Table 4-22 Highest SO_2 concentrations (µg/m³).

Month	Highest Hourly Mean	Highest Daily Mean	Highest Monthly Mean	%Data Captured
May	256.8	54.2	17.3	83.6
June	439.8	78.3	33.5	70.4
July	274.8	120.1	41.4	87.0
August	327.2	92.7	39.8	66.5
September	322.0	138.7	70.2	32.6
October	253.6	66.7	23.0	98.8

Table 4-23: Highest NO_2 concentrations (µg/m³).

Month	Highest Hourly Mean	Highest Daily Mean	Highest Monthly Mean	%Data Captured
May	82.0	22.0	10.3	83.6
June	52.1	16.7	10.2	71.2
July	42.0	13.9	4.0	53.0
August	-	-	-	0
September	-	-	-	0
October	-	-	-	0

Table 4-24: Highest PM10 concentrations (µg/m³).

Month	Highest Hourly Mean	Highest Daily Mean	Highest Monthly Mean	%Data Captured
May	210	70.4	30.2	59.5
June	152.0	17.1	15.1	44.6
July	32.9	14.5	9.0	88.6
August	31.6	10.4	3.5	98.5
September	25.5	10.4	5.7	25.0
October	-	-	-	0

4.3 Modelled Air Pollutant Concentration and Deposition due to Current Baseline Conditions

4.3.1 Dispersion Modelling Methodology

Atmospheric dispersion modelling was undertaken for the existing Kendal Power Station using the CALPUFF modelling suite recommended for regulatory use by the US-EPA for complex terrain environments and regional-scale modelling domains (typically 50 to 250 km). A detailed description of the modelling methodology and data inputs is given in Appendix B. Prior to the use of the dispersion model in assessing incremental and cumulative air pollutant concentrations due to the proposed power station, model results were validated. The validation process is also outlined in Appendix B.

4.3.2 Calculation of 10-minute Averages

The CALPUFF model only facilitates the estimation of hourly or longer period averages. In order to facilitate comparisons with the SA and SANS SO_2 10-minute averages limit, 10-minute SO_2 predicted concentrations were extrapolated from the hourly average predictions using the equation:

$$C_x / C_p = \left(t_p / t_x \right)^n \quad (1)$$

where,
C_x , C_p = concentrations for averaging times t_x and t_p respectively
t_x , t_p = any two averaging times

Some have suggested a single-value ***n*** in the range of 0.16 to 0.25:

Stewart, Gale, Crooks (Slade, 1968)	***n*** = 0.2
Hilst (Slade, 1968)	***n*** = 0.25
Wipperman (Slade, 1968)	***n*** = 0.18
Turner (1970)	***n*** = 0.17 – 0.20
Meade (Nonhebel, 1960)	***n*** = 0.16

Beychok (1979) studied this range summarising the values of ***n*** as follows:

- A single-value n of about 0.2
- Values of n ranging from 0.2 to 0.68.

In this study a single-value of 0.2 for ***n*** was assumed in the estimation of 10-minute average SO_2 concentrations.

4.3.3 Dispersion Model Results

4.3.3.1 Results for Criteria Pollutants

Isopleth plots illustrating predicted sulphur dioxide, nitrogen dioxide and PM10 concentrations and dust deposition rates occurring due to current baseline conditions are presented in Appendix C. A synopsis of the maximum hourly, daily and annual sulphur dioxide, nitrogen dioxide and PM10 concentrations occurring due to current baseline conditions, within the absolute zone of maximum and within neighbouring residential areas, is given in Table 4.23.

Predicted NO and NO_2 daily and annual concentrations were predicted to be well within local and international air quality limits. The highest predicted hourly NO and NO_2 ground level concentrations within the *zone of maximum ground level concentration area* were predicted to exceed the relevant limits/standards by ~ 35%. No exceedances of NO and NO_2 air quality limits were predicted to occur within the neighbouring residential areas of Phola.

The highest predicted daily and annual PM10 concentrations exceeded relevant SANS limits by more than 100%. The predicted highest daily PM10 concentrations at Phola exceeds the SANS limit by 60%. Maximum monthly dustfall rates were typically "slight" (i.e. <250 $mg/m^2/day$) immediately downwind of the Kendal ash dump.

Local and international air quality limits given for sulphur dioxide were predicted to be exceeded for hourly and daily averaging periods within the zone of maximum impact. Within the residential area of Phola, short-term SO_2 ground level concentrations were predicted to exceeded EC hourly air quality limit (and calculated to exceed the SA 10-minute air quality limit). Daily sulphur dioxide concentrations were simulated to be within the air quality limits given for this averaging period at these residential areas.

In order to determine the significance of exceedances of air quality limits, health and vegetation thresholds and material damage thresholds, reference is made to:

- the *distance of exceedance of limits and thresholds* – with specific attention paid to the likelihood of public/vegetation/property exposures within the exceedance area; and

- *frequencies of exceedance of limits and thresholds.* Countries with stringent limit values such as EC member states frequently specifying a number of exceedances permissible prior to listing an area as being in non-compliance. (It should be noted that the SA standard for SO_2 currently makes no provision for permissible frequencies and is therefore considered more stringent that limits passed by the EC, UK, Australia and the US-EPA amongst other countries. Given that permissible frequencies are likely to be added to the SA standards in coming years, reference is made to the permissible frequencies of other countries for information and decision making purposes.)

The distances of exceedance of various SO_2 air quality limits and health risk, vegetation damage and corrosion potential thresholds are illustrated in Figure 4.19. A synopsis is given in Table 4.25 of the frequencies of exceedance of air quality limits and thresholds for selected sensitive receptors and therefore the potential that exists for non-compliance and impacts. The distances of exceedance of NO_2 and PM10 SANS short-term limits are illustrated in Figure 4.20.

Table 4-25 Predicted SO_2, NO, NO_2 and PM10 concentrations occurring due to current baseline conditions – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	4603	299	44	1012	62	9	269	41	8	191	83
Phola	**1151**	119	29	270	11.5	2.2	190	33	5.9	45	5.8
Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.15**	**2.40**	0.88	**1.35**	0.17	0.05	**1.34**	0.22	0.20	**2.55**	**2.08**
Phola	**3.29**	0.95	0.58	0.36	0.03	0.01	0.95	0.18	0.15	0.60	0.15

(a) Within a 25km radius from the proposed Kendal North Power Station sites

Table 4-26 Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations occurring as a result of current baseline conditions

Receptor Category	Receptor Name	Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
		Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4603	229	44	2.2	medium	3.5	2.2	high	low(a)	278	28	FALSE	FALSE
Residential areas	Phola	1151	119	29	1.5	medium	0.9	1.5	moderate	moderate	16	2	FALSE	TRUE

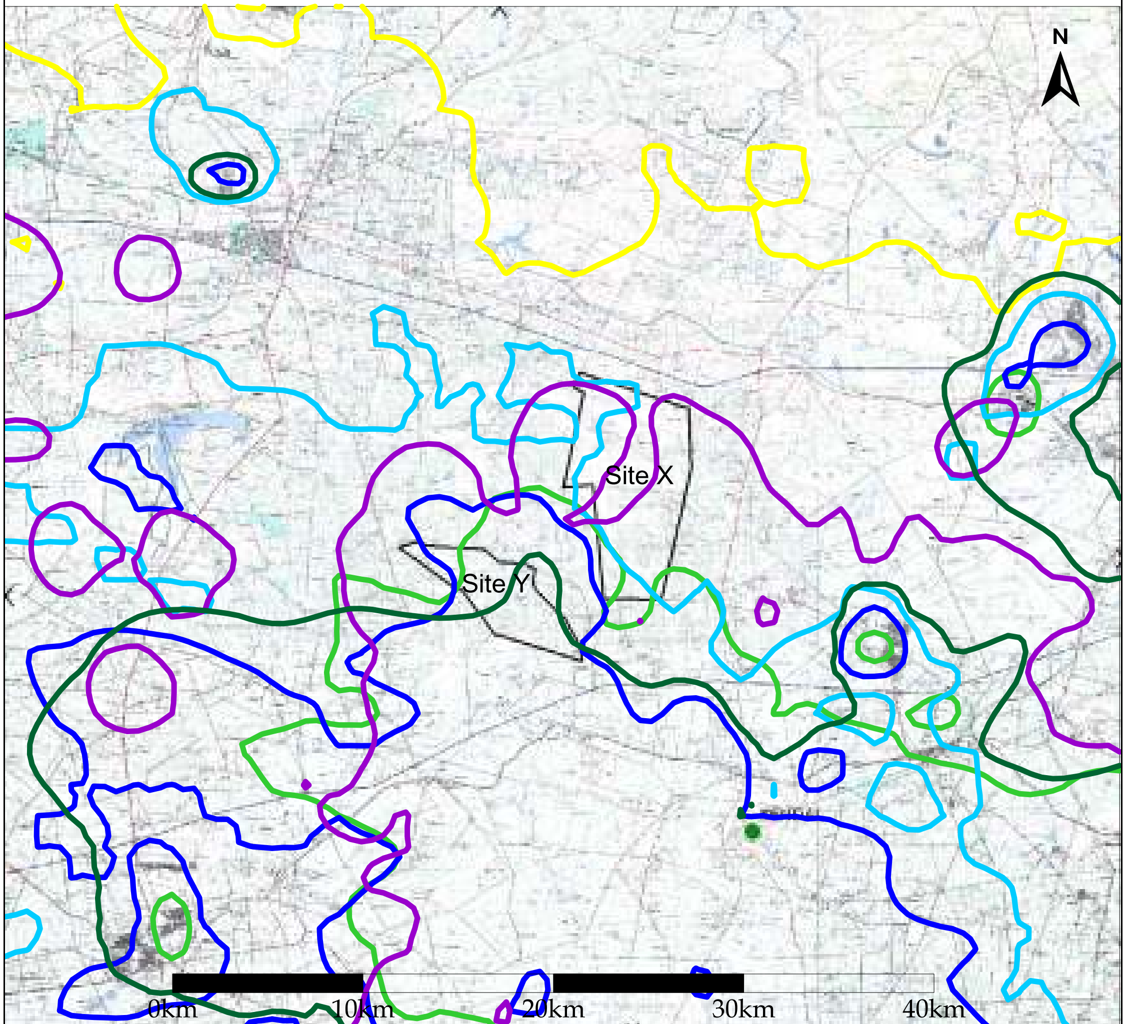
Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

All local and international air quality limit values for sulphur dioxide considered are predicted to be exceeded for hourly and daily averaging periods within the vicinity of the proposed new Kendal North Power Station sites. Within the residential area of Phola, predicted hourly sulphur dioxide concentrations exceed the EC and SA allowable frequencies of exceedance. SA limits are more stringent that EC limits given that no permissible frequencies have been set by DEAT (non-compliance therefore assumed to coincide with one exceedance per year), with the SA standards for SO_2 therefore being more stringent than the UK and EC.

Taking into account the likelihood of exceeding SO_2 thresholds and the potential for exposure given the number of persons residing in the area, it may be concluded that ***medium*** potential exists for vegetation damage, corrosion and health effects due to sulphur dioxide concentrations. The potential for infrequent mild respiratory effects occurring in the Phola area was classified as “moderate” given that the threshold associated with the potential for such effects was exceeded 16 hours per year.

Predicted Distance of Exceedance of SO2 Air Quality Limits and Thresholds for Health Risk, Vegetation Damage and Corrosion Potential due to Current Sources of Emission



- Non-compliance with SA 10-minute SO2 limit (500 µg/m^3; 10 min/year)
- Non-compliance with UK, EC hourly SO2 limit (350 µg/m^3; 24 hrs+/year)
- Non-compliance with SA daily SO2 standard (125 µg/m^3; 1 day+/year)
- Non-compliance with EC daily SO2 limit (125 µg/m^3; 3 days+/year)
- Single exceedance of California EPA Acute Reference Exposure Level given for SO2 (660µg/m^3 - associated with potential for mild respiratory effects)
- Single exceedance of the EC annual SO2 limit for the protection of ecosystems and the threshold for potentially "medium" corrosivity (20 µg/m^3)

Figure 4.19 Areas over which various SO_2 air quality limits and health, vegetation injury and material damage thresholds are exceeded due to existing baseline conditions.

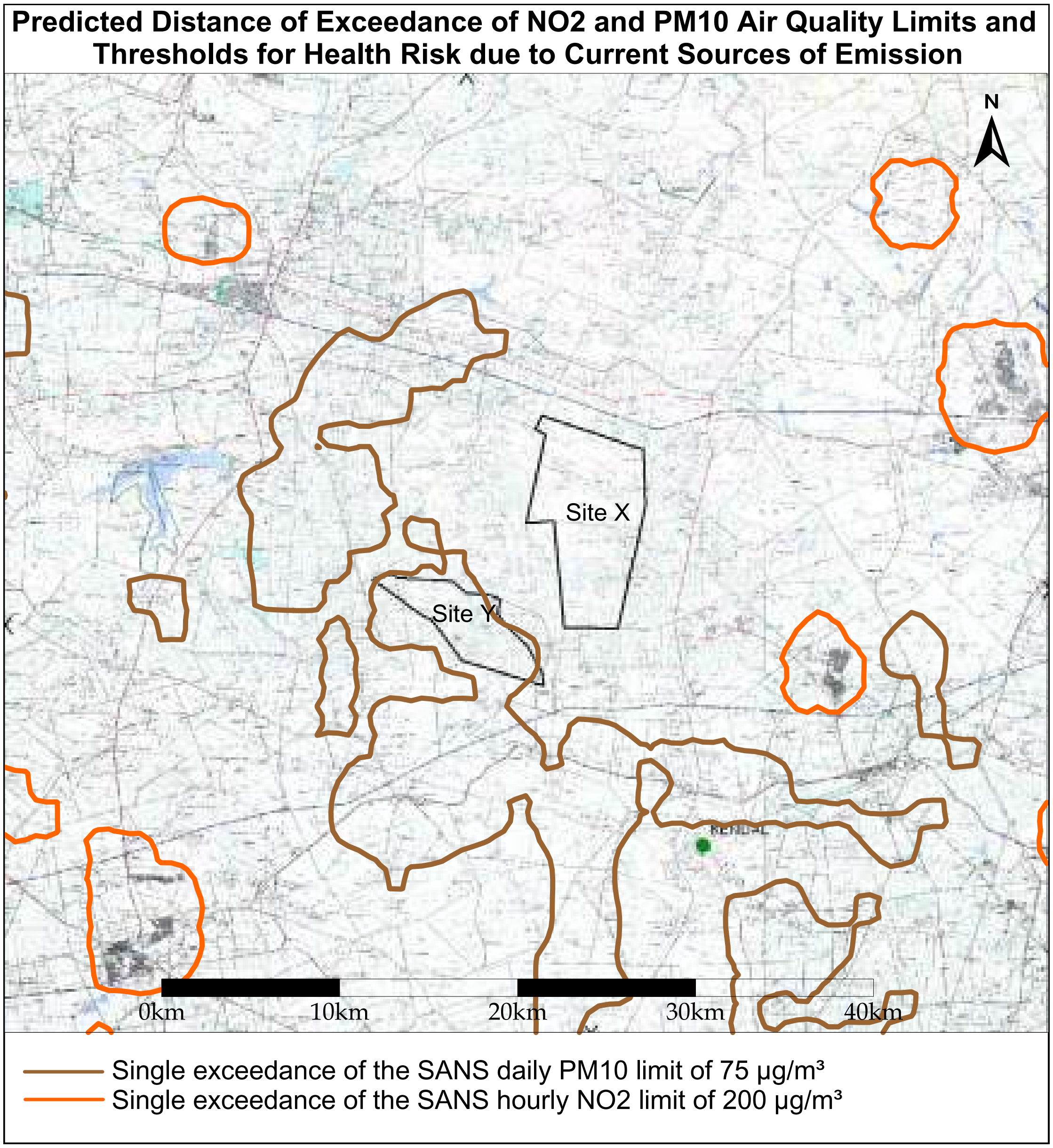


Figure 4.20 Areas over which NO_2 and PM10 SANS short-term limits are exceeded due to existing baseline conditions.

Table 4-27 Predicted ambient trace metal concentrations (in the PM10 range) due to existing Kendal Power Station emissions, with concentrations given as a fraction of the relevant health thresholds. Fractions of > 1 indicate threshold exceedances.

Compound	Predicted Ambient Air Concentrations (µg/m³)			Relevant Health Thresholds (µg/m³)			Predicted Concentrations as a Fraction of the Relevant Health Threshold		
	Highest Hourly	Highest Daily	Annual Average	Acute Health Threshold	Sub-acute Health Threshold	Chronic Health Threshold	Highest Hourly Concentration as a Fraction of the Acute Threshold	Highest Daily Concentration as a Fraction of the Sub-acute Threshold	Annual Average Concentration as a Fraction of the Chronic Threshold
As	1.10E-03	2.16E-04	1.46E-05	0.19		0.03	0.00581		0.00049
Ba	1.14E-01	1.69E-02	1.33E-03	50		5	0.00227		0.00027
Bi	3.58E-04	5.49E-05	4.35E-06						
Co	9.99E-04	1.43E-04	1.12E-05			0.1			0.00011
Cr	2.79E-02	4.27E-03	2.90E-04			0.1			0.00290
Cu	3.50E-03	5.03E-04	3.93E-05	100		1	0.00003		0.00004
Ga	3.45E-03	4.92E-04	3.86E-05						
Ge	4.69E-04	7.15E-05	5.66E-06						
Pb	5.17E-03	8.15E-04	6.45E-05			0.5			0.00013
Hg	6.78E-05	8.05E-06	6.90E-07	1.8		0.09	0.00004		0.00001
Ni	7.10E-03	1.21E-03	9.04E-05	6		0.05	0.00118		0.00181
Nb	3.07E-03	3.97E-04	3.26E-05						
Rb	3.55E-03	5.45E-04	4.32E-05						
Se	1.21E-01	1.86E-02	1.47E-03			20			0.00007
Th	4.09E-03	7.72E-04	5.24E-05						
Sn	9.70E-04	1.65E-04	1.24E-05	20		2	0.00005		0.00001
W	9.69E-04	1.84E-04	1.25E-05	10		1	0.00010		0.00001
U	9.68E-04	1.70E-04	1.20E-05			0.3			0.00004
V	9.33E-03	1.39E-03	1.09E-04		0.2			0.00694	
Y	5.43E-03	8.05E-04	6.34E-05						
Zn	5.55E-03	5.35E-04	4.21E-05	50		5	0.00011		0.00001
Zr	2.82E-02	3.93E-03	3.12E-04	50		5	0.00056		0.00006

4.3.3.2 Results for Heavy Metals

Cancer risks associated with inhalation exposures to predicted lead, arsenic and nickel were calculated based on predicted maximum annual average concentrations. Given the range of unit risk factors published by the California OEHHA, the WHO and the US-EPA it was decided to calculate cancer risks based on the maximum and minimum unit risk factors available (Table 4.28). Cancer risks were calculated to be very low, with total incremental cancer risks across all carcinogens quantified to be in the range of 1: 10 million to 1: 22.5 million.

Table 4-28 Cancer risks calculated due to inhalation exposures to individual carcinogens predicted to be emitted from existing Kendal Power Station emissions (stack and ash dam)

Carcinogens / Suspected Carcinogens	US-EPA IRIS Classification	Calculated Cancer Risk (expressed as a 1: xxx chance of contracting cancer)	
		Based on Lowest Risk Factor (least conservative)	Based on Highest Unit Risk Factor (most conservative)
Arsenic	A	45,517,434	15,878,175
Nickel	A	46,084,809	29,106,195
Lead	B2	1,292,014,603	1,292,014,603

Total incremental cancer risk across all carcinogens quantified	22,500,876	10,192,593

Maximum hourly, daily, monthly and annual average heavy metal concentrations occurring due to power station fly ash emissions and fugitive emissions from the ash dump and coal storage pile are given in Table 4.27. These predicted ambient metal concentrations were compared to relevant health thresholds in order to determine the potential for health impacts. Such health thresholds and the predicted concentrations as a fraction of such thresholds are given in the table. Fractions of greater than 1 indicate an exceedance of the threshold. No inhalation-related, non-carcinogenic health thresholds were predicted to be exceeded.

4.3.3.3 Health Risk Screening for Total Mercury Emissions

In the simulation of ambient mercury concentrations and resultant air quality impacts reference was made to the maximum emission rates (i.e. 6.9 tpa for current Kendal operations). The maximum highest hourly, highest daily and annual average ground level mercury concentrations occurring as a result of existing Kendal Power Station emissions are given in Table 4.29.

Table 4-29 Predicted mercury concentrations given existing Kendal Power Station emissions with reference to applicable guidelines intended to protect human health.

	PREDICTED MERCURY CONCENTRATIONS GIVEN EXISTING AND PROPOSED 4800 MW POWER STATION OPERATIONS		
	Highest Hourly (µg/m³)	**Highest Daily (µg/m³)**	**Annual Average (µg/m³)**
Predicted Maximum Total Hg GLCs (µg/m³)	0.16	0.03	0.002
	RELEVANT GUIDELINES (µg/m³)		
WHO Guideline Value			1.00
US-EPA inhalation reference concentration			0.30
Texas Effect Screening Levels	0.25		0.025
California RELs	1.8		0.09
DEAT Mercury Guideline (a)			0.04

REL – reference exposure level; GLCs – ground level concentrations; DEAT – Department of Environmental Affairs and Tourism
(a) Published in DEAT document “Technical Background Document for Mercury Waste Disposal” (2001).

The predicted maximum hourly, daily and annual average concentrations were well-within the most stringent of the guidelines given for public exposures to ambient mercury concentrations intended for the inhalation pathway (e.g. WHO, US-EPA inhalation reference concentrations, Californian RELs).

It is noted that the major pathway for mercury exposures is ingestion rather than inhalation. For this reason reference was made to the DEAT mercury guideline which was intended to be protective given multiple pathways of exposure. This guideline value (given as 0.04 µg/m³ for chronic exposures) was derived during a recent study initiated by the Department of Environmental Affairs and Tourism. This study included health-risk based research relating to human exposure to mercury and engineering reviews of treatment and disposal options for mercury waste. The purpose of such studies was twofold: (i) to support the drafting of national regulations for mercury waste disposal; and (ii) to provide specific guidance on how best to deal with the mercury waste stockpiled at the Thor Chemical's plant at Cato Ridge, Kwazulu-Natal. The health risk study determined that ambient long-term concentrations of mercury of lower than 0.04 µg/m³ would not result in unacceptable multi-pathway risk given local environments. This guidance is currently being used by the DEAT to assess the acceptability of mercury waste treatment and disposal options.

4.4 Conclusions regarding Baseline Air Quality

The following conclusions were drawn based on the monitored and modelled baseline air quality levels in the study region:

- **Sulphur dioxide** concentrations have been measured to exceed short-term (hourly, daily) air quality limits at the Kendal 2 monitoring station.

The Eskom power stations in the vicinity of the monitor is expected to be the main contributing source to the ambient SO_2 ground level concentrations in the study area due to the magnitude of its emissions. This has being confirmed through atmospheric dispersion modelling of the power station's stack emissions. The highest ground level concentrations due to the power station stack emissions are expected to occur during unstable conditions when the plume is brought to ground in relatively close proximity to the power station. Other significant sources of sulphur dioxide emissions in the immediate study area include household coal burning, industrial emissions (e.g. Highveld Steel & Vanadium), and spontaneous combustion from coal discards.

The comparison of measured and predicted sulphur dioxide concentrations to thresholds indicative of the potential for health, potential corrosion and potential vegetation impacts resulted in the following observations:

- The health threshold given as being associated with mild respiratory effects (660 µg/m³ as an hourly threshold for SO_2) was predicted to be exceeded at Phola.

- Measured and predicted sulphur dioxide concentrations were within limits indicative of medium corrosion potentials.

- Measured and predicted sulphur dioxide concentrations exceeded the EC annual sulphur dioxide limit of 20 µg/m³ that aims to protect ecosystems. This exceedance was predicted to occur for approximately 60 km east west of the existing Kendal Power Station.

- Exceedances of the EC hourly **nitrogen dioxide** limits are predicted to occur but are limited in magnitude, frequency and spatial extent. Although coal-fired power stations add to the ambient concentrations, other sources of NO_x anticipated to occur in the region include combustion within coal discard dumps, other industry emissions, vehicle tailpipe emissions, household coal, wood and paraffin burning and infrequent but significant veld burning.

- Ambient **PM10** concentrations were predicted to slightly exceed the current lenient SA Standards (as given in the second schedule of the Air Quality Act). The highest PM10 concentrations were predicted over household fuel burning areas due to low-level emissions from such areas during periods of poor atmospheric dispersion (night-time).

- Based on the screening of the potential for health risks occurring due to inhalation exposures to trace metals released from existing Kendal Power Station it was concluded that predicted concentrations were within acute and chronic health thresholds and that total incremental cancer risks were very low. This is due to the high control efficiency of fly ash abatement systems in place on stacks and the dust abatement measures being implemented at the ash dam.

- The potential for health risks associated with long-term public exposures to mercury emissions from coincident operations of the existing Kendal Power Station are predicted to be low even given the potential for multi-pathway exposures.

Given the elevated levels of sulphur dioxide and fine particulate concentrations measured/predicted to occur within parts of the study region it is imperative that the potential for cumulative concentrations due to any proposed developments be minimized and carefully evaluated.

5. EMISSIONS INVENTORY FOR PROPOSED OPERATING CONDITIONS

5.1 Proposed Kendal North Power Station

Sources associated with the construction phase of the proposed power station project are discussed and their emissions quantified in Section 5.1.1. Various possible power station configurations were evaluated for the operational phases. These configurations are presented in Section 5.1.2 and the source and emissions data for such scenarios presented.

5.1.1 Construction Phase

The construction phase will comprise land clearing and site development operations at the power station site and the associated infrastructure, specifically the ash dump. In order to determine the significance of the potential for impacts it is necessary to quantify atmospheric emissions and predicted airborne pollutant concentrations and dustfall rates occurring as a result of such emissions.

The construction phase will comprise a series of different operations including land clearing, topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, compaction, (etc.). Each of these operations has its own duration and potential for dust generation. It is anticipated therefore that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. This is in contrast to most other fugitive dust sources where emissions are either relatively steady or follow a discernible annual cycle. It is therefore often necessary to estimate area wide construction emissions, without regard to the actual plans of any individual construction process. Should detailed information regarding the construction phase be available, the construction process would have been broken down into component operations for emissions quantification and dispersion simulations. Due to the lack of detailed information (e.g. number of dozers to be used, size and locations of raw materials stockpiles and temporary roads, rate of on-site vehicle activity), emissions were instead estimated on an area wide basis. The quantity of dust emissions is assumed to be proportional to the area of land being worked and the level of construction activity.

The US-EPA documents emissions factors which aim to provide a general rule-of-thumb as to the magnitude of emissions which may be anticipated from construction operations. Based on field measurements of total suspended particulate, the approximate emission factors for construction activity operations are given as:

$$E = 2.69 \text{ Mg/hectare/month of activity } (269 \text{ g/m}^2\text{/month})$$

These emission factors are most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents, and (iii) semiarid climates. Estimated emissions during the surface infrastructure phase were calculated to be as follows:

Development	TSP Emissions (kg/month)	PM10 Emissions (kg/month)
Power station	269	94

PM10 was assumed to represent ~35% of the TSP emissions given that this is the approximate PM10 component of vehicle-entrainment releases and such releases are anticipated to represent the most significant source of dust during construction operations.

5.1.2 Operational Phase

Sources of atmospheric emission associated with the proposed power station will include stack emissions in addition to fugitive dust releases arising as a result of coal and ash handling and wind entrainment from the ash dump.

5.1.2.1 Power Stack Emissions (Criteria Pollutants)

Power station configuration options which were included in the study are as follows:

Scenario	No. of Units	Proposed Site	Stack Height (m)	SO_2 Control Efficiency
A.1	6 x 900 MW	Site X	150	0%
B.1	6 x 900 MW	Site Y	150	0%
C.1	6 x 900 MW	Site X	220	0%
D.1	6 x 900 MW	Site Y	220	0%
E.1	6 x 900 MW	Site X	300	0%
F.1	6 x 900 MW	Site Y	300	0%
A.2	6 x 900 MW	Site X	150	90%
B.2	6 x 900 MW	Site Y	150	90%
C.2	6 x 900 MW	Site X	220	90%
D.2	6 x 900 MW	Site Y	220	90%
E.2	6 x 900 MW	Site X	300	90%
F.2	6 x 900 MW	Site Y	300	90%

Source parameters and emission rates for these emission scenarios required for input to the dispersion modelling study were provided by Eskom personnel (see Tables 5.1 and 5.2). For the scenarios comprising the control of sulphur dioxide emissions, source parameters and emission rates of other pollutants were assumed to remain the same as for the zero control scenarios. This is a simplistic assumption given that the implementation of abatement technology able to achieve such reductions is likely to alter the stack parameters (e.g. reduction in gas exit temperatures) and possibly increase the emissions of certain other pollutants should the overall combustion efficiency be reduced. In the event that sulphur dioxide abatement is required, a more detailed review of the implications of such abatement for stack configuration and emissions will need to be undertaken.

Table 5-1 Stack parameters for proposed Kendal North Power Station operations

Power Station Configuration	Number of Stacks	Height (m)	Diameter (m)	Exit Velocity (m/s)	Temperature (°K)
6 x 900 MW (5400 MWe)	2	150, 220 or 300(a)	12.82	26.00	403

(a) Stack height dependent on scenario.

Table 5-2 Emission rates for the proposed power station configurations, assuming 0% control efficiency for sulphur dioxide

Capacity	Technology	Annual Emission Rates					
		SO_2	PM	NO_x [(a)]	NO [(b)]	NO_2 [(c)]	Units
5400 MWe	PF	364 082	**7 947**	87 361	55 835	1 747	tpa

(a) NO_x as NO_2.
(b) Provided NO_x (as NO_2) emissions were converted to NO and 98% taken as being emitted from the stacks (pers com. John Keir, 2 June 05).
(c) Provided NO_x (as NO_2) emissions were taken at 2% as NO_2 being emitted from the stacks (pers com. John Keir, 2 June 05).

Diurnal variations in the emissions projected for the proposed new power stations were based on average temporal energy output profiles (provided by Eskom personnel for the period 2003) for all the existing power stations excluding Tutuka, Lethabo and Majuba (Figure 5.1). No monthly emission variation was assumed for the proposed new power station.

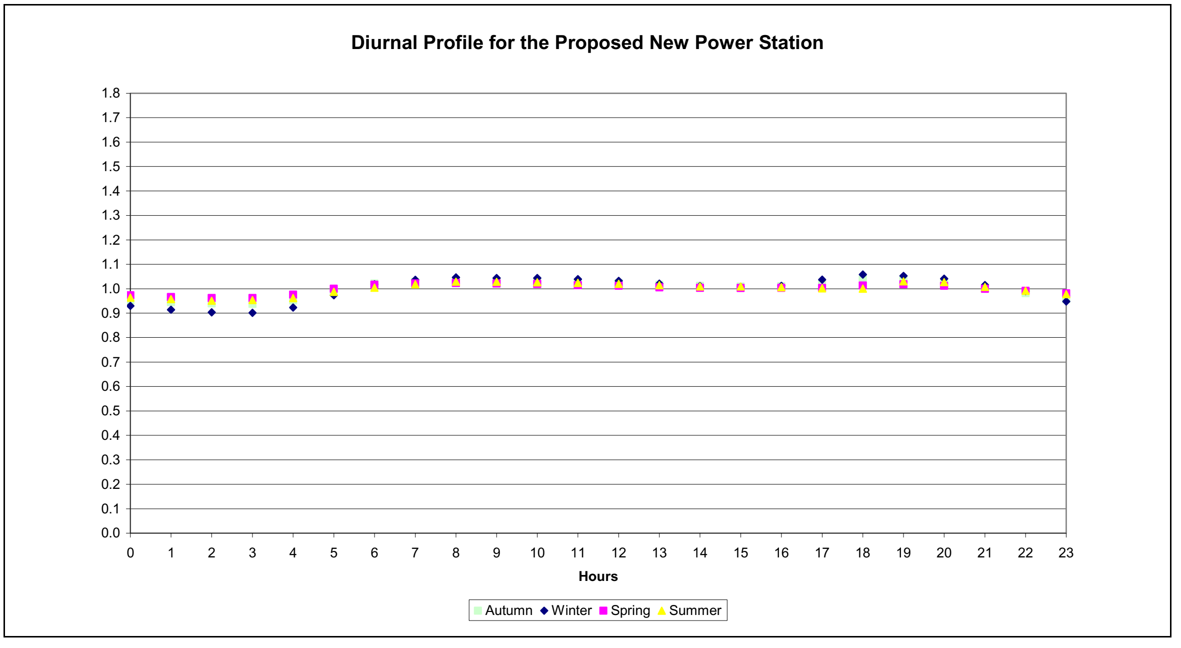


Figure 5.1 Diurnal emissions profile for the proposed new power station

In order to quantify greenhouse gas emissions, nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions were calculated based on information sourced from Eskom's annual emission reporting. The emission factors and resultant tonnages estimated are as follows:

Pollutant	Eskom Emission Factors	
	g/KWh	kg/ton
CO_2	850	1 746.48
N_2O	0.011	0.02

Capacity	Coal Consumption (tpa)	Annual Emissions	
		CO_2	N_2O
		kT/ann	kT/ann
5400 MWe	21,088,567	36,831	0.422

5.1.2.2 Fugitive Dust Emissions

(a) Wind Blown dust from the Ash dump and Coal Storage Pile

Source specific information regarding the nature of the source, the percentage of exposed surface area and the type of material was not available for the current study. Use was therefore made from similar operations. The workable surface of the ash dump was given to be between 100% (initially) and 6% (end of life). For simulation purposes the assumption was made that 20% of the ash dump would be exposed to wind erosion based on similar operations. The location, dimensions and orientations of the ash dump as well as the coal storage pile was attained from site location maps provided.

The source parameters used in the simulations for the ash dump can be found in Table 5.3. Table 5.4 show the particle size distribution used in the simulations.

Table 5-3 Source parameters pertaining to the ash dump and coal storage pile

Source	Height (m)	X length (m)	Y length (m)	Moisture (%)	Clay (%)	Bulk density (g/cm³)
Ash Dump	40	~1000[(a)]	~1000[(a)]	13.45	1	0.771
Coal Storage Pile	5	~1000[(a)]	~1000[(a)]	2.6	7	0.900

(a) Footprint of site layout map

Table 5-4 Particle size distribution for the materials found on the ash dump

Ash		Coal	
µm	fraction	µm	fraction
600	0.0472	75	0.28
404.21	0.0269	45	0.16
331.77	0.0296	30	0.2
272.31	0.0336	15	0.07
223.51	0.0404	10	0.1
183.44	0.0503	5	0.05
150.57	0.0609	2.5	0.07
123.59	0.0687	1	0.07
101.44	0.0728		
83.26	0.0739		
68.33	0.072		
56.09	0.0669		
46.03	0.0607		
37.79	0.0537		
31.01	0.0471		
25.46	0.0407		
17.15	0.0628		
14.08	0.0528		
7.78	0.0285		
3.53	0.0105		

(b) Materials handling

Materials handling operations associated with the activities at the proposed power station includes the transfer of coal by means of tipping, loading and off-loading of trucks. The quantity of dust generated from the tipping of coal material was based on the average amount of material retrieved monthly (2 407 tph of coal was assumed to be handled at the proposed power station). No particle size breakdown was available and use was made of information obtained from similar operations. Where no site-specific information was available on parameters required by the equations use was made of the US.EPA AP42 documentation on similar processes.

The PM10 fraction of the TSP was assumed to be 35%. Hourly emission rates, varying according to the prevailing wind speed, were used as input in the dispersion simulations. A moisture content of 2.6% was assumed for the coal.

5.1.2.3 Heavy Metal Releases from Proposed Power Station – Stack and Ash Dump Operations

The trace metal composition of the proposed power station's fly and bottom ash was assumed to be the same as that generated by the current Kendal Power Station (see subsection 4.1.1.3). The validity of this assumption depends on the combustion technology, operating conditions and trace metal coal composition to be used in comparison to that used by the existing power station.

A synopsis of the maximum mercury emission rates estimated on the basis of the coal composition, EEA and IPPC emission factors as discussed in Section 4.1.1.3 is given in Table 5.5. The emissions estimated on the IPPC emission factors and the EEA emission factors are relatively similar, whereas on the basis of site-specific coal qualities the mercury emissions are higher.

Table 5-5 Comparison of estimated mercury emissions based on mercury content of Kendal coal, IPPC emission factors and EEA emission factors

Power Station	Maximum Hg Emissions based on Coal Quality (tpa)	Maximum Hg Emissions based on IPPC Emission Factors (tpa)	Maximum Hg Emissions based on EEA Emission Factors(tpa)
Future Kendal (max, 2009)	7.21	3.81	3.29
Proposed Kendal North Power Station	10.55	3.70	4.82

5.2 Future Eskom Power Station Operating Conditions

The power stations included in the future baseline scenario include the return to service and existing power stations. In future Eskom will increase the current coal usage due to deteriorating coal qualities. Future emissions for existing power stations were based on projected 2009 emissions (Table 5.5) as provided by Eskom personnel. The future return to service power stations were assumed to operate at peak load factors during the periods 06h00 to 09h00 and 18h00 to 20h00. For Komati and Grootvlei a base and peak load of 30% and 90% was assumed. For Camden the base load of 50% was assumed with a peak load of 90%. Parameters for the future and proposed sources of emissions are given in Table 5.6.

Table 5-6 Emissions (in tonnes per annum) for future and proposed operating conditions

Power Station	SO_2 (tpa)	NO (tpa)[(a)]	NO_2 (tpa)[(b)]	Particulates (tpa)[(c)]
Hendrina	98,503	32,449	1,015	3,141
Arnot	99,756	34,378	1,076	19,979
Kriel	147,160	47,448	1,485	9,433
Matla	224,602	62,159	1,945	4,896
Duvha	215,801	55,099	1,724	3,575

Power Station	SO_2 (tpa)	NO (tpa)[(a)]	NO_2 (tpa)[(b)]	Particulates (tpa)[(c)]
Lethabo	186,490	82,843	2,592	6,266
Kendal	336,084	76,620	2,398	3,654
Tutuka	168,564	46,858	1,466	7,199
Majuba	152,008	39,594	1,239	845
Camden (50% base)	19,729	7,727	592	4,938
Camden (90% peak)	35,512	13,908	1,066	8,889
Komati (30% base)	31,474	8,760	274	3,324
Komati (90% peak)	94,423	26,280	822	9,972
Grootvlei (30% base)	18,568	7,149	402	4,569
Grootvlei (90% peak)	55,705	21,447	1,206	13,707

Notes:
(a) NO_x emissions (reported as NO_2) were converted to NO and 98% taken as being emitted from the stacks (pers com. John Keir, 2 June 05).
(b) 2% of the NO_x emissions (reported as NO_2) were taken as representing the NO_2 emissions from the stacks (pers com. John Keir, 2 June 05).
(c) Particulate emissions assumed to be PM10 due to the gas abatement technology in place

Table 5-7 Stack parameters for Eskom power stations for future baseline conditions

Station	Number of Stacks	Height (m)	Diameter (m)	Exit Velocity (m/s)	Tempera-ture (°K)
Hendrina	2	155	11.14	19.42	402
Arnot	2	195	11.06	20.25	411
Kriel	2	213	14.3	16.62	403
Matla 1-3	1	213	14.3	19.4	397
Matla 4-6	1	275	12.47	25.51	397
Duvha	2	300	12.47	23.78	403
Lethabo	2	275	11.95	25.28	399
Kendal	2	275	13.51	24.08	399
Tutuka	2	275	12.3	24.9	403
Majuba	2	220	12.3	29.83	403
Camden (50% base)	4	154.5	8.74	8	429
Camden (90% peak)	4	154.5	8.74	12.42	429
Komati (30% base)	2	121	10	8	416
Komati (90% peak)	2	121	10	14.13	416
Grootvlei (30% base)	2	152.4	8.99	8	401
Grootvlei (90% peak)	2	152.4	8.99	17.61	401

5.3 Other Sources of Atmospheric Emission

Sources, other than Eskom's power stations, which contribute to ambient air pollutant concentrations within the study region, have been discussed in Section 4.1.3. For future conditions, these sources were assumed to be consistent with current operating conditions.

6. COMPLIANCE AND AIR QUALITY IMPACT ASSESSMENT

6.1 Dispersion Model Results

Atmospheric dispersion modelling was undertaken for the proposed Kendal North Power Station using the CALPUFF modelling suite recommended for regulatory use by the US-EPA for complex terrain environments and regional-scale modelling domains. A detailed description of the modelling methodology and data inputs is given in Appendix B. Prior to the use of the dispersion model in assessing incremental and cumulative air pollutant concentrations due to the proposed power station, model results were validated based on the performance of the model in simulating existing sources of emissions. The validation process is also outlined in Appendix B.

The CALPUFF model only facilitates the estimation of hourly or longer period averages. In order to facilitate comparisons with the SA and SANS SO_2 10-minute averages limit, 10-minute SO_2 predicted concentrations were extrapolated from the hourly average predictions using the equation documented in Section 4.3.2.

In order to establish the potential for cumulative air quality impacts the proposed power station configurations were simulated together with the existing emissions from non-Eskom sources as well as proposed operations from Eskom sources.

The maximum hourly, daily and annual sulphur dioxide, nitrogen dioxide and PM10 concentrations occurring as a result of proposed power station configurations (taking cumulative concentrations into account) are presented in tables in **Appendix D**. The potential for compliance with local and international (UK) limits, and for health risks, vegetation injury and damage to property through corrosion is summarised in tables in **Appendix E** for all scenarios and various selected receptor points.

6.2 Compliance with Ambient Air Quality Limits

In assessing “compliance” with air quality limits it is important to note the following:

- Variations in where air quality limits are applicable. The EC (and UK) stipulate that air quality limits are applicable in areas where there is a reasonable expectation that public exposures will occur over the averaging period of the limit. In the US, the approach is frequently adopted of applying air quality limits within all areas to which the public has access (i.e. everywhere not fenced off or otherwise controlled for public access). In South Africa there is still considerable debate regarding the practical implementation of the air quality standards included in the schedule to the Air Quality Act. The Act does however define “ambient air” as excluding air regulated by the Occupational Health and Safety Act of 1993. This implies that air quality limits may be required to be met beyond the fencelines of industries.

- The SA standards included in the schedule to the Air Quality Act are incomplete when compared to legal limits issued by other countries. Air quality standards typically comprise: thresholds, averaging periods, monitoring protocols, timeframes for achieving compliance and typically also permissible frequencies of exceedance. (Thresholds are generally set based on health risk criteria, with permissible frequencies and timeframes taking into account the existing air pollutant concentrations and controls required for reducing air pollution to within the defined thresholds. The practice adopted in Europe is to allow increasingly more limited permissible frequencies of exceedance, thus encouraging the progressive reduction of air pollution levels to meeting limit values.)

NOTE: Given the above uncertainties a conservative approach was adopted in assessing compliance with SA air quality standards, with single exceedances of thresholds beyond the "fenceline" of the power station being taken as constituting "non-compliance". In order however to demonstrate areas of "non-compliance" should permissible frequencies be issued at a latter date reference is made to the UK air quality limits. The UK and SA primarily support similar short-term thresholds for sulphur dioxide. The UK however permits a number of annual exceedances of these short-term thresholds to account for meteorological extremes and to support progressive air quality improvement.

Impact assessments were undertaken for the following power station configurations:

Scenario	No. of Units	Site	Stack Height (m)	SO_2 Control Efficiency
A.1	6 x 900 MW	Site X	150	0%
B.1	6 x 900 MW	Site Y	150	0%
C.1	6 x 900 MW	Site X	220	0%
D.1	6 x 900 MW	Site Y	220	0%
E.1	6 x 900 MW	Site X	300	0%
F.1	6 x 900 MW	Site Y	300	0%
A.2	6 x 900 MW	Site X	150	90%
B.2	6 x 900 MW	Site Y	150	90%
C.2	6 x 900 MW	Site X	220	90%
D.2	6 x 900 MW	Site Y	220	90%
E.2	6 x 900 MW	Site X	300	90%
F.2	6 x 900 MW	Site Y	300	90%

6.2.1 Nitrogen Oxides

Predicted NO and NO_2 hourly concentrations were predicted to exceed the SA NO standard and the SANS/EC NO_2 limit respectively (including cumulative concentrations due to existing sources of emissions). The daily and annual average ground level concentrations are within relevant standards. Although the existing and new coal fired power stations in the area contribute to the ambient oxides of nitrogen concentrations, other significant sources of NO_x emissions in the area include domestic fuel burning, vehicle tailpipe emissions and other industrial activity. (Appendix D). The contributions of such sources are clearly evident given the zones of predicted maximum ground level concentrations.

6.2.2 Airborne Fine Particulates and Dust Deposition

Predicted total PM10 concentrations arising due to primary and secondary emissions from current and proposed power station operations (i.e. including stack emissions and fugitive dust from coal and ash handling, and wind erosion from the ash dumps) are illustrated in **Appendix F**. Projected dustfall rates are also depicted in this appendix.

Predicted PM10 concentrations were within the SA daily and annual standards but exceeded the SANS and EC daily limit values in the vicinity (within 10 km east) of the ash dump. Public exposure within this area is restricted to scattered farmsteads with an average residential density of ~5 persons/km². Other areas of exceedance are over industrial and household fuel burning area with ground level concentrations originating from low-level sources of emission (i.e. domestic fuel burning, industrial fugitives).

Maximum monthly dustfall rates were typically "moderate" (i.e. 250 - 500 mg/m²/day) immediately downwind of the proposed Kendal North ash dump and materials handling section of the power station, with "slight" dustfalls (i.e. < 250 mg/m²/day) occurring beyond these areas.

6.2.3 Sulphur Dioxide - Uncontrolled

Emissions from the existing Kendal Power Station are predicted to be responsible for exceedances of SA standards particularly downwind of the facility. Given this baseline it is evident that no future development resulting in sulphur dioxide emissions within the same area can be in compliance with the SA standard. It is due to this cumulative impact that all proposed power station configurations are indicated to be in non-compliance with SA standards in Appendix E. The magnitude, frequency of occurrence and area of exceedance of air quality limits varies significantly however between power station configurations. A synopsis of the maximum sulphur dioxide concentrations and frequencies of exceedance of the short-term air quality limits is given in Table 6.1 for all emission scenarios. The areas of exceedance of the SA daily standard and the UK hourly limit are illustrated in Figures 6.1 and 6.2 respectively for current operations and emission scenarios A, B, C, D and E. A single exceedance of the 10-minute SA limit was beyond the study area and was therefore not illustrated. Ground level maximum concentrations and frequencies of exceedance are given in the zone of maximum impact and at Phola.

Table 6-1 Maximum sulphur dioxide concentrations and frequencies of exceedances or air quality limits predicted to occur due to base case operations and cumulatively as a result of uncontrolled emissions from various proposed power station configurations (within ~25km radius from proposed Kendal North Power Station sites)

Receptor Point	Emission Scenario (cumulative for proposed PS, includes existing sources of emissions)	Predicted SO_2 Concentration (µg/m³)			Compliance Potential			
		Highest Hourly	Highest Daily	Annual Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 4, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum Impact Zone	Current Operations	4603	299	44	278	28	FALSE	FALSE
	Future Operations (Basecase)	4814	324	49	296	35	FALSE	FALSE
	Scenario A - uncontrolled	5879	388	73	446	57	FALSE	FALSE
	Scenario B - uncontrolled	4814	438	70	470	64	FALSE	FALSE
	Scenario C - uncontrolled	4814	346	66	394	51	FALSE	FALSE
	Scenario D - uncontrolled	4814	350	67	429	54	FALSE	FALSE
	Scenario E - uncontrolled	4814	343	61	366	48	FALSE	FALSE
	Scenario F - uncontrolled	5170	348	63	389	47	FALSE	FALSE
Phola	Current Operations	1151	119	29	16	2	FALSE	TRUE
	Future Operations (Basecase)	1206	135	34	19	6	FALSE	TRUE
	Scenario A - uncontrolled	1366	222	57	182	28	FALSE	FALSE
	Scenario B - uncontrolled	1206	188	49	110	21	FALSE	FALSE
	Scenario C - uncontrolled	1279	159	51	99	19	FALSE	FALSE
	Scenario D - uncontrolled	1206	153	48	77	16	FALSE	FALSE
	Scenario E - uncontrolled	1206	158	47	68	14	FALSE	FALSE
	Scenario F - uncontrolled	1206	158	45	45	10	FALSE	FALSE

Observations made regarding compliance implications of various power station configurations given uncontrolled emissions:

- SA short-term standards (10-minute and daily) are exceeded within the zone of maximum impact due to base case and all proposed configurations. At Phola the SA 10-minute standard is exceeded for base case and all proposed configurations.

- Under current and future basecase operations there is predicted to be compliance with the UK hourly sulphur dioxide standard at Phola. Non-compliance is predicted for an additional six 900 MW units regardless of the variations in stack location and height considered.

- Emission scenarios A and B, comprising 150 m stack heights at sites X and Y respectively, resulting in the greatest cumulative concentrations within the most affected residential areas. Within the zone of maximum ground level concentration, these emission scenarios resulted in a 5% to 60% increase in the sulphur dioxide concentrations and a 60% to 130% increase in the frequencies of exceedance of hourly and daily limits. Comparatively, the "best-case" emission scenario for Phola was scenario F (i.e. 300 m stack located at site y). This scenario was however still predicted to result in significant increases in the magnitude and frequency of exceedance of air quality limits given for sulphur dioxide.

- Effect of increased stack height: An increase in stack height from 150 m to 220 m (at site x) was predicted to reduce the frequency of exceedance of hourly limits by ~45% at Phola, with the further increase in stack height from 220 m to 300 m served to reduce hourly frequencies of exceedance by ~30%.

It may be concluded that the addition of 6 new 900 MW PF units with no sulphur dioxide abatement in place would result in significant increases in the magnitude, frequency and spatial extent of non-compliance with SA standards within neighbouring residential areas. The venting of emissions from a 300 m high stack would be insufficient to negate the need for abatement measures being considered.

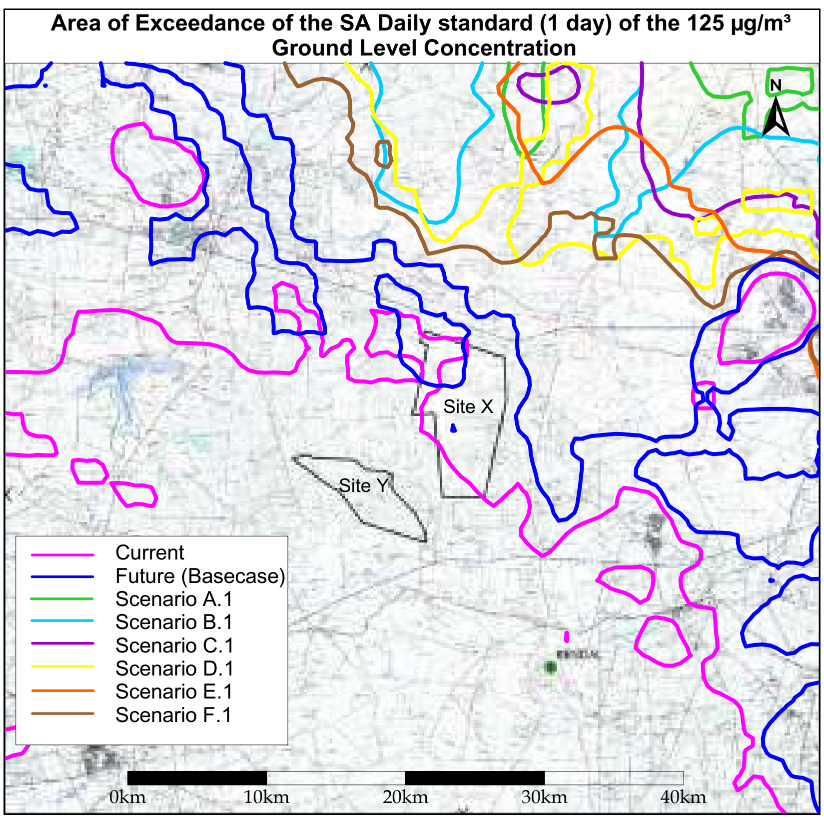


Figure 6.1 Predicted area of a single exceedance of the SA daily SO_2 standard due to all sources of emissions together with uncontrolled emissions from various of the proposed power station configurations.

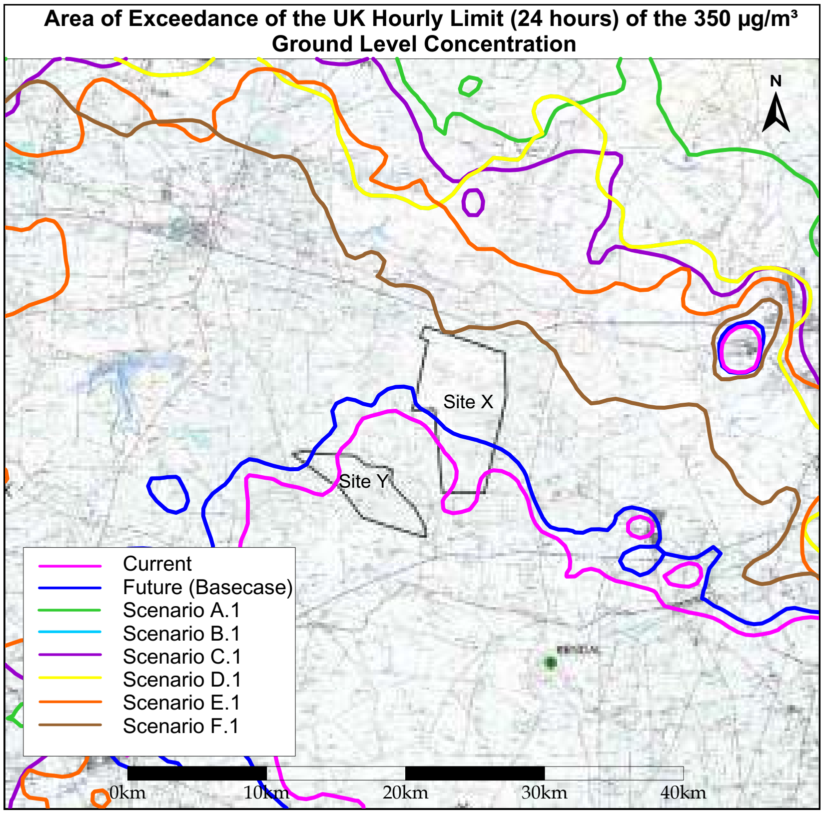


Figure 6.2 Predicted area of exceedance of the UK hourly SO_2 standard (permits a maximum of 24 exceedances per year) due to all sources of emissions together with uncontrolled emissions from various of the proposed power station configurations.

6.2.4 Sulphur Dioxide - Controlled

Changes in projected ground level sulphur dioxide concentrations and limit value exceedances were simulated for a 90% control efficiency for three proposed power station configurations, viz. Scenario A and B (150 m stack), Scenario C and D (220 m stack) and Scenario E and F (300 m stack) at two different sites, viz. Site X and Site Y. A synopsis of the maximum sulphur dioxide concentrations and frequencies of exceedance of the short-term air quality limits is given in Table 6.2. The areas of exceedance of the SA 10-minute standard, the SA daily standard and the UK hourly limit are illustrated in Figures 6.3 to 6.5 for Scenarios A given control efficiencies of 90%. Scenarios B, C, D, E and F were not illustrated to avoid confusion as they show a similar footprint to Scenario A. (Base case results are also depicted in the plots for comparative purposes.)

Table 6-2 Maximum sulphur dioxide concentrations and frequencies of exceedances or air quality limits predicted to occur due to basecase operations and cumulatively as a result of controlled emissions from various proposed power station configurations (within ~25km radius from proposed Kendal North Power Station sites)

Receptor Point	Emission Scenario (cumulative for proposed PS, includes existing sources of emissions)	Predicted SO_2 Concentration (µg/m³)			Compliance Potential			
		Highest Hourly	Highest Daily	Annual Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum Impact Zone	Current Operations	4603	299	44	278	28	FALSE	FALSE
	Future Operations (Basecase)	4814	324	49	296	35	FALSE	FALSE
	Scenario A - 90% CE	4814	326	51	302	35	FALSE	FALSE
	Scenario B - 90% CE	4814	326	51	308	35	FALSE	FALSE
	Scenario C - 90% CE	4814	326	51	302	35	FALSE	FALSE
	Scenario D - 90% CE	4814	327	51	308	35	FALSE	FALSE
	Scenario E - 90% CE	4814	326	50	301	35	FALSE	FALSE
	Scenario F - 90% CE	4814	326	51	308	35	FALSE	FALSE
Phola	Current Operations	1151	119	29	16	2	FALSE	TRUE
	Future Operations (Basecase)	1206	135	34	19	6	FALSE	FALSE
	Scenario A - 90% CE	1206	135	36	19	7	FALSE	FALSE
	Scenario B - 90% CE	1206	135	35	19	7	FALSE	FALSE
	Scenario C - 90% CE	1206	135	35	19	7	FALSE	FALSE
	Scenario D - 90% CE	1206	135	36	19	7	FALSE	FALSE
	Scenario E - 90% CE	1206	135	35	19	7	FALSE	FALSE
	Scenario F - 90% CE	1206	135	35	19	7	FALSE	FALSE

Observations made regarding compliance implications of various power station configurations given controlled emissions:

- Even given a 90% control efficiency for all power station configurations, cumulative sulphur dioxide concentrations would exceed the SA 10-minute standard at the maximum impact zone and at Phola and the SA daily standard in the maximum impact zone, and Phola – primarily due to emissions from the existing Kendal Power Station.

- With the addition of six new units operating coincident with the existing Kendal Power Station, at least a 90% control efficiency would be required to ensure that the magnitude, frequency and spatial extent of non-compliance was within levels comparable to those projected for the basecase. Even given 90% control efficiencies on all six units, the maximum predicted hourly concentrations, the non-compliance with the 10-minute limit in terms of frequencies of exceedance at Phola would be in line with future baseline conditions.

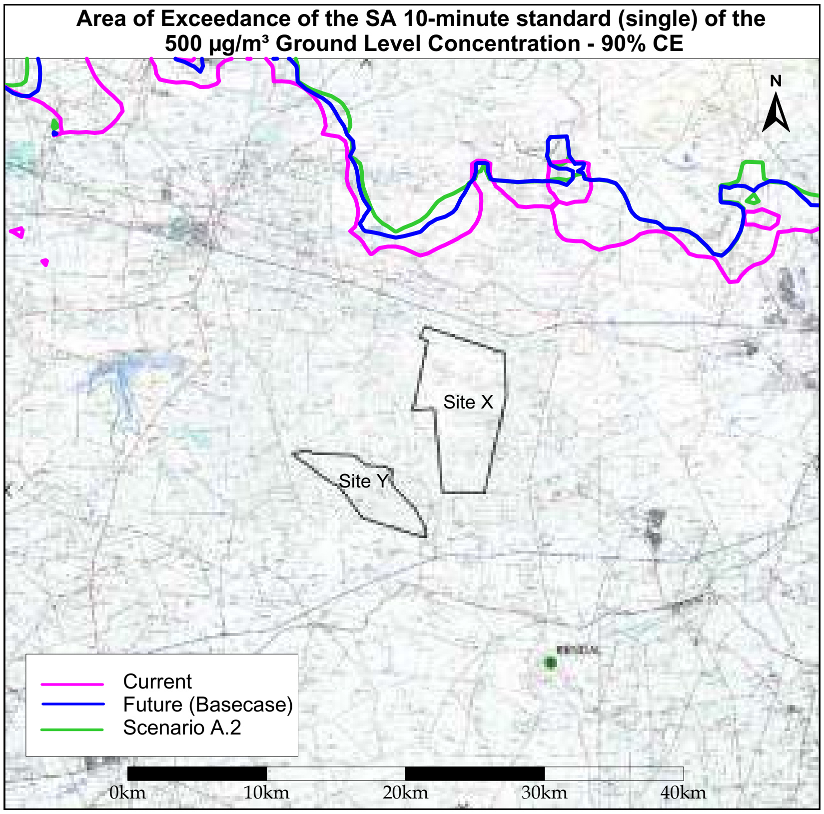


Figure 6.3 Predicted area of a single exceedance of the SA 10-minute SO_2 standard due to Scenario A emissions and existing Kendal PS emissions, given 90% sulphur dioxide abatement efficiencies.

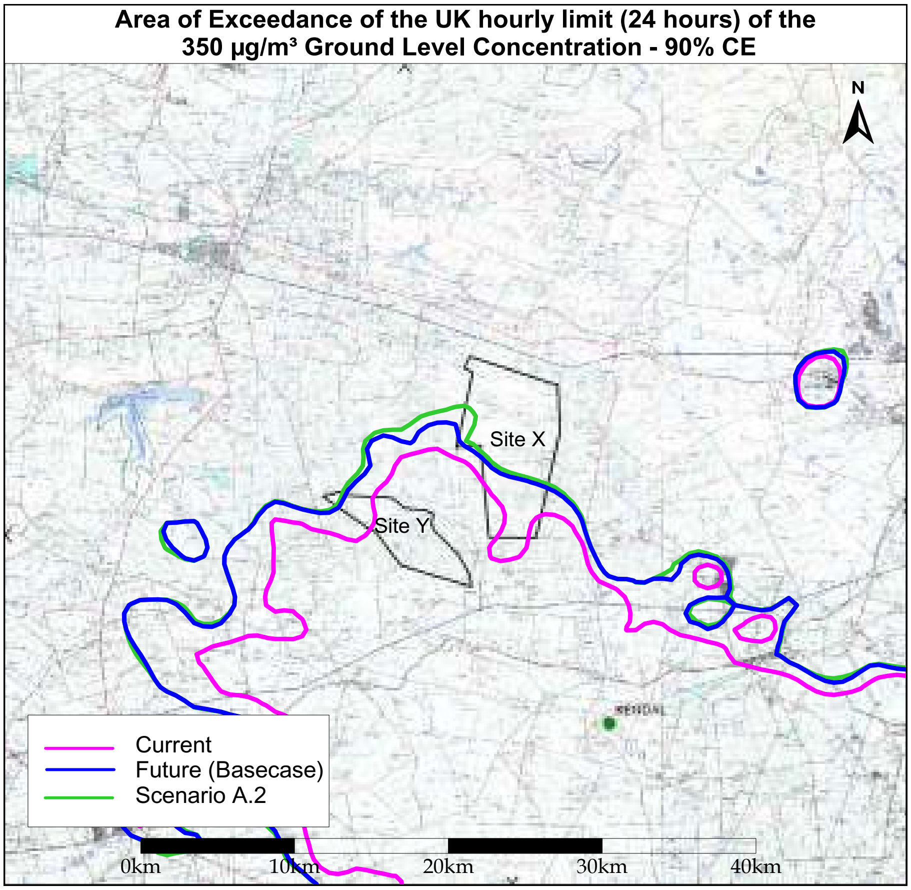


Figure 6.4 Predicted area of a single exceedance of the SA daily SO_2 standard due to Scenario A emissions and existing Kendal PS emissions, given 90% sulphur dioxide abatement efficiencies.

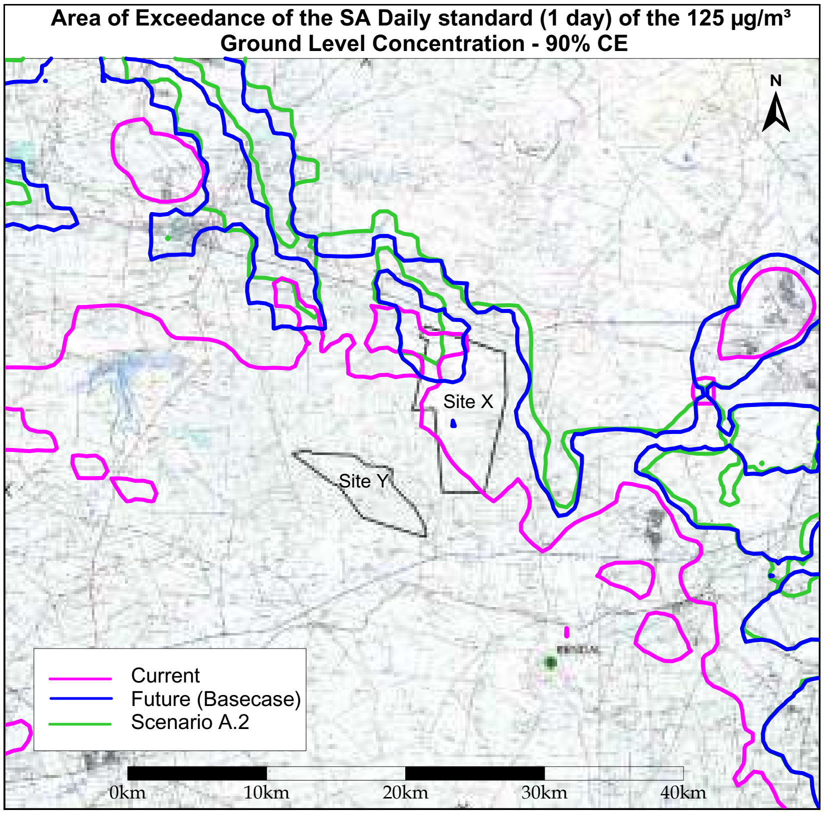


Figure 6.5 Predicted area of exceedance of the UK hourly SO_2 standard (permits a maximum of 24 exceedances per year) due to Scenario A emissions and existing Kendal PS emissions, given 90% sulphur dioxide abatement efficiencies.

6.3 Potential for Health Effects

6.3.1 Baseline Health Risks

Health risks related to exposures to air pollution concentrations occurring as a result of fuel-burning emissions were recently assessed for several regions including the Mpumalanga Highveld, as part of the NEDLAC "Dirty Fuels" study (Scorgie *et al*., 2004). Fuel burning sources quantified in this study included industrial fuel burning, power generation, vehicle exhaust emissions and household fuel burning. Air pollution exposure related respiratory hospital admissions were predicted to be in the order of ~8700 cases per year within the Mpumalanga Highveld region. Significant risks are associated with indoor exposures within fuel burning households. Exposures to emissions from power generation and industrial emissions were also identified as important sources of risk in this region. The contribution of vehicle exhaust emissions to health risks was less significant in this region.

6.3.1.1 Indoor exposures within fuel burning households

Household coal and wood burning is a significant source of indoor air pollution and is associated with significant health impacts. Health effects range from acute respiratory infections and upper respiratory tract illnesses to carbon monoxide poisoning, heart disease and cancer. Indoor air pollution from coal burning has been established as one of the risk factors for the development of acute respiratory illnesses (ARI). Data from local epidemiological studies indicate that acute respiratory infections (ARI) are one of the leading causes of death in black South African children (Terblanche *et al*., 1993).

Residential areas within the study region where household fuel burning is prevalent (specifically during the winter time for space heating purposes) include Phola, Botleng (near Delmas), Kungwini / Zithobeni (near Bronkhorstpruit) and Vosman, Hlalanikahle and KwaGuqa (near Witbank). Elevated health risks are expected to occur in these areas due to inhalation exposures to indoor and ambient air pollutant concentrations, specifically fine particulates, arising due to fuel burning. Maximum highest daily PM10 concentrations (~200 μg/m³) and annual average PM10 concentrations (~80 μg/m³) predicted for these areas are well in excess of air quality and health limits.

6.3.1.2 Increment in health risks due to sulphur dioxide concentrations

Elevated sulphur dioxide concentrations in the study area are associated with significant health risk potentials, particularly where such concentrations coincide with elevated fine particulate concentrations such as in household fuel burning areas.

Sulphur dioxide concentrations occurring due to base case conditions are predicted to be associated with potentially “high” health risks within the Phola residential area. The California EPA Acute Reference Exposure Level for sulphur dioxide (above which mild respiratory effects may occur) having been predicted to be exceeded in this residential area. Exceedances of the reference exposure level were however infrequent. Whether or not health effects occur is dependent on whether persons sensitive to the impacts of sulphur dioxide are exposed at the time of the exceedance.

6.3.2 Proposed Exposures to Sulphur Dioxide Concentrations

Based on the health-related dose-response thresholds for sulphur dioxide outlined in Section 2.4.2 and the classification of risks due to various sulphur dioxide concentrations by the UK (Section 2.4.1) it was decided to categorize risks to SO_2 exposures in the following manner for the purpose of the current study:

Category of Risk(a)	Maximum Hourly Average SO_2 Concentration (µg/m³) (99th percentile)	Basis
Low	<660	California Acute Reference Level for Mild Respiratory Effects given as 660 µg/m³
Moderate	660 – 930	
High	930 – 1400	Upper range of UK's "high" band (i.e. 708 µg/m³ for 15 minute average – projected as 934 µg/m³ for a 1-hourly averaging period)(b). Coincides closely with the dose-response threshold at 916 µg/m³ given for increased airway resistance in asthmatics at exercise
Very high	>1400	UK's "very high" band (i.e. 1064 µg/m³ for 15 minute average – projected as 1404 µg/m³ for a 1-hourly averaging period)(b)

(a) Low risks were assigned to all areas with very low exposure potentials, e.g. neighbouring farms where the average population density is ~5 persons/km².
(b) "High" band expressed by UK Department for Environment, Food and Rural Affairs (DEFRA) as "significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung"
(c) "Very high" band expressed by UK DEFRA as follows: "the effects on sensitive individuals described for 'High' levels of pollution may worsen".

Health risk potentials are depicted in Figures 6.6 to 6.12 for basecase and proposed uncontrolled power station configurations, and in Figures 6.13 for Scenario A.2 (150 m stack) incorporating 90% control efficiency. Scenario B.2, C.2, D.2, E.2 and F.2 show similar impact to Scenario A.2 and thus were not included. These health risk potential plots do not take into account actual exposure, with the likelihood of risk therefore depended on the actual exposures. The residential area of Phola are indicated in the plots to illustrate areas of concentrated settlement and hence high exposure potentials.

A synopsis of the health risks deemed likely to occur, taking predicted sulphur dioxide concentrations in the vicinity of dense settlement into account, is given in Table 6.3. Risks were categorised as "low" in areas with low exposure potentials, such as on neighbouring farms where the average population density is given based on the Census data as being ~5 persons/km². Significant exposure potentials were assumed to occur within Phola residential area.

Sulphur dioxide concentrations occurring due to existing conditions are predicted to be associated with "high" health risks within the Phola residential area. The California EPA Acute Reference Exposure Level for sulphur dioxide (above which mild respiratory effects may occur) is predicted to be exceeded by ~80% for highest hourly ground level concentrations in the vicinity of Phola. Cumulative sulphur dioxide concentrations given the operation of an additional six 900 MW units at the sites proposed is projected to increase this concentrations to exceed the California EPA Acute reference exposure up to 150% for a 150m stack. The implementation of sulphur dioxide abatement measures comprising a 90% control efficiency would not significantly increase the exceedance of this health threshold above baseline levels.

A control efficiency of 90% would be required for all six units to prevent increments in health risk potentials above baseline conditions.

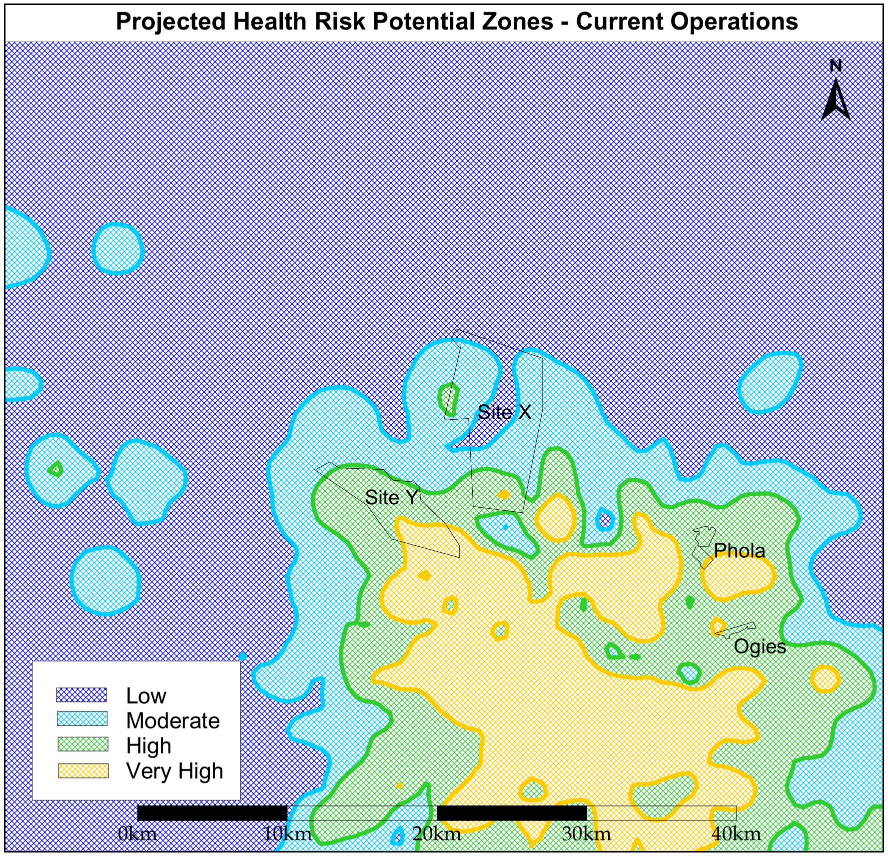


Figure 6.6 Projected health risk potential zones for current Operations

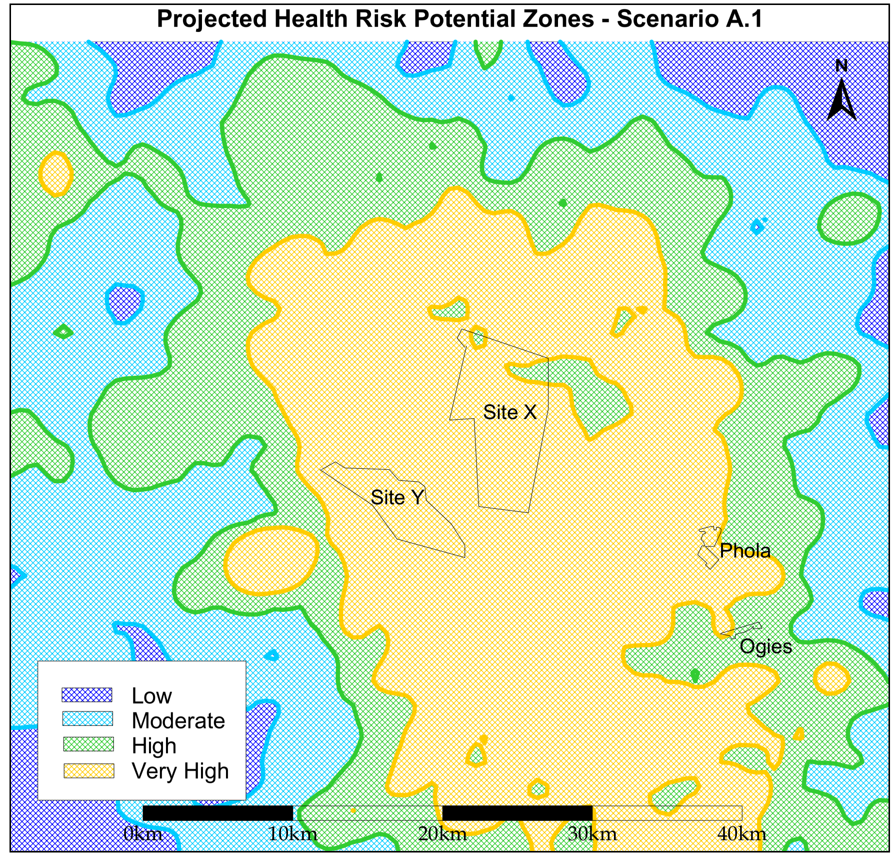


Figure 6.7 Projected health risk potential zones for Scenario A1 Operations (i.e. 6 x 900 MW PF units, 150 m stack, uncontrolled, at Site X)

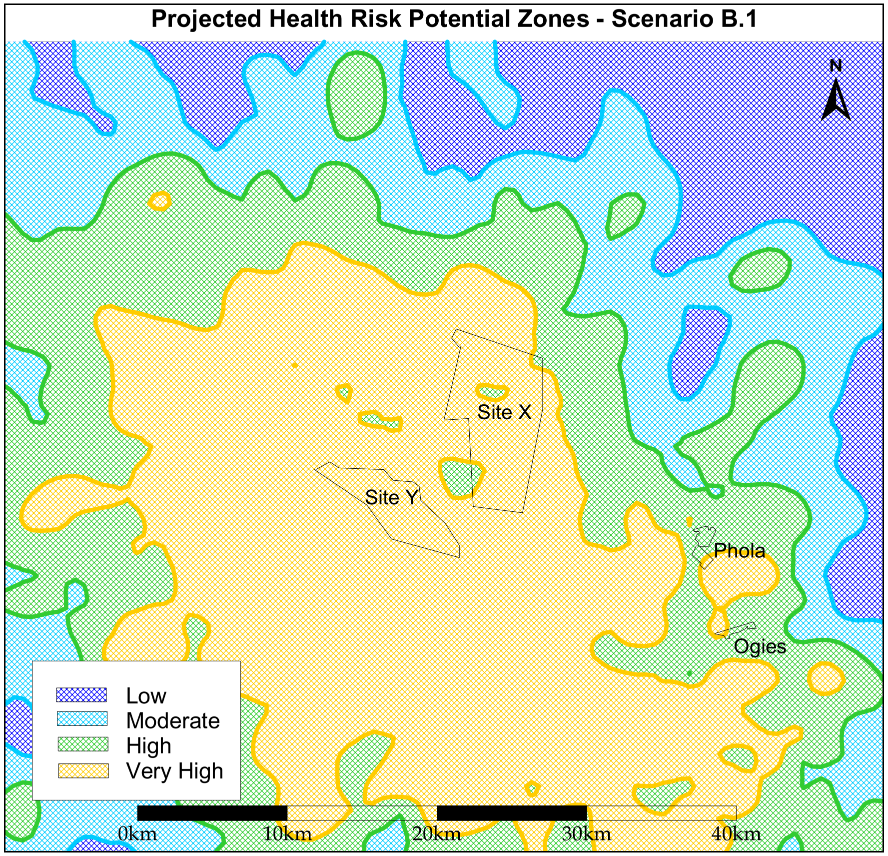


Figure 6.8 Projected health risk potential zones for Scenario B1 Operations (i.e. 6 x 900 MW PF units, 150 m stack, uncontrolled, at Site Y)

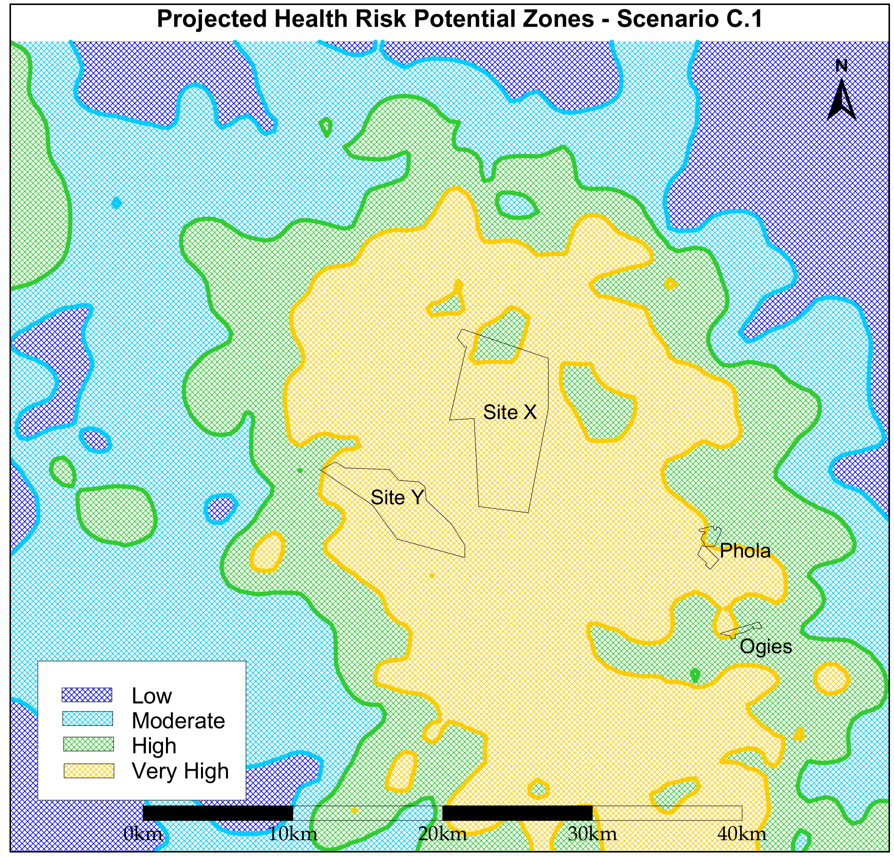


Figure 6.9 Projected health risk potential zones for Scenario C1 Operations (i.e. 6 x 900 MW PF units, 220 m stack, uncontrolled, at Site X)

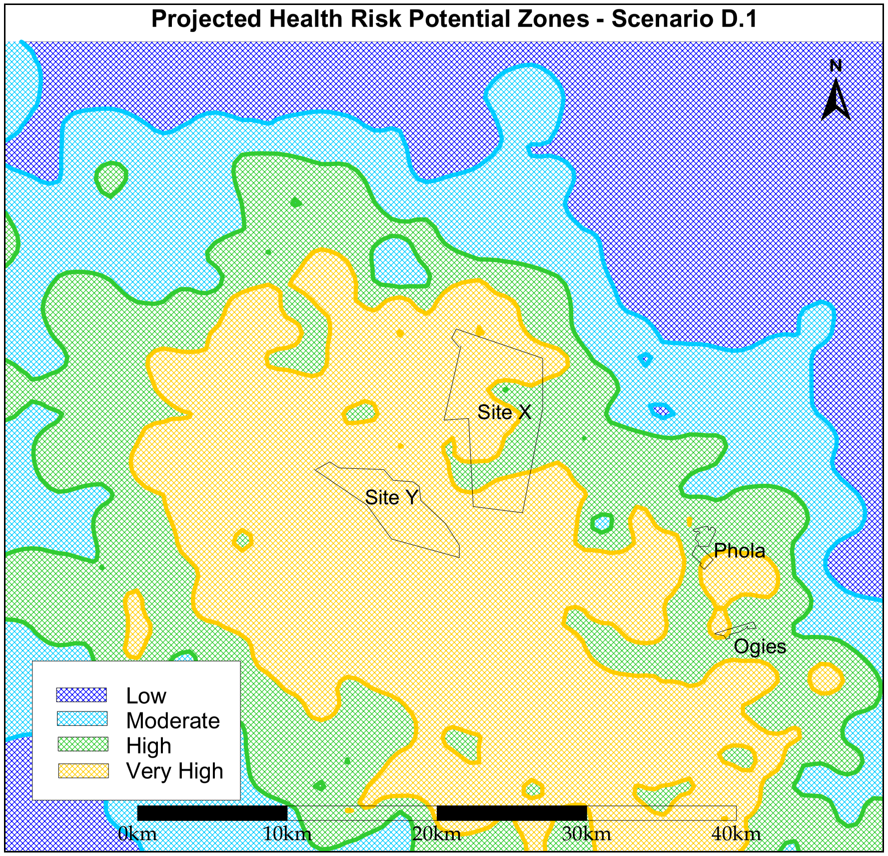


Figure 6.10 Projected health risk potential zones for Scenario D1 Operations (i.e. 6 x 900 MW PF units, 220 m stack, uncontrolled, at Site Y)

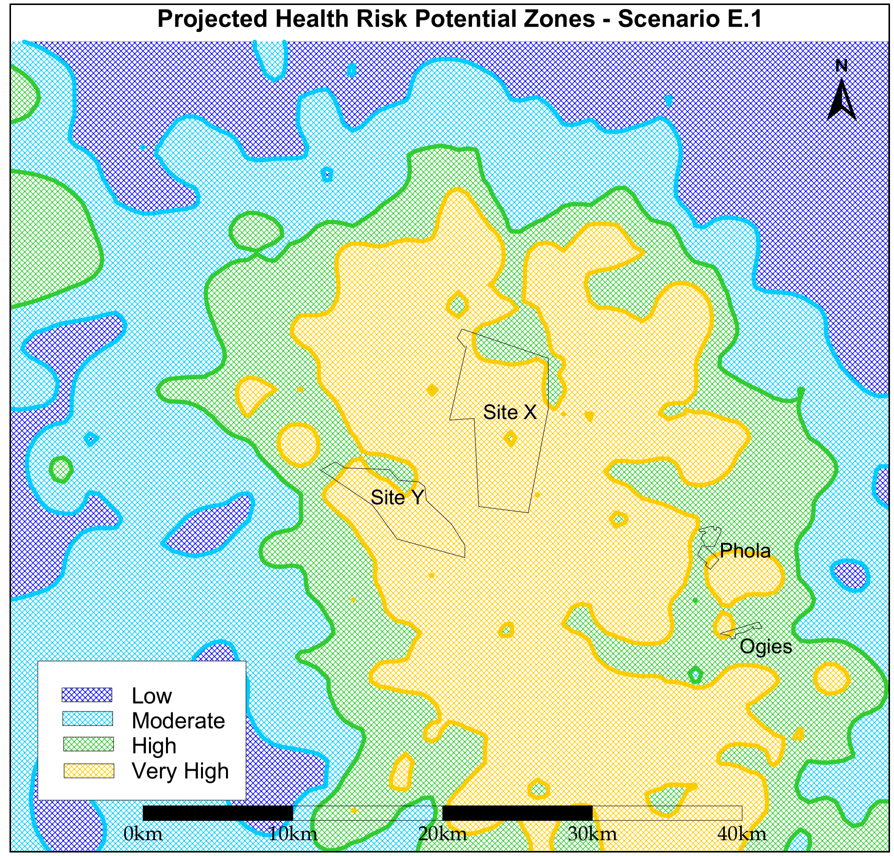


Figure 6.11 Projected health risk potential zones for Scenario E1 Operations (i.e. 6 x 900 MW PF units, 300 m stack, uncontrolled, at Site X)

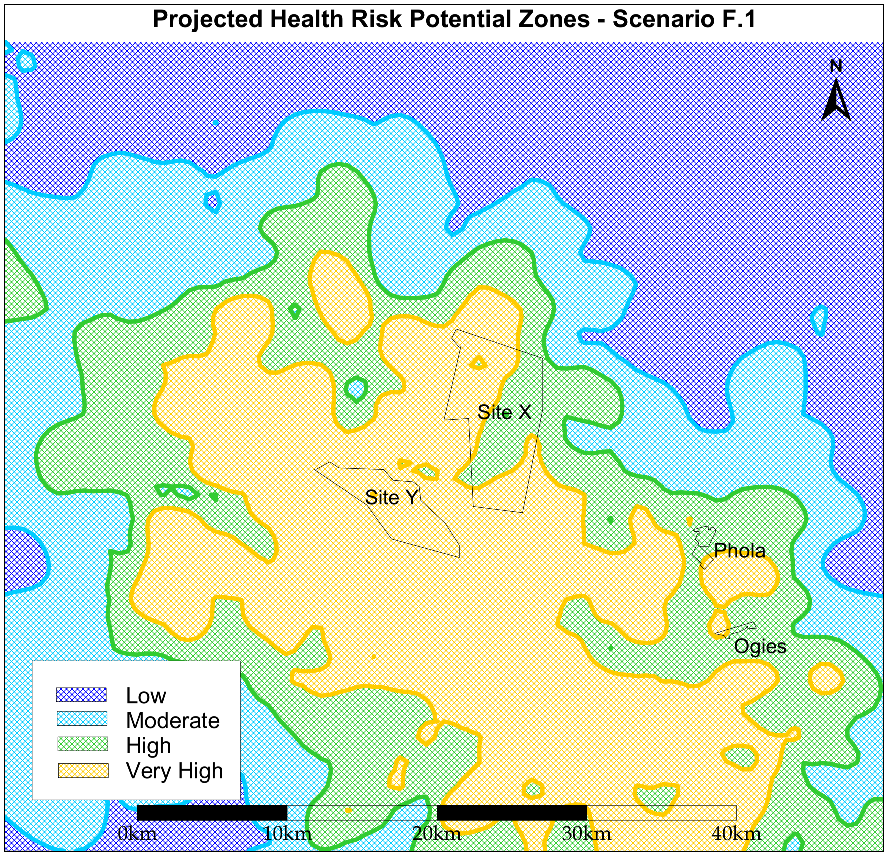


Figure 6.12 Projected health risk potential zones for Scenario F1 Operations (i.e. 6 x 900 MW PF units, 300 m stack, uncontrolled, at Site Y)

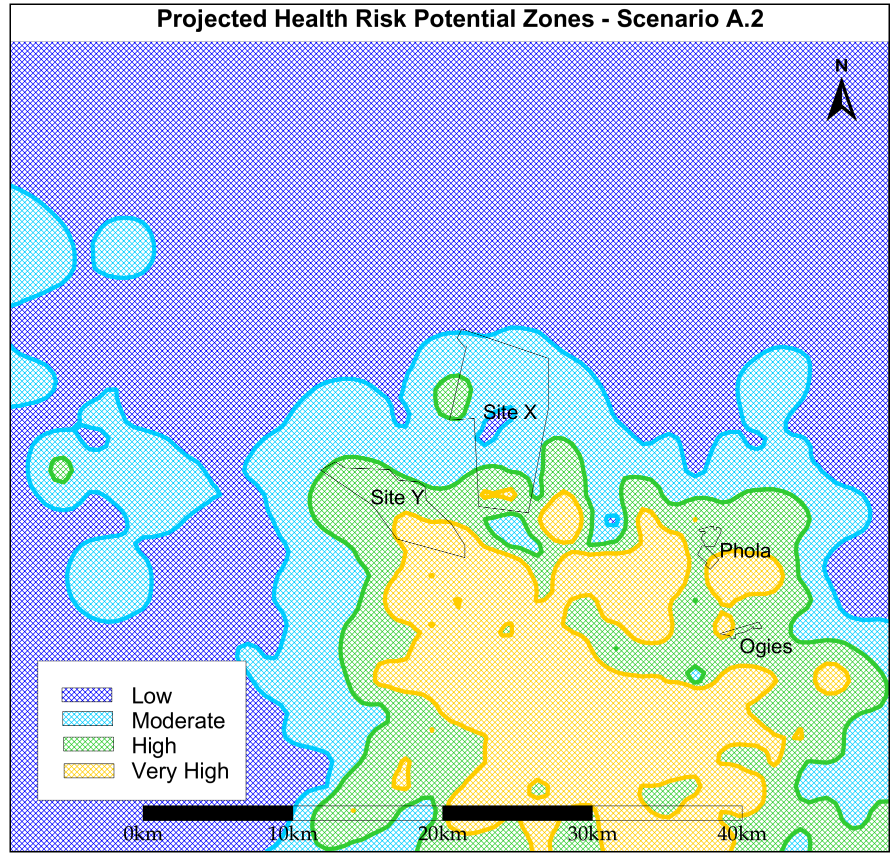


Figure 6.13 Projected health risk potential zones for Scenario A2 Operations (i.e. 6 x 900 MW PF units, 150 m stack, 90% CE, at Site X)

Table 6-3 Synopsis of health risk categories assigned on the basis of projected sulphur dioxide concentrations arising due to various control and uncontrolled emission scenarios

Emission Scenarios(a)	Health Risk Categories basis of projected hourly sulphur dioxide concentrations (µg/m³)
	Phola
Current Operations	high
Future Operations (Basecase)	high
Scenario A1 – 6 x 900 MW Units, Site X, 150 m stack - 0% CE	high
Scenario B1 – 6 x 900 MW Units, Site Y, 150 m stack - 0% CE	high
Scenario C1 – 6 x 900 MW Units, Site X, 220 m stack - 0% CE	high
Scenario D1 – 6 x 900 MW Units, Site Y, 220 m stack - 0% CE	high
Scenario E1 – 6 x 900 MW Units, Site X, 300 m stack - 0% CE	high
Scenario F1 – 6 x 900 MW Units, Site Y, 300 m stack - 0% CE	high
Scenario A2 – 6 x 900 MW Units, Site X, 150 m stack - 90% CE	high
Scenario B2 – 6 x 900 MW Units, Site Y, 150 m stack - 90% CE	high
Scenario C2 – 6 x 900 MW Units, Site X, 220 m stack - 90% CE	high
Scenario D2 – 6 x 900 MW Units, Site Y, 220 m stack - 90% CE	high
Scenario E2 – 6 x 900 MW Units, Site X, 300 m stack - 90% CE	high
Scenario F2 – 6 x 900 MW Units, Site Y, 300 m stack - 90% CE	high

(a) All proposed power station configurations simulated together with the projected sources of emissions (Eskom and non-Eskom sources) to determine potential for cumulative sulphur dioxide concentrations.

Important point of note:

The assumption is made that no residential settlements will be developed within the main impact areas of the power station(s) during their operational phases. Should this not be the case the exposure potential, and hence the health risk potential, would need to be reassessed. (The health risk potential plots presented could aid decision making regarding the siting of residential settlements.)

The exposure potential due to the various scenarios is given in **Appendix G**. From the additional exposure potential due to the activities of the proposed new power station, it is concluded that for uncontrolled scenarios, Site X is more preferable than Site Y with a stack height of 220m to 300m. For controlled scenarios Site X is the preferable location for the power station with a 220m stack height.

6.3.3 Results for Heavy Metals

Cancer risks associated with inhalation exposures to predicted lead, arsenic and nickel were calculated based on predicted maximum annual average concentrations occurring due to existing Kendal Power Station operations in addition to a proposed 5400 MWe power station. Given the range of unit risk factors published by the California OEHHA, the WHO and the US-EPA it was decided to calculate cancer risks based on the maximum and minimum unit risk factors available (Table 6.4). Cancer risks were calculated to be very low, with total incremental cancer risks across all carcinogens quantified to be in the range of 1: 4.5 million to 1: 10 million.

Table 6-4 Cancer risks calculated due to inhalation exposures to individual carcinogens predicted to be emitted from the existing Kendal Power Station and proposed (5400 MWe) Kendal North Power Stations (stack and ash dam)

Carcinogens / Suspected Carcinogens	US-EPA IRIS Classification	Calculated Cancer Risk (expressed as a 1: xxx chance of contracting cancer)	
		Based on Lowest Risk Factor (least conservative)	Based on Highest Unit Risk Factor (most conservative)
Arsenic	A	19,921,504	6,949,362
Nickel	A	21,073,406	13,309,520
Lead	B2	608,446,968	608,446,968
Total incremental cancer risk across all carcinogens quantified		10,071,131	4,531,534

Maximum hourly, daily, monthly and annual average heavy metal concentrations occurring due to existing and projected power station fly ash emissions and fugitive emissions from the existing and planned ash dumps. These predicted ambient metal concentrations were compared to relevant health thresholds in order to determine the potential for health impacts. Such health thresholds and the predicted concentrations as a fraction of such thresholds are given in Table 6.5. Fractions of greater than 1 indicate an exceedance of the threshold. No inhalation-related, non-carcinogenic health thresholds were predicted to be exceeded.

Annual average arsenic and nickel concentrations were also predicted to be well within the recently promulgated EC limits given as 0.006 µg/m³ and 0.02 µg/m³ respectively.

In the simulation of ambient mercury concentrations and resultant air quality impacts reference was made to the maximum emission rates (i.e. 10.55 tpa for proposed Kendal North operations). The maximum highest hourly, highest daily and annual average ground level mercury concentrations occurring as a result of existing Kendal and Proposed Kendal North Power Station emissions is given in Table 6.6.

The predicted maximum hourly, daily and annual average concentrations were well-within the most stringent of the guidelines given for public exposures to ambient mercury concentrations intended for the inhalation pathway (e.g. WHO, US-EPA inhalation reference concentrations, Californian RELs).

Table 6-5 Predicted ambient trace metal concentrations (in the PM10 range) due to existing Kendal and proposed Kendal North Power Station emissions, with concentrations given as a fraction of the relevant health thresholds. Fractions of > 1 indicate threshold exceedances.

Compound	Predicted Ambient Air Concentrations (µg/m³)			Relevant Health Thresholds (µg/m³)			Predicted Concentrations as a Fraction of the Relevant Health Threshold		
	Highest Hourly	Highest Daily	Annual Average	Acute Health Threshold	Sub-acute Health Threshold	Chronic Health Threshold	Highest Hourly Concentration as a Fraction of the Acute Threshold	Highest Daily Concentration as a Fraction of the Sub-acute Threshold	Annual Average Concentration as a Fraction of the Chronic Threshold
As	3.60E-03	4.93E-04	3.35E-05	0.19		0.03	0.01893		0.00112
Ba	5.12E-01	5.91E-02	2.67E-03	50		5	0.01025		0.00053
Bi	1.55E-03	1.84E-04	9.01E-06						
Co	4.75E-03	5.30E-04	2.16E-05			0.1			0.00022
Cr	7.01E-02	9.64E-03	6.61E-04			0.1			0.00661
Cu	1.65E-02	1.85E-03	7.60E-05	100		1	0.00017		0.00008
Ga	1.66E-02	1.84E-03	7.33E-05						
Ge	2.05E-03	2.41E-04	1.16E-05						
Pb	2.17E-02	2.63E-03	1.37E-04			0.5			0.00027
Hg	3.92E-04	3.87E-05	8.76E-07	1.8		0.09	0.00022		0.00001
Ni	2.82E-02	3.52E-03	1.98E-04	6		0.05	0.00470		0.00395
Nb	1.64E-02	1.70E-03	5.13E-05						
Rb	1.53E-02	1.82E-03	8.97E-05						
Se	5.20E-01	6.19E-02	3.07E-03			20			0.00015
Th	7.39E-03	1.44E-03	1.16E-04						
Sn	3.92E-03	4.87E-04	2.71E-05	20		2	0.00020		0.00001
W	3.10E-03	4.23E-04	2.85E-05	10		1	0.00031		0.00003
U	3.40E-03	4.41E-04	2.71E-05			0.3			0.00009
V	4.22E-02	4.86E-03	2.19E-04		0.2			0.02431	
Y	2.46E-02	2.83E-03	1.27E-04						
Zn	1.82E-02	2.01E-03	7.93E-05	50		5	0.00036		0.00002
Zr	1.39E-01	1.51E-02	5.68E-04	50		5	0.00278		0.00011

Table 6-6 Predicted mercury concentrations given existing Kendal and proposed Kendal North Power Station emissions with reference to applicable guidelines intended to protect human health.

	PREDICTED MERCURY CONCENTRATIONS GIVEN EXISTING AND PROPOSED 4800 MW POWER STATION OPERATIONS		
	Highest Hourly (µg/m³)	**Highest Daily (µg/m³)**	**Annual Average (µg/m³)**
Predicted Maximum Total Hg GLCs (µg/m³)	0.18	0.04	0.003
	RELEVANT GUIDELINES (µg/m³)		
WHO Guideline Value			1.00
US-EPA inhalation reference concentration			0.30
Texas Effect Screening Levels	0.25		0.025
California RELs	1.8		0.09
DEAT Mercury Guideline (a)			0.04

REL – reference exposure level; GLCs – ground level concentrations; DEAT – Department of Environmental Affairs and Tourism
(a) Published in DEAT document "Technical Background Document for Mercury Waste Disposal" (2001).

It is noted that the major pathway for mercury exposures is ingestion rather than inhalation. For this reason reference was made to the DEAT mercury guideline which was intended to be protective given multiple pathways of exposure. This guideline value (given as 0.04 µg/m³ for chronic exposures) was derived during a recent study initiated by the Department of Environmental Affairs and Tourism. This study included health-risk based research relating to human exposure to mercury and engineering reviews of treatment and disposal options for mercury waste. The purpose of such studies was twofold: (i) to support the drafting of national regulations for mercury waste disposal; and (ii) to provide specific guidance on how best to deal with the mercury waste stockpiled at the Thor Chemical's plant at Cato Ridge, Kwazulu-Natal. The health risk study determined that ambient long-term concentrations of mercury of lower than 0.04 µg/m³ would not result in unacceptable multi-pathway risk given local environments. This guidance is currently being used by the DEAT to assess the acceptability of mercury waste treatment and disposal options.

6.4 Potential for Vegetation Injury and Corrosion

Based on the dose-response thresholds the exposure of vegetation and ecosystems to ambient sulphur dioxide concentrations outlined previously and the ambient air quality limits issued by the EC and WHO for protection of ecosystems, the potential for vegetation injury was characterised as follows:

Category of Risk for Vegetation Injury(a)	Maximum Hourly Average SO_2 Concentration (µg/m³) (99th percentile)		Maximum Annual Average SO_2 Concentration (µg/m³)	Basis
Low	< 1 300 µg/m³	AND	< 20 µg/m³	EC annual SO_2 limit given as 20 µg/m³ for the protection of ecosystems WHO guideline for annual SO_2 given as in range of 10 – 30 µg/m³ depending on sensitivity of receiving environment Hourly average of 1300 µg/m³ given as being associated with visible effects on the leaves of sensitive plant species (~5% of leaf area affected)
Moderate	> 1 300 µg/m³	OR	20 – 30 µg/m³	
High	> 1 300 µg/m³	AND	> 30 µg/m³	

(a) Assumption of availability of vegetation at all sites – comprises a conservative assumption in certain instances, e.g. where mining activity prevails.

The methodological approach outlined in Section 2 was applied in the assessment or the potential for corrosion given exposures to ambient sulphur dioxide concentrations arising due emissions from existing operations and from proposed power station operations. Corrosion was categorised as follows:

Corrosion Potential	Maximum Annual Average SO_2 Concentration (µg/m³)
Low	< 20 µg/m³
Medium	20 – 657 µg/m³
High	> 657 µg/m³

A synopsis of vegetation injury and corrosion potential characterisation is discussed in Appendix E. The potential for vegetation damage and corrosion due to current predicted ambient sulphur dioxide concentrations is classifiable as “low” to “medium” to the north and south of the proposed Kendal North Power station sites respectively (Figure 6.14). A small portion of the study area was classified as “high” vegetation damage over the existing Kendal Power Station site. The operation of a 5400 MWe power station at the proposed site is predicted to result in “high” risks for vegetation damage and “medium” risks for corrosion over a large portion of the study area should no sulphur dioxide abatement measures be implemented (Figure 6.15 to Figure 6.20). Sulphur dioxide abatement with a 90% control efficiency would result in the potential for corrosion and vegetation damages being classified as “medium” over a large portion of the study area and “high” vegetation injury over the existing Kendal Power Station area (Figure 6.21).

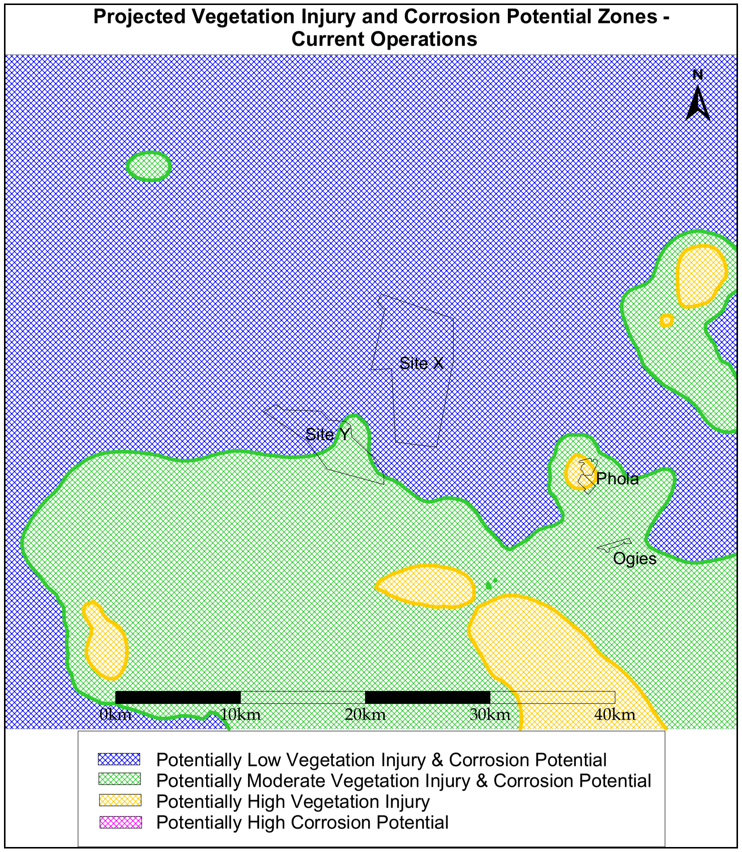


Figure 6.14 Projected vegetation damage and corrosion potential zones for Current Operations

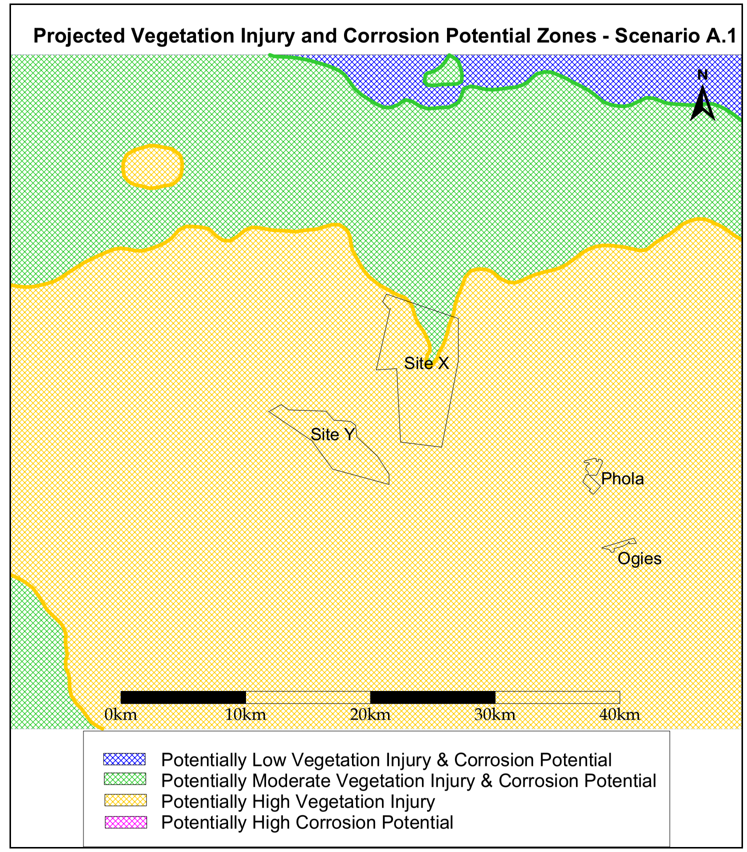


Figure 6.15 Projected vegetation damage and corrosion potential zones for Scenario A1 Operations(i.e. 6 x 900 MW units, Site X, 150 m stack, no control efficiency)

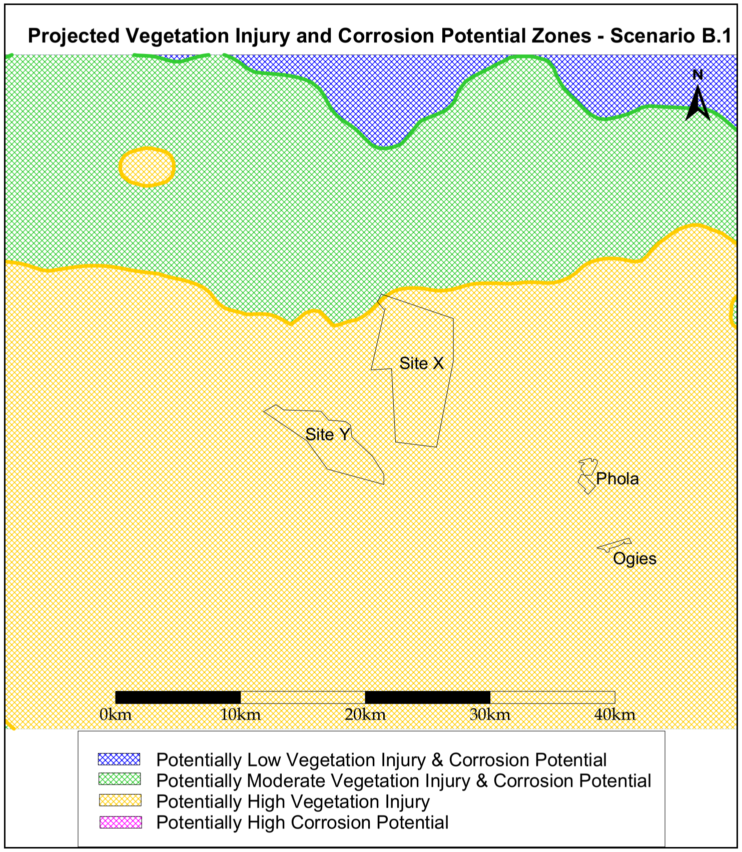


Figure 6.16 Projected vegetation damage and corrosion potential zones for Scenario B1 Operations(i.e. 6 x 900 MW units, Site Y, 150 m stack, no control efficiency)

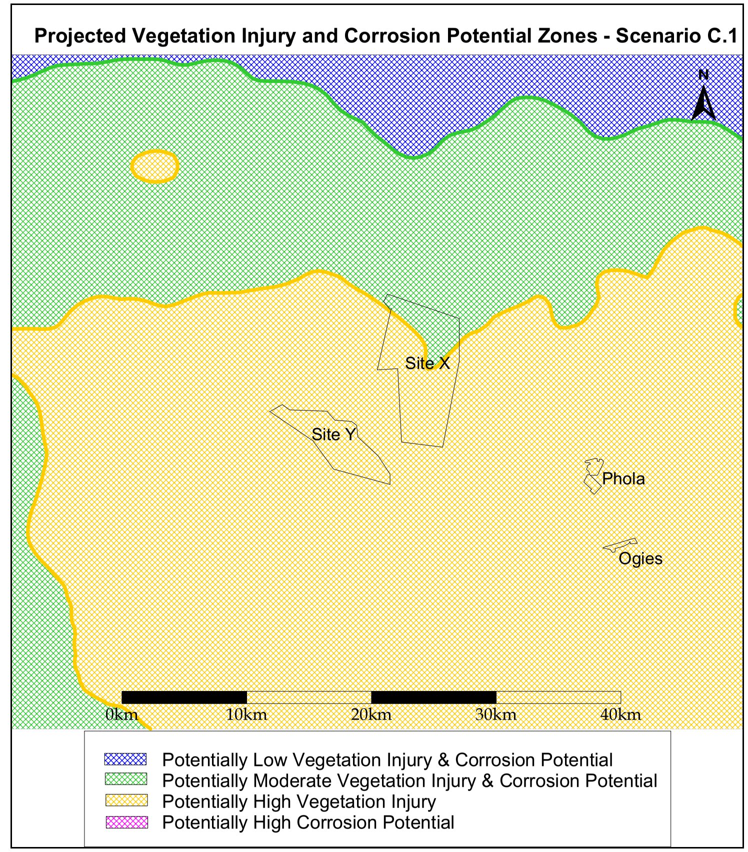


Figure 6.17 Projected vegetation damage and corrosion potential zones for Scenario C1 Operations(i.e. 6 x 900 MW units, Site X, 220 m stack, no control efficiency)

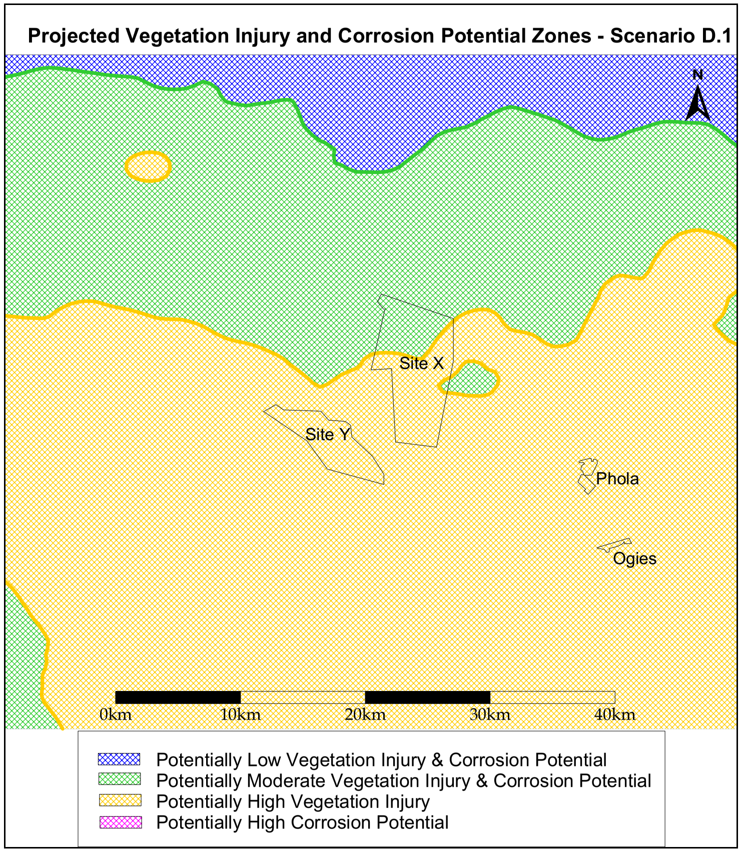


Figure 6.18 Projected vegetation damage and corrosion potential zones for Scenario D1 Operations(i.e. 6 x 900 MW units, Site Y, 220 m stack, no control efficiency)

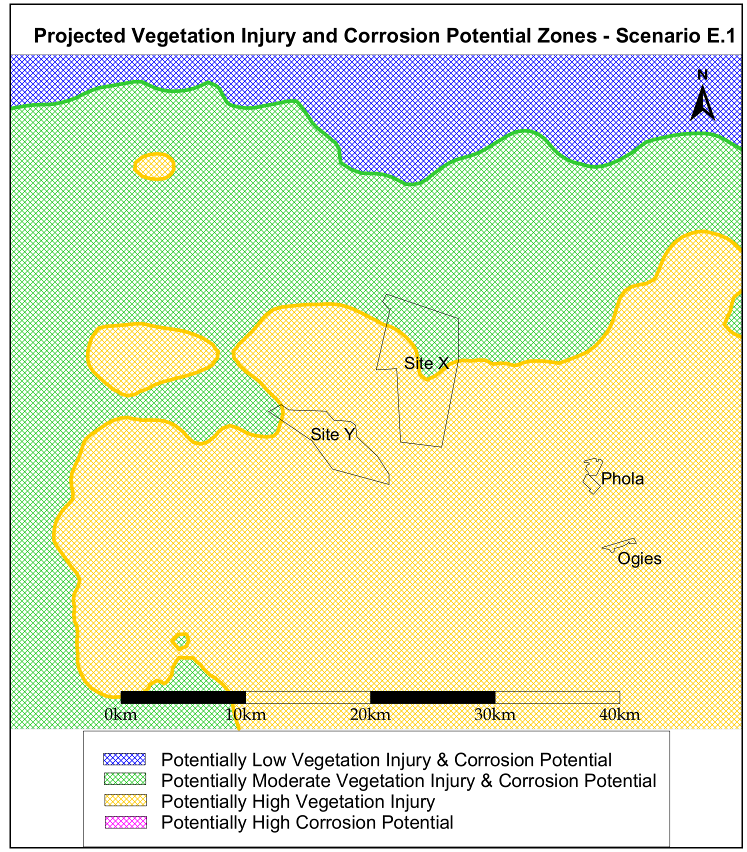


Figure 6.19 Projected vegetation damage and corrosion potential zones for Scenario E1 Operations(i.e. 6 x 900 MW units, Site X, 300 m stack, no control efficiency)

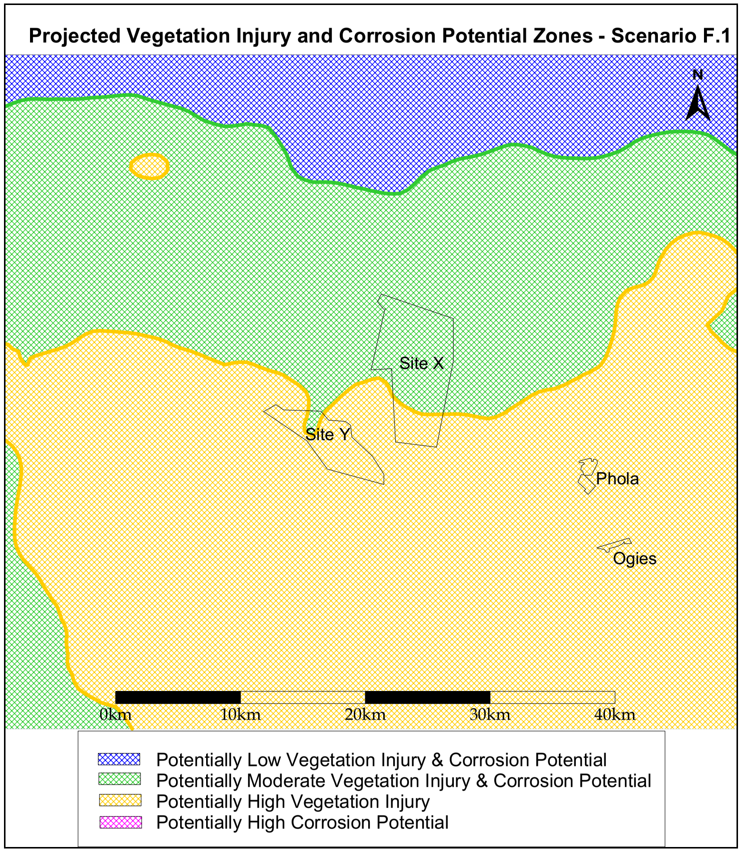


Figure 6.20 Projected vegetation damage and corrosion potential zones for Scenario F1 Operations(i.e. 6 x 900 MW units, Site Y, 300 m stack, no control efficiency)

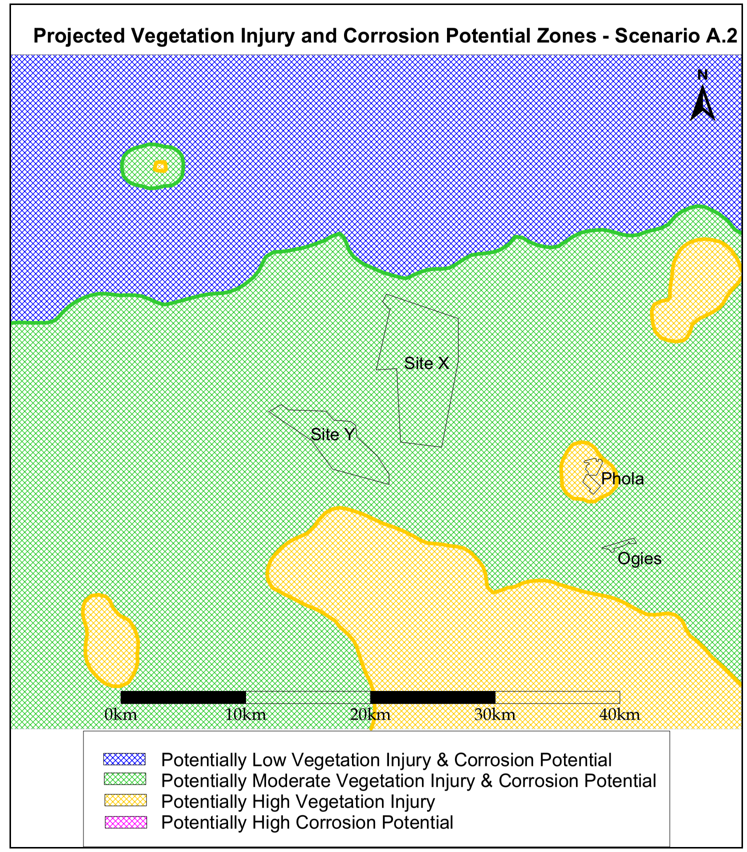


Figure 6.21 Projected vegetation damage and corrosion potential zones for Scenario A1 Operations(i.e. 6 x 900 MW units, Site X, 150 m stack, 90% control efficiency) – Scenario B2, C2, D2, E2 and F2 similar in impact over the study area to Scenario A2.

6.5 Contribution to Greenhouse Gas Emissions

In order to facilitate the estimation of contribution of the proposed power station to global warming potentials, nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions were estimated with nitrous oxide releases being calculated as CO_2 equivalent emissions[8] (Table 6.7). Total greenhouse gas emissions reported to be emitted within South Africa for the year 1994, expressed as CO_2 equivalents, are given in Table 6.8. No more recent data are available.

Table 6-7 Calculated CO_2 equivalent emissions from proposed power station operations

		Annual Emissions		Annual Emissions
		CO_2	N_2O	CO_2 Equivalent
Power Station Capacity	**Coal Consumption (tpa)**	kT/ann	kT/ann	kT/ann
5400 MWe	21,088,567	29,895	0.342	36,831

Table 6-8 Emissions of CO_2, CH_4 and N_2O in South Africa in 1990 and 1994

Greenhouse Gas Source	Gg CO_2 Equivalent							
	CO_2		CH_4		N_2O		Aggregated	
	1990	1994	1990	1994	1990	1994	1990	1994
Energy	252 019	287 851	7 286	7 890	1 581	1 823	260 886	297 564
Industrial Processes	28 913	28 106	69	26	1 810	2 254	30 792	30 386
Agriculture			21 304	19 686	19 170	15 776	40 474	35 462
Waste			14 456	15 605	738	825	15 194	16 430
						Total	**347 346**	**379 842**

Source: South African: Initial National Communication under the United Nations Framework Convention on Climate Change, November 2003.

The emissions from the proposed 5400 MWe power station would increase the energy sectors emissions by 12.8% and would increase the country's contribution to global warming by 9.7%

[8] Nitrous oxide emissions are converted to carbon dioxide equivalents using global warming potentials (GWPs). GWPs are conversion factors that are used to express the relative warming effects of the various greenhouse gases in terms of their carbon dioxide equivalents. The values for a 100 year timeframe have been used, which are equivalent to 310 for nitrous oxide as are recommended by the IPCC (South Africa Initial National Communication under the United National Framework Convention on Climate Change, November 2003).

7. RECOMMENDATIONS AND CONCLUSIONS

7.1 Baseline Air Quality Study Findings

The main findings from the baseline air quality characterisation study, which was based on information from both monitoring and modelling studies, are as follows:

- **Sulphur dioxide** concentrations have been measured to exceed short-term air quality limits at Kendal 2 within exceedance of such limits modelled to occur at the nearby residential area of Phola.

  The Kendal Power Station is likely to be the main contributing source to the ambient SO_2 ground level concentrations in the study area due to the magnitude of its emissions. This has being confirmed through atmospheric dispersion modelling of the power station's stack emissions. Other sources which may contribute significantly due to their low release level include: spontaneous combustion of coal discards associated with mining operations (not quantified in the current study) and potentially household fuel burning within Phola. The highest ground level concentrations due to the Kendal Power Station stack emissions are expected to occur during unstable conditions when the plume is brought to ground in relatively close proximity to the power station.

  The predicted sulphur dioxide concentrations to thresholds indicative of the potential for health, corrosion and vegetation impacts resulted in the following observations:

  - The health threshold given as being associated with mild respiratory effects (660 µg/m³ as an hourly threshold for SO_2) was predicted to be exceeded at Phola.

  - Predicted sulphur dioxide concentrations were within limits indicative of low to medium corrosion potentials over the study area.

  - Predicted sulphur dioxide concentrations exceeded the EC annual sulphur dioxide limit of 20 µg/m³ which aims to protect ecosystems. The WHO guideline to protect ecosystems is given as a range of 10 to 30 µg/m³, depending on ecosystem sensitivity. The lower end of the WHO guideline range (viz. 10 µg/m³ intended for protection of highly sensitive vegetation types) was predicted to be exceeded over the entire study area.

- Kendal Power Station contributes to ambient **nitrogen oxide** and nitrogen dioxide concentrations in the region, with short-term international air quality limit exceedances predicted, to occur over sections in the study area. However, other significant low level sources of NO_x anticipated to occur in the region include combustion within coal discard dumps (not quantified in the current study), vehicle tailpipe emissions, household fuel burning and infrequent veld burning (not quantified in the current study).

- Ambient **PM10** concentrations were predicted to exceed the current lenient SA Standards (as given in the second schedule of the Air Quality Act) and the more stringent SANS and EC limit values over built up residential areas.

  The contribution of the Kendal Power Station to primary and secondary particulates was simulated. (Secondary particulates form in the atmosphere through the conversion of SO_x and NO_x emissions to sulphate and nitrate.)

  Various local and far-field sources are expected to contribute to the suspended fine particulate concentrations in the region. Local dust sources include wind erosion from exposed areas, fugitive dust from mining operations, vehicle entrainment from roadways and veld burning. Household fuel burning also constitutes a local source of low-level emissions. Long-range transport of particulates emitted from remote tall stacks and from large-scale biomass burning in countries to the north of RSA and the accumulation and recirculation of such regional air masses over the interior is well documented (Andreae *et al.*, 1996; Garstang *et al*., 1996; Piketh, 1996).

- Based on the screening of the potential for health risks occurring due to inhalation exposures to trace metals released from existing Kendal Power Station it was concluded that predicted concentrations were within acute and chronic health thresholds and that total incremental cancer risks were very low. This is due to the high control efficiency of fly ash abatement systems in place on stacks and the dust abatement measures being implemented at the ash dump. Ground level concentrations due to gaseous mercury are predicted to be well within health effect screening levels.

Given the elevated levels of sulphur dioxide and fine particulate concentrations measured/predicted to occur within parts of the study region it is imperative that the potential for cumulative concentrations due to any proposed developments be minimized and carefully evaluated.

7.2 Compliance and Air Quality Impact Assessment for Proposed Power Station

Atmospheric emissions released during the construction phase are primarily restricted to fugitive dust from land clearing and site development operations. Such emissions can be significantly reduced, and their impact rendered negligible, through the selection and implementation of effective dust mitigation measures.

Sources of emission associated with the operational stage include particulate and gaseous emissions from the power station stacks, in addition to low-level, fugitive releases from materials handling and ash disposal. Pollutants releases include particulates, sulphur dioxide, oxides of nitrogen, various trace metals, carbon dioxide and nitrous oxide. (The latter two are important due to their global warming potential.)

Stack emissions were estimated and quantified for the following power station configurations:

Scenario	No. of Units	Site	Stack Height (m)	SO_2 Control Efficiency
A.1	6 x 900 MW	Site X	150	0%
B.1	6 x 900 MW	Site Y	150	0%
C.1	6 x 900 MW	Site X	220	0%
D.1	6 x 900 MW	Site Y	220	0%
E.1	6 x 900 MW	Site X	300	0%
F.1	6 x 900 MW	Site Y	300	0%
A.2	6 x 900 MW	Site X	150	90%
B.2	6 x 900 MW	Site Y	150	90%
C.2	6 x 900 MW	Site X	220	90%
D.2	6 x 900 MW	Site Y	220	90%
E.2	6 x 900 MW	Site X	300	90%
F.2	6 x 900 MW	Site Y	300	90%

7.2.1 Compliance with Ambient Air Quality Limits

In assessing "compliance" with air quality limits it is important to note the following:

- Variations in where air quality limits are applicable. The EC (and UK) stipulate that air quality limits are applicable in areas where there is a reasonable expectation that public exposures will occur over the averaging period of the limit. In the US, the approach is frequently adopted of applying air quality limits within all areas to which the public has access (i.e. everywhere not fenced off or otherwise controlled for public access). In South Africa there is still considerable debate regarding the practical implementation of the air quality standards included in the schedule to the Air Quality Act. The Act does however define "ambient air" as excluding air regulated by the Occupational Health and Safety Act of 1993. This implies that air quality limits may be required to be met beyond the fencelines of industries.

- The SA standards included in the schedule to the Air Quality Act are incomplete when compared to legal limits issued by other countries. Air quality standards typically comprise: thresholds, averaging periods, monitoring protocols, timeframes for achieving compliance and typically also permissible frequencies of exceedance. (Thresholds are generally set based on health risk criteria, with permissible frequencies and timeframes taking into account the existing air pollutant concentrations and controls required for reducing air pollution to within the defined thresholds. The practice adopted in Europe is to allow increasingly more limited permissible frequencies of exceedance, thus encouraging the progressive reduction of air pollution levels to meeting limit values.)

NOTE: Given the above uncertainties a conservative approach was adopted in assessing compliance with SA air quality standards, with single exceedances of thresholds beyond the "fenceline" of the power station being taken as constituting

"non-compliance". In order however to demonstrate areas of "non-compliance" should permissible frequencies be issued at a latter date reference was made to the UK air quality limits. (The UK and SA primarily support similar short-term thresholds for sulphur dioxide. The UK however permits a number of annual exceedances of these short-term thresholds to account for meteorological extremes and to support progressive air quality improvement.)

7.2.1.1 Nitrogen Oxides

Predicted NO and NO_2 hourly concentrations were predicted to exceed SA nitric acid standard and the SANS/EC limit respectively (including cumulative concentrations due to existing sources of emissions). The daily and annual average ground level concentrations are within relevant standards. Although the coal fired power stations in the area contribute to the ambient oxides of nitrogen concentrations, other sources of NO_x emissions in the area include domestic fuel burning, vehicle tailpipe emissions and other industrial activity. (Appendix D).

7.2.1.2 Airborne Fine Particulates and Dust Deposition

Predicted PM10 concentrations were within the SA daily and annual standards but exceeded the SANS and EC daily limit values in the vicinity (within 10 km east) of the ash dump. Public exposure within this area is restricted to scattered farmsteads with an average residential density of ~5 persons/km². Other areas of exceedance are over built up areas with ground level concentrations originating from low-level sources of emission (i.e. domestic fuel burning).

Maximum monthly dustfall rates were typically "moderate" (i.e. 250 - 500 mg/m²/day) immediately downwind of the proposed Kendal North ash dump and materials handling section of the power station, with "slight" dustfalls (i.e. < 250 mg/m²/day) occurring beyond these areas.

7.2.1.3 Sulphur Dioxide - Uncontrolled

Emissions from the existing Kendal Power Station are predicted to be responsible for exceedances of SA standards particularly downwind of the facility. Given this baseline it is evident that no future development resulting in sulphur dioxide emissions within the same area can be in compliance with the SA standard. It is due to this cumulative impact that all proposed power station configurations are considered to be in non-compliance with SA standards. The magnitude, frequency of occurrence and area of exceedance of air quality limits varies significantly however between configurations.

The main observations made regarding compliance implications of various power station configurations given uncontrolled emissions were as follows:

- SA short-term standards (10-minute and daily) are exceeded within the zone of maximum impact due to basecase and all proposed configurations. At Phola the SA 10-minute standard is exceeded for basecase and all proposed configurations.

- Under current operations there is predicted to be compliance with the UK hourly sulphur dioxide standard at Phola. This standard is however exceeded at Phola with the addition of six 900 MW units.

- The increase of the stack height from 220 m to 300 m is predicted to result in relatively small cumulative reductions in ground level maximum.

It may be concluded that the addition of 6 new 900 MW PF units with no sulphur dioxide abatement in place would result in significant increases in the magnitude, frequency and spatial extent of non-compliance with SA standards. The extension of the height of the stack by 80 m, from 220 m to 300 m, is not sufficient to negate the need for considering abatement measures.

7.2.1.4 Sulphur Dioxide Emissions - Controlled

Changes in projected ground level sulphur dioxide concentrations and limit value exceedances were simulated for a 90% control efficiency for three proposed power station configurations, viz. Scenario A and B (150 m stack), Scenario C and D (220 m stack) and Scenario E and F (300 m stack) at two different sites, viz. Site X and Site Y. Observations made regarding compliance implications of various power station configurations given controlled emissions were as follows:

- Even given a 90% control efficiency for all power station configurations, cumulative sulphur dioxide concentrations would exceed the SA 10-minute standard at the maximum impact zone and at Phola and the SA daily standard in the maximum impact zone and Phola – primarily due to emissions from the existing Kendal Power Station.

- With the addition of six new units operating coincident with the existing Kendal Power Station, at least a 90% control efficiency would be required to ensure that the magnitude, frequency and spatial extent of non-compliance was within levels comparable to those projected for the basecase. Even given 90% control efficiencies on all six units, the maximum predicted hourly concentrations, the spatial extent of non-compliance with the 10-minute limit and the frequencies of exceedance at Phola would be *marginally* higher than for current operations.

7.2.2 Potential for Health Effects due to Proposed Power Station Operations

Sulphur dioxide concentrations occurring due to existing conditions are predicted to be associated with "high" health risks within the Phola residential area. The California EPA Acute Reference Exposure Level for sulphur dioxide (above which mild respiratory effects may occur) is predicted to be exceeded by ~80% for highest hourly ground level concentrations in the vicinity of Phola. Cumulative sulphur dioxide concentrations given the operation of an additional six 900 MW units at the sites proposed is projected to increase this concentrations to exceed the California EPA Acute reference exposure up to 150% for a 150m stack. The implementation of sulphur dioxide abatement measures comprising a 90% control efficiency would not significantly increase the exceedance of this health threshold above baseline levels.

Significance of stack height – If uncontrolled the proposed power station with a 150 m stack would result in the most significant non-compliance with SO_2 limits and pose the greatest risk to sensitive receptors. Reduced impact potentials can be realised through the extension to ~220 m. Further increments in the stack height were predicted to realise only minor further reductions in ground level concentrations and were associated with potentially more persons being exposed to sulphur dioxide concentrations in excess of air quality limits (due to the larger sphere of influence of the power station).

Significance of site selection – Compliance and exposure potential results for the two candidate sites were mixed[(9)] with neither of the sites being identified as being considerably better than the other site. It is therefore recommended that the site selection be assessed in terms of other criteria.

Cancer risks associated with maximum possible exposures to trace metals released were calculated to be very low, with total incremental cancer risks across all carcinogens quantified to be in the range of 1: 4.5 million to 1: 10 million. Maximum hourly, daily, monthly and annual average metal concentrations were predicted to be within non-carcinogenic health thresholds. Annual average arsenic and nickel concentrations were also predicted to be well within the recently promulgated EC limits given as 0.006 µg/m³ and 0.02 µg/m³ respectively.

Ground level concentrations due to gaseous mercury are predicted to be well within health effect screening levels.

7.2.3 Potential for Vegetation Injury and Corrosion

The operation of a 5400 MWe power station at the proposed sites is predicted to result in "high" risks for vegetation damage and "medium" risks for corrosion over a large section of the study area if uncontrolled. Sulphur dioxide abatement with a 90% control efficiency would result in the potential for corrosion and vegetation damages for these areas being similar to baseline levels. It should be noted, however, that the dose-response thresholds

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[9] For the uncontrolled scenario, a new power station at Site X results in a slightly fewer SO_2 exceedance events with respect to the SA 10-minute and average daily concentrations limits than at Site Y, in the area of maximum ground level concentration. However, when comparing the impact of the power station at Phola, Site Y resulted in fewer exceedances of the SA standards than at Site X. For the controlled scenario, Site X resulted in fewer exceedances than at Site Y, in the area of maximum ground level concentrations, but there was no difference in exceedances at Phola.

are based on studies abroad and may be conservative, given that much of the research supporting such thresholds was undertaken in more humid climates. It is therefore recommended that research be undertaken locally to determine local dose-response thresholds.

7.2.4 Contribution to Greenhouse Gas Emissions

The emissions from the proposed 5400 MWe power station would increase the energy sectors emissions by 12.8% and would increase the country's contribution to global warming by 9.7%

7.3 Mitigation Recommendations

Compliance with ambient air quality standards given for sulphur dioxide cannot be achieved due to the implementation of SO_2 abatement measures for the proposed power station given that non-compliance already occurs due to existing operations.

The need for and required control efficiency of abatement measures was assessed on the basis of avoiding any significant increment in non-compliance or health risks. The aim being to identify SO_2 control efficiencies at which there will be:

- no substantial changes in the magnitude, frequency or spatial extent of non-compliance; and
- no significant increment in the health risk within dense neighbouring settlement areas.

From the study it was concluded that a 90% control efficiency would be required for the proposed 5400 MWe power station to ensure that it could operate coincident with the existing Kendal Power Station without substantial changes in the magnitude, frequency or spatial extent of non-compliance, nor significant increment in health risks. Even given 90% control efficiencies on all six units, the maximum predicted hourly concentrations, the spatial extent of non-compliance with the 10-minute limit and the frequencies of exceedance at Phola would be *marginally* higher than for current operations.

Various abatement technologies may be implemented to achieve the required control efficiencies. Flue Gas Desulfurization (FGD), which includes wet, spray dry and dry scrubbing options, are capable of reduction efficiencies in the range of 50% to 98%. The highest removal efficiencies are achieved by wet scrubbers, grater than 90%, and historically the lowest by dry scrubbers. New dry scrubber designs are however capable of higher control efficiencies, in the order of 90%.

Although the implementation of technologies such as wet or dry FGD would be required to reduce the potential for sulphur dioxide emissions, care should be taken in assessing the environmental implications of the use of such control technologies. Atmospheric emissions are associated with the production, transportation and handling of the reagents used in the process (e.g. limestone, lime) and with the waste produced. FGD may also be associated with a visible plume which could impact on aesthetics. Furthermore, the use of FGD will lower stack gas temperatures and hence reduce plume rise, resulting in potential increases in ground level concentrations of other pollutants not removed by the abatement measures. The use of FGD or any other abatement technology is also likely to impact on the combustion efficiency which would result in increased coal consumption to meet the required energy output requirements. It is recommended that the impacts associated with likely control operations be quantitatively assessed.

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APPENDIX A –

EXTRACT FROM DEAT ‘GUIDELINES FOR SCHEDULED PROCESSES’ (1994)

EXTRACT FROM DEAT 'GUIDELINES FOR SCHEDULED PROCESSES' (1994)

PROCESS 29: POWER GENERATION PROCESSES

Power generation processes: That is to say, processes in which-

(a) fuel is burned for the generation of electricity for distribution to the public or for purposes of public transport;

(b) boilers capable of burning fuel at a rate of not less than 10 tons per hour are used to raise steam for the supply or energy for purposes other than those mentioned in (a) above;

(c) a fuel burning appliance is used that is not controlled in terms of Part III of this Act, excluding appliances in private dwellings.

(a) Basic Information

(i) Low sulphur content of coal is detrimental to efficacy of electrofilter units.
(ii) 1 Ton/h coal produces 10 t/h steam = $\pm$ 22 GJ/h.
(iii) Standard cubic metre (Sm^3 means at 101,3 KPa and 0^{o}C.

(b) Guidelines

II PF plants:

(i) Existing plants: fly-ash emission limits:

discretion of control officer - gas conditioning if possible in which case the guidelines are as follows:

(1) 3-field electrofilter : 270 mg/Sm^3 (actual m^3)

(2) 2-field electrofilter : 320 mg/Sm^3 (actual m^3)

(ii) New Plants:

(1) not more than 100 mg/Sm^3 fly-ash.

(2) "Low NOx" burners must be used.

(3) All new plants to be fitted with opacity monitors - aim at 30% opacity - optical monitor must be fitted with time integrator having six minute intervals. Electrofilters to be fitted with secondary ammeters and voltmeters.

(4) At least 70% of sulphur in the coal must be removed or captured.

APPENDIX B –

ATMOSPHERIC DISPERSION SIMULATION METHODOLOGY

Dispersion Model Selection

Dispersion models compute ambient concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on ground level air pollution concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and determining emission control requirements. Care was therefore taken in the selection of a suitable dispersion model for the task at hand. For the current study, it was decided to use the US Environmental Protection Agency's CALMET meteorological model and the CALPUFF dispersion model in combination.

Most regulatory dispersion models, such as the widely used Industrial Source Complex (ISC) model and the relatively new AERMOD model, are based on the steady-state plume assumption, with meteorological inputs for these models assuming a horizontally uniform flow field. Usually the winds are derived from a single point measurement, which is often made at a nearby non-complex terrain site. The meteorological processors for the regulatory models do not adjust the winds to reflect terrain effects. The steady-state flow fields either do not or only partially reproduce the terrain-induced spatial variability in the wind field. In addition to which, the straight-line trajectory assumption of the plume models cannot easily handle curved trajectories associated with terrain-induced deflection or channelling. These limitations of plume models can significantly affect the models ability to correctly represent the spatial area of impact from sources in complex terrain, in addition to the magnitude of the peak values in certain instances.

CALPUFF is a regional Lagrangian Puff model suitable for application in modelling domains of 50 km to 200 km. Due to its puff-based formulation the CALPUFF model is able to account for various effects, including spatial variability of meteorological conditions, dry deposition and dispersion over a variety of spatially varying land surfaces. The simulation of plume fumigation and low wind speed dispersion are also facilitated.

CALPUFF requires as a minimum the input of hourly average surface meteorological data. In order to take full advantage of the model's ability to simulate spatially varying meteorological conditions and dispersion within the convective boundary layer it is, however, necessary to generate a three-dimensional wind field for input to the CALPUFF model. The CALMET model may be used to generate such a three-dimensional wind field for input to the CALPUFF model.

The CALMET meteorological model contains a diagnostic wind field module that includes parameterized treatments of terrain effects, including slope flows, terrain channelling and kinematic effects, which are responsible for highly variable wind patterns. CALMET uses a two-step procedure for computing wind fields. An initial guess wind field is adjusted for terrain effects to produce a Step 1 wind field. The user specifies the vertical layers through which the domain wind is averaged and computed, and the upper air and surface meteorological stations to be included in the interpolation to produce the spatially varying guess field. The Step 1 (initial guess) field and wind observational data are then weighted through an objective analysis procedure to produce the final (Step 2) wind field. Weighting is undertaken through assigning a radius of influence to stations, both within the surface layer and layers aloft. Observational data are excluded from the interpolation if the distance between the station and a particular grid point exceeds the maximum radius of influence specified (EPA, 1995; Scire and Robe, 1997; Robe and Scire, 1998).

By using CALMET and CALPUFF in combination it is possible to treat many important complex terrain effects, including spatial variability of the meteorological fields, curved plume trajectories, and plume-terrain interaction effects. Maximum hourly average, maximum daily average and annual average concentrations will be simulated through the application of CALPUFF, using as input the relevant emissions data and the three-dimensional CALMET data set.

Chemical Transformation Modelling

CALPUFF allows for first order chemical transformation modelling to determine gas phase reactions for SO_x and NO_x. Chemical transformation rates were computed internally by the model using the RIVAD/ARM3 Scheme. This scheme allows for the separate modelling of NO_2 and NO, whereas the default MESOPUFF II Scheme only makes provision for the combined modelling of NO_x. The RIVAD/ARM3 scheme treats the NO and NO_2 conversion process in addition to the NO_2 and total NO_3 and SO_2 to SO_4 conversions, with equilibrium between gaseous HNO_3 and ammonium nitrate aerosol. The scheme uses user-input ozone data (together with modelled radiation intensity) as surrogates for the OH concentration during the daytime when gas phase free radical chemistry is active.

Dispersion Model Data Requirements

Receptor Locations and Modelling Domain

A modelling domain was defined in order to encapsulate the existing power stations and the RTS and proposed power stations, and the maximum impact zones of such stations. The extent of this domain is demonstrated in Figure B.1. The meteorology was modelled and the dispersion of pollutants simulated for the entire area covering ~160 km (east-west) by 108 km (north-south), with ambient ground-level concentrations and deposition levels being predicted for over 17 280 receptor points. The regular Cartesian receptor grid selected has a resolution of 1 770 m by 1 770 m. Discrete receptor points were specified for each of the monitoring station locations to facilitate the simulation of concentrations and deposition at these locations for application in the validation and calibration of the model.

Meteorological Data Inputs

CALMET was used to simulate the meteorological field within the study area, including the spatial variations – both in the horizontal and in the vertical - and temporal variations in the windfield and atmospheric stability. *Upper air data* required by CALMET include pressure, geopotential height, temperature, wind direction and wind speed for various levels. No upper air monitoring stations are located within the Mpumalanga Highveld region with the nearest SAWS station being located at Irene, Tshwane Municipality. Use was therefore made of

ETA-model data for twelve locations as obtained from the SAWS. Twice daily data were obtained for five sounding levels. The initial guess field in CALMET was therefore determined as a combined weighing of surface winds at nine Eskom monitoring stations and ten SAWS stations, vertically extrapolated using Similarity Theory (Stull, 1997) and upper air winds. Eskom monitoring stations for which data were obtained were Verkykkop, Elandsfontein, Kendal 2, Leandra, Majuba 1, Majuba 3, Makalu, Palmer, and Camden. The SAWS stations used in the study were Johannesburg, Irene, Vereeniging, Witbank, Leandra, Ermelo, Standerton, Newcastle, Verkykkop and Bethal (see Figure B.1).

The CALMET meteorological model requires hourly average *surface data* as input, including wind speed, wind direction, mixing depth, cloud cover, temperature, relative humidity, pressure and precipitation. The mixing depth is not readily measured and needed to be calculated based on readily available data, viz. temperature and predicted solar radiation. The daytime mixing heights were calculated with the prognostic equations of Batchvarova and Gryning (1990), while night-time boundary layer heights were calculated from various diagnostic approaches for stable and neutral conditions. The data availability for each of the surface and upper-air stations used in the current study is given in Table B.1.

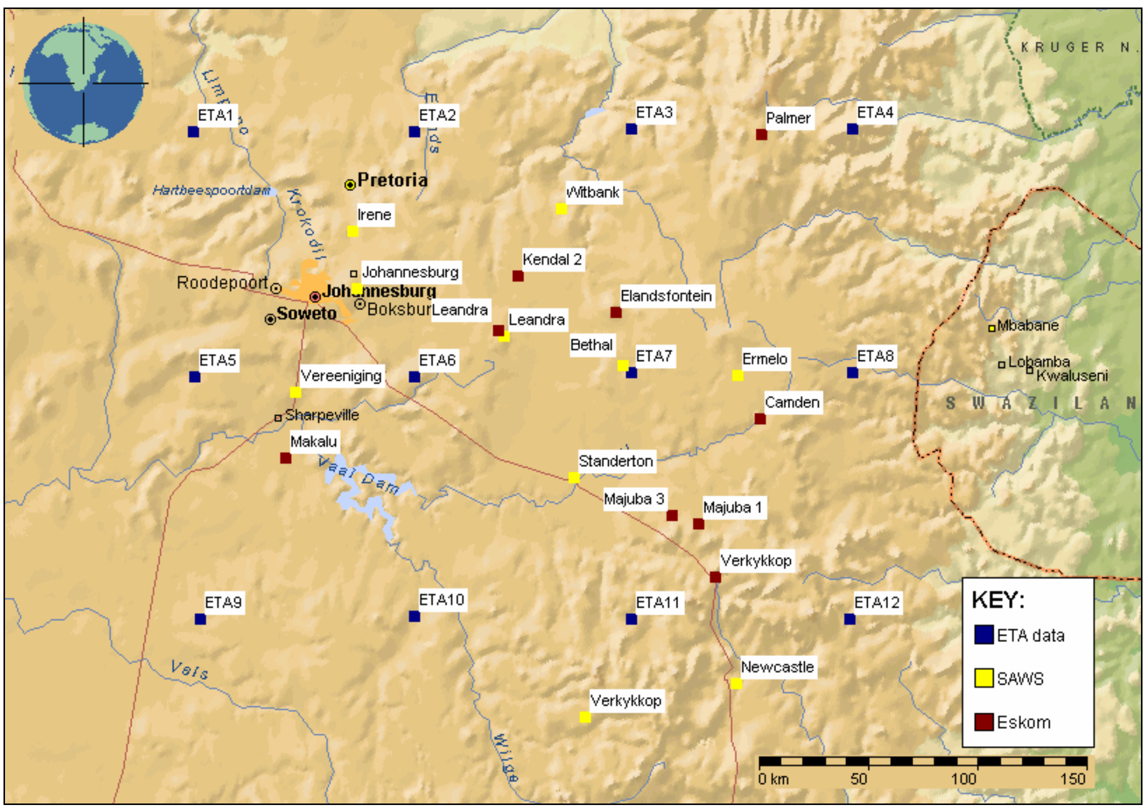

Figure B.1 Location of the ETA-model data points as well as Eskom and SAWS surface monitoring stations for which data were obtained for the simulation of the meteorological field.

A three dimensional meteorological data set for the region was output by the CALMET model for application in the CALPUFF model. This data set parameterised spatial (horizontal and vertical) and temporal variations in the parameters required to model the dispersion and removal of pollutants, including: vertical wind speed, wind direction, temperature, mixing depths, atmospheric stability, (etc.). Meteorological parameters were projected at various heights above the ground, viz.: 20m, 200m, 500m, 1500m, and 3000m. In projecting vertical changes in the windfield, temperature (etc.) it was possible to accurately parameterize the atmospheric conditions characteristic of within valley layers, transitional layers and atmospheric layers located above the terrain. The three-dimensional data set was generated for the base-case years selected (2001 to 2003) and comprised hourly averages for each parameter, thus providing information for each time interval required by the non-steady state CALPUFF dispersion model. For the current study, the base case meteorological year of 2001 was selected for dispersion modelling purposes, giving the most conservative impact results.

Table B.1 Data availability for surface and upper air data for the period 2001 to 2003.

Data	Station	Period		
		2001	**2002**	**2003**
Surface data (SAWS)	Johannesburg	100%	100%	96%
	Irene	99%	91%	92%
	Vereeniging	92%	89%	89%
	Witbank	100%	98%	94%
	Leandra (1)	4%	4%	4%
	Ermelo	100%	100%	99%
	Standerton	90%	97%	95%
	Newcastle	92%	100%	95%
	Verkykkop (1)	4%	4%	4%
	Bethal	12%	12%	10%
Surface data (Eskom)	Verkykkop (VE)	74%	34%	90%
	Elandsfontein (EL)	100%	91%	79%
	Kendal 2 (K2)	93%	96%	100%
	Leandra (LS)	92%	100%	100%
	Majuba 1 (J1)	100%	84%	96%
	Majuba 3 (J3)	82%	88%	93%
	Makalu (MA)	94%	100%	100%
	Palmer (PR)	97%	92%	79%
	Camden (CD) (2)	0%	0%	52%
Upper air data	ETA	100 %	42 %	76%

Notes:
(1) These SAWS stations only record precipitation once a day.
(2) Camden monitoring station was commissioned in 2003.

Source and Emissions Data Inputs

Source parameter requirements for input into the CALPUFF model include stack height, diameter, exit temperature, exit velocity, elevation of stack base above sea level and co-ordinates. Emissions per sources are also required as input to the model (see Section 4 for input source data for the current study).

Model Accuracy and Verification

Comparisons between CALPUFF results, and results generated by the Industrial Source Complex Model Short Term version 3 (ISCST3) model, have shown that CALPUFF is generally more conservative (Strimatis et al., 1998). The ISC model typically produces predictions within a factor of 2 to 10 within complex topography with a high incidence of calm wind conditions. When applied in flat or gently rolling terrain, the USA-EPA (EPA 1986) considers the range of uncertainty of the ISC to be -50% to 200%. CALPUFF predictions have been found to have a greater correlation with observations, with more predictions within a factor of 2 of the observations when compared to the ISC model (Strimatis et al., 1998). It has generally been found that the accuracy of off-the-shelf dispersion models improve with increased averaging periods. The accurate prediction of instantaneous peaks are the most difficult and are normally performed with more complicated dispersion models specifically fine-tuned and validated for the location. The duration of these short-term, peak concentrations are often only for a few minutes and on-site meteorological data are then essential for accurate predictions.

In order to assess whether the dispersion model selected and populated is predicting in the correct order of magnitude, dispersion model results are compared to air pollutant concentrations measured at air quality monitoring stations.

Validation of Dispersion Model Results

In the verification of dispersion model results, predicted concentrations arising due to cumulative basecase emissions from Eskom and other sources were compared to measured concentrations recorded at Eskom and other monitoring stations. Data from the Eskom monitoring stations of Camden (CD), Elandsfontein (EL), Majuba 1 (J1), Majuba 3 (J3), Kendal 2 (K2), Leandra (LS), Makalu (MA), Palmer (PR) and Verkykkop (VE) were compared to simulated results at the monitoring sites. Air quality monitoring data from non-Eskom owned monitoring stations which are in the public domain were also collated to demonstrate model performance in areas where no monitoring is conducted by Eskom. A synopsis of the stations used, the station/data owners and the period of monitoring available is given in Table B.2.

Table B.2 Air quality monitoring data from, available in the public domain, used for verification of dispersion model results

Station	Data Owner	PM10	SO2	NOx
Sasolburg Industrial	Sasol	July 2001 - July 2002	July 2001 - July 2002	July 2001 - July 2002
Boiketlong	Sasol		July 2001 - July 2002	
AJ Jacobs	Sasol		July 2001 - July 2002	
Sasolburg Hospital	Sasol		July 2001 - July 2002	
Bertha Village	New Vaal	2000-2001		
Vanderbijlpark CBD	Mintek	1990-1,1994-5	1992-3	1992-3
Vereeniging	Mintek	1990-1,1994-5		
Orange Farm	City of Joburg	2004-5	2004-5	
Buccleuch	City of Joburg	2005	2005	2005
Alexandra	City of Joburg	Jan 2003 - Sep 2004	Jan 2003 - Sep 2004	Jan 2003 - Sep 2004
Kempton Park	Airkem	2002-3	2002-3	2002-3
Diepsloot	City of Joburg	June - Nov 2004		
Rosslyn	Tshwane Metro		Nov 2003 - July 2004	Nov 2003 - July 2004
Clewer Park	APOLCOM	2000-1	2000-1	2000-1
Strydompark	Mintek	1996-9		
Soweto	CSIR		Jan 1990 - June 1993	Jan 1990 - June 1993
New Town	City of Joburg	April 1999 - June 2002		
Bosjesspruit	Sasol	July 2001 to June 2002	July 2001 to June 2002	July 2001 to June 2002

Modelled SO_2, NO_x and PM10 *concentrations* simulated for current Eskom Power station operations and “other (quantifiable) sources” are compared to monitored concentrations (as recorded by Eskom during 2003) in Table B.3. Measured and modelled highest hourly, highest daily and annual average air pollutant concentrations are given in the table for each of the Eskom monitoring stations. The ratio between measured and modelled concentrations is also presented. Given that the US-EPA gives the range of uncertainty in dispersion model results as being –50% to 200% only model predictions falling outside of this range when compared to monitored concentrations were flagged as being unrepresentative (i.e. measured to modelled ratios of <0.5 or >2.0). Flagged values are indicated in bold print in the table. The measured and modelled frequencies of exceedance of air quality limits are compared in Table B.4.

Table B.3 Comparison of monitored and modelled air pollutant concentrations for current baseline operations (Eskom Power Stations and “other sources”, 2003)

Monitoring Station	Measured SO_2 (µg/m³)			Measured NO_2 (µg/m³)			Measured PM10 (µg/m³)		
	Highest hourly	Highest daily	Annual average	Highest hourly	Highest daily	Annual average	Highest hourly	Highest daily	Annual average
Verkykkop	366	78	14	114	36	9	292	51	15
Elandsfontein	741	138	28	106	25	7	820	202	42
Kendal2	**2112**	**381**	**47**	**144**	**56**	**15**	**2431**	**199**	**57**
Leandra	563	117	23	NM	NM	NM	672	114	46
Majuba1	560	129	18	NM	NM	NM	180	37	19
Majuba3	560	129	18	NM	NM	NM	1265	208	32
Makalu	798	101	19	87	44	14	445	122	26
Palmer	408	147	16	72	24	4	314	57	26

Camden	249	48	9	94	21	4	707	91	23
	Modelled SO_2 (µg/m³)			**Modelled NO_2 (µg/m³)**			**Modelled PM10 (µg/m³)**		
	Highest hourly	**Highest daily**	**Annual average**	**Highest hourly**	**Highest daily**	**Annual average**	**Highest hourly**	**Highest daily**	**Annual average**
Verkykkop	239	36	5	67.0	11.4	1.4	67	22	2
Elandsfontein	490	152	26	137.7	51.4	8.0	154	56	5
Kendal2	**2430**	**374**	**41**	**172.3**	**36.0**	**6.0**	**119**	**53**	**6**
Leandra	362	142	21	143.9	41.8	6.2	102	46	6
Majuba1	1382	184	18	101.4	24.8	3.0	104	39	3
Majuba3	1007	125	13	134.5	17.5	3.2	128	43	3
Makalu	705	88	17	166.4	21.9	3.9	415	55	11
Palmer	75	29	2	27.0	8.3	0.7	32	11	1
Camden	138	57	10	44.4	16.1	3.2	70	29	3
	Ratio between Measured and Modelled SO_2 Concentrations			**Ratio between Measured and Modelled NO_2 Concentrations**			**Ratio between Measured and Modelled PM10 Concentrations**		
	Highest hourly	**Highest daily**	**Annual average**	**Highest hourly**	**Highest daily**	**Annual average**	**Highest hourly**	**Highest daily**	**Annual average**
Verkykkop	0.65	**0.46**	**0.36**	0.59	**0.32**	**0.16**	**0.23**	**0.42**	**0.12**
Elandsfontein	0.66	1.10	0.94	1.30	**2.06**	1.15	**0.19**	**0.28**	**0.13**
Kendal2	**1.15**	**0.98**	**0.87**	**1.20**	**0.64**	**0.40**	**0.05**	**0.26**	**0.10**
Leandra	0.64	1.22	0.90				**0.15**	**0.40**	**0.13**
Majuba1	1.80	1.19	0.64				0.58	1.06	**0.17**
Majuba3	1.80	0.97	0.71				**0.10**	**0.21**	**0.11**
Makalu	0.88	0.87	0.88	1.91	0.50	**0.28**	0.93	**0.45**	**0.42**
Palmer	**0.18**	**0.20**	**0.14**	**0.37**	**0.35**	**0.17**	**0.10**	**0.19**	**0.03**
Camden	0.55	1.18	1.15	**0.47**	0.77	0.80	**0.10**	**0.31**	**0.15**

Comparison of Modelled and Predicted SO_2

Generally there was *very good comparison between the monitored and predicted ground level SO_2 concentrations* at the various monitoring sites, with most of the monitoring stations falling within the accuracy range of the model, i.e. ratio of >0.5 and <2.0 (Tables B.2 and B.3).

At the *Palmer* (PR) station the predicted ground level concentrations were lower than the monitored concentrations for highest hourly (all three years), highest daily (2003) and annual averaging periods (2003). This could be attributed to other sources not being accounted for at the monitoring site during modelling. Similarly, "other sources" located to the south of the modelling domain and not included in the simulations are likely to have resulted in the underprediction of annual average sulphur dioxide concentrations recorded at Verkykkop monitoring station. Due to improved estimates of household coal burning emissions from areas located east of Sasolburg (Zamdela) it was possible to improve the sulphur dioxide concentration predictions at Makalu.

Table B.4 Comparison of monitored and modelled frequencies of exceedance of air quality limits due to current baseline operations (Eskom Power Stations and "other sources", 2003) (Data availabilities given in brackets after measured frequencies.)

Monitoring Station	Frequencies of Exceedance (hours or days per year) of:													
	Hourly EC SO_2 limit of 350 µg/m³		Daily SANS SO_2 limit of 125 µg/m³		Hourly SA NO_2 limit of 382 µg/m³		Hourly SANS NO_2 limit of 200 µg/m³		Daily NO_2 limit of 191 µg/m³		Daily SANS PM10 limit of 75 µg/m³		Daily EC PM10 limit of 50 µg/m³	
	Measured	Predicted	Measured	Predicted	Measured	Predicted	Measured	Predicted	Measured	Predicted	Measured	Predicted	Measured	Predicted
Verkykkop	1 (36%)	0	0 (36%)	0	0 (76%)	0	0 (76%)	0	0 (76%)	0	0 (98%)	0	1 (98%)	0
Elandsfontein	3 (68%)	6	1 (68%)	2	0 (42%)	0	0 (42%)	0	0 (42%)	0	22 (77%)	0	59 (77%)	2
Kendal2	**202(25%)**	**204**	**27 (25%)**	**17**	**0 (98%)**	**0**	**0 (98%)**	**0**	**0 (98%)**	**0**	**15 (98%)**	**0**	**54 (98%)**	**2**
Leandra	19 (21%)	**2**	0 (21%)	**1**	NM	0	NM	0	NM	0	18 (99%)	0	32 (99%)	0
Majuba1	28(11%)	35	1 (11%)	1	NM	0	NM	0	NM	0	0 (97%)	0	0 (97%)	0
Majuba3		14		1	NM	0	NM	0	NM	0	9 (57%)	0	27 (57%)	0
Makalu	6 (73%)	7	0 (73%)	0	0 (99.6%)	0	0 (99.6%)	0	0 (99.6%)	0	16 (95%)	0	45 (95%)	4
Palmer	2 (73%)	0	2 (73%)	0	0 (78%)	0	0 (78%)	0	0 (78%)	0	0 (78%)	0	7 (78%)	0
Camden	0 (67%)	0	0 (67%)	0	0 (67%)	0	0 (67%)	0	0 (67%)	0	4 (67%)	0	42 (67%)	0

NM – not measured

Comparison of Modelled and Predicted NO_2

Measured and monitored nitrogen oxide concentrations compared relatively well at most of the station with the exception of Palmer and Verkkykkop for reasons given above. Annual nitrogen dioxide levels at the Kendal 2 and Makalu sites are also underpredicted (Table B.2 and B.3). Although predicted highest daily nitrogen dioxide concentrations were found to be higher than those measured at Elandsfontein, it is notable that the data availability at this station is only 42% for 2003.

Comparison of Modelled and Predicted PM10

Although predicted ground level concentrations for PM10 did not compare well with monitored data at the various Eskom monitoring stations despite the formation of secondary pollutants being accounted for in the modelling (Table B.2 and B.3). This is to be expected given that certain sources anticipated to contribute significantly to suspended particulate concentrations at these locations could either not be accounted for in the modelling (most notably veld burning, vehicle entrainment along unpaved roads) or are located outside of the modelling domain (long-range regional aerosols from distant biomass burning and aeolian dust).

APPENDIX C –

ATMOSPHERIC DISPERSION SIMULATION RESULTS – AIR POLLUTANT CONCENTRATIONS AND DUST DEPOSITION RATES DUE TO CURRENT BASELINE CONDITIONS

Scenario	Pollutant	Averaging Period	Figure No.
Current Baseline Conditions	Sulphur dioxide	Highest hourly	C.1
		Highest daily	C.2
		Annual average	C.3
		Frequency of exceedance of hourly limit of 350 µg/m³	C.4
		Frequency of exceedance of daily limit of 125 µg/m³	C.5
	Nitrogen dioxide	Highest hourly	C.6
		Annual average	C.7
		Frequency of exceedance of hourly limit of 200 µg/m³	C.8
	PM10	Highest daily	C.9
		Annual average	C.10
		Frequency of exceedance of daily limit of 75 µg/m³	C.11
	Dustfall	Maximum monthly dustfall rate	C.12

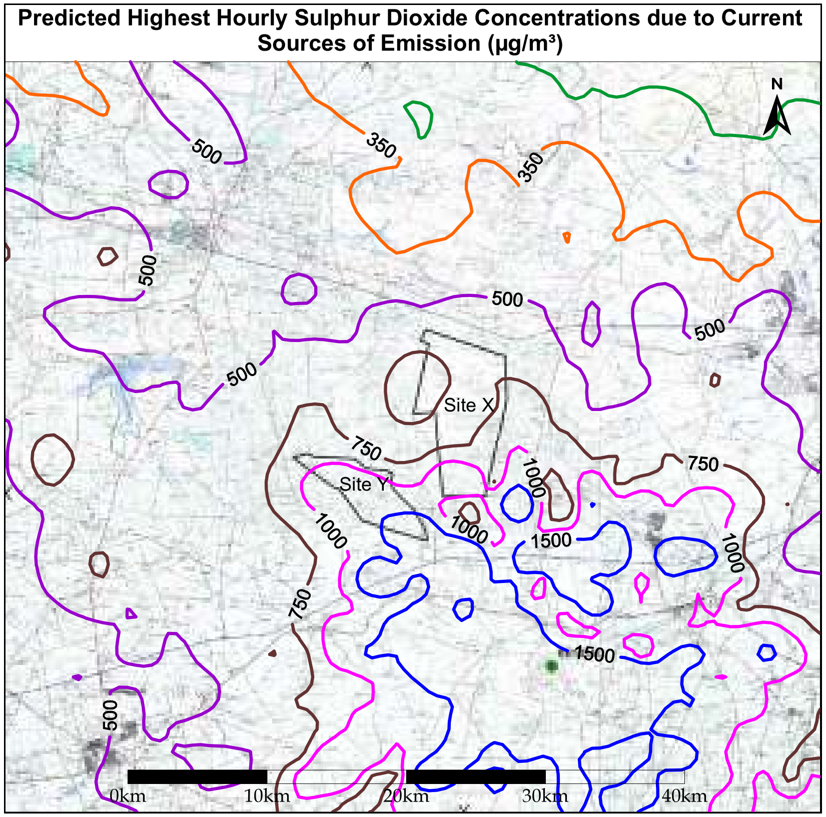

Figure C.1 Predicted highest hourly average sulphur dioxide due to current baseline conditions

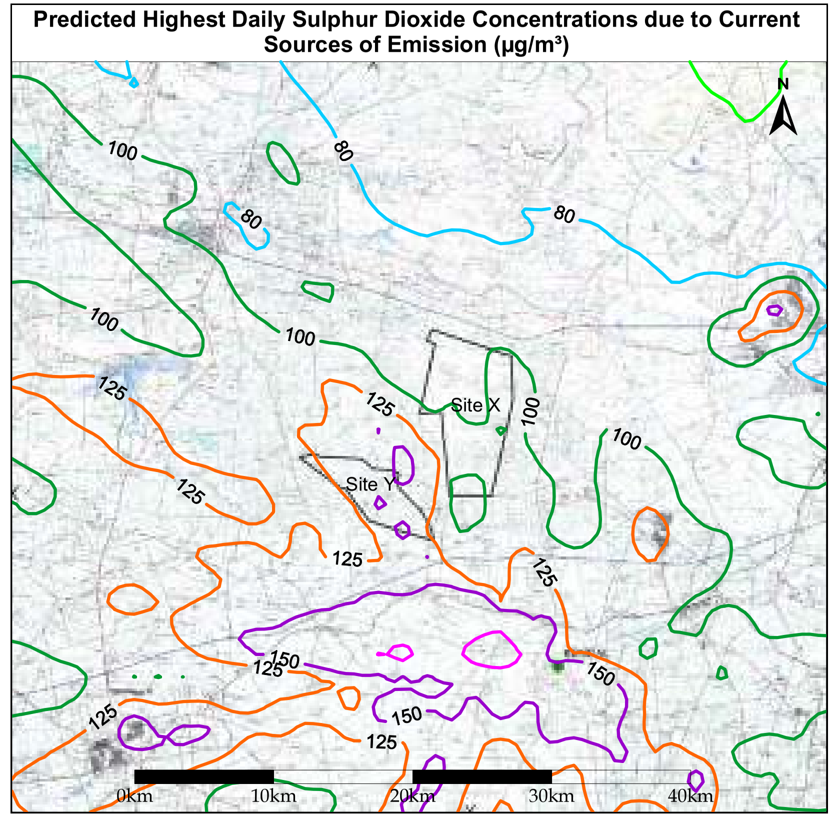

Figure C.2 Predicted highest daily average sulphur dioxide due to current baseline conditions

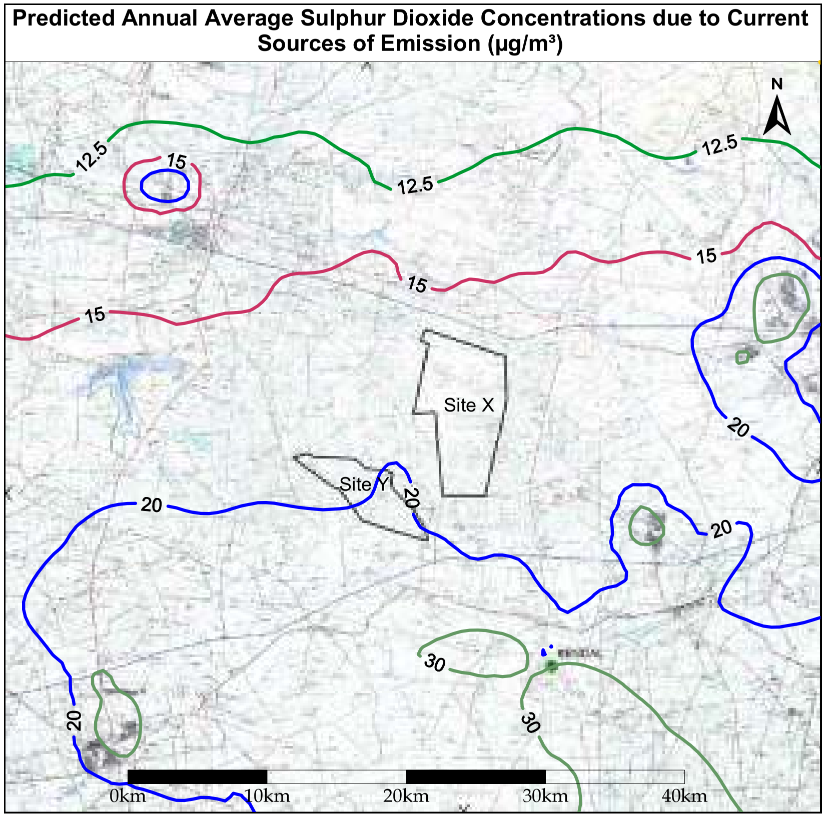

Figure C.3 Predicted annual average sulphur dioxide due to current baseline conditions

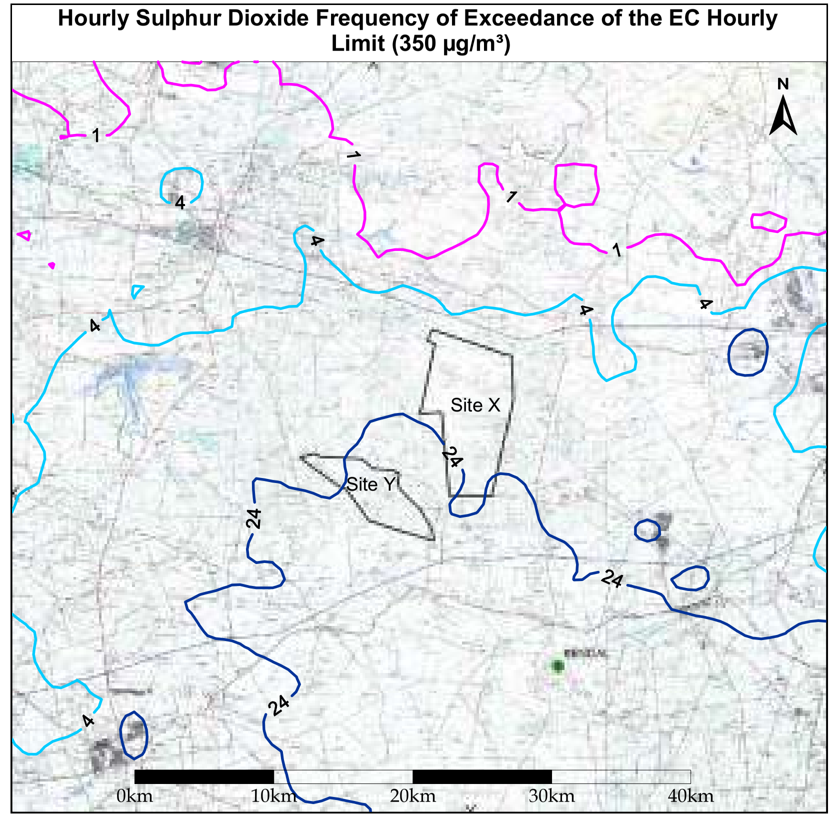

Figure C.4 Predicted frequencies of exceedance of the EC hourly sulphur dioxide limit of 350 µg/m³ due current baseline conditions

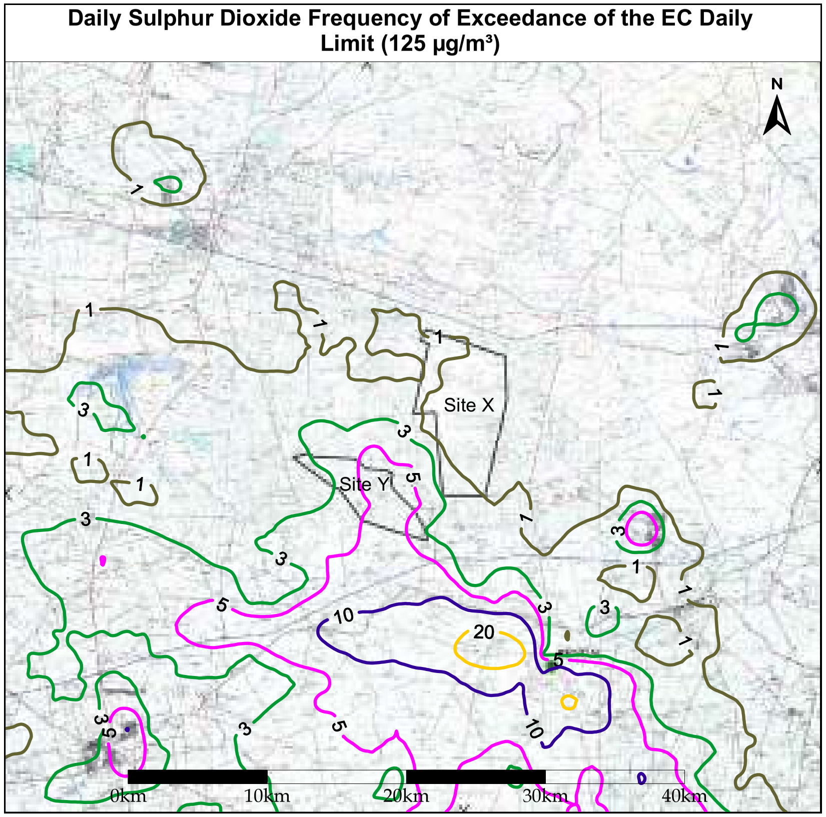

Figure C.5 Predicted frequencies of exceedance of the SA daily sulphur dioxide limit of 125 µg/m³ due current baseline conditions

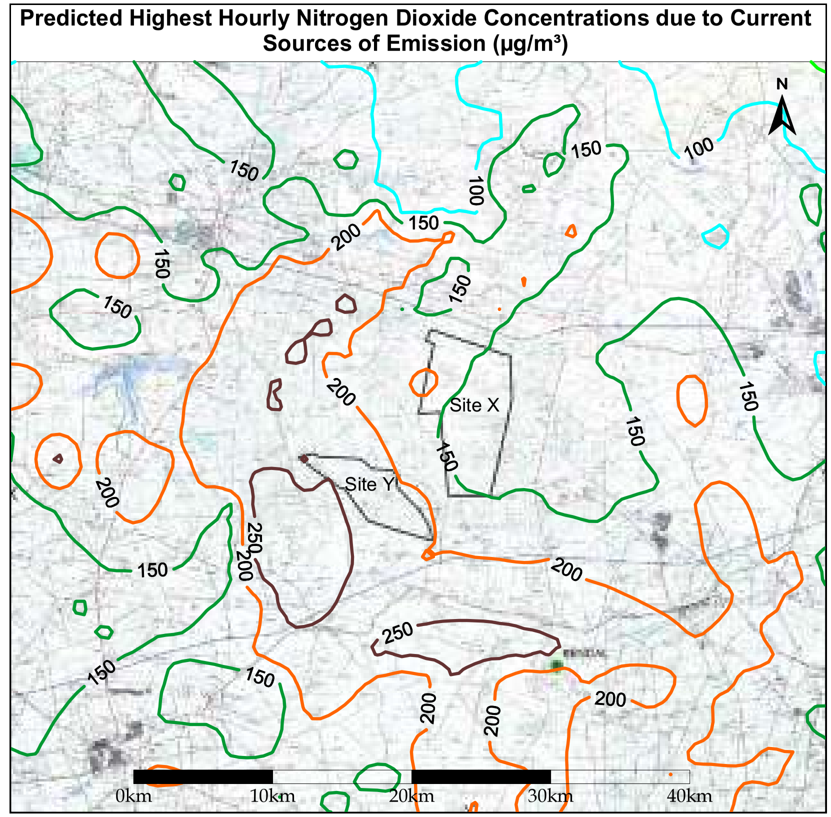

Figure C.6 Predicted highest hourly average nitrogen dioxide due to current baseline conditions

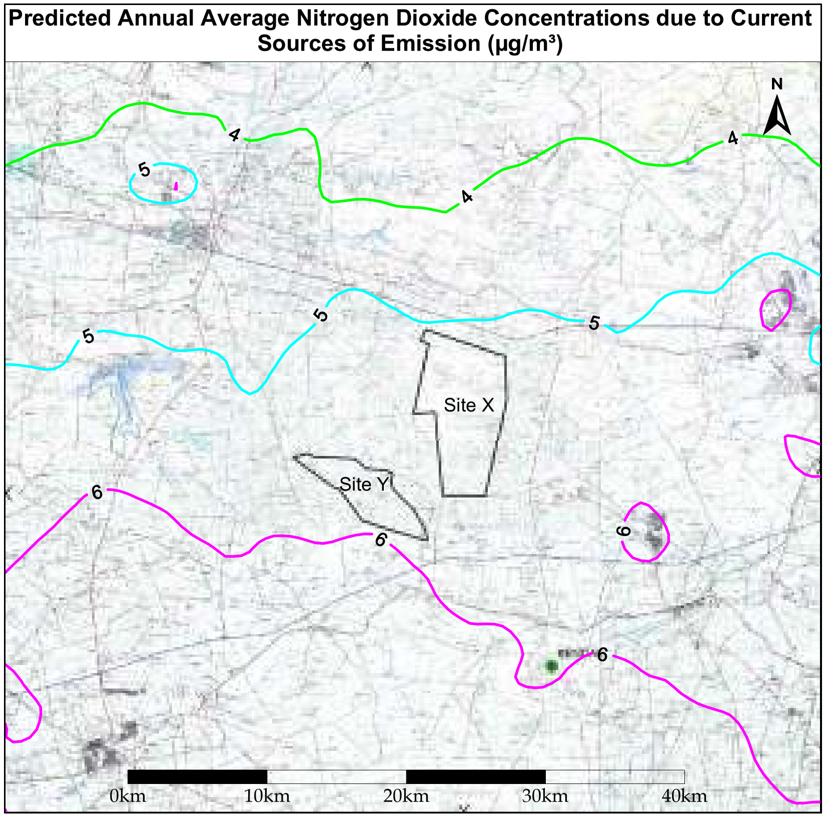

Figure C.7 Predicted annual average nitrogen dioxide due to current baseline conditions

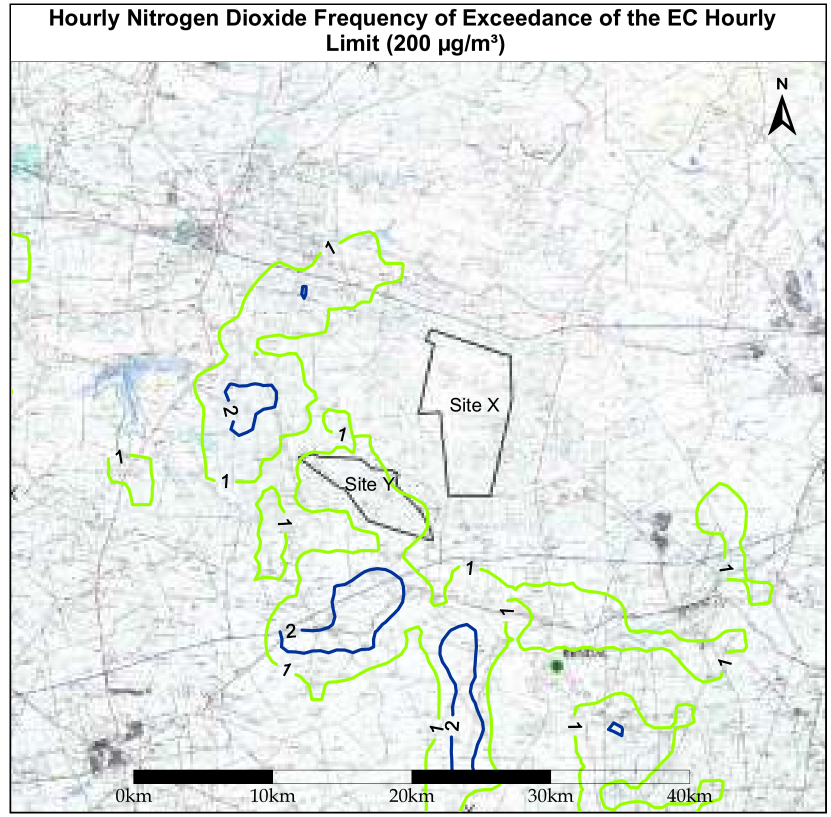

Figure C.8 Predicted frequencies of exceedance of the SANS hourly nitrogen dioxide limit of 200 µg/m³ due current baseline conditions

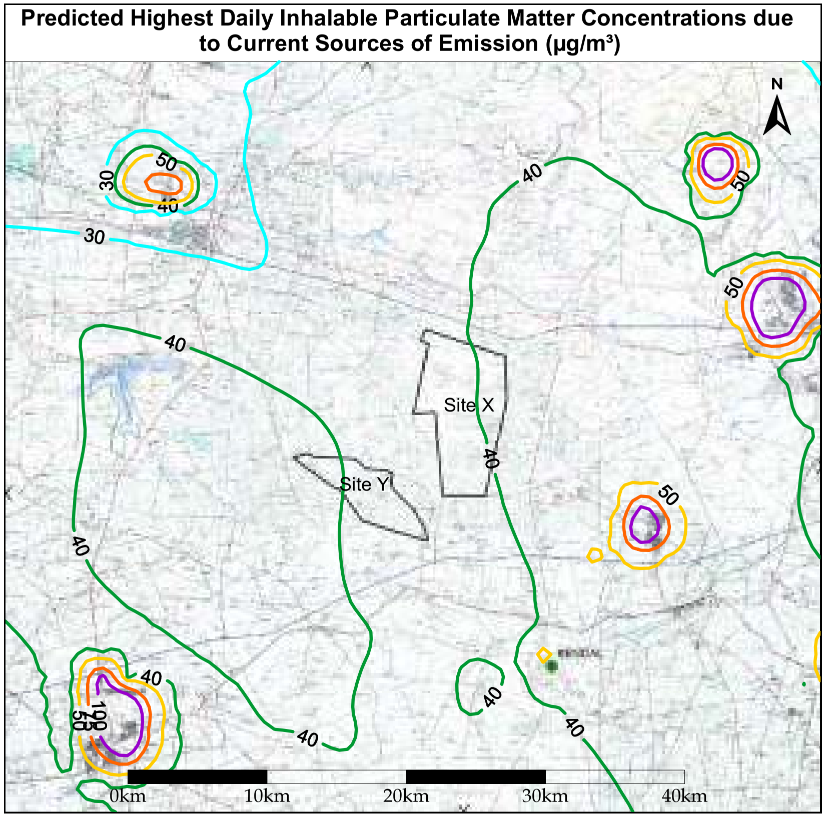

Figure C.9 Predicted highest daily average PM10 concentrations due to current baseline conditions

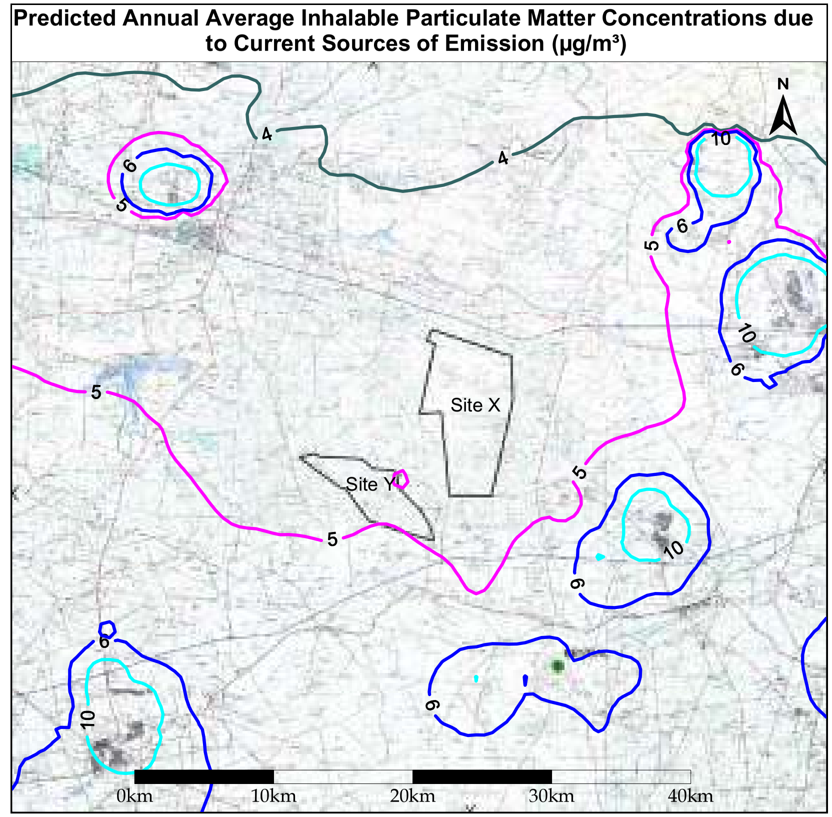

Figure C.10 Predicted annual average PM10 concentrations due to current baseline conditions

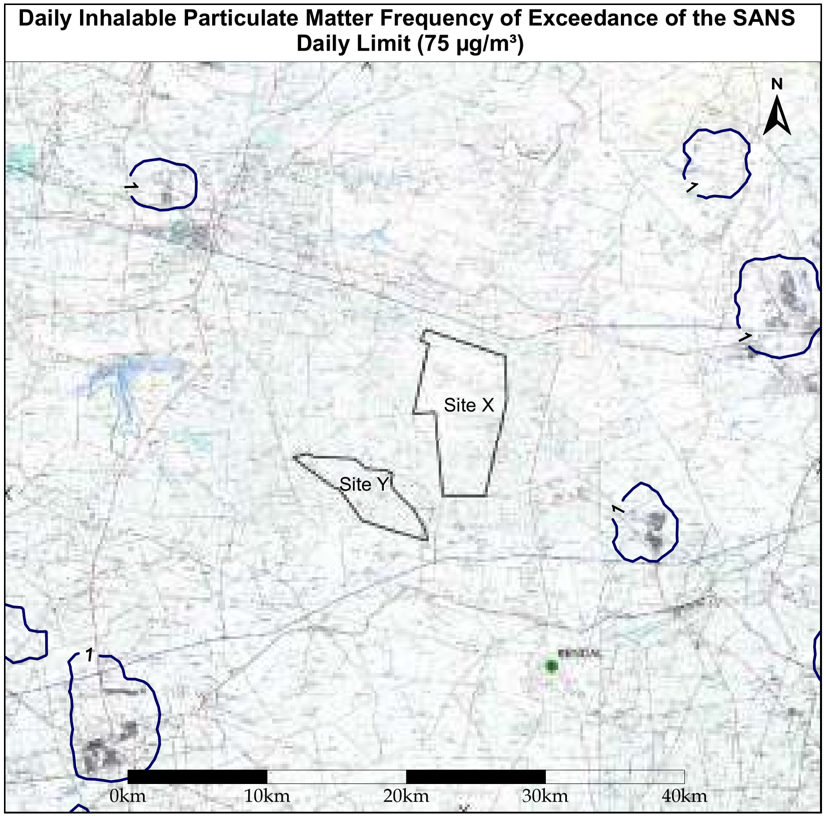

Figure C.11 Predicted frequencies of exceedance of the SANS daily PM10 limit of 75 µg/m³ due current baseline conditions

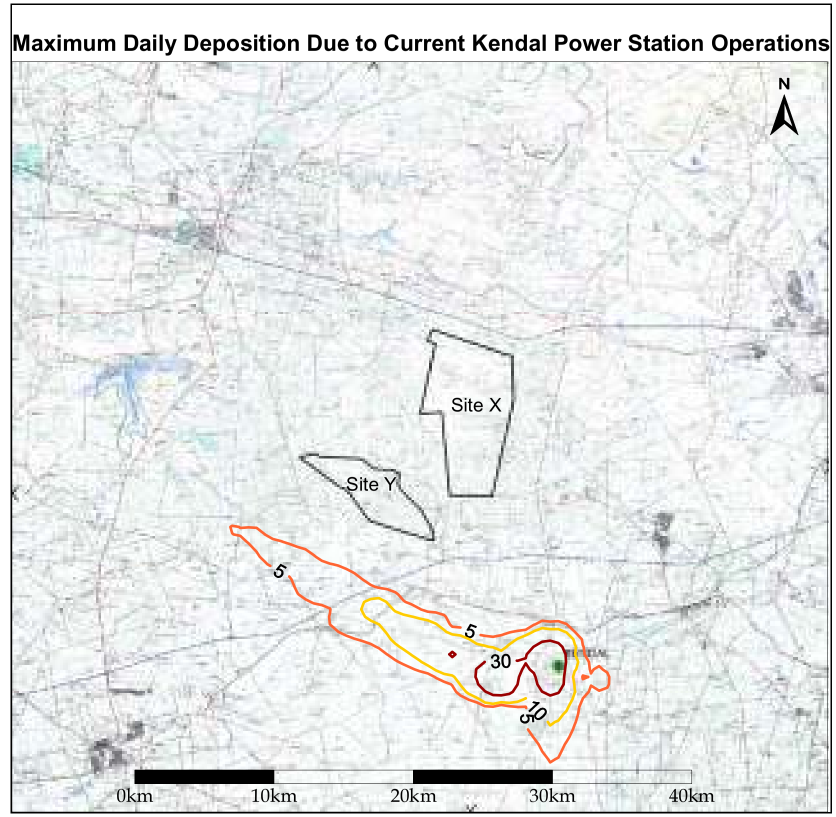

Figure C.12 Predicted maximum monthly dustfall rate due to current baseline conditions

APPENDIX D –

PROPOSED KENDAL NORTH POWER STATION - ATMOSPHERIC DISPERSION SIMULATION RESULTS – MAXIMUM HOURLY, DAILY AND ANNUAL CONCENTRATIONS DUE TO VARIOUS POWER STATION CONFIGURATION SCENARIOS

NOTE: PM10 Concentrations given in tables is due exclusively to stack emissions – including primary particulate releases and secondary particulate formation following atmospheric conversion of SOx and NOx emissions. Total PM10 concentrations due to all sources, stacks and fugitive dust sources, are depicted in Appendix F.

Power station configuration options which were included in the study are as follows:

Scenario	No. of Units	Proposed Site	Stack Height (m)	SO_2 Control Efficiency
A.1	6 x 900 MW	Site X	150	0%
B.1	6 x 900 MW	Site Y	150	0%
C.1	6 x 900 MW	Site X	220	0%
D.1	6 x 900 MW	Site Y	220	0%
E.1	6 x 900 MW	Site X	300	0%
F.1	6 x 900 MW	Site Y	300	0%
A.2	6 x 900 MW	Site X	150	90%
B.2	6 x 900 MW	Site Y	150	90%
C.2	6 x 900 MW	Site X	220	90%
D.2	6 x 900 MW	Site Y	220	90%
E.2	6 x 900 MW	Site X	300	90%
F.2	6 x 900 MW	Site Y	300	90%

SCENARIO A.1 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
Location	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**5879**	**388**	**73**	**1060**	65	12	**347**	53	10	**198**	**85**
Phola	**1366**	**222**	**57**	240	35	9	205	41.6	9.9	120	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**16.80**	**3.10**	**1.46**	**1.41**	0.17	0.06	**1.73**	0.28	0.26	**2.65**	**2.12**
Phola	**3.90**	**1.78**	**1.14**	0.32	0.09	0.05	1.03	0.22	0.25	1.60	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO B.1 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**4814**	**438**	**70**	1060	65	11	**328**	71	11	**197**	85
Phola	**1206**	**188**	49	240	35	8	200	42	9.8	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**3.50**	**1.40**	**1.41**	0.17	0.06	**1.64**	0.38	0.27	**2.63**	**2.12**
Phola	**3.45**	**1.50**	0.98	0.32	0.09	0.04	1.00	0.22	0.25	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO C.1 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**4814**	**346**	**66**	**1060**	65	11	**311**	56	10	**197**	85
Phola	**1279**	**159**	**51**	240	30	8.5	185	41	9.4	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.77**	**1.32**	**1.41**	0.17	0.06	**1.55**	0.30	0.25	**2.62**	**2.12**
Phola	**3.65**	**1.27**	**1.02**	0.32	0.08	0.05	0.93	0.22	0.24	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO D.1 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [a]	**4814**	**350**	**67**	**1060**	65	11	**295**	59	10	**196**	**85**
Phola	**1206**	**153**	48	240	32	8	180	39.8	9.5	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.80**	**1.34**	**1.41**	0.17	0.06	**1.48**	0.32	0.26	**2.61**	**2.12**
Phola	**3.45**	**1.22**	0.96	0.32	0.09	0.04	0.90	0.21	0.24	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO E.1 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**4814**	**343**	**61**	**1060**	65	11	**336**	48	10	**196**	**85**
Phola	**1206**	**158**	47	240	30	8	180	40.3	9	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.75**	**1.23**	**1.41**	0.17	0.06	**1.68**	0.26	0.25	**2.61**	**2.11**
Phola	**3.45**	**1.26**	0.94	0.32	0.08	0.04	0.90	0.21	0.23	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO F.1 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**5170**	**348**	**63**	**1060**	65	10	**292**	59	10	**196**	**85**
Phola	**1206**	**158**	45	240	32	8	180	41	9.2	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**14.77**	**2.78**	**1.26**	**1.41**	0.17	0.06	**1.46**	0.31	0.25	**2.61**	**2.12**
Phola	**3.45**	**1.26**	0.90	0.32	0.09	0.04	0.90	0.22	0.23	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO A.2 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**4814**	**326**	**51**	**1060**	65	12	**347**	53	10	**198**	**84**
Phola	**1206**	**135**	36	240	35	9	**205**	41.6	9.9	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.61**	**1.02**	**1.41**	0.17	0.06	**1.73**	0.28	0.26	**2.63**	**2.11**
Phola	**3.45**	**1.08**	0.72	0.32	0.09	0.05	**1.03**	0.22	0.25	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO B.2 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum (a)	**4814**	**326**	**51**	**1060**	65	11	**328**	71	11	**197**	**84**
Phola	**1206**	**135**	35	240	35	8	200	42	9.8	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.61**	**1.03**	**1.41**	0.17	0.06	**1.64**	0.38	0.27	**2.62**	**2.11**
Phola	**3.45**	**1.08**	0.70	0.32	0.09	0.04	1.00	0.22	0.25	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO C.2 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**4814**	**326**	**51**	**1060**	65	11	**311**	56	10	**196**	**84**
Phola	**1206**	**135**	36	240	30	8.5	185	41	9.4	**120**	30

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.61**	**1.01**	**1.41**	0.17	0.06	**1.55**	0.30	0.25	**2.61**	**2.11**
Phola	**3.45**	**1.08**	0.72	0.32	0.08	0.05	0.93	0.22	0.24	**1.60**	0.75

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO D.2 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**4814**	**327**	**51**	**1060**	65	11	**295**	59	10	**196**	**84**
Phola	**1206**	**135**	35	240	32	8	180	39.8	9.5	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.61**	**1.02**	**1.41**	0.17	0.06	**1.48**	0.32	0.26	**2.61**	**2.11**
Phola	**3.45**	**1.08**	0.70	0.32	0.09	0.04	0.90	0.21	0.24	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO E.2 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**4814**	**326**	**50**	**1060**	65	11	**336**	48	10	**196**	**84**
Phola	**1206**	**135**	35	240	30	8	180	40.3	9	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.61**	**1.01**	**1.41**	0.17	0.06	**1.68**	0.26	0.25	**2.61**	**2.11**
Phola	**3.45**	**1.08**	0.70	0.32	0.08	0.04	0.90	0.21	0.23	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

SCENARIO F.2 - Predicted SO_2, NO, NO_2 and PM10 concentrations occurring – given at the point of maximum ground level concentration (glc) and at nearby sensitive receptor locations. (Exceedance of air quality limit values indicated in bold.)

Location	Sulphur Dioxide Concentrations			Nitric Oxide Concentrations			Nitrogen Dioxide Concentrations			PM10 Concentrations	
	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Hourly (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)	Highest Daily (µg/m³)	Annual Average (µg/m³)
GLC Maximum [(a)]	**4814**	**326**	**51**	**1060**	65	10	**292**	59	10	**196**	**84**
Phola	**1206**	**135**	35	240	32	8	180	41	9.2	**120**	28

Air Quality Limit Value	350	125	50	750	375	188	200	188	40	75	40
Details of Limit Value Used	EC & UK limit, EC permits 4 exceedances; UK 24 exceedances	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SA standard for protection of human health (EC limit for ecosystem given as 20 µg/m³)	SA standard	SA standard	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 8 and 18 exceedances respectively; no permissible frequencies stipulated by SA & WHO	SA standard	SA, WHO, EC, UK Limit – EC & UK permit 3 exceedances; no permissible frequencies stipulated by SA & WHO	SANS limit value (no permissible frequencies stipulated to date)	SANS limit (also EC and UK limit)

	Predicted Sulphur Dioxide Concentrations as a Fraction of the Selected Limit			Predicted Nitric Oxice Concentrations as a Fraction of the Selected Limit			Predicted Nitrogen Dioxide Concentrations as a Fraction of the Selected Limit			Predicted PM10 Levels as a Fraction of Selected Limit	
	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Hourly	Highest Daily	Annual Average	Highest Daily	Annual Average
GLC Maximum	**13.75**	**2.61**	**1.01**	**1.41**	0.17	0.06	**1.46**	0.31	0.25	**2.61**	**2.11**
Phola	**3.45**	**1.08**	0.70	0.32	0.09	0.04	0.90	0.22	0.23	**1.60**	0.70

(a) Within a 25km radius from the proposed Kendal North Power Station sites

APPENDIX E –

PROPOSED KENDAL NORTH POWER STATION – POTENTIAL FOR COMPLIANCE WITH AIR QUALITY LIMITS, HEALTH RISKS, VEGETATION INJURY AND CORROSION

SCENARIO A.1 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

Receptor Category	Receptor Name	Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
		Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	5879	388	73	3.7	medium	4.5	3.7	high	low(a)	446	57	FALSE	FALSE
Residential areas	Phola	1366	222	57	2.9	medium	1.1	2.9	high	moderate	182	28	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO B.1 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	438	70	3.5	medium	3.7	3.5	high	low(a)	470	64	FALSE	FALSE
Residential areas	Phola	1206	188	49	2.5	medium	0.9	2.5	moderate	moderate	110	21	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO C.1 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	346	66	3.3	medium	3.7	3.3	high	low(a)	394	51	FALSE	FALSE
Residential areas	Phola	1279	159	51	2.6	medium	1.0	2.6	high	moderate	99	19	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO D.1 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	350	67	3.3	medium	3.7	3.3	high	low(a)	429	54	FALSE	FALSE
Residential areas	Phola	1206	153	48	2.4	medium	0.9	2.4	high	moderate	77	16	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO E.1 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	343	61	3.1	medium	3.7	3.1	high	low(a)	366	48	FALSE	FALSE
Residential areas	Phola	1206	158	47	2.4	medium	0.9	2.4	high	moderate	68	14	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO F.1 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	5170	348	63	3.2	medium	4.0	3.2	high	low(a)	389	47	FALSE	FALSE
Residential areas	Phola	1206	158	45	2.3	medium	0.9	2.3	high	moderate	45	10	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO A.2 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	326	51	2.5	medium	3.7	2.5	high	low(a)	302	35	FALSE	FALSE
Residential areas	Phola	1206	135	36	1.8	medium	0.9	1.8	moderate	moderate	19	7	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO B.2 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	326	51	2.6	medium	3.7	2.6	high	low(a)	308	35	FALSE	FALSE
Residential areas	Phola	1206	135	35	1.8	medium	0.9	1.8	moderate	moderate	19	7	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO C.2 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	326	51	2.5	medium	3.7	2.5	high	low(a)	302	35	FALSE	FALSE
Residential areas	Phola	1206	135	36	1.8	medium	0.9	1.8	moderate	moderate	19	7	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO D.2 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	327	51	2.6	medium	3.7	2.6	high	low(a)	308	35	FALSE	FALSE
Residential areas	Phola	1206	135	35	1.8	medium	0.9	1.8	moderate	moderate	19	7	FALSE	FALSE

Notes:
(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO E.2 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	326	50	2.5	medium	3.7	2.5	high	low(a)	301	35	FALSE	FALSE
Residential areas	Phola	1206	135	35	1.8	medium	0.9	1.8	moderate	moderate	19	7	FALSE	FALSE

Notes:
(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

SCENARIO F.2 - Potential for non-compliance, health effects, vegetation damage and corrosion occurring due to sulphur dioxide concentrations

		Predicted SO_2 Concentration (µg/m³)			Corrosion Potential		Potential for Vegetation Injury and Ecosystem Damage			Potential for Health Effects	Compliance Potential			
Receptor Category	Receptor Name	Highest Hourly (99th Percentile)	Highest Daily	Annual Average	Annual Average as Fraction of Threshold for "Medium" Corrosivity (20 µg/m³)	Potential for Corrosion	Highest Hourly as Fraction of Hourly Threshold of 1300 µg/m³	Annual Average as Fraction of EC Annual Limit for Protection of Ecosystems (20 µg/m³)	Potential for Vegetation Damage	Health Risk Categorisation based on Highest Hourly Average	Freq Exc SA 10-minute Limit of 500 µg/m³ (no permissible frequencies) / Freq Exc EC Hourly Limit of 350 µg/m³ (EC permits 24, UK 24)	Freq Exc SA Daily Limit of 125 µg/m³ (EC & UK permit 3)	Compliance with SA Standards	Compliance with UK Standards
Maximum	GLC Maximum	4814	326	51	2.5	medium	3.7	2.5	high	low(a)	308	35	FALSE	FALSE
Residential areas	Phola	1206	135	35	1.8	medium	0.9	1.8	moderate	moderate	19	7	FALSE	FALSE

Notes:

(a) In assessing potential reference is made to the frequencies of exceedance of the threshold for mild respiratory effects in addition to the likelihood of exposure – based on the number of persons residing in the area.

APPENDIX F –

ISOPLETH PLOTS DEPICTING TOTAL FINE PARTICULATE CONCENTRATIONS AND DUSTFALL RATES DUE TO CURRENT AND PROPOSED POWER STATION EMISSIONS (STACK AND FUGITIVE EMISSIONS; PRIMARY AND SECONDARY PARTICULATES)

Predicted Highest Daily Inhalable Particulate Matter Concentrations (µg/m³) due to Current Kendal and Proposed Kendal North Power Station (Site X) Operations Including Primary & Secondary Particulates from Stack Releases & Fugitive Dust Emissions (Assuming Maximum Impact from Proposed Development)

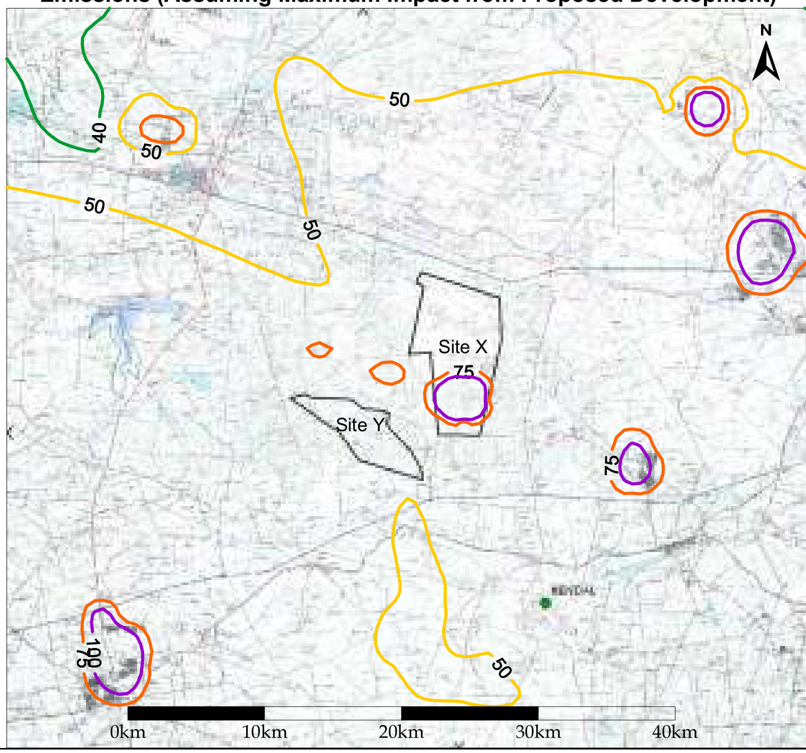

Figure F.1 Highest daily PM10 ground level concentrations due to current Kendal and Proposed Kendal North (at Site X) Power station operations (also including all non-Eskom sources)

Predicted Highest Daily Inhalable Particulate Matter Concentrations (µg/m³) due to Current Kendal and Proposed Kendal North Power Station (Site Y) Operations Including Primary & Secondary Particulates from Stack Releases & Fugitive Dust Emissions (Assuming Maximum Impact from Proposed Development)

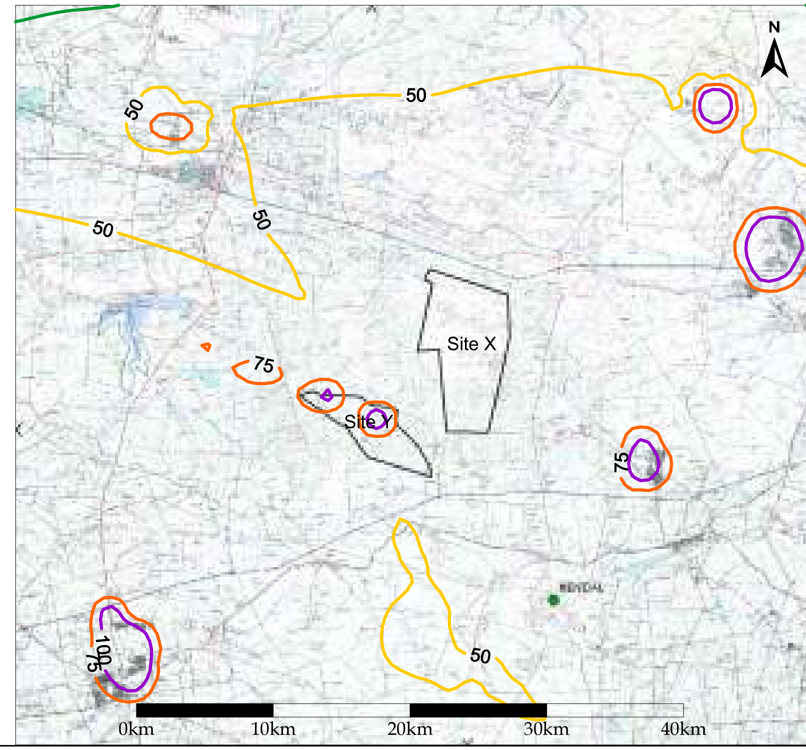

Figure F.2 Highest daily PM10 ground level concentrations due to current Kendal and Proposed Kendal North (at Site Y) Power station operations (also including all non-Eskom sources)

Predicted Annual Average Inhalable Particulate Matter Concentrations (µg/m³) due to Current Kendal and Proposed Kendal North Power Station (Site X) Operations Including Primary & Secondary Particulates from Stack Releases & Fugitive Dust Emissions (Assuming Maximum Impact from Proposed Development)

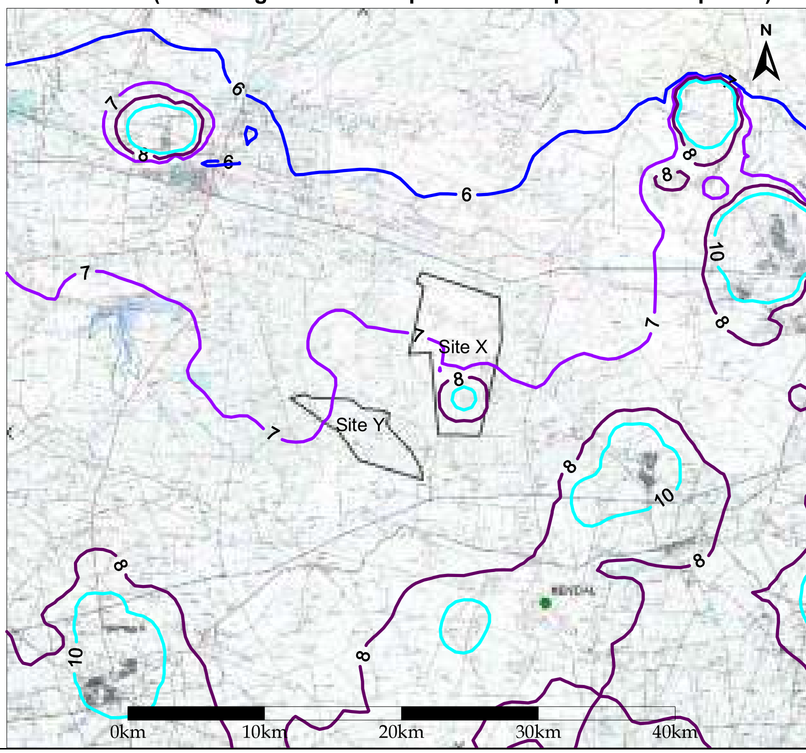

Figure F.3 Annual average PM10 ground level concentrations due to current Kendal and Proposed Kendal North (at Site X) Power station operations (also including all non-Eskom sources)

Predicted Annual Average Inhalable Particulate Matter Concentrations (µg/m³) due to Current Kendal and Proposed Kendal North Power Station (Site Y) Operations Including Primary & Secondary Particulates from Stack Releases & Fugitive Dust Emissions (Assuming Maximum Impact from Proposed Development)

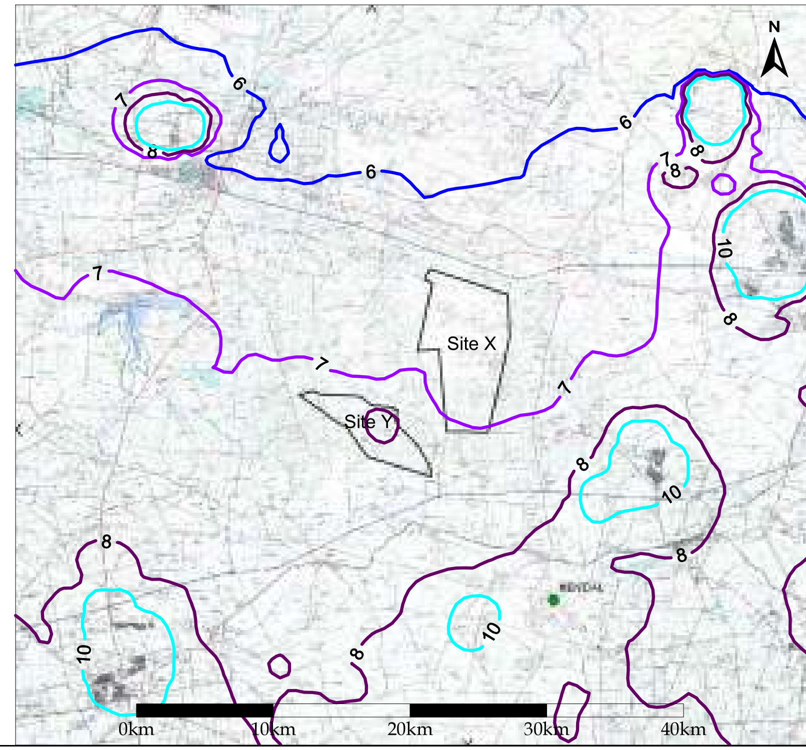

Figure F.4 Annual average PM10 ground level concentrations due to current Kendal and Proposed Kendal North (at Site Y) Power station operations (also including all non-Eskom sources)

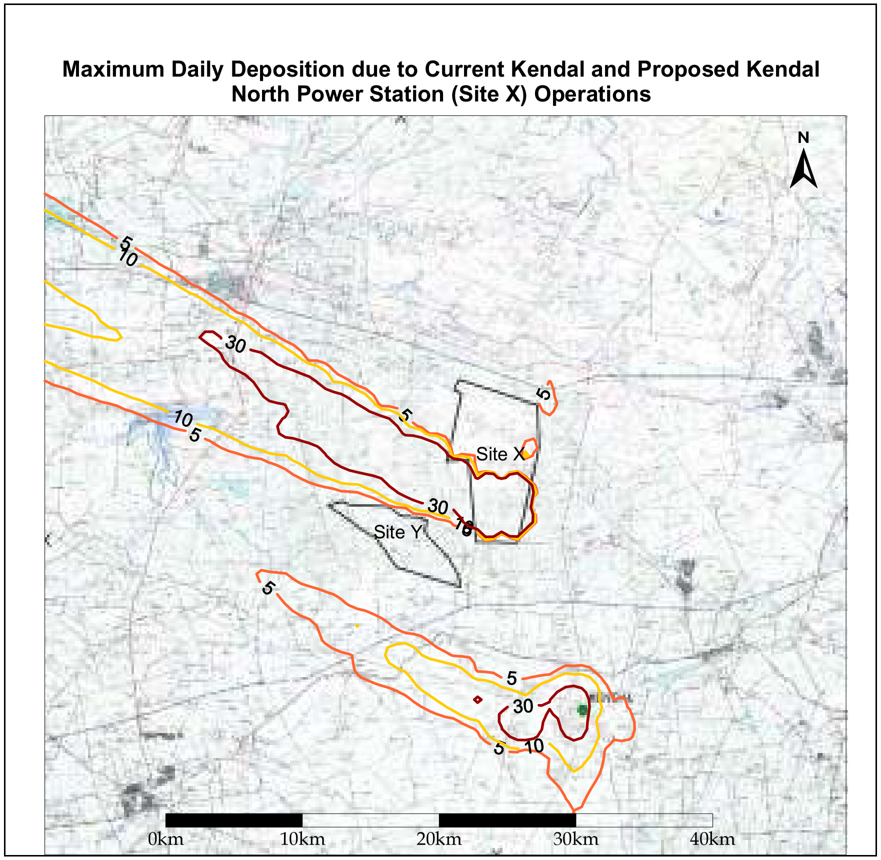

Figure F.5 Maximum daily depostion due to current Kendal and Proposed Kendal North (at Site X) Power station operations

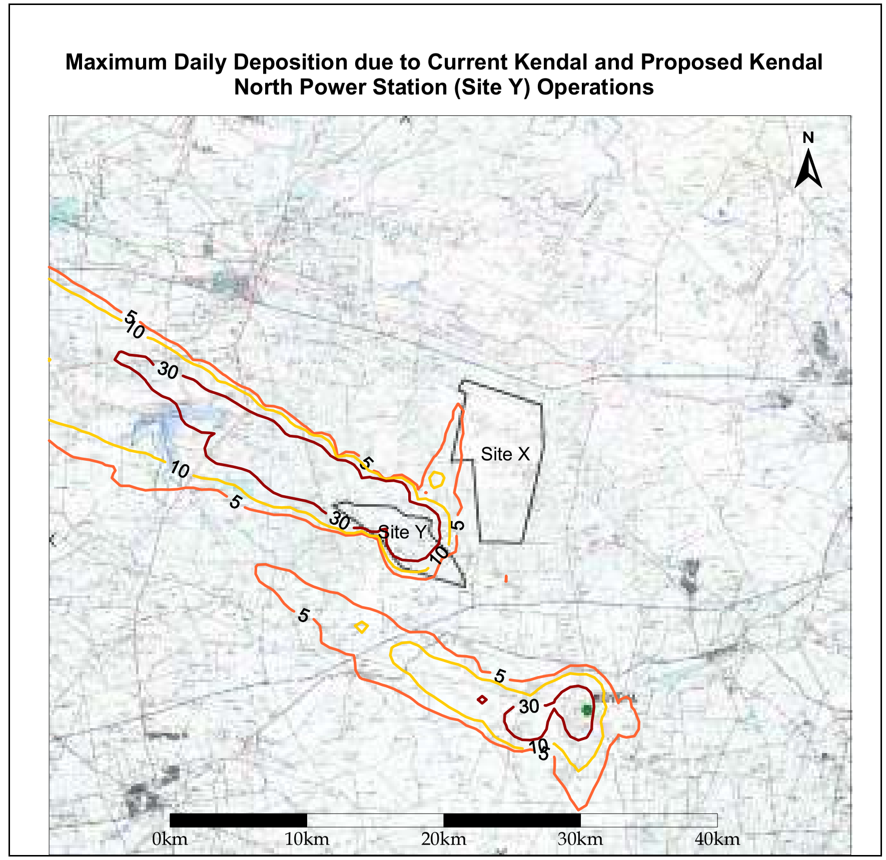

Figure F.6 Maximum daily depostion due to current Kendal and Proposed Kendal North (at Site Y) Power station operations

APPENDIX G –

EXPOSURE POTENTIAL DUE TO THE INTRODUCTION OF THE PROPOSED NEW COAL_FIRED POWER STATION

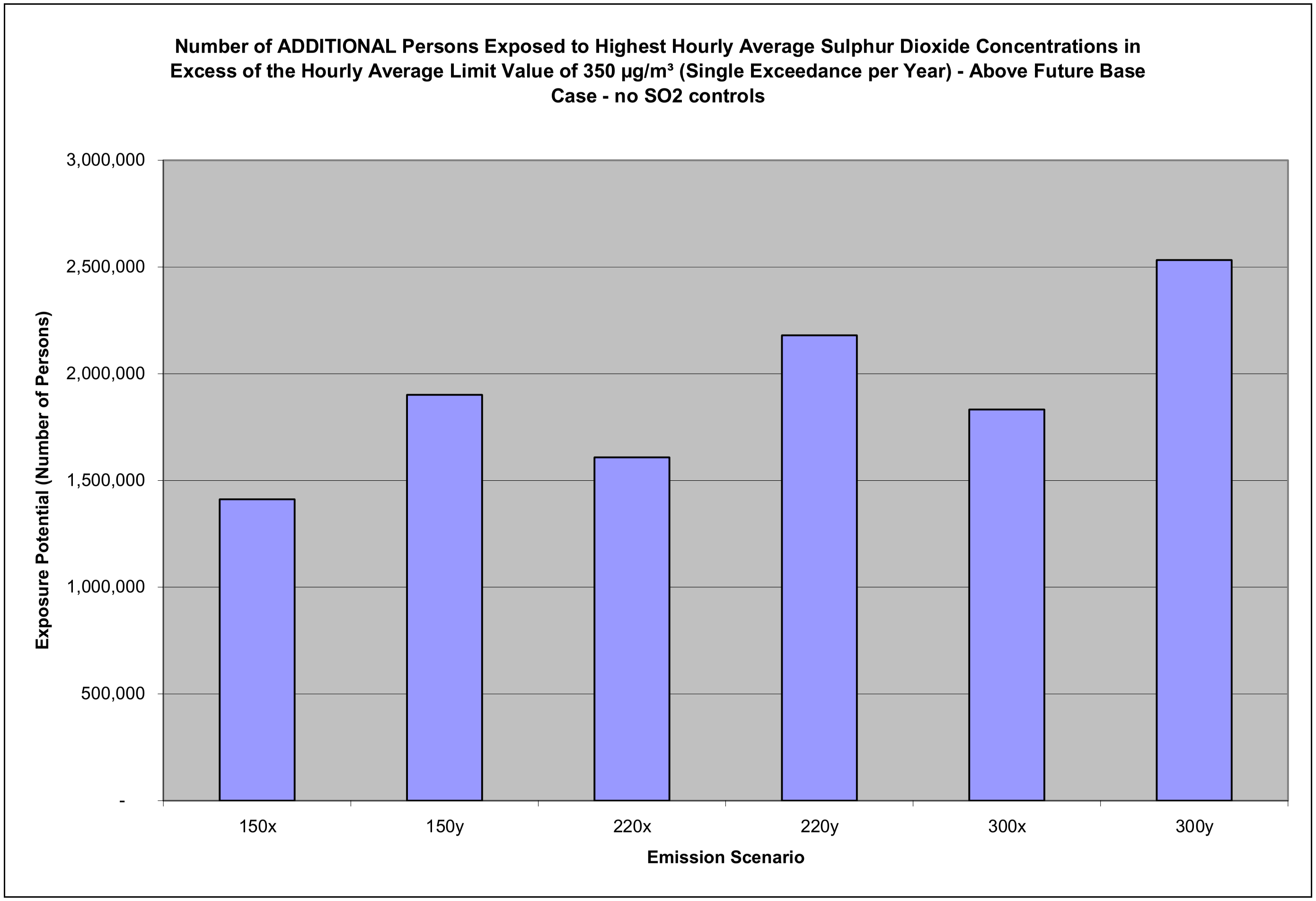

Figure G.1 Additional exposure potential to SO_2 hourly ground level concentrations in excees of the EC hourly limit due to the activities of the proposed new power station <u>with no</u> SO_2 controls in place.

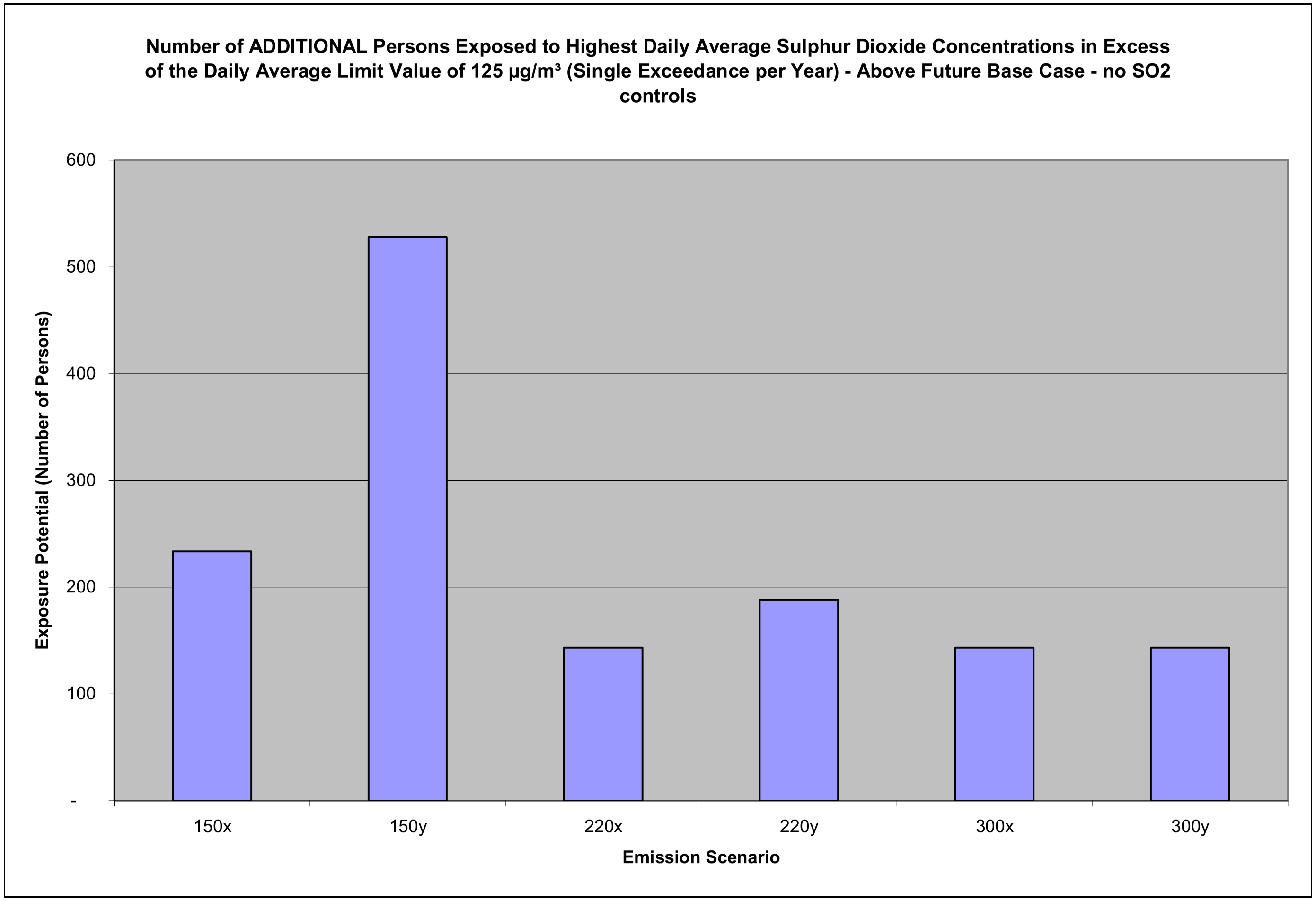

Figure G.2 Additional exposure potential to SO_2 daily ground level concentrations in excees of the EC daily limit due to the activities of the proposed new power station with no SO_2 controls in place.

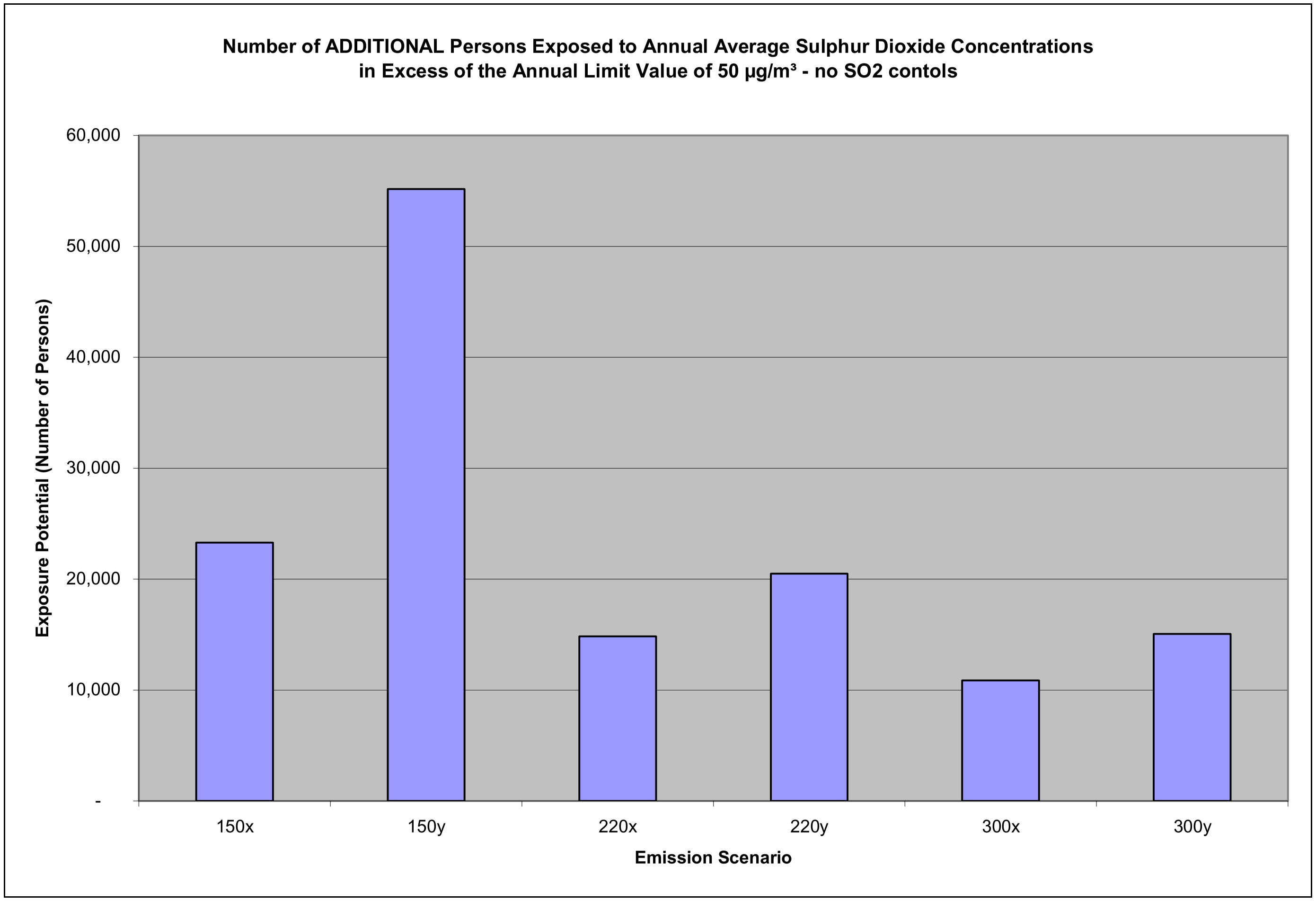

Figure G.3 Additional exposure potential to SO_2 annual ground level concentrations in excees of the EC annual limit due to the activities of the proposed new power station <u>with no</u> SO_2 controls in place.

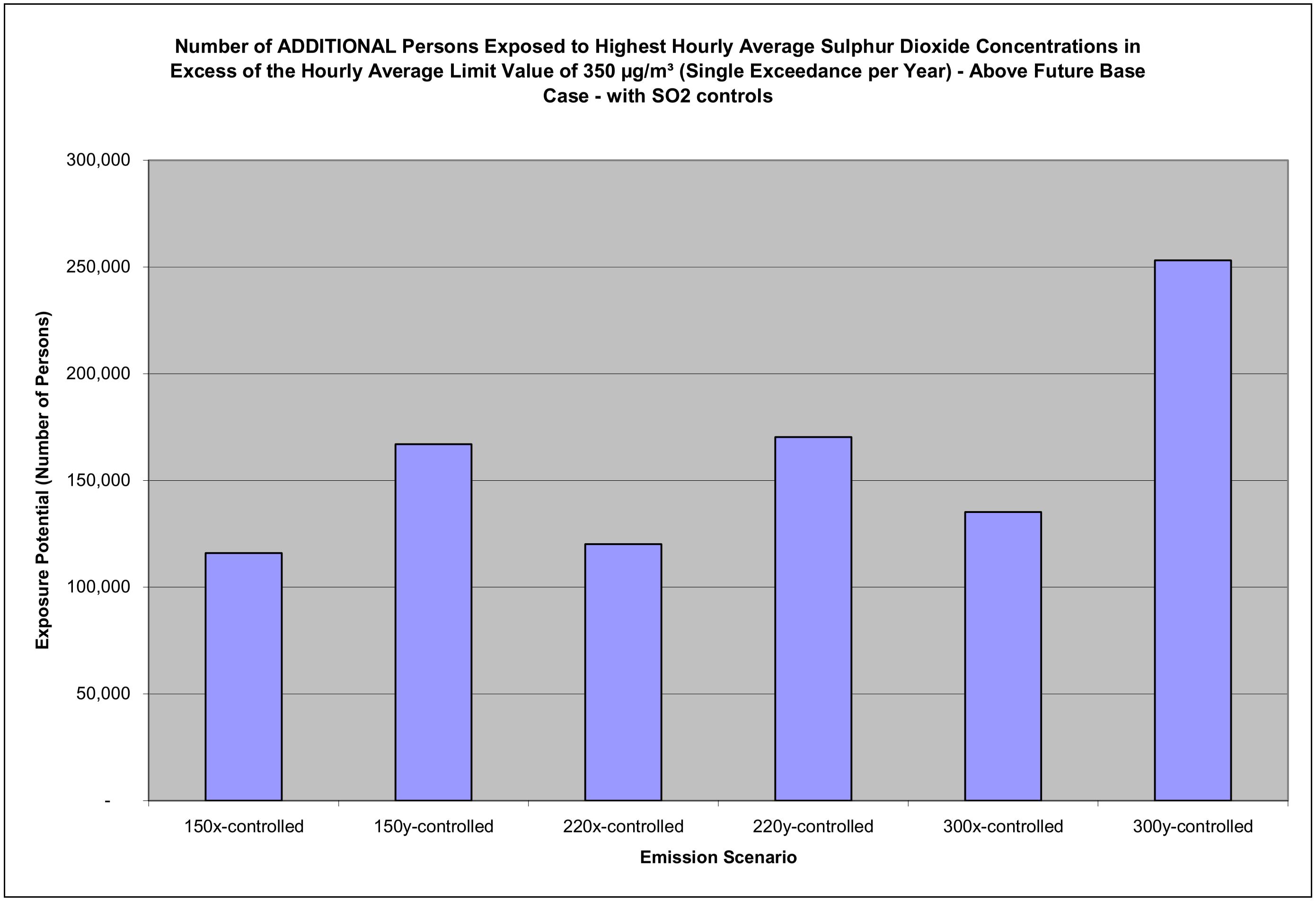

Figure G.4 Additional exposure potential to SO_2 hourly ground level concentrations in excees of the EC hourly limit due to the activities of the proposed new power station <u>with</u> SO_2 controls in place.

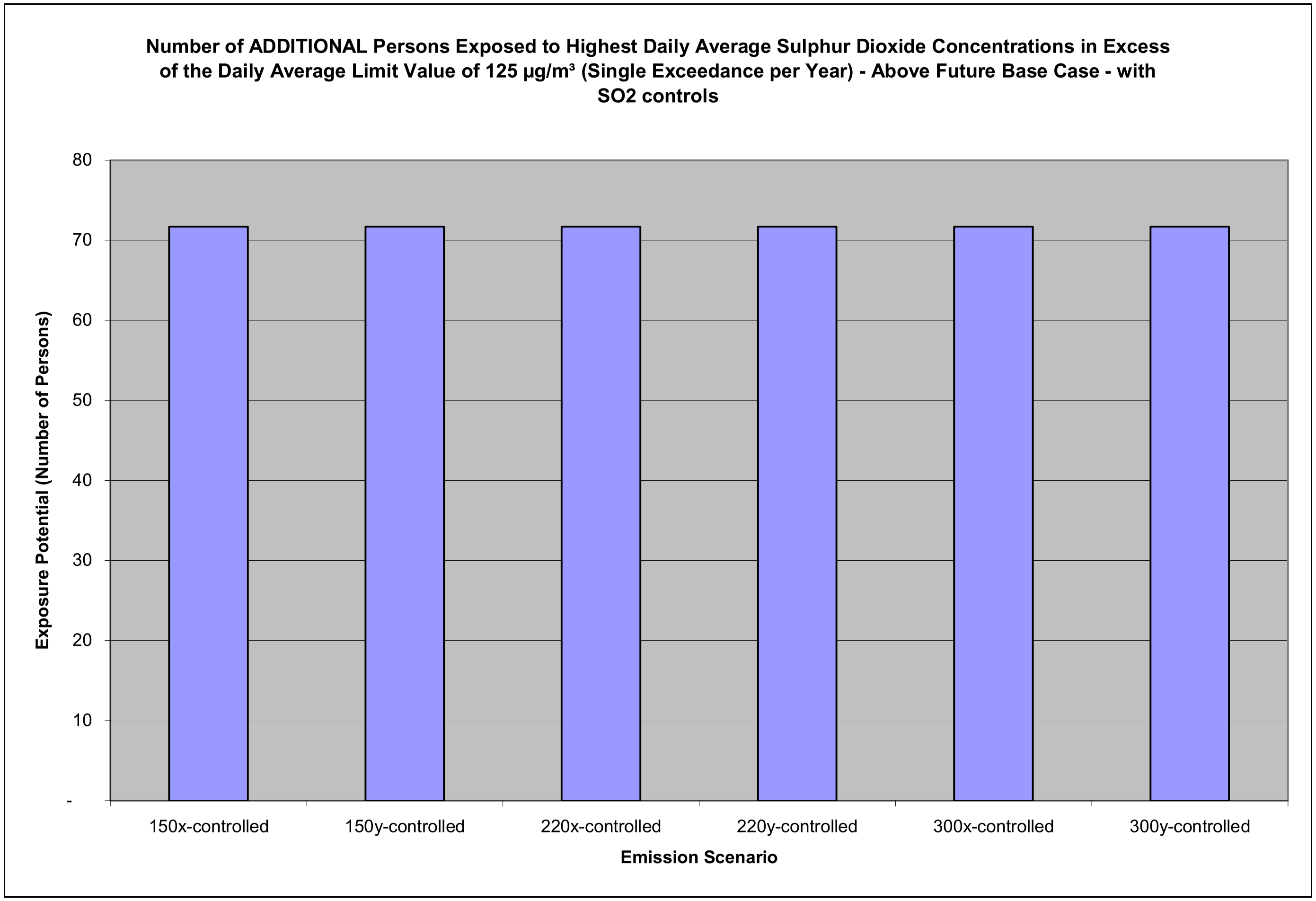

Figure G.5 Additional exposure potential to SO_2 daily ground level concentrations in excees of the EC daily limit due to the activities of the proposed new power station with SO_2 controls in place.

APPENDIX H –

EXPOSURE OF CHICKENS TO SULPHUR DIOXIDE CONCENTRATIONS

With the location of the proposed new power station, a concern was raised regarding the exposure of chickens to sulphur dioxide (SO_2) emissions. Experiments clearly show that SO_2 harms the cardiopulmonary system of the chicken. The allowable concentration of SO_2 is set at ~13 000 µg/m³ (5 ppm). The chickens appear to be less sensitive than most mammals to SO_2, with a maximum allowable hourly and daily concentration for human exposure set at 300 µg/m³ (EC limit) and 125 µg/m³ (SA standard) respectively. Hourly and daily ground level concentrations at the chicken farm (in the close proximity to the proposed power station sites) due to future cumulative operations were predicted to be ~ 4000 µg/m³ and 210 µg/m³ respectively, using the worst case scenario of the proposed Kendal North Power Station (150m stack height with no SO_2 controls). This is equivalent to ~30.8% (hourly concentration) and ~1.6% (daily concentration) of the maximum allowable concentration (13 000 µg/m³). Although predicted concentrations appear low enough not to warrant any concern regarding health risks to chickens, it should be noted that the above-mentioned exposure testing does not reflect the impact of long-term exposure at low SO_2 concentrations.