D6

VOLUME D: AIRSPACE

Aircraft Air Emissions

CONTENTS

FIGURES AND TABLES

Figures (All figures are at the end of the report)

Tables

APPENDICES

Appendix A Health Effects of Air Pollutants Emitted from Aircraft

Appendix B Meteorological Information and Analysis

Appendix C Emissions Reported to the NPI by Industries Near Brisbane Airport

Appendix D Aircraft Emission Estimates

GLOSSARY OF ABBREVIATIONS

APU Auxiliary Power Unit

BAC Brisbane Airport Corporation

BoM Bureau of Meteorology

CO Carbon monoxide

EPA Queensland Government Environment Protection Agency

HC Hydrocarbons

LTO Landing/Take-off Operation

µm micrometre/micron (1µm=1x10^{-6} metres)

µg/m^3 micrograms per cubic metre

mg/m^3 milligrams per cubic metre

NO_2 Nitrogen dioxide

NO_X Nitrogen oxides or oxides of nitrogen

NPI National Pollutant Inventory

NPR New Parallel Runway

O_3 Ozone

$PM_{2.5}$ Particulate matter with equivalent aerodynamic diameter less than 2.5 µm

PM_{10} Particulate matter with equivalent aerodynamic diameter less than 10 µm

ppm parts per million

ppb parts per billion

SO_2 Sulfur dioxide

SODPROPS Simultaneous Opposite Directions Parallel Runway Operations

TSP Total Suspend Particulates

VOC Volatile Organic Compounds

WHO World Health Organisation

SUMMARY OF KEY FINDINGS – AIR EMISSIONS

Baseline Conditions

- Existing air quality in the South East Queensland region is monitored by the Queensland Government Environmental Protection Agency (EPA). The closest monitoring sites to Brisbane Airport are currently at Pinkenba and Wynnum. Until 2005, data from the now decommissioned Eagle Farm Monitoring Site was representative of air quality at the Airport.
- Motor vehicles are the predominant source of air pollutants in the region. While there has been a steady increase in motor vehicle usage in the region the control of individual vehicle emissions through design rules for example, vehicle exhaust and tighter fuel regulations, has ensured that air quality has not deteriorated.
- Air quality and monitoring near Brisbane Airport indicates that air quality remains within the EPA goal apart from isolated episodes of exceedances of the air quality goal for particulate matter less than 10 microns in diameter (PM_{10}). These episodes can be attributed to widespread events such as dust storms or bushfires where the goal is exceeded throughout the Brisbane region.
- The emissions inventory for South East Queensland prepared by the EPA and Brisbane City Council (BCC) indicates that Brisbane Airport is a relatively minor contributor to air pollutants in the region. For example, aircraft emissions of oxides of nitrogen in the South East Queensland region in 2002 were two percent of the total emissions into the airshed. For all other pollutants, the contribution was less.
- Wind patterns were examined at the Airport and surrounds. The general wind patterns were similar at the Airport site to the wind patterns at the nearest monitoring station at Eagle Farm however wind speeds were generally greater at the Airport site. A three-dimensional windfield covering the study area was constructed to represent the variation in wind patterns across the study area. Account was taken of local topography and land use.

Impacts – Aircraft Emissions

- Computer based dispersion modelling was used to assess the impacts of the emissions associated with air traffic. CALPUFF modelling using a three-dimensional windfield representing the variation in meteorology over the study area was undertaken. The conclusions of the study were as follows:
  - Compliance with air quality goals at the nearest sensitive receptors is anticipated for all future operational scenarios.
  - Particulate matter concentrations arising from non-airport related emissions, such as bushfires, may continue to result in elevated levels on occasions.
  - With and without NPR cases are predicted to be very similar. That is, regional air quality with the New Parallel Runway is expected to be similar to air quality without the new runway.
  - NO_2 predictions due to modelled sources consumed the greatest fraction of the air quality goal of all the pollutants.
  - Off-site pollutant concentrations due to aircraft operations are predicted to be higher than for existing operations. However, there is likely to be improvements to aircraft technology and emissions that may offset any increased impacts, but to an unknown degree.

6.1 Introduction

This report has been prepared by Holmes Air Sciences for Brisbane Airport Corporation Pty Ltd (BAC). The purpose of the report is to quantitatively assess air quality impacts associated with the operation of the proposed New Parallel Runway (NPR) at Brisbane Airport.

The proposal involves the construction of a new runway at Brisbane Airport, parallel to the existing main runway. **Figure 6.1** shows Brisbane Airport and surrounds.

The air quality assessment is based on the use of computer-based dispersion modelling to predict air pollutant concentrations in the study area. The assessment considers air pollutants arising from aircraft emissions as well as emissions associated with the general operation of the Airport. To assess the effect that the operation of the NPR could have on existing air quality, the dispersion model predictions have been compared to relevant regulatory air quality criteria.

In summary, the report provides information on the following:

- Description of the proposal;
- The air quality standards and goals relevant for this project;
- Discussion of air quality issues associated with airports;
- Review of the existing environment, including climatic and meteorological conditions and the existing air quality in the area;
- The methods used for determining pollutant emissions and impacts; and
- Interpretation and analysis of predicted air quality impacts.

Cumulative effects of the project form a significant component of the study. The methodology for the study has been formulated to determine how air quality would change as a result of the project.

6.2 Local Setting and Project Description

Figure 6.1 shows the extent of area defined for the purposes of this study as the 'study area'. **Figure 6.2a** shows a three-dimensional representation of the local terrain.

The proposed NPR consists of the following major elements:

- Reclaiming 15 million cubic metres (Mm^3) of sand from Middle Banks in Moreton Bay;
- Reconstructing the existing seawall along the Moreton Bay/Airport boundary;
- Widening and strengthening of the 14/32 runway pavement;
- Constructing the NPR;
- Constructing a new dual parallel taxiway (adjacent to the runway);
- Constructing a link taxiway from the NPR to the main existing runway;
- Constructing rapid exit taxiways from the NPR to the parallel taxiway;
- Establishing new airfield lighting including approach lighting;
- Constructing a new fire station;
- Constructing a road tunnel along Dryandra Road under the link taxiway;
- Constructing new perimeter roads around the airfield;
- Constructing a new permanent drainage channel upstream of the runway;
- Constructing new airfield drainage;
- Installing new security fencing;
- Relocating power and utility services; and
- Rehabilitating the site including the use of mangroves at selected locations along drainage channels.

Figure 6.2b shows the location and layout of the proposed NPR.

6.3 Air Quality Standards and Goals

In assessing the potential impacts of any project with air emissions, it is necessary to compare the air quality impacts of the project with relevant air quality goals. Air quality standards or goals are used to assess the potential for ambient air quality to give rise to adverse health or nuisance effects.

The EPA has set air quality goals as part of its Environmental Protection (Air) Policy 1997 (EPP (Air)) (EPA, 1997). The policy was developed to meet air quality objectives for Queensland's air environment as outlined in the *Environmental Protection Act 1994* (EPA, 1994). The air quality data collected by the EPA refers to Schedule 1 of the EPP (Air) which contains air quality indicators and goals that have been adopted in Queensland.

The National Environment Protection Council of Australia (NEPC) has determined a set of air quality goals for adoption at a national level, which are part of the National Environment Protection Measures (NEPM). It is important to note that the standards established as part of the NEPM are designed to be measured to give an 'average' representation of general air quality. That is, the NEPM monitoring protocol was not designed to apply to the monitoring or modelling of peak concentrations from major emission sources (NEPC, 1998).

In addition, ambient air quality objectives for Brisbane Airport are established under the Airports (Environment Protection) Regulations 1997. Under the regulations, air pollution occurs when a pollutant is present in the air in a quantity, way, condition or circumstance which is likely to cause harm to the environment or unreasonable inconvenience to a person (i) at a place other than the immediate vicinity of the source of the pollutant; or (ii) if the source is in a place to which members of the public have access – in that place. The regulations do not apply to air pollution generated by an aircraft, however the issue is considered under the Air Navigation (Aircraft Engine Emissions) Regulations 1998.

Table 6.3a lists the air quality goals for criteria pollutants noted by the EPA, NEPM and under the Airports Regulations that are relevant for this study. Also included in this table are air quality goals for air toxics developed by NEPC and part of their National Environment Protection (Air Toxics) Measure (NEPC, 2004). At this stage values for air toxics are termed 'investigation levels' rather than goals which are applied on a project basis. The basis of these air quality goals and, where relevant, the safety margins that they provide are discussed in detail in **Appendix A**.

The primary air quality objective of most projects is to ensure that the air quality goals listed in **Table 6.3a** are not exceeded at any location where there is a possibility of human exposure for the time period relevant to the goal.

Table 6.3: Air Quality Goals Relevant to this Project.

Pollutant	Goal	Averaging Period	Agency
Carbon monoxide (CO)	**8 ppm or 10 mg/m³** 9 ppm or 10 mg/m³	8 hour maximum 8 hour maximum	EPA NEPM[1], AR1997
Nitrogen dioxide (NO_2)	0.16 or 320 µg/m³ **0.12 ppm or 246 µg/m³** **0.03 ppm or 60 µg/m³**	1 hour maximum 1 hour maximum[1] Annual mean	EPA, AR1997 NEPM NEPM
Particulate matter less than 10 µm (PM_{10})	150 µg/m³ **50 µg/m³** **50 µg/m³**	24 hour maximum 24 hour maximum Annual mean	EPA NEPM[2] EPA
Particulate matter less than 2.5 µm ($PM_{2.5}$) (advisory only)	25 µg/m³ 8 µg/m³	24 hour maximum Annual average	NEPM NEPM
Total Suspended Particulate Matter (TSP)	**90 µg/m³**	Annual average	EPA, AR1997
Sulfur Dioxide (SO_2)	0.25 ppm or 700 µg/m³ 0.20 ppm or 570 µg/m³ 0.08 ppm or 225 µg/m³ 0.04 ppm or 113 µg/m³ 0.02 ppm or 60 µg/m³	10 minute maximum 1 hour maximum 24 hour maximum 24 hour maximum Annual average	EPA, AR1997 NEPM[1], EPA, AR1997 NEPM[1] EPA NEPM, EPA, AR1997
Ozone (O_3)	0.10 ppm or 210 µg/m³ 0.08 ppm or 170 µg/m³	1 hour maximum 4 hour maximum	NEPM[1], EPA, AR1997 NEPM[1], EPA, AR1997
Lead (Pb)	1.5 µg/m³ 0.5 µg/m³	90-day average Annual average	EPA, AR1997 NEPM
Visibility reducing particles	20 km visibility	-	EPA
*Air Toxics (investigation levels only and not Project-specific goals – refer **Appendix A**)*			
Benzene	0.003 ppm	Annual average	NEPM (Air Toxics)
Benzo(a)pyrene	0.3 ng/m³	Annual average	NEPM (Air Toxics)
Formaldehyde	0.2 ppm 0.04 ppm	30 minute maximum 24 hour maximum	EPA NEPM (Air Toxics)
Toluene	2 ppm or 8 mg/m³ 1 ppm 0.1 ppm	24 hour maximum 24 hour maximum Annual average	EPA NEPM (Air Toxics) NEPM (Air Toxics)
Xylene	0.25 ppm 0.2 ppm	24 hour maximum Annual average	NEPM (Air Toxics) NEPM (Air Toxics)

[1] *One day per year maximum allowable exceedance.*
[2] *Five days per year maximum allowable exceedances.*
AR1997: Airports (Environment Protection) Regulation 1997.
For the purposes of this project the most stringent air quality standards and goals for each pollutant have been adopted. These are shown in bold font.

6.4 Existing Environment

This section describes the dispersion meteorology, general climate and existing air quality of the study area. As well as information on prevailing wind patterns, historical data on temperature, humidity and rainfall are presented to give a more complete picture of the local climate.

Information is presented on local dispersion conditions which are relevant to the modelling to be carried out for the project as well as local sources of air pollution which affect air quality in the vicinity of the Airport. Also provided is a discussion of air quality trends in Brisbane and the contribution of Airport emissions to the Brisbane airshed.

6.4.1 Dispersion Meteorology

The way in which pollution from the Airport is dispersed is dependent on the prevailing meteorological conditions in the Brisbane airshed. This section discusses aspects of local meteorology that are relevant to the dispersion of emissions from the Airport and associated facilities. This information has been used in the dispersion modelling of Airport emissions presented in this report.

The meteorology in the study area (refer **Figure 6.1**) would be influenced by several factors including the local terrain and land use. On a relatively small scale, winds would be largely affected by the local topography (see **Figure 6.2a** for a representation of the local terrain). At larger scales, winds are affected by synoptic scale winds, which are modified by sea-breezes in the daytime, which are stronger in summer but also occur in winter, and by a complex pattern of regional drainage flows that develop overnight.

Given the relatively diverse terrain and land use in the study area, differences in wind patterns at different locations would be expected. These varying wind patterns would arise as a result of the interaction of the air flow with the surrounding topography and the differential heating of the land and water. In a built-up urban environment like central Brisbane, wind dispersion patterns will be complicated by the turbulence induced by buildings and local terrain features. The air flow would also be influenced by the temperature differences between the city and surrounding areas, a phenomenon known as the 'urban heat island effect'. At the Brisbane Airport site, large areas of cleared land with unobstructed wind flow, will result in higher than average local wind speeds compared to the surrounding residential and industrial areas. It will be important for the air quality assessment to take account of these features.

In the air quality assessment that will be carried out for this project it is not necessary to document the complex mechanisms that affect air movements in the area, it is simply necessary to ensure that these air movements are incorporated into the dispersion modelling studies that are done. A limitation of common Gaussian plume dispersion models (such as AUSPLUME, which is commonly used in Queensland for air quality impact assessments) is that they assume that the meteorological conditions are the same spatially over the entire modelling domain for any given hour. This may be adequate for sources in relatively uncomplicated terrain however when the terrain or land use is more complex the meteorological conditions can be more accurately represented using wind field and puff models.

In the last decade there has been a significant improvement in the capability of dispersion models to handle dispersion in areas where complex wind flows occur. In this assessment extensive use has been made of the CALPUFF dispersion model. The CALPUFF model makes use of wind fields generated by the CALMET model. CALMET generates a three-dimensional wind field on an hourly basis by taking observations of winds at selected locations and interpolating these to produce information on wind speed and direction at a grid of regularly spaced points covering the area of interest. Modifications that are imposed on this interpolated wind field (by topography and differential heating and differential surface roughness) are then applied to the winds at each grid point to develop a final wind field.

The final wind field reflects the effect of local topography and the effects of different temperatures experienced by water bodies and land surfaces as well as different surface roughness that arise because of changes in vegetation or other variations in land use, such as the presence of residential and industrial developments. **Figure 6.4a** shows the model extents and terrain information used as input to the CALMET model.

The CALMET and CALPUFF models have undergone many validation studies in Australia, New Zealand and in the United States. The CALPUFF modelling system is the US EPA's preferred model for assessment of long range pollutant transport and for near field applications with complex meteorology. In New South Wales the Department of Environment and Conservation (DEC) has listed CALPUFF as an 'approved' air dispersion model for regulatory impact assessments (DEC, 2005). The Queensland EPA do not list 'approved' air dispersion models in the EPP (Air) (1997).

Meteorological and ambient air quality monitoring data from a number of years has been reviewed to determine the most suitable year for the CALMET and CALPUFF modelling. Typically, one year of records will be sufficient to cover most variations in meteorology that will be experienced at a site, however it is important that selected year is generally typical of the prevailing meteorology.

The year 2004 was chosen for the purposes of this assessment based on the completeness of both the meteorological and ambient air quality monitoring records. The latter are required to account for background pollution levels.

Appendix B provides information on the meteorological data relevant for this study including the wind speed and wind direction frequency tables and comparisons of the Bureau of Meterology (BoM) and EPA surface wind data. BoM data was collected at the Airport and EPA data at Eagle Farm and Pinkenba.

A wind field has been generated by CALMET for each hour of the 2004 calendar year using meteorological data from both BoM and EPA monitoring sites. Further details are discussed below. The CALMET model has essentially used the data from these sites to determine wind patterns over the entire modelling domain given information on the local land use and terrain features.

In addition to surface meteorological records, the CALMET model requires upper air data in order to generate a year-long three-dimensional wind-field. Upper air data records collected by the BoM in 2004 at Brisbane Airport were used to provide the CALMET model with the required information on pressure changes, higher altitude winds and temperature profiles. These data included twice daily records of wind speed, wind direction, temperature, pressure and height and were processed into a form suitable for the CALMET model.

There were occasional missing soundings in the BoM upper air data for 2004 which were supplemented with upper air predictions from the CSIRO's prognostic model (The Air Pollution Model, TAPM). TAPM is a prognostic model which has the ability to generate meteorological data for any location in Australia (from 1997 onwards) based on synoptic information determined from the six hourly Limited Area Prediction System (LAPS) (Puri et al 1997). TAPM is further discussed in the user manual (Hurley, 2002).

A summary of the data and parameters used as part of the meteorological component of this study are shown in **Table 6.4a**.

Table 6.4a: Summary of Meteorological Parameters Used for this Study.

TAPM (v 2.0)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	25 x 25 x 25
Year of analysis	Jan 2004 to Dec 2004
Centre of analysis	Brisbane Airport (27°25.5' S, 153°4' E)
Meteorological data assimilation	Wind velocity data from BoM Airport and EPA Eagle Farm sites
CALMET (v 5.5)	
Meteorological grid domain	40 km x 40 km
Meteorological grid resolution	1 km
Surface meteorological stations	2 sites: BoM Airport and EPA Eagle Farm (for temperature, relative humidity and wind velocity). Cloud cover from Brisbane Airport (BoM). Ceiling height and pressure at the two sites by TAPM
Upper air meteorological station	BoM upper air data records from Brisbane Airport. Missing data were supplemented with predictions by TAPM for Brisbane Airport
Simulation length	8,784 hours (Jan 2004 to Dec 2004)

As will be shown later in the impact assessment section of the report, short term pollutant levels, specifically one hour concentrations of nitrogen dioxide, will potentially have the most impact on ambient air quality. That being the case, it is theoretically possible to undertake an air quality assessment with synthetic meteorological data to present a worst-case. It is more useful however, to use site specific meteorological data to also provide some estimate of long term pollutant concentrations.

The 2004 data used for the assessment contains the range of dispersion conditions which would lead to worst-case impacts. The frequency of these conditions may vary from year to year which would result in minor differences in long term average model predictions, however the way the assessment has been undertaken provides a very conservative estimate of long term impacts.

For the purpose of dispersion modelling, there have been no restrictions put on the operations of the Airport which are dependent on meteorology, that is, all operating modes can occur under any meteorological conditions. This removal of constraints leads to a matching of any type of aircraft operation with the worst-case dispersion conditions. The worst-case predictions for the different operating modes have been used to determine a maximum impact envelope. The annual average impact envelope is also based on the maximum of the annual average for the different operating modes.

In summary, the worst-case one hour nitrogen dioxide concentration, which is the critical assessment criterion for this project, will be predicted by virtually any year of meteorology and the annual average estimates are sufficiently conservative to outweigh year to year variations in the meteorology.

In a built-up urban environment like Brisbane, wind dispersion patterns will be complicated by the turbulence induced by buildings and also by the interaction of the land and the sea. As discussed above, surface wind data is available from two monitoring sites near Brisbane Airport, namely the BoM station at the Airport and the old EPA site at Eagle Farm. **Figure 6.4a** shows the location of these sites. Data from both these sites has been used for the CALMET modelling. The EPA's Eagle Farm site was decommissioned in mid 2005. A site at Pinkenba commenced operation in 2001 and has essentially replaced the Eagle Farm site.

The meteorological data collected from the Airport and Eagle Farm sites included hourly records of temperature, wind speed and wind direction. As discussed, data for 2004 has been selected for development of the meteorological wind field. Wind-roses has been created from the wind data and the pattern of winds observed at each site are discussed below.

Figure 6.4b shows annual and seasonal wind-rose diagrams for the Airport, based on data collected by the BoM in 2004. **Figure 6.4c** shows the 2004 wind patterns at Brisbane Airport by time of day. Annually, the most common winds at this site are from the north to north-north-east, south-west to south-south-west and east-south-east to south-east. The generally north-south pattern of winds would have been an important consideration for the current alignment of the existing Airport runways and proposed NPR.

In summer, winds at the Airport during the day are predominantly from the north to north-east typically as a result of the sea-breeze. The sea-breeze usually commences in the late morning and is well established in the afternoon. Synoptic winds from the east south-east to south-south-east are also observed, generally in the morning before the onset of the dominant sea-breeze. There are also winds from south-west sector in summer. These winds are observed mainly during the late evening and night.

In contrast, the most common winds in autumn and winter are from the south-west and south-south-west. Winter winds in the afternoon are generally from the north to north-east as a result of a winter sea-breeze. In autumn, afternoon and evening winds are observed mostly from the east-south-east.

Spring exhibits a similar pattern to summer but with more winds from the south-west and south-south-west with the transition from winter.

The average wind speed in 2004 at the Airport was 4.4 m/s with a maximum hourly average wind speed of 13.3 m/s. Calm conditions, when hourly average winds were less than or equal to 0.5 m/s, were observed 2.2 percent of the time.

Figure 6.4d presents annual and seasonal wind-roses for 2004 data from Eagle Farm. The distribution of winds for Eagle Farm on an annual and seasonal basis is similar to that at Brisbane Airport. This would be expected given the relatively close proximity of the Eagle Farm site to the Airport site – approximately three km.

As for Brisbane Airport, on an annual basis the winds are predominantly from the south-western quadrant, although there are some winds observed from the north-north-east and east-south-east. The cooler months, autumn and winter, show that winds from the south-west are the most common, while in spring the winds come mainly from the north-north-east. Summer shows slightly different trends to any other season with relatively similar proportions of winds from the north clockwise through to the south-east. In fact, the only area showing very little wind flow is the west-north-western quadrant.

Eagle Farm typically has lower wind speeds than the Airport with a maximum hourly average wind speed of 7.3 m/s and an annual average of 2.0 m/s. The percentage of calms is also significantly higher at 8.4 percent. The lower speed winds at the Eagle Farm site is consistent with its location within an industrial area, where buildings and terrain provide some shielding from the prevailing winds, compared with the more exposed BoM Airport site.

Historically the Eagle Farm site has been used as a reference for the potential air quality impacts in the area of the Airport operations. While this site has now been replaced by the Pinkenba monitoring station, the data from 2004 is representative of the area and similar to the 2004 Pinkenba data (see **Appendix B**).

Figure 6.4e shows a snapshot of winds simulated by the CALMET model for stable night time conditions. The diagram shows the effect of the terrain on the flow of winds for a particular set of atmospheric conditions. The difference in wind speed between the Airport and the Eagle Farm sites is evident.

6.4.2 Atmospheric Stability

Dispersion models typically require information on atmospheric stability class[1] and mixing height[2]. Plume dispersion models usually assume that the atmospheric stability is uniform over the entire study domain and these estimates are commonly calculated from measurements of sigma-theta, cloud cover information or solar radiation and temperature. Hourly estimates of mixing height can be determined by a combination of empirical methods and/or soundings.

The CALPUFF dispersion model, however, obtains estimates of atmospheric stability and mixing height from the CALMET meteorological model. CALMET determines these parameters using the cloud cover data and temperature profiles it is provided in order to run. The output of the CALMET model can subsequently be processed to extract meteorological information for any site of interest in the modelling domain, including atmospheric stability. **Table 6.4b** provides the frequency of occurrence of the six stability classes as determined by CALMET for the Airport and Eagle Farm sites.

It can be seen from **Table 6.4b** that, at the Airport, the most common stability class is determined to be D-class. The prevalence of D-class is due to the relatively high wind speed recorded at this site. Dispersion of pollutants is rapid under these circumstances as D-class stabilities are generally associated with strong winds. At Eagle Farm, F-class stabilities have been determined to occur most often, although D-class stabilities are also common. Pollutant dispersion is slow for F-class stabilities since these conditions are generally associated with light winds with a temperature inversion. Differences in the calculated distribution of stability class is largely due to the different wind speeds at each site, but also from differences in land use.

[1] *In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford-Turner stability class assignment scheme there are six stability classes A through to F. Class A relates to unstable conditions such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.*

[2] *The term mixed-layer height refers to the height of the turbulent layer of air near the earth's surface, into which ground-level emissions will be rapidly mixed. A plume emitted above the mixed-layer will remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.*

Table 6.4b: Frequency of Occurrence of Atmospheric Stability Class.

Pasquill-Gifford-Turner Stability Class	Frequency (Airport, %)	Frequency (Eagle Farm, %)
A	0.0	3.2
B	4.4	14.0
C	15.3	17.1
D	46.5	20.4
E	16.4	6.3
F	17.3	39.0
TOTAL	100	100

Joint wind speed, wind direction and stability class frequency tables generated from the Airport and Eagle Farm monitoring sites are presented in **Appendix B**.

6.4.3 Local Climatic Conditions

The BoM collects climatic information from Brisbane Aerodrome. A range of meteorological data collected from this station is presented in **Table 6.4c** (BoM 2004). Temperature and humidity data consists of monthly averages of 9am and 3pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consists of mean and median monthly rainfall and the average number of raindays per month.

Figure 6.4f graphically shows climate averages of temperature and rainfall at Brisbane Airport. It can be seen from this figure that the warmer months generally accompany higher rainfall. Lower rainfall is generally observed in the cooler months.

Table 6.4c: Climate Information for the Study Area.

Brisbane Aerodrome	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily maximum temperature (°C)	29.1	28.9	28.1	26.3	23.5	21.2	20.6	21.7	23.8	25.6	27.3	28.6	25.4
Mean daily minimum temperature (°C)	20.9	20.9	19.5	16.9	13.8	10.9	9.5	10	12.5	15.6	18	19.8	15.7
Mean 9am air temp (°C)	25.7	25.3	24.1	21.5	18	15.1	14.1	15.5	18.9	21.9	23.9	25.3	20.8
Mean 9am wet bulb temp (°C)	21.4	21.5	20.5	18.1	15	12.3	11.1	12	14.6	17.1	18.9	20.5	16.9
Mean 9am relative humidity (%)	67	70	71	70	71	70	68	63	60	60	61	63	66
Mean 3pm air temp (°C)	27.6	27.5	26.7	25	22.4	20.2	19.6	20.6	22.4	23.9	25.6	26.9	24
Mean 3pm wet bulb temp (°C)	22	22.1	21.2	19.2	16.7	14.5	13.6	14.1	15.9	18	19.7	21.3	18.2
Mean 3pm relative humidity (%)	60	61	60	57	55	51	48	45	48	54	57	59	55
Mean monthly rainfall (mm)	157.7	171.7	138.5	90.4	98.8	71.2	62.6	42.7	34.9	94.4	96.5	126.2	1185
Mean no. of raindays	13	14.2	14.1	11	10.5	7.5	7.2	6.6	6.9	10	10	11.5	122.4
Mean daily evaporation (mm)	7.3	6.5	5.8	4.5	3.2	3	3.2	4.1	5.5	6.3	7.2	7.5	5.3
Mean no. of clear days	4.6	4	8.1	9.8	10.8	13	15	16.7	15.6	10.1	8	6.7	122.4
Mean no. of cloudy days	12.4	12.6	11.6	8.6	9.7	7.5	7	5.5	5.1	8.5	9.7	10.5	108.6
Mean daily hours of sunshine	8.5	7.5	7.7	7.4	6.4	7.2	7.4	8.4	8.9	8.5	8.6	8.8	8

Climate averages for Station: 040223 BRISBANE AERO, Commenced: 1929; Last record: 2000; Latitude (deg S): -27.4178; Longitude (deg E): 153.1142; State: QLD. Source: Bureau of Meteorology, 2004

In summer the average maximum temperature ranges from 28.6°C to 29.1°C and the minimum temperature ranges from 19.8°C to 20.9°C. In winter the average maximum temperature ranges from 20.6°C to 21.7°C and the minimum temperature ranges from 9.5°C to 10.9°C.

The annual average humidity reading collected at 9am from the Brisbane Aerodrome site is 66 percent, and at 3pm the annual average is 55 percent. The months with the highest humidity on average are March and May with a 9am averages of 71 percent, and the lowest is August with a 3pm average of 45 percent.

Rainfall data collected at Brisbane Aerodrome shows that the wettest month is February, during the wetter summer season, with an average rainfall of 171.7 mm over 14.2 days. The lowest rainfall on average is in September, at the end of the winter dry season, with a mean monthly rainfall of 34.9 mm over 6.9 raindays. The average annual rainfall is 1,185 mm over an average of 122 raindays.

The data from **Table 6.4c** shows that the climate at Brisbane Airport is characterised by wet summers and low rainfall in winter. This is typical of the subtropical climate of South East Queensland.

From November to April the weather in Brisbane is warm, humid and windy with high rainfall and storms. These conditions encourage dispersion of pollutants in the air and the rain absorbs gases and particulate matter, removing them from the air. In the cooler months from May to October, there is less rain and the wind is not as strong, so there is less dispersion of pollutants.

Fog is defined as a "suspension of very small water droplets in the air, reducing visibility at ground level to less than a kilometre". If the visibility exceeds 1,000 m then the obscurity is described as a mist (BoM, 2005). Fogs can occur on up to 22 days in a year in Brisbane (BoM, 2006) and generally occur in late autumn or winter when there are cool light winds coming from the south-south-west and there is a temperature inversion low in the atmosphere, typical of stable atmospheric conditions. Fogs may affect the operation of the Airport but would do so with or without the new runway.

The number of clear and cloudy days per month is also recorded at Brisbane Aerodrome. Typically, the warmer months have a greater number of cloudy days while the cooler months generally have more clear days. This pattern is a reflection of the rainfall trend over the year.

The number of frosts recorded at the Airport is highly variable from year to year, ranging from one frost recorded in 1998, up to 13 frosts recorded in 2004 (BoM, 2006).

6.4.4 Extreme Weather Events

Dust storms and bushfires impact on air quality by causing a large increase in the amount of particulate matter in the air and bushfires also tend to increase concentrations of ground level ozone. They can severely reduce visibility at the surface and high in the atmosphere. These events can cause severe respiratory health impacts. Dust storms and bushfires typically occur in Brisbane in periods of drought when there are strong winds from the west-south-west. The most recent significant dust storms in Brisbane occurred on 23 October 2002 and 29 October 2003 (refer to section 6.3.5.3).

Bushfires and/or hazard reduction burning occur in most years and can occur under any wind conditions.

Tropical cyclones can persist for many days and may follow quite erratic paths. They occur frequently on the North Queensland coast, but rarely reach as far south as Brisbane. Tropical cyclones produce strong winds, heavy rainfall with flooding and storm surges that may impact as far south as Brisbane.

Severe thunderstorms are more localised than tropical cyclones and floods and often occur in Brisbane. There are usually between 10 and 20 thunderstorms in Brisbane each year, mostly occurring in warmer, summer months.

While extreme events may affect the operation of the Airport, these would occur regardless of whether the NPR is constructed. However, these events disrupt Airport operations often causing delays, deviation from standard flight paths to avoid storm cells and even temporary closure of the Airport.

6.4.5 Existing Air Quality

This section discusses the concept of background air pollution as it applies to this study and presents a review of air quality monitoring data that can be used to estimate background pollution levels. It also provides a general discussion on air quality trends in Brisbane and their relevance to Airport emissions.

Air quality data is collected by the EPA at 16 sites in the South East Queensland region. The locations of the monitoring sites are shown in **Figure 6.4g**. The closest operating monitoring sites to Brisbane Airport are currently Pinkenba and Wynnum. Until 2005, data from the now decommissioned Eagle Farm site was also representative of air quality in the vicinity of the Airport.

The Pinkenba site effectively replaces the Eagle Farm site and continuously monitors oxides of nitrogen, ozone, carbon monoxide, sulfur dioxide, and PM_{10}. Meteorological data is also collected and includes wind speed, wind direction, air temperature, and relative humidity. The Wynnum site continuously monitors sulfur dioxide and PM_{10}, as well as meteorological data.

Other monitoring sites within 20 km of the Airport include Rocklea, Woolloongabba, South Brisbane and Brisbane CBD.

The air quality data is available from the Queensland EPA website as monthly bulletins, annual summary and trend reports, and annual air monitoring reports to fulfill the annual reporting requirements of the National Environment Protection (Ambient Air Quality) Measure (Air NEPM).

An air emissions inventory was compiled for the South East Queensland region for the base year of 2000. The inventory indicates the pressure of pollutants on the airshed, rather than the concentrations of pollutants that individuals would experience. Nevertheless, the data provides a useful estimate of the sources contributing to air pollution levels and identifies sources, which can be targeted for emission control.

6.4.5.1 Accounting for Background

One of the most difficult aspects in air quality assessments is accounting for the existing levels of pollutants from sources that are not included in the dispersion model. At any location within the airshed the concentration of the pollutant is determined by the contributions from all sources that have at some stage or another been upwind of the source.

In the case of PM_{10} for example, the background concentration may contain emissions from the combustion of wood from domestic heating in winter, from bushfires, from industry, roads, construction sites, wind blown dust from nearby and remote areas, fragments of pollens, moulds, sea-salts and so on.

In an area such as the Brisbane airshed the background level of pollutants could also include recirculated pollutants which have moved through complicated pathways in sea-breeze/land-breeze cycles. In general, the further away a particular source is from the area of interest, the smaller will be its contribution to air pollution at the area of interest. However, the larger the area considered the greater would be the number of sources contributing to the background.

At any particular location, the concentration of a pollutant will vary with time as the dispersion conditions change and as the contributing emission sources change. In all air quality studies it is usually difficult to include the effects of existing background pollution. If all emission sources can be included in the modelling study then the problem is very much simplified. When this can be done (that is, all sources are included) the background can be assumed to be zero and the total concentration is accurately represented by the model predictions. However, there is usually insufficient detailed information to include all sources in the modelling, so accounting for background necessarily involves some approximations.

6.4.5.2 Photochemical Smog

Brisbane is located in a basin surrounded by a semicircle of mountain ranges, as shown by **Figure 6.2a**. The D'Aguilar Range lies to the north-west, Flinders Peak lies to the south-east and Tamborine Mountain is to the south of Brisbane. The terrain of the Brisbane airshed influences the wind patterns of land and sea-breezes, drainage and valley winds that transport and disperse pollution.

Figure 6.4h shows the general pattern of land breezes and drainage flows which would transport emissions to the east and sea-breezes which would transport emissions inland.

In 1997, the Queensland Department of Environment published a technical report on the movement of air pollutants in the South East Queensland airshed (Department of Environment, 1997) as a part of the South East Queensland Regional Air Quality Strategy. The study used ozone concentration as an indicator of photochemical oxidants and used a computer model (Lagrangian Atmospheric Dispersion Model) to simulate the region with its wind patterns and pollution.

The study found that photochemical smog production was favoured by calm and stable weather conditions. Air pollutants emitted in Brisbane were more likely to form high concentrations of ozone in summer when sunlight is more intense, and on days where the sea-breeze occurs late in the day. A low synoptic wind speed and a late sea-breeze, both associated with recirculation of polluted air, prevent the transportation of pollutants away from the city.

6.4.5.3 Long Term Trends

Motor vehicles are the predominant source of air pollutants (such as CO and NO_X) in the South East Queensland region. While there has been a steady increase in motor vehicle usage in the region, the control of individual vehicle emissions through design rules for vehicle exhausts and tighter fuel regulations has ensured that air quality has not deteriorated.

Burning of vegetation has also contributed a large proportion of emissions, especially of CO and particulate matter. This includes bushfires as well as activities such as control burning, improving pasture yields, and removing waste vegetation. Dust storms also generate a significant amount of particulate matter and have led to exceedances of the EPP (Air) goal.

Air quality trends from 1997 to 2004 have been determined based on monthly data reported in the Queensland EPA's monthly air quality bulletins and annual summary and trend reports (EPA, 2005). A summary of the air quality trends in the South East Queensland region follows.

Figure 6.4i shows the long term trends in monthly CO, NO_2, PM_{10} and SO_2 from EPA air quality monitoring data in the Brisbane study area from 1997 to 2005.

Monthly maximum eight hour average CO concentrations show a biennial pattern with the highest concentrations in winter months. The figure shows decreasing concentrations from 1997 to 2005, reflecting the control on motor vehicle emissions through the use of catalytic converters.

Monthly maximum one hour average NO_2 concentrations are also shown in **Figure 6.4i**. While there is a large degree of variability in the data in this time period, there is a discernible biennial pattern with the highest NO_2 concentrations in winter months.

Monthly maximum 24 hour average PM_{10} concentrations show no seasonal variation in PM_{10} concentrations, rather PM_{10} tends to peak as a result of isolated events including bushfires, control burning and dust storms. As discussed in section 6.4.4, the peaks in 2002 and 2003 can be attributed to specific dust storm events.

Monthly maximum one hour average SO_2 concentrations also show no seasonal pattern associated with the SO_2 concentrations. The range of concentrations has remained steady at most monitoring sites since 1997. The higher peaks seen since late 2003 were measured at the Pinkenba industrial site and to lesser extent Wynnum. These peaks are likely to be the result of nearby industrial activities such as the BP refinery, as suggested by the high SO_2 emissions reported by the BP Refinery to the NPI (refer **Appendix C**, **Table C1a**).

Figure 6.4j shows the monthly maximum 1 hour and 4 hour average ozone concentrations in South East Queensland from 1997 to 2005. The monthly maximum 1 hour and 4 hour concentrations show a strong correlation. Ozone concentrations exhibit a seasonal variation peaking in the summer months. The range of concentrations has been steady since 1997. Ozone is more difficult to regulate as it is a secondary pollutant formed from the interaction of oxides of nitrogen and reactive hydrocarbons in the presence of sunlight.

The overall range of concentrations has remained steady since 1997, despite the growth in industry and motor vehicle use over this time. This is a result of improved emission controls for both industry and motor vehicles. This trend is expected to continue with further emission control technology improvements, as well as the introduction of new standards for cleaner fuels in early 2000.

6.4.5.4 Air Quality Monitoring near Brisbane Airport

As discussed at the beginning of this section, the Queensland EPA currently operates or has operated air quality monitoring sites at Eagle Farm, Pinkenba and Wynnum. These sites are all located within a short distance of Brisbane Airport.

The Eagle Farm site was located in a light industrial area at the DPI Quarantine Centre and commenced operating in 1978. The site monitored CO, NO_X, O_3, SO_2 and PM_{10} as well the meteorological parameters wind speed and direction, temperature and humidity. Monitoring was discontinued at Eagle Farm in mid 2005.

The BP Refinery (Bulwer Island) Pty Ltd's monitoring site at Pinkenba was established in 2001, and is located on the grounds of the Pinkenba State School. The site monitors CO, NO_X, O_3, SO_2 and PM_{10} as well the meteorological parameters wind speed and direction, temperature and humidity. Data from the Pinkenba monitoring station from January 2003 is published in the EPA's monthly bulletins.

The Wynnum monitoring station is located in a residential area close to industrial facilities in Wynnum North. From 1999 to 2001 the Wynnum monitoring station measured O_3, NO_2, SO_2 and PM_{10} before it stopped operations. Since it recommenced operating in December 2004, the station has measured SO_2, PM_{10} and meteorology.

The location of Eagle Farm, Pinkenba and Wynnum monitoring sites ensures that the data is representative of the variety of the land use and population densities in the project area.

Table 6.4d summarises the air quality monitoring data collected by the EPA from 2003 and 2005 at Eagle Farm, Pinkenba and Wynnum. The maximum concentrations for each averaging period are shown. Values that are above the air quality goals are shown in bold print.

In 2004 and 2005 PM_{10} (24 hour average) was the only pollutant with recorded levels above the associated air quality goal of 50 µg/m^3 at both the Pinkenba and Wynnum monitoring sites. However, these particulate matter episodes can be attributed to widespread events such as dust storms or bushfires, and the goal was not exceeded as there were less than 5 episodes in the year.

As discussed previously, the Eagle Farm and Pinkenba sites can be used as reference stations to monitor existing air quality in the vicinity of the Airport. The data indicates that the Airport is not adversely affecting the air quality in the closest residential areas.

It is also worth noting that Sydney Airport Corporation Limited (SACL) has conducted an air quality monitoring program since 1994 to assess potential impacts of the new third runway. Following a detailed analysis of 10 years of data by Holmes Air Sciences (2003), it was found that there was no significant or discernable contribution from Airport emission sources on the ambient air quality in the vicinity of the Airport and as a consequence the monitoring program has now been discontinued.

Table 6.4d: Summary of Air Quality Monitoring Data for the Study Area.

Pollutant and Averaging Time	2003	2004	2005	Air Quality Goal*
Eagle Farm				
NO_2, 1 hour maximum (ppm)	0.059	0.061	-	0.12
NO_2, Annual average (ppm)	0.011	0.013	-	0.03
PM_{10}, 24 hour maximum ($\mu g/m^3$)	**88.4**	**79.6**	**-**	50 (5 per year)
PM_{10}, Annual average ($\mu g/m^3$)	19.7	22.8	-	50
SO_2, 1 hour maximum (ppm)	0.043	0.040	-	0.20
SO_2, 24 hour maximum (ppm)	0.007	0.010	-	0.08
SO_2, Annual average (ppm)	0.002	0.002	-	0.02
O_3, 1 hour maximum (ppm)	0.058	0.072	-	0.10
O_3, 4 hour maximum (ppm)	0.053	0.088	-	0.08
Pinkenba				
CO, 8 hour maximum (ppm)	1.2	2.2	1.0	8
NO_2, 1 hour maximum (ppm)	0.039	0.057	0.042	0.12
NOv, Annual average (ppm)	0.010	0.010	-	0.03
PM_{10}, 24 hour maximum ($\mu g/m^3$)	**105.5**	**54.3**	**72.0**	50 (5 per year)
PM_{10}, Annual average ($\mu g/m^3$)	20.0	21.3	18.9	50
SO_2, 1 hour maximum (ppm)	0.067	0.104	0.089	0.20
SO_2, 24 hour maximum (ppm)	0.009	0.009	-	0.08
SO_2, Annual average (ppm)	0.002	0.002	0.002	0.02
O_3, 1 hour maximum (ppm)	0.067	0.069	0.060	0.10
O_3, 4 hour maximum (ppm)	0.057	0.060	0.055	0.08
Wynnum				
PM_{10}, 24 hour maximum ($\mu g/m^3$)	**-**	**-**	**66.1**	50 (5 per year)
PM_{10}, Annual average ($\mu g/m^3$)	-	-	17.4	50
SO_2, 1 hour maximum (ppm)	-	0.019**	0.051	0.20
SO_2, 24 hour maximum (ppm)	-	-	-	0.08
SO_2, Annual average (ppm)	-	-	0.001	0.02

* *Air quality goals presented in this table are the most stringent of the goals as discussed in section 6.3.*
** *One month of data.*

Data from 2001 to mid 2005 for Eagle Farm has been obtained from the EPA in the form of one-hourly average records. These data are presented graphically as time series for NO_2 and PM_{10} in **Figures 6.4k** and **6.4l** respectively. Total NO_2 concentrations (**Figure 6.4k**) exhibit higher concentrations in the winter months than in the summer months.

The graph of PM_{10} (**Figure 6.4l)** shows that there were occasions when the 24 hour concentrations were above the NEPM standard of 50 µg/m^3. These data have been reviewed for completeness and the 2004 data was selected to complement the 2004 meteorological data to provide hourly varying information for modelling purposes.

6.4.5.5 Greenhouse Gases

The greenhouse effect is a term that describes the process whereby outgoing radiation from the earth is absorbed and re-radiated by water vapour droplets and carbon dioxide (CO_2) in the atmosphere. The enhanced greenhouse effect is essentially climate change that has been brought on by the emissions of greenhouse gases including CO_2, nitrous oxide (N_2O) and methane (CH_4) from human activities, which magnifies the natural process.

Potential impacts of climate change include rises in sea level and temperature. The major contributors to greenhouse gas emissions in Queensland are land clearing, electricity generation, agriculture and transport (EPA, 2003).

BAC has been a member of the Greenhouse Challenge since 2001 and reports on greenhouse gas emissions on an annual basis. In 2003 the total net emissions from BAC's operations were equivalent to 37,873 tonnes of CO_2, while in 2004 the net emissions were equivalent to 41,183 tonnes of CO_2. However, although there was an increase in total emissions, after taking growth of the Airport into account, there was an actual reduction in the greenhouse emissions per passenger movement. The main source of greenhouse gas emissions from BAC activities at the Airport is electricity usage from power generated off-site.

Other primary sources of greenhouse emissions at the Airport include:

- Aircraft taxiing, take-off and landing;
- Aircraft auxiliary power units (APU);
- Aviation ground support equipment (GSE) operated by the airlines and airline contractors, including: baggage tugs, pushback tractors, catering trucks, service vehicles;
- Ground power units (GPU); and
- Passenger and commercial vehicle movements to and from the Airport.

Aircraft contribute to greenhouse emissions on a national and global level, and as such these emissions are outside the jurisdiction of the individual airports to control. The Australian Government Department of Transport and Regional Services is responsible for policy to manage and reduce greenhouse emissions from aviation at a national level, while at an international level, aviation greenhouse policy is being developed and managed by the International Civil Aviation Organization (ICAO).

Emissions from the GSE, APU's and GPU's are the responsibility of the individual tenants and operators. However, BAC through its Airport Environment Strategy promotes and encourages greenhouse reduction initiatives to the Airport tenants and operators.

6.4.5.6 Odour

Reported odour impacts from airports are largely associated with emissions of jet fuel (kerosene). These impacts can extend beyond the boundary of the airport on occasions. The source of the impact can often be difficult to determine as airports have many odour-generating associated activities. Surrounding industries and activities, such as the refineries and waste management centre to the east of the Airport, can also be odorous.

Historically, there have been complaints of kerosene odour from residents at Nudgee Beach, however in recent years there have not been any significant complaints to the EPA regarding Airport odours (David Wainwright, EPA, personal communication, 24 May 2006). This is consistent with the significant buffer zone between the Airport and the nearest residential receptors.

6.4.5.7 Oxides of Nitrogen

Some analysis of the percentage of oxides of nitrogen (NO_X) which has been converted to NO_2 is particularly useful for this project as estimates of NO_2 concentrations are commonly derived from NO_X model predictions.

NO_X are produced in most combustion processes and are formed during the oxidation of nitrogen in the fuel and nitrogen in the air. During high-temperature processes, a variety of NO_X are formed including nitric oxide (NO) and NO_2. Generally, at the point of emission NO will comprise the greatest proportion of the emission with 95 percent by volume of the NO_X. The remaining 5 percent will be mostly NO_2.

The effects of NO on human health are such that it is not regarded as an air pollutant at the concentrations at which it is normally found in the environment. The presence of NO_X emissions can be of concern in urban environments where the control of photochemical smog is important.

Ultimately, however, all NO emitted into the atmosphere are eventually oxidised to NO_2 and then further to other higher oxides of nitrogen. The rate at which this oxidisation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone. It can vary from a few minutes to many hours.

The rate of conversion is quite important because from the point of emission to the point of maximum ground-level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low it is unimportant that the oxidation has taken place. However, if the oxidation is rapid and the dispersion slow then high concentrations of NO_2 can occur.

Analysis of the EPA's NO_X monitoring data reveals that the percentage of NO_2 in the air is inversely proportional to the total NO_X concentration. **Figure 6.4m** shows this relationship for the Eagle Farm site. The ratios of NO_2 to NO_X in the 2001 to 2005 data had an average value of 65 percent. This relatively high NO_2 to NO_X ratio may be expected at Eagle Farm given that the site is not within Brisbane CBD where the bulk of NO_X emissions are emitted. Lower ratios are observed closer to the CBD, for example at South Brisbane, the ratio in 2001/2002 was 39 percent (Holmes Air Sciences, 2004).

The ratio of 65 percent does not necessarily reflect the proportion of NO_2 which would be present very close to the emission source. Many studies (for example Pacific Power, 1998 and PPK, 1999) have reported that when NO_X levels are high, the proportion of NO_2 is low. For example, monitoring data collected by the RTA in Sydney (Holmes Air Sciences, 1997) are also consistent with this trend and indicate that close to vehicle emissions (that is, within 60 m of roadways), nitrogen dioxide would make up from 5 percent to 20 percent by weight of the total oxides of nitrogen. Generally, for plumes impacting close to the source, the time interval for oxidation is not sufficient to have converted a large proportion of the plume to the more harmful NO_2.

Figure 6.4m also shows the ratio of NO_2 to NO_X in the 2001 to mid 2005 data when the hourly average wind direction was generally from the Airport, that is, between 0 and 45 degrees. Again, when the NO_X concentration is higher, the fraction of NO_2 in the NO_X is less than about 20 percent. This is an important consideration for the impact assessment as the dispersion modelling has been configured to predict maximum NO_X concentrations due to aircraft operations. Of all the emissions from the Airport, NO_X should have the most readily discernable signature in the air monitoring data if the emissions are significant.

Concentrations of NO_X have been plotted against wind direction, as shown by **Figure 6.4n**. This figure has been created to examine whether elevated NO_X concentrations could be attributed to a particular wind direction or source. Since the Eagle Farm site was south-west of the Airport, it would appear from this figure that there is not a strong relationship between winds from the Airport and elevated NO_X concentrations at Eagle Farm. In fact, no wind directions stand out with significantly higher NO_X concentrations. Therefore, as in the case of Sydney Airport, emissions from Brisbane Airport do not appear to contribute substantially to pollutant levels at nearby monitoring stations.

6.4.5.8 *Volatile Organic Compounds*

A detailed study of ambient volatile organic compound (VOC) concentrations at Eagle Farm was undertaken in 2001 at the EPA's monitoring station (Hawas and others, 2002). This study quantified n-alkanes and cyclic and branched alkanes which accounted for 84.3 percent of the total concentrations, aromatic VOCs 12.3 percent, chlorinated VOCs as well as carbonyls 1.5 percent, and biogenic VOCs which contributed less than 1 percent.

The most abundant individual compounds were characteristic of petrochemicals. There was not a substantial difference between the weekend and the weekday concentrations indicating that evaporative sources were a major contributor. Industrial and motor vehicle exhaust emissions were identified as the major sources of VOCs and evaporative emissions of petrochemicals were found to contribute most substantially to the VOC concentration. This is consistent with the location of the monitoring station in an industrial area.

The concentrations of the VOCs showed a negative correlation with wind speed suggesting that the VOCs were more likely to have been emitted by local industrial sources in the study area. Despite the proximity to industrial sources, the guideline concentrations for individual compounds were not exceeded.

6.4.5.9 *Airshed Air Movements*

An airshed dispersion model developed by the CSIRO has historically been used to simulate wind patterns and air pollution in the South East Queensland region (EPA, 1997). The main aim of the study was to determine weather conditions associated with increased photochemical smog formation.

The airshed simulations suggested that, in summer, morning pollution from the northern and western suburbs were carried over the central business district by the morning drainage flow. In the afternoon, these emissions were carried inland by the sea-breeze (together with photochemical smog and additional afternoon emissions) to the west of Ipswich. These emissions were then recirculated with the following morning drainage flow over the Brisbane.

A second pattern was seen in summer where morning emissions from Brisbane' southern and eastern suburbs were carried towards Moreton Bay by the drainage flow. These emissions were then carried south by the afternoon sea-breeze to the Beaudesert area. Afternoon emissions were carried to Boondah Valley and further south the following day.

In winter, the peak morning pollution was generally transported north towards Deception Bay before recirculating between there and Brisbane, forming a closed loop. Emissions around the middle of the day tended to stagnate near the point of emission before being carried inland by the on-shore sea-breeze. Afternoon peak emissions were generally carried south-west to Ipswich where they stagnated overnight, before returning to Brisbane the next morning and mixing with new emissions which again travelled north to Deception Bay.

Figure 6.4o show examples of the summer and winter air movements around Brisbane.

6.4.5.10 *Some Clarifications About Aircraft Air Emissions*

There are some commonly held beliefs within the community regarding certain practices and issues associated with the aviation industry which are incorrect and require clarification. These activities include:

- Fuel dumping; and
- Dark residues which accumulate on cars, houses and other outdoor objects.

Fuel Dumping

In the course of normal operations aircraft do not dump fuel due to a number of reasons:

- Fuel is an expensive component of airline operations and therefore not good business practice;
- It is environmentally irresponsible; and
- There are regulations preventing this activity except in emergency situations.

Fuel dumping is permitted only in extreme cases when, to land in an emergency situation, an aircraft is overweight and risks structural damage to the undercarriage and consequent risk to life.

Should an emergency situation arise where it is considered fuel must be released prior to attempting the emergency landing, the pilot must first be granted permission and given instructions on where and when to release fuel. In this situation the aircraft is normally directed to release any excess fuel at height and over water where it will vaporise. Fuel is never permitted to be released over residential areas. Fuel release is not permitted lightly as aircraft even in an emergency situation are more likely to be directed to circle the airport to use up fuel rather than dump it. The incidence of fuel being dumped at Brisbane Airport is non-existent. Since the current airport opened in 1988 approval to dump fuel has never been sought or granted.

Dark Residues

Dark residues which accrete on houses, cars and other outdoor objects are quite often attributed by the public to aircraft emissions, particularly in areas which are in the vicinity of the airport. Residues of this nature can be caused from a number of sources including:

- Pollutants combining with dust and other particulate matter;
- Incomplete combustion of fuels which can relate to bushfires and burn offs as well as incomplete combustion from vehicle and other engines;
- Biological residues as a result of release by some plants or fungi.

While some aircraft may contribute to a very small proportion of residues because they produce gaseous emissions at lower height levels during approach, take-off and landings, which can combine with dust and other particles in the atmosphere to create a residue, the levels being emitted are so low in comparison with emissions from cars and other industry (refer to **Table 6.5.1a)** that the contribution, even in the vicinity of the airport, is negligible.

It is therefore considered that aircraft emissions do not have an effect on water quality due to outdoor residues which occur due mainly to other factors being washed off into water catchments or rainwater tanks.

6.5 Estimation of Pollutant Emissions

This section provides information relating to the estimation of pollutant emissions from aircraft and airports. Sources of emission factors are discussed as well as the aircraft movement data used in the study. A summary of the calculated pollutant emissions for the airport is provided in this section.

The National Pollutant Inventory (NPI) Emission Techniques for Airports (NPI, 2001) identifies the major sources of emissions from airports as follows:

- Aircraft operations;
- Airport related surface traffic;
- Ground support equipment (airside vehicles and mobile plant);
- Paint and solvent usage;
- Fuel and organic liquid storage;
- Boilers and space heaters;
- Emergency generators;
- Fire training and emergency simulations;
- Aircraft engine test cells;
- Refuelling operations; and
- General engine testing.

Table 6.5a presents a summary of the emission sources and the typical pollutants emitted from each source.

Table 6.5a: Summary of Emission Sources at Airports.

Operation	Emission Source	Pollutant				
		NO_x	VOCs	CO	TSP	Odour
Aircraft engine operation	Combustion of fuel	✓	✓	✓	✓	✓
Aircraft engine testing	Combustion of fuel	✓	✓	✓	✓	✓
Aircraft refuelling	Fuel evaporation		✓			✓
Fuel storage	Fuel evaporation		✓			✓
Ground support equipment	Combustion of fuel	✓	✓	✓	✓	✓
Airport related traffic	Combustion of fuel	✓	✓	✓	✓	✓
Paint and solvent usage	Product evaporation		✓			✓
Boilers	Combustion of fuel	✓	✓	✓	✓	✓
Emergency generators	Combustion of fuel	✓	✓	✓	✓	✓
Auxiliary power units	Combustion of fuel	✓	✓	✓	✓	✓
Rescue fire fighting service safety training burns	Combustion of fuel	✓	✓	✓	✓	✓

The relevant emissions from aircraft are those emitted from ground-level to approximately 1,000 m above ground-level. Emissions above 1,000 m will be dispersed to low concentrations and their contribution to ground-level air pollution will be negligible and below levels of detection.

Emissions from aircraft vary according to the operational cycle of the aircraft (NPI, 2003). There are four operational stages that have been considered in the determination of aircraft emissions. Collectively these operational stages are termed as the landing/take-off (LTO) cycle.

The four stages of aircraft operation are:

1. Approach mode – emissions are estimated from 1,000 m above ground level (AGL) to ground level;
2. Taxi/Idle mode – applies to both incoming and outgoing aircraft during taxiing and idling operations;
3. Take-off mode – the period between commencement of acceleration on the tarmac and the aircraft reaching 200 m AGL; and
4. Climbout mode – emissions are calculated for the period between 200 m and 1,000 m AGL.

6.5.1 Emission Inventories

In 2003 the South East Queensland Air Emissions Inventory was jointly produced by BCC and the EPA. The inventory provides estimates of the amount of pollutants emitted by different industrial and domestic sources. The inventory indicates the pressure of pollutants on the airshed, rather than the concentrations of pollutants that individuals would experience.

Estimates have been made by BCC and EPA for 2000, and projections have been made for 2005 and 2011. Contributions from aircraft are included as mobile sources. **Table 6.5b** summarises the estimated amount of each pollutant emitted from aircraft in 2000. The aircraft emissions from all airport operations in South East Queensland contribute a minimal proportion of each of the pollutants in the South East Queensland airshed.

Table 6.5c shows emissions from aircraft to the atmosphere as reported to the NPI for 2004–2005, for all of the South East Queensland airshed and also for Brisbane City. The aircraft emissions for the South East Queensland airshed were reported to be the same as the emissions for all of Queensland.

Brisbane Airport is situated in an industrial area which includes oil refineries, chemical manufacturers and the Port of Brisbane. These industries contribute to the air quality in the vicinity of the Airport. Emissions from surrounding industries that have been reported to the NPI are presented in **Appendix C**.

Table 6.5b: Airport Emissions from the South East Queensland Air Emissions Inventory.

Pollutant	Aircraft Emissions in 2000* (t/yr)	Emissions from all Sources in the Airshed 2000 (t/yr)	Aircraft Emissions as a Percentage of Emissions from all Sources (%)
NO_x	1,929	97,385	2.0%
TSP	247	28,104	0.9%
PM_{10}	231	23,906	1.0%
$PM_{2.5}$	216	13,210	1.6%
VOC	447	378,266	0.1%
CO	1,158	617,530	0.2%
SO_2	58	24,855	0.2%
CH_4	47	58,415	0.1%

** Includes emissions from all airports in South East Queensland, including Brisbane Airport, Gold Coast Airport, Sunshine Coast Airport, Amberley RAAF Base, Archerfield Airport.*

Table 6.5c: Aircraft Emissions in South East Queensland as Reported to the NPI.

Substance	t/yr	
	South East Queensland Airshed	All Airports in Brisbane City Local Government Area
Acetaldehyde	19.68	14.00
Acetone	11.21	8.00
Arsenic and compounds	0.21	0.14
Benzene	8.20	5.90
1,3-Butadiene (vinyl ethylene)	7.49	5.40
Cadmium and compounds	0.02	0.01
Carbon monoxide	1,157.14	890.00
Chlorine	14.55	10.00
Chromium (III) compounds	0.22	0.15
Chromium (VI) compounds	0.09	0.07
Cobalt and compounds	0.10	0.07
Copper and compounds	0.10	0.07
Ethylbenzene	0.71	0.51
Formaldehyde (methyl aldehyde)	63.79	46.00
Lead and compounds	0.22	0.15
Manganese and compounds	0.10	0.07
Nickel and compounds	0.12	0.09
Oxides of Nitrogen	1,926.36	1,300.00
PM_{10}	225.55	160.00
Phenol	1.01	0.72
Polycyclic aromatic hydrocarbons	4.44	3.20
Styrene (ethenylbenzene)	1.66	1.20
Sulfur dioxide	58.26	43.00
Toluene (methylbenzene)	2.21	-
Total Volatile Organic Compounds	446.53	-
Xylenes (individual or mixed isomers)	2.02	-
Zinc and compounds	0.32	-

The purpose of these emissions inventories is to provide regulators such as the EPA with information on the major contributors to air emissions within their jurisdiction. This enables Government to target sectors which can be controlled through both planning instruments and engineering solutions. Planning measures include the improvement of roadway networks with projects such as the North-South Bypass Tunnel (NSBT). Such projects also highlight where controls on emissions can be most effective. In the case of roadway projects the most effective control is at the primary source of emissions, that is motor vehicle exhausts.

Projects such as the NPR also provide an opportunity to identify the main sources of pollution at airports, which can then be targeted for possible control and reduction. This is despite the fact that the project itself is likely to have a minimal effect on air quality.

6.5.2 Aircraft Movements

Airservices Australia (AsA) has provided existing aircraft movement data for this project. Tourism Futures International (TFI) has generated forecast aircraft movement data for future years.

The aircraft movements data made available and used for the purposes of the air quality study included the following:

- Existing (2005) aircraft movements by hour of day for four representative days. The four days related to a typical peak movement day for a summer and winter weekday and weekend;
- Aircraft movement projections for 2015 and 2035;
- Aircraft movement projections for constrained (no NPR) and unconstrained (with NPR) operations in 2035;
- Breakdowns of aircraft movements by aircraft type;
- Breakdowns of aircraft movements by aircraft origin and destination.

The aircraft movement data provided by BAC (from the Airservices Australia movement data and TFI forecasts) have been reviewed and are summarised in **Table 6.5d**. Data from the four operating days (that is, summer and winter weekday and weekend) have been weighted in order to generate annualised daily movements. This approach will overestimate the total annual aircraft movements since the selected operating days were based on typical busy day activities. Annual pollutant emissions will therefore be overestimated also by approximately 10 percent.

Figures 6.5a to **6.5e** show the aircraft movements by hour of day. These figures also show the split into arrivals and departures for domestic and international movements.

In 2015, the current planned year of the opening of the NPR, the number and type of aircraft movements are the same with or without the NPR. In 2035 there will be an increase in total aircraft movements with the NPR in a given day.

The aircraft movement data have been estimated for each runway by assuming that after the runway opens, the aircraft arriving from and departing to the north of Brisbane (for example, to and from the Northern Territory, Asia and Europe) and west of Brisbane (for example, to and from Western Australia, South Australia and Africa) will transfer to the NPR. This was necessary to estimate pollutant emissions from each runway and is likely to be the case for most aircraft under normal operating conditions.

Pollutant emissions from the existing and proposed runways have been calculated for input to the CALPUFF dispersion model. The estimated pollutant emissions are discussed below.

Table 6.5d: Summary of Aircraft Movements by Hour of Day.

Hour of day	2005	2015		2035	
	no NPR	no NPR	NPR	no NPR	NPR
1	4	5	5	6	6
2	3	4	4	5	5
3	3	4	4	5	5
4	4	7	7	9	8
5	2	5	5	6	6
6	9	14	14	17	16
7	21	32	32	37	45
8	24	43	43	47	64
9	36	51	51	58	96
10	28	44	44	46	80
11	23	44	44	45	76
12	23	43	43	42	75
13	26	39	39	40	66
14	22	39	39	41	58
15	26	36	36	37	71
16	28	35	35	37	69
17	21	29	29	28	48
18	28	44	44	46	70
19	39	51	51	57	99
20	27	47	47	48	94
21	20	34	34	36	64
22	14	21	21	23	45
23	6	14	14	15	32
24	5	10	10	11	16
DAILY TOTAL	442	697	697	736	1213

6.5.3 Emission Estimates

The most significant emissions at the Airport will be CO, HC, NO_X, SO_2 and PM_{10}. These will arise primarily from aircraft operations, although as discussed in section 6.4.1, there will be emissions from other sources. Estimated emissions of these pollutants are required as input to computer-based dispersion models in order to predict pollutant concentrations in the area of interest and to compare these concentrations with associated air quality goals.

In order to estimate pollutant emissions from aircraft operations, information on aircraft movements are combined with relevant emissions factors. The NPI has published an emissions estimation technique manual for determining aggregated emissions from aircraft (NPI, 2003).

Table 6.5e shows default aircraft operation emissions factors published by the NPI. Emission factors are given in kilograms per LTO for the four modes of operation and for domestic and international flight types.

The emission factors provided in **Table 6.5f** have been used with aircraft movements to estimate pollutants for each runway for each assessment scenario. Estimates have been made for each hour of the day and for each of the four aircraft operating modes.

Table 6.5e: Default Aircraft Emission Factors From NPI.

Pollutant	Aircraft	Emission Factor by Aircraft Mode (kg/LTO)			
		Taxi/Idle	Take-off	Climbout	Approach
CO	Domestic	7.66	0.0835	0.107	0.626
	International	16.9	0.238	0.26	0.989
HC	Domestic	0.891	0.0134	0.0187	0.0387
	International	3.16	0.106	0.101	0.21
NO_x	Domestic	0.973	2.14	2.24	1.27
	International	3.43	18.8	16.7	5.4
SO_2	Domestic	0.25	0.106	0.134	0.157
	International	0.79	0.398	0.49	0.552
TSP	Domestic	0.116	0.0428	0.0465	0.0953
	International	0.769	0.0651	0.104	0.194

Table 6.5f summarises the daily emissions from aircraft operations for existing and future scenarios. Total daily emissions of each pollutant are predicted to increase over existing emissions for future scenarios. These estimates are proportional to the projected increases in aircraft movements and no improvements to technology or emissions have been assumed. A discussion of potential improvements to aircraft emissions, and the implications for the impacts of the NPR, is provided in section 6.5.5.

Table 6.5f: Estimated Emissions from Aircraft Operation.

Aircraft Operations	Estimated Emissions (kg/day)				
	CO	HC	NO_x	SO_2	TSP
2005 Existing					
Existing runway	2175	292	2556	190	92
NPR	-	-	-	-	-
TOTAL	2175	292	2556	190	92
2015 – no NPR					
Existing runway	3483	475	4338	310	149
NPR	-	-	-	-	-
TOTAL	3483	475	4338	310	149
2015 – with NPR					
Existing runway	1808	242	2106	158	76
NPR	1666	231	2158	151	73
TOTAL	3474	473	4264	309	149
2035 – no NPR					
Existing runway	3708	510	4685	332	160
NPR	-	-	-	-	-
TOTAL	3708	510	4685	332	160
2035 – with NPR					
Existing runway	3014	398	3469	261	125
NPR	3020	421	3938	274	132
TOTAL	6034	819	7406	535	257

Emissions have also been estimated by hour of day for use in the dispersion model. **Figures 6.5f** to **6.5h** show the estimated emissions by hour of day for each aircraft mode and for CO, NO_X and TSP respectively.

In addition to the emission estimation technique using the default aircraft operation emissions factors, the NPI provide an alternative technique referred to as 'best practice'. Emission estimation by the best practice technique requires the following information:

- The number of LTO cycles for each aircraft type;
- The number and type of engines for each aircraft type; and
- The time spent in each operating mode, that is, in approach, taxi/idle, take-off and climbout modes.

Emission calculations using the best practice technique have been made for the 2005 aircraft operations. This has been done to compare emissions using the default methodology with the best practice technique.

There were 15 aircraft categories provided in the Airservices movement data. Each category represented one or more aircraft types. This added some complication to emission estimation as the aircraft types in each category usually had different engine types and therefore different emissions. Assumptions were therefore required when assigning emission factors to each of the 15 aircraft categories.

Table 6.5g shows the estimated emission by the default and best practice techniques for the 2005 existing aircraft operations. The results are considered to be very similar. The best practice technique does not provide emission factors for SO_2 or particulate matter so comparisons for these pollutants could not be made.

Table 6.5g: Comparison of Emissions by Default and Best Practice Techniques.

Emission Estimation Technique	Estimated Emissions for 2005 Existing Aircraft Operations (kg/day)		
	CO	HC	NO_X
Default	2,175	292	2,556
Best Practice	2,276	299	2,200
Difference (best practice / default)	1.0	1.0	0.9

Estimated emissions of CO and HC are virtually identical (less than 5 percent) by the two techniques while NO_X was slightly higher (by approximately 10 percent) using the default emission factors.

Given the resultant similarities between the two emission estimation techniques, the results from the default factors are considered to be no less reliable than the best practice emission factors. **Appendix D** provides details of the emission estimation by the default and best practice techniques.

Emissions from auxiliary power units (APUs) have also been estimated for the dispersion modelling. APUs provide pneumatic air for starting main engines and operating the aircraft air conditioning system on the ground and electrical power for lighting and other power requirements. An APU is usually a small gas turbine mounted in or near the tail of the aircraft.

APU emissions were calculated using the NPI Emission Estimation Technique for Aggregated Emissions from Aircraft (NPI, 2003) as described in **Appendix D**. A summary of the estimated emissions are provided in **Table 6.5h**.

Table 6.5h: Estimated Emissions from Auxiliary Power Units.

Aircraft Operations	Estimated Emissions (kg/day)		
	CO	HC	NO_X
2005 Existing	421	27	240
2015 – no NPR	663	43	378
2015 – with NPR	663	43	378
2035 – no NPR	701	45	399
2035 – with NPR	1,155	74	658

6.5.4 Emissions from JUHI

The Joint User Hydrant Installation (JUHI) manages fuel supply at Brisbane Airport. Jet fuel, which is essentially kerosene, is currently stored in three tanks with a total capacity of approximately six million litres. Contents of these are piped to seven hydrant pumps on the Airport site. Mobile tankers are also used to refuel smaller aircraft. Fuel is provided to the facility by two underground pipelines, one from the Shell Terminal at Pinkenba and the other from the BP Oil Refinery.

Approximately 2.3 million litres of jet fuel is used on the Airport each day. A minor quantity, approximately 20,000 litres per month, of Avgas which is equivalent to leaded petrol, is also supplied to the Airport. Therefore lead emissions from the Airport are relatively minor.

The tanks are free vented to the atmosphere and there is no control on the emissions. The number of storage tanks is likely to increase as the Airport grows but this will happen regardless of whether the new runway is built.

It is anticipated that the throughput would increase proportionately with aircraft movements. However, the VOC emissions would not increase to the same extent as only the throughput component of the emissions will change. The storage tanks also lose vapour through breathing and this is related to the tank capacity.

The following equation is used for calculating the total VOCs from horizontal fixed roof tanks (NPI, 2002):

$E_{HFRT} = 4.7E\text{-}02 + 8.1E\text{-}2 \times C_{HFRT} + 1.1E\text{-}03 \times T_{HFRT}$

where:

E_{HFRT} = uncorrected emissions of total VOCs from horizontal fixed roof tanks (kg/year)

C_{HFRT} = tank capacity (kl)

T_{HFRT} = tank throughput (kl)

The equation given above was developed for diesel fuel using the South Australia climatic zone. Climatic variations (particularly minimum and maximum temperature) are an important determinant of total VOC emission, and as such a correction factor is applied to the above equation to account for the location of the tanks. The correction factor for Brisbane is 1.28 (NPI, 2002) There is no correction factor for jet fuel type nor for calculating speciated emissions.

JUHI reports to the NPI and **Table 6.5i** summarises the estimated annual fugitive emissions from the facility for the reporting year 2004–2005. These are minor emissions and are unlikely to lead to any off-site impacts.

Table 6.5i: Estimated VOC Emissions from JUHI (2004–2005).

Emission	Amount (kg)
Volatile Organic Compounds	1,200
Cumene (1-methylethylbenzene)	1.2
Ethylbenzene	0.18
Toluene (methylbenzene)	1.1
Xylenes (individual or mixed isomers)	0.99

6.5.5 Emission Standards and Future Emissions

Aircraft are required to meet the engine certification standards set by the International Civil Aviation Organisation (ICAO) through the Committee on Aviation Environmental Protection (CAEP). CAEP includes five working groups and one support group, two of which deal with the technical and operational aspects of noise reduction and mitigation. The other three working groups deal with technical and operational aspects of aircraft emissions, and with the study of market-based measures to limit or reduce emissions.

CAEP meets as a Steering Group to review and provide guidance on the progress of the activities of the working groups and so far has held six formal meetings: in 1986 (CAEP/1), 1991 (CAEP/2), 1995 (CAEP/3), 1998 (CAEP/4,) 2001 (CAEP/5) and 2004 (CAEP/6). Each formal CAEP meeting produces a report with specific recommendations for the consideration of the ICAO Council. Recommendations for aircraft emission standards were outcomes from CAEP/1, CAEP/2, CAEP/4 and CAEP/6. The standards apply to all newly manufactured turbojet and turbofan engines that exceed 26.7 kN rated thrust output at International Standard Atmosphere (ISA) sea level static (SLS) conditions.

Smoke standards (SN) took effect in 1983 and those for gaseous emissions (unburned HC, CO and NO_X) took effect in 1986.

The data are published in an ICAO exhaust emissions data bank[1]. Engine emissions are given for a standardized LTO cycle represented by an engine power setting of 7 percent (taxiing), 30 percent (approach), 85 percent (climb out) and 100 percent (take-off) of rated output and given times in mode. The databank includes information on fuel flow, emission indices (EI) of HC, CO and NO_X in grams per kilogram of fuel burned, and maximum SN. Except for smoke, the emissions of each LTO cycle mode (EI x fuel flow x time in mode) are summed (Dp) and expressed in the form Dp/F_{00} (g/kN), where F_{00} is the maximum thrust of the engine at take-off under ISA SLS conditions.

The HC, CO and SN standards have remained unchanged with the CAEP process. NO_X emissions have been tightened in accordance with technology gains. The base limit (CAEP/1) was introduced to allow NO_X to rise with maximum engine pressure ratio and associated temperature and is shown in **Figure 6.5i**, taken from "Aviation and the Global Atmosphere", Intergovernmental Panel on Climate Change (http://www.grida.no/climate/ipcc/aviation/003.htm). The figure shows a plot of emissions expressed as Dp/F_{00} (g/kN) versus engine pressure for CAEP/1, CAEP/2 and CAEP/4.

CAEP/2 has been effective for new engine types since 1996 and newly manufactured engines since 2000. CAEP/2 decreased the regulatory NO_X level by 20 percent.

CAEP/4 was adopted in 1998 and has been effective for new engine types since 2004 and decreased NO_X emissions by a further 16 percent.

CAEP/6 was adopted in 2004 and specifies a 12 percent reduction over CAEP/4 for new engine types from 2008.

There is general consensus within the aviation community that CAEP/6 does not go far enough in reducing NO_X emissions as it does not reflect the full extent of current engine NO_X technology and there are calls for a further reduction in NO_X to be introduced at an earlier date than 2010.

The emission estimates for the project do not take account of future improvements and as they are based on an emissions factor database issued in 1995, they do not take account fully of the fleet mix used by the airlines. To that extent the projected air emission estimates are likely to be conservative. For example, Qantas will have replaced its current Boeing B767-300 fleet with the new Boeing B787 Dreamliner by 2015. Boeing has reported that the B787 is about 30 percent more fuel efficient than the B767-300, with a comparable reduction in emissions and additional technology improvements may reduce emissions further.

6.6 Approach to Assessment

Dispersion models have been used as the primary tool to assess air quality impacts arising from this project. This section provides an explanation of the way in which dispersion modelling has been used for air quality assessment purposes.

The approach to the assessment has been to show pollutant concentrations resulting from existing and potential future emissions from the Airport. Predictions for the NPR and no NPR cases have been compared to assess the change to air quality that may arise with the project.

The assessment has made use of the computer-based dispersion model known as CALPUFF. A discussion of some dispersion modelling concepts as well as the application of the CALPUFF model to this project is given below.

6.6.1 Overview of Dispersion Models

A dispersion model can simply be thought of as a calculation which takes information about a pollutant source and determines a concentration at a specified location. Most dispersion models are now computer-based and may include a user interface.

The primary inputs to a dispersion model include:

- Source information;
- Meteorological information; and
- Receptor information.

[1] *See http://www.caa.co.uk/default.aspx?categoryid=702&pagetype=90*

Dispersion models require information on the emission sources. There are generally three main source types; point sources, area sources and volume sources. For point sources the dispersion model requires information on the source location, the source height, internal source tip diameter, temperature of emissions, exit velocity of emissions and the mass emission rate of the pollutants to be assessed. Area sources typically describe such things as ponds or exposed surfaces while volume sources can be used to represent emissions discharged from a single point, a building or even sources located in a series, which may be used to represent a roadway or aircraft runway. As well as the mass emission rate, area and volume sources require information on the dimensions of the source.

Meteorological data are an important aspect of dispersion modelling. In order for the model to determine how a pollutant emitted from a source will disperse, it must be given meteorological information relevant to the area in which the pollutant is emitted. Meteorological data will determine such things as the plume path and the 'spread' of the plume. Meteorological parameters typically include wind speed, wind direction, temperature, atmospheric stability and mixing height. All of these parameters are provided to the model as a data file which contains hourly records spanning approximately one year. In a non-leap year this would correspond to 8,760 records. The basis for providing the model with a year of data is to ensure that almost all possible meteorological conditions, including seasonal variations, are considered in the simulation. A comprehensive discussion of the meteorology of the study area was provided in section 6.4.1.

Receptor information is defined by the user and relates to the locations for which a prediction of pollutant concentration is required. Usually the location of receptors are defined at ground-level, where most people reside, however it is also possible to set a receptor at a location above ground. Examples of above-ground or elevated receptors are air intake points on a building.

The calculations within a dispersion model are organised in a series of loops. The first step the model takes is usually to read one hour of meteorological information. Then, in the case of a single source, the model will determine the plume structure and then calculate the resultant pollutant concentration at every receptor specified by the user. Following these calculations the model reads the next hour of meteorological information and the process repeats itself until all hours in the meteorological file have been read. During the simulation the calculations are stored in the computer's memory and once the model run is complete, statistics such as pollutant maxima and averages can be retrieved.

The units of measurement for pollutant mass emission rates are different from the units of measurement for pollutant concentration and may sometimes cause some confusion. Mass emission rate defines the pollutant by time (for example grams per second) while concentration defines the pollutant by volume; grams per cubic metre for example. Air quality goals are generally specified as a concentration.

It should be also mentioned that air dispersion models can be classed as being one of two types; a steady-state model or a non steady-state model. A thorough description of the differences between the two model types is not necessary for the purposes of this report, however, it is useful to note that the fundamental difference relates to the simulated plume behaviour.

Steady-state models essentially create a plume which extends to infinity downwind. Once the next hour of meteorological data is read a new plume is created and memory of the plume from the previous hour is lost.

Non steady-state models allow the plume to grow and bend with differences in meteorology over the modelling area. Unlike steady-state models these types of models have a 'memory' of the plume for the previous hours. The non steady-state model is considered to be a more realistic simulation of plume behaviour than that provided by steady-state models.

6.6.2 Application of CALMET and CALPUFF

As discussed in section 6.4.1, the CALMET/ CALPUFF modelling system is considered to be one of the most sophisticated dispersion models available. CALPUFF is an advanced non-steady state computer-based dispersion model that simulates the dispersion of emissions by representing emissions as a series of puffs emitted sequentially. Provided the rate at which the puffs are emitted is sufficiently rapid, the puffs will overlap and the serial release will represent a continuous release.

The advantage of the puff modelling approach over the steady-state Gaussian models such as ISCST3 and AUSPLUME, which have also been widely used in source dispersion assessments in the past, is that the progress and dispersion of each individual puff can be treated separately and can be made to account for local wind conditions and the way in which wind conditions at a particular place vary with time.

The CALPUFF model has been chosen as the primary tool for the purposes of this assessment. The main purpose of the CALPUFF modelling was to simulate the air quality impacts of the project over an area 15 km by 18 km, with the Airport located approximately in the centre. This area was chosen to ensure that potential air quality impacts at the nearest residential locations could be clearly examined. It was not considered necessary to model the full extent of the study area as the predicted concentrations beyond this grid were observed to be negligible.

Each runway has been represented as a series of volume sources over the typical length of each mode. Source locations, source characteristics and hourly variable pollutant emissions are provided to the model in the form of an external emissions file. Sources have been chosen to represent the four modes of aircraft operation, that is, approach, taxi/idle, take-off and climbout modes.

Each volume source has a location, elevation, height above ground and two additional parameters relating to the size of the source in the horizontal and vertical planes. Pollutant emissions are modelled to vary by hour of day for every volume source representing part of an aircraft flight or taxiing mode.

Each source which represents part of the approach mode has been given a height above ground that assumes aircraft approach the Airport at an angle of three degrees. Take-off angle has been taken to be seven degrees for source heights representing this mode.

Modelling has been carried out for the existing and new runways in both 01 or 19 mode[1]. The maxima of model output for each receptor location has then been extracted. **Figures 6.6a** to **6.6d** show the location of volume sources which have been used to represent the existing and new runways in 01 and 19 modes for the CALPUFF simulations. **Figure 6.6e** shows the location of modelled sources for the Airport in SODPROPS mode as well as modelled APU sources.

The modelling has been performed using the meteorological information provided by the CALMET model (section 6.4.1) and the emissions information summarised in section 6.5.3. Predictions were made over a large set of ground-level discrete receptors arranged in the study area (see **Figure 6.1** for extents). Spacing between receptors was set finer in areas closer to sources and coarser in areas further from sources. The receptor spacing and locations have been chosen to provide high resolution model output where needed, such as at the nearest residential areas, while still ensuring acceptable mode run times.

The simulations and methodology for processing model output can be summarised as follows:

- 2005, 2015 and 2035 for with and without NPR scenarios;
- Each runway in 01 and 19 mode;
- For 'no NPR' scenarios, the maxima at each receptor location due to the 01 and 19 simulations have been presented;
- For 'with NPR' scenarios, the maxima at each receptor location due to the 01 parallel, 19 parallel and SODPROPS (Simultaneous Opposite Directions Parallel Runway Operations) simulations have been presented.

[1] *01 and 19 are the runway names and can be thought of as the direction of aircraft movement. For Brisbane Airport, in 01 mode aircraft are traveling from south to north while in 19 mode the direction of travel is from north to south. Runways are named according to the compass bearing of their alignment, rounded to the nearest 10 degrees and without a trailing zero.*

An objective of the dispersion modelling was to capture the maximum envelope of air quality impacts due to aircraft operations.

Emissions from cross runway 14/32 have not been specifically allocated to this location but the total emissions are included in the modelling. In its current form, this runway is mainly used by smaller domestic non-jet aircraft only, which contribute about 13 percent of the total aircraft movement and much less in terms of emissions (refer **Appendix D**, **Table D2a**). Assigning these emissions to the14/32 runway in the modelling would not substantially affect the outcome of the modelling. Runway 14/32 may be used by a small number of the narrow body domestic jet aircraft in the future as an interim measure while the NPR is being built, but to what extent is unknown.

6.7 Assessment of Air Quality Impacts

6.7.1 Preamble

This section provides an assessment of the air quality impacts associated with the project. An objective of the study was to assess the likely change to air quality resulting from the project. The dispersion modelling methodology has been developed to allow the impacts both with and without the project to be compared.

ARUP have developed Significance Criteria to quantify the magnitude of potential impacts from the proposed activities. These criteria are shown in **Table 6.7a**. It should be noted that these are not regulatory criteria, but provide a methodology for ranking the impacts of the Project.

Table 6.7a: Significance Criteria: Air Emissions.

Significance	Significance Criteria: Air Emissions
Major Adverse	Substantial exceedance of air quality goals set by the Queensland EPA and the NEPM to the extent that health and amenity would be significantly affected. No opportunity to effectively reduce emissions or create a buffer zone to provide acceptable levels of impact.
High Adverse	High adverse effect on local air quality, in relation to short term and long term local air quality standards. Predicted air quality impacts including project plus background are close to and in some instances, exceed air quality criteria. Limited opportunity to reduce impacts by other emission control or buffer distances.
Moderate Adverse	Moderate detrimental effect on local air quality, in relation to short term and long term local air quality standards. Predicted pollution levels consume a substantial quantity of the goal for at least one pollutant, for example, over 50 percent of the goal without taking account of background. Some mitigation may be available, for example some design feature which affects buffer distance may help mitigate impacts.
Minor Adverse	Slight detrimental effect on local air quality, in relation to short term and long term local air quality standards. Some increase in pollution levels above existing but relatively small percentage of consumption of the air quality goal. Unlikely to be of importance in the decision making process.
Negligible	No appreciable impact on local air quality. Predicted changes to air quality with the project are below the level of detection.
Slight Beneficial	Slight beneficial effect on local air quality, in relation to short term and long term local air quality standards. Predicted ambient air quality concentrations with the Project result in a slight decrease in pollutant levels compared to the do nothing scenario. Unlikely to be of importance in the decision making process.

Figures 6.7b to **6.7ee** have been created from the model results in order to show the effect of emissions from aircraft operations. Results are grouped by criteria pollutants, averaging time and years. The region defined for these results covers an area 15 km by 18 km. The figures show the predicted pollutant concentrations due to emissions from existing and projected aircraft operations.

It should be noted that predictions for maximum levels (that is, maximum 1 hour, 8 hour and 24 hour averages) do not show the dispersion pattern at any one point in time but show the maximum levels that occurred at each location over the entire meteorological dataset. Annual average prediction plots simply show the average levels for each location.

All dispersion model results directly reflect the modelled aircraft movements for the project. Comments on the model results for each of the criteria pollutants are provided below.

6.7.2 Contribution from Non-Modelled Sources

The 2005 model scenarios are considered to represent the air quality impacts of 'existing' aircraft operations. The model results reflect only the contribution from modelled aircraft emissions sources and does not include the effects of existing background pollution. If all emission sources in the study area can be included in the modelling study then the background can be assumed to be zero and the total concentration would be represented by the model predictions. However, modelling all sources is not possible as there is insufficient detailed information to include all sources. Therefore, accounting for background necessarily involves an approximation of the background on which the modelled concentrations are superimposed.

It has been assumed that the contribution from non-modelled sources is simply the maxima of the measured pollutant concentrations at the closest EPA ambient air quality monitoring sites discussed in section 6.4.5. These sites are Eagle Farm, Pinkenba and Wynnum.

The assumed contributions from non-modelled sources (that is, the assumed worse-case background concentrations) are therefore:

- Maximum 8 hour average CO concentrations of 2.2 ppm or 2.8 mg/m^3
- Maximum 1 hour average NO_2 concentrations of 0.06 ppm or 123 µg/m^3
- Annual average NO_2 concentrations of 0.013 ppm or 27 µg/m^3
- Maximum 24 hour average PM_{10} concentrations of 106 µg/m^3
- Annual average PM_{10} concentrations of 23 µg/m^3.

These levels have been taken to apply at the nearest sensitive receptor locations and are to be added to the respective modelled ground level concentrations as indicated in **Figures 6.7b** to **6.7ee**. This approach involves some element of double counting since the monitoring data will contain a contribution from Airport operations that have been explicitly modelled. The use of maximum measured pollutant concentrations is a conservative approach.

6.7.3 Model Predictions at Sensitive Locations

Dispersion model results for six selected locations have been obtained. These locations represent the nearest residential areas to the Airport as well as the three closest EPA monitoring sites. **Figure 6.7a** shows the location of the receptors referred to as Eagle Farm, Hendra, Nudgee, Pinkenba, Wynnum and Nudgee Beach.

Table 6.7b provides the dispersion model results for each of the selected receptor locations. Modelled pollutants include CO, NO_X (and NO_2), SO_2, TSP and HC. Scenarios include 2005, 2015 and 2035 for NPR and no NPR cases.

The model results in **Table 6.7b** show the concentrations due to the major pollutant sources at the Airport and, as discussed in section 6.7.1, existing levels from non-modelled sources need to be considered.

Table 6.7b: Dispersion Model Predictions at Closest Residential Areas and Selected Locations.

Pollutant	CO	NO_x	NO_2	NO_x	SO_2	SO_2	SO_2	TSP (as PM_{10})	TSP (as PM_{10})	HC	HC	HC
Averaging period	Maximum 8 hour	Maximum 1 hour	Maximum 1 hour	Annual	Maximum 1 hour	Maximum 24 hour	Annual	Maximum 24 hour	Annual	Maximum 1 hour	Maximum 24 hour	Annual
Units	mg/m^3	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
Goal	10	-	246	60	570	113	60	50	50	-	-	-
Assumed background	2.8	-	123	27	-	-	-	106	23	-	-	
Eagle Farm												
2005 existing	0.01	23	5	0.4	1.4	0.2	0.03	0.1	0.01	4	0.4	0.05
2015 no NPR	0.01	38	8	0.7	2.3	0.3	0.04	0.2	0.02	6	0.7	0.08
2015 NPR	0.01	25	5	0.6	1.8	0.2	0.04	0.1	0.02	5	0.5	0.08
2035 no NPR	0.02	40	8	0.7	2.5	0.3	0.04	0.2	0.02	7	0.7	0.08
2035 NPR	0.02	48	10	1.0	3.1	0.4	0.06	0.2	0.03	9	1.0	0.13
Hendra												
2005 existing	0.01	35	7	0.3	2.7	0.2	0.02	0.1	0.01	8	0.5	0.03
2015 no NPR	0.02	55	11	0.4	4.1	0.3	0.03	0.1	0.01	12	0.8	0.05
2015 NPR	0.02	41	8	0.5	3.2	0.2	0.03	0.1	0.01	9	0.7	0.05
2035 no NPR	0.02	53	11	0.4	4.1	0.3	0.03	0.2	0.01	12	0.8	0.06
2035 NPR	0.03	60	12	0.8	4.9	0.4	0.05	0.2	0.02	14	1.0	0.09
Nudgee												
2005 existing	0.05	138	28	0.5	9.9	0.7	0.03	0.4	0.02	31	2.2	0.08
2015 no NPR	0.07	219	44	0.8	14.9	1.1	0.05	0.6	0.03	47	3.3	0.13
2015 NPR	0.05	148	30	1.0	9.4	0.7	0.06	0.4	0.03	31	2.3	0.14
2035 no NPR	0.08	217	43	0.9	15.6	1.1	0.06	0.7	0.03	50	3.6	0.14
2035 NPR	0.10	248	50	1.7	17.5	1.3	0.10	0.8	0.05	58	4.3	0.25
Pinkenba												
2005 existing	0.03	60	12	0.9	5.9	0.6	0.05	0.3	0.03	18	1.6	0.13
2015 no NPR	0.05	108	22	1.5	9.6	0.9	0.09	0.5	0.05	30	2.7	0.20
2015 NPR	0.05	75	15	1.0	7.6	0.9	0.07	0.5	0.04	23	2.5	0.17
2035 no NPR	0.05	115	23	1.6	10.9	1.0	0.09	0.6	0.05	33	3.0	0.22
2035 NPR	0.06	131	26	1.8	10.9	1.4	0.12	0.8	0.06	32	3.9	0.29

Pollutant	CO	NO_x	NO_2	NO_x	SO_2	SO_2	SO_2	TSP (as PM_{10})	TSP (as PM_{10})	HC	HC	HC
Averaging period	Maximum 8 hour	Maximum 1 hour	Maximum 1 hour	Annual	Maximum 1 hour	Maximum 24 hour	Annual	Maximum 24 hour	Annual	Maximum 1 hour	Maximum 24 hour	Annual
Units	mg/m^3	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
Goal	10	-	246	60	570	113	60	50	50	-	-	-
Assumed background	2.8	-	123	27	-	-	-	106	23	-	-	
Wynnum												
2005 existing	0.01	21	4	0.2	1.9	0.2	0.01	0.1	0.01	6	0.5	0.03
2015 no NPR	0.02	34	7	0.3	2.8	0.3	0.02	0.1	0.01	9	0.7	0.06
2015 NPR	0.02	32	6	0.3	2.9	0.3	0.02	0.1	0.01	9	0.7	0.05
2035 no NPR	0.02	37	7	0.4	3.0	0.3	0.03	0.2	0.01	9	0.8	0.06
2035 NPR	0.03	63	13	0.6	4.3	0.4	0.04	0.2	0.02	13	1.2	0.09
Nudgee Beach												
2005 Existing	0.02	37	7	0.4	2.8	0.2	0.03	0.1	0.02	9	0.7	0.08
2015 no NPR	0.03	58	12	0.7	4.6	0.4	0.05	0.2	0.03	13	1.1	0.14
2015 NPR	0.04	73	15	1.2	5.1	0.6	0.08	0.4	0.04	16	1.8	0.22
2035 no NPR	0.03	65	13	0.8	5.1	0.4	0.05	0.2	0.03	14	1.2	0.15
2035 NPR	0.07	136	27	2.2	9.2	1.0	0.14	0.6	0.08	28	3.0	0.39

A number of observations were made from the dispersion model results. These include:

- Overall, pollutant levels in all cases were below the relevant ambient air quality goal;
- Of all the pollutants modelled, the predicted NO_2 concentrations were the most considerable relative to the respective air quality goal but still below the goal;
- Addition of predicted maximum NO_2 concentrations for any operating scenario to the maximum background levels results in levels that are below the 246 µg/m^3 goal for all receptor locations;
- The maximum predicted 1 hour, 8 hour and 24 hour pollutant concentrations (for NO_2, CO, SO_2, HC and PM_{10}) for the 2015 future scenarios are typically lower with the NPR than without NPR at the receptors around the Airport, although the differences are considered to be small. In 2035, the model predictions are marginally higher with the NPR;
- The maximum short term (1 hour) predicted concentrations at the Nudgee receptor, to the west of the Airport, are generally slightly higher than at the other locations for most scenarios with or without the NPR;
- The predicted annual average concentrations (for NO_X, SO_2 and PM_{10}) with and without the NPR for future scenarios in 2015 and 2035 are essentially the same. On the basis of air traffic movements provided, the annual average predictions would overestimate concentrations by approximately 10 percent as the modelling assumed that air traffic on a typical busy day would persist throughout the year;
- Predictions for all future scenarios at each receptor location are generally higher than for existing operations. This was expected with the increase in aircraft movements. However, it should be noted that the emission estimates for future scenarios only consider the change in aircraft movements and not any improvements to aircraft technology and resultant emissions that can be expected between now and 2015 or 2035 (refer section 6.5.5).
- Even though there is an increase in aircraft movements in 2035 with the NPR, the difference from the no NPR scenario is generally predicted to be either slightly more or slightly across the receptors (e.g. less than 5 percent and 2 percent of ambient air quality goal for maximum 1 hour NO_2 and annual average NO_2 respectively). The reason for this is the higher NPR emissions appear to be offset by the distribution of emissions sources across the two runways.

It can be seen from **Table 6.7b** that, for short term averaging periods (1 hour maximum) in 2015, most of the selected receptor locations are predicted to experience a slight decrease in pollutant concentrations with the NPR. This does not suggest that all off-site locations would expect some decreases in concentrations, as will be seen in the contour plots discussed in the next three sections, however for the selected locations the dispersion model has indicated some minor change.

The predicted decreases are considered to be small and, when added to existing concentrations in the area, the differences would be difficult to measure. Annual average concentrations are predicted to increase slightly for the NPR case over the no NPR case due to increased emissions from the Airport but again the differences are considered to be small. Also, as discussed in section 6.5.2, annual aircraft movements and consequently annual emissions, will have been overestimated by approximately 10 percent. Annual average predictions should therefore be considered as conservative estimates.

Contour plots have been created for the criteria pollutants (that is CO, NO_X and PM_{10}) and these are discussed below.

6.7.4 Carbon Monoxide

The simulations of CO concentrations in the study area are shown in **Figures 6.7b** to **6.7f**.

The first figure in the series of CO plots (**Figure 6.7b**) shows predictions for 2005. Following 2005 are the 2015 and 2035 simulations which include the NPR and no NPR cases. This grouping pattern is maintained for all pollutants.

The following observations were made from the review of the CO model predictions:

- The existing contribution of aircraft emissions to maximum 8 hour average CO concentrations at the nearest residential areas (Nudgee, to the north-west of the Airport) is predicted to be of the order of 0.05 mg/m^3 or less.
- Off-site CO concentrations due to aircraft operations are predicted to increase for future scenarios (without accounting for emission technology improvements).
- The difference between with and without NPR scenarios at off-site locations is predicted to be negligible and the difference would be difficult to detect by current air quality monitoring instrumentation standards.
- Ground-level off-site CO concentrations would be expected to be well below the 10 mg/m^3 air quality goal for all existing and future scenarios, even when considering background levels.

6.7.5 Nitrogen Dioxide

Predictions of total NO_X and NO_2 concentrations (**Figures 6.7g** to **6.7u**) in the study area for existing and future years present a similar story to the CO predictions. For predictions of maximum 1 hour average NO_2 concentrations it has been assumed that 20 percent of the NO_X is NO_2 (see section 6.4.5.7)

The following observations were made from the review of the NO_X and NO_2 model predictions:

- Maximum 1 hour average off-site NO_2 concentrations at ground-level would be expected to be below the 246 µg/m^3 air quality goal, even when considering background levels, for all existing and future with and without NPR scenarios.
- Comparing the with and without NPR scenarios for 2015, off-site maximum 1 hour average NO_2 concentrations due to aircraft operations are predicted to be slightly lower to the southwest to southeast and slightly higher to the northwest.
- The existing contribution of aircraft emissions to maximum 1 hour average NO_2 concentrations at the nearest residential areas (Nudgee, to the west of the Airport) is predicted to be of the order of 25 µg/m^3.
- Off-site maximum 1 hour average NO_2 concentrations due to aircraft operations are predicted to increase for future scenarios with or without the NPR as a result of increase in aircraft movements – up to about 50 µg/m^3 with the NPR in 2035 (without accounting for emission technology improvements).
- The NPR case is predicted to slightly increase the spread of NO_X concentrations (over the 'no NPR' case) at off-site locations.
- Annual average off-site NO_2 concentrations (assuming that 100 percent of the NO_X is NO_2 for annual averages) are predicted to be well below the 60 µg/m^3 goal in all modelled scenarios.

6.7.6 Particulate Matter (TSP as PM_{10})

Figures 6.7v to **6.7ee** present the dispersion modelling results for TSP. Emissions of TSP from aircraft operations will be predominantly PM_{10} and, for assessment purposes, 100 percent of the TSP is taken to be PM_{10}. The most stringent PM_{10} air quality goals from **Table 6.3a** are 50 µg/m^3 (with 5 exceedances permitted annually) and 30 µg/m^3 for maximum 24 hour and annual averages respectively. Review of the Brisbane air quality monitoring data showed that existing maximum 24 hour background PM_{10} levels can exceed 50 µg/m^3 (up to 106 µg/m^3). The major sources contributing to these levels are bushfires and dust storms.

The dispersion model predictions for PM_{10} are summarised below:

- The existing contribution of aircraft emissions to maximum 24 hour average PM_{10} concentrations at the nearest residential areas is predicted to be of the order of 0.5 µg/m^3 or less.

- Off-site 24 hour average PM_{10} concentrations due to aircraft operations are predicted to increase to about 1 µg/m^3 for future scenarios with or without the NPR due to the increase in aircraft movements.
- PM_{10} emissions from aircraft operations would be considered a very small source of particulates, compared with other sources, and are unlikely to be the cause of exceedances of the 24 hour average PM_{10} goal with or without the NPR.
- The difference between with and without NPR scenarios at off-site locations is considered to be negligible and any difference would be difficult to detect by current air quality monitoring instrumentation standards.
- Predicted current and future off-site 24 hour average and annual average PM_{10} concentrations would be expected to be well below the 50 and 30 µg/m^3 air quality goals, even when considering background levels.

6.8 Other Issues

The foregoing assessment has considered criteria pollutants emitted directly from the aircraft and the major effects on air quality due to the NPR project. Other, potentially equally important, issues are discussed in this section.

6.8.1 VOCs

Total VOC concentrations have been derived from the HC predictions using the following equation (NPI, 2003).

$E_{VOC} = E_{HC} \times 1.0927$

where

E_{VOC} = Emissions of total volatile organic compounds

E_{HC} = Emissions of hydrocarbons

To obtain predictions of selected air toxics the VOC speciation for exhaust emissions from aircraft, shown in **Table 6.8a**, was used.

Table 6.8a: VOC Speciation for Exhaust Emissions From Aircraft.

NPI substance	Weight fraction for commercial aircraft
Benzene	0.0194
Formaldehyde	0.1501
Toluene	0.0052
Xylenes	0.0048

Source: NPI, 2003

Table 6.8b shows the resultant dispersion model predictions at selected locations for Benzene, Formaldehyde, Toluene and Xylenes. All predictions are well below the respective advisory air quality goals for existing and future scenarios.

Table 6.8b: Dispersion Model Predictions for VOCs.

Pollutant	Benzene	Formaldehyde	Toluene	Toluene	Xylenes	Xylenes
Averaging period	Annual	Maximum 24 hour	Maximum 24 hour	Annual	Maximum 24 hour	Annual
Units	ppm	ppm	ppm	ppm	ppm	ppm
Goal	0.003	0.04	1	0.1	0.25	0.2
Eagle Farm						
2005	3.0E-07	5.2E-05	5.9E-07	6.8E-08	4.8E-07	5.5E-08
2015 no NPR	4.7E-07	8.1E-05	9.3E-07	1.1E-07	7.5E-07	8.7E-08
2015 NPR	4.6E-07	6.6E-05	7.6E-07	1.0E-07	6.1E-07	8.4E-08
2035 no NPR	5.1E-07	9.0E-05	1.0E-06	1.1E-07	8.3E-07	9.3E-08
2035 NPR	7.9E-07	1.2E-04	1.4E-06	1.8E-07	1.1E-06	1.5E-07
Hendra						
2005	2.0E-07	6.3E-05	7.2E-07	4.5E-08	5.8E-07	3.7E-08
2015 no NPR	3.2E-07	9.3E-05	1.1E-06	7.2E-08	8.6E-07	5.8E-08
2015 NPR	3.2E-07	8.0E-05	9.1E-07	7.2E-08	7.4E-07	5.8E-08
2035 no NPR	3.4E-07	9.5E-05	1.1E-06	7.7E-08	8.8E-07	6.2E-08
2035 NPR	5.6E-07	1.3E-04	1.4E-06	1.3E-07	1.2E-06	1.0E-07
Nudgee						
2005	5.1E-07	2.7E-04	3.1E-06	1.2E-07	2.5E-06	9.4E-08
2015 no NPR	8.1E-07	4.0E-04	4.6E-06	1.8E-07	3.7E-06	1.5E-07
2015 NPR	8.4E-07	2.8E-04	3.2E-06	1.9E-07	2.6E-06	1.5E-07
2035 no NPR	8.7E-07	4.3E-04	4.9E-06	2.0E-07	4.0E-06	1.6E-07
2035 NPR	1.5E-06	5.2E-04	5.9E-06	3.4E-07	4.8E-06	2.8E-07
Pinkenba						
2005	7.6E-07	2.0E-04	2.2E-06	1.7E-07	1.8E-06	1.4E-07
2015 no NPR	1.2E-06	3.3E-04	3.8E-06	2.8E-07	3.0E-06	2.3E-07
2015 NPR	1.0E-06	3.0E-04	3.4E-06	2.3E-07	2.8E-06	1.9E-07
2035 no NPR	1.3E-06	3.6E-04	4.1E-06	3.0E-07	3.3E-06	2.4E-07
2035 NPR	1.8E-06	4.7E-04	5.4E-06	4.1E-07	4.4E-06	3.3E-07
Wynnum						
2005	2.1E-07	5.7E-05	6.5E-07	4.8E-08	5.3E-07	3.9E-08
2015 no NPR	3.4E-07	9.0E-05	1.0E-06	7.8E-08	8.3E-07	6.3E-08
2015 NPR	3.0E-07	8.8E-05	1.0E-06	6.8E-08	8.1E-07	5.5E-08
2035 no NPR	3.8E-07	1.0E-04	1.1E-06	8.6E-08	9.2E-07	6.9E-08
2035 NPR	5.3E-07	1.5E-04	1.7E-06	1.2E-07	1.4E-06	9.7E-08
Nudgee Beach						
2005	5.2E-07	8.9E-05	1.0E-06	1.2E-07	8.2E-07	9.5E-08
2015 no NPR	8.3E-07	1.4E-04	1.6E-06	1.9E-07	1.3E-06	1.5E-07
2015 NPR	1.3E-06	2.2E-04	2.5E-06	3.0E-07	2.0E-06	2.5E-07
2035 no NPR	9.0E-07	1.5E-04	1.7E-06	2.0E-07	1.3E-06	1.6E-07
2035 NPR	2.4E-06	3.7E-04	4.2E-06	5.4E-07	3.4E-06	4.3E-07

6.8.2 Odour

Odour impacts relate predominantly to emissions of hydrocarbons from the aircraft. As can be seen in **Table 6.8b**, the predicted concentrations due to aircraft operations do not change substantially with the NPR. Therefore, odour impacts are unlikely to change and at present they are not substantial.

6.8.3 Ozone

As discussed, ozone is not a primary emission from aircraft, but is formed in the atmosphere in a complex series of chemical reactions. Controlling ozone concentrations in an airshed is a challenging task, particularly when a large fraction of the precursor components, namely oxides of nitrogen and reactive hydrocarbons are not from regulated point sources.

Changes to precursor compound emissions resulting from the NPR project represent a very small fraction of the total emissions into the airshed. While airshed models can predict photochemical smog formation arising from airshed emissions, this level of change would not lead to any significant changes in predicted ozone formation.

6.9 Conclusions

This report has assessed the effects on air quality of the proposed NPR at Brisbane Airport. Dispersion modelling has been used as the primary tool to quantitatively assess pollutant concentrations in the study area.

The conclusions of the study can be summarised as follows:

- Compliance with air quality goals at the nearest sensitive receptors is anticipated for all future operational scenarios with or without the NPR.
- The With and Without NPR cases are predicted to be very similar. That is, local and regional air quality with the NPR may be expected to be similar to air quality without the NPR.
- Of all the pollutants modelled, the predicted NO_2 concentrations were most substantial relative to the respective air quality goal but still well below the goal.
- Predicted maximum 1 hour NO_2, SO_2 and HC concentrations in 2015 were typically marginally lower at residential areas off-site with the NPR than without the NPR as a result of the source emission being distributed across two runways. In 2035, the predictions were marginally higher with the NPR.
- Off-site pollutant concentrations due to aircraft operations for future scenarios are predicted to be higher than for existing operations, with or without the NPR. However, there is likely to be improvements to aircraft technology and emissions that may offset any increased impacts. Recent technology improvements in new Boeing and Airbus aircraft (e.g. B787 and A380) have emission reductions of 20 percent to 30 percent.
- Particulate matter concentrations arising from non-airport related emissions, such as bushfires, may continue to result in elevated levels on occasions.

In summary, Airport operations are not a major source of local air pollution in a city such as Brisbane, where air quality is largely dominated by motor vehicle emissions. The NPR would not substantially change the air quality in the environs of the Airport and the differences with or without the NPR are considered to be small.

Based on the above assessment, a summary of potential impacts is provided in the following matrix.

Table 6.9: Air Quality Assessment Summary Matrix.

EIS Area: Air Quality Feature / Description	Current Value + Substitutable Y:N	Description of Impact			Additional Compensation (Beyond Standard Practice)	Residual Impact
		Impact	Mitigation Inherent in Design/ Standard Practice Amelioration	Significance Criteria		
Ground-level air quality	Measurement data suggests acceptable air quality at off-site sensitive receptor locations. Not substitutable	Potential minor increases to offsite air pollutant concentrations due to aircraft emissions.	Expected improvements to future aircraft emissions.	Minor to Negligible -ve, D, C, ST	Nil	Minor to Negligible -ve, D, C, ST

Key:
Significance Criteria: Major; High; Moderate; Minor; Negligible
+ve positive; -ve negative
D – direct; I – indirect
C – cumulative; P – permanent; T – temporary
ST – short term; MT – medium term; LT long term

REFERENCES

Bureau of Meteorology (2004)
Climate averages from the Bureau of Meteorology website, www.bom.gov.au

DEC (2005)
"Approved Methods for the Modelling and Assessment of Air Pollutants in NSW", August 2005.

Department of Environment (1997)
"South East Queensland regional air quality strategy: movement of air pollutants in the south-east Queensland airshed" Technical report, August 1997, ISSN 1037-4671

Dockery D W, Pope C A, Xiping Xu, Spengler J D, Ware J H, Fay M E, Ferris B G and Speizer F E (1993)
"An association between air pollution and mortality in six US cities" The New England Journal of Medicine, Volume 329, Number 24,1753-1759.

EPA (1994)
"Environmental Protection Act 1994", prepared the Office of the Queensland Parliamentary Counsel, reprint No. 5C.

EPA (1997)
"Environmental Protection (Air) Policy 1997, prepared the Office of the Queensland Parliamentary Counsel, reprint No. 2A.

EPA & BCC (2004)
"Air Emissions Inventory: South East Queensland region". Prepared by a partnership between Brisbane City Council and the Queensland Government Environmental Protection Agency, 2004.

EPA (2005)
Monthly air quality bulletins. www.epa.qld.gov.au

Hawas O, Hawker D, Chan A, Cohen D, Christensen E, Golding G, Vowles P (2002)
"Characterisation and identification of sources of Volatile Organic Compounds in an industrial area in Brisbane" proceedings of 16th International Clean Air & Environment Conference, Christchurch NZ August 2002.

Health Effects Institute (2003)
"Revised analyses of time-series studies of air pollution and health" Special Report May 2003

Holmes Air Sciences (1997)
"RTA air quality monitoring program", prepared for the NSW Roads and Traffic Authority, January 1997.

Holmes Air Sciences (2003)
"Air Emissions Assessment: Sydney Airport Master Plan".

Holmes Air Sciences (2004)
"Air Quality Impact Assessment: NSBT", 2004.

Hurley, P J (2002)
"The Air Pollution Model (TAPM) Version 2 : User Manual", CSIRO Atmospheric Research Internal Paper No. 25, April 2002

NEPC (1998)
"National Environment Protection Measure", prepared by the National Environment Protection Council, June 1998."

NEPC (2004)
"National Environment Protection (Air Toxics) Measure", prepared by the National Environment Protection Council, April 2004.

NPI (2001)
"Emissions Estimation Technique Manual for Airports". Version 1.1. National Pollution Inventory. ISBN 06 4254 6878

NPI (2002)
"Emissions Estimation Technique Manual for Fuel and Organic Liquid Storage". Version 2.1. National Pollution Inventory. ISBN 06 4254 8064.

NPI (2003)
"Emissions estimation technique manual for Aggregated Emissions from Aircraft", 25 March 2003 – Version 2.2.

Pacific Power (1998)
"Illawarra Ecoenergy Park: Combined Cycle Gas Turbine Power Station", Environmental Impact Statement

PPK (1999)
"Second Sydney Airport", Supplement to Draft Environmental Impact Statement

Puri, K., Dietachmayer, G. S., Mills, G. A., Davidson, N. E., Bowen, R. A., and Logan, L. W (1997)
"The BMRC Limited Area Prediction System, LAPS". Aust. Met. Mag., 47, 203-223

US EPA (1992)
"Procedures for emission inventory preparation. Volume IV: Mobile Sources". EPA420-R-92-009. December 1992.

US EPA (2004)
Website for CALPUFF model user guides: http://www.epa.gov/scram001

Figure 6.1: *Brisbane Airport and Surrounds.*

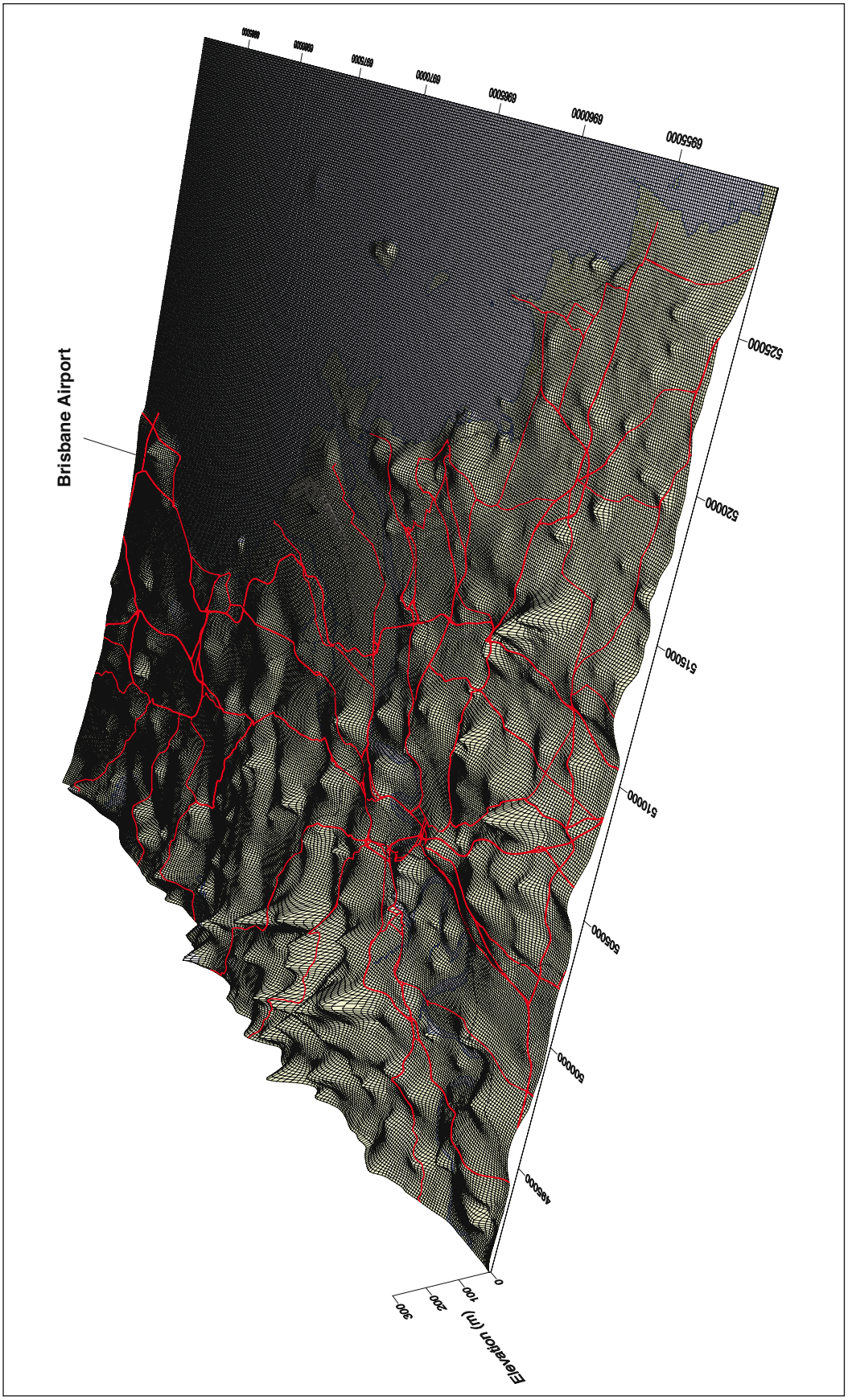


Figure 6.2a: *Pseudo Three-dimensional Representation of the Study Area.*

Figure 6.2b: *Layout of Proposed New Parallel Runway.*

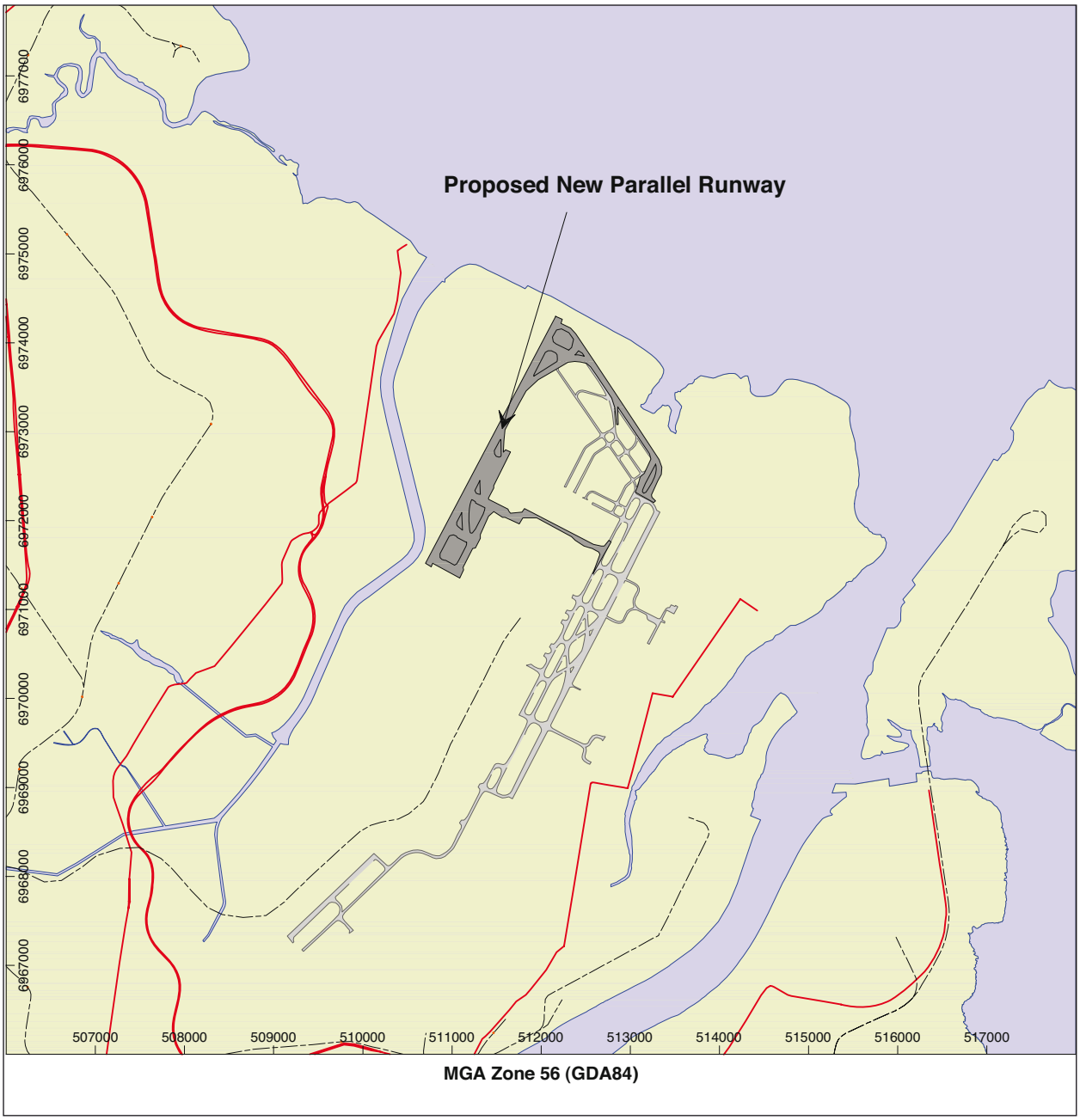


Figure 6.4a: *CALMET Model Grid, Meteorological Stations and Terrain Information.*

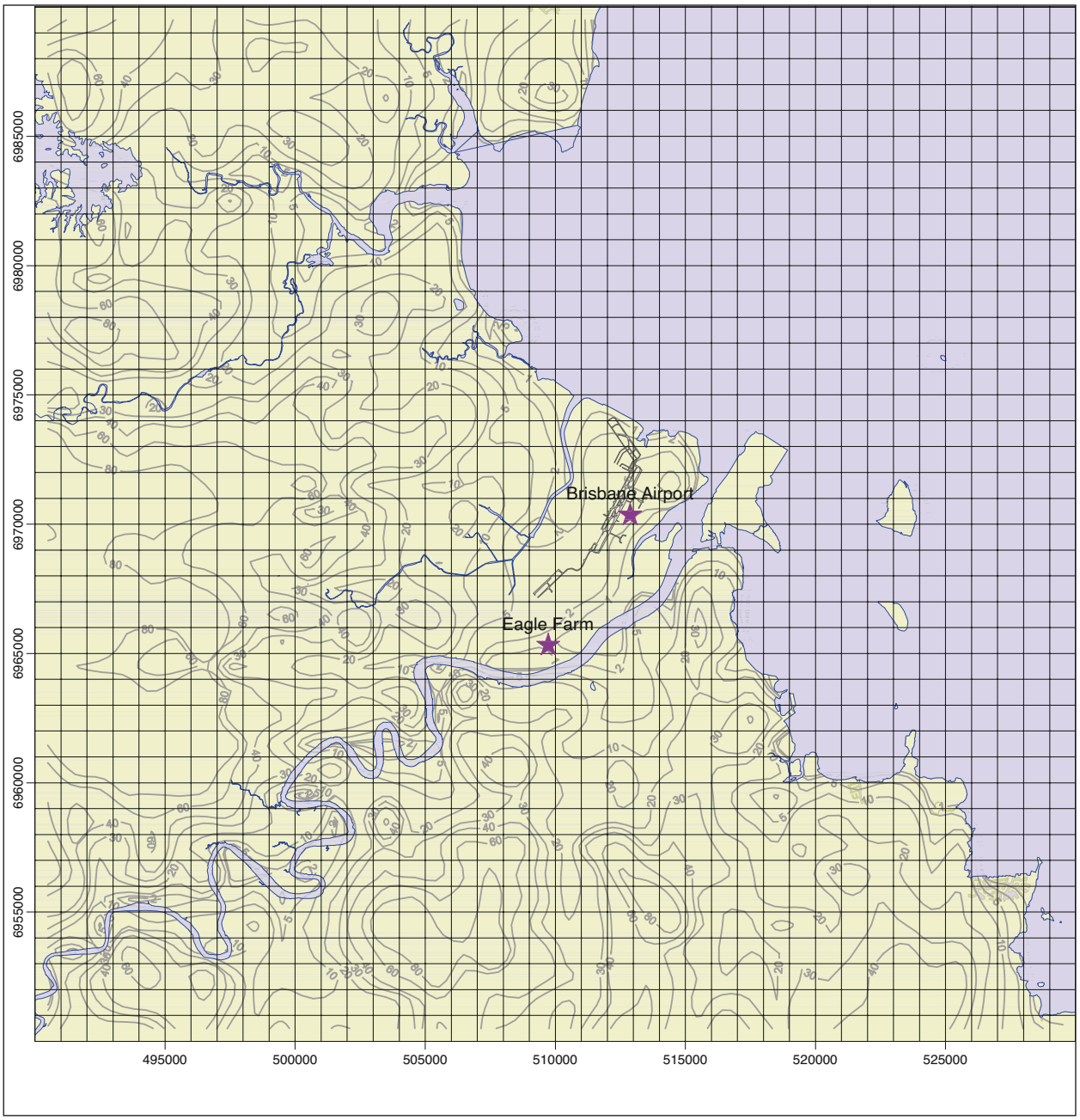


Figure 6.4b: *Annual and Seasonal Windroses for Brisbane Airport (BoM 2004 Data).*

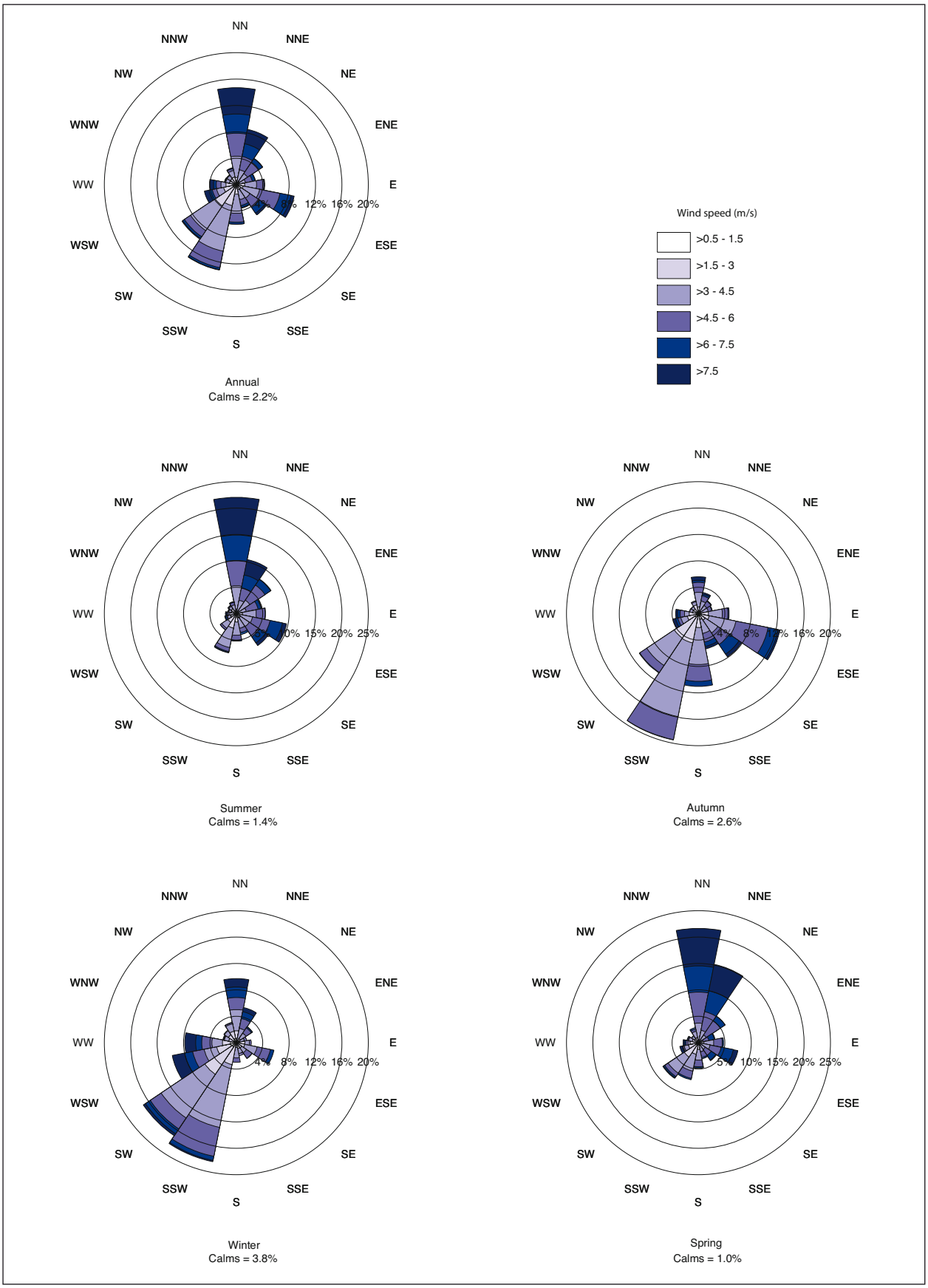


Figure 6.4c: *Brisbane Airport Wind Patterns by Time of Day (BoM 2004 Data).*

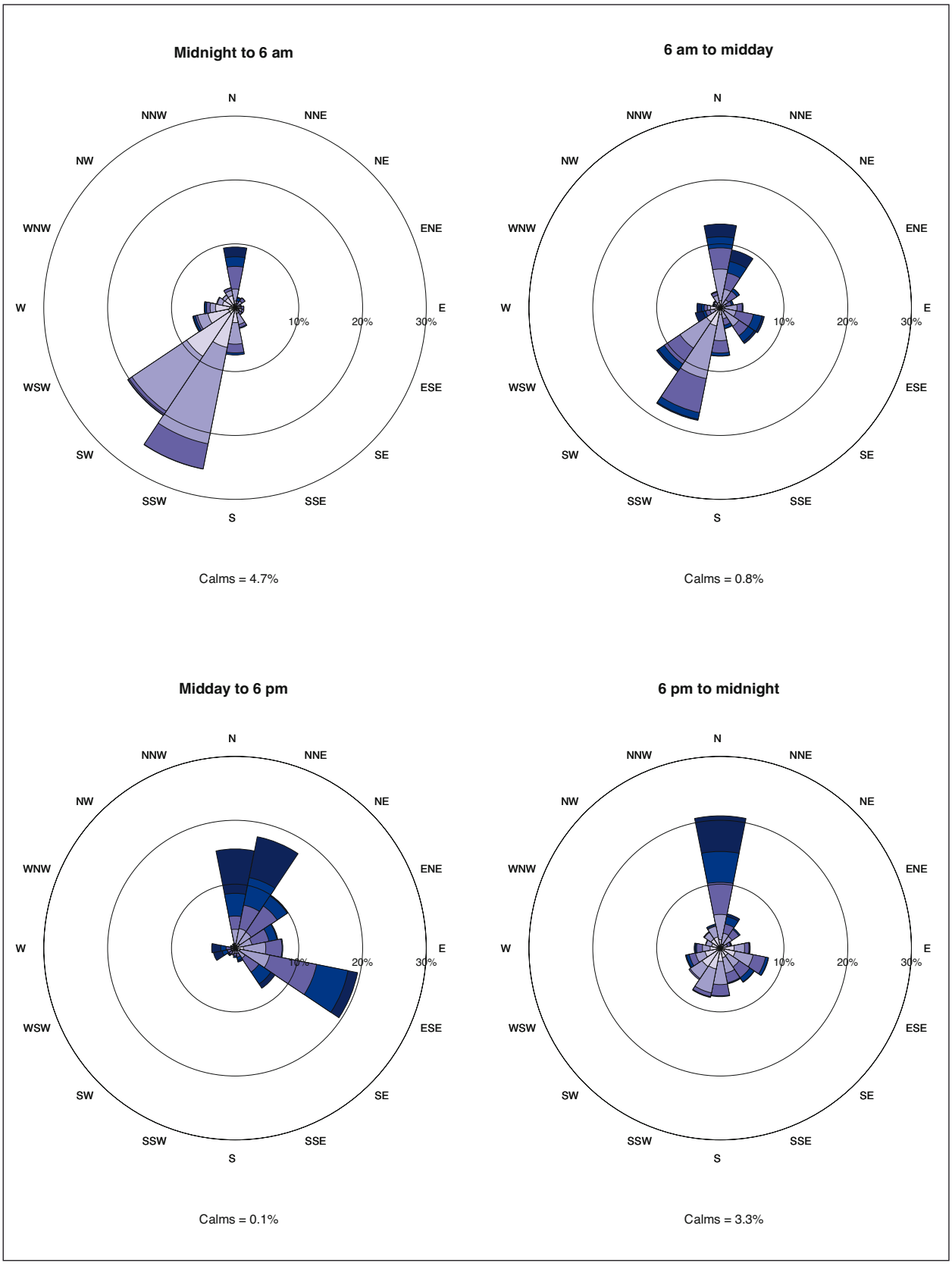


Figure 6.4d: *Annual and Seasonal Windroses for Eagle Farm (EPA 2004 Data).*

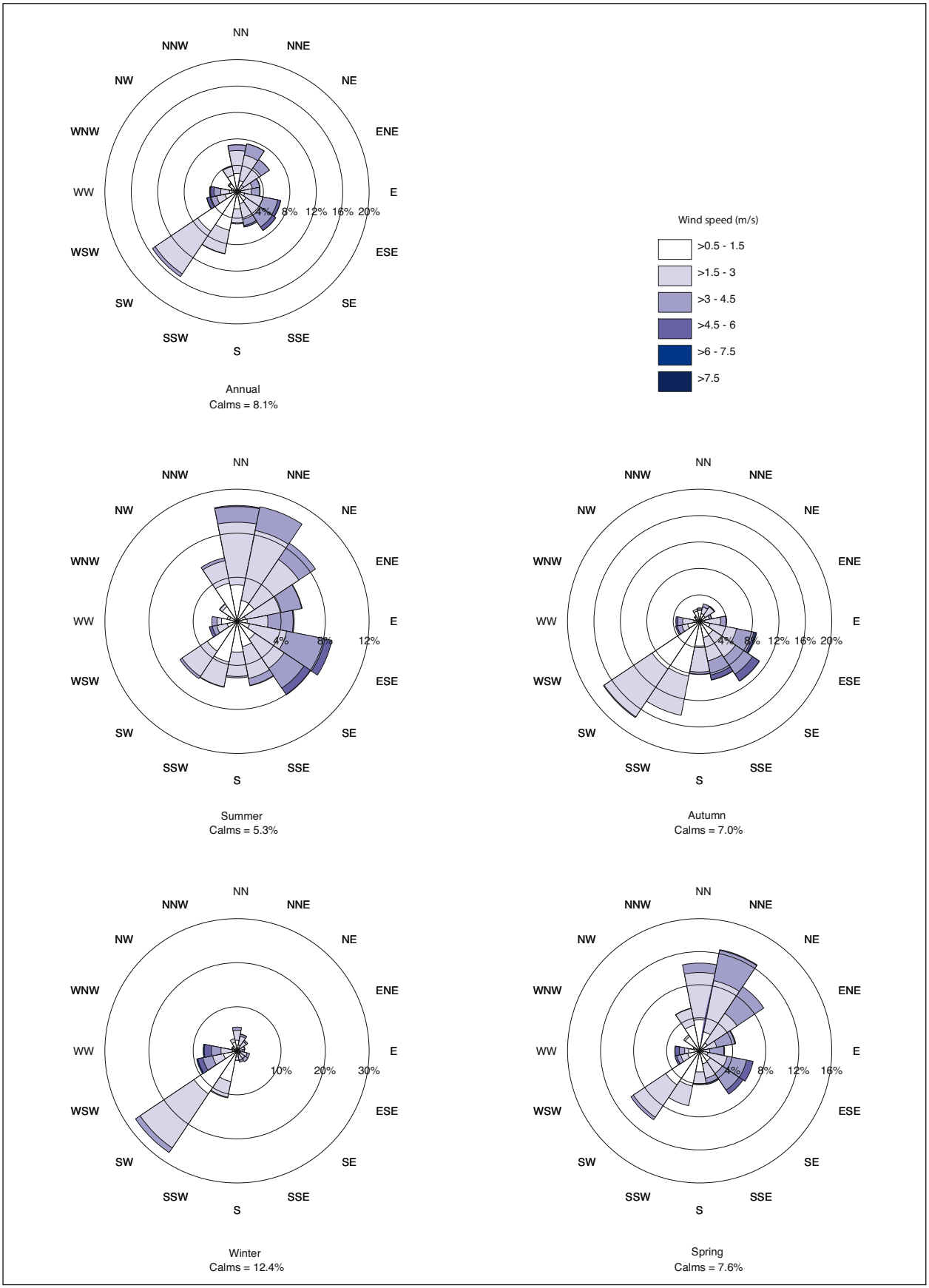


Figure 6.4e: *Ground-level Wind Patterns in the Study Area as Simulated by CALMET (1-Jul-2004 Hour 3).*

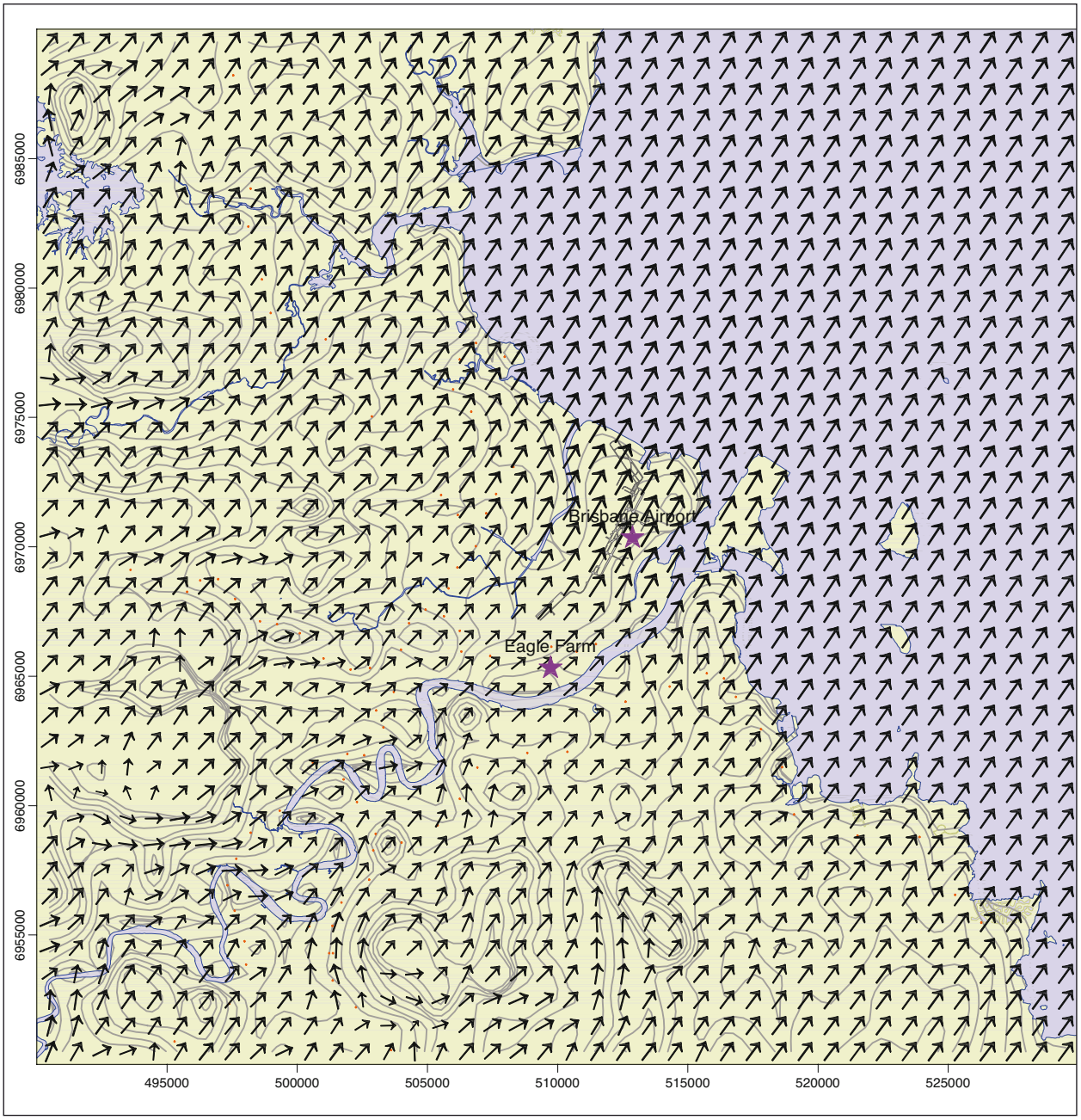


Figure 6.4f: *Climate Averages of Temperature and Rainfall at Brisbane Airport.*

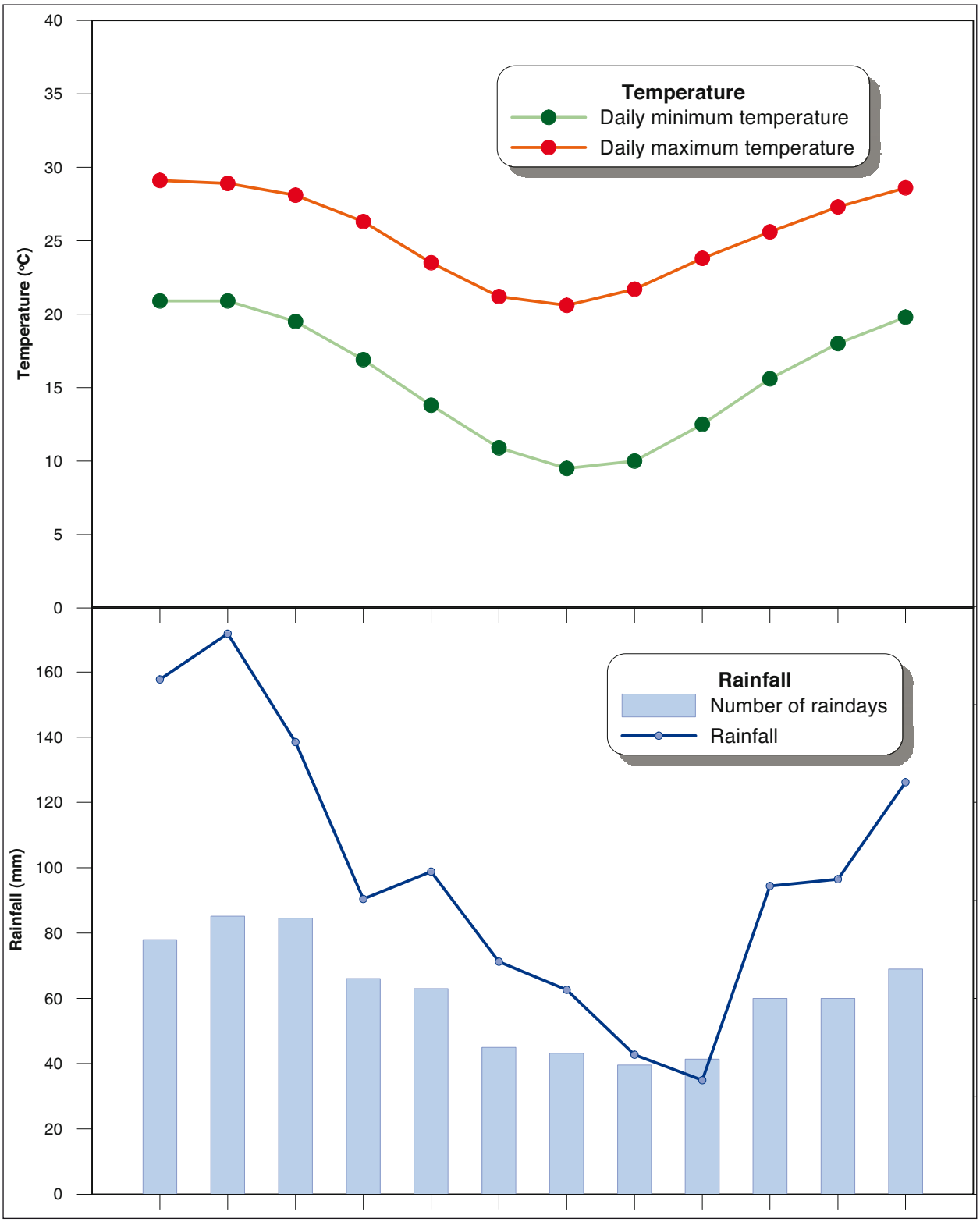


Figure 6.4g: *EPA Air Quality Monitoring Sites in South East Queensland.*

Figure 6.4h: *General Pattern of Land and Sea-breezes Around Brisbane.*

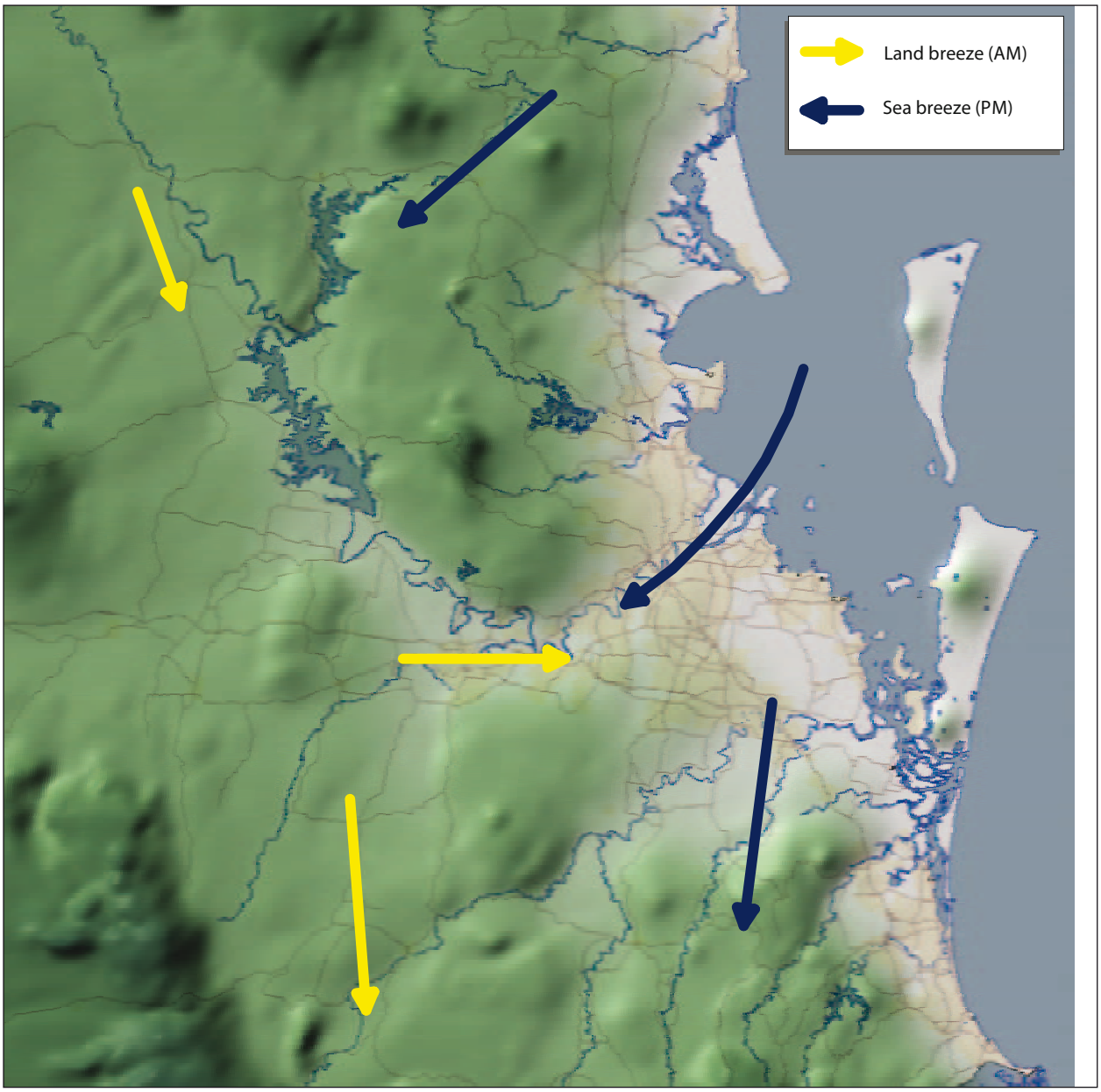


Figure 6.4i: *Long Term Trends of CO, NO_2, PM_{10} and SO_2 in the Study Area.*

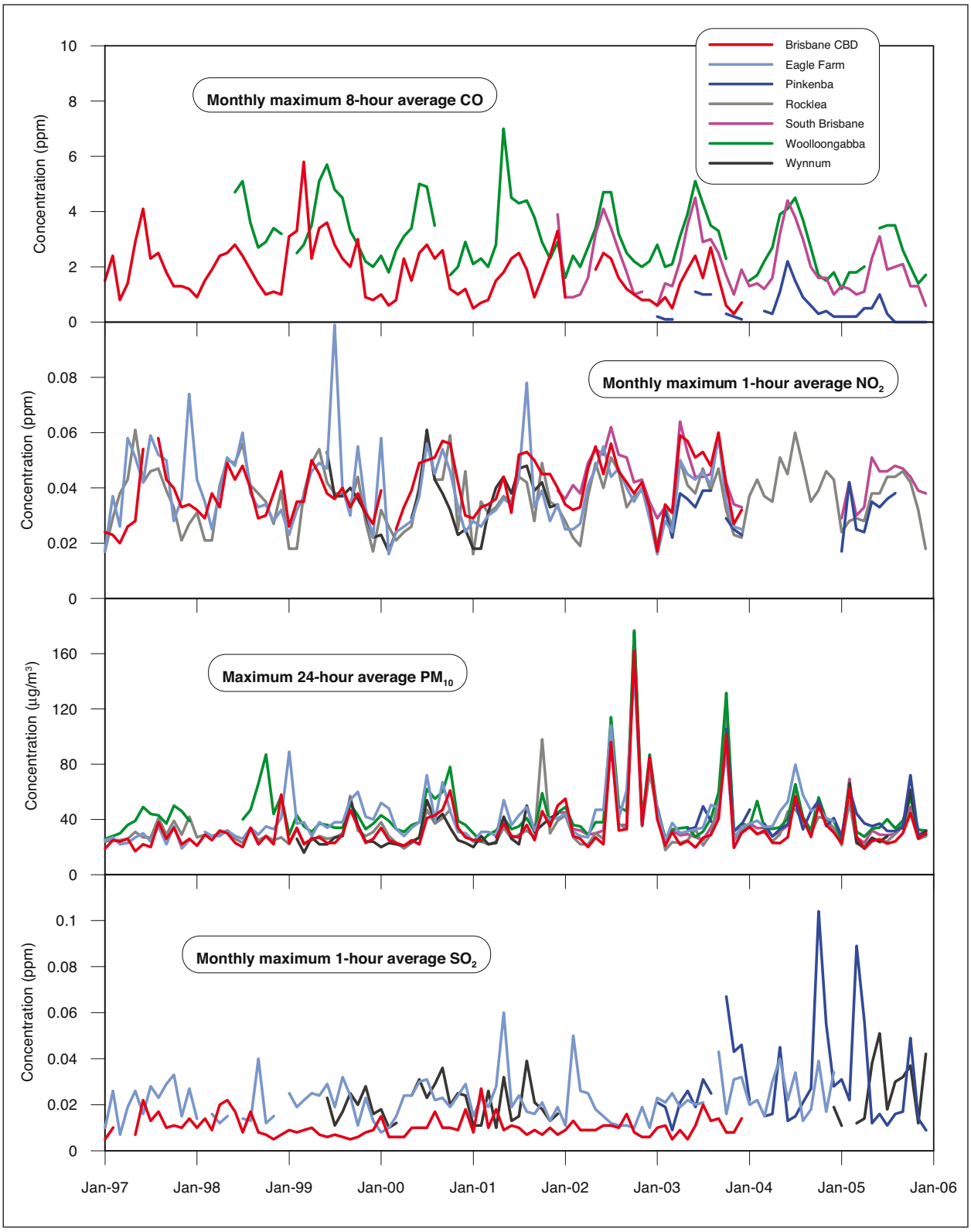
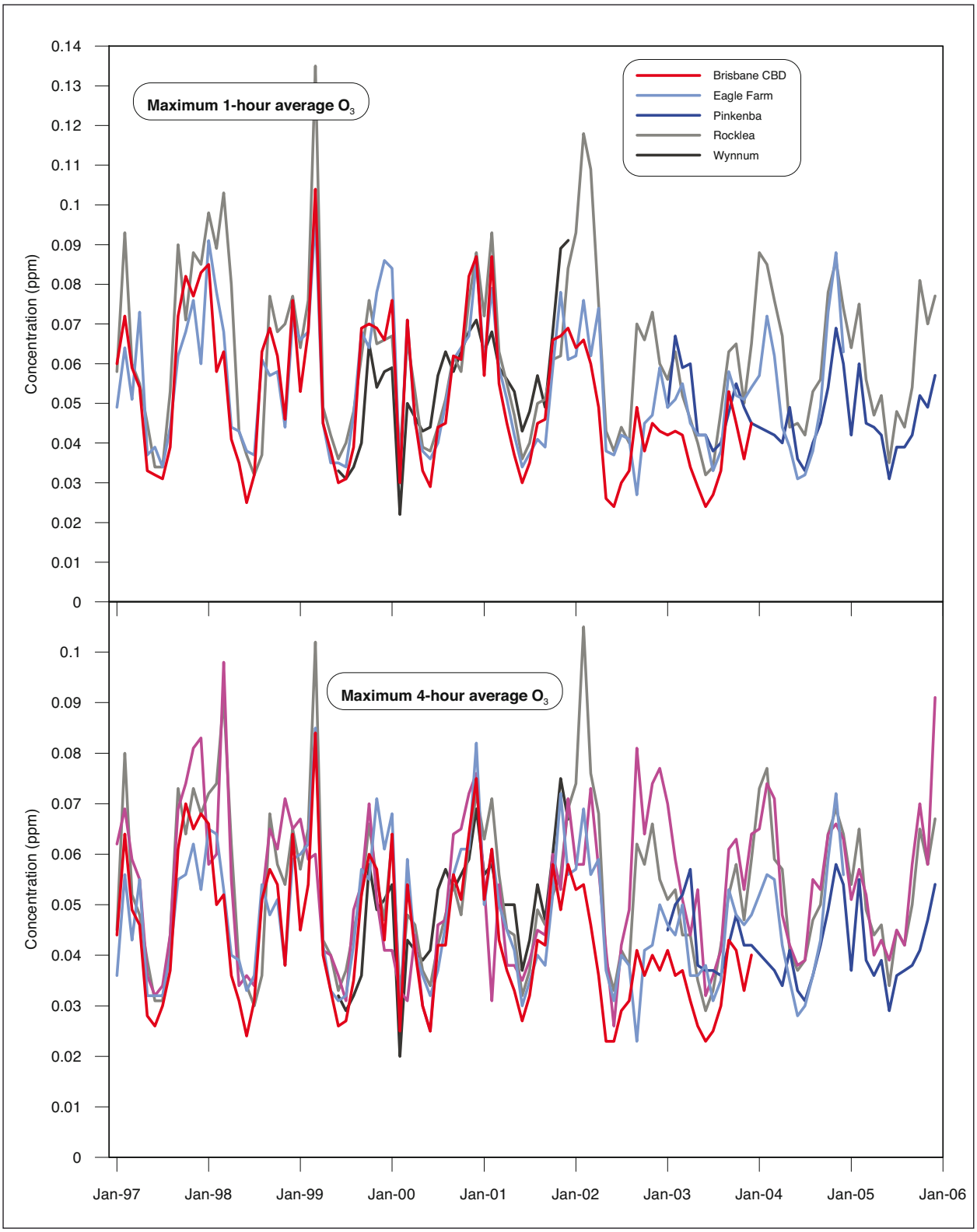


Figure 6.4j: *Long Term Trends of Ozone in the Study Area.*



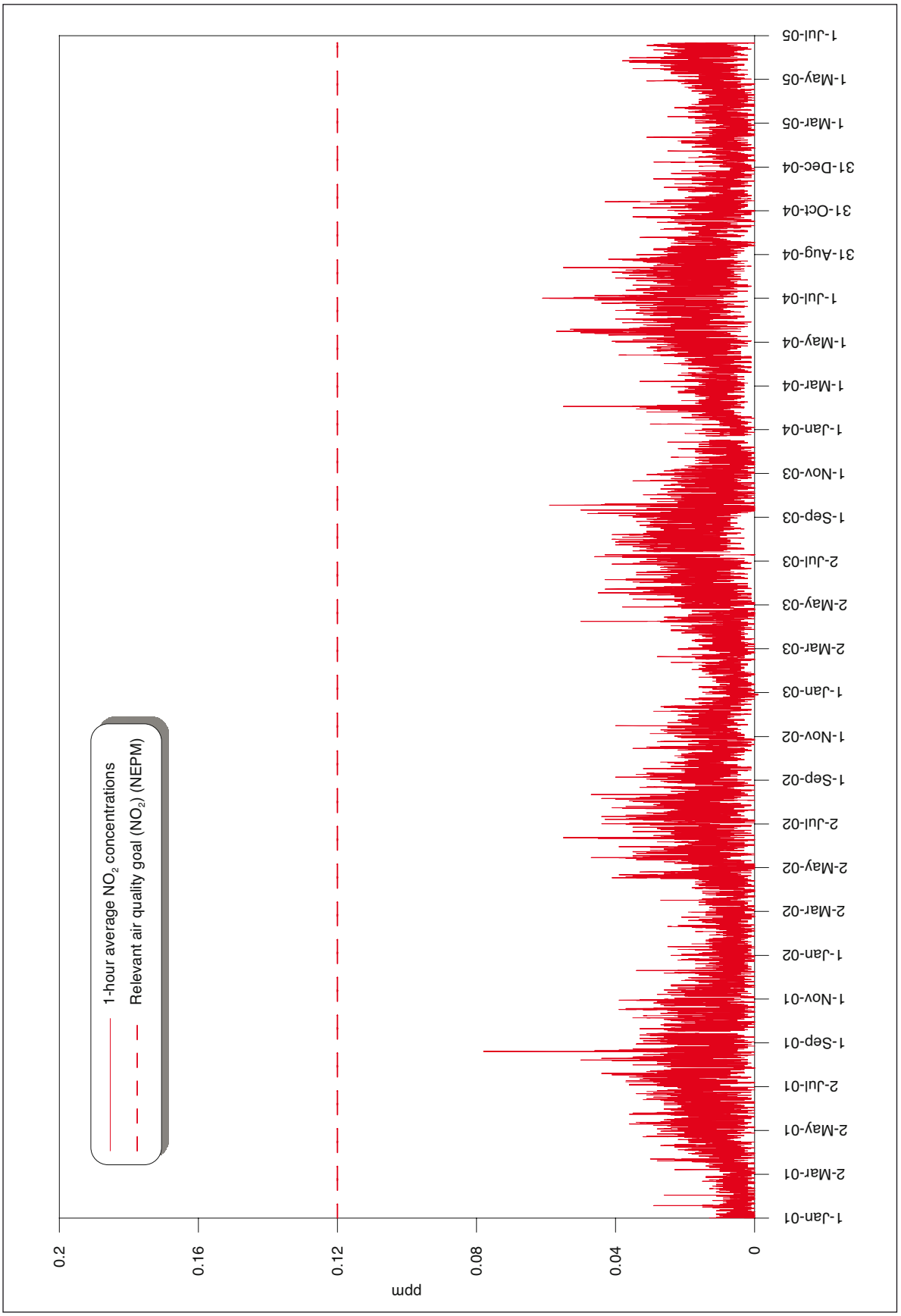


Figure 6.4k: *Measured Nitrogen Dioxide Concentrations at Eagle Farm.*

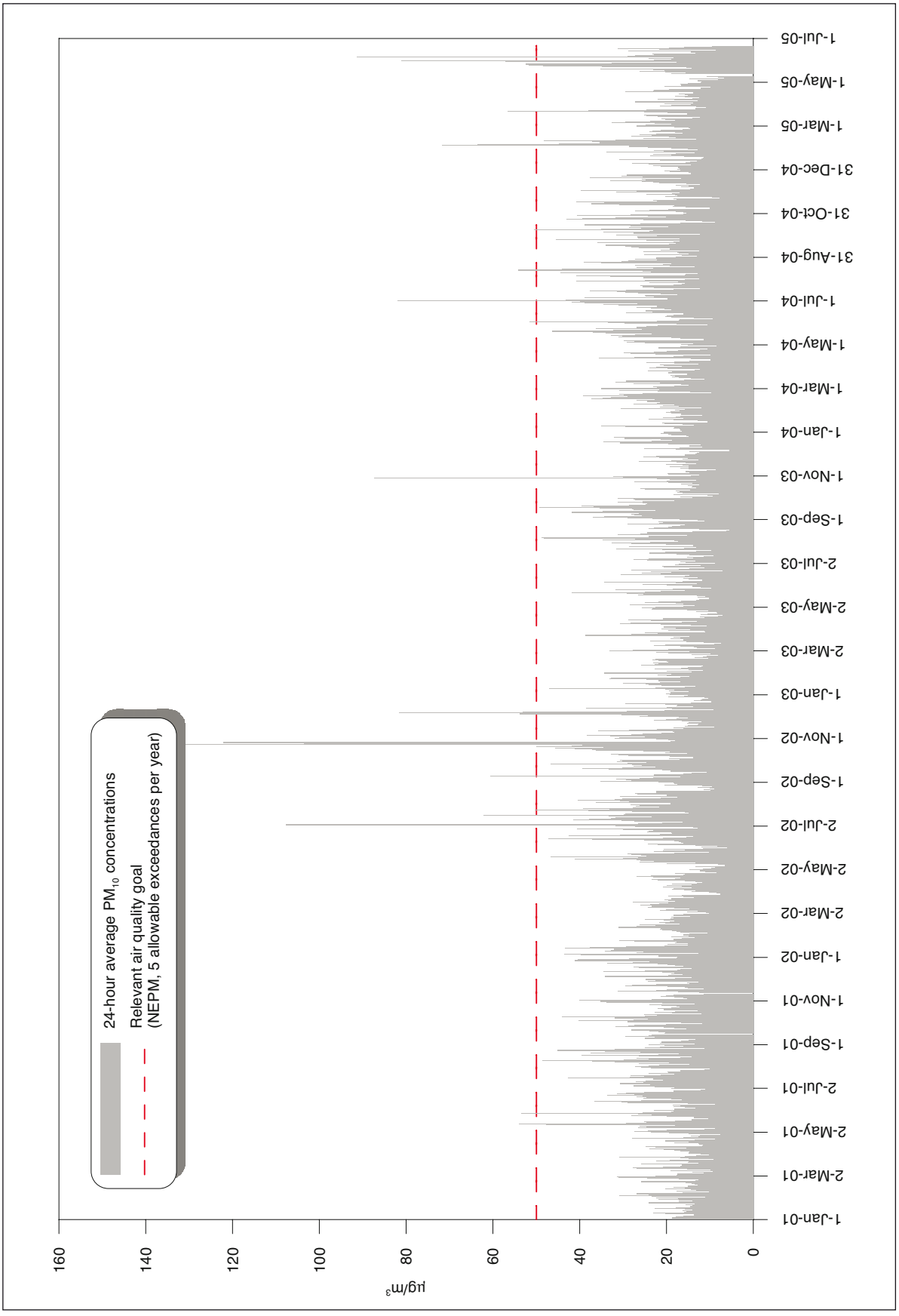


Figure 6.4l: *Measured Particulate Matter (PM_{10}) Concentrations at Eagle Farm.*

Figure 6.4m: *Correlation Between Percentage NO_2 and Total NO_X Concentrations at Eagle Farm.*

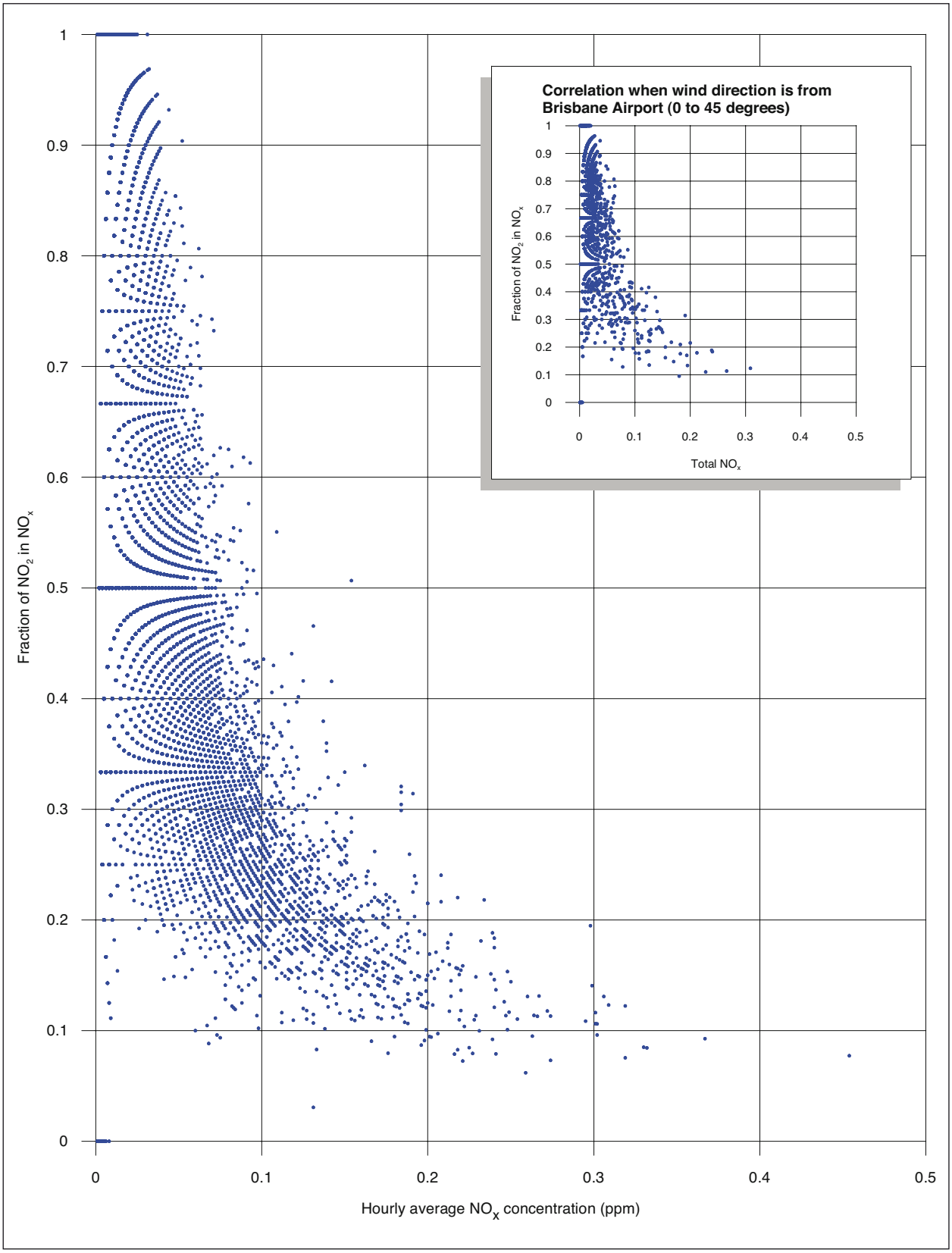


Figure 6.4n: *NO_x Concentration and Wind Direction at Eagle Farm.*

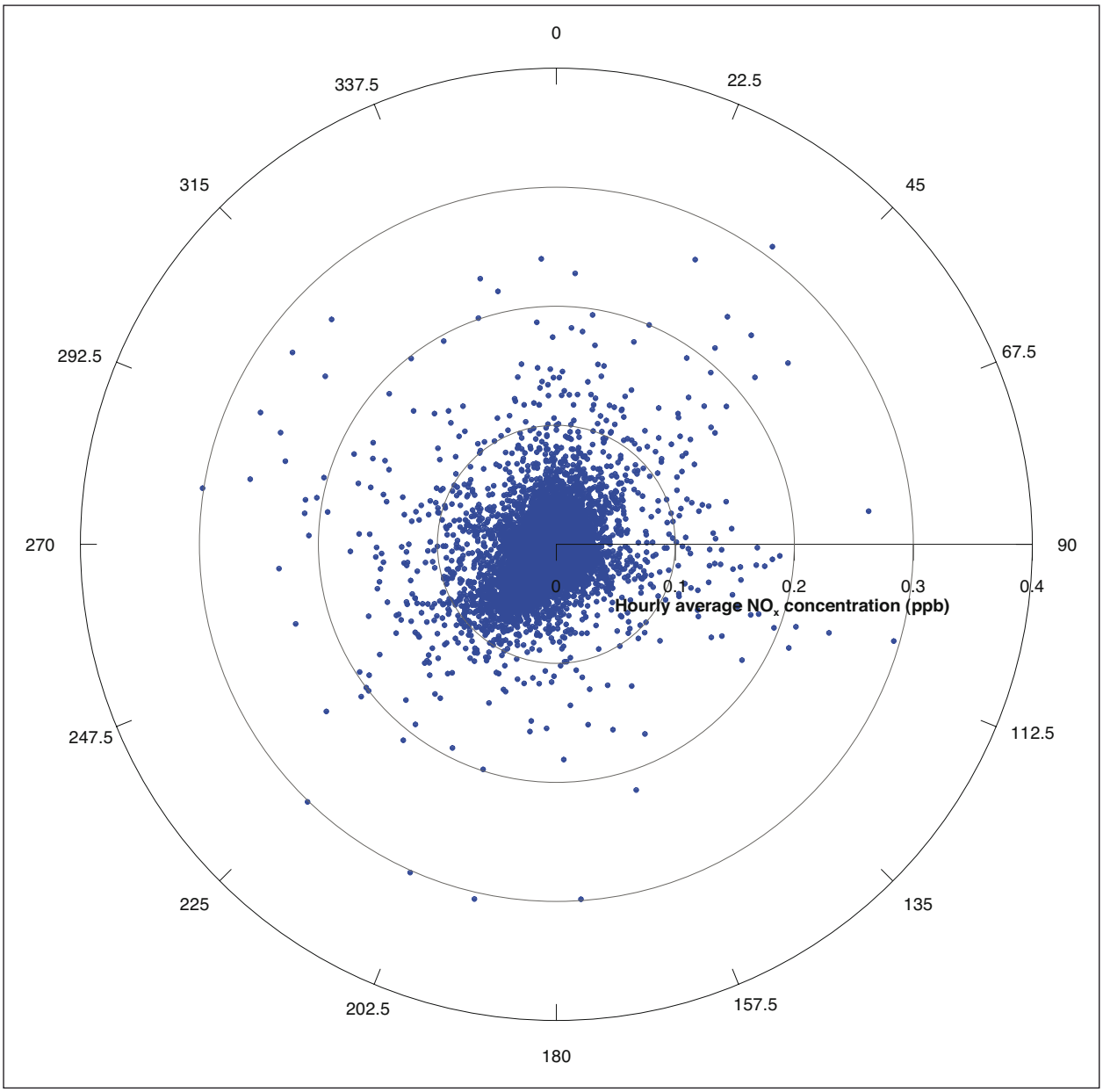


Figure 6.4o: *Summer and Winter Air Movements Around Brisbane.*

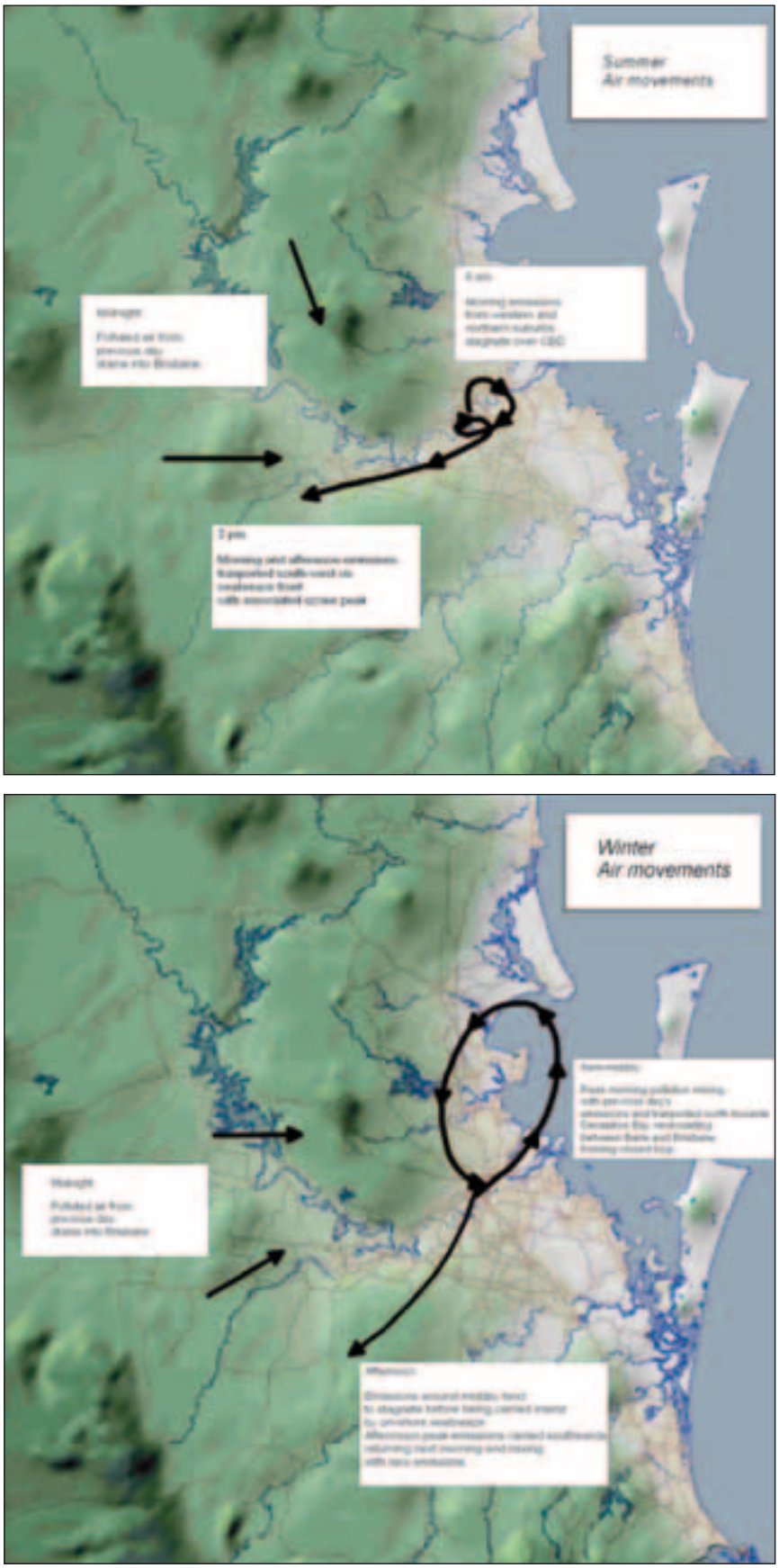


Figure 6.5a: *Aircraft Movements for 2005.*

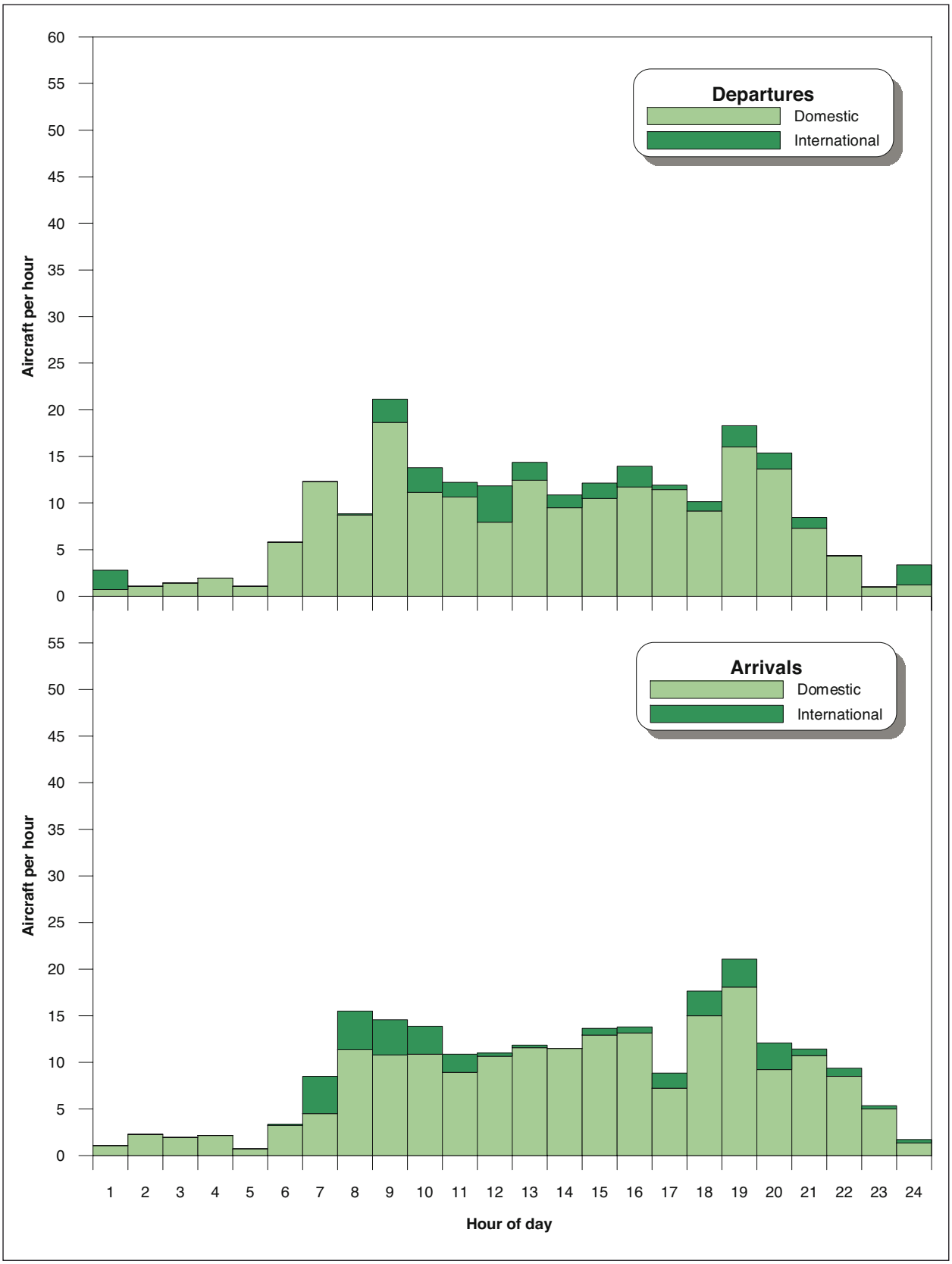


Figure 6.5b: *Aircraft Movements for 2015 Without NPR.*

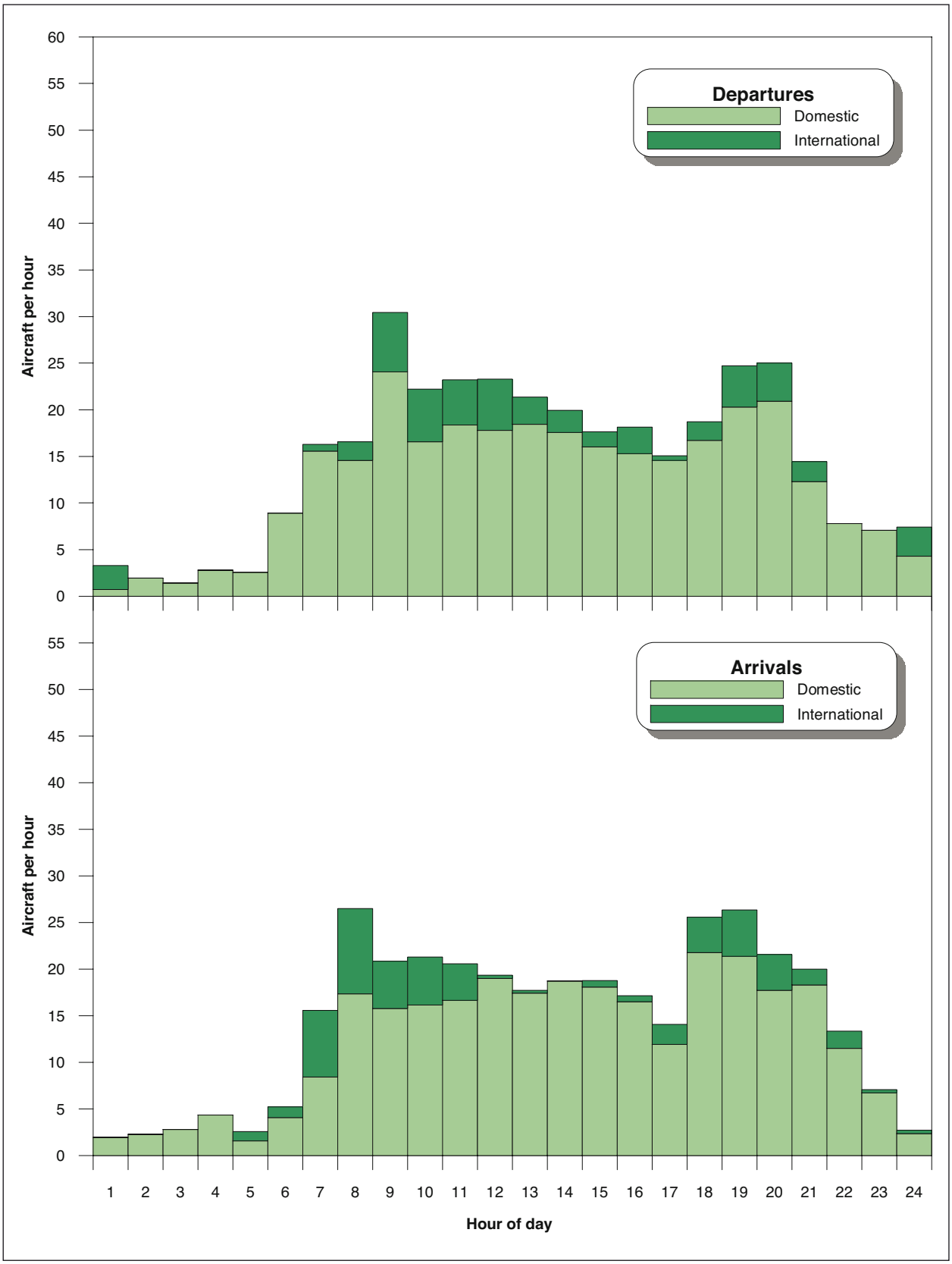


Figure 6.5c: *Aircraft Movements for 2015 With NPR.*

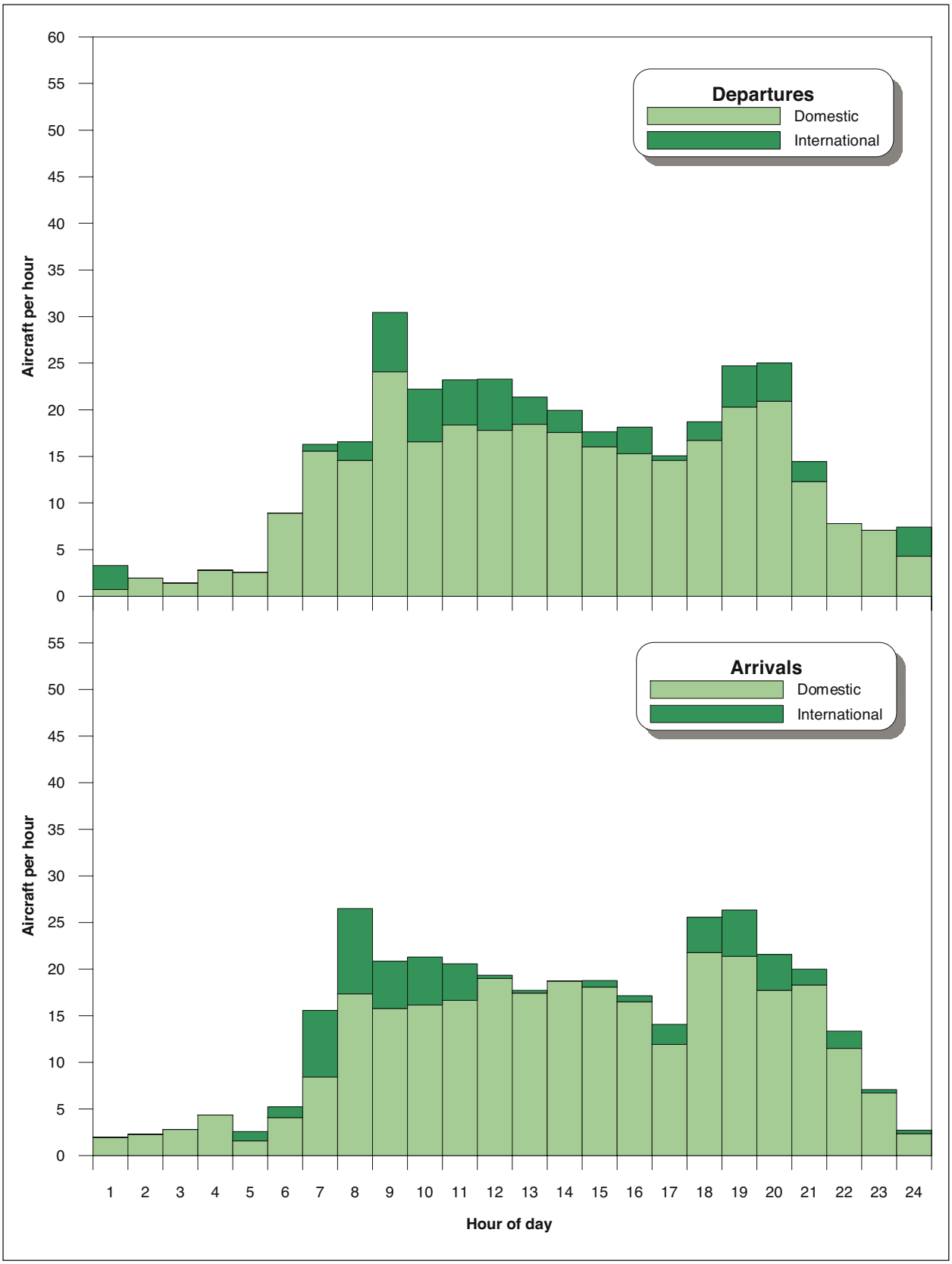


Figure 6.5d: *Aircraft Movements for 2035 Without NPR.*

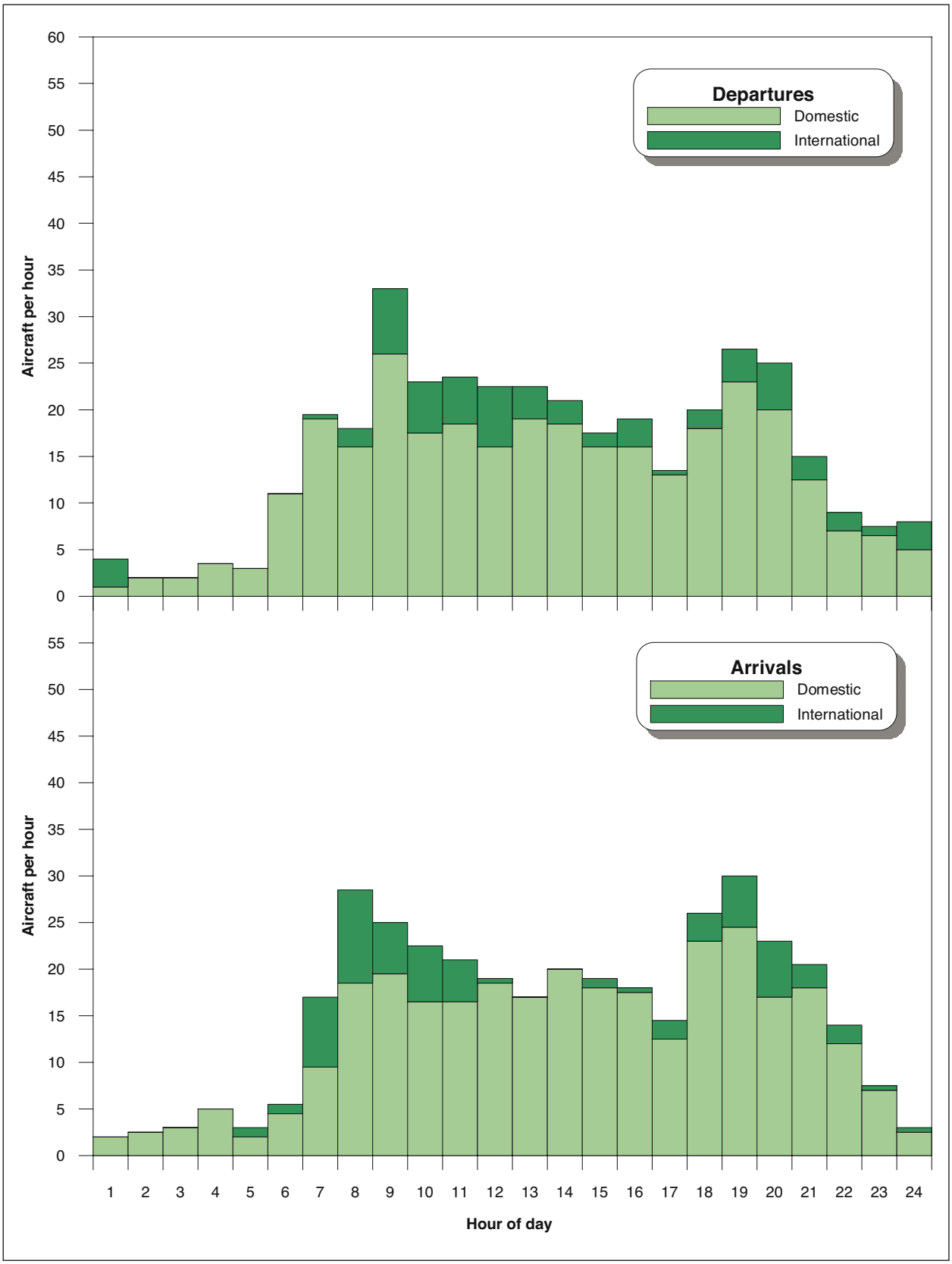


Figure 6.5e: *Aircraft Movements for 2035 With NPR.*

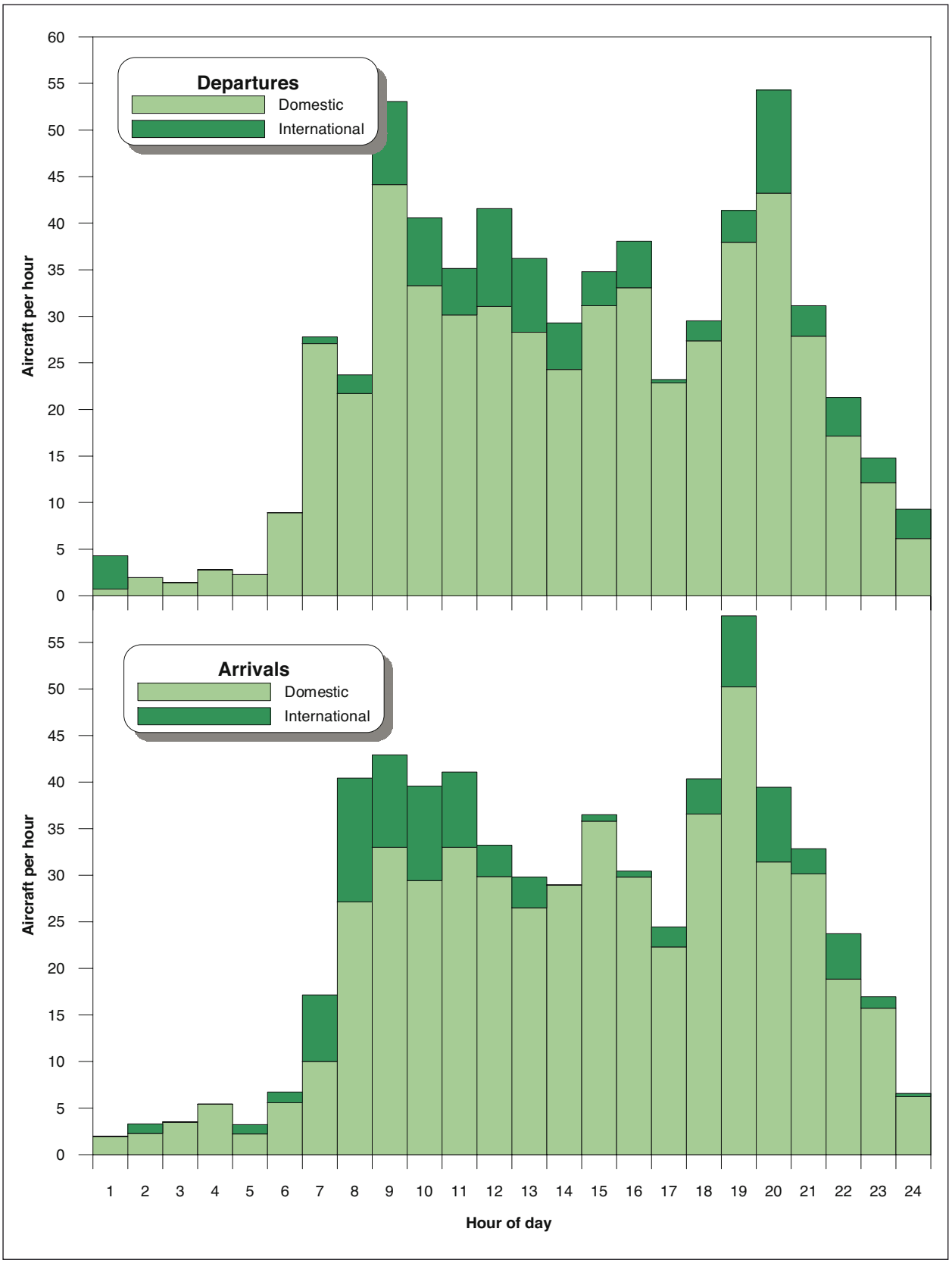


Figure 6.5f: *Estimated CO Estimations from Aircraft Operations by Hour of Day.*

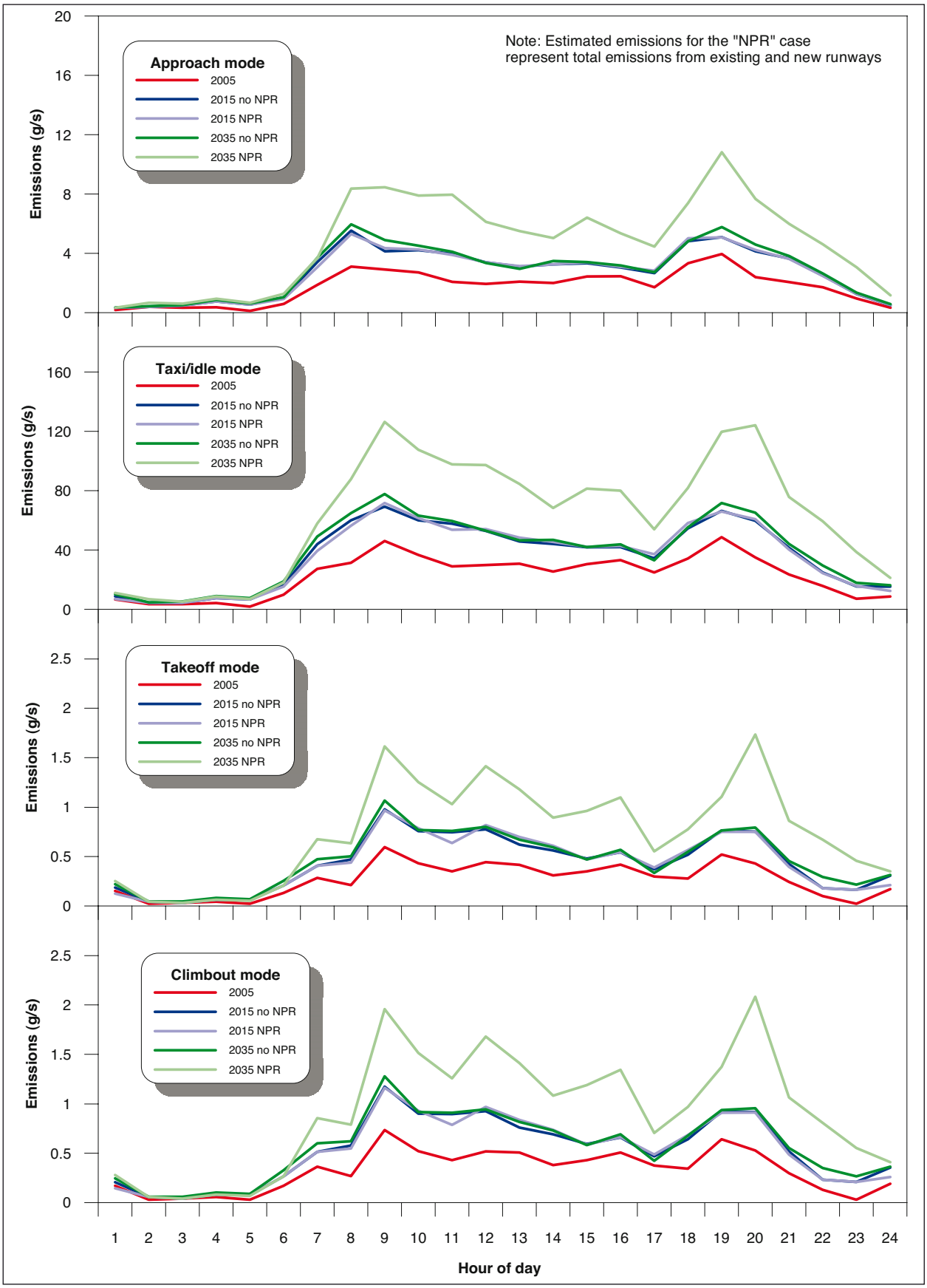


Figure 6.5g: *Estimated NO_x Estimations from Aircraft Operations by Hour of Day.*

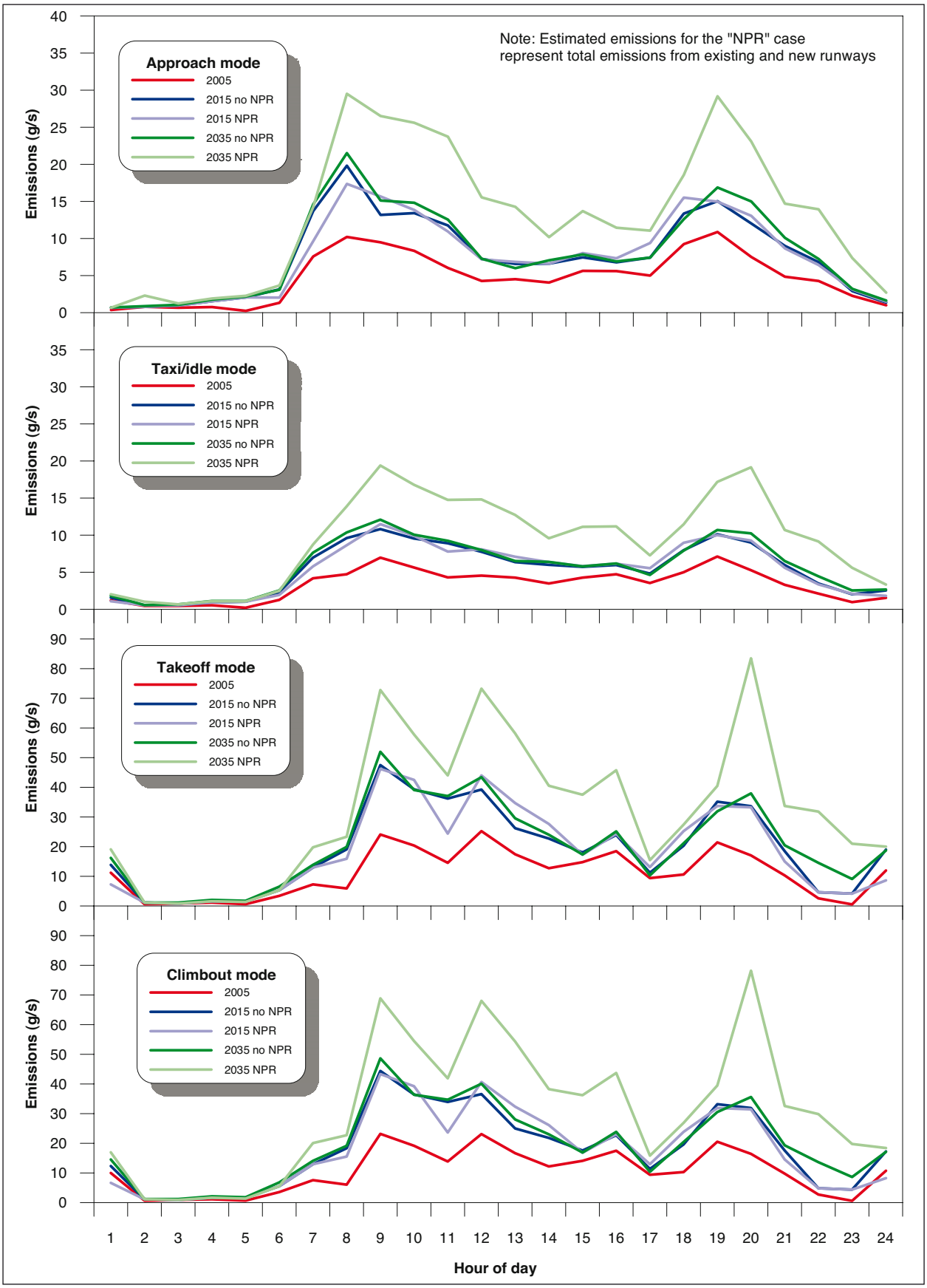
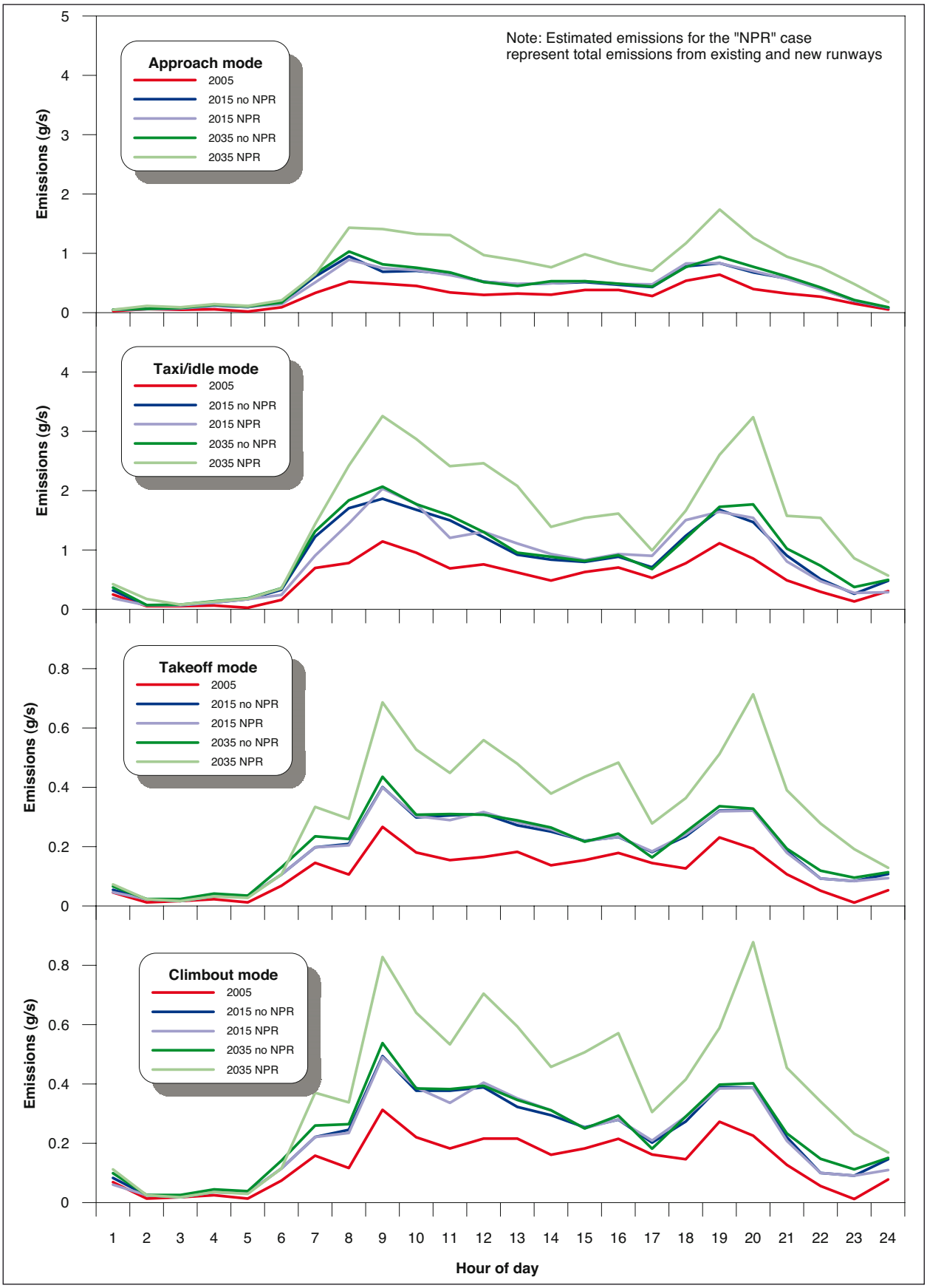


Figure 6.5h: *Estimated TSP Estimations from Aircraft Operations by Hour of Day.*



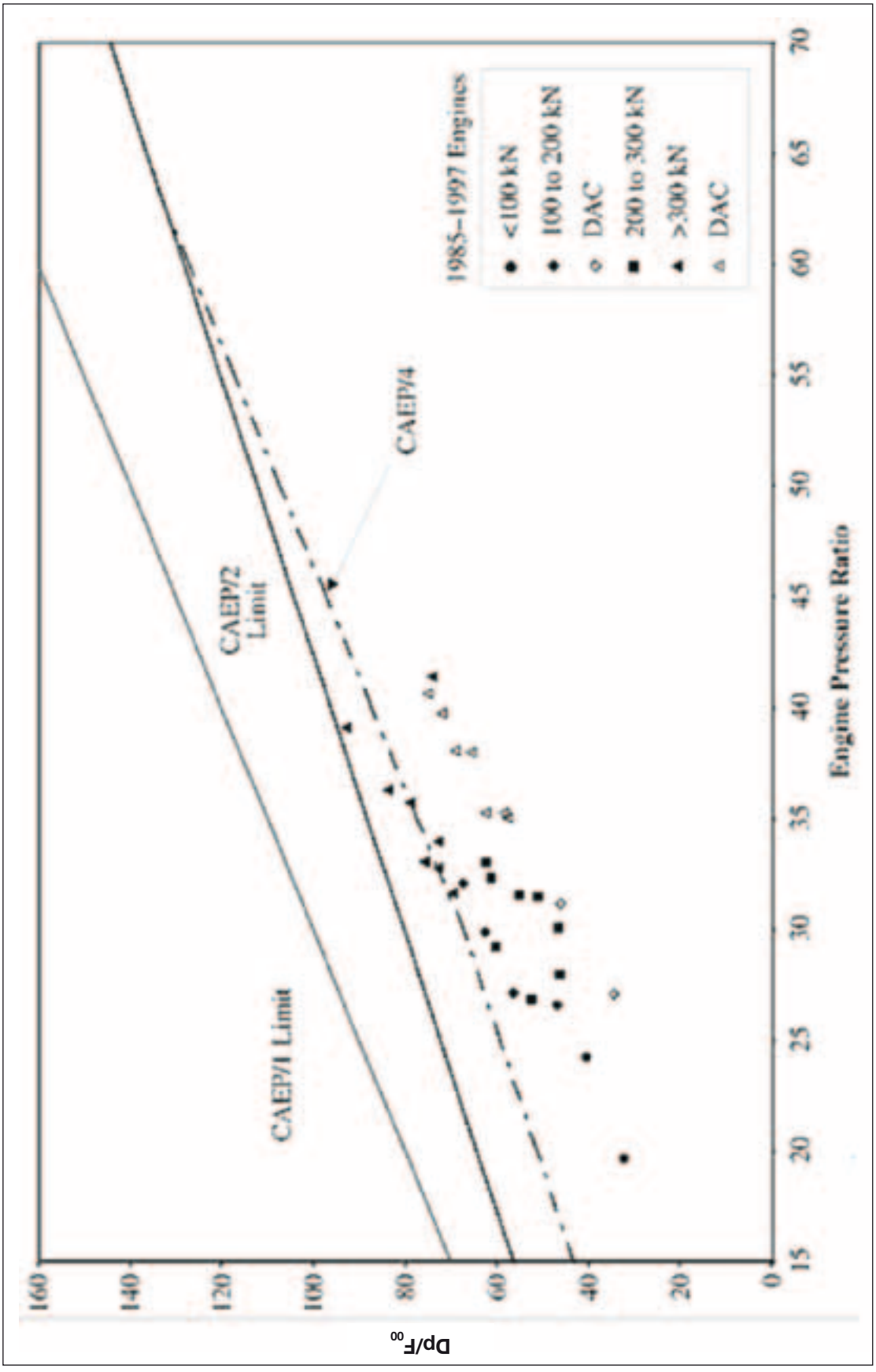


Figure 6.5i: *Engine NO_X Characteristic Values of Dp/F_{00} for ICAO LTO Cycle and Changes in Regulatory Limits.*

Figure 6.6a: *Location of Modelled Sources for Existing 01/19 Runway (01 Mode).*

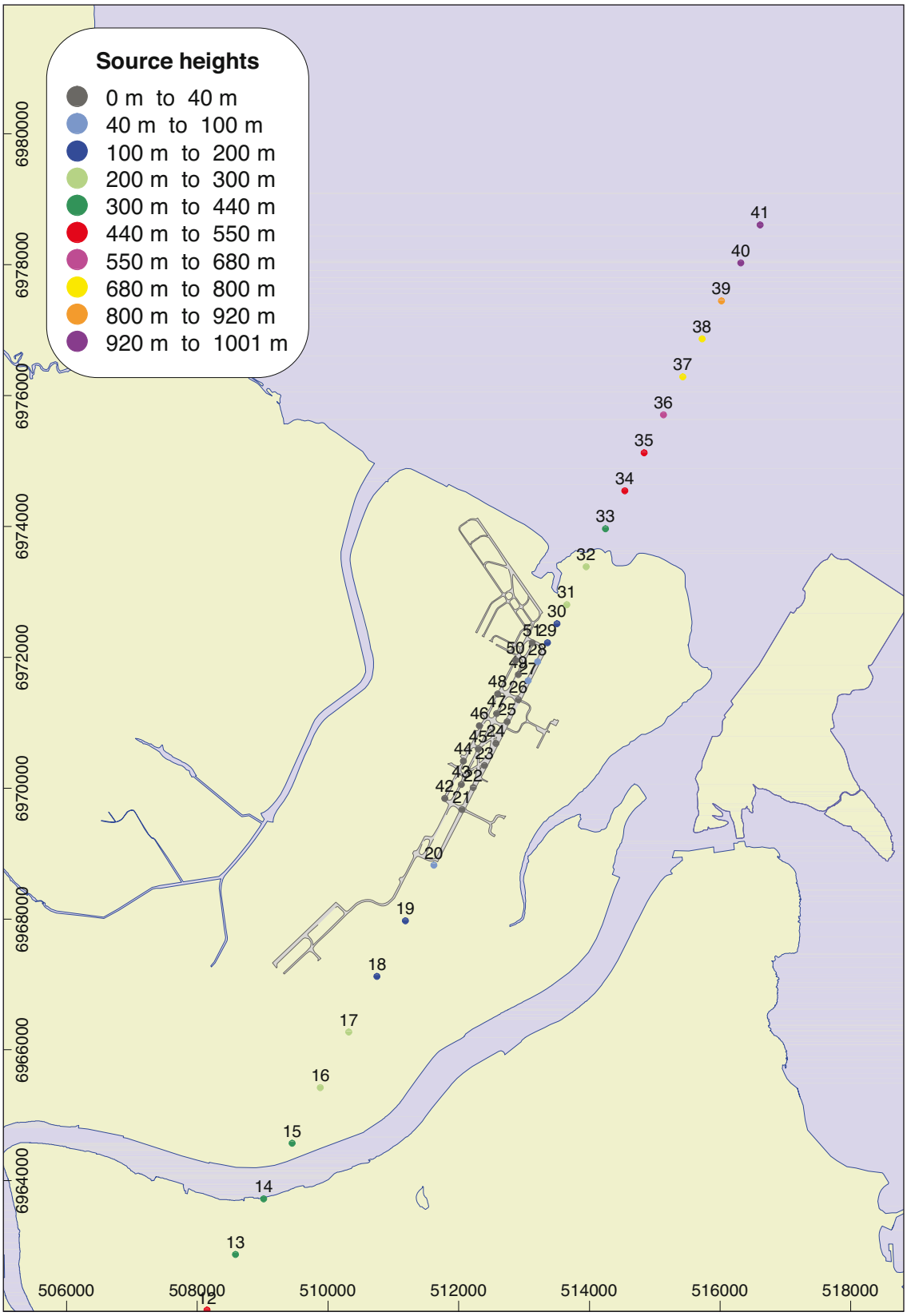


Figure 6.6b: *Location of Modelled Sources for Existing 01/19 Runway (19 Mode).*

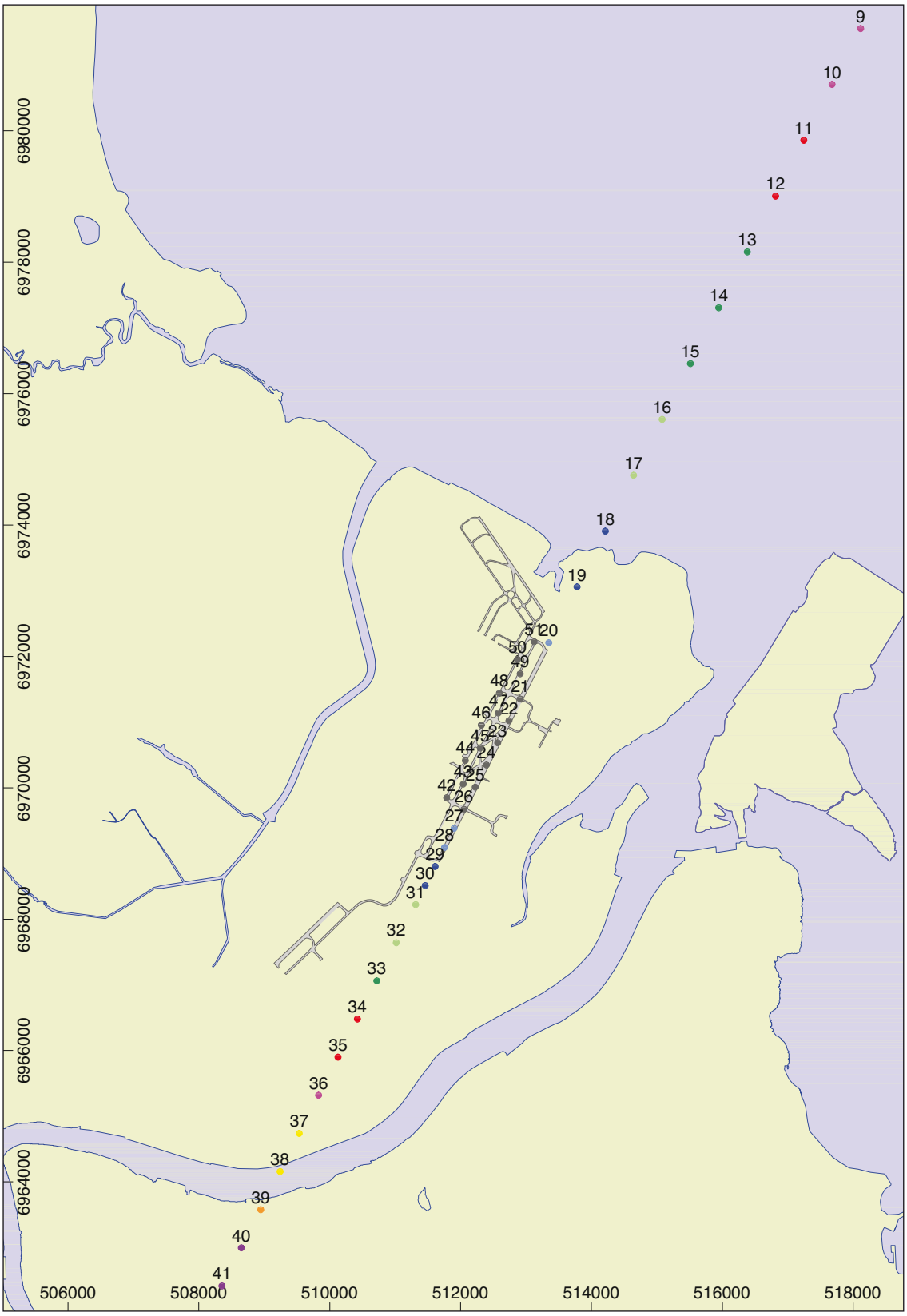


Figure 6.6c: *Location of Modelled Sources for Existing NPR (01 Mode).*

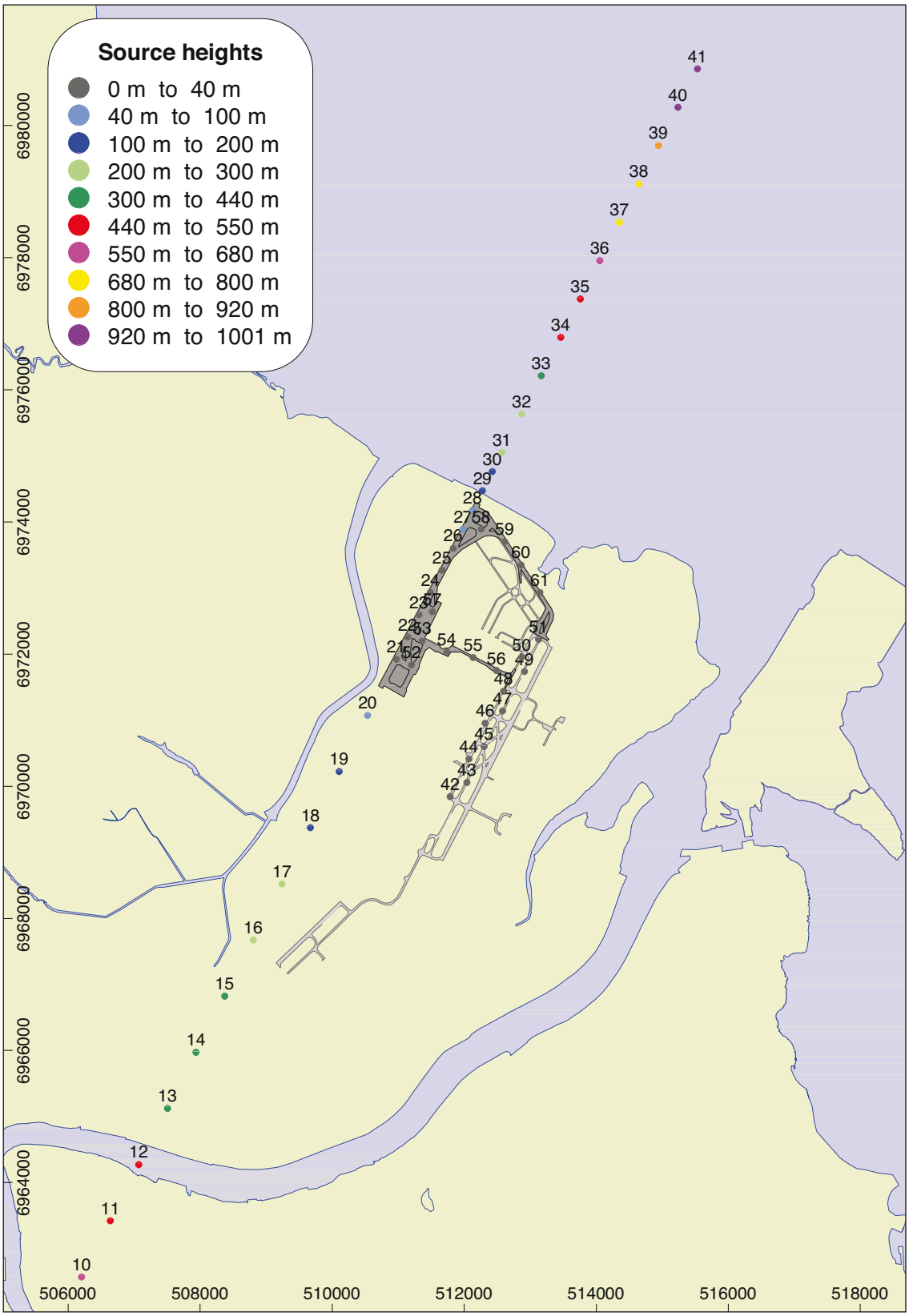


Figure 6.6d: *Location of Modelled Sources for Existing NPR (19 Mode).*

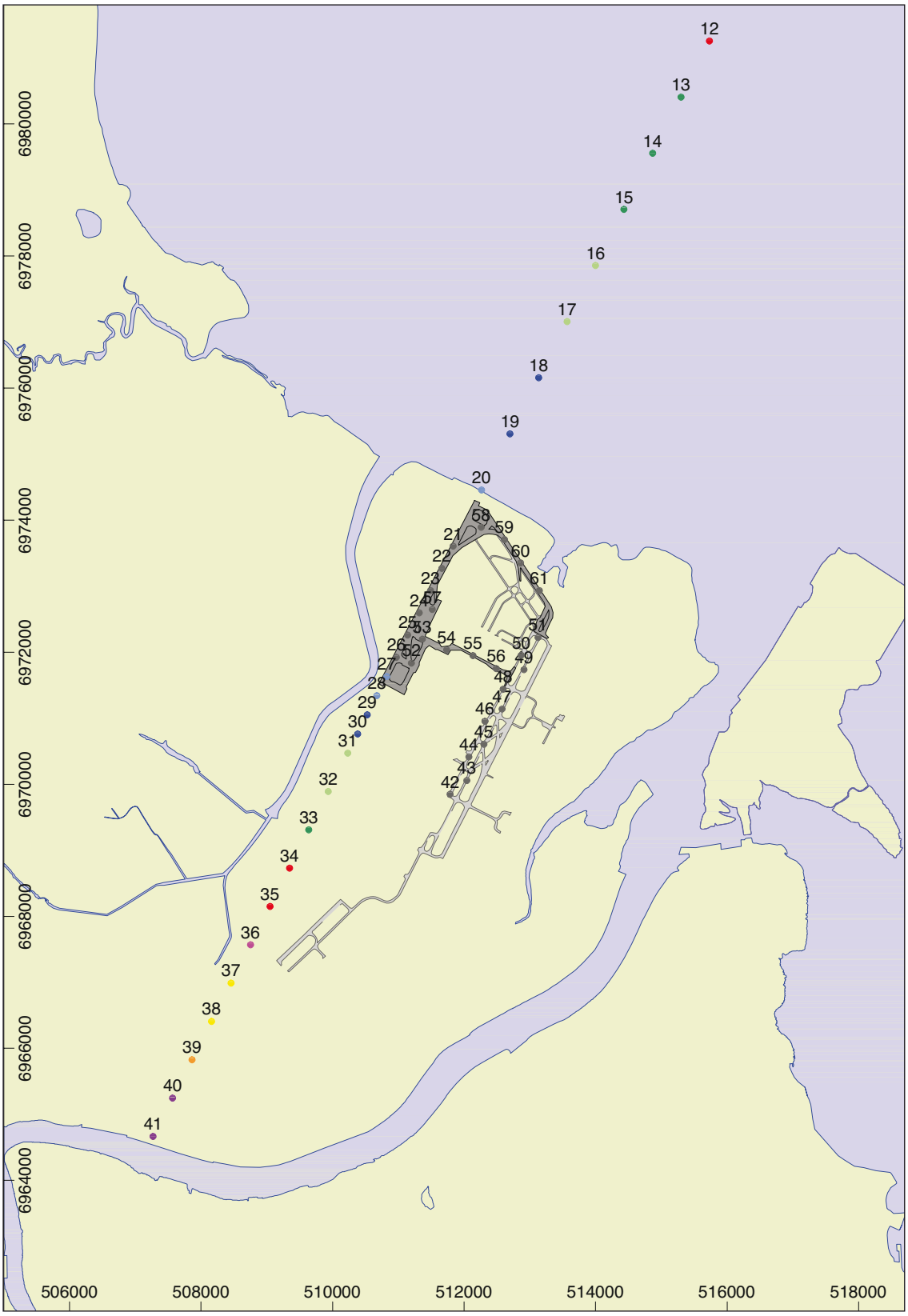
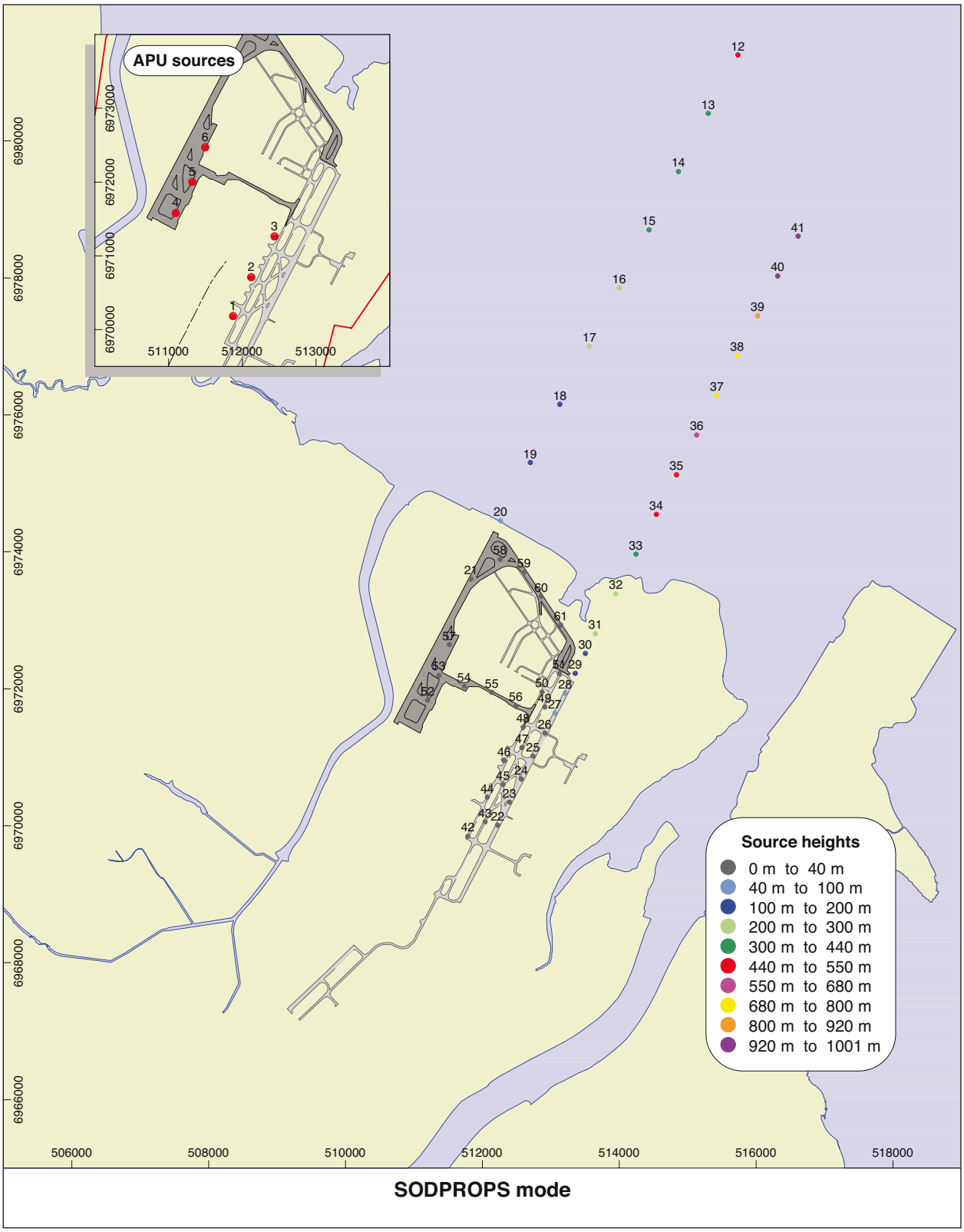


Figure 6.6e: *Location of Modelled Sources for Airport in SODPROPS Mode and APU Sources.*

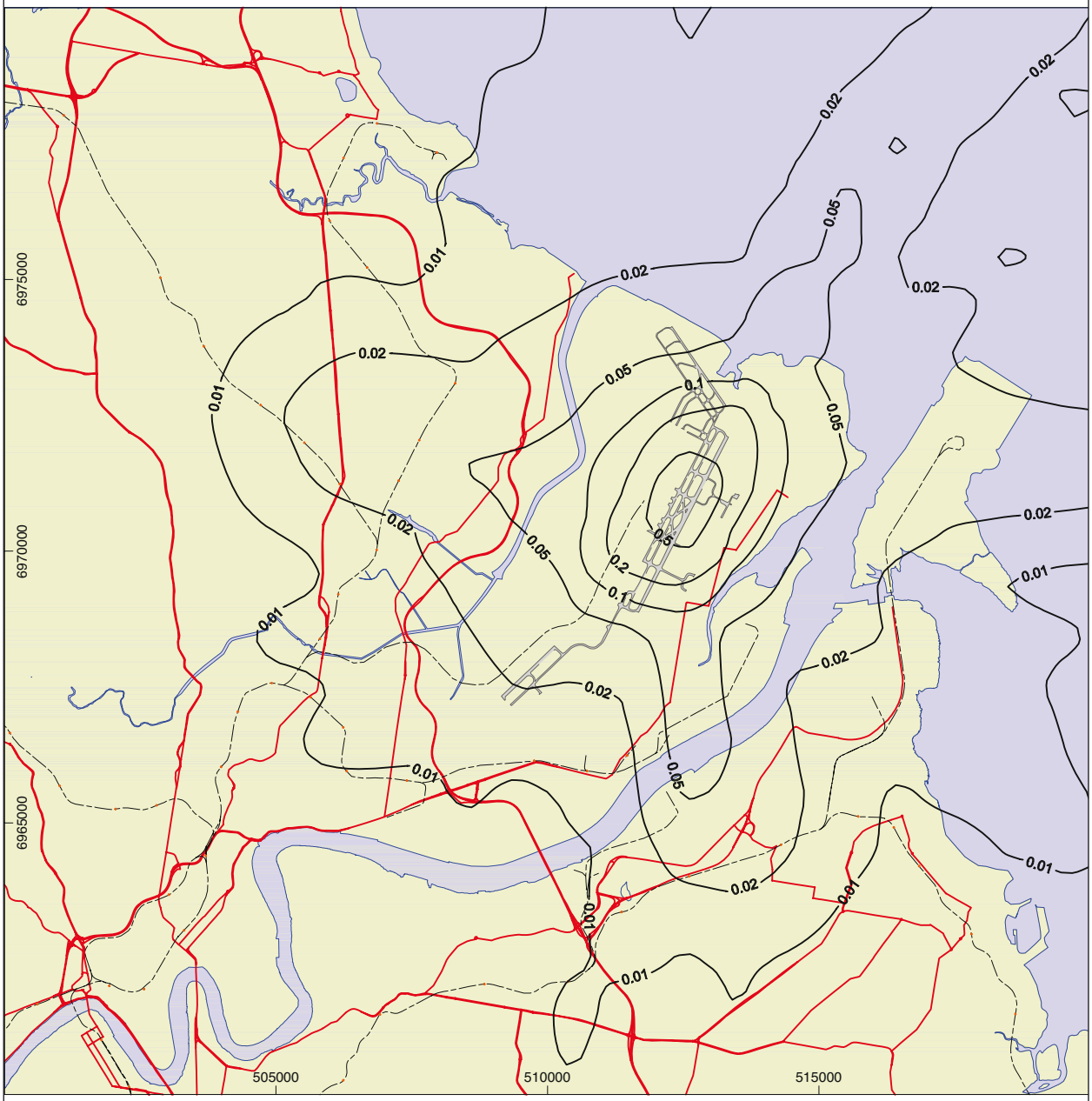


SODPROPS mode

Figure 6.7a: *Sensitive Receptor Locations Chosen for the Assessment.*

Figure 6.7b: *Predicted Maximum 8 Hour Average CO Concentrations in 2005 (µg/m³).*

Air quality goal = 10 mg/m^3
To account for background, add
2.8 mg/m^3 (worst case) to predictions



Existing operations

Figure 6.7c: *Predicted Maximum 8 Hour Average CO Concentrations in 2015 (µg/m³) – Without NPR.*

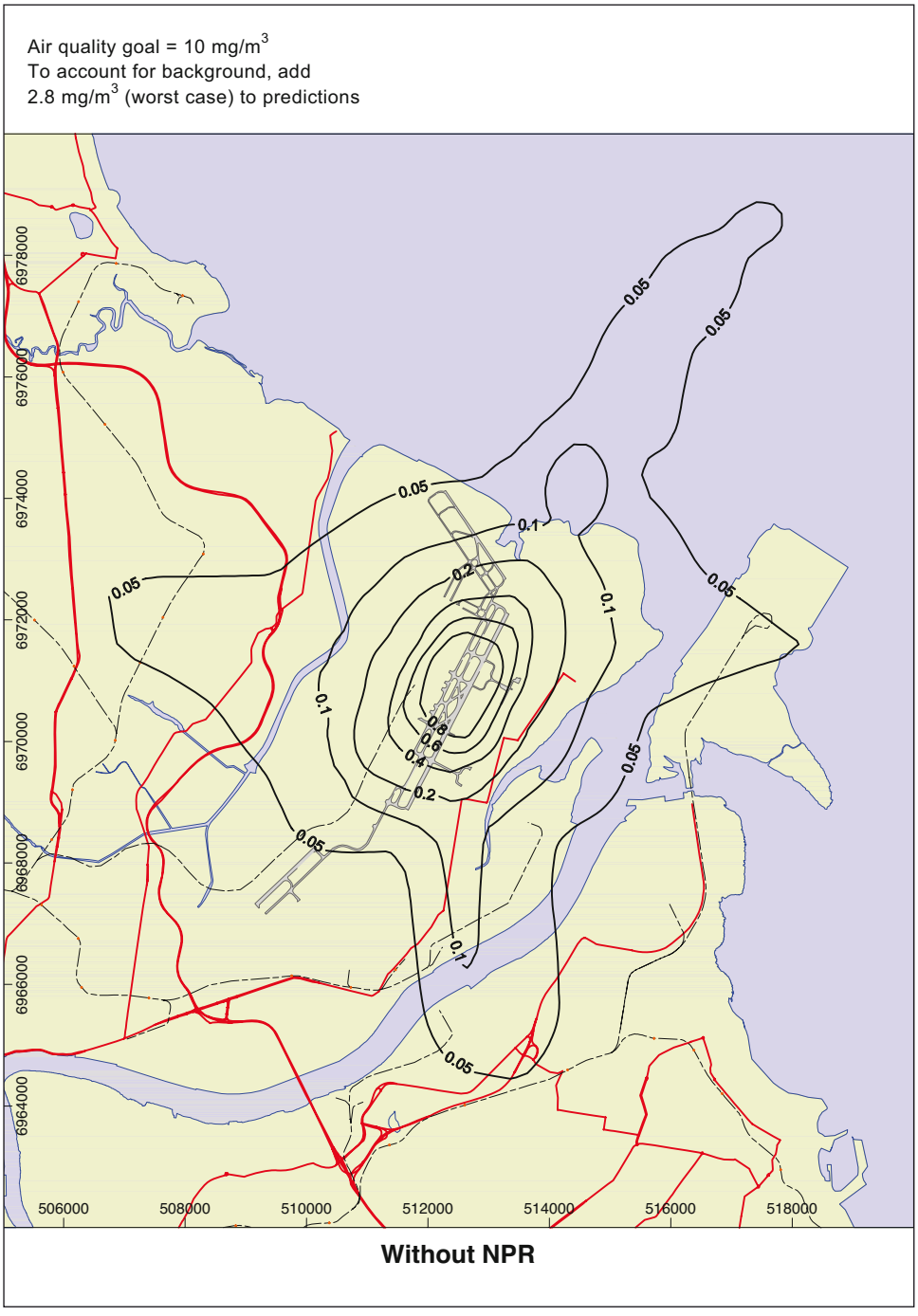


Figure 6.7d: *Predicted Maximum 8 Hour Average CO Concentrations in 2015 (µg/m³) – With NPR.*

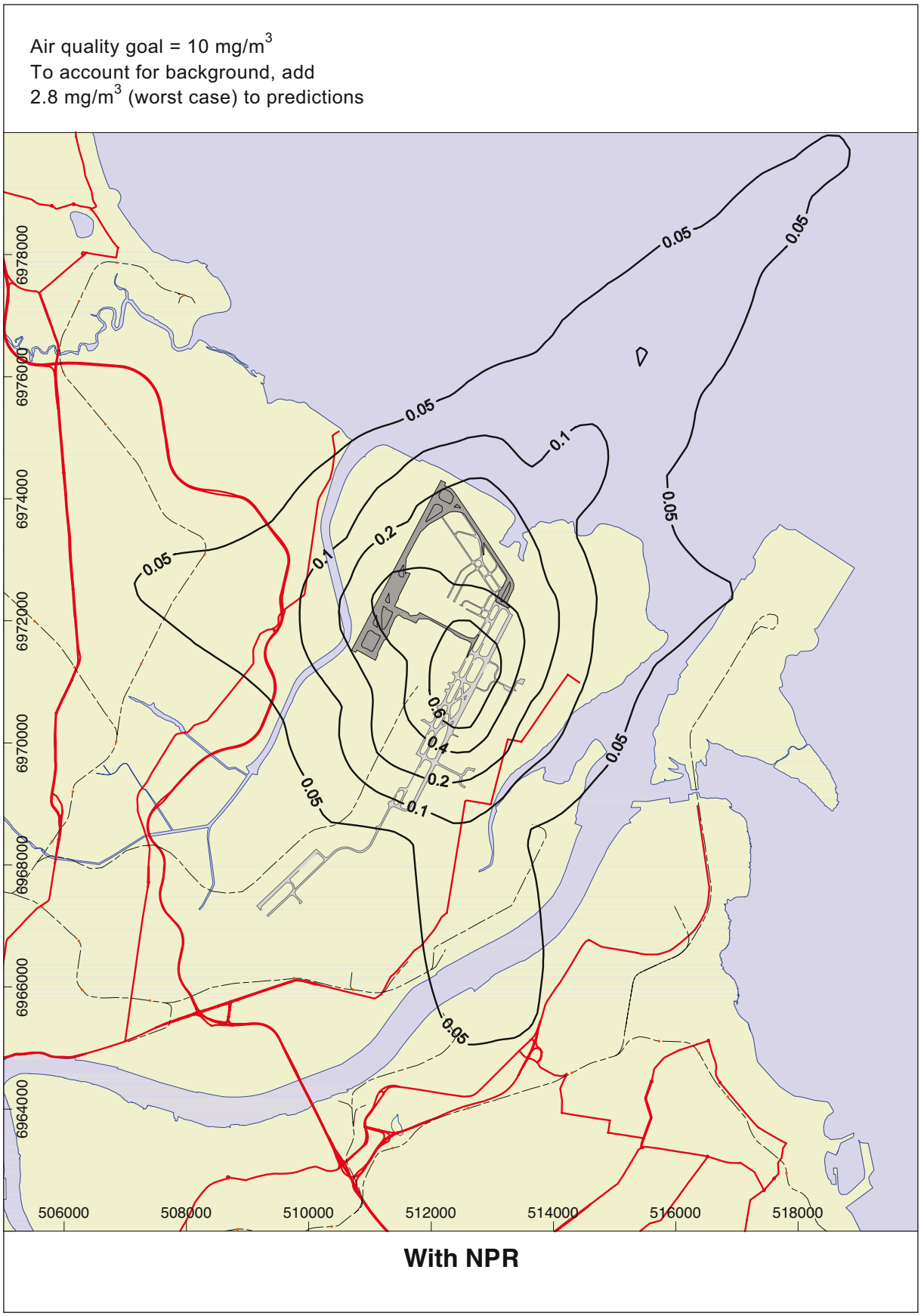
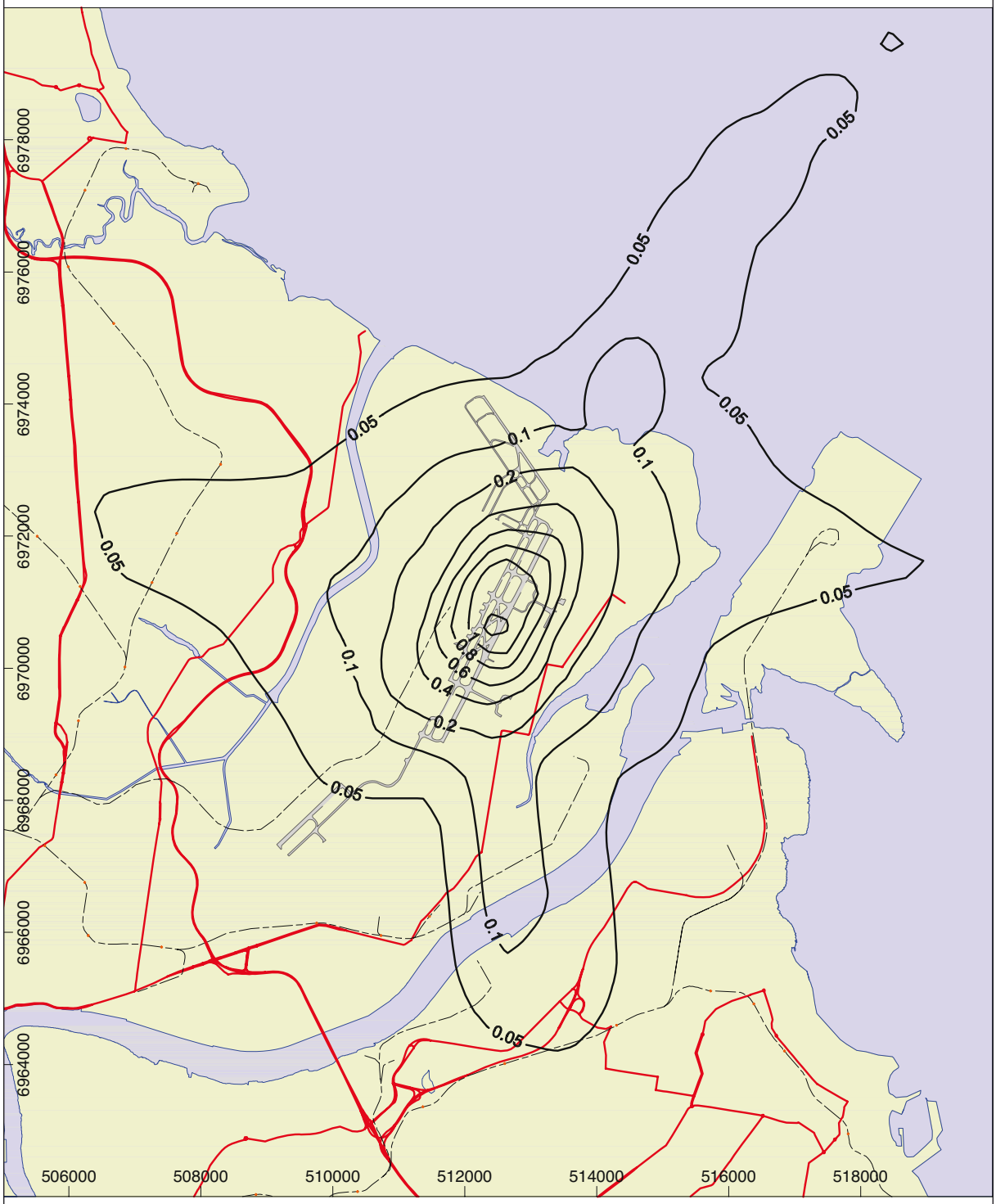


Figure 6.7e: *Predicted Maximum 8 Hour Average CO Concentrations in 2035 (µg/m³) – Without NPR.*

Air quality goal = 10 mg/m^3
To account for background, add
2.8 mg/m^3 (worst case) to predictions



Without NPR

Figure 6.7f: *Predicted Maximum 8 Hour Average CO Concentrations in 2035 (µg/m³) – With NPR.*

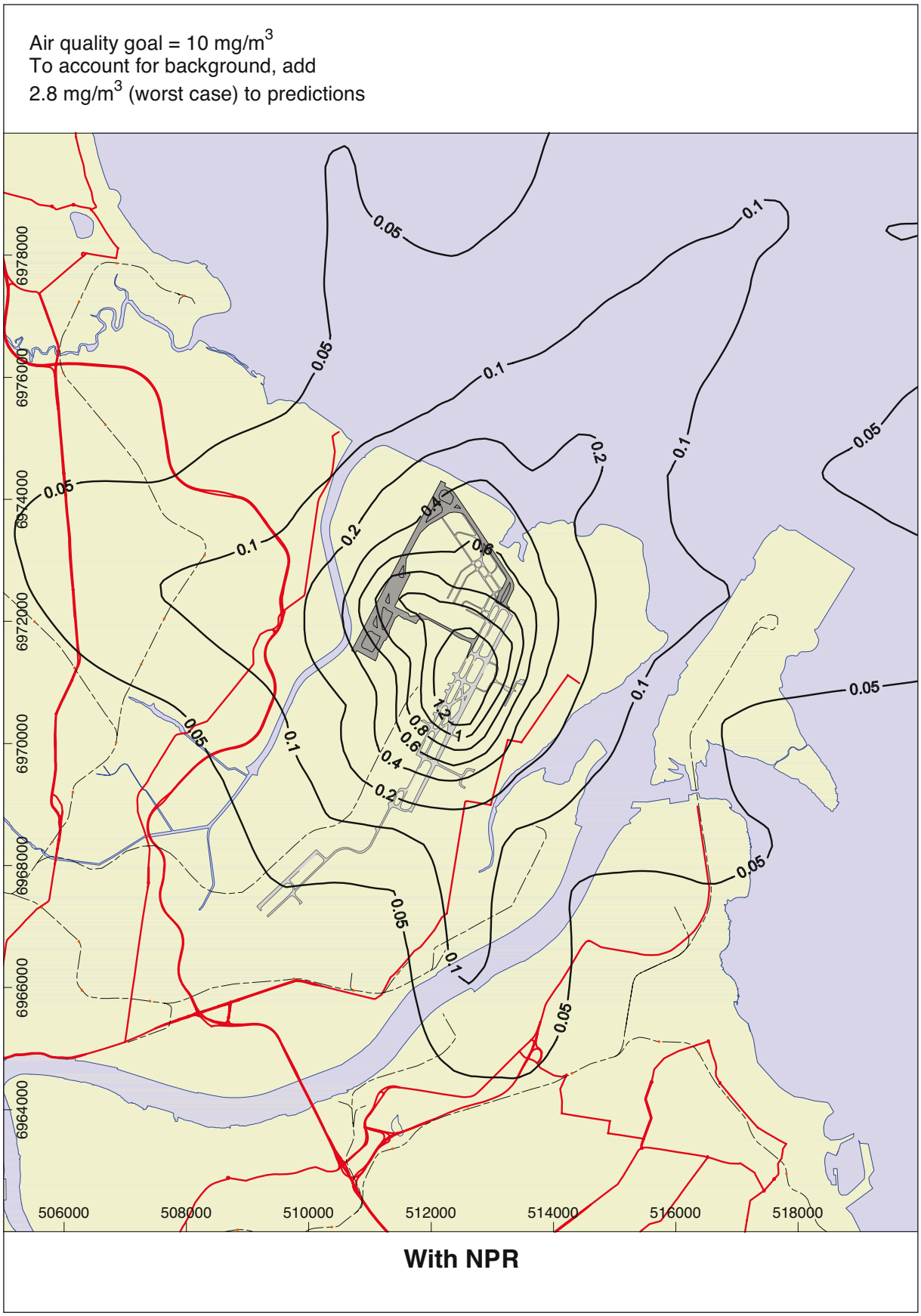


Figure 6.7g: *Predicted Maximum 1 Hour Average NO_x Concentrations in 2005 (µg/m³).*

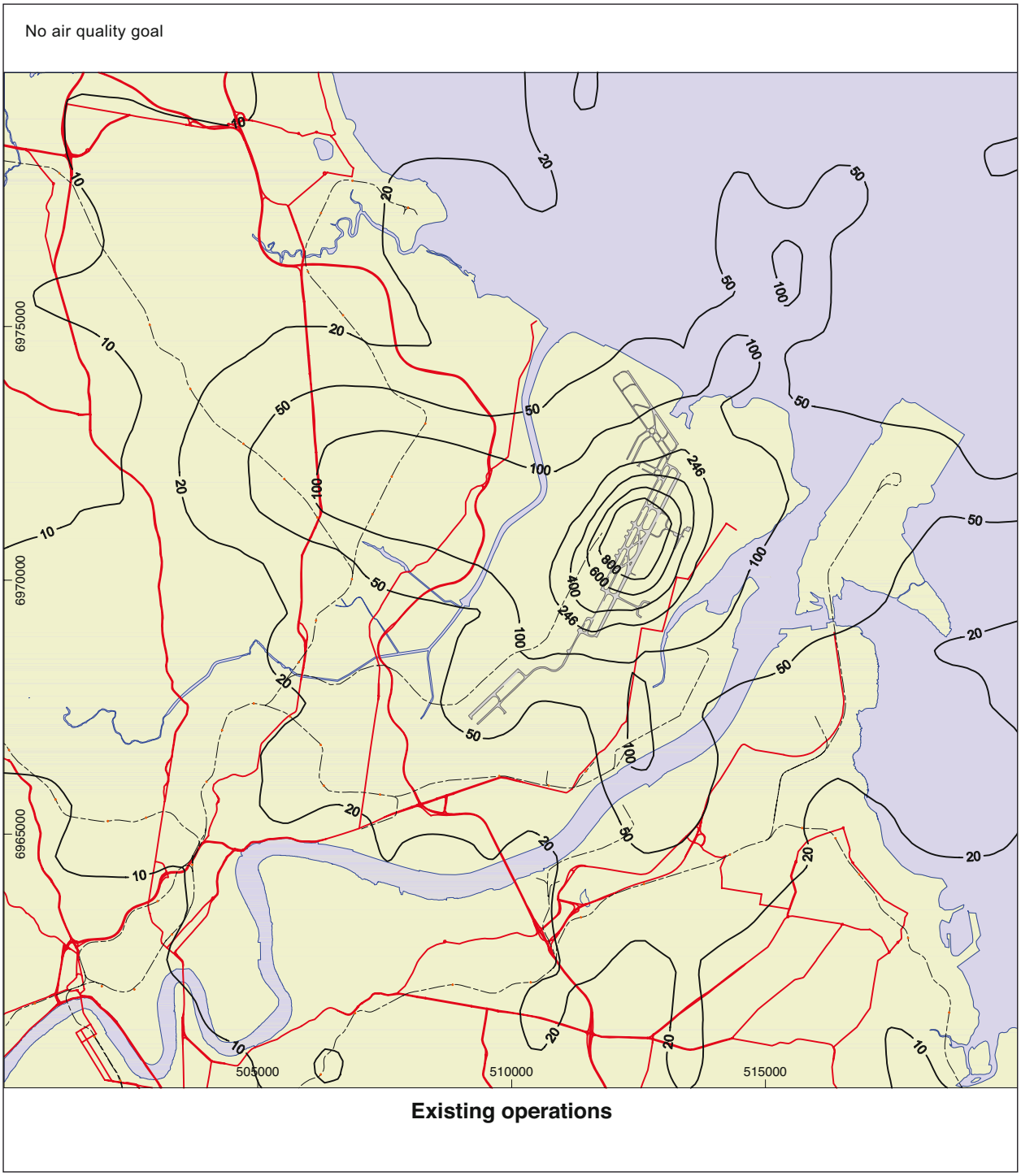
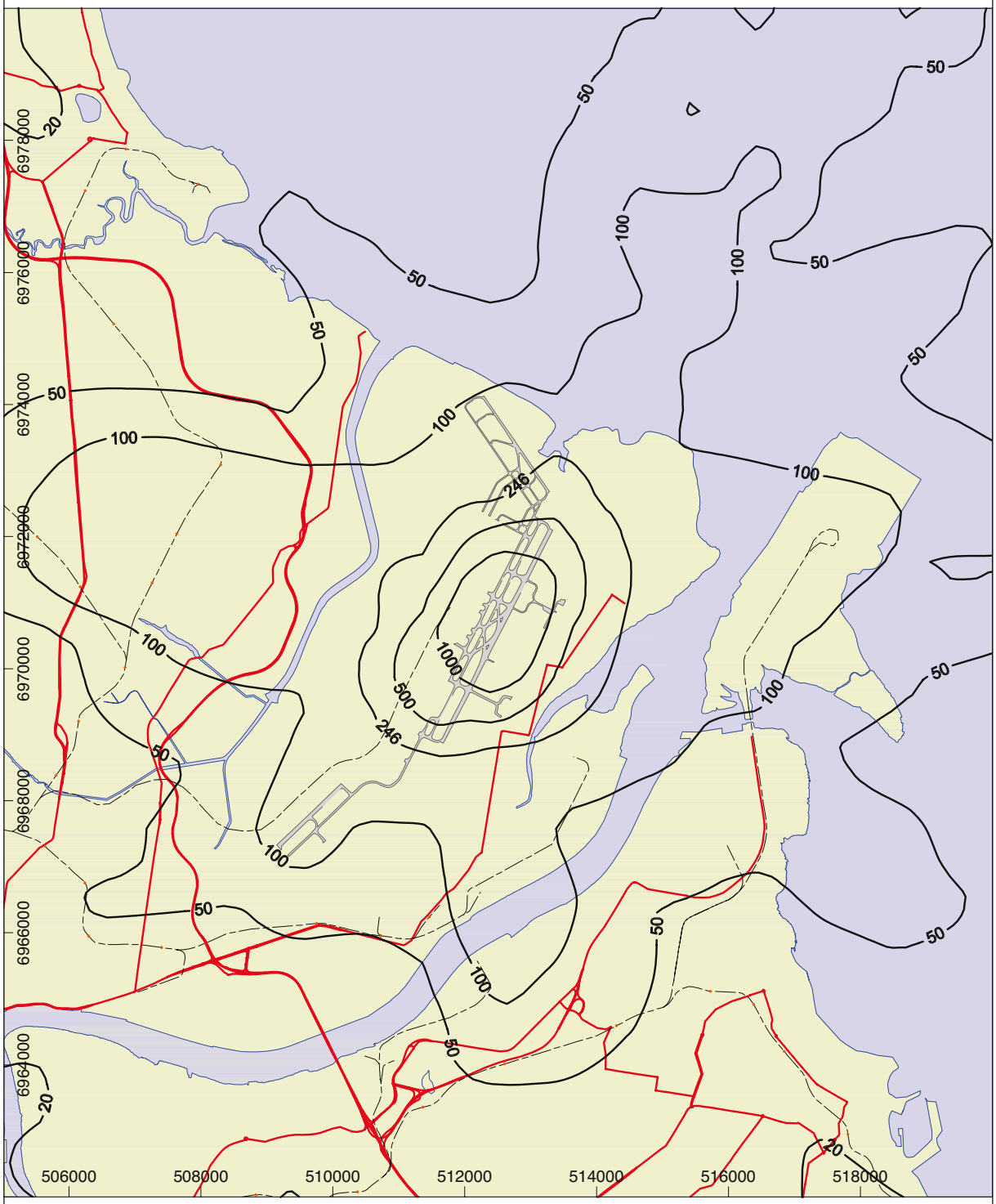


Figure 6.7h: *Predicted Maximum 1 Hour Average NO_x Concentrations in 2015 (µg/m³) – Without NPR.*

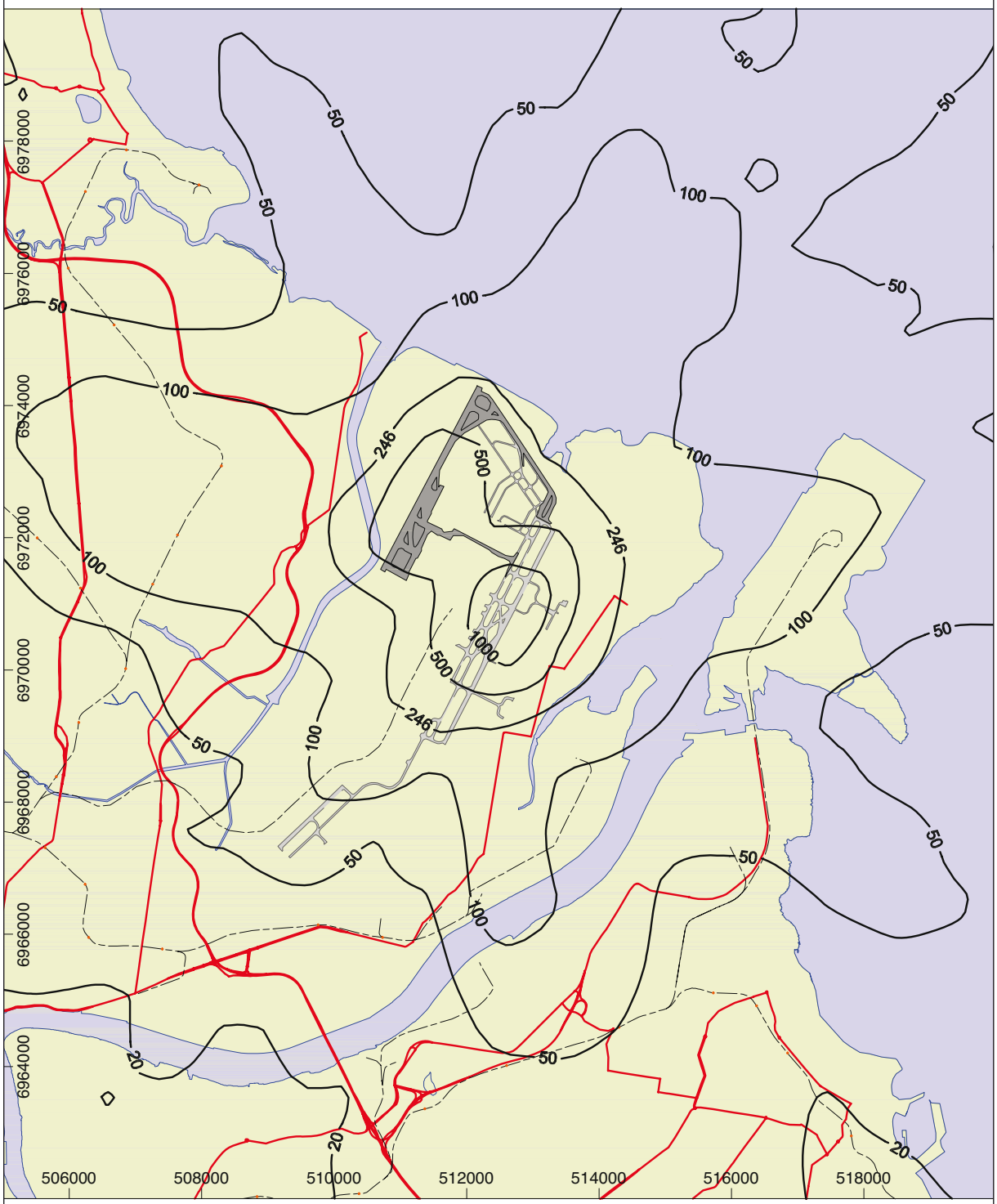
No air quality goal



Without NPR

Figure 6.7i: *Predicted Maximum 1 Hour Average NO_x Concentrations in 2015 (µg/m³) – With NPR.*

No air quality goal



With NPR

Figure 6.7j: *Predicted Maximum 1 Hour Average NO_x Concentrations in 2035 (µg/m³) – Without NPR.*

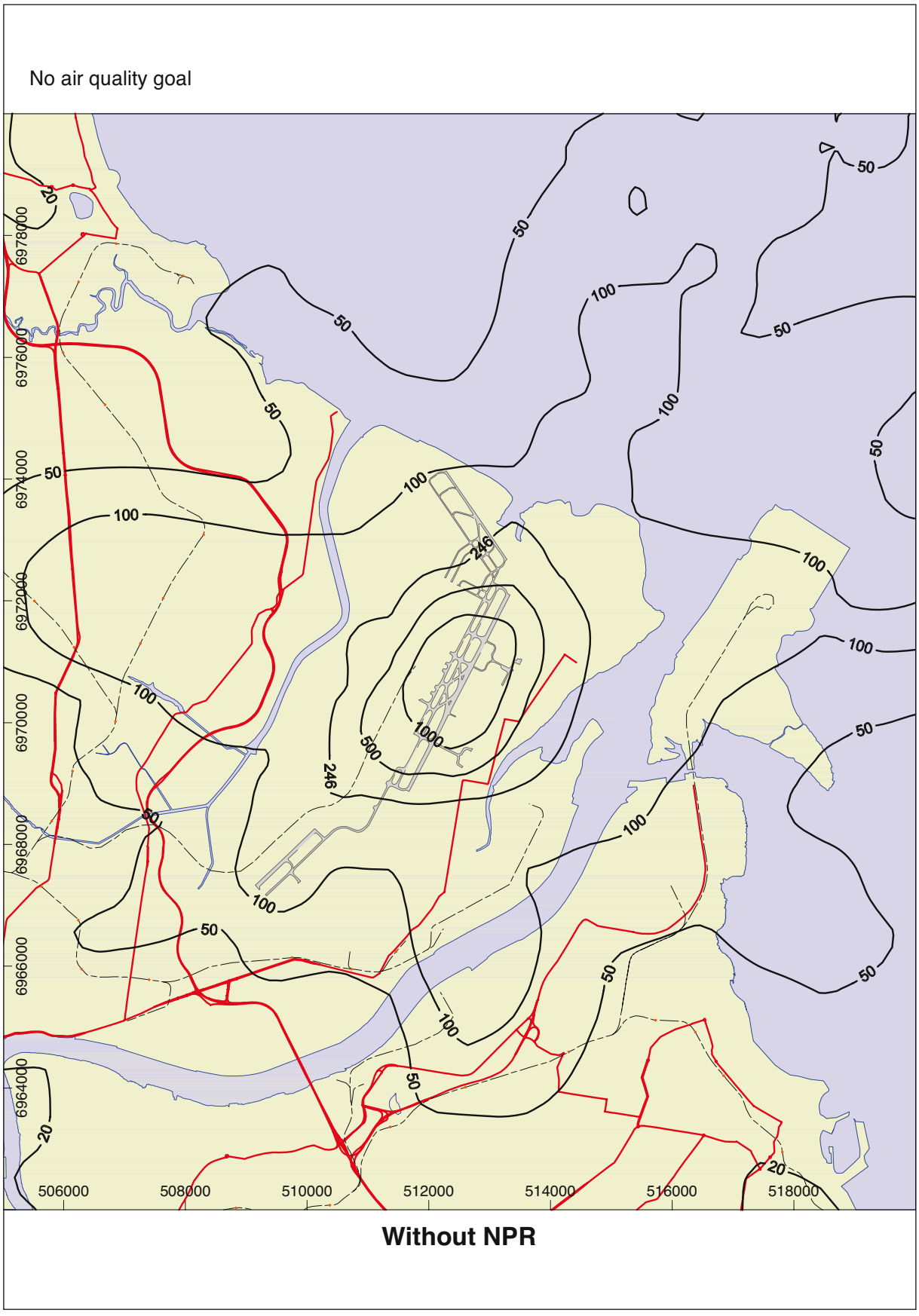
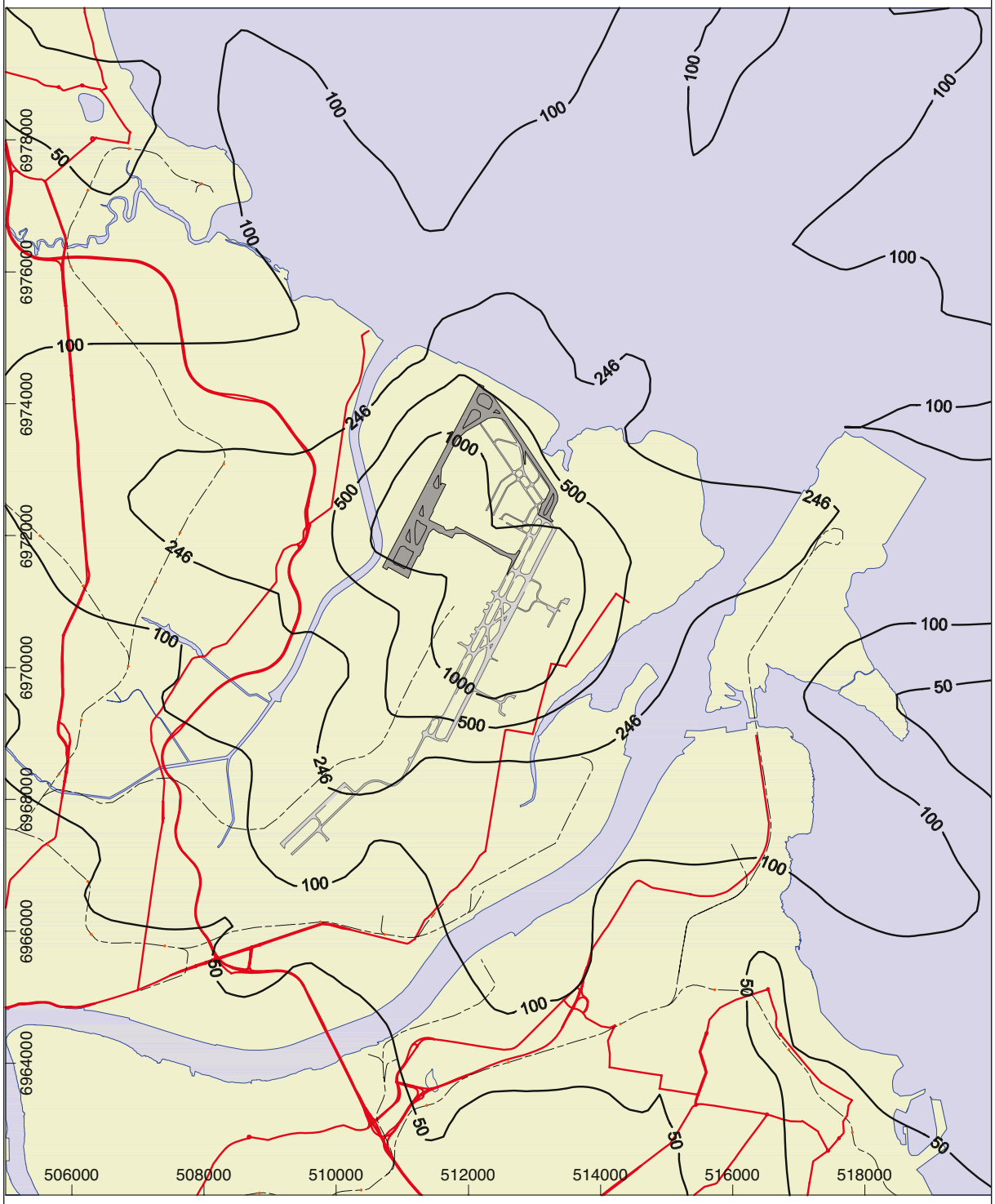


Figure 6.7k: *Predicted Maximum 1 Hour Average NO_x Concentrations in 2035 (µg/m³) – With NPR.*

No air quality goal



With NPR

Figure 6.7I: *Predicted Maximum 1 Hour Average NO_2 Concentrations in 2005 (µg/m³).*

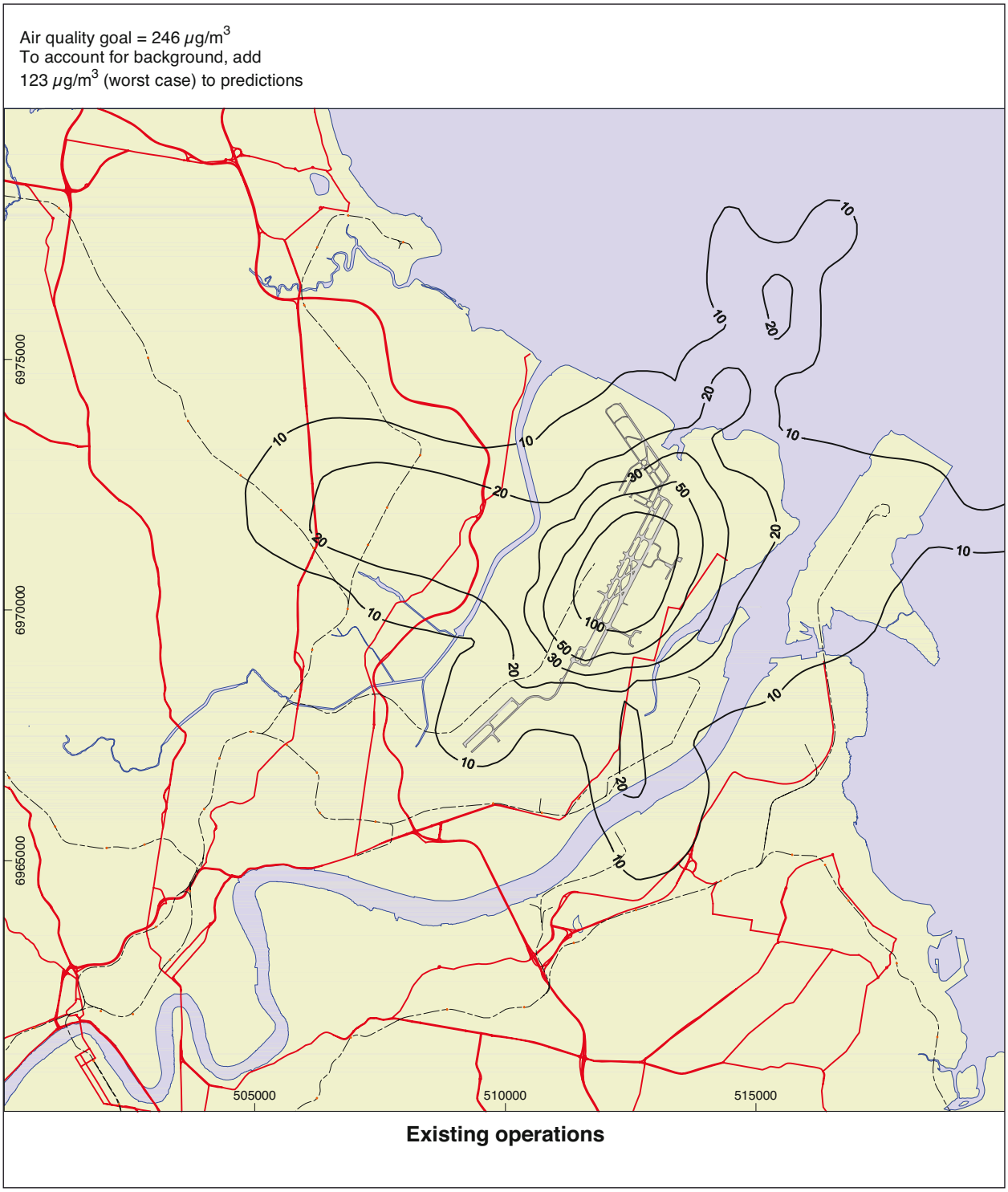
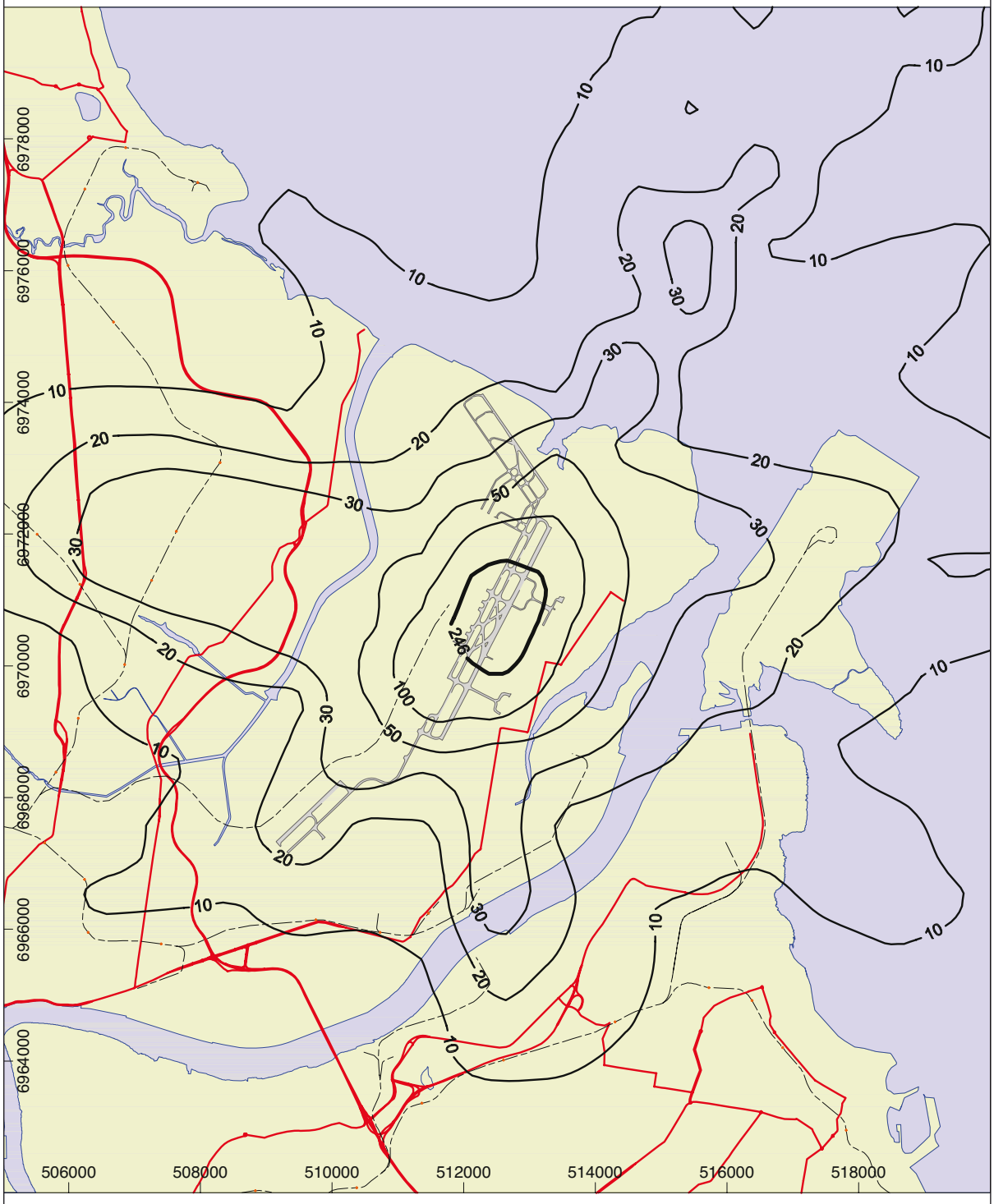


Figure 6.7m: *Predicted Maximum 1 Hour Average NO_2 Concentrations in 2015 (µg/m³) – Without NPR.*

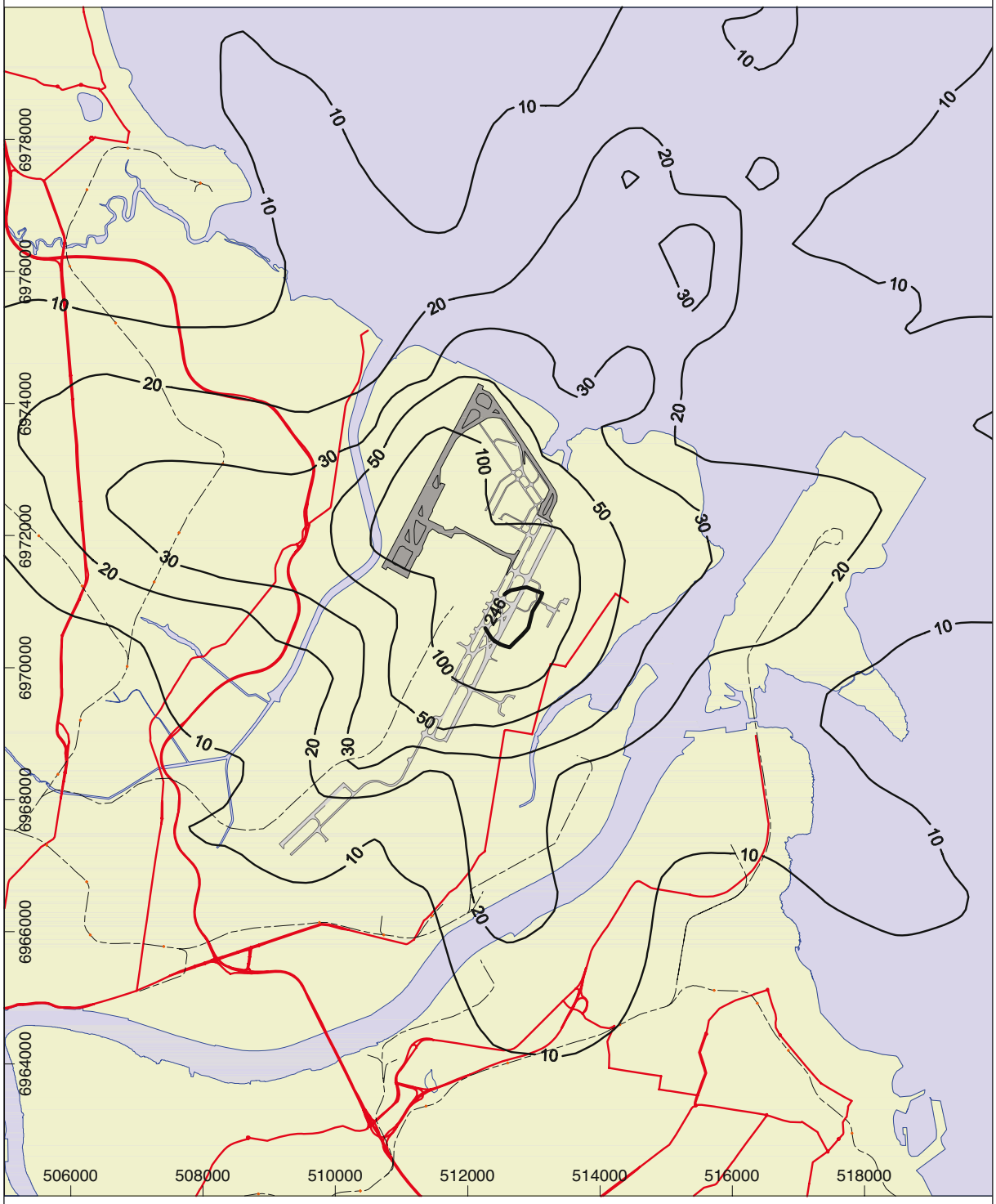
Air quality goal = 246 $\mu g/m^3$
To account for background, add
123 $\mu g/m^3$ (worst case) to predictions



Without NPR

Figure 6.7n: *Predicted Maximum 1 Hour Average NO_2 Concentrations in 2015 (µg/m³) – With NPR.*

Air quality goal = 246 $\mu g/m^3$
To account for background, add
123 $\mu g/m^3$ (worst case) to predictions



With NPR

Figure 6.7o: *Predicted Maximum 1 Hour Average NO_2 Concentrations in 2035 (µg/m³) – Without NPR.*

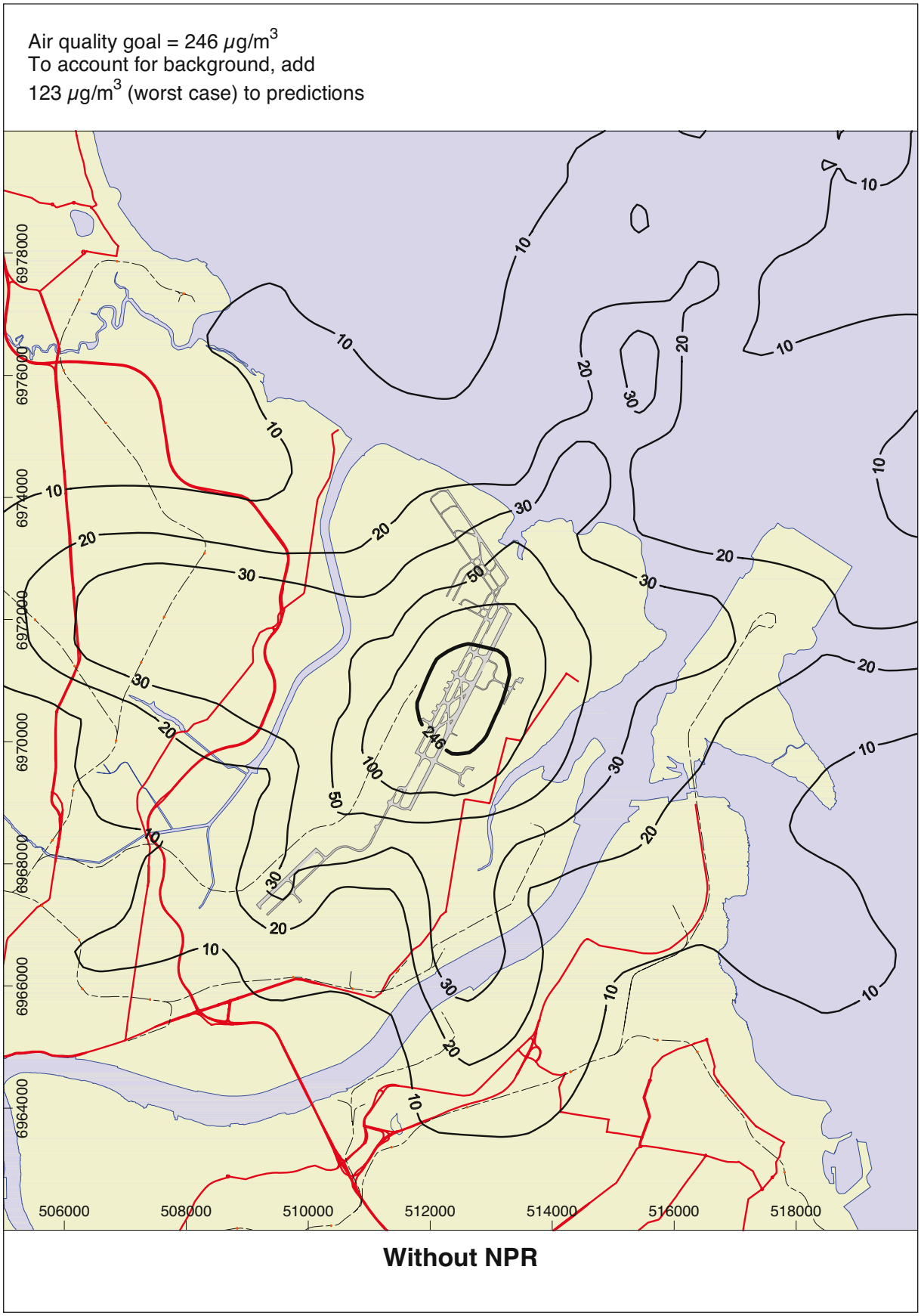
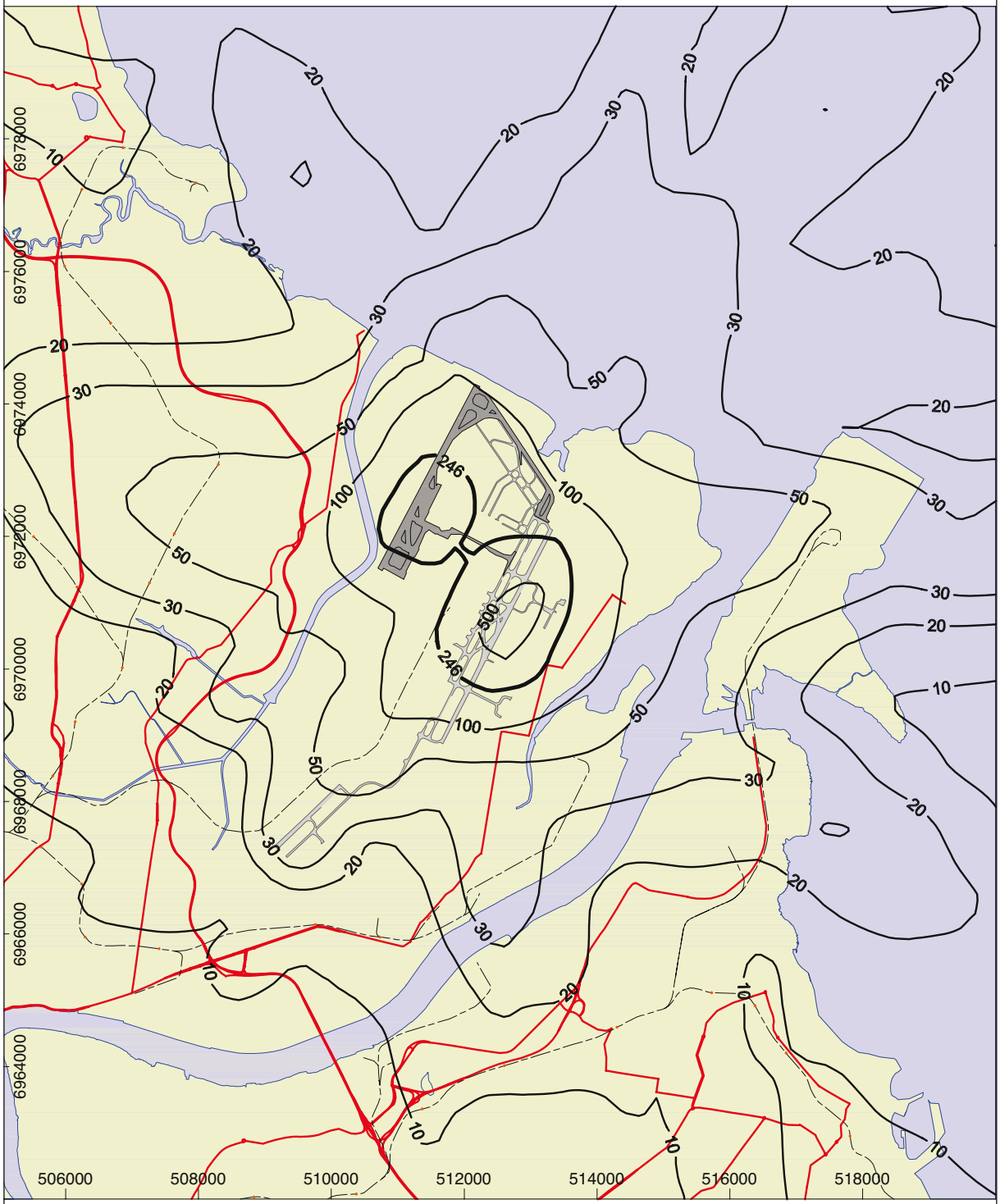


Figure 6.7p: *Predicted Maximum 1 Hour Average NO_2 Concentrations in 2035 (µg/m³) – With NPR.*

Air quality goal = 246 $\mu g/m^3$
To account for background, add
123 $\mu g/m^3$ (worst case) to predictions



With NPR

Figure 6.7q: *Predicted Annual Average NO_x Concentrations in 2005 (µg/m³).*

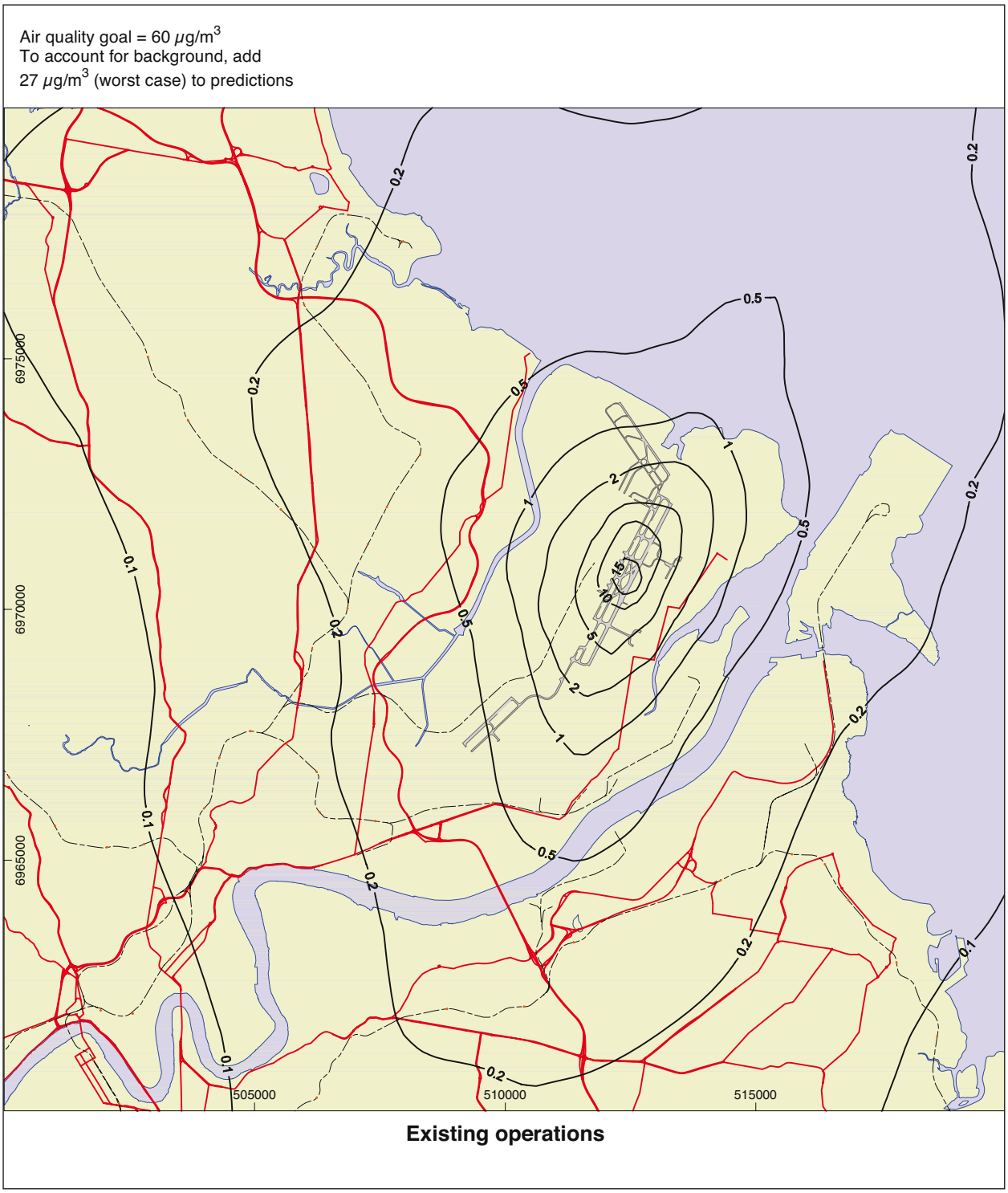


Figure 6.7r: *Predicted Annual Average NO_x Concentrations in 2015 (µg/m³) – Without NPR.*

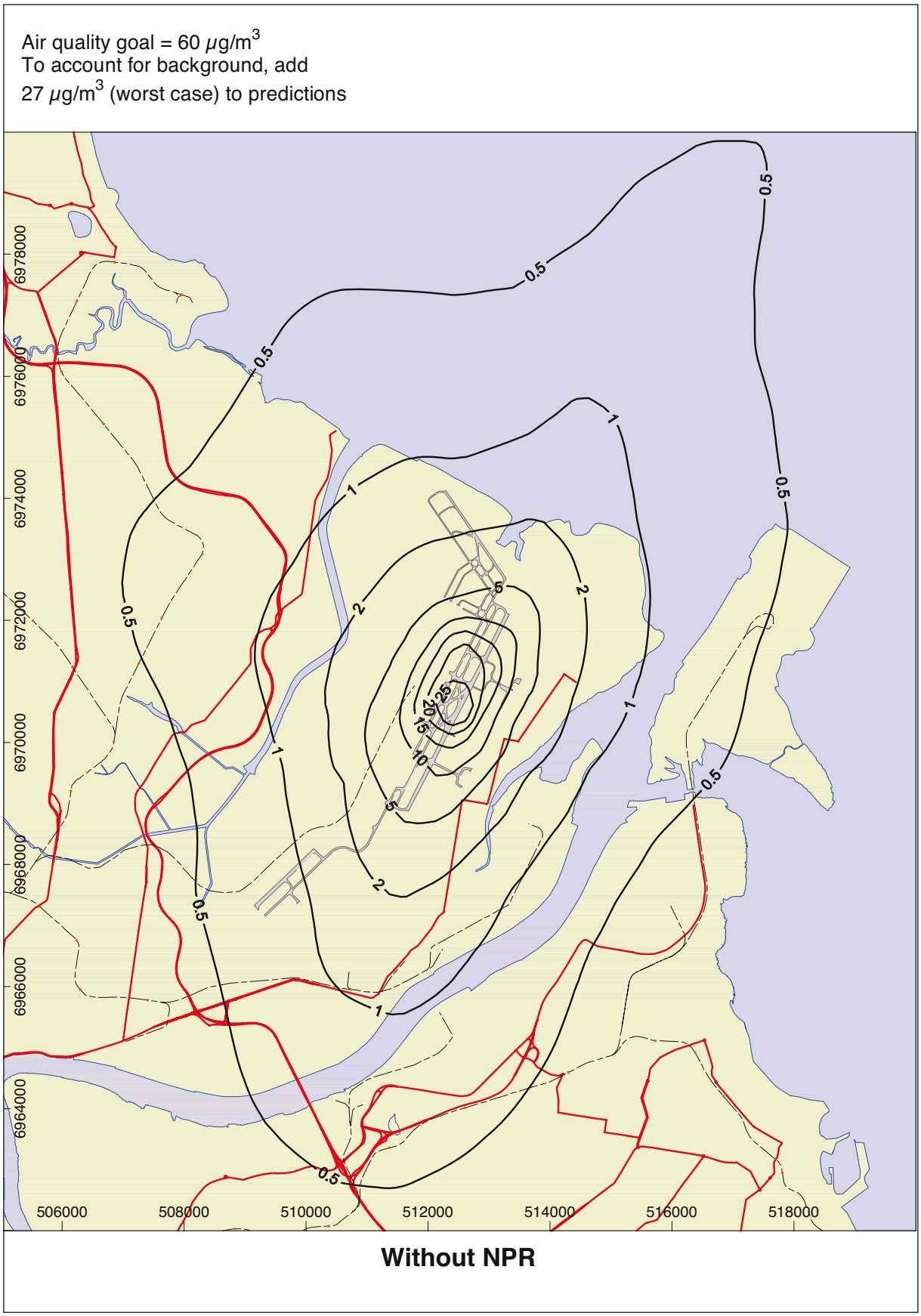
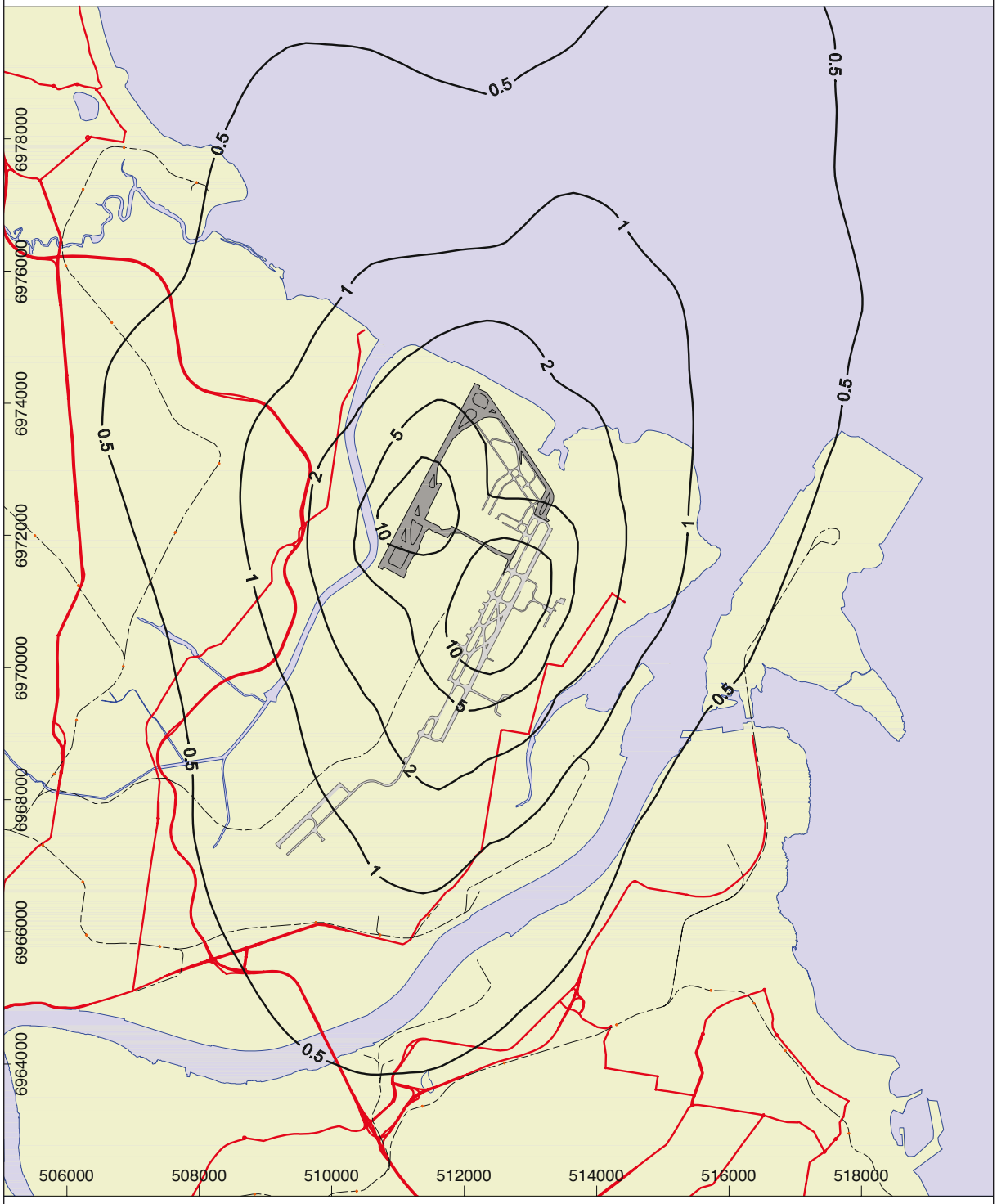


Figure 6.7s: *Predicted Annual Average NO_x Concentrations in 2015 (µg/m³) – With NPR.*

Air quality goal = 60 $\mu g/m^3$
To account for background, add
27 $\mu g/m^3$ (worst case) to predictions



With NPR

Figure 6.7t: *Predicted Annual Average NO_x Concentrations in 2035 (µg/m³) – Without NPR.*

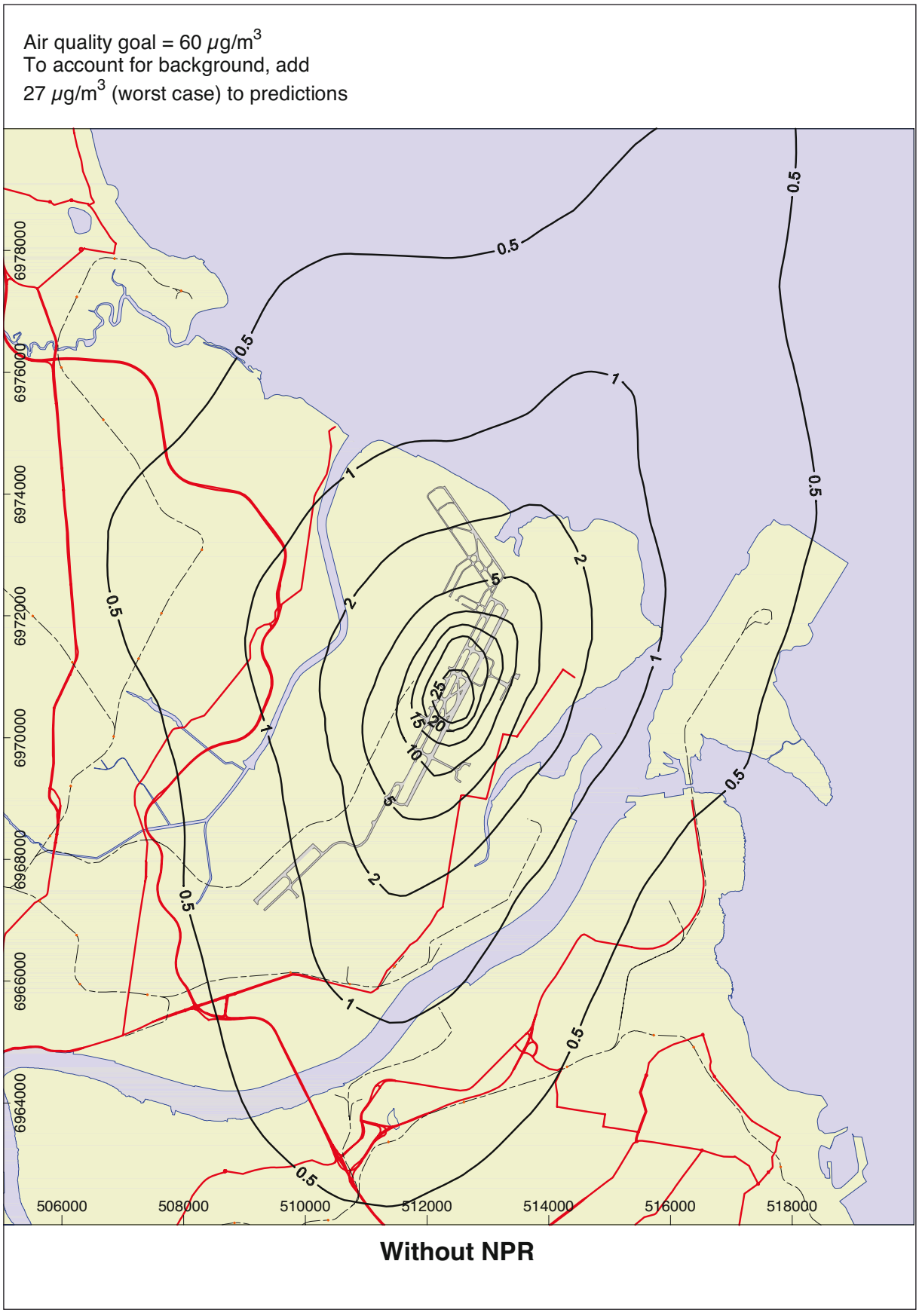


Figure 6.7u: *Predicted Annual Average NO_x Concentrations in 2035 (µg/m³) – With NPR.*

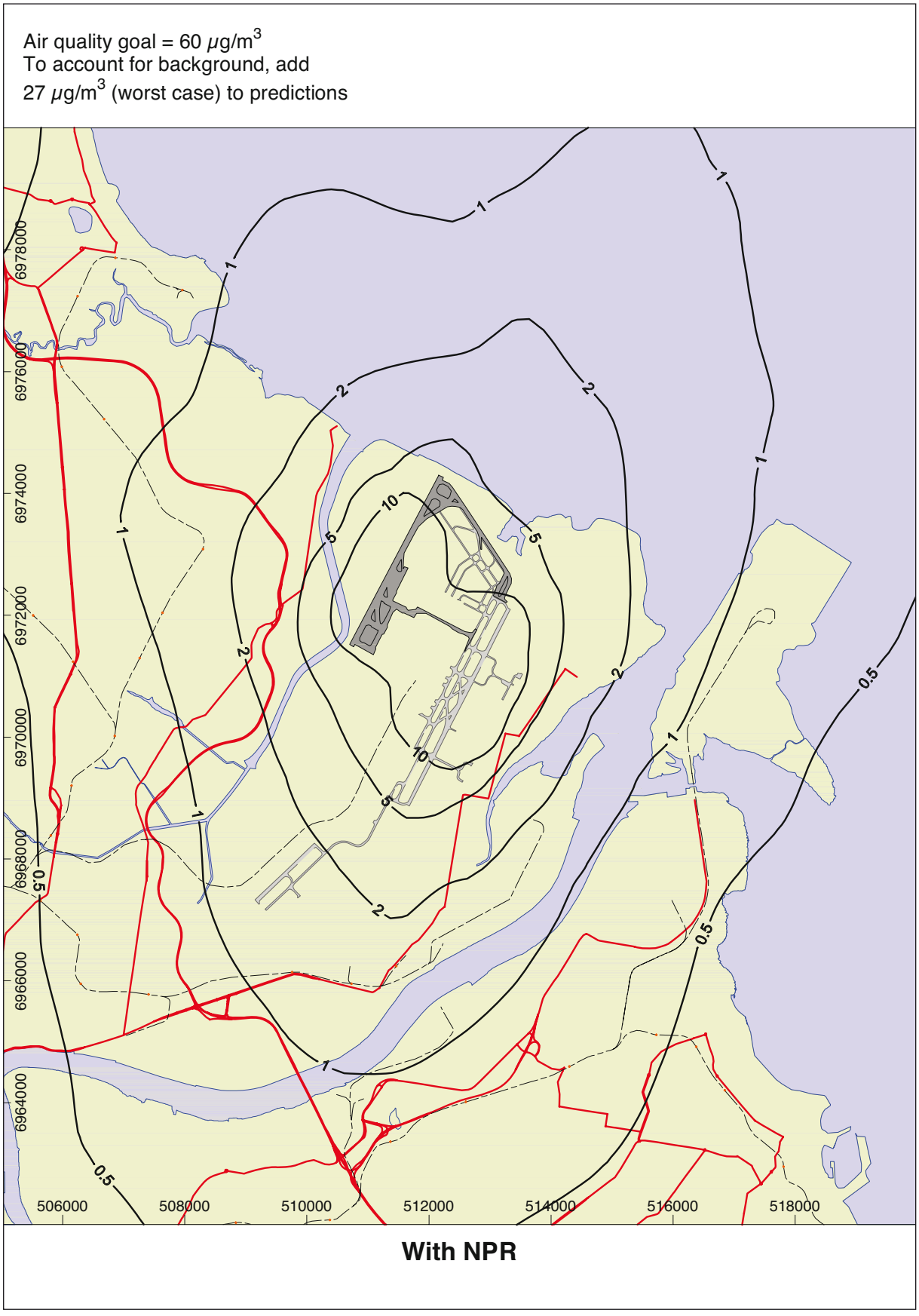


Figure 6.7v: *Predicted Maximum 24 Hour Average TSP (as PM_{10}) Concentrations in 2005 (µg/m³).*

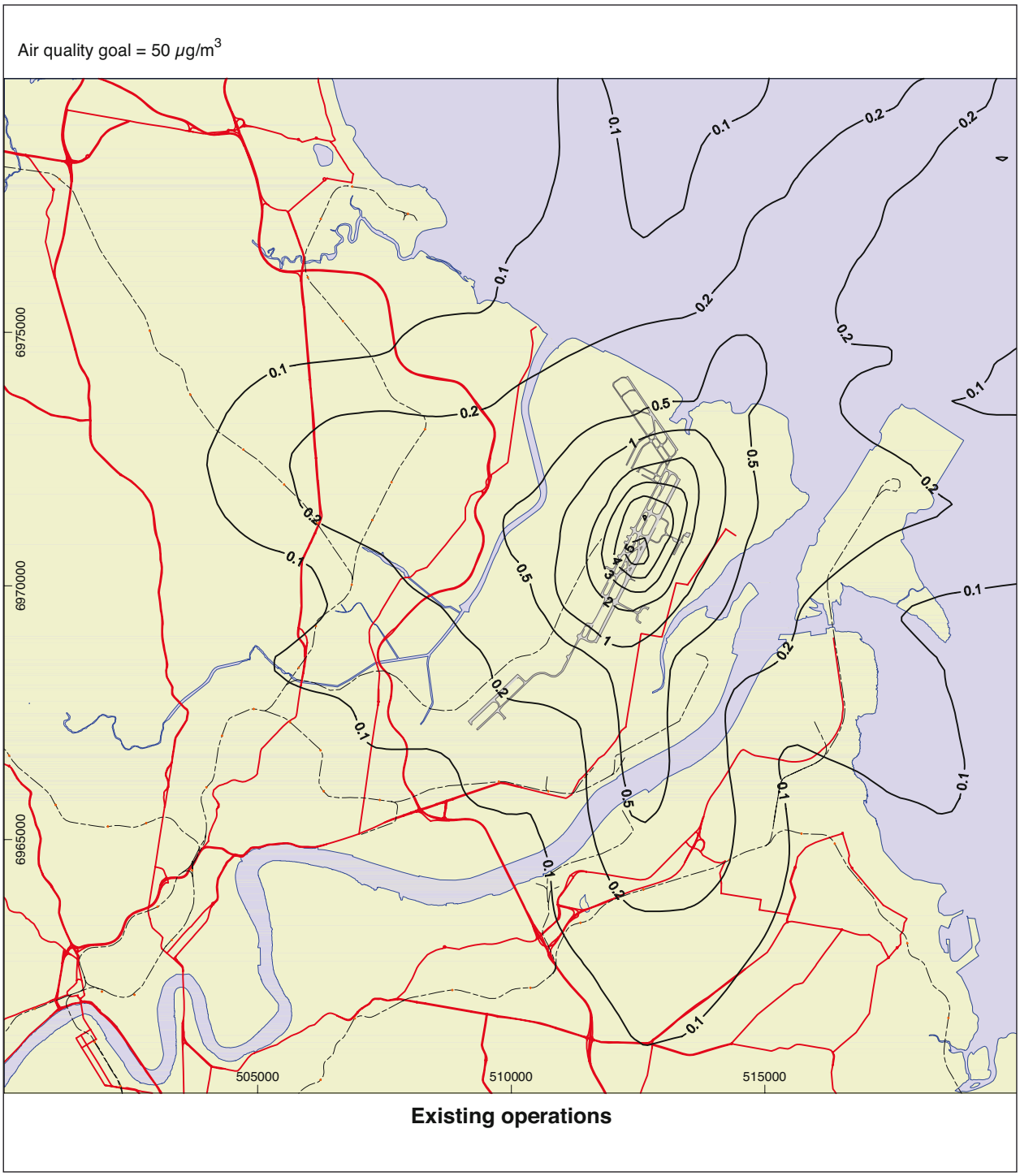


Figure 6.7w: *Predicted Maximum 24 Hour Average TSP (as PM_{10}) Concentrations in 2015 ($\mu g/m^3$) – Without NPR.*

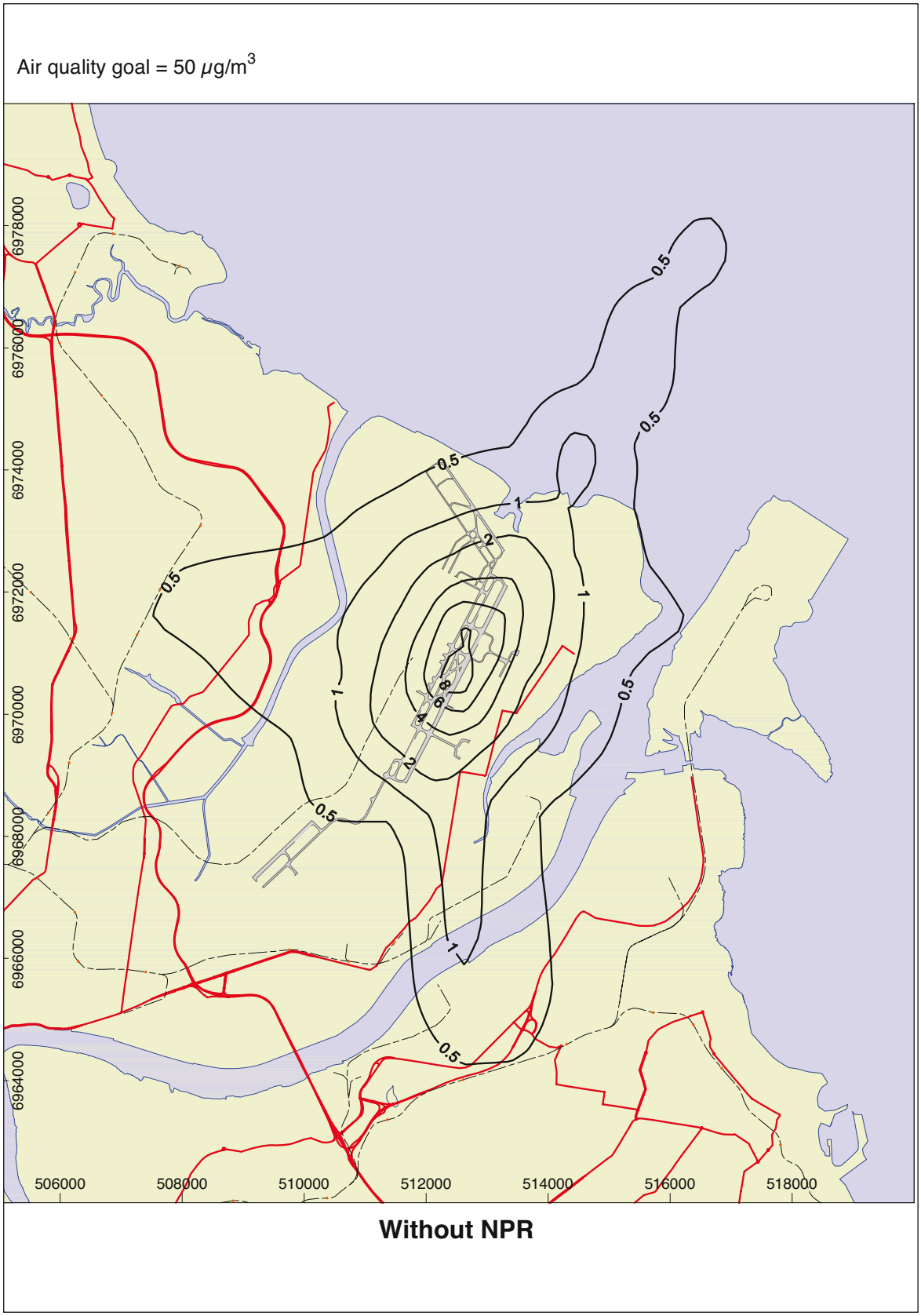


Figure 6.7x: *Predicted Maximum 24 Hour Average TSP (as PM_{10}) Concentrations in 2015 (µg/m³) – With NPR.*

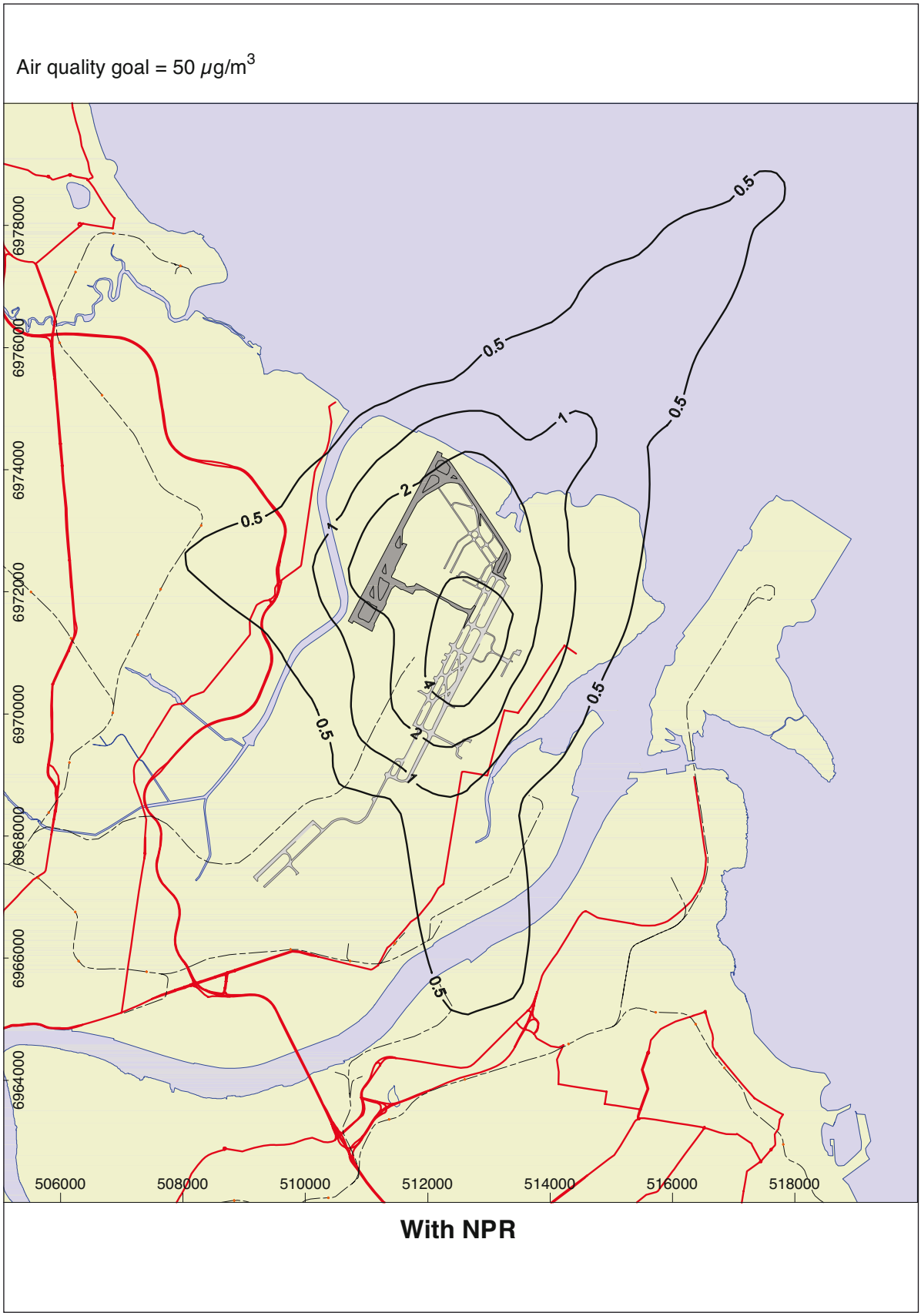


Figure 6.7y: *Predicted Maximum 24 Hour Average TSP (as PM_{10}) Concentrations in 2035 ($\mu g/m^3$) – Without NPR.*

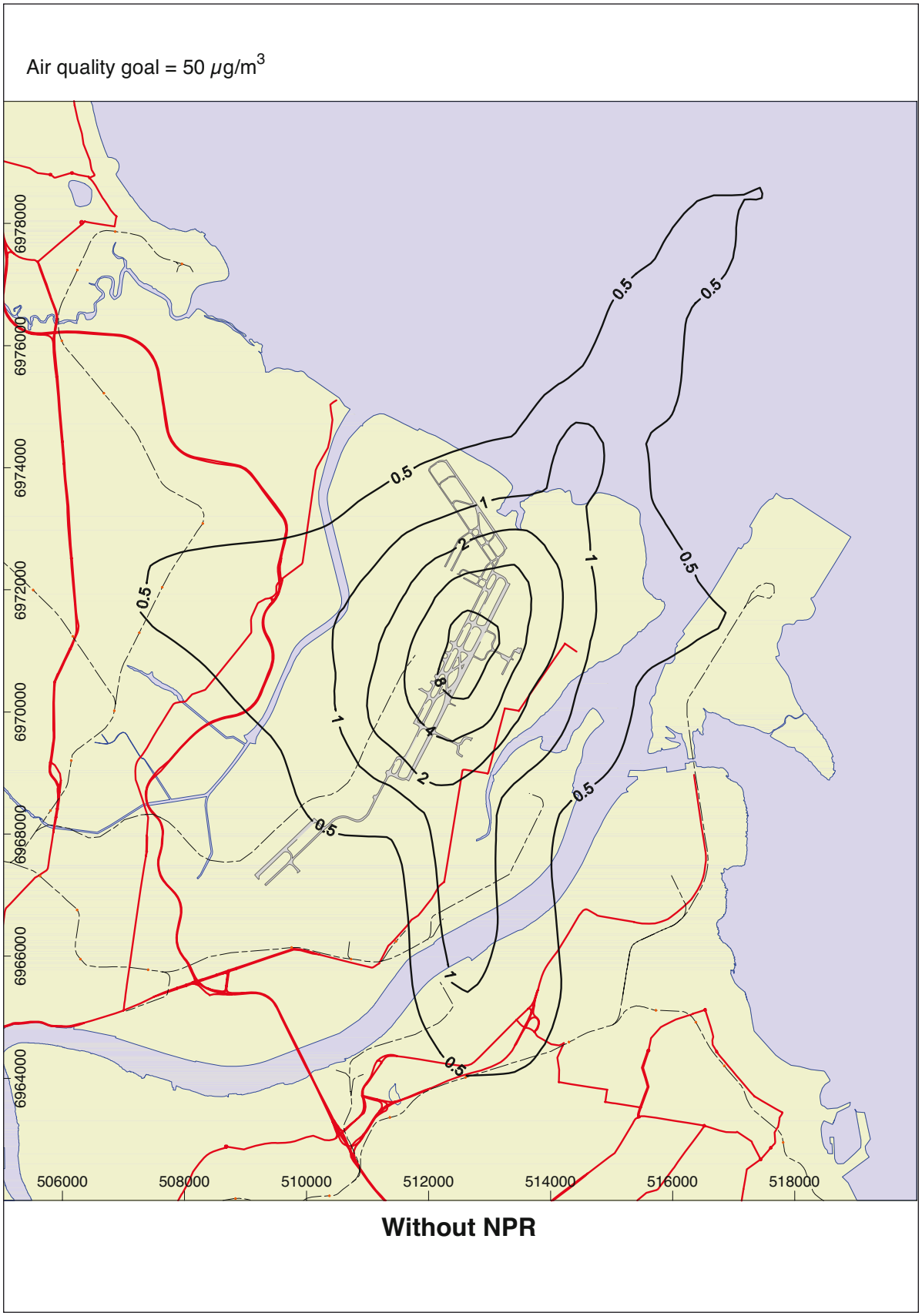


Figure 6.7z: *Predicted Maximum 24 Hour Average TSP (as PM_{10}) Concentrations in 2035 (µg/m³) – With NPR.*

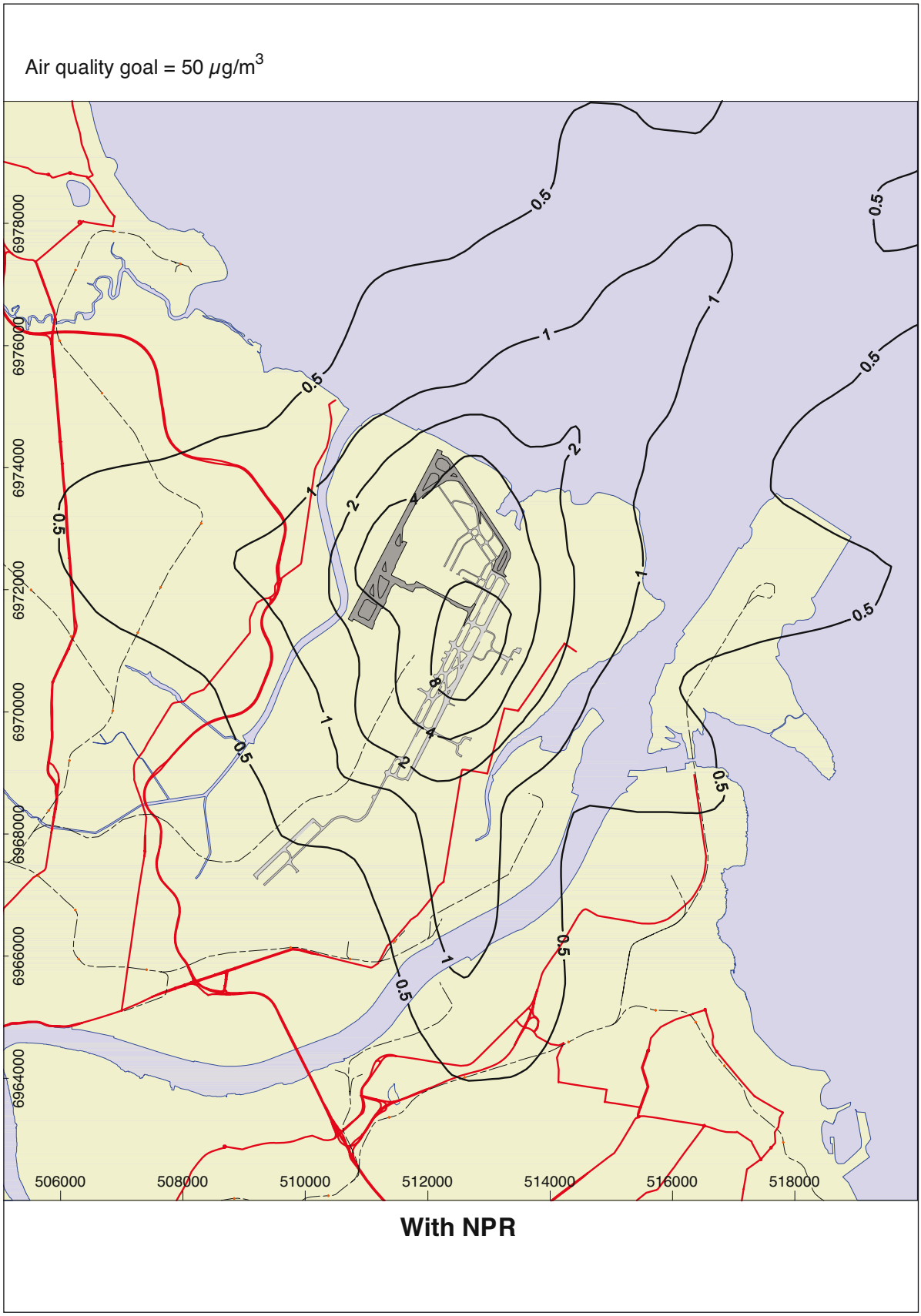


Figure 6.7aa: *Predicted Annual Average TSP (as PM_{10}) Concentrations in 2005 (µg/m³).*

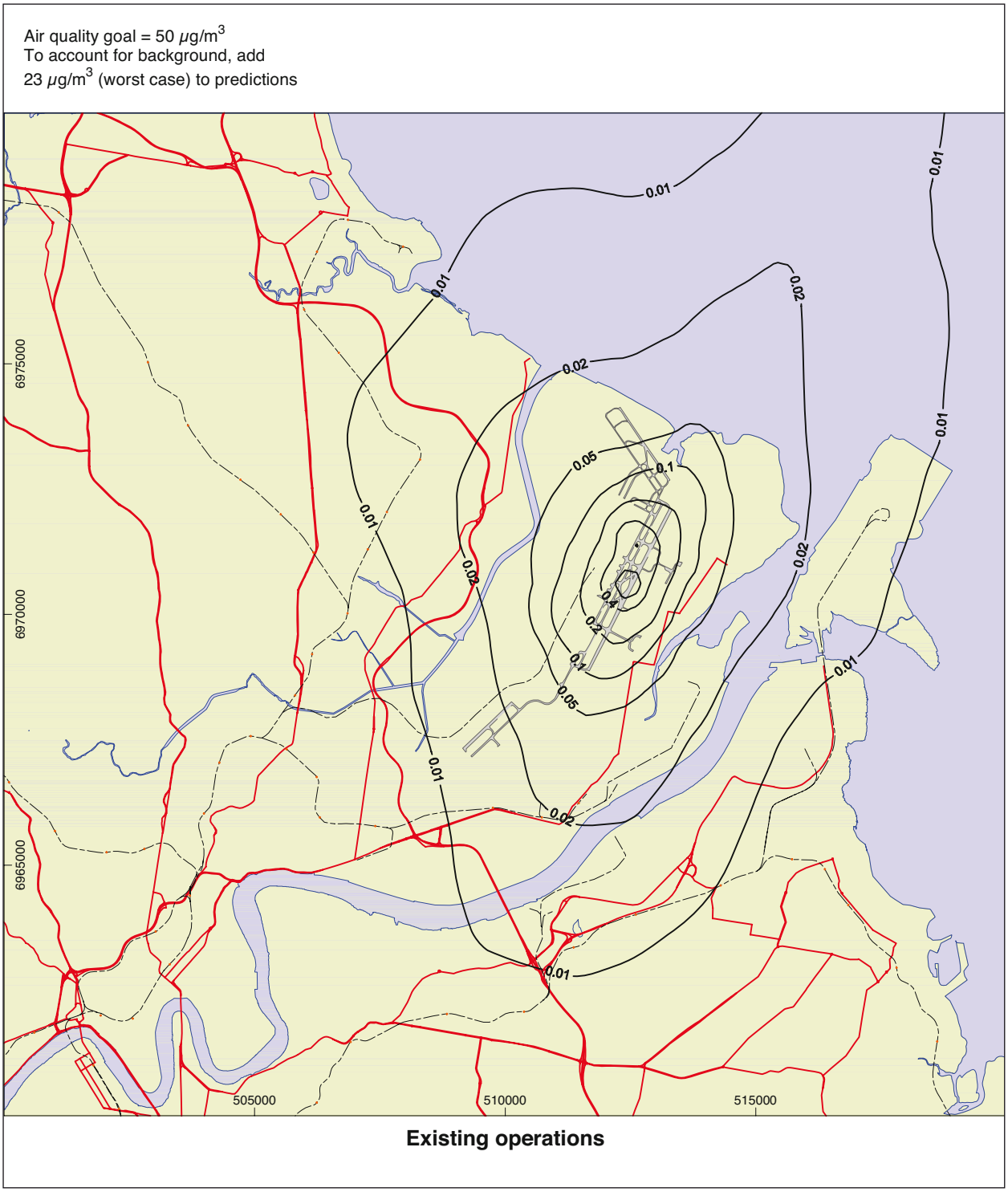
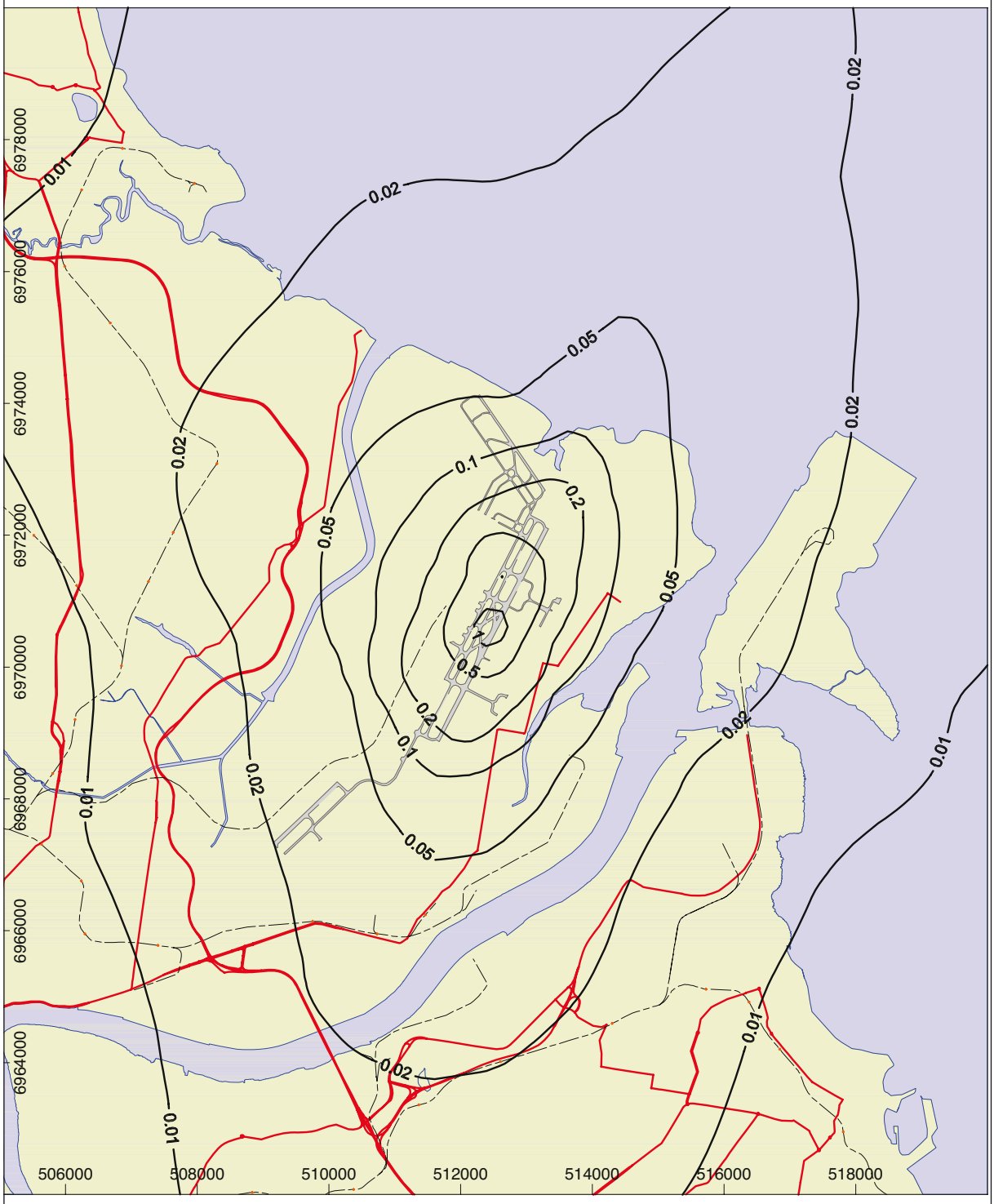


Figure 6.7bb: *Predicted Annual Average TSP (as PM_{10}) Concentrations in 2015 (µg/m³) – Without NPR.*

Air quality goal = 50 $\mu g/m^3$
To account for background, add
23 $\mu g/m^3$ (worst case) to predictions



Without NPR

Figure 6.7cc: *Predicted Annual Average TSP (as PM_{10}) Concentrations in 2015 (µg/m³) – With NPR.*

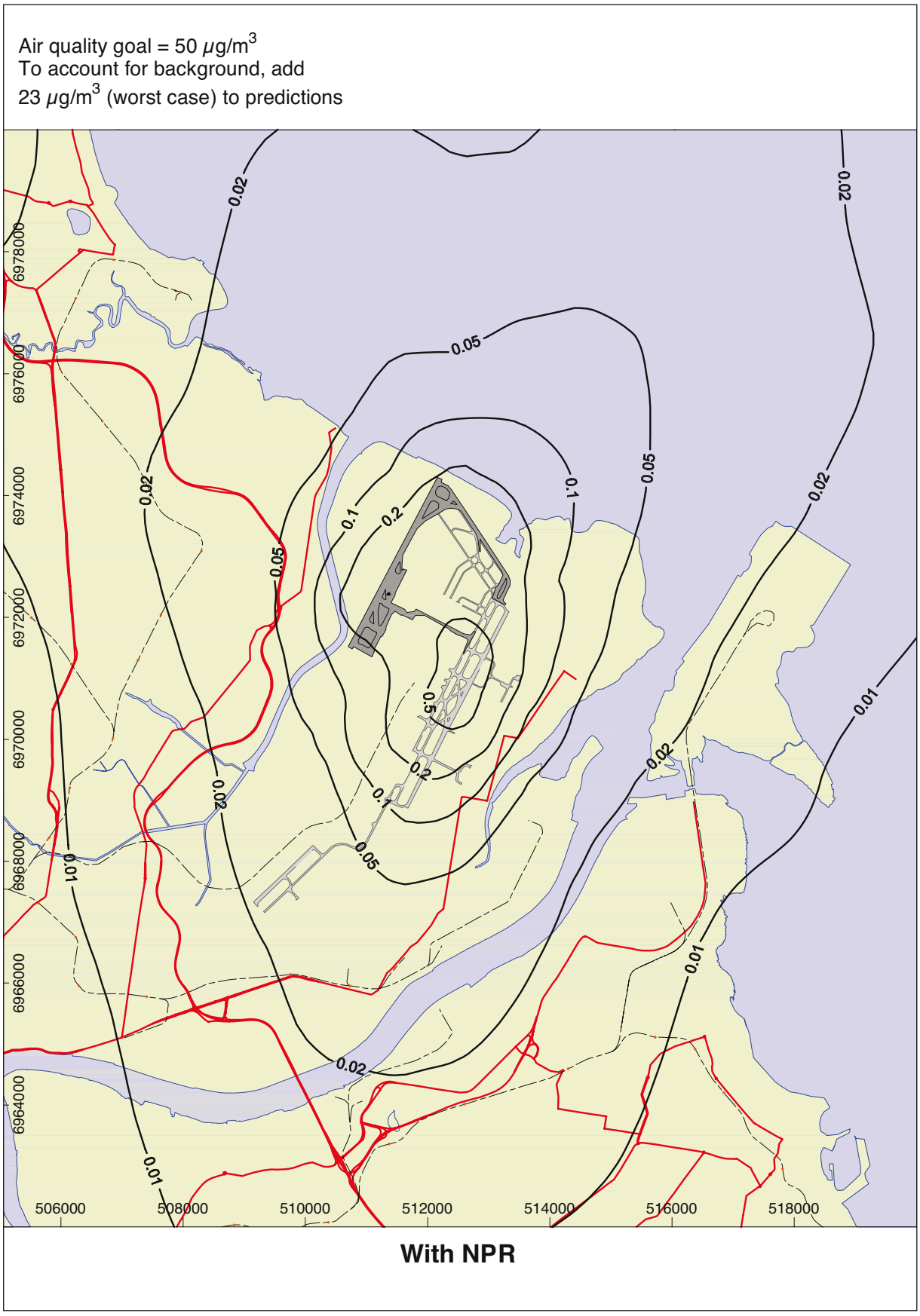
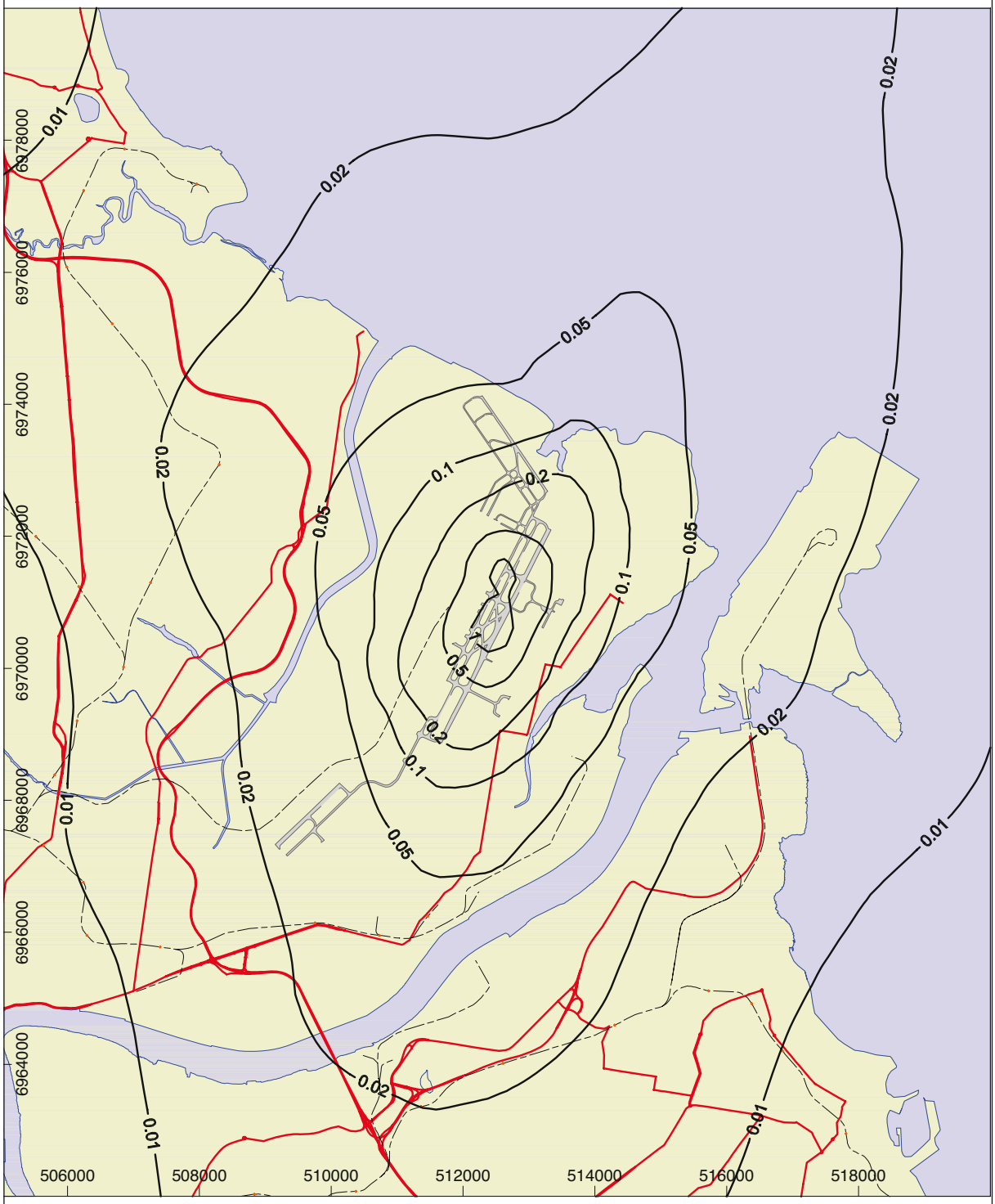


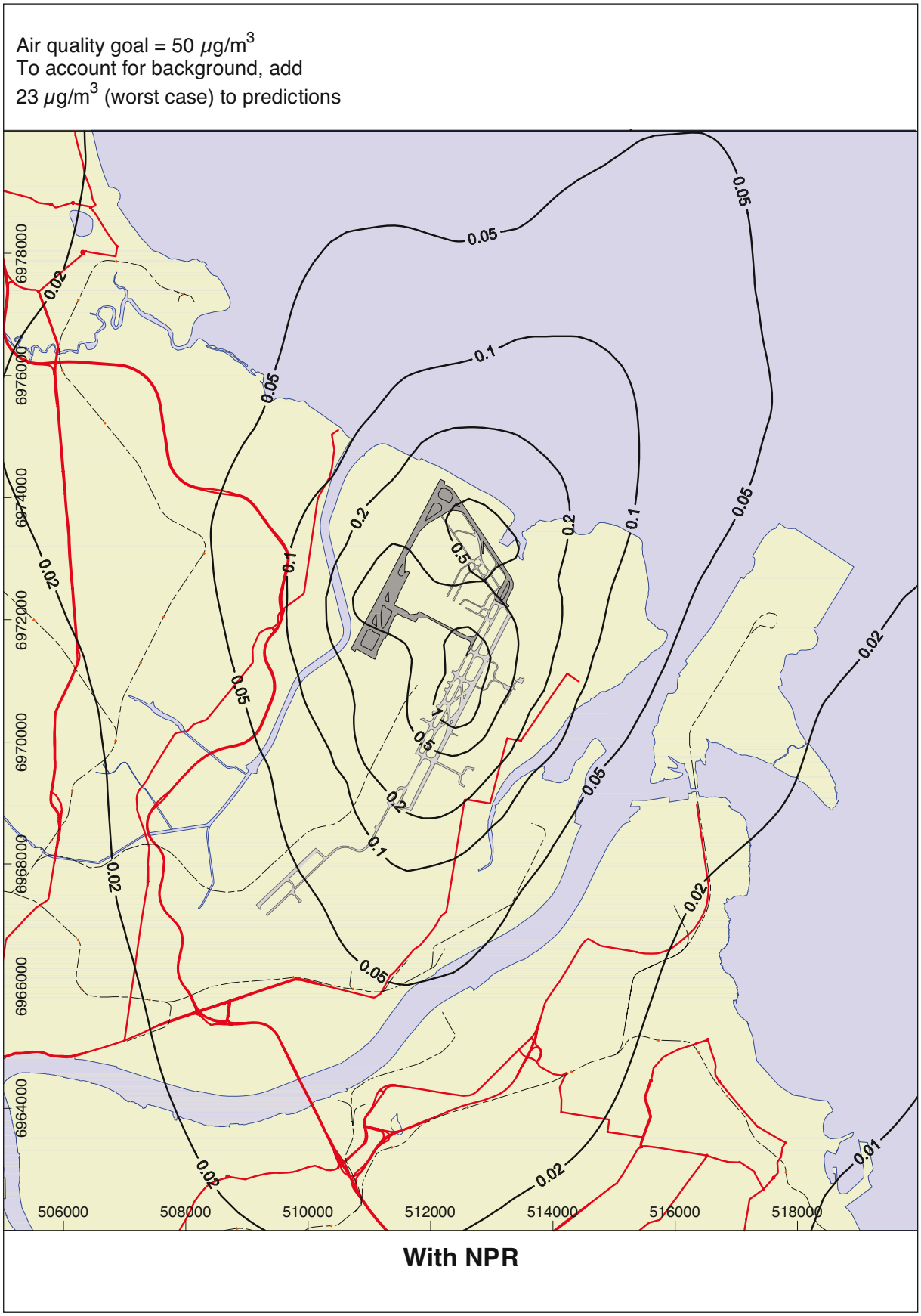
Figure 6.7dd: *Predicted Annual Average TSP (as PM_{10}) Concentrations in 2035 (µg/m³) – Without NPR.*

Air quality goal = 50 $\mu g/m^3$
To account for background, add
23 $\mu g/m^3$ (worst case) to predictions



Without NPR

Figure 6.7ee: *Predicted Annual Average TSP (as PM_{10}) Concentrations in 2035 (µg/m³) – With NPR.*



This page has been left blank intentionally.