Appendix 3: Technical Expert Report – Noise

Government of Western Australia
Department of Environment Regulation

REPORT

Richgro Garden Products

Noise Regulation Technical Advice: Richgro Garden Products – 203 Acourt Road, Jandakot – Acoustic Assessment

Version: Final

October 2016

Document control

Document version history

Date	Name	Role
26/10/16	Jingnan Guo Senior Noise Regulation Officer	Author
03/11/16	Emma Bridgeman Manager Noise Regulation	Reviewer

Corporate file information

File number and/or name	File owner or custodian	File location
2010/008321	Waste Industries	Atrium

Produced and published by
Department of Environment Regulation
168 St Georges Terrace, Perth, Western Australia

June 2016

Disclaimer
The information contained in this document is provided by Department of Environment Regulation in good faith. However, there is no guarantee of the accuracy of the information contained in this document and it is the responsibility of users to make their own enquiries as to its accuracy, currency, relevance and correctness.

The State of Western Australia and Department of Environment Regulation and their servants and agents expressly disclaim liability, in negligence or otherwise, for any act or omission occurring in reliance on the information contained in this document, or for any incident or consequential loss or damage of such act or omission.

The State of Western Australia is committed to providing quality information and has made every attempt to ensure the accuracy, currency, reliability and correctness of the information contained in this document. However, changes in circumstances and legislation after the time of publication may impact on the correctness or quality of this information.

In addition the accuracy, currency, reliability and correctness of links or references to information sources referred to or provided by third parties is outside the control of State of Western Australia and it is therefore the responsibility of the user to make their own decisions on information found on those external sites. Confirmation of any of the information provided in this document may be sought from the relevant originating bodies or the department providing the information; however, users of this material should verify all relevant representations, statements and information with their own professional advisers.

The State of Western Australia and Department of Environment Regulation reserve the right to amend the content of this document at any time without notice.

The information contained in this document is general. It does not constitute, and should be not relied on as, legal advice. The State of Western Australia recommends that users of this information seek advice from a qualified lawyer on the legal issues affecting them before relying on this information or acting on any legal matter.

Questions regarding this report should be directed to:
Department of Environment Regulation
Locked Bag 33 Cloisters Square
PERTH WA 6850
Phone: +61 8 6467 5000
Fax: +61 8 6467 5562
Email: info@der.wa.gov.au
Web: www.der.wa.gov.au

Accessibility This document is available in alternative formats and languages upon request.

Contents

1. Purpose

The purpose of this report is to provide Noise Regulation technical advice in relation to the licence review of Richgro Garden Products located at 203 Acourt Road, Jandakot.

2. Documentation

Noise Regulation has been provided with and reviewed the follow documents in order to provide this advice:

Table 2.1 Documentation

Document title	Author	Date of document	Objective reference
Noise Assessment (AD Facility Commissioning) (Report No. 1415-229): Richgro Garden Products	Emission Assessments	5 June 2015	
Environmental Noise Assessment (Ref: 19170-1-13116): Richgro Jandakot – 2015 Operations Anaerobic Digester – for Emission Assessment	Herring Storer Acoustics (HSA)	12 May 2015	A1069451
Noise Emissions following Control (Ref: 18026-1-12116): Richgro Jandakot	Herring Storer Acoustics (HSA)	16 July 2014	A1084695
Odour, Air and Noise Survey Plan (Commissioning Phase) (Ref: 1314-123): Richgro Garden Products – Works Approval W 5311/2012/1; Licence Conditions 9, 10 and 11	Emission Assessments	3 September 2014	A803157
Licence L7308/1998/13	DER	17 October 2014	A823856
Works Approval W5311/2012/1	DER	18 July 2016	A1133769

3. Advice request summary

In preparing this advice Noise Regulation has been requested to specifically consider/address the items detailed in Table 3.1 below.

Table 3.1 Summary of specifically requested advice

No.	Item
1	Are the methodology and assumptions used in the Noise Report fit for purpose and sufficiently robust?
2	Where relevant, are all modeling inputs and assumptions fully justified and has modeling been undertaken appropriately?
3	What are the applicant's findings on the source of noise, including likelihood and consequence of the emissions?
4	Has the risk of noise been appropriately assessed, taking into account the emissions, pathways and receptors? Please summarise the applicant's findings on risk.

5	Are the controls proposed by the report sufficient at managing noise emissions?
6	Are the results and conclusions on noise emissions reasonable?
7	Has the occupier met compliance with the works approval conditions, namely that the noise assessment for all noise emissions is undertaken during Normal Operating Conditions, as well as ensuring that the following information has been provided: o methods used for noise monitoring at the premises in accordance with Part 3 of the *Environmental Protection (Noise) Regulations 1997*; o an assessment of whether noise emissions from the premises comply with the assigned levels defined in the *Environmental Protection (Noise) Regulations 1997*; and o proposed mitigation measures, actions to be taken and associated timeframes for implementation if the noise monitoring results indicate that noise emissions from the premises exceed the assigned levels.
8	If your assessment identifies that further information or clarification on the proposed controls, what specific questions can DER put to the applicant? Please state these clearly for inclusion in any written request for clarification that DER LAA sends to the applicant.
9	Please also comment on any other noise-related issues requiring consideration in relation to the licence amendment application, given that the premises already conducts mulching operations.

4. Advice

Condition 6 of the Works Approval W5211/2012/1 states:

ODOUR AND NOISE BASELINE ASSESSMENT

6 (a) The Works Approval Holder shall provide to the CEO an Odour and Noise Baseline Assessment Program for current operations on site. This Program shall include a proposed source and field assessment methodology for all noise and odour emissions generated at the premises.

(b) The Works Approval Holder shall ensure that the Odour and Noise Baseline Assessment required by condition 6(a) of this Works Approval shall be conducted and a report detailing the results provided to the CEO at least one month prior to commissioning of the works.

The Condition 9 and 10 of the same Works Approval further states:

NOISE ASSESSMENT OF OPERATIONS

9 During the commissioning stage, the Works Approval Holder shall conduct an assessment of all noise emissions occurring on site during Normal Operating Conditions.

10 On completion of commissioning the Works Approval Holder shall submit a Noise Assessment Report to the Director of the results required in Condition 9 of this Works Approval where the Noise Assessment Report shall contain, but not be limited to:

(i) methods used for noise monitoring at premises in accordance with Part 3 of the Environmental Protection (Noise) Regulations 1997;

(ii) an assessment of whether noise emissions from the premises comply

with the assigned levels defined in the Environmental Protection (Noise) Regulations 1997;

(iii) *proposed mitigation measures, actions to be taken and associated timeframes for implementation if the noise monitoring results indicate that noise emissions from the premises exceed the assigned levels.*

I understand that the noise assessment reports have been submitted to meet the above mentioned conditions.

General comments

The Herring Storer Acoustics (HSA) 2015 noise assessment report states that '*measuring noise emissions at adjacent residential premises for the existing Richgro operations and the AD Facility during flaring (100%) have been attempted but were dominated by background noise from aircraft from Jandakot airport*'. For this reason, noise measurement was only conducted at the Richgro site to measure the sound power levels of the major plant, which were then fed into the noise modelling to predict noise levels at the neighbouring noise sensitive premises. Hence, the assessment of the noise compliance was not conducted directly by measuring the noise levels at the neighbouring noise sensitive premises, but indirectly by the noise modelling.

This approach for demonstrating the noise compliance may be acceptable, if the actual noise emission levels at the neighbouring noise sensitive premises could not be measured. While I understand that Jandakot Airport is a busy airport and the frequency of the aircraft movements is high, there should be time periods that aircraft noise is not significant/dominating at these noise sensitive premises neighbouring the Richgro site. These time periods should provide opportunities for a proper measurement of the noise emitted from the Richgro site. I note that HSA was able to measure the noise from the Wood Hog shredder at Acourt Road in 2014, '*in the absence of significant other noise sources such as aircraft and barking dogs*'. Hence, it is likely a direct noise measurement to demonstrate the noise compliance could have been conducted in the 2015 assessment.

HSA has also stated "*It is noted that the reason why the assessment has been carried out by acoustic modelling (rather than measurement at noise sensitive premises) is to allow for 'worst case' wind conditions where maximum sound propagation conditions occur, and to permit assessment without the complexity of background noise from aircraft and barking dogs*". I would support the acoustic modelling incorporating the 'worst case' wind conditions to demonstrate noise compliance, particularly when the 'worst case' weather conditions were not observed during a site noise measurement. However, noise compliance is still required to be demonstrated by actual noise measurement at the noise sensitive premises. Noise modelling should only be used as a supplement to the actual measurement.

HSA states that there may be times when the noise emissions from the shredder will be 'tonal' at noise sensitive receiver locations. However, due to the prevalence of aircraft noise the tonal characteristic may be masked for ***some of the time*** and therefore no adjustment for tonality is required. While I agree that the tonal characteristic of the noise from the shredder may be masked by aircraft noise from time to time, there are periods that noise from aircraft movements is not significant and dominant, when the tonal characteristic of the noise from the shredder cannot be masked. An adjustment for tonality may be still required.

It is noted that residential development is occurring on the closest neighbouring lot to the north-west. HSA has identified that noise from Richgro may not be able to comply with the assigned noise level at this lot when the residential development is completed and occupied. HSA has proposed a bund adjacent to the AD Facility with the height at RL35.5 to address the noise non-compliance for this scenario, which may be sufficient.

It is predicted by HSA that *"there is potential from specific noisy equipment to contribute to an exceedance of the weekday 'assigned level' at some noise sensitive premises. This is due to the occasional use of a greenwaste shredder by Richgro"*. To address this potential noise non-compliance issue HSA states that: (1) the noise modelling was for 'worst case' wind conditions hence the actual noise level should be lower; and (2) the noise sensitive premises surrounding Richgro / AD Facility are currently exposed to significant aircraft noise from Jandakot Airport traffic and from the special 'dog precinct'. HSA does not expect noise emissions from the AD Facility to be intrusive at these receivers and hence has not proposed any noise mitigation measures to address this identified potential noise non-compliance. The statement that the noise emissions will not be intrusive is not supported as both aircraft noise and dog barking is intermittent and will not mask the shedder noise. Implementation of appropriate noise mitigation measures, as required by Condition 10(iii) of the Works Approval, remains relevant for the premises.

Answers to questions

My answers to the each of the questions are as below:

1. ***Are the methodology and assumptions used in the Noise Report fit for purpose and sufficiently robust?***

   As discussed in General comments, the assessment of the noise compliance was conducted indirectly by noise modelling, rather than direct noise measurement/monitoring at the noise sensitive premises.

2. ***Where relevant, are all modelling inputs and assumptions fully justified and has modelling been undertaken appropriately?***

   The modelling inputs and assumptions are appropriate. However, as stated above, noise compliance verification should be focused on noise measurement at the noise sensitive premises.

3. ***What are the applicant's findings on the source of noise, including likelihood and consequence of the emissions?***

   The major noise sources, including likelihood and consequence of the emissions seem to be identified correctly.

4. ***Has the risk of noise been appropriately assessed, taking into account the emissions, pathways and receptors? Please summarise the applicant's findings on risk.***

   The risk of noise has not been appropriately assessed, particularly in terms of tonality assessment and the potential noise non-compliance identified at some neighbouring noise sensitive premises

5. ***Are the controls proposed by the report sufficient at managing noise emissions?***

   A bund adjacent to the AD Facility with its height at RL35.5 has been proposed for the scenario when the residential development to the north-west is completed and occupied. This may be sufficient at managing the noise emissions for this particular residence, however no noise mitigation measures have been proposed for the potential noise non-compliance at other noise sensitive premises as required under Condition 10(iii) of the Works Approval. HSA's statement that "*the noise sensitive premises surrounding Richgro / AD Facility are currently exposed to significant aircraft noise from Jandakot Airport traffic and from the special 'dog precinct'. It is not expected that noise emissions from the AD Facility will be intrusive at these receivers*" may not be correct. No noise mitigation measures have been proposed for this potential noise non-compliance scenario.

6. ***Are the results and conclusions on noise emissions reasonable?***

   The modelled noise emission levels seem reasonable.

7. ***Has the occupier met compliance with the works approval conditions, namely that the noise assessment for all noise emissions is undertaken during Normal Operating Conditions, as well as ensuring that the following information has been provided:***

   - ***methods used for noise monitoring at the premises in accordance with Part 3 of the Environmental Protection (Noise) Regulations 1997;***
   - ***an assessment of whether noise emissions from the premises comply with the assigned levels defined in the Environmental Protection (Noise) Regulations 1997; and***
   - ***proposed mitigation measures, actions to be taken and associated timeframes for implementation if the noise monitoring results indicate that noise emissions from the premises exceed the assigned levels.***

   Please see comments above.

8. ***If your assessment identifies that further information or clarification on the proposed controls, what specific questions can DER put to the applicant? Please state these clearly for inclusion in any written request for clarification that DER LAA sends to the applicant.***

   The Works Approval holder could be required to redo the noise compliance assessment by measuring noise levels at the neighbouring noise sensitive premises under various operating and weather conditions. Because HSA has identified exceedence of the assigned levels through modelling, implementation of appropriate noise mitigation measures (as required by Condition 10(iii) of the Works Approval) remains relevant for the premises.

9. ***Please also comment on any other noise-related issues requiring consideration in relation to the licence amendment application, given that the premises already conducts mulching operations.***

   None.

5. Limitations

Technical expert advice in any field is subject to various limitations. Important limitations to the attached advice include:

- The noise modelling and the predicted noise emission levels presented by HSA have not been verified by the author.

Signatures

Author Name Jingnan Guo	Signature [redacted]
Position Senior Noise Regulation Officer	Date [redacted]
Reviewer Name Emma Bridgeman	Signature [redacted]
Position Manager Noise Regulation	Date [redacted]

Appendix 4: Technical Expert Report – Groundwater

Government of **Western Australia**
Department of **Environment Regulation**

REPORT

Richgro Garden Products, Jandakot

Groundwater quality issues and potential sources of contamination

Version: Final

January 2017

Document control

Document version history

Date	Name	Role
24/01/17	Dr Steve Appleyard	Author
24/01/17	Paul Newell	Reviewer

Corporate file information

File number and/or name	File owner or custodian	File location
2010/008321	Industry Regulation (Waste Industries)	

Produced and published by
Department of Environment Regulation
168 St Georges Terrace, Perth, Western Australia

December 2016

Disclaimer
The information contained in this document is provided by Department of Environment Regulation in good faith. However, there is no guarantee of the accuracy of the information contained in this document and it is the responsibility of users to make their own enquiries as to its accuracy, currency relevance and correctness.

The State of Western Australia and Department of Environment Regulation and their servants and agents expressly disclaim liability, in negligence or otherwise, for any act or omission occurring in reliance on the information contained in this document, or for any incident or consequential loss or damage of such act or omission.

The State of Western Australia is committed to providing quality information and has made every attempt to ensure the accuracy, currency, reliability and correctness of the information contained in this document. However, changes in circumstances and legislation after the time of publication may impact on the correctness or quality of this information.

In addition the accuracy, currency, reliability and correctness of links or references to information sources referred to or provided by third parties is outside the control of State of Western Australia and it is therefore the responsibility of the user to make their own decisions on information found on those external sites. Confirmation of any of the information provided in this document may be sought from the relevant originating bodies or the department providing the information; however, users of this material should verify all relevant representations, statements and information with their own professional advisers.

The State of Western Australia and Department of Environment Regulation reserve the right to amend the content of this document at any time without notice.

The information contained in this document is general. It does not constitute, and should be not relied on as, legal advice. The State of Western Australia recommends that users of this information seek advice from a qualified lawyer on the legal issues affecting them before relying on this information or acting on any legal matter.

Questions regarding this report should be directed to:
Department of Environment Regulation
Locked Bag 33 Cloisters Square
PERTH WA 6850
Phone: +61 8 6467 5000
Fax: +61 8 6467 5562
Email: info@der.wa.gov.au
Web: www.der.wa.gov.au

Accessibility This document is available in alternative formats and languages upon request

Contents

1. Purpose

This report documents expert advice related to the changes in groundwater quality that have taken place near the Richgro Garden Products site in Jandakot. Large increases in concentrations of sulfate and ammonium ions have been detected in water pumped from the water supply production bore J130 which is located next to the north-eastern boundary of the Richgro site. Specific advice has been provided on the following issues:

1. Whether the increase in contaminants (particularly ammonium and sulfate ions) in groundwater from the Water Corporation production bore J130 is likely to have come from the composting premises and if so, whether contaminant levels likely to increase in the future (and by how much);
2. The worst case scenario of impacts that may occur at receptors (groundwater, surface water etc.) and over what timescales may this occur;
3. If contamination is considered likely to be from the composting premises, whether the groundwater monitoring results indicate that any particular infrastructure/location/activities on the premises may be the source;
4. If the increase in contaminants is not considered to result from the composting premises, what the likely source of these contaminants is;
5. Whether the data indicates any increasing trends of other contaminants that may represent a risk to nearby receptors; and
6. Whether the quality of groundwater in private bores is likely to be being impacted by emissions from the premises and if so, what impacts may residents be experiencing, e.g. odour, staining.

These issues are addressed within this report.

2. Development of a conceptual site model

2.1. Hydrogeological setting

The Richgro composting facility is located on the Jandakot Mound, a large groundwater flow system within the Superficial Aquifer to the south of the Swan-Canning Estuary (Fig.1). The Superficial aquifer beneath the Jandakot Mound has a saturated thickness of about 40 metres and the aquifer is predominantly comprised of unconsolidated sandy sediments of the Bassendean and Gnangara Sands (Davidson, 1995). The regional direction of groundwater flow in the area is generally in a northerly direction towards the Swan-Canning Estuary (Fig. 1). However, it is likely that in the immediate vicinity of the Richgro site groundwater flows in an easterly to north-easterly direction due to the effects of pumping from nearby water supply production bores.

Groundwater from the Jandakot Mound is used for public water supply, and a water supply production bore (bore number J130) is located adjacent to the north-eastern boundary of the Richgro site. This bore is likely to be screened in the lower part of the Superficial aquifer and therefore the quality of groundwater pumped from the bore will generally only slowly respond to water quality changes that take place at the water table. Monitoring data from this production bore have shown a progressive increase in both ammonium and sulfate ion concentrations over the last sixteen years (Figs 2 and 3).

The potential sources of these chemical constituents in groundwater are discussed in following sections in this report.

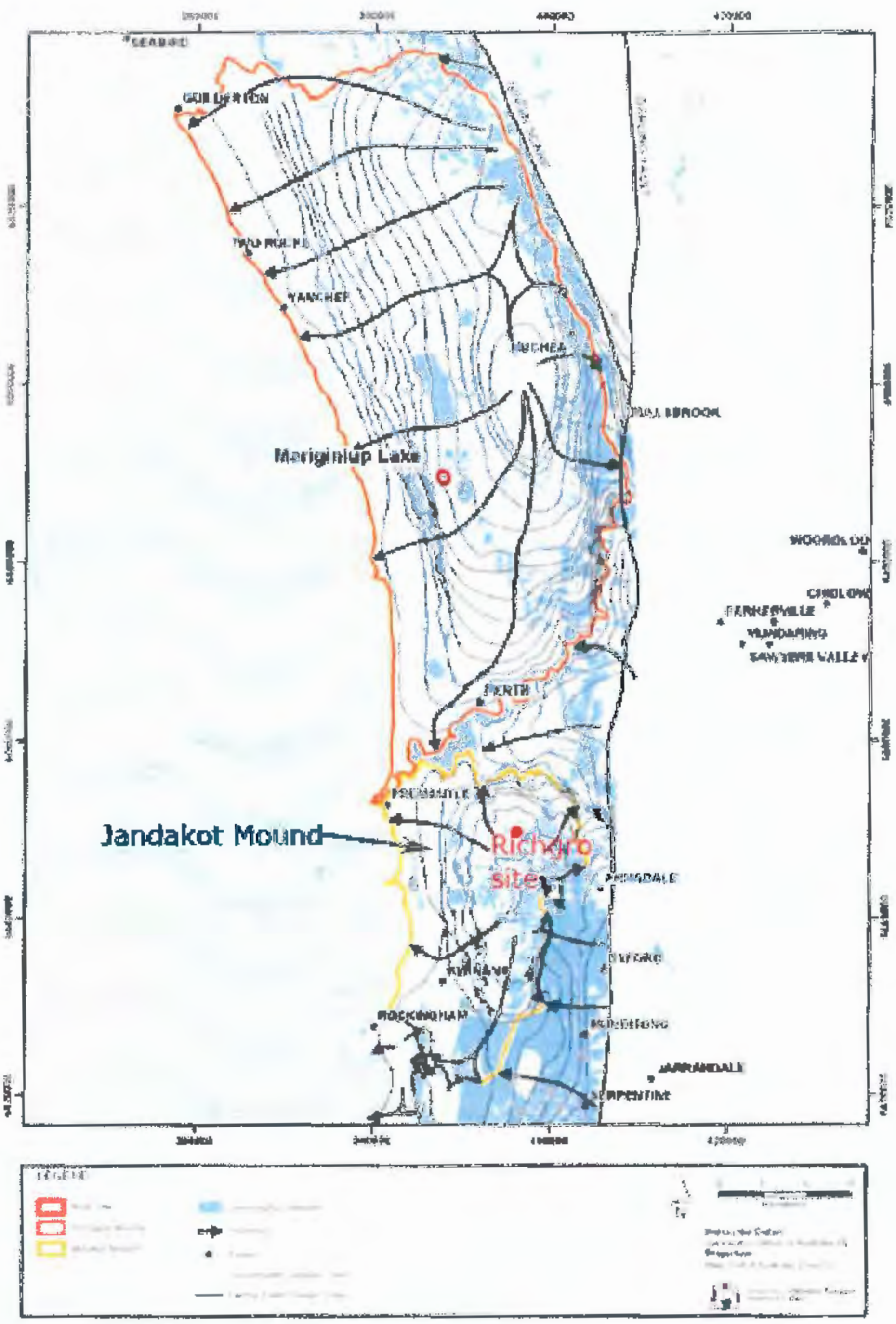


Figure 1. Location of the Richgro site and the principal groundwater flow systems in the Superficial Aquifer in the Perth region (adapted from Searle et al., 2010)

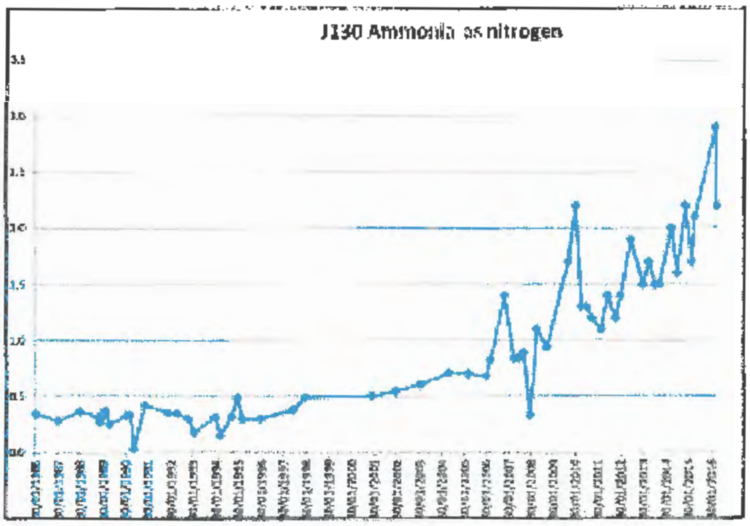


Figure 2. Variation of ammonium nitrogen concentrations (in mg/L) with time in water supply production bore J130

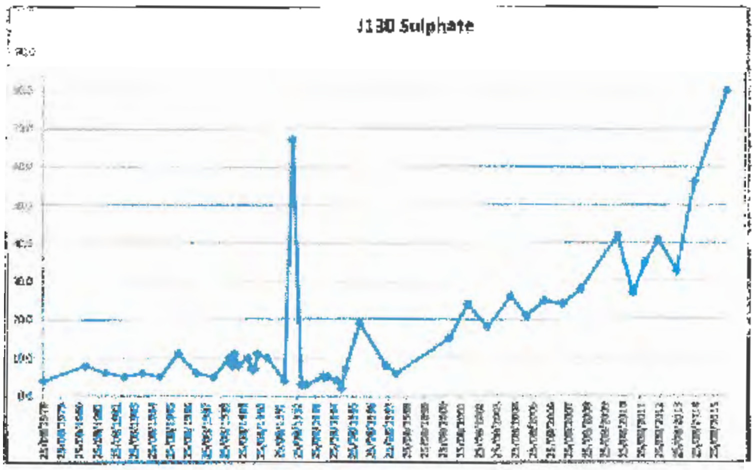


Figure 3. Variation of sulfate concentrations (in mg/L) with time in water supply production bore J130

2.2. Potential sources of sulfate in groundwater

Historical groundwater investigations on the Jandakot Mound (Larsen *et al.*, 1998) have indicated that background concentrations of sulfate in shallow groundwater at that time (before the onset of the rising trend shown in Fig. 2) were generally less than 50 mg/L. The sulfate/chloride ratio at that time (Larsen *et al.*, 1998) suggested that the sulfate had a mixed origin and was derived from salts in rainfall deposited in the region, from the leaching of sulfate salts from fertiliser use, and from the oxidation of sulfide minerals in aquifer sediments.

Many of the monitoring bores screened near the base of the Superficial aquifer in 1998 had negligible levels of sulfate and very low sulfate/chloride ratios, suggesting that sulfate reducing conditions occurred near the base of the aquifer in some locations at that time.

Since 1998, there has been a general decrease in rainfall in the Jandakot area, with the average annual rainfall over the last ten years being about 744 mm compared to the long-term average of about 844 mm. This rainfall decline has caused a regional lowering of the water table and the increased drying of a number of wetlands on the Jandakot Mound (Department of Water, 2016).

The decline in the height of the water table is likely to have caused increased oxidation of sulfide minerals in aquifer sediments as they are being exposed to oxygen, increasing the level of both acidity and sulfate concentrations in shallow groundwater. There is evidence that this is taking place at Jandakot Airport near the Richgro site, as monitoring of shallow groundwater at the airport site has indicated that groundwater is acidic and has an average pH of about 4.5 (Jandakot Airport, 2016). Shallow groundwater is also acidic on the Richgro site, but the pH of groundwater is higher generally than values measured at the airport site. The average pH of shallow groundwater at the Richgro site is about 5.5.

A similar association between shallow groundwater acidity and increasing sulfate concentrations near the base of the Superficial aquifer has also been observed in groundwater on the Gnangara Mound (Appleyard and Cook, 2009; Clohessy *et al.*, 2013) in an area where the water table is falling due to low rainfall and the effects of high rates of groundwater abstraction in the Mirrabooka borefield. Investigations on the Gnangara Mound have indicated that although groundwater near the base of the superficial aquifer was not acidic, there was a progressive increase in sulfate concentrations over a twenty year period, similar to the trend observed in bore J130 near the Richgro site.

Investigations on the Gnangara Mound and elsewhere in the Perth region (Prakongkep *et al.*, 2012; Salmon *et al.*, 2014) have indicated that the Bassendean Sand contains sufficient pyrite (an iron sulfide mineral) to release acidity and sulfate into groundwater when the water table is lowered beyond its natural seasonal range of fluctuations.

However, it is likely that most of the acidity and sulfate that is released into groundwater from the falling water table is derived from wetland sediments which typically have more than ten times the pyrite content of Bassendean Sand soil materials (see *e.g.* Searle *et al.*, 2010). It is therefore likely that the oxidation of sediments in Lukin Swamp, which is located immediately up-gradient of the Richgro site, is the most significant source of the sulfate concentration increases that are being detected in water supply production bore J130.

2.3. Potential sources of ammonium in groundwater

Historical groundwater investigations on the Jandakot Mound (Larsen *et al.*, 1998) indicated that ammonium concentrations in groundwater in the area were generally less than 1 mg/L as N before the rising trend observed in bore J130 took place. At that time, elevated ammonium concentrations in groundwater were considered to have been derived from livestock wastes on hobby farms and from septic tanks.

Since that time, there has been a progressive increase in ammonium concentrations detected in production bore J130. One possible source of the additional ammonium is seepage from the Richgro site, as shallow monitoring bores at this site have shown elevated concentrations of this chemical constituent in groundwater. However, the significant correlation between ammonium and sulfate ion concentrations measured in bore J130 (correlation coefficient = 0.63) and the similar trends of concentration increases with time shown by these ions suggest that they are derived from a common source. The oxidation of organic-rich wetland sediments that contain pyrite are known to release high concentrations of both ammonium and sulfate ions into groundwater (Appleyard *et al.*, 2006; Searle *et al.*, 2010), and therefore it seems likely that the drying of sediments in Lukin Swamp is the principal source of the ammonium concentration increases that have been observed in bore J130.

Figure 2 indicates that periodic concentration peaks of ammonium have occurred in bore J130 that are superimposed on a trend of increasing background concentrations of this chemical constituent in groundwater. These concentration peaks may be due to seepage from the Richgro site, but in practice it would be difficult to distinguish between potential sources of ammonium ions for groundwater in the vicinity of bore J130.

2.4. Other contaminants that may be associated with acidic groundwater

Increased acidity caused by a falling water table is known to increase the concentrations of some metals in shallow groundwater, especially concentrations of aluminium, iron and zinc. In areas that have been affected by groundwater acidity, aluminium concentrations in particular can reach levels that are toxic to garden plants that are irrigated by water pumped from shallow bores.

In areas where wetland sediments contain high levels of arsenic, high concentrations of this element can also be released into groundwater by the oxidation of pyrite as the water table is lowered. For instance, elevated arsenic concentrations have been released into groundwater from urban dewatering within the City of Stirling. As a result of this, arsenic concentrations of up to 7000 µg/L were measured in a domestic bore in this area (Appleyard *et al.*, 2006) due to the oxidation of arsenic-rich pyrite (arsenian pyrite) in sediments in this area. This concentration is a thousand times higher than the Australian drinking water guideline for arsenic, and a hundred times the limit for arsenic in water from domestic bores that has been recommended by the Department of Health. It is not known whether sediments in the vicinity of the Richgro site contain elevated concentrations of arsenic.

Radium is also a contaminant that should be considered when looking at "worst case" scenarios for the potential impacts of acidic groundwater on environmental receptors. Although radium concentrations have not been assessed in acidic shallow groundwater in the Perth region, investigations in similar sandy aquifers in the USA (Denham *et al.*, 2005; Szabo et al., 2012) have indicated that radium levels would commonly exceed the Australian drinking water criterion when groundwater pH fell below about pH 6 due to the desorption of this element from minerals in the aquifer matrix. The ultimate source of the radium was found to be the rare-earth mineral monazite which is present at low levels within aquifer sediments. The radium was found to have been released over a long period of time from the monazite and then adsorbed on mineral coatings on sand grains within the aquifer.

As sediments of the Bassendean Sands are also known to contain low levels of monazite and have a similar mineralogy to acidic sandy aquifers in the USA with high radium concentrations, there is a risk that similar elevated radium concentrations could be present in shallow acidic groundwater on the Jandakot Mound.

Contaminants released into groundwater from acidification at the water table are unlikely to significantly affect the quality of groundwater that is pumped for public water supply from near the base of the Superficial aquifer. This is because the level of acidity in deep groundwater is likely to be ameliorated by reaction with calcareous sediments that are present near the base of the Superficial aquifer in the Jandakot area (the Ascot Beds) which is likely to reduce the concentrations of many contaminants in groundwater. Additionally, groundwater that is pumped for public water supply in the area is treated and water quality is regularly monitored to ensure that it is suitable for potable use.

However, Water Corporation and the Department of Health may wish to review whether the treatment and monitoring program for bore J130 is adequate to manage the range of chemical constituents that have been discussed above.

3. Assessment of the potential impacts of contamination on environmental receptors

3.1. Principal receptors and the rate of groundwater flow

As has been indicated in previous sections, the principal source of ammonium and sulfate contamination that is being detected in bore J130 is likely to be from the oxidation of wetland sediments associated with Lukin Swamp. The principal receptors for these chemical constituents, and other potential groundwater contaminants, are considered to be water supply production bore J130 and domestic garden bores in a housing development located hydraulically downgradient of the Richgro site. Other potential receptors include phreatophytic vegetation and wetlands downgradient of bore J130.

The rate of groundwater flow is likely to vary between Lukin Swamp and bore J130 due to the presence of a cone of depression at the water table caused by the pumping of this and neighbouring production bores. In the immediate vicinity of Lukin Swamp, the rate of groundwater flow is probably about 50 m/year, but the flow rate is likely to increase to more than 100 m/year in close proximity to the production bore due to the steepening of the hydraulic gradient caused by pumping. Assuming an average rate of groundwater flow of about 100 m/year, it would take about four years for groundwater to travel from Lukin Swamp to production bore J130

3.2. Potential range of contaminant concentrations in groundwater at receptors

Information from bores in similar hydrogeological settings in the Perth region can be used to estimate the highest concentrations of sulfate and ammonium ions that might be reached in groundwater pumped from bore J130.

For instance, sulfate concentrations in a similar production bore located near oxidising wetland sediments in the Gwelup borefield (bore G80) increased from less than 50 mg/L to a maximum concentration of about 300 mg/L over a twenty year period (Appleyard *et al.*, 2006) due to the oxidation of pyrite in peaty material. Sulfate concentrations in groundwater from this bore have since remained in the range of about 200-300 mg/L and are possibly maintained at this level by the solubility of gypsum. This is also likely to be the highest sulfate concentration that would be reached in production bore J130. Sulfate concentrations of up to 300 mg/L would exceed the drinking guideline value of 250 mg/L, but this could be remedied by mixing with water with a lower sulfate content. The increases in calcium concentration that would be likely to co-occur with sulfate increases (Appleyard *et al.*, 2006) could affect the hardness of the water and may increase the cost of treating the groundwater to make it suitable for public supply.

Ammonium concentrations in Gwelup bore G80 are lower than levels measured in bore J130 and therefore cannot be used for comparison. However, ammonium concentrations of up to 10 mg/L as N are commonly observed in bores near wetlands in the Perth region. This concentration is considered to be the upper limit ammonium in groundwater pumped from bore J130. Ammonium concentrations of this magnitude have the potential to change the effectiveness of chlorination of water that is pumped for public supply because of the formation of chloramines.

The most significant changes in groundwater quality caused by the lowering of the regional water table are likely to take place in shallow groundwater. Consequently, domestic bores and deep-rooted vegetation in residential areas near J130 are most likely to be affected by chemical constituents associated with shallow, acidic groundwater. The contaminant that is most likely to affect domestic bore use in the area is aluminium.

This is because elevated aluminium concentrations (more than about 1 mg/L) can damage some sensitive garden plants. Aluminium concentrations of this magnitude commonly occur in areas where the pH of groundwater is less than about 5 (Clohessy *et al.*, 2013). In situations where shallow groundwater is extremely acidic (with a pH less than about 3.5), the concentration of aluminium and soluble salts in groundwater can reach levels that will cause widespread death of garden plants that are irrigated with domestic bores.

The "worst case" scenario for groundwater use from shallow domestic bores in the area would be where groundwater is moderately acidic (*i.e.* with no observable effects on plant health) and has arsenic concentrations in excess of 70 µg/L, the concentration that the Department of Health considers will limit the suitability of groundwater for garden irrigation. Arsenic concentrations of this magnitude would only be detected by chemical analysis of groundwater, as there would be no other visible signs of contamination. Such groundwater could also contain radium levels in excess of the ANZECC 2000 guideline values (*i.e.* 5 Bq/L for radium-226 and 2 Bq/L for radium-228). No information is available to indicate whether shallow groundwater in the area contains elevated concentrations of arsenic or radium.

4. Responses to specific issues

On the basis of information provided in this report, the following responses are provided to address the main issues associated with groundwater quality issues near the Richgro site in Jandakot.

Issue 1: Source of the ammonium and sulfate ions detected in bore J130

The principal source of the sulfate and ammonium ions in groundwater pumped from bore J130 is likely to be from the oxidation of sediments in Lokin Swamp. Sulfate concentrations in this bore will probably increase to a maximum concentration of about 200-300 mg/L. Ammonium levels are also likely to increase, possibly to a maximum concentration of about 10 mg/L as N. Periodic ammonium concentration peaks in this bore that have been observed since 2006 may be associated with contamination from the Richgro site.

Issue 2: "Worst case" scenarios for the impacts of contamination on receptors

Contaminants released from the oxidation of sediments are unlikely to cause significant impacts on the quality of groundwater near the base of the Superficial aquifer which is being pumped for public water supply. There is a risk that shallow groundwater in the residential area near bore J130 will contain concentrations of aluminium at levels that could affect the health of some garden plants that are irrigated using domestic bores. The "worst case" scenario is that shallow groundwater beneath the residential area contains concentrations of arsenic or radium at levels that the Department of Health would consider to be unacceptable for domestic bores to be used. Sampling and chemical analysis of domestic bores would be required to determine whether this scenario is taking place in this area.

Issue 3: Potential sources of contamination at the Richgro premises

Monitoring data suggest that the Richgro site is not a major source of offsite groundwater contamination. The most significant source of localised groundwater contamination at the site is likely to be seepage from a wastewater pond.

Issue 4: Sources of groundwater contamination

Refer to the response to query 1 Contaminants may also be locally released into groundwater from the oxidation of sulfide minerals in sandy sediments as the water table falls due to declining rainfall in the region

Issue 5: Impacts of groundwater contaminants other than sulfate and ammonium on receptors

Refer to the response to query 2. Groundwater monitoring data from both the Richgro site and production bore J130 are not adequate to characterise the risks posed by shallow acidic groundwater to receptors. The likely range of contaminants present in shallow groundwater in the area was estimated by comparison with studies at similar sites, both in the Perth region and from other parts of the world with similar sandy aquifers and acidic groundwater.

Issue 6: Impacts of emissions from the Richgro premises on domestic bores

It is unlikely that groundwater contaminants from the Richgro site are significantly affecting the quality of groundwater pumped from domestic bores in the residential area near production bore J130. It is more likely that groundwater quality in the residential area is being affected by contaminants leached from aquifer sediments by the lowering of the water table.

References

Appleyard, S.J., Angeloni, J. and Watkins, R., 2006. Arsenic-rich groundwater in an urban area experiencing drought and increasing population density, Perth Australia. *Applied Geochemistry*, **21**, 83-97.

Appleyard, S.J and Cook, T., 2009. Reassessing the management of groundwater use from sandy aquifers: acidification and base cation depletion exacerbated by drought and groundwater withdrawal on the Gnangara Mound, Western Australia. *Hydrogeology Journal*, **17**, 579-588.

Clohessy, S., Appleyard, S.J. and Vogwill, R., 2013. Groundwater acidification near the water table of the Superficial aquifer, Swan Coastal Plain, Western Australia. *Applied Geochemistry*, 36, 140-152.

Davidson, W.A., 1995. *Hydrogeology and Groundwater Resources of the Perth Region, Western Australia*. Geological Survey of W.A., Bulletin 142.

Denham, M., Millings, M. and Noonkoster, 2005. Intermittent Elevated Radium Concentrations in Coastal Plain Groundwater of South Carolina, U.S.A. US Department of Energy, Savannah River National Laboratory report. The report is available from web site http://sti.srs.gov/fulltext/2005/ms2005565.pdf.

Department of Water, 2016. *Environmental Management of Groundwater from the Jandakot Mound: Annual Compliance Report to the Office of the Environmental Protection Authority*. Department of Water Report

Jandakot Airport, 2016. *Jandakot Airport Groundwater Management Plan*. Technical report available from web site http://www.jandakotairport.com.au/images/files/Environment/Groundwater-Management-Plan-v5.5.pdf.

Larsen, R.M., Watkins, K.L., Steel, N.A., Appleyard, S.J. and Bauld, J., 1998. *A Groundwater Quality Assessment of the Jandakot Mound, Swan Coastal Plain, Western Australia*. Australian Geological Survey Organisation (AGSO) Record 1998/18. The report is available from web site https://www.data.gov.au/dataset/a-groundwater-quality-assessment-of-the-jandakot-mound-swan-coastal-plain-western-australia.

Prakongkep, N., Gilkes, R.J., Singh, B. and Wong, S., 2012. Pyrite and other sulphur minerals in giant aquic spodosols, Western Australia. *Geoderma*, **181-182**, 78-90.

Salmon, S.U., Rate, A.W., Rengel, Z., Appleyard, S., Prommer, H. and Hinz, C., 2014. Reactive transport controls on sandy acid sulfate soils and impacts on shallow groundwater quality. *Water Resources Research*, **50**, 4924-4952.

Searle, J.A., McHugh, S.L., Paton, A.C. and Bathols, G.R., 2010. *Perth Shallow groundwater Systems Investigation: Lake Mariginiup*. Western Australian Department of Water Hydrogeological Record Series, Report No HG36.

Szabo, Z., DePaul, V.T., Fischer, J.M, Kraemer, T.F. and Jacobsen, E., 2012. Occurrence and geochemistry of radium from principal drinking-water aquifer systems of the United States. *Applied Geochemistry*, **27**, 729-752.

5. Limitations

1. The information provided is assumed to be correct, and it is assumed that groundwater samples from the site have been sampled and analysed in an appropriate manner.

Signatures

Author Name	S. Appleyard	Signature	[signature]
Position	Principal Hydrogeologist	Date	24/1/2017
Reviewer Name	Paul Newell A/SENIOR MANAGER	Signature	[signature]
Position		Date	24/01/17

Appendix 5: Technical Expert Report – Ponds

Government of **Western Australia**
Department of **Environment Regulation**

REPORT

Richgro Garden Products, Jandakot

Onsite groundwater monitoring and potential for seepage from wastewater ponds

Version: Final

April 2017

Document control

Document version history

Date	Name	Role
xx/04/17	Dr Steve Appleyard	Author
xx/04/17	Andrew Miller	Reviewer

Corporate file information

File number and/or name	File owner or custodian	File location
2010/008321	Industry Regulation (Waste Industries)	

Produced and published by
Department of Environment Regulation
168 St Georges Terrace, Perth, Western Australia

April 2017

Disclaimer
The information contained in this document is provided by Department of Environment Regulation in good faith. However, there is no guarantee of the accuracy of the information contained in this document and it is the responsibility of users to make their own enquiries as to its accuracy, currency, relevance and correctness.

The State of Western Australia and Department of Environment Regulation and their servants and agents expressly disclaim liability, in negligence or otherwise, for any act or omission occurring in reliance on the information contained in this document, or for any incident or consequential loss or damage of such act or omission.

The State of Western Australia is committed to providing quality information and has made every attempt to ensure the accuracy, currency, reliability and correctness of the information contained in this document. However, changes in circumstances and legislation after the time of publication may impact on the correctness or quality of this information.

In addition the accuracy, currency, reliability and correctness of links or references to information sources referred to or provided by third parties is outside the control of State of Western Australia and it is therefore the responsibility of the user to make their own decisions on information found on those external sites. Confirmation of any of the information provided in this document may be sought from the relevant originating bodies or the department providing the information; however, users of this material should verify all relevant representations, statements and information with their own professional advisers.

The State of Western Australia and Department of Environment Regulation reserve the right to amend the content of this document at any time without notice.

The information contained in this document is general. It does not constitute, and should be not relied on as, legal advice. The State of Western Australia recommends that users of this information seek advice from a qualified lawyer on the legal issues affecting them before relying on this information or acting on any legal matter.

Questions regarding this report should be directed to:
Department of Environment Regulation
Locked Bag 33 Cloisters Square
PERTH WA 6850
Phone: +61 8 6467 5000
Fax: +61 8 6467 5562
Email: info@der.wa.gov.au
Web: www.der.wa.gov.au

Accessibility This document is available in alternative formats and languages upon request.

Contents

1. Introduction

This report provides technical advice on the suitability of the current groundwater monitoring network at the Richgro Garden Products site in Jandakot, and on the risk of seepage from wastewater ponds which may have bases that are constructed below seasonally high elevations of the water table. Specific advice has been provided on the following queries.

- The adequacy of the existing groundwater monitoring network at the composting premises with regards to bore locations and groundwater flow direction and specify if and where any additional bores are required to be installed at the premises.
- How often the ponds are likely to be below groundwater/hydraulically contained.
- Consequences associated with leachate ponds being located within groundwater on both the liner integrity and groundwater quality beneath the site.
- The likely contaminant flux through the liner in a year (diffusion + leakage)?
- Consideration on whether the potential for leachate ponds to be situated within groundwater changes the findings from the previous Technical Expert report change in regards to site impacts on groundwater quality.
- Consideration on how long would it take for any contaminants to reach the Water Corporation bore north of the premises.
- Consideration on the parameter that can be analysed in groundwater samples to distinguish between seepage of leachate from site operations and parameters naturally occurring within the groundwater (i.e. over abstraction impacts on Lukin Swamp).
- Recommendations for monitoring improvements such as sampling frequency and suite of parameters currently monitored.
- . Recommendations on ambient groundwater action levels for groundwater parameters given the existing ammonium and sulphate ions present within groundwater.

These issues are addressed within this report. It is recommended that this report is read in conjunction with the previous Expert Report on the Richgro site which was prepared in December 2016 and which provides more background information on the hydrogeology of the site.

2. Groundwater flow direction and bore locations

Water table contours for the vicinity of the Richgro site (Fig.1) were obtained from the Perth Groundwater map which is hosted on the Department of Water web site (at URL http://www.water.wa.gov.au/maps-and-data/maps/perth-groundwater-atlas). The water table contours shown in the online map appear to be identical to those in the published hardcopy Perth Groundwater Atlas which were compiled using May 2003 water levels. Consequently, the water table contours shown in Figure 1 may not be representative of current groundwater flow conditions in the area which are likely to have been affected by a prolonged period of below average rainfall and the effects of groundwater abstraction for public water supply since May 2003.

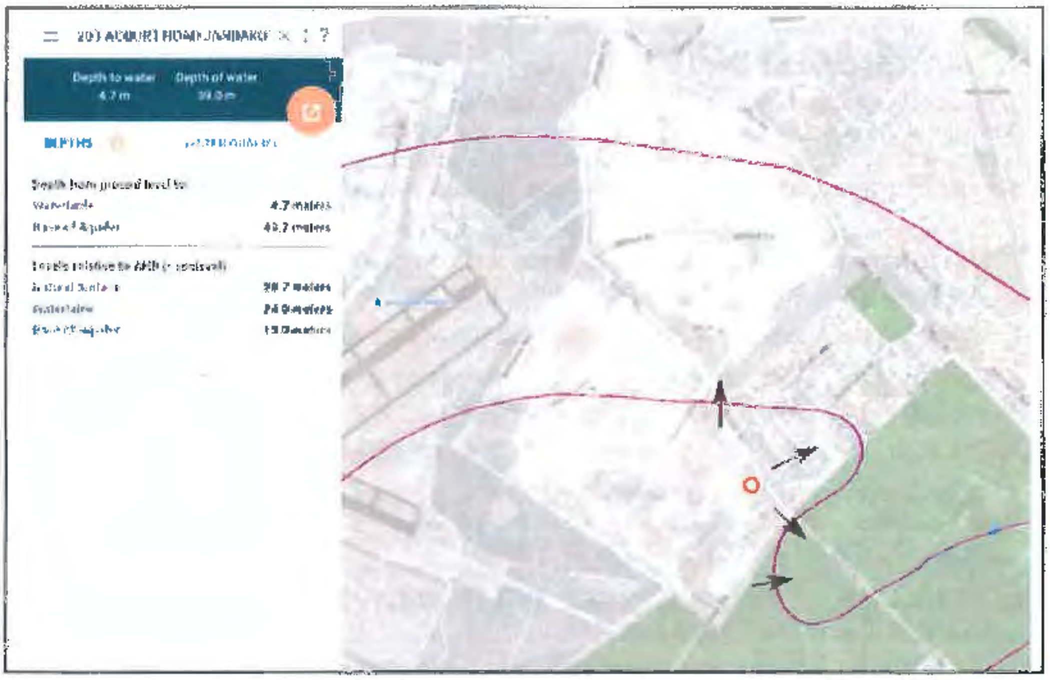


Figure 1. Water table contours (elevations in mAHD) in the vicinity of the Richgro site from the Department of Water online Perth Groundwater Map. Groundwater flow directions at the water table are indicated by arrows.

However, assuming that the water table contours shown in Figure 1 are representative of the current groundwater flow regime in the area, the Richgro site appears to be located on a local groundwater flow divide where groundwater near the water table on the western half of the site flows in a general northerly direction, whereas shallow groundwater on the eastern portion of the site flows in a north-easterly to south-easterly direction. This variability in groundwater flow directions is likely to have a significant effect on the viability of the current network of groundwater monitoring bores on the Richgro site, as there do not appear to be sufficient bores present on the site to monitor transport pathways from potential sources of contamination at the site.

In particular, most of the current monitoring bores on the Richgro site appear to be located hydraulically upgradient of potential sources of contamination at the site including wastewater storage ponds and the composting pads and would be unlikely to detect discharges to groundwater in some parts of the site.

As a consequence of this, some potential additional bore sites are shown in Figure 2 which are probably located hydraulically downgradient of significant potential sources of contamination on the site. Bores constructed with a screened interval from the water table to a depth of about 3 metres below the water table would be suitable for groundwater monitoring at these locations.

Figure 2. Potential new monitoring bore locations on the Richgro site

3. Seasonal variations in water table elevation

Hydrographs from Department of Water monitoring bores in the vicinity of the Richgro site (Figure 3) indicate that the height of the water table in the area varies seasonally by about 1.0 to 1.5 metres, although this varies from year to year depending on annual rainfall and on the distribution and magnitude of groundwater abstraction in the area. The highest water table elevation usually occurs in September-October each year, whereas the water table reaches its lowest point in April-May each year.

It is understood that measured water levels measured in bores near the main pond on the Richgro site varied in depth between 3.5 metres to 4.2 metres below ground between June 2016 and January 2017 respectively. Given that these water level measurements were made at times when the water table is not at its lowest and highest point, and given the seasonal range of hydrographs shown in Figure 3, it is possible that the seasonal highest water table elevation near the main pond on the Richgro site is up to 30 cm higher than measured and the seasonal lowest water table elevation is up to 30 cm lower than measured. This would suggest that the pond liner at the base of this pond is located below the water table for up to a six month period each year and that in September-October each year the pond base could be up to 0.8 metres below the water table.

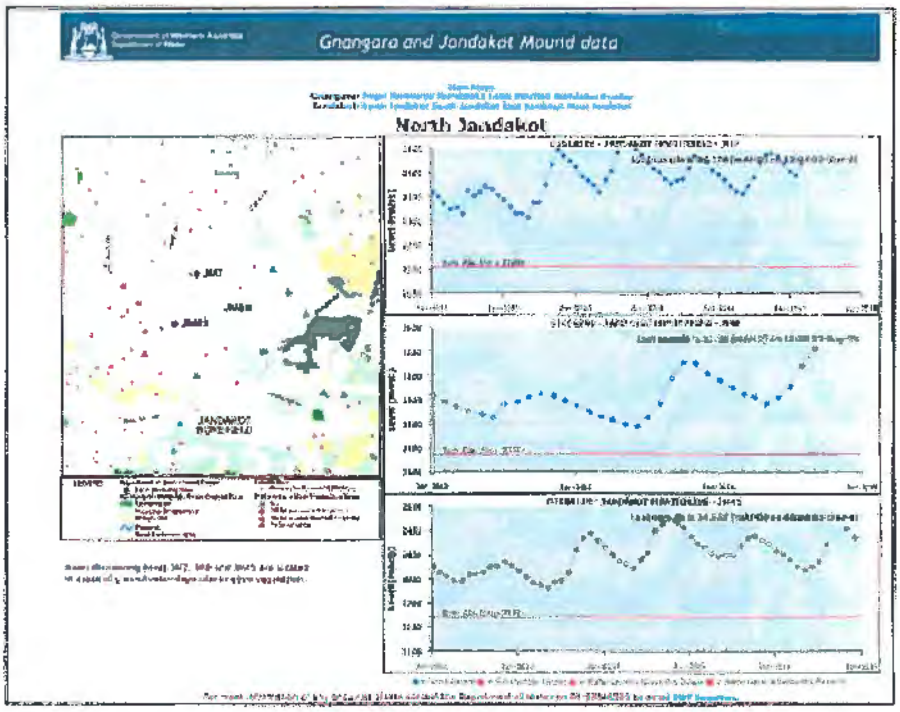


Figure 3. Hydrographs from Department of Water monitoring bores showing the seasonal range of water table elevations on the northern part of the Jandakot Mound.

4. Potential consequences of pond construction below the water table

The potential consequences of constructing a geotextile-lined pond below the water table would depend on the characteristics of the geotextile liner and on the difference in the hydraulic head between water in the pond and the water table. In a situation where the pond has been constructed below the water table without an active underdrain system (as appears to be the case at the Richgro site) and the pond is empty, hydrostatic uplift of the liner would be likely to take place which would have the potential to cause damage to welded or glued seams in this structure. The risk of damage to the liner would be minimised by maintaining water in the pond, but expert advice would be required from a qualified geotechnical engineer to indicate the minimum water level that should be maintained in ponds on the site to prevent damage to the liner from hydrostatic uplift.

If the water level in the lined ponds is lower than the water table elevation some groundwater ingress to the ponds would take place, although the rate of inflow would depend on the characteristics of the liner. For example, under conditions where the water table is 0.3 metres higher than the water level in the pond and the liner contains 3 small holes per hectare (typical for many geotextile liners), groundwater inflow into a pond could be up to 1000 litres per hectare of pond area per day (Koerner and Koerner, 2006). This could increase to up to 30 000 litres per hectare of pond area per day under conditions where the liner is partially degraded and contains 3 large holes per hectare.

5. Estimation of contaminant fluxes through pond liners due to seepage and diffusion

Due to seasonal variations in the elevation of the water table at the Richgro site, it is likely that some water will seep through the pond liners in ponds to groundwater during the summer months, and that some ingress of groundwater will take place at the ponds during the late-winter and early-spring months. This means that during summer, some contamination will be discharged to groundwater in seepage from the ponds. By contrast, during periods where the water table is higher than the pond water level, some discharge from a pond to groundwater will take place by diffusion due to the concentration gradient that will exist across the geotextile liner between contaminant concentrations in the pond and groundwater (UK Environment Agency, 2004). The potential magnitude of these contaminant fluxes are estimated below:

5.1 Seepage fluxes due to leakage from a pond

It will be assumed in the following calculations that the Total Nitrogen concentration in the wastewater ponds will be 100 mg/L, a typical concentration for leachate from compost materials (Flury *et al.*, 2015). It will also be assumed that the background Total Nitrogen level in shallow groundwater in the area is about 2 mg/L.

If it is assumed that the head of water in a wastewater pond is on average 0.3 metres higher than the water table for a six-month period each year and that the geotextile liner has on average three small holes per hectare of area, from Table 1 in Koerner and Koerner (2009) the seepage flux from a pond can be determined to be 1000 litres per hectare per day. That is, the nitrogen input to groundwater from a hypothetical one hectare pond on the site would be 100 g/day or about 1.8 kg over a six-month period. If there is no seepage from the pond over the remaining six-month period of the year, the annual seepage flux from the pond would be 1.8 kg/year.

This nitrogen contamination in the seepage from the pond will mix with groundwater flow over a depth interval of about 3 metres near the water table in the Superficial aquifer. The volume of groundwater flowing beneath the pond can be determined using Darcy's Law:

$$Q = K.i.A$$

Where
Q = groundwater flowrate (m^3/day)
K = hydraulic conductivity of the aquifer (about 10 m/d near the water table in the vicinity of the Richgro site
i = hydraulic gradient (determine to be about 0.001 from water table contours near the Richgro site)
A = cross sectional area of the aquifer (or 3 m x 100 m = 33 m^2 for the hypothetical pond)

Using these figures, the volume of groundwater flowing beneath the hypothetical pond is determined to be 0.33 m^3/day or 330 litres per day. The flux of nitrogen contributed by groundwater flow beneath the hypothetical pond would therefore be 0.7 g/day or about 0.25 kg/year over a period of a year. The mass-flux of nitrogen contributed by groundwater is therefore 0.25 kg/year.

The concentration of nitrogen in shallow groundwater beneath the pond can then be determined using a simple mixing model:

$$C_1 = \frac{J_o}{Q_o + Q_g} - \frac{J_g}{Q_o + Q_g}$$

(from Appendix 5.5 in Danish EPA, 2002)

Where J_o = mass flux seeping from the pond (g/year)
J_g = mass flux contributed by groundwater (g/year)
Q_o = volume of water input by seepage (L/year)
Q_g = volume of water input by groundwater (L/year)

Using the mass flux and discharge rate estimates determined above, the concentration of nitrogen in shallow groundwater that has been affected by seepage through defects in the pond liner is estimated to be about 4 mg/L. If seepage were to take place through defects in the pond liner throughout the year rather than for a six-month period, the concentration of nitrogen in shallow groundwater beneath the pond would be about 7 mg/L.

5.2 Seepage fluxes due to diffusion through a pond liner

In situations where the both base of a lined pond and the water level in the pond are situated below the water table, groundwater ingress to the pond will take place. Under these circumstances, contaminants will not be lost from a pond by advection through defects in the pond liner, but diffusion of contaminants from the pond into groundwater could take place if there is a large concentration gradient across the pond liner (UK Environment Agency, 2001).

The diffusive flux of nitrogen through the liner at the base of a hypothetical 1 hectare pond was calculated using the spreadsheet diffusion model developed by the UK Environment Agency (model and explanatory notes are available from web site https://www.gov.uk/government/publications/contaminant-fluxes-from-hydraulic-containment-landfills-a-review). The model was run with the assumptions that the concentration of nitrogen in water in the pond was 100 mg/L, that the liner had 3 small holes per hectare of liner area, and that the water level in the pond was below the water table elevation for a period of six months each year. Under these conditions, the diffusive flux of nitrogen from the pond was calculated to be about 4 g/year.

This mass flux is negligible in comparison to the advective flux of nitrogen previously calculated (about 1.8 kg/year). Therefore it is unlikely that diffusion of contaminants through the pond liner would be a significant source of groundwater contamination at the Richgro site.

6. Comparison of estimated leakage rates of nitrogen from ponds with existing nitrogen levels in groundwater

Groundwater monitoring near a water supply production bore downgradient of the Richgro site has shown a progressive increase in nitrogen concentrations to the current level of about 2-3 mg/L. As indicated in the previous technical report on the Richgro site, this trend is unlikely to be due to groundwater contamination from the Richgro site for the following reasons:

Firstly, nitrogen concentrations in groundwater near the production bore downgradient of the Richgro site have slowly increased over a twenty year period, a trend that is not consistent with the pattern of concentration increases that would be expected with leakage from a nearby leaking pond where much more rapid concentration increases would be expected. Secondly, the nitrogen concentration increases observed in groundwater near the production bore were closely associated with concentration increases of sulfate to levels that are inconsistent with compost leachate being the source of contamination.

Finally, an assessment of the fate and transport of nitrogen in groundwater using a spreadsheet-based calculation of the Domenico analytical solution (Pennsylvania DEP, 2014) indicated that nitrogen concentrations in groundwater flowing from the Richgro site would probably be reduced from 4 mg/L to below 1 mg/L within a distance of 100 metres from the contamination source by the effects of denitrification and hydrodynamic dispersion within the Superficial aquifer.

7. Rate of contaminant transport in groundwater

As indicated in Section 2, groundwater flow directions on the Richgro site are highly variable. Consequently, groundwater only flows in a north-easterly direction towards the production bore from part of the site. However, if it is assumed that contaminants from the Richgro site are transported in groundwater towards the production bore, the rate of transport can be estimated using the following equation that can be derived from Darcy's Law:

$$V = K.i/\theta$$

Where
K = hydraulic conductivity (m/day – about 10-20 m/d in the area)
i = hydraulic gradient (m/m – about 0.001 near the Richgro site)
θ = aquifer porosity (about 0.3 in a sandy aquifer

Using these figures, the groundwater flow rate at the water table near the Richgro site is likely to be about 12 – 24 m/year. That is, it would take groundwater about 12 to 24 years to travel a distance of about 300 metres to the production bore if the hydraulic gradient were to remain constant over the travel distance. In practice, however, the hydraulic gradient will steepen greatly within the cone of depression of the production bore so that the minimum travel time for groundwater to the production bore could probably be reduced to about 10 years.

It should be noted, however, that these travel times are for groundwater. The rate of transport of some contaminants in groundwater will be much slower due to the effects of sorption of some chemical constituents on minerals in the aquifer matrix (a phenomenon known as "retardation").

8. Distinguishing between potential sources of contamination

There are a number of possible sources of nitrogen contamination in groundwater in the area that have the potential to affect the quality of water pumped from water supply production bores in the area. These include:

- Fertiliser use on gardens and public open space in the area;
- Livestock grazing in semi-rural properties (hobby farms) in the area;
- The oxidation of organic matter in the soil profile and in wetlands associated with regional declines in the elevation of the water table; and
- Industrial sources of contamination through activities such as compositing.

In the vicinity of the Richgro site, the most likely sources of nitrogen contamination in groundwater are likely to be the oxidation of organic matter in soils and leachate from composting as there is only a limited amount of residential and agricultural land use near the site. Potential ways of using groundwater monitoring data to distinguish between these sources of contamination include:

(i) Use of sulfate/chloride ratios in groundwater

Sediments below the water table in the Superficial aquifer and in wetlands contain microscopic crystals and framboids of the mineral pyrite which is oxidised when the water table is lowered, causing increases in the sulfate concentration in groundwater. Nitrogen compounds are released into groundwater from the oxidation of organic matter during this process. The sulfate/chloride mass ratio in groundwater is also increased from its natural level of about 0.15 in shallow groundwater on the Jandakot Mound to a mass ratio that often exceeds a value of 0.5 in groundwater that has been influenced by pyrite oxidation.

By contrast, leachate from a composting facility should not significantly change the sulfate/chloride mass ratio in shallow groundwater.

(ii) Use of measurements of bicarbonate concentrations in groundwater

The oxidation of pyrite caused by the lowering of the water table releases sulfuric acid which reacts with bicarbonate ions in groundwater and causes a depletion in the alkalinity of groundwater. As a consequence of this, groundwater that has been affected by pyrite oxidation often has bicarbonate ion concentrations of less than 50 mg/L.

By contrast, bicarbonate is typically produced by bacteria from organic matter during the composting process. As a consequence of this, groundwater that has been contaminated by compost leachate may have bicarbonate concentrations that exceed 500 mg/L.

(iii) Use of nitrogen isotope measurements

Nitrogen compounds in groundwater that have been derived from compost leachate are likely to have a very different isotopic signature to those produced from the oxidation of organic matter due to declines in the elevation of the water table. It is likely that measurements of nitrogen isotopes would enable these potential sources of nitrogen to be distinguished from each other.

9. Groundwater monitoring to detect compost leachate discharges

Groundwater monitoring programs should enable changes in groundwater quality to be detected that are an early warning of a contamination problem as well as exceedances of concentrations of chemical parameters that might indicate an imminent threat of environmental impacts. Consequently, it is often useful to include parameters in a groundwater monitoring suite that are not by themselves environmentally harmful but which indicate that environmentally harmful changes in groundwater quality are likely to be occurring as a result of groundwater contamination.

On the basis of this reasoning, the following suite of chemical parameters could be considered for groundwater monitoring at the Richgro site which has been adapted from the UK Environment Agency landfill monitoring guidelines (UK Environment Agency, 2014):

Field measurements: Temperature, Electrical Conductivity, pH, Redox potential

Laboratory measurements: Total Dissolved Solids, Total Nitrogen, Ammoniacal nitrogen, Nitrate + Nitrite (as nitrogen), Total Organic Carbon, Biological Oxygen Demand, Chemical Oxygen Demand, Calcium, Magnesium, Sodium, Potassium, Bicarbonate + Carbonate, Sulfate, Chloride, Iron, Manganese.

In addition to the suite of chemical parameters outlined above, the proponents may wish to include arsenic in the groundwater monitoring suite as arsenic is commonly released from iron oxide coatings on minerals in aquifer sediments due to chemical reactions with leachate that contains a high biological oxygen demand. Given the proximity of a water supply production bore, monitoring of groundwater quality on a six-monthly basis would a suitable monitoring frequency to manage the risks of groundwater contamination at the site.

As the most sensitive beneficial use for groundwater downgradient of the Richgro site is for public water supply, it is important that the concentration of ammonium in groundwater from the site does not exceed the national drinking water criterion of 0.5 mg/L on arrival at the nearest water supply production bore which is located about 300 m from the site boundary. Preliminary modelling using the spreadsheet-based Quick-Domenico fate and transport model (Pennsylvania DEP, 2014) suggests maintaining groundwater concentrations of ammonium below 5 mg/L in groundwater at the Richgro site should ensure that concentrations of this chemical constituent do not exceed 0.5 mg/L in the downgradient public water supply bore (assuming that the Richgro site is the only source of groundwater contamination).

10. Responses to specific issues

On the basis of information provided in this report, the following responses are provided to address the additional issues associated with groundwater quality issues near the Richgro site:

Issue 1: Adequacy of the existing groundwater monitoring network

The existing monitoring bore network on the site does not adequately consider the variability of groundwater flow directions or potential sources of contamination on the site. Consequently, groundwater monitoring bores are often located hydraulically upgradient of potential sources of contamination. These issues are discussed in more detail in Section 2 of this report.

Issue 2: Hydraulic containment of ponds

The bottom liner in some ponds on the site could be located below the water table for a period of up to six months each year. This issue is discussed in more detail in Section 3 of this report.

Issue 3: Consequence of leachate ponds being located within groundwater

There is a risk that hydraulic uplift could cause damage to the liner if the water level in the pond were to be maintained below the water table elevation for prolonged periods. Further advice would be required from a suitably qualified geotechnical engineer to manage this risk. This issue in discussed in more detail in Section 4 of this report.

Issue 4: Contaminant flux through the liner

The annual mass flux of nitrogen from ponds on the site is estimated to be about 1.8 kg per hectare of pond area. The annual diffusive flux of nitrogen through pond liners is estimated to be about 4 g per hectare of pond area and is therefore negligible by comparison to the advective flux through the pond liners. This issue is discussed in more detail in Section 5 of this report.

Issue 5: Considerations of advice in the previous Technical Expert Report

Advice provided in this report does not significantly change the conclusion drawn in a previous report that the oxidation of sulfidic organic matter due to water table decline is likely to be the principal source of ammonium and sulfate recorded in groundwater at the water supply bore located near the Richgro site. However, the organic matter and sulfide minerals are likely to be much more widely distributed in aquifer sediments in the area than Lukin Swamp. This issue is discussed in more detail in Section 6 of this report.

Issue 6: Estimated time for contaminants to reach nearest production bore

It is estimated that groundwater would take between 10 and 24 years to travel from the Richgro site to the nearest public water supply production bore. The rate of transport of some contaminants in groundwater would be lower than this due to the effects of retardation in the Superficial aquifer. This issue is discussed in more detail in Section 7 of this report.

Issue 7: Groundwater parameters to distinguish between seepage of leachate and naturally occurring issues

Potential chemical parameters that could be used to distinguish between sources of nitrogen contamination in groundwater near the Richgro site are the used of the sulfate/chloride mass ratio, the use of bicarbonate ion concentration measurements and the use of nitrogen isotope measurements. This issue is discussed in more detail in Section 8 of this report.

Issue 8: Recommendations for monitoring improvements

A suitable groundwater monitoring suite for the site is provided in Section 9 of this report. Monitoring on a six-monthly basis should be adequate for managing the potential impacts of groundwater contamination on the downgradient water supply production bore.

Issue 9: Recommendations on ambient groundwater action levels

Maintaining ammonium concentrations below 5 mg/L in groundwater at the Richgro site should ensure that concentrations of this chemical constituent do not exceed 0.5 mg/L in the downgradient public water supply bore (assuming that the Richgro site is the only source of groundwater contamination). This is discussed in more detail in Section 9 of this report.

References

Danish EPA, 2002. *Guidelines on Remediation of Contaminated Sites*. Technical guidelines available from web site http://www2.mst.dk/udgiv/publications/2002/87-7972-280-6/pdf/87-7972-281-4.pdf

Flury, M., Mullane, J., Chahal, M and Cogger, C.G., 2015. *Experimental Evaluation of Compost Leachates*. Washington State University Technical Report which is available from web site https://www.wsdot.wa.gov/research/reports/fullreports/848.1.pdf.

Koerner, R.M. and Koerner, J.R., 2006. *Survey of U.S State Regulations on Allowable Leakage rates in Liquid Impoundments and Wastewater Ponds*. U.S. Geosynthetic Institute, GRI White Paper No 15 which is available from web site http://www.geosynthetic-institute.org/papers/paper15.pdf.

Pennsylvania DEP, 2014. User's Manual for the Quick Domenico Groundwater Fate-and-Transport Model. Technical report which is available from web site http://files.dep.state.pa.us/EnvironmentalCleanupBrownfields/LandRecyclingProgram/LandRecyclingProgramPortalFiles/GuidanceTechTools/QD_manual_v3b%2002-28-2014.pdf.

UK Environment Agency, 2004. *Contaminant Fluxes from Hydraulic Containment Landfills – A Review*. UK Environment Agency Science Report SC0310/SR. The report is available from web site https://www.gov.uk/government/publications/contaminant-fluxes-from-hydraulic-containment-landfills-a-review.

UK Environment Agency, 2014. *Guidance on Monitoring of Landfill Leachate, Groundwater and Surface Water*. UK Environment Agency Technical Report LFTGN02 which is available from web site https://www.gov.uk/government/publications/monitoring-of-landfill-leachate-groundwater-and-surface-water-lftgn-02.

11. Limitations

1. The information provided is assumed to be correct, and it is assumed that groundwater samples from the site have been sampled and analysed in an appropriate manner.

Signatures

Author Name STEVE APPLEYARD	Signature [redacted]
Position PRINCIPAL HYDROGEOLOGIST	Date [redacted]
Reviewer Name Andrew Miller	Signature [redacted]
Position Senior Manager	Date [redacted]

Appendix 6: City of Cockburn dust sampling results

SUMMARY REPORT ON THE ANALYSIS OF SAMPLES RECEIVED ON 12TH APRIL AND 4TH MAY 2017

INTRODUCTION

One (1) swab sample was received on 12th April 2017 from the City of Cockburn. A further four (4) swabs and one (1) soil sample were received on 4th May 2017 for various analysis as outlined below.

SAMPLE IDENTIFICATION

ChemCentre No	Sample Marks	Analysis Required	Date Received
16S2406/001	Battersea Rd Canningvale	Metals, elemental & particle size	12/04/2017
16S2628/001	Merrit Loop #4	Metals, elemental & particle size	4/05/2017
16S2628/002	Merrit Loop #3	Metals, elemental & particle size	4/05/2017
16S2628/003	Merrit Loop #5	Metals, elemental & particle size	4/05/2017
16S2628/004	Fraser Rd #2	Metals, elemental & particle size	4/05/2017
16S2628/005	From roof gutter Merrit Loop	Metals, elemental, particle size & TOC	4/05/2017

METHOD

Material	Analyte Code	Method Name
Swab + soil	Metals screen	iMET1SBICP - Metals in swabs by Nitric/Hydrochloric digestion and ICPAES.
Swab + soil	Elemental composition	SEM-EDS – Scanning Electron Microscopy Energy Dispersive Spectroscopy
Swab + soil	Particle size	SEM-EDS – Scanning Electron Microscopy Energy Dispersive Spectroscopy
Soil	Total organic carbon (TOC)	(combs) - Total carbon, total organic carbon (acid pretreatment), total inorganic carbon (calculation) and Sulfur in soils by combustion, in-house method S57.

RESULT OF ANALYSIS

The results of analysis are given on the following page(s).

These results apply only to the sample(s) as received. Results may not be reproduced except in full.

Unless requested otherwise, sample(s) will be disposed of after 30 days of the issue of this report.

[redacted]

Chemist
Scientific Services Division
27th June 2017

16S2406 & 16S2628: Results of Metals Analysis µg/cm² unless specified otherwise

Compound Name	16S2406 /001	16S2628 /001	16S2628 /002	16S2628 /003	16S2628 /004	16S2628 /005[1]
Arsenic	<0.20	<0.20	<0.20	<0.20	<0.20	1.0
Barium	<0.020	<0.020	<0.020	0.028	0.094	15
Boron	<1.0	<1.0	<1.0	<1.0	<1.0	6.0
Cadmium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.05
Chromium	<0.020	<0.020	<0.020	<0.020	0.041	10
Cobalt	<0.020	<0.020	<0.020	<0.020	<0.020	54
Copper	0.033	0.023	0.034	0.049	0.11	15
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	5.9
Manganese	<0.020	<0.020	<0.020	0.035	0.2	24
Molybdenum	<0.10	<0.10	<0.10	<0.10	<0.10	<0.5
Nickel	<0.10	<0.10	<0.10	<0.10	<0.10	9.0
Selenium	<0.20	<0.20	<0.20	<0.20	<0.20	<2.0
Vanadium	<0.040	<0.040	<0.040	<0.040	0.041	5.7
Zinc	1.9	1.5	1.5	1.4	2.5	160

[1] Results in mg/kg

16S2406 & 16S2628: Results of Total Organic Carbon in Percentage (%)

Compound Name	16S2628 /005
Total Organic Carbon	1.71

16S2406 & 16S2628: Results of Particle Size Analysis in micrometres (µm)

Compound Name	16S2406 /001	16S2628 /001	16S2628 /002	16S2628 /003	16S2628 /004	16S2628 /005
Particle size range	1 - 650	5 - 300	2 - 70	1 - 110	5 - 220	1 - 650

Compound Name	16S2628 /005	World wide Crustal abundance[2]	Ecological Investigation Levels[3]	Health Investigation Levels[4]
	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Arsenic	1.0	1.8	20	100
Barium	15	390	400	5370
Boron	6.0	9	N/A	N/A
Cadmium	<0.05	0.16	3	20
Chromium	10	122	50	210
Cobalt	54	29	**50***	100
Copper	15	68	60	1000
Lead	5.9	13	300	300
Manganese	24	1060	500	1500
Molybdenum	<0.5	1.2	40	390
Nickel	9.0	99	60	600
Selenium	<2.0	0.05	N/A	N/A
Vanadium	5.7	136	50	550
Zinc	160	76	200	7000
Total Organic Carbon	1.71%	1 to 2% Perth	N/A	N/A

* the result for cobalt (54mg/Kg) exceeds ecological investigation guideline levels but remains under the health investigation guideline levels.
N/A – not applicable or no guideline published

Elemental analysis by SEM-EDS

The majority of the particles in samples 16S2406/001, 16S2628/003, 16S2628/004 and 16S2628/005 contained silicon and oxygen with associated minor elements, these particles would be consistent with sand. The remaining samples all contained minor or trace amounts of the same type of material the particles ranged in size from 5-300µm.

The majority of the particles in samples 16S2628/001 and 16S2628/002 contained carbon with associated minor elements, these particles would be consistent with organic substances. The remaining samples all contained minor or trace amounts of the same type of material the particles ranged in size from 5-500µm.

---

[2] Worldwide crustal abundance – the average amount of each of the elements in the earth's crust
[3] DoE (2003) Ecological Investigation Level
[4] DoE (2003) Health Investigation Level 'A' (Standard Residential)

Appendix 7: Technical Expert Report – Odour

Government of **Western Australia**
Department of **Environment Regulation**

REPORT

Technical Expert Report

Richgro Garden Products – Odour emissions

Version: Final

April 2017

Document control

Document version history

Date	Name	Role
05/04/17	Philippe Najean Senior Air Quality Officer	Author
05/04/17	Adrian Blockley Principal Expert – Air Quality	Reviewer

Corporate file information

File number and/or name	File owner or custodian	File location
DER2017/000819	Air Quality Services	Booragoon

Produced and published by
Department of Environment Regulation
168 St Georges Terrace, Perth, Western Australia

April 2016

Questions regarding this report should be directed to:
Department of Environment Regulation
Locked Bag 33 Cloisters Square
PERTH WA 6850
Phone: +61 8 6467 5000
Fax: +61 8 6467 5562
Email: info@der.wa.gov.au
Web: www.der.wa.gov.au

Accessibility This document is available in alternative formats and languages upon request

1. Introduction

This report provides technical advice on potential odours emissions and impacts related to the Richgro Garden Products (Richgro) premises located at 203 Acourt Road in Jandakot.

Specific advice has been provided on the following queries:

- Anaerobic Digestion (AD) Receival Hall:
  - Consideration on whether the doors are sufficient to prevent gusts of wind from entering the receival hall and releasing odour;
  - Consideration if this building is a significant source of odour; and
  - The adequacy of the air extraction system and negative pressure within this building
- AD Biofilter:
  - Consideration of the biofilter being fit for purpose;
  - Adequacy of the biofilter in treating all waste types received; and
  - Consideration if the biofilter if a significant odour source.
- Consideration of whether the AD tanks are significant sources of odour.
- Residence time within AD tanks and associated impacts to digestate odour.
- Leachate Ponds:
  - Consideration of the leachate ponds as a significant odour source; and
  - Adequacy of the pond aerators for odour management; and
  - Consideration of any additional measures that could reduce odour within the ponds.
- AD plant digestate:
  - Consideration on the significance of odour from the application of digestate; and
  - Consideration of the conditions when digestate could be applied
- Consideration of offsite odour sources

2. Documentation

AQS has reviewed the follow documents:

Table 2.1 Documentation

Document	Author	Date of document	Objective reference
File Note – Reporting Richgro site visit 6 February 2017	Philippe Najean - AQS	7/02/2017	Unknown
Extract of the 4th Ed. Essentials of Chemical Reaction Engineering	H. Scott Fogler & M.	2008	N/A

http://www.umich.edu/~essen/html/byconcept/chapter13.pdf	Nihat Gurmen		
L7308 Richgro Draft Inspection Report	Hayden Nebel	November 2016	A1167935

3. Background

The current licence granted under Part V, Division 3 of the *Environmental Protection Act 1986* is valid until 22 October 2025.

Since June 2016, DER has received a significant increase in odour complaints with the Richgro premises as the alleged odour source. A previous desktop study undertaken by DER Officers regarding these odour complaints has showed that complaints could reasonably be attributed to the Richgro premises.

Richgro operates an anaerobic digester (AD) plant which involves the acceptance of liquid and solid wastes into the AD tanks, generating biogas for electrical power generation and producing a liquid digestate. Richgro also composts green waste, pine bark and sawdust in uncovered windrows located in an open area.

Digestate from the AD plant is applied to the pine bark and green waste windrows (130m^3/day) without current authorisation under the licence. Officers within Air Quality Services (AQS) attended the Richgro premises on 6 February 2017 to obtain a better understanding of the process and operations at the facility in regards to odour mitigation and management.

During the February site visit, AQS officers witnessed that pine bark received water and not digestate and they were advised by the site manager that only green waste windrows are mixed with digestate.

DER considers that the likely sources of odour onsite are:

- AD plant including receival hall and biofilter
- Leachate ponds;
- Outdoor compost windrows;

With other potential odour sources identified in the vicinity of the premises being:

- Irrigation of groundwater; and
- The Lukin Swamp located adjacent to the Richgro premises boundary

4. Provision of advice

Advice provided in this report is based on:

- site visit undertaken on 6 February 2017;
- Richgro process review dated 2013 (works approval application);
- discussions with IR and Compliance & Enforcement (C&E) officers;
- review of complaints on ICMS between December 2013 and March 2017;
- AQS officer odour patrol findings around the Richgro premises in 2013 and at the end of 2016; and

- AQS odour specialist experience with AD, compost processes and odour management.

4.1. AD plant

The AD plant comprises three major sections, namely the Receival Hall, the biofilter and the AD tanks. Queries considered in this advice are addressed below.

4.1.1. AD receival hall

The large door used by trucks to enter the AD hall is automatic and closes as soon as a truck has moved in or out. There will be situations when wind enters the hall, creates an over-pressured environment and pushes odorous air out. However, due to the automatic door and the limited level of odour (as observed during the visit) in the building, which is also diluted when fresh air enters, possible odour impacts at sensitive receptors would be highly intermittent, very short in duration and with very low odour intensity.

On the day of the AQS visit, Richgro received dehydrated milk waste during the early morning, which created a characteristic odour in the hall although it was not strong in intensity. The volumes of waste present in the hall were not large, other than pallets of sodas that were waiting to be processed. It appears that the receival areas have limited capacity. Vegetables and fruits, which represent the majority of the solid waste, arrive fresh daily. When considering the limited volume of the receival areas and the volume of the mixing tank, the holding time of the solid waste is likely to be sufficiently restricted to avoid any putrefaction of the waste and associated odours when added into the mixing tank. However, a detailed inventory of the waste will provide more certainty on the amount of highly odorous waste.

Liquid wastes have the potential to be more odorous, however all liquids are directly mixed in the mixing tank upon arrival. It was also noted that the mixing tank, located in the hall, is covered with a tarpaulin which also limits the level of odours emitted in the hall. The odorous headspace underneath the tarpaulin is extracted and treated by the biofilter.

The duct collecting the air in the hall follows the perimeter wall on three sides of the building. The negative pressure was observed when entering the building. There is no collection duct above the main door that would normally be used to collect some of the air escaping the building when the door is open. It is, nonetheless, not expected to alter the risk of emissions and impacts off-site as previously explained.

The site manager indicated on the day of the visit that the Air Exchange Rate (AER) in the hall (when closed) was $4h^{-1}$ which is a typical rate for this size of ventilated volume.

4.1.2. AD biofilter

The biofilter is made of two (2) cells with a surface area (A) of $200m^2$ each. With an AER of $4h^{-1}$ and an average volume of $12,000m^3$ for the receival hall, the volumetric flow rate (Q) extracted from the building and directed to the biofilter is estimated to be almost $50,000\ m^3/h$.

This means that the specific load is $Q / A = 37.5\ m^3/h/m^2$ which is within the recommended specifications. The usual specification in a biofilter design would recommend a specific load approximately 100 $m^3/h/m^2$ or lower.

The Empty Bed Contact Time (EBCT) is used to provide an estimate of the velocity of the air through the depth of the biofilter. In this case the EBCT is equal to 144 seconds. The recommended specification is generally around 30 to 60 seconds. This means that the volumetric air flow rate is suitably low compared to the surface area of the biofilter in order to provide enough contact time for the odorous air to be degraded by bacteria present in the media.

The biofilter is within a shed with walls and roof made of tarpaulin that limits variations in the operational conditions. It will especially avoid any downwash of the microorganisms in the media during heavy rains.

On the day of the visit, it was possible to enter the biofilter shed. The odour level was low in the confined space above the media. This odour was weak with a very mild odour character that is unlikely to be recognised off-site. This odour is different to those experienced by the AOS odour specialist during several odour patrols performed in the vicinity of the facility under various meteorological conditions in 2013 and 2016. The biofilter therefore appears to work efficiently to degrade the odorous air sent from the AD hall and from the headspace of the mixing and dosing tanks.

A detailed inventory of these wastes is required to answer the question about the capability of the biofilter to handle the possible additional waste types. However, the current throughput of the AD plant, the enclosed conditions of biofilter operations, the current low specific load and high ECBT should allow the biofilter to cope with a limited increase in odour load due to the additional waste stream in the AD process.

4.1.3. AD tanks

The mixing tank (inside the hall) and dosing tank (outside the hall) are the two tanks where odorous air headspace is collected and sent to the biofilter. The outlet tank headspace is connected back to Digester Number 2, as the headspace would contain small amounts of methane. This would ultimately end up at the generator. AD tanks do not have any vents on their roofs.

In summary, AD tanks are not a source of odour as their headspace is either directed to the biofilter (mixing tank) or to the generator (digester and outlet tanks).

4.1.4. AD residence time

Digestion is driven by chemical and biological reactions that have their own kinetics. The site manager claimed that there is an average residence time of 30 days between the mixing tank and the outlet tank. From experience, this appears to be plausible.

The idea behind evaluating the mean residence time is that individual molecules spend different amounts of time in the system (here the AD tank train), with some molecules having a short residence time and others taking much longer to traverse the system.

It is impossible to assess the residence time for the AD plant tanks from a simple calculation and with the limited available information. It is generally achieved by the injection of a tracer under specific conditions to determine the Residence-Time Distribution (RTD) function. In this case it is expected that the train of tanks is considered as a train of continuous flow stirred-tank reactors (CSTR) in which case some specific distributions may apply.

Consequently, it is expected that the average composition and odour potential of the digestate is constant over time, assuming:

- the residence time of about 30 days indicated by the plant manager is correct; and
- the previous discussion about the steady types and volumes of waste added into the AD plant process over time.

4.2. Leachate ponds

On the day of the AQS visit, it was noted that the main pond was fitted with eight (8) surface aerators. The water agitated above the aerator appeared to be muddy. Although DER officers were intermittently downwind of the pond when the wind was shifting, it was not possible to confirm the presence of odour.

Ponds 1 and 2 are fitted with solid traps at their entrance which prevent large volumes of solids entering the pond. These ponds are also fitted with aeration systems and no specific odours could be recognised downwind of ponds.

Aeration is a recommended operation to be implemented on such ponds to increase the level of oxygen and limit the reduction of chemical compounds that may then become odorous.

In addition, downwind olfactive inspection of a large pile of pine bark sprayed with water from the pond system did not reveal any specific odour (intensity and character) on the day of the site visit.

Operations currently implemented to manage leachate ponds are the usual and recommended operations to limit odour emissions from such sources.

4.3. Digestate

The digestate is the final product of the digestion system and is stored in the outlet tank. Richgro is currently mixing this digestate with green waste (and with pine bark as advised to DER Officers) although not authorised under the licence. During the visit, the site manager indicated that for the pine bark products, lime, urea and treated water from the main pond are used.

On the day of the AQS visit, a windrow of green waste was mixed with digestate. Digestate has replaced chicken manure in the green waste compost. Some sawdust is also added to the windrow. A volume between 100 and 130 m^3 of digestate is used daily for the fermentation phase of composting. The digestate is collected in a tanker, then the truck is connected to the windrow turner machine which adds the digestate while mixing and turning the windrow.

Two pipes deliver the digestate at the front of the turner while processing the windrow. The flow rate of digestate delivered by the 2 pipes is constant. Therefore, the operator slightly modifies the traveling speed of the turner to add more or less moisture to the windrow. From the observations on site, it appears this method of injection allows a better mixing of the liquid phase (moisture) in the windrow, limits air contact from the digestate and improves the control of added volume (limiting over-saturation and production of leachates).

DER officers stood at close distance downwind of the turner while the digestate was injected into the windrow. A decomposing organic type odour at an odour intensity level between weak and distinct was noted. However, it was not possible to confirm that this odour was the same odour as that recognised off site during odour patrols in November and December 2016. The odour dissipated quickly after 15 to 20 meters. Several older green waste windrows were on the hardstand area and downwind olfactive inspection did not reveal any strong odour on this day.

In an AD plant, anaerobic digestion must be performed under constant conditions within strict limited ranges of temperature and pH but not only. It is therefore beneficial for the proponent to maintain steady conditions within the process. It is important that the type and volume of waste to be mixed have minimal variation. The volume of the mixing, digester and outlet tanks is large enough that the production of a digestate would not be expected to vary significantly (residential time of 30 days according to the site manager). It does mean that the odour potential from the digestate should therefore be relatively constant over time. Highly odorous raw solid waste should be avoided to limit the carry-over of the odour through the system up to the outlet tank.

However, there are several limitations for the comparison of observations during the AQS visit with other operational and meteorological conditions that occur at the site:

- The wind velocity was 4 to 5 m/s on the day of inspection, which is significantly different from still conditions that may be more conducive to odour transport and impacts off-site;
- Observations were made between 9am and 10am when atmospheric conditions are likely different from early morning conditions and less conducive for transport and possible impacts off-site;
- The site manager indicated that regular moisture tests are performed. However, it was not confirmed that initial green waste moisture tests are carried out to determine the volume of digestate necessary to achieve the expected moisture in the windrow when initially blended.
- No significant leachates were observed running on the hardstand area on the day of the visit, however, additional information, including the volume (ratio) of digestate added to the windrows and the mode of determination of these volumes is required.

Despite no identification of significant odours or sources of odour during the site visit, DER has received numerous odour complaints for the last several months. These indicate that Richgro may be the cause of impacts and therefore that a source, or more likely several sources (cumulative emissions), are likely to be present on the site.

Observations during odour patrols have confirmed the presence of odour impacts at residential locations with some distinct odour intensity levels. It was confirmed that there were no any other odour sources upwind of the Richgro facility that could have produced this same odour. Additional investigations are required to be undertaken by the proponent to identify the origin of the odour within their site impacting the neighbourhood.

From experience with off-site Richgro odour recognition during previous odour patrols in 2013, the odour characteristic has evolved from composting odour to putrid and rancid odour detected at the same locations (2016) under similar meteorological conditions. This means that odours emitted have changed. A review of the process and operational conditional between 2012 and now, shows that changes are related to the AD plant and the composting process with the use of digestate instead of manure for green waste composting.

As stated before, it is unlikely that the AD Receival Hall, the biofilter or the AD tanks would be significant odour sources. Even their contribution to odour emissions from a cumulative point of view is likely to be insignificant for the odours experienced off-site. Finally, according to the odour characteristic and the results from the various odour patrols, indicating a wide spread of odour impacts, one likely source would be the green waste composting windrows applied with the digestate. It is not certain that the mixing (initial and during the fermentation process) would be the major source due to the conditions of addition of the digestate in the green waste windrow (see previous discussion).

It should also be possible to assess if the claimed 130 kL of digestate used daily in the green waste process is the optimum amount for the green waste composting process. There are two possibilities:

- this volume is required to maintain the moisture in all green waste windrows daily. Water balance and moisture management operational procedures should assist in determining this; it would be expected that this volume varies between dry and wet weather periods;
- this volume is not necessary for the composting process and only needs to be removed from the outlet tank to provide enough capacity for daily digestate production under current inlet throughput.

In regards to the question related to the possible authorisation of digestate application and conditions (wind speed and direction and digestate volume) to reduce odour, the above discussion shows that the application and mixing of the digestate into the windrow is an unlikely cause of odours. If further investigations by the proponent demonstrate otherwise, it would be suggested that application occurred between 10am and 3pm, under wind speed above 2m/s and wind direction from two specific sectors (sector 1: north-west (NW) to south-west (SW) and sector 2: north (N) to east-south-east (ESE)). These limiting parameters will likely need to be refined and tested under specific licence conditions initially.

4.4. Potential offsite odour sources

4.4.1. Lukin Swamp

It is difficult determine if the Lukin Swamp is a significant odour source as it will depend on the ability of the swamp to retain water after heavy rains, mainly in the winter period, and if this water may degrade and release odours.

It is expected that during the summer period this swamp is dry and therefore has no odour emission.

Finally, although this swamp cannot be totally disregarded as an odour source, it wasn't identified as a source of the numerous odours recognised to the north of the Richgro site during odour patrols in 2013 and 2016.

4.4.2. Production bores

It is unlikely that the main odour recognised during the odour patrols would be confused with bore water odour. Bore water odour has been experienced during odour patrols in this area and has a different odour type to that from Richgro. This odour is known by residents and experience has shown (Southern Metropolitan Regional Council case study) that there is no possible confusion between bore water and another type of odour similar to compost-type processes.

5. Limitations

Please note the following important information relevant to the review of this proposal by AQS:

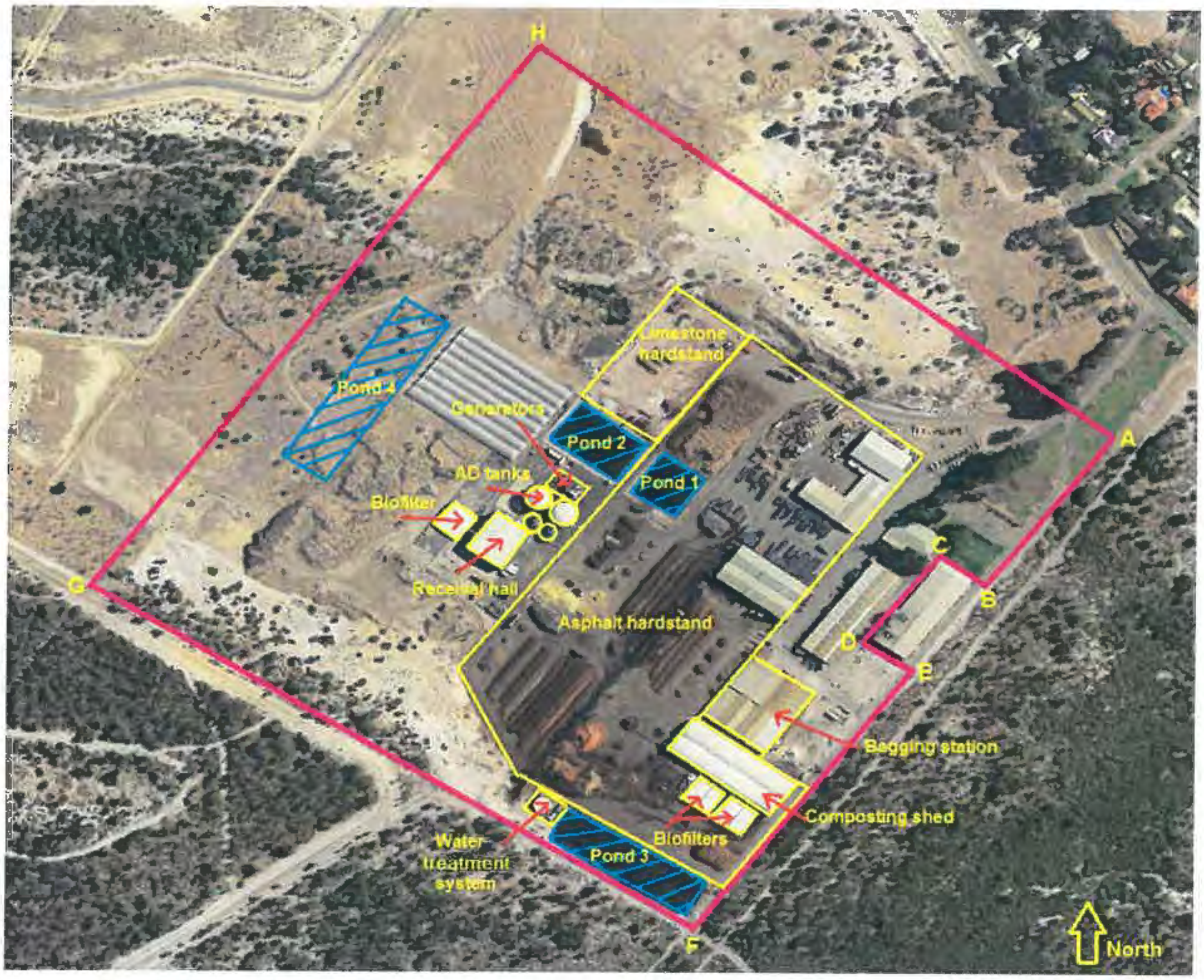
- Pollutant of concern considered in this review is odour. There may be other pollutants emitted at trace levels or other atmospheric processes (e.g. particles associated with organic compounds, semi-volatile species, transient species, complex mixtures, etc.) that may contribute to cumulative concentrations and impacts in the regional airshed. AQS has no reason to believe that such emissions constitute a significant public health risk, but caution that there are few data available to make an assessment at this time;
- AQS cannot not assess the proposed technology in terms of emission control, and how this relates to requirements for implementation of "Best Practice" as per EPA Guidance Statement No. 55;
- AQS does not have expert knowledge in the areas of process/chemical engineering, laboratory analytical methods, stack testing methods or Anaerobic Digestion plant and composting operations, all of which are critical to the construction of an emission inventory of this nature;
- Notwithstanding the valid advice provided herein, this review does not constitute formal endorsement and approval by DER. This would require an independent review by an accredited auditor of industrial sites, with extensive knowledge of Anaerobic Digestion plant and composting operations. This AQS review should be considered as an assessment of "as supplied" documentation by an air quality generalist, with the intent of alerting you to issues we consider important;
- AQS does not have primary responsibility for the assessment of public health issues, including Health Risk Assessment, in relation to air pollution. This is the role of the Department of Health;
- AQS cannot provide buffer determinations for urban land development subdivision proposals near existing industry or other air pollution sources. The primary reference for minimum separation distances is EPA Guidance Statement 3: *Separation Distances between Industrial and Sensitive Land Uses*. **Please note that air quality modelling or monitoring are generally not suitable for resolving amenity issues caused by urban encroachment on industrial or intensive agricultural sites.**

Signatures

Author Name	Philippe Najean	Signature	
Position	Senior Air quality officer	Date	05/04/17
Reviewer Name	Adrian Blackley	Signature	
Position	Principal Expert	Date	05/04/17

Attachment 1: Premises map

The ***Premises*** is shown in the map below. The pink line depicts the boundary to the ***Premises***. The yellow numbers refer to the GPS coordinates specified on page i of the ***Licence***.



Attachment 2: Groundwater monitoring bore map

The location of the groundwater monitoring bores are depicted as yellow dots shown on the map below.