Salty Lagoon
Post Closure Monitoring

Project Management and Ecosystem Health Report
August 2020

GeoLINK
environmental management and design

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1. Introduction

1.1 Introduction

This document comprises the first 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 July 2020 until 31 August 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 first 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 1 September 2020. Water quality samples were collected between the hours of 7:30 am and 12:00 pm on that day. A high tide of 1.37 m was forecast for 7:48 am.

Discrete water quality samples were taken from surface water (approximately 0.2 m depth) at three 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. 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 content. Samples were placed upon ice in an esky and delivered to the Coffs Harbour Laboratory 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. Maps of the monitoring meander and detailed data are provided in the annual reports. No aquatic weed monitoring was undertaken during this monitoring period. The next aquatic weed monitoring is scheduled for early November 2020.

2.4 Erosion Monitoring

A series of stations have been set up around the active 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**.

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.

HOBO U20 water level loggers were installed in the water at each PWQMS and a third HOBO 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 1 September 2020 and replaced by a serviced and calibrated set.

The status of the two deployed YSI EXO3 sondes on 1 September 2020 is displayed in **Table 2.3**.

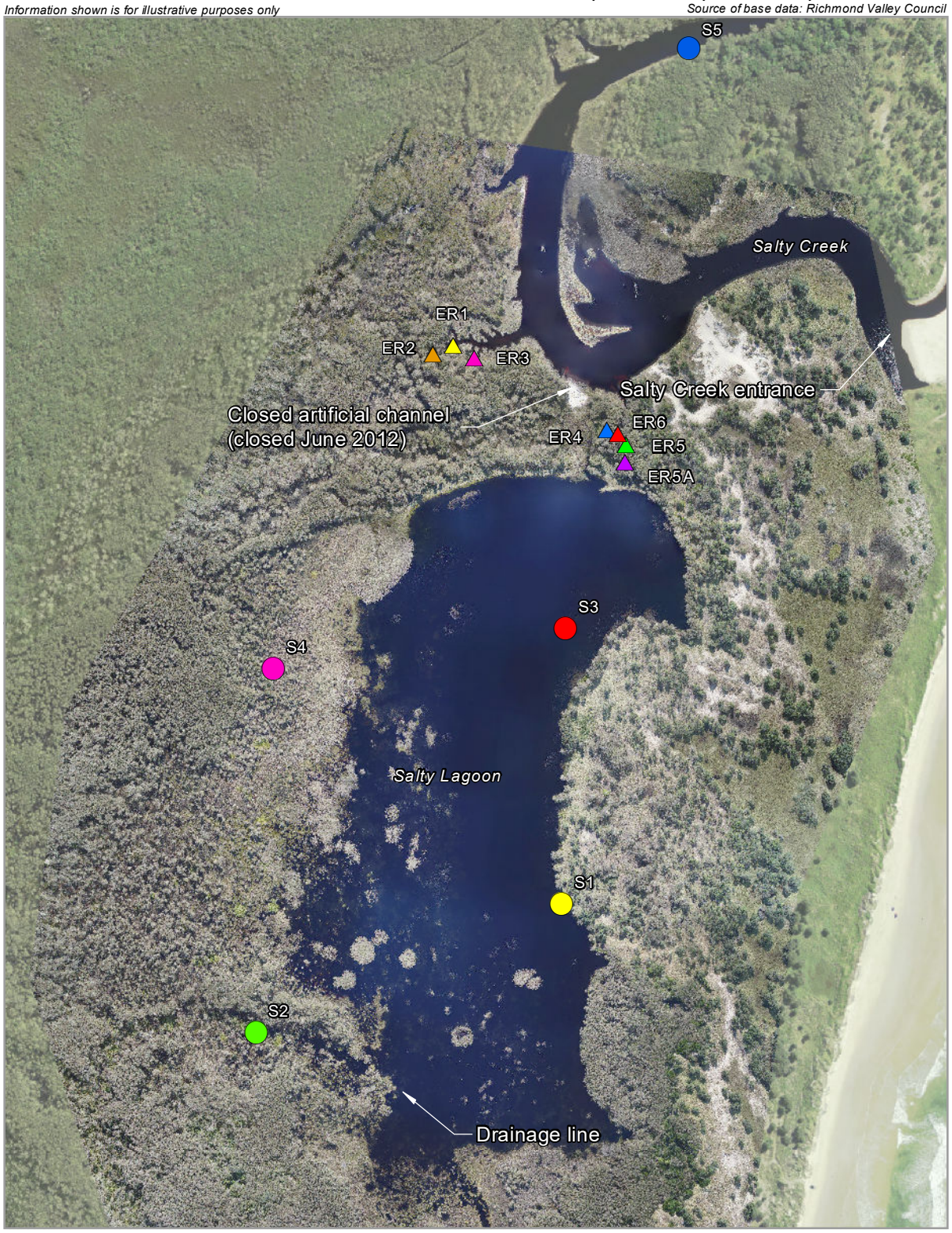
Table 2.3 YSI Sonde Status on 1 September 2020

Sonde	*SN17F104100*	*SN 17H104488*	*Spare Probes*
pH (cap life expectancy 18 months)	EXO pH 17H105047 Manufactured 08/2017 New cap 05/2019	EXO pH 17H105048 Manufactured 08/2017 New cap 08/2020	EXO pH 17H105049 Manufactured 08/2017 New cap 03/2019
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F102047 Manufactured 06/2017	EXO Wiped CT 17F103252 Manufactured 06/2017	EXO Wiped CT 17F102685 Manufactured 06/2017
DO (cap life expectancy 18 months)	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 05/2019	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2019	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 03/2019
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H101465 Manufactured 08/2017	YSI EXO Turbidity 17H101468 Manufactured 08/2017	YSI EXO Turbidity 17H103513 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	- Serviced probes installed in Salty Lagoon 1/07/2020 - Sonde repaired under warranty 04/2019 - New batteries installed 1/09/2020	- Serviced probes installed in Salty Creek 1/09/2020 - New Batteries installed 1/09/2020	- Awaiting service and calibration - Probes Removed from Salty Creek 1/09/2020
Notes	- 218 days estimated battery life - Memory cleared – 50045.3 days logging available - pH probe needs new cap	- 218 days estimated battery life - Memory cleared – 50045.3 days logging available	- pH probe needs new cap

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 facility routine sampling information was provided by Richmond Valley Council.

Drawn by: DSA Checked by: AB Reviewed by: AB Date: 27/10/2020
Source of base data: Richmond Valley Council

Information shown is for illustrative purposes only



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 1 September 2020 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 1 September 2020

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**	**5000**	ns	**<100**	**<1000**	ns	**<1000**	**<100**	**0**	**<100**
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**	<0.010	ns	<0.010	0.01	ns	<0.010	0.043	**0.11**	<0.010
Total Kjeldahl Nitrogen (mg/L)	**1.6**	1.43	ns	1.05	1.49	ns	1.41	1.58	**1.63**	0.8
Total Nitrogen (mg/L)	**1.6**	1.43	ns	1.05	1.49	ns	1.41	1.58	**1.63**	0.8
Total Phosphorus(mg/L)	**0.14**	0.07	ns	0.03	0.07	ns	0.07	<0.03	**0.04**	<0.03
Orthophosphate (mg/L)	**0.11**	0.028	ns	0.017	0.031	ns	0.025	<0.010	**0.01**	<0.010
Chlorophyll-a (µg/L)	**5**	**8**	ns	<1	**5**	ns	**6**	<1	**3**	**4**
Enterococcus (CFU/100mL)	**170**	28	ns	14	16	ns	10	8	**40**	26
Faecal Coliforms (CFU/100mL)	**135**	24	ns	4	4	ns	0	4	**150**	16
Temp (˚C)	**25.9**	18.99	18.88	16.77	18.79	18.66	ns	16.07	**13.1 - 28.8**	22.06
pH	**6.9**	6.65	6.65	6.16	6.82	6.76	ns	5.09	**4.3 - 6.8**	6.35
ORP (mV)	**-**	164	145	184	182	184	ns	264	**-**	186
Cond (mS/cm)	**8.0**	0.862	0.862	0.587	0.864	0.864	ns	1.47	**0.3 - 21.5**	17.8
Turbidity (NTU)	**13**	5.6	6.7	0.9	4.9	6.4	ns	5.2	**11**	5.6
DO (mg/L)	**4.09**	7.4	7.17	**2.22**	8.23	7.89	ns	**3.05**	**5.52**	7.14
DO (% sat)	**-**	82.2	79.6	23.6	91.2	87.2	ns	32.1	**-**	88.8
TDS (mg/L)	**-**	0.552	0.552	0.376	0.553	0.553	ns	0.94	**-**	11
Sal (ppt)	**-**	0.4	0.4	0.3	0.4	0.4	ns	0.7	**-**	10.5
Depth (m)	**-**	Surface	1	Surface	Surface	1	Surface	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
TNTC = too numerous to count

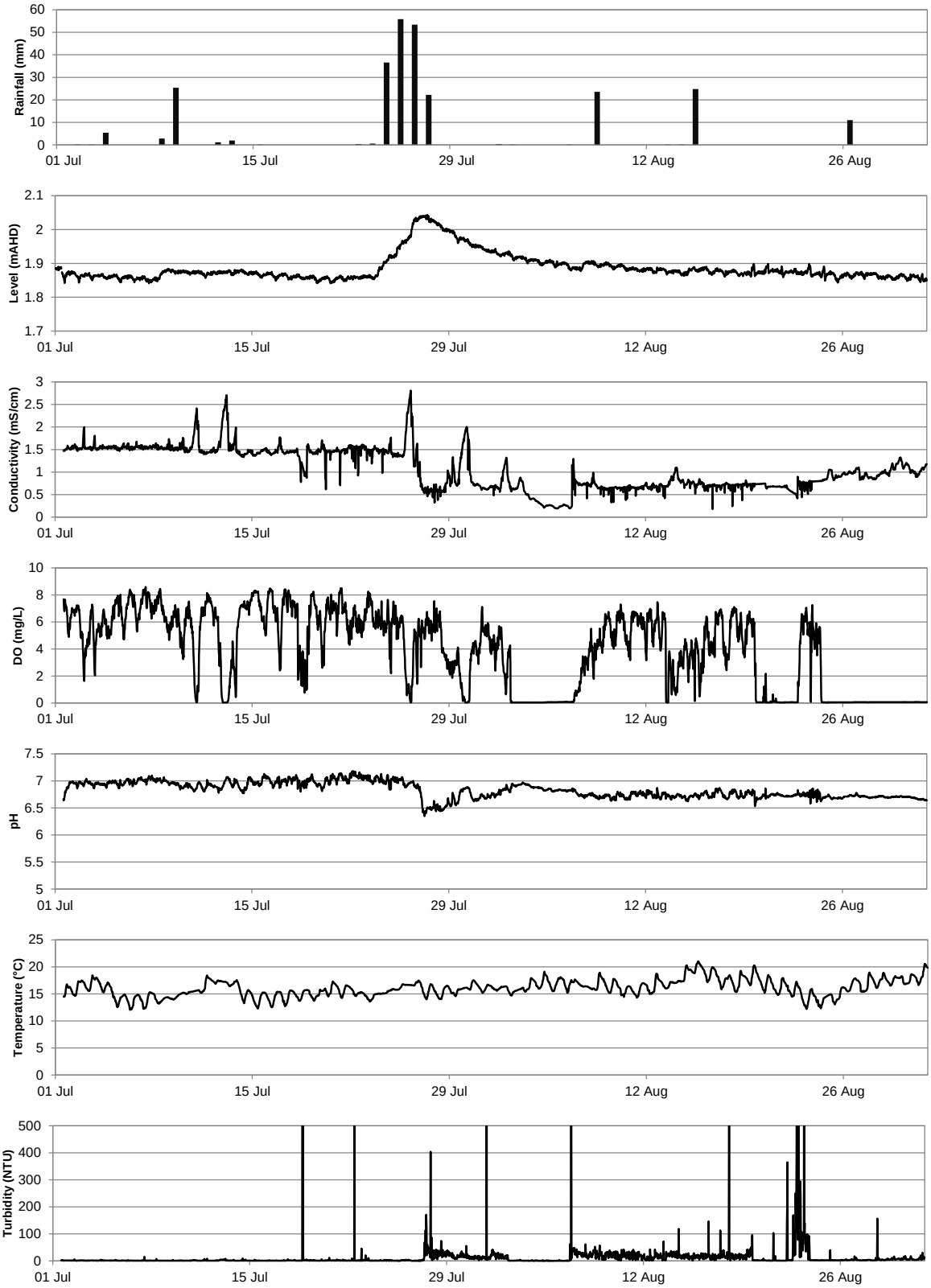
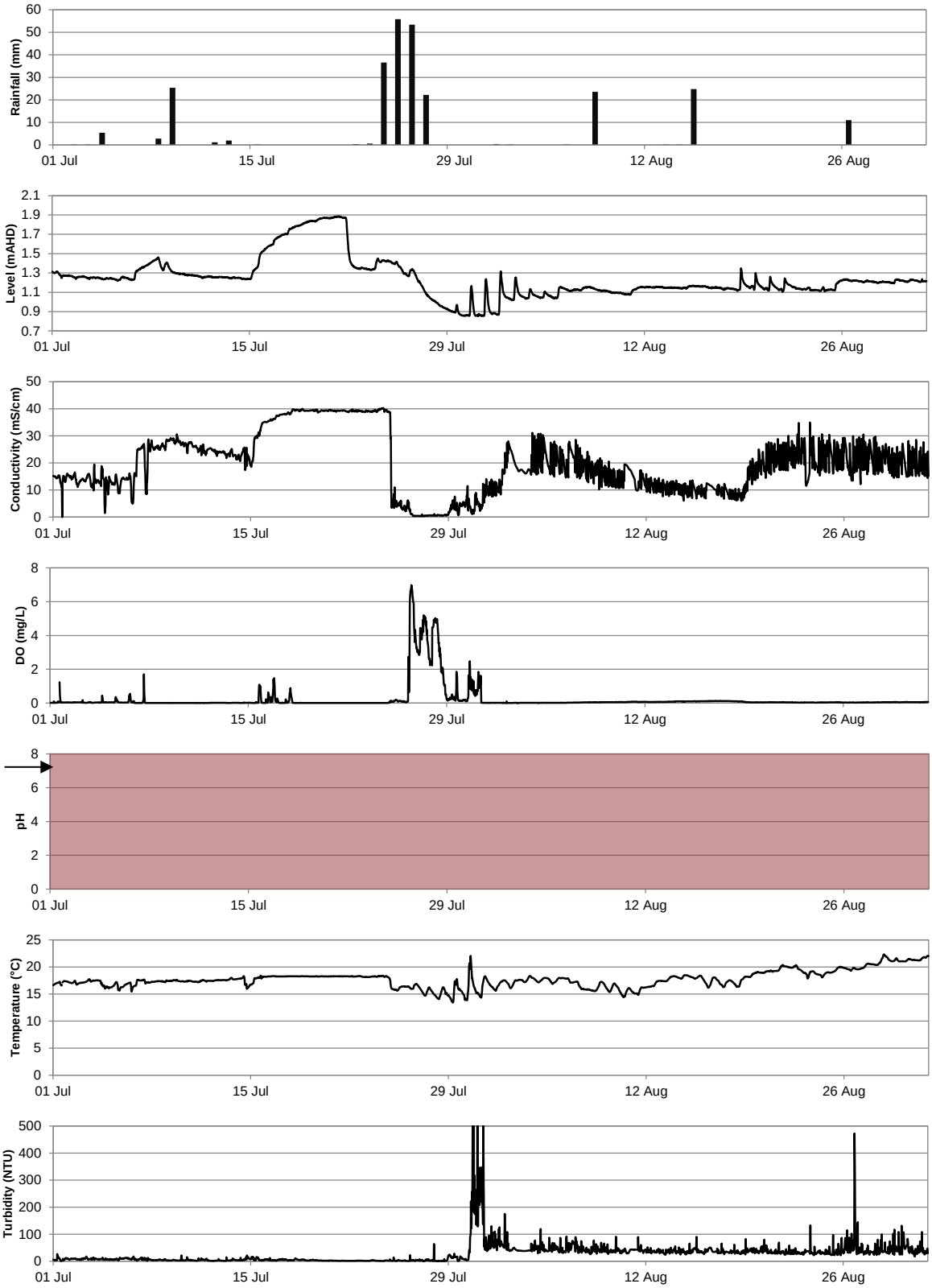


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 July 2020 to 31 August 2020



No Data. pH probe malfunction.

Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 July 2020 to 31 August 2020

3.3 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2** and **Illustration 3.3**. There was a small advance of the head cuts at two of the three impact stations in relation to the previous measurements on 1 July 2020. The head cut has advanced at least 27 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion Monitoring Results from 1 September 2020

Station	*Control/ Impact*	*Distance 25 July 2017 (m)*	*Distance 1 September 2020 (m)*	*Cut Movement (m)*
ER1	Control	7.55	7.35	0.20
ER2	Control	10.20	8.90	1.30
ER3	Control	9.95	9.90	0.05
ER4	Impact	8.35	-5.25	13.60
ER5	Impact	12.35	-15.55	27.90
ER6	Impact	10.40	6.15	4.25

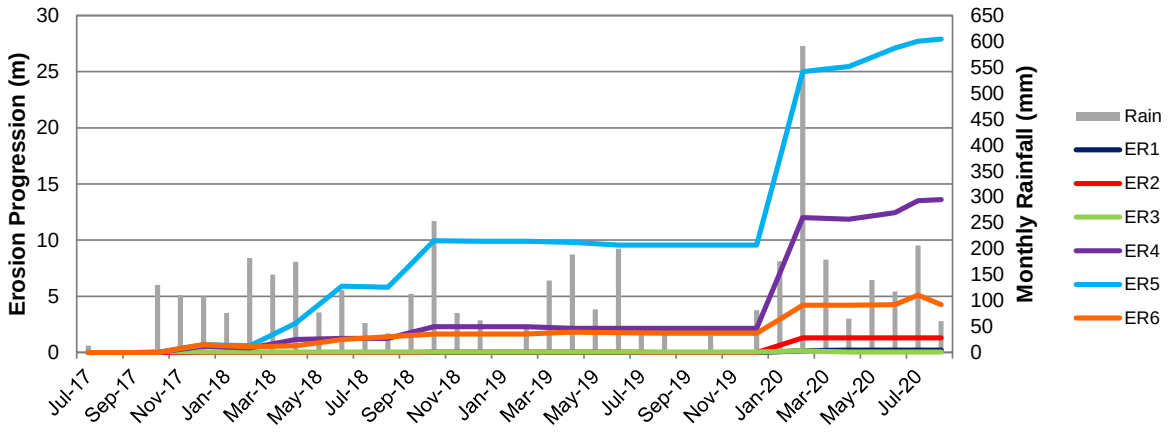


Illustration 3.3 Erosion progression plotted against monthly rainfall since July 2017

4. Discussion

4.1 Water Quality

The logged water quality data for this reporting period was slightly impacted by technical problems. The pH probe on the Salty Creek logger was malfunctioning for the entire monitoring period, probably due to an early demise of the pH cap for an unknown reason. At the time of writing the pH cap had been replaced.

Total rainfall for this reporting period comprised of several evenly spaced small to moderate events and one large event between 24 and 27 July 2020. The conductivity and level data from the Salty Creek PWQMS indicate that the entrance to Salty Creek was constricted from the beginning of the monitoring period and seawater ingress resulted in very high water levels until the entrance opened on 21 July 2020 and water drained quickly. Heavy rainfall in the week afterwards resulted in a further opening, very low water levels and fresh water conditions. Two short periods of tidal movements led to a return of saline water conditions. At the time of the site inspection on 1 September 2020, the entrance to Salty Creek was narrowly open, shallow and flowing slowing outwards. The water level in Salty Lagoon remained relatively high throughout this monitoring period, increasing significantly in response to the large rainfall event and decreasing slowly at other times, probably as water flowed out into Salty Creek (as observed during an adaptive management site inspection on 27 July 2020). Daily water level fluctuations in Salty Lagoon were low again during this reporting period due to lower temperatures and smaller temperature fluctuations.

The conductivity measured at the Salty Lagoon PWQMS decreased in response to the heavier rainfall, indicating that dilution by rainfall runoff was one of the factors driving water quality. The conductivity measurements at the Salty Creek PWQMS fluctuated in response to rainfall, seawater ingress and tidal movements. At the time of the site inspection on 1 September 2020 the water in Salty Lagoon was fresh and the water in Salty Creek was stratified into a freshwater surface layer and a brackish bottom layer. The conductivity measurements collected on 1 September 2020 complied with guiding values at all sites.

Erosion monitoring indicated that the head cut advanced slightly during this reporting period at two of the three impact sites. This was in response to sustained low level runoff from Salty Lagoon into Salty Creek and rapid runoff following the heaviest rainfall event. There was no advance of the head cuts at the control sites. The head cut is now approximately 14 m from the current banks of Salty Lagoon. If it reaches Salty Lagoon, the channel formed is highly likely to increase in size when tidal movements occur and some of the conditions that previously led to fish kills will be restored. Such a scenario could have an impact on future planning for the disposal of treated wastewater.

The DO concentrations in discrete samples collected on 1 July 2020 were below the guiding values at the two westernmost sites in Salty Lagoon. The DO concentrations measured at the other sites were healthy. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4). The data from the Salty Lagoon PWQMS indicates that the DO concentrations in Salty Lagoon were mostly healthy during this reporting period but that persistently low DO occurred over two short periods. The data from the Salty Creek PWQMS indicate that low DO concentrations persisted at the bottom of the water column for almost the entire monitoring period and healthy DO concentrations were only measured when mixing occurred in response to the largest rainfall event.

For the second consecutive monitoring period all of the nutrient concentrations in samples collected complied with guiding values. It is likely that dilution from rainfall resulted in lower nutrient concentrations in Salty Lagoon, in the same way it resulted in lower conductivity measurements. Chlorophyll-a concentrations, however, did not comply with guiding values at S1, S3, or S5. The chlorophyll-a concentrations measured indicated an algal bloom of small proportions. Algal concentrations are usually low in the winter months, particularly when low nutrient concentrations persist. Blue-green algae were recorded in all five samples, only the third time since MPPC monitoring commenced that blue-green algae have been detected. As nutrient concentrations remained low it is assumed that blue-green algae entered the system from further up in the catchment. Continued monitoring will determine whether there is any trend forming.

All other results complied with guiding values.

4.2 Other Observations

The entrance to Salty Creek was narrowly open on 1 September 2020. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Pelican, Black Swan, Pied Cormorant and Little Black Cormorant.

Plate 4.1 The open entrance to Salty Creek on 1 September 2020

Plate 4.2 The erosive headcut is now within approximately 14 m of Salty Lagoon

5. Key Points

1. Water levels remained high in Salty Lagoon throughout the current monitoring period. Water levels in and Salty Creek were dynamically variable in response to rainfall conditions, entrance status and seawater ingress.
2. Only a small number of results did not comply with the guiding values.
3. Nutrient and chlorophyll-a concentrations remained low but chlorophyll-a concentrations did not comply with guiding values at three sites.
4. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek advanced slightly south towards Salty Lagoon and west during this reporting period. There is a continued risk that the eroding channel will break into Salty Lagoon during the next heavy rainfall, or if moderate rainfall conditions persist for an extended period.
5. The risk rating for the Salty Lagoon Response Protocol is 'uncertain', due to the potential for the erosive channel to break into Salty Lagoon. Heavy rainfall may lead to a 'high' risk rating and require a site inspection in the coming months. An adaptive management site inspection was undertaken in response to heavy rainfall on 27 July 2020. No environmental incident was recorded but the headcut was noted to have advanced towards Salty Lagoon.

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