# Supporting information for the Lagoon Crocodile Farm EPL application

PRI Farming Pty Ltd

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# 1 INTRODUCTION

Primary Resources Investment (PRI) Farming Pty Ltd operate the Lagoon Crocodile Farm (the LCF) in Berrimah, Northern Territory. The LCF was first established in 1987 with approximately 3,000 to 5,000 saltwater crocodiles (*Crocodylus porosus*). Over time, the operations have expanded to meet the increasing demand for crocodile products and the farm currently has capacity for approximately 23,000 animals.

LCF is a commercial production farm from incubation (wild-harvested eggs) to hatching and growing. The animals are harvested on-site and sent to an off-site location for further processing and packaging. The end-use markets include raw crocodile skin, meat and by-products.

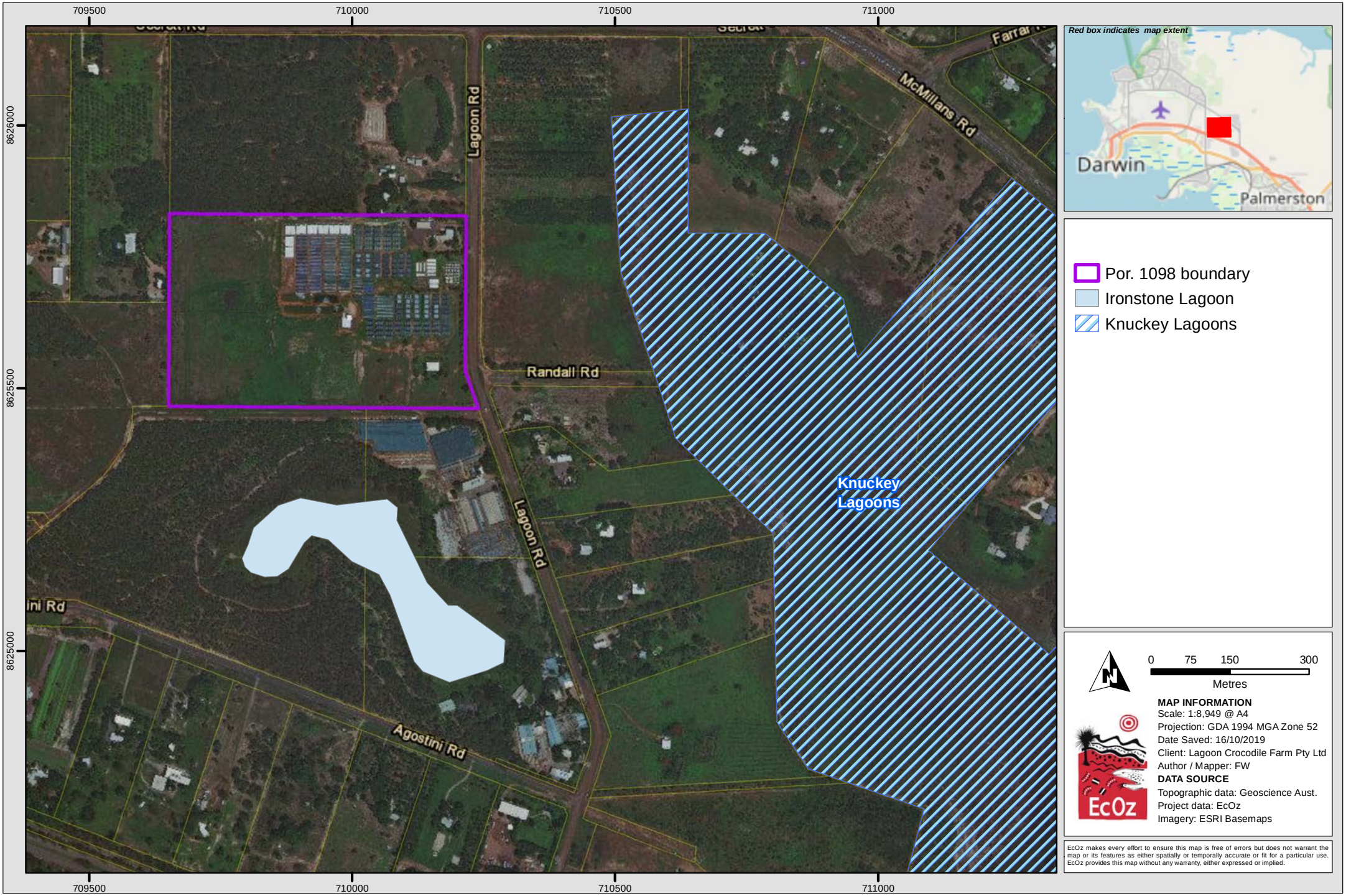
The nature of the farming operation results in the generation of animal effluent, a listed waste under Schedule 2 of the *Waste Management and Pollution Control (Administration) Regulations.* In accordance with the requirements of the *NT Waste Management and Pollution Control Act*, PRI is applying for an Environment Protection Licence (EPL) to address the ongoing production and management of animal effluent.

This document presents information to support the EPL application for this project, and will be included within the online EPL application process.

# 2 PROJECT DESCRIPTION

## 2.1 Siting, design and layout

Lagoon Crocodile Farm is located on Parcel 1098 in the Hundred of Bagot, 125 Lagoon Road, Knuckey Lagoon (Figure 2-1). The site is zoned Rural, as are all the adjacent parcels of land. The total area of the site is approximately 18 ha, comprising around 7 ha of crocodile ponds and associated infrastructure; 0.5 ha of effluent treatment ponds; and 11 ha of open pasture/grassland (Figure 2-2).




Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19071 - Lagoon Croc Farm EPL\01 Project Files\Figure X-X. Map of Lagoon Crocodile Farm location.mxd

**Figure 2-1. Location map of Lagoon Crocodile Farm**


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**Figure 2-2. Map of Lagoon Crocodile Farm layout**

## 2.2 Site operations and activities

### 2.2.1 Overview

The crocodile production process is summarised as follows:

1. Eggs are wild-collected (by a separate entity) and are assessed and cleaned in the egg laboratory, with viable eggs transferred to the incubator room
2. Animals hatch in an incubator, then are immediately transferred to hatching pens
3. When animals are about one year old, they are transferred to grow-out pens
4. When animals approach a size suitable for market, they are transferred to finishing pens for 6-12 months to ensure best possible skin and meat condition
5. Animals are harvested from the finishing pens, prepared for transport using a dedicated trailer and then sent to an off-site location for further processing.

The LCF currently harvests 400-500 animals a month for off-site processing to produce raw crocodile skins, meat products and other saleable by-products. Mortality rates are highest in the hatchery at 7% whilst mortality in the grower and finishing pens is less than 1%.

The operations at LCF are permitted under a Parks and Wildlife Commission *Permit to Keep Protected Wildlife in the Northern Territory, To Bring Protected Wildlife into (Import) and Take Protected Wildlife out of (Export) the Northern Territory* (Permit No. 10770), pursuant to section 56 of the *Territory Parks and Wildlife Conservation Act*.

The infrastructure on-site includes:

- Hatching, grow-out and finishing pens
- Site office and manager/caretaker residence (including standard septic systems)
- Egg laboratory and incubation
- Workshop
- Chemical storage container
- Wastewater treatment system, including nine solids collection pits, Spirac filter, two rotary drum filters and three effluent ponds
- Tank farm (630 kL capacity) for farm water supply:
    - 26 x 20,000 L tanks, 2 x 30,000 L tanks, 2 x 25,000 L tanks
- Five groundwater bores

### 2.2.2 Water supply

The LCF holds a groundwater extraction licence (Licence No: BCFMICC10196) with a total maximum extraction entitlement of 140 ML/year, from five bores detailed in Table 2-1. The bores are all located within the property boundary and source water from the Burrell Creek Formation - Micket Creek Sub-catchment.

**Table 2-1. Groundwater bore details**

| Bore | LCF Bore Name | Depth (m) | Yield (L/s) | Average annual extraction (ML) |
|---|---|---|---|---|
| RN026333 | Bore 1 | 72 | 1.5 | 112 |
| RN028372 | Bore 2 | 78 | 1 | |
| RN034327 | Bore 3 | 133 | 5 | |
| RN034785 | Bore 4 | 133 | 1.5 | |
| RN027058 | Bore 5 | 78 | 2 | Not used |
| | | | **Total** | **112** |

The primary use of water on site is for regular flushing of the animal pens to maintain hygiene and health of the animals. On average, water usage is estimated at 800 kL/day, with the source being a combination of mains water and bore water abstracted from four of the five water supply bores on site. Generally, the ratio of mains:bore water is 50:50, although the mains water use is generally higher during the dry season, when groundwater yields become limited. The mains and bore water is pumped into a number of storage tanks (approximately 630 kL capacity) where it is dosed with chlorine via an automated system, and then reticulated around the farm.

Water for amenities, firefighting and the caretaker's residence is sourced exclusively from mains water.

### 2.2.3 Farming routine

As the animals move through the different growth stages, the farming routine changes accordingly. Table 2-2 outlines the water, food and cleaning schedules for the three types of growth pens.

**Table 2-2. LCF Farming Routine**

| | Hatching Pens | Grower Pens | Finishing Pens |
|---|---|---|---|
| **Water input** | Mix of town and bore water (ratio changes depending on bore water stock) | | |
| **Chlorine** | Chlorine dosed at low concentration (3-4ppm) at the water inlet pumps<br>Granulated chlorine also added to the finishing pens ad-hoc when algae build-up is prevalent | | |
| **Food** | 6 times / week | 5 times / fortnight | 2 times / week |
| **Cleaning** | Daily | 5 times / fortnight | Constant water purge<br>02:00 – 07:30<br>Complete water renewal once / month |
| **Sanitizer** | Weekly | Monthly | Monthly |
| **Potassium Permanganate** | No | Once every 2 months | Monthly (4 days before cleaning) |

Feed consists of kangaroo meat for hatchlings, a combination of kangaroo meet and minced lamb hearts for juvenile crocodiles (1-2 years) then finally chicken heads for mature crocodiles. The feed contains food additives to ensure optimal growth of the animals (Calcium carbonate, Monsoon Crocodile CH premium and Protexin probiotic powder).

Potassium permanganate is added to grower and finishing pens to prevent bacteriological skin conditions that may impact on the quality of the skin as a product.

Antibiotics are only administered in the hatchery to specific animals requiring treatment as opposed to blanket inoculations to the whole cohort. It is very rare that antibiotics are administered to animals in the grow-out or finishing pens as illness is not common and the antibiotics impact on the ability to process the animal for meat products.

### 2.2.4 Wastewater flows and current treatment

Wastewater from the pens is currently directed through a wastewater treatment system that consists of a filtration (Spirac system) and screening process (two rotary drum filters) to remove grit and sludge. The wastewater then flows into a series of three earthen (unlined) facultative treatment ponds with an overflow outlet constructed on the western end of Pond 3. Water is aerated in the treatment ponds to assist in the breakdown of nutrients and minimise odour issues. The effluent ponds act as aerobic or wastewater storage ponds and therefore do not generate large volumes of sludge that require ongoing maintenance.

A basic schematic of the current wastewater treatment plant is outlined in Figure 2-3.

Overflow from Pond 3 occurs late in the week (water is run non-stop during the week, so levels in the ponds rise, then turned off on weekends) and following heavy rainfall events during the wet season. The wastewater passively discharges from the overflow outlet onto an unused grassed area within the site boundary. The natural lay of the land causes the water to flow in a southerly direction away from the operational area.

A map detailing the wastewater drainage through the different farm areas is included in Figure 2-4

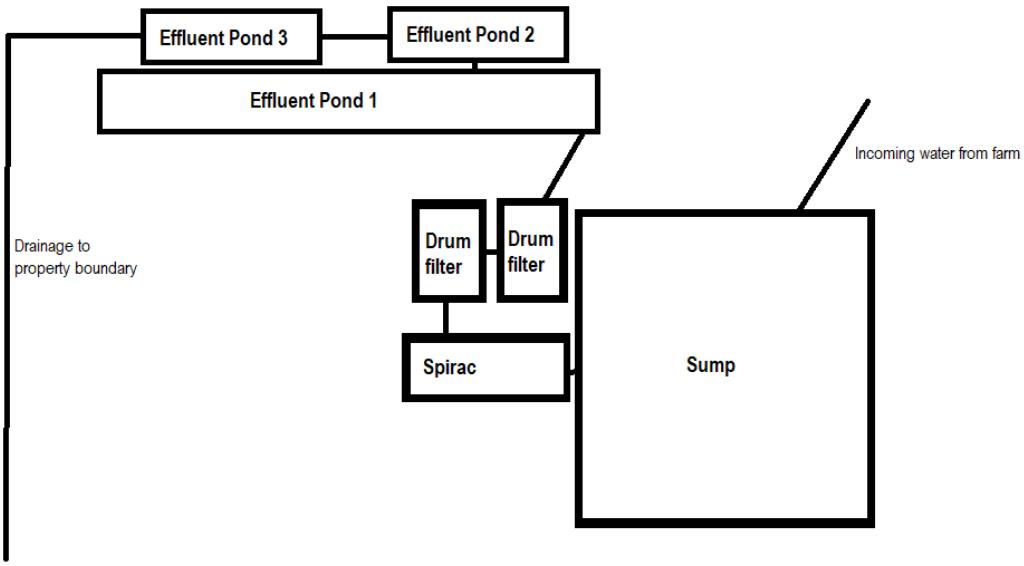



**Figure 2-3. Schematic diagram of current wastewater treatment plant**

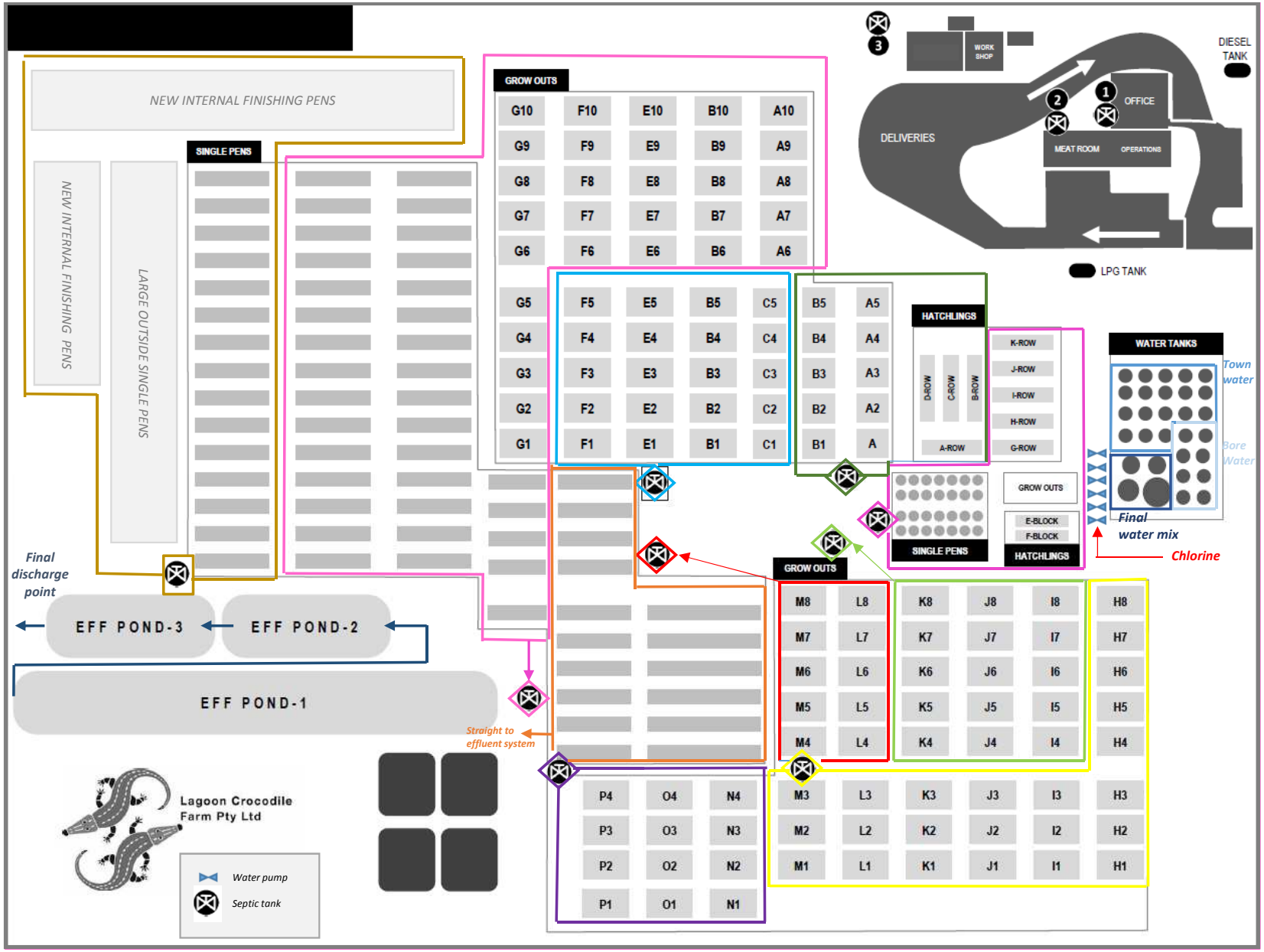



**Figure 2-4. Map showing wastewater flow paths**

### 2.2.5 Proposed wastewater treatment

A water and nutrient balance was undertaken on the site wastewater to determine the viability and suitability of irrigation on-site as a disposal solution. The assessment was undertaken in accordance with the *Land Capability Assessment for Onsite Wastewater Management Guidelines 2010* (NT Department of Health and Families) and AS/NZS 1547:2012 *On-site domestic wastewater management*. There is currently 5 ha of available space on the property for irrigation, with potential for further area in neighbouring blocks with agreement from neighbouring landowners.

As part of the assessment, several water samples were taken from around the farm, as well as soil samples from the proposed irrigation area, to determine the suitability for land application. Overall, irrigation alone is not a suitable solution for wastewater management as the current available area of 5.2 ha is insufficient for the volume of wastewater generated daily, as well as the high nitrogen levels in the current effluent. Full details of the water and nutrient balance and other irrigation considerations are included in Appendix A.

LCF have engaged two wastewater treatment specialists to review the wastewater, and design suitable solutions for treatment. There are two potential benchmarks for treatment; treatment for reuse within the crocodile pens, or treatment for off-site discharge.

#### *Treatment option one – Particulate Air Separation System*

The proposed particulate air separation system (PASS) utilises ozone, flocculants and other chemicals (such as pH control) in combination with particulate removal and foam fractionation to improve the quality of a waste-water stream prior to further filtration, reuse or discharge. The process uses diffused air and ozone, resulting in rising gas bubbles that produce a foam that continuously discharges unwanted waste from the water system. Ozone is often used in wastewater treatment as it is effective in decreasing biochemical oxygen demand (BOD), removing bacteria and some metals. PASS can also effectively remove some dissolved compounds, such as nitrogens, large light particles and colloidal material, without specific targeting required.

Other benefits of using PASS are that it:

- Uses no media, screens, barriers or membranes so requires no re-charging, replacement, replenishing or cleaning of media.
- Removes the unwanted material from the stream as a matter of process and on a continuous basis.
- Typically has a smaller footprint than most water treatment process as it functions at much higher velocities.
- Is wide ranging in its ability to remove matter, is compact and continuously removes the unwanted material from the stream.

LCF are investigating a trial version of the PASS, capable of treating 35 $m^3$ of water per hour. There is potential for the PASS to be able to treat the water to a suitable quality for reuse back through the crocodile production process. If the treated water requires further treatment to meet the requirements for reuse or off-site discharge, LCF are also investigating a polishing system comprised of specific algal filters to be added to the system post PASS treatment. A Wastewater Treatment Trial plan detailing the trial system is provided in Appendix B.

#### *Treatment option two – High Rate Algal Ponds*

The second treatment option currently being reviewed is a High Rate Algal Pond (HRAP) system. The HRAP system is comprised of a series (raceways) of constructed, lined ponds suited for a high growth rate of algae. The construction requires a relatively shallow depth (0.5 m) and a baffle channel design to improve

the hydrodynamics. There are a number of benefits in HRAP application and the concept is used widely in wastewater treatment. A process flow diagram for the proposed system is included in Appendix C.

The HRAP system will rely on the following components:

- Pre-treatment – balancing – the existing covered sump can be utilised as a balancing tank for the various volumes and contaminant concentrations generated in the different sections of the farm.
- Pre-treatment – gross solids removal – the current spirac screen can be retained for removal of large solids to maximise efficiency of the downstream treatment processes. The current rotary drum filters are not necessary as a pre-treatment process for the HRAP system.
- Existing effluent ponds – The design has incorporated the use of these ponds, however is not dependent on them. The intention is to remove these ponds in the future as they are not lined and are currently in poor condition. Timelines for their removal and subsequent rehabilitation are yet to be confirmed due to pending results of the trial and therefore the current ponds will be utilised until such time.
- HRAP – the outlet from the current effluent ponds will feed into the new HRAP system with the following considerations:
    - The sizing has been based on a hydraulic retention time (HRT) of at least 10 days, which allows the system a high degree of redundancy for short term fluctuations, seasonal farm operations and/or monsoonal rain impacts.
    - The average flow across the year is 770 $m^3$/day with monthly maximums exceeding 960 $m^3$/day (allowing for maximum flow).
    - A HRT of 10 days and maximum flow of 960 $m^3$ gives a required HRAP volume of 9,600 $m^3$ at a depth of 0.5 m.
- Post treatment storage – A 30 ML lined storage pond is proposed to hold treated water for reuse or irrigation.

HRAP systems also have a number of add-on benefits in addition to treating the water, including:

- Harvesting of algae for use as a bio-fuel on site.
- Recovery of the bio-fuel combustion $CO_2$ for injection back into the process as an additional carbon source.
- Harvesting and sale of algae for composting or aquaculture.

### *Irrigation*

Whilst the site water and nutrient balance found that irrigation of the combined wastewater is not a feasible option, separate assessments were undertaken on the wastewater generated from the three different growth sections of the farm; the hatchery, grow-out pens and finishing pens. The assessments reviewed the capacity of the area to irrigate the volume of wastewater generated, and how much (if any) storage is required over the wet season. It also included a calculation of the area required for appropriate uptake of nitrogen and phosphorus without overloading the receiving system. The results of the assessments are summarised in Table 2-3, with full details included in Appendix D.

**Table 2-3. Water and nutrient balance outcomes for the different farm sections**

| Farm section | % of total wastewater | Storage volume required ($m^3$) | Maximum irrigation area required (ha) |
|---|---|---|---|
| Hatchery | 10% | 0 | 32.6 |
| Grow-out pens | 60% | 20,900 | 19.2 |

| | | | |
|---|---|---|---|
| Finishing pens | 30% | 5,300 | 2.4 |

Whilst the hatchery only generates a small percentage of the overall wastewater volume, it is very high in nutrients. This is due to the high density of animals in the pens and the intensive feeding regime. The nutrient levels are a limiting factor in direct irrigation of this wastewater.

The grow-out pens generate the highest percentage of wastewater volumes for the farm which would require additional storage through the wet season in order to successfully irrigate. However, the grow-out pens are still also high in nutrients and therefore a 19.2 ha area would be required to ensure sufficient nutrient uptake.

It is feasible to directly irrigate the wastewater generated by the finishing pens, as only 5,300 $m^3$ of storage is required through the wet season and only 2.4 ha of land is required for nutrient uptake.

Irrigation remains an option for the other wastewater types if they can be treated to an acceptable criteria first. However, given the costs involved in developing a treatment system, it is preferential to treat the water to a quality suitable for reuse within the system or direct discharge off-site.

***Preferred next steps***

Based on the initial proposals, both treatment options are worth exploring further. For this reason, LCF have engaged the PASS contractors to develop a trial system capable of treating the hatchery wastewater, with the intention of treating the water for reuse. The trial will be undertaken over three months (June to August when hatchery is at peak biomass) to gather sufficient data to progress. Based on the success of the trial, there is opportunity to increase the capacity of the system to treat a higher percentage of the overall wastewater volume.

In addition to the treatment trial, LCF have also engaged the HRAP consultant to undertake a detailed design in order to refine the site variables and minimise the current unknowns in the system capabilities.

The information from the PASS trial and the HRAP detailed design can then be reviewed to determine the most suitable treatment option for the farm. There is potential to include either system or a combination of both in order to provide the best outcomes. There is a preference on treating water for reuse in order to minimise the current reliance on town and bore water, however the systems will also be tested for the capacity to treat the water to a suitable quality for off-site discharge.

If irrigation is required (either for untreated or treated wastewater) as an additional wastewater management measure, an Irrigation Management Plan (IMP) will be prepared and submitted to the NT EPA for amendment to the EPL.

Once a treatment solution has been determined, amendments to the EPL will be submitted to the NT EPA for approval. These updates will include final system details, an updated water balance and estimated volumes, and a discharge location for treated water that meets the criteria and is not required for reuse.

LCF acknowledge that this proposal does not provide an immediate solution for all the farm wastewater, however LCF do commit to investing in the research and capital infrastructure required to implement a permanent wastewater management solution. This investment will be undertaken through a staged approach with a complete system implemented by 2024.

### 2.2.6 Waste

**Solid Waste**

General putrescible waste is stored in lidded waste receptacles around site and removed from site by a waste contractor.

Animal waste and deceased crocodiles from mortalities are stored in closed waste bins and collected and disposed off-site by a licenced waste contractor to a licenced facility. These bins are located adjacent to Site Office and facilities area of the site.

Waste oils and chemicals from equipment servicing on-site is stored in appropriate sealed containers and removed by a licenced contractor.

**Septic and liquid waste**

When the pens are cleaned and the water purged, all the waste products collect in a series of (nine) solids collections pits (septics) installed around the farm. The septics are designed to hold all the sludge and solid waste whilst the wastewater is pumped through to the site wastewater treatment system. The septics are pumped out once every two months (or as required) by a licenced contractor and taken to a wastewater treatment facility for disposal. Grit and sludge removed by the Spirac system is directed to a closed waste bin and is also disposed of with the other animal wastes. The liquid sludge generated by the RDF is directed to a septic tank which is pumped out by a licenced liquid waste removalist on a quarterly basis.

The estimated volumes of waste products generated during the PASS trial treatment process is provided in Table 2-4. The waste streams are pumped from the PASS back to the septic pit. Sludge from the treatment septic pits will be pumped on a weekly basis and taken to a license liquid waste facility for disposal.

**Table 2-4. Estimated volumes of waste products**

| Waste stream | Estimated volume (L/day) |
|---|---|
| Hydrocyclones | 450 |
| Foam fractionator | 250 |
| Media filter | 7,500 |
| **Total** | **8,200** |

Waste oils and chemicals from equipment servicing on site is stored in appropriate sealed containers and removed by a licenced contractor.

An estimate of annual waste volumes generated and removed from LCF is provided in Table 2-5 below.

**Table 2-5. Estimated annual volumes of waste removed from LCF**

| Waste type | Annual volume |
|---|---|
| Animal waste – solids | 100 tonnes |
| Animal waste – grit & sludge | 25 tonnes |
| Septic (liquid) | 216,000 litres |
| General waste | 50 tonnes |
| Waste oil | 100 litres |

### 2.2.7 Hazardous materials storage and handling

The farm has a single 5,000 L diesel fuel storage tank, which is used for re-fuelling of farm equipment (i.e. tractors). There is also a 3,000 L LPG tank which is used to heat the water for the hatchery.

Liquid chlorine is the primary hazardous material stored on site and is used to disinfect the water in the tank farm (i.e. combination of mains and bore water) prior to distribution to the animal pens. Bulk chlorine is kept

in the chemicals storage shed (shipping container) and the maximum volume stored on site at any given time is 2,000 L.

Other chemicals stored and used on site include the following:

- Potassium permanganate for disinfection treatment of holding water in crocodile pens
- Lime for treatment of odour in effluent ponds (maximum of 1 tonne)
- Cleaners and disinfectants (maximum of 100 L)
    - F10SC Veterinary disinfectant, foaming sanitiser
- Herbicide for weed treatment (Glyphosate, maximum of 20 L)
- Oils/lubricants for farm equipment (maximum of 100 L)
- Paints and thinners (maximum 100 L)
- Epoxy sealants (maximum 1,000 L for short periods)

LCF maintain a hazardous substances register for the site, which includes storage location, summary of hazardous/dangerous goods status and links to the Safety Data Sheets (SDSs).

All hazardous substances, chemicals and other farm products are stored, used and managed in accordance with their SDSs (including appropriate bunding requirements).


Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19071 - Lagoon Croc Farm EPL\01 Project Files\Figure X-X. Map of existing and proposed infrastructure.mxd

**Figure 2-5. Map showing existing and proposed wastewater treatment infrastructure**

# 3 SURROUNDING ENVIRONMENTS, LAND USES AND ACTIVITIES

## 3.1 Climate

The LCF experiences a tropical monsoonal climate with distinct wet and dry seasons and little variation in temperature. The wet season is characterised by higher humidity and rainfall, and occurs between October and April. The dry season extends from May to September and is characterised by lower humidity and very little rainfall.

Climate observations are made by the Bureau of Meteorology (BoM). The closest BoM weather monitoring station to the site is the Darwin Airport (station number 014015). Average annual rainfall recorded at this station is 1,731 mm with the highest rainfall occurring in January and the lowest in July (Table 3-1). Over 87% of annual average rainfall falls between November and March. The average annual regional evaporation is 2,400 mm and exceeds the average annual rainfall. Evaporation is highest in October and lowest in February and March. These figures informed the water and nutrient balances for the site.

**Table 3-1. Average rainfall and evaporation (BoM)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | 429 | 372 | 315 | 102 | 21 | 2 | 1 | 5 | 16 | 70 | 143 | 251 |
| Evaporation (mm) | 175 | 160 | 177 | 189 | 211 | 204 | 211 | 223 | 228 | 248 | 230 | 205 |

Wind rose data available for the Darwin Airport station (no. 041015, 9am and 3pm) shows that the dry season is dominated by south-easterly and easterly wind directions. During the wet season, wind direction is more varied, particularly in the morning, while the afternoons are dominated by westerly and north-westerly breezes.

## 3.2 Surrounding land

The LCF is adjoined by a plant nursery and residence with a private lagoon (Ironstone Lagoon) to the south. To the east is Lagoon Rd, a cleared block and then one of the Knuckey Lagoons (a Conservation area). West of the farm is predominantly cleared land and a residence, and north a residence with a large area of woodland. All adjoining properties are zoned as Rural under the NT Planning Scheme.

These sites are located within the Shoal Bay Site of Conservation Significance (SOCS). The area has high ecological and hydrological value as a system and supports a number of water and migratory bird species.

## 3.3 Surface and groundwater

Lagoon Farm is located at the head of two catchments; the Milners Creek catchment, which drains to the east, and the Micketts Creek catchment, which drains to the north. The majority of (or all) surface water run-off sheet flows from the farm into Ironstone Lagoon to the south and then into the Knuckey Lagoons and Milners Creek system. Due to the large volumes of water being pumped through the farm effluent ponds, the overflow has created its own channel running south to the property boundary where it eventually makes its way into Ironstone Lagoon. Ironstone Lagoon is also subject to surface water runoff from the neighbouring Berrimah Business Park to the west, and surrounding roads.

Sustainable water yield from the Burrell Creek Formation is generally low (0.5 L/s) unless fractures are present, and geological cross-sections indicate that a groundwater divide exists under Knuckey Lagoon, which means groundwater flows to the north and to the south (Verma 2000). It is predicted that groundwater flowing north contributes to the springs at Holmes Jungle, and groundwater flowing south can be seen as perennial seepage along Wishart Road.

## 3.4 Soils and land units

According to the Greater Darwin Region Landunits (mapped at 1:25000 scale), the majority of the property has Kandosol soils (with nil to low level seasonal inundation). A very small area of Hydrosols (moderate to high level of seasonal waterlogging) occurs along the southern boundary.

Ironstone Lagoon to the south is subjected to a severe level of soil water logging or inundation for extended periods. A broader area surrounding this is subjected to moderate to high levels of soil water logging (Department of Infrastructure, Planning and Environment 2004).

Soil sampling was undertaken in the potential irrigation area to assist with the water and nutrient balance for wastewater application. The majority of the area contains silty loam soils with poor structure (high permeability) and predominately grey brown to orange yellow in colour. A basic soil analysis of sodicity indicates the area is suitable for irrigation and the phosphate sorption rate is sufficient for phosphorus uptake.

The whole site has been previously cleared.

## 3.5 Weeds

The majority of the property is grassed and is maintained by mowing/slashing. Some weed species are present, including the declared Class B (NT *Weed Management Act*) weeds Gamba Grass (*Andropogon gayanus*) and Flannel Weed (*Sida cordifolia*). Weeds are routinely sprayed with glyphosate herbicide.

# 4 CONCEPTUAL SITE MODEL

A conceptual site model (CSM) has been developed to identify key sources, pathways and receptors of potential contaminants and include the following considerations:

- Potential contaminants
- Inferred sources
- Pathways and mechanisms for transport
- Potential sensitive receptors.

## 4.1 Potential contaminants

The contaminants of concern that could result from the operations of the LCF include:

- Nitrates, phosphates, ammonia, bacteria and pathogens (i.e. *E. coli*, enterococci or faecal coliforms) from the farming of animals.
- The use of cleaning products in the pens include multipurpose cleaners and disinfectant sanitisers which contain chlorine based compounds.
- The storage of bulk hazardous chemicals such as diesel and liquid chlorine.
- The generation of airborne contaminants and nuisance odour.

The release of these contaminants could result in an increased biochemical oxygen demand, reduced dissolved oxygen, changes in pH, increased electrical conductivity, turbidity or total suspended solids, an increase in chlorophyll-a and/or an increase in hydrocarbons in the receiving waterbodies. Additionally, airborne contaminants or nuisance odours could result in an impact to neighbours and surrounding properties.

## 4.2 Sources

Sources of potential contaminants include feed inputs, faecal matter, cleaning products used in pens and the storage of bulk hazardous chemicals.

## 4.3 Pathways and transport

Controlled and uncontrolled discharges to surfaces waters, and vertical migration through watercourses and soil into groundwater. Nuisance odours carried by wind and potential irrigation activities generating molecules with the potential to become wind-borne.

## 4.4 Receptors and fate

Receptors include the receiving surface water and groundwater. Those receptors affected by discharges include adjacent properties, Ironstone Lagoon, Knuckey Lagoons (both located within the Shoal Bay SOCS) and recreational users; as well as terrestrial and aquatic organisms within downstream waterbodies such as fish and shellfish.

Those receptors affected by migration of potential contaminants to groundwater include neighbouring properties that utilise groundwater. Neighbouring properties would also be impacted by nuisance odour from the farm activities and the irrigation of wastewater.

The use of large volumes of groundwater can potentially have drawdown effects on neighbouring users and ecosystems (i.e. lagoons).

# 5 ENVIRONMENTAL RISK ASSESSMENT

The potential environmental risks associated with operational activities of the LCF have been assessed. The likelihood and consequence categories adopted in the aspects and impacts register are provided in Table 5-1 and Table 5-2, and have been combined to derive an overall risk rating using the matrix in Table 5-3. The environmental risk assessment table is included as Table 5-4.

**Table 5-1. Likelihood categories**

| Categories | Score | Likelihood Description |
|---|---|---|
| Remote | 1 | Never heard of, but not impossible |
| Rare | 2 | Highly unlikely; will only occur in exception circumstances |
| Unlikely | 3 | Could occur at some time, but unlikely |
| Moderate | 4 | Might occur at some stage; has previously occurred |
| Likely | 5 | Known to occur or will probably occur; has occurred several times |
| Almost certain | 6 | Common or repeating occurrence; is expected to occur in most circumstances |

**Table 5-2. Consequence categories**

| Categories | Score | Consequence Description |
|---|---|---|
| Negligible | 0 | No/low measureable impact on the environment |
| Minor | 1 | Some, minor, temporary environmental impact |
| Moderate | 2 | Contained temporary, or permanent minor, localised environmental damage |
| Severe | 3 | Wider and longer-term environmental impacts |
| Major | 4 | Very serious impact with long-term environmental damage |
| Catastrophic | 5 | Environmental disaster |

**Table 5-3. Risk matrix**

| | | Consequence | | | | | |
|---|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** | **5** |
| **Likelihood** | **6** | Negligible (0) | Low (6) | Moderate (12) | High (18) | Extreme (24) | Extreme (30) |
| | **5** | Negligible (0) | Low (5) | Moderate (10) | High (15) | Extreme (20) | Extreme (25) |
| | **4** | Negligible (0) | Low (4) | Moderate (8) | Moderate (12) | High (16) | Extreme (20) |
| | **3** | Negligible (0) | Low (3) | Low (6) | Moderate (9) | Moderate (12) | High (15) |
| | **2** | Negligible (0) | Low (2) | Low (4) | Low (6) | Moderate (8) | Moderate (10) |
| | **1** | Negligible (0) | Low (1) | Low (2) | Low (3) | Low (4) | Low (5) |

**Table 5-4. Environmental aspects and impacts register**

| Aspect | Potential impact | Initial risk | | | Management and mitigation controls (overview) | Residual risk | | |
|---|---|---|---|---|---|---|---|---|
| | | L/hood | Cons | Risk | | L/hood | Cons | Risk |
| Extraction of groundwater | Reduction in groundwater availability | 3 | 3 | **Mod (9)** | • Extract water within permitted volumes.<br>• Meter and monitor water extraction rates to ensure volumes are within permit. | 2 | 2 | **Low (4)** |
| Treatment of wastewater | Inadequate treatment of water quality<br><br>Generation of contaminated by-products<br><br>Generation of excessive odours<br><br>Creation of mosquito breeding habitat | 6 | 3 | **High (18)** | • Undertake treatment trials to determine effectiveness of proposed treatment methods<br>• Install returns to ensure re-treatment of water that does not meet the approved criteria for reuse or discharge<br>• Waste by-products to be directed to sludge pits for removal by a licensed waste handler<br>• Ensure wastewater treatment system is operating effectively and not generating excessive odour<br>• Achievement of adequate treatment to reduce odour<br>• Design of wastewater treatment systems to minimise biting insect breeding habitat (i.e. constant flow in algae ponds, steep banks and maintenance to remove algae regularly) in accordance with the *Guidelines for preventing mosquito breeding associated with wastewater treatment and disposal in the Northern Territory* | 4 | 3 | **Mod (12)** |

| Aspect | Potential impact | Initial risk | | | Management and mitigation controls (overview) | Residual risk | | |
|---|---|---|---|---|---|---|---|---|
| | | L/hood | Cons | Risk | | L/hood | Cons | Risk |
| Discharge of wastewater to neighbouring properties (active or passive) and receiving waterways. | Reduction in water quality downstream of discharge point (addition of nutrients), and subsequent impacts on aquatic ecosystem health downstream of discharge point. | 6 | 3 | **High (18)** | • Provide adequate waste water storage for wet season runoff events.<br>• Treat waste water prior to discharge/reuse.<br>• Only discharge from authorised discharge points.<br>• Establish a monitoring program.<br>• If irrigation is to be undertaken, establish irrigation area (vegetated and actively managed) for discharge of waste water. Irrigation design to incorporate appropriate irrigation rates to prevent surface water ponding and generation of runoff. | 4 | 3 | **Mod (12)** |
| Discharge of wastewater into groundwater aquifers | Reduction in water quality of underlying aquifers. | 4 | 3 | **Mod (12)** | • Provide adequate waste water storage for wet season runoff events.<br>• Treat waste water prior to discharge/reuse.<br>• Only discharge from authorised discharge points.<br>• Establish a monitoring program.<br>• If irrigation is to be undertaken, establish irrigation area (vegetated and actively managed) for discharge of waste water. Irrigation design to incorporate appropriate irrigation rates to prevent surface water ponding and generation of runoff. | 2 | 3 | **Low (6)** |
| Overspray/mist generation | Impacts on comfort of neighbouring properties<br>Windborne particles spreading potential contaminants | 4 | 3 | **Mod (12)** | • Irrigation design to include provision for large droplet size to prevent mist generation.<br>• Irrigation activities confined to approved irrigation areas and appropriate buffers maintained. | 2 | 3 | **Low (6)** |

| Aspect | Potential impact | Initial risk | | | Management and mitigation controls (overview) | Residual risk | | |
|---|---|---|---|---|---|---|---|---|
| | | L/hood | Cons | Risk | | L/hood | Cons | Risk |
| Spills of chemicals, hydrocarbons or hazardous substances | Uncontrolled discharge of dangerous goods or hazardous substances.<br>Contamination of pens, and discharge of contaminated water into receiving environment.<br>Reduction in water quality downstream of discharge or spill point, and subsequent impacts on aquatic ecosystem health downstream of discharge point.<br>Reduction in water quality of underlying aquifers. | 3 | 2 | **Mod (8)** | • Training and site inductions provided to all employees.<br>• Appropriate hazardous substance storage and handling procedures.<br>• Spill kits will be onsite, adequately sizes and stocked to respond to a spill if required.<br>• Chemical register is kept up to date for all chemicals, their volumes and storage locations.<br>• Following the 3 C's (contain, communicate, clean-up). | 2 | 2 | **Low (4)** |
| Storage of waste | Poorly managed site attracting native fauna and pests<br>Contamination to land/soils | 3 | 1 | **Low (3)** | • Ensure waste is stored/disposed of in appropriate containers for waste type prior to disposal.<br>• Removal of waste products by licenced waste contractors.<br>• Monitoring of waste disposal areas. | 2 | 1 | **Low (2)** |
| Desludging and disposal of sludge material | Impacts on water quality (turbidity and nutrients) and consequential impacts on aquatic ecosystem health. | 3 | 1 | **Low (3)** | • Adherence to pen cleaning schedule.<br>• Sludge and solid waste pumped from pens into solid waste pits (septics) and removed by a licenced waste contractor<br>• Sludge from treatment ponds removed during the dry season only and managed for on-site reuse<br>• Appropriate sediment controls installed around any stockpiles during the wet season | 2 | 1 | **Low (2)** |

| Aspect | Potential impact | Initial risk | | | Management and mitigation controls (overview) | Residual risk | | |
|---|---|---|---|---|---|---|---|---|
| | | L/hood | Cons | Risk | | L/hood | Cons | Risk |
| Operating farm equipment | Degradation of air quality, including dust and emissions | 3 | 1 | **Low (3)** | • Maintenance of equipment to minimise air emissions as far as possible.<br>• Avoid activities generating excessive dust and if required, implement dust mitigation measures. | 2 | 1 | **Low (2)** |
| Excessive odours | Disturbance to neighbouring properties | 3 | 1 | **Low (3)** | • Adherence to pen cleaning schedule.<br>• All putrescible waste to be stored appropriately prior to removal from site by a licenced waste contractor.<br>• Ensure wastewater treatment system is operating effectively and not generating excessive odour<br>• Achievement of adequate treatment to reduce odour<br>• Irrigation design to include provision for large droplet size to minimise mist and odour generation.<br>• Irrigation activities confined to approved irrigation areas and appropriate buffers maintained.<br>• Irrigation to be managed to avoid ponding or runoff, which can increase odour | 2 | 1 | **Low (2)** |
| Movement of vehicles and equipment | Spread of weeds | 3 | 2 | **Low (6)** | • Regular inspections of farm for weed occurrence.<br>• Regular control of weeds by herbicide spraying.<br>• Regular slashing. | 2 | 2 | **Low (4)** |

| Aspect | Potential impact | Initial risk | | | Management and mitigation controls (overview) | Residual risk | | |
|---|---|---|---|---|---|---|---|---|
| | | L/hood | Cons | Risk | | L/hood | Cons | Risk |
| Creation of mosquito breeding habitat | Impacts on comfort of employees/neighbours and increased disease risk | 3 | 1 | **Low (3)** | • Minimise any stagnant water by ensuring containers are kept out of rain.<br>• Adherence to pen cleaning schedule.<br>• Regular inspections of site to identify areas of ponding water and subsequent rectification.<br>• Design of wastewater treatment systems to minimise biting insect breeding habitat (i.e. constant flow in algae ponds, steep banks and maintenance to remove algae regularly) in accordance with the *Guidelines for preventing mosquito breeding associated with wastewater treatment and disposal in the Northern Territory* | 2 | 1 | **Low (2)** |
| Mortality | Quarantine issues or spread of diseases. | 3 | 1 | **Low (3)** | • Established quarantine practices.<br>• Established monitoring and surveillance program to identify any potential disease outbreak. | 1 | 1 | **Low (1)** |
| Continued use of poor condition wastewater ponds | Impacts on output and treatment of water<br>Contamination to soils/groundwater | 3 | 2 | **Mod (8)** | • Establish buffer zones around the ponds ensuring all infrastructure is located away from the ponds<br>• Intercept and transfer overland flow to appropriate drainage network<br>• Control vegetation that grows on treatment pond embankments<br>• Reinforce embankments to strengthen bank material | 2 | 2 | **Low (4)** |

# 6 ENVIRONMENTAL MANAGEMENT PLAN

This Environmental Management Plan (EMP) provides a consolidated plan for environmental management to mitigate the environmental risks identified in Section 5. Table 6-1 identifies the potential impacts of the LCF operations on the environment and includes environmental objectives, management and mitigation measures, performance criteria and target indicators, corrective actions and contingencies, monitoring and reporting and record-keeping mechanisms for each aspect.

## 6.1 Table of provisions

**Table 6-1. Environmental management summary**

| Aspect | POTENTIAL IMPACT | OBJECTIVE / OUTCOME | MANAGEMENT ACTION | TARGET / PERFORMANCE INDICATOR | MONITORING | Corrective actions and contingencies | Reporting and record-keeping |
|---|---|---|---|---|---|---|---|
| Filling and replenishing pens | Reduction in groundwater availability | No reduction in groundwater availability due to extraction. | Extract water within permitted volumes. | No exceedance of licenced groundwater extraction volumes | Meter and monitor water extraction rates to ensure volumes are within licence. | • Revise meter monitoring procedure and introduce a more frequent meter reading schedule.<br>• Review potentials for water reuse.<br>• Assess extraction limits and investigate potential to increase extraction volumes. | • Water usage is recorded in the Waste database<br>• Groundwater usage detailed in Annual Report |
| Treatment of wastewater | Inadequate treatment of water quality | No discharge or reuse of water above the treatment criteria limits | • Undertake treatment trials to determine effectiveness of proposed treatment methods<br>• Install returns to ensure re-treatment of water that does not meet the approved criteria for reuse or discharge | No exceedance of approved criteria in reuse or discharge water | • Establish a monitoring program, which incorporates monitoring quality of treated wastewater prior to reuse/discharge | • Review treatment methods<br>• Review water quality and implement additional treatment if required | • Reporting undertaken through Monitoring Report and Annual Return |
| | Generation of excessive odours | No impacts on neighbouring properties from odour during treatment process | • Ensure wastewater treatment system is operating effectively and not generating excessive odour<br>• Achievement of adequate treatment to reduce odour | No complaints received in relation to odour | • Establish a monitoring plan which incorporates odour monitoring by site staff<br>• Establish a monitoring program, which incorporates monitoring quality of treated wastewater prior to reuse/discharge | • Review treatment methods<br>• Review water quality and implement additional treatment if required (e.g. to reduce odour from BOD, oil and grease, bacteria) | • Record and respond to any complaints received<br>• Reporting undertaken through Monitoring Report and Annual Return |
| | Creation of mosquito breeding habitat | • To prevent mosquito breeding opportunities<br>• To reduce the potential for contact between mosquitoes and people | • Design of wastewater treatment systems to minimise biting insect breeding habitat (i.e. constant flow in algae ponds, steep banks and maintenance to remove algae regularly) in accordance with the *Guidelines for preventing mosquito breeding associated with wastewater treatment and disposal in the Northern Territory* | • No increase in biting insects as a result of treatment systems<br>• No incidence of mosquito borne disease | • Regular inspections of ponds/treatment systems to identify breeding sites | • Review design of treatment ponds<br>• Rectify any areas supporting breeding habitat | • Inspection records<br>• Record and respond to any complaints received |
| Discharging waste water (effluent) | Reduction in water quality downstream of discharge point (addition of nutrients), and subsequent impacts on aquatic ecosystem health downstream of discharge point. | No reduction of water quality in receiving environments. | • Design and installation of water treatment system to treat water to a quality suitable for reuse or discharge<br>• Establish irrigation area (vegetated and actively managed) for discharge of wastewater (treated/untreated)<br>• Irrigation design to incorporate appropriate irrigation rates to prevent surface water ponding and generation of runoff | • No exceedance of approved discharge criteria in discharge water<br>• No recorded incidents of wastewater runoff from irrigation area | • Establish a monitoring program, which incorporates monitoring quality of waste water prior to and following irrigation/discharge.<br>• Monitor and record discharge, reuse and irrigation volumes. | • Review water treatment system capabilities and opportunities for improvement.<br>• Review potentials for water reuse<br>• Review monitoring program to allow for further detection of potential contaminants | • Record all water quality results in a database and compare to guideline values.<br>• Record and respond to any complaints received in regards to discharges.<br>• Discharge reporting undertaken through Monitoring Report and Annual Return |
| | Reduction in water quality of underlying | No reduction of water quality | • Design and installation of water | • No change in quality of inlet water from bores in | • Establish a monitoring program, which incorporates | • Review water treatment system | • Record all water quality results in a |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | aquifers. | in underlying aquifers. | treatment system to treat water to a quality suitable for reuse or discharge<br>• Establish irrigation area (vegetated and actively managed) for discharge of wastewater (treated/untreated)<br>• Irrigation design to incorporate appropriate irrigation rates to prevent surface water ponding and generation of runoff | comparison to historical data | monitoring of groundwater to determine any impacts.<br>• Monitoring of wastewater quality prior to and following irrigation/discharge<br>• Monitor and record discharge, reuse and irrigation volumes. | capabilities and opportunities for improvement.<br>• Review potentials for water reuse<br>• Review monitoring program to allow for further detection of potential contaminants | database and compare to guideline values.<br>• Record and respond to any complaints received in regards to discharges.<br>• Discharge reporting undertaken through Monitoring Report and Annual Return |
| Irrigation of treated/untreated waste water | Overspray/mist | No impacts on neighbouring properties from irrigation | • Develop and implement Irrigation Management Plan<br>• Irrigation design to include provision for large droplet size to prevent mist generation.<br>• Irrigation activities confined to approved irrigation areas and appropriate buffers maintained (>50m from neighbouring properties).<br>• Irrigation restrictions pending weather conditions | • No complaints received in regards to mist generation | • Establish a monitoring plan which incorporates visual inspections of irrigation areas | • Review Irrigation Management Plan, including irrigation rates, areas and timing | • Record and respond to any complaints received<br>• Reporting undertaken through Monitoring Report and Annual Return |
| | Odour generation | No impacts on neighbouring properties from odour during irrigation | • Develop and implement Irrigation Management Plan<br>• Irrigation design to include provision for large droplet size to prevent odour generation.<br>• Irrigation activities confined to approved irrigation areas and appropriate buffers maintained (>50m from neighbouring properties).<br>• Irrigation restrictions pending weather conditions (wind) | • No complaints received in relation to odour | • Establish a monitoring plan which incorporates odour monitoring by site staff<br>• Establish a monitoring program, which incorporates monitoring quality of waste water prior to and following irrigation | • Review Irrigation Management Plan, including irrigation rates, areas and timing<br>• Review water quality and implement additional treatment if required (e.g. to reduce odour from BOD, oil and grease, bacteria) | • Record and respond to any complaints received<br>• Reporting undertaken through Monitoring Report and Annual Return |
| Storage and use of chemicals, hydrocarbons and hazardous substances | • Uncontrolled discharge of dangerous goods or hazardous substances.<br>• Contamination of ponds, and discharge of contaminated water into receiving environment.<br>• Reduction in water quality downstream of discharge or spill point, and subsequent impacts on aquatic ecosystem health downstream of discharge point.<br>• Reduction in water quality of underlying aquifers. | No contamination to farm water, sediments of surface water as a result of chemical, hydrocarbon or hazardous substance spill. | • All refuelling of vehicles occurs within a designated area.<br>• No hazardous chemicals are added to the ponds from which discharge occurs.<br>• Fuel storage within self-bunded container<br>• All other chemicals stored in designated bunded area<br>• Training and site induction provided to all employees<br>• Appropriate spill kits kept on-site and stocked in chemical storage and refuelling areas | • No indication of spills of chemicals or hazardous substances.<br>• Any spill of stored product is contained and remediated through the spill response procedure.<br>• No leaks from equipment. | • Regular inspections of chemical and hazardous substance storage areas through operational activities.<br>• Water quality performance will be monitored through the monitoring program. | • Review storage and handling practices for chemicals and hazardous substances.<br>• Increase the amount of bunding and containment for chemical and hazardous substance storage areas.<br>• Increase the number, capacity or type of spill kit materials. | • Incident reporting records<br>• Water quality database<br>• Reporting undertaken through the Monitoring Report and Annual Return<br>• Chemical and SDS register maintained<br>• Hazardous material tracking undertaken through invoicing process |
| Waste generation | • Poorly managed site attracting native fauna and pests<br>• Contamination to land/soils | • No introduction of pest species or increase in native fauna as a result of poor waste management practices<br>• No contamination as a | • Ensure waste is stored/disposed of in appropriate containers for waste type prior to disposal.<br>• Removal of waste products by licenced waste contractors. | • No recorded incidents of pests or native fauna accessing waste<br>• No indication of land/soil contamination | • Monitoring of waste disposal areas. | • Review waste handling and disposal practices | • Inspection records<br>• Incident reporting records |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | result of poor waste management practices | | | | | |
| Pen and pond maintenance (desludging and disposal of sludge material) | Impacts on water quality (turbidity and nutrients) and consequential impacts on aquatic ecosystem health. | • No release of sediments or sediment and nutrient laden water to the receiving environment. | • Adherence to pen cleaning schedule.<br>• Sludge and solid waste pumped from pens into solid waste pits (septics) and removed by a licenced waste contractor<br>• Sludge from treatment ponds removed during the dry season only and managed for on-site reuse<br>• Appropriate sediment controls installed around any stockpiles during the wet season | • No indication of sediment release into receiving environment | • Daily pen inspections<br>• Undertake visual inspections of sediment storage areas and sediment controls after rain events | • Review sludge handling and removal procedures | • Record all water quality results in a database and compare to guideline values.<br>• Record and respond to any complaints received in regards to discharges. |
| Farming of live animals | Quarantine issues or spread of diseases. | • No introduction or spread of disease across the farm or into the receiving environment. | • Established quarantine practices within LCF. | • No recorded incidents of disease spread/outbreak | • Established monitoring and surveillance program to identify any potential disease outbreak. | • Review quarantine practices<br>• Review monitoring program | • Inspection records<br>• Incident reporting records |
| General farm operations | Degradation of air quality, including dust and emissions from operating farm equipment | • Minimise air emissions | • Maintenance of equipment to minimise air emissions as far as possible.<br>• Avoid activities generating excessive dust and if required, implement dust mitigation measures. | • No complaints in relation to air quality | • Maintenance regime for all plant and equipment.<br>• Visual monitoring during periods of dry weather and high winds. | • Review maintenance regime<br>• Review dust control measures and implementation | • Record and respond to any complaints received |
| | Disturbance to neighbouring properties associated with excessive odours | • Minimise odour | • Adherence to pen cleaning schedule.<br>• General housekeeping around farm to reduce odour sources.<br>• All putrescible waste to be stored appropriately prior to removal from site by a licenced waste contractor. | • No complaints in relation to odour. | • Daily pen inspections.<br>• Inspections of waste management areas. | • Review of cleaning schedule<br>• Review of waste management practices | • Record and respond to any complaints received |
| | Spread of weeds | • To prevent spread of established weeds within and off the property<br>• To prevent introduction of new weed species to the property | • Regular control of weeds by herbicide spraying.<br>• Regular slashing. | • No increase in the distribution of existing weed species.<br>• No introduction of new weed species. | • Undertake regular weed outbreak inspections. | • Review weed control activities and frequency | • Inspection records<br>• Incident reporting records |
| | Creation of mosquito breeding habitat impacting on comfort of employees/neighbours and increased disease risk | • To prevent mosquito breeding opportunities<br>• To reduce the potential for contact between mosquitoes and people | • Minimise any stagnant water by ensuring containers are kept out of rain.<br>• Adherence to pen cleaning schedule. | • No prolonged areas of ponding water on-site<br>• No incidence of mosquito borne disease | • Regular inspections of site to identify areas of ponding water and subsequent rectification. | • Review stormwater controls and site flow paths.<br>• Review inspection regime. | • Inspection records<br>• Record and respond to any complaints received |

## 6.2 Roles and responsibility

Unless otherwise specified, the provisions within this EMP are the responsibility of the Farm Manager.

## 6.3 Induction, communication and training

A daily pre-start meeting is held where all issues, including those pertaining to the environment, are discussed. Staff members are able to raise any concerns or issues.

All new site personnel, contractors, and unaccompanied visitors will be presented with a site induction package featuring essential environmental management information. Inductees will also be required to complete an Induction Questionnaire to demonstrate understanding of the induction presentation. Induction and training activities will be reviewed regularly to ensure they contain the most up-to-date information and procedures.

Scheduled regular toolbox meetings will keep employees informed of environmental issues, as well as safety awareness and hazards in the workplace. This will ensure that personnel are continually aware of environmental management activities on the site, and enable any issues to be identified and resolved.

Relevant staff will have training provided so that they are able to undertake the environmental management and monitoring activities specified in this plan. In-house training will be provided by relevant contractors (consultants) in specific environmental monitoring tasks.

## 6.4 Non-conformance and corrective actions

The specific environmental actions stipulated in this section provide the overarching performance indicators for the site, against which management methods can be assessed. If it is identified that the safeguards are not being met, or unexpected issues arise, a process must be in place to implement corrective actions and adapt management methods.

Any non-conformance will be documented through site inspections/audits stating the nature of the non-conformance and the mechanisms implemented to correct the incident.

The Farm Manager should be notified of any non-conformance within 24 hours of it occurring. Corrective/preventative action should be completed within a timely manner (e.g. within seven days of the event occurring) to ensure that the incident is addressed. Records will be kept of all environmental incidents that occur, and corrective actions implemented. If management controls are not implemented and completed in the designated manner, additional training may be required for the Farm Manager, employees and/or subcontractors.

# 7 ENVIRONMENTAL MONITORING PLAN

## 7.1 Inspections and audits

Pen areas are inspected daily and any issues are recorded in a daily report. Inspections include the following environmental aspects:

- Water levels in pens and input requirements
- Food waste build-ups and cleaning requirements
- Wastewater outbreaks or leaks
- Animal health and potential disease outbreaks
- Chemical and fuel volumes

Visual inspections of the irrigation area for mist/overspray, odour and potential runoff will be undertaken daily during irrigation activities.

A quarterly site inspection is undertaken by an independent assessor. This inspection includes OHS and environmental aspects of the operation. The assessor reports findings to the Farm Manager and Managing Director.

Assessment of the condition of chlorine and gas holding facilities is regularly undertaken by the suppliers, who retain ownership of this infrastructure.

Internal and external audits are undertaken on a yearly basis. These audits include occupational health & safety and environmental aspects of the operation. The auditor reports findings to the Farm Manager and the Managing Director.

## 7.2 Water monitoring

### 7.2.1 Sampling locations

There are no off-site surface water monitoring locations, as there are no well-defined watercourses flowing onto the site (representing background/reference) or receiving water from the site that would be representative of site impacts (see Section 3.3 surface and groundwater above for more detail). The monitoring site at the property boundary is indicative of the quality of water leaving the site.

Samples are taken from locations prior to and post treatment through the current wastewater treatment system. Additional samples will also be taken from the PASS treatment trial and after the algal polishing filters (if the trial progresses with these).

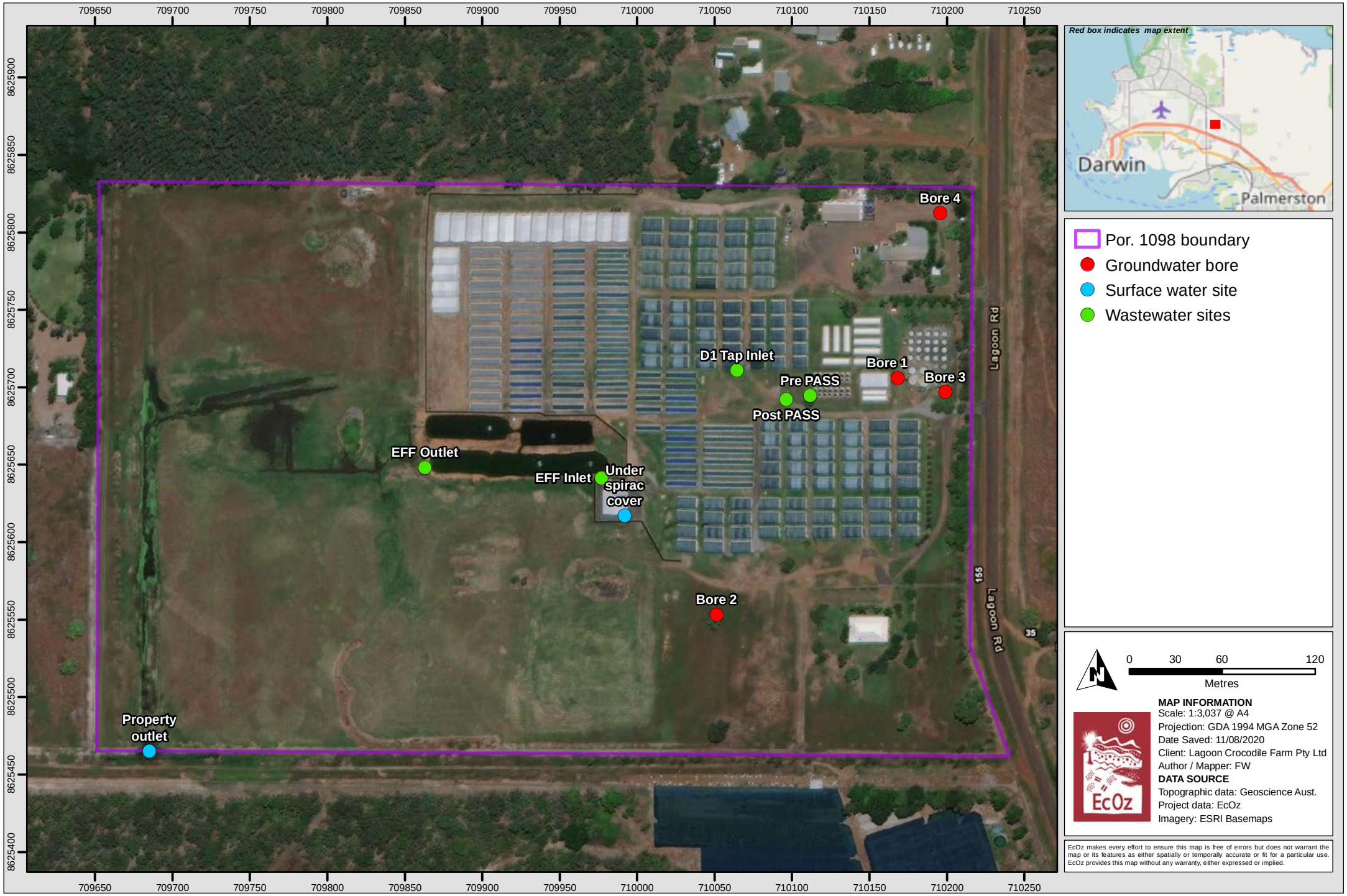
Groundwater samples will be taken from the four bores currently supplying water to the farm.

The sampling locations for surface water and groundwater are shown on Figure 7-1 and a description of each site is included in Table 7-1.

**Table 7-1. Description of monitoring sites**

| Site Name | Sample Type | Description |
|---|---|---|
| Bore 1 | Groundwater | Water supply bore |
| Bore 2 | Groundwater | Water supply bore |
| Bore 3 | Groundwater | Water supply bore |

| Site Name | Sample Type | Description |
|---|---|---|
| Bore 4 | Groundwater | Water supply bore |
| D1 tap inlet | Surface water | Inlet water post mixing (town + bore) and chlorination |
| Property outlet | Surface water | Point where surface runoff passively discharges from site |
| Under spirac cover | Wastewater | Wastewater pre-treatment |
| EFF inlet | Wastewater | Wastewater post treatment |
| EFF outlet | Wastewater | Final wastewater quality |
| Pre PASS | Wastewater | Wastewater pre-treatment through the PASS trial |
| Post PASS | Wastewater | Wastewater post treatment through the PASS trial |




Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19071 - Lagoon Croc Farm EPL\01 Project Files\Figure 7-1. Map showing monitoring locations.mxd

**Figure 7-1. Map showing monitoring locations**

### 7.2.2 Sampling methodology and quality assurance

All sampling and handling of samples is to be undertaken in accordance with the relevant standards and guidelines as outlined below:

- Australian Standard on Water Quality Sampling - *Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples* (AS/NZS 5667.1:1998);
- Australian Standard on Water Quality Sampling – *Part 6: Guidance on sampling of rivers and streams* (AS/NZS 5667.6:1998);
- Australian Standard on Water Quality Sampling – *Part 10: Guidance on sampling of waste waters* (AN/NZS 5667.10:1998)
- Australian Standard on Contaminated Soil Sampling – *Guide to the sampling and investigation of potentially contaminated soil – Part 1: Non-volatile and semi-volatile compounds* (AS4482.1-2005)
- ANZECC & ARMCANZ 2000, *Australian Guidelines for Water Quality Monitoring and Reporting*, National Water Quality Management Strategy Paper No 7, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
- ANZECC & ARMCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management Strategy Paper No 4, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

All samples are to be analysed at a National Association of Testing Authorities (NATA) approved laboratory, with the exception of field parameters such as pH and EC.

### 7.2.3 Monitoring parameters and frequencies

***Surface water and wastewater***

The monitoring parameters and frequencies of sampling for surface waters (including wastewaters) are outlined in Table 7-2. Additional monitoring of the wastewater being treated through the treatment trial will be undertaken during the trial period. Once sufficient data has been gathered on the effectiveness of the trial, the sampling frequencies will be reduced in line with all other monitoring.

**Table 7-2. Monitoring parameters and frequencies for surface water**

| Parameter | Sampling frequency surface water & wastewater - current | Sampling frequency Wastewaters – for treatment trial |
|---|---|---|
| ***Field parameters*** | | |
| pH | Monthly | Daily |
| EC | Monthly | Daily |
| DO | Monthly | Daily |
| ***Laboratory parameters*** | | |
| TSS | Monthly | Weekly |
| Total P | Monthly | Weekly |

| | | |
|---|---|---|
| Total N, NOx, NH3 | Monthly | Weekly |
| BOD | Monthly | Weekly |
| *E.coli*, *Enterococci*, Total coliforms | Monthly | Weekly |
| Oil and grease | Annually | - |
| Metals | Annually | - |
| Herbicides | Annually | - |

***Groundwater***

The monitoring parameters and frequencies of sampling for groundwater are outlined in Table 7-3.

**Table 7-3. Monitoring parameters and frequencies for groundwater**

| Parameter | Sampling frequency |
|---|---|
| ***Field parameters*** | |
| Groundwater usage | Monthly |
| pH | Quarterly |
| EC | Quarterly |
| ***Laboratory parameters*** | |
| Total P | Quarterly |
| Total N, Nitrate | Quarterly |
| Major ions | Quarterly |

## 7.3 Assessment criteria

***Surface water***

The current inlet quality of water into the pens has been used as a guidance for treatment of water for reuse. The Hazen percentile calculator was used to calculate 80$^{th}$ percentile parameters from the current data available to set target levels (see Table 7-4).

**Table 7-4. Water quality objectives for treatment for re-use in production**

| Parameter | Trigger value |
|---|---|
| pH | 7.31 |
| EC[a] | 200 µS/cm |
| TSS | 15 mg/L |
| BOD | 1 mg/L |
| Total P | 0.2 mg/L |
| Total N | 6.3 mg/L |
| NOx | 6.8 mg/L |
| NH3 | 1 mg/L |
| *E.coli* | <1 fu/100mL |

[a]Electrical conductivity has not previously been tested. The Darwin Harbour Water Quality Objective has been adopted as per the surface water triggers for off-site discharge, but may be updated based on future sampling.

The Darwin Harbour Water Quality Objectives for freshwater rivers and streams will be used as a guidance for trigger values (Table 7-5) for water that is treated for off-site discharge.

**Table 7-5. Water quality objectives for treatment for off-site discharge**

| Parameter | Trigger value |
|---|---|
| pH | 6.0-7.5 |
| EC | <200 µS/cm |
| Total P | <0.01 mg/L |
| Total N | <0.23 mg/L |
| NOx | <0.008 mg/L |
| *E.coli* | <200 cfu/100mL |

***Groundwater***

Groundwater quality will be compared against baseline conditions (historical and current data). The Hazen percentile calculator was used to calculate 80$^{th}$ percentile parameters across the bores from the current data available, in order to develop trigger values for comparison (see Table 7-6). Where there are significant increases in the parameters measured, further assessment will be undertaken to determine potential sources of contamination.

**Table 7-6. Groundwater trigger levels**

| Parameter | Trigger Value |
|---|---|
| pH | 6.60 |
| EC[a] | 200 µS/cm |
| Total P | 0.12 mg/L |
| Total N | 18.0 mg/L |
| Nitrate | 14.1 mg/L |
| Major ions[b] (Ca, Mg, Na, K, Cl, $SO_4$, $CaCO_3$) | 10mg/L ($CaCO_3$ – 33mg/L) |

[a]Electrical conductivity has not previously been tested. The trigger value has been adopted as per the surface water triggers for off-site discharge, but may be updated based on future sampling.
[b]Historically, only calcium, magnesium and hardness have been tested. Future monitoring is to also include potassium, sodium, chloride and sulfate, in order to calculate 80$^{th}$ percentiles.

## 7.4 Irrigation monitoring

If an irrigation system is to be designed, a rigorous irrigation management plan and monitoring regime will be developed in accordance with the conditions of the EPL. This will include soil sampling within the irrigation area.

## 7.5 Reporting and review

### 7.5.1 Internal

The EMP will be reviewed annually to reflect any changes in operations at the LCF.

Details of environmental incidents, non-conformances or other relevant information are included in daily reports which are issued to the Managing Director. Records of all incidents, inspections and reports are maintained through an electronic filing system.

All environmental monitoring records will be maintained in a water and soil quality database.

An annual report is also prepared which details and reviews annual water usage, waste generation and energy use across the farm.

### 7.5.2 External

LCF will report any non-compliance with the EPL by completing a Non-Compliance Notification via the NT EPA website within 24 hours of the event.

An Annual Return will be submitted to the NT EPA on the anniversary date of the EPL to summarise the activities and outcomes of the previous 12 months. Additionally, a Monitoring Report will be prepared and submitted with the Annual Return that includes a trend analysis of the water quality monitoring data and an assessment of any environmental impacts from the LCF operations.

# 8 EMERGENCY RESPONSE PLAN

Emergency response planning includes responses to environmental emergencies, and operational actions that cause an environmental incident. This Emergency Response Plan (ERP) outlines the environmental emergency risks, emergency preparedness, mitigation and reporting requirements specifically relating to environmental incidents for LCF. A copy of the LCF emergency site map is included in Appendix E.

## 8.1 Emergency incidents

Emergency incidents that may occur within LCF include:

- **Extreme weather event** (i.e. cyclone) resulting in damage to farm facilities, and/or flooding that leads to uncontrolled discharges to the surrounding properties
- **Flooding** as a result of high rainfall events leading to uncontrolled discharges to the surrounding properties
- **Lightning strike** that may disrupt power sources and impact on farm operations
- **Disease outbreak** that leads to crocodile mortalities and large scale quantities of biological wastes
- **Fuel or chemical spill** that may contaminate water or soils
- **Fire** as a result of bushfire or accidental fire as a result of operations.

## 8.2 Emergency contacts

The Farm Manager is the contact person for all emergencies and environmental incidents. All incidents which cause or have the potential to cause material or serious environmental harm, will be reported to the NT Environment Protection Authority (NT EPA) within 24 hours as required under Section 14 of the NT *Waste Management and Pollution Control Act*.

The details of the designated contact persons responsible for on-site environmental management are included in Table 8-1. Also included are emergency contacts for reporting pollution incidents (including non-urgent problems such as dust/noise) and contacts for provision of advice.

**Table 8-1. Emergency contact details**

| Contact | Details |
|---|---|
| Farm Manager | Craig Moore<br>GPO Box 4600<br>Darwin NT 0801<br>Phone (08) 8984 3997<br>Mobile 0405 133 721<br>Email craig@lagooncrocfarm.com.au |
| NT EPA<br>Pollution Hotline / Pollution Reporting | GPO Box 3675, Darwin NT, 0801<br>Pollution Hotline: 1800 064 567<br>pollution@nt.gov.au |
| EcOz Environmental Consultants | 70 Cavenagh Street, Darwin NT, 0801<br>08 8981 1100<br>ecoz@ecoz.com.au |

| Contact | Details |
|---|---|
| NT Police | 131 444 |

Environmental conditions are monitored as part of the Environmental Monitoring Plan presented in Section 6.2, as well as by the Farm Manager through the Bureau of Meteorology website, NT Police, Fire and Emergency Services announcements, social media and local radio emergency.

## 8.3 Objectives, targets and indicators of the ERP

The objectives, targets and indicators of this ERP are summarised in Table 8-2.

**Table 8-2. Emergency objectives, targets and indicators summary**

| Objectives | Targets | Indicators |
|---|---|---|
| • Protect people, property and the environment | • No incidents of harm to people, property or the environment from activities associated with an environmental emergency | • Number of incidents recorded |
| • Identify potential environmental emergency risks | • All risks identified and management controls are in place | • Audits and inspection findings |
| • Identify and implement management and mitigation controls to reduce the residual risk | | |
| • Ensure emergency response equipment requirements are able to be identified and are available | • All risks are identified and management controls are in place.<br>• Emergency response scenarios have been identified | • Audits and inspection findings |
| • Ensure a high level of preparedness is maintained | | |
| • Facilitate efficient response to emergencies to limit the impacts to the environment | | |
| • Ensure emergency response training is relevant for the types of emergencies that LCF may experience | • Training for all employees | • Training records |

## 8.4 Emergency response procedures

### 8.4.1 General emergency preparedness

LCF commit to continuous emergency preparedness through the following actions:

- Ensure that all personnel including management have received a site induction that specifically covers emergency response procedures.
- The Farm Manager regularly liaises with staff to ensure that they are competent in responding to emergencies

- Conduct regular inspections on all emergency response equipment and ensure that all equipment is in good working order
- Following an emergency event, undertake an incident debrief and provide all staff with training into improved emergency response procedures or actions.

When advice is issued by authorities (i.e. cyclone watch, cyclone warning, evacuation order, etc.), the Farm Manager will ensure that the following steps will be undertaken:

- All employees and contractors will report to the assembly point, and receive further instructions regarding preparations for the emergency or evacuation.
- Where there is sufficient preparation time (i.e. in the event of a cyclone watch issued by the Bureau of Meteorology),
    - All essential vehicles will be fuelled, if required to evacuate employees, and non-essential vehicles will be parked, secured and locked.
    - All potentially mobile items will be secured, tied down and/or stored and locked in the site office or workshop.

### 8.4.2 Spills response procedure

In the case of any spills the following procedure is to be implemented:

- Locate the source to identify volume and type of spill
- Assess the risk to workers and environment to ensure appropriate PPE and measures to be implemented.
- Control and contain the spill by isolating or removing source.
- Clean the spill using spill kit and absorbent material or installing bunds.
- Dispose of contaminated spill control material appropriately.
- Report significant spills or spills that have entered stormwater to NT EPA Pollution Hotline (1800 064 567).

Spill containment equipment kits will be available in works areas. All personnel on site will be trained how to use these spill kits

# 9 CONSULTATION & COMMUNICATION PLAN

## 9.1 Relevant stakeholders and consultation

The LCF engages regularly with a broad range of stakeholders and interested parties. The stakeholders relevant to this EPL and their relationship to LCF is summarised in Table 9-1.

Should any further stakeholders or interested parties arise, they will be added to the list of relevant stakeholders and included in communications and consultations into the future.

**Table 9-1. Summary of relevant stakeholders**

| Stakeholder | Relationship to LCF |
|---|---|
| **Government** | |
| Department of Environment and Natural Resources – Water Resources | Groundwater usage regulation |
| NT EPA | Issuer and regulator of the EPL and its compliance |
| Parks and Wildlife Commission | Issuer and regulator of wildlife permits |
| **LCF** | |
| Employees | LCF workforce |
| Partnering contractors | LCF workforce |
| **Neighbours** | |
| Ironstone Lagoon | Neighbour |
| Darwin Horse and Pony Club | Neighbour |
| Kyam Electrical | Neighbour |
| **Industry bodies** | |
| Crocodile Farmers Association NT | Crocodile farming industry body for NT |

Consultation with stakeholders is undertaken directly through written (letters, emails) or verbal communication (meetings, phone calls).

## 9.2 Complaint management

For any complaints received regarding the operations of the farm, a register of complaints will be kept that records:

- Date and time of complaint
- Method by which complaint was made (i.e. telephone, letter, meeting, etc.)
- Name, address, contact telephone number of complainant
- Details of complaint
- Action taken in response to the complaint, including follow up contract with the complainant
- Any monitoring to confirm the complaint has been satisfactorily resolved
- If no action was taken, the reason for no action being taken.

An example of the complaints register is included in Table 9-2.

**Table 9-2. Example complaints register**

| Complaint number | Name of recorder | Personnel responsible for responding to complainant | Date/time complaint received | Complainant contact details | Details of complaint | Corrective action summary | Reasons for no action taken |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# 10 REFERENCES

Department of Infrastructure, Planning and Environment, 2004. Litchfield Shire Seasonally Waterlogged Soils Map. Conservation and Natural Resources Group, DIPE. Palmerston.

Verma, M. N., 2000. Hydrogeology of Knuckey Lagoons and Holmes Jungle Nature Park. Report No. 43/2001. Natural Resources Division, Department of Lands, Planning and Environment, Darwin.

# APPENDIX A IRRIGATION CONSIDERATIONS AND OVERALL WATER BALANCE

# IRRIGATION CONSIDERATIONS

The quality of water to be used for irrigation is summarised in Table 1 (based on sampling undertaken at the outflow of the effluent treatment ponds from 2014 – 2019).

**Table 1. Irrigation water quality**

| pH | EC | TDS | BOD | O&G | NH3 | TN | TP | *E.Coli* | Faecal Coliforms |
|---|---|---|---|---|---|---|---|---|---|
| - | *µS/cm* | *mg/L* | *mg/L* | *mg/L* | *mg/L* | *mg/L* | *mg/L* | *CFU/100ml* | *CFU/100ml* |
| 8.1 | 270.8 | 176 | 10 | <5 | 7.8 | 15 | 4 | 6500 | 6500 |

Table 1 above shows the current treated effluent irrigation water quality for TN, TP, BOD, TSS, oil and grease, pH and *E.Coli*. If these concentrations are assessed based on the criteria used in Table 3.1 of the NSW EPA *Environmental Guidelines - Use of Effluent by Irrigation* (DEC 2004), the current wastewater concentration is classified as "low" strength (Table 2).

**Table 2. Classification of effluent based on DEC 2004 criteria**

| | Current irrigation water quality | Strength (average concentration mg/L) | | |
|---|---|---|---|---|
| | | Low | Medium | High |
| Total Nitrogen | 15 | <50 | 50-100 | >100 |
| Total Phosphorus | 4 | <10 | 40-1500 | >1500 |
| BOD | 10 | <40 | 40-1500 | >1500 |
| TDS | 176 | <600 | 600-1000 | >1000 |

## Organic content

The average maximum daily organic loading rate is calculated from the irrigation rate and the BOD (mg/L) concentration of the applied effluent. The *Environmental Guidelines – Use of effluent by irrigation* (DEC 2004) suggest that an average loading rate of 1,500 kg/ha/month can be taken as the maximum organic loading for most soils.

The current median BOD content of the wastewater for irrigation is 10 mg/L. The minimum irrigation area required based on organic loading can be estimated as follows:

A = CQ / (1,000 x Lc)

Where:

A = irrigation area (ha)

C = concentration of BOD5 (mg/L)

Q = average effluent flow rate (kL/month)

Lc = critical loading rate of constituent (kg/ha/month)

**For LCF:**

A = 10 mg/L x 24,000 kL / month / (1,000 x 1,500 kg/ha/month)

A = 0.16 hectares

Therefore, the current nominated irrigation area of 5.2 ha is sufficient in regards to organic content loading.

## pH

The *Environmental Guidelines – Use of effluent by irrigation (DEC 2004)* suggest effluent with a pH between 5.0 and 8.5 is generally acceptable for use in irrigation. If the effluent is very acidic (pH less than 5), or very alkaline (pH greater than 8.5), it may need to be neutralised before application as soil pH affects the availability of nutrients and other elements to plants.

## Metals

ANZECC (2000) Guidelines, Volume 3, Section 9.2.5 identify the maximum concentrations of metals in irrigation waters considered acceptable for continuous use. The current concentration of metals in the wastewater is shown below (Table 3) along with the long-term trigger value (LTV) and short-term trigger value (STV) guidelines adapted from the Guidelines. The current metal levels in the wastewater are mostly below the detectable limit and are therefore well below the LTV.

**Table 3. Summary of irrigation water long-term trigger value (LTV) and short-term trigger value (STV) guidelines for heavy metals and metalloids**

| Metal | LTV in irrigation water (mg/L) | STV in irrigation water (mg/L) | LCF wastewater quality |
|---|---|---|---|
| As | 0.1 | 2.0 | <0.001 |
| Cd | 0.01 | 0.05 | <0.0001 |
| Cr(VI) | 0.1 | 1 | <0.001 |
| Cu | 0.2 | 5 | <0.001 |
| Pb | 2 | 5 | <0.001 |
| Hg | 0.002 | 0.002 | <0.0001 |
| Ni | 0.2 | 2 | <0.001 |
| Zn | 2 | 5 | <0.005 |

## Mineral salts and specific ions

The Electrical Conductivity (EC) and concentration of salts and specific ions (sodium, chloride, alkalinity, bicarbonate etc) in the wastewater are relatively low. The aim is to protect soil structure and downstream surface and groundwater, and to not exceed the salt tolerance of pasture grasses.

## Oil and grease

The levels of oil and grease in the wastewater are currently below detection limits. These low levels will not present problems in regards to clogging irrigation systems or coating leaf surfaces of irrigated crops.

## Pathogens

The concentration of *E.coli* and other pathogens in the wastewater for irrigation is significantly lower than the wastewater coming directly out of the crocodile pens. This is likely due to the UV exposure through the current effluent ponds. Bacterial movement through soils is extremely limited and the harsh sunlight and climatic conditions typical of Australia rapidly diminish viable populations of bacteria. The irrigation area is also off-limits to the public, therefore any pathogens in the wastewater are not expected to cause any harm.

## Nutrients

Irrigation of treated effluent aims to balance nutrients applied with their uptake and removal by plants and soil through crop (pasture) growth and subsequent harvest and removal. This ensures that excess nutrients do not build up over time and leave the site in runoff or groundwater flows. A nutrient balance was undertaken to determine the irrigation area required to ensure suitable uptake of nitrogen and phosphorus in the wastewater. A number of parameters from the *Land Capability Assessment for Onsite Wastewater Management Guidelines* (2010) (LCA Guidelines) were utilised in the calculations.

The following input data was used in the nutrient balance:

| **Input Data** | | |
|---|---|---|
| Hydraulic load | L/day | Based on irrigation volumes in water balance |
| Effluent N concentration | mg/L | 15 |
| N lost to soil | - | 0.2 (standard multiplier from LCA guidelines) |
| Effluent P concentration | mg/L | 4 |
| Design life of system | Years | 50 (standard design life) |
| Crop N uptake | kg/ha/year | 220 (from LCA guidelines) |
| Crop P uptake | kg/ha/year | 50 (from LCA guidelines) |
| P-sorption rate | mg/kg | 3500 (based on sampling results) |
| Bulk density | g/cm3 | 1.3 (conservative from LCA guidelines) |
| Depth of absorbing layer | m | 0.4 |
| % of P sorbed | %P | 0.75 (standard multiplier as per LCA guidelines) |

Based on the water quality in the effluent ponds, an area of 13.4 ha is required to ensure sufficient nitrogen uptake, therefore nitrogen levels are a limiting factor for irrigation.

The current phosphorus levels in the wastewater for irrigation require a maximum area of 3.4 ha to ensure sufficient uptake.

## Salinity & sodicity

### *Salinity*

In order to assess the suitability of water and soil for irrigation, the quality of the irrigation water, characteristics of the soil to be irrigated and the salt tolerance of the crop to be grown must be considered. Electrical conductivity (EC) is a measure of the total soluble salts in water. Some general irrigation electrical conductivity (ECi) ratings (DERM 2009) for water are shown in Table 4. The current average EC of the wastewater for irrigation is 0.2 dS/m, which is considered low for irrigation.

**Table 4. Salinity ratings for water (ANZECC 2000)**

| ECi (ds/m) | Water salinity rating |
|---|---|
| <0.65 | Low |
| 0.65-1.3 | Moderate |
| 1.3-2.9 | High |
| 2.9-5.2 | Very high |
| >5.2 | Extremely high |

### *Sodicity*

Sodic soils have a range of adverse properties including poor soil structure and stability, surface crusting, poor aggregation, increased runoff and erosion, poor seedling emergence and slow water infiltration. Soil sampling was undertaken in the proposed irrigation area and the exchangeable sodium percentage (ESP) was less than 6%.

Soils with an ESP between 6 and 15% are considered sodic, and an ESP greater than 16% is considered strongly sodic. Soils with an ESP less than 6% are considered non-sodic.

High concentrations of sodium in irrigation water can result in the degradation of soil structure. The potential for this excess sodium on soils is commonly assessed using the sodium adsorption ratio (SAR). The sodium adsorption ratio is used to predict the potential for sodium to accumulate in the soil, which would result from continued use of sodic water.

The SAR in the wastewater for irrigation was found to be 1.4 which is not considered an issue, as outlined in Table 5.

**Table 5. Sodicity classes for irrigation water**

| SAR | Sodicity class |
|---|---|
| <3 | No sodium problem |
| 3-6 | Low sodium, few problems except with sodium sensitive crops |
| 6-8 | Medium sodium, increasing problems |
| 8-14 | High sodium, not generally recommended |
| >14 | Very high sodium - unsuitable |

Source: *QLD DPI&F Notes: Interpreting water analysis for crop and pasture*

### *Relationship*

Based on the low salinity rating of the soil and the low SAR for the irrigation water, it is not expected that irrigation will have an impact on the soil structure. The levels also fall within the “stable soil structure” area on the EC/SAR relationship graph detailed in the ANZECC 2000 guidelines and below (Figure 1).

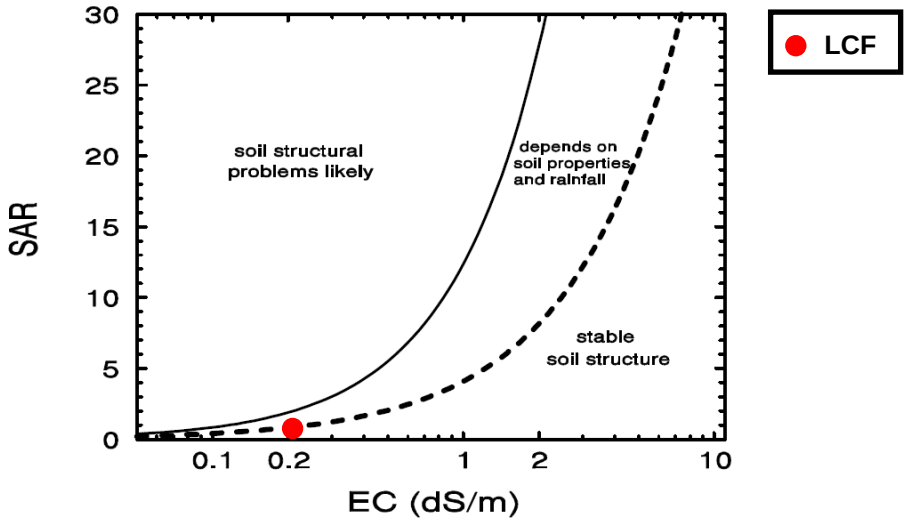



**Figure 1. Relationship between SAR and EC of irrigation water for prediction of soil structural stability**

# OVERALL WATER BALANCE

The following input data was used in the water balance:

| **Input Data** | | |
|---|---|---|
| Monthly water usage | L/day | Client supplied data |
| Design Irrigation Rate | mm/day | 5 |
| Nominated Land Application Area | $m^2$ | 52000 |
| Crop Factor | unitless | 0.8-0.9 |
| Retained Rainfall | unitless (most conservative) | 0.5 |
| Rainfall Data | mm/month | BOM mean for Darwin Airport |
| Evaporation Data | mm/month | BOM mean for Darwin Airport |
| Pen area (shade cloth cover) | $m^2$ | 34040 |

The total inputs, outputs, percentage wastewater lost, total volume remaining and storage requirements by month are detailed in Table 6.

**Irrigation rate**

The design irrigation rate was set at 5 mm per day as recommended by the Australian Standard for *On-site domestic wastewater management* (AS/NZS 1547:2012) for drip or spray irrigation.

**Nominated land application area**

The current available area on-site for irrigation is 5.2 hectares, which is the basis of the water balance. There is potential to increase the irrigation area into surrounding properties, which would also decrease the storage requirements in the wet season, however this has not yet been thoroughly explored.

**Crop factor**

The LCA Guidelines stipulate a crop factor of 0.8-1.0 would be appropriate for irrigation design purposes, based on the generally high year-round daytime temperatures in the NT. For this assessment a crop factor of 0.8 was used for the dry season months and 0.9 for the wet season.

**Retained rainfall**

A factor of 0.5, or 50%, was used based on the *Draft NT Effluent Irrigation Areas Standard Sizing and Design* (2007), a supplement to the *NT Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent* (1996).

**Pen areas**

A proportion of the crocodile pens are covered with a thick shade cloth material during the wet season, which decreases evaporation and rainfall infiltration. To account for this cover, a rainfall infiltration factor of 10% and evaporation factor of 20% was assumed for these areas. The remaining pens are fully enclosed and therefore have not been factored into calculation of rainfall infiltration and evaporation rates.

**Table 6. LCF site water balance and storage requirements**

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total water inputs (usage + rainfall) | m3/day | 1073.6 | 1223.9 | 911.1 | 746.5 | 860.8 | 680.7 | 736.7 | 967.8 | 910.1 | 875.6 | 1066.0 | 960.2 |
| Total outputs (irrigation + evaporation) | m3/day | 602.6 | 616.3 | 602.8 | 603.8 | 639.9 | 629.9 | 633.6 | 666.0 | 681.6 | 737.4 | 726.5 | 657.8 |
| % wastewater lost | % | 56% | 50% | 66% | 81% | 74% | 93% | 86% | 69% | 75% | 84% | 68% | 69% |
| Total volume remaining | $m^3$/day | 471.0 | 607.5 | 308.3 | 142.7 | 220.9 | 50.8 | 103.0 | 301.7 | 228.6 | 138.2 | 339.5 | 302.4 |
| Cumulative storage | $m^3$/mnth | 14599.9 | 31611.1 | 41167.6 | 45448.4 | 52295.5 | 53819.0 | 57012.8 | 66366.9 | 73223.7 | 77508.3 | 87693.2 | 97066.4 |

# APPENDIX B WASTEWATER TREATMENT TRIAL PLAN

# Wastewater Treatment Trial
# Lagoon Crocodile Farm

PRI Farming Pty Ltd

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## Figures



## Appendices

# 1 BACKGROUND

Croc Pac Pty Ltd operate the Lagoon Crocodile Farm (the LCF) in Berrimah, Northern Territory. The LCF was first established in 1987 with approximately 3,000 to 5,000 saltwater crocodiles (*Crocodylus porosus*). Over time, the operations have expanded to meet the increasing demand for crocodile products and the farm currently has capacity for approximately 23,000 animals.

LCF is a commercial production farm from incubation (wild-harvested eggs) to hatching and growing. The animals are harvested on-site and sent to an off-site location for further processing and packaging. The end-use markets include raw crocodile skin, meat and by-products.

The nature of the farming operation results in the generation of animal effluent, a listed waste under Schedule 2 of the *Waste Management and Pollution Control (Administration) Regulations.* The animal effluent is mixed with water (as part of the farming process) resulting in large volumes of wastewater that requirement management.

LCF have engaged AQUA, a division of PFG Group Pty Ltd to undertake a trial wastewater treatment system on site to determine viability for a full-scale operation. The trial treatment plant and process is outlined in this plan.

# 2 DESCRIPTION OF OPERATIONS

The crocodile production process is summarised as follows:

1. Eggs are wild-collected (by a separate entity) and are assessed and cleaned in the egg laboratory, with viable eggs transferred to the incubator room
2. Animals hatch in an incubator, then are immediately transferred to hatching pens
3. When animals are about one year old, they are transferred to grow-out pens
4. When animals approach a size suitable for market, they are transferred to finishing pens for 6-12 months to ensure best possible skin and meat condition
5. Animals are harvested from the finishing pens, prepared for transport using a dedicated trailer and then sent to an off-site location for further processing.

The LCF currently harvests 400-500 animals a month for off-site processing to produce raw crocodile skins, meat products and other saleable by-products.

The primary use of water on site is for regular flushing of the animal pens to maintain hygiene and health of the animals. On average, water usage is estimated at 800 kL/day, with the source being a combination of mains water and bore water abstracted from four of the five water supply bores on site. Generally, the ratio of mains to bore water is 50:50, although the mains water use is generally higher during the dry season, when groundwater yields become limited. The mains and bore water is pumped into a number of storage tanks (approximately 630 kL capacity) where it is dosed with chlorine via an automated system, and then reticulated around the farm.

# 3 WASTEWATER SUMMARY

## 3.1 Wastewater flows

Wastewater generated from the different farm stages are directed to nine separate septic collection tanks. Wastewater then flows from the septic tanks to an existing wastewater treatment system that consists of a filtration (Spirac system) and screening process (two rotary drum filters) to remove grit and sludge. The wastewater then flows into a series of three earthen (unlined) facultative treatment ponds with an overflow outlet constructed on the western end of Pond 3. Water is aerated in the treatment ponds to assist in the breakdown of nutrients and minimise odour issues. A basic schematic of the current wastewater treatment plant is outlined in Figure 3-1. From the effluent ponds, the treated wastewater then overflows from the pond outlet and passively discharges across an unused grassed area within the site boundary. The natural lay of the land causes the water to flow in a southerly direction away from the operational area towards the southern site boundary.

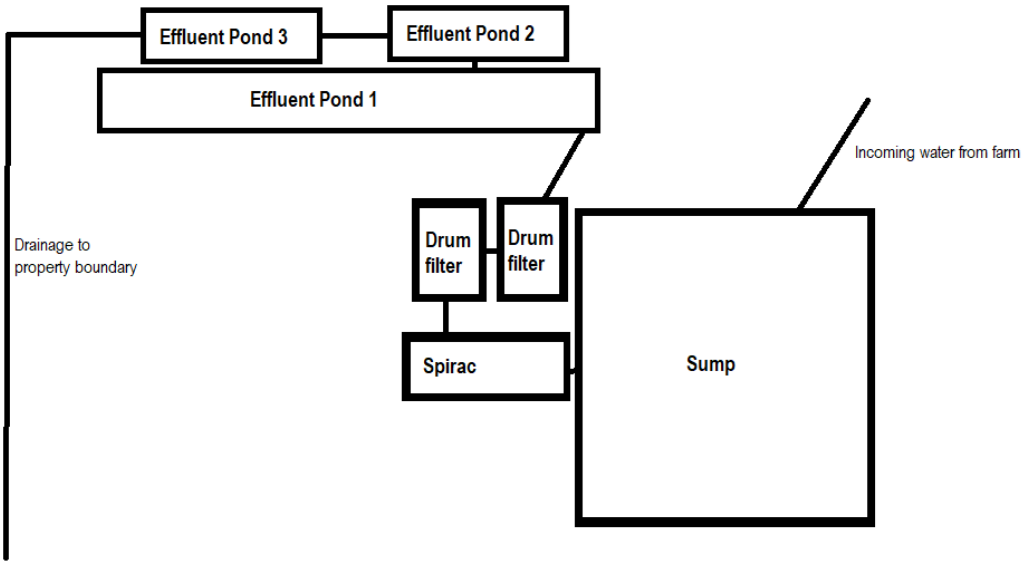



**Figure 3-1. Schematic diagram of current wastewater treatment plant**

## 3.2 Wastewater volumes

Actual wastewater volumes currently generated are unknown, however water inputs are metered and therefore wastewater volumes can be estimated based on usage. The estimated monthly wastewater volumes and percentages generated within each growth stage is detailed in Table 3-1.

**Table 3-1. Estimated monthly wastewater volumes**

| Growth stage | Wastewater (ML/month) | Wastewater % of total |
|---|---|---|
| Hatchery | 1.5 | 6.67% |
| Grow out | 13.5 | 60.00% |
| Finishing | 7.5 | 33.33% |

| Growth stage | Wastewater (ML/month) | Wastewater % of total |
|---|---|---|
| **Total** | **22.5** | **-** |

## 3.3 Wastewater quality

Wastewater quality data has been collected for LCF at several locations around the farm over the following periods of time:

- Effluent ponds (inlet and outlet) – monthly water monitoring conducted 2014 to 2016
- Effluent ponds (inlet and outlet) and combined effluent pre-treatment – biannual water monitoring conducted 2017 to 2019
- Specific growth stages – July 2019

A summary of the wastewater quality across these locations is provided in Table 3-2.

**Table 3-2. Wastewater quality at different locations**

| Sampling location | pH | EC (µS/cm) | BOD (mg/L) | TSS (mg/L) | Total N (mg/L) | Total P (mg/L) |
|---|---|---|---|---|---|---|
| Hatchery | 7.7 | 1800 | 900 | 500 | 380 | 30 |
| Grow out | 7.8 | 175 | 4 | 10 | 25 | 6 |
| Finishing | 7.6 | 230 | 1 | 6 | 6 | 2 |
| Combined pre-treatment | 7.6 | * | 230 | 280 | 64 | 8 |
| Combined post- treatment (effluent pond inlet) | 7.6 | * | 54 | 130 | 32 | 5 |
| Effluent pond outlet | 8.1 | * | 10 | 40 | 16 | 4 |

* Not recorded

The nitrogenous compounds in the wastewater are as a result of faeces, liquid crocodile waste, uneaten food and background levels in the input water. Typical crocodile effluent is comprised of ammonia (25.4%), urea (4.5% and uric acid (63.5%).

The hatchery wastewater whilst lowest in volume, is highest in nutrient concentration due to the density of animals and feeding regimes. The concentration of nutrients reduces as the growth stages progress due to the decreased animal density and targeted feeding regimes (i.e. less solid food matter in the wastewater stream). The wastewaters from the individual growth stages are then combined for treatment and the concentrations of contaminants decreases as the treatment stages progress. The pH remains steady throughout all stages, however slightly increases in the effluent ponds. This is most likely due to the addition of lime to the effluent ponds to help address odour concerns.

# 4 TRIAL TREATMENT SYSTEM

## 4.1 System overview

The trial wastewater treatment system proposed for LCF is a particulate air separation system (PASS). PASS utilises ozone, flocculants and other chemicals (such as pH control) in combination with particulate removal and foam fractionation to improve the quality of a waste-water stream prior to further filtration, reuse or discharge. The process uses diffused air and ozone, resulting in rising gas bubbles that produce a foam that continuously discharges unwanted waste from the water system. Ozone is often used in wastewater

treatment as it is effective in decreasing biochemical oxygen demand (BOD), removing bacteria and some metals. PASS can also effectively remove some dissolved compounds, such as nitrogens, large light particles and colloidal material, without specific targeting required.

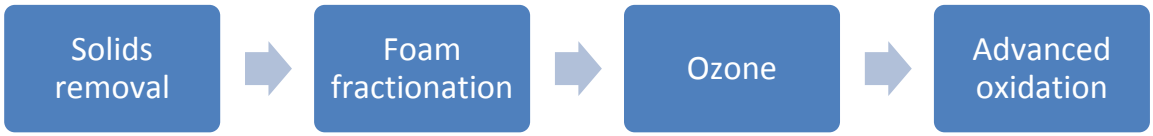
Other benefits of using PASS are that it:

- Removes the unwanted material from the stream as a matter of process and on a continuous basis.
- Typically has a smaller footprint than most water treatment process as it functions at much higher velocities.
- Is wide ranging in its ability to remove matter, is compact and continuously removes the unwanted material from the stream.

## 4.2 Trial PASS

The trial PASS system is to be constructed adjacent to the hatchery in the centre of the site (Figure 4-1). The trial is going to focus on the hatchery wastewater only, as it has the highest nutrient concentration. The trial PASS will be capable or treating up to 35m$^3$ of water per hour with the intent of treating the water to an acceptable quality for reuse as input water back through the farm.

The treatment process will occur as follows:




***Solids removal***

Wastewater from the hatchery will be pass through a Stage 1 Solids Removal system consisting of 600µm Static Screens and will be collected in the adjacent septic pit. It then passes through a Stage 2 Solids removal system (Hydrocyclone) prior to the PASS. This will remove a large portion of solid material from the process flow before it is broken down into its nitrogenous compounds.

Post the PASS process pump and prior to the ozone and flocculant contact chamber, the water passes through a Stage 3 Solids removal process consisting of another Hydrocyclone.

Post the contact chamber, water will then pass through a media filter to remove flocculated particles and BOD followed by a third Hydrocyclone acting as a breakthrough particulate filter

Hydrocyclone is the solids removal system used at three points in the system, at the beginning and end of the process. The waste stream from each Hydrocyclone is estimated at 150 L per purge with one purge per day (particulates and flocculant).

The waste stream from the media filter is estimated at 5,000 to 7,500L per purge.

***Foam fractionation***

This process produces a foam of accumulated organic matter, which is drained away and discarded. Many of the dissolved substances are surfactant molecules; one end of the molecule is polar and the other is non-polar. The polar end of the molecule is attracted to the water molecules surrounding it and is termed hydrophilic whereas the non-polar end is not attracted to water molecules and is termed hydrophobic. These molecules congregate on an air/water interface with the hydrophobic end on the air side of the interface and the hydrophilic end on the water side.

The compounds a foam fractionator will remove include; urea, ammonia gas, particulate organic matter size (typically below 30 microns), compounds that bind with proteins, amines, phenols, ortho phosphates, excess

carbon dioxide, excess nitrogen, colloidal protein matter, albumin, microscopic single celled algae, free floating micro algae, indoles, some amount of heavy metals, some fats, many pigments and so on. These compounds may not necessarily all be removed by the foam fractionation process but by the water turbulence and intense aeration within the reactor.

Flocculants and foaming agent will be dosed on an as needed basis to enhance the fractionation process. The proposed flocculant is Phlocc Medio, with the dose rate to be determined during commissioning but with a target of 1:1 with P levels.

***Ozone***

Ozone is a powerful oxidant capable of degrading complex organic compounds into those more easily removed by other processes such as foam fractionation and adsorption. At pH levels above 9, ozone can react directly on dissolved ammonia, with a conversion to nitrogen gas. The PASS has the ability to alter the process water pH level to achieve a desired result.

Ozone also works as a flocculant and will aid in the removal of dissolved and particulate nitrogenous waste through the foaming process and in the final solid removal step (hydrocyclone).

***Advanced oxidation***

Ozone used in conjunction with high dose ultra-violet (UV) generates hydroxyl free radicals (OH) in a process known as advanced oxidation. Hydroxyl free radicals work effectively in degrading dissolved nitrogen compounds such as ammonia and urea, minimising the accumulation of nitrogen in the process water.

UV is incorporated at the end of the PASS process as final disease barrier step, but also to help maintain dissolved ozone levels below the maximum limit as specified by the particular application.

***Zeolite (optional)***

The trial will monitor the increase in total dissolved nitrogen levels in relation to background levels presented in the makeup water. If the inherent PASS processes are not sufficient to maintain the dissolved nitrogen levels and predetermined concentrations, then there is the option to remove nitrogen from the process water utilising powdered zeolite.

Zeolite binds with dissolved nitrogenous waste (ammonia, nitrite and nitrate) removing it from the process water. Powdered zeolite will be dosed into the existing PASS contact chambers and then removed from the process water via the foam fractionator and second stage hydrocyclone particulate filter. The quantity of zeolite to be used will be determined during the trial and based on maintaining dissolved nitrogen levels in-line with makeup water background levels.

Layout drawings of the proposed trial system are included in Appendix A.

## 4.3 Treatment objectives

The aim of the treatment trial is to treat the wastewater quality to a level suitable for reuse back through the crocodile production process. The current inlet quality of water into the pens has been used as a guidance target level for treatment of water for reuse. The Hazen percentile calculator was used to calculate 80$^{th}$ percentile parameters from the current data available to set target levels Table 4-1.

**Table 4-1. Water quality objectives for treatment for re-use in production**

| Parameter | Target value |
|---|---|
| pH | 6.0 – 8.5 |
| Dissolved oxygen | 80 – 100% |

| Parameter | Target value |
|---|---|
| TSS | <10 mg/L |
| BOD | <20 mg/L |
| Total P | <0.03 mg/L |
| Total N | <5.0 mg/L |
| *E.coli* | <10 cfu/100mL |

## 4.4 Treatment by-products

The removal of contaminants from a wastewater stream often generates a sludge or liquid by-product that requires disposal. The estimated volumes of waste products generated during the treatment process is provided in Table 4-2. The waste streams are pumped from the PASS back to the septic pit. Sludge from the septic pits will be pumped on a weekly basis and taken to a license liquid waste facility for disposal.

**Table 4-2. Estimated volumes of waste products**

| Waste stream | Estimated volume (L/day) |
|---|---|
| Hydrocyclones | 450 |
| Foam fractionator | 250 |
| Media Filter | 7,500 |
| **Total** | **8,200** |

## 4.5 Trial period

The treatment trial will be undertaken for a period of four months in order to refine the process and determine whether the treatment objectives can be met. Based on the success of the trial, the system will be progressively scaled in order to manage larger quantities of wastewater and increase re-use targets back in the farm production.

# 5 MONITORING AND REPORTING

## 5.1 Daily monitoring

Daily inspections of the PASS will be undertaken to ensure the process is running efficiently and to identify any issues such as leaks, spills, maintenance concerns etc. Log sheets will be kept of all daily inspections as a record for quality monitoring purposes.

## 5.2 Water quality monitoring

Water quality monitoring will be conducted on the wastewater prior to and post treatment. Samples will be collected pre-treatment from the wastewater tank and post-treatment from the clean water tank. The monitoring parameters and frequency of sampling is provided in Table 5-1.

**Table 5-1. Monitoring parameters and frequencies**

| Parameter | Frequency |
|---|---|
| ***Field parameters*** | |
| pH | Daily |
| EC | Daily |
| DO | Daily |
| ***Laboratory parameters*** | |
| TSS | Weekly |
| Total P | Weekly |
| Total N | Weekly |
| BOD | Weekly |
| *E.coli*, *Enterococci*, Total coliforms | Weekly |

## 5.3 Assessment of performance indicators

Water quality monitoring of the treated effluent will be used to determine the suitability for reuse. Where the treated water meets the target treatment criteria, the water will be stored in the clean water tank for use directly back in the hatchery. Where the treated water does not meet the criteria for reuse, it will be pumped back into the wastewater tank for further treatment.

## 5.4 Reporting

### 5.4.1 Internal

Details of environmental incidents, non-conformances or other relevant information are included in daily reports which are issued to the Managing Director. Records of all incidents, inspections and reports are maintained through an electronic filing system.

All environmental monitoring records will be maintained in a water and soil quality database.

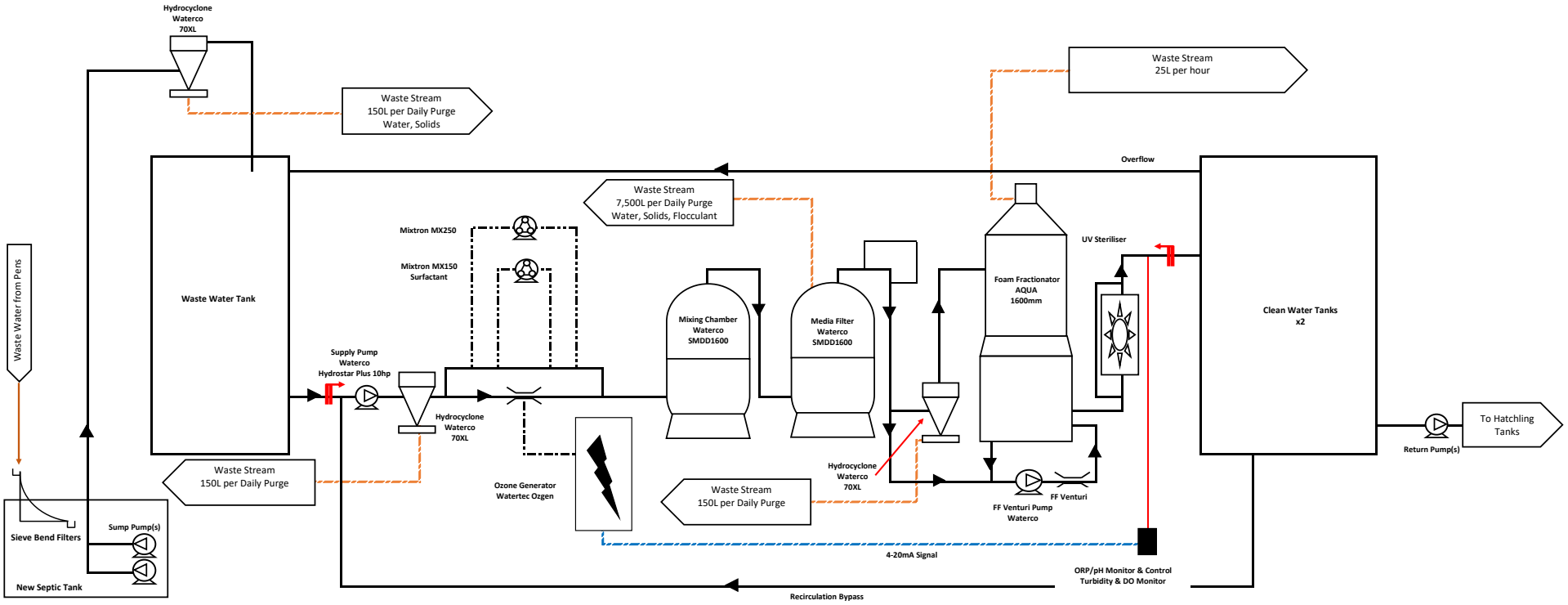
An annual report is also prepared which will detail the treatment process including volumes and quality information.

### 5.4.2 External

LCF will report any non-compliance with the EPL by completing a Non-Compliance Notification via the NT EPA website within 24 hours of the event.

An Annual Return will be submitted to the NT EPA on the anniversary date of the EPL to summarise the activities and outcomes of the previous 12 months. Additionally, a Monitoring Report will be prepared and submitted with the Annual Return that includes a trend analysis of the water quality monitoring data and an assessment of any environmental impacts from the LCF operations, including the wastewater treatment process.

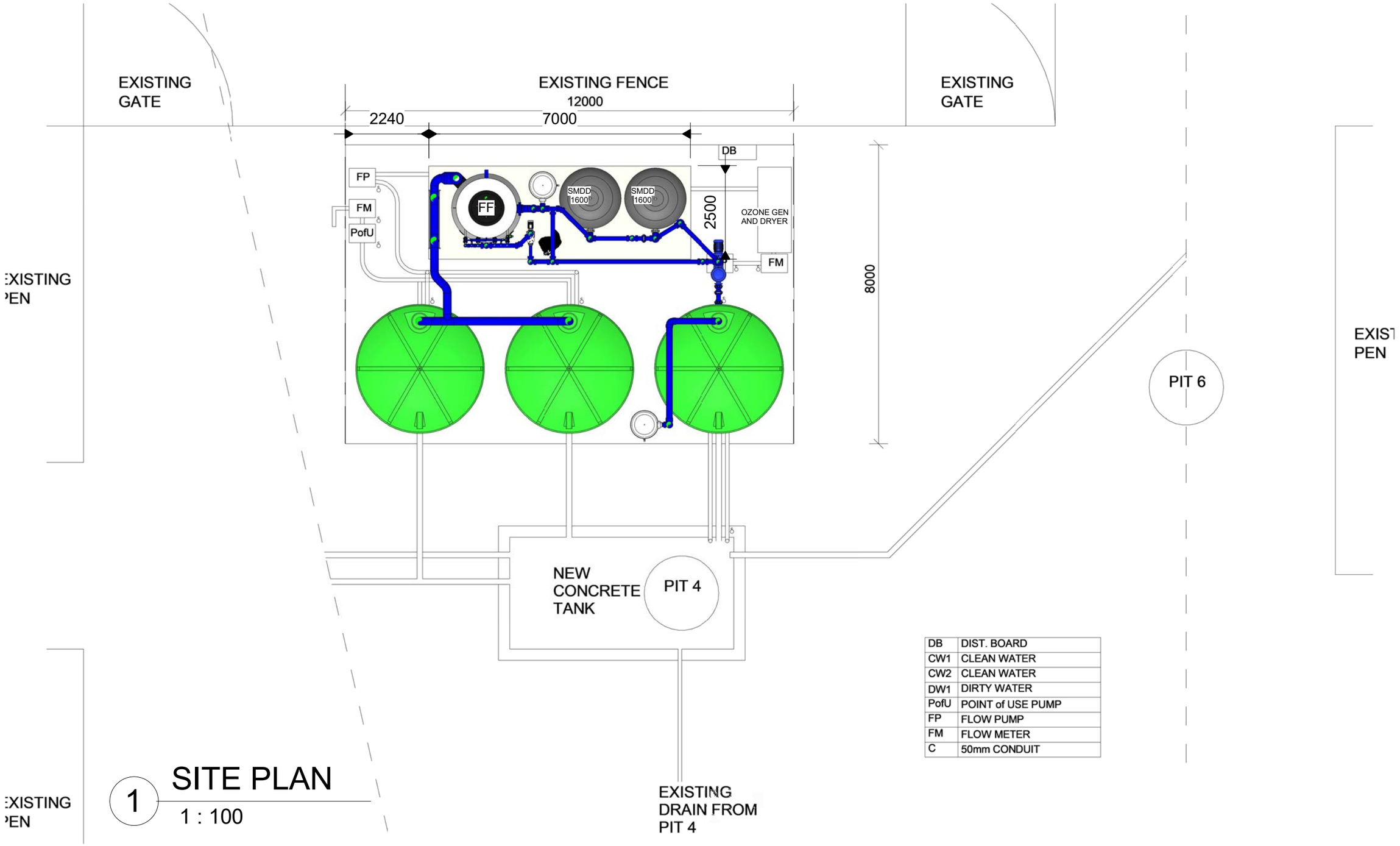
# APPENDIX A PASS SYSTEM LAYOUT DRAWINGS




**Timothy Graham (AQUA)**
48/252 Botany Road
Alexandria, NSW, Australia, 2015
P: +61 (0) 401 595 078
E: tim@aquamanagement.com.au


**Note:**
Dose pumps are watered powered
PFD indicates equipment sequence only and does not specify qty's of equipment required.
Reference LSS Design Data for equipment numbers and specifictions.
Indicates extent of original PASS System Quote

| | | | |
|---|---|---|---|
| **Project:** | Lagoon PASS System | | |
| **Client:** | PRI Group | | |
| **Title:** | Lagoon PASS System PFD | | |
| **Drawing no.:** | AQUA/PRI/001 | **Revision:** | H |
| **Drawn:** | TG | **Checked:** | |
| **Date:** | 16/04/2020 | | NTS |

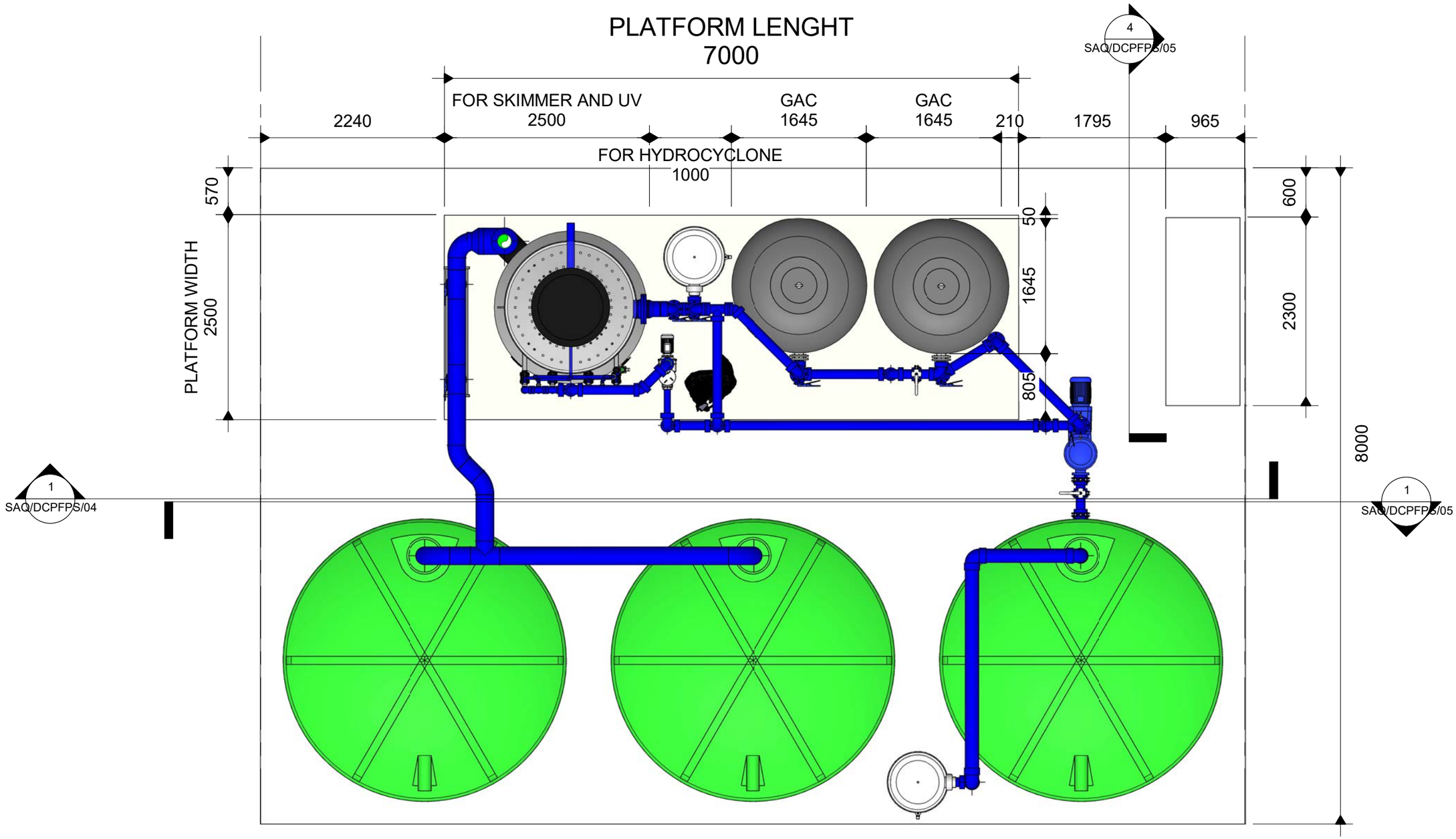



| | |
|---|---|
| DB | DIST. BOARD |
| CW1 | CLEAN WATER |
| CW2 | CLEAN WATER |
| DW1 | DIRTY WATER |
| PofU | POINT of USE PUMP |
| FP | FLOW PUMP |
| FM | FLOW METER |
| C | 50mm CONDUIT |

1 SITE PLAN
1 : 100

AQUA
CREATIVE : STRATEGY : MANAGEMENT

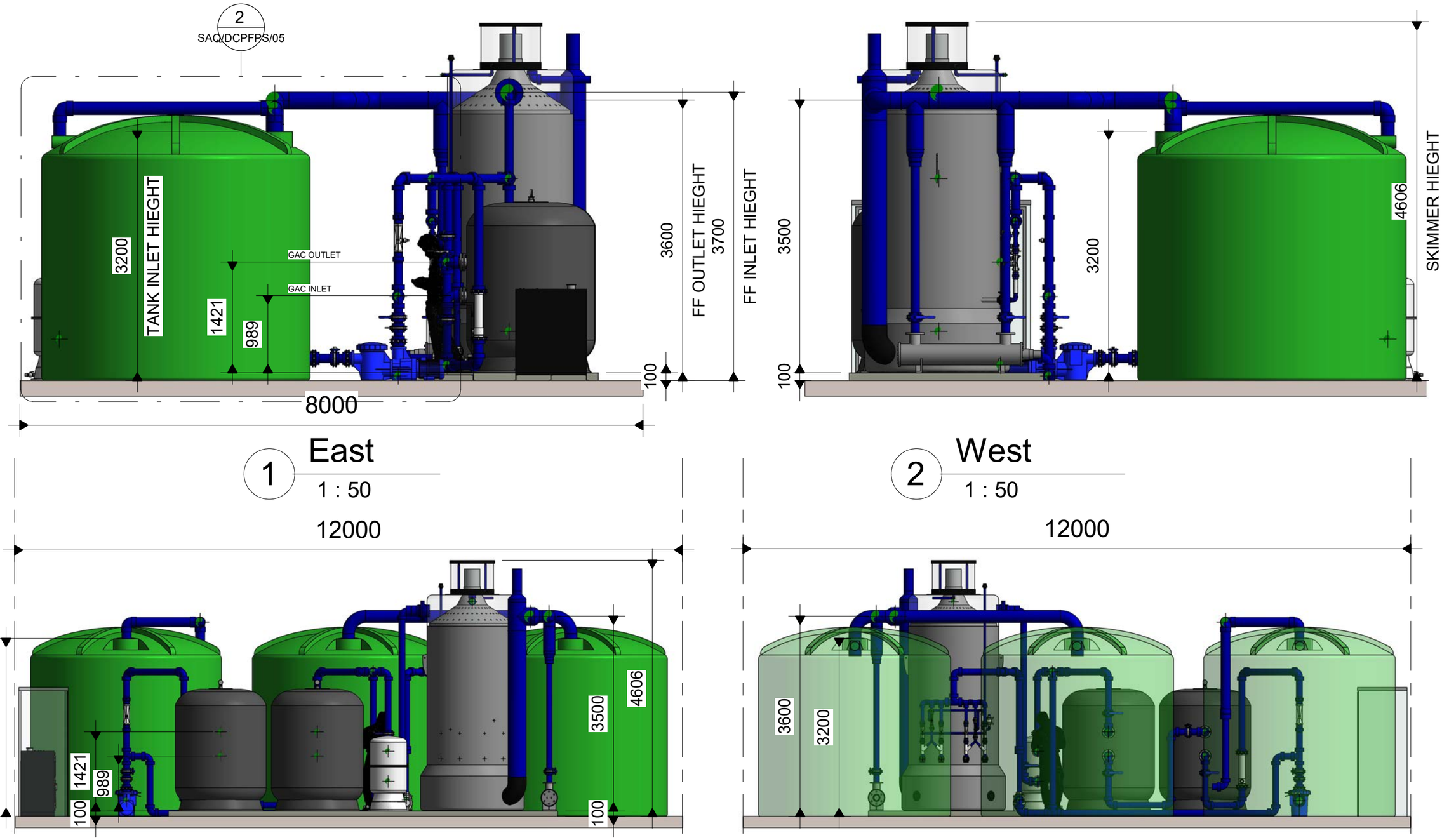
| PROJECT TITLE: | SHEET CONTENT: | DRAWN BY: | APPROVED BY: | ISSUED FOR: | SHEET NUMBER: | |
|---|---|---|---|---|---|---|
| LAGOON CROC FARM PASS SYSTEM | SITE PLAN | G.L | | ☐ REVIEW<br>☐ CONSTRUCTION<br>☐ REFERENCE<br>☐ OWNER'S COPY<br>☐ OTHERS | SAQ/DCFPS/01 | |
| | | CHECKED BY: | DATE ISSUED: | | REV.: | SIZE: |
| | | T.G | MAY 2020 | | | A3 |




1 PLAN VIEW

1 : 50

| | | | | | | |
|---|---|---|---|---|---|---|
| AQUA CREATIVE : STRATEGY : MANAGEMENT | PROJECT TITLE: LAGOON CROC FARM PASS SYSTEM | SHEET CONTENT: PLAN VIEW | DRAWN BY: G.L | APPROVED BY: | ISSUED FOR: ☐ REVIEW ☐ CONSTRUCTION ☐ REFERENCE ☐ OWNER'S COPY ☐ OTHERS | SHEET NUMBER: SAQ/DCFPS/02 |
| | | | CHECKED BY: T.G | DATE ISSUED: MAY 2020 | | REV.: / SIZE: A3 |




1 East
1 : 50

2 West
1 : 50

3 North
1 : 70

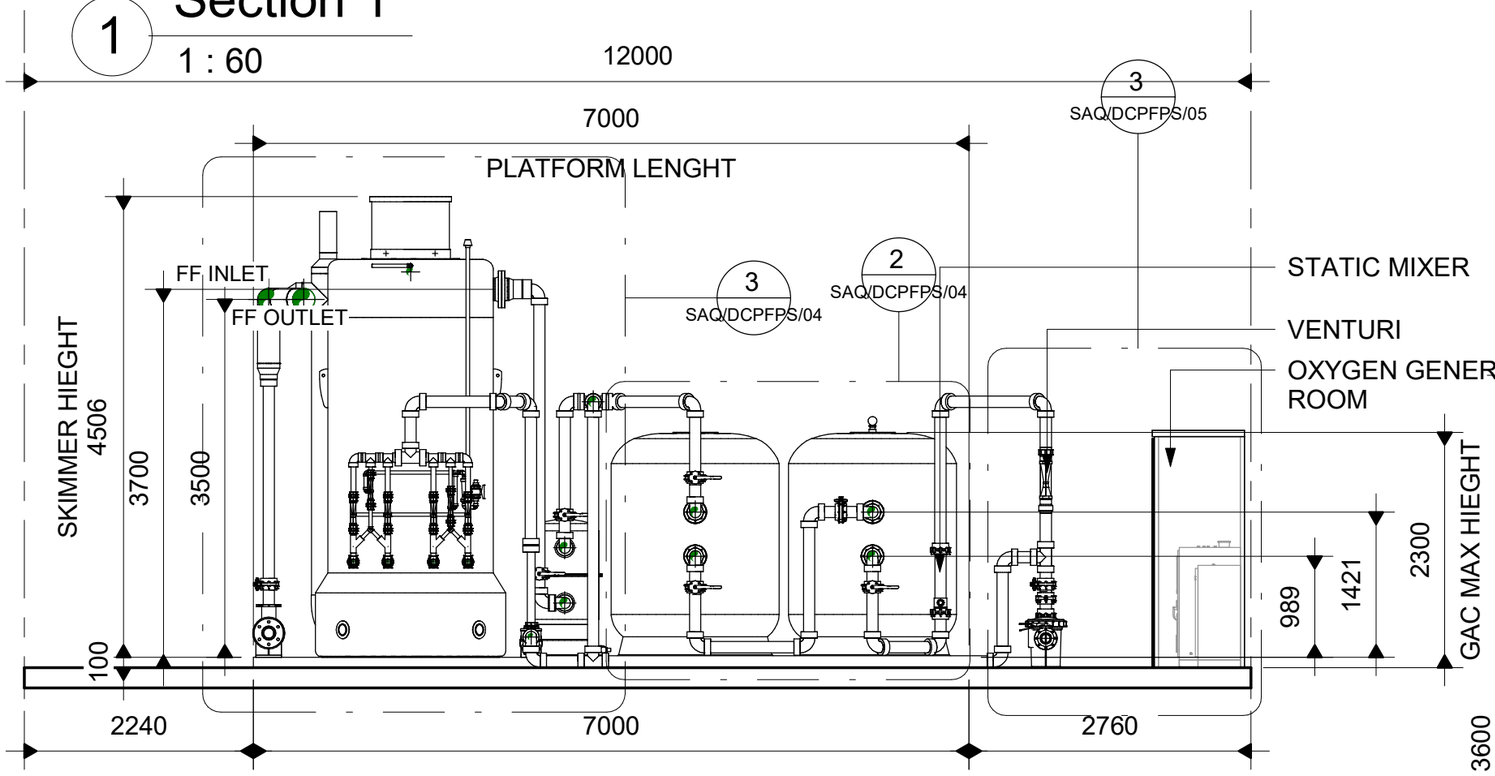
4 South
1 : 70

AQUA
CREATIVE : STRATEGY : MANAGEMENT

| PROJECT TITLE: | SHEET CONTENT: | DRAWN BY: | APPROVED BY: | ISSUED FOR: | SHEET NUMBER: | |
|---|---|---|---|---|---|---|
| LAGOON CROC FARM PASS SYSTEM | EAST VIEW, WEST VIEW NORTH VIEW, SOUTH VIEW | G.L | | ☐ REVIEW ☐ CONSTRUCTION ☐ REFERENCE ☐ OWNER'S COPY ☐ OTHERS | SAQ/DCFPS/03 | |
| | | CHECKED BY: | DATE ISSUED: | | REV.: | SIZE: |
| | | T.G | MAY 2020 | | | A3 |

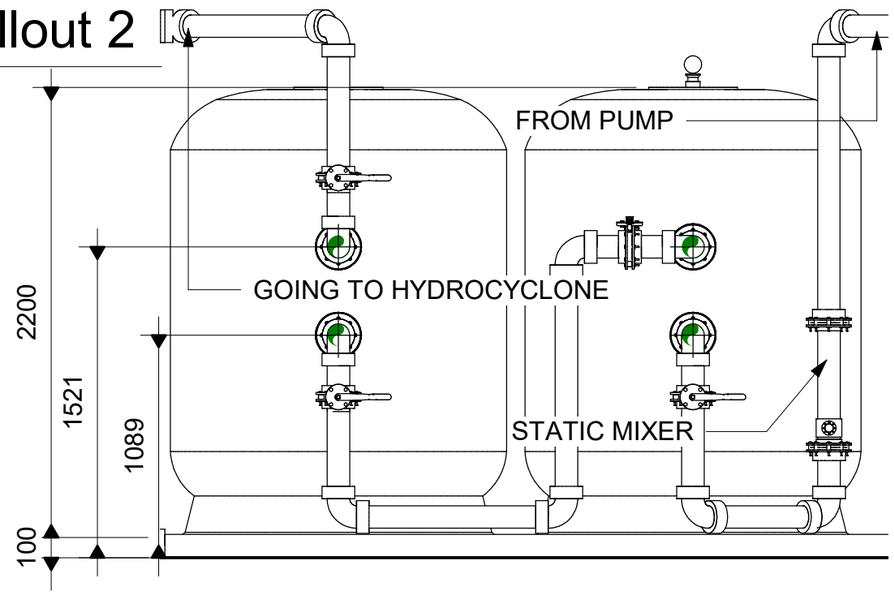
## 1 Section 1

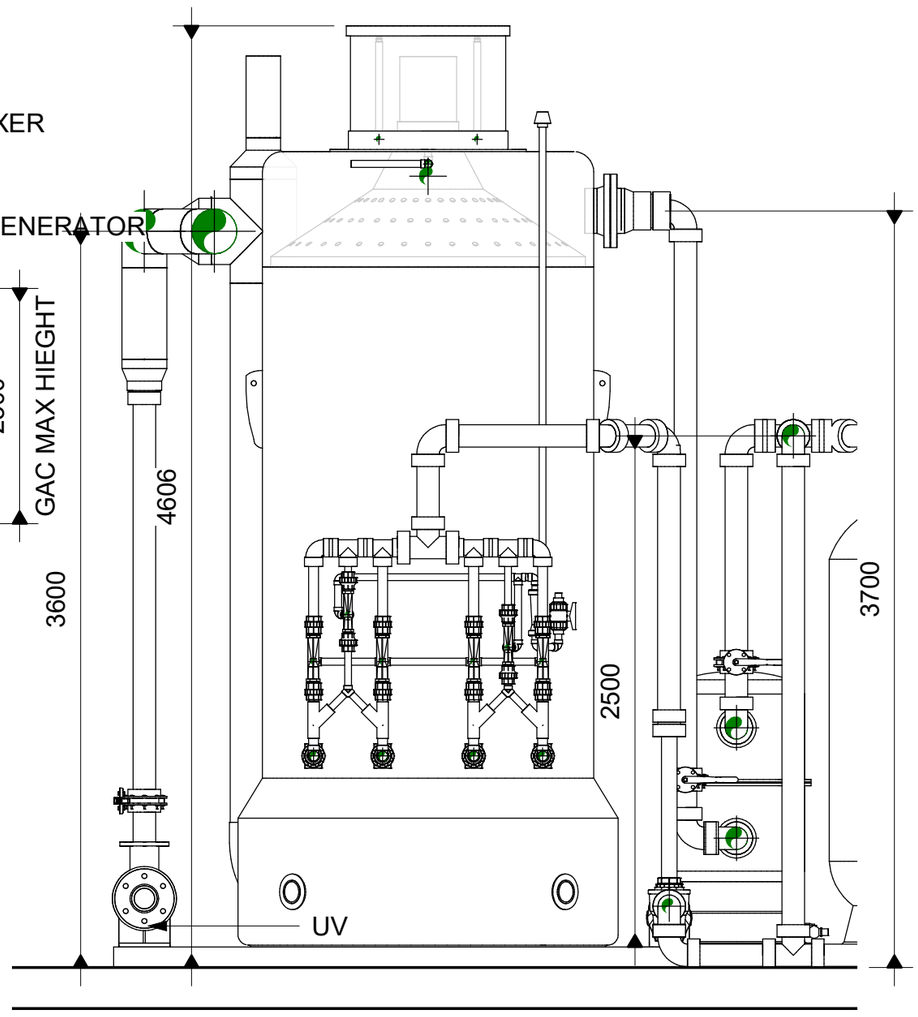
1 : 60




## 2 Section 1 - Callout 2

1 : 30




## 3 Section 1 - Callout 1

1 : 30

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|---|---|---|---|---|---|
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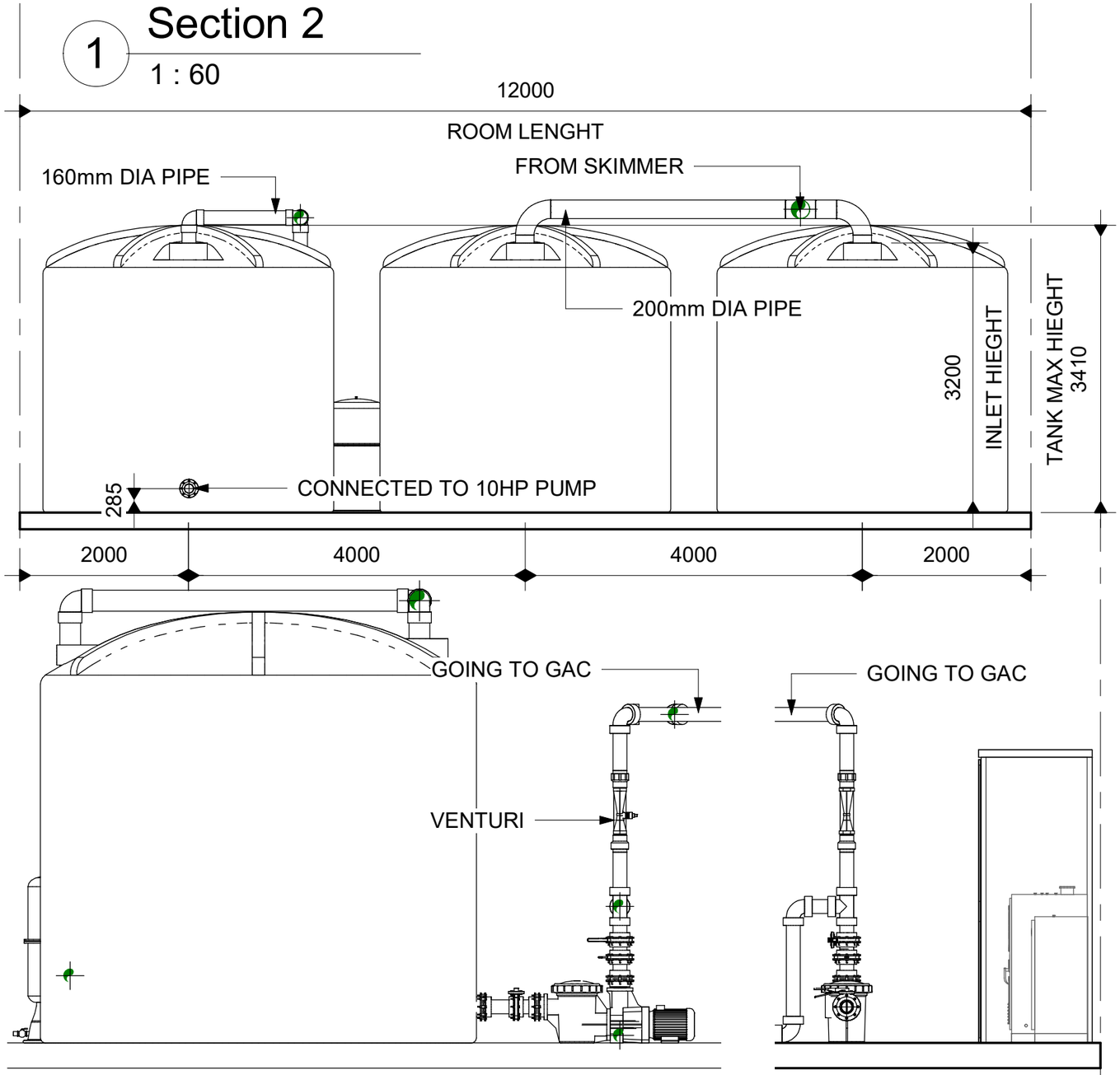
| | | | CHECKED BY: T.G | DATE ISSUED: MAY 2020 | |

| SHEET NUMBER: | |
|---|---|
| SAQ/DCFPS/04 | |
| REV.: | SIZE: |
| | A3 |

## 1 Section 2

1 : 60

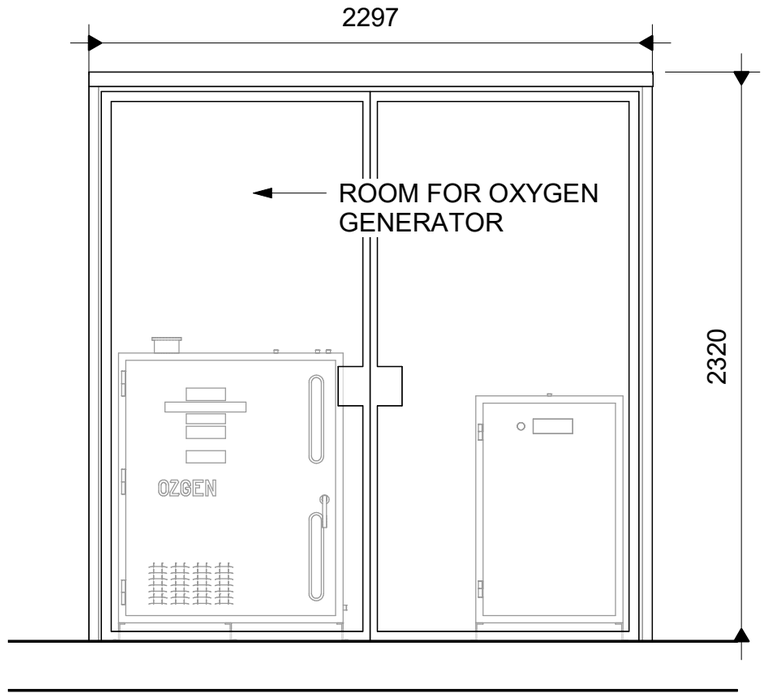



## 2 East - Callout 1

1 : 40

## 3 Section 1 - Callout 3

1 : 40




## 4 Section 3

1 : 25

AQUA
CREATIVE : STRATEGY : MANAGEMENT

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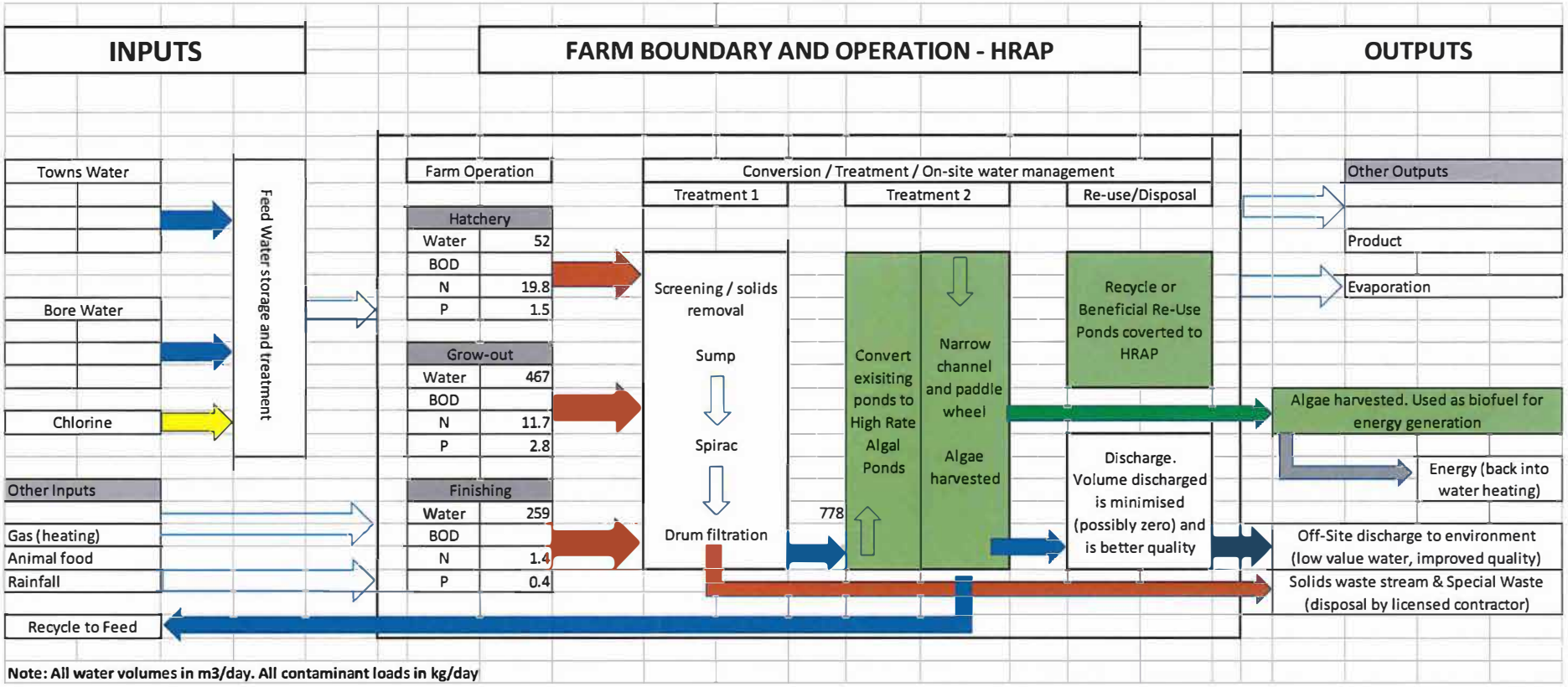
|---|---|---|---|---|---|
| LAGOON CROC FARM PASS SYSTEM | SECTION VIEW | G.L | | ☐ REVIEW<br>☐ CONSTRUCTION<br>☐ REFERENCE<br>☐ OWNER'S COPY<br>☐ OTHERS | SAQ/DCFPS/05 |
| | | CHECKED BY: | DATE ISSUED: | | REV.: / SIZE: |
| | | T.G | MAY 2020 | | A3 |

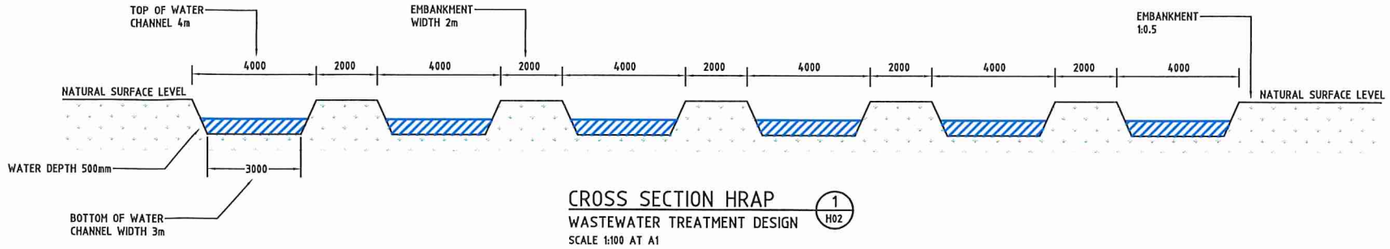
# APPENDIX C HRAP TREATMENT SYSTEM FLOW DIAGRAM

# Process Flow Diagram

## High Rate Algal Ponds (HRAP)



HIGH RATE ALGAL POND (HRAP)
6 CHANNELS
0.5m WATER DEPTH
STEEP EMBANKMENT (IF CONDITIONS SUIT)




CROSS SECTION HRAP (1 / H02)
WASTEWATER TREATMENT DESIGN
SCALE 1:100 AT A1




SITE PLAN - HIGH RATE ALGAL POND LAYOUT (HRAP)
WASTEWATER TREATMENT DESIGN
SCALE 1:500 AT A1

CLIENT

| Rev | Description | Date |
|---|---|---|

**PRELIMINARY**

ADDRESS
LOT 1098, LAGOON ROAD
NORTHERN TERRITORY

PROJECT
LAGOON ROAD
CROCODILE FARM

TITLE
SITE PLAN
HIGH RATE ALGAL POND
LAYOUT

| Date | Scale | |
|---|---|---|
| 22/08/2019 | AS SHOWN | A1 |

| Drawn | Designed | Checked |
|---|---|---|
| LM | DM | DM |

| Project No. | Drawing No. | Rev |
|---|---|---|
| 216D1786 | H02A | A |

# APPENDIX D FARM SECTIONS - WATER AND NUTRIENT BALANCE ASSESSMENTS

## INPUT DATA

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. days | | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 |
| Total water usage | m3/month | 20654.5 | 23330.0 | 18988.0 | 19410.0 | 26061.5 | 20371.0 | 22803.8 | 29865.7 | 26839.7 | 25080.0 | 27776.5 | 22382.5 |
| Total water usage | m3/day | 666.3 | 833.2 | 612.5 | 647.0 | 840.7 | 679.0 | 735.6 | 963.4 | 894.7 | 809.0 | 925.9 | 722.0 |
| Hatchery | m3/day | 44.4 | 55.6 | 40.9 | 43.2 | 56.1 | 45.3 | 49.1 | 64.3 | 59.7 | 54.0 | 61.8 | 48.2 |
| Grow-out | m3/day | 399.8 | 499.9 | 367.5 | 388.2 | 504.4 | 407.4 | 441.4 | 578.0 | 536.8 | 485.4 | 555.5 | 433.2 |
| Finishing | m3/day | 222.1 | 277.7 | 204.2 | 215.6 | 280.2 | 226.3 | 245.2 | 321.1 | 298.2 | 269.7 | 308.6 | 240.6 |

**Areas**

| | | |
|---|---|---|
| Hatchery | m2 | 1130 |
| Grow-out | m2 | 19120 |
| Outdoor Finishing | m2 | 14920 |
| Indoor Finishing | m2 | 2800 |
| Irrigation | m2 | 52000 |

| **Average Nutrient Levels** | | **Total N** | **Total P** |
|---|---|---|---|
| Hatchery | mg/L | 382.5 | 29.75 |
| Grow-out | mg/L | 25.05 | 6.12 |
| Finishing | mg/L | 5.57 | 1.71 |
| Overall Outlet | mg/L | 15 | 4 |

## COMPLETE SYSTEM

### WATER BALANCE

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total water inputs (usage + rainfall) | m3/day | 1073.6 | 1223.9 | 911.1 | 746.5 | 860.8 | 680.7 | 736.7 | 967.8 | 910.1 | 875.6 | 1066.0 | 960.2 |
| Total ouputs (irrigation + evaporation) | m3/day | 602.6 | 616.3 | 602.8 | 603.8 | 639.9 | 629.9 | 633.6 | 666.0 | 681.6 | 737.4 | 726.5 | 657.8 |
| % wastewater lost | % | 56% | 50% | 66% | 81% | 74% | 93% | 86% | 69% | 75% | 84% | 68% | 69% |
| Total volume remaining | m3/day | 471.0 | 607.5 | 308.3 | 142.7 | 220.9 | 50.8 | 103.0 | 301.7 | 228.6 | 138.2 | 339.5 | 302.4 |

### NUTRIENT BALANCE

**IRRIGATION AREA REQUIRED FOR NUTRIENT UPTAKE (BASED ON IRRIGATION VOLUMES FROM WATER BALANCE)**

| **N Area Required** | Unit | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | **MAX AREA REQ** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m2 | 111092.7 | 113282.7 | 111092.7 | 110296.4 | 116468.2 | 115074.5 | 115472.7 | 120848.2 | 123635.5 | 134386.4 | 132395.5 | 120649.1 | **134386.4** |
| **P Area Required** | Unit | | | | | | | | | | | | | |
| | m2 | 28690.97 | 29256.56 | 28690.97 | 28485.30 | 30079.24 | 29719.32 | 29822.15 | 31210.42 | 31930.27 | 34706.81 | 34192.64 | 31159.01 | |

Nitrogen limiting factor

## HATCHERY SYSTEM

### WATER BALANCE

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total water inputs (usage + rainfall) | m3/day | 404.6 | 401.0 | 304.9 | 131.1 | 73.8 | 46.7 | 50.0 | 68.1 | 73.3 | 112.8 | 185.7 | 258.7 |
| Total ouputs (irrigation + evaporation) | m3/day | 526.9 | 479.5 | 529.7 | 507.8 | 546.5 | 528.0 | 546.1 | 563.1 | 561.1 | 637.6 | 602.4 | 572.4 |
| % wastewater lost | % | 130% | 120% | 174% | 387% | 740% | 1130% | 1093% | 827% | 765% | 565% | 324% | 221% |
| Total volume remaining | m3/day | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

### NUTRIENT BALANCE

**IRRIGATION AREA REQUIRED FOR NUTRIENT UPTAKE (BASED ON HATCHERY VOLUMES)**

| **N Area Required** | Unit | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | **MAX AREA REQ** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m2 | 225705.4 | 282131.7 | 207404.9 | 219096.9 | 284673.5 | 230280.5 | 249089.3 | 326357.8 | 302973.9 | 273998.2 | 313649.1 | 244514.2 | **326357.8** |
| **P Area Required** | Unit | | | | | | | | | | | | | |
| | m2 | 17122.03 | 21402.54 | 15733.76 | 16620.71 | 21595.35 | 17469.10 | 18895.93 | 24757.53 | 22983.62 | 20785.53 | 23793.45 | 18548.86 | |

Nitrogen limiting factor

## GROW-OUT SYSTEM

### WATER BALANCE

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total water inputs (usage + rainfall) | m3/day | 786.4 | 870.8 | 651.0 | 482.6 | 523.5 | 409.0 | 442.4 | 582.2 | 551.5 | 548.6 | 688.6 | 659.3 |
| Total ouputs (irrigation + evaporation) | m3/day | 569.8 | 525.8 | 571.1 | 552.0 | 599.4 | 575.2 | 595.7 | 621.4 | 618.0 | 694.1 | 660.6 | 620.8 |
| % wastewater lost | % | 72% | 60% | 88% | 114% | 115% | 141% | 135% | 107% | 112% | 127% | 96% | 94% |
| Total volume remaining | m3/day | 216.6 | 344.9 | 79.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 28.0 | 38.5 |

### NUTRIENT BALANCE

**IRRIGATION AREA REQUIRED FOR NUTRIENT UPTAKE (BASED ON GROW-OUT VOLUMES)**

| **N Area Required** | Unit | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | **MAX AREA REQ** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m2 | 132727.3 | 165909.1 | 122109.1 | 128745.5 | 167236.4 | 135050 | 146331.8 | 191790.9 | 178186.4 | 160931.8 | 184325 | 143677.3 | **191790.9** |
| **P Area Required** | Unit | | | | | | | | | | | | | |
| | m2 | 30850.50 | 38563.13 | 28382.46 | 29924.99 | 38871.63 | 31390.39 | 34012.68 | 44578.98 | 41416.80 | 37406.23 | 42843.63 | 33395.67 | |

Nitrogen limiting factor

## FINISHING SYSTEM

### WATER BALANCE

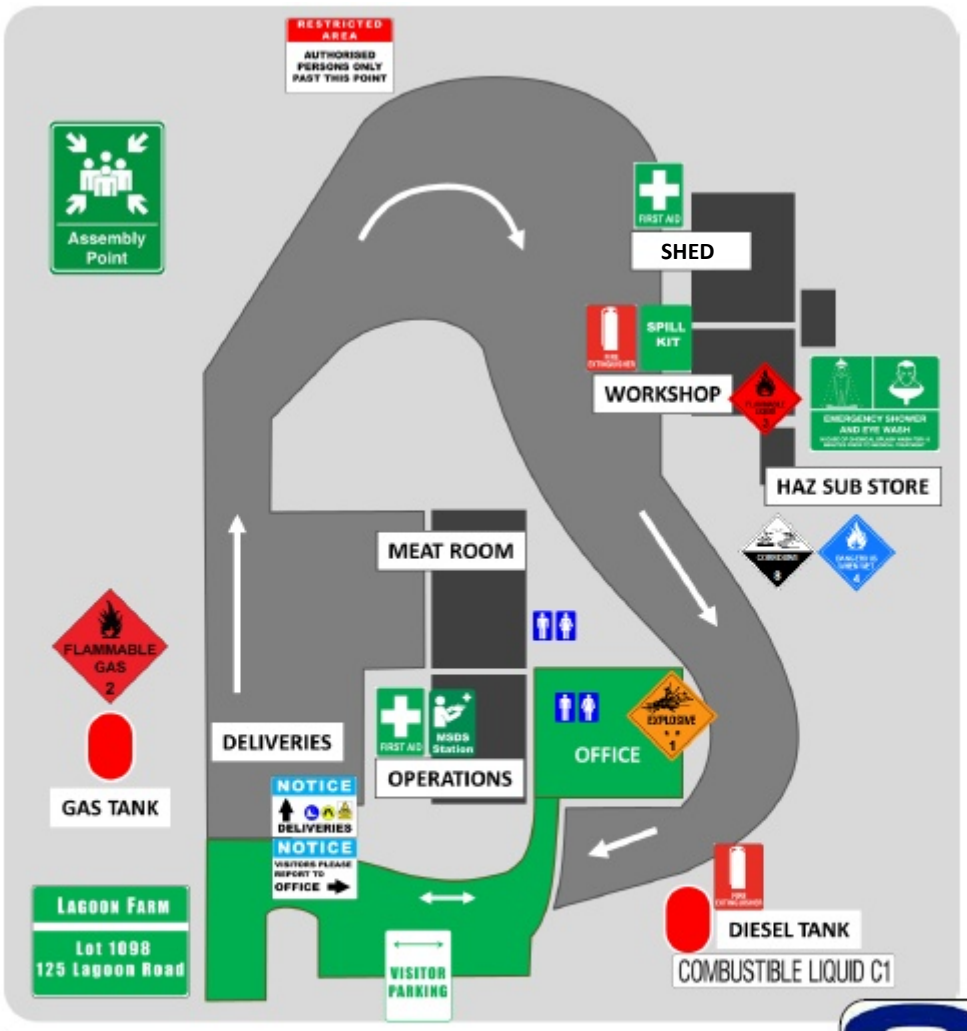
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total water inputs (usage + rainfall) | m3/day | 602.9 | 643.0 | 483.3 | 308.7 | 299.0 | 227.9 | 246.2 | 325.2 | 312.7 | 331.9 | 439.7 | 463.4 | |
| Total ouputs (irrigation + evaporation) | m3/day | 554.4 | 508.8 | 556.5 | 536.6 | 580.3 | 558.9 | 578.2 | 600.0 | 597.7 | 674.5 | 639.7 | 603.7 | |
| % wastewater lost | % | 92% | 79% | 115% | 174% | 194% | 245% | 235% | 184% | 191% | 203% | 146% | 130% | |
| Total volume remaining | m3/day | 48.5 | 134.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **MAX STORAGE REQ** |
| Storage requirement | m3/month | 1504.608 | 3758.441 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **5263.0** |

### NUTRIENT BALANCE

**IRRIGATION AREA REQUIRED FOR NUTRIENT UPTAKE (BASED ON FINISHING VOLUMES)**

| **N Area Required** | Unit | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | **MAX AREA REQ** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | m2 | 16500.65 | 20662.98 | 15162.76 | 16054.69 | 20811.64 | 16797.96 | 18210.18 | 23859.05 | 22149.53 | 20068.36 | 22967.13 | 17912.87 | **23859.1** |
| **P Area Required** | Unit | | | | | | | | | | | | | |
| | m2 | 4851.24 | 6074.98 | 4457.90 | 4720.13 | 6118.68 | 4938.65 | 5353.85 | 7014.63 | 6512.03 | 5900.16 | 6752.40 | 5266.44 | |

# APPENDIX E EMERGENCY SITE MAP


RESTRICTED AREA
AUTHORISED PERSONS ONLY PAST THIS POINT
Assembly Point
SHED
SPILL KIT
WORKSHOP
EMERGENCY SHOWER AND EYE WASH
HAZ SUB STORE
MEAT ROOM
FLAMMABLE GAS 2
GAS TANK
DELIVERIES
NSDS Station
OPERATIONS
OFFICE
EXPLOSIVE 1
NOTICE
DELIVERIES
NOTICE
VISITORS PLEASE REPORT TO OFFICE
LAGOON FARM
Lot 1098
125 Lagoon Road
VISITOR PARKING
DIESEL TANK
COMBUSTIBLE LIQUID C1
125 LAGOON ROAD
OPERATIONS MANAGER
0405 133 721
000
EMERGENCY

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