the acid dew point of the fume and also that, the operating cost would be too excessive. Therefore CEM's were not BATNEEC. However in 1999 the company were convinced that to fit CEM's to a chimney was a good idea. These have now been fitted although the reliability of the data remains of concern and interpretation of the results is still being pondered over. For this reason formal reporting of the data is yet to be incorporated in the permission and the data we have gained has been for discussion purposes only.

In addition to Kiln monitoring both the company and the Borough Council are maintaining ambient air monitoring station at locations "down wind" of the site together with the collection of real time meteorological.
