Annual Report 2018

Salty Lagoon Post-Closure Monitoring Program (Years 6 – 10)

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Table of Contents

Illustrations

Tables

Plates

Figures

Appendices

Executive Summary

GeoLINK and Aquatic Science and Management have been engaged by Richmond Valley Council (RVC) to implement the Salty Lagoon Post Closure Monitoring Program. This report (Annual Report 2018) summarises the results of the monitoring undertaken between July 2017 and June 2018. Key findings are summarised below.

Water Quality (Monitored at Salty Lagoon and Salty Creek)

- Water level: The water level in Salty Lagoon remained full for the second half of the reporting period after low levels persisted during dry weather.
- Conductivity: Conductivity fluctuated throughout the reporting period with evidence of significant water movement from Salty Creek into Salty Lagoon on three occasions.
- Dissolved oxygen (DO): During this reporting period the DO concentration measured at the Salty Lagoon permanent water quality monitoring station (PWQMS) dropped below 1 mg/L on a reduced number of occasions (approximately 10 per cent). However, the DO concentration was 6 mg/L or less on approximately 69 per cent of occasions. These figures are comparable with most of the results from the MPPC.
- pH: The pH measurements at the Salty Lagoon PWQMS have been very stable but relatively high throughout this monitoring period.
- Temperature: Over the reporting period temperature fluctuated according to both daily and seasonal patterns. There is a relationship between water level in Salty Lagoon and the magnitude of temperature variation.
- Turbidity: During the current monitoring period turbidity measurements were relatively stable. Recorded fluctuations were in response to various factors such as wind driven sediment suspension and microalgal growth.
- Nitrogen: During the current reporting period the concentrations of total nitrogen (TN) were relatively stable with a few exceptions. In general, TN concentrations reduced after heavy rainfall and increased during extended dry periods. This indicates that nitrogen stored in the sediment in Salty Lagoon is the major source of nitrogen in the system, not rainfall runoff or the release of treated effluent upstream.
- Phosphorus: Variation in phosphorus concentrations at the sites in Salty Lagoon did not conform precisely to a specific pattern. Site S2 is the site most influenced historically by discharged effluent from the Evans Head STP and is most often the site with the highest phosphorus concentration. As with MPPC monitoring TN and total phosphorus (TP) concentrations appear to have varied independently during this reporting period. For most of the results, the greater proportion of the TP present was present as orthophosphate. This has important implications for the growth of algal material, which requires phosphorus to be present in the bioavailable form of orthophosphate.
- Chlorophyll-a: Chlorophyll-a concentrations generally complied with guiding values during this reporting period. The highest chlorophyll-a concentrations measured were recorded in the summer months and not generally associated with increased total nutrient concentrations or bioavailable nutrient concentrations.
- Blue green algae: Blue green algae were not detected during this monitoring period.

- Faecal indicator organisms: With the exception of a few spikes the enterococcus and faecal coliform concentrations were low at all sites during the reporting period. The major contributors to the observed variation in the concentration of faecal indicator organisms are runoff from the catchment and the presence of waterfowl. The results do not suggest that discharge from the Evans Head Sewage Treatment Plant (STP) or leaks from the Evans Head sewerage system are strongly influencing the concentrations of faecal indicator organisms.

Aquatic Vegetation/ Weeds

- No significant introduced species of aquatic weeds have been recorded in the current monitoring period, though two native species sometimes considered nuisance plants have been recorded.
- The risk of weed invasion into Salty Lagoon remains.

Erosion

The erosive head cut migrating towards Salty Lagoon from Salty Creek advanced significantly during this monitoring period. This remains a considerable risk to the positive changes recorded in the Salty Lagoon environment since the closure of the artificial channel.

Terrestrial Vegetation (Supplementary Melaleuca Dieback/ Recolonisation Monitoring)

Supplementary melaleuca dieback/ recolonisation monitoring was undertaken through establishment of three 150 m long belt transects on the western side of Salty Lagoon. The results provide a comprehensive record of melaleuca occurrence along the belt transects. Any changes in melaleuca numbers, size, condition and location along the belt transects should be detectible during the subsequent monitoring event in 2021/22.

1. Introduction

1.1 Background

GeoLINK and Aquatic Science and Management (ASM) have been engaged by Richmond Valley Council (RVC) to implement *the Salty Lagoon Post Closure Monitoring Program* (GeoLINK 2017a). Prior to this current engagement, RVC implemented the *Salty Lagoon Ecosystem Response Monitoring Program* (ERMP – Worley Parsons) and the Salty Lagoon Monitoring Program: Pre/Post Channel Closure (MPPC – Hydrosphere 2010a).

In brief, the ERMP sought to monitor the ecological health of the system for a two-year period, and to collect data across a range of disciplines to allow for further planning to be undertaken in accordance with the broader aims of the rehabilitation strategy. The study site for the ERMP was more extensive than that being monitored under the MPPC or the current engagement and included sampling sites along the entire length of the drainage channel from the Evans Head Sewage Treatment Plant (STP) to Salty Lagoon, and areas of adjoining bushland to the north of this facility. This work was completed in March 2010 (Hydrosphere 2010b) and included the following components:

- Water quality and hydrology
- Diatoms
- Macroinvertebrates
- Fish
- Frogs and waterbirds
- Flora and vegetation mapping
- Weeds.

The MPPC sought to monitor the ecological health of the system before and after a trial closure of the artificial channel that once connected Salty Lagoon and Salty Creek. The study site for the MPPC was the same as the current engagement. The MPPC concluded at the end of June 2017 and included the following components:

- Water quality and hydrology
- Macroinvertebrates
- Fish
- Frogs and waterbirds
- Flora and vegetation mapping
- Aquatic Weeds.

The current post closure monitoring program continues from the MPPC monitoring with a reduced frequency of site visits and a reduced overall suite of monitoring components (GeoLINK 2017a).

1.2 Objectives

The objectives of the post closure monitoring program are summarised as follows:

1. Monitor the health of the Salty Lagoon ecosystem and confirm that the Evans Head STP discharge is not adversely impacting water quality and ecology at Salty Lagoon.
2. Monitor water quality and ecological attributes of the MPPC where predicted trends have not been confirmed and risks to the ecosystem remain.
3. Observe medium to long-term changes in the Salty Lagoon system in response to channel closure.

This report (*Annual Report 2018)* summarises the results of the monitoring undertaken between July 2017 and June 2018 as part of the post closure monitoring program.

2. Water Quality

2.1 Introduction

Adequate water quality has been identified as a key factor influencing the ecosystem processes in Salty Lagoon. Issues with water quality such as high nutrient concentrations and rapid changes in conductivity and dissolved oxygen have been identified in previous monitoring. Poor water quality in the past has led to fish kills, indicating ecosystem collapse (Hydrosphere 2009). The Salty Lagoon water quality monitoring program provides the key information for understanding the Salty Lagoon ecosystem.

Ongoing monitoring of water quality in Salty Lagoon has changed for the post closure monitoring period. However, there is still a multi-faceted approach to water quality sampling involving permanent water quality monitors, discrete sampling of surface waters and an additional response protocol. The range of parameters covered by each of these approaches to water quality monitoring is described in Table 2.1.

Table 2.1 Approaches to Water Quality Monitoring and Parameters Measured for the MPPC

Approach	*Sampling Type*	*Parameters*
Permanent water quality monitoring stations (PWQMS)	Physico-chemical	Temperature, conductivity, dissolved oxygen (DO), pH, turbidity, water level
Monthly discrete sampling and adaptive management response sampling	Physico-chemical	Temperature, conductivity, dissolved oxygen (DO), pH, turbidity, secchi depth, redox potential
	Chemical	Total nitrogen, ammonia, nitrate, nitrite, total kjeldahl nitrogen, total phosphorus, orthophosphate
	Biological	Chlorophyll-a, blue green algae, faecal coliforms, enterococci

2.2 Methods

2.2.1 Permanent Water Quality Monitoring Stations

There are two permanent water quality monitoring stations (PWQMS) in place measuring water level, temperature, pH, conductivity, turbidity and dissolved oxygen (DO) concentration. Each PWQMS is fitted with an YSI EXO3 sonde and a HOBO U50 water level data logger. Data is collected at 30-minute intervals, logged and accessed during bi-monthly site inspections. The water level data is corrected prior to reporting using the surveyed levels of the measuring boards at each of the permanent water quality monitoring stations and a barometric pressure logger deployed at Salty Lagoon (S1). The individual probes on each EXO3 sonde are removed from the PWQMS, calibrated and serviced after a four-month deployment.

2.2.2 Routine Discrete Sampling

Discrete water quality samples were taken from surface water (approx. 0.2 m depth) at four sites in Salty Lagoon (S1-S4) and a single site (S5) in Salty Creek on a bi-monthly basis. An additional quality assurance (QA) replicate sample was collected from a randomly chosen site each monitoring event. The specific locations of all sites sampled are presented in **Table 2.2** and displayed in **Illustration 2.1**. Sampling was undertaken bi-monthly (every second month) commencing in October 2017 for the reporting period (five events in total).

Table 2.2 Locations of Water Quality Sample Sites in Salty Lagoon and Salty Creek (WGS84)

Site	*S1*	*S2*	*S3*	*S4*	*S5*
Easting	0542064	0541799	0542037	0541738	0542187
Northing	6782801	6782669	6783013	6783033	6783665
Site description	Salty Lagoon PWQMS	SE of drainage channel	NE area of lagoon	NW area of lagoon	Salty Creek PWQMS

Physico-chemical water quality parameters in discrete surface water samples were measured with an HORIBA U-52 hand held water quality meter. Depth profiling of physicochemical parameters was undertaken at one metre intervals at sites where the water depth was sufficient to allow it. Depth profiling is undertaken to improve the understanding of stratification of the water column at times when the water level is high. The results of depth profiling are reported in bi-monthly ecosystem health reports and will not be repeated here.

Discrete samples were collected in jars for analysis of chemical and biological parameters at the Coffs Harbour Laboratory (CHL). Sterile jars were used for bacteriological analysis and brown glass jars were used for analysis of chlorophyll-a and blue green algal (BGA) content. Samples were placed upon ice in an Esky and delivered to CHL within 24 hours of collection.

2.2.3 Adaptive Management WQ Sampling

The MPPC Salty Lagoon Response Protocol was reviewed and updated in October 2017 to guide adaptive management as part of the post closure monitoring program (GeoLINK 2017b). The new protocol involves assessing the collected water quality data and environmental variables such as the status of the entrance to Salty Creek, the status of the headcut between Salty Creek and Salty Lagoon and seasonal rainfall fluctuations to prepare a risk level.

Adaptive management water quality sampling is only implemented when the Salty Lagoon system is in a ‘high risk’ status, a site inspection is undertaken, and an environmental incident is noted. During this reporting period Salty Lagoon retained a low risk status and there were no adaptive management site inspections undertaken.

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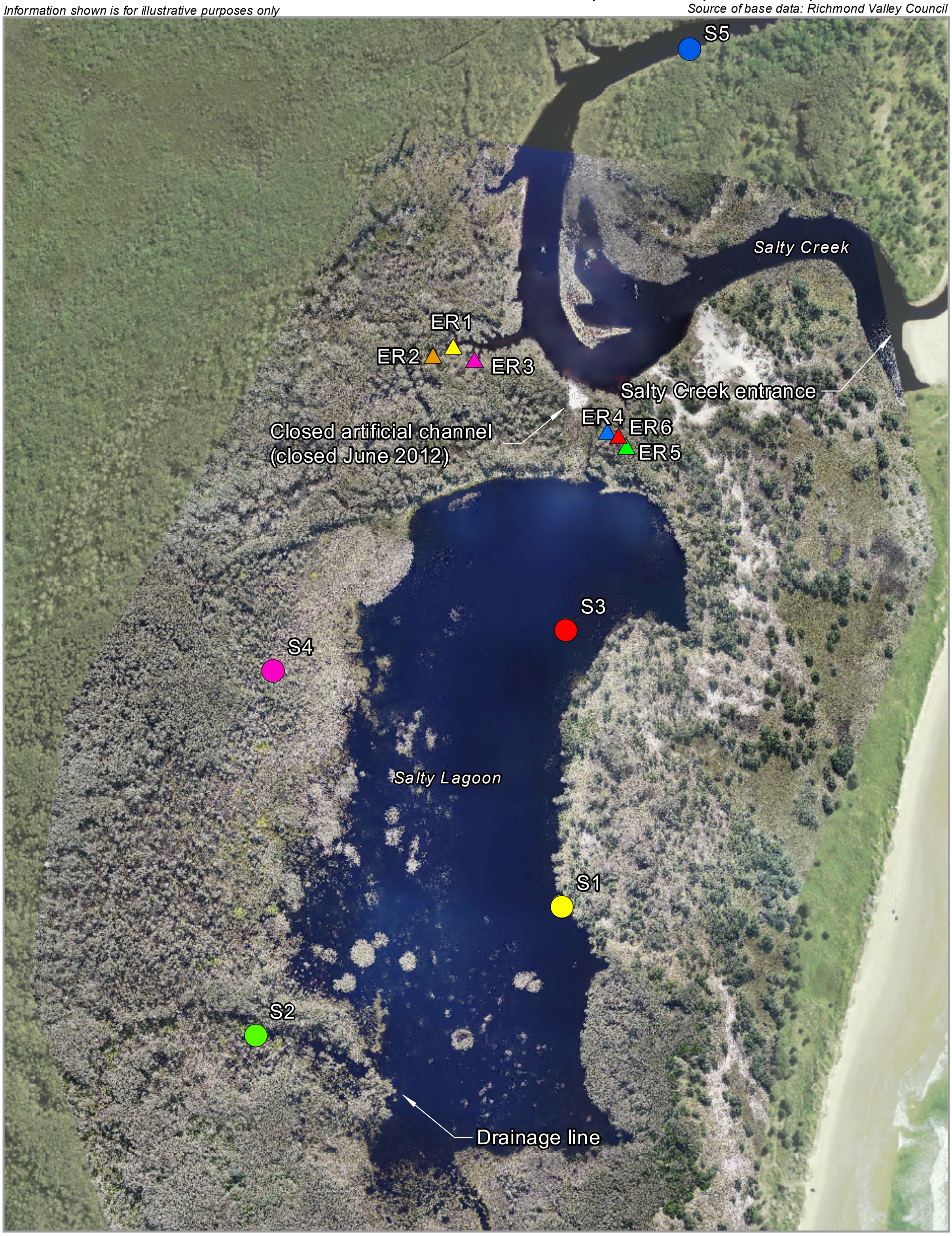
Source of base data: Richmond Valley Council
Information shown is for illustrative purposes only



LEGEND

Water Quality Site	Erosion Monitoring Site
S1	ER1
S2	ER2
S3	ER3
S4	ER4
S5	ER5
	ER6

0 120

Location of Water Quality and Erosion Monitoring Sites

2.2.4 Guiding Values

Guiding values for the MPPC monitoring program were revised in September 2012 using water quality data collected between April 2011 and September 2012 as part of the MPPC project. They were developed separately for Salty Lagoon and Salty Creek, from surface water data collected at all sites and incorporated all parameters measured as part of the MPPC.

The guiding values were set at the 80th percentile value of the collected data set for Salty Lagoon and Salty Creek with the following exceptions:

- The guiding values for dissolved oxygen were set at the 20th percentile value.
- A guiding value range was developed for pH, conductivity and temperature in Salty Creek due to the varying influences of sea water and freshwater runoff. The outlying points for the guiding value ranges were set at the 10th and 90th percentile values.

The guiding values were developed to assist with the contextualisation of results, rather than as a measure of the health of the waterway. However, guiding values also provide a yardstick, around which the adaptive management of Salty Lagoon can be discussed.

These guiding values are being used as part of the current post closure monitoring program for all water quality parameters being sampled; and are presented in **Table 2.3**.

Table 2.3 Guiding Values for all Water Quality Parameters

Measure		***Guiding Value***	
		Salty Lagoon	***Salty Creek***
Chemical	Total nitrogen (mg/L)	1.6	1.64
	Ammonia (mg/L)	0.05	0.11
	Nitrate (mg/L)	0.01	0.01
	Nitrite (mg/L)	0.01	0.01
	Total kjeldahl nitrogen (mg/L)	1.6	1.64
	Total phosphorus (mg/L)	0.14	0.04
	Orthophosphate (mg/L)	0.11	0.01
Biological	Chlorophyll-a (µg/L)	5	3
	Faecal coliforms (CFU/100mL)	135	150
	Enterococci (CFU/100mL)	170	40
	Blue green algae (cells/mL)	0	0
Physical	Dissolved oxygen (mg/L)	4.09	5.52
	Turbidity (NTU)	13.0	11.0
	pH	6.9	4.3 – 6.8
	Conductivity (mS/cm)	8.0	0.3 – 21.5
	Temperature (˚C)	25.9	13.1 – 28.8

2.3 Results and Discussion

2.3.1 Rainfall

Rainfall, or lack thereof, is a key factor influencing water quality in Salty Lagoon and Salty Creek. Monthly rainfall conditions for the reporting period are displayed in **Figure 2.1**. Daily rainfall for the reporting period is displayed in **Figure 2.2** and **Figure 2.3**. The monitoring period was characterised by very dry weather in the period between July 2017 and September 2017, and close to average monthly rainfall for most of the rest of the reporting period. Overall, rainfall was significantly below average for the reporting period and most of the rain fell as part of small to moderate rainfall events. There were only two daily rainfall totals of greater than 50 mm during this reporting period.

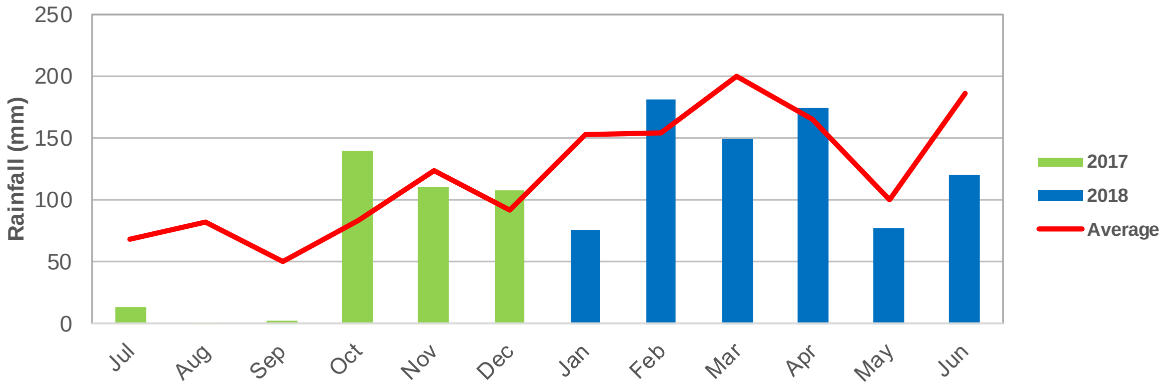


Figure 2.1 Monthly rainfall at the Evans Head BOM weather station for the reporting period displayed against average monthly rainfall (BOM 2018)

2.3.2 Permanent Water Quality Monitoring Stations

2.3.2.1 Data Quality and Consistency

Following the installation of the YSI EXO3 water quality monitoring systems in October 2017 the data quality and consistency improved significantly. However, between July and October 2017 there are several gaps in the data from the PWQMS. These are either:

- Regular short-term gaps in the data set ranging from one 30-minute interval reading to over three hours.
- A large gap in the data between August and October 2017 (between the end of the MPPC program and the beginning of the post closure monitoring program) where no data was collected or collected data was unreliable.

Over the monitoring period from 1 June 2017 to 30 June 2018 the missed data points from the Salty Lagoon PWQMS were as follows:

- 2173 (12.4 per cent) missed temperature, pH, conductivity and turbidity data points.
- 3206 (18.3 per cent) missed DO data points (the DO measurements from the old logging equipment became unreliable at an earlier stage).

- 6944 (39.6 per cent) missed water level data points (the deployment of the HOBO water level loggers occurred two months after the deployment of the YSI EXO3 sondes).

Over the monitoring period from 1 June 2017 to 30 June 2018 the missed data points from the Salty Creek PWQMS were as follows:

- 3151 (18.0 per cent) missed temperature, pH, conductivity, turbidity and dissolved oxygen data points.
- 6892 (39.3 per cent) missed water level data points (the deployment of the HOBO water level loggers occurred two months after the deployment of the YSI EXO3 sondes).

The majority of the missed data points from both PWQMS stations occurred in the gap between the end of the MPPC monitoring and the beginning of the post closure monitoring.

As part of routine maintenance, the logged results are compared in the field with data collected from a handheld water quality probe every month. In general, the results correlate very well. The correlation has improved further since the deployment of the YSI EXO3 equipment.

2.3.2.2 Key Points Arising from the Salty Lagoon Data Set

The results from the Salty Lagoon PWQMS are presented in **Figure 2.2** and are discussed below.

Water Level

The water level was very low in Salty Lagoon at the beginning of the reporting period but following saline water ingress on 20 August 2017 and rainfall in early October 2017 Salty Lagoon filled up and water levels remained high for the remainder of the reporting period. As a result, water moved from Salty Lagoon into Salty Creek for most of the reporting period after October 2017. There were two exceptions to this, during early and late February 2018, when water levels in Salty Creek rose rapidly in response to rainfall and saline water, stored in Salty Creek, moved upstream into Salty Lagoon. The water level chart in **Figure 2.2** indicates that the maximum water level reached in Salty Lagoon for the reporting period was 2.16 m AHD (Australian Height Datum), after heavy rainfall on 6 March 2018.

Conductivity

Conductivity is a measure of the saltiness of the water. The key driving factors causing fluctuations in the conductivity of the water recorded in Salty Lagoon during this reporting period were rainfall, evaporation and saline water inflow from Salty Creek. Evaporation causes a gradual increase in conductivity measurements. Rainfall has the opposite effect but typically operates over shorter timeframes. Saline water inflow from Salty Creek occurred on three occasions during the reporting period. In combination with the below average rainfall this led to higher than normal conductivity measurements for much of the reporting period. The average conductivity measured was 5.31 m^2/cm. After saline water ingress in February 2018 conductivity measurements did not return to levels usually associated with freshwater environments until late April 2018.

Small and short-term variations in the conductivity measured at the Salty Lagoon PWQMS also often result from changes in the intensity of wind and flow driven mixing of the water column. However, this is usually only evident when water levels are low.

The conductivity measurements indicate that saline water movement from Salty Creek into Salty Lagoon was a major feature impacting water quality during this reporting period.

Dissolved Oxygen

The dissolved oxygen measurements from the Salty Lagoon PWQMS indicate that variations in DO concentrations occur due to daily fluctuations in response to light availability (diurnal fluctuations), short-term irregular variation in response to wind driven mixing, seasonal variation relating to water temperatures and medium-term fluctuations in response to rapid changes in the water quality, such as heavy rainfall runoff.

Variation in the dissolved oxygen concentrations measured in Salty Lagoon relate to the following features (GeoLINK 2017b):

- Diffusion: The surface of the water is exposed to the air and dissolves oxygen constantly through diffusion. For this reason, DO concentrations tend to be higher in surface waters.
- Microalgal concentrations: Microalgae produce oxygen during the day through photosynthesis and consume it at night through respiration. Nutrient availability has an impact on DO concentrations indirectly through supporting microagal concentrations.
- Light availability: This influences the photosynthetic activity of microalgae throughout the water column and attached to the benthos. Turbidity, therefore, is a key regulator of DO concentrations.
- Wind and flow driven mixing: Mixing of the water column serves to bring well oxygenated water from the surface into lower parts of the water column. The stronger the wind or flow, the deeper the mixing. North and south winds have the greatest effect on Salty Lagoon due to the north-south orientation.
- Water level: The depth of the water determines the impact of wind driven mixing and the availability of light at the bottom of the water column.
- Salinity: There have been sharp reductions in DO concentration associated with saline water ingress in previous years, possibly due to the impact upon microalgal concentrations.

During this reporting period the major features of dissolved oxygen variation were:

- Lower dissolved oxygen concentrations during times of higher salinity.
- Lower dissolved oxygen concentrations and greater daily fluctuations during the summer months.
- Extended periods of stable, healthy dissolved oxygen concentrations following periods of heavy rainfall.
- Greater stability of dissolved oxygen concentrations in freshwater conditions.

During this reporting period the DO concentration measured at the Salty Lagoon PWQMS dropped below 1 mg/L on a moderate number of occasions. In the current reporting period the DO concentration was 6 mg/L or less on approximately 70 per cent of occasions and 1 mg/L or less on approximately 10 per cent of occasions. This suggests a decrease in the occurrence of hypoxic conditions at the Salty Lagoon PWQMS relative to reporting period during the MPPC monitoring. More reliable dissolved oxygen measurements from the new equipment may have contributed to this result.

pH

The pH measurements at the Salty Lagoon PWQMS were relatively stable during this reporting period. The data indicates that the pH in Salty Lagoon varied mostly in response to saltwater ingress from Salty Creek. There are also small daily fluctuations in pH associated with other diurnal changes in water quality such as dissolved oxygen concentration and small reductions in the pH are notable after heavy rainfall. Overall the variation was low, with the measured pH mostly between 6.5 and 7.5.

Temperature

Over the reporting period temperature fluctuated according to both daily and seasonal patterns. There is also a relationship between water level in Salty Lagoon and the magnitude of daily temperature variation. When water levels are low, temperature variation tends to be greater. Other sources of variation evident from the data for this reporting period include greater temperature stability following saltwater ingress (probably due to stratification) and rapid reductions in temperature following moderate to heavy rainfall.

Water temperature indirectly and directly impacts upon other parameters. For example, at higher temperatures water has a lower oxygen carrying capacity and higher temperatures encourage microalgal growth and activity and contribute to algal blooms.

Turbidity

Turbidity measurements fluctuate in response to various other factors such as wind driven sediment suspension and microalgal growth. During the current monitoring period turbidity measurements were relatively stable and mostly remained below 5 NTU. There were only short periods of higher turbidity measurements and these were associated with a period of high conductivity measurements, indicating a relation to saline water ingress from Salty Creek, and a period of low dissolved oxygen concentrations.

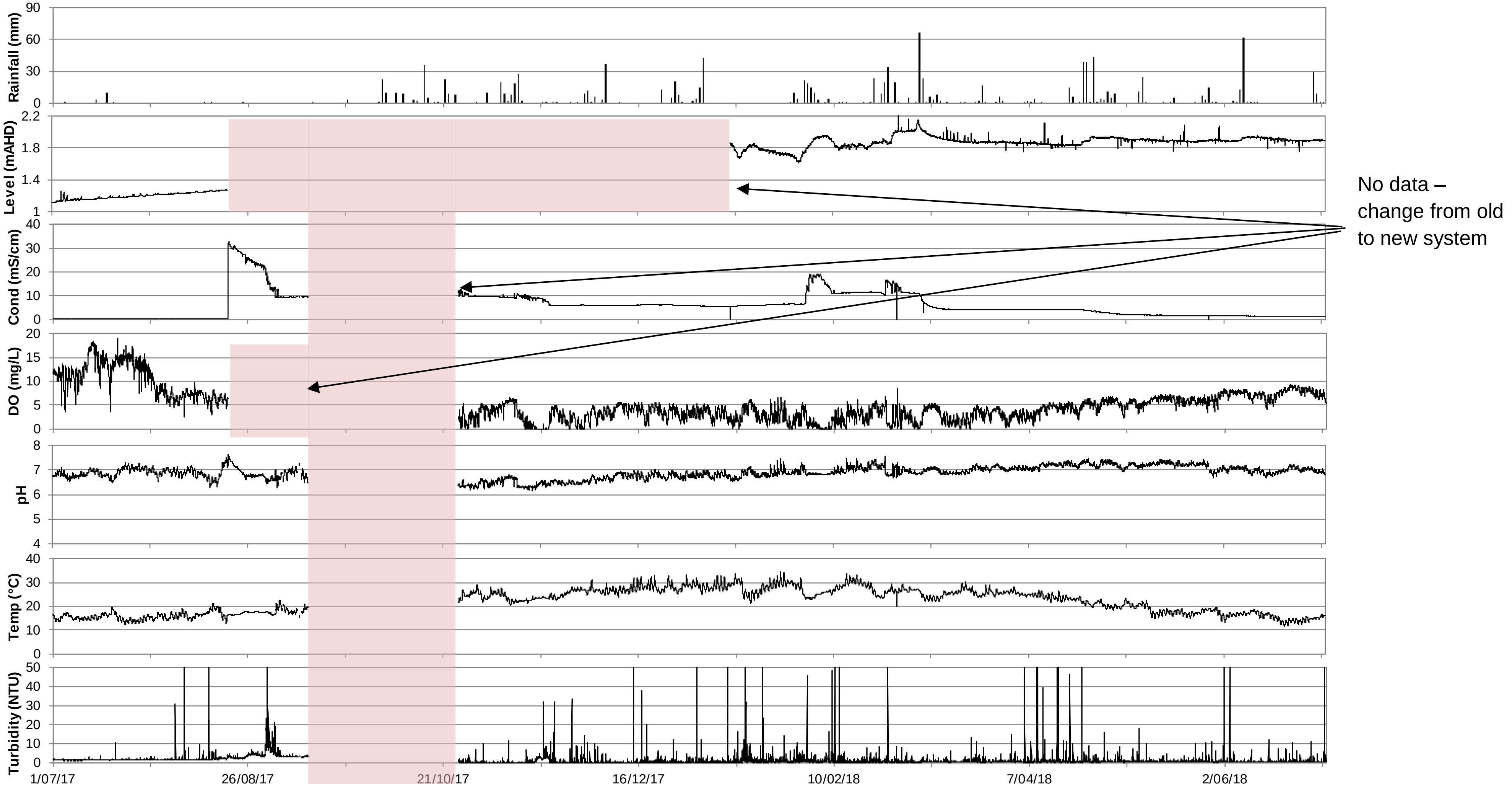


Figure 2.2 Data from the Salty Lagoon PWQMS for the 2017/18 reporting period

2.3.2.3 Key Points Arising from the Salty Creek Data Set

The Salty Creek PWQMS is important in the context of managing Salty Lagoon as it provides information about how water quality in Salty Creek can impact upon Salty Lagoon. The results from the Salty Creek PWQMS are presented in **Figure 2.3** and discussed below.

Water Level

The most important factor affecting the water level in Salty Creek is the status of its entrance. The collected data indicates that the entrance to Salty Creek opened at least eight times in the current reporting period, compared with a minimum of two and a maximum of 17 times in the annual reporting periods of the MPPC. The level of Salty Creek increased sharply on several occasions during this reporting period as a result of seawater ingress during large swell and storm surge conditions. The entrance to Salty Creek tends to close during the same conditions, which result in sand delivery to the beach and an increased height of the entrance berm. Other increases in level occurred in response to very heavy rainfall events, which can lead to the entrance opening and a later reduction in the water level.

Conductivity

The conductivity measurements from the Salty Creek PWQMS fluctuated widely in response to the dynamic state of the entrance, seawater ingress and medium and heavy rainfall events. The dataset indicates varying influences of rainfall, tidal movements and seawater ingress but the conductivity measurements most often reflect either very saline or very fresh conditions. Extended periods of brackish water conditions were rare. However, during the times when conductive saline water dominated the readings from the Salty Creek PWQMS, discrete water quality samples from the surface of the water frequently showed that the water column was stratified into a heavy saline layer and a freshwater surface layer. During the current reporting period, saline conditions were more common than freshwater conditions.

Dissolved Oxygen

Dissolved Oxygen (DO) concentrations measured at the Salty Creek PWQMS fluctuated widely throughout the year. A variety of factors influence the DO concentrations in Salty Creek. The general patterns of variation were as follows:

- DO concentration tended to be higher during periods of freshwater dominance and when water levels were low.
- DO concentrations in Salty Creek fluctuated diurnally over the majority of the reporting period. During this reporting period diurnal fluctuations were most prominent when there was a combination of low water levels and saline conditions.
- The water column in Salty Creek is often stratified with respect to DO concentration, although this is not apparent from the logged information.

The DO concentration measured at the Salty Creek PWQMS was 6 mg/L or less for approximately 91 per cent of the reporting period and 1mg/L or less for approximately 50 per cent of the reporting period. These figures indicate that low DO concentrations were much more prevalent in this reporting period than during the years of the MPPC.

pH

The pH measurements from the Salty Creek PWQMS fluctuated regularly during this reporting period and were closely associated with conductivity and the state of the entrance. Runoff from the catchment is naturally acidic, resulting in a pH of < 5 in Salty Creek following heavy rainfall. This contrasts strongly with the pH after seawater ingress which can have the effect of increasing the pH measurements to over pH 8. The pH in Salty Creek thus tends to be either quite high or very low, following seawater ingress or heavy rainfall respectively. However, when conditions are stable the pH often trends towards neutral from either direction.

Temperature and Turbidity

Temperature measurements in Salty Creek fluctuated on a daily and seasonal basis. Daily fluctuations in temperature are strongest when water levels are low. Turbidity measurements from the Salty Creek PWQMS were generally low, with periods of greater turbidity following seawater ingress and heavy rainfall.

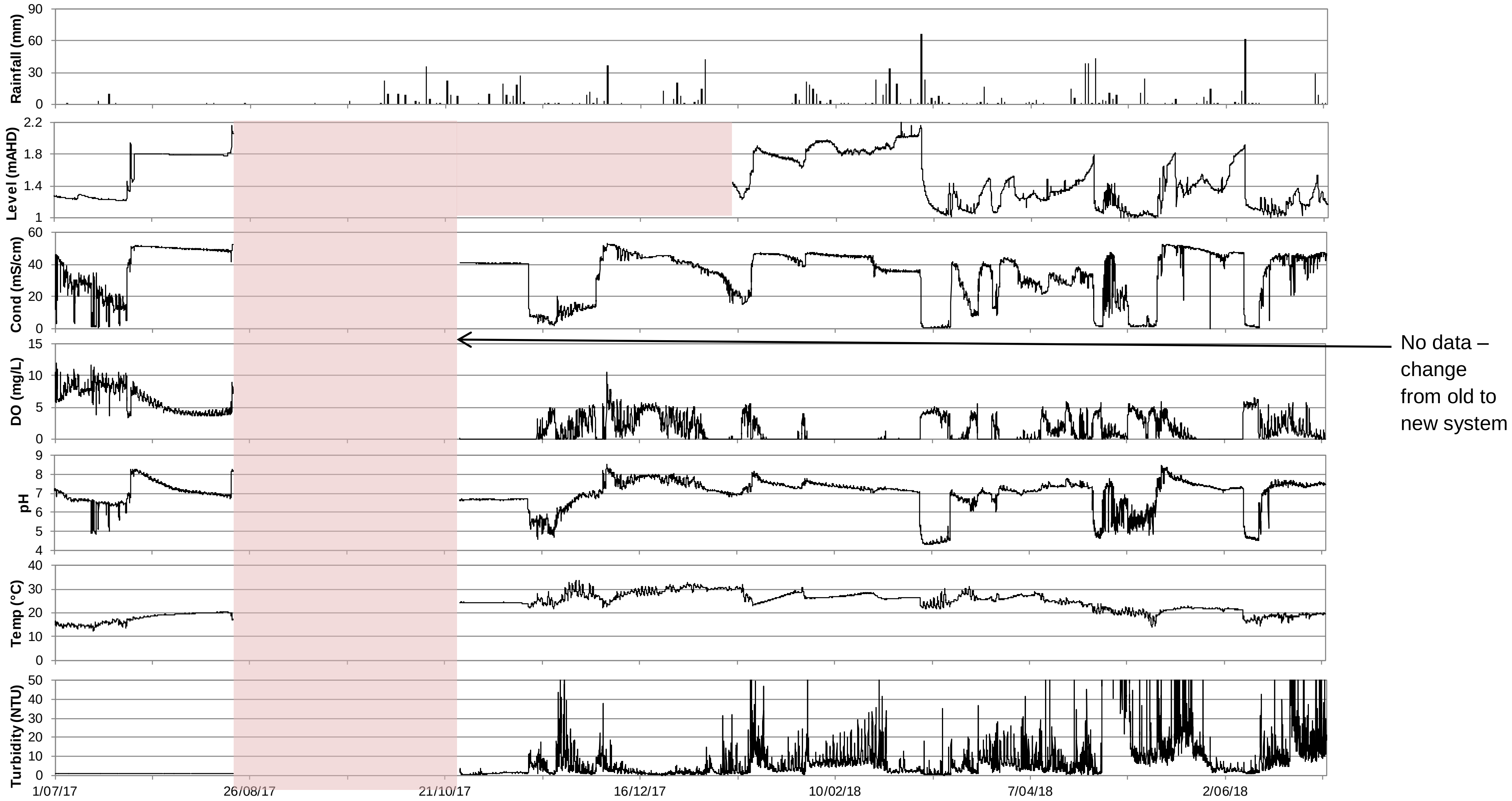


Figure 2.3 Data from the Salty Creek PWQMS for the 2017/18 reporting period

2.3.3 Discrete Water Quality Samples

This section describes the results of discrete water quality samples collected during normal bi-monthly water quality monitoring. A summary of median results for all samples from all sites is presented in **Table 2.4**. Most of the median results complied with guiding values.

Results from individual sites are compared in **Section 2.3.3.1** to **Section 2.3.3.5**.

Table 2.4 Median Results of Discrete Samples from Surface Waters at all Sites Between 1 July 2017 and 30 June 2018

Indicator	*Site*				
	S1	*S2*	*S3*	*S4*	*S5*
Nitrite nitrogen (mg/L)	0.000	0.000	0.000	0.000	0.000
Nitrate nitrogen (mg/L)	**0.011**	0.000	0.000	0.000	0.000
Oxidized nitrogen (mg/L)	0.011	0.000	0.000	0.000	0.000
Ammonia nitrogen (mg/L)	0.020	0.000	0.015	0.000	0.000
Total kjeldahl nitrogen (mg/L)	1.16	1.45	1.15	1.52	1.16
Total nitrogen (mg/L)	1.18	1.45	1.17	1.52	1.16
Total phosphorus (mg/L)	0.07	0.10	0.07	0.03	0.00
Orthophosphate (mg/L)	0.027	0.051	0.025	0.000	0.000
Chlorophyll-a (µg/L)	0	4	2	2	0
Enterococcus (CFU/100mL)	15	125	10	50	65
Faecal coliforms (CFU/100mL)	25	**190**	22	15	**214**
Blue green algae (cells/L)	0	0	0	0	0
Temp (˚C)	22.50	23.25	22.16	21.91	19.24
pH	**7.02**	6.23	**7.11**	5.49	4.47
ORP (mV)	163	160	186	193	288
Cond (mS/cm)	5.64	1.49	6.17	1.25	1.56
Turbidity (NTU)	2.60	1.00	1.70	4.10	1.00
DO (mg/L)	5.92	**2.42**	7.33	**2.86**	**5.23**
DO (% sat)	73.70	29.50	87.40	30.20	58.90
TDS (ppt)	3.62	1.00	3.76	0.84	1.00
Salinity (ppt)	3.70	1.00	4.00	0.60	0.80

*Note: **red text:** not compliant with MPPC guiding values (GeoLINK 2012)*

2.3.3.1 Nitrogen

Nitrogen is an element that is essential to life. In waterways it plays an important role in supporting food webs. However, problems arise from excessive nitrogen concentrations in water. Nitrogen is frequently monitored as an indicator of water quality and its capacity to support a healthy aquatic ecosystem. Nitrogen is present in water in several forms. It can be dissolved or particulate and can be present in organic molecules that are unavailable for biological uptake or inorganic molecules that are bioavailable. For the MPPC and post closure monitoring, nitrogen is measured as total nitrogen (TN), and the dissolved inorganic nitrogen (DIN) forms; ammonia, nitrate and nitrite.

Some of the factors that have been found to influence nitrogen concentrations in Salty Lagoon and Salty Creek include seawater ingress, historical pollution, evaporative distillation and rainfall runoff (GeoLINK 2017b).

During the current reporting period the concentrations of TN were variable but within the ranges measured during the MPPC project (**Figure 2.4**). The highest TN concentrations were measured at sites S2 and S4 during the hottest and/or driest periods of the year. At sites S1 and S3 all TN concentrations recorded complied with the guiding values.

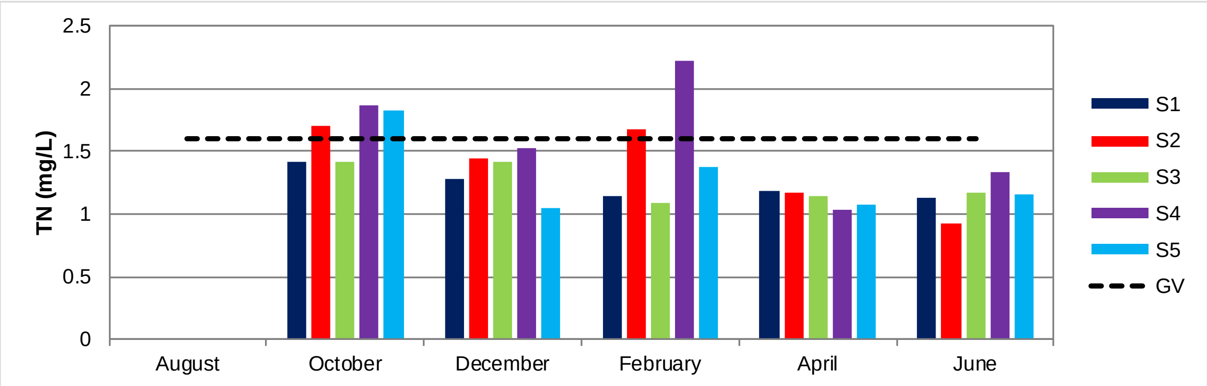


Figure 2.4 Time series of TN concentrations at all sites for the 2017/18 reporting period

Aside from infrequent spikes in the concentration of nitrite, nitrate and ammonia, average DIN concentrations were low at all sites for this reporting period (**Figure 2.5**). There was no obvious trend notable in the variation observed.

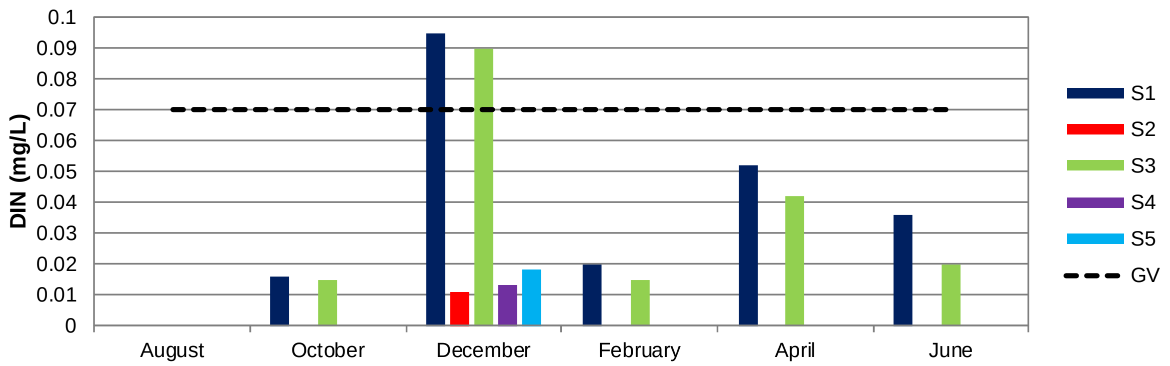


Figure 2.5 Time series of Dissolved inorganic nitrogen concentrations at all sites for the current reporting period

2.3.3.2 Phosphorus

Phosphorus is also essential to life and, like nitrogen, plays a role in supporting aquatic food webs and can be detrimental to aquatic ecosystems at excessive concentrations. Phosphorus exists in a variety of forms in water, either as bioavailable phosphorus (orthophosphate) or organic molecules containing phosphorus unavailable for biological uptake.

The variation in phosphorus concentrations at the sites in Salty Lagoon did not conform precisely to a specific pattern (refer to **Figure 2.6** and **Figure 2.7)**. However, the data does allow for some general observations:

- Site S2 is the site most influenced by historical and current discharged effluent from the Evans Head STP and is most often the site with the highest total phosphorus and orthophosphate concentrations.
- No phosphorus was detected in Salty Creek in any sample during this reporting period.
- TN and TP concentrations appear to have varied independently during this reporting period. This indicates that the processing of nitrogen and phosphorus in Salty Lagoon also occurs independently.

For most of the results, the greater proportion of the total phosphorus present was present as orthophosphate. This has important implications for the growth of algal material, which requires phosphorus to be present in the bioavailable form of orthophosphate. However, the relationship between available phosphorus and algal concentrations was cryptic.

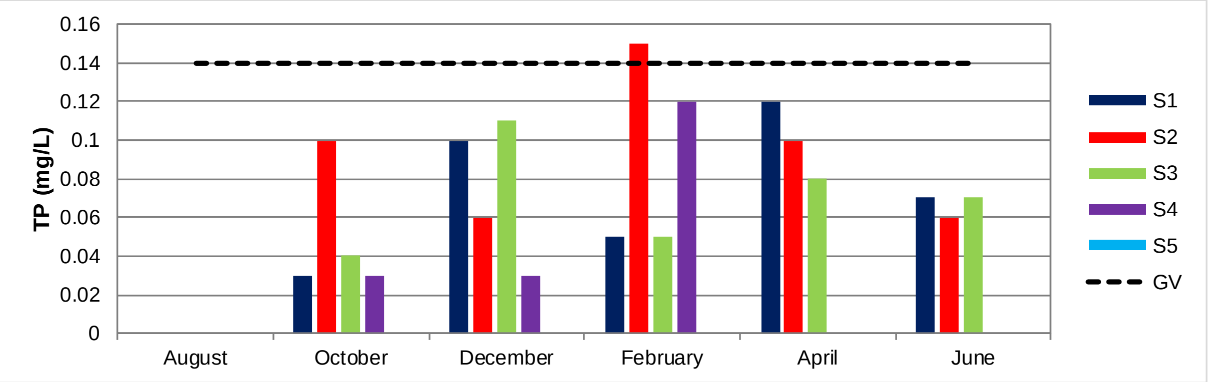


Figure 2.6 Time series of TP concentrations at all sites for the 2017/18 reporting period

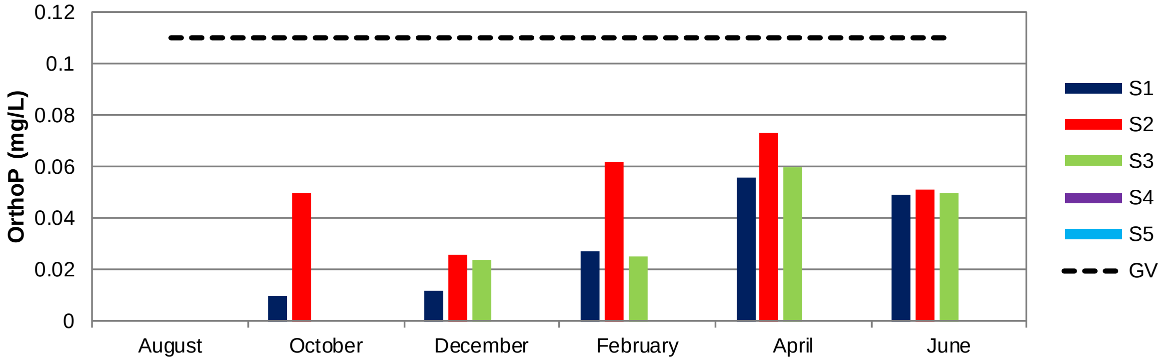


Figure 2.7 Time series of orthophosphate concentrations at all sites for 2017/18 reporting period

2.3.3.3 Chlorophyll-a

The concentration of chlorophyll-a is a measurement of microalgae in the water column. Microalgal abundance fluctuates naturally in response to temperature, nutrient concentrations and light availability, but algal blooms are usually considered to be an indication of poor ecosystem health. Chlorophyll-a concentrations in Salty Lagoon complied with guiding values for the majority of samples collected during this reporting period (refer to **Figure 2.8**).

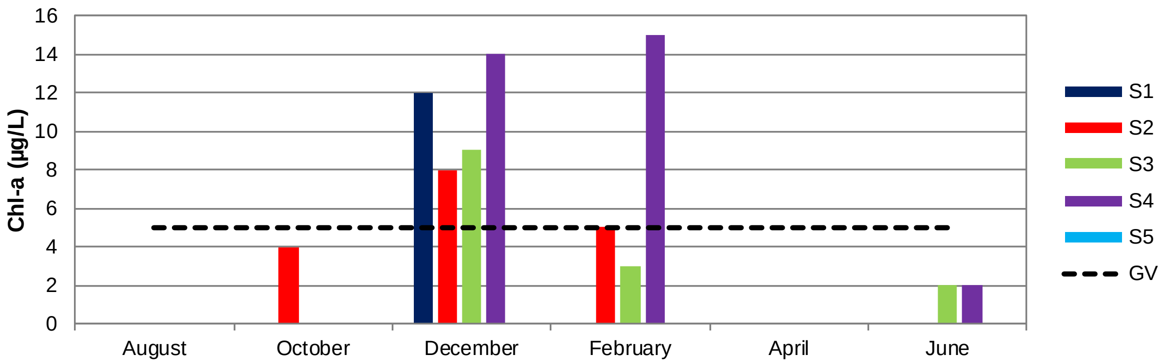


Figure 2.8 Time series of chlorophyll-a concentrations at all sites for the 2017/18 reporting period

The highest chlorophyll-a concentrations measured were collected during the summer months and associated with increased nutrient concentrations or bioavailable nutrient concentrations (DIN and orthophosphate). There was no chlorophyll-a detected in any samples from Salty Creek during this reporting period.

2.3.3.4 Blue Green Algae

Blue green algae are naturally occurring photosynthetic bacteria. Under bloom conditions they can be toxic to humans and aquatic fauna and can cause other problems related to deoxygenation of the water column and reduced light penetration. Blue green algae were not detected in any samples during this reporting period.

2.3.3.5 Faecal Indicator Organisms

Enterococcus and faecal coliforms are bacteria that can be measured as an indication of faecal pollution of waterways. Both enterococcus and faecal coliforms can be sourced from humans or animals and sometimes from rotting vegetation. Faecal indicator organisms are most commonly measured to assess the risks associated with recreational activity in and on waterways.

There was a high degree of variation but no pattern to the faecal indicator organism results collected during this reporting period (refer to **Figure 2.9** and **Figure 2.10**). The median faecal coliform concentration at S2 and S5 did not comply with the guiding values for the project.

The major contributors to the observed variation in the concentration of faecal indicator organisms are runoff from the catchment and the presence of waterfowl. The sources of faecal pollution in Salty Lagoon are most likely to be terrestrial fauna and avifauna utilising the lagoon and its immediate catchment. The results do not suggest that discharge from the Evans Head STP or leaks from the Evans Head sewerage system are influencing the concentrations of faecal indicator organisms. Faecal coliform concentrations in discharge from the Evans Head STP are routinely lower than those measured in Salty Lagoon (GeoLINK 2017b).

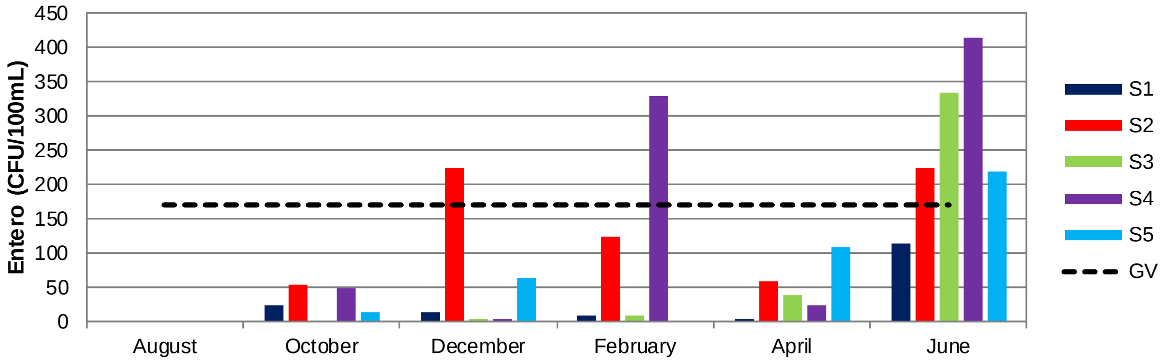


Figure 2.9 Time series of enterococcus concentrations at all sites for the 2017/18 reporting period

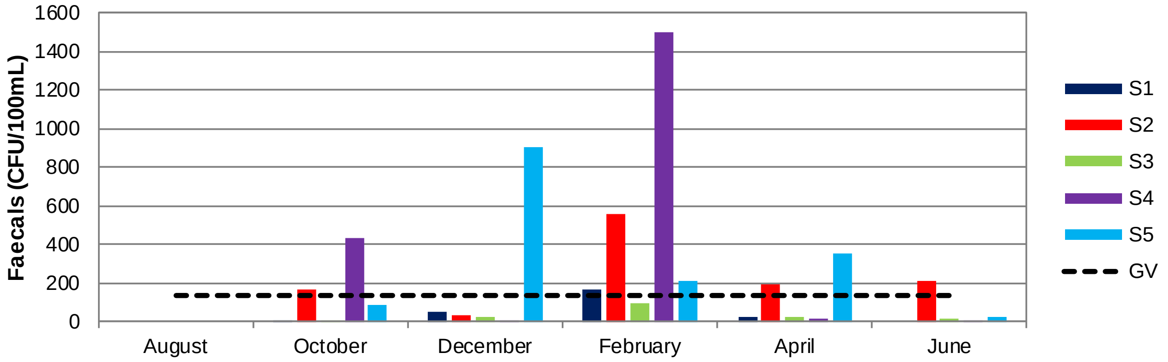


Figure 2.10 Time series of faecal coliform concentrations at all sites for 2017/18 reporting period

2.3.4 Comparison against Rehabilitation Targets

The primary purpose of the MPPC program is to confirm prediction that closure of the artificial channel will result in an overall improvement to the ecological and cultural values of Salty Lagoon. A key objective of the post closure monitoring program is to monitor water quality and the ecological attributes of the MPPC where predicted trends have not been confirmed and risks to the ecosystem health remain. A summary of the predicted major changes to the Salty Lagoon system and the post closuring findings are provided in **Table 2.5**. Collectively the outcomes measured during this reporting period were positive. Particularly:

- The Salty Lagoon system has continued to move towards a predominantly freshwater lagoon system, with the monitoring recording relatively stable water quality conditions.
- Many of the predicted changes are occurring, including positive changes such as a more natural hydrology and salinity regime; reduced magnitude and rate of water level variation; less frequent saline water ingress; and reduced risk of fish kill.
- The results indicate a continued trend towards overall improved ecological health at Salty Lagoon.

Table 2.5 Predicted Major Changes to the Salty Lagoon System and Outcomes for the 2017-2018 Reporting Period

Predicted Major Changes to System	Summary of Annual Reporting Period Findings
More natural hydrology and salinity regime including higher water levels – 1.9 m AHD for approximately 63% of the time.	Positive outcome for this reporting period: Water levels remained high during this reporting period with water levels of 1.9 m AHD or greater for 25% of captured data and water levels of 1.8 m AHD or greater for 68% of the captured data.
A reduced magnitude and rate of water level variation.	Positive outcome for this reporting period
Less frequent saline water ingress.	Positive outcome for this reporting period. This prediction has been realised, though saline water ingress was a feature during this reporting period.
Improved productivity of the benthic microalgal assemblage resulting in nutrient assimilation reduced algal blooms and reduced potential for deoxygenation.	Unclear outcome for this reporting period: It is uncertain if the productivity of the benthic macroalgal assemblage has changed since the closure of the artificial channel. However, algal blooms and deoxygenation events were both recorded at lower frequencies during this reporting period.
Reduced water column algal biomass.	Positive outcome for this reporting period: Average chlorophyll-a concentrations were low for this reporting period.
Improved water quality generally with a risk of poor water quality episodes in the period immediately following the channel closure.	Variable outcome for this reporting period: With respect to nutrient and microalgal concentrations there was an improvement in the average water quality conditions during this reporting period. With respect to turbidity and pH there has been an improvement and stabilisation of water quality respectively. Relative to the years prior to and following channel closure there were no poor water quality episodes during this reporting period. The risk of an environmental incident remained low for the entire reporting period and there were no fish kills or other ecological incident.
Less temperature variability.	Positive outcome for this reporting period: There were no extreme maximum or minimum water temperatures recorded.

Predicted Major Changes to System	Summary of Annual Reporting Period Findings
Reduced average and maximum pH values.	Positive outcome for this reporting period: This prediction has been realised relative to the pre-channel closure state.
Generally higher DO concentrations with a reduction in dramatic DO crashes and more predictable diurnal variation of DO.	Positive outcome for this reporting period: The DO concentrations in surface waters were increased in the open water area of Salty Lagoon (but decreased to the west) during this reporting period. The DO crashes that were associated with fish kill events prior to channel closure have not eventuated during this reporting period.
Potential for low DO occurring as a result of high BOD of the marsh sediments and/or increased photo-oxidation of tannins in the warmer months.	Neutral outcome for this reporting period: This prediction has been realised.
Reduced probability of wind driven turbidity increases and no draining related turbidity spikes.	Positive outcome for this reporting period: This prediction has been realised.
Reduced TP concentrations over time resulting from greater benthic microbial uptake and higher burial rates.	Positive outcome for this reporting period: Lower TP concentrations have been measured during this reporting period though the mechanisms are not certain.
Poor water quality episodes around high-risk periods such as low water levels and high temperatures.	Positive outcome: This predicted risk has not been realised during this reporting period as water levels remained high and temperature spikes did not eventuate.
Reduced TN concentrations and continued dominance of DON.	Positive outcome for this reporting period: TN concentrations were lower during this reporting period. The predicted continued dominance of DON as the major form of nitrogen in samples has continued.
Reduced severity of Salty Creek drawdown during draining events.	Neutral outcome for this reporting period: Drawdown rates for Salty Creek were variable during draining events.
Less protracted entrance opening of Salty Creek.	Positive outcome for this reporting period: Opening events at the Salty Creek entrance were relatively short during this reporting period.
Potential for aquatic weed growth in early stages with change to freshwater.	Positive outcome for this reporting period: The risk of aquatic weed invasion has not been realised.
Reduced risk of fish kills.	Positive outcome for this reporting period: There have been no fish kill events during this reporting period and the conditions that were related to fish kills in the past have not eventuated.

2.3.5 Emerging Trends and Issues

The erosive headcut to the east of the old artificial channel continues to present a threat to the project. Ongoing monitoring has observed continued advancement of the headcut, at a rate increased in relation to the previous reporting period. The position and continued advance of the headcut could potentially lead to a new channel between Salty Lagoon and Salty Creek supporting flow in both directions and return Salty Lagoon to the pre-closure state. Erosion monitoring is explained in more detail in **Section 3**.

3. Erosion Monitoring

3.1 Introduction

An eroding head cut to the east of the infilled artificial channel has been identified as a risk to the freshwater ecosystem values that are emerging in the Salty Lagoon system. The head cut was first identified as a potential risk after heavy rainfall in 2014 (GeoLINK 2014). In the final years of the MPPC it advanced approximately 20 m towards Salty Lagoon, effectively eroding a channel that could reconnect Salty Lagoon and Salty Creek at much lower water levels than they are currently.

Eventually, the eroding channel has the potential to reverse the work done to restore the freshwater values identified in the Salty Lagoon environment. A monitoring program was implemented in July 2017 to measure the progress of the headcut over the course of the post closure monitoring program.

3.2 Methods

A series of six monitoring stations, three at the impact site and three at a control site were set up to assess the progression of erosion between Salty Lagoon and Salty Creek. The specific locations of all sites sampled are presented in **Table 3.1** and **Illustration 2.1**.

The stations were set up in July 2017 at the head cut (Stations ER4, ER5 and ER6), with control sites at points where lateral tributaries from Salty Creek lead towards Salty Lagoon (Stations ER1, ER2 and ER3). At each site the bi-monthly monitoring involves a fixed-point photo and a measurement from a fixed peg to the nearest point of the head cut.

Table 3.1 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**

3.3 Results

The headcut at the impact site advance significantly during this reporting period. The progression of the erosion towards the monitoring pegs at all six monitoring sites is displayed in **Figure 3.1**.

At site ER5, the most easterly of the erosion sites, the headcut progressed 5.8 m towards Salty Lagoon during this monitoring period. The progression of the head cut towards the other monitoring pegs was slower, 1.25 m and 1.4 m towards stations ER4 and ER6 respectively. The majority of the progression at each of the impact sites happened after February 2018, coinciding with the period of higher water levels in Salty Lagoon (see **Figure 2.2**). There was no significant measured progression of erosion at any of the control sites.

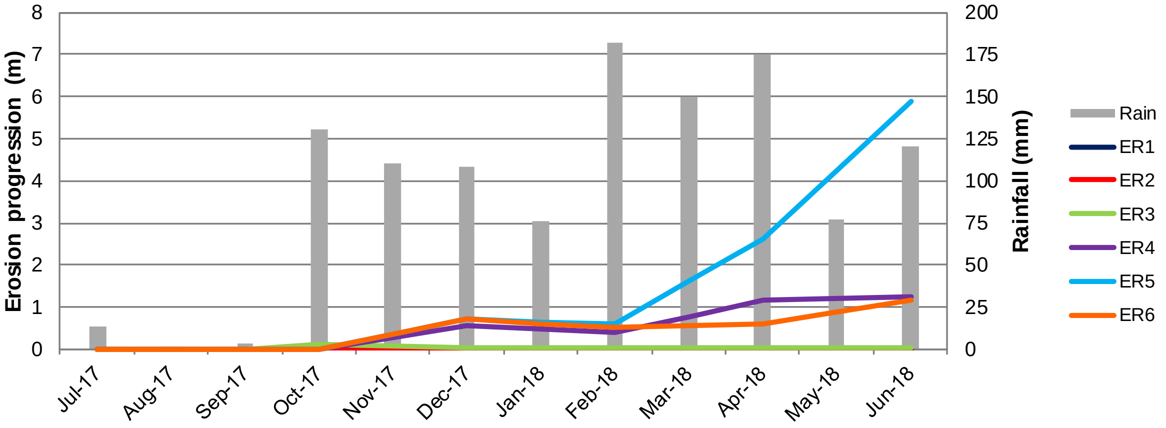


Figure 3.1 Measured erosion progression at all six sites plotted against monthly rainfall (BoM 2018)

3.4 Discussion

The erosion monitoring detected a significant advance in the erosive headcut between Salty Creek and Salty Lagoon. Station ER5 best monitors the advance of the erosion directly towards Salty Lagoon. The measured advance of the headcut at Station ER5 was 5.8 m during this reporting period. Stations ER4 and ER6 measure lateral, secondary advance of the headcut. The measured advance at these two sites was 1.24 m and 1.4 m respectively. There was no significant advance measured at any of the control sites selected.

The erosive headcut between Salty Creek and Salty Lagoon could result in a new channel forming with the potential to undo the measurable positive benefits of the recent channel closure. This is a very high priority for the ongoing management of Salty Lagoon.

RVC and National Parks and Wildlife Services (NPWS) have been liaising in relation to the headcut remediation. Remediation designs have been developed by RVC, while a Review of Environmental Factors (Part 5 of the *Environmental Planning and Assessment Act 1979* {EP&A Act} assessment) has been prepared by NPWS. Funding investigations for the rehabilitation works are continuing.

Plate 3.1 The position of the headcut from station ER5 in December 2017

Plate 3.2 The position of the headcut from station ER5 in June 2018

4. Aquatic Vegetation/ Weeds

4.1 Introduction

Aquatic weed invasion is considered a significant risk during the period following the closure of the artificial channel as Salty Lagoon makes the transition to a permanently fresh water system. In order to assess the response of aquatic vegetation to the changes and to provide a mechanism for adaptive management of aquatic weeds, regular survey were undertaken as part of the MPPC program and have continued as part of the post closure monitoring program. Incidental observations of aquatic weeds noted during the bi-monthly site inspections are also recorded.

4.2 Methods

Aquatic weeds were monitored on a seasonal basis across all seasons except winter. The dates of the aquatic weed surveys undertaken during this reporting period are 28 October 2017 (spring), 11 January 2018 (summer) and 1 May 2018 (autumn).

The aquatic weed surveys involved following a meandering transect selected to cover most of the open water areas of Salty Lagoon. Each species of aquatic plant, weedy or otherwise, encountered during the survey was recorded. The position of any aquatic weed encountered was recorded with a handheld GPS unit and the aerial extent of the weed population estimated and recorded. Plants that could not be identified in the field were sampled for later identification.

The pathway of the meandering transect was recorded using the tracking feature of a handheld GPS set to track points at intervals of 20 seconds. The approximate transect pathways used during weed surveys are displayed in **Illustration 4.1**.

4.3 Results

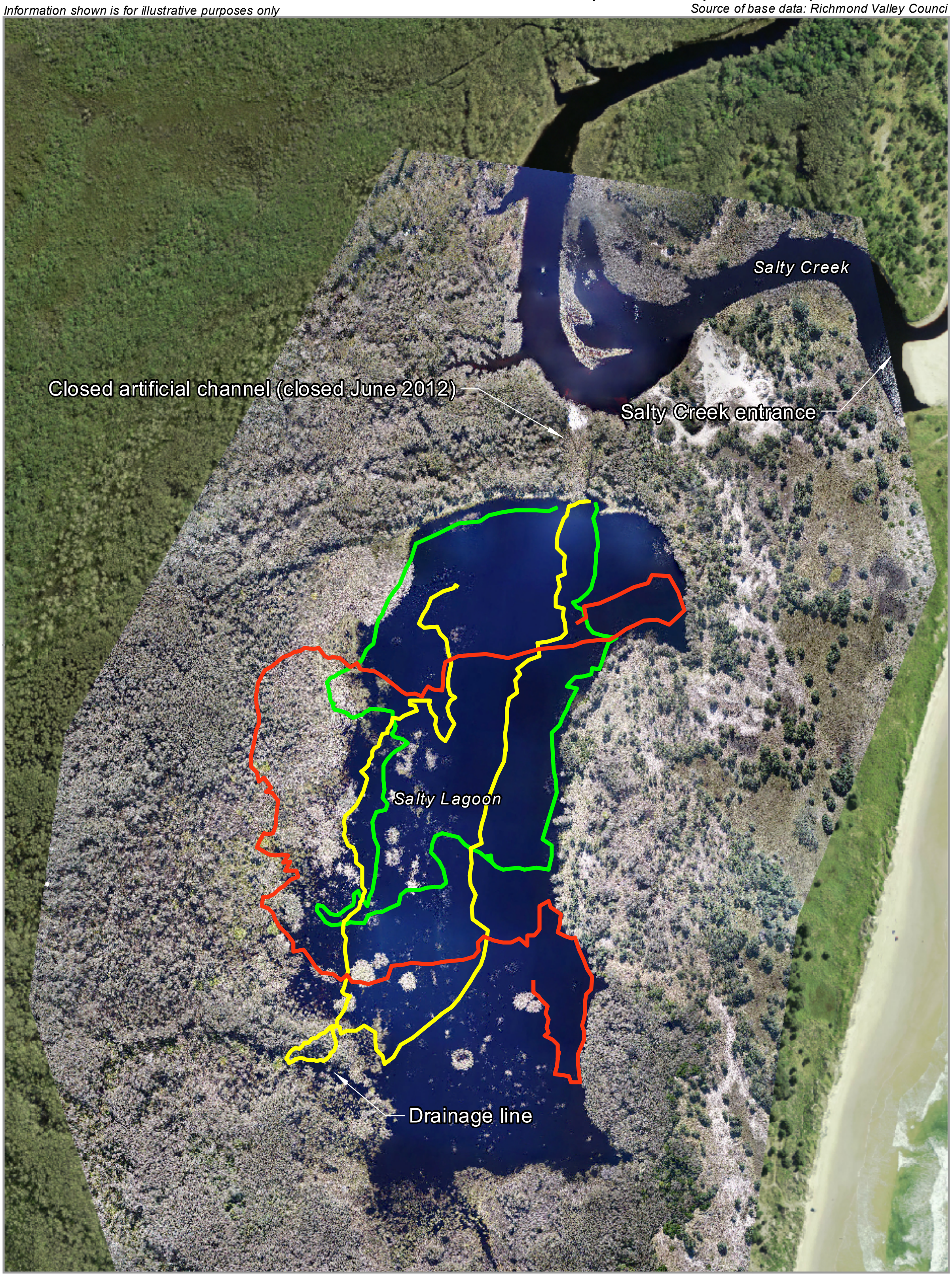
There have been no notable aquatic weeds observed during the current reporting period. A total of 21 plant taxa were observed during this reporting period. Of these, all were observed among the 38 plant taxa identified during the MPPC project. Two types of native aquatic plant sometimes regarded as nuisance plants have been encountered. These were Pacific Azolla (*Azolla flilculoides*) and Duckweed (*Lemna sp.*).

Blue Green Algae were not detected during the aquatic weed surveys or in any of the water quality samples collected during this reporting period. Pacific Azolla and Duckweed were encountered at varying densities to the west of Salty Lagoon, particularly around site S2. The abundance of these two plants tends to fluctuate in response to temperature and freshwater flow. They are less likely to be observed growing at high densities during the winter months.

During the aquatic weed surveys, a list of all aquatic plant species encountered was collected and a basic estimate of their abundance made. The list of aquatic plant species encountered is shown in **Table 4.1.**

Drawn by: DSA Checked by: AB Reviewed by: AB Date: 02/10/2018
Source of base data: Richmond Valley Counci

Information shown is for illustrative purposes only



LEGEND

- Spring 2017 weed transect
- Summer 2018 weed transect
- Autumn 2018 weed transect

0 120

Aquatic Weed Monitoring Transects

GeoLINK environmental management and design

Annual Report 2018 - Salty Lagoon Post-Closure Monitoring Program
(Years 6 - 10)
1731-1306

Illustration 4.1

Table 4.1 List of all Aquatic Plant Species Detected During Aquatic Weed Surveys and an Assessment of Abundance

Species Name	***Common Name***	***Survey***		
		Spring 2017	***Summer 2018***	***Autumn 2018***
Hydrocotyle verticillata	Shield Pennywort	C	C	C
Enydra fluctuans	Buffalo Spinach	C	C	C
Lobelia anceps	Angled Lobelia		UC	
Ceratophyllum demersum	Hornwort		UC	
Baumea articulata	Jointed Twigrush	UC	UC	
Baumea sp.	A Rush	VC	C	VC
Cyperus exaltatus	Giant Sedge	UC		
Cyperus difformis	Dirty Dora	C	UC	C
Gahnia sieberiana	Red-fruit Saw-sedge	C	UC	UC
Shoenoplectus validus	River Club-rush	VC	VC	VC
Shoenoplectus mucronatus	Marsh Club-rush			UC
Juncus krausii	Sea Rush	UC	C	UC
Lemna sp.	Duckweed	UC	UC	UC
Utricularia spp.	Bladderwort	VC	C	C
Nymphoides indica	Water Snowflake	UC		UC
Bacopa monnieri	Water Hyssop	UC	UC	UC
Paspalum vaginatum	Saltwater Couch	VC	VC	VC
Phragmites australis	Common Reed	VC	VC	VC
Azolla filiculoides	Pacific Azolla	UC	UC	UC
Typha orientalis	Cumbungi	VC	VC	VC
Enteromorpha sp.	Enteromorpha	C	VC	C

Note *UC = Uncommon, C = Common, VC = Very Common*
^ *Introduced Species*

4.4 Discussion

The aquatic weed surveys undertaken during this reporting period did not detect any significant aquatic weeds. Despite this, the risk of weed invasion into Salty Lagoon remains, particularly as the system continues the transition to a freshwater ecosystem.

A change to the overall aquatic plant community in Salty Lagoon was noted during the MPPC (GeoLINK 2017b). The aquatic weed surveys undertaken during this reporting period indicate that the freshwater aquatic plant community has stabilised. All taxa identified during this reporting period were encountered during the MPPC.

5. Supplementary Melaleuca Dieback/ Recolonisation

5.1 Introduction

5.1.1 General

Predicted terrestrial vegetation changes and outcomes for the MPPC included melaleuca recolonisation and reduction in area of dieback along the western edge of Salty Lagoon. Vegetation monitoring undertaken as part of the MPPC found the prediction had not been realised to any significant extent (GeoLINK 2017b). There was little evidence of recolonisation of Broad-leaved Paperbark (*Melaleuca quinquenervia*) or any evidence of further dieback occurring. The overall health of the trees was good, with thick foliage throughout and no signs of stress detected on any trees.

The inclusion of the supplementary melaleuca dieback/ recolonisation (belt transect) monitoring as part of the post closure monitoring is to capture changes in melaleuca condition that have not been realised by the methodology in the MPPC (GeoLINK 2017b). Melaleuca recolonisation would provide a number of positive environmental outcomes including water quality benefits (including bioavailable nutrient uptake), improved ecological/ habitat values and improved visual amenity.

5.1.2 Predicted changes to *Melaleuca* condition

Predictions of expected changes in the MPPC (Hydrosphere 2010a; 2011) included expansion of Broad-leaved Paperbark on the western side Salty Lagoon to the east and reduction in area of dieback. Historical information and evidence on site (i.e. several large tree stumps in the lagoon) indicates that Broad-leaved Paperbark once occurred further east, closer to the lagoon. Indicators of this prediction may include:

- Expansion and growth of Broad-leaved Paperbark within Swamp Forest within the melaleuca dieback zone.
- Melaleuca plants remain in good health.
- No additional melaleuca dieback detected.
- The Swamp Forest/ Fringing Marsh boundary moves east.

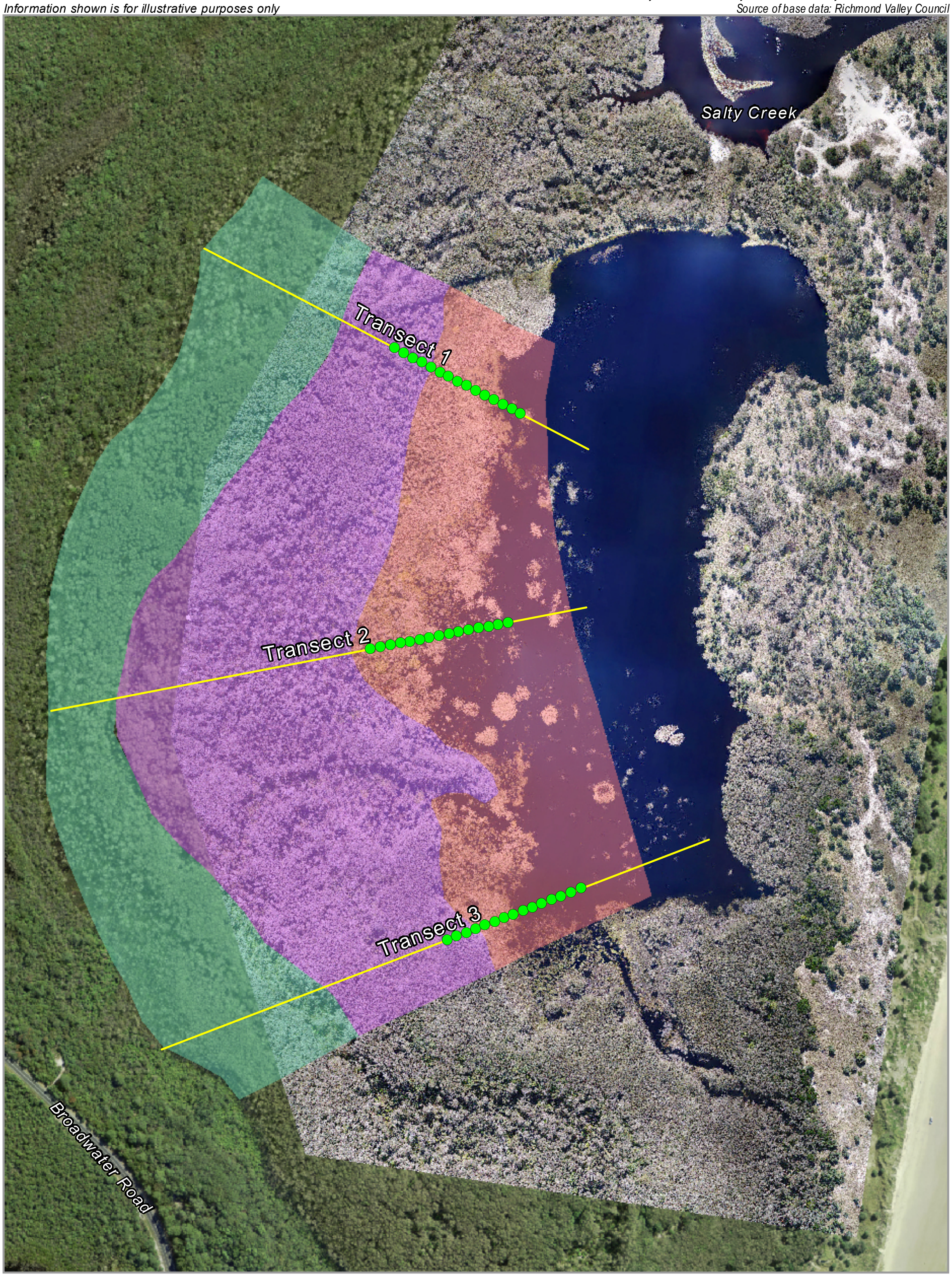
5.2 Methods

The supplementary melaleuca dieback/ recolonisation monitoring involves three 150 m long belt transects located on the western side of Salty Lagoon (refer to **Illustration 5.1**). The belt transects overlap the existing melaleuca dieback transects, though extend a further 50 m east or west depending on melaleuca recolonisation potential. Circular plots with a three-metre radius (covering an area of 28.27 m^2) were established at fixed 10 m intervals along each transect (15 plots per transect; 45 plots in total). Each plot was established by installing a central peg and recording data within a three-metre radius from that point. Transects are numbered 1 to 3 north to south; while plots are numbered 1-15 west to east.

The following data was collected at each plot:

- Vegetation type.
- Presence or absence of dead melaleucas.
- Presence or absence of live melaleucas.
- Where melaleucas are present, the following observations were made:
  - Tree health (presence of necrotic spots on leaves, galls on small branches);
  - Presence or absence of trees (DBH>10 cm), small trees (DBH <10 cm to >5 cm), saplings (DBH <5 cm; height >0.5 m) and seedlings (height <0.5 m), including tree height within each category; and
  - Condition of trees (DBH>10 cm) and small trees (DBH <10 cm to >5 cm) using the following categories: unaffected/ full recovery; resprouting; and dying.

The supplementary melaleuca dieback/ recolonisation monitoring was undertaken on 25 November 2017 and would be compared against data collected in 2021/22.



LEGEND

- Melelaeuca dieback / recolonisation belt transect plot
- Vegetation monitoring transect
- Fringing Marsh
- Sedge Swamp
- Swamp Forest

0 120

Melaleuca Dieback/ Recolonisation Monitoring Sites

5.3 Results and Discussion

Results from the supplementary melaleuca dieback/ recolonisation monitoring are provided in **Appendix A** and summarised in **Table 5.1**.

Table 5.1 Summary of Supplementary Melaleuca Dieback/ Recolonisation Results

Melaleuca Growth Status	*Attribute*	*Transect*			*Total*
		1	*2*	*3*	
Dead Melaleuca	Number of plots with dead melaleuca	2	7	7	16
	Total number of dead melaleuca	4	21	45	70
	Mean	0.3	1.4	3.0	1.6
	Standard deviation	0.7	1.9	4.2	2.8
Alive Melaleuca	Number of plots with alive melaleuca	11	5	4	20
Trees	Number of plots with trees	3	1	4	8
	Total number of trees	14	2	45	61
	Mean number of trees (per quadrat)	0.9	0.1	3.0	1.4
	Standard deviation	2.3	0.5	5.2	3.4
Small Trees	Number of plots with small trees	8	0	3	11
	Total number of small trees	38	0	14	52
	Mean number of small trees (per quadrat)	2.5	0.0	0.9	1.2
	Standard deviation	3.8	0.0	2.3	2.7
Saplings	Number of plots with saplings	7	5	2	14
	Total number of saplings	23	25	3	51
	Mean number of saplings (per quadrat)	1.5	1.7	0.2	1.1
	Standard deviation	1.9	2.8	0.6	2.0
Seedlings	Number of plots with seedlings	1	0	0	1
	Total number of seedlings	1	0	0	1
	Mean number of seedlings (per quadrat)	0.1	0.0	0.0	0.0
	Standard deviation	0.3	0.0	0.0	0.1

Dead Melaleuca

Dead trees occurred in 16 of the 45 belt transect plots (35.6 per cent). Transects 2 and 3 supported seven plots with dead trees; while Transect 1 contained two plots with dead trees. Dead trees occurred in the Swamp Forest (six plots), Fringing Marsh -Swamp Forest Ecotone (six plots), Fringing Marsh (one plot) and Fringing Marsh – Open Water Ecotone (three plots). No dead trees occurred within the open water.

Alive Melaleuca

Alive melaleucas occurred in 20 of the 45 plots (44.4 per cent). Transect 1 supported the highest number of plots with alive melaleucas in 11 plots; followed by Transects 2 and 3 with five and four plots respectively. Plots with alive melaleucas were located within the Swamp Forest (eight plots), Fringing Marsh -Swamp Forest Ecotone (nine plots), Fringing Marsh (two plots) and Fringing Marsh – Open Water Ecotone (one plot) vegetation zones. No alive trees occurred within open water.

Where living *Melaleuca* was present 14 plots recorded good health and six plots recorded moderate health. Necrotic spots were observed on melaleuca foliage at 17 (85 per cent) plots. Galls on small branches were not observed on any living melaleuca plants.

Growth Stage Comparison

A relatively low occurrence of trees (DBH>10cm) was recorded, present only in eight out of the 45 plots (17.8 per cent). Similar low occurrences were recorded for small trees (DBH <10 cm to >5 cm) (11 out of 45 plots; 24.4 per cent), and saplings (DBH <5 cm; height >0.5 m) (14 out of 45 plots; 31.1 per cent). Regenerating melaleuca seedlings (<0.5 m) were only observed in one plot (1 out of 45 plots; 2.2 per cent), located along Transect 1.

Trees and associated vegetation types

Transect 3 supported the highest number of trees and plots with trees (four plots with 45 trees in total) followed by Transects 1 (three plots with 14 trees in total) and 2 (one plot with two trees). Tree heights ranged from 4 – 15 m, with the tallest trees occurring in Transect 3 and the shortest trees occulting in Transect 2. Trees occurred in the Swamp Forest (six plots with 58 trees in total) and Fringing Marsh -Swamp Forest Ecotone (two plots with three trees in total) vegetation zones.

Small trees and associated vegetation types

Transect 1 supported the highest number of small trees and plots with small trees (eight plots with 38 small trees in total) followed by Transect 3 (three plots with 14 small trees in total). No small trees were recorded at Transect 2. Small tree heights ranged from 3 – 12 m with the tallest small trees occurring in Transect 3 and the shortest small trees occulting in Transect 2. Small trees occurred in the Swamp Forest (six plots with 41 small trees in total) and Fringing Marsh -Swamp Forest Ecotone (five quadrats with 11 small trees in total) vegetation zones.

Saplings and associated vegetation types

Transect 2 supported the highest number of saplings and plots with saplings (five plots with 25 saplings in total) followed by Transects 1 (seven plots with 23 saplings in total) and 3 (two plots with three saplings in total). Sapling heights ranged from 0.6 – 5 m with the tallest saplings occurring in Transect 1 and the shortest saplings occulting in Transect 3. Saplings occurred in the Swamp Forest (six plots with 18 saplings in total), Fringing Marsh -Swamp Forest Ecotone (six plots with 31 saplings in total) and Fringing Marsh (two plots with two saplings in total) vegetation zone.

Seedlings and associated vegetation types

One seedling (0.4 m tall) was recorded within one plot at Transect 1 within Fringing Marsh – Open Water Ecotone vegetation zone.

Discussion

The supplementary melaleuca dieback/ recolonisation monitoring results provide a comprehensive record of melaleuca occurrence along the belt transects. Any changes in melaleuca numbers, size, condition and location along the belt transects should be detectible during the subsequent monitoring event in 2021/22.

6. Conclusion

6.1 Conclusion

The Salty Lagoon Post Closure Monitoring project began in July 2017. The post closure monitoring approach involves changed methods but will maximise the utility of the existing data from the MPPC program, which concluded at the end of June 2018. This first annual report of monitoring documents the methods used, and results obtained during water quality, erosion, aquatic weed and supplementary melaleuca dieback/ recolonisation monitoring. The aims of continued monitoring in Salty Lagoon are to:

- Monitor the health of Salty Lagoon and confirming that Evans Head Sewage Treatment Plant discharge is not adversely impacting water quality and ecology at Salty Lagoon.
- Monitor water quality and the ecological attributes of the MPPC where predicted trends have not been confirmed and risks to the ecosystem health remain.
- Observe medium to long-term changes in the Salty Lagoon system in response to channel closure.

The current monitoring period comprised relatively dry weather for the region. Annual rainfall was below average and seven of the 12 months of monitoring saw rainfall significantly below monthly averages. The driest months were the first three months of the monitoring period.

The water quality in Salty Lagoon remained adequate during this reporting period. The majority of the median monitoring results complied with the guiding values developed. The results that did not comply were unlikely to be associated with the operation of the Evans Head Sewage Treatment Plant and more likely to be associated with natural environmental variables such as rainfall, the general environment of the catchment and the movements of animals in and around the aquatic system.

Although aquatic weed invasion remains a risk in Salty Lagoon, the three aquatic plant surveys undertaken during this reporting period failed to encounter any serious aquatic weeds.

The erosive head cut between Salty Creek and Salty Lagoon that developed during the later years of the MPPC, continued to advance towards Salty Lagoon during this reporting period. It remains a threat to the positive changes recorded in the Salty Lagoon environment during the MPPC. The channel forming, if it reaches Salty Lagoon, could potentially lead to a new channel between Salty Lagoon and Salty Creek supporting flow in both directions and return Salty Lagoon to the pre-closure state. Remediation designs have been developed whilst funding investigations for the works are continuing.

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Appendix A

Supplementary Melaleuca Dieback/ Colonisation Monitoring Results

Table A1 Supplementary Melaleuca Dieback / Colonisation Monitoring Results - 2017

Transect	*Point*	*Vegetation*	*Dead Melaleuca?*	*Dead Melaleuca Count*	*Alive Melaleucas?*	*Tree Health*	*Necrotic Spots*	*Galls on Small Branches*	*Number of Trees*	*Tree Height - Low Range (m)*	*Tree Height - High Range (m)*	*Tree condition*	*Number of Small trees*	*Small Tree Height - Low Range (m)*	*Small Tree Height - High Range (m)*	*Small Tree Condition*	*Number of Saplings*	*Saplings Height - Low Range (m)*	*Saplings Height - High Range (m)*	*Sapling Condition*	*Number of Seedlings*	*Seedlings Height - Low Range (m)*	*Seedlings Height - High Range (m)*	*Seedling Condition*	*Comment*
1	1	Swamp Forest	No	0	Yes	Moderate	Yes	No	0	0	0	-	0	0	0	-	3	1.6	2.1	resprouting	0	0	0	-	-
1	2	Swamp Forest	No	0	Yes	Moderate	Yes	No	7	6.8	8	unaffected/ full recovery	12	6	8	unaffected/ full recovery	4	1.7	3.5	unaffected/ full recovery	0	0	0	-	-
1	3	Swamp Forest	Yes	2	Yes	Good	Yes	No	0	0	0	-	5	4.5	7	unaffected/ full recovery	4	0.65	5	unaffected/ full recovery	0	0	0	-	-
1	4	Swamp Forest	Yes	2	Yes	Good	Yes	No	6	6	7	unaffected/ full recovery	10	4.5	6.5	unaffected/ full recovery	4	1.8	5	unaffected/ full recovery	0	0	0	-	-
1	5	Fringing Marsh-Swamp Forest Ecotone	No	0	Yes	Good	Yes	No	1	4	4	unaffected/ full recovery	3	4	5	unaffected/ full recovery	0	0	0	-	0	0	0	-	-
1	6	Fringing Marsh-Swamp Forest Ecotone	No	0	Yes	Good	Yes	No	0	0	0	-	3	3.5	4	unaffected/ full recovery	4	2.5	4.5	unaffected/ full recovery	0	0	0	-	-
1	7	Fringing Marsh-Swamp Forest Ecotone	No	0	Yes	Good	Yes	No	0	0	0	-	2	3.5	4	unaffected/ full recovery	3	0.75	3.5	-	0	0	0	-	-
1	8	Fringing Marsh-Swamp Forest Ecotone	No	0	Yes	Good	No	No	0	0	0	-	2	3	3.5	unaffected/ full recovery	0	0	0	-	0	0	0	-	-
1	9	Fringing Marsh-Swamp Forest Ecotone	No	0	Yes	Moderate	No	No	0	0	0	-	1	3.5	3.5	unaffected/ full recovery	0	0	0	-	0	0	0	-	-
1	10	Fringing Marsh	No	0	Yes	Moderate	Yes	No	0	0	0	-	0	0	0	-	1	2.5	0	unaffected/ full recovery	0	0	0	-	-
1	11	Fringing Marsh	No	0	No	-	-	0	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
1	12	Fringing Marsh-Open Water Ecotone	No	0	Yes	Good	No	No	0	0	0	-	0	0	0	-	0	0	0	-	1	0.4	0.4	unaffected/ full recovery	-
1	13	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
1	14	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
1	15	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	Emergent sedges
T1 Count	-	-	2	-	11	-	-	-	3	-	-	-	8	-	-	-	7	-	-	-	1	-	-	-	-
T1 Total	-	-	-	4	-	-	-	-	14	-	-	-	38	-	-	-	23	-	-	-	1	-	-	-	-
T1 Mean	-	-	-	0.3	-	-	-	-	0.9	-	-	-	2.5	-	-	-	1.5	-	-	-	0.1	-	-	-	-
T1 Standard Deviation	-	-	-	0.7	-	-	-	-	2.3	-	-	-	3.8	-	-	-	1.9	-	-	-	0.3	-	-	-	-
2	1	Fringing Marsh-Swamp Forest Ecotone	Yes	2	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
2	2	Fringing Marsh-Swamp Forest Ecotone	Yes	6	Yes	Good	Yes	No	0	0	0	-	0	0	0	-	8	1.4	2.5	unaffected/ full recovery	0	0	0	-	-
2	3	Fringing Marsh-Swamp Forest Ecotone	Yes	4	Yes	Good	Yes	No	0	0	0	-	0	0	0	-	6	0.6	2.4	unaffected/ full recovery	0	0	0	-	-
2	4	Fringing Marsh-Swamp Forest Ecotone	Yes	2	Yes	Moderate	Yes	No	2	4	4.5	unaffected/ full recovery	0	0	0	-	4	1.1	2.5	unaffected/ full recovery	0	0	0	-	-
2	5	Fringing Marsh-Swamp Forest Ecotone	Yes	3	Yes	Good	Yes	No	0	0	0	-	0	0	0	-	6	0.7	1.7	unaffected/ full recovery	0	0	0	-	-
2	6	Fringing Marsh	No	0	Yes	Moderate	Yes	No	0	0	0	-	0	0	0	-	1	2.2	2.2	-	0	0	0	-	-

Transect	Point	Vegetation	Dead Melaleuca?	Dead Melaleuca Count	Alive Melaleucas?	Tree Health	Necrotic Spots	Galls on Small Branches	Number of Trees	Tree Height - Low Range (m)	Tree Height - High Range (m)	Tree condition	Number of Small trees	Small Tree Height - Low Range (m)	Small Tree Height - High Range (m)	Small Tree Condition	Number of Saplings	Saplings Height - Low Range (m)	Saplings Height - High Range (m)	Sapling Condition	Number of Seedlings	Seedlings Height - Low Range (m)	Seedlings Height - High Range (m)	Seedling Condition	Comment
2	7	Fringing Marsh	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
2	8	Fringing Marsh-Open Water Ecotone	Yes	1	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
2	9	Fringing Marsh-Open Water Ecotone	Yes	3	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
2	10	Fringing Marsh-Open Water Ecotone	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
2	11	Fringing Marsh-Open Water Ecotone	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
2	12	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	Minor emergent sedges
2	13	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	Emergent sedges
2	14	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	Emergent sedges
2	15	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	Emergent sedges
T2 Count	-	-	7	-	5	-	-	-	1	-	-	-	0	-	-	-	5	-	-	-	0	-	-	-	-
T2Total				-					2				0				25	-	-		0	-	-	-	-
T2 Mean	-	-	-	-	-	-	-	-	0.1	-	-	-	0.0	-	-	-	1.7	-	-	-	0.0	-	-	-	-
T2 Standard Deviation	-	-	-	1.9	-	-	-	-	0.5	-	-	-	0.0	-	-	-	2.8	-	-	-	0.0	-	-	-	-
3	1	Swamp Forest	Yes	6	Yes	Good	Yes	No	10	13	15	unaffected/ full recovery	4	6	12	unaffected/ full recovery	2	0	0	unaffected/ full recovery	0	0	0	-	-
3	2	Swamp Forest	Yes	12	Yes	Good	Yes	No	12	13	15	unaffected/ full recovery	8	8	10	unaffected/ full recovery	1	0.6	0.6	unaffected/ full recovery	0	0	0	-	-
3	3	Swamp Forest	Yes	8	Yes	Good	Yes	No	13	10	12	unaffected/ full recovery	2	8	10	unaffected/ full recovery	0	0	0	-	0	0	0	-	-
3	4	Swamp Forest	Yes	8	Yes	Good	Yes	No	10	9	10	unaffected/ full recovery	0	0	0	-	0	0	0	-	0	0	0	-	-
3	5	Fringing Marsh-Swamp Forest Ecotone	Yes	8	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	6	Fringing Marsh	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	7	Fringing Marsh	Yes	1	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	8	Fringing Marsh-Open Water Ecotone	Yes	2	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	9	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	10	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	11	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	12	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	13	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	14	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
3	15	Open Water	No	0	No	-	-	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-
T3 Count	-	-	7	-	4	-	-	-	4	-	-	-	3	0	0	-	2	-	-	-	0	-	-	-	-
T3 Total	-	-	-	45	-	-	-	-	45	-	-	-	14	-	-	-	3	-	-	-	0	-	-	-	-

Transect	Point	Vegetation	Dead Melaleuca?	Dead Melaleuca Count	Alive Melaleucas?	Tree Health	Necrotic Spots	Galls on Small Branches	Number of Trees	Tree Height - Low Range (m)	Tree Height - High Range (m)	Tree condition	Number of Small trees	Small Tree Height - Low Range (m)	Small Tree Height - High Range (m)	Small Tree Condition	Number of Saplings	Saplings Height - Low Range (m)	Saplings Height - High Range (m)	Sapling Condition	Number of Seedlings	Seedlings Height - Low Range (m)	Seedlings Height - High Range (m)	Seedling Condition	Comment
T3 Mean	-	-	-	3.0	-	-	-	-	3.0	-	-	-	0.9	-	-	-	0.2	-	-	-	0.0	-	-	-	-
T3 Standard Deviation	-	-	-	4.2	-	-	-	-	5.2	-	-	-	2.3	-	-	-	0.6	-	-	-	0.0	-	-	-	-
Total: All Transects	-	-	-	70	-	-	-	-	61	-	-	-	52	-	-	-	51	-	-	-	1	-	-	-	-
Mean: All Transects	-	-	-	1.6	-	-	-	-	1.4	-	-	-	1.2	-	-	-	1.1	-	-	-	0.0	-	-	-	-
Standard Deviation: All Transects	-	-	-	2.8	-	-	-	-	3.4	-	-	-	2.7	-	-	-	2.0	-	-	-	0.1	-	-	-	-