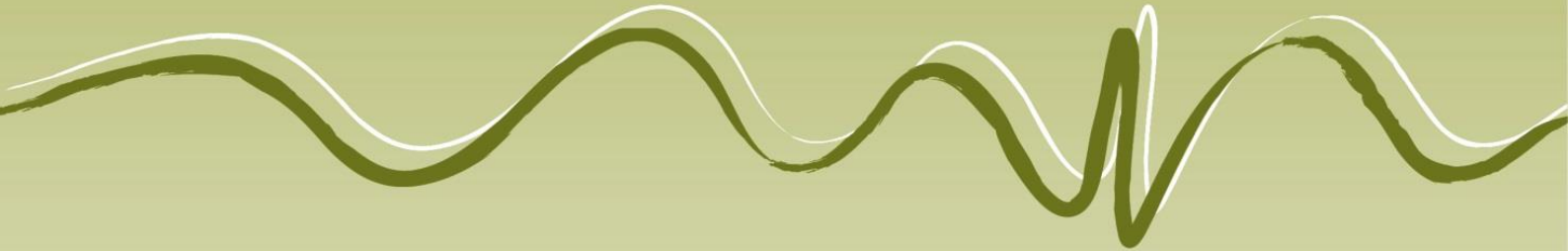


Salty Lagoon

Post Closure Monitoring

Project Management and Ecosystem Health Report

December 2020



AQUATIC SCIENCE AND MANAGEMENT

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<i>UPR</i>	<i>Description</i>	<i>Date Issued</i>	<i>Issued By</i>
1731-1336	First issue	19/02/2021	David Andrighetto
1731-1337	Second issue	26/02/2021	David Andrighetto



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1. Introduction

1.1 Introduction

This document comprises the third bi-monthly monitoring report for year 9 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 2020 until 31 December 2020.

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 9 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 4 January 2021. Water quality samples were collected between the hours of 7:30 am and 13:00 pm on that day. A high tide of 1.74 metres was forecast for 12.45 pm.

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	S 1	S 2	S 3	S 4	S 5
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 following 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. Maps of the monitoring meander and detailed data are provided in the annual reports. Aquatic weed monitoring was undertaken during the site inspection on 4 January 2021.

2.4 Erosion Monitoring

A series of 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**. Remediation of the headcut was undertaken by NSW National Parks and Wildlife Service (NPWS) in late 2020 through creation of a rock, geofabric and sand spillway at the outlet. Erosion monitoring is continuing to confirm if the headcut has stabilised (especially as the headcut scour was not infilled).

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 Creek PWQMS were removed on 4 January 2021 and replaced by a serviced and calibrated set.

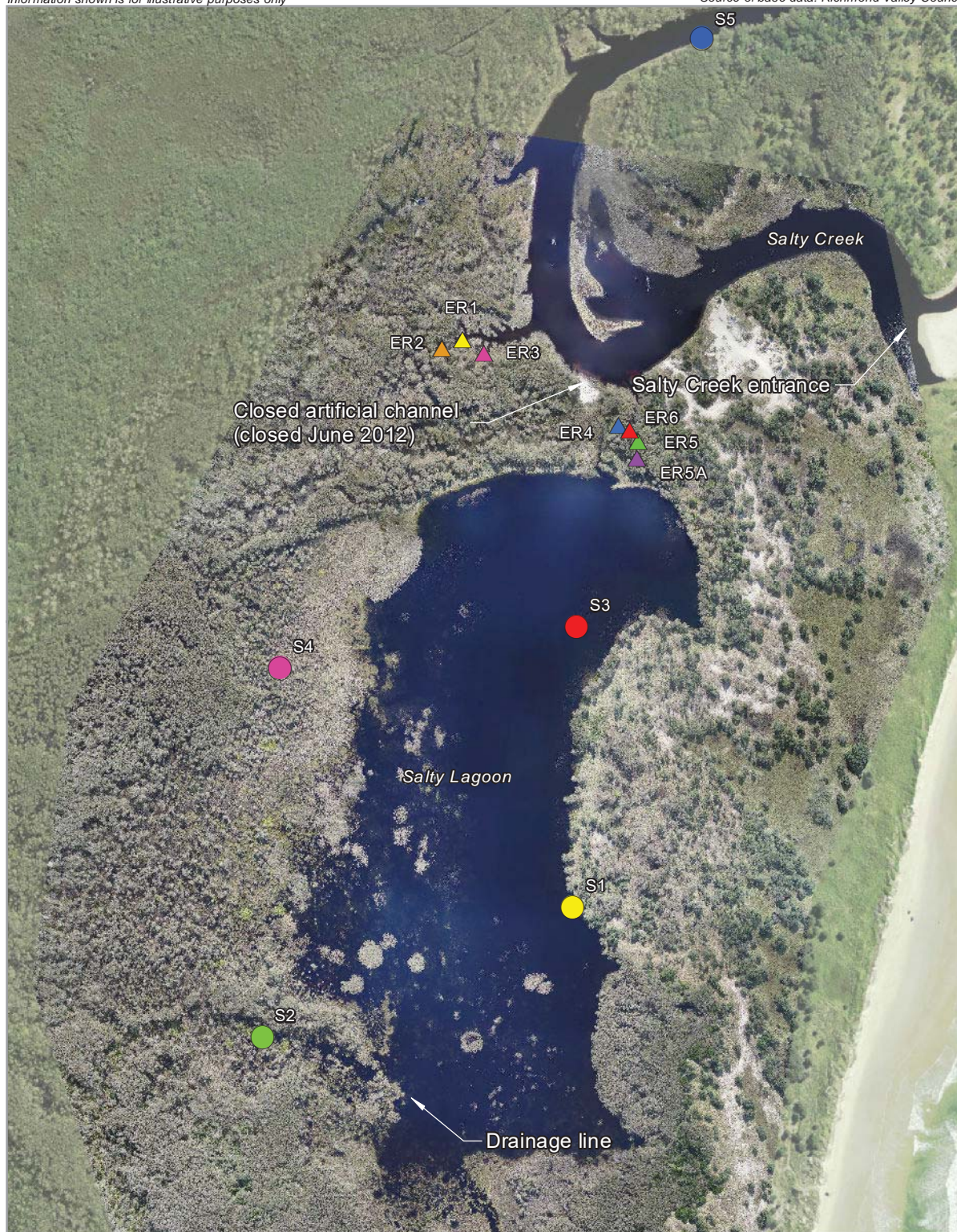
At the time of the site visit on 4 January 2021 the batteries in the Salty Creek sonde were completely discharged, despite new batteries having been installed on 2 November 2020 as per protocol. The batteries were replaced with Duracell branded batteries, which have performed well in the YSI sondes.

The status of the two deployed YSI EXO3 sondes on 4 January 2021 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 4 January 2021

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 09/2020
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 03/2019	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 05/2019	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2019
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 New wiper brush installed 07/2020	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 2/11/2020 - New batteries installed 4/01/2021 	<ul style="list-style-type: none"> - Serviced probes installed in Salty Creek 4/01/2021 - New Batteries installed 4/01/2021 	<ul style="list-style-type: none"> - Awaiting service and calibration. - Probes Removed from Salty Creek 4/01/2021
Notes	<ul style="list-style-type: none"> - 218 days estimated battery life - Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> - 218 days estimated battery life - Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> - New pH cap required - malfunction

Climate information was sourced from the Evans Head bombing range weather station on the Bureau of Meteorology website (BOM 2020). 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 4 January 2021 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 4 January 2021

Parameter	Salty Lagoon								Salty Creek	
	Guiding Value	S1	S1 (1m)	S2	S3	S3 (1m)	S3 (QA)*	S4	Guiding Value	S5
Blue Green Algae ID (cells/mL)	0	<1000	ns	<100	<1000	ns	<1000	<100	0	nil
Nitrite Nitrogen (mg/L)	0.01	<0.010	ns	<0.010	<0.010	ns	<0.010	<0.010	0.01	<0.010
Nitrate Nitrogen (mg/L)	0.01	<0.010	ns	<0.010	<0.010	ns	<0.010	<0.010	0.01	<0.010
Oxidized Nitrogen (mg/L)	-	<0.010	ns	<0.010	<0.010	ns	<0.010	<0.010	-	<0.010
Ammonia Nitrogen (mg/L)	0.05	0.15	ns	<0.010	0.23	ns	0.23	0.012	0.11	0.016
Total Kjeldahl Nitrogen (mg/L)	1.6	1.84	ns	1.44	1.89	ns	1.85	1.21	1.63	1.62
Total Nitrogen (mg/L)	1.6	1.84	ns	1.44	1.89	ns	1.85	1.21	1.63	1.62
Total Phosphorus(mg/L)	0.14	0.12	ns	0.14	0.12	ns	0.11	<0.03	0.04	<0.03
Orthophosphate (mg/L)	0.11	0.063	ns	0.14	0.077	ns	0.077	<0.010	0.01	<0.010
Chlorophyll-a (µg/L)	5	27	ns	4	13	ns	19	<1	3	<1
Enterococcus (CFU/100mL)	170	25	ns	125	15	ns	215	240	40	5
Faecal Coliforms (CFU/100mL)	135	<5	ns	<5	10	ns	10	10	150	35
Temp (°C)	25.9	26.91	26.68	24.13	27.48	27.32	ns	24.47	13.1 - 28.8	25.12
pH	6.9	6.61	6.56	6.38	6.66	6.61	ns	5.74	4.3 - 6.8	4.21
ORP (mV)	-	126	97	58	136	140	ns	194	-	248
Cond (mS/cm)	8.0	0.875	0.886	0.287	0.917	0.915	ns	0.398	0.3 - 21.5	0.326
Turbidity (NTU)	13	6.3	2.7	0	2.7	2.8	ns	0	11	0
DO (mg/L)	4.09	8.1	2.16	0	3.21	2.81	ns	1.86	5.52	4.13
DO (% sat)	-	103.1	27.4	0	41.2	36	ns	22.7	-	51.1
TDS (mg/L)	-	0.56	0.567	0.186	0.587	0.585	ns	0.259	-	0.212
Sal (ppt)	-	0.4	0.4	0.1	0.4	0.4	ns	0.2	-	0.2
Depth (m)	-	Surface	1	Surface	Surface	1	1	Surface	-	Surface

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

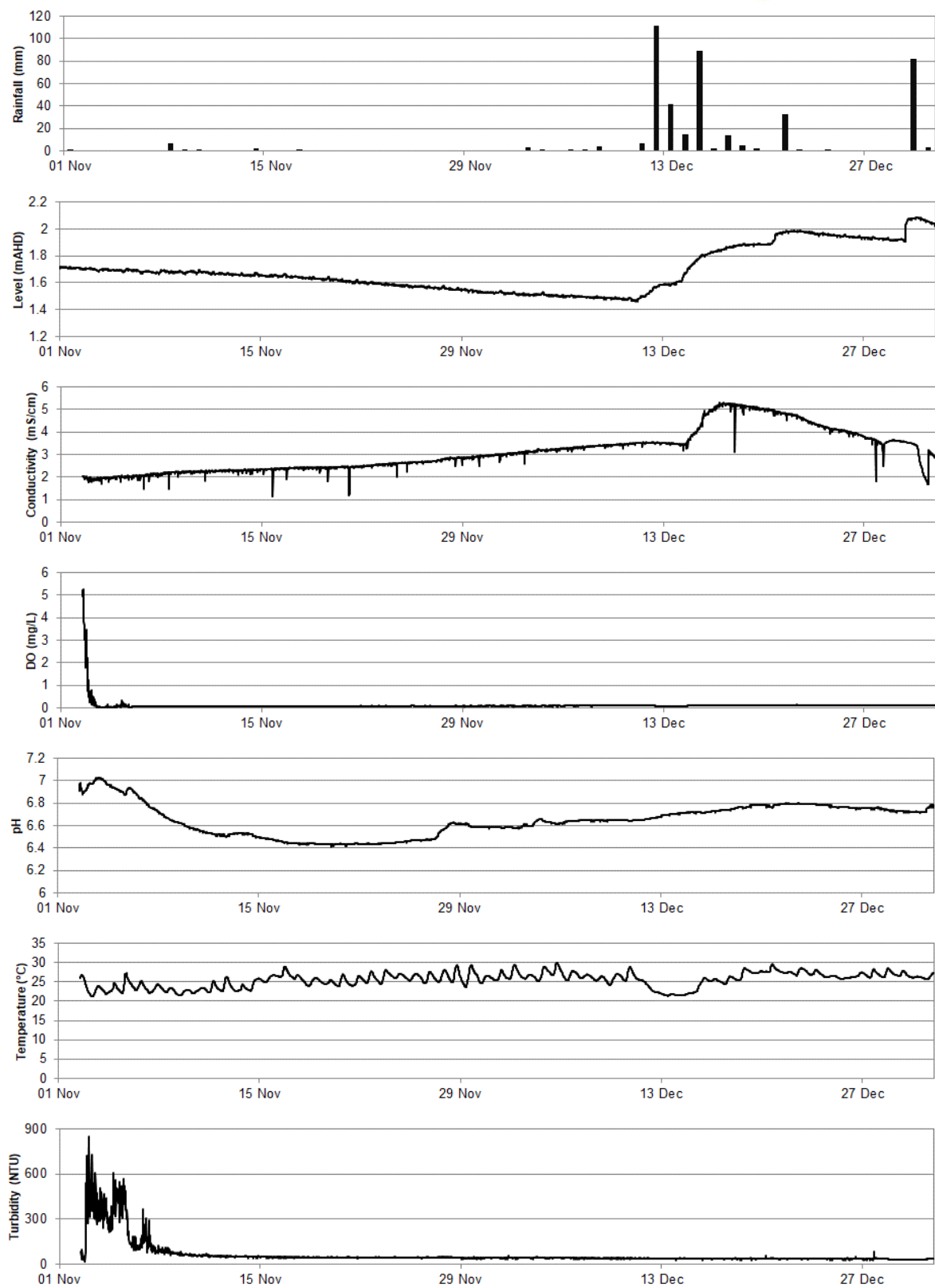
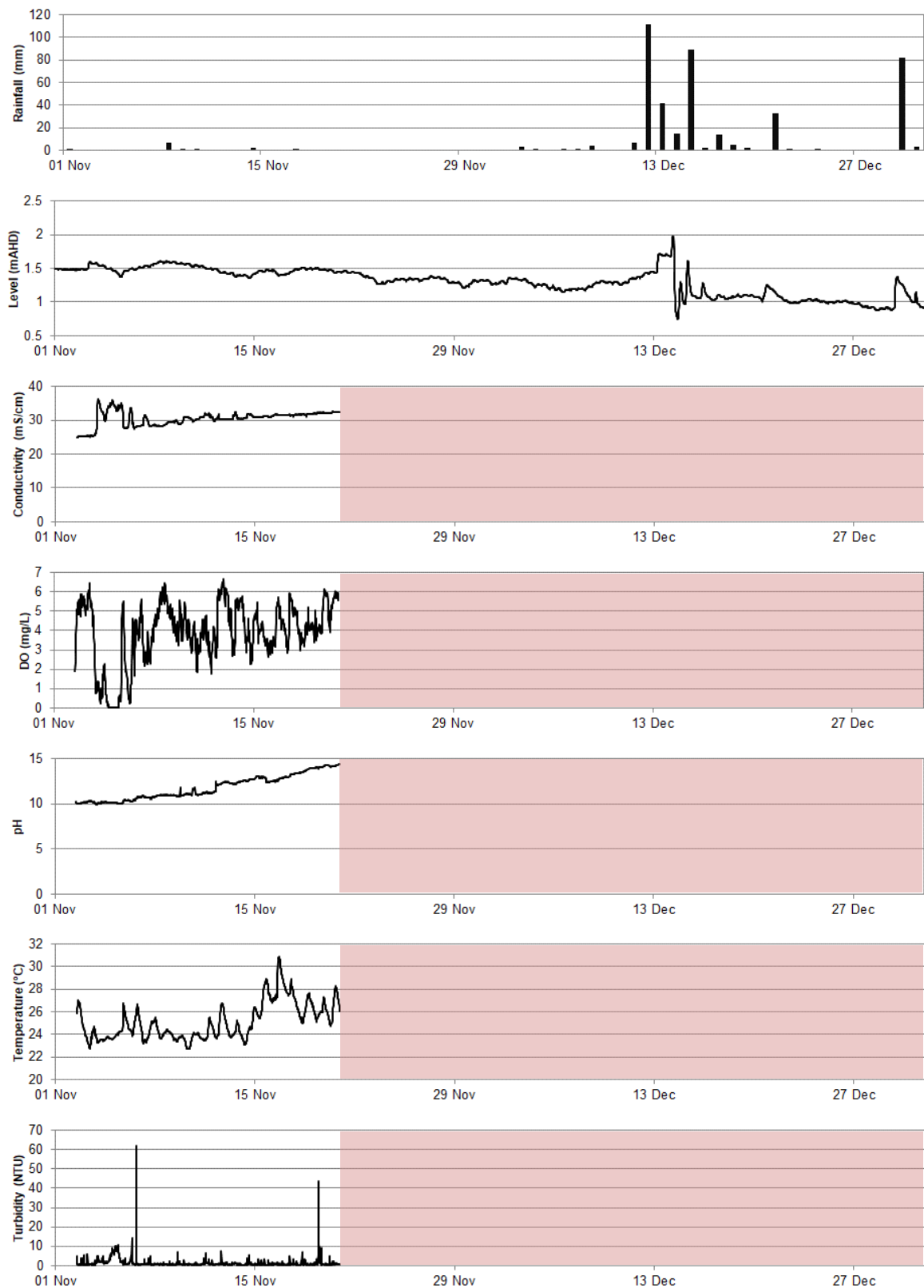


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1
November 2020 to 31 December 2020



**Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data
1 November 2020 to 31 December 2020**

3.3 Aquatic Weed Monitoring

No significant aquatic weeds were identified during the aquatic weed survey on 4 January 2021.

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 only a minor advance of the head cuts at the three impact stations in relation to the previous measurements on 2 November 2020. The head cut has advanced at least 28 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion Monitoring Results from 4 January 2021

Station	Control/ Impact	Distance 25 July 2017 (m)	Distance 4 January 2021 (m)	Cut Movement (m)
ER1	Control	7.55	7.4	0.15
ER2	Control	10.20	8.50	1.70
ER3	Control	9.95	9.80	0.15
ER4	Impact	8.35	-5.55	13.90
ER5	Impact	12.35	-15.80	28.15
ER6	Impact	10.40	6.10	4.30

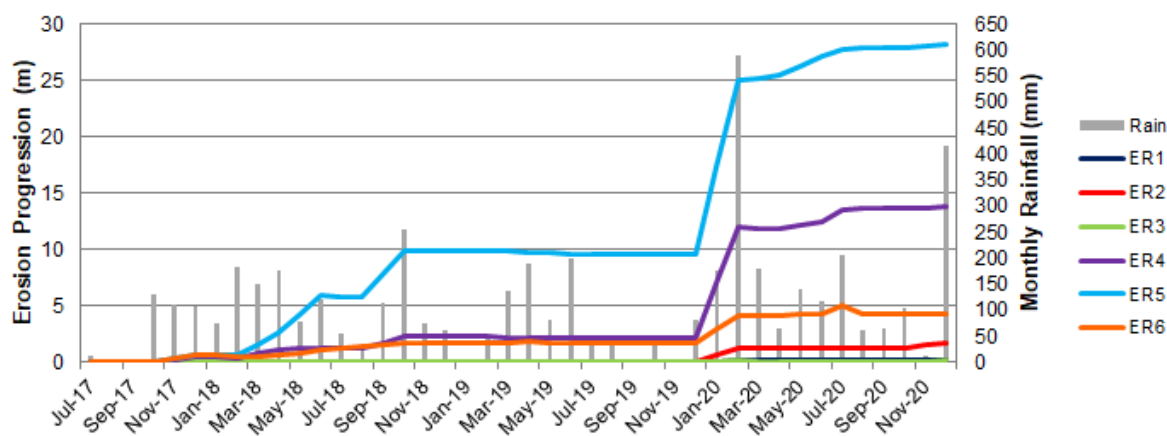


Illustration 3.3 Erosion Progression Plotted against Monthly Rainfall since July 2017



4. Discussion

4.1 Water Quality

The logged water quality data for this reporting period was impacted by technical problems. The batteries in the Salty Creek sonde failed on 20 November 2020 although new batteries (of a reputable brand) had been installed on 1 November 2020 and the same batteries (from the same retailer) had been installed in the Salty Lagoon sonde without failure. The batteries in the Salty Lagoon sonde were checked and found to be operational on 8 December 2020. As a result, the Salty Creek sonde was not checked. Prior to battery failure the pH measurements collected at the Salty Creek PWQMS were faulty. A replacement pH cap has been ordered.

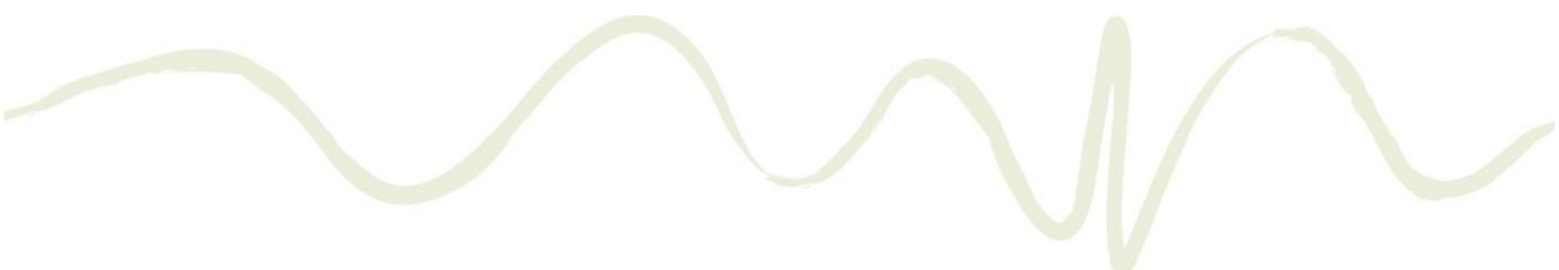
Total rainfall for this reporting period comprised of several small to moderate events and two heavy events, between 12 and 15 December 2020 and on 30 December 2020. No adaptive management site inspections were undertaken because work to reduce erosive pressure on the headcut had been completed. The rainfall in November 2020 was far below average and the rainfall in December 2020 was far above average. Total rainfall for the two months was approximately twice the average amount.

The level data from the Salty Creek PWQMS indicates that the entrance to Salty Creek was closed from the beginning of the monitoring period until heavy rainfall from 12 December led to very high water levels and subsequent opening of the entrance on 14 December. After opening, the entrance remained tidal for only 3 days, before closing again. At the time of the site inspection on 4 January 2021, the entrance to Salty Creek was open and flowing out (**Plate 4.1**), after opening in response to heavy rainfall on 30 December 2020. The water level in Salty Lagoon was dynamic during this monitoring period. The effects of evaporation led to significant decreases in the water level during the first 6 weeks of this monitoring period, before heavy rain led to a relatively rapid increase. The conductivity and level data indicate that Salty Lagoon received saline water inflow from Salty Creek on 14 December 2020 when water levels in Salty Creek were at a level of almost 2 mAHd.

The conductivity measured at the Salty Lagoon PWQMS was relatively dynamic during this reporting period in response to evaporation, saline water inflow from Salty Creek and dilution from rainfall runoff. Overall, the conductivity measurements increased slightly but remained brackish. The available conductivity measurements from the Salty Creek PWQMS show that Salty Creek was saline at the beginning of the reporting period. At the time of the site inspection on 4 January 2021 the water in Salty Lagoon was well mixed and fresh, indicating that further dilution with rainfall runoff had occurred. The water in Salty Creek was also well mixed and fresh. The conductivity measurements collected on 4 January 2021 complied with guiding values at all sites.

Erosion monitoring indicated that the head cut did not advance significantly during this reporting period. The level information indicates that runoff from Salty Lagoon into Salty Creek only occurred between 20 December 2020 and the end of the reporting period. At the control sites there was only a small advance of the head cut at one site. The head cut remains approximately 14 m from the current banks of Salty Lagoon. It appears that the works undertaken to reduce erosive pressure on the head cut are currently working.

The DO concentrations in discrete samples collected on 4 January 2021 were below the guiding values at all sites, although the surface water measurement at S1 was above the guiding value. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4) but low DO concentrations in the open water of Salty Lagoon are unusual. The available data from



the Salty Lagoon PWQMS indicates that the DO concentrations at the bottom of the water column in Salty Lagoon remained at very low levels for most of the reporting period. The available data from the Salty Creek PWQMS indicate that DO concentrations were fluctuating according to normal diurnal cycles.

A small number of nutrient concentrations from samples collected on 4 January 2021 did not comply with guiding values. These included TN and ammonia concentrations from S1 and S3 and the orthophosphate concentration from S2. Increased nutrient concentrations noted in the previous bi-monthly report are likely to have been diluted by the heavy rainfall experienced in December 2020. Chlorophyll-a concentrations at S1 and S3 did not comply with guiding values and indicated algal blooms of small to moderate proportions. Blue-green algae were recorded from all four Salty Lagoon sites for the third consecutive time, although concentrations were lower than the previous record. The blue-green algae detected were from the genera *Pseudanabaena* (S1, S2 and S3), *Anabeana* (S1) and *Cyanodictyon* (S4). *Pseudanabaena* and *Anabeana* are common in freshwater environments. *Cyanodictyon* is a rarely encountered marine genus. Some species of *Anabeana* form toxic blooms (Entwistle *et al.* 1997).

All other results complied with guiding values with the exception of the enterococcus concentrations from S3 and S4 and the temperature measurements from Salty Lagoon. The high enterococcus concentrations were probably associated with waterbird use of the area or rainfall runoff and the temperature measurements are normal seasonal variations.

4.2 Other Observations

The entrance to Salty Creek was open on 4 January 2021. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Black Swan, Pelican, Little Pied Cormorant, Little Black Cormorant, Pied Cormorant and Great Cormorant. Blue-green Algae were noted at S1. An individual Striped Rocket Frog (*Litoria nasuta*) was observed at S1.



Plate 4.1 The open entrance to Salty Creek on 4 January 2021



Plate 4.2 Scour spillway installed to reduce the erosive pressure on the head cut.



5. Key Points

1. Significant data loss occurred at the Salty Creek PWQMS as a result of poor battery performance.
2. Water levels increased in Salty Lagoon throughout the current monitoring period. Water levels in and Salty Creek were variable in response to entrance conditions and rainfall.
3. A moderate number of results did not comply with the guiding values.
4. Nutrient and chlorophyll-a concentrations were improved in comparison with the previous report.
5. Blue-green algae were detected for the third consecutive month albeit at reduced concentrations. One genera identified from S1 is potentially a type that can cause toxic blooms. This is the first observation of a potentially toxic blue-green algae genera since the beginning of the MPPC.
6. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek did not advance significantly during this reporting period despite heavy rainfall. It appears that the installation of a spillway has successfully reduced erosive pressure on the headcut.
7. The risk rating for the Salty Lagoon Response Protocol is low, although blue-green algae concentrations and genera will be monitored closely over the coming months to observe if there are any developments in the occurrence and abundance of potentially toxic blue-green algae blooms.



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