VOLUME 2 APPENDICES FEBRUARY 2009

AGL Leafs Gully Power Project Environmental Assessment

MP 08_0077

Appendix E

Regional Air Quality Assessment (600 MW)

URS

AGL

Switched on Business.

Photochemical Smog Assessment for a Proposed Power Plant at Appin, NSW

Merched Azzi

ET/IR874

August, 2006

Prepared for URS Pty. Ltd. on behalf of
Australian Gas Light Company Pty. Ltd.

Commercial-in-confidence

Final Report

Enquiries should be addressed to:

Dr Merched Azzi

CSIRO Energy Technology

Private Mailbag 7, Bangor NSW 2234

Email: merched.azzi@csiro.au

Use of this Report

The use of this Report is to subject to the terms on to which it was prepared by CSIRO. In particular, the Report may only be used for the following purposes.

- this Report may be copied for distribution within the Client's organisation;
- the information in this Report may be used by the entity for which it was prepared ("the Client"), or by the Client's contractors and agents for the Client's internal business operations (but not licensing to third parties);
- extracts of the Report distributed for these purposes must clearly note that the extract is part of a larger Report prepared by CSIRO for the Client.

The Report must not be used as a means of endorsement without the prior written consent of CSIRO.

The name, trade mark or logo of CSIRO must not be used without the prior written consent of CSIRO.

Executive Summary

This report examines the potential impacts on photochemical smog oxidants formation of a 600-MW gas-fired power plant in south-western Sydney at Appin, proposed by Australian Gas Light Company Pty. Ltd. (AGL). The main pollutant emissions of concern are nitrogen oxides (NO_x), which are precursors to ozone formation.

The specific objectives of this project were:

- to develop model scenarios and data sets that can be used to evaluate and predict impacts of emissions from the proposed power plant at Appin, NSW and
- to carry out regional modelling to assess the potential impact of the proposed plant on ozone formation.

The three-dimensional CIT-LCC photochemical model was used to assess the regional formation of ozone and NO_2 when the plant is operational under different conditions. Six modelling emissions scenarios were considered. The first selected scenario is the base case scenario that consists of using the current emission inventory without additional NO_x from the proposed power plant. The test case scenarios consist of using the current setup of the base case scenario in addition to emissions from the proposed new point source at different time of the day.

Five selected ozone event days with meteorological conditions known to be conducive to photochemical smog events were proposed by the NSW Department of Environment and Conservation (DEC) Science Department as a basis for the photochemical smog assessment. The impact of the proposed plant on ozone formation within the Sydney region was assessed by comparing the relative changes in peak ozone concentration predictions for the base-case (without additional NO_x) with the test case (with additional NO_x) scenarios.

The obtained modelling results did not show any substantial adverse impacts on photochemical smog formation that may be produced as a result of potential use of a power plant. The study found that two proposed configurations of the plant would produce a maximum local increase of 6.8 ppb of ozone and 2.5 ppb of NO_2. However, these increases were predicted to occur over small areas to the west or south-west of the plant represent only a maximum increase of 6.8% and 2% of the NEPM guidelines of ozone and NO_2 respectively.

Since the proposed power plant will operate only as a peaking plant, any pollution impacts that may occur will also be less than if it was operating continuously.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

CSIRO Energy Technology was commissioned by URS Pty Ltd on behalf of Australian Gas Lighting Company (AGL) Pty. Ltd. to assess the potential photochemical smog formation associated with emissions from a proposed power plant at Appin, in the south-west Sydney region.

Stack emissions from oil and gas combustion for power generation technologies will result in emissions of nitrogen oxides, carbon monoxide, sulfur dioxide, volatile organic compounds, and particulate matter. These products of combustion are considered pollutants and are known to, either directly or indirectly, cause harmful effects on humans and the environment if they reach or go over the National Environment Protection Measures (NEPM) guideline levels, http://www.ephc.gov.au/nepms/air/air_nepm.html.

The NSW Government has adopted standards for several pollutants that are typically referred to as “criteria” pollutants. Maximum ground-level concentrations of criteria pollutants are based on the National Environment Protection Measures (NEPM) guidelines. The NEPM standards for nitrogen dioxide and ozone are given in Table 1.

Table 1. National Environment Protection Measures (NEPM) Guidelines for NO_2 and O_3

Pollutant	Averaging period	Maximum concentration, ppm *	Goal within 10 years (Maximum allowable exceedences)
Ozone	1 h	0.10	1 day/year
	4 h	0.08	1 day/year
Nitrogen dioxide	1 h	0.12	1 day/year
	12 months	0.03	

* arithmetic mean concentrations
Source: National Environment Protection Measure and Revised Impact Statement for Ambient Air Quality (NEPC, 1998)

Ozone is a photochemical oxidant and the major component of smog. While ozone in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation from the sun, high concentrations of ozone at ground level are a major health and environmental concern. Ozone is not emitted directly into the air from anthropogenic sources but is formed through complex chemical reactions between precursor emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NO_x). These reactions are stimulated by sunlight and temperature so that peak ozone levels typically occur during warmer periods of the year. Because the reactions are not linear, reducing or adding additional amounts of NO_x or VOC emissions to a given air parcel does not necessarily result in an equivalent decrease or increase in ozone concentration.

The reactivity of ozone causes health problems because it damages lung tissue, thereby reducing lung function. Scientific evidence indicates that high ambient levels of ozone not only affect people with impaired respiratory systems, such as asthmatics, but healthy adults and children as well.

Meteorological conditions play a very important role in the distribution of these compounds and in the rates at which they react. Stagnation or recirculation episodes, which are also common, can allow emitted pollutants to accumulate over periods of several days.

Previous studies (Hyde and Johnson, 1990) carried out to assess the photochemical smog formation in the west and south west regions of the Sydney basin, where the new NO_x plume is to be located, have shown that the area can be subject to high ozone episodes. The ozone problem in the south-west and north-west of the Sydney basin can be directly influenced by upwind sources located to the north and the east of the region. Because of the existing photochemical smog state of the region it is necessary to show that the new source would not deteriorate the current air quality. To provide advice on the potential impact of emission changes due to the new emissions it is important to characterise the current air quality of the selected area and to determine the photochemical smog state of air masses that have the potential to generate high ozone events.

The task outlined in the consultancy brief was to assess the potential impacts of emissions from the proposed power plant on regional ozone concentrations. However, to improve understanding of chemical processes involved in the formation of photochemical smog oxidants, the photochemical smog regime prevailing during high ozone episodes might also be examined.

Photochemical Smog Phenomena

Photochemical oxidation, responsible for producing NO_2 from NO and then creating ozone, is a very complex chemical process. The ozone produced is difficult to control because it is a secondary pollutant, and the chemistry that leads to its formation is complex and non-linear. It has however been shown that the Integrated Empirical Rate (IER) model developed at CSIRO (Johnson et al. 1984), describes the progress of the photochemical reactions in a simple way. It does this by parameterising the process in terms of the quantity of nitric oxide oxidised plus the quantity of ozone produced. Formation of photochemical smog oxidants can be either VOC- or NO_x-limited, depending on VOC/ NO_x ratios, VOC reactivity, sunlight exposure, and meteorological dispersion. Determining which contaminant is the controlling factor is, however, difficult in practice.

The photochemical IER model was derived from extensive outdoor smog chamber studies carried out at CSIRO and consists of a set of algebraic equations describing photochemical smog formation. It is a model requiring ambient monitoring data to predict the photochemical characteristics of a given air parcel. The model does not require information on emissions or transport calculations.

The progress of photochemical smog reactions is usefully expressed as a function of sunlight exposure. The concentration of smog produced (SP) represents the concentration of NO consumed by photochemical processes plus concentration of ozone produced. At constant volume, the following expression can be written:

$$[SP]_t = [O_3]_t + [NO]_0 - [NO]_t \qquad 1$$

where subscript “0” denotes an initial time and “t” denotes some subsequent time.

The IER model shows that the concentration of smog produced (SP), given in equation 1, increases approximately linearly with cumulative light flux until the NO_x decreases to zero. At this stage SP becomes constant. The first linear increase prior to NO_x=0 is called the light-limited regime, and this is followed by the NO_x-limited regime.

The IER model has also includes the extent parameter, E that indicates how far photochemical reactions have progressed towards attaining the NO_x-limited regime.

The rate at which the photo-oxidation processes proceed in the atmosphere has a great bearing on the actual concentrations of NO_2 and O_3 that are attained. This is because, in polluted air, the concentrations of NO_2 and O_3 are the result of the relative rates of two competing processes, i.e.:

(i) the rates of production of NO_2 and O_3, and
(ii) the rate of dilution and dispersion of the pollutants by cleaner air.

Factors Affecting Ozone Formation

Once ozone precursors enter the atmosphere, their concentrations decrease as they mix with clean air and undergo different chemical reactions. The final concentration of a given contaminant depends on the rate of production and dilution and is driven by atmospheric conditions.

Several factors influence the temporal and spatial distribution of ozone formation. These include:

- the distance from primary source emissions, the amount of sunlight exposure and the reactivity of VOCs will determine the rate of ozone formation,
- the VOC/NO_x ratios will determine which precursor may control the ozone formation,
- proximity to fresh NO_x emissions will determine the rate of ozone destruction by chemical reaction,
- wind speed and direction will determine where ozone precursors and ozone are transported.

Several meteorological conditions can enhance the ozone formation. For example, the existence of temperature inversion that reduces the atmospheric mixing may cause ozone to be trapped near the Earth's surface and increase ozone concentration. Stagnating atmospheric conditions will also give rise to ozone concentration.

Previous plume chemistry studies carried out during summer conditions have shown that there are basically three stages of plume chemistry evolving in NO_x point-source plumes. The initial stage is dominated by high NO_x concentrations that titrate the existing ozone with NO to produce NO_2. At this stage the chemistry is highly VOC-limited. As the plume grows and mixes with background air masses that are rich in VOCs, the ozone formation starts on the plume edges and the concentrations may exceed the ambient background on these edges. Meanwhile ozone-deficient zones may still exist in the plume centre where higher NO_x concentrations reside. At the last stage the ozone will increase and NO_x plume will be reduced.

Since the proposed power plant will only operate intermittently as a peaking plant, any impacts that may occur will be less than if it was operating continuously as a base-load plant.

Methodology

Photochemical transport models are the most useful tools to predict changes in pollutant levels due to a variety of possible emission scenarios. Three-dimensional photochemical air quality models have been used to assess the potential effects of pollutant emissions on local and regional air quality. These models include two important modules: (i) meteorological modelling, and (ii) transport/chemistry modules. Meteorological results provide the input data required to run the transport/chemistry modules. To enable the model to simulate a specific event in space and time, the model also requires additional important data, such as those from an emissions inventory, or land use and global meteorological data sets. The emissions inventory provides, in time and space, the amount of pollutant emitted to the atmosphere.

When performing air quality modelling for photochemical smog formation, a complex interaction among many sources, including the proposed source, are considered. The unique chemistry involved in ozone formation provides reactions that are not linear in nature. Adding an additional amount of NO_x or VOC emissions to a mix does not give an equivalent increase in ozone formation. If emissions are decreased by a certain amount, this may not generate similar reductions with ozone. As a result of this complex behaviour, potential additional NO_x emissions expected from the new power plant may or may not contribute to the ozone formation in the region. Air quality models are used to determine the effect of the additional NO_x on regional ozone formation.

The photochemical transport-transformation was simulated using a modified version of Carnegie/Mellon, California Institute of Technology Model (CIT; Harley et al., 1993). The current version includes an updated numerical plume rise algorithm and improvements to the vertical advection and mass conservation algorithms. This model incorporates the Lurmann/Carter/Coyner mechanism (Lurmann et al., 1987), a comprehensive chemical transformation mechanism, which enables the dynamics of photochemical smog development in the selected domain to be simulated in detail. The version of the model that was modified by CSIRO is currently used by NSW Department of Environment and Conservation (DEC) to carry out air quality modelling scenarios. The use of the CIT-LCC photochemical smog model is driven by the emission inventory and the meteorological fields developed by suitable other models.

The comprehensive CIT-LCC photochemical model system, containing detailed chemical mechanisms, can only be used to simulate short periods (e.g. selected days), as it is computationally demanding, requiring the assessment of many atmospheric chemical/physical interactions. The model was set for an outer domain extending from the Hunter Valley in the north to the southern part of the Illawarra region. The sub-domain of the Sydney region was set as a regular square with the southwest corner at (240, 6200) and north-east at (360, 6300) given in AMG coordinates in km. The model resolution was set at 3 X 3 km. There were 120 X 120 model grid cells in the longitudinal and latitude directions.

In the current study, six modelling emissions scenarios were used to assess the impact of the proposed power plant on downwind ozone formation. The first base case scenario consists of using the current emission inventory without additional NO_x from the proposed power plant. The base case scenario results for all selected days were provided by DEC. The test case scenarios consist of using the current setup of the base case scenario in addition to emissions from the proposed new point source. Test case scenario A includes continuous daily NO_x emissions from the proposed power plant. Test cases B, C and D invoke the option of the plant being a peaking plant operating intermittently at different time of the day. For test case A we considered that the plant would operate at 800 and 900

hours, test case B the plant would operate at 1300 and 1400 hours, test case C the plant would operate at 1500 hours and 1600 hours. The final scenario E proposed by DEC is a hypothetical scenario assuming that the plant would operate continuously at 150ºC in the aim to cap emissions within the boundary layer.

The following modelling scenarios presented in Table 2 set the basis for providing the best known answers to these questions.

Table 2. Emission parameters for scenarios used in the current CIT-LCC assessment

Scenarios	Stack height (m)	Gas exit temperature (°C)	Stack exit diameter (m)	Gas exit velocity (m/s)	NO_x (as NO_2) (g/s)	Time of emissions
Base case	-	-	-	-	-	Only the emission inventory
Test case A	35	532	6	40	77.4	Continuous hourly NOx emissions
Test case B	35	532	6	40	77.4	Proposed NO_x emissions only at 8 and 9 am
Test case C	35	532	6	40	77.4	Proposed NO_x emissions only at 1 and 2 pm
Test case D	35	532	6	40	77.4	Proposed NO_x emissions only at 3 and 4 pm
Test case E	35	150	6	40	77.4	Capping emissions within the boundary layer

The Atmospheric Science Section of NSW DEC provided a list of 5 days that have been used in the current study to carry out the current assessment. These days have been studied in details by DEC and reported in the State of Knowledge (SoK) Report (2005). The model performance for each of the selected days has been assessed through comparison with air pollutant observations recorded at different monitoring sites located in the Sydney basin.

Brief analyses of the air characteristics for the selected days are given below. The analysis will focus on monitoring data collected from the areas relevant to the proposed power station, such as Bargo and Oakdale. In addition, data collected at other monitoring stations have been analysed in order to understand the spatial and temporal extent of ozone occurrences in the region.

The selected modelling days are December 20, 2000, January 12, 2001, January 22, 2001, February 10, 2004, and November 27, 2004.

Base-case model simulation results were obtained from DEC's Atmospheric Science Section. These simulations were carried out using the emission inventory data without the proposed new NO_x sources. Model test case simulations were performed in which emissions from different stack characteristics were added to the inventory. The assessment was carried out by the development of a set of test-case emission scenarios which when compared to the base case scenarios, enabled the net power station impacts to be evaluated.

The plant is proposed to be operated when needed, that is, as a peaking plant. The expected NO_x emissions would therefore be emitted at any time of the day for a short period.

This type of operation was also included in this study where the following discrete emissions were considered:

- Morning NO_x emissions assumed to be released at 0800 and 0900 hours to cover morning energy demand if required.
- Two afternoon NO_x emission periods at 1300 and 1400 hours for the first afternoon period, and at 1500 hours and 1600 hours for the second period.

A final hypothetical scenario suggested by DEC was also considered, i.e. to cap all emissions within the boundary layer to allow for maximum ground level impact to be evaluated. This option was obtained by reducing the stack temperature to 150ºC as proposed by the DEC scientists.

The goal in performing these emissions scenarios was to determine whether the proposed power plant would substantially cause deteriorations or new exceedances of the current air quality standards.

For the current study, all known major air emissions from other sources have been considered and included in the assessment. Results of model simulations are compared to acceptable ambient concentrations as given by the NEPM guidelines. If concentrations are below these guidelines, then it is assumed that no adverse environmental effects will be generated and there should not be any concerns with respect to the magnitude of impact, or to its geographic extent, duration and frequency.

The project has been discussed with representatives of the Science and Policy Department of NSW DEC. It has been agreed that for assessing the potential impact of the proposed power plant on downwind ozone concentrations, DEC will select different days with meteorological conditions conducive to ozone formation in the Sydney basin. These days have been thoroughly studied and examined by DEC and reported in the State of Knowledge (SoK) report published by DEC in 2005. The base case scenarios of the selected days have been provided by DEC.

Air quality monitoring data for these selected days, collected at the DEC monitoring sites located in the west and south-west regions were used in the current assessment. The Bargo monitoring site was expected to most closely reflect the ambient conditions at the Appin site. For the five selected days, data were available for O_3, NO_2, wind speed and direction.

To determine how real air masses are likely to respond to changes in the ozone precursors (NO_x and VOCs), ambient air quality data can be analysed to determine the state of photochemical smog regime of the surrounding air where the new emissions will be advected to and mixed. This analysis relates NO_x emissions to smog formation using observed O_3, NO, and NO_y (NO_x plus gas phase oxidation products of NO_x) concentrations. This approach can provide the basis to corroborate modelling results independent of uncertainties in emissions inventories, chemical modelling mechanisms and atmospheric modelling in general.

The information acquired on the chemical characteristics of the ambient air in the region will identify the chemical processes that may take place when the new NO_x plume interacts with background air while being dispersed and transported downwind from one area to areas with different ambient characteristics. This raises the following questions:

(i) Is the ambient air, where the plume is dispersing and mixing, hydrocarbon rich or NO_x rich?

(ii) Which ozone precursor would better control the current ozone levels?

(iii) Is the information provided by the modelling results supported on a scientific basis?

Figure 1 shows the study area including, the location of the proposed power station development with the following AMG coordinates: 296000 m for Eastings and 6220000m for Northings.

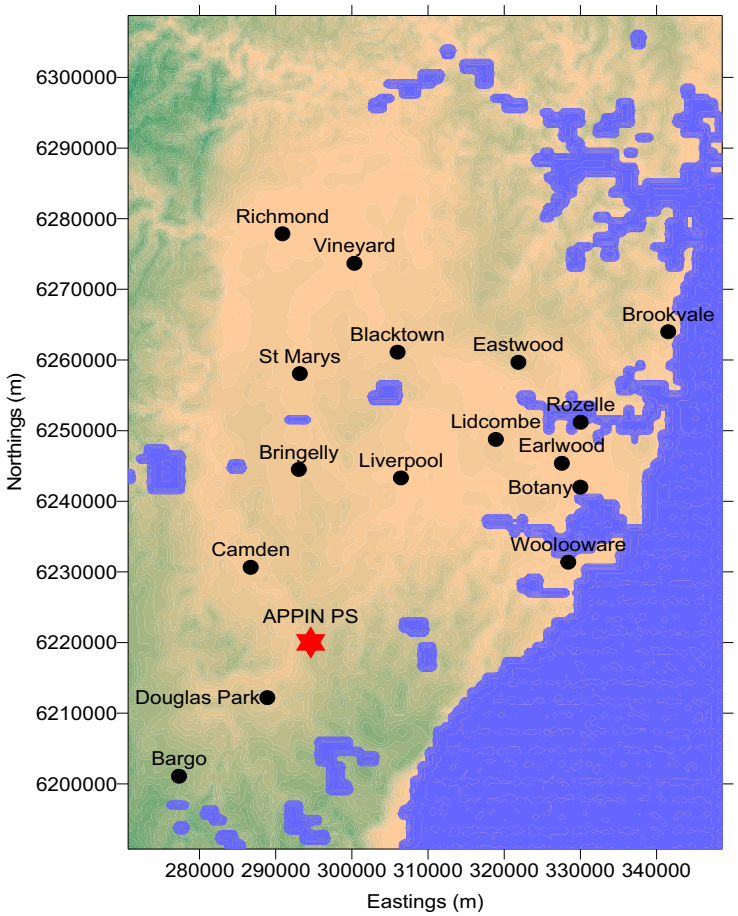

Figure 1. Map of the study area showing the location of the proposed Appin power station

Results and Discussion

Nature of Photochemical Smog Episodes in the South-West Region of the Sydney Basin

Five modelling days selected by DEC were used for detailed IER analysis to determine the status of photochemical smog formation and to demonstrate the extent of photochemical smog reactions in the region. Smog produced (SP) and the photochemical reaction extent parameter (E) were calculated using monitoring data. When E is less than 1, the air parcel is hydrocarbon-limited where the rate of smog formation depends on the sunlight intensity and

the reactivity of the existing reactive VOCs. When the concentration of NO_x approaches zero, E will reach a maximum value of 1. During this period the air parcel is in the NO_x-limited regime. When E = 1, further emissions of NO_x into the air parcel will enable ozone production to recommence.

Analyses of the selected monitoring data have shown that concentrations of ozone exceeded 100 ppb during summer days were associated with high temperatures and wind speeds of less than 2 m/s. A close assessment of the photochemical characteristics of existing air masses measured in the study area show that ozone starts to build up in the morning, shortly after the sunrise, when the boundary layer is expanding. These "stall" conditions allow the photochemistry to proceed at a rate determined by the reactivity of hydrocarbons, sunlight fluxes received by the selected air parcel, and the availability of NO_x. During this period, the calculated IER parameters showed that the smog produced increased linearly to higher levels, with an E value less than 1. This diagnostic analysis of selected air parcels indicated that the air masses still have available NO_x and have the potential to react further to produce more ozone. During this period, any additional NO_x emissions will not affect the process of photochemical oxidant formation. In the late morning and during the mid-day period, the photochemical reactivity of air parcels continues to produce ozone and increases the production of smog (SP), to higher levels. The photochemical activity of the air increases the SP value to 16 pphm, while E has reached 1, indicating that the photochemistry has been very active in consuming all available NO_x existing in these air parcels. During this period, the ambient air is in a NO_x -limited condition where any additional NO_x emissions will titrate the available O_3 to produce NO_2 - which will then react to form additional ground-level ozone, depending on the amount of NO_x emitted.

It is important to note that the arrival of a sea breeze at monitoring sites increases the concentrations of ozone to the highest values at a specific site. The arrival of a sea-breeze front is associated with sharp increases of the ozone concentrations, change in wind direction to easterly flows, a drop in temperature and an increase in humidity and wind speed. A sample of ambient air monitoring data presented, and the analysis of these data are illustrated in Figures 2 to 4.

In summary, the analysis of ambient data collected from monitoring stations located in the west and south west of the Sydney basin showed the following:

- Ozone concentrations greater than 10 pphm can occur during the hot summer periods in the west and south-west regions of the Sydney basin.
- The highest value of smog production (SP) can occur at any of the four monitoring sites on any day irrespective of the ozone concentration.
- In the selected region, high late-morning ozone episodes of greater than 10 pphm can occur under NO_x-limited conditions.
- Elevated ozone concentrations occur at the selected monitoring sites under north to north-easterly winds.
- Maximum ozone concentrations occur predominately in the afternoon with the arrival of the sea breeze.

Assessment of the air quality data shows relatively low concentrations of nitrogen dioxide, and a number of events with moderate to high ozone concentrations, occurring in summer afternoons, with the air travelling usually to the west and south-west of the Sydney basin. These conditions are very relevant to the consideration of plume influences on regional photochemistry.

Regional Air Quality Modelling

The results of ozone modelling performed for each selected day, using the specific stack emission scenarios, are summarised in Tables 3 to 7. Each table reports the maximum one-hour ozone concentration, the maximum 4-hour ozone concentration, the number of grid cells in the modelling domain that exceed the 1-hour and 4-hour NEPM Guidelines, and the number of grid cell hours across the modelling domain that exceed the 1-hour and 4-hour NEPM guidelines to generate a measure of the dosage. These parameters indicate the worst case option associated with the ozone increase, as well as the extent of the area.

A summary of modelling results is given below:

Modelling results obtained for December 20, 2000, presented in Table 3, showed that the proposed plant may have the potential to increase the maximum 1-hour and 4-hour ozone concentrations by an amount of 5 ppb and 2 ppb respectively. The number of grid cells predicted to exceed the NEPM guidelines was found to be 42 (representing 4.5% increase) and 22 (representing 2.12% increase) for the 1-hour and 4-hour averages respectively. The describe increases was obtained when the plant was anticipated to operate at full load, Scenario A. The model predictions for Scenario E have produced similar results to the Scenario A. The modelling results obtained for this day present the highest impact in terms of maximum ozone production in comparison with other selected days. There were no significant changes of NO_2 concentration due to the proposed emissions.

The predicted contributions of the NO_x emissions from the proposed plant for January 12, 2001, are presented in Table 4. These predictions indicate that the NO_x from the plant could increase the maximum 1-hour and 4-hour ozone concentrations in the selected modelling domain by an insignificant amount of 0.2 ppb. However, the highest difference of 6.3 ppb between the base case and test case scenarios was predicted to occur downwind of the plant at small location as it is shown in Figure 15. The maximum difference of 3.4 ppb of 4-hour ozone was obtained at Campbelltown between the base case and scenario case A. This maximum has occurred between 1200 and 1300 hours. As well, results predicted an increase of 1 ppb of NO_2 that was observed at 1100 hours.

For January 22, 2001, February 10, 2004 and November 27, 2004, the results presented in Tables 5, 6 and 7 indicate that the plant did not contribute to any significant changes to the maximum 1-hour and 4-hour ozone concentrations. However, the difference of the ozone time series of the base case and test case A, showed that an increase of up to around 6 ppb could be generated as a result of the additional NO_x plume. The 1-hour NO_2 concentration could increase by a maximum of around 2.5 ppb at selected locations.

Modelling results and analysis for each selected day are given below.

Air Quality Analysis and Modelling for December 20, 2000

On this day, Oakdale monitoring station recorded the highest ozone concentration of 113 ppb in the Sydney region. This ozone episode was influenced by a high pressure system with hot, sunny conditions and light northerly synoptic flows. These conditions are recognised as being conducive to photochemical pollution episodes in the Sydney region. Using ambient monitoring data for NO_x and O_3, the smog production and the extent of reaction of a given air parcel were calculated. The calculated parameters presented in Figure 2, showed that when ozone exceeded 10 pphm the surrounding ambient air was under the NO_x-limited regime. As a result of this situation, we would expect that any additional NO_x emissions from the proposed power plant would firstly quench the ozone levels. The amount of ozone reduction would depend on the amount of NO emitted. However, with favourable meteorological conditions and depending on the amount of sunlight available, the ozone production may resume later over downwind areas.

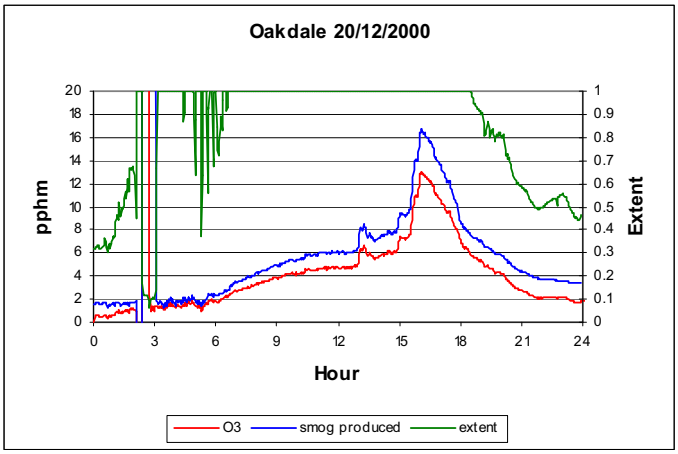

Figure 2. Calculated IER parameters using ambient monitoring data collected at Oakdale monitoring site

The other monitoring sites located in the west and south-west region of the Sydney basin have recorded concentrations less than 100 ppb. An illustration of selected ambient air quality analysis carried out using Bringelly monitoring data is given below.

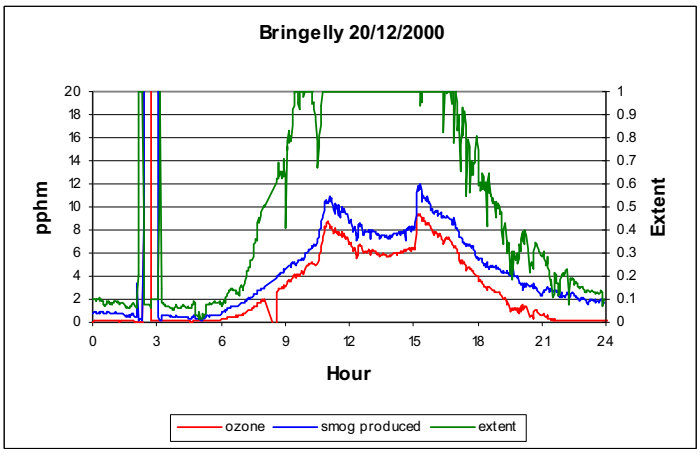

Figure 3. Calculated IER parameters using ambient monitoring data collected at Bringelly monitoring site

Two peaks of ozone of around 9 pphm were recorded at Bringelly. The first peak was observed at around 1100 hours with north, north-westerly winds blowing at around 2 m/s. The air parcels were within the transition regime changing from the hydrocarbon-limited to

the NO_x-limited conditions. After 1100 hours, the NO_x-limited condition prevailed over the area until the arrival of the sea breeze at around 1500 hours. The sea breeze arrival increased the ozone concentration to reach a maximum of 9 pphm before dropping back to lower levels as illustrated in Figure 4. If additional NO_x had to mix with ambient air in the selected region, the potential production of ozone due to the additional NO_x will depend on the amount of NO_x that would have been emitted, the rate of dispersion and the amount of sunlight exposure.

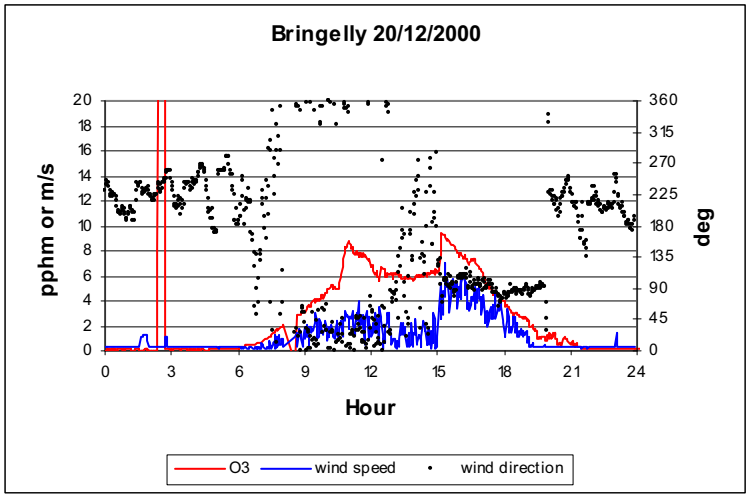

Figure 4. Air quality monitoring data for ozone, wind speed and wind direction recorded at Bringelly on December 20, 2000

The modelling results obtained for December 20, 2000 are presented in Table 3 for the selected test case scenarios defined in table 2. The table 3 reports the maximum one-hour ozone concentration, the maximum 4-hour ozone concentration, the number of grid cells in the modelling domain that exceed the 1-hour and 4-hour NEPM Guidelines of 100 and 80 ppb respectively, and the number of grid cell hours across the modelling domain that exceed the 1-hour and 4-hour NEPM guidelines to generate a measure of the dosage. These parameters were used to identify the worst case option associated with the ozone increase as well as the potential ozone extent over the selected domain.

The results presented in Table 3, showed that the worst case scenarios were predicted for the continuous full load operation scenario, Case A and for the test case C, when the plant was assumed to operate intermittently at 1300 and 1400 hours. Similar maximum 1-hour and 4-hour ozone concentrations to Case A were predicted for the hypothetical case E where the NOx plume was capped within the boundary layer. The maximum 1-hour and 4-hour ozone concentrations predicted for this day and obtained for Scenario A were 114.9 ppb and 96.2 ppb respectively compared with 109.9 ppb and 96.3 ppb for the base case scenario.

A comparison of modelling results obtained for the base case scenario and the test case A of the full load operation representing the worst case scenario, showed that the proposed plant was predicted to increase the maximum 1-hour concentration by a maximum of 5 ppb representing an increase of 4.55%. Additional 42 grid cells were predicted to exceed the 1-hour NEPM guidelines, representing an increase of 0.3% over the modelling domain.

Table 3. Simulated maximum ozone concentrations, December 20, 2000

20/12/2000	Maximum 1-h ozone (ppb)	Maximum 4-h ozone (ppb)	% change in 1-h max ozone	% change in 4-h max ozone	Area exceeding 1-h (grid cells	Area exceeding 4-h (grid cells	Dosage 1-h (grid cell hours)	Dosage 4-h (grid cell hours)
base case	**109.9**	**94.2**	**0.00**	**0.00**	**186.0**	**371.0**	**213.0**	**667.0**
Test case A	114.9	96.2	4.55	2.12	228.0	392.0	284.0	751.0
Test case B	109.9	94.2	0.00	0.00	186.0	371.0	213.0	669.0
Test case C	114.0	95.4	3.73	1.27	211.0	377.0	253.0	704.0
Test case D	110.5	95.0	0.55	0.85	207.0	380.0	246.0	702.0
Test case E	114.9	96.3	4.55	2.23	229.0	392.0	285.0	750.0

Contours of the daily maximum 1-hour and 4-hour O_3 average differences between base case and the test case A scenario for December 20, 2000 simulation are presented in Figures 7 and 8. These contours illustrate the spatial extent of areas that were predicted to be affected by the changes of ozone levels. As stated earlier the net increase of the 1-hour ozone was less than 6 ppb. The most affected areas by the predicted ozone increases were predicted to be located approximately to the south-west of the proposed plant location.

The highest 4-hour ozone predictions were obtained for Case A (96.2 ppb) and Case E (96.3 ppb) representing around 2 ppb of increase to the base case concentration of 94.2 ppb (Figure 6). The predicted area that may exceed the 4-hour ozone guideline was predicted to increase from 371 grid cells to 392 grid cells representing an increase of 0.1% over the modelling domain.. Contours of 4-hour O_3 average differences between the base case and test case scenarios for December 20, 2000 simulation are illustrated in Figure 8.

For the test case B associated with morning emissions the model did not predict any increase of ozone levels. During this period, the air was in the hydrocarbon regime and NO_x emissions do not control the progress of the photochemistry. For the test case D of the afternoon emissions, there were slight increases of less than 1% in the 1-hour and 4-hour ozone concentrations. However, the number of grid cells where 1-hour ozone has exceeded 100 ppb have increased by 0.1% over the far south-west region.

Similar results to the test A scenario were obtained for the hypothetical Case E scenario.

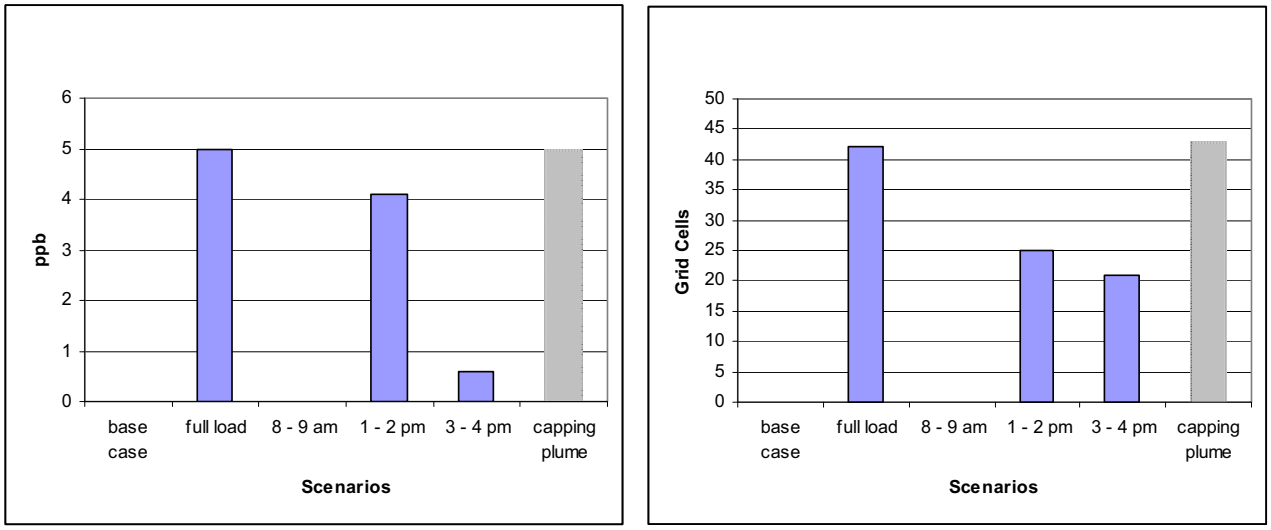

Figure 5. Net changes to the maximum 1-hour ozone concentrations (right) and to the number of grid cells exceeding 100 ppb for selected scenarios predicted for December 20, 2000

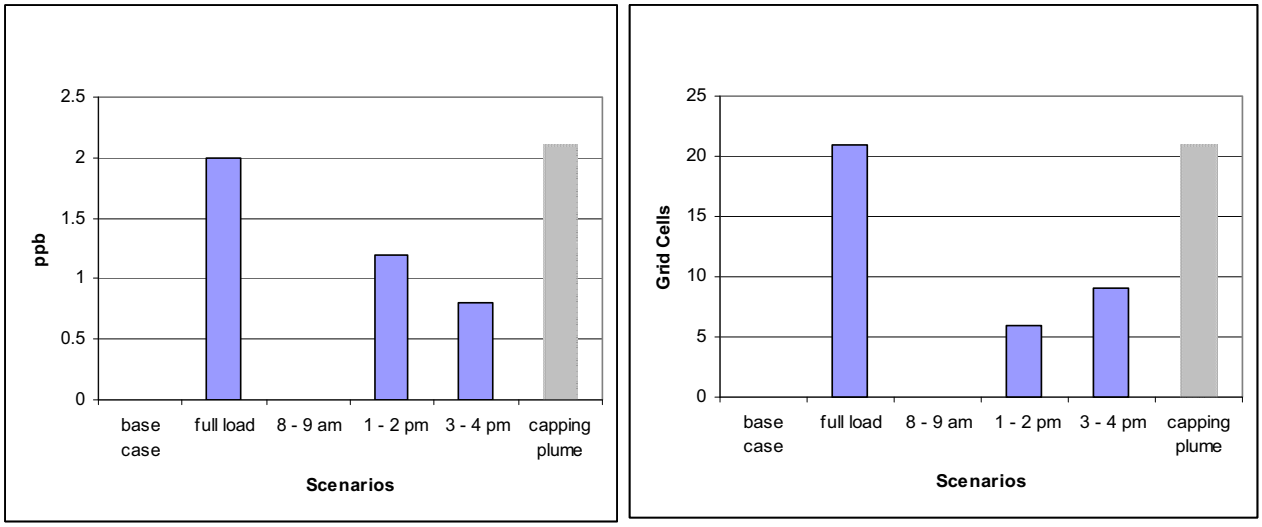

Figure 6. Net changes to the maximum 4-hour ozone concentrations (right) and to the number of grid cells exceeding 4-hour ozone guideline of 80 ppb for selected scenarios predicted for December 20, 2000

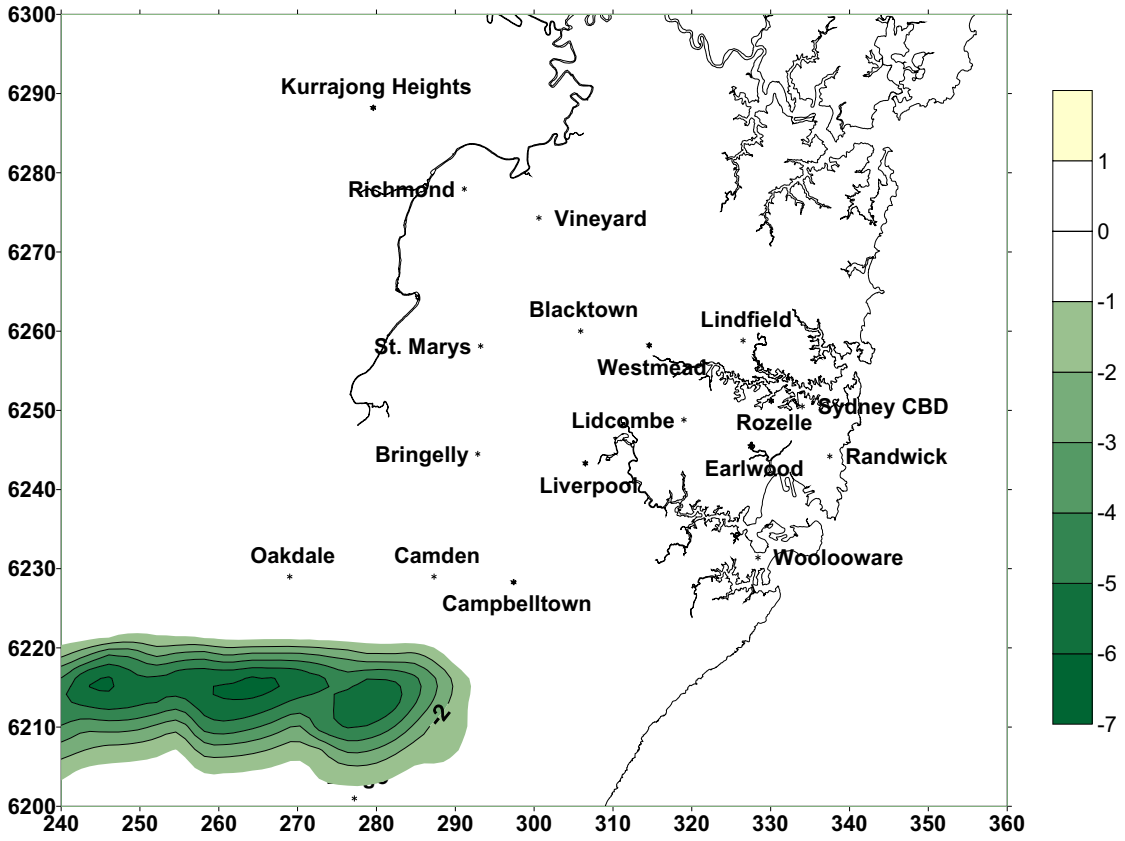

Figure 7. Contours of the daily maximum 1-hour O_3 average differences between base case and test case scenarios for December 20, 2000 simulation

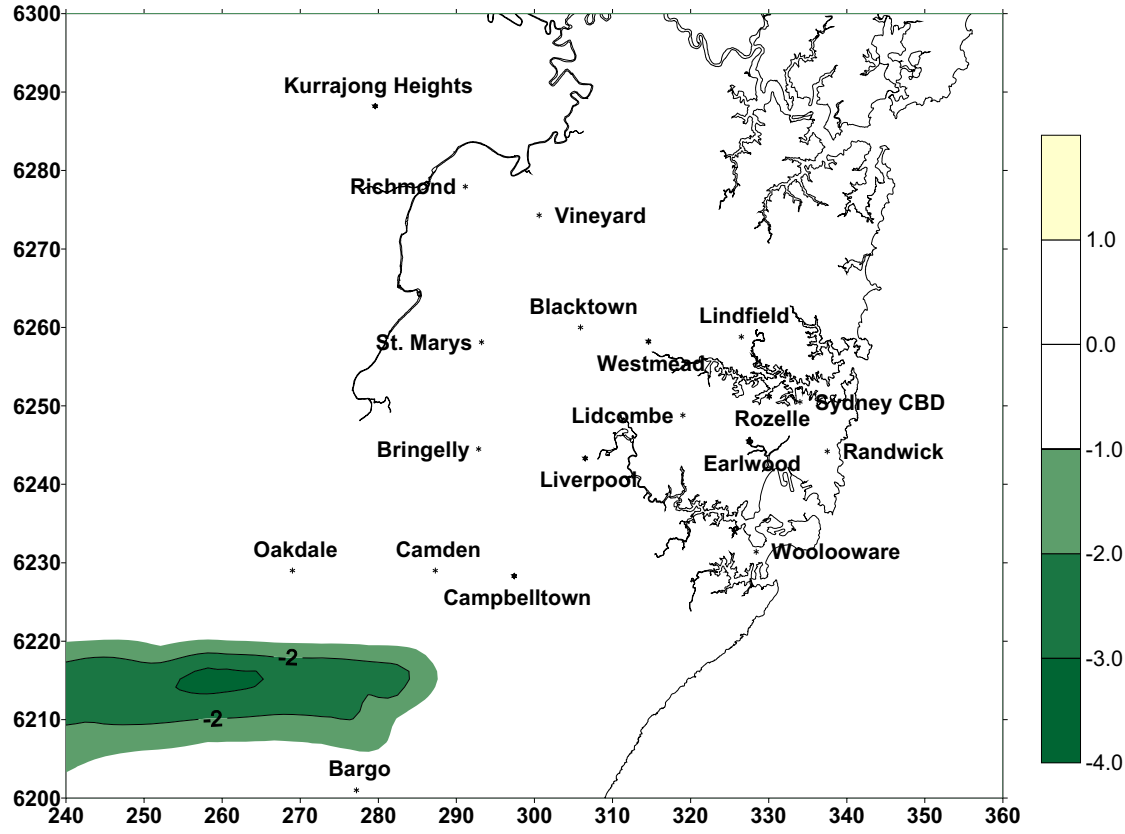

Figure 8. Contours of the daily maximum 4-hour O_3 average differences between base case and test case scenarios for December 20, 2000 simulation

Modelling data were extracted from selected monitoring stations to show the model performance and to assess the additional NO_x plume impacts on ozone formation at these sites. Results presented in Figures 9 and 10 show that although the system perform well for monitoring stations located in the central and south-west regions (Figure 9), predicted concentrations for Oakdale and Bargo were less accurate (Figure 10). These two sites are the closest sites to the proposed power plant.

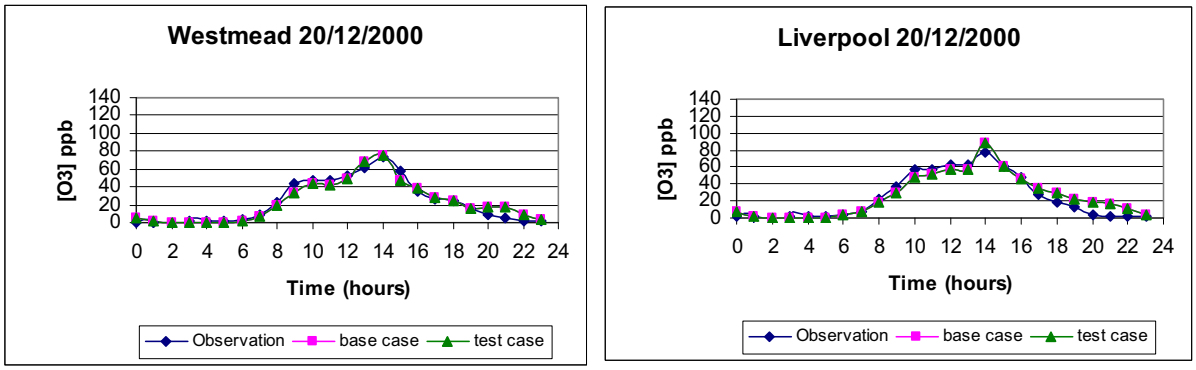

Figure 9. Observed and modelled 1-hour time series of ozone concentrations for selected monitoring stations for December 20, 2000

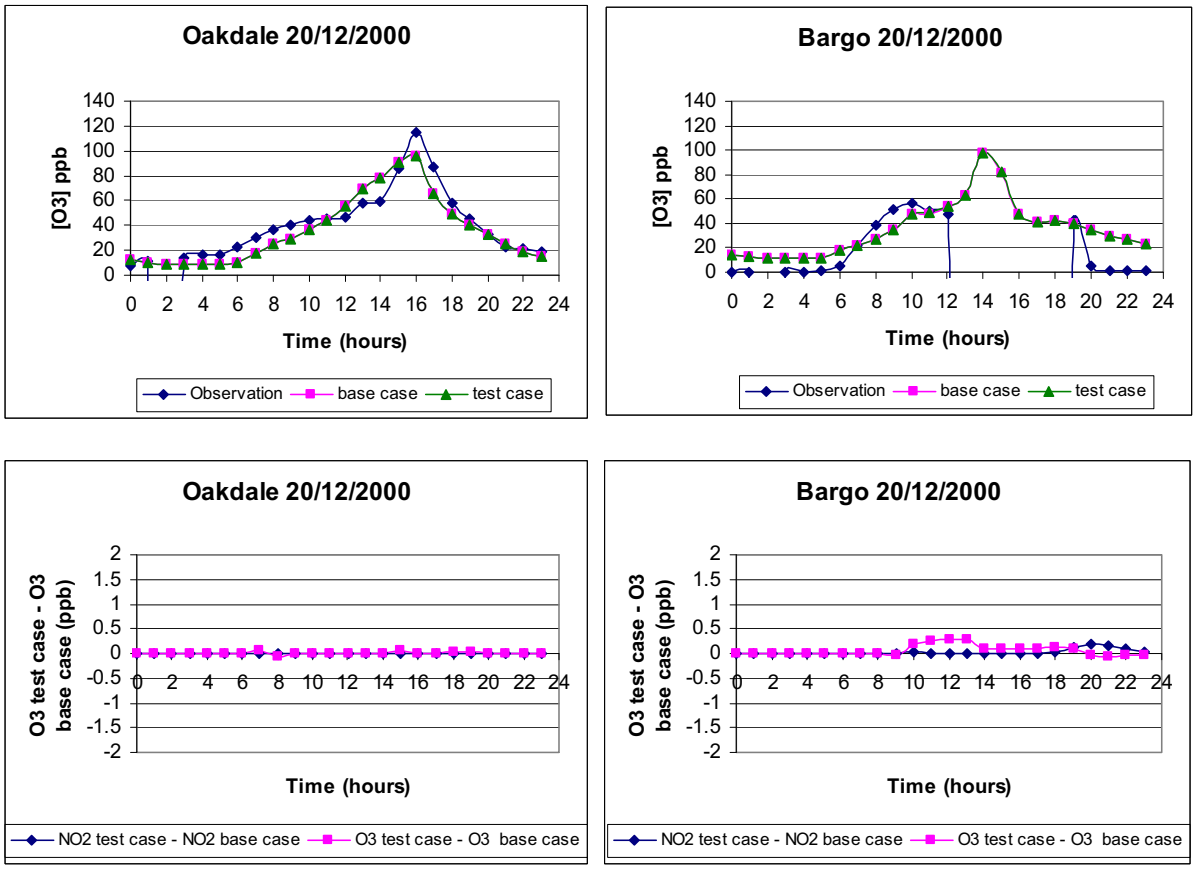

Figure 10. Observed and predicted ozone concentrations at Bargo and Oakdale for base case and full load case scenarios (top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios December 20, 2000 simulation (bottom)

At Oakdale, the model was able to reproduce the observed tendency for peak ozone concentration time series. In particular, the timing for the maximum ozone occurrences was predicted in agreement with observation. Observed data for Bargo were missing between 1200 hours and 1900 hours.

The difference between the predicted base case (without emissions from the power plant) and test case (case A of continuous full load daily emissions) ozone and NO_2 time series did not show any major impact on NO_2 and O_3 as it is shown in Figure 10. The maximum predicted increase in ozone was less than 0.5 ppb at Bargo. All other monitoring stations did not show any changes in ozone and NO_2 concentrations.

The chemical model LCC used in this study is good for reaching the maximum ozone value, but does not correctly model the morning build up of ozone. Therefore it is not expected that the overall model can accurately simulate pre sea breeze ozone events. This also has an impact on morning build up for the sea breeze events investigated here

Air Quality Analysis and Modelling for January 12, 2001

On this day, the west, south-west and north-west regions of the Sydney basin recorded high ozone concentrations. Bargo showed around 90 ppb of ozone under NO_x-limited conditions. Oakdale recorded around 14 pphm of ozone that occurred at around 1600 hours under NO_x-limited conditions Figure (11). In the north-west region, Blacktown also recorded around 13 pphm of ozone under NO_x-limited conditions Figure (12). Additional NO_x emissions at any location within the selected region may initially reduce the ozone concentration because of the titration process. However, if enough sunlight is available the ozone production may resume over downwind areas.

The CIT-LCC modelling results obtained for January 12, 2001 are presented in Table 4. The predicted data show that the worst case scenario in terms of ozone production was associated with the scenario A. An increase of 0.15% of the maximum 1-hour ozone concentration was predicted for the full load scenario when the plant was assumed to operate full time at full load. The highest contribution to the maximum 1-hour ozone produced by the additional NO_x from the proposed power plant was 0.2 ppb (Figure 13). The predicted increase is not significant as it is within the precision of the model predictions. Results obtained for the other test case scenarios were less than those obtained for the Case A

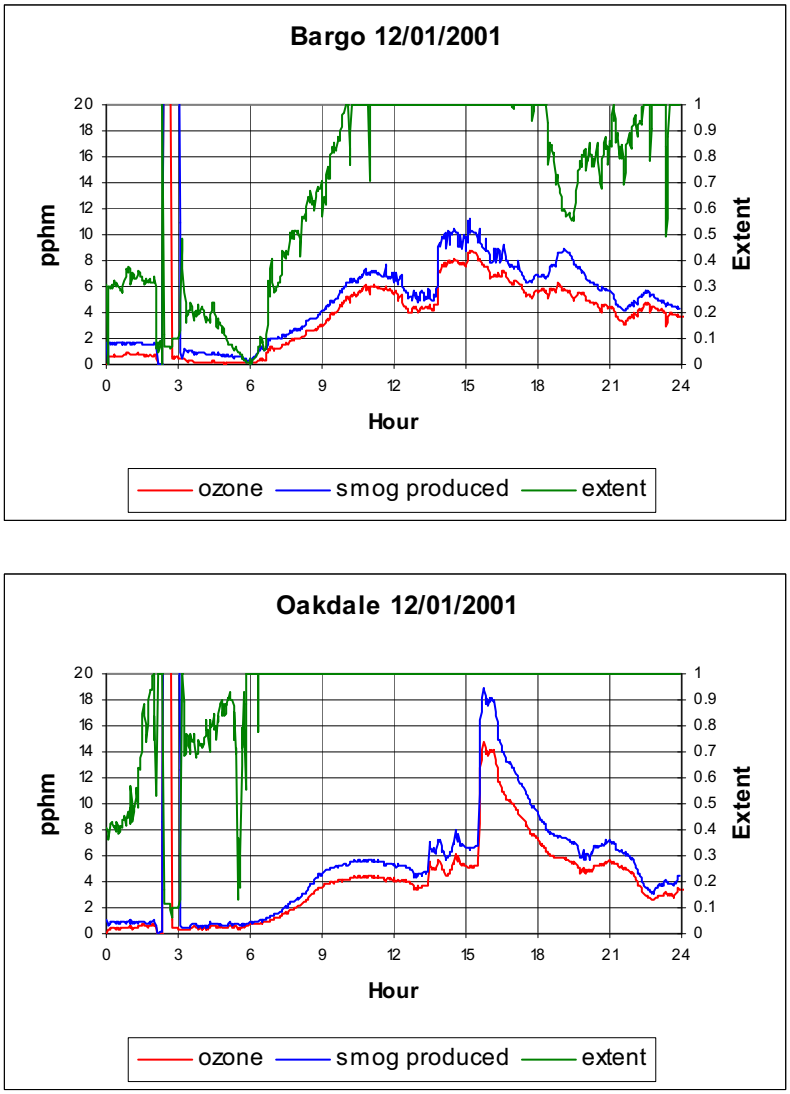

Figure 11 . Calculated IER parameters using ambient monitoring data collected at Bargo (top) and Oakdale (bottom) monitoring stations

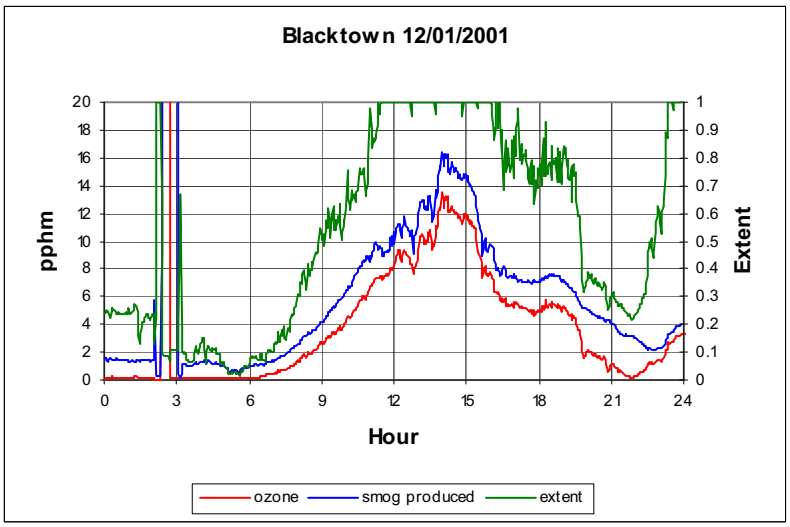

Figure 12. Calculated IER parameters using ambient monitoring data collected at Blacktown station

Table 4. Simulated maximum ozone concentrations, January 12, 2001

12/01/2001	Maximum 1-h ozone (ppb)	Maximum 4-h ozone (ppb)	% change in 1-h max ozone	% change in 4-h max ozone	Area exceeding 1-h (grid cells	Area exceeding 4-h (grid cells	Dosage 1-h (grid cell hours)	Dosage 4-h (grid cell hours)
Base case	**136.7**	**96.6**	**0.00**	**0.00**	**81.0**	**136.0**	**161.0**	**164.0**
Test case A	136.9	96.8	0.15	0.21	82.0	138.0	165.0	169.0
Test case B	136.8	96.7	0.07	0.10	81.0	137.0	164.0	167.0
Test case C	136.7	96.6	0.00	0.00	81.0	137.0	162.0	164.0
Test case D	136.7	96.6	0.00	0.00	81.0	136.0	161.0	164.0
Test case E	136.8	96.7	0.07	0.10	82.0	138.0	165.0	169.0

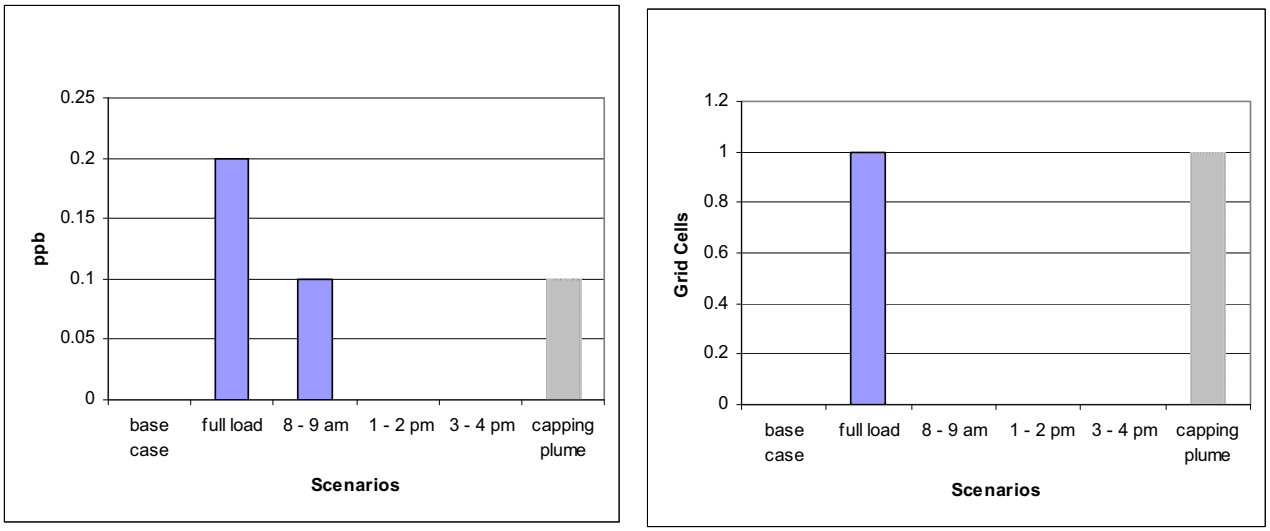

Figure 13. Net changes to the maximum 1-hour ozone concentrations (left) and to the number of grid cells exceeding 1-hour ozone guideline of 100 ppb for selected scenarios predicted for January 12, 2001

The predicted maximum net changes to the maximum 4-hour ozone concentrations was 0.2 ppb. This additional 0.21% increase to the 4-hour ozone concentrations that was associated with scenario case A (Figure 15) does not represent a significant increase to the 4-hour ozone concentration.

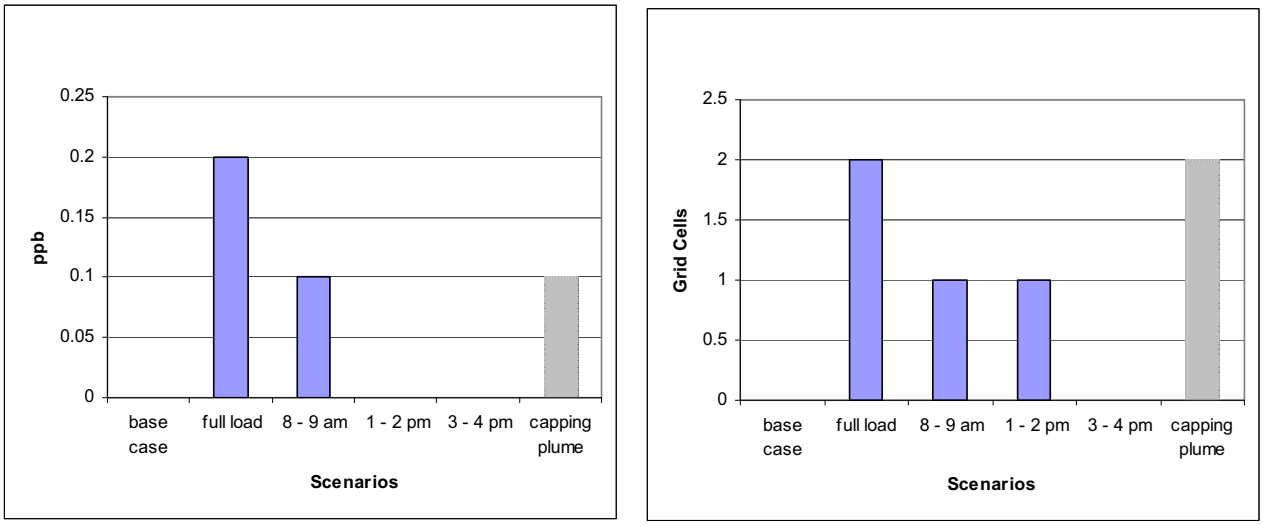

Figure 14. Net changes to the maximum 4-hour ozone concentrations (left) and to the number of grid cells exceeding 4-hour ozone guideline of 80 ppb for selected scenarios predicted for January 12, 2001

The difference between the base case and test case of the daily maximum 1-hour and 4-hour ozone averages were gridded and presented in Figures 15 and 16 respectively. On this day, the difference in ozone was predicted to mostly affect the ozone concentration to the west of the power plant. The highest 1-hour ozone increases of 6.85 ppb were predicted approximately to the west of the proposed site.

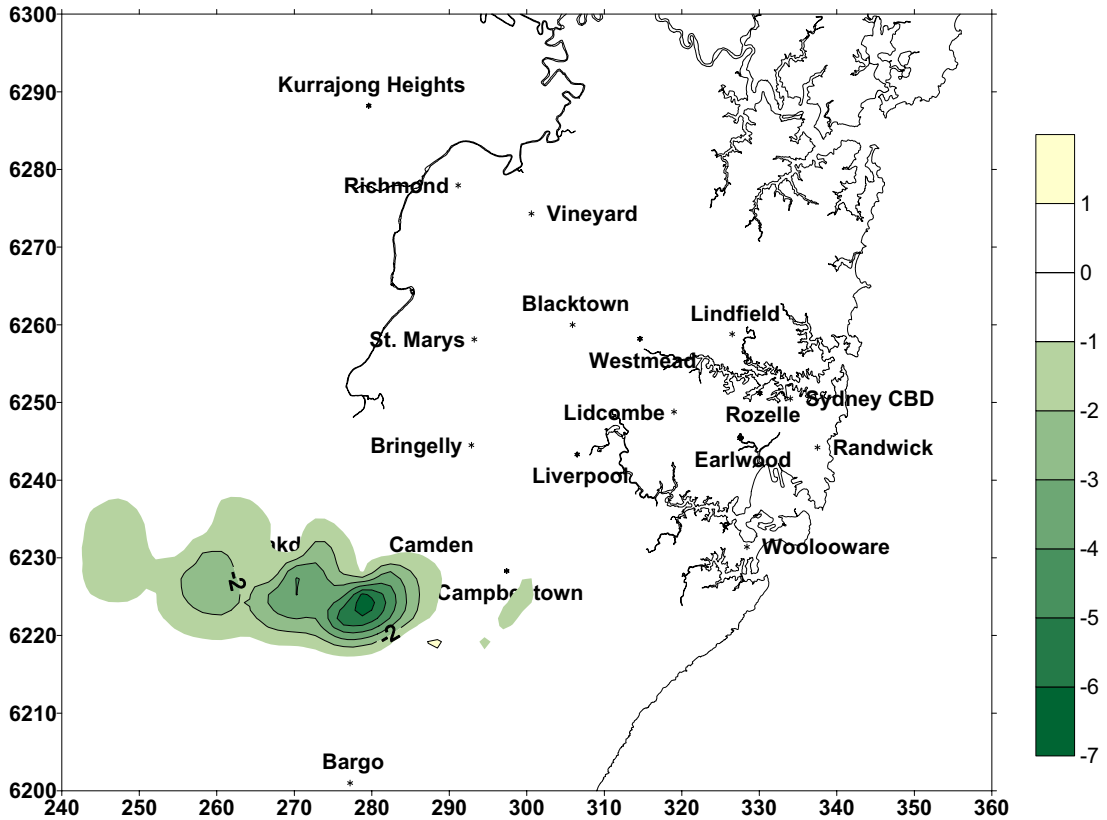

Figure 15. Contours of the daily maximum 1-hour O_3 average differences between base case and test case scenarios for January 12, 2001 simulation

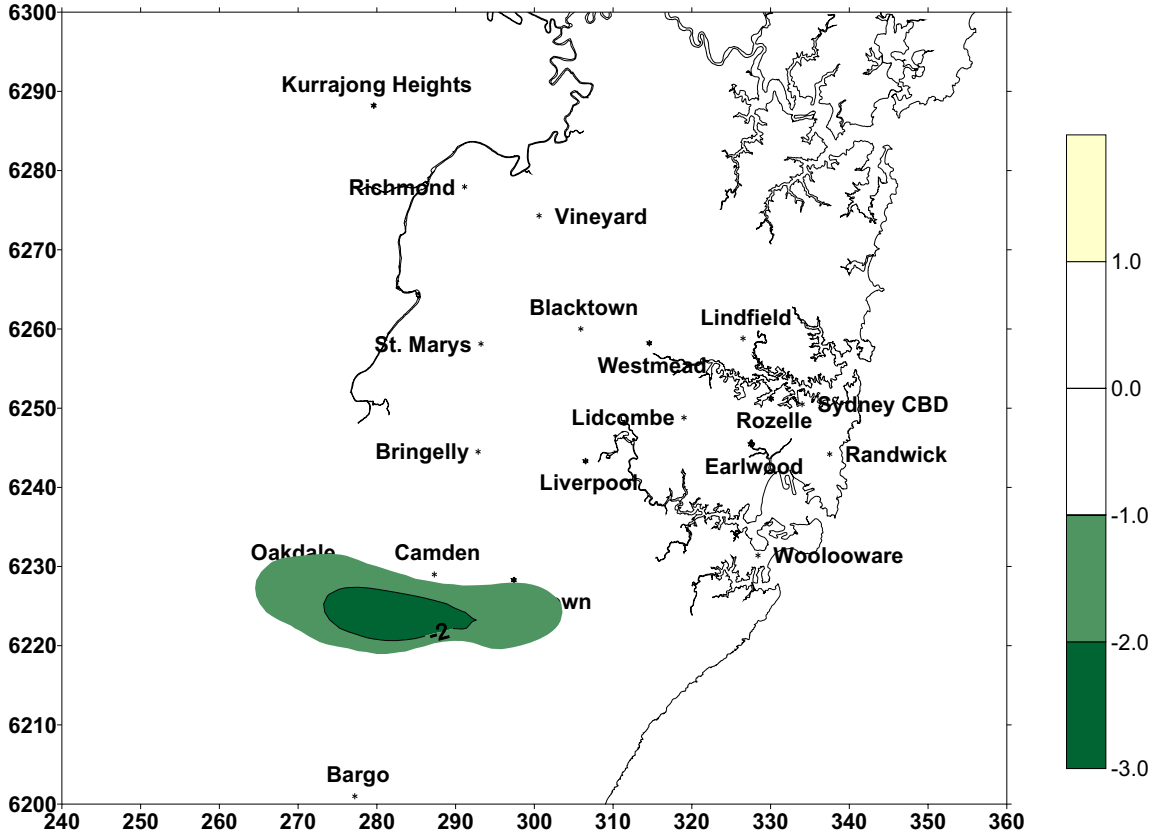

Figure 16. Contours of the daily maximum 4-hour O_3 average differences between base case and test case scenarios for January 12, 2001 simulation

To assess the model performance, recorded observed data for ozone time series, collected at selected monitoring stations, were compared to the predicted data at the same locations. At Oakdale, and up to 1400 hours, the model performed well in terms of predicting the ozone. However, after this time, the model under predicts the ozone at this location (Figure 17). At Bringelly and Bargo the model achieved better predictions for ozone concentrations (Figures 17 and 18). At Campbelltown, the signal received from the ozone monitor may not form a good basis for potential ozone comparison.

The difference between the base case and test Case A associated with the full load plant operation, calculated using the predicted ozone concentrations, showed that the plant has the potential to produce additional 3 ppb of ozone at Oakdale and Campbelltown. The maximum calculated NO_2 concentration of 1 ppb was calculated at these two sites (Figures 17 and 18). The increase of NO_2 at Campbelltown at 1100 hours was followed by an increase in ozone at 1200 and 1300 hours (Figure18). The increase of NO_2 at Oakdale occurred late in the afternoon at 1700 hours.

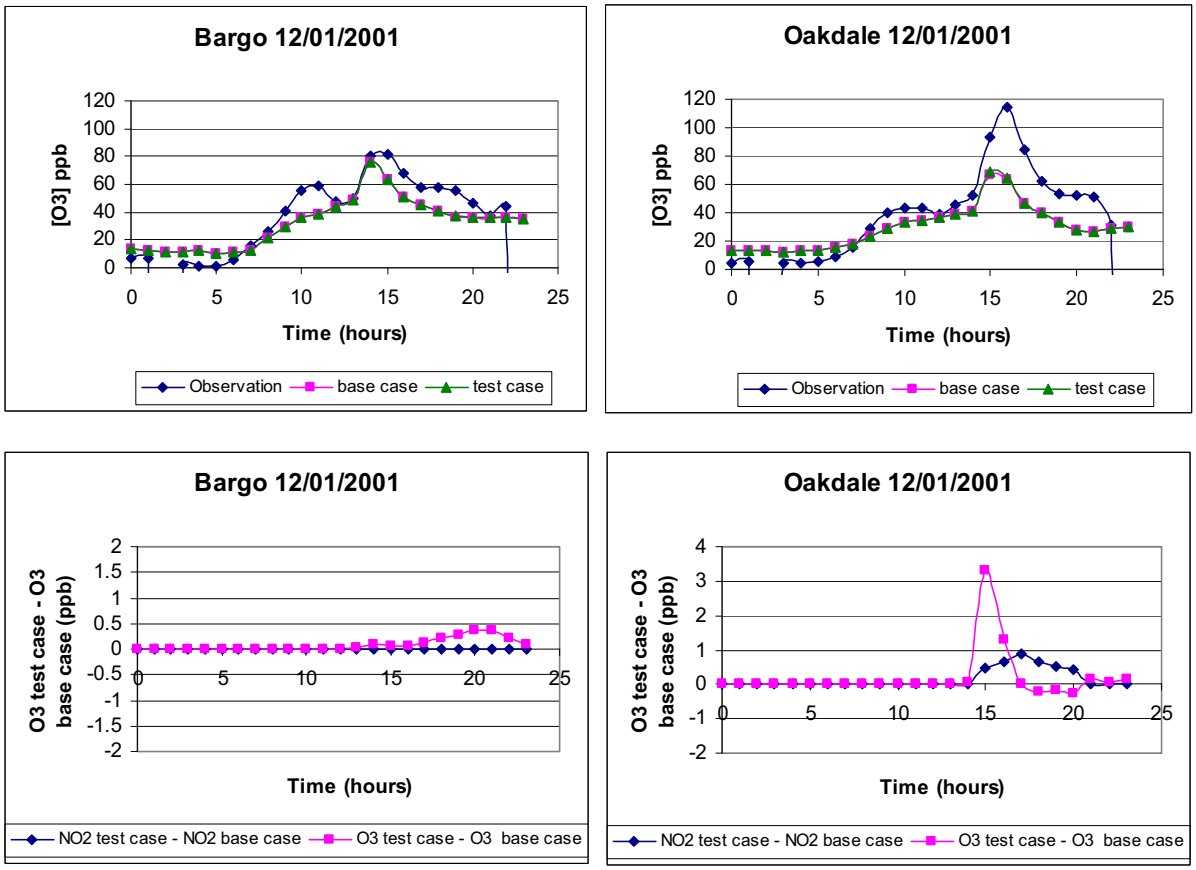

Figure 17. Observed and predicted ozone concentrations at Bargo and Oakdale for base case and full load case scenarios (top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios(bottom)

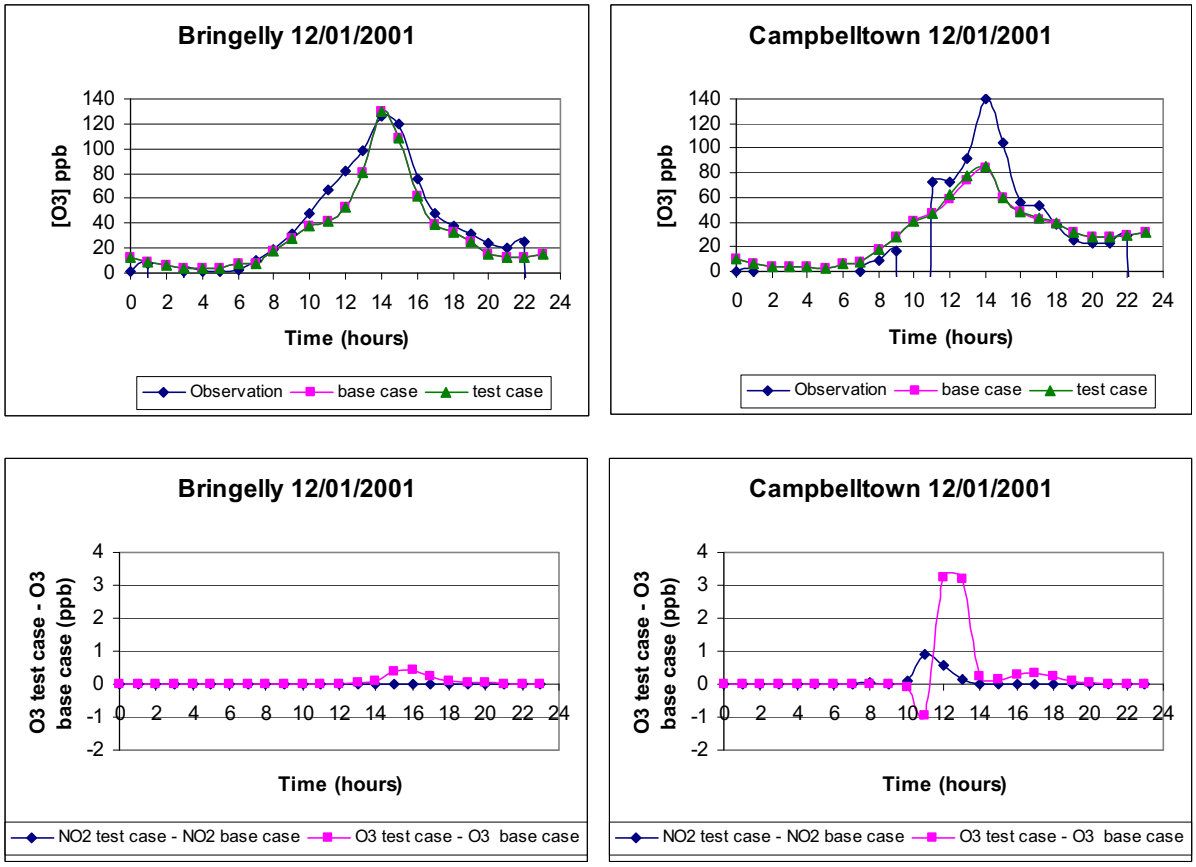

Figure 18. Observed and predicted ozone concentrations at Bringelly and Campbelltown for base case and full load case scenarios(top); (bottom) Calculated differences of O_3 and NO_2 for the test case and base case scenarios(bottom)

It is important to highlight that the highest increase in ozone concentration may not occur simultaneously with the maximum ozone concentration observed for this day. For example, the maximum increase predicted at Campbelltown of around 3 ppb occurred at 1300 hours while the maximum ozone concentration of 85 ppb occurred at 1400 hours with an insignificant difference between the base case and test case scenarios.

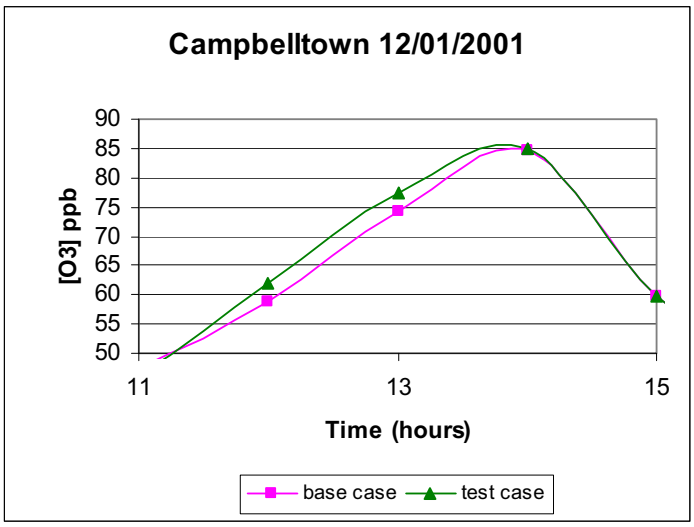

Figure 19. Time series of predicted ozone for the base case and test case A scenarios.

Air Quality Analysis and Modelling for January 22, 2001

On January 22, 2001, the maximum 1-hour ozone concentration was the lowest of the five base case days. Only at Bringelly the 1-hour ozone exceeded the NEPM standard under the NO_x limited conditions as presented in Figure 21. Most monitoring sites located in the south-west and north-west regions of the Sydney basin recorded ozone concentrations greater than 8 pphm but less than 10 pphm. The calculated IER parameters and ozone time series for selected sites are presented in Figures 20, 21 and 22.

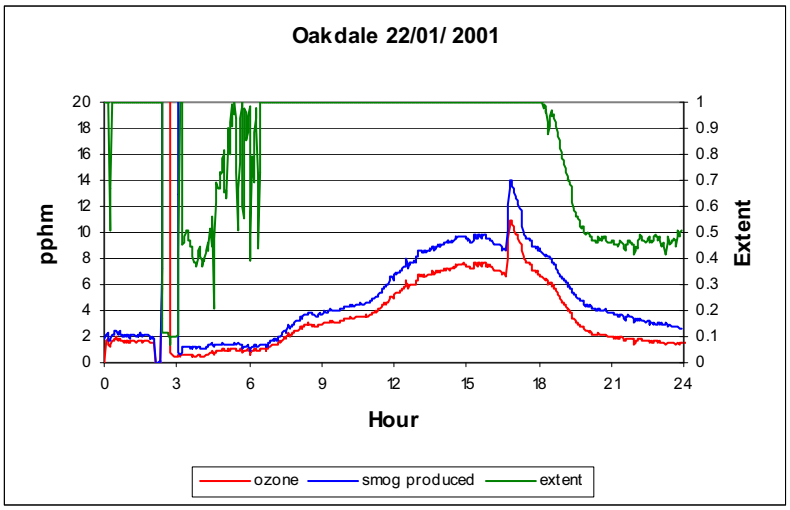

Figure 20 . Calculated IER parameters using ambient monitoring data collected at Oakdale monitoring station

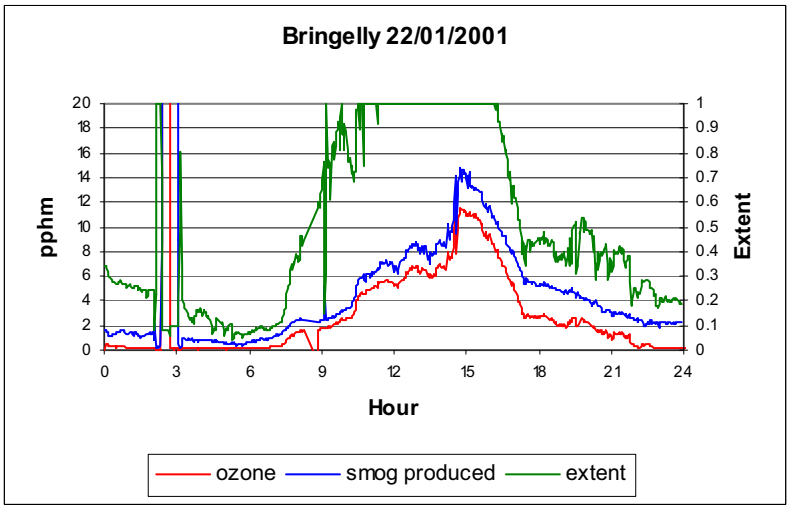

Figure 21 . Calculated IER parameters using ambient monitoring data collected at Bringelly monitoring station

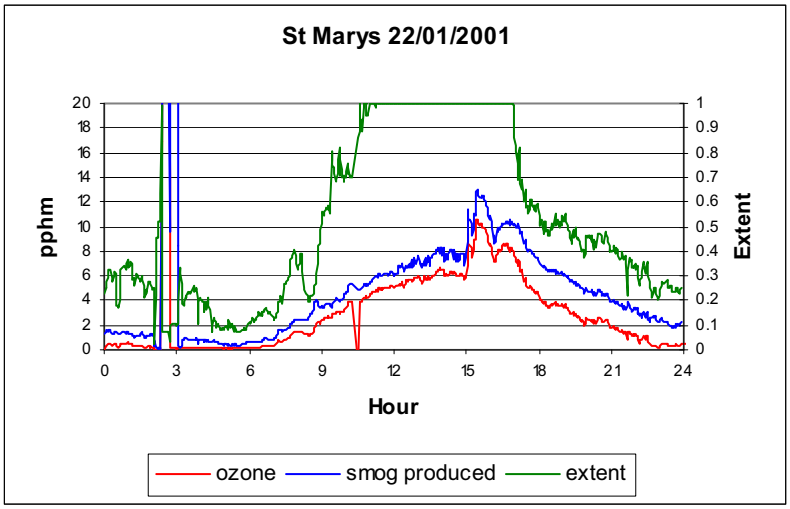

Figure 22 . Calculated IER parameters using ambient monitoring data collected at St Marys monitoring station

The CIT-LCC modelling results obtained for January 22, 2001 are presented in Table 5. The model predictions for all selected scenarios did not show any changes to the maximum 1-hour ozone concentrations predicted for the region. However it is predicted that the NO_x emissions from the plant may have the potential to produce a net increase of the 1-hour and 4-hour ozone concentrations by around 2.5 ppb and 2 ppb respectively as it is presented in Figures 24 and 25.

Table 5. Simulated maximum ozone concentrations, January 22, 2001

22/01/2001	Maximum 1-h ozone (ppb)	Maximum 4-h ozone (ppb)	% change in 1-h max ozone	% change in 4-h max ozone	Area exceeding 1-h (grid cells	Area exceeding 4-h (grid cells	Dosage 1-h (grid cell hours)	Dosage 4-h (grid cell hours)
base case	**106.2**	**89.3**	**0.00**	**0.00**	**79**	**263**	**79**	**550**
Test case A	106.2	89.3	0.00	0.00	79	274	79	571
Test case B	106.2	89.3	0.00	0.00	79	263	79	551
Test case C	106.2	89.3	0.00	0.00	79	269	79	560
Test case D	106.2	89.3	0.00	0.00	79	267	79	560
Test case E	106.2	89.3	0.00	0.00	79	272	79	569

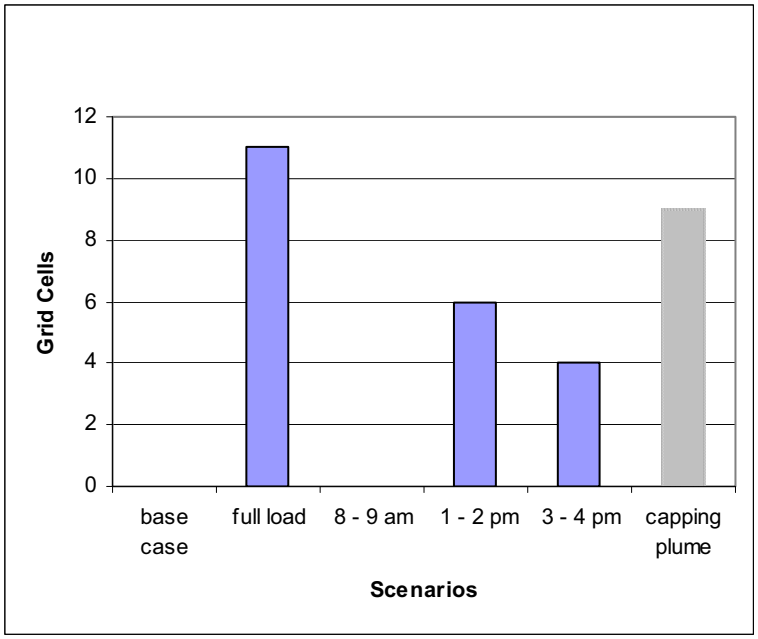

Figure 23. Net changes of the number of grid cells exceeding 4-hour ozone guideline of 100 ppb predicted for January 22, 2001

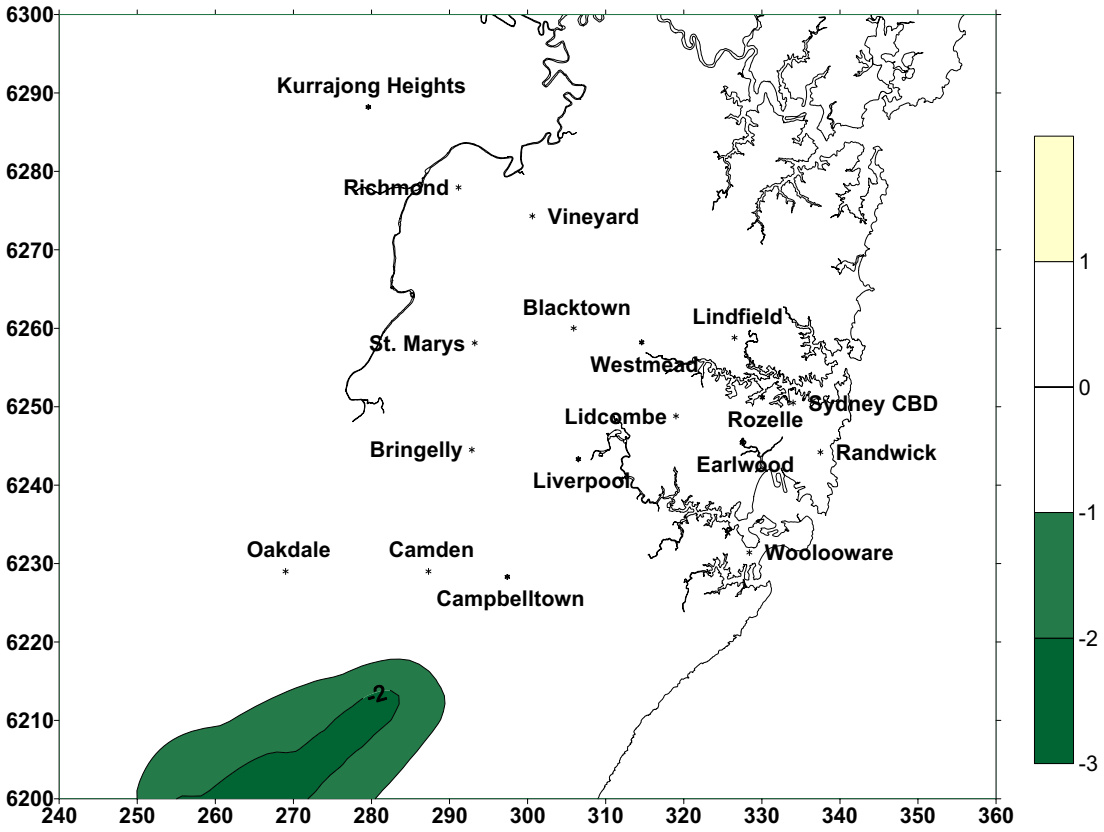

Figure 24. Contours of 1-hour O_3 average differences between base case and test case scenarios for January 22, 2001 simulation

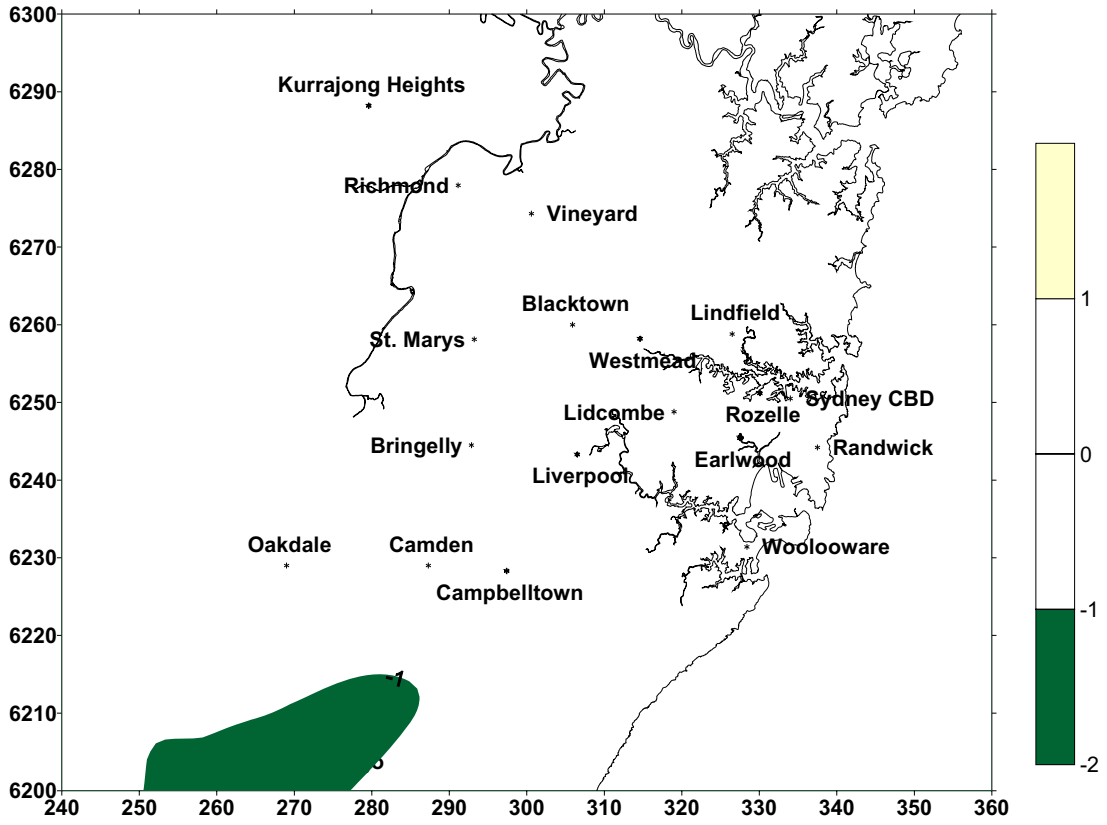

Figure 25. Contours of 4-hour O_3 average differences between base case and test case scenarios for January 22, 2001 simulation

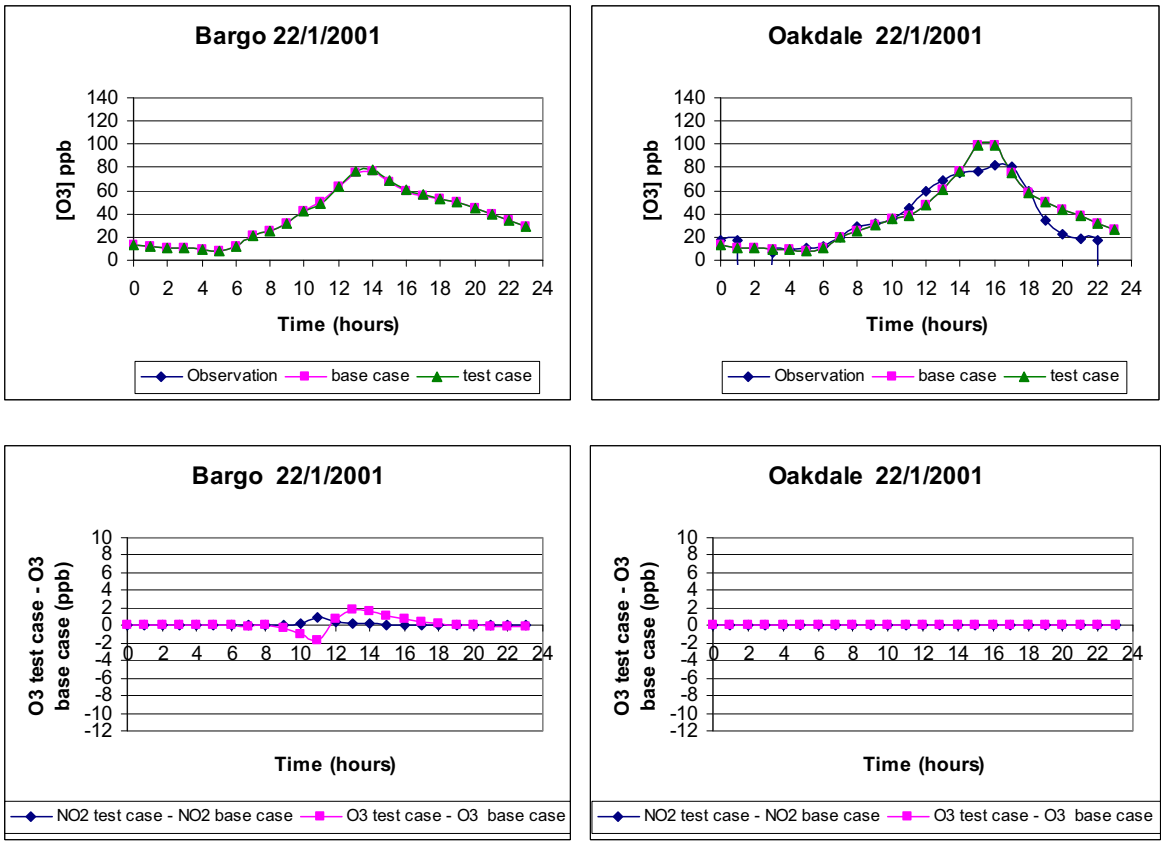

Figure 26. Observed and predicted ozone concentrations at Bargo and Oakdale for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the selected scenarios (bottom)

The difference calculated for ozone concentrations predicted for the base case scenario and test case scenario A showed an increase of 2 ppb in ozone formation at Bargo. This increase was not associated with the occurrence of maximum ozone concentration as shown in Figure 27.

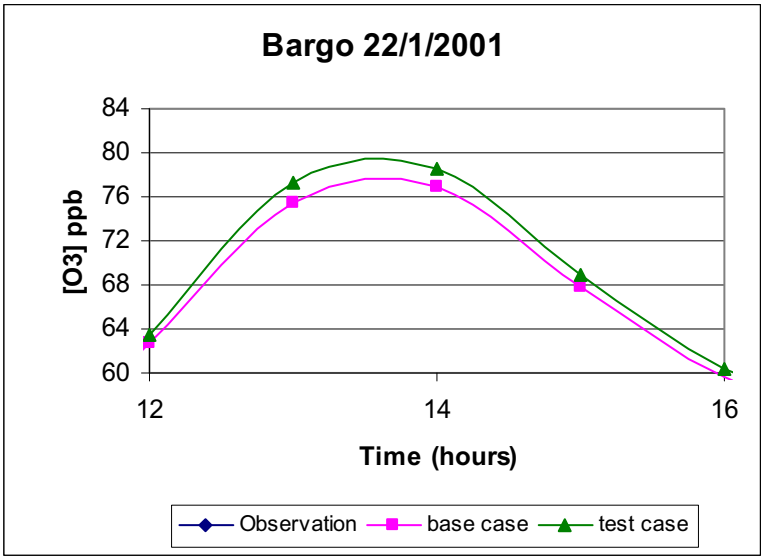

Figure 27. Time series of ozone concentrations predicted for the base case and test case scenarios

Air Quality Analysis and Modelling for February 10, 2004

On this day the selected south west region of the Sydney experienced high ozone concentrations. Oakdale monitoring station recorded ozone concentrations that exceeded 10 pphm under NO_x-limited conditions. At Campbelltown, ozone concentration reached 10 pphm under conditions where the photochemical smog regime was in transition from the hydrocarbon limited conditions towards the NO_x-limited conditions. Examples of the calculated IER parameters are given in Figures 28 and 29.

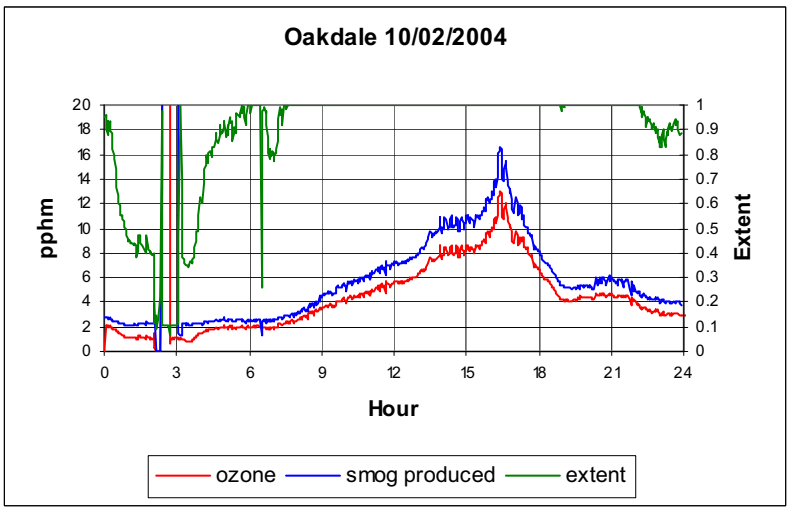

Figure 28 . Calculated IER parameters using ambient monitoring data collected at Oakdale monitoring station

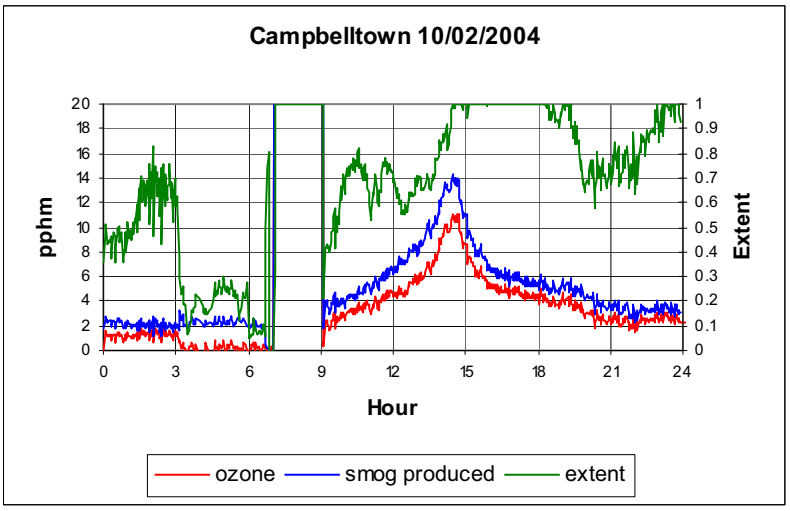

Figure 29 . Calculated IER parameters using ambient monitoring data collected at Campbelltown monitoring station

The CIT-LCC modelling results obtained for February 10, 2004 are presented in Table 6. Modelling of the impact of NO_x emissions from the proposed power plant predicted no increase to the 1-hour maximum ozone concentration (Figure 30). The maximum 4-hour ozone concentration was predicted to increase by an insignificant amount of 0.1 ppb (Figure 31).

Table 6. Simulated maximum ozone concentrations, February 10, 2004

10/02/2004	Maximum 1-h ozone (ppb)	Maximum 4-h ozone (ppb)	% change in 1-h max ozone	% change in 4-h max ozone	Area exceeding 1-h (grid cells	Area exceeding 4-h (grid cells	Dosage 1-h (grid cell hours)	Dosage 4-h (grid cell hours)
base case	**108.2**	**85.0**	**0.00**	**0.00**	**54**	**108**	**54**	**173**
Test case A	108.2	85.1	0.00	0.12	59	148	59	237
Test case B	108.0	84.7	-0.18	-0.35	54	120	54	189
Test case C	107.9	84.7	-0.28	-0.35	57	125	57	196
Test case D	108.2	85.1	0.00	0.12	59	136	59	224
Test case E	108.2	85.1	0.00	0.12	59	146	59	233

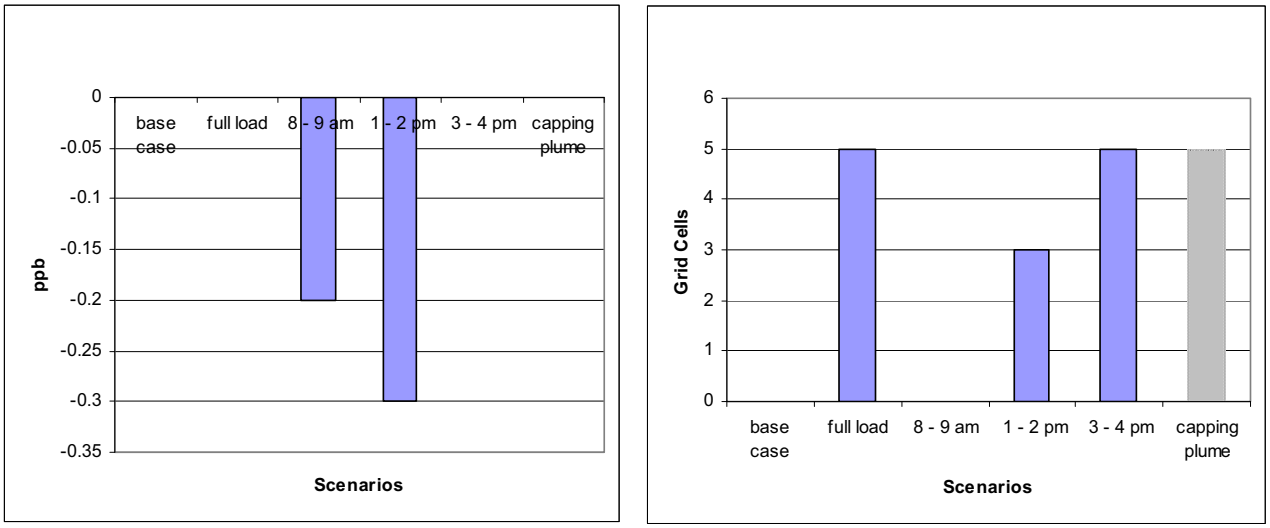

Figure 30. Net changes to the maximum 1-hour ozone concentrations (right) and to the number of grid cells exceeding 1-hour ozone guideline of 100 ppb for selected scenarios predicted for February 10, 2004

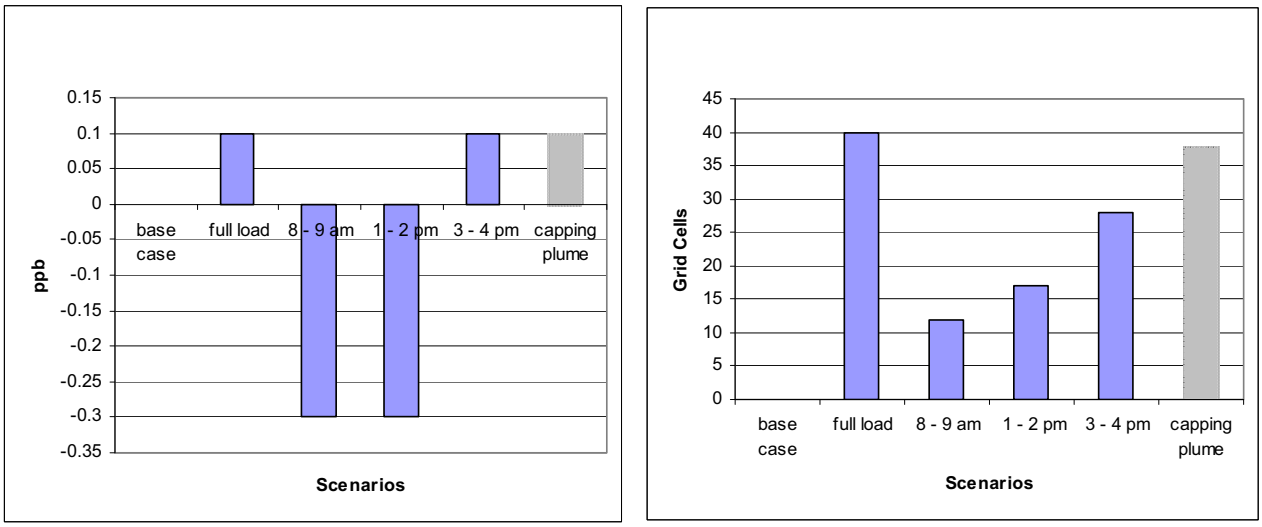

Figure 31. Net changes to the maximum 4-hour ozone concentrations (right) and to the number of grid cells exceeding 4-hour ozone guideline of 80 ppb for selected scenarios predicted February 10, 2004

Figures 32 and 33 illustrate the spatial extent of the ozone changes resulting from the potential impact of the additional NO_x from the proposed power plant. A maximum ozone increase of around 6.5 ppb was predicted to occur to the south west of the proposed plant.

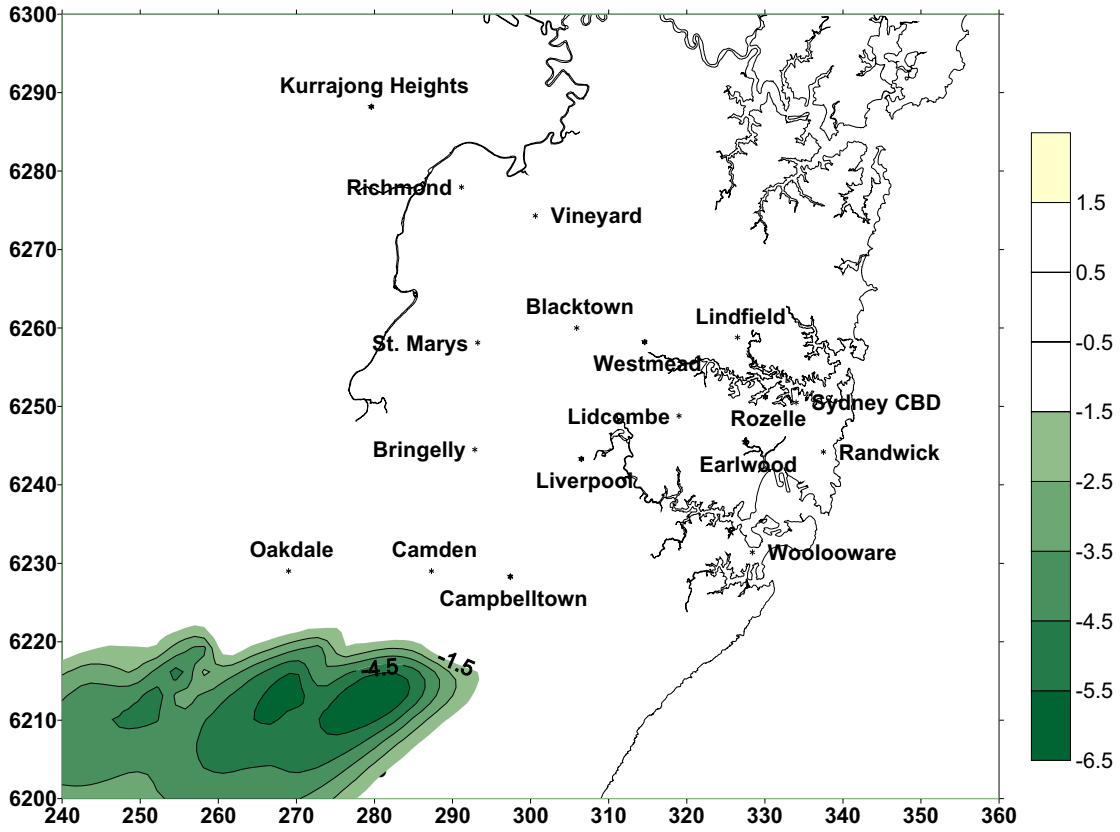

Figure 32. Contours of first-highest ozone differences between base case and test case scenarios for February 10, 2004 simulation

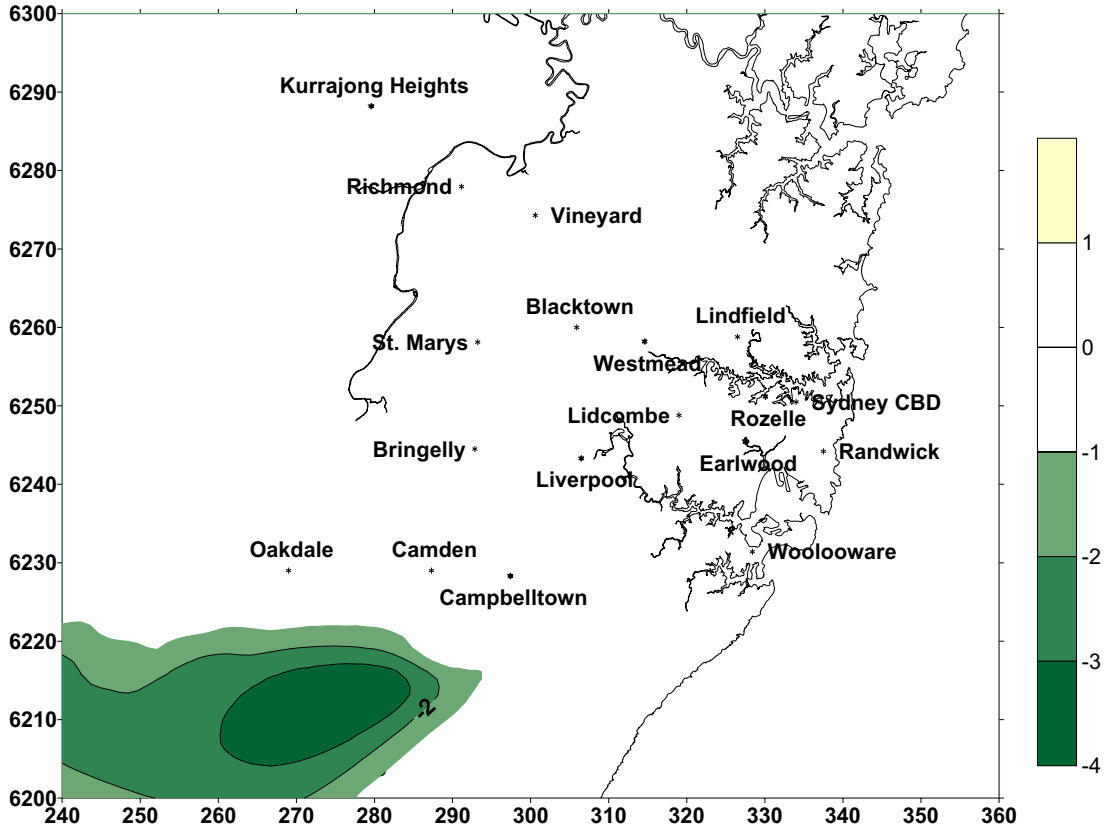

Figure 33. Contours of 4-hour O_3 average differences between base case and test case scenarios for February 10, 2004 simulation

The difference calculated for 1-hour ozone concentrations predicted for the base case scenario and test case scenario A showed an increase of around 2.3 ppb in ozone concentration at Bargo (Figure 34). At 9 am the maximum difference of NO_2 concentrations predicted at Westmead has reached a value of around 2.5 ppb before dropping back to background levels by around 11 am (Figure 35). The amount of the predicted1-hour NO_2 increases still considered as non significant when compared to the NEPM guidelines of 120 ppb.

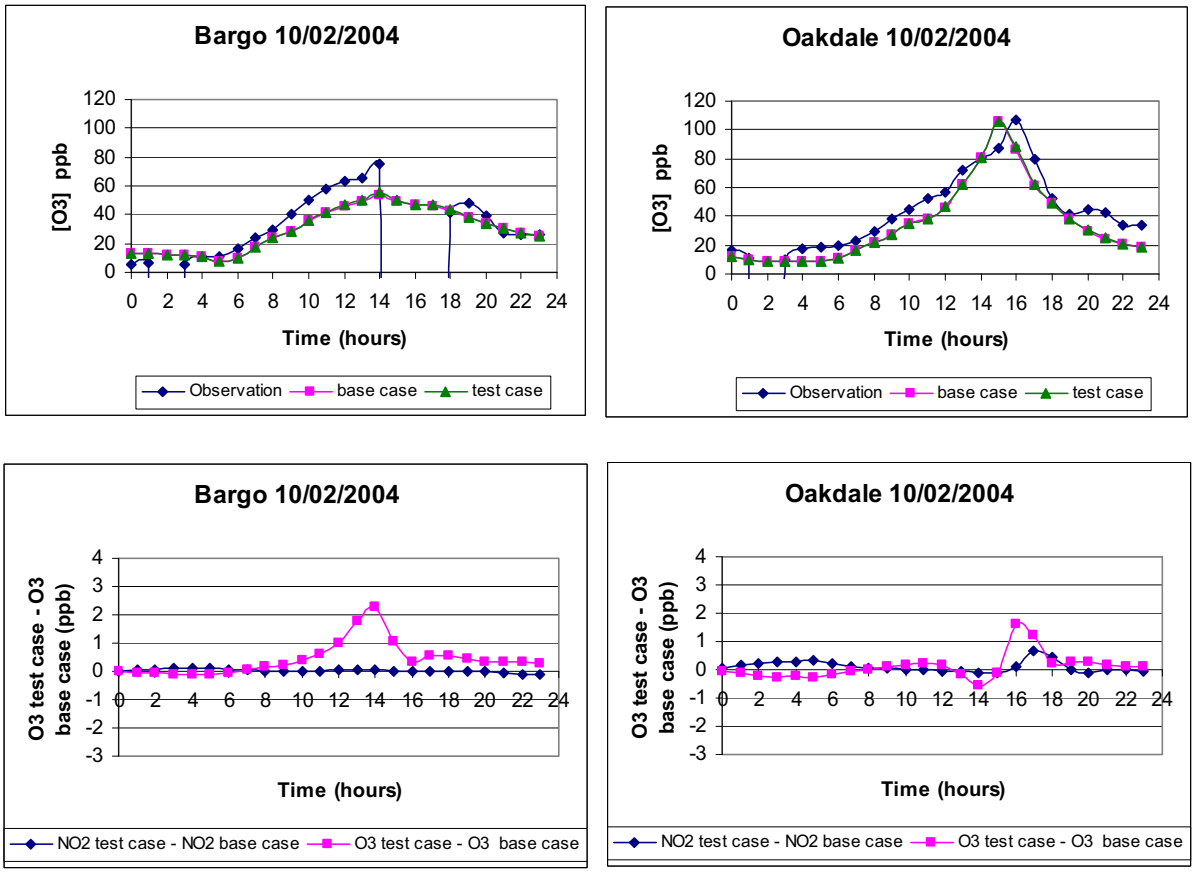

Figure 34. Observed and predicted ozone concentrations at Blacktown and Westmead for base case and full load case scenarios (top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

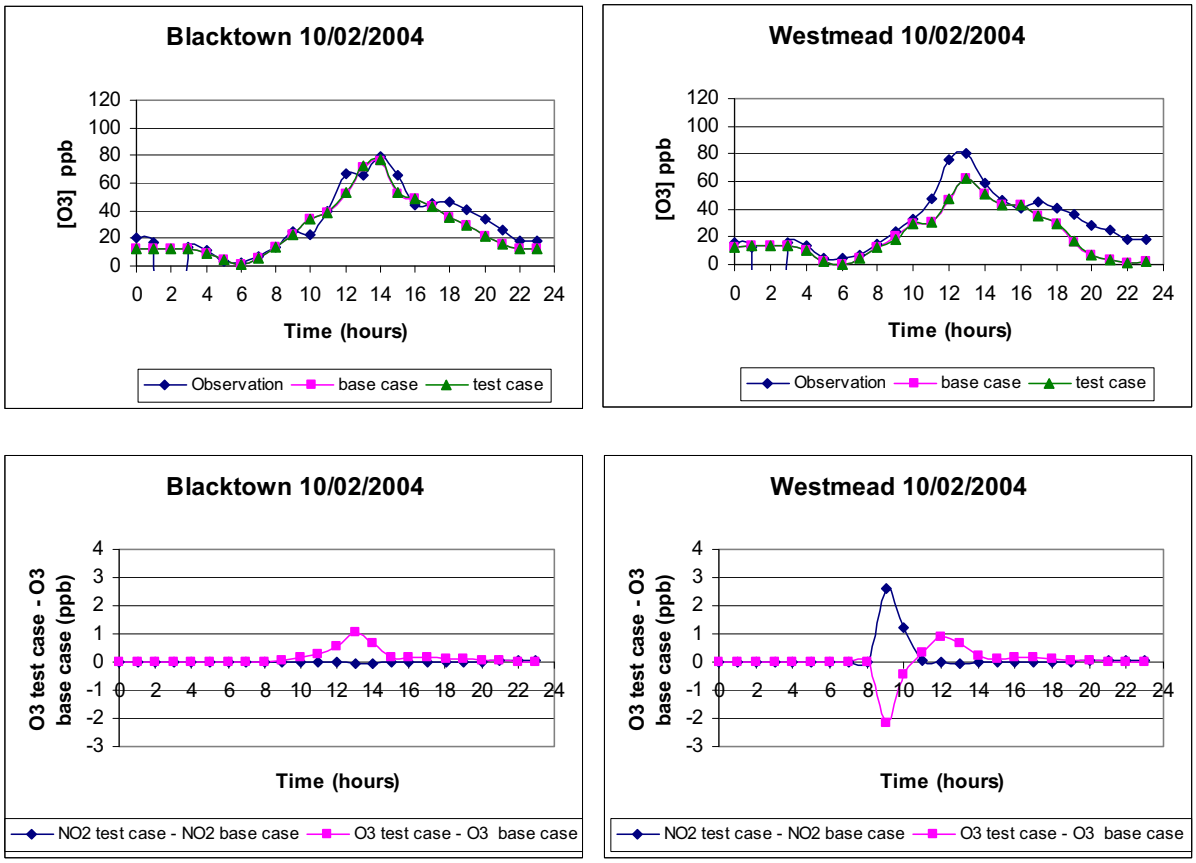

Figure 35. Observed and predicted ozone concentrations at Blacktown and Westmead for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

.

Air Quality Analysis and Modelling for November 27, 2004

On this day ambient air quality data, recorded at different monitoring stations located around the Sydney region, showed that the ambient air monitoring data collected at the central, west and south-west regions were dominated by high ozone concentrations.

Air monitoring data collected at Bargo, presented in Figure 36, showed that the ozone concentration was constantly less than 8 pphm. However, the ozone concentrations at Oakdale, Bringelly St Marys and Lidcombe exceeded the 1-hour NEPM guideline for ozone of 100 ppb. Photochemical analysis of air masses collected at Lidcombe presented in Figure 37 showed that the extent parameter (E) was less than 1, indicating that the air was in the hydrocarbon or transitional regimes. These NO_x-rich conditions prevailing in the area are generated by fresh emissions from local industries or emissions transported from other urban areas. Fresh emissions enrich the existing air parcels with the ozone precursors VOC and NO_x allowing for photochemical reactions to proceed actively and produce more ozone as the air masses travel downwind. This process will produce more ozone for downwind areas until most of the available NO_x is consumed. By the time the relevant chemical reactions consume most of the available NO_x the air becomes NO_x-limited. The analysis of data calculated for Bringelly (Figure 37) and for St Marys (Figure 38) indicates that the air parcels have reached the NO_x-limited regime (when E is close or equal 1) during the late-morning and afternoon periods. Under these NO_x-limited conditions, any additional NO_x emissions would initially quench a given amount of ozone in proportion to the amount of NO_x available, then later the ozone formation may resume depending on the atmospheric conditions.

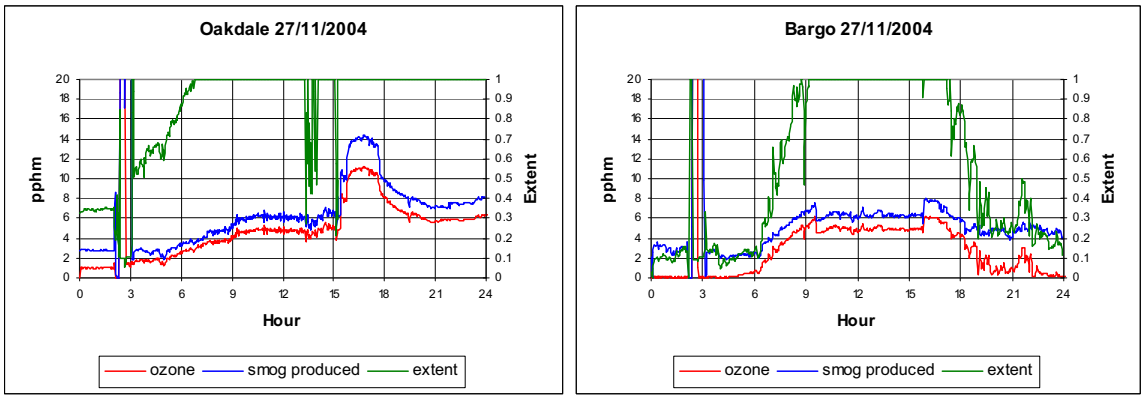

Figure 36. Calculated IER parameters using ambient monitoring data collected at Oakdale and Bargo monitoring stations

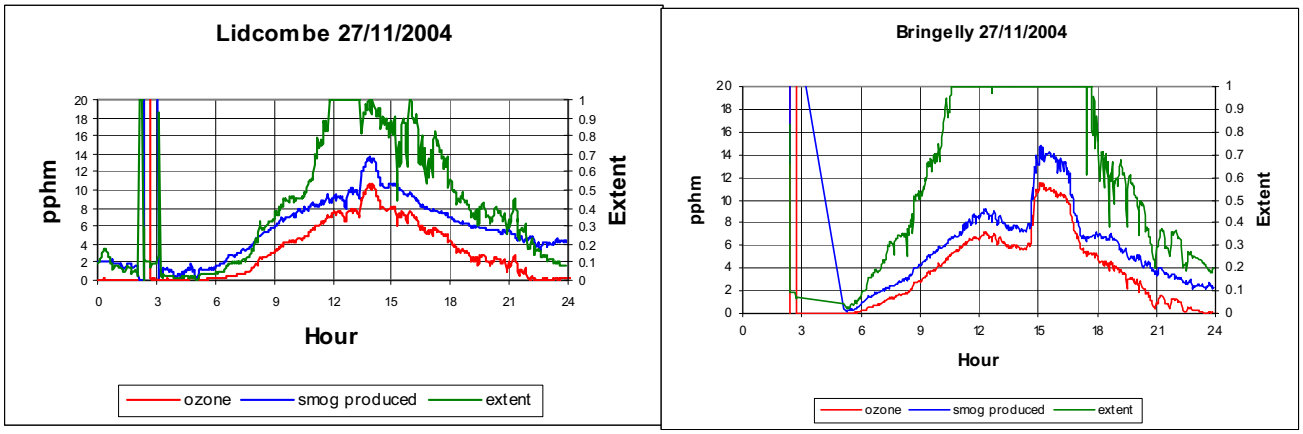

Figure 37 . Calculated IER parameters using ambient monitoring data collected at Lidcombe and Bringelly monitoring stations

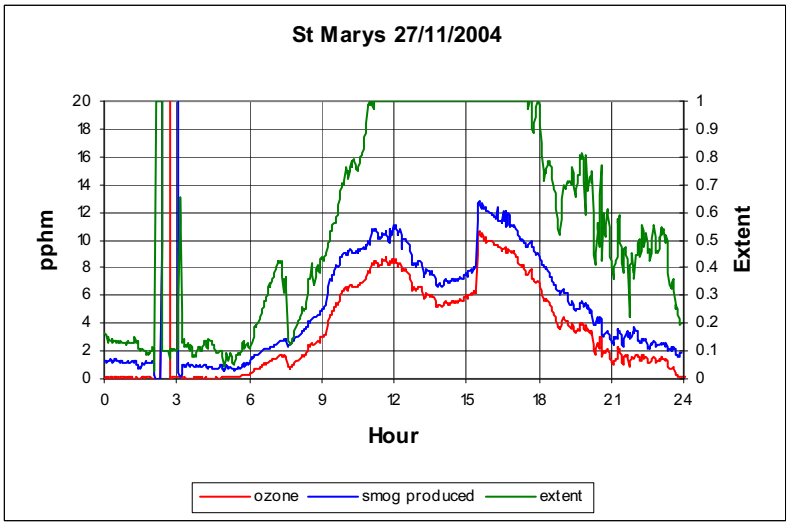

Figure 38. Calculated IER parameters using ambient monitoring data collected at St Marys monitoring station

The CIT-LCC modelling results obtained for November 27, 2004 are presented in Table 7. Modelling of the impact of NO_x emissions from the proposed power plant predicted no changes to the 1-hour maximum ozone concentration (Figure 39). The maximum 4-hour ozone concentration was predicted to increase by an insignificant amount of 0.1 ppb (Figure 40).

Table 7. Simulated maximum ozone concentrations, November 27, 2004

27/11/2004	Maximum 1-hr Ozone (ppb)	Maximum 4-hr Ozone (ppb)	% change in 1-hr max ozone	% change in 4-hr max ozone	Area exceeding 1-hour (grid cells)	Area exceeding 4-hour (grid cells)	Dosage 1-hour (grid cell hours)	Dosage 4-hour (grid cell hours)
base case	**131.2**	**116**	**0.00**	**0.00**	**362**	**439**	**582**	**1354**
Test case A	131.2	116	0.00	0.00	366	446	592	1373
Test case B	131.2	116	0.00	0.00	362	439	582	1354
Test case C	131.2	116	0.00	0.00	362	439	582	1354
Test case D	131.2	116	0.00	0.00	365	442	591	1367
Test case E	131.2	116	0.00	0.09	374	446	603	1382

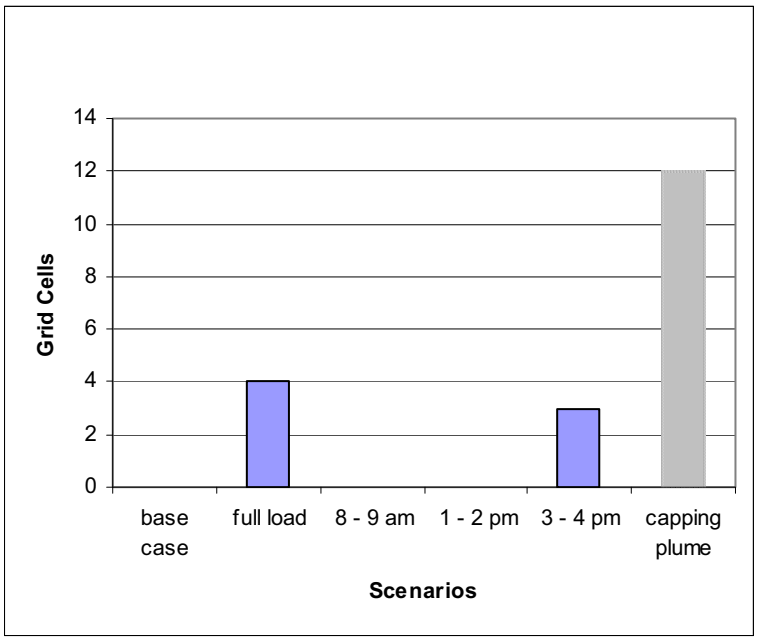

Figure 39. Net changes of the number of grid cells exceeding 1-hour ozone guideline of 100 ppb predicted for November 27, 2004

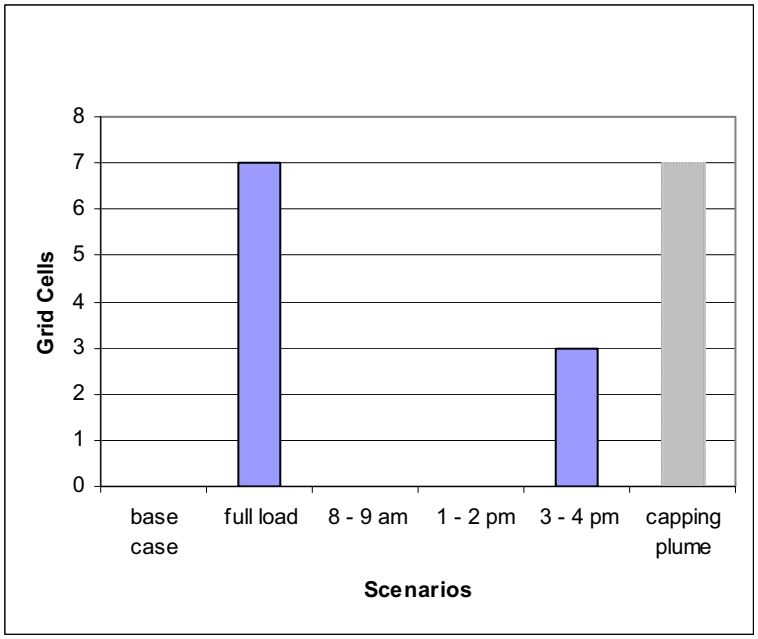

Figure 40. Net changes of the number of grid cells exceeding 4-hour ozone guideline of 80 ppb predicted for November 27, 2004

Figures 41 and 42 illustrate the spatial extent of the 1-hour and 4-hour ozone changes resulting from the potential impact of the additional NO_x from the proposed power plant

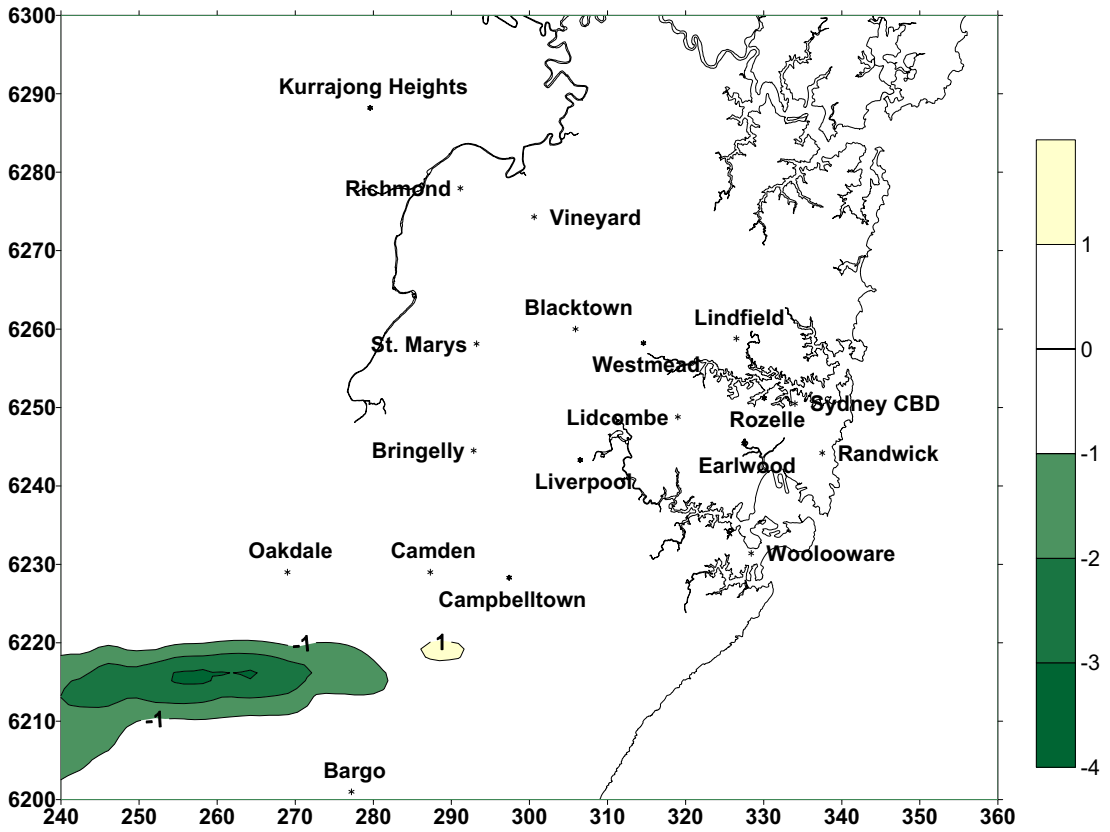

Figure 41. Contours of 1-hour O_3 average differences between base case and test case scenarios for November 27, 2004 simulation

The highest increase in 1-hour ozone of around 3.5 ppb was predicted to occur over areas located approximately to the south-west region of the proposed pant location as it is shown in Figure 41. However, the 4-hour ozone concentration has increased by around 2.3 ppb as illustrated in Figure 42.

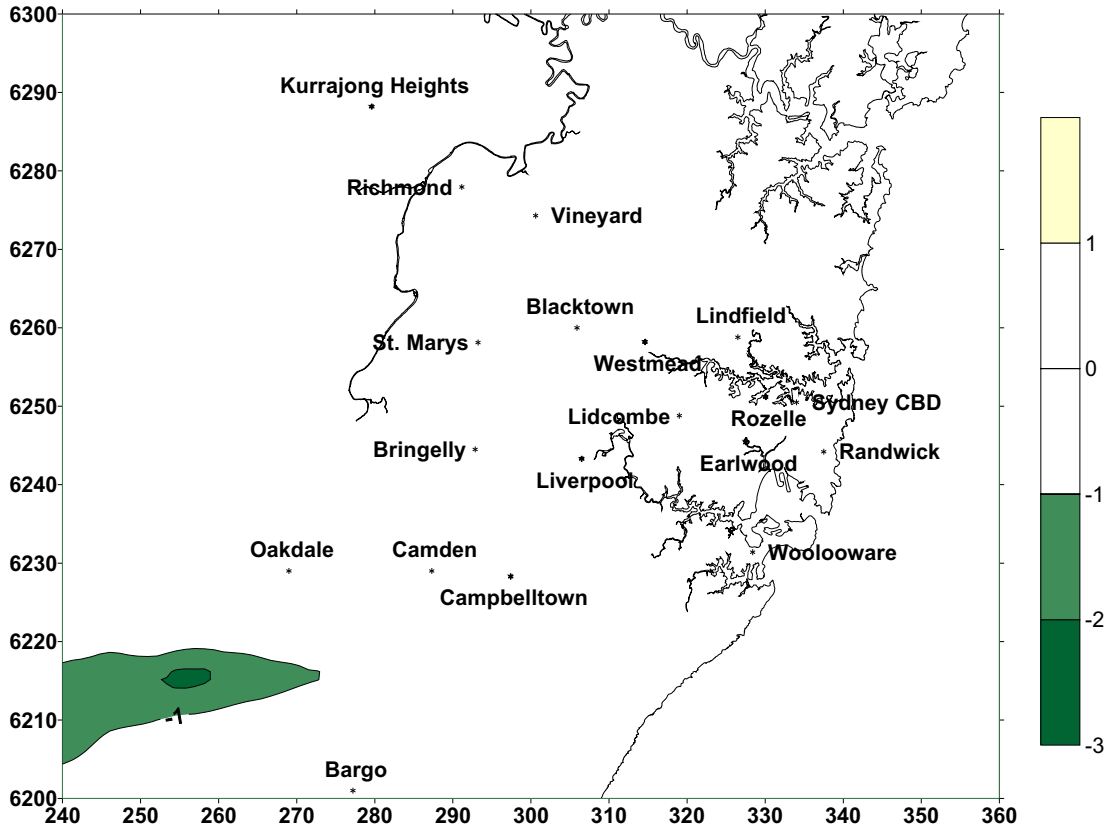

Figure 42. Contours of 4-hour O_3 average differences between base case and test case scenarios for November 27, 2004 simulation

The modelling results obtained for ozone compared well against observations collected at Oakdale, Bargo, Chullora and Liverpool presented in Figures 43, 44,and 45. On this day the difference calculated for ozone time series predicted for the base case scenario and test case scenario A showed a maximum increase of around 6 ppb in ozone formation - at Macarthur occurring between 1900 hours and 2000 hours (Figure 44). Bringelly calculated data showed a difference of 4 ppb occurring between 1900 hours and 2000 hours. Oakdale and Bargo predicted a maximum of ozone difference of 3 ppb.
It is important to highlight that the mentioned increases occurred only during periods when ozone levels are around the background values.

On this day the modelling results of the impacts of NO_x emissions from the proposed power plant on regional ozone concentrations predicted that the plant may have the potential to increase local O_3 by a maximum of around 3 ppb during the day when photochemical reactivity is progressing.

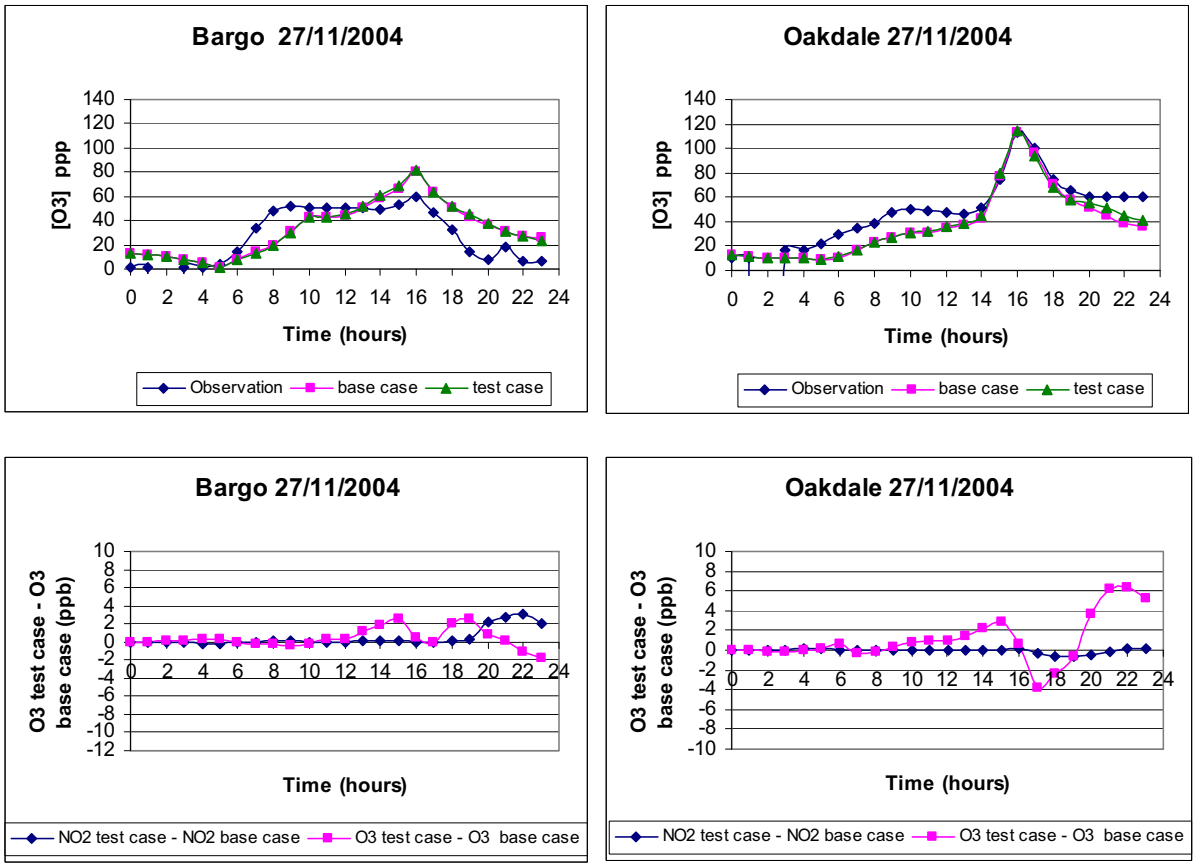

Figure 43. Observed and predicted ozone concentrations at Bargo and Oakdale for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

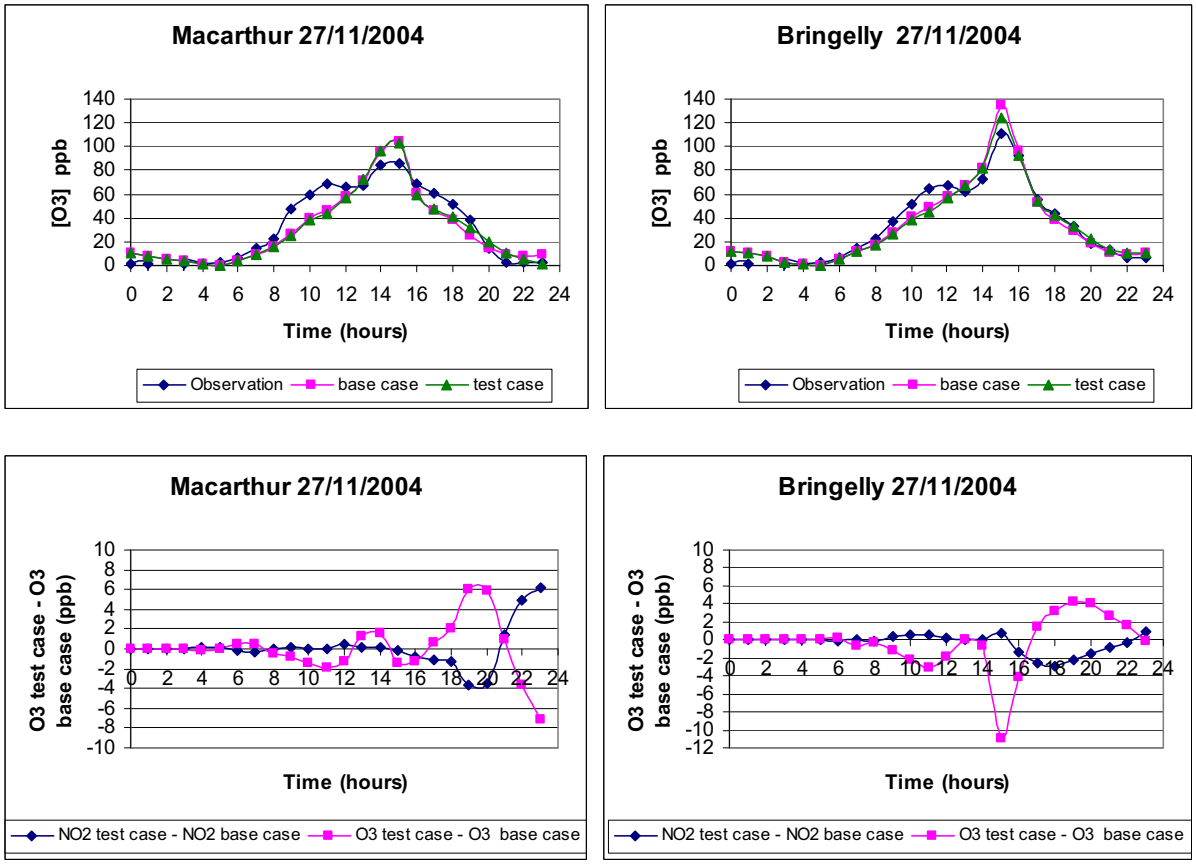

Figure 44. Observed and predicted ozone concentrations at Bringelly and Macarthur for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

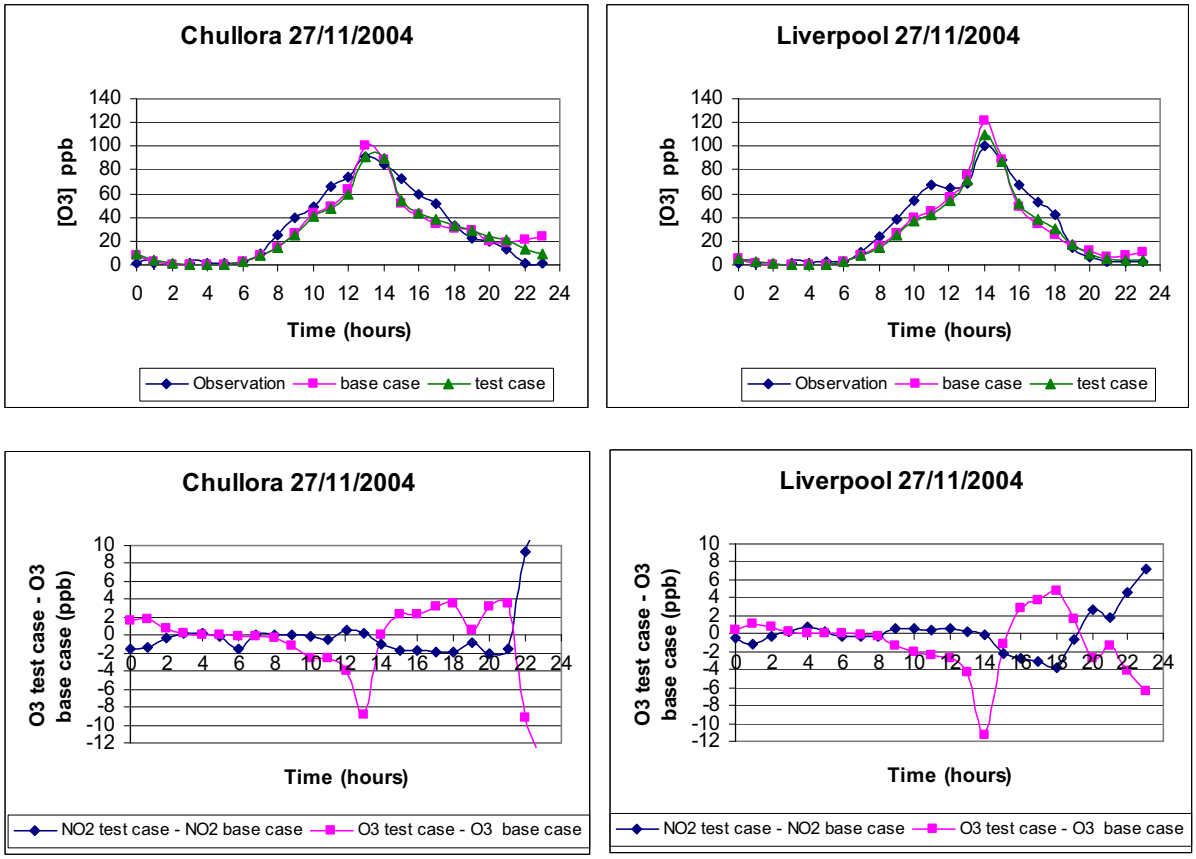

Figure 45. Observed and predicted ozone concentrations at Chullora and Liverpool for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

Conclusions

The CIT-LCC photochemical transport model was used to assess the potential impact of NO_x emissions from a proposed power plant at Appin, NSW, on regional and local photochemical smog formation. The impact of the proposed plant on ozone formation within the Sydney region has been assessed by comparing the relative change in peak ozone concentration predictions for the base-case (without additional NO_x) with the test case (with additional NO_x) scenarios.

The model simulated the ozone formation for five selected days chosen by the Atmospheric Science Section of NSW DEC. The impact on ozone formation was assessed for the proposed plant NO_x emission scenarios, representative of worst case operation conditions. Modelling results predicted that the plant may increase the 1-hour ozone concentration over downwind areas located to the south or south-west of the proposed power plant by a maximum of around 6.8 ppb.

The table below summarises the modelling results predicted for the worst cases scenario of full load operation

	max 1-h ozone ppb	**% change in 1-h max ozone**	**max 4-h ozone ppb**	**% change in 4-h max ozone**	**number grid cells >= 100 ppb**	**number grid cells >= 80ppb**	**max 1-h diffrence ppb**	**max 4-h difference ppb**
20/12/2000								
Base Case	**109.9**	**0**	**94.2**	**0**	**186**	**371**		
full load operation	114.9	4.55	96.2	2.12	228	392	6.5	3.4
12/01/2001								
Base case	**136.7**	**0**	**96.6**	**0**	**81**	**136**		
full load operation	136.9	0.15	96.8	0.21	82	138	6.8	3
22/01/2001								
Base case	**106.2**	**0**	**89.3**	**0**	**79**	**263**		
full load operation	106.2	0	89.3	0	79	274	2.4	2
10/02/2004								
Base case	**108.2**	**0**	**85**	**0**	**54**	**108**		
full load operation	108.2	0	85.1	0.12	59	148	6.5	3.8
27/11/2004								
Base case	**131.2**	**0**	**116**	**0**	**362**	**439**		
full load operation	131.2	0	116	0	366	446	3.5	2.2

The maximum net increases of NO_2 was calculated as difference between the base and test case scenarios. The calculated changes of NO_2 concentration was predicted to increase by a maximum of around 2.5 ppb on February 10, 2004. This increase is considered insignificant when it is compared to the 1-hour NO_2 NEPM guideline of 120 ppb.

Of all considered case scenarios, the highest impacts were predicted to be produced when the plant would operate with full load over 24 hours on the selected days. The proposed power plant was predicted to contribute a maximum of 2.5 ppb to the 1-hour NO_2 concentration at selected locations of the modelling domain. This increase is assumed to represent around 2% of the NEPM guideline of 120 ppb.

All described results were obtained for the full load operation of the plant. Since the proposed power plant will operate only as a peaking plant, any impacts that may occur will be less than if it was operating continuously.

Acknowledgements

The author thank the NSW DEC for assistance in this project through the provision of the base case modelling scenarios, air quality data and the MAQS inventory. The project benefited greatly from contributions of and discussions with DEC scientists Suzanne Quigley and Jason Spencer in the modelling study.

The author wish to express his gratitude to Dr Mark Dell'Amico and Dr Graeme Batley for their careful reading of the draft report.

References

DEC, NSW (2005). State of Knowledge (SoK)

Johnson G. (1984). A simple model for predicting the ozone concentration of ambient air, In: Proceedings of the 8th International Clean Air and Environment Conference, Melbourne, Vol 2, pp. 715-731.

Hyde, R., and Johnson, G.M. (1990). Pilot study, Report to the NSW Department of Planning, NSW State Pollution Control Commission, and the Commonwealth Department of Transport and Communications, Macquarie University and CSIRO.

Harley R.A., Russell A.G., McRae G.J. Cass G.R. and Seinfeld J.H., (1993). Photochemical modelling of the southern California air quality study. Environ. Sci. Technol., 27:378-388.

National Environment Protection Measures (NEPM):
http://www.ephc.gov.au/nepms/air/air_nepm.html

Appendix A
Investigation of an Additional Plant Configuration

As requested by the client, the potential impact on downwind photochemical smog formation has been investigated for an additional plant configuration with different emission characteristics,. The stack characteristics for emissions expected from the new configuration of the proposed plant are given below in Table A1.

Table A1. Emission parameters for scenarios used in the current CIT-LCC assessment

Scenarios	Stack height (m)	Gas exit temperature (°C)	Stack exit diameter (m)	Gas exit velocity (m/s)	NO_x (as NO_2) (g/s)	Time of emissions
Base case	-	-	-	-	-	Only the emission inventory
Test case A	28	411	3.4	50	41	Continuous hourly NOx emissions

The CIT model was used to predict maximum 1- hour and 4-hour average ground-level concentrations resulting from the new configuration of the proposed plant operations. The selected five days identified by DEC as being typical of photochemical smog events that can occur in the Sydney basin have been used to simulate the potential impact of the plant emissions on ozone formation. The difference of the simulated 1-hour and 4-hour average ground-level concentrations of ozone were calculated and presented in Table A2.

Table A2. Summary of Simulated maximum ozone concentrations for the five selected modelling days

	Max 1-h ozone ppb	% change in 1-h max ozone	Max 4-h ozone ppb	% change in 4-h max ozone	Number grid cells >= 100 ppb	Number grid cells >= 80ppb	Max difference 1-h Ozone ppb	Max difference 4-h Ozone ppb
20-12-2000								
Base case	**109.90**		**94.20**		**186.00**	**371.00**		
full load operation	112.70	2.55	95.40	1.27	215.00	382.00	3.87	2.07
12/01/2001								
Base case	**136.70**		**96.60**		**81.00**	**136.00**		
full load operation	136.70	0.00	96.60	0.00	81.00	137.00	5.89	2.93
22/01/2001								
Base case	**106.20**		**89.30**		**79.00**	**263.00**		
full load operation	106.20	0.00	89.30	0.00	79.00	272.00	1.43	1.28
10-Feb-04								
Base case	**108.20**		**85.00**		**54.00**	**108.00**		
full load operation	108.10	-1.64	84.97	-9.80	58.00	136.00	6.32	3.66
27/11/2004								
Base case	**131.20**		**116.00**		**362.00**	**439.00**		
full load operation	131.20	0.00	116.00	0.00	370.00	440.00	3.20	2.16

It has been previously shown that worst case scenarios for the previous configuration of the plant operations were obtained for the daily full operation scenarios. On this basis and for the new configuration of the plant which is anticipated to run at lower NO_x emissions, we simulated the potential impact of the new NO_x emissions from the proposed plant on ozone formation using the full load scenarios.

The obtained modelling results showed that the plant may contribute to 1-hour ozone formation by a maximum of around 2.8 ppb. This increase was predicted for the December 12, 2000 simulation case. Similarly a maximum increase of 1.2 ppb to the maximum 4-hour ozone was predicted on December 12, 2000. The simulations carried out for the other selected modelling days did not show any significant changes associated with the maximum 1-hour and 4-hour ozone concentrations as it is presented in Table A2.

The calculated 1-hour and 4-hour differences predicted for the base case and test case scenarios for all selected days were gridded and plotted as it is illustrated in Figures A1 to A10. These results provide knowledge about the potential spatial extent for ozone changes as a result of the new NO_x emissions from the proposed plant.

These results show that the far region areas of the south-west region may be subject to a maximum increase of 1- hour and 4-hour ozone of around 6.3 ppb (NEPM 100 ppb) and 3.66 (NEPM 80 ppb) respectively. These increases predicted to occur at selected isolated areas within the selected modelling domain, were predicted to be produced on the February 10, 2004. The second highest increase in ozone was predicted to occur on January 12, 2001.

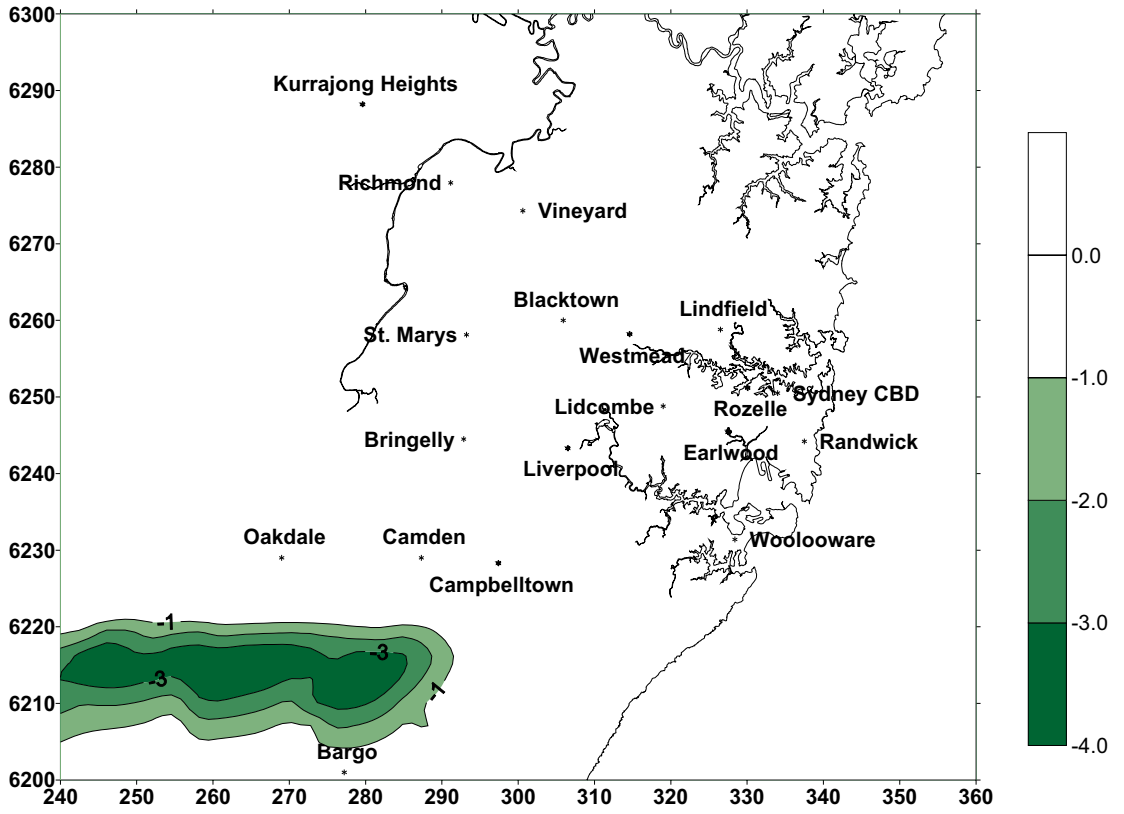

Figure A1. Contours of 1-hour O_3 average differences between base case and test case scenarios for December 20, 2000 simulation using the LMS100 configuration

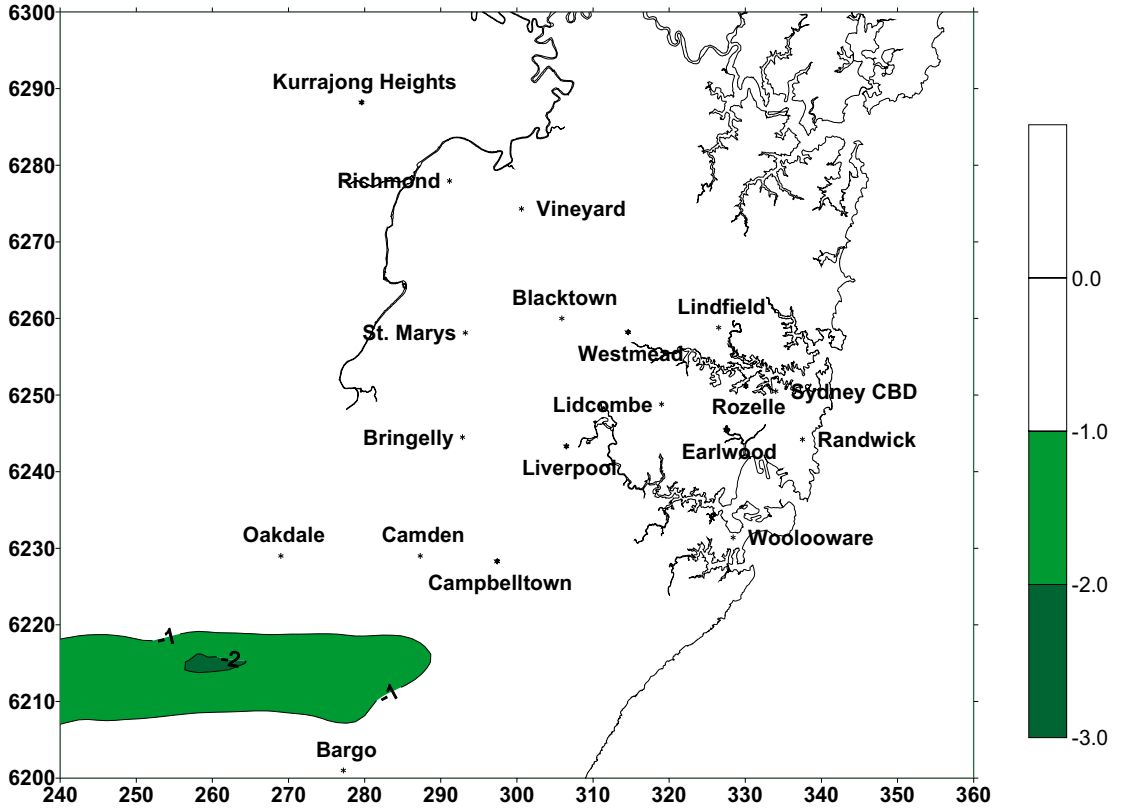

Figure A2. Contours of 4-hour O_3 average differences between base case and test case scenarios for December 20, 2000 simulation using the LMS100 configuration

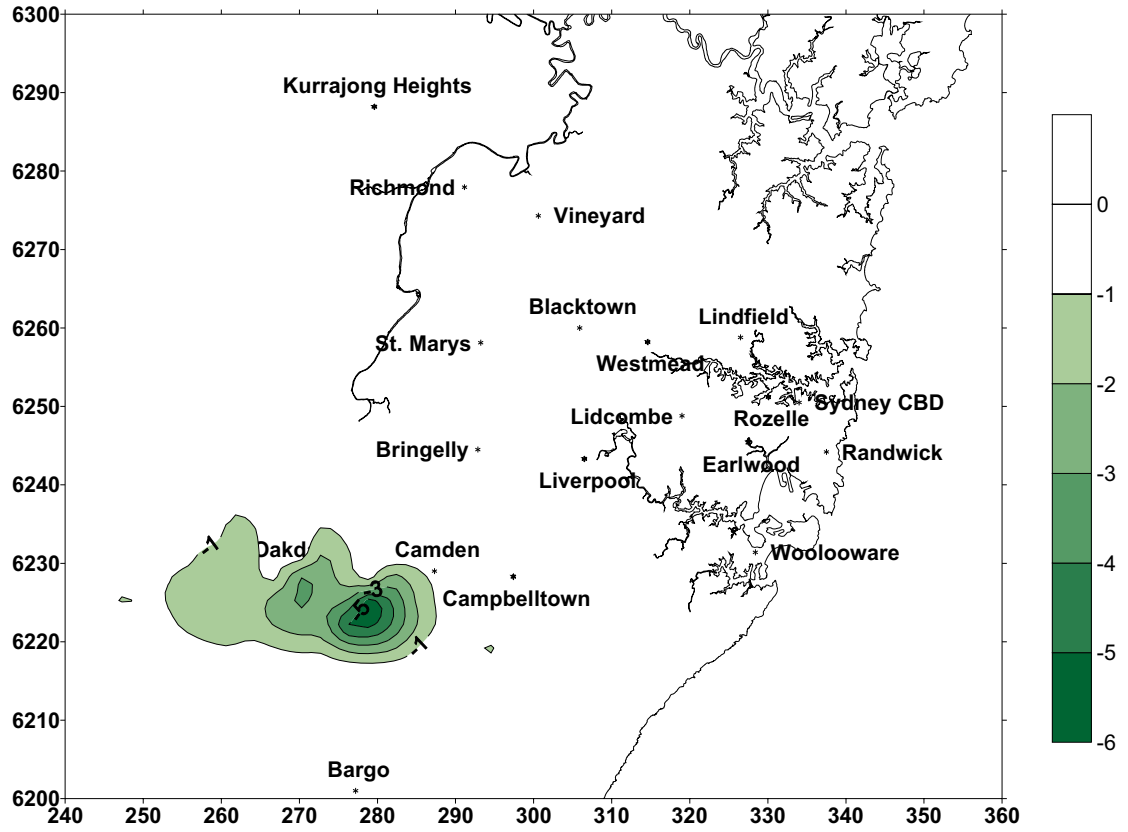

Figure A3. Contours of 1-hour O_3 average differences between base case and test case scenarios for January 12, 2001 simulation using the LMS100 configuration

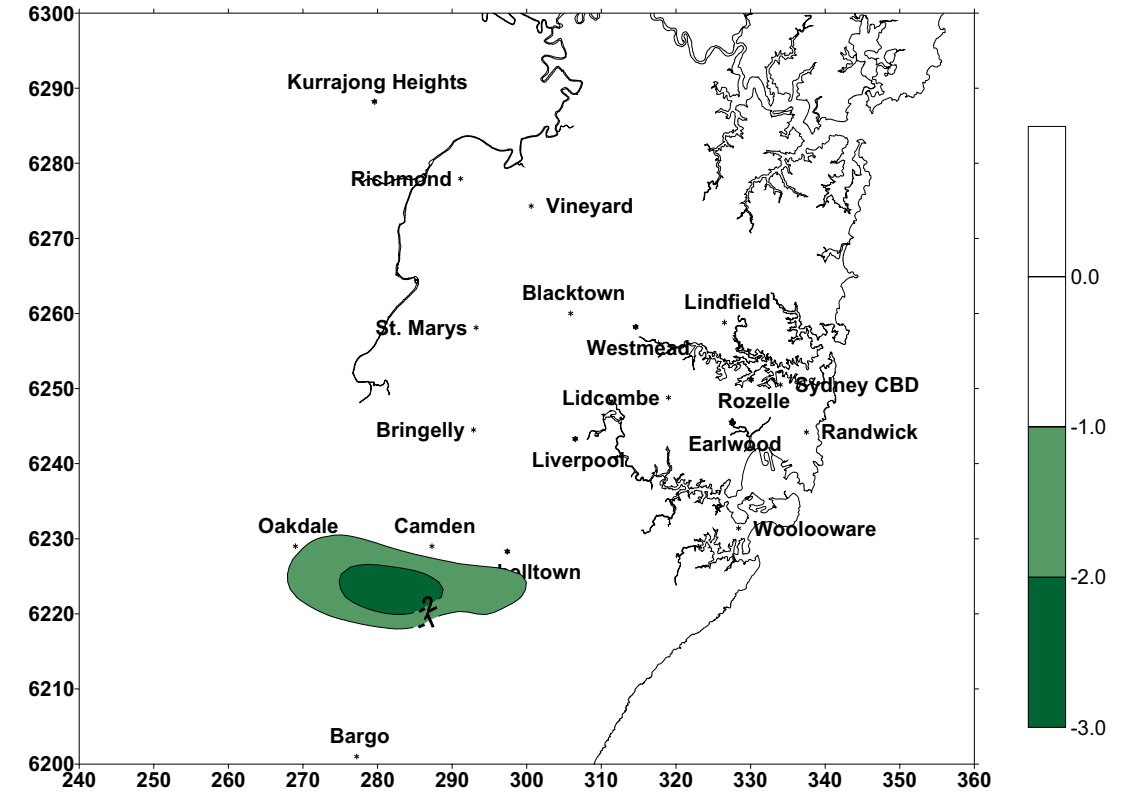

Figure A4. Contours of 4-hour O_3 average differences between base case and test case scenarios for January 12, 2001 simulation using the LMS100 configuration

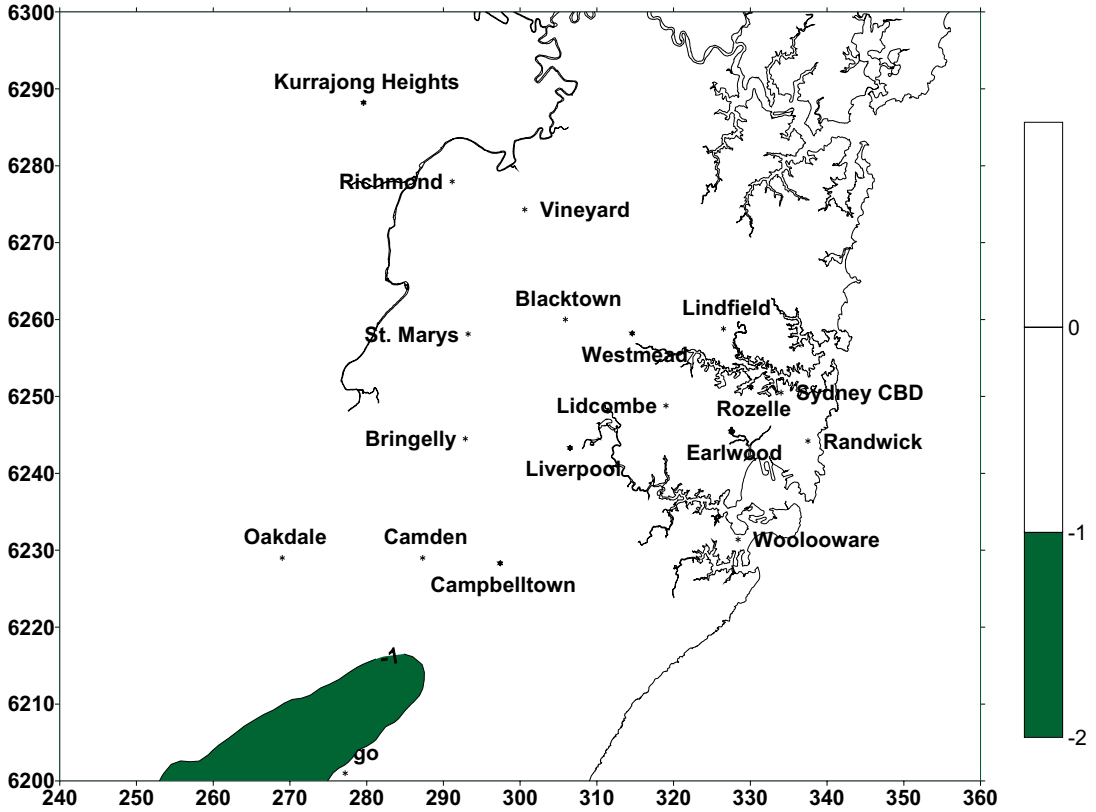

Figure A5. Contours of 1-hour O_3 average differences between base case and test case scenarios for January 22, 2001 simulation using the LMS100 configuration

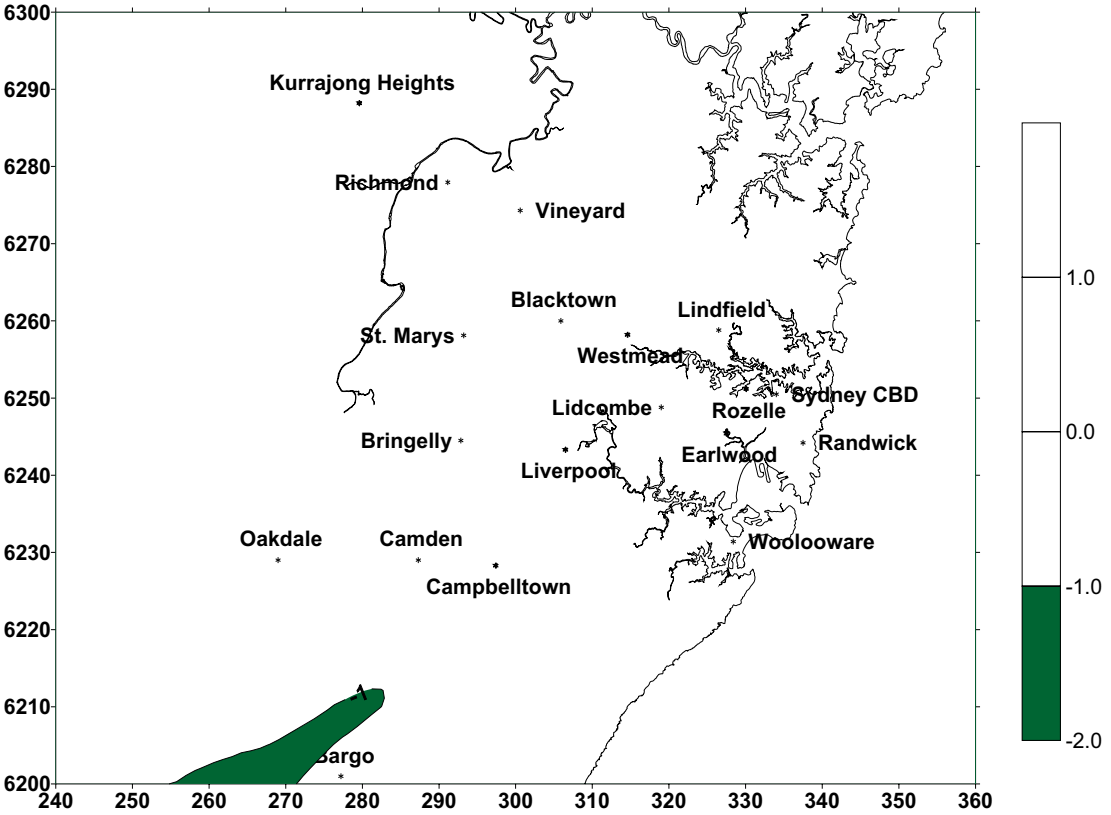

Figure A6. Contours of 4-hour O_3 average differences between base case and test case scenarios for January 22, 2001 simulation using the LMS100 configuration

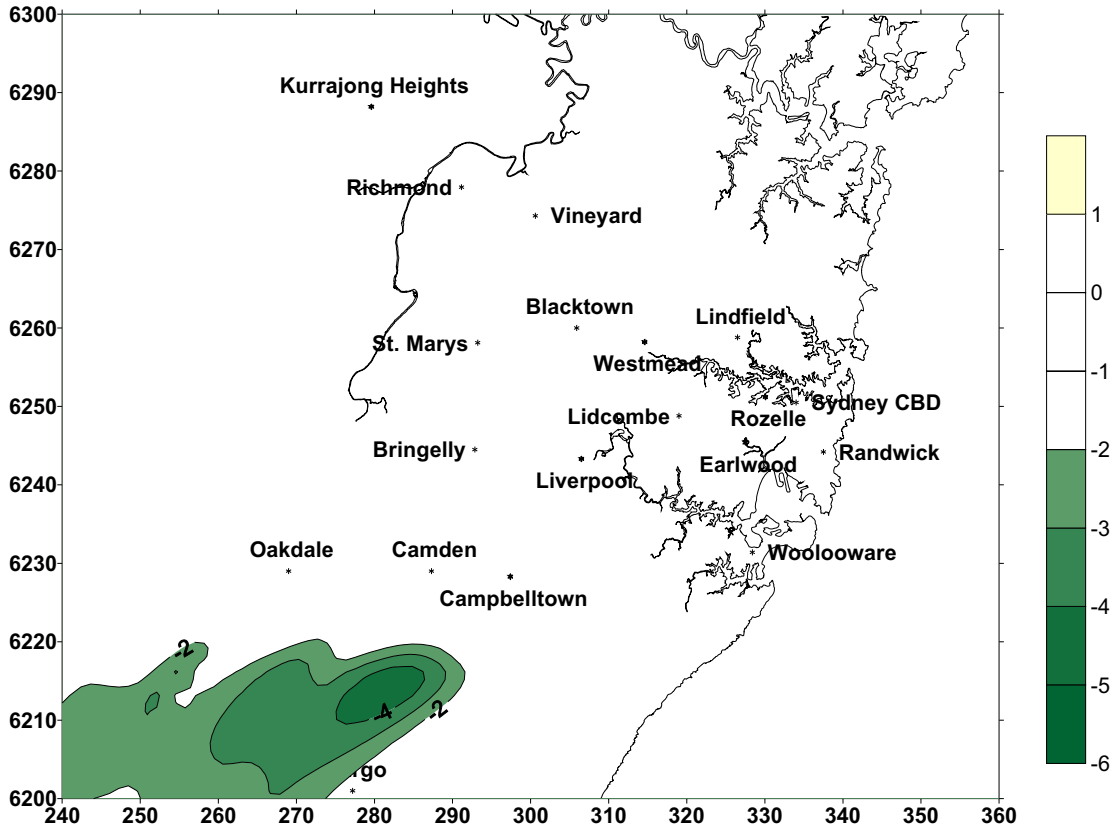

Figure A7. Contours of 1-hour O_3 average differences between base case and test case scenarios for February 10, 2004 simulation using the LMS100 configuration

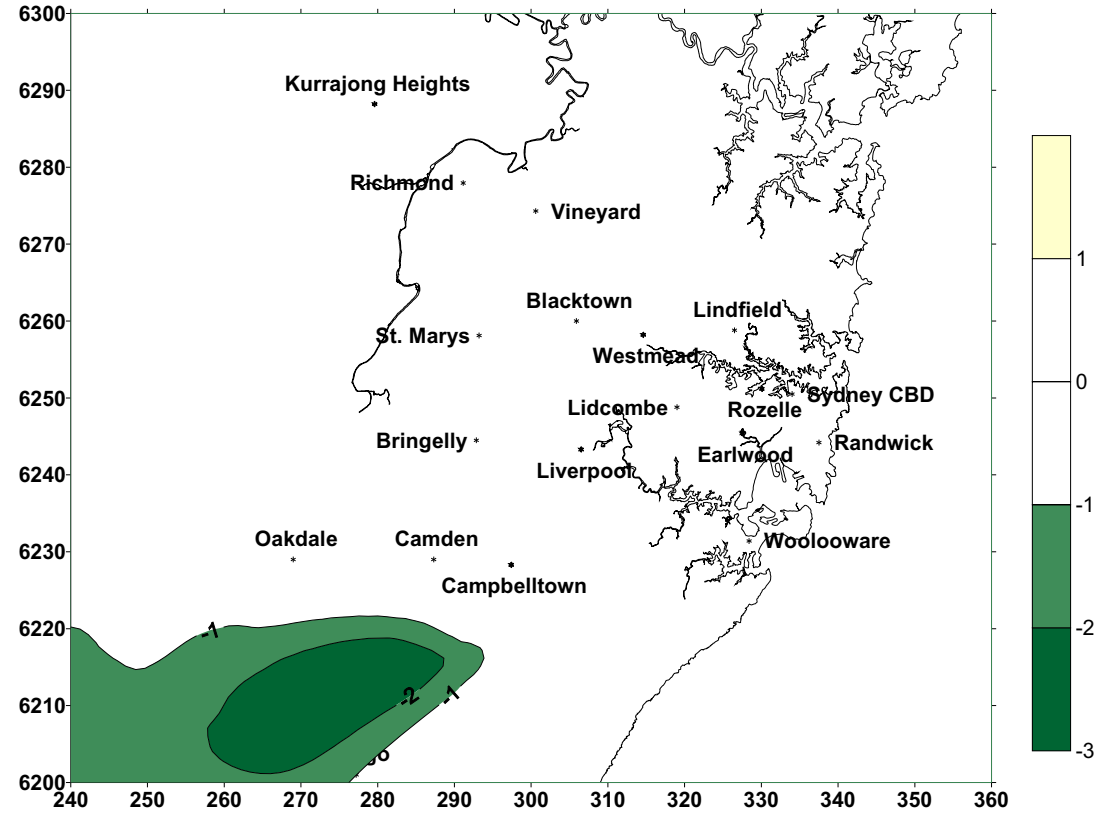

Figure A8. Contours of 4-hour O_3 average differences between base case and test case scenarios for February 10, 2004 simulation using the LMS100 configuration

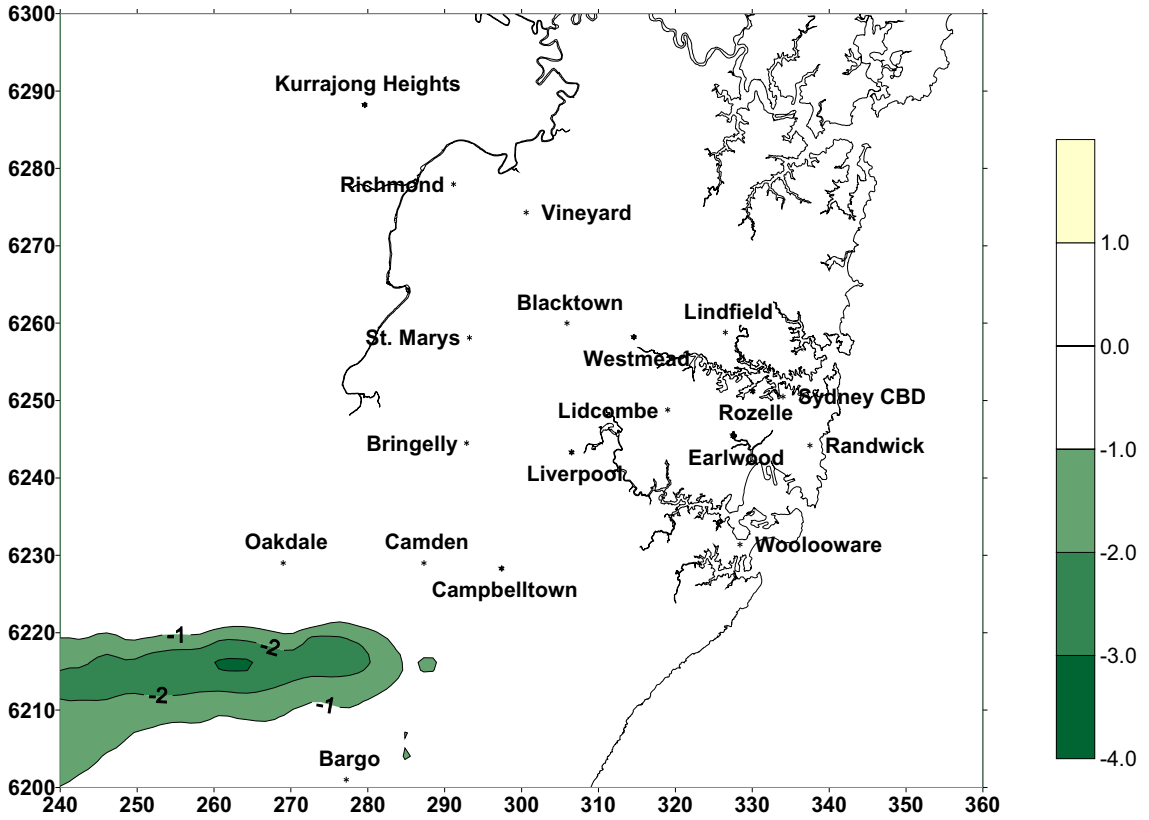

Figure A9. Contours of 1-hour O_3 average differences between base case and test case scenarios for November 27, 2004 simulation using the LMS100 configuration

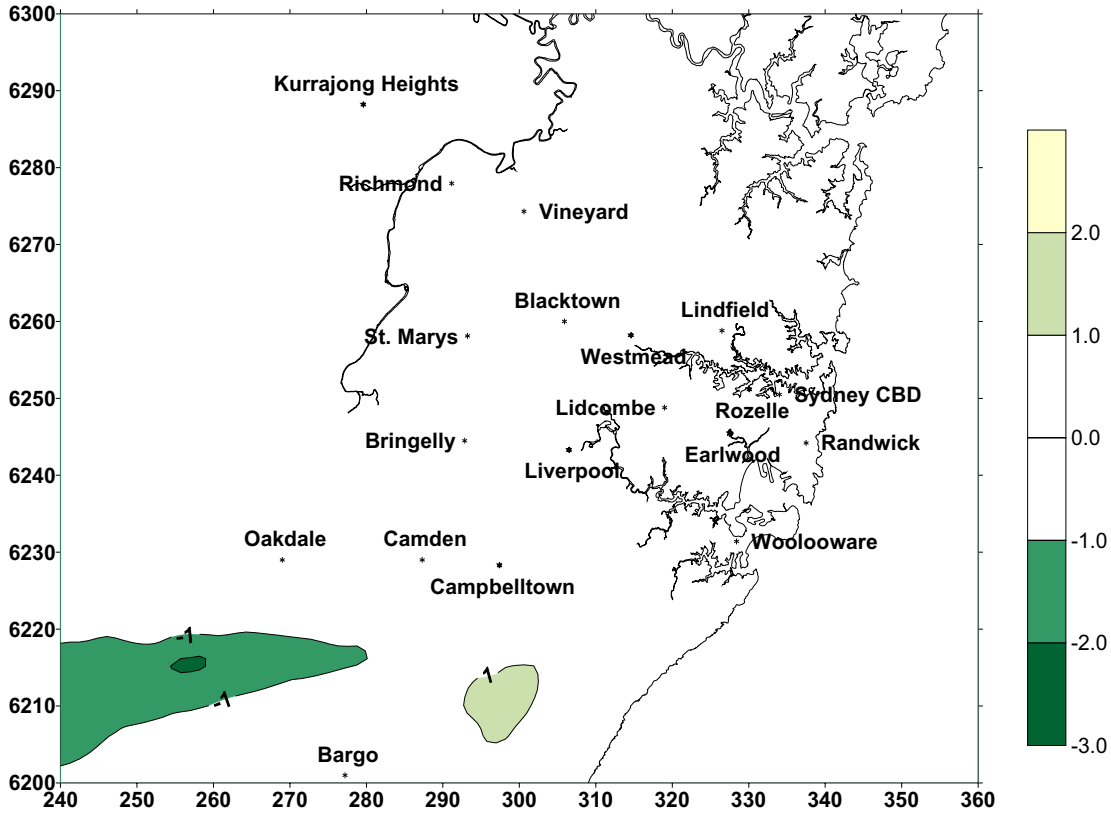

Figure A10. Contours of 4-hour O_3 average differences between base case and test case scenarios for November 27, 2004 simulation using the LMS100 configuration

The difference between the ozone time series predicted for the base case scenarios and test case (A) scenarios were calculated at selected monitoring sites. The highest increase in ozone production was predicted for November 27, 2004. On this day, the model results showed that the area may be subject to increase of ozone concentrations by a maximum of around 6 ppb that was predicted at Macarthur (Figure A18). These increases were predicted to occur late in the afternoon when the photochemical reactivity of the air would have been nearly stopped. At this time of the day the ozone concentrations go below 50 ppb.

Bringelly calculated data showed a difference of 4 ppb occurring between 1800 hours and 2000 hours. Oakdale and Bargo predicted a maximum of ozone difference of 3 ppb.
It is important to highlight that the plant operation may contribute to the NO_2 formation by a maximum of around 3 ppb predicted over 1-hour period. This increase of around 3 ppb is considered insignificant when compared to 120 ppb of the 1-hour NEPM guideline for NO_2.

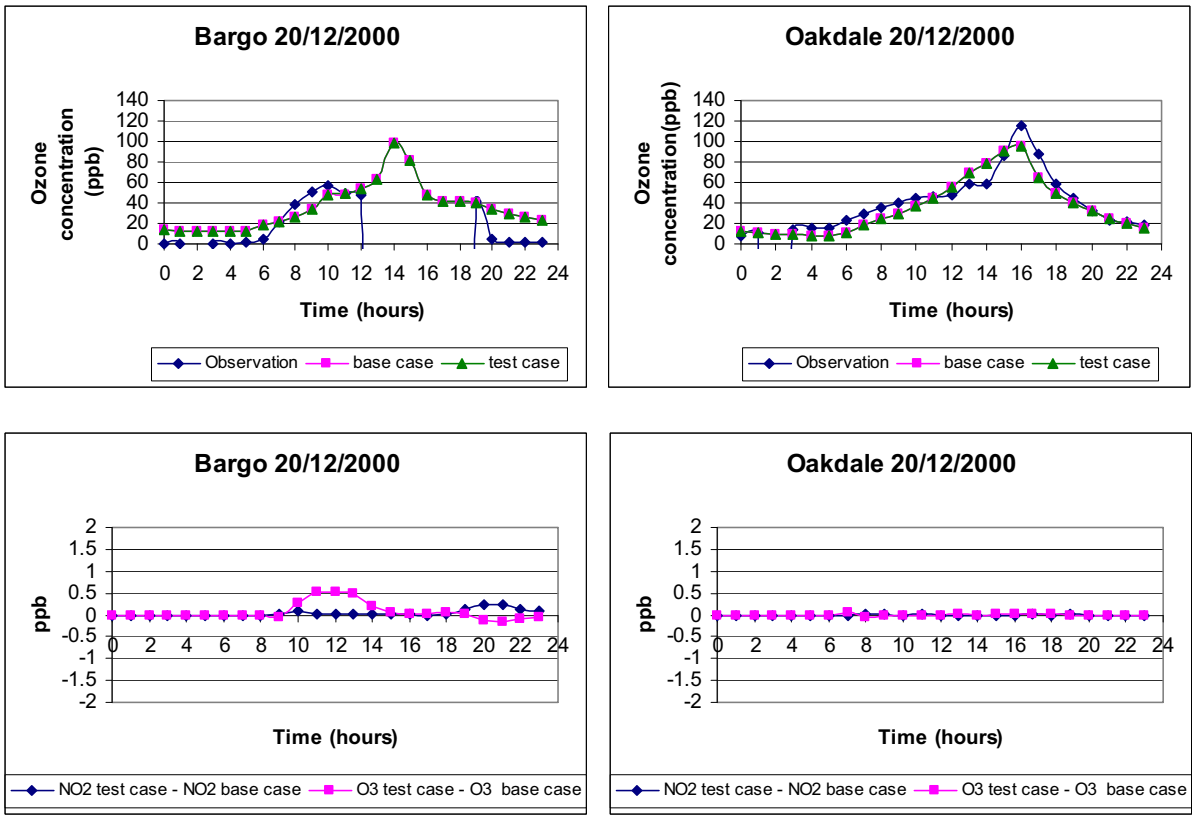

Figure A11. Observed and predicted ozone concentrations at Bargo and Oakdale for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

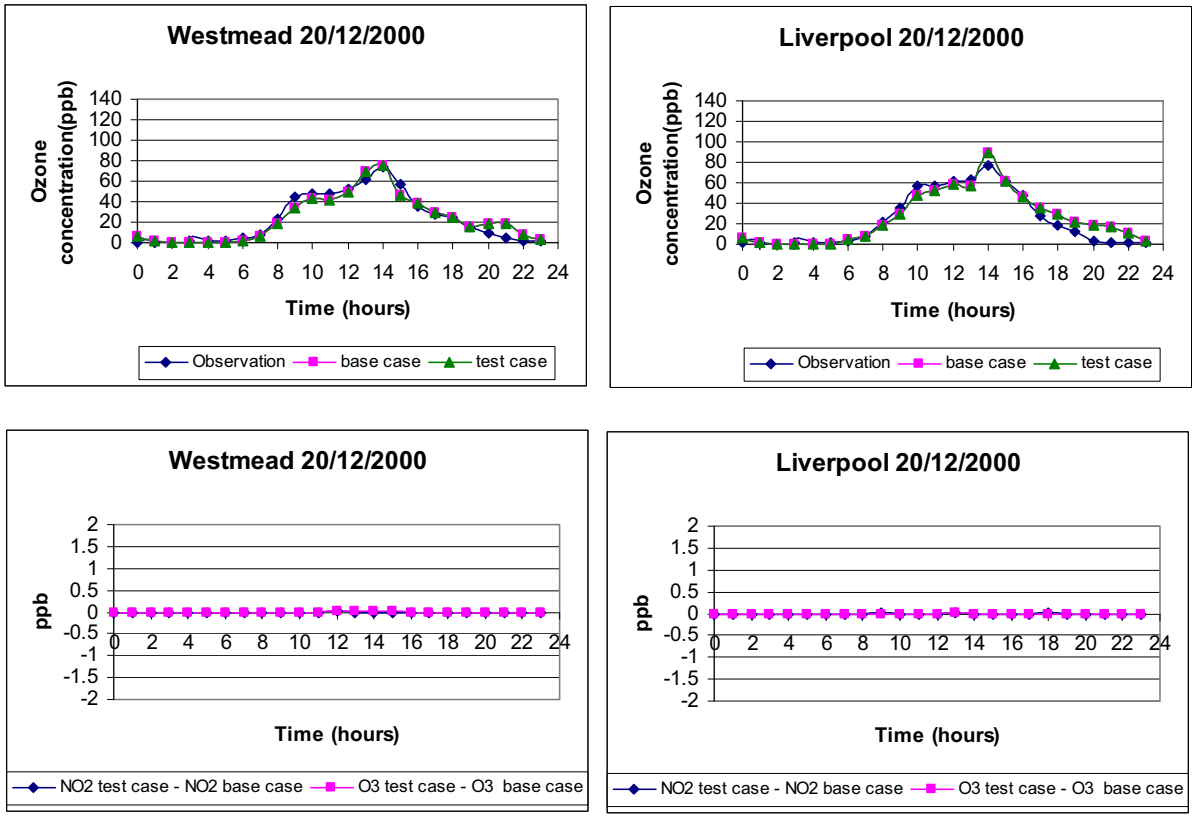

Figure A12. Observed and predicted ozone concentrations at Westmead and Liverpool for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

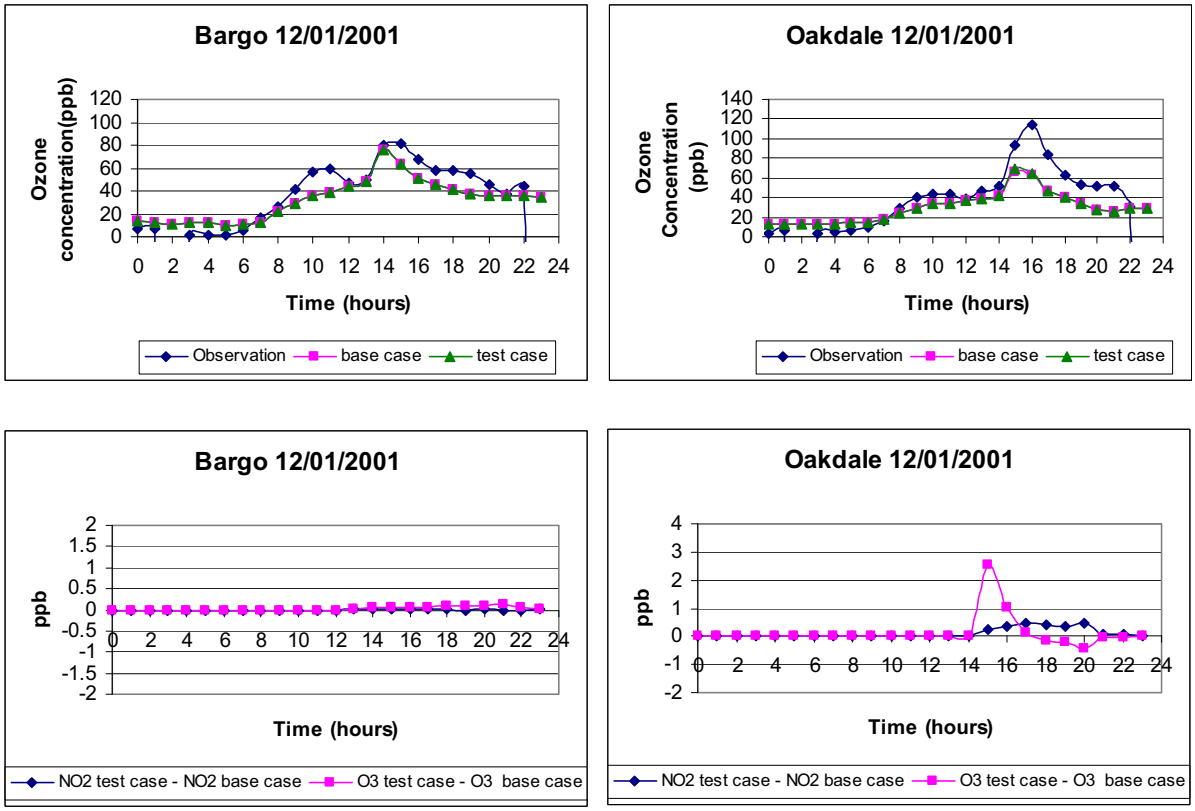

Figure A13. Observed and predicted ozone concentrations at Bargo and Oakdale for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

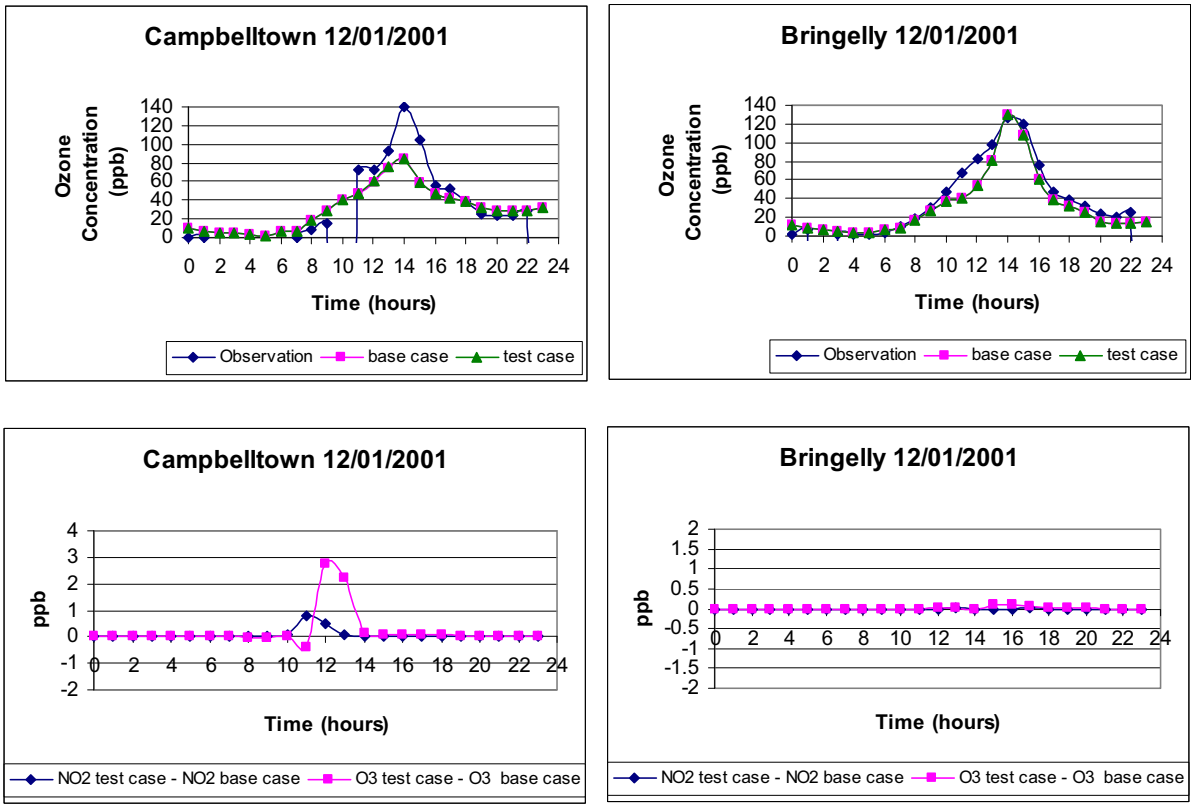

Figure A14. Observed and predicted ozone concentrations at Campbelltown and Bringelly for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

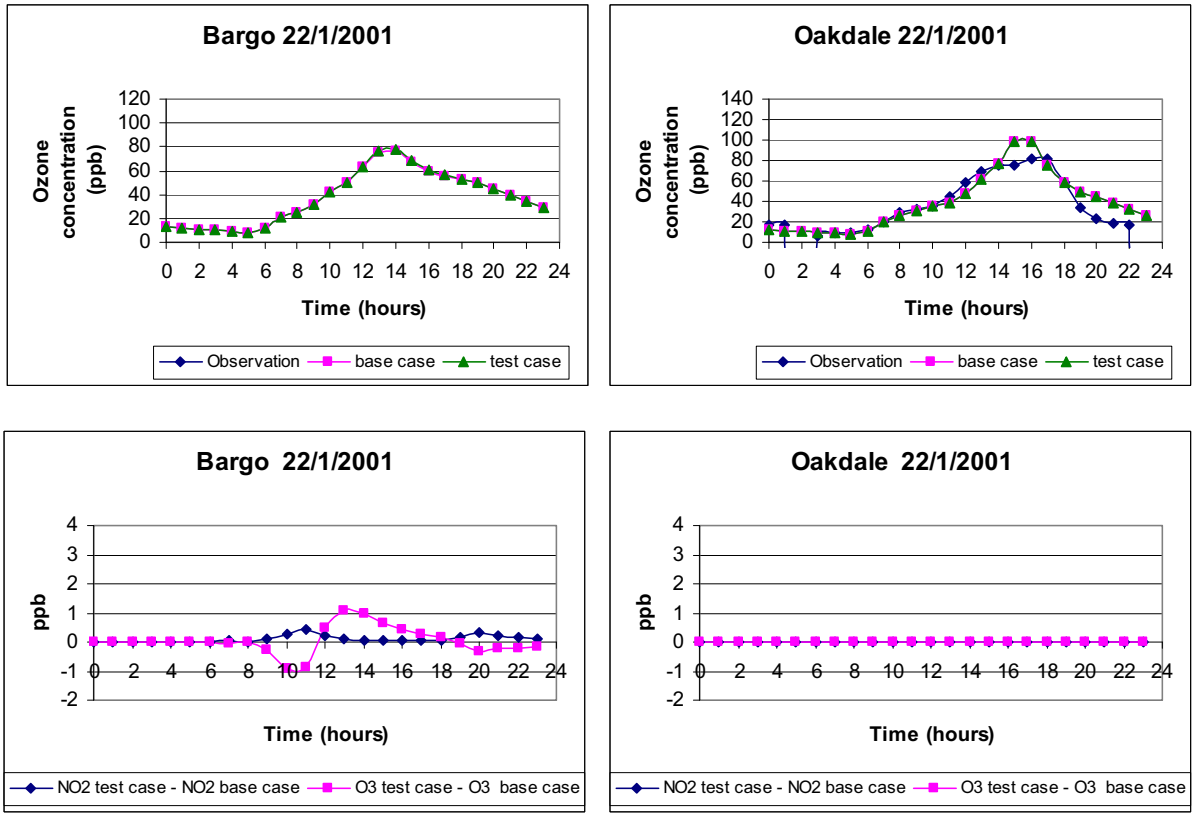

Figure A15. Observed and predicted ozone concentrations at Bargo and Oakdale for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

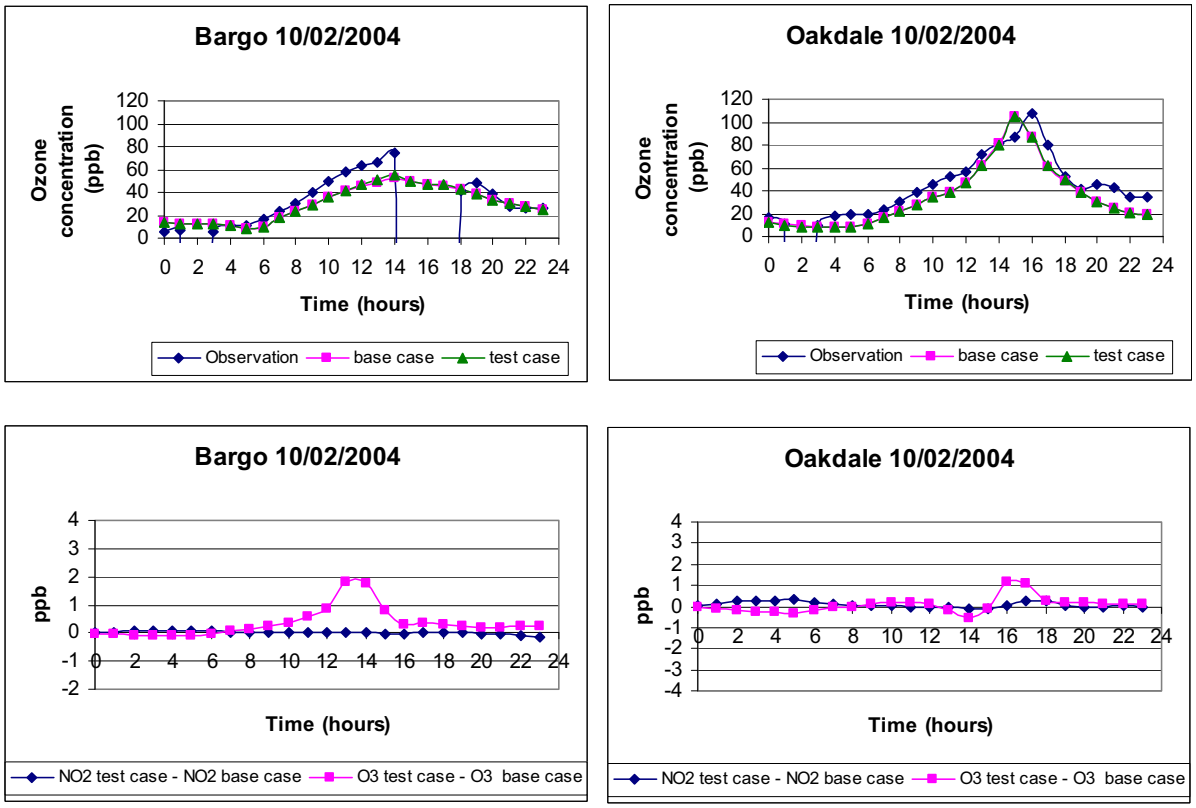

Figure A16. Observed and predicted ozone concentrations at Bargo and Oakdale for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

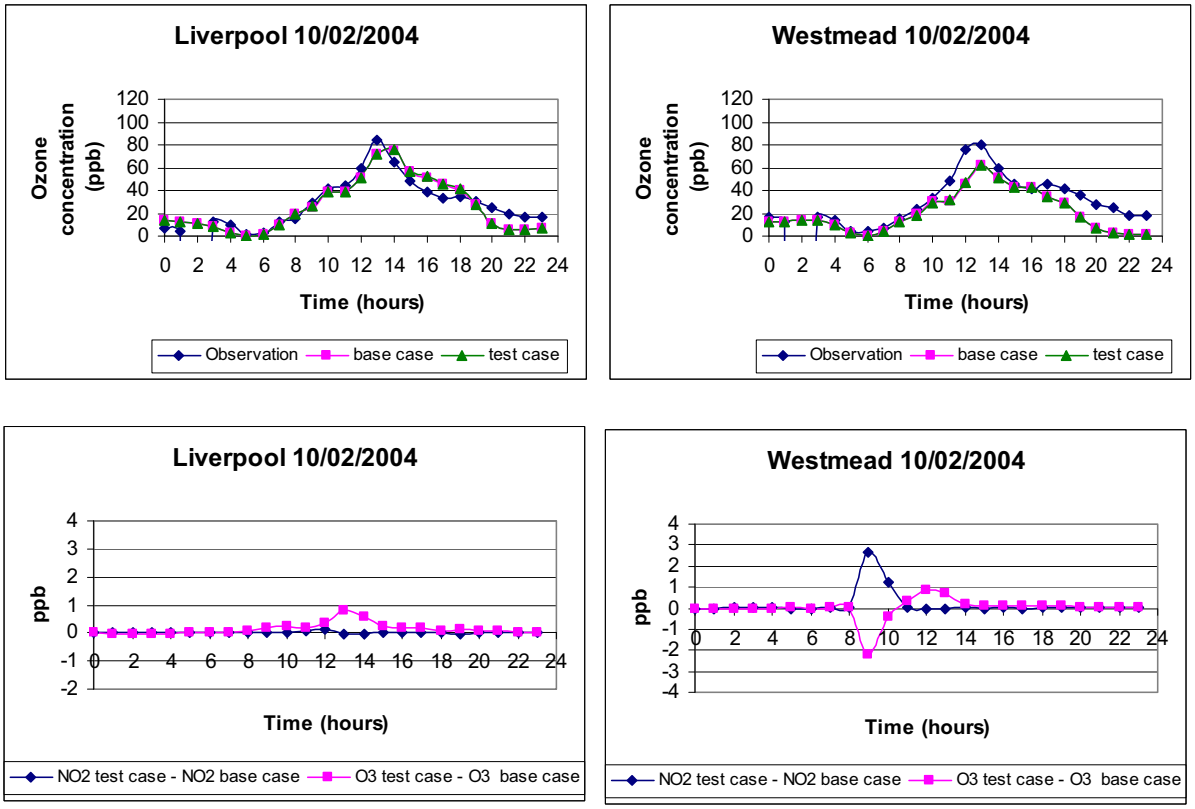

Figure A17. Observed and predicted ozone concentrations at Liverpool and westmead for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

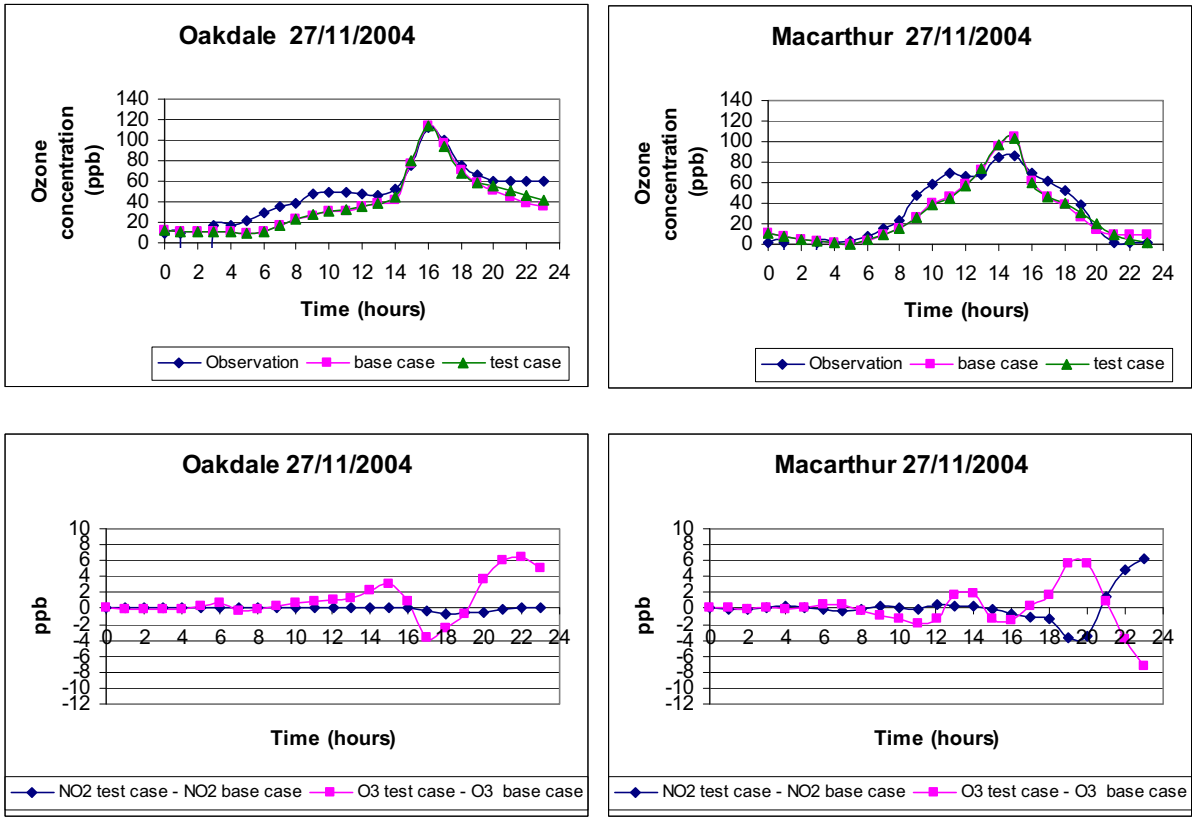

Figure A18. Observed and predicted ozone concentrations at Oakdale and Macarthur for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

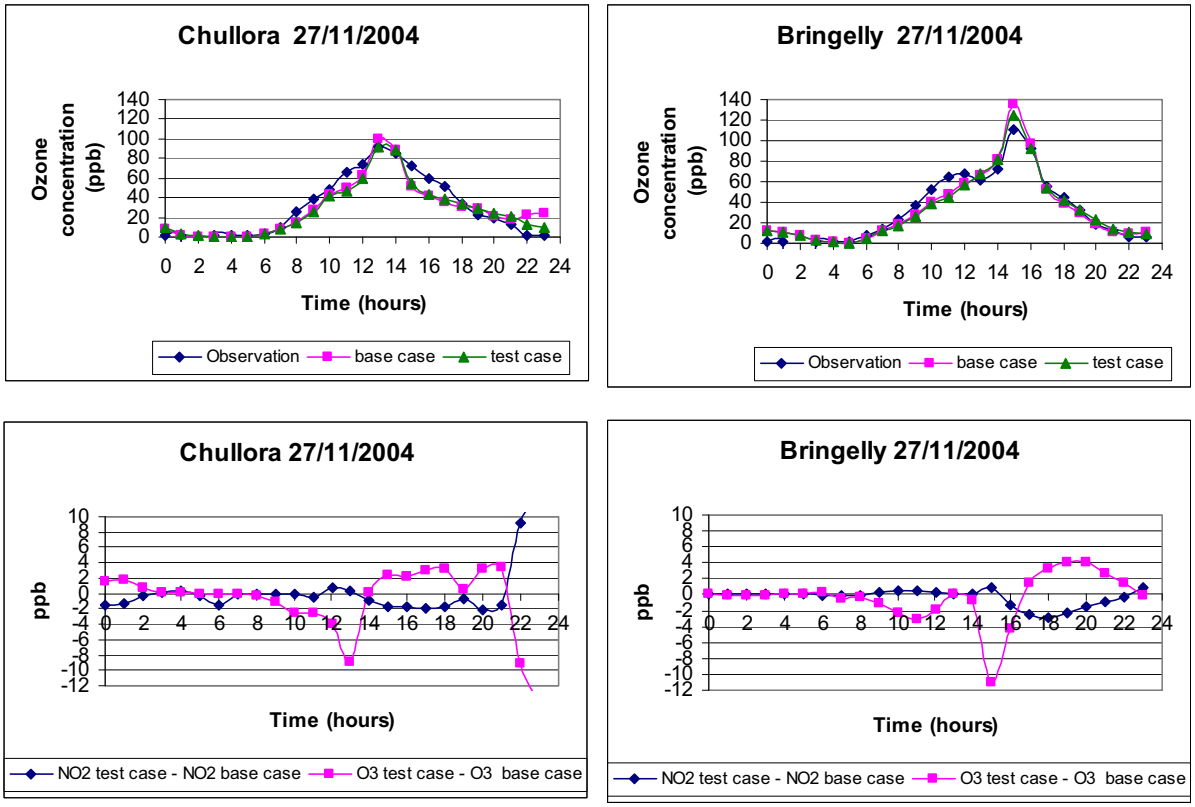

Figure A19. Observed and predicted ozone concentrations at Chullora and Bringelly for base case and full load case scenarios(top); Calculated differences of O_3 and NO_2 for the test case and base case scenarios (bottom)

In summary, the obtained modelling results for the new proposed plant configuration showed that the plant would produce maximum local increases of ozone and NO_2 of around 6 ppb and 2.3 ppb respectively. Since the highest predicted increase of ozone occurred when ambient ozone concentrations were below 50 ppb, the predicted O_3 increases may not represent a significant adverse impact on ozone levels.