SILVERTOWN TUNNEL

Preliminary Environmental Information Report: Appendix 6.A

Model Verification

MAYOR OF LONDON

TRANSPORT FOR LONDON
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CONTENTS

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1. INTRODUCTION

1.1.1 The comparison of modelled concentrations with local monitored concentrations is a process termed 'verification'. Model verification identifies any discrepancies between modelled and measured concentrations, which can arise for a range of reasons. The following are examples of potential causes of such discrepancies:

- estimates of background pollutant concentrations;
- meteorological data uncertainties;
- traffic data uncertainties;
- emission factor uncertainties;
- model input parameters, such as 'roughness length'; and
- overall limitations of the ability of the dispersion model to model dispersion in a complex urban environment.

1.1.2 The verification process involves a review of the modelled pollutant concentrations against corresponding monitoring data to determine how well the air quality model has performed. Depending on the outcome it may be considered that the model has performed adequately and that there is no need to adjust any of the modelled results.

1.1.3 Alternatively the model may perform poorly[1] against the monitoring data, as a result there is a need to check all the input data to ensure that it is reasonable and accurately represented in the air quality modelling process. Where all input data, such as traffic data, emissions rates and background concentrations have been checked and considered reasonable, then the modelled results may require adjustment to best align with the monitoring data. This may be either be a single verification adjustment factor to be applied to the modelled concentrations across the study area or a range of different adjustment factors to account for different situations in the study area.

[1] The acceptable limits of model verification performance are set out in Defra's Local Air Quality Management Technical Guidance (2009)

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2. RESIDUAL UNCERTAINTY

2.1.1 Residual uncertainty may remain after systematic error or ‘overall model accuracy’ has been accounted for in the final predictions. Residual uncertainty may be considered synonymous with the ‘residual inaccuracies’ of the model predictions, i.e. how wide the scatter or residual variability of the predicted values compare with the monitored true value, once systematic error has been allowed for. The quantification of final model accuracy provides an estimate of how the final predictions may deviate from true (monitored) values at the same location over the same period.

2.1.2 Suitable local monitoring data for the purpose of verification is available for concentrations of NO_2 at the locations shown in Table 6A-3. This monitoring data has been used to validate the dispersion model prediction and obtain adjustment factors which can be applied to predictions of pollutant concentrations in the base and future years.

Model Performance

2.1.3 An evaluation of model performance has been undertaken to establish confidence in model results. LAQM.TG(09) (Defra, 2009) identifies a number of statistical procedures that are appropriate to evaluate model performance and assess the uncertainty. The statistical parameters used in this assessment are:

- root mean square error (RMSE);
- fractional bias (FB); and
- correlation coefficient (CC).

2.1.4 A brief for explanation of each statistic is provided in Table 6A-1, and further details can be found in LAQM.TG(09) Box A3.7.

Table 6A-1Statistical Parameters used to estimate model performance

Statistical Parameter	Comments	Ideal value
RMSE	RMSE is used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared. If the RMSE values are higher than 25% of the objective being assessed, it is recommended that the model inputs and verification should be revisited in order to make improvements. For example, if the model predictions are for the annual mean NO_2 objective of 40 μg/m^3, if an RMSE of 10 μg/m^3 or above is determined for a model it is advised to revisit the model parameters and model verification. Ideally an RMSE within 10% of the air quality objective would be derived, which equates to 4 μg/m^3 for the annual mean NO_2 objective.	0.01
FB	It is used to identify if the model shows a systematic tendency to over or under predict. FB values vary between +2 and -2 and has an ideal value of zero. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.	0.00
CC	It is used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship. This statistic can be particularly useful when comparing a large number of model and observed data points.	1.00

2.1.5 These parameters estimate how the model results agree or diverge from the observations. These calculations have been carried out prior to, and after, adjustment and provide information on the improvement of the model predictions as a result of the application of the verification adjustment factors.

3. AIR QUALITY MONITORING DATA

3.1.1 The air quality monitoring data collected as part of this assessment and detailed in the baseline section was reviewed to determine the suitability of each of the monitoring locations for inclusion into the model verification process. The criteria used to determine the suitability of the monitoring for inclusion into the verification exercise is outlined below:

- within 50m of roads forming the air quality study area
- monitoring from diffusion tubes for 2012 was used in preference to other years where there was greater than 75% data capture
- where there was less than 75% data capture from the diffusion tubes in 2012 but a greater level of data capture (greater than 75%) in other years (2010,2011,2013) these results were taken in preference and annualised (using the relationship between annual mean concentrations at automatic roadside monitoring stations within the study area).
- automatic monitoring data was used where there was greater than 90% data capture
- monitoring was discounted where there was less than 75% data capture in 2012 and poor data capture in other years
- monitoring was excluded from verification if major sources were missing from the traffic model that may influence monitored concentrations and therefore could not be included in the air quality modelling (such as large car parks, industrial stacks in close proximity etc).
- sites where the location of the monitoring could not be confirmed to a satisfactory standard were omitted from the verification.

3.1.2 The monitoring sites excluded from the verification process not as a result of data capture are presented in Table 6A-2 along with the reason for exclusion. Diffusion tubes collocated at automatic analysers were also removed as the results from the automatic stations were used in preference.

Table 6A-2: Monitoring Sites Excluded from the Verification Process

Site	Reason for exclusion
THA52	Too far from road to be representative
BDI07	Coordinates unreliable – XY suggest that site is located inside a building

Site	Reason for exclusion
THA83	Not all sources represented – traffic model misses large scrapyard access and arm of junction.

4. VERIFICATION METHODOLOGY

4.1.1 The verification method following the process detailed in LAQM.TG(09). The initial verification was undertaken by comparing the modelled versus monitored Road NO_x. Road NO_x measured at the diffusion tubes were calculated using the latest Defra NO_x to NO_2 calculator (v4.1), because diffusion tubes only measure NO_2 and do not directly measure NO_x.

4.1.2 Concentrations of road NO_x recorded at automatic monitors was were calculated by subtracting background concentrations of NO_x (acquired from Defra background maps) from the total NO_x recorded at the automatic site.

4.1.3 Modelled PM_{10} and $PM_{2.5}$ were compared against monitoring data at the automatic sites to determine whether adjustment was required.

4.1.4 Following the removal of the monitoring locations with low data capture and locations which could not be described in the model a total of 115 tubes diffusion tube and automatic monitoring sites were used in the verification. The initial modelled versus monitored NO_2 and NO_x are presented in Table 6A-3.

Table 6A-3: Modelled versus Monitoring Initial Results 2012

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
RBG10	540200	178367	RBG	Automatic	71	45	28.8	52.9	-25%	61.8	166	-63%
HYD45	539831	179181	Scheme	Diffusion Tube	39.3	42.6	27.6	31.8	-19%	9.0	26.8	-66%
HYD46	539568	178765	Scheme	Diffusion Tube	44.4	45.5	29.0	36.3	-18%	16.3	36.8	-56%
HYD47	539732	178646	Scheme	Diffusion Tube	37.6	45.5	29.0	35.7	-5%	15.0	19.5	-23%
HYD48	539732	178585	Scheme	Diffusion Tube	37.9	45.5	29.0	33.2	-12%	9.2	20.3	-55%
HYD49	539775	178290	Scheme	Diffusion Tube	42.8	45.5	29.0	36.2	-15%	16.2	32.3	-50%
HYD51	540025	178291	Scheme	Diffusion Tube	53.4	45.0	28.8	38.5	-28%	22.2	63.4	-65%
HYD52	540337	178361	Scheme	Diffusion Tube	71.2	45.0	28.8	42.6	-40%	32.7	125.7	-74%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
HYD53	540278	178275	Scheme	Diffusion Tube	53.4	45.0	28.8	41.6	-22%	29.9	63.1	-53%
GW36	540200	178367	RBG	Diffusion Tube	53.6	42.6	27.6	40.2	-25%	29.2	66.9	-56%
GW50	539831	179181	RBG	Diffusion Tube	73.0	45.0	28.8	50.6	-31%	54.9	132.7	-59%
GW51	539568	178765	RBG	Diffusion Tube	47.4	42.6	27.6	35.6	-25%	17.9	48.4	-63%
HYD17	539732	178646	Scheme	Diffusion Tube	50.8	48.2	30.8	39.0	-23%	18.8	50.4	-63%
GW42	539732	178585	RBG	Diffusion Tube	50.5	43.8	28.2	43.6	-14%	36.6	55.9	-35%
L1	539775	178290	LBL	Diffusion Tube	37.8	45.7	29.6	34.7	-8%	11.1	18.5	-40%
THA10	540025	178291	LBTH	Diffusion Tube	54.5	65.1	39.0	49.3	-10%	25.5	40.0	-36%
THA19	540337	178361	LBTH	Diffusion Tube	49.8	65.1	39.0	49.1	-1%	25.0	27.0	-7%
THA23	540278	178275	LBTH	Diffusion Tube	50.6	50.5	31.9	42.8	-15%	25.6	47.0	-46%
THA24	539320	179234	LBTH	Diffusion Tube	58.6	58.0	35.7	45.0	-23%	22.4	61.7	-64%

Tube Id	**X**	**Y**	**Data Owner**	**Monitoring Method**	**Monitored NO_2 (µg/m³)**	**BG NO_x (µg/m³)**	**BG NO_2 (µg/m³)**	**Md Total NO_2 (µg/m³)**	**Mn V Md Total NO_2 % Diff**	**Md Rd NO_x (µg/m³)**	**Mn Rd NO_x (µg/m³)**	**Mn v Md Rd NOx % Diff**
THA30	540203	178367	LBTH	Diffusion Tube	61.4	65.1	39.0	46.6	-24%	18.3	61.4	-70%
THA35	539638	179024	LBTH	Diffusion Tube	147.8	50.5	31.9	57.7	-61%	68.9	459.1	-85%
THA49	540737	182923	LBTH	Diffusion Tube	48.3	54.8	34.1	40.7	-16%	15.2	35.0	-57%
THA50	538317	177652	LBTH	Diffusion Tube	67.3	48.5	30.9	43.0	-36%	28.5	105.3	-73%
THA57	536111	177579	LBTH	Diffusion Tube	37.1	55.4	34.4	37.3	1%	6.4	6.0	8%
THA58	534208	181341	LBTH	Diffusion Tube	38.7	54.1	33.7	41.0	6%	16.9	11.4	48%
THA59	534803	181325	LBTH	Diffusion Tube	50.0	48.5	30.9	43.5	-13%	29.7	47.9	-38%
THA6	535598	180819	LBTH	Diffusion Tube	86.5	63.4	38.1	53.7	-38%	40.1	159.6	-75%
THA73	535174	181288	LBTH	Diffusion Tube	46.2	47.4	30.3	39.2	-15%	20.4	38.7	-47%
THA74	534237	181581	LBTH	Diffusion Tube	68.4	47.4	30.3	45.9	-33%	37.8	111.0	-66%
THA75	535990	180874	LBTH	Diffusion Tube	39.3	54.1	33.7	38.1	-3%	10.0	12.8	-21%
THA76	5369	1812	LBTH	Diffusion	67.5	55.4	34.4	42.7	-37%	19.3	95.7	-80%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
	64	45		Tube								
THA86	536940	180992	LBTH	Diffusion Tube	45.2	47.4	30.3	41.7	-8%	26.7	35.9	-26%
THA9	537532	181290	LBTH	Diffusion Tube	50.5	63.4	38.1	50.2	-1%	30.2	31.1	-3%
THA2	537539	180688	LBTH	Automatic	62.0	52.4	32.9	51.9	-16%	48.2	98.6	-51%
THA80	536973	180628	LBTH	Diffusion Tube	60.3	49.9	31.6	41.0	-32%	22.0	78.6	-72%
THA81	533829	180929	LBTH	Diffusion Tube	103.2	54.8	34.1	50.8	-51%	42.0	245.6	-83%
THA84	538672	180739	LBTH	Diffusion Tube	53.6	52.4	32.9	46.9	-13%	34.0	53.4	-36%
HYD36	538271	180760	Scheme	Diffusion Tube	47.6	43.9	28.0	33.7	-29%	12.6	48.2	-74%
DT E	537661	180768	LBR	Diffusion Tube	48.6	42.9	27.6	39.6	-18%	27.8	52.0	-47%
WAF4	537942	181027	LBWF	Diffusion Tube	41.2	46.7	29.4	39.6	-4%	23.4	27.4	-15%
HYD21	538955	180925	Scheme	Diffusion Tube	43.2	44.2	28.7	33.9	-22%	11.5	34.3	-67%
HYD22	533999	180608	Scheme	Diffusion Tube	40.6	39.9	26.0	30.9	-24%	10.6	34.0	-69%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
HYD25	538290	181452	Scheme	Diffusion Tube	41.3	42.5	27.7	33.0	-20%	11.5	31.6	-64%
HYD59	537581	183208	Scheme	Diffusion Tube	36.2	41.2	26.7	31.8	-12%	11.0	21.4	-48%
DT M	537903	182994	LBR	Diffusion Tube	77.3	40.1	26.1	36.7	-53%	23.9	158.1	-85%
THR14	538366	181180	TC	Diffusion Tube	68.0	32.1	21.8	33.9	-50%	26.6	131.7	-80%
THR26	539474	187856	TC	Diffusion Tube	40.1	33.3	22.6	30.9	-23%	17.9	40.3	-56%
THR45	540822	188371	TC	Diffusion Tube	40.7	32.1	21.8	28.2	-31%	13.5	43.5	-69%
HYD1	539025	186945	Scheme	Diffusion Tube	67.7	47.0	30.1	48.9	-28%	46.6	108.5	-57%
HYD2	543425	183913	Scheme	Diffusion Tube	49.3	47.0	30.1	39.9	-19%	22.5	47.7	-53%
HYD3	542649	187015	Scheme	Diffusion Tube	41.4	47.0	30.1	35.1	-15%	11.1	26.4	-58%
HYD15	543587	185259	Scheme	Diffusion Tube	48.5	45.4	29.2	42.3	-13%	30.8	47.6	-35%
HYD16	541556	189245	Scheme	Diffusion Tube	49.7	44.7	28.9	39.3	-21%	23.9	51.8	-54%
HYD26	5418	1881	Scheme	Diffusion	48.1	42.0	27.0	38.6	-20%	26.4	51.8	-49%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
	80	70		Tube								
HYD30	555311	179417	Scheme	Diffusion Tube	40.0	36.8	24.2	31.8	-21%	16.6	36.6	-55%
HYD31	556314	178765	Scheme	Diffusion Tube	38.0	36.8	24.2	28.3	-25%	8.8	31.5	-72%
HYD32	555286	179501	Scheme	Diffusion Tube	39.4	32.1	21.8	26.4	-33%	9.6	40.4	-76%
BDI20	540295	181768	LBBD	Diffusion Tube	63.8	36.8	24.2	43.0	-33%	44.6	111.1	-60%
DA14	540302	181791	DBC	Diffusion Tube	60.0	34.2	23.1	52.4	-13%	71.2	94.8	-25%
DA20	540299	181841	DBC	Diffusion Tube	41.0	34.2	23.1	37.3	-9%	31.2	40.2	-22%
DA21	541445	181866	DBC	Diffusion Tube	35.0	34.2	23.1	33.4	-5%	22.0	25.7	-14%
DA22	542739	182119	DBC	Diffusion Tube	53.0	34.2	23.1	44.4	-16%	48.9	73.0	-33%
DA24	545603	183461	DBC	Diffusion Tube	35.0	32.6	22.2	32.9	-6%	22.7	27.6	-18%
DA44	547752	183529	DBC	Diffusion Tube	44.0	34.2	23.1	33.1	-25%	21.3	47.9	-56%
DA84	547742	183479	DBC	Diffusion Tube	58.0	34.2	23.1	48.5	-16%	60.0	88.4	-32%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
THR10	555350	179894	LBTH	Diffusion Tube	52.9	36.0	24.0	38.8	-27%	32.7	70.7	-54%
DA50	547059	183597	DBC	Diffusion Tube	41.0	27.4	19.1	36.4	-11%	37.6	49.1	-23%
DA72	555484	174441	DBC	Diffusion Tube	38.0	32.8	22.5	29.3	-23%	14.1	34.2	-59%
DA81	555660	174863	DBC	Diffusion Tube	39.0	32.8	22.5	30.0	-23%	15.7	36.6	-57%
DA89	555497	174025	DBC	Diffusion Tube	38.2	27.4	19.1	32.0	-16%	27.3	42.1	-35%
DA90	555600	174030	DBC	Diffusion Tube	37.9	27.4	19.1	29.6	-22%	21.9	41.4	-47%
RBG4	555632	173558	RBG	Automatic	47.0	33.9	22.8	35.1	-25%	27.5	68.1	-60%
HYD63	555656	174053	Scheme	Diffusion Tube	39.5	27.4	19.1	32.1	-19%	28.1	46.7	-40%
HYD66	555574	174068	Scheme	Diffusion Tube	35.6	36.1	24.0	34.7	-3%	23.7	25.8	-8%
HYD69	557570	177789	Scheme	Diffusion Tube	37.4	36.1	24.0	32.3	-13%	18.1	30.1	-40%
HYD70	553783	172319	Scheme	Diffusion Tube	35.2	38.7	25.5	32.4	-8%	15.2	21.8	-30%
HYD71	5564	1721	Scheme	Diffusion	38.3	38.7	25.5	31.2	-19%	12.4	29.2	-58%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
	33	24		Tube								
BEX1	556368	172344	LBB	Diffusion Tube	47.8	34.8	23.3	36.4	-24%	29.3	60.1	-51%
BEX16	553795	172259	LBB	Diffusion Tube	40.5	31.0	21.1	33.4	-18%	27.0	45.0	-40%
BEX24	553957	172275	LBB	Diffusion Tube	59.4	31.0	21.1	36.7	-38%	35.1	103.5	-66%
BEX3	544997	175098	LBB	Diffusion Tube	49.2	34.8	23.3	34.4	-30%	24.5	64.2	-62%
BEX413	553158	172562	LBB	Diffusion Tube	35.8	31.8	21.6	28.8	-20%	15.4	31.9	-52%
BEX414	543371	175056	LBB	Diffusion Tube	63.7	31.8	21.6	32.0	-50%	22.7	117.6	-81%
BEX415	543530	175196	LBB	Diffusion Tube	34.2	31.8	21.6	28.3	-17%	14.2	28.0	-49%
BEX416	541474	175415	LBB	Diffusion Tube	35.0	31.8	21.6	26.4	-25%	10.2	29.9	-66%
BEX417	541718	175296	LBB	Diffusion Tube	45.8	31.8	21.6	30.0	-34%	18.2	58.5	-69%
BEX418	545000.1	175098	LBB	Diffusion Tube	30.7	31.8	21.6	25.4	-17%	8.1	19.8	-59%
GW103	547676	174328	RBG	Diffusion Tube	51.0	39.9	26.1	39.4	-23%	30.5	62.7	-51%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
GW23	547608	174344	RBG	Diffusion Tube	40.6	45.0	28.9	36.6	-10%	17.4	27.1	-36%
GW32	545080	175067	RBG	Diffusion Tube	48.7	45.0	28.9	42.2	-13%	31.3	48.9	-36%
GW55	546253	174774	RBG	Diffusion Tube	55.9	34.8	23.3	37.1	-34%	31.1	85.5	-64%
RBG9	546260	174730	RBG	Automatic	44.0	38.7	25.5	33.6	-24%	18.0	58.3	-69%
GW105	546228	174613	RBG	Diffusion Tube	53.6	35.9	24.0	39.2	-27%	34.9	76.5	-54%
GW38	546173	174473	RBG	Diffusion Tube	36.2	38.7	25.5	31.2	-14%	12.3	24.1	-49%
GW54	546313	174493	RBG	Diffusion Tube	61.2	38.7	25.5	36.4	-40%	24.7	98.1	-75%
GW59	546386	174437	RBG	Diffusion Tube	42.9	38.7	25.5	33.6	-22%	18.0	41.2	-56%
HYD6	540935	176575	Scheme	Diffusion Tube	39.9	45.5	29.2	33.1	-17%	8.6	24.7	-65%
HYD7	540420	177706	Scheme	Diffusion Tube	40.1	45.5	29.2	32.3	-20%	6.7	25.2	-74%
HYD8	540661	177227	Scheme	Diffusion Tube	37.6	45.5	29.2	31.0	-18%	3.8	19.0	-80%
HYD11	5450	1750	Scheme	Diffusion	38.0	45.4	29.2	33.4	-12%	9.2	19.8	-54%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
	05	97		Tube								
HYD13	541885	175016	Scheme	Diffusion Tube	34.3	47.9	30.2	32.9	-4%	6.0	9.0	-34%
HYD14	541143	174294	Scheme	Diffusion Tube	34.5	54.9	33.6	35.4	3%	4.1	2.1	97%
HYD19	541885	175045	Scheme	Diffusion Tube	41.2	48.9	30.8	33.6	-19%	6.1	24.3	-75%
HYD20	541915	175039	Scheme	Diffusion Tube	31.7	44.0	28.4	30.5	-4%	4.5	7.3	-38%
HYD27	541885	175016	Scheme	Diffusion Tube	39.4	45.5	29.2	32.3	-18%	6.7	23.4	-71%
HYD39	540180	180371	Scheme	Diffusion Tube	34.2	38.6	25.3	28.3	-17%	6.3	19.6	-68%
HYD40	540641	180148	Scheme	Diffusion Tube	38.6	54.9	33.6	35.2	-9%	3.7	11.5	-68%
HYD56	540636	180192	Scheme	Diffusion Tube	36.2	46.8	29.5	35.0	-3%	12.0	14.9	-19%
GW29	541060	181491	RBG	Diffusion Tube	64.0	45.3	28.8	39.4	-38%	24.2	98.5	-75%
GW49	543694	180899	RBG	Diffusion Tube	46.6	38.6	25.3	38.4	-18%	29.9	51.8	-42%
GW52	542937	180912	RBG	Diffusion Tube	43.9	46.8	29.5	41.7	-5%	28.3	34.1	-17%

Tube Id	X	Y	Data Owner	Monitoring Method	Monitored NO_2 (µg/m³)	BG NO_x (µg/m³)	BG NO_2 (µg/m³)	Md Total NO_2 (µg/m³)	Mn V Md Total NO_2 % Diff	Md Rd NO_x (µg/m³)	Mn Rd NO_x (µg/m³)	Mn v Md Rd NOx % Diff
THA44	541939	180194	LBTH	Diffusion Tube	53.0	56.2	34.8	41.8	-21%	16.2	46.4	-65%
THA53	543748	181309	LBTH	Diffusion Tube	60.1	49.9	31.6	42.6	-29%	25.9	77.6	-67%
THA79	540260	180329	LBTH	Diffusion Tube	48.1	49.9	31.6	34.8	-28%	7.0	40.8	-83%

4.1.5 The modelled versus monitored annual mean NO_2 concentrations were plotted on a scatter graph as presented on Figure 6A-1.

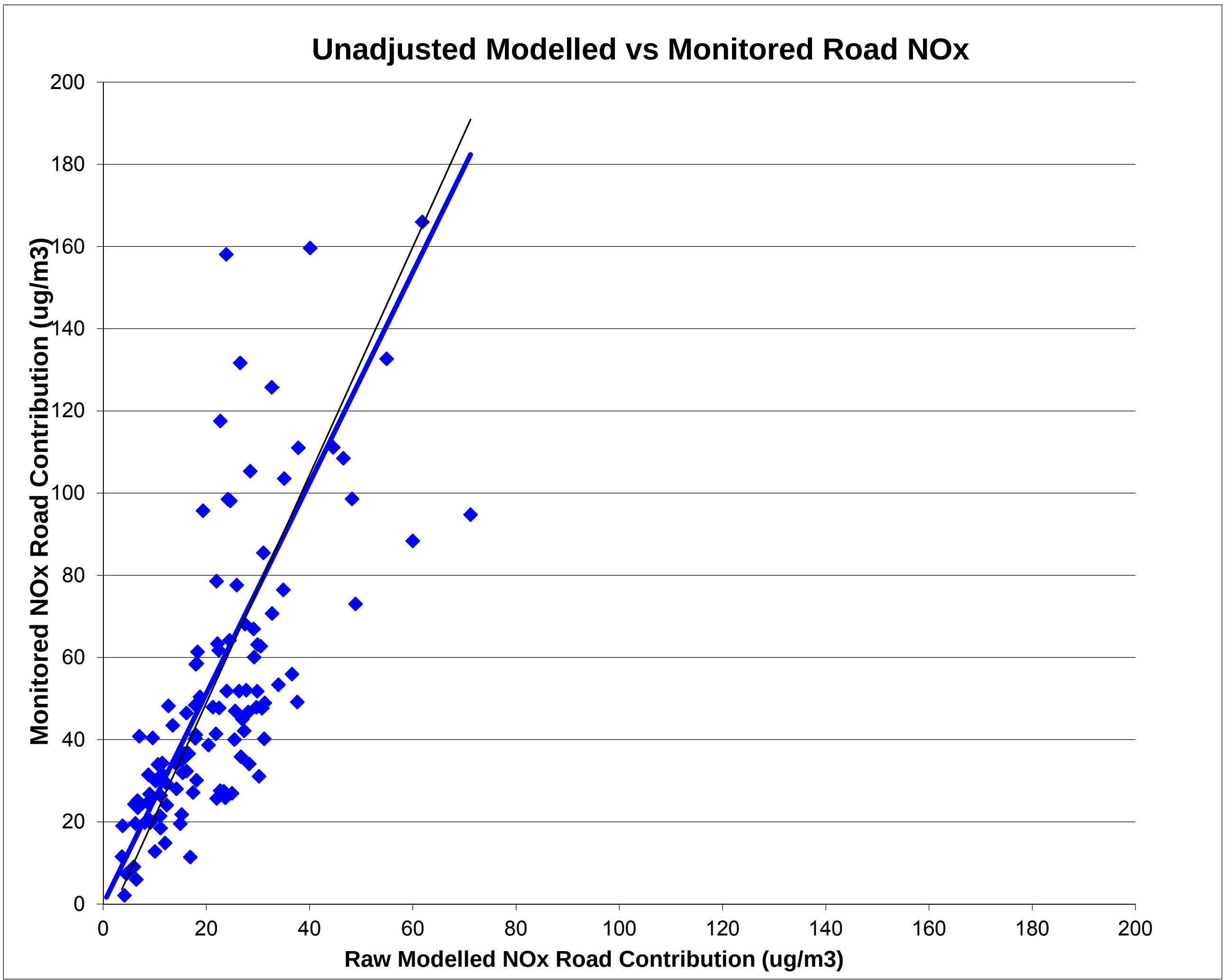

Figure 6A-1: Modelled Versus Monitored Road NOx

4.1.6 Figure 6A-1 illustrates that the modelled tends to under predicts against the monitored concentrations. Table 6A-4 shows that the model is performing poorly with only 72% of the modelled NO_2 being within 25% of the modelled.

4.1.7 The verification of such a large model is not simple as a result of the complexity of the area. A number of verification tests were therefore carried out to determine the best approach these included the following;

- Basic verification –Factor applied to all motorways and all A-roads separately

- Overall Factor – one single verification factor for all receptors
- Detailed Verification - Splitting the model into 11 Verification Zones following review of the modelled versus monitoring (including splitting specific Sections of the road network into different zones).

4.1.8 Following a review of the verification the detailed verification was judged to ensure that the model performed well. The road NO_x verification factors for each of the modelled zones are presented in Table 6A-4.

Table 6A-4: Road NOx Verification Factors for Each Model Verification Zone.

	Verification Factor	Number of Monitoring sites used	RMSE
Greenwich Peninsular	2.60	12	5.2
Central London	3.54	21	16.1
East Cross Route	2.96	7	15.2
Bromley-by-bow	3.11	3	4.2
North Circular	4.80	5	9.3
A13	2.49	13	6.7
M25 Dartford	1.47	8	4.1
A2	2.14	25	6.5
South Circular	2.73	5	5.4
Silvertown	2.83	11	2.6
Woolwich Road	2.09	4	9.0

4.1.9 When the 11 verification factors in Table 6A-4 were applied to the raw modelled results, total annual mean NO_2 concentrations at 84% of the modelled sites were within 25% of monitored NO_2 concentrations as summarised in Figure 6A-3.

4.1.10 Figures 6A-3 demonstrates that the once adjusted for road NO_x, total modelled NO_2 concentrations are closer to monitored total NO_2 concentrations, than the unadjusted total modelled NO_2 in Figure 6.

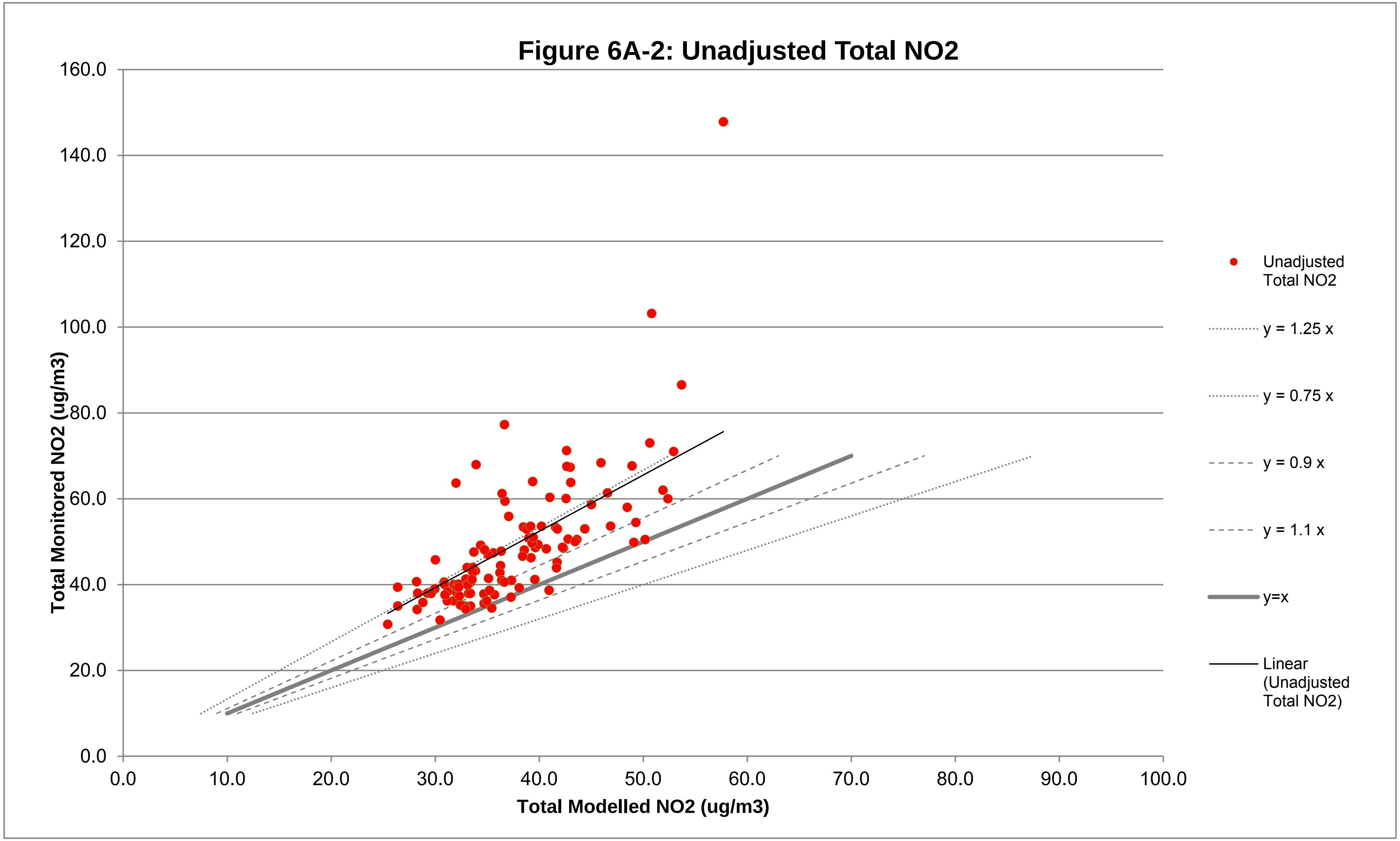
Figure 6A-2: Unadjusted Total NO2
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Total Monitored NO2 (ug/m3)
Total Modelled NO2 (ug/m3)
Unadjusted Total NO2
y = 1.25 x
y = 0.75 x
y = 0.9 x
y = 1.1 x
y=x
Linear (Unadjusted Total NO2)

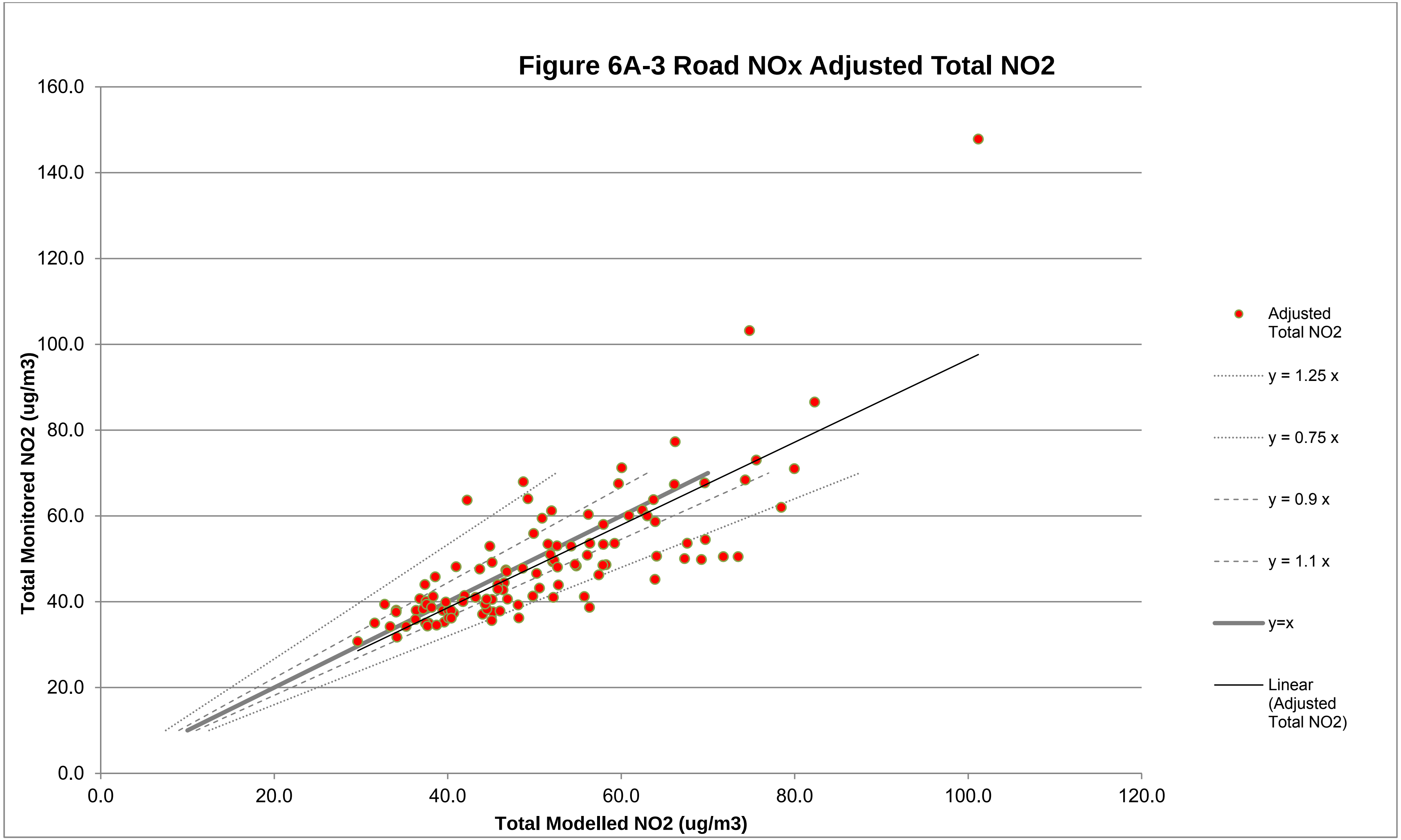
Figure 6A-3 Road NOx Adjusted Total NO2
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Total Monitored NO2 (ug/m3)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
Total Modelled NO2 (ug/m3)
Adjusted Total NO2
y = 1.25 x
y = 0.75 x
y = 0.9 x
y = 1.1 x
y=x
Linear (Adjusted Total NO2)

Table 6A-5 Model performance Statistics

Parameter	No Adjustment	NO_x Contribution Adjustment
RMSE	16.0	9.4
FB	0.3	0.0
CC	0.73	0.80

4.1.11 The model performance statistics show that the uncertainty in the predictions of the total NO_2 using the unadjusted model is large as the RMSE is 16.0 µg/m^3. Additionally, the model had a tendency to under-predict actual concentrations because the FB is greater than zero. Adjustment of model predictions is therefore required to achieve acceptable model performance. With the application of NOx roads contribution adjustment, the RMSE is reduced from 16.0 µg/m^3 to 9.4 µg/m^3, and the model doesn't under or over predict actual concentrations because the FB is zero.

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5. MODEL VERIFICATION OF PM10/PM2.5

5.1.1 The modelled versus monitored concentration for PM_{10} are presented in Table 6A-6.

Table 6A-6 Modelled versus Monitored PM10 2012

Site	X	Y	Monitored total PM_{10} ($\mu g/m^3$)	Modelled total PM_{10} ($\mu g/m^3$)	Percentage Difference
Burrage Grove (GR10/GN0)	544084	178881	27	22.4	-17%
Westhorne Avenue (GR9)	541879	175016	20	23.5	18%
RB4 Gardener Close, Wanstead	540810	188370	20	25.2	26%
Woolwich Flyover (GR8)	540200	178367	33	26.6	-19%
Tower Hamlets Blackwall	538290	181452	26	28.1	8%
Belvedere West FDMS (BQ8)	548259	179473	16	19.5	22%
Blackheath Hill (GR7)	538141	176710	28	22.7	-19%
Falconwood (GB6)	544997	175098	26	22.9	-12%
Trafalgar Road (GR5)	538960	177954	23	22.9	-1%
CT3 - John Cass School	533475	181179	26	26.2	1%

5.1.2 The model both under and over predicts at the various monitoring sites. All the modelled concentrations are within 25% of the monitored concentrations with the exception of Woolwich Flyover. The overall factor for the modelled versus monitored concentrations was 0.96 and as a result the modelled results were not adjusted.

Table 6A-7 Modelled versus Monitored PM2.5 2012

Site	X	Y	Monitored $PM_{2.5}$ ($\mu g/m^3$)	Modelled $PM_{2.5}$ ($\mu g/m^3$)	Percentage Difference
Burrage Grove (GR10/GN0)	544084	178881	18	15.5	-14%
Westhorne Avenue (GR9)	541879	175016	16	16.1	1%

Site	**X**	**Y**	**Monitored $PM_{2.5}$ (µg/m³)**	**Modelled $PM_{2.5}$ (µg/m³)**	**Percentage Difference**
RB4 Gardener Close, Wanstead	540810	188370	15	17.1	14%
Woolwich Flyover (GR8)	540200	178367	15	18.2	21%
Tower Hamlets Blackwall	538290	181452	15	19.0	27%
Belvedere West FDMS (BQ8)	548259	179473	9	13.8	53%

5.1.3 The modelled versus monitored $PM_{2.5}$ concentrations were generally over predicted, the results of the modelling were therefore not adjusted.