Hay Point Maintenance Dredge Water Quality Monitoring

North Queensland Bulk Ports (NQBP)

2019

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EXECUTIVE SUMMARY

Maintenance dredging at Hay Point, Queensland was undertaken by NQBP for a 33-day period from 31 March to 2 May 2019. Approximately 353,740 m^2 of material was relocated to the DMPA during the program. Water quality undertaken by VE was guided by the MEMP and included periods of monitoring during the Pre Dredge (17/18 February to 31 March) and Post Dredge (3 May to 30 May) phases. Dredge management was informed by real time surface turbidity data from two trigger sites (Round Top Island and Victor Island) and two control sites (Slade Islet and Freshwater Point), for which trigger values based on long term ambient data sets, had been calculated. Additionally, manual sampling occurred at these and several support sites during all phases of the program.

During dredge operations, surface turbidity at all four monitoring locations remained within Management Zone A (normal operations) and therefore did not exceed their respective intensity thresholds for longer than the allowable 77 h of duration. This was despite some severe weather events occurring during dredging with average daily wind speeds exceeding 15 kts for 63% of the dredging period, compared to only 29% of occasions during Pre Dredge. Although benthic turbidity at Victor Island also remained within Management Zone A during dredge operations, benthic turbidity at Round Top Island reached Management Zone C by exceeding the intensity threshold for 217 hours, during one of the strongest weather events of the monitoring program. Note that real time management of the dredge was reliant on real time surface turbidity (as opposed to benthic), and Management Zone D (cease dredge operations) was never reached at any location during the dredging period.

Slade Islet, a control site, had the highest number of threshold exceedances for a surface site, followed by Round Top Island surface trigger and Freshwater Point control site (ranging from 63 h down to 54 h). In contrast the Victor Island trigger site exceeded thresholds for no more than 7 h during dredging for surface and benthic. Turbidity was highly responsive to increased wind speed, which was mostly from a southerly direction, although large flow events from the Pioneer River and Sandy Creek were also influential on occasion.

Several additional parameters were measured continuously at both the surface and benthic stations and displayed typical patterns associated with seasonal climatic changes. Although the pH remained consistent across the monitoring period, temperature declined due to seasonal cooling. Conductivity at the surface declined intermittently in response to freshwater flow events and dissolved oxygen displayed typical diurnal patterns associated with photosynthetic activity generated by fluctuations in algal populations. Overall it appears that dredge operations had little impact on turbidity or the additional sampled parameters during the Dredge phase.

Depth profiling through the water column was carried out at the four trigger/control sites, in addition to four support sites during all phases of the monitoring project, with parameters typically mirroring the results of the real time surface monitoring. Generally, parameters were consistent down the profile at all locations except for Mackay Harbour, the most inshore site, which often displayed results dissimilar to the more oceanic locations, as would be expected. WQO on occasion were exceeded at several sites including control and support sites during all phases of the program. However, as there is currently insufficient information to establish localised WQO for Freshwater Point, Victor Island and Round Top Island and therefore by default, the more stringent and not necessarily appropriate high ecological value WQO were

applied to these sites, it is not surprising that these sites exceeded the turbidity WQO on all occasions.

Nutrients, dissolved metals and organics were measured during all phases of the project. Nutrient concentrations were relatively low across the monitoring period with occasional exceedances of WQO of selected nutrient forms at several sites across all phases of the dredge project. There appeared to be little relationship between nutrient concentrations and the relevant dredge phases during the monitoring program. Metal concentrations measured during the monitoring program were low and unremarkable. Most concentrations were below LOR and all concentrations during all phases were below the AWQG.

Although mean turbidity was generally more elevated during the Dredge phase at all sites and locations compared to Pre and Post Dredge, wind speeds which are conducive to increasing turbidity, were also more extreme during this phase. Of the surface dredge management locations, the highest number of exceedances occurred at the Slade Islet control site with the lowest number of exceedances being recorded at the Victor Island trigger site. Thus, it appears that climatic conditions had more of an impact on the measured parameters, as opposed to dredge operations.

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Acronyms

APHA	American Public Health Association
AWQG	Australian Water Quality Guidelines
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
BOM	Bureau of Meteorology
DMPA	Dredge Material Placement Area
EMP	Environmental Management Plan
HSEQ	Health Safety Environment and Quality
IDF	Intensity, duration, frequency
JCU	James Cook University
LAT	Lowest Astronomic Tide
LMDMP	Long-term Maintenance Dredge Management Plan
LOR	Limits of Reporting
MEMP	Marine Environmental Monitoring Program
MS	Management System
NQBP	North Queensland Bulk Ports
NTU	Nephelometric Turbidity Units
QA/QC	Quality Assurance/Quality Control
RA	Rolling Average
SMART	Self-Monitoring Algorithm in Real Time
TSHD	Trailing Suction Hopper Dredge
TSS	Total Suspended Solids
VE	Vision Environment
WQO	Water Quality Objectives

1 INTRODUCTION

The Port of Hay Point is North Queensland Bulk Ports Corporation's (NQBP) southernmost port. The Port encompasses two coal terminals, which export in excess of over 100 million tonnes of coal per year. In order to maintain safe navigational depths necessary for the manoeuvring and transit of ships in and around the Port of Hay Point, regular maintenance dredging is required to remove naturally accumulated sediment impacting the required depths. As such, NQBP developed the Port of Hay Point Long-term Maintenance Dredge Management Plan (LMDMP) (NQBP, 2018a) and Port of Hay Point Maintenance Dredging Environmental Monitoring Plan (EMP) (NQBP, 2018b) in order to manage accumulated sediment within the port in the most sustainable way. Several state and federal approvals were gained in order to undertake the 2019 Port of Hay Point maintenance dredging program, which included the implementation of the NQBP Marine Environmental Monitoring Program (MEMP) (NQBP, 2018c) linked to the LMDMP and EMP.

As per the MEMP, NQBP was required to measure continuous water quality (turbidity) at two trigger sites and two control sites before, during and after dredge operations, in addition to supplementary manual water sampling. The monitoring would provide information for both the impact and adaptive tiers of the monitoring program, which supported the ongoing ambient monitoring tier of the program undertaken by James Cook University, Tropwater (JCU). The ambient monitoring program utilised continuous benthic instruments to measure turbidity at the four sites, with data being downloaded regularly. The three-year data set was used to calculate threshold or trigger values (intensity, duration and frequency (IDF)) of naturally elevated turbidity, which would be utilised to adaptively manage dredge operations. However, in order to manage dredge operations in real time, data needed to be telemetered to be available in real time. This would enable adaptive management responses to be enacted in a timely manner in response to trigger value exceedances in order to avoid harm to sensitive ecological receptors, such as corals and seagrasses.

Telemetered or real time surface monitoring stations were deployed by Vision Environment (VE) along with continuous benthic units at the four sites during an 8-week baseline period from 31 August to 30 October 2018. The purpose was to identify relationships between the existing JCU ambient data set and real time surface data sets, so that required adjustments to IDF trigger values could be undertaken prior to the commencement of dredging in 2019 (PCS, 2018).

VE commenced Pre Dredge monitoring at the four sites from 17/18 February until 31 March 2019 when dredging commenced. NQBP undertook maintenance dredging in the Port of Hay Point from 7am on 31 March to 3pm on 2 May 2019. Approximately 353,740 m^3 of sediment material was removed from the Hay Point berths, apron and departure channel and relocated to the Port of Hay Point Dredge Material Placement Area (DMPA) during the 33-day program. Post Dredge monitoring followed, which was completed on 30 May.

This report presents the results of the 2019 Port of Hay Point maintenance dredge monitoring program (17 February to 30 May 2019), including the interpretation of continuous surface and benthic physicochemistry and water sampling data, collected by VE.

2 METHODOLOGY

Monitoring was undertaken prior to, during and after dredging operations (Table 1). A summary of monitoring sites and the type of monitoring that was undertaken, is displayed in Table 2 and Figure 1. Site GPS locations are listed in the Appendix (Table 12).

Table 1 Monitoring phases during the maintenance dredge monitoring program.

Dredge phase	Dates
Pre Dredge	17 and 18 February to 31 March 2019
Dredging	31 March to 2 May 2019
Post Dredge	3 May 2019 to 30 May 2019

Table 2 Monitoring sites and deployed equipment for the Hay Point dredging project.

Site	Status	Water quality sampling	Subsurface telemetered dual physico-chemistry	Benthic self-logging dual physico-chemistry	Dual altimeter
Round Top Island	Trigger	√	√	√	√
Victor Island	Trigger	√	√	√	
Slade Islet	Control	√	√		
Freshwater Point	Control	√	√		
Hay Point/Reef	Support	√			
Relocation Ground	Support	√			
Mackay Harbour	Support	√			
Keswick Island	Support	√			

2.1 Continuous Physicochemistry Dataloggers

2.1.1 Telemetered Surface Equipment

At the four sites (Slade Islet, Round Top Island, Victor Island and Freshwater Point), two multi-parameter sondes (YSI EXO3), each encased in a copper plated cage, were placed into secured antifouled PVC tubes attached to the base of a modified Special Marker buoy (Figure 2). Telemetered loggers programmed the sondes to record turbidity (NTU), temperature (°C), conductivity (mS/cm), pH and dissolved oxygen (% saturation), every 10 minutes at approximately 0.75 m below the water surface. The central wiper was set to clean the sonde probes prior to each data log.

The loggers were attached to solar powered telemetry units installed within the buoy. Parameter data was transferred via telemetry to the VECloud database every 10 minutes.

All sondes were scheduled to be maintained as required based on examination of real time data. Each sonde was calibrated, and log-tested prior to deployment as per VE Health Safety Environment and Quality (HSEQ) Management System (MS) protocols.

2.1.2 Self-logging Benthic Equipment

Benthic sondes were installed on fixed frames and deployed by divers on the benthos at the two trigger sites (Round Top Island and Victor Island) in order to continue the assessment of the surface and benthic data relationship. Dual YSI EXO3 sondes were installed on the frames with sensors approximately 0.75 m above the seabed (Figure 3). Similar to the surface sondes, temperature, conductivity, pH, turbidity and dissolved oxygen were recorded every 10 minutes in self-logging mode with sondes exchanged and data downloaded during regular maintenance visits.

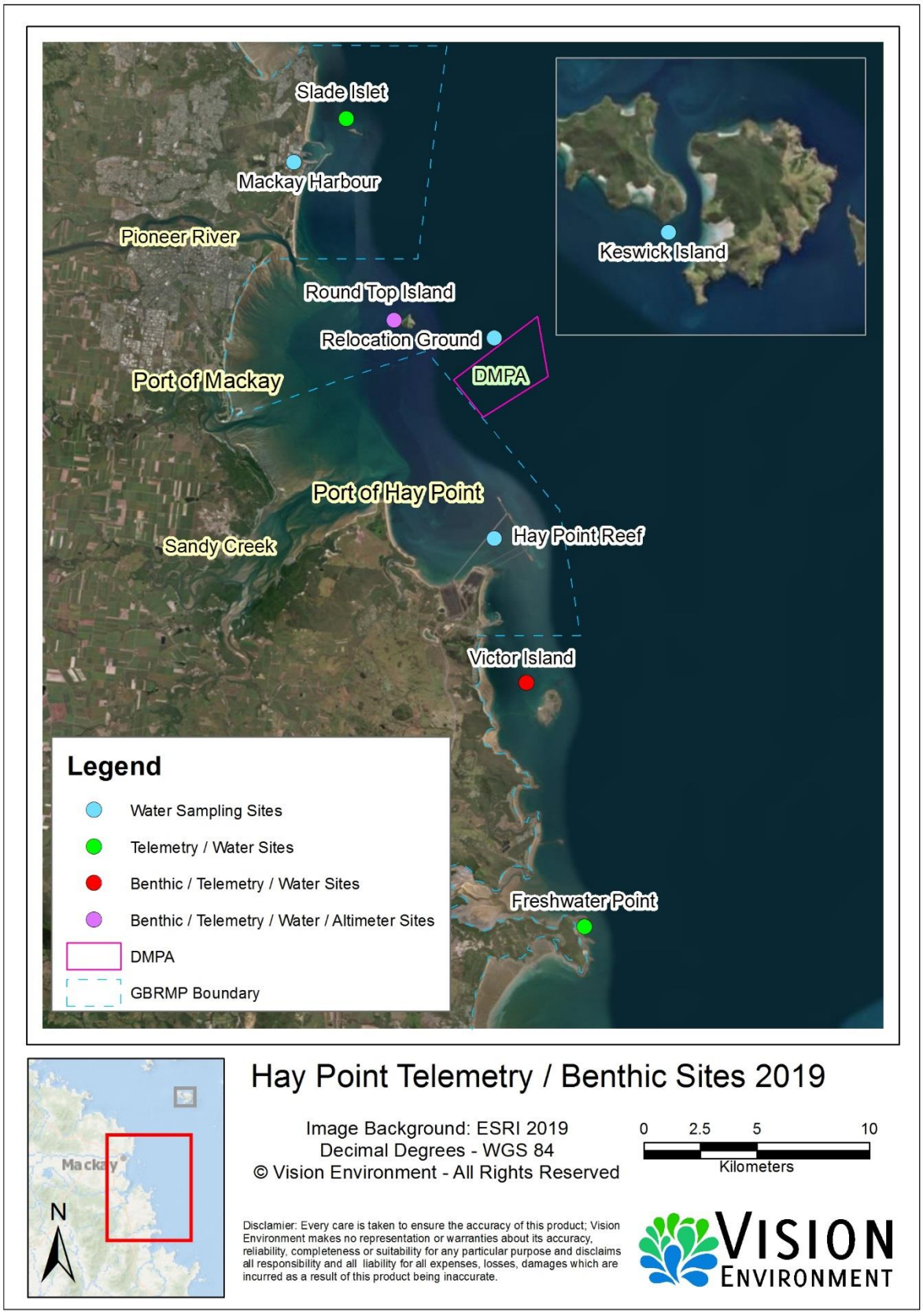

Figure 1 Monitoring sites for the Hay Point Maintenance dredge monitoring program from 17 February 2019 to 30 May 2019.

Figure 2 Dual surface telemetered physicochemistry monitoring station.

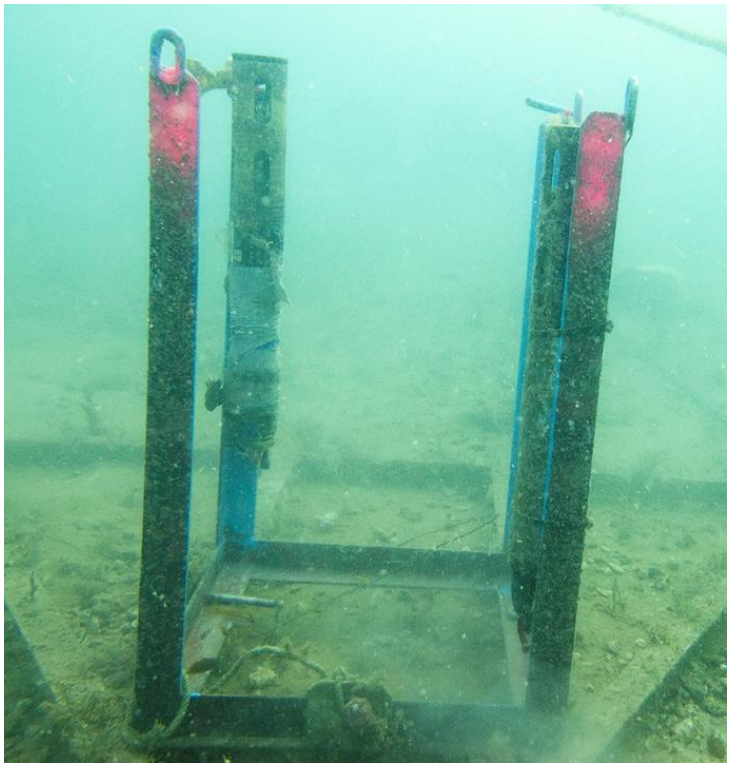

Figure 3 Dual benthic self-logging physicochemistry monitoring station.

2.1.3 Data Management

Telemetered data was transmitted every 10 minutes to the secure VECloud where automatic Self-Monitoring Algorithm in Real Time (SMART) processing occurred. SMART was developed by VE as an initial automatic data deconfounding process in order to filter out erroneous raw real time data from multiple instruments, to provide a more accurate and instantly usable real time data set. Management of physicochemistry logger data was undertaken as per VE HSEQ MS protocols.

Following the initial deconfounding, the SMART data was manually validated by VE personnel for daily reporting after having undergone QA/QC review. Erroneous data was identified by SMART (and manually) using VE HSEQ MS protocols. Self-logged benthic data sets were manually validated utilising the same data deconfounding protocols.

Although turbidity statistics have been reported using mean data from the dual loggers, a smoothing technique was applied and plotted for comparative purposes, and for comparison against licence trigger values. As per the MEMP, real time one-hour rolling averages (RA) were used to establish the cumulative duration above the threshold trigger values.

2.2 Altimeter

2.2.1 Equipment

Data pertaining to sedimentation rates was collected at the Round Top Island benthic site during all three phases of dredging, using dual ALTUS acoustic altimeters, which are similar to a side scan sonar. Altimeters were installed on frames and deployed by divers approximately 300 mm above the benthos, adjacent to the benthic physicochemistry sonde frame. Altimeters were exchanged and data downloaded during regular maintenance visits.

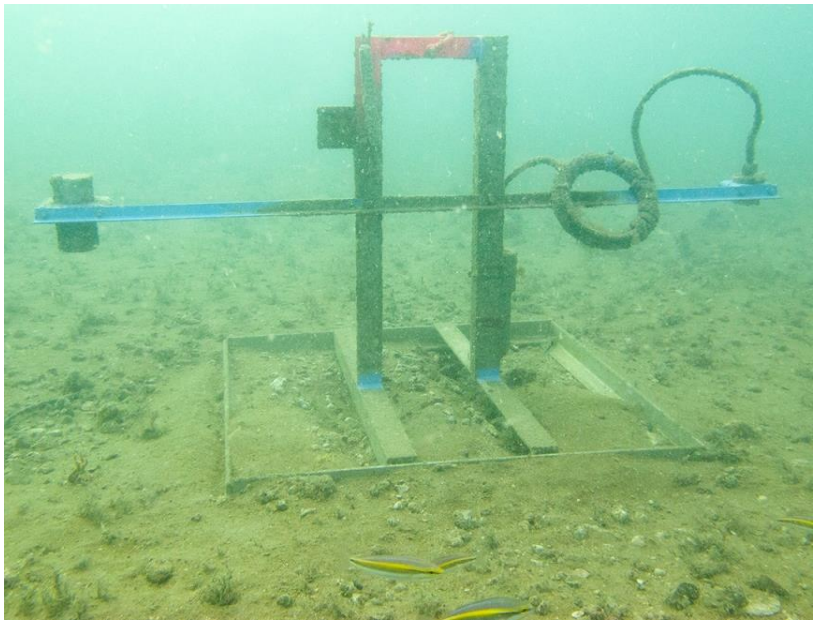

Figure 4 Dual benthic self-logging altimeter sedimentation rate monitoring station.

Changes in energy from wind waves, currents and/or tidally induced flows can result in variations in sedimentation patterns, ranging from accumulation of sediments originating from another location (deposition), resuspension of sediments with no net change in the seabed or the resuspension of sediments and transportation to another location (erosion). Altimeters provide two forms of information to help identify these processes:

- Instantaneous bed level change calculated every 10 minutes indicating the level of sediment flux occurring at a set point in time; and
- Net cumulative change in bed level over a given period.

2.2.2 Data Management

Management of altimeter data is undertaken as per VE HSEQ MS protocols and erroneous data is removed from the data set following several set identifiers. Altitude data is produced every 10 minutes from threshold outputs. When insufficient echo is received back from the seafloor to produce a valid altitude reading, negative readings are logged. These readings are removed prior to further examination of the data. Similar to dual sondes, the use of duplicate altimeters assists in validating data. Altitude data provides sediment flux dynamics and is used to analyse surficial sediment deposition and erosion. Cumulative daily bed level change (change from original 'baseline' reading) can be calculated using the mean from both instruments, in order to gain long-term sediment erosion or deposition patterns.

2.3 Water Sampling and Analysis

Water sampling was carried out at eight sites (Table 2, Figure 1) as per the VE HSEQ MS protocols on the following occasions:

- 12 March 2019 – Pre Dredge phase;
- 9/10 April 2019 – Dredge phase; and
- 30 May 2019 – Post Dredge phase.

The comprehensive water quality component of the program involved the monitoring of *in-situ* physicochemistry, nutrients, chlorophyll *a*, dissolved metals and organics. Samples were collected in accordance with standard protocols derived from worldwide authorities, including:

- Australian and New Zealand Standards for water quality sampling (AS/NZS, 1998a, b, c);
- The American Public Health Association Standard Methods for the Examination of Water and Wastewater (APHA, 2005);
- Australian and New Zealand Water Quality Guidelines (ANZECC, 1992, 1998, ANZECC/ARMCANZ, 2000, ANZG, 2018);
- The Queensland Water Quality Guidelines (DERM, 2009); and
- The Department of Environment and Science Monitoring and Sampling Manual (DES, 2018).

Water samples for analyses were collected at a depth of ~0.5 m using a perspex pole sampler to which a 1 L Nalgene bottle was attached (Figure 5a). Nalgene bottles were acid-washed with hydrochloric acid in the VE laboratory clean room prior to sampling, and triple rinsed in ambient water prior to sample collection at each site. Powder free gloves were worn to avoid contamination.

Samples which required filtration (dissolved metals: aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, mercury, nickel, and zinc; filtered nutrients: filterable reactive phosphorus, nitrogen oxides, and ammonia) were immediately filtered through a 0.45 µm sterile surfactant free cellulose acetate membrane syringe filter (Minisart 16555K) into their respective sample bottles provided by the analysing laboratory (Figure 5b). Each pre-packaged syringe and filter were pre-rinsed in site water prior to sample collection. For samples which did not require filtration (chlorophyll *a*, total nutrients and organics) water samples were decanted directly into the laboratory provided sample bottles.

Samples were stored on ice for transport to the analysing laboratory. A duplicate water sample for all parameters was collected at one site per survey as per established protocols, with a

field and laboratory blank also collected. Analytical laboratory quality control measures included laboratory duplicates, laboratory blanks, analysis of certified reference material and matrix spikes. All water samples were analysed at ALS laboratories and within recommended holding periods.

Figure 5 Manual water sampling (a), filtering (b) and depth profiling (c).

2.4 Physicochemical Depth-Profiling

Although weekly sampling was scheduled in the MEMP during the dredge phase, fortnightly sampling was adopted due to availability of real time data at the four main sites. Thus, depth profiling was utilized as a validation tool. Despite fortnightly sampling being proposed, this could not be achieved due to persistent adverse weather conditions. Manual measurement of the physicochemical water environment was carried out on the following occasions and sites:

- 12 March 2019 (all sites) – Pre Dredge phase;
- 9/10 April 2019 (all sites) – Dredge phase;
- 15 April 2019 (Round Top Island and Victor Island) – Dredge phase;
- 3/4 May 2019 (all sites except Keswick Island) – Dredge/Post Dredge phase; and
- 29 May 2019 (all sites) – Post Dredge phase.

A pre-calibrated YSI ProDSS multi-parameter water meter was utilised to measure the physicochemical parameters (temperature, conductivity, pH, dissolved oxygen and turbidity) through the water column at 1.0 m intervals to the benthos (Figure 5c). Triplicate sub-surface readings (0.5 m depth) were recorded at each site.

Concurrent light measurements were also taken to calculate the vertical light attenuation coefficient (K_d, the rate at which light or Photosynthetic Active Radiation diminishes with depth through the water column) and resultant euphotic depth (the optical depth to which photosynthesis can occur/where light levels are ~1% of those at the surface) in order to compare light attenuation through the water column at different sites and on different sampling occasions.

2.5 Water Quality Objectives

Dissolved metal concentrations were compared to 95% species protection trigger level Australian Water Quality Guidelines or AWQG (ANZG, 2018). Organics (pesticides) were also compared to WQOs (where available)(ANZG, 2018). Depth profiled physicochemical

parameters and nutrients, including chlorophyll *a*, were compared to local WQO as per DEHP (2013).

Note that the Freshwater Point, Victor Island and Round Top Island sites are located in water area HEV2385, where insufficient information is available to establish WQO. As such, these values have been compared to HEV2383 WQO, in which Keswick Island is located, which are likely to be overly stringent for these sites located closer to the shoreline.

2.6 Intensity, Duration & Frequency Thresholds

As per the MEMP, respective trigger sites and control sites were determined based on Royal HaskoningDHV IDF analyses of the JCU ambient three-year benthic data set (Royal HaskoningDHV, 2018). Appropriate intensity thresholds incorporating prevailing wind direction for both the wet and dry seasons, were based on seasonal percentiles of the ambient data in order to manage dredge operations. Duration thresholds were also established based on a 40-day dredge program. If and when the cumulative duration increased and reached either: average duration (90th percentile duration) or maximum duration, then a series of management zones would be triggered (NQBP, 2018c).

The benthic trigger values established in the MEMP were reassessed prior to dredging, based on the need for the use of real time surface turbidity monitoring for dredge management. By comparing real time surface data (and continuous benthic data) collected by VE during the baseline period with the JCU long term benthic data set, a correlation factor could be established to allow surface turbidity data to represent benthic turbidity data during dredge compliance (PCS, 2018). The revised trigger values (Table 3) were further validated utilizing additional comparative data collected by VE during the Pre Dredge phase (PCS, 2019a).

Trigger values were applied to real time surface turbidity data (using the real time one-hour average) at the two trigger sites during dredging. Note that dredge management was based on real time data received from the surface instruments, however benthic data which was collected from both JCU and VE sites and reviewed on a regular basis, served as a validation tool.

Table 3 Wet season benthic and surface turbidity thresholds for the trigger and control sites (PCS, 2019a).

Location	Benthic turbidity Intensity Threshold (NTU)	Surface turbidity Intensity Threshold (NTU)
Slade Islet (control)	43	8.9
Round Top Island (trigger)	11	8.1
Victor Island (trigger)	32	13.7
Freshwater Point (control)	104	24.3

Management zones were applied to specified durations of time that the intensity thresholds were exceeded at trigger sites (Table 4). This extended from Management Zone A, which was normal operations, through two higher levels to Management Zone D, when dredge operations would cease.

Management zones B and C involved various levels of investigation to determine if the intensity exceedances were naturally derived (weather related) or due to dredge operations, in addition to the instigation of mitigation and management actions (NQBP, 2018c). Wind

direction was also taken into account during intensity exceedances in respect to the weight of evidence placed on respective trigger and control sites (NQBP, 2018c).

Table 4 Intensity thresholds and allowable duration for respective management zones for surface turbidity (PCS, 2019b).

	Intensity Threshold (NTU)	Management Zone A (Hours)	Management Zone B (Hours)	Management Zone C (Hours)	Management Zone D (Hours)
Round Top Island Surface	8.1	<77	77 - 164	164 - 300	>300
Victor Island Surface	13.7	<77	77 - 241	241 - 291	>291

As per the State Environmental Authority water quality conditions, Total Suspended Solids (TSS) calculated on a six-hour rolling mean at the four real time sites was also not permitted to exceed 100 mg/L during the Dredge phase. The trigger value was converted to a six-hour rolling mean of turbidity and compared to real time surface data during dredging.

3 RESULTS & DISCUSSION

3.1 Dredge Volumes

The Trailing Suction Hopper Dredge (TSHD) “Brisbane” operated from 07:00 on 31 March 2019 to 15:00 on 2 May 2019. Approximately 353,740 m^3 of material was dredged across berth pockets, apron and departure channel and disposed at the Port of Hay Point DMPA.

Stations for water quality monitoring were deployed on 17 February at Slade Islet Surface; 18 February at Round Top Island Surface, Victor Island Surface and Freshwater Point Surface; and 19 February at Round Top Island Benthic and Victor Island Benthic. All monitoring stations were demobilised on 30 May 2019.

3.2 Metocean Conditions

Approximately 522 mm of rainfall was recorded over the monitoring period from 17 February 2019 to 30 May 2019, as reported by the Mackay BOM station 033119 (BOM, 2019). Significant rainfall periods during the Pre Dredge phase included 3 to 9 March (131 mm), and 28 to 30 March (66 mm), while during the Dredge phase a rainfall event of approximately 179 mm was recorded from 22 to 25 April (Figure 6). Minimal rainfall (~ 40 mm) was recorded during the 28-day Post Dredge phase.

Flow from the Pioneer River and Sandy Creek (Figure 1) increased in response to the rain events, with flow at both waterways peaking on 25 April (384 m^3/s and 67 m^3/s, respectively). Minor peaks were also recorded in both waterways (Figure 6) on 9 March (106 m^3/s and 14 m^3/s, respectively).

Average daily wind speeds were highest on 25 February (21 kts), with average daily wind speeds over 15 kts recorded on 21 days of the 33-day Dredge phase between 31 March to 2 May. Wind speeds also exceeded 15 kts from 11 to 19 May during Post Dredge (Figure 6). Average daily wind speeds over 15 kts during all dredge phases propagated from a southerly direction (including south easterly and south westerly). During the monitoring period, highest wind gusts (43 kts) were recorded at around 1pm on 19 April (Dredge phase), with gusts over 20 kts recorded at least daily during the Dredge phase (Figure 6).

Spring tides associated with the full and new moons occurred on 20 February (6.75 m tidal range), 7 and 21 March (4.92 and 6.48 m tidal ranges), 5 and 19 April (4.84 and 5.98 m tidal ranges), and 5 and 19 May (5.15 and 5.60 m tidal ranges).

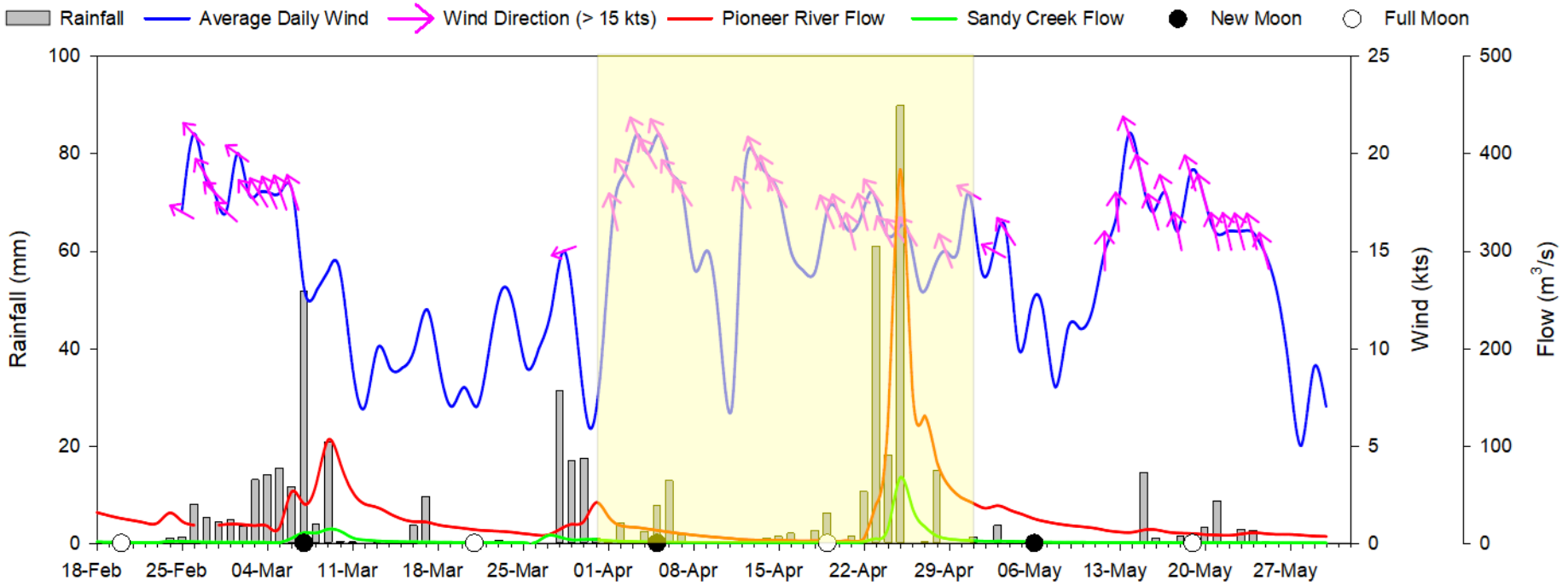

Figure 6 Wind speeds and direction, rainfall, river flow and lunar phases during the maintenance dredge monitoring program from 18 February to 30 May 2019. *Arrows indicate direction that wind is travelling towards. Yellow shaded period indicates Dredge phase.*

3.3 Turbidity

Turbidity intensity thresholds (Table 3) were applied to all sites, with the durations of the exceedance of the turbidity threshold also calculated for the monitoring period (Table 4). Note that only real time surface data was applicable to dredge management at the time of operation.

Five of the six monitoring sites remained within Management Zone A (normal operations), exceeding their respective turbidity intensity thresholds for less than 77 hours (Table 5). In contrast, Round Top Island benthic reached Management Zone C (165 to 300 hours) with turbidity intensity threshold exceedances at this site recorded at 217 hours (Table 5). However, Round Top Island surface turbidity, from which the dredge management was enacted, remained in Management Zone A.

Table 5 Sub-surface and benthic turbidity statistics for continuous logger monitoring sites during phases of the maintenance dredge monitoring 18 February to 30 May 2019.
Pre Dredge: Deployment on 17/18/19 February to 7am 31 March; Dredge: 7am 31 March to 3pm 2 May; and Post Dredge: 3pm 2 May to retrieval on 30 May 2019. [1]Values gained from PCS (PCS, 2019b).

Site	Dredge phase	Statistic	Turbidity (NTU)	Turbidity Intensity Threshold (NTU)	Duration of Exceedance (Hours/Zone)[1]
Slade Islet Surface	Pre Dredge	Mean ± se	3.3 ± 0.0	-	
		Range (n)	<1 – 19 (6001)		
	Dredge	Mean ± se	5.6 ± 0.0	8.9	63/A
		Range (n)	<1 – 22 (4799)		
	Post dredge	Mean ± se	4.8 ± 0.0	-	
		Range (n)	2 – 13 (3837)		
Round Top Island Surface	Pre Dredge	Mean ± se	3.8 ± 0.0	-	
		Range (n)	<1 – 17 (5902)		
	Dredge	Mean ± se	4.3 ± 0.0	8.1	54/A
		Range (n)	<1 – 21 (4784)		
	Post dredge	Mean ± se	3.6 ± 0.0	-	
		Range (n)	1 – 10 (3859)		
Round Top Island **Benthic**	Pre Dredge	Mean ± se	5.5 ± 0.1	-	
		Range (n)	<1 – 27 (5366)		
	Dredge	Mean ± se	12 ± 0	11	217/C
		Range (n)	<1 – 98 (4943)		
	Post dredge	Mean ± se	3.6 ± 0.0	-	
		Range (n)	1 – 33 (3983)		
Victor Island Surface	Pre Dredge	Mean ± se	4.4 ± 0.1	-	
		Range (n)	<1 – 32 (5883)		
	Dredge	Mean ± se	6.1 ± 0.0	13.7	2/A
		Range (n)	<1 – 17 (4653)		
	Post dredge	Mean ± se	5.3 ± 0.0	-	
		Range (n)	3 – 11 (3996)		
Victor Island **Benthic**	Pre Dredge	Mean ± se	12 ± 0	-	
		Range (n)	<1 – 87 (3752)		
	Dredge	Mean ± se	12 ± 0	32	7/A
		Range (n)	2 – 56 (4657)		
	Post dredge	Mean ± se	4.2 ± 0.1	-	
		Range (n)	<1 – 26 (4004)		
Freshwater Point Surface	Pre Dredge	Mean ± se	8.4 ± 0.1	-	
		Range (n)	<1 – 48 (5853)		
	Dredge	Mean ± se	13 ± 0	24.3	53/A
		Range (n)	<1 – 53 (4652)		
	Post dredge	Mean ± se	6.1 ± 0.1	-	
		Range (n)	2 – 29 (3990)		

The highest number of threshold exceedances at surface sites occurred at the Slade Islet control site (63 h), with slightly lower exceedances recorded at Round Top Island (54 h) and Freshwater Point (53 h). The remaining trigger site at Victor Island surface recorded very few threshold exceedances during the dredge phase (2 h). Similarly, Victor Island benthic turbidity only recorded 7 h of threshold exceedances (Table 5). Management Zone D (cease dredge operations) was not reached at any stage at any location during the dredging period.

Data was available during the whole monitoring period at all sites except for Pre Dredge data for Victor Island benthic from 12 to 26 March when logging failed on both sondes. Mean turbidity values across the sites and varying dredge phases ranged from 3.3 to 13 NTU, with highest turbidity generally occurring during the Dredge phase for all sites and depths (Table 5). Only Round Top Island benthic exhibited a mean Dredge phase turbidity value (12 NTU) slightly higher than its turbidity intensity threshold (11 NTU).

The northern control site at Slade Islet demonstrated similar mean turbidity values across all dredge phases which were similar to the northern trigger site at Round Top Island surface. In contrast the southern control site (Freshwater Point) mean surface turbidity values, were almost double the southern trigger site of Victor Island surface during Pre and Dredge phases, but similar during Post dredge (Table 5).

Benthic mean turbidity values were generally more elevated and variable than at the surface for both Round Top Island and Victor Island during the Pre Dredge and Dredge phases, but were similar to their surface counterparts during the Post Dredge period (Table 5).

Although intensity thresholds were only applicable during the Dredge phase, during the Pre Dredge period, all surface sites exhibited turbidity peaks higher than their pertinent intensity thresholds from the period of 22 February to 6 March (Figures 7 to 10). A similar pattern was evident for benthic sites, with Victor Island benthic exhibiting an extended period of turbidity peaks (19 February to 11 March). All turbidity peaks corresponded to the strong >15 kts south easterly winds observed during these periods.

Multiple turbidity peaks exceeding applicable intensity thresholds were also recorded at all locations during the Dredge phase, with the majority of exceedances occurring in response to persistent strong south easterly winds, rather than rainfall and/or tidal conditions (Figures 7 to 10). However as mentioned, the duration of exceedances did not exceed the allowable hours with the majority of sites remaining in Management Zone A.

Maximum surface turbidity values within the Dredge phase occurred on the 6 April during a period of elevated wind speeds with 53 NTU recorded at Freshwater Point and 17 NTU at Victor Island surface. At Round Top Island and Slade Islet maximum surface turbidity peaks during the Dredge phase occurred on the 25 April (21 and 20 NTU, respectively). The timing of this latter peak may have been in response to rainfall producing a wide reaching coastal freshwater plume from the Pioneer River when flows peaked at 384 m^3/s (Figure 6), with only moderate wind speeds recorded at this time. Benthic turbidity showed little response suggesting the plume was mainly restricted to the surface (Figures 7 to 9). The rainfall event also increased surface turbidity at Freshwater Point (33 NTU) and to less of a degree at Victor Island Surface (14 NTU), both of which may have been influenced by smaller flows from Sandy Creek (Figures 9 and 10).

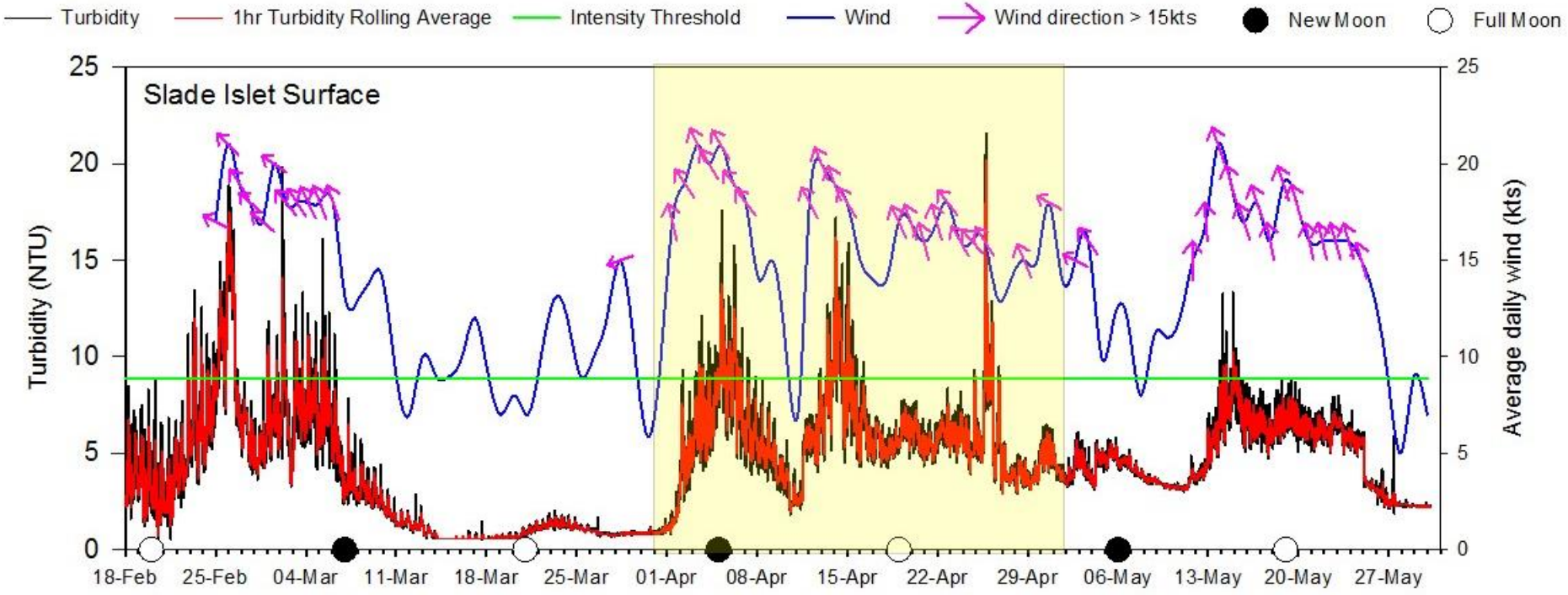

Figure 7 Turbidity at Slade Islet surface monitoring site from 18 February to 30 May 2019.
Yellow shaded area indicates dredge period. Intensity Threshold (green line) applicable to the dredge phase only. Arrows indicate direction that wind is travelling towards.

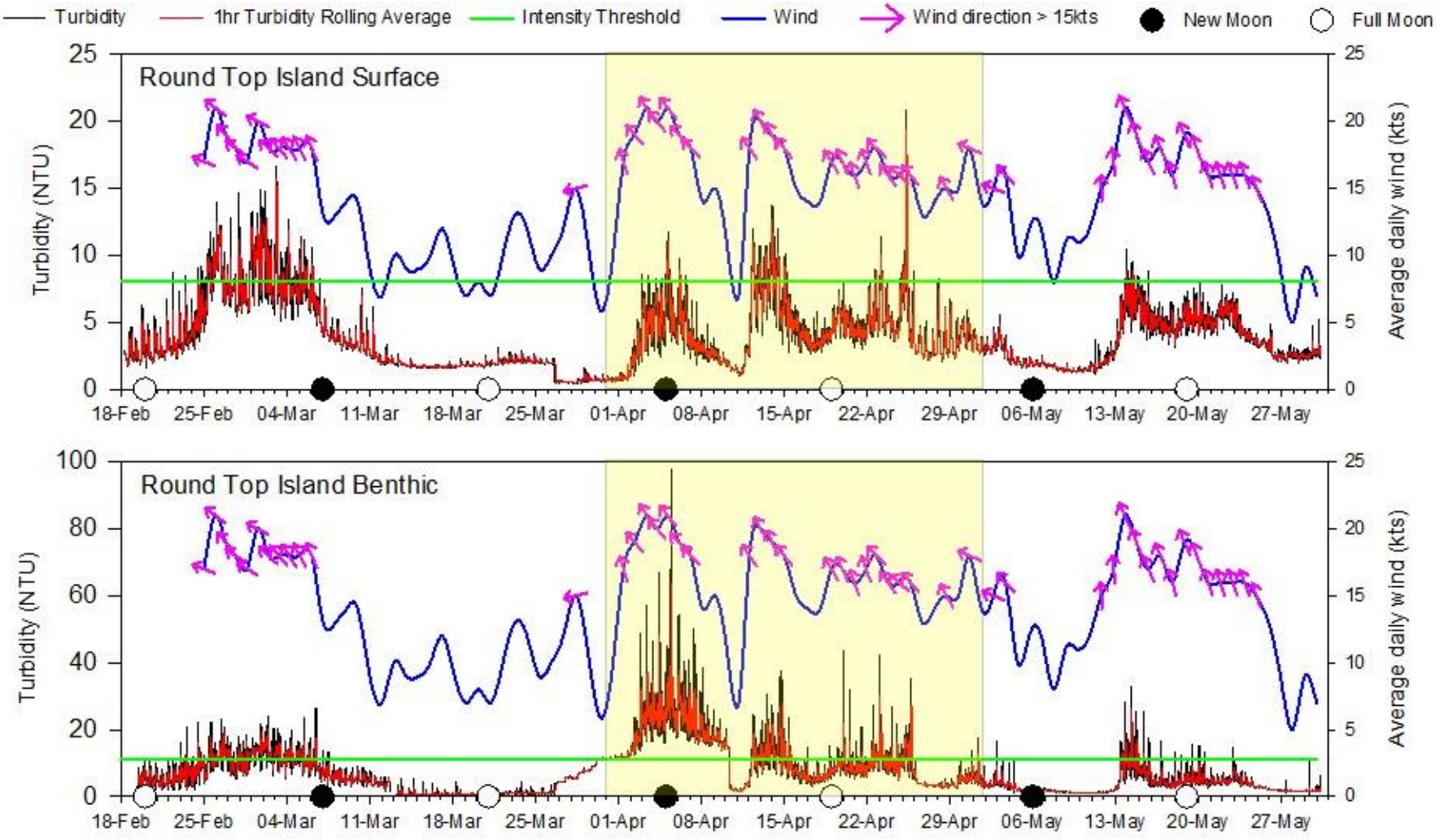

Figure 8 Turbidity at Round Top Island surface and benthic monitoring sites from 18 February to 30 May 2019.
Yellow shaded area indicates dredge period. Intensity Threshold (green line) applicable to the dredge phase only. Arrows indicate direction that wind is travelling towards.

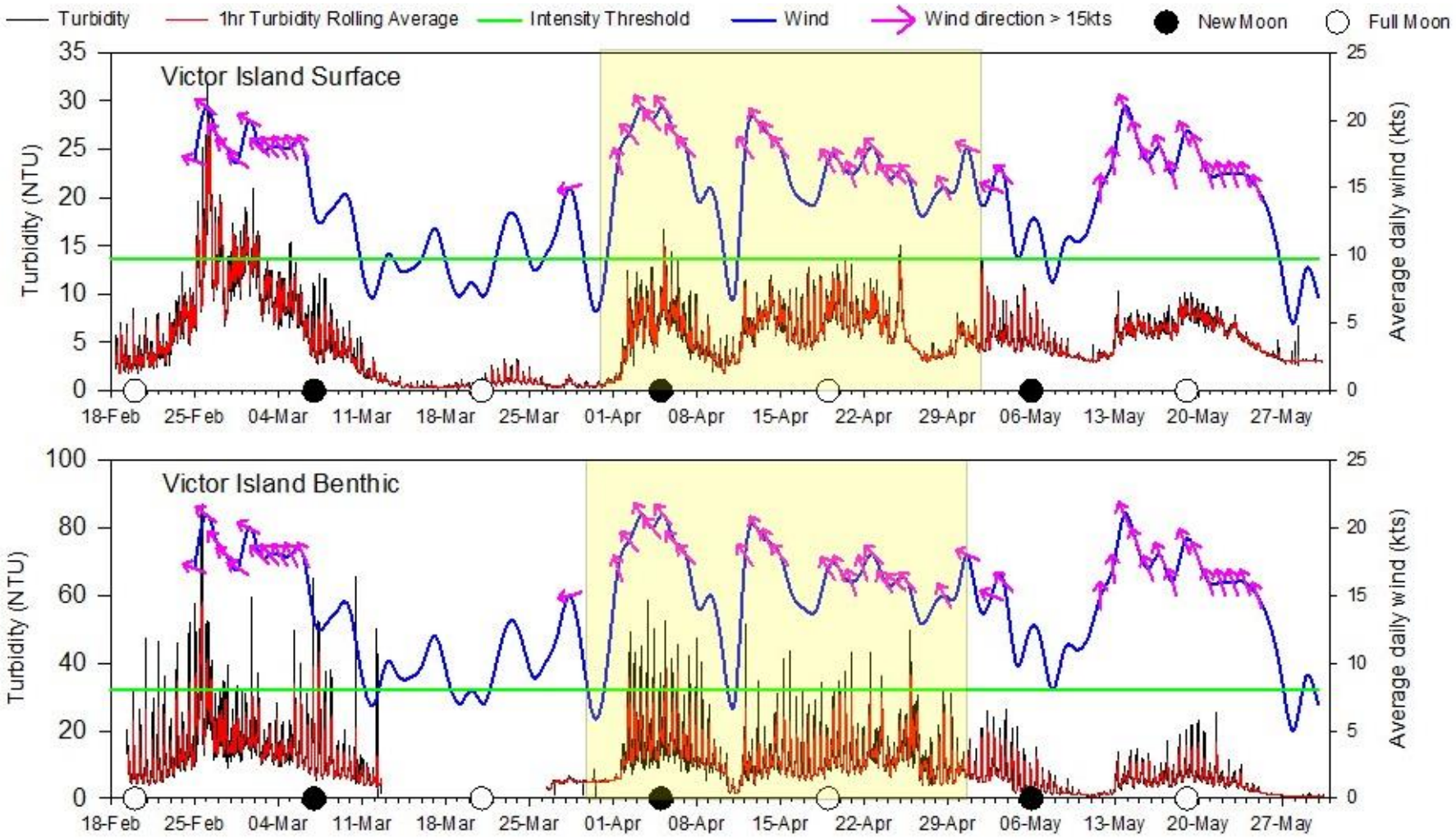

Figure 9 Turbidity at Victor Island surface and benthic monitoring sites from 18 February to 30 May 2019.
Yellow shaded area indicates dredge period. Intensity Threshold (green line) applicable to the dredge phase only. Arrows indicate direction that wind is travelling towards.

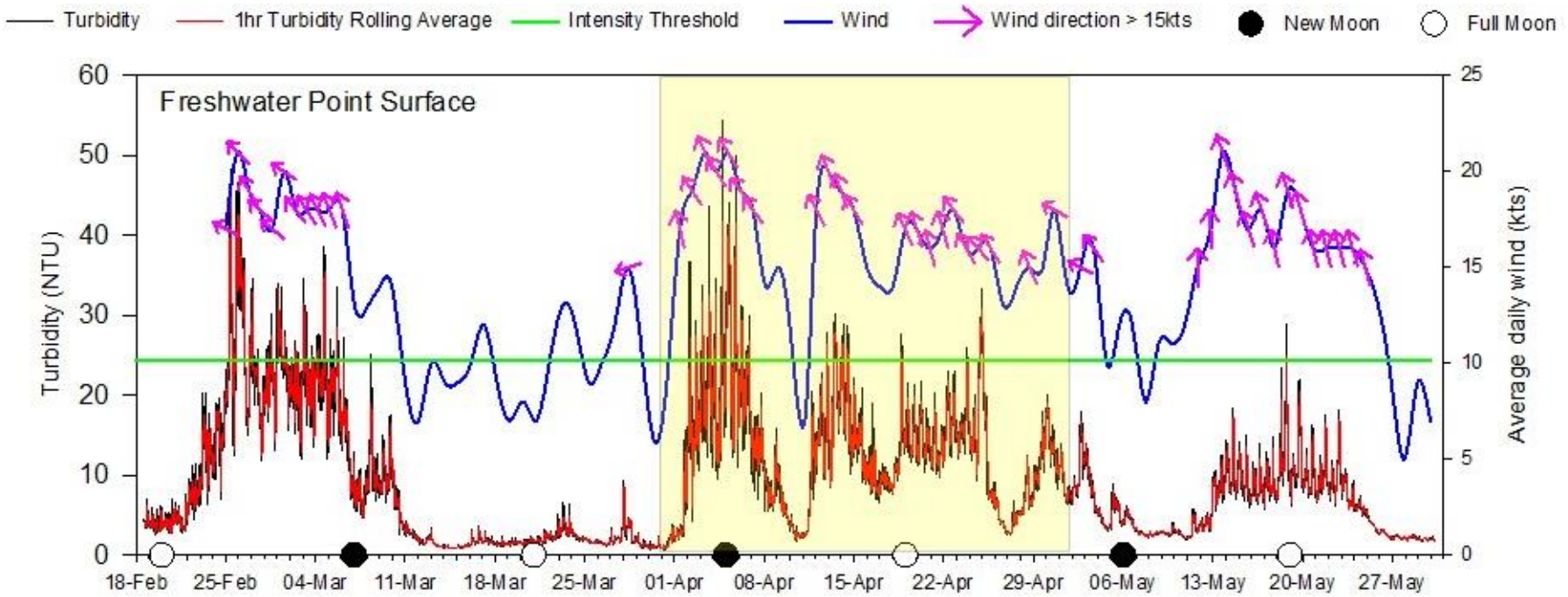

Figure 10 Turbidity at Freshwater Point surface monitoring site from 18 February to 30 May 2019.
Yellow shaded area indicates dredge period. Intensity Threshold (green line) applicable to the dredge phase only. Arrows indicate direction that wind is travelling towards.

Benthic turbidity exceeded applicable intensity thresholds on multiple occasions at both sites during the Dredge phase, generally during strong wind conditions. Maximum benthic turbidity at Round Top Island (98 NTU) and Victor Island (56 NTU), were recorded on 5 and 3 April respectively, during a period of strong winds (>20 kts). However maximum benthic turbidity at Victor Island overall (87 NTU) was recorded during Pre Dredge (Table 5). Round Top Island benthic turbidity values were consistently higher than the applicable intensity threshold from 30 March to 10 April returning to <5 NTU values when the strong winds eased (Figures 9 and 10).

Post Dredge turbidity values at each site were generally lower than applicable intensity thresholds. During the period of strong south, south easterly winds on 13 to 15 May, values higher than applicable thresholds were recorded only for short periods at Slade Islet, Round Top Island (surface and benthic) and Freshwater Point (Figures 7 to 10).

As per Sate Environmental Authority water quality conditions the six-hour rolling average of turbidity (converted from 100 mg/L TSS) did not exceed the respective trigger value at any of the four real time sites during the Dredge phase (Table 6).

Table 6 Surface turbidity six-hour rolling average values during Dredge phase in comparison with state compliance values.

Location	Surface turbidity 6 h rolling average range (NTU)	State Compliance Value (NTU)
Slade Islet (control)	<1 - 12	83.3
Round Top Island (trigger)	<1 - 12	73.5
Victor Island (trigger)	<1 - 14	68
Freshwater Point (control)	1 - 38	125

3.4 Additional Parameters

Overall, mean sea surface temperatures at all locations decreased from 28.2 to 28.3°C during the Pre Dredge period, to 23.4 to 23.5°C during Post Dredge due to seasonal cooling (Table 7). Benthic temperatures were only slightly cooler than their surface counterparts, indicating a well-mixed water column. During the Pre Dredge phase, a short period of cooler water temperature was observed (25 February to 10 March), associated with a large rain event which resulted in ambient cooling (Figure 11). Both ambient and seawater temperatures increased following this period (BOM, 2019).

Despite several significant rainfall events which can affect pH, mean pH during the monitoring period was consistent at all locations. The pH ranged from 8.0 to 8.3 and increased slightly over the entire monitoring period (Table 7, Figure 11).

Mean surface conductivity values ranged from 54.1 mS/cm (Slade Islet, Pre Dredge) to 56.9 mS/cm (Freshwater Point, Post Dredge, Table 7). Mean benthic conductivity values were slightly higher than their surface counterparts, due to less exposure to freshwater inputs during rainfall events (with seawater being denser than freshwater, thus freshwater remaining on the surface). Round Top Island surface conductivity values appeared very responsive to the local rainfall and resultant flow events due to its location adjacent to the Pioneer River mouth. During the rainfall period from 23 to 25 April, short-lived periods of decreased conductivity were recorded at Round Top Island (14 mS/cm), Slade Islet (20 mS/cm) and Freshwater Point (45 mS/cm). However, no notable change was recorded at Victor Island surface (52 mS/cm) (Figure 12).

Dissolved oxygen means ranged from 99 to 104% saturation across the sites during the monitoring period. Slightly lower dissolved oxygen was recorded at benthic sites (98 to 100 % saturation). Oxygen production from photosynthetic organisms, such as zooplankton and algae, which are predominantly found at the sea surface are likely responsible for the higher surface concentrations.

Large diurnal fluctuations in dissolved oxygen were recorded at all locations with Freshwater Point exhibiting the greatest variability in DO saturation (Figure 12). This site is located closest to the shoreline where there is likely to be a higher load of organic matter. DO concentrations outside of the WQO range of 95 to 105% saturation were regularly recorded at Freshwater Point, with concentrations >130 % saturation occurring mid-March and late May and values <90% saturation during 30 to 31 March. These large DO fluctuations correspond to the large temperature fluctuations noted at Freshwater Point (Figure 11) during a period of little rainfall, when ambient sunlight would be optimal for photosynthetic activity.

3.5 Depth-Profiling

Depth-profiling was carried out on five occasions across the three dredging phases: Pre Dredge: 12 March; Dredge: 9/10 and 15 April; and Post Dredge: 3/4 and 30 May 2019 (Table 8). Depth-profiling on 15 April was undertaken during an unscheduled visit, and as such only the trigger monitoring sites of Victor and Round Top Islands were profiled. During the profiling immediately Post Dredge (3/4 May), adverse weather conditions prevented the profiling of the offshore site of Keswick Island.

Temperature during each survey was consistent across the sites but decreased over the monitoring period as cooler weather conditions occurred (Figure 13) with the autumn season. Overall, temperatures decreased by approximately 5°C during the monitoring period ranging from 27.2 to 28.0°C on 12 March to 22.9 to 23.5°C on 30 May, consistent with the surface sonde trends. Temperature was consistent through the profile at most sites on all occasions with slight decreasing gradients detected at the shallower sites. Slightly warmer surface temperatures were observed during the earlier 12 March and 10 April surveys. Additionally, Mackay Harbour also displayed a decreasing temperature gradient on 29 May that was not detected at other sites.

Despite several occasions of precipitation, conductivity remained consistent between sites and surveys, ranging from 52.9 to 55.1 mS/cm (Figure 14). Unlike the continuous loggers the profiles provide only a snapshot in time and may not capture extreme events. However, profiling on 12 March a few days after the 131 mm rainfall event identified a freshwater surface layer to approximately 1.0 m depth at Hay Point. Slightly lower surface conductivity was also detected at the Relocation Ground and Round Top Island sites on this occasion. Conductivity through the profile was consistent at all sites during remaining surveys, although Mackay Harbor tended to record overall lower conductivity with a decreasing gradient detected on all occasions except 29 May. This was particularly evident on 4 May, following the 179 mm rain event of the 22 to 25 April, with the other occasions also following recent rain activity.

The pH across the sites ranged from 7.9 to 8.2 (Figure 15) across the monitoring period. At several sites (both inshore and offshore) the pH was below the recommended WQO range of 8.1 to 8.4 during each survey, including at Keswick Island. The pH was mostly consistent through the profile at all sites and surveys, except for Mackay Harbour on 4 May and Freshwater Point on 10 April, where an increasing gradient to the benthos was recorded.

Table 7 Sub-surface and benthic temperature, pH, conductivity and dissolved oxygen statistics for continuous logger monitoring sites during phases of the maintenance dredge monitoring 18 February to 30 May 2019.
Pre Dredge: Deployment on 18/19 February to 7am 31 March; Dredge: 7am 31 March to 3pm 2 May; and Post Dredge: 3pm 2 May to retrieval on 30 May 2019. Values are means ± se (n =3752 to 6001).

Parameter	Dredge Phase	Slade Islet	Round Top Island	RTI Benthic	Victor Island	VI Benthic	Freshwater Point
Temperature (ºC)	Pre Dredge	28.2 ± 0.0	28.2 ± 0.0	28.0 ± 0.0	28.3 ± 0.0	27.9 ± 0.0	28.3 ± 0.0
	Dredge	26.0 ± 0.0	26.1 ± 0.0	26.3 ± 0.0	26.0 ± 0.0	26.0 ± 0.0	26.0 ± 0.0
	Post Dredge	23.5 ± 0.0	23.5 ± 0.0	23.5 ± 0.0	23.4 ± 0.0	23.4 ± 0.0	23.4 ± 0.0
pH	Pre Dredge	8.1 ± 0.0	8.0 ± 0.0	8.1 ± 0.0	8.0 ± 0.0	8.2 ± 0.0	8.0 ± 0.0
	Dredge	8.2 ± 0.0	8.1 ± 0.0	8.1 ± 0.0	8.2 ± 0.0	8.2 ± 0.0	8.1 ± 0.0
	Post Dredge	8.3 ± 0.0	8.2 ± 0.0	8.1 ± 0.0	8.2 ± 0.0	8.2 ± 0.0	8.1 ± 0.0
Conductivity (mS/cm)	Pre Dredge	54.1 ± 0.0	53.2 ± 0.0	54.3 ± 0.0	55.2 ± 0.0	54.7 ± 0.0	55.0 ± 0.0
	Dredge	53.3 ± 0.1	53.2 ± 0.1	56.3 ± 0.0	55.5 ± 0.0	56.2 ± 0.0	54.3 ± 0.0
	Post Dredge	55.3 ± 0.0	54.2 ± 0.0	54.7 ± 0.0	55.6 ± 0.0	54.5 ± 0.0	56.9 ± 0.0
Dissolved oxygen (% saturation)	Pre Dredge	101 ± 0	103 ± 0	100 ± 0	102 ± 0	98 ± 0	101 ± 0
	Dredge	101 ± 0	102 ± 0	98 ± 0	100 ± 0	98 ± 0	99 ± 0
	Post Dredge	101 ± 0	104 ± 0	99 ± 0	101 ± 0	100 ± 0	100 ± 0

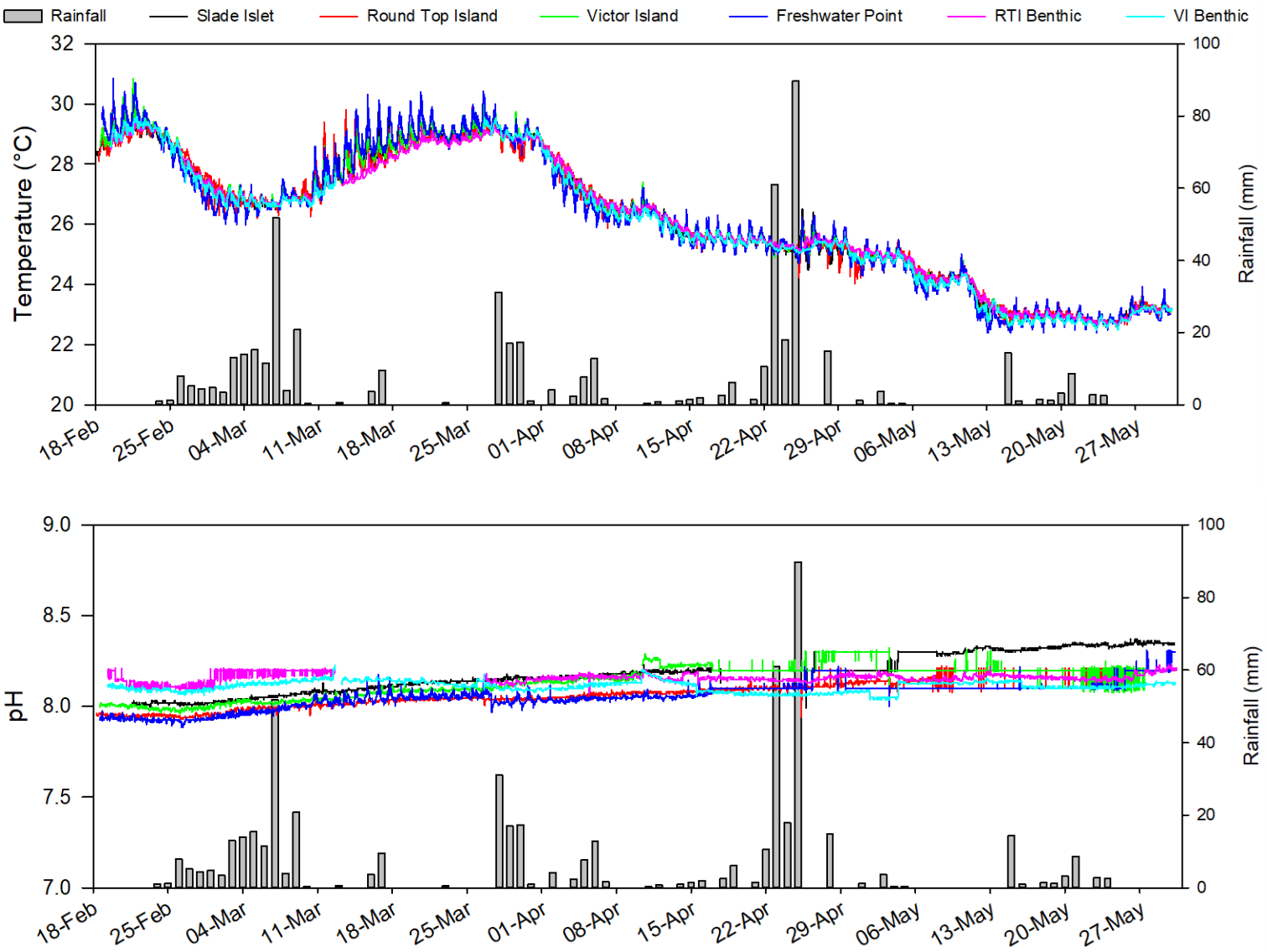

Figure 11 Temperature and pH at monitoring sites from 18 February to 30 May 2019.

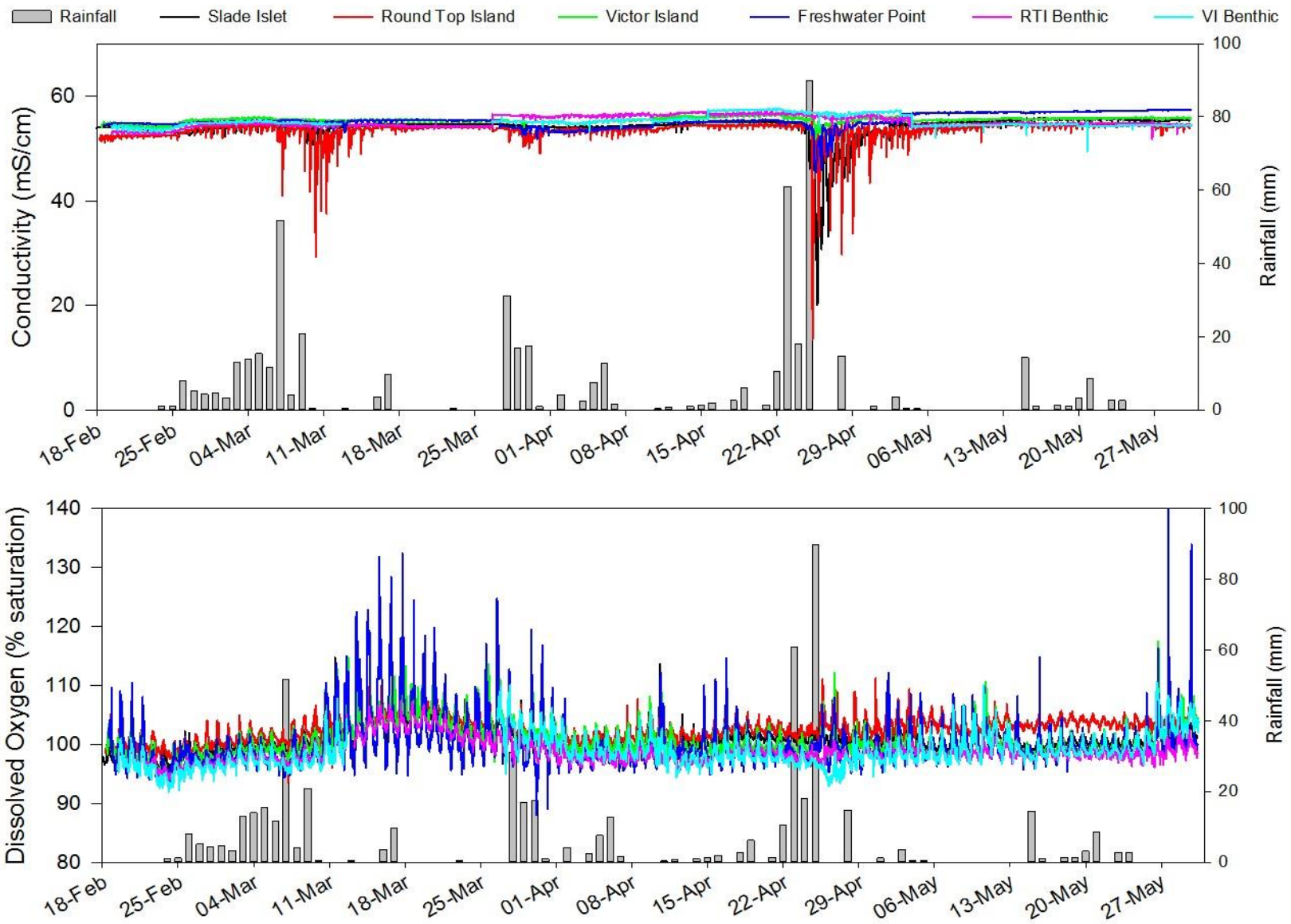

Figure 12 Conductivity and dissolved oxygen at monitoring sites from 18 February to 30 May 2019.

Table 8 Discrete physicochemical statistics from depth-profiling of the entire water column during Pre Dredge (12 March 2019), Dredge (9 & 10 April and 15 April) and Post Dredge (3 and 4 May, and 30 May 2019) monitoring.
*Values are means ± se (n = 17 - 46 for physicochemical, n = 10 - 39 for Kd). The WQO for individual water areas as per EHP (EHP, 2013) is provided for comparison. Field values highlighted when above WQO.WQO for MD2341 and MD2343 are identical. *Note that Freshwater Point, Victor Island and Round Top Island are located in water area HEV2385, where insufficient information is available to established WQO. As such, these values have been compared to HEV2383 WQO which are likely to be overly stringent for these more inshore sites. [1] Wet Season turbidity WQO applicable from November to April. [2] Dry Season turbidity WQO applicable from May to October.*

Parameter	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	WQO MD2341 MD2343	Freshwater Point*	Victor Island*	Round Top Island*	Keswick Island	WQO HEV2383
Pre Dredge 12 March 2019										
Temperature (°C)	27.5 ± 0.0	28.0 ± 0.0	27.5 ± 0.1	27.3 ± 0.0	-	27.2 ± 0.0	27.3 ± 0.0	27.4 ± 0.0	27.5 ± 0.0	-
Conductivity (mS/cm)	53.7 ± 0.0	53.1 ± 0.0	54.0 ± 0.1	54.3 ± 0.1	-	54.3 ± 0.0	54.2 ± 0.0	54 ± 0.1	54.8 ± 0.0	-
Dissolved Oxygen (% sat.)	100 ± 0	101 ± 0.0	99 ± 0	100 ± 0	95 – 105	98 ± 0	100 ± 0	100 ± 0	100 ± 0	95 – 105
pH	8.1 ± 0.0	8.0 ± 0.0	8.0 ± 0.0	8.0 ± 0.0	8.1 – 8.4	7.9 ± 0.0	7.9 ± 0.0	8.0 ± 0.0	8.1 ± 0.0	8.1 – 8.4
Turbidity (NTU)	1.3 ± 0.0	1.1 ± 0.1	3.7 ± 0.4	<1	33[1]	1.9 ± 0.1	1.5 ± 0.0	1.1 ± 0.0	<1	1
Kd	0.5 ± 0.1	0.6 ± 0.2	0.8 ± 0.0	0.2 ± 0.0	-	0.6 ± 0.0	0.6 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	-
Euphotic Depth (m)	9.2	7.7	5.9	26	-	7.1	8.2	19	23	-
Dredge - 9 & 10 April 2019										
Temperature (°C)	26.6 ± 0.0	26.7 ± 0.0	26.3 ± 0.0	26.6 ± 0.0	-	26.8 ± 0.0	26.3 ± 0.0	26.4 ± 0.0	26.9 ± 0.0	-
Conductivity (mS/cm)	53.9 ± 0.0	53.4 ± 0.0	54.1 ± 0.1	54.7 ± 0.0	-	54.2 ± 0.0	54.2 ± 0.0	54.0 ± 0.0	54.1 ± 0.0	-
Dissolved Oxygen (% sat.)	101 ± 0	100 ± 1	98 ± 0	100 ± 0.0	95 – 105	106 ± 2	99 ± 0	99 ± 0	99 ± 0	95 – 105
pH	8.0 ± 0.0	7.9 ± 0.0	8.1 ± 0.0	8.1 ± 0.0	8.1 – 8.4	8.1 ± 0.0	8.1 ± 0.0	8.1 ± 0.0	8.1 ± 0.0	8.1 – 8.4
Turbidity (NTU)	2.8 ± 0.0	2.8 ± 0.4	5.4 ± 1.1	1.3 ± 0.0	33[1]	2.2 ± 0.3	4.2 ± 0.1	1.7 ± 0.0	1.0 ± 0.0	1
Kd	0.5 ± 0.1	1.0 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	-	0.7 ± 0.0	1.4 ± 0.1	0.7 ± 0.0	0.1 ± 0.0	-
Euphotic Depth (m)	9.4	4.7	21	30	-	6.5	3.4	7.0	38	-
Dredge - 15 April 2019										
Temperature (°C)	-	-	-	-	-	-	25.8 ± 0.0	25.6 ± 0.0	-	-
Conductivity (mS/cm)	-	-	-	-	-	-	54.6 ± 0.0	54.7 ± 0.0	-	-
Dissolved Oxygen (% sat.)	-	-	-	-	95 – 105	-	101 ± 0	99 ± 0	-	95 – 105
pH	-	-	-	-	8.1 – 8.4	-	8.0 ± 0.0	8.0 ± 0.0	-	8.1 – 8.4

Parameter	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	WQO MD2341 MD2343	Freshwater Point*	Victor Island*	Round Top Island*	Keswick Island	WQO HEV2383
Turbidity (NTU)	-	-	-	-	33[1]	-	4.4 ± 0.2	5.4 ± 0.2	-	1
Post Dredge - 3 & 4 May 2019										
Temperature (°C)	24.9 ± 0.0	24.8 ± 0.0	24.9 ± 0.0	25.0 ± 0.0	-	24.9 ± 0.0	24.9 ± 0.0	25.0 ± 0.0	-	-
Conductivity (mS/cm)	53.8 ± 0.0	52.9 ± 0.0	54.4 ± 0.0	54.5 ± 0.0	-	54.4 ± 0.0	54.6 ± 0.0	54.1 ± 0.0	-	-
Dissolved Oxygen (% sat.)	99 ± 0	92 ± 0	99 ± 0	101 ± 0	95 – 105	100 ± 0	101 ± 0	102 ± 0	-	95 – 105
pH	8.2 ± 0.0	8.1 ± 0.0	8.2 ± 0.0	8.2 ± 0.0	8.1 – 8.4	8.1 ± 0.0	8.2 ± 0.0	8.2 ± 0.0	-	8.1 – 8.4
Turbidity (NTU)	2.9 ± 0.0	2.9 ± 0.1	9.8 ± 1.3	2.7 ± 0.1	8[2]	5.8 ± 0.1	3.2 ± 0.1	2.1 ± 0.0	-	1
Kd	0.4 ± 0.0	0.8 ± 0.0	1.5 ± 0.1	0.5 ± 0.1	-	1.0 ± 0.1	0.7 ± 0.1	0.5 ± 0.0	-	-
Euphotic Depth (m)	11	5.7	3.1	9.8	-	4.4	7.0	9.4	-	-
Post Dredge - 29 May 2019										
Temperature (°C)	23.2 ± 0.0	23.4 ± 0.1	23.1 ± 0.0	23.2 ± 0.0	-	22.9 ± 0.0	23.1 ± 0.0	23.2 ± 0.0	23.5 ± 0.0	-
Conductivity (mS/cm)	54.5 ± 0.0	54.3 ± 0.0	54.8 ± 0.0	54.7 ± 0.0	-	55.1 ± 0.0	55.0 ± 0.0	54.6 ± 0.0	54.3 ± 0.0	-
Dissolved Oxygen (% sat.)	102 ± 0	100 ± 0	101 ± 0	101 ± 0	95 – 105	101 ± 0.0	103 ± 0	101 ± 0	101 ± 0	95 – 105
pH	8.0 ± 0.0	7.9 ± 0.0	7.9 ± 0.0	7.9 ± 0.0	8.1 – 8.4	7.9 ± 0.0	7.9 ± 0.0	7.9 ± 0.0	8.0 ± 0.0	8.1 – 8.4
Turbidity (NTU)	<1	1.9 ± 0.1	1.3 ± 0.0	<1	8[2]	1.0 ± 0.0	<1	<1	<1	1
Kd	0.2 ± 0.0	0.5 ± 0.0	0.3 ± 0.0	0.2 ± 0.0	-	0.3 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.1	-
Euphotic Depth (m)	20	9.0	15	24		14	21	27	22	

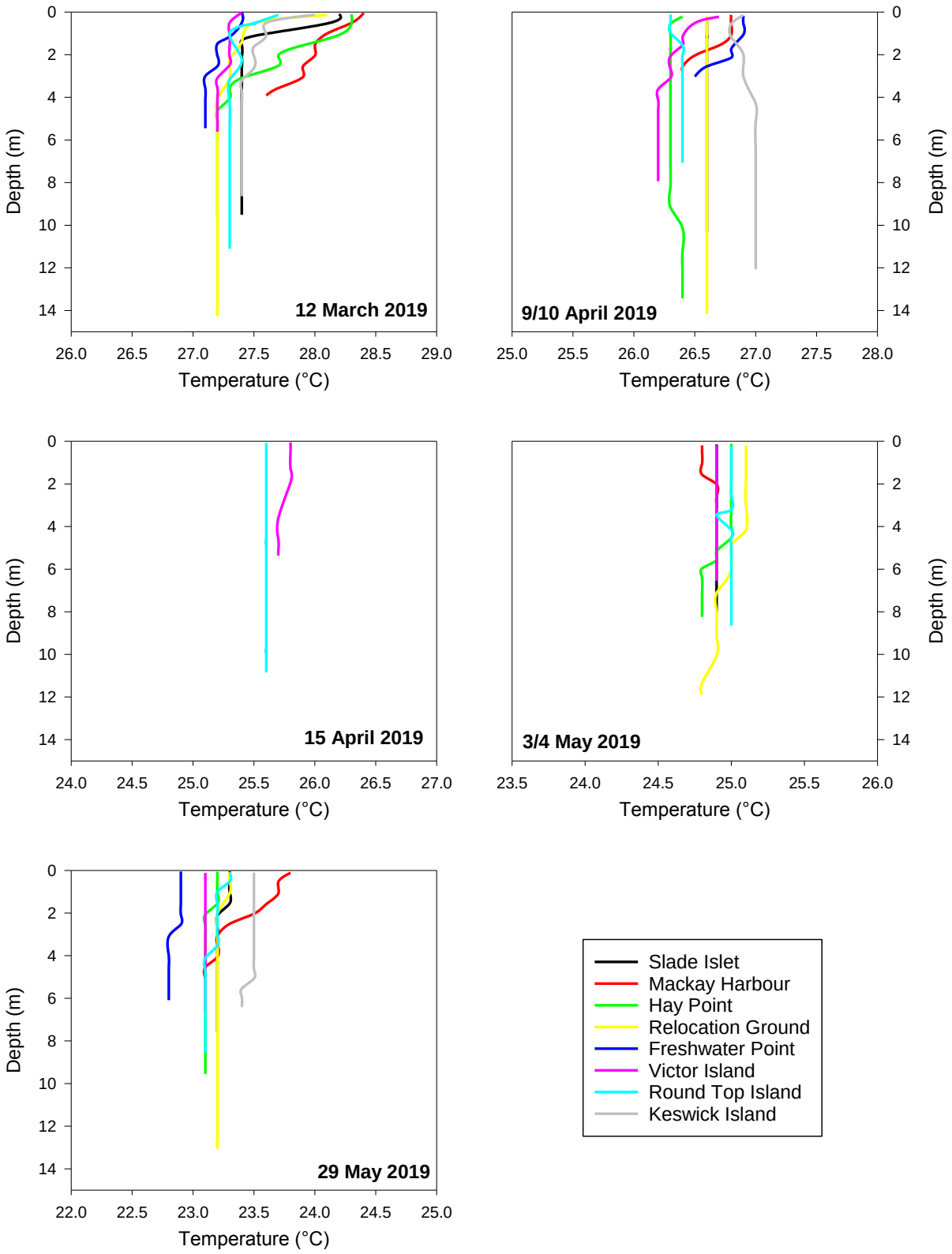

Figure 13 Depth-profiled temperature at water quality monitoring sites during Pre Dredge, Dredge and Post Dredge phases.
Note the varying scales on individual plots.

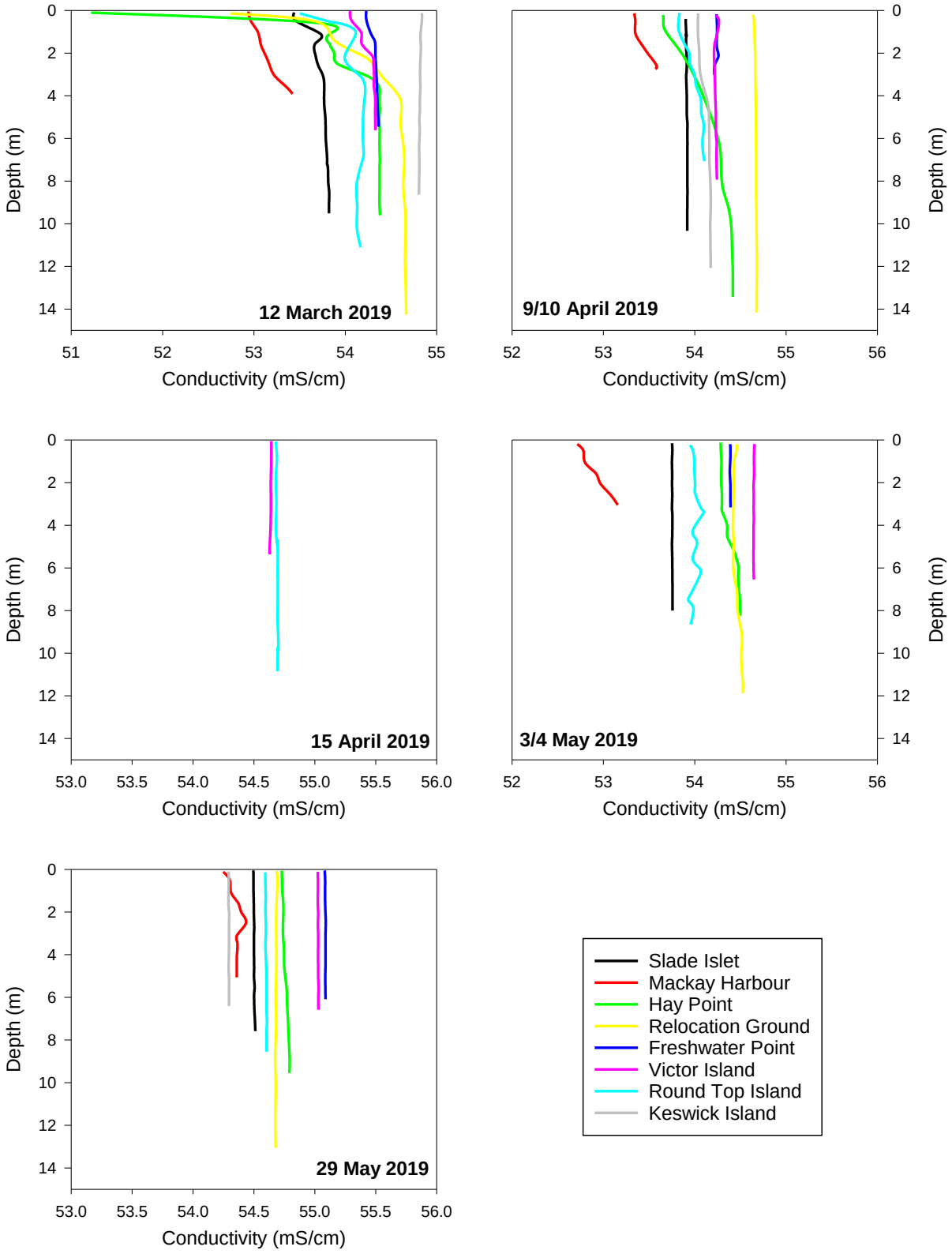

Figure 14 Depth-profiled conductivity at water quality monitoring sites during Pre Dredge, Dredge and Post Dredge phases.
Note the varying scales on individual plots.

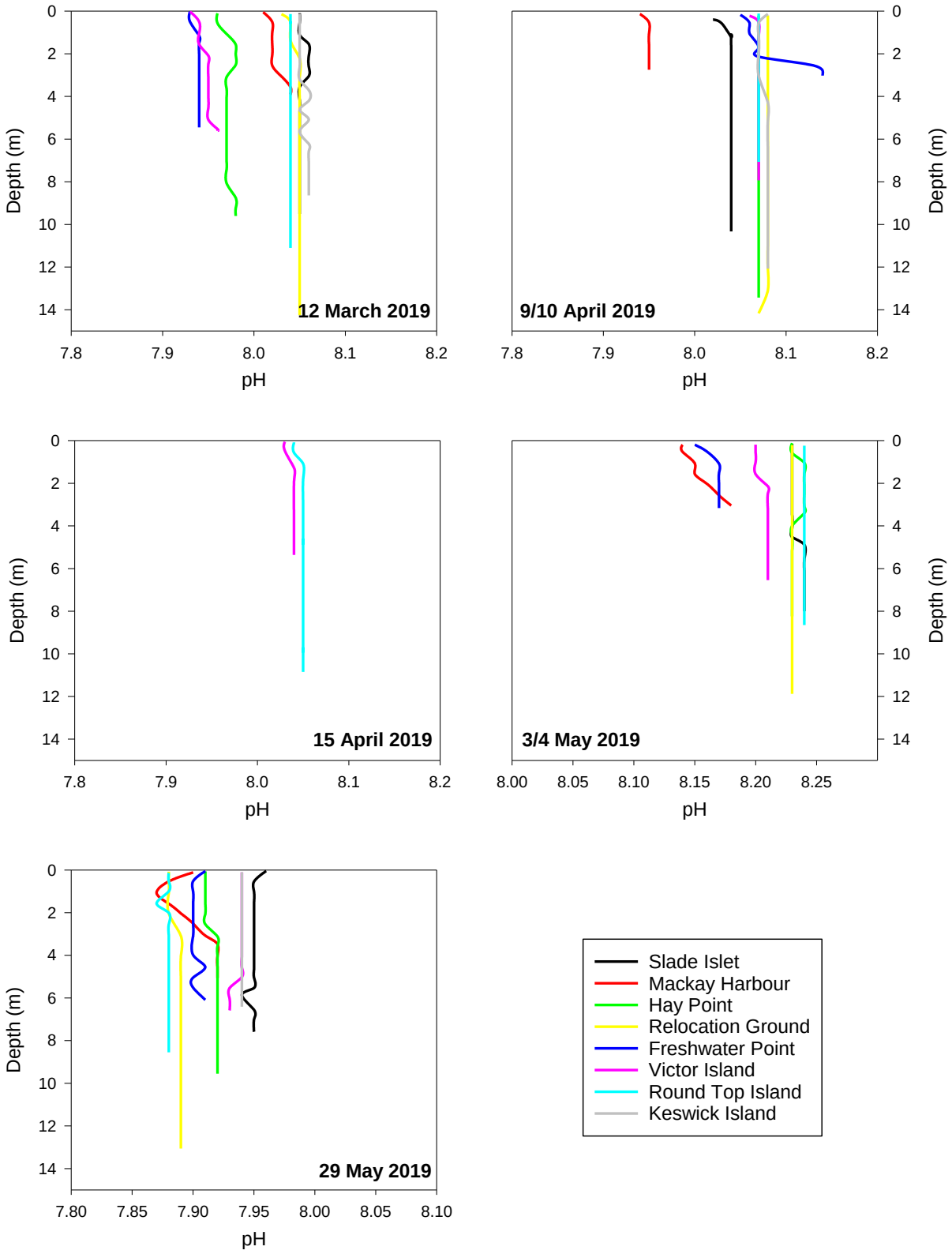

Figure 15 Depth-profiled pH at water quality monitoring sites during Pre Dredge, Dredge and Post Dredge phases.
Note the varying scales on individual plots.

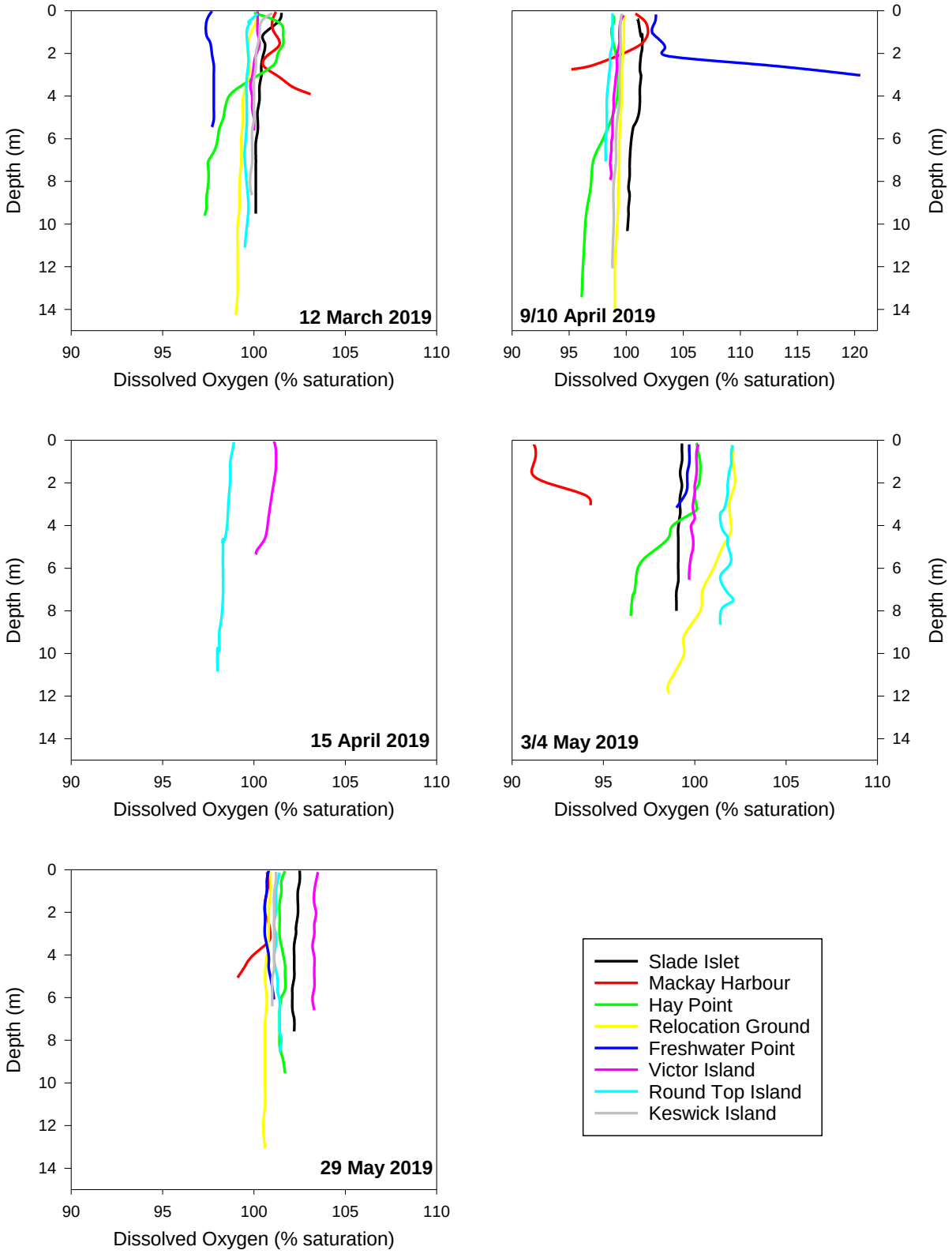

Figure 16 Depth-profiled dissolved oxygen at water quality monitoring sites during Pre Dredge, Dredge and Post Dredge phases.
Note the varying scales on individual plots.

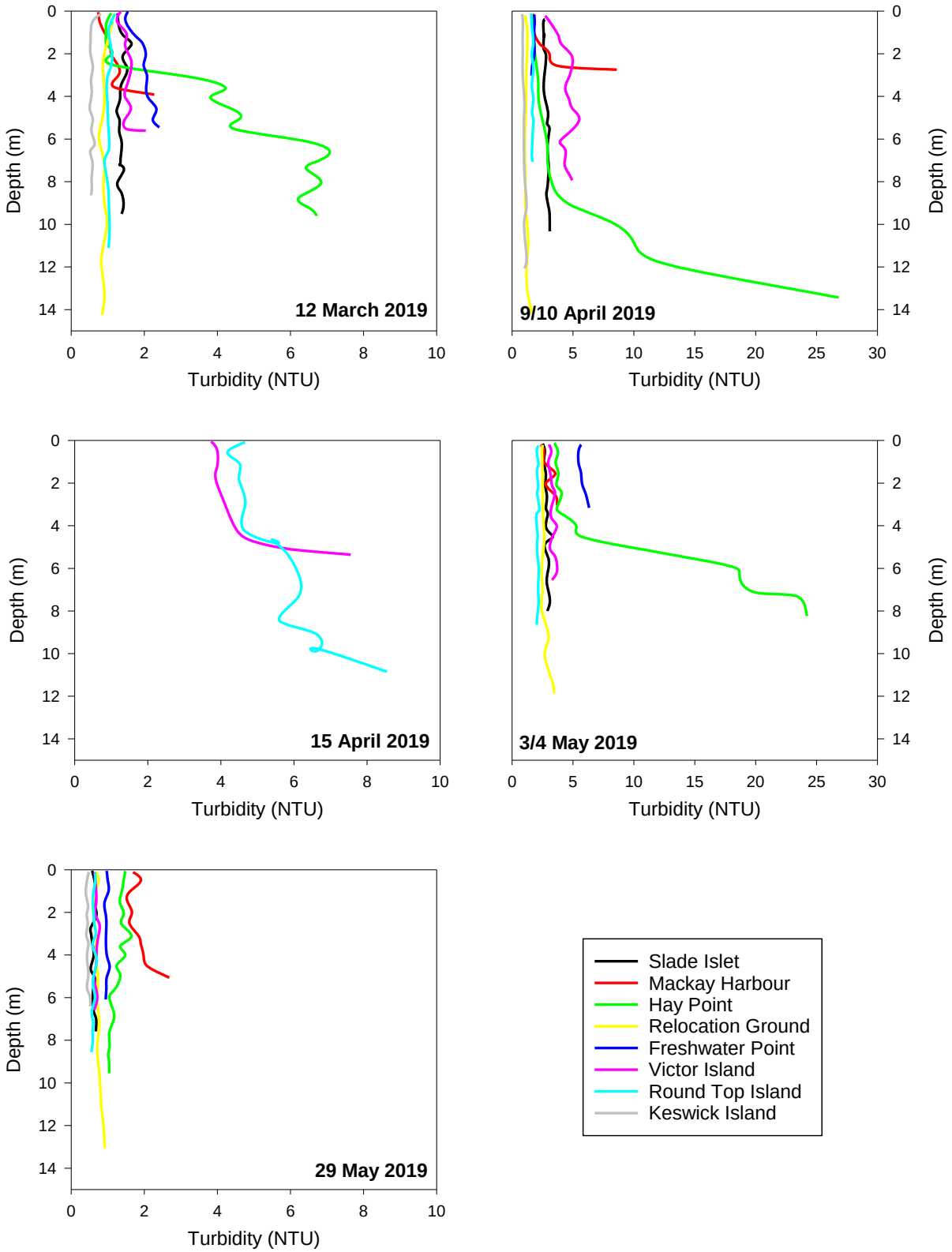

Figure 17 Depth-profiled turbidity at water quality monitoring sites during Pre Dredge, Dredge and Post Dredge phases.
Note the varying scales on individual plots.

Dissolved oxygen also remained reasonably consistent across sites and surveys, remaining within the recommended WQO range of 95 to 105% saturation. Of note, however, was the lower than typical DO values at Mackay Harbour (92% saturation) on 4 May (Figure 16), following the larger rain event. This is consistent with increased biological and chemical oxygen demand (BOD and COD) following rain events due to the breakdown of organic material such as detritus introduced through storm water run-off. Typically increases in BOD and COD are also associated with lower pH as was also recorded at Mackay Harbour on this occasion (Figure 15) and on 10 April. DO values remained consistent through the water column for most occasions with the exception of Freshwater Point on 10 April where dissolved oxygen increased from ~100% saturation on the surface to ~120% saturation at the benthos at 3 m depth. This is suggestive of increased photosynthetic activity from benthic organic matter such as benthic algae, which was prevalent at this shallow shoreline site. Warmer temperatures at this site on the 10 April would have been conducive to photosynthetic activity, which also resulted in increased benthic pH recorded at this site (Figure 15).

Depth-profiled turbidity remained below the applicable WQO at inshore sites during each survey except for Hay Point (9.8 NTU) which exceeded the Dry Season WQO of 8 NTU on 4 May. The WQO of 1 NTU was exceeded during most surveys at Freshwater Point (1.0 to 2.2 NTU), Victor Island (<1 to 4.4 NTU) and Round Top Island (<1 to 5.4 NTU). However, it must be noted that the WQO for open coastal waters zone (HEV2383) were used for comparison, which may be too stringent for these three sites which are located in the mid-estuary waters of HEV2385, where WQO have not yet been established due to insufficient information. The WQO for these sites was more stringent at 1 NTU, compared to 33 and 8 NTU for wet and dry seasons, respectively, for remaining sites.

Turbidity values generally remained consistent with depth except for Hay Point, where benthic turbidity was generally more than triple the surface turbidity during three of the four surveys where it was recorded (Figure 17). Typically, an increasing gradient of turbidity was recorded through the profile rather than localised benthic resuspension. This was also observed at Round Top Island on 15 April.

Light attenuation rate (K_d, the rate at which light or PAR diminishes with depth through the water column) and resultant euphotic depth (the depth to which net photosynthesis can occur/where light levels are ~1% of those at the surface) were also calculated (Table 8). Highest euphotic depths were calculated for all sites during the 29 May Post Dredge survey, with euphotic depths during remaining surveys (Table 8) being similar. The shallowest euphotic depths were typically recorded at MacKay Harbour and Hay Point, which reflects the typically higher levels of turbidity experienced at these sites (Table 8). The deepest euphotic depth values were calculated at the offshore sites of Keswick Island (22 to 38 m) and the Relocation Ground (9.8 to 24 m), where turbidity in the surface and water column was generally low (Table 8).

3.6 Water Analysis

Water sampling was conducted for nutrients, dissolved metals and organics on one occasion each during the Pre Dredge (12 March), Dredge (9/10 April) and Post Dredge (30 May) phases (refer Tables 9 and 10 for nutrients and metals). Organic results can be found in the Appendix (Table 13) along with a summary of QA/QC across the three surveys.

3.6.1 Nutrients

During the Pre Dredge survey, total phosphorus remained below laboratory limits of reporting (LOR) at all eight sites (Table 9). During the Dredge phase, values ranged from <5 to 15 µg/L, with highest values recorded in Mackay Harbour. However, all values remained below their applicable WQO. During the Post Dredge phase, detectable concentrations (12 µg/L) were recorded only at Mackay Harbour, with remaining sites <5 µg/L.

A similar pattern was evident for filterable reactive phosphorus, the readily bioavailable phosphorus fraction (Table 9). Concentrations during Pre and Post Dredge were < LOR (1 µg/L). During the Dredge phase, concentrations ranged from <1 µg/L at Keswick Island and the Relocation Ground, to 7 µg/L at Mackay Harbour, which exceeded the applicable WQO of 5 µg/L.

Total nitrogen was also recorded at similar values at monitoring sites during the Pre Dredge (90 to 141 µg/L), Dredge (77 to 135 µg/L) and Post Dredge (76 to 138 µg/L) phases. Highest nitrogen was typically found at Mackay Harbour (135 to 139 µg/L), while lowest values were generally evident at Keswick Island (76 to 103 µg/L). Of note was the higher value recorded at Hay Point during Pre Dredge (141 µg/L) compared to subsequent surveys (78 to 81 µg/L).

Pre Dredge total nitrogen values at Round Top Island (130 µg/L) exceeded the applicable WQO of 115 µg/L. However, it must be noted that the WQO for open coastal waters zone (HEV2383) were used for comparison, which may be too stringent for Round Top Island which is located in the mid-estuary waters of HEV2385, where WQO have not been able to be established due to insufficient information.

Total nitrogen and total kjeldahl nitrogen (TKN) were found at identical values at each site except Mackay Harbour, indicating that the majority of nitrogen at most sites was in an organic and less bioavailable form. At Mackay Harbour, the readily bioavailable inorganic form of nitrogen oxides (NOx - nitrate and nitrite) was detected at concentrations exceeding the applicable WQO (10 µg/L) during each survey (15 to 24 µg/L). NOx was generally < LOR at other sites during each survey, with the exception of the Relocation Ground and Round Top Island (7 to 8 µg/L) during the Pre Dredge survey. Ammonia concentrations remained <LOR at each site during each survey.

Chlorophyll *a* concentrations provide an indication of algal biomass within the water column. Microalgal populations respond to increased availability of nutrients in addition to increased temperature and light (Popovich and Marcovecchio, 2008). As the water temperature decreased with each subsequent survey, chlorophyll *a* concentrations also exhibited a decrease: Pre Dredge 0.44 to 0.85 µg/L; Dredge: 0.31 to 0.93 µg/L; and Post Dredge: 0.08 to 0.3 µg/L. Exceedances of applicable WQO (0.45 µg/L) were evident only at Victor Island and Round Top Island during the Pre Dredge and Dredge phases, and at Keswick Island during the Pre Dredge phase only.

Table 9 Nutrient concentrations during Pre Dredge (12 March 2019), Dredge (9 & 10 April 2019) and Post Dredge (30 May 2019) monitoring.
*N = 1. The WQO for individual water areas as per EHP (2013) is provided for comparison. Field values highlighted when above WQO. *Note that Freshwater Point, Victor Island and Round Top Island are located in water area HEV2385, where insufficient information is available to established WQO. As such, these values have been compared to HEV2385 WQO which are likely to be overly stringent for these more inshore sites.*

Nutrient (µg/L)	Slade Islet	Mackay Harbour	WQO MD2341	Hay Point	Relocation Ground	WQO MD2343	Freshwater Point*	Victor Island*	Round Top Island*	Keswick Island	WQO HEV2383
Pre Dredge 12 March 2019											
Phosphorus	<5	<5	20	<5	<5	20	<5	<5	<5	<5	15
FRP	<1	<1	5	<1	<1	5	<1	<1	<1	<1	3
Nitrogen	110	139	160	141	112	160	101	111	130	98	115
TKN	110	124	-	141	105	-	101	111	122	98	-
Ammonia	<10	<10	15	<10	<10	15	<10	<10	<10	<10	9
NOx	<2	15	10	<2	7	10	<2	<2	8	<2	3
Chlorophyll a	0.48	0.81	2	0.5	0.49	2	0.44	0.58	0.49	0.85	0.45
Dredge 9 & 10 April 2019											
Phosphorus	7	15	20	6	<5	20	10	5	<5	<5	15
FRP	3	7	5	3	<1	5	3	2	3	<1	3
Nitrogen	106	135	160	81	77	160	98	96	98	103	115
TKN	106	117	-	81	77	-	98	96	98	103	-
Ammonia	<5	<5	15	<5	<5	15	<5	<5	<5	<5	9
NOx	<2	18	10	<2	<2	10	<2	<2	<2	<2	3
Chlorophyll a	0.59	0.93	2	0.53	0.52	2	0.44	0.61	0.57	0.31	0.45
Post Dredge 30 May 2019											
Phosphorus	<5	12	20	<5	<5	20	<5	<5	<5	<5	15
FRP	<1	<1	5	<1	<1	5	<1	<1	<1	<1	3
Nitrogen	98	138	160	78	85	160	88	86	107	76	115
TKN	98	114	-	78	85	-	88	86	107	76	-
Ammonia	<15	<15	15	<15	<15	15	<15	<15	<15	<15	9
NOx	<2	24	10	<2	<2	10	<2	<2	<2	<2	3
Chlorophyll a	0.3	0.15	2	0.23	0.3	2	0.3	0.09	0.2	0.08	0.45

3.6.2 Dissolved Metals

A number of dissolved metals were ≤ LOR at each site during each of the three surveys, including cadmium, cobalt and lead (<0.2 µg/L), chromium and nickel (<0.5 µg/L), mercury (<0.04 µg/L) and zinc (<5 µg/L, Table 10).

Dissolved arsenic was the only metal to be detected across all sites during each survey with similar concentrations across the sites and surveys, ranging from 1.4 to 1.8 µg/L. Dissolved aluminium concentrations were <LOR (5 µg/L) during the Pre Dredge and Dredge surveys, but were detected at Slade Islet, Mackay Harbour and Hay Point (6 to 17 µg/L) during the Post Dredge survey. Concentrations remained below the 95% species protection AWQG of 24 µg/L. In contrast dissolved iron was detected during the Pre Dredge survey at the Relocation ground, Victor Island, Round Top Island and Keswick Island (6 to 9 µg/L) but remained <LOR (5 µg/L) at all other sites, and during the Dredge and Post Dredge surveys (Table 10).

Dissolved copper exceeded the 95% species protection AWQG of 1.3 µg/L at Mackay Harbour during the Pre Dredge survey (2 µg/L). Concentrations of 1 µg/L were recorded at the same site during the Dredge and Post Dredge surveys, while concentrations at all other sites during the three surveys remained <LOR (1 µg/L).

3.6.3 Organics

Approximately 87 multiresidue pesticides were examined at each site during each survey. Concentrations were < LOR for all analytes, with the exception of diuron (0.05 µg/L) at Mackay Harbour, and diuron (0.03 µg/L) and atrazine (0.02 µg/L) at Hay Point during the Pre Dredge survey (Table 13 in Appendix). Concentrations of these analytes were < LOR in subsequent surveys. Concentrations were well below the marine low reliability trigger values of 1.8 µg/L for diuron and 13 µg/L for atrazine (ANZG, 2018).

3.7 Altimeter

Dual altimeters were deployed at Round Top Island for the duration of the monitoring period to measure sedimentation rates. As with all multiple instrument deployments, the second or subsequent instruments act as validation tools. Despite each altimeter measuring a different location on the seafloor, being positioned 1.5 m apart on the deployment frame (Figure 4), generally the instruments will measure within an acceptable range of each other and therefore the mean value of the combined instruments can be utilised.

This was the case for the dual altimeters at Round Top Island for the majority of the Pre Dredge period (Figure 18). Bed level for both altimeters was similar up until 25 March when benthic turbidity began to rise leading into a significant and persistent wind speed event. Daily average wind speed from 30 March to the 10 April exceeded 20 kts and maximum benthic turbidity of 56 NTU was recorded at Round Top Island on 5 April. Benthic turbidity exceeded the intensity threshold throughout this period (Figure 18).

Table 10 Dissolved metal concentrations during Pre Dredge (12 March 2019), Dredge (9 & 10 April 2019) and Post Dredge (30 May 2019) monitoring.
*N = 1. 95% species protection AWQG trigger values listed for comparison (ANZG, 2018). Field values highlighted when exceeding WQO. * 95% value for CrIII species.*

Dissolved Metal (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island	95% AWQG
Pre Dredge 12 March 2019									
Aluminium	<5	<5	<5	<5	<5	<5	<5	<5	24
Arsenic	1.4	1.6	1.4	1.4	1.5	1.6	1.8	1.5	-
Cadmium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	5.5
Chromium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.4*
Cobalt	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1
Copper	<1	2	<1	<1	<1	<1	<1	<1	1.3
Iron	<5	<5	<5	6	<5	9	6	8	-
Lead	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	4.4
Mercury	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.4
Nickel	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	70
Zinc	<5	<5	<5	<5	<5	<5	<5	<5	15
Dredge 9 & 10 April 2019									
Aluminium	<5	<5	<5	<5	<5	<5	<5	<5	24
Arsenic	1.4	1.8	1.4	1.5	1.5	1.4	1.5	1.6	-
Cadmium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	5.5
Chromium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.4*
Cobalt	0.2	0.2	0.2	0.2	<0.2	0.2	<0.2	<0.2	1
Copper	<1	1	<1	<1	<1	<1	<1	<1	1.3
Iron	<5	<5	<5	<5	<5	<5	<5	<5	-
Lead	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	4.4
Mercury	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.4
Nickel	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	70
Zinc	<5	<5	<5	<5	<5	<5	<5	<5	15
Post Dredge 30 May 2019									

Dissolved Metal (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island	95% AWQG
Aluminium	14	17	6	<5	<5	<5	<5	<5	24
Arsenic	1.6	1.6	1.6	1.5	1.4	1.7	1.6	1.7	-
Cadmium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	5.5
Chromium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.4*
Cobalt	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1
Copper	<1	1	<1	<1	<1	<1	<1	<1	1.3
Iron	<5	<5	<5	<5	<5	<5	<5	<5	-
Lead	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	4.4
Mercury	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.4
Nickel	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	70
Zinc	<5	<5	<5	<5	<5	<5	<5	<5	15

Although sediment flux remained consistent from this point for both altimeters, bed level recorded by each altimeter digressed. Bed level at altimeter 2 remained fairly stable for the entire monitoring period. However, the strong wind event from the 30 March resulted in rapid erosion of the bed level (-24 mm) at the altimeter 1 location from 2 to 8 April. A second period of erosion (-20 mm) also occurred at this location from 17 to 21 April following a subsequent period of elevated benthic turbidity associated with increased wind speeds. Some recovery was evident with slight deposition being recorded (~ 6mm), which may have been associated with the large rain event and river flows from 22 to 25 April, introducing new sediments. From this point bed level at the altimeter 1 location remained fairly stable for the remainder of the monitoring period, in a similar trend to altimeter 2 (Figure 18).

During the Pre Dredge and Post Dredge periods the difference in bed level changes between the two altimeters was 13.7 and 7.2 mm, respectively (Table 11). However, during the Dredge phase there was a 77 mm difference in overall bed level change between the two altimeters. The substrate at this location could be classified as a combination of sand and rubble (Figure 4), with the rubble littering the seafloor being made up of broken coral fragments, likely as a legacy of previous tropical cyclones. Rolling rubble dispersed during high wind speed events can be problematic when using echo measurements, as the harder substrate transiting past the sonar will cause interference with the echo return. It is likely that this has occurred at the altimeter 1 location but these may not necessarily be considered erroneous readings.

Table 11 Net Bed Level Change statistics from data collected from dual altimeters deployed at Round Top Island during monitoring program.

Dredge Phase	Net bed level change (mm)		
	Altimeter 1	**Altimeter 2**	**Mean of Altimeters**
Pre Dredge	+10	-3.7	+3.2
Dredge	-52	+15	-19
Post Dredge	-5.8	+1.4	-2.2
Total	-47.8	+12.7	-18

Overall for altimeter 2, slight deposition was recorded over the monitoring period with the majority occurring during the dredge period (+15 mm) particularly during the high wind speed event in early April and during the rain/flow event from 22 April. Discounting the significant period of erosion (-52 mm) during the Dredge phase, altimeter 1 also resulted in slight deposition for the monitoring period. Overall bed level change for the monitoring period would be considered minor.

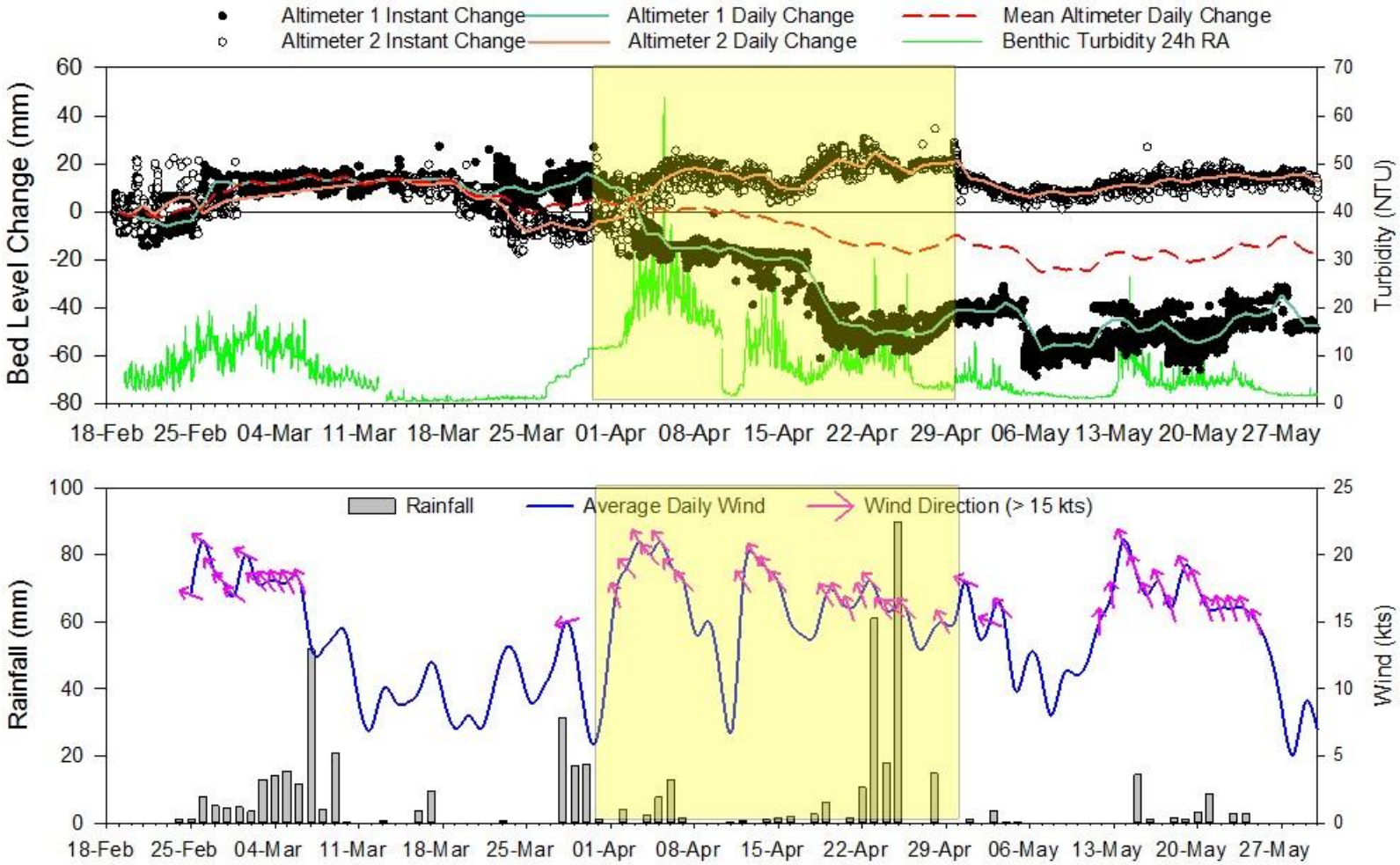

Figure 18 Instantaneous and daily averaged bed level change at Round Top Island during Pre Dredge, Dredge and Post Dredge compared to ambient benthic turbidity (24 hour rolling average), rainfall, wind speed and direction.
Yellow shaded area indicates dredge period. Arrows indicate the direction of travel for winds greater than 15 knots.

4 SUMMARY

Maintenance dredging at Hay Point, Queensland was undertaken by NQBP for a 33-day period from 31 March to 2 May 2019. Approximately 353,740 m^2 of material was removed by the Brisbane Dredge from the departure channel and associated berths and relocated to the DMPA during this period. Water quality undertaken by VE was guided by the MEMP and included periods of monitoring during the Pre Dredge (17/18 February to 31 March) and Post Dredge (3 May to 30 May) phases.

Monitoring included real time surface measurements of water quality (every 10 min) at two trigger sites (Round Top Island and Victor Island) and two control sites (Slade Islet and Freshwater Point). In addition, benthic water quality was logged at the two trigger sites and manual water quality sampling was undertaken at the four telemetered sites in addition to four support sites. Altimeters were also installed on the benthos at Round Top Island to measure sedimentation rates.

Trigger values (IDF) were applied to real time surface turbidity data at the two trigger sites during dredging, from which dredge management would be enacted. The intensity and duration thresholds if exceeded would trigger a series of management zones (A – normal operations to D – cease dredging), at which various levels of investigation and mitigation would be implemented in order to manage dredge operations. Manual sampling results were also compared to relevant WQO that are applicable to this region.

During dredge operations, surface turbidity at all four monitoring locations remained in Management Zone A and therefore did not exceed their respective intensity thresholds for longer than the allowable 77 h of duration. This was despite some severe weather events occurring during dredging with average daily wind speeds exceeding 15 kts for 63% of the dredging period, compared to only 29% of occasions during Pre Dredge.

Although benthic turbidity at Victor Island also remained within Management Zone A during dredge operations, benthic turbidity at Round Top Island reached Management Zone C by exceeding the intensity threshold for 217 hours. Most of the cumulative exceedances occurred from the 31 March to 10 April during the strongest weather event of the monitoring program, when average wind speeds of greater than 20 kts were persistently recorded and turbidity at this site reached a maximum of 98 NTU. Note that real time management of the dredge was reliant on real time surface turbidity, and Management Zone D (cease dredge operations) was never reached at any location during the dredging period.

Although remaining sites exceeded intensity thresholds on many occasions during the Dredge phase, none of the locations exceeded the allowable hours for Management Zone A. Slade Islet, a control site, had the highest number of threshold exceedances, followed by Round Top Island surface and Freshwater Point control site (ranging from 63 h down to 54 h). In contrast the Victor Island trigger site exceeded thresholds for no more than 7 h during dredging for surface and benthic. Although trigger values were only applicable to the Dredge phase, all sites exceeded their respective intensity thresholds during one or more of the other dredging phases, particularly during Pre Dredge when wind speeds were consistently above 15 kts for almost a 12-day period, potentially influenced by ex-Tropical Cyclone Oma.

Turbidity at all sites and locations responded similarly to increased wind speeds, which propagated mostly from a southerly (including south easterly and south westerly) direction, rather than to tidal conditions or rainfall. However, large flow events from the Pioneer River and Sandy Creek following heavy rainfall appeared to generate short lived surface turbidity

peaks at nearby monitoring site locations. The peaks were not detected at benthic monitoring stations suggesting the turbidity plume was localised to the surface.

Several additional parameters were measured continuously at both the surface and benthic stations. Temperature over the monitoring period declined with seasonal cooling and despite some significant rain events, the pH remained fairly consistent across the monitoring period. In contrast surface conductivity at the three sites closest to the estuarine discharges was very responsive to flow events with conductivity rapidly dropping as a result of freshwater inundation. In contrast benthic conductivity remained consistent due to the less dense freshwater remaining close to the surface. Dissolved oxygen demonstrated typical diurnal patterns associated with photosynthetic activity generated by phytoplankton and algae concentrated in the surface waters. Increased oxygen production was temperature dependent and more noticeable at the shallower site of Freshwater Point, where WQO were exceeded on a number of occasions.

Depth profiling through the water column was carried out at the four trigger/control sites, in addition to four support sites during all phases of the monitoring project and typically mirrored the results of the real time surface monitoring. Although fortnightly monitoring was proposed during the dredge phase, this could not be achieved due to persistent adverse weather conditions. Generally, parameters were consistent down the profile at all locations except for Mackay Harbour, the most inshore site which often displayed profile gradients and results dissimilar to the more oceanic locations, as would be expected. This site displayed lower DO (outside the WQO range) after the major rain event in late April, most likely due to consumption of oxygen as a result of increased BOD and COD, due to storm water run-off. Surface layers of freshwater were also detected at some sites when sampled soon after a rain event. Increased benthic DO at Freshwater Point (exceeding the WQO) was suggestive of increased benthic photosynthetic activity potentially produced by benthic algae at this shallow coastal site.

Turbidity through the water column was also consistent at most locations on most sampling occasions. The exception was Hay Point, which typically displayed an increasing gradient of turbidity as opposed to localised benthic resuspension, on three of the four monitoring occasions. The WQO for turbidity were exceeded at Hay Point on one occasion. There is currently insufficient information to establish localised WQO for Freshwater Point, Victor Island and Round Top Island and therefore by default, the more stringent and not necessarily appropriate HEV2383 WQO were applied to these sites. Not surprisingly, these sites exceeded the turbidity WQO (1 NTU) on all occasions. Several sites were also outside the WQO range for pH during all phases of the monitoring program, including Keswick Island.

Nutrients, dissolved metals and organics were measured during all phases of the project. Nutrient concentrations were relatively low across the monitoring period with occasional exceedances of WQO of selected forms of nutrients at Mackay Harbour, Round Top and Victor Islands which occurred both during Pre Dredge and Dredge phases, with Mackay Harbour also exceeding during the Post Dredge phase. Note that once again the WQO applied to Victor and Round Top Islands may be overly stringent for these sites. Chlorophyll *a*, a measure of algal biomass, also exceeded WQO at three sites including Keswick Island during Pre and Dredge phases. There appeared to be little relationship between nutrient concentrations and the relevant dredge phases during the monitoring program.

Metal concentrations measured during the monitoring program were both low and unremarkable. Most concentrations were below LOR and all concentrations during all phases

were below the AWQG. The exception was an exceedance of dissolved copper at Mackay Harbour during Pre Dredge. Of the 87 multiresidue pesticides measured during all three dredge phases, only two were detected above LOR during Pre Dredge. None of the concentrations were above the AWQG.

The dual altimeters used to measure sedimentation rates at Round Top Island provided interesting results over the monitoring program. Typically, due to the two altimeters trending similarly, the mean of the two instruments is calculated in a similar manner to the water quality sondes. However, during the major weather event towards the end of March the two altimeter readings began to digress. This has been attributed to the substrate at this location being a combination of sand and coral rubble, the latter of which is known to roll across the seabed during high energy events. It is likely that the rubble has interfered with the readings at one of the altimeter locations.

Both altimeters tracked well during both the Pre and Post Dredge phases, recording slight deposition associated with wind speed and flow events. This trend was also evident for one altimeter during the Dredge phase however the alternate altimeter recorded significant erosion, mainly during the two major large wind speed events. In summary, it is likely that there has been little change in bed level at this site across all dredge phases.

Overall it appears that dredging had little impact on turbidity or additional sampled parameters during the Dredge phase. Although mean turbidity was generally more elevated during the Dredge phase at all sites and locations compared to Pre and Post Dredge, wind speeds which are conducive to increasing turbidity, were also more extreme during this phase. Periods of elevated turbidity during all phases of the monitoring period were directly related to increases in wind speed, and on occasions river flows. Apart from the Round Top Island benthic location, for which the mean turbidity during dredging exceeded the intensity threshold, the highest number of exceedances were recorded at the Slade Islet control site with the Victor Island trigger site recording the lowest number of exceedances. Thresholds were based on a three-year data set of historical ambient monitoring and therefore should be reflective of natural historical conditions at these sites.

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6 Appendix

6.1 Monitoring Sites

Table 12 Location of water quality monitoring sites in decimal degrees (WGS84).

Site	GPS location
Round Top Island	-21.1731° S, 149.2600° E
Victor Island	-21.3176° S, 149.3128° E
Slade Islet	-21.0927° S, 149.2411° E
Freshwater Point	-21.4148° S, 149.3360° E
Hay Point/Reef	-21.2600° S, 149.3000° E
Relocation Ground	-21.1800° S, 149.3000° E
Mackay Harbour	-21.1100° S, 149.2200° E
Keswick Island	-20.9300° S, 149.4200° E

Table 13 Organics concentrations during Pre Dredge (12 March 2019), Dredge (9 & 10 April 2019) and Post Dredge (30 May 2019) monitoring. *N = 1.*

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Pre Dredge 12 March 2019								
Azinphos-methyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Azinphos-ethyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Bromophos-ethyl	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Carbofenothion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorfenvinphos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorpyrifos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorpyrifos-methyl	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Coumaphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Demeton-O & S	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Demeton-S-methyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Diazinon	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dichlorvos	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dimethoate	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Disulfoton	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
EPN	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ethoprophos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenamiphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenchlorphos (Ronnel)	<10	<10	<10	<10	<10	<10	<10	<10
Fenitrothion	<2	<2	<2	<2	<2	<2	<2	<2
Fensulfothion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenthion	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Malathion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mevinphos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Monocrotophos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Omethoate	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Parathion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Parathion-methyl	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Phorate	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pirimiphos-ethyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pirimiphos-methyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Profenofos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Prothiofos	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfotep	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sulprofos	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Temephos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Terbufos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tetrachlorvinphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Triazophos	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Trichlorfon	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Trichloronate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aldicarb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Bendiocarb	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Benomyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbaryl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbofuran	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Hydroxy Carbofuran	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Methiocarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methomyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molinate	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Oxamyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Thiobencarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thiodicarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pendimethalin	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Trifluralin	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Hexazinone	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Metribuzin	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cyproconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Difenoconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Flusilazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Hexaconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Paclobutrazole	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Penconazole	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propiconazole	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Tebuconazole	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyprodinil	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrimethanil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Diuron	<0.02	0.05	0.03	<0.02	<0.02	<0.02	<0.02	<0.02
Fluometuron	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tebuthiuron	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Bromacil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorsulfuron	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Metolachlor	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ametryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atrazine	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanazine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cyromazine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Prometryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Propazine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Simazine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Terbuthylazine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Terbutryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Diclofop-methyl	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fenarimol	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Irgarol	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Oxyfluorfen	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Thiamethoxam	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Imidacloprid	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dredge 9 & 10 April 2019								
Azinphos-methyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Azinphos-ethyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Bromophos-ethyl	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Carbofenothion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorfenvinphos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorpyrifos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorpyrifos-methyl	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Coumaphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Demeton-O & S	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Demeton-S-methyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Diazinon	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dichlorvos	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dimethoate	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Disulfoton	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
EPN	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Ethoprophos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenamiphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenchlorphos (Ronnel)	<10	<10	<10	<10	<10	<10	<10	<10
Fenitrothion	<2	<2	<2	<2	<2	<2	<2	<2
Fensulfothion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenthion	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Malathion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mevinphos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Monocrotophos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Omethoate	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Parathion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Parathion-methyl	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Phorate	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pirimiphos-ethyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pirimiphos-methyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Profenofos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Prothiofos	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfotep	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sulprofos	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Temephos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Terbufos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tetrachlorvinphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Triazophos	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Trichlorfon	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Trichloronate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aldicarb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Bendiocarb	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Benomyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbaryl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbofuran	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Hydroxy Carbofuran	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Methiocarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methomyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molinate	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Oxamyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thiobencarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thiodicarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pendimethalin	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Trifluralin	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Hexazinone	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Metribuzin	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cyproconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Difenoconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Flusilazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Hexaconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Paclobutrazole	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Penconazole	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propiconazole	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Tebuconazole	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyprodinil	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrimethanil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Diuron	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluometuron	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tebuthiuron	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Bromacil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorsulfuron	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Metolachlor	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ametryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atrazine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanazine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cyromazine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Prometryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propazine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Simazine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Terbuthylazine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Terbutryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Diclofop-methyl	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fenarimol	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Irgarol	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Oxyfluorfen	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Thiamethoxam	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Imidacloprid	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Post Dredge 30 May 2019								
Azinphos-methyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Azinphos-ethyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Bromophos-ethyl	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Carbofenothion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorfenvinphos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorpyrifos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorpyrifos-methyl	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Coumaphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Demeton-O & S	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Demeton-S-methyl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Diazinon	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dichlorvos	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dimethoate	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Disulfoton	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
EPN	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ethoprophos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenamiphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenchlorphos (Ronnel)	<10	<10	<10	<10	<10	<10	<10	<10
Fenitrothion	<2	<2	<2	<2	<2	<2	<2	<2
Fensulfothion	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fenthion	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Malathion	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mevinphos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Monocrotophos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Omethoate	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Parathion	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Parathion-methyl	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Phorate	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pirimiphos-ethyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pirimiphos-methyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Profenofos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Prothiofos	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfotep	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sulprofos	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Temephos	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Terbufos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tetrachlorvinphos	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Triazophos	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Trichlorfon	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Trichloronate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aldicarb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Bendiocarb	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Benomyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbaryl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Carbofuran	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-Hydroxy Carbofuran	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Methiocarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Methomyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molinate	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Oxamyl	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thiobencarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thiodicarb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pendimethalin	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Trifluralin	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Hexazinone	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Metribuzin	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cyproconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Difenoconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Flusilazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Hexaconazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Paclobutrazole	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Organics (µg/L)	Slade Islet	Mackay Harbour	Hay Point	Relocation Ground	Freshwater Point	Victor Island	Round Top Island	Keswick Island
Penconazole	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propiconazole	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Tebuconazole	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyprodinil	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrimethanil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Diuron	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluometuron	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tebuthiuron	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Bromacil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chlorsulfuron	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Metolachlor	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ametryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atrazine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanazine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cyromazine	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Prometryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propazine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Simazine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Terbuthylazine	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Terbutryn	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Diclofop-methyl	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fenarimol	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Irgarol	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Oxyfluorfen	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Thiamethoxam	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Imidacloprid	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

6.2 Quality Assurance/Quality Control

6.2.1 Pre Dredge Sampling 12 March 2019

Samples sent to ALS were analysed within recommended holding periods (Table 13). ALS laboratory blanks were all below detection limits, and acceptable differences (Relative Percent Difference, or RPD) were found between laboratory duplicates (split samples). Acceptable recovery was recorded in the laboratory control spikes. VE field and lab blank concentrations were below LOR (Table 14), with minimal RPD (≤ 13 %) between duplicate samples.

Table 14 Summary of ALS QA/QC data during Pre Dredge sampling 12 March 2019.

Report of analysis number	EB1906279
Date Samples Analysed	Acceptable
Method blank concentrations	Acceptable
RPD Laboratory duplicates	Acceptable
Recovery from laboratory control sample	Acceptable
Recovery from matrix spike samples	Acceptable

Table 15 Summary of VE quality control data during Pre Dredge sampling 12 March 2019.
ND = not determined as one or more samples was below LOR.

Parameter (µg/L)	VE Field Blank	VE Lab Blank	Replicate		Variation %
			HP-A	HP-B	
Dissolved Aluminium	<5	<5	<5	<5	ND
Dissolved Arsenic	<0.2	<0.2	1.4	1.6	13%
Dissolved Cadmium	<0.05	<0.05	<0.2	<0.2	ND
Dissolved Chromium	<0.2	<0.2	<0.5	<0.5	ND
Dissolved Cobalt	<0.1	<0.1	<0.2	<0.2	ND
Dissolved Copper	<0.5	<0.5	<1	<1	ND
Dissolved Iron	<2	<2	<5	<5	ND
Dissolved Lead	<0.1	<0.1	<0.2	<0.2	ND
Dissolved Mercury	<0.00004	<0.00004	<0.00004	<0.00004	ND
Dissolved Nickel	<0.5	<0.5	<0.5	<0.5	ND
Dissolved Zinc	<1	<1	<5	<5	ND
Ammonia (mg/L)	<0.005	<0.005	<0.010	<0.010	ND
Nitrite (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
Nitrate (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
Nitrite + Nitrate (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
TKN (mg/L)	<0.050	<0.050	0.141	0.132	6
Total Nitrogen (mg/L)	<0.050	<0.050	0.141	0.132	6
Total Phosphorus (mg/L)	<0.005	<0.005	<0.005	<0.005	ND
Reactive Phosphorus (mg/L)	<0.001	<0.001	<0.001	<0.001	ND
Azinphos-methyl	<0.02	<0.02	<0.02	<0.02	ND
Azinphos-ethyl	<0.02	<0.02	<0.02	<0.02	ND
Bromophos-ethyl	<0.10	<0.10	<0.10	<0.10	ND
Carbofenothion	<0.02	<0.02	<0.02	<0.02	ND
Chlorfenvinphos	<0.02	<0.02	<0.02	<0.02	ND
Chlorpyrifos	<0.02	<0.02	<0.02	<0.02	ND
Chlorpyrifos-methyl	<0.2	<0.2	<0.2	<0.2	ND
Coumaphos	<0.01	<0.01	<0.01	<0.01	ND

Parameter (µg/L)	VE Field Blank	VE Lab Blank	Replicate		Variation %
			HP-A	HP-B	
Demeton-O & Demeton-S	<0.02	<0.02	<0.02	<0.02	ND
Demeton-S-methyl	<0.02	<0.02	<0.02	<0.02	ND
Diazinon	<0.01	<0.01	<0.01	<0.01	ND
Dichlorvos	<0.20	<0.20	<0.20	<0.20	ND
Dimethoate	<0.02	<0.02	<0.02	<0.02	ND
Disulfoton	<0.05	<0.05	<0.05	<0.05	ND
EPN	<0.05	<0.05	<0.05	<0.05	ND
Ethion	<0.02	<0.02	<0.02	<0.02	ND
Ethoprophos	<0.01	<0.01	<0.01	<0.01	ND
Fenamiphos	<0.01	<0.01	<0.01	<0.01	ND
Fenchlorphos (Ronnel)	<10	<10	<10	<10	ND
Fenitrothion	<2	<2	<2	<2	ND
Fensulfothion	<0.01	<0.01	<0.01	<0.01	ND
Fenthion	<0.05	<0.05	<0.05	<0.05	ND
Malathion	<0.02	<0.02	<0.02	<0.02	ND
Mevinphos	<0.02	<0.02	<0.02	<0.02	ND
Monocrotophos	<0.02	<0.02	<0.02	<0.02	ND
Omethoate	<0.01	<0.01	<0.01	<0.01	ND
Parathion	<0.2	<0.2	<0.2	<0.2	ND
Parathion-methyl	<2.0	<2.0	<2.0	<2.0	ND
Phorate	<0.1	<0.1	<0.1	<0.1	ND
Pirimiphos-ethyl	<0.01	<0.01	<0.01	<0.01	ND
Pirimiphos-methyl	<0.01	<0.01	<0.01	<0.01	ND
Profenofos	<0.01	<0.01	<0.01	<0.01	ND
Prothiofos	<0.1	<0.1	<0.1	<0.1	ND
Sulfotep	<0.005	<0.005	<0.005	<0.005	ND
Sulprofos	<0.05	<0.05	<0.05	<0.05	ND
Temephos	<0.02	<0.02	<0.02	<0.02	ND
Terbufos	<0.01	<0.01	<0.01	<0.01	ND
Tetrachlorvinphos	<0.01	<0.01	<0.01	<0.01	ND
Triazophos	<0.005	<0.005	<0.005	<0.005	ND
Trichlorfon	<0.02	<0.02	<0.02	<0.02	ND
Trichloronate	<0.5	<0.5	<0.5	<0.5	ND
Aldicarb	<0.05	<0.05	<0.05	<0.05	ND
Bendiocarb	<0.10	<0.10	<0.10	<0.10	ND
Benomyl	<0.01	<0.01	<0.01	<0.01	ND
Carbaryl	<0.01	<0.01	<0.01	<0.01	ND
Carbofuran	<0.01	<0.01	<0.01	<0.01	ND
3-Hydroxy Carbofuran	<0.02	<0.02	<0.02	<0.02	ND
Methiocarb	<0.01	<0.01	<0.01	<0.01	ND
Methomyl	<0.01	<0.01	<0.01	<0.01	ND
Molinate	<0.1	<0.1	<0.1	<0.1	ND

Parameter (µg/L)	VE Field Blank	VE Lab Blank	Replicate		Variation %
			HP-A	HP-B	
Oxamyl	<0.01	<0.01	<0.01	<0.01	ND
Thiobencarb	<0.01	<0.01	<0.01	<0.01	ND
Thiodicarb	<0.01	<0.01	<0.01	<0.01	ND
Pendimethalin	<0.05	<0.05	<0.05	<0.05	ND
Trifluralin	<10.0	<10.0	<10.0	<10.0	ND
Hexazinone	<0.02	<0.02	<0.02	<0.02	ND
Metribuzin	<0.02	<0.02	<0.02	<0.02	ND
Cyproconazole	<0.02	<0.02	<0.02	<0.02	ND
Difenoconazole	<0.02	<0.02	<0.02	<0.02	ND
Flusilazole	<0.02	<0.02	<0.02	<0.02	ND
Hexaconazole	<0.02	<0.02	<0.02	<0.02	ND
Paclobutrazole	<0.05	<0.05	<0.05	<0.05	ND
Penconazole	<0.01	<0.01	<0.01	<0.01	ND
Propiconazole	<0.05	<0.05	<0.05	<0.05	ND
Tebuconazole	<0.01	<0.01	<0.01	<0.01	ND
Cyprodinil	<0.01	<0.01	<0.01	<0.01	ND
Pyrimethanil	<0.02	<0.02	<0.02	<0.02	ND
Diuron	<0.02	<0.02	0.03	0.03	0
Fluometuron	<0.01	<0.01	<0.01	<0.01	ND
Tebuthiuron	<0.02	<0.02	<0.02	<0.02	ND
Bromacil	<0.02	<0.02	<0.02	<0.02	ND
Chlorsulfuron	<0.2	<0.2	<0.2	<0.2	ND
Metolachlor	<0.01	<0.01	<0.01	<0.01	ND
Ametryn	<0.01	<0.01	<0.01	<0.01	ND
Atrazine	<0.01	<0.01	0.02	0.02	0
Cyanazine	<0.02	<0.02	<0.02	<0.02	ND
Cyromazine	<0.05	<0.05	<0.05	<0.05	ND
Prometryn	<0.01	<0.01	<0.01	<0.01	ND
Propazine	<0.01	<0.01	<0.01	<0.01	ND
Simazine	<0.02	<0.02	<0.02	<0.02	ND
Terbuthylazine	<0.01	<0.01	<0.01	<0.01	ND
Terbutryn	<0.01	<0.01	<0.01	<0.01	ND
Diclofop-methyl	<0.05	<0.05	<0.05	<0.05	ND
Fenarimol	<0.02	<0.02	<0.02	<0.02	ND
Irgarol	<0.002	<0.002	<0.002	<0.002	ND
Oxyfluorfen	<1.0	<1.0	<1.0	<1.0	ND
Thiamethoxam	<0.02	<0.02	<0.02	<0.02	ND
Imidacloprid	<0.01	<0.01	<0.01	<0.01	ND

6.2.2 Dredge Sampling 9/10 April 2019

Samples sent to ALS were analysed within recommended holding periods (Table 15). ALS laboratory blanks were all below detection limits, and acceptable differences (Relative Percent Difference, or RPD) were found between laboratory duplicates (split samples). Acceptable recovery was recorded in the laboratory control spikes. Both the VE Field and Lab blanks contained detectable concentrations of ammonia (33 to 41 µg/L, Table 16). As concentrations were similar, it appears likely that contamination was due to sample bottles or laboratory processes, as opposed to fieldwork processes. However, all field concentrations were <5 µg/L suggesting no contamination was present in these samples. Minimal RPD (≤ 20 %) was found between duplicate samples.

Table 16 Summary of ALS QA/QC data during Pre Dredge sampling 9/10 April 2019.

Report of analysis number	EB1909436
Date Samples Analysed	Acceptable
Method blank concentrations	Acceptable
RPD Laboratory duplicates	Acceptable
Recovery from laboratory control sample	Acceptable
Recovery from matrix spike samples	Acceptable

Table 17 Summary of VE quality control data during Dredge sampling 9/10 April 2019.
ND = not determined as one or more samples was below LOR.

Parameter (µg/L)	VE Field Blank	VE Lab Blank	Replicate		Variation %
			RTI-A	RTI-B	
Dissolved Aluminium	<5	<5	<5	<5	ND
Dissolved Arsenic	<0.2	<0.2	1.5	1.2	20
Dissolved Cadmium	<0.05	<0.05	<0.2	<0.2	ND
Dissolved Chromium	<0.2	<0.2	<0.5	<0.5	ND
Dissolved Cobalt	<0.1	<0.1	<0.2	<0.2	ND
Dissolved Copper	<0.5	<0.5	<1	<1	ND
Dissolved Iron	<2	<2	<5	<5	ND
Dissolved Lead	<0.1	<0.1	<0.2	<0.2	ND
Dissolved Mercury	<0.00004	<0.00004	<0.00004	<0.00004	ND
Dissolved Nickel	<0.5	<0.5	<0.5	<0.5	ND
Dissolved Zinc	<1	<1	<5	<5	ND
Ammonia (mg/L)	0.033	0.041	<0.005	<0.005	ND
Nitrite (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
Nitrate (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
Nitrite + Nitrate (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
TKN (mg/L)	<0.050	<0.050	0.098	0.110	11
Total Nitrogen (mg/L)	<0.050	<0.050	0.098	0.110	11
Total Phosphorus (mg/L)	<0.005	<0.005	<0.005	0.019	ND
Reactive Phosphorus (mg/L)	<0.001	<0.001	0.003	0.003	0
Azinphos-methyl	<0.02	<0.02	0.57	0.46	19
Azinphos-ethyl	<0.02	<0.02	<0.02	<0.02	ND
Bromophos-ethyl	<0.02	<0.02	<0.02	<0.02	ND
Carbofenothion	<0.10	<0.10	<0.10	<0.10	ND
Chlorfenvinphos	<0.02	<0.02	<0.02	<0.02	ND

Parameter (µg/L)	VE Field Blank	VE Lab Blank	Replicate		Variation %
			RTI-A	RTI-B	
Chlorpyrifos	<0.02	<0.02	<0.02	<0.02	ND
Chlorpyrifos-methyl	<0.02	<0.02	<0.02	<0.02	ND
Coumaphos	<0.2	<0.2	<0.2	<0.2	ND
Demeton-O & Demeton-S	<0.01	<0.01	<0.01	<0.01	ND
Demeton-S-methyl	<0.02	<0.02	<0.02	<0.02	ND
Diazinon	<0.02	<0.02	<0.02	<0.02	ND
Dichlorvos	<0.01	<0.01	<0.01	<0.01	ND
Dimethoate	<0.20	<0.20	<0.20	<0.20	ND
Disulfoton	<0.02	<0.02	<0.02	<0.02	ND
EPN	<0.05	<0.05	<0.05	<0.05	ND
Ethion	<0.05	<0.05	<0.05	<0.05	ND
Ethoprophos	<0.02	<0.02	<0.02	<0.02	ND
Fenamiphos	<0.01	<0.01	<0.01	<0.01	ND
Fenchlorphos (Ronnel)	<0.01	<0.01	<0.01	<0.01	ND
Fenitrothion	<10	<10	<10	<10	ND
Fensulfothion	<2	<2	<2	<2	ND
Fenthion	<0.01	<0.01	<0.01	<0.01	ND
Malathion	<0.05	<0.05	<0.05	<0.05	ND
Mevinphos	<0.02	<0.02	<0.02	<0.02	ND
Monocrotophos	<0.02	<0.02	<0.02	<0.02	ND
Omethoate	<0.02	<0.02	<0.02	<0.02	ND
Parathion	<0.01	<0.01	<0.01	<0.01	ND
Parathion-methyl	<0.2	<0.2	<0.2	<0.2	ND
Phorate	<2.0	<2.0	<2.0	<2.0	ND
Pirimiphos-ethyl	<0.1	<0.1	<0.1	<0.1	ND
Pirimiphos-methyl	<0.01	<0.01	<0.01	<0.01	ND
Profenofos	<0.01	<0.01	<0.01	<0.01	ND
Prothiofos	<0.01	<0.01	<0.01	<0.01	ND
Sulfotep	<0.1	<0.1	<0.1	<0.1	ND
Sulprofos	<0.005	<0.005	<0.005	<0.005	ND
Temephos	<0.05	<0.05	<0.05	<0.05	ND
Terbufos	<0.02	<0.02	<0.02	<0.02	ND
Tetrachlorvinphos	<0.01	<0.01	<0.01	<0.01	ND
Triazophos	<0.01	<0.01	<0.01	<0.01	ND
Trichlorfon	<0.005	<0.005	<0.005	<0.005	ND
Trichloronate	<0.02	<0.02	<0.02	<0.02	ND
Aldicarb	<0.5	<0.5	<0.5	<0.5	ND
Bendiocarb	<0.05	<0.05	<0.05	<0.05	ND
Benomyl	<0.10	<0.10	<0.10	<0.10	ND
Carbaryl	<0.01	<0.01	<0.01	<0.01	ND
Carbofuran	<0.01	<0.01	<0.01	<0.01	ND
3-Hydroxy Carbofuran	<0.01	<0.01	<0.01	<0.01	ND

Parameter (µg/L)	VE Field Blank	VE Lab Blank	Replicate		Variation %
			RTI-A	RTI-B	
Methiocarb	<0.02	<0.02	<0.02	<0.02	ND
Methomyl	<0.01	<0.01	<0.01	<0.01	ND
Molinate	<0.01	<0.01	<0.01	<0.01	ND
Oxamyl	<0.1	<0.1	<0.1	<0.1	ND
Thiobencarb	<0.01	<0.01	<0.01	<0.01	ND
Thiodicarb	<0.01	<0.01	<0.01	<0.01	ND
Pendimethalin	<0.01	<0.01	<0.01	<0.01	ND
Trifluralin	<0.05	<0.05	<0.05	<0.05	ND
Hexazinone	<10.0	<10.0	<10.0	<10.0	ND
Metribuzin	<0.02	<0.02	<0.02	<0.02	ND
Cyproconazole	<0.02	<0.02	<0.02	<0.02	ND
Difenoconazole	<0.02	<0.02	<0.02	<0.02	ND
Flusilazole	<0.02	<0.02	<0.02	<0.02	ND
Hexaconazole	<0.02	<0.02	<0.02	<0.02	ND
Paclobutrazole	<0.02	<0.02	<0.02	<0.02	ND
Penconazole	<0.05	<0.05	<0.05	<0.05	ND
Propiconazole	<0.01	<0.01	<0.01	<0.01	ND
Tebuconazole	<0.05	<0.05	<0.05	<0.05	ND
Cyprodinil	<0.01	<0.01	<0.01	<0.01	ND
Pyrimethanil	<0.01	<0.01	<0.01	<0.01	ND
Diuron	<0.02	<0.02	<0.02	<0.02	ND
Fluometuron	<0.02	<0.02	<0.02	<0.02	ND
Tebuthiuron	<0.01	<0.01	<0.01	<0.01	ND
Bromacil	<0.02	<0.02	<0.02	<0.02	ND
Chlorsulfuron	<0.02	<0.02	<0.02	<0.02	ND
Metolachlor	<0.2	<0.2	<0.2	<0.2	ND
Ametryn	<0.01	<0.01	<0.01	<0.01	ND
Atrazine	<0.01	<0.01	<0.01	<0.01	ND
Cyanazine	<0.01	<0.01	<0.01	<0.01	ND
Cyromazine	<0.02	<0.02	<0.02	<0.02	ND
Prometryn	<0.05	<0.05	<0.05	<0.05	ND
Propazine	<0.01	<0.01	<0.01	<0.01	ND
Simazine	<0.01	<0.01	<0.01	<0.01	ND
Terbuthylazine	<0.02	<0.02	<0.02	<0.02	ND
Terbutryn	<0.01	<0.01	<0.01	<0.01	ND
Diclofop-methyl	<0.01	<0.01	<0.01	<0.01	ND
Fenarimol	<0.05	<0.05	<0.05	<0.05	ND
Irgarol	<0.02	<0.02	<0.02	<0.02	ND
Oxyfluorfen	<0.002	<0.002	<0.002	<0.002	ND
Thiamethoxam	<1.0	<1.0	<1.0	<1.0	ND
Imidacloprid	<0.02	<0.02	<0.02	<0.02	ND

6.2.3 Post Dredge Sampling 30 May 2019

Samples sent to ALS were analysed within recommended holding periods (Table 17). ALS laboratory blanks were all below detection limits, and acceptable differences (Relative Percent Difference, or RPD) were found between laboratory duplicates (split samples). Acceptable recovery was recorded in the laboratory control spikes. VE field and lab blank concentrations were below LOR (Table 18), with minimal RPD (≤ 2 %) between duplicate samples.

Table 18 Summary of ALS QA/QC data during Post Dredge sampling 30 May 2019.

Report of analysis number	EB1914282
Date Samples Analysed	Acceptable
Method blank concentrations	Acceptable
RPD Laboratory duplicates	Acceptable
Recovery from laboratory control sample	Acceptable
Recovery from matrix spike samples	Acceptable

Table 19 Summary of VE quality control data during Post Dredge sampling 30 May 2019.
ND = not determined as one or more samples was below LOR.

Parameter (µg/L)	**VE Field Blank**	**VE Lab Blank**	**Replicate**		**Variation %**
			FP-A	FP-B	
Dissolved Aluminium	<5	<5	<5	<5	ND
Dissolved Arsenic	<0.2	<0.2	1.4	1.4	0
Dissolved Cadmium	<0.05	<0.05	<0.2	<0.2	ND
Dissolved Chromium	<0.2	<0.2	<0.5	<0.5	ND
Dissolved Cobalt	<0.1	<0.1	<0.2	<0.2	ND
Dissolved Copper	<0.5	<0.5	<1	<1	ND
Dissolved Iron	<2	<2	<5	<5	ND
Dissolved Lead	<0.1	<0.1	<0.2	<0.2	ND
Dissolved Mercury	<0.00004	<0.00004	<0.00004	<0.00004	ND
Dissolved Nickel	<0.5	<0.5	<0.5	0.7	ND
Dissolved Zinc	<1	<1	<5	<5	ND
Ammonia (mg/L)	<0.005	<0.005	<0.015	<0.015	ND
Nitrite (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
Nitrate (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
Nitrite + Nitrate (mg/L)	<0.002	<0.002	<0.002	<0.002	ND
TKN (mg/L)	<0.050	<0.050	0.088	0.086	2
Total Nitrogen (mg/L)	<0.050	<0.050	0.088	0.086	2
Total Phosphorus (mg/L)	<0.005	<0.005	<0.005	<0.005	ND
Reactive Phosphorus (mg/L)	<0.001	<0.001	<0.001	<0.001	ND
Azinphos-methyl	<0.02	<0.02	<0.02	<0.02	ND
Azinphos-ethyl	<0.02	<0.02	<0.02	<0.02	ND
Bromophos-ethyl	<0.10	<0.10	<0.10	<0.10	ND
Carbofenothion	<0.02	<0.02	<0.02	<0.02	ND
Chlorfenvinphos	<0.02	<0.02	<0.02	<0.02	ND
Chlorpyrifos	<0.02	<0.02	<0.02	<0.02	ND
Chlorpyrifos-methyl	<0.2	<0.2	<0.2	<0.2	ND
Coumaphos	<0.01	<0.01	<0.01	<0.01	ND

Parameter (µg/L)	VE Field Blank	VE Lab Blank	Replicate		Variation %
			FP-A	FP-B	
Demeton-O & Demeton-S	<0.02	<0.02	<0.02	<0.02	ND
Demeton-S-methyl	<0.02	<0.02	<0.02	<0.02	ND
Diazinon	<0.01	<0.01	<0.01	<0.01	ND
Dichlorvos	<0.20	<0.20	<0.20	<0.20	ND
Dimethoate	<0.02	<0.02	<0.02	<0.02	ND
Disulfoton	<0.05	<0.05	<0.05	<0.05	ND
EPN	<0.05	<0.05	<0.05	<0.05	ND
Ethion	<0.02	<0.02	<0.02	<0.02	ND
Ethoprophos	<0.01	<0.01	<0.01	<0.01	ND
Fenamiphos	<0.01	<0.01	<0.01	<0.01	ND
Fenchlorphos (Ronnel)	<10	<10	<10	<10	ND
Fenitrothion	<2	<2	<2	<2	ND
Fensulfothion	<0.01	<0.01	<0.01	<0.01	ND
Fenthion	<0.05	<0.05	<0.05	<0.05	ND
Malathion	<0.02	<0.02	<0.02	<0.02	ND
Mevinphos	<0.02	<0.02	<0.02	<0.02	ND
Monocrotophos	<0.02	<0.02	<0.02	<0.02	ND
Omethoate	<0.01	<0.01	<0.01	<0.01	ND
Parathion	<0.2	<0.2	<0.2	<0.2	ND
Parathion-methyl	<2.0	<2.0	<2.0	<2.0	ND
Phorate	<0.1	<0.1	<0.1	<0.1	ND
Pirimiphos-ethyl	<0.01	<0.01	<0.01	<0.01	ND
Pirimiphos-methyl	<0.01	<0.01	<0.01	<0.01	ND
Profenofos	<0.01	<0.01	<0.01	<0.01	ND
Prothiofos	<0.1	<0.1	<0.1	<0.1	ND
Sulfotep	<0.005	<0.005	<0.005	<0.005	ND
Sulprofos	<0.05	<0.05	<0.05	<0.05	ND
Temephos	<0.02	<0.02	<0.02	<0.02	ND
Terbufos	<0.01	<0.01	<0.01	<0.01	ND
Tetrachlorvinphos	<0.01	<0.01	<0.01	<0.01	ND
Triazophos	<0.005	<0.005	<0.005	<0.005	ND
Trichlorfon	<0.02	<0.02	<0.02	<0.02	ND
Trichloronate	<0.5	<0.5	<0.5	<0.5	ND
Aldicarb	<0.05	<0.05	<0.05	<0.05	ND
Bendiocarb	<0.10	<0.10	<0.10	<0.10	ND
Benomyl	<0.01	<0.01	<0.01	<0.01	ND
Carbaryl	<0.01	<0.01	<0.01	<0.01	ND
Carbofuran	<0.01	<0.01	<0.01	<0.01	ND
3-Hydroxy Carbofuran	<0.02	<0.02	<0.02	<0.02	ND
Methiocarb	<0.01	<0.01	<0.01	<0.01	ND
Methomyl	<0.01	<0.01	<0.01	<0.01	ND
Molinate	<0.1	<0.1	<0.1	<0.1	ND

Parameter (µg/L)	VE Field Blank	VE Lab Blank	Replicate		Variation %
			FP-A	FP-B	
Oxamyl	<0.01	<0.01	<0.01	<0.01	ND
Thiobencarb	<0.01	<0.01	<0.01	<0.01	ND
Thiodicarb	<0.01	<0.01	<0.01	<0.01	ND
Pendimethalin	<0.05	<0.05	<0.05	<0.05	ND
Trifluralin	<10.0	<10.0	<10.0	<10.0	ND
Hexazinone	<0.02	<0.02	<0.02	<0.02	ND
Metribuzin	<0.02	<0.02	<0.02	<0.02	ND
Cyproconazole	<0.02	<0.02	<0.02	<0.02	ND
Difenoconazole	<0.02	<0.02	<0.02	<0.02	ND
Flusilazole	<0.02	<0.02	<0.02	<0.02	ND
Hexaconazole	<0.02	<0.02	<0.02	<0.02	ND
Paclobutrazole	<0.05	<0.05	<0.05	<0.05	ND
Penconazole	<0.01	<0.01	<0.01	<0.01	ND
Propiconazole	<0.05	<0.05	<0.05	<0.05	ND
Tebuconazole	<0.01	<0.01	<0.01	<0.01	ND
Cyprodinil	<0.01	<0.01	<0.01	<0.01	ND
Pyrimethanil	<0.02	<0.02	<0.02	<0.02	ND
Diuron	<0.02	<0.02	<0.02	<0.02	ND
Fluometuron	<0.01	<0.01	<0.01	<0.01	ND
Tebuthiuron	<0.02	<0.02	<0.02	<0.02	ND
Bromacil	<0.02	<0.02	<0.02	<0.02	ND
Chlorsulfuron	<0.2	<0.2	<0.2	<0.2	ND
Metolachlor	<0.01	<0.01	<0.01	<0.01	ND
Ametryn	<0.01	<0.01	<0.01	<0.01	ND
Atrazine	<0.01	<0.01	<0.01	<0.01	ND
Cyanazine	<0.02	<0.02	<0.02	<0.02	ND
Cyromazine	<0.05	<0.05	<0.05	<0.05	ND
Prometryn	<0.01	<0.01	<0.01	<0.01	ND
Propazine	<0.01	<0.01	<0.01	<0.01	ND
Simazine	<0.02	<0.02	<0.02	<0.02	ND
Terbuthylazine	<0.01	<0.01	<0.01	<0.01	ND
Terbutryn	<0.01	<0.01	<0.01	<0.01	ND
Diclofop-methyl	<0.05	<0.05	<0.05	<0.05	ND
Fenarimol	<0.02	<0.02	<0.02	<0.02	ND
Irgarol	<0.002	<0.002	<0.002	<0.002	ND
Oxyfluorfen	<1.0	<1.0	<1.0	<1.0	ND
Thiamethoxam	<0.02	<0.02	<0.02	<0.02	ND
Imidacloprid	<0.01	<0.01	<0.01	<0.01	ND