Submission to Unitary Plan Submission Team, Auckland Council, on “PROPOSED AUCKLAND UNITARY PLAN” (FEBRUARY 2014)

INTRODUCTION

1. The Coal Association of New Zealand[1] and Straterra[2] welcome the opportunity to submit on the proposed Auckland Unitary Plan. The submission deadline of 28 February 2014 is noted.

2. CANZ members include industrial users of coal-fired boilers, as a source of cost-effective process heat (refer to membership list in **Appendix 1**). Accordingly, this submission confines itself to the proposed Auckland Ambient Air Quality Standards (AAAQS), in particular, for 24-hour, average sulphur dioxide (SO_2) concentration.

3. We submit from the point of view that economic development in New Zealand needs to be enabled or promoted, subject to fit-for-purpose regulatory requirements concerning the environment, including air quality.

4. In preparing this submission, CANZ/Straterra have consulted with relevant parties within our membership. We acknowledge the work of Golder Associates air quality experts in support of this submission (refer to Appendices 2 and 3). We are aware of a number of industry parties who share our concerns.

5. We would welcome the opportunity for further engagement with the Unitary Plan Submission Team on the issues raised in this submission.

[1] The Coal Association is an industry body representing the NZ coal sector, including producers, exporters, distributors, and users.
[2] Straterra represents the New Zealand minerals sector. Our members comprise minerals producers and explorers, research providers, equipment suppliers engineering and geotechnical firms, mining professionals, and firms providing legal, accounting, environmental and other ancillary services. CANZ is represented on the Straterra Board.

CONTENTS

EXECUTIVE SUMMARY

6. As a general comment, CANZ/Straterra supports fit-for-purpose regulation of ambient SO_2 levels in the air. We contend that the proposed Auckland Unitary plan fails to provide that.

7. Two concerns are raised in relation to the proposed adoption of the World Health Organisation 24-hour guideline for the average concentration of SO_2, of 20 micrograms per cubic metre (20µg/m^3), cf. the current 24-hour requirement in New Zealand of 120µg/m^3:

   a) The WHO guideline is not fit for purpose because it is based on a flawed or incomplete interpretation of the underpinning science. It is, therefore, inappropriate for use in the Auckland region, and within New Zealand generally, noting that a number of other developed countries have reached the same view in respect of their jurisdictions; and

   b) An issue of equity has not been addressed between activities that require a resource consent, in relation to atmospheric discharges of SO_2 (and other pollutants), and permitted activities.

8. The WHO guidance was adopted following an observed reduction in adverse human health effects in Hong Kong, in response to reduced ambient SO_2 levels, primarily from vehicle pollution. The evidence is, however, that the SO_2 levels were a proxy for other hazardous pollutants, such as ultrafine particles.

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9. We consider, therefore, that the WHO guideline is inappropriate in the New Zealand context, particularly in relation to industrial point sources. It would make more sense to retain the existing guideline, which has a track record of both safeguarding human health and the environment, while providing for businesses to operate effectively and efficiently.

10. If introduced, the WHO guideline would adversely affect large, industrial users of coal, either in Auckland, or elsewhere in New Zealand. It is, therefore, of deep concern to CANZ/Straterra that the section 32 report did not include any analysis of the benefits and costs of introducing the WHO guideline. It is our opinion that the marginal cost to society of introducing the WHO guideline would far outweigh the marginal benefit, to the extent that any benefit would result.

11. As to the equity concern, it is often observed that most of the air pollution is caused by permitted activities, rather than consented activities, which are subject to regulatory controls. That can place an unfair, and unjustified burden on local businesses without necessarily benefiting human health or the environment. Where these businesses compete with imported products, an additional risk to business is created.

12. The above is a national issue, we believe, requiring policy development at a national level. The Ministry for the Environment (MfE) would be the appropriate agency. Work on template plans may be an appropriate context. Straterra has flagged the matter with MfE.

RECOMMENDATIONS

13. CANZ/Straterra recommends the Auckland Plan Submission Team to:

    a) Note CANZ/Straterra's support for fit-for-purpose regulation of ambient SO_2 levels in the air;

    b) Agree that the WHO guideline on 24-hour average concentration of SO_2 is inappropriate for application in Auckland (and elsewhere in New Zealand) because it relates to research carried out in Hong Kong, that mad an unsubstantiated link *between* reduced adverse health effects on humans *and* reduced ambient SO_2 levels;

    c) Note CANZ/Straterra's concern that no section 32 analysis was carried out in relation to the issue of SO_2, and our view that had such an analysis been carried out, that the marginal cost to local businesses of introducing the WHO guideline would far outweigh the marginal benefit, to the extent that any benefit exists;

d) In relation to Recs. (b) and (c), agree to retain the current SO_2 guideline as fit for purpose in Auckland (and elsewhere in New Zealand);

e) Note CANZ/Straterra's view that an issue of equity between activities that require a resource consent, in relation to atmospheric discharges of SO_2 (and other pollutants), and permitted activities, has not been addressed in the proposed Auckland Unitary Plan;

f) In relation to Rec. (e), note CANZ/Straterra's view that this is a national issue, requiring resolution at a national level, to avoid the risk of creating an undesirable precedent in the Auckland Unitary Plan, in respect of plan development or reviews elsewhere in New Zealand; and

g) Note that CANZ/Straterra has flagged the matters coved in Recs. (e) and (f) with the Ministry for the Environment.

DISCUSSION

The WHO guideline is not fit for purpose

14. The WHO 24-hour guideline for average concentration of SO_2, of 20 micrograms per cubic metre ($20\mu g/m^3$), was published in 2006.

15. The driver for this was the observation in Hong Kong of reductions in adverse health effects within the population, attributed at the time to a reduction in fuel oil sulphur content, and related reductions in ambient SO_2 levels.

16. The New Zealand Ministry for the Environment subsequently promoted in 2008-2009 the new WHO standard within New Zealand for adoption as a national guideline.

17. Of note is that the WHO guideline has not been adopted by most developed countries, not even in Hong Kong[3]. An exception is Singapore where it has been set as a long-term goal.

18. In response to the Ministry's approach, an independent report[4] was prepared in 2008 by Dr Francesca Kelly, a public health physician, and Roger Cudmore, an air quality expert with Golder Associates. The report was commissioned by a group of New Zealand industry, including Genesis Energy, Ravensdown, Fonterra, and Solid Energy. This group had concerns over the scientific basis for the Ministry's suggestion of applying the WHO guideline in New Zealand.

19. Kelly and Cudmore (2008) concluded:

    a) New research into the health effects of diesel fuel emissions on people, plus research findings on the role of diesel fuel sulphur[5] in ultrafine particle (UFP) formation, suggests that the reduced ambient SO_2 levels in Hong Kong during the 1990s were likely to have been a surrogate[6] for reductions in other pollutants, principally UFP, that actually caused the adverse health effects; and

    b) In that case, the culprit for the adverse health effects in Hong Kong had to do with diesel fuel emissions in general terms, and not SO_2 per se.

20. Therefore, there is no basis for application of the WHO guideline in New Zealand, particularly in the context of industrial sites. That is not to say that Auckland Council should have no concerns over SO_2; at issue is the need for fit-for-purpose regulation of SO_2. It is the industry's view that the current 24-hour guideline of $120 \mu g/m^3$, as well as the one-hour requirement specified in the National Environmental Standards for air quality, are adequate and appropriate for industrial sites in Auckland (and elsewhere in New Zealand).

[3] Source: Golder Associates
[4] The Kelly and Cudmore (2008) report is available on request.
[5] Diesel fuel SO_2 emissions in Hong Kong would have been to do mainly with vehicles operating in a congested city, rather than industrial point sources.
[6] i.e., correlation does not always impute cause

21. Further work by Golder Associates on the WHO guideline (refer to **Appendix 2** for "Literature review on sulphur dioxide air guidelines"), and its lack of suitability for application in New Zealand, is attached to this submission, as evidence in support of this submission.

22. We draw the council's attention, in particular, to the following statement from the report (referenced in para 21): "It is our opinion that the WHO (2006) 24-hour guideline is not sufficiently robust for adoption as an air quality standard. This opinion is consistent with recent decisions by expert committee/reviews in Canada, Australia and the UK". Nor has the US adopted the WHO guideline, on the same rationale.

23. Our proposals for amending the proposed plan provisions in relation to air quality issues are attached as **Appendix 3**.

Equity between activities requiring a resource consent and permitted activities

24. The high-level policy issue has to do with equity between activities requiring consents, and permitted activities.

25. The high-value resource users, i.e., industry, wish to avoid being landed with most of the mitigation costs for pollution, while the majority of the pollution is caused by emitters who bear no responsibility, e.g., motorists, householders, people lighting fires. Such is often the experience in New Zealand:

- Most polluters bear no responsibility;
- Point sources may be unfairly penalised, because the responsibility for avoiding, remedying and mitigating effects on air quality is shifted from one set of emitters to another; and
- Effects on the environment may not be adequately measured or managed.

26. We suggest that Plans should contain Rules that provide for equitable and economically-efficient resource allocation, and effects management.

27. The proposed Auckland Unitary plan does not address the issue of equity in the AAAQS. That is not a criticism - this is a national issue that has never been adequately addressed.

28. Straterra is aware that MfE is scoping the potential for further national direction in relation to plans, including the concept of template plans, to support councils around the country, in writing or reviewing their plans. We suggest this would be an appropriate context for developing good policies to address the triple concern (para 26). That would be preferable to each council in New Zealand individually developing solutions, with the risk of undesirable precedents being created.

Chris Baker
Chair, CANZ
CEO, Straterra

APPENDIX 1: COAL ASSOCIATION MEMBERSHIP

Alliance Group Ltd
Doug Hood Ltd
G L Bowron & Co Ltd
Genesis Power
Gold Mount Investments & Development Company Limited
Golden Bay Cement
Johnson Brothers 2006 Ltd
Lincoln University
Lyttelton Port Co Ltd
Mangapapa B2 Incorporation
McDonalds Lime Ltd
Ministry of Business, Innovation & Employment
Mr A. Broome
New Zealand Steel Ltd
Process Flow Limited (formerly Peat (NZ) Limited)
Real Journeys Ltd - TSS Earnslaw
SGS New Zealand Ltd
Shipherd Nurseries
Sinclair Knight Merz
South Port NZ Ltd
Stevenson Engineering Ltd
Synlait Milk Ltd
Taylor Coal Ltd
TNL Group Limited
University of Canterbury
Value Proteins Ltd
Websters Hydrated Lime Co Ltd
Westland Milk Products
Birchfield Coal Mines Limited
Buller Coal Limited
Burkes Creek Coal
Canterbury Coal Ltd
Francis Mining Co Ltd
Glencoal Energy Ltd
Harliwich Holdings Ltd
Kai Point Coal Co Ltd
New Creek Mining
Roa Mining Co Ltd
Solid Energy NZ Ltd
CRL Energy Ltd
GNS Science
Komatsu Australia Pty Ltd

Energy for Industry
Vector Gas Limited
Solid Energy Waikato
Golder Associates NZ Ltd
RCR Energy (NZ) Ltd
Southtile Limited
Heinz-Watties Limited
Lion Breweries South
Andritz Pty Ltd
Kenroll Industrial Coal (2011) Ltd

19 February 2014

Literature Review on Sulphur Dioxide Air Guidelines

Submitted to:
Golder Associates Pty Ltd NZ

REPORT

Report Number. 147613011-R-001-Rev0

Distribution:

Electronic Copy

Executive Summary

Golder Associates were requested to prepare a review of the health effects of sulphur dioxide (SO_2) with particular emphasis on the proposed adoption by the Auckland Council of an ambient air quality standard 20 µg/m^3 [1]as a 24 hour (hr) average.

The current National Environmental Standard for Ambient Air Quality for SO_2 include (MfE 2011):

Threshold concentration	***Number of exceedances allowed***
350 µg/m^3 *expressed as a 1-hour mean*	*9 in a 12-month period*
570 µg/m^3 *expressed as a 1-hour mean*	*None*

The MfE (2002) has also published ambient air guidelines intended as a guide to risk managers regarding emission control strategies. The ambient air quality guidelines (2002) for SO_2 are the same as the National Standards detailed above with the addition of a guideline with an averaging time of 24 hours (referred to as the '24-hr guideline':

Threshold concentration	***Number of exceedances allowed***
120 micrograms per cubic metre expressed as a 24-hour mean	*Not defined*

Objective

The objective of the present literature review was to consider whether or not there is a scientific justification for the adoption of 20 µg/m^3 as a 24-hour standard for the Auckland Region.

We reviewed literature on the following to achieve the objective:

a. What are the health effects of SO_2 and is there a definable threshold?

b. Over what timeframe do the effects occur?

c. What is the basis for the WHO (2006) 20 µg/m^3 *24-hour average guideline*?

d. Should the WHO (2006) recommendation be adopted by Auckland Council?

The literature review focussed where possible on critical reviews of SO_2 published by health authorities. In addition primary literature was reviewed to assess critical studies.

Health Effects of SO_2

Human Evidence in Clinical Studies

[1] Conversion between µg/m^3 to ppb depend on the molar volume. Molar volume changes with temperature and pressure. For the purposes of this report conversions were made at 25^{o}C. The conversion factor is ppb =0.38 x µg/m^3. If the conversion is conducted at 20^{o}C ppb = 0.3 x µg/m^3

A review of primary clinical studies clearly demonstrates important increases in airway resistance in moderately exercising asthmatics briefly exposed to 0.4 – 1.0 ppm (1.1 mg/m^3 to 2.6 mg/m^3)[2] SO_2. A brief summary follows with respect to acute exposures:

- In SO_2 responsive exercising asthmatics bronchoconstriction occurs within 5 – 10 min exposure to effective concentrations.
- The broncho-constrictor response is brief.
- Recovery is rapid on cessation of exposure.
- The effect of repeated exposures within a short time is less than the first exposure, suggesting adaptive changes.
- The initial response (at < 10 min) does not worsen with continued exposure.
- The no observable adverse effect level (NOAEL) for exercising SO_2 responding asthmatics is 0.2 ppm (0.5 mg/m^3).
- Significant increases in symptoms are observed at ≥ 0.4 ppm (≥ 1.1 mg/m^3) SO_2.
- The NOAEL for non-asthmatics is approximately 5 ppm (13.1 mg/m^3).
- The moist mucosal surfaces of the upper respiratory tract efficiently remove SO_2 from inspired air and thereby protect the bronchi.

Population based Studies

With respect to ambient air SO_2 population studies show:

- There is causal evidence for an association between short term ambient SO_2 exposure and respiratory symptoms in children.
- These findings are consistent with human clinical and animal studies demonstrating bronchoconstriction and other respiratory symptoms.
- Epidemiological studies are suggestive of an association between ambient SO_2 concentrations and mortality. However it is unclear whether this association is a primary effect of SO_2 or is due to a combination of air pollutants or other factors.
- Epidemiological results are inadequate to infer a causal relationship between long term exposure and any health endpoints (both morbidity or mortality).

Time frame for Health Effects

Bronchoconstriction can occur quickly, within 5 min to 10 min, when SO_2 - responsive asthmatics are exposed to biologically effective concentrations of the gas while they are exercising (Horstman et al. 1988). If moderate to heavy exercise is being undertaken then the response could begin within 2-min to 3-min but does not reach maximal levels until the exposure lasts for about five minutes (Balmes et al. 1987). The bronchoconstrictor response is however brief. According to the US EPA (1994) numerous studies have shown that SO_2 induced bronchoconstriction during exercise typically returns to normal within an hour of exposure. Even if SO_2 exposure continues, lung function can return to normal providing the individual ceases exercise and ventilation rates return to normal (Hackney et al. 1984).

[2] Calculated at 25 °C and absolute pressure of 101.325 kPa

Is the derivation of the WHO (2006) guideline consistent with the evidence?

The guideline derived by WHO 2006 is based on a precautionary qualitative assessment of population based studies to protect against long term effects of SO_2 and in particular mortality. This approach has several deficiencies:

- The concentration response relationships in the population based studies are weak or non-existent thus these are not a robust basis for standard setting.
- It is not clear whether the associations between SO_2 and mortality are clearly attributed to ambient exposure to SO_2 alone or a mixture of air pollutants.
- Causal relationships between long term effects and SO_2 exposure have not been established. The recent US EPA integrated science assessment of SO_2 concluded that there is inadequate evidence of a causal association with mortality.
- The intent of the 24-h guideline is unclear – if it is to protect against acute health effects it is flawed given the well understood mode of action for SO_2 and the clear thresholds for the biological response. A precautionary approach would be to limit peak concentrations and this is already achieved by a 1-h standard which has a greater propensity to control 5-10 min peak concentrations than a 24-hr average.

It is our opinion that the WHO (2006) 24-hr guideline is not sufficiently robust for adoption as an air quality standard. This opinion is consistent with recent decisions by expert committee/reviews in Canada, Australia and the UK.

Is a 24-hr Standard needed at all?

Both US EPA and Australia have previously discussed the possible adoption of a 10 min sulphur dioxide standard. Although the reviews in both countries acknowledged that the key health effects associated with short term SO_2 exposure occur over a short time frame (5-15 min) both countries did not adopt a guideline value over such a short averaging period due to practical considerations[3].

The US EPA has adopted a new 1-hr SO_2 standard at a level of 75 parts per billion (ppb), based on the 3-yr average of the annual 99th percentile of 1-hr daily maximum concentrations (US EPA 2010). The primary reasons for adopting a standard with a 1-hr averaging period include (US EPA 2008, 2009):

- Coherency between controlled human exposure studies and short term epidemiological findings of respiratory effects.
- Consistency with the mode of action from animal studies and controlled human exposure studies.
- Given the key SO_2 health effects occur over a very short period of time, it was considered important to choose an averaging time that would could control 5-10 min peaks. The US EPA considered that a 1-hr standard can substantially reduce the upper end of the distribution of SO_2 levels more likely to be associated with adverse respiratory effects. Standards with longer averaging periods to control peaks in short term exposures (5-min).

The above reasoning is consistent with the current approach in New Zealand. That is a formal 1-hr National Environmental Standard for Ambient Air Quality supported by a 24 h guideline of 125 µg/m^3.

[3] US EPA state that the adoption of a 5 min standard "would result in significant and unnecessary instability due to the likelihood that locations would frequently shift in and out of attainment"

Conclusions

Based on the scientific assessment of the WHO (2006) 24-hr guideline and the scientific literature it is our opinion Auckland Council should retain the current National Ambient air Quality Standard for SO_2 as well as the current MfE 24-hr ambient air guideline.

We note that this conclusion is consistent with recent expert reviews in Australia, Canada and the UK which further supports that there is no benefit in adopting a 24-hr average SO_2 limit of 20 µg/m^3.

Table of Contents

1.0 INTRODUCTION & BACKGROUND

Golder Associates (Golder) was requested to provide a critical appraisal and opinion on the Auckland Council's (AC) proposed adoption of the very stringent 2005 World Health Organisation (WHO) Ambient Guideline for 24 h for sulfur dioxide (SO_2).

The New Zealand Ministry for the Environment (MfE) consistent with all other jurisdictions in the world currently maintains the previous 24-hr average SO_2 guideline value of 120 $\mu g/m^3$ published by WHO. The key question is why have none of the countries with similar science policy approaches to MfE have not adopted the WHO (2006) recommendation for a 24-hr average SO_2 guideline of 20 $\mu g/m^3$?

The present paper provides a scientific rationale for why this might be the case. WHO makes the point that the implementation of the recommended guideline needs to be carefully considered.

It is important to distinguish between ambient air guidelines and Air Quality Standard Derivation.

Ambient air guideline values are:

- Derived in a manner consistent with the intention to provide guidance within a risk assessment context to enable decisions concerning the protection of human health.
- Derived in a manner that provides protection of human health due to exposure (either acute or chronic) of the general population in the ambient environment.
- Intended to be protective of identified and proven (i.e. not theoretical) sensitive subpopulations within the general population.
- Derived in a clear and transparent fashion following a comprehensive review of and evaluation of available information on the biological effects of a substance.
- Intended to typically consider information on the relative contribution of concentrations in other important exposure media such as the diet or drinking water.

Air Quality Standards setting can include risk management or other considerations such as available resources, air quality policy issues, capacity of air sheds, aspects of odour and well-being, ability to measure the pollutant and economic impacts.

Many large, medium and small industrial sites in New Zealand create 24-hr average impacts that are close to the site boundary and are much higher than 20 $\mu g/m^3$ (Personal Correspondence Golder NZ 2014). However the spatial and temporal extent of these impacts is usually severely limited, which is rarely accounted for when regulators apply ambient guidelines or standards in New Zealand.

2.0 OBJECTIVES

The objectives of the present study are to:

- *Provide a scientifically based report regarding SO_2 health effects and a commentary on the proposed 24-hr SO_2 standard for Auckland of 20 $\mu g/m^3$.*
- *Provide the latest scientific information regarding guidelines or standards for 24-hr SO_2 that achieve the aim of protecting human health.*

3.0 APPROACH

The literature review focussed where possible on critical reviews of SO_2 published by health authorities. In addition primary literature was reviewed to assess critical studies.

The literature review focussed where possible on critical reviews of SO_2 published by health authorities. In addition primary literature was reviewed to assess critical studies.

Published literature on sulphur dioxide (SO_2) were identified from searches of various databases, including Medline, Toxline, Web of Science, Science Direct, and Wiley scientific bibliographic databases. Reviews by competent organisations (NEPC 2013, 2004, US EPA 2010, WHO 2006, UK COMEAP 2013) were also used to identify pertinent publications. Abstracts of the papers by the authors were obtained through the electronic databases in most instances and where a study was considered to provide important information the entire article was acquired. In all, over 50 articles on the toxicology and health effects of SO_2 have been collected and reviewed.

The following key questions were asked:

a. What are the health effects of SO_2 and is there a definable threshold?

b. Over what timeframe do the health effects occur?

c. What is the basis for the WHO (2006) 20 µg/m^3 *24-hr average guideline*?

d. Should the WHO (2006) recommendation be adopted by Auckland Council?

4.0 ACUTE HUMAN HEALTH EFFECTS OF SO_2

4.1 Clinical and Experimental Evidence

Most, if not all of the quantitative information regarding the acute dose response of SO_2 in humans has been derived from clinical studies in which the exposure to SO_2 has been carefully controlled. Such investigations, conducted in environmental chambers or with face masks/mouth pieces, enable the effects of SO_2 to be studied alone or in combination with other factors (e.g. exercise, cold air, with and without medication, and with other pollutants) on healthy volunteers or subjects whose respiratory function is compromised by various stages of illness. The significant advantages of these studies are that accurate exposures can be delivered and the effects of co-factors can be evaluated in a pre-designed and controlled manner. Chamber studies have provided very useful information on the short term effects of SO_2, exposure response relationships and the reversibility and variability of response between individuals exposed to the same concentration. They do however rely on informed volunteer consent and therefore inherently tend to exclude children.

It is clear from a variety of reviews on SO_2 (US EPA 1994, 1996b, Streeton 1997, ATSDR 1998a, OEHHA 1999b, EC 2005) that healthy, non-asthmatic individuals are essentially unaffected by acute exposures to SO_2 when concentrations are about 1 ppm to 2 ppm (approximately 2,600 µg/m^3 to 5,300 µg/m^3), and that the population of concern for the effects of short-term SO_2 exposure consists of individuals who are mild to moderate asthmatics, are SO_2 responders and are undertaking exercise/activity that raises ventilation rate . However, not all asthmatics in these circumstances will experience adverse effects on exposure to SO_2 concentrations of < 0.6 ppm (1, 600 µg/m^3). With the proportion of asthmatic individuals who do respond, the magnitude of the response, and the occurrence of symptoms increase as SO_2 concentration and ventilation rates increase.

The major effect of acute exposure of SO_2 experienced by sensitive asthmatics is bronchoconstriction (measured as increased specific airways resistance (SRaw) or decreased FEV_1) and the occurrence of symptoms such as wheezing, chest tightness and shortness of breath. A level of 0.5 ppm to 0.6 ppm (1.3 µg/m^3 to 1.6 µg/m^3) appears to represent a break in the dose-response in that incidence and severity of response at > 0.6 ppm is twice as great than at < 0.5 ppm. In addition at 0.6 ppm, > 25% subjects had a decrease in FEV1 > 20%, whereas, < 25% of subjects responded at < 0.5 ppm (US EPA 1994, 1996b, ATSDR 1998).

The available short term exposure studies investigating the effects of SO_2 on respiratory function are summarised in Appendix A Table 1. These studies involve asthmatics, either at rest or exercising while exposed to levels of SO_2 from 0.1 ppm (260 µg/m^3) up to 5 ppm (13.1 µg/m^3) in whole chamber conditions or via mouth pieces. Not surprisingly the studies indicate the pulmonary effects of SO_2 can be significantly enhanced by exercise. To clarify the exposure response relationship, the results of the controlled exposure investigations have been arranged in Appendix A Table 1. Thus a single study may appear in the table more than once if it investigated more than one concentration of SO_2. In addition Appendix A Table 1 is arranged in two segments, the first showing exposures that did not cause significant changes in respiratory function, while the second portion contains SO_2 concentrations which according to the investigating authors resulted in a significant change in respiratory function.

Overall the database clearly demonstrates clinically important increases in airway resistance in moderately exercising asthmatics briefly exposed to SO_2 at concentrations of 0.4 ppm to 1.0 ppm (1.1 µg/m^3 to 2.6 µg/m^3). Only one study has shown minor lung function changes in asthmatics exposed through a mouthpiece to ≤ 0.25 ppm (~ 660 µg/m^3) (Sheppard et al. 1981). The response at 0.1 ppm was observed in the two most sensitive individuals of the study; these same individuals had significant changes at 0.25 ppm. From this and other studies the US EPA (1994) concluded that approximately 25% of mild to moderate asthmatics undergoing moderate exercise may exhibit a 100% increase of airways resistance, compared with clean air, when exposed to 0.25 ppm to 0.5 ppm SO_2.

Overall the weight of evidence on the exposure response for SO_2 induced-bronchoconstriction in Appendix A Table 1 shows that short term exposures (approximately 5-min to 15-min) of ≤ 0.2 ppm (~ 525 µg/m^3) are without significant effect in asthmatics that are resting or exercising. This concentration represents the no observed adverse effect level (NOAEL) for SO_2 –sensitive asthmatics.

The NOAEL of 0.2 ppm inferred from the dose response information in Table 4.1 is consistent with a SO_2 hyper-responsiveness study conducted as part of the European community respiratory health survey (Nowak et al. 1997). In that survey, the prevalence of SO_2 hyper-responsiveness[4] in 786 adults was 3.4%. None of these individuals responded to concentrations of SO_2 < 0.25 ppm, 0.6% responded to < 0.5 ppm, 1.7% responded to < 1 ppm and 1.5% responded to < 2 ppm. Within the age range of the volunteers (20 yr to 44 yr) there was no significant relationship between age and the percentage or degree of hyper-responsiveness to methacholine[5] or SO_2. Rondinelli et al. (1987) also found in a non-population-based sample of subjects airway responsiveness to SO_2 did not differ significantly between subjects aged 55 yr to 73 yr and younger subjects.

A NOAEL of 0.2 ppm is also consistent with the deliberations of the UK Expert Panel on Air Quality Standards (refer to Section 5.2 in UK EPAQS 1995). Similarly the US EPA (1994) concluded only a relatively small percentage (≤ 10% to 20%) of mild and moderate asthmatic individuals exposed to SO_2 concentrations of 0.2 ppm to 0.5 ppm during moderate exercise are likely to experience lung function changes distinctly larger than those they typically experience. Furthermore it was concluded that compared to responses above 0.6 ppm the response at concentrations below 0.5 ppm are less likely to be perceptible and of immediate health concern.

[4] The SO_2 hyper-responsiveness in Nowak et al. 1997) was defined as a 20% decrease in FEV_1. The study showed 99.6% specificity for methacholine responsiveness as a predictor for SO_2 hyper-responsiveness. Since the total frequency of nonspecific airway hyper-responsiveness was 22.6% (228/1,006) (CI 20.1-25.3%) many of the volunteers who were hyper responsive to SO_2 were also asthmatic. SO_2 challenge was conducted under hyperventilation isocapnic conditions to imitate the increase ventilation that occurs with exercise (Sheppard et al. 1981, see also Section 4.1.1) and while subjects wore nose clips, i.e. mouth only breathing.

[5] Methacholine is a synthetic choline ester that acts as a non-selective muscarinic receptor agonist in the parasympathetic nervous system

4.2 *Response time(s) for SO_2 bronchoconstriction*

Bronchoconstriction can occur quickly, within 5-min to 10-min, when SO_2 - responsive asthmatics are exposed to biologically effective concentrations while they are exercising (Horstman et al. 1988). If moderate to heavy exercise is being undertaken then the response could begin within 2-min to 3-min but does not reach maximal levels until the exposure lasts for about five minutes (Balmes et al. 1987). The bronchoconstrictor response is however brief. According to the US EPA (1994) numerous studies have shown that SO_2 induced bronchoconstriction during exercise typically returns to normal within an hour of exposure. Even if SO_2 exposure continues, lung function can return to normal providing the individual ceases exercise and ventilation rates return to normal (Hackney et al. 1984).

Consistent with the notion of rapidly acquired attenuation of response, longer periods of SO_2 exposure during exercise do not lead to a statistically significant worsening compared with the initial response (Kehrl et al. 1987). Thus exposure to SO_2 at 1 ppm during exercise caused significant bronchoconstriction within 2-min but the increase in airway resistance after 10-min of exposure was not significantly increased when the exposure was extended to 30-min (Horstman and Folinsbee, 1986).

4.3 Epidemiological Evidence

While controlled clinical studies in healthy and asthmatic volunteers provide good data set for establishment of an exposure response curve for airways narrowing with acute exposure to SO_2, similar data are not available other health endpoints. Population based studies in which hospital admissions for the diagnosis of interest have been correlated with area measurements of ambient air pollution provide information about the relationship between SO_2 and health effects. There have been many such studies investigating the relationship between air pollution and acute or chronic illnesses. These studies are often difficult to interpret with respect to establishing guidelines or standards for a number of reasons, e.g. identifying representative exposure, differences in exposure measurement, the presence of other air pollutants and additional environmental confounders.

The most recent causal examination of SO_2 and health effects was reported by the US EPA (2008). Table 1 summarises the US EPA conclusions on causal association between SO_2 and health effects.

Table 1: US EPA (2008, 2009) Conclusions on SO_2 Health Effects

Health Effect	**Conclusion**
Short Term	
Respiratory	Causal
Cardiovascular	Inadequate to infer a causal relationship
Mortality	Suggestive of a causal relationship
Long Term	
Carcinogenic effects	Inadequate to infer a causal relationship
Prenatal and Neonatal Outcomes	Inadequate to infer a causal relationship
Mortality	Inadequate to infer a causal relationship

Generally the association between hospital admissions for respiratory diseases and air pollution *per se* is highly correlated. However, the impact of SO_2 is relatively weak compared to the influence of other pollutants. Where air pollution has been implicated in long term health effects, particulates and gaseous pollutants other than SO_2 are more strongly correlated with the effect. For example Burnett et al. (1999) found only 2% to 8% of excess daily hospital admissions (respiratory, cardiac, cerebral vascular and peripheral vascular diseases) in Toronto between 1980 and 1994 were associated with SO_2. NO_2 accounted for 40%, O_3 and PM_{10} each for 20% and CO for 17%. In Brisbane, O_3 was consistently associated with hospital admissions for asthma and respiratory disease with limited evidence of a threshold. However SO_2, although significantly associated with admissions for respiratory disease was also associated with the control illness of digestive disorders, thus suggesting that the association of SO_2 with other effects was likely a chance, spurious correlation (Petroeschevsky et al. 2001).

The Australian Environment Protection and Heritage Council (EPHC 2005, 2009) conducted an extensive multi-city study to modern time-series epidemiology standards to investigate health impacts of air pollution in seven Australian and New Zealand cities (Auckland, Brisbane, Canberra, Christchurch, Melbourne, Perth and Sydney) representative of about 50% of the total population of the two countries. The study authors consistent with overseas practice state that the results from a group of cities are more indicative than independent single city analyses.

The study examined the short term effects of air pollution on health in Australian and New Zealand cities for a four-year period from January 1998 to December 2001; the study derived estimates for the associations between increases in daily outdoor concentrations of major air pollutants and increases in daily hospital admissions and daily mortality counts.

A range of pollutant averaging periods were selected based on the National Environment Protection Measure (NEPM) reporting requirements: daily 24-hr averages for $PM_{2.5}$, PM_{10} and NO_2; daily average 8-hr maxima for CO and O_3; daily 1-hr maxima for NO_2 and O_3; and a daily average 4-hr maxima for O_3. Although EPHC (2005) includes data for SO_2 (1-hr maximum, 24-hr average values) the final report (EPHC 2010) excludes discussion of SO_2 without stating the reason for the exclusion. Air quality data was procured from the environmental protection agencies in each jurisdiction.

The report estimates the associations between increases in daily outdoor concentrations of major air pollutants and increases in daily hospital admissions and daily mortality counts. The focus was on the identification of short-term effects of air pollutants on health outcomes i.e. the acute effects arising from immediate exposure to air pollution. Therefore, only the health effects arising from exposure to air pollution on the same day or the previous day (used as an average of exposures on both days) were examined. Although the EPHC 2005 study report tables include statistics and meta analyses results for SO_2 these results are not discussed in the final report (EPHC 2010). Reasons are not provided and this may be because SO_2 was not associated with most health endpoints.

Hedley et al. (2002) presents the results of an observational study which aimed to assess the effects of an intervention introduced in Hong Kong in 1990, which required the use of fuel oil with a sulphur content of not more than 0.5% by weight, on mortality rates over the 5 yr after the intervention was introduced. The data were obtained from the Census and Statistics Department databases for the following groups: all-cause mortality, respiratory disease (ICD-9 460-519), cardiovascular disease (ICD-9 390-459), neoplasm (ICD-9 140-239) and all other cause mortality (ICD-9 001-009; 140-161; 163-246; 280-294; 320-326; 520-629; 710-719). Poisson regression model of deaths each month between 1985 and 1995 was used to estimate changes in trends in deaths.

The paper concluded that "*Pollution resulting from sulphur-rich fuels has an effect on death rates, especially respiratory and cardiovascular deaths. The outcome of the Hong Kong intervention provides direct evidence that control of this pollution has immediate and long-term health benefits*." It was noted that the reduction in risk for overall mortality was greater in districts that had large reductions in SO_2 than in those that did not and that the greatest reduction was observed for respiratory deaths. The paper although suggestive of a decline in death rates with decreasing ambient SO_2 concentrations has two limitations. Firstly the paper did not specifically address the influence of influenza epidemics which vary from year to year and influence the trend in mortality. This is important as the trend in mortality across the intervention point co-occurred with an upward trend in mortality. The resulting decline in mortality following the intervention thus may have more to do with factors (influenza) that were not controlled within the study. The second issue is that the paper does not preclude the possibility that other constituents in the pollution mixture contributed to the adverse effects reported. Hedley (2006) reported large reductions in ambient nickel and vanadium concomitantly with reductions of sulfur after the intervention. SO_2 also may be serving as a modifier of the effect of respirable particles (US EPA 2008).

Wong et al. (2002) presents the results of an observational study with a principle aim of determining if the effects of air pollution on daily hospital admissions are consistent between Hong Kong and London. Data was collected for patients admitted to hospital emergency departments (or equivalent) in Hong Kong from 1995 – 1997 and in London from 1992 – 1994, for the following four groups: Asthma for ages 15 yr to 64 yr (ICD-9 493); respiratory disease for ages ≥ 65 yr (ICD-9 460-519); cardiac diseases for all ages (ICD-9 396-429); and ischemic heart disease (IDH) for all ages (ICD-9 410-414).

Although WHO (2005) cites the Wong et al. paper as showing that there was "*no evidence of a threshold for health effects at 24-hour (sic) SO_2 concentrations in the ranges of 5 - 40 $\mu g/m^3$*", the paper does not provide sufficient data to determine a dose response-relationship. There are two main issues with respect to concentration response in the paper. Firstly, the findings were not statistically significant and secondly, the SO_2 associations were substantially reduced after NO_2 was added to the models. A third issue relates to the concentration in Hong Kong. The 24-hr mean SO_2 concentration is reported as 17.7 *$\mu g/m^3$* (i.e. within the range quoted by the WHO) yet the authors do not report an excess risk due to SO_2 emergency admissions for asthma or respiratory effects (refer to Table 5 and 6 of Wong 2002).

Pope et al. (2002) presents the results of an observation study with the aim of assessing "*the relationship between long-term exposure to fine particulate air pollution and all-cause, lung cancer and cardiopulmonary mortality*". The analysis was based on data collected by the American Cancer Society (ACS) as a part of the Cancer Prevention Study II, an ongoing prospective mortality study of approximately 1.2 million adults. Volunteers in the study were required to be a minimum of ≥ 30 yr at the start of the study. Data were assessed for all-cause mortality and also the subgroups of cardiopulmonary mortality (ICD-9 401-440 and 460-519), lung cancer mortality (ICD-9 162) and all-other cause mortality.

In addition to $PM_{2.5}$, all the gaseous pollutant data were retrieved for the extended period and analyzed for their associations with death outcomes. As in the 1995 analysis, the air pollution exposure estimates were based on the daily average concentrations. The main finding of this paper is that $PM_{2.5}$ was associated with total, cardiopulmonary, and lung cancer mortality but not with deaths for all other causes. SO_2 was associated with all the mortality outcomes, including all other causes of deaths. The SO_2 relative risk (RR) estimate for total mortality was 1.03 (95% CI: 1.02, 1.05) per 5 ppb increase (1982 to 1998 avg). The association of SO_2 with mortality for all other causes (sulfate also showed this pattern) makes it difficult to interpret the effect estimates. This lack of specificity for SO2 (in contrast to PM) is not consistent with causal inference (US EPA 2008).

In Rome no correlation was found between SO_2 concentrations (up to a 2-d lag) and total respiratory hospital admissions but NO_2 and CO correlated with admissions for asthma and chronic obstructive pulmonary disease (COPD) (Micheloozi et al. 2001, Fusco et al. 2001). Similarly there was no association observed with respiratory disease hospitalisation rates and SO_2 in Rouen (France) (Hautemaniere et al, 2000) or Valencia (Tenias et al. 2002). Masjedi et al. (2003) also found no association between daily SO_2 levels (range 14 ppb to 66 ppb, 24 h average; 37 µg/m^3 to 170 µg/m^3) and hospital admissions for asthma. However Guillen et al. (1995) established that excess asthma admissions correlated with high (> 80 µg/m^3, ~31 ppb) SO_2 with a 10- d lag period. The odds ratio was 3.6.

Michaud et al. (2004) had access to 53 months of hourly ambient measurements of SO_2 and PM_1 in a city affected by volcano activity in Hawaii. This was concurrent with data for hospital emergency department visits for asthma/COPD, cardiac, flu, cold and pneumonia. After adjusting for month, year and day of week only COPD/asthma were consistently positively correlated with air pollution. The strongest associations were for SO_2 with a 3-d lag (6.8% per 10 ppb) and PM_1 with a 1-d lag (13.8% per 10 µg/m^3). A notable finding of this study was the fact that month of year was more strongly correlated with emergency department visits for asthma/COPD than was air pollution. Asthma/COPD diagnosis was 56% higher in February than July but the increase in average emergency visits per day for the highest 1% SO_2 exposures (~34 ppb) versus 0 ppb was only 25%. Although the temporal variation remains unexplained the authors point out it had a bigger influence on health than SO_2 and is a significant confounder of air pollution studies.

After adjusting for temperature, day of the week, season and temporal trends there was little evidence between air pollution and hospital admissions for respiratory causes in Birmingham but there was for Minneapolis – St Paul. For the latter city, O_3 on the previous day was most strongly correlated; there was an increase in hospital admissions of 5.15% with a 15 ppb increase in O_3 (Moolgavkar et al. 1997).

In the large European Union financed APHEA-1 study a meta analysis using the results of each city revealed the daily number of natural deaths was associated with increases in the levels of particulate matter, SO_2, O_3 and NO_2. However emergency hospital admissions for the whole group of respiratory disorders were less consistently associated with particulate matter, SO_2 and NO_2 whereas there was an association with O_3. With respect to specific illnesses the study concluded NO_2 and SO_2 may play a role in exacerbating asthma particularly in children. The overall conclusion was an association between daily variations in urban air pollution and adverse health effects existed. The association was weak but because large populations are potentially exposed to SO_2 the author considered it was an important public health concern (Vigotti 1999). Some of the older literature (e.g. Sunyer et al. 1991, 1993) has shown associations for between hospitalisation for COPD and ambient air SO_2.

Conclusions:

In relation to ambient air SO_2 the population studies described above collectively show:

- No or only weak association with general symptoms of respiratory illness.
- A variable association with increased hospital visits/admissions for respiratory illnesses.
- An inconsistent pattern suggestive of SO_2 associated mortality.

5.0 BASIS FOR WHO (2006) GUIDELINE

WHO released a global update in 2005 to their *WHO Air quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide* guidelines. This document summarises the risk assessments undertaken when updating certain guidelines. The document presents two guidelines for SO_2, which are as follows:

- 20 µg/m^3 24-hour mean (short term exposure).

- 500 µg/m^3 10-minute mean (long term exposures (over 24-hours).

The document explains that the short-term guidelines of 500 µg/m^3 was recommended based on controlled studies involving exercising asthmatics, which indicated that a proportion experience changes in pulmonary function and respiratory symptoms after periods of exposure to SO_2 as short as 10 minutes. No references for the studies are provided by WHO. The document states that due to numerous variables in short term exposure "*it is not possible to apply a simple factor to the value in order to estimate corresponding guideline values over longer time periods, such as 1 hour*".

In reference to **long-term exposure**, the document provides a revised guideline value of 20 µg/m^3 24-hour mean. This value was revised from the original 1987 value of 125 µg/m^3 (as a 24hour average), which was linked at the time to the corresponding guideline value for PM. The document states that more recent data indicated the separate and independent adverse public health effects of PM and SO_2, which resulted in WHO separating the two guidelines. The document then provides further review of several observational studies, which WHO suggests, indicates the original value of 125 µg/m^3 was not conservative enough. The referenced studies include *Hedley et al.* (2002), *Pope et al.* (2002) and *Wong et al.* (2002). Summaries of these studies are provided in Section 4.3. It is important to note that the papers address different endpoints (Pope and Hedley are interested in mortality, while Wong is interested in short term morbidity) and different basic research questions (Pope is most interested in particulate associations with mortality and re-analysed/reconstructed data for gases at a later time, Wong is interested in the concordance between morbidity between two cities with similar traffic related air pollution). Each of these papers do not provide sufficient detail to discriminate an exposure response function SO_2 health effects. This is important given the robust understanding of the mode of action of SO_2 related toxicity. It is also important to point out that causal associations between SO_2 and mortality have not been demonstrated (US EPA 2008, US EPA 2010).

The document provides two 24-hour average Interim Target levels (IT-1: 125 µg/m3 (noted to be the former WHO Air Quality Guideline (WHO, 200)) and IT-2: 50 µg/m3). The document states "since the revised 24-hour guidelines may be quite difficult for some countries to achieve in the short term, a stepped approach using interim goals is recommended".

6.0 RECENT APPROACHES TO STANDARD SETTING

The following is not intended to be a summary of international and overseas guidelines. It is a contextual look at whether:

National guidelines have been updated since publication of the WHO (2006) 24-hr guideline. The sulphur dioxide target values adopted by the New Zealand (Ministry for the Environment, 2011), UK (UK Government, 2010) and Europe (EU, 2008) are consistent with one another. Interestingly none of the authorities have adopted the WHO (2006) guidelines.

6.1 UK 2013

The UK National Air Quality Objectives (UK Government, 2010) provide the following target values for sulphur dioxide for the protection of human health:

- 266 µg/m^{-3} (15 minute mean).
- 350 µg/m^{-3} (1 hour mean).
- 125 µg/m^{-3} (24 hour mean).

The Air Quality (Standards) Regulations 2010 (UK Government, 2010) transpose into English law the requirements of Directives 2008/50/EC and 2004/107/EC on ambient air quality.

The key expert advisory committee on the health effects of ambient air pollution in the UK (Committee on the Medical Effects of Air Pollutants Standards Advisory Subgroup) recently reviewed the UK air quality index (AQI) (COMEAP 2011) to ensure the index values were still suitable since their release 12 years earlier given the developments in the air quality field. The AQI is normally based on the latest health based air guideline value. COMEAP note that it is normal practice to adopt WHO guidelines in such updates. As part of the review COMEAP evaluated the revised WHO Air Quality Guidelines, published in 2006. WHO noted SO_2 effects following long-term exposure (mortality) and daily exposure (hospital admissions and daily mortality) however there was uncertainly whether SO_2 was directly responsible for these effects or acted more as a surrogate for an active component of the pollution mixture. WHO chose to adopt the precautionary approach and recommended the 24-hour average AQG of 20 μg/m^3, the UK COMEAP did not adopt this value in the update of the AQI and in doing so did not recommend additional review of the existing UK Air Quality Standards for SO_2.

As well as considering the WHO recommendations COMEAP also evaluated the predecessor of the COMEAP Standards Advisory Subgroup, the Expert Panel on Air Quality Standards (EPAQS). In line with WHO, EPAQS adopted the viewpoint that most of the asthma sufferers would not suffer clinically significant effects at ambient concentrations of SO_2 below 200 ppb (parts per billion) (equivalent to 532 μg/m^3). EPAQS did however recommend a Standard of 100 ppb (266 μg/m^3) averaged over 15 minutes. COMEAP concluded '*the standard recommended by EPAQS as more appropriate for adoption as the breakpoint between the Low and Moderate bands than the WHO AQG'*. Therefore COMEAP did not adopt the WHO recommendations but instead left the SO2 AQI unchanged as per the EPAQS evaluation. "

The UK assessment is consistent with the findings of the present report that the scientific rationale for adoption of the WHO 24-hr guideline of 20 μg/m^3 is not appropriate.

6.2 Canada 2012

Ontario MoE (2008) have set a health based air quality standards of

- 1hr guideline of 690 μg/m^3.
- 24-hr guideline of 275 μg/m^3.

A review of relevant government authority information did not indicate that Canada are considering the adopting the WHO (2006) 24 h guideline of 20 μg/m^3 .

A recent Canadian expert review of the WHO (2006) SO_2 guideline is highly critical of the WHO (2006) approach. The review states (Fraser Institute 2012 Chapter 5 pg 26-28):

There is currently uncertainty over whether low levels of SO2 have effects on human health. The World Health Organization recommends 24-hour average concentrations under 7 ppb (20 μg/m3), a recommendation based on a handful of cited studies that the World Health Organization has misinterpreted.

Closer analysis of Burnett et al. (2004) reveals that the average concentrations are between 5 ppb (14.28 μg/m^3) and 10 ppb (29 μg/m^3); the World Health Organization misread the units of measure in the Canadian study. Burnett and his colleagues find a very small positive effect on mortality for SO_2 when nitrogen dioxide (NO2) is included in the model (the result is statistically significant at the 5% level but not the 1% level). The effect is relatively smaller than that of other pollutants, suggesting that reductions of SO_2 provide lower health benefits than reductions of other pollutants.

It should also be noted that the study by Burnett et al. only proves correlation between SO_2 and mortality and is not evidence of a causal relationship. Two other studies (Buringh et al., 2000; Wichman et al., 2000) cited by the World Health Organization's report show no causal relationship between SO_2 and mortality when particulate matter is included in the analysis. Thus, the report by Burnett and colleagues (2004) does not prove a link between SO_2 and mortality since particulate matter and SO_2 were never included in the analysis at the same time. Clearly, the extent of the effects upon health of exposure to SO_2 is still open for debate.

6.3 Australia 2013

Australia is in the process of considering changes to the ambient air National Environmental Protection Measure. The adoption of the WHO 24-hr guideline of 20 µg/m^3 is not being considered to our knowledge[6]

6.4 New Zealand 2011

The New Zealand Ministry for the Environment (2011) ambient air quality guidelines for sulphur dioxide are:

- 350 µg.m^{-3} (one hour average).
- 120 µg.m^{-3} (24 hour average).

Short-term (less than 24-hour exposure) guideline values for SO_2 have been developed based on the minimum concentrations associated with adverse effects in asthmatic patients exercising in a laboratory situation (World Health Organisation, 2000). Thus the guideline values represent a protective level for vulnerable groups within the community.

Information on the effects of exposure for longer periods (e.g. 24-hour) was obtained from epidemiological studies, which show associations between contaminants such as SO_2 and health impacts in communities and selected panels (Ministry for the Environment, 2002).

In evaluating the health evidence relating to SO_2 exposure for the New Zealand ambient air quality guideline values, because of the correlations between SO_2 and other contaminants in the air it is difficult to confidently attribute the observed effects in the epidemiological studies to SO_2 alone. Experimental studies were therefore used to derive the dose-response relationships underpinning the ambient air quality guideline values for SO_2 for New Zealand (Ministry for the Environment, 2002).

Previously, the 1994 ambient air quality guideline values for New Zealand (Ministry for the Environment, 1994) included a 10 minute average SO_2 guideline value of 500 µg.m^{-3}, this was removed in 2001 (Ministry for the Environment, 2001).

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Previously, the 1994 ambient air quality guideline values for New Zealand (Ministry for the Environment, 1994) included a 10 minute average SO_2 guideline value of 500 µg.m^{-3}, this was removed in 2001 (Ministry for the Environment, 2001).

[6] Golder Associates were contracted by the National Environmental Protection Council to produce a health risk assessment for the purposes of informing the standard setting process in Australia. The health effects assessment in this risk assessment was conducted by a panel of health experts from academia and government. The HRA did not model the health benefits of adopting the WHO (2006) proposed 24 hr guideline for SO_2

6.5 US EPA 2010

In 2010, EPA revised the primary SO_2 NAAQS by establishing a new 1-hour standard at a level of 75 parts per billion (ppb). EPA revoked the two existing primary standards because they would not provide additional public health protection given a 1-hour standard at 75 ppb.

The primary rationale (US EPA 2008, 2009) for the development of the US EPA standard was the combination of available controlled human exposure data (both 5- and 10-minute exposure durations, have been combined and treated as representing 5-minute responses). The combined dataset was then used to develop the probabilistic exposure-response relationships (using a Bayesian Markov Chain Monte Carlo approach).

The methodology of combining data from different controlled human exposure studies and applying the data in a probabilistic model is novel for the setting of health based guidelines.

Within the context of the current paper it is worth mentioning that the US EPA did not develop a ambient air standard based on a concentration response function derived from the existing dataset of time-series epidemiology studies available of SO_2. This is because most if not all of these studies do not provide sufficient evidence to establish a plausible concentration response function over a 1-hr averaging time.

6.6 Europe 2008

The EU (2008) Ambient Air Quality Directive provide the following limit values for sulphur dioxide for the protection of human health:

- 350 µg/m^{-3} (1 hour mean).
- 125 µg/m^{-3} (24 hour mean).

No evidence could be found that the EU are actively reviewing the SO_2 standard.

6.7 Other Guidelines

The UK (EPAQS 1995) considered that most of the acute clinical studies did not show an effect below 250 ppb and although ‘occasional subjects’ had responded to lower concentrations with transient changes in measurements of lung function, these transient changes were “*insufficient to be associated with symptoms*”. Furthermore it was considered that the transient changes occurred in asthmatic subjects breathing through a mouthpiece while exercising on a bicycle thus the normal protective mechanism of nasal mucosal scrubbing of SO_2 was bypassed. The Panel recommended an Air Quality Standard for SO_2 in the United Kingdom of 100 ppb, measured over a 15 minute averaging period. The dose response analysis in Table 4.1 suggests an effect would not be anticipated in sensitive individuals until the UK guideline had been exceeded 2 -3 fold. The rationale used by the UK panel for setting such a low standard was that exacerbation of asthmatic symptoms could occur with exposures as short as 1 minute however it is impractical to measure SO_2 over this very short time frame. Fifteen minutes was considered the shortest practical period for measurement. Nevertheless this period of measurement could include very brief times of higher concentrations, which could be as much as double the average, and therefore have an effect on susceptible individuals when the average appears safe. The UK panel took this into consideration, as well as the need for an adequate margin of safety for those individuals more severely affected by asthma when they set a level of 100 ppb measured over a 15 minute averaging period.

ASTDR (1998) point out some studies have reported a lack of significant lung function changes in asthmatics following exposure up to 0.5 ppm and that bronchoconstrictive responses to SO_2 are highly variable among individual asthmatics. In some studies, asthmatics were preselected for sensitivity to SO_2 and subject selection may explain the range of SO_2 induced responses obtained by different investigators. In addition SO_2 is water soluble and administration through a mouth piece, as in many of the clinical studies, eliminates scrubbing by the nasal mucosa and results in delivery of larger doses to the lower airways. Furthermore according to OEHHA (2000) the results seen in some studies at 0.25 ppm could not be reproduced at higher exposures and workloads.

ASTDR (1998) state *"most clinical studies in humans have demonstrated statistically significant but subtle effects (i.e. in the normal range) which are not considered pathological"*. Therefore the effects were classified as minimal according to the ATSDR definition which describes minimal effects as *"those that reduce the capacity of a organ or organ system to absorb additional toxic stress but will not necessarily lead to the inability of the organ or organ system to function normally"*. The ASTDR consider 0.25 ppm SO_2 exposure in exercising asthmatics as a low observed adverse effect level (LOAEL) for short term exposure and 0.1 ppm as a minimal LOAEL[7]. In calculating a minimal risk level for acute exposure ATSDR have used 0.1 ppm as a minimal LOAEL and divided it by an uncertainty factor of 9 (3 for use of minimal LOAEL and 3 to account for human variability) to yield an acute minimal risk level of 0.01 ppm. It should be noted that acute MRLs are established for exposures of 1 – 14 days. In addition many other authorities (e.g. WHO 2000a and OEHHA 2000b) consider the concentrations that ATSDR deem as minimal LOAEL to be effective NOAEL's (see also Table Att6.1).

In contrast to the ATSDR (1998), California EPA (OEHHA 2000b) based on a thorough review of the literature consider the LOAEL for 5-75 minute SO_2 exposure of moderately exercising asthmatics to be 0.4 – 0.5 ppm, with a NOAEL of 0.2 - 0.25 ppm which they believe would not result in discomforting respiratory effects in sensitive individuals, i.e. exercising asthmatics, for a period of 1 hour. The California EPA did not apply their traditional uncertainty factors for intraspecies variability in response and set an acute reference exposure level (REL) of 0.25 ppm. They state "*This level is felt to protect asthmatic individuals because adverse effects are consistently observed only at higher concentrations under conditions of moderate exercise (ventilation rates of >40 L/minute) and there is inconsistency in response to SO_2 exposure at lower concentrations*". Thus the California EPA acute REL does not rule out the possibility that very sensitive individuals will not experience adverse effects at concentrations of 0.2 ppm.

[7] The choice of concentration for minimum LOAEL by the ATSDR is driven by science policy considerations set in their procedure used for deriving minimum risk levels. This procedure does not easily allow a weight of evidence approach for selecting points of departure in establishing health guidelines hence the extremely low value of the SO_2 MRL. It is also pointed out that the acute MRL is for an exposure of 1 – 14d, this is a time frame that is not compatible with the known response times of asthmatics to SO_2. Furthermore the dose response information shows continuing exposure at a concentration that does not produce a effect within approximately 5 – 10 minutes does not elicit a response when the exposure is for much longer times.

7.0 CONCLUSIONS

Golder conducted a review of the health effects of sulphur dioxide (SO_2) with particular emphasis on the proposed adoption by the Auckland Council of an ambient air quality standard 20 µg/m^3 as a 24 hour (hr) average.

The objective of the present literature review was to consider whether or not there is a scientific justification for the adoption of 20 µg/m^3 as a 24-hr standard for the Auckland Region.

The literature review focussed where possible on critical reviews of SO_2 published by health authorities. In addition primary literature was reviewed to assess critical studies.

Important findings of the review include:

- The key SO_2 effect is bronchoconstriction which occurs within 5 – 10 min exposure to effective concentrations. The effect occurs in a subset of the exercising asthmatics. This effect is:
  - Brief (< 10 min) and does not worsen with continued exposure.
  - Recovery is rapid on cessation of exposure.
  - The effect of repeated exposures within a short time is less than the first exposure, suggesting adaptive changes.
  - The no observable adverse effect level (NOAEL) for exercising SO_2 responding asthmatics is 0.2 ppm (0.5 mg/m^3).
  - Significant increases in symptoms are observed at ≥ 0.4 ppm (≥ 1.1 mg/m^3) SO_2.
  - The NOAEL for non-asthmatics is approximately 5 ppm (13.1 mg/m^3).
- Population based studies have found associations between ambient levels of SO_2 and emergency department records for asthma and respiratory effects. Importantly:
  - There is causal evidence for an association between short term ambient SO_2 exposure and respiratory symptoms in children.
  - These findings are consistent with human clinical and animal studies demonstrating bronchoconstriction, and other respiratory symptoms.
  - Epidemiological studies are suggestive of an association between ambient SO_2 concentrations and mortality. However it is unclear whether this association is a primary effect of SO_2 or is due to a combination of air pollutants or other factors.
  - Epidemiological results are inadequate to infer a causal relationship between long term exposure and any health endpoints (both morbidity or mortality).

The guideline derived by WHO 2006 (and now proposed as a ambient standard for the Auckland Region) is based on a precautionary qualitative assessment of population based studies to protect against long term effects of SO_2 and in particular mortality. This approach has several deficiencies:

- The concentration response relationships in the population based studies are weak or non-existent thus these are not a robust basis for standard setting.
- It is not clear whether the associations between SO_2 and mortality are clearly attributed to ambient exposure to SO_2 alone or a mixture of air pollutants.

- Causal relationships between long term effects and SO_2 exposure have not been established. The recent US EPA integrated science assessment of SO_2 concluded that there is inadequate evidence of a causal association with mortality.

- The intent of the 24 hr guideline is unclear – if it is to protect against acute health effects it is flawed given the well understood mode of action for SO_2 and the clear thresholds for the biological response. A precautionary approach would be to limit peak concentrations and this is already achieved by a 1 hr standard, which has a greater propensity to control 5-10 min peak concentrations than a 24 hr average.

It is our opinion that the WHO (2006) 24 hr guideline is not sufficiently robust for adoption as an air quality standard. This opinion is consistent with recent decisions by expert committee/reviews in Canada, Australia and the UK.

Is a 24 h Standard needed at all?

Both US EPA and Australia have previously discussed the possible adoption of a 10 min sulphur dioxide standard. Although the reviews in both countries acknowledged that the key health effects associated with short term SO_2 exposure occur over a short time frame (5-15 min) both countries did not adopt a guideline value over such a short averaging period due to practical considerations[8].

The US EPA has adopted a new 1-hr SO_2 standard at a level of 75 parts per billion (ppb), based on the 3-yr average of the annual 99th percentile of 1-h daily maximum concentrations. The primary reasons for adopting a standard with a 1-hr averaging period include:

- Coherency between controlled human exposure studies and short term epidemiological findings of respiratory effects.

- Consistency with the mode of action from animal studies and controlled human exposure studies.

- Given the key SO_2 health effects occur over a very short period of time, a short averaging time (1 hr v 24 hr) is more appropriate to control 5-10 min peaks.

The above reasoning is consistent with the current approach in New Zealand. That is a formal 1 h National Environmental Standard for Ambient Air Quality supported by a 24-hr guideline of 125 µg/m^3.

Golder concludes that the adoption of the current WHO guideline for 24-hr SO_2 is not justified on the basis of human health protection. The continued reliance on the New Zealand Ministry for Environment's Guideline value is considered adequate.

[8] US EPA state that the adoption of a 5 min standard "would result in significant and unnecessary instability due to the likelihood that locations would frequently shift in and out of attainment"

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Report Signature Page

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APPENDIX A

SO_2 Concentration Response

APPENDIX B

Limitations

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APPENDIX 3: CANZ/STRATERRA SUBMISSION TABLE

Proposed Unitary Plan Provision	Submission	Decision Sought
PART 1 – REGIONAL POLICY STATEMENT (RPS) CHAPTER		
B.1.2 Enabling economic well-being and B.3.1 Commercial and Industrial Growth.	The background section on enabling economic well-being appropriately recognises that industrial activities are key drivers of economic growth. Likewise, the chapter on Commercial and Industrial Growth contains objectives and policies which appropriately recognise and provide for industrial activity within the region. CANZ/Straterra supports these provisions that provide for industrial activity within the Region.	Retain the Background Section in B.1.2 and the Objectives and Policies in B.3.1.
B.1.5 Sustainably Managing our Natural Resources.	The Section 32 Analysis undertaken for the PAUP does not address the extent to which non-compliance with the AAAQS has resulted in adverse effects on health and amenity within Auckland. CANZ/Straterra suggests that the issue refers to acceptable levels rather than standards which by themselves do not determine a level of effects. Acceptable levels would be influenced by a range of parameters such as sensitive receptors in the vicinity of the discharges, and also the frequency and	**Make the following amendments to the Issue for Air Quality in B.1.5** ***Air quality*** *Clean air is fundamental to our health, well-being and environment. Auckland, compared to many cities in the world, has good air quality. However, air quality sometimes fails to meet acceptable levels or comply with the Resource Management (National Environmental Standards for Air Quality) 2004.* ~~*the government's national environmental standards for air quality or Auckland Ambient Air Quality standards (AAAQS).*~~ *Emissions to air can result in elevated levels of particulate matter, nitrogen dioxide and other pollutants which are linked to negative health effects.* *The social and economic cost from particulate emissions in Auckland is significant….*

Proposed Unitary Plan Provision	Submission	Decision Sought
	intensity of discharges experienced. It is considered appropriate that reference is retained to the NES Air Quality where the issues are better understood and national guidance is in effect, however the document should be referred to by its correct title.	
B.6.1 Air Quality, Introduction	The introduction states that the AAAQS have been developed to "*provide <u>guidance</u> in this Unitary Plan on the management of a range of contaminant discharges".* CANZ/Straterra supports the intention set out in this section of the plan for the AAAQS to provide guidance on the management of contaminant discharges, but opposes the AAAQS being applied as standards which cannot be exceeded under any circumstances. This approach is taken by other plan provisions and is discussed later in this submission. Changes are sought through this submission to recognise that the AAAQS be used to provide guidance in decision making on applications to discharge contaminants to air, as opposed to being absolute standards (except where this is already addressed by the NES Air Quality).	Retain the Introduction to B.6.1 Air Quality, Introduction
B.6.1 Air Quality, Objective 2	Objective 2 aims to ensure that the AAAQS and NES Air Quality are met. While CANZ/Straterra considers it appropriate to achieve	Make the following amendments to B.6.1 Air Quality, Objective 2: *~~The Auckland Ambient Air Quality Standards~~ <u>Acceptable air quality is achieved throughout</u>*

<table>
<tr><th>Proposed Unitary Plan Provision</th><th>Submission</th><th>Decision Sought</th></tr>
<tr><td></td><td>compliance with the NES Air Quality which is mandatory, it is considered that rather than seeking to simply achieve compliance with the AAAQS, recognition is given to achieving acceptable levels of air quality within the region, including ensuring compliance with the NES.</td><td>Auckland including meeting the ~~and~~ Resource Management (National Environmental Standards for Air Quality) Regulations 2004~~are met~~ and the Ministry for the Environment's Ambient Air Quality Guidelines, and in particular priority is given to meeting the annual average standards for fine particles (PM10 and PM2.5) and hourly and 24 hourly standards for nitrogen dioxide.</td></tr>
<tr><td>B.12 Environmental Results Anticipated, Table 5</td><td>Table 5 sets out the Environmental Results Anticipated (ERA) with respect to Natural Resources, including Air Quality.

CANZ/Straterra notes that the ERAs for Air Quality are the same as the objectives of the RPS and rather than being true environmental results are instead more consistent with prescriptive standards seeking compliance with the AAAQS.

Additionally, the ERA relating to the implementation of the Resource Management NES Air Quality is not an ERA.

Amendments are proposed to the table accordingly, including changes sought previously in this submission in relation to the applicable RPS objectives.</td><td>Amend B.12 Environmental Results Anticipated, Table 5 as follows:

<table>
<tr><td>Air discharges and the use and development of land are managed to improve air quality, enhance amenity values and reduce reverse sensitivity in Auckland's urban areas and to maintain air quality at existing levels in rural and coastal marine areas.</td><td>~~Air discharges and the use and development of land are managed to~~ Improved air quality~~,~~ ~~enhance amenity values~~ and a reduction in reverse sensitivity complaints in Auckland's urban areas and to maintain air quality at existing levels in rural and coastal marine areas.</td></tr>
<tr><td>Acceptable air quality is achieved throughout Auckland including meeting the ~~and~~ Resource Management (National Environmental Standards for Air Quality) Regulations 2004 and the Ministry for the Environment's Ambient Air Quality Guidelines ~~are met~~, and in particular priority is given to meeting the annual average standards for fine particles</td><td>Air quality consistent with protecting human health and amenity is achieved throughout the Auckland Region. ~~The Auckland Ambient Air Quality Standards and National Environmental Standards are met, and in particular priority is given to meeting the annual average standards for fine particles (PM10 and PM2.5) and hourly and~~</td></tr>
</table>
</td></tr>
</table>

Proposed Unitary Plan Provision	Submission	Decision Sought
		(PM10 and PM2.5) and hourly and 24 hourly standards for nitrogen dioxide. ~~*24hourly standards for nitrogen dioxide.*~~
PART 2 – REGIONAL AND DISTRICT OBJECTIVES AND POLICIES		
C.5.1 Air Quality, Background	The Background section to the Regional and District Objectives and Policies for Air Quality recognises that *"…there are also industrial processes that cannot avoid discharging contaminants into the air and their operation needs to be recognised and supported. Therefore, their effects need to be managed using suitable control technology, on-site management techniques and by locating such industries in appropriate areas."* While the recognition of the need to support these activities is supported by CANZ/Straterra, it is unnecessary and inconsistent with the purpose and principles of the Resource Management Act 1991, to specify how these effects shall be managed. Furthermore, it is important to recognise that some activities are constrained in their location - in particular activities which are already established with a significant investment in one location, or are dependent on a fixed natural resource, and cannot otherwise	Make the following amendments to C.5.1 Background: *…there are also industrial processes that cannot avoid discharging contaminants into the air and their operation needs to be recognised and supported. ~~Therefore,~~ The~~ir~~ effects of these activities can ~~need to~~ be managed through methods such as ~~using suitable~~ the use of suitable control technology, on-site management techniques and ~~by~~ where practicable locating such industries in appropriate areas.*

Proposed Unitary Plan Provision	Submission	Decision Sought
	relocate without significant capital expenditure. In many circumstances, relocation of an activity is not a practicable option and therefore this should be recognised as only appropriate where it is practicable.	
C.5.1 Air Quality, Objective 1	Objective 1 states: *Air quality is maintained in those parts of Auckland that have excellent or good air quality, and air quality is enhanced in those parts of Auckland where it is poor.* CANZ/Straterra supports the Objective as it seeks appropriate outcomes without requiring compliance with specific standards as do other objectives and policies which are opposed.	Retain C.5.1 Air Quality, Objective 1
C.5.1 Air Quality, Policy 1	Policy 1 seeks to protect human health by requiring that air discharges do not cause air quality to exceed the AAAQS, and manage the discharge of other contaminants so that the adverse effects on human health, including cumulative adverse effects, are minimised. The policy, like Objective 2 discussed above focusses heavily on meeting the AAAQS standards rather than overall air quality and takes a format more consistent with a rule than a policy. CANZ/Straterra proposes	Make the following amendments to Policy 1 *Protect human health <u>by ensuring air discharges do not cause adverse effects to human health and that cumulative effects are minimised.</u> ~~by requiring that air discharges do not cause air quality to exceed the AAAQS in Table 1 for the specified contaminants, and manage the discharge of other contaminants so that the adverse effects on human health, including cumulative adverse effects, are minimised.~~*

Proposed Unitary Plan Provision	Submission	Decision Sought
	amendments accordingly.	
C.5.1 Air Quality, Policy 18	Policy 18 specifies a number of requirements that applications to discharge contaminants to air must comply with. CANZ/Straterra considers that these requirements are inappropriate as a policy. Rather than addressing decision making, they seek to control what an application may or may not contain, and would be more appropriately written as an information requirements section on applications for resource consent. Notwithstanding the above comments, bullet point (a) of Policy 18 is particularly inappropriate as part of a policy as it effectively prohibits any applications being made which seek to discharge contaminants at a concentration in excess of the AAAQS. As written, this is more reflective of a prohibited activity rule. CANZ/Straterra proposes that this policy is deleted, and the following submission point suggest a new rule addressing relevant matters for AC's discretion and assessment criteria.	Delete Policy 18 ~~*18. Require applications for activities requiring resource consent for air discharges to:*~~ ~~*a. have combined concentrations arising from the air discharge activity and background levels below the AAAQS in Table 1*~~ ~~*b. show discuss whether how the amenity provisions of the zone, and any adjacent zone where there are effects from the activity, are met*~~ ~~*c. assess air discharges using best-practice methods, such as modelling and monitoring, appropriate to the scale of the discharge and any potential adverse effects*~~ ~~*d. demonstrate best practice management including minimising discharges*~~ ~~*e. demonstrate that the chosen method and amount of discharge does not have a practicable alternative that causes less adverse effects*~~ ~~*f. demonstrate that the location of the activity and any discharge is suitable to avoid adverse*~~

<table>
<tr><th>Proposed Unitary Plan Provision</th><th>Submission</th><th>Decision Sought</th></tr>
<tr><td></td><td></td><td>~~effects on the environment, health and amenity especially on sensitive activities~~

~~g. provide details of how the offsets policy will be met, where relevant~~

~~h. avoid, remedy or mitigate any cumulative adverse effects~~

~~i. demonstrate that any risk to people and property has been adequately avoided or mitigated~~

~~j. demonstrate that adequate separation distances are available for the duration of the consent to ensure that adverse effects on health and amenity of activities sensitive to air discharges are avoided~~

~~k. assess the potential for reverse sensitivity effects to occur.~~</td></tr>
<tr><td>C.5.1 Air Quality, Table 1: Auckland Ambient Air Quality Standards (AAAQS)</td><td>Table 1 sets out the proposed AAAQS values. As discussed in the introduction to this submission, CANZ/Straterra is particularly concerned with the introduction of a 24 hour averaging standard for SO_2 of 20µg/m^3.

Achieving compliance with the proposed standard could require significant fuel and/or process changes for some industries, or alternatively the installation of SO_2 scrubbing systems for point source discharges of SO_2 that otherwise cause minor or less than minor environmental effects.</td><td>Amend the requirement for an SO_2 standard as follows:

<table>
<tr><th>Contaminant</th><th>Standard</th><th>Averaging Time</th><th>Number of permissible exceedances per year</th></tr>
<tr><td>Sulphur dioxide (SO_2)</td><td>350 µg/m^3</td><td>1 hour</td><td>9</td></tr>
<tr><td></td><td>570 µg/m^3</td><td>1 hour</td><td>0</td></tr>
<tr><td></td><td>120 µg/m^3</td><td>24 hour</td><td>0</td></tr>
</table></td></tr>
</table>

Proposed Unitary Plan Provision	Submission	Decision Sought
	These measures would also come at substantial economic cost which could be tens of millions of dollars as a one-off cost and annual operating and maintenance costs in the millions. Many large, medium and small industrial sites in New Zealand create 24 hour average SO_2 impacts that,close to the site boundary, are much higher than 20 µg g/m^3. However the spatial and temporal extent of these impacts is usually limited. As discussed in the review included as Appendix 2 to this submission, CANZ/Straterra consider the proposed guideline of 20 µg g/m^3 is not sufficiently robust for adoption as an air quality standard and based on the scientific assessment of the WHO (2006) 24 hour guideline and the scientific literature, that Auckland Council should retain the current National Ambient Air Quality Standard for SO_2 as well as the current MfE 24 hour ambient air guideline. These conclusions are consistent with recent expert reviews overseas. There is not considered to be any benefit in adopting a 24-hour average SO_2 limit of 20 µg/m^3.	

Proposed Unitary Plan Provision	Submission	Decision Sought
PART 3 – REGIONAL AND DISTRICT RULES		
New Rule H.4.1.1 Activity Table	A new rule is proposed to reflect that where an activity cannot comply with the AAAQS, the activity may still be appropriate and can be granted in accordance with the RMA subject to the effects of the activity being acceptable. This is particularly important for activities which seek to replace an existing air discharge permit. As discussed in relation to Policy 18 above, rather than implementing a policy which has implications similar to a prohibited activity, a more effective alternative is that where an activity cannot achieve compliance with the AAAQS, it is proposed that a catch all rule is included in the plan for a restricted discretionary activity, and an additional set of matters for discretion is also included. CANZ/Straterra notes that any activity seeking to discharge contaminants to air but that would not otherwise comply with the NES would not be granted consent in any case.	Insert a new rule in section H.4.1.1 Activity Table as follows: *1. Activity Table* *Any activity failing to meet the AAAQS – Restricted Discretionary* Insert an additional set of matters for discretion into Rule H.4.1.5.1 as follows: *12. Activities not complying with the AAAQS* *a. Whether the activity is in the most practicable location for the activity;* *b. Whether the discharge will meet the amenity provisions of the zone and surrounding zones* *c. The modelling and monitoring undertaken and proposed for the activity* *d. The chosen method of discharge* *e. Whether the activity will comply with the offsets policy* *f. Effects on human health* *g. Potential for reverse sensitivity effects* h. *Separation distances from sensitive activities*
H.4.1.5.2.8, Combustion Activities	Matter for Discretion 8(a) for the assessment of combustion activities states: *Effect on meeting the Auckland ambient air quality standards* The matter for discretion could be better worded and	Amend to: *The Auckland ambient air quality standards*

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	an amendment is proposed accordingly.	
H.4.1.5.2, Assessment Criterion 1	Assessment criterion 1 states: *The degree to which Auckland Ambient Air Quality Standards and/or nationally and internationally accepted standards, guidelines and guidance are likely to be met.* This provision is supported by CANZ/Straterra.	Retain the assessment criterion.
GENERAL		
Consequential Amendments	CANZ/Straterra seeks that any consequential changes or alternative relief to give effect to changes sought in CANZ/Straterra's submission are made by Auckland Council.	Make appropriate consequential changes to the Plan to give effect to the relief sought in this submission.
SECTION 32 REPORT		
Section 32 Assessment	The section 32 analysis of the PAUP with respect to the proposed AAAQS and supporting policy and rule framework is inadequate and fails to meet the requirements of Section 32 of the RMA. No consideration has been given to the costs and benefits of implementing the AAAQS and no scientific or technical assessment has been undertaken in respect of the AAAQS or the supporting policy and rule framework.	Straterra/CANZ seeks that an adequate Section 32 analysis be undertaken in respect of the proposed AAAQS, and the supporting policy and rule framework. Straterra/CANZ seeks that this analysis recognizes the changes sought in this submission.

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