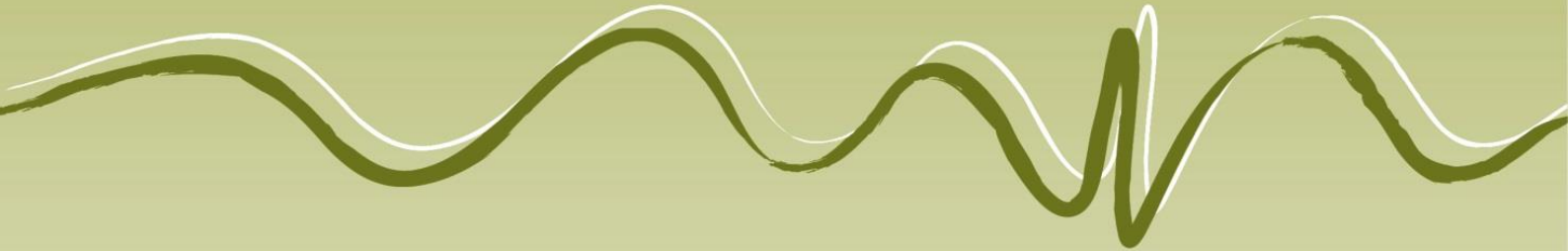


Salty Lagoon

Post Closure Monitoring

Project Management and Ecosystem Health Report

December 2021



AQUATIC SCIENCE AND MANAGEMENT

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Table of Contents

1.	Introduction	1
1.1	Introduction	1
1.2	Guiding Values	1
2.	Methodology	2
2.1	Discrete Sampling	2
2.2	Fixed Point Photo Monitoring	2
2.3	Aquatic Weed Monitoring	2
2.4	Erosion Monitoring	3
2.5	Permanent Water Quality Monitoring Stations	3
3.	Results	6
3.1	Water Quality Samples	6
3.2	Permanent Water Quality Monitoring Stations	6
3.3	Aquatic Weed Monitoring	10
3.4	Erosion Monitoring Stations	10
4.	Discussion	11
4.1	Water Quality	11
4.2	Other Observations	12
5.	Key Points	14

Illustrations

Illustration 2.1	Water Quality and Erosion Monitoring Site Locations	5
Illustration 3.1	Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 November 2021 to 31 December 2021	8
Illustration 3.2	Salty Creek Rainfall and Water Quality Monitoring Station Data 1 November 2021 to 31 December 2021	9
Illustration 3.3	Erosion Progression Plotted against Monthly Rainfall since July 2017	10
Illustration 4.1	Water levels in Salty Lagoon and Salty Creek during this reporting period	11

Plates

Plate 4.1	The open entrance to Salty Creek on 12 January 2022	13
Plate 4.2	Higher water levels on 12 January 2022 showing a hydraulic connection between Salty Lagoon and Salty Creek over the erosion control structure.	13



Tables

<u>Table 2.1</u>	<u>Locations of Water Quality Sample Sites in Salty Lagoon and Salty Creek (WGS84)</u>	<u>2</u>
<u>Table 2.2</u>	<u>Type and Locations (WGS84) of Erosion Monitoring Sites</u>	<u>3</u>
<u>Table 2.3</u>	<u>YSI Sonde Status on 12 January 2022</u>	<u>4</u>
<u>Table 3.1</u>	<u>Results of Discrete Samples Collected 12 January 2022</u>	<u>7</u>
<u>Table 3.2</u>	<u>Erosion Monitoring Results from 12 January 2022</u>	<u>10</u>



1. Introduction

1.1 Introduction

This document comprises the third bi-monthly monitoring report for year 10 of Salty Lagoon Post-Closure monitoring year's 6-10 program (GeoLINK 2017). The monitoring program is as described in *Final Evaluation Report – Salty Lagoon Monitoring: Pre-Post Closure of Artificial Channel – Project Finalisation Report*, which forms an extension of the monitoring undertaken as part of the *Salty Lagoon Ecosystem Recovery Monitoring Program; Pre-Post Closure of Artificial Channel* (MPPC) (Hydrosphere Consulting 2010).

This report is for the monitoring period 1 November 2021 until 31 December 2021.

1.2 Guiding Values

Guiding values were developed for Salty Lagoon and Salty Creek as part of the MPPC program (GeoLINK 2012) to assist with the contextualisation of monthly water monitoring results, rather than as a measure of the health of the waterway. These values are used as part of the current post-closure monitoring and provide a yardstick around which the adaptive management of Salty Lagoon can be discussed.



2. Methodology

2.1 Discrete Sampling

This was the third bi-monthly site visit for year 10 post-closure monitoring at Salty Lagoon. It included routine maintenance of permanent water quality monitoring stations and discrete water quality sampling. The site visit was undertaken on 12 January 2022. Water quality samples were collected between the hours of 7:00 am and 12:00 am on that day. A low tide of 0.72 metres was forecast for 11.45 am.

Discrete water quality samples were taken from surface water (approximately 0.2 metre depth) at four sites in Salty Lagoon and a single site (S5) in Salty Creek. An additional quality assurance (QA) replicate sample was collected at S3. The specific locations of all sites sampled are presented in **Table 2.1** and **Illustration 2.1**. They are the same sites previously used for the MPPC (GeoLINK 2017).

Table 2.1 Locations of Water Quality Sample Sites in Salty Lagoon and Salty Creek (WGS84)

Site	S1	S2	S3	S4	S5
Eastings	0542064	0541799	0542037	0541738	0542187
Northings	6782801	6782669	6783013	6783033	6783665
Site Description	Lagoon monitoring station	SE of Drainage Channel	NE area of lagoon	NW area of lagoon	Creek monitoring station

Physico-chemical water quality parameters were measured with a calibrated HORIBA U-52 hand held water quality meter. Samples were collected from the surface, and at depth intervals of one metre where water levels allowed.

Samples were collected in jars for analysis of chemical and biological parameters at the Coffs Harbour Laboratory (CHL). Sterile jars were used for collection of samples for bacteriological analysis and brown glass jars were used for collection of samples for analysis of chlorophyll-a and blue green algal (BGA) content. Samples were placed upon ice in an esky and delivered to CHL on the same day.

2.2 Fixed Point Photo Monitoring

In addition to water quality samples, photos were taken showing the environment to the north, east, south and west of each water quality sample site. An additional photo monitoring site is located on the in-filled artificial channel.

2.3 Aquatic Weed Monitoring

Aquatic weed monitoring occurs three times each year; once in each of the summer, autumn and spring seasons. The summer aquatic weed survey was undertaken during the site inspection on 12 January 2022.

2.4 Erosion Monitoring

A series of reference stations have been set up around the head cut to the east of the infilled channel and some nearby control sites to assess the progression of erosion between Salty Lagoon and Salty Creek. The specific locations of all sites sampled are presented in **Table 2.2** and **Illustration 2.1**. Repairs to the control structure installed by NSW National Parks and Wildlife Service (NPWS) in late 2020 were undertaken in June and July 2021. Erosion monitoring is continuing to confirm if the headcut has stabilised.

The stations were set up in July 2017 at the head cut (Stations 4, 5 and 6), with control sites at points where lateral tributaries from Salty Creek lead towards Salty Lagoon (Stations 1, 2 and 3). At each site the monitoring involves a fixed-point photo and a measurement from a fixed peg to the nearest point of the head cut. In March 2020 site ER5 had to be extended because the fixed peg was overtaken by the erosion. A new site, ER5A was created but allows erosion progression to be measured from the same initial reference point as ER5.

Table 2.2 Type and Locations (WGS84) of Erosion Monitoring Sites

Site	Control/ Impact	Peg Location	
		Easting	Northing
ER1	Control	541961	6783356
ER2	Control	541934	6783355
ER3	Control	541978	6783342
ER4	Impact	542112	6783277
ER5	Impact	542129	6783262
ER5A	Impact	542128	6783245
ER6	Impact	542121	6783272

2.5 Permanent Water Quality Monitoring Stations

There are two permanent water quality monitoring stations (PWQMS) in place with YSI EXO3 series water quality sondes measuring temperature, pH, conductivity, turbidity and dissolved oxygen (DO) concentrations at 30-minute intervals. One PWQMS is located in Salty Lagoon at S1 and one in Salty Creek at S5. The data from these sites is downloaded at bi-monthly intervals for reporting purposes.

HOB0 U20 water level loggers were installed in the water at each PWQMS and a third HOB0 was installed above the water at S1 to collect barometric pressure data for offsetting atmospheric variability.

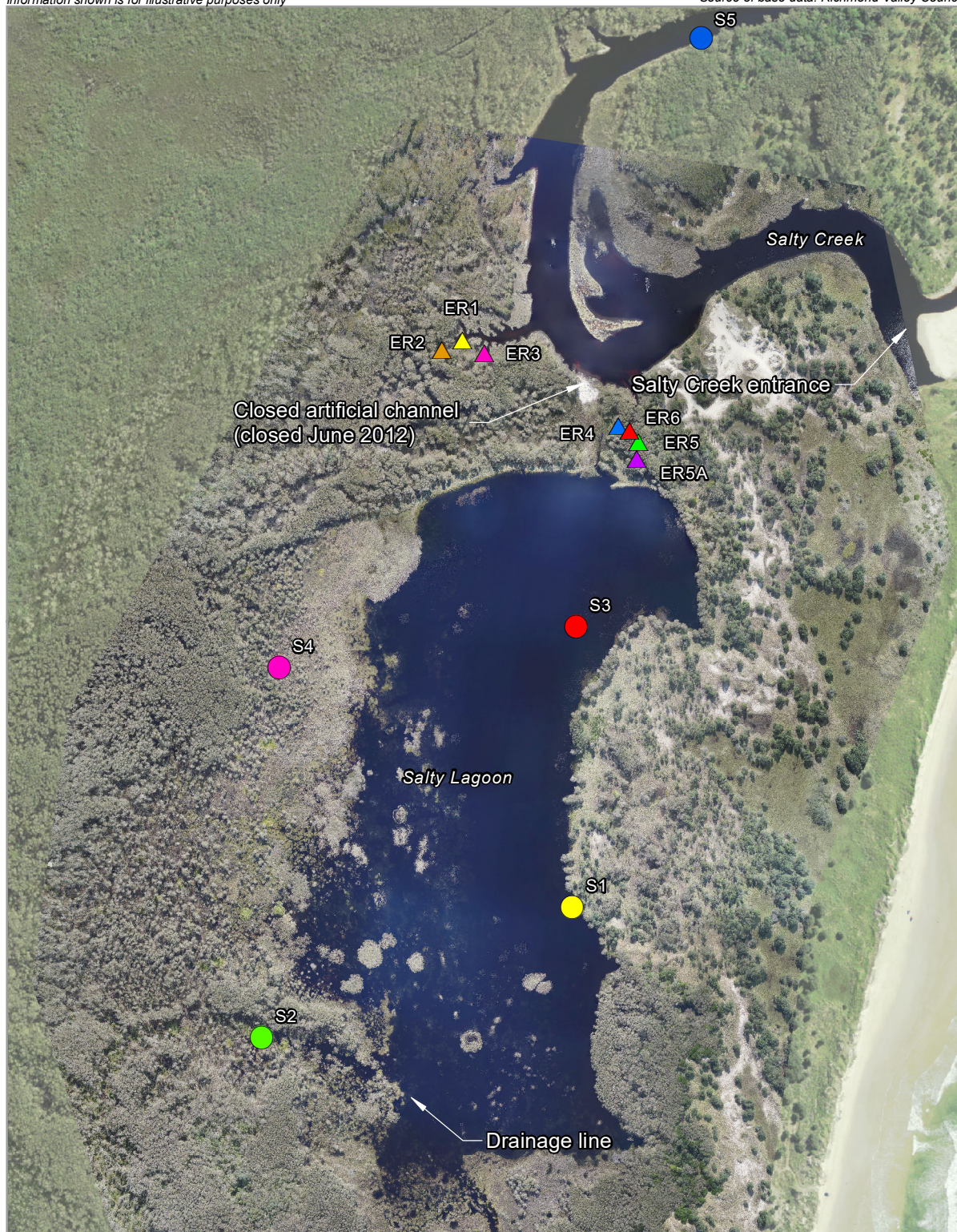
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sonde installed at the Salty Lagoon PWQMS were removed on 12 January 2022 and replaced by a serviced and calibrated set.

The status of the two deployed YSI EXO3 sondes on 12 January 2022 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 12 January 2022

Sonde	SN17F104100	SN 17H104488	Spare Probes
pH (cap life expectancy 18 months)	EXO pH 17H105048 Manufactured 08/2017 New cap 10/2020	EXO pH 17H105047 Manufactured 08/2017 New cap 01/2021	EXO pH 17H105049 Manufactured 08/2017 New cap 02/2021
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F102685 Manufactured 06/2017	EXO Wiped CT 17F102047 Manufactured 06/2017	EXO Wiped CT 17F103252 Manufactured 06/2017
DO (cap life expectancy 24 months)	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 04/2021	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 06/2021	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2021
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H103513 Manufactured 08/2017	YSI EXO Turbidity 17H101465 Manufactured 08/2017	YSI EXO Turbidity 17H101468 Manufactured 08/2017
Wiper	YSI Exo Wiper 17G101952 Malfunction. Removed for service	YSI Exo Wiper 17G101954 New wiper brush installed 03/2020	No Spare Wiper
Status	<ul style="list-style-type: none"> - Serviced probes installed in Salty Lagoon 12/01/2022 - New batteries installed 12/01/2022 	<ul style="list-style-type: none"> - Serviced probes installed in Salty Creek 17/11/2021 - New Batteries installed 12/01/2022 	<ul style="list-style-type: none"> - Awaiting service and calibration. - Probes Removed from Salty Lagoon 12/01/2022
Notes	<ul style="list-style-type: none"> - 218 days estimated battery life - Memory cleared – 49082 days logging available 	<ul style="list-style-type: none"> - 218 days estimated battery life - Memory cleared – 49082 days logging available 	-

Climate information was sourced from the Evans Head bombing range weather station on the Bureau of Meteorology website (BOM 2022). Evans Head Sewage Treatment Plant (STP) facility routine sampling information was provided by Richmond Valley Council (RVC).



LEGEND

Water Quality Site

- S1
- S2
- S3
- S4
- S5

Erosion Monitoring Site

- ▲ ER1
- ▲ ER2
- ▲ ER3
- ▲ ER4
- ▲ ER5
- ▲ ER5A
- ▲ ER6

0 120



Location of Water Quality and Erosion Monitoring Sites



3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 12 January 2022 are reported in **Table 3.1**.

3.2 Permanent Water Quality Monitoring Stations

The data collected at the PWQMS, and rainfall data correlating to the reporting period are presented in **Illustration 3.1** and **Illustration 3.2**.



Table 3.1 Results of Discrete Samples Collected 12 January 2022

Parameter	Salty Lagoon							S4	Salty Creek		
	Guiding Value	S1	S1 (1m)	S2	S3	S3 (1m)	S3 (QA)*		Guiding Value	S5	S5 (1m)
Blue Green Algae ID (cells/mL)	0	nil	ns	<100	nil	ns	nil	<100	0	nil	ns
Nitrite Nitrogen (mg/L)	0.01	<0.010	ns	<0.010	<0.010	ns	<0.010	<0.010	0.01	<0.010	ns
Nitrate Nitrogen (mg/L)	0.01	0.023	ns	<0.010	0.022	ns	0.02	<0.010	0.01	<0.010	ns
Oxidized Nitrogen (mg/L)	-	0.028	ns	<0.010	0.028	ns	0.027	<0.010	-	<0.010	ns
Ammonia Nitrogen (mg/L)	0.05	0.049	ns	<0.010	<0.010	ns	<0.010	<0.010	0.11	<0.010	ns
Total Kjeldahl Nitrogen (mg/L)	1.6	1.72	ns	1.71	1.86	ns	1.83	2.32	1.63	1.67	ns
Total Nitrogen (mg/L)	1.6	1.74	ns	1.71	1.88	ns	1.85	2.32	1.63	1.67	ns
Total Phosphorus(mg/L)	0.14	0.06	ns	0.1	0.08	ns	0.07	<0.03	0.04	<0.03	ns
Orthophosphate (mg/L)	0.11	0.028	ns	0.059	0.024	ns	0.023	<0.010	0.01	<0.010	ns
Chlorophyll-a (µg/L)	5	<1	ns	<1	21	ns	28	7	3	<1	ns
Enterococcus (CFU/100mL)	170	110	ns	205	10	ns	10	25	40	30	ns
Faecal Coliforms (CFU/100mL)	135	10	ns	15	10	ns	15	<5	150	25	ns
Temp (°C)	25.9	29.8	26.67	25.16	32.9	29.04	ns	24.54	13.1 - 28.8	24.48	24.53
pH	6.9	6.38	6.26	5.85	6.7	6.47	ns	4.63	4.3 - 6.8	4.14	6.41
ORP (mV)	-	122	98	3	154	165	ns	174	-	285	-136
Cond (mS/cm)	8.0	2.55	2.66	0.385	2.66	2.65	ns	1.17	0.3 - 21.5	0.923	46.3
Turbidity (NTU)	13	0.4	1.8	3.7	1.1	7.4	ns	5.2	11	0.2	2.5
DO (mg/L)	4.09	3.67	2.02	0.34	5.18	3.64	ns	1.1	5.52	4.3	1.18
DO (% sat)	-	49	25.7	4.3	72	48	ns	13.5	-	52.7	17.2
TDS (mg/L)	-	1.63	1.7	0.251	1.7	1.7	ns	0.749	-	0.591	28.2
Sal (ppt)	-	1.3	1.4	0.2	1.4	1.4	ns	0.6	-	0.5	30
Depth (m)	-	Surface	1	Surface	Surface	1	Surface	Surface	-	Surface	1

Note: * = randomly selected quality assurance sample.

red text = not compliant with MPPC guiding values (see GeoLINK 2012).

levels below detection limits will be incorporated into databases as 0 for the purpose of statistical analyses

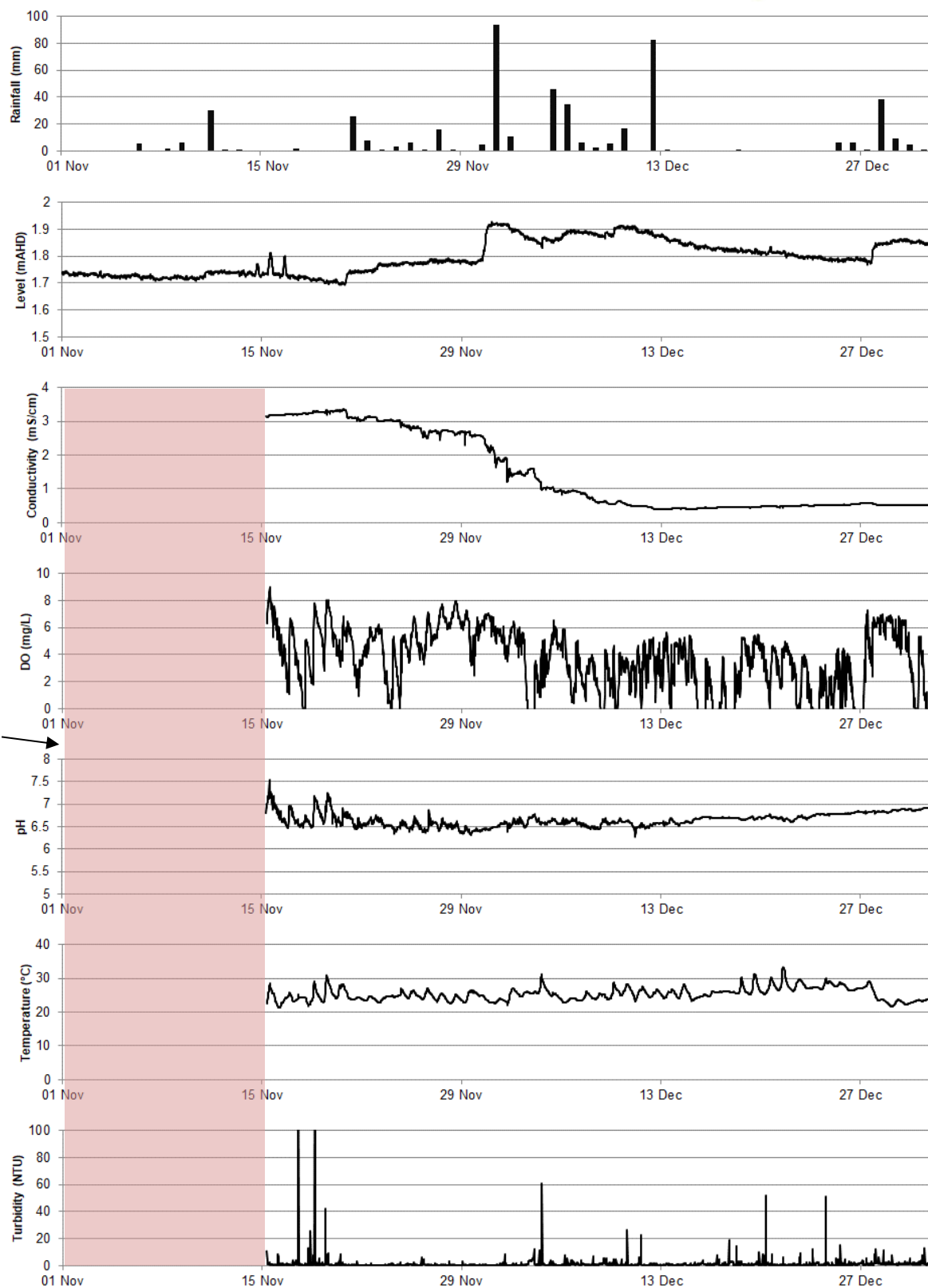


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1
November 2021 to 31 December 2021

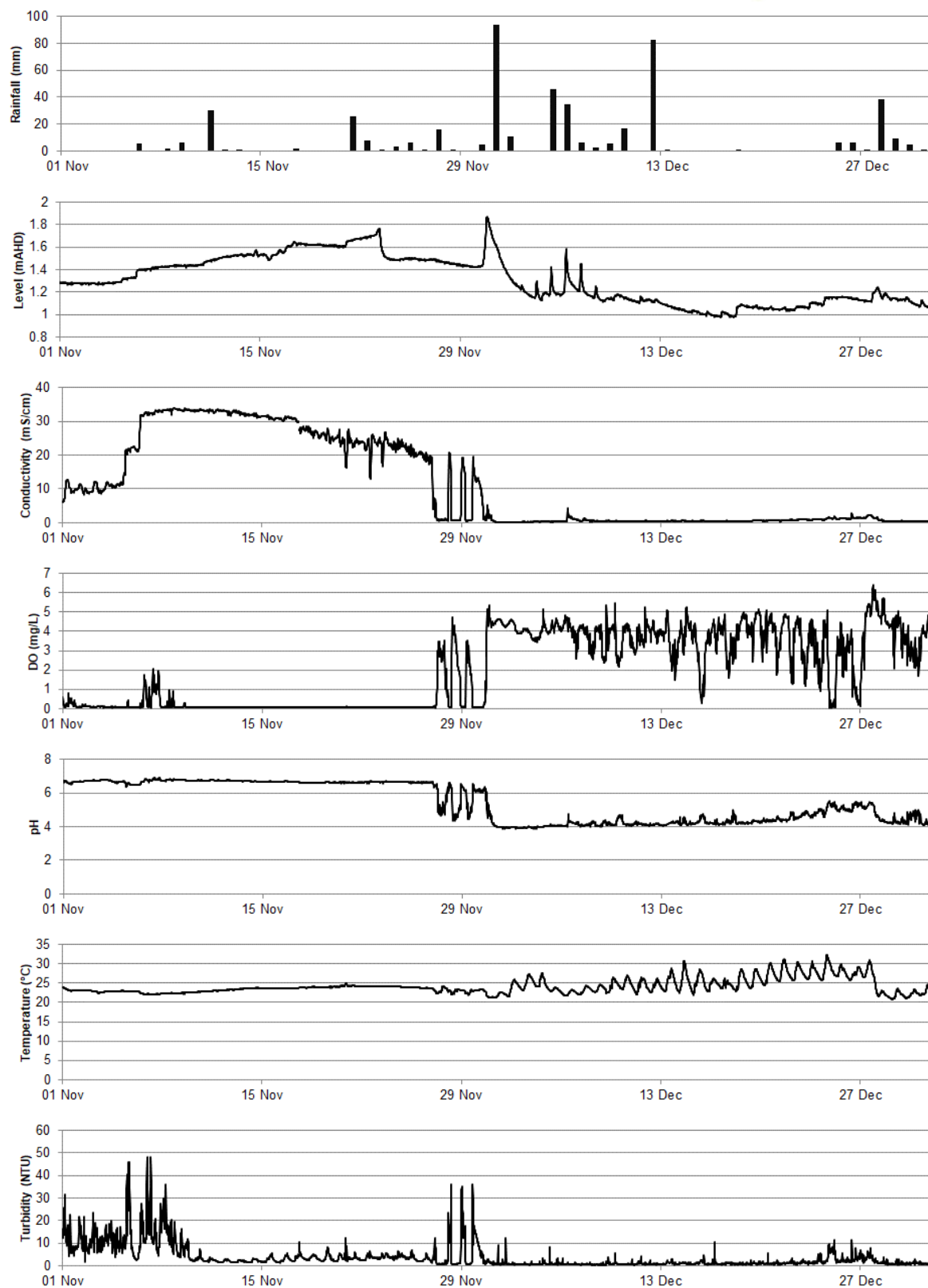


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1
November 2021 to 31 December 2021

3.3 Aquatic Weed Monitoring

No significant aquatic weeds were identified during the aquatic weed survey on 12 January 2022. One plant not previously identified in aquatic weed surveys, *Alternanthera denticulata* (Lesser Joyweed), was observed on the northern margin of Salty Lagoon.

3.4 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2** and **Illustration 3.3**. There was no significant advance of the head cut at ER5 in relation to the previous measurements on 15 November 2021. The head cut has advanced more than 50 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion Monitoring Results from 12 January 2022

Station	Control/ Impact	Distance 25 July 2017 (m)	Distance 12 Jan 2022 (m)	Cut Movement (m)
ER1	Control	7.55	7.35	0.20
ER2	Control	10.20	7.70	2.50
ER3	Control	9.95	9.80	0.15
ER4	Impact	8.35	-5.75	14.10
ER5	Impact	12.35	-38.4	50.75
ER6	Impact	10.40	6.15	4.25

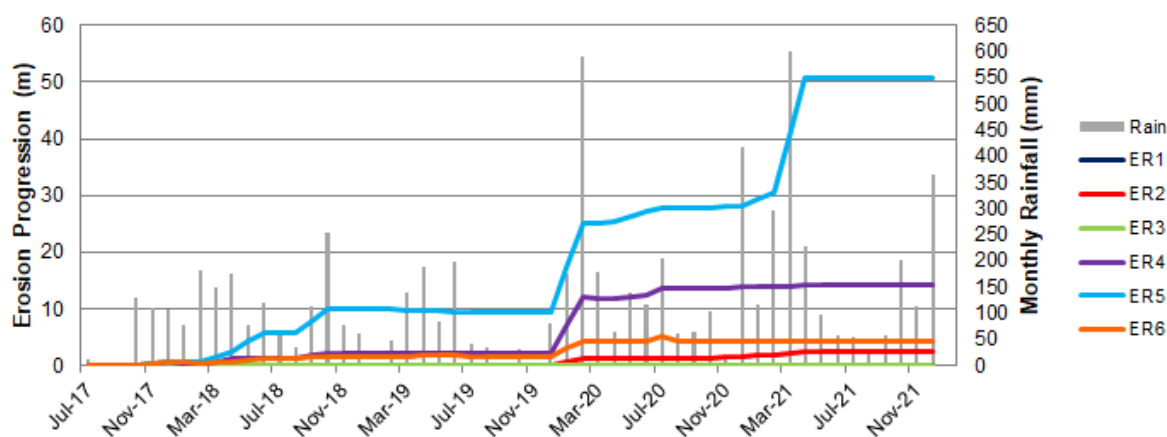


Illustration 3.3 Erosion Progression Plotted against Monthly Rainfall since July 2017

4. Discussion

4.1 Water Quality

Rainfall for this reporting period comprised of several medium to large events and a number of small events. Rainfall was recorded on more than half of the days of the reporting period. The total rainfall for this reporting period was approximately 220 percent of the average amount. This is the second consecutive bi-monthly reporting period where rainfall far exceeded the average amount.

The water level at the Salty Creek PWQMS was particularly dynamic during this reporting period, in response to rainfall runoff, seawater ingress, the entrance opening on two separate occasions and tidal movements. Although water levels became very high on 30 November 2021 in response to very heavy rainfall, they were low at the beginning of the reporting period and very low at the end. The data indicates that the entrance to Salty Creek was open and flowing out for the final 20 days of the reporting period. Water levels in Salty Lagoon remained relatively high for the majority of the reporting period, increasing to very high levels in response to some of the heavier rainfall events. Water would have flowed from Salty Lagoon into Salty Creek for the majority of the reporting period, with the exception of two short periods prior to entrance opening events where the waterways were hydrologically connected (**Illustration 4.1**).

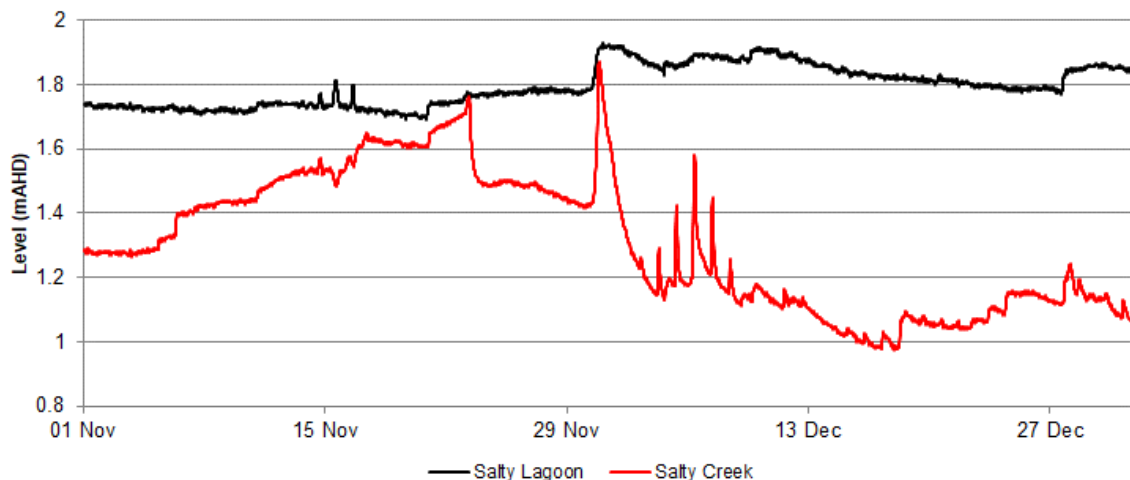
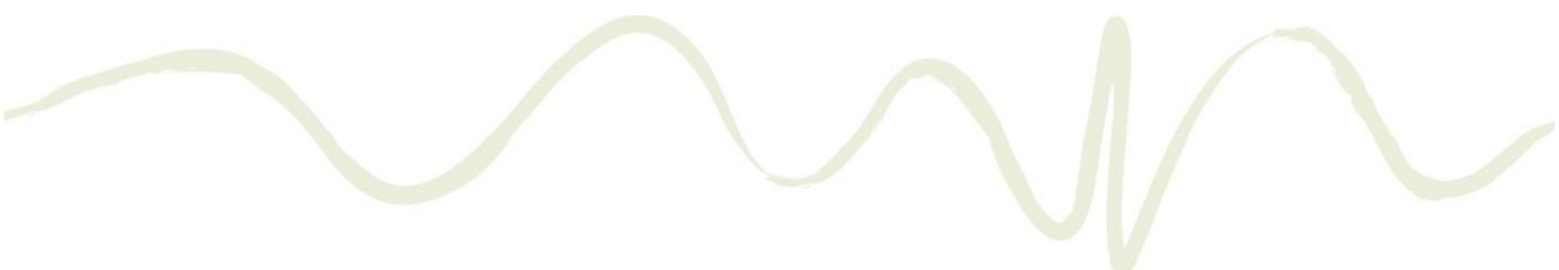


Illustration 4.1 Water levels in Salty Lagoon and Salty Creek during this reporting period

The conductivity measured at the Salty Lagoon PWQMS decreased overall during this reporting period in response to consistent rainfall runoff. The conductivity measurements from the Salty Creek PWQMS clearly indicate the influence of seawater ingress initially and then consistent rainfall runoff flowing through the open entrance. At the time of the site inspection on 12 January 2022 the water in Salty Lagoon was well mixed and brackish, and the water in Salty Creek was stratified into a slightly brackish surface layer and a more saline, heavier bottom layer, indicating that further seawater ingress may have occurred after 31 December 2021. The conductivity measurements collected on 12 January 2022 complied with guiding values at all sites except S5, where the sample collected from deeper water indicated the conductivity had increased in response to seawater ingress.

The DO concentrations in discrete samples collected on 12 January 2022 were below the guiding values in all but one sample from S3. Low DO concentrations are naturally prevalent at the sites to



the west of Salty Lagoon but unusual in the open water sites. Low DO concentrations in the open water sites are often associated with saline water ingress, which is likely to have occurred between 31 December 2021 and the site inspection. Logged data from the Salty Lagoon PWQMS indicates that the DO concentrations at the bottom of the water column in Salty Lagoon were highly variable during this reporting period in response to light availability and other factors. Logged data from the Salty Creek PWQMS indicates that the DO concentration at the bottom of the water column in Salty Creek improved when freshwater conditions prevailed but was still variable in response to light availability.

Many of the nutrient concentrations from samples collected on 12 January 2022 did not comply with guiding values. In particular, all of the TN concentrations and nitrate concentrations from S1 and S3 exceeded guiding values. Chlorophyll-a concentrations from S3 and S4 exceeded the guiding values, indicating a small algal bloom at S4 and a moderate algal bloom at S3.

Blue-green algae were recorded from S2 and S4 for the second consecutive reporting period. At both sites the concentrations were very low but at S4 there were signs of a large algal bloom in the surrounding shallow waters. The blue-green algae detected at S2 were from the genera *Planktolyngbya* and at S4 they were *Pseudanabeana*. Neither are known for forming toxic blooms in Australian waters. The bloom observed in the waters around S4 during the previous reporting period appears to have dispersed naturally.

All other results complied with guiding values with the exception of some of the temperature measurements and the enterococcus measurement from S2. The elevated enterococcus concentration at S2 is likely to be associated with natural processes, such as waterbird use of the area or rainfall runoff carrying animal faecal material into the waterbody. The high temperatures measured at S1 and S3 are a function of seasonal variation, the timing of the samples (later in the day than most samples) and the strong tannin staining of the water.

Erosion monitoring showed no further movement of the primary head cut towards Salty Lagoon since the previous measurements taken on 15 November 2021, despite consistent flow from Salty Lagoon into Salty Creek and a hydraulic head of up to approximately 0.8 m (**Illustration 4.1**). This is an indication that the repairs to the erosion control structure in the eroding channel have functioned well during this reporting period.

4.2 Other Observations

The entrance to Salty Creek was open on 12 January 2022 (**Plate 4.1**). A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Little Pied Cormorant, Little Black Cormorant, Pied Cormorant, and Pelican. There was a bloom of *Azolla fimbristylis* at S2 that covered most of the pool. This is the second consecutive observation of such a bloom. They have occurred irregularly between October and December throughout the years of monitoring at Salty Lagoon.



Plate 4.1 The open entrance to Salty Creek on 12 January 2022



Plate 4.2 Higher water levels on 12 January 2022 showing a hydraulic connection between Salty Lagoon and Salty Creek over the erosion control structure.



5. Key Points

1. Water levels in Salty Lagoon were relatively high during this reporting period in response to above average rainfall.
2. A moderate number of results did not comply with the guiding values.
3. Chlorophyll-a concentrations were high at S3. Total nitrogen concentrations were high at all sites.
4. Blue-green algae were detected for the eighth consecutive reporting period. However, concentrations were low and the *Microcystis* bloom observed at S4 in the previous reporting period appears to have dispersed naturally.
5. Although rainfall has greatly exceeded average conditions and a large hydraulic head persisted for much of this reporting period, the erosive headcut has not advanced since the measurements on 12 September 2021, indicating that the repairs to the erosion control structure are functioning well so far.
6. The risk rating for the Salty Lagoon Response Protocol is low.



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