
under: the Resource Management Act 1991

in the matter of: the proposed Canterbury Air Regional Plan

and: **Gelita NZ Limited**
Submitter 63201
Further Submitter 103493

Statement of evidence of Roger Cudmore

Dated: 18 September 2015

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STATEMENT OF EVIDENCE OF ROGER CUDMORE

- 1 My full name is Roger Steven Cudmore.
- 2 I am a Principal and a current Director of Golder Associates (NZ) Limited (*Golder*). I graduated from the University of Canterbury with a degree in Chemical Engineering awarded with honours in 1986.
- 3 I have worked as a consultant in air quality management for over 20 years, working for industry, Regional Councils and the Ministry for the Environment (*MfE*). Over this time I have had significant involvement in the development of national guideline documents for air quality management including the MfE ambient air quality guidelines (*AAQGs*) for New Zealand. This process commenced during the mid-1990s and led to our current Ministry for Environment *AAQGs* (MfE, May 2002). I took part in workshops run by MfE from 2000 to 2004 for developing various good practice guidelines and for establishing the Resource Management (National Environmental Standards for Air Quality) Regulations (*NES-AQ*) (MfE, 2004). In 2008, I co-authored a review of the World Health Organisation (*WHO*) guideline for sulfur dioxide (SO_2) (Kelly & Cudmore, 2008) and co-authored reports (MfE, August 2002) that were the basis for the current MfE Odour Management Guideline (MfE, 2003).
- 4 I have significant involvement with air quality management in Canterbury and have previously provided expert evidence with respect to the existing air quality sections of the Canterbury Natural Resources Regional Plan (*NRRP*) on behalf of Environment Canterbury (*ECan*). That expert evidence was related to airshed modelling of Christchurch City's respirable particulate (PM_{10}) levels to confirm contributions from domestic, vehicle and industry sectors. In the early 2000s, I also prepared procedures to assist in the assessment of odour effects that have been largely retained and adopted in the current Plan.
- 5 A more detailed list of my experience in air quality management is contained in **Appendix 1** to this evidence.
- 6 I have been engaged by Gelita NZ Limited (*Gelita*) to provide expert technical assistance in relation to the proposed Canterbury Air Regional Plan (the *Plan* or the *pCARP*). I have also prepared evidence regarding the pCARP on behalf of Fonterra Co-operative Group Limited and Ravensdown Co-operative Group Ltd. This evidence adopts much of that evidence except where I comment upon Gelita's submission points and the application of the Best Practicable Option (BPO).

- 7 In preparing this evidence I have read the evidence of **Mr Kevin Bligh**. I have also reviewed the Canterbury Regional Policy Statement (*RPS*), the Plan, Gelita's and other industry submissions to the Plan. I have reviewed the recent World Health Organisation review of evidence on health aspects of air pollution (WHO 2013).

SCOPE OF EVIDENCE

- 8 In my evidence I comment on:

- 8.1 use of the MfE AAQG's;
- 8.2 application of *BPO*; and
- 8.3 parts of the Officers' section 42A Report

- 9 I have read the Expert Witness Code of Conduct set out in the Environment Court Practice Note 2014. I have complied with the code in preparing this evidence and I agree to comply with it while giving oral evidence. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

SUMMARY OF EVIDENCE

- 10 The pCARP should have definitions that distinguish between localised and airshed ambient air quality. Further, the use of uniform air quality targets throughout rural and urban airsheds (through policies such as 6.2 and 6.3) is not likely to enable industrial development or renewal of consents.
- 11 The vast majority of the population live within urban areas and many people do suffer ill-health effects that are mostly driven by persistent ambient PM_{2.5} and, to a lesser extent, PM₁₀ levels. The ambient levels of these contaminants within polluted airsheds are largely derived from domestic fires and traffic emissions. Industry is a minor contributor to these levels.
- 12 I support Policy 6.4 of the pCARP. But consider that this Policy should encourage ECan to directly monitor PM_{2.5} levels at urban ambient air quality monitoring sites. This would provide the most relevant and accurate information regarding the status of urban air quality in Canterbury.
- 13 Policies 6.2 and 6.3 in the pCARP are also artefacts of MfE Air Quality Indicator Categories and are only appropriate applied to the

assessment of monitoring data that is generated from regional ambient monitoring stations.

- 14 I conclude that the plan should include a modified definition of ambient air quality that excludes those locations where air quality is significantly influenced by a specific source. Further, I consider the plan should distinguish between local and airshed wide ambient air quality.
- 15 **Ms Justine Ashley's** evidence (on behalf of Fonterra) has provided a definition for ambient air in her evidence which I agree with. In this evidence I also provide a definition for localised air quality effects that would further assist in making a clear distinction between this and ambient air quality.
- 16 Having the clear distinction discussed above, is necessary to underpin the appropriate application of MfE AAQGs and MfE Air Quality Indicator Categories. The clear distinction also underpins the appropriate use of MfE AAQGs for the assessment of air quality effects from industrial discharges.
- 17 I agree with the Officer's report regarding the amendment of policies 6.20 and 6.21 in a manner that utilises the BPO to achieve appropriate outcomes. Further, I consider the appropriate outcomes of the BPO should be related to localised air quality effects from industry (Policy 6.20) as well as industry contributions to the airshed ambient air quality (Policy 6.21).
- 18 **Ms Ashley's** evidence also recommends the deletion of Rules 7.17 and 7.18 which I can support. Notwithstanding this I have also conditionally supported Ravensdown's suggestion for an amended rule to replace Rules 7.17 and 7.18.
- 19 The Officer's section 42A report overstates the significance of industry contributions to existing non compliances with the NESAQ for PM₁₀ in urban areas of Canterbury. This appears to have been the basis for onerous provisions in the pCARP that could result in industry having to adopt the best available technology, or else relocate.
- 20 Airshed modelling investigations of sector wide PM₁₀ emissions in Christchurch for 2006 indicates industry to be a relatively minor source of ambient PM₁₀ levels in Christchurch. I consider this is very likely to apply to all urban airsheds within Canterbury.

MINISTRY FOR THE ENVIRONMENT AMBIENT AIR QUALITY GUIDELINES

- 21 The MfE AAQG document (MfE, 2002) was primarily developed to specify ambient air quality guidelines (that is, concentrations of various contaminants) that provide protection to the health of humans, flora and fauna.
- 22 Unlike the NES-AQs, the MfE AAQGs were developed primarily for regional councils to use for assessing the results from their ambient air quality monitoring stations. Both the MfE AAQG (MfE, 2002) and their subsequent guideline for siting ambient monitoring sites (MfE, 2009) gave clear direction for these sites to be located away from areas of localised air quality impacts from industry or transport.
- 23 The MfE recommended Air Quality Indicator Categories (MfE, 2002), which were designed to provide councils with guidance about when to take actions based on their regional ambient monitoring results. A key category was the "Alert" category. This was triggered when monitoring data was greater than 66% of the AAQG for a particular contaminant. The "Alert" meant that the relevant Council should be alerted to the need to undertake some actions. For example, increased monitoring, investigation of sources, consideration of plan changes, etc.
- 24 In explaining the intent of the AAQGs, the MfE (2002) stated that these guidelines did not apply to the assessment of industrial air quality impacts. But in practice there was a vacuum created by the absence of criteria for such assessments.
- 25 The AAQG values for various air contaminants have been routinely used as tools for assessing the site specific potential effects of industrial air discharges. Exceedance of these guidelines (as predicted by models) was invariably used as a trigger for conducting closer (more expensive) investigations.
- 26 However, the Air Quality Indicator Categories that form part of the MfE AAQGs (MfE, 2002) are often cited in reference to localised air quality impacts from industry. Where these exceed 66% of an AAQG, the significance of impacts can be greatly overstated. I consider that the pCARP Policies 6.2 and 6.3 can also have this outcome.
- 27 Further to this, requiring industrial air quality effects to meet MfE Air Quality Indicator Categories beyond the site boundary (through application of the pCARP policies) is not necessary to avoid significant adverse effects and would often equate to less than minor potential for any adverse effects.

- 28 Instead, the site specific localised impacts of industry can be appropriately assessed against MfE NES-AQ, AAQGs and other air quality criteria since the RMA came into force. While localised air quality impacts from industry are of concern, it is also reasonable to consider a site's contributions to the airshed wide ambient air quality.
- 29 The Officer's section 42A report – Appendix 1 appears overstate industry's contribution to the wider ambient air quality which appears to be the basis for the approach of the pCARP.
- 30 However, imposing regulatory controls on industrial air emissions to manage their localised air quality impacts is typically sufficient to ensure a minor effect upon the wider airshed air quality. From my experience this always holds true for industrial facilities operating within non-polluted rural environments. But it also typically holds true for industry that operates within airsheds that are gazetted as being polluted by the MfE.
- 31 Notwithstanding the above, the consideration of what are the contributions of an industrial discharge to the wider ambient air quality should not be ignored.
- 32 In regards to PM_{2.5} or PM₁₀ impacts on the wider airshed, I have reached the view that acceptable incremental impact of PM_{2.5} at least, must be low (in the order of several µg/m³ as a daily average) to be considered as having potential adverse effects that can be considered less than minor. The appropriate number also comes down to the particular environment and the extent to which the BPO is applied by the discharger.

LOCALISED AND AMBIENT AIR QUALITY

- 33 In my opinion it is important for the pCARP to provide distinctions between wider airshed air quality and that are significantly influenced by localised industrial impacts. This would ensure Policies 6.2, 6.2, 6.20 and 6.21 are appropriately applied under the Plan. I would add that it also help ensure outcome of enabling industrial development while managing effects upon local and airshed ambient air quality to sustainable levels.
- 34 Therefore I recommend the proposed wording for the definition of ambient air quality provided in the evidence of **Ms Ashley**. This includes the additional words to the definition as proposed in the Officer's Report and reads as follows:

Means the quality of air outside of buildings or structures where people are likely to be exposed to the contaminants. It does not

include indoor air, air in the workplace, contaminated air being discharged from a source, or air that is enclosed or sheltered in a way which makes it untypical of the air in the surrounding area. Ambient air quality does not include air quality that is substantially modified by the localised effects of specific/individual sources.

- 35 I also consider that have a definition for localised air quality effects is practical and would help enable the desirable outcomes I mention above in paragraph 36. My suggested wording for localised air quality effects is as follows:

Localised Air Quality: Is the air quality that is localised to areas of Canterbury where emissions from a specific activity significantly influences air contaminant concentrations at ground level in a relatively small area adjacent to the source. The localised air contaminant concentrations are less persistent than, and not characteristic of those that typically occur within the wider rural, urban or business district areas.

- 36 I consider the above definition can be practically applied to the analysis of industrial air discharge modelling predictions of contaminant exposure concentrations surround an existing or proposed facility. **Mr Chilton's** evidence provides an example of such contours that routinely prepared in association with air quality impact assessments for industry.

- 37 Other potential benefits in terms enabling sustainable industry activity are as follows:

- 37.1 allowing for greater utilisation of MfE AAQGs (e.g. above 66% of the AAQG), within areas of localised impact whilst requiring a more stringent level of compliance (e.g. below 33% of the AAQG) for ambient air quality impacts;
- 37.2 discourage the application of the MfE Air Quality Indicator Categories (MfE, 2002) to the assessment of localised impacts from industrial air discharges. This can cause unnecessary alarm and concern within a community regarding the perceived health risk that is associated with an "Alert" category being triggered for impacts occurring on a spatially limited area and often for peaks that are infrequent; and
- 37.3 encouraging the Canterbury Regional Council and air quality practitioners to use the MfE Air Quality Indicator Categories for the assessment of ambient air quality data that is generated by the Regional Council or other stakeholders.

APPLICATION OF BEST PRACTICABLE OPTION

- 38 The assessment of and requirement to meet the BPO has been a common feature most air discharge consenting processes for industry since the 1991 RMA came into force. I have supported its use as a cornerstone to the amended Policies 6.20 and 6.21 as requested by Fonterra and Ravensdown.
- 39 I am of the view that it is in all stakeholder interests that both small and large scale industrial facilities need to employ the BPO for controlling the effects of their air discharges. Meeting the BPO provides the best opportunity to find an appropriate balance between enabling industry and achieving sustainable air quality effects on the community and ensuring that costs imposed on industry are equitable and fair given their significance on a site by site basis.
- 40 The evidence of **Mr Pene** discusses requirements to employ the BPO. I consider provides a useful and accurate summary of the BPO and I agree with **Mr Pene's** evidence regarding the use of the BPO within Policies but not within Rules.
- 41 In effect, the BPO provides a framework for balancing economic and environmental matters when establishing an appropriate level of air discharge controls for industrial facilities.
- 42 I agree with the notion that while an industry may adequately control the effects PM₁₀ or PM_{2.5} discharges upon the local environment that the cumulative effect upon the wider airshed is an additional and necessary consideration. I understand from reading the Officer's section 42A report that they are concerned that industry could excessive influence on the wider airshed levels of PM₁₀ despite adequately managing local effects. My view is that the proposed amended Policy 6.21 in **Ms Ashley's** evidence should address this concern.
- 43 The consideration of the BPO for managing both the local air quality impacts of all contaminants, as well as for reducing contributions to the ambient air quality of the wider airshed is likely to lead to an equitable and fair level of restriction on industrial air discharges. This would be put into effective by the amended policies 6.20 and 6.21 proposed in **Ms Ashley's** evidence.
- 44 The consideration of the BPO will allow industry to provide evidence of their actual contribution to ambient air quality and the likely benefit and cost of imposing further controls. By default this allows for the scale of an industrial facility, and its specific location within an airshed to be accounted for. A more simple and prescriptive regime for defining appropriate air discharge controls is likely to be

more onerous on industry in my view – especially small to medium scale industrial facilities.

- 45 By comparison, the pCARP may well lead to best available technology (BAT) being imposed, which is confirmed within the Officer's section 42A report. This is likely to impose very onerous costs on industry for minimal benefit in terms of NES-AQ compliance or improved health outcomes for the community.

RULE 7.28

- 46 With respect to rule 7.28 which addresses activities discharging odour beyond the site boundary, I concur with **Mr Pene's** evidence that the FIDOL factors should apply to the effects of the odour not the discharge itself.
- 47 I note there are numerous activities that produce low levels of odour beyond the boundary, which unless they are permitted, would be captured by this provision.
- 48 I further note that the wording of the rule is technically incorrect. The discharge of odour is always within the site boundary, and it is the effects that occur beyond the boundary.

SECTION 42A REPORT

- 49 I have provided detailed comment on the Section 42a Report in my evidence prepared for Fonterra and Ravensdown to this hearing. In summary, the concerns raised in respect to the Officer's report include:
- 49.1 the Officer's significant overstatement on the industry sector contributions to ambient PM₁₀ concentrations in polluted airshed.
- 49.2 the Officer's doubtful assumption that PM_{2.5} within a polluted airshed can be monitoring and effectively managed using PM₁₀ as a surrogate.
- 49.3 the Officer's reluctance to accept the need, or the ability to distinguish between local air quality impacts from industry separately from airshed ambient air quality.

CONCLUSIONS

- 50 I conclude that pCARP policies and rules for industrial activities lack the support of airshed modelling science. Subsequently I conclude that the Plan is based on misinformed assumptions regarding the

significance of industry air discharge contributions to PM₁₀ levels within polluted airsheds.

- 51 Polices and rules for managing the cumulative effects of all sectors upon airshed wide air quality should not be applied to localised air quality effects surrounding industrial sites.
- 52 The provision of specific policies for managing the local and airshed wide effects of industrial air discharges are important for industry to be enabled under the Plan.
- 53 Under the proposed amendments to policies, the MfE AAQGs should be used appropriately to assess the potential for adverse effects on the environment.
- 54 The proposed amendments to policies within the plan as outlined in the evidence of **Ms Ashley** would help enable industrial emissions while ensuring a minor potential for adverse effects on the environment.
- 55 Having a definition in the plan for distinguishing localised ambient air quality for airshed wide ambient air quality would help enable the correct application of the amended policies and in doing so enable industry to exist and develop within both urban and rural airsheds.
- 56 Finally I support Policy 6.4 of the Plan but recommend the plan goes further and encourages monitoring of ambient PM_{2.5} as a priority for polluted airsheds in Canterbury.

Dated: 18 September, 2015

Roger Cudmore

REFERENCES

Cudmore (2008): Expert testimony given to the Environment Court Appeal hearing for the Canterbury Natural Resource Regional Plan – Domestic Heating Rules, Chapter 3.

Cudmore (March 2015): Expert testimony given to the Auckland Unitary Plan Hearings in regards to Topic 35 – Air Quality.

J. Frangos (March 2015): Expert testimony given to the Auckland Unitary Plan Hearings in regards to Topic 35 – Air Quality.

Kelly and Cudmore (2008): Review of the World Health Organisation's Guideline for 24-Hour Sulfur Dioxide – Implications for New Zealand. Environ Medical Services Ltd. August 2008.

MfE, (May 2002): Ambient Air Quality Guidelines – 2002 Update. Air Quality Report No. 32. Ministry for the Environment, Wellington, New Zealand, ISBN: 0-478-24064-3.

MfE, (June 2003): Good Practice Guide for Assessing and Managing Odour in New Zealand. Air Quality Report No. 36. Ministry for the Environment, Wellington, New Zealand, ISBN: 0-478-24090-2.

MfE, (May 2008): Good Practice Guide for Assessing Air Discharges from Industry. Ministry for the Environment, Wellington, New Zealand, Publication No. ME880, ISBN: 978-0-478-30235-6

MfE, (April 2009): Good Practice Guide for Air Quality Monitoring and Data Management 2009. Ministry for the Environment, Wellington, New Zealand, Publication No. ME993, ISBN: 978-0-478-33167-7

MfE, (May 2008): Good Practice Guide for Assessing Air Discharges from Industry. Ministry for the Environment, Wellington, New Zealand, Publication No. ME880, ISBN: 978-0-478-30235-6

MfE, (April 2009): Good Practice Guide for Air Quality Monitoring and Data Management 2009. Ministry for the Environment, Wellington, New Zealand, Publication No. ME993, ISBN: 978-0-478-33167-7

WHO (2013): Review of evidence on health aspects of air pollution - REVIHAAP Project. Technical Report, World Health Organisation, Regional Office for Europe, Copenhagen Ø, Denmark

APPENDIX 1

QUALIFICATIONS AND EXPERIENCE

I am an experienced air quality & wastewater consulting engineer with 25 years of professional experience working on both New Zealand and international air quality projects. I graduated from the University of Canterbury in 1986 with an honours degree in Chemical & Process Engineering. For many years, I have been routinely engaged by Fonterra, Alliance, Ravensdown, Lowe Corp, Solid Energy and other industries as well as regulatory organisations to provide air quality management advice and expert testimony. This has involved both Environment Court and council hearings since the early days of the Resource Management Act and with respect to air quality management matters. These have largely involved the consideration of health and nuisance effects of air emissions and their effective mitigation via engineering and management systems and consent conditions. Over the years I have had to work very closely with professionals in environmental law & planning, human health, toxicology related air quality effects and have gained a wide knowledge of air quality regulation and management in New Zealand and internationally.

My professional affiliations and positions including the following:

- Resource Management Law Association of NZ (RMLA)
- Chairman of the RMLA Air Quality Special Interest Group
- Past NZ Branch Chairman of the Clean Air Society of Australia and New Zealand (CASANZ)
- Past Chair of the CASANZ Odour Special Interest Group
- Corporate Member of the Clean Air Society of Australia and New Zealand (CASANZ)

REGULATORY SECTOR

I have undertaken a number of air quality management related projects and acted as an expert witness for the regulatory sector since the early 1990's. This has involved audits of consent applications for industrial and commercial processes on behalf of various Regional Councils, airshed air quality modelling, research of literature, and providing expert testimony to the Environment Court on behalf of the Canterbury Regional Council. Examples are listed below.

- Audit of Cresta Mushrooms air discharge consent variation for Waikato Regional Council (2013)

- Review of air quality effects assessment for the Transmission Gully By-Pass for Greater Wellington Regional Council and the NZ Environmental Protection Agency (2011)
- Investigation of air quality effects research due to urban outdoor burning practices and presentation of expert testimony on behalf of ECan (2010).
- Technical lead of airshed modelling of transport, industry and domestic sector emissions for the city of Christchurch (2007-2008)
- Presentation of expert testimony to the Environment Court in respect to appeals against the Canterbury Natural Resources Regional Plan - Air Section (2008)
- Audit of air quality health risk assessment due to contaminated under a super market complex in the North Shore for the Auckland Council (2007)
- Review of dioxin emission controls on behalf of MfE in association with the remediation of the contaminated Mapua site, Tasman District (2005).
- Prepare Technical Report 24 for MfE with respect to Good Practice Odour Management and Assessment tools (2002)
- MfE review panel member for the development of the up-dated ambient air quality guidelines (2002) and good practice guide for atmospheric dispersion modelling.
- ECan commissioner that heard and granted the application for Christchurch Airport Engine Testing Facility (early 2000s)
- Preparation of technical reports regarding outside burning practices and odour management to assist in the preparation of the Canterbury Regional Plan - Air Chapter.
- Prepared schedule for the proposed Canterbury Regional Plan - Air Chapter of residential chimney stack rain hat covers (late 1990's).
- Prepare report for MfE on use of olfactometry for regulation of environmental odours in NZ: Odour Nuisance Control: Recommendations to the Ministry for the Environment", Agricultural Engineering Institute Report 2496/1, New Zealand (1994)

ENVIRONMENTAL IMPACT ASSESSMENT - AIR QUALITY

I have completed numerous environmental impact assessments (EIAs) mainly in support of resource consent applications or other similar licenses overseas. The EIAs have covered a wide range of sectors including transport, industrial, manufacturing and mining sectors.

These assessments have been largely based on atmospheric modelling of emissions from industrial stack discharges involving common and hazardous pollutants. Industrial activities have involved large coal-fired and gas-fired energy plants (NZ, New Guinea), industrial and municipal incinerators (Singapore), kraft and mechanical pulp & paper mills (NZ), cement manufacture, mineral processing (Armenia Bulgaria, Fiji and NZ), fertiliser, food and manufacturing and other chemical & process industries (NZ).

I have been the technical lead for a number of airshed air quality assessments that account for emissions from the domestic, industry and transport sectors with urban areas. This involved the use and analysis of air emission inventory, airshed modelling and source apportionment investigations. These projects were undertaken for both regulatory and private sector clients for the Christchurch, Nelson and Dunedin City Airsheds.

EXAMPLES OF PROJECTS

Fonterra (2015): Provide expert testimony to the Auckland Unitary Plan and Southland Regional Plan hearings with respect the use of Ministry for the Environment and World Health Air Quality Guidelines.

Gelita (NZ) (2015): Provide expert testimony to ECan air discharge hearing regarding the mitigation of odour effects from gelatine manufacturing site, Christchurch.

NZ Transport Agency (2014). Technical review of reports regarding validation of the vehicle emission model (VEPM) and for the assessment of air quality effects from the proposed West Belfast By-Pass, Christchurch.

NZ Transport Agency (2014). Team member for the research project, Understanding Vehicle Emission trends in New Zealand.

Alliance Group Ltd (2013-2014). Technical lead on the BPO review and modelling based assessments of air quality effects associated with air discharges from the Lorneville meat processing site near Invercargill. Processes include coal-fired boiler discharges, rendering, fellmongery and wastewater treatment odour emissions.

SembCorp, Singapore (2013-2014). Air dispersion modelling based assessment of a proposed 1000 tons/day municipal waste to energy incineration plant for Jurang Island, Singapore.

Exxon Mobil (2013). Review of odour assessments prepared for rehabilitation of old tank farm land at Auckland Port and assisted in resolving an appeal to the Environment Court regarding odour mitigation measures imposed by the Auckland Council.

Todd Energy (2011 and 2012). Air quality impact assessment for 150 MW gas-fired generation two plants in the Taranaki region and assistance with consenting and conditions.

Solid Energy Renewable Fuels (2005-2012). Assessment of waste wood drying and processing for pellet production.

Ravensdown Co-operative Group (2003-2011). Completing air quality assessments for fluoride, SO₂, PM₁₀ and total acidic discharge (H₂SO₄ equiv) Acidic discharge and fluoride emissions were assessed for potential damage to commercial crops and vegetation. Identified acidic discharges as cause of observed vegetation damage as opposed to the convention view that fluoride was responsible. Specified measures for mitigation of crop effects due to acidic discharges to air.

Oceania Gold (2010). Technical review of pressure oxidation plant emissions modelling for the Macraes Flat site, Otago.

Fonterra Edendale (1997-2010). Provided air consultancy services to the Edendale dairy factory site since late 1990's to support the progressive site expansions including the assessment of existing coal-fired boilers. Work included recommended mitigation strategies to minimise ambient SO₂ impacts soot problems, validation of complex dispersion model tools at the site as part of a government funded FRST research programme and prepared annual air quality monitoring reports.

Namosi Joint Venture (2009). Project direction and technical review of an assessment of air quality and greenhouse gases as part of the Waisoi Project Pre-feasibility Stage Environmental and Social Impact Assessment (ESIA) study.

Solid Energy NZ Ltd (2009). Assessment of air quality effects due to a proposed coal mine air shaft emissions from the Huntley Coal Mine.

Trust Power (2008-2009). EIA of air quality effects (construction) and expert testimony the Regional Council and Environment Court hearings for the Mahinerangi Wind Farm, Otago.

Trust Power (2008-2009). Assessment of air quality effects (construction) and expert testimony the Environment Court for a large

scale hydropower schemes on the Arnold River (West Coast) and Waiou River Marlborough.

Solid Energy NZ Ltd (2004-2008). The assessment of air emissions from domestic heating (including wood pellet fires), industry and the vehicle sectors within a number of South Island Cities including Christchurch, Nelson and Dunedin. Work has included reviewing emission inventories, complex modelling, expert testimony and assistance with successful mediation talks.

New Zealand Industry Group, (2008). Co-authored a technical review recent and historical research investigations that have been cited by the WHO 2005 in developing their recommended guideline for 24-hr SO₂.

Fonterra (1997-2008). Prepare modelling based assessment of air emissions at the Clandeboye dairy factory using complex modelling of air emissions using TAMP and CALMET and CALPUFF to assess impacts on flat terrain where inversion fumigation events. This was to support the progressive site expansions including new coal fired energy plants and powder plants. Work included recommending emissions mitigation measures, manage the implementation of the site's air quality monitoring programme preparing annual reports to Environment Canterbury. Also included design and installation of a biofilter for treating wastewater tank odours and presentation of expert testimonies to various Regional and District Council Hearing committees.

Genesis Energy (2007-2008). New Plymouth: Assessment of air contaminant emissions on human health for a proposed new LNG Terminal including modelling of air discharges from the New Plymouth Power Station (Gasbridge).

Deno Gold Mining Company (2007). Project direction and technical review of baseline survey of air quality and contributions from the gold mining and ore processing operation in township of Kapan, Republic of Armenia.

Fonterra / Genesis Energy (2006-2007). Site assistance (then NZDG) in applying for a variation to existing air permit conditions for the operation of the gas-fired cogeneration plant at Te Awamutu while allowing for an increased NO_x discharge.

Dundee Precious Metals Inc. (2006-2007). Project director and technical review for the assessment of contaminant emission rates and potential effects from an existing mine and proposed expansion in Chelopech, Bulgaria.

NZ Refinery Company (2006-2007). Assessment of cumulative sulphur dioxide emission impacts using complex modelling due to the New Zealand Oil Refinery at Marsden Point and proposed re-firing of the Marsden B

Power station. Submissions to Marsden B consent hearings and the variations to the Northland Regional Plan.

Fonterra (2006). Prepared an assessment of effects reports for boiler discharges at the Marlborough and Brightwater sites (Nelson).

Contact Energy (2005). Combustion emissions assessment and dispersion modelling of air quality effects of a confidential coal-fired power station proposal in the North Island of New Zealand.

Fonterra (2004). Prepared an assessment of effects report to assist with the process plant being re-commissioned and including a new powder plant water scrubber at Morrinsville, Waikato.

NZ Aluminium Smelters, Te Wai Point, (2004). Combustion emissions assessment and dispersion modelling of air quality effects of a confidential coal-fired power station proposal in the North Island of New Zealand.

Fonterra Whareroa, Taranaki (2003-2004). Assessed air emissions from a proposed new 250 MW coal-fired co-generation plant. Including the selection of the appropriate site, combustion calculations and emissions quantification, complex modelling of air emissions CALMET/CALPUFF and assessment of mitigation options to minimise particulate and SO₂ impacts. Presentation of expert testimony to the Environment Court in regards to CO₂ emissions and the potential corrosion effects due to SO_x emissions to air.

Holcim New Zealand (2003). Complex modelling and assessment of dioxins, metal and general priority pollutant effects due to kiln emissions and use of alternative fuels.

Tasman Pulp Mill (2000) and Carter Holt Harvey (2003). Management of community wide environmental surveys for both Kinleith and Tasman Pulp Mill sites. Dispersion modelling assessment of pulp mill air emissions.

Carter Holt Harvey Kinleith & Kawerau. (1997, 2001, 2003). Technical expert for mediation talks regarding the appeal of air permit conditions by CHHL for their Kinleith site, as granted by Environment Waikato (Completed 1999).

Oceania Gold NZ (Macraes) (2002). Assessment of pressured oxidation plant emissions technology at the Reefton gold mine site.

Fonterra (2002). Prepared an assessment of effects to assist with the site expansion to include new gas-fired boilers.

New Zealand Industry Group, (2000). Prepared an Odour Management Report that was hosted by MfE's that was the original

technical report utilised by the MfE Technical Report no. 24 (2002) and the current MfE odour guidelines (2003).

Kanudi Power Station, Papua New Guinea (1998). Assessment of air quality effects arising from diesel and gas firing.

Weyerhaeuser NZ Inc. (1997-1998). Provide air quality assessments for proposed green field site and existing wood processing sites.

P Fields (1997). Review as air discharge assessment and presentation of expert testimony in regards to the emissions from the Nelson Pines.

International Wools Services Ltd (1996). Air dispersion modelling based assessment of the LEMAR sludge incinerator operated at Kaputone Woolscour, Belfast and presentation of evidence to ECan hearing.