Salty Lagoon
Post Closure Monitoring

Project Management and Ecosystem Health Report
October 2018

GeoLINK
environmental management and design

AQUATIC SCIENCE AND MANAGEMENT

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1. Introduction

1.1 Introduction

This document comprises the second 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 between 1 September 2018 until 31 October 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

This was the second 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 7 November 2018. Water quality samples were collected between the hours of 8:30 am and 12:30 pm on that day. A high tide of 1.76 metres was forecast for 8.45 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 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 spring 2018 season was undertaken during this reporting period on 7 November 2018.

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 will be downloaded at bi-monthly intervals for reporting purposes.

HOBO U20 water level loggers were installed at each PWQMS and a third HOBO was installed at S1 to collect barometric pressure data for offsetting atmospheric 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 7 November 2018 is displayed in **Table 2.3**.

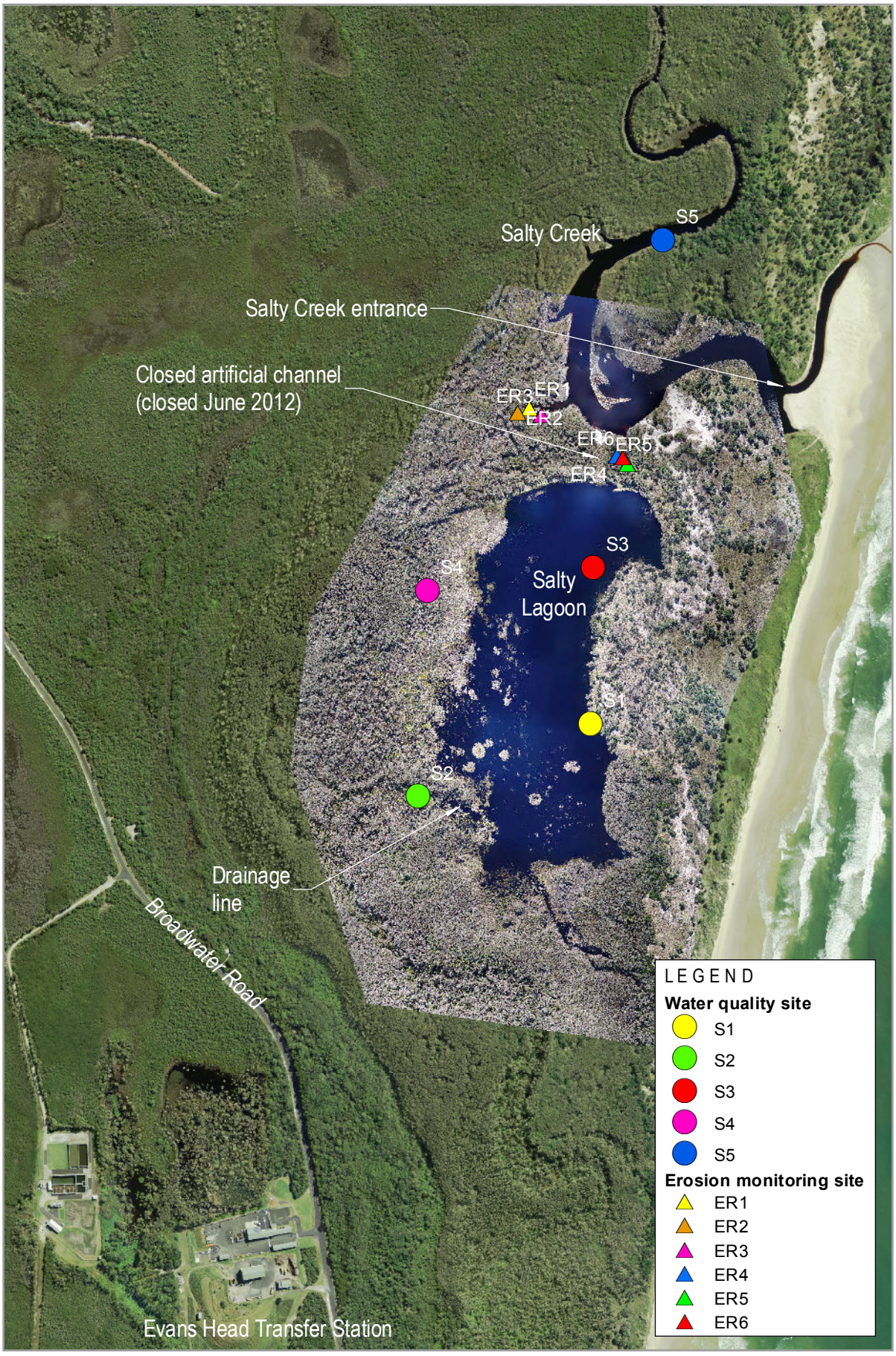
Table 2.3 YSI sonde Status on 7 November 2018

Sonde	*SN17F104100*	*SN 17H104488*	*Spare Probes*
pH (cap life expectancy 18 months)	EXO pH 17H105048 Manufactured 08/2017	EXO pH 17H105049 Manufactured 08/2017	EXO pH 17H105047 Manufactured 08/2017
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F103252 Manufactured 06/2017	EXO Wiped CT 17F102685 Manufactured 06/2017	EXO Wiped CT 17F102047 Manufactured 06/2017
DO (cap life expectancy 18 months)	EXO Optical DO 17H103495 Manufactured 08/2017	EXO Optical DO 17H103494 Manufactured 08/2017	EXO Optical DO 17H103493 Manufactured 08/2017
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H101468 Manufactured 08/2017	YSI EXO Turbidity 17H103513 Manufactured 08/2017	YSI EXO Turbidity 17H101465 Manufactured 08/2017
Wiper	YSI Exo Wiper 17G101952	YSI Exo Wiper 17G101954	No Spare Wiper
Status	Serviced probes installed in Salty Lagoon 05/09/2018	Serviced probes installed in Salty Creek 07/11/2018	Probes being calibrated and serviced for redeployment
Notes	- 157.9 days estimated battery life - Memory cleared – 50045.3 days logging available	- 154.9 days estimated battery life - Memory cleared – 50045.3 days logging available	- Probes Removed 07/11/2018

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).

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: RE Reviewed by: DSA Date: 9/01/2018
Source of base data: Richmond Valley Council



North

0 200

Water Quality and Erosion Monitoring Site Locations

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3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 7 November 2018 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 7 November 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**	**0.041**	ns	<0.010	**0.038**	ns	<0.010	<0.010	**0.01**	<0.010
Oxidized Nitrogen (mg/L)	**-**	0.041	ns	<0.010	0.038	ns	<0.010	<0.010	**-**	<0.010
Ammonia Nitrogen (mg/L)	**0.05**	**0.074**	ns	<0.010	**0.1**	ns	<0.010	<0.010	**0.11**	0.045
Total Kjeldahl Nitrogen (mg/L)	**1.6**	**1.73**	ns	**1.68**	**1.66**	ns	**1.73**	**1.73**	**1.63**	1.18
Total Nitrogen (mg/L)	**1.6**	**1.77**	ns	**1.68**	**1.7**	ns	**1.73**	**1.73**	**1.63**	1.18
Total Phosphorus(mg/L)	**0.14**	**0.16**	ns	0.13	**0.15**	ns	0.03	0.03	**0.04**	<0.03
Orthophosphate (mg/L)	**0.11**	**0.11**	ns	0.082	**0.11**	ns	<0.010	<0.010	**0.01**	<0.010
Chlorophyll-a (µg/L)	**5**	**8**	ns	2	<1	ns	3	<1	**3**	**4**
Enterococcus (CFU/100mL)	**170**	72	ns	168	8	ns	32	36	**40**	**56**
Faecal Coliforms (CFU/100mL)	**135**	16	ns	38	26	ns	18	20	**150**	124
Temp (˚C)	**25.9**	**29.39**	**28**	25.41	**27.4**	**26.87**	24.32	ns	**13.1 - 28.8**	**30.1**
pH	**6.9**	**7.09**	**7**	6.64	**7.26**	**7.04**	5.79	ns	**4.3 - 6.8**	**6.84**
ORP (mV)	**-**	160	162	161	168	177	168	ns	**-**	148
Cond (mS/cm)	**8.0**	0.595	0.596	0.379	0.586	0.587	0.623	ns	**0.3 - 21.5**	16.1
Turbidity (NTU)	**13**	0.5	0	0.6	0	0.1	2.3	ns	**11**	8.2
DO (mg/L)	**4.09**	**3.81**	**2.89**	**0.87**	4.87	4.43	**1.16**	ns	**5.52**	**4.5**
DO (% sat)	**-**	50.2	37.4	10.8	62.3	56.3	14.2	ns	**-**	63.1
TDS (mg/L)	**-**	0.381	0.381	0.246	0.375	0.375	0.399	ns	**-**	9.95
Sal (ppt)	**-**	0.3	0.3	0.2	0.3	0.3	0.3	ns	**-**	9.4
Depth (m)	**-**	Surface	1m	Surface	Surface	1m	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

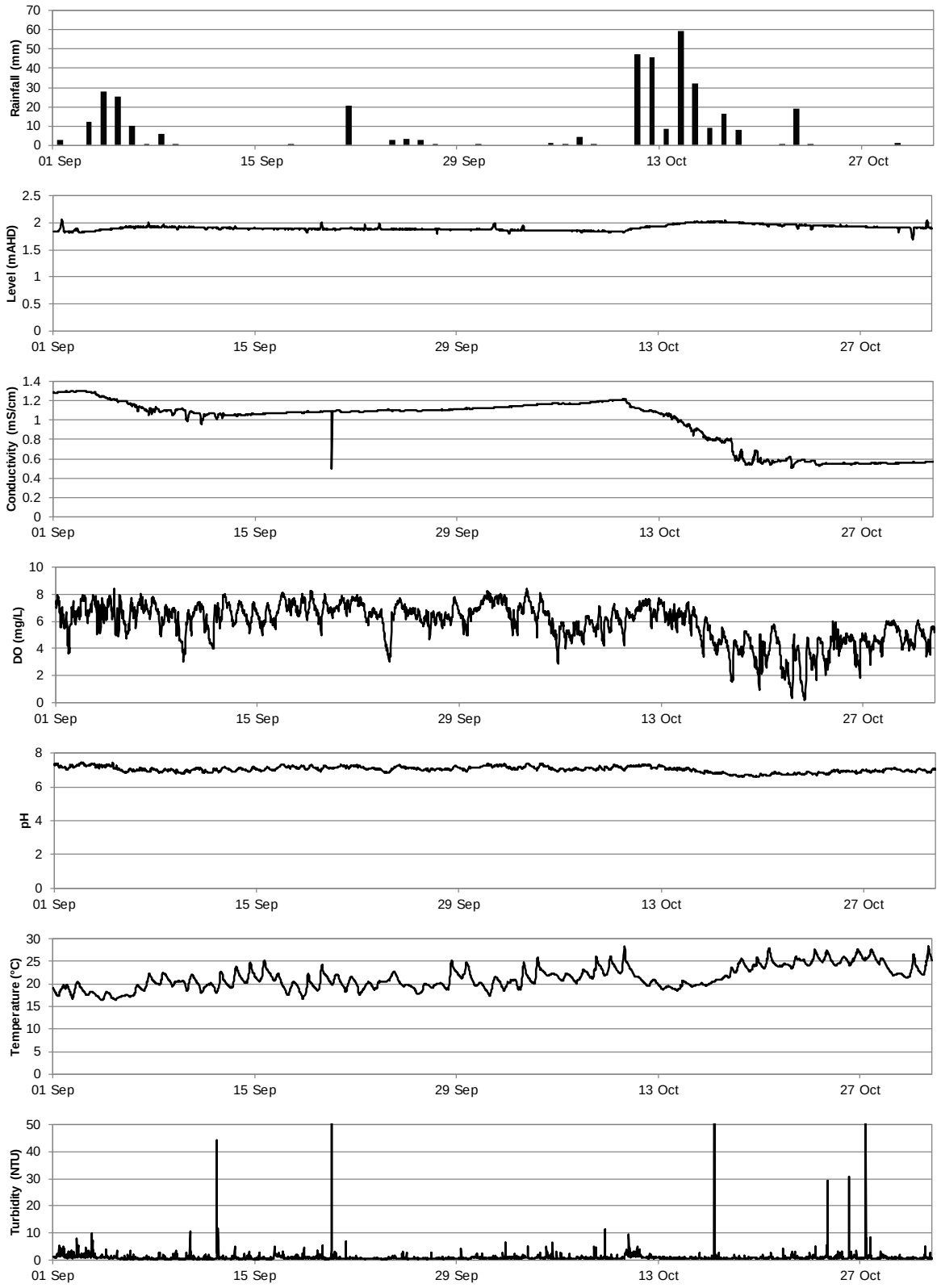

Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 September 2018 to 31 October 2018

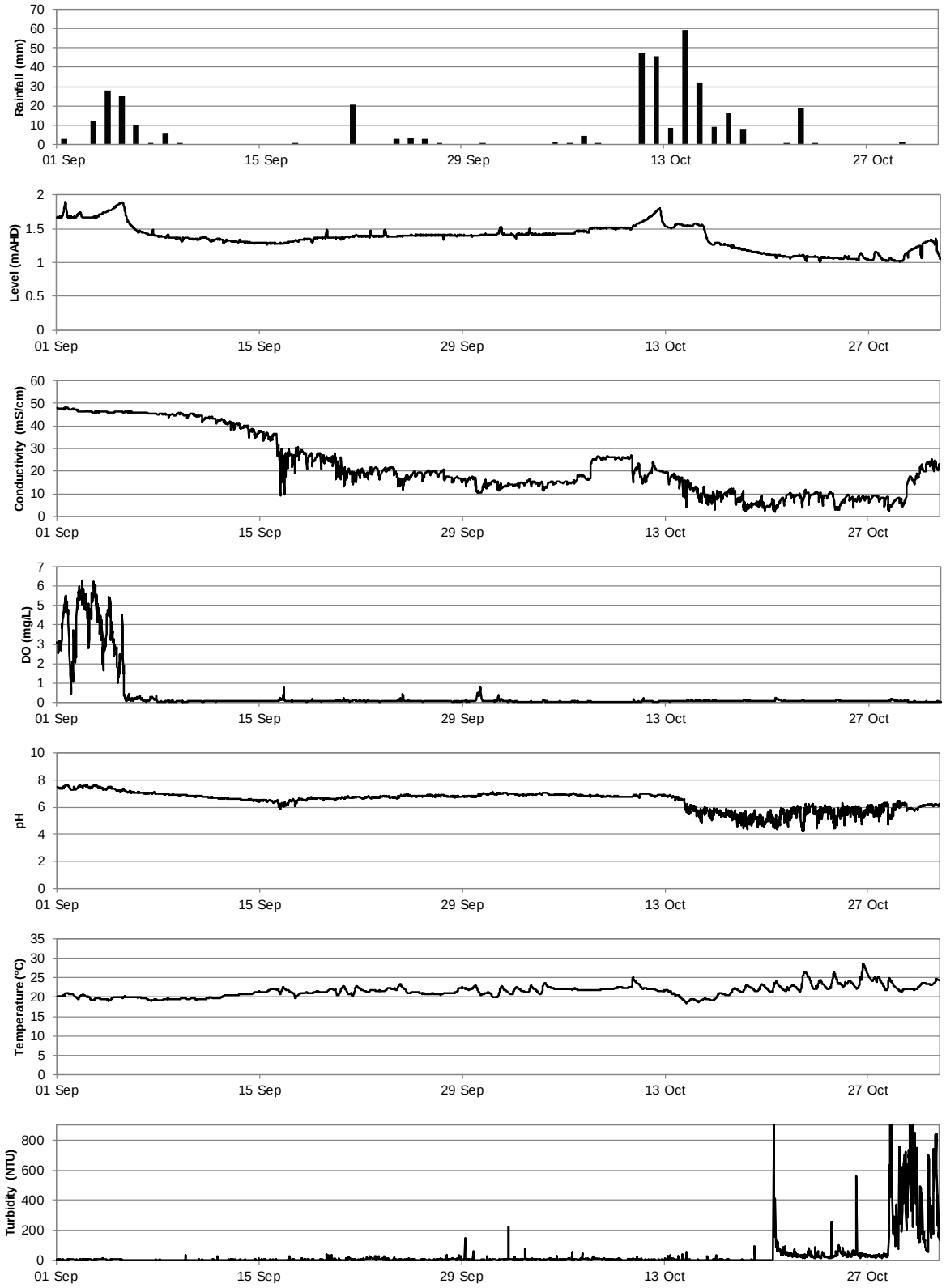

Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 September 2018 to 31 October 2018

3.3 Aquatic Weed Monitoring

No aquatic weeds were identified during the spring 2018 aquatic weed monitoring on 7 November 2018.

3.4 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2**. There was a significant advance of the head cut at the three impact stations in relation to the previous measurements in September 2018. The head cut has advanced at least 9.95 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion monitoring results from 7 November 2018

Station	*Control/Impact*	*Distance 25 July 2017 (m)*	*Distance 5 September 2018 (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	2.40	9.95
ER6	Impact	10.40	8.75	1.65

Plate 3.1 Fixed point photo from ER5 on 1 May 2018

Plate 3.2 Fixed point photo from ER5 on 7 November 2018

4. Discussion

4.1 Water Quality

There were several moderate to heavy days of rainfall during this reporting period in addition to numerous days of light rainfall. The monthly rainfall for October at the Evans Head RAAF Bureau of Meteorology station was more than 2.5 times the average (BOM 2018). The conductivity and level data from the Salty Creek PWQMS indicates that the entrance to Salty Creek opened in response to rainfall on three separate occasions during this monitoring period. At the time of the site inspection on 7 November 2018 the entrance to Salty Creek was open and flowing with some evidence of tidal movements. The water level in Salty Lagoon was relatively stable during this monitoring period and remained at high levels. Water level measurements from the Salty Lagoon PWQMS indicate that water drained from Salty Lagoon into Salty Creek for the entire monitoring period.

Erosion monitoring indicated that the head cut has advanced at least 9.95 m since July 2017. There has been little or no measured advance of the head cuts at the three control sites. The advance of the head cut during this reporting period was between 1.05 m (ER4) and 4.15 m (ER5). The consistent heavy rainfall in October 2018 would have caused the advancing erosion and the size of the advance during this reporting period demonstrates how quickly the system can change under such conditions.

Conductivity measurements from the PWQMS show the impact of both rainfall and low-level seawater ingress on Salty Creek and the impact of both dilution from rainfall runoff and evaporation on Salty Lagoon. Conductivity measurements from the Salty Creek PWQMS indicate that rainfall runoff was the dominant factor with respect to water quality during this reporting period but that the water in Salty Creek remained brackish for the majority of the reporting period. The conductivity measurements from the Salty Lagoon PWQMS remained low but indicated that rainfall runoff was the dominant factor with respect to water quality over the course of this reporting period. At the time of the site inspection the conductivity measurements in Salty Lagoon showed that the water column was well mixed at all sites. The measurements from Salty Creek indicated that the water was somewhat stratified into a more brackish bottom layer and a less brackish surface layer.

The DO concentrations in discrete samples collected on 7 November 2018 were relatively low at all sites and did not comply with guiding values except at site S3. Low DO concentrations in the open water of Salty Lagoon (sites S1 and S3) are unusual after periods of heavy rainfall. However, low DO concentrations are common at the sites to the west of Salty Lagoon (sites S2 and S4) and in Salty Creek during brackish conditions. The measurements from the Salty Lagoon PWQMS indicate that the diurnal fluctuations in light availability were the major source of variation during this reporting period. The measurements from the Salty Creek PWQMS indicate that the DO concentration at the bottom of the water column remained very low (anoxic) for the majority of the reporting period, after the entrance opened in response to rainfall on 5 September 2018.

The nutrient concentrations from samples collected on 7 November 2018 were relatively high in the samples from Salty Lagoon and many of the results did not comply with guiding values. The results that did not comply with guiding values included the TN concentrations from all sites in Salty Lagoon, and the TP, phosphate, nitrate and ammonia concentrations from S1 and S3. The chlorophyll-a concentrations complied with the guiding value at all sites except S1 and S5, where the concentrations were still in the low range. There were no blue-green algae detected in any samples. Nutrient and chlorophyll-a concentrations measured during the MPPC and post-closure monitoring programs have typically been lower following periods of heavy rainfall but higher during the warmer months of spring

and summer. The results from this monitoring period are outlying and there is no clear indication of a cause for the relatively high concentrations detected in these samples.

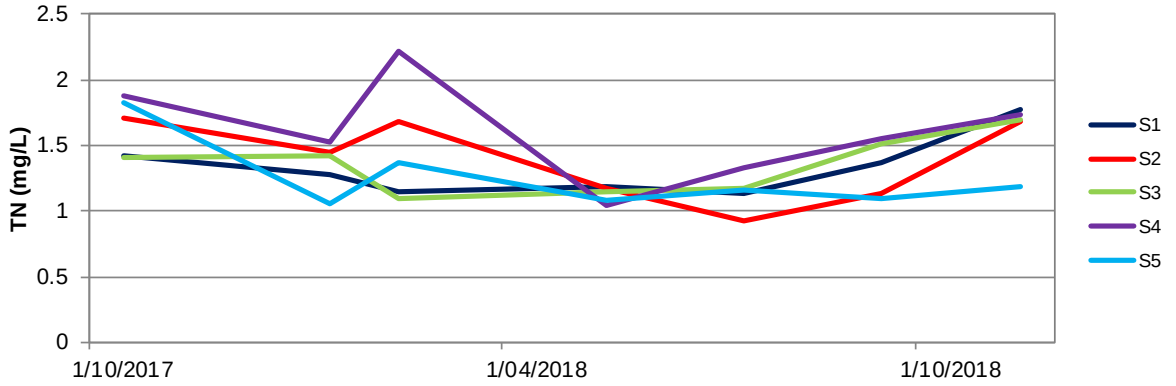

Figure 4.1 TN concentrations at all sites since October 2017

Other results that did not comply with guiding values included the pH and temperature measurements from S1, S3 and S5 and the enterococcus concentration from S5. All other measurements complied with guiding values. The high pH measurements from S5 is normal when brackish and saline conditions persist. The high pH measurements from S1 and S3 are further indication that a buffering mechanism persists in Salty Lagoon that neutralises the low pH runoff from the catchment. The high faecal indicator organism concentration at S5 is likely to be associated with waterbird use of that area and potentially with rainfall runoff. The high temperature measurements are seasonal.

4.2 Other Observations

The entrance to Salty Creek was open on 7 November 2018. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, White-eyed Duck, Wood Duck, Eurasian Coot, Intermediate Egret, Darter, Pied Cormorant, Little Black Cormorant and White-bellied Sea Eagle.

5. Key Points

1. Conditions in Salty Lagoon were relatively stable during this reporting period with respect to water levels and conductivity.

2. A relatively large number of results did not comply with the guiding values.

3. Total nutrient concentrations were relatively high in Salty Lagoon but there was no indication of algal blooms.

4. Chlorophyll-a concentrations complied with guiding values at most sites.

5. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek advanced substantially during this reporting period.

6. The risk rating for the Salty Lagoon Response Protocol is uncertain, due to the advance of the erosive headcut. An adaptive management site inspection may be advised if heavy rainfall conditions eventuate.

References

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