

Mardie Project Marine Water Quality Baseline

Mardie Minerals Pty Ltd



CLIENT: Mardie Minerals Pty Ltd
STATUS: Rev 2 **REPORT No.:** R190056
ISSUE DATE: 24th March 2020



Important Note

This report and all its components (including images, audio, video, text) is copyright. Apart from fair dealing for the purposes of private study, research, criticism or review as permitted under the Copyright Act 1968, no part may be reproduced, copied, transmitted in any form or by any means (electronic, mechanical or graphic) without the prior written permission of O2 Marine.

This report contains maps that include data that are copyright to the Commonwealth of Australia (Geoscience Australia) 2006, Department of Water and Environmental Regulation (2001), Department of Biodiversity, Conservation and Attractions (2019) and Microsoft Corporation Earthstar Geographics SIO (2019).

This report has been prepared for the sole use of the **Mardie Minerals Pty Ltd** (herein, 'the client'), for a specific site (herein 'the site', the specific purpose specified in Section 1 of this report (herein 'the purpose'). This report is strictly limited for use by the client, to the purpose and site and may not be used for any other purposes.

Third parties, excluding regulatory agencies assessing an application in relation to the purpose, may not rely on this report. O2 Marine waives all liability to any third-party loss, damage, liability or claim arising out of or incidental to a third-party publishing, using or relying on the facts, content, opinions or subject matter contained in this report.

O2 Marine waives all responsibility for loss or damage where the accuracy and effectiveness of information provided by the Client or other third parties was inaccurate or not up to date and was relied upon, wholly or in part in reporting.



WA Marine Pty Ltd t/as O2 Marine

ACN 168 014 819

Originating Office – Southwest

Suite 5, 18 Griffin Drive, Dunsborough WA 6281

T 1300 739 447 | info@o2marine.com.au



Version Register

Version	Status	Author	Reviewer	Change from Previous Version	Authorised for Release (signed and dated)	
Rev 0	Final	M Wellington C Del Deo	C Lane		C Lane	11 th June 2019
Rev 1	Final	M Wellington	C Lane	Updated Monitoring Data	C Lane	24 th March 2020
Rev 2	Final	M Wellington	C Lane	Updated Project Description	C Lane	24 th March 2020

Transmission Register

Controlled copies of this document are issued to the persons/companies listed below. Any copy of this report held by persons not listed in this register is deemed uncontrolled. Updated versions of this report if issued will be released to all parties listed below via the email address listed.

Name	Email Address
Neil Dixon	Neil.Dixon@bciminerals.com.au

Acronyms and Abbreviations

Acronyms/Abbreviation	Description
ADCP	Acoustic Doppler Current Profiler
ANZG	Australia and New Zealand Environment and Conservation Council Guidelines
ANZECC	Australia and New Zealand Environment and Conservation Council
AQUADOP	Single Point Doppler Current Profiler
BCI	BCI Minerals Ltd
BCH	Benthic Communities and Habitats
BoM	Bureau of Meteorology
CALM	Conservation and Land Management
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTD	Conductivity, Temperature, Depth
DLI	Daily Light Integral
EPA	Environmental Protection Authority
ESD	Environmental Scoping Document
HAT	Highest Astronomical Tide
IMO	In- Situ Marine Optics
ISLW	Indian Spring Low Water
LAT	Lowest Astronomical Tide
LEP	Level of Environmental Protection
MHWS	Mean High Water Spring
MHWN	Mean High Water Neap
MODIS	Moderate Resolution Imaging Spectroradiometer
MSL	Mean Sea Level
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
NTU	Nephelometric Turbidity Units
NTUSB	Nephelometric Turbidity Unit (plus Fluorometer)
PAR	Photosynthetically Active Radiation
pHiDO	pH and Dissolved Oxygen
QAQC	Quality Assurance/Quality Control
SOP	Sulfate of Potash
TRH	Total Recoverable Hydrocarbons
TPH	Total Petroleum Hydrocarbons
WA	Western Australia
WAMSI	Western Australian Marine Science Institute

Table of Contents

1.	Introduction	1
1.1.	Project Description	1
1.2.	Scope and Objectives	6
2.	Existing Environment	7
2.1.	Climatology and Oceanography	7
2.2.	Marine Environmental Quality	11
2.3.	Water Quality Characteristics	13
3.	Methods	15
3.1.	Water Quality Stations	15
3.2.	Monitoring Location	16
3.3.	Deployment Period	16
3.4.	Water Quality Instrument Maintenance & Calibration	18
3.5.	Marine Water Sampling	18
3.6.	Data analysis	19
4.	Results and Discussion	21
4.1.	Physico-chemical Parameters	21
4.2.	Laboratory Results	33
5.	Conclusion	37
6.	Reference List	39

Figures

Figure 1	Mardie Project Regional Location	4
Figure 2	Mardie Project Development Envelopes: Marine, Ponds and Terrestrial Infrastructure and Transshipment Corridor.	5
Figure 3	Wind Rose plots for Dry Season (left) and Wet Season Months (right) based on analysis of the measured data from Mardie airport	7
Figure 4	Climate Statistics for Mardie (BOM).	8
Figure 5	Tracks of notable cyclones impacting Karratha (left) and Onslow (right)	8
Figure 6	Wave high and direction recorded offshore of the Mardie project location for Dry Season months (left) and Wet Season Months (right) based for the period April 2018 – January 2019.	9
Figure 7	Measured water level data from inshore Aquadopp location November 2018	11
Figure 8	Current Levels of Ecological Protection in the Vicinity of the Mardie Project (Source: LEP Layer supplied by DWER in April 2019).	12
Figure 9	Example of Water Quality Instrument Frame deployed at inshore monitoring location with IMO-CTD instrument	15
Figure 10	Water Quality Monitoring Locations	17
Figure 11	Depth (m) recorded by the IMO-CTD at the inshore water quality monitoring location	21
Figure 12	Depth (m) recorded by the IMO-MS9 instrument at the offshore monitoring location	22
Figure 13	TC Veronica passing project site on the 23 rd March 2019 causing decrease in local barometric pressure.	22

Figure 14	Temperature data recorded In-situ at the Inshore Monitoring Location (Outfall)	23
Figure 15	Mean daily temperature data recorded In-situ at the Offshore Monitoring Location (ADCP)	23
Figure 16	Salinity data recorded In-situ at the Inshore Monitoring Location (Outfall)	25
Figure 17	Daily Rainfall data for Mardie (www.bom.gov.au).	26
Figure 18	Low pressure system approaching WA coast on 05 June 2018 (www.bom.gov.au)	26
Figure 19	Solar elevation angle at 1200 (midday) at Mardie, WA over a full annual cycle (source: keisan.casio.com).	28
Figure 20	Daily Light Integral (DLI) for the offshore monitoring site with 14-day running mean, as well as Jones <i>et al.</i> (2019) defined thresholds for <i>Possible</i> and <i>Probable</i> Effects on Coral.	28
Figure 21	Daily Light Integral (DLI) for the inshore monitoring site with 14-day running mean, as well as Jones <i>et al.</i> (2019) defined thresholds for <i>Possible</i> and <i>Probable</i> Effects on Coral	28
Figure 22	Synoptic chart showing TC “Riley” passing the Mardie project site on the 27/01/2019 (www.bom.gov.au)	29
Figure 23	24-hour mean turbidity (NTU) recorded at inshore location between November 2018 and September 2019.	31
Figure 24	24-hour rolling mean turbidity (NTU) recorded at Off-shore location between November 2018 and September 2019	31
Figure 25	24 hour mean Suspended Sediment Concentration (SSC) (mg/l) derived from NTU recorded at Inshore location between November 2018 and September 2019 using surrogate calibration derived for the Wheatstone dredging project (Fisher & Jones 2019).	32
Figure 26	24 hour rolling mean Suspended Sediment Concentration (SSC) (mg/L) derived from NTU recorded at offshore location between Nov 2018 and September 2019 using surrogate calibration derived for the Wheatstone dredging project (Fisher & Jones 2019).	32
Figure 27	Extract from sampling period of tidal data showing relationship with mean daily turbidity (NTU)	33

Tables

Table 1	Short Summary of the Proposal	1
Table 2	Location and proposed extent of physical and operational elements	3
Table 3	Water Quality Monitoring Objectives and Key Considerations / Scope Limitations	6
Table 4	Mardie Tidal Planes (location 21.03572 S, 115.92766 E, National Tide Centre)	11
Table 5	Water Quality Station specifications	15
Table 6	Mardie water quality monitoring locations and instrumentation	16
Table 7	Dates and works conducted relating to the water quality station in-situ at Mardie	18
Table 8	Summary Water Temperature Statistics recorded from the Inshore & Offshore Monitoring Locations	23
Table 9	Summary Salinity (psu) Statistics recorded from the Inshore Monitoring Location	25
Table 10	Summary Statistics for Daily Light Integral ([mol/m ²]/day) measured at light monitoring locations	27
Table 11	Summary statistics for Turbidity (NTU) and SSC (Mg/L) at the inshore and offshore monitoring locations	30
Table 12	Results of baseline water quality sampling at Mardie, Western Australia, with ANZG (2018) species protection levels for marine water quality	33

Appendices

Appendix A – Laboratory Analysis Reports

1. Introduction

1.1. Project Description

1.1.1. Short Summary of the Proposal

Table 1 Short Summary of the Proposal

Proposal Title	Mardie Project
Proponent Name	Mardie Minerals Pty Ltd
Short Description	<p>Mardie Minerals Pty Ltd is seeking to develop a greenfields high quality salt and sulphate of potash (SOP) project and associated export facility at Mardie, approximately 80 km south west of Karratha, in the Pilbara region of WA. The proposal will utilise seawater to produce a high purity salt product, SOP and other products derived from sea water.</p> <p>The proposal includes the development of a seawater intake, concentrator and crystalliser ponds, processing facilities and stockpile areas, bitterns disposal pipeline and diffuser, trestle jetty export facility, transshipment channel, drainage channels, access / haul roads, desalination (reverse osmosis) plant, borrow pits, pipelines, and associated infrastructure (power supply, communications equipment, offices, workshops, accommodation village, laydown areas, sewage treatment plant, landfill facility, etc.).</p>

1.1.2. Proposal Description

Mardie Minerals Pty Ltd (Mardie Minerals) seeks to develop the Mardie Project (the proposal), a greenfields high-quality salt project in the Pilbara region of Western Australia (Figure 1). Mardie Minerals is a wholly-owned subsidiary of BCI Minerals Limited.

The proposal is a solar salt project that utilises seawater and evaporation to produce raw salts as a feedstock for dedicated processing facilities that will produce a high purity salt, industrial grade fertiliser products, and other commercial by-products. Production rates of 4.0 Million tonnes per annum (Mtpa) of salt (NaCl), 100 kilo tonnes per annum (ktpa) of Sulphate of Potash (SoP), and up to 300 ktpa of other salt products are being targeted, sourced from a 150 Gigalitre per annum (GLpa) seawater intake. To meet this production, the following infrastructure will be developed:

- > Seawater intake, pump station and pipeline;
- > Concentrator ponds;
- > Drainage channels;
- > Crystalliser ponds;
- > Trestle jetty and transshipment berth/channel;
- > Bitterns disposal pipeline and diffuser;
- > Processing facilities and stockpiles;
- > Administration buildings;
- > Accommodation village,
- > Access / haul roads;

- > Desalination plant for freshwater production, with brine discharged to the evaporation ponds; and
- > Associated infrastructure such as power supply, communications, workshop, laydown, landfill facility, sewage treatment plant, etc.

Seawater for the process will be pumped from a large tidal creek into the concentrator ponds. All pumps will be screened and operated accordingly to minimise entrapment of marine fauna and any reductions in water levels in the tidal creek.

Concentrator and crystalliser ponds will be developed behind low permeability walls engineered from local clays and soils and rock armoured to protect against erosion. The height of the walls varies across the project and is matched to the flood risk for the area.

Potable water will be required for the production plants and the village. The water supply will be sourced from desalination plants which will provide the water required to support the Project. The high salinity output from the plants will be directed to a concentrator pond with the corresponding salinity, or managed through the project bitterns stream.

A 3.4 km long trestle jetty will be constructed to convey salt (NaCl) from the salt production stockpile to the transshipment berth pocket. The jetty will not impede coastal water or sediment movement, thus ensuring coastal processes are maintained.

Dredging of up to 800,000 m³ will be required to ensure sufficient depth for the transhipper berth pocket at the end of the trestle jetty, as well as along a 4 km long channel out to deeper water. The average depth of dredging is approximately 1 m below the current sea floor. The dredge spoil is inert and will be transported to shore for use within the development.

The production process will produce a high-salinity bittern that, prior to its discharge through a diffuser at the far end of the trestle jetty, will be diluted with seawater to bring its salinity closer to that of the receiving environment.

Access to the project from North West Coastal Highway will be based on an existing public road alignment that services the Mardie Station homestead and will require upgrading (i.e. widening and sealing).

The majority of the power required for the project (i.e. approximately 95%) is provided by the sun and the wind, which drives the evaporation and crystallisation processes. In addition, the Project will require diesel and gas to provide additional energy for infrastructure, support services and processing plant requirements.

The proposal will be developed within three separate development envelopes. The boundaries of these development envelopes are shown in Figure 2 and described in Table 2.

Table 2 Location and proposed extent of physical and operational elements

Element	Ref.	Proposed Extent
Physical Elements		
Ponds & Terrestrial Infrastructure Development Envelope – evaporation and crystalliser ponds, processing facilities, access / haul road, desalination plant, administration, accommodation village, quarry, laydown, other infrastructure.	Fig. 2	Disturbance of no more than 11,142 ha within the 15,667 ha Ponds & Terrestrial Infrastructure Development Envelope.
Marine Development Envelope – trestle jetty, seawater intake and pipeline, bitterns pipeline.	Fig. 2	Disturbance of no more than 7 ha within the 53 ha Marine Development Envelope.
Dredge Channel Development Envelope – berth pocket, channel to allow access for transshipment vessels, bitterns outfall diffuser, bitterns dilution seawater intake.	Fig. 2	Disturbance of no more than 55 ha within the 304 ha Dredge Channel Development Envelope.
Operational Elements		
Desalination Plant discharge	Fig. 2	Discharge to concentrator ponds or to bitterns stream.
Dredge volume	Fig. 2	<p>Dredging is only to occur within the Dredge Channel Development Envelope.</p> <p>Dredging of no more than 800,000 m³ of material from the berth pocket and high points within the transshipment channel, with the material to be deposited within the Ponds & Infrastructure Development Envelope.</p>
Bitterns discharge	Fig. 2	Discharge of up to 3.6 gigalitres per annum (GLpa) of bitterns within a dedicated offshore mixing zone.



Figure 1 Mardie Project Regional Location

18WAU002/ R190056 Mardie Minerals Ltd
Mardie Project – Marine Water Quality Baseline

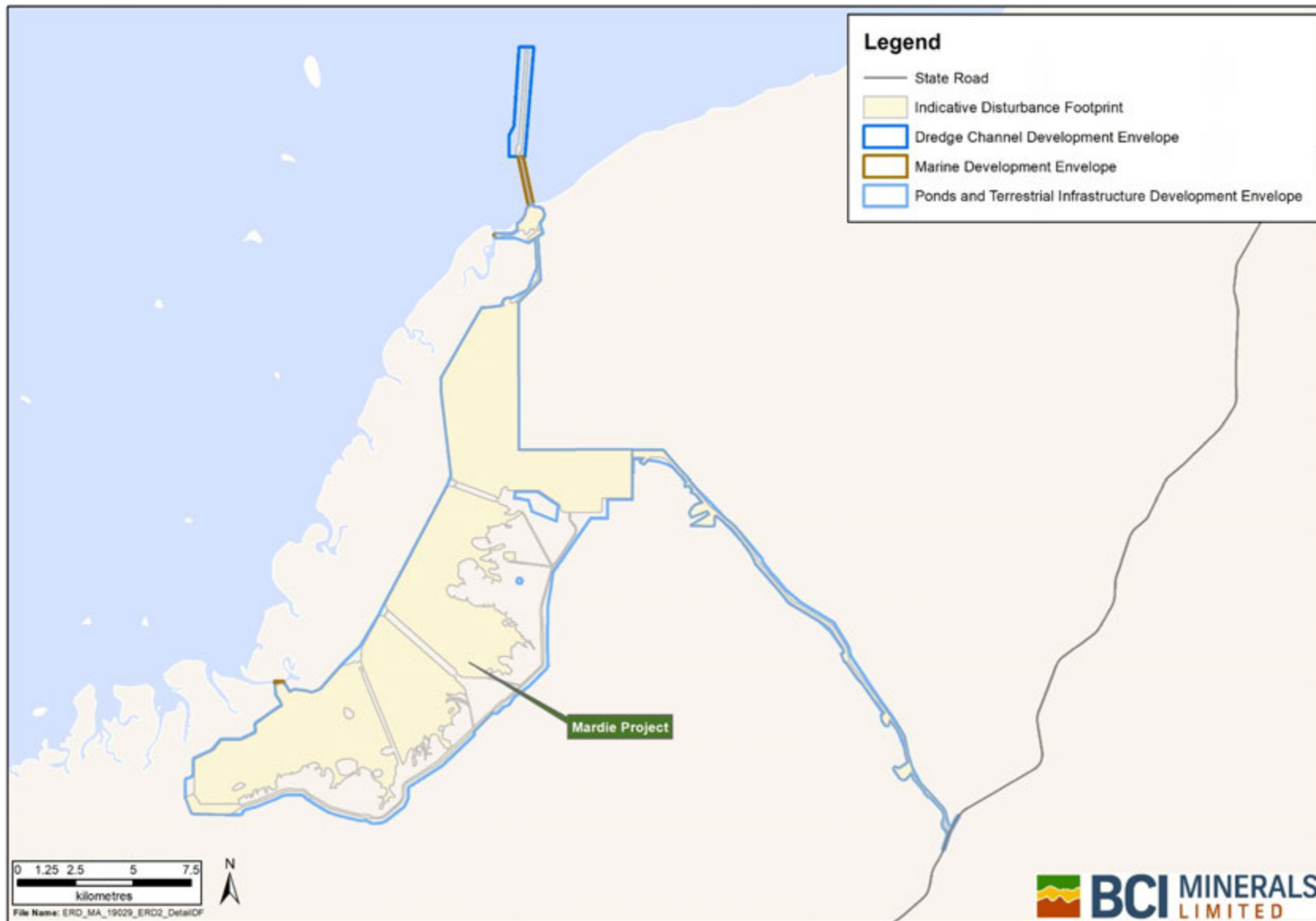


Figure 2 Mardie Project Development Envelopes: Marine, Ponds and Terrestrial Infrastructure and Transhipment Corridor.

1.2. Scope and Objectives

The objectives of this document are to:

- > Characterise the existing water quality conditions in the Mardie region to provide a benchmark for interpretation of potential impacts due to activities associated with construction and operations of the Mardie Project;
- > Document spatial and temporal variation of background marine water quality; and
- > Review other water quality information collected for the area for comparison against baseline data collected in this report.

The requirements of the Environmental Scoping Document (ESD) together with key considerations / scope limitations are discussed in **Table 3**.

Table 3 Water Quality Monitoring Objectives and Key Considerations / Scope Limitations

Monitoring Objectives	Key Considerations / Limitations
ESD Item 6 - Collect adequate baseline water quality data to describe baseline light and turbidity values at sensitive receptors and to inform dredge plume impact modelling.	Monitoring for the Proposed Mardie Port commenced in December 2018, once the Port location was determined. Baseline light and turbidity monitoring were undertaken between October 2018 and September 2019
ESD Item 29 - Undertake a baseline water quality assessment at the bitterns outfall location including physical characteristics and chemical constituents.	Outfall location was moved three times during the Monitoring Period (i.e. March 2018 – September 2019).
ESD Item 35 - Collect adequate baseline water and sediment quality data to document background marine environmental quality (including spatial and temporal variation) within the receiving marine environment. Baseline data acquisition will be adequate for the derivation of environmental quality criteria for indicators relevant to the discharge(s) e.g. water, sediment and/or infauna quality indicators.	Sediment quality data is presented in a separate report.

2. Existing Environment

2.1. Climatology and Oceanography

The southern Pilbara region has a tropical monsoon climate with distinct wet and dry seasons. The dry season extends from May to October, and is characterised by warm to hot temperatures, easterly to south easterly winds from the continental landmass, clear and stable conditions as the subtropical high-pressure ridge migrates over this area. In the afternoon, the wind direction shifts to north-westerly, particularly later in the dry season, associated with the onset of the land sea breeze as the temperature difference between the continent and the ocean increases throughout the day. In the wet season the wind climate is dominated by westerly and north-westerly winds. Wind rose plots for the Dry Season months (May to October) and Wet Season months (November to April) are presented in **Figure 3** based on analysis of the measured wind records from Mardie Airport over the period 2011 - 2018.

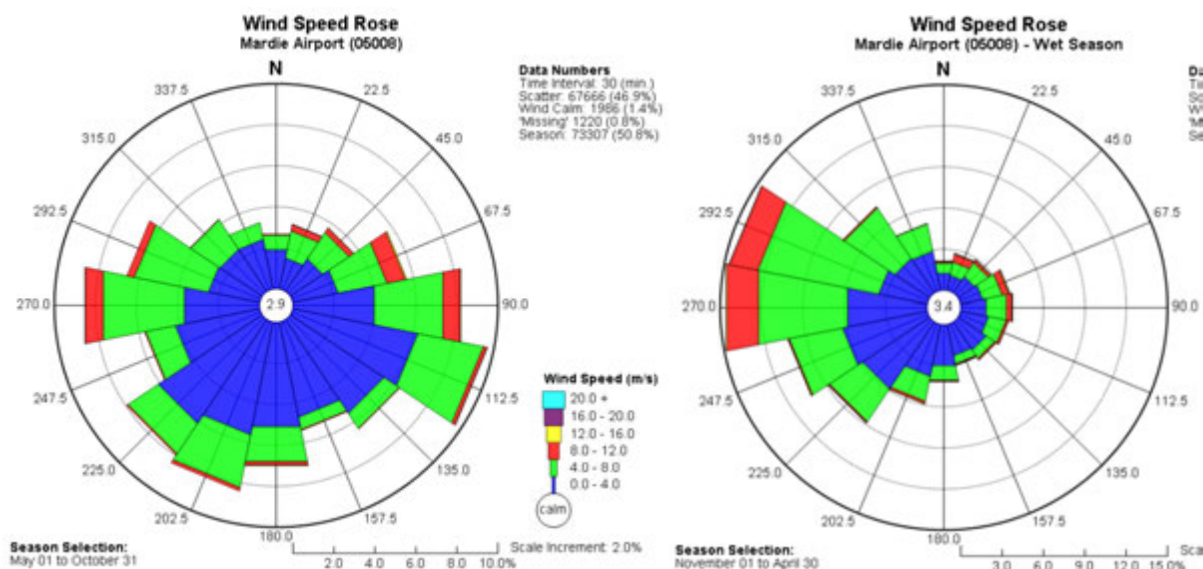


Figure 3 Wind Rose plots for Dry Season (left) and Wet Season Months (right) based on analysis of the measured data from Mardie airport

Climate statistics for Mardie Airport are presented in **Figure 4** from the BoM site which is approximately 16km inland. Maximum daily temperatures at Mardie average 33.9 °C throughout the year, peaking at 38.0 °C in January and falling to 27.7 °C in July. The Pilbara is influenced by northern rainfall systems of tropical origin. These systems are responsible for heavy falls during the summer months, while the southern low-pressure systems sometimes bring limited winter rains. The annual average rainfall is only 128 mm, and the mean monthly rainfall has a bimodal distribution, peaking in January to March and also May to June, with very little rainfall from July to December (**Figure 4**). Daily rainfall can reach over 300 mm during extreme events that may occur one to two times per decade. Evaporation rates in the region are high, estimated to exceed by ten times the annual rainfall.

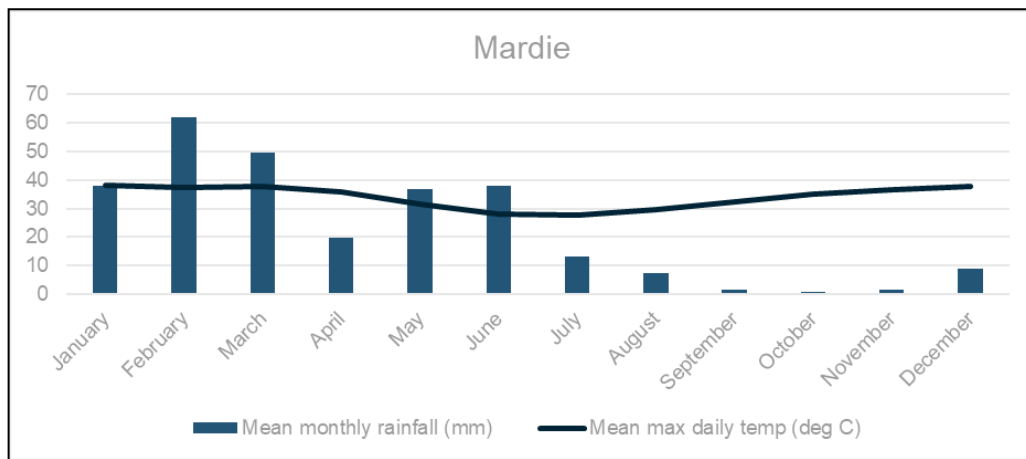


Figure 4 Climate Statistics for Mardie (BOM).

The Australian cyclone season extends from November through to April with an average of 10 cyclones per year, although not all make landfall. Tropical cyclone winds can generate extreme coastal water levels through storm surge and these systems are frequently associated with heavy rainfall that can cause significant flooding. The Pilbara region of Western Australia has a high exposure to tropical cyclone events, with a typical cyclone track recurving and making landfall on the coastline between Broome and Exmouth. The season typically runs from mid-December to April, peaking in February and March. The Karratha to Onslow coastline is the most-cyclone prone section of the Australian coast, typically experiencing one landfalling event every two years. The northwestern coastline of Western Australia is highly vulnerable to the occurrence of storm surge. This is due to the frequency of tropical cyclones, the wide continental shelf and relatively shallow ocean floor over the North West Shelf, as well as the low-lying nature of much of the coastline. In addition, tropical cyclone events are strongly associated with flooding due to widespread heavy rainfall.

Historical events of significance impacting between Karratha and Onslow include: Trixie 1975, Chloe 1984, Orson 1989, Olivia 1996, John 1999, Monty 2004, Clare 2006 and Glenda 2006 (**Figure 5**). In late March 2019 the passage of TC Veronica tracked west over the region from offshore of Karratha losing intensity as it continued west offshore of Mardie as a tropical low system.

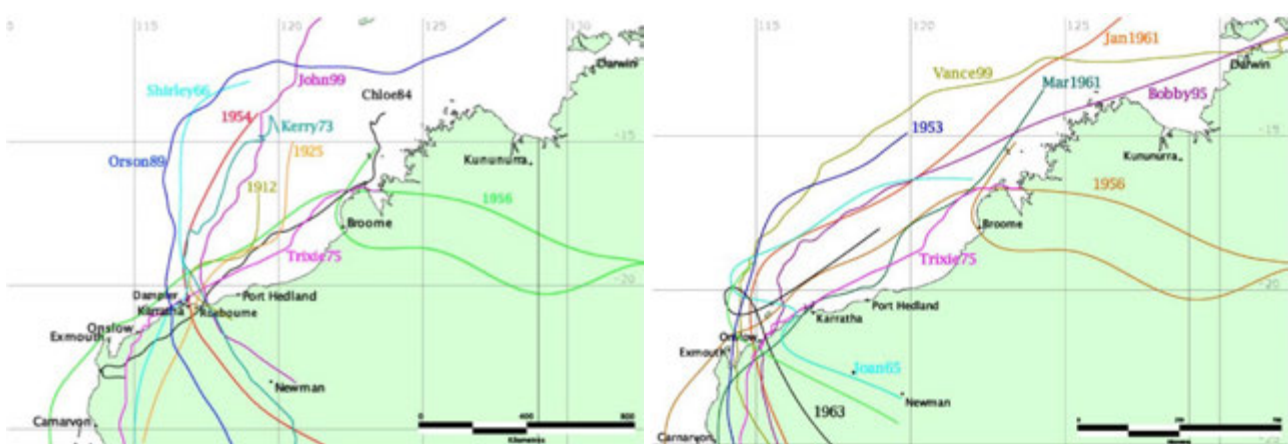


Figure 5 Tracks of notable cyclones impacting Karratha (left) and Onslow (right)

The astronomical tide is the periodic rise and fall of the sea surface caused by the combination of the gravitational force exerted by the moon and the Sun upon the Earth and the centrifugal force due to rotations of the Earth and moon, and the Earth and the Sun around their common centre of gravity. Tides are subject to spatial variability due to hydrodynamic, hydrographic and topographic influences. At the study area, the tides are characterised by amplification of tidal range due to the shallow bathymetry over the North West Shelf and complex hydrographic and topographic features. The tide levels recently analysed from data near the project site indicates that the mean spring tide range exceeds 3.5 m and the maximum tide range is ≈ 5.1 m.

The northwest shelf of Western Australia experiences waves generated from three primary sources: Indian Ocean swell, locally generated wind-waves and tropical cyclone waves. Along the shoreline the ambient (non-cyclonic) wave climate is generally mild. In dry season months low amplitude swell originating in the Indian Ocean propagates to the site and occurs in conjunction with locally generated sea waves of short period (<5 s). In the wet season the wave climate is locally generated sea waves from the southwest. In general, the significant wave height is dominated by locally generated sea conditions within the range of 0.5m to 1m at short wave periods ($T_p < 5$ s). Measured data from an ADCP instrument deployed approximately 15km offshore for the project has been analysed to characterise the wave conditions in the wet and dry seasons as shown in **Figure 6**.

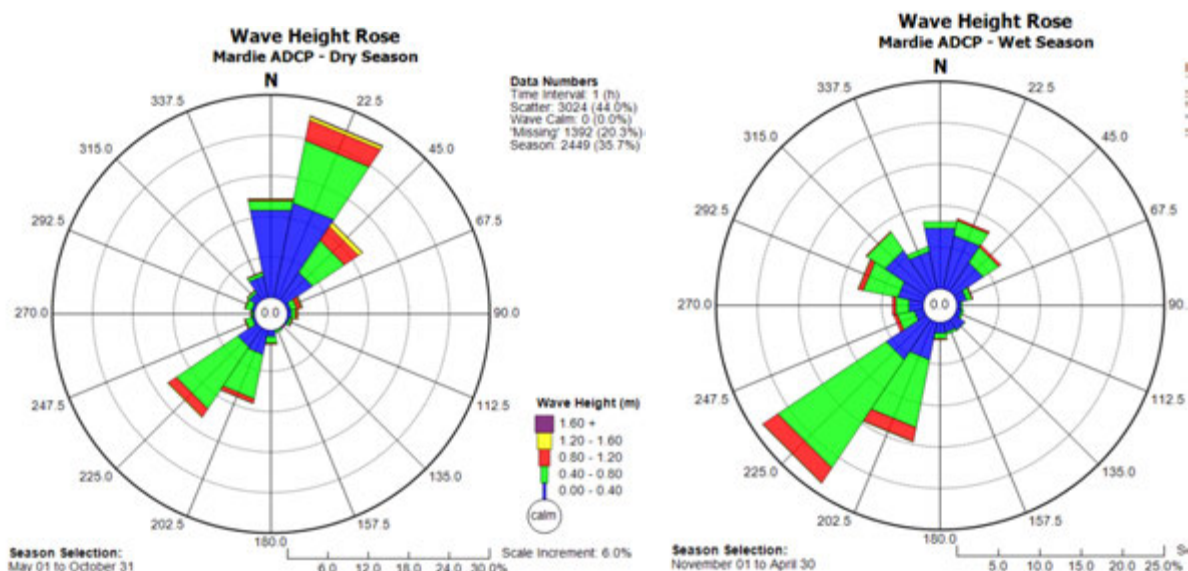


Figure 6 Wave high and direction recorded offshore of the Mardie project location for Dry Season months (left) and Wet Season Months (right) based for the period April 2018 – January 2019.

Whilst the non-cyclonic ambient wave conditions are generally mild, in contrast the strong winds in a tropical cyclone can generate extreme wave conditions. It is noted that the offshore island features would provide some natural protection from extreme wave conditions depending on the direction of propagation. Extreme cyclonic waves contribute to the total water level through wave run-up which is the maximum vertical extent of wave uprush on a beach and is comprised of both wave set-up and swash. The impact of cyclonic waves on the study site is dependent on the prevailing water level conditions and direction of cyclone approach. If coincident with a spring tide and storm surge, waves could propagate beyond the typical position of the beach and induce erosion of the shoreline as well as sediment transport.

Tropical cyclones are typically associated with heavy rainfall prior to, during and after the landfall of the system, which can lead to catchment flooding. The elevation in coastal water levels caused by the storm tide and wave processes can also propagate into estuarine waterways. The peak flood levels within the waterways will be influenced by the combination of fluvial and ocean, and coastal based processes, the interaction of which is highly dependent on the timing of peak of each process and the specific bathymetry and topography of the catchment and the inlet.

2.1.1. Geomorphology

The geomorphology of the site is characterised by tidal creeks and a wide inner shelf region which have generally evolved in response to the ongoing tidal current forcing. Consequently, the nearshore bathymetry is very shallow. Immediately offshore of the Mardie coast are series of low-lying limestone reefs and islands that bound the area to the north and west. Rainfall in this environment is highly intermittent and it is likely that rainfall runoff occurs as sheet flow over the local drainage catchments that have relatively small catchment areas towards the tidal creek drainage network. Sediment is delivered periodically to the coast through networks of rivers and streams. Extreme water levels and waves and associated rainfall and runoff under cyclonic conditions would be a significant driver of geomorphic changes along the coast, leading to erosion and enhanced sediment transport processes (Eliot *et al.* 2013).

The primary mechanism for sediment transport in nearshore areas appears to be the tidal flows. The measured data from inshore shows a marginally stronger flood magnitude compared with the ebb, likely due to the shallow water and complex bathymetry which funnels water in on the flood tide between the reefs and islands. Based on measured data from inshore, the depth averaged velocity in spring tides is in the range of 0.3m/s to 0.5 m/s, whilst on the neaps the current speed is 0.2m/s to 0.3 m/s. Whilst the site is generally protected from swells, the sea waves and swell will contribute to nearshore and shoreline sediment transport processes

Sediment samples from the nearshore areas around the project site collected by O2Marine in 2018 and 2019 confirm the seabed composition is made up of predominantly sand fractions with varying degrees of fines. The samples collected from the seabed through the region of the proposed berth pocket and entrance channel showed fine fractions (silt and clay) of 20% to 30%. Further offshore (approximately 5km) the sediment sampling indicated the fine fractions reduced to less than 5% of the sample with the composition of the seabed sediment dominated by sand fractions.

2.1.2. Tide and Water Levels

The Mardie project location experiences a dominant semi-diurnal tide (two highs and two lows a day) and the tidal planes have been defined by the National Tide Centre (NTC) based on field measurements completed for the project in late 2018 (O2 Marine 2019). The Mardie Gauge (MardiLAT18) datum definition completed by the NTC shows that the offset between LAT and MSL is 2.75 m and the total tidal range is 5.185 m with tidal planes shown in **Table 4**. The mean tide range is 3.6 m in springs and 1m in neaps.

It is noted that the calculated tidal planes for Mardie are larger than for the nearest stations at Steamboat Island, Barrow Island Tanker Mooring and North Sandy Island likely as a result of the closer inshore location (O2Marine 2019).

Table 4 Mardie Tidal Planes (location 21.03572 S, 115.92766 E, National Tide Centre)

Tidal Planes	Elevation (m LAT)
HAT	5.185
MHWS	4.557
MHWN	3.226
MSL	2.75
MLWN	2.275
MLWS	0.943
ISLW	0.528
LAT	0

Measured data from an inshore Aquadopp in November 2018 is shown in **Figure 7** illustrating the water level time series through the spring and neap cycles. It is noted that the instrument could not measure tide levels below -2m MSL.

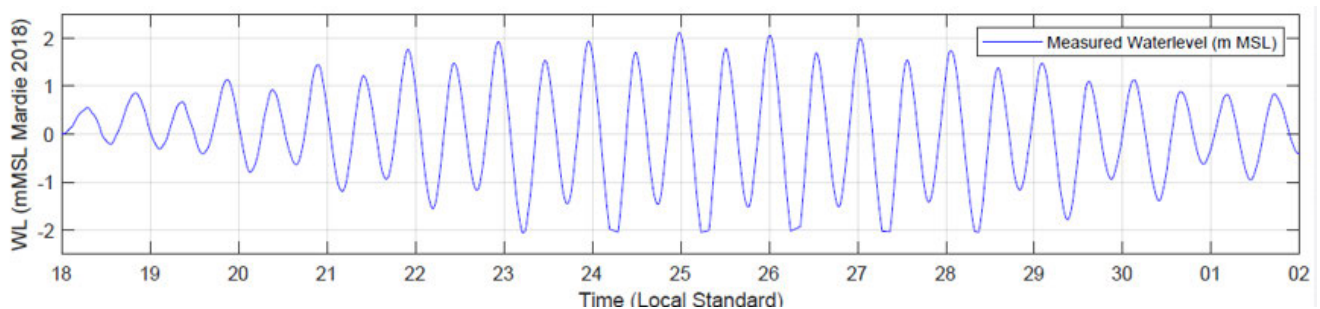


Figure 7 Measured water level data from inshore Aquadopp location November 2018

2.2. Marine Environmental Quality

The Pilbara Coastal Waters Consultation Outcomes (DoE 2006) assigned Levels of Ecological Protection (LEP) for the waters surrounding the Mardie Project area. Specifically, the nearshore marine waters surrounding the Mardie coastline, are assigned a 'Maximum' level of ecological protection to approximately 3-5km offshore, where the adjacent coastal waters are assigned a 'High' level of ecological protection (**Figure 8**).

These classifications infer that the "environmental condition for this area are essentially pristine, with no detectable change from natural background conditions and no effects on marine life as a result of waste inputs or contamination" (Department of Environment, 2006).

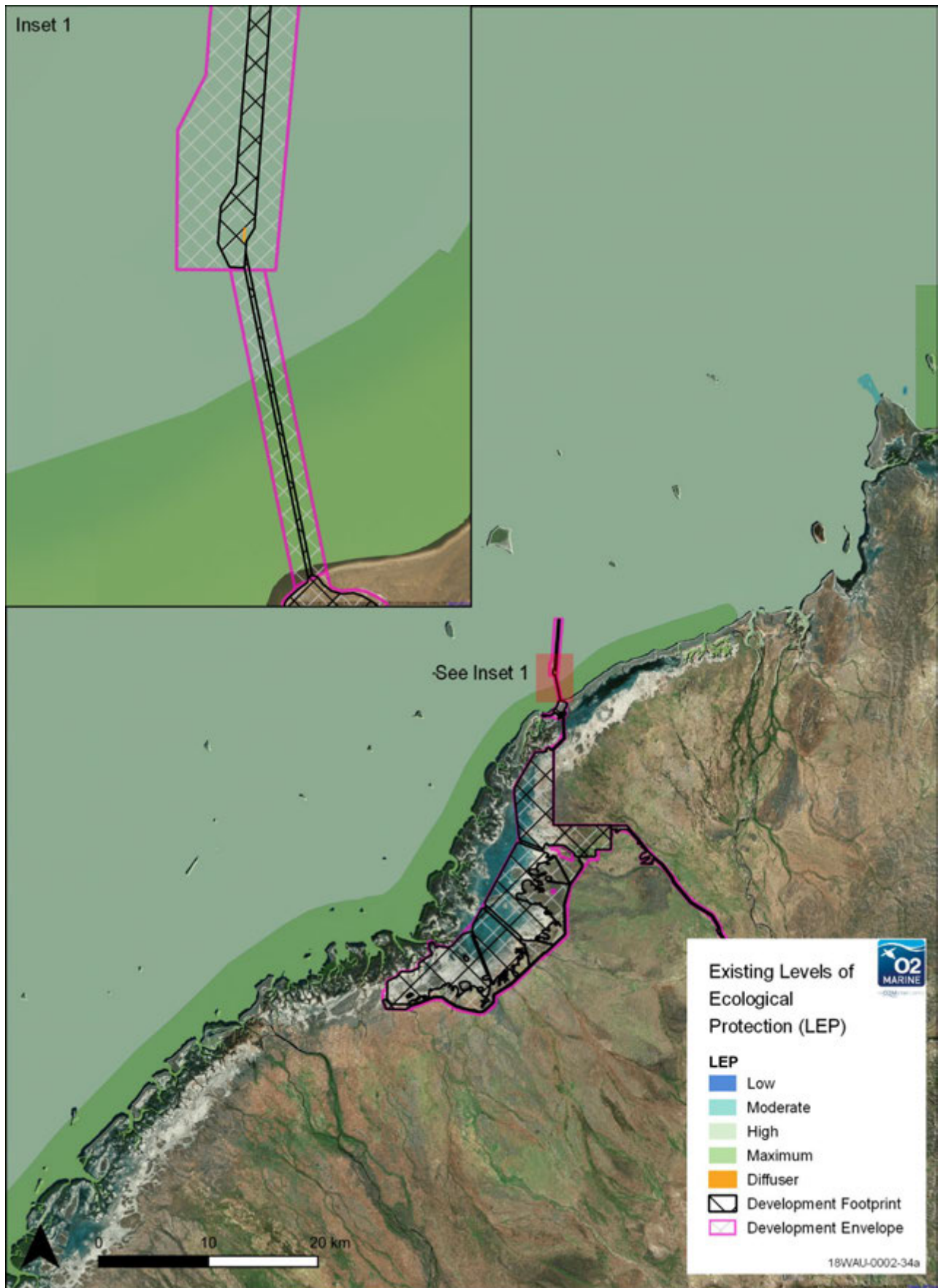


Figure 8 Current Levels of Ecological Protection in the Vicinity of the Mardie Project (Source: LEP Layer supplied by DWER in April 2019).

2.3. Water Quality Characteristics

2.3.1. Salinity

Variable salinity is common in nearshore waters of the west Pilbara (Pearce *et al.* 2003). During the summer monsoonal season, salinity may be impacted by freshwater flows from nearby Fortescue River, Robe River and local watercourses. No public data for salinity information is available in the immediate vicinity of the Project area. However, water quality studies of the nearshore Pilbara regions have shown surface water salinities to range between from 35.1 to 37.1 ppt (CALM 2005). Freshwater flow from nearby watercourses during the summer monsoon season has potential to reduce nearshore salinity in surface waters and increase salinities in bottom waters.

Within the Dampier Archipelago, surface salinity increases from inshore (about 36.7 ppt west of King Bay in March) to further offshore (about 35.5 ppt, around 35 km north of East Intercourse Island in March) (Pearce *et al.* 2003). Mermaid Sound displays a 'winter hydrographic regime' whereby cooler and more saline water forms within the Archipelago and wedges seaward beneath open North West Shelf waters. During summer, a 'summer hydrographic regime' is characterised by vertical stratification on the open continental shelf and elevated salinity in shallower coastal waters (Pearce *et al.* 2003).

Further south, Oceanica (2004) reported nearshore salinities around Hope Point on the eastern side of Exmouth Gulf as ranging from a minimum of 35.9 ppt to maximum of 42.7 ppt, with a median of 37.9 ppt. These results were also consistent with the findings of Ayuki and Miller (1998), which reported salinities around Hope Point as being approximately 2-3 ppt higher than the entrance to Exmouth Gulf.

2.3.2. Temperature

Studies in the area have demonstrated higher temperatures in inshore waters than offshore during summer, while the inverse is correct during winter (Pearce *et al.* 2003). Prior to commencement of baseline monitoring the project site at Mardie did not have seawater temperature data available, although the shallow inshore waters of nearby Cape Preston are known to produce highly variable temperature ranges from 18 °C in winter to 31.5 °C in the summer (CALM 2005). With a wide temperature range, some IMP species may be unable to survive or reproduce successfully.

2.3.3. Turbidity, Suspended Sediment & Light

Nearshore waters are often more turbid than deeper offshore waters at Mardie due to a variety of factors. Turbidity also varies temporally and at smaller localised scales. Tide is particularly influential on turbidity, which is naturally higher during spring than neap tides, due to increased current velocities (Jones *et al.* 2015). Large inshore areas of shallow, flat bathymetry are affected by wind driven waves and currents which easily resuspend fine sediments in the area. In addition, blooms of the cyanobacteria *Trichodesmium spp* occur commonly in the area which increases the turbidity of surface waters (Maunsell 2006; RPS 2008).

Marine water quality studies conducted at nearby Cape Preston have recorded turbidity from 0 – 23 NTU (URS 2007) and Suspended Sediment Concentration (SSC) between 1.2 – 48.1 mg/l (Maunsell 2006) and 2-10 mg/l (URS 2007).

MScience (2009) undertook a comprehensive study using 3 years (i.e. 2006 – 2009) of historic MODIS imagery to characterise baseline water quality (i.e. SSC, turbidity and light attenuation) for the nearshore coastal waters around Onslow, which included waters at the southern end of the Mardie Project area. The nearshore waters are described as encompassing waters up to 10 m depth, covering

mainly soft substrates, but including a ridge of scattered patch shoals that support corals and sponges, which is consistent with the subtidal BCH description of the Mardie Project area provided in O2 Marine (2019a). Overall, MScience (2009) found that light attenuation, turbidity and SSC were higher in summer (November–April inclusive) than in winter (May–October inclusive) and higher inshore than offshore. Calibrated MODIS imagery found inshore sites (as defined above) to have mean turbidity of 3.0 NTU, SSC of 5.3 mg/l and Light Attenuation of 0.20 E/m (MScience 2009). Median values for the same sites were 1.1 NTU, 3.2 mg/l SSC and 0.13 E/m Light Attenuation.

3. Methods

3.1. Water Quality Stations

Marine water quality baseline monitoring was conducted over a period between March 2018 to September 2019. A range of instruments were deployed on site to record in-situ physico-chemical parameters, each attached to purpose-designed seabed frames. **Table 5** presents the instruments used and the parameters they measure.

Table 5 Water Quality Station specifications

Instrument	Physico-chemical Parameters
In-Situ Marine Optics CTD	Electrical Conductivity Salinity Temperature Depth/Pressure
In-Situ Marine Optics MS9 Light logger	Photosynthetically Active Radiation (PAR) Temperature Depth/Pressure
WetLab NTUSB Nephelometric Turbidity Unit	Turbidity (NTU)

The frames are designed to stand upright on the seabed, while maintaining the instruments at approximately 0.3 m above the seafloor and to reduce the likelihood of interaction of sensors with sediment, large rocks and rubble on the seafloor. An example of the monitoring station configuration is seen below in **Figure 9**.

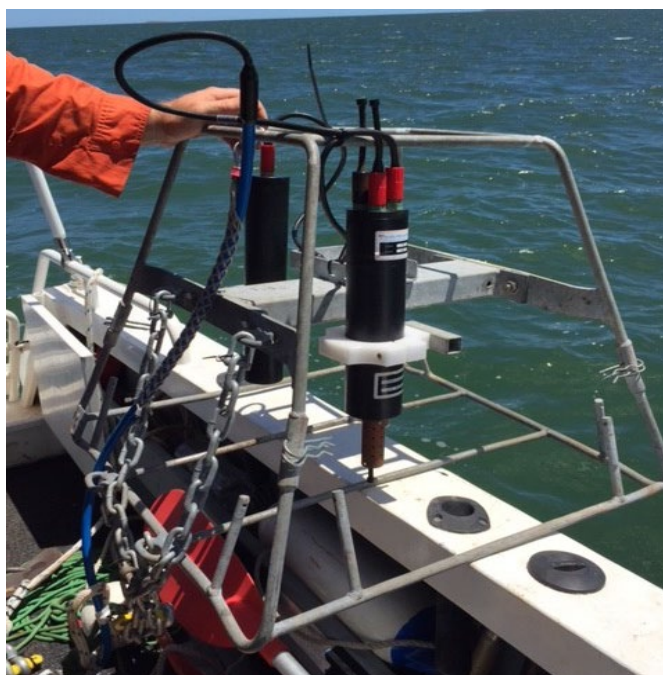


Figure 9 Example of Water Quality Instrument Frame deployed at inshore monitoring location with IMO-CTD instrument

3.2. Monitoring Location

The deployment location for each monitoring station is presented in **Table 6** and in **Figure 10**.

Table 6 Mardie water quality monitoring locations and instrumentation

Instrument	Parameters	Latitude	Longitude	Details	Deployment Period
IMO-CTD	Temperature (°C) Salinity (ppt) Depth (m)	21 ° 02.200 S	115° 55.576 E	Inshore Location (Diffuser - First Location)	March 2018 – August 2018
IMO-CTD	Temperature (°C) Salinity (ppt) Depth (m)	21 ° 02.208 S	115° 55.548 E	Inshore Location (Diffuser - Second Location)	August 2018 – September 2019
WetLab NTUSB	Turbidity (NTU)	21° 02.244 S	115°55.710 E	Inshore Location (Diffuser - Second Location)	November 2018 – September 2019
WetLab NTUSB	Turbidity (NTU)	20° 55.833 S	115° 57.167 E	Offshore Location (End of transshipment channel)	November 2018 – March 2019 July 2019 – September 2019
IMO-MS9	PAR Depth (m) Temperature (°C)	20° 55.833 S	115° 57.167 E	Offshore Location (End of transshipment channel)	December 2018 – August 2019
IMO-MS9	PAR Depth (m) Temperature (°C)	21° 02.244 S	115°55.710 E	Inshore Location (Diffuser - Second Location)	December 2018 – August 2019

3.3. Deployment Period

The deployment period for each instrument / location are shown in **Table 6**. The monitoring deployment period varied for each instrument and locations due to changing Project elements and priorities as outlined in **Section 1.2**.



Figure 10 Water Quality Monitoring Locations

3.4. Water Quality Instrument Maintenance & Calibration

Regular (i.e. every 6 – 8 weeks) maintenance and data download was required to ensure data was not compromised through biofouling of the sensors or failed batteries. Maintenance, calibration checks, battery replacement and data download/backup were carried out in line with manufacturer specifications and QAQC protocols. Where calibration checks were not satisfactory, a new calibration was performed as per manufacturer specification. Each maintenance service involved retrieval of the frame onto land, maintenance carried out and then redeployment usually occurring within a 24-hr period. Water quality instrument frames were deployed and retrieved using the commercial vessel *Freedom II*.

A schedule of trips undertaken at Mardie throughout the monitoring period related to water quality station deployment, retrieval and maintenance is included in **Table 7** below.

Table 7 Dates and works conducted relating to the water quality station in-situ at Mardie

Field trip	Dates	Objective
1	14-Mar-2018	Water Quality Station Deployment
2	5-Apr-2018	Retrieval, deployment. Maintenance, calibration and data recovery
3	25-May-2018	Retrieval, deployment. Maintenance, calibration and data recovery
4	28-Aug-2018	Unable to retrieve instrument, as monitoring equipment was missing, presumed stolen. New WQ Station was deployed and moved to a new location without telemetry buoy.
5	24-Oct-2018	Retrieval. Maintenance, calibration and data recovery
	27-Oct-2018	Deployment.
6	7-Nov-2018	Retrieval, Maintenance, calibration and data recovery
7	15-Dec-2018	Retrieval. Maintenance, calibration and data recovery
	18-Dec-2018	Deployment
8	24-Jan-2019	Retrieval. Maintenance, calibration and data recovery
	26-Jan-2019	Deployment
9	2-March-2019	Retrieval. Maintenance, calibration and data recovery
	3-March-2019	Deployment
10	15-May-2019	Retrieval. Maintenance, calibration and data recovery
	16-May-2019	Deployment
11	8-July-2019	Retrieval. Maintenance, calibration, data recovery and redeployment
12	9-Sep-2019	Retrieval. Maintenance, calibration, data recovery and demobilisation of equipment

3.5. Marine Water Sampling

Marine water samples were collected from the surface 0.5 m during two field campaigns from the Inshore Monitoring Location; one on the 16th January 2019, and one on the 3rd March 2019. Samples were sent to a NATA accredited laboratory and analysed for the following;

- > Alkalinity and Hardness;
- > Nutrients;
- > Total Recoverable Hydrocarbons (TRH);

- > Total Petroleum Hydrocarbons (TPH);
- > BTEXN;
- > Total Organic Carbon (TOC);
- > Dissolved Major Cations and Anions;
- > Dissolved Metals; and
- > Fluoride.

3.6. Data analysis

Subsequent to the download of data, preliminary data QA/QC checks were undertaken to assess the data integrity and ensure the instrument was operating correctly. The dataset was examined for outliers by scanning for any anomalous recordings, and prolonged identical or unrealistic elevated readings. All rejected data were retained for quality assurance and quality control (QA/QC) purposes. All available QA/QC checked data was compiled from the various downloaded events. Outliers, irrelevant and erroneous data points (e.g. data recorded after retrieval/before deployment or data affected by biofouling) were identified and removed from the dataset.

3.6.1. Water Depth, Temperature & Salinity

All data was plotted and examined. Temperature and salinity datasets underwent statistical analysis to determine monthly and seasonal means, medians, minimums, maximums, as well as 20th and 80th percentiles. Data was also compared to meteorological and tidal data collected for the baseline periods to identify natural trends at the monitoring stations.

3.6.2. Light & Turbidity

Light and turbidity data were analysed to calculate mean, median, 80th, 95th and 99th percentile values for the monitoring period to date.

O2 Marine (2019a) identified that coral benthic communities and habitat was at most risk from indirect dredging related impacts. Therefore, the baseline light and turbidity data was further analysed to enable comparison against recently published WAMSI thresholds for coral mortality described in Jones *et al.* (2019). Jones *et al.* (2019) published a complete hazard profile for running means enabling comparison against 1 day – 30 day running mean threshold values, however, Jones *et al.* (2019) notes that the 14-day running mean showed the strongest relationships with the probability of non-zero coral mortality for both turbidity and light stress. Therefore, for the purpose of preliminary comparison of baseline data against these threshold values, only the 14-day running mean threshold has been evaluated.

To enable comparison of baseline light data against the Jones *et al.* (2019) coral thresholds, the Photosynthetically Active Radiation (PAR) measurements ($\mu\text{Mol}/\text{m}^2/\text{sec}$) from the IMO-MS9 logger were converted to a Daily Light Integral (DLI) ($[\text{mol}/\text{m}^2]/\text{day}$) and a 14-day rolling mean DLI was calculated to enable direct comparison against the thresholds.

To enable comparison of baseline turbidity data against the Jones *et al.* (2019) coral thresholds, turbidity data was converted to SSC using the surrogate correlation coefficient (i.e. 1 NTU : 1.1 mg/L SSC), that was derived via linear correlation of NTU and SSC from a recent dredging project offshore of Onslow (Fisher & Jones 2019) and a 14-day rolling mean turbidity and SSC was calculated to enable direct comparison against the thresholds. Turbidity data was not recorded at the offshore site between the 28th July 2019 to 10th July 2019, due to water ingress and instrument failure.

The 14-day rolling mean for both DLI and SSC were compared against the Jones *et al.* (2019) 14-day rolling mean thresholds for possible effects (DLI = 2.5 [mol/m²]/day; SSC = 11.7 mg/l) and probable effects (DLI = 1.1 [mol/m²]/day; SSC; 18.0 mg/l) on corals. Laboratory Results

Laboratory derived results were compared against the ANZG (2018) Marine Water Quality Guidelines.

4. Results and Discussion

4.1. Physico-chemical Parameters

Results from the IMO-CTD (Temperature, Depth & Salinity), IMO-MS9 Light logger (Daily Light Integral, Water Temperature & Depth) and *WetLab* NTUSB (Nephelometric Turbidity Units) are presented below.

Data gaps were experienced for two periods across the monitoring program. The gap experienced for the period 30 Apr to 26 May 2018 was due to excessive biofouling on the logger sensors, while the data gap experience for the period 26 June to 28 August 2018 was due to equipment theft, making download of the recorded data impossible.

4.1.1. Water Depth

The annual variability in depth was recorded at the inshore location between March 2018 and February 2019 and at the offshore location between December 2018 and February 2019 and are presented in **Figure 11** and **Figure 12** respectively. Bi-monthly peaks and troughs in the data indicate large tidal range and correspond with spring tide periods and neap tide periods, respectively. The amplitude of the spring tides in the area of approximately 4.5 m (O2 Marine 2018) was reflected in depth changes at both monitoring locations.

Due to deployment and retrieval occurring multiple times over the survey period, average depth (~ 6.5 m) at the inshore monitoring locations changed slightly over the course of the year. The inshore location was also relocated to the revised outfall location (~6m) on the 28th August 2018. The average depth of the offshore location was approximately 11 metres.

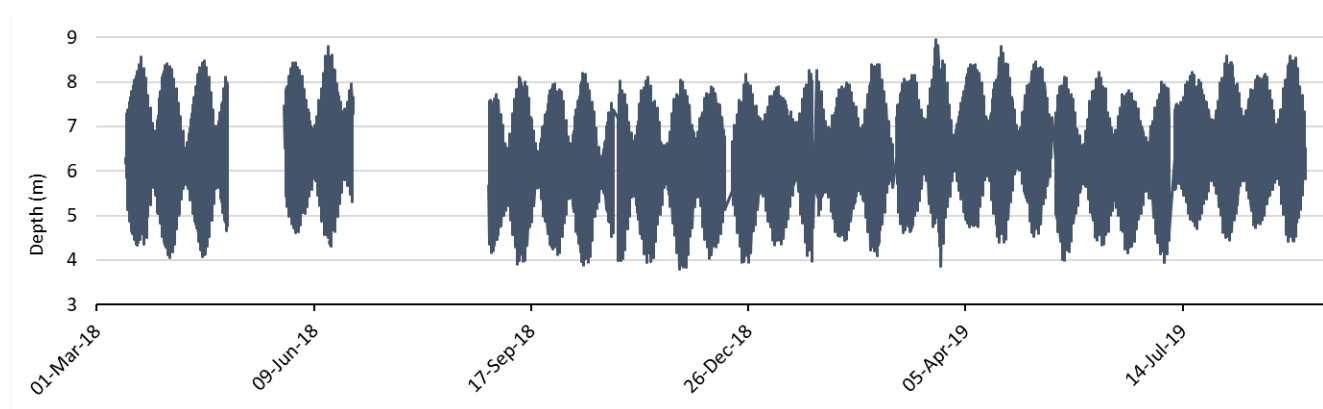


Figure 11 Depth (m) recorded by the IMO-CTD at the inshore water quality monitoring location

The increase in depth range (8.5 - 14 m) at the offshore monitoring location between the 21st to the 26th of March 2019 was likely linked to sudden changes in barometric pressure due to the passing of TC Veronica (**Figure 13**).

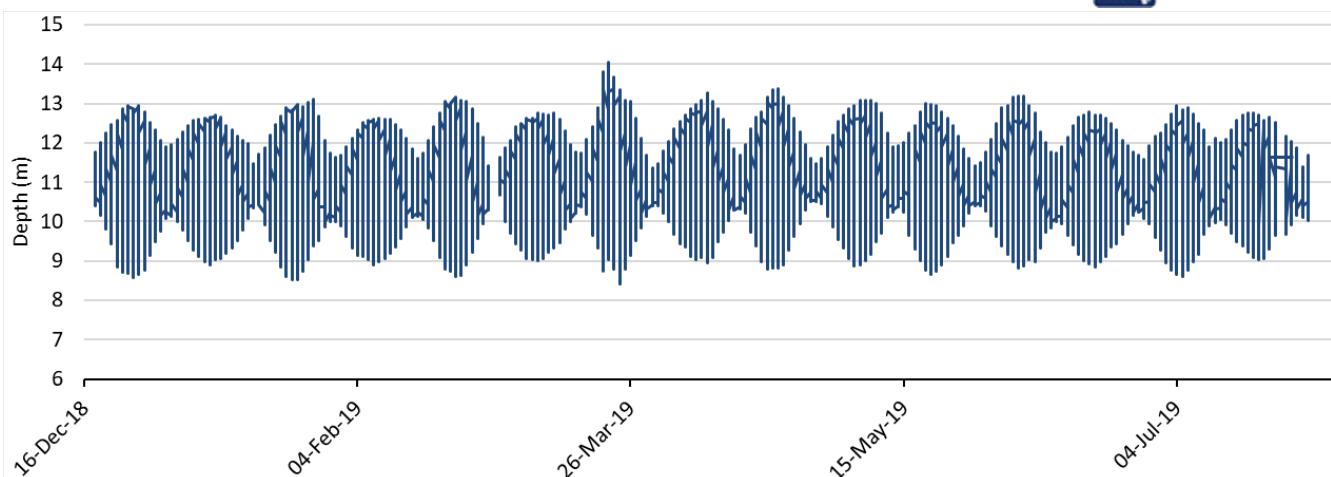


Figure 12 Depth (m) recorded by the IMO-MS9 instrument at the offshore monitoring location

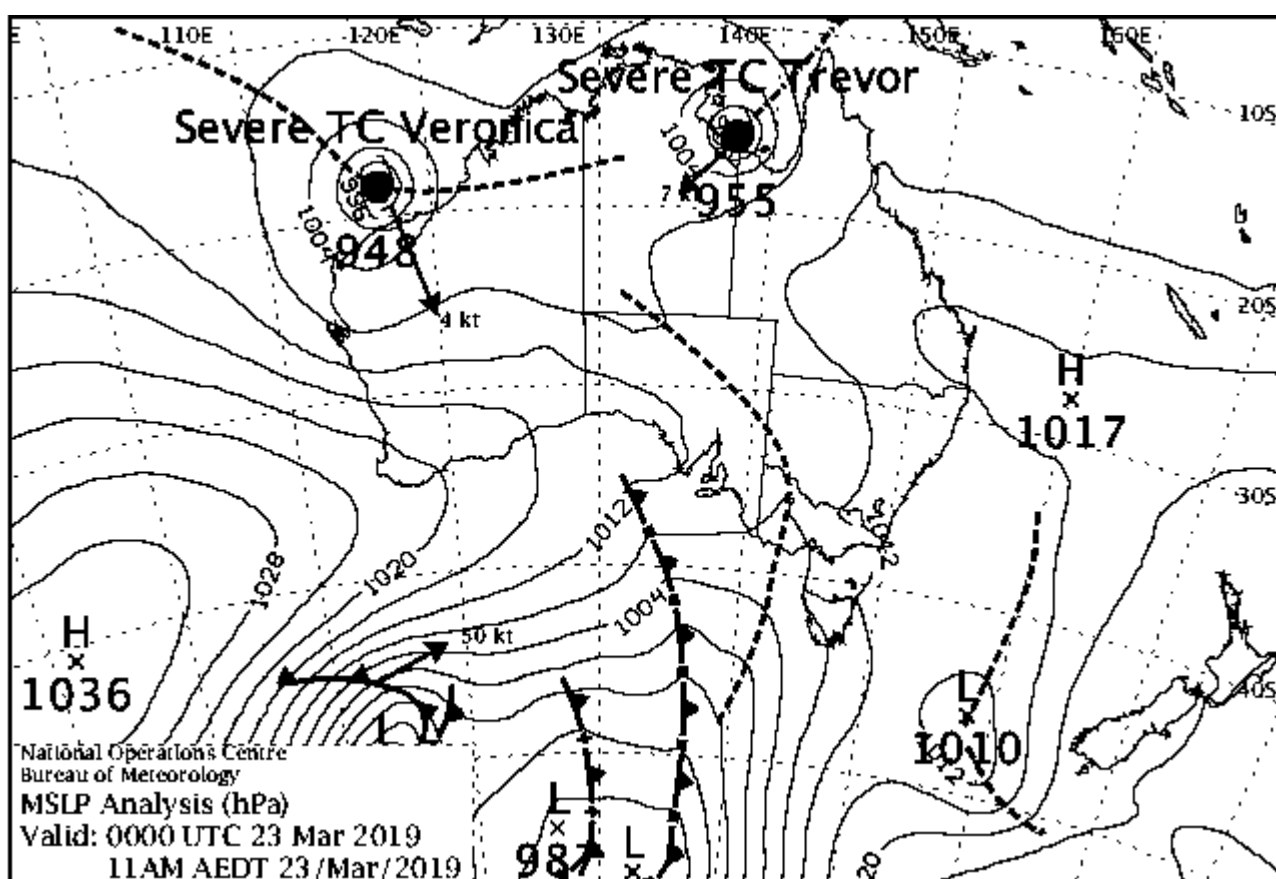


Figure 13 TC Veronica passing project site on the 23rd March 2019 causing decrease in local barometric pressure.

4.1.2. Temperature

Temperature was recorded at the inshore monitoring location from 14th March 2018 to 8th September 2019 and offshore monitoring location from 18th Dec 2018 to 2nd August 2019 and are presented in **Figure 14** and **Figure 15** with summary statistics provided in **Table 8**.

Lowest temperatures at the inshore location were recorded during the dry season (range 18-26 °C), with the highest recorded during the wet season (range 22-33 °C). Temperature variability at the offshore location was lower than at the inshore location, however the sampling period for temperature

was at the offshore location was limited to approximately 8 months, compared to the inshore location which sampled a full annual cycle. Lower variability in temperature at the offshore location in comparison to the inshore location is likely explained by the greater influence of oceanic water at the offshore site and greater depth of the instrument. Deeper oceanic waters are generally less influenced by diurnal temperature variation than shallower inshore waters (Pearce *et al.* 2003).

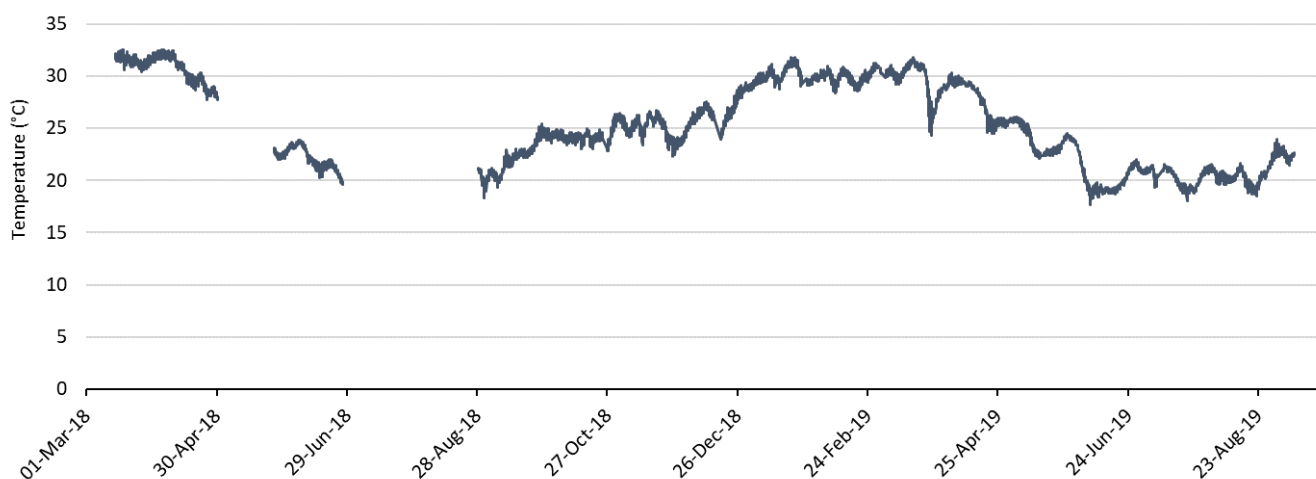


Figure 14 Temperature data recorded In-situ at the Inshore Monitoring Location (Outfall)

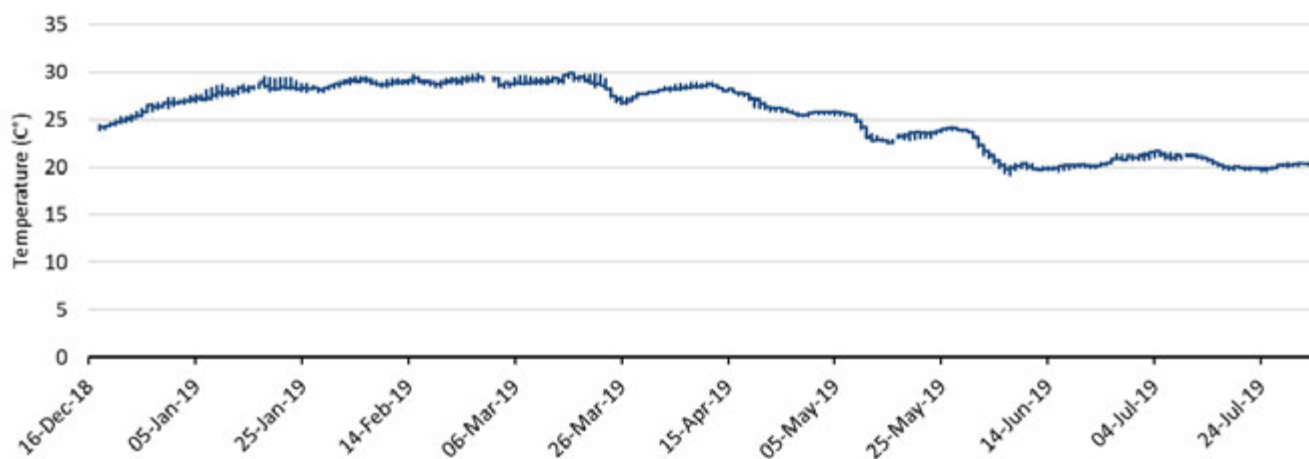


Figure 15 Mean daily temperature data recorded In-situ at the Offshore Monitoring Location (ADCP)

Table 8 Summary Water Temperature Statistics recorded from the Inshore & Offshore Monitoring Locations

Season	Month	Location	Median	Maximum	Minimum	20th Percentile	80th Percentile	95th Percentile
Dry	May	offshore	23.81	25.88	22.56	23.19	25.56	25.75
	May	inshore	22.97	26.08	21.97	22.45	24.45	25.84
	Jun	offshore	20.19	23.06	19.25	19.88	20.94	21.81
	Jun	inshore	21.63	23.89	17.70	20.30	23.23	23.67
	July	offshore	20.75	21.69	19.56	20.00	21.19	21.44
	July	inshore	20.49	21.52	18.01	19.36	21.05	21.31
	Aug	offshore	20.31	20.44	20.25	20.31	20.38	20.44

Season	Month	Location	Median	Maximum	Minimum	20th Percentile	80th Percentile	95th Percentile
Wet	Aug	inshore	20.47	23.96	18.35	19.84	21.06	22.24
	Sep	inshore	22.39	25.37	18.96	21.00	23.31	24.46
	Oct	inshore	24.20	26.33	22.81	23.77	24.56	25.41
	Nov	inshore	25.13	26.70	22.38	24.07	25.91	26.24
	Dec	offshore	25.31	27.25	23.88	24.56	26.44	26.69
	Dec	inshore	26.50	29.35	23.68	25.62	28.06	28.92
	Jan	offshore	28.19	29.44	26.44	27.38	28.63	29.13
	Jan	inshore	29.87	31.81	28.66	29.46	30.78	31.24
	Feb	offshore	29.00	29.75	28.50	28.81	29.25	29.44
	Feb	inshore	29.90	31.25	28.41	29.37	30.38	30.81
	Mar	offshore	28.94	29.94	26.69	27.69	29.38	29.63
	Mar	inshore	31.29	32.50	24.30	30.70	31.69	32.03
Dry	Apr	offshore	27.94	28.94	25.31	26.00	28.50	28.75
	April	inshore	29.95	32.54	24.45	28.59	31.81	32.22
	Dry	offshore	21.06	25.88	19.25	20.06	23.69	25.63
	Wet	offshore	28.44	29.94	23.88	26.88	29.06	29.38
	Dry	inshore	22.00	26.33	17.70	20.40	23.57	24.67
	Wet	inshore	30.09	32.54	22.38	28.32	31.57	32.07
	Overall	offshore	26.69	29.94	19.25	21.06	28.81	29.31
	Overall	inshore	26.92	32.54	17.70	21.89	31.03	31.94

Note – Offshore location was only deployed between December 2018 and August 2019.

4.1.3. Salinity

Salinity was recorded at the inshore monitoring location from 14 March 2018 to 8th September 2019 and is presented in **Figure 16** and summary statistics are provided in **Table 9**. Salinity showed intra-daily variability with negligible seasonal patterns observed in the dataset.

The salinity conditions (i.e. median salinity of ~37.5 psu) recorded at the inshore monitoring location for the dry and wet seasons has a comparable salinity range (36.6 - 38.3 psu), but slightly higher than the salinity range (i.e. 35.1 to 37.1 ppt) previously reported by CALM (2005) for the coastal Pilbara region, with nearshore waters (i.e., <2 km) exhibiting a greater range and higher overall salinities. Monitoring of nearshore salinity for the eastern side of Exmouth Gulf reported a salinity range of 35.9 - 42.7 ppt (Oceanica, 2004). The metahaline salinity conditions reported at Mardie appear to have characteristics of a sheltered bay/ partially enclosed waters, which have limited exchange with lower salinity oceanic currents.

Hydrodynamic modelling undertaken by Baird (2019) found that due to the alignment of the island and reef features of the Passage Islands the majority of incoming tidal flow on the flood tide is directed through the gap between Scholl Island and Mardie Island, approximately 10 km to the north of the inshore monitoring location. Seawater exchange from the open ocean to the inshore region in the vicinity of the project marine facility is therefore influenced by this constraint of flows around the

Passage Islands, which is likely to affect the rate of mixing with the open ocean (Baird, 2019). It is therefore possible, that restricted mixing with lower salinity oceanic currents, combined with high evaporation rates and very little freshwater runoff to the nearshore waters has contributed to creation of a higher salinity environment in the vicinity of the inshore monitoring location.

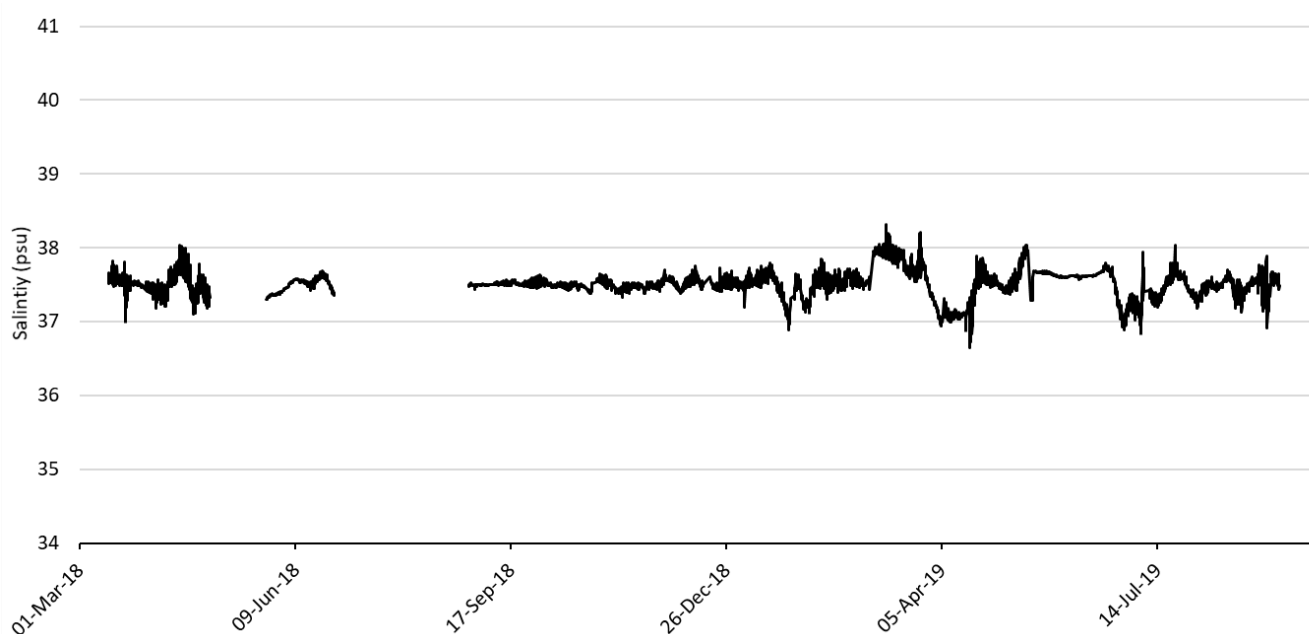


Figure 16 Salinity data recorded In-situ at the Inshore Monitoring Location (Outfall)

Table 9 Summary Salinity (psu) Statistics recorded from the Inshore Monitoring Location

Season	Month	Median	Maximum	Minimum	80th percentile	95th percentile	20th percentile
Dry	May	37.49	38.04	37.29	37.67	37.86	37.36
	June	37.55	37.80	36.89	37.62	37.67	37.46
	Jul	37.40	38.04	36.85	37.60	37.71	37.29
	Aug	37.49	37.77	37.12	37.55	37.62	37.42
	Sep	37.50	37.89	36.91	37.55	37.62	37.49
	Oct	37.49	37.64	37.38	37.53	37.58	37.46
Wet	Nov	37.48	37.70	37.32	37.53	37.58	37.44
	Dec	37.51	37.75	37.38	37.57	37.62	37.46
	Jan	37.52	37.79	36.89	37.61	37.70	37.34
	Feb	37.52	37.85	37.13	37.61	37.70	37.45
	March	37.54	38.31	37.01	37.66	37.96	37.48
	April	37.44	38.03	36.64	37.62	37.76	37.31
Wet		37.51	38.31	36.64	37.61	37.82	37.39
Dry		37.52	38.04	36.85	37.61	37.67	37.41
Overall		37.51	38.31	36.64	37.61	37.75	37.40

4.1.4. Rainfall

Rainfall data for the monitoring period was retrieved from BOM (2020) for Mardie (station number: 5008) and is presented below in **Figure 17**. Five main rain events were recorded during the monitoring period. The highest rain fall event was recorded on the 6th June 2018 with over 30 mm precipitation and high salinity and low temperature values were also observed for this period. This event was related to a large low-pressure system approaching Western Australia (**Figure 18**) and occurred outside of the characteristics wet season for the Pilbara region which is from Nov to April. The remaining four rain events were recorded within the typical wet season period (i.e. end of March 2018 and between January and February 2019) and ranged from 4 to 8 mm precipitation. Rainfall on the 26th of January was associated with TC “Riley” (**Figure 22**). Several smaller rainfall events were recorded in the latter half of the wet season in early 2019 as well as the early part of the 2019 dry season.

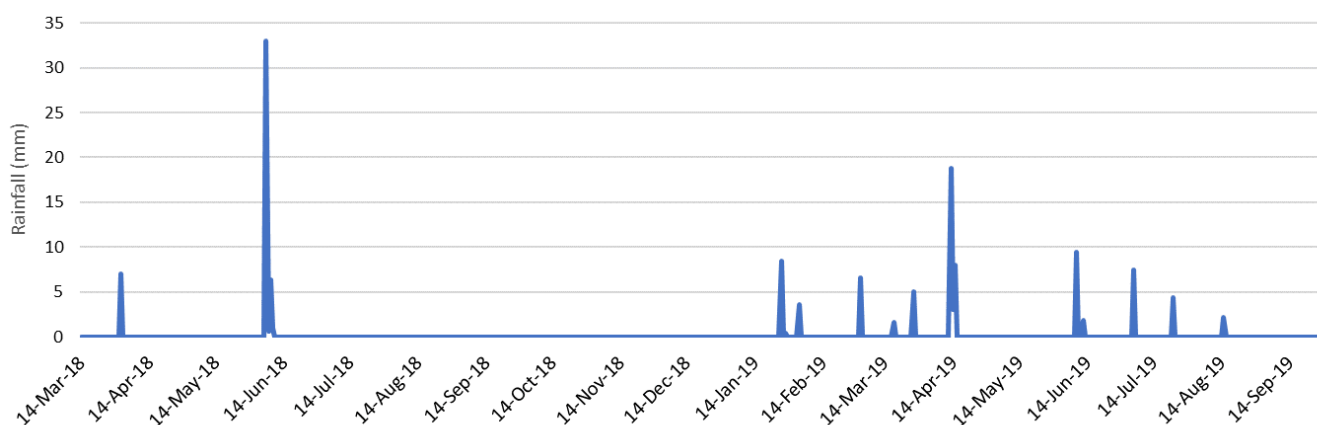


Figure 17 Daily Rainfall data for Mardie (www.bom.gov.au).

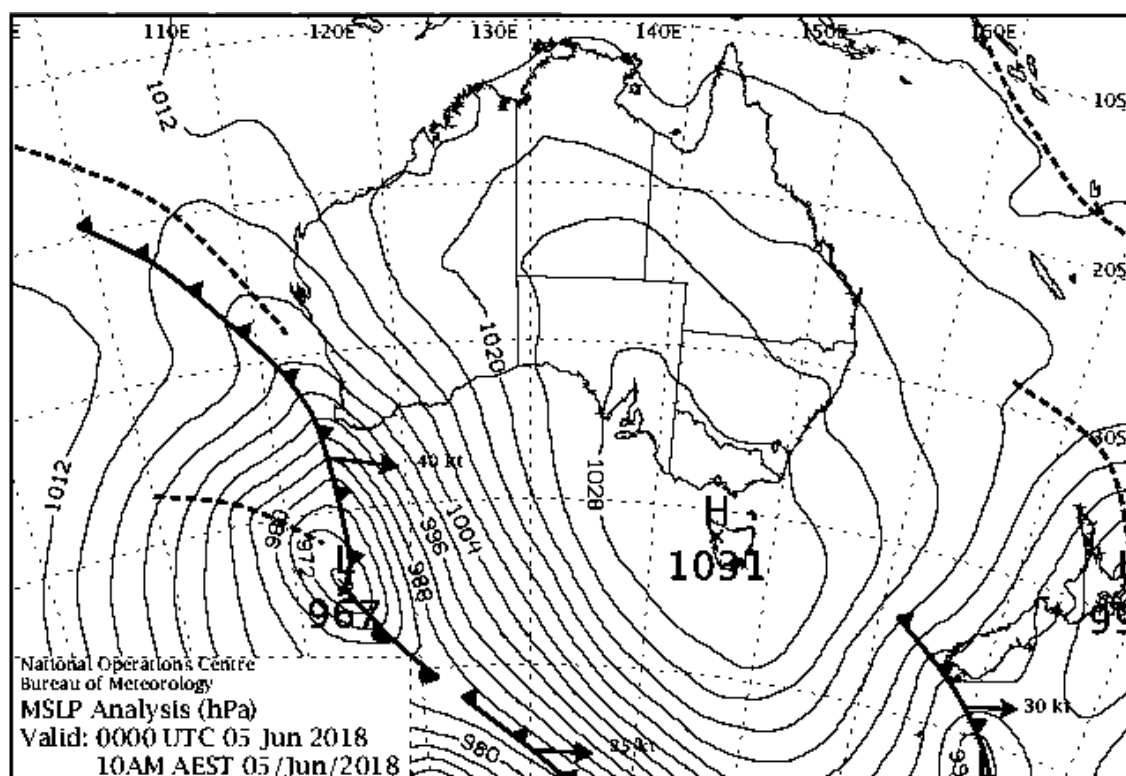


Figure 18 Low pressure system approaching WA coast on 05 June 2018 (www.bom.gov.au)

4.1.5. Light

Light data was collected from the inshore monitoring location between 19th Dec 2018 - 3rd Aug 2019 (**Figure 20**) and the offshore location between 19th Dec 2018 - 3rd Aug 2019 (**Figure 21**). Light data is presented as a DLI (Daily Light Integral) using units of ([mol/m²]/day) and compared against the DLI thresholds for coral defined in Jones *et al* (2019). Summary statistics for DLI are presented in **Table 10**.

Light levels are significantly affected by water depth due to absorption, refraction and diffraction through the water column (Jones et al. 2019). Despite the greater depth of the offshore site (11 m) than the inshore site (6 m), higher light levels were recorded on the seabed offshore for most of the monitoring period. This is supported by general field observations of higher water clarity offshore than inshore.

Light levels in coastal waters are typically influenced by the amount of suspended sediment/turbidity present through the water column, which can be driven by a variety of environmental and oceanographic factors, including wind, sea, swell height and period, terrestrial runoff, tides and sediment characteristics amongst others (CSIRO, 2006). DLI recorded at both the inshore and offshore locations for typically identifies highest levels during neap tides and lowest during spring tides when compared with the results from the IMO-MS9 pressure/depth data (**Figure 11**).

Seasonal trends in light levels were observed at the offshore site while a trend was less apparent at the inshore site. During the wet season, the offshore site had higher light levels, while the inshore site had slightly lower light levels. The wet season is generally associated with increased runoff, westerly winds and eastward currents at Mardie, while the dry season is associated with easterly winds, westward currents and longer period swell. While these factors have a significant impact on the inshore shallower site, seasonal trends in seabed light levels at the offshore site seem to be largely driven by the change in angle of solar elevation (**Figure 19**). This influences the angle at which light penetrates the water column, with greater light absorption and diffraction occurring at a greater angle of incidence. Therefore, a lower level of light is observed at the seabed during the dry season (winter) when the solar elevation is lowest and vice-versa. This effect is more pronounced at the deeper offshore site while other seasonal factors such as cyclones and drive changes in seabed light levels at the inshore site.

At the offshore site, the DLI recorded ranges between 0 - 16.5 (mol/m²)/day, with the maximum recorded on the 16 January 2019 and the minimum recorded on 28th January, 21st of March, 11th April, 17th May, 3rd June and 28th July 2019. The maximum DLI for the inshore sites was recorded on 9th July 2019 and the timing of several of the extended light minimum events corresponded with those listed for the offshore site. One period of low light coincided with TC Veronica approaching the coast on the 21st of March (**Figure 13**) and the other coincided with the low pressure system on the 3rd of June 2019 (**Figure 18**). **Figure 17** additionally indicates 8.4 mm of rainfall received on the 26 January, which was associated with TC Riley and may have also contributed to the low DLI measured during this period. This event was reflected in the corresponding turbidity maximums shown in **Figures 23, 24, 25 & 26**.

Table 10 Summary Statistics for Daily Light Integral ([mol/m²]/day) measured at light monitoring locations

Monitoring Location	Parameter	Mean	Median	20th Percentile	80th Percentile	95th Percentile	99th Percentile
Offshore	DLI ([mol/m ²]/day)	3.18	1.87	0.92	5.49	9.81	13.74
Inshore	DLI ([mol/m ²]/day)	1.06	0.87	0.16	1.75	3.05	4.21

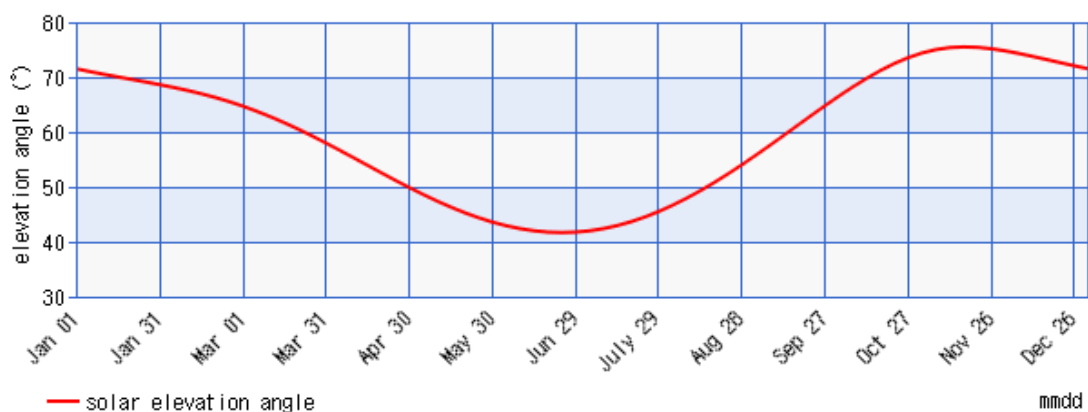


Figure 19 Solar elevation angle at 1200 (midday) at Mardie, WA over a full annual cycle (source: keisan.casio.com).

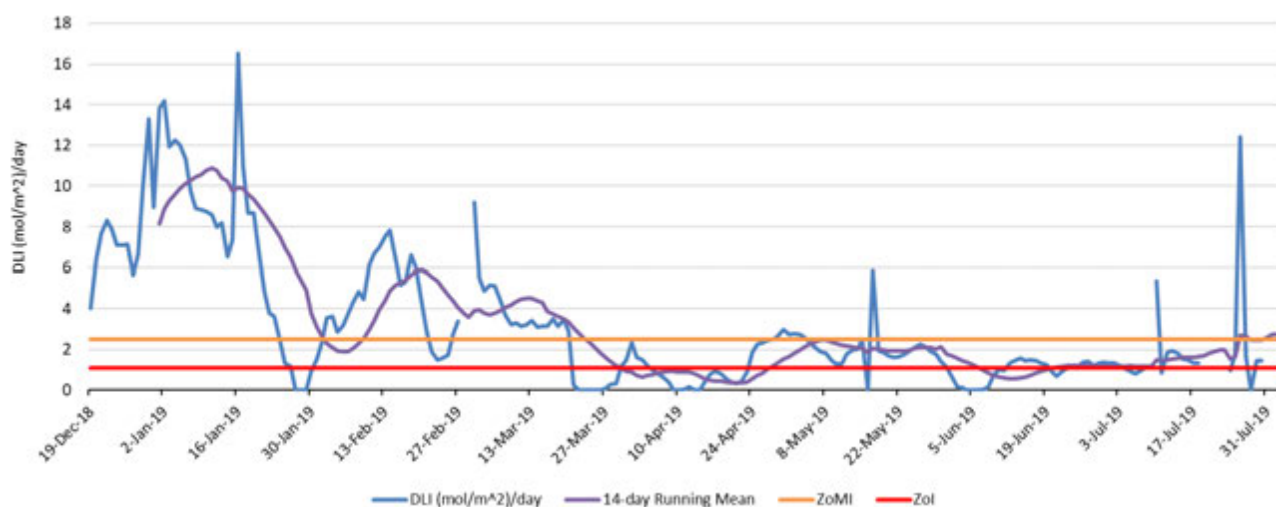


Figure 20 Daily Light Integral (DLI) for the offshore monitoring site with 14-day running mean, as well as Jones et al. (2019) defined thresholds for Possible and Probable Effects on Coral.

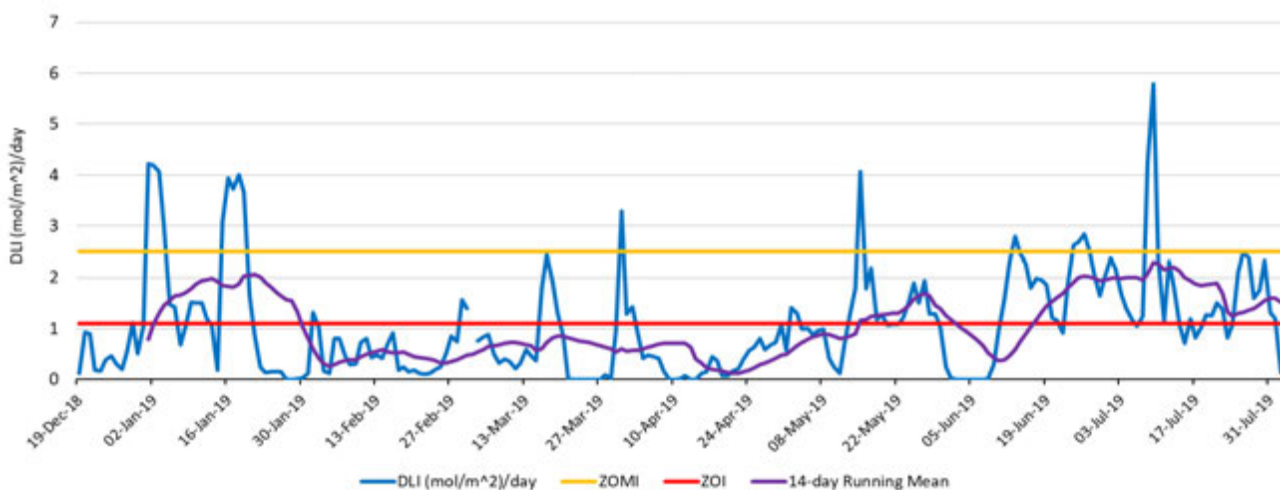


Figure 21 Daily Light Integral (DLI) for the inshore monitoring site with 14-day running mean, as well as Jones et al. (2019) defined thresholds for Possible and Probable Effects on Coral

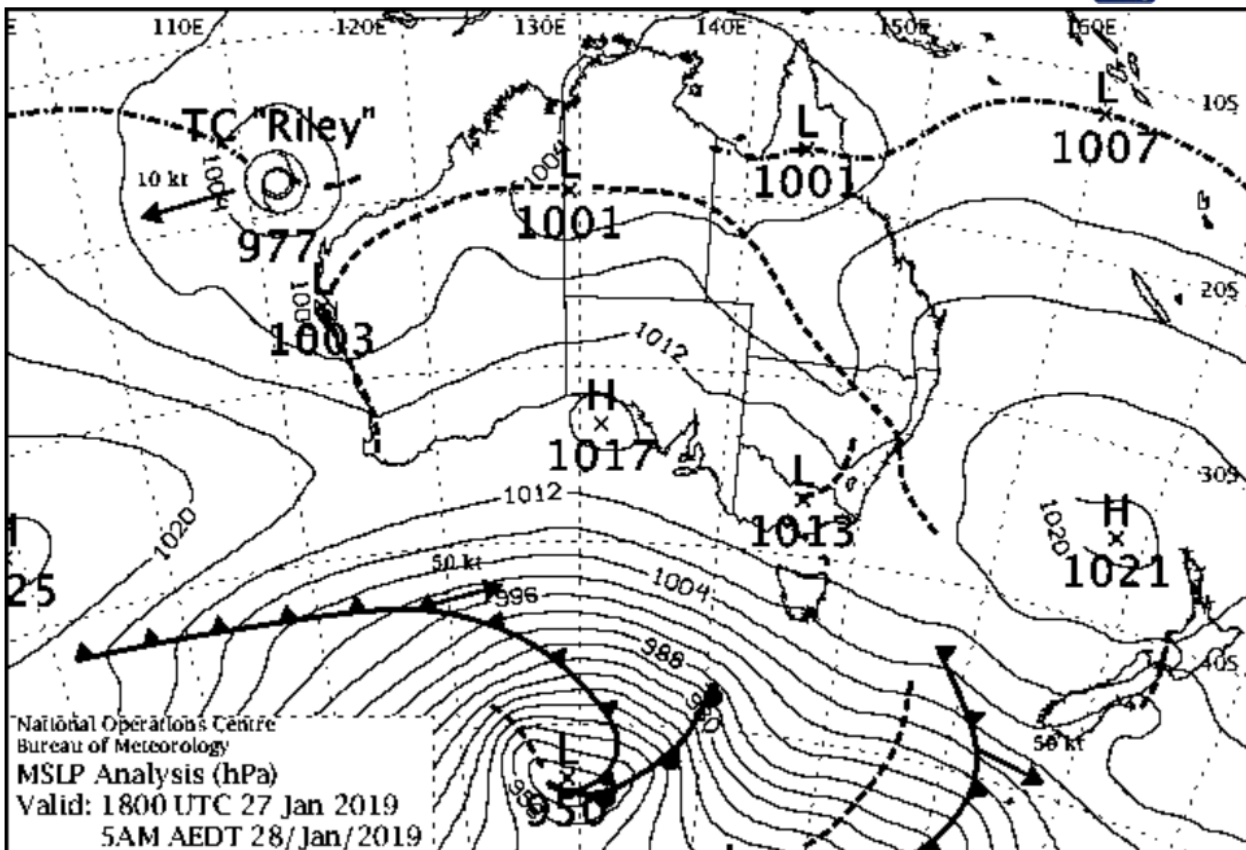


Figure 22 Synoptic chart showing TC “Riley” passing the Mardie project site on the 27/01/2019 (www.bom.gov.au)

In consideration of recent WAMSI (Jones *et al.* 2019) recommendations, the 14-day rolling DLI mean was compared with the DLI thresholds for probable and possible effects on coral. At both inshore and offshore locations, the 14-day rolling mean consistently breached the threshold of Probable effects (1.1 [mol/m²]/day) and the less conservative threshold of Possible effects (2.5 [mol/m²]/day) (**Figure 20 & Figure 21**). However, during the wet season DLI at the offshore location was generally above the threshold for Possible effects (2.5 [mol/m²]/day) (Figure 20).

These results indicate that the natural benthic light conditions at the offshore location exhibit high variability and naturally exceed the Jones *et al.* (2019) thresholds, particularly when affected by severe local weather conditions such as tropical cyclones and low-pressure systems. Therefore, the Jones *et al.* (2019) coral thresholds for light are not considered appropriate to inform future dredge monitoring and development of site-specific thresholds would be required.

4.1.6. Turbidity

Turbidity (NTU) data recorded between the 7th November 2018 and 9th September 2019 at inshore and offshore locations is presented in **Figure 23** and **Figure 24**. Suspended Sediment Concentrations (SSC) were derived from the NTU data and are presented in **Figure 25** and **Figure 26**. Summary statistics for turbidity (SSC) at both the offshore and inshore locations are provided in **Table 11**.

Table 11 Summary statistics for Turbidity (NTU) and SSC (Mg/L) at the inshore and offshore monitoring locations

Monitoring location	Parameter	mean	median	20th percentile	80th percentile	95th percentile	99th percentile
Inshore	Turbidity (NTU)	14.03	6.92	4.27	11.54	63.88	95.73
	SSC (mg/l)	15.43	7.61	4.71	12.69	70.27	105.31
Offshore	Turbidity (NTU)	1.45	0.66	0.53	1.03	2.18	32.76
	SSC (mg/l)	1.59	0.72	0.59	1.13	2.39	36.03

Comparisons of the NTU and SSC between the inshore and offshore locations illustrate the notable difference in turbidity between monitoring locations. In general turbidity was found to be much higher at the inshore location (Mean = 14.03 NTU) than at the offshore location (Mean = 1.45 NTU), which is consistent with the MScience (2009) analysis, which also found turbidity and SSC declined with distance from shore.

Peak turbidity levels were recorded at both locations on the 28th of January 2019 due to the nearby passing of Tropical Cyclone (TC) “Riley” (**Figure 22**) which generated gale force winds, high waves, rainfall (river outflows and land runoff) and storm surge in the Project area. Other peak turbidity events corresponded with TC Veronica (5th March), rainfall events (10-14 April) and a low-pressure system (7th June). These were consistent with the timing of low light (as DLI) events described in Section 4.1.5 which can be explained by the elevated levels of Suspended Sediment in the water column.

At the inshore location, **Figure 25** show that the 14-day rolling mean of natural baseline SSC frequently exceeded the Jones *et al.* (2019) thresholds for possible and probable effects on corals. Conversely, the 14-day rolling mean for SSC at the offshore location did not exceed either of the Jones *et al.* (2019) coral thresholds (**Figure 26**). Therefore, whilst these thresholds may be appropriate criteria for dredge monitoring in the offshore areas, they are not suitable for dredge monitoring in the inshore areas.

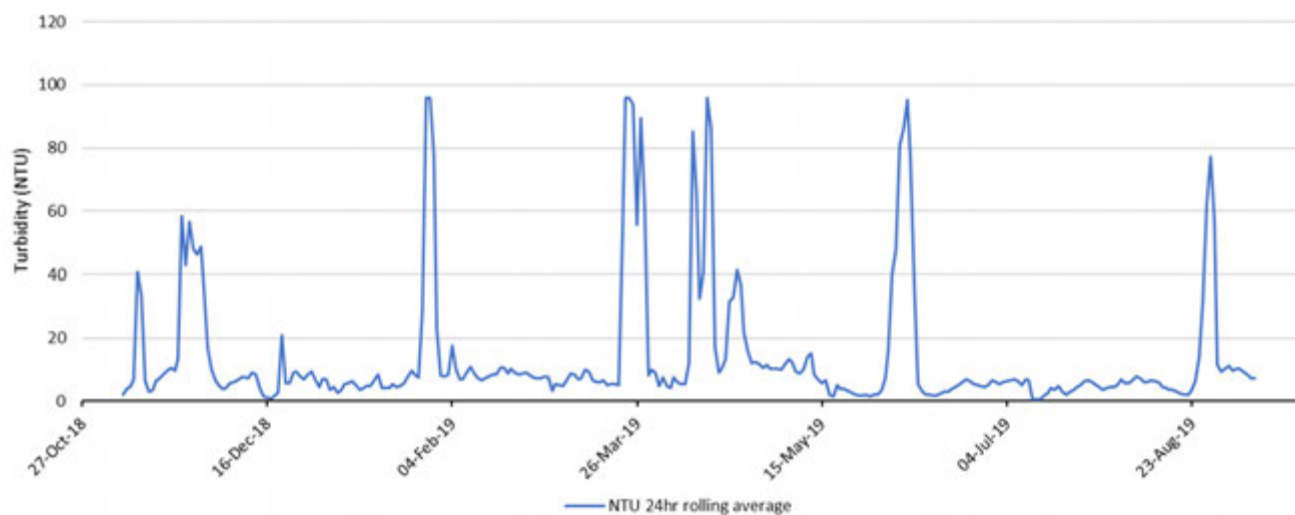


Figure 23 Rolling 24-hour mean turbidity (NTU) recorded at Inshore location between November 2018 and September 2019.

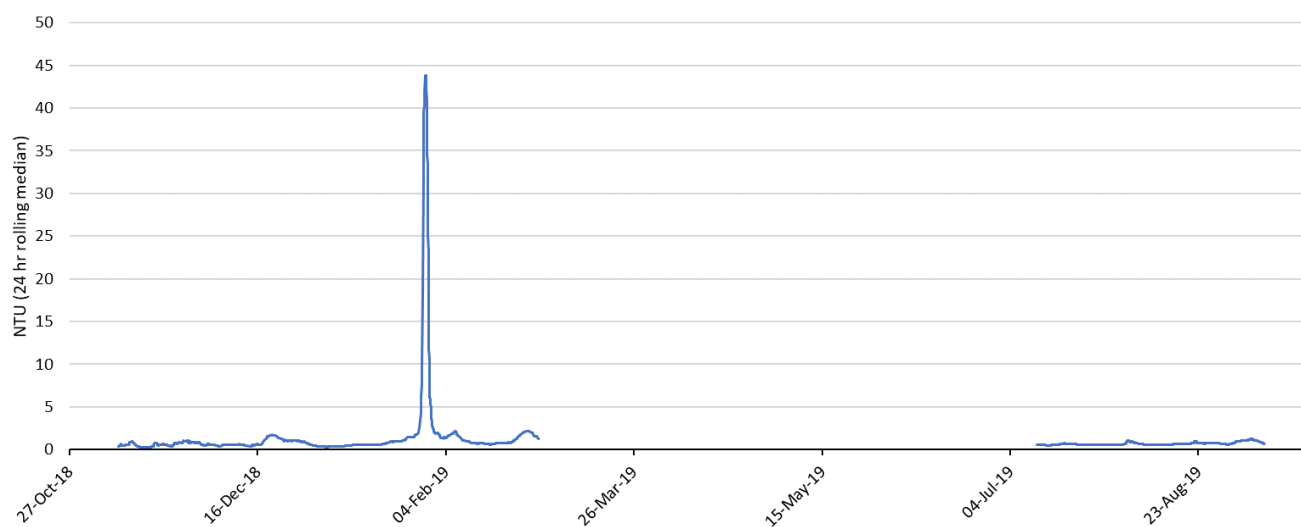


Figure 24 Rolling 24-hour mean turbidity (NTU) recorded at Off-shore location between November 2018 and September 2019

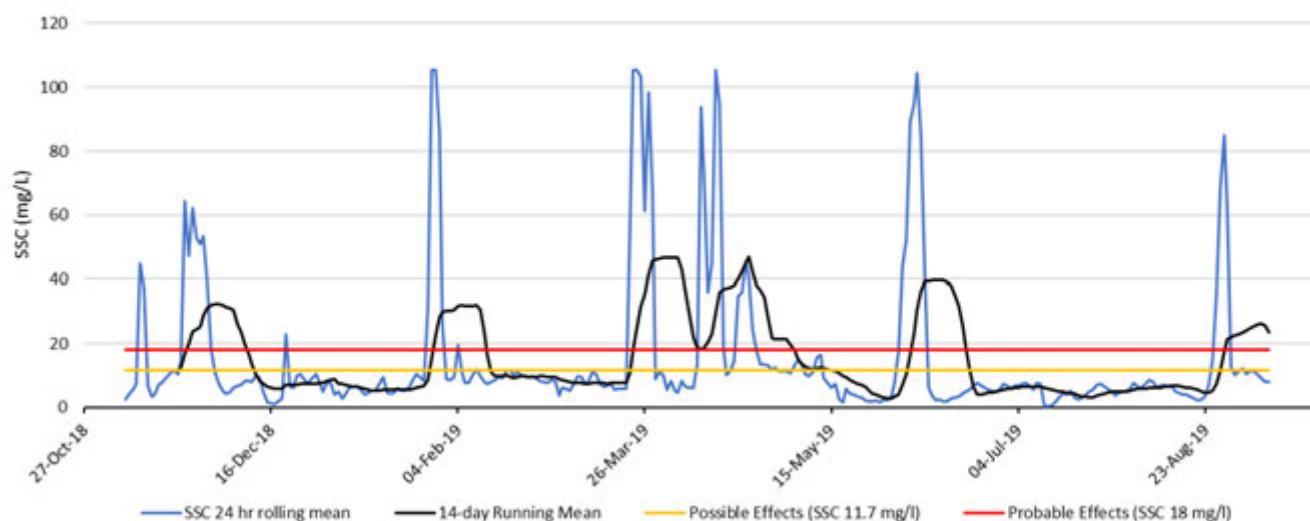


Figure 25 Rolling 24-hour mean Suspended Sediment Concentration (SSC) (mg/l) derived from NTU recorded at Inshore location between November 2018 and September 2019 using surrogate calibration presented in Fisher & Jones (2019).

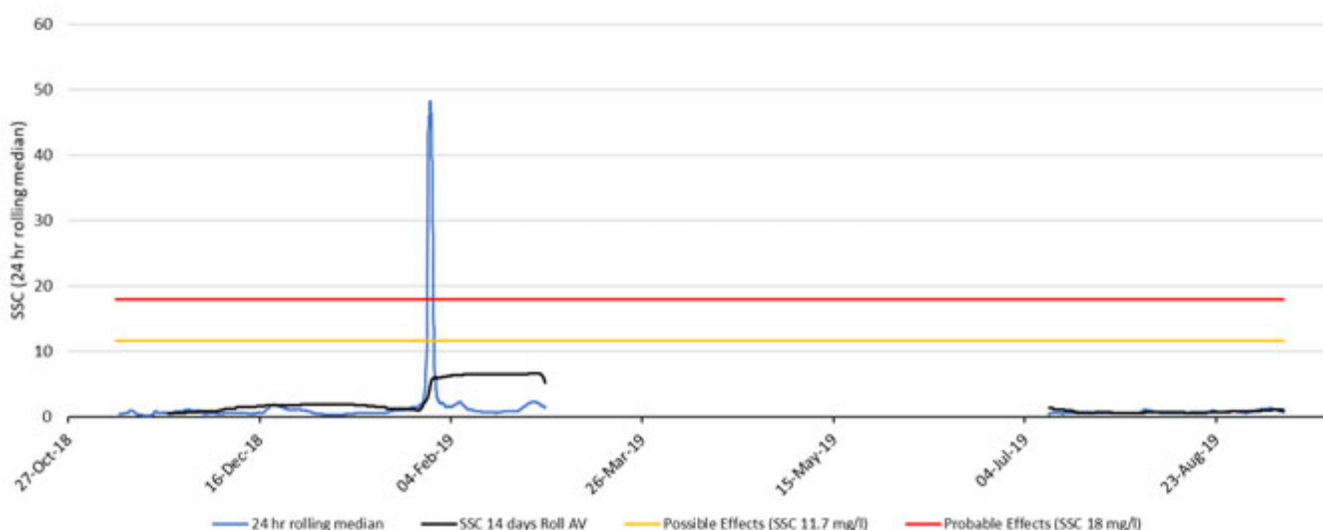


Figure 26 Rolling 24-hour mean Suspended Sediment Concentration (SSC) (mg/L) derived from NTU recorded at offshore location between Nov 2018 and September 2019 using surrogate calibration presented in Fisher & Jones (2019).

Two spring-neap tidal cycles were extracted from the turbidity and tide data to investigate the effect of normal tidal variation on turbidity at the inshore location (**Figure 27**). However, no strong relationship was observed in the data analysed, with a weak correlation coefficient for the two variables ($R^2 = 0.3143$).

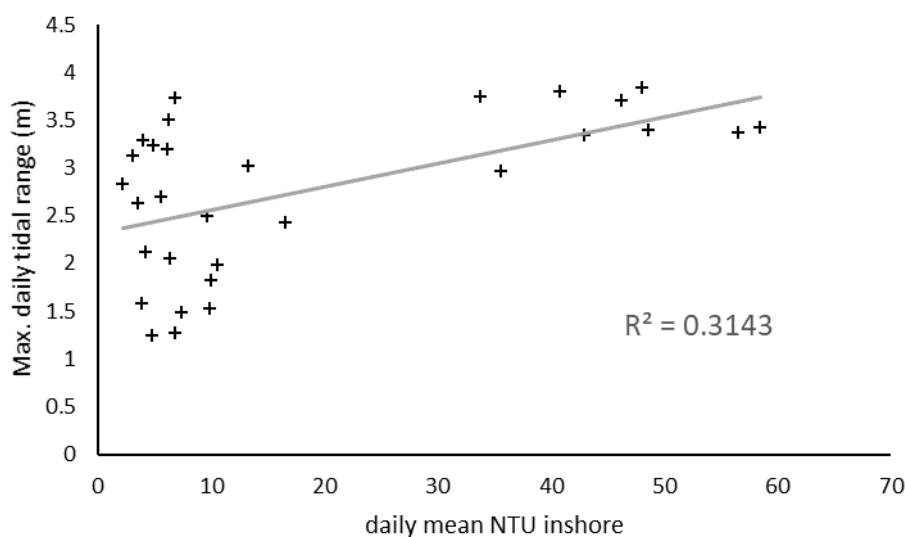


Figure 27 Extract from sampling period of tidal data showing relationship with mean daily turbidity (NTU)

4.2. Laboratory Results

Results from the two rounds of water quality sampling from the Inshore Location are presented in **Table 12**. All results were below the ANZG (2018) 99% species protection guidelines for all analytes with stated guideline values. These results indicate that the current allocation of maximum and high levels of ecological protection are appropriate for the marine waters of the Mardie Project area.

Table 12 Results of baseline water quality sampling at Mardie, Western Australia, with ANZG (2018) species protection levels for marine water quality

Analyte grouping/ Analyte	Unit	LoR	Sampling Round		Species Protection Levels (ANZG 2018)				Low Reliability Values ANZG (2018)
			Jan 19	Mar 19	99%	95%	90%	80%	
Dissolved Metals and Metalloids									
Aluminium	µg/L	5	9	<5					
Antimony	µg/L	0.5	<0.5	<0.5					
Arsenic	µg/L	0.5	1.6	1.7					As(III) = 2.3 As (V) = 4.5
Barium	µg/L	1	7	7					
Beryllium	µg/L	0.1	<0.1	<0.1					
Bismuth	µg/L	0.1	<0.1	<0.1					
Boron	µg/L	100	4650	3880					
Bromine	mg/L	0.1	63.3	69.3					

Analyte grouping/ Analyte	Unit	LoR	Sampling Round		Species Protection Levels (ANZG 2018)				Low Reliability Values ANZG (2018)
			Jan 19	Mar 19	99%	95%	90%	80%	
Cadmium	µg/L	0.2	<0.2	<0.2	0.7	5.5	14	36	
Chromium	µg/L	0.5	<0.5	<0.5	7.7 (CrIII) 0.14 (CrIV)	27.4(CrIII) 4.4 (CrIV)	48.6(CrIII) 20 (CrIV)	90.6(CrIII) 85 (CrIV)	
Cobalt	µg/L	0.2	<0.2	<0.2	0.005	1	14	150	
Copper	µg/L	1	<1	<1	0.3	1.3	3	8	
Iodine	mg/L	0.1	<1.0	<1.0					
Iron	µg/L	5	<5	<5					
Lead	µg/L	0.2	<0.2	<0.2	2.2	4.4	6.6	12	
Lithium	µg/L	1	211	121					
Manganese	µg/L	0.5	<0.5	<0.5					80
Mercury	mg/L	0.00004	<0.00004	<0.00004	0.1	0.4	0.7	1.4	
Molybdenum	µg/L	0.1	12.4	11.8					
Nickel	µg/L	0.5	<0.5	<0.5	7	70	200	560	
Selenium	µg/L	2	<2	<2	5	11	18	34	
Silver	µg/L	0.1	<0.1	<0.1	0.8	1.4	1.8	2.6	
Strontium	µg/L	10	9270	9270					
Thallium	µg/L	0.1	<0.1	<0.1					17
Thorium	µg/L	0.1	0.6	<0.1					
Tin	µg/L	5	6	<5					
Titanium	µg/L	5	<5	<5					
Uranium	µg/L	0.1	3.6	3.4					
Vanadium	µg/L	0.5	2.3	3.8	50	100	160	280	
Zinc	µg/L	5	<5	<5	7	15	23	43	
Nutrients									
Ammonia as N	mg/L	0.01	0.14	0.04	500	910	1200	1700	
Nitrite as N	mg/L	0.01	<0.01	<0.01					
Nitrite + Nitrate as N	mg/L	0.01	<0.01	<0.01					
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.2	0.2					
Total Nitrogen as N	mg/L	0.1	0.2	0.2					
Total Phosphorus as P	mg/L	0.01	<0.01	0.04					
Total Petroleum Hydrocarbons									
C6 – C9 Fraction	µg/L	20	<20	<20					
C10 – C14 Fraction	µg/L	50	<50	<50					
C15 – C28 Fraction	µg/L	100	<100	<100					

Analyte grouping/ Analyte	Unit	LoR	Sampling Round		Species Protection Levels (ANZG 2018)				Low Reliability Values ANZG (2018)
			Jan 19	Mar 19	99%	95%	90%	80%	
C29 – C36 Fraction	µg/L	50	<50	<50					
C10 – C36 Fraction (sum)	µg/L	50	<50	<50					
Total Recoverable Hydrocarbons									
C6 – C10 Fraction	µg/L	20	<20	<20					
C6 – C10 Fraction minus BTEX (F1)	µg/L	20	<20	<20					
>C10 – C16 Fraction	µg/L	100	<100	<100					
>C16 – C34 Fraction	µg/L	100	<100	<100					
>C34 – C40 Fraction	µg/L	100	<100	<100					
>C10 – C40 Fraction (sum)	µg/L	100	<100	<100					
>C10 – C16 Fraction minus Naphthalene (F2)	µg/L	100	<100	<100					
BTEXN									
Benzene	µg/L	1	<1	<1	700	900	900	1300	
Toluene	µg/L	2	<2	<2					
Ethylbenzene	µg/L	2	<2	<2					
meta- & para-Xylene	µg/L	2	<2	<2					
ortho-Xylene	µg/L	2	<2	<2					
Total Xylenes	µg/L	2	<2	<2					
Sum of BTEX	µg/L	1	<1	<1					
Naphthalene	µg/L	5	<5	<5	70	90	90	120	
TPH/BTEX surrogates									
1,2-Dichloroethane-D4	%	2	96.2	90.6					
Toluene-D8	%	2	104	101					
4-Bromofluorobenzene	%	2	102	86.6					
Dissolved Major Anions									
Silicon	mg/L	0.05	<0.25	0.09					
Dissolved Major Cations									
Calcium	mg/L	1	424	472					
Magnesium	mg/L	1	1260	1450					
Sodium	mg/L	1	10400	11100					

Analyte grouping/ Analyte	Unit	LoR	Sampling Round		Species Protection Levels (ANZG 2018)				Low Reliability Values ANZG (2018)
			Jan 19	Mar 19	99%	95%	90%	80%	
Potassium	mg/L	1	368	625					
Alkalinity/Hardness									
Hydroxide Alkalinity as CaCO ₃	mg/L	1	<1	<1					
Carbonate Alkalinity as CaCO ₃	mg/L	1	<1	<1					
Bicarbonate Alkalinity as CaCO ₃	mg/L	1	102	108					
Total Alkalinity as CaCO ₃	mg/L	1	102	108					
Total Hardness as CaCO ₃	mg/L	1	6250	7150					
Ionic Balance									
Total Anions	meq/L	0.01	617	593					
Total Cations	meq/L	0.01	587	642					
Ionic Balance	%	0.01	2.52	3.96					
Total Organic Carbon (TOC)									
Total Organic Carbon	mg/L	1	1	2					
Other analytes									
Specific Gravity		0.01	1.00	1.00					
Chloride	mg/L	1	19600	18800					
Fluoride	mg/L	0.1	1.0	1.1					
Sulfate as SO ₄ – Turbidimetric	mg/L	1	2980	2900					

5. Conclusion

Baseline data was collected at the proposed Mardie project area to describe the natural variability of marine water quality at Mardie. The following key observations are made regarding the baseline data collected from the Mardie Project area:

- > Salinity levels were comparable but slightly higher than other records in the area (Median of 37.5 ppt) and appeared to be indicative of a sheltered bay, which was thought to be due to the influence of the Passage Islands which act as a natural barrier and appear to restrict mixing with lower salinity oceanic waters;
- > Turbidity and SSC were found to be higher at the inshore monitoring location than at the offshore location, which is consistent with other Pilbara water quality investigations (Jones *et al.* 2019; MScience 2009; Pearce 2003);
- > Derived DLI for the offshore location was highest during wet season and lowest during the dry season and correlated with seasonal change in solar elevation angle, which is a primary factor influencing the amount of available benthic light at the offshore location. DLI was low year-round at the inshore location. Factors influencing benthic light levels are different between the offshore and inshore areas. However, the lowest light levels corresponded closely with high SSC and turbidity levels, with the lowest values recorded during the passing of several Tropical Cyclones and low-pressure systems over the sampling period;
- > The recently published WAMSI (Jones *et al.* 2019) SSC and DLI thresholds for *possible* and *probable* effects on coral were not found to be suitable as criteria for monitoring dredging effects in the offshore or inshore portion of the Mardie Project area. Frequent natural exceedances of SSC and DLI thresholds indicates that these thresholds are not appropriate for use as dredge monitoring criteria in the Mardie Project area. It is noted that Jones *et al.* (2019) recognises these potential limitations of the thresholds and advises that WAMSI is in the process of developing thresholds for turbid water coral communities. Once these new turbid water thresholds are available, they should be evaluated against the baseline data collected in this program and as part of the pre-dredging baseline to determine suitability for use in dredge monitoring; and
- > Laboratory analysis of marine water samples showed no evidence of contamination and the current allocation of maximum and high levels of ecological protection are appropriate for the marine waters of the Mardie Project area.

The baseline data collected to date demonstrates that the marine waters of the Mardie Project area are pristine and not currently affected by anthropogenic impacts. Although further baseline data collection is recommended to develop site-specific Environmental Quality Criteria (EQC) and refine monitoring and management plans, the data collected to date is considered sufficient to inform the assessment of environmental impacts of the Proposal.

Nevertheless, to derive site-specific EQC for monitoring and management, the EPA guidance (EPA 2016) recommends collection of 2 years of baseline data. Therefore, O2 Marine recommends continued collection of baseline water quality data to inform dredge management and as part of the operational Marine Environmental Quality Management Plan.

The following additional baseline data collection is recommended to be incorporated into the implementation of these management plans:

Marine Environmental Quality Management Plan

Implement baseline marine environmental monitoring program which includes the following:

- > Continue collection of water samples for laboratory analysis of potential contaminants on a quarterly basis;
- > Consider inclusion of suitable reference monitoring location (s) for comparison against data collected at the proposed inshore (outfall) location; and
- > Compile all baseline data and derive site specific EQC using the methods outlined in ANZG (2018).

Dredging Management Plan

Implement baseline monitoring prior to commencement of dredging, which includes the following:

- > Continue baseline data collection of light, turbidity, temperature and depth in the vicinity of the proposed dredging for a further 12 months prior to commencement of dredging; and
- > Compare baseline data against the proposed (to be developed) WAMSI thresholds for turbid water coral communities to determine suitability for future dredge management; OR
- > Derive site specific dredge monitoring criteria for SSC based on 80th and 95th percentile.

6. Reference List

- ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1: The Guidelines*, Prepared by Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT, October 2000.
- ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia. Viewed [23/04/2019], [<http://www.waterquality.gov.au/anz-guidelines>].
- Baird (2019) Mardie Project. Hydrodynamic Modelling Report. Prepared for BCI Minerals Limited 2019. Perth, WA.
- BOM (2019) *Monthly climate statistics*, Australian Bureau of Meteorology, www.bom.gov.au (accessed: 31/01/2019)
- CALM (2005) *Indicative Management Plan for the proposed Dampier Archipelago Marine Park and Cape Preston Marine Management Area*, Conservation and Land Management, Government of Western Australia, Perth.
- CSIRO (2006). *Background quality for coastal marine waters of the North West Shelf, Western Australia*. North West Shelf Joint Environmental Management Study, CSIRO Marine Research, GPO Box 1538, Hobart Tasmania 7001. Report by Wenziker K.J., McAlpine, K. W., Apte, S.C. and Masini, R.J.
- Department of Environment (2006) *Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives*. Department of the Environment, Government of Western Australia, Marine Series Report No. 1. pp. 67
- Eliot I, Gozzard B, Eliot M, Stul T and McCormack G. (2013) *Geology, Geomorphology & Vulnerability of the Pilbara Coast, In the Shires of Ashburton, East Pilbara and Roebourne, and the Town of Port Hedland*, Western Australia. Damara WA Pty Ltd and Geological Survey of Western Australia, Innaloo, Western Australia.
- Fisher R, Jones R, Bessell-Browne P, (2019). *Effects of dredging and dredging related activities on water quality: Impacts on coral mortality and threshold development Report of Theme 4 - Project 4.9*, prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia, 94 pp.
- Fisher R. and Jones, R. (2019). *Deriving and operationalizing thresholds for managing dredging impacts on coral reefs. Report of Theme 4 - Project 4.9*, prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia, 94 pp.
- EPA (2016). *Technical Guidance for Protecting the Quality of Western Australia's Marine Environment*. Environmental Protection Authority, Western Australia

- Jones R, Fisher R, Bessell-Brown P, Negri A, Duckworth A (2019) *Theme 4 | Synthesis Report: Defining thresholds and indicators of coral response to dredging-related pressures*. Western Australian Marine Science Institution (WAMSI). Perth, Western Australia pp. 36.
- Jones R, Fisher R, Stark C & Ridd P (2015) Temporal Patterns in Seawater Quality from Dredging in Tropical Environments. PLoS ONE 10(10): e0137112. doi:10.1371/journal.pone.0137112
- Maunsell (2006) *Marine and Coastal Environmental Report*. Prepared for Mineralogy Pty Ltd.
- MScience (2009) Wheatstone LNG Development: Baseline Water Quality Assessment Report. Report to URS Australia Pty Ltd, November 2009.
- O2 Marine (2018) *Mardie Project - Preliminary Data - Progress Report #2 for Metocean Data Collection*. Report Prepared for BCI Minerals Ltd.
- O2 Marine (2019) Mardie Project- Sediment Sampling and Analysis Plan. Prepared for BCI Minerals Limited 2019. Perth, WA.
- O2 Marine (2019a) Mardie Project- Benthic Communities and Habitat. Prepared for BCI Minerals Limited 2019. Perth, WA.
- Preston Consulting (2018) *Environmental Scoping Document for Mardie Project*, submitted to EPA WA
- Pearce, A. F.; Buchan, S.; Chiffings, T.; D'Adamo, N.; Fandry, C. B.; Fearn, P. R. C. S.; Mills, D. J.; Phillips, R. C.; Simpson, C. A review of the oceanography of the Dampier Archipelago, Western Australia. In: Wells, F. E.; Walker, D. I.; Jones, D. S. Editors, editor/s. (2003) *The Marine flora and fauna of Dampier, Western Australia*: proceedings of the Eleventh International Marine Biological Workshop; 24 July-11 Aug. 2000; Dampier, Western Australia. Perth, W.A.: Western Australian Museum; 2003. 13-50.
- RPS (2008) *Devils Creek Apache Energy Devil Creek Development Project, Marine Baseline Studies*.
- URS (2007) *Cape Preston Preliminary Water Quality Investigations*. Prepared for CITIC Pacific Mining Pty Ltd.

Appendix A - Laboratory Analysis Reports

CERTIFICATE OF ANALYSIS

Work Order : **EP1900710**
Client : **WA MARINE PTY LTD**
Contact : Claudio Deldeo
Address : SUITE 5, 5/18 GRIFFON DRIVE PO BOX 1370
DUNSBOROUGH, PERTH WA, AUSTRALIA 6281
Telephone : ----
Project : 18WAU-0002 Mardie Project: Sediment Sampling
Order number :
C-O-C number : ----
Sampler : ----
Site : ----
Quote number : EP/233/18 V2
No. of samples received : 1
No. of samples analysed : 1

Page : 1 of 6
Laboratory : Environmental Division Perth
Contact : Customer Services EP
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : +61-8-9406 1301
Date Samples Received : 24-Jan-2019 13:24
Date Analysis Commenced : 24-Jan-2019
Issue Date : 04-Feb-2019 21:14



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Michael Byrne	Laboratory Technician	Perth Inorganics, Wangara, WA
Stephanie Tilson	Instrument Chemist	Perth Inorganics, Wangara, WA
Vanessa Nguyen	Organic Chemist	Perth Organics, Wangara, WA



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ORC Metals analysis conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.
- EG020: Bromine & Iodine quantification may be unreliable due to its low solubility in acid, leading to variable volatility during measurement by ICPMS.
- EG020: Some samples were diluted and rerun due to matrix interference and LOR's have been raised accordingly. (High Total Dissolved Solids)
- ED040F (Major Anions - Dissolved) : LOR has been raised due to possible matrix interference.
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					16-Jan-2019 08:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1900710-001	-----	-----	-----	-----
				Result	----	----	----	----	----
EA050: Specific Gravity									
Specific Gravity	----	0.01	-		1.00	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		102	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		102	----	----	----	----
ED040F: Dissolved Major Anions									
Silicon	7440-21-3	0.05	mg/L		<0.25	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		2980	----	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		19600	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		424	----	----	----	----
Magnesium	7439-95-4	1	mg/L		1260	----	----	----	----
Sodium	7440-23-5	1	mg/L		10400	----	----	----	----
Potassium	7440-09-7	1	mg/L		368	----	----	----	----
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L		6250	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Bromine	7726-95-6	0.1	mg/L		63.3	----	----	----	----
Iodine	7553-56-2	0.1	mg/L		<1.0	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		9	----	----	----	----
Antimony	7440-36-0	0.5	µg/L		<0.5	----	----	----	----
Arsenic	7440-38-2	0.5	µg/L		1.6	----	----	----	----
Barium	7440-39-3	1	µg/L		7	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L		<0.1	----	----	----	----
Bismuth	7440-69-9	0.1	µg/L		<0.1	----	----	----	----
Boron	7440-42-8	100	µg/L		4650	----	----	----	----
Cadmium	7440-43-9	0.2	µg/L		<0.2	----	----	----	----
Chromium	7440-47-3	0.5	µg/L		<0.5	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					16-Jan-2019 08:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1900710-001	-----	-----	-----	-----
					Result	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS - Continued									
Cobalt	7440-48-4	0.2	µg/L		<0.2	----	----	----	----
Copper	7440-50-8	1	µg/L		<1	----	----	----	----
Iron	7439-89-6	5	µg/L		<5	----	----	----	----
Lead	7439-92-1	0.2	µg/L		<0.2	----	----	----	----
Lithium	7439-93-2	1	µg/L		211	----	----	----	----
Manganese	7439-96-5	0.5	µg/L		<0.5	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L		12.4	----	----	----	----
Nickel	7440-02-0	0.5	µg/L		<0.5	----	----	----	----
Selenium	7782-49-2	2	µg/L		<2	----	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	----	----	----	----
Strontium	7440-24-6	10	µg/L		9270	----	----	----	----
Thallium	7440-28-0	0.1	µg/L		<0.1	----	----	----	----
Thorium	7440-29-1	0.1	µg/L		0.6	----	----	----	----
Tin	7440-31-5	5	µg/L		6	----	----	----	----
Titanium	7440-32-6	5	µg/L		<5	----	----	----	----
Uranium	7440-61-1	0.1	µg/L		3.6	----	----	----	----
Vanadium	7440-62-2	0.5	µg/L		2.3	----	----	----	----
Zinc	7440-66-6	5	µg/L		<5	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		1.0	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.14	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		0.2	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		0.2	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		617	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					16-Jan-2019 08:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1900710-001	-----	-----	-----	-----
				Result	----	----	----	----	----
EN055: Ionic Balance - Continued									
Total Cations	----	0.01	meq/L		587	----	----	----	----
Ionic Balance	----	0.01	%		2.52	----	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		1	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L		<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L		<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L		<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L		<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L		<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L		<100	----	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		<100	----	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	----	----	----	----
Toluene	108-88-3	2	µg/L		<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	----	----	----	----
^ Total Xylenes	----	2	µg/L		<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L		<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L		<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		96.2	----	----	----	----
Toluene-D8	2037-26-5	2	%		104	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%		102	----	----	----	----



Surrogate Control Limits

Sub-Matrix: **WATER**

		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	61	141
Toluene-D8	2037-26-5	73	126
4-Bromofluorobenzene	460-00-4	60	125

CERTIFICATE OF ANALYSIS

Work Order : **EP1902033**
Client : **WA MARINE PTY LTD**
Contact : Claudio Deldeo
Address : SUITE 5, 5/18 GRIFFON DRIVE PO BOX 1370
 DUNSBOROUGH, PERTH WA, AUSTRALIA 6281
Telephone : ----
Project : 18WAU-0002 Mardie Project
Order number :
C-O-C number : ----
Sampler : JOSH ABBOTT
Site : ----
Quote number : EP/233/18 V2
No. of samples received : 1
No. of samples analysed : 1

Page : 1 of 6
Laboratory : Environmental Division Perth
Contact : Customer Services EP
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : +61-8-9406 1301
Date Samples Received : 06-Mar-2019 02:20
Date Analysis Commenced : 06-Mar-2019
Issue Date : 13-Mar-2019 19:24



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Vanessa Nguyen	Organic Chemist	Perth Organics, Wangara, WA



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- Metals analysis conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.
- EG020: Bromine & Iodine quantification may be unreliable due to its low solubility in acid, leading to variable volatility during measurement by ICPMS.
- EG020: Some samples were diluted and rerun due to matrix interference and LOR's have been raised accordingly. (High Total Dissolved Solids)
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					03-Mar-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1902033-001	-----	-----	-----	-----
				Result	----	----	----	----	----
EA050: Specific Gravity									
Specific Gravity	----	0.01	-		1.00	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		108	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		108	----	----	----	----
ED040F: Dissolved Major Anions									
Silicon	7440-21-3	0.05	mg/L		0.09	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		2900	----	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		18800	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		472	----	----	----	----
Magnesium	7439-95-4	1	mg/L		1450	----	----	----	----
Sodium	7440-23-5	1	mg/L		11100	----	----	----	----
Potassium	7440-09-7	1	mg/L		625	----	----	----	----
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L		7150	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Bromine	7726-95-6	0.1	mg/L		69.3	----	----	----	----
Iodine	7553-56-2	0.1	mg/L		<1.0	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		<5	----	----	----	----
Antimony	7440-36-0	0.5	µg/L		<0.5	----	----	----	----
Arsenic	7440-38-2	0.5	µg/L		1.7	----	----	----	----
Barium	7440-39-3	1	µg/L		7	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L		<0.1	----	----	----	----
Bismuth	7440-69-9	0.1	µg/L		<0.1	----	----	----	----
Boron	7440-42-8	100	µg/L		3880	----	----	----	----
Cadmium	7440-43-9	0.2	µg/L		<0.2	----	----	----	----
Chromium	7440-47-3	0.5	µg/L		<0.5	----	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ1	----	----	----	----
Client sampling date / time				03-Mar-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1902033-001	-----	-----	-----	-----
				Result	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS - Continued								
Cobalt	7440-48-4	0.2	µg/L	<0.2	----	----	----	----
Copper	7440-50-8	1	µg/L	<1	----	----	----	----
Iron	7439-89-6	5	µg/L	<5	----	----	----	----
Lead	7439-92-1	0.2	µg/L	<0.2	----	----	----	----
Lithium	7439-93-2	1	µg/L	121	----	----	----	----
Manganese	7439-96-5	0.5	µg/L	<0.5	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L	11.8	----	----	----	----
Nickel	7440-02-0	0.5	µg/L	<0.5	----	----	----	----
Selenium	7782-49-2	2	µg/L	<2	----	----	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	----	----	----	----
Strontium	7440-24-6	10	µg/L	9270	----	----	----	----
Thallium	7440-28-0	0.1	µg/L	<0.1	----	----	----	----
Thorium	7440-29-1	0.1	µg/L	<0.1	----	----	----	----
Tin	7440-31-5	5	µg/L	<5	----	----	----	----
Titanium	7440-32-6	5	µg/L	<5	----	----	----	----
Uranium	7440-61-1	0.1	µg/L	3.4	----	----	----	----
Vanadium	7440-62-2	0.5	µg/L	3.8	----	----	----	----
Zinc	7440-66-6	5	µg/L	<5	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	1.1	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	0.04	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.2	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	0.2	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.04	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	593	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					03-Mar-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1902033-001	-----	-----	-----	-----
					Result	----	----	----	----
EN055: Ionic Balance - Continued									
Total Cations	----	0.01	meq/L		642	----	----	----	----
Ionic Balance	----	0.01	%		3.96	----	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		2	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L		<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L		<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L		<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L		<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L		<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L		<100	----	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		<100	----	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	----	----	----	----
Toluene	108-88-3	2	µg/L		<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	----	----	----	----
^ Total Xylenes	----	2	µg/L		<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L		<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L		<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		90.6	----	----	----	----
Toluene-D8	2037-26-5	2	%		101	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%		86.6	----	----	----	----



Surrogate Control Limits

Sub-Matrix: **WATER**

		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	61	141
Toluene-D8	2037-26-5	73	126
4-Bromofluorobenzene	460-00-4	60	125

CERTIFICATE OF ANALYSIS

Work Order : **EP1900710**
Client : **WA MARINE PTY LTD**
Contact : Claudio Deldeo
Address : SUITE 5, 5/18 GRIFFON DRIVE PO BOX 1370
DUNSBOROUGH, PERTH WA, AUSTRALIA 6281
Telephone : ----
Project : 18WAU-0002 Mardie Project: Sediment Sampling
Order number :
C-O-C number : ----
Sampler : ----
Site : ----
Quote number : EP/233/18 V2
No. of samples received : 1
No. of samples analysed : 1

Page : 1 of 6
Laboratory : Environmental Division Perth
Contact : Customer Services EP
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : +61-8-9406 1301
Date Samples Received : 24-Jan-2019 13:24
Date Analysis Commenced : 24-Jan-2019
Issue Date : 04-Feb-2019 21:14



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Michael Byrne	Laboratory Technician	Perth Inorganics, Wangara, WA
Stephanie Tilson	Instrument Chemist	Perth Inorganics, Wangara, WA
Vanessa Nguyen	Organic Chemist	Perth Organics, Wangara, WA



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ORC Metals analysis conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.
- EG020: Bromine & Iodine quantification may be unreliable due to its low solubility in acid, leading to variable volatility during measurement by ICPMS.
- EG020: Some samples were diluted and rerun due to matrix interference and LOR's have been raised accordingly. (High Total Dissolved Solids)
- ED040F (Major Anions - Dissolved) : LOR has been raised due to possible matrix interference.
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					16-Jan-2019 08:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1900710-001	-----	-----	-----	-----
				Result	----	----	----	----	----
EA050: Specific Gravity									
Specific Gravity	----	0.01	-		1.00	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		102	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		102	----	----	----	----
ED040F: Dissolved Major Anions									
Silicon	7440-21-3	0.05	mg/L		<0.25	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		2980	----	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		19600	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		424	----	----	----	----
Magnesium	7439-95-4	1	mg/L		1260	----	----	----	----
Sodium	7440-23-5	1	mg/L		10400	----	----	----	----
Potassium	7440-09-7	1	mg/L		368	----	----	----	----
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L		6250	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Bromine	7726-95-6	0.1	mg/L		63.3	----	----	----	----
Iodine	7553-56-2	0.1	mg/L		<1.0	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		9	----	----	----	----
Antimony	7440-36-0	0.5	µg/L		<0.5	----	----	----	----
Arsenic	7440-38-2	0.5	µg/L		1.6	----	----	----	----
Barium	7440-39-3	1	µg/L		7	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L		<0.1	----	----	----	----
Bismuth	7440-69-9	0.1	µg/L		<0.1	----	----	----	----
Boron	7440-42-8	100	µg/L		4650	----	----	----	----
Cadmium	7440-43-9	0.2	µg/L		<0.2	----	----	----	----
Chromium	7440-47-3	0.5	µg/L		<0.5	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					16-Jan-2019 08:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1900710-001	-----	-----	-----	-----
					Result	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS - Continued									
Cobalt	7440-48-4	0.2	µg/L		<0.2	----	----	----	----
Copper	7440-50-8	1	µg/L		<1	----	----	----	----
Iron	7439-89-6	5	µg/L		<5	----	----	----	----
Lead	7439-92-1	0.2	µg/L		<0.2	----	----	----	----
Lithium	7439-93-2	1	µg/L		211	----	----	----	----
Manganese	7439-96-5	0.5	µg/L		<0.5	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L		12.4	----	----	----	----
Nickel	7440-02-0	0.5	µg/L		<0.5	----	----	----	----
Selenium	7782-49-2	2	µg/L		<2	----	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	----	----	----	----
Strontium	7440-24-6	10	µg/L		9270	----	----	----	----
Thallium	7440-28-0	0.1	µg/L		<0.1	----	----	----	----
Thorium	7440-29-1	0.1	µg/L		0.6	----	----	----	----
Tin	7440-31-5	5	µg/L		6	----	----	----	----
Titanium	7440-32-6	5	µg/L		<5	----	----	----	----
Uranium	7440-61-1	0.1	µg/L		3.6	----	----	----	----
Vanadium	7440-62-2	0.5	µg/L		2.3	----	----	----	----
Zinc	7440-66-6	5	µg/L		<5	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		1.0	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.14	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		0.2	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		0.2	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		617	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					16-Jan-2019 08:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1900710-001	-----	-----	-----	-----
				Result	----	----	----	----	----
EN055: Ionic Balance - Continued									
Total Cations	----	0.01	meq/L		587	----	----	----	----
Ionic Balance	----	0.01	%		2.52	----	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		1	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L		<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L		<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L		<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L		<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L		<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L		<100	----	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		<100	----	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	----	----	----	----
Toluene	108-88-3	2	µg/L		<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	----	----	----	----
^ Total Xylenes	----	2	µg/L		<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L		<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L		<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		96.2	----	----	----	----
Toluene-D8	2037-26-5	2	%		104	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%		102	----	----	----	----



Surrogate Control Limits

Sub-Matrix: **WATER**

		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	61	141
Toluene-D8	2037-26-5	73	126
4-Bromofluorobenzene	460-00-4	60	125

CERTIFICATE OF ANALYSIS

Work Order : **EP1902033**
Client : **WA MARINE PTY LTD**
Contact : Claudio Deldeo
Address : SUITE 5, 5/18 GRIFFON DRIVE PO BOX 1370
 DUNSBOROUGH, PERTH WA, AUSTRALIA 6281
Telephone : ----
Project : 18WAU-0002 Mardie Project
Order number :
C-O-C number : ----
Sampler : JOSH ABBOTT
Site : ----
Quote number : EP/233/18 V2
No. of samples received : 1
No. of samples analysed : 1

Page : 1 of 6
Laboratory : Environmental Division Perth
Contact : Customer Services EP
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : +61-8-9406 1301
Date Samples Received : 06-Mar-2019 02:20
Date Analysis Commenced : 06-Mar-2019
Issue Date : 13-Mar-2019 19:24



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Vanessa Nguyen	Organic Chemist	Perth Organics, Wangara, WA



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- Metals analysis conducted by ALS Sydney, NATA accreditation no. 825, site no 10911.
- EG020: Bromine & Iodine quantification may be unreliable due to its low solubility in acid, leading to variable volatility during measurement by ICPMS.
- EG020: Some samples were diluted and rerun due to matrix interference and LOR's have been raised accordingly. (High Total Dissolved Solids)
- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					03-Mar-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1902033-001	-----	-----	-----	-----
				Result	----	----	----	----	----
EA050: Specific Gravity									
Specific Gravity	----	0.01	-		1.00	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		108	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		108	----	----	----	----
ED040F: Dissolved Major Anions									
Silicon	7440-21-3	0.05	mg/L		0.09	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		2900	----	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		18800	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		472	----	----	----	----
Magnesium	7439-95-4	1	mg/L		1450	----	----	----	----
Sodium	7440-23-5	1	mg/L		11100	----	----	----	----
Potassium	7440-09-7	1	mg/L		625	----	----	----	----
ED093F: SAR and Hardness Calculations									
Total Hardness as CaCO3	----	1	mg/L		7150	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Bromine	7726-95-6	0.1	mg/L		69.3	----	----	----	----
Iodine	7553-56-2	0.1	mg/L		<1.0	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		<5	----	----	----	----
Antimony	7440-36-0	0.5	µg/L		<0.5	----	----	----	----
Arsenic	7440-38-2	0.5	µg/L		1.7	----	----	----	----
Barium	7440-39-3	1	µg/L		7	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L		<0.1	----	----	----	----
Bismuth	7440-69-9	0.1	µg/L		<0.1	----	----	----	----
Boron	7440-42-8	100	µg/L		3880	----	----	----	----
Cadmium	7440-43-9	0.2	µg/L		<0.2	----	----	----	----
Chromium	7440-47-3	0.5	µg/L		<0.5	----	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				WQ1	----	----	----	----
Client sampling date / time				03-Mar-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1902033-001	-----	-----	-----	-----
				Result	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS - Continued								
Cobalt	7440-48-4	0.2	µg/L	<0.2	----	----	----	----
Copper	7440-50-8	1	µg/L	<1	----	----	----	----
Iron	7439-89-6	5	µg/L	<5	----	----	----	----
Lead	7439-92-1	0.2	µg/L	<0.2	----	----	----	----
Lithium	7439-93-2	1	µg/L	121	----	----	----	----
Manganese	7439-96-5	0.5	µg/L	<0.5	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L	11.8	----	----	----	----
Nickel	7440-02-0	0.5	µg/L	<0.5	----	----	----	----
Selenium	7782-49-2	2	µg/L	<2	----	----	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	----	----	----	----
Strontium	7440-24-6	10	µg/L	9270	----	----	----	----
Thallium	7440-28-0	0.1	µg/L	<0.1	----	----	----	----
Thorium	7440-29-1	0.1	µg/L	<0.1	----	----	----	----
Tin	7440-31-5	5	µg/L	<5	----	----	----	----
Titanium	7440-32-6	5	µg/L	<5	----	----	----	----
Uranium	7440-61-1	0.1	µg/L	3.4	----	----	----	----
Vanadium	7440-62-2	0.5	µg/L	3.8	----	----	----	----
Zinc	7440-66-6	5	µg/L	<5	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	1.1	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	0.04	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.2	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	0.2	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	0.04	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	593	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WQ1	----	----	----	----
Client sampling date / time					03-Mar-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EP1902033-001	-----	-----	-----	-----
					Result	----	----	----	----
EN055: Ionic Balance - Continued									
Total Cations	----	0.01	meq/L		642	----	----	----	----
Ionic Balance	----	0.01	%		3.96	----	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		2	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L		<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L		<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L		<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L		<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L		<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L		<100	----	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		<100	----	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	----	----	----	----
Toluene	108-88-3	2	µg/L		<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	----	----	----	----
^ Total Xylenes	----	2	µg/L		<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L		<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L		<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		90.6	----	----	----	----
Toluene-D8	2037-26-5	2	%		101	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%		86.6	----	----	----	----



Surrogate Control Limits

Sub-Matrix: **WATER**

		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	61	141
Toluene-D8	2037-26-5	73	126
4-Bromofluorobenzene	460-00-4	60	125