Air Quality Issues

Proposed Malting Facility & Packing Plant, MINTO NSW

RESPONSE TO LIPA PHARMACEUTICALS OBJECTIONS

February 2009

Prepared for
Cardno Pty Ltd

by

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1. INTRODUCTION

This report has been prepared by PAEHolmes on behalf of Cardno Pty Ltd who in turn are acting for Joe White Maltings Pty Ltd (JWM) and ABB Grain Limited. It presents a response to the objections provided by Lipa Pharmaceuticals Limited of 21 Reaghs Farm Road, Minto to the proposed development of a malting plant in the neighbouring lot at Stonny Batter Road, Minto.

The report comprises the following components:

- Review of issues raised in the objection
- Estimate of odour emissions from the plant
- Dispersion modelling results
- Estimate of odour "taint" in Lipa products

Following the submission of the Lipa objection representatives from Holmes Air Sciences and Cardno visited the Lipa property to obtain a greater understanding of the companies concerns and the processes carried out at the property. This meeting took place in the Lipa boardroom on the 9 February 2009 and Lipa did not permit a tour of their property.

2. REVIEW OF ISSUES RAISED BY LIPA

Joe White Maltings Pty Ltd (JWM) propose to establish a malt processing plant and export grain packing facility to be located at Stonny Batter Road, Minto.

The site location is shown in **Figure 1.**

The layout of the proposed JWM plant is shown in **Figure 2**.

The plant would convert barley into malt through a kilning process. In addition the grain packing facility would receive and pack wheat, oats, barley and a variety of other grain/pulse commodities for overseas dispatch. The annual capacity of the malt plant would be 110,000 tonnes.

The initial air quality assessment was conducted by Holmes Air Sciences, 9th October 2008 (**Holmes Air Sciences, 2008**). Objections to the development of this plant have been raised by Lipa Pharmaceuticals Limited who operate a plant in the neighbouring lot to the south.

Reports were prepared in support of this objection by Mr Alex Jochelson of Pollution Control Consultancy and Design (**PCCD, 2008**) and Dr Richard Oppenheim, Principal of Dr Richard C Oppenheim (**Oppenheim, 2008**). They relate to potential air quality impacts of the proposed plant on the Lipa product.

Report by Alex Jochelson

The report prepared by Mr Jochelson addresses the need for an odour assessment and the assessment of the impacts of nitrogen oxides.

A detailed odour assessment according to the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South (**DECC, 2005**)* was not initially prepared as this was not one of the specific Director-General's requirements. Furthermore DECC did not specify a quantitative assessment.

While it is the case that the JWM plant does have odour emissions, they are not of an inherently objectionable nature. According to Mr Jochelson's report, Lipa staff work three 8-hour shifts therefore there would be no possibility of anyone at the Lipa plant being exposed 24-hours a day to odour from the JWM plant.

Modelling of oxides of nitrogen was originally carried out for both a 50 metre and 20 metre grid spacing. Building wakes were included in the modelling. An output file is attached with the details. The maximum predicted concentration of total NO_x was slightly less than 300 $\mu g/m^3$ for both grid spacings.

We have also carried out modelling runs with 10 metre spacing as suggested by Mr Jochelson and the maximum concentration is 310 $\mu g/m^3$. Model runs were also carried out for heights above ground level of 3 and 6 metres and the maximum predicted concentrations were 301 and 310 $\mu g/m^3$ respectively. Therefore the maximum predicted concentrations of NO_x at the Lipa site were captured in the original modelling.

The impacts of JWM NO_x emissions are very localised and would not have any substantial regional effects. Background levels will be variable but the most significant contributor to NO_x in Sydney is roadway traffic rather than industrial sources and there is no reason to believe that local levels would be substantially different from other DECC monitoring sites in Sydney. The DECC Campbelltown site was in fact operated by Pilkington, the major point source in the area referred to by Mr Jochelson and is therefore likely to capture the impacts of this source.

Mr Jochelson is correct in assuming that the exit velocity in our October 2008 assessment is not correct. The modelled exit velocity was 26.9 m/s and the exhaust air temperature was 27^o C. There were typographic errors in Table 8 of our report.

Report by Dr Richard Oppenheim

The report by Dr Oppenheim discusses the potential for contamination of Lipa products with odorous material in JWM plant emissions. The report provides detailed information about the senses of taste and smell and the potential consequences of odour from JWM emissions being adsorbed or absorbed by any of the material used in the production of the therapeutic goods. The filtration systems on the building are designed to control particulate matter and microorganisms, but not odour or ultrafine particles.

As Dr Oppenheim noted, contamination is theoretically possible but the extent of the contamination (if any) and its consequences in terms of acceptability for Lipa product users, is very difficult to quantify at this stage.

The Lipa plant is in an industrial location with other emission sources, such as the nearby Australian Specialty Inks plant immediately to the east, and next to a railway which carries diesel-powered goods trains. The existing Lipa plant is therefore potentially affected by existing odour sources. Discussions with Lipa indicate they do not take any special precautions to control existing odour emissions. As such, it is anticipated they do not receive any complaints in relation to odour impact on their product.

Nevertheless an odour assessment has been undertaken based on emissions from the operational JWM plant in Perth. As the proposed Minto malting plant is based on the Perth plant this provides a sound

source of information. The focus of the assessment is the potential for odorous air to enter the Lipa building and thereafter taint the Lipa products.

3. EMISSION ESTIMATION

The odour emission rates used in this study were obtained for this purpose from testing conducted at the JWM plant in Perth. Odour measurements were undertaken by The Odour Unit and results are included in the **Appendix A**. The intensity of the odour was also determined using the German Standard VDI3882 Intensity Scale.

Four main sources of odour emissions were identified at the facility as follows:

- The kiln, used to produce hot air for drying the malt, a closed system that circulates hot air which is opened periodically to the atmosphere to exchange air;
- The germination vessels which are four large vats that keep the malt moist for the malting process to take place;
- The steep, an initial process for wetting the malt prior to entering the germination vessels; and
- The wastewater treatment system.

Table 1 below summaries the emission assumption used in the modelling. For the purposes of this assessment the malting process wastewater treatment plant was excluded as it considered that odour from this source would need to be controlled sot that there was no off-site impact.

One of the measurements from the germination vessel was excluded as it was considered that this was an outlier and not representative of normal emission conditions.

Table 1 : Odour emission estimation for JWM plant Minto

Source	Stack height (m)	Temperature (degrees)	Exit velocity (m/s)	Diameter (m)	ou.m^3/s
Kiln Stack	16.92	50	3.61	11.1	1015582
Germ 1	7.98	20.3	3.25	5.36	16923
Germ 2	7.98	21.9	4.28	5.36	23913
Germ 3	7.98	23	2.69	5.36	22013
Germ 4	7.98	22.3	3.64	5.36	18321
Steep (6 vessels)	13	17	12.7	0.257	7393

4. DISPERSION MODELLING

Potential impacts of the proposed facility on the Lipa plant have been assessed using AUSPLUME Version 6. AUSPLUME is an advanced Gaussian dispersion model developed on behalf of the Victorian EPA (**VEPA, 1986**). It is widely used throughout Australia and is regarded as a "state-of-the-art" model. AUSPLUME has been used extensively for assessing odour impacts and it is the model specified by the NSW DECC in the publication on approved methods for air quality assessments (**NSW DEC, 2005**).

The meteorological data used was as described in the Holmes Air Sciences (**Holmes Air Sciences, 2008**) report.

Model runs were undertaken with the different odour source types modelled separately and combined.

5. APPROACH TO ESTIMATION OF ODOUR IN LIPA PRODUCTS

The following conservative approach has been adopted to provide an estimate of the potential for odour (taint) in Lipa's products. This approach cannot be regarded as rigorous as it does not take into account manufacturing processes undertaken at the Lipa property that impact on odour adsorption and absorption by the range of materials used in the plant. Rather we are assessing the potential impact from the proposed JWM plant as an educated estimate of the upper limit of the potential contamination of the product by odour in JMW emissions.

As noted by Dr Oppenheim and confirmed in discussions with Lipa management and staff during an on-site meeting held on 9 February 2009, Lipa manufacture a wide range of goods and there are a large range of materials including soft capsules, tablets, hard shell capsules, liquids and creams which could act as substrates for the absorption/adsorption of odorous compounds.

The approach adopted has been to estimate odour concentrations based on dispersion modelling at the air intake points of the Lipa building. From the information provided by Lipa on 13 February with respect to the height of the building and ventilation design within the building some sensitivity testing has been undertaken to determine odour levels at a series of heights above ground level ranging from 3 – 12 metres. From a visual inspection it is likely that the roof of the Lipa building and hence the air intake points would be between9 and 12 metres above ground level.

The approach is not a conventional odour assessment where air quality criteria for odour and peak-to-mean factors are incorporated into the model. As noted above, in this instance, the assessment is attempting to estimate the amount of odorous materials in the JWM air emissions than could be absorbed/adsorbed by material used within the Lipa building over an 8-hour period.

Maximum predicted 8-hour, 24-hour and annual average odour concentrations at the various inlet points are summarised in **Table 2.** Contour plots of ground level odour for the different source types and different averaging times are shown in **Figure 4** to **Figure 11**.

The assumed locations of these air-intake points were as provided by Lipa and are shown in **Figure 3**. As the height of the building has been stated at 9.3m, concentrations at these receptors were modelled for 3, 6, 9, and 12 metres above ground level. This range of heights forms an acceptable assessment approach because the predictions were found to be not very sensitive to height above ground level.

Table 2 : Predicted odour concentration (ou) at air intake points on the Lipa building

Air intake point ID as noted on figure	X coordinate (m)	Y coordinate (m)	Height above ground level (m)	Maximum 8-hour average odour	Maximum 24-hour average odour	Annual average odour
1	300623	6231627	3	9.03	4.18	0.63
2	300557	6231629	3	9.19	5.20	0.96
3	300622	6231567	3	7.30	3.25	0.37
4	300534	6231575	3	9.46	3.51	0.64
5	300599	6231517	3	7.03	2.96	0.31
6	300553	6231515	3	7.61	3.49	0.41
1	300623	6231627	6	9.11	4.29	0.66
2	300557	6231629	6	9.62	5.27	1.00
3	300622	6231567	6	7.38	3.28	0.37
4	300534	6231575	6	10.24	3.79	0.65
5	300599	6231517	6	7.15	3.00	0.31
6	300553	6231515	6	8.01	3.61	0.41
1	300623	6231627	9	9.23	4.44	0.71
2	300557	6231629	9	10.20	5.49	1.06
3	300622	6231567	9	7.50	3.33	0.38
4	300534	6231575	9	11.36	4.19	0.68
5	300599	6231517	9	7.34	3.06	0.32
6	300553	6231515	9	8.50	3.77	0.42
1	300623	6231627	12	9.57	4.63	0.78
2	300557	6231629	12	12.00	5.97	1.13
3	300622	6231567	12	7.65	3.39	0.40
4	300534	6231575	12	12.62	4.64	0.71
5	300599	6231517	12	7.61	3.16	0.33
6	300553	6231515	12	8.87	3.91	0.43

1. Training Room and Retention Store
2. Raw Material Warehouse
3. Canteen and Reception
4. Warehouse, Office and Sample booth
5. Office extension and Microlabs
6. Softgel fresh

JWM provided information on the range of chemicals that could be present in the odour from the malting process (see **Appendix B**).

An 8-hour material exposure period has been selected as representative of a typical work shift. Note that the values in **Table 2** are the maximum 8-hour values over a year. Across the plant roof they average at 9 - 11 odour units. On an annual average basis, they range from 0.3 to 1 odour unit.

It has been assumed that air at a concentration of 10 odour units is taken into the building and exchanged twenty times an hour in a room in which material is being prepared. It has also been assumed that this air is able to effectively flow through a liquid substrate (assumed to be water) and that all odour in the air is absorbed by the liquid over an 8-hour period with twenty air changes per hour. Therefore for every litre of odorous air flowing into the building, it is assumed that a litre of liquid absorbs 160 times (20 x 8) the mass of the odorant in that litre of air.

This of course would not happen in practice as the exposed liquid surface would be quite small and absorption and adsorption would be limited. No account has been taken of the solubility in water or partition coefficient of the compound. This approach is therefore very conservative as it is likely to be a significant overestimation of the amount of odorous compounds retained by material used in preparation of the products.

In order to quantify the odour absorption it is necessary to have information on odour thresholds of individual compounds and to convert the odour units estimated in the intake air to concentrations in mg/m^3. Once the compounds have been adsorbed in the water it is necessary to convert those concentrations in ppb back to detectable odour in the air above the liquid.

Compounds have been assessed where there are available data on the odour threshold in ambient air and odour threshold in the air above the liquid in which the compound is dissolved based on the concentration of the specific compound in the liquid.

The estimated concentration of a particular compound in the odorous air is based on reported odour thresholds for that compound. Various sources of data are referenced in the table below. The concentration of odorants "captured" by the liquid is then compared with the odour detection threshold reported for compounds dissolved in water. The odour threshold in the air above the water refers to the concentration of the compound in the water in ppb (www.leffingwell.com). The method (**Buttery et al, 1971**) (**Guadagni et al, 1963**)requires the substance to be dissolved in water which is used to half fill a polyethylene bottled fitted with a tube that can be inserted just inside the nostril. The panel member squeezes the bottle to push the air above the water into the nose. The odour detection threshold is reported as the concentration of the substance in water when 10% of the panel can detect the presence of chemical relative to controls of pure water.

Seven representative compounds from the list provided by JWM and reproduced in **Appendix B** were assessed.

Table 3 : Estimate concentrations of odorous compounds in Lipa product

Compound	Odour threshold in air (mg/m^3)	Concentration at 10 odour units (mg/m^3)	Estimated concentration in water after 8 hours and 20 air changes(ppb)	Odour threshold in air above water (ppb)
Acetaldehyde [a]	0.12	1.2	192	12
Trans-2-hexenal[b]	0.0744	0.744	119.	17
Furfural[a]	2.72	27.2	4352	3000
Dimethyl sulfide[-c]	0.0267	0.267	43	0.3
Butylamine[a]	0.26	2.6	416	50000
Pyridine[a]	0.054	0.54	86	2000
Vanillin[d]	0.002	0.02	3	20
Log average concentration			**125**	**120**

a. AIHA 1989
b. Ullrich and Grosch 1988
c. Ruth 1986
d. Calkin and Jellinek 1994

For some compounds the predicted concentration in the water is higher than the odour threshold and for some it is lower. Given the large range in odour thresholds, the log average of the estimated concentrations has been compared with the log average of the odour threshold for the compounds. The values are very similar. This means that the combined concentrations of the odorants is just at the odour threshold.

This indicates that with very conservative assumptions, the odour from "taint" due to JWM products would be barely perceptible in the Lipa products.

Without any specific manufacturing information from Lipa about their operation it is not possible to be more rigorous. However the approach adopted has been to estimate an upper limit of the degree of potential contamination.

6. CONCLUSIONS

This report has addressed air quality issues raised my Mr Alex Jochelson and Dr Robert Oppenheim in support of an objection raised by Lipa Pharmaceuticals to the proposed JWM plant.

The issue of potential NO_2 impacts raised by Mr Jochelson has been addressed by additional modelling which demonstrates that there is unlikely to be any impact.

The issue of potential taint in Lipa's product is more difficult to address and at this stage Lipa have not provided any specific information on plant operation. Nevertheless it is recognised that Lipa have concerns about potential customer complaints and noted in the on-site meeting that some customers are very particular about product odour.

A conservative approach has been adopted which provides a likely upper estimate of product contamination. This upper estimate indicates that there is unlikely to be any perceptible effect on Lipa products at the odour concentrations likely to occur due to JWM operations. The nature of the odour is also relevant, as it has a "food" quality rather than a "synthetic" chemical quality. It is therefore less likely to be identified as a taint in the product.

7. REFERENCES

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"Odor thresholds for Chenicals with Established Occupational Health Standards"prepared by American Industrial Hygiene Association, 475 Wolf leges parkway Akron, OH 44311-1087 1989.

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"Perfumery: Practice and Principles" John Wiley & Sons, Inc.

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

Guadagni GG, Buttery RG and Okano S (1963)

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"Odour thresholds and irritation levels of several chemical substances: A review" Am. Ind. Hyg. Assoc. J. 47 A142-A151.

Ullrich F & Grosch W (1988)

"Flavour deterioration of soy-bean oil: Identification of intense odour compounds formed during flavour reversion" Fat Science Technology 90 932-6, 1988.

VEPA (1986)
"The Ausplume Gaussian Plume Dispersion Model", Environment Protection Authority, Olderfleet Buildings, 477 Collins Street, Melbourne Victoria 3000, Publication Number 264.

FIGURES

Figure 1: Site location

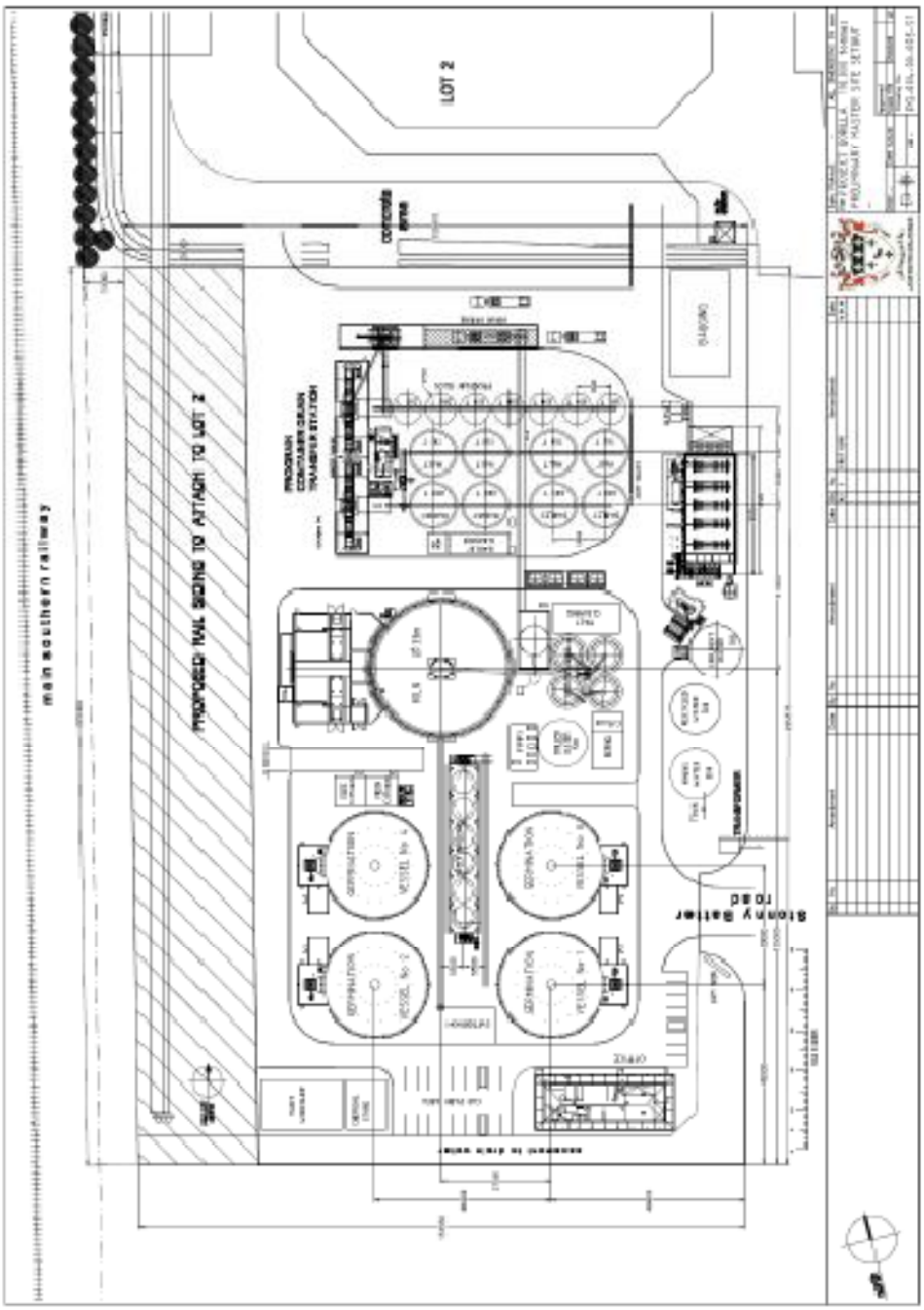

Figure 2 Site layout

Figure 3: Air-intake points at Lipa Pharmaceuticals

Figure 4: Maximum 8 hour average of all sources (ou)

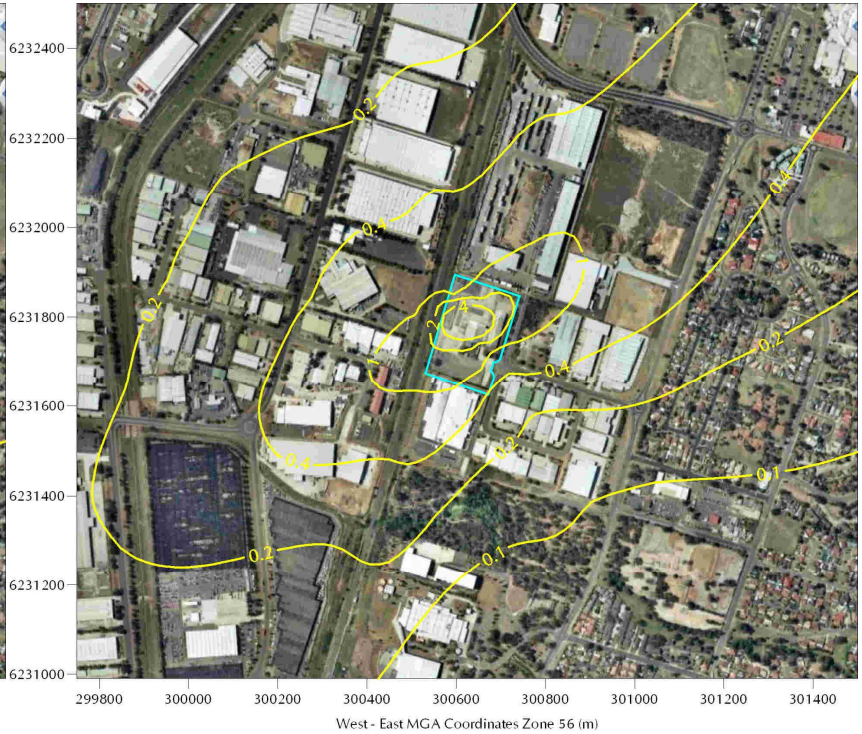

Figure 5: Maximum concentration over all hours (ou)

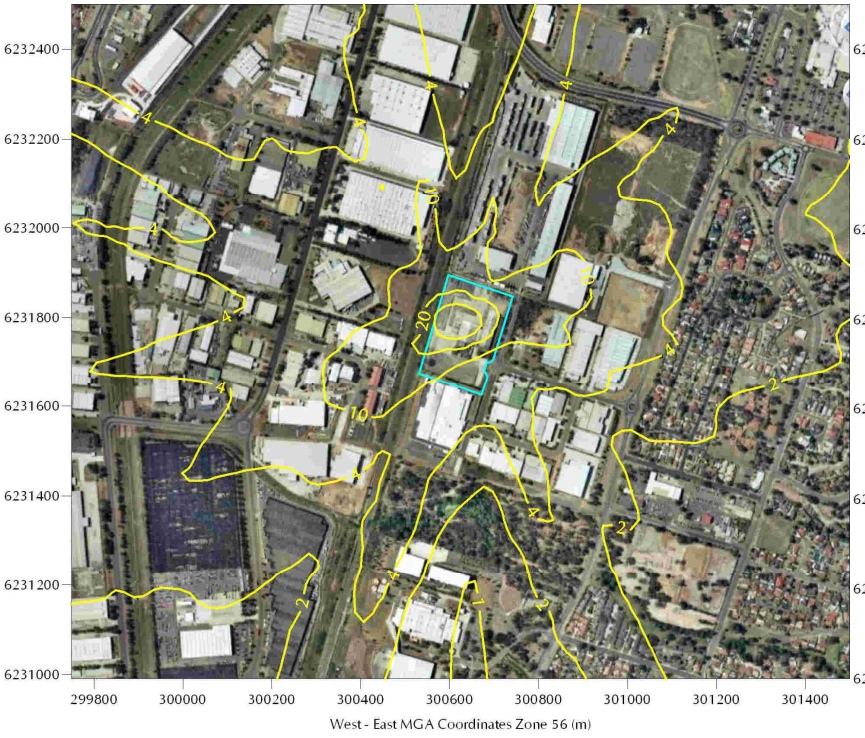

Figure 6: Maximum 8 hour average of Kiln source only (ou) source only (ou)

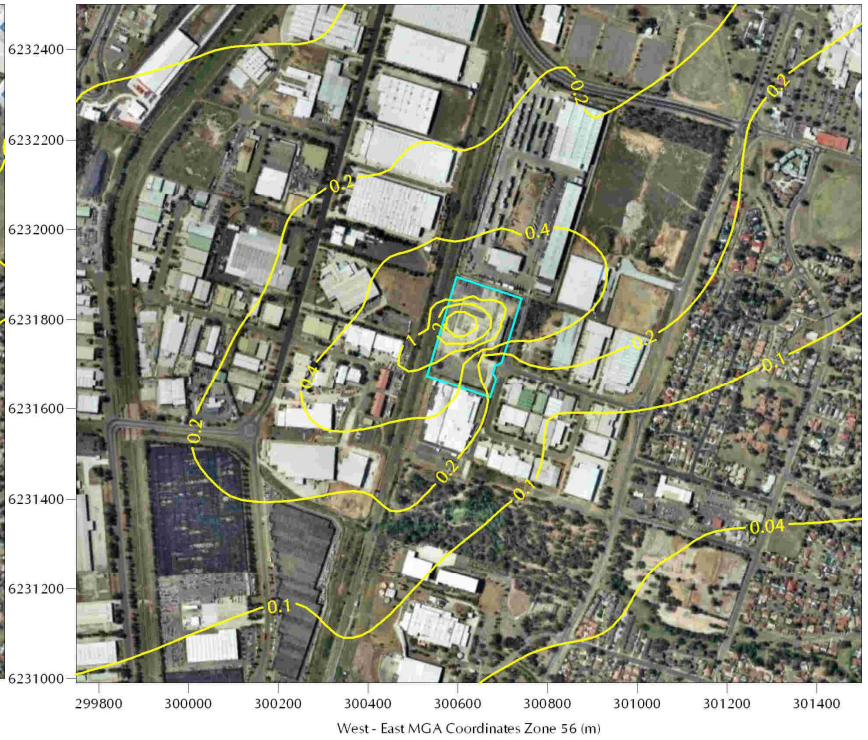

Figure 7: Maximum concentration over all hours for Kiln

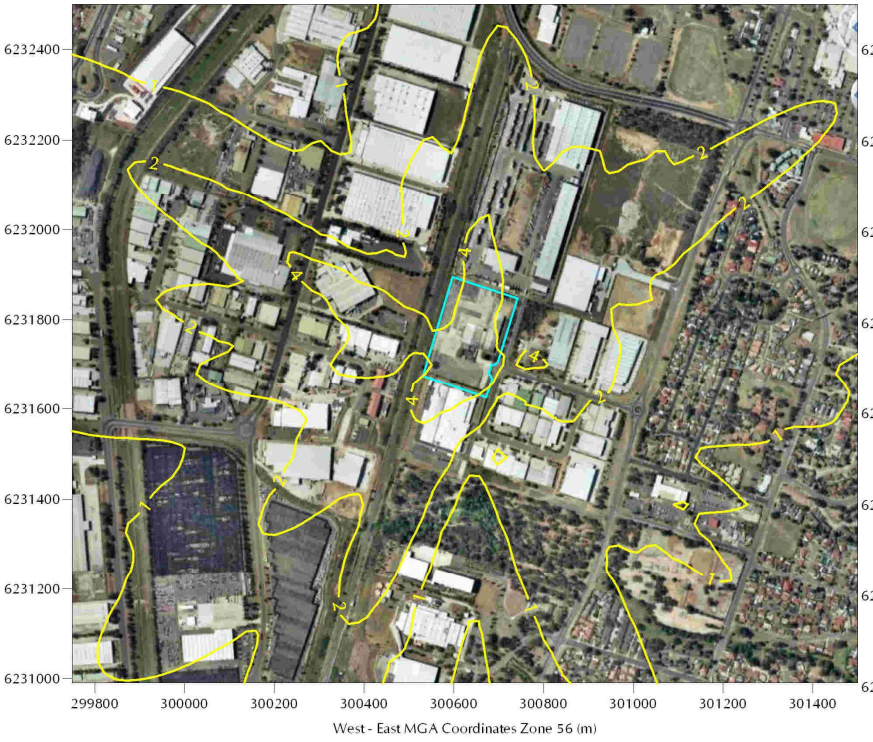

Figure 8: Maximum 8 hour average of Germination vessels only (ou) Germination vessels only (ou)

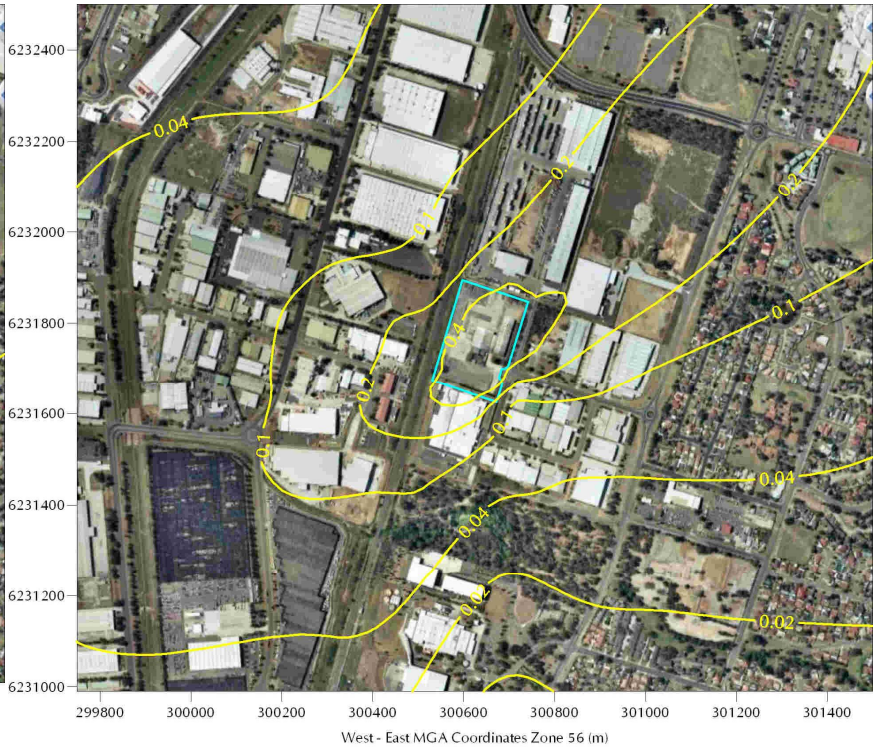

Figure 9: Maximum concentration over all hours for

Figure 10: Maximum 8 hour average of Steep building (ou) only (ou)

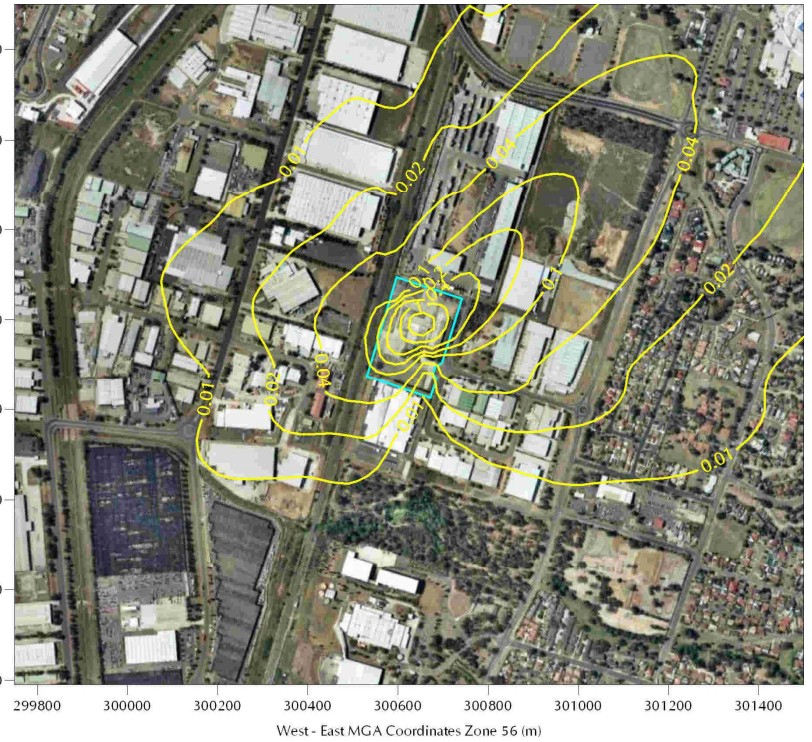

Figure 11: Maximum concentration over all hours for Steep building

APPENDIX A: Odour Unit testing results

THE ODOUR UNIT (WA) PTY LTD

THE ODOUR UNIT

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NATA

Accreditation Number: 14974

Form 06 - Perth Laboratory
Odour Concentration Measurement Results

The measurement was commissioned by:

Organisation	Joe White Maltings Pty Ltd	Telephone	03 9804 8308
Contact	Andrew Gee	Facsimile	-
Sampling Site	Forrestfield	Email	Andrew.Gee@abb.com.au
Sampling Method	Drum & Pump	Sampling Team	C. Hough / J. Hurley

Order details:

Order requested by	Andrew Gee	Order accepted by	John Hurley
Date of order	16th September 2009	TOU Project #	W1467R
Order number	TBA	Project Manager	John Hurley
Signed by	TBA	Testing operator	Clayton Hough

Investigated Item	Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag. Odour character is also assessed, however, AS4323.3:2001 and NATA accreditation do not cover the performance of this service. Where parties other than The Odour Unit perform the dilution of samples, the result that has been modified by the dilution factor is not covered by The Odour Units NATA accreditation. The collection of IFH samples and calculation of the SOER is not covered by The Odour Units NATA accreditation.
Identification	The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or Identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.
Method	The odour concentration measurements were performed using dynamic olfactometry according to the Australian Standard 'Determination of Odour Concentration by Dynamic Olfactometry AS/NZS4323.3:2001. The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.
Measuring Range	The measuring range of the olfactometer is $2^2 \leq \chi \leq 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. This is specifically mentioned with the results.
Environment	The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained at 25°C or less, with temperature fluctuations of less than ± 3 °C.
Measuring Dates	The date of each measurement is specified with the results.
Instrument Used	The olfactometer used during this testing session was: ODORMAT SERIES V04
Instrumental Precision	The precision of this instrument (expressed as repeatability) for a sensory calibration must be $r \leq 0.477$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $r = 0.298$ (11th & 12th December, 2008) Compliance – Yes
Instrumental Accuracy	The accuracy of this instrument for a sensory calibration must be $A \leq 0.217$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $A = 0.063$ (11th & 12th December, 2008) Compliance – Yes
Lower Detection Limit (LDL)	The LDL for the olfactometer has been determined to be 16 ou (four times the lowest dilution setting)
Traceability	The measurements have been performed using standards for which the traceability to the national standard has been demonstrated. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen.

Date: Friday, 30 January 2009 Report Number / Panel Roster Number: PER20090130

T. Schulz
Principal and Managing Director

C. Hough
Authorised Signatory

THE ODOUR UNIT (WA) PTY LTD

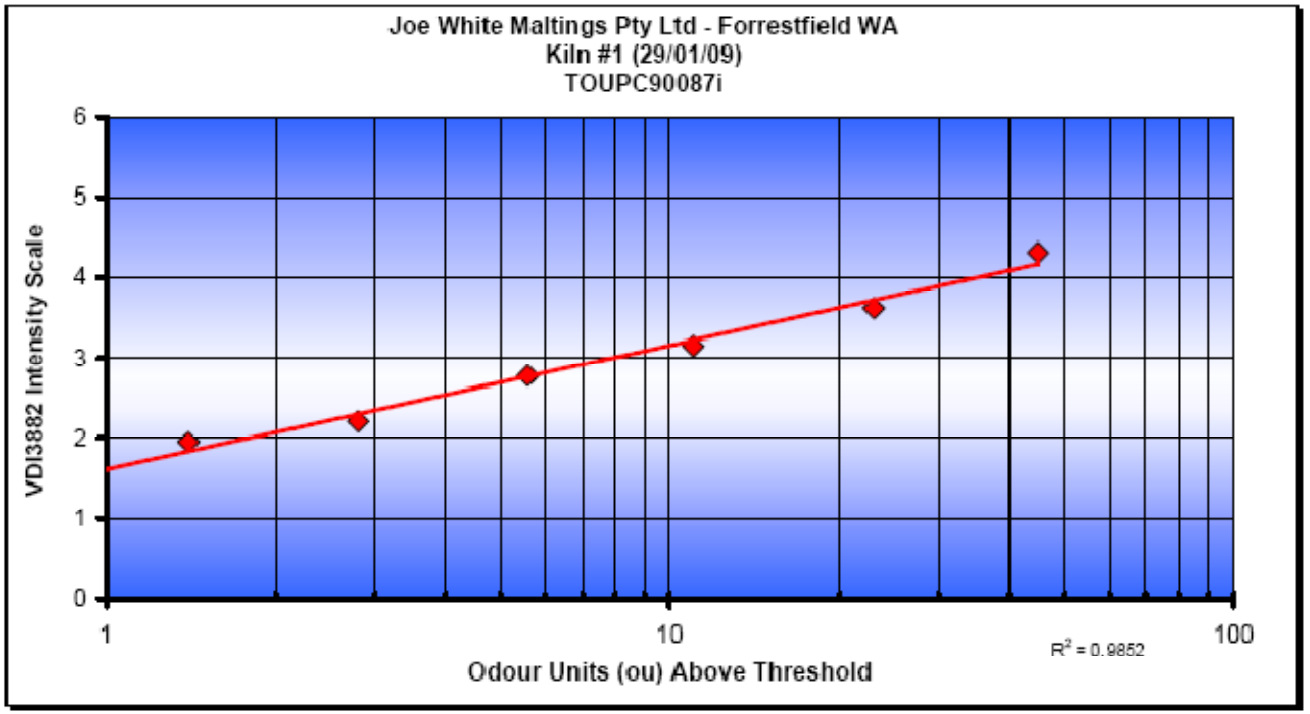
Accreditation Number: 14974

Odour Sample Measurement Results

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (ou)	Sample Odour Concentration (Final, allowing for dilution) (ou)	Odour Character
Steep 7 – Sample #2	PC90080	29/01/2009 @ 10:05hrs	30/01/2009 @ 11:32hrs	4	8	-	-	19,500	19,500	Sweet yoghurt / sour-fermented
Steep 12 – Sample #2	PC90082	29/01/2009 @ 10:15hrs	30/01/2009 @ 11:56hrs	4	8	-	-	17,900	17,900	Sweet yoghurt / sour-fermented
Kiln 1 – Sample #1	PC90083	29/01/2009 @ 10:30hrs	30/01/2009 @ 12:28hrs	4	8	-	-	2,660	2,660	Sprouts / cooked vegetables
Kiln 1 – Sample #2	PC90084	29/01/2009 @ 10:35hrs	30/01/2009 @ 12:54hrs	4	8	-	-	3,160	3,160	Sprouts / cooked vegetables

THE ODOUR UNIT (WA) PTY LTD

Accreditation Number: 14974



Comments: The German Standard VDI3882 Intensity Scale value of *three (3)* is classified as "distinct". The Odour Units (OU) above threshold that correspond to the German Standard VDI3882 Intensity Scale value of *three (3)* is = 7.9 OU

THE ODOUR UNIT (WA) PTY LTD

Accreditation Number: 14974

Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppm)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS4323.3:2001 (Yes / No)
n-butanol	PER2009.01.30	49.8	$20 \leq \chi \leq 80$	724	69	Yes

Comments: The measurement of odour intensity from odour samples is based on the German Standard VDI 3882 Part 1: *Olfactometry – Determination of Odour Intensity*.

END OF DOCUMENT

THE ODOUR UNIT (WA) PTY LTD

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ABN: 70 126 439 076

NATA
Accreditation Number: 14974

Form 06 - Perth Laboratory
Odour Concentration Measurement Results

The measurement was commissioned by:

Organisation	Joe White Maltings Pty Ltd	Telephone	03 9604 8308
Contact	Andrew Gee	Facsimile	-
Sampling Site	Forrestfield	Email	Andrew.Gee@abb.com.au
Sampling Method	Drum & Pump, IFH	Sampling Team	C. Hough / J. Hurley

Order details:

Order requested by	Andrew Gee	Order accepted by	John Hurley
Date of order	16th September 2009	TOU Project #	W1467R
Order number	TBA	Project Manager	John Hurley
Signed by	TBA	Testing operator	Clayton Hough

Investigated Item	Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag. Odour character is also assessed, however, AS4323.3:2001 and NATA accreditation do not cover the performance of this service. Where parties other than The Odour Unit perform the dilution of samples, the result that has been modified by the dilution factor is not covered by The Odour Units NATA accreditation. The collection of IFH samples and calculation of the SOER is not covered by The Odour Units NATA accreditation.
Identification	The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.
Method	The odour concentration measurements were performed using dynamic olfactometry according to the Australian Standard 'Determination of Odour Concentration by Dynamic Olfactometry AS/NZS4323.3:2001. The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.
Measuring Range	The measuring range of the olfactometer is $2^2 \leq \chi \leq 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. This is specifically mentioned with the results.
Environment	The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained at 25°C or less, with temperature fluctuations of less than ± 3 °C.
Measuring Dates	The date of each measurement is specified with the results.
Instrument Used	The olfactometer used during this testing session was: ODORMAT SERIES V04
Instrumental Precision	The precision of this instrument (expressed as repeatability) for a sensory calibration must be $r \leq 0.477$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $r = 0.298$ (11th & 12th December, 2008) Compliance – Yes
Instrumental Accuracy	The accuracy of this instrument for a sensory calibration must be $A \leq 0.217$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $A = 0.063$ (11th & 12th December, 2008) Compliance – Yes
Lower Detection Limit (LDL)	The LDL for the olfactometer has been determined to be 16 ou (four times the lowest dilution setting)
Traceability	The measurements have been performed using standards for which the traceability to the national standard has been demonstrated. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen.

Date: Thursday, 22 January 2009 Report Number / Panel Roster Number: PER20090122

T. Schulz
Principal and Managing Director

C. Hough
Authorised Signatory

THE ODOUR UNIT (WA) PTY LTD

Accreditation Number: 14974

Odour Sample Measurement Results

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (OU)	Specific Odour Emission Rate ($ou.m^3/s$ / m^2)	Odour Character
Waste Water Pond – Sample #1	PC90066	21/01/2009 @ 10:10hrs	22/01/2009 @ 14:44hrs	5	8	-	-	3,160	1.92	Shellfish / estuary / foul
Waste Water Pond – Sample #2	PC90067	21/01/2009 @ 10:45hrs	22/01/2009 @ 15:18hrs	5	10	-	-	3,330	1.98	Shellfish / estuary / foul

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Accreditation Number: 14914

Odour Sample Measurement Results

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITFs	Nominal Sample Dilution	Actual Sample Dilution (adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (OU)	Sample Odour Concentration (Final, allowing for dilution) (OU)	Odour Character
Germinator Vessel#3	P090058	21/01/2009 @ 11:28hrs	22/01/2009 @ 10:39hrs	5	10	-	-	194	194	Rotten fruit / sweet / yoghurt / fermented
Germinator Vessel#1	P090059	21/01/2009 @ 11:47hrs	22/01/2009 @ 11:09hrs	5	10	-	-	315	315	Rotten fruit / sweet / yoghurt / fermented
Germinator Vessel#7	P090060	21/01/2009 @ 12:09hrs	22/01/2009 @ 11:39hrs	5	10	-	-	128	128	Rotten fruit / sweet / yoghurt / fermented
Germinator Vessel#6	P090061	21/01/2009 @ 12:28hrs	22/01/2009 @ 13:44hrs	5	10	-	-	475	475	Rotten fruit / sweet / yoghurt / fermented
Germinator Vessel#8	P090062	21/01/2009 @ 12:34hrs	22/01/2009 @ 12:36hrs	5	10	-	-	294	294	Rotten fruit / sweet / yoghurt / fermented
Germinator Vessel#4	P090063	21/01/2009 @ 12:42hrs	22/01/2009 @ 14:09hrs	6	10			3,670	3,670	Rotten fruit / sweet / yoghurt / fermented
Germinator Vessel#2	P090064	21/01/2009 @ 12:48hrs	22/01/2009 @ 12:02hrs	5	10	-	-	338	338	Rotten fruit / sweet / yoghurt / fermented

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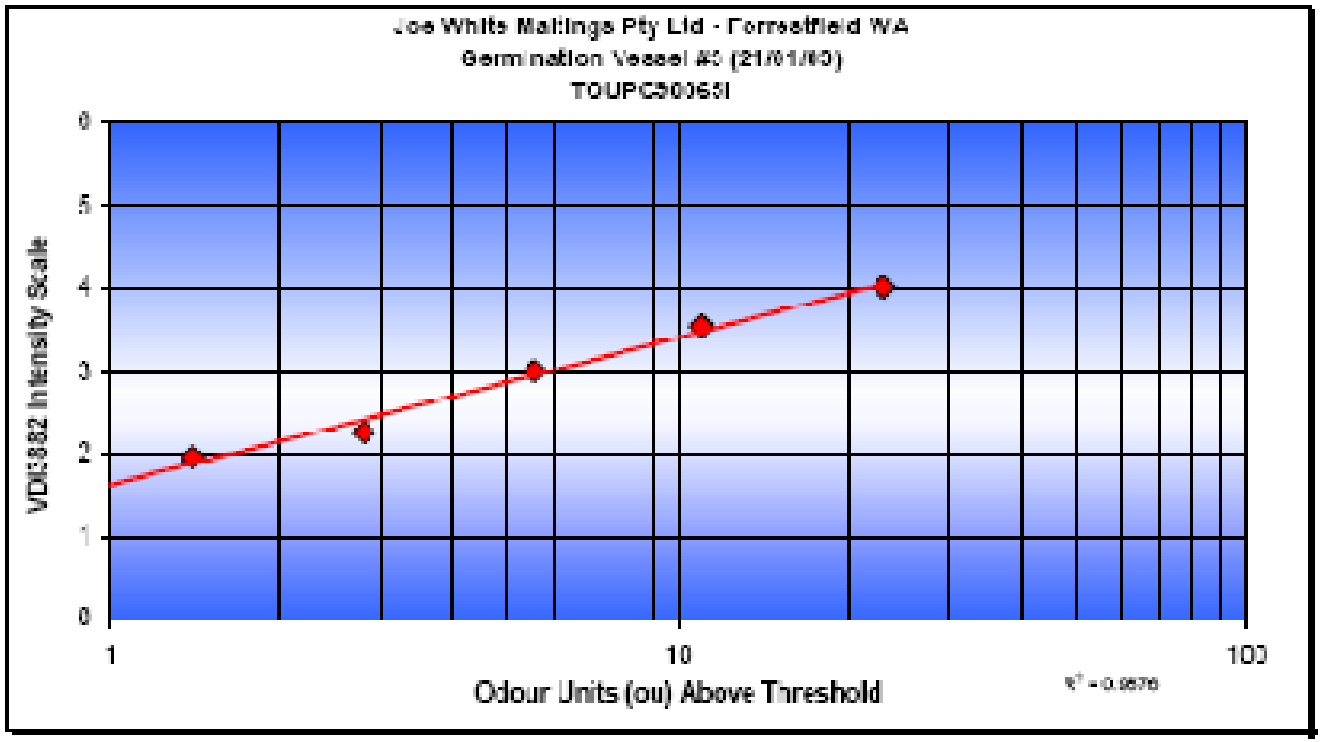
Accreditation Number: 14974



Comments: The German Standard VDI3882 Intensity Scale value of three (3) is classified as "distinct". The Odour Units (OU) above threshold that correspond to the German Standard VD 3882 Intensity Scale value of three (3) is = 5.9 OU

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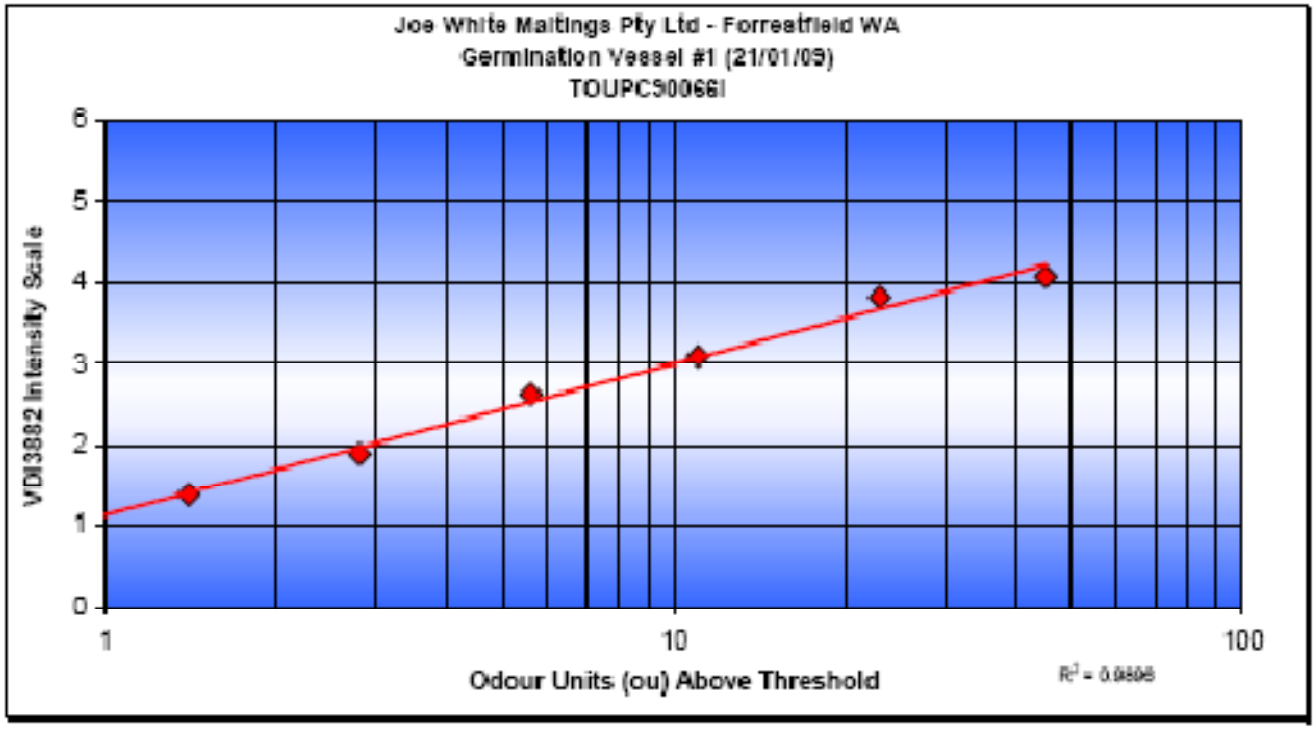
Accreditation Number 14974



Comments: The German Standard VDI3882 Intensity Scale value of *three (3)* is classified as "distinct". The Odour Units (OU) above threshold that correspond to the German Standard VDI3882 Intensity Scale value of *three (3)* is = **10.0 OU**

Report Number / Panel Roster Number: PER20090122

- 5 -

The Odour Unit (WA) Pty Ltd
ACN 126 439 076
Form 08 – Odour Concentration Results Sheet

Issue Date: 13.11.2003
Issued By: SB
Odour Measurement Manual

Revision: 6
Revision Date: 20.09.2007
Approved By: TJS

THE ODOUR UNIT (WA) PTY LTD

Accreditation Number: 14974

Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppm)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS4323.3:2001 (Yes / No)
n-butanol	PER2009.01.22	49.8	$20 \leq \chi \leq 80$	724	69	Yes

Comments: Specific Odour Emission Rate (SOER) results are normalised to 25°C.

The measurement of odour intensity from odour samples is based on the German Standard VDI 3882 Part 1: *Olfactometry – Determination of Odour Intensity*.

END OF DOCUMENT

THE ODOUR UNIT (WA) PTY LTD

THE ODOUR UNIT

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Internet: www.odourunit.com.au
ABN: 70 126 439 076

NATA

Accreditation Number: 14974

Form 06 - Perth Laboratory
Odour Concentration Measurement Results

The measurement was commissioned by:

Organisation	Joe White Maltings Pty Ltd	Telephone	03 9604 8308
Contact	Andrew Glee	Facsimile	-
Sampling Site	Forrestfield	Email	Andrew.Glee@abb.com.au
Sampling Method	Drum & Pump	Sampling Team	C. Hough / J. Hurley

Order details:

Order requested by	Andrew Glee	Order accepted by	John Hurley
Date of order	16th September 2009	TOU Project #	W14657R
Order number	TBA	Project Manager	John Hurley
Signed by	TBA	Testing operator	Clayton Hough

Investigated Item	Odour concentration in odour units 'ou', determined by sensory odour concentration measurements, of an odour sample supplied in a sampling bag. Odour character is also assessed, however, AS4323.3:2001 and NATA accreditation do not cover the performance of this service. Where parties other than The Odour Unit perform the dilution of samples, the result that has been modified by the dilution factor is not covered by The Odour Units NATA accreditation. The collection of IPH samples and calculation of the ISOER is not covered by The Odour Units NATA accreditation.
Identification	The odour sample bags were labelled individually. Each label recorded the testing laboratory, sample number, sampling location (or identification), sampling date and time, dilution ratio (if dilution was used) and whether further chemical analysis was required.
Method	The odour concentration measurements were performed using dynamic olfactometry according to the Australian Standard "Determination of Odour Concentration by Dynamic Olfactometry AS/NZS4323.3:2001. The odour perception characteristics of the panel within the presentation series for the samples were analogous to that for butanol calibration. Any deviation from the Australian standard is recorded in the 'Comments' section of this report.
Measuring Range	The measuring range of the olfactometer is $2^2 \leq \chi \leq 2^{18}$ ou. If the measuring range was insufficient the odour samples will have been pre-diluted. This is specifically mentioned with the results.
Environment	The measurements were performed in an air- and odour-conditioned room. The room temperature is maintained at 25°C or less, with temperature fluctuations of less than ± 3 °C.
Measuring Dates	The date of each measurement is specified with the results.
Instrument Used	The olfactometer used during this testing session was: ODORMAT SERIES V04
Instrumental Precision	The precision of this instrument (expressed as repeatability) for a sensory calibration must be $r \leq 0.477$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $r = 0.298$ (11th & 12th December, 2008) Compliance – Yes
Instrumental Accuracy	The accuracy of this instrument for a sensory calibration must be $A \leq 0.217$ in accordance with the Australian Standard AS/NZS4323.3:2001. ODORMAT SERIES V04: $A = 0.053$ (11th & 12th December, 2008) Compliance – Yes
Lower Detection Limit (LDL)	The LDL for the olfactometer has been determined to be 16 ou (four times the lowest dilution setting)
Traceability	The measurements have been performed using standards for which the traceability to the national standard has been demonstrated. The assessors are individually selected to comply with fixed criteria and are monitored in time to keep within the limits of the standard. The results from the assessors are traceable to primary standards of n-butanol in nitrogen.

Date: Thursday, 29 January 2009 Report Number / Panel Roster Number: PER20090129

T. Schulz
Principal and Managing Director

C. Hough
Authorised Signatory

THE ODOUR UNIT (WA) PTY LTD

Accreditation Number: 14974

Odour Sample Measurement Results

Sample Location	TOU Sample ID	Sampling Date & Time	Analysis Date & Time	Panel Size	Valid ITEs	Nominal Sample Dilution	Actual Sample Dilution (adjusted for Temperature)	Sample Odour Concentration (as received, in the bag) (OU)	Sample Odour Concentration (Final, allowing for dilution) (OU)	Odour Character
Steep 1 – Sample #1	PC90077	29/01/2009 @ 09:40hrs	29/01/2009 @ 13:14hrs	5	10	-	-	2,200	2,200	Sweet yoghurt / sour-fermented
Steep 1 – Sample #2	PC90078	29/01/2009 @ 09:45hrs	29/01/2009 @ 14:12hrs	5	10	-	-	5,790	5,790	Sweet yoghurt / sour-fermented
Steep 7 – Sample #1	PC90079	29/01/2009 @ 10:00hrs	29/01/2009 @ 14:32hrs	5	10	-	-	15,300	15,300	Sweet yoghurt / sour-fermented
Steep 12 – Sample #1	PC90081	29/01/2009 @ 10:10hrs	29/01/2009 @ 14:56hrs	5	10	-	-	13,300	13,300	Sweet yoghurt / sour-fermented

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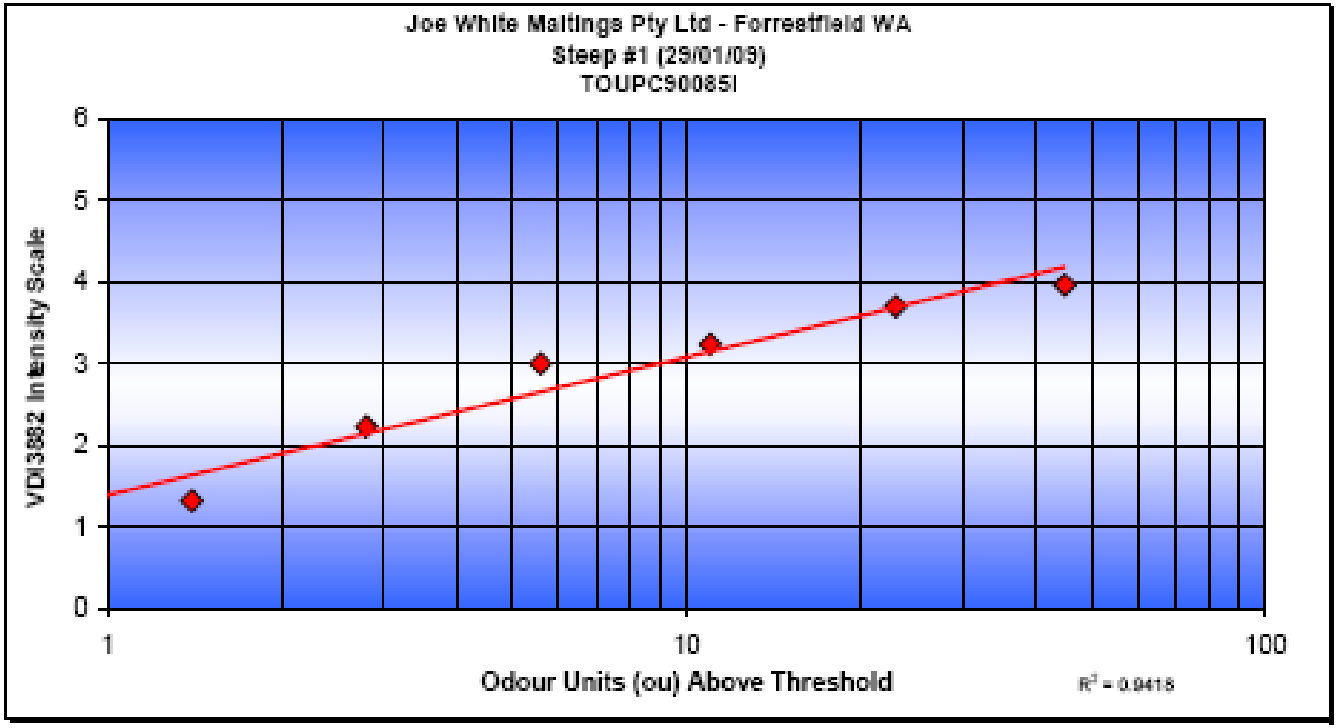
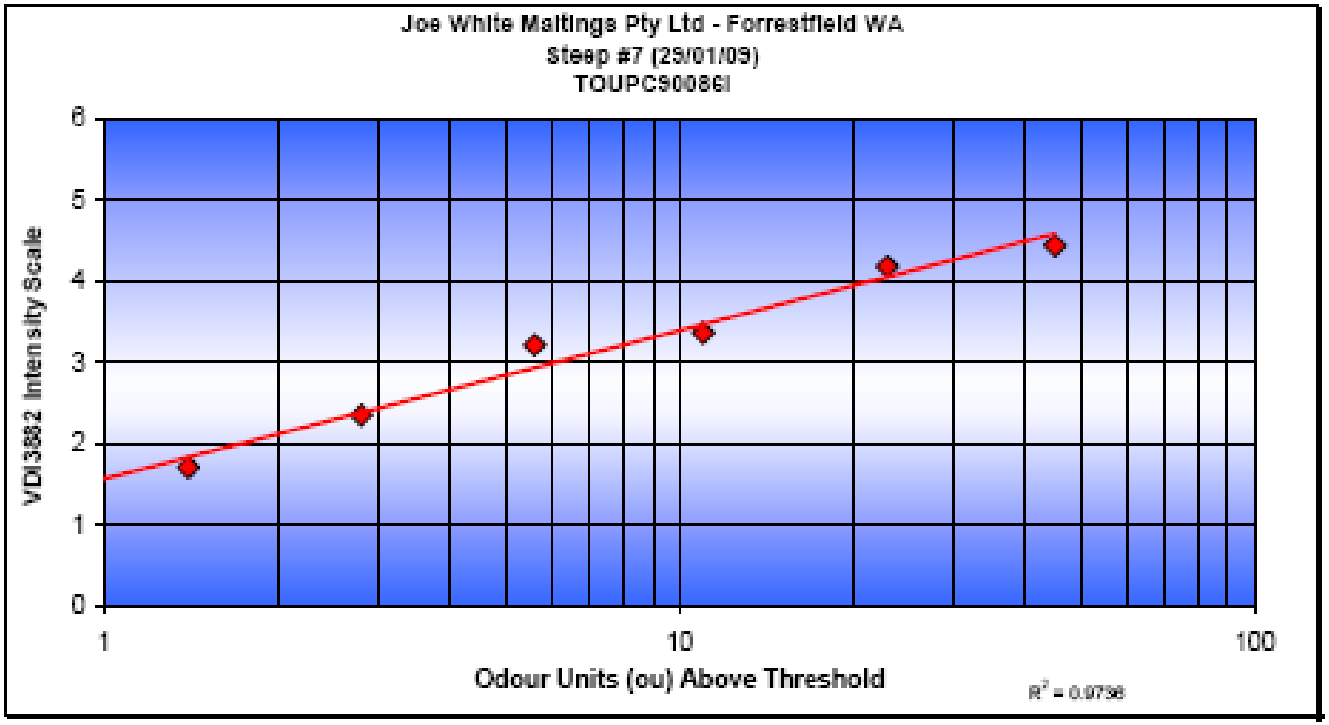
Accreditation Number: 14974



Comments: The German Standard VDI3882 Intensity Scale value of *three (3)* is classified as "distinct". The Odour Units (OU) above threshold that correspond to the German Standard VDI3882 Intensity Scale value of *three (3)* is = **9.0 OU**

THE ODOUR UNIT (WA) PTY LTD

Accreditation Number: 14974



Comments: The German Standard VDI3882 Intensity Scale value of *three (3)* is classified as "distinct". The Odour Units (OU) above threshold that correspond to the German Standard VDI3882 Intensity Scale value of *three (3)* is = 6.1 OU

THE ODOUR UNIT (WA) PTY LTD

Accreditation Number: 14974

Odour Panel Calibration Results

Reference Odorant	Reference Odorant Panel Roster Number	Concentration of Reference gas (ppm)	Panel Target Range for n-butanol (ppb)	Measured Concentration (ou)	Measured Panel Threshold (ppb)	Does this panel calibration measurement comply with AS/NZS4323.3:2001 (Yes / No)
n-butanol	PER2009.01.29	49.6	$20 \leq \chi \leq 60$	724	69	Yes

Comments: The measurement of odour intensity from odour samples is based on the German Standard VDI 3882 Part 1: *Olfactometry – Determination of Odour Intensity.*

END OF DOCUMENT

APPENDIX B
INFORMATION ON COMPOUNDS IN MALTING PROCESS
PROVIDED TO PAEHOLMES BY JWM

Table 4.14 Examples of volatile substances with flavour and aroma characteristics that have been found in dark malts and roasted barley

	Examples
From lipids	Hexanal, *trans*-2-hexenal, *trans,trans*-2, 4-hexadienal, heptanal, *trans*-2-octenal, *trans*-2-nonenal, *trans*-2-*cis*-6-nonadienal, *trans,trans*-2, 4-nonadienal, 1-hepten-3-ol, 1-hexanol, *trans*-2-hexen-1-ol, 1-octanol, 1-nonanol, *trans,trans*-2, 4-decadienol, hexanoic acid, octanoic acid
Aldehydes from Strecker degradations	Acetaldehyde, propionaldehyde, isobutyraldehyde, isovaleraldehyde, methional, benzaldehyde, 2-phenylacetaldehyde
Compounds with oxygen heterocyclic ring structures	Furfural, furfuryl alcohol, 2-pentylfuran, 2-acetylfurfural, 5-methylfurfural, 3-phenylfuran, maltol, isomaltol, furan-2-carboxylic acid
Sulphur-containing molecules	Hydrogen sulphide, methyl mercaptan, ethyl mercaptan, carbon disulphide, dimethyl sulphide, diethyl sulphide, dimethyl disulphide, furfuryl mercaptan
Heterocyclic sulphur-containing molecules	Thiazole, 4-methylthiazole, 2-acetylthiazole, various thiazolines, thiophenes
Other substances	Ethanol, vanillin, *p*-hydroxybenzaldehyde, acetic acid and other volatile acids
Amines	Ammonia, methylamine, dimethylamine, ethylamine, *s*-butylamine, isobutylamine, *n*-butylamine, *p*-hydrobenzylamine, isoamylamine
Heterocyclic nitrogen-containing molecules	Pyrrolidine, 2-formylpyrrole, 2-acetylpyrrole, 2-methylpyrazine, dimethylpyrazine, ethylpyrazine, 3,6-dimethyl-2-ethylpyrazine, indole, pyridine, methylpyridine, 2-acetylpyridine, 5-methyl-6,7-dihydro-5*H*-cyclopentapyrazine
Phenolic substances	4-Hydroxybenzaldehyde, 4-vinylguaiacol, 4-vinylphenol, vanillin
Other groups of substances	Other alcohols, aldehydes, esters, alkanes, alkenes, aromatic hydrocarbons, lower fatty acids, lactones
Diketopiperazines	Cyclized dipeptides, e.g. *cyclo*-L-phenylalanine-L-proline, *cyclo*-L-proline-L-proline

(After Bärwald *et al.* (1969); Slaughter and Uvgard (1971); Harding *et al.* (1978); Tressl *et al.* (1975, 1979, 1981); Farley and Nursten (1980); Hough *et al.* (1982); Moir (1989).

Below is some general information on the flavour compounds in malt

- Table 4.14 above from Briggs (Malts and Malting by Dennis Briggs, Thompson Publishing, 1st ed, 1998) list a number of volatile compounds which may contribute in some way to the flavour of malt, although many of these form later in the process during kilning.
- The exact contributions of the various volatiles detected do have to be assessed however with the consideration of the odour thresholds and concentrations. For example the strongest peak in a GC-MS trace does not necessarily equal the most potent compound. In fact it is quite often the opposite which may be related to the odour threshold of the compound or the sampling technique.
- There is little information on the flavour and aroma compounds responsible for the odours of 'green/germinating malt'. One book suggested that **amines** that are formed during the germination process are responsible for the characteristic aroma of germinating barley (The Dictionary of Beer and Brewing by Dan Rabin and Carl Forget, Routledge Publishing, 2nd ed, 1998)
    - I would imagine that they are talking about **small molecular weight amines** such as those mentioned in the table above.
    - Other types of compounds from my past experience that could potentially be present and have green/hay type aromas are lipid degradation products such as those listed in the table above **(C6-C9 aliphatic derivatives)** as well as **methoxypyrazines**. However I do not have any references to support this just past experience with other crops. Often the aroma of germinating malt is described as 'green, hay-like, cucumber-like, grassy. These compounds all have these types of aromas and have the potential to form in the field or during germination.
    - I would not expect too many of the other compounds mentioned in the table above to be present during the germination as they are formed during complex reactions such as the Malliard reaction during kilning. These include aldehydes from Stecker degradation, compounds with oxygen heterocyclic ring structures, sulphur containing compounds, heterocyclic nitrogen-containing molecules (apart from the methoxypyrazines perhaps), phenolics and the other compounds mentioned