



This document has been prepared on behalf of Metford Road Pty Ltd by:

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37/39 Metford Road, Tenambit – Potential Odour Constraints

Addressee(s): Metford Road Pty Ltd

Report Reference: 17.1003.FR1V1

Date: 18 August 2016

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Quality Control

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| THE PROPOSED DEVELOPMENT SITE | Final | Northstar Air Quality | BE/DG/MD | GCG |
| LEGISLATION AND GUIDANCE | Final | Northstar Air Quality | BE/DG/MD | GCG |
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Final Authority

This report must be regarded as draft until the above study components have been each marked as final, and the document has been signed and dated below.

Gary Graham



18 August 2016

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Units Used in the Report

All units presented in the report follow the International System of Units (SI) conventions, unless derived from references using non-SI units.

In this report, units formed by the division of SI and non-SI units are expressed as a negative exponent, and do not use the solidus (/) symbol. For example:

- 50 micrograms per cubic metre is presented as $50 \mu\text{g m}^{-3}$ and not $50 \mu\text{g}/\text{m}^3$; and,
- 0.2 kilograms per hectare per hour is presented as $0.2 \text{ kg ha}^{-1} \text{ hr}^{-1}$ and not 0.2 kg/ha/hr .

1. INTRODUCTION

Metford Road Pty Ltd has engaged Northstar Air Quality Pty Ltd (Northstar) to perform a review of air quality (odour) matters relating to 37/39 Metford Road, Tenambit (Lot 11, DP 1197316).

1.1. Purpose of the Report

This report provides a summary of the interpretation of a range of information and technical reports used to assess the potential odour impacts associated with the operation of the Morpeth Wastewater Treatment Works (WWTW) operated by the Hunter Water Corporation (HWC) located off Butchers Lane in Tenambit, NSW which is approximately 350 metres to the east of the proposed development site.

The purpose of this report is to provide an opinion as to whether the future use of land at 37/39 Metford Road, Tenambit is likely to be impacted by unacceptable offensive odour impacts (as determined by the POEO Act and current NSW EPA guidance) from the operation of the Morpeth WWTW, and whether that odour represents a reasonable constraint for the type and nature of future land uses.

1.2. Documents Reviewed

In performing this task, the following documents have been reviewed:

- MWH (2013) Morpeth Wastewater Treatment Works – Odour Impact Assessment (ref: 83501340-P-101 0 Morpeth WWTW Final Odour Assessment IE, dated November 2013) (MWH, 2013);
- Hunter Water Corporation (2004) Buffer Zone Policy – Wastewater Treatment Plants (HWC 2004);
- Gosford City Council (undated) Sewage Treatment Works – Buffer Zones – Gosford City Council Policy Manual (GCC ref1)¹;
- NSW Planning (2010) NSW Best Practice Odour Guideline - Sewerage systems including sewage treatment plants, water recycling facilities, sewage reticulation systems and sewer mining (Draft); (DPE 2010)²
- NSW DEC (2006) Technical framework - Assessment and management of odour from stationary sources in NSW (OEH 2006)³;
- Maitland City Council (26 March 2013) Ordinary Meeting, 10.3 DA 12-1896 pp101 – 121 (MCC 2013a)
- Holmes Air Sciences (2008) Morpeth Waste Water Treatment Works Upgrade and Thornton North Dual Reticulation Scheme (ref: Morpeth_WWTW_Final, dated 25 September 2008) (HAS 2008);
- MJM Environmental (2012) Ausplume Level 1 Air Quality Impact Assessment (ref: BK081112A, dated November 2012) (MJM 2012); and,

¹ <http://search.gosford.nsw.gov.au/documents/00/13/00/07/0013000709.pdf>

² http://www.sinia.cl/1292/articles-55464_NSW.pdf

³ <http://www.epa.nsw.gov.au/resources/air/20060440framework.pdf>

- Maitland City Council (9 April 2013) Ordinary Meeting, 10.1 DA 11-222 pp44 – 65 (MCC 2013b).

Note: on page 45 of the Council decision discussed above on 9 April 2013 (MCC 2013b), the Council refers a report issued by SLR Consulting Australia (referenced in the minutes on page 45 as “SLR Global Environmental Solutions”). For transparency, the author and reviewer of this report were both previously employed by SLR Consulting Australia and the author was a signatory to that referenced report.

Notwithstanding the above, this report presents an unbiased opinion of the situation, as understood for the above documentation, and is prepared without conflict of interests.

A copy of the CVs of the Northstar author and reviewer are presented in Appendix B.

2. THE PROPOSED DEVELOPMENT SITE

Metford Road Pty Ltd are examining options for the development of the land at 37/39 Metford Road, Tenambit. The approximate location of the land and its proximity to the Morpeth WWTW is illustrated in Figure 1 below (provided for indication only):

Figure 1 Approximate location of the proposed development land and Morpeth WWTW



At the time of preparing this report it is understood that the current options being reviewed by Metford Road Pty Ltd for potential future land uses include the following, or a combination thereof:

- Seniors Housing (“Retirement Village” in Appendix A);
- Manufactured Home Estate (MHE) (“Relocatable Home Village” in Appendix A); and/or,
- Residential subdivision.

It is worth noting that for the purposes of an odour assessment, there should be no differentiation between the above proposed uses. Essentially they all represent ‘residential uses’ and should be equally considered to be sensitive to odour impacts and should equally be entitled to the same expectation of amenity.

For context, there is a general preference to reduce the potential odour impacts that may be generated or exacerbated by locating conflicting land uses at close proximity to each other. Typically, a potentially odorous land use such as a WWTW should be separated from land uses that may be sensitive to odour, which would include residential uses. At the highest level, this separation is often implemented through planning mechanisms as ‘buffer zones’. The documentation listed above references buffer zones as a high-level planning tool, including HWC 2004, GCC ref1, DPE 2009 and OEH 2006:

3. LEGISLATION AND GUIDANCE

3.1. Protection of Environmental Operations Act

In NSW, all wastewater treatment systems that have an installed capacity of 70,000 L.day⁻¹ or 2,500 person-equivalent are regulated under Schedule 1 of the *Protection of Environment Operations Act* (1997), and under the POEO Act they are required to operate with an Environmental Protection Licence issued by the NSW EPA.

The HWC operations at the Morpeth WWTW are currently regulated under POEO Licence 10693 as a 'sewage treatment processing by small plants' in the scale of >5000-10000 ML discharged, although there is a s58 licence variation application to increase this regulated capacity.

Condition L6 of EPL Licence 10693⁴ states:

L6 Potentially offensive odour

L6.1: No condition in this licence identifies a potentially offensive odour for the purposes of section 129 of the Protection of the Environment Operations Act 1997.

Note: Section 129 of the Protection of the Environment Operations Act 1997 provides that the licensee must not cause or permit the emission of any offensive odour from the premises but provides a defence if the emission is identified in the relevant environment protection licence as a potentially offensive odour and the odour was emitted in accordance with the conditions of a licence directed at minimising odour.

For clarity, the term "offensive odour" is defined in the POEO Act as:

"offensive odour" means an odour:

- (a) that, by reason of its strength, nature, duration, character or quality, or the time at which it is emitted, or any other circumstances:*
 - (i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*
 - (ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*
- (b) that is of a strength, nature, duration, character or quality prescribed by the regulations or that is emitted at a time, or in other circumstances, prescribed by the regulations.*

Interpreting the POEO Act, and how the Morpeth WWTW is regulated by the NSW EPA under that Act, the operation of the plant is conditioned so as to not give rise to an 'offensive odour' beyond the boundary of the site of the plant, irrespective of the application of buffer zones, which are primarily used as planning tools.

⁴ <http://www.epa.nsw.gov.au/prpoeoapp/ViewPOEOLicence.aspx?DOCID=60215&SYSUID=1&LICID=10693>

3.2. Odour Nuisance

The standards protecting amenity (odour) will usually be specified over short-duration averaging periods as the time required to register an odour that affects amenity, and which may give rise to a nuisance complaint, is typically very short. However, for the same air pollutant, the time required to give rise to an ill-health effect will be longer than that required to cause an odour complaint. The concentration values vary according to the relative toxicity effects and the concentration threshold at which it may be typically detected as a human olfactometric response (i.e. the threshold of nasal detectability). This concentration is called the odour detection threshold (ODT) and defines 1 odour unit (1 OU) for that odorant. The actual mass/volume airborne concentration ($\mu\text{g}\cdot\text{m}^{-3}$) that equates to the ODT for each air pollutant will be different, even though they all have an equivalence to 1 OU.

In an outdoor environment, the odour concentration at which an odour is perceived to potentially be a nuisance typically ranges from around 2 OU to around 10 OU depending on the interaction of various factors including the composition of the odorants exposed, the sensitivity of the receiving environment, how offensive the odour is, the frequency, intensity and duration at which it is experienced etc.

3.3. Odour Impact Assessment Criterion in NSW

The current policy framework for assessing and managing activities that emit odour in NSW is presented in the Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW (EPA 2006). EPA 2006 provides guidance on how odour impacts are to be assessed with the aim of achieving the control of odour implemented through the POEO Act (see Section 3.1).

In NSW, the Office of Environment and Heritage (OEH) recommends an odour performance goal of 7 OU (as the 99th percentile of 1-second TWA concentrations), which is adjusted on a scale of 2 OU to 7 OU to account for more densely populated areas, as replicated below:

Table 1 NSW odour assessment criteria

| Population of affected community | Odour assessment criterion (OU) |
|---|---------------------------------|
| Single residence (≤ 2) | 7 |
| ~10 | 6 |
| ~30 | 5 |
| ~125 | 4 |
| ~500 | 3 |
| Urban area (≥ 2000) and/or schools and hospitals | 2 |

The concept underpinning the scale of the odour assessment criterion is based on the likelihood of a person being more sensitive to odour than the average person being resident within a given population i.e. the larger the number of people potentially impacted by the odour, the greater the possibility that someone within that group of people will be sensitive to the odour.

The most sensitive landuse receptors are identified as urban areas of ≥ 2000 people and/or schools and hospitals. The adopted odour impact criteria for such a population is 2 OU.

The guidelines provide that *“an odour assessment criterion of 7 OU is likely to represent the level below which ‘offensive’ odours should not occur. Therefore, the Technical Framework recommends that, as a design criterion, no individual should be exposed to ambient odour levels of greater than 7 OU (99th percentile, nose response time average).”*

4. REVIEW OF TECHNICAL REPORTS

4.1. MWH (2013) Morpeth Wastewater Treatment Works – Odour Impact Assessment

MWH 2013 presents a detailed odour impact assessment conducted on behalf of Hunter Water Australia (HWA). The report presents an assessment of the odour impacts associated with the inlet upgrade works, and presents a (i) before and (ii) after odour impact assessment. Importantly, the assessment of the difference between the two scenarios examines the likely changes associated with the capacity increase and inlet upgrade works.

This report does not form a structured peer review of that report, although the report has been read so that an opinion may be formed that relates to the potential for odour impacts at the proposed development site.

Of note, the following is considered to be relevant:

- The assessment (MWH 2013) has been performed using the CALPUFF dispersion model and in accordance with the relevant NSW guidance as set out in the Approved Methods. The emission rates used in the modelling assessment have been derived from on-site measurements at Morpeth WWTW and using proprietary septicity modelling by MWH. It is considered that the assessment complies with the NSW requirements as set out in the Approved Methods and is appropriate for this application.
- Section 2.5 (p5) of the assessment report states that “*HWC [Hunter Water Corporation] has stated that Morpeth WWTW does not have a history of odour complaints from the surrounding community as per Robert de Boos email dated 6th of December 2013*”. Evidence regarding the performance of the WWTW since December 2013 is not provided.
- The predicted odour impacts (as the 99th percentile 1-second average odour concentration in odour units) is presented in Figure 6-1 (p28) of the assessment report. The corresponding odour predictions relating to upgrade option 6A (a discarded upgrade option) and upgrade option 6B are graphically illustrated in Figure 6-2 (p32) and Figure 6-4 (p34) of MWH 2013 respectively. In all instances, the isopleths representing the 6 OU and the 2 OU contours have been illustrated.
- Figure 7-2 (p36) of MWH 2013 illustrates the comparison of the ‘existing baseline’ (pre upgrade works) and Option 6B (post upgrade works). It is noted that the isopleths are virtually identical, and in realistic terms the modelling predicts that the level of odour emissions post upgrade works are predicted to be the same as pre-upgrade works.
- Appendix F of MWH 2013 provides the corresponding modelling isopleths as the 100th percentile 1-second average odour concentrations. In NSW the relevant odour criterion is the 99th percentile value, allowing for 88 hours of odour predictions to exceed the criterion value. The third plot in Appendix F of MWH 2013 presents the 100th percentile 1-second odour concentrations as the 6 OU and 2 OU concentration values. It can be seen that the predicted 2 OU contour extends to the outlying eastern

properties located along Canterbury Drive and Carlisle Place, Tenambit. It is noted that the impact of the 100th percentile odour concentration predictions does not show a non-achievement of the NSW odour criterion (being the corresponding 99th percentile value) but does indicate that (based upon the assumptions of the odour assessment presented in MWH 2013) that some properties may experience odour at a concentration exceeding 2 OU at times. This does not necessarily mean that an odour that may lead to a complaint is evident, as that may occur at a time at which the potential for exposure is low (typically and highly likely to be late night / early morning), the residents may deem the odour to be acceptable, not frequent or intense enough to warrant a complaint, or that the MWH 2013 modelling may be over-estimating the potential odour emissions.

- Given that the pre-upgrade and post-upgrade odour predictions are essentially the same and that there are no pre-upgrade odour complaints, it would be reasonable to conclude that a similar situation would be prevalent post-upgrade. A search of the Environmental Protection Licence database⁵ does not indicate that HWA has been issued with any pollution prevention notices in regard to odour. On the assumption that there has not been a significant number of odour complaints post-upgrade, it would be reasonable to conclude that the risk of odour complaints remains the same.

4.2. MJM Environmental (2012) Ausplume Level 1 Air Quality Impact Assessment

MJM 2012 presents a Level 1 odour impact assessment to examine the potential for Morpeth WWTW to give rise to odour impacts at Lot 1011, Metford Road, Tenambit.

There are a number of technical issues with the MJM 2012 assessment, which means that it is not straight forward to extract the predicted 99th percentile 1-second average concentration at the proposed development site.

There is no receptor used in MJM 2012 that represents the proposed development site, although receptors S3 and S4 are noted to be broadly representative of the western boundary of the site (i.e. further away from the WWTW). Figure 10.3 of MJM 2012 (p22) shows the predicted 99th percentile 1-second average odour concentrations at five receptor locations including receptors S3 and S4, and the concentrations predicted are shown in Figure 10.3 to be less than 0.5 OU.

Interpretation of the data presented in Appendix B of MJM 2012 shows the following:

- Receptor S3 3.6 OU (100th percentile) 0.4 OU (99th percentile)
- Receptor S4 4.4 OU (100th percentile) 0.3 OU (99th percentile)

Whilst not directly comparable to the MWH 2013 report, the two reports show that the 100th percentile predictions are broadly comparable, and importantly does not contradict the MWH 2013 report.

⁵ <http://www.epa.nsw.gov.au/prpoeoapp/>

4.3. Maitland City Council (9 April 2013) Ordinary Meeting (Section 10.1 – DA 11-222)

The minutes of the MCC ordinary meeting regarding the above residential development includes extracts of further odour impact assessment reporting conducted for various purposes around the Morpeth WWTW, including:

- SLR Consulting Australia (5 February 2013) Odour Assessment – 62 Butchers Lane, Morpeth (630.10270-R1); and,
- Holmes Air Sciences (2008) Morpeth WWTW Final

Details of the SLR report is not available (the minutes present a single page extract showing the predicted odour isopleth plots only), and as such it is not possible to provide an opinion as to the adequacy of this assessment to represent the potential situation regarding the potential for odour from Morpeth WWTW to impact upon the proposed development site. However, it is evident that Maitland City Council was satisfied as to their adequacy in the past and approved the residential development at 62 Butchers Lane, which is significantly closer to the Morpeth WWTW than the proposed development site (pp47-49, 62-63).

The 2008 Holmes Air Sciences report was conducted on behalf of Hunter Water as part of the Stage 1 upgrading of the Morpeth WWTW. Page 11 of the HAS 2008 report predicted that at the existing residences on the subject site, predicted odour concentration would be 0.2 OU under normal operations with anaerobic areas covered. This is clearly less than the 2 OU criterion.

As above, the work performed by SLR Consulting and Holmes Air Sciences (now Pacific Environment Limited) do not contradict the MWH 2013 study.

5. CONCLUSIONS

5.1. Legislation

The defining control regarding the control of odour from the operation of the Morpeth WWTW is provided through the POEO Act (see Section 3.1), which is replicated into Condition L6.1 of Environmental Protection Licence No 10693:

Section 129 of the Protection of the Environment Operations Act 1997 provides that the licensee must not cause or permit the emission of any offensive odour from the premises...

The term 'offensive odour' is a defined term in the POEO Act, and does not mean "any odour":

"offensive odour" means an odour:

- (a) that, by reason of its strength, nature, duration, character or quality, or the time at which it is emitted, or any other circumstances:*
 - (i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*
 - (ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*
- (b) that is of a strength, nature, duration, character or quality prescribed by the regulations or that is emitted at a time, or in other circumstances, prescribed by the regulations.*

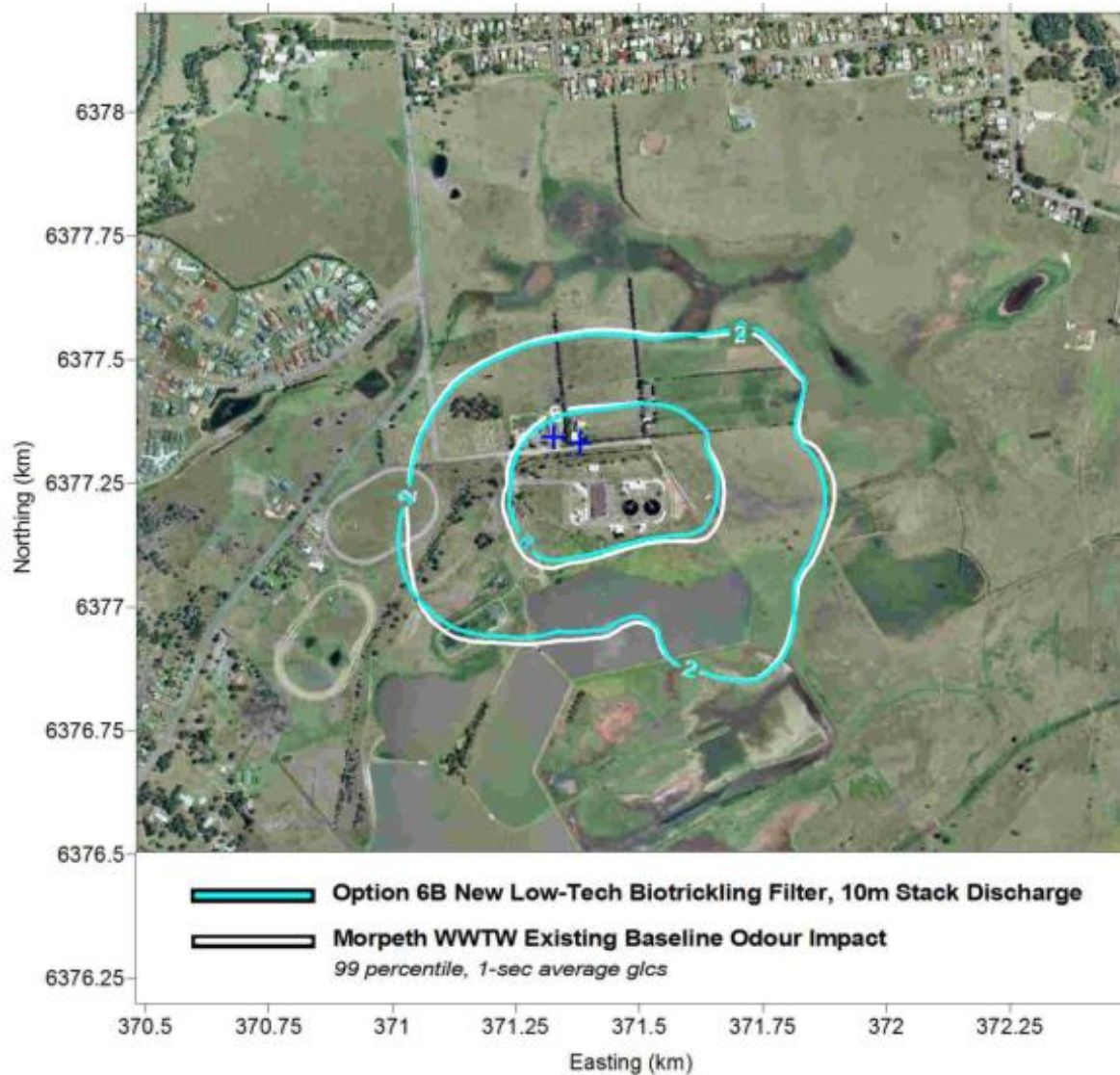
Environmental Protection Licence No 10693 (which regulates how the Morpeth WWTW operates) regulates the ongoing operational performance of the WWTW. The EPL contains relevant operational conditions to ensure that the actual operating performance of the WWTW (in terms of odour) is generally in line with the predictions presented in MWH 2013 (see Section 4.1 and Section 5.2).

5.2. Review of Technical Reports

Based upon the information available, it is concluded that the odour contour plots presented in MWH 2013 represent a reasonable and not contradicted assessment of the potential odour impact from the Morpeth WWTW. The assessment is based upon a range of on-site hydrogen sulphide measurements and MWH septicity modelling using HWC flow data, which provides reduced uncertainty regarding the emissions estimation used.

The predicted odour impacts presented in MWH 2013 is discussed in Section 4.1, and the graphics presented in MWH 2013 for the 99th percentile concentration values are reproduced below in Figure 2.

Figure 2 Predicted odour concentration plot as the 99th percentile 1-second average odour concentration (OU) (MWH 2013, Figure 6-4)



It may be determined that the predicted 99th concentration plots for the upgrade modelling scenario (option 6B) is virtually identical to that associated with the 'existing' (i.e. pre-upgrade) scenario, and accounting for the uncertainty of modelling of short-term metrics it should essentially be interpreted as the same result.

The MWH 2013 modelling report was prepared on behalf of HWC. Other modelling studies, including MJM 2012, SLR 2013 and HAS (2008) all show similar results, and this should be regarded as supporting evidence (i.e. non contradictory) to the validity of the MWH 2013 report.

On the basis of the above, Metford Road Pty Ltd has proposed a number of potential future land uses for the land at 37/39 Metford Road, Tenambit. These indicative layouts are reproduced in Appendix A, and each has the MWH 2013 2 OU odour concentration contour overlaid on the layout design.

It may be noted that in the proposed layout designs the proposed residential land uses are beyond the 2 OU odour contour and, based upon the above assumptions, they should not experience odour at a concentration exceeding 2 OU for more than 1% of the year. The portion of the proposed development site that is predicted to be potentially impacted above the 2 OU criterion (notionally the north-eastern quadrant) is shown to be utilised as open space and/or storage use and not designated for residential uses.

In regard to the predicted odour impact plots, these should not be regarded as thresholds for “impact / no impact”. As discussed in Section 4.1, the MWH 2013 report indicates that a proportion of the site is predicted to be impacted by *some* odour at *some* time (predicted as the 100th percentile plot), although this is not the reference metric to determine ‘unacceptable odour impacts’. Figure 2 is essentially an odour risk plot, with a graduated scale of risk depending upon the corresponding odour concentration value as the 99th percentile, which, by definition allows for odour to exceed this value for 1% of the year. As discussed previously that may not necessarily be interpreted as an event that will lead to an odour complaint, or even an odour detection, as that depends on a range of other factors such as the “strength, nature, duration, character or time” of that event.

However, based upon the above, it is my opinion that the proposed options for the residential development of the land at 37/39 Metford Road, Tenambit (see Appendix A) are not conflicted by the HWC odour impact assessment which is reported in MWH 2013, and the proposed residential development should not be refused on the grounds of potential odour impact from the Morpeth WWTW.

5.3. Recommendations

It is recommended that the proposed development schemes may be enhanced by including a number of designs that would assist to reduce the potential risk of odour impacting the site, including the following.

- Development control that selectively moves land uses that may potentially be more sensitive to odour impacts or those that may provoke stronger responses to locations further away from the sources (such land uses may include facilities for child care which may provoke protective responses).
- Preferential landscaping that may include bunds and/or dense vegetative screens to offer a visual screening of the Morpeth WWTW from the proposed development site.
- The planting of dense, multi-layered vegetated screens between the Morpeth WWTW and the proposed development site would assist in the dispersion of odour due to the physio-chemical absorption of odorants onto the vegetation and enhanced plume dispersion caused by increasing air turbulence as it passes through / over the vegetated screen. The potential for screens to help manage odour impacts are observed, although the effects are difficult to quantify. However, the effect of near-ground air turbulence (‘mixing’) is recognised as a preferable odour dispersion condition to flat ground that may promote plume pooling or adiabatic drainage flows.

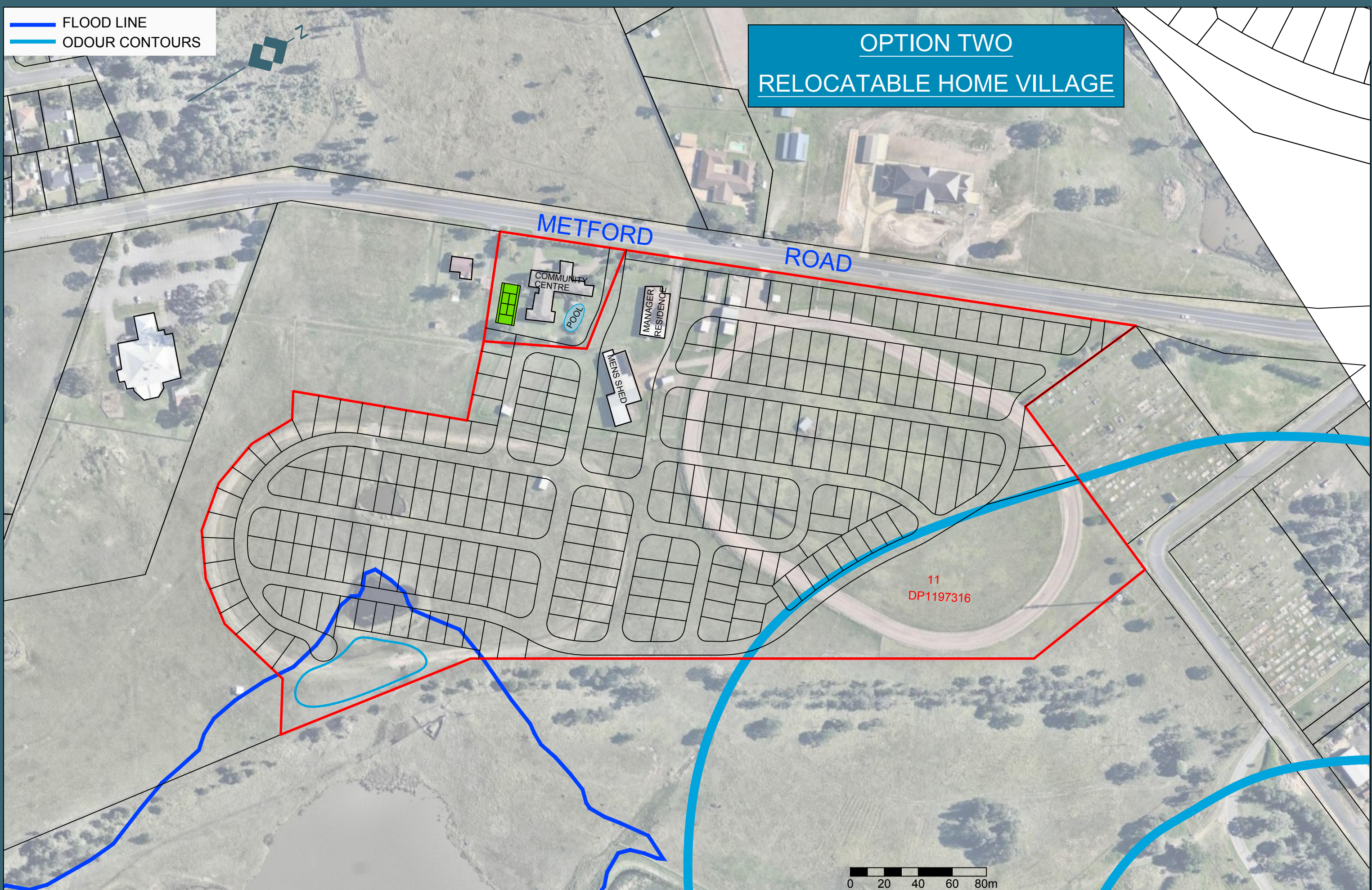
Whilst offering improved odour management in the pathway of emitted odours, the above may also enhance the overall amenity value of the site, generating a cost-effective improvement.

Ultimately however, the onus for odour control is not on the land owner but on the owner of the source of odour, which in this case is restricted through an Environmental Protection Licence of giving rise to offensive odour beyond the site boundary.

APPENDIX A – PROPOSED DEVELOPMENT LAYOUTS

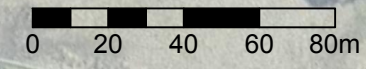
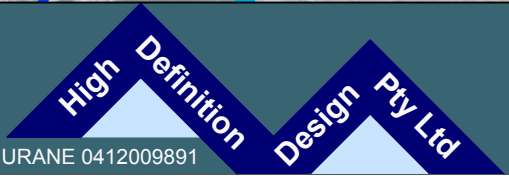
FLOOD LINE
ODOUR CONTOURS

OPTION TWO
RELOCATABLE HOME VILLAGE



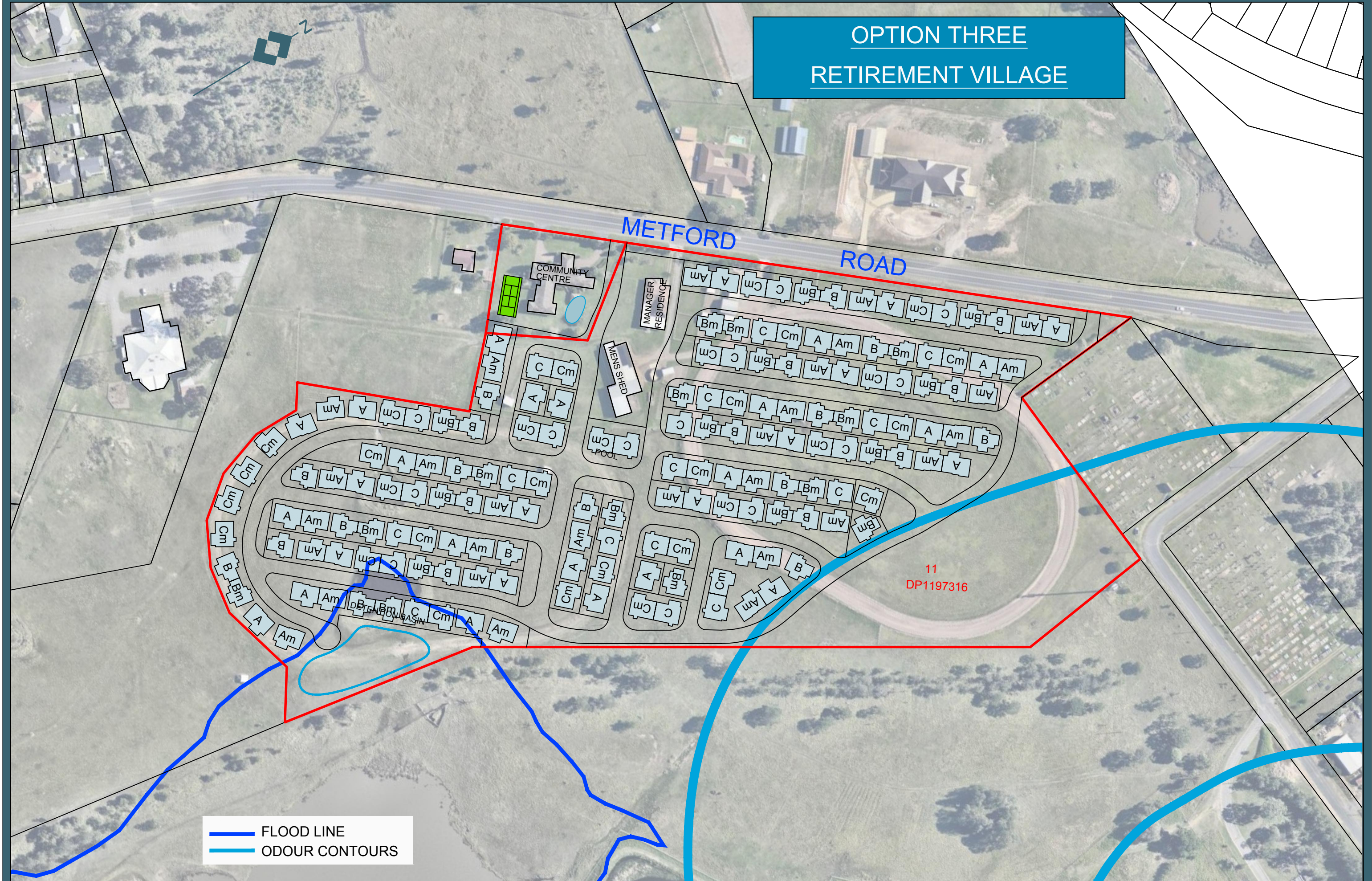
TITLE: MELROSE DRIVE
TENAMBIT

KEVIN URANE 0412009891



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|----------|----------------------------------|--------|-----------|-----------|----|-------------|--------|
| Date: | 13.04.16 | Scale: | 1:2000 A3 | Designed: | KU | Project No: | HD56 |
| Cad Ref: | HD56 mobile home village 18-5-16 | | | | | Drawing No: | 2-HD03 |
| | | | | | | Revision: | 1 |
| No | Amendment | Drawn | Date | | | | |
| 1 | ORIGINAL ISSUE | KU | 04.07.16 | | | | |

OPTION THREE RETIREMENT VILLAGE



— FLOOD LINE
— ODOUR CONTOURS

TITLE: MELROSE DRIVE
TENAMBIT

High Definition Design Pty Ltd
 KEVIN URANE 0412009891

| | | | | | | | |
|----------|--------------------------------|------------|----------------|-----------|----|-------------|--------|
| Date: | 13.04.16 | Scale: | 1:5000 A3 | Designed: | KU | Project No: | HD56 |
| Cad Ref: | HD56 retirement villas 18-5-16 | | | | | Drawing No: | 3-HD03 |
| | | | | | | Revision: | 1 |
| No: | 1 | Amendment: | ORIGINAL ISSUE | Drawn: | KU | Date: | 4.7.16 |
| | | | | | | | |

APPENDIX B – CV

Gary Graham

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qualifications

- Bachelor of Science with Honours BSc (hons), Environmental Science, 1992
- Master of Science (MSc), Wastes Management, 1994
- Chartered Scientist (CSci)
- Chartered Environmentalist (CEnv)
- Chartered Water and Environmental Manager (C.WEM)

membership

- Elected Executive Member of Clean Air Society of Australia and New Zealand (CASANZ) Council, CASANZ Treasurer
- Elected Member of Clean Air Society of Australia and New Zealand (CASANZ) Committee for NSW, NSW Treasurer
- Member of the Chartered Institution of Water and Environmental Management (MCIWEM)
- Institute of Acoustics Certificate and Competence in Environmental Noise Measurement (IoA CoC)

special expertise

Gary provides a range of expertise including:

- Expert witness, testimony and evidence
- Peer review of technical reports
- Air quality impact assessment
- Air quality monitoring programs
- Odour and dust management
- Indoor air quality and occupational exposure
- Process due diligence and Industrial regulation
- Management of Environmental Impact Assessment studies and planning applications

background

Gary is a Director with Northstar and has over 20 years' experience in consulting environmental science with a specialism in air quality management.

He is a Chartered Scientist (CSci), Chartered Environmentalist (CEnv), Chartered Water and Environmental Manager (C.WEM MCIWEM) and a certified project manager with extensive experience in multi-disciplinary consultancy with an emphasis within the air quality, environmental permitting, compliance, environmental planning and waste management sectors. He has significant expertise in matters relating to odour management.

He has provided technical and management advice to a broad cross-section of clients, including the World Bank, European Bank for Reconstruction and Development, central government agencies in Europe and Australia, (including Australian DOD, NSW DECCW/EPA, INSW, UK DEFRA and Highways Agency), local government, development agencies, energy, industry, infrastructure, wastewater, and urban renewal sectors.

He has substantial experience in advising clients through the environmental assessment process, and has directed and managed multi-disciplinary Environmental Assessments for a wide range of developments, including being lead environmental advisor and co-ordinator for the master-planning of a £5.5 billion urban renewal development in NW England.

He regularly provides peer review services on behalf of Councils and other stakeholders, and frequently provides expert witness, testimony and evidence in Australia on air quality, dust, odour and spray drift matters. He has provided significant representation at Public Inquiry in the UK in relation to air quality impacts from road infrastructure developments.

selected project experience



Agribusiness

- Intensive Poultry Facility, Peer Review, WA
- Intensive Poultry Facility, Peer Review and Expert Witness, VIC
- Equine Odour Risk Assessment, NSW
- Pig Rearing Facility Peer Review (1), WA
- Blayney Abattoir, NSW
- Broiler Farm Peer Review, Dungog, NSW
- Pig Rearing Facility Peer Review (2), WA
- Westmere Grains, VIC
- Walfertan Tannery Odour Assessment, Expert Witness, NSW
- Kurri Kurri Viniculture Spray Draft Assessment, NSW
- Carbon Foot-printing Tool, UK

Clients in this sector include: 360 Environmental, Australian Turf Club, Darley Estates, Shire of Serpentine Jerrahdale, Hunter Thoroughbred Breeders Association, Saines Lucas Solicitors, TFE Pastoral Company, UK Horticultural Association.



Resources & Waste

- East Arm Waste Transfer Station Risk Assessment, NT
- Cleanaway, Erskine Park Waste Transfer Station, NSW
- Boral Kooragang Concrete Batching Plant, NSW
- Bingo Waste Transfer Stations (St Marys, Mortdale), NSW
- Institute of Quarrying Australia Field Booklet – Dust Management
- Woodlawn Bioreactor Project, NSW
- Eastern Creek Organic Resource Recovery Facility, NSW
- Redhill Waste Management Facility, WA
- Tropicana Gold Mine, WA
- Area C Iron Ore Mine, WA

- Rockdale Waste Transfer Station, NSW
- Kemps Creek Alternative Waste Treatment Facility, NSW
- Carrow/Koppio Project, SA
- Chullora, Resource Recovery Park,
- North Ryde Resource Recovery Centre, NSW
- Wafi Golpu, PNG
- Metropolitan Colliery Independent Auditor NSW
- P'nyang Project, PNG
- Eastern Creek Landfill Odour Assessment, NSW
- Genesis Landfill, Expert Auditor, NSW
- Centennial Coal Company, PRP Assessments, NSW
- Roy Hill Iron Ore Project, WA
- Peabody Energy, PRP Assessments, NSW
- FMG Solomon, WA
- Tropicana Gold Project, WA
- Boral Scoresby, VIC
- Drayton South Peer Review, NSW
- Hidden Valley Mine Project, PNG
- Tamparkan Project, Philippines
- Woodsreef Mine Rehabilitation Project, NSW
- Waste Management Centre, Expert Opinion, NSW
- Cavehill Quarry, VIC
- Donald's Mineral Sands, VIC
- Wagga Wagga Sand and Gravel Extraction, NSW
- Bigryli Uranium Exploration Project, NT
- East Guyong Quarry, NSW
- UHG Phase II Mine Extension, Mongolia
- Pre-Acquisition Advice, UK
- Energy from Waste Plant PPC, UK
- Blue Circle Compliance Program, UK
- NEWS Loss of Amenity Study, UK
- Assessment of the Risks to Human Health of Waste Transfer Stations, UK

Clients in this sector include: Aggregates UK Energy Resources, Anglo Gold Ashanti, APP Corporation, BHP BIO, Blue Circle, Coffey International, Eastern Metropolitan Regional Council, Energy Metals, Environmental Earth Sciences, Gamut Consulting,

Hanson, Hunter Thoroughbred Breeders Association, Institute of Quarrying Australia, Mongolian Mining Corporation. Norfolk Environmental Waste Service, NSW DPE, NSW EPA, NSW Dept of Mines, NSW WAMC, Peabody Energy, Port Stephens Council, Roy Hill Iron Ore, SITA, Tellus Holdings, UK Environment Agency, Vallance.



Property

- Childcare Centre, Expert Witness, NSW LEC
- Kitchen Exhaust Ventilation Assessment. Expert Witness, NSW DC,
- Beerwah Land Sterilisation Investigation, QLD
- Marsden Park North Development, NSW
- Leppington Precinct Development, NSW
- South Orange Urban Release Area, NSW
- Oakdale Central Development, NSW
- Warehouse and Distribution Facility, Chullora NSW
- Berry's Bay Marina Project, NSW
- Equine Development, Peer Review and s.34 Conferencing, NSW
- Wilton Junction Land Use Mapping, NSW
- Oakdale West Development, NSW
- Mercure Odour Audit, NSW
- Crowne Plaza Hunter Valley Brewery Odour Assessment, NSW
- Willoughby Council Compliance Assessment, NSW
- Crowne Plaza Newcastle Brewery Odour, NSW
- Hurricanes Bar & Grill Odour Management, Darling Harbour, Bondi, Brighton-le-Sands, NSW
- Bungarabee Estate Data Centre, NSW
- Ridges World Square Schwartz Brewery Odour Audit, NSW
- Residential Risk Assessment, Peer Review, NSW
- Odour Risk Assessment, Peer Review, NSW
- McDonalds Retained Odour Expert, Expert Witness LEC Multiple Sites, NSW
- Catherine Fields Part Precinct, NSW

- Smash Repair Facility Odour Peer Review, Peer Review, NSW
- Brooklyn Child Care Centre, NSW
- Countess of Chester Health Park Environmental Expert, UK
- Bacton Homes Background Environmental Studies, UK
- Environmental Auditing (Pre-acquisition), UK

Clients in this sector include: Bellway Homes, Camden Council, City of Sydney Council, Elton Consulting, English Partnerships, GAT & Associates, Geolyse, Goodman, Hosking Munro, Hurricanes, JBA Planning, Kamrani Estates, NSW DPE, NSW EPA, NSW Land and Environment Court (direct appointment), Port Stephens Council, Shine Pre-School, Valad Property Group, Worley Parsons, Willoughby Council.



Transport & Infrastructure

- NorthConnex Peer Review, NSW
- Lower Main North Quadruplication Lite, NSW
- Sydney Harbour Bridge Lead Paint Removal Compliance and Verification, NSW
- Capital Metro Stage 1 EIS, ACT
- WestConnex Peer Review, NSW
- NorthWest Rail Link, Baseline Program, NSW
- Kranji Marshes, Singapore
- Toowoomba Second Range Crossing, QLD
- Sentosa Gateway Junction Project, Singapore
- JSF Impact Assessment, NSW, NT, QLD, SA, WA
- Enfield Intermodal Logistics Centre, NSW
- North Ryde Transport Orientated Development, NSW
- Enfield to Chatswood Rail Line, NSW
- Mitchell's Transportation Efficiency Project, WA
- M1 Motorway Service Station, NSW
- Brisbane North Guided Busway, QLD
- RAAF Williamtown AQ Program Review, NSW
- New Raynesway Grade Separated Junction Expert Witness, UK

- Manchester Airport Freight Forwarding Unit EIA, UK
- Farnworth Multi-Use Development UK
- Manchester Airport Terminal 3 Apron Extension EIA, UK
- Beverley Southern Relief Road EIA, UK
- A1 Dualling and Realignment Stage 2/3, UK
- Templeborough Estates EIA, UK
- Denbigh Multi-Use Development EIA, UK
- Liverpool Water Environmental Co-ordinator, UK
- Preston East Employment Park EIA, UK
- ForthQuarter Development EIA, UK
- Liverpool Garden Festival EIA, UK
- Merseytravel Mersey Rapid Transit EIA, UK
- Bishkek Public Transport Assessment, Ministry for Transport, Kyrgyzstan
- Woolston Riverside EIA, UK
- WWTW Odour Impact Assessment (multiple sites), UK
- Lower Liffey Crossing, Eire
- M60 Improvement Program J12-J18, UK
- Local Air Quality Management, AQRA, Local Authorities (numerous) UK

Clients in this sector include: Australian DoD, Bank of Ireland, Camden Council, Cathco Property Group, East Riding of Yorkshire Council, EG Property Group, ForthQuarter plc, Grampian Water, Hornsby Shire Council, Jaguar Estates, Kamrani Estates, Langree Housing, Lend Lease, Manchester Airport plc, Merseytravel plc, Mitchell's, NSW DPE, NSW EPA, NSW Land and Environment Court (direct appointment), NSW Ports, Peel Group, QLD DTMR, South East England Development Agency, Strathfield Council, Sydney Harbour Bridge Alliance, Sydney Water, Transport for NSW, UK Highways Agency, Urbis, Yorkshire Water, World Bank / EBRD.



Industry

- APC Performance Evaluation Insurance Advice, NSW
- Boral Kooragang Island Materials Recycling Facility, NSW
- Bayswater Concrete Batching Plant, Expert Witness, WA SAT
- Fire and Rescue Compartmental Fire Behaviour Training Facility, NSW
- Frenchs Forest Bushland Crematorium, NSW
- Crash Repair Facility, Peer Review and s34 Conferencing, NSW
- Pentarch Munitions Disposal Project, NSW
- Orica Accidental Ammonia Discharge, Peer Review and Expert Opinion, NSW
- Boral Scoresby Opportunities and Constraints Assessment, QLD
- Port of Melbourne Peer Review, VIC
- Tuggeranong Crematorium, ACT
- VOC Exposure from Household Sources NSW EPA, NSW
- Boral Berrima Cement Works, NSW
- Nuplex POEO Review, NSW
- Boral Granville Concrete Batching Plant, NSW
- Givaudan Odour Management, NSW
- HCMC Bakery Odour Assessment, Vietnam
- Hunter River Remediation Project Compliance Program, NSW
- Walfertan Tannery Odour Assessment, Expert Witness, NSW
- Adelaide Desalination Plant Environmental Management Plans, SA
- Nestlé, Hayes Odour Management, UK
- Nestlé, Burton-on-Trent, Odour Management, UK
- Quinn Radiators, UK
- Ford Dagenham Compliance Program, UK
- Ford Halewood Compliance Program, UK
- Ardagh Glass, UK
- Humber Energy / Fibres Worldwide PPC, UK
- British Steel / Tata Compliance Program, UK

- UK HMIP / Environment Agency Clinical & Chemical Incineration Sector Compliance Program

Clients in this sector include: AB Mauri, Ardagh Glass, British Steel / Tata Steel, City of Sydney Council, Darley Stud, Environmental Property Services, Fibres Worldwide, Ford Motor Company, Givaudan, Ignite Architects, Moray & Agnew, Nestlé, NSW Fire and Rescue, Nuplex, Pentarch, Port of Melbourne Corporation, Quinn Radiators, SA Water, Theiss, WA Limestone, UK Environment Agency.



Energy

- Port Hedland Power Station, WA
- Sydney Exhibition Centre at Glebe Island, NSW
- West Qurna II Gas Field Development, Iraq
- LGI Landfill Flare Assessments, NSW
- Geelong Refinery Semi-Quantitative Occupational Risk Assessment, VIC
- Solomon Project, WA
- Santos Fairview CS1&2 LNG, QLD
- Immingham Gas Terminal Compliance Program, UK
- Industrial Regulation Advice, UK
- PFI Hospital Site GHG Emissions Trading Scheme Applications, (multiple sites) UK
- Bioverda Energy EIA, PPC, COMAH Assessments, UK
- Isles of Scilly Waste from Energy Plant, UK
- Stockton Energy from Waste, UK
- Tees valley Biofuels Seed Crushing Plant, UK

Clients in this sector include: Atlinta Energy, Balfour Beatty Capital Projects, Bioflame, Bioverda Energy, Coffey International, FMG, Immingham Gas Terminal, INSW, Jersey States, Landfill Gas Industries, Lend Lease, Santos, Shell, SUEZ, Tees Valley Biofuels.

publications

Balch A, Graham G & Knaggs B, *FIDOL Factors, Odour Nuisance and Risk: The Adaptation of Field Based Odour Assessments using a Field Olfactometer* Proceedings of the 22nd International Clean Air and Environment Conference, Melbourne 2015

Rahaman F, Lawrence K, Starke G, Graham G & Doyle M, *Estimation of Odour Emissions from Broiler Farms – An Alternative Approach* Proceedings of the 21st Clean Air Society for Australia and New Zealand, Sydney 2013

Graham G, Lawrence K & Doyle M, *Development of Odour Impact Assessment Methodologies Accounting for Odour 'Offensiveness' or Hedonic Tone* Proceedings of the 21st Clean Air Society for Australia and New Zealand, Sydney 2013

Graham G, & Lawrence K, *Managing Emissions to Air* Monograph 28 - Australasian Mining and Metallurgical Operating Practices (AMMOP) - Third Edition, Published by The Australasian Institute of Mining and Metallurgy, 2013

Graham G *Sensitivities in Assessing Cumulative Impacts from Extractive Processes* Proceedings of the 4th Annual Dust Management Strategies, Brisbane, Australia, 2010

Bradbeer E, Clayton J, Graham G & Wood S, *Cost Effective Health Risk Assessments: An Occupational Health and Safety Approach* Proceedings of the 5th International Workshop on Chemical Bioavailability in the Environment, Adelaide, Australia 2009

Martin Doyle

Director

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qualifications

- PhD Air Quality Meteorology (University of East Anglia, UK, 2004)
- BSc (Hons) Environmental Science (University of East Anglia, UK, 1998)
- Certified Air Quality Professional (CAQP), Clean Air Society of Australia and New Zealand (CASANZ)

membership

- CASANZ NSW Branch Committee member 2007 - 2012
- CASANZ NSW Branch Training Activities Coordinator 2007 - 2012
- CASANZ Federal Deputy Chair Training Activities Executive 2008 - 2010

special expertise

Martin provides a range of expertise including:

- Air quality and greenhouse gas impact assessment
- Dispersion modelling studies including a range of specialist software
- Ambient air quality and meteorology studies
- Satellite remote sensing
- Geographical Information Systems (GIS)
- Indoor air quality and occupational exposure assessment
- Process & air pollution control due diligence and testing
- Odour impact assessment and audit
- Climate change impact assessment
- Expert testimony and witness
- Independent peer review and audit

background

Martin has over 16 years of experience in the field of air quality, from academic research to public and private environmental consultancy. He completed his doctorate in 2004 in the area of air pollution meteorology and was a Senior Research Associate at the University of East Anglia, which has the UK's highest rating for the quality of environmental research undertaken. His work has been included in UK Department of the Environment, Food and Rural Affairs Air Quality Expert Group state-of-science reports on PM₁₀ and NO₂.

His major areas of expertise include air quality monitoring (including monitoring network design and data analysis), emissions inventory development, atmospheric dispersion modelling (using TAPM, CALPUFF, AUSPLUME, CALINE and AERMOD), greenhouse gas assessment and climate change impact assessment, independent peer review and performance of audits.

Martin has significant experience across all sectors (see overleaf) and broad experience in assessment of air pollutants including odour.

Use of Geographical Information Systems (GIS) and other software to present data to non-specialists in easy to understand formats is one of Martin's key interests.

selected project experience



Agribusiness

- Blayney Abattoir, NSW
- Bourke Small Stock Abattoir, NSW
- The Ranch Poultry Complex, NSW
- Abattoir and Rendering Plant, NSW
- Maylands Poultry Farm, NSW
- Milk Production Facility, NSW
- Serpentine Poultry Farm Expansion, WA
- Westmere Grains, VIC

Clients in this sector include: CAPRA Development, Dairy Farmers, Darmad, Saines Lucas Solicitors, Scolexia, Thomas Foods International Tamworth.



Resources & Waste

- East Arm Waste Transfer Station Risk Assessment, NT
- Erskine Park Waste Transfer Station, NSW
- Bingo Waste Transfer Stations (St Marys, Mortdale), NSW
- Albion Park Quarry, NSW
- Glenfield Waste Services Materials Recycling Facility, NSW
- Kemps Creek Alternative Waste Treatment Facility, NSW
- Twinza Oil Project, PNG (GHG)
- Wafi Golpu Project, PNG (GHG)
- P'nyang Project, PNG (GHG)
- Mandalong Southern Extension Project, NSW
- Springvale Mine Extension Project, NSW
- Angus Place Mine Extension Project, NSW
- Lidsdale Siding Extension Project, NSW
- Airly Mine Extension Project, NSW
- Clarence Colliery REA V Project, NSW
- Northern Coal Logistics Project, NSW
- Neubeck Coal Project, NSW
- Karuah Quarry East Expansion Project, NSW
- Jandra Quarry Expansion Project, NSW
- Woodsreef Mine Rehabilitation Project, NSW
- Eastern Creek Organic Resource Recovery Facility, NSW
- Centennial Coal Company, PRP Assessments, NSW
- Peabody Energy, PRP Assessments, NSW
- Solomon Project, WA
- Carrow/Koppio Project, SA
- Area C Iron Ore Mine, WA
- Ace Landscapes Dust Management, NSW
- Redhill Waste Management Facility, WA
- Dromana Landfill, Mornington Peninsula, VIC
- Tropicana Gold Mine, WA
- Woodlawn Bioreactor Project, NSW
- Bigryli Uranium Exploration Project, NT
- Narrabri Coal Project, NSW
- Roy Hill Iron Ore Project, WA
- Glebe Island Bulk Sands Project, NSW
- Duralie Coal Mine Extension Project, NSW
- Cavehill Quarry, VIC
- Central Coast Sands, NSW
- Donalds Mineral Sands, VIC
- Brickworks (Client Confidential), VIC
- Sepon Gold and Copper Mine, Laos
- Werris Creek Coal Mine, NSW
- East Guyong Quarry, NSW
- Darling Downs Sand Extraction Project, QLD
- Belmont and Sunnyside Coal, NSW
- Whitehaven CHPP, NSW
- Wagga Wagga Sand and Gravel Extraction, NSW
- Roy Hill Iron Ore, WA
- Solomon Iron Ore Project, WA
- Leongatha Quarry Extension, VIC (GHG)
- Narrabri CSG Power Plant, NSW (GHG)
- Sunnyside Coal Project, NSW (GHG)

Clients in this sector include: Ace Landscapes, Anglo Gold Ashanti, APP Corporation, BHP BIO, Boral, Centennial Coal Company, Cleanaway, Cleary Bros, Coffey International, Energy Metals, Environmental Earth Sciences, Environmental Property Services, EMRC, Erias Group, ExxonMobil, Fortescue Metals Group, Hanson, Holcim, NSW Department of Mines, Peabody Energy, Roy Hill Iron Ore, SUEZ Australia, Tellus Holdings Ltd, Veolia, Whitehaven Coal, Xstrata.



Property

- Horsley Drive Business Park Warehouse and Distribution Facility, NSW
- Marsden Park North Development, NSW
- Survitec Development Application, NSW
- Tyres4U Development Application, NSW
- Leppington Precinct Development, NSW
- Emerald Hills Development, NSW
- Trinity Point Marina Project, NSW
- South Orange Urban Release Area, NSW
- Warehouse and Distribution Facility, Chullora NSW
- Berrys Bay Marina Project, NSW
- Culburra STP, NSW
- Oakdale Central Development, NSW
- Oakdale West Development, NSW
- Acacia Ridge Campus AQ Investigation, QLD
- Wilton Junction Land Use Mapping, NSW
- Bungaribee Estate Data Centre, NSW
- Orange Pump Station No.1, NSW
- North Orange Pump Station, NSW
- Crowne Plaza Newcastle Brewery Odour, NSW
- Crowne Plaza Hunter Valley Brewery Odour Assessment, NSW
- P&N Beverages Odour Assessment, NSW
- Hurricanes Bar & Grill Odour Management, Darling Harbour, Bondi, Brighton-le-Sands, NSW
- Ridges World Square Schwartz Brewery Odour Audit, NSW
- Newtown Hotel Odour Audit, NSW
- Leppington Part Precinct, NSW

- Currarong Sewerage Scheme - CEMP audit, NSW
- Brooklyn Child Care Centre, NSW
- Emirates Wolgan Valley Resort - CEMP audit, NSW
- Fairfield RSL - Environmental Audit, NSW
- VOC Monitoring, Reserve Bank of Australia, NSW
- Great Barrier Reef Marine Park Authority, QLD (GHG)

Clients in this sector include: ADW Johnson, Cardno, City of Sydney Council, Commercial & Industrial Property Group, Elton Consulting, Frasers Property Group, Geolyse, Goodman, Hosking Munro, JBA Planning, Meriton, Mirvac, QLD DPW, Shine Pre-School, Urbis, Worley Parsons.



Transport & Infrastructure

- WestConnex Peer Review, NSW
- NorthConnex Peer Review, NSW
- Lower Main North Quadruplication Lite, NSW
- Epping to Chatswood Rail Line, NSW
- Enfield Intermodal Logistics Centre, NSW
- Northern Coal Logistics, NSW
- Capital Metro Stage 1 EIS, ACT
- Solomon Project Road Transportation Study, WA
- Sydney Harbour Bridge Lead Paint Removal Compliance and Verification, NSW
- North Ryde Transport Orientated Development, NSW
- Enfield to Chatswood Rail Line, NSW
- M1 Motorway Service Station, NSW
- Mitchell's Transportation Efficiency Project, WA
- Enfield Intermodal Logistics Centre, NSW
- M2 Upgrade, Sydney NSW
- Majura Parkway, ACT
- Clarrie Hermes Drive Extension, ACT

Clients in this sector include: Centennial Coal, EG Property Group, Fortescue Metals Group, Goodman, Hornsby Shire Council, Leightons Contractors, McDonalds Australia, Mitchell's, NSW Ports, P&N Beverages, Parsons Brinkerhoff, SMEC, Strathfield Council, Sydney Harbour Bridge Alliance, Transport for NSW, Urbis.

- Powergen, UK
- TXU Energi, UK

Clients in this sector include: Alinta Energy, Coffey International, Fortescue Metals Group, GHD, NSW Department of Planning and Environment, Infracore Energy, Santos.



Industry

- Boral Kooragang Island Materials Recycling Facility, NSW
- Frenchs Forest Bushland Crematorium, NSW
- Boral Scoresby Opportunities and Constraints assessment, QLD
- Bluescope Steel PRP Assessment, NSW
- Pentarch Munitions Disposal Project, NSW
- Shoalhaven Starches Odour Audit, NSW
- Boral Granville Concrete Batching Plant, NSW
- Tuggeranong Crematorium, ACT
- Vopak Terminals PRP Assessment, NSW
- Eastern Asphalt Plant, Bairnsdale VIC
- Givaudan Odour Management, NSW
- Allens Asphalt, QLD
- SIMS Metal, QLD
- Metals Recycling Facility, NSW

Clients in this sector include: Bluescope Steel, Boral, Canberra Cemeteries, Environmental Property Services, Givaudan, Ignite Architects, Pentarch, Shoalhaven Starches, Vopak.



Energy

- Port Hedland Power Station, WA
- Solomon Project, WA
- West Qurna II Gas Field Development, Iraq
- Munmorah & Bayswater B Independent Peer Review, NSW
- Santos Fairview CS1&2 LNG, QLD
- Bamarang Power Station, NSW (including Plume Rise Assessment)

publications

Rahaman F, Lawrence K, Starke G, Graham G & Doyle M, *Estimation of Odour Emissions from Broiler Farms – An Alternative Approach* Proceedings of the 21st Clean Air Society for Australia and New Zealand, Sydney 2013

Graham G, Lawrence K & Doyle M, *Development of Odour Impact Assessment Methodologies Accounting for Odour 'Offensiveness' or Hedonic Tone* Proceedings of the 21st Clean Air Society for Australia and New Zealand, Sydney 2013

Doyle M & Dorling SR, *Particulate Pollution: New Perspectives on Measurement, Source Apportionment and Policy*, Proceedings of the 5th Urban Air Quality Conference, Valencia, Spain, 2005

Doyle M & and Dorling SR, *Meteorological Classification and Aggregation Approaches in Support of Models-3 Air Quality Simulations*, Proceedings of the 4th International Conference on Urban Air Quality. Prague, Czech Republic, pp424-427, 2003

Chatterton T, Dorling SR, Doyle M et al. *A Rigorous Inter-comparison of Ground-level Ozone Predictions*, Atmospheric Environment 37, 3237-3253, 2003

Doyle M & and Dorling SR, *Visibility Trends in the UK 1950 -1997*, Atmospheric Environment, 36, 3161-3172, 2002

Doyle M & and Dorling SR, *Satellite and Ground Based Monitoring of Aerosol Plumes*, Water, Air and Soil Pollution, Volume 2, Numbers 5-6, pp615-629, 2002