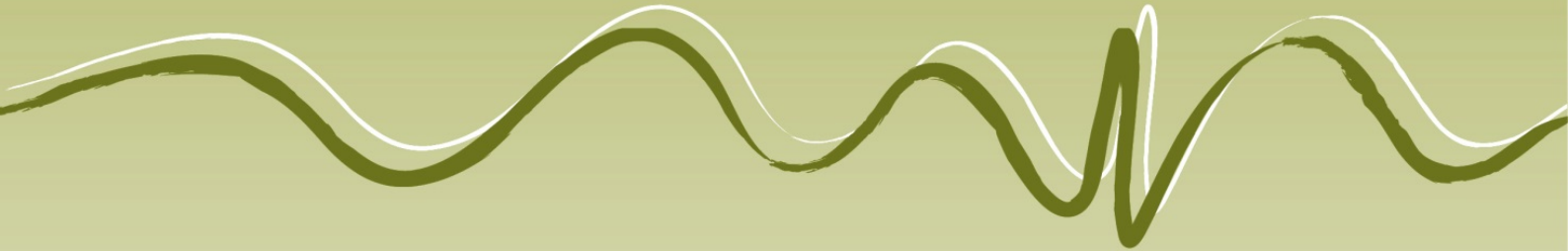


Salty Lagoon

Post Closure Monitoring

Project Management and Ecosystem Health Report

June 2018



AQUATIC SCIENCE AND MANAGEMENT

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1. Introduction

1.1 Introduction

This document comprises the fifth bi-monthly monitoring report for the Salty Lagoon Post-Closure monitoring years 6-10 (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 May 2018 until 30 June 2018.

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

The fifth bi-monthly site visit for post-closure monitoring at Salty Lagoon included routine maintenance of permanent water quality monitoring stations and discrete water quality sampling. The site visit was undertaken on 2 July 2018. Water quality samples were collected between the hours of 3:00 pm and 5:30 pm on that day. A low tide of 0.66 metres was forecast for 4.29 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 S1. 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 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.

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

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

2.4 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 are installed at each PWQMS and a third HOBO was installed at S1 to collect barometric pressure data for offsetting atmospheric pressure variability.

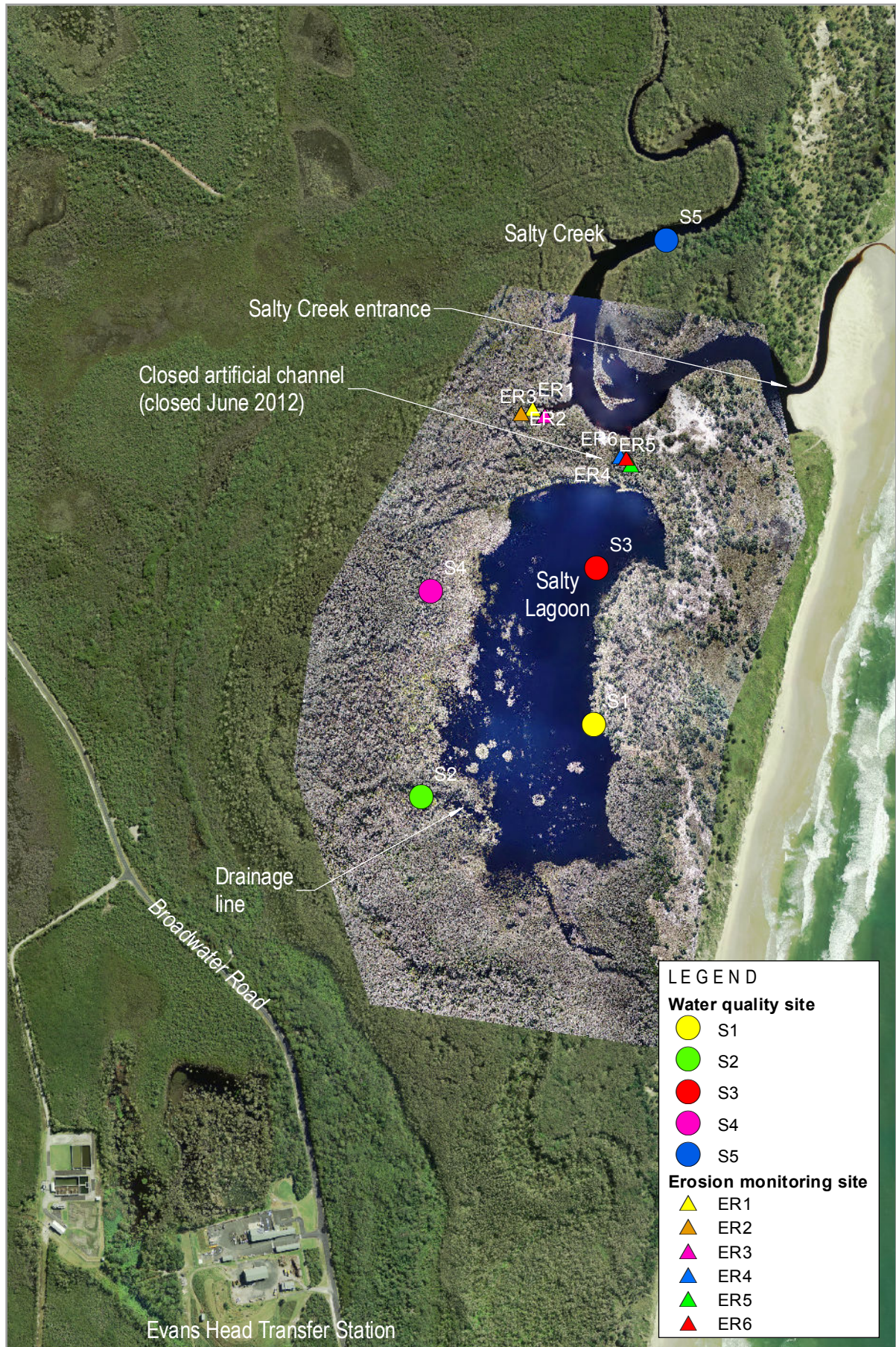
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sondes installed at the Salty Creek PWQMS were removed and replaced by a calibrated and serviced set.

The status of the two YSI EXO3 sondes on 02 July 2018 is displayed in **Table 2.3**.

Table 2.3 YSI sonde Status on 02 July 2018

Sonde	SN17F104100	SN 17H104488	Spare Probes
pH (cap life expectancy 18 months)	EXO pH 17H105049 Manufactured 08/2017	EXO pH 17H105047 Manufactured 08/2017	EXO pH 17H105048 Manufactured 08/2017
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 18 months)	EXO Optical DO 17H103494 Manufactured 08/2017	EXO Optical DO 17H103493 Manufactured 08/2017	EXO Optical DO 17H103495 Manufactured 08/2017
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	YSI Exo Wiper 17G101954	No Spare wiper
Status	Serviced probes installed in Salty Lagoon 01/05/2018	Serviced probes installed in Salty Creek 02/07/2018	Probes being calibrated for redeployment
Notes	- Estimated sonde battery life 135 days - Memory 50045.3 days logging	- Estimated sonde battery life 166.2 days - Memory 50045.3 days logging	- Probes Removed 02/07/2018

Climate information was sourced from the Evans Head bombing range weather station on the Bureau of Meteorology website (BoM 2018). Evans Head Sewage Treatment Plant (STP) facility routine sampling information was provided by Richmond Valley Council (RVC).



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Water Quality and Erosion Monitoring Site Locations

Salty Lagoon Project Management & Ecosystem Health Report, June 2018
1731-1297

Illustration 2.1



3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 02 July 2018 are reported in **Table 3.1**.

3.2 Permanent Water Quality Monitoring Stations

The water quality and level 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 02 July 2018

<i>Parameter</i>	<i>Salty Lagoon</i>								<i>Salty Creek</i>	
	<i>Guiding Value</i>	<i>S1</i>	<i>S1* (QA)</i>	<i>S1 (1m)</i>	<i>S2</i>	<i>S3</i>	<i>S3 (1m)</i>	<i>S4</i>	<i>Guiding Value</i>	<i>S5</i>
Blue Green Algae ID (cells/mL)	0	Nil	Nil	ns	Nil	Nil	ns	Nil	0	Nil
Nitrite Nitrogen (mg/L)	0.01	<0.010	<0.010	ns	<0.010	<0.010	ns	<0.010	0.01	<0.010
Nitrate Nitrogen (mg/L)	0.01	0.026	0.023	ns	<0.010	0.02	ns	<0.010	0.01	<0.010
Oxidized Nitrogen (mg/L)	-	0.026	0.023	ns	<0.010	0.02	ns	<0.010	-	<0.010
Ammonia Nitrogen (mg/L)	0.05	0.01	<0.010	ns	<0.010	<0.010	ns	<0.010	0.11	<0.010
Total Kjeldahl Nitrogen (mg/L)	1.6	1.1	1.08	ns	0.93	1.15	ns	1.33	1.63	1.16
Total Nitrogen (mg/L)	1.6	1.13	1.1	ns	0.93	1.17	ns	1.33	1.63	1.16
Total Phosphorus(mg/L)	0.14	0.07	0.07	ns	0.06	0.07	ns	<0.03	0.04	<0.03
Orthophosphate (mg/L)	0.11	0.049	0.05	ns	0.051	0.05	ns	<0.010	0.01	<0.010
Chlorophyll-a (µg/L)	5	<1	<1	ns	<1	2	ns	2	3	<1
Enterococcus (CFU/100mL)	170	115	45	ns	225	335	ns	415	40	220
Faecal Coliforms (CFU/100mL)	135	0	4	ns	210	12	ns	2	150	22
Temp (°C)	25.9	16.04	ns	16.06	13.41	15.94	15.87	14.39	13.1 - 28.8	16.89
pH	6.9	6.72	ns	6.7	6.04	7.11	7	5.49	4.3 - 6.8	4.06
ORP (mV)	-	208	ns	211	214	186	193	237	-	290
Cond (mS/cm)	8.0	1.04	ns	1.04	0.415	1.03	1.03	0.96	0.3 - 21.5	1.56
Turbidity (NTU)	13	0.8	ns	0.5	0	0.8	1.1	0	11	0
DO (mg/L)	4.09	7.54	ns	7.51	2.97	7.88	7.81	6.25	5.52	7.28
DO (% sat)	-	79.1	ns	78.8	29.5	82.5	81.7	63.3	-	77.9
TDS (mg/L)	-	0.665	ns	0.669	0.27	0.661	0.659	0.614	-	0.997
Sal (ppt)	-	0.5	ns	0.5	0.2	0.5	0.5	0.5	-	0.8
Depth (m)	-	Surface	Surface	1m	Surface	Surface	1m	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

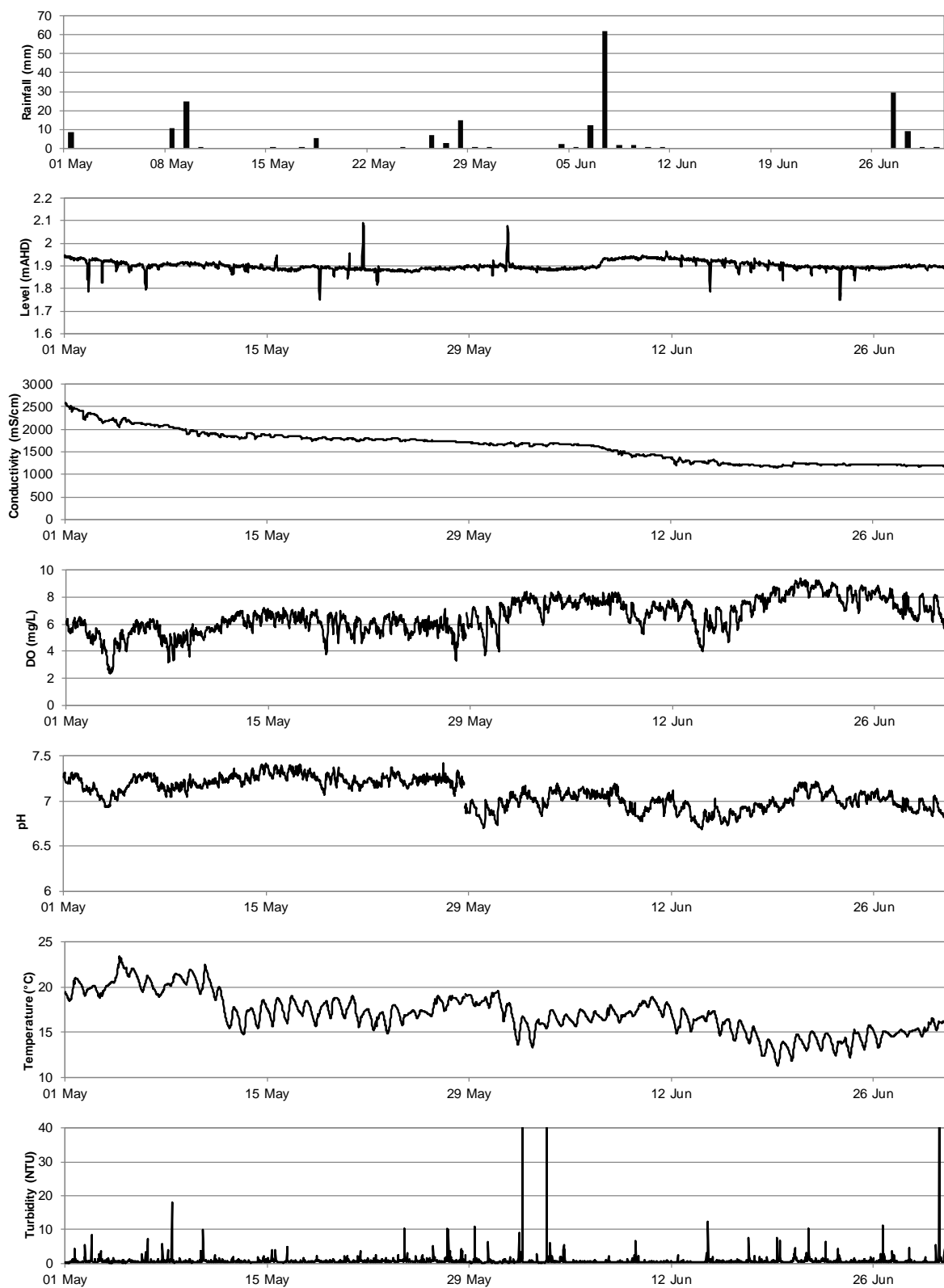


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 May 2018 until 30 June 2018

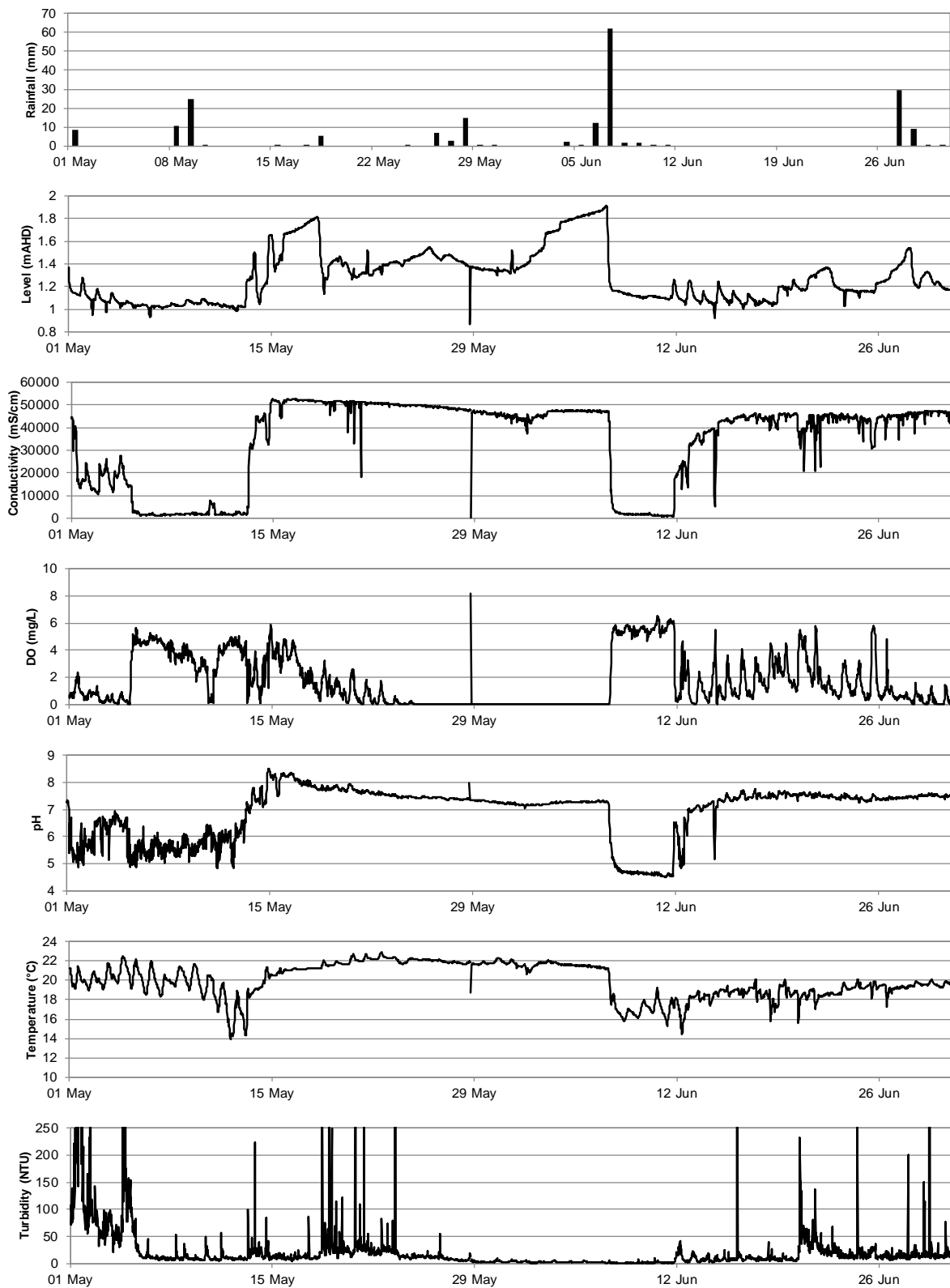


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 May 2018 until 30 June 2018

3.3 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2**. There was variable advance of the head cut at the three impact stations in relation to the previous measurements in April 2018. There was no advance at any of the control stations.

Table 3.2 Erosion monitoring results from 01 May 2018

Station	Control/Impact	Distance 25 July 2017 (m)	Distance 02 July 2018 (m)	Cut Movement (m)
ER1	Control	7.55	7.55	0.00
ER2	Control	10.20	10.25	-0.05
ER3	Control	9.95	9.90	0.05
ER4	Impact	8.35	7.10	1.25
ER5	Impact	12.35	6.45	5.90
ER6	Impact	10.40	9.25	1.15



4. Discussion

4.1 Water Quality


There were several small to moderate rainfall events during this reporting period and one heavy rainfall event (on 6 June 2018). The water level in Salty Lagoon remained relatively stable throughout the monitoring period but the water level in Salty Creek was dynamic, fluctuating in response to a combination of rainfall runoff, seawater ingress, the state of the entrance and tidal movements. Only the heavy rainfall event appears to have had an impact upon water levels and quality in Salty Creek. The data from the Salty Creek PWQMS indicates that the entrance to Salty Creek was open and tidal for some of the reporting period and closed on at least two occasions. Water appears to have flowed out of Salty Lagoon into Salty Creek for the entire monitoring period. At the time of the site inspection on 2 July 2018, the entrance to Salty Creek was open and there was evidence of tidal movements.

Erosion monitoring indicated that the head cut has advanced between 1.15 and 5.9 m since July 2017 in three distinct locations. Measurements collected during this reporting period indicate that the head cut advanced significantly in the past two months, up to 3.3m at one site. There has been little or no advancement of the head cuts at the control sites. This indicates that, either the control sites are inherently more stable or that water is leaving Salty Lagoon preferentially through the pathway to the east of the old artificial channel.

Conductivity measurements from the PWQMS in Salty Lagoon and Salty Creek clearly show the impact of rainfall, seawater ingress and saline water movements on Salty Creek and Salty Lagoon. Conductivity in Salty Lagoon reduced gradually for the second consecutive reporting period and has now returned to levels commonly associated with freshwater environments. At the time of the site inspection the water column was well mixed at the Salty Lagoon sites. Results from the Salty Creek PWQMS show that the conductivity in Salty Creek fluctuated dynamically throughout the reporting period in response to rainfall, seawater ingress, entrance conditions and tidal movements. On 2 July 2018 at the Salty Creek site the water column was distinctly stratified into a fresh upper layer and saline lower layer. This is typical in Salty Creek when seawater ingress is followed by rainfall runoff.

The DO concentrations in discrete samples collected on 2 July 2018 were typical at all sites, except S4 which, unusually, complied with the guiding values for the second consecutive reporting period. The DO concentrations also complied with guiding values in the open water sites of Salty Lagoon but not at S2, which is usually oxygen poor. The DO concentration at the Salty Creek also complied with guiding values. The DO concentrations measured at the Salty Lagoon PWQMS were relatively stable throughout the monitoring period, indicating that diurnal fluctuations in light availability were the major source of variation. The DO concentrations measured at the Salty Creek PWQMS were highly variable, with a strong, inverse relationship between DO concentration and conductivity apparent. This common pattern indicates that seawater ingress disrupts the biological processes, such as microalgal photosynthesis, that release oxygen into the water column.

All of the nutrient concentrations complied with guiding values for this reporting period except for the nitrate concentrations from S1 and S3. The chlorophyll-a concentrations complied with the guiding values at all sites. This is the second consecutive reporting period where this has been the case. Such reductions of nutrient concentrations following significant rainfall events indicate that historical nutrient pollution is the cause of elevated nutrient concentrations in Salty Lagoon and also that continued nutrient loss to the system will eventually result in lower average nutrient concentrations. There were no blue-green algae detected in any samples.



Other results that did not comply with guiding values included the pH measurements from S3 and S5; the enterococcus concentrations from S2, S3, S4 and S5; and the faecal coliform concentrations from S2. All other measurements complied with guiding values. High pH measurements from S3 are common, particularly in times where saline water ingress has occurred. There appears to be some pH buffering pathway operating in the open water area of Salty Lagoon because the inflow from the catchment is typically of low to very low pH. The high faecal indicator organism concentrations at S2, S3, S4 and S5 are likely to be associated with waterbird use of those areas and rainfall runoff in the days prior to the site inspection. There is no current trend towards high faecal indicator organism concentrations in Salty Lagoon or Salty Creek.

4.2 Erosion Monitoring

The impact headcuts advanced significantly during this monitoring period while there was no movement at the control headcuts. There has been a total advance of between 1.15 m and 5.9 m in the impact headcuts since the monitoring points were established in July 2017 and an increase in the past two months of up between 0.1 and 3.3m.

4.3 Other Observations

The entrance to Salty Creek was open on 02 July 2018 (**Plate 4.1**). A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Australasian Grebe, Eurasian Coot, Black Swan, Pelican, Great Egret, Darter and Little Black Cormorant.



Plate 4.1 Water draining from the open entrance to Salty Creek on 2 July 2018



Plate 4.2 Calm late afternoon conditions on Salty Lagoon

5. Key Points

1. Salty Lagoon has returned to freshwater conditions following significant rainfall. At Salty Creek, tidal movements and seawater ingress also influenced water quality.
2. A small number of results did not comply with the guiding values.
3. Total nutrient concentrations were relatively low at all sites. Bioavailable nitrogen concentrations were moderately high at the open water sites in Salty Lagoon.
4. Chlorophyll-a concentrations complied with guiding values at all sites. No BGA were detected.
5. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek advanced significantly during this reporting period (**Plates 4.3 and 4.4**).



Plate 4.3 Erosion monitoring site E5 in July 2017



Plate 4.4 Erosion monitoring site E5 in July 2018, showing an advance of 5.9m



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