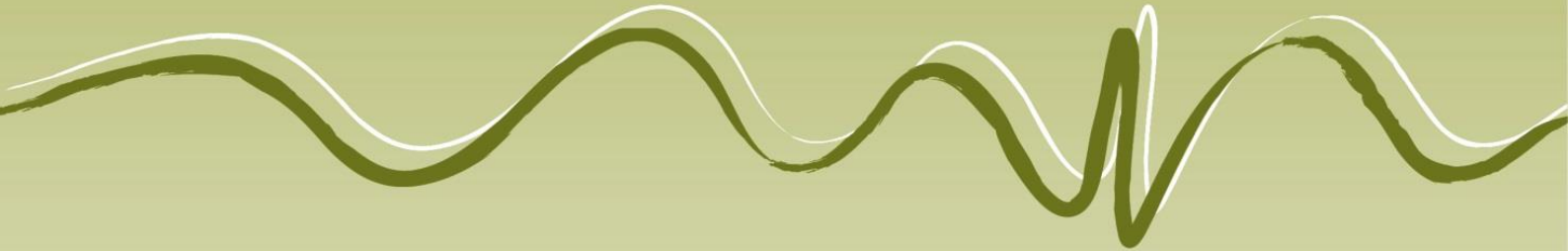


Salty Lagoon

Post Closure Monitoring

Project Management and Ecosystem Health Report

December 2019



AQUATIC SCIENCE AND MANAGEMENT

PO Box 119
Lennox Head NSW 2478
T 02 6687 7666

PO Box 1446
Coffs Harbour NSW 2450
T 02 6651 7666

info@geolink.net.au

Prepared for: Richmond Valley Council
© GeoLINK, 2020

<i>UPR</i>	<i>Description</i>	<i>Date Issued</i>	<i>Issued By</i>
1731-1322	First issue	3/03/2020	David Andrighetto
1731-1323	Second issue	4/03/2020	David Andrighetto



Table of Contents

1.	Introduction	1
1.1	Introduction	1
1.2	Guiding Values	1
2.	Methodology	2
2.1	Discrete Sampling	2
2.2	Fixed Point Photo Monitoring	2
2.3	Aquatic Weed Monitoring	2
2.4	Erosion Monitoring	3
2.5	Permanent Water Quality Monitoring Stations	3
3.	Results	6
3.1	Water Quality Samples	6
3.2	Permanent Water Quality Monitoring Stations	6
3.3	Aquatic Weed Monitoring	10
3.4	Erosion Monitoring Stations	10
4.	Discussion	11
4.1	Water Quality	11
4.2	Other Observations	12
5.	Key Points	14

Illustrations

Illustration 2.1	Water Quality and Erosion Monitoring Site Locations	5
Illustration 3.1	Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 November 2019 to 31 December 2019	8
Illustration 3.2	Salty Creek Rainfall and Water Quality Monitoring Station Data 1 November 2019 to 31 December 2019	9
Illustration 4.1	Discrete Measurements of TN and TP at all Sites Since January 2018 Plotted Against the Salty Lagoon Guiding Value	12

Tables

Table 2.1	Locations of Water Quality Sample Sites in Salty Lagoon and Salty Creek (WGS84)	2
Table 2.2	Type and Locations (WGS84) of Erosion Monitoring Sites	3
Table 2.3	YSI Sonde Status on 22 January 2020	4
Table 3.1	Results of Discrete Samples Collected 22 January 2020	7
Table 3.2	Erosion Monitoring Results from 22 January 2020	10

Plates

Plate 4.1	The closed entrance to Salty Creek on 22 January 2020	13
Plate 4.2	Dense macroalgal growth at S2 on 22 January 2020	13



1. Introduction

1.1 Introduction

This document comprises the third bi-monthly monitoring report for year 8 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 November 2019 until 31 December 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 third bi-monthly site visit for year 8 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 22 January 2020. Water quality samples were collected between the hours of 8:30 am and 12:30 am on that day. A high tide of 1.75 m was forecast for 7:21 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. There was insufficient water at S4 to constitute a sample. 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 2019 – 2020 summer period was completed on-foot and from a canoe during the site visit on 22 January 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.

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.

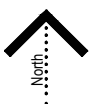
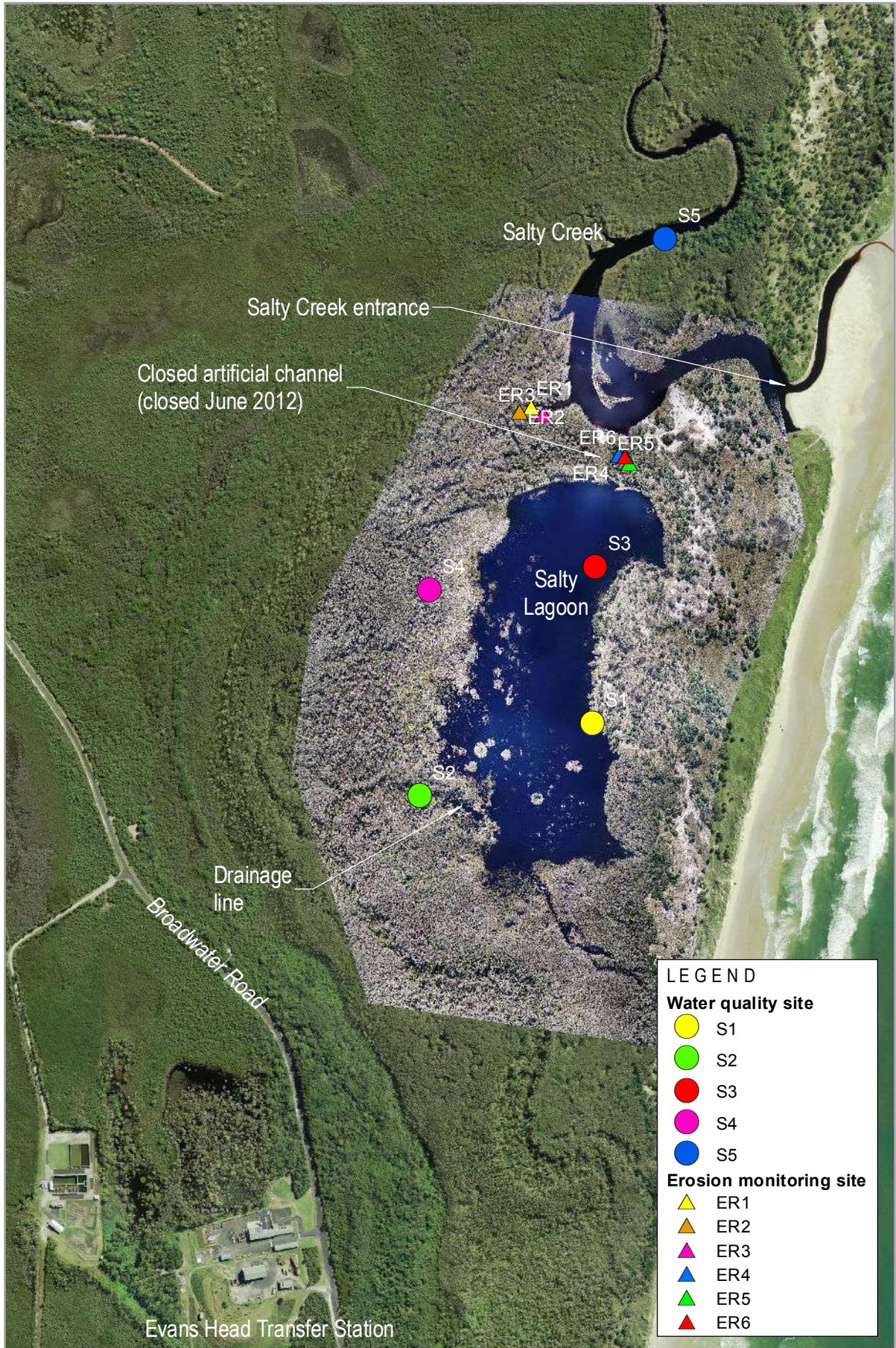
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sonde installed at the Salty Lagoon PWQMS were removed on 22 January 2020 and replaced by a serviced and calibrated set. The malfunctioning DO sensor that was removed from the Salty Creek PWQMS on 7 November 2019 was serviced and then calibrated normally.

The status of the two deployed YSI EXO3 sondes on 22 January 2020 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 22 January 2020

Sonde	SN17F104100	SN 17H104488	Spare Probes
pH (cap life expectancy 18 months)	EXO pH 17H105049 Manufactured 08/2017 New cap 03/2019	EXO pH 17H105047 Manufactured 08/2017 New cap 05/2019	EXO pH 17H105048 Manufactured 08/2017 New cap 03/2019
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 New cap 03/2019	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 05/2019	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2019
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 22/01/2020 Sonde repaired under warranty 04/2019 New batteries installed 22/01/2020	Serviced probes installed in Salty Creek 07/11/2019 New Batteries installed 07/11/2019	Awaiting service and calibration.
Notes	<ul style="list-style-type: none"> ■ 220 days estimated battery life ■ Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> ■ 157 days estimated battery life ■ Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> ■ Probes Removed from Salty Lagoon 22/01/2020

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 (STP) facility routine sampling information was provided by Richmond Valley Council (RVC).



0 200

GeoLINK
environmental management and design

Water Quality and Erosion Monitoring Site Locations

Salty Lagoon Project Management & Ecosystem Health Report, December 2019
1731-1297

Illustration 2.1



3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 22 January 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 22 January 2020

<i>Parameter</i>	<i>Salty Lagoon</i>								<i>Salty Creek</i>		
	<i>Guiding Value</i>	<i>S1</i>	<i>S1 (1m)</i>	<i>S1 (QA)*</i>	<i>S2</i>	<i>S3</i>	<i>S3 (1m)</i>	<i>S4</i>	<i>Guiding Value</i>	<i>S5</i>	<i>S5 (1m)</i>
Blue Green Algae ID (cells/mL)	0	Nil	ns	Nil	Nil	Nil	ns	Nil	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	0.027	ns
Oxidized Nitrogen (mg/L)	-	<0.010	ns	<0.010	<0.010	<0.010	ns	-	-	0.027	ns
Ammonia Nitrogen (mg/L)	0.05	<0.010	ns	<0.010	0.13	<0.010	ns	-	0.11	0.022	ns
Total Kjeldahl Nitrogen (mg/L)	1.6	1.81	ns	1.71	1.66	1.81	ns	-	1.63	0.96	ns
Total Nitrogen (mg/L)	1.6	1.81	ns	1.71	1.66	1.81	ns	-	1.63	0.99	ns
Total Phosphorus(mg/L)	0.14	0.1	ns	0.07	0.47	0.1	ns	-	0.04	<0.03	ns
Orthophosphate (mg/L)	0.11	<0.010	ns	<0.010	0.46	<0.010	ns	-	0.01	<0.010	ns
Chlorophyll-a (µg/L)	5	87	ns	62	19	102	ns	-	3	9	ns
Enterococcus (CFU/100mL)	170	35	ns	70	970	5	ns	-	40	15	ns
Faecal Coliforms (CFU/100mL)	135	30	ns	25	105	25	ns	-	150	0	ns
Temp (°C)	25.9	27.9	27.67	ns	28.37	31.56	28.92	-	13.1 - 28.8	31.14	30.69
pH	6.9	7.06	7.04	ns	5.94	8.3	8.06	-	4.3 - 6.8	7.33	7.31
ORP (mV)	-	103	63	ns	162	95	101	-	-	135	136
Cond (mS/cm)	8.0	29.1	29.1	ns	22.2	28.7	28.8	-	0.3 - 21.5	33.9	34
Turbidity (NTU)	13	10	10.1	ns	3.8	20.3	13.3	-	11	2.4	3.7
DO (mg/L)	4.09	3.13	2.47	ns	3.82	12.03	8.82	-	5.52	4.87	3.63
DO (% sat)	-	44.6	35.1	ns	53.4	180.7	127.6	-	-	74.3	55.1
TDS (mg/L)	-	18	18	ns	13.8	17.8	17.8	-	-	20.7	20.7
Sal (ppt)	-	17.9	18	ns	13.3	17.6	17.7	-	-	21.2	21.3
Depth (m)	-	Surface	0.5	Surface	Surface	Surface	0.5	Surface	-	Surface	0.5

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

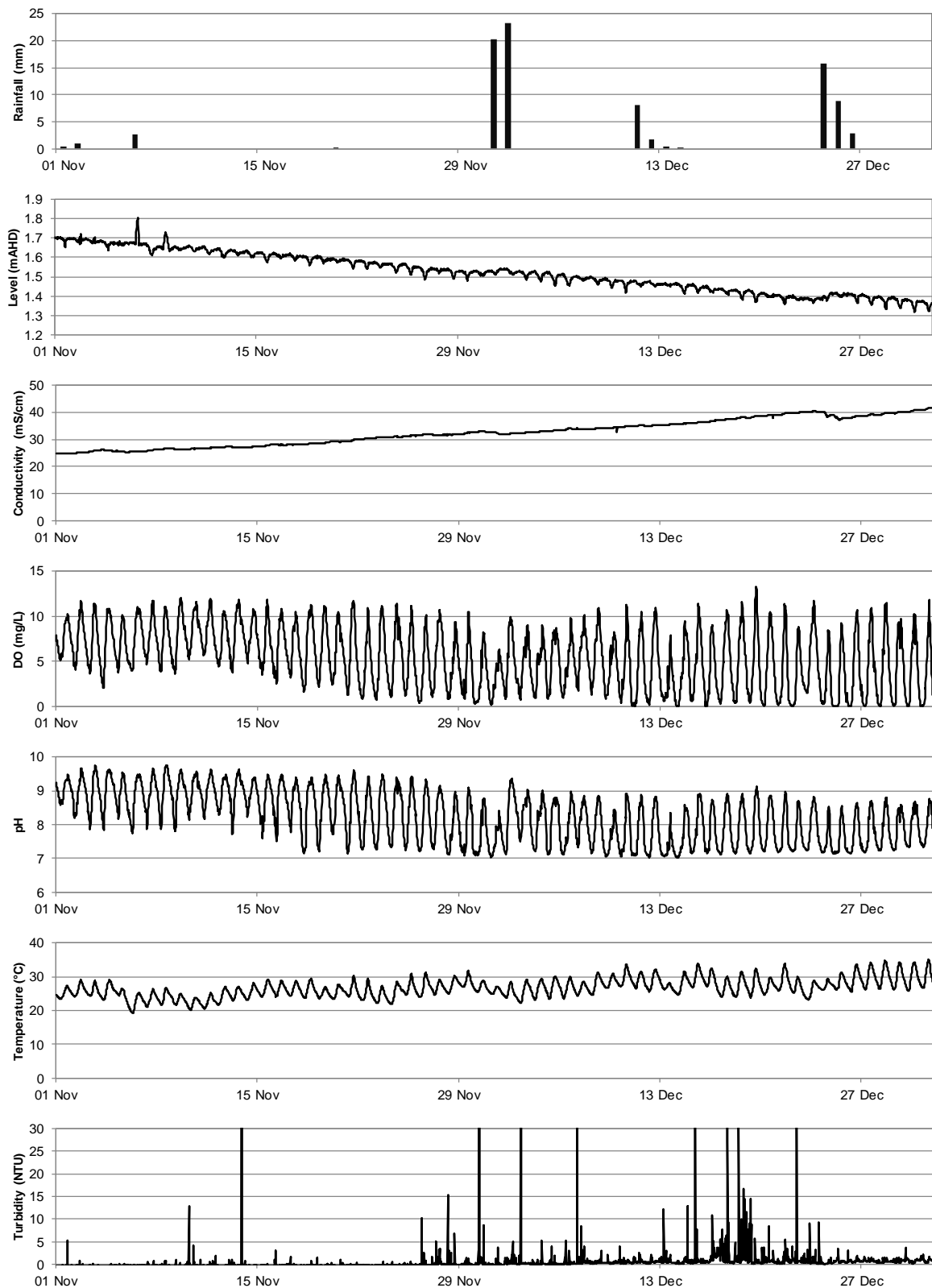


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 November 2019 to 31 December 2019

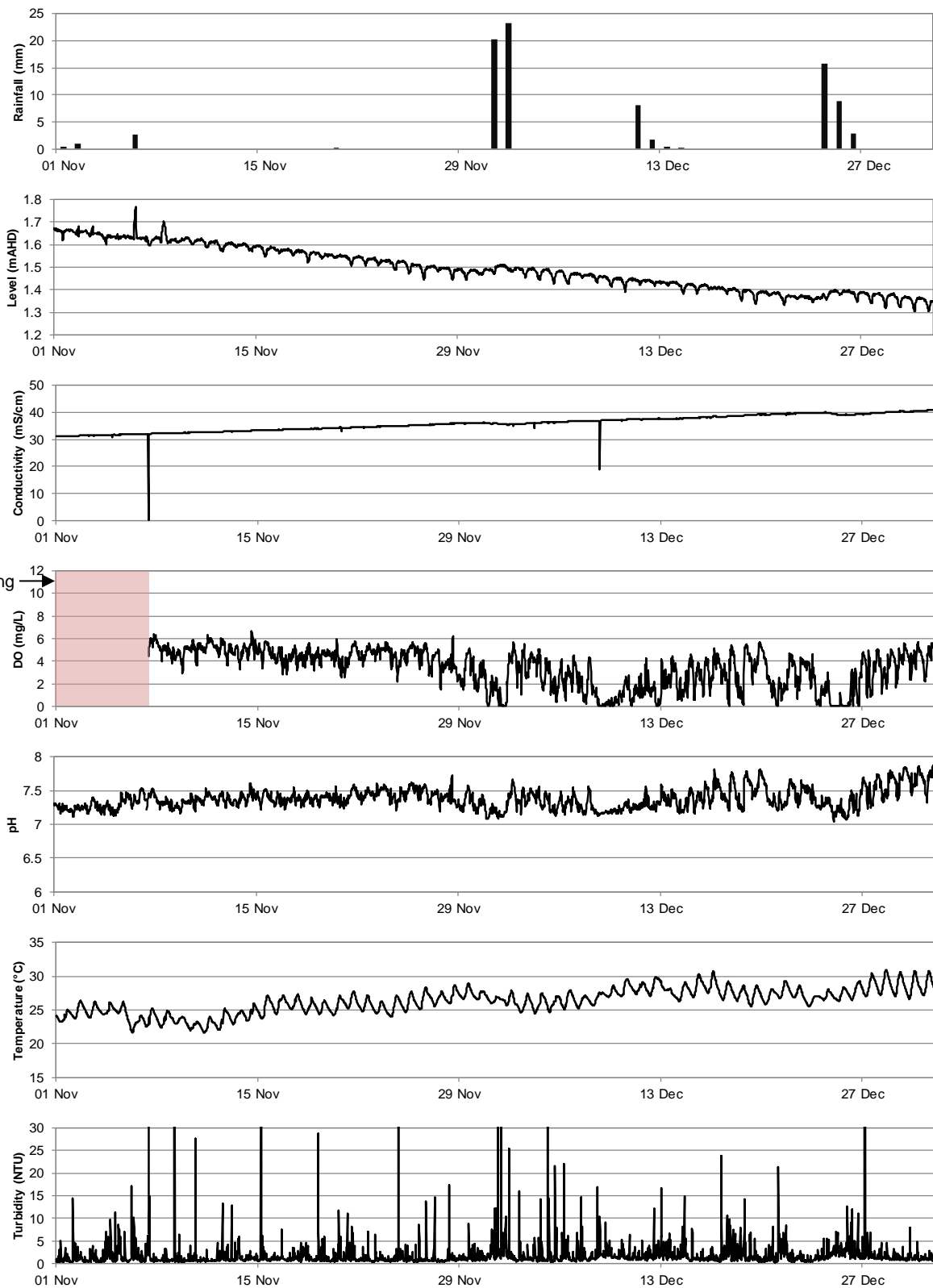


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 November 2019 to 31 December 2019

3.3 Aquatic Weed Monitoring

No significant aquatic weeds were identified during the aquatic weed survey on 22 January 2020. Dense growth of green algae formed mats in some parts of the lagoon.

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 cuts at the three impact stations in relation to the previous measurements on 7 November 2019, and the head cut has been relatively stable since October 2018. The head cut has advanced at least 9.55 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion Monitoring Results from 22 January 2020

Station	Control/Impact	Distance 25 July 2017 (m)	Distance 22 January 2020 (m)	Cut Movement (m)
ER1	Control	7.55	7.55	0.00
ER2	Control	10.20	10.20	0.00
ER3	Control	9.95	9.90	0.05
ER4	Impact	8.35	6.20	2.15
ER5	Impact	12.35	2.80	9.55
ER6	Impact	10.40	8.70	1.70



4. Discussion

4.1 Water Quality

Total rainfall for this reporting period was 41 per cent of the long-term average (1998 - 2019). The rain fell in two moderate events and a few small events. The conductivity and level data from the Salty Creek PWQMS indicate that the entrance to Salty Creek remained closed for the entire reporting period. It also shows that the water level in Salty Creek reduced consistently throughout the monitoring period and that rainfall had little impact. At the time of the site inspection on 22 January 2020, the entrance to Salty Creek was still closed. The water level in Salty Lagoon also reduced consistently over the course of this monitoring period. The levels in both waterways fell by more than 0.3 m between 1 November and 31 December 2019. At the time of the site inspection there was not enough water at S4 to sample. Interestingly, daily water level fluctuations of more than 0.5 cm were measured in Salty Lagoon and Salty Creek on the hottest days when water temperatures were fluctuating by as much as 10 °C. It is likely that the dark tannin staining and large surface area to depth ratio of the water contributes to these fluctuations through expansion and contraction but also that they may reflect groundwater fluctuations in response to evapotranspiration. The conductivity measured at the Salty Lagoon and Salty Creek PWQMS increased steadily over the course of the monitoring period, indicating that evaporation was a major factor driving water quality. At the time of the site inspection on 22 January 2020 the salinity in Salty Lagoon was approximately 80 per cent seawater, the highest it has been in the post-channel monitoring. The conductivity measurements collected on 22 January 2020 were higher than the guiding values at all sites.

Erosion monitoring indicated that the head cut did not advance significantly during this reporting period and has been relatively stable since October 2018. There has been little or no measured advance of the head cuts at the three control sites. This indicates that, for the seventh consecutive bi-monthly period, there was little flow from Salty Lagoon to Salty Creek.

The DO concentrations in discrete samples collected on 22 January 2020 were below the guiding values at all sites except S3. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4) and, also, often in Salty Creek when brackish and saline conditions persist. The difference between the values at S1 and S3 is due to the timing of the samples. The sample at S3 was taken in the middle of the day, when light availability was at a maximum and the DO concentration at its highest. **Illustration 3.1** shows that very strong daily fluctuations were occurring in the DO concentrations in Salty Lagoon during this reporting period. The diurnal fluctuations became more regular and more pronounced as the reporting period progressed. At the time of the site inspection on 22 January 2020 there was abundant growth of a green macroalgae in the open water of Salty Lagoon. This is highly likely to have been the source of the strength and regularity of diurnal DO fluctuations as the algae produce oxygen during the day (photosynthesis) but consume it during the night (respiration). The DO measurements from the Salty Creek PWQMS do not vary as routinely but light availability is evidently still a factor and the lowest measurements were collected during rainfall events.

Most of the nutrient concentrations from samples collected on 22 January 2020 complied with guiding values. The exceptions were the TN concentrations from S1, S2 and S3, the nitrate concentration from Salty Creek and the ammonia, TP and orthophosphate concentrations from S2. Nutrient concentrations typically increase in Salty Lagoon in periods where evaporation is much greater than rainfall (**Illustration 4.1**), often in the summer months. Bioavailable nitrogen was not detected in any samples from Salty Lagoon and bioavailable phosphorus was only detected at S2. Chlorophyll-a

concentrations did not comply with guiding values at any sites. At S1 and S3 they indicated an algal bloom of large proportions, at S2 an algal bloom of moderate proportions and at S5 an algal bloom of small proportions. There were no blue-green algae detected in any samples.

Several other results did not comply with guiding values, including

- The pH measurements from all sites, except S2, where it has remained low historically. The pH measurements recorded at the Salty Lagoon PWQMS showed very strong diurnal fluctuations during this reporting period, perhaps indicating a response to light availability, oxygen availability or temperature. The very high measurements from S3, collected near the middle of the day, reflects the daily changes at the time.
- The temperature measurements from all sites. This is a combination of seasonality, depth and the colour of the water.
- The enterococcus concentration at S2, probably related to bird use of the area.
- The turbidity measurements at S3.

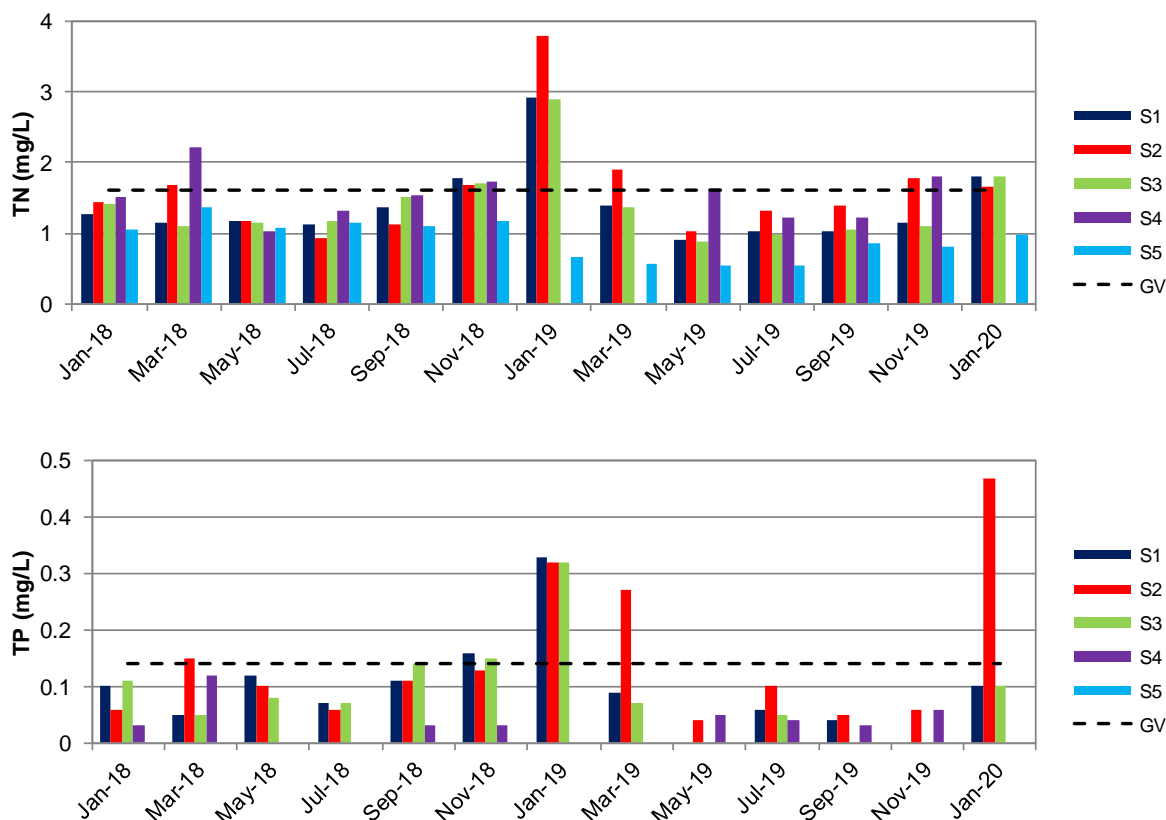


Illustration 4.1 Discrete Measurements of TN and TP at all Sites Since January 2018 Plotted Against the Salty Lagoon Guiding Value

4.2 Other Observations

The entrance to Salty Creek was closed on 22 January 2020. A large number and wide variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Chestnut Teal, Pelican, Black Swan, White Ibis, Great Egret, White-faced Heron, Masked Lapwing, Red-capped Plover, Pied Stilt, Sharp-Tailed Sandpiper, Curlew Sandpiper, Sanderling and White-bellied Sea

Eagle. Large areas of rushes in the open water of Salty Lagoon, mostly *Typha orientalis*, *Schoenoplectus validus* and *Phragmites australis*, have continued dying back in response to saline conditions. Large fish were observed on several occasions.



Plate 4.1 The closed entrance to Salty Creek on 22 January 2020



Plate 4.2 Dense macroalgal growth at S2 on 22 January 2020



5. Key Points

1. Water levels fell in Salty Lagoon and Salty Creek during this reporting period due to evaporation. Rainfall was very low again during this reporting period.
2. A large number of results did not comply with the guiding values.
3. Nutrient concentrations and chlorophyll-a concentrations were higher than in previous reporting periods, as is often the case following periods of above average evaporation.
4. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek did not advance significantly 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 a continued drop in the water levels have had a negative impact on some of the flora around the lagoon.



References

Bureau of Meteorology (2020). <http://www.bom.gov.au/>. Accessed 10/02/2020.

GeoLINK (2012). *Salty Lagoon Monitoring: Pre-Post Closure of Artificial Channel – Project Management and Ecosystem Health Monthly Report – September 2012*. Report to Richmond Valley Council.

GeoLINK (2017). *Final Evaluation Report - Salty Lagoon Monitoring: Pre-Post Closure of Artificial Channel – Project Finalisation Report*. Report to Richmond Valley Council.

Hydrosphere (2010). *Salty Lagoon Monitoring Program Pre/Post Closure of the Artificial Channel*. Unpublished report to Richmond Valley Council. Hydrosphere Consulting, Ballina.



Copyright and Usage

©GeoLINK, 2020

This document, including associated illustrations and drawings, was prepared for the exclusive use of Richmond Valley Council. It is not to be used for any other purpose or by any other person, corporation or organisation without the prior consent of GeoLINK. GeoLINK accepts no responsibility for any loss or damage suffered howsoever arising to any person or corporation who may use or rely on this document for a purpose other than that described above.

This document, including associated illustrations and drawings, may not be reproduced, stored, or transmitted in any form without the prior consent of GeoLINK. This includes extracts of texts or parts of illustrations and drawings.