EPL320 Monitoring Report
Lambells Lagoon Crocodile Farm

Reporting period: 1 May 2022 – 30 April 2023

PRI Group Pty Ltd

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ACRONYMS

ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
BoM	Bureau of Meteorology
CFU	colony forming units
EC	electrical conductivity
EPL	Environment Protection Licence
GEL	groundwater extraction licence
LLCF	Lambells Lagoon Crocodile Farm
LOR	limit of reporting
mBTOC	meters below top of casing
NATA	National Association of Testing Authorities
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTG	Northern Territory Government
SOCS	Site of Conservation Significance
SWL	standing water level
TBA	To be advised
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids

1 INTRODUCTION

PRI Group Pty Ltd (PRI) operate Lambells Lagoon Crocodile Farm (LLCF), on Section 1611 and 1688 Hundred of Guy, at the end of Alphatonia Road, 5.5 km north of the Arnhem Highway (Figure 1-1). Development of the farm occurred in two stages. Stage one became operational in early 2021 and includes the incubation, hatchery, and associated auxiliary infrastructure. Stage two became operational in early 2022 and includes the grow-out pens, finishing pens, auxiliary infrastructure, and water management infrastructure (Figure 1-2).

Surface water, groundwater, and soil monitoring are undertaken at LLCF to ensure that operations do not impact waterways downstream i.e. Black Jungle Swamp, Lambells Lagoon, and the Adelaide River. This monitoring is also a requirement of Environment Protection Licence 320-01 (EPL320-01), first issued to PRI Group Pty Ltd by the Northern Territory Environment Protection Authority (NT EPA) under the *Waste Management and Pollution Control Act* on 12 April 2021.

Monitoring Reports are required annually, as per Condition 54 of EPL320-01. These must be prepared in accordance with the NT EPA 'Guideline for Reporting on Environmental Monitoring'. Each report must include all requirements as set out in EPL320 Condition 55.

This particular Monitoring Report covers all water quality and soil monitoring undertaken for the reporting period starting 1 May 2022 and ending 30 April 2023 (herein referred to as the 'reporting period'), data from the previous reporting period will also be used to discuss possible trends in the results. This is the second Monitoring Report since commencement of EPL320-01 on 12 April 2021.

1.1 Purpose and scope

This Monitoring Report is prepared in accordance with the following EPL320-01 conditions:

Condition 54

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

Condition 55

The licensee must ensure that each Monitoring Report:

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

55.2 includes a tabulation of all monitoring data required as a condition of this licence. Data must be provided electronically in Microsoft Excel format;

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

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

55.5 includes long term trend analysis of monitoring data to demonstrate any environmental impact associated with the activity over a minimum period of three years (where the data is available). Data used in the analysis must be provided electronically in Microsoft Excel format; and

55.6 includes an assessment of environmental impact from the activity.

1.2 EPL320-01 compliance monitoring and reporting

EPL320-01 authorises discharge to land (irrigation) using wastewater from the two authorised discharge points, see Figure 1-3. The authorised discharge point for wastewater from Stage one operations is the pump station at ADP1, and from Stage two operations is the retention basin pump station at ADP2.

In order to monitor for potential environmental impacts from this activity, surface water, groundwater and soil monitoring at LLCF is undertaken in accordance with Attachment A of EPL320-01 and all monitoring-related conditions of the licence, i.e. Conditions 41 to 46. The *LLCF Irrigation Management Plan* (EcOz 2021) details the monitoring sites, physical (field) and laboratory parameters measured, sampling methods and procedures. Monitoring site locations are shown below in Figure 1-3 and detailed in Table 4-1. Parameters to be measured, monitoring frequency and trigger values, taken from Attachment A of EPL320-01, are outlined below in Table 4-2, Table 4-3, Table 4-4, and Table 4-5. In addition to the above, the volumes and timing of irrigated water application must be recorded; as per EPL320-01 Condition 39.

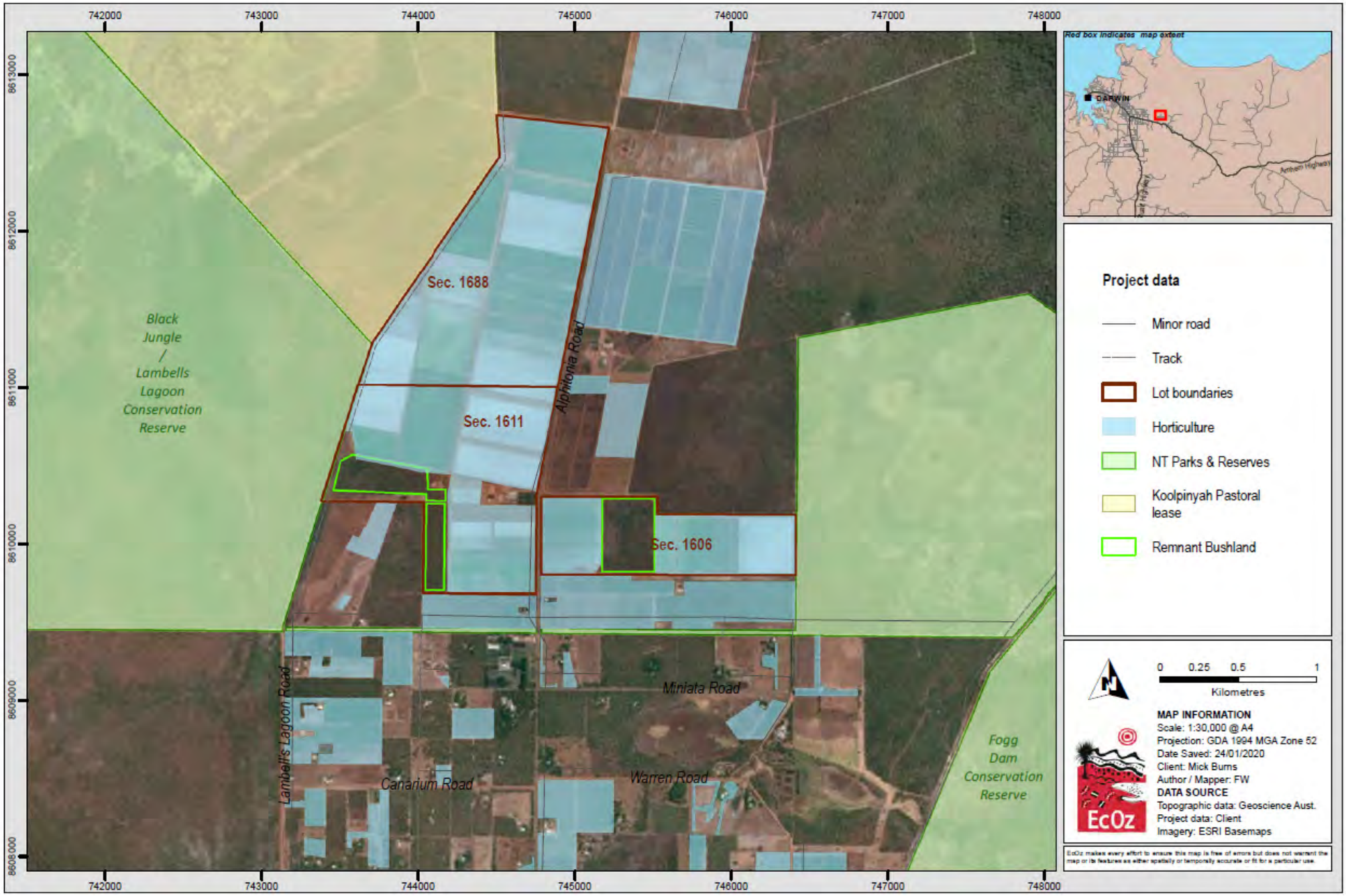

Figure 1-1. Map of LLCF location

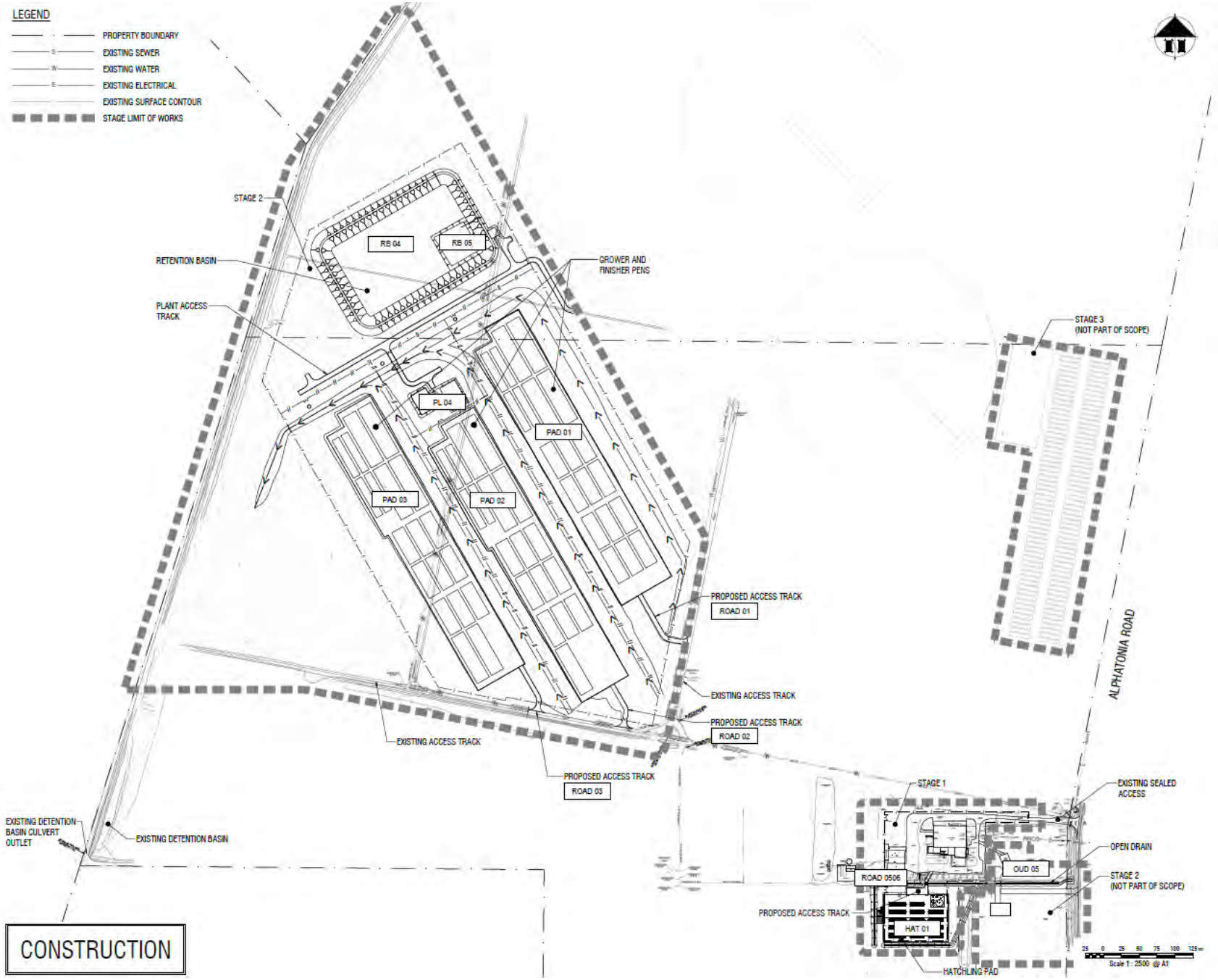

Figure 1-2. Map of LLCF layout

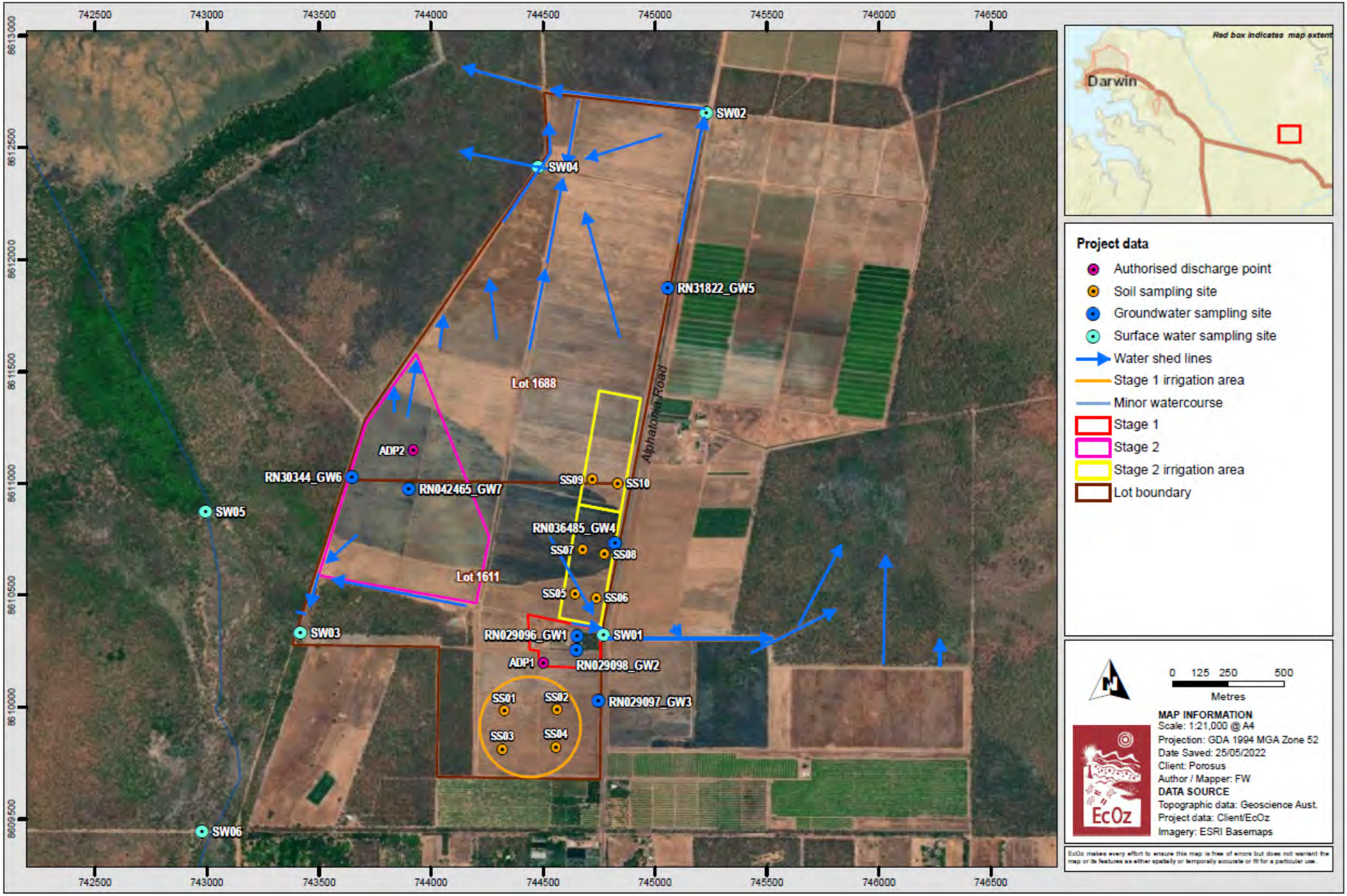

Figure 1-3. Map of LLCF surface water, groundwater, soil monitoring sites and surface drainage

2 LLCF OPERATIONS OVERVIEW

The information provided below is a brief overview of LLCF operations and environmental setting. For more detail, please refer to the following documents:

EcOz 2022, *Supporting information for the Lambells Lagoon Crocodile Farm EPL320 Amendment*, report prepared for PRI Farming Pty Ltd by EcOz Pty Ltd, January 2022

EcOz 2021, *Irrigation Management Plan, Lambells Lagoon Crocodile Farm*, report prepared for PRI Farming Pty Ltd by EcOz Pty Ltd, November 2021

2.1 Farm operations

Development of the farm occurred in two stages. Stage one included the incubation building refurbishment, hatchery pens, administration building refurbishment, water management infrastructure (water supply tank, effluent collection sump, wastewater storage tank, wastewater screening and an interim irrigation area), and associated infrastructure.

Stage two included the growers, finishers, and a large wastewater system.

The crocodile production process at LLCF is summarised as follows:

1. Eggs are collected from breeding pens (other farms) and the wild. The eggs are assessed and cleaned in egg laboratory, with viable eggs transferred to the incubator room
2. Animals hatch in the incubator then are immediately transferred to hatching pens
3. When animals are of suitable size, they are transferred from the hatchery to grower pens
4. Animals approaching a size suitable for market are transferred to finishing pens to ensure best possible skin and meat condition
5. Animals are harvested from the finishing pens when they are about two years of age.

2.2 Water supply and usage

The primary use of water on site is for regular flushing of the hatchery, grower and finishing pens to maintain crocodile hygiene and health. LLCF has a groundwater extraction entitlement of 3,216 ML/year (Groundwater Extraction Licence [GEL] HGS10000) from 11 existing bores. The bores are located within the LLCF property and extract from the Howard Groundwater system, comprising the Koolpinyah Dolostone.

Each water supply bore has an automated flow meter, and the volumes of water extracted must be reported to the NT Controller of Water Resources on a monthly basis. Table 2-1 below lists the bores used for water supply and also monitoring. The volume of water extracted from each bore during the 12-month period May 2022 to April 2023 inclusive is provided. The total volume of water extracted over this period was for all bores combined was 535 ML compared to 721 ML in the previous year.

Table 2-1. Groundwater bore details and water usage for May 2022 to April 2023 inclusive
GEL – Groundwater Extraction Licence HGS10000

Monitoring Bore ID	Bore (RN)	Year of completion	Depth (m)	Purpose	Water extracted May 22 – Apr 23 (ML)
N/A	029733	1994	87.5	Included in GEL. Water supply only	51.439
GW1	029096	1995	47.0	Included in GEL. Water supply and monitoring.	80.309
GW3	029097	1995	103.3	Included in GEL. Not currently used for water supply. Monitoring only.	0
GW2	029098	1995	44.5	Included in GEL. Water supply and monitoring.	1.791
GW6	030344	1995	36.5	Monitoring only/ NT Water Resources bore.	0
N/A	030410	1996	75.6	Included in GEL. Water supply only.	0
N/A	030412	1996	Backfilled	Included in GEL.	0
N/A	030418	1996	90.8	Included in GEL. Not currently used.	0
GW5	031822	1998	87.6	Included in GEL. Not currently used for water supply. Monitoring only.	0
N/A	031829	1998	84.9	Included in GEL. Water supply only	0
GW4	036485	2009	62.2	Included in GEL. Water supply and monitoring.	0.227
GW7	042465	2021	41.0	Included in GEL. Water supply and monitoring.	401.55

2.3 Wastewater flows, treatment, and irrigation

Wastewater from the hatchery (Stage one) is directed to the effluent collection sump prior to primary treatment through coarse screening of solids followed by fine screening. Wastewater is then directly irrigated to land. A Pierce C600 centre pivot system is used as the irrigation mechanisms for wastewater disposal over the Stage one irrigation area, where Mariner Rhodes grass is grown.

Wastewater from the growers and finishers (Stage two) is directed to the Stage two effluent collection sump prior to primary treatment through coarse screening of solids followed by fine screening. Wastewater is then pumped to the retention basin for irrigation to the Stage two irrigation area, where African Mahogany is grown. The irrigation mechanism used in the area is an in-line drip system.

2.4 Environmental setting

The region of the project area experiences a tropical climate with a distinct dry season (May to October) and wet season (November to April). Typically, for this region, humidity, maximum and minimum temperatures are highest in the wet season, and annual evaporation far exceeds annual rainfall.

Climate data is sourced from the Bureau of Meteorology (BoM) weather monitoring station at Middle Point Rangers (station number 014090) and McMinns Lagoon (station number 014219), given that no rainfall records are available for 2022 at Middle Point Rangers. Average annual rainfall at McMinns Lagoon (18 km west of the site) is 1,883 mm, with the highest rainfall occurring in January and the lowest in July.

Annual evaporation at Middle Point Rangers (7 km south-east of the site) is 2,191 mm, which exceeds the average annual rainfall. Evaporation is the highest in October and lowest in February.

Table 2-2. Average rainfall and evaporation (taken from BoM Station No. 14090 and 14219)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	459.6	382.0	321.9	106.2	17.6	1.2	0.8	3.5	15.9	81.0	183.7	312.4	1894.9
Evaporation (mm)	160.7	141.7	158.5	169.3	178.7	173.3	183.9	204.6	217.4	226.9	195.9	180	2190.9

LLCF is located on a relatively flat area, with a gradient of <2%. The area is moderately well-drained, allowing adequate infiltration and minimal surface water runoff. Existing constructed drains located on site, collect and direct overland flows towards the property boundaries (see Figure 1-3). Surface water drainage from the Stage one area sheds to the east through existing box culverts under Alphatonia road, flowing towards Lambells Lagoon.

The northern portion of the project area (section 1688) flows to the north-west into Black Jungle Swamp. The south-west section of 1688 and western portion of section 1611 (primarily Stage two) flows to the south-west into a drainage line flowing into Black Jungle Swamp. Overland flows in the eastern parts of sections 1611 and south-east corner of section 1688 drain to the east towards Lambells Lagoon.

The site is located within the lower Adelaide River catchment and is surrounded by the Adelaide River coastal floodplains. The Adelaide River floodplain is designated as a Site of Conservation Significance (SOCS) by the Northern Territory Government and encompasses the project area. However, the site area does not encompass habitats of recognised conservation value or significance within the SOCS due to pre-existing clearing and land use.

Agriculture and Conservation Reserves are the main land zones in the neighbouring land. The site is located between two Conservation Reserves, the Black Jungle to the west and Lambells Lagoon to the east. North-west of the site the land is zoned as horticultural, where a fruit farming business (Darwin Fruit Farms) is located.

A nursery (Darwin Plan Wholesalers) and volunteer fire brigade station are located south of the site. In addition to the horticultural infrastructure, there are multiple buildings on neighbouring properties used for rural living, to the south of the irrigation and farming operations areas. Alphatonia Road is immediately to the east of section 1611 and 1688. Other surrounding land users accessing Alphatonia Road past the Project includes the Koolpinyah Station.

3 RAINFALL AND DISCHARGES

3.1 Rainfall

Figure 3-1 shows monthly rainfall totals for the reporting period taken from the McMinns Lagoon BoM station No. 14219. Average monthly rainfall totals are also shown for comparison. Rainfall was above average for all months except for May, January and March. Total rainfall for the reporting period was 2,223.3 mm, which is above the annual average (1,883 mm).

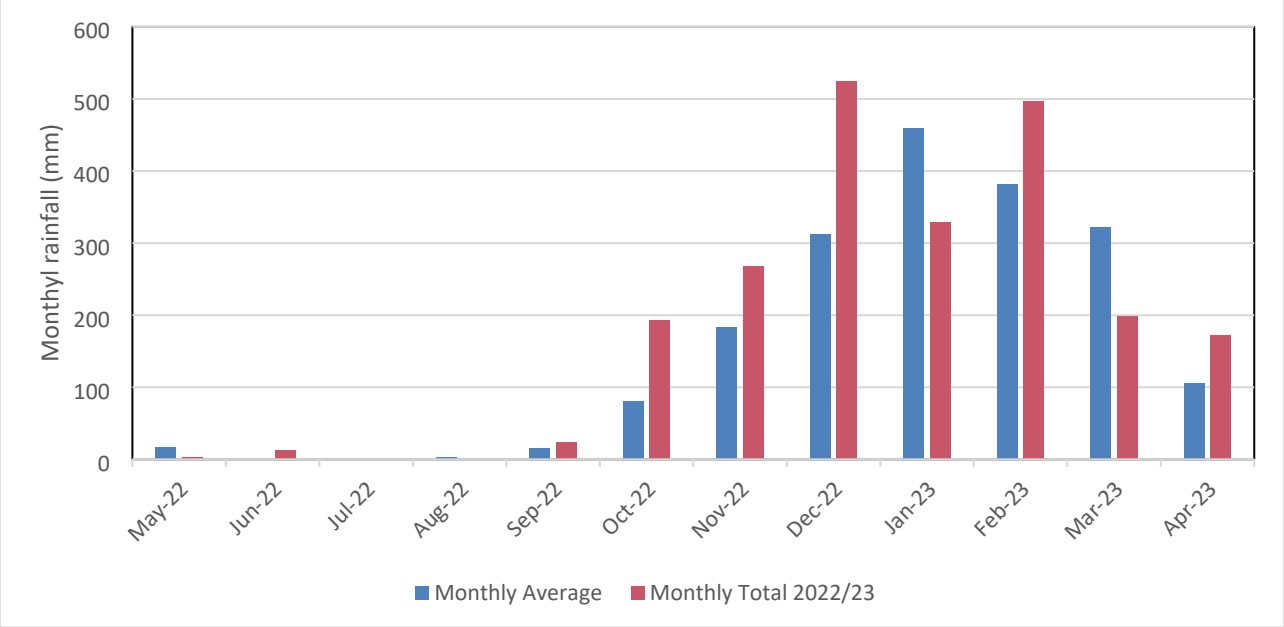

Figure 3-1. Monthly rainfall totals May 2022 to April 2023 (McMinns Lagoon BoM station No. 14219)

3.2 Reporting period discharge details

Irrigation volumes from the two authorised discharge points during the reporting period are provided in Table 3-1. The exact volumes of water irrigated are not available for the reporting period due to a malfunction in the system that records such volumes. Therefore, the volumes were extrapolated from the groundwater extraction volumes. It was assumed that volumes from RN029096 are reflective of ADP1, and those from RN029733 and RN042465 are reflective of ADP2.

Irrigation was undertaken when soils were not saturated to avoid runoff, as described in the LLCF *Irrigation Management Plan* (EcOz 2021). A total of 533.298 ML were irrigated during the reporting period. The highest volumes were irrigated between August -December 2022 from ADP2.

Table 3-1. Irrigation discharges during the reporting period May 2022 –April 2023

Month	ADP1 pivot irrigation volumes (ML)	ADP2 plantation irrigation volumes (ML)
May 22	3.383	14.732
Jun 22	10.850	21.797
Jul 22	7.706	30.071
Aug 22	21.337	53.631
Sep 22	12.091	51.239
Oct 22	8.009	48.678
Nov 22	4.938	50.795
Dec 22	4.454	65.076
Jan 23	1.947	26.608
Feb 23	1.754	22.917
Mar 23	1.454	30.772
Apr 23	2.386	36.673
Total	**80.309**	**452.989**

4 MONITORING UNDERTAKEN

During the reporting period, monitoring was undertaken as per EPL320-01 requirements using the methods outlined in the LLCF *Irrigation Management Plan* (EcOz 2021) and summarised below.

4.1 Monitoring sites

Details for surface water, groundwater and soil monitoring sites as listed in EPL320-01 Appendix A are shown in Figure 1-3 and detailed below in Table 4-1.

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

Site ID	Context and purpose	GPS Coordinates	
		Latitude	Longitude
Surface Water Sites			
ADP1 – Irrigation Pivot	'Authorised discharge point' listed in EPL320-01. Stage one wastewater pump station authorised discharge point. This site represents water applied to the Stage one pivot irrigation area, located on the southern portion of LLCF.	744501	8610198
ADP2 – Irrigation Plantation	'Authorised discharge point' listed in EPL320-01. Stage two wastewater pump station authorised discharge point. This site represents water applied to the Stage two plantation irrigation area located on the eastern portion of LLCF.	743920	8611147
SW01	Drainage line west of Alphatonia Rd. at Property entrance, receives runoff from Stage one – parcel 1611, flowing east to Lambells Lagoon.	744770	8610323
SW02	Drainage line west of Alphatonia Rd. at the north-east corner of parcel 1688. Receives surface water runoff from Alphatonia Rd flowing west along the northern boundary into Black Jungle Swamp.	745229	8612655
SW03	Drainage line on south-west boundary corner of parcel 1611 flowing west to Black Jungle Swamp. Downstream stormwater drainage from Stage two.	743417	8610332
SW04	Drainage line north-west of parcel 1688 flowing west to Black Jungle Swamp. Receives surface water runoff from Stage two plantation irrigation area.	744480	8612413
SW05	Drainage line on western side of LLCF that flows into Black Jungle Swamp. Site is located downstream of SW3 and the LLCF.	742993	8610872
SW06	Drainage line on western side of LLCF that flows into Black Jungle Swamp. Site is located upstream of SW3 and the LLCF.	742978	8609442
Groundwater Bores			
GW1	Bore located adjacent to the office facilities and east of incubation building. Water supply bore.	744654	8610320
GW2	Bore located adjacent to the hatchery for irrigation use.	744649	8610254
GW3	Bore located west of Alphatonia Rd. within south-east section of parcel 1611.	744748	8610026
GW4	Bore located west of Alphatonia Rd. within north-east section of parcel 1611. Water supply bore.	744823	8610734
GW5	Bore located west of Alphatonia Rd. within parcel 1688.	745056	8611871

Site ID	Context and purpose	GPS Coordinates	
		Latitude	Longitude
GW6	Water Resources Bore equipped with water level logger. Located on the western side of LLCF on boundary, SW corner of parcel 1688 downstream of Stage two.	743648	8611027
GW7	Bore located in Stage two area near retention basin. Water supply bore for Stage two operations.	748905	8618978
Soil Sites			
SS01	Stage one irrigation area (15 ha)	744326	8609983
SS02		744560	8609986
SS03		744317	8609812
SS04		744557	8609821
SS05	Stage two irrigation area (20 ha)	744683	8610449
SS06		744679	8610651
SS07		744772	8610801
SS08		744725	8610971
SS09		744811	8611124
SS10		744811	8611299

4.2 Monitoring frequency, parameters, and trigger values

Table 4-2, Table 4-3, Table 4-4 and Table 4-5 list the parameters to be measured at each site, the sampling frequency and trigger values currently specified in EPL320-01 Attachment A.

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

Monitoring site	Parameter	Sampling frequency	Trigger value
Irrigation extraction points / authorised discharge points: ADP1 (-12.562519, 131.250281) ADP2 (-12.553989, 131.244869)	pH	Monthly when discharging and quarterly when not discharging	6 – 9[1]
	EC (electrical conductivity)		1,300 µs/cm[1]
	Total Phosphorus (TP)		12 mg/L[1]
	Total Nitrogen (TN)		125 mg/L[1]
	E. coli, Enterococci, Total coliforms		1,000 cfu/100mL (fodder) [1]
	Cations and anions (Ca, Mg, Na, K, SO_4, Cl, CO_3 + HCO_3)		N/A

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

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

Monitoring sites	Parameter	Sampling frequency	Trigger value
GW1, GW2, GW3, GW4, GW5, GW6[2] and GW7	Standing water level (SWL)	Monthly	N/A
	pH	Quarterly	7.0 – 8.5[1]
	EC		400 µs/cm[1]
	TP		Any increase from

Monitoring sites	Parameter	Sampling frequency	Trigger value
	TN		previous monitoring round
	E. coli, Enterococci, Total coliforms		
	Cations and anions (Ca, Mg, Na, K, SO_4, Cl, CO_3 + HCO_3)		N/A

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

[2] *NT Water Resources Bore – SWL only- accessed online*

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

Monitoring sites	Parameter	Sampling frequency	Trigger value
SW01, SW02*, SW03, SW04, SW05 and SW06*	pH	3 times during the wet season (start, mid, end)	6.0 – 7.5[1]
	EC		200 µs/cm[1 2]
	TP		0.01 mg/L[1 2]
	TN		0.23 mg/L[1 2]
	E. coli, Enterococci, Total coliforms		Any increase from previous monitoring round

**Trigger values not applicable*

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

[2] *If the concentration at SW06 is greater than the trigger value then the concentration at SW06 becomes the trigger value for that monitoring round*

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

Monitoring sites	Parameter	Sampling frequency	Trigger value*
SS01, SS02, SS03, SS04, SS05, SS06, SS07, SS08, SS09 and SS10	pH	Annually	6 – 8
	EC		Any increase from the previous monitoring round
	TP		
	TN		
	E. coli, Enterococci, Total coliforms		

** B horizon results*

4.3 Sampling procedures

All sampling is undertaken in accordance with the LLCF *Irrigation Management Plan* (EcOz 2021) and the following standards and guidelines:

Australian/New Zealand Standard on Water Quality Sampling - *Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples* (AS/NZS 5667.1:1998), Standards Australia, New South Wales.

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

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

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

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

Australian Standard on Contaminated Soil Sampling – *Guide to the sampling and investigation of potentially contaminated soil – Part 1: Non-volatile and semi-volatile compounds* (AS4482.1-2005), Standards Australia, New South Wales

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

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

Water sampling was carried out by either an EcOz Environmental Consultant or LLCF staff, who have received on-site training in sampling methods from EcOz, as well as on-going guidance from EcOz.

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

All surface water monitoring sites were sampled into a laboratory-supplied sample bottle. Field parameters i.e. pH, electrical conductivity (EC) and total dissolved solids (TDS), are also measured in the laboratory.

Groundwater is purged for a minimum of 10 minutes until field parameters stabilised. Once this occurred, the lab samples were collected directly into the lab-supplied bottles. No parameters are measured in-situ and as such, all parameters, including pH, are measured at the laboratory.

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

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

All laboratory documentation are stored in an online filing system maintained by EcOz (M-Files). PRI also maintain copies of all laboratory documentation.

4.4 Monitoring undertaken during the reporting period

Table 4-6 outlines the monitoring undertaken during the reporting period and compliance against EPL320-01 monitoring requirements. The following dot points explain the reasons for some non-compliances with the monitoring requirements:

- The LLCF site and surrounding areas are very flat and most runoff sheet flows into indistinct drainage lines that only flow during heavy rainfall. Sampling the six surface water sites has proved very difficult, as sampling needs to occur during heavy rain and at a time that allows the samples to be delivered to the interstate laboratory within the required analyte holding time i.e. must be delivered to laboratory shopfront in Darwin prior to 2 pm and only on Monday to Thursday. During the reporting period, two sites were sampled mid wet season (SW01 and SW05) and one site sampled late wet season (SW05).
- Water quality samples were taken at ground water sites GW1, GW2, GW3, GW4 and GW5, except for the December sampling round, where only GW1, GW2 and GW3 were sampled. GW6 and GW7 were not accessible for sampling.

PRI will endeavour to improve compliance with monitoring requirements by investigating how to achieve sampling of the surface water sites when they are flowing and still meet analytical holding time requirements.

Table 4-6. Monitoring undertaken during the reporting period

Site ID	Frequency required	Dates sampled	Compliance with sampling frequency	Compliance with parameters measured
ADP1 – Irrigation Pivot	Monthly during discharge, quarterly when not discharging	13/07/2022 16/08/2022 26/09/2022 11/10/2022 24/11/2022 22/12/2022 24/01/2023 15/02/2023 15/03/2023	Compliant	Compliant, except in February 2023, when concentrations of *E. coli*, total coliforms and enterococci were not analysed.
ADP2 – Irrigation Plantation			Compliant	
SW01, SW02, SW03, SW04, SW05, SW06	Three times during wet season (start, mid and end)	24/01/2023 (SW01 & SW05) 15/02/2023 (SW5 only)	Sampling of all sites was attempted. However, most sites were dry at the time of sampling as flow only occurs during heavy rainfall.	Compliant except for *E. coli*, total coliforms and enterococci which were not analysed in samples collected in February 2023.
GW1, GW2, GW3, GW4, GW5, GW6, GW7	Standing water levels (SWL) monthly	01/05/2022 01/06/2022 01/07/2022 01/08/2022 01/09/2022 01/10/2022 01/11/2022 01/12/2022 01/01/2023 01/02/2023 01/03/2023 01/04/2023	Compliant. Data for GW6 is restricted to that which is available through the NT Water Data WebPortal https://water.nt.gov.au. However, the only data available for GW6 during the reporting period is for October 2022.	Compliant
	Water quality quarterly	14/06/2022 26/09/2022 22/12/2022 15/03/2023	Compliant with GW1, GW2, GW3, GW4 and GW5. GW4 and GW5 were not sampled in the December sampling round. GW6 and GW7 are not accessible for sampling.	Compliant
SS01, SS02, SS03, SS04, SS05, SS06, SS07, SS08, SS09, SS10	Annually	30/01/2023	Compliant	Compliant

5 RESULTS AND DISCUSSION

Monitoring results for the reporting period are presented and discussed in the sections below. Note that given annual monitoring for EPL320-01 begun in April 2021, data from the previous monitoring round will be referenced for comparison and to outline possible trends in the data. All historical data for parameters with a defined trigger value are graphed in Appendix A.

5.1 Authorised discharge points

Table 5-1 provides all water quality monitoring results for the two authorised discharge points (irrigation source water taken from ADP1 (Irrigation Pivot) and ADP2 (Irrigation Plantation) for all sampling undertaken since monitoring began in May 2021.

All pH concentrations remained within the trigger value range at both ADP1 (ranged between 7.42 and 8.09) and ADP2 (ranged between 7.49 and 8.98), and no increasing or decreasing trends were evident when compared to previous data.

All EC, TN and TP concentrations were below the trigger values at both ADP1 and ADP2. No increasing trend was evident.

Given the nature of the wastewater sampled at the ADP1 and ADP2 sites, high concentrations of pathogens are expected. However, the bacterial load of irrigation water from ADP1 and ADP2 have almost always exceeded the trigger values for *E. Coli*, enterococci and total coliforms (i.e. well above 1,000 CFU/100 mL), with higher concentrations mostly recorded at ADP1 than ADP2. Spikes in bacterial load were recorded in the reporting period, but concentrations always decreased and as such, no increasing trend has been observed (see Figure 5-1to Figure 5-3). Historical data also indicates that the spikes recorded in this reporting period are considerably lower than that reported in April 2022.

In 2022, Marine Rhodes was grown at Stage One (ADP1) but was never harvested. Since 2023, Jarra grass is grown at Stage One and was first harvested in April 2023. The grass was used as fodder by a third person farmer who, given the potential risks of infection of livestock, was made aware of the high bacterial load of the water used to irrigate the crop.

The African Mahogany plantation on the Stage Two irrigation area is not to be used for consumption, as such bacterial concentrations should not pose a problem.

5.2 Groundwater quality

During the reporting period, bores GW1, GW2, GW3, GW4 and GW5 were sampled quarterly with the exception of December, when GW4 and GW5 were not sampled. Table 5-2 provides the groundwater quality results for all sampling undertaken during the reporting period, as well as historical data available for the monitoring bores.

pH remained within the trigger value range of 7.0 to 8.5 in all five bores sampled (GW1, GW2, GW3, GW4 and GW5), except in June 2022, when pH at GW2 and GW4 was slightly below 7.0. No long-term increasing or decreasing trend in pH is evident in any of the five bores.

EC concentrations have always been well below the trigger value since monitoring began in February 2020 and no increasing trend is evident in any of the bores.

As shown in Table 5-2*, E. coli* and enterococci concentrations in groundwater were mostly negligible in all bores, with the exception of GW2 which consistently recorded results above the laboratory limit of reporting (1 CFU/100 mL). In December 2023, the highest *E. Coli* concentration recorded since monitoring started was reported at GW2, while in June 2022, the highest enterococci concentration was recorded at the same bore. The high concentrations of *E. Coli* (330 CFU/100 mL) and enterococci (2,300 CFU/100 mL) at this bore are

potentially indicating that water contaminated with animal faeces is seeping into the aquifer. Faecal bacterial load is expected to decrease with distance from the source and as such, the bacterial levels detected at GW2 are not expected to pose a risk to the receiving environment (i.e. surface water systems that receive discharges from the Howard Groundwater system). However, there are no monitoring bores downgradient from GW2 which limits the assessment of any lateral migration of contaminants through the groundwater system. No increasing trend in bacterial load was observed in the monitoring period.

Compared to the previous reporting period, the 2022-23 results show relatively high concentrations of total coliforms at site GW2 (Appendix A), with a peak of 19,000 CFU/100mL in September and consistent elevated values (13,000 CFU/100mL) in December 2022 and March 2023. All other sites recorded values consistent with the previous monitoring round.

Samples from GW2 are collected from a sprinkler, which could potentially impact on the representativeness of the results obtained. Although no potential source of contamination of the sprinkler has been identified (i.e. it is not likely to receive wastewater from sprinklers used in the irrigation areas), cross-contamination of the sample site cannot be discarded.

Overall nutrient concentrations (TN and TP) are consistent with previous results, with only a few exceptions. Increments in TN concentrations were recorded at GW4 in June 2022 (3.1 mg/L) and March 2023 (2.6 mg/L), and at GW1 and GW3 in September (1.8 mg/L and 1.9 mg/L respectively). TP concentrations also increased in June and September GW4 (0.06 mg/L and 0.15 mg/L respectively) and in March at GW2 (0.10 mg/L). However, no increasing trends were observed.

5.3 Groundwater bore standing water levels

Figure 5-4 shows the standing water levels (SWLs) measured in all bores since monitoring started in May 2021. Table 5-3 provides SWL data from the May 22 – April 23 monitoring period. Data shows a lowering of groundwater levels over the dry season and recharge throughout the wet season.

SWLs in mBTOC for GW6 were calculated adding the depth below ground reported in the NT Water Resources website (DEPWS 2022b) and the top of casing height (0.436 m; DEPWS 2022a). The groundwater levels for GW6 were only recorded in October 2022 by NT Water Resources during the monitoring period.

Groundwater levels in the 2022-23 wet season were slightly lower than the levels seen in the 2021-22 wet season, even though rainfall was higher in the 2022-23 wet season and less volumes (186 ML) were extracted from the GEL in this monitoring round. No long-term lowering of groundwater levels due to extraction at the farm are inferred from the results presented in Table 5-3. However, further monitoring is required to identify any potential impact on groundwater levels at GW7.

5.4 Surface water sites

Table 5-4 provides the surface water quality results for sampling undertaken during the reporting period, as well as the limited data collected previously.

The pH in surface water at the site is almost always slightly acidic and below the trigger value range. This is typical of fresh rainwater in the tropics and not of concern.

All EC concentrations remain well below the trigger value.

TN and TP concentrations are usually slightly above the very conservative Darwin Harbour water quality objectives but concentrations are not increasing and are typical of runoff from agricultural land.

E. Coli and enterococci concentrations reported at SW01 in January 2023 is the highest reported at this site since monitoring started in 2020. It is the first time that SW5 is sampled and as such, it is not possible to assess its bacterial load. The *E. coli* and enterococci detections at this site are indicative of faecal contamination, but it is not possible to determine if such concentrations are influenced by discharges of surface water runoff from the farm as SW06 (upstream from the farm) has not been sampled.

5.5 Soils

Table 5-5 provides the soil monitoring results for the reporting period i.e. the annual sampling undertaken in January 2023, including the data from the previous monitoring round. Note that irrigation of the Stage one area only started in early 2021 and in the Stage two area in early 2022.

pH values have significantly decreased compared to the previous sampling round (January 2022), with 10 out of 20 samples outside the trigger values. The lowest recorded value being 5.2 pH at SS8 at both surface and 0.5 m samples (Table 5-5).

EC concentrations were between 41 to 119 µS/cm at surface and between 19 and 87 µS/cm at 0.5 m depth. All concentrations were higher than those recorded in 2022.

Overall, the nutrient concentrations in the soil samples were lower in the 2022-2023 sampling round (Figure 5-5). TN at the surface at Stage one irrigation area ranged between 650 and 1140 mg/kg and between 160 and 400 mg/kg at 0.5 m depth, which indicates a reduction in bacterial load at depth. The highest TN concentrations at 0.5 depth in the Stage one irrigation area were reported at SS1 and SS4. At the Stage two irrigation area, TN concentrations at surface were between 560 and 950 mg/kg, and between 80 and 550 mg/kg at 0.5 m, which also show lower bacterial loads at depth. No considerable variations are seen between the irrigation areas.

The Stage one irrigation area had TP concentrations between 299 and 456 mg/L at surface, and 79 and 103 mg/L at 0.5 m depth. The highest concentration in this area was recorded at SS2. TP at the Stage two irrigation area ranged between 164 and 443 mg/L at surface, and 91 and 134 mg/L at 0.5 m depth. SS6 had the highest concentration at surface. TP concentrations between the two irrigation areas were not considerably different.

During the monitoring period, enterococci ranged between 230 and 660 MPN/g dry weight in the Stage one area and 74 to 1,200 MPN/g dry weight in Stage two. Total coliforms detected in the Stage one irrigation area were between 390 MPN/g dry weight and 23,000 MPN/g dry weight, while the Stage two area sampling sites recorded concentrations between 360 MPN/g dry weight and 27,000 MPN/g dry weight. *E. coli* concentrations at the Stage one soil sampling sites were considerably lower than the previous year (<11 to 87 MPN/g dry weight), while they were slightly higher at Stage two (<11 to 8,300 MPN/g dry weight). This is likely due to the stage two area not being irrigated until after the 2022 sampling took place.

Bacteria and nutrients have the potential to migrate off-site through surface water runoff. However, more surface water quality data is required to determine if such migration exists and its potential impacts on the receiving environment.

Table 5-1. Authorised discharge point (irrigation source) water quality monitoring results for 2021-22 and 2022-23

Concentrations exceeding EPL320-01 trigger values for irrigation water highlighted in orange

Site ID	Date	pH	EC	TDS	Nitrite + Nitrate	TKN	TN	TP	E coli	Faecal Coliforms	Total Coliforms	Enterococci	Hydroxide Alkalinity as CaC03	Carbonate Alkalinity as CaC03	Bicarbonate Alkalinity as CaC03	Total Alkalinity as CaC03	Sulfate as S04	Chloride	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
			µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/100mL	CFU/100mL	CFU/100mL	CFU/100mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	mg/m3
Irrigation EPL320 trigger values		**6.0 - 9.0**	**1300**	-	-	-	**125**	**12**	**1000**	-	**1000**	**1000**	-	-	-	-	-	-	-	-	-	-	-	-
Irrigation Pivot (ADP1)	13/05/2021	7.23	433	268	240	165	405.0	37.30	2200	-	30000	2500	<1	<1	180	180	6	33	30	16	23	4	-	-
Irrigation Pivot (ADP1)	25/05/2021	7.75	1120	507	1.05	109	110.0	4.65	8300000	-	~9100000	13000000	<1	<1	517	517	6	28	54	26	19	7	-	-
Irrigation Pivot (ADP1)	9/06/2021	6.65	344	206	<0.01	5.4	5.4	1.38	320000	-	~3200000	7100	<1	<1	168	168	8	19	32	17	14	3	-	-
Irrigation Pivot (ADP1)	6/07/2021	7.77	506	288	<0.01	20.6	20.6	4.18	~290000	-	130000	30000	<1	<1	216	216	2	28	46	21	19	3	-	-
Irrigation Pivot (ADP1)	12/08/2021	7.35	524	300	<0.01	16.8	16.8	2.30	25000	-	~50000	61000	<1	<1	234	234	4	37	26	16	26	3	-	-
Irrigation Pivot (ADP1)	16/09/2021	7.82	812	374	0.01	57.3	57.3	4.32	180000	-	450000	58000	<1	<1	392	392	8	28	34	20	20	8	-	-
Irrigation Pivot (ADP1)	20/10/2021	7.93	688	412	0.69	71.2	71.9	6.02	4100000	-	19000000	~1300000	<1	<1	317	317	7	34	40	21	26	12	-	-
Irrigation Pivot (ADP1)	30/11/2021	7.88	560	280	0.28	34.9	35.2	3.58	9800000	-	~12000000	~90000	<1	<1	252	252	7	27	33	19	22	7	5.94	4.35
Irrigation Pivot (ADP1)	20/12/2021	7.98	776	391	0.66	72.0	72.7	10.1	24000000	-	160000000	4500000	<1	<1	347	347	14	32	36	21	30	16	8.13	5.24
Irrigation Pivot (ADP1)	24/01/2022	7.63	482	298	5.88	14.5	20.4	3.56	-	-	-	-	<1	<1	179	179	7	30	30	20	28	11	4.57	4.64
Irrigation Pivot (ADP1)	22/02/2022	7.67	325	163	<0.01	4.6	4.6	1.55	96000	-	140000	29000	<1	<1	157	157	4	13	29	15	11	3	3.59	0.17
Irrigation Plantation (ADP2)	22/02/2022	6.99	70	37	0.02	3.3	3.3	0.37	69000	-	~99000	5400	<1	<1	30	30	2	4	6	1	3	2	0.75	0.56
Irrigation Pivot (ADP1)	30/03/2022	7.66	564	329	0.65	63.2	63.8	5.50	1400000000	-	~2800000000	9500000	<1	<1	221	221	3	28	33	21	24	10	5.27	4.67
Irrigation Plantation (ADP2)	30/03/2022	8.61	217	110	0.02	11.4	11.4	2.08	<2	-	~28	420	<1	12	38	50	11	18	18	4	8	7	1.74	1.75
Irrigation Pivot (ADP1)	26/04/2022	7.95	679	352	0.97	46.4	57.4	3.68	1000000000	-	1900000000	59000000	<1	<1	295	295	5	29	29	19	21	9	6.82	7.47
Irrigation Plantation (ADP2)	26/04/2022	7.73	444	242	0.02	20.7	20.7	3.85	190000	-	~1100000	18000	<1	<1	136	136	30	31	30	7	15	15	4.22	4.59
Irrigation Pivot (ADP1)	13/07/2022	7.95	711	308	0.89	55.2	56.1	3.84	~9000000	-	110000000	410000	<1	<1	294	294	6	20	37	20	15	7	6.56	8.27
Irrigation Plantation (ADP2)	13/07/2022	8.62	282	184	0.24	6.1	6.3	1.20	250	-	2500000	16	<1	29	105	134	7	12	29	15	8	1	3.16	----
Irrigation Pivot (ADP1)	16/08/2022	7.95	360	187	0.80	6.3	7.1	0.59	150000	-	200000	~70000	<1	<1	158	158	3	13	28	18	11	1	3.59	3.38
Irrigation Plantation (ADP2)	16/08/2022	8.98	311	196	0.19	9.2	9.4	2.00	720	-	~700000	1700	<1	22	88	110	5	34	31	10	20	2	3.26	3.29
Irrigation Pivot (ADP1)	26/09/2022	7.85	538	213	0.03	25.6	25.6	6.30	110000	-	540000	~110000	<1	<1	239	239	6	21	39	20	17	4	5.49	4.43
Irrigation Plantation (ADP2)	26/09/2022	8.10	288	165	<0.01	7.8	7.8	1.12	<2	-	~64	30	<1	<1	90	90	2	33	24	7	23	4	2.77	2.88
Irrigation Pivot (ADP1)	11/10/2022	7.80	728	254	<0.01	53.3	53.3	3.08	7700000	-	32000000	180000	<1	<1	341	341	9	20	30	22	16	7	7.56	8.05
Irrigation Plantation (ADP2)	11/10/2022	7.77	563	278	0.62	43.4	44.0	10.70	330000	-	3900000	~50000	<1	<1	233	233	23	24	35	20	17	6	6.15	7.39
Irrigation Pivot (ADP1)	24/11/2022	8.09	674	245	0.29	55.5	55.8	6.03	480000	-	3000000	110000	<1	<1	328	328	7	21	34	18	16	7	7.29	8.04
Irrigation Plantation (ADP2)	24/11/2022	8.52	315	186	0.26	7.1	7.4	1.91	1800	-	35000	10000	<1	<1	120	120	5	24	25	15	14	3	3.34	3.17
Irrigation Pivot (ADP1)	22/12/2022	7.95	545	225	1.20	33.8	35	3.99	570000	-	3600000	44000	<1	<1	296	296	6	15	34	18	10	5	6.46	6.38
Irrigation Plantation (ADP2)	22/12/2022	7.97	390	230	<0.01	11.1	11.1	3.31	~<2	-	~<2	28	<1	<1	194	194	<1	26	28	19	13	5	4.61	4.45
Irrigation Pivot (ADP1)	24/01/2023	7.42	484	228	<0.01	26.5	26.5	2.47	100000	-	22000000	230000	<1	<1	209	209	11	15	28	15	12	6	4.83	5.2
Irrigation Plantation (ADP2)	24/01/2023	7.49	308	184	0.01	8	8	2.02	100000	-	5800000	380000	<1	<1	120	120	5	24	22	10	14	5	3.18	3.23
Irrigation Pivot (ADP1)	15/02/2023	7.35	563	286	0.01	26.2	26.2	2.96	-	-	-	-	<1	<1	265	265	10	16	35	20	12	6	5.95	6.25
Irrigation Plantation (ADP2)	15/02/2023	7.09	758	268	<0.01	43.6	43.6	9.36	-	-	-	-	<1	<1	355	355	<1	23	36	20	15	8	7.74	7.93
Irrigation Pivot (ADP1)	15/03/2023	7.50	498	200	<0.01	21.8	21.8	2.23	81000	-	24000000	32000	<1	<1	224	224	4	21	27	16	18	5	5.15	5.13
Irrigation Plantation (ADP2)	15/03/2023	7.84	256	114	<0.01	7.3	7.3	2.45	720	-	8200	400	<1	<1	105	105	2	20	19	7	12	5	2.70	2.70

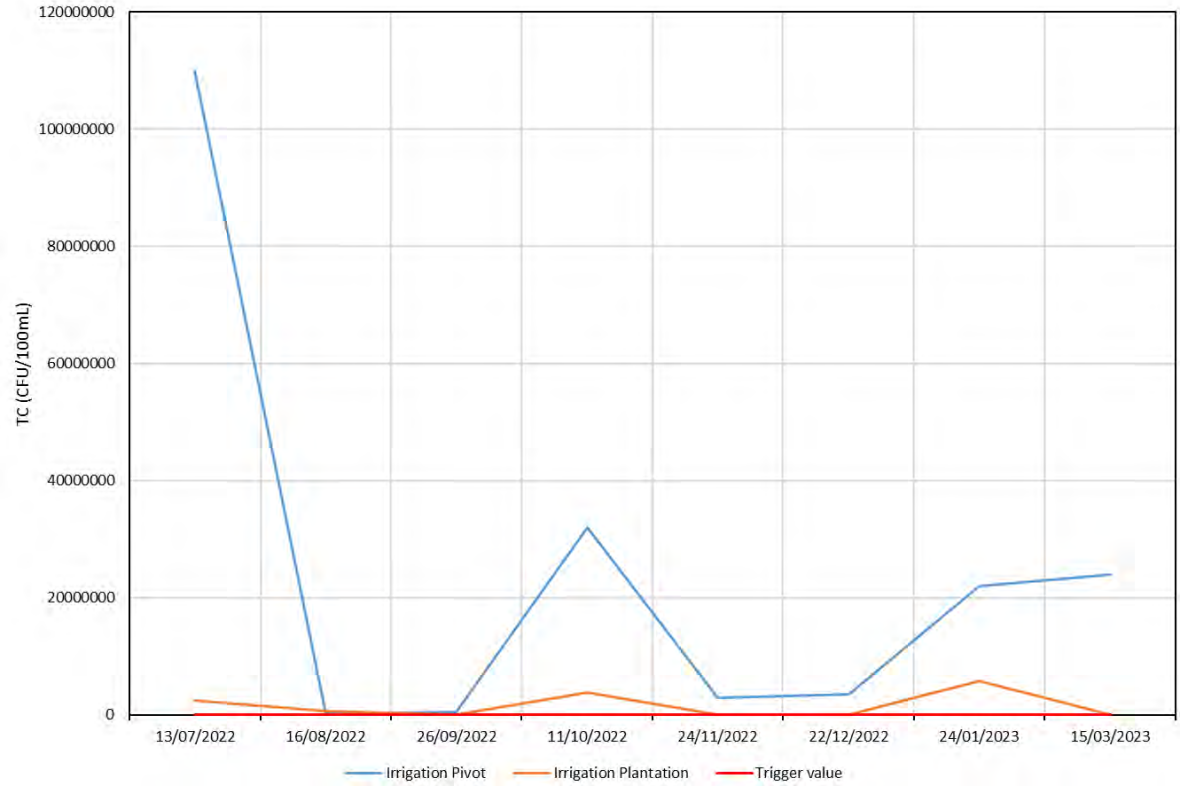

Figure 5-1. Total coliforms at the Irrigation Pivot (ADP1) and Irrigation Plantation (ADP2) in the reporting period.

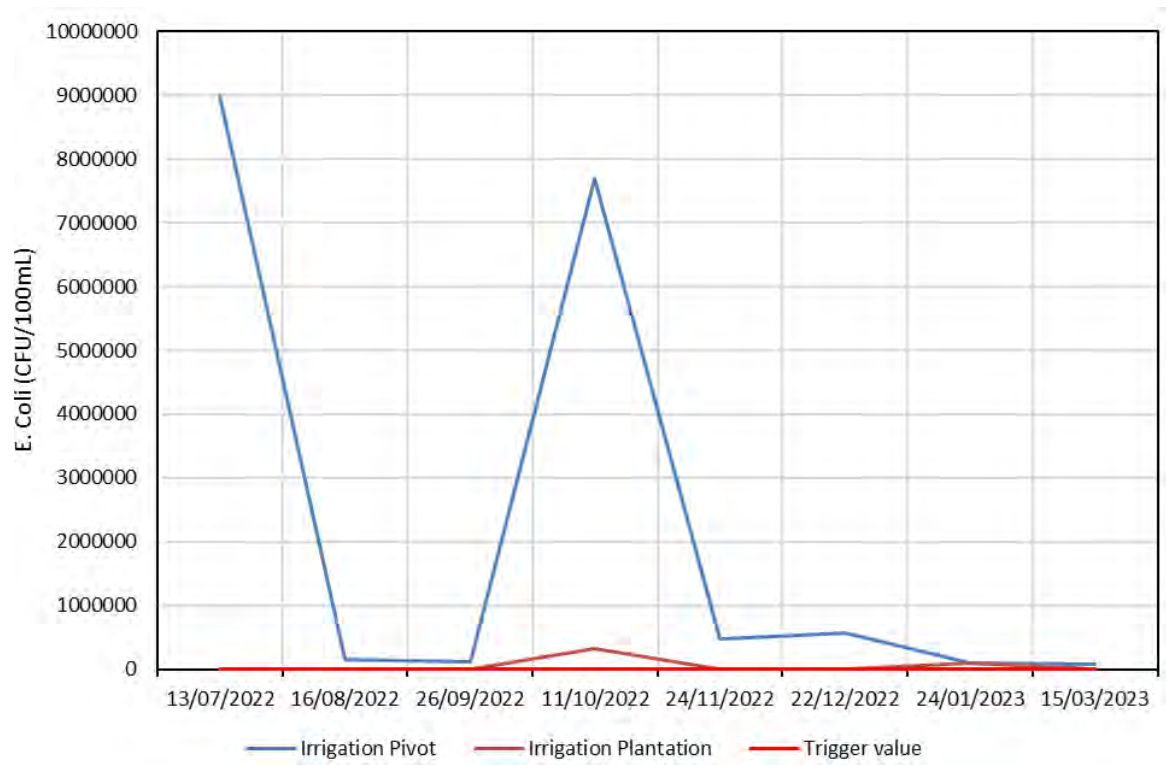

Figure 5-2. *E. Coli* at the Irrigation Pivot (ADP1) and Irrigation Plantation (ADP2) in the reporting period.

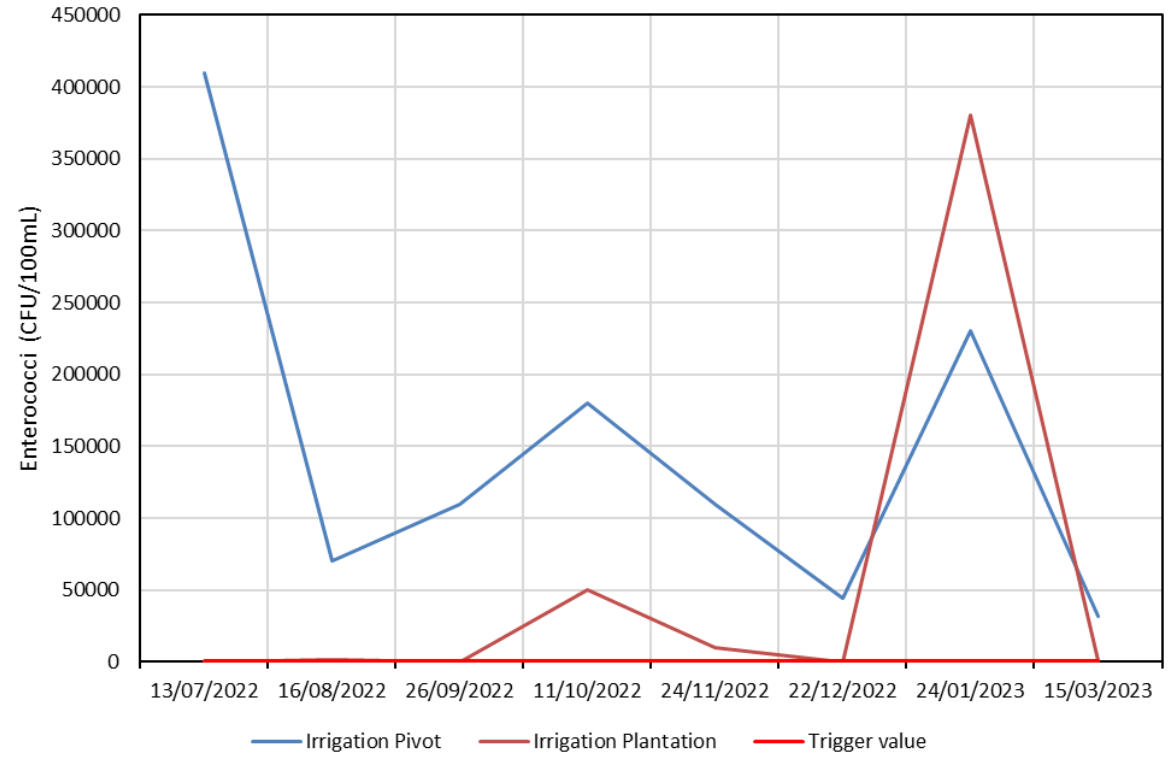

Figure 5-3. Enterococci at the Irrigation Pivot (ADP1) and Irrigation Plantation (ADP2) in the reporting period.

Table 5-2. Groundwater quality monitoring results for 2021-22 and 2022-23

Concentrations outside EPL320-01 trigger values for groundwater highlighted in orange

Site ID	Date	pH	EC	TDS	Nitrite + Nitrate	TKN	TN	TP	E coli	Total Coliforms	Enterococci	Hydroxide Alkalinity as CaC03	Carbonate Alkalinity as CaC03	Bicarbonate Alkalinity as CaC03	Total Alkalinity as CaC03	Sulfate as S04	Chloride	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
			µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/100mL	CFU/100mL	CFU/100mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	mg/m3
Groundwater EPL320 trigger values		**7.0 - 8.5**	**400**	-	-	-	any increase from previous	any increase from previous	any increase from previous	any increase from previous	any increase from previous	-	-	-	-	-	-	-	-	-	-	-	-
GW1_RN029096	6/07/2021	8.01	283	159	1.41	<0.1	1.4	<0.01	<2	<2	<2	<1	<1	143	143	1	14	30	18	8	<1	-	-
GW2_RN029098	6/07/2021	8.00	244	142	1.98	<0.1	2.0	<0.01	<2	6	<2	<1	<1	110	110	1	16	24	15	8	<1	-	-
GW3_RN029097	6/07/2021																						
GW4_RN036485	6/07/2021	8.00	178	101	2.23	0.1	2.3	0.01	<2	<2	<2	<1	<1	96	96	<1	3	21	14	4	<1	-	-
GW5_RN031822	6/07/2021																						
GW1_RN029096	12/08/2021	7.08	272	158	1.44	<0.1	1.4	0.01	<1	1	<1	<1	<1	138	138	1	12	23	17	8	<1	-	-
GW2_RN029098	12/08/2021	6.85	188	114	2.31	0.4	2.7	<0.01	<1	300	<1	<1	<1	96	96	<1	11	17	12	6	<1	-	-
GW3_RN029097	12/08/2021																						
GW4_RN036485	12/08/2021	7.04	187	117	2.02	0.2	2.2	0.02	<1	<1	<1	<1	<1	107	107	<1	3	15	11	3	<1	-	-
GW5_RN031822	12/08/2021																						
GW1_RN029096	16/09/2021	7.07	287	138	1.36	0.1	1.5	0.02	<1	650	<1	<1	<1	135	135	1	12	25	17	7	<1	-	-
GW2_RN029098	16/09/2021	6.88	239	134	1.81	0.4	2.2	0.01	<1	14	<1	<1	<1	115	115	1	14	20	15	8	<1	-	-
GW3_RN029097	16/09/2021																						
GW4_RN036485	16/09/2021	6.86	200	128	1.30	0.1	1.4	0.02	<1	1	<1	<1	<1	114	114	<1	4	20	13	3	<1	-	-
GW5_RN031822	16/09/2021																						
GW1_RN029096	30/11/2021	7.37	270	181	1.29	<0.1	1.3	0.02	1	4	<1	<1	<1	137	137	1	12	26	18	7	<1	3.10	3.08
GW2_RN029098	30/11/2021	7.77	270	179	1.54	0.2	1.7	0.04	3	<1	3	<1	<1	140	140	1	13	27	18	8	<1	3.18	3.18
GW3_RN029097	30/11/2021																						
GW4_RN036485	30/11/2021	7.65	215	133	1.99	0.1	2.1	0.01	18	<1	1	<1	<1	122	122	<1	4	23	15	3	<1	2.55	2.51
GW5_RN031822	30/11/2021																						
GW1_RN029096	22/02/2022	7.72	270	145	1.26	<0.1	1.3	0.02	2	1	3	<1	<1	135	135	<1	11	25	18	7	<1	3.01	3.03
GW2_RN029098	22/02/2022	7.60	247	127	0.81	0.2	1.0	0.07	1	<1	6	<1	<1	118	118	<1	12	19	14	7	<1	2.70	2.40
GW3_RN029097	22/02/2022																						
GW4_RN036485	22/02/2022	7.54	147	82	2.54	0.3	2.8	0.05	5	9	<1	<1	<1	68	68	<1	3	13	9	3	<1	1.44	1.52
GW5_RN031822	22/02/2022																						
GW1_RN029096	14/06/2022	7.62	230	131	1.34	0.1	1.4	0.04	<1	<1	<1	<1	<1	134	134	<1	12	26	19	6	<1	3.02	3.12
GW2_RN029098	14/06/2022	6.96	125	86	1.60	0.3	1.9	0.02	60	12000	2300	<1	<1	101	101	<1	13	19	15	5	<1	2.38	2.40
GW3_RN029097	14/06/2022	7.26	280	161	1.52	0.2	1.7	0.02	<1	3	<1	<1	<1	125	125	<1	15	26	19	7	<1	2.92	3.16
GW4_RN036485	14/06/2022	6.75	126	82	2.64	0.5	3.1	0.06	2	14	58	<1	<1	58	58	<1	4	12	9	1	<1	1.27	1.38
GW5_RN031822	14/06/2022	7.25	276	167	1.52	0.3	1.8	0.03	<1	5	<1	<1	<1	124	124	<1	15	26	19	6	<1	2.90	3.12
GW1_RN029096	26/09/2022	7.68	293	159	1.49	0.3	1.8	0.02	<1	460	21	<1	<1	133	133	1	12	25	18	9	<1	3.02	3.12
GW2_RN029098	26/09/2022	7.59	260	150	1.72	0.4	2.1	0.02	14	19000	<1	<1	<1	104	104	1	13	22	16	9	<1	2.46	2.81
GW3_RN029097	26/09/2022	7.74	295	152	1.58	0.3	1.9	0.02	<1	<1	<1	<1	<1	125	125	1	15	25	18	10	<1	2.94	3.16
GW4_RN036485	26/09/2022	7.62	161	101	0.58	0.9	1.5	0.15	<1	43	3	<1	<1	74	74	<1	4	15	11	4	<1	1.59	1.83
GW5_RN031822	26/09/2022	7.79	290	158	1.58	0.3	1.9	0.03	<1	6	<1	<1	<1	117	117	1	14	25	18	10	<1	2.75	3.16
GW1_RN029096	22/12/2022	8.02	278	149	1.40	0.2	1.6	0.05	<1	<1	<1	<1	<1	144	144	<1	14	24	18	7	<1	3.27	-
GW2_RN029098	22/12/2022	7.93	224	126	<0.01	0.6	0.6	0.04	330	13000	53	<1	<1	107	107	<1	14	19	14	7	<1	2.53	-
GW3_RN029097	22/12/2022	8.12	281	147	1.63	0.3	1.9	0.04	1	14	1	<1	<1	128	128	1	17	23	17	9	<1	3.06	-
GW4_RN036485	22/12/2022																						
GW5_RN031822	22/12/2022																						
GW1_RN029096	15/03/2023	7.76	292	132	1.45	0.4	1.8	0.02	<1	<1	<1	<1	<1	136	136	1	12	25	16	11	1	3.08	3.07
GW2_RN029098	15/03/2023	7.37	133	56	<0.01	1.0	1	0.10	20	13000	560	<1	<1	57	57	<1	10	11	6	7	1	1.42	1.37
GW3_RN029097	15/03/2023	7.80	288	146	1.44	0.5	1.9	0.01	<1	<1	1	<1	<1	134	134	1	12	21	16	8	<1	3.04	2.85
GW4_RN036485	15/03/2023	7.82	288	144	1.39	1.2	2.6	0.02	<1	1	<1	<1	<1	134	134	1	12	22	15	8	<1	3.04	2.77
GW5_RN031822	15/03/2023	7.83	288	130	1.44	0.5	1.9	0.02	<1	<1	<1	<1	<1	133	133	1	13	23	15	7	<1	3.04	2.82

Table 5-3. Bore standing water levels measured in metres below top of casing (mBTOC)

Date	GW1	GW2	GW3	GW4	GW5	GW6	GW7
01/05/2022	7	7.8	7.5	6.8	11.5	-	6.6
01/06/2022	8.4	9.1	8.1	8.3	12.6	-	7.2
01/07/2022	-	-	-	-	-	-	-
01/08/2022	11	11.6	11.1	10.3	14.4	-	9.4
01/09/2022	12.3	13	12	11.6	15.1	-	11.1
01/10/2022	13	13.5	13.2	12.4	15.5	9.42	15.4
01/11/2022	14	15	14.1	13.5	15.8	-	18.2
01/12/2022	14	15	14.1	13.5	15.8	-	18.2
01/01/2023	12.1	12.3	11.8	11.3	12.9	-	15.2
01/02/2023	8.4	9.4	8.2	8.3	12.4	-	13.1
01/03/2023	6.3	7.4	6.9	6.4	11.1	-	11.3
01/04/2023	7.2	7.6	7.4	7.1	12	-	6.1

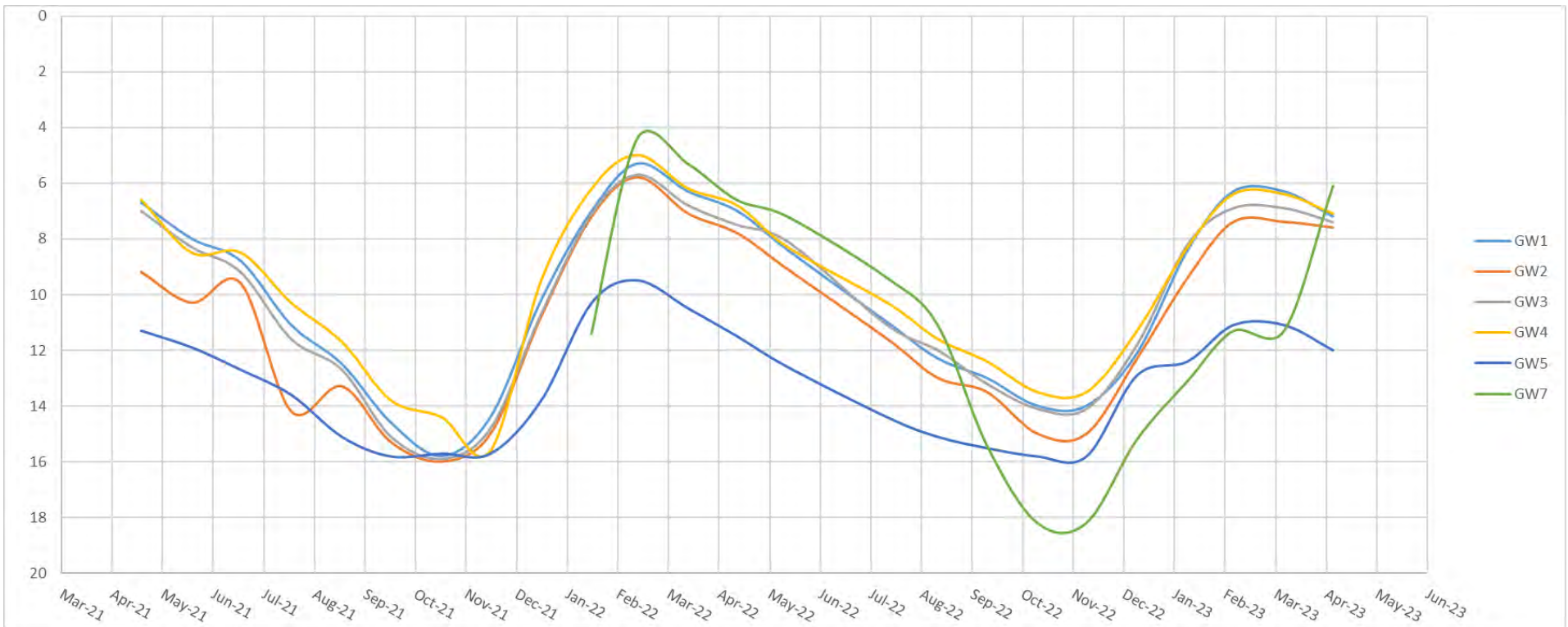

Figure 5-4. Graph of SWLs (mBTOC) from May 21 – May 23

Table 5-4. Surface water quality monitoring results since 2020.

Concentrations in breach of EPL320-01 trigger values for surface water highlighted in orange.

Site ID	Date	pH	EC	TDS	Nitrite + Nitrate	TKN	TN	TP	E coli	Faecal Coliforms	Total Coliforms	Enterococci	Hydroxide Alkalinity as CaC03	Carbonate Alkalinity as CaC03	Bicarbonate Alkalinity as CaC03	Total Alkalinity as CaC03	Sulfate as S04	Chloride	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
			µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/100 mL	CFU/100 mL	CFU/100 mL	CFU/100 mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	mg/m3
Surface Water EPL320 trigger values		**6.0 - 7.5**	**200**	-	-	-	**0.23**	**0.01**	any increase from previous	-	any increase from previous	any increase from previous	-	-	-	-	-	-	-	-	-	-	-	-
SW01	22/01/2020	5.64	17	13	0.04	0.2	0.2	0.09	~3000	~3000	-	23000	<1	<1	4	4	<1	<1	<1	<1	<1	1	0.08	0.02
SW02	22/01/2020	5.52	16	11	0.02	0.2	0.2	<0.01	~3000	~3000	-	3200	<1	<1	2	2	<1	<1	<1	<1	<1	<1	0.04	<0.01
SW03	22/01/2020	5.83	19	14	<0.01	0.5	0.5	0.06	~1100	~1100	-	7800	<1	<1	5	5	<1	<1	<1	<1	<1	2	0.10	0.05
SW04	22/01/2020	5.62	24	18	0.02	0.2	0.2	0.12	9000	9000	-	2100	<1	<1	8	8	<1	<1	1	<1	<1	2	0.16	0.10
SW01	22/12/2020	-	-	-	0.36	0.3	0.7	0.09	4000	4000	-	1100	<1	<1	9	9	<1	2	1	2	<1	<1	0.24	0.21
SW03	30/03/2022	6.56	49	25	<0.01	0.4	0.4	<0.01	~49	-	~2500	44	<1	<1	18	18	<1	3	3	2	3	<1	0.44	0.44
SW03	26/04/2022	5.52	31	25	<0.01	0.6	0.6	0.02	~310	-	10000	~80	<1	<1	16	16	<1	3	2	<1	1	<1	0.40	0.14
SW01	24/01/2023	5.88	33	98	0.85	<1.0	<1.0	0.39	12000	-	2200000	12000	<1	<1	6	6	<1	2	<1	<1	<1	5	0.18	-
SW05	24/01/2023	5.85	32	60	0.01	0.6	0.6	0.06	~560	-	38000	560	<1	<1	11	11	<1	3	2	1	2	<1	0.3	-
SW05	15/02/2023	5.99	28	26	<0.01	0.5	0.5	0.03	-	-	-	-	<1	<1	9	9	<1	3	2	<1	2	<1	0.26	-

Table 5-5. Soil monitoring results for 2021-22 and 2022-23

Concentrations outside of EPL320-01 trigger values for groundwater highlighted in orange.

Site ID	Date	Depth	Moisture content	pH	EC	NOx	TKN	TN	TP	Enterococci	Total Coliforms	E.Coli
		m	%	pH Unit	µS/cm	mg/kg	mg/kg	mg/kg	mg/kg	MPN/g dry wt	MPN/g dry wt	MPN/g dry wt
EPL320 trigger values		-	-	6-8	Any increase from previous	-	-	Any increase from previous	Any increase from previous	Any increase from previous	Any increase from previous	Any increase from previous
SS1	24/01/2022	surface	-	6.6	8	1.1	650	660	560	720	22000	19000
SS1	24/01/2022	0.5	-	6.7	7	0.8	500	500	340	1900	600	<11
SS2	24/01/2022	surface	-	6.7	11	2.7	1300	1300	740	890	8700	66
SS2	24/01/2022	0.5	-	5.9	10	3.3	330	330	120	13	<12	<12
SS3	24/01/2022	surface	-	6.6	11	2.2	790	790	440	11000	>27000	>27000
SS3	24/01/2022	0.5	-	7.2	10	0.7	300	300	120	48	220	37
SS4	24/01/2022	surface	-	7.1	16	1.4	1300	1300	580	780	13000	60
SS4	24/01/2022	0.5	-	7.0	12	2.0	500	500	120	140	190	<11
SS5	24/01/2022	surface	-	6.9	8	2.2	940	950	300	670	4000	610
SS5	24/01/2022	0.5	-	6.7	24	1.8	790	790	290	520	50	13
SS6	24/01/2022	surface	-	6.8	14	3.0	1200	1200	620	840	110	26
SS6	24/01/2022	0.5	-	6.7	10	8.8	390	400	130	38	4900	<12
SS7	24/01/2022	surface	-	6.6	10	7.7	1100	1100	370	1800	150	47
SS7	24/01/2022	0.5	-	6.2	11	3.6	230	240	120	72	47	<11
SS8	24/01/2022	surface	-	6.7	8	1.8	940	940	420	1300	24	<12
SS8	24/01/2022	0.5	-	6.9	10	7.5	370	380	110	260	660	<11
SS9	24/01/2022	surface	-	6.7	10	9.4	1100	1100	480	610	>28000	<12
SS9	24/01/2022	0.5	-	5.9	14	7.9	230	240	120	<11	<11	<11
SS10	24/01/2022	surface	-	6.8	15	8.1	990	1000	470	450	1600	1400
SS10	24/01/2022	0.5	-	7.4	11	7.2	330	340	180	97	480	<11
SS1	30/01/2023	surface		6.2	60	2.2	650	650	299	390	1500	<11
SS1	30/01/2023	0.5		6.1	43	3.2	190	190	94	63	1100	12
SS2	30/01/2023	surface		6.3	107	5.0	1140	1140	456	230	23000	87
SS2	30/01/2023	0.5		5.5	32	2.7	160	160	93	<11	72	<11
SS3	30/01/2023	surface		6.0	67	2.3	830	830	354	260	390	<13
SS3	30/01/2023	0.5		5.9	47	4.1	180	180	79	<11	72	<11
SS4	30/01/2023	surface		6.4	84	3.2	720	720	328	660	5500	<11
SS4	30/01/2023	0.5		5.9	65	4.3	400	400	103	47	97	<11
SS5	30/01/2023	surface		6.2	65	1.0	560	560	348	860	360	<12
SS5	30/01/2023	0.5		6.6	68	5.0	300	300	105	47	750	<11
SS6	30/01/2023	surface		6.3	92	2.2	820	820	443	74	11000	<12
SS6	30/01/2023	0.5		6.7	40	1.1	380	380	134	23	3400	<12
SS7	30/01/2023	surface		5.6	119	1.7	770	770	345	290	4600	460
SS7	30/01/2023	0.5		6.0	46	0.5	550	550	91	110	330	47
SS8	30/01/2023	surface		5.2	41	1.2	780	780	164	600	27000	8300
SS8	30/01/2023	0.5		5.2	19	0.6	300	300	91	11	23	<11
SS9	30/01/2023	surface		5.7	91	0.7	620	620	255	1200	9100	130
SS9	30/01/2023	0.5		5.6	71	0.4	80	80	95	<11	58	<11
SS10	30/01/2023	surface		5.4	42	1.9	950	950	279	830	10000	71
SS10	30/01/2023	0.5		5.9	87	1.8	350	350	104	120	360	<12

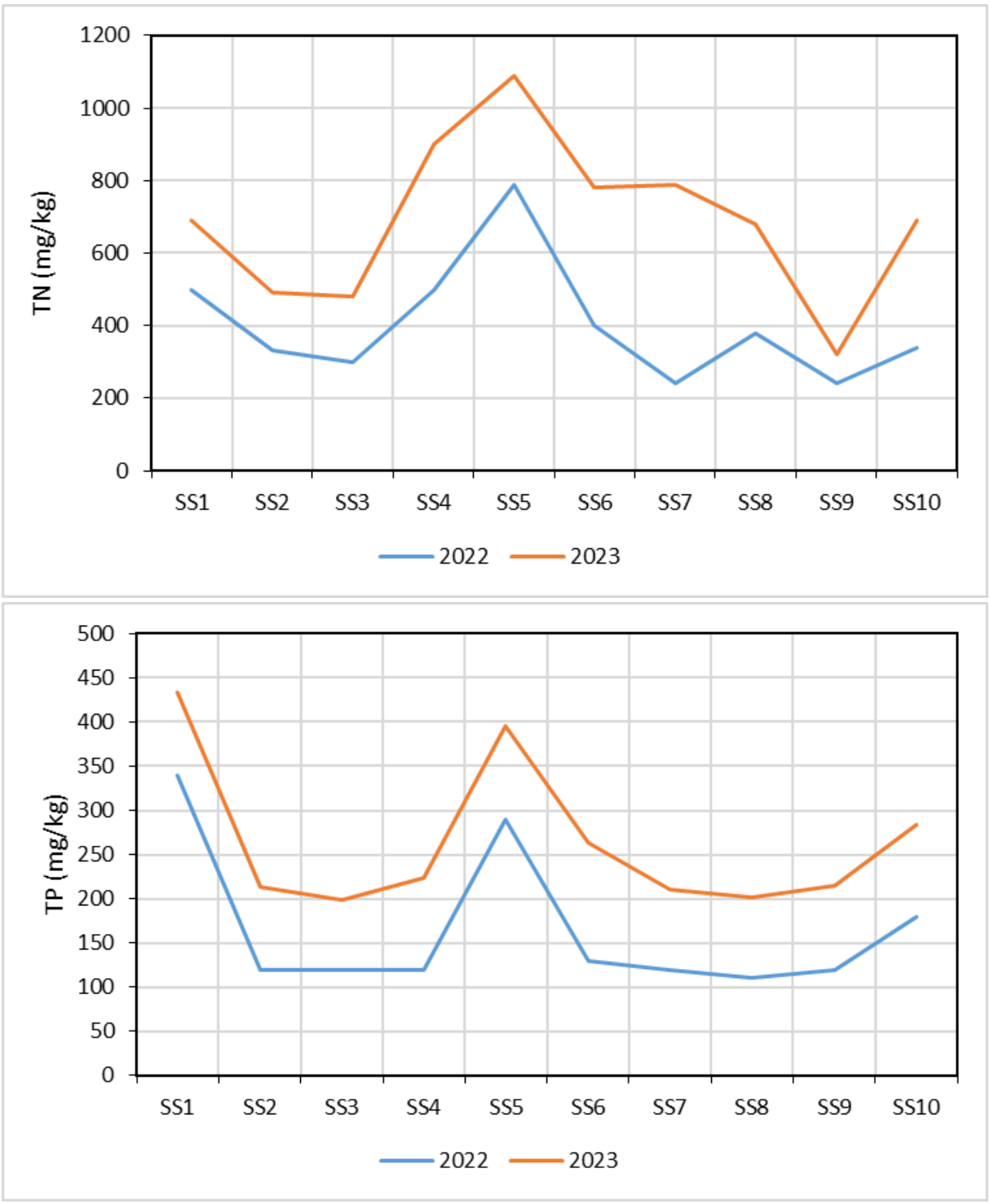

Figure 5-5. Nutrient concentrations 2022 and 2023 in soil samples collected from Horizon B

6 TOTAL N AND TOTAL P LOADS

Condition 38 of EPL320-01 states that:

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

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

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

Total annual loads of TN and TP applied to the Stage one irrigation area using water from the authorised discharge points (ADP1 and ADP2) are calculated below.

During the reporting period, the total volume of irrigated water was 80.309 ML and the median TN and TP concentrations of the irrigation water were 26.5 mg/L and 3.08 mg/L respectively. This equates to a total load of 2,128.19 kg of TN and 247.35 kg of TP applied to the Stage one irrigation area, where Mariner Rhodes was grown in 2022 and Jarra grass is actually grown, over the reporting period.

The total volume of irrigated water in the Stage two irrigation area was 452.989 ML and the median TN and TP concentrations of the irrigation water were 8 mg/L and 2.02 mg/L respectively. As a result, a total load of 3,623.91 kg of TN and 915.03 kg of TP were applied to the Stage two irrigation area, where African Mahogany is grown.

Table 4.2 in the *NSW Environmental Guidelines, Use of Effluent by Irrigation* (DEC 2004) lists grain crops only and thus information could not be used for any of the crops at the LLCF. However, the average yield for forage sorghum crop type was used to obtain an indicative value of nitrogen and phosphorus removal.

The average yield for forage sorghum is 15 tonnes/ha/dry matter, with a nutrient content of 1.8% nitrogen and 0.3% phosphorus. This equals a nitrogen removal of 270 kg/ha/year and phosphorus removal of 45 kg/ha/year. The total area of irrigation at the LLCF is approximately 35 ha (15 ha at Stage one and 20 ha at Stage two). Consequently, 9,450 kg of nitrogen and 1,575 kg of phosphorus would be removed through harvesting per year. These loads are above the current nitrogen and phosphorus loads (5,752.1 kg and 1,162.4 kg respectively) applied to the total irrigation area.

7 CONCLUSIONS

All monitoring was undertaken as per EPL320-01 Attachment A requirements, except for the non-compliances as listed in Table 4-6 and explained in Section 4.4.

Discharge points (ADP1 and ADP2) were compliant with pH, EC, TN, and TP trigger values in the 2022- 2023 monitoring round, but exceeded the trigger values for *E. coli*, total coliforms, and enterococci. Despite the exceedances reported, bacterial load mostly decreased in the reporting period. Since ADP2 became operational in February 2022, all parameters have stabilised with no concerning trends found in the data.

Groundwater monitoring results were largely compliant with trigger values, based on the monitoring of five (GW1, GW2, GW3, GW4, and GW5) of the seven bores requiring sampling. With GW6 and GW7 not available for sampling, and GW4 and GW5 not accessible in December 2022. Bacteria levels at GW2 appear to indicate some groundwater contamination. However, the concentrations did not follow an increasing trend and if contamination exists it is likely to decrease with distance from the source.

Groundwater levels in May 2023 were comparable to those measured 12-months earlier in May 2022. This indicates full recovery of levels over the 2022/23 wet season and that a long-term lowering of groundwater levels due to extraction at the farm is not presently evident. Further monitoring is required to determine any potential impact on groundwater levels at GW7.

Surface water monitoring was limited during the reporting period (see Section 4.4). In January, SW1 exceeded the trigger values for TP, *E. coli*, total coliforms and enterococci. SW5 was sampled for the first time in this monitoring round and as such, it is not possible to assess its bacterial load. However, nutrients concentration at this site were above the guideline. PRI will endeavour to improve compliance with monitoring requirements by investigating how to achieve sampling of the surface water sites when they are flowing and still meet analytical holding time requirements.

Soil sample results recorded many exceedances by increases from previous results, which is expected in site SS5 – SS10, as this is the first round of sampling after the commencement of irrigation in this area.

The nitrogen and phosphorus removal by the current crops on site were not calculated as these are not listed in the NSW environmental guideline *Use of Effluent by Irrigation (DEC 2004)*. However, the calculation was done for forage sorghum to have an indicative value.

Based on the results obtained in this monitoring round, it is recommended that alternative surface water sites are included into the monitoring plan given the limited data available at all the surface water sites. Additionally, in-situ parameters (i.e. pH and EC) should be measured on-site as these parameters usually have a short holding time which eventually impacts on the accuracy of the results provided by the laboratory.

Further investigations into the sample point and sampling procedure used at GW2 are recommended given samples are collected from a sprinkler which could potentially be cross-contaminated.

8 REFERENCES

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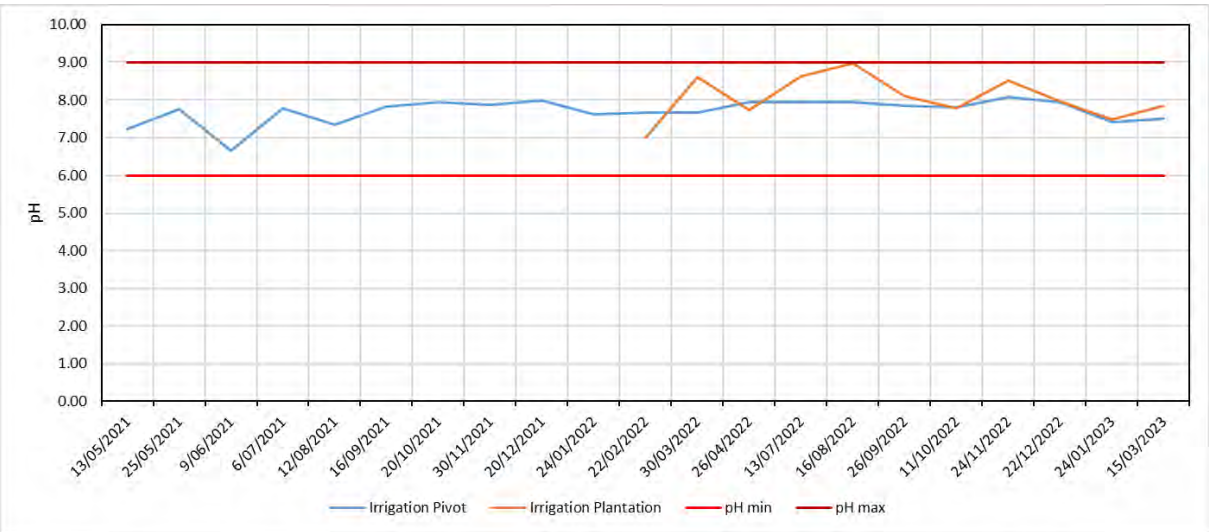
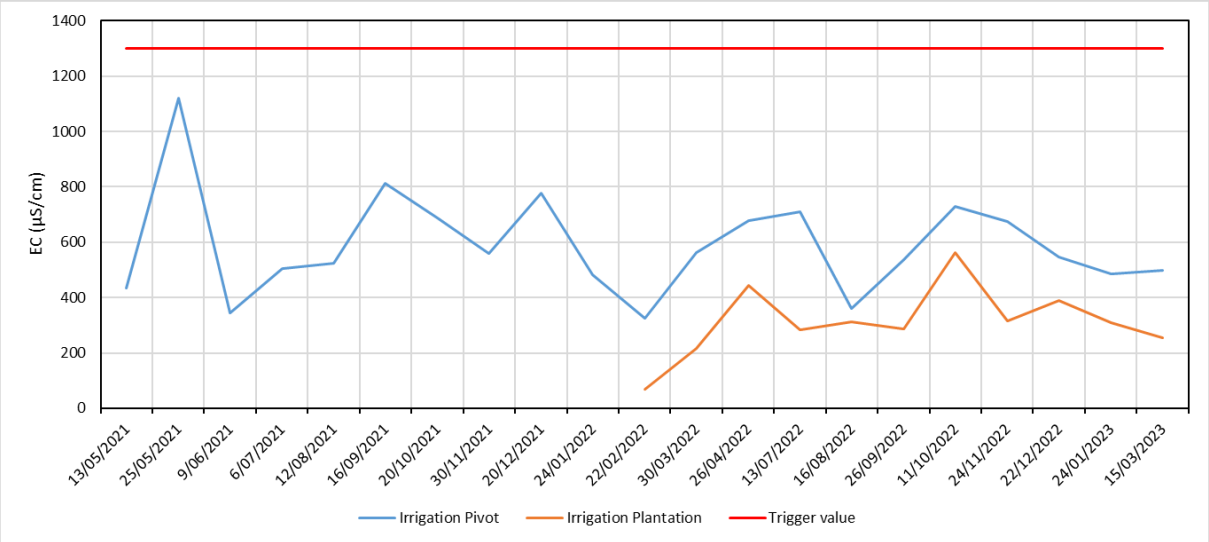
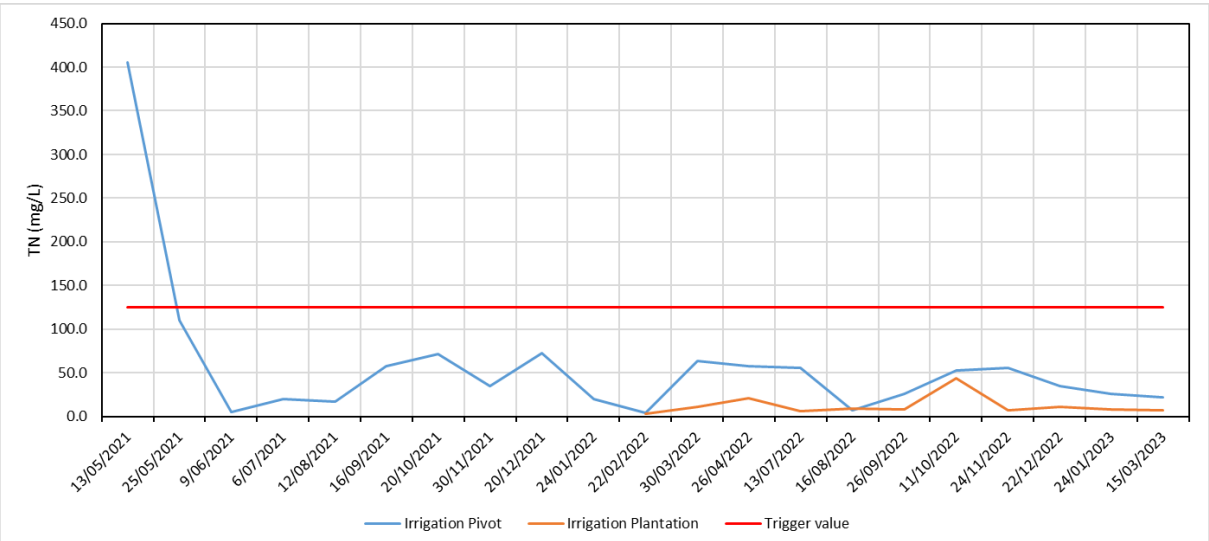
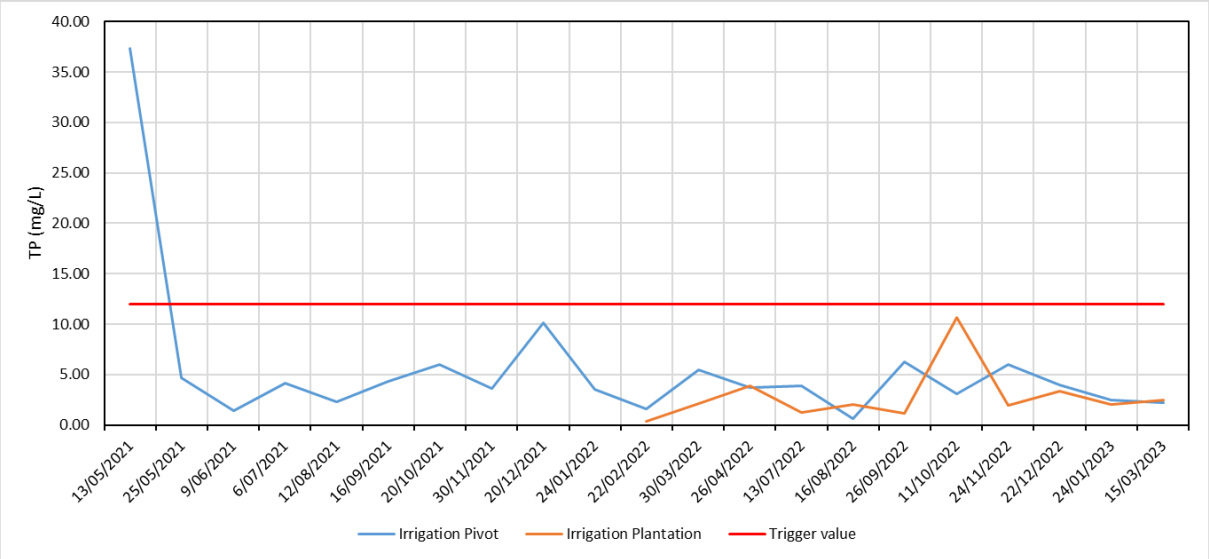
APPENDIX A HISTORICAL DATA PLOTS

Authorised Discharge Points





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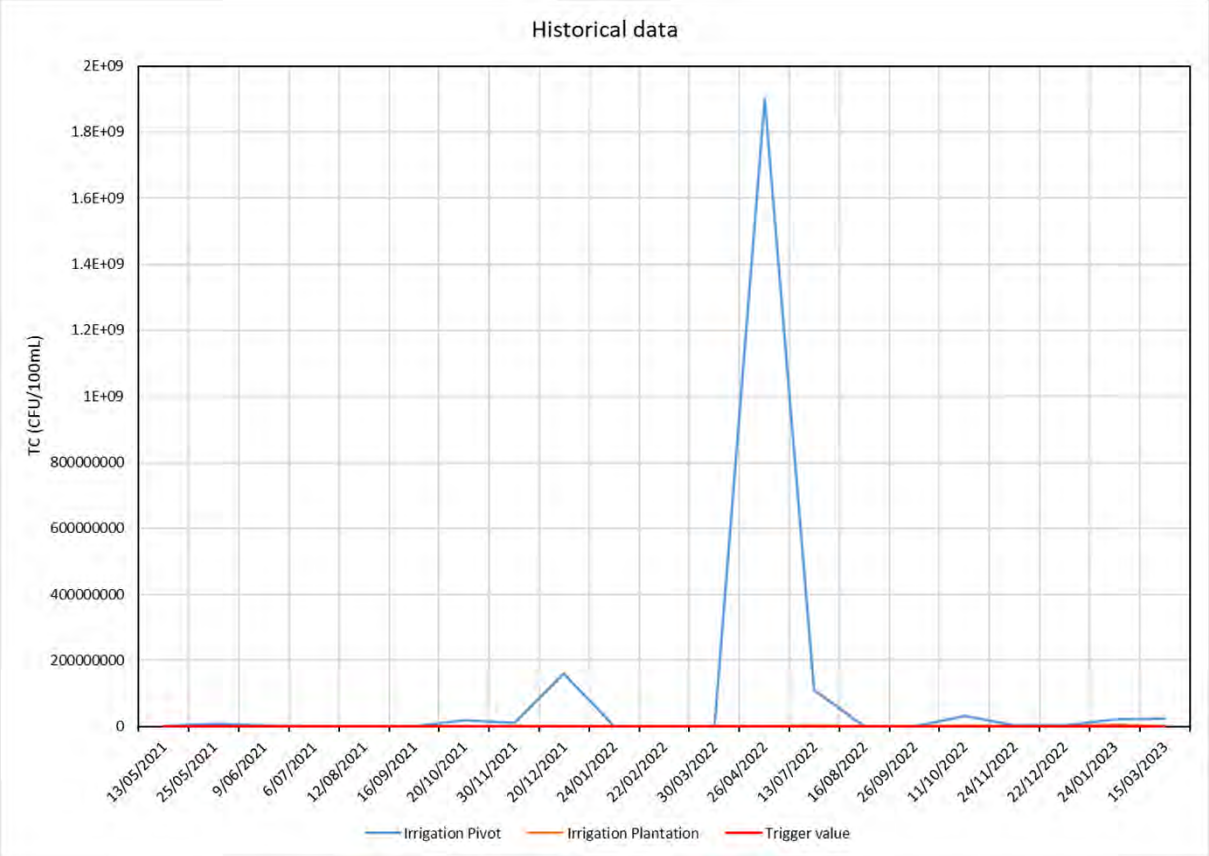
Irrigation Pivot
Irrigation Plantation
Trigger value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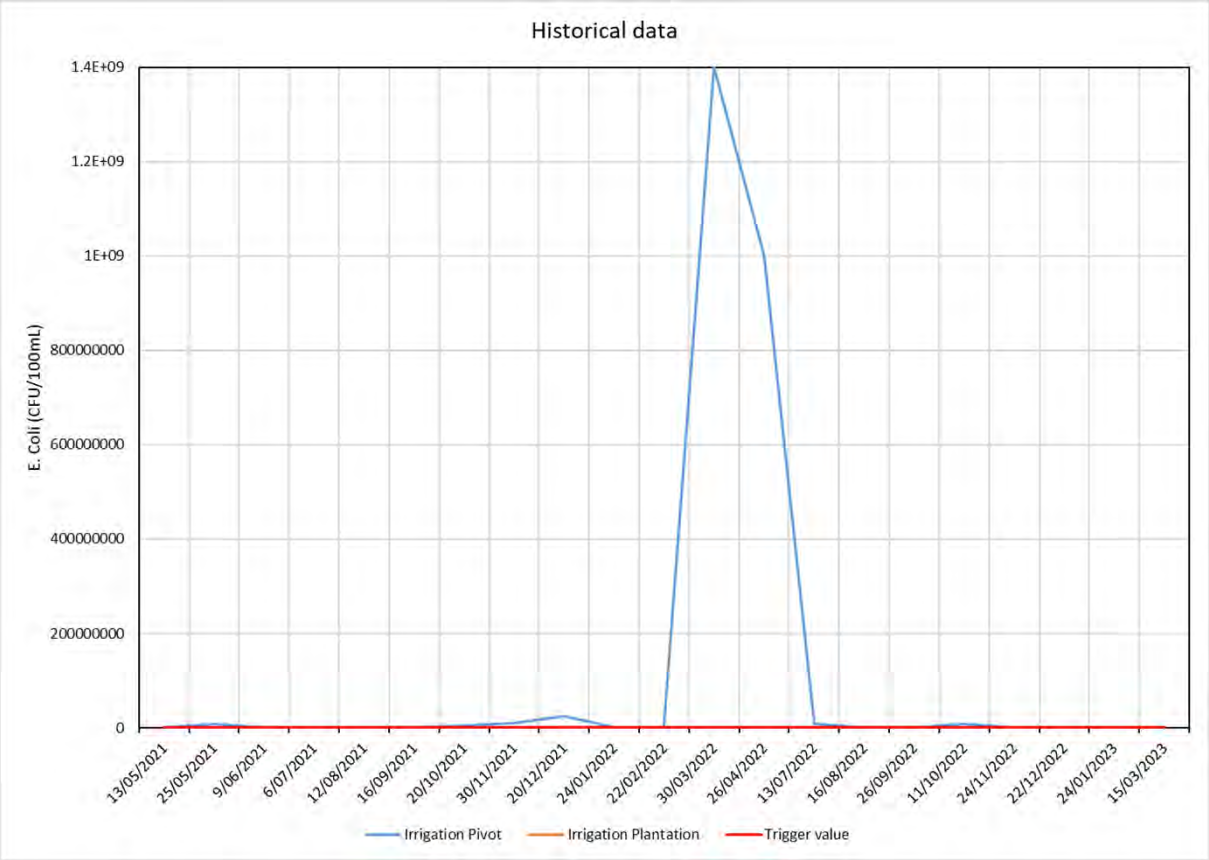
Trigger value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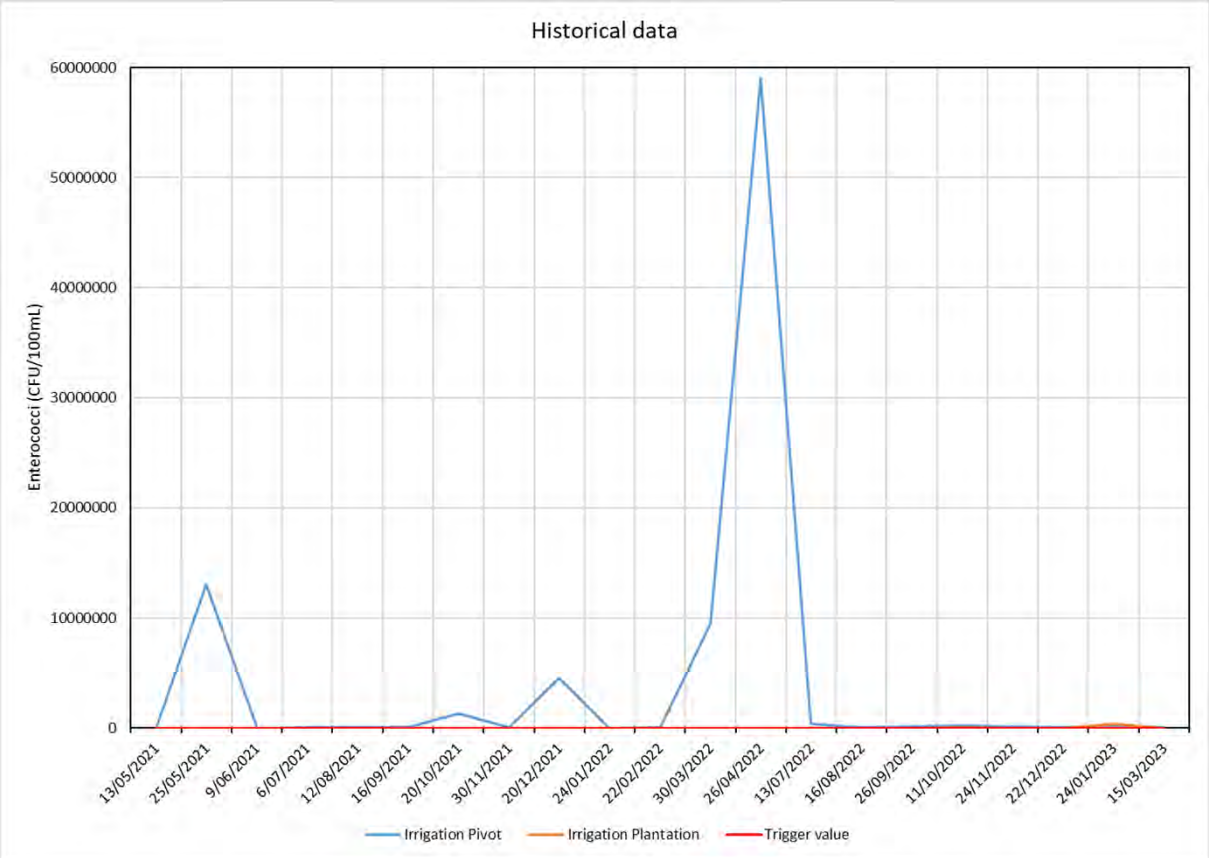

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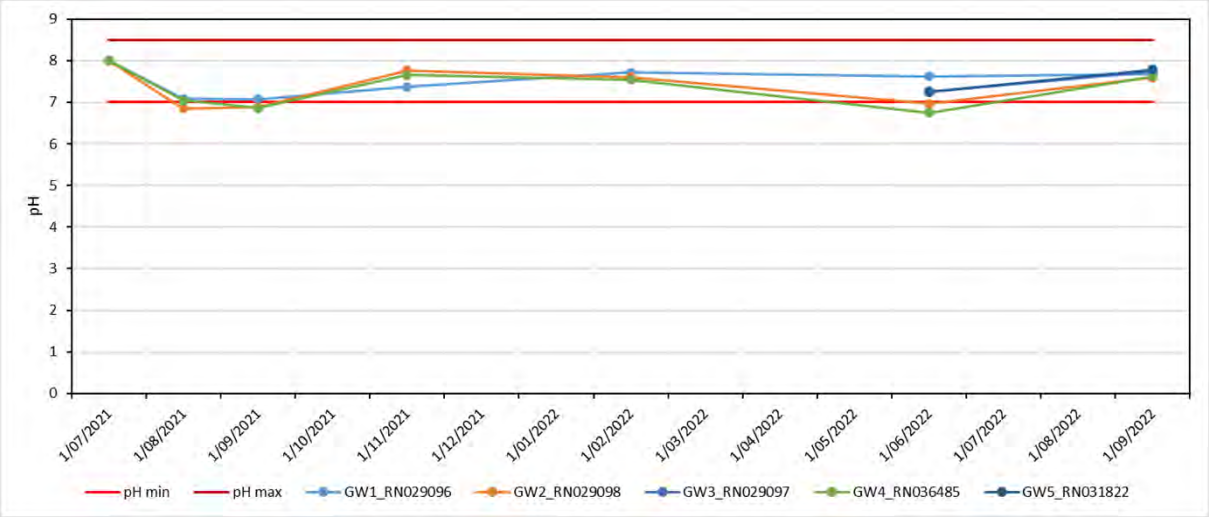

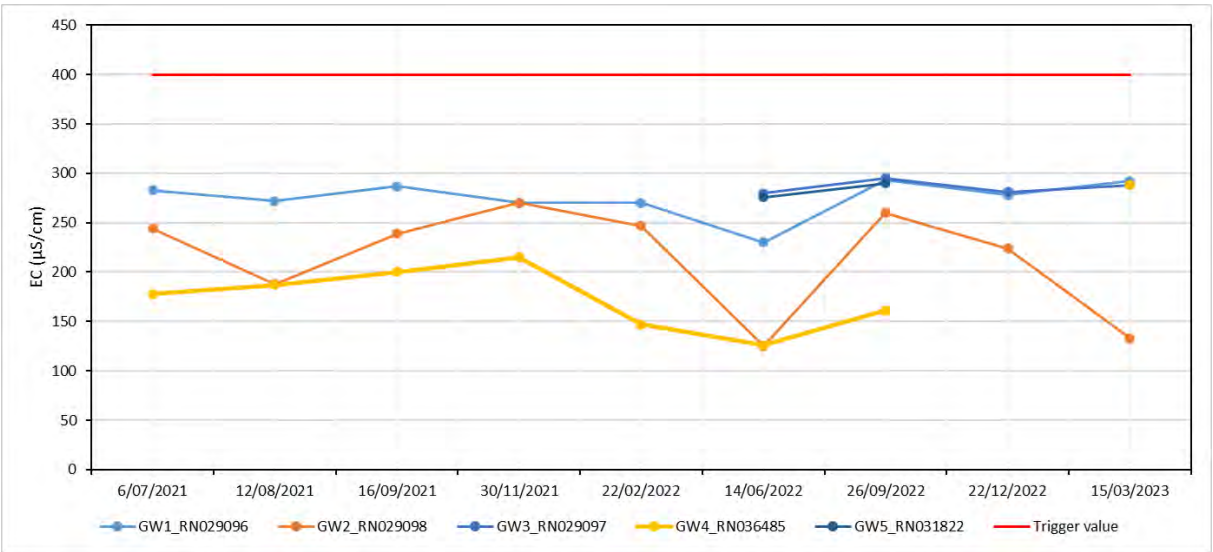
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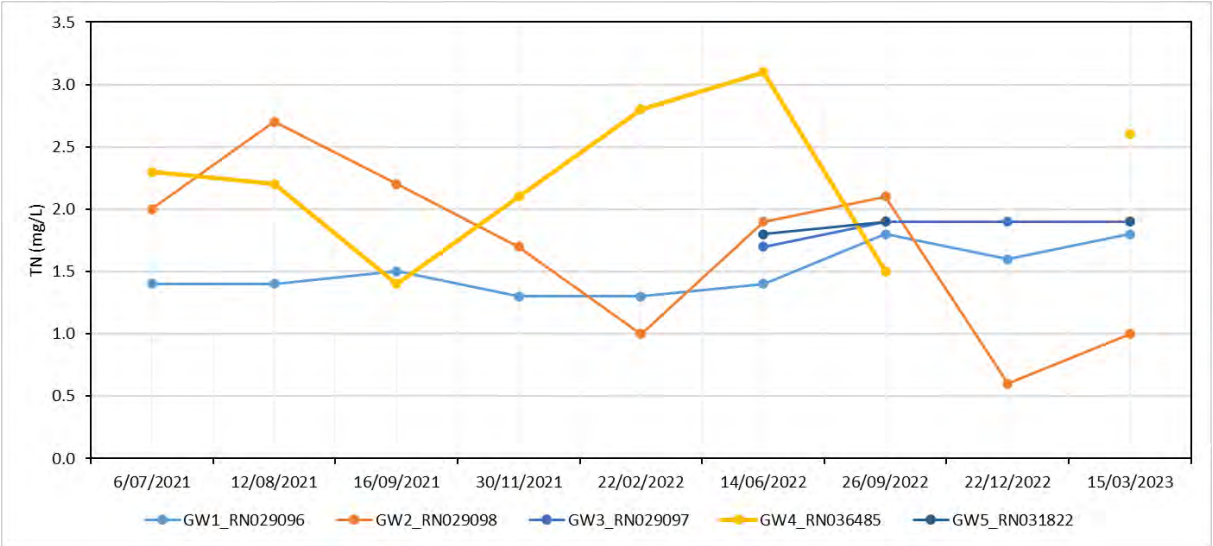
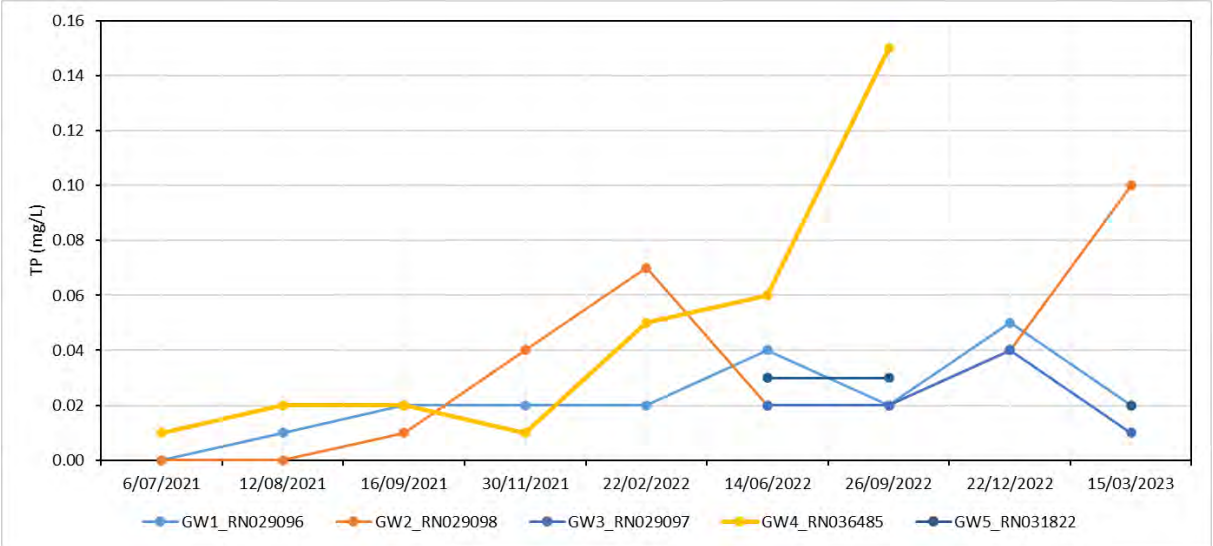
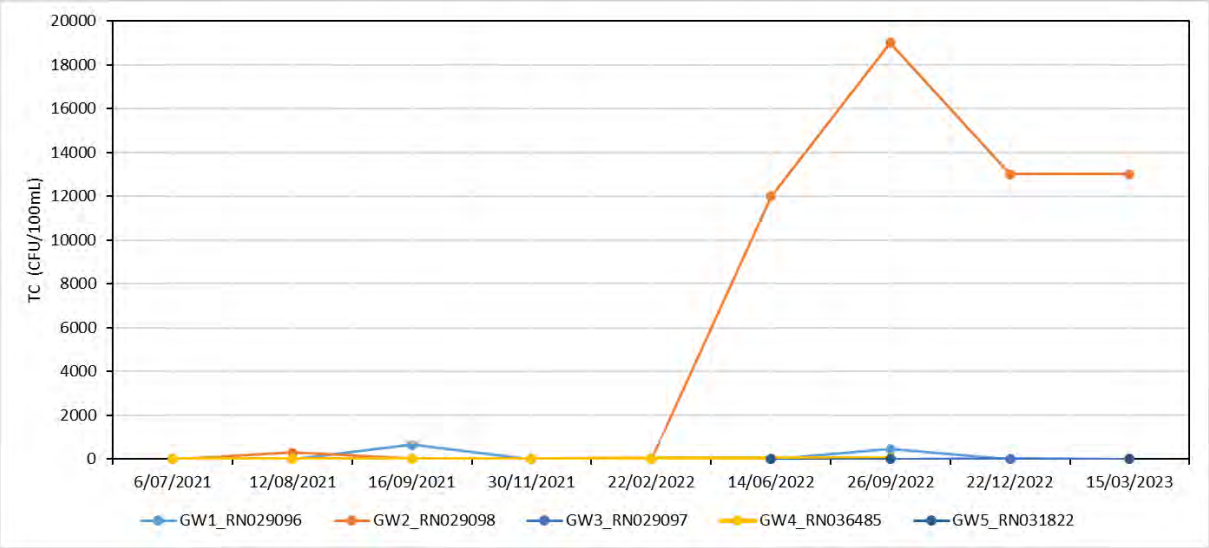
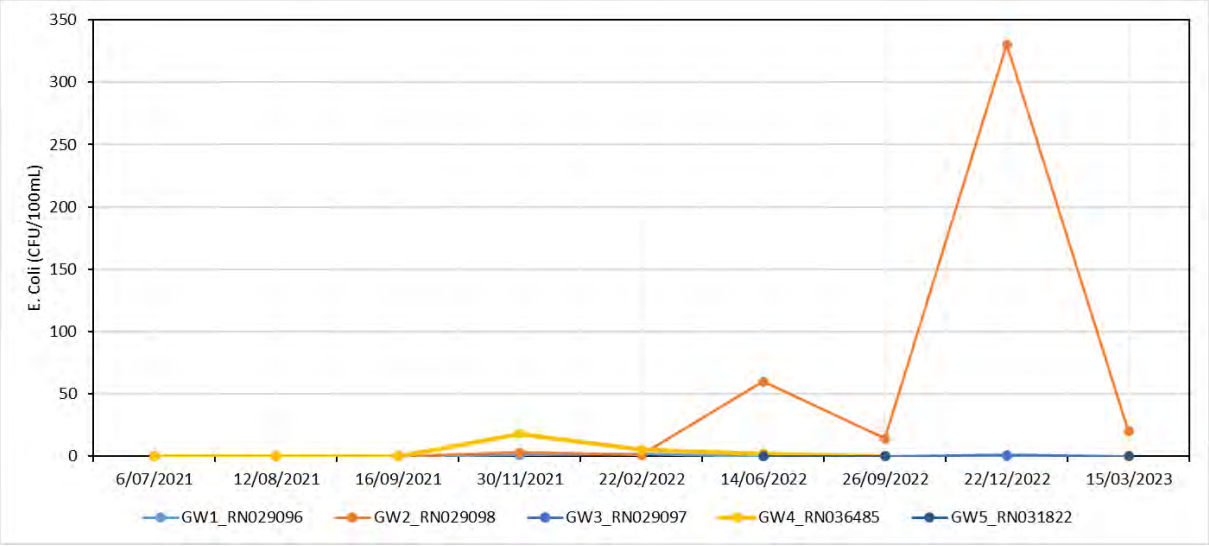
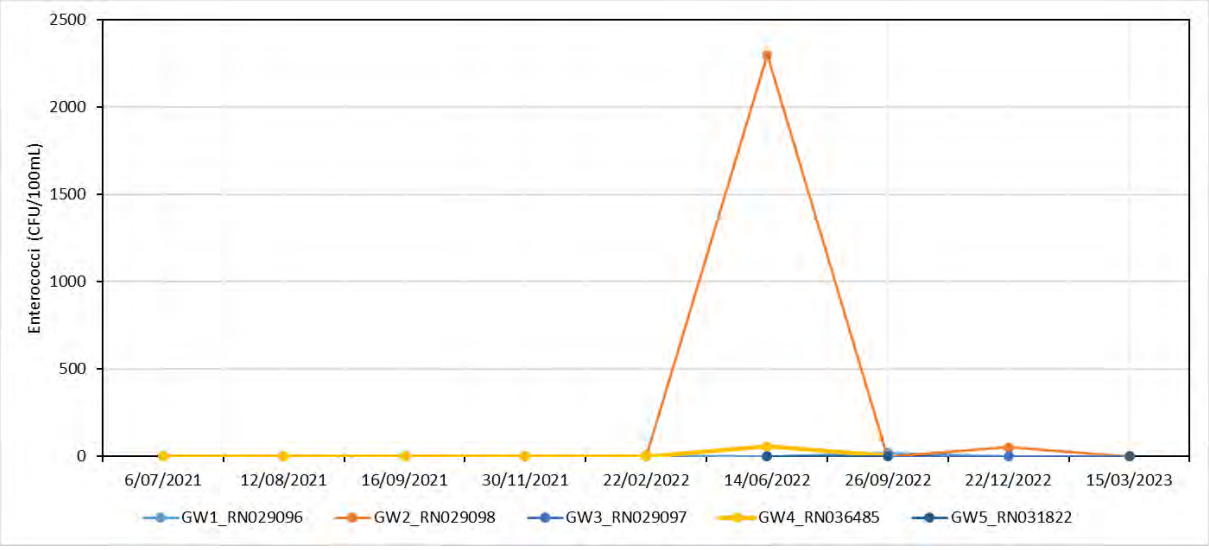
30/11/2021
22/02/2022
14/06/2022
26/09/2022
22/12/2022
15/03/2023
GW1_RN029096
GW2_RN029098
GW3_RN029097
GW4_RN036485
GW5_RN031822
Trigger value


TN (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6/07/2021
12/08/2021
16/09/2021
30/11/2021
22/02/2022
14/06/2022
26/09/2022
22/12/2022
15/03/2023
GW1_RN029096
GW2_RN029098
GW3_RN029097
GW4_RN036485
GW5_RN031822

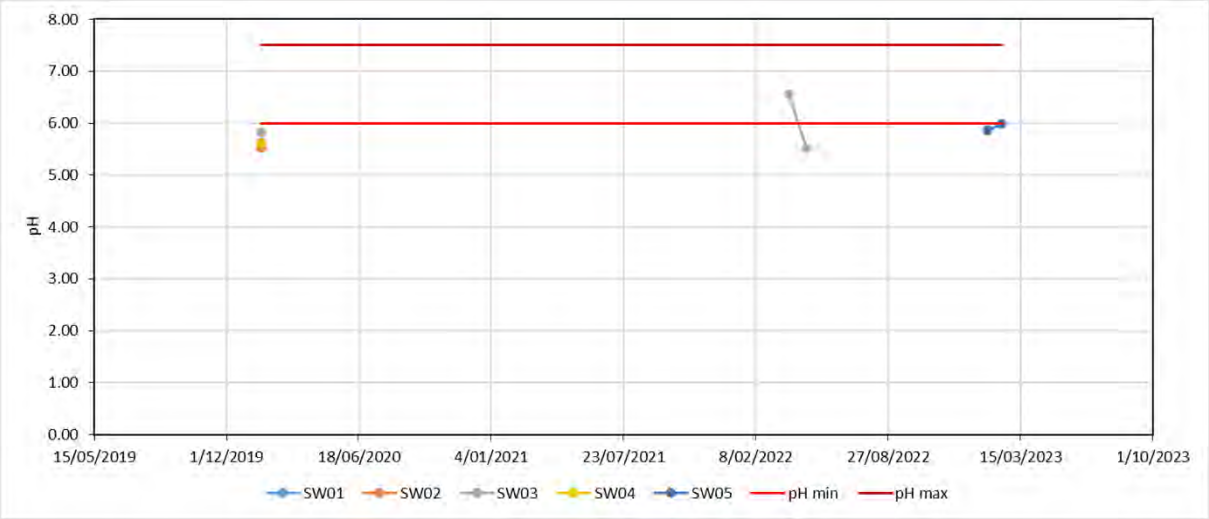

TP (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
6/07/2021
12/08/2021
16/09/2021
30/11/2021
22/02/2022
14/06/2022
26/09/2022
22/12/2022
15/03/2023
GW1_RN029096
GW2_RN029098
GW3_RN029097
GW4_RN036485
GW5_RN031822

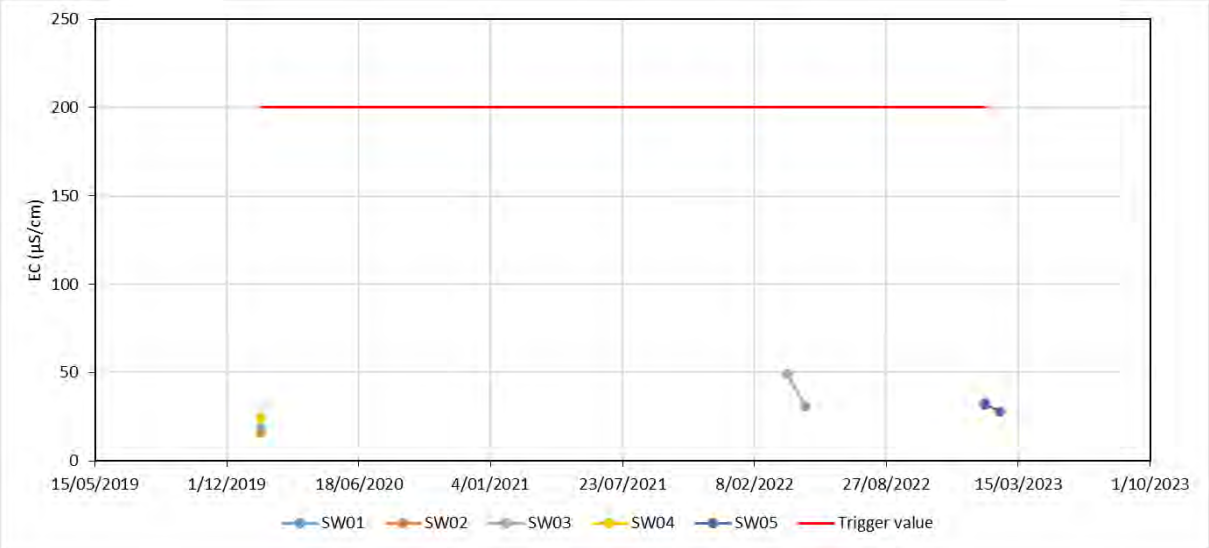

20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
TC (CFU/100mL)
6/07/2021
12/08/2021
16/09/2021
30/11/2021
22/02/2022
14/06/2022
26/09/2022
22/12/2022
15/03/2023
GW1_RN029096
GW2_RN029098
GW3_RN029097
GW4_RN036485
GW5_RN031822

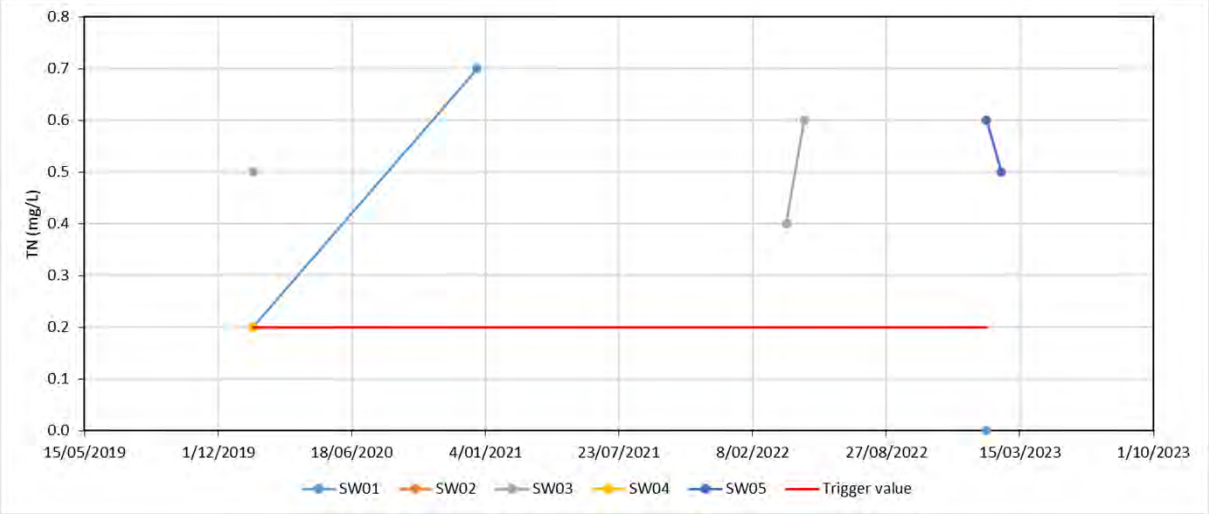

350
300
250
200
150
100
50
0
E. Coli (CFU/100mL)
6/07/2021
12/08/2021
16/09/2021
30/11/2021
22/02/2022
14/06/2022
26/09/2022
22/12/2022
15/03/2023
GW1_RN029096
GW2_RN029098
GW3_RN029097
GW4_RN036485
GW5_RN031822

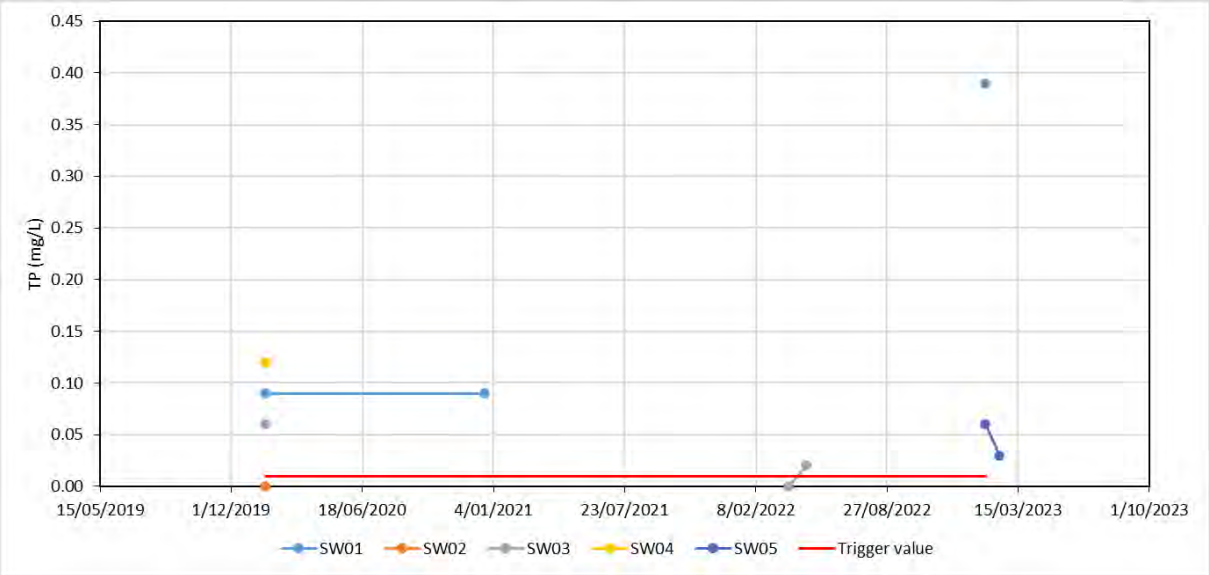

2500
2000
1500
1000
500
0
Enterococci (CFU/100mL)
6/07/2021
12/08/2021
16/09/2021
30/11/2021
22/02/2022
14/06/2022
26/09/2022
22/12/2022
15/03/2023
GW1_RN029096
GW2_RN029098
GW3_RN029097
GW4_RN036485
GW5_RN031822

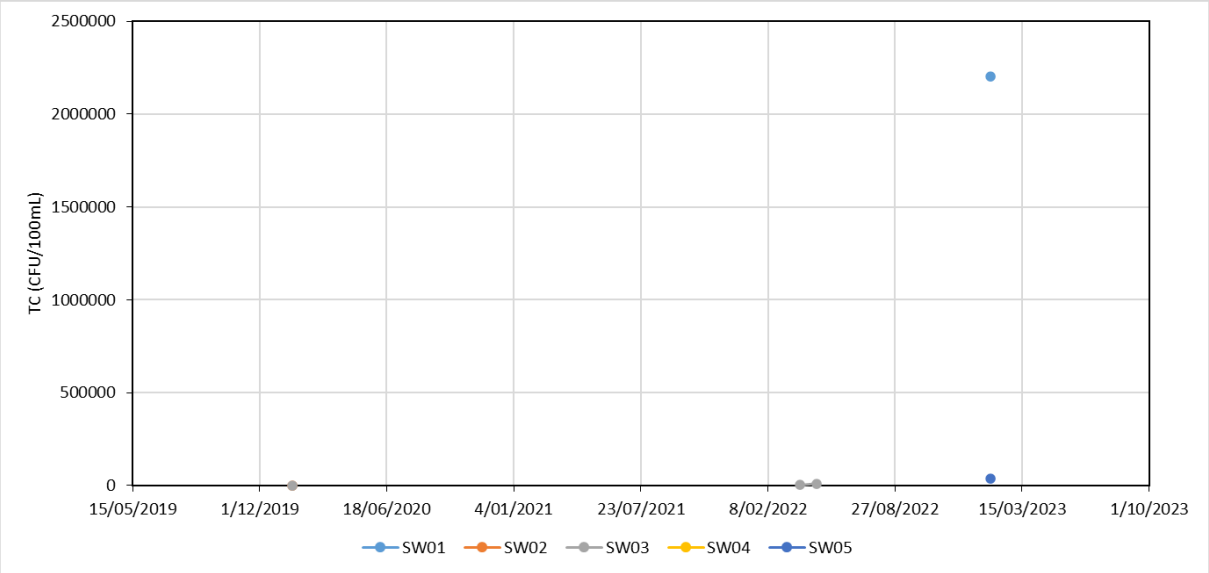
Surface water

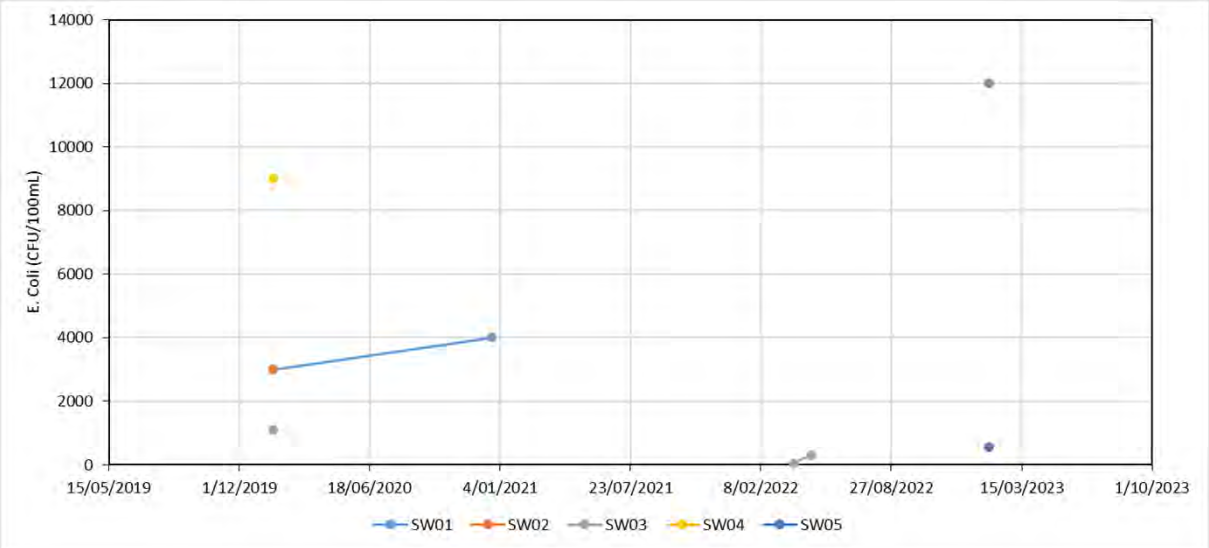


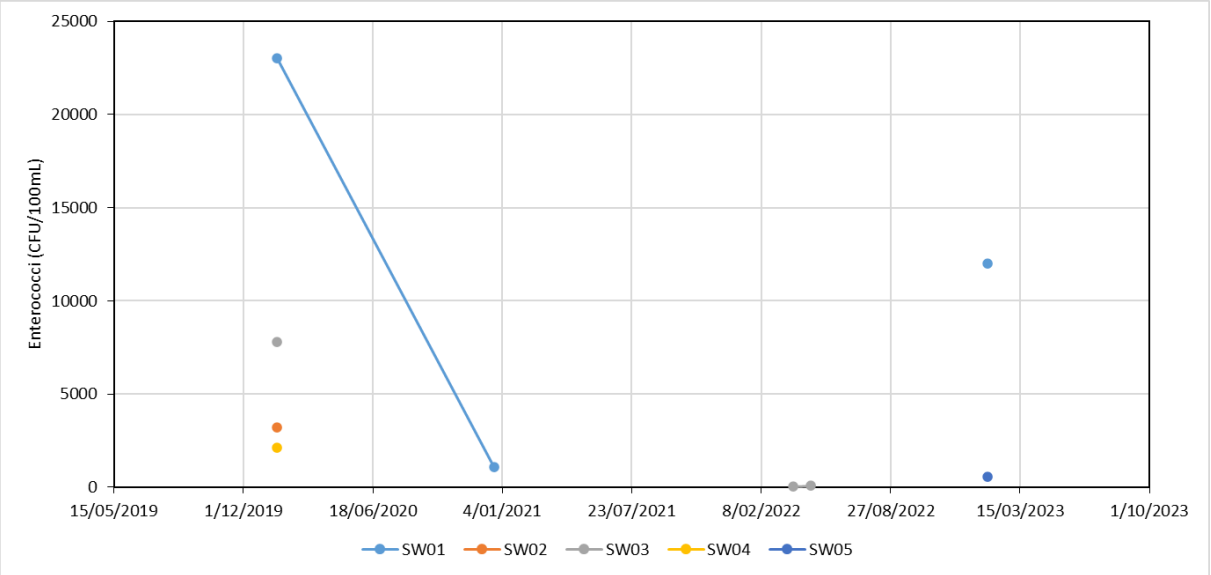




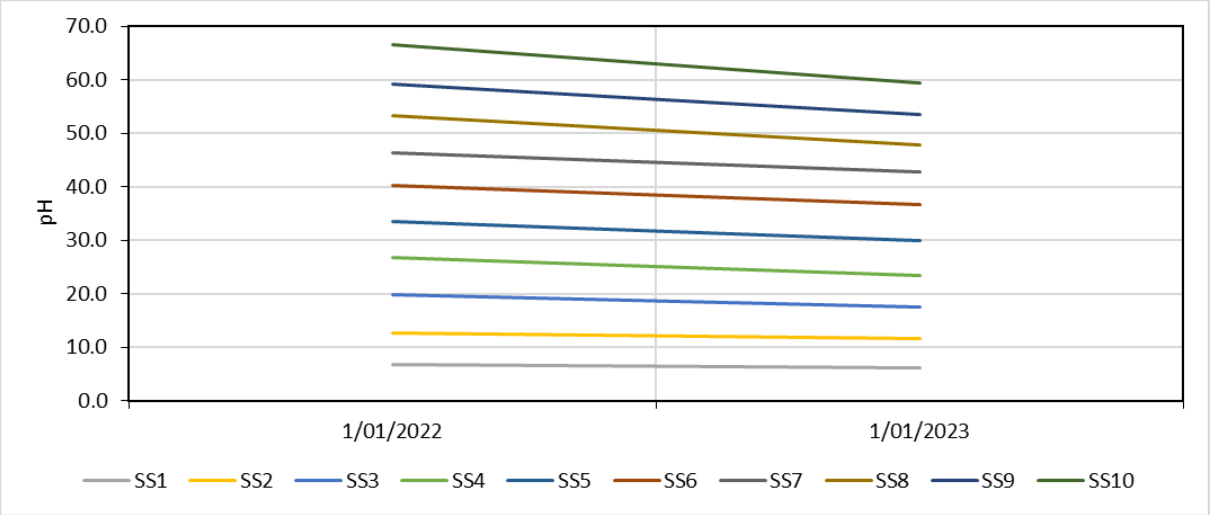

0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
TP (mg/L)
15/05/2019
1/12/2019
18/06/2020
4/01/2021
23/07/2021
8/02/2022
27/08/2022
15/03/2023
1/10/2023
SW01
SW02
SW03
SW04
SW05
Trigger value

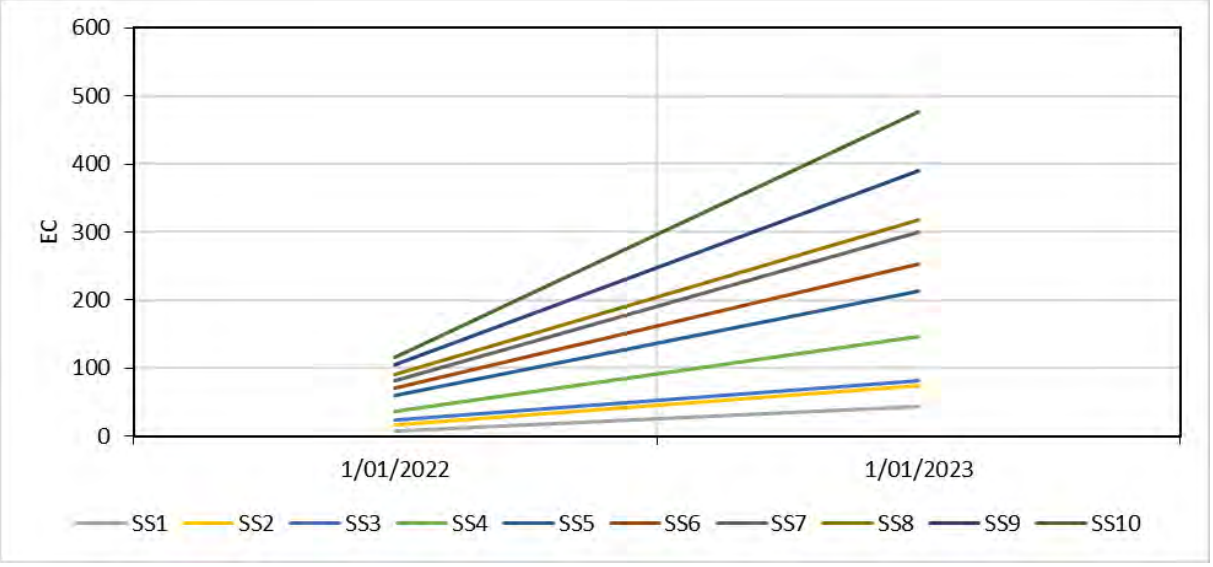

2500000
2000000
1500000
1000000
500000
0
TC (CFU/100mL)
15/05/2019
1/12/2019
18/06/2020
4/01/2021
23/07/2021
8/02/2022
27/08/2022
15/03/2023
1/10/2023
SW01
SW02
SW03
SW04
SW05

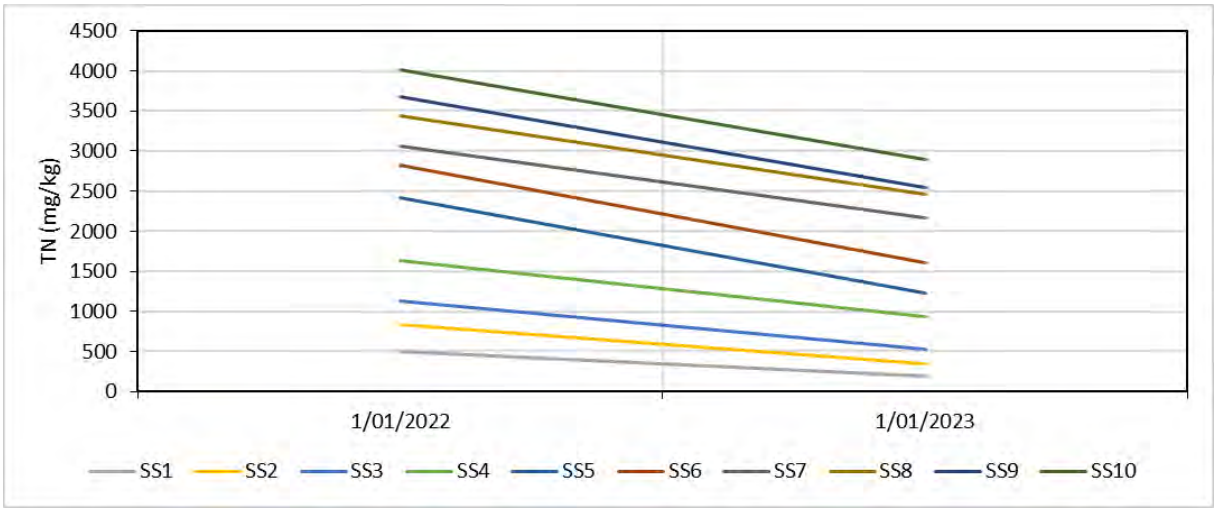

14000
12000
10000
8000
6000
4000
2000
0
E. Coli (CFU/100mL)
15/05/2019
1/12/2019
18/06/2020
4/01/2021
23/07/2021
8/02/2022
27/08/2022
15/03/2023
1/10/2023
SW01
SW02
SW03
SW04
SW05

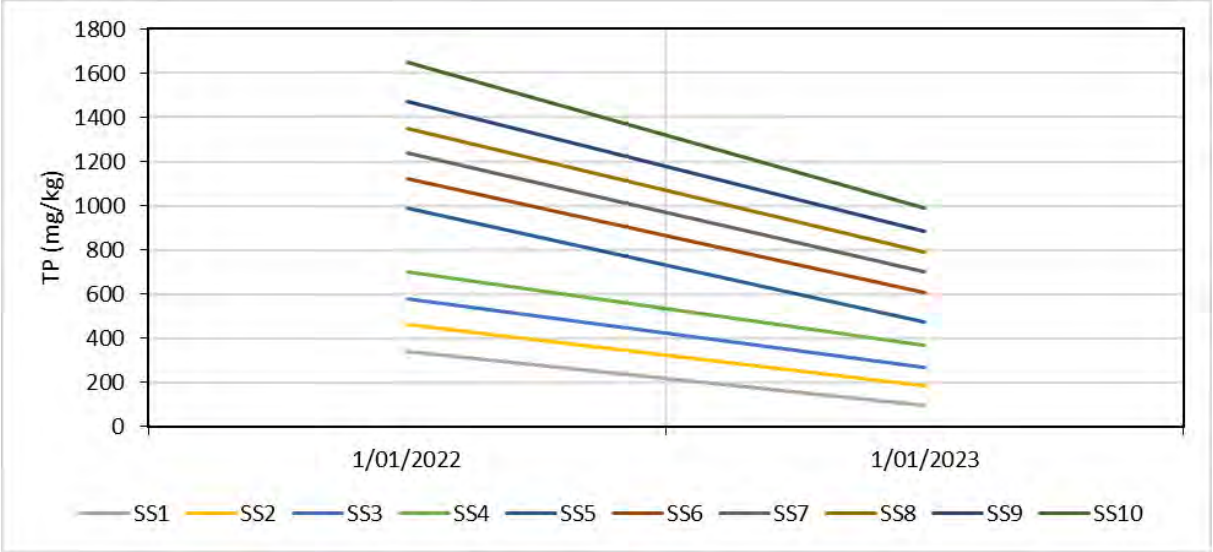

25000
20000
15000
10000
5000
0
Enterococci (CFU/100mL)
15/05/2019
1/12/2019
18/06/2020
4/01/2021
23/07/2021
8/02/2022
27/08/2022
15/03/2023
1/10/2023
SW01
SW02
SW03
SW04
SW05

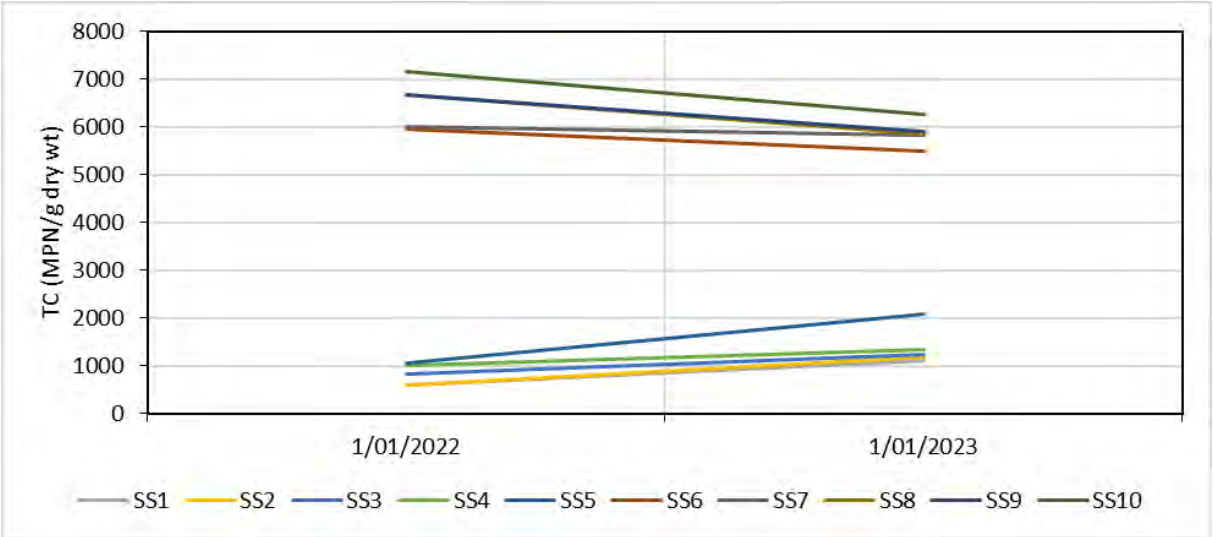
Soils

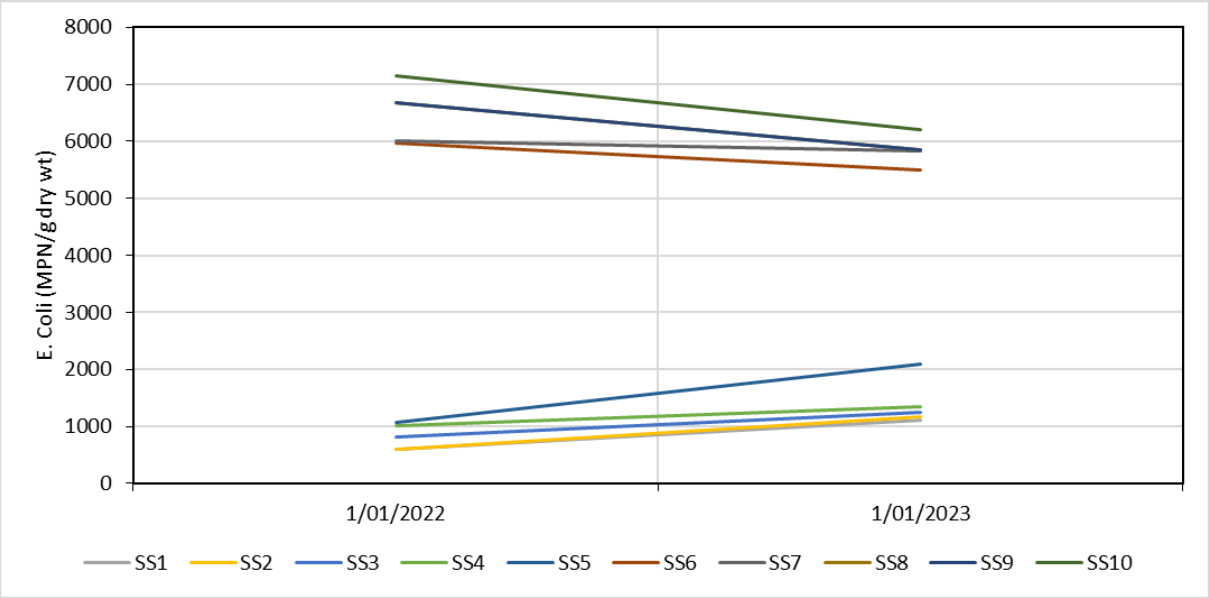

70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
pH
1/01/2022
1/01/2023
SS1
SS2
SS3
SS4
SS5
SS6
SS7
SS8
SS9
SS10

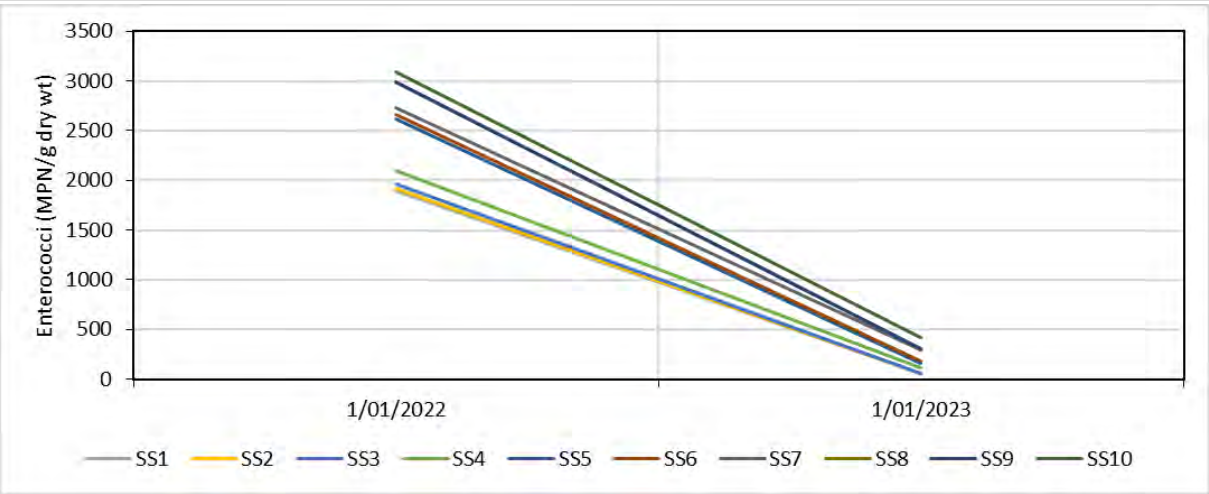

600
500
400
300
200
100
0
EC
1/01/2022
1/01/2023
SS1
SS2
SS3
SS4
SS5
SS6
SS7
SS8
SS9
SS10


4500
4000
3500
3000
2500
2000
1500
1000
500
0
TN (mg/kg)
1/01/2022
1/01/2023
SS1
SS2
SS3
SS4
SS5
SS6
SS7
SS8
SS9
SS10


1800
1600
1400
1200
1000
800
600
400
200
0
TP (mg/kg)
1/01/2022
1/01/2023
SS1
SS2
SS3
SS4
SS5
SS6
SS7
SS8
SS9
SS10


8000
7000
6000
5000
4000
3000
2000
1000
0
TC (MPN/g dry wt)
1/01/2022
1/01/2023
SS1
SS2
SS3
SS4
SS5
SS6
SS7
SS8
SS9
SS10


8000
7000
6000
5000
4000
3000
2000
1000
0
E. Coli (MPN/g dry wt)
1/01/2022
1/01/2023
SS1
SS2
SS3
SS4
SS5
SS6
SS7
SS8
SS9
SS10


3500
3000
2500
2000
1500
1000
500
0
Enterococci (MPN/g dry wt)
1/01/2022
1/01/2023
SS1
SS2
SS3
SS4
SS5
SS6
SS7
SS8
SS9
SS10

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