EPL302 Monitoring Report
Janamba Crocodile Farm

Reporting period: 1 June 2022 – 31 May 2023

PRI Group Pty Ltd

TABLE OF CONTENTS

Tables

Figures

ACRONYMS

ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
CFU	colony forming units
DO	dissolved oxygen
EC	electrical conductivity
EPL	Environment Protection Licence
JCF	Janamba Crocodile Farm
LOR	limit of reporting
MPN	Most probable number
NATA	National Association of Testing Authorities
NOx	nitrate NO_3 + nitrite NO_2
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
SWL	Standing water level
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids

1 INTRODUCTION

PRI Group Pty Ltd operate Janamba Crocodile Farm (JCF), located at 630 Anzac Parade, Middle Point in the Northern Territory (NT); location shown in Figure 1-1. Water quality and soil monitoring is undertaken at JCF to ensure that operations do not impact waterways downstream i.e. the Harrison Dam Conservation Area and the Adelaide River. This monitoring is also a requirement of Environment Protection Licence 302 (EPL302), issued to Croc Pac Pty Ltd (now PRI Group Pty Ltd) by the NT Environment Protection Authority (NT EPA) under the *Waste Management and Pollution Control Act.*

Monitoring Reports are required annually, as per Condition 57 of EPL302. These must be prepared in accordance with the NT EPA 'Guideline for Reporting on Environmental Monitoring'. Each report must include all requirements as set out in EPL302 Condition 58.

This particular Monitoring Report covers all water quality and soil monitoring undertaken for the reporting period starting 1 June 2022 and ending 31 May 2023 (herein referred to as the 'reporting period'). This is the updated or comprehensive Monitoring Report for EPL302 since its commencement in August 2021. PRI Group submitted a provisional Monitoring Report to the NT EPA by the due date of 31 May 2023 (PRI Group 2023a), which detailed the monitoring program with results provided as excel file. This report fills the gap of an assessment of results and discussion with respect to trigger values and compliance as per EPL 302.

1.1 Purpose and scope

This Monitoring Report is prepared in accordance with the following EPL302 conditions:

Condition 57

The licensee must complete and provide to the NT EPA a Monitoring Report, as prescribed by this licence, by 31 May each year.

Condition 58

The licensee must ensure that each Monitoring Report:

58.1 is prepared in accordance with the requirements of the NT EPA 'Guideline for Reporting on Environmental Monitoring';

58.2 includes a tabulation of all monitoring data required as a condition of this licence;

58.3 calculations for maximum total annual loads of Nitrogen and Phosphorus required as a condition of this licence;

58.4 reports on all trigger value exceedances and investigations required as a condition of this licence;

58.5 includes long term trend analysis of monitoring data to demonstrate any environmental impact associated with the activity over a minimum period of three years (where the data is available); and

58.6 includes an assessment of environmental impact from the activity.

1.2 EPL302 compliance monitoring and reporting

EPL302 authorises discharge to land using wastewater from the authorised discharge point, see Figure 1-2 ('irrigation source water'). The authorised discharge point is located in the centre of the farm, downstream of the wastewater treatment system and settling ponds, where all wastewater from farm operations is directed. From here, the water is pumped to two irrigation areas: one is situated in the eastern half of the property,

where it is irrigated onto fodder crops via a centre pivot. Water is secondly used to irrigate a sandalwood plantation on the western end of the property via a drip line system.

In order to monitor for potential environmental impacts from this activity, surface water, groundwater and soil monitoring at JCF is undertaken in accordance with Attachment A of EPL302 and all monitoring-related conditions of the licence; i.e. Conditions 41 to 46. The JCF *Irrigation Management Plan* (EcOz 2020) details the monitoring sites, physical (field) and laboratory parameters measured, sampling methods and procedures. Monitoring site locations are shown below in Figure 1-3 and detailed in Table 4-1. Parameters to be measured, monitoring frequency and trigger values, taken from Attachment A of EPL302, are outlined below in Table 4-2, Table 4-3, Table 4-4 and Table 4-5.

In addition to the above, the volumes and timing of irrigated water application must be recorded; as per EPL302 Condition 39.

1.2.1 Unauthorised discharge

Any off-site discharge of wastewater from JCF is a non-compliance against Conditions 27, 35 and 36 of EPL302. The situation currently is that during the wet season, the volumes of water collected in the lagoons of JCF are in excess of what can be irrigated, and for extended periods, depending on rainfall, water flows off-site at the 'property outlet' (see Figure 1-3). From here, the water then flows into Harrison Dam. This passive discharge contains a component of farm wastewater, along with storm water from the breeding lagoon area of JCF. Incidences of this off-site discharge must be recorded as a non-compliance as per Condition 49, and reported to the NT EPA, as per Condition 50 and 51.

For the unauthorised discharge during the 2022/2023 wet season, the NT EPA was informed on 12 January 2021 of detection of the discharge on 03 January 2023. A non-compliance report in accordance with Condition 51 was submitted on 31 May 2023, summarising the period of discharge (03 January 2023 to 02 April 2023), and volume per month as measured through a V-notch weir and total volume discharged, which was approximately 80.8 ML (PRI Group 2023b).

The water quality of this unauthorised discharge was measured, with results shown in Table 5-4 and assessed in section 5.3 of this report.

Corrective actions to reduce the volume of unauthorised discharge in future wet seasons currently include increasing the extent of irrigation areas, and decreasing the nutrient load at the discharge point, as described by PRI Group (2023b).

.

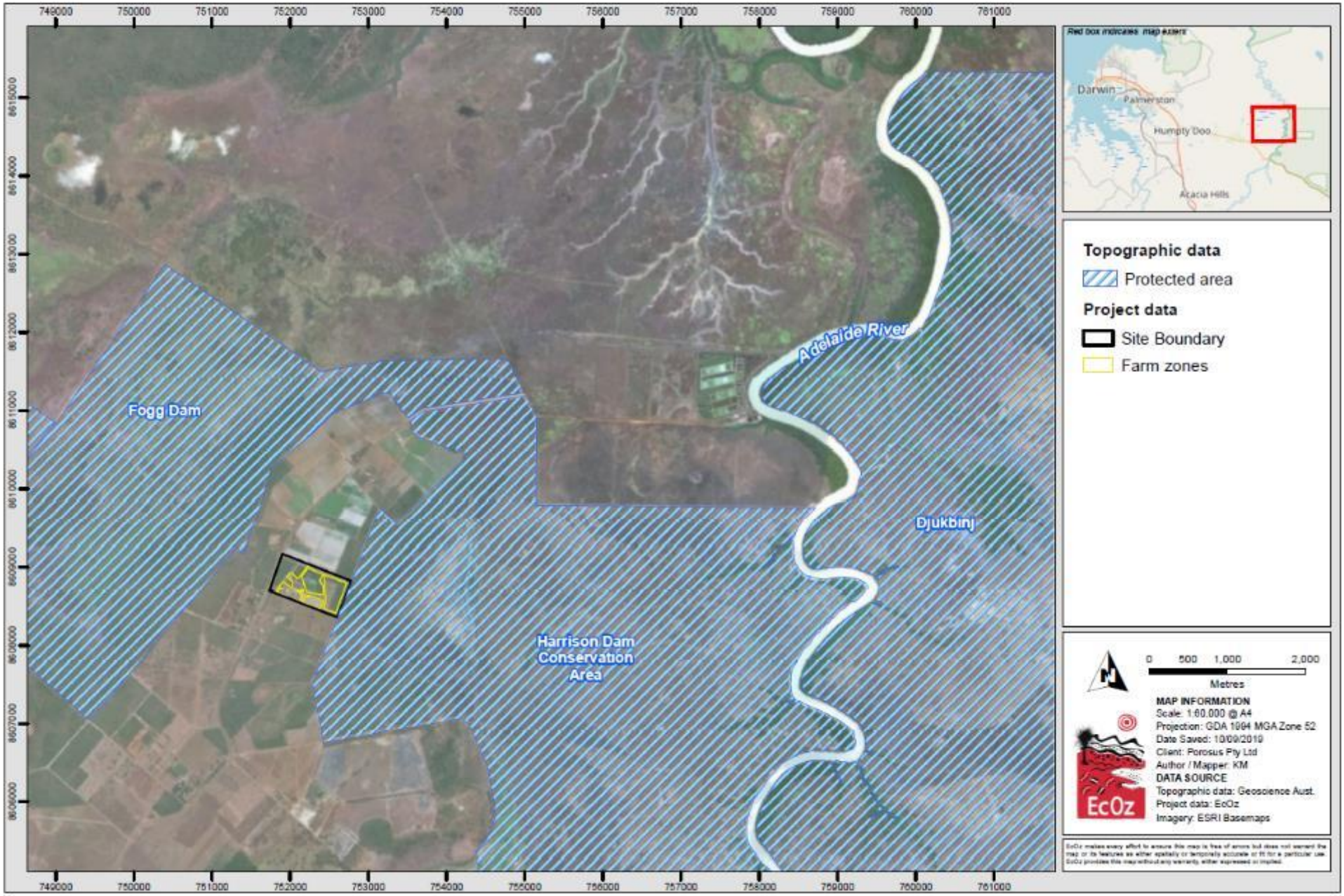

Figure 1-1. Map of Janamba Crocodile Farm location

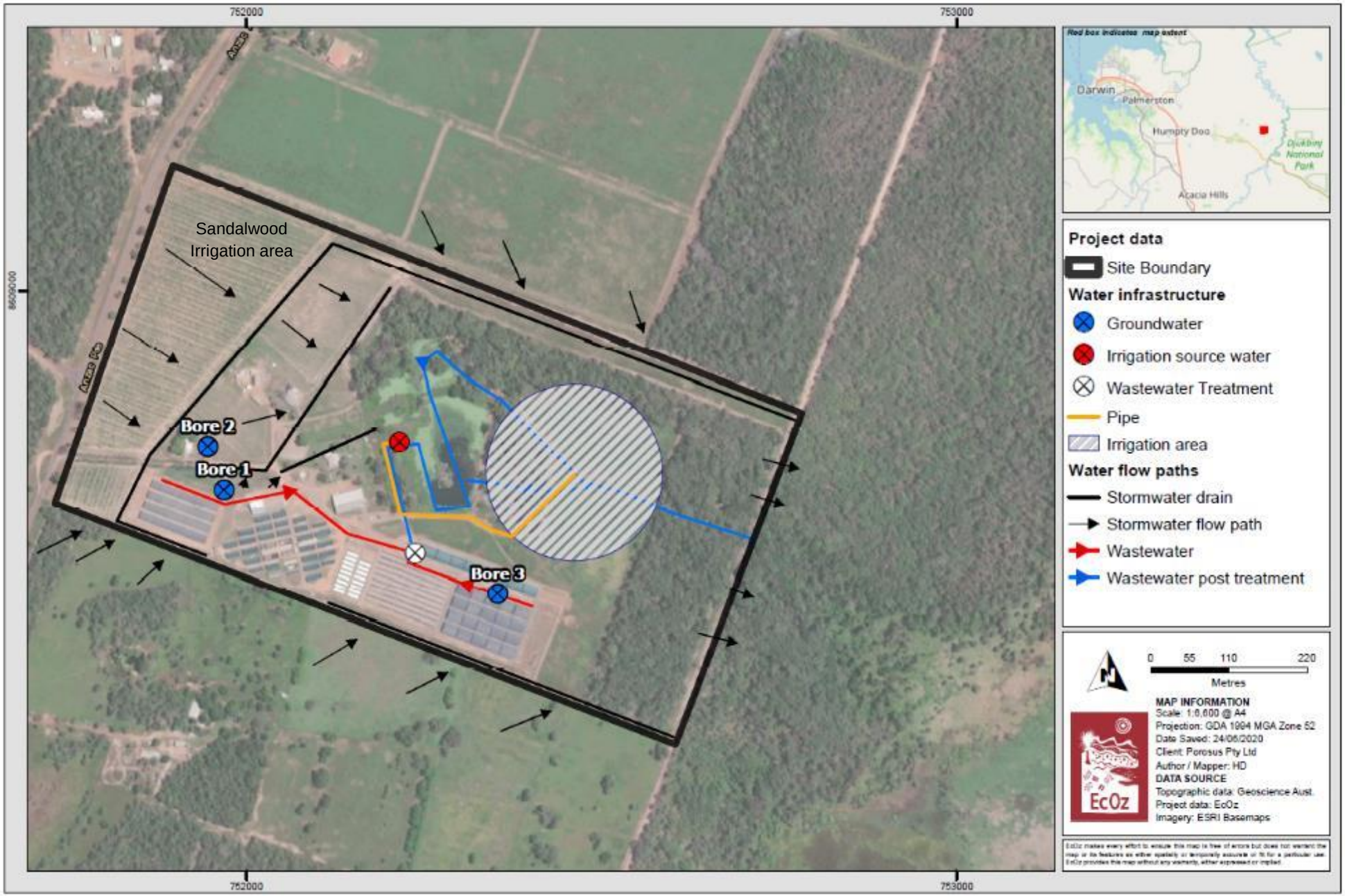

Figure 1-2. Water infrastructure, water flow paths and irrigation areas at Janamba Crocodile Farm

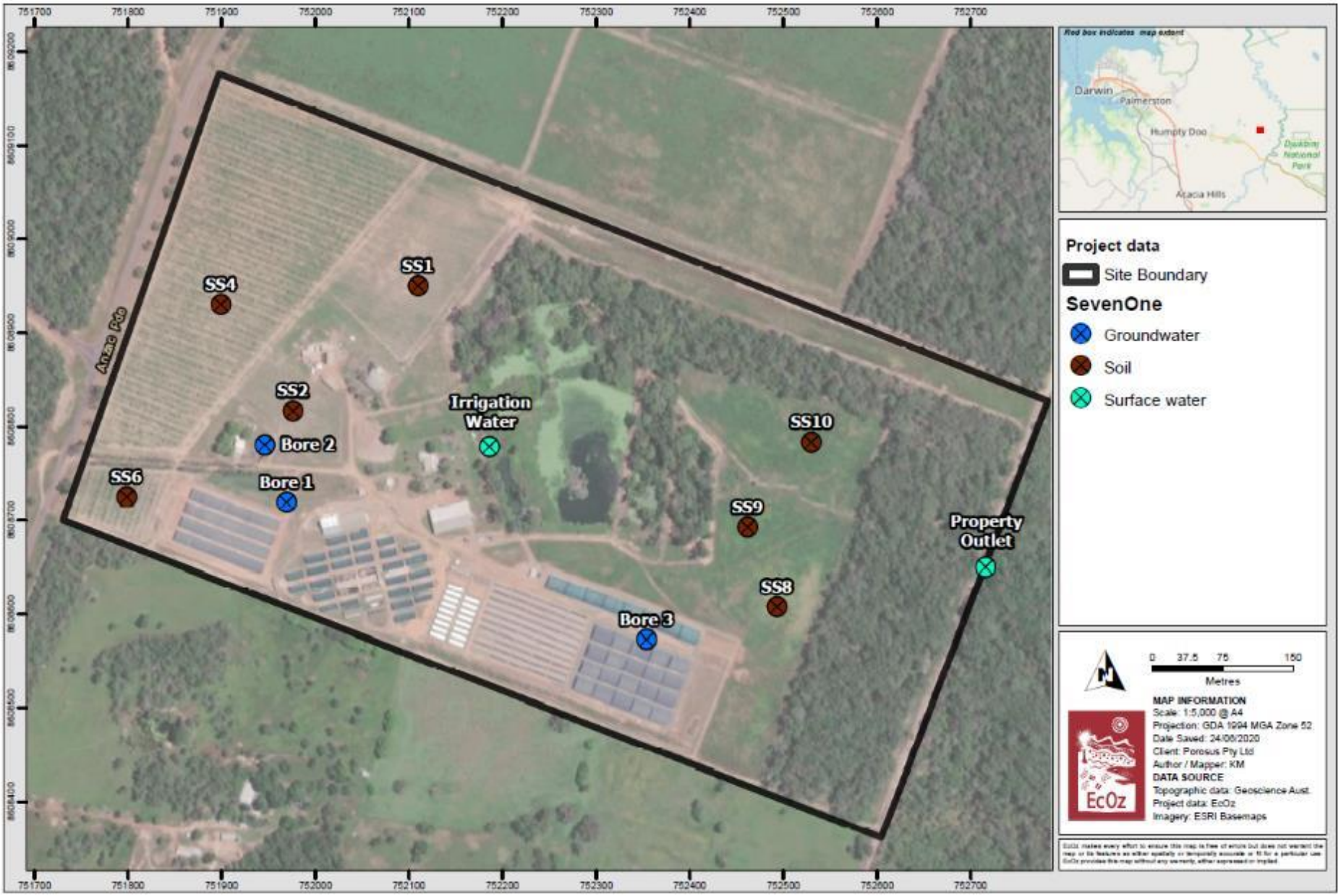

Figure 1-3. Monitoring site locations on Janamba Crocodile Farm

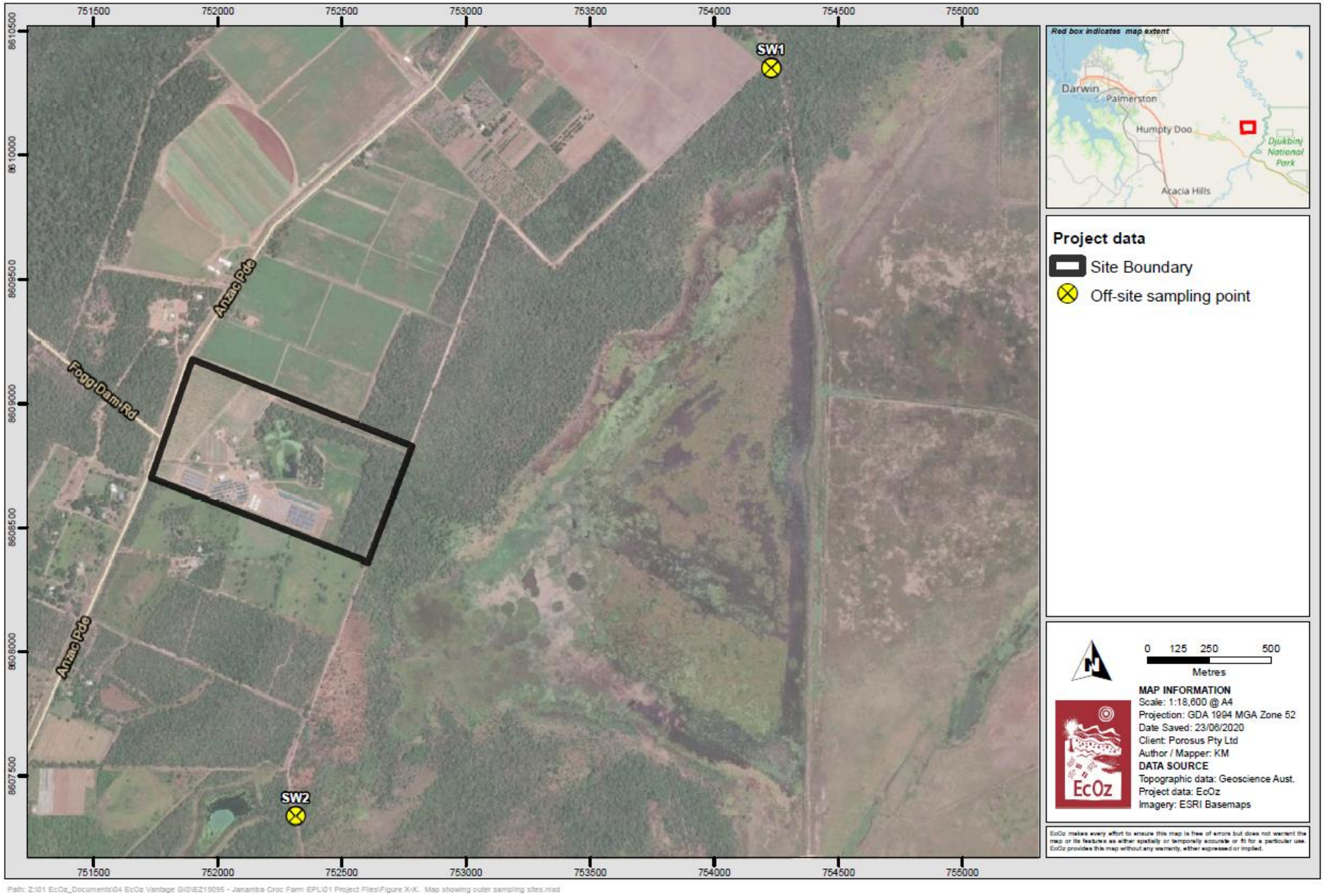

Figure 1-4. Surface water monitoring locations outside the property

2 JCF OPERATIONS OVERVIEW

2.1 Environmental setting

The region has 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 Middle Point (station number No. 14041). Average annual rainfall recorded at this station is 1,682 mm, with the highest rainfall occurring in January and the lowest in May, June and July (Table 2-1). Over 84 % of annual average rainfall falls between November and March. The average annual regional evaporation is 2,000 mm and exceeds the average annual rainfall. Evaporation is highest in October and lowest in January to March.

Table 2-1. Average rainfall and evaporation (taken from BoM Station No. 14041)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	484	379	100	131	0	1	1	0	4	85	217	277
Evaporation (mm)	143	124	150	158	165	168	175	183	210	215	195	174
Temperature (°c)	33.5	32.4	35.2	35.7	34.5	32.6	30.9	34.8	37.2	36.6	36.1	34.5

JCF lies within the Adelaide River catchment, at the top of the sub-catchment area (water on the opposite side of Anzac Parade to JCF, flows to the west towards Fogg Dam which is categorised as another sub-catchment area). Surface water from the operational areas of JCF flows in a south-easterly direction from Anzac Parade towards Harrison Dam.

The land surrounding JCF includes privately-owned lots zoned for horticulture to the north and south (including Koolpinyah Station), where a number of bores exist and groundwater is utilised. To the west of the site on the opposite side of Anzac Parade there is a school and a scientific research village. Surrounding land users (private and commercial) all utilise equipped production bores for water supply.

Directly east of JCF is the Harrison Dam Conservation Area, while north-west is Fogg Dam Conservation Area; both of these conservation areas are supported by groundwater during the dry season. The property is within the Adelaide River coastal floodplain Site of Conservation Significance (NR Maps). Several nearby wetlands including Fogg and Harrison Dams are listed in the Directory of Important Wetlands (NR Maps).

The site contains land units that are characterised by well-drained soils, which is beneficial when considering the site for irrigation purposes. Whilst land unit mapping indicates the presence of hydrosols, the irrigation area is not seasonally inundated or saturated and current and historical soil data (obtained from NR maps) for the irrigation area indicate the soils are predominately well-drained, sandy loam in texture and have moderate to high permeability.

2.2 Farm operations

The crocodile production process at JCF is summarised as follows:

1. Eggs are collected from breeding pens and lagoons (in addition to wild-collected eggs) and are assessed and cleaned in egg laboratory, with viable eggs transferred to the incubator room

2. Animals hatch in the incubator then are immediately transferred to hatchling pens
3. When animals are about one-year-old, they are transferred to grow-out pens
4. Animals approaching a size suitable for market 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 a separate facility for further processing.

JCF harvests 130 animals per week for off-site processing to produce raw crocodile skins, meat products and other saleable by-products.

2.3 Water supply

JCF has a groundwater extraction entitlement of 600 ML/year (Water Extraction Licence KD17) obtained from three bores (see Table 2-2 and Figure 1-2). The aquifer utilised is in the Koolpinyah Dolomite Formation. On average, Janamba uses approximately 50 ML of water per month predominately from bores 1 and 3. All the production bores are equipped and therefore their standing water levels (SWLs) is difficult to measure due to the pump obstructing the deployment of a dip meter.

Table 2-2. Groundwater bore details

Site Name	Bore No.	Year of completion	Depth (m)	SWL (m)	Yield (L/s)	Average monthly extraction (ML)
Bore 1	RN040609	2018	45	6	20	25
Bore 2	RN027100	1990	42	6	20	0
Bore 3	RN038956	2015	40	4	10	25

The primary use of water on site is for regular flushing of the animal pens to maintain hygiene and health of the animals. The bores also supply water to the office and site facilities. Bore 1 supplies water to the grower pens, hatchery and office buildings, whilst bore 3 supplies water to the finishing pens. On average, the water usage at JCF is estimated at 1,600 KL/day.

2.4 Wastewater flows, treatment and irrigation

Bore water is pumped through the hatchery, grower and finishing pens, and the effluent from each stage discharges into a concrete-lined drainage system. The drainage system is currently directed through a wastewater treatment system that consists of a filtration and screening process to remove grit and sludge (Spirac and drum filters). The treated wastewater then flows into a series of interconnected lagoons which are also utilised for housing breeding crocodiles to supply the farm with eggs. The treated wastewater enters the 'first settling pond', which then flows through into the main breeding lagoons. As the lagoons are all interconnected, breeding crocodiles inhabit all areas. This flow of wastewater through the lagoons facilitates a bio-remediation process to reducing the nutrient and microbial levels in the wastewater.

Earthen drainage lines result in excess water from the lagoons (predominately during the wet season) flowing towards the eastern boundary and ultimately discharging off-site.

Surface water from the operational areas of JCF flows in a south-easterly direction from Anzac Parade towards Harrison Dam. JCF have constructed drainage channels on the property boundaries to divert storm water run on from neighbouring properties around the active farm areas and discharging from the eastern boundary towards Harrison Dam (Figure 1-2). Runoff from the farm areas flows as sheet flow towards the eastern boundary and into the Harrison Dam Conservation Area.

Over time, overflows from the breeding lagoon have caused a drainage channel to form from the lagoon towards the eastern boundary. JCF have constructed a discharge outlet on the property boundary to dissipate surface water flows from site. From the property discharge outlet, there are no defined channels or watercourses that the surface water flows into. Surface water flows as sheet flow into the Harrison Dam Conservation Area, which is a wide expanse of waterholes and wetlands. Wet season rainfall dilutes wastewater as it flows off-site, which assists in the bioremediation process.

The sandalwood irrigation area was established in August 2018 and the area increased in 2019 to a total of 9.42 ha. Water for irrigation is extracted from the breeding lagoon ponds post treatment. Depending on the season, between 5,000 KL and 30,000 KL of water is used for irrigation per month through a drip line system.

The eastern irrigation area of 4.85 ha is being prepared for plantation with pasture grass irrigated using a pierce centre pivot system. On average, around 3,786 KL water per month was applied to this irrigation area. Irrigation of the vegetation was halted from December 2020 to April 2021 during the wet season. At present, the paddock is ploughed and irrigation will be performed for two weeks prior to seeding, which is anticipated for the first half of August 20213. In the 2022/23 wet season, the existing vegetation (grasses and groundcover plants) was irrigated and no crop harvested.

3 RAINFALL AND DISCHARGES

3.1 Rainfall

Figure 3-1 shows monthly rainfall totals for the reporting period taken from the Middle Point BoM station No. 14041. Average monthly rainfall totals are also shown for comparison. Rainfall during October and November 2022 was above average. Rainfall during January 2023 was below average. For all other months during the reporting period, rainfall was around average. The total rainfall for 2022/23 was below average.

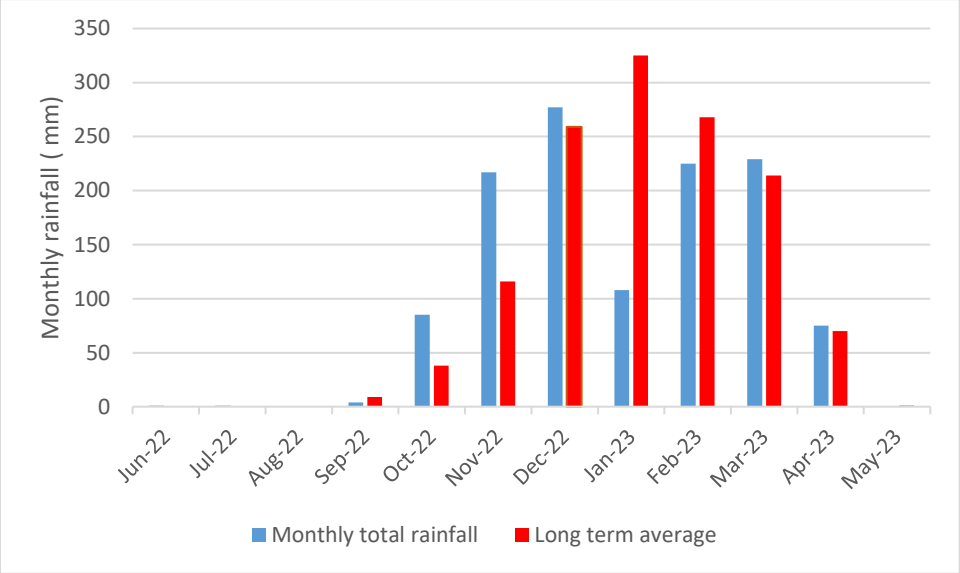

Figure 3-1. Monthly rainfall totals June 2022 to May 2023 (Middle Point BoM station No. 14041)

3.2 Reporting period discharge details

Table 3-1 outlines the discharges that occurred to land i.e. irrigation applied to the two irrigation areas using water pumped from the authorised discharge point. Irrigation was undertaken during the late dry season / early wet season period, stopping in the pasture crop from October 2022 to April 2023 and on the sandalwood from January 2023 to April 2023, when irrigation was not appropriate given soils in the irrigation areas were saturated.

Table 3-1. Irrigation discharges during reporting period 1 June 2022 – 30 April 2023

Month	Water reuse sandalwood project (ML)	Water reuse pivot irrigation (ML)	
Jun 22	26.09	0	
Jul 22	24.9	4.1	
Aug 22	17.6	21.1	
Sept 22	13.8	6.3	
Oct 22	15.5	0	
Nov 22	3.7	0	
Dec 22	17.9	2.11	
Jan 23	O	0.82	

Month	Water reuse sandalwood project (ML)	Water reuse pivot irrigation (ML)	
Feb 23	0	5.68	
Mar 23	0	0	
Apr 23	4.8	0.03	
Total	**124.6**	**40.35**	

4 MONITORING UNDERTAKEN

During the reporting period, monitoring was undertaken as per EPL302 requirements using the methods outlined in the JCF *Irrigation Management Plan* (EcOz 2020) and summarised in the following.

4.1 Monitoring sites

Details for surface water, groundwater and soil monitoring sites as listed in EPL302 Appendix A are shown in Figure 1-3 and Figure 1-4 and detailed below in Table 4-1.

Table 4-1. Surface water, groundwater and soil monitoring site details

Site ID	Context and purpose	GPS Coordinates	
		Latitude	Longitude
Surface Water Sites			
Irrigation Source	'Authorised discharge point' listed in EPL302. Located centrally in JCF property. All wastewater from farm operations flows via a wastewater treatment system into a settling lagoon and then to this point. Represents water applied to the irrigation areas occupying the north eastern as well as the north western portions of JCF.	-12.57457	131.32108
Property outlet	Site where outflow from the breeding lagoons leaves the property. During the wet season, this location presently becomes an unauthorised discharge point.	-12.57576	131.32594
SW1	Harrison Dam northern inflow monitoring site – providing comparison surface water quality information.	-12.55997	131.33980
SW2	Harrison Dam southern inflow monitoring site – providing comparison surface water quality information.	-12.59724	131.32234
Groundwater Bores			
Bore 1	RN040609, used to supply water to farm operations (grower pens, hatchery, office buildings).	-12.575289	131.31912
Bore 2	RN027100, mostly unused.	-12.574767	131.318858
Bore 3	RN038956, used to supply water to farm operations (finishing pens).	-12.576533	131.322636
Soil Sites			
SS 1	Soil sites are spread across the two irrigation areas.	-12.573196	131.320367
SS 2		-12.574417	131.619148
SS 4		-12.573395	131.318432
SS 6		-12.575261	131.31752
SS 8		-12.576264	131.323923
SS 9		-12.575499	131.323628
SS 10		-12.574680	131.324250

4.2 Monitoring frequency, parameters and trigger values

Table 4-2, Table 4-3, Table 4-4 and Table 4-5 list the parameters to be measured at each site, the sampling frequency and trigger values currently specified in EPL302 Attachment A.

Table 4-2. Monitoring program and trigger values for irrigation water

Monitoring site	Parameter	Sampling frequency	Trigger value
Authorised discharge point (irrigation source water) Latitude: -12.57457 Longitude: 131.32108	pH	Monthly when discharging and quarterly when not discharging	6 – 9[1]
	EC (electrical conductivity)		1,300 µs/cm[1]
	Total P (phosphorus)		12 mg/L[1]
	Total N (nitrogen)		125 mg/L[1]
	E. coli, Enterococci, Total coliforms		1,000 cfu/100mL (fodder) [1]
	Cations and anions (Ca, Mg, Na, K, SO_4, Cl, CO_3 + HCO_3)		N/A

[1]*Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 3 – Chapter 9 – Primary Industries (ANZECC, 2000)*

Table 4-3. Monitoring program and trigger values for groundwater sites

Monitoring sites	Parameter	Sampling frequency	Trigger value
Bore 1, Bore 2 and Bore 3	Standing water level (SWL)	Monthly	N/A
	pH	Quarterly	7.0 – 8.5[1]
	EC		400 µs/cm[1]
	Total P		Any increase from previous monitoring round
	Total N		
	E. coli, Enterococci, Total coliforms		
	Cations and anions (Ca, Mg, Na, K, SO_4, Cl, CO_3 + HCO_3)		N/A

[1] *Darwin Harbour Water Quality Objectives for groundwater (2010)*

Table 4-4. Monitoring program and trigger values for surface water sites

Monitoring sites	Parameter	Sampling frequency	Trigger value
Property outlet, SW1* & SW2*	pH	3 times during the wet season (start, during, end)	6.0 – 7.5[1]
	EC		200 µs/cm[1,2]
	Total P		0.01 mg/L[1,2]
	Total N		0.23 mg/L[1,2]
	E. coli, Enterococci, Total coliforms		Any increase from previous monitoring round

**Trigger values not applicable for SW1 & SW2*

[1] *Darwin Harbour Water Quality Objectives for freshwater rivers and streams*

[2] *If the concentration at SW1 is greater than the trigger value then the concentration at SW1 becomes the trigger value for that monitoring round*

Table 4-5. Monitoring program and trigger values for soil sites

Monitoring sites	Parameter	Sampling frequency	Trigger value*
SS1, SS2, SS4, SS6, SS8, SS9 and SS10	pH	Annually	6 – 8
	EC		Any increase from the previous monitoring round
	Total P		
	Total N		
	E. coli, Enterococci, Total coliforms		

** B horizon results*

4.3 Sampling procedures

All sampling is undertaken in accordance with the JCF *Irrigation Management Plan* (EcOz 2020) and the following standards and guidelines:

Australian/New Zealand 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), Standards Australia, New South Wales.

Australian Standard/New Zealand Standard on Water Quality Sampling - *Part 4: Guidance on sampling from lakes, natural and manmade* (AS/NZS 5667.4:1998), Standards Australia, New South Wales.

Australian/New Zealand Standard on Water Quality Sampling - *Part 6: Guidance on sampling of rivers and streams* (AS/NZS 5667.6:1998), Standards Australia, New South Wales.

Australian Standard/New Zealand Standard on Water Quality Sampling – *Part 10: Guidance on sampling of waste waters* (AN/NZS 5667.10:1998), Standards Australia, New South Wales.

Australian/New Zealand Standard on Water Quality Sampling – *Part 11: Guidance on sampling of groundwater* (AN/NZS 5667.11:1998), Standards Australia, New South Wales.

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), Standards Australia, New South Wales

ANZECC & AMRCANZ 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 (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.

ANZECC & AMRCANZ 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 (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Canberra.

ANZG (2018): Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia.

Department of Environment and Conservation (2004): *Use of Effluent by Irrigation; Environmental Guidelines*, Department of Environment and Conservation (DEC), New South Wales Government, Sydney.

Water sampling was carried out by JCF staff, who have received on-site training in sampling methods from EcOz Environmental Consultants except for sampling performed in September 2020, which was the training date and data were jointly collected by EcOz and JCF staff.

Soil sampling was undertaken by EcOz as well as JCF staff, who have received on-site training in sampling methods from EcOz Environmental Consultants.

All laboratory samples were collected into ALS Laboratory-supplied sample bottles/jars; some of which contain preservative where required. Once collected, these samples were kept cold in an esky with ice bricks until dispatched to the ALS shopfront on the same day as sampling in order to meet holding times.

All surface water monitoring sites were sampled into a laboratory-supplied sample bottle. Field parameters (i.e. pH, temperature, dissolved oxygen (DO) and electrical conductivity (EC)) were measured only in September 2022 when a water quality metre was available.

All groundwater bores were equipped with a pump and thus standing water levels (SWL) were measured irregularly. The equipped bores were turned on and the water run for at least 10 min and until field parameters stabilised. Once this occurred the lab samples were collected directly into the lab-supplied bottles. Field parameters were only recorded in September 2022 when a water quality metre was available.

Soil samples were collected from the B horizon (around 0.4 to 0.5 m below ground surface) using a mechanical augur which was decontaminated between each sample site.

Surface water, groundwater and soil field parameters and observations were recorded on a dedicated *Field Data Sheet*, developed to ensure all EPL302 information requirements as per Condition 46 were collected.

Field and laboratory results are stored in an Excel database updated and maintained by JCF with EcOz also maintaining a database.

Field data sheets (scanned copies) and laboratory documentation are stored in an online filing system maintained by EcOz (M-Files). JCF also maintain copies of all laboratory documentation.

4.4 Monitoring undertaken during the reporting period

Table 4-6 lists the monitoring undertaken during the reporting period. Compliance against EPL302 monitoring requirements is outlined.

Table 4-6. Monitoring undertaken during the reporting period

Site ID	Frequency required	Dates sampled	Compliance with sampling frequency	Compliance with parameters measured
Irrigation Source	Monthly during discharge, quarterly when not discharging	12/05/22 06/06/22 06/07/22 08/08/22 05/09/22 05/10/22 03/11/22 20/12/22 05/01/23	Compliant except missed Feb, March and April	Compliant
Property outlet SW1* SW2*	Three times during wet season, start, mid and end		Compliant for the property outlet site, only one sample date for SW1 and SW2.	Compliant
Bore 1 Bore 2 Bore 3	Standing Water Level (SWL) monthly; Water quality quarterly	12/05/22 06/06/22 6/07/22 08/08/22 5/09/22 05/10/22	Compliant only two of the three bores were measured . All bores are equipped and thus SWL measurements were irregular in 2022/23.	Compliant

Site ID	Frequency required	Dates sampled	Compliance with sampling frequency	Compliance with parameters measured
		03/11/22 20/12/22 05/01/23		
SS 1 SS 2 SS 4 SS 6 SS 8 SS 9 SS 10	Annually	2/7/2023	Compliant	Compliant

5 RESULTS AND DISCUSSION

5.1 Authorised discharge point

Table 5-2 provides the water quality results for all sampling undertaken during the reporting period of the authorised discharge point (irrigation source). pH, EC, TN and TP were all below the trigger values listed in EPL302 Appendix A, Table 1.

Exceedances in the bacterial parameters were recorded throughout the reporting period. Total coliforms were always well above the guideline value with concentrations ranging between 5100 CFU/100mL and 4600000 CFU/100mL, the latter being the highest concentration recorded since monitoring started (please refer to Appendix A). *E. coli* was mostly above the guideline with concentrations ranging between 160 CFU/100mL and 280000 CFU/100mL. Enterococci ranged between 8 CFU/100mL and 28000 CFU/100mL. Exceedances in enterococci concentrations were recorded in July, October, November and December 2022.

Overall, the results obtained indicate that bacterial concentrations are high in the settling lagoon (where irrigation water is sourced) and that natural disinfection from UV light is mostly ineffective. It is worth noting that the bacterial guidelines are for livestock (fodder). The current process is to irrigate the pasture grass, then harvest and use it as fodder. While it is recognised that contamination from crop irrigation can lead to disease outbreaks, this is usually linked to contamination with human or livestock faeces. Crocodiles are reptiles and as cold-blooded animals carry a different composition of faecal flora than the intended warm-blooded livestock consumers. This could be a risk reducing factor. On the other hand, crocodiles are recognised for their strong immune system, which could mean that the bacterial flora present in their faeces might pose a greater risk for infection of livestock with less strong immune systems.

Overall, the concentrations of the pathogen indicator *E. coli* was mostly high in the irrigation water and consideration might be given to process the crop in a way that would reduce bacterial numbers prior to using as fodder, for example drying in the ambient high UV conditions. In any case, the third person farmer harvesting the crop needs to be made aware of the high bacterial numbers in the irrigation water. There was no fodder production in 2022/23 and thus no risk of potential infection of animals via the pasture grass.

The sandalwood irrigation area is much larger than the pasture irrigation area and greater volumes of water are irrigated there. As this crop is not to be used for consumption, bacterial concentrations should not pose a problem.

.

5.2 Groundwater bores

SWLs are difficult to measure in equipped bores and thus records of SWLs for this reporting period are somewhat irregular (Table 5-1). The data show drawdown over the dry season and recharge throughout the wet season. These data will serve as baseline for the update of the conceptual site model.

Table 5-1. Standing water levels (m from top of casing) in groundwater bores

Date	Bore 1	Bore 2	Bore 3
May 22	-	-	-
June 22	5.3	5.2	7.5
July 22	6.5	6.14	8.8
August 22	-	-	-
Sept 22	6.9	7	9.5
Oct 22	7.9	8	7.6
Nov 22	8.2	8.3	7.9
Dec 22	6.2	6.6	6.6
Jan 23	4.2	4.2	5.9
Feb 23	6.7	4.9	6.3
March 23	3.9	3.4	6.3
April 23	5.7	5.9	6.6

Table 5-3 provides the groundwater quality results for all sampling undertaken during the reporting period. Sampling of Bore 2 was not undertaken during the reporting period due to…

pH and EC were mostly compliant with their respective trigger values, except for an EC exceedance recorded at Bore 1 in April 2023 (489 µg/L). The EC exceedance was only slightly above the trigger value (400 µg/L) and as such, it is not a source of concern. The upcoming sampling will be used to assess whether this might be the beginning of an increase in EC.

There were some TN and TP exceedances at Bores 1 and 3, where concentrations increased in comparison to the previous monitoring round. These concentrations decreased during the following monitoring round and as such, an increasing trend was not evident.

Exceedances in total coliforms were recorded at Bore 1 (May, September and November 2022, and February, March and April 2023) and Bore 3 (August, October and November 2022, and April 2023). Most of these exceedances are not likely associated with faecal contamination as E. Coli and enterococci were mostly below the laboratory limit of reporting (1 CFU/100mL).

In November 2022, the highest concentration of total coliforms, E. Coli and enterococci recorded since monitoring started was reported at Bore 1. These high concentrations and the detection of E. Coli and enterococci are indicative of faecal contamination, which is potentially caused by the infiltration of water contaminated with animal faeces into the groundwater system. Concentrations decreased to less than 1 CFU/100mL in the following months and hence there is no increasing trend apparent. Enterococci and E. coli were not detected at Bore 3 between November 2022 and April 2023. This bore is downgradient (based on the topography of the site and SWL) from Bore 1 and as such, the results are potentially indicating a limited migration of the contamination. However, a better understanding of the aquifer and sampling of more bores downgradient from Bore 1 would be required to better delineate the contamination extent

5.3 Surface water sites

Table 5-4 provides the surface water quality results for all sampling undertaken during the reporting period. The EPL302 trigger values only apply to the property outlet (or property discharge) location. The Sampling were done through the v-notch weir located on the eastern side of the farm in January, March and April 2023. Samples were collected during the discharges and as such, these results will be assessed against the guidelines. The two stream sites outside of the property SW1 and SW2 provide information on the background water quality in the vicinity of JCF.

pH and EC were always above the EPL302 guideline value at the v-weir, except for pH in January. Sites SW1 and SW2 were always below the guidelines for both parameters, indicating that the water flowing out of JCF was of poorer quality.

The bacterial concentrations are assessed in order to investigate the establishment of an increasing trend at the property outlet. E. Coli and total coliforms increased at the v-weir in March 2023 with respect to the January 2023 results. However, concentrations were lower in April 2023. Enterococci concentrations were also higher in January and April 2023 than in the previous months (February 2022 and March 2023 respectively). Further monitoring will be required to determine any increasing trend in the Enterococci concentration.

As shown in Appendix A, bacterial concentrations were significantly higher at the property discharge outlet site than at SW1 and SW2 during the reporting period.

All TN and TP concentrations at the property discharge site were above the trigger concentration. The TN concentrations ranged between 3.20 mg/L and 6.50 mg/L, while TP was between 1.11 mg/L and 1.58 mg/L. As shown in Appendix A, the TN concentration at the property discharge outlet in April 2023 is the highest recorded since 2016.

TN and TP were also above the guidelines at the SW1 and SW2 sites. However, these concentrations were lower than those recorded at the property discharge outlet site. This unauthorised discharge of water containing increased nutrient concentrations would contribute to nutrient enrichment in the receiving environment, which is Harrison Dam. However, it is likely that the nutrient concentrations in this wetland can be naturally seasonally high towards the end of the dry season (Schult & Welch 2006).

5.4 Soils

Table 5-5 provides the soil monitoring results for the reporting period i.e. the annual sampling undertaken in February 2023.

pH was frequently acidic and below the trigger value range at five of the eight sites during January 2021. Based on historical data, the results obtained during this monitoring round are most likely indicative of the natural characteristics of the soil.

EC concentrations were all lower than those recorded in 2022 and ranged between 35 µS/cm and 94 µS/cm.

TN concentrations increased at SS4, SS6 and SS10, while TP increased at SS6, SS8, SS9 and SS10. More data will be required to determine any increasing trend.

Higher concentrations of total coliforms and E. coli were recorded in samples collected at SS4 in 2023 than in those from 2022. Enterococci concentrations at SS4, SS6 and SS9 also increased in this monitoring period. More data will be required to determine any increasing trend in the concentration of these bacteria at the soil sample sites previously mentioned.

Table 5-2. Authorised discharge point (irrigation source) water quality monitoring results for the reporting period
Concentrations exceeding EPL302 trigger values for irrigation water highlighted in red

Site ID	Date	Water Type	pH	EC	TN	TP	Faecal Coliforms	E.coli	Total coliforms	Enterococci
				µS/cm	mg/L	mg/L	CFU/100 mL	CFU/100 mL	CFU/100 mL	CFU/100 mL
Irrigation water EPL302 trigger values			6.0-9.0	1300	125	12	1000	1000	1000	1000
Irrigation	6/6/2022	Irrigation	7.82	423	6.8	1.55		1500	5100	190
Irrigation	7/6/2022	Irrigation	7.35	343	5.2	1.02		3900	2600000	5600
Irrigation	8/8/2022	Irrigation	7.83	383	5.1	1.08		590	210000	190
Irrigation	9/5/2022	Irrigation	7.48	380	7.5	1.41		2200	24000	230
Irrigation	10/5/2022	Irrigation	7.63	554	22.9	3.14		410000	580000	28000
Irrigation	11/3/2022	Irrigation	7.69	653	28.5	3.65		280000	4600000	12000
Irrigation	12/20/2022	Irrigation	7.84	378	-	-		7600	45000	5100
Irrigation	1/5/2023	Irrigation	6.70	202	9.1	0.42		160	19000	11
Irrigation	2/21/2023	Irrigation	6.86	240	9.3	1.08		180	25000	110
Irrigation	3/15/2023	Irrigation	6.81	140	1.2	0.12		550	15000	8
Irrigation	4/19/2023	Irrigation	7.13	242	5.8	1.04		12000	220000	610

Table 5-3. Groundwater quality monitoring results for the reporting period
Concentrations outside EPL 302 trigger values for groundwater highlighted in red

Site ID	Date	Water Type	pH	EC	TN	TP	Faecal Coliforms	E.coli	Total coliforms	Enterococci
Groundwater EPL302 trigger valu			7.0-8.5	400	any increase from	any increase from	any increase from	any increase from	any increase from	any increase from previous
Bore 3	6/6/2022	Bore	7.75	314	0.3	<0.01		<1	<1	<1
Bore 3	7/6/2022	Bore	7.35	256	0.3	0.05		~<1	~1	<1
Bore 3	8/8/2022	Bore	7.60	274	0.40	0.02		<1	~4	<1
Bore 3	9/5/2022	Bore	7.57	264	0.4	<0.01		<1	<1	<1
Bore 3	10/5/2022	Bore	7.86	296	0.3	0.11		2	~5	<1
Bore 3	11/3/2022	Bore	7.93	259	0.3	0.12		<1	11	<1
Bore 3	12/20/2022	Bore	7.92	260	-	-		<1	~1	<1
Bore 3	1/5/2023	Bore	7.62	316	0.4	0.03		<1	~2	<1
Bore 3	2/21/2023	Bore	7.31	278	0.8	0.01		<1	~1	<1
Bore 3	3/15/2023	Bore	7.75	283	0.5	0.06		<1	1	<1
Bore 3	4/19/2023	Bore	7.63	298	0.5	0.02		<1	11	<1

Table 5-4. Surface water quality monitoring results for the reporting period

Concentrations in breach of EPL302 trigger values for surface water highlighted in red. Trigger values only apply to the property discharge site. If the concentration at SW1 is greater than the trigger value then the concentration at SW1 becomes the trigger value for that monitoring round.

				Laboratory Results							
Site ID	**Date**	**Water Type**	**Comments**	**pH**	**EC**	**TN**	**TP**	**Faecal Coliforms**	**E.coli**	**Total coliforms**	**Enterococci**
					µg/L	**mg/L**	**mg/L**	**CFU/100mL**	**CFU/100mL**	**CFU/100mL**	**CFU/100mL**
Surface water EPL302 trigger values				6.0-7.5	200	0.23	0.01	any increase from previous	any increase from previous	any increase from previous	any increase from previous
Property Discharge (outlet)	1/5/2023	Surface		7.42	236	3.30	1.58		900	12000	600
SW1	2/21/2023	Surface		6.29	46	0.60	0.02		110	31000	85
Property discharge (outlet)	3/15/2023	Surface		7.66	285	3.20	1.11		1800	82000	380
SW1	3/15/2023	Surface		6.67	52	1.00	0.04		60	13000	19
SW2	3/15/2023	Surface		6.77	109	1.90	0.21		36	20000	24
Property discharge (outlet)	4/19/2023	Surface		7.68	342	6.50	1.51		1800	35000	1200

Table 5-5. Soil monitoring results for the reporting period

Concentrations outside of EPL302 trigger values for groundwater highlighted in red.

Site ID	Date	pH	Electrical Conductivity	NOx	TKN	Total Nitrogen	Total Phosphurous	*E. coli*	Total coliforms	Enterococci
	Unit			mg/kg	mg/kg	mg/kg	mg/kg	MPN/g dry wt	MPN/g dry wt	MPN/g dry wt
	Limit of reporting	0.1	1	0.1	20	20	2			
EPL 302 Appendix A		6-8	Any increase from previous			Any increase from previous	Any increase from previous	Any increase from previous	Any increase from previous	Any increase from previous
SS 1	21/01/2021	5.1	17	2.2	640	640	151			
SS 2	21/01/2021	4.9	17	2.7	260	260	87			
SS 4	21/01/2021	4.7	43	6.8	310	320	137			
SS 6	21/01/2021	5.3	13	0.8	300	300	107			
SS 8	21/01/2021	6.4	14	1.1	270	270	83			
SS 9	21/01/2021	4.4	98	<0.1	210	210	91			
SS 10	21/01/2021	7.8	43	0.3	290	290	86			
SS 11	21/01/2021	6.4	16	1.6	280	280	73			
SS1	9/06/2021							<12	23000	1000
SS2	9/06/2021							<11	>26000	8700
SS4	9/06/2021							<13	16000	2000
SS6	9/06/2021							<12	9500	2300
SS8	9/06/2021							<12	>28000	1100
SS9	9/06/2021							390	>27000	2400
SS10	9/06/2021							<11	100	500

6 TOTAL N AND TOTAL P LOADS

Condition 38 of EPL302 states that:

The licensee must ensure that the total annual loads of Total Nitrogen and Total Phosphorus applied to land from the authorised discharge point do not exceed the calculated maximum total annual loads:

37.1 The total annual load for total nitrogen must be calculated using the equations detailed in the NSW environmental guideline Use of Effluent by Irrigation and be based on the specific soil type and crop present in the irrigation area receiving wastewater from the authorised discharge point.

37.2 The total annual load of total phosphorus must be based on the annual maximum uptake of phosphorus for the specific crop type present as listed in Table 4.2 of the NSW environmental guideline Use of Effluent by Irrigation

Total annual loads of TN and TP applied to the irrigation area using water from the authorised discharge point (irrigation source) are calculated below.

In regards to the total TN and TP load applied to the two irrigation areas during the reporting period, the total volume of irrigated water was 164.95 ML, and the median TN and TP concentrations of the irrigation water were 10.14 mg/L and 1.34 mg/L respectively. This equates to a total load of 1,266 kg of TN and 167 kg of TP applied to the two irrigation areas over the reporting period.

The established sandalwood plantation in the western part of JCF received a load of 956.kg of TN and 126.1 kg of TP. The pivot irrigation section on the eastern side of the premise received a load of 310 kg of TN and 40.9 kg of TP. The land is currently being prepared by ploughing for planting seeds. It is planned to grow *Rhodes* Grass/or grain sorghum, which will be harvested every six to eight weeks.

Table 4.2 in the *NSW Environmental Guidelines, Use of Effluent by Irrigation* (DEC 2004) lists grain crops only and thus information could only be used for grain sorghum, where the average yield is approx. 2.5 tonnes/ha/dry matter, with a nutrient content of 2.1 % nitrogen and 0.3 % phosphorus.

This equals a nitrogen removal of 72.5 kg/ha/annum and a phosphorus removal of 7.5 kg/ha/annum. The eastern irrigation area has a size of 4.85 ha and thus would be capable of removing 349.2 kg of nitrogen through harvesting per annum and 36.4 kg of phosphorus. This is well in excess of the amount of TN and TP applied to the irrigation area in the irrigated wastewater and as such, this irrigation is sustainable and would not result in excess TN and TP.

A calculation for the sandalwood plantation was not possible based on the information provided in Table 4.2 in the NSW *Environmental Guidelines, Use of Effluent by Irrigation* (DEC 2004).

7 CONCLUSIONS

All monitoring was undertaken as per EPL302 Attachment A requirements, except for some minor non-compliances as listed in Table 4-6 above

Irrigation water, surface water, groundwater and soil monitoring results largely complied with the trigger values. The few isolated cases where trigger values were exceeded the trigger value exceedance was not repeated during subsequent monitoring rounds and no increasing trend is indicated.

Loads of TN and TP currently applied to the irrigation area are sustainable.

Unauthorised discharge during the 2022-23 wet season via a V-notch weir was reported to the NT EPA (PRI Group 2023b) and did carry TN and TP concentrations above recommended guidelines and also higher than at the environmental comparison sites SW1 and SW2.

8 REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000): *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy*, ANZECC, Canberra, ACT.

ANZG (2018): *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Bureau of Meteorology (2021): *Climate Data Online*. [online] Available at: http://www.bom.gov.au/climate/data/ [Accessed 13 July 2021]

DEC (2004): *Use of Effluent by Irrigation; Environmental Guidelines*, Department of Environment and Conservation (DEC), New South Wales Government, Sydney.

EcOz (2020): *Irrigation Management Plan, Janamba Crocodile Farm*, report prepared for Croc Pac Pty Ltd by EcOz Pty Ltd, May 2020.

NRETAS (2014): *Darwin Harbour Water Quality Protection Plan*, Department of Land Resource Management, NT Government, Palmerston.

Northern Territory Government (2021): *Natural Resource (NR) Maps (DENR) Search – Available at:* https://nrmaps.nt.gov.au/nrmaps.html. [Accessed July 2021].

PRI Group (2022a): *Monitoring Report EPL302* – Janamba Crocodile Farm Pty Ltd. Reporting Period 01/09/2022 – 31/05/2023. Report submitted to the NT EPA on 31 May 2023.

PRI Group (2023b): *Incident Investigation Report EPL302*. Janamba Crocodile Farm Pty Ltd. Date 06/08/2020 – date 31/05/2021. Report submitted to the NT EPA on 31 May 2023.

Schult J., Welch M. (2006): *The water quality of fifteen lagoons in the Darwin region*. Report 13/2006D, Aquatic Health Unit, Department of Natural Resources, Environment and the Arts. Available at: https://territorystories.nt.gov.au/10070/625340 [accessed 15 July 2021].