

Leanyer Sanderson WSP Performance Audit

Summarised Report

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Client: Power and Water Corporation

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Prepared by

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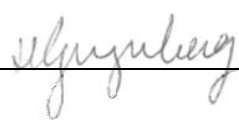
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Abbreviations

| | |
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| ADWF | Average Dry Weather Flow |
| BOD | Biological Oxygen Demand |
| DENR | Department of Environment and Natural Resources |
| DO | Dissolved Oxygen |
| DRP | Dissolved Reactive Phosphorus. |
| EP ep | Equivalent Person |
| FIDOL | Frequency, Intensity, Duration, Offensiveness, Location |
| GPS | Global Positioning System |
| LSWSP | Leanyer Sanderson Waste Stabilisation Ponds |
| MPN | Most Probable Number |
| NTEPA | Northern Territory Environment Protection Authority |
| OU | Odour Units |
| PWC | Power and Water Corporation |
| TP | Total Phosphorus |
| TSS | Total Suspended solids |
| WDL | Waste discharge Licence |
| WSP | Waste Stabilisation Pond |
| WWTP | Waste Water Treatment Plant. |

1.0 Introduction

1.1 Background

Power and Water Corporation (PWC) owns and operates the Leanyer Sanderson Waste Stabilisation Ponds (LSWSP), to treat an average dry weather flow of approximately 14 ML/d domestic and commercial wastewater, with a connected population of approximately 50,000 in Darwin's northern suburbs. The raw wastewater arrives at the LSWSP via Casuarina and Sanderson trunk sewers, and goes through a series of facultative ponds and maturation ponds. The treated effluent is then discharged into Buffalo Creek as licensed by a Waste Discharge License under the Water Act. A portion of the treated effluent is diverted to the Northlakes Reuse Plant for further treatment and irrigation on sporting fields.

The pond system uses a cost effective and natural form of treatment that relies heavily on sunlight. AECOM Australia Pty Ltd (AECOM) understands that nuisance odour issues occur, particularly during season change period, which has been raised by the nearby residents. Recently PWC was issued a Show Cause Notice by the Department of Environment and Natural Resources for an odour event that occurred in September 2017 at the LSWSP. The show cause notice required PWC to: provide specific details of all investigations and or operational process reviews to provide a complete understanding of the causes of the odours.

Consequently, PWC decided to undertake a voluntary audit of the pond system to assess the current performance of the ponds and ensure that the operations on site meet industry best practice and are reasonably adequate in mitigating odours.

AECOM was appointed to undertake the audit as agreed with the regulator. The project team was led by Dr Harry Grynberg; a Victorian and NT EPA accredited Environmental Auditor (Industrial facilities) with a strong wastewater treatment background, and Dr Zhuo Chen, a wastewater treatment specialist.

1.2 Scope of Works and Methodology

The methodology comprised of an inception meeting and data request, review of information, site inspection and reporting.

AECOM undertook the following work:

1. Inception meeting (15 December 2017)
2. Desktop assessment of current operation and maintenance.
3. Desktop performance assessment of the pond system.
- 3 Site Inspection.(7-9 February 2018)
- 4 Meeting with Department of Environment and Natural Resources (DENR) to discuss the scope of the audit.
- 5 Reporting

AECOM wish to thank the PWC staff for the timely provision of information and cooperation throughout the audit process.

2.0 Assessment of the Sewage Treatment System

2.1 Current treatment systems

2.1.1 Description of Current treatment systems

The LSWSP is located northeast of the Darwin suburbs Leanyer and Wulagi, and approximately 13 km northeast of the Darwin CBD. The plant consists of two similar treatment streams (i.e. Leanyer side and Sanderson Side) each comprising one facultative pond and four maturation ponds in series.

Two distinct trunk sewers from the surrounding northern suburbs deliver the raw sewage into the plant: Casuarina Trunk Sewer and Sanderson Trunk Sewer.

The combined sewage flow enters an inlet channel which divides the flow into Leanyer and Sanderson facultative ponds (L1 and S1) via flow splitting gates which are manually adjusted. Current inlet ADWF for the plant is approximately 14 ML/day, with an approximate 50/50 split between Leanyer and Sanderson streams. In 2018 a 60/40 split was initiated with the introduction of flow meters on each pond inflow. All flows enter the pond system and may cause overtopping of the ponds during wet weather conditions.

A schematic of the WSP process units is shown in Figure 1. The depths of the ponds are typical for the design purpose, although the first maturation pond appears to be much deeper than typically applied maturation (polishing) pond depth. It is for all intents operating as a secondary facultative pond rather than a maturation pond. With future connections, which may ultimately cause overloading of the facultative pond (hunter h₂O, 2016), there may be an opportunity for utilising the first maturation pond as a facultative pond operating in parallel with the existing facultative pond. Further discussion is provided in Section 4.0 in the context of odour issues.

Although wastewater treatment technology has advanced significantly in the past couple of decades, it should be noted that waste stabilisation ponds (WSPs) are still widely applied for domestic wastewater treatment around the world, as they do offer completely natural purifying processes. For instance, in the US alone, more than 50% (>8000) of WWTPs are WSP system (USEPA 2011). There are more than 2500 pond treatment systems in France representing 20% of the total number of urban wastewater treatment plants, and around 3000 WSPs out of around 10,000 plants in Germany are currently in operation (Mara 2009). WSPs are commonly used for smaller communities in Australia but no data could be found on numbers of plants.

2.1.2 Overall pond performance

The current sludge accumulation within the Leanyer pond system is recorded to be approximately 10% to 25%, less than 1/3 of the pond depth. De-sludging is not considered necessary at present, even though it exceeds the PWC requirement. Pond 1 is likely to require de-sludging within the next 3-5 years.

The Sanderson stream has never been desludged due to various factors including ground stability issues, as well as work prioritisation. This has resulted in the over-delay of the desludging of Sanderson stream ponds and significant loss of the hydraulic capacity of this stream. High levels of the sludge in the Sanderson ponds may form a deeper anaerobic layer, which contributes to the enhanced sludge degradation and consolidation.

According to the existing operating volumes, the hydraulic residence times for these two streams are found to be approximately 43 days and 22 days, respectively. Further discussion on the contaminant removal is presented in Section 2.1.2.2. The observation is that there is still a certain level of conservatism in the current hydraulic capacity, allowing increased flow through the system while still meeting the treatment targets.

A detailed design review of the LSWSP is beyond the scope of this investigation. However a brief summary of the key design criteria is provided in below. The design of Leanyer & Sanderson WSP follows the PWC design manual (Ashworth and Skinner 2011). It was concluded that:

Detention time: Long retention time in the maturation ponds may cause over growth of algae and may lead to high TSS levels in the final effluent. However given the high ratio of wet weather flows to dry weather flows the maturation ponds provide hydraulic buffer.

Raw Sewage: The observed raw sewage strength largely falls in the design range, although the ammonia and total nitrogen levels may vary to slightly higher levels. However the BOD is in the lower range for Australian Domestic catchments. This may be due to rainwater inflow and infiltration into the aged wastewater collection system.

Facultative Ponds Loading: Currently ponds are not overloaded when compared to design surface loading rate. However a recent study demonstrated that overloading would occur in 10 years' time (hunter h2o 2016)

Maturation Pond Loading: Overall acceptable loading rate

Depth of the facultative pond: is slightly higher than the typical industry standard (2m) but does provide additional sludge storage.

Depths of the maturation ponds: are slightly higher than design criteria. High depth of maturation pond may reduce disinfection potential, lead to stratification of the pond and over growth of algae.

Flooding Impact: AECOM understand that the whole LSWSP is located on the floodplain, which may be completely inundated during peak wet weather coupled with high tide. In addition, due to the high inflow and infiltration in the aged network the peak wet weather flow may cause overtopping of the ponds.

Desludging: Leanyer stream was last desludged in 2010-2013 with current sludge depth estimated at 10-25%. Leanyer Facultative pond sludge exceeds the design criteria. Sanderson (20-70% sludge volume) stream desludging is overdue.

2.1.3 Pond flow and short circuiting

It should be noted that the theoretical retention time calculations do not take into consideration that the actual pond flow is not ideal and there is dead volume and short circuiting in each pond.

During AECOM's site visit on Feb 7th and 8th 2018, it was observed that there are a few baffles installed in Leanyer Pond 1 and Pond 2 to assist with hydraulic performance of the ponds. Short-circuiting is the greatest constraint to consistent pond performance. AECOM was informed by PWC during this audit that GPS Drogues tests were undertaken previously to identify the dominant pond flow patterns, without much success. The degree of pond mixing and the actual pond hydraulic retention time is still unknown.

In AECOM experience, a pond dye test is one of the most useful tools or methods to identify dead volume percentages within pond systems. Sludge accumulation has been estimated at between 10-25% by volume in the Leanyer Pond system and between 70-20% in the Sanderson pond system.

Furthermore, the hydraulic connectivity between ponds appears to be problematic at the moment, as manifested at multiple connection points on site. The high solids content and algae growth lead to blocking of some pond inlet channels, which causes hydraulic imbalance across the system.

2.1.4 Pond contaminant removal performance

The contaminants removal performance at the LSWSP is considered typical for WSP systems. This is largely due to the long retention time currently observed in the system. The observed removal rates for BOD and total nitrogen are approximately 74% and 76%, respectively. The median ammonia removal rate was found to be above 90%.

The recent effluent quality (Jan. 2016 to Jan. 2018) as provided by PWC was reviewed. Currently no Waste Discharge Licence (WDL) limits have been specified in the issued Waste Discharge Licence, and no assessment of the surface water, sediment, or terrestrial sampling results is included in this study. Overall, the effluent quality appears to be typical for WSP systems, except that high TSS which may be largely due to algae over growth may occur from time to time. This also contributes to relatively high BOD in the discharge.

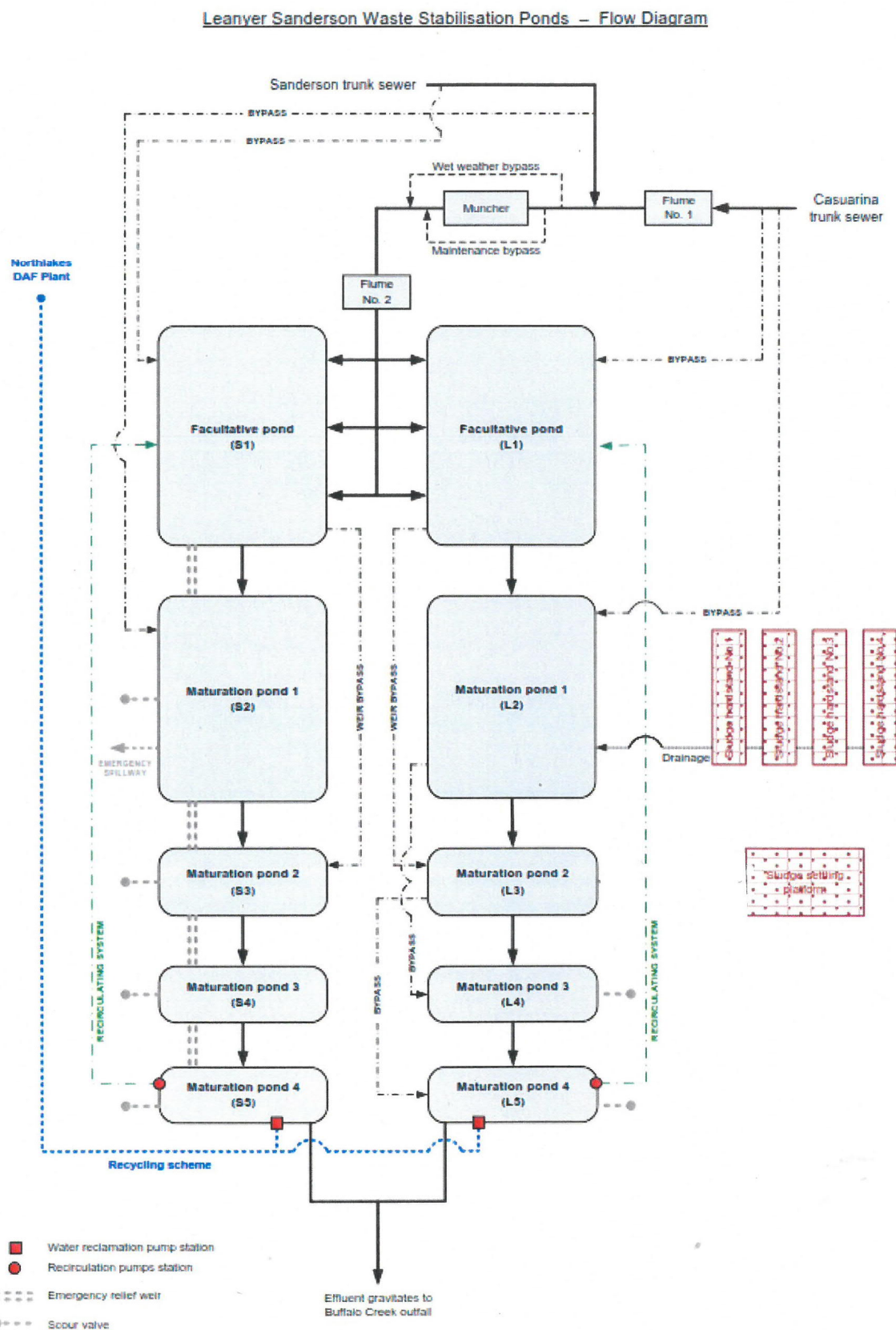


Figure 1 Schematic flow diagram for Leanyer Sanderson WSP (provided by PWC)

2.2 Proposed upgrades for the Treatment Systems

As part of this investigation, AECOM has reviewed PWC's Continuous Improvement Programme developed for Leanyer Sanderson WSP (Improvement Plan 2017). This is one of the performance improvement initiatives that PWC developed in consultation with NT EPA. We understand that there are a suite of measures or upgrade projects currently underway, to optimise the pond performance and ensure improvement in community and environment protection. These are listed as follows:

- Leanyer Sanderson WSP Inlet Works upgrade
- Pond hydraulic improvements and pond model validation
- In-pond augmentation trials (e.g. AquaMats)
- Buffalo Creek hydrodynamic and water quality modelling
- Effluent recirculation
- Desludging of Sanderson ponds
- Thermistor strip
- Additional instrumentation (DO, pH measurement)
- Aeration

Conclusions and recommendations regarding these upgrades/improvements are discussed in Section 2.5.

2.3 Assessment of Operations and Maintenance

2.3.1 Review Findings

Based on direct communication between AECOM and PWC staff, it was confirmed that duty operators of the LSWSP usually attend site at least once every week with daily attendance subsequent to the odour issues, carrying out general operational tasks as indicated in the PWC's WSP Operation Manual.

Review of the documents and discussion with PWC's staff indicate that a regular maintenance and monitoring schedule is in place to ensure the smooth operation of the WSP system.

The current WSP Operation Manual is dated July 2010, and is an overarching document covering key operational and maintenance guidance for all WSPs currently owned and operated by PWC. It is AECOM's opinion that the performance requirements and operating configuration should be updated to be site-specific for LSWSP system. We understand that this is currently underway.

WSP is generally a low-cost wastewater treatment system, with minimal routine maintenance required once the ponds have established a steady-state operation. However there are some essential routine maintenance tasks that need to be carried out regularly.

2.4 Best Industry Practices

The PWC Waste Stabilisation Manual having been reviewed by D. Mara, one of the most respected authorities on pond operations, indicates that the manual describes best practice approaches to design. The key objective is to ensure that the hydraulic system is designed and constructed such that the theoretical hydraulic retention time is approached. Consequently reasonable success in terms of treatment performance can be assured irrespective of the design method selected.

In terms of pond operation, there is not a great deal of literature in relation to facultative pond best practice. The operating procedures outlined in the WSP Operations Manual were compared to operating procedures in a number of documents including:

- Principals of design and Operations of Wastewater Treatment Pond Systems for Plant managers, Engineers and Managers USEPA August 2011
- Design and Management of Tasmanian Sewage Lagoon Systems (DELM Nov.1996)
- Wastewater Treatment in the Australian Red Meat Processing Industry (AMPC 2012)

In broad terms where the operations are consistent with the Design Guidelines and the Operations Manual, they are consistent with the best practice requirements. However to the extent that the pond

are overloaded during desludging or excess sludge accumulates in the ponds (both of which occur) these are not consistent with best practice.

There are also a number of papers that discuss the issue of Stratification including, the Tasmanian Guidelines, USEPA Guidance, and

- Abis and Mara Temperature Measurement and stratification in Facultative Waste Stabilisation Ponds in the UK Climate (Environmental Monitoring and Assessment 2006)
- Lazur and Britt Pond Recirculating Production Systems Southern region Aquaculture Centre Nov 1997
- Gu and Stefan Stratification Dynamics in Wastewater stabilisation Ponds Water Research 1995

These reports and studies indicate that pond stratification (due to temperature) occurs in all climates. The general approach to preventing temperature stratification and the associated destratification includes:

- Baffles- to enhance flow and associated mixing,
- Positioning of inlets to mix and equalise temperatures, this may differ with seasons,
- recirculation to provide oxygen and address odours, and
- mixing using directional aerators or mixers.

USEPA (2011) observes that ponds should not be located up wind of receptors based on the periods when de-stratification occurs and should be “away from residents”.

The issue of desludging is not addressed in detail in the best practice documents noted above. The general practice is to desludge using a hydraulic dredging system. This does allow for continued operation of the pond. The sludge can be pumped to drying beds or to dewatering equipment e.g. a centrifuge or a belt press. This has the advantage of not taking the pond out of line and not causing overloading of the associated ponds.

PWC has incorporated some of these features into pond operations. As discussed later in this report, much greater recirculation, aeration and or mixing are required to test whether these can ameliorate odours through prevention of stratification- destratification and or oxidising odours before they are emitted.

2.5 Recommendations

Based on the site observations and the effluent quality monitoring results, AECOM considers that the performance of the pond system is typical at LSWSP. Although a detailed discharge effluent assessment is not within the scope of this investigation, a limited review of the effluent quality showed that the WSP is, in general, performing well with respect to removing constituents in the raw sewage, albeit with high suspended solids and associated BOD in the effluent due to algae grown in the ponds.

PWC is currently undertaking a variety of operational measures, in addition to planned upgrade works, to ensure good plant operation and performance. A WSP operation manual and a relevant water quality monitoring programme are in place to provide guidance on the plant operation, maintenance, and monitoring requirements. However, there are some improvements that could be applied to the site to optimise the plant's performance and improve the quality of the discharge effluent entering Buffalo Creek. The key recommendations include:

2.5.1 Plant Operation and Maintenance Manual

A site-specific LSWSP Operation and Maintenance Manual should be developed, within the framework of PWC's current WSP Operations Manual, to reflect the specific site information at Leanyer & Sanderson WSP. The manual will need to include the operation and maintenance of the new inlet works and management of the waste streams (screenings and grit). Given the size of the plant, it is advisable to have a dedicated operations team to maintain the plant and tend to all regular and emergency requirements that may arise at this plant.

2.5.2 Improved online instrumentation

The pond system was commissioned in 1970's, with limited mechanical components and automatic control system. For instance, the influent flow measurement is currently not very accurate, with the actual flow splitting between the two streams uneven and difficult to control. AECOM understand that this will be improved significantly with the plant inlet upgrade project. Automatic weir level control will provide flexibility in flow splitting between Leanyer and Sanderson streams.

It is also desirable to obtain online measurement of dissolved oxygen, water column temperature profile, and pH at various key locations in the WSP, in addition to the final effluent monitoring. The measurements should be recorded in the SCADA system and may be used to raise alerts to operator when they reach certain levels. Based on direct communication with PWC staff, various trials and upgrade projects have been developed in this regards, including more thermistor strips in various ponds, and development of Contingency Plans pending a strategy for control of odour.

2.5.3 Improved plant hydraulics

All process units appear to operate within the acceptable hydraulic capacity, although currently a 60:40 split is used between Leanyer stream and Sanderson stream ponds due to the over-accumulation of pond sludge within Sanderson stream. The performance of the ponds can be further enhanced if the hydraulic capacity of the system is maximised. This may be accomplished by:

- De-sludging the Sanderson Stream ponds. We understand that sludge survey is scheduled for accurate measurement of the accumulated sludge level within the pond system and desludging work for the Sanderson ponds is envisaged to occur in 2018.
- Installation of appropriately sized baffling walls/curtains within the ponds to ensure an even distribution of flows within the pond, reducing the dead volume.

In order to obtain a better understanding of the hydraulic performance of the pond system, a dye test could be carried out after the desludging work is completed. This will provide a reliable estimate in terms of actual hydraulic retention time, in comparison to the theoretical one. This information can be used to update the current pond process model, and aid with placing the right baffles for pond flow enhancement.

In addition, the hydraulic connections between the ponds may also need some maintenance care. Excessive solids, scum, and macrophyte growth appeared to have a potential to block the pond transfer channels and openings, which may impact the hydraulic balance of the entire system.

2.5.4 Improved plant loading control

The design of the LSWSP system follows typical design equations widely used for WSP sizing and is well documented in the PWC Design Manual for the "tropical environment" in Darwin. The observed contaminant removal performance is typical at Leanyer & Sanderson WSP. This is largely because of the long residence time within the pond system. The total suspended solids are elevated, which is largely due to the algae over growth as a result of local climate and long residence time in the current pond system. With BOD overloading envisaged in the next 10 years, there may be an opportunity of turning the first maturation pond into a facultative pond operating in parallel with the current facultative pond. This will reduce the loading onto the WSP system and shorten the residence time, controlling algae over growth.

3.0 Assessment of Odour Issues- Background

3.1 Odour Considerations

Odours are volatile chemicals in the air that can be detected by members of the community. The detection of odours and the submission of a complaint is a complex process. Members of the community have varying capacities to detect and “tolerate” odours and/or to complain.

Odour recognition can be related to 5 elements called FIDOL.

- a. Frequency- how often
- b. Intensity-strength
- c. Duration- how long it occurs
- d. Offensiveness- how “bad” the smell is
- e. Location- distance from the source to the receptor.

Not all these elements need to be present for an odour incident, for example a one off offensive odour of short duration can result in complaints. A complicating factor is that longer term residents may tolerate odour incidents (i.e. are used to them); new residents may be less tolerant.

Another factor that needs to be taken into account is the odour needs to be transferred from the source to the receptor (member of the community). This is usually by the wind but can be by diffusion under low or no wind conditions. Strong winds can disperse odours so the impacts are reduced; very light or no winds can result in little dispersion and the movement of high concentration odours.

Odours are measured as Odour Units (OU). One OU is defined as just being detectable by 50% of the members of an odour panel. The odour panel is selected to exclude individuals who are highly sensitive or have a very low sensitivity to odours.

It is generally considered that Odour Units (OU) detection and response by the community is as follows:

- 1-2 OU not recognised and may not be detected
- 2-3 OU may be detected and some recognition
- 3-5 OU can be detected and recognised; may result in a complaint.

Repeated exposure to odours can result in recognition and detection at lower odour concentrations.

3.2 Odour Modelling

GHD (2017) undertook odour modelling of the WSP based on odour emission testing conducted in June 2014 (dry season) in the Leanyer ponds only. The odour emission rates from the various odour sources were estimated and modelled, based on a number of assumptions

Odour monitoring results confirm that the two ponds have similar odour emission concentrations although the Sanderson Facultative pond has a significant sludge inventory (estimated at 70%).

The dry season odour emission rates are much higher than the wet season emission rates. This may be due to the wet weather flows diluting the influent sewage. Further monitoring is required to confirm whether this is the case.

The odour monitoring measurements do not include scum odour emissions that could be higher than the ponds themselves.

3.3 Odour Complaints

Complaints due to odours have been reported to DENR and to PWC. No analysis has been undertaken as to whether complainants contact both organisations. Both organisations may attempt to verify the odour complaints.

PWC provided an Odour Complaint Map and odour complaint listing to NT DENR (PWC response to Directions Letter dated 15 September 2017). These were reviewed and used in the following discussions.

NT EPA indicated in a meeting in February 2018 that during the September 2017 odour incident there were approximately 100 complaints.

The complaints were from the western and southwestern suburbs relative to the LSWSP.

PWC has undertaken an analysis of complaint history against selected meteorological conditions for a number of odour incidents (May 2016, August 2016, and September 2017). The prime conditions that have led to odour complaints have been:

- significant overnight air temperature drop,
- wind direction towards the neighbours, and
- potentially wind speed (both high or low).

The temperature drop results in colder pond water overlying warmer pond waters, which can lead to an inversion i.e. odorous sludge rising to the surface (“de-stratification”). A key factor was the temperature difference between the upper pond layer and the lower pond layer. The analysis indicated that seasonal change at the start and end of the dry season were significant factors. This aligns with the anecdotal information that pond turnover (de-stratification) occurs in April-May and August-September and that the largest proportion of complaints occurred during these periods.

These findings are considered in the discussion of operational factors that follows.

3.4 Separation Distances

The NT Draft Guideline *Recommended Land Use Separation Distances* (June 2017) proposes separation distances from sewage treatment plants to sensitive land uses such as residences. The recommended separation distances are based on the treatment processes. These guidelines predate the current land use and have yet to be adopted. Some guidelines nominate recommended separation distances e.g. Victorian EPA. However in the Victorian EPA guidelines the buffer distances are to address upset conditions and not normal operating conditions (under normal operating conditions there should be no pollution (objectionable odour) beyond the boundary of the premises). An example of the application of this concept (upset conditions) would be de-stratification of the facultative ponds causing odour emission. The separation distance for a LSWSP (50,000ep) would be in excess of 1800m.

The approximate distances to the nearest houses are as follows:

| | |
|--|------|
| Leanyer Facultative Pond | 660m |
| Leanyer Maturation Pond (L2) | 540m |
| Eastern end of the biosolids management area | 150m |
| Biosolids drying area | 450m |

These separation distances are well below the Victorian EPA recommendations for upset conditions.

There is also a General Environmental Duty (that includes odour emissions) under Section 12 of the Waste Management and Pollution Control Act (NT) to *prevent or minimise pollution or environmental harm*.

3.5 LSWSP Assessments

PWC commissioned a number of reports that assess the upgrade options for the LSWSP.

In 2011 MWH (September 2011) prepared a report entitled LSWWTP Treatment Options Study. The main objective was to assess options for upgrading the plant to improve treated effluent quality and biosolids management. While not an explicit objective the report does assess odour management.

In October 2016, hunter h₂O reported on an In-Pond Upgrade Options Investigation. The stated objective was to improve effluent quality, with a cost of less than \$5M (plus 30% contingency). Odour reduction was not part of the scope.

Both these reports did not address odour reduction as a main objective. The MWH report did identify the inlet works and biosolids management as odour sources and the risk of encroachment of housing. PWC are installing new inlet works with odour control, and the encroachment of housing virtually to the site boundary has occurred.

PWC also commissioned hunter h₂O (hunter h₂O October 2017) to assess the events which lead to the significant odour event in August 2017. The assessment identified a number of likely /potential odour sources and circumstances as follows:

- Odours from the inlet works
- Overloading of the Leanyer ponds during inlet works construction including the discharge of H₂S and Volatile Fatty Acids due to anaerobic processes.
- Low Pond pH resulting in H₂S emissions
- Low overnight temperatures leading to pond inversion
- Low wind speed or still conditions facilitating odour movement without dilution
- Excessive build-up of sludge in the lagoons above Operation Plan requirements

hunter h₂O recommended a program which has *the high probability of reducing odour risk whilst limiting the chance of sunken capital (i.e. investment that is not consistent with a long term strategy)*.

The proposed approach comprised:

The findings and recommendations from these reports as well as the observations made by the audit team and discussions with PWC staff and NT EPA inform the discussion in section 4.0.

4.0 Assessment of Odour Issues-Current Situation

The current situation comprises the plant with approximately 50,000 ep with inlet works being constructed that include odour control facilities.

4.1 Routine Operations

The identified sources of odour that could be emitted from the site operations and discharged across the boundary were:

- Inlet sewers that discharged into either open channels or channels that had been covered (“inlet Works”),
- Facultative Ponds (Sanderson 1 and Leanyer 1),
- Facultative Ponds during April/May and August/September due to pond de-stratification,
- Maturation Ponds (Sanderson 2 and Leanyer 2),
- Floating scum on the facultative and maturation ponds, and
- Biosolids Management: Dewatering of wet biosolids, and Biopiles.

4.1.1 Operations without de-stratification

An assessment of odour emission rates and odour impact has been conducted (GHD October 2017).

The modelling indicated that for 8 hours per year nearby residences could be subject to odour impacts of from 2-5 OU to 5-7.5 OU. The latter range is likely to be identifiable. The odour complaint history is such that there do not appear to have been significant numbers of odour complaints under these conditions unless there has been pond thermal de-stratification.

The modelling indicated that, with the implementation of the inlets works and odour controls, for 8 hours per year nearby residences could be subject to odour impacts of from 2-3.5 OU (excluding de-stratification). This would not be expected to generate complaints, however given the recent odour incidents (e.g. August 2017) lower OU may result in complaints.

The pond systems comply with design requirements during typical operations except for the detention time in Sanderson Facultative Pond 1 that is lower than the PWC Design Manual values due to sludge accumulation. PWC's Design Manual (Ashworth and Skinner 2011) indicates a minimum maturation pond detention time of 3 days. On this basis, during normal operations (excluding de-stratification and sludge removal), odour production is unlikely to cause large numbers of odour complaints.

4.1.2 De-stratification

De-stratification of the ponds can occur when there is a significant temperature difference between the temperature at depth in the pond and the surface of the pond. This is a not uncommon feature of lagoon systems and has been reported widely (e.g. Abis and Mara 2005). Anecdotally this can occur at the end of the wet season (March/April) and at the end of the dry season (August/September). Under these conditions the temperature at depth is higher than the surface temperature due to cooling of the water surface and/or lower sewage temperatures (particularly overnight). This causes the deeper layers of the pond that are anaerobic and more odorous to rise to the surface and cause high odour emissions. Anecdotally this occurs every year, however based on past experience this does not always result in odour complaints. However, most of the complaints occur during periods (April/May 2016 and August/September 2017) when de-stratification is likely to have occurred.

The modelling (GHD 2017) estimated that the inversion could result in an increase in overall odour emission rate of 60%. The results indicate that odour at numerous residences could be in the range 3.5-7.5 for more than 8 hours per year. Given inversions occur during perhaps 2-4 months of the year, in order to impact on the nearest residences (to the west) the wind direction would need to be in an easterly direction and coincide with the destratification, or winds are very light with little associated dilution. The wind rose for the dry season (May to October) has a significant easterly component (12% of the period).

Therefore it can be concluded that addressing de-stratification through prevention or mitigation of the impacts will be essential, in preventing major odour incidents, the associated complaints and most importantly adversely impacting on the amenity of the neighbouring communities.

4.1.3 Floating Scum

The floating scum is an unquantified odour source. The scum accumulates on the facultative pond surface and it accumulates on the pond walls driven by the wind. Floatables that should be removed by the new inlet works are a component of the scum. Scum is currently removed from time to time manually. Odour risk will be reduced should the scum be continually collected, removed and disposed of regularly.

4.1.4 Biosolids Management

As noted in section 4.1.1 based on odour emission estimates excluding destratification, biosolids management contributes 5% to the odour inventory currently. With the completion of the inlet works this will rise to 11% of the odour inventory. The biosolids management area is the closest operation to the community. The most odorous aspect is likely to be the initially drying of sludge that has been removed from the dewatered ponds. This occurs at the eastern end of the biosolids management area approximately 430m from the nearest residents. It is proposed to move this activity to an area north of the Leanyer maturation pond. This will provide a distance of approximately 750 m from the nearest residents. This will allow the biosolids composting to occur at the location of the existing drying bed. The biosolids management is a “hotspot” in the modelling, so moving all the activities closer to the treatment facilities will be an improvement. It is unclear as to whether any of the odour complaints relate to biosolids management.

4.2 Infrequent Operations

4.2.1 Plant Upgrade

Currently (February 2018) the plant is undergoing construction works during which screening and grit removal systems incorporating odour control will be installed together with modification to sewer lines and metering installations. This has resulted in some changes to operations including lowering of facultative pond levels to minimise groundwater intrusion into excavations and pumped transfers between the two facultative ponds. These changes are transient and have not been assessed in detail. They could result in a marginal increase in odours through lower pond operating levels.

4.2.2 Desludging of facultative ponds and associated increased loading on the second Facultative pond

The desludging process involves transfer of supernatant from the facultative pond and the diversion of all the plant inflows into the second facultative pond. The dewatered pond is then allowed to dry out. The operation occurs over the dry season with duration of approximately 2-3 months. The wet sludge is transferred to sludge drying beds on the western side of the site that are reportedly sprinkled with lime to minimise odour; this would control sulphides but enhance ammonia emissions.

After drying, the biosolids are placed in windrows and turned monthly to enhance degradation and stabilisation. Operation staff reported that the drying of the biosolids and the dewatering drying in the ponds are considered not odorous. This could not be verified by AECOM as no desludging was occurring at the time of the site inspection. Sanderson Facultative pond 1 is scheduled for desludging in 2018.

The desludging of the ponds is an essential part of efficient and effective operations. The greater the liquid depth above the sludge layer the lower the likelihood of odour emissions and the greater the treatment efficiency, both due to a deeper aerobic layer. In addition the dewatering of one pond and resultant discharge to a single desludged facultative pond should have a lower odour impact because of a deeper aerobic layer. The dewatering of the Sanderson ponds results in greater loadings on the Leanyer ponds that are closer to the community. More frequent desludging will reduce the period in which the Leanyer pond has a higher loading due to diversion of all the flow to the Leanyer system.

The Waste Stabilisation Pond Operations Manual (PWC 2010) recommends that Facultative Ponds and Maturation Ponds be desludged when they reach 25% capacity. This has not been complied with

for the Sanderson Ponds. The Leanyer Facultative Pond 1 and all the Sanderson Ponds except Sanderson Maturation pond 4 are at levels that requiring desludging.

During proposed desludging of the Sanderson Facultative Pond 1 the loadings and detention time in the Leanyer Pond 1 would be higher than the design criteria. As a mechanism to reduce the loadings on the Leanyer Facultative pond, consideration could be made of utilising either Leanyer or Sanderson Maturation Pond 2 as an additional facultative pond. Leanyer Pond 2 is preferable due to the relatively low sludge inventory but is closer to the community. This would result in reduced organic loadings to levels similar to current operations during desludging and reduced odour risk from the facultative ponds.

4.2.3 Desludging of maturation pond and associated increased loading on the other ponds

When maturation ponds are deslugged there is likely to be a lesser impact compared to the facultative ponds. This is because the maturation ponds are generally small (e.g. pond 3, 4 and 5), given the lower organic loadings they will be more aerobic and sludge degradation should be enhanced, the redistribution of loadings can be effectively managed.

4.3 Impact of Proposed Short Term Improvements

4.3.1 Inlet Works Under construction

The major short term improvement is the installation of a screenings and grit removal system that will be covered and include a biofilter and activated carbon adsorption odour control system. This should have the following benefits:

- removing screening and grit that contribute to the sludge inventory in the ponds,
- improving sludge quality to facilitate reuse,
- remove floatable that contribute and exacerbate scum formation,
- remove an estimated 35% of the odour emissions (assuming that the covered inlet channel is included in the odour control system), and
- facilitate effective flow proportioning between the facultative ponds

4.3.2 Enhanced Monitoring

PWC is implementing an enhanced monitoring program in line with the recommendations from the hunter h₂O 2017 report including collection of odour samples for the ponds, fence line monitoring, additional in situ pond pH and Temperature monitoring and additional and comprehensive monitoring of odour emanating from the ponds. This monitoring program will enhance the understanding of odour emissions and may be able to predict potential periods of high odour emissions that are likely to cause complaints

This monitoring is likely to confirm what is known i.e. that the major sources are the inlet works, pond inversions and potentially biosolids management.

4.4 Discussion of Odour Reduction Options in relation to the current situation

4.4.1 Non Compliance with PWC Guidance

In the course of the assessment a number of non-compliances with PWC design and operating requirements have been identified and are discussed below.

Sludge has been allowed to accumulate in the ponds at well above the requirement of 25%. This impacts pond performance and increases the odour risk. A program of de-sludging the ponds should be prepared and implemented to comply with PWC requirements.

The BOD loading on the Leanyer facultative pond, when the Sanderson facultative pond is taken off line for desludging, will exceed the design requirement. PWC should develop systems to minimise the odour risk from the facultative pond. These could include:

- conversion of one of the “second maturation ” ponds into a facultative pond for 2-3 months,
- provision of surface aerators (e.g. aspirator types that do not impact the sludge layer on the facultative pond), or
- other odour prevention measures such as nitrate addition(Tasmanian Lagoon Guidance); note that given the long detention times and large areas dosing will be complex, and
- desludging using a pumping system that provides for ongoing pond operation and would eliminate the overloading of the residual pond as is currently the status .

4.4.2 Discussion of Odour Reduction by Odour Source

The sources of odours are as follows from highest to lowest potential impact and the basis for ranking (basis is indicated in brackets):

a. Facultative Pond De-stratification (estimated by GHD 2017)

The work to date by PWC has identified this as the prime cause of complaints over the past few years. Excellent work has been done to identify the factors that results in pond de-stratification and monitoring is being implemented to inform prediction of conditions likely to cause de-stratification. The key is then how to prevent or mitigate the odour emissions due to de-stratification. Options include:

- **The use of surface aerators** (“aspirator” aerators or Mapal aeration systems, as examples) to aerate the top 1 m of the pond, create a swirl throughout the pond and enhance mixing in the upper layer could reduce odour potential. The aerators may prevent periods of potential pond inversion by reducing the temperature differential in the pond upper layer through mixing and providing an aerated layer to oxidise odorous compounds.
- **Recirculation of maturation pond liquors to the plant inlet:** Increasing the recirculation rate would have a greater impact and reduce odour potential compared to the current recirculation rate. Given the long detention times and large pond area additional flow is unlikely to increase the pond mixing significantly or prevent stratification. This option would require the addition of mixers in the upper layers of facultative pond to equalise the temperatures to prevent destratification.
- **Comparison of surface aeration and Recirculation:** The oxygenation efficiency of the recirculation pumps (as kgO₂/kWhr) should be assessed against the oxygen efficiency of surface aerators (generally around 1-1.2 kgO₂/kWhr). This should be assessed in a cost benefit to inform a preferred system for additional aeration in the facultative ponds that will reduce odour risk during routine operations.

b. Inlet works (quantified by GHD 2017)

The proposed works are predicted to reduce odour emission by up to 35% and result in few if any complaints due to routine operations, subject to the odour control facilities performing as expected. In the interim the inlet flows remain a significant source of odour. The inlet channel should continue to be covered and the sewage should be discharged to depth.

The use of additives such as oxygenating compounds (oxygen, nitrates) or sulphide immobilisation (using iron salts) could be used as interim measures until the inlet works are commissioned. However due to the long detention times and large areas it will take a long time to impact on the whole of the facilitative ponds

c. Facultative ponds (quantified by GHD 2017)

The use of either surface aeration or enhanced pond recirculation would both reduce the odour risk for the facultative ponds during normal operation.

d. Maturation ponds (quantified by GHD 2017)

Additional aeration in the facultative ponds should improve BOD removal and should reduce the loading on the maturation ponds. This should in turn reduce the odour emissions.

e. Pond desludging (not quantified)

PWC operations staff advised that pond desludging is not considered a significant odour source. The last desludging was in 2013 (Maturation pond 4) and the last facultative pond desludging was in 2011, both when the adjacent residential suburb was much less developed. PWC are of the opinion that the additional loading on the facultative pond is the main odour source under these circumstances. As noted, the desludging of the ponds using a pumped system could eliminate the need to overload the other facultative pond, as would pond reconfiguration. However, whether using sludge drying beds or a dewatering device, management of odour will be necessary.

f. Biosolids management (quantified by GHD 2017)

The proposed sludge repositioning of the drying ponds should reduce the odour risk. This would also allow for compost piles to be located further from residents. Aerated biopiles have the advantage of containing odour and enhanced rates of stabilisation. These are generally covered, with discharge points at the top that can also facilitate collection and treatment.

g. Scum on ponds (not quantified)

The implementation of “continuous” scum removal and associated collection and disposal will reduce the odour risk. This could be in the form of a floating scum collector that could be repositioned based on wind direction and scum location.

4.4.3 Community Consultation

AECOM understand that, limited community consultation has been conducted to date, but that a program is being developed. Community consultation should be part of any program of upgrades and changes in routine operations such as pond desludging. This may not eliminate complaints, should odour occur, but an informed community should result in reduced complaints. Notwithstanding this approach, PWC’s objective should be to eliminate the causes of odour.

4.5 Management Aspects

4.5.1 Operational Responses

The operator attends the site daily, and uses a checklist to assess the status and potential issues. Should there be issues to manage e.g. removal of scum, then the operator discusses this with Senior Technical Coordinator and Headworks Treatment Coordinator and these are enacted.

At the time of the site inspections we did not observe emergency response equipment on site that could be used to address e.g. odour emissions. There are no contingency plans to address incidents. The Operations Manual does indicate that should odour occur, other PWC staff should be contacted: the water quality technician and the senior water treatment engineer. The following are options to address odour in the near future under the current pond configuration.

Operational Management Response to Odour Issues

Assuming that the odour controls implemented as part of the current inlet works project are as effective as predicted, there are a range of activities that could be used to attempt to control odours from in particular the facultative lagoons (the next highest odour source). As discussed previously, due to the size of the ponds (and hence the very large area that can emit odour) the effectiveness of the “additives” and effluent recycling may be limited and take some time to impact.

Significant investment would be required to provide an aerobic upper layer across the whole of each of the facultative ponds (e.g. 1m depth) during routine operations.

Desludging Facultative Pond using the current approach

As noted previously this could be addressed through conversion of the first maturation pond to a facultative pond. It would be recommended that this should include transfer of the aerators (should these be implemented) to the temporary facultative operation in order to maintain the aerobic upper layer.

Desludging Facultative Pond using a pumped system

De-sludging the ponds using e.g. floating pontoon mounted pumps, could allow ongoing operation. This would be logistically very difficult due to the pond size, and potentially multiple aerators on the

pond. Also given the uncertainty regarding the lining of the Sanderson Ponds, in particular, the impact of a pumped desludging system on pond liner integrity would need to be assessed.

4.5.2 Complaints Management

The complaints management procedure (PWC 2016 Registering and Managing Complaints (TRIM)) and a draft Water Services Complaints Process flowchart (PWC 2018) were reviewed and indicates that after a complaint is received an action officer is identified who is responsible for addressing the issue. In the case of e.g. odours from the LSWSP, it is unclear who and how the appropriate action officer would be selected. If the complaint is not closed out within 5 days it is escalated with in the client relations section. However, how it may be escalated within the operations or planning group is not defined in documents provided. Triggers for involving senior (executive) management are not defined in the complaints procedure.

4.5.3 Planning

As part of the application for renewal of the discharge licence PWC has developed Improvement Plans. The Improvement plans for 2015 and 2017 were reviewed, neither of them mentioned odour; the plans are focused on treated effluent quality improvement and operational improvement. This is consistent with the licensable activity.

In terms of planning and capital investment and delivery the PWC systems appear to be robust and appropriate. It does appear that with respect to odour issues, these have not been given due consideration in all cases. The original inlet works brief did not address odour issues specifically but this was later incorporated into the design in two stages: initially the biofilter and subsequently the activated carbon system. PWC are to be commended for these improvements.

PWC has invested in understanding the causes of the odour issues with a view to being able to predict significant odour emission episodes. This approach has identified the key issues as noted in this report. To date the PWC approach to addressing these odour issues is geared towards potential “simple” uncomplicated “fixes” that will not involve significant capital investment.

4.6 Conclusions

The successful implementation of the inlets works resulting in the elimination of the inlet area as a significant odour source should result in a significant reduction in odour risk from day to day operations.

PWC should implement a desludging program to align with its own design and operational procedures.

Pond desludging is a major odour risk due to the impacts on the operation of the other facultative pond. A number of options to reduce the odour risk have been described above including pumped sludge removal, conversion of a maturation pond into a facultative lagoon, additional aeration and pond recirculation to the “overloaded pond”.

Pond de-stratification has been the major cause of odour complaints. PWC has undertaken an excellent analysis of the attributes of pond operations and complaint history. Pond de-stratification occurs in all climates and is a common feature of “change in seasons” that results in colder water overlying warmer water. These conditions occur for a month or two during the start (April May) and end (August September) of the dry season. The options for prevention of de-stratification identified include a combination of

- minimising sludge inventory,
- enhanced mixing and aeration of the upper 1m of the pond by way of recirculation discharges of maturation pond at high rates, baffles, mixers and or aspirator aerators.

The management of biosolids including the desludging mechanism (pumping rather than dewatering and drying) can be enhanced through aerated compost systems.

Community Consultation should be incorporated into a program of implementation of the preferred approach.

PWC should develop Contingency Plans to address odour and undertake a detailed planning process to determine the preferred approach to mitigate the known odour sources. This approach should be incorporated into an Improvement plan or other development plan for the LSWSP.

The complaints management procedure should be more explicit in relation to odour complaints, outlining the roles and responsibilities including senior/executive management.

These conclusions relate to the current operations. The long term operations (71,300 ep) are discussed in Section 5.0. The preferred longer term approach may impact on the options that should be implemented in the short term. However the objective remains to minimise, and if possible eliminate, causes of odour complaints.

5.0 Assessment of Odour Issues-Potential Long Term Situation

5.1 Introduction

The long term strategy is currently defined in the PWC Improvement Plan 2017 (March 2017) submitted in support of the discharge licence application. This plan does not mention odour or address odour issues or biosolids management explicitly. It does propose the following:

- Inlet works – Construction and Commissioning 2017-2019: will mitigate odours (see Section 4.3.1).
- Pond Hydraulic improvements and pond Model Validation: could marginally reduce odours.
- Aquamat trials (Maturation Ponds) 2017-2018: will not mitigate odours.
- Hydrodynamic modelling of Buffalo creek 2017-2021: will not mitigate odours.
- Draft Options Paper for key stakeholders: relates to treated water quality >2021.

As discussed in Section 4.3 there are also a number of short term assessments and modifications being undertaken. Of these, the inlet works with successful commissioning provides the greatest impact in terms of reducing day to day odour emissions. The various reports commissioned by PWC have indicated that the ultimate population of 71,300ep could be reached in 10 years (2028).

This is a design horizon that is relatively close, given the recent experience with the inlet works. AECOM understands the inlet works project had a period of more than 5 years from the initial identification to construction commencing (2017).

The impact of the increased contributing population on the LSWSP would be:

- Potentially increased encroachment with new populations more sensitive to odours issues, given the recent history
- Increased loadings on the ponds and associated increased day to day odours
- Greater sludge accumulation and need for more frequent desludging and biosolids management
- On-going heightened awareness of odour issues in the existing adjacent community

5.2 Odour Modelling

GHG (2017) modelled the situation when the contributing population is 71,500ep.

The emission inventory indicated that the future load would result in:

- an increase in odour emission rates of approximately 44% comparing the future system with inlet works to current situation with inlet works.
- A reduction of 6% from the current plant without the inlet works compared to the future plant with inlet works
- The modelled inversion (de-stratification) emission rates (including inlet works) were greater than the current modelled inversion emission rates without the inlet works.

On this basis the future odour emission rates are such that our complaints are very likely.

The odour contours show that a greater number of nearby residents would be impacted for more than 8 hours per day for the 2.5-3.5OU and 3.5-5OU. The latter would lead to possible complaints. Under the modelling of pond inversion significant numbers of residents would be subject to 5-7.5 OU most likely leading to complaints. It should be noted that the nature of the modelling is that all weather conditions are included and inversion emission rates are modelled to occur throughout the year. As noted in Section 3.1 there are a number of factors that need to align to result in discharges of odour to the community, in particular wind direction and speed.

The overall conclusion that can be drawn from the odour modelling of the 71500 ep scenario is that odour impact will be greater and more likely to cause complaints. This assumes that none of the proposed improvements (other than the inlet works) are effective in significantly removing odour.

5.3 Potential Pathways Forward

The impact of community encroachment into buffer zones around sewage treatment plants is very common. It leads to the need for the Sewerage Authority to expend significant capital on addressing the issues. This includes covers and odour controls and very significant changes to treatment processes.

The information provided in Sections 3.0 and 4.0 identifies the major odour sources and discusses various “short term” options that if successful could contribute to longer term solutions. The major odour sources are discussed in the context of the future population in this section.

5.3.1 Facultative ponds

Based on the modelling noted in Section 5.2 the facultative ponds are the major odour source in day to day operations and particularly when de-stratification occurs. The desludging of the facultative ponds results in increased odour emission due to pond overloading. The impact will be more significant than present, at greater contributing populations.

As number of options have been discussed based on utilising the existing ponds including through changed configuration, increased aeration and mixing, increased recirculation, and pumped desludging, etc. The likely success of these options will rely on increased aeration and mixing. Given the current constraints on power supply and the size of the lagoons, the use of the multiple mixers and aerators necessary will require significant capital and operating cost.

Other options include conversion of part of the existing lagoon into either an aerated lagoon (approx. 2 days detention time) or activated sludge plant (approx. 1 day aeration tank detention time). This would eliminate the odour sources due to the operation of the existing facultative ponds. In addition the system can be designed to enable removal and management of the sludge on an ongoing basis without adversely affecting other treatment plant processes. The reduced loading on the maturation ponds would also reduce odour risk and sludge accumulation. An associated effect should be an improvement in treated effluent quality. As a first step the aeration requirements could be assessed relative to the aerators/ mixers necessary to achieve sufficient mixing and aeration for both the facultative ponds under each design scenario. An initial assessment found that the power requirements were not dissimilar.

It is recognised that this will have significant cost implications; however given the potential for very significant odour impacts associated with the future population, it is recommended that this option for the long term scenario be considered further.

5.3.2 Sludge Management

The sludge management going forward will be dependent on the preferred upgrade options as discussed below. The selection of preferred options should take into account odour risk.

5.3.2.1 Pond Upgrades utilising increased mixing and aeration

This scenario involves a pumped sludge removal system (e.g. on a floating pontoon) discharging either to Sludge drying beds or via a dewatering device to the composting plant.

Pumped sludge removal is considered best practice. An aerated compost plant would result in stabilisation over a shorter period and allow reduced biosolids inventory on site. This would reduce odour potential.

Other options include anaerobic or aerobic digesters, but given the degradation that occurs in the facultative pond these are not seen as appropriate.

5.3.2.2 Facultative Pond Reconfiguration

The preferred dewatering option is that discussed in Section 5.3.2.1.

5.3.2.3 Aerated Lagoon or Activated Sludge

Under the aerated pond option a settling pond would be configured after the aeration pond. A floating pontoon type pump could be used to pump the biosolids to drying beds or a dewatering device. The dewatered and/or dry biosolids could be stabilised in a compost facility. The sludge is likely to be less degraded than under the current facultative pond operations and therefore aerated biopiles with odour management would be suitable. This would reduce odour risk. Alternately an aerobic or anaerobic digestion system (e.g. lined and covered anaerobic pond) could be used, to stabilise the biosolids before composting.

In the case of an activated sludge system (assuming extended aeration with a long sludge age), sludge would be continuously removed and require dewatering and additional stabilisation. Dewatering can comprise of a thickener, centrifuge or belt press. Belt presses are more common. The dewatered sludge could then be stabilised in an aerated compost facility with odour control.

6.0 Conclusions and Recommendations

AECOM was engaged by PWC to carry out a site audit of the Leanyer Sanderson Waste Stabilisation Pond (LSWSP) system, in response to a Show Cause Notice issued by NT EPA for an odour event that occurred in September 2017. The key objective of this audit involves assessment of the pond performance and operation in comparison with industry best practice, particularly, in odour emission mitigation.

The site inspection occurred between 7th and 9th February 2018. A desktop review of documentation provided by PWC was also undertaken by AECOM technical team. The reviewed documents included, but were not limited to, the LSWSP design manual, process model, relevant upgrade investigation or design reports, recent LSWSP process data and water quality monitoring results, operational manual, and maintenance schedule.

A key focus of the review was to have a clear understanding of the current odour generation potential, and associated odour mitigation measures. Hence the odour complaint records, in the context of the site layout and climatic conditions, have been reviewed by AECOM. Recent odour modelling work was also reviewed as part of this project with further odour improvement options explored.

Direct communication with PWC staff was held throughout this project, to obtain an understanding of the site improvement strategy and key issues related to odour management and mitigation.

Through a high level comparison between current LSWSP operational status and the design manual, AECOM understands that the design of the LSWSP system follows largely the PWC design manual, with relatively long and conservative retention time in the system. Based on the reviewed monitoring results, especially the recent effluent quality records, it is our opinion that LSWSP performs typically for a waste stabilisation pond system. The observed removal rates for BOD₅, total nitrogen, and ammonia were 74%, 76%, and higher than 90%, respectively. Total suspended solids in the final pond effluent are elevated, largely due to algal overgrowth which may be a result of long residence time of the system. This contributes to relatively high discharge BOD.

The performance of the LSWSP reflects the fit-for-purpose design and relatively good operational care provided by PWC Staff. Regular maintenance and monitoring, and schedule of improvements implementation is in place to ensure the smooth operation of the plant.

Following the review of the pond design and current operational practice, AECOM has recommended a set of improvement options that may be applicable at LSWSP to enhance plant operation. During this audit process, AECOM has been notified that there are currently a suite of operational measures or upgrade projects underway at LSWSP, in order to optimise the pond performance and ensure the protection or enhancement of community amenity values. Some of these improvement measures can have a direct positive impact on odour generation or mitigation, because they address directly the identified odour sources.

The key odour source (listed in order of impact higher to lower) identified include:

- Facultative pond de-stratification
- Inlet works
- Directly emitted from ponds during normal operation
- Pond desludging
- Biosolids management
- Scum on ponds

The key upgrade projects and operational/management improvement options and associated AECOM recommendations are discussed in detail in this report, and include, including but not limited to, the following:

- LSWSP inlet works upgrade – involves a complete enclosed new screening and grit removal facility with associated odour extraction and treatment system. It is estimated to reduce current overall odour emissions by up to 35% based on the modelling.

- Pond hydraulic improvements – involves development and update of the pond hydraulic model and improvement of hydraulic connectivity between ponds. The impact on odour reduction at LSWSP is hard to quantify, but may be marginal.
- Buffalo Creek hydrodynamic and water quality modelling - involves development of the hydrodynamic model for the Buffalo Creek incorporating a water quality modelling component in the hydrodynamic model. This objective of this work is to explore alternative effluent discharge strategies to minimise potential environmental effects. This project is not envisaged to have any direct impact on odour management on site.
- Desludging of Sanderson ponds – The current sludge removal process involves isolation of an individual pond and complete pond drainage. Although pond desludging was not historically considered a significant odour source, it may become one as residential development has encroached the buffer distance significantly in recent years. Overloading of other facultative ponds during desludging elevates the odour generation risks. Pumped sludge removal with well managed dewatering process under favourable meteorological conditions may help minimise the potential for odour generation.
- In-pond augmentation trials (e.g. AquaMats) – retrofitting one or several maturation ponds with vertical baffles/mats which promote attached biological growth hence improving treatment capacity. Pending the trial design, aeration may be provided. This is targeted to improve effluent quality. If aeration is provided, this may improve odour impacts from the upgraded pond.
- Effluent recirculation – involves higher recirculation pump capacity to balance influent load variation and improve Dissolved Oxygen (DO) deficit in the facultative ponds. Given the long residence times and large area it is unlikely that the additional flow (30 L/s) will mitigate odour generation through prevention of pond de-stratification or oxidising odour compounds.
- Additional aeration/mixing – previous localised aeration testing was not successful, possibly due to the inadequate design in regards to aerator type selection and aeration capacity. Facultative pond de-stratification has been identified as a prime cause of odour complaints. AECOM consider that the proper use of surface aerator (e.g. aspirator type or MAPAL type as examples) for the aeration of top 1 m depth of the pond may ameliorate odour issues through preventing stratification and destratification by reducing the temperature differential driving force. AECOM concluded that addressing de-stratification through prevention or mitigation of the impacts will be essential, in preventing major odour incidents, the associated complaints and most importantly adversely impacting on the amenity of the neighbouring communities.
- Additional instrumentation, including additional thermistor strip - involves additional DO, pH, and temperature profile measurements at various locations of the plant, providing better indication of pond health and diurnal pattern. The online monitoring results should be used to inform operational action to prevent excessive odour generation, although at the time of this review, response actions are limited.
- Sludge management – the current biosolids dewatering and windrowing location is to be moved further away from residential areas, which may alleviate the odour complaint issue in the short term. Further sludge management strategy is currently in development, and will incorporate effective odour risk management. AECOM recommend a pumped sludge removal system with an aerated compost plant, which will help reduce odour emission potential on site.
- Community Consultation should be incorporated into a program of implementation of the preferred approach.
- PWC should develop Contingency Plans to address odour and undertake a detailed planning process to determine the preferred approach to mitigate the known odour sources. This approach should be incorporated into a revised Improvement Plan for the LSWSP.
- The complaints management procedure should be more explicit in relation to odour complaints outlining the roles and responsibilities including for senior/executive management.

Apart from the upgrade projects and operational enhancement measures listed above, which are already in progress by PWC, AECOM propose additional recommendations in improving LSWSP plant operation and management. These include:

- A site-specific LSWSP Operation and Maintenance Manual should be developed in place of the existing plan covering all treatment plants, within the framework of PWC's current WSP Operations Manual, to reflect the specific site information at Leanyer & Sanderson WSP. The manual will need to include the operation and maintenance of the new inlet works and management of the waste streams (screenings and grit), while not adding to odour emissions.
- Given the size of the plant, it is advisable to have a dedicated operations team to maintain the plant and tend to all regular and emergency requirements that may arise at this plant.
- In order to obtain a better understanding of the hydraulic performance of the pond system, a dye test may be carried out after the desludging work is completed. This will provide a reliable estimate in terms of actual hydraulic retention time, in comparison to the theoretical one. This information can be used to update the current pond process model, and aid with placing the right baffles for pond flow enhancement.

The projected ultimate population for the LSWSP is 73,000. This population will result in increased odour issues. On this basis the following was recommended.

- In the longer term the facultative ponds will be the major odour source in day to day operations and particularly when de-stratification occurs. With BOD overloading envisaged in the next 10 years, there are a suite of options available for flexible control of facultative pond loading for the long term. Potential options include changed configuration (e.g. turning first maturation pond into a facultative pond, etc.), increased aeration/mixing, increased effluent recirculation, etc. It may also be applicable to convert part of the existing lagoon into either an aerated lagoon or activated sludge plant. Further investigation will be required to assess the aeration capacity, along with power consumption and associated capital/operating costs.

7.0 References

At the request of PWC the list of references has been removed as some of the reports are commercial in confidence.

8.0 Limitations

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