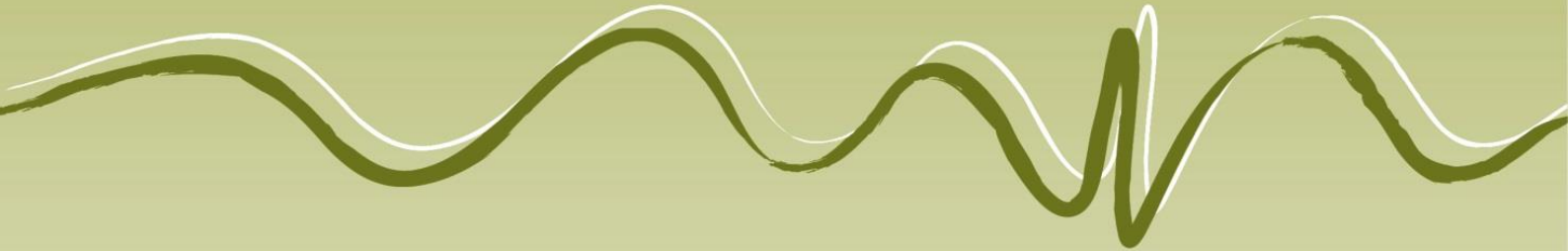


# **Salty Lagoon**

## **Post Closure Monitoring**

### **Project Management and Ecosystem Health Report**

**February 2021**



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# 1. Introduction

## 1.1 Introduction

This document comprises the fourth bi-monthly monitoring report for year 9 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 2021 until 28 February 2021.

## 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 9 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 2 March 2021. Water quality samples were collected between the hours of 7:00 am and 12:30 pm on that day. A high tide of 1.81 metres was forecast for 11.26 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 S3. 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. The summer 2020-21 aquatic weed monitoring was undertaken during the site inspection on 4 January 2021. The autumn 2021 aquatic weed monitoring is scheduled for the beginning of May 2021.

## 2.4 Erosion Monitoring

A series of stations have been set up around the 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**. Remediation of the headcut was undertaken by NSW National Parks and Wildlife Service (NPWS) in late 2020 through creation of a rock, geofabric and sand spillway at the outlet. Erosion monitoring is continuing to confirm if the headcut has stabilised (especially as the headcut scour was not infilled).

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. In March 2020 site ER5 had to be extended because the fixed peg was overtaken by the erosion. A new site, ER5A was created but allows erosion progression to be measured from the same initial reference point as ER5.

**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
ER5A	Impact	542128	6783245
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.

HOB0 U20 water level loggers were installed in the water at each PWQMS and a third HOB0 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 2 March 2021 and replaced by a serviced and calibrated set.

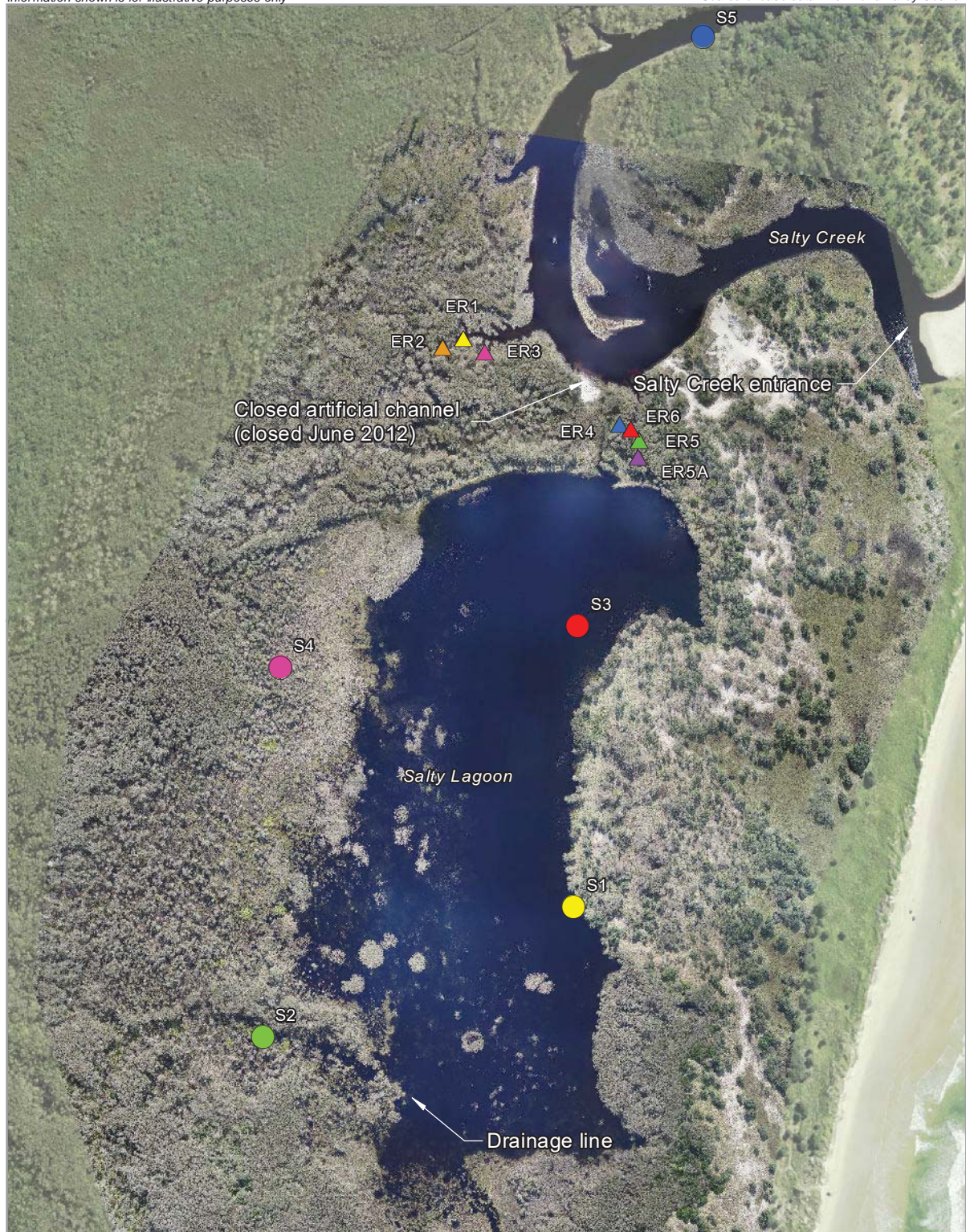
The status of the two deployed YSI EXO3 sondes on 2 March 2021 is displayed in **Table 2.3**.

**Table 2.3 YSI Sonde Status on 2 March 2021**

<b>Sonde</b>	<b>SN17F104100</b>	<b>SN 17H104488</b>	<b>Spare Probes</b>
pH (cap life expectancy 18 months)	EXO pH 17H105049 Manufactured 08/2017 New cap 02/2021	EXO pH 17H105047 Manufactured 08/2017 New cap 01/2021	EXO pH 17H105048 Manufactured 08/2017 New cap 10/2020
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F103252 Manufactured 06/2017	EXO Wiped CT 17F102047 Manufactured 06/2017	EXO Wiped CT 17F102685 Manufactured 06/2017
DO (cap life expectancy 24 months)	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2019	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 05/2019	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 03/2019
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H101468 Manufactured 08/2017	YSI EXO Turbidity 17H101465 Manufactured 08/2017	YSI EXO Turbidity 17H103513 Manufactured 08/2017
Wiper	YSI Exo Wiper 17G101952 New wiper brush installed 07/2020	YSI Exo Wiper 17G101954 New wiper brush installed 03/2020	No Spare Wiper
Status	<ul style="list-style-type: none"> <li>- Serviced probes installed in Salty Lagoon 2/03/2021</li> <li>- New batteries installed 2/03/2021</li> </ul>	<ul style="list-style-type: none"> <li>- Serviced probes installed in Salty Creek 4/01/2021</li> <li>- New Batteries installed 2/03/2021</li> </ul>	<ul style="list-style-type: none"> <li>- Awaiting service and calibration.</li> <li>- Probes Removed from Salty Lagoon 2/03/2021</li> </ul>
Notes	<ul style="list-style-type: none"> <li>- 218 days estimated battery life</li> <li>- Memory cleared – 47861 days logging available</li> </ul>	<ul style="list-style-type: none"> <li>- 218 days estimated battery life</li> <li>- Memory cleared – 50045.3 days logging available</li> </ul>	<ul style="list-style-type: none"> <li>- New DO cap required</li> </ul>

Climate information was sourced from the Evans Head bombing range weather station on the Bureau of Meteorology website (BOM 2021). Evans Head Sewage Treatment Plant (STP) facility routine sampling information was provided by Richmond Valley Council (RVC).





## LEGEND

### Water Quality Site

- S1
- S2
- S3
- S4
- S5

### Erosion Monitoring Site

- ▲ ER1
- ▲ ER2
- ▲ ER3
- ▲ ER4
- ▲ ER5
- ▲ ER5A
- ▲ ER6

0 120



## Location of Water Quality and Erosion Monitoring Sites



## 3. Results

### 3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 2 March 2021 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**.



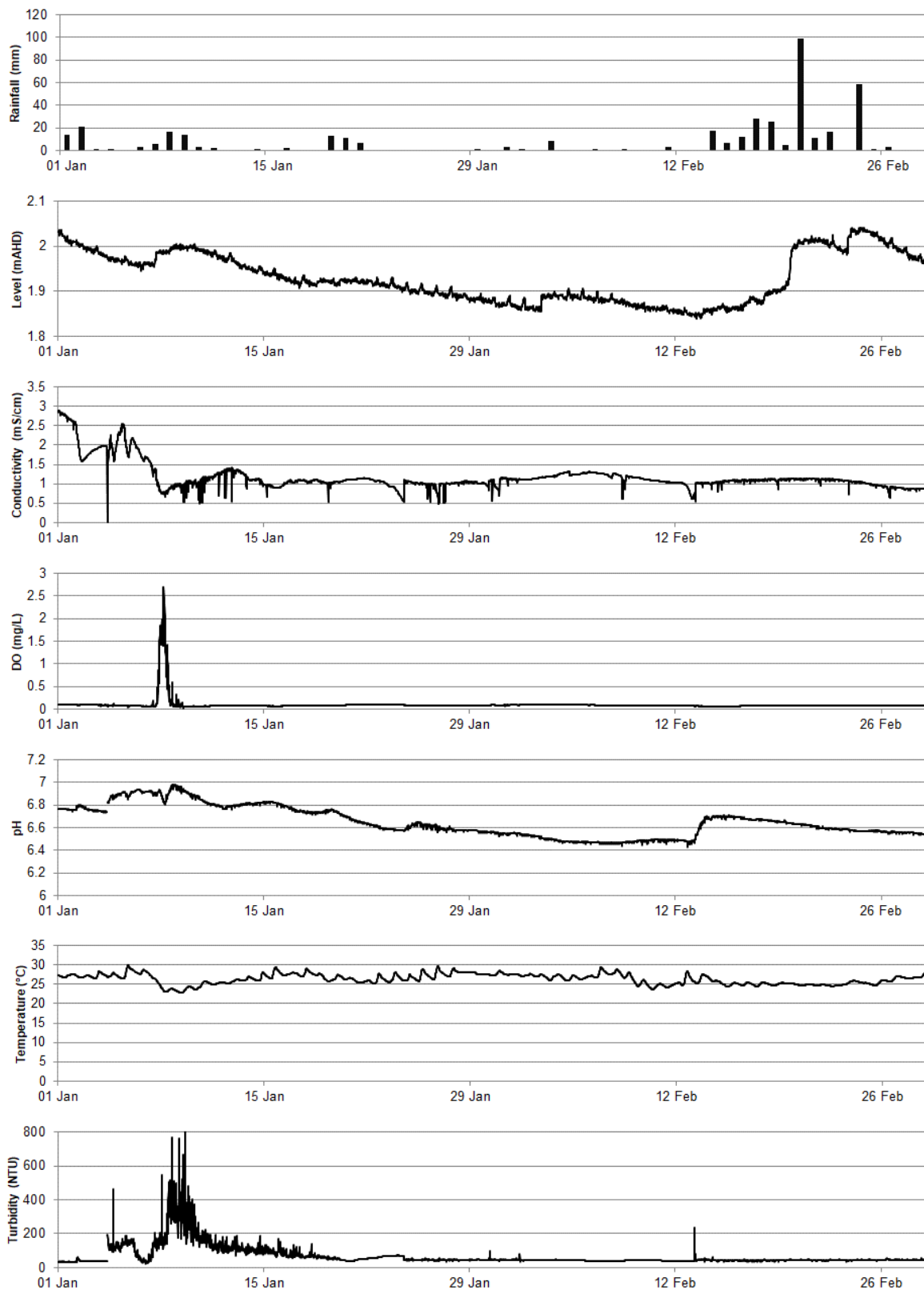
**Table 3.1 Results of Discrete Samples Collected 2 March 2021**

Parameter	Salty Lagoon								Salty Creek	
	Guiding Value	S1	S1 (1m)	S2	S3	S3 (1m)	S3 (QA)*	S4	Guiding Value	S5
Blue Green Algae ID (cells/mL)	0	<100	ns	<100	nil	ns	nil	<100	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	0.016	ns	<0.010	0.023	ns	0.029	<0.010	0.11	<0.010
Total Kjeldahl Nitrogen (mg/L)	1.6	1.54	ns	1.68	1.49	ns	1.49	1.33	1.63	1.06
Total Nitrogen (mg/L)	1.6	1.54	ns	1.68	1.49	ns	1.49	1.33	1.63	1.06
Total Phosphorus(mg/L)	0.14	0.09	ns	0.14	0.07	ns	0.08	<0.03	0.04	<0.03
Orthophosphate (mg/L)	0.11	0.071	ns	0.14	0.061	ns	0.066	0.015	0.01	<0.010
Chlorophyll-a (µg/L)	5	8	ns	2	3	ns	3	3	3	1
Enterococcus (CFU/100mL)	170	75	ns	70	35	ns	35	45	40	35
Faecal Coliforms (CFU/100mL)	135	15	ns	<5	<5	ns	<5	10	150	25
Temp (°C)	25.9	26.04	25.88	25.07	26.11	26	ns	24.48	13.1 - 28.8	23.19
pH	6.9	6.46	6.37	6.3	6.38	6.31	ns	5.05	4.3 - 6.8	4.44
ORP (mV)	-	187	192	181	199	203	ns	198	-	247
Cond (mS/cm)	8.0	0.441	0.442	0.299	0.445	0.445	ns	0.519	0.3 - 21.5	5.29
Turbidity (NTU)	13	3.4	2.9	0	2.3	2.2	ns	0	11	0
DO (mg/L)	4.09	3.63	3.63	0.14	3.23	3.3	ns	0.42	5.52	14.8
DO (% sat)	-	45.5	45.4	1.8	40.5	41.3	ns	5.2	-	179.8
TDS (mg/L)	-	0.287	0.287	0.194	0.289	0.289	ns	0.332	-	3.33
Sal (ppt)	-	0.2	0.2	0.1	0.2	0.2	ns	0.2	-	2.8
Depth (m)	-	Surface	1	Surface	Surface	1	1	Surface	-	Surface

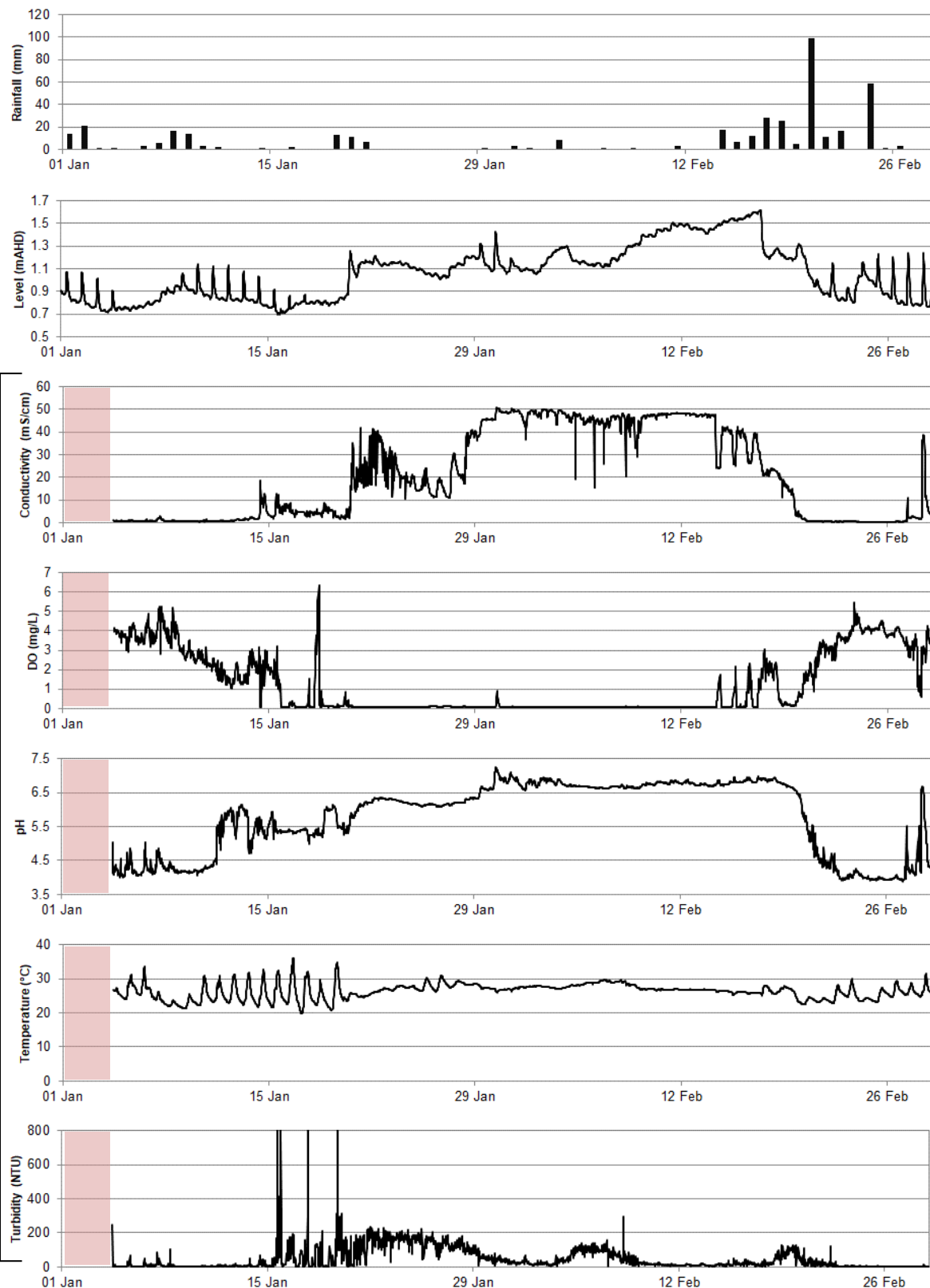
Note: \* = randomly selected quality assurance sample.

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 January 2021 to 28 February 2021



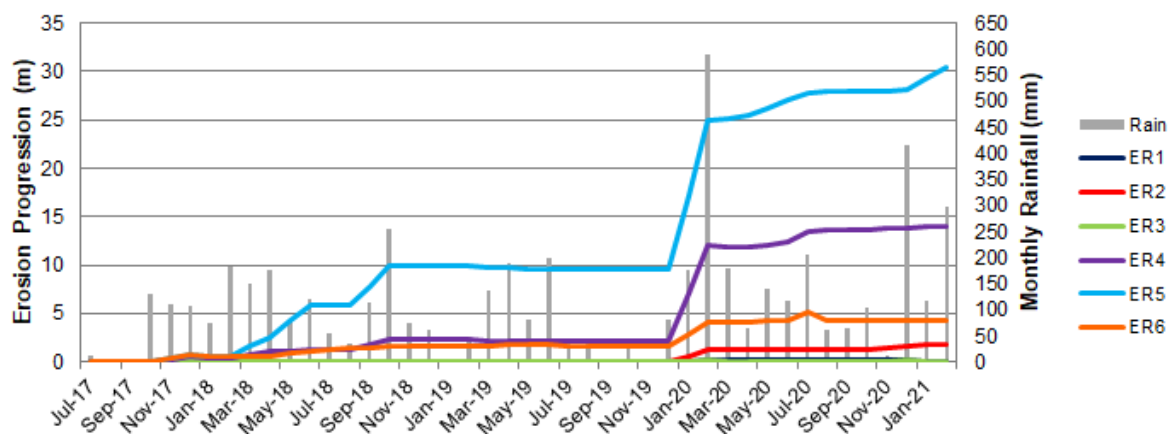
**Illustration 3.2** Salty Creek Rainfall and Water Quality Monitoring Station Data  
1 January 2021 to 28 February 2021

### 3.3 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2** and **Illustration 3.3**. There was local advancement of the head cut at ER5, progressing approximately 2.3m towards Salty Lagoon since the previous measurement on 4 January 2021 (post completion of the remediation works). The head cut has advanced at least 30 m towards Salty Lagoon since the monitoring began in July 2017.

**Table 3.2 Erosion Monitoring Results from 2 March 2021**

Station	Control/ Impact	Distance 25 July 2017 (m)	Distance 2 March 2021 (m)	Cut Movement (m)
ER1	Control	7.55	7.45	0.10
ER2	Control	10.20	8.40	1.80
ER3	Control	9.95	9.90	0.05
ER4	Impact	8.35	-5.60	13.95
ER5	Impact	12.35	-18.10	30.45
ER6	Impact	10.40	6.15	4.25



**Illustration 3.3 Erosion Progression Plotted against Monthly Rainfall since July 2017**



## 4. Discussion

### 4.1 Water Quality

Total rainfall for this reporting period comprised of several evenly spaced moderate events and two large rainfall events between the middle of February 2021 and the end of the reporting period. No adaptive management site inspections were undertaken because work to reduce erosive pressure on the headcut had been completed. The rainfall in January 2021 was slightly below average and the rainfall in February 2021 was far above average. Total rainfall for the two months was approximately 30 percent greater than the average amount.

The water level data from the Salty Creek PWQMS indicates that the entrance to Salty Creek was open and tidal movements were evident from the beginning of the monitoring period until 20 January 2021, when it became constricted and Salty Creek slowly filled with saline water. After heavy rainfall, it opened again on 17 February 2021, draining Salty Creek to very low levels and operating tidally until the end of the monitoring period. At the time of the site inspection on 2 March 2021, the entrance to Salty Creek was open and flowing out (**Plate 4.1**), with clear evidence of tidal movements. The water level in Salty Lagoon remained high throughout this monitoring period with very high levels recorded at the beginning and end of the monitoring period in response to heavy rainfall. The water levels from the Salty Lagoon PWQMS indicate that water from Salty Lagoon would have flowed into Salty Creek for the duration of the monitoring period.

The conductivity measured at the Salty Lagoon PWQMS was relatively stable during this reporting period, remaining low in response to continued rainfall runoff. Overall, the conductivity measurements decreased slightly from slightly brackish to freshwater. The conductivity measurements from the Salty Creek PWQMS show that Salty Creek remained fresh for the first 3 weeks of the reporting period, became saline for an extended period and was fresh again for the final week of the monitoring period after a very heavy rainfall event on 19 February 2021. At the time of the site inspection on 2 March 2021 the water in Salty Lagoon was well mixed and fresh, and the water in Salty Creek was fluctuating between brackish and saline in response to tidal movements. The conductivity measurements collected on 2 March 2021 complied with guiding values at all sites.

Erosion monitoring indicated that the head cut did advanced slightly during this reporting period. The level information indicates that runoff from Salty Lagoon into Salty Creek occurred for the majority of the reporting period. At the control sites there was only a small advance of the head cut at one site. The head cut remains approximately 12 m from the current banks of Salty Lagoon. It appears that the works undertaken to reduce erosive pressure on the head cut are currently working, but that erosion is still occurring, just to a lesser extent.

The DO concentrations in discrete samples collected on 2 March 2021 were below the guiding values at all sites in Salty Lagoon for the second consecutive month. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4) but low DO concentrations in the open water of Salty Lagoon are unusual, particularly after heavy rainfall. The data from the Salty Lagoon PWQMS indicates that the DO concentrations at the bottom of the water column in Salty Lagoon remained at very low levels for the entire reporting period. The DO concentration from Salty Creek on 2 March 2021 was very high. The data from the Salty Creek PWQMS indicate that DO concentrations were fluctuating in response to shifts in the salinity of the water for the entire monitoring period with high concentrations measured at times of freshwater dominance. This a common pattern in Salty Creek.

Almost all of the nutrient concentrations from samples collected on 2 March 2021 complied with guiding values. The exceptions were the TN, TP and ortho-phosphate concentrations from S2. Dilution from continued heavy rainfall experienced at the end of the reporting period would have contributed to low nutrient concentrations. The chlorophyll-a concentration at S1 did not comply with guiding values and indicated an algal bloom of small proportions. Blue-green algae were recorded from three of the four Salty Lagoon sites, but in very low concentrations. The blue-green algae detected were from the genera *Anabeana* and *Aphanocapsa* (S1 and S4) and *Cyanodictyon* and *Synechoccus* (S2). *Anabeana* are common in freshwater environments and some species form toxic blooms (Entwistle *et al.* 1997). *Aphanocapsa* is not a toxic bloom forming genus common in freshwater and brackish environments. *Cyanodictyon* is a rarely encountered marine genus and *Synechoccus* is a commonly encountered marine genus.

All other results complied with guiding values with the exception of the temperature measurements from Salty Lagoon. The temperature measurements are normal seasonal variations.

## 4.2 Other Observations

The entrance to Salty Creek was open and tidal on 2 March 2021. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Little Pied Cormorant, Little Black Cormorant, Pied Cormorant and White-Bellied Sea Eagle. Blue-green Algae were noted at S1. Lots of jumping Sea Mullet (*Mugil cephalus*) were observed at S1.



**Plate 4.1** The open entrance to Salty Creek on 2 March 2021

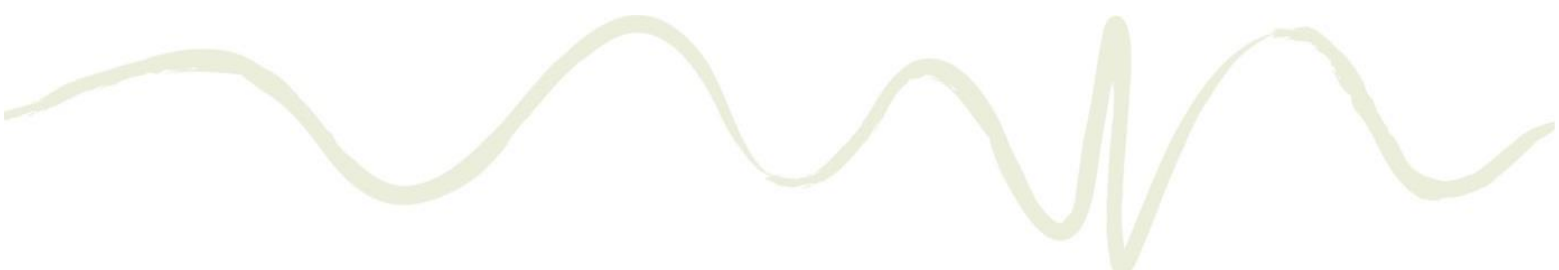


**Plate 4.2** Evidence of a slight reduction in the level of the scour spillway installed to reduce the erosive pressure on the head cut.

## 4.3 Adaptive Management – Risk Evaluation

Due to the recent progression of the head cut between Salty Lagoon and Salty Creek post remediation (spillway) works, the risk of a channel forming between the two water bodies has heightened. Should the headcut continue and form a channel, the system would become a more dynamic ecosystem, although less than pre-channel closure conditions provided the head cut remediation (spillway) works in late 2020 is maintained.





In accordance with the project *Environmental Response Protocol* (GeoLINK 2017b), the risk rating for the Salty Lagoon Response Protocol is uncertain. Adaptive management site visits are recommended for periods of potential head cut progression, with the following triggers:

- >50 mm of rainfall with 24 hrs.
- >200 mm of rainfall within a week.
- Other high risk events, for example >100 mm of rainfall within 72 hours, significant storm surge, atypically large tides, etc. Due consideration would be given to rainfall intensity and volume, and the Salty Creek entrance status when known as appropriate.



## 5. Key Points

1. Water levels remained high in Salty Lagoon throughout the current monitoring period. Water levels in Salty Creek were variable in response to entrance conditions and rainfall.
2. A small number of results did not comply with the guiding values.
3. Nutrient and chlorophyll-a concentrations were improved in comparison with the previous report.
4. Blue-green algae were detected for the fourth consecutive bi-monthly monitoring event but at reduced concentrations and a lower number of sites. One genera identified from S1 and S4 is potentially a type that can cause toxic blooms.
5. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek advanced slightly during this reporting period in response to heavy rainfall.
6. The risk rating for the Salty Lagoon Response Protocol is uncertain due to the advance of the headcut. Heavy rainfall may lead to a high risk rating and require a site inspection in the coming months.



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