4A-105 - AEROBIC AND ALGAL TREATMENT OF PIGGERY WASTEWATERS FOR HEAT RECOVERY, EFFLUENT TREATMENT AND WATER REUSE

Report prepared for the Co-operative Research Centre for High Integrity Australian Pork

By

Professor Howard Fallowfield and Dr Ngai Ning Cheng

Health and Environment Group, College of Science and Engineering, Flinders University, Adelaide

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Executive Summary

The project contributed to Program 4 Carbon Conscious Nutrient Inputs and Outputs of the Pork CRC, which aimed to reduce effluent emissions through novel management strategies. This included an aspirational target to reduce greenhouse gas emissions (GHG) from 6-8 kg CO₂e kg meat⁻¹ to 1 kg CO₂e kg meat⁻¹ for at least 5% of meat produced. There was also a vision to explore the application of algal biotechnology in the pork industry. Subsequently, a review¹ which included a life cycle assessment identified wastewater treatment, capable of integration with current practice, as the most likely approach to meet these objectives.

Algae grow prolifically, in suitable wastewaters while using carbon dioxide. The algal biomass can be converted on-site to energy, offsetting CO₂ emissions from fossil fuel derived electricity and reducing GHG emissions. Anaerobic lagoons are the predominant treatment systems employed within the Australian pork industry. The effluent is reused within the production environment. It is generally of poor quality containing high concentrations of ammonia and microorganisms. These have been shown to have an adverse effect on pig health; potentially increasing time and associated feed costs to achieve slaughter weight. High concentrations of ammonia also inhibit algal growth. Aerobic treatment of effluent from anaerobic lagoons was identified as a technology which could convert ammonia into nitrate removing its adverse impact on both pig health and algae. The integration of anaerobic - aerobic - algal treatment of piggery wastewater was investigated at Roseworthy Piggery, Adelaide.

A research pilot plant was constructed comprising a 13m³ aerobic reactor with a 1.1 kW aerator. Aeration, to convert ammonia to nitrate, is controlled by continuous monitoring of dissolved oxygen to reduce energy consumption. The aerobic treatment is followed by nutrient removal and disinfection in a 59m², 19 m³ at 0.3 m depth high rate algal pond (HRAP). The HRAP is a single pass raceway, with a maximum operational depth of 0.5m, mixed by a paddlewheel powered by a 0.75 kW motor and gearbox. The pilot plant is operated and monitored remotely using cloud based software.

Unfortunately delays in receiving permissions and leasing agreements significantly delayed construction. The pilot plant was commissioned. The aerobic reactor was commissioned and nitrification of anaerobically pre-treated slurry was clearly demonstrated. Early estimated suggest an energy consumption between 1.4 - 2.2 kW d⁻¹. Further significant evaluation is required to determine treatment performance (nutrient removal and disinfection) and the potential for algal biomass energy recovery.

The pilot plant is a unique durable asset to further research to enhance the quality of wastewater reused in piggery operations with the objective of reducing emissions, generating on-site energy and improving pig and occupational health.

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1. Introduction

The Pork CRC at its inception had an aspirational target to reduce current greenhouse gas emissions (GHG) from 6-8 kg CO$_2$e kg meat$^{-1}$ to 1 kg CO$_2$e kg meat$^{-1}$ for at least 5% of meat produced. More recently, the GHG emissions for the national herd were estimated at 3.6 kgCO$_2$e kg$^{-1}$ live weight (Wiedemann et al., 2016) suggesting the lower estimate 6 kg CO$_2$e kg HSCW$^{-1}$ was the more likely. A review commissioned by the CRC (Buchanan et al., 2013) provided a high level life cycle assessment (LCA) of current and proposed manure handling strategies to enable comparison in units of kg CO$_2$e emitted per kg of HSCW of meat produced. The LCA identified the integration of anaerobic-aerobic and algal treatment (Figure 1.1), followed by on-site energy generation, as the approach which would significantly reduce GHG emissions, while recognising this scenario required most capital investment.

![Figure 1.1 Proposed integrated anaerobic - aerobic and algal treatment of piggery wastewaters to reduce greenhouse gas emissions from pork production (Buchanan et al. 2013)](image)

83% of Australian pork producers treat piggery waste in multiple anaerobic and facultative ponds (Piazza Research 2010). Covered anaerobic ponds are increasingly being adopted by the industry for wastewater treatment, methane production and subsequent electricity generation. Anaerobically treated wastewater, however, has high concentrations of ammonium (NH$_4$-N) and suspended solids. A study on a fully covered anaerobic pond reported 6.61 gL$^{-1}$ and 1.21 gL$^{-1}$ of total solids and NH$_4$-N respectively within the treated effluent (Birchall 2010). High concentrations of ammonium/ammonia and suspended solids both adversely affect the growth of algae.

The ammonium ion is the predominant form at neutral or slightly basic pH, however, it dissociates (NH$_4^+$ pK$_{a}$ 9.25) to ammonia at alkaline pH values frequently reported during the growth of algae. The ammonia (NH$_3$) is toxic to microalgae and its presence significantly reduces microalgal photosynthesis and growth. The photosynthesis of the micro-green alga *Scenedesmus obliquus*, for example, was inhibited by 90% at > pH9.0 (10-25°C) at an NH$_3$ concentration >20 mgL$^{-1}$ (Azov & Goldman, 1982). The solids content of the wastewater has a major influence on abiotic absorption of light with depth, adversely affecting the availability of light.
for microalgae for photosynthesis. It is clear that anaerobically treated effluent requires further treatment to enable the growth of algae for GHG abatement, energy production and wastewater treatment.

Aerobic treatment of piggery wastewater, while intrinsically an efficient treatment process, offers a number of advantages if coupled with anaerobic digestion particularly when considering subsequent algal production on the treated effluent. Specifically, aerobic treatment offers the potential to biologically oxidise ammonia to nitrate, preventing ammonia inhibition of algal growth; aerobic treatment also enhances subsequent solids separation and odour control (Buchanan et al, 2013). Anaerobic pre-treatment removes much of the organic carbon before aerobic treatment; reducing the oxygen demand and associated energy consumption associated with carbon oxidation. The oxygen demand is lower since it is mainly required for ammonium oxidation to nitrate (Eq 1.1 & 1.2), preserving a nitrogen source for algal growth which is not toxic to microalgae.

\[
\text{Nitrosomonas spp. bacteria} \\
\text{NH}_4^+ + 1.5 \text{O}_2 \rightarrow \text{NO}_2^- + 2\text{H}^+ + \text{H}_2\text{O} \quad \text{Equation 1.1}
\]

\[
\text{Nitrobacter spp. bacteria} \\
\text{NO}_2^- + 0.5 \text{O}_2 \rightarrow \text{NO}_3^- \quad \text{Equation 1.2}
\]

Nitrification is an exothermic reaction. Heat evolution, expressed as a function of oxygen consumed, was established at 1.2 kWh kg O\(_2\)\(^-1\) by Evans et al., (1982), Metcalf & Eddy et al., (2003).

Carbon oxidation in concentrated raw slurries is the most energy releasing reaction, and always occurs when aerobic conditions are maintained. Approximately 60% of this energy is used by micro-organisms to synthesise biomass while the rest is lost in the form of heat. The heat evolution has been expressed as a function of oxygen consumed and a value of 4 kWh kg O\(_2\)\(^-1\) was established (Svoboda and Evans, 1987). This heat increases the temperature of aerated, concentrated raw slurry in heat insulated systems, and with efficient aerators the slurry treatment temperature can reach over 50°C. This autoheating process has been utilised for various purposes, as mainly for slurry hygienisation (pathogen destruction) and utilisation of generated heat.

Green algae grow prolifically in wastewaters, recovering nutrients and producing significant amounts of biomass which can be further digested to methane for electricity generation. Published algal biomass productivities when grown in piggery wastewaters range from 2.5 - 25 g m\(^{-2}\)d\(^{-1}\) (Boersma et al, 1975, De Pauw et al, 1978 Groeneweg et al., 1980, Lincoln & Hill, 1980, Lee & Dodd, 1980, Fallowfield & Garrett, 1985a, Svoboda and Fallowfield, 1989) with an energy content of 21.17 kJ g\(^{-1}\) (Fallowfield & Garrett, 1985a).
Laboratory research has diluted the piggery wastewater to reduce the ammonium and suspended solids to concentrations which enable algal growth (Barlow et al., 1975 and Boersma et al., 1975; Wilson and Houghton, 1974; Waygood et al., 1980 and Baumgarten, et al., 1999). Larger scale treatment systems typically grow the algae in shallow, mechanically mixed ponds of meandering channel design - high rate algal ponds (HRAPs). The application of HRAPs to wastewater treatment was recently reviewed (Young et al., 2017).

Many of the published studies also use dilution to manage the challenges associated with high NH$_4$-N and suspended solids. Fallowfield & Garrett, (1985a) pretreated the raw slurry using rotary press screen separation, polymer flocculation and sedimentation, however, the decanted liquid phase required 1:9 dilution with water to enable algal growth. In Scotland raw pig slurry was aerobically pre-treated and diluted 1:4; (Svoboda and Fallowfield, 1989) and 1:5 (Fallowfield et al., 1999). Gantar et al., (1991) compared the performance of Spirulina platensis and Scenedesmus quadricauda grown in laboratory culture on 10 - 50% diluted pig slurry. Olguin et al., (2001) investigated the effect of low light and nitrogen deficiency on the chemical composition of Spirulina sp. grown somewhat impractically in a mixture of 2% anaerobically digested pig slurry in sea-water from the Gulf of Mexico. Canazares-Villanueva et al., (1994) investigating Phormidium for wastewater treatment used 10, 25 and 50% anaerobically pretreated manure. It is, however, widely recognised that dilution of piggery wastewaters to enable large scale algal biomass production is impracticable.

More recently Hawley (2017) has conducted laboratory research, funded by the Pork CRC, which demonstrated proof of concept. A longer theoretical hydraulic retention time (THRT; 10d) together with returning 20% of the settled activated solids to the reactor (RAS) reduced NH$_4$-N concentrations by 82% while maintaining the nitrogen in the treated wastewater as either NO$_2$-N or NO$_3$-N (Figure 1.2).
Figure 1.2 Effect of 20% return activated sludge (RAS) vs. No-RAS on mixed liquor inorganic N transformation (mean ±SD) before and after aeration at an air saturation level up to 100% and THRT of either 5 d (ST5 and R3) or 10 d (ST6 and R1); (Hawley 2017)

Similarly, a 79% reduction in total suspended solids in the treated effluent compared to the influent was achieved by in a laboratory scale aerobic reactor at a 10d THRT with 20% RAS (Figure 1.3; Hawley 2017).

Subsequently, algal growth experiments were conducted using anaerobically pre-treated wastewater from the Roseworthy Piggery aerated at 6.44 ± 10.5 mg O₂ L⁻¹ at a 10 d THRT with 20% RAS). The initial composition of the anaerobically treated wastewater is shown in Table 1.1. The aerobically treated wastewater was inoculated (10% algae: 90% slurry) with natural occurring algae within wastewater from the HRAP at Kingston on Murray, South Australia.
Figure 1.3: A comparison of the mean TSS load when RAS feedback was present to those of the non-recycled trials of Chapter 5 under the same operating parameters; up to 100% DO saturation (uncontrolled) and either a 5 or 10 d THRT (Hawley 2017).

Table 1.1 Composition of the initial anaerobically pre-treated wastewater and following aerobic treatment at a residence time of 10d with 20% return activated solids (after Hawley, 2017)

<table>
<thead>
<tr>
<th></th>
<th>Anaerobically treated wastewater</th>
<th>Post aerobic treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total suspended solids (mg/L)</td>
<td>2.49</td>
<td>0.5</td>
</tr>
<tr>
<td>NH₄-N (mg N/L)</td>
<td>0.96</td>
<td>0.17</td>
</tr>
<tr>
<td>NO₂-N (mg N/L)</td>
<td>ND</td>
<td>0.43</td>
</tr>
<tr>
<td>NO₃ - N (mg N/L)</td>
<td>ND</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Significant algal growth (Figure 1.4) was demonstrated using chlorophyll a, the photosynthetic pigment present in green algae, as a surrogate measure for algal biomass. These results clearly demonstrated that integrated anaerobic and aerobic treatment had reduced both the suspended solids and the ammonium concentrations to levels which enabled algal growth.
Chlorophyll a concentrations in the inoculated (treatment) and uninoculated (control) anaerobically-aerobically treated mixed liquor over a 28 d growth period under continuous light (PAR400 -700nm; 26.5 µmol m·s·1 at 24°C on an orbital shaker (100 rpm); Hawley (2017).

Due to the high nutrient and organic load of the treated slurry it is not suitable to discharge into environmental waters (Tucker, McGahan et al. 2010). For many piggeries the supply of potable water is limited and certainly insufficient to allow for regular flushing and wash down exclusively with potable water. In Australia 71% of pork producers treating solid waste and 61% treating liquid waste are land spreading as fertiliser (Piazza Research 2010). Effluent from treatment systems is reused within the shed for 78% of total production within the Australian pig industry (Piazza Research 2010). 22% of large producers reuse this effluent as wash down water as well as flushing water. A review (Buchanan et al, 2013) identified subclinical disease as a consequence of poor manure handling strategies. Poorly disinfected wastewater reused for wash down and flushing potentially reintroduces pathogenic and commensal organisms. Murphy et al. (2012) presented evidence of a significant link between ammonia and the airborne concentration of commensal bacteria within pig sheds on pig health. They observed an adverse, synergistic relationship between high ammonia concentration and high levels of commensal alpha haemolytic cocci on weight gain and other health indicators. Murphy (2011), showed that using recycled effluent as flush water raised the in-shed airborne concentration of total culturable bacteria and ammonia to a level significantly higher than when potable water was used for flushing and had a significant negative effect on pig daily growth rate, other health indicators and consequently cost of pork production.
Buchanan et al (2013) identified research needs associated with the integration of anaerobic-aerobic and algal treatment of piggery wastewaters (Table 1.2). The project reported here contributes to fulfilling these research needs. The aims of the project were to:

- Design & construct an integrated wastewater treatment plant (iWWTP) comprising aerobic treatment (AT) and high rate algal ponds (HRAPs)
- Commission the iWWTP
- Evaluate the performance of the iWWTP - carbon oxidation/heat recovery, nitrogen conversion, algal biomass production, disinfection and reuse water quality.

Table 1.2 Research needs identified in Algae for Energy and Feed: A Wastewater Solution. A Review (Buchanan et al, 2013)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Research need</th>
</tr>
</thead>
</table>
| Aerobic treatment   | • Integration of anaerobic and aerobic systems with the objective of oxidising the high ammonia content of anaerobic effluent to nitrate to enable growth of algae in the absence of toxic ammonia in high rate algal ponds.  
                       • Development of cost effective methods of recovering the CO₂ from aerobic treatment for algal culture in high rate algal ponds.  
                       • Determination of energy yield from nitrifying aerobic reactor fed anaerobically pre-treated pig slurry. |
| Algal growth in HRAPs | • Infrastructure investment to enable pilot, on-farm research on the integration of anaerobic treatment (covered lagoons and/or engineered vessels) with aerobic or biofiltration technologies, to manage both light attenuation by solids and ammonia toxicity, with HRAPs to enhance wastewater treatment (nutrient and pathogen removal) for reuse and enable growth and biomass production of microalgae for fuel and fertiliser.  
                       • Determination of the impact on algal productivity of supplementary heating of HRAPs using recovered heat from energy generation from CH₄ or aerobic treatment.  
                       • Life cycle assessment of integrated anaerobic-aerobic-high rate algal pond systems using performance data from pilot scale operation. |

HRAPs have higher disinfection capacities than standard lagoons. Piggery water that has been treated in a HRAP will not only have significantly reduced pathogen levels and possibly fewer commensal organisms but also have significantly reduced NH₄ levels (Buchanan et al, 2013). Bolton (2013) recently reviewed the disinfection performance of various systems for the treatment of piggery wastewaters (in Buchanan, et al 2013).
2. Design & Construction of the Integrated Wastewater Treatment Plant Comprising Aerobic Treatment (AT) and High Rate Algal Ponds (HRAP)

2.1 Design, Planning and Licensing

Roseworthy Piggery, University of Adelaide (34°30'45.62"S, 138°40'43.85"E; Plate 2.1), after consultation with industry and the Pork CRC, was selected as the site for the pilot plant. The construction of the pilot plant required Development Approval from Light Regional Council. The original design (Appendix 1) of the civil works, and subsequent amendments (Appendix 2), submitted for approval were prepared by Gayler Professional Services. The Development Application was submitted 21st May 2015 with the assistance of Stewart Payne Planning Consultancy Services. In addition to the Development Application and covering letter the application comprised copies of the Certificate of Title, Development Report, Appendices to the Development report, Location Plan, site, detail and elevation plans. The Development Application required community consultation before approval could be granted. Development Plan Consent (Appendix 3) was granted 17th July 2015, Building Rules (Appendix 4) were granted 12th August 2015 and the final Development Approval (Appendix 5) was granted 17th August 2015 and subsequently amended 7th February 2017 to acknowledge replacement of instrument shed with a shipping container and reduction in the size of the high rate algal pond due to cost constraints.

Plate 2.1 Roseworthy Piggery showing anaerobic lagoon and adjacent pilot site for integrated aerobic-algal wastewater treatment
Dr Neil Buchanan the Postdoctoral RA on the project fell ill at the end of 2014. The CRC generously agreed to retain Neil on the project when absent either on annual or sick leave from 5th January - 9th April 2015. Dr Neil Buchanan, died July 2nd 2015. The project was conducted without Postdoctoral support until the appointment of Dr Cheng from 14th March 2016 - 14th March 2018.

Discussions regarding a licensing agreement to lease land at Roseworthy from University of Adelaide were protracted, commencing 10th March 2015. The Roseworthy Piggery Board approved progression of the project 9th November 2016. The Licensing Agreement (Appendix 6) was signed by Flinders University 7th December 2016 and executed by Adelaide University 7th May 2017, following significant intervention from Prof. Wayne Hein, Sarah Hocking and Flinders Building and Property Division.

2.2 Construction

Discussions with contractors commenced 24th February 2017; Ridley’s and Dematec were engaged (March 2017) for provision of civil works and control/data acquisition systems respectively. Bristers Engineering were contracted for provision and installation of paddlewheel mixer for the high rate algal pond. Identification of materials commenced January and procurement in April 2017. Construction commenced with earthmoving 3rd May 2017; estimated time to completion was 6 - 8 weeks. The sizes and specifications of pumps, mixers and aerator are shown in Table 2.1. Tank sizes and wall penetrations are provided in Appendix 7.

A single, earthen walled HRAP with a base surface area of 59 m², lined with geotextile and 1.5mm HDPE liner was constructed (Figure 2.1). The HRAP volume is 19m³ at an operational depth of 0.3m. The concrete channel divider and a concrete mounting block supported an 8 blade stainless steel paddlewheel, driven by a 0.75 kW motor coupled directly to a 1:100 reduction gear box with shear pin. The paddlewheel was designed to rotate at ~ 12 rpm to provide a mean surface velocity of 0.2 m s⁻².

However, further delays were encountered. The electricity supply was sourced from the Roseworthy office rather than the sow shed in close proximity to the pilot plant - this incurred additional cost and time for construction. In May the contractor was notified that the delivery time for pumps had extended from one to eight weeks ultimately they were received 8th August 2017. Consequently, this delayed installation of control and monitoring equipment by Dematec. The insulated shipping container comprising pumps, mains board, the control and monitoring systems was placed on site 11th September 2017. Electrical installations ceased until 9th October since the piggery manager requested no power interruptions to the piggery over this period. Procurement of replacements for rodent damaged or faulty probes and transmitter controllers caused in further delays. Construction was completed (Plate 2.2 - 2.4) and the plant was handed over to Flinders University in January 2018.
<table>
<thead>
<tr>
<th>Tank No.</th>
<th>Name</th>
<th>Volume (L)</th>
<th>Overall height (m)</th>
<th>Top of wall height (m)</th>
<th>Overflow height (m)</th>
<th>Diameter (m)</th>
<th>In tank mixer/aerator</th>
<th>Electrically connected devices</th>
</tr>
</thead>
</table>
| T1      | Slurry reception pit       | 5,000      | 2.20               | 1.94                   | -                   | 1.80         | Mixer: BRIO 1.0 (415 three phase); 1200kL/h                                              | • Four float switches (LL, Low, High, and HH)   
|         |                            |            |                    |                        |                     |              |                                                                                       | • Flow switch (for P2)    
|         |                            |            |                    |                        |                     |              |                                                                                       | • P2 - One 0.75kW pump    
|         |                            |            |                    |                        |                     |              |                                                                                       | • M1 - One mixer (1.2kW)  |
| T2      | Aerobic reactor           | 13,500     | 2.63               | 2.17                   | 2.82                |              | Aerator: Acqua & Co Force 7.1                                                              | • One Krohne pressure level transmitter                                        
|         |                            |            |                    |                        |                     |              | • Voltage 415V/3ph                                                                    | • Two float switches (LL and HH)                                             
|         |                            |            |                    |                        |                     |              | • Rated Power (KW): 1.1                                                                  | • One temperature transmitter                                           
|         |                            |            |                    |                        |                     |              | • RPM: 2800                                                                              | • Flow switch (for P3)                                                     
|         |                            |            |                    |                        |                     |              | • Aeration (m³ Water /Hr): 80                                                              | • P3 - One 0.75kW pump                                                 |
|         |                            |            |                    |                        |                     |              | • Air Delivery Rate (m³ Air /Hr): 13                                                    | • A1 - One 1.1kW submersible aerator                                          |
|         |                            |            |                    |                        |                     |              | • O₂ Delivery Rate (m³ O₂ /Hr): 3.3                                                     | • ABB DO transmitter                                                     |
|         |                            |            |                    |                        |                     |              | • O₂ Delivery Rate (kg O₂ /Hr) at 0º C: 2.35                                            | • ABB pH transmitter                                                      |
| T3      | Sedimentation tank        | 4,000      | 2.65               | -                      | -                   | Top: 1.73    | *Floating suction blocks x2 attached to pipe                                             |                                                                                                                              |
|         |                            |            | (Top to stand: 1.45| Stand: 1.20 Bottom outlet to pump4 to ground: 0.30) |                     | Bottom: 1.66 |                                                                                          |                                                                                                                              |
| T4      | Make up tank              | 10,000     | 2.35               | 2.00                   | 2.12                | 2.5         | -                                                                                       | • Four float switches (LL, Low, High, and HH)                                      
|         |                            |            |                    |                        |                     |              |                                                                                       | • Two float switches (for P4 and P5)                                            
|         |                            |            |                    |                        |                     |              |                                                                                       | • P4 - One 0.75kW pump                                                  
|         |                            |            |                    |                        |                     |              |                                                                                       | • P5 - One 0.75kW pump                                                  |
| T5      | Disposal sump             | 2,000      | 2.26               | 1.99                   | -                   | 1.17        | -                                                                                       | • Four float switches (LL, Low, High, and HH)                                      
|         |                            |            |                    |                        |                     |              |                                                                                       | • Flow switch (for P6)                                                      
|         |                            |            |                    |                        |                     |              |                                                                                       | • P6 - One 0.75kW pump                                                  |
Plate 2.2 Construction of high rate algal pond

Plate 2.3 Integrated anaerobic-aerobic-algal wastewater treatment at Roseworthy Piggery

Plate 2.4 Control centre
Figure 2.1 Integrated wastewater treatment system as constructed at Roseworthy Piggery
2.3 Operational Overview

Anaerobically treated pig slurry has high ammonia and suspended solids concentration which precludes using it as a substrate for the growth of microalgae for wastewater treatment, disinfection and sustainable biomass energy production. The objective of the research was to incorporate aerobic treatment of the slurry to convert the ammonia to nitrate using naturally occurring populations of aerobic nitrifying bacteria. The process to be operated on a continuous basis.

Anaerobically digested piggery effluent from the existing lagoon is firstly transferred to a reception pit (T1) and then to the aerobic reactor at programmed intervals. NH$_3$N is converted to NO$_3$N under aerobic conditions using naturally occurring populations of aerobic nitrifying bacteria. The resulting treated slurry is then pumped into a sedimentation tank (T2) where the supernatant liquid phase is delivered to a make-up tank (T3). Finally, effluent from the makeup tank is transferred into HRAP for nutrient removal via growth of the algal biomass. The HRAP is mixed by an eight bladed paddlewheel and its hydraulic residence time is determined by the rate of slurry addition and/or change in HRAP depth (maximum operating depth 0.5m). Treated HRAP effluent is returned to sump (T4) and then returned to anaerobic pond prior to land spreading (see Figure 2.2)
2.4 Aerobic Reactor: Operational and control philosophy

All tanks have high and low level switches to avoid tank overflows and for cessation of pumping events respectively. There are also flow sensing device (thermal dispersion sensors) installed for each pump for the purpose of protecting the pump in a dead head scenario. The programming functionality will raise an alarm and stop the pump if it has been running for a predefined duration with no flow achieved. There is also a flow meter between the make-up tank and the HRAP which allows monitoring of gravity flow into the HRAP. There is an option to return settled sludge from aerobically treated effluent from the separation tank to the aerobic reactor to maintain process and enhance the population of nitrifying bacteria. All tanks can be emptied of slurry by using existing pumps and changing valve arrangements with the slurry directed to the sump for subsequent discharge to the anaerobic lagoon. All valves can be manually operated.

A 7 inch colour human machine interface (HMI) was installed as the user interface for the system (see Plate 2.5 - 2.10). The HMI content comprises:

- Overall process ‘mimic panel’ (Plate 2.5) which was amended during commissioning to better identify pumps and their function (Plate 2.6)
- Two log-in levels - viewer and operator
- Process variables setpoints page (Plate 2.7).
- Manual control pages for pumps, dissolved oxygen (DO) and pH (Plate 2.8).
- System fault handling requirements: Alarm list (Plate 2.9)
  - System faults are classified as either ‘warnings’ or ‘alarms’.
  - Alarms stop the automatic system operation and send an email alert to a designated address.
  - Warnings are displayed on the user HMI until acknowledged but do not shut down the process.
- Remote access to enable viewing and control (if authorised) of the operator interface

Remote access is via a secure 3G gateway connection supplied by Dematec Automation. There is an annual cost to provide the secure remote access connection.
Plate 2.5 Original Roseworthy integrated system overview (Feb 2018)

Plate 2.6 Amended Roseworthy integrated system overview (June 2018 and onward)
**SENSORS - AEROBIC REACTOR**

<table>
<thead>
<tr>
<th></th>
<th>DO</th>
<th>PH</th>
<th>TEMP</th>
<th>LEVEL</th>
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<td>0</td>
<td>0°C</td>
<td>0 L</td>
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<td>SENSOR MAX:</td>
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<td>1560 L</td>
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<td>3,573 L</td>
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Plate 2.7 Process variables set-point page.

**CONTROLS**

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<th>PMP 1</th>
<th>PMP 2</th>
<th>PMP 3</th>
<th>PMP 4</th>
<th>PMP 5</th>
<th>PMP 6</th>
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<tbody>
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<td>MANUAL RUN</td>
<td>MANUAL OFF</td>
<td>MANUAL RUN</td>
<td>MANUAL OFF</td>
<td>AUTO</td>
</tr>
<tr>
<td>AUTO</td>
<td>MANUAL RUN</td>
<td>MANUAL OFF</td>
<td>MANUAL RUN</td>
<td>MANUAL OFF</td>
<td>AUTO</td>
</tr>
</tbody>
</table>

Plate 2.8 Manual control pages for pumps, dissolved oxygen (DO) and pH.
2.4.1 Data storage and trending setup

There is a connection to a secure Dematec Automation IIOT (Industrial Internet of Things) database which provides a cloud based location for data collection, storage, backup, and trending.

This system provides:
1. Dematec IIOT database with secure partition for Pork CRC WTP data collection and user access.
2. Database connections for Pork CRC WTP process data.
3. Data trending interface and automated reporting (via email) on key process parameters.

The benefits of this option were:
1. Provision of secure cloud based storage and presentation of process data with minimal upfront configuration and licensing cost.
2. Automated collation and delivery of process reports (by email) to nominated recipients.
3. No requirement for PC or server hardware at site.
4. Flexible retrieval and presentation of process data.
5. Allows concurrent login for multiple users without additional licensing charges.
6. Updates to the database software and cloud server system are included in the annual hosting charge.
2.4.2 Wastewater treatment process configurations

The integrated treatment system comprises three unit operations, which need to be optimised and their performance evaluated - the aerobic reactor, the clarifier and the HRAP. The respective components require evaluation for their effect on carbon oxidation, NH$_4$-N oxidation, suspended solids removal and algal biomass production. The disinfection potential of each unit operation needs also be determined by measuring respective inlet and outlet values.

In addition to manual operation there are currently three automated process options for the integrated treatment system (Plate 2.10):

**Option 1 - Continuous Stirred-Tank Reactor (CSTR)**

**Option 2 - Continuous Stirred-Tank Reactor w/Activated Sludge Recycling (AS-CSTR)**

**Option 3 - Sequencing Batch Reactor (SBR)**

The process operations for each scenario are provided in more detail in Appendix 8.

**Plate 2.10 Automated process options for the integrated treatment system as displayed on the HMI.**

**Option 1 - Continuous Stirred-Tank Reactor (CSTR)**

In this operational mode the aerobic reactor is operated within programmable upper and lower DO setpoints. There is ‘continuous’ controlled addition of wastewater throughout the day proportional to the desired experimental residence (treatment) time (days). Initiation of wastewater addition commences by cessation of aeration followed by transfer of a predetermined volume of treated wastewater from the aerobic reactor (T2) to the sedimentation tank (T3). A volume equal to that discharged from the aerobic reactor is then
transferred from the reception pit (T1) to the aerobic reactor (T2) after which aeration re-commences under DO control until the next wastewater addition is required when the process is repeated.

Specific Settings for CSTR mode (Plate 2.11):

i. Hydraulic residence time: x (day)
   a. Current Aerobic reactor volume (total volume is 13500 L): x (L)
   b. Expected Aerobic reactor working volume (current): x (L)
   c. Expected daily volume delivery: x (L)

ii. Enter- Daily volume delivery: x (L)

iii. Interval event volume: x (L); default value 500L
   a. Expected interval event: x (event)
   b. Expected hourly interval between: x (h)

iv. Aerator off delay: y (min); default value 5 min

v. Aerator on delay: y (min); default value 0 min

vi. Mixer 1 on delay: y (min); default value 5 min

vii. Aerobic reactor DO to activate Aerator: x (unit, adjusted accordingly based on current DO unit)

viii. Aerobic reactor DO to stop Aerator: x (unit, adjusted accordingly based on current DO unit)

Were, x = volume (L) and y = time (minutes)

<table>
<thead>
<tr>
<th>SETPOINTS</th>
<th>CALCULATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic Residence Time (days):</td>
<td>5</td>
</tr>
<tr>
<td>Daily Volume Delivery (L):</td>
<td>2,000</td>
</tr>
<tr>
<td>Interval Event Volume (L):</td>
<td>500</td>
</tr>
<tr>
<td>Aerator Off Delay (min):</td>
<td>5</td>
</tr>
<tr>
<td>Aerator On Delay (min):</td>
<td>0</td>
</tr>
<tr>
<td>Mixer 1 On Delay (min):</td>
<td>0</td>
</tr>
<tr>
<td>Aerobic DO Start Setpoint (ppm):</td>
<td>2.30</td>
</tr>
<tr>
<td>Aerobic DO Stop Setpoint (ppm):</td>
<td>2.60</td>
</tr>
<tr>
<td>Current Aerobic Reactor Volume (L):</td>
<td>3,571 L</td>
</tr>
<tr>
<td>Expected Aerobic Reactor Volume (L):</td>
<td>73 L</td>
</tr>
<tr>
<td>Expected Daily Volume Delivery (L):</td>
<td>715 L</td>
</tr>
<tr>
<td>Expected Interval Event (#):</td>
<td>4</td>
</tr>
<tr>
<td>Expected Hourly Interval Between (h):</td>
<td>6 hr</td>
</tr>
</tbody>
</table>

Plate 2.11 Settings required for operation of the aerobic reactor as a Continuous Stirred-Tank Reactor (CSTR).
**CSTR case scenario**

1. Manually fill up T1 and T2 before experiment, to make sure there is sufficient volume in both tanks before commencement of this mode. Check the working volume is higher than 3,500 L. “Working volume” is calculated due to the limitation of pipe height (will be discussed later in ‘The aerobic reactor tank (Tank 2)’ section)

2. Assume T2’s working volume is 10,000L. If the hydraulic residence time is set as 5 days, the total volume to be delivered to T3 should be 2,000 L in each day, for 5 days in total to meet the 10,000L

   \[
   \text{e.g.: } \frac{2000 \text{ L/d}}{500 \text{ L}} = 4 \text{ interval events; } \frac{24 \text{ hr}}{4 \text{ interval events}} = \text{ Hourly interval between 6h}
   \]

3. Step 1 of this mode should always be pumping the equal interval event volume from T2 to T3 first, with the equivalent volume pump from T1 (reception pit) to T2 (aerobic reactor).

   e.g.
   
   i. Aerator stopped 5min before P3
   ii. By P3, T2 -> T3 500L
   iii. By P2, T1 -> T2 500L
   iv. By P5, T3 -> T4, whenever T3 high level is reached
   v. Wait for the start of a hourly interval i.e. 6h, start from (i) again

**Option 2 - Continuous Stirred-Tank Reactor w/Return Activated Sludge Recycling (RAS-CSTR)**

In this mode of operation the aerobic reactor is operated as a CSTR (above), however, the influent is derived from two sources, anaerobically pre-treated effluent and settled sludge from the sedimentation tank. The relative proportion of influent from the two sources is programmable.

**Specific Settings for this mode:**

i. Hydraulic residence time: x (day)
   
   a. Current Aerobic reactor volume (total volume is 13500 L): x (L)
   b. Expected Aerobic reactor working volume (current): x (L)
   c. Expected daily volume delivery: x (L)

ii. Enter Daily volume delivery: x (L)

iii. Interval event volume: x (L)
   
   a. Expected interval event: x (event)
   b. Expected hourly interval between: x (h)

iv. Fraction of recycled activated sludge from ST: x (%)

v. Aerator off delay: x (min)

vi. Aerator on delay: x (min)

vii. Mixer 1 on delay: x (min)

viii. Aerobic reactor DO to activate Aerator: x (unit, adjusted accordingly based on current DO unit)

ix. Aerobic reactor DO to stop Aerator: x (unit, adjusted accordingly based on current DO unit)
Option 3 - Sequencing Batch Reactor (SBR)

In this operational mode the aerobic reactor is operated within programmable upper and lower DO setpoints for predetermined, programmable intervals of time i.e. batch aeration. Prior to addition of predetermined volume of wastewater, aeration is ceased, aerobically treated wastewater is then transferred from the aerobic reactor (T2) to the sedimentation tank (T3). An equivalent volume of anaerobically pre-treated wastewater is transferred, whilst be mixed, from the reception pit (T1) to the aerobic reactor (T2). Aeration recommences after the transfer for the duration of the batch operational time after which the process cycle is repeated. The number of process cycles is programmable.

Specific Settings for this mode:

i. Enter - Required batch delivery volume: x (L); default 200L
   a. Current Aerobic reactor volume (total volume is 13500 L): x (L)
   b. Expected Aerobic reactor working volume (current): x (L)

ii. Enter - Batch event number: x (event); default 10 events

iii. Aerator off delay: x (min); default 5 minutes

iv. Batch aerator off delay: x, x (hr, min); default 30 min

v. Aerator on delay: x (min); default 0 min

vi. Pump 2 on delay: x (min); default 5 min

vii. Aerobic reactor DO to activate Aerator: x (unit, adjusted accordingly based on current DO unit)

viii. Aerobic reactor DO to stop Aerator: x (unit, adjusted accordingly based on current DO unit)

SBR SETTINGS

<table>
<thead>
<tr>
<th>SETPOINTS</th>
<th>CALCULATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Batch Delivery Volume (L):</td>
<td>Current Aerobic Reactor Volume (L):</td>
</tr>
<tr>
<td></td>
<td>(Max Capacity 13500L): 3,557 L</td>
</tr>
<tr>
<td>Batch Event Number (#)</td>
<td>Expected Aerobic Reactor Working Volume (L); (Current)</td>
</tr>
<tr>
<td>(Enter 0 to run continuously)</td>
<td>65 L</td>
</tr>
<tr>
<td>Aerator Off Delay (min):</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch Aerator Off Delay (hr Min):</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump 2 On Delay (min):</td>
<td>Current Batch Number</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Aerator On Delay (min):</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerobic reactor DO Start Setpoint (ppm):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.30</td>
</tr>
<tr>
<td>Aerobic reactor DO Stop Setpoint (ppm):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.20</td>
</tr>
</tbody>
</table>

Plate 2.12 Sequencing Batch Reactor (SBR) programmable interface.
Option 4 - Manual Aeration

The aerator can be run using the DO start and stop functionality described in the other modes. In this mode no other pumps will be run and allowing users to manually pump water whilst still controlling the DO within the aerobic reactor. This mode can be activated as per the other modes and can only be disabled by changing the mode of the system.

<table>
<thead>
<tr>
<th>SETPOINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerator DO Start Setpoint (ppm):</td>
</tr>
<tr>
<td>Aerator DO Stop Setpoint (ppm):</td>
</tr>
</tbody>
</table>

Plate 2.13 Manual operation of aerator
3. Methodology

3.1 Commissioning the integrated anaerobic-aerobic-algal treatment system

During commissioning the aerobic reactor was operated in as Single Sequencing Batch Reactor (SBR; Option 3). A nitrifying bacterial population was cultivated and maintained by aerating anaerobically pre-treated slurry (ANPS) at full air saturation DO 7.3 mg O₂ L⁻¹ with aerobic reactor level 2500L. This is to provide a source of nitrifying bacteria should the aerobic reactor mixed liquor require seeding.

Anaerobically pre-treated slurry (ANPS) was transferred, whilst being mixed from the reception pit (T1) to the aerobic reactor (T2). In this operational mode, programmable upper (4.5 mg O₂ L⁻¹) and lower (3 mg O₂ L⁻¹) DO setpoints were controlled for 30 days in 7000 L ANPS.

3.2 Sampling, ANPS and wastewater quality analysis

Sampling of the aerobic reactor was carried out for 30 days and effluent samples from the aerobic reactor were collected twice daily, at 6 am and 6 pm, by a refrigerated (1 °C) autosampler, (Avalanche® Sampler, Teledyne ISCO Lincoln, NE). The two samples collected each day formed a daily composite sample (0.4 L). The results for these samples were considered an average over the day. After the samples had been retrieved they were transported, while being refrigerated at 1 °C in the dark, and analysed within 24 h.

Water quality analyses were carried out for DO, pH, total suspended solids (TSS; American Public Health Association Standard Methods, 1992), ammonia- nitrogen (NH₄⁺-N), nitrite (NO₂⁻-N) and nitrate (NO₃⁻-N) using a YSI Pro Digital Multiprobe Sensor (YSI Ltd Ohio).
4. Aerobic System Commissioning

Commissioning and evaluation of system performance was necessarily been limited since funding for the Postdoctoral RA position ceased 14th March 2018.

4.1 Aerobic Reactor determination of aerator performance

The aerobic reactor was filled with 10m$^3$ of water and the aerator operated continuously to determine the oxygen transfer rate of the aerator and coincidentally the respiration rate of the biota within the water (Figure 4.1). The reaeration rates and the respiration rates calculated from the slope of the lines shown in Figure 4.1 are presented in Table 4.1. The net oxygen transfer rate was 2.5kg h$^{-1}$ which matched the published specification for the aerator.

![Figure 4.1 Aerator performance in 13m$^3$ water; re-aeration (1), respiration (2).](image_url)

Table 4.1 Aerobic reactor: oxygen transfer and respiration rate; aerator operated continuously in 10m$^3$ of water

<table>
<thead>
<tr>
<th></th>
<th>Rate of oxygen transfer</th>
<th></th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO rate (mg/L/min)</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>0.47</td>
<td>0.39</td>
<td>0.37</td>
</tr>
<tr>
<td>DO rate (mg/L/hr)</td>
<td>28.05</td>
<td>23.50</td>
<td>22.46</td>
</tr>
<tr>
<td>Respiration rate</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>(mg/L/min)</td>
<td>0.04</td>
<td>0.06</td>
<td>0.08</td>
</tr>
<tr>
<td>Respiration rate</td>
<td>2.51</td>
<td>3.78</td>
<td>4.66</td>
</tr>
<tr>
<td>(mg/L/hr)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The aerobic reactor was briefly operated in batch mode and fed 2m³ d⁻¹ of anaerobically pre-treated piggery wastewater. The same volume of aerobically treated effluent was transferred to the HRAP daily providing a THRT of 10d. The HRAP was filled with 19m³ of water to which was added 60L of algal rich wastewater from the HRAP operated for domestic wastewater treatment at Kingston on Murray (equivalent to and inoculum of 0.3%). A microalgal population was quickly established after 10 days (Plate 4.1). No detailed analysis could be conducted on the respective water quality following aerobic and algal treatment. The system has been operating under the SBR mode with approximately 2,000L aerated pig slurry inlet to the HRAP daily.

Plate 4.1 Algal population established within 10d of supplying 2m³ d⁻¹ of aerobically treated wastewater.

4.2 Commissioning: Preliminary identification of operational issues

**Foaming within the aerobic reactor**

Hawley (2017) determining the performance of a laboratory scale aerobic reactor did not observe foaming of anaerobically pretreated wastewater sourced from the Roseworthy anaerobic lagoon. The production of a stable foam has been observed during the treatment of raw pig slurry (Evan et al. 1982). The stability was presumed to be due proteins within the wastewater from faeces and feed. The prolonged anaerobic treatment at Roseworthy, digesting proteins and other agents contributing to foam formation, was proposed as an explanation for the absence of foam in laboratory studies (Hawley, 2017). Foaming was
observed during the commissioning of the aerobic reactor at Roseworthy (Plate 4.2). The recent emptying of the anaerobic lagoon before the commissioning phase may have resulted in less well digested material being delivered to the aerobic reactor - contributing to foam formation. More prolonged operation of the reactor is required to determine if this is a persistent phenomenon. Foaming control methods are available and include installation of a skimming or foam cutting system, baffles or the introduction of surfactants to collapse the foam.

Plate 4.2 Foam in the aerobic reactor treating anaerobically pretreated wastewater.

**Tank syphoning**

During commissioning of the treatment plant it was found that water would syphon through pumps to equalise the levels between different tanks. This would not allow for correct operation of some treatment options. Unfortunately, passive non-return valves will not fix the syphoning as the flow is in the same direction as normal the pumping. If a non-return valve was put in to stop the syphoning, then it would obviously prevent active flow from the pumps. The solution requires the installation of new control valves to halt the flow of water when pumps are not running. In this case, actuator valves are required to be electrically connected to the control system. An additional multicore cable will be run into the pump room and will allow for digital control of 4 control valves (to be supplied and installed by others) via the existing programmable logic controller (PLC). The PLC program will be updated to include control of the new valves. Logic will be such that when a pump is requested to start, its corresponding valve will open and the pump will start after a short delay. When a pump is requested to stop, the pump will stop and the corresponding valve will close after a short delay.

The HMI screen will require updating to show the state of each valve (open or closed) and manual controls will allow for Auto/Manual Open/Manual Close of each valve. This will be on a separate page and not shown on the main overview. The delay before the valves open and close with a pump will also be added to the HMI as a setpoint.
**Failure of inlet pump 1 to maintain prime**

Pump No.1 was losing prime and consequently could not be automatically operated. The problem was caused by thermal overload switch and a failure of the valve inside the pump to provide an air tight seal and stop return flow to the anaerobic pond. A number of fieldtrips were required over the period of August to October to overcome this challenge. Pump Tech provided repair service for fixing the self-priming, centrifugal pump, as well as an additional foot valve installation to the suction pipe to provide an air-seal and prevent pig slurry backflow.

4.3 The effect of intermittent aeration at DO 3 to 4.5 mg O\textsubscript{2} L\textsuperscript{-1} on suspended solids removal and ammonia oxidation in anaerobically pre-treated pig slurry (ANPS) in SBR

<table>
<thead>
<tr>
<th>TSS (g/L)</th>
<th>NH\textsubscript{4}\textsuperscript{+} -N (mg/L)</th>
<th>NO\textsubscript{3}\textsuperscript{-} -N (mg/L)</th>
<th>NO\textsubscript{2}\textsuperscript{-} -N (mg/L)</th>
<th>pH</th>
<th>DO(mg O\textsubscript{2}/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANPS</td>
<td>0.92</td>
<td>815.86</td>
<td>104.00</td>
<td>20.32</td>
<td>7.79</td>
</tr>
</tbody>
</table>

The typical diurnal change in mixed liquor temperature within the aerobic reactor is shown in Figure 4.2

![Figure 4.2 Temperatures of the mixed liquor in the aerobic reactor, DO 3 - 4.5 mg O\textsubscript{2} L\textsuperscript{-1}, aerobic reactor volume 7000L, 31\textsuperscript{st} Oct 10:30am till 22\textsuperscript{nd} Nov 10:30am.](image)

Figure 4.2 shows activation and deactivation of the aerator to maintain a DO setpoints of 3 - 4.5 mg DO L\textsuperscript{-1} in the mixed liquor of the aerobic reactor. This information was used to estimate aerator energy consumption during commissioning.
Figure 1.3 The mixed liquor DO 3 - 4.5 mg L⁻¹, aerobic reactor volume 7000L, 31st Oct 10:30am till 22nd Nov 10:30am; Date 5th-7th Nov was shut down for maintenance hence the low DO levels

Figure 4.4 and 4.5 demonstrated a significant amount of nitrification took place during aeration at low DO saturation as shown by the higher nitrate and nitrite concentrations measured. The TSS level observed in the ANPS was decreased by microbial action during aeration (Figure 4.6).

Figure 4.4 The nitrification of ammonia to nitrite in aerated ANPS during aerobic treatment at a DO setpoints 3 - 4.5 mg O₂ L⁻¹ at 17 °C (approx. 31 - 47% saturation).

Figure 4.5 The nitrification of ammonia to nitrate on aerated ANPS before and after undergoing aerobic treatment at a DO setpoints 3 - 4.5 mg O₂ L⁻¹ at 17 °C (approx. 31 - 47% saturation).
Figure 4.6 TSS concentrations following aeration in the single SBR operating regime

Figure 4.7 Effect of aeration on the daily pH changes

The pH (Figure 4.7) of the mixed liquor was initially high (pH 9.0), however, it subsequently stabilised at approximately pH 8.6 suggesting there was minimum ammonia loss through volatilisation.

4.4 Daily power consumption estimates for operation of the 1.1 kW aerator

The preliminary estimate of daily power consumption from the aerator ranged between 1.4 - 2.2 kW d\(^{-1}\), total daily aeration time ranged from 85 to 120 minutes when the reactor was operated at 7000L at DO setpoints of 3 - 4.5 mg O\(_2\) L\(^{-1}\).

4.5 Conclusion

The present study has commissioned the aerobic reactor and clearly demonstrated its ability to nitrify anaerobically pre-treated pig slurry. Furthermore, aerobic treatment reduced suspended solids concentration by approximately 30%

The single SBR operation has clearly demonstrated the nitrification of ammonia and reduction of TSS. The next step will be a demonstration of growing microalgae on the ammonia reduced and aerated ANPS on a continuous basis.
5. Outcome/Deliverables

There is now a unique Core Facility for innovative research on piggery wastewater treatment. The pilot-demonstration system will also contribute to technology transfer and professional development within the pork industry.

The aerobic reactor was commissioned and its performance in single sequencing batch mode evaluated. Nitrification of ammonia was clearly demonstrated during commissioning of the aerobic reactor. Preliminary confirmation of ‘proof of concept’ has been achieved. Microalgal growth was observed, but not quantified in the high rate algal pond fed piggery wastewater sequentially treated in an anaerobic lagoon and an aerobic reactor. This implied that the inhibition of algal growth by ammonia and suspended solids had been ameliorated.

The project and the pork industry was supported by international engagement with Dr Ivo Svoboda - an acknowledged expert in the aerobic treatment of animal slurries.

Publications

- Publications in peer reviewed journals, conference proceedings and the pork industry
6. Application of Research

The construction and commissioning of the pilot plant provides a durable asset for research to improve the treatment of wastewater for reuse in the production environment. This is at a time when the industry aspires to reduce inputs; most notably those associated with the development of antimicrobial resistance. Improving the quality of reuse water used for shed flushing and wash down will significantly improve those environments and consequently, both pig and occupational health. It is anticipated that the improvement in pig health will increase productivity while reducing input costs. The pilot plant provides the opportunity for the industry to explore the environmental and production cost benefit of advanced wastewater treatment, coupled with greenhouse gas abatement and energy production.

The construction of the pilot plant was significantly delayed. This was caused by the bureaucracy in large institutions rather than the complexity of the treatment system. The system was constructed largely from ‘off the shelf’ equipment. The plant was constructed for research purposes. Consequently, it comprises of more monitoring and data logging equipment than would be envisaged for on farm operation where there would also be economies of scale. The pilot plant design was focused on the ability to operate and monitor the system remotely and provided an opportunity to design, install and demonstrate systems to meet these requirements. This capability will be of benefit for future adoption.

The performance of the pilot plant requires significantly more evaluation with regards to nutrient conversions and removals and its ability to disinfect piggery wastewater. The plant has attracted international interest from the research community associated with wastewater treatment, nutrient recovery and energy production.

7. Conclusion

An advanced, integrated piggery wastewater treatment plant was designed, constructed and the component operations commissioned. The plant was designed to enable integration with anaerobic lagoon treatment, which is the treatment system most commonly employed by Australian pork producers.

A 13m3 aerobic reactor operated under dissolved oxygen control further treats the wastewater from the anaerobic lagoon. The aerobic reactor can be operated automatically in 3 modes, as a continuously stirred tank reactor (CSTR), a sequencing batch reactor, as a CSTR with return activated solids (RAS). The plant may also be operated manually. The solids from aerobically treated effluent are settled in a sedimentation tank. A proportion of the solids enriched with desirable, active populations of microorganisms can be returned to the aerobic reactor with the objective enhancing treatment performance (CSTR-RAS). The liquid phase is delivered to a balance storage tank prior to delivery to a high rate algal pond (HRAP).

The HRAP was constructed using earthen walls, lined with geotextile and HDPE sheet. The HRAP is a single pass raceway 12m long with two channels each of 2.45m width giving a base
surface area of 59\(m^2\) and a working volume of 19\(m^3\) at 0.3m depth. The HRAP is mixed using an 8 blade stainless steel paddlewheel with integrated electric motor-gearbox design to provide mean fluid surface velocity of \(\sim 0.2\) m s\(^{-1}\). Following treatment in the HRAP the wastewater is returned to the anaerobic pond to meet existing site licensing requirements.

Delays in obtaining permissions and site leasing arrangements curtailed detailed evaluation of treatment performance. The aerobic reactor was commissioned and its performance in single sequencing batch mode evaluated. Nitrification of ammonia was clearly demonstrated during commissioning of the aerobic reactor. Microalgal growth was observed on the nitrified effluent. This outcome suggests that the potential inhibition from high ammonia and suspended solids concentrations had been alleviated by treatment. Further detailed evaluation of nitrification, nutrient removal and disinfection is required to establish optimum operating conditions.

8. Limitations/Risks

The technology, while offering significant potential benefits to the pork production industry, obviously requires further evaluation before adoption can be considered.

9. Recommendations

The Roseworthy integrated pilot plant is a unique and substantial asset to further development of advanced wastewater treatment by the industry. It is recommended that the industry capitalize on the Pork CRC investment by supporting collaborative research through APRIL with the following objectives:

- Evaluating and optimising the nitrification performance of the aerobic reactor to remove ammonia from wastewaters reused in piggery operations to improve air quality and pig respiratory health.
- Aid an emerging minimal input strategy for pork production by:
  - Determine the survival of pathogens (animal and human) and opportunistic pathogens throughout the integrated treatment chain.
  - Determine the survival of antimicrobial resistant microorganisms
- Evaluate the potential of algal biomass production and energy conversion including validating previous life cycle assessments.

10. Acknowledgements

Authors wish to acknowledge the contribution of Richard Gayler, Gayler Professional Services for civil design; Stewart Payne, Planning Consultancy Services for support in gaining the Development Approval; David Hart from Dematec Automation for design of monitoring control; Jason Ridley and Steven Haggarty, Ridleys SA Earthmoving; Professor Wayne Hein and Sarah Hocking, University of Adelaide; David Banks, Buildings and Property Division, Flinders University. The continuing support from Roger Campbell, Pork CRC.
11. References


Appendices

Appendix 1: Application site detail and elevation drawings submitted with Devel App
Appendix 2 DA amendments
Appendix 3 DNF 176.2015 Development Plan Consent
Appendix 4 Building Rules Consent Granted
Appendix 5 Development approval and subsequent variation
Appendix 6 Licence and Services Agreement EXECUTED
Appendix 7 Tank sizes and penetrations
Appendix 8 Unit operations for each of the aerobic reactor treatment configurations
Appendix 1 Application site detail and elevation drawings submitted with Development Application

PROPOSED HIGH RATE ALGAL POND RESEARCH FACILITY
GRAINGERS ROAD
ROSEWORTHY, SA., 5400
DEVELOPMENT PLAN CONSENT

DEVELOPMENT NUMBER: 313/176/2015
APPLICANT: Flinders University
OWNER: The University of Adelaide
NATURE OF DEVELOPMENT: Wastewater research facility comprising new high rate algal treatment pond, slurry reception pit and storage tanks in association with existing piggery
SUBJECT LAND: 274 Graingers Road WASLEYS, SEC: 684 HP: 140700 CT: 5407/765

Please find enclosed a copy of the Decision Notification Form for Development Plan Consent pursuant to the Development Act 1993 for the above mentioned Development Application.

Conditions may be attached to the Decision Notification Form. These should be carefully read and understood to ensure that you are aware of the requirements, your rights and responsibilities and of any further action that you may need to take. Please ensure that all parties involved (including all contractors) in the construction of the development are aware of any conditions.

The granting of this consent does not absolve the applicant from obtaining all other consents which may be required pursuant to the provisions of any other legislation.

Should you have any questions in relation to your obligations or the conditions imposed, please do not hesitate to contact the Freeling Branch Office on 8525 3200.

Yours sincerely,

on behalf of the
Development Assessment Team
LIGHT REGIONAL COUNCIL

cc: The University of Adelaide
    Campus Services
    Roseworthy Campus
    ROSEWORTHY SA 5371
For Development Application

Dated : 04/05/2015
Registered On : 07/05/2015

TO: Flinders University
Professor Howard Fallowfield
Flinders University
GPO Box 2100 ADELAIDE SA 5001

LOCATION OF PROPOSED DEVELOPMENT:
SEC: 684 HP: 140700 CT: 5407/765 274 Graingers Road WASLEYS.

NATURE OF PROPOSED DEVELOPMENT:
Wastewater research facility comprising new high rate algal treatment pond, slurry reception pit and storage tanks in association with existing piggery

From Light Regional Council

In respect of this proposed development you are informed that:

<table>
<thead>
<tr>
<th>NATURE OF DECISION</th>
<th>CONSENT</th>
<th>NO. OF CONDITIONS</th>
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<td>DEVELOPMENT APPROVAL</td>
<td>Still Required</td>
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</table>

Reasons for this decision, any conditions imposed, and the reasons for imposing those conditions are set out on the attached sheet.

YOU MUST NOT START ANY SITE WORKS OR BUILDING WORK OR CHANGE THE USE OF THE LAND UNTIL YOU HAVE ALSO RECEIVED NOTIFICATION OF A DEVELOPMENT APPROVAL.

Date of Decision : 16 July 2015
Signed :
Date : 17 July 2015

☑ Council Chief Executive Officer or Delegate
☐ Private Certifier
☐ Development Assessment Commission or Delegate
☒ Sheets Attached
DEVELOPMENT PLAN CONSENT

The following condition(s) apply:

(1) The development shall proceed in accordance with the details of Development Application No 313/176/2015 and the approved plans and correspondence submitted, except when varied by the following conditions of consent.

(2) All stormwater from buildings, paving and from areas that immediately surround the perimeter of the building shall be disposed of in a manner that does not result in entry of water into the building, or affect the stability of the building, or create an unhealthy or dangerous condition, or run onto or over land of an adjoining owner.

Storm water disposal systems must be completed by the completion of the construction of the building. During construction, adequate measures must be taken to ensure the temporary disposal of surface or roof water does not affect neighbouring properties.

(3) The algal pond must be constructed with a 150mm compacted clay base and overlaid with a 1.0mm HDPE liner and A24 Bidim (or equivalent) geofabric below the HDPE liner in accordance with manufacturer’s specifications. An ‘as constructed’ report must be prepared by an appropriately qualified person and provided to Council in order to confirm the construction of the algal pond.

Note: You are advised that the Development Plan Consent hereby granted will lapse within 12 months from the date of this Consent, unless Building Rules Consent is sought by the applicant within this period. Any request for an extension of time must be lodged with Council prior to the expiration of time periods specified above.

BUILDING RULES CONSENT

Still Required

FOOTNOTES

(1) The Council has not surveyed the subject land and has, for the purpose of its assessment, assumed that all dimensions and other details provided by the Applicant are correct and accurate.

(2) The site shall be maintained in a neat and tidy condition to the reasonable satisfaction of the Council or its delegate.

(3) The granting of this consent does not remove the need for the Applicant to obtain all other consents which may be required by any other legislation or regulation. The Applicant’s attention is particularly drawn to the need to consult all relevant electricity suppliers with respect to high voltage power lines.

(4) The applicant is reminded of its general environmental duty, as required by Section 25 of the Environment Protection Act, to take all reasonable and practicable measures to ensure that the activities on the whole site, including during construction, do not pollute the environment in a way which causes or may cause environmental harm.

(5) EPA information sheets, guidelines documents, codes of practice, technical bulletins etc can be accessed on the following web site: http://www.epa.sa.gov.au

(6) This Development Plan Consent will lapse within 12 months of the date of this notice unless full Development Approval has been obtained.

(7) Underground assets may exist in the area that is subject to your application. In the interests of health and safety and in order to protect damage to third party assets please telephone 1100 before excavating or erecting structures. If alterations are required to the configuration, size, form or design of the development upon contacting the Dial Before You Dig service, an amendment to the development consent (or a new development application) may be necessary. Individuals owe asset owners a duty of care that must be observed when working in the vicinity of plant or assets. It is the individual’s responsibility to anticipate and requires the nominal location of plant or assets on the relevant property via Dial Before You Dig “1100” number in advance of any construction activities.

(8) Telstra (and its authorised contractors) are the only companies that are permitted to conduct works on Telstra’s network and assets. Any person interfering with a facility or installation owned by Telstra is committing an offence under the Criminal Code Act 1995 (Cth) and is liable for prosecution. Furthermore, damage to Telstra’s infrastructure may result in interruption to the provision of essential services and significant costs. If you are aware of any works or proposed works which may affect or impact on Telstra’s assets in any way, please contact Telstra’s Network Integrity Team on 1800 810 443.
If the development is likely to disturb or impact upon telecommunications infrastructure, written confirmation from the service provider that they have agreed to the proposed works must be submitted to the Principal Certifying Authority prior to the issue of a Construction Certificate or any works commencing, whichever occurs first.

The arrangements and costs associated with any adjustment to telecommunications infrastructure shall be borne in full by the applicant/developer.

**REASONS FOR COUNCIL'S DECISION**

The above conditions were imposed upon the consent notice pursuant to Section 42 of the Development Act, 1993 (as amended).

SIGNED: ............................................................
Authorised Officer

DATE: 17 July 2015
IMPORTANT INFORMATION – APPEAL RIGHTS AND TIME FRAMES

1. You may have a right of appeal if this notification is:
   - a refusal (appeal rights do not apply to applicants for non-complying forms of development)
   - a consent with conditions attached

Pursuant to Section 86 of the Development Act, 1993 (as amended) you may lodge an appeal against any of the
conditions imposed upon the consent notice within two (2) months of the date of the decision.

Please note that any appeal has to be lodged with the Environment, Resources and Development Court and not with
the Council.

Council will not act as a representative for other parties before the Court and Council Officers can provide preliminary
advice only regarding the Court's procedures. If you wish to pursue an appeal, you are strongly urged to take
professional advice on the matter.

For assistance in lodging an appeal, it is suggested that you contact the Court which is located in the Sir Samuel Way
Building, Victoria Square, Adelaide or phone the Court on (08) 82040300.

2. If your application was the subject of third party representations, any consent, or consent subject to conditions
shall not operate until fifteen (15) business days from the date of the decision made on the application. If there is
an appeal by a third party, any consent or consent subject to conditions shall not operate until determination of the
appeal. Fifteen (15) business days from the date of the decision on your application, you are advised to contact
the Environmental Resources and Development Court to find out if there has been an appeal lodged.

3. If this is a consent or consent with conditions:
   - the development must be substantially commenced within twelve (12) months of the date of this notification
     unless this period has been extended by the Council or Development Assessment Commission.
   AND
   - Any act or work that has been substantially commenced within twelve months, must be completed within
     three (3) years of the date of the notification or a longer time as allowed by the Council or the Development
     Assessment Commission.

If you fail to satisfy the above requirements, and you wish to proceed with the development, a new Development
Approval will be required.

ADDITIONAL INFORMATION

Public Land
The applicant is advised to contact Council's Works and Technical Services Department prior to commencement of
any work on Council property or public land.

Other Legislation
The granting of this consent does not absolve the applicant from obtaining all other consents which may be required
pursuant to the provisions of any other legislation.

Allotment Boundaries
Allotment boundaries are not certified by Council staff. The onus of ensuring that buildings are sited in the approved
position on the correct allotment is the responsibility of the owner.

Environment Protection Act
The developer or building owner is to ensure compliance with the requirements of the Environment Protection Act
1993 and associated policies. Applicants are reminded of their obligation to minimise the amount of soil and silt
leaving the site. Council may issue an expiation in accordance with the provisions of the Act.

Damage
Section 233 of the Local Government Act 1999 provides that where damage to Council roads, footpaths, kerbing or
services occurs as a result of the development, the owner/applicant shall be responsible for the cost of repairs to the
damage. Your co-operation is sought in ensuring that the street, road, kerb, gutter, and footway are protected from
damage during delivery of any building materials to the site. Re-instatement costs can be recovered from the owner in
addition to a penalty imposed by a court, if damage is caused.
Lanscaping & Driveways
Any changes to existing entranceways must be approved by Council. Ensure when landscaping that there are no tripping hazards are created on the verge (area of land between the front boundary and gutter/road edge). For example, do not construct kerbing or garden edging across the verge, plant bushes and trees or place letterboxes on the verge. Simple landscaping such as grass is suitable. Contact Council’s Infrastructure and Works department for further details.

The Council appreciates feedback on all matters relating to customer service. Should you wish to provide comments please visit the Light Regional Council website at www.light.sa.gov.au to submit a compliment or complaint form accessed from the “Tell Us” tab on the home page or alternatively a Customer Feedback Form is available from either the Kapunda or Freeling offices of Council.
12 August 2015

Light Regional Council
PO Box 72,
KAPUNDA SA 5373

Development Number: 313/176/2015

Subject Site: 274 Graingers Road, Wasleys SA 5400
Parcel: D 140700
Description: WASTEWATER RESEARCH FACILITY COMPRISING NEW HIGH RATE ALGAL TREATMENT POND, SLURRY RECEPTION PIT AND STORAGE TANKS IN ASSOCIATION WITH EXISTING PIGGERY

Pursuant to Section 93(1)(b) of the Development Act 1993 you are hereby advised that BUILDING RULES CONSENT HAS BEEN GRANTED for the proposed development work described on the attached Decision Notification Form.

Attached for your attention are:

- Two copies of the Decision Notification Form,
- Two copies of the documentation endorsed with the Certifier's consent,
- The Schedule of Essential Safety Provisions (if applicable)

All as prescribed in Development Regulation 92.

Pursuant to Regulation 92(2)(e), the Applicant has confirmed, and we certify that the Building Rules Consent is consistent with the Development Plan Consent and any condition or notes that apply in relation to the Development Plan Consent (if such consent was required).

If all of the requisite Consents have been granted the development is an approved development pursuant to Section 33. Please notify the applicant that the proposed work is an approved development effective from the date of the last consent issued.

The Applicant is also reminded that Section 86(1)(a) of the Development Act, 1993 provides for a right of appeal to the Environmental, Resources and Development Court against this decision, or the imposition of conditions attaching to the authorisation, within two months after receipt of this notice (Section 86(4) of the Act).

The Applicant is also reminded that no work can commence on the land as a result of this decision – this consent is for Development Plan and Building Rules Consent, only the Council must issue Development Approval prior to the commencement of any work.

Private Certifier: Alan Taylor
Reg. Number: 020
Schedule 22A – Certificate of Consistency

To: Light Regional Council

Development No: 313/176/2015

Proposed Development: WASTEWATER RESEARCH FACILITY COMPRISING NEW HIGH RATE ALGAL TREATMENT POND, SLURRY RECEPTION PIT AND STORAGE TANKS IN ASSOCIATION WITH EXISTING PIGGERY

Site Address: 274 Graingers Road, Wasleys SA  5400

I verify that I have examined carefully a copy of the development plan consent (including any conditions and notes) described below, together with a copy of the plans approved and endorsed pursuant to regulation 42(4) of the Development Regulations 2008 for that consent.

The plans and supporting documentation submitted for Building Rules Consent have been assessed for compliance with the Building Rules, while the development plan consent plans have been reviewed to ensure that all buildings and structures included in the building rules assessment are consistent with the Development Plan Consent.

I hereby certify in accordance with Regulation 92(2)(e) of the Development Regulations 2008 that the Building Rules Consent issued on 12-Aug-2015 for 274 Graingers Road, Wasleys SA  5400 is consistent with the following development authorisation (including any conditions and notes) giving Development Plan Consent 313/176/2015 issued on 16-Jul-2015 by Light Regional Council (relevant authority) subject only to the variations specified below in the Table of Variations to meet Regulatory Requirements, attached for the purposes of Section 93(2) of the Development Act 1993, which are necessary for compliance with the Building Rules or any other legislation specified therein.

Table of variations to meet regulatory requirements—pursuant to section 93(2) of the Development Act 1993

<table>
<thead>
<tr>
<th>Item</th>
<th>Legislation/Regulation/Code</th>
<th>Reason for variation</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Signed: [Signature]

Private Certifier: Alan Taylor
Reg. Number: 020
Date: 12-Aug-2015
DECISION NOTIFICATION

TO: Light Regional Council
PO Box 72,
KAPUNDA SA 5373

Development Number: 313/176/2015
Reference: 989/2015/IN

FOR DEVELOPMENT APPLICATION BRC LODGED DATE: 04-Aug-2015

APPLICANT
Flinders University
C/- Professor Howard Fallowfield
GPO Box 2100
ADELAIDE SA 5001

LOCATION OF PROPOSED DEVELOPMENT:
Subject Site: 274 Graingers Road, Wasleys SA 5400
Parcel: D 140700
Certificate of Title: CT-5407/765

Nature of Proposed Development:
WASTEWATER RESEARCH FACILITY COMPRISING NEW HIGH RATE ALGAL TREATMENT POND,
SLURRY RECEPTION PIT AND STORAGE TANKS IN ASSOCIATION WITH EXISTING PIGGERY

In respect of this proposed development you are informed that:

<table>
<thead>
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<th>Nature of Decision</th>
<th>Consent</th>
<th>No. of Conditions</th>
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<td>Other</td>
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</tr>
<tr>
<td>DEVELOPMENT APPROVAL</td>
<td>*NOTE</td>
<td></td>
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</tbody>
</table>

Building Classification: 10B – Plant and Equipment 10A - Shed

This approval does not purport to represent final approval under the Development Act 1993, and does not provide approval for compliance with the conditions of the Development Plan Consent. If there were third party representations, any consent/approval with conditions does not operate until the periods specified in the Act have expired. Reasons for this decision, any conditions imposed, and the reasons for imposing those conditions, are set out on the Development Plan Consent.

*NOTE: No development may be undertaken unless the development is an approved development (Section 32). A development is an approved development if, and only if, a relevant authority has assessed the development against, and granted a consent in respect of each of the matters prescribed in Section 33 (1).

Date of Decision: 12-Aug-2015

Signed: [Signature]

Private Certifier: Alan Taylor
Reg. Number: 020
Regulation 42 Eleventh Schedule  Development Number: 313/176/2015
Reference: 989/2015/IN

BUILDING RULES CONSENT in respect of the proposed development is GRANTED subject to the following conditions:

1. The building owner shall ensure that suitable portable fire extinguishers are installed in the building in accordance with Australian Standard AS 2444.
   
   Reason: To ensure the occupants have means of fighting small fires

Your attention is drawn to the Notes appended to this Consent. They have been included as a matter of information only, and do not profess to represent a definitive statement of requirements.

Signed: [Signature]

Private Certifier: Alan Taylor
Reg. Number: 020
Decision Date: 12-Aug-2015
Regulation 42 Eleventh Schedule  Development Number:  313/176/2015

Reference:  989/2015/IN

BUILDING RULES CONSENT in respect of the proposed development has been GRANTED subject to Conditions and the NOTES below are included for your attention:

**Step 1 - Statement of Compliance**
The Development Act requires that at the completion of the building work a “Statement of Compliance” shall be supplied to Council signed by both the Licensed Builder and the Owner declaring that the building work carried out has been undertaken in accordance with the relevant approvals.
A pro-forma of the Statement of Compliance is enclosed which may be used to submit to Council. Should the building work be undertaken by an Owner Builder then the Statement shall be signed by a Building Works Supervisor or Private Certifier as well as the Owner.

**Step 2 - Schedule of Essential Safety Provisions**
Enclosed you will find a “Schedule of Essential Safety Provisions – Form 1” which outlines the essential safety provisions which are to be installed in the building.
Also enclosed is a “Certificate of Compliance with Essential Safety Provisions - Form 2” must be signed by the relevant person/s responsible for the installations and sent to Council before Council can issue the Certificate of Occupancy.

**Step 3 - Certificate of Occupancy**
The building MUST NOT be OCCUPIED in whole or in part until a Certificate of Occupancy has been issued by Council. A Certificate of Occupancy can be issued upon completion of the building work.
You MUST make application for the Certificate of Occupancy when the building is completed by submitting a statement from an appropriately qualified person to Council and paying the relevant fee.
Please note it is an offence under the Development Act to occupy, or allow a building to be occupied without a valid “Certificate of Occupancy”.
If relevant, Certificate of Compliance with Essential Safety Provisions - Form 2 must also be submitted with the statement prior to the issuing of the Certificate of Occupancy.

**Step 4 - Certificate of Compliance with maintenance procedures for Essential Safety Provisions**
In certain circumstances at the time of approval you will have also been provided with a “Certificate of Compliance with maintenance procedures for Essential Safety Provisions – Form 3”. This form is to completed and supplied to Council at the beginning of each calendar year by the owner of the building.

Private Certifier:  Alan Taylor
Reg. Number:  020
Decision Date:  12-Aug-2015
Statement of Compliance
Development Act 1993
Development Regulation 1993 – Regulation 83AB

Note: Pursuant to section 45(1) of the Development Act, 1993, a person must not perform building work, or cause it to be performed, except in accordance with technical details, particulars, plans, drawings and specifications approved under the Act.

This statement relates to:

Council: Light Regional Council
Development Number: 313/176/2015
(989/2015/IN)
Building Work: WASTEWATER RESEARCH FACILITY COMPRISING NEW HIGH RATE ALGAL TREATMENT POND, SLURRY RECEPTION PIT AND STORAGE TANKS IN ASSOCIATION WITH EXISTING PIGGERY
Site Address: 274 Graingers Road, Wasleys SA 5400
Applicant: Flinders University
Decision Date: 12-Aug-2015
Classification: 10B – Plant and Equipment 10A - Shed

PART A – BUILDERS WRITTEN STATEMENT

This statement must be signed by the building work contractor responsible for carrying out the relevant building work or, if there is no such person, by a registered building work supervisor or a private certifier.

I certify the following:

1. The building work described above (disregarding any variation of a minor nature that has no adverse effect on the structural soundness or safety of the building, or on the health of the occupants of the building, or any other variation undertaken with the consent of the relevant authority) has been performed in accordance with the documents referred to in Part B.

2. All service connections have been made in accordance with the requirements of the relevant supply authority.

3. All requirements under regulation 76(3) of the Development Regulations 1993 relating to the essential safety provisions have been satisfied.

4. All notifications require under section 59 of the Development Act 1993 have been given in accordance with that Act and the requirements of the Development Regulations 1993.

Signed: ……………………………………………… Name: ……………………………………………………………
Date: ……………………………………………… Status: ……………………………………………………………
Licence Number: …………………………… Contact number: ……………………………………………………………
Address: …………………………………………………………………………………………………………………

PART B – OWNERS WRITTEN STATEMENT

This statement must be signed by the owner of the relevant land, or by someone acting on his or her behalf.

I certify the following:

1. The documents (including all contract documents, amendments, attachments, instructions, annotations, variations and clarifying correspondence) issued for the purposes of the building work described above (disregarding any variation of a minor nature that has no adverse effect on the structural soundness or safety of the building, or on the health of the occupants of the building, or any other variation undertaken with the consent of the relevant authority) are consistent with the relevant development approval issued on the 12-Aug-2015.

Signed: ……………………………………………… Name: ……………………………………………………………
Date: …………………………… Address: …………………………………………………………………………………
Appendix 5 Development Approval and subsequent variation

Parcel: 9501
Assessment: 5536
VG: 3151531005

17 August 2015

Flinders University
Professor Howard Fallowfield
Flinders University
GPO Box 2100
ADELAIDE SA 5001

Dear Sir/Madam,

DEVELOPMENT APPROVAL

DEVELOPMENT NUMBER
APPLICANT
OWNER
NATURE OF DEVELOPMENT
SUBJECT LAND

313/176/2015
Flinders University
The University of Adelaide
Wastewater research facility comprising new high rate algal treatment pond, slurry reception pit and storage tanks in association with existing piggery
274 Graingers Road WASLEYS, SEC: 684 HP: 140700 CT: 5407765

Please find enclosed a copy of the Decision Notification Form for Development Approval pursuant to the Development Act 1993 for the above mentioned Development Application.

Conditions may be attached to the Decision Notification Form. These should be carefully read and understood to ensure that you are aware of the requirements, your rights and responsibilities and of any further action that you may need to take. Please ensure that all parties involved (including all contractors) in the construction of the development are aware of any conditions.

The granting of this consent does not absolve the applicant from obtaining all other consents which may be required pursuant to the provisions of any other legislation.

Should you have any questions in relation to your obligations or the conditions imposed, please do not hesitate to contact the Freeling Branch Office on 8525 3200.

Yours sincerely

on behalf of the
Development Assessment Team
LIGHT REGIONAL COUNCIL

cc The University of Adelaide
Campus Services
Roseworthy Campus
ROSEWORTHY SA 5371
7 February 2017

Flinders University
Professor Howard Fallowfield
Flinders University
GPO Box 2100 ADELAIDE SA 5001

Dear Sir/Madam,

AMENDED DEVELOPMENT APPROVAL
Minor variation pursuant to 47A of the Development Regulations 2008

VARIATION: Reduction in pond size, removal of equipment shed and placement of shipping container for use as equipment facility

DEVELOPMENT NUMBER 313/176/2015
APPLICANT Flinders University
OWNER The University of Adelaide
NATURE OF DEVELOPMENT Wastewater research facility comprising new high rate algal treatment pond, slurry reception pit and storage tanks in association with existing piggery
SUBJECT LAND 274 Graingers Road WASLEY, SEC: 684 HP: 140700 CT: 5407/765

Please find enclosed a copy of the amended Decision Notification Form for Development Approval pursuant to the Development Act 1993 for the above mentioned Development Application.

Conditions may be attached to the amended Decision Notification Form. These should be carefully read and understood to ensure that you are aware of the requirements, your rights and responsibilities and of any further action that you may need to take. Please ensure that all parties involved (including all contractors) in the construction of the development are aware of any conditions.

The granting of this consent does not absolve the applicant from obtaining all other consents which may be required pursuant to the provisions of any other legislation.

Should you have any questions in relation to your obligations or the conditions imposed, please do not hesitate to contact the Fleurieu Branch Office on 8525 3200.

Yours sincerely,

on behalf of the
Development Assessment Team
LIGHT REGIONAL COUNCIL

cc The University of Adelaide
Campus Services
Roseworthy Campus
ROSEWORTHY SA 5371

Postal Address:
PO Box 72, Kapunda, South Australia 5373

Principal Office
93 Main Street, Kapunda, SA 5373
Fax: (08) 8566 3262

Branch Office
12 Hanson Street, Freeling, SA 5372
Fax: (08) 8525 2441
LICENCE AND SERVICES AGREEMENT

THE UNIVERSITY OF ADELAIDE

FLINDERS UNIVERSITY OF SOUTH AUSTRALIA
<table>
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<tr>
<th>Section</th>
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<td>Notices</td>
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<td>Services</td>
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</table>
LICENCE AND SERVICES AGREEMENT

DATED

PARTIES

1 THE UNIVERSITY OF ADELAIDE ABN 61 249 878 937, a body corporate established pursuant to the provisions of the University of Adelaide Act 1971 (SA) of North Terrace, Adelaide SA 5005 (Licensor); and

2 FLINDERS UNIVERSITY OF SOUTH AUSTRALIA ABN 65 542 596 200, a body corporate established pursuant to the provisions of the Flinders University of South Australia Act 1966 (SA) of Sturt Road, Bedford Park, SA 5042 (Licensee).

BACKGROUND

A The Licensor is the owner of, or has control and management of, the Land.

B The Licensor has agreed to grant the Licensee a licence to use the Land for the Permitted Use on the terms and conditions contained in this Agreement.

C The Licensor has also agreed to procure the provision of Services to the Licensee.

THE PARTIES AGREE

1 Definitions and interpretation

1.1 Definitions

The following definitions apply unless the context requires otherwise:

Business Day means a day other than a Saturday, Sunday or public holiday in Adelaide, South Australia.

Commencement Date means the date specified in Item 1 of Schedule 1.

GST has the meaning given in the A New Tax System (Goods and Services Tax) Act 1999 (Cth).

Improvements includes all improvements, fixtures or structures existing on the Land at the Commencement Date.

Law means any statute, regulation, code, order, rule, subordinate legislation or other document enforceable under any statute, regulation, code, order, rule or subordinate legislation.

Land means the portion of the land in Certificate of Title Volume 5407 Folio 765 set out in the plan at Schedule 2, including all improvements.

Licence means the licence granted pursuant to clause 3.1.

Licence Fee means the amount specified in Item 3 of Schedule 1.

Licensee’s Property means anything installed, placed, located or affixed on the Land, by or for the Licensee, including any property of the Licensee’s Representatives.

Make Good Period has the meaning given by clause 5.7.
Permitted Use means the use specified in Item 4 of Schedule 1.

Pork CRC Agreement means the Aerobic and algal treatment of piggery wastewaters for heat recovery, effluent treatment and water reuse agreement dated 1 July 2014 between the Licensor, Licensee and Pork CRC Ltd.

Services means the services detailed in Schedule 3 and any other services agreed between the parties from time to time.

Representative of a party includes an employee, agent, customer, officer, director, auditor, adviser, partner, consultant, joint venturer, wholly owned or controlled entity, sub-licensee or subcontractor of the party or any other person on the Land with the consent (express or implied) or at the invitation of the party.

Term means the Term set out in Item 2 of Schedule 1 (or as otherwise extended pursuant to clause 3.3(b)).

2 Condition Precedent

2.1 Operation of Agreement

This Agreement shall not come into effect unless the Licensee obtains all necessary development approvals associated with using the Land for the Permitted Use from the relevant authority and provides written confirmation to the Licensor, on or before the date that is 6 months after the date of this Agreement (or such later date as agreed by the parties, acting reasonably).

3 Licence

3.1 Grant of licence

(a) The Licensor grants to the Licensee a non-exclusive licence to use the Land for the Permitted Use subject to the terms and conditions contained in this Agreement (Licence).

(b) The Licensee must ensure the Licensee’s Representatives comply with this Agreement.

(c) The Licensor gives no warranty and makes no representation to the Licensee that the Land is or will remain suitable for the Permitted Use.

3.2 Acknowledgement

The Licensee acknowledges and agrees that:

(a) the Licensor undertakes activities and its business on parts of the Land from time to time; and

(b) it will use its best endeavours to ensure that it will not disrupt or interfere with the Licensor’s activities or business, or that of its Representatives, while using the Land and undertaking the Permitted Use.

3.3 Term

(a) The Licence commences on the Commencement Date and continues for the Term, unless it is terminated earlier in accordance with this Agreement.

(b) The parties may agree in writing to extend the Term of the Licence.
4 Payments

4.1 Payment of Licence Fee

(a) The Licensee must pay to the Licensor (or as directed by the Licensor) the Licence Fee on the Commencement Date.

(b) The Licensee must pay the Licence Fee to the Licensor during the Make Good Period on a pro rata basis.

(c) If the parties agree to extend the Term of the Licence, the parties will undertake a market review of the Licence Fee at the end of the current Term and agree a new Licence Fee for the extended term.

(d) In determining the new Licence Fee, the parties will:

(i) agree a licence fee that is consistent with the licence fee obtainable for comparable premises in the market at the end of the current Term; and

(ii) take into account the current market value of the Land, the use of the Land on the terms and conditions of this Agreement, the Licensee’s rights and benefits contained in this Agreement, and any other matters the Licensor considers appropriate (acting reasonably).

(e) If the parties fail to agree a new Licence Fee within 1 month of the end of the current Term, the Licensor may appoint an independent valuer to determine the new Licence Fee. In determining the new Licence Fee, the valuer will:

(i) be deemed to be acting as an expert and not as an arbitrator;

(ii) be appointed at joint cost; and

(iii) have regard to the matters set out in clause 4.1(d).

4.2 Outgoings

(a) The Licensee is responsible for and must pay for:

(i) all utilities (including, but not limited to, electricity, water and gas) on the Land;

(ii) Council rates (if any); and

(iii) the costs of installing all infrastructure required for separate metering of utilities (including to allow provision of the Services).

(b) Electricity and water usage on the Land will be separately metered and the Licensor will invoice the Licensee for the Licensee’s usage on a quarterly basis. The Licensee must pay to the Licensor the invoiced amount within 14 days of receiving the invoice.

4.3 GST

(a) The Licensee acknowledges the amounts payable by the Licensee to the Licensor under this Agreement do not include any GST.

(b) If a party (the supplier) is required to pay GST in respect of a supply made under, or pursuant to, or by reason of a breach of, this Agreement, the recipient of the supply must (in addition to any other payment for, or in connection with, the supply) in receipt of a valid
tax invoice from the supplier for the supply, pay to the supplier an amount equal to such GST.

5 Licensee's Obligations

5.1 General obligations

The Licensee must at all times:

(a) only use the Land for the Permitted Use;
(b) maintain the Land in good and substantial repair, order and condition;
(c) ensure that the Land is not damaged and make good any damage which occurs as soon as practicable; and
(d) keep the Land in a clean and tidy condition free from fire hazards and take adequate precautions against the risk of fire arising on, or spreading from, the Land.

5.2 Hazards, pollution and nuisance

The Licensee must at all times:

(a) keep the Land in a clean and tidy condition free from pollution or contamination of any kind (including rubbish or litter) or contamination of any kind other than the kind of pollution or contamination that would naturally occur as a result of the Land being used by the Licensee for the Permitted Use;

(b) not use, permit or allow the Land or any part of the Land to be used in a manner which:

(i) creates a nuisance or interferes with other users of the Land or adjoining buildings or properties;
(ii) causes any industrial waste or potentially hazardous, dangerous, flammable, volatile or explosive substance to be abandoned, brought, or dumped on the Land; or
(iii) allows pollution, an environmental hazard or contamination to arise

other than any such occurrences that would naturally occur as a result of the Land being used by the Licensee for the Permitted Use.

5.3 Alterations and additions

The Licensee must not (without the prior written consent of the Licensor):

(a) erect any buildings, fixtures or structures of any kind on the Land, other than required to undertake the Permitted Use; or

(b) make any alterations, improvements or additions to the Land or the topography of the Land other than required to undertake the Permitted Use.
5.4 Compliance with Licensor’s directions

The Licensee must:

(a) comply with all directions given by the Licensor or the Licensor’s Representatives from time to time in relation to the Land or the Licensee’s use of the Land (including directions regarding the maintenance of the Land and in relation to the Services); and

(b) comply with the Licensor’s requirements regarding the security of the Land.

5.5 Permits, approvals and compliance with Laws

(a) The Licensee must:

(i) comply with all relevant Laws in connection with the Licensee’s use of the Land; and

(ii) at its cost, obtain all necessary licences, permits, approvals, authorisations and accreditations (Approvals) which are required in connection with the Licensee’s use of the Land or which are necessary for the Licensee to comply with this Agreement.

(b) On request by the Licensor, the Licensee must provide the Licensor with evidence of compliance with any relevant Laws or Approvals or the existence and/or currency of its Approvals.

5.6 Notification of incidents

The Licensee must immediately notify the Licensor if it becomes aware of:

(a) any damage or contamination to the Land; or

(b) any work, health and safety incident or personal injury which occurs on the Land.

5.7 Rectification of the Land

(a) On the expiration or earlier termination of this Agreement, and on demand by the Licensor, the Licensee must (to the Licensor’s reasonable satisfaction in its sole discretion, acting reasonably):

(i) remove the Licensee’s Property and any other property or items brought onto the Land as a result of the Licensee using the Land and undertaking the Permitted Use from the Land;

(ii) make good any damage caused to the Land and remediate any pollution or contamination arising as a result of the Licensee using the Land and undertaking the Permitted Use; and

(iii) reinstate the Land to substantially the same condition the Land was in at the Commencement Date, including, but not limited to, re-seeding the Land (if required by the Licensor).

(b) The Licensee must comply with clause 5.7(a) within a reasonable time from the date of the termination or expiration of this Agreement, but must not take longer than 3 months (Make Good Period).

(c) The Licensee must, from the date of this Agreement, set aside sufficient funds in a separate account to fund its estimated obligations under clauses 5.7(a) and 5.7(b) and must provide to the Licensor evidence of such funds if requested by the Licensor.
(d) If the Licensee's Property is not removed by the Licensee in accordance with clauses 5.7(a) and 5.7(b), the Licensor may treat the Licensee's Property as abandoned and deal with it as the Licensor thinks fit without being liable to make any compensation to the Licensee.

(e) If the Licensee fails to comply with clauses 5.7(a) to 5.7(c), the Licensor may, or may engage a third party to, carry out any works it considers necessary to rectify the Land in accordance with clause 5.7(a) and recover all costs or expenses from the Licensee.

6 Access

6.1 Licensor's right to access

(a) The Licensor and the Licensor's Representatives may enter the Land at any time without notice, and for any reason, including to:

(i) inspect the Land;

(ii) do any works the Licensor considers desirable having taken all reasonable steps to avoid adversely impacting on the Licensee's use of the Land for the Permitted Purpose;

(iii) provide the Services;

(iv) exercise any of the Licensor's rights under this Agreement; and

(v) remedy any default by the Licensee.

(b) The Licensor will not be required to compensate the Licensee or the Licensee's Representatives in any way in connection with the right of access set out in clause 6.1(a).

7 Indemnity and release

7.1 Indemnity

The Licensee indemnifies the Licensor and the Licensor's Representatives from and against all liability, claims, actions, demands, losses, damages, costs or expenses arising from any negligent or wilful act or omission by the Licensee from or in connection with:

(a) the use of the Land by the Licensee or its Representatives;

(b) the provision of the Services;

(c) any breach of this Agreement by the Licensee or its Representatives;

(d) any damage to the Land (including any contamination) or any property on the Land (including the Licensee's Property); and

(e) any injury suffered by any person to the extent caused by a negligent act or omission of the Licensee or its Representatives,

except to the extent caused by the negligent or wilful act or omission, or breach of this Agreement, by the Licensor or its Representatives.
7.2 Release

The Licensee agrees to occupy the Land at its own risk and releases (to the fullest extent permitted by law) the Licensor and the Licensor's Representatives from all claims or liability of any kind in connection with:

(a) the use of the Land by the Licensee or its Representatives;
(b) the provision of the Services;
(c) any damage to the Licensee's Property or the Licensee's Land;
(d) the condition or quality of the Land or any nuisance arising from the Land (including odours); or
(e) a failure by the Licensee or its Representatives to comply with its obligations under this Agreement,

except to the extent caused by the negligent act or omission, or breach of this Agreement, by the Licensor or its Representatives.

8 Insurance

8.1 Public liability

The Licensee must take out and keep current during the Term a public liability insurance policy noting the Licensor's interest for not less than the amount stated in Item 5 or such higher amount as the Licensor from time to time requires and approves (Insurance).

8.2 Copies of insurance

(a) The Licensee must, prior to the Commencement Date and at any time on request by the Licensor, provide the Licensor with a true copy of the Insurance and a certificate of currency in relation to the Insurance or evidence of approval as a self-insurer (as applicable).

(b) On each anniversary of the Commencement Date during the Term, the Licensee must forward to the Licensor proof that the Insurance has been renewed and / or is still current.

8.3 Failure to comply

If the Licensee fails to comply with this clause 8, the Licensor may take out the Insurance at the Licensee's cost (including premiums, broker's fees, stamp duty and valuation costs).

8.4 Notification

The Licensee must notify the Licensor immediately if the Insurance is cancelled or an event occurs which may allow a claim or affect rights under the Insurance.

9 Services

9.1 Scope of Services

(a) The Licensor must provide or procure the provision of the Services to the Licensee during the Term in accordance with the terms and conditions of this Agreement.

(b) The Licensor must at all times provide or procure the provision of the Services:
(i) professionally and competently;

(ii) in a timely and efficient manner;

(c) To the extent it is reasonably able, the Licensor agrees to use its best endeavours to remedy any failure to provide or procure the provision of the Services to the Licensee, and will do all things necessary to assist the Licensee in remedying such failure to provide or procure the provision of the Services to the Licensee.

(d) Subject to this Agreement, the Licensor agrees to cooperate with the Licensee, in good faith, to allow the Licensee to comply with its obligations under the Pork CRC Agreement.

9.2 Costs of Services

(a) All costs and expense reasonably incurred by the Licensor in providing or procuring the Services or installing or removing any required equipment or infrastructure in connection with the provision of the Services, will be paid by the Licensee.

(b) The Licensee must within a reasonable time reimburse any such reasonable costs to the Licensor on the Licensee receiving a demand from the Licensor.

9.3 No liability

The Licensor will be relieved of any obligation to provide the Services to the extent that:

(a) third party approvals or consents are required, and are delayed or cannot reasonably be obtained; or

(b) they may contravene any applicable law or regulation.

However, the Licensor is not actually aware of any such consents or restrictions on providing the Services as at the date of this Agreement but where third party approvals or consents are required to provide the Services then the Licensee agrees to do all things necessary and sign all documents necessary to assist the Licensee in gaining any such approval or consent.

10 Assignment and sub-licensing

10.1 Assignment

The Licensee must not, without the prior written consent of the Licensor:

(a) assign or transfer its rights under this Agreement; or

(b) enter into any sub-licence in relation to the Land.

11 Termination

11.1 Termination by the Licensor

During the Term, the Licensor may revoke and terminate this Agreement:

(a) immediately on written notice to the Licensee if the Licensee or a Representative of the Licensee breaches a term or condition of this Agreement and the Licensee has failed to rectify the breach after receiving at least thirty (30) days' notice from the Licensor to rectify the breach.
(b) for convenience, without cause, at its absolute discretion by giving 90 days’ written notice to the Licensee.

11.2 Termination by the Licensee

During the Term, the Licensee may terminate the Licence and this Agreement:

(a) immediately on written notice to the Licensor if the Licensor or a Representative of the Licensor breaches a term or condition of this Agreement and the Licensor has failed to rectify the breach after receiving at least thirty (30) days’ notice from the Licensor to rectify the breach.

(b) for convenience, without cause, at its absolute discretion by giving 90 days’ written notice to the Licensee.

11.3 Automatic termination

This Agreement will terminate automatically if the Licensor sells the Land, and the Licensor shall give as much notice to the Licensee as reasonably possible if the Licensor is likely to sell the Land.

11.4 Refund on termination

(a) If the Licensor terminates this Agreement with clause 11.1(b), the Licensor will refund any Licence Fees which the Licensee has paid in respect to the period after the termination date (on a pro rata basis), but the Licensee will not be entitled to any other compensation.

(b) If this Agreement is terminated in accordance with clauses 11.1(a) or 11.2 or for any other reason, the Licensee will not be entitled to a refund of the Licence Fee or any other compensation.

11.5 No limitation

Termination of this Agreement will not affect the rights of either the Licensor or the Licensee accrued prior to the date of termination.

12 Notices

12.1 Giving of notices

A notice, approval, direction, consent, offer, demand or other communication in connection with this Agreement may be:

(a) in writing;

(b) signed by an authorised officer of the relevant party; and

(c) given to the recipient party:

(i) by hand delivery to the address of the recipient party set out below;

(ii) by pre-paid mail sent to the address of the recipient party set out below;

(iii) by facsimile transmission to the facsimile number of the recipient party set out below; or
(iv) by email transmission to the email address of the recipient party set out below,

and in each case must be marked for the attention of the person specified below in relation to the recipient party:

Licensor

Name: The University of Adelaide
Address: North Terrace, Adelaide SA 5005
Attention: Stephen Payn
Manager, Property & Leasing
Facsimile: (08) 8313 4400
Email: Stephen.payn@adelaide.edu.au

Licensee

Name: Flinders University of South Australia
Address: Sturt Road, Bedford Park, SA 5042
Attention:
Facsimile:
Email:

Where 2 or more persons comprise a party, notice to or by one is effective notice to and by all.

12.2 Change of details

(a) A party may from time to time change any of the details specified above by not less than five Business Days' notice to the other party.

(b) If details are changed in accordance with this clause, this clause applies as if those changed details were set out above.

12.3 Effective on receipt

Unless proved to the contrary, notice given in accordance with clause 12.1 takes effect when taken to be received (or at a later time as specified in it), and is taken to be received:

(a) if hand delivered, on delivery;

(b) if sent by pre-paid mail, on the second Business Day after the date of posting (or on the seventh Business Day after the date of posting if posted to or from a place outside Australia);

(c) if sent by facsimile transmission, when the sender's facsimile system generates a message confirming successful transmission of the entire notice; and

(d) if sent by email transmission, when the sender's email system confirms the time of sending of the email (unless the sender receives a delivery failure notification indicating the email has not been delivered to the addressee),
but if the delivery, receipt or transmission is not on a Business Day or is after 5 pm on a Business Day, the notice is taken to be received at 9 am on the next Business Day.

13 Costs

13.1 Licensee's costs

(a) The Licensee must pay the Licensor's costs with respect to

the Licensor granting a consent in accordance with the terms of this Agreement.

(b) The Licensee must pay its own costs in connection with the use of the Land and compliance with the terms of this Agreement.

13.2 Parties' Costs

(a) The Licensee must pay all costs of the Licensor in relation to the negotiation and preparation of this Agreement.

(b) The Licensee must pay, and indemnify the Licensor in respect of any stamp duty in respect of this Agreement and any further document required.

14 Miscellaneous

14.1 No further rights

The rights conferred on the Licensee by this Agreement are contractual only and nothing in this Agreement creates any tenancy between the Licensor and the Licensee or gives the Licensee any interest in the Land or any part of the Land (including occupation rights (other than this Agreement), easements or rights of way of any kind).

14.2 Survival

Clauses 1, 4, 5.7, 7, 11, and this clause 14 survive the expiration or earlier termination of this Agreement.

14.3 Method of Payment

The Licensee will make all payments due by it under this Agreement by 11.00 am on the date for payment (or if that is not a Business Day, on the following Business Day), in Australian dollars in immediately available funds, in full without set-off or counterclaim.

14.4 No waiver

A party's failure or delay to exercise a power or right is not a waiver of that right, and the exercise of a power or right does not preclude the future exercise of that or any other power or right. A waiver of a power or right must be in writing and signed by the party giving the waiver.

14.5 Entire agreement

This Agreement is the entire agreement between the parties as to its subject matter. It supersedes all prior agreements, representations, conduct and understandings.

14.6 Amendments

No amendment of, nor addition to, this Agreement is binding unless it is in writing and executed by the parties to this Agreement.
14.7 Law

The law of this Agreement is the State of South Australia, and the parties submit to the non-exclusive jurisdiction of the courts of South Australia.

14.8 Further acts

The parties will do all things and execute all documents required to permit or facilitate the performance of the transactions contemplated by this Agreement.

14.9 Counterparts

This Agreement may be executed in counterparts, which when taken together are one instrument.

14.10 Severability

If a clause or a part of a clause of this Agreement is found to be invalid or unenforceable (whether in respect of a party or generally), it will be severed from this Agreement and this Agreement will otherwise continue in force.

14.11 No merger

A party's rights and obligations do not merge on completion of any transaction under this Agreement.

14.12 Relationship

Except where this Agreement expressly states otherwise, this Agreement does not create a relationship of employment, trust, agency or partnership between the parties.

14.13 Survival

Any indemnity under this Agreement is independent from the other obligations of the parties and survives termination or expiration of this Agreement. Any other term in this Agreement which is expressed to, or by its nature is intended to, survive termination or expiration of this Agreement (including this clause 14.13), survives termination or expiration of this Agreement.

14.14 Warranty of authority

Each person who executes this Agreement on behalf of a party under a power of attorney declares and warrants that he or she is not aware of any fact or circumstance that might affect his or her authority to do so under that power of attorney.

14.15 Indemnities

Unless expressly provided otherwise:

(a) each indemnity in this Agreement is a continuing obligation, separate and independent from the other obligations of the parties, and survives termination, completion or expiration of this Agreement;

(b) it is not necessary for a party to incur expense or make any payment before enforcing a right of indemnity conferred by this Agreement; and

(c) the making of a claim by a party under an indemnity contained in this Agreement in respect of a particular event does not preclude that party from subsequently making further claims
under that indemnity in respect of any further loss arising out of the same event for which it has not previously been indemnified.

15 Interpretation rules

In this Agreement, unless a contrary intention appears:

(a) a reference to this Agreement or any other document is a reference to this Agreement or other document as amended, varied, novated, supplemented or replaced from time to time;

(b) a reference to any legislation or any provision of any legislation includes:
   (i) all regulations, orders or instruments issued under the legislation or provision; and
   (ii) any modification, consolidation, amendment, re-enactment, replacement or codification of such legislation or provision;

(c) words or expressions:
   (i) importing the singular include the plural and vice versa; and
   (ii) denoting individuals include corporations, firms, unincorporated bodies, authorities and instrumentalities;

(d) a reference to a party to this Agreement or any other instrument includes that party's executors, administrators, successors and permitted assigns;

(e) a reference to a clause number or Schedule number is a reference to a clause or Schedule of this Agreement;

(f) any heading, index, table of contents or marginal note is for convenience only and does not affect the interpretation of this Agreement;

(g) a provision of this Agreement must not be construed to the disadvantage of a party merely because that party was responsible for the preparation of this Agreement or the inclusion of the provision in this Agreement;

(h) any Schedules and the Background to this Agreement form part of this Agreement and have effect as if set out in full in this Agreement;

(i) where an act would be required to be done, or a time limit or period would expire, on a day which is not a Business Day, the act must be done, or the limit or period will expire, on the following Business Day;

(j) the words including, for example and such as (and any other forms of those words) are to be construed without limitation;

(k) if a party to this Agreement is made up of more than one person, or a term is used in this Agreement to refer to more than one party, an obligation of those persons is joint and several, a right of those persons is held by each of them separately, and any other reference to that party or term is a reference to each of those persons separately, so that (for example) a representation, warranty or undertaking is given by each of them separately;

(l) a reference to a payment in immediately available funds refers to cash, a bank cheque the drawer of which is an Australian bank, a telegraphic transfer of cleared funds or a direct credit of cleared fund; and
(m) references to day, month, quarter and year mean a calendar day, month, quarter and year respectively.
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Commencement Date</td>
<td>On the date the Condition Precedent in clause 2.1 is satisfied.</td>
</tr>
<tr>
<td>2</td>
<td>Term</td>
<td>24 months (from the Commencement Date).</td>
</tr>
<tr>
<td>3</td>
<td>Licence Fee</td>
<td>$5,000 plus GST.</td>
</tr>
<tr>
<td>4</td>
<td>Permitted Use</td>
<td>The construction of an integrated wastewater treatment plant (IWWTP) comprising aerobic treatment with heat recovery and high rate algal ponds and the evaluation of the performance of the IWWTP in accordance with the terms of the Pork CRC Agreement.</td>
</tr>
<tr>
<td>5</td>
<td>Public Liability Insurance</td>
<td>$20,000,000 per claim or event.</td>
</tr>
</tbody>
</table>
Schedule 2 – Land
Schedule 3 – Services

1 Electricity
   (a) Single phase and 3 phase supply.
   (b) Separately metered.
   (c) To be supplied to the iWWTP from either the main switchboard at the front of the ‘Piggery Unit’, the ‘Finisher Shed’, ‘Dry Sow Shed’ or another location proposed by theLicensor and reasonably acceptable to the Licensee.

Unless otherwise agreed by the parties, Electricity will only be supplied to the extent it can be accommodated by the Licensor’s existing connection and infrastructure (without the Licensor incurring additional costs) after providing for the Licensor’s reasonable power requirements.

2 Potable water
   Potable water.

3 Effluent
   Agreed access to anaerobically pre-treated effluent from the existing anaerobic lagoon.

4 Raw slurry
   Raw slurry to be pumped from the ‘Piggery Receival Pit’ to a reception pit located on the Land.

5 Return of effluent
   Piped return of all effluent from the iWWTP to the existing anaerobic lagoon.
EXECUTED as an agreement.

EXECUTED by 
THE UNIVERSITY OF ADELAIDE
by its authorised officer 
in the presence of: 

Signature of Authorised Officer

VICE-CHANCELLOR
Office Held

Warren Begginton
Print Name of Authorised Officer

Signature of Witness

Print Name of Witness

SIGNED for and on behalf of the 
FLINDERS UNIVERSITY OF SOUTH AUSTRALIA 
by its duly constituted Attorney pursuant to Power of 
Attorney No. 12520725 who has not received a notice 
of the revocation of that Power of Attorney in the 
presence of:

Witness

Signature of Attorney

Vice-President (Corporate Services)
Position of Attorney

Full Name of Witness
Address: c/-Flinders University 
Sturt Road, Bedford Park SA 5042 
Tel: 8201 3911

Full Name of Attorney 
Address: c/-Flinders University 
Sturt Road, Bedford Park SA 5042 
Tel: 8201 3911
Appendix 7 Tank sizes and penetrations
# Tank 2

## Nozzle Schedule - CSW2000

<table>
<thead>
<tr>
<th>Nozzle</th>
<th>PE Size</th>
<th>Fitting Description</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>110</td>
<td>Flange C/W Table E Cal B/Flange</td>
<td>0</td>
</tr>
<tr>
<td>N2</td>
<td>110</td>
<td></td>
<td>90°</td>
</tr>
<tr>
<td>N3</td>
<td>110</td>
<td></td>
<td>135°</td>
</tr>
<tr>
<td>N4</td>
<td>110</td>
<td></td>
<td>170°</td>
</tr>
<tr>
<td>N5</td>
<td>110</td>
<td></td>
<td>270°</td>
</tr>
<tr>
<td>N6</td>
<td>63</td>
<td>Flange C/W Table E Cal B/Flange</td>
<td>180°</td>
</tr>
<tr>
<td>N7</td>
<td>63</td>
<td></td>
<td>120°</td>
</tr>
</tbody>
</table>

## Plan View

- Scale: 1:5
- Site Parts List

## Client Approval

- Name:
- Signature:
- Date:

---

**All Tolerances Unless Otherwise Stated:** 0.05mm / 0.1"
## Appendix 8 Unit operations for each of the aerobic reactor treatment configurations

<table>
<thead>
<tr>
<th>Device</th>
<th>Option 1 CSTR</th>
<th>Option 2 SBR</th>
<th>Option 3 Activated Sludge CSTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump 3 (P3) Aerobic Reactor to Sedimentation Tank</td>
<td>Starts on (hourly interval between aerator off delay) and pumps down (interval event volume).</td>
<td>Starts after aerator off delay and pumps required batch delivery volume.</td>
<td>Starts on (hourly interval between aerator off delay) and pumps down (interval event volume).</td>
</tr>
<tr>
<td>Pump 4 (P4) Sedimentation Tank to Aerobic Reactor</td>
<td>Not used.</td>
<td>Not used</td>
<td>Starts after Pump 3 is done and pumps down (interval event volume). Pump (interval event volume x fraction of recycled activated sludge), ideally simultaneously with the activation of Pump 2</td>
</tr>
<tr>
<td>Pump 2 (P2) Reception Tank to Aerobic Reactor</td>
<td>Starts after Pump 3 is done and pumps down (interval event volume).</td>
<td>Starts after pump 2 on delay and pumps batch delivery volume.</td>
<td>Starts after Pump 3 is done and pumps down (interval event volume). Pump (interval event volume x (100% - fraction of recycled activated sludge)), ideally simultaneously with the activation of Pump 4</td>
</tr>
<tr>
<td>Aerator 1 (A1) Aerobic Reactor Aerator</td>
<td>Stops (aerator off delay) before Pump 3 is due to start and while it’s running. Starts and operates independently after Pump 3 is done, based on (Aerobic reactor DO to activate Aerator) and (Aerobic reactor DO to stop Aerator) until Step 1 again i.e. (hourly interval between aerator off delay)</td>
<td>Stops (aerator off delay) before Pump 3 is due to start and while it’s running. After Mixer 1 is off (i.e. step 9), starts and operates independently again based on (Aerobic reactor DO to activate Aerator) and (Aerobic reactor DO to stop Aerator) until a new batch aerator off delay</td>
<td>Stops (aerator off delay) before Pump 3 is due to start and while it’s running. Starts and operates independently after Pump 3 is done, based on (Aerobic reactor DO to activate Aerator) and (Aerobic reactor DO to stop Aerator) until Step 1 again i.e. (hourly interval between aerator off delay)</td>
</tr>
<tr>
<td>Mixer 1 (M1) Reception Tank Mixer</td>
<td>Mixer 1 runs (mixer 1 on delay) first, leading up to Pump 2 starting and while Pump 2 is running.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump 1 (P1) Anaerobic Lagoon to Reception Tank</td>
<td></td>
<td>When the Reception Tank Low Float is reached, Pump 1 runs until the High Float is reached.</td>
<td></td>
</tr>
<tr>
<td>Pump 5 (P5) Sedimentation Tank to Make Up Tank</td>
<td></td>
<td>When the Sedimentation Tank High Float is reached, Pump 5 runs until the Low Float is reached.</td>
<td></td>
</tr>
<tr>
<td>Mixer 2 (M2) HRAP Paddlewheel</td>
<td></td>
<td>The Paddlewheel runs continuously.</td>
<td></td>
</tr>
<tr>
<td>Pump 6 (P6) Disposal Sump to Anaerobic Lagoon</td>
<td></td>
<td>When the Disposal Sump High Float is reached, Pump 6 runs until the Low Float is reached.</td>
<td></td>
</tr>
</tbody>
</table>