EPL239 Annual Monitoring Report

Reporting period: 1 April 2022 – 31 March 2023

Humpty Doo Barramundi Pty Ltd

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ACRONYMS

AI	Adelaide Intake – water intake point from Adelaide River
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AQIS	Australian Quarantine and Inspection Service
ASS	acid sulfate soils
BAP	Best Aquaculture Practices program
BOD	biochemical oxygen demand
Chl-a	chlorophyll-a
DPWS	Department of Environment, Parks and Water Security (Northern Territory)
DO	dissolved oxygen
DP	Development Permit
DP1	Discharge Point 1 – Authorised Discharge Point 1 in EPL239
DP2	Discharge Point 2 - Authorised Discharge Point 1 in EPL239
EC	electrical conductivity
EMP	Environmental Management Plan
EPL	Environment Protection Licence
FRP	filterable reactive phosphorus
HDB	Humpty Doo Barramundi Pty Ltd
HDPE	High Density Polyethylene
LOR	limit of reporting
NATA	National Association of Testing Authorities
NOx	nitrate NO_3 + nitrite NO_2
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NOI	Notice of Intent
PASS	potential acid sulfate soils
QA/QC	quality assurance, quality control
RPD	relative percentage difference
S1N	Stage 1 Nursery
S2N	Stage 2 Nursery
SOCS	Sites of Conservation Significance
SSTV	site specific trigger value
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
WMPC Act	*Waste Management and Pollution Control Act* (Northern Territory)
WQMP	Water Quality Monitoring Plan

1 EXECUTIVE SUMMARY

Humpty Doo Barramundi Pty Ltd (HDB) operates a barramundi farm near the Adelaide River in the Northern Territory. Water quality monitoring is undertaken to safeguard downstream water quality, ecosystems, and water users and to ensure compliance with the Environment Protection Licence 239 currently in its 4th revision (EPL239-04). This Monitoring Report covers the period from April 2022 to March 2023, serving as the sixth and final report under EPL239.

HDB conduct all water quality monitoring in accordance with their WQMP and EPL239 which includes five authorised discharge point and eight designated monitoring points including 3 sites on the Adelaide River which serve as their 'compliance points' depending on tidal flow. Monitoring must be conducted weekly when discharge is occurring, or at least once per discharge event if the discharge is less than one week. All three Adelaide River compliance points as well as respective discharge monitoring points must be sampled during every discharge monitoring event. Water quality at the three Adelaide River compliance points are assessed against SSTVs derived from 2 years of baseline data collected from 2016 to 2018.

During the 2022-23 reporting period, lower than average rainfall, combined with maintenance works in the previous reporting period resulted in a significant decrease in the total water discharged (308ML) compared to the previous year (1,319ML). All weekly discharge monitoring was conducted, and all start/stop dates and flow volumes were recorded in accordance with EPL239. Three non-compliances, with regards to SSTV exceedances, were recorded and reported to the EPA with the specified 24 hour period as per condition 35 and 36. The combined total Nitrogen and Phosphorous load discharge into the Adelaide River was 2,320kg, significantly less than the previous reporting period (9,045kg), accounting for only 0.07% of the total discharge by the Adelaide river catchment as calculated by upstream N+P data.

Physical parameters measured during all monitoring events exhibited naturally fluctuating results consistent with historical recordings. pH remained within SSTV values during all monitoring events. EC fluctuated significantly with changes in seasonal rainfall with the lowest values recorded in January and the highest values recorded in November. Dissolved oxygen and Turbidity also showed natural seasonal fluctuations consistent with historic values with very.

All three exceedances reported to the EPA were with regards to ammonia concentrations with 4 out of 11 monitoring events exceeding SSTVs. Concluded risks and impacts to the Adelaide river from elevated ammonia in farm discharges remain very low for several reasons; Ammonia concentrations remain well below that which is toxic to aquatic organisms (AWQG 95% species protection), TN and TP concentrations did not exceed relative SSTV with several exceptions, during which the upstream site ARUS, also recorded the same values indicating natural levels, all other parameters did not and have never exceed relative trigger values including chlorophyll-a and BOD, indicating that no algal blooms have occurred and that farm discharges do not reduce dissolved oxygen levels within the river.

Despite increases in TN and TP in discharge water due to expansions in farm size long term trends within the river do no show any current increasing trends of concern

2 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 2-1). 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 EPL239-03 issued 6 December 2022). This Monitoring Report covers all water quality monitoring undertaken for the reporting period starting 1 April 2022 and ending 31 March 2023 (herein referred to as the 'reporting period'). This is the sixth and last Monitoring Report under EPL239 (first version) commenced on 6 June 2018.

2.1 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.

2.2 EPL239-02 compliance monitoring and reporting

Table 2-1 below lists the farm's authorised discharge points into the Adelaide River as listed in Table 3 of EPL239-03. See Figure 2-2 for a map of authorised discharge point locations.

Table 2-1. Authorised discharge points as listed in EPL239-03

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 EPL239-03 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 2-2 and detailed in Table 5-1. 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 Attachment A of EPL239-03 are applied during a discharge, is the downstream Adelaide River sampling site ARDS. All sampling must be undertaken on an outgoing tide. Table 5-2 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.

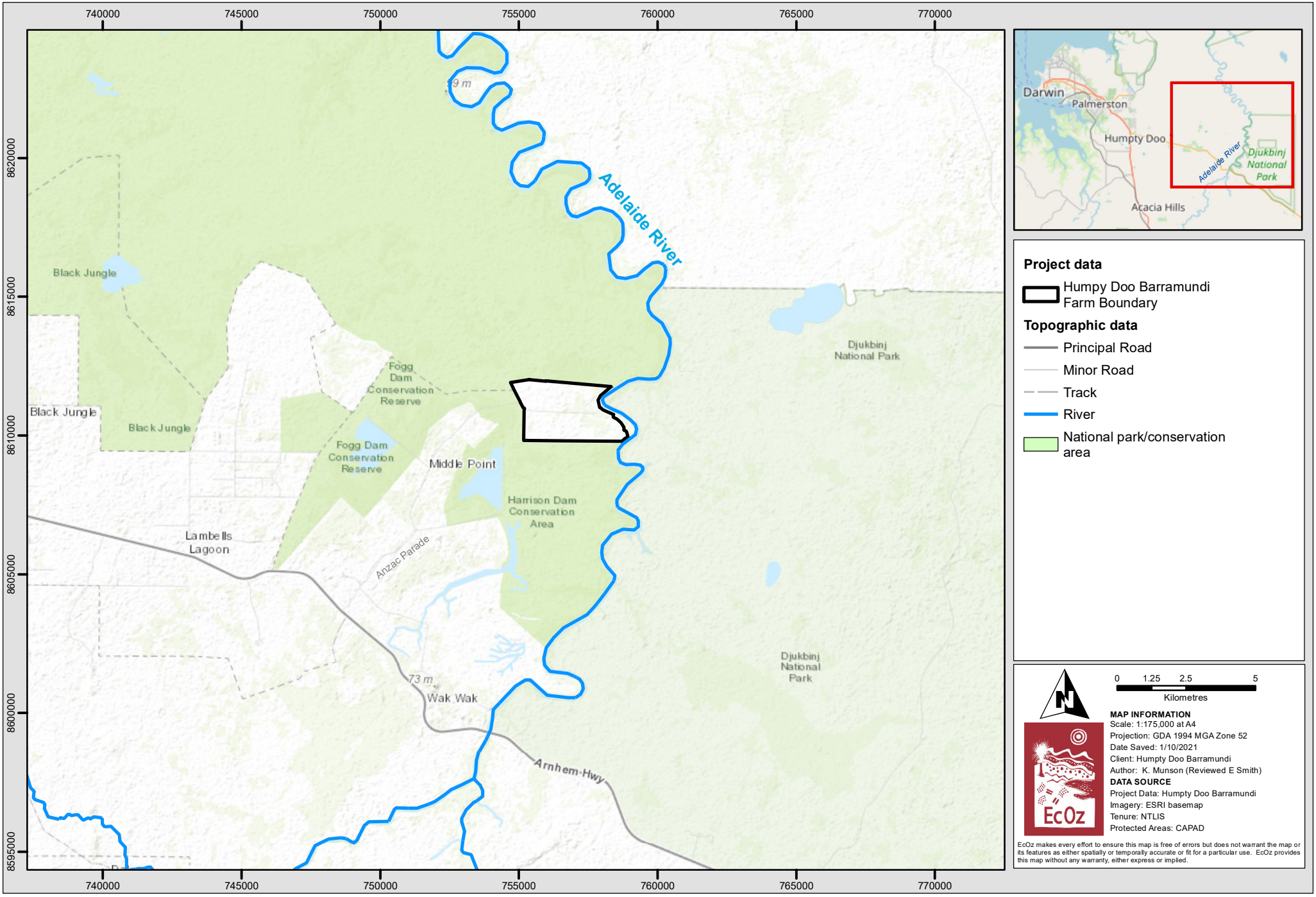

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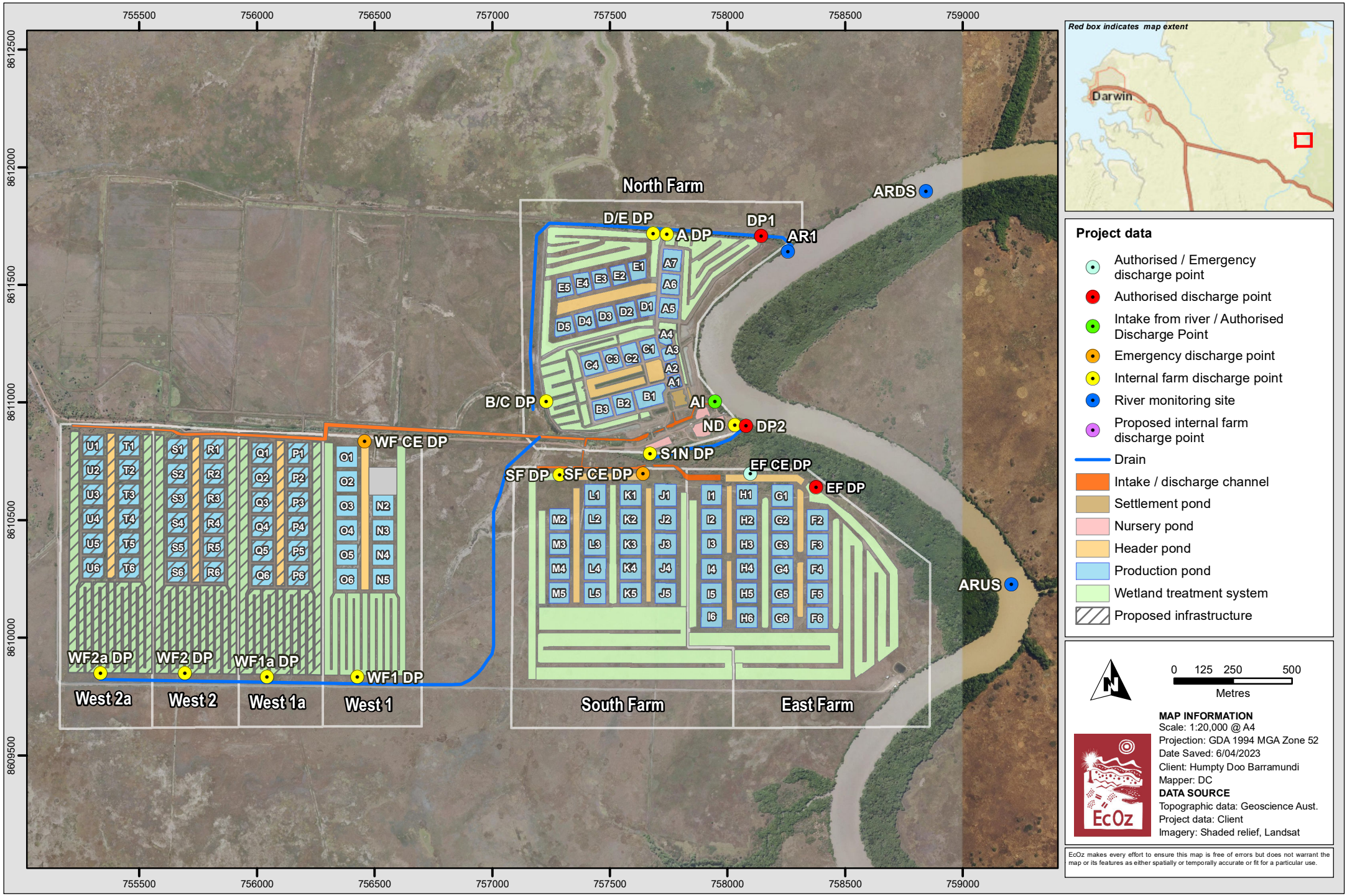
Figure 1-1. Location map of Humpty Doo Barramundi farm



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ21225 - EPL Amendment\01 Project Files\Report maps\West Farm Site Layout with all of HDB Farm.mxd

Figure 1-2. Map of farm pond layout, discharge monitoring points and receiving waterways

3 HDB FARM BACKGROUND

3.1 Farm operations

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

- **North Farm** covering an area of approximately 60 ha, comprising 20 production (grow-out) ponds, 4 broodstock 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.
- **West Farm – Stage 1** covering an area of approximately 33 ha, which currently includes 10 productions ponds 1 header pond and a large wetland treatment system.

The flow system design of all four 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 overtopping, 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 2-2 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.

3.2 Discharge points

There are five authorised discharge points where water from the farm’s wetland treatment systems enter the Adelaide River (see Table 2-1). 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 2-2. 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, ‘South Farm Controlled Emergency

Discharge Point' (SF 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.

Discharge from the West Farm currently occurs via a controlled valve at WF DP. When the valve is opened water runs through a pipe in the earthen bank and into a drainage channel that crosses underneath and runs parallel to the main access road into site finally entering the Adelaide River at discharge point AI

3.3 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 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 1,420 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.

4 RAINFALL AND DISCHARGES

4.1 Rainfall

Figure 4-1 shows monthly rainfall totals taken from the Middle Point BoM station No. 14041 from April 2022 to March 2023 (orange bars). Mean monthly rainfall totals are also shown for comparison (blue bars). Total rainfall for the 12-month reporting period was 1,272mm, which is below the annual average of 1,400 mm.

Rainfall during October, November and December 2022 was above average, whereas January 2023, February 2023 and March 2023 were below average. All other months were close to average.

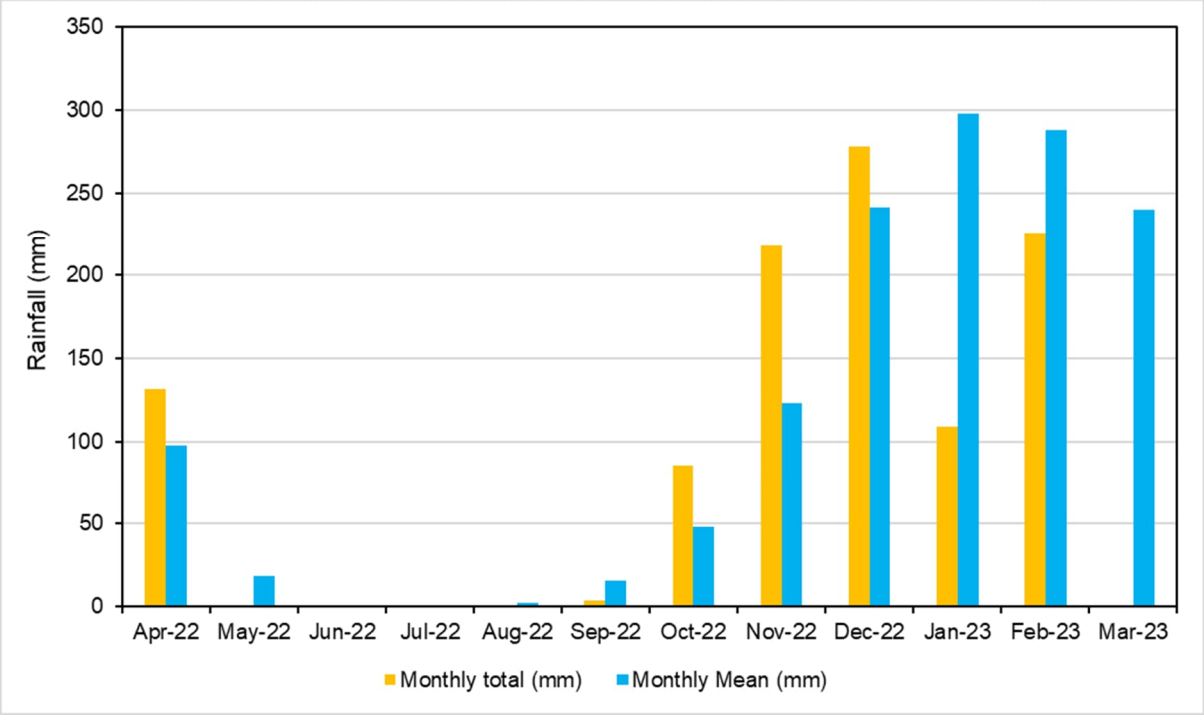


Figure 4-1. Monthly rainfall totals April 2022 to March 2023 (Middle Point BoM station No. 14041)

4.2 Reporting period discharge details

Table 4-1 outlines the discharges that occurred during the reporting period. Discharges that occurred in May and November 2022 were undertaken to allow for pond maintenance and water exchange. Discharges between December 2022 and March 2023 were due to rainfall and were required to prevent ponds overtopping.

Total discharge volume this reporting period (308.5 ML) was significantly less than the previous reporting period, which was 1,319.4 ML.

Table 4-1. Discharges during Reporting Period 1 April 2022 – 31 March 2023

Discharge Source	Discharge Point	Dates	Duration	Volume (ML)	Purpose	Monitoring dates
North Farm	DP1	10/05/2022 – 19/05/2022	9 days	90	Emptying ponds for maintenance and refurbishment	12/05/22 17/05/22
East Farm	EF DP	20/10/2022 – 10/11/2022	21 days	7	Water exchange	25/10/2022 31/10/2022 07/11/2022
East Farm	EF DP	31/12/2022 – 5/01/2023	5 days	34.2	Rainfall	04/01/2023
South Farm	SFDP > AI	31/12/2022 – 5/01/2023	5 days	22.9	Rainfall	04/01/2023
West Farm	WF DP > AI	31/12/2022 – 5/01/2023	5 days	18.3	Rainfall	04/01/2023
Stage 1 Nursery	S1N DP > DP2	31/12/2022 – 04/01/2023	4 days	2.4	Rainfall	04/01/2023
North Farm	DP1	31/12/2022 – 5/01/2023	5 Days	27.5	Rainfall	04/01/2023
South Farm	SF DP > AI	27/01/2023 – 31/01/2023	4 days	3	Rainfall	30/01/2023
South Farm	SF DP > AI	12/02/2023 – 17/02/2023	5 days	1.2	Rainfall	16/02/2023
East Farm	EF DP	12/02/2023 – 18/02/2023	6 days	1.8	Rainfall	16/02/2023
West Farm	WF DP > AI	12/02/2023 – 16/02/2023	4 days	1.2	Rainfall	16/02/2023
North farm	DP1	12/02/2023 – 16/02/2023	4 days	2.4	Rainfall	16/02/2023
South Farm	SF DP > AI	25/02/23 – 03/03/2023	6 days	7.9	Rainfall	02/03/2023
East Farm	EF DP	23/02/2023 – 04/03/2023	9 days	31.2	Rainfall	23/02/23 02/03/2023
West Farm	WF DP > AI	23/02/2023 – 03/03/2023	8 days	9.7	Rainfall	23/02/23 02/03/2023
North Farm	DP1	23/02/2023 – 03/03/2023	8 days	36.7	Rainfall	23/02/23 02/03/2023
Stage 1 Nursery	S1N DP > DP2	23/02/2023 – 04/03/2023	9 days	5.5	Rainfall	23/02/23 02/03/2023
Nursery	NDP > DP2	23/02/2023 – 03/03/2023	8 days	4.8	Rainfall	23/02/23 02/03/2023

5 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.

5.1 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.

EPL239-03 was approved on the 14th February 2023 and requires monitoring of an additional Adelaide River location AR1.

Monitoring point locations are shown in Figure 2-2 and detailed below in Table 5-1.

Table 5-1. 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
AR1	Adelaide River 1	On Adeliade river at the mouth of the creek where DP1 dischage meets the main river.	-12.548383	131.37668

5.2 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. EPL 239-03 required the Adelaide River sites ARUS and ARDS to 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. Water quality monitoring parameters

Table 5-2 lists the parameters that are measured at each site, and the assessment criteria currently specified in EPL239-02 Attachment A.

Table 5-2. 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*
Physical (field) parameters			
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
Laboratory parameters			
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_3) as N	mg/L	0.06	0.18
Total Nitrogen (TN) as N	mg/L	1.00	3.00
Nitrogen Oxides NO_3 + NO_2 (NOx) as N	mg/L	0.41	1.23
Nitrate (NO_3) as N	mg/L	0.41	1.23
Nitrite (NO_2) 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
Other information recorded			
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			

5.3 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/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, ARDS and AR1 are accessed using a boat in order to gain a representative sample from the middle of the river. River samples are ideally 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.

5.4 Assessment criteria and non-compliance reporting

Table 5-2 lists the assessment criteria to be applied to water quality monitoring results for the downstream compliance point ARDS, as taken from EPL239-03 Attachment A. Site-specific trigger values (SSTVs) are applied to most parameters. These SSTVs were derived based on calculating the 80th 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).

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.

EPL239-03 Condition 34 states the following, in relation to the assessment criteria listed in Table 5-2:

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.

5.5 Monitoring undertaken during the reporting period

All weekly monitoring during discharges was undertaken as per EPL239-02 requirements (see Table 4-1).

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.

6 RESULTS AND DISCUSSION

Discharge water quality data and Adelaide River monitoring site data for the 1 April 2022 to 31 March 2023 reporting period is provided in Appendix A. As explained in Section 4 above, during each discharge monitoring round, the Adelaide River sites ARUS, ARDS and, as of March 2023, AR1 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, WF 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

6.1 Discharge water quality

Table 6-1 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 A.

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 NOx, TKN, TN, TP and FRP, there is no significant difference in the medians of the upstream and downstream Adelaide River sites.

Table 6-1. Summary statistics for all monitoring sites for the Reporting Period 1 April 2022 – 31 March 2023

	Temp	pH	EC	TDS	Sal	DO	Turbidity	BOD	Chl a	TSS	NH3 as N	NO2 as N	NO3 as N	NOx 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
ARDS																		
Max	31.5	8.09	29198	18979	17.9	73.7	248.06	4	1	318	0.72	0.01	0.34	0.34	1.1	1.3	0.19	0.017
Min	27.6	7.37	60.7	37.18	0.03	52.1	14.1	1	0.5	17	0.04	0.005	0.01	0.01	0.08	0.08	0.02	0.002
Median	30.1	7.59	550	327	0.24	57.7	49.95	1	0.5	49	0.06	0.005	0.16	0.16	0.7	0.9	0.05	0.004
ARUS																		
Max	31.4	7.57	27020	17563	16.44	66	4091	12	1.5	217	0.26	0.01	0.35	0.35	1.1	1.4	0.19	0.008
Min	27.6	6.8	20.8	13	0.01	52.3	15.9	1	0.5	20	0.02	0.005	0.005	0.005	0.08	0.08	0.02	0.001
Median	30.1	7.44	534	317	0.23	59.8	78.76	1	0.5	56	0.09	0.005	0.15	0.15	0.8	1	0.06	0.003
DP1																		
Max	31.9	8.94	19495	12672	11.57	171.4	133.06	14	186	64	4.73	2.68	0.02	2.7	9.6	9.6	2.76	1.41
Min	26.9	7.5	15396	9401.5	8.35	6.1	20.37	2	14	10	0.05	0.005	0.005	0.005	2.4	2.4	0.87	0.571
Median	29.05	8.28	16957	10270.2	9.435	69.55	27.3	4	37.5	50.5	0.75	0.1675	0.005	0.1225	3.7	4.75	1.18	0.9005
EF DP																		
Max	32.1	7.7	19845	12899	11.73	86.3	18.29	6	34	35	1.03	1.51	2.85	2.94	5.4	8.2	1.01	0.638
Min	27.3	7.1	12891	7909.84	6.93	27.3	0.8	2	19	10	0.05	0.005	0.005	1.09	3	4.9	0.61	0.323
Median	31.1	7.58	16342	10623	9.54	70.35	7.86	3	23	18	0.84	0.76	1.51	2.12	4.1	6.1	0.7	0.443
SF DP																		
Max	31.2	7.92	16161	10505	9.42	88.2	24.43	7	42	35	1.47	0.78	1.96	2.41	5.8	7	2.38	2.28
Min	27.6	7.42	11964	7347.33	6.4	37	3.3	1	20	13	0.52	0.45	0.54	1.21	4	5.9	1.61	0.67
Median	29.1	7.57	16125.5	9651	8.845	50	10.85	3.5	27.5	22	0.68	0.72	0.91	1.685	4.55	6.5	2.225	1.885
WF DP																		
Max	31.5	8.42	17705	11380	10.28	117	117.3	3	36	57	2.91	0.9	0.22	1.04	4.7	5.2	0.12	0.052
Min	27.5	7.47	13892	8551.84	7.54	47.6	18.4	1	4	42	1.05	0.36	0.005	0.36	2.6	3.6	0.06	0.005
Median	29	7.76	17117.5	10070.31	8.965	86.85	27.215	1	26	45.5	2.145	0.67	0.0225	0.72	3.85	4.5	0.105	0.0075
NDP																		
Max	29.3	7.97	18224	10941.14	9.83	99.6	186.1	1	31	33	0.66	0.2	3.91	4.11	2.4	6.4	0.89	0.679
Min	28	7.78	14077	8647.5	7.63	94.6	91.7	1	13	19	0.65	0.16	3.78	3.94	2.3	6.3	0.75	0.642
Median	28.65	7.875	16150.5	9794.321	8.73	97.1	138.9	1	22	26	0.655	0.18	3.845	4.025	2.35	6.35	0.82	0.6605
S1NDP																		
Max	28.6	7.99	18438	11985	10.88	96.1	123.1	2	64	83	1.22	0.19	2.1	2.21	4	5.7	0.8	0.374
Min	27	7.57	15021	9282.97	7.94	85.7	71.5	1	11	26	0.28	0.07	1.02	1.09	3.2	4.3	0.4	0.133
Median	27.7	7.94	18313	11141.24	8.24	89.2	107.09	1	15	49	0.34	0.11	1.5	1.69	3.3	5.5	0.5	0.241

6.2 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 2,320 kg comprising 1,909 kg of TN and 411 kg of TP.

The Adelaide River catchment is approximately 7,462 km^2, 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. 0.07% and unlikely to have an impact.

Table 6-2. Nutrient loads into the Adelaide River during the Reporting Period 1 April 2022 – 31 March 2023

					C_d					V_d	L_d		Sum of L_d		Flow weighted conc.		Total volume	
Farm/Nursery Discharging	Monitoring Point	Sampling Dates	TN as N	TP as P	Average TN as N	Average TP as P	Discharge Vol.	Duration	Flow rate	Flow rate	TN as N	TP as P	TN as N	TP as P	TN as N	TP as P	TN as N	TP as P
			mg/L	mg/L	mg/L	mg/L	kL	days	L/s	kL/day	kg/day	kg/day	kg	kg	kg/kL	kg/kL	kg	kg
North Farm	DP1	12/05/2022	5.7	1.69	7.7	2.23	90000	9	116	10000	76.5	22.3	688.5	200.3	0.0077	0.0022	689	200
		17/05/2022	9.6	2.76														
East Farm	EF DP	25/10/2022	8.2	0.88	7.2	0.91	7068	21	4	337	2.4	0.3	50.7	6.4	0.0072	0.0009	51	6
		31/10/2022	7.2	0.84														
		7/11/2022	6.1	1.01														
South Farm	SF DP	4/01/2023	5.9	2.19	5.9	2.19	22957	12	22	1913	11.3	4.2	135.4	50.3	0.0059	0.0022	135	50
North Farm	DP1	4/01/2023	6.9	1.26	6.9	1.26	27540	12	27	2295	15.8	2.9	190.0	34.7	0.0069	0.0013	190	35
East Farm	EF DP	4/01/2023	7.0	0.70	7.0	0.70	34272	12	33	2856	20.0	2.0	239.9	24.0	0.0070	0.0007	240	24
West Farm	WF DP	4/01/2023	3.6	0.11	3.6	0.11	18364	12	18	1530	5.5	0.2	66.1	2.0	0.0036	0.0001	66	2
Stage 1 Nursery	S1N DP	4/01/2023	5.7	0.80	5.7	0.80	2448	4	7	612	3.5	0.5	14.0	2.0	0.0057	0.0008	14	2
South Farm	SF DP	30/01/2023	7.0	2.38	7.0	2.38	3060	4	9	765	5.4	1.8	21.4	7.3	0.0070	0.0024	21	7
South Farm	SF DP	16/02/2023	6.6	2.26	6.6	2.26	1224	5	3	245	1.6	0.6	8.1	2.8	0.0066	0.0023	8	3
East Farm	EF DP	16/02/2023	5.6	0.61	5.6	0.61	1836	6	4	306	1.7	0.2	10.3	1.1	0.0056	0.0006	10	1
West Farm	WF DP	16/02/2023	5.2	0.12	5.2	0.12	1224	4	4	306	1.6	0.0	6.4	0.1	0.0052	0.0001	6	0
North Farm	DP1	16/02/2023	2.4	0.87	2.4	0.87	2448	4	7	612	1.5	0.5	5.9	2.1	0.0024	0.0009	6	2
North Farm	DP1	23/02/2023	3.4	1.10	3.6	1.02	36720	8	53	4590	16.5	4.7	132.2	37.3	0.0036	0.0010	132	37
		2/03/2023	3.8	0.93														
East Farm	EF DP	23/02/2023	4.9	0.66	5.3	0.65	31212	9	40	3468	18.2	2.3	163.9	20.3	0.0053	0.0007	164	20
		2/03/2023	5.6	0.64														
South Farm	SF DP	2/03/2023	6.4	1.61	6.4	1.61	7956	6	15	1326	8.5	2.1	50.9	12.8	0.0064	0.0016	51	13
West Farm	WF DP	23/02/2023	4.5	0.10	4.5	0.1	9792	8	14	1880	8.5	0.2	67.7	1.2	0.0069	0.0001	68	1
		2/03/2023	4.5	0.06														
Nursery	NDP	23/02/2023	6.4	0.75	6.35	0.82	4896	8	7	612	3.9	0.5	31.1	4.0	0.0064	0.0008	31	4
		2/03/2023	6.3	0.89														
Stage 1 Nursery	S1N DP	23/02/2023	4.3	0.40	4.9	0.45	5508	9	7	612	3.0	0.3	27.0	2.5	0.0049	0.0005	27	2
		2/03/2023	5.5	0.50														
																Total (kg):	1909	411
																Total TN+TP (kg):	2320	
																Total TN+TP (tonnes):	2.320	

6.3 Assessment of impacts during discharges April 2022 – March 2023

6.3.1 Physical parameters

Table 6-3 presents an assessment of impacts on Adelaide River water quality for physical parameters during the discharges that occurred during the reporting period. Appendix A provides the raw water quality parameter concentrations measured during the discharge periods.

The assessment criteria listed in Table 5-2 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, except for 23rd February 2023, were undertaken during an outgoing tide, as such, ARDS was always the downstream compliance point, and ARUS the upstream reference site. During the February round of sampling tide timing meant sampling could only occur during the incoming tide. In this scenario ARUS should be assessed as the compliance point however, with the large volume of freshwater flowing down the river, changes in flow direction at this time of year do not happen with tide changes. With this in mind both ARDS and ARUS are assessed for compliance.

The assessment of impacts in Table 6-3 also determines whether any of the non-compliance scenarios listed in EPL239-03 Condition 34 (see Section 4.5 above) have occurred.

6.3.2 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 A provides the raw water quality parameter concentrations measured during the discharge periods.

The assessment criteria listed in Table 5-2 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 6-3. 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.	No impact

EC	EC at the Adelaide River sites varied widely according to the seasons over the course of the reporting period, ranging from 20.8µS/cm during the wet season (04/01/2023) to 29,198 µS/cm after the dry season (08/11/2022) 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 142% for all discharge monitoring rounds during the reporting period. This was except for early January (monitoring rounds 04/01/2023, and 02/03/2023) when the downstream site (ARDS) recorded a higher EC compared to the upstream site (ARUS). The largest RPD was 101% on 04/01/2023. These higher RPDs were observed following significant rainfalls when discharge was occurring from multiple areas of the farm. They also coincide with the lowest two recorded EC values during the reporting period.	No impact
DO	DO at the Adelaide River sites varied little over the reporting period, ranging between 52 % saturation and 74 % saturation, with an average of 59 % saturation. 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 8 % saturation on 16/02/2023 i.e. ARDS was 74 % sat and ARUS was 66 % sat. A difference of 8 % sat or less is very small, and not indicating an impact on DO from any of the discharges.	No impact
Turbidity	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. Turbidity at the Adelaide River sites during the reporting period ranged from 14 NTU on 16/02/2023 to 274 NTU on 17/05/2022 with an outlier of 4091 in January. 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.	No impact

Table 6-4. 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	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. While a result of 2mg/L being equal to the LOR is above the SSTV of 1mg/L, it should be noted 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 <2 mg/L. In order to calculate the 80th percentile, all <2 mg/L values needed to be changed to a number value, nominally half the LOR i.e. 1 mg/L. 4mg/L was recorded at ARDS on the 20/10/2022 however this result is indicative of elevated background levels as monitoring occurred at a time when no discharge was occurring.	No impact
Chlorophyll-a	Chlorophyll-a was below the SSTV at the downstream compliance point (ARDS) during all discharges for the reporting period. This was except for on 12/05/2022,31/10/2022, and 8/11/2022 when the concentration were equal to the LOR of 1, although still below the SSTV of 2.	No impact

Parameter	Discussion	Impact assessment
Ammonia (NH_3 as N)	Ammonia concentrations at the downstream compliance point (ARDS) were above the SSTV for 4 out of the 11 total discharge monitoring rounds undertaken during the reporting period. There were three non-compliance notifications submitted to the NT EPA to cover incidences where the non-compliance criteria, as per condition 34 of EPL239-03, had been breached. Non-compliance notifications for these exceedances were submitted to the NT EPA as follows: • *Non-compliance notification – Humpty Doo Barramundi EPL239-03: ammonia exceedances, February 2023*, submitted to the NT EPA on 03 March 2023 • *Non-compliance notification – Humpty Doo Barramundi EPL239-02: ammonia exceedances, March 2023*, submitted to the NT EPA on 10 March 2023. All notifications concluded the exceedances had minimal impact on the Adelaide River environment for the following reasons: • TN concentrations, while elevated above the SSTV at the downstream compliance point during 5 of 11 sampling rounds, similar results or even high values were recorded at the upstream site indicating current natural 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.	Slight to no impact
NO_x as N and NO_3 as N	NO_x and NO_3 concentrations were all below the SSTV at the downstream compliance point (ARDS) during all discharges for the reporting period.	No impact
NO_2 as N	NO_2 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_2 is half the LOR.	No impact
TN as N	TN concentrations recorded very slight exceedances of the SSTV during 5 out of 11 sample rounds at the downstream compliance point. All of these exceedance however, were also seen at the upstream site with only one instance on the 2/3/2023 where the downstream site exceeded and the upstream site did not. In this instance the exceedance was only by 0.1mg/L.	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 one incidence 17/05/2022. Similarly to TN, TP results at the upstream site during this sample round was identical to the downstream site indicating natural levels flowing down the river and no impact from discharge.	Slight to no impact
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

6.4 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 6-1), 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 with little or no difference in results between upstream and downstream readings during discharge sampling events. 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 6-2 to Figure 6-5.

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 6-2). Similarly, the concentrations of TP in the Adelaide River have remained largely consistent with the SSTV of 0.13 mg/L (Figure 6-3).

The concentrations of TN and TP in discharge are highly variable (Figure 6-4). Most concentrations are less than 8 mg/L for TN and less than 2mg/L for TP, 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. 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 TN and TP in discharge from the South Farm (SF DP), North Farm (DP1) and Stage 1 Nursery (S1N DP) displayed an increasing trend from below detection to around 1.5 mg/L (Figure 6-5). These concentrations have now stabilised, with decreases observed in data from 2021 to 2023.

Since commissioning of the East Farm in 2019 significant increases in TN and TP were observed in discharge which is to be expected with increases in farm capacity and the wetland treatment system not yet being fully mature. The current reporting period of 2022-23 saw stabilisation of TN and a decrease in TP from EF DP

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. In 2022 dredging and refurbishment of the North farm and its ageing wetland treatment system was completed with aims to improve the removal of TP in production pond wastewater prior to reuse in the production ponds and discharge. TP data from the 2022-23 reporting period significant decreased when compared to the previous 3 years.

Up until October 2019, the Stage 2 Nursery (ND) recorded relatively high TP concentrations. These have since reduced to below 1 mg/L following improvements to the wetland treatment system.

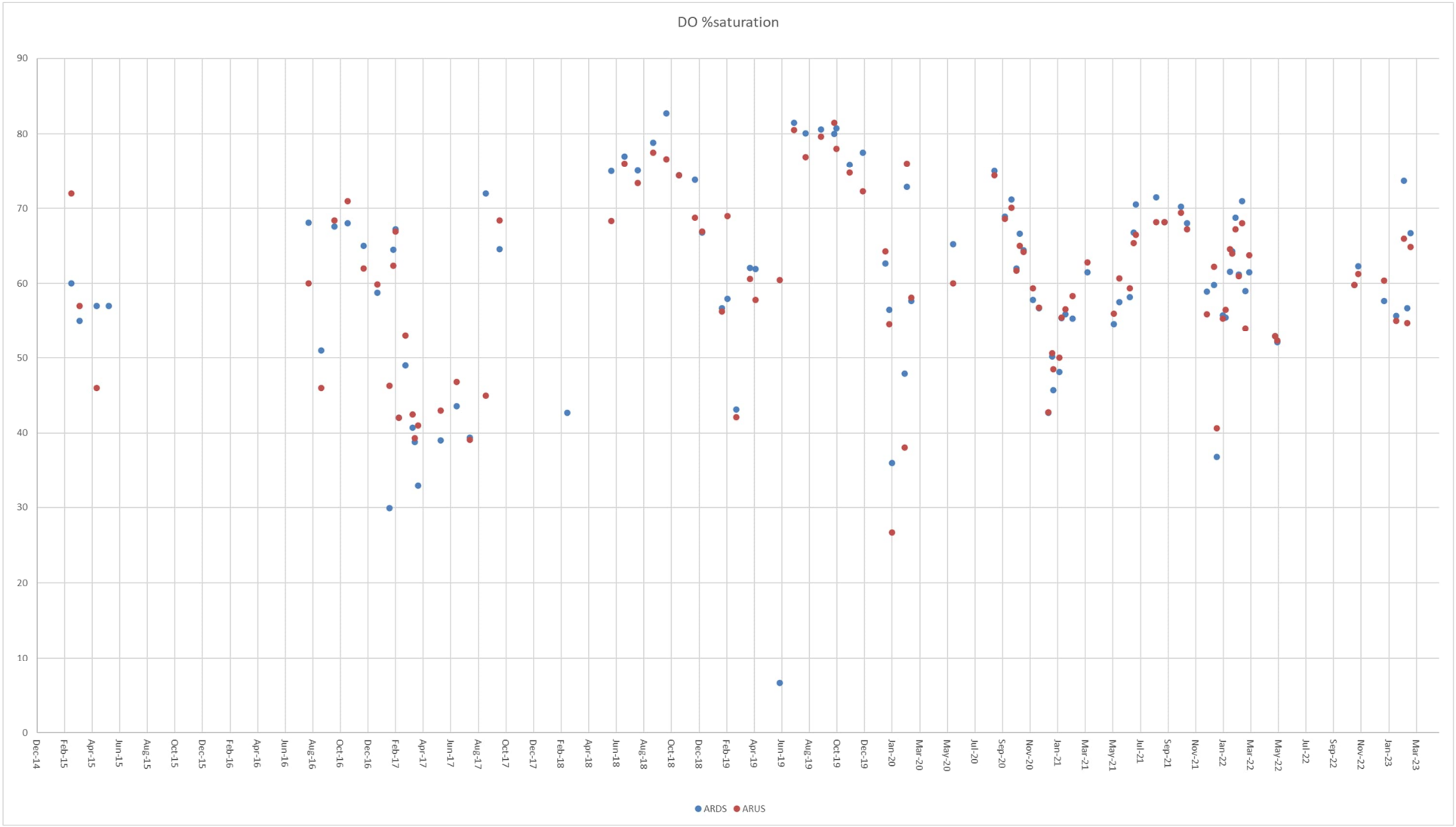


Figure 6-1. Graph of DO concentrations at the Adelaide River monitoring sites since monitoring began in 2015

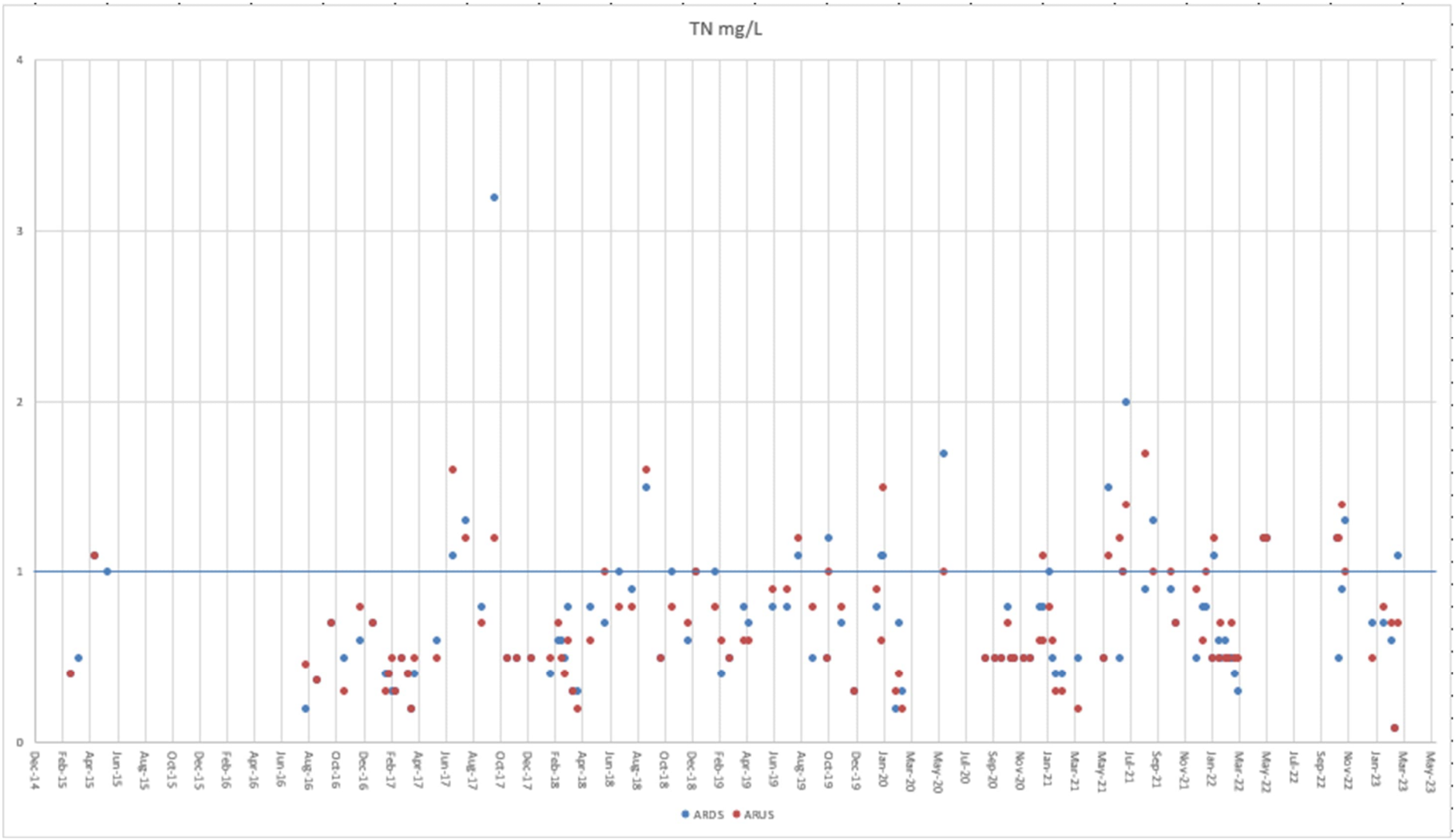


Figure 6-2. Graph of TN concentrations at the Adelaide River monitoring sites since monitoring began in 2015. SSTV shown as blue line

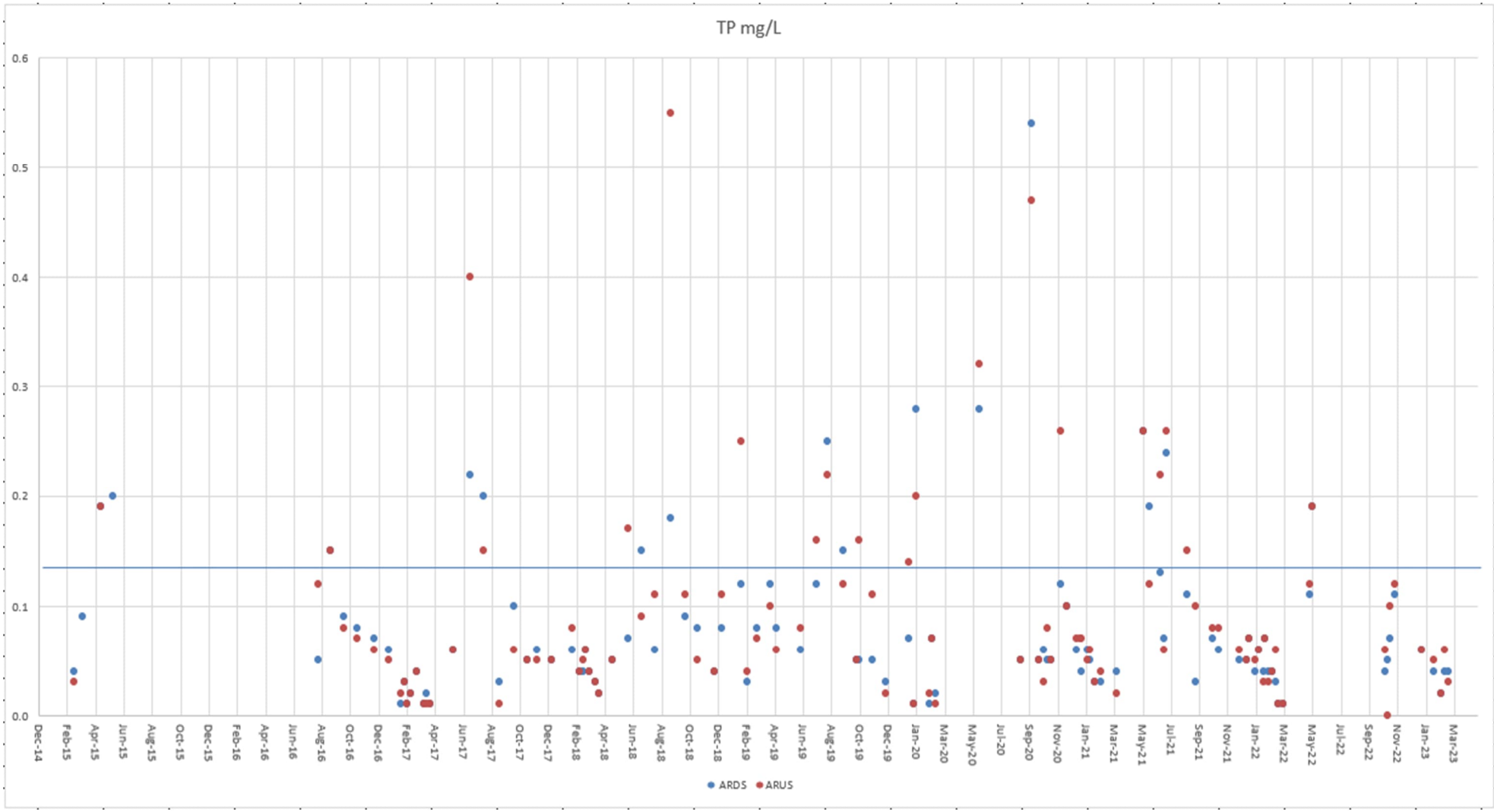


Figure 6-3. Graph of TP concentrations at the Adelaide River monitoring sites since monitoring began in 2015. SSTV shown as blue line.

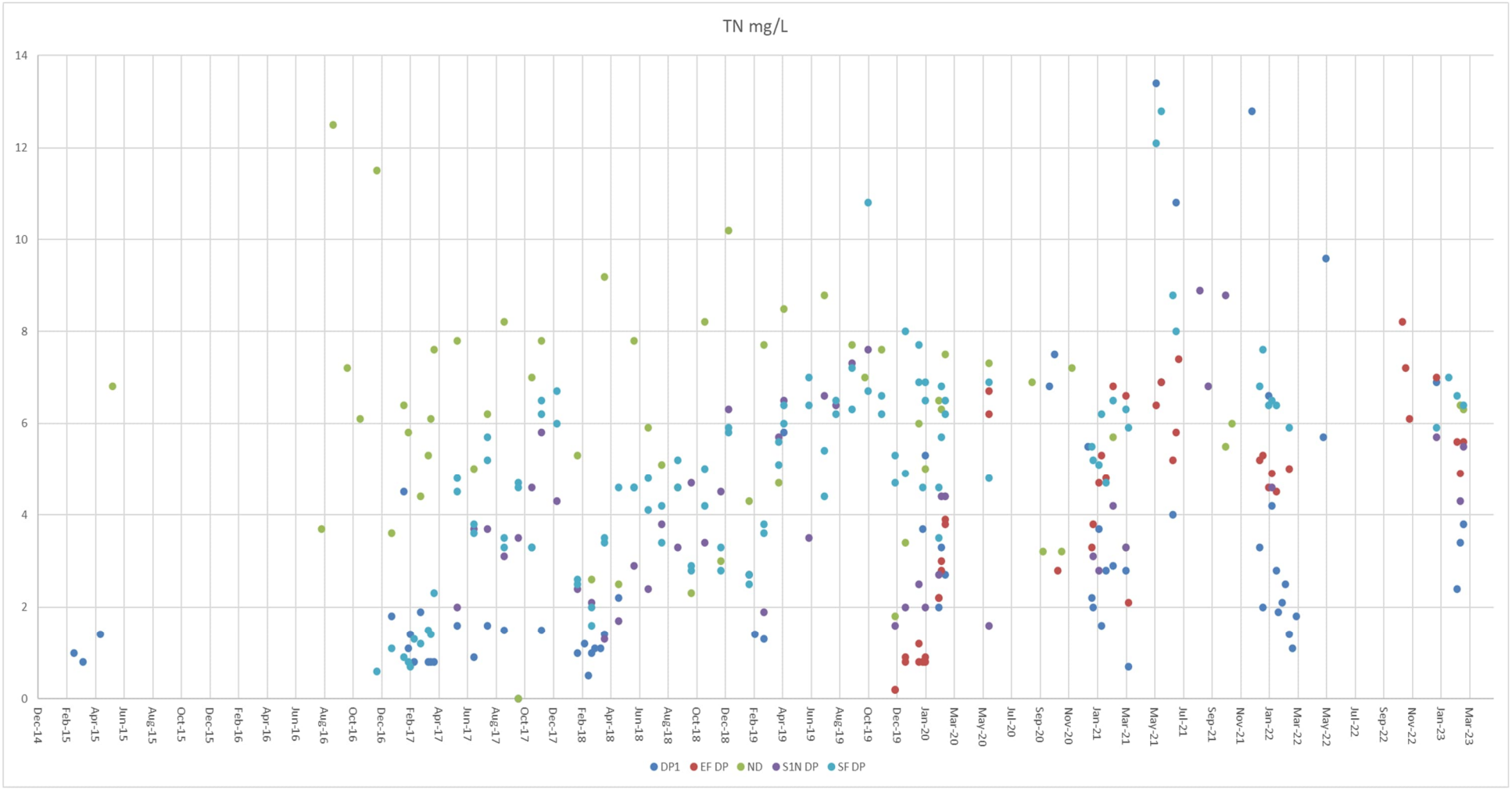


Figure 6-4. Graph of TN concentrations at the discharge monitoring sites since monitoring began in 2015

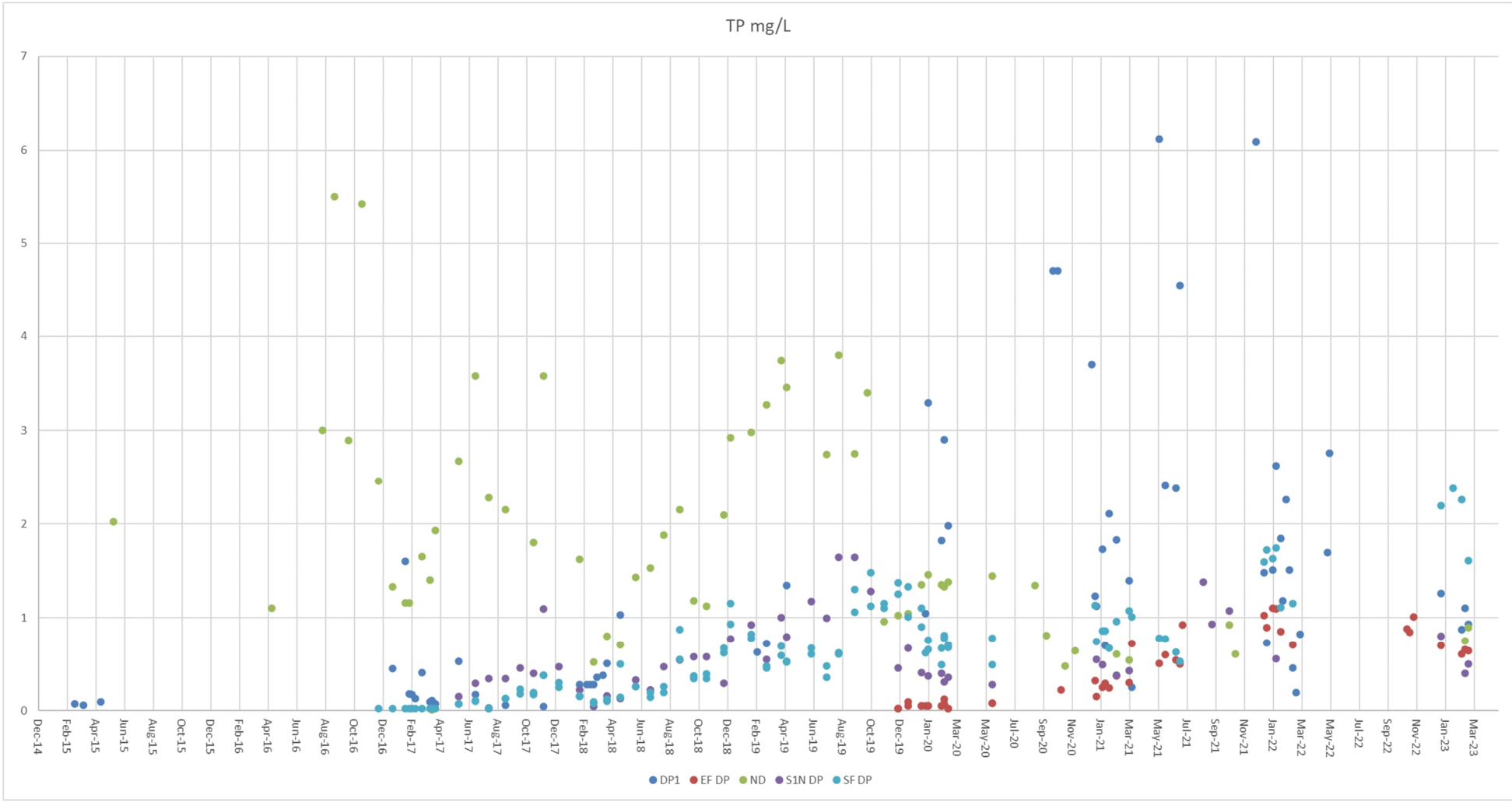


Figure 6-5. Graph of TP concentrations at the discharge monitoring sites since monitoring began in 2015

7 CONCLUSIONS

During the 1 April 2022 to 31 March 2023 reporting period, all discharge monitoring was undertaken in accordance with all EPL239-03 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. 0.07% 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 EPL239-03 Condition 34 apart from those already reported to the NT EPA in the following notifications:

- *Non-compliance notification – Humpty Doo Barramundi EPL239-03: ammonia exceedances, February 2023*, submitted to the NT EPA on 3rd March 2023
- *Non-compliance notification – Humpty Doo Barramundi EPL239-02: ammonia exceedances, March 2023*, submitted to the NT EPA on 10 March 2023.
- *Non-compliance report – Humpty Doo Barra EPL239-03 ammonia exceedance, February-March 2023. Submitted to the EPA 23rd March 2023.*

All notifications concluded that 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 in the river 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.

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APPENDIX A RAW WATER QUALITY DATA

Site ID	Date	Time	Field Parameters												Laboratory Parameters:					
		24 hr	°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
Limit of Reporting			0.1	0.01	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
DP1	12/05/2022	703	27.9	8.26	15396	9480	8.43	6	20.37	5	176	33	0.30	<0.01	<0.01	<0.01	5.7	5.7	1.69	1.110
ARDS	12/05/2022	643	29.9	7.52	550	327	0.24	53	167.04	<2	1	141	0.06	<0.01	0.16	0.16	1.0	1.2	0.11	0.002
ARUS	12/05/2022	645	29.9	7.22	534	317	0.23	53	160.6	<2	<1	134	0.09	<0.01	0.15	0.15	1.1	1.2	0.12	0.002
DP1	17/05/2022	1116	31.9	8.33	16131	9914	9.35	25	133.06	14	186	64	4.73	<0.01	<0.01	<0.01	9.6	9.6	2.76	1.410
ARDS	17/05/2022	1215	30.2	7.59	674	421	0.32	52	48	<2	<1	318	0.04	<0.01	0.17	0.17	1.0	1.2	0.19	0.004
ARUS	17/05/2022	1219	30.1	7.47	669	446	0.32	52	274.37	<2	<3	217	0.05	<0.01	0.16	0.16	1.0	1.2	0.19	0.007
ARDS	20/10/2022	737	30.1	7.51	23219	15022	13.9		42.54	4	<1	46	0.04	0.01	0.33	0.34	0.9	1.2	0.04	0.007
ARUS	20/10/2022	745	30.2	7.45	23229	15101	14.0		42.51	<2	<1	32	0.21	0.01	0.34	0.35	0.8	1.2	0.06	0.008
ARDS	25/10/2022	1011	31.1	7.60	27805	18073	17.0		83.78	<2	<2	72	<0.10	<0.01	0.32	0.32	<0.5	<0.5	0.05	0.002
ARUS	25/10/2022	1017	31.0	7.54	26245	17059	15.9		123.75	12	<2	90	0.26	<0.01	0.35	0.35	0.9	1.2	<0.05	0.001
EF DP	25/10/2022	946	32.1	7.66	18270	11876	10.7		10.15	2	20	18	1.03	<0.01	2.85	2.85	5.4	8.2	0.88	0.638
ARDS	31/10/2022	643	31.1	7.47	24736	16078	14.92	60	49.95	<2	1	32	<0.10	<0.01	0.34	0.34	0.6	0.9	0.07	0.006
ARUS	31/10/2022	653	31.2	7.44	23056	14986	13.82	60	155.68	<2	<2	72	<0.10	<0.01	0.35	0.35	1.0	1.4	0.10	0.008
EF DP	31/10/2022	1002	32.1	7.70	18854	12255	11.08	83	11.47	4	21	16	0.44	1.51	0.32	1.83	5.4	7.2	0.84	0.383
ARDS	8/11/2022	2835	31.5	7.38	29198	18979	17.9	62	56.39	<2	1	50	0.16	<0.01	0.29	0.29	1	1.3	0.11	0.017
ARUS	8/11/2022	1036	31.4	7.44	27020	17563	16.44	61	78.76	<2	1	59	0.03	<0.01	0.3	0.3	0.7	1	0.12	0.002
EF DP	8/11/2022	1023	31.1	7.66	19845	12899	11.73	74	7.86	5	34	19	0.84	1.1	<0.01	1.09	5	6.1	1.01	0.616
ARUS	4/01/2023	805	27.6	6.94	20.8	13	0.01	60	4091	<2	<1	52	0.02	<0.01	0.01	0.01	0.5	0.5	0.06	0.003
ARDS	4/01/2023	759	27.6	7.62	63.4	41	0.03	58	54.53	<2	<1	49	0.06	<0.01	0.02	0.02	0.7	0.7	0.06	0.002
N1DP	4/01/2023	720	27	7.57	18438	11985	10.88	89	107.09	2	15	83	0.34	0.19	1.5	1.69	4	5.7	0.8	0.374
DP1	4/01/2023	713	26.9	7.5	19495	12672	11.57	72	72.53	5	26	64	0.19	2.68	0.02	2.7	4.2	6.9	1.26	0.865
EFDP	4/01/2023	900	27.3	7.1	16342	10623	9.54	27	18.29	6	25	35	0.95	0.8	2.14	2.94	4.1	7	0.7	0.468
SFDP	4/01/2023	907	27.6	7.42	16161	10505	9.42	38	24.43	<2	25	35	0.77	0.78	0.93	1.71	4.2	5.9	2.19	1.84
WFDP	4/01/2023	840	27.5	7.47	17508	11380	10.28	82	21.73	<2	4	57	1.05	0.82	0.22	1.04	2.6	3.6	0.11	0.052
ARUS	30/01/2023	727	29.9	7.37	133	79	0.06	55	25.9	3	<1	38	0.1	<0.01	0.04	0.04	0.8	0.8	0.05	0.003
ARDS	30/01/2023	722	29.9	7.68	141	83.8	0.06	56	21.2	2	<1	39	0.08	<0.01	0.03	0.03	0.7	0.7	0.04	0.003
SFDP	30/01/2023	806	30.1	7.5	16095	9911	9.38	37	16.5	4	42	13	1.47	0.67	0.54	1.21	5.8	7	2.38	2.28
ARUS	16/02/2023	900	29.5	6.8	99.1	59.34	0.04	66	15.9	<2	<1	20	0.04	<0.01	0.01	0.01	0.7	0.7	0.02	0.002
ARDS	16/02/2023	853	29.4	7.37	110.7	66.35	0.05	74	14.1	<2	<1	17	0.04	<0.01	0.01	0.01	0.6	0.6	0.02	0.002
SFDP	16/02/2023	1102	31.2	7.92	16156	9391	8.31	88	3.3	7	20	27	0.52	0.77	0.89	1.66	4.9	6.6	2.26	1.93
EFDP	16/02/2023	1017	31.1	7.57	15943	9276.28	8.2	86	3.8	3	27	23	<0.10	0.54	1.58	2.12	3.5	5.6	0.61	0.323
WFDP	16/02/2023	1034	31.5	8.42	17705	10241	9.12	117	117.3	3	27	42	1.93	0.52	<0.01	0.5	4.7	5.2	0.12	0.008
DP1	16/02/2023	1052	31	8.94	19387	11299	10.15	171	27	3	14	49	<0.10	<0.01	<0.01	<0.01	2.4	2.4	0.87	0.663
ARUS	23/02/2023	1157	30.4	7.57	167.9	98.89	0.07	55	27	<2	<1	29	0.13	<0.01	0.02	0.02	0.08	0.08	0.06	0.004
ARDS	23/02/2023	1150	30.3	7.98	182	107.64	0.08	57	30.4	<2	<1	28	0.37	<0.01	0.02	0.02	0.08	0.08	0.04	0.004
DP1	23/02/2023	1025	29.6	8.3	17783	10626.4	9.52	67	27.6	2	36	10	1.77	0.33	<0.01	0.24	3.2	3.4	1.1	0.936
EFDP	23/02/2023	1015	29.9	7.58	15187	9025.38	7.97	49	1.3	2	23	10	0.68	0.36	1.51	1.87	3	4.9	0.66	0.443
WFDP	23/02/2023	1118	30.1	7.61	16727	9899.614	8.81	48	32.7	<2	25	46	2.91	0.36	<0.01	0.36	4.1	4.5	0.1	0.007
NDP	23/02/2023	1032	29.3	7.78	18224	10941.14	9.83	95	186.1	<2	13	19	0.66	0.2	3.91	4.11	2.3	6.4	0.75	0.679
N1DP	23/02/2023	1006	28.6	7.94	18313	11141.24	7.94	86	71.5	<2	11	26	1.22	0.07	1.02	1.09	3.2	4.3	0.4	0.241
ARUS	2/03/2023	926	28.1	7.23	49.5	30.34	0.02	65	36.7	<2	<1	56	0.18	<0.01	<0.01	<0.01	0.7	0.7	0.03	<0.001
ARDS	2/03/2023	916	28.2	8.09	60.7	37.18	0.03	67	26.6	<2	<1	50	0.72	<0.01	0.01	0.01	1.1	1.1	0.04	0.007
DP1	2/03/2023	1128	28.5	8.26	15421	9401.5	8.35	113	20.9	2	39	52	1.2	0.76	<0.01	0.72	3.1	3.8	0.93	0.571
EFDP	2/03/2023	1055	28.1	7.3	12891	7909.84	6.93	67	0.8	2	19	10	0.87	0.76	1.51	2.27	3.3	5.6	0.64	0.356
WFDP	2/03/2023	1116	27.9	7.91	13892	8551.84	7.54	91	18.4	<2	36	45	2.36	0.9	0.04	0.94	3.6	4.5	0.06	0.005
NDP	2/03/2023	1136	28	7.97	14077	8647.5	7.63	100	91.7	<2	31	33	0.65	0.16	3.78	3.94	2.4	6.3	0.89	0.642
N1DP	2/03/2023	1141	27.7	7.99	15021	9282.97	8.24	96	123.1	<2	64	49	0.28	0.11	2.1	2.21	3.3	5.5	0.5	0.133
SFDP	2/03/2023	1105	28.1	7.64	11964	7347.33	6.4	62	5.2	3	30	17	0.59	0.45	1.96	2.41	4	6.4	1.61	0.67

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