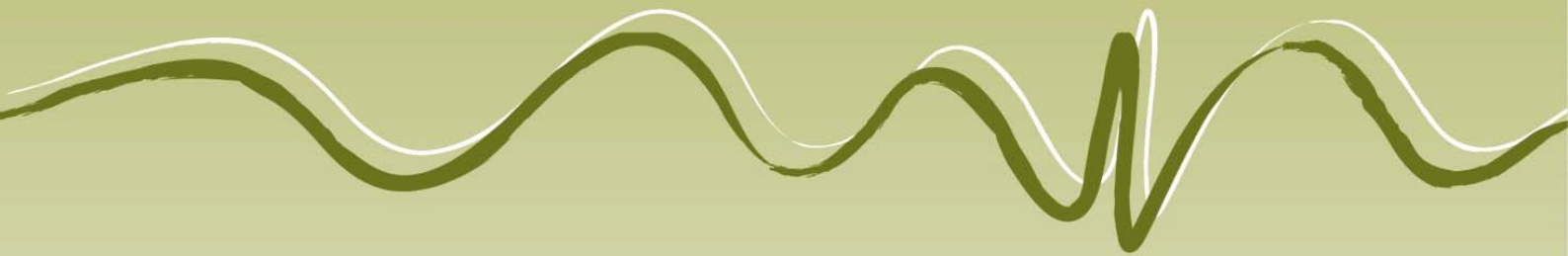


Salty Lagoon

Post Closure Monitoring

Project Management and Ecosystem Health Report

February 2018



AQUATIC SCIENCE AND MANAGEMENT

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<i>UPR</i>	<i>Description</i>	<i>Date Issued</i>	<i>Issued By</i>
1731-1300	First issue	10/04/2018	David Andrighetto



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1. Introduction

1.1 Introduction

This document comprises the third 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 January 2018 until 28 February 2018.

1.2 Guiding Values

Guiding values were developed for Salty Lagoon and Salty Creek as part of the MPPC program (GeoLINK 2012). They were developed 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 of the bi-monthly site visits for 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 28 February 2018. Water quality samples were collected between the hours of 7:00 am and 11:00 am on that day. A high tide of 1.89 metres was forecast for 7.45 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 S4. 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 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 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 will be downloaded at bi-monthly intervals for reporting purposes.

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

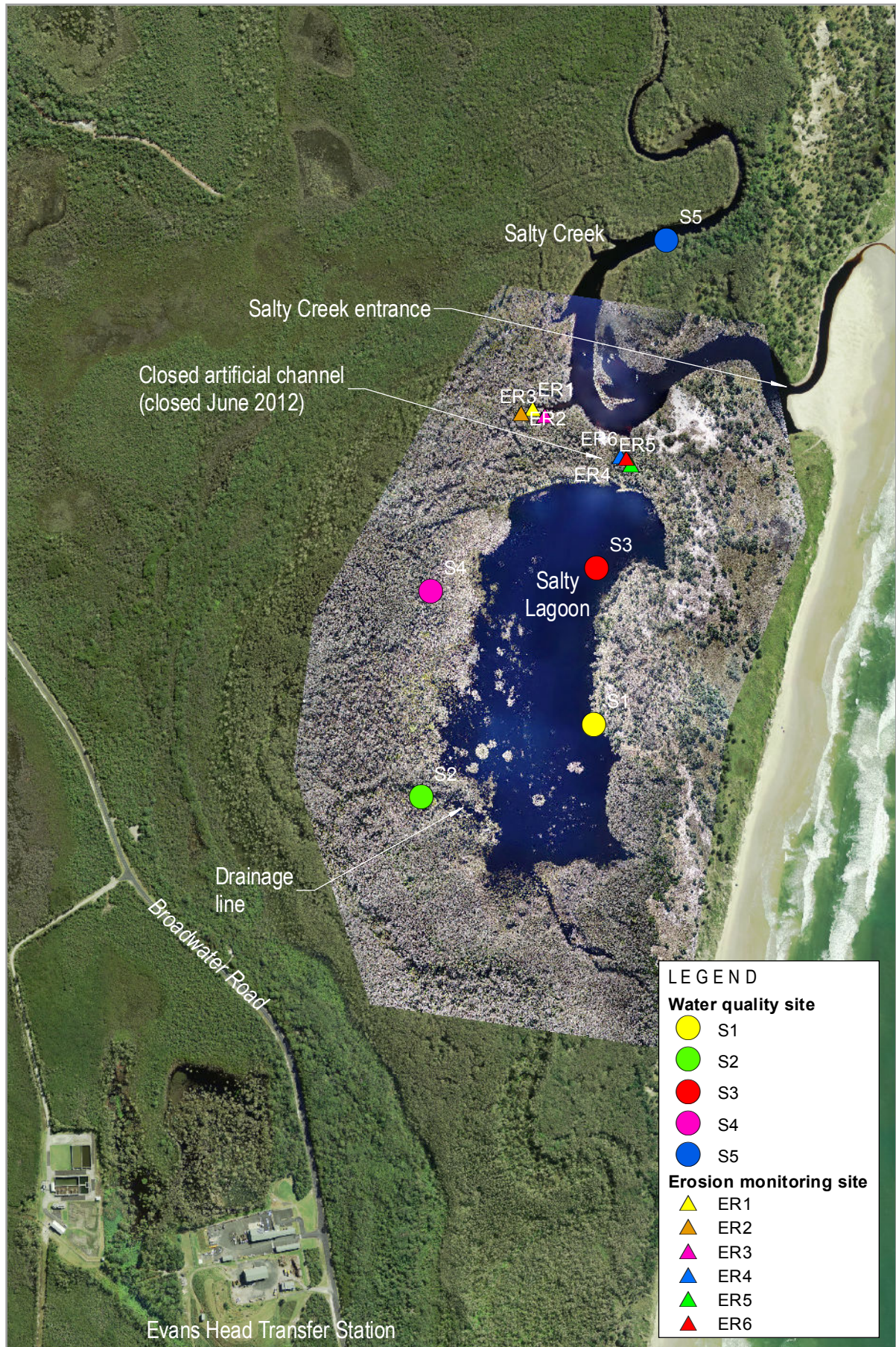
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sondes installed at the Salty Creek PWQMS were removed and replaced by a calibrated set.

The status of the two YSI EXO3 sondes on 28 February 2018 is displayed in **Table 2.3**.

Table 2.3 YSI sonde Status on 28 February 2018

Sonde	SN17F104100	SN 17H104488	Spare Probes
pH (cap life expectancy 18 months)	YSI EXO pH 17H105047 Manufactured 08/2017	EXO pH 17H105048 Manufactured 08/2017	EXO pH 17H105049 Manufactured 08/2017
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	EXO Optical DO 17H103495 Manufactured 08/2017	EXO Optical DO 17H103494 Manufactured 08/2017
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	YSI Exo Wiper 17G101954	No Spare wiper
Status	New probes installed in Salty Lagoon 11/01/2018	Serviced probes installed in Salty Creek 28/02/2018	Probes being calibrated for redeployment
Notes	<ul style="list-style-type: none"> - First deployment of probes - Probes manufacture calibrated - Batteries changed - Estimated sonde battery life 217.9 days - Memory 50045.3 days logging 	<ul style="list-style-type: none"> - Batteries changed - Estimated sonde battery life 217.9 days - Memory 50045.3 days logging 	<ul style="list-style-type: none"> - Probes Removed 28/02/2018

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



3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 28 February 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**. The water level loggers were installed on 11 January 2018 so water level data is only available from that date.

Table 3.1 Results of Discrete Samples Collected 28 February 2018

Parameter	Salty Lagoon								Salty Creek	
	Guiding Value	S1	S1 (1m)	S2	S3	S3 (1m)	S4	S4* (QA)	Guiding Value	S5
Blue Green Algae ID (cells/mL)	0	Nil	ns	Nil	Nil	ns	Nil	Nil	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	0.02	ns	<0.010	0.015	ns	<0.010	<0.010	0.11	<0.010
Total Kjeldahl Nitrogen (mg/L)	1.6	1.15	ns	1.68	1.09	ns	2.22	2.18	1.63	1.37
Total Nitrogen (mg/L)	1.6	1.15	ns	1.68	1.09	ns	2.22	2.18	1.63	1.37
Total Phosphorus(mg/L)	0.14	0.05	ns	0.15	0.05	ns	0.12	0.1	0.04	<0.03
Orthophosphate (mg/L)	0.11	0.027	ns	0.062	0.025	ns	<0.010	<0.010	0.01	<0.010
Chlorophyll-a (µg/L)	5	<1	ns	5	3	ns	15	13	3	<1
Enterococcus (CFU/100mL)	170	10	ns	125	10	ns	330	300	40	<5
Faecal Coliforms (CFU/100mL)	135	162	ns	560	94	ns	TNTC >1000	TNTC >1000	150	214
Temp (°C)	25.9	24.4	24.55	23.25	24.33	24.46	23.94	ns	13.1 - 28.8	26.79
pH	6.9	7.09	7.05	6.23	6.92	7.05	6.24	ns	4.3 - 6.8	4.32
ORP (mV)	-	163	166	-83	155	161	-68	ns	-	289
Cond (mS/cm)	8.0	11.5	11.6	7.25	11.5	11.7	7.27	ns	0.3 - 21.5	0.99
Turbidity (NTU)	13	1.1	1	28.3	12.9	6.1	63	ns	11	1
DO (mg/L)	4.09	5.83	5.55	0.8	6.91	6.43	0.5	ns	5.52	4.12
DO (% sat)	-	73.7	70.4	9.8	87.4	81.4	6.2	ns	-	52.4
TDS (mg/L)	-	7.13	7.2	4.57	7.16	7.23	4.58	ns	-	0.634
Sal (ppt)	-	6.5	6.6	4	6.6	6.6	4	ns	-	0.5
Depth (m)	-	Surface	1m	Surface	Surface	1m	Surface	Surface	-	Surface

Note: * = randomly selected quality assurance sample.

TNTC = Too numerous to count

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

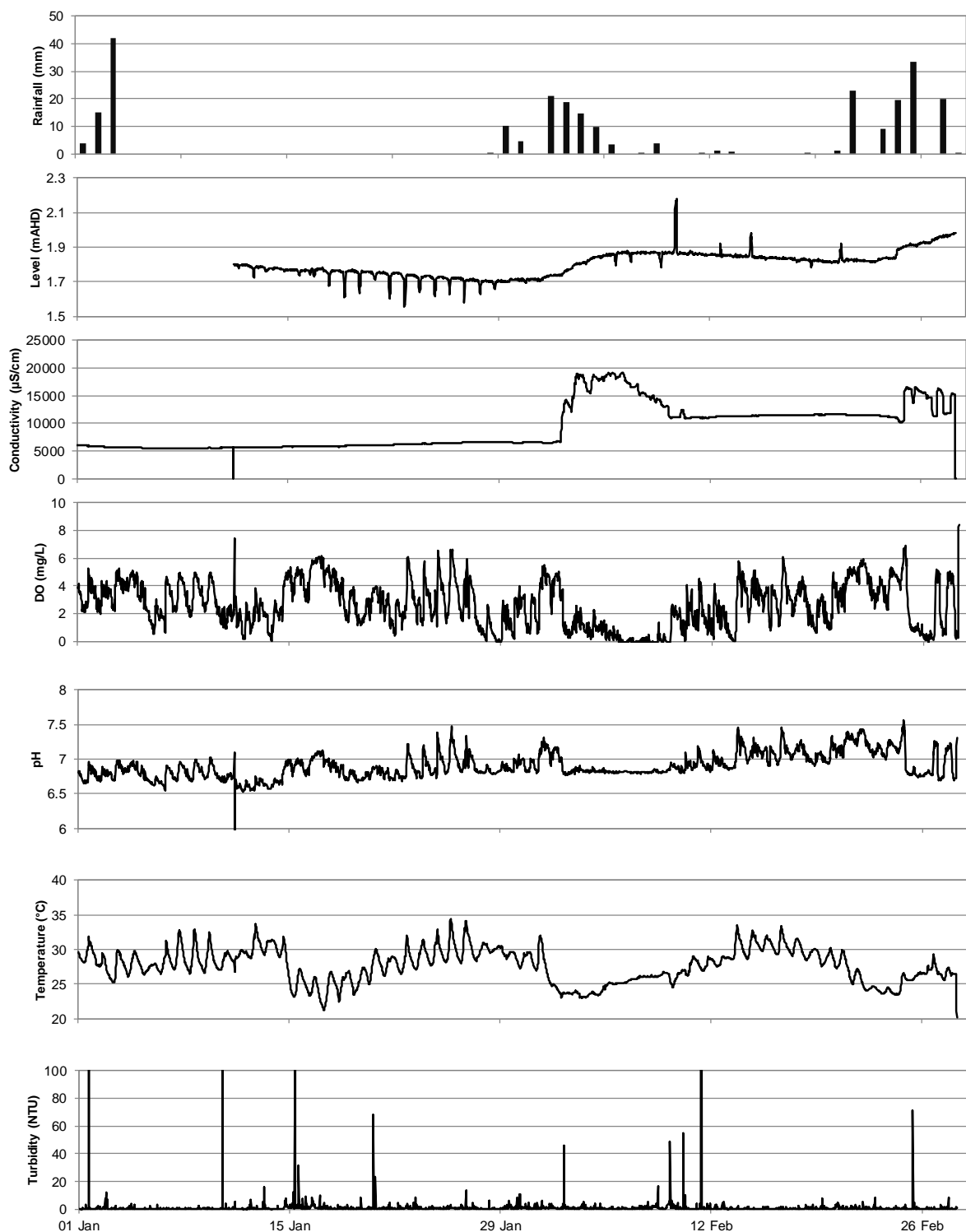


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 January 2018 to 28 February 2018

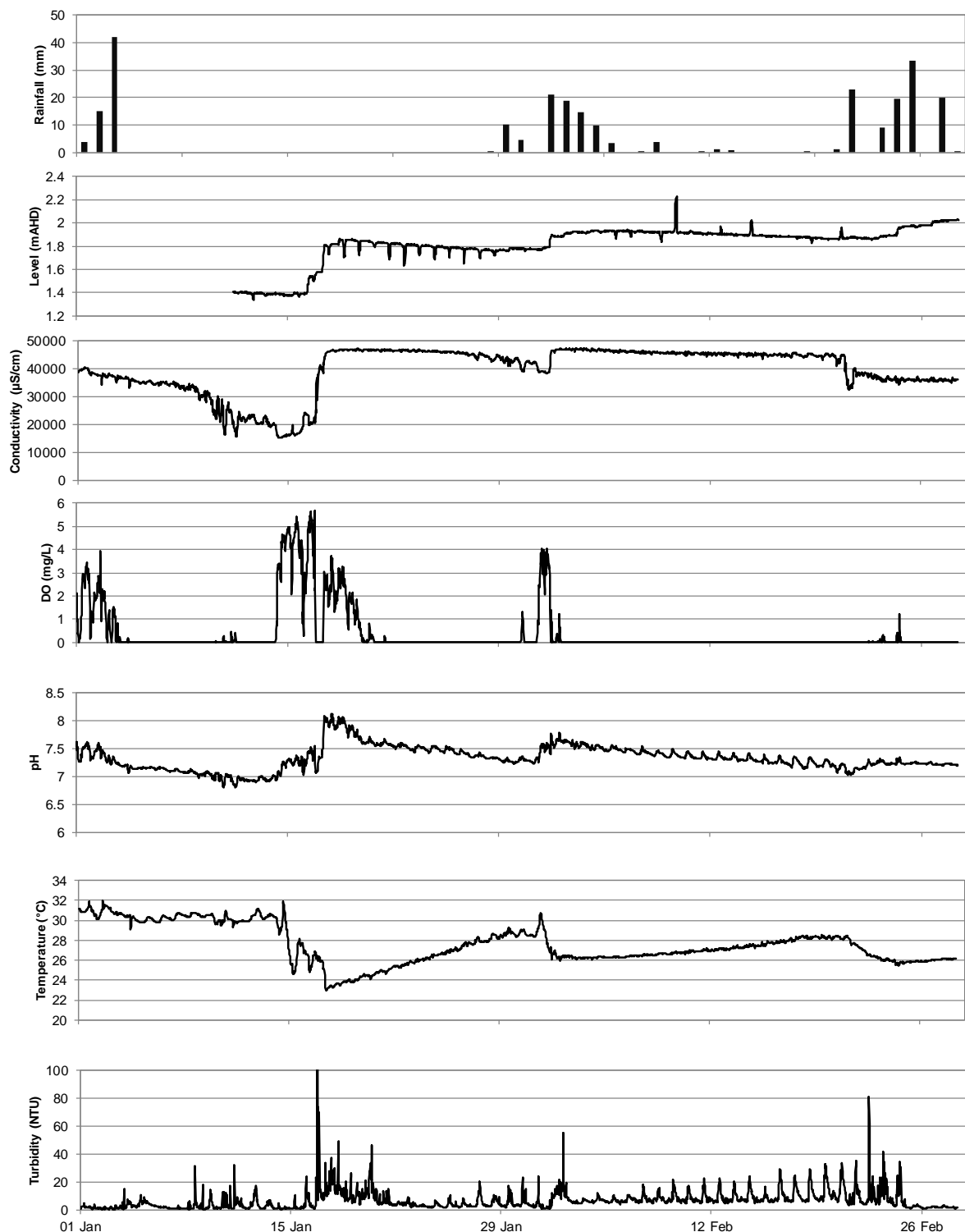


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 January 2018 to 28 February 2018

3.3 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2**. There was a clear advance of the head cut at the three impact stations between October 2017 and 11 January 2018, though no advancement between 11 January and 28 February 2018.

Table 3.2 Erosion monitoring results from 28 February 2018

<i>Station</i>	<i>Control/Impact</i>	<i>Distance 25 July 2017 (m)</i>	<i>Distance 28 February 2018 (m)</i>	<i>Cut Movement (m)</i>
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	7.95	0.40
ER5	Impact	12.35	11.75	0.60
ER6	Impact	10.40	9.90	0.50



4. Discussion

4.1 Water Quality


There were three distinct periods of moderate to heavy rainfall during this reporting period, each spanning between three days and a week. There were also a number of small rainfall events. However, seawater ingress had a greater impact upon water levels and quality. The data from the Salty Creek PWQMS indicates that the entrance to Salty Creek was closed for the majority of the reporting period but that there were two seawater ingress events that led to increased water levels and conductivity measurements. The final period of rainfall further increased the water level in Salty Creek resulting in (relatively) very high levels. The level and conductivity data from the Salty Lagoon PWQMS indicates that saline water from Salty Creek flowed into Salty Lagoon on two occasions, 1 February and 24 February 2018. On the first of these occasions the water levels in Salty Creek had increased in response to both saline water ingress and rainfall. On the second occasion the levels increased in response to rainfall only. At the time of the site inspection on 28 February 2018 the entrance to Salty Creek was closed and water levels were still very high.

Erosion monitoring indicated that the head cut has advanced between 0.4 and 0.6 m since July 2017 in three distinct locations. These measurements indicate that the head cut did not advance at all during this reporting period. There has been little or no advancement of the head cuts at the control sites. This indicates that water has not been moving from Salty Lagoon into Salty Creek in high volumes. The status of this can be expected to change significantly when the entrance to Salty Creek next opens and Salty Creek drains to low levels.

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. At the time of the site inspection the conductivity measurements in the open water parts of Salty Lagoon were higher than the guiding values. The conductivity measurements from the western sites in Salty Lagoon complied with guiding values but were still among the highest measurements since the closure of the artificial channel. The water column was well mixed at the Salty Lagoon sites. 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 28 February 2018 were typical at all sites. The DO concentrations complied with guiding values in the open water sites of Salty Lagoon but not at the two westernmost sites in Salty Lagoon, which are usually oxygen poor. The DO concentration at the Salty Creek site did not comply with guiding values. Low DO concentrations in Salty Creek are often associated with seawater ingress.

Most of the nutrient concentrations complied with guiding values for this reporting period with the exception of the TN concentrations from S2 and S4 and the TP concentration from S2. The chlorophyll-a concentrations did not comply with the guiding value at S2 and S4 also. The results suggest an algal bloom of minor to moderate proportions at those two sites. Prolonged unusually brackish conditions at these sites may have led to an increased rate of dead and decaying plant matter, resulting in increased nutrient concentrations. At S2 there was a notable brown algal bloom, species unknown, in the water column just below the surface (**Plate 4.2**). There were no blue-green algae detected in any samples.



Other results that did not comply with guiding values included the pH measurements from S1 and S3, the turbidity measurements from S2 and S4, the enterococcus concentrations from S4 and the faecal coliform concentrations from S1, S2, S4 and S5. All other measurements complied with guiding values. The high pH measurements from S1 and S3 are likely to be associated with the continued presence of saline water. The high faecal indicator organism concentrations at S1, S2, S4 (particularly) 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. The high turbidity measurements from S2 and S4 are most likely to be associated with algal growth.

4.2 Erosion Monitoring

The impact and control headcuts did not advance during this monitoring period. However, there has been some advance in the impact headcuts since the monitoring points were established in July 2017. The high water levels in Salty Lagoon at the time of the survey imply that the impact headcuts will advance when water levels in Salty Creek reduce.

4.3 Other Observations

The entrance to Salty Creek was closed on 28 February 2018 (**Plate 4.1**). A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, White-eyed Duck, Australasian Grebe, Eurasian Coot, Dusky Moorhen, Black Swan, Pelican, Intermediate Egret, Darter, Pied Cormorant, Little Black Cormorant and Little Pied Cormorant. There was an unusual brown algal bloom at S2 (**Plate 4.2**).



Plate 4.1 The closed entrance to Salty Creek on 28 February 2018



Plate 4.2 An unusual brown algal bloom at S2 on 28 February 2018



5. Key Points

1. Significant rainfall fell during this monitoring period but seawater ingress and saline water movement from Salty Creek into Salty Lagoon was the key aspect controlling water quality.
2. A relatively high number of results did not comply with the guiding values.
3. Total nutrient concentrations were high at the western sites, S2 and S4, in Salty Lagoon but bioavailable nutrients concentrations remained relatively low.
4. Chlorophyll-a concentrations did not comply with guiding values at S2 and S4, indicating an algal bloom of minor proportions. An algal bloom of an unidentified species was visible at S2.
5. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek did not advance in this reporting period.



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