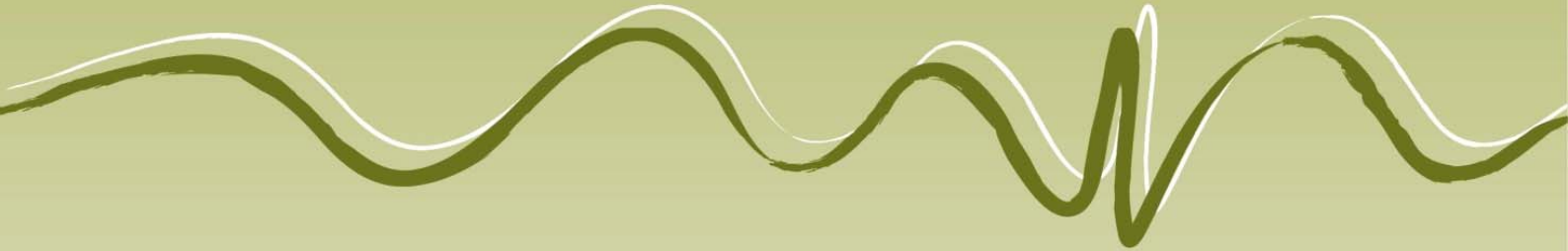


Salty Lagoon Post Closure Monitoring

Project Management and Ecosystem Health Report
February 2019



GeoLINK
environmental management and design

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1. Introduction

1.1 Introduction

This document comprises the fourth bi-monthly monitoring report for year 7 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 January 2019 until 28 February 2019.

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 fourth bi-monthly site visit for year 7 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 11 March 2019. Water quality samples were collected between the hours of 6:30 am and 11:00 am on that day. A low tide of 0.52 metres was forecast for 6.01 am.

Discrete water quality samples were taken from surface water (approximately 0.2 metre 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. There was no water at site 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 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 for the autumn 2019 season was undertaken during the site inspection for this reporting period on 11 March 2019.

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.

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
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.

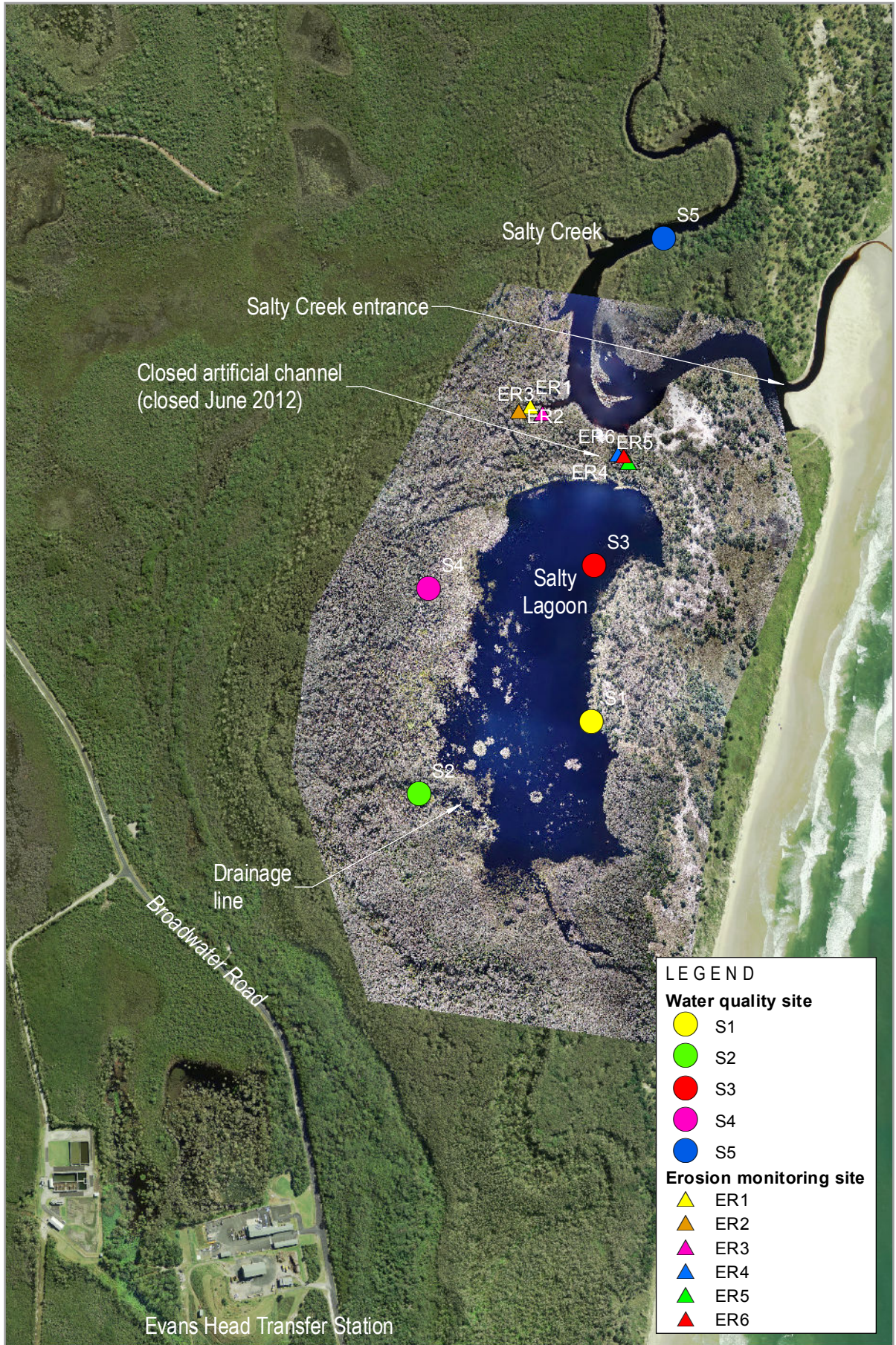
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sonde installed at the Salty Creek PWQMS were removed on 11 March 2019 and replaced by a serviced and calibrated set.

The status of the two YSI EXO3 sondes on 11 March 2019 is displayed in **Table 2.3**. There was a problem with the sonde at the Salty Lagoon PWQMS, with only sporadic and erroneous data collected after 6:00 am on 19 January 2019. The sonde returned an error message 'Port 1 Overpower (pH)'. Efforts to rectify the problem in the field were unsuccessful. The sonde was removed and the cause of the error is currently being investigated.

Table 2.3 YSI sonde Status on 11 March 2019

Sonde	SN17F104100	SN 17H104488	Spare Probes
pH (cap life expectancy 18 months)	EXO pH 17H105047 Manufactured 08/2017	EXO pH 17H105048 Manufactured 08/2017 New cap 03/2019	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 New cap 03/2019	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	Serviced probes installed in Salty Lagoon 14/01/2019 Sonde and probes removed 11/03/2019 for servicing	Serviced probes installed in Salty Creek 11/03/2019	Probes being calibrated and serviced for redeployment
Notes	<ul style="list-style-type: none"> - 555 days estimated battery life - Memory cleared – 50045.3 days logging available - Sonde and probes removed 11/03/2019 for servicing 	<ul style="list-style-type: none"> - 174 days estimated battery life - Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> - Probes Removed 11/03/2019

Climate information was sourced from the Evans Head bombing range weather station on the Bureau of Meteorology website (BoM 2019). 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 11 March 2019 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 11 March 2019

Parameter	Salty Lagoon								Salty Creek		S5
	Guiding Value	S1	S1 (1m)	S2	S2* (QA)	S3	S3 (1m)	S4	Guiding Value	S5	
Blue Green Algae ID (cells/mL)	0	Nil	ns	Nil	Nil	Nil	ns	-	0	Nil	ns
Nitrite Nitrogen (mg/L)	0.01	<0.010	ns	<0.010	<0.010	<0.010	ns	-	0.01	<0.010	ns
Nitrate Nitrogen (mg/L)	0.01	<0.010	ns	<0.010	<0.010	<0.010	ns	-	0.01	<0.010	ns
Oxidized Nitrogen (mg/L)	-	<0.010	ns	<0.010	<0.010	<0.010	ns	-	-	<0.010	ns
Ammonia Nitrogen (mg/L)	0.05	<0.010	ns	<0.010	<0.010	<0.010	ns	-	0.11	<0.010	ns
Total Kjeldahl Nitrogen (mg/L)	1.6	1.4	ns	1.9	1.9	1.36	ns	-	1.63	0.56	ns
Total Nitrogen (mg/L)	1.6	1.4	ns	1.9	1.9	1.36	ns	-	1.63	0.56	ns
Total Phosphorus(mg/L)	0.14	0.09	ns	0.27	0.27	0.07	ns	-	0.04	<0.03	ns
Orthophosphate (mg/L)	0.11	0.023	ns	0.076	0.074	0.023	ns	-	0.01	<0.010	ns
Chlorophyll-a (µg/L)	5	13	ns	51	47	8	ns	-	3	<1	ns
Enterococcus (CFU/100mL)	170	15	ns	140	155	10	ns	-	40	25	ns
Faecal Coliforms (CFU/100mL)	135	30	ns	4	10	10	ns	-	150	0	ns
Temp (°C)	25.9	26.45	26.23	26.97	ns	26.8	26.82	-	13.1 - 28.8	27.34	27.36
pH	6.9	7.58	7.52	6.54	ns	7.58	7.59	-	4.3 - 6.8	7.02	7.05
ORP (mV)	-	147	142	96	ns	158	151	-	-	195	191
Cond (mS/cm)	8.0	43.1	43.1	39.9	ns	43.1	43.1	-	0.3 - 21.5	51.6	51.7
Turbidity (NTU)	13	4.6	4.6	8.7	ns	6	5.5	-	11	1.4	1.8
DO (mg/L)	4.09	3.7	3.13	1.68	ns	4.42	4.38	-	5.52	3.28	3.19
DO (% sat)	-	54.9	46.2	24.7	ns	65.8	65.2	-	-	51.3	49.8
TDS (mg/L)	-	26.3	26.3	24.3	ns	26.3	26.3	-	-	31	31
Sal (ppt)	-	27.8	27.8	25.4	ns	27.7	27.7	-	-	33.9	34
Depth (m)	-	Surface	0.6m	Surface	Surface	Surface	0.6m	-	-	Surface	1m

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

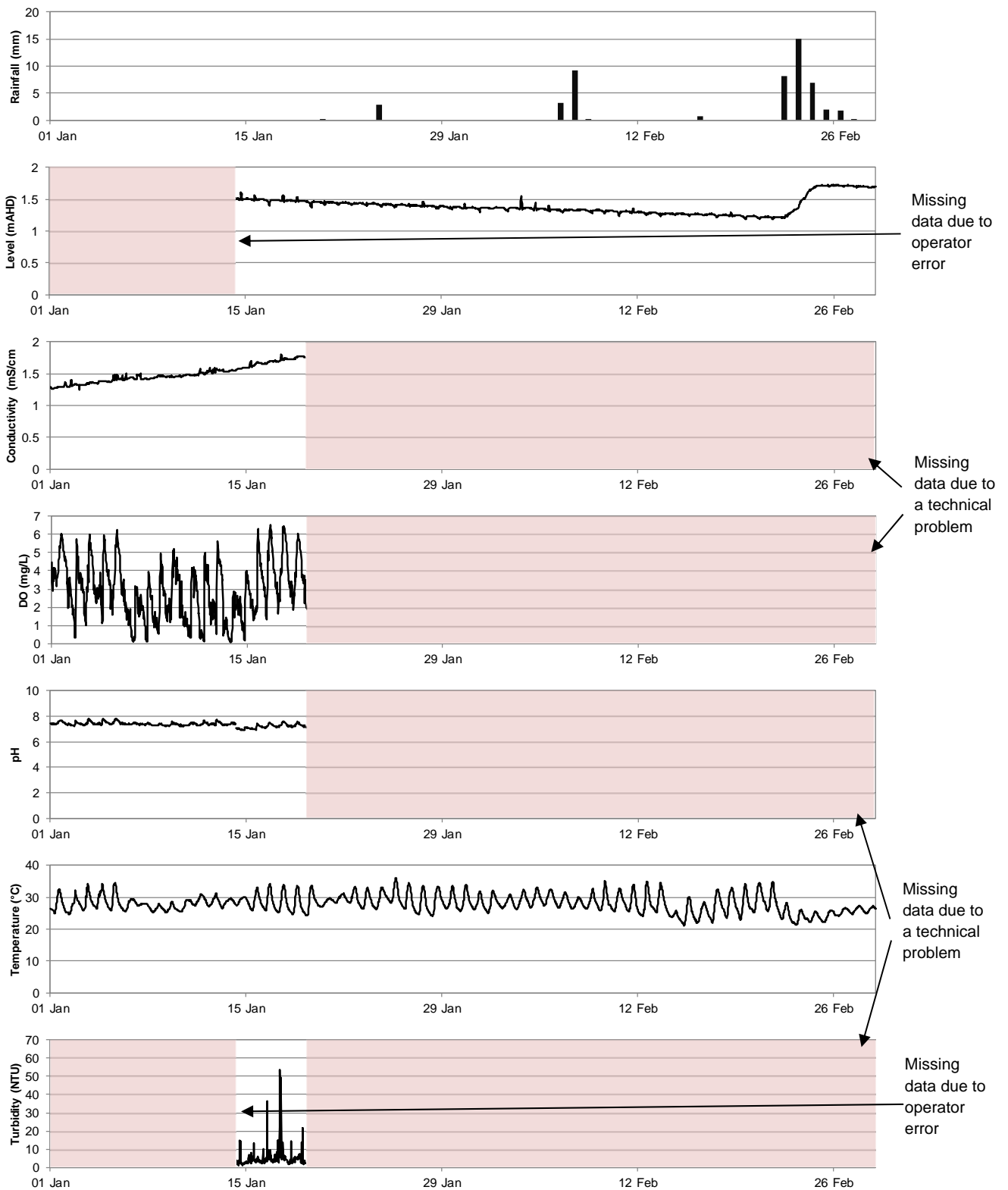


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 January 2019 to 28 February 2019

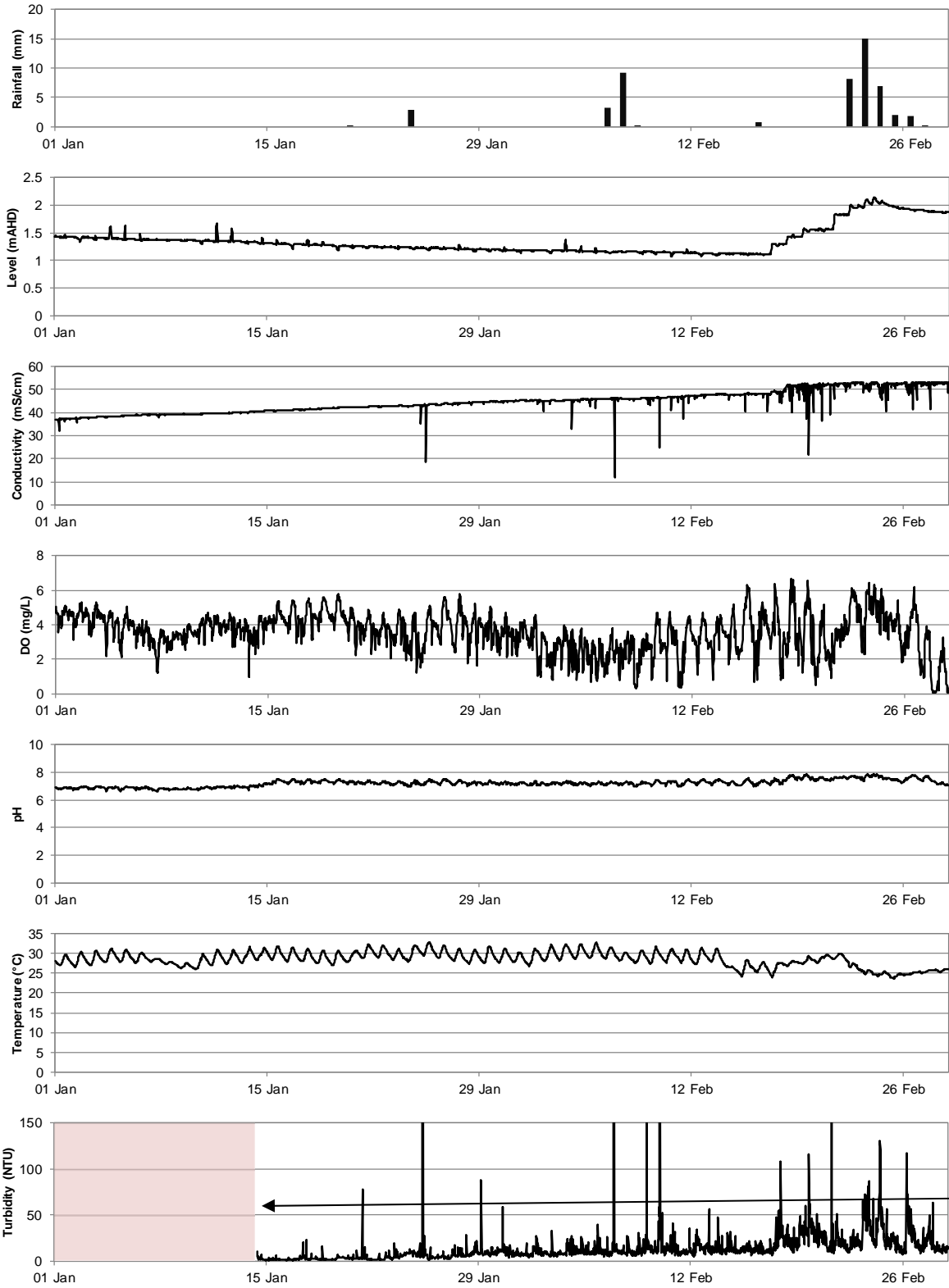


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 January 2019 to 28 February 2019

3.3 Aquatic Weed Monitoring

No aquatic weeds of significance were identified during the autumn 2019 aquatic weed monitoring on 11 March 2019.

3.4 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2**. There was no advance of the head cut at the three impact stations in relation to the previous measurements on 14 January 2019. The head cut has advanced at least 9.90 metres towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion monitoring results from 11 March 2019

Station	Control/Impact	Distance 25 July 2017 (m)	Distance 11 March 2019 (m)	Cut Movement (m)
ER1	Control	7.55	7.55	0.00
ER2	Control	10.20	10.15	0.05
ER3	Control	9.95	9.90	0.05
ER4	Impact	8.35	6.05	2.30
ER5	Impact	12.35	2.45	9.90
ER6	Impact	10.40	8.75	1.65



4. Discussion

4.1 Water Quality


Rainfall was significantly below average for this monitoring period. The rainfall for January was extremely low but there were a number of days of low to moderate rainfall in February. Ten of the past twelve months have had below average rainfall. The conductivity and level data from the Salty Creek PWQMS indicate that the entrance to Salty Creek remained closed for the entire monitoring period. It also shows that the water level in Salty Creek reduced steadily (due to evaporation) for most of the monitoring period prior to increasing rapidly in response to seawater ingress (with very high sea levels and large surf resulting in the entrance bar being overtopped). At the time of the site inspection on 11 March 2019 the entrance to Salty Creek was closed. The water level in Salty Lagoon was not logged at the beginning of the monitoring period due to a human error but the available data shows that it reduced steadily (due to evaporation) from 14 January 2019 until 22 February 2019 when water flowed in from Salty Creek after the level in Salty Creek exceeded approximately 1.83 m AHD. Seawater ingress via overtopping of the Salty Creek entrance bar and subsequent saline water flow into Salty Lagoon was the major feature impacting water quality during the current reporting period. The conductivity measurements from all sites were higher than the guiding values.

The Salty Lagoon water levels on the 22 February 2019 were among the lowest measured in the post-channel closure period. Conductivity measurements from the site inspection on 11 March 2019 show that the water flowing in from Salty Creek was very saline and are the highest conductivity measurements collected from Salty Lagoon in the post-channel closure period. However, the water levels in Salty Lagoon at the time of the site inspection on 11 March 2019 were still relatively low. Due to the low water levels in Salty Lagoon there was no water at S4, to the west of Salty Lagoon, and no results to report from that site.

Erosion monitoring indicated that the head cut did not advance during this reporting period. There has been little or no measured advance of the head cuts at the three control sites. This indicates that, for the second consecutive bi-monthly period, there was little flow from Salty Lagoon to Salty Creek during this monitoring period. It also indicates that flow from Salty Creek to Salty Lagoon does not exacerbate the existing erosion.

Conductivity measurements from the Salty Lagoon PWQMS, though limited, show the impact of evaporation on water quality at the start of the monitoring period. Conductivity measurements from the Salty Creek PWQMS show that the conductivity at the beginning of the monitoring period was high and that conductivity measurements equivalent to seawater occurred after seawater ingress on 18 February 2019. At the time of the site inspection on 11 March 2019 the conductivity measurements in Salty Lagoon were approximately 80 per cent those of seawater, indicating that the volume of water that entered Salty Lagoon from Salty Creek was close to 400 per cent of the volume prior to the event. Measurements from 11 March 2019 also show that the water column was well mixed at all sites and saline water had penetrated the channel to the Evans Head STP.

The DO concentrations in discrete samples collected on 11 March 2019 were relatively low at all sites and, for the third consecutive bi-monthly monitoring event, did not comply with guiding values except at site S3. In Salty Lagoon, low DO concentrations have often been linked with saline water ingress. Low DO concentrations are also naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4) and in Salty Creek when brackish and saline conditions persist. The limited measurements from the Salty Lagoon PWQMS indicate that the diurnal fluctuations in light availability were the major



source of variation during in the period prior to saline water ingress. The measurements from the Salty Creek PWQMS indicate that the DO concentration also fluctuated mostly in response to light availability but that the amplitude of the variation increased significantly following seawater ingress.

With the exception of the TN and TP measurements from S2 all of the nutrient concentrations from samples collected on 11 March 2019 complied with guiding values. The key factor influencing nutrient concentrations was seawater ingress and the low water levels prior to it. In general, bioavailable nitrogen and bioavailable phosphorus concentrations were low at all sites. Despite this, the chlorophyll-a concentrations only complied with the guiding value at S5, and the concentrations at S2 indicated an algal bloom of moderate to large proportions, coinciding with higher nutrient concentrations measured at that site. There were no blue-green algae detected in any samples.

Other results that did not comply with guiding values included the pH measurements from all sites except S2 and the temperature measurements from all sites in Salty Lagoon. All other measurements complied with guiding values. High pH measurements are associated with seawater ingress. Seawater has a pH of approximately 8.3 and strong pH buffering capacity. The high temperature measurements are seasonal.

4.2 Other Observations

The entrance to Salty Creek was closed on 11 March 2019. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Purple Swamphen, Pelican, White-faced Heron, Little Black Cormorant, and White-bellied Sea Eagle.



5. Key Points

1. Water levels increased and conductivity increased in Salty Lagoon during this reporting period due to saline water flow in from Salty Creek. One site to the west of Salty Lagoon was still dry at the time of the site inspection.
2. A moderate number of results did not comply with the guiding values.
3. Total nutrient concentrations were mostly low in Salty Lagoon and Salty Creek but chlorophyll-a concentrations were moderate in the open water of Salty Lagoon and high at one site to the west.
4. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek did not advance during this reporting period.
5. The risk rating for the Salty Lagoon Response Protocol is uncertain, due to the potential ongoing impacts of saline water in Salty Lagoon. Persistent saline conditions and hot weather are likely to have a negative impact on some of the flora around the lagoon. An adaptive management site inspection may be advised if very dry and hot conditions persist.



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