



**New Zealand Sulphur Dioxide
Industrial Emission Inventory –
2007**

Prepared by Environet Ltd

**Prepared by Emily Wilton and Melanie
Baynes¹ and John Iseli²**

¹Environet Ltd

²Specialist Environmental Services

2008

Contents

1	Introduction	8
1.1	Sulphur Dioxide – SO ₂	8
1.2	New Zealand management of SO ₂	9
1.3	SO ₂ concentrations and sources in New Zealand	9
1.4	Health basis for SO ₂ guidelines	10
1.5	World Health Organisation updated air quality guidelines	14
1.6	Health impact basis for the WHO revision of the SO ₂ guideline	15
2	Inventory methodology	18
2.1	Inventory design	18
2.2	Identification of industry	18
2.3	Data collection	19
2.4	Emission factors	19
2.5	Emissions calculations	20
2.6	Quality Assurance	21
3	Survey Results	21
3.1	Sulphur content of New Zealand fuels	21
3.2	MW ratings of boilers in New Zealand	22
3.3	Annual coal and LFO consumption	23
4	Industrial SO ₂ emissions in New Zealand	24
	References	35
	Appendix A: SO ₂ Emissions Inventory - Industrial Questionnaire	37
	Appendix B: New Zealand Coal and Oil Properties	47

Tables

Table 1.1: Epidemiological Studies on the Health Impacts of SO ₂ up to 2000 ...	12
Table 1.2: 2005 Updated WHO Air quality guidelines	15
Table 1.3: Epidemiological Studies on the Health Impacts of SO ₂ since 2000. ...	17
Table 2.1: SO ₂ Emission Factors used in this report.....	20
Table 4.1: Regional summary of industrial sources of SO ₂ emissions	24
Table 4.2: Scale of industrial SO ₂ emissions in New Zealand.....	26
Table 4.3: SO ₂ Emissions from Industries in New Zealand	29

Figures

Figure 4.1: Annual SO ₂ emissions (tonnes/ year) by industry in New Zealand...	27
Figure 4.2: Maximum daily SO ₂ emissions (kilograms per day) by industry in New Zealand	28
Figure 4.3: Sector contributions to annual SO ₂ emissions in New Zealand.....	29

Acknowledgements

The information contained in this report was collated with the co-operation and assistance of a large number of industries throughout New Zealand. There are too many to list here, but all the time and help received from industry was much appreciated.

We would like to thank the following Regional Council staff for their help in providing industry lists and emissions assessments.

- Paul Baynham, Northland Regional Council
- Suzanne Watt, Otago Regional Council
- Richard Frizzel and David Jackson, Nelson City Council
- Jenny Keene, Marlborough District Council
- Rini Hidajat, Environment Canterbury
- Stefan Beaumont and Jonny Horrox, West Coast Regional Council
- John Engel, Southland Regional Council
- Jason Pene, Greater Wellington Regional Council
- John Phillips and Darryl Lew Hawkes Bay Regional Council
- Yves Denicourt and Shane Iremonger, Environment Bay of Plenty
- Gary Bedford, Taranaki Regional Council
- Harold Barnet, Horizons Regional Council
- Sarwan Kumar, Gisborne District Council
- Charles Kirkby, Auckland Regional Council
- Jonathon Caldwell, Environment Waikato
- Trevor James, Tasman District Council

The report and database were reviewed by Steve Goldthorpe of Steve Goldthorpe Energy Analysts.

Executive Summary

In 2006 the World Health Organisation (WHO) released updated air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide. The most significant revision was the WHO guideline for sulphur dioxide (SO₂) for a 24 hour averaging period, which was reduced from 125 µg m⁻³ to 20 µg/m³. A guideline concentration of 500 µg/m³ over a 10 minute averaging period was also introduced.

The New Zealand national environmental standard for ambient SO₂ is 350 µg/m³ for a 1-hour average with a maximum of 9 exceedances per year and a maximum of 570 µg/m³ for a 1-hour average (no allowable exceedances). The national environmental standard (NES) is a mandatory requirement for the management of air quality in New Zealand.

The Ministry for the Environment (MfE) is responsible for providing advice and guidance on the management of air quality in New Zealand. MfE has been requested by the National Air Quality Working Group to prepare a policy position on the WHO 2005 guidelines for SO₂. This report undertakes one of the first steps towards determining a policy position on SO₂ in New Zealand by quantifying the SO₂ output from industrial discharges.

The purpose of this report is to identify industry in New Zealand with significant discharges of SO₂ and to quantify the daily SO₂ emissions.

Industries with significant SO₂ emissions were identified using information from resource consent databases provided by Regional Councils. Key industry sources included were coal, light fuel oil (LFO) or used oil-fired boilers with a net rated heat output of 3 MW or greater, fertiliser manufacturing plants, asphalt plants (fired by LFO or waste oil), refineries, steel works, aluminium smelters, cement kilns, power stations and other combustion processes greater than 3MW burning coal, LFO or used oil.

Of a total of 245 industries considered, 133 met these criteria and were included in the inventory. A further 16 boilers that were slightly below the 3 MW rating were also included in the inventory. Sulphur dioxide emission estimates were made based on fuel use, production or emissions data provided by the industry or Regional Councils. The resulting maximum daily SO₂ emissions for each industry are shown in Figure E1.

SO₂ Emissions

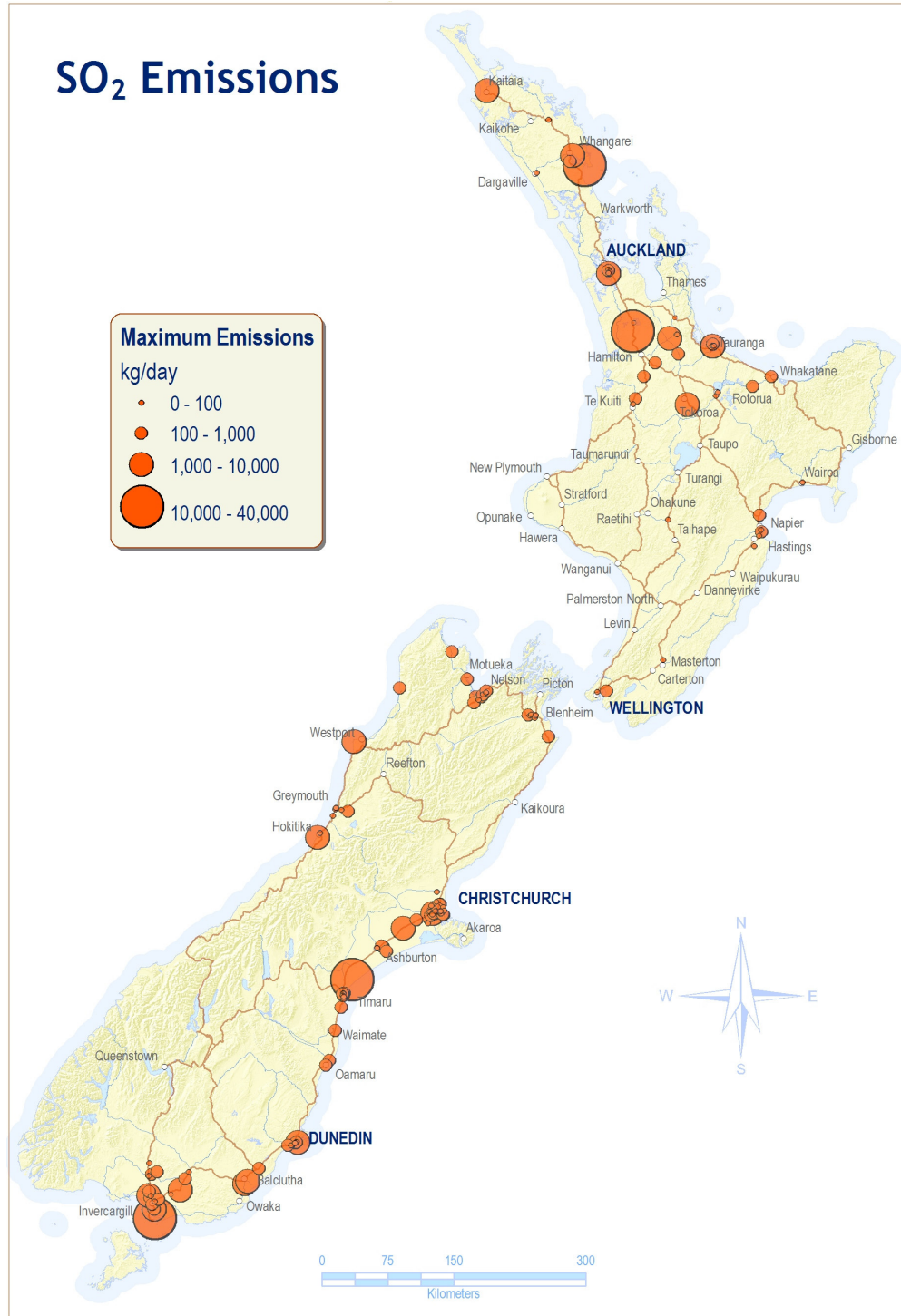


Figure E1: Maximum daily SO₂ industry emissions in New Zealand

1 Introduction

In 2006 the World Health Organisation (WHO) released updated air quality guidelines for what are considered to be contaminants. These contaminants are particulate matter, ozone, nitrogen dioxide and sulphur dioxide. The most significant revision was the WHO guideline for sulphur dioxide for a 24 hour averaging period, which was reduced from $125\mu\text{g m}^{-3}$ to $20\mu\text{g m}^{-3}$. A guideline concentration of $500\mu\text{g m}^{-3}$ over a 10 minute averaging period was also introduced.

In addition, the WHO 2005 air quality guidelines have been expanded to cover the whole world; previously they were for Europe only (WHO, 2005).

The New Zealand Air Quality Working Group that comprises of air experts from Regional Council and Unitary Authorities has requested a policy position from the Ministry for the Environment in relation to new WHO guideline for sulphur dioxide.

This report undertakes one of the first steps towards determining a policy position on SO_2 in New Zealand by quantifying the SO_2 output from industrial discharges.

1.1 Sulphur Dioxide – SO_2

Sulphur dioxide, or SO_2 , is a colourless gas with a sharp odour that belongs to the family of sulphur oxide gases (SO_x). It easily dissolves in water vapour to form acid, and interacts with other gases and particles in the air to form sulphates and other products that can be harmful to people and their environment.

Typically the main sources of sulphur dioxide are burning fossil fuels, smelting, paper manufacture and the production of sulphuric acid. The main natural sources of sulphur dioxide are volcanoes, forest fires and oceans.

Sulphur oxides and nitrogen oxides react with other substances in the air to form acids, which fall to earth as rain, fog, snow, or dry particles. This is generally called acid rain, and is not a common problem in New Zealand. In other countries especially in the Northern Hemisphere, acid rain is known to damage forests and crops, change the makeup of soil, and have made lakes and streams acidic and unsuitable for fish.

Overseas experience shows that continued exposure to SO_2 over a long time changes the natural variety of plants and animals in an ecosystem. It also accelerates the decay of building materials and paints.

Sulphur dioxide causes a wide variety of health impacts. It is a potent respiratory irritant when it is inhaled. Particularly sensitive groups include people with asthma, children, the elderly, and people with heart or lung disease.

The symptoms of SO_2 inhalation may include wheezing, chest tightness, shortness of breath, or coughing. If exposure occurs during exercise, the observed response may be accentuated because of an increased breathing rate associated with exercise.

1.2 New Zealand management of SO₂

The Ministry for the Environment (MfE) is responsible for providing guidance and advice on the management of air quality throughout New Zealand. In 1994 MfE published the first ambient air quality guidelines for New Zealand. These included values for SO₂ of 500 µg m⁻³ (10 minute), 350 µg/m³ (1 hour average), 125 µg/m³ (24-hour average) and 50 µg/m³ (annual average). Revisions to these were proposed in a discussion document (MfE, 2002), which also outlined results from a number of technical reports relating to health impacts of different contaminants. In 2002 MfE released the resulting updated Ambient Air Quality Guidelines. The guidelines for SO₂ were:

- 350 µg/m³ (1 hour average)
- 120 µg/m³ (24 hour average)

In 2004, MfE published the National Environmental Standards for Ambient Air Quality (NES). The environmental standards are mandatory and are administered under the Resource Management Act (1991). The NES for SO₂ is:

- 350 µg/m³ 1-hour average 9 exceedances
- 570 µg/m³ 1-hour average 0 exceedances

The standards came into effect in September 2005. This means that for SO₂ an ambient air quality concentration limit of 350 µg/m³ (one hour average) must be met for all but nine hours each year and a maximum ambient air quality concentration limit of 570 µg/m³ (one hour average) that must be met all of the time with no allowable exceedances.

The primary purpose of the ambient standards is to provide a guaranteed level of protection for the health of all New Zealanders. The SO₂ standard was selected specifically to manage point source SO₂ emissions in New Zealand (MfE, 2004). Regional Councils are also required to consider the cumulative effects of SO₂. The standards are averaged over an hour and based on preventing adverse health impacts on lung function and other respiratory symptoms of vulnerable sub-groups, including asthmatics. The maximum limit of 570 µg/m³ (one-hour average) is the same as the 1998 Australian national environmental protection measure for SO₂ (MfE, 2005).

1.3 SO₂ concentrations and sources in New Zealand

In 2003 MfE produced a report on 'Monitoring of CO, NO₂, SO₂, ozone, benzene and benzo(a)pyrene in New Zealand' (MfE, 2003a). The report notes that air quality monitoring for SO₂ in New Zealand has been carried out mainly in Canterbury and Auckland with limited monitoring in other locations. Christchurch data shows that in most areas 24-hour average concentrations were well below the 24-hour average SO₂ guideline of 120 µg/m³. The exception was the suburb of Hornby, an industrial area where SO₂ concentrations have approached the 24-hour average SO₂ guideline of 120 µg/m³. However, the report indicates that there were no guideline exceedances for either the one-hour average guideline of 350 µg/m³ or the 24-hour average from 1992–2001.

In Auckland (Penrose) and around some industrial sites, one-hour average SO₂ concentrations have been recorded as being near the maximum limit of the Air Quality Guideline (350 µg/m³, 1 hour average).

Based on the information that was available in the 2003 monitoring report, it would seem that SO₂ concentrations in urban areas are unlikely to exceed the NES of 350 µg/m³ (24-hour average) and 570 µg/m³ (1-hour average) in the absence of a significant point source discharge. Similarly, it would seem unlikely that ambient air concentrations of SO₂ would exceed 120 µg/m³ 24-hour average in urban areas of New Zealand unless there is a significant local point source discharge. It should be noted, however, that limited monitoring of SO₂ has been done in high density areas where coal burning is a predominant method of home heating.

The situation may change if the WHO revised 24-hour guideline for SO₂ were adopted. Ambient air quality monitoring in Christchurch and Timaru indicates SO₂ concentrations could exceed the 2005 WHO guideline of 20 µg/m³ (24-hour average). Monitoring results from the urban areas of Rangiora, Kaiapoi and Ashburton suggest that the 20 µg/m³ (24-hour average) guideline is unlikely to be exceeded in these areas.

Industry has been identified as the main source of SO₂ in most urban areas of New Zealand (MfE, 2003b). However, in areas where industrial emissions are minimal or domestic coal burning is prevalent, domestic heating can be the main source of SO₂. One example of this is Reefton where domestic heating is estimated to contribute at least 47% of the daily SO₂ emissions, compared with up to 39% from industrial emissions. Another example is Gore, where domestic heating is estimated to contribute 59% of the daily SO₂ emissions. Invercargill is the largest city in New Zealand that has a reasonable proportion of households using coal for domestic heating at 39% (Wilton, 2005). Meteorological conditions in Invercargill are also conducive to elevated pollution from low level sources such as domestic heating. Consequently, Invercargill may represent a location where exceedance of the 24-hour average WHO guideline for SO₂ may occur as a result of domestic coal burning.

1.4 Health basis for SO₂ guidelines

The health basis for the New Zealand Ambient Air Quality Guidelines is outlined in 'Health Effects of Five Common Air Contaminants and Recommended Protective Ranges' prepared by Denison et al (2000).

The report summarises the data up to 2000 on the health impacts of SO₂. These results are summarised in Table 1.1.

The results of clinical studies as well as a number of reviews of the health impacts of SO₂ were also considered by Denison et al. Key findings of these are outlined below:

- Experimental clinical studies up to 2000 showed that people with asthma may develop symptoms and decreases in lung function when exposed, to SO₂ concentrations in the range 700 to 1,400 µg/m³ during exercise. No effects were seen in healthy, non-asthmatic subjects at levels up to 2,800 µg/m³.

- The literature cited in Streeton (1997) indicates that exercising asthmatics are sensitive to short-term exposures to SO₂. Bronchospasm has been observed in some asthmatics exposed briefly (i.e., 10 to 15 minutes) at 710 µg/m³, and in 50% of asthmatics at 2,100 µg/m³. No similar effects are observed in healthy subjects below concentrations of 2,800 µg/m³.
- Epidemiological data on the human health effects of SO₂ exposure are difficult to interpret because of the relationship between this exposure and particle pollution.
- In 2000 the overall picture for SO₂ had not changed significantly since the National Environment Protection Council, Australia, review (Streeton, 1997).

Table 1.1: Epidemiological Studies on the Health Impacts of SO₂ up to 2000

Author	SO ₂ Concentration	Averaging period	Type of study	Health impact	Summary
Katsouyanni et al, (1997)	15 to 250 µg/m ³ across the entire study region.	Daily	Epidemiological	Daily mortality from all-cause, respiratory and cardiovascular causes	The increases in daily mortality per 50 µg m ⁻³ increase in 24-hour SO ₂ for the Western European cities were 3% for all-cause, 4% for cardiovascular and 5% for respiratory mortality.
Ponka et al (1998)	Between 1 and 41 µg/m ³	Daily	Epidemiological	Daily mortality	A significant positive association was found between 24-hour average SO ₂ levels and daily mortality from cardiovascular causes with a 7-day lag.
Lee et al, (1999)	Between 23–89 µg/m ³	Daily	Epidemiological	Daily mortality	A 12–13% increase in daily mortality per 143 µg m ⁻³ increment in 24-hour SO ₂ levels was observed.
Wietlisbach et al (1996)	The mean 24-hour average SO ₂ level during this study was 26 µg/m ³	Daily	Epidemiological	Daily mortality	A non linear relationship was found between SO ₂ and daily mortality but the effects were not significant in a multi pollutant model.
Anderson et al, (1997)	Mean 24-hour SO ₂ levels ranged from 21 to 53 µg/m ³	Daily	Epidemiological	Hospital admissions	Significant positive association has been found between 24-hour average SO ₂ levels and hospital admissions for COPD in six European cities.
Sunyer et al (1997)	Twenty-four-hour SO ₂ levels ranged from 1 to 220 µg/m ³ with an average for the cities of between 16 and 41 µg/m ³	Daily	Epidemiological	Hospital admissions	For the less than 15 years age group, a 7.5% increase in emergency room attendances for asthma per 50 µg m ⁻³ increment in 24-hour SO ₂ levels was observed.
Streeton, (1997)			Epidemiological	Respiratory	There is no consistent evidence that long-term levels of SO ₂ exposure influence the prevalence of respiratory symptoms or lung function
Lewis et al (1998)	Annual average SO ₂ levels ranged from 1.6 to 9.0 ppb.		Epidemiological	Respiratory	No significant associations were found for any health outcome with SO ₂ for children aged 8 to 10 years.

Timomen and Pekkanen (1997)	The mean 24-hour SO ₂ level was 6 µg/m ³ , with a maximum of 32 µg/m ³ .		Epidemiological	Respiratory health in children with asthma or cough	A significant negative association was found between SO ₂ and both evening PEF and upper respiratory symptoms in children with cough. The authors concluded that the lack of an effect in asthmatic children might have been due to the very low levels of SO ₂ during the study period and a possible lack of sensitivity of the diary method in picking up the effects.
-----------------------------	---	--	-----------------	---	---

Source: Adapted from Denison et al, 2000.

1.5 World Health Organisation updated air quality guidelines

The World Health Organisation is the directing and coordinating authority for health within the United Nations. The organization is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends (WHO, 2006).

WHO produced air quality guidelines in 1987. The guidelines were updated in 1997 and the results of this were published in 2000. The 2000 updated air quality guidelines were focused on Europe and did not have a global application (WHO, 2006). The guidelines for SO₂ were:

- 125 µg/m³ over a 24 hour averaging period
- 50 µg/m³ for an annual average.

In 2005 new guidelines were developed by WHO to apply worldwide. They were published in 2006 and are based on expert evaluation of current scientific evidence and were finalised during a meeting of experts in epidemiology, toxicology, air quality exposure assessment, air quality management, and public policy in Germany in October 2005. The experts recommend revised limits for the concentration of selected air pollutants: particulate matter (PM), ozone (O₃), nitrogen dioxide (NO₂) and sulphur dioxide (SO₂).

The main reasons for the update of the air quality guidelines include:

- Currently there are serious risks to health from exposure to PM and O₃ in many cities of developed and developing countries. It is possible to derive a quantitative relationship between the pollution levels and specific health outcomes (increased mortality or morbidity). This allows invaluable insights into the health improvements that could be expected if air pollution is reduced.
- Even relatively low concentrations of air pollutants have been related to a range of adverse health effects.
- Poor indoor air quality may pose a risk to the health of over half of the world's population. In homes where biomass fuels and coal are used for cooking and heating, PM levels may be 10–50 times higher than the guideline values.
- Significant reduction of exposure to air pollution can be achieved through lowering the concentrations of several of the most common air pollutants emitted during the combustion of fossil fuels. Such measures will also benefit programmes for the reduction of greenhouse gases (WHO, 2005).

Table 1.2 shows the updated WHO air quality guidelines. They are recommended to be achieved throughout the world in order to significantly reduce the adverse health effects of pollution.

Table 1.2: 2005 Updated WHO Air quality guidelines

Pollutant	Averaging time	AQG value
Particulate matter PM _{2.5}	1 year 24 hour (99th percentile)	10 µg/m ³ 25 µg/m ³
PM ₁₀	1 year 24 hour (99th percentile)	20 µg/m ³ 50 µg/m ³
Ozone O ₃	8 hour, daily maximum	100 µg/m ³
Nitrogen dioxide NO ₂	1 year 1 hour	40 µg/m ³ 200 µg/m ³
Sulphur dioxide SO ₂	24 hour 10 minute	20 µg/m ³ 500 µg/m ³

Source: World Health Organisation 2005.

As part of the updated air quality guidelines WHO developed interim targets that are intended to be incremental steps in reducing air pollution. The interim targets are designed to reflect the different levels of resources throughout the world to manage air quality. Their main purpose is to account for reducing pollution in developing countries. For example, for PM₁₀ the WHO guideline is 50 µg/m³, however there are three interim targets of 150 µg/m³, 100 µg/m³ and 75 µg/m³ (WHO, 2005).

For SO₂ the WHO interim target is 50 µg/m³ for the 24 hour average. The WHO considered that the 50 µg/m³ goal could be achieved by controlling motor vehicles, industrial emissions or power production. There is no interim target for the 10 minute average.

1.6 Health impact basis for the WHO revision of the SO₂ guideline

Studies indicate that a proportion of people with asthma experience changes in pulmonary function and respiratory symptoms after periods of exposure to SO₂ as short as 10 minutes. For this reason the 10 minute average 500 µg/m³ guideline has been developed.

The revision of the 24-hour guideline for SO₂ from 125 to 20 µg/m³ is based on the following considerations:

- Health effects are now known to be associated with much lower levels of SO₂ than previously believed. A greater degree of protection is needed.

- Although the causality of the effects of low concentrations of SO₂ is still uncertain, reducing SO₂ concentrations is likely to decrease exposure to co-pollutants.

Table 1.3 outlines some of the health impact studies that have been undertaken since 2000 that provide improved detail on the health effects of SO₂ and were used as the basis by WHO to revise the SO₂ guideline.

Table 1.3: Epidemiological Studies on the Health Impacts of SO₂ since 2000.

Author	Averaging period	Type of study	Health impact	Summary
Hedley et al, (2002)	10 minutes	Epidemiological	Childhood respiratory disease and all age mortality outcomes	A major reduction in sulphur content in fuels over a very short period of time shows an associated substantial reduction in health effects.
Wong et al, (2002)		Epidemiological	Hospital admissions for cardiac disease	No evidence of a concentration threshold within the range of 5-40 µg/m ³ of SO ₂ in both Hong Kong and London.
Burnett et al, (2004)	Daily	Epidemiological	Daily mortality	Daily SO ₂ concentration was significantly associated with daily mortality in 12 Canadian cities.
Wichmann et al., (2000)	Daily	Epidemiological	Daily mortality	Germany showed a strong reduction in SO ₂ concentrations over a decade. Although mortality also decreased with time, the association between SO ₂ and mortality was not judged to be causal. The fall in mortality was instead attributed to a similar time trend in a different pollutant (PM).
Buringh, Fisher & Hoek, (2000)	Daily	Epidemiological	Daily mortality	Netherlands showed a strong reduction in SO ₂ concentrations over a decade. Although mortality also decreased with time, the association between SO ₂ and mortality was not judged to be causal. The fall in mortality was instead attributed to a similar time trend in a different pollutant (PM).

Source: Adapted from World Health Organisation, 2005.

2 Inventory methodology

2.1 Inventory design

The key issue for which the inventory is being designed is the potential health impacts of daily exposure to SO₂ for New Zealand. This dictates the following design parameters:

- Scope - National.
- Contaminant - SO₂.
- Temporal resolution - 24-hour average.

Sources included in the inventory were limited to industrial sources and key contributors were identified as coal-fired, light fuel oil-fired and used oil-fired boilers greater than 3 MW net output, other large-scale combustion sources burning these fuels, asphalt plants burning used oil or LFO, power stations, smelters, steel works, cement kilns, refineries and fertiliser manufacturers.

The proposed temporal resolution is worst case and average 24-hour SO₂ emissions with an estimate of seasonal variations in average consumption. The latter provides an indication of consistency of the discharge across a year.

The inventory collected emission estimates and fuel consumption data based on the most recent year which was 2007. However, as the objective of the inventory was to provide the basis for a 2008 assessment of the impact of SO₂, industries that had ceased to discharge by May 2008 were excluded from the assessment. Similarly, new plants such as Synlait (Canterbury), Dairy Trust (Southland) and New Zealand Dairies (Canterbury) which were not fully operational in 2007 were included in the assessment.

2.2 Identification of industry

The following process was undertaken to identify industries to be included in the inventory:

1. Existing industry lists were examined from emission inventories, in-house knowledge and other information provided to identify knowledge gaps.
2. Regional Council staff were contacted and briefed on the project and requested to assist with the provision of information from Council data bases and the identification of industries.
3. A list of potential industries for each Region was established.

The information that was collected during this period included the discharge type, scale of the operation, contact details and the location of the industry, where this was readily available from Council databases.

Two hundred and forty five industries were identified as probable or possible sources of significant SO₂ emissions.

2.3 Data collection

All industry identified by Council staff as probable or possible significant SO₂ dischargers were surveyed using a combination of a mail survey and six weeks of follow up phone calls.

The activity data that was collected via the survey included average daily fuel consumption and seasonal variations, worst case fuel consumption and frequency of occurrence, fuel type/ quality (including coal type/ types or average sulphur content), and results of emissions tests, where available. A copy of the survey form is in Appendix A.

Responses were received from around 236 of the 244 industries originally surveyed. Of these, 93 were found not to meet the criteria specified for significant SO₂ discharges in a preliminary assessment. Two industries were not able to be found and were assumed to be decommissioned. Of the 149 industry appearing to meet the criteria, 16 industries supplied survey information indicating that they did not meet the 3MW requirement. One industry was removed from the database after providing survey information because the operation ceased during the survey period.

Once the activity data was collected it was compared to data collated by Bioenergy Association of New Zealand (BANZ) from the '*Heat Plant in New Zealand - Heat Plant Sized Greater than One Hundred Kilowatts Thermal Segmented by Industry Sector as at March 2008*' database. An additional four potential boilers were identified as a result of this comparison. Three of these were found to be no longer operational and one additional boiler was surveyed. A total of 149 industries were therefore included in the inventory.

Around ten industries refused to provide survey information. Information for these industries was obtained using a combination of information from historical emission inventories, information from resource consent files, emission estimates from Regional Council staff or worst case emission estimates from other similar industry if no other data were readily available.

No industries meeting the criteria were found in the Taranaki or Gisborne areas.

2.4 Emission factors

An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors are averages of all available data from a particular process that are of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category. Reliable emission factors have been developed for SO₂ from combustion sources because emissions can be calculated from the conversion of sulphur in the fuel. In this report, emission factors were used for coal and oil combustion and for asphalt production.

Sulphur oxides from coal burning are primarily sulphur dioxide (SO₂), with a much lower quantity of sulphur trioxide (SO₃) and gaseous sulphates. These compounds form as the organic and pyritic sulphur (FeS₂) in the coal are oxidized during the combustion process. The emission factors for SO₂ used in this report are listed in Table 2.1. Because of variation in the types of coal burned throughout New Zealand and differences between NZ and USA coals (where the AP42 factors were derived), it

has been conservatively assumed for this study that 95% of sulphur present in coal is converted to SO₂.

During oil combustion, sulphur oxides (SO_x) are emitted as a result of the oxidation of sulphur contained in the fuel and are dominated by SO₂. The main determinant is the sulphur content of the fuel and factors such as boiler size or burner design have no impact. On average, more than 95 percent of the fuel sulphur is converted to SO₂, about 1 to 5 percent is further oxidized to sulphur trioxide (SO₃), and 1 to 3 percent is emitted as sulphate particulate (USEPA, AP42). For the purpose of this study it has been conservatively assumed that all sulphur in fuel oils is converted to SO₂.

Table 2.1: SO₂ Emission Factors used in this report

Combustion Source	Emission Factor	Unit	Source
Coal-fired boiler	19 x S ¹	kg/tonne coal burnt	Stoichiometry (based on 95% conversion to SO ₂)
LFO or Used Oil-fired boiler	20 x S	kg/tonne oil burnt	Stoichiometry (based on 100% conversion to SO ₂)
Asphalt plant	15 x S less S retained in product ²	kg/tonne asphalt produced	Footnote c, AP-42 Table 11.1-7

¹ Where S = percentage sulphur content by weight in fuel.

² S retained in product equates to 50% of the sulphur up to 0.05kg SO₂ per tonne of product

2.5 Emissions calculations

Daily SO₂ emissions were calculated for each industry based on one of three methods:

1. Results of SO₂ emission testing, provided by the industry and reworked to kg/day.
2. Application of emission factors to fuel use data provided by industry.
3. Estimates of the emission rate of SO₂ (g/sec or kg/day) provided by the industry or via the resource consent.

Average daily and maximum daily SO₂ emissions were estimated using equations 2.1 to 2.4. Seasonal variations in emissions were estimated based on survey information provided by industry.

Equation 2.1 Average emissions (kg/day) = Average emission rate (g/s) x 3.6 x hours operated per day

Equation 2.2 Maximum emissions (kg/day) = Maximum emission rate (g/s) x 3.6 x hours operated per day

Equation 2.3 Average emissions (kg/day or tonnes/year) = Emission factor (kg/tonne) x Average fuel use (tonnes/day or tonnes/ year)

Equation 2.4 Maximum emissions (kg/day) = Emission factor (kg/tonne) x Maximum fuel use (tonnes/day)

For coal and oil-fired boilers, estimates of fuel use in tonnes per day were based on annual fuel consumption and the days that the boiler was operating as per the following equation:

$$\text{Equation 2.5} \quad \text{Daily fuel (tonnes)} = \text{Annual use (tonnes)} \times \text{seasonal factor (\%)} / \text{days the burner is operated for that season}$$

Seasonal factor is the proportion of annual fuel use that is consumed during the season for which daily fuel use was estimated and was obtained from industry.

2.6 Quality Assurance

Survey data were manually entered into a Microsoft Excel spreadsheet for subsequent analysis. A number of quality assurance checks were made on these data. These included:

- Annual fuel consumption data appropriate compared with other data provided.
- Sulphur contents of coal provided were consistent with coal types specified. Industries with disparate results were contacted to clarify coal and sulphur contents.
- Sulphur contents of coal were consistent with resource consent maximum coal limits (i.e., less than) where the latter information had been provided by Councils.
- Validation/ recheck of all data entry by data entry staff and coal consumption and sulphur content by the project manager.

3 Survey Results

3.1 Sulphur content of New Zealand fuels

The two most common high sulphur fuels used in New Zealand are coal and LFO. Information on the sulphur content of the fuels used was provided by industry via the survey. In most cases industries with coal fired boilers identified the coal type and provided the sulphur content. For around one third of the coal boilers the sulphur content provided was the average sulphur content for that coal as specified in the New Zealand Energy Information Handbook (Appendix B, Table A1). In the remainder of cases sulphur content information differed slightly to the average from the fuel specifications and was assumed to be based on the coal delivery specifications. The latter information was preferable because it is uncertain the extent to which lower sulphur coal consignments for a given mine may be preferentially exported. Similarly, the sulphur content of LFO was either based on delivery specifications or the maximum of 2% for LFO in New Zealand (Appendix B, Table A2).

One issue identified during the quality assurance checks on the sulphur content of coals was the variability in the sulphur content for Terrace Coal which is given in CRL (2004) as 1.1 %. A number of industries either using this fuel or a blend of it with Spring Creek Coal (75% Terrace/ 25% Spring Creek) reported average sulphur contents of the blend of around 0.6-0.7% (compared with 0.84% based on the weighted average of the two coals from CRL 2004). One reason for a lower sulphur content

would be if the location or seam of coal being mined had changed since the 2004 analysis. An update of the CRL (2004) analysis is being carried out later in 2008 (pers comm. Trevor Matheson, CRL, 2008).

An evaluation of the sulphur contents of the coals provided showed the average sulphur content across all coal boilers of 0.6%. This compares with a sulphur content of 1.6-2% for LFO in New Zealand. Overall, 23% of the industry used fuel with a sulphur content >1%. The proportion of coal fired boilers with a sulphur content greater than 1% was 11%. The highest sulphur coal used by industry included in this study was New Creek Coal (4.2% S) which was used by one 4 MW coal fired boiler on the West Coast.

The potential for high ground level concentrations of SO₂ increases with higher sulphur coals and it may be possible that smaller boilers (<3MW) with lower stacks could result in elevated 24-hour SO₂ when using high sulphur coals. The extent to which these may be an issue can be evaluated in subsequent stages of the investigation into the impacts of SO₂ in New Zealand.

Overall the quality of information on the sulphur content of the fuels used was high with most industries being able to identify their coal type or blend proportions and either the average sulphur content of that coal type or the actual sulphur contents from delivery specifications.

3.2 MW ratings of boilers in New Zealand

Information requested from Regional Councils included the megawatt (MW) rating of the boiler if consent databases held this level of detail. In some cases the Council's databases did include the MW rating of the boiler but in many instances this information was not supplied.

The industry survey included a query on the MW rating of the boiler. This question proved difficult for some of the respondents, particularly those who were not the boiler operators but who were able to gather information on fuel use from industry records. In other cases the MW rating from the survey forms differed to other data on the MW rating of the boilers from consents databases, previous industry surveys or assessments of environmental effects (AEEs) held by the authors.

A comparison of boilers MW ratings from this study was made with those in the BANZ 2008 database. The latter was found to include a number of boilers that were no longer operational and exclude a large number of boilers that we had confirmed were operating. For example, the BANZ database does not include the coal or LFO fire boiler for McCains (Canterbury) or a coal fired boiler for Heinz Watties (Canterbury). In Canterbury alone there were more than 10 industrial boilers identified in this study that were not included in the BANZ 2008 database¹.

As a result of incompleteness and the inconsistencies with other information, the MW rating of the boilers included in the BANZ database is not considered highly reliable.

¹ These included New Zealand Light Leathers, Sandford Limited, NZ Defense Force, Christchurch Launderers, Island Horticulture, General Cable Ltd, AlSCO Ltd, Amcor Kiwi Packaging, Bluebird Foods, New Zealand Engineering Services and Christchurch Quality Yarns.

3.3 Annual coal and LFO consumption

Coal and LFO consumption data were obtained for all industry types included in the survey except some process industries where SO₂ emissions test data were more relevant.

For coal consumption, annual fuel use data was provided directly by the industry. In four instances, industry was not able to provide this information within the specified time period and fuel consumption data from a 2006 industry survey was used. Three industries not operating for the whole of 2007 were included in the survey because stage two of this project included an evaluation of the impacts of SO₂ for 2008. In both cases an estimate of annual fuel consumption was made by the industry. For the fuel consumption comparisons below only the actual coal consumption from these industries for 2007 was included.

The total coal consumed by industry for 2007 was estimated at 2.2 million tonnes. This excluded New Zealand Steel who provided information on measured SO₂ emissions rather than annual fuel consumption. Energy Data Files for New Zealand indicated that New Zealand Steel consumed 0.8 million tonnes during 2007 (MED, 2008). Other industry for which coal consumption data was not obtained include Carter Holt Harvey – Kinleith, Tasman Pulp and Paper (excluding PB2 and PB3), Golden Bay Cement and three limeworks. Total coal consumption for 2007, excluding the latter six industries was around 3.0 million tonnes and compares with an estimated 3.1 million tonnes from the Energy Data Files. The latter is estimated using a top down approach of evaluating coal production, imports and exports.

The information on fuel consumption supplied by industry for this study is considered reliable. Industries appeared to have knowledge of their fuel consumption and were willing to provide this information. There was no apparent motivation for them to misrepresent the data and overall it appears to be of high quality.

4 Industrial SO₂ emissions in New Zealand

The Southland Region emits the greatest amount of SO₂ and has 17 industries with significant discharges in the area (Table 4.1). Around 79% of the annual SO₂ emissions in Southland are from the New Zealand Aluminium Smelter and a further 14% from Fonterra in Edendale. In the Waikato, Genesis Energy Huntly is a key contributor to the SO₂ emissions contributing around 72% of annual emissions. Fonterra are also a significant contributor in the Waikato at 16% of the Waikato annual SO₂ emissions. The Waikato ranks as the second highest SO₂ emitting area. The Canterbury Region had the largest number of qualifying industries with 48 identified as having the potential for significant SO₂ discharges. The majority of these were coal-fired boilers with the largest being Fonterra in Clandeboyne (17% of Canterbury emissions). There is only one significant process source in Canterbury (Ravensdown Fertiliser in Christchurch) which contributes 13% of the annual SO₂ emissions. Industries in the Northland Region emit a similar quantity of SO₂ emissions as Canterbury but from only five activities. The main sources are the New Zealand Refining Company (90% of Northland emissions) and the Ballance Agrinutrients fertiliser plant (7%).

Table 4.1: Regional summary of industrial sources of SO₂ emissions

Region	Number	SO ₂ kg/ day (weekday average per season)				SO ₂ kg/ day Maximum	SO ₂ tonnes Annual
		Sept – Nov	Dec – Feb	Mar - May	Jun - Aug		
Auckland	5	2653	2882	2653	2653	2882	958
Bay of Plenty	8	3744	3210	3349	2941	3930	1093
Canterbury	48	9792	9623	9323	7367	11518	2869
Hawkes Bay	6	974	995	992	973	995	197
Manuwatu/ Wanganui	1	73	42	55	72	73	22
Marlborough	5	629	520	560	834	838	242
Nelson	5	282	311	292	337	450	82
Northland	5	14079	13257	14329	14060	14518	4953
Otago	10	3312	3854	4193	3157	4794	1136
Southland	17	27497	28314	27550	23200	28848	9497
Tasman	5	2822	2675	2635	2324	2996	935
Waikato	9	16319	13563	16032	14672	17661	5522
Wellington	3	74	74	73	73	74	18
West Coast	6	7031	6706	6554	5862	7085	2290
Total	133	89281	86028	88590	78526	96661	29814

¹ This number is lower than the 149 industry included in the maps as the summary excludes boilers less than 3 MW

The location and extent of SO₂ emissions from the 149 industries are shown in Figure 4.1 (annual emissions) and 4.2 (daily emissions – maximum). These include 16 smaller scale boilers for which emissions were also estimated. The annual estimates provide an indicator of long term exposure, whereas the daily emissions provide an indicator of the potential worst case situation.

Table 4.2 shows the number of industry with emissions within different emission range categories. Additional information shown in Table 4.2 is the average daily SO₂ emissions for each season of the year. This information is relevant in assessing the implications of the revised WHO guidelines as it provides an indication of average 24-hour emissions. Around 43% of the industries included in the inventory had daily maximum SO₂ emissions of less than 100 kilograms per day and around two thirds had annual emissions less than 50 tonnes. At the other end of the scale, the three largest SO₂ emitters (New Zealand Aluminium Smelters (NZAS), Genesis Energy Huntly and The New Zealand Refining Company) contributed 50% of the total annual SO₂ emissions for New Zealand.

Emissions from NZAS were estimated by source based on emissions data provided by the industry from their 2005 resource consent application. The emission rates provided from the consent application were compared with stack test data for 2007 which was also provided by NZAS. The latter data indicated SO₂ emissions were 1.7% higher than the values used in the consent application. Because of the minimal difference in emissions and because the consent information provided greater detail of emissions by process the emission rates from the consent were used in the inventory.

The SO₂ emissions from Genesis Energy Huntly were estimated using the fuel consumption data provided for 2007 and the weighted average sulphur content of this fuel (0.2%). Results indicated coal consumption for 2007 was lower than usual owing to a delay in commissioning of Unit five that lead to the gas purchased for Unit five being burnt in Units 1-4 instead.

In addition, information was provided on natural gas consumption. This source was not included in the inventory because the sulphur content of natural gas is low (<0.006%). However, an estimate of SO₂ emissions from this source was made to evaluate whether the inclusion of even larger users of natural gas would be appropriate. Results indicated minimal SO₂ emissions from natural gas combustion and expansion of the inventory to include gas fired power stations was not implemented.

Overall the quality of the emission estimates for industrial SO₂ dischargers was high with reliable information on emission rates or fuel consumption and sulphur contents being provided directly by industry. In the few cases where industry did not provide this information alternative sources of the information were available. The exception was Downer Works asphalt plants located in Wellington and Bay of Plenty. Emission estimates from these asphalt plants was based on the worst case emission rate for other asphalt plants in New Zealand. This equated to 30 kilograms per day of SO₂ and compares with an average emission rate for asphalt plants in New Zealand of around 14 kilograms per day. Use of the maximum discharge rate is unlikely to bias the emission inventory assessment because of the low magnitude of emissions relative to other sources. However, selection of the worst case emission rate for these industries may become significant in the second stage of the study, which is likely to use the height of the discharge to evaluate impacts.

Figure 4.3 shows the distribution of annual SO₂ emissions in New Zealand by discharge type. This illustrates the contribution of the three major sources identified above but also the collective contribution of the dairy industry at 12% of the total annual SO₂ emissions for New Zealand.

Table 4.3 shows SO₂ emissions from industry. Grid references are provided as an indicator of the location of the industry for mapping purposes and do not provide the exact discharge point within any site. In many cases, there are several SO₂ discharge

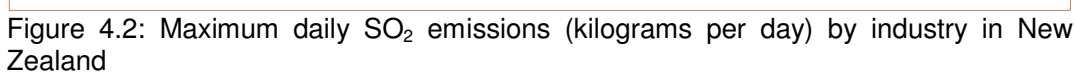
locations some of which may be separated by some distance (e.g., Huntly power station stacks).

Table 4.2: Scale of industrial SO₂ emissions in New Zealand

Maximum SO ₂ emission rate (kg/day)	No. of industry	SO ₂ emission rate (tonnes/year)	No. of industry
0-100	64	0-50	99
100-500	52	50-100	20
500-1000	12	100-500	22
1000-5000	13	500-1000	3
5000-15000	5	1000-5000	4
> 15000	3	>5000	1



Figure 4.1: Annual SO₂ emissions (tonnes/ year) by industry in New Zealand



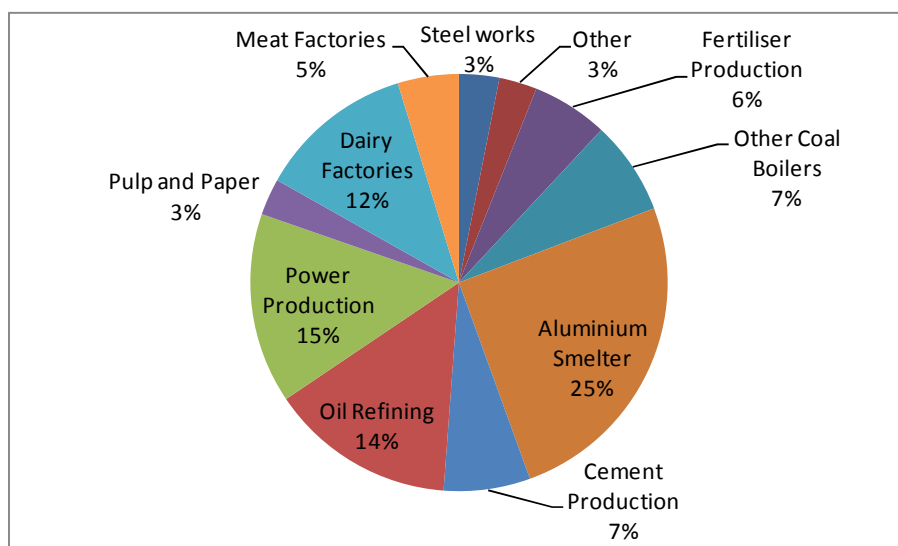

Figure 4.3: Sector contributions to annual SO₂ emissions in New Zealand

Table 4.3: SO₂ Emissions from Industries in New Zealand

Industry Name	Grid references		Average daily SO ₂ emission (kg)				Max SO ₂ kg/day	Annual SO ₂ tonnes/year
	Northing	Easting	Sept - Nov	Dec - Feb	Mar - May	Jun - Aug		
New Zealand Aluminium Smelters	5392300	2155800	20702	20702	20702	20702	20702	7556
Genesis Energy - Huntly	6404500	2700000	12108	9794	12935	13414	39917	4407
New Zealand Refining Company	6594337	2645384	12000	12000	12000	12000	31000	4300
Holcim NZ Ltd	5936815	2382814	5374	5374	5374	5374	5374	1876
Fonterra Co-operative Group Ltd -Edendale	5424990	2185118	4969	4877	4048	723	7344	1330
New Zealand Steel	6470808	2672909	2557	2557	2557	2557	2557	933
Fonterra Co-operative Group - Waitoa	6397071	2742374	2850	2470	2014	805	4104	741
Carter Holt Harvey Pulp and Paper Kinleith	6321300	2762600	1621	1621	1621	1621	1621	576
Fonterra Co-operative Group Limited (Clandebye)	5665100	2380600	1923	1836	1321	317	11712	486
Ballance Agri-Nutrients Ltd - Mt Maunganui	6388019	2790990	1447	1353	1573	1022	2102	483
Ravensdown Fertiliser Co-operative Limited (Dunedin)	5479384	2319137	1217	1217	1217	1217	1909	444
Ravensdown	5740600	2472500	1022	1022	1022	1022	2160	373
PPCS Limited (Fineland)	5432400	2258500	756	1530	1945	848	1945	328
Ballance Agrinutrients	6605300	2632000	1054	151	1368	1095	2760	315

Westland Milk Products	5827500	2341600	1253	1045	743	93	1253	285
Carter Holt Harvery Pulp and Paper - Whakatane	6353310	2858290	705	713	697	697	741	257
McCain Food (NZ) Limited	5648901	2370040	667	546	787	660	959	243
Hexion Speciality Chemicals (NZ) Ltd	6387880	2791440	1011	589	542	602	1771	220
Fonterra Co-operative Group - Te Awamutu	6353200	2712800	833	842	659	47	852	217
Alliance Group Lorneville	5418700	2149300	298	1055	1032	590	1292	194
Alliance Group Limited - Pukeuri Plant	5573104	2354879	633	714	554	530	714	190
South Canterbury By-Products Company Limited	5649470	2371490	497	503	492	492	675	181
Goodman Fielder	5740800	2475200	534	509	358	309	658	156
Ravensdown Fertiliser Co-operative Limited	6176000	2846900	425	425	425	425	976	155
Kaputone Woolscour (1994) Limited	5751000	2480800	396	433	439	314	439	144
PPCS Limited (Belfast)	5751100	2481100	442	447	656	656	601	144
JS Ewers Ltd	5987523	2521478	393	275	344	493	690	138
Golden Bay Cement	6598810	2629143	370	370	370	370	370	135
Fonterra Limited - Takaka	6039084	2494336	482	473	393	70	570	129
Fonterra Co-operative Group Limited (Stirling)	5434860	2261914	460	453	170	57	1032	105
Synlait Milk Limited	5723700	2438900	1076	1088	608	304	1088	100
Karamea Tomatoes	5997519	2435290	295	199	303	292	303	99
Alliance Group Ltd - Mataura	5437700	2190600	200	448	537	240	646	93
NZ Marine Services Ltd	6390353	2791269	425	430	421	421	691	88
Dominion Salt Limited	5942321	2604347	289	195	95	286	289	88
Talleys Frozen Foods Limited	5703013	2415952	240	146	380	285	380	87
Talleys Fisheries Limited	5966977	2581577	201	198	218	268	322	82
Fonterra Limited - Brightwater	5980745	2519871	304	298	247	44	494	81
PPCS – Pareora	5633500	2368200	136	364	370	206	333	77
Energy for Industry	5478957	2316193	148	112	147	330	330	67
New Zealand Dairies Limited	5607379	2361623	276	226	130	26	353	60
Keep it Clean Ltd	5476013	2307782	230	155	228	152	200	60

Alliance Group Makarewa	5423500	2150000	224	271	265	133	271	58
Bridgestone / Firestone (NZ) Limited	5746399	2477970	154	123	161	187	187	57
ENZA Food New Zealand Ltd	5987691	2527934	99	101	209	209	330	57
Cerebos Gregg's Limited	5479200	2317100	171	152	169	189	222	53
Dairy Trust Ltd	5402939	2155648	262	177	115	29	5463	53
Canterbury District Health Board (Christchurch)	5745204	2479706	145	117	132	189	189	53
New Zealand Breweries Limited	5741200	2479800	223	177	189	204	275	52
Primary Producers Co-operative Society (PPCS) Limited (Ashburton -Fairton)	5703300	2414100	241	220	200	116	281	51
Prime Range Meats	5416150	2150817	184	186	121	121	287	48
University of Canterbury	5742683	2476257	78	79	77	284	284	48
Canterbury Meat Packers Limited	5697600	2420120	102	176	213	107	234	47
Clifton Wool Scour Ltd	5407400	2153300	88	89	130	130	192	40
Quality yarns New Zealand Limited	5449600	2274600	198	108	196	256	274	40
Tegel Foods Limited	5741431	2472134	135	136	134	134	212	39
McDonalds Lime Ltd – Otorohanga	6327677	2703240	104	104	104	104	104	38
Primary Producers Co-operative Society (PPCS) Limited (Canterbury - also in Belfast)	5750422	2480425	133	162	185	53	434	35
Fonterra Co-operative Group – Hautapu	6368700	2726100	139	122	71	45	139	34
Heinz-Wattie Limited	5738500	2470400	30	129	96	119	182	34
Carter Holt Harvey Pulp and Paper Tasman Mill	6341790	2836897	102	68	61	145	360	33
Southland District Health Board	5408823	2153051	90	55	89	125	125	33
Perry Lime Ltd - Te Kumi Quarry	6321078	2700766	96	96	96	96	96	32
Sealord Products Ltd	5994368	2533425	88	48	67	134	134	31
Christchurch Yarns (NZ) Limited	5746105	2474646	118	119	116	116	119	31
G L Bowron & Co Limited	5738897	2484672	123	76	118	142	150	30
Canterbury Woolscourers Limited	5648500	2370000	100	101	99	99	101	30

Timaru Hospital and Community Service	5642700	2371200	69	87	91	77	100	30
Summit Wool Spinners Limited	5567115	2351016	83	58	79	98	133	29
Alliance Group Limited (Smithfield)	5646700	2370400	130	62	128	44	171	29
Southland Veneers	5414427	2160352	106	82	105	105	106	29
Gelita NZ Limited	5739143	2484290	81	67	77	74	109	27
Bluebird Foods Limited	5648879	2370484	102	103	101	101	103	27
Lumbercorp NZ Ltd - Ohinewai	6414000	2701300	71	29	85	99	99	26
Alliance Group Limited	5740800	2473500	102	91	114	51	117	26
South Pacific Meats Ltd	5402871	2155524	74	149	109	36	149	24
McAlpines Rangiora	5764466	2477144	65	66	65	65	66	24
CMP Kokiri	5857200	2376300	73	74	98	46	146	23
Nelson Marlborough Health Services Ltd	5990994	2532812	61	42	56	85	94	22
NZ Defence Force	6189613	2740492	73	42	55	72	73	22
New Zealand Defence Force Burnham Camp	5733000	2454200	63	27	58	94	109	22
Open Country Cheese	6379003	2752391	88	77	40	33	104	22
Auckland Meat Processors	6472384	2673616	66	67	65	65	80	17
Affco New Zealand Limited – Wairoa	6232217	2893311	37	87	73	49	87	16
Coast Health Care	5858929	2361718	44	44	43	43	60	16
RNZAF Base Woodbourne	5965594	2582926	49	12	26	79	89	15
General Cable New Zealand Limited	5741229	2474627	17	11	33	93	421	14
Amcor Kiwi Packaging Ltd	5739580	2471550	43	87	64	21	88	14
Whirinaki Power Station	6195252	2844852	456	456	456	456	456	14
ALSCO NZ	5411600	2155700	52	64	62	31	64	14
Juken NZ Ltd (Northland Mill)	6679200	2534500	22	22	36	65	6840	13
Lincoln University	5729030	2466950	35	2	31	70	75	13
Canterbury District Health Board(Burwood)	5747507	2484348	34	27	31	44	44	12
PPCS Pacific	6170694	2844067	38	57	56	37	95	12
Sealord Aquaculture	5990144	2529865	49	39	47	47	49	12
New Zealand Light Leathers	5649300	2370400	47	29	50	54	67	12

Limited								
Talleys Limited - Motueka	6007677	2511862	22	7	29	95	201	12
Alsco Limited	5739808	2480897	44	53	43	35	53	11
AFFCO	6645911	2604401	26	53	52	43	61	11
Southtile Ltd	5417466	2151663	97	20	96	77	97	11
Island Horticulture Limited	5753590	2476580	28	23	29	42	91	11
Ashburton and Rural Health Services	5700632	2409244	28	22	27	33	43	10
Carter Holt Harvey Limited	5739600	2471200	35	31	45	35	48	10
Cavalier Spinners Limited (Awatoto Branch)	6177736	2846710	36	37	36	36	42	9
Wairau Hospital	5963182	2588705	25	19	23	36	60	9
Graeme Lowe Otago	5475400	2311000	0	71	69	0	71	9
AB Lime Ltd	5442800	2152800	34	55	33	1	331	8
Blue Sky Meats (NZ) Ltd	5419500	2174500	25	41	39	18	43	8
Air New Zealand Engineering Services Limited	5746623	2473385	26	0	0	61	61	8
DB Mainland Brewery	5648725	2370487	48	36	24	12	48	8
McAlpines (Rotorua) Ltd	6334750	2797060	12	8	16	36	36	7
Launderers (Christchurch) Limited	5740100	2482200	34	34	22	22	40	7
Freshpork Bay City Limited	5646342	2370205	22	23	22	22	23	7
P H Kinzett Limited	5967109	2584897	15	7	14	36	67	7
Scenicland Laundry	5860300	2362400	25	25	16	16	25	6
University of Otago	5479500	2316800	10	3	17	37	37	6
Websters Hydrated Lime Company Limited	6158929	2838451	16	16	16	16	16	6
PPCS Waitane Limited	5445060	2194472	18	21	18	3	37	5
Otago Polytechnic	5479500	2317200	10	3	20	34	34	5
Fulton Hogan Ltd - Nelson	5990108	2529600	57	129	70	28	160	5
Works Infrastructure Limited	6474687	2672621	30	30	30	30	91	5
Downer EDI Works	6387950	2791183	30	30	30	30	91	5
Higgins Contractors Ltd	6388120	2792430	20	20	20	20	91	5
Downer EDI Works Limited	5992631	2659841	30	30	30	30	91	5
International Panel & Lumber	5851708	2358951	14	14	14	14	14	5

PPCS Te Aroha	6400976	2750458	19	19	19	19	20	5
PPCS Dargaville	6585311	2590914	13	22	22	19	22	5
Sanford Limited (Timaru)	5645500	2371200	18	18	18	18	18	5
Fernhill Limeworks Ltd	5455200	2149600	24	19	19	2	32	4
BW Hanna Limited	5984023	2524578	6	6	6	26	26	4
Mair Venison (trading as PPCS)	5831864	2344361	26	26	14	7	26	4
City Care	5738650	2472090	13	13	13	13	30	3
New Zealand Growing Media Ltd	5445500	2158700	97	98	96	120	120	3
Winton Stock Feed	5440400	2149300	24	17	17	10	24	3
Fulton Hogan Limited (Canterbury)	5742400	2469100	9	19	11	8	61	3
Holiday Inn On Avon Christchurch	5742495	2481470	9	4	8	13	15	3
Speights Brewery Limited	5478300	2315800	15	15	10	10	15	3
Carter Holt Harvey - Penrose Mill	6473958	2672505	0	228	0	0	228	2
Suttons Moss Ltd	5858500	2368200	22	0	22	43	46	2
UC College of Education	5742920	2475221	4	4	3	13	13	2
Nelson Laundries	5992183	2532941	8	10	8	6	10	2
Oldfield Asphalts Ltd	6029217	2734708	30	30	30	30	65	2
PPCS Paeroa	6419772	2748242	8	0	0	8	20	1
Allied Asphalt Limited Tauranga	6330878	2794722	4	9	5	3	47	1
The Isaac Construction Company Limited	5748890	2470810	4	4	4	4	4	1
Aranui High School	5743344	2485486	2	0	2	13	15	1
ALSCO NZ	5966281	2589987	4	5	4	3	5	1
Pacific Steel and Pacific Wire	6470808	2672909	0	0	0	0	0	0
Shell New Zealand Ltd	5994140	2670371	0	0	0	0	108	0

¹ Occasional use only

References

Bioenergy Association of New Zealand (BANZ), 2008, Heat Plant in New Zealand - Heat Plant Sized Greater Than One Hundred Kilowatts Thermal Segmented by Industry Sector as at March 2008, Database Maintained by East Harbour Management Services on behalf of the Bioenergy Association of New Zealand in conjunction with Energy Efficiency and Conservation Authority (EECA) and the Ministry of Economic Development.

Coal Association of New Zealand, 2004, Analysis Update 2004, Analysis of New Zealand Industrial Coals 2004, Coal Association of New Zealand publication.

Denison et al, 2000, Health Effects of Five Common Air Contaminates and Recommended Protective Ranges, Ministry for the Environment Publication.

Eng, Bywater & Hendtlass., 2008, New Zealand Energy Handbook, Third Edition, CAENZ Publication.

Ministry for Economic Development web site www.med.govt.nz

Ministry for Economic Development, 2008, New Zealand Data Energy Files June 2008, Ministry for Economic Development publication ISSN 1177-6684 .

Ministry for the Environment, 2000, Proposals for Revised and New Ambient Air Quality Guidelines. Discussion Document. Ministry for the Environment Publication.

Ministry for the Environment, 2002, Ambient Air Quality Guidelines for New Zealand, Ministry for the Environment Publication.

Ministry for the Environment, 2003(a), Monitoring of CO, NO₂, SO₂, ozone, benzene and benzo(a)pyrene in New Zealand, Air Quality Technical Report No. 42, Prepared by Environet Limited. Ministry for the Environment Publication.

Ministry for the Environment, 2004, Proposed National Environmental Standards for Air Quality Resource Management Act, Section 32 Analysis of the costs and benefits, Ministry for the Environment Publication.

Ministry for the Environment, 2003(b), Emission Inventories for CO, NO_x, SO₂, ozone, benzene and benzo(a)pyrene in New Zealand Technical Report No. 44, Prepared by Environet Limited. Ministry for the Environment Publication.

Ministry for the Environment, 2005, Updated Users Guide to Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) Regulations 2004 (Including Amendments 2005) Ministry for the Environment.

Streeton, JA. 1997. A Review of Existing Health Data on Six Air Pollutants. Report to the National Environment Protection Council. Australia.

United States Environmental Protection Authority website:
<http://www.epa.gov/air/urbanair/so2/what1.html>

United States Environmental Protection Authority website:
<http://www.epa.gov/ttn/chief/ap42/>

Wilton, E., 2005 Invercargill and Gore Air Emission Inventory – 2004. Environment Southland Report.

World Health Organisation, 2000, Air Quality Guidelines for Europe – Second Edition, World Health Organisation Publication.

World Health Organisation, 2005, Air Quality Guidelines Global Update 2005 Report on a working group meeting, Bonn, Germany, 18--20 October 2005, World Health Organisation Publication.

World Health Organisation, 2005, Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide Global Update 2005 Summary of Risk Assessment, World Health Organisation Publication.

World Health Organisation, 2006, Use of the air quality guidelines in Protecting Public Health: A Global Update, World Health Organisation Publication.

World Health Organisation website: <http://www.who.int/en/>

Appendix A: SO₂ Emissions Inventory - Industrial Questionnaire

Company Name: _____

Person completing Questionnaire: _____

Email address: _____

Telephone Number _____

This survey is intended for the following activity types. Please tick which applies to your industry:

Coal fired boilers	<input type="checkbox"/>
Light Fuel Oil or used oil-fired boilers (not diesel)	<input type="checkbox"/>
Asphalt Plants burning used oil or Light Fuel Oil	<input type="checkbox"/>
Fertiliser manufacturer	<input type="checkbox"/>
Aluminium Smelter	<input type="checkbox"/>
Steel works	<input type="checkbox"/>
Cement kiln	<input type="checkbox"/>
Refinery	<input type="checkbox"/>
Power station	<input type="checkbox"/>
Other (any combustion process greater than 3 MW burning coal, Light Fuel Oil or used oil)	<input type="checkbox"/>

Guide to completing this questionnaire

Plant type	Please complete Questions:
Boiler	1, 5 and 6
Asphalt Plant	2, 5 and 6
Fertiliser Plant	3, 5 and 6
All other activities	4, 5 and 6

QUESTION 1: BOILERS

Q1a: During the winter months, how many days per week do you use the boiler/ boilers? _____

Q1b: What is the maximum quantity of fuel burned in any 24 hour period (tonnes)? _____

Q1c: Please fill in the following information for each boiler:

Discharge type e.g., coal boiler	Output (MW, kg steam/hr)	Fuel source (coal only) ¹	Gross calorific value if known (MJ/kg)	Sulphur content (% by weight)	Boiler type (e.g., vekos, overfeed, underfeed, chain grate, LFO)	Chimney height above ground level (m)	Chimney approx diameter at stack tip (m)	Annual quantity of fuel used (tonnes/year)
E.g., Coal	4MW	Ohai coal	24.1	0.28%	Chain grate	32	0.5	800 tonnes
1.								
2.								
3.								

¹ If mix state average sulphur content or proportion of each source used, e.g., 40% Ohai: 60% Heaphy or 1.5% Sulphur blend

Q1d: What proportion of annual fuel use is used during the following months?

September – November _____

December – February _____

March – May _____

June – August _____

Boilers please go to Question 5 (page 6)

Example	
September – November	10%
December – February	10%
March – May	30%
June – August	50%

QUESTION 2: ASPHALT PLANTS ONLY

Q2a: During the winter months, how many days per week do you use the asphalt plant _____

Q2b: What is the maximum quantity of asphalt produced (tonnes) in any 24 hour period? _____

Q2c: Please fill in the following information for each discharge:

Discharge number.	Maximum output (tonnes/hr asphalt)	Fuel source (e.g., waste oil, LFO)	Sulphur content (% by weight)	Chimney height above ground level (m)	Chimney approx diameter approx at stack tip (m)	Annual quantity of asphalt (tonnes/year)	Particulate or SO ₂ control technology (if any) eg. bag filter, wet scrubber
1.							
2.							
3.							

2d: Seasonal variation in SO₂ emission rate

If the SO₂ emission rate varies throughout the year, please indicate the peak period (as 100%) and comparative discharge rates for other seasons (as a percentage of the peak)

September – November _____

December – February _____

March – May _____

June – August _____

Asphalt plants please go to Question 5 (page 6)

Example	
September – November	100% <i>peak emission rate</i>
December – February	80%
March – May	100%
June – August	100%

QUESTION 3: FERTILISER MANUFACTURING PLANTS ONLY

Q3a: How many days per week is the plant operational: _____

Q3b: Please fill in the following information for each discharge:

Discharge point.	Maximum SO ₂ emission rate (e.g., grams per second)	Maximum hours operated per day (e.g., 24)	Average SO ₂ emission rate during peak 24 hour period (g/s)	Chimney height above ground level (m)	Chimney approx diameter at stack tip (m)	SO ₂ abatement technology (if any)	Annual closure period (if any)
Stack 1.							
Stack 2.							
Stack 3.							

Q3c: Seasonal variation in SO₂ emission rate

If the SO₂ emission rate varies throughout the year, please indicate the peak period (as 100%) and comparative discharge rates for other seasons (as a percentage of the peak)

September – November _____

December – February _____

March – May _____

June – August _____

Fertiliser manufacturing plants please go to Question 5 (page)

Example	
September – November	100% peak emission rate
December – February	80%
March – May	100%
June – August	100%

QUESTION 4: OTHER ACTIVITIES

Q4a: How many days per week is the plant operational: _____

Q4b: Please fill in the following information for each discharge:

Discharge point.	Maximum SO ₂ emission rate (e.g., grams per second)	Maximum hours operated per day (e.g., 24)	Fuel source (e.g., waste oil, light fuel oil)	Sulphur content (% by weight)	Average SO ₂ emission rate during peak 24 hour period (g/s)	Chimney height above ground level (m)	Chimney approx diameter at stack tip (m)	SO ₂ abatement technology (if any)	Annual closure period (if any)
Stack 1.									
Stack 2.									
Stack 3.									

Q4c: Seasonal variation in SO₂ emission rate

If the SO₂ emission rate varies throughout the year, please indicate the peak period (as 100%) and comparative discharge rates for other seasons (as a percentage of the peak)

September – November _____

December – February _____

March – May _____

June – August _____

Example	
September – November	100% <i>peak emission rate</i>
December – February	80%
March – May	100%
June – August	100%

Other plants please go to Question 5 (page 6)

QUESTION 5: Emission test results:

If you have had any SO₂ or PM₁₀ emission testing done on your stack, please fill in the following table (or alternatively, attach the test reports to this survey form). This information will be used to refine the estimated discharge from your activity.

Year of emissions test	SO ₂ Discharge rate (e.g., kilograms per hour)	PM ₁₀ Discharge rate (e.g., kilograms per hour)
1.		
2.		
3.		

QUESTION 6: Scheduled changes between 2008 and 2020:

Do you have any major refurbishment/upgrade or fuel switching plans?

Yes/ No

If yes please describe and indicate proposed year of change:

Thank you for completing this survey. If you have any questions please call Melanie Baynes 03 9825967

Please return this survey to:
Melanie Baynes
Environet
130b Montreal Street
Christchurch 8023

Appendix B: New Zealand Coal and Oil Properties

Table A1: Analysis of NZ industrial coals (2004)²

Name of mine	Moisture %	Ash %	Gross CV MJ/kg(hhv)	Sulphur %
Waikato				
Huntly East No 1	20.6	3.8	22.93	0.21
Kopako	26.7	3.9	20.17	0.15
O' Reileys*	19.8	5.8	22.13	0.23
Rotowaro	21.0	4.6	22.24	0.23
Buller				
Cascade	9.7	1.6	29.96	0.60
Heaphy	18.1	3.8	24.20	2.25
New Creek	18.9	1.6	23.93	4.2
Stockton	8.1	2.9	31.65	1.9
Reefton				
Echo	5.9	2.1	30.87	0.46
Giles Creek	29.4	2.8	19.04	0.42
Island Block	6.6	2.1	30.46	1.51
Terrace	15.1	5.1	24.95	1.11
Greymouth				
Roa	6.7	6.5	31.95	0.27
Spring Creek	10.2	2.5	29.83	0.35
Canterbury				
Mt Somers	28.1	11.6	17.71	2.50
Canterbury Coal	27.5	3.0	20.84	0.38
Otago				
Harliwich	28.8	6.3	18.52	0.43
Kai Point	30.4	4.7	19.67	1.52
Goodwin (Lignite)	42.2	3.1	14.98	0.47
Southland				
New Vale (Lignite)	40.5	3.1	15.25	0.34
Ohai	18.3	4.4	24.11	0.28
Waituna (Lignite)	39.6	5.5	14.53	0.58

² Source:- New Zealand Energy Information Handbook Third edition 2008
 Original source of data:- Coal Association of New Zealand , 2004)
 All data on as-received coal basis

Table A2: Typical Properties of refined liquid fuels in New Zealand ³

Refined product	Gross CV MJ/kg (hhv)	Gross CV MJ/litre (hhv)	Maximum Sulphur %
Petrol	47.2	34.5	0.005
Kerosene/Jet A1	46.4	36.6	0.2
Premium kerosene	46.1	37.4	0.02
Road diesel	45.9	38.1	0.005*
Marine diesel	45.6	38.3	0.3
Light fuel oil	44.1	39.7	2
Heavy fuel oil	42.8	40.6	3.5
Bunker fuel oil	42.4	40.7	4

* From 1st Jan 2009 maximum sulphur in road diesel decreases to 0.001% (10 ppm)

³ Source:- New Zealand Energy Information Handbook Third edition 2008
Original source of data:- New Zealand Refining Company.