BEFORE ENVIRONMENT SOUTHLAND

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of Lorneville Processing Plant resource consent applications

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STATEMENT OF EVIDENCE OF ROGER CUDMORE
ON BEHALF OF ALLIANCE GROUP LIMITED

Dated July 2016

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QUALIFICATIONS AND EXPERIENCE

1 My full name is Roger Steven Cudmore.

2 I am a Principal and current director of Golder Associates (NZ) Limited (Golder), and 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 24 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 MfE run workshops from 2000 to 2004 for developing various good practice guidelines and for establishing the Resource Management (National Environmental Standards for Air Quality) Regulations (NESAQ) (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 I have co-authored reports (MfE, August 2002) that were the basis for the current MfE Odour Management Guideline (MfE, 2003).

4 A more detailed list of my experience in air quality management is attached to this evidence as **Attachment A**.

5 I have been the technical lead for the following relevant investigations and studies all of which were attached to the Assessment of Environmental Effects (AEE) for the applications:

(a) Baseline survey of existing odour effects around Alliance Lorneville – Golder Report 1378104044-014-R-Rev1-030, October 2015, **(Attachment F to the AEE)**.

(b) Assessment of Process Odour Mitigation – Golder Report 1378104044-013-R-Rev4-090, October 2015, **(Attachment G to the AEE)**.

(c) Assessment of Wastewater Odour Mitigation – Golder Report 1378104044-013-R-Rev4-090, October 2015, **(Attachment R to the AEE)**.

(d) Assessment of Lorneville's background ambient air quality – Golder Report **Error! Unknown document property name.**, October 2015, (**Attachment E to the AEE**).

(e) Assessment of the coal-fired boilers (CFB) air discharge effects – Golder Report 1378104044_017_R_Rev2_060, October 2015, **(Attachment M to the AEE**).

6 I have visited the Alliance Lorneville processing plant on numerous occasions during the last 21 years primarily in association with the provision of environmental consulting services.

7 In preparing this evidence I have reviewed the following:

(a) The reports and statements of evidence of other experts giving evidence relevant to my area of expertise, including:

(i) Evidence of Alliance representative, Mrs Frances Wise

(ii) Evidence of Mr Azam Khan, Pattle Delamore Partners Ltd

(iii) Evidence of Mr John Kyle, Mitchell Partnerships Ltd

(b) The Section 42 Officer's Report and the evidence of Mr John Iseli.

8 I have read and agree to comply with the Code of Conduct for Expert Witnesses (Environment Court Practice Note 2014). This evidence is within my area of expertise except where I state that I am relying on facts or information provided by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

SCOPE OF EVIDENCE

9 My evidence addresses the following matters:

(a) Existing and future odour effects

(b) Mitigation of process odour emissions

(c) Mitigation of wastewater odour emissions

(d) Background ambient air quality

(e) Coal fired boiler (CFB) discharge effects

(f) CFB discharge mitigation

(g) Summary and conclusions

THIS EVIDENCE

10 This evidence is primarily based upon the key technical investigations I have led to assist Alliance with an application for air discharge consents required for the continued operation of its flagship Lorneville meat processing site.

11 In this evidence I will refer to these technical reports and summarise the investigation approaches and key conclusions. I will also draw upon my own experience undertaking air quality assessments for New Zealand and international projects.

12 In the first section of this evidence I discuss the existing odour effects and the expected change in potential effects likely to result from one of the main wastewater management system (WMS) upgrade options. These are being put forward by Alliance as part of their application for renewed discharge to river consents. I also comment upon the various new odour mitigation measures that I recommend Alliance implements to mitigate odour effects from the upgraded WMS, as well as additional mitigation measures that can be implemented, if required, to avoid significant odour effects beyond the site boundary.

13 In the second section of this evidence I will discuss the CFB air discharge effects and mitigation. In particular, I will discuss the level of existing and proposed future mitigation of combustion-related emissions having regard to the nature of the effects of those discharges.

BACKGROUND

14 The AEE describes the Alliance Lorneville operations and following is a summary various sources of discharge to air including:

- *Discharges of odour associated with operations at the processing plant including stockyards, soup stock, rendering and pelt processing (fellmongery) processes; Discharges of odour* *associated with various components of the site's wastewater treatment system; and*

- *Discharges of combustion products from the CFB operations;*

15 As discussed above, Alliance proposes a progressive upgrade of the site's WMS. This evidence addresses the implications of proposed upgrades in terms of potential odour effects and mitigation.

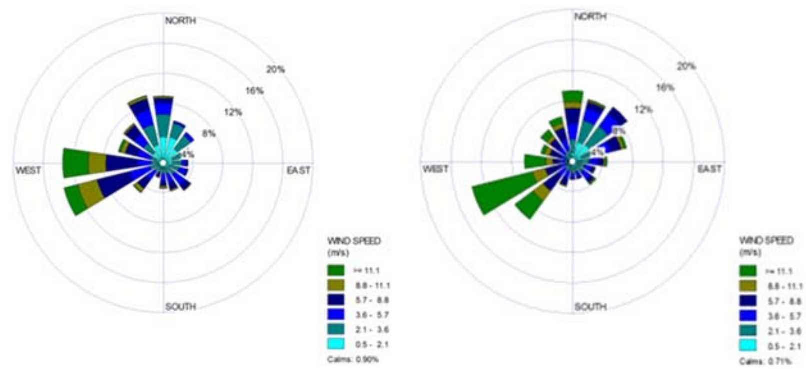
16 Alliance is also proposing a staged reduction in CFB emissions and periodic technical reviews of the BPO for CFB exhaust air emission controls to ensure that the controls on emissions remain up to date in terms of available technology and are in conformance with regulatory requirements throughout the term of the consent. In addition, Alliance proposes a radically improved method for real-time monitoring of CFB ambient effects and directly linking these to compliance conditions. This is in place of the historical practice of annual stack emissions testing. In this evidence I will explain the basis for the compliance monitoring regime changes and why they represent a more environmentally and sustainably responsible approach than the status quo – that is periodic stack emissions testing and reporting.

RECEIVING ENVIRONMENT

17 The receiving environment surrounding the Alliance Lorneville site boundary is shown in Figure 1 of Attachment B. The area is predominantly rural, with isolated residential dwellings and low density clusters of dwellings. Wallacetown, with an approximate population of 600, is approximately 1.5 km to the northwest of the wastewater treatment ponds and 3 km to the northeast of the process site. The nearest edge of the Invercargill City residential area is approximately 2 km south-southeast of the process site and further still from the wastewater ponds. Recreational and public facilities surrounding the site include a golf club, school, and several community halls.

18 The wind patterns shown below are for Invercargill airport and Wallace town (going left to right). These provide good indication of the wind patterns occurring at the Alliance site. Both sites have predominant westerly and southwesterly components as well weaker winds from the north and northwest. Drainage flows (air drift during cold, light-wind

conditions) are expected to drift mainly towards the southwest, approximately following the river system.



19 Figure 1 (attached) highlights that Alliance owns a large area of rural land surrounding the processing site and wastewater treatment area, and this is a significant factor in mitigating the effects of air discharges whether they be odour from the site ponds or combustion products from the CFBs.

20 When accounting for wind patterns at the site, I consider that CFB emissions to air largely bypass the urban area of Invercargill City. The same is true for Wallacetown. Neither are downwind of either the site's CFBs or wastewater ponds during prevalent wind directions, or drainage flow conditions on cold still nights that can be associated with worst case ambient effects. So not only does the Alliance-owned land provide significant mitigation via substantive buffer distances, but the prevalent wind directions and cold air drainage flow patterns at the site also help minimise the potential for exposure to Alliance's air discharges.

21 Of all the properties surrounding the site, it is those immediately to the east of the process site (near to and including respondents 8 and 9 in Figure 2 (Attachment B) that have the greatest potential for exposure to process odours (rendering and fellmongery), stockyard and CFB emissions. This is based on their closer proximity to these sources compared to other residential dwellings and the site wind patterns.

22 Similarly, it is those closest residential dwellings to the south of the wastewater treatment ponds (respondents 3, 12, 13, 24 and 4, in Figure 2 (Attachment B) that have the greatest potential for exposure to wastewater plant odour emissions. Again this is based on the closer proximity to the wastewater ponds compared to other residential dwellings

and the site wind patterns. In this case, light northerly winds and drainage flows could direct pond odours towards the south of the ponds.

ASSESSMENT OF EXISTING (BASELINE) ODOUR EFFECTS

23 Odour complaint records were also reviewed to help establish existing effects and trends since the new rendering plant was fully commissioned in the late summer of 2013. However, I consider these records on their own to provide an unreliable means of assessing odour effects and they are best used to indicate the need for more robust investigations.

24 However, it is useful to look at trends in complaints over time, especially where and when they tend to occur and what information is available about the character and source of the odour. Again, we have to be careful placing too much weight on such information except where there are consistent patterns and/or verifications with wind conditions.

25 For the above reasons, I considered it important to conduct an independent baseline odour survey involving the surrounding community. This involved mainly face to face interviews of residents living in areas surrounding the Alliance boundary during two consecutive years – April 2013 and June 2014 (see **Attachment F** to the AEE).

Odour Assessment Methodology

26 It is important to consider both acute and chronic odour exposure effects and apply different criteria to these. These are accepted terms and mechanisms of odour effect that are routinely assessed by air quality practitioners in New Zealand (Ministry for Environment, 2003).

27 The significance of odour exposure effects on people living or working from either process or wastewater odours would be related to the **FIDOL** factors (MfE 2003) – although it is the combination of the first three "**FID"** factors (*frequency, intensity* and *duratio*n of odour events) that need to be considered when assessing chronic (long term) odour effects. The "O" factor is misleading as it is referred to as "objectionableness" but in actual fact this parameter is directly related to the *odour character*.

28 The "**O**" factor has been equated to hedonic tone or unpleasantness rating – possibly because this is a qualitative rating of objectionableness. But in

my view, it is most important to account for the ***character*** of the odour and its associated **source** as these are the underlying drivers of an odour's unpleasantness or acceptance within any specific receiving environment context (i.e., the specific location "**L**"), and hence this drives the appropriate exposure criteria to apply.

29 Therefore the last FIDOL factor (**L**) relates to the land-use activity where the odour exposures occur. In this instance, I focused on residential dwellings and occupants.

30 The first three FIDOL factors are collectively accounted for via the parameter % odour time (% odour hours) and this criterion is an appropriate form for assessing the potential for chronic odour effects.

31 For acute odour effects, the absolute exposure time in minutes or hours is a more relevant form of assessment criterion. However, as for chronic odour effects, I have also considered a more stringent percentile time limit (% odour time) in addition to % odour hours, to assist in assessing the potential for acute odour effects.

32 In section 4.2 of **Attachment F** to the AEE I have proposed criteria for acute and chronic exposures to process and wastewater odours. The recommended criteria are listed as follows:

a. Chronic (long term) exposure to process and wastewater odours < 3 % odour hours per annum (at residential dwellings)

b. Acute (short term) exposure to strong process and wastewater odours < 0.5 % odour hours per annum and individual acute odour events less than 2 odour hours in duration.

33 I should clarify at this point that an "odour hour" is any hour when odours are recognisable for 10 % of that hour (6 minutes) or more. This is the definition provided by *Verband Deutscher Ingenieure* (VDI) based odour guidelines that MfE (2003) and its pending update recommend for use in New Zealand.

34 Another matter to clarify is that the above criteria I have used to assess the potential for either chronic or acute odour exposures to cause objectionable or offensive effects are not nationally accepted guidelines or standards.

35 They are based on values I have established over many years of undertaking odour diaries and odour surveys within New Zealand and that I have documented in the DSL Environmental Handbook (DSL, 2009) and presented at Clean Air Society odour workshops. In my view, these are the only criteria currently available in New Zealand for providing an objective basis for assessing the likelihood of odour impacts being either objectionable and/or offensive to the average reasonable person.

36 The odour criteria (maximum % odour hours, or maximum hours) I list in paragraph 32 are appropriate for most environmental odours occurring in rural areas. However, when assessing chemical odours associated with health concerns (e.g. agricultural spray drift odours) I would recommend lower values to provide guidance on the potential for adverse effects. In the case of odours from the Lorneville site these lower values are not appropriate.

37 Therefore for the assessment of odour effects I used the analysis of FIDO data generated via community surveys. This enabled me to estimate the levels of both acute and chronic odour exposures to a local residents (living within the different areas shown in Figure 4 (attached) as a result of Alliance's wastewater and process odour discharges. The comparison of these exposure levels against the criteria detailed in paragraph 32 provided an indication of the potential for objectionable or offensive odour effects. For example, calculated exposures well below these criteria indicate only a minor potential effect.

38 The survey also provided information from respondents on the weather conditions, the intensity and character of the odour as well as comments on the perceived sources of odour for typical odour events. This information was used to assess the likely significance of any high intensity short term odour exposures (i.e., acute odour effects).

39 Finally, the general comments provided by respondents regarding their tolerance of existing odour effects provides key additional information that can be reconciled with the FIDOL information.

Odour Sources

40 The main sources of odour arise from the rendering, fellmongery, and stockyard operations at the main processing site, and the anaerobic and

aerated treatment ponds located to the western side of the processing site. Figure 3 (attached) highlights the locations of these sources with respect to the locations of residents that were surveyed.

41 As I discussed in paragraph 21, the residents to the east of the process site have the highest potential exposure to rendering, fellmongery and stockyard odours (Group C in Figure 4, Attached).

42 As discussed paragraph 22, residential dwellings to the south of the wastewater ponds (Group F in Figure 4, Attached) have the highest potential for exposure to wastewater odours – particularly those from the anaerobic pond and inlet area to the first aerated pond.

Survey Design

43 The survey questionnaire is shown in Appendix B of **Attachment F** to the AEE. This provided direct feedback from residents on FIDO factors, character/source. The survey also sought information on the times of day, and typical weather conditions when odours were noticed around their houses.

44 The above information was collated for all the groups shown in Figure 4 (attached). This figure also helps explain the need to group different residents' responses together based on their location. Based on location, the experience of odour would be very different because of proximity to these sources and the prevalent wind patterns at the site.

45 The two key groupings for assessing survey information involved those areas discussed above in paragraphs 41 and 42 – Groups C and F.

Survey Findings

46 Following my assessment of the survey results, I concluded that for all residential areas surrounding Alliance's Lorneville property, except for Group F, the existing odour impacts from Alliance's process plant and wastewater ponds in 2014 were not of sufficient frequency, duration and intensity (either chronic or acute), to cause objectionable or offensive effects. For all groups surrounding the site, other than Group F, the survey data indicated odour exposure duration and frequencies that were well below the criteria in paragraph 32.

47 Furthermore, with respect to the Alliance Fellmongery operation, I concluded that a rare combination of light wind conditions and elevated releases of sulphide odours (predominantly on Monday mornings) had the potential to cause an objectionable or offensive odour beyond the site boundary up until process changes were made in 2014. Later in this evidence I discuss process changes that appear to have reduced this potential to a minor level.

48 For residents who live closest to the southern property boundary of Alliance (off Leonard Road), there are infrequent occasions when the odour discharges from the WMS's anaerobic pond have the potential to cause objectionable and/or offensive effects. This generally occurs in the autumn period when the anaerobic pond is still relatively active, and when more still atmospheric conditions are establishing. Later in this evidence I discuss progressive upgrades to the WMS that should eliminate these infrequent events of objectionable anaerobic pond odour.

49 Finally, a comparison of survey results between the 2013 and 2014 surveys indicated that the improved control of the rendering plant in 2014 resulted in a lower potential for rendering odours and to a level that appears to be minor.

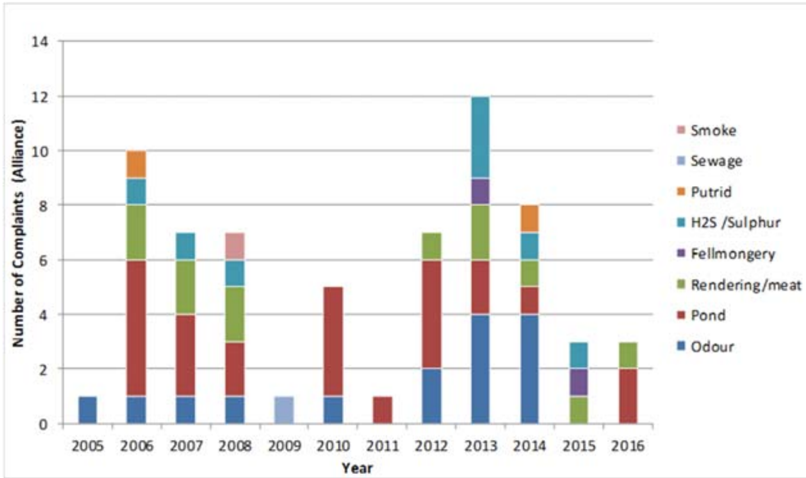
50 I consider the analysis of the survey data and findings above to be consistent with general feedback from the significant majority of survey respondents – that odour levels from Alliance's activities had significantly reduced over the years, and are now at an acceptable level. Only three respondents expressed the view that odours impacts still needed to reduce from existing levels - these people lived in locations represented by Groups C and F.

51 The survey findings are also consistent with my own observations of odours from Alliance's rendering and wastewater activities over the last 21 years – these have gone from being readily recognisable at the site boundary to being difficult to detect when directly downwind.

Odour Complaint Records

52 I have not relied on complaint records to assess existing odour effects, but consider it useful to confirm the trends and review descriptions of odour incidents from residents and independent council officers.

53 The figure below shows the number and type of odour complaints received by Alliance Lorneville in the years from 2005 to 2016.



54 The number of complaints lodged by the public is relatively low (i.e., 3 per year), given the scale of Alliance's meat processing operation at Lorneville. I fully expect the wastewater ponds to be the main remaining source of odour when the fellmongery and rendering plant are operating normally.

Conclusion on existing odour

55 My main conclusion regarding existing odour effects from Alliance's activities is that the best practicable option (BPO) should be implemented to minimise odour emissions from both the process plant and the WMS.

56 Finally, I consider that future upgrades to the WMS to improve the wastewater discharge quality can also provide a good opportunity to further reduce odour emissions from the WMS anaerobic pond and the fellmongery wastewater discharge.

PROCESS ODOUR MITIGATION

Overview

57 I will now discuss the various odour sources at the processing site and my assessment of the Best Practicable Option (BPO) for minimising the odour emissions in each case. During 2014 I undertook several field visits to review the rendering, fellmongery, soup stock manufacturing, blood

processing and the stockyards. The findings and recommendations of these reviews are documented in Attachment **G to the AEE**. Figure 1 in this attachment shows the general location of the aforementioned process odour source.

Stockyards

58 Sheep yards have a distinct odour characteristic that is synonymous with farm woolsheds, due to mainly to the build-up of animal waste. This odour is minimised by the raised floor design that allows waste to drop through the floor grating and to collect on a concrete surface that is periodically hosed down and the resulting wastewater removed.

59 An oxidant, chlorine dioxide is sprayed below the grated floor to reduce the build-up of ammonia concentrations. Occupational Safety and Health (OSH)-type monitors produce an alarm when ammonia exposure limits are exceeded, to protect worker health – this also acts to reduce stockyard odour emissions.

60 In my opinion, the regular hosing down of animal waste and use of chlorine dioxide to control ammonia levels provides effective control of stockyards and these measures, combined with the separation distance to off-site residential dwellings (over 500 metres), represent the BPO for minimising odour effects beyond the site boundary.

Soup Stock

61 The soup stock production at the site involves processing 100 to 140 tonnes/week of chilled fresh beef bones from offsite into soup stock, edible tallow and bagged bone meal. Therefore this is a relatively small scale process that produces a relatively neutral (if not pleasant) odour character that is synonymous with aromas I associate with making home-made stock.

62 I consider that the small scale of this process, its odour character and distance to neighbouring dwellings collectively result in minor or less odour effects. The scale of the process, use of chilled fresh materials and separation distances represent the BPO for minimising odour effects in this instance.

Wool Hydrolysing

63 The site operates a pressurised batch and one continuous wool hydrolyser – these remove wool from heads, hocks and skin pieces that are produced at the site. The hydrolysers' exhaust gases (containing significant odours) are extracted as well as pre-cooled blood drying exhaust air, and discharged with the CFB's inlet combustion air stream. Therefore the odorous compounds within the hydrolyser discharge would be mostly destroyed via oxidation with the CFB's combustion zone and discharged to air via the CFB dispersion stacks. I consider that this system represents the BPO for minimising the wool hydrolyser odours and results in in minimal odour effects.

Blood Processing

64 Blood generated at the Lorneville site, as well as that received in bins from Makarewa's venison processing plant, is processed into meal. Blood is held in a storage tank from where it is pumped to a steam coagulation unit. The resultant hot wet solid is first cooled, then dewatered via a decanter centrifuge to produce a wet solid. This solid is dried in an indirect contact steam dryer and the exhaust air from this process contains the main source of odour resulting from blood processing.

65 The blood dryer exhaust stream is cooled by a water jacket heat exchanger and the resulting odorous air stream is discharged alongside the hydrolyser exhaust air and is oxidised within the CFBs. As for hydrolyser odours, I consider this system and some further measures to collectively represent the BPO for minimising the blood drying odours.

66 These other controls include processing blood within 24 hours of slaughter whenever possible and never storing raw blood for more than 48 hours and implementing annual checks upon the effectiveness of the water cooled heat exchanger for cooling / condensing the blood dryer exhaust and confirming the effectiveness of the extraction system that delivers hydrolyser and blood dryer exhaust streams to the CFBs combustion chamber.

Low Temperature Rendering

67 Low temperature continuous by-product rendering is undertaken in a new state of the art rendering facility that was fully commissioned and operating in the summer of 2013. This new plant replaced the old and relatively odorous batch-cooking process that had operated for many decades at the site. Waste animal by-products from processing at the Lorneville and Mataura meat processing plants are all processed through the new facility at Lorneville. Seasonally the Lorneville rendering plant processes skinned fallen stock.

68 The rendering process is shown in Figure 4 of **Attachment R** to the AEE. The process consists of separate *solids* and *liquid* processing routes. The solids processing starts with truck delivery and unloading of raw by-products (from off-site) and into an enclosed air-extracted storage building. Both this material and by-product solids that are generated at the site are mechanically conveyed to bins that supply one of two rendering process lines that are operated within the new rendering building.

69 From here the material is continuously transferred within enclosed conveyors, cooked with steam, then pressed/squeezed to reduce the water content of the cooked solids, before drying and milling of solids to produce a meal product.

70 The liquid processing stream starts with the collection of liquid that is squeezed from the cooked solids. This is heated and subjected to centrifugal processes to recover tallow, before the process liquor is concentrated via the waste heat evaporation plant (WHE) to produce a liquor concentrate that can be returned to the solids stream and processed into meal product.

71 The above solids and liquor processing stages are summarised as follows:

a) Raw material reception and grinding

b) Ground material storage

c) Solids transfer

d) Cooking / pressing

e) Solids drying

f) Milling / screening and dispatch

g) Tallow recovery

h) Waste heat evaporation

72 All of the above process stages are shown in Figure 4 of **Attachment G to the AEE**.

73 All of the sources listed above produce odorous emissions that require containment via an extraction system and treatment of the resultant air stream to remove odour. For example, the unloading of by-products into the raw material reception building results in building air being discharged to the atmosphere.

74 Likewise the cooking of by-products, transfer conveyors and especially drying of cooked solids all produce significant odorous emissions. Meal processing stages including milling, bagging and load out produce some odour but of a relatively neutral character that is far less significant than cooking and drying related odours. The storage and heating of recovered tallow produces a relatively minor odour.

75 I have reviewed the extraction and cooling systems that target all of the above sources listed in paragraph 71 as well as the biofilter system that treats the resultant mixed gas stream.

76 I conclude that the design of this system represents the best practice that would be found in New Zealand and that the normal operation of this system is likely to ensure minor odour effects from the Alliance rendering facility. Therefore, I also conclude that the level of odour control that Alliance has employed at the new rendering plant readily meets the BPO and these odour controls would be the best example to be found in the New Zealand rendering industry.

77 By comparison, the milling, screening and dispatch of dry meal solids does produce an exhaust to atmosphere that contains meal odour. However the direct extraction and control of this stream is not necessary in my opinion. This is because the odour character and strength combined with distance to neighbouring properties are likely to result in this odour causing only minor or less effects. In fact in most cases it would not be recognisable beyond the Alliance site boundary given the rendering of fresh materials.

78 In summary the BPO for mitigation of meal processing odours is the rendering of fresh material that is not degraded and odorous, as well as the filtering of meal dust from the exhaust air that is ventilated from the rendering meal processing / dispatch building.

Fellmongery

79 The Fellmongery at Lorneville is relatively large and processes fresh sheep skins from Lorneville processing or on occasions salted skins from other Alliance plants to produce pickled pelts. These are the main feedstock for leather manufacturing.

80 The process involves washing the sheep skins, wool removal (including sulfide painting) and drying, batch processing (in process drums) of green pelts into pickled pelts. It is the latter processing in drums that produces a strong wastewater stream (that releases sulfide odours) and odorous emissions to air directly from the drums.

81 Wool drying, wool removal and washing create minor odours compared with the drum processing and associated wastewater streams.

82 Odour emissions from the ten process drums are vented to atmosphere and consist mainly of sulfide and ammonia that are odorous compounds. The sulfide content of the discharge (primarily in the form of hydrogen sulfide – H_2S) dominates the odour content of this discharge.

83 For many fellmongeries in New Zealand the discharges from process drums are ventilated to either scrubbers or biofilters to remove odours. However I do not consider that is necessary at Alliance Lorneville as the nearest property boundary is more than 600 metres from the fellmongery. I would not expect the sulfide based odour emissions from the process drums to be recognisable beyond this distance under normal operating conditions.

84 To cross check my view, I oversaw the measurement of sulfide emissions from the processing drums by Coal Research Ltd staff, and used the sulfide emission data to calculate equivalent odour emissions. An air dispersion model was then used to conduct an odour impact assessment that is reported in Appendix B of **Attachment G to the AEE**.

85 This assessment also found that there is likely to be a minor potential for off-site odour effects due to normal odour emissions to air from the processing drums at Alliance Lorneville.

86 However, there have been significant odours arise from the fellmongery operation in the recent past that I consider to be related to emissions following the discharge of spent processing liquors from the process drums. In my view, there are two scenarios that lead to this situation.

87 The release of H_2S from the fellmongery wastewater reticulation system results in localised odour within the site when spent alkaline process liquors (containing high levels of dissolved sulfide) and waste acid pickle liquors routinely mix within the reticulation system. This releases H_2S and can cause a rotten egg type odour and has the potential to be observed off site.

88 The worst case scenario for this odour occurs on some Monday mornings when a number of process drums have liquors simultaneously discharged to drain over a short period of time – and when these liquors have previously been stored within the process drums over the weekend.

89 I consider that a procedural change can effectively reduce the source of odour and requires operators to stagger the discharge of spent liquors from process drums on Monday mornings. Unless this occurs the peak in odour emissions that can occur due to multiple drums discharging spent liquors at the same time has the potential to cause a short term unpleasant odour beyond the site boundary.

90 Another key measure to mitigate against sulfide odours is to reticulate the acidic spent pickle liquors separately to alkaline lime liquors so the two do not mix and therefore generate odour sulfide emissions. Furthermore the acidic pickle liquors are discharged directly to the aerated section of the WMS and bypass the anaerobic pond. Although this measure will not avoid the dissolved sulphide load within the spent alkaline lime liquors being liberated from the anaerobic pond, the significance of this release would be reduced.

91 A long term solution for reducing sulfide based odour emissions from the fellmongery wastewater is to pre-oxidise dissolved sulphides using a conventional manganese catalysed oxidation process. However with the isolation of acidic liquors so they cannot mix with sulfide bearing waste streams, additional sulfide oxidation would not be needed to avoid sulfide

odours being released from the wastewater reticulation system. Furthermore, sulfide oxidation would not avoid the reconversion of oxidised sulfides to odorous sulfides within the WMS's anaerobic pond.

92 Instead, the sulfide oxidation option would be best implemented as part of any future WMS upgrade which I explain later in this evidence. Until such a time, the oxidation of sulphides within the spent lime liquors will convert back to odorous sulphides within the existing anaerobic pond. The subsequent sulphide odour would be liberated within the first stage of the aerated loop and from the anaerobic pond itself.

93 The WMS upgrade is likely to employ processes that realise the benefits of sulfides within the fellmongery spent lime liquors being pre-oxidised.

94 I therefore conclude that while the level of odour control employed in the Alliance fellmongery operation is less than at many other sites in NZ, the buffer distance from the fellmongery to the property boundary at Lorneville is sufficiently large to result in minor odour effects.

95 Furthermore the complete segregation and discharge of spent acidic pickle liquors to avoid any mixing with spent sulfide bearing liquors would effectively minimise the release of sulfide odours from the WMS reticulation system.

96 Therefore the current BPO for minimising fellmongery related odour emissions and effects is to modify the existing WMS reticulation system so it discharges acidic pickling liquors directly to the first aerated section of the WMS. The BPO would also include the staggered discharge of spent liquors from process drums on Monday or any other morning, as a standard procedure. I understand that this procedural change has already occurred. However process drum air extraction and treatment for sulphides and pre-oxidation of sulfide bearing liquors are not likely to provide any material reduction of the fellmongery odour emissions.

97 Given the above BPO measures are implemented then only minor odour effects are likely to result from the site's fellmongery operations.

WASTEWATER ODOUR MITIATION

98 I have investigated the mitigation of wastewater treatment related odours and prepared a report on this that is included as **Attachment R to the**

AEE. The existing location of the wastewater ponds with respect to the most impacted residential properties to the south is shown in Figure 1 of Attachment D. Whereas Figure 2 of this attachment more clearly highlights the anaerobic pond and where it discharges into the first section of the aerobic pond system.

99 There is little doubt that odours from the WMS are noticed on occasion beyond the Alliance site boundary. This is evident from complaint records and our surveys discussed earlier in this evidence. It is also clear that the anaerobic pond is the most significant source of WMS odour. Lesser potential sources have included odours from the WMS reticulation system that connects to the fellmongery and the first stage of the aerobic pond system that received effluent from the anaerobic pond.

100 Whilst the WMS odours are occasionally noticed, I have concluded (see paragraph 46) that most of Alliance's neighbours do not experience levels of WMS and other sources of odour that are significant. Except in the case of those residents living near to the southern boundary of the Alliance property (off Leonard Road), and due south of the wastewater ponds.

101 For these residents, I have concluded that there are infrequent occasions when the odour discharges from the anaerobic pond have the potential to cause objectionable and / or offensive effects. Therefore the main focus of mitigating existing odour effects relates to the anaerobic pond operation and proposed upgrades that significantly impact on this.

Mitigation – Existing Odour Effects

102 The simplest approach for mitigating anaerobic pond odours is to reduce the biodegradable organic load to the pond. Also the biological reduction of sulfides or sulfates within the anaerobic pond to odorous H_2S is highly likely. Therefore, reducing the loading of sulfides, or sulfates into the anaerobic pond is also effective.

103 With respect to further reducing organic loading to the WMS there are two key measures that Alliance propose. Firstly, the segregation of the plant's high strength (HS) and low strength (LS) wastewater streams, would allow for more effective treatment of the former. According to PDP (2013) the high strength waste streams contain approximately 30 % of the site's

biological oxygen demand (BOD) discharge within only 1 % of the site's total flow.

104 Therefore the targeted treatment of these streams and directing recovered protein to the rendering plant would significantly reduce the current organic loading to the anaerobic pond system and represent part of the current BPO for minimising anaerobic odour emissions.

105 Another component of the BPO is the direct discharge of the fellmongery's acidic pickle liquors directly to the aerobic ponds system (recommended in paragraph 96). This measure is expected to reduce the loading of sulfates and sulfides into the anaerobic pond by 40 %, according to PDP (2014).

106 Pre-oxidation of sulfides in the fellmongery's alkaline liquors would not be effective because they will readily reconvert to odorous H_2S within the anaerobic pond.

107 For the existing system, the removal of sulfides from the fellmongery's alkaline liquors would be effective from a technical standpoint. This involves using chemical agents, or acids to react with the sulfide and remove it from the waste stream. However it has been assessed by PDP (2014) that these technologies are either too expensive to operate (i.e., sulfide removal via precipitation with ferric chloride), or not operationally reliable (in the case of acid stripping / alkaline scrubbing for recovery of sulfide and recycling to the fellmongery process).

108 Additionally it is my view that such technologies should be compatible with the proposed WMS upgrade. In this respect, the conventional process for pre-oxidation of strong sulfide bearing liquors would appear to be the more appropriate sulfide pre-treatment.

109 In addition to reducing organic and sulfide loads to the anaerobic pond, there are other key mitigation measures that relate to management practices that impact on the anaerobic pond's natural cover and sludge build up within the WMS.

110 The maintenance of an organic crust layer on the anaerobic pond provides a significant level of control over the emission of odours. Allowing floatable solids and fat into the pond since the late 1990s has helped the progressive establishment of the crust layer (about one third of which is covered in grasses).

111 Therefore the recommendation to reduce organic load from HS waste streams needs to be managed so that fat loadings are still sufficient to maintain the substantive crust layer on the anaerobic pond. I expect that significant reductions in the loading of fatty materials can probably occur before any material impact on the existing pond crust but this should be monitored for any breaking up and disintegration in parallel with upgrades in HS waste stream treatment at the site.

112 Sludge management within the anaerobic and especially the aerated pond system is essential to avoid these filling up with sludge as this is likely to result in environmentally significant odour effects beyond the site boundary. Once the settled sludge levels within the aerobic pond are less than one metre below the pond water surface, pond odours can become significant.

113 Therefore, I consider annual sludge depth monitoring and periodic de-sludging operations (occurring during winter months) as necessary to maintain a minimum water column depth of one metre. This represents part of the BPO for minimising WMS odours.

114 Finally, if sulfide odours that can be generated at the inlet of the aerobic pond system were to cause significant odour effects then air stripping of anaerobic pond effluent prior to discharge into the aerobic system, and treatment of the sulfide enriched air stream, is a contingency measure that could be implemented. This would be an expensive measure that does not appear to be justified. Additionally the proposed mitigation (i.e., pickle liquor discharging directly to the aerobic ponds) and future upgrades to the existing WMS are likely to make this measure redundant.

115 In summary, I consider the BPO for minimising odours from the existing WMS to include the following:

a) Fellmongery pickle liquors to be isolated and discharged directly to the aerobic pond system.

b) Segregation of HS waste streams (containing about 30 % of the site's organic loading) and improved pre-treatment to reduce biologically available organic loading.

c) Annual monitoring of the anaerobic pond cover in response to reduced organic loadings and for sludge levels within the WMS.

d) Removal of sludge from the aerobic pond system to maintain at least one metre of water column above the settled sludge layer.

e) Sulfide stripping and treatment adopted as a contingency measure if needed.

Potential Upgrade of the Wastewater Management System

116 The evidence of Mr Khan provides details the proposed WMS upgrade. The associated location of the new process plant, future monofill and organic solids irrigation areas are all shown in Figure 5 (attached).

117 I understand that the WMS upgrade is likely to entail the anaerobic treatment of primary treated HS waste streams through a new covered anaerobic lagoon. The discharge from the anaerobic process and the fellmongery's sulfide bearing liquor streams (pre-oxidised via the conventional manganese catalysed aeration process) would then be co-treated within a biological nitrogen removal (BNR) pond. This latter process is an aerobic / anoxic cycling process.

118 The final treated stream would discharge to the head of the existing aerobic pond system, as the existing anaerobic pond does.

119 Both the above new processes can be controlled so they produce minimal odour. However it is anticipated by PDP (2013) that 700 m^3/day of dilute waste activated sludge (WAS) will need to be wasted from the BNR pond. The processing of this stream, its storage and discharge to land, monofill or off-site creates the potential for a new odour source. This will need management systems and mitigation measures to be put in place.

120 Also as part of the up-graded WMS, the major proportion of LS wastewater streams (approximately 15,000 m^3/day) would continue to discharge to the existing anaerobic pond that then discharges into the aerobic pond system.

121 As a result, the existing anaerobic pond would receive an approximately 80 % reduction in existing organic load and nearly 100 % reduction in sulfide load. Therefore its current odour potential should decrease drastically and become minor, unless the disintegration of its natural cover occurs due to the significant load reductions. This outcome could potentially counter the benefits of significant load reductions.

122 The aerated pond system would therefore receive much lower organic loads from the existing anaerobic pond as well as the treated wastewater stream from the BNR pond.

New Odour Sources and Mitigation - WMS

123 A realistic and achievable outcome of the WMS upgrade is the effective elimination of odours from the existing anaerobic pond and any sulfide odours from the aerobic pond. To some extent this could be countered by the occurrence of waste sludge processing / disposal related odours and / or odorous air vented from the new anaerobic lagoon. However these two new sources can be practically mitigated in my view. Likewise should the existing anaerobic pond cover disintegrate (following the large reduction in organic loading) then there are practical measures that can be implemented here as well.

124 If the existing anaerobic pond's organic crust layer begins to disintegrate (despite attempts to manage the crust layer via fat loadings), then the BPO for mitigation could be to transfer this process into a smaller pond that is covered and operates a gas flare system. The latter incinerates the odour content of the biogas that is generated within the pond.

125 For the new covered anaerobic lagoon, its biogas discharge can also be captured and its odour content eliminated by operating a flare. This would effectively incinerate odorous compounds, reduce greenhouse gas emissions, and would create a potential thermal energy source for Alliance. This is considered the BPO for mitigation of biogas odour.

126 For the new uncovered BNR pond there is a low odour risk because of its cycle of aerobic / anoxic conditions. There is a low risk that pre-oxidised sulfides within fellmongery liquors convert back to odorous sulfide forms within the BNR pond and should that happen, then it may well not manifest in a material odour issue. Otherwise, more extensive oxidation of sulfides could be instigated using hydrogen peroxide for example.

127 The key point I am making is that there are a number of possible odour issues arising from the new WMS processes and existing anaerobic pond, however the nature of these is such that there are practical (technical and economically viable) options to deal with any of these issues as they arise.

128 In summary, I consider the BPO for minimising odours from the upgraded WMS treatment processes to include:

a) BPO measures (a) to (d) recommended above in paragraph 115.

b) Pre-oxidation of strong sulfide bearing liquors from the fellmongery using the conventional manganese oxidation process.

c) Biogas flare for the new anaerobic lagoon.

d) More extensive oxidation of strong sulfide bearing liquors from the fellmongery using hydrogen peroxide or other options as a contingency measure.

e) Transfer of existing anaerobic pond to smaller pond with cover and flare system as a contingency measure.

f) An adaptive management approach that ensures that various WAS management procedures are optimised to minimise odours during storage and processing as well as ensuring land spreading procedures and restrictions are effective in avoiding adverse odour effects.

New Odour Sources and Mitigation – Waste Activated Sludge

129 Waste activated sludge (WAS) will be drawn off the BNR process as a dilute 1 wt% slurry. This will need to be stored prior to being concentrated into wet solids via a centrifuge decanter or a similar process. I understand that these concentrated solids could be spread over land or further dewatered ahead of landfilling or off-site disposal.

130 The BPO for odour control would entail the use of maximum storage times for the dilute WAS and the dewatered solids to avoid the onset of anaerobic conditions ahead of land spreading or other disposal methods.

131 This maximum time will largely depend on the extent of aeration provided to the stored WAS and concentrated solids. With sufficiently high aeration of the WAS, then this time can be extended for very long periods.

132 It would not be as easy to effectively aerate concentrated solids and therefore spreading over land or disposal to landfill will probably require much shorter storage time frames with or without lime addition to avoid odour issues.

133 I consider that operational experience will be necessary to establish the most appropriate storage times of raw and dewatered WAS ahead of land spreading and landfilling operations.

134 Clearly the spreading of decayed / anaerobic solids is likely to cause odour issues and is to be avoided. Furthermore, to avoid odour issues from the spreading of non-odorous solids to land, the maximum solids loading rates (kg/ha/application) will need to be established.

135 In addition it will be useful to manage spreading operations so they best account for forecast wind conditions during the day of spreading, and maintain appropriate buffer distances to nearby residential properties.

136 If from experience it is found that the above measures are not able to avoid significant odour effects occurring beyond the site boundary then contingency measures would need to be considered.

137 Potential contingency measures include alternative solids management and disposal options such as landfilling (to a purpose built Monofill), or composting (off-site or on-site).

138 The design of the Monofill and ability to cover and contain odours that will arise from the formation of anaerobic conditions will dictate the extent of odour emissions from this activity. Ensuring that the active face at the Monofill can be effectively covered, and the use of lime and/or soil to mitigate odours from uncovered material are standard measures that can be employed as necessary to reduce odours to a minor level.

139 Finally, the siting of the Monofill as far as practical away from residential houses and the site boundary would represent part of the overall BPO.

140 In summary, I consider the BPO for minimising odours from the WAS management and disposal processes to include:

a) An adaptive management approach that ensures that various WAS management procedures are optimised to minimise odours during storage and processing as well as ensuring land spreading procedures and restrictions are effective in avoiding adverse odour effects.

b) The necessary limits and procedures relate to the extent of WAS and dewatered WAS storage times as a function of aeration and lime addition procedures.

c) For land spreading, limits for organic and / or solids surface loading rates need to be specified and reviewed as well as procedures for weather forecasting and setting minimum buffer distances.

d) Regarding the Monofill option, controlling odours from this should be relatively straightforward and involve simple covering procedures and use of soil and lime.

e) Ultimately the disposal of solids off-site can be utilised if the proposed measures described above are not sufficiently effectively and practical to implement.

BACKGROUND AMBIENT AIR QUALITY

Study Approach

141 To assist with the assessment of effects from the Alliance coal-fired boiler (CFB) emissions, I directed an assessment of the existing back ground air quality at several locations near to the Lorneville processing plant. The resulting information enabled the assessment of cumulative air quality effects due to the CFB emissions and existing ambient air contaminant levels.

142 **Attachment E** to the AEE provides a copy of Golder's report on the monitored background ambient air quality around Lorneville and a summary of other sources of background air quality information that was relevant to the assessment the CFB emissions to air.

143 The key contaminants that were monitored included respirable particulate (PM_{10}) and sulfur dioxide (SO_2). Other contaminants discharged from the CFB's such as metals and nitrogen oxides (NOx) have relatively low background levels for which assumed values suffice to provide a robust cumulative impact assessment – in other words, for these contaminants the CFB emissions significantly dominate the cumulative effects upon air quality.

144 $PM_{2.5}$ (that is ultra-fine particulate that is a sub-fraction of PM_{10}) was also monitored for several weeks during the summer of 2015. Whilst not directly regulated, this contaminant is regulated by default in New Zealand via the MfE NESAQ for PM_{10} (of which $PM_{2.5}$ is a subset). Given $PM_{2.5}$ is

the key driver of potential health effects associated with PM_{10} then having some data on background levels is very useful. As such, regulatory bodies worldwide are all moving towards direct $PM_{2.5}$ monitoring and management. This issue is also currently being reviewed by New Zealand's MfE.

Air Quality Standards and Guidelines

145 Table 1 below summarises applicable MfE NESAQ and AAQGs relevant to this project. This lists the contaminant, guideline or standard ambient concentration limit, time averaging period and the source which defines the standard or guideline. Note that concentration limits (mass of a contaminant per unit volume of air) relate to the average value over a specific time period.

146 Therefore the concentration limits need an associated time period that they relate to. Furthermore, a specific contaminant can have a range of different concentration limit values specified for different time periods. These different combinations usually relate to different types of adverse effect e.g. acute versus chronic exposure effects for a particular air contaminant. We can see examples of this in Table 1 below.

Table 1: Air quality standards and guidelines (adapted from Attachment E)

Contaminant	Guideline/standard (µg/m³)	Averaging period	Allowable exceedances per year	Source

SO_2	350	1-hour	9	NES (MfE 2004)
	570	1-hour	0	NES
	120	24-hour	0	AAQG MfE 2002
	20	Annual	0	MfE 2002
NO_2	200	1-hour	9	NES
	100	24-hour	0	AAQG
PM_{10}	50	24-hour	1	NES
	20	Annual	0	AAQG
$PM_{2.5}$	25	24-hour	1	Indicative#
	10	Annual	0	Indicative#
Lead	0.2	3-month moving average, calculated monthly	N/A	AAQG
Arsenic	0.0055	Annual	N/A	AAQG
Cadmium	0.02	Annual	N/A	(OEHHA 2008)
Chromium VI	0.0011	Annual	N/A	AAQG
Chromium metal and Chromium III	0.11	Annual	N/A	AAQG
Mercury	0.33	Annual	NA	AAQG
Dioxin and Furans	Tolerable daily intake 1 pg TEQ/kg body weight/day*.	Annual	N/A	MfE (2001)

*Acceptable incremental risk of increased cancer rates in the population of <1 in 1,000,000.

World Health Organisation (2006)

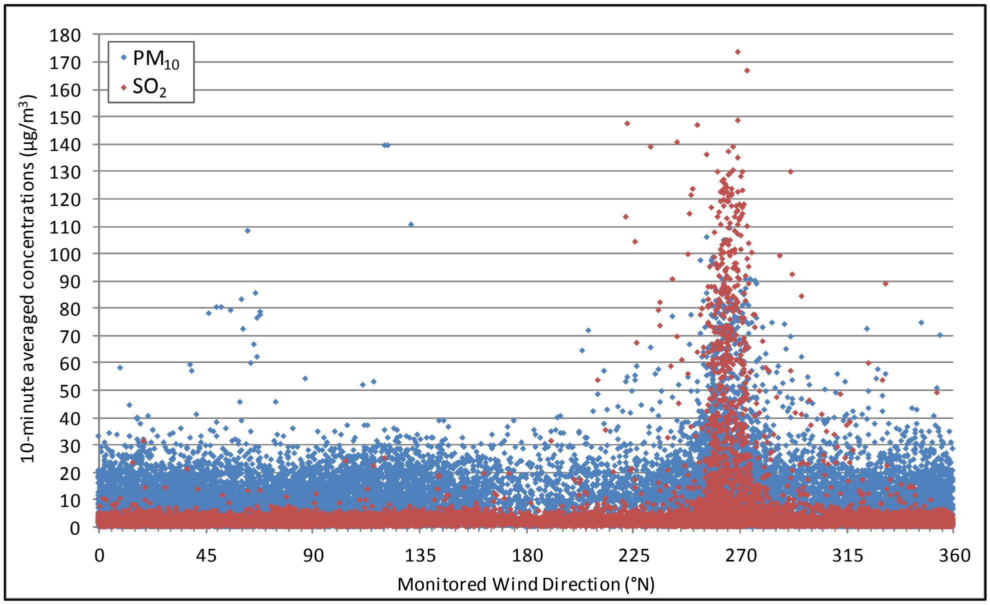
147 Table 1 is taken from Attachment E to the AEE, but includes the addition of an indicative air quality guideline for $PM_{2.5}$ based on World Health Organisation recommendations.

Respirable Particulate (PM_{10})

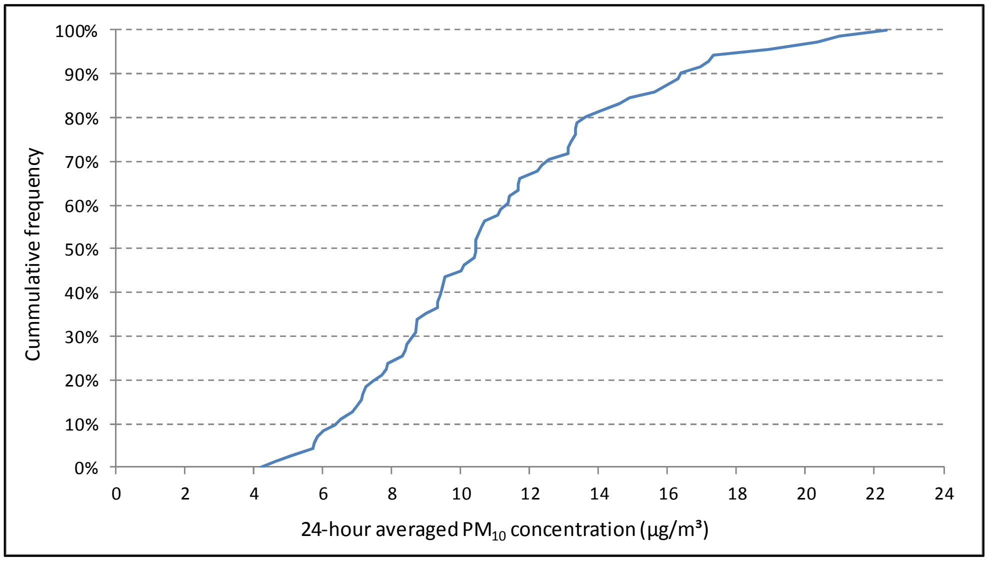
148 Background PM_{10} was monitored in the winter of 2013 approximately 1km to the west of the site and in the summer of 2014 approximately 500 m due east of the site (locations are shown in Figure 4 of **Attachment E** to the AEE). Monitoring in 2013 (at the wastewater pond monitoring site) involved conventional high-volume sampling on to a filter for 24 hours followed by gravimetric analysis. This monitoring yielded very low ambient PM_{10} values. I decided this data was useful for confirming that polluted urban air from Invercargill or Wallacetown did not greatly influence the background levels around Lorneville. This outcome could be expected as on days of high background PM_{10} (cold still days) the urban PM_{10} emissions from urban home fires would tend to travel away from the direction of the Alliance site.

149 The 2014 summer monitoring (February to late May) involved real-time continuous measurement of PM_{10} using a NESAQ compliant instrumental method. This was undertaken at the eastern monitoring site shown in the figure below where the orange "+" shows the monitoring location**.** The blue "+" shows the off-site private dwelling that is nearest to the CFBs.

150 During the monitoring period, PM_{10} and SO_2 were both continuously measured in parallel with wind direction and speed measurements so that the contaminant measurements influenced by the CFB emissions could be separated from the background data. Because the CFBs are the only significant source of SO_2 in the area, the parallel monitoring of short term PM_{10} and SO_2 concentrations in early 2014 clearly identified what PM_{10} data was or was not influenced by the CFB emissions. This is highlighted in the figure below (Figure 8, **Attachment E** to the AEE).



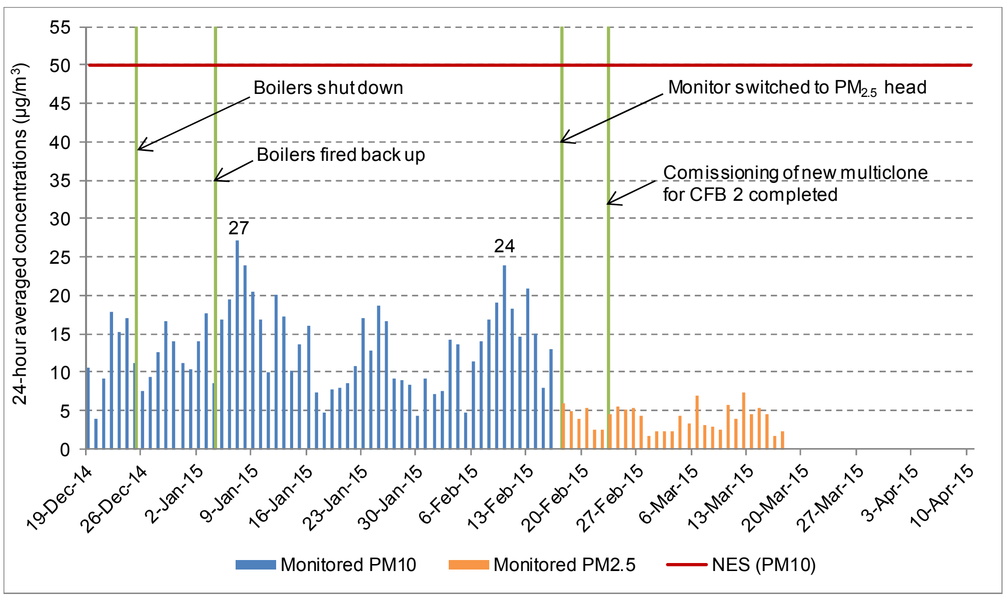
151 The figure below (Figure 9 of Attachment E to the AEE) summarises the background 24 hour average PM_{10} concentrations that were measured early in 2014. These data were used to establish an appropriate background PM_{10} concentration of 15 µg/m³ (24 hour average) for use in the assessment of cumulative PM_{10} impacts due to the CFB emissions and the existing background. This is consistent with the MfE recommendation of 15 µg/m³ (24 hour average) for a summertime background level in a rural site.



152 Therefore the typical background PM_{10} during the peak processing season is up to 30% of the NES for PM_{10} and the highest value was 45% of the NES.

153 Based on the 2014 background data set I also established that a background annual averaged PM_{10} concentration of 10 µg/m³ was appropriate for the assessment of CFB emissions.

154 During the latter part of 2014 and early 2015 some further ambient PM_{10} and then $PM_{2.5}$ monitoring was undertaken with the primary purpose of monitoring impacts from the CFBs at the same monitoring location used for the early 2014 PM_{10} monitoring. The data indicated that background concentrations of $PM_{2.5}$ are typically 5 µg/m³ (24 hour average) and about 1/3rd of the background PM_{10} of 15 µg/m³ (24 hour average). This was assessed from the data shown in the figure below (from Figure 5, **Attachment M** to the AEE). Note that the data below was collected after the new multi-clone was installed on CFB 2.



155 In 2010 Environment Southland monitored 24 hour average PM_{10} with high-volume samplers in Miller Street, Invercargill (approximately 9 km to the south east of the site) and therefore well into the centre of the city. Monitoring with high-volume samplers was also conducted in Wallacetown during the winter of 2010. Invercargill experienced a number of exceedences of the NES for PM_{10} (50 µg/m³, 24 hour average), while the much smaller urban area of Wallacetown had none.

156 In summary, the assessment of cumulative impacts from the CFB emissions and the background was aided by a solid base of both rural and nearby urban ambient PM_{10} data. For the rural environment the monitoring has also provided a good indication of background $PM_{2.5}$ (24 hour average) concentrations.

Nitrogen Dioxide

157 For NO_2 background concentration information for Invercargill has been produced by NZTA using passive sampling devices. From a review of this data (presented in Figure 12 of **Attachment E** of the AEE), I conclude that the typical background NO_2 concentrations for the area surrounding the Alliance Lorneville plant would be 15 µg/m³ for both the 1 hour and 24 hour average time periods (i.e. 15% of the MfE AAQG). This value is also recommended by MfE for rural areas where no monitoring data is available.

Sulphur Dioxide

158 To establish background SO_2 concentrations surround the site, I relied on the continuous monitoring undertaken in the summer of 2014 at the same monitoring site used for PM_{10} (i.e. the eastern monitoring site shown in Figure 4 of **Attachment E)**. As for PM_{10}, the SO_2 monitoring data was filtered to remove results that were influenced by the CFB emissions. From this filtered data I conclude that a typical background SO_2 concentration within the area surrounding the site is 5 µg/m³ for both the 1 hour and 24 hour average concentrations (i.e. 1% and 4% of NES and AAQG criteria respectively).

159 For the annual average concentration I conclude that this will be approximately 3 µg/m³ and therefore 15% of the MfE AAQG.

Metals

160 The more significant types of metals that are discharged in trace levels from the combustion of New Zealand coal include; arsenic, cadmium, chromium, lead, and mercury. The ambient background levels of these metals is negligible and is assumed to be zero for this assessment.

Dioxins and Furans

161 Background levels of dioxins and furans in rural areas of New Zealand are very low and have been reported by MfE (2008). From this data I conclude that background dioxins and furan concentrations for the area surrounding the Alliance Lorneville plant is 16 fg I-TEQ /m³ as an annual average. One "fg" or femto-gram is 0.000000000001 milligrams). TEQ refers to International Toxic Equivalents. TEQ units allow a complex mixture of different toxic compounds to be defined as an equivalent mass of one dioxin compound that has an equivalent toxicity.

162 The following table summarises the background air contaminant concentrations I discussed above.

Summary of Background Air Quality

Pollutant	Source of data reviewed	Averaging period	Background concentration µg/m³
PM_{10}	Alliance monitoring	24-hour	15
		Annual	10
$PM_{2.5}$	Alliance monitoring	24-hour	5
		Annual	5
NO_2	NZTA, MfE	1-hour	15
		24-hour	15
SO_2	Alliance monitoring	1-hour	5
		24-hour	5
		Annual	3
Metals: arsenic, cadmium lead, and mercury	N/A	3-month and Annual	0
Dioxins and Furans	MfE monitoring	Annual	16.0 fg I-TEQ /m³

COAL FIRED BOILER ASSESSMENT

163 In this section of evidence I will discuss the assessment of CFB air emission, the associated assessment of effects and mitigation. The full report on these matters is **Attachment M** to the AEE.

164 The site operates two CFBs that are fired on a lignite coal supplied from the Newvale mine. The maximum steam production rates (tonnes/hr) and coal burning rates (tonnes/hr) are as follows:

- CFB 1: produces 26.7 tonnes/hr of steam (at 8 Bar) when burning coal at 7.23 tonnes/hr (**18 MW output**)
- CFB 2: produces 18.8 tonnes/hr of steam (at 8 Bar) when burning coal at 4.57 tonnes/hr (**12.7 MW output**)

165 At 30.7 MW total thermal output (i.e. 18 MW and 12.7 MW), the two CFBs represent a moderate to large energy plant for a New Zealand industrial site. Figure 2 of **Attachment M** to the AEE shows the location of the CFBs discharge stacks (as the yellow dots). The discharges of exhaust combustion gases from each CFB and associated contaminants occurs from these two stacks that are 31 and 34 metres high for CFB 1 and CFB 2 respectively.

Nature of Air Discharges

166 The exhaust combustion gas stream from the CFBs mostly consists of nitrogen (N_2), unconsumed oxygen (O_2) and water vapour. The combustion process creates carbon dioxide CO_2, SO_2, nitrogen oxides (NO and NO_2) and CO. The process also creates a wider range of partially oxidised volatile organic compounds (VOCs) and trace levels of nitrous oxide (N_2O).

167 Metals within the coal are either released with the exhaust gases, or retained within the ash – the split here depends on the metal's volatility. The more volatile, the greater fraction is discharged to air and less retained in the ash.

168 The VOCs are an important contaminant that result from incomplete combustion of organic material. They lead to the formation of dioxin and furans and other toxins in trace (very low) levels. More importantly the less volatile fraction of VOCs condense post the combustion chamber as the exhaust gases are cooled. This condensation process forms what is

commonly referred to as "smoke" and this smoke can dominate the level of $PM_{2.5}$ that is discharged from the CFBs.

169 This is important, because managing combustion conditions to minimise unburnt VOCs in turn minimises the formation of $PM_{2.5}$ – this contaminant creates the greatest potential (weight for weight) to cause adverse heath-effects in humans and for which PM_{10} is largely a surrogate in terms of potential effects. In other words, it appears that most of the adverse health effect that are associated with PM_{10} exposure are in fact driven by its finer $PM_{2.5}$ sub-fraction. As I will discuss later, this has significant implications for monitoring and mitigation of respirable particulate emissions.

Receiving Environment

170 I described the receiving environment in paragraph 17 of this evidence in regards to potential odour effects and that description is largely relevant to the CFB discharges to air. In regards to local air quality impacts (that have the higher level of impact) from the CFBs, the off-site dwelling shown in the figure below paragraph 149 that is 770 metres from the CFBs is identified as the key sensitive receptor. There is another house to the south west of the private dwelling – this is owned by Alliance and located within the Alliance property boundary.

Assessment Approach

171 A full copy of the assessment of air quality effects from the CFB emissions is provided in **Attachment M** to the AEE. This assessment is based on the prediction of increased ambient contaminant concentrations (µg/m^3) beyond the property boundary due to the coal-fired boiler emissions. This was achieved by modelling incremental concentrations and adding the result to known background levels. The subsequent predictions were directly checked by making a comparison to measurements of PM_{10} and SO_2 concentrations from the monitoring site location – discussed in paragraph 149. The monitoring site is within the area that is most impacted by the CFB emissions to air.

172 The discharged air contaminants assessed included PM_{10}, $PM_{2.5}$, SO_2, NO_2, heavy metals and dioxins - these result from the combustion of coal within the CFBs and are contained within their exhaust gases.

173 I have described the ambient monitoring of the primary contaminants listed above in paragraphs 142 to 154 above. Suffice to say, that I consider the monitoring of air contaminant levels to have been undertaken at an ideal location that is within the area of highest potential impact from the CFB discharges – both in terms of magnitude and frequency. It is also the most appropriate location for future monitoring purposes.

174 Air quality modelling involves running mathematically complex equations to simulate the dispersion and gradual dilution of contaminants released into the air from the CFB stacks. This allows the increase in ground level concentrations (GLCs) of these contaminants to be estimated for different time averaging periods.

175 The accuracy of the model's predictions is directly related to the accuracy of the estimated rates for which contaminants are released from the stacks. The velocity, temperature of the exhaust air, height of the discharge stacks, the prevalent wind patterns and atmospheric conditions are all importance factors affecting the model predictions. However, these factors are accurately accounted for by the air dispersion model.

176 The variation of contaminant emission rates over time can be accurately estimated within an upper limit based on the coal properties and recorded CFB steam production data.

177 In practice, PM_{10} emissions (grams per second) are most difficult to define as a function of variable CFB operating rate (MW), so this is often conservatively estimated by assuming a constant in-stack exhaust concentration for PM_{10} that equates to a practically achievable maximum value (e.g. 300 mg/Nm^3). Stack testing helps confirm this limit over time but is of limited value. I argue later in this evidence that continuous real-time downwind monitoring and reporting of ambient PM_{10} and $PM_{2.5}$ at the eastern monitoring site provides the most effective means of compliance monitoring of the CFB PM_{10} and $PM_{2.5}$ discharge impacts and their subsequent potential effect.

178 In summary, the modelling produces estimates of increased ambient concentrations of air contaminants (short and long term concentrations) due to the CFB emissions for all locations surrounding the site and well beyond. The ambient monitoring measures the cumulative impact of the CFB emissions plus the background at a strategic location. Both methods are important to use and the latter produces data that can be used to cross

check (validate) the modelling assumptions for the CFBs PM_{10} and SO_2 discharge rates. This in turn helps to ensure a more reliable assessment of potential effects than provided by modelling alone.

179 The validation process is mathematically complex, but it provides much greater reliability of the predicted off-site ambient contaminant levels and certainty to the assessment.

Ambient Monitoring Results

180 Appendix H, of **Attachment M** to the AEE presents ambient monitoring data for contaminant concentrations at the eastern monitoring site during January to May 2014 as well as CFB stack emission test results for PM_{10}. The ambient monitoring data gives direct information of cumulative impacts and background concentrations during this peak operating period. But to make real use of this information it is necessary to know what rate of contaminant discharge was occurring from the CFBs during that period (usually estimated from CFB stack emission test results for PM_{10}). The combination of this information helps us be more certain about the air quality impacts that are likely to occur in the future when meeting proposed CFB stack discharge limits.

181 Appendix I of **Attachment M** to the AEE presents an analysis of monitoring data for PM_{10}, SO_2, and wind direction versus the model predictions of the contaminant concentrations at the eastern monitoring site during January to May 2014. This analysis allowed the in-stack concentrations and emission rates of PM_{10} and SO_2 to be back-calculated during that period. These back-calculated values could then be compared to stack testing results as a check upon their accuracy.

182 This analysis indicated that actual PM_{10} discharge from the CFB stacks during the 2014 monitoring programme was typically 375 mg/Nm^3 +/- 20%. By comparison the average of CFB stack test results from 2011 to 2014 is 350 mg/Nm^3. This average increases to 410 mg/Nm^3 when including a very high test result from 2010. I concluded from this assessment, that the CFBs could currently meet a discharge limit for PM_{10} of 300 mg/Nm^3 (averaged between the two CFBs) given an up-grading of combustion controls and to the CFB 2's multi-clone – discussed later in this evidence. However prior to this, and during the 2014 monitoring programme the CFBs may well have had short periods of discharging PM_{10} well above the 375 mg/Nm^3.

183 Mr Iseli has expressed his concern that the back-calculation process described above may have underestimated the magnitude of the CFBs PM_{10} emissions and associated stack concentrations. The more extreme statistics in the analysis suggest that PM_{10} within the CFB discharge stacks could have been as high as 675 mg/Nm^3 (i.e. higher than 375 mg/Nm^3). I agree that stack concentrations above 375 mg/Nm^3 could have occurred for a minority of the time during the monitoring period and prior to the up-grading of combustion/emission controls after the monitoring period.

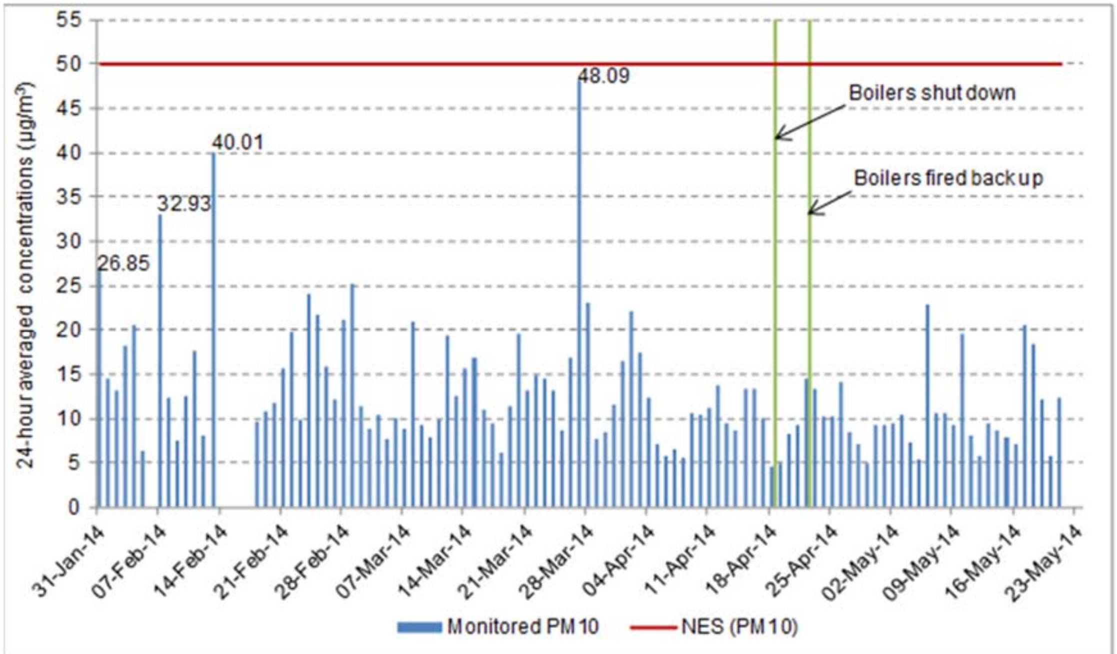
184 However, I consider the discharge concentration of 375 mg/Nm^3 would be representative of normal emissions prior to these upgrades in 2014. This is indicated by our analysis and the average of stack testing results during recent years. Now I am confident that the CFBs can operate within a PM_{10} discharge concentration of 300 mg/Nm^3 and have recommended ambient compliance limits based on this value.

185 If instead, a much higher discharge concentration of PM_{10} from CFBs was typically occurring above 375 mg/Nm^3 this would have significant implications on the analysis of PM_{10} ambient monitoring results for 2014 (shown in paragraph 187). If the typical PM_{10} concentrations in the CFB discharge were significantly higher than 375 mg/Nm^3 were typically occurring during the monitoring period of January 2014, then actual ambient PM_{10} impacts resulting from the proposed emission caps of 300 and 250 mg/Nm^3 for the CFBs would have been vastly lower than those shown in paragraph 187. Furthermore, the ambient impacts of $PM_{10,}$ under limits of the proposed CFB discharge limits of 300 and 250 mg/Nm^3, would also be significantly lower than those shown in paragraph 154 above (Appendix H of Attachment M to the AEE).

186 However I consider the ambient PM_{10} impacts shown in paragraph 154 are representative of the CFBs discharging PM_{10} at around 300 mg/Nm^3. If Mr Iseli's concerns that PM_{10} emissions were significant highly than this, then by default those impacts in paragraph 154 would actually overstate potential effects.

187 However, I do not consider this to be the case. Furthermore the PM_{10} monitoring data shown below (prior to the upgrading of combustion controls and installation of a new mult-clone) are reflective of the CFBs discharging PM_{10} at around 375 mg/Nm^3 with isolated peak emissions

above this figure. These monitored PM_{10} impacts are presented in the figure below:



188 The benefits of the up-grading the combustion controls for CFB 2 in 2015 can be seen from the comparison of the data displayed in the figure above, with further subsequent ambient data that was collected at the end of 2014 and early 2015 – shown in paragraph 155 of this evidence. This shows peaks of 24 hour average PM_{10} peaks below 30 µg/m^3, whereas before the up-grade these were above 40 µg/m^3. I consider this data (post the up-grade) demonstrates ambient PM_{10} levels that result from the CFBs discharging PM_{10} at 300 mg/Nm^3 with few (if any) occasional peaks above this level. In other words, the ambient data shown paragraph 154 of this evidence is representative of the ambient effects allowed for by the new consent being applied for.

189 There are similar time series figures for SO_2 shown in Appendix H, of Attachment M to the AEE, and these confirm that actual impacts levels of this contaminant beyond the site boundary are well below NES and AAQG values. In my view this monitoring confirmed that actual SO_2 emissions from the CFBs are 30% lower than those calculated from worst case coal sulfur content and coal ash retention assumptions. If the modelling assumed 30% higher emissions of SO_2 then the predicted impacts would be 30% higher than the monitoring data. Therefore modelling the theoretical worst emissions based on the maximum coal sulfur of 0.5 wt%

and assuming 5 % sulfur retention in the ash clearly over stated the impacts of ambient SO_2. Therefore in my view, increasing the SO_2 emission rate assumption by 30% (from 78 to 112 kg/hr) results in a theoretical emission rate and ambient impact that overstates the actual impacts that would occur in practice.

Air Discharge Modelling

190 The air dispersion modelling predicted the off-site ambient concentrations of contaminants due to their discharge from the CFBs – these contaminants are listed in paragraphs 166 to 169. The downwind ambient concentration is directly proportional to the rate of release (grams per second) of each contaminant from the CFB stack. A schematic diagram of the modelling process (in this instance using the accepted regulatory models, CALPUFF and CALMET) is shown in figure 5, of **Attachment M** to the AEE.

191 The PM_{10} emission rates are discussed above (based on in-stack concentrations). The NO_2 and TEQ-dioxin emission rates are estimated from the type of coal (lignite) and its burning rate (kg/second). Whereas SO_2 and metal emission rates are based on the coal burning rate and its composition. The emission calculations and summary of results are provided in Section 3 of **Attachment M**.

192 For the prediction of 24 hour average concentrations, the model's input contaminant emission rates were varied each hour and ranged between zero and their respective maximum rates (grams per second) based on the coal burning rate profile for the CFBs. The coal burning rate was accurately specified by time series steam production data for the CFBs. This means that predicted air quality impacts for 24 hour and longer averaging periods are not grossly over predicted.

193 For hourly predictions of air quality effects, the CFBs contaminant discharge rates assumed by the modelling were held at maximum rates for extended periods, and then held at lower rates for periods of low CFB output. This helped ensure that one-off worst case hourly air quality effects were not missed by the modelling. The conservative CFB operating rate assumptions of modelling compared to actual operating rates over time are shown in Figure 6 (attached).

SOIL METAL ANALYSIS

194 As part of this assessment I assisted Alliance in the specification of an assessment of metals within soils that surround the CFBs. The purpose was to establish if any deposition of metals due to coal-combustion over many decades would show up as accumulated concentrations within the surrounding soil.

195 The results indicated that changes in soil metal concentrations of chromium, copper, lead, nickel, and zinc in the vicinity of the CFBs were consistent with the modelled long term ambient concentrations of CFB contaminants. That is higher levels of metals were found in soils from areas of higher long term average contaminant concentrations due to the CFB discharges.

196 However, the soil concentrations of arsenic and cadmium were not higher than background (control site) levels. For chromium, copper, lead, nickel, and zinc the assessment found soil metal concentrations that were respectively 5 %, 17 %, 4 %, 23% and 24 % of relevant guidelines. In one hundred years' time, if the CFBs continue operating at the current level, the soil concentrations of (chromium, copper, lead, nickel, zinc), respectively, may reach 7 %, 26 %, 6 %, 36 % and 37 %, of the respective guideline values.

197 In summary the soil metal analysis did detect an impact of chromium, copper, lead, nickel, and zinc deposition from the CFB air discharges, but at levels and a rate that appears to be minor against guideline criteria for soil metal concentrations.

ASSESSMENT OF CUMULATIVE EFFECTS

198 I now discuss the cumulative effects of the CFB emissions and background air quality when utilising the modelling results that are presented in Section 9 of **Attachment M** to the AEE**.**

199 For the discharges of metals, volatile organic compounds and nitrogen oxides, the modelling results indicate a very minor level of impact and potential effect from all these compounds.

200 The metal emissions create ambient impacts that are well below the applicable health standards and unlikely to cause any adverse effects. The soil monitoring confirmed a very low rate of deposition and subsequent build-up of soil metal levels despite many decades of CFB operation.

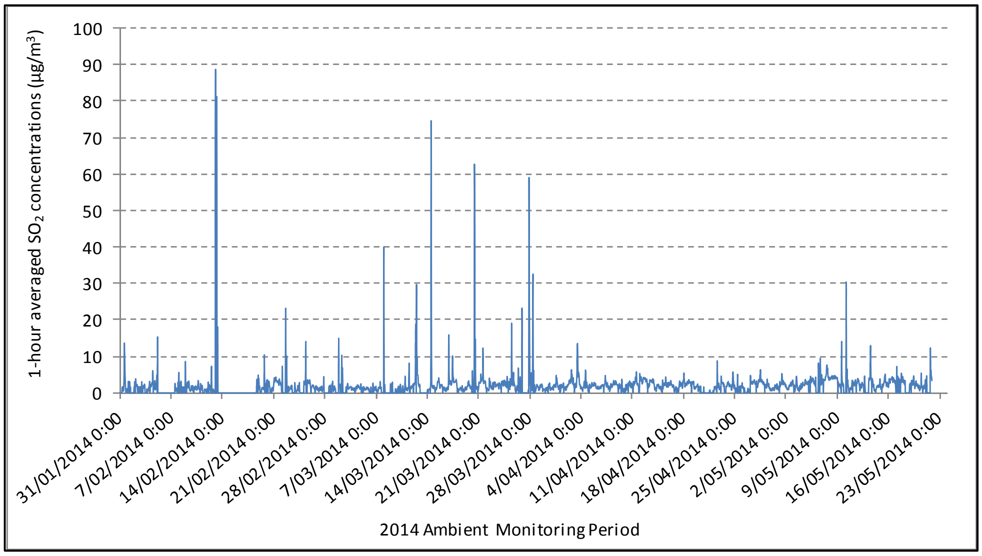
201 The highest ambient dioxin levels due to the CFBs are likely to create a health risk that are orders of magnitude lower than the MfE's acceptable health risk of 10^{-5}.

202 In regards to NO_2, the modelled cumulative ambient concentrations at the maximum off-site and highest impacted off-site dwelling locations are very likely to be very low against the NES for 1-hour and AAQG for 24-hour average concentrations and would create a negligible potential for any adverse effects.

203 In regards to SO_2, the modelled cumulative ambient concentrations are a relatively high proportion of their respective NES (1-hour average) and AAQG (24-hour average) criteria. But these are still sufficiently low to indicate a very minor potential for health effects to occur – even at the nearest and impacted residential dwelling. The following table summarised the highest ambient ground level concentration (GLC) SO_2 at the nearest off-site house:

Averaging period	**GLC at highest impacted off site dwelling ($\mu g/m^3$)**			**Assessment criterion**
	Modelled GLC	**Background**	**Cumulative GLC**	
1-hour maximum	169	5	174	**570**
1-hour 99.9th Percentile	143	5	148	**350**
24-hour	62	5	67	**120**
Annual	7	3	10	**30**

204 The above table shows that worst case SO_2 impacts at the nearest house are generally half or less of their respective health effects criteria. These are modelled worst case impacts. A more accurate picture of the actual ambient SO_2 impacts that occur near to the closest off-site residential house is shown by the ambient monitoring undertaken in 2014 and shown in the figures below for 1-hour average ambient impacts.



205 The above figure shows hourly SO_2 concentrations measured at a location in close proximity to the nearest house. The NES target for hourly SO_2 is 570 µg/m³ and a more conservative health criteria from the WHO is 350 µg/m³ (1 hour average). By comparison the isolated measured peaks (due to the CFBs) are below 100 µg/m³ (1 hour average) and typically the ambient levels are 30 µg/m³.

206 Therefore, based on the monitoring and modelling, I conclude the potential for SO_2 emissions from the Alliance CFBs to cause health effects is very minor. This reflective of the fact that Alliance use a very low sulfur content coal (southern lignite).

207 I should note on uninhabited land, closest to the Alliance property boundary, the predicted ambient SO_2 impacts are higher than those at the closest residence because those areas are nearer to the CFBs. However, even at these nearest locations, the modelled worst cast short-term exposure levels (1 hour values approaching 300 µg/m³) are below the WHO health guidelines and well below the NES for hourly SO_2. There is one occasion of a modelled 24-hour average SO_2 GLC being slightly above the MfE AAQG. However, because of the most likely exposure time for people, I would only be concerned if hourly average impacts were breached as these are most relevant to SO_2 health effects. Based on the modelling results and monitoring in a similar location, this outcome is very unlikely. I refer to the evidence in paragraph 189 for reasons why I consider it inappropriate assess the potential impacts of SO_2 within these areas for increased emissions (by 30%) above those assumed by the modelling – as recommended by Mr Iseli.

208 I will now discuss PM_{10} impacts (and its finer subset of $PM_{2.5}$), that is respirable particulate (RP). Unlike other air contaminants, RP can occur within relatively clean rural air at a significant levels. Close to the Lorneville site, background RP can be around 30% of the NES for PM_{10}. The other issue with RP is that unlike SO_2, it does not have a clear threshold ambient level that below which no observable effect occurs.

209 So while the NES for 24 hourly PM_{10} is 50 µg/m³ and the annual AAQG is 20 µg/m³ having maximum impacts below these levels does not necessarily equate to minor or less potential for adverse health effects. However, it is clear that health risk decreases with lower exposures and we can obtain some guidance from WHO (2005) who state that

"The long-term mean $PM_{2.5}$ guideline concentration of 10 µg/m³ is based on the lower end of the range at which significant effects on survival were observed in the American Cancer Society's (ACS) study, including cardiopulmonary and lung cancer mortality…"

210 For PM_{10} impacts the modelling assessment considered impacts from the CFB in the urban areas of Wallacetown and the nearest edge of the Invercargill urban boundary (airshed wide impact). It also assessed impacts at the nearest off-site residential house (localised impact).

211 The urban areas received maximum 24 hour PM_{10} impacts from the CFBs that are below 5 µg/m³ so therefore causing annual average impacts that would be well below 1 µg/m³. I consider that it can be safely assumed that annual exposure to PM_{10} and $PM_{2.5}$ impacts due to the CFB emissions are very unlikely to cause any health effect on residents within surrounding urban areas of Invercargill or Wallacetown.

212 When considering 24 hour average PM_{10} GLCs, the most significant issue is cumulative levels when the urban areas already have high background concentrations due primarily to domestic heating. The assessment shows that on cold still days, the CFB emissions disperse away from Invercargill and Wallacetown. As such, the days when these urban areas have high 24 hour PM_{10} levels, the CFBs would only make a minor additional contribution in order of 2 µg/m³ to 3 µg/m³ and typically much less at the outer north western edge of the Invercargill city limit.

213 For the Miller Street ambient PM_{10} monitoring site that is in centre of Invercargill (and when ambient PM_{10} would be relatively high), the CFB

emissions would have no measurable impact on monitored levels in my opinion.

214 In conclusion, I consider the Alliance CFBs PM_{10} emissions create no material environmental or NES compliance issues for either the Invercargill airshed or Wallacetown. I will now discuss the PM_{10} and $PM_{2.5}$ impacts at the nearest off-site dwelling (this is near the eastern monitoring site).

215 For this location, I have the benefit of both the modelling assessment and directly monitored PM_{10} and $PM_{2.5}$ values at a location that is about 50 metres closer to the CFBs than the aforementioned dwelling.

216 I refer back to the monitoring data shown in paragraph 154 of this evidence. This provides the best indication of cumulative PM_{10} and $PM_{2.5}$ impacts near to the most sensitive dwelling during the peak processing season. The results indicate that annual average PM_{10} and $PM_{2.5}$ would be less than 50% and 30% of their respective annual WHO criteria – that is the long term exposure is at the lower end of the range at which significant effects on survival were observed (discussed in paragraph 209).

217 Further to this, the modelling assessment indicated the CFBs would increase the annual average PM_{10} level by less than 20% of the WHO annual average criteria. Given the ambient monitoring has indicated $PM_{2.5}$ to be up to 50% of the PM_{10}, then this infers a similar level of exposure to $PM_{2.5}$ compared to its WHO annual average criteria.

218 In summary, the annual average $PM_{2.5}$ exposure is the most significant driver of health effect in people. The monitoring and modelling results near the most impact dwelling indicates $PM_{2.5}$ concentrations are low against WHO's guidelines. In addition I note that in regards to 24 hour average PM_{10} impacts that Mr Iseli discusses in his evidence, the worst-case increases do not cause any issue of NES non-compliance, and typical increases due the CFBs are relatively low. In terms of potential health effects, the 24 hour peaks are less relevant than the cumulative annual average increase in PM_{10} and $PM_{2.5}$ which are both low compared to their respective WHO's guidelines.

219 I am not a health expert and therefore are not qualified to state that the above results necessarily mean that the potential for adverse health effects is only minor. However, I can confirm that the PM_{10} and $PM_{2.5}$

annual exposure levels are likely to be significantly lower than the WHO criteria that has been set at the lower end of the range at which significant effects on survival were observed in the American Cancer Society's (ACS) study (WHO, 2005).

220 I can also confirm that the PM_{10} and $PM_{2.5}$ ambient monitoring data presented in paragraph 154 is comparable to what I consider to be good air quality. If this ambient monitoring data was indicative of a significant potential for adverse health effects, then that would be surprising as many rural areas in New Zealand would experience similar ambient PM10 and $PM_{2.5}$ levels. It is generally accepted that the air quality in New Zealand's rural areas is very good, if not excellent.

221 I should note that the ambient PM_{10} monitoring results shown within paragraph 187 of this evidence, do indicate isolated events when the CFBs were most likely to be discharging well above the in-stack PM_{10} concentration limit of 300 mg/Nm^3. However, as I will discuss below, the reasons for this were identified and rectified by the up-grades to the CFB 2 particulate emission control system in 2014.

222 In my view the isolated peak impacts of ambient PM_{10} highlighted in paragraph 187 were of concern and may have had the potential to cause some short term adverse health effects. However, that level of impact is now historical in my view and is not what the application and proposed conditions would allow for.

223 Furthermore, the real-time ambient compliance monitoring that Alliance has proposed is the only reliable way of ensuring that any loss of PM_{10} emission control and subsequent return to those historical discharges, would be quickly detected. By comparison, the traditional compliance monitoring approach of annual stack testing would be a relatively ineffective method for detecting this situation occurring.

224 Finally, the modelling results shown in Figures 7 and 8 (Attachment M to the AEE) indicate that ambient exposures to PM_{10} or $PM_{2.5}$ as a result of the CFBs decrease significantly for other residential dwellings that are further away from Alliance's boundary that the nearest dwelling.

MITIGATION

225 I will now discuss the mitigation of SO_2 and PM_{10} emissions from the CFBs.

226 With regards to SO_2 I consider the level of impacts to be sufficiently minor and of negligible environmental concern, that the proposed mitigation measures are appropriate given the continued use of the low sulfur lignite coal for firing the CFBs.

227 These measures include the weekly sampling of supplied coal and analysis for sulfur content. This will enable the demonstration of compliance with the proposed maximum coal sulfur limit of 0.5 wt% (as received basis). Meeting this limit will ensure the ambient impacts of SO_2 remain within the envelope presented in Attachment M to the AEE and therefore ensuring a very minor potential for any adverse health effects.

228 I note Mr Iseli's evidence indicates that the potential SO_2 effects justify continuous in-stack monitoring of SO_2 emissions. I disagree and consider this type of monitoring has only been appropriately applied in circumstances where industrial discharges cause ambient SO_2 levels that routinely approach or breach health guideline levels. In these cases, the high initial expense and operational costs of in-stack continuous monitoring is justified. However for Alliance's CFBs the level of SO_2 impact is relatively low and any change in coal sulfur over time would be detected by the weekly coal sulfur monitoring that is proposed.

229 With regards to the mitigation of PM_{10} and $PM_{2.5}$ emissions from the CFB, I do not consider that there is a strong effects based argument to justify best practice end-of pipe (EoP) emission controls (e.g. full baghouse filter, or an Electrostatic Precipitator (ESP)) at this stage.

230 As discussed at paragraphs 206 to 222 of this evidence, the level of PM_{10} and $PM_{2.5}$ impact from the CFBs is low (both locally and within the closest urban areas). It is not clear to me that the very high expense of EoP emission controls would be justified by subsequent environmental benefits.

231 To minimise PM_{10} and $PM_{2.5}$ potential effects, I recommend that the CFBs initially meet a flow weighted average PM_{10} discharge concentration limit of 300 mg/Nm^3 (corrected to 12 vol.% CO2) which is now achievable with recent up-grades to the CFB 2 multi-clone and ash removal systems in 2015.

232 Then within 5 years the CFBs should achieve a lower PM_{10} in-stack concentration of 250 mg/Nm^3 (corrected to 12 vol.% CO2). I note Mr Iseli's evidence considers this limit should be achieved within 2 years of a consent being granted. That may be too tight a time frame in my view for the following reasons.

233 Firstly, to routinely achieve the lower limit, I recommend that Alliance implement state-of-the-art boiler combustion control technology that includes continuous in-stack monitoring and automated control of carbon monoxide (CO) and oxygen (O_2) within the CFB exhaust. This would be a significant step forward for Alliance and provides the most cost-effective means of reducing $PM_{2.5}$ emissions from the CFBs. This is because $PM_{2.5}$ is largely derived from unburnt VOCs and optimising combustion conditions so that CO is minimised is the most efficient approach for minimising VOCs in the first instance.

234 In addition to the up-graded combustion controls, it may also be necessary to also up-grade CFB 1's multi-clone system. Having optimised the CFB operation, it would be sensible to review the subsequent PM_{10} and $PM_{2.5}$ ambient monitoring data to assess the true success of these measures and confirm that a real reduction to a 250 mg/Nm^3 discharge limit for PM_{10} has been achieved. The review of the ambient monitoring data would also allow for the associated $PM_{2.5}$ discharge to be confirmed.

235 The monitoring provided by the proposed conditions requires continuous PM_{10} and $PM_{2.5}$ ambient monitoring at the key eastern monitoring location and that this monitoring meets specified ambient limits.

236 The time to install and operate upgraded combustion controls, review monitoring data, consider the need for further up-grades such as the CFB 1's multi-clone are the reason for requesting a five year period. I consider the 2 year timeframe recommended by Mr Iseli and the Section 42A report is too short for this process to occur.

237 I accept that in time, Alliance may need to implement further significant mitigation of PM_{10} or $PM_{2.5}$ (or possibly both) emissions from the CFBs. During the term of any long consent period, new ambient standards and/or evolving science can indicate that a significant investment in further mitigation via end-of-pipe treatment of the CFBs exhaust air may be justified. Depending on the details of any new PM_{10} or $PM_{2.5}$ regulations that may be imposed at a national or regional level, the most cost-effective

option for further reducing particulate emissions could be an ESP, or some form of modified full baghouse filter (FBHF). The latter, when combined with a multi-clone, is often assumed to represent the current Best Practice for CFB particulate emission controls in New Zealand.

238 However, I consider the current best practicable option (BPO) of control of boiler particulate matter (RP) emissions is to achieve the 250 mg/Nm^3 in-stack discharge limit as outlined above. I also consider that use of FBHF, ESP or similar end-of-pipe treatments instead represents the current best practice for PM_{10} or $PM_{2.5}$ emission controls.

239 Notwithstanding the above, I consider that world-wide shift from regulation of ambient PM_{10} to the regulation of ambient $PM_{2.5}$ is likely to also occur in New Zealand – because of the health related science that points to the key role of $PM_{2.5}$ exposure in driving health effects. However, it is not yet clear what the most effective approach for $PM_{2.5}$ emission control will actually be apart from minimising its formation by improved combustion control systems for the CFBs. Beyond this it maybe that some form of modified FBHF technology emerges or ESPs will be established as the more effective and required mitigation measure.

240 The reason I consider standard FBHF systems may not be effective is that I consider that these systems are not necessarily highly efficient at removing $PM_{2.5}$ emissions. This is because much of the $PM_{2.5}$ passes straight through a FBHF in gaseous form and then condenses to form $PM_{2.5}$ as it cools within the CFB discharge stack.

241 If the aim is only to reduce PM_{10} impacts and achieve even lower ambient levels against the NES for PM_{10}, then a FBHF would be effective and would be the BPO where this is necessary to achieve NES compliance. However in this case, there is no concern with the Alliance CFBs causing cumulative impacts that result in any non-compliance with the NES (either locally or within surrounding urban areas).

242 However, if the real aim (as it should be) is to minimise the potential for health effects then it is not clear that FBHFs technology is either the BPO or Best Practice. This is because, in respect to $PM_{2.5}$ emissions the effectiveness of FBHFs would appear doubtful.

243 Given the above, I consider the appropriate approach for the mitigation of potential health effects from the CFB is to implement the new combustion control and ambient monitoring measures discussed above outlined within

conditions of consent proposed by Alliance. In addition to this, I support the approach of reviewing the growing mass of PM_{10} and $PM_{2.5}$ monitoring data at routine periods to re-assess the CFB ambient impacts over time. I also support the routine re-assessment of the emerging scientific and engineering information related to both PM_{10} and $PM_{2.5}$ controls and health effects. The review and reassessment approach is provided for within a review condition proposed by Alliance.

Compliance Monitoring

244 Alliance is proposing to undertaken real-time continuous monitoring of ambient PM_{10} and $PM_{2.5}$ at the eastern monitoring site used for the 2014 and 2015 monitoring campaigns for the duration of the consent. Additionally, they propose that the monitoring is to meet nominated ambient compliance concentration limits that are detailed within the proposed consent conditions. This approach is similar to that taken with some water discharge consents where compliance limits are set for in-stream contaminant concentrations – at a compliance point beyond the mixing zone. To apply this approach to monitoring and controlling the CFB emissions of PM_{10} and $PM_{2.5}$ is a significant advancement over the traditional approach of annual measurement of PM_{10} or TSP discharge rates from the stack.

245 The ambient compliance monitoring approach for the CFBs PM emissions makes it entirely appropriate to only check the discharge rates from the CFB stacks in response to trigger levels being exceeded in the ambient environment. Beyond this, stack discharge testing is not required nor do I consider it a cost effective method for confirming compliance.

246 I have been concerned for many years that traditional stack testing of TSP and PM_{10} emissions has not been a reliable means of compliance testing nor that its growing costs are an efficient use of resources - in my view they are clearly not. This is especially the case for quantifying $PM_{2.5}$ emissions, where the existing methods are very expensive and not likely to accurately indicate the actual $PM_{2.5}$ emission rate.

247 By comparison, the real-time ambient monitoring will readily detect short term peaks in PM_{10} and $PM_{2.5}$ emissions from the CFBs as well as the long term trends in ambient concentrations. The cost to benefit ratio to Alliance of this approach is greater than a compliance monitoring approach based on traditional stack testing. Furthermore, there are far

greater benefits to the community in terms of increased certainty of actual effects from the CFB emissions and far greater assurances that non-compliant ambient impacts would be detected - compared to the traditional annual stack testing regime.

248 I therefore disagree with the evidence of Mr Iseli and the Section 42A report that recommends Alliance implement the ambient compliance monitoring regime and continue with the traditional stack testing approach. The latter is becoming very expensive, especially if following the full US EPA methods for $PM_{2.5}$ measurement that includes condensable VOCs (i.e the fraction of PM that can past straight through FBHFs). To reiterate, while very expensive, this method is not particularly accurate.

249 I note that the test method for stack testing proposed in the Section 42A report and recommended by Mr Iseli could allow for the use of older filterable particulate test method for measuring PM_{10} emissions from the CFB stacks. This is less expensive, but still in the order of $10,000 every time a round of stack tests is required.

250 It is my opinion that there are enough trigger conditions requiring CFB stack emissions testing already within the proposed ambient compliance monitoring conditions especially with the additional maximum 24 hour PM_{10} ambient trigger concentration trigger of 40 $\mu g/m^3$ that Mr Iseli has recommended.

251 If Alliance can operate the CFBs within the proposed ambient limits for PM_{10} without breaching any of these ambient PM_{10} concentration trigger levels then there would little reason or need to undertake annual stack for further good measure. That would be a very inefficient use of resources with little benefits to be gained in my view. If for whatever reason, Alliance were to struggle to operate the CFBs so that the ambient limits are met (developed for stack discharge concentrations for PM_{10} of 300 mg/Nm^3 and 250 mg/Nm^3) then the proposed consent conditions would impose significant requirements for multiple stack testing investigations.

252 I agree in principal with the concept of a maximum 24 hour PM_{10} ambient trigger concentration as proposed in Mr Iseli's evidence and recommended as a consent condition. However, at the time of writing this evidence I have not been able to consider in detail if the value of 40 $\mu g/m^3$ proposed by Mr Iseli, or a higher value of 45 $\mu g/m^3$ is

appropriate. It is in the right ball park but I would confirm this value at the hearing.

THE EVIDENCE OF MR ISELI

253 I have discussed key matters that Mr Iseli has raised in his evidence that relate to compliance monitoring and mitigation and provide further comment on various paragraphs follows:

254 In Para 4.13, Mr Iseli considers that there may be a 20 % under-prediction of PM_{10} impacts by modelling assessment (Attachment M of the AEE). I disagree and consider the modelling is relatively accurate and reflects the maximum PM_{10} discharge concentration of 300 mg/Nm^3 within the CFB stacks. I refer to paragraph 188 of this evidence to explain this view further.

255 In Para 4.13, Mr Iseli also considers that there may be a 44 % under-prediction of SO_2 impacts by modelling assessment (Attachment M of the AEE). I also disagree and consider that the SO_2 modelled impacts are realistic and consistent with (if not higher) than the monitoring data would otherwise indicate. I refer to paragraph 189 of this evidence to explain this view further.

256 In Para 5.6, Mr Iseli recommends continuous in stack SO_2 monitoring. This is not necessary as the proposed coal sulfur monitoring would detect any increasing trending in coal sulfur over time. I have also explained why this extensive type of monitoring is not justified in paragraphs 226 to 228 of this evidence.

257 In Para 5.8, Mr Iseli notes an exceedance of WHO 24 hour average guideline for SO_2 at nearest dwelling. I consider the use of this guideline to be inappropriate and not at all indicative of there being a potential for adverse effects. The reference to this guideline should be discounted as it is not effects based.

258 In Para 5.13, Mr Iseli recommends a two year implementation for automated boiler controls. I refer the Commissioners to my evidence in paragraph 236, where I note this is too short a time frame.

259 In Paras 5.14 to 5.16, Mr Iseli considers that adverse effects of PM_{10} are more than minor at dwellings east of plant. I do not consider that monitoring or modelling data supports this conclusion for the reasons discussed in paragraphs 209 to 224 of this evidence. I accept that there

are isolated ambient impacts of 24 hour average PM_{10} above 10 µg/m^3, but consider these are more relevant to meeting NES compliance (which they do when combined with the background). I refer to paragraph 218 of this evidence where I discuss the significance of annual and 24 hour average PM_{10} impacts at the nearest off-site dwelling.

260 As I have noted in this evidence, the ambient PM_{10} results are similar to those associated with rural environments. Furthermore the annual averages of PM_{10} and $PM_{2.5}$ that are most relevant to potential health effects are below WHO criteria that is set at the lower end of where significant effects occur (see paragraph 209 of this evidence)

261 In paragraph Para 6.2, Mr Iseli recommends the maximum coal sulfur content set at 0.45 wt% rather than 0.5 wt% I have recommended in paragraph 227 of this evidence. I consider the lower value of 0.45wt% provides insufficient space between actual maximum levels and the consent limit, which can simply result in technical non compliances that do not equate to any significant potential for adverse effects.

CONCLUSIONS

262 There are three main issues with respect to the Alliance Lorneville air discharge consent. These include odour, SO_2 and PM_{10}, for which I make the following conclusions.

263 Odour emissions have been steadily decreasing from the Alliance site over the last 15 years. I conclude that existing odour impacts beyond the site boundary cause only minor effects for most people living or working beyond the site boundary. There are some occasional more than minor effects for a few neighbours who live due south of the wastewater ponds – these occur on infrequent occasions. I conclude that the proposed future mitigation via the upgrading of the primary and then secondary wastewater treatment system is likely to resolve these residual odour issues.

264 Regarding the potential effects of SO_2 emissions from the CFBs, I conclude that these are only minor or less and that proposed monitoring of coal sulfur content once per week will provide a sufficiently reliable confirmation that SO_2 emissions and ambient effects remain within the levels I have assessed and discussed in the evidence.

265 I also conclude that Mr Iseli's evidence overstates the potential for SO_2 effects due to the Alliance CFBs.

266 Regarding the potential effects of PM_{10} and $PM_{2.5}$ emissions from the CFBs, I conclude that these are likely to result in cumulative ambient levels at the most impacted off site residential dwelling that are comparable to those associated with good rural ambient air quality. Furthermore I conclude that this monitoring information combined with the annual and 24 hour average exposures to both PM_{10} and $PM_{2.5}$ cumulative concentrations (at the most impacted offsite dwelling), do not clearly indicate a potential for more than minor effects.

267 Therefore I conclude that the imposition of a FBHF or ESP type technology is not justified based on any clear cost benefit considerations that are required to meet the BPO test.

268 Therefore I conclude that the CFBs meeting the discharge limit of 300 mg/Nm^3 and then reducing to 250 mg/Nm^3 within five years represents the current BPO for the application. Furthermore I conclude that the extremely comprehensive ambient monitoring proposed by Alliance will provide very clear information regarding the actual impacts of the CFB particulate emissions over time. This will enable the level of ambient effect of particulate emissions to be further reviewed over time and assessed against evolving standards and guidelines and allow the BPO to be robustly reviewed.

Roger Cudmore
July 4, 2016

REFERENCES

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MfE and MoH 2002. Ambient Air Quality Guidelines 2002 update. MfE Air Quality Report No. 32. Ministry for the Environment and the Ministry of Health.

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OEHHA 2012. Acute, 8-hour and chronic reference exposure levels. Office of Environmental Health Hazard Assessment as on Feb 2012, California. Accessed August 2013. http://www.oehha.ca.gov/air/allrels.html

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PDP 2014. Sulphide removal from Wastewater – Feasibility Study. December 2014. PDP Job reference number A01856211. 14 December 2014

World Health Organisation (WHO) 2005. *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide*. Global update 2005, Summary of risk assessment. Available at: http://www.euro.who.int/__data/assets/pdf_file/0005/78638/E90038.pdf

ATTACHMENT A

Qualifications and Experience

Evidence of Roger Cudmore

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 provided 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 worked 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 an expert witness for the regulatory sector since the early 1990s. 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 that covers (late 1990s).

- 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).

EXPERT TESTIMONY

With regards to expert testimony provided to the Environment Court or Air Plan Hearing Commissioners, examples include the following:

- Expert air quality evidence to the Proposed Canterbury Air Regional Plan, Policies and Rules. Fonterra and Ravensdown, 2015/16.

- Expert air quality evidence to policies and rules within the Southland Regional Air Plan – Stage 1 ("Proposed Air Plan"). Fonterra, 2015.

- Expert air quality evidence to the Proposed Auckland Unitary Plan Hearings for Topic 035 regarding proposed use of World Health Guidelines for Air Quality. NZ Starch, 2015.

- Expert air quality evidence to the Court regarding reverse sensitivity effects of residential development opposite the Belfast Industrial Zone. Lowe Corporation, 2011.

- Expert air quality evidence to the Court regarding sulphur dioxide (SO_2) effects and associated modelling from an acid manufacturing plant. Ravensdown Fertiliser, 2010.

- Expert evidence to the Court regarding dust effects from the construction the extended Marlborough District Hydro-scheme. Main Power, 2009.

- Expert air quality evidence to the Court regarding the Appealed Canterbury Regional Air Plan. Canterbury Regional Council, 2009.

- Expert air quality testimony to the Court regarding odour effects from an existing mushroom compost. NZ Mushrooms Ltd. 2007.

- Expert air quality testimony to the Court regarding an appeal of the Selwyn District planning rules for intensive piggery expansions. NZ Pork Board vs Selwyn District Council. 2006.

- Expert witness regarding nuisance odour effects from a proposed chicken growing operation. Environment Court Decision (Canterbury Regional Council v M & D Rickerby C/2002). For MJ & DT Rickerby. 2002 – 2005.

- Expert air quality evidence to the Court regarding the appeal of the air permit term as granted by Environment Southland (2002). For Alliance Group Limited. 2002.

- Expert evidence to the Court regarding dust nuisance effects from a peat harvesting operation. Environment Court Decision (Ravensdown Growing Media Limited v Southland Regional Council C194/2000). For Ravensdown Growing Media Ltd. 1997 / 98.

- Provided expert odour nuisance evidence to the Court regarding an injunction applied for by Green-McCarghill against the continued operation of the Rosedale Landfill, Northshore City.

- Provided expert evidence given to the Court regarding odour effects from the AFFCO Imlay rendering plant. 1997.

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 have 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 - 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 (H2SO2 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 1990s 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 NOx 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 SOx 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.

ATTACHMENT B

FIGURES

Evidence of Roger Cudmore

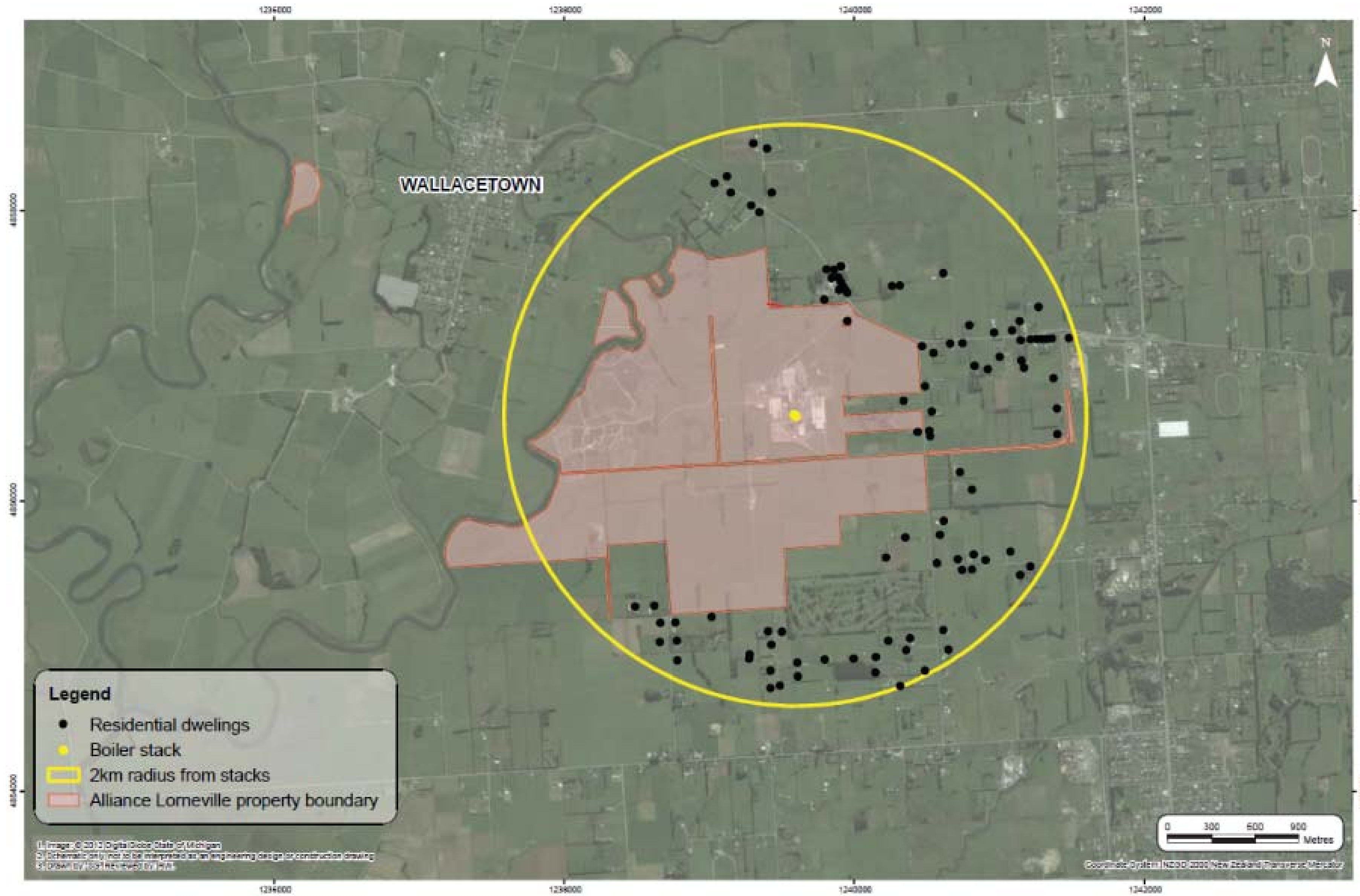

Figure 1: Receiving environment surrounding the Alliance Lorneville site.

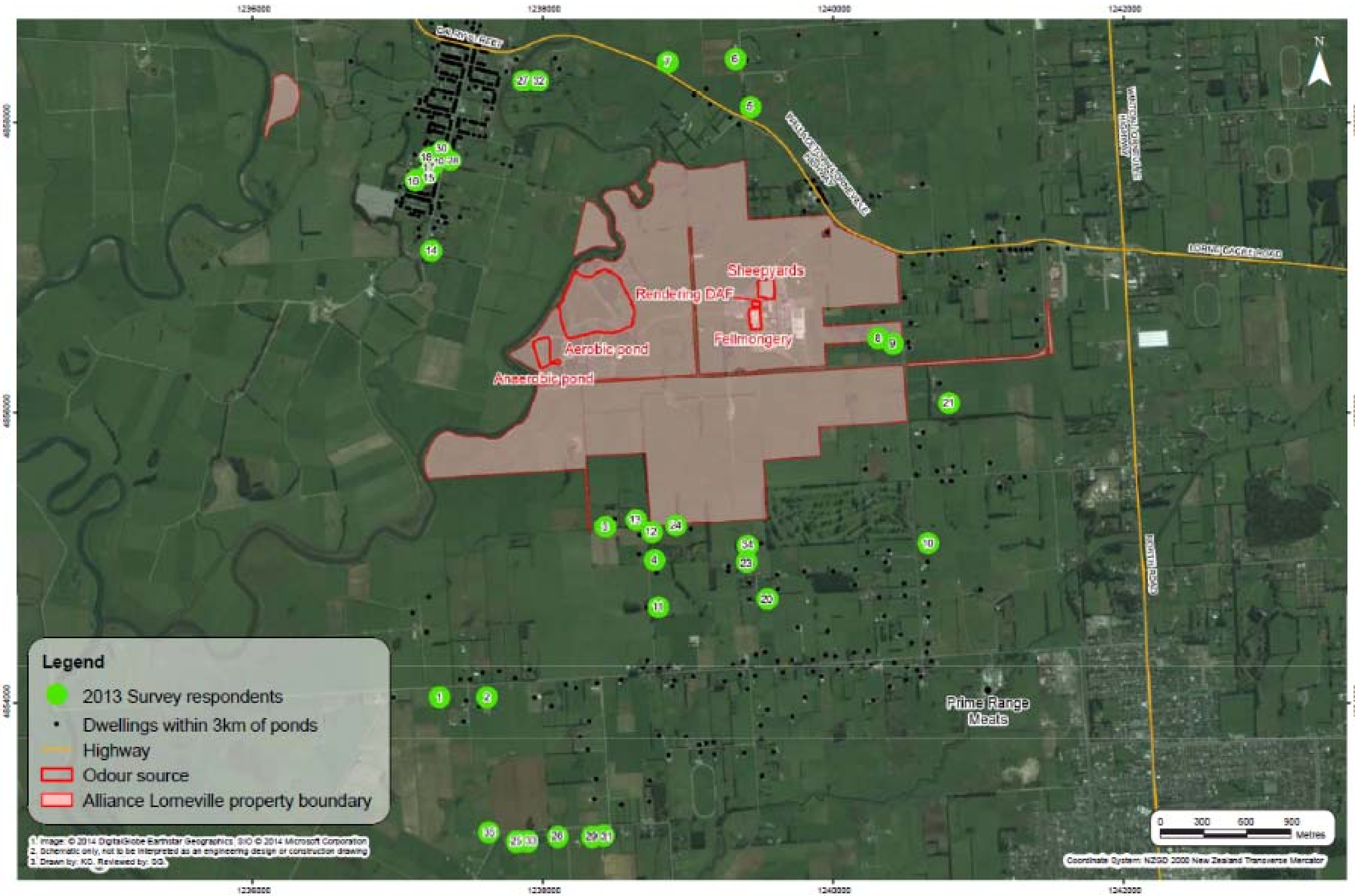

Figure 2: Locations of 2013 survey respondents.

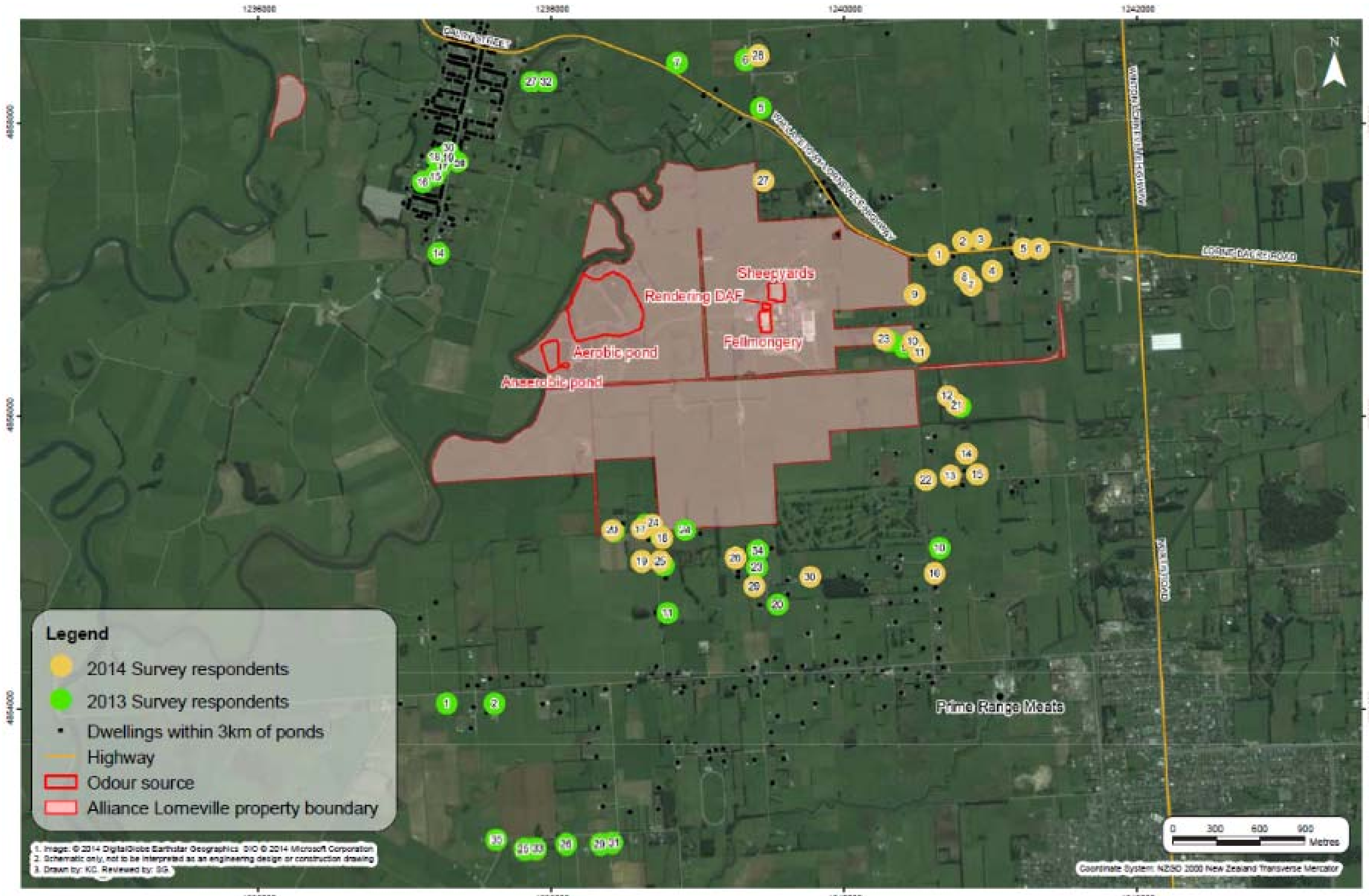

Figure 3: Locations of 2013 and 2014 survey respondents.

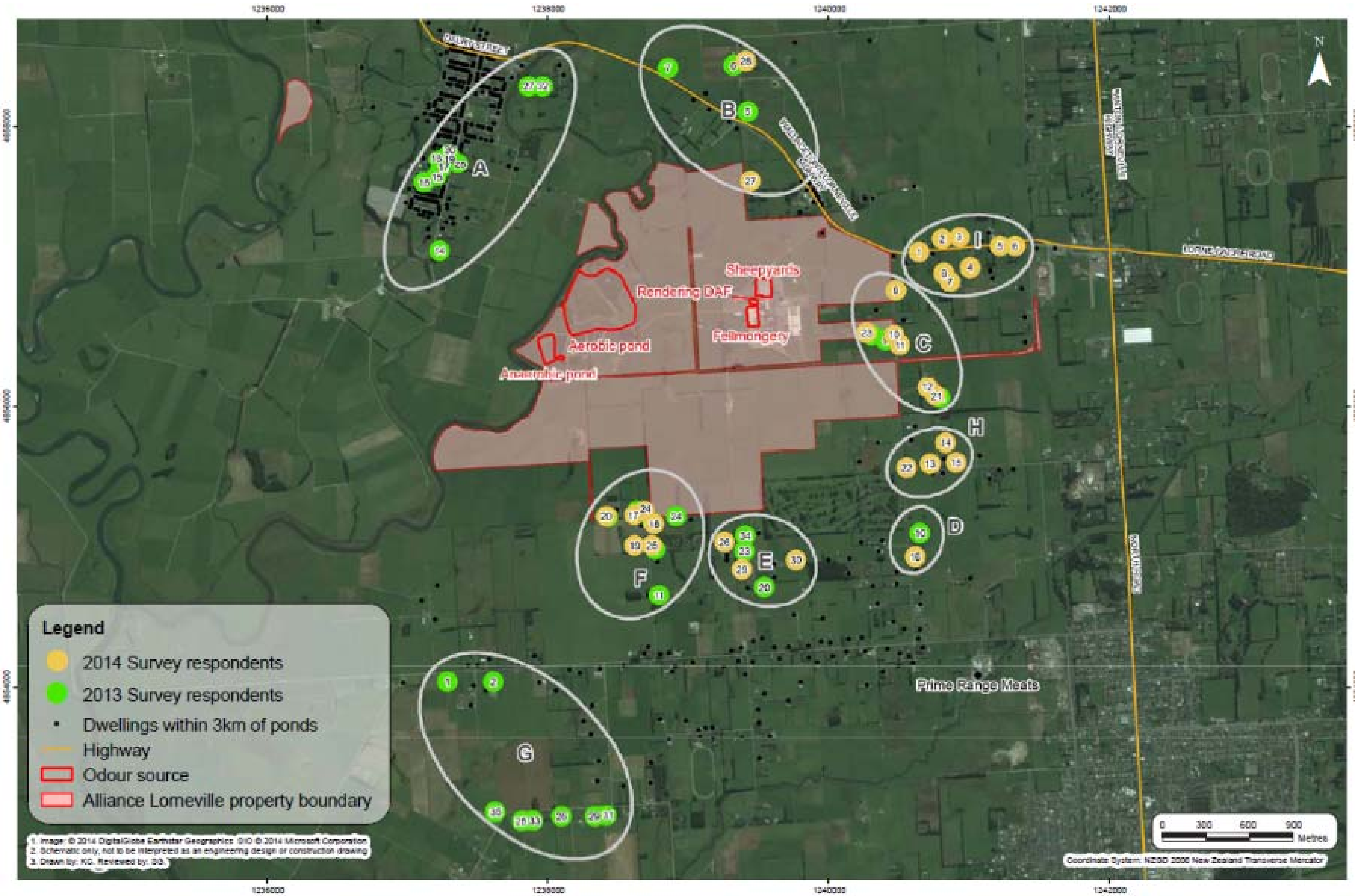

Figure 4: Odour survey groupings.

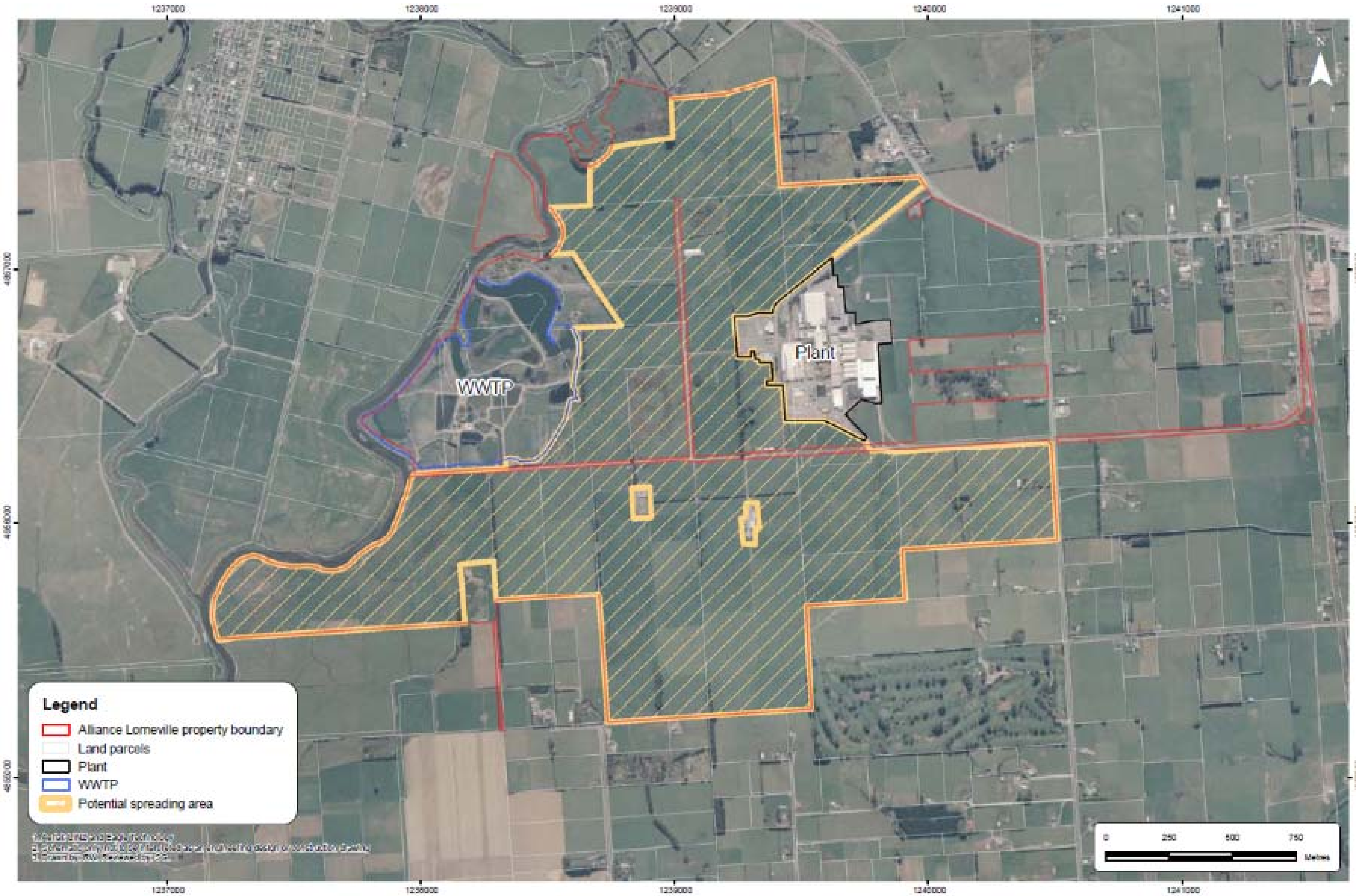

Figure 5(a): Alliance owned land potentially available for biosolids spreading.

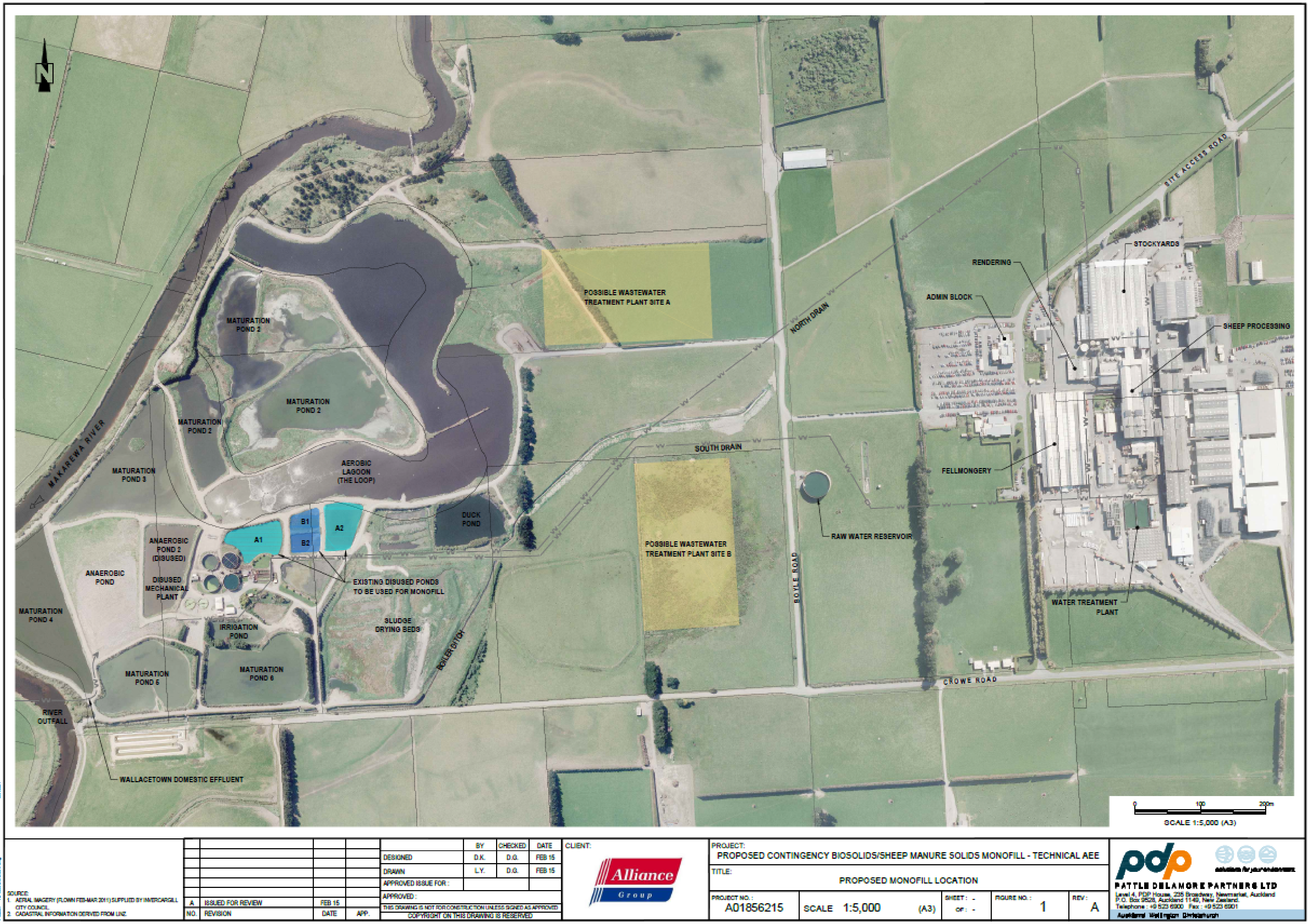

Figure 5(b): Proposed monofill location.

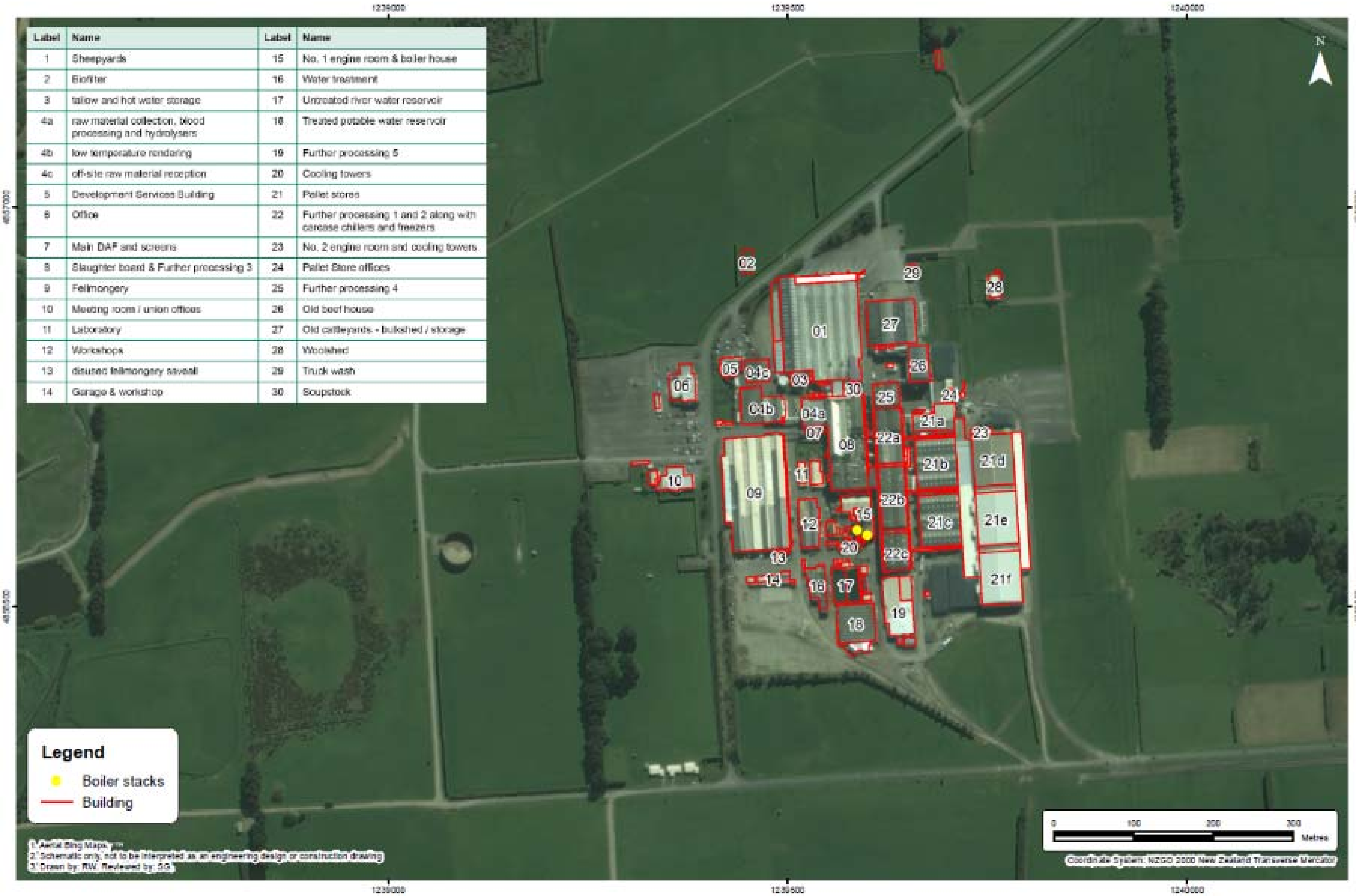
Label	Name	Label	Name
1	Sheepyards	15	No. 1 engine room & boiler house
2	Biofilter	16	Water treatment
3	tallow and hot water storage	17	Untreated river water reservoir
4a	raw material collection, blood processing and hydrolysers	18	Treated potable water reservoir
4b	low temperature rendering	19	Further processing 5
4c	off-site raw material reception	20	Cooling towers
5	Development Services Building	21	Pallet stores
6	Office	22	Further processing 1 and 2 along with carcase chillers and freezers
7	Main DAF and screens	23	No. 2 engine room and cooling towers
8	Slaughter board & Further processing 3	24	Pallet Store offices
9	Fellmongery	25	Further processing 4
10	Meeting room / union offices	26	Old beef house
11	Laboratory	27	Old cattleyards - bulkshed / storage
12	Workshops	28	Woolshed
13	disused fellmongery saveall	29	Truck wash
14	Garage & workshop	30	Soupstock

Figure 1 in Attachment G to the AEE / Figure 2 in Attachment M to the AEE (as referenced in the evidence): Processing site layout.

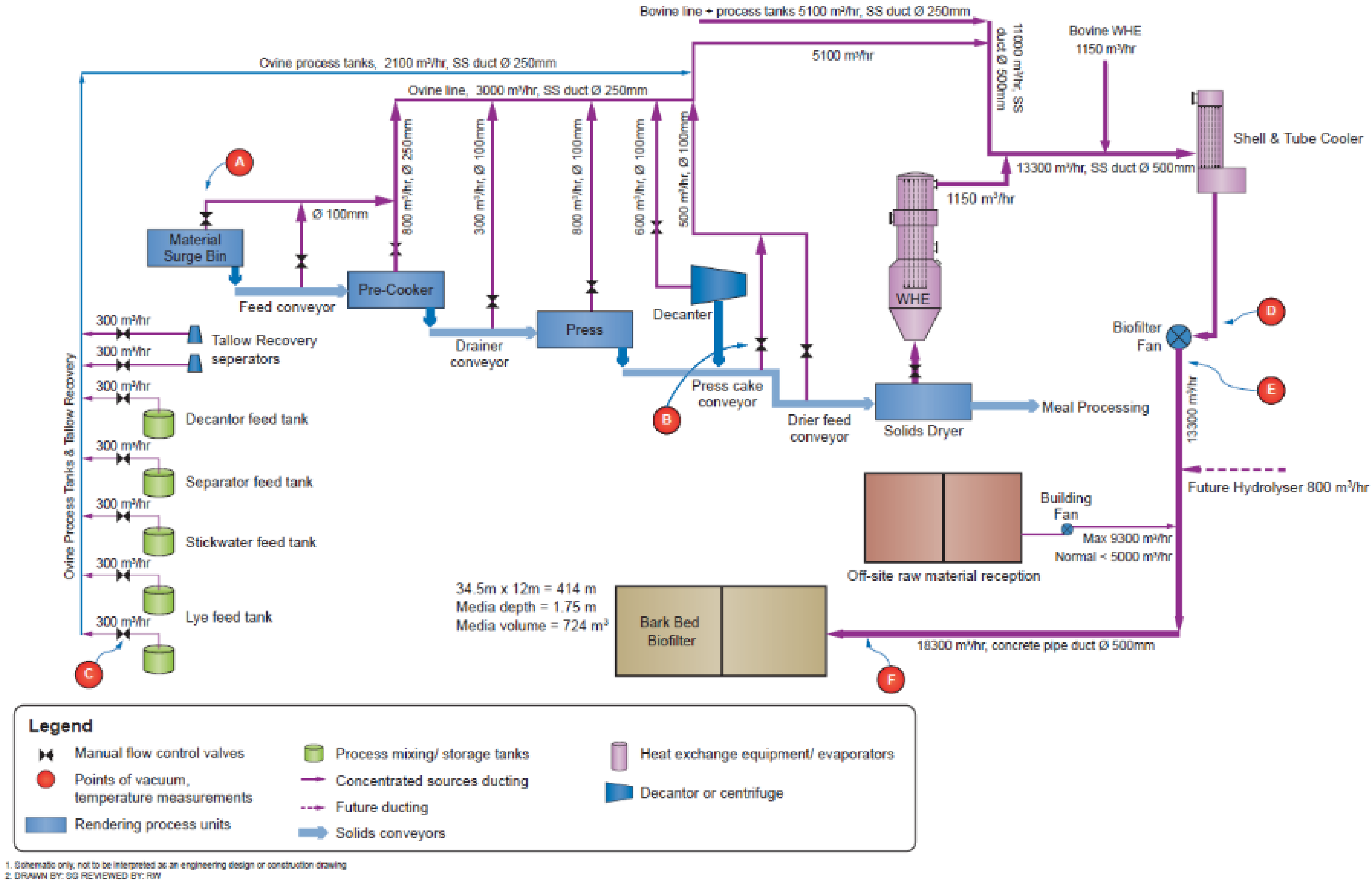

Figure 4 in Attachment G to the AEE (as referenced in the evidence): Rendering plant odour control system.

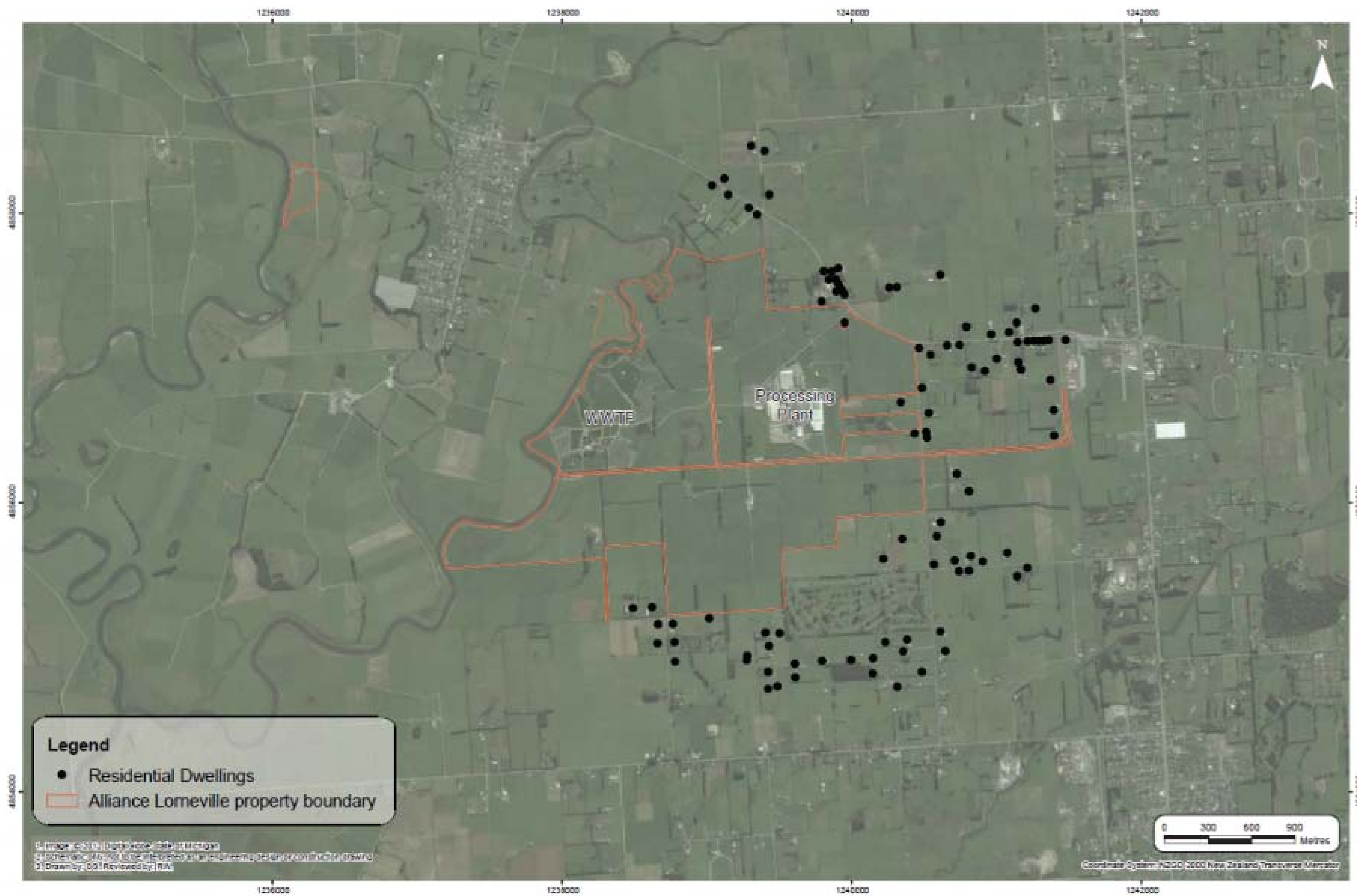

Figure 1 in Attachment R to the AEE (as referenced in the evidence): Aerial map of site and surrounding areas.

Figure 2 in Attachment R to the AEE (as referenced in the evidence): Wastewater Treatment Plant.

Figure 4 in Attachment E to the AEE (as referenced in the evidence): Background air quality monitoring sites for 2013 and 2014 programmes.

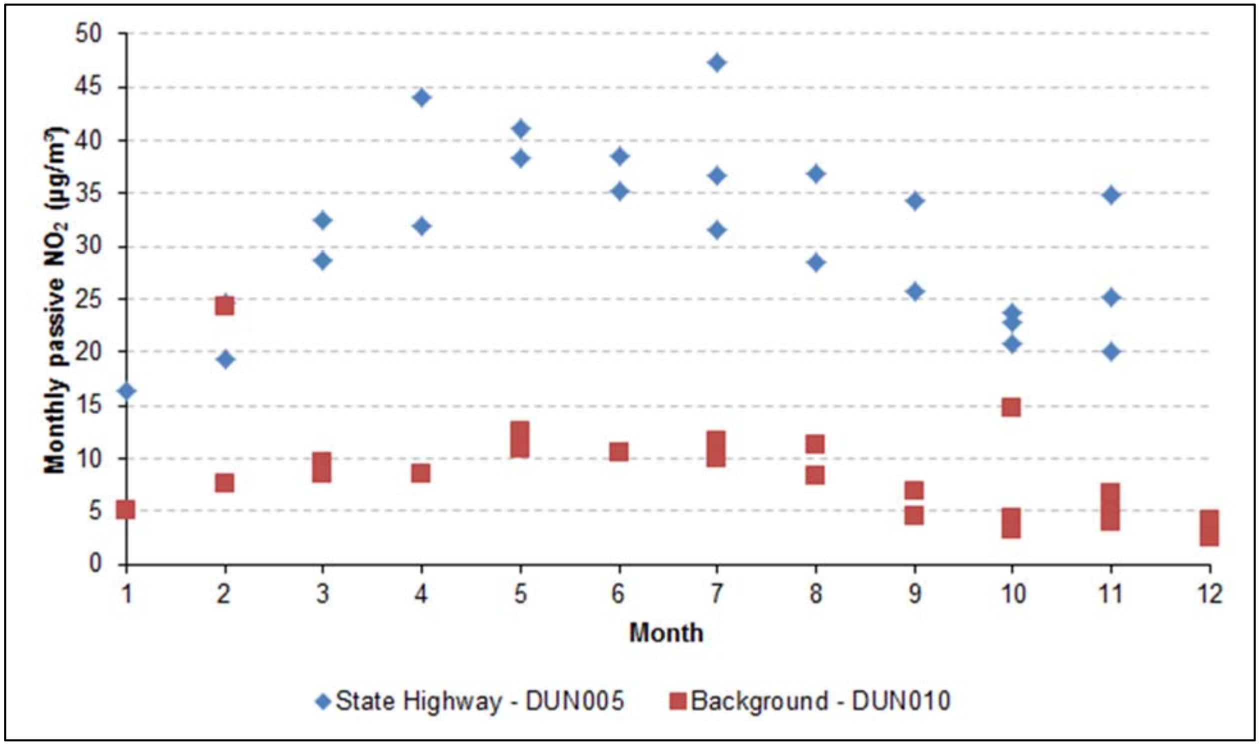

Figure 12 in Attachment E to the AEE (as referenced in the evidence): Annual pattern in monthly passive NO2 concentrations for the Invercargill stations.

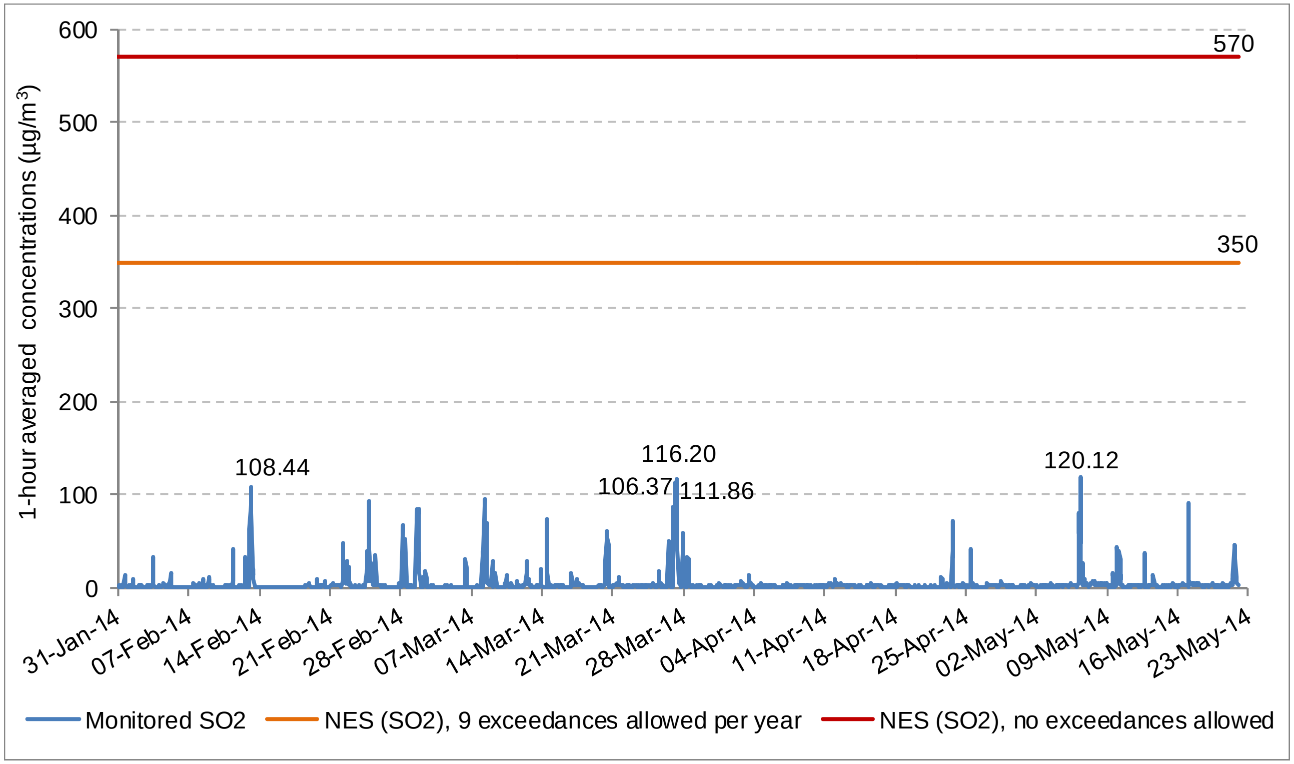

Figure 2 in Appendix H of Attachment M to the AEE (part of "*time series figures for SO_2*" as referenced in the evidence): 1-hour averaged SO_2 concentrations monitored from 31/01/2014 to 21/05/2014.

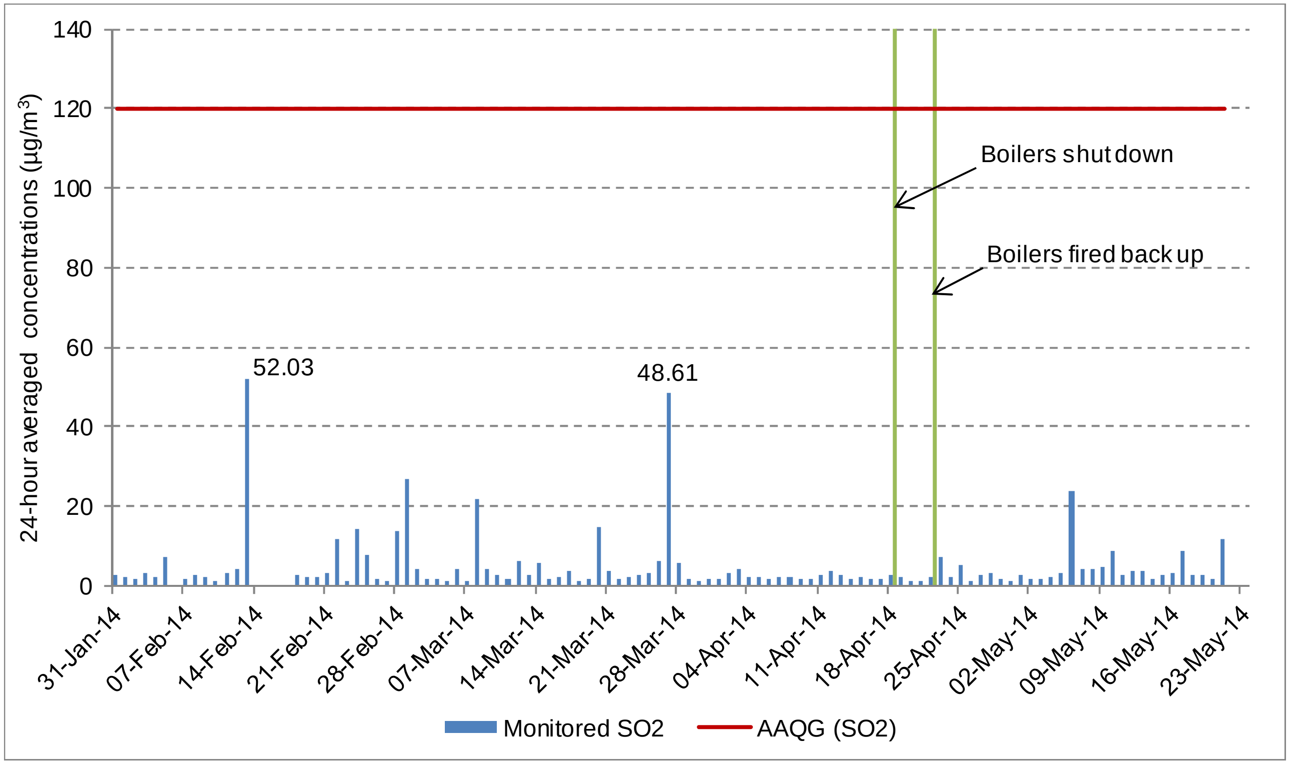

Figure 3 in Appendix H of Attachment M to the AEE (part of "*time series figures for SO_2*" as referenced in the evidence): 24-hour averaged SO_2 concentrations monitored from 31/01/2014 to 21/05/2014.

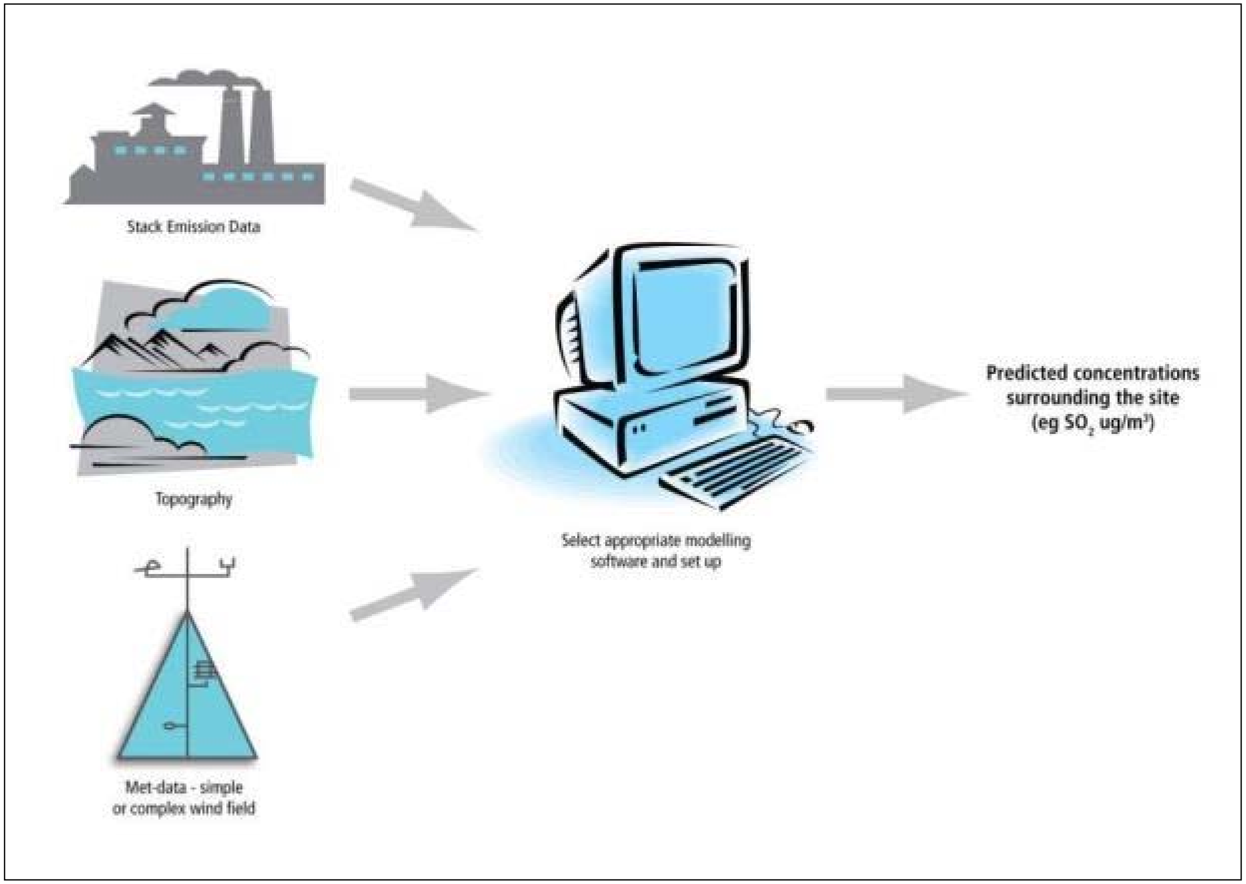

Figure 5 in Attachment M to the AEE (as referenced in the evidence): Schematic of dispersion modelling process.

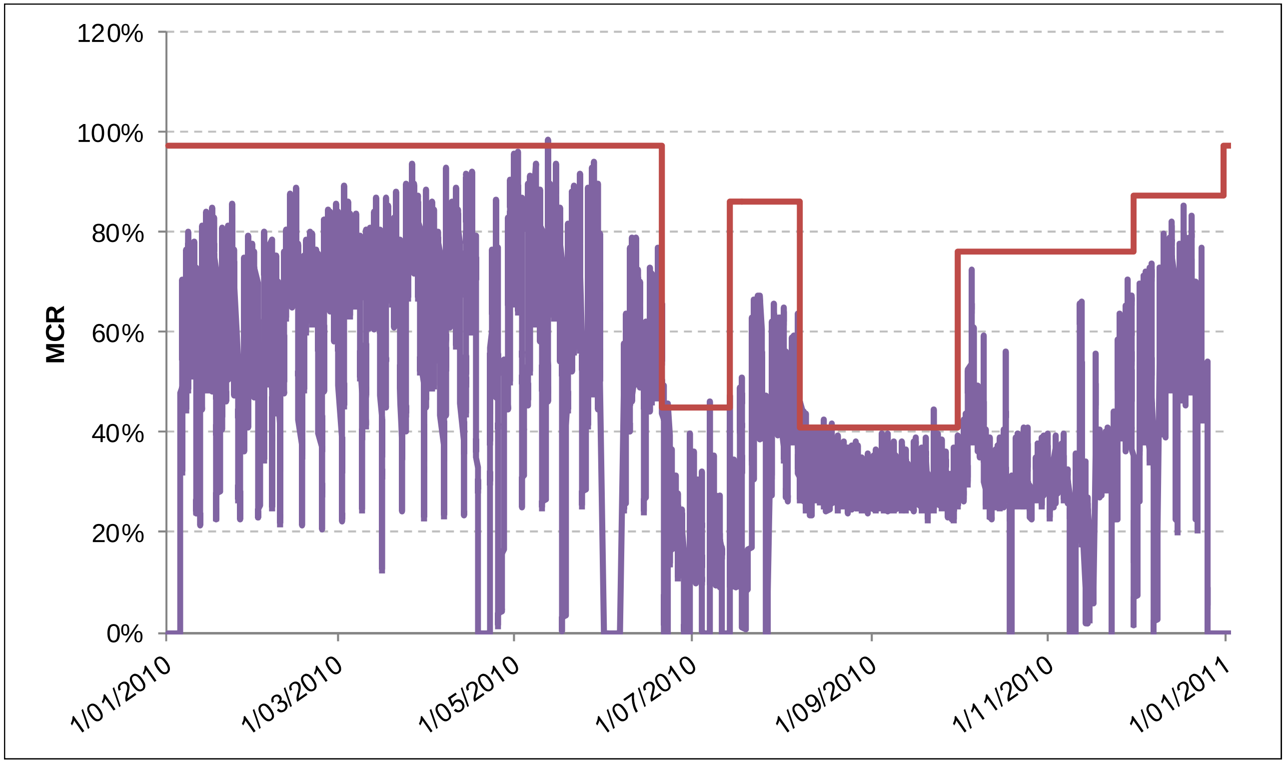

Figure 6 in Attachment M to the AEE (as referenced in the evidence): Modelled envelope operations profile (redline) for combined boilers in comparison to the combined hourly varying operations profile.

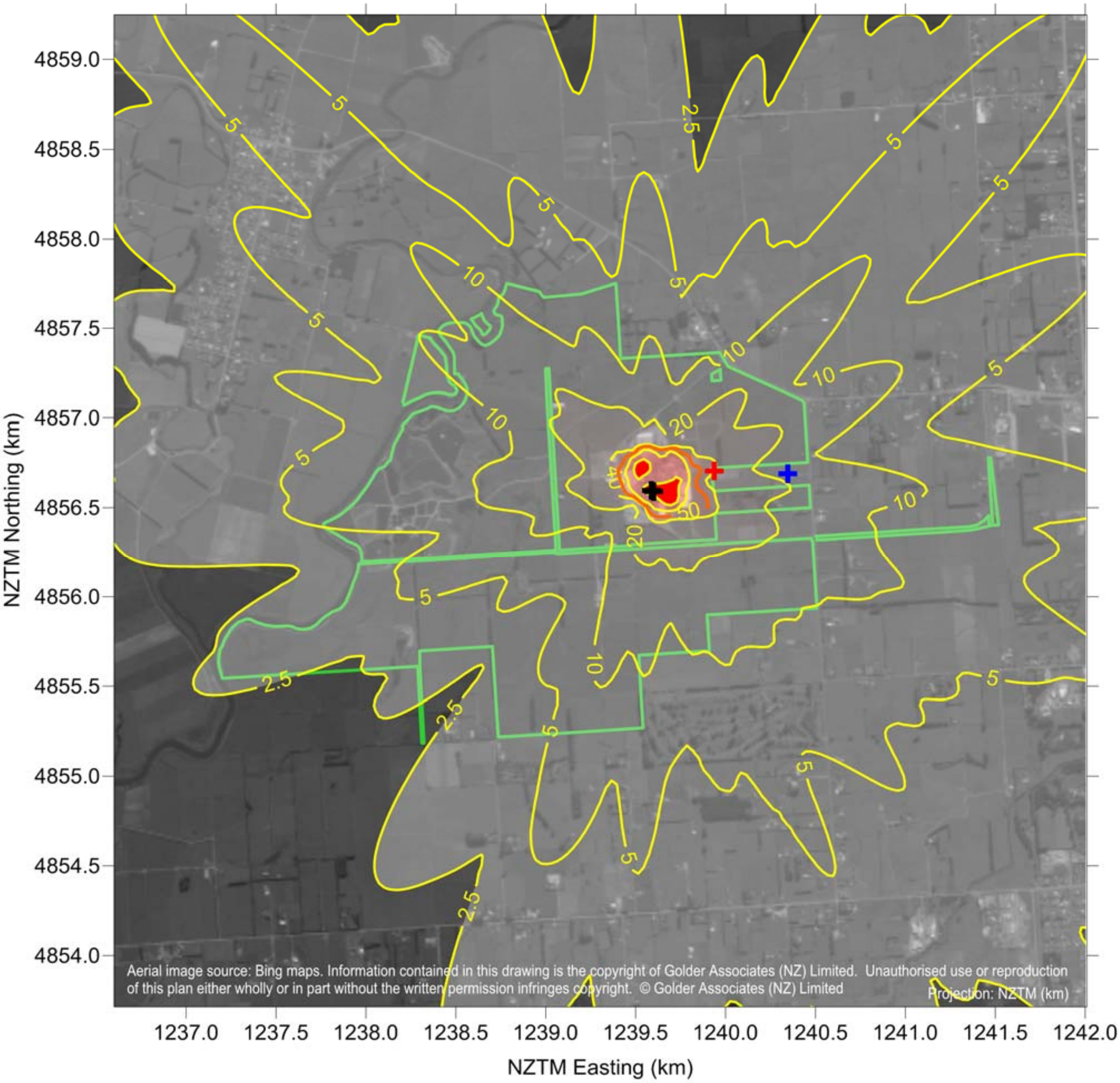

Figure 7 in Attachment M to the AEE (as referenced in the evidence): Predicted maximum 24-hour average PM_{10} ground level concentrations (µg/m^3) based on the hourly varying emissions but excluding background concentrations. The assessment criterion (50 µg/m^3) is indicated by the orange contour.

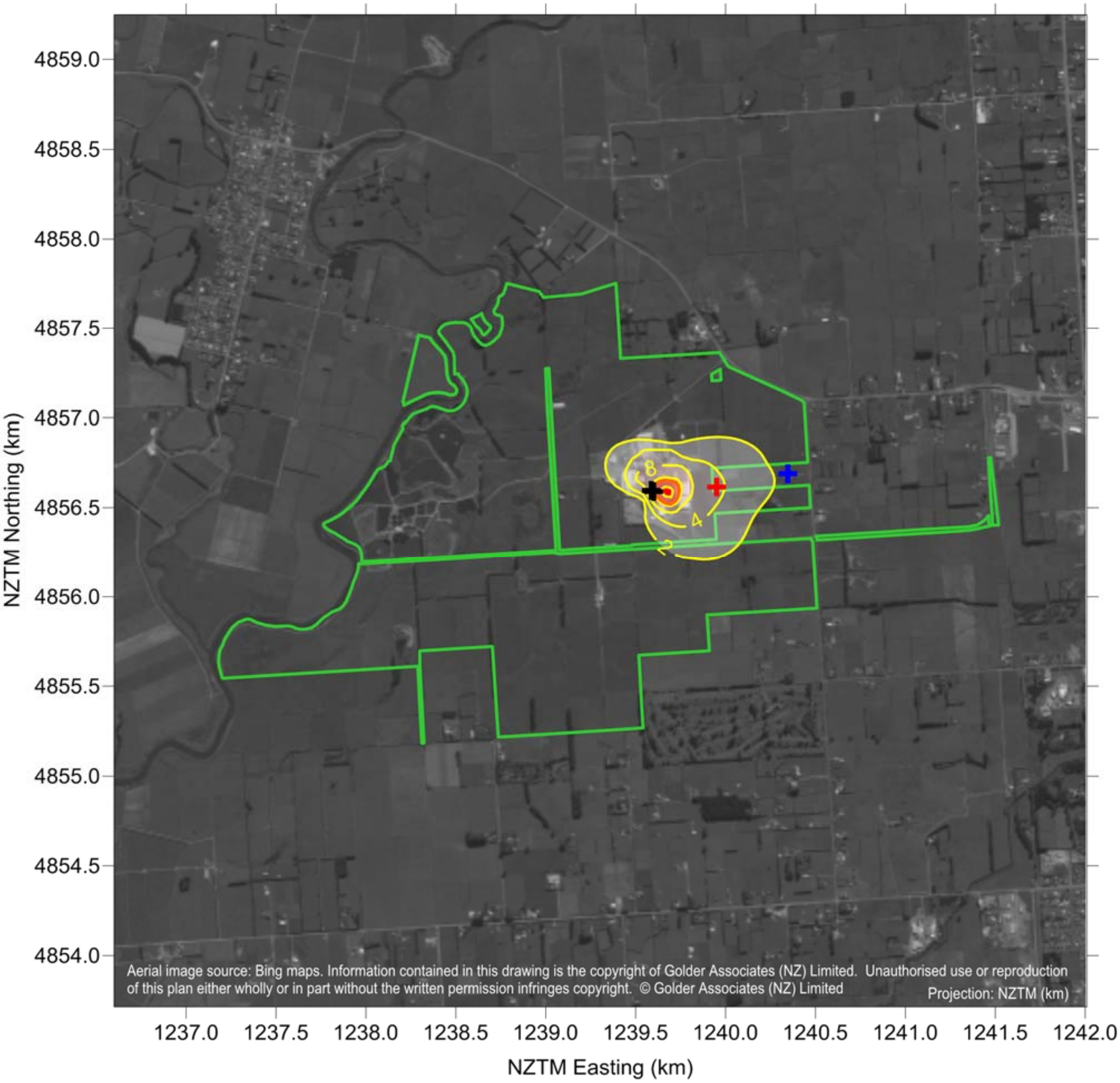

Figure 8 in Attachment M to the AEE (as referenced in the evidence): Predicted annual average PM_{10} ground level concentrations (µg/m^3) based on the hourly varying emissions but excluding background concentrations. The assessment criterion (20 µg/m^3) is indicated by the orange contour.