



# EPL239 Monitoring Report

*Reporting period: 1 April 2021 – 31 March 2022*

Humpty Doo Barramundi Pty Ltd



# DOCUMENT CONTROL RECORD

<b>Job</b>	EZ21088
<b>Document ID</b>	213819
<b>Author(s)</b>	Emma Smith

## DOCUMENT HISTORY

Rev	Reviewed by	Approved by	Issued to	Date
1	Emma Lewis	Emma Lewis	Humpty Doo Barramundi	21 April 2022
2	Humpty Doo Barramundi	Humpty Doo Barramundi	NT EPA	29 April 2022
3	NT EPA	Humpty Doo Barramundi	NT EPA	31 May 2022

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## ACRONYMS

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<b>AI</b>	Adelaide Intake – water intake point from Adelaide River
<b>ANZECC</b>	Australian and New Zealand Environment and Conservation Council
<b>ARMCANZ</b>	Agriculture and Resource Management Council of Australia and New Zealand
<b>AQIS</b>	Australian Quarantine and Inspection Service
<b>ASS</b>	acid sulfate soils
<b>BAP</b>	Best Aquaculture Practices program
<b>BOD</b>	biochemical oxygen demand
<b>Chl-a</b>	chlorophyll-a
<b>DPWS</b>	Department of Environment, Parks and Water Security (Northern Territory)
<b>DO</b>	dissolved oxygen
<b>DP</b>	Development Permit
<b>DP1</b>	Discharge Point 1 – Authorised Discharge Point 1 in EPL239
<b>DP2</b>	Discharge Point 2 - Authorised Discharge Point 1 in EPL239
<b>EC</b>	electrical conductivity
<b>EMP</b>	Environmental Management Plan
<b>EPL</b>	Environment Protection Licence
<b>FRP</b>	filterable reactive phosphorus
<b>HDB</b>	Humpty Doo Barramundi Pty Ltd
<b>HDPE</b>	High Density Polyethylene
<b>LOR</b>	limit of reporting
<b>NATA</b>	National Association of Testing Authorities
<b>NO<sub>x</sub></b>	nitrate NO <sub>3</sub> + nitrite NO <sub>2</sub>
<b>NT</b>	Northern Territory
<b>NT EPA</b>	Northern Territory Environment Protection Authority
<b>NOI</b>	Notice of Intent
<b>PASS</b>	potential acid sulfate soils
<b>QA/QC</b>	quality assurance, quality control
<b>RPD</b>	relative percentage difference
<b>S1N</b>	Stage 1 Nursery
<b>S2N</b>	Stage 2 Nursery
<b>SOCS</b>	Sites of Conservation Significance
<b>SSTV</b>	site specific trigger value
<b>TN</b>	total nitrogen
<b>TP</b>	total phosphorus
<b>TSS</b>	total suspended solids
<b>WMPC Act</b>	<i>Waste Management and Pollution Control Act</i> (Northern Territory)
<b>WQMP</b>	Water Quality Monitoring Plan

# 1 INTRODUCTION

Humpty Doo Barramundi Pty Ltd (HDB) operate a barramundi farm located approximately 58 km east of Darwin near the Middle Point locality on the Adelaide River (Figure 1-1). Water quality monitoring is undertaken by HDB to ensure that operations do not impact downstream Adelaide River water quality, ecosystems, or water users. This monitoring is also a requirement of the Environment Protection Licence 239 (EPL239), issued to HDB by the Northern Territory Environment Protection Authority (NT EPA) under the *Waste Management and Pollution Control Act*.

Monitoring Reports are required annually, as per Condition 39 of EPL239 (see latest version EPL239-02 issued 28 October 2020). This Monitoring Report covers all water quality monitoring undertaken for the reporting period starting 1 April 2021 and ending 31 March 2022 (herein referred to as the 'reporting period'). This is the fifth Monitoring Report since commencement of EPL239 (first version) on 6 June 2018.

## 1.1 Purpose and scope

This Monitoring Report is prepared in accordance with the following EPL239-02 conditions:

### **Condition 39**

*The licensee must complete and provide to the NT EPA a Monitoring Report, as prescribed by this licence, in accordance with the reporting schedule specified in Table 4:*

**Table 4 - Reporting Schedule**

Reporting Period	Report Due Date
01 August 2017 - 31 March 2018	31 May 2018
01 April 2018 - 31 March 2019	30 April 2019
01 April 2019 - 31 March 2020	30 April 2020
01 April 2020 - 31 March 2021	30 April 2021
01 April 2021 - 31 March 2022	30 April 2022
01 April 2022 - 31 March 2023	30 April 2023

### **Condition 40**

*The licensee must ensure that each Monitoring Report:*

- 40.1 *is prepared in accordance with the requirements of the NT EPA 'Guideline for Reporting on Environmental Monitoring';*
- 40.2 *includes a tabulation of all monitoring data required as a condition of this licence, in excel format;*
- 40.3 *includes a discharge summary for each discharge event, which consists of the:*
  - 40.3.1 *water quality data for all authorised monitoring points in accordance with Attachment A;*
  - 40.3.2 *flow data, discharge volumes and discharge times; and*
  - 40.3.3 *a summary of exceedances of trigger values in accordance with condition 37.*
- 40.4 *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*
- 40.5 *includes an assessment of environmental impact from the activity.*

## 1.2 EPL239-02 compliance monitoring and reporting

Table 1-1 below lists the farm's authorised discharge points into the Adelaide River; as listed in Table 3 of EPL239-02. See Figure 1-2 for a map of authorised discharge point locations.

**Table 1-1. Authorised discharge points as listed in EPL239-02**

Authorised Discharge Point	Source of Discharge Water	Location
DP1	Discharge Point 1. Receives wastewater from the North Farm wetland treatment system.	Latitude: -12.54778 Longitude: 131.37553
DP2	Discharge Point 2. Receives wastewater from the Stage 1 Nursery and the Stage 2 Nursery.	Latitude: -12.55530 Longitude: 131.37485
AI	Adelaide River Intake. Receives wastewater from the South Farm wetland treatment system. This is also the intake channel used to deliver water to the farm when pumping from Adelaide River.	Latitude: -12.55416 Longitude: 131.37390
EF DP	East Farm Discharge Point. Receives wastewater from the East Farm wetland treatment system.	Latitude: -12.55690 Longitude: 131.37500
EF CE DP	East Farm Controlled Emergency Discharge Point. Receives wastewater from the East Farm wetland treatment system.	Latitude: -12.55740 Longitude: 131.37800

Water quality monitoring at HDB is undertaken in accordance with Attachment A of EPL239-02 and all water monitoring related conditions of the licence; i.e. Conditions 24 to 31. HDB's *Water Quality Monitoring Plan* (WQMP) details the monitoring sites, physical (field) and laboratory parameters measured, sampling methods and procedures.

Monitoring site locations are shown in Figure 1-2 and detailed in Table 4-1. Water quality sampling at these sites is to be undertaken weekly when discharging, or at least once per discharge event, if the event is less than one week.

The 'compliance point', where the water quality assessment criteria (trigger values) listed in Appendix A of EPL239-02 are applied during a discharge, is the downstream Adelaide River sampling site ARDS. All sampling must be undertaken on an outgoing tide. Table 4-2 lists the required water quality parameters to be measured and the trigger values for determining compliance.

The following conditions apply to the water quality monitoring results recorded at the ARDS compliance point during a discharge:

### **Condition 22**

*The licensee must ensure that the discharge from all discharge events does not exceed the trigger values and where relevant the water quality of the Adelaide River upstream monitoring location at the compliance point, in accordance with Attachment A.*

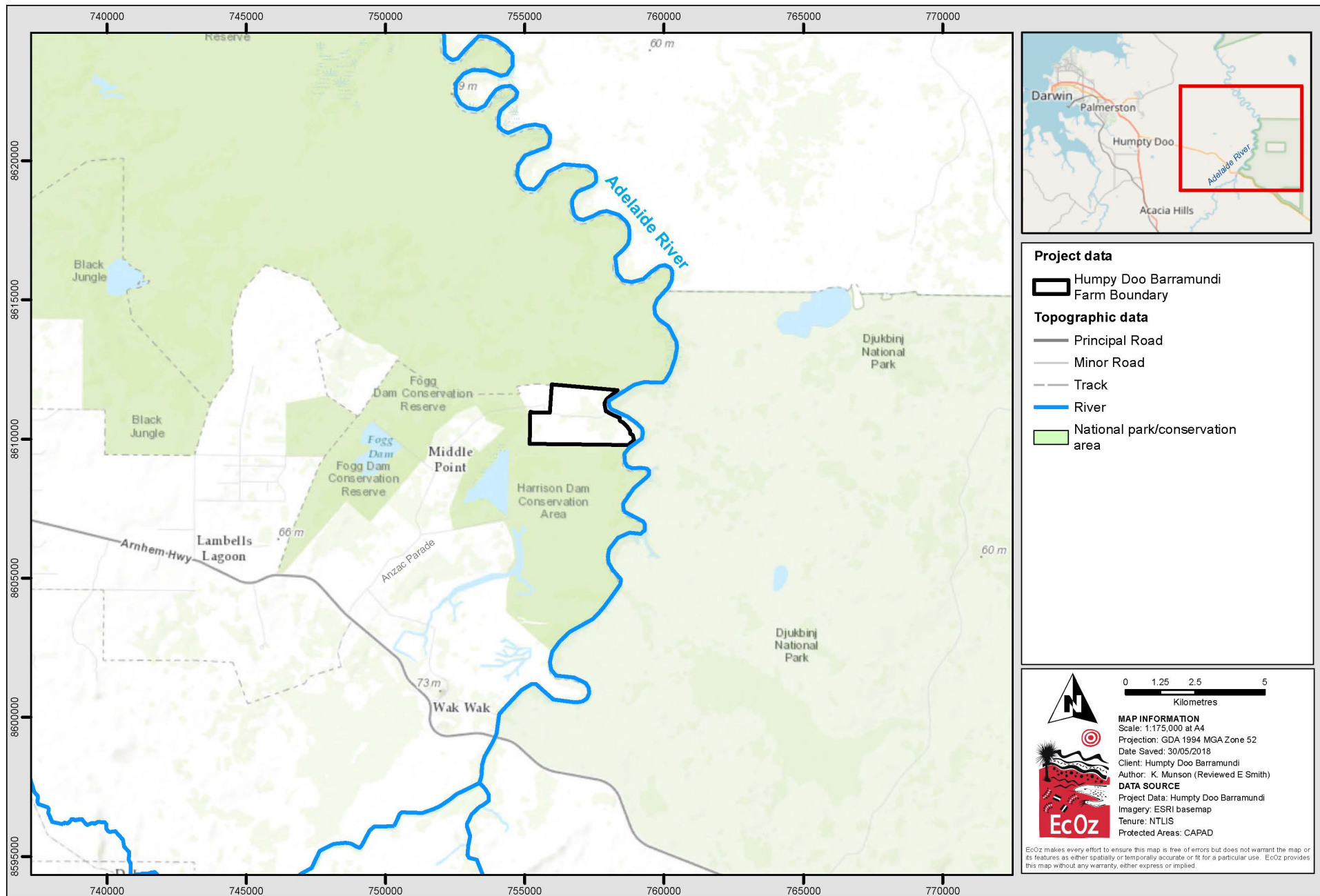


Figure 1-1. Map of HDB farm location

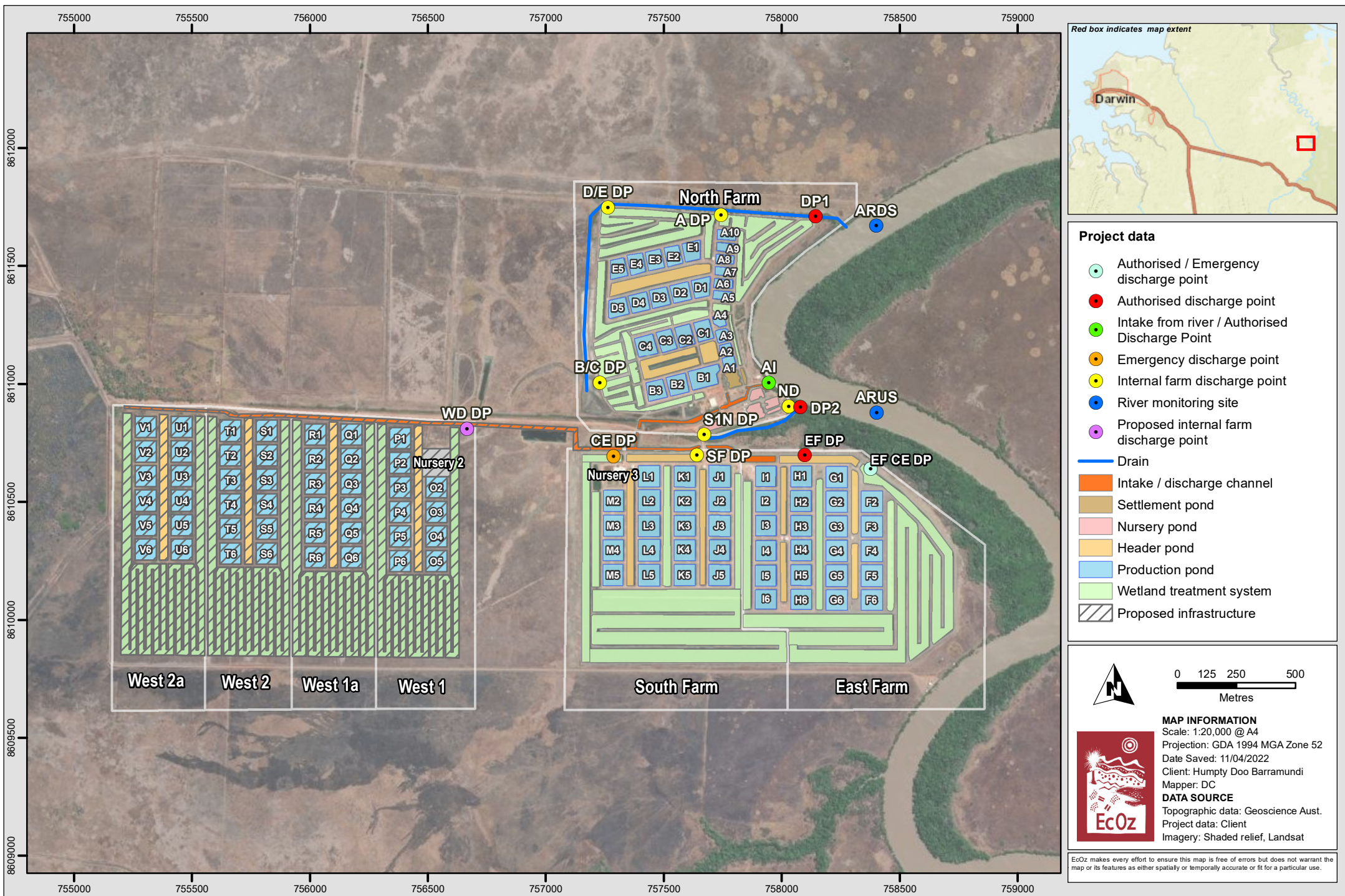


Figure 1-2. Map of farm layout and monitoring sites

## 2 HDB FARM BACKGROUND

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### 2.1 Farm operations

Figure 1-2 shows the HDB farm layout. This currently includes the:

- **North Farm** covering an area of approximately 60 ha, comprising 26 production (grow-out) ponds, 3 associated header ponds (for gravity flows), and 3 wetland treatment systems.
- **South Farm** covering an area of approximately 70 ha, comprising 19 production ponds, 3 associated header ponds, and a very large dedicated wetland treatment system.
- **East Farm** covering an area of approximately 68 ha, which currently includes 23 production ponds, 3 header ponds, and a very large dedicated wetland treatment system.

The flow system design of all three farms is essentially the same, where water flows from the header ponds, to the production ponds, then through the wetland treatment system. Once treated through the wetlands, the water is of sufficient quality for return to the header ponds for reuse in the production ponds. This minimises the need for discharge to, or refilling from, the Adelaide River. Water can be recirculated indefinitely, and discharge to the Adelaide River is usually limited to the wet season to prevent ponds overflowing, occasionally during the dry season when topping-up the ponds to maintain optimal salinity for fish health, or to allow for pond maintenance and upgrades to infrastructure.

The flow system design at HDB also means that all discharges (when required) are via the wetland treatment systems; no wastewater is discharged direct from the production ponds into the Adelaide River.

The HDB farm includes a Stage 1 Nursery (fingerlings up to 1 g), Stage 2 Nursery (fish between 1 and 30 g), and Stage 3 Nursery (fish between 30 and 200 g). Once juvenile fish are large enough, they are transferred to the production ponds for grow out. Each of these nurseries utilises a wetland treatment system; the Stage 1 Nursery and 2 Nursery each have their own wetland treatment ponds, and the Stage 3 Nursery utilises the South Farm wetland treatment system.

Water required to top-up farm ponds and nursery tanks is pumped from the Adelaide River from the point shown in Figure 1-2 as 'AI' (Adelaide Intake).

Other supporting farm infrastructure includes a packing shed, feed storage shed, workshop, office building, back-up generators, fuel storage and a small staff accommodation block.

### 2.2 Discharge points

There are five authorised discharge points where water from the farm's wetland treatment systems enter the Adelaide River (see Table 1-1). The source of discharge to each of these points is explained below.

Discharge from the North Farm is via 'Discharge Point 1' (DP1); see Figure 1-2. When any of the three wetland treatment systems of the North Farm overflow, they release water into a perimeter drain that then flows to DP1.

Discharge from the South Farm is via 'Adelaide Intake' (AI). All South Farm production ponds flow into a single large wetland water treatment system. The Stage 3 Nursery also utilises this wetland treatment system. When discharging, an operator-controlled valve at 'South Farm Discharge Point' (SF DP) is opened, and water is released through a pipe in the earthen bank into a channel. This channel then flows to discharge point AI where it enters the Adelaide River. An additional discharge point, 'Controlled Emergency Discharge Point' (CE DP), is located where the wetland treatment system for the South Farm discharges into the drainage channel (leading to AI) during extreme flood events, if required, when the capacity of SF DP is exceeded.

Discharge from the East Farm is via 'East Farm Discharge Point' (EF DP). When discharging, an operator-controlled valve at EF DP is opened, and water is released through a pipe in the earthen bank into the

mangroves lining the Adelaide River. An additional discharge point EF CE DP, is located where the wetland treatment system for the East Farm discharges during extreme flood events into the mangroves lining the Adelaide River, if required, when the capacity of EF DP is exceeded.

Discharges from the Stage 1 Nursery and Stage 2 Nursery report to DP2 prior to flowing into the Adelaide River. Water from the Stage 2 Nursery is released via a PVC pipe connected directly to the nursery into the drainage line just upstream of where it meets the Adelaide River (i.e. discharge point ND). Water from the Stage 1 Nursery wetland treatment system discharges into the drainage line at S1N DP, from where it flows down to DP2, and into the Adelaide River.

## 2.3 Environmental setting

The Adelaide River is a major NT river system. It lies within a very large, seasonally-inundated freshwater floodplain comprising a mix of tidal and seasonal wetland habitats dominated by grass and sedge communities, and fringed by open woodland with pockets of monsoon forest (see *Adelaide River coastal floodplain, Sites of Conservation Significance Factsheet* (DEPWS, previously known as DENR)). The main land use within the floodplain is pastoral operations, with other uses including conservation, recreation, tourism, Indigenous, horticulture and aquaculture. Approximately 25% of the area is managed as conservation reserves.

The Adelaide River mouth is a tide-dominated estuary (see [www.ozcoasts.gov.au](http://www.ozcoasts.gov.au) and Ryan et al 2003). The tidal limit is located at Marrakai Crossing, approximately 150 km upstream of the river mouth tracing the river channel including meanders (~100 km direct along general river course). HDB is located approximately 77 km upstream including meanders (45 to 50 km direct). The tidal range where the HDB farm is situated, is typically around 3 m during spring tides, and 2 m during neap tides; as measured at the nearest river level gauge, which is approximately another 20 km further upstream of the farm, at the Arnhem Highway crossing (NT Government Gauge Station No. G8170021). At this point, the river is mangrove-lined, and brackish to saline; salinity ranging from over 16 ppt during the dry season, to less than 1 ppt during the wet season. The strong tidal currents, and resuspension of fine sediments, also mean the river water is highly turbid; typically ranging between 60 NTU and 200 NTU depending on the tide, season, rainfall and river flows.

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. Average annual rainfall is 1420 mm, taken from the Middle Point Rangers Bureau of Meteorology (BoM) weather station No. 14090. Over 86% of annual average rainfall falls between November and March.

# 3 RAINFALL AND DISCHARGES

## 3.1 Rainfall

Figure 3-1 shows monthly rainfall totals taken from the Middle Point BoM station No. 14041 from April 2021 to March 2022 (blue bars). Mean monthly rainfall totals are also shown for comparison (orange bars). Total rainfall for the 12-month reporting period was 1,520 mm, which is above the annual average of 1,386 mm.

Rainfall during December 2021, January 2022 and February 2022 was above average, whereas March 2022 was below average. All other months were close to average.

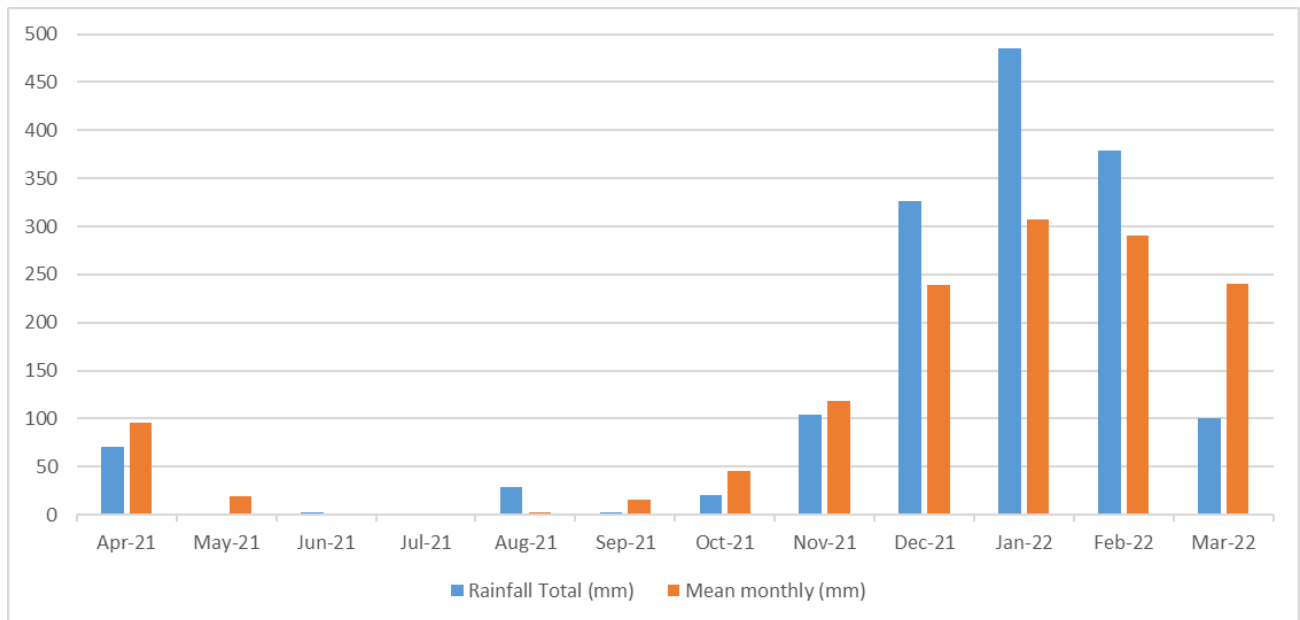


Figure 3-1. Monthly rainfall totals April 2021 to March 2022 (Middle Point BoM station No. 14041)

## 3.2 Reporting period discharge details

Table 3-1 outlines the discharges that occurred during the reporting period. Discharges that occurred between May 2021 and November 2021 were undertaken to allow for pond maintenance and water exchange. Discharges between December 2021 and March 2022 were due to rainfall and were required to prevent ponds overflowing.

Total discharge volume this reporting period (1,319.4 ML) was slightly less than for the previous reporting period, which was 1,468.5 ML.

**Table 3-1. Discharges during Reporting Period 1 April 2021 – 31 March 2022.**

Discharge Source	Discharge Point	Dates	Duration (days)	Volume (ML)	Discharge purpose	Monitoring dates
North Farm	DP1	25/05/2021-07/06/2021	13 days	118	Water exchange	26/05/2021 7/06/2021
South Farm	SF DP -> AI	25/05/2021-07/06/2021	13 days	36	Water exchange	26/05/2021 7/06/2021
East Farm	EF DP	25/05/2021-07/06/2021	13 days	40	Water exchange	26/05/2021 7/06/2021
North Farm	DP1	25/06/2021-11/07/2021	16 days	30.8	Water exchange	30/06/2021 8/07/2021
South Farm	SF DP -> AI	28/06/2021-11/07/2021	13 days	75.6	Water exchange	30/06/2021 8/07/2021
East Farm	EF DP	28/06/2021-19/07/2021	21 days	110.5	Water exchange	30/06/2021 8/07/2021 13/07/2021
Stage 1 Nursery	S1N DP-> DP2	25/08/2021-28/08/2021	3 days	3.8	Water exchange	26/08/2021
Stage 1 Nursery	S1N DP-> DP2	13/09/2021-13/09/2021	1 day	3.5	Pond maintenance	13/09/2021
Stage 1 Nursery	S1N DP-> DP2	18/10/2021-19/10/2021	1 day	3	Water exchange	19/10/2021
Stage 2 Nursery	ND -> DP2	19/10/2021-21/10/2021	2 days	5	Water exchange	19/10/2021
Stage 2 Nursery	ND -> DP2	29/10/2021-01/11/2021	3 days	7	Water exchange	1/11/2021
North Farm	DP1	9/12/2021-15/12/2021	6 days	7.1	Rainfall	14/12/2021
North Farm	DP1	25/12/2021-07/01/2022	13 days	15.4	Rainfall	30/12/2021 5/01/2022
South Farm	SF DP -> AI	28/12/2021-07/01/2022	10 days	10.8	Rainfall	30/12/2021 5/01/2022
East Farm	EF DP	28/12/2021-07/01/2022	10 days	12.1	Rainfall	30/12/2021 5/01/2022

Discharge Source	Discharge Point	Dates	Duration (days)	Volume (ML)	Discharge purpose	Monitoring dates
North Farm	DP1	16/01/2022-20/03/2022	63 days	342.1	Rainfall	18/01/2022 24/01/2022 3/02/2022 7/02/2022 15/02/2022 22/02/2022 1/03/2022 8/03/2022 16/03/2022
South Farm	SF DP -> AI	16/01/2022-06/02/2022	21 days	153.3	Rainfall	18/01/2022 24/01/2022 3/02/2022
East Farm	EF DP	16/01/2022-06/02/2022	21 days	229.9	Rainfall	18/01/2022 24/01/2022 3/02/2022
Stage 1 Nursery	S1N DP-> DP2	24/01/2022-24/01/2022	1 day	1.5	Rainfall	24/01/2022
South Farm	SF DP -> AI	25/02/2022-03/03/2022	6 days	45.6	Rainfall	1/03/2022
East Farm	EF DP	25/02/2022-03/03/2022	6 days	68.4	Rainfall	1/03/2022
<b>Total discharge (ML) for 2021/2022:</b>				<b>1,319.4</b>		

## 4 MONITORING UNDERTAKEN

During the reporting period, monitoring was undertaken as per EPL239-02 requirements using the methods outlined in HDB's *Water Quality Monitoring Plan (WQMP)*. This WQMP is the guidance document for ensuring all monitoring is consistent, complies with the relevant Australian Standards, and meets the monitoring specifications of EPL239-02 i.e. Conditions 24 to 31 and Attachment A. Below is an outline of the monitoring undertaken during the reporting period.

### 4.1 Monitoring sites

Monitoring points as per EPL239-02 Attachment A comprise the following:

- Discharge points i.e. DP1, ND, S1N DP, SF DP, and EF DP.
- Adelaide River water quality locations (i.e. ARUS and ARDS), used for determining any impacts on river water quality during discharge events.

Monitoring point locations are shown in Figure 1-2 and detailed below in Table 4-1.

**Table 4-1. Monitoring location details**

Site ID	Site Name	Location	GPS Coordinates	
			Latitude	Longitude
DP1	Discharge Point 1	Point where drain along western and northern perimeter of North Farm discharges into the Adelaide River. This drain receives overflows from the wetland treatment systems for the North Farm via the internal discharge points B/C DP, D/E DP and A DP.	-12.54778	131.37553
SF DP	South Farm Discharge Point Note: Previously 'K/J DP'	Where South Farm treatment system discharges into channel that flows to AI and into Adelaide River.	-12.55694	131.37109
EF DP	East Farm Discharge Point	Where East Farm treatment system discharges into mangroves lining Adelaide River.	-12.55693	131.37530
S1N DP	Stage 1 Nursery Discharge Point	Discharge point from Stage 2 Nursery treatment ponds into drainage line that flows into Adelaide River via DP2	-12.55617	131.37137
ND	Stage 2 Nursery Discharge Point	Stage 2 Nursery water prior to discharge into drainage line that flows into Adelaide River via DP2.	-12.55530	131.37485
ARUS	Adelaide River Upstream	On Adelaide River, approx. 350 m upstream of DP2.	-12.55527	131.37810
ARDS	Adelaide River Downstream	On Adelaide River, approx. 150 m downstream of DP1.	-12.54811	131.37802

## 4.2 Monitoring frequency

Monitoring must be conducted weekly when discharge is occurring, or at least once per discharge event if the discharge is less than one week. The Adelaide River sites ARUS and ARDS must always be sampled during each discharge monitoring event. The point/s where discharge is occurring must also be sampled e.g. if the North Farm is discharging, DP1 must be sampled. If the South Farm, East Farm and Stage 2 Nursery are all discharging, then SF DP, EF DP and ND must all be sampled.

## 4.3 Water quality monitoring parameters

Table 4-2 lists the parameters that are measured at each site, and the assessment criteria currently specified in EPL239-02 Attachment A.

**Table 4-2. Water quality parameters and assessment criteria**  
*AR – assess against the quality of Adelaide River upstream location at time of sampling*  
*\*for assisting with determining EPL239-02 Condition 34 non-compliance*

Parameters	Units	Assessment Criteria	3x Assessment Criteria*
<b>Physical (field) parameters</b>			
Flow	kL/day	N/A	N/A
pH	pH units	7.2 – 8.2	N/A
Electrical Conductivity (EC)	µS/cm	AR	3xAR
Dissolved Oxygen (DO)	% saturation	AR	3xAR
Turbidity	NTU	AR	3xAR
Temperature	°C	N/A	N/A
<b>Laboratory parameters</b>			
Biochemical Oxygen Demand (BOD)	mg/L	1.00	3.00
Filterable Reactive Phosphorus (FRP) as P	mg/L	0.04	0.12
Total Phosphorus (TP) as P	mg/L	0.13	0.39
Ammonia (NH <sub>3</sub> ) as N	mg/L	0.06	0.18
Total Nitrogen (TN) as N	mg/L	1.00	3.00
Nitrogen Oxides NO <sub>3</sub> + NO <sub>2</sub> (NO <sub>x</sub> ) as N	mg/L	0.41	1.23
Nitrate (NO <sub>3</sub> ) as N	mg/L	0.41	1.23
Nitrite (NO <sub>2</sub> ) as N	mg/L	0.005	0.015
Total Kjeldahl Nitrogen (TKN) as N	mg/L	N/A	N/A
Chlorophyll-a	µg/L	2	6
<b>Other information recorded</b>			
Site Name, Date, Time and Sampler/s name			
Tide (high/low/spring/neap/incoming/outgoing)			
If discharge is occurring and any comments relating to site condition – e.g. any visible pollutants, scum, water colour, clarity, water plants/algae, dead fish, any odours			

## 4.4 Sampling procedures

All sampling is undertaken in accordance with the WQMP 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.

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.

All sampling was carried out by Kirsten Beames from HDB, who has received on-site training in sampling methods from EcOz Senior Environmental Consultant Emma Smith, as well as on-going guidance from EcOz.

All laboratory samples are collected into ALS Laboratory-supplied sample bottles; some of which contain preservative where required.

The Adelaide River sites ARUS and ARDS are accessed using a boat in order to gain a representative sample from the middle of the river. River samples are always collected during an outgoing tide to ensure ARDS is 'downstream' of the farm and ARUS is 'upstream' of the farm. The river can only be safely accessed from the farm at high tide. At low tide, the crocodile risk is too great, as the boat would need to be dragged across the mud bank to get to the water.

All discharge point monitoring sites are sampled from the land using a long pole, with a lab-supplied sample bottle on the end, in order to gain a sample a few metres from the bank. Sample is decanted from this bottle into bottles that contain preservative.

All field parameters are recorded on a dedicated *Field Data Sheet*, developed to ensure all EPL239-02 information requirements are collected. The field parameter meter is calibrated immediately prior to each sampling round.

All field and laboratory results are stored in an Excel database maintained by EcOz.

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

## 4.5 Assessment criteria and non-compliance reporting

Table 4-2 lists the assessment criteria to be applied to water quality monitoring results for the downstream compliance point ARDS, as taken from EPL239-02 Attachment A. Site-specific trigger values (SSTVs) are applied to most parameters. These SSTVs were derived based on calculating the 80<sup>th</sup> percentile of background Adelaide River water quality during times when no discharge was occurring at monthly intervals for at least a two-year period (August 2016 to August 2018). The report outlining SSTV derivation is provided at Appendix A.

SSTVs are applied to all parameters except for electrical conductivity (EC), dissolved oxygen (DO), and turbidity, as, given the highly seasonal variability in these parameters, it is more appropriate to assess these against the water quality of the upstream Adelaide River site (ARUS) at the time of sampling.

EPL239-02 Condition 34 states the following, in relation to the assessment criteria listed in Table 4-2:

### **Condition 34**

*A non-compliance with this licence includes:*

- 34.1 *an exceedance of a trigger value at the compliance point, as specified in Attachment A, on three consecutive sampling occasions;*
- 34.2 *an exceedance of three times or more a trigger value at the compliance point, as specified in Attachment A, on a single sampling occasion;*
- 34.3 *when Electrical Conductivity, Turbidity or Dissolved Oxygen measured at the compliance point exceed the ambient water quality of the Adelaide River upstream monitoring point on three consecutive sampling occasions, in accordance with Attachment A;*
- 34.4 *when Electrical Conductivity, Turbidity or Dissolved Oxygen measured at the compliance point exceed three times or more the ambient water quality of the Adelaide River upstream monitoring point on a single occasion, in accordance with Attachment A.*

When any of the above scenarios occur, the NT EPA must be notified within 24 hours of becoming aware of the non-compliance, as per Conditions 35 and 36.

## 4.6 Monitoring undertaken during the reporting period

All weekly monitoring during discharges was undertaken as per EPL239-02 requirements (see Table 3-1).

All start and finish dates for all discharges were recorded.

All discharge volumes for all discharges were recorded. This was via the permanently installed automated flow gauges at DP1, SF DP and EF DP, and by manual flow measurements at the discharge points S1N DP and ND.

## 5 RESULTS AND DISCUSSION

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Discharge water quality data and Adelaide River monitoring site data for the 1 April 2021 to 31 March 2022 reporting period is provided in Appendix B. As explained in Section 4 above, during each discharge monitoring round, the Adelaide River sites ARUS and ARDS must be sampled along with the site/s discharging at the time i.e. either one or a combination of DP1, SF DP, EF DP, S1N DP and/or ND.

The complete HDB water quality monitoring database containing the results of all samples collected since March 2015 is also provided as an excel spreadsheet, submitted to the NT EPA via email along with this Monitoring Report.

The sections below present and discuss:

- The water quality of each discharge that occurred during the reporting period
- The nutrient load of each discharge into the Adelaide River during the reporting period
- Compliance of water quality with SSTV's at the downstream compliance point (ARDS) during the reporting period and any potential impacts on Adelaide River water quality
- Long term trends in discharge water quality and Adelaide River water quality

### 5.1 Discharge water quality

Table 5-1 provides the summary statistics for all monitoring sites calculated using all data collected during the reporting period. These statistics are discussed below. For the raw data see Appendix B.

The temperature, pH and DO of all discharge sites (DP1, EF DP, SF, DP, ND and S1N DP) remained within the same range as the upstream Adelaide River site (ARUS). There is also no significant difference in these parameters between the upstream and downstream (ARDS) site, indicating no impacts to these water quality parameters from discharge.

The EC/TDS/salinity in the Adelaide River varies significantly from very high at the end of the dry season (over 20 ppt) to lower during the wet season (down to 0.03 ppt). The discharge salinity varies within this range from between 2.6 and 15 ppt).

Turbidity and TSS in the Adelaide River are almost always higher than in the discharge waters.

BOD measured at the discharge sites is generally slightly higher than the detection limit of <2 mg/L, with the highest median value recorded for DP1 of 7 mg/L. There is no significant difference between the BOD measured at the downstream Adelaide River site (ARDS) compared to the upstream site (ARUS).

Chlorophyll-a measured at the discharge sites is high compared to the upstream Adelaide River site, with the nurseries (ND and S1N DP) recording the highest median concentrations of 23 and 45 µg/L. There is however no significant difference between the BOD measured at the downstream Adelaide River site (ARDS) compared to the upstream site (ARUS).

Ammonia concentrations in the discharge waters are higher than the upstream Adelaide River site, with the highest median concentration recorded for SF DP (1.42 mg/L). There is however no significant difference between the ammonia measured at the downstream Adelaide River site (ARDS) compared to the upstream site (ARUS), recording medians of 0.09 and 0.08 mg/L respectively.

Similarly for NO<sub>x</sub>, TKN, TN, TP and FRP, there is no significant difference in the medians of the upstream and downstream Adelaide River sites.

**Table 5-1. Summary statistics for all monitoring sites for the Reporting Period 1 April 2021 – 31 March 2022**

	Temp	pH	EC	TDS	Sal	DO	Turbidity	BOD	Chl a	TSS	NH <sub>3</sub> as N	NO <sub>2</sub> as N	NO <sub>3</sub> as N	NO <sub>x</sub> as N	TKN as N	TN as N	TP as P	FRP as P
	°C	pH units	µS/cm	mg/L	ppt	%sat	NTU	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
<b>ARDS</b>																		
<b>Max</b>	32.6	8.29	29140	18940	20.68	72	514.2	5	3	586	0.29	<0.01	0.44	0.44	1.6	2.0	0.26	0.013
<b>Min</b>	25.7	5.79	75	49	0.03	37	20.14	<2	<1	15	0.02	<0.01	<0.01	<0.01	0.3	0.3	<0.01	0.001
<b>Median</b>	28.9	7.74	366	202	0.17	62	66.8	<2	<1	37	0.08	<0.01	0.29	0.29	0.6	0.8	0.07	0.004
<b>ARUS</b>																		
<b>Max</b>	32.7	8.21	28425	18480	20.23	69	322.8	4	2	602	0.24	<0.01	0.41	0.41	1.3	1.7	0.26	0.012
<b>Min</b>	25.9	6.28	71	46	0.03	41	20.32	<2	<1	18	0.02	<0.01	<0.01	<0.01	0.4	0.5	<0.01	<0.001
<b>Median</b>	29.1	7.45	313	194	0.14	64	74.56	<2	<1	48	0.09	<0.01	0.26	0.26	0.6	0.8	0.07	0.004
<b>DP1</b>																		
<b>Max</b>	32.5	8.68	22154	14400	14.03	118	49.96	26	87	88	4.32	1.34	2.61	3.23	12.6	13.4	6.12	5.920
<b>Min</b>	22.6	6.40	867	3185	2.59	17	5.06	<2	2	12	0.04	<0.01	<0.01	<0.01	1.1	1.1	0.19	0.153
<b>Median</b>	29.1	7.47	14620	7788	8.15	66	13.7	7	13	29	0.23	0.14	0.06	0.105	2.7	3.1	1.68	1.305
<b>EF DP</b>																		
<b>Max</b>	32.0	8.12	19445	12622	11.48	128	87.33	8	37	50	2.72	1.11	2.2	2.22	7.0	7.4	1.10	0.908
<b>Min</b>	25.1	7.27	11337	7369	6.40	25	4.61	<2	2	9	0.12	0.02	<0.01	0.38	2.7	4.5	0.50	0.099
<b>Median</b>	28.2	7.76	17600	11156	10.30	82	13.69	4	15	27	0.76	0.67	0.32	1.03	4.0	5.2	0.85	0.475
<b>SF DP</b>																		
<b>Max</b>	32.1	7.97	19647	12887	11.70	93	22.68	7	44	34	4.27	1.96	2.06	2.81	10.1	12.8	1.74	1.490
<b>Min</b>	24.8	6.58	12532	8146	7.14	43	4.09	3	4	9	0.34	0.08	0.09	0.71	3.8	5.9	0.53	0.144
<b>Median</b>	29.0	7.62	17545	10977	10.50	66	11.55	5	15	17	1.42	1.24	0.39	1.965	5.9	7.2	1.13	0.778
<b>ND</b>																		
<b>Max</b>	30.1	7.67	24384	15850	14.72	111	65.9	4	32	86	1.24	0.90	0.96	1.86	4.9	6.0	0.92	0.319
<b>Min</b>	29.5	7.15	22434	14580	13.43	109	57.1	<2	13	63	1.20	0.34	0.28	0.62	4.1	5.5	0.61	0.092
<b>Median</b>	29.8	7.41	23409	15215	14.08	110	61.5	2	23	75	1.22	0.62	0.62	1.24	4.5	5.8	0.77	0.206
<b>S1N DP</b>																		
<b>Max</b>	30.6	8.52	19183	12470	11.33	127	63.9	14	118	114	0.67	0.31	0.60	0.78	8.7	8.9	1.38	0.688
<b>Min</b>	28.3	7.89	8424	5480	4.64	64	29.4	3	8	37	0.13	<0.01	0.02	0.02	3.8	4.6	0.56	0.122
<b>Median</b>	29.3	8.00	16653	10824	9.72	104	46.35	6	45	77	0.56	0.18	0.26	0.44	7.5	7.8	1.00	0.204



## 5.2 Discharge nutrient loads

The nutrient load (i.e. TN and TP) discharged into the Adelaide River during each discharge during the reporting period has been calculated using the method prescribed in Section 2.2.5 in *Load Calculation Protocol*, June 2009, (NSW EPA 2009). The total load of TN+TP into the river for the entire reporting period was 9,045 kg comprising 7,483 kg of TN and 1,921 kg of TP.

The Adelaide River catchment is approximately 7,462 km<sup>2</sup>, with a mean annual discharge into the sea of 2,693 GL (Hughes et al 2018). Based on the median TN and TP concentrations in the Adelaide River measured at ARUS, this equates to around 3,043 tonnes of TN+TP. As such, the load from HDB only adds a negligible amount i.e. 0.3% and unlikely to have an impact.

**Table 5-2. Nutrient loads into the Adelaide River during the Reporting Period 1 April 2021 – 31 March 2022**

Site Discharging	Sampling Dates	TN as N mg/L	TP as P mg/L	C <sub>d</sub>		Discharge Vol. kL	Duration days	Flow rate L/s	V <sub>d</sub>	L <sub>d</sub>		Sum of L <sub>d</sub>		Flow weighted conc.		Total volume			
				Average TN as N mg/L	Average TP as P mg/L				Flow rate kL/day	TN as N kg/day	TP as P kg/day	TN as N kg	TP as P kg	TN as N kg/kL	TP as P kg/kL	TN as N kg	TP as P kg		
DP1	26/05/2021	13.4	6.12	10.2	4.27	118000	13	105	9077	92.1	38.7	1197.7	503.3	0.0102	0.0043	1198	503		
	7/06/2021	6.9	2.41																
EF DP	26/05/2021	6.4	0.51	6.7	0.56	40000	13	36	3077	20.5	1.7	266.0	22.2	0.0067	0.0006	266	22		
	7/06/2021	6.9	0.60																
SF DP	26/05/2021	12.1	0.78	12.5	0.78	36000	13	32	2769	34.5	2.1	448.2	27.9	0.0125	0.0008	448	28		
	7/06/2021	12.8	0.77																
DP1	30/06/2021	4.0	2.38	7.4	3.47	30821	16	22	1926	14.3	6.7	228.1	106.8	0.0074	0.0035	228	107		
	8/07/2021	10.8	4.55																
EF DP	30/06/2021	5.2	0.54	6.1	0.65	110484	21	61	5261	32.3	3.4	677.6	72.2	0.0061	0.0007	678	72		
	8/07/2021	5.8	0.50																
	13/07/2021	7.4	0.92																
SF DP	30/06/2021	8.8	0.63	8.4	0.58	75625	13	67	5817	48.9	3.4	635.3	43.9	0.0084	0.0006	635	44		
	8/07/2021	8.0	0.53																
S1N DP	26/08/2021	8.9	1.38	8.9	1.38	3750	3	14	1250	11.1	1.7	33.4	5.2	0.0089	0.0014	33	5		
S1N DP	13/09/2021	6.8	0.93	6.8	0.93	3500	1	41	3500	23.8	3.3	23.8	3.3	0.0068	0.0009	24	3		
ND	19/10/2021	5.5	0.92	5.5	0.92	5000	2	29	2500	13.8	2.3	27.5	4.6	0.0055	0.0009	28	5		
S1N DP	19/10/2021	8.8	1.07	8.8	1.07	3000	1	35	3000	26.4	3.2	26.4	3.2	0.0088	0.0011	26	3		
ND	1/11/2021	6.0	0.61	6.0	0.61	7000	3	27	2333	14.0	1.4	42.0	4.3	0.0060	0.0006	42	4		
DP1	14/12/2021	12.8	6.09	12.8	6.09	7112	6	14	1185	15.2	7.2	91.0	43.3	0.0128	0.0061	91	43		
DP1	30/12/2021	3.3	1.48	2.7	1.11	15410	13	14	1185	3.1	1.3	40.8	17.0	0.0027	0.0011	41	17		
	5/01/2022	2.0	0.73																
EF DP	30/12/2021	5.2	1.02	5.3	0.96	12141	10	14	1214	6.4	1.2	63.7	11.6	0.0053	0.0010	64	12		
	5/01/2022	5.3	0.89																
SF DP	30/12/2021	6.8	1.59	7.2	1.66	10771	10	12	1077	7.8	1.8	77.6	17.8	0.0072	0.0017	78	18		
	5/01/2022	7.6	1.72																
DP1	18/01/2022	6.6	1.51	2.7	1.4	342105	63	63	5430	14.7	7.5	927.5	471.0	0.0027	0.0014	927	471		
	24/01/2022	4.2	2.62																
	3/02/2022	2.8	1.84																
	7/02/2022	1.9	1.18																
	15/02/2022	2.1	2.26																
	22/02/2022	2.5	1.51																
	1/03/2022	1.4	0.46																
	8/03/2022	1.1	0.19																
EF DP	18/01/2022	4.6	1.10	4.67	1.01	229878	21	127	10947	51.1	11.1	1072.8	232.9	0.0047	0.0010	1073	233		
	24/01/2022	4.9	1.09																
	3/02/2022	4.5	0.85																
SF DP	18/01/2022	6.4	1.63	6.4	1.5	153253	21	84	7298	46.9	10.9	985.9	228.9	0.0064	0.0015	986	229		
	24/01/2022	6.5	1.74																
	3/02/2022	6.4	1.11																
S1N DP	24/01/2022	4.6	0.56	4.6	0.56	1500	1	17	1500	6.9	0.8	6.9	0.8	0.0046	0.0006	7	1		
EF DP	1/03/2022	5.0	0.71	5.0	0.71	68421	6	132	11404	57.0	8.1	342.1	48.6	0.0050	0.0007	342	49		
SF DP	1/03/2022	5.9	1.15	5.9	1.15	45614	6	88	7602	44.9	8.7	269.1	52.5	0.0059	0.0012	269	52		
																<b>Total (kg):</b>		<b>7483</b>	<b>1921</b>
																<b>Total TN+TP (kg):</b>		<b>9405</b>	
																<b>Total TN+TP (tonnes):</b>		<b>9.405</b>	

## 5.3 Assessment of impacts during discharges April 2021 – March 2022

### 5.3.1 Physical parameters

Table 5-3 presents an assessment of impacts on Adelaide River water quality for physical parameters during the discharges that occurred during the reporting period. Appendix B provides the raw water quality parameter concentrations measured during the discharge periods.

The assessment criteria listed in Table 4-2 for physical parameters provide a SSTV range for pH, but for EC, DO and turbidity, concentrations are assessed against the upstream Adelaide River location at the time of sampling. All monitoring rounds during the reporting period were undertaken during an outgoing tide, as such, ARDS was always the downstream compliance point, and ARUS the upstream reference site.

The assessment of impacts in Table 5-3 also determines whether any of the non-compliance scenarios listed in EPL239-02 Condition 34 (see Section 4.5 above) have occurred.

### 5.3.2 Laboratory parameters

Table 5-2 presents an assessment of impacts on Adelaide River water quality for laboratory parameters during the discharges that occurred during the reporting period. Appendix B provides the raw water quality parameter concentrations measured during the discharge periods.

The assessment criteria listed in Table 4-2 provide SSTVs for all laboratory parameters. All monitoring rounds during the reporting period were undertaken during an outgoing tide, as such, ARDS was always the downstream compliance point.

Table 5-2 also determines whether any of the non-compliance scenarios listed in EPL239-02 Condition 34 (see Section 4.5 above) have occurred.

**Table 5-3. Assessment of physical parameter water quality impacts on the Adelaide River from discharges during the reporting period**

*ARDS was the downstream compliance point during all sampling and ARUS the upstream reference site.*

Parameter	Discussion	Impact assessment
pH	pH remained within the SSTV range at the downstream compliance point (ARDS) during all discharges. This was except for a pH slightly above the SSTV range on 30/06/2021 and 22/02/2022, and slightly below the range on 13/07/2021 and 05/01/2022. These occasional pH values only very slightly outside the SSTV range, are within the variability of Adelaide River water quality and not considered indicative of impacts from discharge water quality.	No impact
EC	EC at the Adelaide River sites varied widely according to the seasons over the course of the reporting period, ranging from 71 $\mu\text{S}/\text{cm}$ during the wet season (01/03/2022) to 27,625 $\mu\text{S}/\text{cm}$ after the dry season (14/12/2021) and prior to significant wet season rainfall.  The relative percentage difference (RPD) between EC concentrations measured at the upstream (ARUS) and downstream (ARDS) river sites remained below 14% for all discharge monitoring rounds during the reporting period. This was except for during late December/early January (monitoring rounds 30/12/2021, 05/01/2022 and 18/01/2022) when the downstream site (ARDS) recorded a slightly higher EC compared to the upstream site (ARUS). The largest RPD was 22% on 30/12/2021. These RPDs are however, still very small, and did not persist for long, with all RPDs after 18/01/2022 being less than 6%.	No impact

DO	<p>DO at the Adelaide River sites varied little over the reporting period, ranging between 37 % saturation and 72 % saturation, with an average of 62 % saturation.</p> <p>The largest difference between DO concentrations measured at the upstream (ARUS) and downstream (ARDS) river sites for all discharge monitoring rounds during the reporting period was 4 % saturation on 13/07/2021 i.e. ARDS was 71 % sat and ARUS was 67 % sat. A difference of 4 % sat or less is very small, and not indicating an impact on DO from any of the discharges.</p>	No impact
Turbidity	<p>The Adelaide River sites are highly turbid compared to the discharge monitoring sites. This is generally always the case based on the long-term monitoring record commencing in 2015 (see excel database provided along with this report) due to suspended sediments in the strong tidal currents of the Adelaide River.</p> <p>Turbidity at the Adelaide River sites during the reporting period ranged from 20 NTU on 07/02/2022 to 514 NTU on 30/06/2021.</p> <p>Given the turbidity of the discharge waters is generally always less than river, any differences between the upstream and downstream turbidity in the river are attributed to localised differences in tidal currents and degree of sediment resuspension in the river and would not be indicating an impact from discharge.</p>	No impact

**Table 5-4. Assessment of laboratory parameter water quality impacts on the Adelaide River for discharges during the reporting period.**

*ARDS was the downstream compliance point during all sampling rounds.*

Parameter	Discussion	Impact assessment
BOD	<p>BOD was equal to or below the laboratory limit of reporting (LOR) at the downstream compliance point (ARDS) during all discharges for the reporting period. This was except for a concentration of 5 mg/L on 14/12/2021. Of note here is that the SSTV of 1 mg/L for BOD is an artefact of how the SSTV was calculated. Background (reference site) BOD concentrations measured monthly in the river for over 2 years were mostly always below the LOR and recorded as &lt;2 mg/L. In order to calculate the 80<sup>th</sup> percentile, all &lt;2 mg/L values needed to be changed to a number value, nominally half the LOR i.e. 1 mg/L. As such, a concentration of 5 mg/L is only slightly above the LOR and not significant to be indicating an impact from the discharges.</p>	No impact
Chlorophyll-a	<p>Chlorophyll-a was below the SSTV at the downstream compliance point (ARDS) during all discharges for the reporting period. This was except for on 19/10/2021 and 01/11/2021 when the concentration was only slightly above the SSTV.</p>	No impact

Parameter	Discussion	Impact assessment
Ammonia (NH <sub>3</sub> as N)	<p>Ammonia concentrations at the downstream compliance point (ARDS) were above the SSTV for 14 out of the 21 total discharge monitoring rounds undertaken during the reporting period.</p> <p>There were two non-compliance notifications submitted to the NT EPA to cover incidences where the non-compliance criteria, as per condition 34 of EPL239-02, had been breached. Non-compliance notifications for these exceedances were submitted to the NT EPA as follows:</p> <ul style="list-style-type: none"> <li>• <i>Non-compliance notification – Humpty Doo Barramundi EPL239-02: ammonia exceedances, Oct 2021 – January 2022</i>, submitted to the NT EPA on 20 January 2022</li> <li>• <i>Non-compliance notification – Humpty Doo Barramundi EPL239-02: ammonia exceedances, Jan – Feb 2022</i>, submitted to the NT EPA on 25 February 2022.</li> </ul> <p>Both these notifications concluded the exceedances had minimal impact on the Adelaide River environment for the following reasons:</p> <ul style="list-style-type: none"> <li>• TN concentrations at the downstream compliance point have generally remained below the SSTV. The compliant TN concentrations indicate that the total amount of nitrogen available to cause environmental problems such as algal blooms has not changed from background levels.</li> <li>• Despite ammonia concentrations recording above background river levels (as represented by a SSTV of 0.06 mg/L), the concentrations remain well below that which is toxic to aquatic organisms. The ANZG 2018 default guideline value for toxic effects in marine ecosystems (such as the estuarine environment of the Adelaide River) is 0.91 mg/L for 95% species protection.</li> <li>• No other parameters have consistently exceeded their respective SSTVs at the compliance point. This includes chlorophyll-a, which has always remained close to the laboratory detection limit, providing evidence that no algae blooms have occurred. Similarly, BOD has also remained close to the laboratory detection limit at the compliance point indicating that discharge from the farm is not causing an increased risk of low dissolved oxygen levels in the river.</li> <li>• The risk of an algae bloom in the river is low given the river is naturally very turbid and light is limited preventing algae growth. Nutrients are most likely to be washed out to sea rather than be utilised for algae growth. Stream flow and tidal currents moving past the farm are extremely large in comparison to discharge volume.</li> </ul>	Slight to no impact
NO <sub>x</sub> as N and NO <sub>3</sub> as N	NO <sub>x</sub> and NO <sub>3</sub> concentrations were all below the SSTV at the downstream compliance point (ARDS) during all discharges for the reporting period. This was except for one isolated incidence on 13/09/2021, where the concentration was very slightly above the SSTV. This is not considered a significant or long-lasting exceedance that could cause an impact.	No impact
NO <sub>2</sub> as N	NO <sub>2</sub> concentrations at the downstream compliance point (ARDS) were all below the LOR during all discharges for the reporting period. Note that for the same reason as explained above for BOD, the SSTV for NO <sub>2</sub> is half the LOR.	No impact
TN as N	TN concentrations were all below the SSTV of 1 mg/L at the downstream compliance point (ARDS) during all discharges for the reporting period. This was except for four incidences where the concentration was slightly above the SSTV (07/06/2021, 13/07/2021, 13/09/2021 and 24/01/2022). All these incidences were isolated and did not occur for the subsequent weekly monitoring round. These are not considered significant or long-lasting exceedances that could cause an impact.	Slight to no impact
TP as P	TP concentrations were all below the SSTV of 0.13 mg/L at the downstream compliance point (ARDS) during all discharges for the reporting period. This was except for three incidences (26/05/2021, 07/06/2021 and 13/07/2021). These were isolated occurrences, given TP concentrations during the other 18 discharge monitoring rounds were all below the SSTV.	Slight to no impact

Parameter	Discussion	Impact assessment
FRP as P	FRP concentrations were all below the SSTV at the downstream compliance point (ARDS) during all discharges for the reporting period.	No impact

## 5.4 Long-term trend analysis

The key contaminants of concern in discharge from the farm are the nutrients nitrogen (N) and phosphorus (P). These can exist in various forms (ammonia, nitrate, nitrite, organic nitrogen, filterable reactive phosphorus etc) but their total amounts are represented by the laboratory parameters TN and TP. Other parameters are also measured in farm discharge, and in the Adelaide River, that are indicators of the effects of excess, nutrients, e.g. excessive plant growth (algae, phytoplankton, cyanobacteria) and subsequent breakdown of these plants. This process is referred to as eutrophication and indicators of eutrophication are increasing BOD and chlorophyll-a, and large diurnal swings in DO, which can become very low during the night / early morning.

The concentrations of BOD and chlorophyll-a in the Adelaide River remain very low i.e. both are usually below detection (see Section 5.1 above). DO concentrations in the river vary seasonally (see Figure 5-1), with the highest concentrations during the dry season and lowest concentrations during the wet season. It is difficult to discern any impacts from farm discharge on DO in the river. As such, the remainder of this trend analysis focuses on the key parameters TN and TP.

The long-term trends in TN and TP concentrations measured in the Adelaide River at sites ARUS and ARDS, and at each discharge monitoring site, have been reviewed. Graphs of TN and TP concentrations measured since monitoring began in 2015 are provided in Figure 5-2 to Figure 5-5.

The concentrations of TN in the Adelaide River have remained largely consistent with the SSTV of 1 mg/L, whereby the majority (i.e. 80%) of concentrations remain less than the SSTV (Figure 5-2). See Appendix A for an explanation of SSTV derivation for the farm. Similarly, the concentrations of TP in the Adelaide River have remained largely consistent with the SSTV of 0.13 mg/L (Figure 5-3).

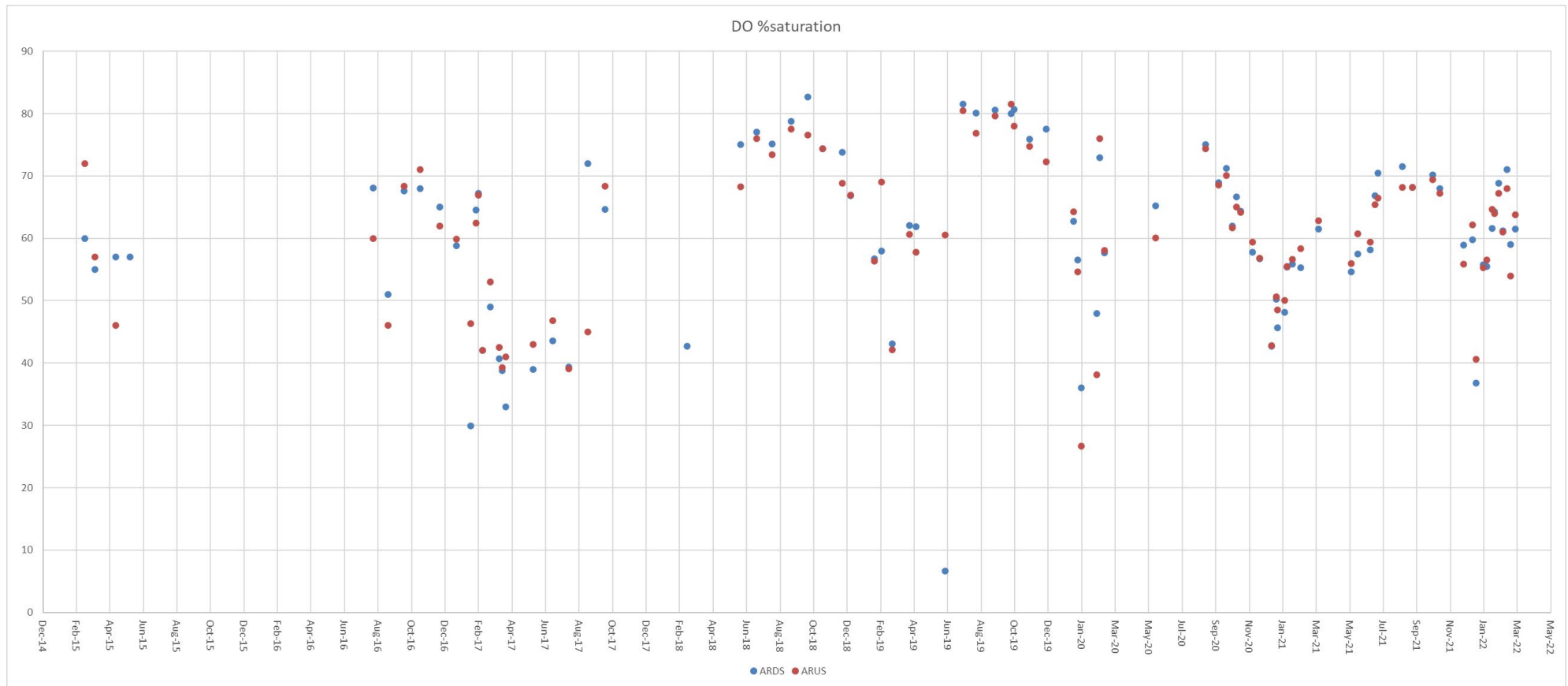
The concentrations of TN in discharge are highly variable (Figure 5-4). Most concentrations are less than 8 mg/L, with occasional spikes above this. The lowest concentrations generally occur during the wet season (December to March). This is also when the highest volumes of discharge occur. There are currently no consistently increasing trends in TN concentrations at any of the discharge points. The Stage 2 Nursery discharge (ND) was previously recording relatively high concentrations above 8 mg/L prior to October 2019, however these have since reduced, following improvements to the wetland treatment system.

During the period December 2016 to October 2019, the concentrations of TP in discharge from the South Farm (SF DP), North Farm (DP1) and Stage 1 Nursery (S1N DP) were gradually increasing from below detection to around 1.5 mg/L (Figure 5-5). These concentrations have now stabilised, with no increasing trend evident in the data from 2019 to the present.

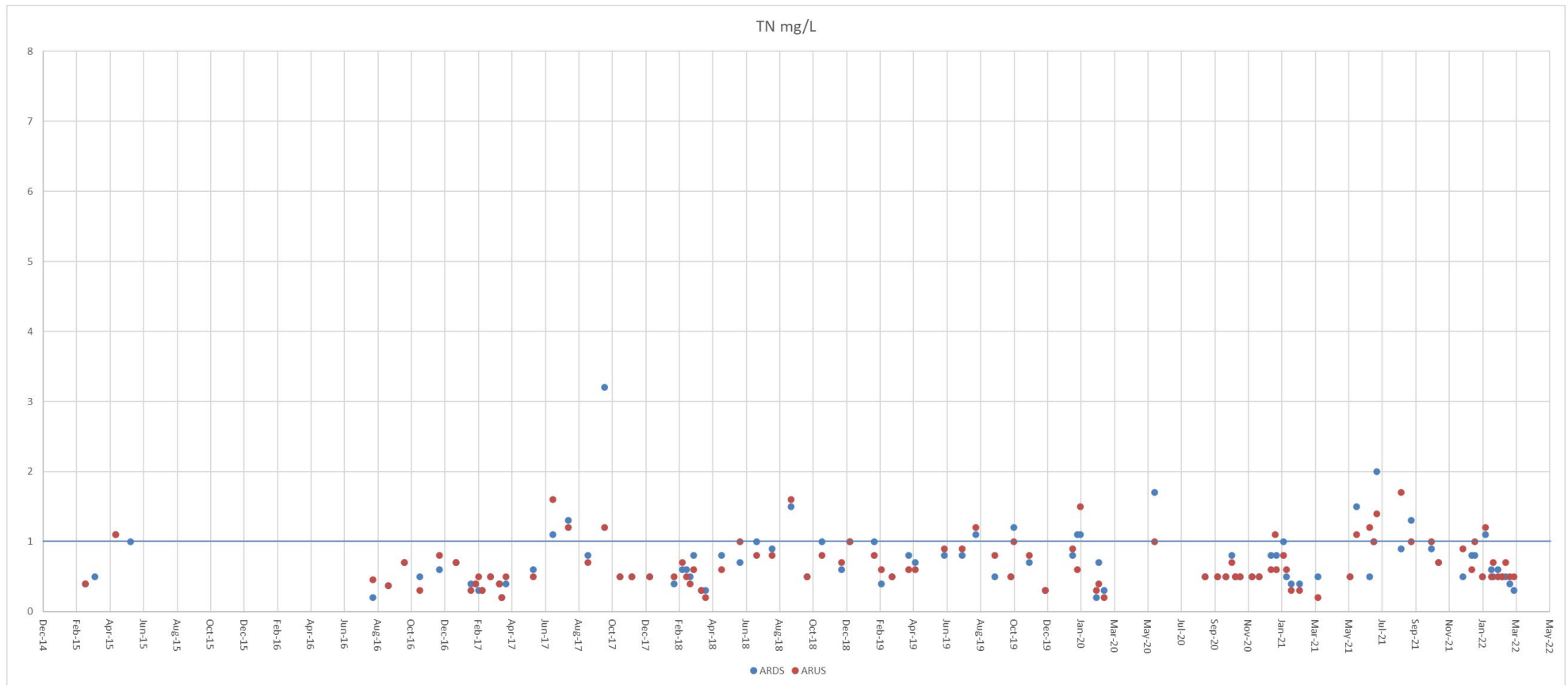
For the last two years (since January 2020), DP1 has occasionally recorded spikes in TP concentrations above 2 mg/L. The majority of concentrations however, still remain below 2 mg/L. The current program to progressively dredge and remove the built-up of sediment in the ageing wetland treatment systems of the North Farm aim to improve the removal of TP in production pond wastewater prior to reuse in the production ponds and discharge.

Up until October 2019, the Stage 2 Nursery (ND) recorded relatively high TP concentrations. These have since reduced to below 1.5 mg/L following improvements to the wetland treatment system.

The East Farm discharge (EF DP) recorded increasing TP concentrations starting from below detection, when the farm started operating in late 2019, to around 1.1 mg/L in January 2022. Decreasing concentrations were then recorded in February and March 2022.



**Figure 5-1. Graph of DO concentrations at the Adelaide River monitoring sites since monitoring began in 2015.**



**Figure 5-2. Graph of TN concentrations at the Adelaide River monitoring sites since monitoring began in 2015. SSTV shown as blue line.**

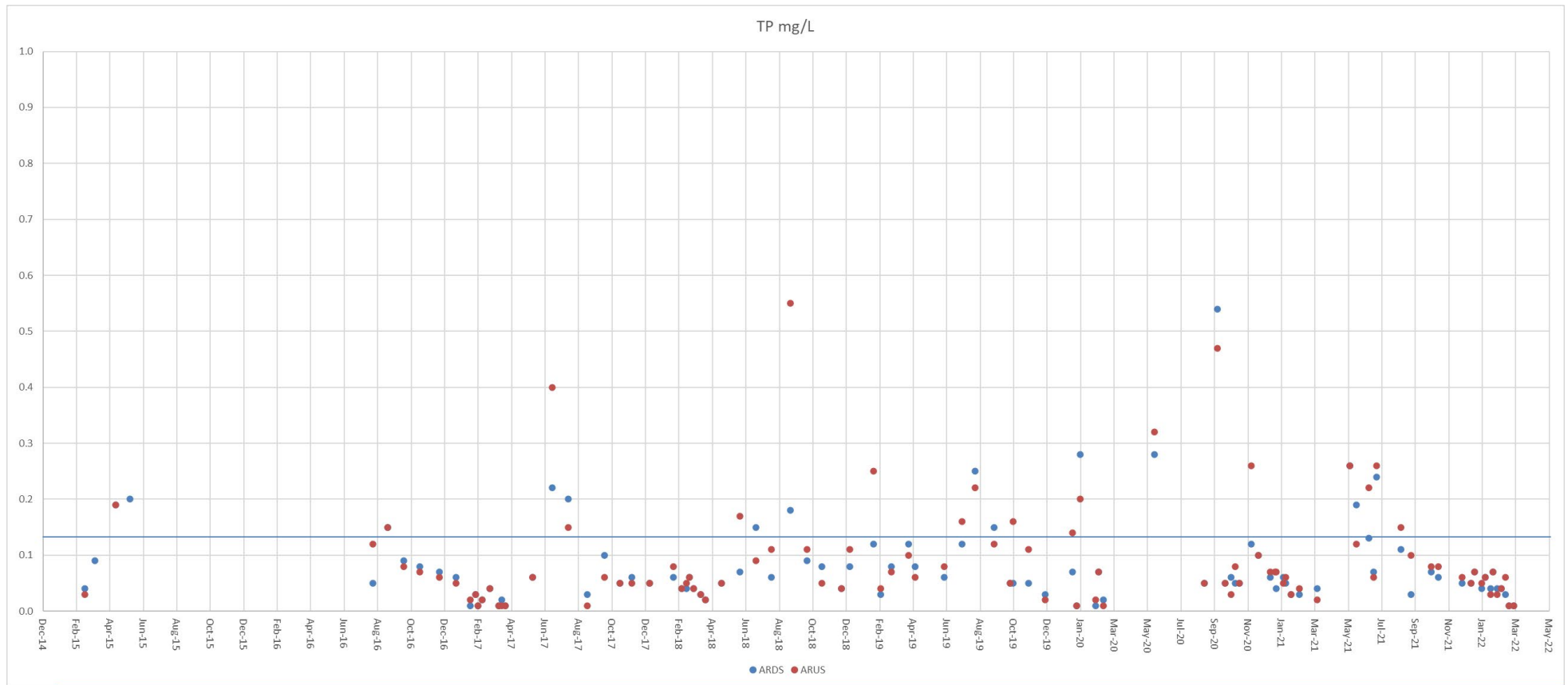
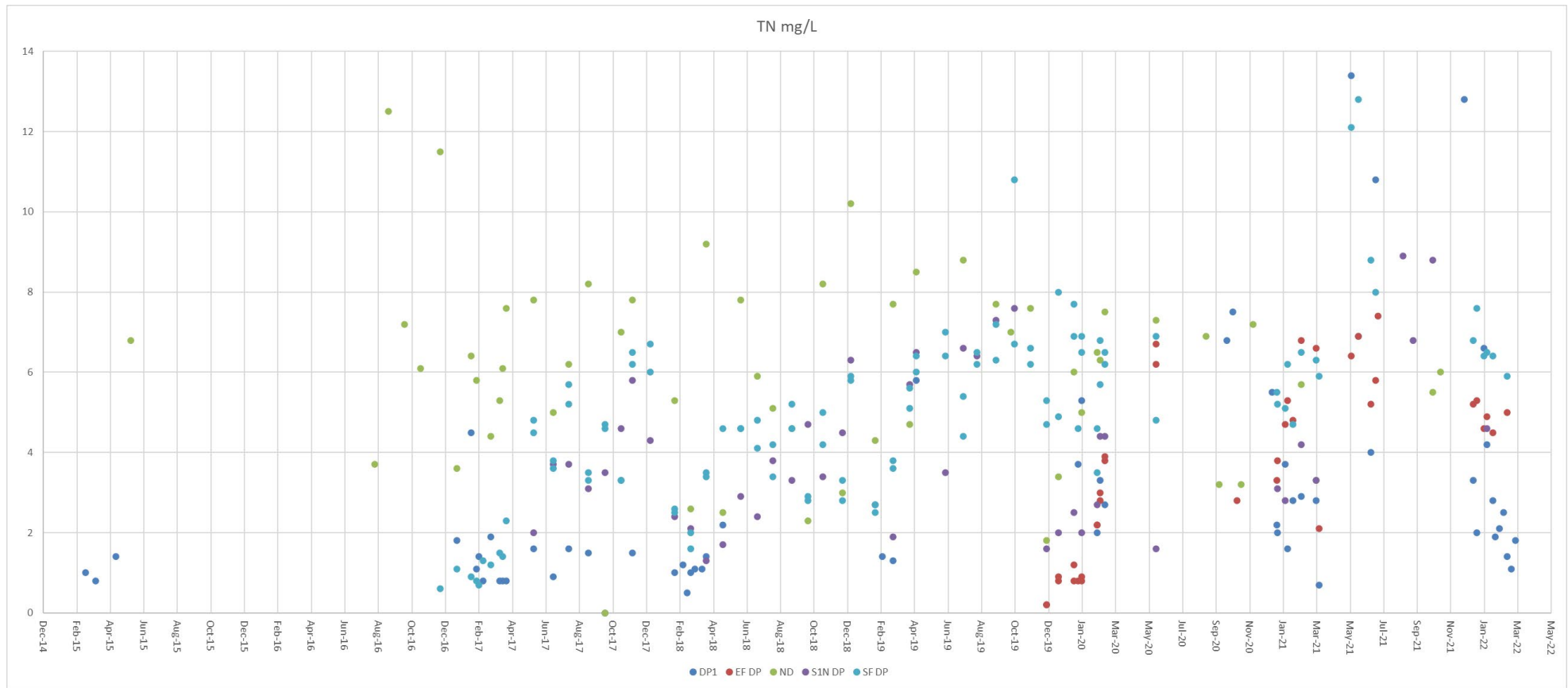


Figure 5-3. Graph of TP concentrations at the Adelaide River monitoring sites since monitoring began in 2015. SSTV shown as blue line.



**Figure 5-4. Graph of TN concentrations at the discharge monitoring sites since monitoring began in 2015**

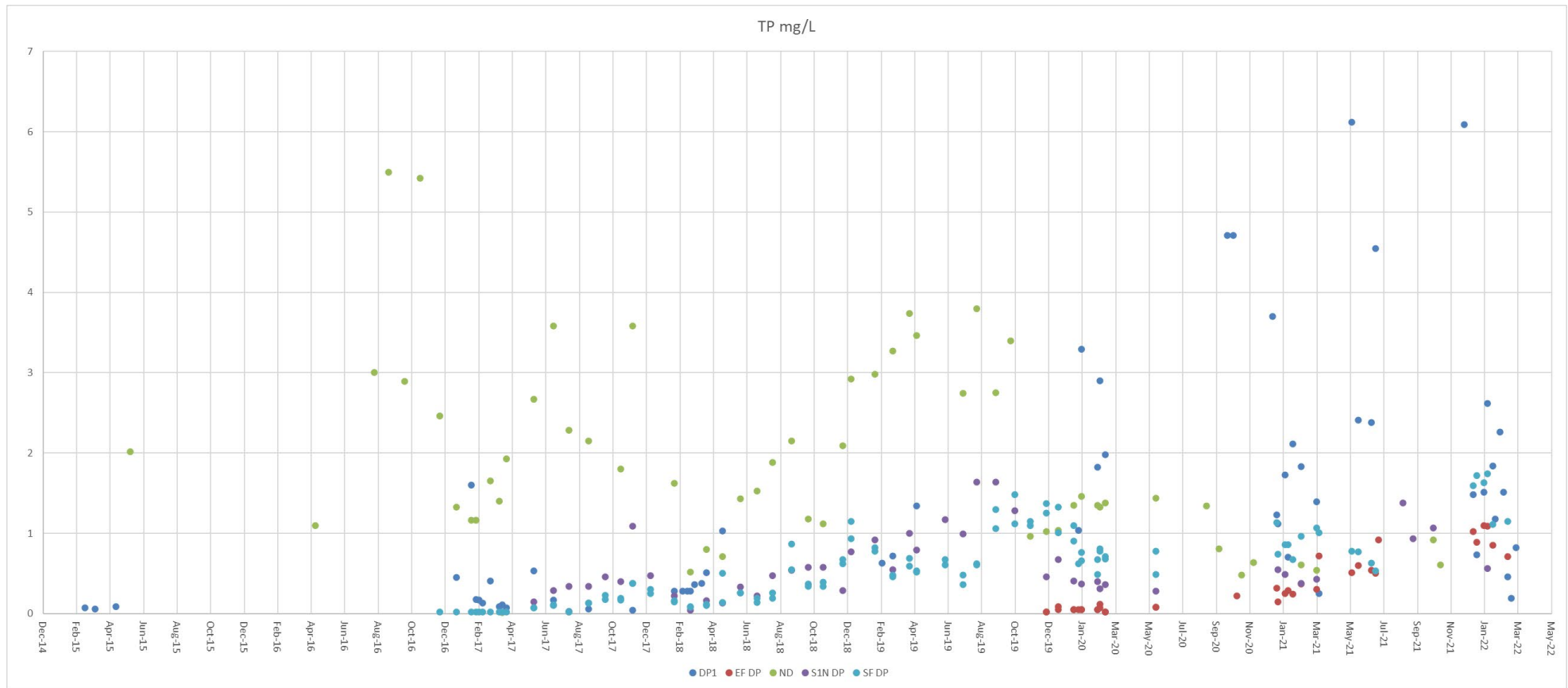


Figure 5-5. Graph of TP concentrations at the discharge monitoring sites since monitoring began in 2015

## 6 CONCLUSIONS

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During the 1 April 2021 to 31 March 2022 reporting period, all discharge monitoring was undertaken in accordance with all EPL239-02 conditions.

All discharge volumes and the start and finish times of all discharges were recorded. The load of TN and TP into the Adelaide River during the reporting period was also calculated and shown to be very small in relation to the existing loads in the river from the catchment i.e. 0.3% and likely having a negligible impact.

Monitoring during discharges did not detect any significant impacts on Adelaide River water quality and there were no non-compliances as per EPL239-02 Condition 34 apart from those already reported to the NT EPA in the following notifications:

- *Non-compliance notification – Humpty Doo Barramundi EPL239-02: ammonia exceedances, Oct 2021 – January 2022*, submitted to the NT EPA on 20 January 2022
- *Non-compliance notification – Humpty Doo Barramundi EPL239-02: ammonia exceedances, Jan – Feb 2022*, submitted to the NT EPA on 25 February 2022.

Both these notifications concluded the exceedances had minimal impact on the Adelaide River environment for the following reasons:

- TN concentrations at the downstream compliance point have generally remained below the SSTV. The compliant TN concentrations indicate that the total amount of nitrogen available to cause environmental problems such as algal blooms has not changed from background levels.
- Despite ammonia concentrations recording above background river levels (as represented by a SSTV of 0.06 mg/L), the concentrations remain well below that which is toxic to aquatic organisms. The ANZG 2018 default guideline value for toxic effects in marine ecosystems (such as the estuarine environment of the Adelaide River) is 0.91 mg/L for 95% species protection.
- No other parameters have consistently exceeded their respective SSTVs at the compliance point. This includes chlorophyll-a, which has always remained close to the laboratory detection limit, providing evidence that no algae blooms have occurred. Similarly, BOD has also remained close to the laboratory detection limit at the compliance point indicating that discharge from the farm is not causing an increased risk of low dissolved oxygen levels in the river.
- The risk of an algae bloom in the river is low given the river is naturally very turbid and light is limited preventing algae growth. Nutrients are most likely to be washed out to sea rather than be utilised for algae growth. Stream flow and tidal currents moving past the farm are extremely large in comparison to discharge volume.

Long-term trend analysis of the key parameters TN and TP did not show any current increasing trends of concern. Increasing TN and TP concentrations in discharge in the past have been addressed by making improvements to the wetland treatment systems. These improvements have so far appeared to have been successful.

## 7 REFERENCES

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## APPENDIX A SSTV DERIVATION REPORT



# EPL239 Amendment Application

## *Site Specific Trigger Values*

### Humpty Doo Barramundi Pty Ltd





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# DOCUMENT CONTROL RECORD

<b>Job Number</b>	EZ18119
<b>Document ID</b>	170694
<b>Project manager</b>	Emma Smith
<b>Author(s)</b>	Emma Smith

Revision	Date	Document history	Approver
1	25 Sept 2018	Submitted to NT EPA	T. Elder

Recipients are responsible for eliminating all superseded documents in their possession.

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# ACRONYMS AND ABBREVIATIONS

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<b>ANZECC</b>	Australian and New Zealand Environment and Conservation Council
<b>BOD</b>	Biological Oxygen Demand
<b>Chl-a</b>	Chlorophyll a
<b>DO</b>	Dissolved Oxygen
<b>EC</b>	Electrical Conductivity
<b>EPL</b>	Environment Protection Licence
<b>FRP</b>	Filterable Reactive Phosphorus
<b>NATA</b>	National Association of Testing Authorities
<b>NOx</b>	Nitrate NO <sub>3</sub> + Nitrite NO <sub>2</sub>
<b>NT</b>	Northern Territory
<b>NT EPA</b>	Northern Territory Environment Protection Authority
<b>SSTV</b>	Site Specific Trigger Value
<b>TN</b>	Total Nitrogen
<b>TP</b>	Total Phosphorus
<b>WQMP</b>	Water Quality Monitoring Plan

# 1 INTRODUCTION

---

This report presents the Site Specific Trigger Values (SSTVs) calculated for Adelaide River water quality adjacent to the Humpty Doo Barramundi (HDB) farm. These SSTVs are to be used in compliance monitoring of farm discharges as required by HDB's *Environment Protection Licence 239* (EPL239) issued by the Northern Territory Environment Protection Authority (NT EPA) under the *Waste Management and Pollution Control Act*.

In accordance with the ANZECC 2000 methodology for deriving SSTVs, at least two-years of monthly water quality data at a suitable reference site is required. At the time of application for EPL239 in August 2017, only 12 months of consecutive monthly data had been collected from the three Adelaide River reference sites "ARUS", "ARDS" and "AI" (Figure 1-1). Interim SSTVs were calculated based on the available data and listed in EPL239 Appendix A as the water quality trigger values to be applied at the compliance point during discharges from the farm. The EPL239 compliance point is the Adelaide River downstream monitoring site at the time of sampling depending on the tide i.e. ARDS during an outgoing tide and ARUS during an incoming tide.

A condition of EPL239 was to recalculate SSTVs once the minimum 12-months of consecutive water quality data was obtained. This was achieved in August 2018 and the recalculated SSTVs are presented here for submission to the NT EPA as an amendment to EPL239.

## 1.1 Purpose

This report presents the SSTVs calculated for use in future compliance monitoring of discharges from the HDB farm in accordance with EPL239. This was a requirement of EPL239 Condition 48:

*The licensee must provide to the NT EPA, by 01 October 2018, site specific trigger values to replace the interim trigger values specified in Attachment A of this licence. The licensee must ensure that:*

*48.1 the background data used to derive the site specific trigger values is from an appropriate reference system;*

*48.2 the site specific trigger values are derived using a minimum of 2 years monthly monitoring data from the appropriate reference system; and*

*48.3 the site specific trigger values are derived in accordance with recognised Australian standards and guidelines, such as ANZECC/ARMCANZ.*

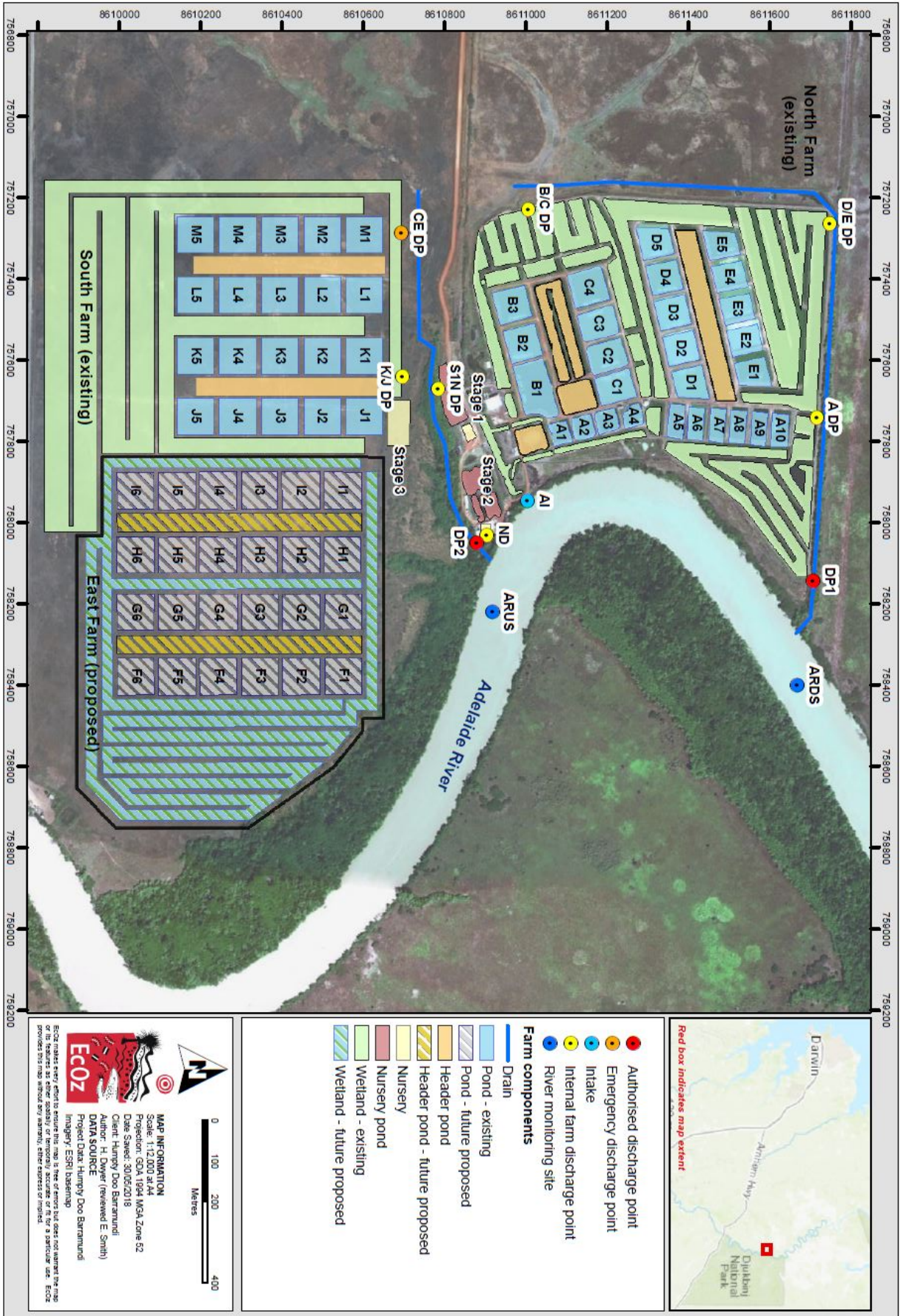


Figure 1-1. Farm layout and monitoring site/discharge point locations.

## 2 MONITORING UNDERTAKEN

---

Monthly and weekly (during discharge) water quality monitoring of all internal farm and Adelaide River monitoring sites is undertaken in accordance with the requirements of EPL239, and as per HDB's *Water Quality Monitoring Plan* (WQMP).

### 2.1 Monitoring sites

The eleven monitoring sites located within the farm and on the adjacent Adelaide River conform to those listed in Attachment A of EPL239 (Figure 1-1 shows site locations and Table 2-1 shows site details). As prescribed in EPL239, there are two authorised discharge points (DP1 and DP2), where discharge from the farm is permitted to enter the Adelaide River.

Sites ARUS (Adelaide River Up-Stream), ARDS (Adelaide River Down-Stream) and AI (Adelaide Intake) are located on the Adelaide River, and the data from these sites is used in SSTV calculation. ARUS is around 150 m upstream of DP2, and ARDS is around 150 m downstream of DP1. AI is between these two sites at the intake point where river water is pumped to supply the farm. Most importantly, during monthly sampling, when there is no farm discharge, all three sites are suitable reference sites and used in the SSTV calculation. However, during weekly monitoring of discharge events, only the upstream site is suitable i.e. either ARUS or ARDS depending on whether the tide is incoming or outgoing at the time of sampling.

ARUS and ARDS are also the EPL239 "compliance point", where trigger values are applied during discharges to assess any impacts on river water quality i.e. ARDS during an outgoing tide and ARUS during an incoming tide.

**Table 2-1. Monitoring site details.**

Site Code	Details	
<b>Authorised Discharge Points</b>		
<b>DP1</b>	End of North Farm perimeter drain where it discharges into Adelaide River. Perimeter drain receives waste water from North Farm production ponds (Series A, B, C, D and E) via discharge points A DP, B/C DP, and D/E DP. <i>Sampling Frequency: Weekly during discharge or at least once per discharge event.</i> <b>Flow meter installed at this site to measure total discharge volumes from North Farm.</b>	
<b>DP2</b>	End of drainage channel where it discharges into Adelaide River. This drainage channel receives waste water from the South Farm and (proposed) East Farm production ponds (Series F to M) via discharge point K/J DP and, during extreme flood events, via CE DP. Drainage channel also receives waste water from Stage 1 Nursery (S1N DP) and Stage 2 Nursery (ND). <i>*NOTE: this site is not sampled due to difficult access and high risk of crocodile attack. Rather, the individual inputs into the drainage channel are sampled – see below.</i>	
<b>Internal Farm Discharge Points</b>		<b>Reports to Authorised Discharge</b>
<i>Sampling Frequency: Monthly regardless of discharging or not; Weekly during discharge or at least once per discharge event.</i>		
<b>A DP</b>	Where wastewater treatment system for A Series production ponds discharges into perimeter drain.	DP1
<b>B/C DP</b>	Where wastewater treatment system for B and C Series production ponds discharges into perimeter drain.	DP1
<b>D/E DP</b>	Where wastewater treatment system for D and E Series production ponds discharges into perimeter drain.	DP1
<b>ND</b>	Discharge point from Stage 2 nursery into drainage channel. <b>Discharge volumes calculated by manually measuring flow at pipe outlet and recording start and end times of discharge.</b>	DP2
<b>S1N DP</b>	Discharge point from Stage 1 nursery into drainage channel. <b>Discharge volumes calculated by manually measuring flow at pipe outlet and recording start and end times of discharge.</b>	DP2
<b>K/J DP</b>	Where wastewater treatment system for South Farm and (proposed) East Farm production ponds (Series F to M) discharges into drainage channel. <b>Flow meter installed at this site to measure total discharge volumes from South and East Farms.</b>	DP2
<b>CE DP</b>	Where wastewater treatment system for South Farm and (proposed) East Farm production ponds (Series F to M) discharges into drainage channel during extreme flood events when capacity of K/J DP is exceeded. <b>Discharge volumes calculated by manually measuring flow at spillway and recording start and end times of discharge.</b>	DP2
<b>Adelaide River Sites</b>		
<b>ARUS</b>	Approximately 150 m upstream of DP2. This site is “upstream” of farm discharges on an <u>outgoing</u> tide and “downstream” on an <u>incoming</u> tide. As such during discharge, <b>this site is the EPL Compliance Point on an incoming tide.</b> <i>Sampling Frequency: Monthly regardless of discharging or not; Weekly during discharge or at least once per discharge event.</i>	
<b>ARDS</b>	Approximately 150 m downstream of DP1. This site is “upstream” of farm discharges on an <u>incoming</u> tide and “downstream” on an <u>outgoing</u> tide. As such during discharge, <b>this site is the EPL Compliance Point on an outgoing tide.</b> <i>Sampling Frequency: Monthly regardless of discharging or not; Weekly during discharge or at least once per discharge event.</i>	
<b>AI</b>	Intake point for water pumped from the Adelaide River to supply farm production ponds (when required). <i>Sampling Frequency: Monthly regardless of discharging or not.</i>	

## 2.2 Water quality parameters and interim SSTVs

Table 2-2 lists the parameters measured in the field and laboratory, and the assessment criteria currently specified in EPL239 Attachment A. SSTVs are applied to all parameters except electrical conductivity (EC), dissolved oxygen (DO), and turbidity. It is more appropriate to assess these against the water quality of the upstream Adelaide River site at the time of sampling.

**Table 2-2. Water quality parameters and assessment criteria.**

*AR – assess against the quality of Adelaide River upstream location at time of sampling.*

Parameters	Units	Assessment Criteria
<b>Field Measurements</b>		
Flow	kL/day	N/A
pH	pH units	6.7 – 7.9
Electrical Conductivity (EC)	µS/cm	AR
Dissolved Oxygen (DO)	% saturation	AR
Turbidity	NTU	AR
Temperature	°C	N/A
<b>Laboratory Parameters</b>		
Biological Oxygen Demand (BOD)	mg/L	1.15
Filterable Reactive Phosphorus (FRP) as P	mg/L	0.025
Total Phosphorus (TP) as P	mg/L	0.12
Ammonia (NH <sub>3</sub> ) as N	mg/L	0.06
Total Nitrogen (TN) as N	mg/L	0.7
Nitrogen Oxides NO <sub>3</sub> + NO <sub>2</sub> (NO <sub>x</sub> ) as N	mg/L	0.37
Nitrate (NO <sub>3</sub> ) as N	mg/L	0.37
Nitrite (NO <sub>2</sub> ) as N	mg/L	0.005
Total Kjeldahl Nitrogen (TKN) as N	mg/L	N/A
Chlorophyll-a	µg/L	2
<b>Other information recorded</b>		
Site Name, Date, Time and Sampler/s name		
Tide (high/low/spring/neap/incoming/outgoing)		
If discharge is occurring and any comments relating to site condition – e.g. any visible pollutants, scum, water colour, clarity, water plants/algae, dead fish, any odours		

## 2.3 Sampling procedures

All sampling is undertaken in accordance with the WQMP 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 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 on Water Quality Sampling – *Part 10: Guidance on sampling of waste waters* (AN/NZS 5667.10:1998), 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.

Sampling is carried out by Fiona Taylor from HDB, who has received on-site training in sampling methods from EcOz Senior Environmental Consultant Emma Smith, as well as on-going guidance from EcOz.

All laboratory samples are collected into ALS Laboratory-supplied sample bottles containing preservative where required.

The Adelaide River sites ARUS and ARDS are sampled from a boat in order to gain a representative sample from the middle of the river. All other sites are sampled from the land using a long pole, with a lab-supplied sample bottle on the end, in order to gain a sample a few metres from the shore. Sample is decanted from this bottle into bottles that contain preservative.

All field parameters are recorded on a dedicated *Field Data Sheet*, developed to ensure all EPL239 information requirements are collected. The field parameter meter is calibrated immediately prior to each sampling round.

All field and laboratory results are stored in an Excel database maintained by EcOz.

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

Photos are taken at each site during each sample round and stored by EcOz in a photo database (M-Files).

## 3 SSTV CALCULATION

### 3.1 Methodology

The data used to calculate SSTVs is provided in Appendix 1. This includes intermittent monitoring undertaken between March 2015 and April 2016 and the consistent monthly monitoring carried out between August 2016 and August 2018. Periods where discharge was occurring are highlighted in yellow. At this time only the upstream Adelaide River site was used.

The Hazen percentile calculator Excel spreadsheet available on the New Zealand Ministry for the Environment website: <http://www.mfe.govt.nz/publications/fresh-water/bathewatch-user-guide/hazen-percentile-calculator> was used.

As per the ANZECC 2000 guidelines for “slightly disturbed” sites, the 80<sup>th</sup> percentile of reference site data is taken to be the SSTV. For the lower pH range threshold, the 20<sup>th</sup> percentile was used.

Where a concentration was below laboratory detection limits the concentration was taken to be half the detection limit e.g. if the concentration was <0.01 mg/L then the concentration was taken to be 0.005 mg/L.

### 3.2 SSTVs

Table 3-1 presents the SSTV calculation results. When compared to the interim SSTVs, BOD is slightly lower, ammonia, nitrite and Chlorophyll-a are unchanged, and FRP, TP, TN, NOx and nitrate are slightly higher.

**Table 3-1. SSTV calculation results.**

Parameter	BOD	Chl-a	NH <sub>3</sub>	NOx	NO <sub>3</sub>	NO <sub>2</sub>	TP	FRP	TN	pH 80	pH 20
Units	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-	-
Number data points used	65	67	67	67	67	67	67	67	67	68	68
Minimum concentration	1	0.5	0.005	0.005	0.005	0.005	0.005	0.0005	0.1	6.14	6.14
Maximum Concentration	3	12	0.16	0.47	0.47	0.11	0.55	0.079	3.2	9.36	9.36
SSTV	1.00	2.00	0.06	0.41	0.41	0.005	0.13	0.04	1.00	8.2	7.2
Interim SSTV	1.15	2	0.06	0.37	0.37	0.005	0.12	0.025	0.7	7.9	6.7

## 4 RECOMMENDATIONS

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It is recommended that the SSTVs presented in Table 3-1 are adopted in EPL239 for compliance monitoring during discharges from HDB farm at the specified compliance monitoring point.

## 5 REFERENCES

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

## APPENDIX 1 – WATER QUALITY MONITORING DATA USED FOR SSTVS

Details:													Laboratory Parameters:										
Site ID	Date	Tide point for ARUS, ARDS, AI	Temp	pH	EC	TDS	Sal	DO	DO	ORP	Turbidity	BOD	Chl a	TSS	NH <sub>3</sub> as N	NOx as N	NO <sub>3</sub> as N	NO <sub>2</sub> as N	TKN as N	TN as N	TP as P	FRP as P	
		High/Outgoing/Incoming/Low	(°C)	pH units	mS/cm	g/L	ppt	%sat	mg/L	mV	NTU	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Limit of Reporting			-	0.1	0.01	0.01	0.01	0.1	1	1	1	5	5	1	0.01	0.05/0.01	0.02/0.01	0.02/0.01	0.2/0.1	0.2/0.1	0.05/0.01	0.05/0.001	
ANZECC 2000 default			-	-	7.0 - 8.5	-	-	80 - 120	-	-	20	-	2	-	0.91	0.03	-	-	-	0.25	0.02	0.005	
Site-specific trigger			-	-	6.7-7.9	AR	-	-	AR	-	-	AR	1.15	2	-	0.06	0.37	0.37	0.005	-	0.7	0.12	0.025
ARUS	12-03-2015	-	32.9	6.34	-	-	-	72	-	-	-	-	0.5	-	0.01	0.05	0.05	0.01	0.4	0.4	0.03	0.005	
ARUS	30-03-2015	Low	-	6.14	-	-	-	57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
ARDS	06-05-2015	Incoming	26.0	6.43	-	-	-	57	-	-	-	-	1	-	0.01	0.22	0.22	0.01	0.9	1.1	0.19	0.010	
AI	27-04-2016	High	31.4	8.38	0.713	0.46	0.30	102	-	-	462.0	2.5	0.5	170	0.01	0.19	0.19	0.01	0.1	0.1	0.10	0.025	
ARDS	09-08-2016	Low	25.5	8.36	6.150	4.00	3.30	68	-	-	61	30.0	2.5	29	0.01	0.39	0.38	0.01	0.1	0.1	0.03	0.025	
ARUS	09-08-2016	Low	25.4	7.71	6.320	4.11	3.40	60	-	-	74	216.0	2.5	97	0.01	0.39	0.39	0.01	0.5	0.5	0.12	0.025	
AI	11-08-2016	Low	-	7.98	6.320	4.10	3.50	68	-	-	165	218.0	2.5	160	0.03	0.42	0.42	0.01	0.1	0.4	0.14	0.025	
ARDS	05-09-2016	Low/Slightly Incoming	27.6	7.36	13.290	8.64	7.60	51	-	-	241	186.0	2.5	160	0.01	0.37	0.37	0.01	0.1	0.4	0.15	0.025	
AI	04-10-2016	High/Slightly Incoming	30.2	7.49	20.489	13.32	12.16	87	-	-	182	125.0	1	108	0.03	0.33	0.33	0.01	0.5	0.8	0.09	0.010	
ARDS	04-10-2016	High/Slightly Incoming	30.1	7.33	25.203	16.38	15.25	68	-	-	189	142.3	1	96	0.03	0.32	0.32	0.01	0.4	0.7	0.09	0.011	
ARUS	04-10-2016	High/Slightly Incoming	30.3	7.34	24.725	16.07	14.93	68	-	-	161	111.2	1	83	0.03	0.32	0.32	0.01	0.4	0.7	0.08	0.012	
AI	01-11-16	High	31.3	6.82	28.760	18.69	17.60	69	-	-	259.0	1	0.5	202	0.08	0.30	0.30	0.01	0.1	0.3	0.07	0.001	
ARDS	01-11-16	High/Incoming	30.7	6.61	25.940	16.89	15.70	68	-	-	210.0	1	2	164	0.06	0.31	0.31	0.01	0.2	0.5	0.08	0.013	
ARUS	01-11-16	High/Incoming	31.1	7.22	26.600	17.28	16.10	71	-	-	214.0	1	0.5	184	0.05	0.34	0.34	0.01	0.1	0.3	0.07	0.053	
AI	06-12-16	Mid/Incoming	32.0	6.87	21.064	13.69	12.50	71	-	-	224	100.8	1	76	0.07	0.31	0.31	0.01	0.3	0.6	0.06	0.025	
ARDS	06-12-16	Low/Outgoing	31.4	6.26	20.613	13.40	12.22	65	-	-	238	87.5	3	98	0.01	0.32	0.32	0.01	0.3	0.6	0.07	0.017	
ARUS	06-12-16	Low/Outgoing	31.6	7.10	19.591	12.73	11.56	62	-	-	234	70.0	1	68	0.04	0.38	0.38	0.01	0.4	0.8	0.06	0.024	
ARDS	05-01-17	High/Incoming	29.0	6.56	0.062	0.04	0.03	59	-	-	224	107.0	1	691	0.10	0.01	0.01	0.01	0.7	0.7	0.06	0.013	
ARUS	31-01-17	Low/Outgoing	31.7	7.13	0.072	0.05	0.00	46	-	-	198	22.3	1	26	0.04	0.03	0.03	0.01	0.3	0.3	0.02	0.010	
ARUS	09-02-17	Outgoing	28.0	6.81		0.00	62					1	0.5	31	0.05	0.04	0.04	0.01	0.4	0.4	0.03	0.013	
ARUS	14-02-17	Outgoing	28.8	7.43		0.00	67					1	1	19	0.08	0.01	0.01	0.01	0.5	0.5	0.01	0.008	
ARUS	21-02-17	Outgoing	30.1	7.17		0.00	42					1	2	16	0.03	0.01	0.01	0.01	0.3	0.3	0.02	0.005	
ARUS	07-03-17	Outgoing	30.1	7.71		0.00	53					1	0.5	48	0.02	0.01	0.11	0.11	0.4	0.5	0.04	0.034	
ARUS	23-03-17	Outgoing	28.9	7.62		0.00	43					1	5	12	0.08	0.02	0.02	0.01	0.4	0.4	0.01	0.008	
ARDS	28-03-17	Incoming	30.2	8.06		0.00	39					3	0.5	18	0.06	0.01	0.01	0.01	0.2	0.2	0.02	0.016	
ARUS	04-04-17	Outgoing	29.7	7.31		0.00	41					1	0.5	18	0.03	0.01	0.01	0.01	0.5	0.5	0.01	0.009	
AI	23-05-17	High	28.5	8.21		0.00	38					1	0.5	68	0.04	0.21	0.21	0.01	0.3	0.5	0.06	0.056	
ARDS	23-05-17	High	28.2	8.34		0.00	39					1	0.5	132	0.04	0.21	0.21	0.01	0.4	0.6	0.06	0.044	
ARUS	23-05-17	High	27.9	8.09		0.00	43					1	0.5	72	0.04	0.21	0.21	0.01	0.3	0.5	0.06	0.044	
AI	27-06-17	Outgoing	24.5	8.36		1.00	40					1	1	717	0.01	0.33	0.33	0.01	1.0	1.3	0.30	0.026	
ARDS	27-06-17	Outgoing	24.3	8.74		1.00	44					1	12	136	0.02	0.34	0.34	0.01	0.8	1.1	0.22	0.029	
ARUS	27-06-17	Outgoing	24.9	8.23		1.00	47					1	0.5	903	0.02	0.31	0.31	0.01	1.3	1.6	0.40	0.054	
AI	25-07-17	Outgoing	24.9	8.04		3.00	44					1	1	751	0.02	0.38	0.38	0.01	1.0	1.4	0.29	0.013	
ARDS	25-07-17	Outgoing	24.9	8.11		3.00	39					1	1	363	0.02	0.38	0.38	0.01	0.9	1.3	0.20	0.032	
ARUS	25-07-17	Outgoing	25.0	7.94		3.00	39					1	1	472	0.02	0.41	0.41	0.01	0.8	1.2	0.15	0.013	
AI	29-08-17	Incoming	25.3	8.30		5.00	50					1	0.5	99	0.02	0.46	0.46	0.01	0.2	0.7	0.01	0.010	
ARDS	29-08-17	Incoming	25.3	8.38		5.00	72					1	2	113	0.02	0.47	0.47	0.01	0.3	0.8	0.03	0.014	
ARUS	29-08-17	Incoming	25.7	8.20		5.00	45					1	1	24	0.02	0.47	0.47	0.01	0.2	0.7	0.01	0.010	
AI	28-09-17	Incoming	29.8	8.18		12.00	68					1	0.5	251	0.16	0.44	0.44	0.01	1.2	1.6	0.10	0.015	
ARDS	28-09-17	Incoming	30.4	8.33		11.00	65					1	1	106	0.15	0.44	0.44	0.01	2.8	3.2	0.10	0.021	
ARUS	28-09-17	Incoming	30.1	8.18		12.00	68					1	0.5	77	0.09	0.44	0.44	0.01	0.8	1.2	0.06	0.015	
AI	26-10-17	Outgoing	31.3	8.03		16.00		2.70			15	1	0.5	325	0.03	0.34	0.34	0.01	0.3	0.3	0.10	0.018	
ARDS	26-10-17	Outgoing	31.3	8.02		16.00		2.70			15	1	2	96	0.09	0.35	0.35	0.01	0.3	0.3	0.03	0.016	
ARUS	26-10-17	Outgoing	31.2	7.94		16.00		2.80			15	1	4	85	0.03	0.36	0.36	0.01	0.3	0.3	0.03	0.016	
ARUS	16-11-17	Outgoing	30.4	7.60		16.00		2.83			15	1	2	165	0.03	0.32	0.32	0.01	0.3	0.3	0.03	0.016	
AI	18-12-17	Outgoing	32.4	8.08		17.00		3.20			27	1	2	34	0.03	0.34	0.34	0.01	0.3	0.3	0.03	0.020	
ARDS	18-12-17	Outgoing	32.3	8.24		17.00		3.47			27	1	2	33	0.08	0.35	0.35	0.01	0.3	0.3	0.03	0.059	
ARUS	18-12-17	Outgoing	32.3	8.00		17.00		2.60			42	1	2	51	0.03	0.34	0.34	0.01	0.3	0.3	0.03	0.019	
ARUS	30-01-18	Outgoing	25.8	9.36		0.00		4.24				1	0.5	105	0.03	0.01	0.01	0.01	0.5	0.5	0.08	0.008	
ARUS	14-02-18	Outgoing	30.1	7.33		0.00		3.80				1	2	49	0.09	0.05	0.05	0.01	0.7	0.7	0.04	0.004	
ARUS	22-02-18	Outgoing	30.6	7.60		0.00		5.30			35	1	5	33	0.14	0.01	0.01	0.01	0.5	0.5	0.05	0.011	
ARUS	28-02-18	Outgoing	31.0	7.81		0.00		2.50				1	1	36	0.04	0.04	0.04	0.01	0.4	0.4	0.06	0.001	
ARUS	07-03-18	Outgoing	31.7	7.17		0.00		3.72			25	2	0.5	32	0.05	0.05	0.05	0.01	0.6	0.6	0.04	0.010	
ARUS	20-03-18	Outgoing	30.5	7.67																			



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## APPENDIX B RAW WATER QUALITY RESULTS

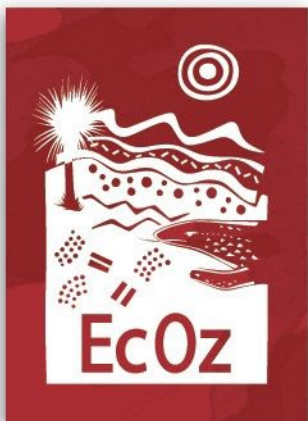
**Monitoring results during discharges that occurred between April 2021 and March 2022.**

*AR – assess against the quality of Adelaide River upstream location at time of sampling i.e. only for EC, DO and turbidity*

*Concentrations that are highlighted are above the SSTV (or outside the SSTV range in the case of pH).*

*Note that only the downstream compliance point ARDS concentrations are assessed against the SSTVs.*

Site ID	Date	Field Parameters							Laboratory Parameters:										
		Time	Temp	pH	EC	Sal	DO	Turbidity	BOD	Chl a	TSS	NH <sub>3</sub> as N	NO <sub>2</sub> as N	NO <sub>3</sub> as N	NO <sub>x</sub> as N	TKN as N	TN as N	TP as P	FRP as P
		24 hr	°C	pH units	µS/cm	ppt	%sat	NTU	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Limit of Reporting			0.1	0.01	0.01	0.1	1	1	2	1	5	0.01	0.01	0.01	0.01	0.1	0.1	0.01	0.001
SSTV as per EPL239-02			-	7.2-8.2	AR	-	AR	AR	1.0	2	-	0.06	0.005	0.41	0.41	-	1.0	0.13	0.04
ARDS	26/05/2021	1046	27.8	7.52	795	0.38	55	431	<2	<5	253	0.15	<0.01	0.22	0.22	<0.5	<0.5	0.26	0.004
ARUS	26/05/2021	1042	27.9	7.71	764	0.37	56	317	<2	<5	580	0.09	<0.01	0.22	0.22	<0.5	<0.5	0.26	0.006
DP1	26/05/2021	1104	27.9	7.94	19100	11.68	118	16.6	9	38	44	0.22	1.34	1.89	3.23	10.2	13.4	6.12	5.920
EF DP	26/05/2021	1102	27.9	7.99	17700	10.81	97	15.7	2	15	44	1.40	0.89	0.32	1.21	5.2	6.4	0.51	0.176
SF DP	26/05/2021	1114	27.6	7.67	17900	10.95	79	8.6	7	13	17	4.27	1.88	0.09	1.97	10.1	12.1	0.78	0.350
ARDS	7/06/2021	854	26.0	7.86	1021	0.50	58	155.1	<2	<1	197	0.11	<0.01	0.30	0.30	1.2	1.5	0.19	0.006
ARUS	7/06/2021	915	26.4	8.21	1089	0.54	61	125.4	<2	<1	94	0.09	<0.01	0.29	0.29	0.8	1.1	0.12	0.011
DP1	7/06/2021	903	22.6	7.43	17326	10.22	38	37.5	12	8	47	1.04	<0.01	0.02	0.02	6.9	6.9	2.41	1.000
EF DP	7/06/2021	935	25.6	8.12	18255	10.78	85	15.0	4	16	50	1.66	0.86	0.08	0.94	6.0	6.9	0.60	0.157
SF DP	7/06/2021	927	25.0	7.67	18631	11.03	68	11.7	4	4	34	3.37	1.9	0.91	2.81	10.0	12.8	0.77	0.312
ARDS	30/06/2021	1237	26.5	8.29	2458	1.26	58	514.2	<2	<3	311	0.03	<0.01	0.40	0.40	<0.5	<0.5	0.13	0.004
ARUS	30/06/2021	1241	26.6	8.01	2260	1.15	59	322.8	<2	<2	388	0.04	<0.01	0.36	0.36	0.8	1.2	0.22	0.004
DP1	30/06/2021	1207	26.1	8.68	16845	9.88	118	15.5	7	24	26	0.12	<0.01	0.04	0.04	4.0	4.0	2.38	1.530
EF DP	30/06/2021	1217	26.5	8.07	16082	9.39	82	13.4	5	23	27	0.76	1.11	0.16	1.27	3.9	5.2	0.54	0.099
SF DP	30/06/2021	1225	25.9	7.75	16126	9.42	61	13.4	6	29	16	2.27	1.28	1.07	2.35	6.5	8.8	0.63	0.158
ARDS	8/07/2021	933	25.7	8.09	3891	2.05	67	416.4	<2	<2	180	0.08	<0.01	0.38	0.38	0.6	1.0	0.07	0.006
ARUS	8/07/2021	944	25.9	8.08	3689	1.94	65	146.8	<2	<1	48	0.12	<0.01	0.40	0.40	0.6	1.0	0.06	0.006
DP1	8/07/2021	1030	24.4	8.12	16658	9.77	93	22.9	7	87	56	0.14	0.19	2.61	2.80	8.0	10.8	4.55	1.900
EF DP	8/07/2021	1006	25.1	8.09	16323	9.55	87	14.9	3	5	30	1.64	0.67	<0.01	0.67	5.1	5.8	0.50	0.144
SF DP	8/07/2021	1013	24.8	7.97	16590	9.73	65	11.4	4	16	21	1.72	1.32	0.39	1.71	6.3	8.0	0.53	0.144
ARDS	13/07/2021	1215	26.1	6.44	5119	2.74	71	225.4	<2	<3	586	0.11	<0.01	0.38	0.38	1.6	2.0	0.24	0.003
ARUS	13/07/2021	1217	26.0	7.24	4742	2.53	67	301.2	<2	<2	602	0.06	<0.01	0.38	0.38	1.0	1.4	0.26	0.004
EF DP	13/07/2021	1235	26.5	7.36	17163	10.07	60	5.2	7	2	29	2.72	0.49	<0.01	0.39	7.0	7.4	0.92	0.461
ARDS	26/08/2021	1201	27.1	7.87	14699	8.51	72	205.6	<2	<2	186	0.02	<0.01	0.39	0.39	0.5	0.9	0.11	0.013
ARUS	26/08/2021	1205	27.1	7.74	13769	7.93	68	188.3	<2	<2	232	0.15	<0.01	0.41	0.41	1.3	1.7	0.15	0.003
S1N DP	26/08/2021	1130	28.3	8.00	16339	9.53	127	32.2	3	14	39	0.54	0.18	0.60	0.78	8.1	8.9	1.38	0.688
ARDS	13/09/2021	1313	28.3	7.54	20048	11.90	68	66.8	<2	1	44	0.04	<0.01	0.44	0.44	0.9	1.3	0.03	0.005
ARUS	13/09/2021	1316	28.0	7.54	19141	11.32	68	143.4	<2	<1	159	0.02	<0.01	0.37	0.37	0.6	1.0	0.10	0.007
S1N DP	13/09/2021	1332	30.6	8.52	8424	4.64	112	63.9	14	76	114	0.13	<0.01	0.02	0.02	6.8	6.8	0.93	0.188
ARDS	19/10/2021	944	30.6	7.34	29052	17.82	70	84.2	<2	3	33	0.15	<0.01	0.31	0.31	0.6	0.9	0.07	0.008
ARUS	19/10/2021	950	30.6	7.45	28141	17.21	69	111.7	4	2	76	0.14	<0.01	0.32	0.32	0.7	1.0	0.08	0.002
ND	19/10/2021	1010	30.1	7.67	22434	13.43	111	65.9	4	32	86	1.20	0.34	0.28	0.62	4.9	5.5	0.92	0.319
S1N DP	19/10/2021	1000	29.3	8.00	19183	11.33	64	60.5	6	118	114	0.58	0.05	0.05	0.10	8.7	8.8	1.07	0.122
ARDS	1/11/2021	754	30.8	7.45	29140	17.87	68	70.0	<2	3	34	0.13	<0.01	0.29	0.29	0.4	0.7	0.06	0.005
ARUS	1/11/2021	757	30.8	7.52	28425	17.39	67	92.1	<2	<2	41	0.09	<0.01	0.30	0.30	0.4	0.7	0.08	<0.001
ND	1/11/2021	830	29.5	7.15	24384	14.72	109	57.1	<2	13	63	1.24	0.90	0.96	1.86	4.1	6.0	0.61	0.092
ARDS	14/12/2021	629	31.1	7.29	24118	20.68	59	40.7	5	<1	53	0.10	<0.01	0.30	0.30	<0.5	<0.5	<0.05	0.003
ARUS	14/12/2021	632	31.2	7.28	27625	20.23	56	55.3	2	<1	58	0.21	<0.01	0.26	0.26	0.6	0.9	0.06	<0.001
DP1	14/12/2021	712	30.0	7.39	18449	14.03	17	23.9	26	48	53	4.32	<0.01	0.18	0.18	12.6	12.8	6.09	5.810
ARDS	30/12/2021	632	27.4	7.58	352	0.17	60	77.7	<2	1	31	0.09	<0.01	0.04	0.04	0.8	0.8	0.05	0.007
ARUS	30/12/2021	636	27.4	7.43	283	0.13	62	83.8	<2	<1	84	0.07	<0.01	0.04	0.04	0.6	0.6	0.05	0.004
DP1	30/12/2021	835	28.7	7.78	16162	9.41	86	38.1	<2	6	35	0.18	0.38	<0.10	0.41	2.9	3.3	1.48	1.270
EF DP	30/12/2021	814	28.9	7.76	19404	11.48	74	14.3	2	2	14	0.22	0.72	0.90	1.62	3.6	5.2	1.02	0.853
SF DP	30/12/2021	733	28.3	7.44	19410	11.49	48	21.8	4	5	31	0.48	1.96	<0.10	1.96	4.8	6.8	1.59	1.450
ARDS	5/01/2022	1104	31.4	5.79	366	0.15	37	76.46	<2	<1	89	0.16	<0.01	0.02	0.02	0.8	0.8	0.07	0.002
ARUS	5/01/2022	1059	31.5	6.28	313	0.14	41	74.56	2	<1	78	0.07	<0.01	0.02	0.02	1.0	1.0	0.07	<0.001
DP1	5/01/2022	809	32.4	6.40	867	3.02	87	49.96	3	14	88	0.04	<0.01	0.02	0.02	2.0	2.0	0.73	0.469
EF DP	5/01/2022	958	32.0	7.27	19445	11.44	128	4.61	6	37	26	0.12	0.1	0.28	0.38	4.9	5.3	0.89	0.573
SF DP	5/01/2022	1026	32.1	6.58	19647	11.70	86	6.54	5	24	22	0.82	1.2	0.35	1.55	6.0	7.6	1.72	1.260
ARDS	18/01/2022	1020	30.4	7.95	112	0.05	56	45.89	2	<1	37	0.02	<0.01	0.01	0.01	0.5	0.5	0.04	0.004
ARUS	18/01/2022	1030	30.3	7.70	91	0.04	55	46.69	<2	<1	36	0.04	<0.01	0.02	0.02	0.5	0.5	0.05	0.003
DP1	18/01/2022	10.06	29.4	7.77	22154	13.26	52	14.7	12	23	46	0.37	0.07	<0.01	0.03	6.6	6.6	1.51	0.627
EF DP	18/01/2022	8.33	30.7	7.39	18533	10.89	25	87.33	<2	4	33	0.61	0.83	0.20	1.03	3.6	4.6	1.10	0.514
SF DP	18/01/2022	8.56	30.5	7.30	18742	11.03	43	22.68	3	13	14	1.06	1.16	0.27	1.43	5.0	6.4	1.63	0.913
ARDS	24/01/2022	1130	30.4	7.82	153	0.07	56	29.12	2	<1	28	0.29	<0.01	<0.01	<0.01	1.1	1.1	0.06	0.004
ARUS	24/01/2022	1142	30.4	7.15	153	0.07	57	29.14	2	<1	32	0.07	<0.01	<0.01	<0.01	1.2	1.2	0.06	0.006
DP1	24/01/2022	930	28.6	7.30	16899	9.88	39	12.7	10	16	31	0.87	0						



## EcOz Environmental Consultants

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