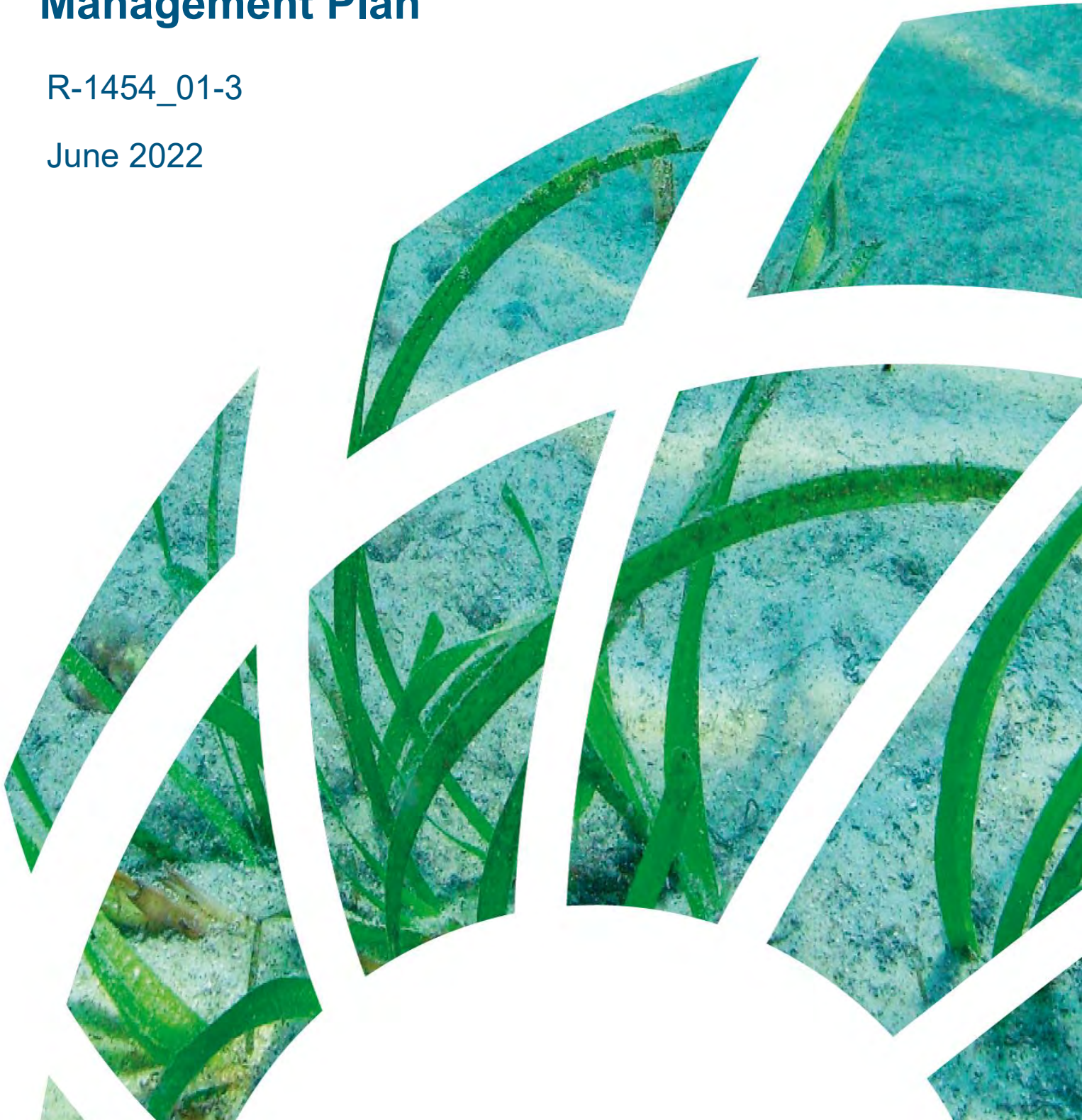




Jurien Bay Boat Harbour Maintenance Dredging Long Term Monitoring and Management Plan

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List of Abbreviations and Terms

ANZG	Australian and New Zealand Government
ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid sulfate soils
BCH	Benthic communities and habitats
BTEX	Benzene, toluene, ethylbenzene and xylene
°C	Degrees Celsius
CA	Commonwealth of Australia
CALM Act	<i>Conservation and Land Management Act 1984</i>
CD	Chart datum
CSMC	Cockburn Sound Management Council
CSD	Cutter suction dredge
DAWE	Australian Department of Agriculture, Water and the Environment
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions
DBT	Dibutyltin
DEIA	Dredging Environmental Impact Assessment
DO	Dissolved oxygen
DoEE	Australian Department of the Environment and Energy
DoT	Western Australian Department of Transport
DPLH	Western Australian Department of Planning, Lands and Heritage
EMF	Department of Transport's Maintenance Dredging – Environmental Management Framework
EPA	Western Australian Environmental Protection Authority
EP Act	<i>Environmental Protection Act 1986</i>
EPBC Act	<i>Environmental Protection Biodiversity Conservation Act 1999</i>
EQC	Environmental Quality Criteria
FRP	Filterable reactive phosphorus
GPS	Global positioning system
ha	Hectare
H ₂ S	Hydrogen sulfide
IDER	Initial Desktop Environmental Review
IMS	Introduced marine species
JBMP	Jurien Bay Marine Park
JBMPMP	Jurien Bay Marine Park Management Plan
km	Kilometre
km ²	Kilometre square
LAC	Light attenuation coefficient
LAU	Local Assessment Unit
LoR	Laboratory limit of reporting
LTMMMP	Long Term Monitoring and Management Plan
m	Metre
m ³	Cubic metre
MBT	Monobutyltin
mm	Millimetre
Mm ³	Million cubic metres
MAG	Maritime Advisory Group
NAGD	National Assessment Guidelines for Dredging
NH ₃	Ammonia
NH ₄ ⁺	Ammonium
no.	Number
NO _x	Nitrate+nitrite
NSHA	Noongar Standard Heritage Agreement

NTU	Nephelometric Turbidity Units
NVCP	Native Vegetation Clearing Permit
PAHs	Polycyclic aromatic hydrocarbons
PAR	Photosynthetically active radiation
PSD	Particle size distribution
RIU	Remote imagery unit
SAP	Sampling and Analysis Plan
SDP	Sea Dumping Permit
SD Act	<i>Environment Protection (Sea Dumping) Act 1981</i>
SWALSC	South-West Land and Sea Council
TACC	Technical Advisory and Consultative Committee
TBT	Tributyltin
TN	Total nitrogen
TNTM	Temporary Notice to Marinas
TOC	Total organic carbon
TP	Total phosphorous
TPHs	Total petroleum hydrocarbons
TRHs	Total recoverable hydrocarbons
UCL	Upper confidence limit
µm	micron
WA	Western Australia
WCRLMF	West Coast Rock Lobster (Managed) Fishery
ZoHI	Zone of High Impact
ZoI	Zone of Influence
ZoMI	Zone of Moderate Impact

Executive Summary

The Jurien Bay Boat Harbour (hereafter; the Boat Harbour) is located north of the Jurien Bay town site and ~225 km north of Perth, Western Australia. Department of Transport (DoT) is responsible for management and maintenance of the Boat Harbour under the *Marine and Harbours Act 1981*. DoT is required to carry out routine maintenance dredging within and adjacent to the Boat Harbour (hereafter; the dredge area) over the period 2020–2030. The maintenance dredging will involve the removal of sand and wrack material using a small cutter-suction dredge.

Offshore disposal is proposed for dredged sediments into a naturally deep basin (hereafter; the offshore disposal area). This area was selected based on its proximity to the dredge area, natural retentive nature, capacity to receive dredged material over the next ten years and lack of benthic habitat. The offshore disposal area is within the Jurien Bay Marine Park (JBMP).

This document presents a Long-Term Monitoring and Management Plan (LTMMP) for maintenance dredging at the Boat Harbour over the 2020–2030 period. LTMMPs outline both the framework and specific measures for management, mitigation and monitoring of potential environmental impacts. LTMMPs are a statutory requirement for the issue of a long-term Sea Dumping Permit under the *Environment Protection (Sea Dumping) Act 1981*. This LTMMP also forms the environmental impact assessment and management document for issue of a Lawful Authority under the *Conservation and Land Management Act 1984*.

Dredge area sediments have been tested and assessed against the National Assessment Guidelines for Dredging (CA 2009) framework and are considered suitable for unconfined ocean disposal. Modelling of the extent of turbid plumes at the disposal area indicates that significant reduction in light attenuation (and associated impacts to benthic habitats) is unlikely. Impacts to marine fauna, water quality and direct smothering to benthic communities and habitat are also considered to be unlikely to occur. However, monitoring and management will be completed to ensure the environmental impacts of offshore disposal are minimised to as low as reasonably practicable.

Weekly and end of campaign environmental reports will be compiled to ensure all data collected is of sufficient quality and is compliant with this LTMMP. Any exceedances of management targets will result in management actions implemented to ensure no significant impact to the environment.

Stakeholder consultation has commenced and will continue throughout the Project duration. The DoT Maritime Advisory Group (MAG) will be utilised as the primary, long-term stakeholder input into maintenance dredging. Other key stakeholders, including Department of Biodiversity, Conservation and Attractions (DBCA) Marine Park Managers, will be consulted through the life of the permit.

This LTMMP will undergo revision prior to each maintenance dredging campaign to ensure it is still current and management and monitoring is in keeping with best scientific practice. Significant revisions will be provided to Department of Agriculture, Water and the Environment (DAWE)¹ and DBCA for approval prior to implementation.

¹ Formerly Department of the Environment and Energy (DoEE) – Sea Dumping Branch.

1 Introduction

The Jurien Bay Boat Harbour (hereafter referred to as the Boat Harbour) is north of the Jurien Bay town site and ~225 km north of Perth, Western Australia (WA; Figure 1.1). The Boat Harbour's entrance channel has a design depth of -4.0 m chart datum (CD), and the basin has design depths of -3.5 m CD, reducing to -3.0 m CD in the inner areas.

In January 1988, the Boat Harbour opened to provide refuge and service facilities for the Central West Coast fishing industry. The Boat Harbour is within an exclusion zone of the Jurien Bay Marine Park (JBMP) and contains 69 boat pens, four service jetties, a four-lane public boat ramp and boat maintenance facilities. The Boat Harbour supports a range of community uses, including recreational tourism and commercial and industrial development, with several land-backed facilities. Four live western rock lobster exporting facilities are located at the Boat Harbour. These storage facilities require seawater with adequate dissolved oxygen levels to sustain the western rock lobsters and retain the freshness necessary for transport.

Department of Transport (DoT) is responsible for management and maintenance of the Boat Harbour under the *Marine and Harbours Act 1981*. DoT is required to complete routine maintenance dredging within and adjacent to the Boat Harbour over the period 2020–2030. The maintenance dredging will involve the removal of sand and wrack (seagrass and macroalgae detached from the seabed) and benefits of the works will include:

- restoring the Boat Harbour to design depths to ensure safe navigation
- removing potential restrictions to natural flushing
- removal of significant volumes of wrack and eliminating the source of decomposing organic material within the Boat Harbour
- deepening the area along the northern breakwater to slow wrack and sediment alongshore transport into the Boat Harbour and to return the shoreline to pre-construction alignment
- ensure ongoing operational use of the Boat Harbour, surrounding industry and facilities.

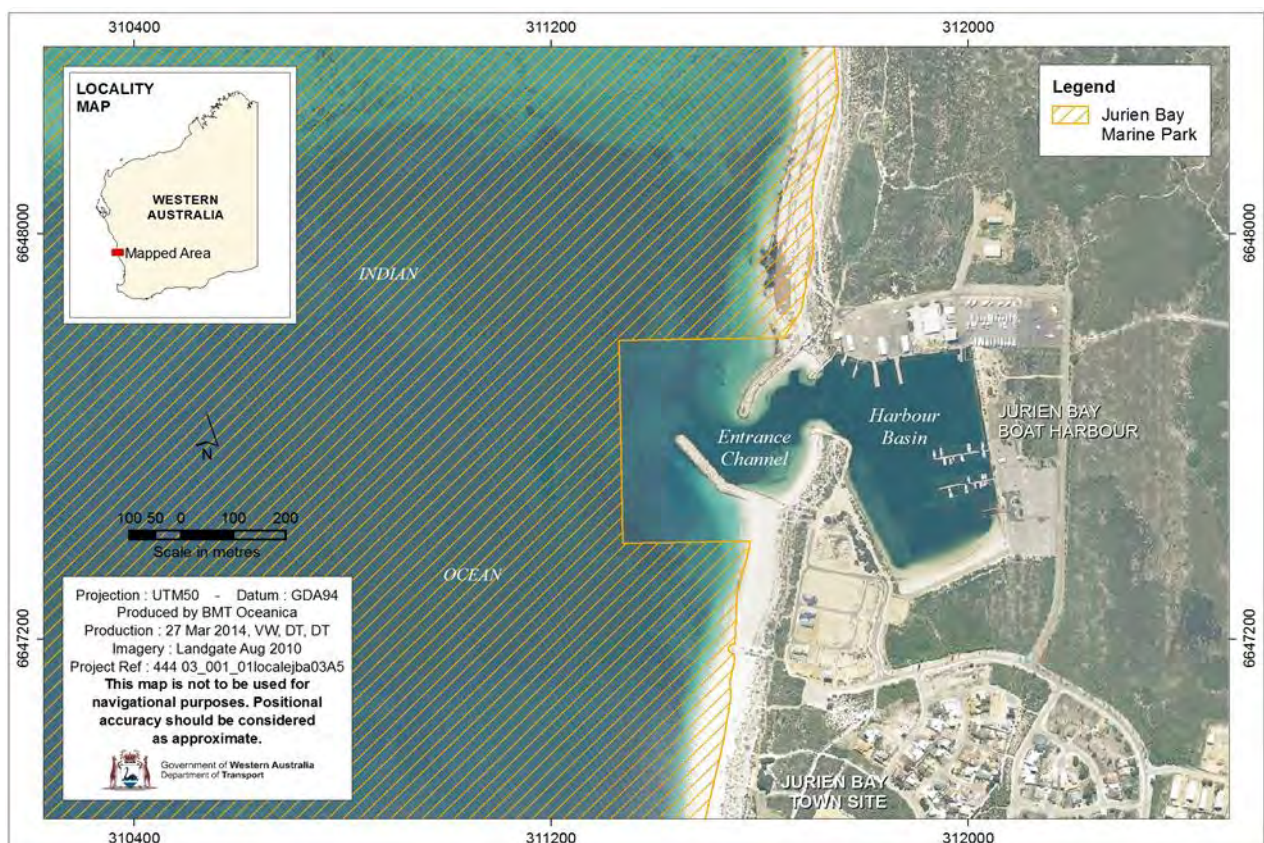


Figure 1.1 Jurien Bay Boat Harbour and the boundary of the Jurien Bay Marine Park, Western Australia

1.1 Purpose of this document

This document presents a Long Term Monitoring and Management Plan (LTMMP) for maintenance dredging of the Boat Harbour over the 2020-2030 period. LTMMPs outline both the framework and specific measures for management, mitigation and monitoring of potential environmental impacts. LTMMPs are a statutory requirement for the issue of a long-term Sea Dumping Permit (SDP) under the *Environment Protection (Sea Dumping) Act 1981*. This LTMMP also forms the environmental impact assessment and management document for issue of a Lawful Authority under the *Conservation and Land Management Act 1984*.

1.1.1 Continuous improvement

This LTMMP will undergo revision prior to each maintenance dredging campaign to ensure it is still current and management and monitoring is in keeping with best scientific practice. Significant revisions will be provided to Department of Agriculture, Water and the Environment (DAWE)² and Department of Biodiversity, Conservation and Attractions (DBCA) for approval prior to instigation. The Jurien Bay Maritime Advisory Group (MAG) will be invited to provide comment on the LTMMP following substantial revisions (Section 8.1).

1.2 Overall environmental management framework

1.2.1 Environmental Management Framework

DoT has a Maintenance Dredging – Environmental Management Framework (EMF; BMT 2021) that provides guidance for the environmental management of their state-wide maintenance dredging operations. The EMF includes guidance on sediment sampling and analysis with reference to relevant environmental guidelines. The intention of the EMF is to ensure DoT's maintenance dredging activities fulfil the following objectives:

- protection of the environment
- clear, relevant and practical identification of environmental issues
- efficient management and completion of environmental assessments as required.

The EMF is updated ~ annually, ensuring that best practice environmental management is applied to maintenance dredging. This LTMMP has been written in accordance with the DoT's EMF (BMT 2021), and defines the specific methods, actions and roles required of the Principal (DoT) and Dredging Contractor (hereafter; Contractor).

1.2.2 Jurien Bay Marine Park

The Boat Harbour's dredging and disposal areas overlap with the general use zone of the JBMP. The JBMP is currently managed via the Jurien Bay Marine Park Management Plan (JBMPMP) 2005–2015 (CALM 2005). The JBMP extends along the coastline between Wedge Island to the south and Green Head to the north, and offshore 3 nautical miles. Under the JBMPMP, dredging activities are permitted in general use zones, but is subject to assessment and approval (CALM 2005).

DBCA are responsible for overall management of the JBMP to ensure its values as stipulated in CALM (2005) are maintained and improved. This includes assessment of proposed dredging and disposal activities. Of relevance to this LTMMP are the management objectives and targets contained in Table 1.1, for environmental factors that may be potentially impacted by maintenance dredging. This LTMMP has been written to ensure these management objectives are met throughout the proposed dredging and disposal, and the associated values for each factor are maintained.

² Formerly Department of the Environment and Energy (DoEE) – Sea Dumping Branch.

Table 1.1 Environmental values, management objectives and management targets for at-risk factors in the Jurien Bay Marine Park

Environmental factor	Ecological value	Management objective	Management target
Water and sediment quality	The waters and sediments of the JBMP are largely pristine and are essential to the maintenance of a healthy marine ecosystem.	To ensure the water and sediment quality of the JBMP is not significantly impacted by the input of contaminants.	No change from background levels, unless approved by the appropriate government regulatory authorities.
Seagrass meadows	Extensive and diverse perennial seagrass meadows are an important habitat and nursery area for marine life and are important primary producers.	To ensure seagrass meadows in the JBMP are not permanently damaged by existing and future mooring and anchoring activities.	No permanent loss in the above-ground biomass of perennial seagrass from 2004 levels as a result of human activities in the JBMP.
Macroalgal communities	Extensive subtidal macroalgal communities with high floral diversity occur in the JBMP. These communities are important primary producers and refuge areas for diverse fish and invertebrate assemblages.	To develop an increased understanding of the distribution and diversity of macroalgal habitats in the JBMP.	No reduction in macroalgal species diversity or macroalgal habitat below 2004 levels as a result of human activities in the JBMP.

Source: CALM (2005)

1.3 Previous dredging and disposal

The Boat Harbour has historically been maintained through dredging (capital and maintenance), wrack trawling and land-based excavation. Historical dredge frequency and volumes for previous maintenance campaigns are outlined in Table 1.2 and further details are provided in the below sections.

Table 1.2 Historical dredging, wrack trawling and sand excavation works completed at Jurien Bay Boat Harbour

Year	Volume	Comments
2020/21	~46,000 m ³	Maintenance dredging and disposal to approved offshore disposal area.
2016/17	~62,000 m ³	Maintenance dredging and disposal to cleared onshore disposal area.
2015/16	~79,500 m ³	Maintenance dredging and disposal to cleared onshore disposal area.
	~4700 m ³	Wrack trawling.
2014	~8500 m ³	Sand excavation.
	~4500 tonnes	Wrack trawling.
2013	~2000 tonnes	Wrack trawling.
2011	~100 tonnes	Wrack trawling.
2005/2006	~41, 000 m ³	Maintenance dredging, disposal to dunes, wrack disposal options considered.
1988	~550,000 m ³	Capital construction. Material removed from the Boat Harbour for residential development south and south-east of the Boat Harbour. A portion of the material was also disposed of to the north of the Boat Harbour.

1.3.1 Capital dredging

Capital dredging to construct the Boat Harbour was carried out in 1985 and completed in 1986 (Table 1.2). The basin was dry-excavated to approximately -3 m CD, the entrance channel to approximately -3.5–4 m CD and the harbour entrance to approximately -5–6 m CD (JFA 2006). Material removed from the Boat Harbour was used for residential development to the south and south-east of the Boat Harbour. However, a portion of the material was also disposed to the north of the Boat Harbour (JFA 2006). The total volume of material removed during the Boat Harbour construction was ~550,000 m³.

1.3.2 Maintenance dredging

Since construction, the Boat Harbour has required maintenance dredging on four occasions, in 2005/2006, 2015/16, 2016/17 and 2020/21 (Table 1.2; BMT Oceanica 2014a,b; BMT 2021a). Dredged material from the 2005/2006 campaign was disposed of onto sand dunes north of the Boat Harbour (and subsequently re-vegetated). Sediment from the 2015/16 and 2016/17 campaigns was disposed of into cleared areas onshore and progressively revegetated (Note:

1. The north-eastern boundary extent of the Onshore Disposal Area was reduced following the Aboriginal Heritage survey that identified a potential Aboriginal Heritage site
2. The boundary extent has changed over time to allow for extensions to receive additional dredged material

Figure 1.2). However, this is not considered to be appropriate for future campaigns, as there is a finite amount of area that can be cleared and continual clearing of native vegetation for the disposal of marine sediments is not considered environmentally sustainable. The first maintenance campaign to involve offshore disposal (covered by this LTMMMP and associated approvals) was completed in 2020/21, and sediments were disposed to the approved Offshore Disposal Area (SD2019/3984) via floating and submerged pipelines (BMT 2021a).

1.3.3 Wrack trawling

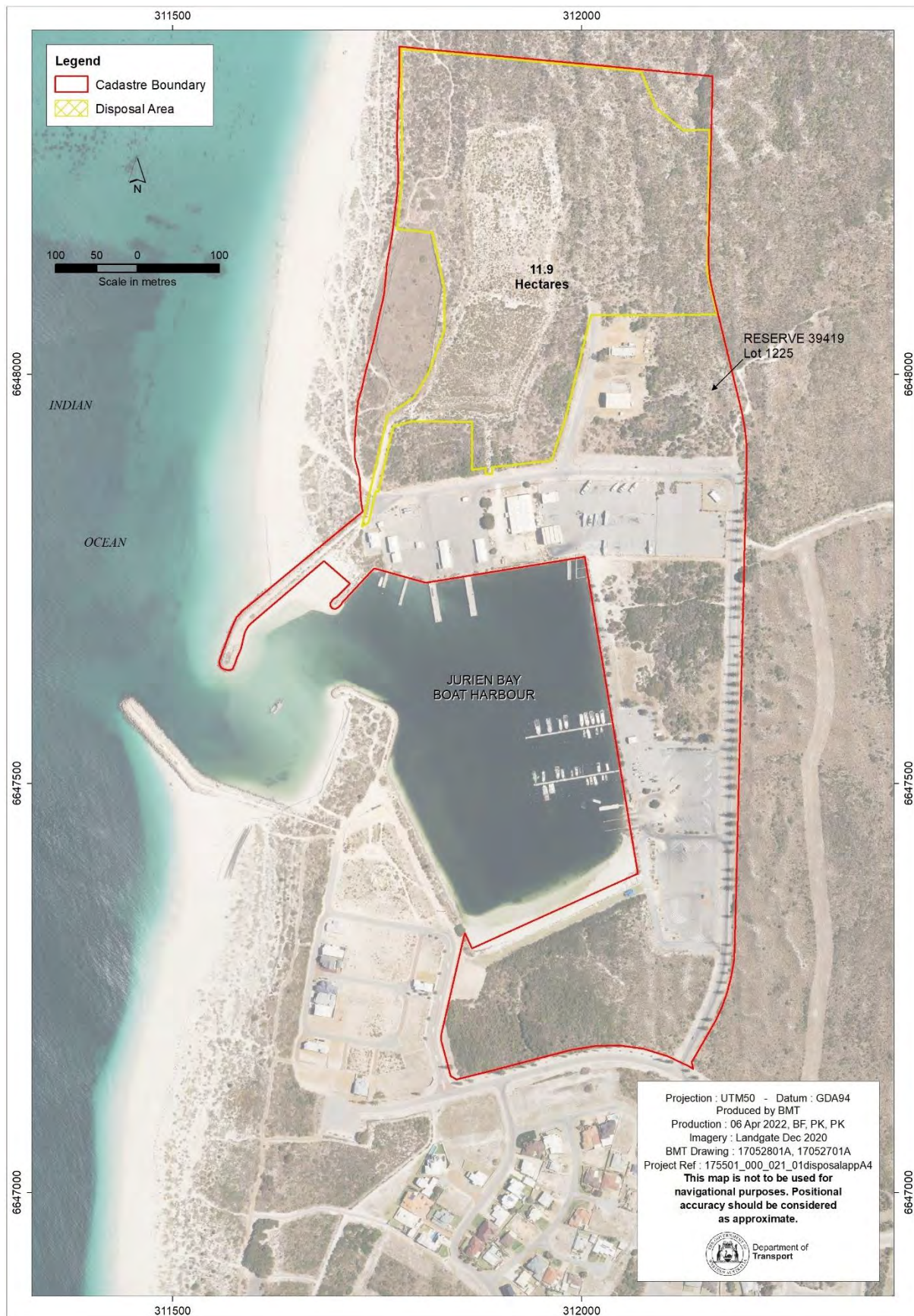
Wrack trawling in the Boat Harbour's entrance channel was completed in 2011, 2013 and 2014 (Table 1.2). The 2011 campaign was a trial that involved the removal of ~100 tonnes of wrack (JFA 2012). Prolonged stormy weather conditions in Jurien Bay in winter 2013 led to a substantial wrack build up within the Boat Harbour and along nearby beaches. This resulted in

fish kills and poor navigability within the Boat Harbour's basin and entrance channel. As a result, emergency trawling works removed ~2000 tonnes of wrack from the Boat Harbour in October/November 2013 (BMT Oceanica 2013). Similar works were completed in June/July 2014 when 4500 tonnes of wrack was removed in an attempt to pre-emptively reduce the amount of wrack in the Boat Harbour's entrance channel ahead of 2014 winter storms.

During each campaign, wrack was removed from the entrance channel using a beam trawl and a heavy-duty net. The wrack was placed within the DoT's Harbour Reserve and reused as mulch by local Jurien Bay residents. Minor turbidity was observed during the three trawling campaigns, but the turbid plume was not seen to extend beyond the Boat Harbour breakwaters (BMT Oceanica 2014c,d).

1.3.4 Sand excavation

Excavation of sediments adjacent to the Boat Harbour's inner northern sand trap was completed in 2014 (Table 1.2). The works involved the removal of ~8500 m³ of sand to improve navigability in the entrance channel and allow access to the Boat Harbour's jetties. The material was stockpiled on the inner northern sand trap and was be used for the construction of the onshore bunded disposal area for the 2014/2015 dredging campaign. Turbidity generated during the sand excavation campaign did not extend beyond the Boat Harbour breakwaters (BMT Oceanica 2014e).



Note:

- The north-eastern boundary extent of the Onshore Disposal Area was reduced following the Aboriginal Heritage survey that identified a potential Aboriginal Heritage site
- The boundary extent has changed over time to allow for extensions to receive additional dredged material

Figure 1.2 Jurien Bay Boat Harbour reserve and onshore disposal area for the 2015/2016 and 2016/17 maintenance dredging campaigns

2 Description of Dredging and Disposal

2.1 Dredging

Maintenance dredging campaigns involve the removal of recently deposited marine sediments and wrack to restore design depths with the primary purpose of maintaining safe navigation into and within the Boat Harbour. Accretion of sand and wrack is a dynamic process with material accreting in different areas and volumes depending on weather conditions which vary temporally. Therefore, maintenance dredging could reasonably be required at any location within the exclusion zone of the JBMP to maintain waterways into and within the Boat Harbour. Figure 2.1 shows design depths within the navigation channel and basin. It also shows target depths for areas immediately adjacent to the channel and entrance structures that are presently affected by significant accretion and are anticipated to require dredging in the near-to mid-future (Figure 2.1). Maintenance dredging areas shown in Figure 2.1 represent the presently anticipated areas requiring dredging but future dredging within the exclusion zone of the JBMP would be amended to include any accretion impacting safe navigation of the Boat Harbour's entrance. Coordinates for the exclusion zone of the JBMP (where the shoreline boundaries of the JBMP extend out to the east of the Boat Harbour's entrance) where any future maintenance dredging could occur are presented in Figure 2.2 and listed in Table 2.1.

Since construction of the Boat Harbour, significant accretion of more than 500,000 m³ of sediment has occurred along the beaches immediately north and south of the Boat Harbour's entrance resulting in the shoreline moving seaward ~80–100 m. This accretion has introduced a large sand supply immediately adjacent to the Boat Harbour, formed a more direct pathway for alongshore sediment transport to deliver material to the Boat Harbour's entrance, increasing the need for maintenance dredging. Removal of some of the accreted sand from the shoreline north and south of the Boat Harbour (north Areas C and K and south Area G; Figure 2.1) has become necessary to improve the performance of the entrance breakwaters in inhibiting material accretion within navigational areas and to reduce the frequency of maintenance dredging. Coordinates of the proposed Area K located within the JBMP to be included in the maintenance dredging area are presented in Figure 2.2 and listed in Table 2.1. In Area K, the dredging area has been designed to return this segment of the north shoreline to the pre-construction alignment and provide capacity for accretion outside the harbour.

The depth of sediment accretion above design depths will vary per campaign, however; the maximum estimated dredging depth is anticipated ~5 m below water level (Table 2.2). Dredge areas, target dredge depths and estimated dredge volumes including over-dredge allowance (based on September 2018 survey) are shown in Table 2.2. The maximum dredging volume (inclusive of the over-dredge allowance) per maintenance campaign is anticipated to be ~210 100 m³ with an estimated duration of ~40 weeks (Table 2.2). The dredge volumes are conservative and will vary prior to each maintenance dredging campaign. Since it is unlikely there will be sufficient funding available to achieve all target areas, volumes and depths in an individual maintenance campaign, the anticipated volume per campaign is more likely to be ~80 000 m³ based on historical dredging volumes (Table 1.2), with an anticipated campaign duration of ~18 weeks. Areas within the Boat Harbour that are still at or below the declared design depths will require minimal or no dredging. These areas will be determined from pre-dredge hydrographic surveys prior to each maintenance dredging campaign.

It is anticipated that dredging will be completed with a small cutter-suction dredge (CSD), as used for the previous maintenance dredging campaigns. The use of a CSD should limit turbid plumes and sedimentation to the dredge area, though this depends on sediment characteristics and local hydrodynamics (Ports Australia 2014)

2.2 Sediment redistribution

Condition 4 of the approved SDP (SD2019/3984) requires the Offshore Disposal Area does not become shallower than -8 m CD from the disposal of dredged material. Sediment redistribution within the Offshore Disposal Area may be required if the height from disposal of dredged material

exceeds the conditioned height tolerance limit in the SDP. Sediment redistribution involves the redistribution of previously dredged marine sands from the Boat Harbour deposited within the Offshore Disposal Area. Based on previous dredge volumes, a typical maintenance dredging campaign can range between ~40,000–70,000 m³. (Table 1.2). A small portion of material disposed offshore may require small-scale redistribution of the deposited dredged material if the conditioned height is exceeded during disposal. It is anticipated that the duration for remedial dredging will be short-term at the campaign completion³. Sediment redistribution will only be required in the event the Contractor disposes dredged material above -8m CD to allow for flexibility to rectify disposal heights and ensure safe navigability in the JBMP. The Contractor will be instructed to ensure the vertical height tolerance is monitored during the maintenance dredging campaign and frequent repositioning of the disposal pipeline is undertaken to avoid accretion of sands above the conditioned height.

Redistribution methods within the Offshore Disposal Area may vary dependent on operational considerations and equipment availability but are likely to include ploughing or dredging of potential high spots generated from deposited dredged material into adjacent deeper pockets of unvegetated seabed (Figure 2.4). Any redistribution works will be considered as 'operational' dredging days as specified in approvals and the same environmental monitoring methods and management actions outlined in this LTMMMP will be applied (Section 7).

³ The volume of sediment redistribution is anticipated to be small-scale (~1000 m³) over a short-term duration (~1 week) and will only be required if the contractor's disposal methods does not adhere to the vertical height limit and disposes above -8 CD.

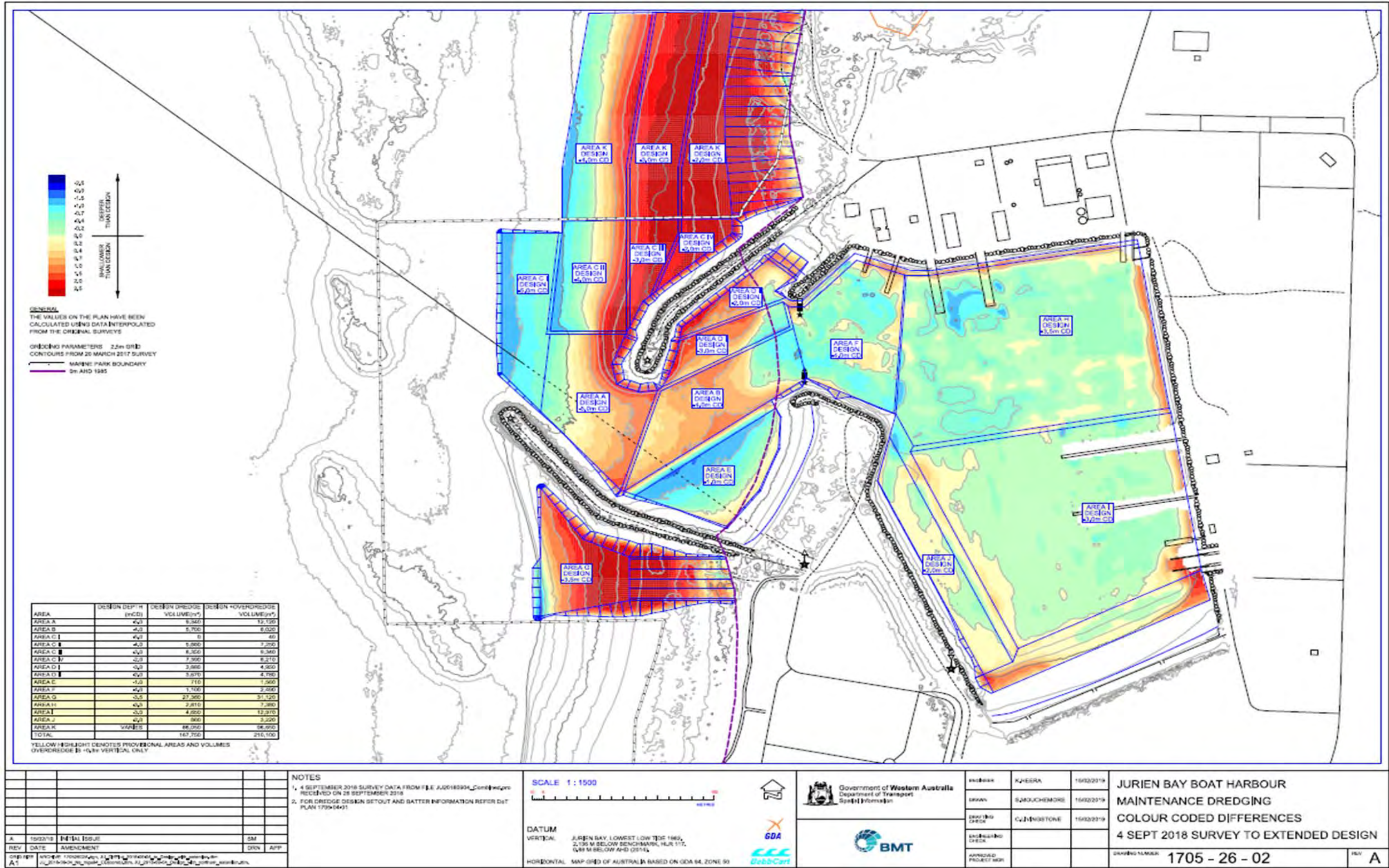


Figure 2.1 Jurien Bay Boat Harbour proposed maintenance dredging areas and volumes

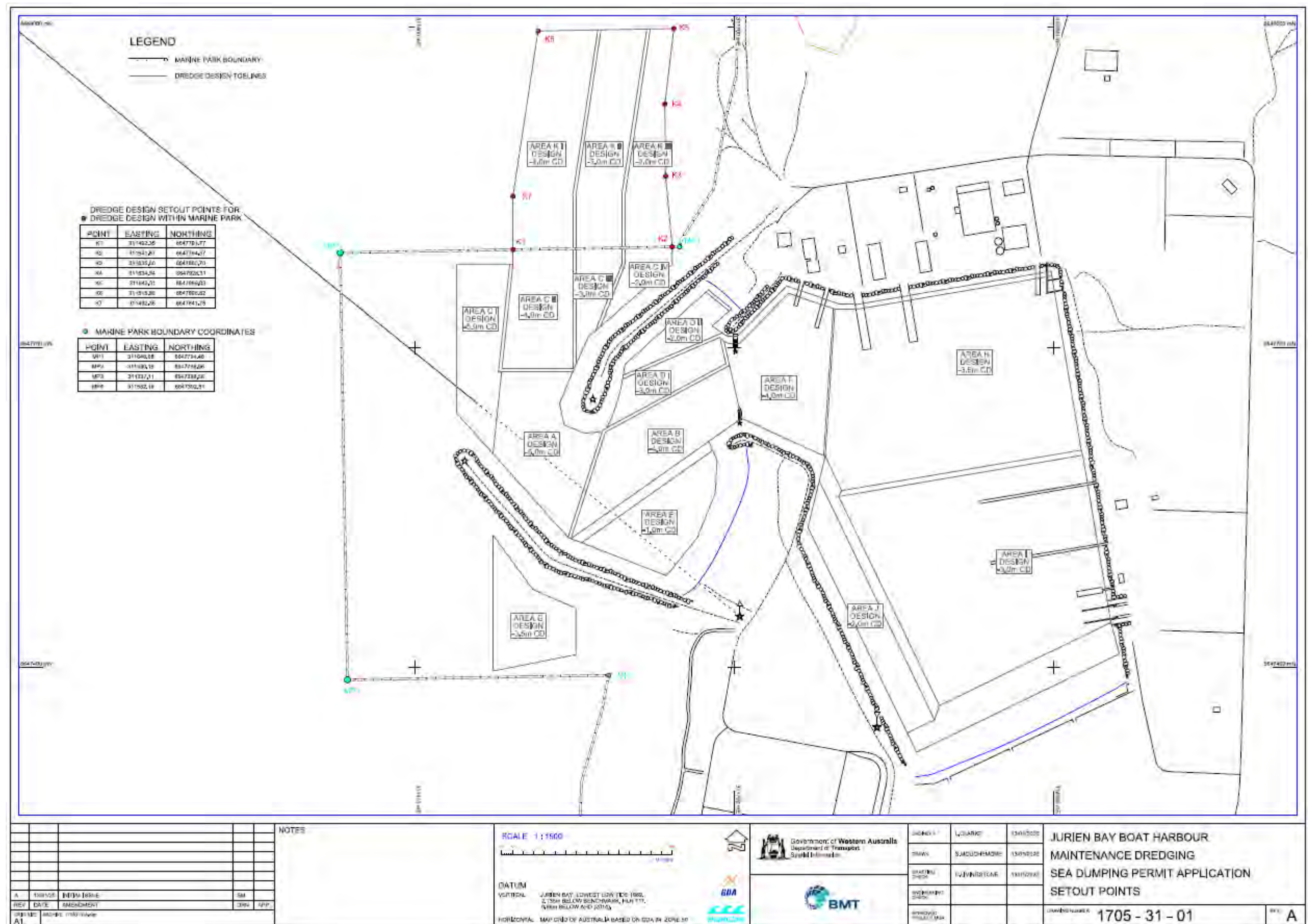


Figure 2.2 Jurien Bay Boat Harbour proposed maintenance dredging areas and corner point coordinates

Table 2.1 Corner point coordinates for the exclusion zone of the Jurien Bay Marine Park and for the proposed maintenance dredging area located within the Jurien Bay Marine Park (Area K)

Area	Corner point	Easting ¹	Northing ¹	Latitude	Longitude
JBMP boundary	MP1	311648	6647794	30° 17.217' S	115° 2.498' E
	MP2	311330	6647788	30° 17.217' S	115° 2.300' E
	MP3	311337	6647388	30° 17.434' S	115° 2.300' E
	MP4	311582	6647392	30° 17.434' S	115° 2.453' E
Area K	K1	311492	6647791	30° 17.217' S	115° 2.401' E
	K2	311641	6647794	30° 17.217' S	115° 2.494' E
	K3	311635	6647860	30° 17.181' S	115° 2.491' E
	K4	311634	6647928	30° 17.144' S	115° 2.492' E
	K5	311643	6647999	30° 17.106' S	115° 2.497' E
	K6	311515	6647996	30° 17.106' S	115° 2.418' E
	K7	311492	6647841	30° 17.190' S	115° 2.402' E

Notes:

1. GDA 94, UTM 50J.
2. JBMP = Jurien Bay Marine Park.
3. Refer to Figure 2.2 for explanation of areas and location of corner points.

Table 2.2 Target dredge depths and estimated dredge volumes for the proposed Jurien Boat Harbour maintenance dredging campaigns

Dredge area	Target dredge depth (m CD)	Dredge design volume (m ³)	Dredge design and over-dredge volume (0.3 m) (m ³)
A	-5.0	9340	12,120
B	-4.0	5700	8020
CI	-5.0	0	40
CII	-4.0	5880	7250
CIII	-3.0	8350	9340
CIV	-2.0	7390	8210
DI	-3.0	3880	4950
DII	-2.0	3670	4780
E*	-1.0	710	1560
F	-4.0	1100	2490
G*	-3.5	27,360	31,120
H*	-3.5	2810	7380
I*	-3.0	4650	12,970
J*	-2.0	860	3220
K*	Varies	86,050	96,650
Total	N/A	167,750	210,100

Notes:

1. Refer to Figure 2.1 for explanation of dredge areas.
2. '*' = Provisional areas and volumes; 'm' = metre; 'CD' = chart datum, 'm³' = cubic metre, 'N/A' = not applicable.
3. Volumes are conservative and represent upper estimates within each dredge area and will vary for each maintenance dredging campaign depending on natural siltation rates.
4. Small-scale sediment redistribution may be undertaken within the Offshore Disposal Area if disposal of dredged exceeds the conditioned height limit stipulated in Condition 4 of the approved SDP (SD2019/3984).

2.3 Disposal

For maintenance dredging campaigns it is proposed that marine sediments from the Boat Harbour will be disposed offshore. The proposed offshore disposal area is located ~1 km northwest of the Boat Harbour in ~12 m water depth (Figure 2.3, Table 2.3). Dredged material from the Boat Harbour will be hydraulically pumped via floating/submerged pipeline. The offshore disposal area is ~36 ha and has the capacity to receive dredged material over the next ten years to a maximum volume of ~1.1 Mm³ (based on ~five campaigns, biennially). It is anticipated the overall depth of the offshore disposal area will be reduced to -8.0 m CD. If the disposal of dredged material within the Offshore Disposal Area exceeds the conditioned height limit specified in the SDP (SD2019/3984), small-scale sediment redistribution may be required at the completion of the campaign. Sediment high spots will be redistributed to adjacent areas of deeper unvegetated seabed (Figure 2.4) to achieve the conditioned height tolerance (Section 2.2). The Contractor will be required monitor disposal heights during dredging and sediment redistribution will only be undertaken if required. The offshore disposal area is located within the JBMP and disposal of material is subject to additional approvals from DBCA. Several alternative disposal options have been previously considered for the placement of dredged material for maintenance dredging campaigns (BMT Oceanica 2017). In consideration of the principles of waste avoidance and promotion of resource recovery, offshore placement was prioritised over the onshore alternatives, to:

- reduce the potential for dredged material to be re-distributed back into the Boat Harbour
- retain sediments within the natural marine system
- avoid routine clearing of onshore native vegetation (Figure 2.3).

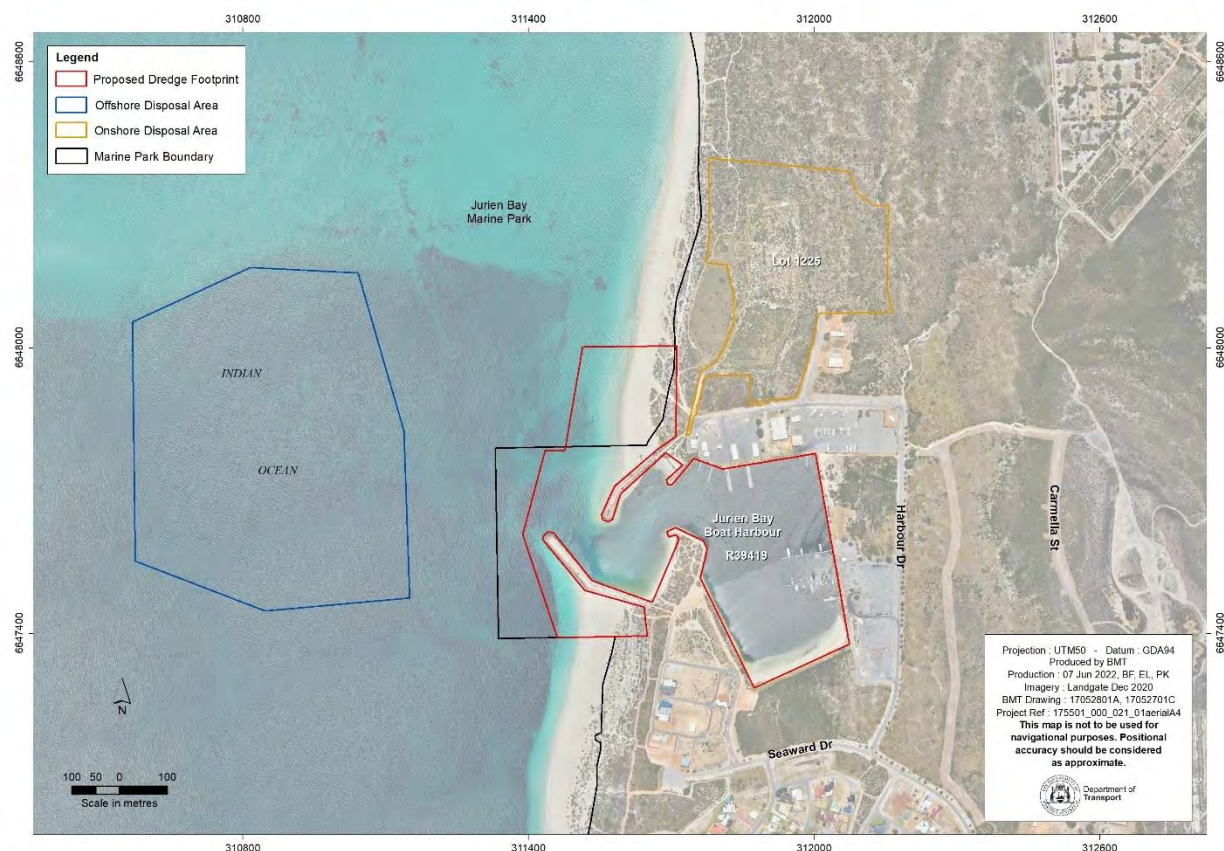


Figure 2.3 Jurien Bay Boat Harbour maintenance dredging layout: proposed dredge area, offshore disposal area, alternative onshore disposal area and Jurien Bay Marine Park excision boundary

Table 2.3 Jurien Bay Boat Harbour proposed offshore disposal area corner point coordinates

Corner	Easting ¹	Northing ¹	Latitude	Longitude
North-west	310568	6648054	30° 17.066' S	115° 1.827' E
North	310816	6648168	30° 17.007' S	115° 1.984' E
North-east	311042	6648157	30° 17.015' S	115° 2.125' E
East	311138	6647824	30° 17.196' S	115° 2.181' E
South-east	311151	6647474	30° 17.386' S	115° 2.185' E
South	310847	6647447	30° 17.397' S	115° 1.995' E
South-west	310574	6647551	30° 17.338' S	115° 1.826' E

Notes:

1. GDA 94, UTM 50S

2.3.1 Disposal area assessment

The offshore disposal area has been chosen based on its proximity to the dredge area (<2 km pumping distance), retentive nature (Appendix A) and sparse benthic habitats (Section 5.3.1, Figure 2.4). Figure 2.4 demonstrates the criteria applied to site selection of the offshore disposal area with consideration of maximum pumping distance and distribution of benthic habitats throughout this area. Previously, offshore disposal onto the Favourite Island Sandbar had been nominated (BMT Oceanica & BMT JFA 2014); however, this area is no longer considered suitable because:

- the shallow depth increases the area required to accommodate sediments for the 10-year permit duration and the area is exposed to greater wave action (resulting in movement of disposed material away from the area)
- the sandbar acts as a source to the beach north of the Boat Harbour (BMT 2018a), and sediments are naturally transported by coastal processes from this area into the Boat Harbour's entrance channel.

Anticipated potential impacts to the physical, biological and social environments from using the proposed offshore disposal area are discussed in Section 6. Associated monitoring and management to reduce potential impacts are detailed in Table 7.3 and Section 0.

The offshore disposal area will not be entirely utilised in one campaign, rather progressively filled from several maintenance campaigns over a 10 year duration. The area is anticipated to be retentive (Appendix A) with little movement of sand outside of the modelled impact areas. Following adoption of monitoring and management measures, use of the offshore disposal area presents minimal risk of significant environmental impacts and is considered suitable for the proposed maintenance dredging campaigns.

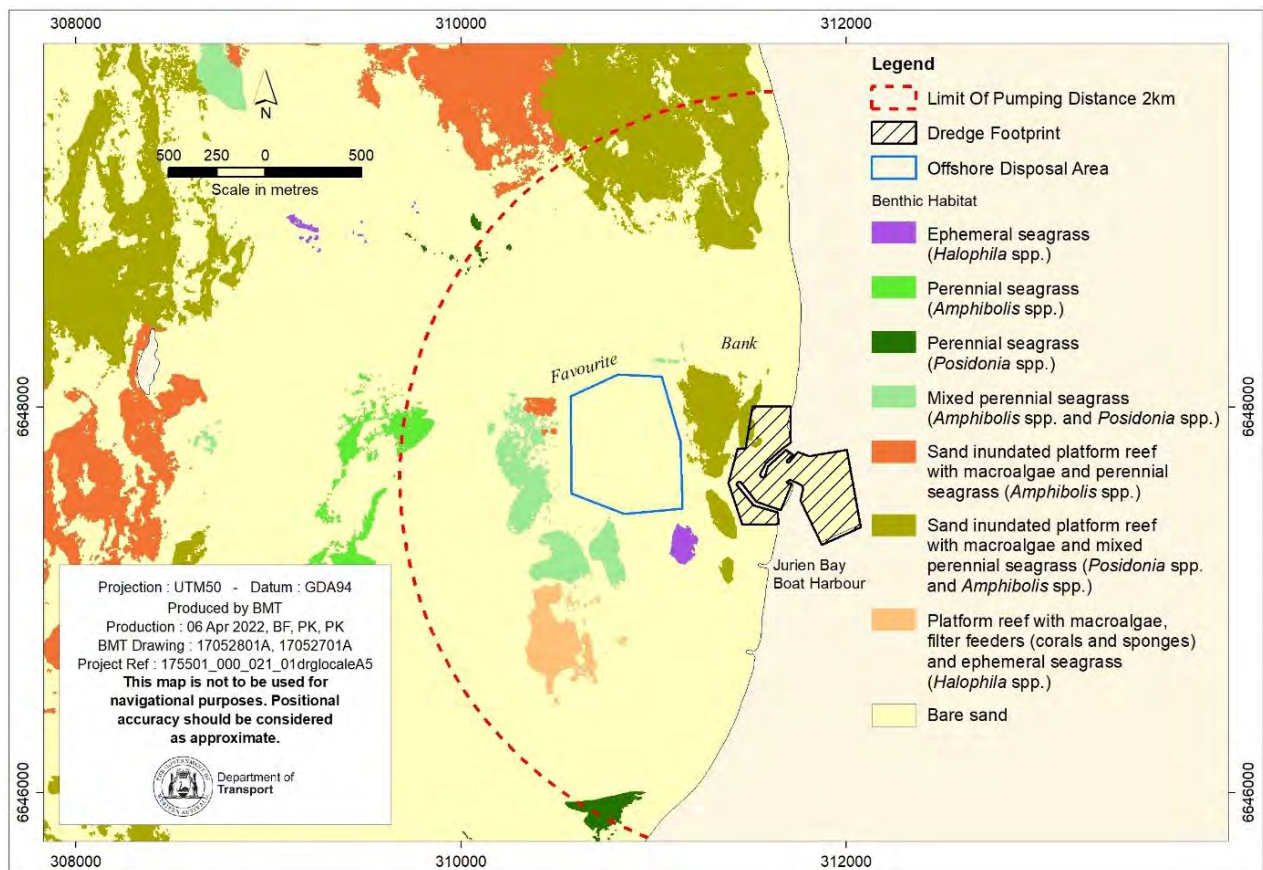


Figure 2.4 Classification and distribution of benthic habitat and communities surrounding Jurien Bay and Criteria for selection of Jurien Bay offshore disposal area

2.3.2 Alternatives considered

Alternatives to sea disposal were assessed in the context of risk to financial, environmental, social and human health factors (Table 2.4). Not dredging the Boat Harbour is considered an unfeasible alternative to ocean disposal and would result in the closure of the Boat Harbour from infilling and risk to navigational safety. This would mean that DoT is not meeting its obligations under the *Marine and Harbour Act 1981*, and the users of the Boat Harbour and Jurien Bay community would likely suffer social and economic impacts.

Landfill disposal of sediment is not considered in keeping with the objectives of the *Waste Avoidance and Resource Recovery Act 2007*. In addition, the large volumes of material and associated trucking costs, fees and levy's mean that landfill disposal is economically prohibitive.

Beach disposal has previously been considered by DoT for maintenance dredging. Beach disposal involves pumping the dredge slurry ~3 km north of Boat Harbour and disposing dredged material directly onto the beach within the JBMP. It is assumed that disposal will occur above the low water mark. Once complete, the area of material disposed will encompass ~50–100 m across shore, and between 350 m and 1 km (pre-emptive dredging) along the shoreline. This option was considered not feasible due to engineering constraints with pumping distances, the proximity to terrestrial native vegetation, benthic habitats (nearshore reef), and the risk that disposed material would exacerbate sand accretion north of the Boat Harbour and increase flow of wrack and sand back into the Boat Harbour.

Onshore disposal of sediments has been considered as an alternative option. DoT has obtained a clearing permit under Part V of the EP Act (permit CPS 6181/2) for the remaining area within the Harbour Reserve. However, the onshore disposal of marine sediments is not considered suitable because:

- available capacity of the available Harbour Reserve area is insufficient to accommodate the estimated dredging volume without increasing the ground elevation in excess of 4 m above natural surface
- onshore disposal would raise the level of the ground throughout the lease by at least 4 m significantly affecting future development options
- onshore disposal of sediments is not considered environmentally sustainable in the long-term to clear terrestrial native vegetation to accommodate dredged material
- the dredge material is not contaminated and is considered suitable for unconfined ocean disposal according to the National Assessment Guidelines for Dredging (NAGD; CA 2009) framework, and therefore presents a low risk of causing contamination
- sediments and wrack originate from the JBMP, therefore returning the material to the JBMP is considered the most ecologically sustainable and responsible approach.

Table 2.4 Summary of alternative options considered for Jurien Bay Boat Harbour maintenance dredging

Option	Description	Comparative cost	Environmental impacts	Social impacts	Human health impacts
Sea dumping	Disposal of sediments to the proposed offshore disposal area	This scenario is the most cost effective and is a baseline for comparison with other disposal options	Low – management of impacts per this LTMMMP (Section 0) will ensure minimal long-term impacts to the environment	Low – no ongoing impacts are anticipated, however, there would be some loss of amenity during the works (Section 6)	None – material for disposal is clean marine sands (Section 4.3)
Onshore disposal	Disposal of sediments to a cleared DoT onshore reserve	<p>Incurs costs in addition to the baseline due to:</p> <ul style="list-style-type: none"> • vegetation clearance • earthworks for bunded enclosure and drainage management • management of land degradation (i.e. weed control, dust suppression) 	High – clearing of up to 14.22 ha native dune vegetation to allow for disposal of marine sediment	Medium – located within the Yued Indigenous Land Use Agreement and with potential disturbance to Southwest Native Title Settlement Land. Poor public perception would be anticipated from clearing terrestrial native vegetation to dispose marine sediment that should remain in its natural system	Low – potential for ongoing dust impacts from disposed sediment
Disposal to landfill	Disposal of sediments to local landfill	<p>Incurs costs in addition to the baseline due to:</p> <ul style="list-style-type: none"> • establishment of temporary holding and dewatering dams • vegetation clearance • rehandling dredged material when loading into trucks • establishing temporary roads to the dewatering area • significant trucking costs for volumes required • significant landfill disposal costs (levy) for volume required – up to \$150/m³ 	Low – disposal of sediments to landfill is not in keeping with the <i>Waste Avoidance and Recovery Act 2007</i>	Low – some loss of amenity would be anticipated during the works and poor social perception from significant use of allocated state funded Maintenance Dredging Program budget to accommodate trucking and levy's and/or from removing marine sediment from it's natural system	None

Option	Description	Comparative cost	Environmental impacts	Social impacts	Human health impacts
		<ul style="list-style-type: none"> • revegetation or stabilisation of temporary holding areas 			
Beach disposal	Disposal of sediments to the beach north of the Boat Harbour	<p>Incurs costs in addition to the baseline due to:</p> <ul style="list-style-type: none"> • significant distance to pump material to a suitable location north from dredge areas • mobilisation of ~3 times the length of pipeline required for offshore disposal to reduce the risk of rapid return of sand into the Boat Harbour • mobilisation and operation of 2 additional booster pumps • machinery required to manage and reprofile the disposal area 	Medium – disposal of sand to the nearshore/beach environment could alter coastal processes of Jurien Bay and potentially smother benthic habitats	Low – some loss of amenity would be anticipated during the works	None
Not dredging	Not dredging the Boat Harbour	n/a	High – this is likely to result in closure of the Boat Harbour and poor water quality conditions resulting in fish kills, as experienced historically	High – no dredging will limit navigational access to the Boat Harbour, restricting/ceasing commercial and recreational use and the anticipated poor water quality from not dredging the Boat harbour would also reduce amenity	Medium – poor water quality could lead to human health impacts from primary (i.e. swimming) and secondary contact (i.e. odour; boating, water sports)

Notes:

1. Comparative cost assessment is per campaign.
2. DoT= Western Australian Department of Transport; LTMMMP = Long Term Monitoring and Management Plan; n/a = not applicable.

3 Regulatory Approvals and Policy Content

The anticipated approvals required for ongoing maintenance dredging of the Boat Harbour and offshore disposal are:

- Lawful Authority under the *Conservation and Land Management Act 1984* (CALM Act)
- Issue of a SDP under the *Environmental Protection (Sea Dumping) Act 1981* (SD Act)
- Potential referral and/or native vegetation clearing permit under the *Environment Protection Act 1986* (EP Act)
- Establishment of a Noongar Standard Heritage Agreement with the Yued Group

3.1 Department of Biodiversity Conservation and Attractions Lawful Authority

A Lawful Authority is required from DBCA to dispose sediments within JBMP. To issue the Lawful Authority, DBCA will need to be satisfied that proposed dredging and disposal will not impact on the values of the JBMP, detailed in the JBMPMP (CALM 2005; Table 1.1).

Approval has been obtained for offshore disposal of sediments and wrack dredged from the Boat Harbour and JBMP into a naturally deep basin in the JBMP (dated 06 August 2020 and valid from 25 June 2020 to 25 June 2022). Subsequent approvals will be obtained following further consultation with DBCA, and any conditions imposed on DoT through a Lawful Authority will be met through the implementation of this LTMMMP.

3.2 Environmental Protection (Sea Dumping) Act 1981

Ocean disposal of dredged material is regulated through a SDP issued under the SD Act by DAWE. Under the SD Act, the Australian Government assesses proposals to load and dump wastes and other materials at sea, permits acceptable activities, and sets conditions of approval to mitigate and manage environmental impacts.

DAWE has the authority to grant 10 year SDP's for long-term routine maintenance dredging requiring ocean disposal. This LTMMMP was submitted to DAWE for assessment and approval of a 10 year SDP permit for ongoing maintenance of the Boat Harbour. A SDP (no. SD2019/3984, valid 12 October 2020 to 30 September 2030) was approved pursuant to implementation of this LTMMMP and permit conditions. Conditions imposed on DoT through this SDP will be met through the implementation of this LTMMMP.

3.3 Environment Protection Act 1986

Although potential impacts to the Environmental Protection Authority's (EPA's) environmental factors of marine environmental quality and benthic communities and habitat (BCH; EPA 2021a) may be anticipated, offshore disposal of sediments will likely not require referral under Part IV of the EP Act. The objectives for each environmental factor can be met through the implementation of this LTMMMP. Review and approval of the LTMMMP by DAWE and DBCA under the SD and CALM Acts (as relevant Determining Authorities) will ensure objectives are met and environmental impacts are minimised.

Within the dredge area there is 0.5 ha of sand inundated platform reef with macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp) (refer to Section 5.3.1). The type of CSD anticipated to be used for the dredging is for removal of soft sediment and would not have the capability to remove harder substrates like reef structures. Mapped areas of BCH within the dredge areas will therefore be actively avoided during dredging and no direct removal is anticipated. If direct removal of BCH is considered required, a Native Vegetation Clearing Permit (NVCP) will need to be obtained under Part V of the EP Act.

If modifications to the existing dredge laydown area (onshore) require the direct removal of native vegetation, a NVCP will need to be obtained under Part V of the EP Act. If future disposal of

material is required to the historical onshore disposal area (Section 2.3), this will be regulated through the existing NVCP (permit CPS 6181/2).

3.4 Noongar Standard Heritage Agreement

The Boat Harbour and adjacent lands are within a Native Title Determination Area registered under the South-West Land and Sea Council (SWALSC) Indigenous Land Use Agreement for the Yued Group. The Yued Noongar Standard Heritage Agreement (NSHA) is a State Government endorsed heritage agreement for use by Government proponents seeking to undertake on-ground activities that are anticipated to impact heritage values (including those in State waters) in the native title Determination Area. DoT have executed the NSHA with SWALSC (for and on behalf of the Yued Agreement Group; (Reference No. LEG,1463, 27 February 2020).” and under this agreement, DoT is required to consult with Yued group for on-ground activities occurring within the determination area to ensure cultural values are protected and compliance with the *Aboriginal Heritage Act 1972*.

4 Sediment Sampling and Analysis

4.1 Currency of sediment quality data

To support this LTMMMP, sampling and analysis of sediments were undertaken in April 2019 from the proposed Boat Harbour dredge area and offshore disposal area (Figure 2.3). Sampling and analysis of sediments were completed in accordance with an approved Sediment Sampling and Analysis Plan (SAP; further detail available in Section 4.2) and results are presented in a SAP Implementation Report (further detail available in Section 4.3). A review of previous sediment sampling and analysis completed at the Boat Harbour is provided in Section 4.4.

In accordance with the NAGD (CA 2009), sampling and analysis of sediments from the proposed dredge area and offshore disposal area will be completed every five years throughout the life of this LTMMMP. Prior to each maintenance dredging campaign, an Initial Desktop Environmental Review (IDER) will also be completed, as required by the EMF (BMT 2021), to assess the adequacy of the sediment quality data for application, regardless of its currency. If the IDER demonstrates that there is a valid reason (i.e. report of significant environmental incident since last sampling occasion, significant change to surrounding land use tenure since last sampling occasion, etc.) for the sediment quality data to be considered as inadequate for continued application, additional sampling would be undertaken, as required.

4.2 Sediment sampling and analysis plan

An approved Sediment Sampling and Analysis Plan (SAP) is provided in Appendix B (BMT 2019a). The SAP was prepared to facilitate sampling and analysis of sediments from the proposed Boat Harbour dredge area and offshore disposal area (Figure 2.3) in April 2019 (refer Section 4.3) and will be applied to future sampling occasions (required every five years; Section 4.1). The SAP includes a review of the potential sources of contamination of the sediment proposed to be dredged (Appendix B).

4.3 Description of the material for disposal

The full results from sampling and analysis completed in April 2019 are detailed in the SAP Implementation Report provided in Appendix C (BMT 2019b). Surface sediment grab samples were collected from 15 sites within the dredge area and from seven sites within the offshore disposal area (Figure 4.1).

Dredge area sediments were analysed for particle size distribution (PSD), total organic carbon (TOC), total and elutriate metals, elutriate nutrients and hydrocarbons (total recoverable hydrocarbons [TRHs], total petroleum hydrocarbons [TPHs], polycyclic aromatic hydrocarbons [PAHs] and benzene, toluene, ethylbenzene and xylene [BTEX]). Sediments were generally characterised by fine to medium grained sands with fast settling rates (<2 minutes for 50% of particles to settle through 1 m of water and <1.2 hours for 90% of particles to settle through 1 m of water) and low TOC content (0.08–1.31%). Concentrations of total metals were below the relevant NAGD Screening Levels (CA 2009), however, mean concentrations of elutriate copper and zinc exceeded the relevant ANZECC/ARMCANZ (2000)⁴ trigger values for toxicants at the 95% and 99% species levels of protection. Sediment results showed elevated concentrations of elutriate nutrients. Mean concentrations of elutriate total phosphorous (TP), filterable reactive phosphorus (FRP), total nitrogen (TN), nitrate+nitrite (NO_x) and ammonium (NH₄⁺) exceeded the relevant ANZECC/ARMCANZ (2000) default trigger values for physical and chemical stressors for south-west Australia for slightly disturbed marine inshore ecosystems. The mean concentration of elutriate ammonia (NH₃) exceeded the relevant ANZECC/ARMCANZ (2000) trigger value for toxicants at the 95% and 99% species levels of protection. Concentrations of hydrocarbons were below the relevant NAGD Screening Levels (CA 2009).

⁴ At the time of preparing BMT (2019b), the ANZG (2018) marine water quality guidelines were not available for application due to resolving issues/inconsistencies on the website, and it was recommended to refer to the ANZECC/ARMCANZ (2000) marine water quality guidelines in the interim.

Offshore disposal area sediments were sampled to establish ambient baseline concentrations and were analysed for PSD, TOC, hydrocarbons and metals. Sediments were characterised by very fine to fine grained sands with low TOC content (0.25–3.79%) and concentrations of total metals were below the relevant NAGD Screening Levels (CA 2009).

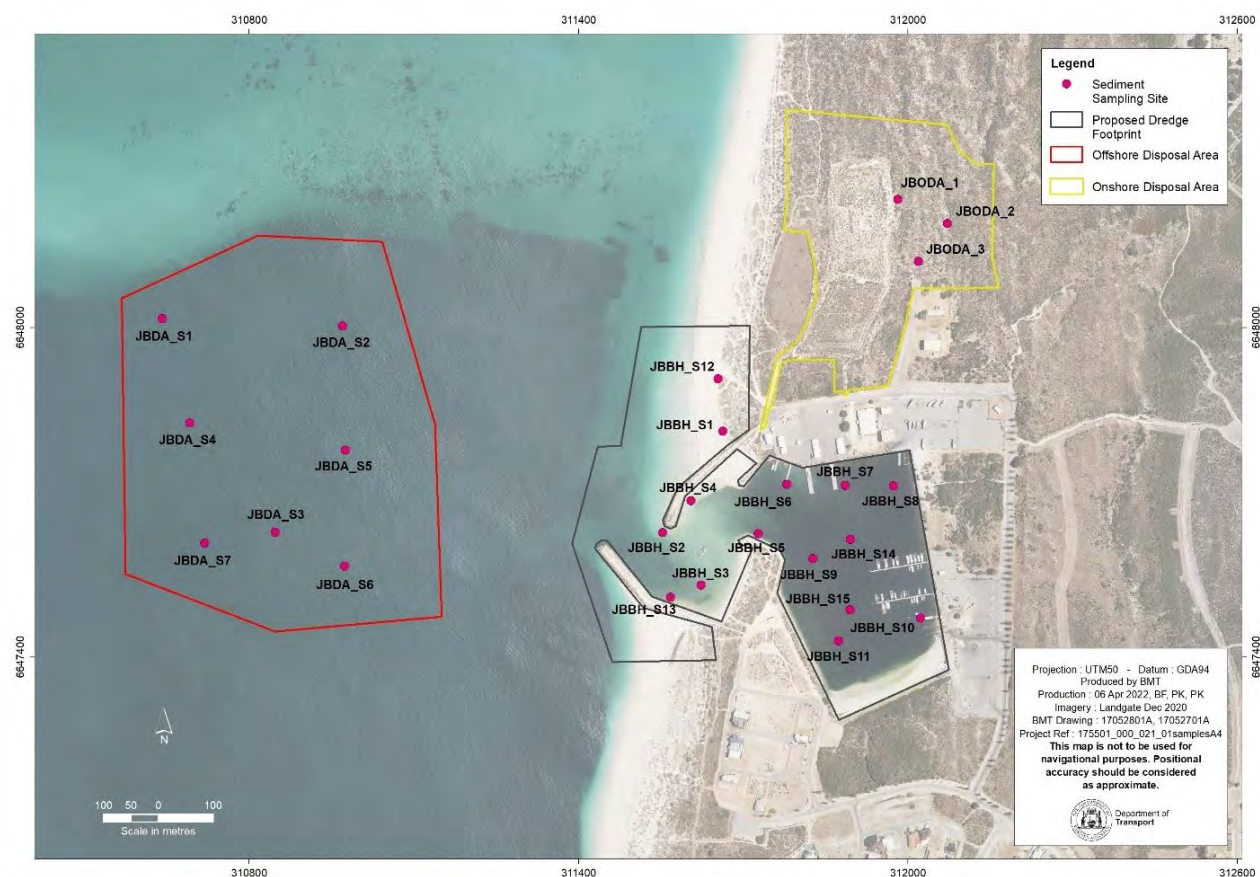


Figure 4.1 Sediment sampling sites within the proposed Jurien Bay Boat Harbour dredge area an offshore disposal area

4.4 Review of previous sampling and analysis

Sediments and wrack within the Boat Harbour have historically been sampled to inform DEIA's for maintenance dredging campaign and sampling results are summarised below.

4.4.1 Sediment sampling and analysis 2005

In 2005, six sediment cores were obtained from within the Boat Harbour entrance channel and one from within the basin (Oceanica & JFA 2005). The sediment samples were analysed for PSD, TOC, total metals and elutriate nutrients. Results showed sediments within the dredge area were comprised of clean medium/fine sands interspersed with decomposing seagrass wrack layers. There was no evidence of acid sulfate soils (ASS; Oceanica & JFA 2005). Sediment PSD showed material was predominantly medium to fine marine sands (83–96%) with some silt (<15%) and clay (<3.0%) and rapid settling velocity (Oceanica & JFA 2005). The TOC content of sediments was assessed via weight loss from combustion for one hour at 500°C and 1000°C with results ranging between 5–14% and 35–39%, respectively. Total metal concentrations were below relevant ANZECC/ARMCANZ (2000) interim sediment quality guidelines (available guidelines for comparison at the time). Elevated concentrations of elutriate nutrients were detected. Elutriate ammonia exceeded the relevant ANZECC/ARMCANZ (2000) water quality guideline at one site; however; this was considered attributable to decomposing seagrass within sediments. Elutriate nutrient results were considered over conservative of potential water quality impacts given the dilution within the receiving environment and water to sediment mix during dredging is sufficient to reduce concentrations below relevant guidelines.

4.4.2 Sediment sampling and analysis 2014

In April 2014, seven sediment cores were sampled within the inner northern breakwater sandtrap to support a sediment dredging and wrack trawling Dredging Environmental Impact Assessment (DEIA; BMT Oceanica 2014a). The sediment samples were analysed for PSD, TOC, total and elutriate metals, total nutrients, organotins (tributyltin [TBT], monobutyltin [MBT] and dibutyltin [DBT]), hydrocarbons (TRHs, PAHs and BTEX) and elutriate hydrogen sulfide (H₂S). Sediments were mostly comprised of medium grained sands, with small amounts of organic material. Particle size distribution results showed sediments were predominantly sands (96–100%), with some silt (<4%), clay (<0.2%) and gravel (<1%) and short settling times (<2.5 minutes for 90% of particles) across all sample sites.

The TOC content of the sediments ranged from 2.3–6.6%. Total metals, organotin and hydrocarbons concentrations were below the relevant NAGD Screening Levels (CA 2009). One site recorded a low-level exceedance for mercury at depth (0.2 mg/kg), however; remaining sediment samples within the dredge area were below the laboratory limit of reporting (LoR) and therefore overall test statistics met the NAGD Screening Level (CA 2009). Elutriate analysis of mercury at the individual site that exceeded was below the LoR. High concentrations of total nutrients were recorded and considered attributable to the decomposing seagrass wrack entrained within the sediments (it is noted that there are no sediment quality guidelines available for total nutrients). All sediments had concentrations of elutriate H₂S below the LoR.

In August 2014, sediment cores were collected from 19 sites within the Boat Harbour's entrance channel and basin and were analysed for PSD, TOC, total metals, total and elutriate nutrients, organotins (TBT, MBT and DBT), hydrocarbons (PAHs, TRHs and BTEX) and ASS (BMT Oceanica 2014b). Sediments comprised of by fine to medium sands with small portions of silt and gravel with fast settling rates. Most samples contained organic matter (in the range of <1–90%), exhibited a sulfidic odour and had low TOC content (<1% for most samples with exception to one sample that had a TOC content of 15% due to the sample being characterised by 90% organic matter). Total metals, organotins and hydrocarbons concentrations were below the relevant NAGD Screening Levels (CA 2009). Elevated concentrations of total and elutriate nutrients were detected in sediment samples and elutriate nutrients exceeded relevant ANZECC/ARMCANZ (2000) water quality guidelines. Elevated nutrient concentrations were attributed to decomposing seagrass wrack that accumulates in the Boat Harbour. Boat Harbour sediments were below the DEC (2013) ASS Action Criteria for all but one sample. The sample,

however, exhibited an overall net negative acidity following acid base accounting thereby indicating a low risk of ASS generation during dredging and disposal.

4.4.3 Wrack sampling and analysis 2011

In November 2011, wrack trawled from the entrance channel of the Boat Harbour was sampled and analysed for total metals, organotins (TBT, MBT and DBT) and hydrocarbons (TPHs, PAHs and BTEX) (Oceanica 2012). Given that there are no specific guidelines available to assess contamination within wrack, results were compared to NAGD Screening Levels for sediment quality (CA 2009). Concentrations of total metals, organotins and hydrocarbons were below the relevant NAGD Screening Levels (CA 2009) with exception to a low-level cadmium exceedance in one sample and an exceedance of the 95% upper confidence limit (UCL) for concentrations of TPHs. The cadmium exceedance was not of concern given that metal concentrations in seagrass are often higher than those in sediments due to bioaccumulation (Oceanica 2012; and those references cited herein). Analysis of TPHs identifies both petroleum-based and nonpetroleum-based hydrocarbons, which are typically associated with vegetable and animal products (including oils, sugars and fatty acids). To remove any interference from these nonpetroleum based compounds, a silica gel clean-up of the samples should be performed, of which was not completed by the laboratory that completed the analysis. It was therefore considered that the elevated concentrations of TPHs were unlikely to be petroleum-based hydrocarbons, but organics from biogenic matter instead.

4.4.4 Wrack sampling and analysis 2014

Wrack samples were collected April 2014 from six sites within the Boat Harbour entrance channel. The wrack samples were analysed for TOC, total metals, total nutrients, organotins (TBT, MBT and DBT), hydrocarbons (TPHs, PAHs and BTEX) and elutriate H₂S. All samples exhibited a sulfidic odour and were predominantly characterised by *Amphibolis* spp. stems. Total metals, organotins and hydrocarbons concentrations were below the relevant NAGD Screening Levels (CA 2009). The samples had high TOC content (100%) with elevated concentrations of total nutrients, as expected given the marine flora organic constituents. Concentrations of elutriate H₂S were also detected but no marine guidelines are available for comparison to assess potential impacts. Wrack naturally accretes and resuspends from natural processes within the marine system and potential impacts from elevated concentrations of total nutrients and elutriate H₂S were not considered to be of concern assuming sufficient dilution within the receiving environment.

5 Description of the Environment

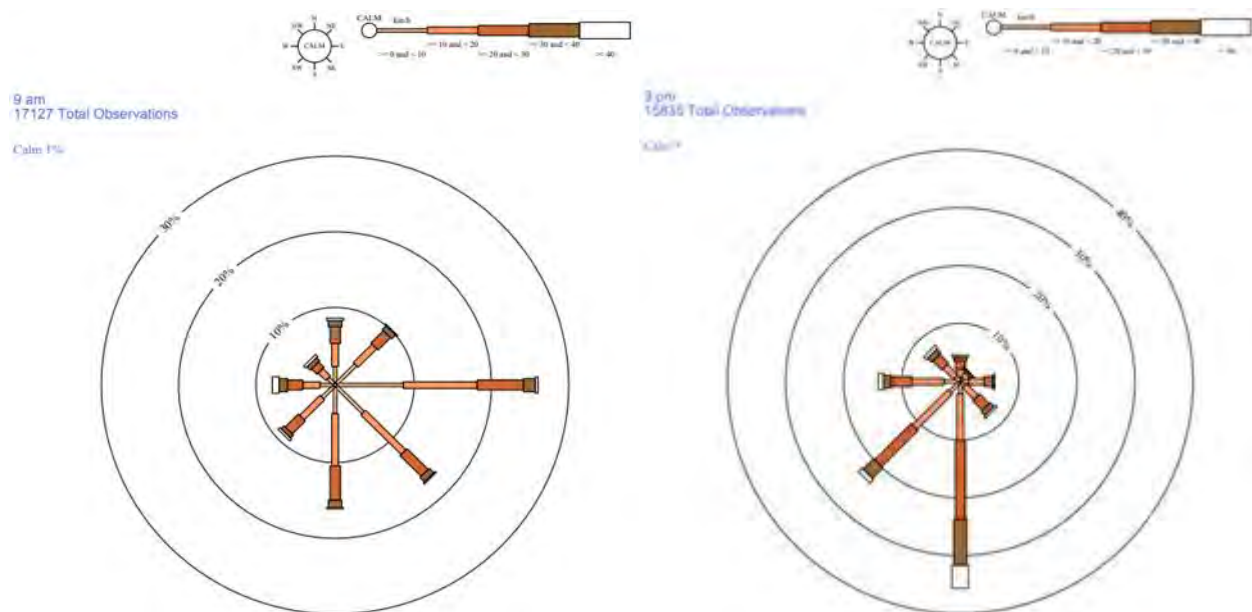
5.1 Physical environment

The Boat Harbour is located within the greater South-West Marine Region, which is divided further into seven bioregions, as defined by the Integrated Marine and Coastal Regionalisation of Australia Version 4.0 (DEWHA 2007). The Southwest Shelf Transition bioregion comprises the continental shelf between Perth in the south and Kalbarri in the north. This bioregion extends from nearshore areas to the edge of the continental shelf, the majority of which is under Commonwealth jurisdiction. With a maximum depth of 200 m, this nearshore bioregion is characterised by a high level of marine biodiversity, including sub-tropical, tropical and temperate marine species (DEWHA 2007).

5.2 Climate

Jurien Bay experiences a Mediterranean climate with hot, dry summers and mild, wet winters. During summer, mean monthly temperature ranges between ~16–31°C and during winter between ~9–21°C (BoM 2019). Rainfall in Jurien Bay is highly variable throughout the year, with an annual rainfall average of ~549 mm (BoM 2019). Seasonal rainfall levels range from a maximum monthly average of ~114 mm in July to a minimum monthly average of ~7 mm in December (BoM 2019).

Wind data recorded between 1969 and 2018 indicates that winds are predominantly from the east and south-east in the morning (0900) and from the south and south-west in the afternoon (1500) (BoM 2019; Figure 5.1). Mean annual wind speed was 17.2 and 22.8 km/h at 0900 and 1500 respectively, infrequently exceeding 50 km/h (BoM 2019; Figure 5.1).



Source: BoM (2019)

Notes:

1. Wind speed recorded at Jurien bay between 1969 and 2018 at 0900 (left) and 1500 (right)
2. * = calm is <0.5%

Figure 5.1 Jurien Bay wind speed and direction

5.2.1 Geology and geomorphology

The Southwest Shelf Transition bioregion includes a narrow continental shelf (40–80 km wide) that is characterised by complex physical features (DEWHA 2007). Nearshore, eroded limestone reefs and pinnacles form ridges, depressions and inshore lagoons. The inner shelf is a smooth plain with a series of ridges that develop into a tropical reef in the northern area of the bioregion (e.g. Houtman Abrolhos Islands). The greater Gingin-Dandaragan coastline is characterised by

Safety Bay Sand from the Quindalup Dune systems. The coastal areas of the Jurien Bay region consist of curved beaches backed by low dunes. The shoreline in the Jurien Bay area consists of a continuous beach that is more exposed in the north and sheltered in the south (Eliot et al. 2012). Onshore, parabolic dunes in the south migrate north, forming mobile sand sheets with vegetation cover.

Beaches are separated by sand promontories or points, rocky headlands and low limestone cliffs. A series of elongated limestone reefs run parallel to the shore and provide the shoreline with some shelter from offshore waves (Oceanica & JFA 2005). Associated with these reefs are numerous emergent rocks and islands (CALM 2005).

5.2.2 Hydrodynamics

Hydrodynamics of the continental shelf are influenced by the Leeuwin and Capes currents, and seasonal variations in wind regimes (Gallop et al. 2012). The Leeuwin Current drives the offshore currents along the shelf break; whereas coastal currents are mostly wind-driven (DEWHA 2007). The Leeuwin Current is a warm, narrow and shallow current that transports tropical waters southward with low nutrients and salinity levels, predominantly during the Autumn and Winter months (March–August) (Gersbach et al. 1999, DEWHA 2007). The Leeuwin Current forms eddies in several predictable locations in this bioregion, including Jurien Bay. These eddies occur as cross-shelf currents that mix nutrient-rich, deep waters with the shallower water from the continental shelf, thereby enhancing the overall biological productivity for the region.

The Capes Current is a cool, counter-current that flows northward close inshore, resulting in localised upwelling and cooler water on the upper continental shelf (Pearce & Pattiaratchi 1999). In the Southwest Shelf Transition bioregion, the Capes Current also transports temperate species larvae from the southern regions to the northern areas along the inner, nearshore shelf (DEWHA 2007). The Capes Current is present mostly in the summer months (December–February).

Coastal currents are predominantly wind-driven by the strong south-westerly sea breezes occurring each afternoon (DEWHA 2007). This sea breeze system generates winds generally in excess of 50 km/h (Pattiaratchi et al. 1997), thus creating diurnal changes to wave heights, wave periods, nearshore currents and sediment levels and transport (Masselink & Pattiaratchi 1998). Under ambient conditions, the winter wind regime is generally calm and south-westerly, with a weaker sea breeze component. Winter storms (mid-latitude depressions) may generate strong winds, usually from the north-west (Lemme et al. 1999).

5.2.3 Coastal processes

Sand along the Jurien Bay coastline is transported via several coastal processes. Wind influences sand movement in the ocean (with the nearshore waves and currents) and on land, forming transgressive dunes (Ecoscape 2005). In winter, storm events generally transport nearshore sand in a southerly direction; whereas in summer, prevailing winds tend to transport nearshore sand in a northerly direction. In addition, waves and tides generate longshore currents that result in the littoral drift and cross-shelf transport of sand.

Onshore of Jurien Bay, unstable landforms are highly susceptible to changes from weather and metocean processes (Eliot et al. 2012). This coastal risk is evident in exposed beaches, mobile sand sheets and active blowouts in the sand dune complexes. Historically, wind and rainfall changes increased the coastal activity in the area, causing substantial fluctuations in sand dunes and blowouts.

5.2.4 Water and sediment quality

In February 2004, water samples were collected from 14 sites located in the nearshore, lagoonal and offshore areas of the JBMP and were analysed for dissolved metals and organic chemicals (DoE 2005). Concentrations of dissolved metals in the water samples were all below the relevant ANZECC/ARMCANZ 2000 trigger values for toxicants at the 99% species levels of protection and

concentrations of organic chemicals were all below the LoR (DoE 2005). Spatial and seasonal nutrient dynamics were also examined from nearshore, lagoonal and offshore areas of the JBMP in 2014 and results found low concentrations of nutrients across all sampling periods with little variation between sampling areas (Rule et al. 2012).

A description of Boat Harbour sediment quality is provided in Section 4.

5.3 Biological environment

The Southwest Shelf Transition bioregion contains a unique mixture of both tropical and temperate marine species, including a high number of endemic fauna as well as the highest seagrass species diversity globally (DEWHA 2007). In the nearshore areas (<50 m deep), the biological environment is characterised by Australia's largest, continuous limestone reef with numerous rocks and islands creating sheltered environments for diverse mixture of temperate and tropical species of marine flora and fauna (CALM 2005, Eliot et al. 2012).

5.3.1 Benthic communities and habitats

To inform long-term dredging and disposal options, and marine environmental monitoring and management for the Boat Harbour maintenance dredging campaigns, BMT completed benthic habitat mapping of Jurien Bay in November 2017 (BMT 2018b; Appendix D). The specific objectives of the mapping project were to:

- i. collect digital baseline data on the spatial extent and characteristics of BCH in the mapping area, and
- ii. qualitatively characterise the extent of BCH surrounding the Boat Harbour and develop a mapping product of suitable quality to meet multiple purposes (including informing dredging operations and potential future environmental approvals applications, if necessary).

A total of 3667.2 ha of BCH were mapped during the project and the following dominant habitat types were identified (Table 5.1):

- bare sand (57.9%),
- sand inundated platform reef with macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.) (18.3%)
- sand inundated platform reef with macroalgae and perennial seagrass (*Amphibolis* spp.) (13.9%)
- reef dominated by macroalgae (6.1%)

A small proportion of mapped BCH is inhabited by mixed perennial seagrass (*Amphibolis* spp. and *Posidonia* spp.; 2.6%) and even less by mono-specific perennial and ephemeral seagrass meadows (~1.0% for *Amphibolis* spp., *Posidonia* spp. and *Halophila* spp. combined). Filter feeders such as corals and sponges within the mapped area represented only a small proportion (0.3%). Macroalgae habitat were dominated by the kelp *Ecklonia radiata* with fewer *Sargassum* spp. and red foliose species, where present as part of mixed assemblages (BMT 2018b).

The nearshore area north of the Boat Harbour is mostly comprised of a mixed assemblage of macroalgae and perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.) overlying a sand inundated platform reef, extending ~500 m to 1 km offshore (Figure 5.2). South of the Boat Harbour, BCH is less vegetated and is dominated by mobile sands with small scattered meadows of perennial seagrass (mixed assemblages of *Posidonia* spp. and *Amphibolis* spp. and mono-specific assemblages of *Posidonia* spp.) and ephemeral seagrass (*Halophila* spp.; Figure 5.2). This predominantly sandy area surrounding the Boat Harbour extends ~3 km offshore.

Further offshore, BCH is dominated by a mixed assemblage of macroalgae and perennial seagrass (*Amphibolis* spp.) on sand inundated platform reef (Figure 5.2). Next to the dominant offshore BCH, areas containing a mixed assemblage of macroalgae and mixed perennial seagrass (*Amphibolis* spp. and *Posidonia* spp.) also occur (Figure 5.2). In the north-west

offshore region of the mapped area there is an expansive area of reef dominated by macroalgae (Figure 5.2).

Inside the Boat Harbour entrance channel, BCH is predominantly characterised by wrack overlying bare sand. Adjacent to the Boat Harbour entrance channel, wrack and sparse meadows of seagrass (*Posidonia* spp.) are present covered in sand and epiphytic growth of calcareous algae. These seagrass meadows appeared partially dead and flattened on the seafloor, and therefore were classified as wrack for mapping purposes. It is noted that areas of wrack have been classified as bare sand in Figure 5.2. The extent of sand inundated platform reef with macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.) inside the dredge footprint boundary is 0.5 ha (Figure 5.2).

The selection of a suitable offshore disposal area was based on the findings of the mapping project. The proposed offshore disposal area is described in Section 3.2 and is located over bare sand (Figure 5.2).

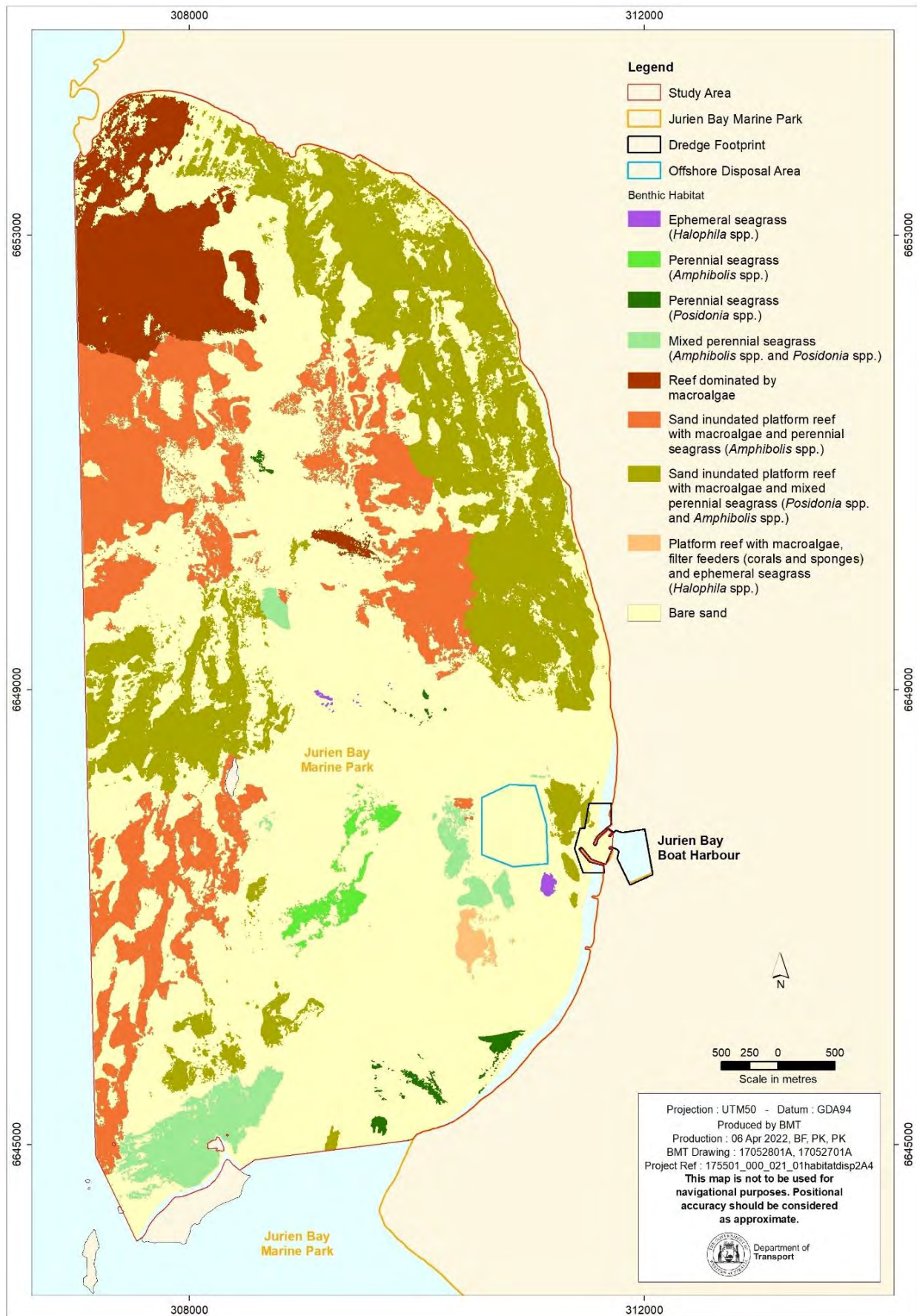
Table 5.1 Area and proportion occupied by benthic habitat categories

Benthic habitat type	Area (ha)	Proportion ¹ (%)
Ephemeral seagrass (<i>Halophila</i> spp.)	2.6	0.1
Perennial seagrass (<i>Amphibolis</i> spp.)	23.4	0.6
Perennial seagrass (<i>Posidonia</i> spp.)	12.2	0.3
Mixed perennial seagrass (<i>Amphibolis</i> spp. and <i>Posidonia</i> spp.)	94.5	2.6
Reef dominated by macroalgae	222.1	6.1
Sand inundated platform reef with macroalgae and perennial seagrass (<i>Amphibolis</i> spp.)	508.2	13.9
Sand inundated platform reef with macroalgae and mixed perennial seagrass (<i>Posidonia</i> spp. and <i>Amphibolis</i> spp.)	670.2	18.3
Platform reef with macroalgae, filter feeders (corals and sponges) and ephemeral seagrass (<i>Halophila</i> spp.)	11.5	0.3
Bare sand	2122.5	57.9
Total	3667.2	100

Source: BMT (2018b)

Note:

1. Percentages do not add up to exactly 100% due to rounding.



Source: BMT (2018b)

Figure 5.2 Classification and distribution of Jurien Bay benthic communities and habitat

5.3.2 Protected flora and fauna

The threatened fauna that are likely to occur in the vicinity (within 5 km) of the Boat Harbour were determined using the *Environmental Protection Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool (DAWE 2022a; Appendix E). The results identified 40 listed threatened species as potentially occurring within a 5 km radius of the Boat Harbour. Relevant to maintenance dredging campaigns, listed threatened species included plants (3), birds (22), mammals (2) marine reptiles (4) and sharks (5); Table 5.2).

Table 5.2 Threatened flora and fauna species identified as potentially occurring within 5 km of the Jurien Bay Boat Harbour

Taxa group	Scientific name	Common name	EPBC Act status
Birds	<i>Anous tenuirostris melaops</i>	Australian lesser noddy	Vulnerable
	<i>Calidris canutus</i>	Red Knot	Endangered
	<i>Calidris ferruginea</i>	Curlew Sandpiper	Critically Endangered
	<i>Charadrius leschenaultii</i>	Greater Sand Plover,	Vulnerable
	<i>Diomedea epomophora epomophora</i>	Southern royal albatross	Vulnerable
	<i>Diomedea epomophora sanfordi</i>	Northern royal albatross	Endangered
	<i>Diomedea exulans amsterdamensis</i>	Amsterdam albatross	Endangered
	<i>Diomedea exulans</i>	Wandering albatross	Vulnerable
	<i>Leipoa ocellata</i>	Malleefowl	Vulnerable
	<i>Limosa lapponica baueri</i>	Bar-tailed Godwit (baueri)	Vulnerable
	<i>Limosa lapponica menzbieri</i>	Northern Siberian Bar-tailed Godwit	Critically Endangered
	<i>Macronectes giganteus</i>	Southern giant-petrel	Endangered
	<i>Macronectes halli</i>	Northern giant-petrel	Vulnerable
	<i>Numenius madagascariensis</i>	Eastern Curlew	Critically Endangered
	<i>Phoebastria fusca</i>	Sooty Albatross	Vulnerable
	<i>Rostratula australis</i>	Australian Painted Snipe	Endangered
	<i>Sternula nereis nereis</i>	Australian fairy tern	Vulnerable
	<i>Thalassarche carteri</i>	Indian yellow-nosed albatross	Vulnerable
	<i>Thalassarche cauta cauta</i>	Shy albatross	Vulnerable
	<i>Thalassarche cauta steadi</i>	White-capped albatross	Vulnerable
	<i>Thalassarche melanophris</i>	Black-browed albatross	Vulnerable
	<i>Thalassarche steadi</i>	White-capped Albatross	Vulnerable
	<i>Zanda latirostris</i>	Carnaby's Black Cockatoo, Short-billed Black-cockatoo	Endangered (listed as Calyptrorhynchus latirostris)
Mammals	<i>Balaenoptera musculus</i>	Blue whale	Endangered
	<i>Dasyurus geoffroii</i>	Chuditch, Western Quoll	Vulnerable
	<i>Eubalaena australis</i>	Southern right whale	Endangered
	<i>Macroderma gigas</i>	Ghost Bat	Vulnerable
	<i>Neophoca cinerea</i>	Australian sea lion	Vulnerable
Marine reptiles	<i>Caretta caretta</i>	Loggerhead turtle	Endangered
	<i>Chelonia mydas</i>	Green turtle	Vulnerable
	<i>Dermochelys coriacea</i>	Leatherback turtle	Endangered
	<i>Natator depressus</i>	Flatback turtle	Vulnerable
Sharks	<i>Carcharias taurus</i> (west coast population)	Grey nurse shark	Vulnerable
	<i>Carcharodon carcharias</i>	Great white shark	Vulnerable
	<i>Pristis pristis</i>	Freshwater Sawfish	Vulnerable
	<i>Rhincodon typus</i>	Whale shark	Vulnerable

Taxa group	Scientific name	Common name	EPBC Act status
	<i>Sphyrna lewini</i>	Scalloped Hammerhead	Conservation Dependent
Flora	<i>Andersonia gracilis</i>	Slender Andersonia	Endangered
	<i>Eucalyptus argutifolia</i>	Yanchep Mallee, Wabbling Hill Mallee	Vulnerable
	<i>Hemianandra gardneri</i>	Red Snakebush	Endangered

Source: EPBC Act Protected Matters Search Tool (DAWE 2022; Appendix E).

5.3.2.1 Birds

The Boat Harbour may be visited by seabirds and shorebirds, although the area is not known to contain critical habitats for any of these species (DAWE 2022; Appendix E). The Boat Harbour is not located in close proximity (<5 km) to a wetland of International Importance under the Ramsar Convention (DAWE 2022; Appendix E). However, at least 15 species of seabirds use the offshore islands within the JBMP as breeding and nesting areas and are recognised as a significant ecological value of the greater Central West Coast region (CALM 2005). It is therefore likely that protected seabird species may be sighted frequently at the Boat Harbour as they transit to nearby nesting areas.

5.3.2.2 Mammals

Five threatened mammal species may occur within 5 km of the Boat Harbour: blue whale, southern right whale, Australian sea lion, chuditch and ghost bat (DAWE 2022; Appendix E). No critical habitats for these species are known to occur within 5 km of the Boat Harbour (DAWE 2022; Appendix E).

Blue whales are documented in deep waters off the Perth coast, near the edge of the continental shelf (500–1000 m water depth) and feeding in the Perth Canyon and Rottnest Trench annually between January and May (McCauley & Jenner 2010, McCauley et al. 2001). Rare sightings of southern right whales have been recorded along the WA coastline, but there are no known critical habitats for this species in the Jurien Bay region (Bannister et al. 1996). Therefore, although these whale species are known to migrate and feed in deeper waters off the WA coastline, sightings of these whale species in the vicinity of the Boat Harbour are likely to be rare and infrequent.

Australian sea lion rookeries and haul-out sites are documented along WA's Central West Coast, supporting a population of ~800–1000 animals that breed on offshore islands, including East Beagle, North Fisherman and Buller Islands (CALM 2005). Of these rookeries, North Fisherman Island is the closest (<20 km north) to the Boat Harbour. Australian sea lion monitoring data have been collected from the Central West Coast, documenting ~150 pups born in this area (Campbell 2005). These sea lions may be genetically distinct from the nearest population and thus, may require additional conservation and protection (CALM 2004). Up to 18 offshore islands of the Central West Coast are known haul-out sites for Australian sea lions (CALM 2004). Male Australian sea lions are known to forage 60–180 km away from their rookeries (Hamer et al. 2011). Therefore, Australian sea lions are known to breed and haul-out at offshore islands in the Jurien Bay area, and it is likely that this species may be encountered frequently as they transit to rookery and haul-out sites along the Central West Coast.

Among other listed marine mammal species identified as 'Other Matters Protected by the EPBC Act' (DAWE 2022; Appendix E), bottlenose dolphins (including both *Tursiops aduncus* and *T. truncatus*) are likely to be sighted in the vicinity of the Boat Harbour (DAWE 2022; Appendix E). These dolphins are primarily found between the continental shelf and the coastline (<200 m water depth) in reef, sandy and seagrass habitats (DSEWPaC 2012a). With resident groups in nearshore waters of WA, bottlenose dolphins are considered to be a coastal species regularly sighted in the JBMP (CALM 2005). In both estuarine and coastal habitats in Perth, surveys documented resident bottlenose populations for over 20 years on a year-round basis, confirming their long-term residency and short-term associations with coastal, non-resident dolphins

(Finn 2005; Chabanne et al. 2012). Therefore, as bottlenose dolphins are known to occur throughout WA marine areas, it is likely that they may be encountered in proximity to the Boat Harbour.

Chuditches are known to occur in the south-west corner of Australia, as the remaining populations occur in jarrah forests and woodlands. There has been occasional records in drier woodland and mallee shrubland in the Wheatbelt and Goldfield regions (DEC 2012). It is unlikely for Chuditch populations to occur in the terrestrial dredge area laydown areas given the existing level of disturbance in the Harbour Reserve and unsuitable habitat. Ghost bats are known to roost in caves and deep cracks in rocks, and unlikely to occur in close proximity to the Boat Harbour given the located within a disturbed Harbour Reserve and absence of suitable habitat.

5.3.2.3 Marine reptiles

Four marine turtle species may occur in proximity to the Boat Harbour; green, flatback, leatherback and loggerhead turtles (DAWE 2022; Appendix E). In the South-West Marine Region, these species are commonly found in coral and rocky reefs, sandy beach and seagrass habitats (DEWHA 2007). Although no breeding or nesting is known to occur in the vicinity of the Boat Harbour (DAWE 2022; Appendix E), resident green and loggerhead turtles are sighted throughout the year, most likely foraging, while the leatherback and flatback turtles are recognised as occasional visitors in the area (CALM 2005, DEWHA 2007). None of these species have critical habitats within the vicinity of the Boat Harbour, with key known habitats for breeding and nesting found in the north-west region of WA (DSEWPaC 2012b, DEWHA 2007). Therefore, it is possible that infrequent sightings of marine turtles may occur in proximity to the Boat Harbour.

5.3.2.4 Sharks

Five shark species were identified as possibly occurring in proximity to the Boat Harbour (DAWE 2022; Appendix E), all of which are known to reside in warm, temperate seas (DEWHA 2007). The grey nurse shark is commonly found in inshore waters as well as deeper waters along the continental shelf, and they spend most of their time at depths between 20–60 m (DSEWPaC 2012c). In the South-West Marine Region, there are no known movement patterns, critical habitats or aggregation areas for this species, and their occurrence in the vicinity of the Boat Harbour is likely to be rare and infrequent.

Great white sharks are known to occur in the South-West Marine Region and the coastal waters of Perth, possibly with a seasonal pattern of travelling south in summer months (DEWHA 2007). Most of the great white sharks have been recorded along the 100 m depth contour in Australian waters (DSEWPaC 2012c). They can be found in inshore (in rocky reefs and shallow coastal bays) and offshore areas (such as the continental shelf and slope). Although they are considered to be rare compared to other shark species, great white sharks are known to aggregate around seal and sea lion colonies around Australia (DSEWPaC 2012c). Despite this, sightings of great white sharks in the vicinity of the Boat Harbour are likely to be rare and infrequent.

Whale sharks are not known to aggregate or have interactions in the South-West Marine Region, as the largest congregation of whale sharks are known to occur in Ningaloo Reef in north-west WA (DSEWPaC 2012c), which is more than 800 km north of the Boat Harbour. Although they have a wide range and broad distribution in tropical and temperate waters, it is unlikely that whale sharks will be sighted near the Boat Harbour.

Sawfish are not known to aggregate in the South-West Marine Region, as the last significant populations of sawfish is known to occur in the North-West Marine Region (Stevens et al 2008). It is unlikely that sawfish will be sighted near the Boat Harbour.

Scalloped hammerheads have a wide distribution occurring from Sydney, New South Wales around to tropical north to Geographe Bay in the southwest of WA (Lopez et al 2022). Scalloped hammerheads are known to occur in the coastal and offshore waters from Jurien Bay to more

tropical regions in the North West of Australia (Lopez et al 2022). Despite this, sightings of scalloped hammerheads in the vicinity to the boat harbour are unlikely and rare.

5.3.2.5 Flora

The threatened flora species are found in swamps, winter-wet flats, sandplains, open heath, shrubland and woodland or forest areas (DEC 2006, CALM 2000, CALM 2004) and are not likely to be found in the foredune adjacent to the Boat Harbour. The foredune vegetation immediately adjacent to onshore disposal area and Boat Harbour consists of degraded and regularly disturbed patches of coastal vegetation species and native shrubs and considered unlikely to support populations of protected flora due to the existing level of disturbance in the Harbour Reserve.

5.3.3 Other fauna of significance

5.3.3.1 Western rock lobster

The western rock lobster (*Panulirus cygnus*) is the target species of WA's largest and most valuable fishery; the West Coast Rock Lobster (Managed) Fishery (WCRLMF; DPIRD 2019a). In 2014, the estimated value of the WCRLMF was \$359 million based on the total commercial catch of 5947 tonnes (DPIRD 2019a). At Jurien Bay, commercial fishing for western rock lobster forms a significant component of the town's economy, where there is a commercial fishing fleet that operate out of the Boat Harbour and live crayfish receival depots located on the Boat Harbour's premises.

Endemic to WA, the western rock lobster inhabits clear, oxygenated waters from the North West Cape south to Cape Leeuwin (Chittleborough 1975) but is most abundant between Geraldton and Perth (DoF 2011a). The lifecycle of the western rock lobster is well known and includes a planktonic pelagic stage (living in the open ocean) of ~9–11 months before migrating to shallow coastal (<20 m) regions to begin the benthic life cycle stage (living on the seafloor) (DoF 2011a). Full development from larvae to sexual maturity takes ~4.5–6 years (Gray 1992).

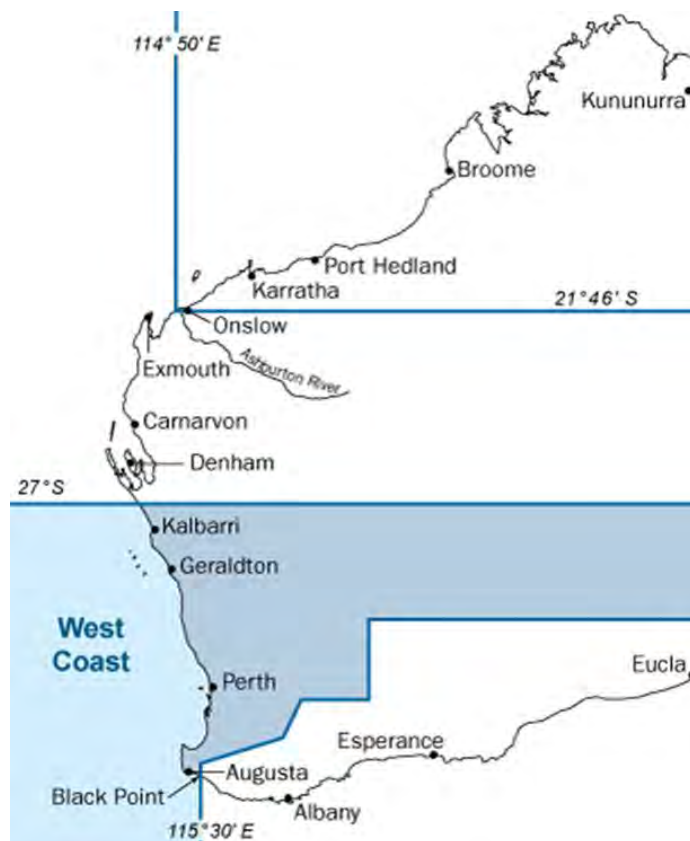
Inshore and outer reefs, such as those that occur along the Jurien Bay coastline, are important habitat for post-puerulus (late-larval stage) and juvenile western rock lobster, which typically inhabit small crevices of coastal limestone reefs (Chittleborough et al. 1975, Fitzpatrick et al. 1989; cited in MacArthur et al. 2007, Jernakoff 1990). Juveniles usually inhabit these reefs for 3–4 years, feeding and growing, until reaching ~80 mm carapace length and undergo a synchronised moult event (DoF 2011a, Bellchambers et al. 2012). This particular moult is significant as it marks the beginning of the 'white' phase of the western rock lobster's lifecycle that coincides with its migratory phase when the lobsters leave the coastal reefs and embark on a mass migration to offshore deep water (up to 100 m deep) breeding grounds (DoF 2011a, Bellchambers et al. 2012). This event typically occurs in November through to mid-January each year (Gray 1992).

5.3.3.2 Blue swimmer crab

The blue swimmer crab (*Portunus armatus*; formerly known as *P. pelagicus*) is found along the entire WA coast, in a wide range of inshore and continental shelf areas, from the intertidal zone to ~50 m depth (Fletcher and Santoro 2012). Within the West Coast bioregion (Figure 5.3), the species is targeted by four commercial fisheries (DPIRD 2019b). In 2013/14, the estimated value of the West Coast bioregion blue swimmer crab fishery was \$1 million based on the total commercial catch of 163 tonnes. At Jurien Bay, the blue swimmer crab is a popular species targeted by recreational fishers but is not commercially fished.

Blue swimmer crabs typically reside beneath sand during the day and are most active at night when they become mobile to search for food (DoF 2011b). The timing and movements of blue swimmer crabs vary among locations (DoF 2011b). In the ocean, blue swimmer crabs begin life as small larvae termed 'zoea' and develop over a ~4–6 week period during summer, drifting in bays along the coast up to 80 km offshore (DoF 2011b). Zoea are easily preyed upon by fish and experience very high rates of mortality during this period (DoF 2011b). By late summer, most of

the survivors reach shallow nursery areas where they settle on the seafloor and begin to moult frequently and grow rapidly, transforming into a more crab-like state called 'megalopae' (DoF 2011b). By autumn, most megalopae have formed into juvenile crabs (with a 3–6 cm wide carapace), and by winter, most juvenile crabs have reached maturity (with a 9 cm wide carapace; DoF 2011b). Mating typically takes place in autumn, and then spawn in spring and early summer, producing between 180 000–2 million eggs in a single spawning (and may spawn more than once in a season; DoF 2011b).



Source: DPIRD (2019c)

Figure 5.3 West coast bioregion

5.3.3.3 Finfish

The inshore lagoons of the South West Shelf Transition (Section 5.1) are inhabited by demersal and pelagic fish (DEWHA 2007). Extensive schools of migratory fish visit the area annually including herring, garfish, tailor and Australian salmon (DEWHA 2007). These small to mid-sized predators feed on smaller pelagic fish and squid, and in turn are preyed upon by larger predatory species such as mullet, snapper, samson fish, Spanish mackerel and whaler sharks (DEWHA 2007). Small pelagic fish including herring, sardine, scaly mackerel, jack mackerel, yellow tail, blue mackerel, anchovy, blue sprat and sandy sprat, are considered a particularly important trophic link between plankton communities and larger fish-eating predators (DEWHA 2007).

The high biodiversity of marine species that occur in the region has resulted in recreational fishing being a valued activity at Jurien Bay. Some popular finfish species targeted by recreational fishers at Jurien Bay include the West Australian dhufish (*Glaucosoma hebraicum*), Pink Snapper (*Pagrus auratus*) and Baldchin Groper (*Choerodon rubescens*; DoF 2008; as cited in Lozano-Montes et al. 2011). The West Australian dhufish and Baldchin Groper are endemic to WA, whereas the Pink Snapper has a larger distribution and is found in coastal waters off China, Japan, Taiwan, the Philippines, New Zealand and Australia (DoF 2011c,d,e).

The peak spawning period for West Australian dhufish is typically between December and March, when water temperatures are elevated (DoF 2011c). Adult West Australian dhufish prefer to live around rocky outcrops and ledges in water 20–50 m deep (DoF 2011c). For Baldchin Groper, the

peak spawning period is between November to early January (DoF 2011d). Baldchin Grouper are most abundant at the Abrolhos Islands (located ~350 km north north-west of Jurien Bay), which is also where their main known spawning aggregation area is located (DoF 2011d). The timing of the spawning season for Pink Snapper varies with its location; in WA there are two significant spawning aggregation areas for this species that includes Shark Bay (located ~600 km north of Jurien Bay), where fish spawn between April to October, and Cockburn Sound (located ~250 km south of Jurien Bay), where fish spawn between October to December (DoF 2011e). Pink Snapper typically live in waters 20–250 m deep (DoF 2011e).

6 Potential Environmental Impacts

The potential environmental impacts on environmental factors that may arise due to maintenance dredging campaigns have been assessed in the context of the EPA's Environmental Factors and Objectives (EPA 2021a). The potential environmental impacts are discussed in the sections below and are anticipated to affect the following EPA (2021a) environmental factors:

- BCH (Section 6.2)
- marine and terrestrial environmental quality (Section 6.3)
- marine fauna (Section 6.4)
- coastal processes (Section 6.5)
- social surroundings (Section 6.6).

6.1 Modelling potential impacts to the environment

To assess potential impacts of offshore disposal to surrounding sensitive environmental receptors, modelling was completed to simulate the extent of any turbid plume from disposal of dredged material, and the retentive or dispersive nature of the Disposal Area under worst-case conditions (Appendix A). The model considered tide, wind and wave interactions to predict the estimated plume extent and TSS concentration upon the cessation of daily dredging in the Disposal Area. A representative summer period of one month (November 2017) was used to assess the likely dredge plume dispersion and fate of dredged material following disposal. This period was considered representative of a summer wind pattern, when dredging is most likely to occur. Two storm events (measured between 18 May and 16 June 2016) were used to simulate worst case conditions for spoil ground stability. Sediment PSD from BMT (2019b) were used to represent dredge material.

Results demonstrated that although the selected simulation period is relatively energetic (which could potentially result in higher intensity plume dispersion), TSS levels reduced below 5 mg/L within 3 hours after cessation of dredging. Remaining TSS in the water column further settled to below a model-detectable level (1 mg/L) before the start of dredging the next day. Sedimentation from disposal activities was primarily limited to within the Disposal Area.

The result of the acute storm simulation demonstrated that the spoil ground (filled to design level of -8m LAT) is stable under both the northerly and southerly severe storm conditions. The resuspension of the fine materials from the disposal area is minimal due to the storm activities.

The full modelling methods, inputs, assumptions and results are detailed in Appendix A.

6.2 Benthic communities and habitats

The main potential impacts from dredging on seagrasses include physical removal or burial of vegetation at the dredging/disposal areas, and increased turbidity (light reduction) and increased sedimentation to adjacent seagrass meadows (Erftemeijer & Lewis 2006). In addition, temporarily reduced dissolved oxygen concentration, release of nutrients and contaminants (from contaminated sediments) and hydrographic changes may also occur and have indirect effects on the seagrass ecosystem (Erftemeijer & Lewis 2006).

Given the dredging and disposal activities are likely to be completed within a 4–5 month period (~18 weeks) and settling velocities indicate that 90% of particles should settle through the water column in ~12 hours (BMT 2019b; Appendix C) impacts from light reduction are considered to be minimal. Dredging will also not occur on weekends or public holidays, allowing some recovery and a reduction in potential stress on marine flora through increased light availability (following the findings of Statton et al. 2017). Regardless, the relative impacts and subsequent

management for protecting BCH has been assessed the context of EPA (2016a)⁵ *Technical Guidance: Environmental Impact Assessment of Marine Dredging Proposals*.

6.2.1 Indirect impacts to benthic communities and habitats

The primary indirect impact of increased water column turbidity is the associated reduction in photosynthetically available light to benthic primary producers (Erftemeijer & Lewis 2006). Resulting impacts can be short or long-term in nature, depending on the period and intensity of shading. The capacity of seagrasses to cope with episodes of light deprivation from overlying turbid waters may not only depend on the absolute quantity of light they receive and the duration over which it is reduced, but also on how the light deprivation varies through time, for example, the temporal separation (frequency) of pulsed turbidity events (Statton et al. 2017). Seagrass initially responds to stress from light reduction through physiological adjustments, before responding through morphological adjustments like reduced leaf extension, shoot density or canopy height (Mackey et al 2007, Ralph 2007, Collier et al 2007, 2008, 2009, 2012a,b, Lavery et al. 2009, McMahon et al. 2011, 2013). A long, continuous period of low light is more detrimental to seagrasses than 'pulses' of lower light interspersed with high light levels, even if the total light received by the plant over the same period is consistent (Statton et al 2017).

Mapped seagrass communities near the dredge area consist of *Posidonia* spp. (primarily *P. sinuosa*) and *Amphibolis* spp. (primarily *A. griffithii*), and sand inundated reef platforms with macroalgae and mixed perennial seagrass (BMT 2018b). Therefore, these communities are potentially at risk of reduced light resulting from turbid plumes during dredging and disposal. McMahon et al. (2011) studied light reduction for *A. griffithii* meadows in Jurien shaded for 3 months with full recovery after 300 days. Light requirements for *P. sinuosa*, have similar minimum light requirements to *A. griffithii*; however; a longer recovery period (Short et al. 2017). Macroalgae species have a higher tolerance to decreased light availability (0.5–0.01% of surface light; Markanger & Sand-Jensen 1994) compared to seagrasses (2–24% for various *Posidonia* and *Amphibolis* spp.; Erftemeijer & Lewis 2006). The key 'environmental window' for temperate seagrasses and macroalgae species is between October and April, based on sensitive life history periods (Short et al. 2017). Therefore, this section only considers indirect impacts of increased water column turbidity on the dominant seagrass species (*P. sinuosa* and *A. griffithii*), as a conservative approach to protecting all benthic primary producers in the region.

6.2.1.1 Relationship between modelled total suspended solids and light attenuation coefficient

The relationship between the modelled TSS (Section 6.1) and LAC was determined by laboratory simulations completed by the Marine and Freshwater Research Laboratory using sediment and wrack samples collected from the Boat Harbour sediment sampling (BMT 2019a,b). A subset of Jurien Bay sediment samples JBBH_S1–JBBH_S15 were wet sieved to collect <180 µm fractions. These fractions are representative of composite fine sands and silts from across these sites.

Homogenous portions of the <180 µm sieved material were added to a 1000 L seawater tank mesocosm with a light source at the base - fitted with a diffuser, two logging photosynthetically active radiation (PAR) light sensors (0.5 m apart - 600 mm and 100 mm away from light source), two submersible pumps to produce a well-mixed simulated plume within the tank and a YSI logger to measure turbidity/Nephelometric Turbidity Units (NTU) during sequential additions of sediments. Following each sediment addition, the mixing was allowed to equilibrate and then triplicate TSS/NTU samples were collected from the tank water and NTU and PAR were logged.

A total of 10 samples in triplicate (total of 30) were collected sampled for TSS and NTU measurement. LAC was calculated from measured PAR data, and the correlation between LAC and TSS/NTU determined specific to the Jurien Bay sediments. These correlations are provided

⁵ EPA (2016a) recently superseded by EPA (2021b).

in Figure 6.1 and Figure 6.2 respectively. The strong correlation between both TSS and LAC ($R^2 = 0.98$, Figure 6.1) and turbidity ($R^2 = 0.98$, Figure 6.2) suggest LAC can be determined from turbidity from modelled TSS.

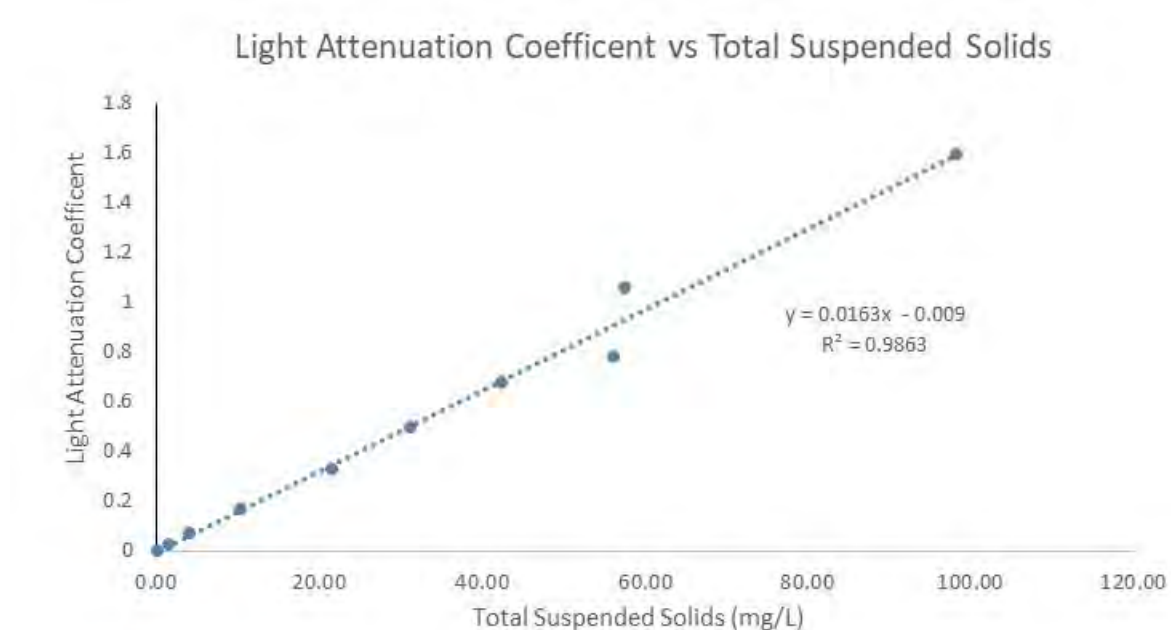


Figure 6.1 Total suspended solids correlation to light attenuation coefficient for Jurien Bay Boat Harbour sediment samples

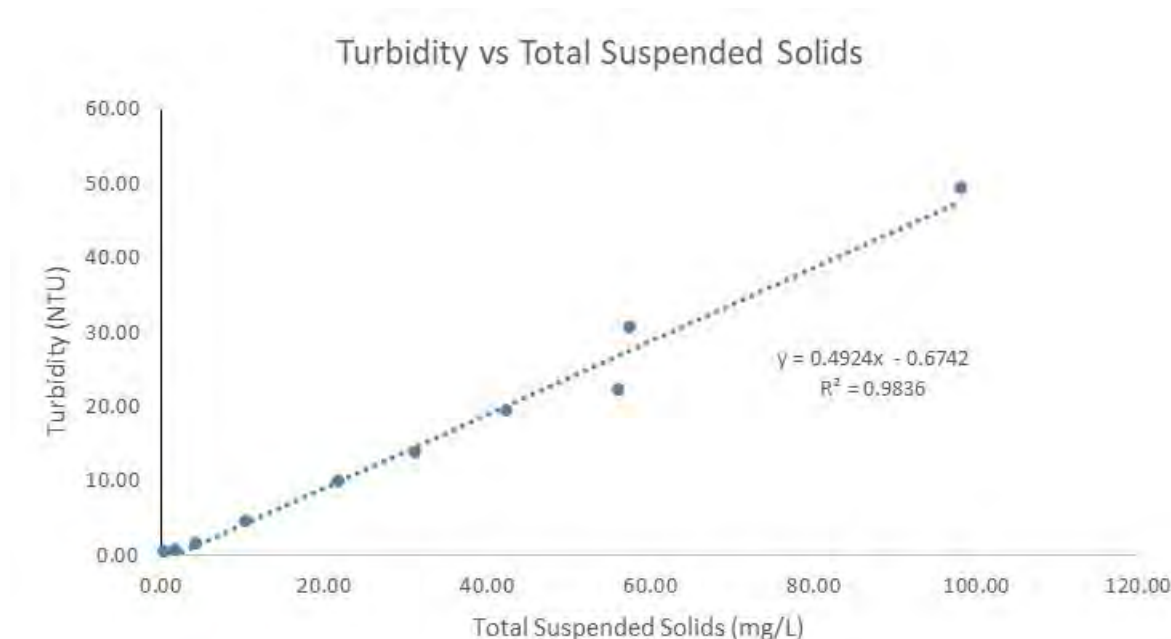


Figure 6.3 Total suspended solids correlation to turbidity for Jurien Bay Boat Harbour sediment samples

6.2.1.2 Seagrass light impact thresholds

The Cockburn Sound Management Council (CSMC) provide annual environmental quality criteria (EQC) for Light Attenuation Coefficient (LAC; CSMC 2018) to determine thresholds for seagrass protection. The CSMC (2018) EQC for LAC for high and moderate protection levels have been applied as the threshold values for potential impacts to seagrass in Jurien Bay (Table 6.1).

Table 6.1 Levels of protection and correlating light attenuation coefficient, total suspended solids and turbidity threshold criteria for Jurien Bay seagrass light assessment

Levels of protection	LAC ¹	Modelled TSS (mg/L)	Modelled Turbidity (NTU)
Moderate	0.114	7.89	3.05
High	0.096	6.80	2.50

Notes:

1. Data sourced from CSMC (2018).
2. LAC = light attenuation coefficient, TSS = total suspended solids, NTU = nephelometric turbidity units.

The CSMC (2018) values are considered applicable because data are current and from a similar environment to Jurien Bay (Warnbro Sound, ~250 km south). The data were also collated over a long time period and represent a robust spatial and temporal long-term dataset. The data collected as part of the McMahon and Lavery (2008) study were considered in the development of triggers, however; absence of baseline light data for the proposed disposal area meant that meaningful Hsat baseline data could not be calculated for the derivation of appropriate thresholds.

Modelled zones of protection for Jurien Bay were developed by comparing the LAC threshold criteria (Table 6.1) with TSS equivalents from the model. The zones were overlaid on mapped BCH (Figure 5.2) to show modelled potential impacts in relation to the offshore disposal area. These zones are demonstrated in Figure 6.2. The contours delineate the 95% confidence intervals for the relevant LAC/TSS threshold at CSMC (2018) EQC for high and moderate protection from Table 6.1. These zones were used to determine potential BCH loss from a reduction in light attenuation during disposal activities (refer Section 6.2.3).

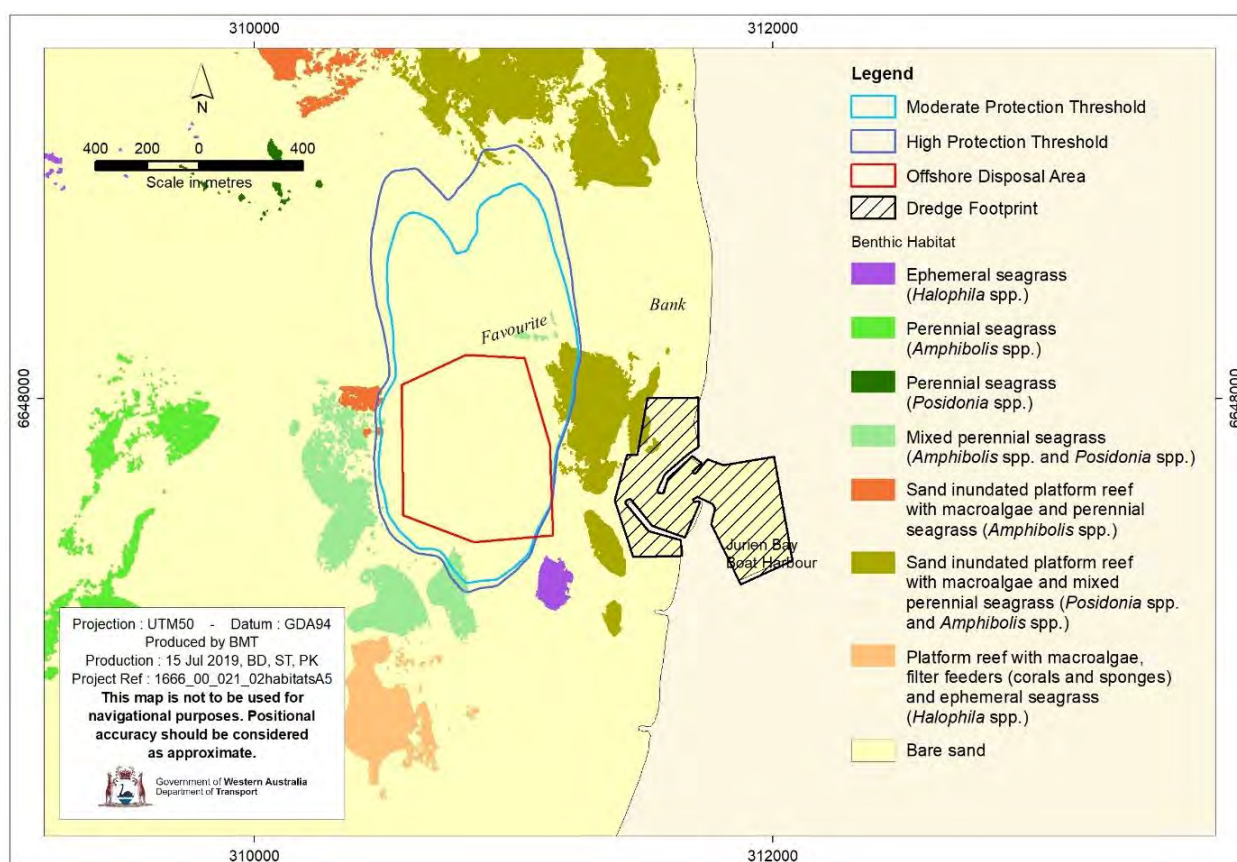


Figure 6.2 Modelled ecological protection zones based on seagrass light impact thresholds

6.2.2 Direct impacts to benthic communities and habitats

Where configuration of the disposal pipeline is along the seafloor, the pipeline will be positioned such that BCH are avoided where practicable to minimise direct impacts to mapped BCHs (refer to Section 5.3.1). Where direct avoidance of BCH is not practicable, it is anticipated interaction of the pipeline with the seabed would be highly localised and temporarily sunk overlying the seabed through the weight of the slurry in the pipeline. The pipeline diameter is ~30 cm and the weight of the filled pipeline would be sufficient to minimise movement on the seafloor, and potential impacts of scouring are considered low. There will be no direct removal of mapped areas of benthic habitats within the dredge area (0.5 ha of sand inundated platform reef with macroalgae and mixed perennial seagrass [*Posidonia* spp. and *Amphibolis* spp.]; Section 5.3.1) as these areas will be actively avoided during dredging (Section 3.3). If direct removal of BCH is considered required, a NVCP will need to be obtained under Part V of the EP Act.

Sedimentation from disposal of dredged material was modelled (refer Appendix A for details). Results demonstrated that sedimentation outside of the offshore disposal area was limited, with nearby BCH experiencing at most 0.10–0.15 m of sedimentation from the disposal plume (Figure 6.3). The model showed a maximum sedimentation thickness of 0.60–0.65 m within the offshore disposal area (Figure 6.3).

Given the low level of sedimentation modelled beyond the offshore disposal area and high tolerance of seagrass species to sedimentation (Coupland 1997, Cabaco et al. 2008), significant permanent impacts are not anticipated. However, the anticipated area of seagrass impacted by sedimentation has been included in a cumulative loss assessment (Section 6.2.3).

Sediment infauna has been shown to be able to migrate through up to 30 cm of burial (Wilber & Clarke 2007). Given the level of sedimentation outside of the offshore disposal area is anticipated to be less than 30 cm, impacts to infauna are not anticipated to be significant.

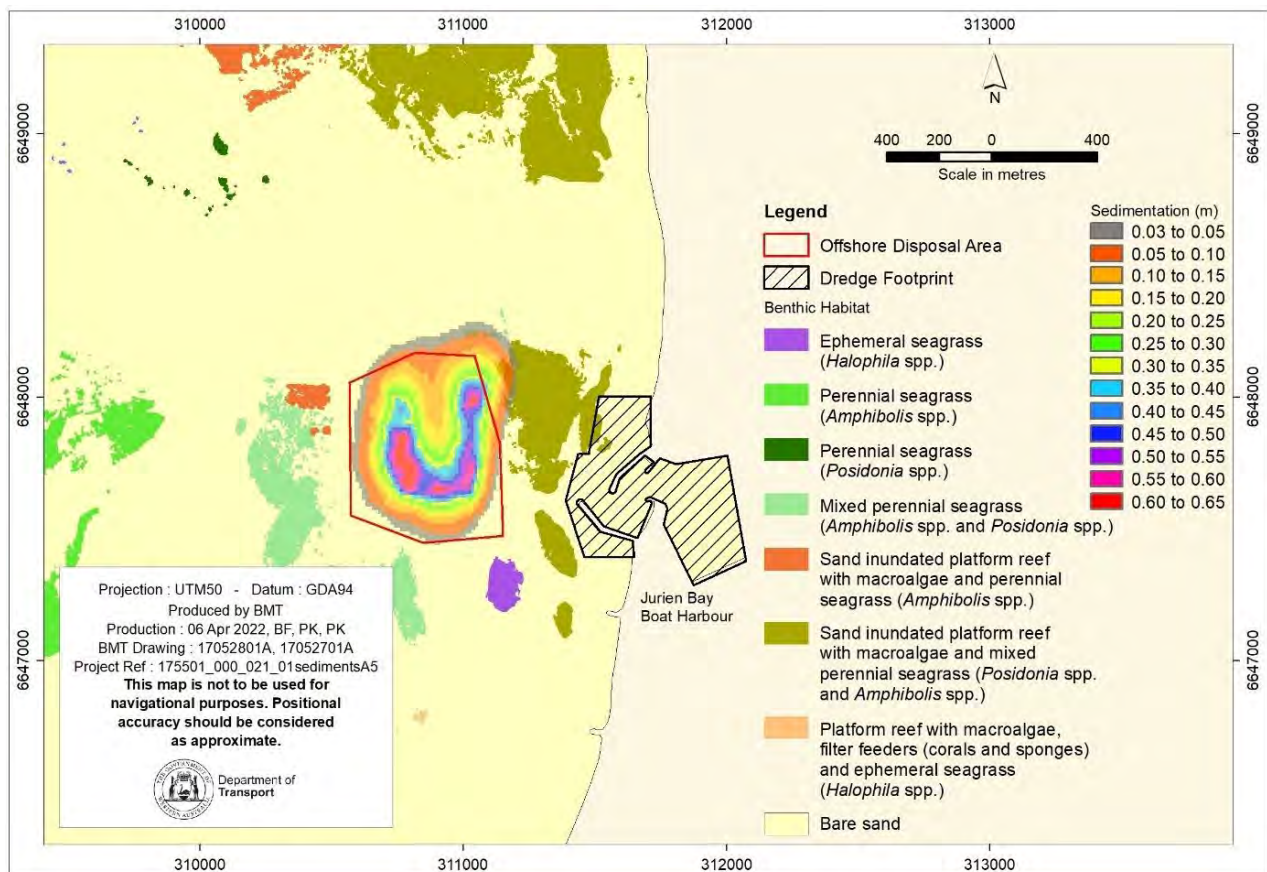


Figure 6.3 Modelled sedimentation thickness within the offshore disposal area resulting from one maintenance campaign at Jurien Bay

6.2.2.1 Stability of sediment placed in the offshore disposal area

The stability of dredged sediment placed within the offshore disposal area was assessed over acute storm conditions which cover the main storm characteristics at Jurien Bay (including northerly, westerly and southerly winds, Appendix A). Results demonstrated that the filled disposal area (filled to design level of -8 m CD) is anticipated to be stable under severe storm conditions from the range of directions with minimal resuspension of fine materials at the northern and southern boundaries of the disposal area (<0.1 mg/L).

The resuspension of the fine materials from the offshore disposal area was minimal from storm activities. The model demonstrated the natural shallow areas in the vicinity of the offshore disposal area, including the sand bar and beaches in Jurien Bay would experience significantly higher bed shear stress when compared with the offshore disposal area (filled to -8 m CD) and therefore are more prone to erosion and sediment mobility (compared with the filled offshore disposal area).

6.2.3 Cumulative impacts to benthic communities and habitats

6.2.3.1 Delineating zones of impact

Assessment of potential dredging impacts to BCH has been completed in-line with EPA (2016a) guidance. To comply with this guidance, proponents must demonstrate impacts according to zones of potential habitat loss. The three zones (zone of high impact [ZoHI], zone of moderate impact [ZoMI] and zone of influence [Zol]) are described in Table 6.2

Table 6.2 Impact zone definitions

Zone	Definition
Zone of High Impact (ZoHI)	The area where impacts on benthic communities or habitats are predicted to be irreversible. The term irreversible means 'lacking a capacity to return or recover to a state resembling that prior to being impacted within a timeframe of five years or less'. Areas within and immediately adjacent to proposed dredge and disposal sites are typically within ZoHIs.
Zone of Moderate Impact (ZoMI)	The area within which predicted impacts on benthic organisms are recoverable within a period of five years or less following completion of the dredging activities. This zone abuts, and lies immediately outside of, the ZoHI.
Zone of Influence (Zol)	The area within which changes in environmental quality associated with dredge plumes are predicted and anticipated during the dredging operations, but where these changes would not result in a detectable impact on benthic biota.

Source: EPA (2016a).

The following sections provide the rationale and justification for the conservative establishment of these zones for Jurien Bay, based on: (i) predictive modelling of the plume extent and intensity; and (ii) the tolerance of benthic biota.

Zones of impact have been determined for dredge and disposal areas for potential BCH loss assessment and during dredging monitoring (Table 6.3; Figure 6.4). The zones have been determined from the modelled LAC thresholds for seagrass (Figure 6.2) in relation to the boundaries of the dredge and disposal areas. A 50 m buffer has been applied to the dredge footprint to determine the ZoMI, based on the observed plume during previous campaigns (BMT Oceanica 2014c,d,e; BMT JFA 2015; BMT JFA 2017).

Given dredging will primarily occur within the Boat Harbour entrance and not near BCH (and that only small turbid plumes are generated by CSD in marine sands), there is a comparatively greater risk of potential impacts to BCH at the offshore disposal area (where there is a point source of turbidity throughout maintenance campaigns). The Zol boundary was defined as the edge of the discernible plume, where modelled TSS returns to <1 mg/L above background. No

impacts to BCH are anticipated within the ZoI (EPA 2016a); however; the boundary was used to determine appropriate placement of monitoring sites (Section 7.3.2.1).

Table 6.3 Zones of impact and correlating light attenuation coefficient, total suspended solids and turbidity

Impact zone	LAC ¹	Modelled TSS (mg/L)	Modelled Turbidity (NTU)
Zone of High Impact	0.114	7.89	3.05
Zone of Moderate Impact	0.096	6.80	2.50
Zone of Influence	n/d	1.00	n/d

Notes:

1 Data sourced from CSMC (2018).

2 LAC = light attenuation coefficient, TSS = total suspended solids, NTU = nephelometric turbidity units, n/d = not determined.

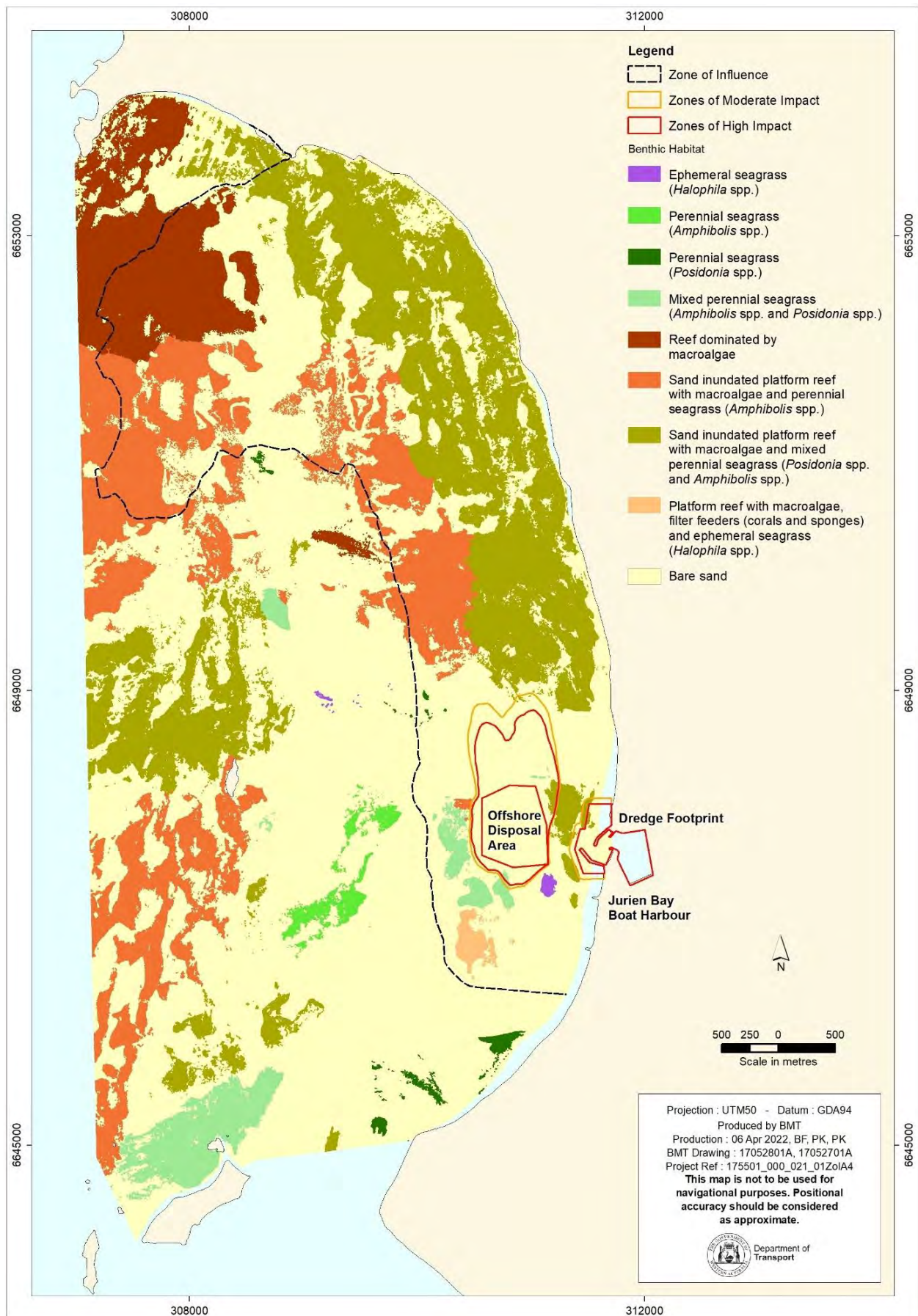


Figure 6.4 Zones of High and Moderate Impact and Zone of Influence for Jurien Bay maintenance dredging campaigns

6.2.3.2 Benthic community and habitat loss assessment

A loss assessment has been completed in the context of EPA (2016b) *Technical guidance on the protection of benthic habitats*. The proportion of each habitat within the ZoHI (permanent loss) and ZoMI (recoverable loss) has been determined.

The entire area mapped in BMT (2018b) was used as a local assessment unit (LAU). This is considered suitable for an impact assessment in the context of EPA (2016b) as the area mapped is similar to the recommended LAU size (37 km² compared to the recommended 50 km²) and is representative of the local ecological environment and key processes. Given the presence of the JBMP and the lack of current infrastructure within the mapped area it is considered that the BCH mapped in BMT (2018b) is representative of pre-European settlement and is a suitable baseline for assessment of impacts to BCH in line with EPA (2016b).

Habitat areas from within the ZoHI and ZoMI were conservatively combined for a cumulative loss assessment. This allows for an assessment of the unlikely outcome that habitats within the ZoMI do not recover between dredging campaigns. Bare sand presents the highest proportion of potential loss (5.6%, Table 6.4), followed by sand inundated platform reef (3.4%, Table 6.4) and perennial seagrass beds (1.2%, Table 6.4). Remaining habitat categories did not fall within the ZoHI or ZoM (Table 6.4). Bare sand is unlikely to be 'lost' as dredge material being placed in the ZoHI will result in bare sand habitat (which will be available for re-colonisation), and bare sand within the ZoHI but outside the dredge or disposal areas is unlikely to be impacted by maintenance dredging campaigns.

It should also be noted that the LAU is less than the EPA (2016b) suggested area, and should an entire 50 km² be mapped, it is likely that the proportion of potential habitat loss would be less than those reported in Table 6.4. The habitat with the largest proportion lost (Sand inundated platform reef with macroalgae and mixed perennial seagrass [*Posidonia* spp. and *Amphibolis* spp.] Table 6.4) is well represented throughout Jurien Bay (and the wider JBMP [CALM 2005]). Therefore, potential small-scale loss as a result of dredging and disposal activities is not anticipated to result in a significantly impact the ecological values of the JBMP as defined in the JBMBMP (CALM 2005).

Table 6.4 Anticipated cumulative permanent and temporary benthic habitat loss for Jurien Bay maintenance dredging campaigns

Benthic habitat type ²	Area mapped ³	Area of permanent loss (ZoHI) ³	Area of recoverable loss (ZoMI) ³	Total area impacted	Proportion of total mapped
Ephemeral seagrass (<i>Halophila</i> spp.)	2.6	0.0	0.0	0.0	0.0%
Perennial seagrass (<i>Amphibolis</i> spp.)	23.4	0.0	0.0	0.0	0.0%
Perennial seagrass (<i>Posidonia</i> spp.)	12.2	0.0	0.0	0.0	0.0%
Mixed perennial seagrass (<i>Amphibolis</i> spp. and <i>Posidonia</i> spp.)	94.5	0.8	0.4	1.1	1.2%
Reef dominated by macroalgae	222.1	0.0	0.0	0.0	0.0%
Sand inundated platform reef with macroalgae and perennial seagrass (<i>Amphibolis</i> spp.)	508.2	<0.1	0.2	0.2	<0.1%
Sand inundated platform reef with macroalgae and mixed perennial seagrass (<i>Posidonia</i> spp. and <i>Amphibolis</i> spp.)	670.2	2.6	2.2	4.8	0.7%
Platform reef with macroalgae, filter feeders (corals and sponges) and ephemeral seagrass (<i>Halophila</i> spp.)	11.5	0.0	0.0	0.0	0.0%
Bare sand	2122.5	97.1	21.8	118.9	5.6%

Notes:

1. 'ZoHI' = Zone of High Impact; 'ZoMI' = Zone of Moderate Impact
2. Habitat types impacted within the ZoHI is predicted to be irreversible, habitat types impacted within the ZoMI are predicted to recover within two years following completion of dredging activities
3. All areas presented in hectares

To ensure that impacts to light attenuation are equivalent to those modelled and the ZoHI and ZoMI are appropriate, light will be monitored during dredging. Light monitoring and management requirements are given in Table 7.3, and methods provided in Section 7.3.2.

6.3 Marine and terrestrial environmental quality

6.3.1 Hydrocarbon spills and waste

Various hydrocarbons will be used during maintenance dredging, including fuel, oil and lubricants for the maintenance dredging machinery. There is a subsequent potential risk of accidental hydrocarbon spills to the marine environment, negatively impacting all Boat Harbour users as well as marine flora and fauna. Rubbish and hazardous waste may also be generated, which can pollute the environment if not contained and removed from site. Hydrocarbon use and waste will be actively managed during the campaign, as outlined in Section 0.

6.3.2 Release of nutrients and contaminants

6.3.2.1 Nutrients

Dredge area sediments sampled in April 2019 comprised elevated concentrations of elutriate nutrients (Section 4.3). Mean concentrations of elutriate TP, FRP, TN, NO_x and NH₄⁺ exceeded the relevant ANZECC/ARMCANZ (2000)⁶ default trigger values for physical and chemical

⁶ At the time of preparing BMT (2019b), the ANZG (2018) marine water quality guidelines were not available for application due to resolving issues/inconsistencies on the website, and it was recommended to refer to the ANZECC/ARMCANZ (2000) marine water quality guidelines in the interim.

stressors for south-west Australia slightly disturbed marine inshore ecosystems (Section 4.3). Consistently high concentrations of nutrients in marine environments (particularly in enclosed waters such as the Boat Harbour) may cause excess algal growth that can subsequently lead to reduced light penetration and oxygen in the water column. The mean concentration of elutriate NH_3 exceeded the relevant ANZECC/ARMCANZ (2000) trigger value for toxicants for 95% and 99% species levels of protection (Section 4.3). Consistently high concentrations of ammonia in marine environments can be toxic to biota (ANZECC/ARMCANZ 2000).

Elevated concentrations of elutriate nutrients from dredge area sediments have been reported within the Boat Harbour since 2005 (Section 4.4) and are anticipated from the high proportion of decomposing wrack material within the sediments (some dredge area sediment samples contained up to 30% organic matter; BMT 2019b). In May and September 2018, the Boat Harbour was estimated to respectively contain ~916 tonnes and ~3297 tonnes (wet weight) of wrack material (dominated by *Amphibolis spp.*) covering ~34% (or ~4.7 ha) and ~39% (or ~5.5 ha) of the seafloor within the Boat Harbour (BMT 2018b). These findings were comparable to estimates by Oldham et al. (2017) for respective months in September 2016. The environmental impacts that have previously occurred from significant accumulations of wrack within the Boat Harbour are discussed in Sections 6.3.3; any potential impacts to Boat Harbour water quality from the release of nutrients during dredging will be short-term and considered negligible compared to the long-term (chronic) impacts from reduced water quality that currently exist within the Boat Harbour from wrack accumulation.

It is noted that the ANZECC/ARMCANZ (2000) are environmental guidelines and should not be applied directly to effluent concentrations from laboratory samples, rather consider dilution must be considered within the receiving environment. In accordance with NAGD (CA 2009), the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values should not be exceeded after allowing for initial dilution, defined as 'that mixing that occurs within four hours of dumping'. Given that elutriate tests use a dilution of 1:4, wet sediment: added seawater, water quality impacts are greatly overestimated by the order of a hundred times or more (and often much more) compared to what would be expected after the four-hour mixing period (CA 2009).

As per the NAGD (CA 2009), the elutriate nutrient data was scaled to account for initial dilution at the discharge area for appropriate assessment against the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values (Table 6.5). The elutriate nutrient data was first converted to a dilution of 1:9 (wet sediment: added seawater), which provides a better representation of the concentrations likely to be present in the average dredge slurry (Table 6.5). Following guidance from the NAGD (CA 2009), initial dilution was then approximated as: 'the liquid and suspended particulate phases of the waste may be assumed to be evenly distributed after four hours over a column of water bounded on the surface by the release zone and extending to the ocean floor, thermocline or halocline, if one exists, or to a depth of 20 m, whichever is shallower' (for the offshore disposal area a release zone of 36 ha and a depth of 12 m applied; Table 6.5). The volume of material to be discharged over the four-hour period was based on a dredging production rate of 105 m³/hour (this is the average dredging production rate of previous Boat Harbour maintenance dredging campaigns; BMT JFA [2017]; BMT JFA [2015]). The resultant concentrations of elutriate nutrients were well below the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values (Table 6.5); therefore, potential impacts from the release of nutrients at the offshore disposal area is anticipated to be negligible.

Since water circulation and movement within the shallow and partially-enclosed Boat Harbour basin would be limited compared to receiving environment at the offshore disposal area located in deeper open ocean, there is a higher likelihood of potential nutrient related impacts occurring in this area during maintenance dredging.

While it was considered unlikely that the potential release of nutrients during dredging and disposal would cause a significant environmental impact, given the location of the Boat Harbour is near the JBMP and that the offshore disposal area is located within the JBMP, monitoring measures were implemented during the first maintenance campaign (BMT 2021a). Water quality

monitoring was completed on two occasions during dredging, and the results were compliant with the management trigger on both monitoring occasions (BMT 2021a). Potential impacts from release of nutrients during dredging and disposal is considered unlikely to cause a significant environmental impact based on monitoring results and water quality monitoring during dredging for subsequent campaigns will be discontinued. If routine sediment sampling results show nutrients concentrations are significantly higher than historical concentrations recorded in the Boat Harbour and exceed relevant guidelines, the requirement to reinstate water quality monitoring during maintenance dredging will be assessed.

6.3.2.2 Contaminants

Concentrations of total metals and hydrocarbons in dredge and disposal area sediments sampled in April 2019 were below relevant NAGD (CA 2009) Screening Levels (Section 4.3) indicating that sediments were suitable for unconfined ocean disposal. Samples were elutriated for metals concentrations to determine the potential release of metals in the water column within the JBMP during disposal. Mean concentrations of elutriate metals (specifically for copper and zinc) in dredge area sediments, exceeded the relevant ANZECC/ARMCANZ (2000) trigger values for toxicants at the 99% species levels of protection (Section 4.3). After scaling the elutriate metal data to account for initial dilution at the discharge area, concentrations of elutriate metals were well below the relevant ANZECC/ARMCANZ (2000) trigger values for toxicants at the 99% species level of protection (Table 6.5). While potential impacts associated with the release of contaminants during disposal was anticipated to be negligible, water quality monitoring was completed on two occasions during the 2020/21 maintenance dredging campaign to measure realised potential impacts (Section 6.3.2.1; BMT 2021a). The results of this monitoring were compliant with the management trigger on both monitoring occasions (BMT 2021a). Potential release of contaminants during dredging and disposal is considered unlikely to cause significant environmental impact, based on monitoring results and water quality monitoring during dredging for subsequent campaigns will be discontinued. If routine sediment sampling results show potential contaminant concentrations are significantly higher than historical concentrations recorded in the Boat Harbour and exceed relevant guidelines, the requirement to reinstate water quality monitoring during maintenance dredging will be assessed.

Table 6.5 Concentrations of elutriate nutrients and metals of sediment samples from Jurien Bay Boat Harbour dredge area scaled to account for initial dilution at the offshore disposal area for assessment against the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values

Analyte	Elutriate nutrients (µg/L)									Elutriate metals (µg/L)						
	TP	FRP	TN	NO _x	NH ₄ ⁺	NH ₃	Nitrite	Nitrate	TKN	As	Cd	Cr	Cu	Pb	Ni	Zn
Default trigger values for south-west Australia marine inshore waters ²	20	5	230	5	5	–	–	–	–	–	–	–	–	–	–	–
99% species level of protection ³	–	–	–	–	–	500	–	–	–	–	0.7	7.7 ⁸	0.3	2.2	7	7
Concentrations of elutriate nutrients from dredge area sediments (assuming dilution of 1:4 wet sediment: added seawater)⁴																
Mean ⁷	77.1	53.0	2088.7	14.1	1509.1	1607.6	nd	13.5	2075.4	11.9	0.4	nd	4.6	nd	1.0	47.5
Max	185.0	145.0	6113.3	63.0	4753.3	5063.3	7.0	63.0	6103.3	17.5	0.8	0.4	7.7	0.2	1.4	135.3
Concentrations of elutriate nutrients from dredge area sediments (assuming dilution of 1:9 wet sediment: added seawater)⁵																
Mean ⁷	34.2	23.6	928.3	6.3	670.7	714.5	nd	6.0	922.4	5.3	0.2	nd	2.1	nd	0.4	21.1
Max	82.2	64.4	2717.0	28.0	2112.6	2250.4	3.1	28.0	2712.6	7.8	0.4	0.2	3.4	0.1	0.6	60.1
Concentrations of elutriate nutrients from dredge area sediments (assuming dilution of 1:9 wet sediment: added seawater and an even distribution of concentrations within the limits of the offshore disposal area from a dredging production rate of 105 m³/hour and a four hour discharge period)⁶																
Mean ⁷	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	nd	<0.1	<0.1	<0.1	<0.1	nd	<0.1	nd	<0.1	<0.1
Max	<0.1	<0.1	<0.1	<0.1	0.2	0.2	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Notes:

1. 'TP' = total phosphorus; 'FRP' = filterable reactive phosphorus; 'TN' = total nitrogen; 'NO_x' = nitrate+nitrite; 'NH₄⁺' = ammonium; 'NH₃' = ammonia; TKN' = total kjeldahl nitrogen; 'As' = arsenic; 'Cd' = cadmium; 'Cr' = total chromium; 'Cu' = copper; 'Pb' = lead; 'Ni' = nickel; 'Zn' = zinc; '–' = no guideline value available; 'nd' = statistic not determined because the dataset contains >25% of values below the laboratory limit of reporting.
2. ANZECC/ARMCANZ (2000) default trigger values for physical and chemical stressors applicable to south-west Australia for slightly disturbed marine inshore ecosystems.
3. ANZECC/ARMCANZ (2000) trigger values for toxicants at the 99% (applicable to offshore disposal area) species level of protection.
4. Dilution of 1:4 wet sediment: added seawater is the concentration the laboratory used to undertake the elutriate testing.
5. Dilution of 1:9 wet sediment: added seawater provides a better representation of the concentrations likely to be present in the average dredge slurry.
6. Concentrations were scaled in accordance with guidance from the NAGD (CA 2009).
7. Where data was below the laboratory limit of reporting half of the value was used to calculate the mean value.
8. ANZECC/ARMCANZ (2000) trigger value for Cr III conservatively applied in the absence of a guideline value for total Cr.
9. Red text indicates exceedance of the relevant ANZECC/ARMCANZ (2000) marine water quality trigger value.

6.3.3 Hypoxia

Hypoxia is the condition in which dissolved oxygen (DO) is below the level necessary to sustain most animal life (CENR 2000). If large amounts of organic material were to be released into the water column at the dredging or disposal areas, bacterial decomposition of this material could deplete oxygen levels and lead to hypoxia.

The Boat Harbour has a history of accumulating substantial amounts of wrack, shed from offshore seagrass beds and transported into the Boat Harbour during north-westerly storms. The accumulation and subsequent decomposition of wrack that is unable to naturally flush out of the Boat Harbour causes hypoxic conditions to occur within the Boat Harbour basin. In October 2013 and November 2014, hypoxic conditions in the Boat Harbour basin coincided with fish kill events. Emergency and pre-emptive wrack trawling campaigns have previously been undertaken as a management solution to improve the water quality within the Boat Harbour basin (Section 1.3).

During previous maintenance dredging campaigns, monitoring of DO within the water column of the Boat Harbour basin has been undertaken (BMT JFA 2015, BMT JFA 2017). During the monitoring, highly variable DO levels were recorded that ranged from 0–122% (BMT JFA 2015, BMT JFA 2017). Despite periods where very low levels of DO were recorded within the Boat Harbour basin during previous maintenance dredging campaigns, this was not considered of concern since the DO levels were within the range of those known to occur during periods where no maintenance dredging is occurring (from the high amount of decomposing wrack in the Boat Harbour) and no adverse environmental impacts were observed (i.e. fish kill events; BMT JFA 2015, BMT JFA 2017).

Dredge area sediments sampled in April 2019 comprised considerable portions of organic material (up to 30%; BMT 2019b, Appendix C); therefore, maintenance dredging may potentially contribute to hypoxia within the Boat Harbour basin, in the short-term, when the organic material is released into the water column. The benefit of periodic maintenance dredging that removes accumulated wrack from the Boat Harbour basin to enable improvement to water quality in the long-term is considered to outweigh any potential short-term negative impacts. At the offshore disposal area, dilution in the receiving environment is anticipated to be sufficient for the potential impact of hypoxia to be considered low risk.

Active monitoring measures for indicators of hypoxia related impacts (i.e. localised fish kills) will be implemented during maintenance dredging campaigns as outlined in Section 0.

6.3.4 Introduced marine species

The arrival of machinery at the dredging and disposal areas may potentially introduce non-native introduced marine species (IMS) from other areas, thereby disrupting the local ecosystem. IMS may be transported between sites within ballast water and on vessel hulls (i.e. biofouling). However, the risk of transferring IMS to the JBMP during maintenance dredging campaigns is considered negligible because:

- The dredge to be used during the has no ballast water.
- The vessel hull has an anti-foul coating, and prior to mobilisation, the dredge and pipes will be cleaned to ensure that no water or sediment remains when loading the vessel onto the trailer for transport.
- The vessel be dry docked and travelling via road to Jurien Bay.

In consideration of the above, no active management associated with introduced with marine species is required. Should the dredge or associated support vessels be sourced from outside WA, from a port with known introduced marine pests, or not conform to the justification above, management will be required, as detailed in Section 0.

6.3.5 Vegetation disturbance/removal

No native vegetation is anticipated to be directly removed or cleared during ongoing maintenance dredging campaigns. However, if vegetation disturbance or removal is required, an application for a NVCP will be prepared and submitted for approval.

6.4 Marine fauna

6.4.1 Marina fauna collision and/or entanglement

There is a potential risk of marina fauna collision and/or entanglement from the presence of vessels, equipment and machinery during Boat Harbour maintenance dredging campaigns. Potential impacts of marine fauna collision and/or entanglement incidences may include death, injury, adverse behavioural and physiological changes, and reduced body condition and/or immune function to individual fauna. Active monitoring and management measures will be implemented during maintenance dredging campaigns, outlined Section 0, to minimise the risk of potential marina fauna collision and entanglement incidences.

Approximately 90% pipeline will be submerged onto the seafloor except for ~40 m at each end where the pipe connects to the dredge or is suspended below the water surface by the disposal buoy. This configuration substantially reduces the risk of marine fauna colliding with the disposal pipeline.

6.4.2 Environmental impact of noise

Noise generated by dredging has the potential to disturb marine fauna, causing temporary or long-term avoidance of an area that may be important for feeding, reproduction or sheltering. Underwater sounds may interfere with communication systems of fish and marine mammals, masking important biological cues or causing behavioural disturbance (Richardson et al. 1995, National Research Council 2005, Southall et al. 2007). Intense underwater sounds in close proximity to marine fauna may cause temporary or permanent hearing damage or death (Southall et al. 2007). These impacts may affect critical behaviours and functions, such as feeding, migration, breeding and response to predators, all of which may ultimately affect an individual animal's survival (National Research Council 2005). Depending on the duration and intensity of underwater noise, an animal may avoid the source of the disturbance completely, thereby altering the overall use and ecology of that marine environment.

The Boat Harbour is not an important area for feeding, reproduction or sheltering by marine mammals. It is unlikely that marine mammals close to the Boat Harbour will be significantly impacted by the low-frequency sounds generated from maintenance dredging. Bottlenose dolphins have hearing thresholds that are most sensitive to higher frequencies (Southall et al. 2007), and no hearing information exists for Australian sea lions or the larger baleen whales (such as blue or humpback whales). Therefore, based on known hearing sensitivities and the temporary duration of maintenance dredging campaigns, it is unlikely that the underwater noise will have a significant impact on any marine fauna likely to be in the area.

6.4.3 Impacts to protected fauna and other fauna of significance

Consideration of the 'significant impact criteria' (Table 6.6) for critically endangered and endangered species, defined under the EPBC Act Significant Impact Guidelines 1.1, was conservatively applied to risk assess potential impacts from maintenance dredging campaigns to protected fauna (Section 5.3.2) and other fauna of significance (Section 5.3.3) likely to occur in the vicinity of the Boat Harbour. The outcome of the assessment indicates there is a low risk of maintenance dredging campaigns impacting on protected fauna and other fauna of significance (Table 6.6). The Project is therefore not considered significant to warrant referral or assessment under the EPBC Act.

Table 6.6 Assessment of significant impact criteria for critically endangered and endangered species

Criteria	Significant impact criteria	Risk	Notes
1	Lead to a long-term decrease in the size of a population	Low	<ul style="list-style-type: none"> Maintenance dredging campaigns are small scale and short-term in duration (Section 2.1). There is a low risk of maintenance dredging campaigns disrupting the breeding cycle of a population (refer to notes for significant impact criteria #3). There is a low risk of maintenance dredging campaigns adversely affecting BCH (refer to notes for significant impact criteria #4). There is a low risk of maintenance dredging campaigns introducing IMS or disease to the Project area (refer to notes for significant impact criteria #7 and #8). Dredge area sediments are characterised by relatively clean marine sands that present a low environmental risk of introducing stressors or toxicants into the environmental at levels harmful to marine flora/fauna (Section 4.3 and 6.3.2). Monitoring and management measures are in place to minimise the risk of potential marina fauna collision and entanglement incidences (Table 7.3).
2	Fragment an existing population into two or more populations	Low	<ul style="list-style-type: none"> As above (refer to notes for significant impact criteria #1).
3	Disrupt the breeding cycle of a population	Low	<ul style="list-style-type: none"> There are no documented critical breeding, nesting or spawning areas for threatened fauna or other fauna of significance in the Project area (Sections 5.3.2 and 5.3.3)
4	Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Low	<ul style="list-style-type: none"> The potential impact of maintenance dredging campaigns causing direct and indirect impacts to BCH has been risk assessed in Section 6.2 and it is considered to not be ecologically significant. Disposal of dredged sediments to the proposed offshore disposal area is anticipated to result accretion of up to ~70 cm per campaign within the disposal area, and ~1-3 cm immediately adjacent to the offshore disposal area (Section 6.2.2). Monitoring of the dredge and disposal position will be completed during maintenance dredging campaigns to ensure operations remain restricted to the approved areas (Section 7.3.1). Sub-sea light loggers will be deployed to monitor light-attenuation during maintenance dredging campaigns (Section 7.3.2). Ongoing turbidity monitoring will be undertaken during maintenance dredging campaigns (Section 7.3.2).
5	Adversely affect habitat critical to the survival of a species	Low	<ul style="list-style-type: none"> As above (refer to notes for significant impact criteria #4).
6	Reduce the area of occupancy of the species	Low	<ul style="list-style-type: none"> As above (refer to notes for significant impact criteria #4).
7	Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	Low	<ul style="list-style-type: none"> The potential impact of maintenance dredging campaigns introducing IMS to the Project area has been risk assessed in Section 6.3.4 and is considered negligible. Management measures are in place to ensure no IMS are introduced to JBMP (Table 7.3).

Criteria	Significant impact criteria	Risk	Notes
8	Introduce disease that may cause the species to decline	Low	<ul style="list-style-type: none"> The risk of non-native species being introduced to the Project area from maintenance dredging campaigns is considered negligible (Section 6.3.4); therefore, the potential risk of introducing disease to the Project area via this pathway is also considered negligible. It is considered that there are no other significant pathways for disease to be transferred to the Project area from maintenance dredging campaigns.
9	Interfere with the recovery of the species.	Low	<ul style="list-style-type: none"> The Project area does not feature in action recovery plans for critically endangered or endangered species (DBCA 2018; CA 2015; DSEWPac 2011; DSEWPac 2012d).

6.5 Coastal processes

Maintenance dredging campaigns are not anticipated to impact on the coastal processes of Jurien Bay. The offshore disposal area is anticipated to be retentive (Appendix A), therefore, sand is not expected to migrate back onshore. Dredging of the beach to the north and south of the Boat Harbour breakwater will, at worst, return the shoreline toward pre-construction alignment. It is anticipated that the dredged area will then naturally infill as sediment moves north and south toward the Boat Harbour, as has taken place following previous maintenance dredging campaigns at the Boat Harbour. Therefore, impacts to coastal processes are not anticipated to require monitoring or management.

6.6 Social surroundings

6.6.1 Public safety, visual amenity and beach access

The Boat Harbour is widely utilised for recreational boating, fishing, swimming and other recreational activities. The operation of heavy machinery within the Boat Harbour during dredging will temporarily impact visual amenity and pose a short-term risk to public safety when accessing the Boat Harbour and groynes (used for recreational fishing). Any short-term negative impacts of the dredging campaign to public amenity are likely outweighed by the long-term improvement in access to the Boat Harbour as a result of the dredging. The dredging is not expected to have an adverse impact on recreational users of the Boat Harbour since the impact on users and public safety shall be limited due to:

- minimised where possible with no dredging occurring over public holiday periods and weekends
- fencing and public information signs will be installed on site
- pipeline lay-down areas will be specifically designated and sign-posted to preserve public safety

Nevertheless, public safety, visual amenity and beach access will be actively managed during campaigns (Section 0).

There may be some impact on commercial operators that intake water from the Boat Harbour for live lobster holding tanks. However, the potential negative impacts of maintenance dredging campaigns are outweighed by the long-term improvement to the overall harbour amenity as a result of dredging. Maintenance dredging is not expected to have any impact on recreational users of the southern inner beach. The impact on harbour users and public safety will be limited because:

- The duration of the dredging campaign will be minimised where possible and no dredging will occur over the Christmas holiday period. Dredging will occur Monday to Saturday (inclusive).
- The material to be dredged will be relatively clean marine sediments with no aesthetic or health concerns to the public.
- The level of conflict between Boat Harbour and beach users and maintenance operations has been manageable to date

The dredging is considered to pose a medium risk level to public safety and harbour amenity at the Boat Harbour, and a low risk level at the offshore disposal area. The impact of dredging on public safety and harbour amenity at both sites will be actively managed, as outlined in Section 0.

6.6.2 Navigational hazards

The Boat Harbour is primarily utilised by recreational vessels. Dredging operations may pose a navigational hazard to vessels as the dredge has no self-propulsion (using only anchors and spuds to move). The discharge pipeline is typically submerged onto the seabed, with the exception of short end-sections of floating pipeline at the dredge and discharge end. The dredge and pipelines will be clearly visible on the water surface during the day and both the dredge and floating pipeline sections are illuminated at night. The dredge will maintain a navigable channel, and vessel access through the entrance channel will be monitored where practicable throughout the dredging works. A Temporary Notice to Mariners (TNTM) will be issued to inform the public of navigational hazards associated with maintenance dredging. Boat Harbour maintenance dredging campaigns are not anticipated to impact navigational use, however; marine safety will require management throughout dredging operations (Section 0).

6.6.3 Social impact of noise

Residential areas are usually considered to be the most sensitive receptors to noise, whereas commercial and recreational areas are considered to be less sensitive. Several residential properties are located on the southern side of the Boat Harbour (~200–500 m away from the dredge area). Vessels launch, land and motor through the Boat Harbour on a daily basis, thus creating a high level of ambient noise already in the area.

The short-term period of the dredging campaign will restrict noise exposure to a short-term and temporary duration. Previous dredging and trawling campaigns have not received noise complaints from the community around the Boat Harbour. Therefore, it is unlikely that noise generated by dredging will significantly impact local residents. In addition, measures to further limit the social impact of noise will be outlined in Section 0, along with contingency measures should public complaints be received.

6.6.4 Heritage

6.6.4.1 Aboriginal heritage

A search of Department of Planning, Lands and Heritage (DPLH) Heritage Inquiry System shows no Registered Aboriginal Heritage Sites within the dredge or disposal areas (DPLH 2021).

An Activity Notice pursuant to Clause 8.2 of the NSHA for the maintenance dredging campaigns was submitted to SWALSC as the Yued Body Corporate on 15 August 2019, and updated and resubmitted 22 October 2020 (Section 3.4). Following assessment, SWALSC advised an Aboriginal archaeological and ethnographic Site Identification heritage survey of the Onshore Disposal Area and equipment laydown areas was required to assess potential impacts to Aboriginal heritage. A survey was undertaken 23 February 2021 and no existing Aboriginal archaeological sites or artefacts were identified in the areas, however; a potential Aboriginal cultural site was identified within the north-eastern corner of the Onshore Disposal Area (Archae-aus 2021). The site was lodged as an Other Heritage Place for review by the Aboriginal Cultural Material Committee (DPLH 2021) for assessment as an Aboriginal Site under the *Aboriginal Heritage Act 1972*. The site was excised from the Onshore Disposal Area (with a 30 m buffer) for direct avoidance should onshore disposal is required in future campaigns (Archae-aus 2021).

6.6.4.2 European heritage

A search of the Heritage Council State Heritage Office inHerit database revealed no European Heritage sites that would be impacted by proposed dredging or disposal works (GWA 2018).
Management Measures and Contingencies

7 Management Measure and Contingencies

7.1 Roles and responsibilities

The roles and responsibilities for the implementation of the commitments outline in the LTMMMP (this document) are summarised in Table 7.1.

Table 7.1 Roles and responsibilities

Role	Responsibility
Proponent (DoT) and Proponents Representative (BMT)	<ul style="list-style-type: none"> Contract holder and ultimately responsible for all aspects of the Project Responsibility for the implementation of LTMMMP Responsible for reporting any HSEQ incidents as a result of the Project Ensure clear communication of Project milestones to relevant stakeholders
Environmental Representative (BMT)	<ul style="list-style-type: none"> Prepares and implements a Sampling and Analysis Plan in accordance with the requirements of this LTMMMP Complete required environmental management and monitoring commitments of this LTMMMP Ensures adequate training for employees carrying out the requirements of this LTMMMP Prepares environmental monitoring/compliance reports Provides environmental advice, as required
Dredging Contractor (Contractor)	<ul style="list-style-type: none"> Ensures employees are adequately trained in-line with the requirements of this LTMMMP Complete required environmental management and monitoring commitments of this LTMMMP Report any HSEQ incidents to DoT/BMT within 24 hours Ensure all equipment is in good working order Implement management and monitoring
All personnel involved with the Project	<ul style="list-style-type: none"> Comply with all contract requirements including implementation of LTMMMP and supporting documentation requirements Adequately trained to perform the task at hand Report any HSEQ incidents as soon as practical

Notes:

1. 'LTMMMP' = Long Term Monitoring and Management Plan; 'HSEQ' = Health, Safety, Environment and Quality

7.2 Management strategies and actions

Management objectives and management targets for each environmental factor (EPA 2021a) are provided in Table 7.2. These objectives and targets have been adapted from those in CALM (2005) to ensure the values of the JBMP are maintained throughout maintenance dredging campaigns. These objectives and targets will be met through environmental management and monitoring actions, and triggers for response, as outlined in Table 7.3. Where required, methods for monitoring potential impacts are provided in Section 7.3.

Table 7.2 Management objectives and targets for the Jurien Bay Boat Harbour maintenance dredging campaigns

Environmental Factor ¹	Management Objective ²	Management Target ²
Benthic communities and habitats	To ensure seagrass meadows in the JBMP are not permanently damaged	No permanent loss of perennial seagrass meadows from dredging and disposal activities
	To develop an increased understanding of the distribution and diversity of macroalgal habitats in the marine park	No reduction in macroalgal species diversity or macroalgal habitat as a result of human activities in the JBMP.
Marine and terrestrial environmental quality	To ensure the water and sediment quality of the marine park is not significantly impacted by the input of contaminants.	No change from background levels, unless approved by the appropriate government regulatory authorities.
Marine fauna	To ensure that human activity does not significantly disturb marine fauna populations in the JBMP	No significant disturbance to mammal, pinniped, seabird and turtle populations in the JBMP from human activities.
Social surroundings	To ensure social surroundings (Aboriginal and European heritage, public amenity) are not significantly interrupted by dredging and disposal activities	Maintenance of public access and amenity to beached and the Boat Harbour. No impact to Aboriginal or European heritage sites

Notes:

1. EPA (2021a)
2. Adapted from CALM (2005)

Table 7.3 Summary of environmental management commitments for the Jurien Bay Boat Harbour maintenance dredging campaigns

Factor	Potential Impact	Monitoring				Management Trigger	Management			
		Action	Responsibility	Timing/Frequency	Evidence		Action	Responsibility	Timing/Frequency	Evidence
Benthic communities and habitats	Direct loss or burial of subtidal benthic habitats outside of defined dredge area	Dredge position monitoring to ensure no dredging outside of proposed design footprint (Section 7.3.1)	BMT	During dredging	Positional data from an independent GPS logger affixed to dredge	Recorded position outside of approved dredge area while dredging (checked weekly)	Inform Contractor immediately Move dredge back to inside approved dredge area boundary	BMT Contractor		
		Placement of disposal pipeline end no closer than 20 m from the offshore disposal area boundary (Section 7.3.1)	Contractor		Position of disposal pipeline end at each re-location recorded on daily reports	Recorded position outside of approved disposal area boundary (checked weekly)	Inform Contractor immediately Move disposal pipeline end back to inside approved disposal area boundary	BMT Contractor		
		Placement of disposal pipeline in areas devoid of mapped benthic primary producer habitat where practicable	Contractor		BMT to provide Contractor with the spatial data of the mapped benthic primary producer habitats for their reference during configuration of disposal pipeline	Disposal pipeline unsecured and observed over an extensive area of mapped benthic primary producer habitat	Move disposal pipeline to area devoid of mapped benthic primary producer habitat, where possible	Contractor		
	Indirect loss of benthic habitats	Plume sketches (Section 7.3.2.1)	Contractor	On every working day during dredging	Plume sketches sent to BMT weekly	Plume sketch records visible turbid plume outside of the Zol	BMT to discuss in consultation with Contractor revising dredging and/or disposal methods and/or locations to manage excessive visible turbid plume extent	BMT Contractor	As required	Summarised in weekly progress reports
		Site photographs (Section 7.3.2.1)			Site photographs sent to BMT weekly	Site photograph verifies record of visible turbid plume outside the Zol in plume sketch				
		Remote imagery (Section 7.3.2.1)	BMT	During dredging	One low resolution image will automatically be sent to BMT daily and high-resolution images will be downloaded after campaign completion	Remote imagery verifies record of visible turbid plume outside the Zol in plume sketch	Contractor to implement measures to manage excessive visible turbid plume extent			
		Drone aerial photography (Section 7.3.2.1)		Monthly during dredging	Drone aerial photography	Georeferenced image shows visible turbid plume outside of the Zol	BMT to discuss in consultation with Contractor revising dredging and/or disposal methods and/or locations to manage excessive visible turbid plume extent Contractor to implement measures to manage excessive visible turbid plume extent	BMT Contractor		

Factor	Potential	Monitoring				Management	Management			
						Georeferenced image shows dredge outside of approved dredge area during dredging or disposal pipeline end outside of approved disposal area during disposal	Inform Contractor immediately Move dredge back to inside approved dredge area boundary or disposal pipeline end back to inside approved disposal area boundary	BMT Contractor		
		Sub-sea light logging at impact sites located on the outer boundaries of the ZoHI and ZoMI and at reference sites located outside of the ZoI (Section 7.3.2.2)	BMT	During dredging	Loggers serviced with data downloaded at ~6 week intervals Results reported in the relevant weekly progress report(s)	Median impact site LAC exceeds the relevant impact zone boundary LAC threshold defined in Table 6.3 and the 80 th percentile of the reference sites	Inform DBCA of the management trigger exceedance Modify dredging/disposal method to reduce turbidity (i.e. move disposal pipeline further away from disposal area boundary or deeper into the water column) Complete next logger service with data download after ~4 weeks If management trigger exceedance continues, dredging and disposal to temporarily cease pending approval to continue following consultation with DBCA	BMT Contractor/BMT	As required	Summarised in the relevant weekly progress report(s)
Marine and terrestrial environmental quality	Release of nutrients or contaminants	Screening of dredge/disposal area sediments in accordance with EMF (BMT 2021) and NAGD (CA 2009) (Section 7.3.3.1)	BMT	~<5 yearly prior to dredging	SAPIR and DEIA reports	Contaminants above relevant guidelines	Assess requirement for re-sampling for new contamination	BMT	As required, prior to dredging occurring	Summarised in DEIA and SAPIR
		Reassess the requirement to reinstate water quality monitoring during dredging potential contaminant concentrations significantly exceed historical concentrations recorded in Boat Harbour sediments	BMT	One off during relevant maintenance dredging campaign as indicated from sediment sampling (Section 7.3.3.1)	SAPIR and laboratory results	Median analyte concentration over a defined area above the ANZG (2018) marine water quality guidelines or 80 th percentile of reference site data	Increase dredge slurry dilution, change location of dredge area Re-sample as soon as practicable to confirm effectiveness If issue persists, stop dredging and consult with DBCA	Contractor BMT	As required	Summarised in weekly reports and close out reports

Factor	Potential	Monitoring				Management	Management											
	Hydrocarbon spills and waste into the environment	Inspect and maintain equipment	Contractor	Throughout the campaign	Requirement communicated to Contractor prior to campaign commencement	Evidence of hydrocarbon leaks on dredge, dredge equipment, or within the dredge and disposal area	Manage the spill/waste following the work instructions and using the items in the spill kit if practicable	Contractor Contractor Contractor BMT/DoT	As required	Summarised in the relevant weekly progress report(s)								
		Visually inspect work area for spills and waste/rubbish					Review equipment/work method to ensure no further spills											
		Follow/maintain approved refuelling procedures					Immediately notify BMT and if significant spill, notify the DoT Maritime Environmental Emergency Response Unit (24 hour reporting number: [08] 9480 9924)											
		Appropriately store all fuels, oils and lubricants on site					Determine if additional environmental sampling or notification to DBCA is required											
		Keep and maintain a spill kit on site with all necessary materials for mitigation of accidental spillage of hydrocarbons																
		Monitor public complaints																
		Ensure work site is clear of rubbish following campaign completion																
	Introduced marine species	Contractor	Prior to dredging	Department of Primary Industries and Regional Development risk assessment tool reports	Origin of vessel and dredge related equipment (i.e. pipeline) communicated to Contractor prior to the campaign commencement	Outcome of the origin of the vessel and dredge related equipment	Outcome of risk assessment does not comply with a low risk rating	Complete actions to manage vessels and equipment to a low risk rating and complete risk assessment again to check effectiveness	Contractor	As required	Department of Primary Industries and Regional Development risk assessment tool reports							

Factor	Potential	Monitoring				Management	Management			
		Contractor will use designated access routes			campaigns commencement and in this LTMMMP		removal			
Marine fauna	Marine fauna collision	MFO on board dredge vessel during dredging (can be one of the dredge crew)	Contractor	While dredging is occurring	Marine fauna observation and/or interaction log (maintained to species level, where possible; Appendix F)	Marine fauna observed within 300 m from dredge while operating	<p>Suspend dredging until either 20 minutes after the last marine fauna is observed in the monitoring zone (within 300 m from the dredge), or the dredge vessel has moved to another position where a minimum distance of 300 m between the dredge vessel and any marina fauna can be maintained</p> <p>Complete marine fauna observation log (Appendix F) and provide to BMT</p> <p>If observed marine fauna are injured or dead, DBCA and DAWE are to be notified immediately and dredging is only to resume following approval from DBCA and DAWE</p>	Contractor Contractor BMT	As required	Reported in marine fauna observation and/or interaction logs and summarised in weekly progress reports
						Marine fauna collision incident with dredge vessel while operating	<p>Suspend dredging until either 20 minutes after the last marine fauna is observed in the monitoring zone (within 300 m from the dredge), or the dredge vessel has moved to another position where a minimum distance of 300 m between the dredge vessel and any marina fauna can be maintained</p> <p>Complete marine fauna interaction log (Appendix F) and provide to BMT</p> <p>If marine fauna from the collision incident are injured or dead, DBCA and DAWE are to be notified</p>	Contractor Contractor BMT		

Factor	Potential	Monitoring				Management	Management			
							immediately and dredging is only to resume following approval from DBCA and DAWE			
Social surroundings	Public safety (including navigational safety)	Monitor public complaints	Contractor	Throughout the campaign	Requirement communicated to Contractor prior to campaign commencement Any public or navigational safety incidents or complaints received to be noted in the relevant weekly progress report(s)	Public or navigational safety incident Public complaint regarding public or navigation safety	Cease works if required to prevent further incidents until safety risk is resolved	Contractor Contractor BMT	As required	Incident report to DoT and other relevant regulators, as required
		Dredge/vessel master to maintain visual contact with approaching vessels and Boat Harbour access					Inform BMT immediately and if applicable, implement management actions as per the Safety Management Plan			
		Monitor VHF channel 16 and respond to any incidents involving dredging equipment					Complete incident report and investigation			
		Correct lighting always displayed on dredge vessel and pipeline								
		Conformance to Safety Management Plan outlined in Project Execution Plan								
		TNTM	Contractor/BMT	Prior to dredging	TNTM					
	Social impact of noise	Monitor public complaints	Contractor	Throughout the campaign	Requirement communicated to Contractor prior to campaign commencement Any malfunctioning equipment or complaints received to be noted in the relevant weekly progress report(s)	Significant number of valid complaints received in relation to noise	Implement noise control measures (i.e. noise monitoring, minimise hours of construction)	Contractor	As required	Summarised in the relevant weekly progress report(s)
		Equipment and silencers are in working order to maintain noise levels								
		Operate between 0700 and 1800 Monday to Saturday unless otherwise directed in accordance with Australian Standards 1269 and 2436, Environmental Protection (Noise) Regulations 1997 (DEP 1997), and any additional requirements of the local government authority and relevant regulatory authorities								

Notes:

- 'BCH' = benthic communities and habitats; 'BMT' = BMT Commercial Australia Pty Ltd; 'Contractor' = Contractor Dredging; 'DAWE' = Department of Agriculture, Water and the Environment; 'DBCA' = Department of Biodiversity, Conservation and Attractions; 'DEIA' = Dredging Environmental Impact Assessment; 'DEMP' = Dredging Environmental Management Plan; 'DoT' = Department of Transport; 'EMF' = Environmental Management Framework; 'GPS' = global positioning system; 'JBMP' = Jurien Bay Marine Park; 'm' = metre; 'MFO' = Marine Fauna Observer; 'NAGD' = National Assessment Guidelines for Dredging; 'NVCP' = Native Vegetation Clearing Permit; 'SAPIR' = Sampling and Analysis Plan Implementation Report; 'TNTM' = Temporary Notice to Mariners; 'VHF' = very high frequency; ; 'ZoI' = Zone of Influence; 'ZoMI' = Zone of Moderate Impact; 'ZoHI' = Zone of High Impact.
- The term 'immediately' should be treated as within 24 hours.

7.3 Monitoring methods

7.3.1 Direct loss or burial of subtidal benthic habitats outside of defined dredge area

An independent global positioning system (GPS) logger will be mounted on the dredge to monitor the position of the dredge. Positional data from the GPS logger will be sent to BMT in real time and reviewed weekly to ensure the dredge does not operate outside of the defined dredge area. The Contractor will position the disposal pipeline end no closer than 20 m from the offshore disposal area boundary and record its position at each re-location. The Contractor will include the recorded positions on daily reports that will be submitted to BMT and reviewed weekly to ensure no disposal occurs outside of the approved area. Following dredging and disposal, a hydrographic survey will be completed to assess if dredging depths were achieved and provide a broad-scale spatial representation of potential nearshore seabed elevations within the disposal area. Results will be discussed in the campaign closeout report (Section 7.4).

7.3.2 Indirect impacts to benthic communities and habitats

7.3.2.1 *Plume sketches, remote imagery, site photographs and drone aerial photography*

The Contractor will complete a sketch of the extent of visible turbid plumes at the dredging and disposal areas on every working day (nominally Monday to Saturday) during maintenance dredging campaigns. Any aesthetic water quality observations of significant changes to biological or ecological indicators (e.g. localised fish kills, significant localised algal blooms and/or presence of rubbish, foams or oils on water surface) beyond natural variation will also be recorded (via the provided aesthetics water quality observations checklist on the plume sketch). Plume sketches will be completed daily between 1100 and 1300 when sun glint on the water surface is minimal. Plume sketches will be completed on a pre-designed template (Appendix G). All fields in the plume sketch template are to be completed (including the aesthetics water quality observation checklist). The Contractor will provide all completed plume sketches to BMT weekly during maintenance dredging campaigns for review.

Two remote imagery units (RIUs) will be installed by BMT to monitor turbidity and water quality aesthetics during maintenance dredging campaigns. One RIU will be installed with a view of the Boat Harbour and the second RIU will be installed on the dredge vessel. Each RIU will remotely capture time and date stamped images to a resolution of up to 12 megapixels at half-hourly intervals during daylight hours. One low-resolution image from each RIU will be automatically sent to BMT daily and reviewed weekly. High-resolution images from each RIU will be downloaded after campaign completion and compiled to form time-lapse videos.

The Contractor will take daily site photographs of the disposal area on every working day (nominally Monday to Saturday) during maintenance dredging campaigns. If a RIU malfunctions, the Contractor will also be required to take daily photographs at the relevant site. The photographs will be taken at a time (nominally between 1100 and 1300) and in a direction to minimise sun glint from the water surface. A digital camera with resolution ≥ 12 megapixels will be used to take the photographs. Wherever possible, the same camera will be used for the duration of the campaign to ensure all photographs are of the same quality. The camera should be configured such that the date and time of the photographs will be automatically stamped on the image. The Contractor will provide all site photographs to BMT weekly during maintenance dredging campaigns for review.

BMT will coordinate the capture of drone aerial photography monthly during maintenance dredging campaigns. The capture of drone aerial photography will record a large-scale visual record of the works and spatial extent of any visible turbid plumes during dredging and disposal. Drone aerial photography will ideally be orthorectified and should cover the entire extent of any visual plume from dredging and disposal. BMT will review the drone aerial photography as soon as practicable during maintenance campaigns.

The plume sketches, remote imagery, site photographs and drone aerial photography will be used to assess the likelihood of potential turbidity related environmental impacts occurring from maintenance dredging campaigns and to ensure any aesthetic water quality observations of significant changes to biological or ecological indicators beyond natural variation are documented and/or captured. Observations from the plume sketches, remote imagery, site photographs and drone aerial photography will be discussed in the close-out report (Section 7.4).

7.3.2.2 Sub-sea light logging

Sub-sea light loggers will be deployed at three impact sites located on the outer boundaries of the ZoHI and ZoMI (in high risk areas, as determined by modelling), at two reference sites located outside of the ZoI (Table 7.4; Figure 7.1) and at one onshore site (location to be determined) before, during and after offshore disposal. Loggers will be deployed for a ~six-week period prior to being retrieved, downloaded and re-deployed throughout the campaign duration. A TNTM will be obtained and DCBA approval for subsea logger locations. Loggers will record light data at ~15 minute intervals during daylight hours.

Data from the light loggers will be processed per the EPA (2005) standard operating procedures. Data will be analysed following each download to assess compliance with the management trigger (Table 7.3) and will verify the predictive numerical plume extent modelling used to establish the impact zones (refer to Section 6.2.3.1). Since the thresholds that were used to define modelled boundaries of potential impact zones are based on CMSC (2018) EQG for LAC in Cockburn Sound (refer to Section 6.2.1.2), the management trigger also factors assessment of LAC established at reference sites (Figure 7.1) should application of CMSC (2018) EQG for LAC in Cockburn Sound vary spatially to the environment at Jurien Bay. Results will be reported in the weekly environmental checklists (template in Appendix H) and campaign closeout report (Table 7.3).

Given there were no exceedances of the management trigger during the 2020/21 campaign, a stepped approach will be applied for future campaigns (Table 7.3), whereby if an exceedance is detected after ~six weeks of monitoring, the loggers will be serviced and data downloaded ~four weeks later. If an exceedance continues, then dredging and disposal will temporarily cease pending approval to continue following consultation with DBCA.

If exceedances of management triggers are reported (Table 7.3), an additional investigation into the accuracy of modelled predictions for plume dispersion will be completed and summarised in the campaign closeout report. If it is identified the modelled predictions for plume dispersion are not accurate, the model will be updated for improvement prior to the next maintenance dredging campaign and any dependent environmental management measures will be revised accordingly.

Table 7.4 Jurien Bay light logger monitoring site coordinates

Site	UTM 50s, GDA94		Depth (m)
	Easting	Northing	
JB_ZoMI	310 964	6 648 970	7.2
JB2_ZoHI	310 983	6 648 819	6.3
JB_R1	309 577	6 646 147	6.3
JB_R2	309 497	6 645 629	7.5
JB1_ZoHI	311 233	6 648 088	6.2

Notes:

1. 'ZoI' = Zone of Influence, 'ZoMI' = Zone of Moderate Impact, 'ZoHI' = Zone of High Impact.

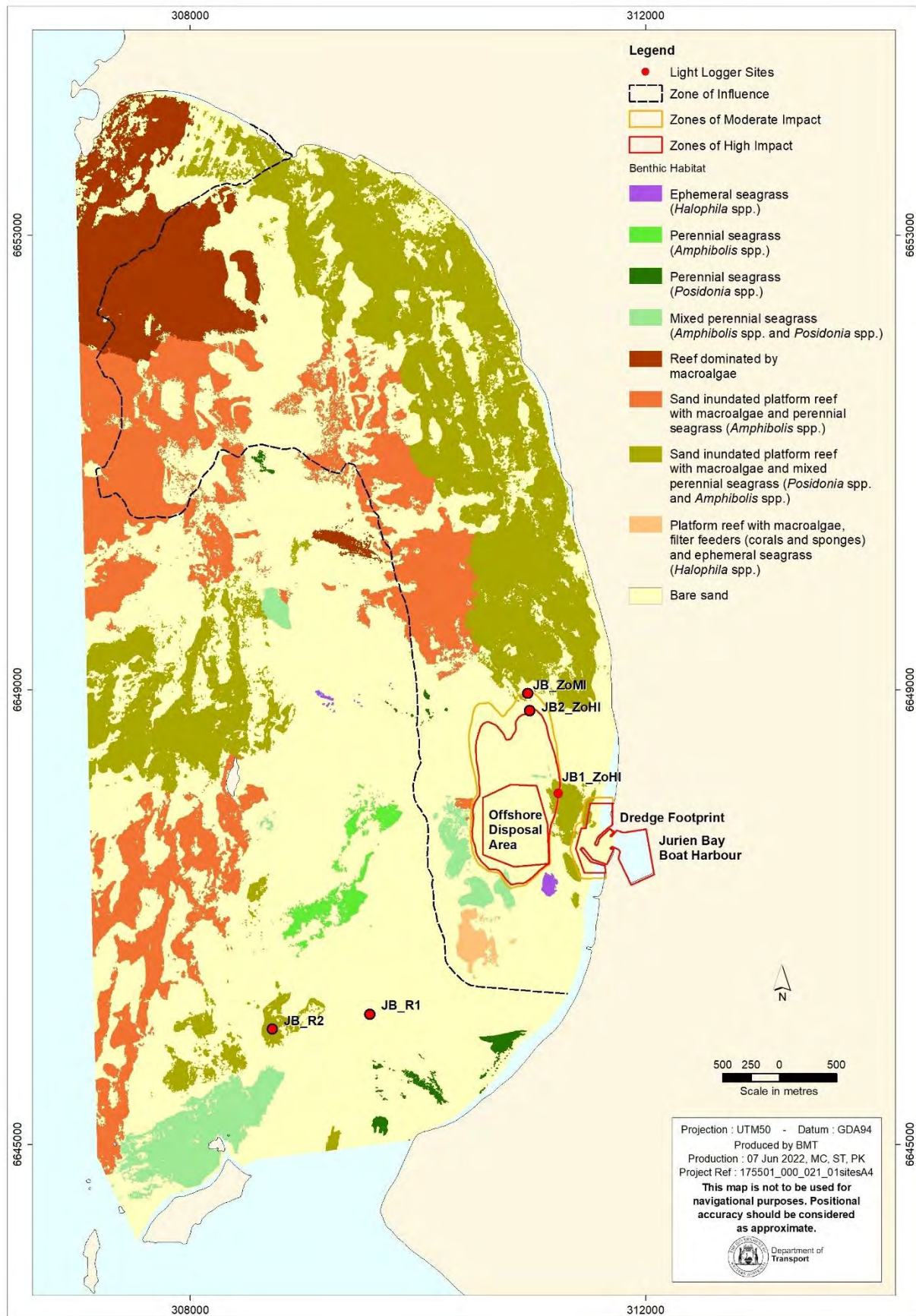


Figure 7.1 Jurien Bay light logger monitoring sites during maintenance dredging campaigns

7.3.3 Release of nutrients or contaminants

7.3.3.1 Screening of dredge/disposal area sediments

In accordance with NAGD (CA 2009) and EMF (BMT 2021), sampling and analysis of sediments from the proposed Boat Harbour dredge areas and offshore disposal area will be completed every five years throughout the life of this LTMMP (Section 4.1). This is required to ensure appropriate monitoring and management continues to be implemented during maintenance dredging campaigns based on good quality and current sediment quality data (CA 2009). As outlined in Section 4, sediment sampling and analysis will be completed following the procedures detailed in the approved SAP (Appendix B; BMT 2019a). If routine sediment sampling and analysis identifies an increased risk of release of nutrients or contaminants above relevant guidelines and significantly higher than the historical range recorded in Boat Harbour sediments (Section 6.3.2), the requirement for during dredging water quality monitoring will reassessed for subsequent campaigns (Section 7.3.3.2).

7.3.3.2 During dredging water quality sampling

If indicated during screening of dredge/disposal area sediments (Section 7.3.3.1), water quality monitoring for analytes of potential concern (as identified from sediment sampling and analysis) will be completed (Table 7.2). Water sampling will be undertaken at the edge of the Offshore Disposal Area (according to the plume trajectory) and at three reference sites (Table 7.2). Water quality monitoring will be undertaken once off during dredging of the Boat Harbour sediments as determined during initial screening of dredge/disposal area sediments (Section 7.3.3.1). The requirement for additional water quality sampling will be assessed if exceedances are observed following receipt of the results from the initial monitoring. The selected sample analytes will be based results where exceedances of sediment guidelines are observed in the initial screening (Section 7.3.3.1).

To accurately target the disposal area plume, a drogue shall be released at the discharge point prior to sampling. Movement of the drogue shall be tracked for ~20 minutes and based on the location of the drogue at this time, a plume trajectory⁷ will be calculated. A single depth integrated water sample will be obtained at the point where the plume trajectory meets the edge of the disposal area boundary. Depth integrated water samples will also be collected from three reference sites (one sample per site) located ~1 km up-current of the disposal area and beyond the influence of the plume to ascertain the background water quality for comparison (Table 7.2). The water samples against the management triggers (Table 7.2; as described in Section 7.2).

The data from each sampling event will be analysed as soon as practicable upon receipt⁸. If any of the results exceed the management triggers (Section 7.2), DBCA will be notified⁹ and the disposal area plume will be re-sampled for the exceeded analyte as soon as practicable. Investigations to the possible cause-effect pathways for the exceedance will be conducted to ascertain if dredging operations are the cause of the exceedance. If the exceedance continues and is attributable to dredging operations, DBCA will be notified and the agreed mitigation measures (this may include reducing dredging output and/or modification of dredge/disposal methods) to reduce the impact on water quality will be implemented. A survey will be conducted as soon as practicable once mitigation measures are implemented to ascertain if the exceedance remains.

7.4 Reporting and auditing

The dredging contractor (Contractor) will provide all monitoring data weekly to BMT. BMT will then prepare a weekly environmental monitoring report, outlining monitoring completed and

⁷ The plume trajectory will be a straight line between the disposal site and drogue location after ~20 minutes.

⁸ Due to various turnaround time for the analytes measured (e.g. water chemical analysis may take ~ 5–10 working days), data will be analysed as soon as practicable with the aim to analyse data within 48 hours upon receipt of all required data.

⁹ All required DBCA notifications will be carried out within 24 hours of the detection of an exceedance or determination of significant change.

conformance with the LTMMMP (Appendix H). Any exceedances of a management trigger will be reported as per Table 7.3.

The LTMMMP (this document) will be publicly available on DoT's website for the duration of maintenance dredging campaigns. The DoT website will also indicate that environmental monitoring results can be made available on request. BMT will compile any public complaints into a complaint register. BMT will report any significant environmental incidents to DBCA, DAWE and DoT within 48 hours.

BMT will also compile, analyse and interpret all environmental monitoring data in the close-out report on completion of maintenance dredging campaigns. The close-out report will include an audit of project performance against this LTMMMP.

This LTMMMP will also be reviewed and updated to reflect best practise in environmental management and monitoring prior to each dredge campaign, per Section 1.1.1.

8 Stakeholder Consultation

8.1 Jurien Bay maritime advisory group

Given that maintenance dredging campaigns proposed under this LTMMMP are small scale and minor in nature, it is not considered necessary that a technical advisory and consultative committee (TACC) be established specific to maintenance dredging activities. DoT maintains a MAG for Jurien Bay, which currently meet ~annually or as required. In the context of the requirements of the LTMMMP, the MAG is considered to fulfil the requirements of a TACC. The MAG purpose is to:

- provide and maintain strong local community/stakeholder input into management decisions affecting maritime facilities and activities in the State.
- assist in the formulation of planning and development strategies, standards and guidelines for the Boat Harbour, including the review of options for the development of new facilities and leases.
- address safety and environmental issues involving the harbour and adjacent waters, including the designation and management of special use areas.
- raise and discuss any coastal management or other issues (including environmental incidents) that may be of concern in the area, to enable these issues to be communicated to appropriate persons within DoT.

The MAG membership consists of 6–12 members who have an interest in the Boat Harbour. The membership reflects a fair representation of all user groups of the Boat Harbour. Typical membership may include members from:

- Local Government/relevant State Government Agencies
- Industry/User Groups, such as the professional fishing industry, charter boat industry, service vessels etc
- Regional Development Organisations
- Recreational/Stakeholder/Community User groups
- Local business/Chamber of Commerce
- Leaseholders
- DoT (Regional Services Manager/Facility Manager)
- DoT (Coastal Facilities representative)

The quorum for all MAGs shall be half of the members of the MAG. For resolutions of a meeting to be valid, the number of members necessary to form the quorum must be present throughout the meeting. Meeting minutes are retained by the DoT representative, and disseminated to DoT managers for action, as required, including the state-wide maintenance dredging programme team.

8.2 Stakeholder consultation completed to date

Stakeholder consultation, encompassing relevant decision-making authorities, interested parties and the Jurien Bay local community was completed over a two-week consultation period. Ongoing consultation throughout the permit duration will be completed via the MAG (Section 8.1) and with relevant decision-making authorities, as required. A summary of consultation completed to date is provided in Table 8.1. Details of consultation (including responses to queries, media releases and email correspondence) is provided in Appendix I.

Table 8.1 Stakeholder consultation completed in relation to the Jurien Bay Boat Harbour maintenance dredging campaigns and proposed offshore disposal

Date	Stakeholder type	Description of consultation
2014-ongoing	Department of Biodiversity, Conservations and Attractions	<p>Ongoing liaison and consultation with Jurien Bay Marine Park (JBMP) managers on the maintenance of Jurien Bay Boat Harbour (JBBH) and protection of JBMP values throughout maintenance dredging campaigns.</p> <p>Department of Transport (DoT) currently holds an existing licence (2971/101) to "undertake dredging of marine sediment and disposal of marine wrack and sediment in JBMP".</p> <p>This Long Term Monitoring and Management Plan (LTMMMP) is the supporting document for a Regulation 4 Lawful Authority application to dispose dredged material into the proposed offshore disposal area within the JBMP.</p>
2018-ongoing	Department of Agriculture, Water and the Environment (DAWE)	<p>This LTMMMP forms the supporting document for an application for a Sea Dumping Permit to dispose dredged material into the JBMP. Consultation with DAWE specific to this Project commenced in 2018, and endorsement of the Sampling and Analysis Plan (Appendix B) was received on 1 April 2019.</p>
27/03/2019-ongoing	Department of Planning, Lands and Heritage (DPLH), South West Land and Sea Council (SWALSC) and Yued Group	<p>. DoT has entered into a Noongar Standard Heritage Agreement with SWALSC as the representative Body corporate for the Yued Group. Potential impacts Aboriginal heritage or native title associated with the proposed maintenance campaigns will be managed under this agreement (refer to Section 3.4).</p>
02/08/2019	Department of Water and Environmental Regulation (DWER) – Environmental Protection Authority Services Division	<p>DoT informed DWER of the proposed maintenance dredging campaigns and upcoming stakeholder consultation process via email (attached Appendix I.). Feedback was invited from DWER, however; to date, (26 March 2020) no reply has been received.</p> <p>DWER mid-west office were also contacted as part of the community consultation, however; declined to provide feedback on the proposed dredging and disposal.</p>
21/08/2019	Jurien Bay residents JBBH pen holders, lease holders and JBBH Maritime Advisory Group (MAG)	<p>An article was published into the local Jurien Bay paper 'Craytales' (Appendix I) for circulation to the local community on 21 August 2019. Public comment was invited until 4 September 2019, through DoT's website.</p> <p>A targeted email obtaining the same information was circulated to the JBBH MAG, pen holders and lease holders (Appendix I).</p> <p>A total of six comments were received during the stakeholder consultation process, which are provided with DoT's response in Appendix I.</p>

In addition, a number of key stakeholders and government departments relevant to maintenance dredging at Boat Harbour already work in close unison to determine:

- the requirement for dredging
- the proposed volumes, disposal areas and timing of the maintenance campaigns
- dredge management in accordance with DoT's EMF (BMT 2021) and any other licence or permit issued.

A description of each of these key stakeholders and their role in decision-making for Boat Harbour maintenance dredging campaigns is provided in Table 8.2. This framework allows for informed

decision-making on the requirement for dredging, and the management required to reduce potential environmental impacts to as low as reasonably practicable.

Table 8.2 Key stakeholders involved in decision making for maintenance dredging at Jurien Bay Boat Harbour

Name/Department	Description	Role
DoT Navigational Safety	<p>The Navigational Safety branch of DoT is responsible for ensuring that waterways managed by DoT are maintained to ensure navigable safety. This includes:</p> <ul style="list-style-type: none"> regular hydrographic surveys of waterways to ensure charted depths are maintained maintenance of navigational aids management of public complaints in regard to navigational safety if required, instigation of maintenance dredging of waterways and boat harbours 	<p>The Navigational Safety branch will be informed should a navigational safety issue exist at the Boat Harbour that needs management or remediation.</p>
DoT MBU	<p>The MBU branch of DoT is responsible for the day-to-day management of DoT's marine facilities and infrastructure. This includes:</p> <ul style="list-style-type: none"> liaison with key stakeholders and facility users management and implementation of the state-wide maintenance dredging program reviews of hydrographic survey data to ensure designs depths are maintained management of public complaints in relation to DoT facilities 	<p>MBU are responsible for completing maintenance dredging of DoT assets to maintain navigable depths. This includes developing and implementing environmental impact assessment and management plans, stakeholder consultation and dredge contractor management.</p> <p>MBU will determine the requirement for dredging at Jurien Bay Boat Harbour, the timing of works and implementation of specific management, in accordance with its state-wide maintenance dredging program</p>
DBCA Jurien Bay	<p>The Jurien Bay DBCA is the managing authority for the JBMP</p>	<p>As managing authority for the disposal site, DBCA will be consulted prior to any works, and a lawful authority issued to DoT under the CALM Act</p>

Notes:

- 'DoT' = Western Australian Department of Transport; 'MBU' = Maritime Business Unit, 'DBCA' = Department of Biodiversity, Conservation and Attractions, JBMP = Jurien Bay Marine Park.

9 References

- ANZECC, ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1: The Guidelines. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australian Capital Territory, 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. Available from www.waterquality.gov.au/anz-guidelines [Accessed 26 July 2019]
- Archae-aus (2021) Report on an Aboriginal Archaeological and Ethnographic Heritage Survey for the Jurien Bay Boat Harbour Maintenance Dredging and Entrance Reconfiguration Work, Jurien Bay, Western Australia. Prepared for BMT by Archae-aus Pty Ltd, North Fremantle, May 2021
- Bannister JL, Kemper CM, Warnecke RM (1996) The Action Plan for Australian Cetaceans. Australian Nature Conservation Agency, Canberra, Australian Capital Territory
- Bellchambers L, Mantel P, Chandrapavan A, Pember M, Evans S (2012) Western Rock Lobster Ecology – The State of Knowledge Marine Stewardship Council Principle 2: Maintenance of Ecosystem. Fisheries Research Report No. 236. Government of Western Australia Department of Fisheries, Perth, Western Australia, July 2012
- BMT (2018a) 2018 Jurien Bay Boat Harbour Wrack Biomass Study. Prepared for Department of Transport by BMT Western Australia Pty Ltd, Report No. 1470_006/1_Rev0, Perth, Western Australia, October 2018
- BMT (2018b) Jurien Bay Benthic Habitat Mapping. Prepared for Department of Transport by BMT, Report No. 444_07_001/1_Rev1, Perth, Western Australia, March 2018
- BMT (2019a) Jurien Bay Boat Harbour – Long-term Maintenance Dredging Sediment Sampling and Analysis Plan. Prepared for Department of Transport by BMT, Report No. R-1454_01-1/Rev1, Perth, Western Australia, March 2019
- BMT (2019b) Jurien Bay Boat Harbour – Long-term Maintenance Dredging Sediment Sampling and Analysis Plan Implementation Report. Prepared for Department of Transport by BMT, Report No. R-1454_01-2Rev/0, Perth, Western Australia, July 2019
- BMT (2021) Department of Transport Maintenance Dredging – Environmental Management Framework. Prepared for Department of Transport by BMT Commercial Australia Pty Ltd, Report No. R-1755_00-01, Perth, Western Australia, November 2021
- BMT (2021a) 2020/21 Jurien Bay Boat Harbour Maintenance Dredging – Environmental Closeout Report. Prepared for department of Transport by BMT Commercial Australia Pty Ltd, Report No. R-1755_00-10, Perth, Western Australia, June 2021
- BMT JFA (2015) Jurien Bay Boat Harbour Maintenance Dredging 2014/15 Closeout Report. Prepared for Department of Transport by BMT JFA Consultants Pty Ltd. Report No. R-300.08-14-1, Perth, Western Australia, January 2015
- BMT JFA (2017) Jurien Bay Boat Harbour Maintenance Dredging 2016 Closeout Report. Prepared for Department of Transport by BMT JFA Consultants Pty Ltd. Report No. R-J16001.09-1, Perth, Western Australia, November 2017

- BMT Oceanica (2013) Jurien Bay Boat Harbour Emergency Wrack Removal – Environmental Impact Assessment. Prepared for the Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd. Report No 444_02_001/1_Rev0, Perth, Western Australia, November 2013
- BMT Oceanica (2014a) Jurien Bay Sediment Dredging and Wrack Trawling – Environmental Impact Assessment. Prepared for the Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd. Report No 444_03_002/2_Rev0, Perth, Western Australia, May 2014
- BMT Oceanica (2014b) Jurien Bay Boat Harbour Dredging Environmental Impact Assessment. Prepared for the Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd. Report No 444_03_001/2_Rev1, Perth, Western Australia, December 2014
- BMT Oceanica (2014c) Jurien Emergency Wrack Trawling Environmental Monitoring Summary Memorandum. Prepared for the Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd. Perth, Western Australia, January 2014
- BMT Oceanica (2014d) Jurien Bay Boat Harbour Wrack Trawling Environmental Monitoring Close-out Memorandum. Prepared for the Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd. Perth, Western Australia, September 2014
- BMT Oceanica (2014e) Jurien Bay Boat Harbour Sand Excavation Environmental Monitoring Close-out Memorandum. Prepared for the Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd. Perth, Western Australia, November 2014
- BMT Oceanica (2017) Jurien Bay Long Term Disposal Options Approvals Pathways, Memorandum prepared for BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd, May 2017
- BMT Oceanica and BMT JFA (2014) Jurien Bay Maintenance Boat Harbour – Maintenance Dredging Sediment Sampling and Analysis Plan. Prepared for the Department of Transport, by BMT Oceanica Pty Ltd and BMT JFA Consultants Pty Ltd, Perth, Western Australia, August 2014
- BoM (2019) Climate Statistics for Australian Locations. Bureau of Meteorology, Canberra, Australian Capital Territory. Available at http://www.bom.gov.au/climate/averages/tables/cw_009131.shtml [Accessed 19 February 2019]
- CA (2009) National Assessment Guidelines for Dredging. Commonwealth of Australia, Canberra, Australian Capital Territory
- CA (2015) Conservation Management Plan for the Blue Whale (2015–2025): A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth of Australia, Canberra, Australian Capital Territory
- Cabaco S, Santos R, Duarte CM (2008) The impact of sediment burial and erosion on seagrasses: A review. *Estuarine, Coastal and Shelf Science* 79: 354–366 April 2008.
- CALM (2000) Shrubland And Woodlands On Muchea Limestone Interim Recovery Plan 2000–2003 No. 57. Perth, WA. Department of Conservation and Land Management. Retrieved from: <https://www.awe.gov.au/sites/default/files/documents/muchea-limestone-woodlands.pdf>

- CALM (2004). Red Snakebush (*Hemiandra gardneri*) Interim Recovery Plan 2004–2009. Available on the Department of Parks and Wildlife Retrieved from: <http://www.dpaw.wa.gov.au/plants-and-animals/threatenedspecies-and-communities/198-approved-interim-recovery-plans>.
- CALM (2004) Turquoise Coast Island Nature Reserves Management Plan. Management Plan No. 50. Prepared for the Conservation Commission of Western Australia. Department of Conservation and Land Management, Government of Western Australia, Perth, Western Australia
- CALM (2005) Jurien Bay Marine Park Management Plan 2005–2015. Management Plan Number 49. Department of Conservation and Land Management, Government of Western Australia, Perth, Western Australia
- Campbell, R (2005) Historical distribution and abundance of the Australian sea lion (*Neophoca cinerea*) on the west coast of Western Australia. Fisheries Research Report No. 148. Department of Fisheries, Government of Western Australia, Perth, Western Australia, March 2005
- CENR (2000) Integrated assessment of hypoxia in the Northern Gulf of Mexico. National Science and Technology Council, Committee on Environment and Natural Resources, Washington DC, USA
- Chabanne D, Finn H, Salgado-Kent C, Bejder L (2012) Identification of a resident community of bottlenose dolphins (*Tursiops truncatus*) in the Swan Canning Riverpark, Western Australia, using behavioural information. *Pacific Conservation Biology* 18:247–262
- Chittleborough RG (1975) Environmental factors affecting growth and survival of juvenile western rock lobsters *Panulirus longipes** (Milne-Edwards). *Australian Journal of Marine and Freshwater Research* 26:177–196
- Collier CJ, Lavery PS, Masini R., Ralph PJ (2007) Morphological, growth and meadow characteristics of the seagrass *Posidonia sinuosa* along a depth-related gradient of light availability. *Marine Ecological Progress Series*. 337:103–115
- Collier CJ, Lavery PS, Ralph PJ, Masini RJ (2008) Physiological characteristics of the seagrass *Posidonia sinuosa* along a depth-related gradient of light availability. *Marine Ecology Progress Series* 353:65–79
- Collier CJ, Lavery PS, Ralph PJ, Masini RJ (2009) Shade-induced response and recovery of the seagrass *Posidonia sinuosa*. *Journal of Experimental Marine Biology and Ecology* 370:89–103
- Collier CJ, Waycott M, McKenzie LJ (2012) Light thresholds derived from seagrass loss in the coastal zone of the northern Great Barrier Reef, Australia. *Ecological Indicators* 23:211–219
- Collier JC, Waycott M, Giraldo Ospina A (2012) Responses of four Indo-West Pacific seagrass species to shading. *Marine Pollution Bulletin* 65:342–35
- Coupland, G. (1997) Rhizome and shoot structure, growth and response to sediment burial in *Amphibolis griffithii* (Black) den Hartog. Department of Botany. University of Western Australia
- CSMC (2018) 2017-2018 Updated Coburn Sound Environmental Quality Criteria. Prepared by the Cockburn Sound Management Council. Available at https://www.der.wa.gov.au/images/documents/about/Cockburn_Sound_Management_Council/2017-2018_Updated_EQC.pdf [Accessed 2 July 2019]

- DAWE (2022) Protected Matters Search Tool. Australian Government Department of the Environment, Canberra, Australian Capital Territory. Available from <<http://www.environment.gov.au/epbc/protected-matters-search-tool>> [Accessed 25 April 2022]
- DBCA (2018) Wildlife Conservation Plan for Migratory Shorebirds Commonwealth of Australia 2015: Adopted as an Interim Recovery Plan for the Threatened Migratory Shorebirds visiting Western Australia. Wildlife Management Program No. 65. Western Australia Department of Biodiversity, Conservation and Attractions, Perth, Western Australia, December 2018
- DEC (2012). Chuditch (*Dasyurus geoffroyi*) National Recovery Plan – Wildlife Management Program No. 54. Perth, WA: DEC. Retrieved from: <http://www.environment.gov.au/cgi-bin/sprat/public/publicshowallrps.pl>
- DEC (2013) Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes: Acid Sulfate Soils Guideline Series. Department of Environment and Conservation, Perth, Western Australia, March 2013
- DEC (2006). Slender Andersonia (*Andersonia gracilis*) Interim Recovery Plan 2006-2011. Interim Recovery Plan No. 228. Department of Environment and Conservation, Western Australia.
- DEP (1997) Environmental Protection (Noise) Regulations 1997. Department of Environmental Protection, October 1997
- DEWHA (2007) The South-west Marine Bioregional Plan – Bioregional Profile. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra, Australian Capital Territory
- DoE (2005) Background Concentrations of Selected Toxicants in the Coastal Waters of the Jurien Bay Marine Park. Department of Environment, Report No. 119, Perth, Western Australia, March 2005
- DoEE (2019a) Protected Matters Search Tool. Australian Government Department of the Environment and Energy, Canberra, Australian Capital Territory. Available at <<https://www.environment.gov.au/epbc/protected-matters-search-tool>> [Accessed 14 June 2019]
- DoEE (2019b) *Megaptera novaeangliae* in Species Profile and Threats Database. Australian Government Department of the Environment and Energy, Canberra, Australian Capital Territory. Available at <http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=38> [Accessed 14 June 2019]
- DoF (2011a) Fisheries Fact Sheet – Western Rock Lobster. Government of Western Australia Department of Fisheries, Perth, Western Australia. Available at <http://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_western_rock_lobster.pdf> [Accessed 20 June 2019]
- DoF (2011b) Fisheries Fact Sheet – Blue Swimmer Crab. Government of Western Australia Department of Fisheries, Perth, Western Australia. Available at <https://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_blue_swimmer.pdf> [Accessed 20 June 2019]
- DoF (2011c) Fisheries Fact Sheet – West Australian Dhufish. Government of Western Australia Department of Fisheries, Perth, Western Australia. Available at

<https://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_dhufish.pdf> [Accessed 20 June 2019]

DoF (2011d) Fisheries Fact Sheet – Baldchin Groper. Government of Western Australia Department of Fisheries, Perth, Western Australia. Available at <https://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_baldchin_groper.pdf> [Accessed 20 June 2019]

DoF (2011e) Fisheries Fact Sheet – Pink Snapper. Government of Western Australia Department of Fisheries, Perth, Western Australia. Available at <https://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_pink_snapper.pdf> [Accessed 20 June 2019]

DPIRD (2019a) Rock Lobster Commercial Fishing. Government of Western Australia Department of Primary Industries and Regional Development, Perth, Western Australia. Available at <<http://www.fish.wa.gov.au/Species/Rock-Lobster/Pages/default.aspx>> [Accessed 20 June 2019]

DPIRD (2019b) Blue Swimmer Crab Commercial Fishing. Government of Western Australia Department of Primary Industries and Regional Development, Perth, Western Australia. Available at < <https://www.fish.wa.gov.au/Species/Blue-Swimmer-Crabs/Pages/Blue-Swimmer-Crab-Commercial-Fishing.aspx>> [Accessed 20 June 2019]

DPIRD (2019c) West Coast Bioregion Government of Western Australia Department of Primary Industries and Regional Development, Perth, Western Australia. Available at <http://www.fish.wa.gov.au/fishing-and-aquaculture/recreational-fishing/recreational-fishing-rules/west-coast-bioregion/Pages/default.aspx> [accessed 19 August 2019]

DPLH (2021) Aboriginal Heritage Inquiry System–Register of Aboriginal Sites. Department of Aboriginal Affairs, Available at <<http://maps.dia.wa.gov.au/AHIS2/>> [Accessed 04 October 2021]

DSEWPaC (2011) National recovery plan for threatened albatrosses and giant petrels 2011–2016. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory. Available at <<https://www.environment.gov.au/system/files/resources/bb2cf120-0945-420e-bdfa-d370cf90085e/files/albatrosses-and-giant-petrels-recovery-plan.pdf>> [Accessed 26 July 2019]

DSEWPaC (2012a) Species Group Report Card – Cetaceans. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory. Available at <<http://www.environment.gov.au/system/files/pages/1670366b-988b-4201-94a1-1f29175a4d65/files/north-west-report-card-cetaceans.pdf>> [Accessed 14 June 2019]

DSEWPaC (2012b) Species Group Report Card – Reptiles. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory. Available at <<http://www.environment.gov.au/archive/coasts/mbp/temperate-east/publications/pubs/te-report-card-reptiles.pdf>> [Accessed 14 June 2019]

DSEWPaC (2012c) Species Group Report Card – Sharks. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory. Available at <<http://www.environment.gov.au/archive/coasts/mbp/south-west/publications/pubs/report-card-sharks.pdf>> [Accessed 14 June 2019]

- DSEWPaC (2012d) Conservation Management Plan for the Southern Right Whale (2011–2021): A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999*. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory. Available at <<https://www.environment.gov.au/system/files/resources/4b8c7f35-e132-401c-85be-6a34c61471dc/files/e-australis-2011-2021.pdf>> [Accessed 29 July 2019]
- Ecoscape (2005) Lancelin foreshore land-use and management plan. Prepared by Ecoscape (Australia) Pty Ltd for the Shire of Gingin, North Fremantle, WA, June 2005
- Eliot I, Gozzard JR, Eliot M, Stul T, McCormack G (2012) The Coast of the Shires of Gingin and Dandaragan, Western Australia: Geology, Geomorphology and Vulnerability. Prepared by Damara WA Pty Ltd and Geological Survey of Western Australia for the Department of Planning and Department of Transport, Perth, Western Australia, March 2012
- EPA (2016a) Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals, Environmental Protection Authority, Perth, December 2016
- EPA (2016b) Technical Guidance – Protection of Benthic Communities and Habitats, Environmental Protection Authority, Perth, December 2016
- EPA (2021a) Statement of Environmental Principles, Factors and Objectives, Perth, Western Australia, October 2021
- EPA (2021b) Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals, Environmental Protection Authority, Perth, September 2021
- Erftemeijer, P.L.A. and Lewis, R.R.R. (2006) Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin* 52, 1553–1572
- Finn H (2005) Conservation biology of bottlenose dolphins (*Tursiops* sp.) in Perth metropolitan waters. PhD Thesis, Murdoch University, Perth, Western Australia, September 2005
- Fletcher WJ, Santoro K (eds) (2012) Status Reports of the Fisheries and Aquatic Resources of Western Australia 2011/12: The State of the Fisheries. Government of Western Australia Department of Fisheries, Perth, Western Australia, October 2012
- Gallop SL, Verspecht F, Pattiaratchi CB (2012) Sea breezes drive currents on their inner continental shelf off southwest Western Australia. *Ocean Dynamics* 62:569–583
- Gersbach GH, Pattiaratchi CB, Ivey GN, Cresswell GR (1999) Upwelling on the south-west coast of Australia – source of the Capes Current? *Continental Shelf Research* 19:363–400
- Gray H 1992, The western rock lobster *Panulirus cygnus*. Book 1: a natural history, Westralian Books, Geraldton.
- GWA (2018) Government of Western Australia Heritage Council and State Heritage. Available at <http://inherit.stateheritage.wa.gov.au/Public/Search/Results?newSearch=True&placeNameContains=&streetNameContains=&suburbOrTownContains=jurien+bay&lgaContains=&isCurrentlyStateRegistered=false> [Accessed 24 May 2018]
- Hamer DJ, Ward TM, Shaughnessy PD, Clark SR (2011) Assessing the effectiveness of the Great Australian Bight Marine Park in protecting the endangered Australian sea lion *Neophoca cinerea* from bycatch mortality in shark gillnets. *Endangered Species Research* 14:203–216
- Hedley SL, Bannister JL, Dunlop RA (2011) Abundance estimates of Southern Hemisphere Breeding Stock ‘D’ Humpback Whales from aerial and land-based surveys off Shark Bay,

- Western Australia, 2008. Journal of Cetacean Research Management Special issue 3:209–221
- Jenner KCS, Jenner M-N, McCabe KA (2001) Geographical and temporal movements of humpback whales in Western Australian waters. APPEA Journal 2001:749–765
- Jernakoff P (1990) Distribution of newly settled western rock lobsters *Panulirus cygnus*. Marine Ecology Progress Series 66:63–74
- JFA (2006) Jurien Boat Harbour Maintenance Dredging 2005–2006 Contract Closeout Report. Prepared for the Department for Planning and Infrastructure, Government of Western Australia by JFA Consultants Pty Ltd, Perth, Western Australia, January 2006
- JFA (2012) 2011 Jurien Bay Boat Harbour Weed Trawling Trial – Closeout Report 201. Prepared for the Department of Transport by JFA Consultants Pty Ltd, Perth, Western Australia, January 2012
- Lavery PS, McMahon K, Mulligan M, Tennyson A (2009) Interactive effects of timing, intensity and duration of experimental shading on *Amphibolis griffithii*. Marine Ecology Progress Series 394:21–33
- Lemme AJ, Hegge BJ, Masselink G (1999) Offshore wave climate, Perth (Western Australia), 1994–96. Marine and Freshwater Review 50:95–102
- Lopez NA, Mcauley RB, Meeuwig JJ (2022) Identification of the southernmost aggregation of scalloped hammerhead sharks (*Sphyrna lewini*) in Australia. Austral Ecology 0: 1–6
- Lozano-Montes HM, Loneragan NR, Babcock RC, Jackson K (2011) Using trophic flows and ecosystem structure to model the effects of fishing in the Jurien Bay Marine Park, temperate Western Australia. Marine and Freshwater Research 62:421–431
- Mackey P, Collier CJ, Lavery PS (2007) Effects of experimental reduction of light availability on the seagrass *Amphibolis griffithii*. Marine Ecology Progress Series 342:117–126
- Markanger S, Sand-Jensen K (1994) The physiology and ecology of light–growth relationship in macroalgae. Progress in Phycological Research 10, 209–298.
- Masselink G, Pattiaratchi C (1998) The effect of sea breeze on beach morphology, surf zone hydrodynamics and sediment resuspension. Marine Geology 146:115–135
- McCauley RD, Jenner C (2010) Migratory patterns and estimated population size of pygmy blue whales (*Balaenoptera musculus brevicauda*) traversing the Western Australian coast based on passive acoustics. Unpublished Paper (SC/62/SH26) presented to the International Whaling Committee Scientific Committee, Morocco, June 2010.
- McCauley RD, Jenner C, Bannister JL, Burton CLK, Cato DH, Duncan A (2001) Blue whale calling in the Rottnest Trench – 2000, Western Australia Report R2001-6. Centre for Marine Science & Technology, Perth, Western Australia
- McMahon K, Lavery PS (2008) The responses of *Amphibolis griffithii* to reduced light availability. Final Report on the Strategic Research Fund for the Marine Environment (SRFME) Collaborative Research Project: Ecophysiology of benthic primary producers. Prepared for Strategic Research Fund for the Marine Environment (SRFME), Geraldton Port Authority by Centre for Marine Ecosystems Research Edith Cowan University, Report No. 2008-01, Joondalup, Western Australia

- McMahon K, Lavery PS, Mulligan M (2011) Recovery from the impact of light reduction on the seagrass *Amphibolis griffithii*, insights for dredging management. *Marine Pollution Bulletin* 62:270–283
- McMahon K, Collier C, Lavery PS (2013) Identifying robust bioindicators of light stress in seagrasses: A meta-analysis. *Ecological Indicators* 30:7–15
- National Research Council (2005) *Marine Mammal Populations and Ocean Noise: Determining when Noise causes Biologically Significant Effects*. National Academies Press, Washington, DC, USA
- Oceanica (2012) Jurien Bay Boat Harbour Removal of Trawled Wrack – Data Report. Prepared for Department of Transport by Oceanica Consulting Pty Ltd, Report No. 444_01_001/1, Perth, Western Australia, February 2012
- Oceanica & JFA (2005) Maintenance Dredging Jurien Boat Harbour Environmental Impact Assessment. Prepared for the Department for Planning & Infrastructure by Oceanica Consulting Pty Ltd and JFA Consultants Pty Ltd, Report No 444/01, Perth, Western Australia, June 2005
- Oldham C, McMahon K, Hipsey M, Huang P, Lavery P (2017) The Impact of Marine Wrack Degradation on the Water Quality of Jurien Bay Boat Harbour. Prepared for Department of Transport by The University of Western Australia, Report No. 306815, Perth, Western Australia, June 2017
- Pattiaratchi C, Hegge B, Gould J, Eliot I (1997) Impact of sea-breeze activity on nearshore and foreshore processes in southwestern Australia. *Continental Shelf Research* 17:1539–1560
- Pearce AF & Pattiaratchi CB (1999) The Capes Current: A summer counter-current flowing past Cape Leeuwin and Cape Naturaliste, Western Australia. *Continental Shelf Research* 19:401–420
- Ports Australia (2014) *Dredging and Australian Ports: Subtropical and Tropical Ports*. Prepared by Ports Australia, Sydney, New South Wales, April 2014
- Richardson WJ, Greene Jr CR, Malme CI, Thomson DH (1995) *Marine Mammals and Noise*. Academic Press, San Diego, California, USA
- Rule MJ, Bancroft KP, Kendrick AJ (2012) Baseline water quality of the Jurien Bay Marine Park: a benchmark for warm temperate Western Australia? *Conservation Science W. Aust.* 8: 241–249
- Short J, Fraser M, McLean D, Kendrick G, Byrne M, Caley J, Clarke D, Davis A, Erftemeijer P, Field S, Gustin-Craig S, Huisman J, Keesing J, Keough M, Lavery P, Masini R, McMahon K, Mergersen K, Rasheed M, Statton J, Stoddart J, Wu P (2017). Effects of dredging-related pressures on critical ecological processes for organisms other than fish or coral. Report of Theme 9 – Project 9.1 prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia, 47 pp
- Southall BL, Bowles AE, Ellison WT, Finneran JJ, Gentry RL, Greene Jr CR, Kastak D, Ketten DR, Miller JH, Nachtigall PE, Richardson WJ, Thomas JA, Tyack PL (2007) Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals* 33:411–520
- Statton J, McMahon KM, McCallum R, Kendrick GA, Lavery PS (2017) Response and recovery of a mixed tropical seagrass assemblage to variation in the frequency and magnitude of light deprivation. Report of Theme 5 - Project 5.5.3 prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia.

- Stevens, JD, McAuley, RB, Simpfendorfer, CA & Pillans, RD (2008). Spatial distribution and habitat utilisation of sawfish (*Pristis* spp) in relation to fishing in northern Australia. Prepared for the Australian Government Department of Environment and Heritage, Canberra.
- Strydom, S., McMahon, K., & Lavery, P. S. (2017). Response of the seagrass *Halophila ovalis* to altered light quality in a simulated dredge plume. *Marine Pollution Bulletin*, 121(1-2)
- Wilber, DH, Clarke, DG (2007) Defining and Assessing Benthic Recovery Following Dredging and Dredged Material Disposal. *Proceedings of the world dredging congress* 1:603-618.

Appendix A Jurien Bay Boat Harbour Maintenance Dredging Plume Modelling Report



Offshore Dredge Disposal at Jurien Bay: Assessment of Dredge Plume Dispersion and Disposal Area Stability

R-1666_00-2

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List of Terms and Abbreviations

CD	Chart Datum (m)
DEIA	Dredging Environmental Impact Assessment
DoT	Department of Transport
FV	Finite Volume
JBBH	Jurien Bay Boat Harbour
km	Kilometre
m	Metre
m ³	Cubic metre
mg/L	Milligrams per litre
m/s	Metre per second
NLSWE	Non Linear Shallow Water Equation
NOAA	National Oceanic and Atmospheric Administration
PSD	Particle Size Distribution
ST	Sediment Transport
TSS	Total suspended solids (mg/L)
3D	Three dimensional
2D	Two dimensional
WWIII	Wave Watch three

1 Introduction

1.1 Background

Maintenance dredging is required at Jurien Bay Boat Harbour (JBBH) to maintain navigability and water quality. Maintenance dredging has been undertaken using a cutter suction dredge on three occasions since harbour construction in 1986; 2006, 2014/2015 and 2016/2017.

Considerable accretion of sand and wrack has occurred since the last maintenance dredging campaign at JBBH such that maintenance dredging will be required in 2020. It is anticipated that at least 80,000 m³ of material will need to be removed: 60,000 m³ from the entrance and 20,000 m³ immediately south of the entrance. For planning purposes, a breakdown of accreted material volumes and dredging areas is shown in Drawing 1705-26-02-A (Appendix A).

While the total material volume within all dredging design areas including over dredge is approximately 210,000 m³, it is anticipated that, due to limitations in budget and equipment availability, single maintenance dredging campaigns will be limited to ~80,000 m³ over a period of about 18 weeks.

1.2 Study objectives

The objectives of this numerical study are:

- assess the likely dispersion/advection of the plume resulting from dredging disposal at the proposed offshore disposal area
- assess the mobility/stability of dredged material placed within the proposed offshore dredge disposal area.

Outcomes from this study are intended to inform a Dredging Environmental Impact Assessment (DEIA).

The scope of the assessment is outlined below:

- Analysis and simulation (by numerical modelling) of the hydrodynamic processes likely to influence sediment plume dispersion and dredge disposal area stability.
- Simulation of the likely dredge plume dispersion and assessment of the spatial and temporal evolution of the plume characteristics.
- Assessment of the mobility/stability during severe storm conditions of the dredged material placed within the proposed offshore disposal area (disposal area stability assessment).

The outcomes of the study will be subsequently used in the DEIA for assessing the likely impact of the proposed maintenance dredging work and offshore disposal on the sensitive environmental receptors.

1.3 Review of sediment transport in Jurien Bay

Regional metocean conditions, coastal processes, landforms and sediment movement have been well described in various sources (e.g. DoP, 2012; Woods and Gilkes, 1982; Chua, 2002; Holloway 2008).

In summary, regional metocean conditions are dominated by prevailing winds from the southwest to southeast during summer and from the northwest to southwest during winter. Ocean swell is persistent from the southwest all year and within Jurien Bay swell is extensively refracted and diffracted by passage through, and around reefs, islands and banks.

Jurien Bay lies at the very northern end of the primary sediment Cell extending from Moore River to North Head. Within Jurien Bay itself there are three tertiary sediment cells (DoP, 2012) listed in Table 1-1.

Table 1-1 Jurien Bay tertiary sediment cells

Cell	Cell area
30	Island Point to Middle Head
31	Middle Head to Pumpkin Hollow
32	Pumpkin Head to North Head

In general, the coastal sediment transport in this region is dominated by onshore transport of unconsolidated material from coastal landscape inundated during the Holocene (Woods, 1982) and distribution of nearshore sediment from south to north by south-westerly seas and swells. The following key points drawn from Woods (1982) summarise the present understanding of sediment transport around Jurien Bay and are illustrated in Figure 1-1.

- Sediment is transported northward from Essex Bay (to the south) into Jurien bay through the passage between Boullanger Island and Island Point; in shallow water and near the beach. This pathway spills into the south end of Jurien Basin and also feeds sediment into the beach system.
- Along the beach, sediment transport is predominantly to the north. Sheltered from southerly wind waves there is significant shoreline accretion in the lee of Island Point.
- Evidence indicates there is significant long-term (~350 years) variability in the feed of sediment into the south of Jurien Bay affecting the rate of shoreline progradation between Island Point and Favourite Bank.
- Refracting swell and wind-driven currents are the dominant mechanism transporting sediment onshore along Favorite Bank (the sand bank extending between Favourite Island and the mainland) which joins the shore approximately 600 m north of JBBH. Steep banks north and south of the Jurien Basin indicate infilling of the basin along both margins.
- Nearshore sediment transport is considered to be predominantly northward from Favorite Bank.
- Finer sediment traversing Favorite Bank appears to be deposited near Middle Head suggesting that net northward littoral drift reduces significantly north of Middle Head.
- Although some net northward alongshore transport was anticipated near JBBH due to southerly wind waves, factors in favour of siting the facility in its present location included sheltering by Boullanger and Favorite Banks to the south and north, limited fetch, and lack of feed of fine sediments from either the south or north.

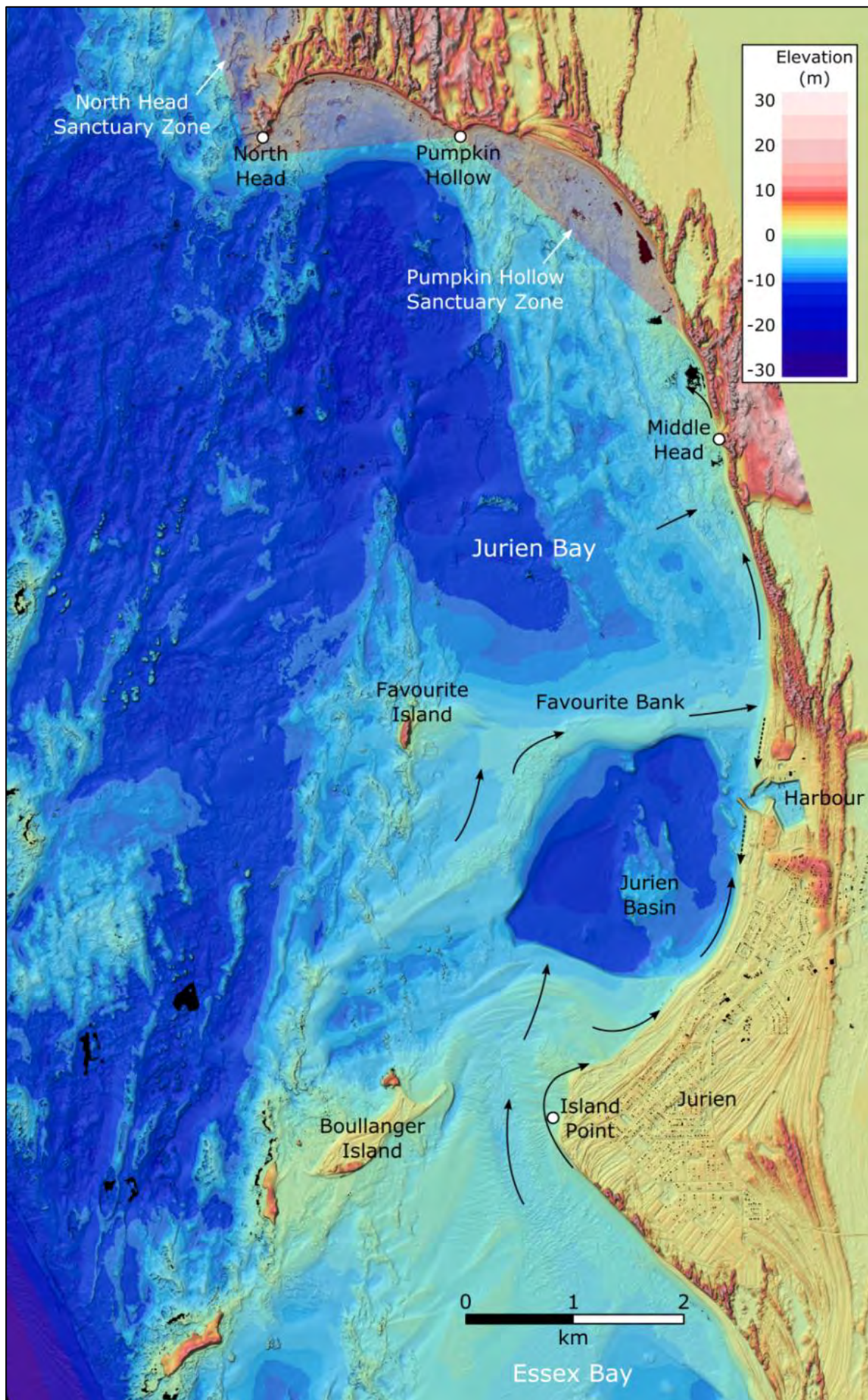


Figure 1-1 Jurien Bay sediment transport pathways (elevation map from LIDAR 2016)

From the coastal response around the harbour and other monitoring data over the 35 years since the assessment by Woods and Gilkes (1982) the following observations can be made:

- Net northward transport along the Jurien townsite shoreline has been significant since 1985 with an average annual influx of approximately 43,000 m³ per year into this area.
- Near the harbour winter storms typically result in a net southerly transport as evidenced by local shoreline erosion immediately south of the harbour entrance.
- There is a net southward transport into the area between the harbour entrance and Favorite Bank, evidenced by the lobe of accretion in this area and net erosion in the 1 km north of Favorite Bank. This is likely due to the southward transport by northwesterly winds and waves typical during the early phase of winter storms, depositing sediment near the northern breakwater; an area at least partially sheltered from southerly wind waves during storms or summer seabreeze.
- The substantial shoreline accretion south of the harbour represents sediment that would otherwise have fed into beaches north of JBBH. The total 1.7 million m³ of accretion north and south of JBBH since ~1985, if distributed along the 11 km shoreline between Island Point and Pumpkin Head would result in the shoreline prograding by 15–20 m, or 0.7 m/year; equivalent to the rate of shoreline advance measured from 1942–1965 and inferred from landform and sediment dating (Wood, 1982).
- Between 1985 and 2004 there was essentially no shoreline movement from Favorite Bank north. However, between 2004 and 2016 the shoreline in this area prograded up to 2 m/yr. This suggests that there is significant variability in the rate of sediment feeding from Favorite Bank into the nearshore system, with a sand supply pulse during the 2004–2016 period. This may also be the reason for the significant increase in rate of shoreline accretion north of the harbour during the same period. Furthermore, it is interesting to note that the zone of shoreline accretion extends well north of Middle Head, previously inferred to be the terminus of northward transport (Wood, 1982).

North of Middle Head the presence of nearshore reef platform and perched beach increases. Between 500–700 m north of Middle Head the platform becomes intertidal and is fringed by water up to 5 m deep. This area forms a natural sink for sand. Transport of sand northward past this platform may only occur substantially when there is an abundance of sand feeding the beach in this area.

Approximately 1.5 km south of Pumpkin Hollow the shoreline swings westward toward North Head. This segment of coast is sheltered by North Head from northwest storm waves and faces more or less directly toward the predominant southwest winds and waves. This combined with the broad, shallow reef sheltering the beach from incident waves is expected to result in minimal sediment transport except during energetic events coinciding with very high tide and storm surge levels.

1.4 Interpretation of model results for sediment pathway at beaches

Hydrodynamic modelling of storm events shows very energetic alongshore currents extending approximately 4 km north of the harbour (Figure 1-2). During northerly winds the broad southward alongshore current rapidly intensifies between chainage 9–10 km (Figure 1-2). This is due to this area receiving reduced sheltering from northerly winds by North Head and the presence of shallow reef nearshore. Current velocity and shear stress both decrease between chainage 7–8 km, which indicates an area of net deposition during northerly winds. South of Favorite Bank currents and shear stress increase somewhat toward the harbour.

During southerly winds the pattern is fairly similar to the northerly condition, but with alongshore current directed northward. However, between chainage 7–8 km, just north of Favorite Bank the current and shear stress is significantly higher than during northerly winds.

Shoreline movement analysis showed that from 1965 on, the shoreline between chainage 7–8 km was either static or eroding. This is consistent with the model showing an increase in shear stress to the south of this region during southward currents, and an increase in shear stress to the north

during northward currents. The zone of reduced current speeds and shear stress lies between about 1–1.5 km north of the harbour. Although both winter southerly winds and summer southwest sea breezes drive northward seas and a northward sediment transport along the beach, the model indicates there is sufficient energy drive a significant southward transport from this area during northwest storms bringing sand toward the harbour. On this basis it is not advisable to dispose of material from maintenance dredging on the beach within about 2 km north of the harbour.

Immediately north of chainage 10 km the model indicates that transport both to the north and south is significantly lower. In this area 2016 LIDAR data indicates a shallow reef platform extending up to 400 m off the beach, with sheltered pools up to about 5 m deep in places. General accretion in this area is supported by nearshore cusped sand features indicated in the LIDAR data and by shoreline accretion rates of up to 2 m/yr between chainage 10–11 km from 2004–2016.

Locating a beach disposal area between chainage 9–10 km will likely result in a major fraction of placed material being dispersed northward, either as sand on the perched beach, thin sand cover on the shallow reef or into the deeper pools.

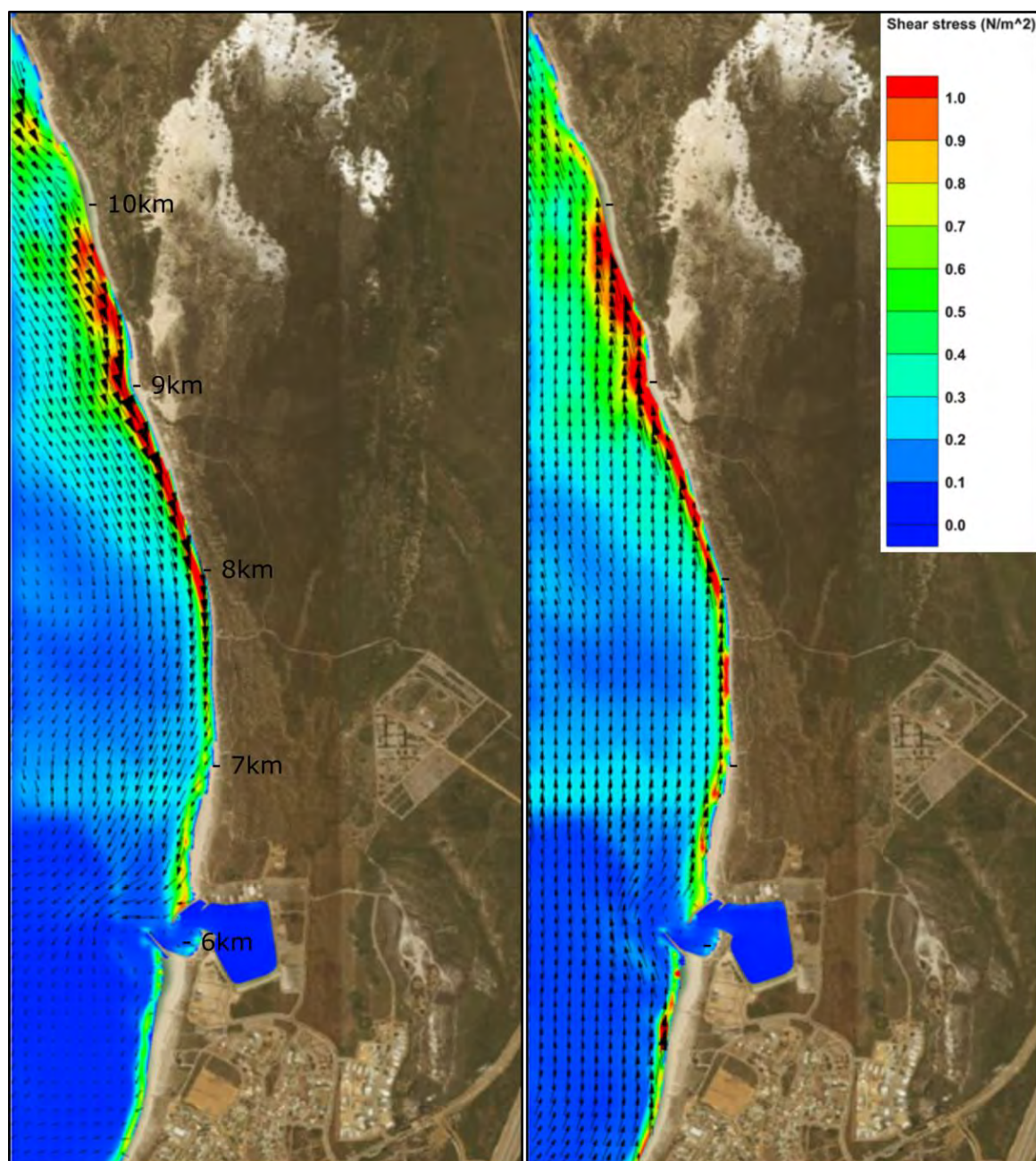


Figure 1-2 Modelled current vectors and shear stress along beach disposal area. NW wind 5PM 19/07/2014 (left); southerly wind 6AM 22/07/2014 (right)

2 Numerical Modelling

2.1 Model description

A calibrated wave and hydrodynamic modelling framework for Jurien Bay (BMT 2016) was used to assess the dredge plume fate over the period of dredging and assess the stability of the offshore dredge disposal area during acute storm conditions. The domain of the wave and hydrodynamic model is shown in Figure 2-1 and Figure 2-2, respectively.

The hydrodynamic modelling framework includes the following physical processes:

- Water levels and currents associate with astronomical tides, shelf waves and barotropic circulation
- Synoptic winds, atmospheric pressure and local winds
- Wind induced currents
- Open ocean swell waves, wind-driven waves
- Wave propagation, wave breaking, wave induced currents, bed shear stress and orbital velocity
- Salinity, temperature and stratification

The model domain used to simulate the 3-dimensional hydrodynamic circulation in Jurien Bay and in the vicinity of the JBBH covers the coastal waters from Perth to Geraldton. The model framework is comprised of a wave component (SWAN) and a circulation component (TUFLOW Finite Volume [FV]). The domains for each component are shown in Figure 2-1 and Figure 2-2, respectively.

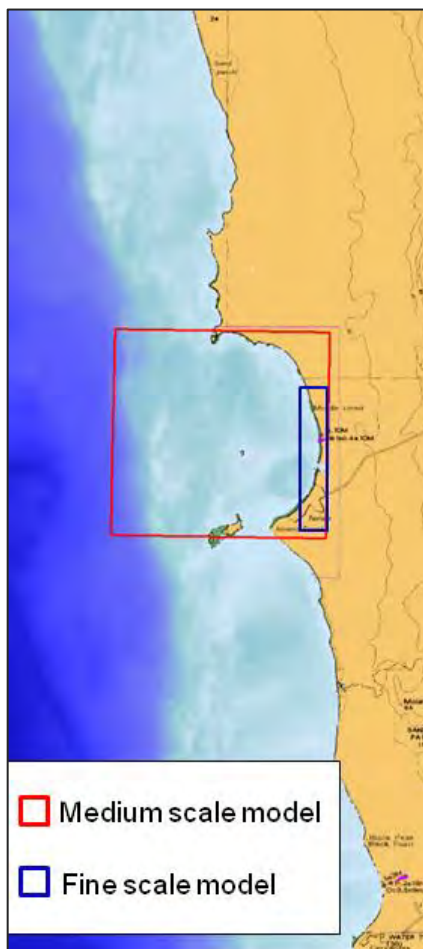


Figure 2-1 Nearshore nested SWAN grid domains



Figure 2-2 Domain of the Hydrodynamic model

The modelling framework has been calibrated against data measured by the Department of Transport (DoT) and was successfully used to simulate waves, circulation and transport of seagrass wrack in Jurien Bay (BMT 2017, BMT 2018). The model, domain and calibration are briefly outlined in the following sections.

2.1.1 Wave model (SWAN)

The SWAN wave model is a third-generation spectral wave model based on the wave action balance equation with sources and sinks and can be used on any scale relevant for wind generated surface gravity waves (Delft University of Technology 2006, Booij and Holthuijsen 1999). This is a global industry standard modelling package that has been applied with reliable results to many investigations worldwide.

Wave forcing was included in the present study for the role of wave action in sediment dispersion and resuspension for assessment of both the dredge plume and disposal area stability.

Resolving wind waves propagating from offshore deep waters to nearshore shallow waters at a large scale requires local refinement of the grid near the coast. This was achieved by employing a nesting approach. The resolution of the model is increased from offshore to nearshore by applying four nested (stepped) grids. The established large-scale wave model for Jurien covers an area of approximately 170 km (offshore) x 380 km (along the coastline). Figure 2-1 illustrates the second nested grid (semi-coarse scale grid) and the area of the medium scale and fine scale grid which provides high resolution wave information in the shallow nearshore areas in the vicinity of the disposal area and boat harbour.

The wave model was forced with a combination of waves from a global model (NOAA WWIII) and the local wind measured at Jurien Bay. The nested wave model reproduced local wave generation, propagation of waves into Jurien Bay and resolved wave breaking over reefs and nearshore.

The SWAN wave model was coupled with the 3-dimensional TUFLOW FV hydrodynamic model to simulate the dispersion of the dredge discharge plume and resuspension of material in the offshore disposal area. This required the wave simulations (wave and hydrodynamic) to be completed separately, with the model output stored at hourly intervals on regular grids. During the subsequent sediment re-suspension and dispersion simulations, the wave conditions were linearly interpolated spatially from the grids to the TUFLOW FV mesh.

2.1.2 Hydrodynamic model (TUFLOW FV)

TUFLOW-FV is a finite-volume hydrodynamic model (including both two and three-dimensional (2D and 3D) schemes), developed and distributed by BMT WBM (2013), which solves the Non-Linear-Shallow-Water-Equations (NLSWE). By adopting the flexible mesh approach the entire large-scale area and the high-resolution nearshore area are covered in a single mesh. The flexible mesh allows for seamless boundary fitting along complex coastlines or channels as well as efficiently representing complex bathymetries with a minimum number of computational elements (TUFLOW FV 2014).

2.1.3 Sediment transport model

TUFLOW FV Sediment Transport (ST) is a sediment transport modelling module. It was coupled with the wave and hydrodynamic models to simulate the following aspects of sediment movement:

- dispersion, settling and resuspension of particles released into the water column at the disposal area (dredge plume modelling)
- resuspension of particles from the seabed within the disposal area, and their subsequent transport and deposition during a severe storm (disposal area stability assessment).

The sediment transport modelling scope excludes the response of the existing native bed materials to the metocean conditions (e.g. bed erosion and accretion on the beaches) and focuses on

assessing the likely impact of the dredge dispose material above the background native suspended sediment levels.

2.2 Model validation

The wave and hydrodynamic model were forced with a combination of the global model data and local measurements. The wave and circulation models were previously calibrated for the period of July 2014 when measured wave and current data were available at three locations as shown in Figure 2-3 (BMT 2017). The instrument locations cover approximately 2.5 km along the coastline and are located in various depths from approximately 5 m to 13 m. The three instruments have various exposures to the incoming wave energy (due to the sheltering caused by shallow reefs) suitability representing the variation in the metocean conditions (wave and currents) experienced from the north to the south of the Jurien Boat Harbour.

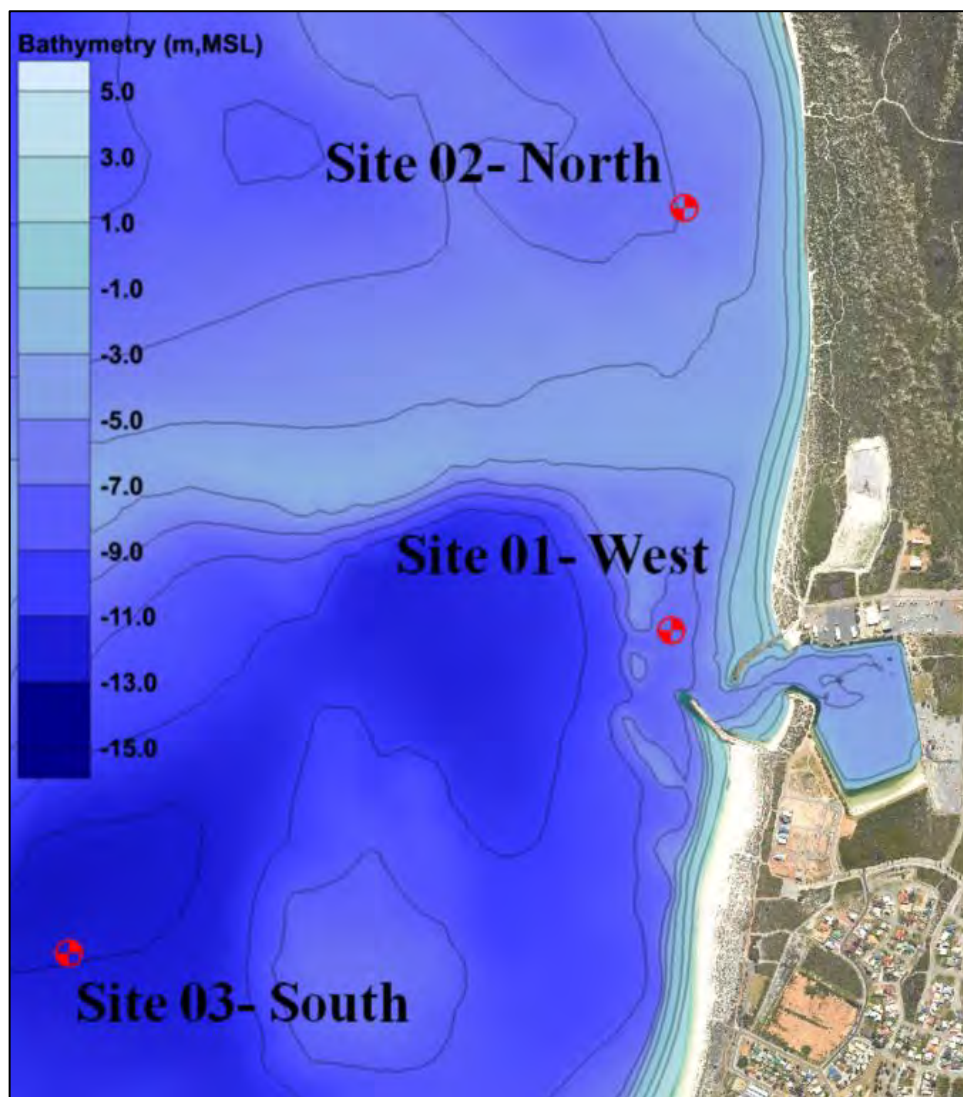


Figure 2-3 Locations for July 2014 acoustic wave and current instrument deployment

Modelled water level and currents were validated at three measurement sites in Jurien Bay (Figure 2-4). The modelled water levels and current profiles were strongly correlated to instrument records at all three measurement sites, demonstrating the capability of the model framework for investigating the circulation within Jurien Bay. Further detail on the modelling boundary conditions and validation is available in BMT (2017).

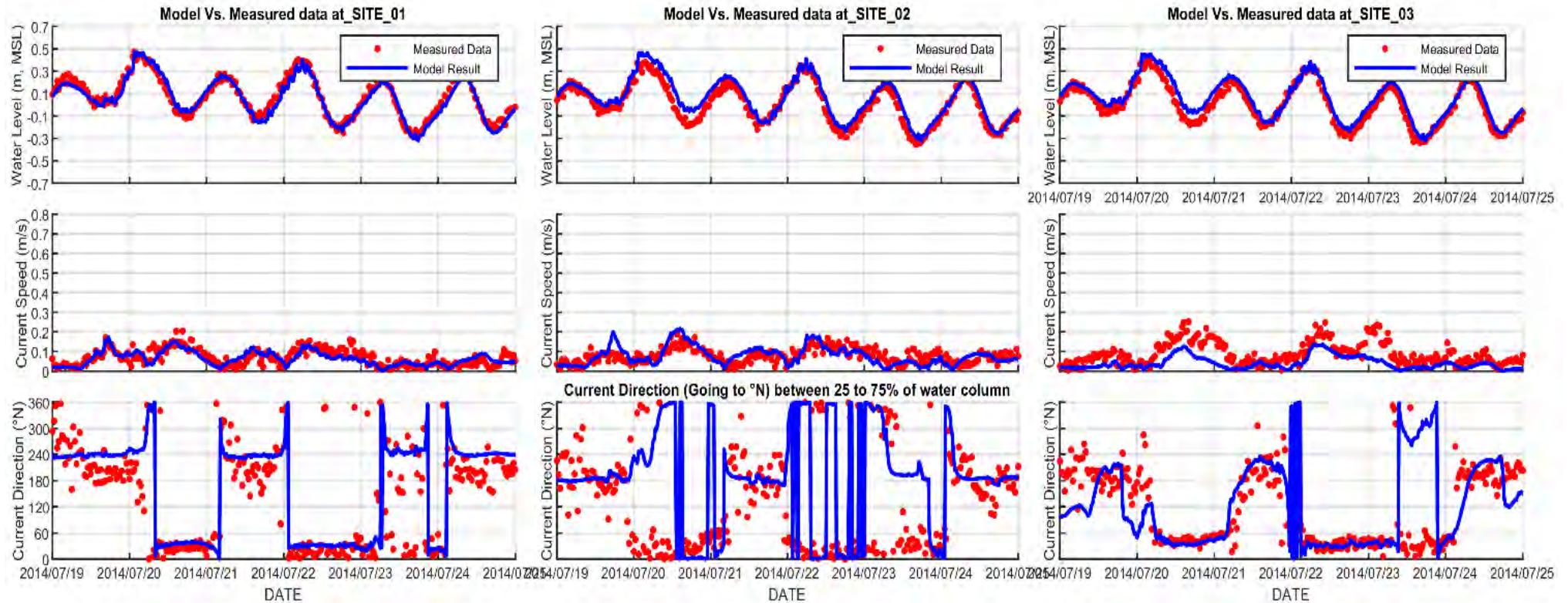


Figure 2-4 Validation of modelled water level (top), current speed (middle) and current direction (bottom) with measured data at three sites

2.3 Dredge disposal plume modelling

2.3.1 Dredged material characteristics

The particle size distributions (PSD) for materials to be dredged were obtained from the environmental sampling report (BMT 2019). Three particle fractions of sand, silt and clay were simulated to assess the dispersion and fate of the dredge discharge plume. A weighted average distribution of the sediment fractions was calculated based on the PSD of sediment samples and the volume of dredging at each area (Table 2.1). The volume of dredging for each area was obtained from the dredge design drawing BMT 1705-26-02_RevA (Appendix A).

The settling velocity for each of the particle fractions applied in the numerical model is tabulated Table 2.1. The settling velocities have been nominated conservatively to represent the settling process and for all the fractions are consistent with, or lower than settling velocities used on Wheatstone project as in Sun et al. (2016).

Table 2.1 Composition of modelled dredge material

Sediment Type	Grain Size (µm)	Composition (%)	Settling Velocity (mm/sec)
Sand	>63	96.0	10
Silt	4-63	3.9	1
Clay	0-4	0.1	0.05

2.3.2 Discharge of dredged material to the disposal area

The simulation mirrors the anticipated practice for discharge of dredged material. Dredged material is released within the proposed offshore disposal area (Figure 2-5) The discharge point is moved gradually within the boundary of the disposal area. In the plume modelling simulations, the dredge disposal is released within the top two metres of the water column.

Parameters for dredging operations used as inputs to the plume model are summarised in Table 2.2. It has been conservatively assumed that the dredge will work seven days a week (rather than the typical five) and 12 hours per day. There is no allowance for dredge standby (e.g. due to weather) and shorter hours (e.g. mechanical maintenance or during weekends) in this assessment.

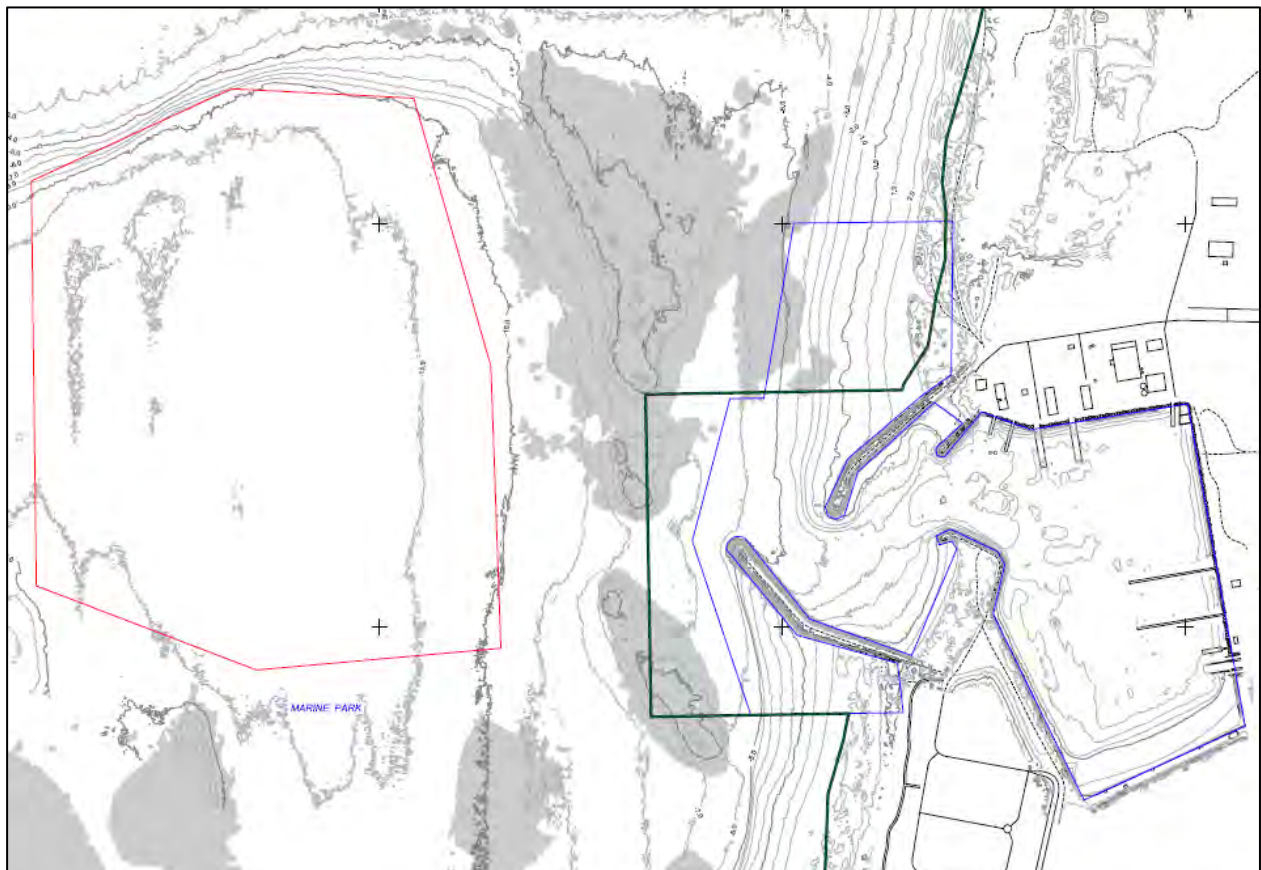


Figure 2-5 Dredging area (blue), offshore disposal area (red) and Jurien Bay Marine Park boundary (green)

Table 2.2 Dredging operation parameters used in the plume modelling

Parameter	Value	Unit
Production rate	100	m ³ /hr
Operating days	7	days/week
Dredging hours	12	hours/day

2.3.3 Conditions during dredging

The available measured wind data from 2014–2018 was reviewed and winds during November were identified as representative of the variety of wind conditions over the period of future maintenance dredging campaigns (over spring and summer). Maintenance dredging at JBBH has been consistently completed between October and March. Figure 2-6 shows the monthly wind roses of the measured data at Jurien Bay, as shown the wind characteristics of November are representative for the nominated periods of maintenance dredging.

The period of November 2017 was selected for the simulation to assess the likely dredge plume fate dispersion. November 2017 was selected for the plume modelling period as it incorporates a range of weather conditions likely to be experienced during the dredging campaigns. These conditions include the occasional spring storm (cold front), periods of 1-3 days of light winds, and the summer daily cycle of morning easterly winds and afternoon south-westerly sea breeze (Figure 2-7).

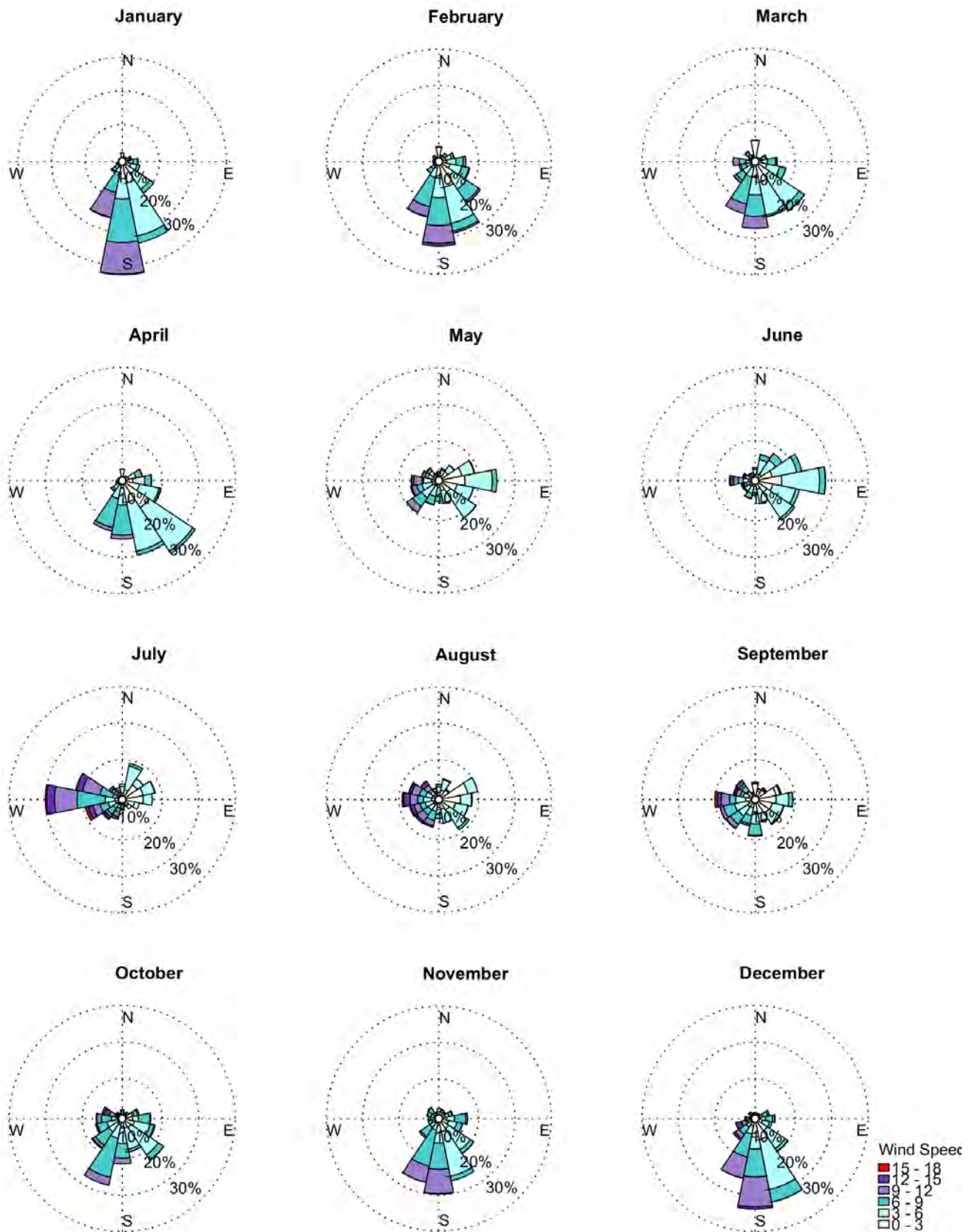


Figure 2-6 Wind roses (m/s) of available measured data at Jurien Bay (May 2014 to Feb 2018)

The results of the assessment are presented in Section 3 of this report.

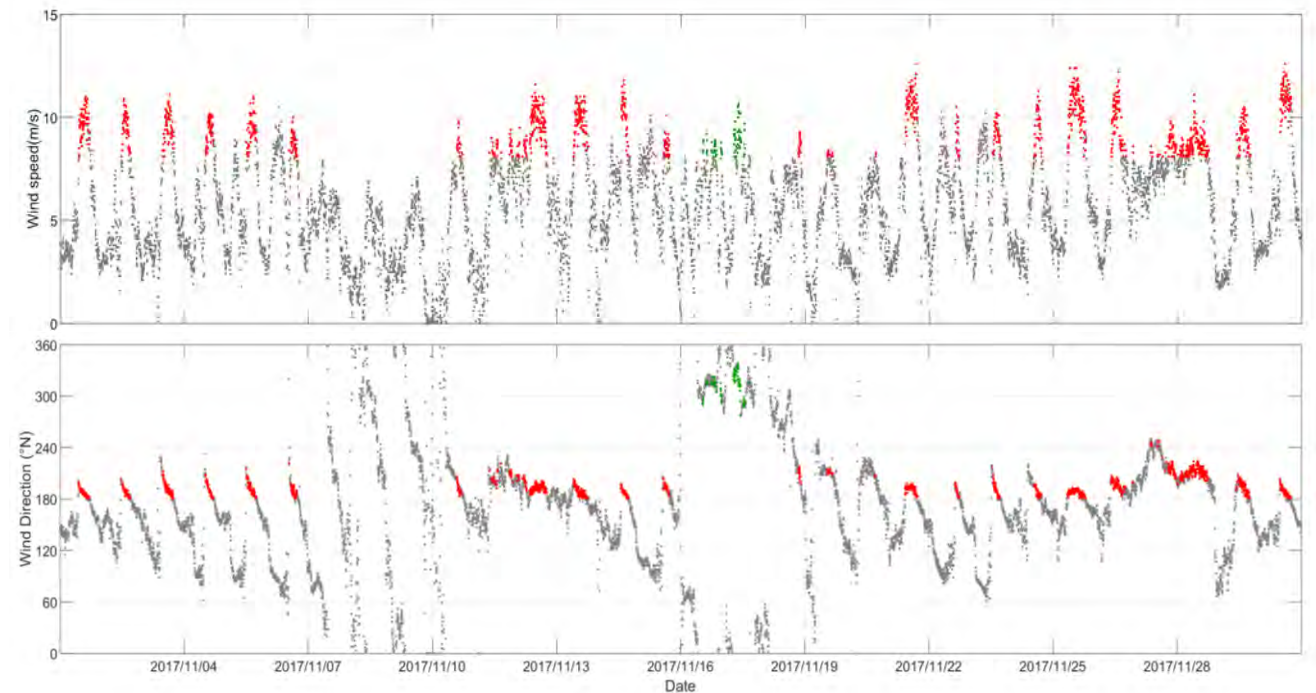


Figure 2-7 November 2017 wind time series. (red indicates wind speed >8 m/s between 180-270 degrees; green indicates wind >8 m/s between 270-360 degrees)

2.4 Disposal area stability assessment

The stability of the proposed dredge disposal area was assessed under severe storm forcing conditions, during which larger waves and stronger currents have the potential to remobilise dredged material placed on the seabed within the offshore disposal area. The assessment was carried out for the design fill level of -8mCD at the proposed disposal area. This level has been estimated to accommodate 10–12 dredging campaigns over ~15–20 years based on the historical maintenance dredging volumes. In the model, the seabed level within the disposal area was raised to the level of -8 mCD (~4 m above the existing bed level). The raised disposal area at -8 mCD hereafter in this report is referred to as the filled disposal area.

2.4.1 Seabed composition at the filled disposal area

To assess the stability of the filled disposal area, it was conservatively assumed that prior to the storm the seabed material would have the same sediment composition as the dredged material. This assumes that no fine material will be dispersed out of the proposed disposal area during the dredging and discharge operation.

In reality, and as demonstrated by plume modelling (Section 3), a portion of the fine sediment fraction (e.g. silt and clay) discharged will disperse out of the disposal area before settling to the seabed and, therefore, the remaining materials at the seabed within the disposal area will contain less fines and will be less prone to sediment resuspension and movement. To isolate the sediment movement only for the filled disposal area, the seabed material for areas outside the disposal area was configured as a non-erodible bed.

2.4.2 Acute storm scenario

2.4.2.1 Selection of the acute storm event

The storm scenario modelled was selected based on review of historical wind data at Jurien. Wind speed and direction recorded from 18/5/2016 to 16/6/2016 is shown in Figure 2-8. During the survey period a major storm occurred on 21/5/2016 with a period of almost 12 hours where winds greater than 10 m/s blew with a northerly component, with a northerly maximum of 20.3m/s. The wind direction then swung rapidly to the southwest with speeds exceeding 10 m/s for another 12 hours, with a southerly maximum of 21.8 m/s. Although there were other wind events during the

survey period only on 24/5/2016 were winds from the northwest, exceeding 10 m/s for 6 hours, with a maximum speed of 14.3 m/s. Remaining events were relatively short and do not well represent the potential of northerly storms.

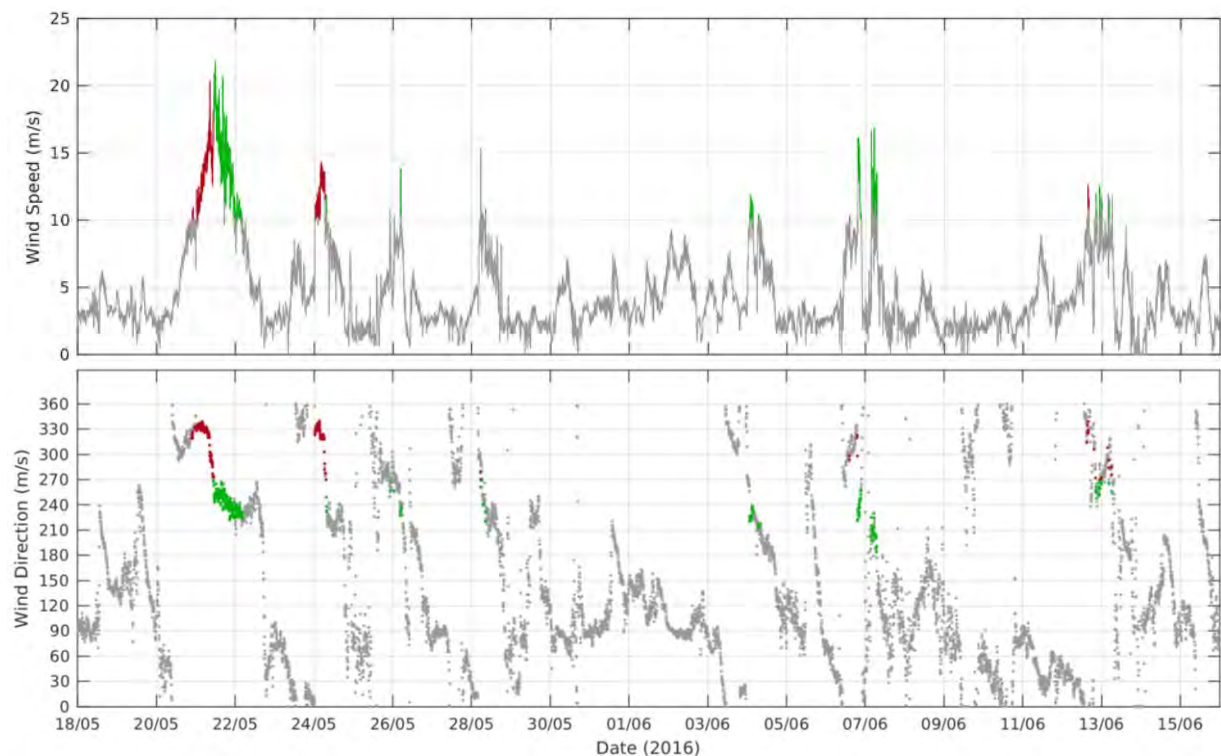


Figure 2-8 Jurien wind 18/5/2016 to 16/6/2016 (red indicates wind speed >10 m/s between 180-270 degrees; green indicates wind >10 m/s between 270-360 degrees)

The period from 20/5/2016 to 23/5/2016 was selected as the condition for the disposal area stability assessment runs and is shown in Figure 2-9.

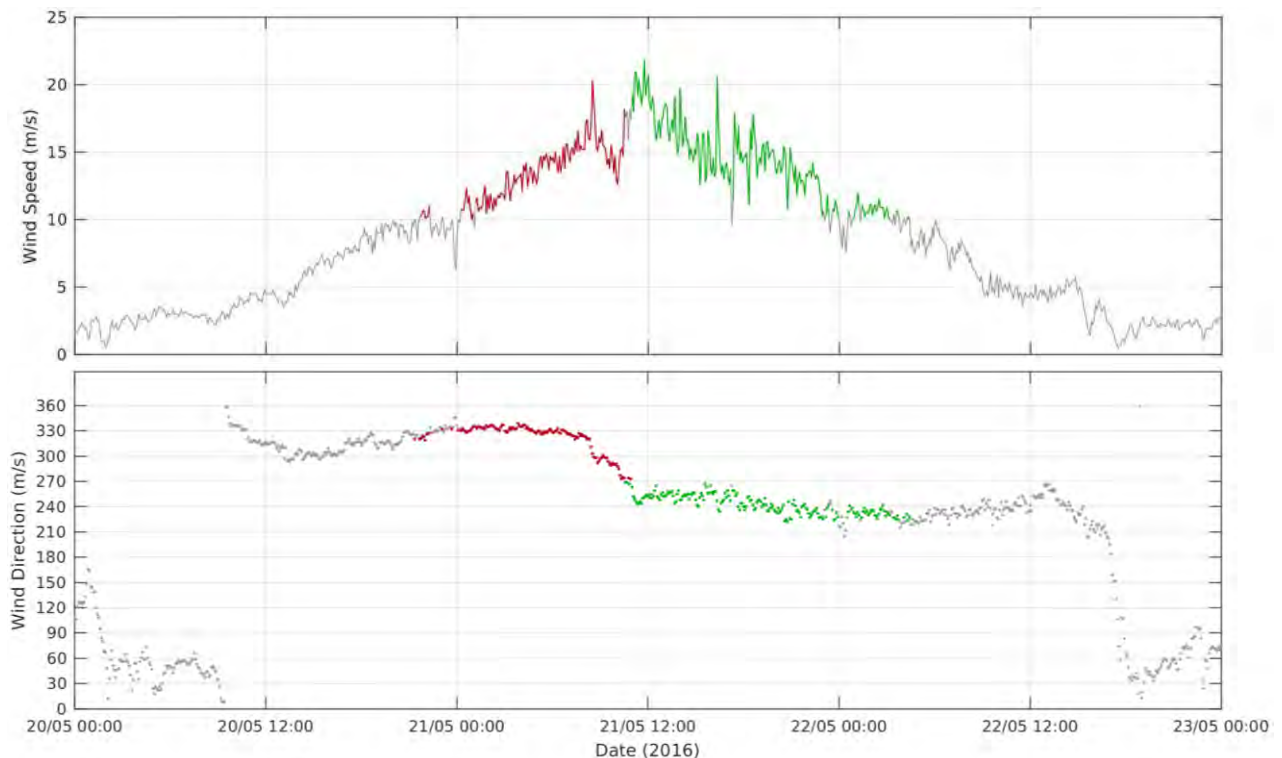


Figure 2-9 Wind speed and direction measured at Jurien Bay used for the modelled storm (20-23 May 2016)

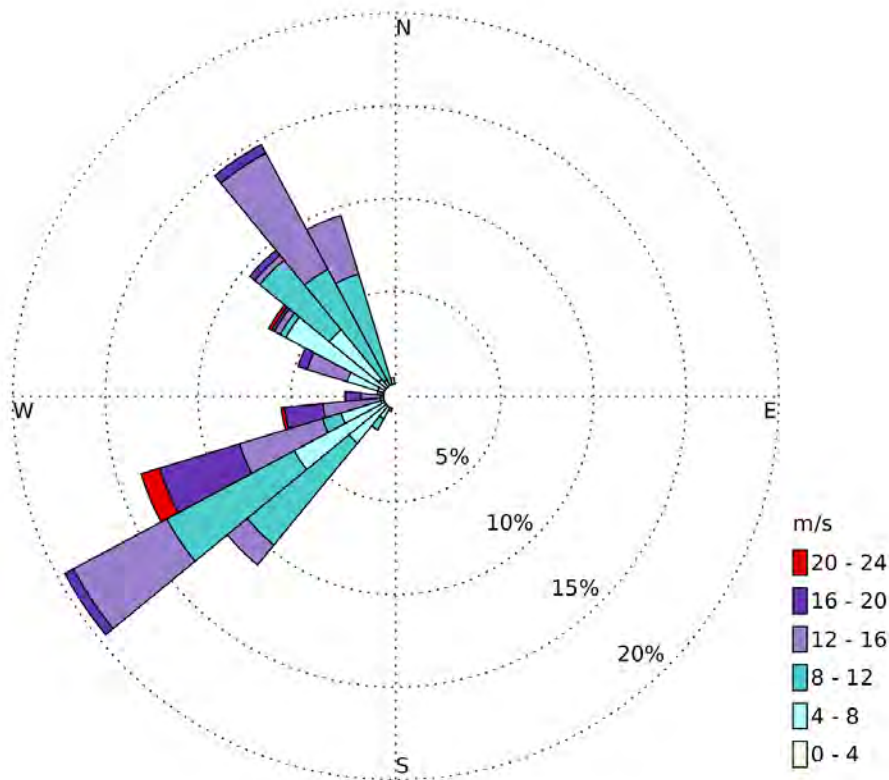


Figure 2-10 Wind rose for the modelled storm (20-23 May 2016)

2.4.2.2 Review of the measured wave data over the acute storm period

Figure 2-11 demonstrates the measured wave height, direction and period over the selected acute storm period at Jurien Site 01-West AWAC location which is the closest instrument to the proposed disposal area (instrument location shown on Figure 2-3. The instrument head depth is approximately -8 m CD which is close to the design fill level of -8mCD at the proposed disposal site.

As shown the significant wave height of ~1.6 m has been captured at the peak of the storm. To demonstrate the likelihood of such a severe event, all the available measured wave data over the period of March 2014 to October 2017 was analysed. Figure 2-12 and Figure 2-13 illustrate the wave roses of the measured wave height and period over the noted period. As shown the predominant wave energy sectors at the instrument location are the north west and westerly sectors. This is partially due to the fact that the nearshore reefs provide sheltering against the southerly sea waves and south westerly swell conditions.

Figure 2-14 presents the exceedance curve of the measured total significant wave height over the noted period of 3.5 years (March 2014 to 2017 October). Approximately 99% of the time the omnidirectional significant wave height at the disposal area is below 1.0 m. The review of the measured wave data also supports that the selected 2016 storm condition with the wave height of approximately 1.6 m is a very rare extreme storm at the disposal area.

As shown the selected storm period 20/5/2016 to 23/5/2016 represents the range of wind and wave conditions considered to be most important for sediment transport, namely strong winds from the northwest, west and southwest. The result of the disposal area stability assessment is presented in the next section.

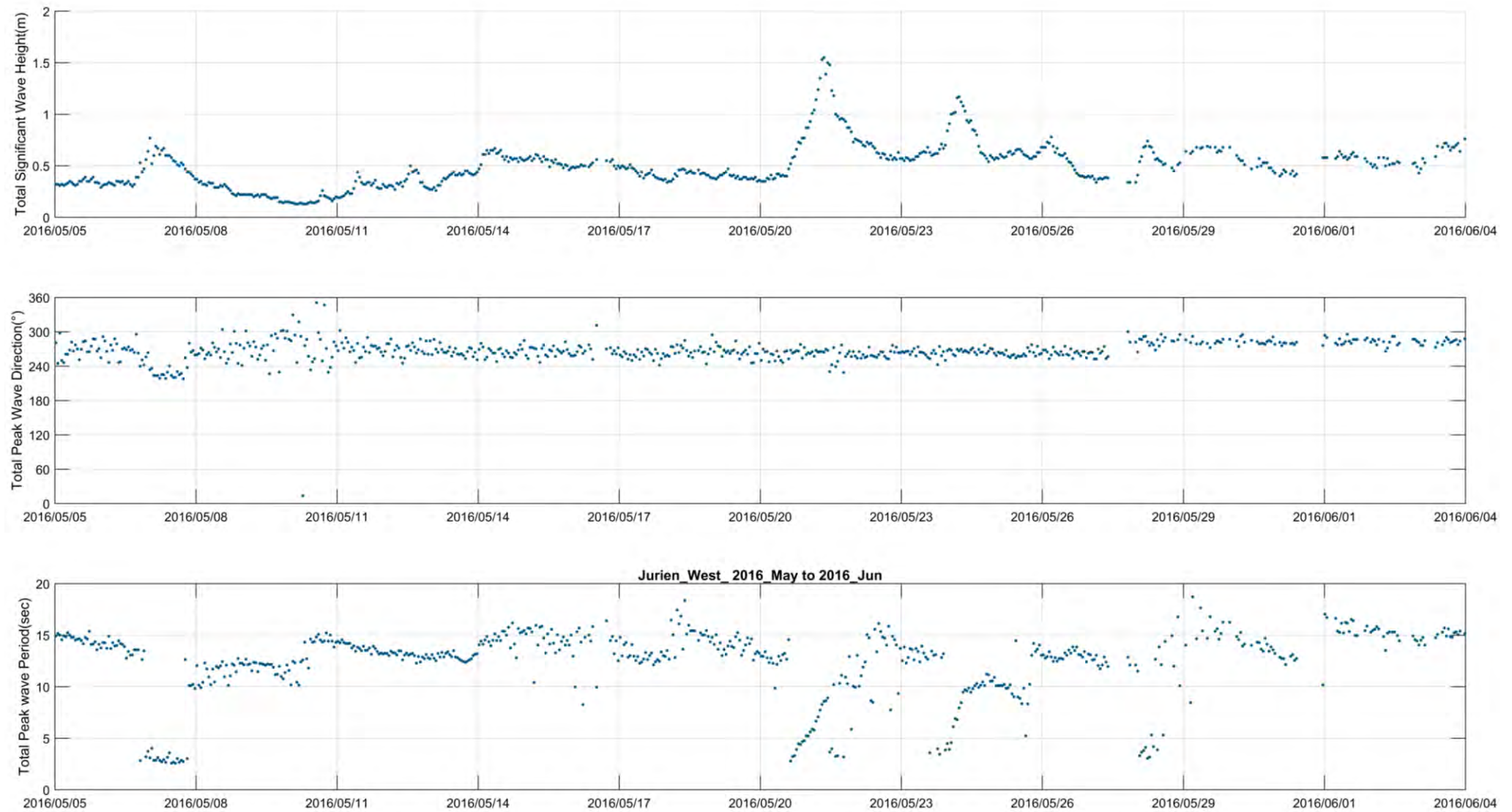


Figure 2-11 Time series of the measured wave height, period and direction during 2016 storm at Jurien Site 01-West AWAC

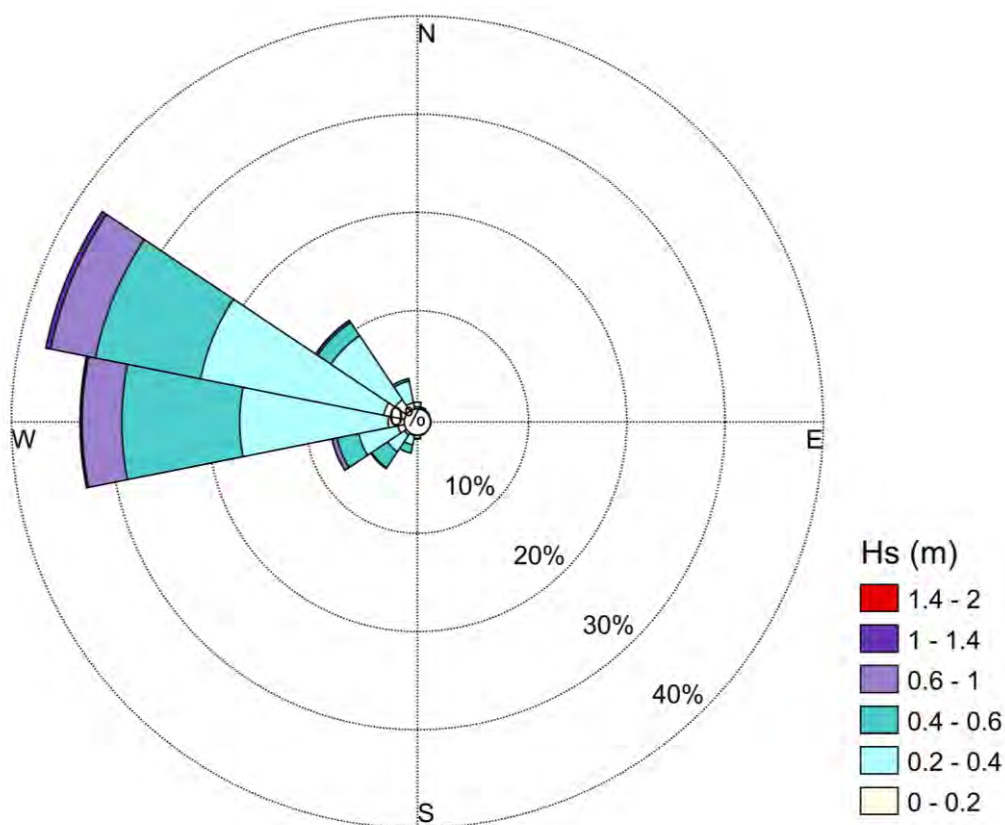


Figure 2-12 Significant wave height rose at Jurien Site 01-West AWAC (available measured data from March 2014 to October 2017)

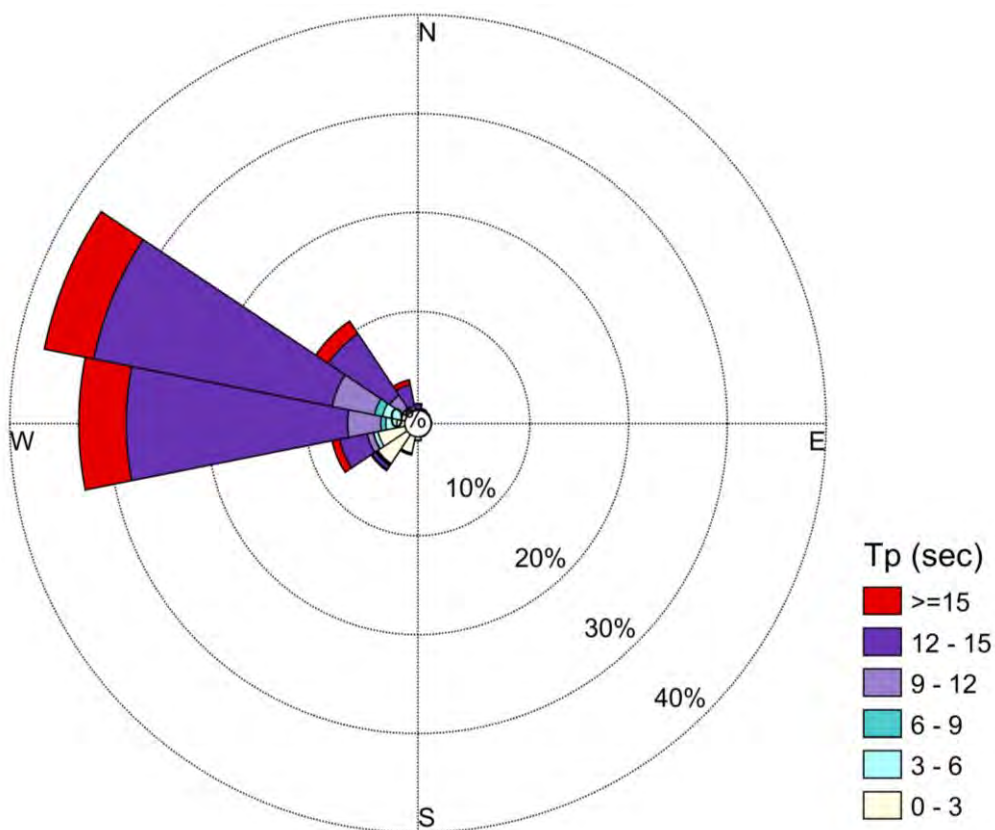


Figure 2-13 Peak wave period rose at Jurien Site 01-West AWAC (available measured data from March 2014 to October 2017)

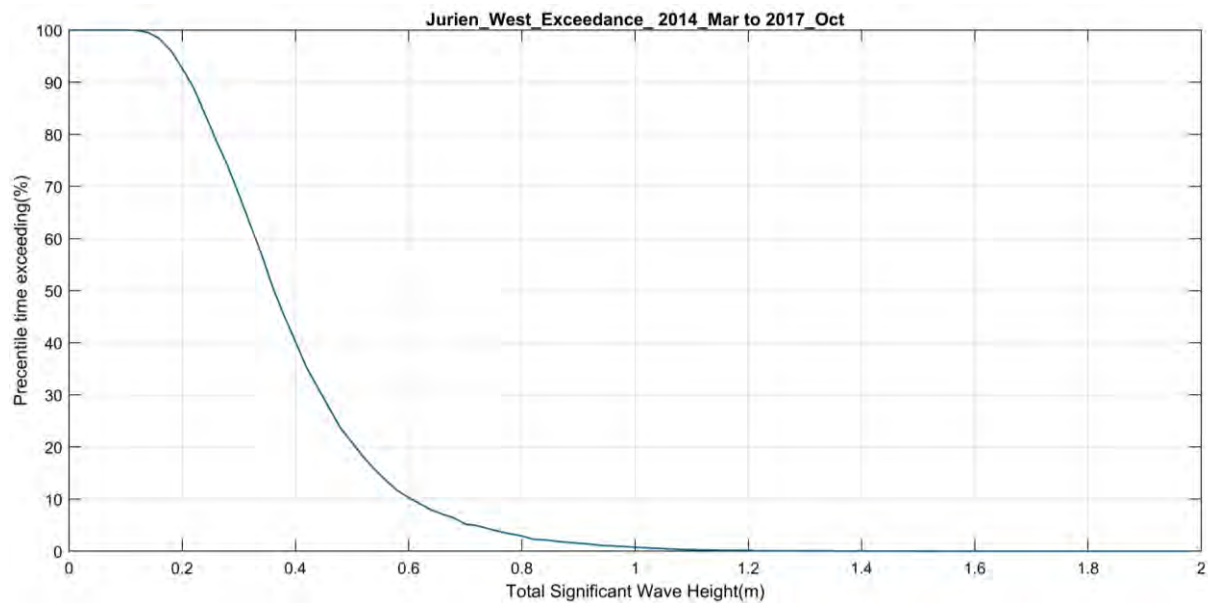


Figure 2-14 Exceedance curve of significant wave height at Jurien Site 01-West AWAC (available measured data from March 2014 to October 2017)

3 Modelling Results

3.1.1 Dredge plume modelling assessment

Spatial plots of 90th and 95th percentile plots (10% and 5% exceedance levels respectively) of the Total Suspended Solid (TSS which is a representative measure of the plume sediment concentration) are presented in Figure 3-1 and Figure 3-2. The TSS exceedance plots demonstrate a tendency for the sediment plume to advect more toward the north of Jurien Bay (compared to the southward plume extent). This behaviour is likely influenced by the predominant southerly winds, in addition the southern section of Jurien Bay being partially sheltered from the dominant south westerly swell direction (due to the nearshore reef, Fisherman Islands and Favourite Bank) as opposed to the north section of Jurien Bay where swells and south westerly seas can penetrate into the bay, while experiencing less reduction due to sheltering (BMT 2017).

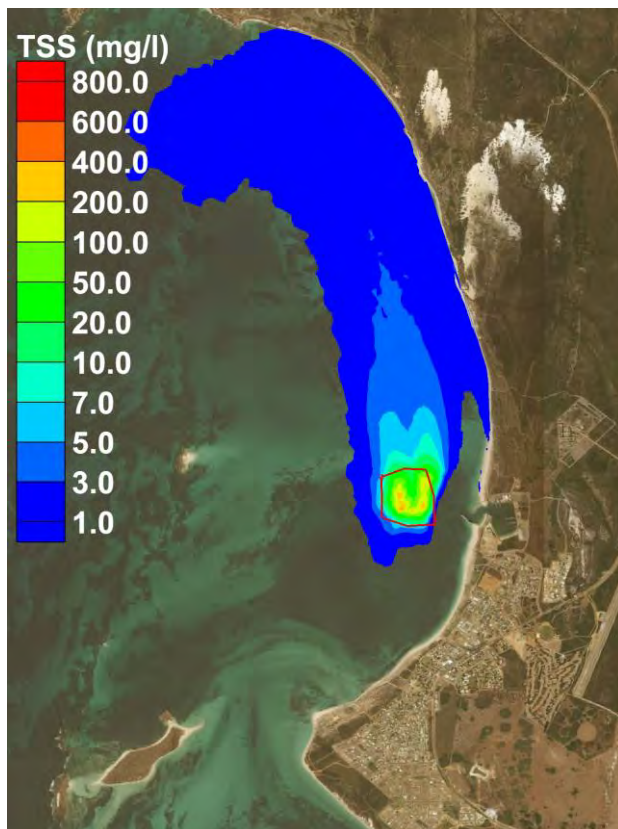


Figure 3-1 95th percentile TSS contours (5% of time exceedance). Red polygon shows the designated proposed dredge disposal area

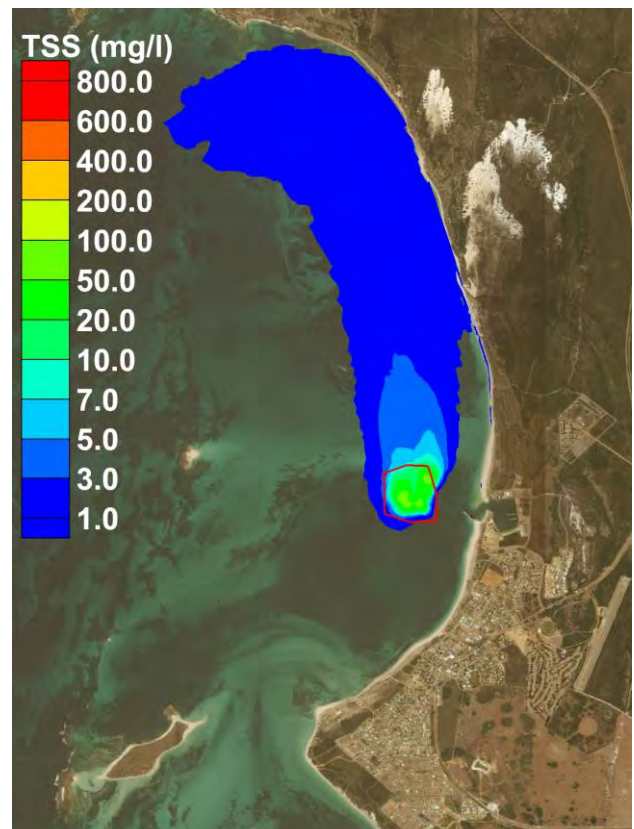


Figure 3-2 90th percentile TSS contours (10% of time exceedance). Red polygon shows the designated proposed dredge disposal area.

Figure 3-3 shows the simulated seabed sedimentation levels at the end of dredge plume scenario. The model results show that approximately 90% of the dredge disposal material settled within the footprint of the designated disposal area.

The dredge plume simulation results demonstrated that although the November 2017 simulation period is relatively energetic (which could potentially result a more persistent plume, greater plume extent, and delayed particle settlement), every day during the 12 hours of no-dredging, TSS levels reduced below 5 mg/L a few hours after stopping the daily dredging operation. Most of the suspended solids settled overnight and on the next day the remaining TSS level in the water column was minimal (below 1 mg/L) prior to recommencement of dredging operations. Figure 3-5 and Figure 3-6 show the modelled TSS timeseries during the dredge plume scenario at three points located at 0 km, 0.5 km and 1.5 km south of the disposal area and three points located 0 km, 1.5 km and 3 km north of the disposal area (locations shown on Figure 3-4).

These modelling results will subsequently be mapped and compared against the trigger levels for the sensitive environmental receptors as part of the DEIA scope of work.

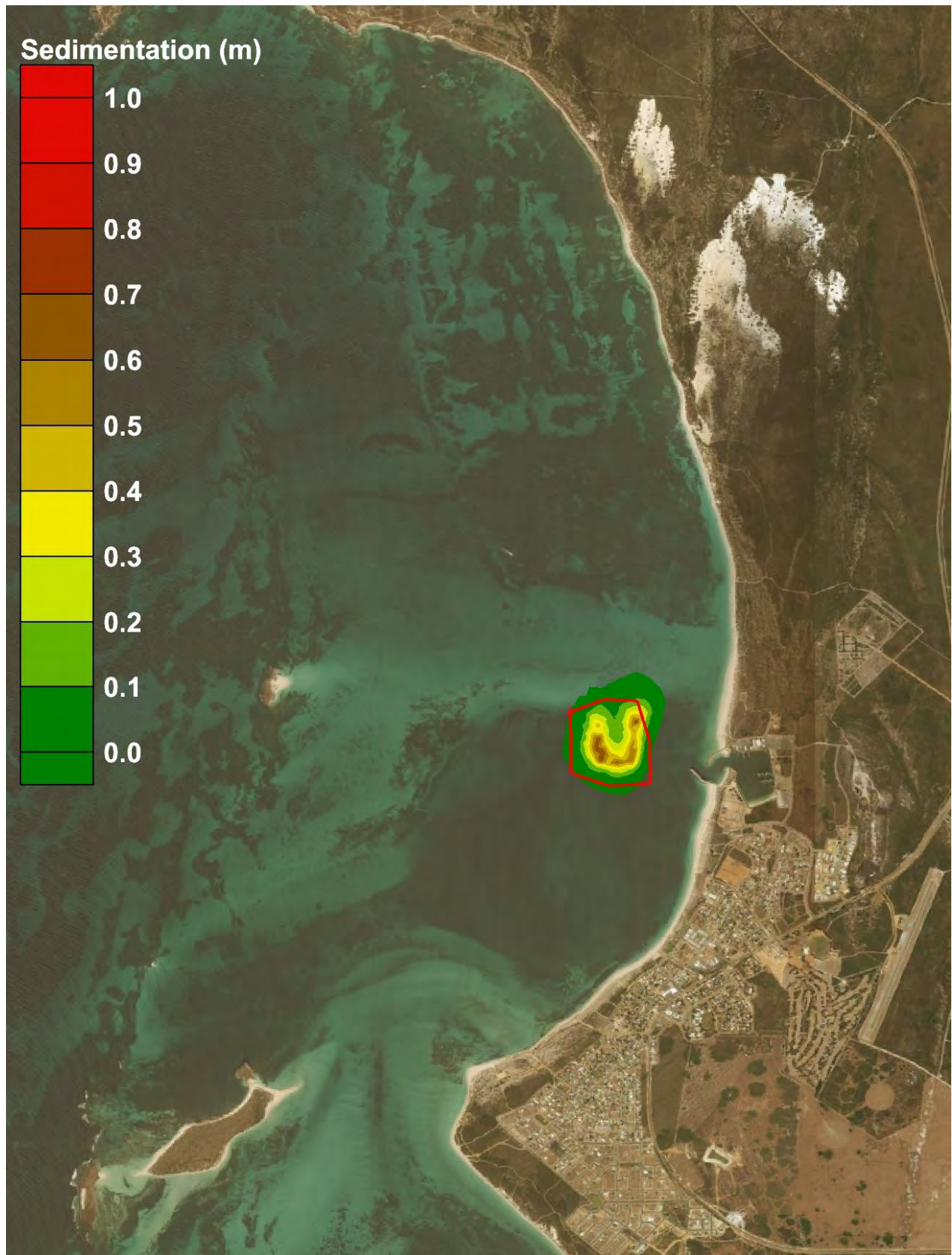


Figure 3-3 Seabed sedimentation thickness at the end of the plume simulation (red polygon shows the proposed dredge disposal area)

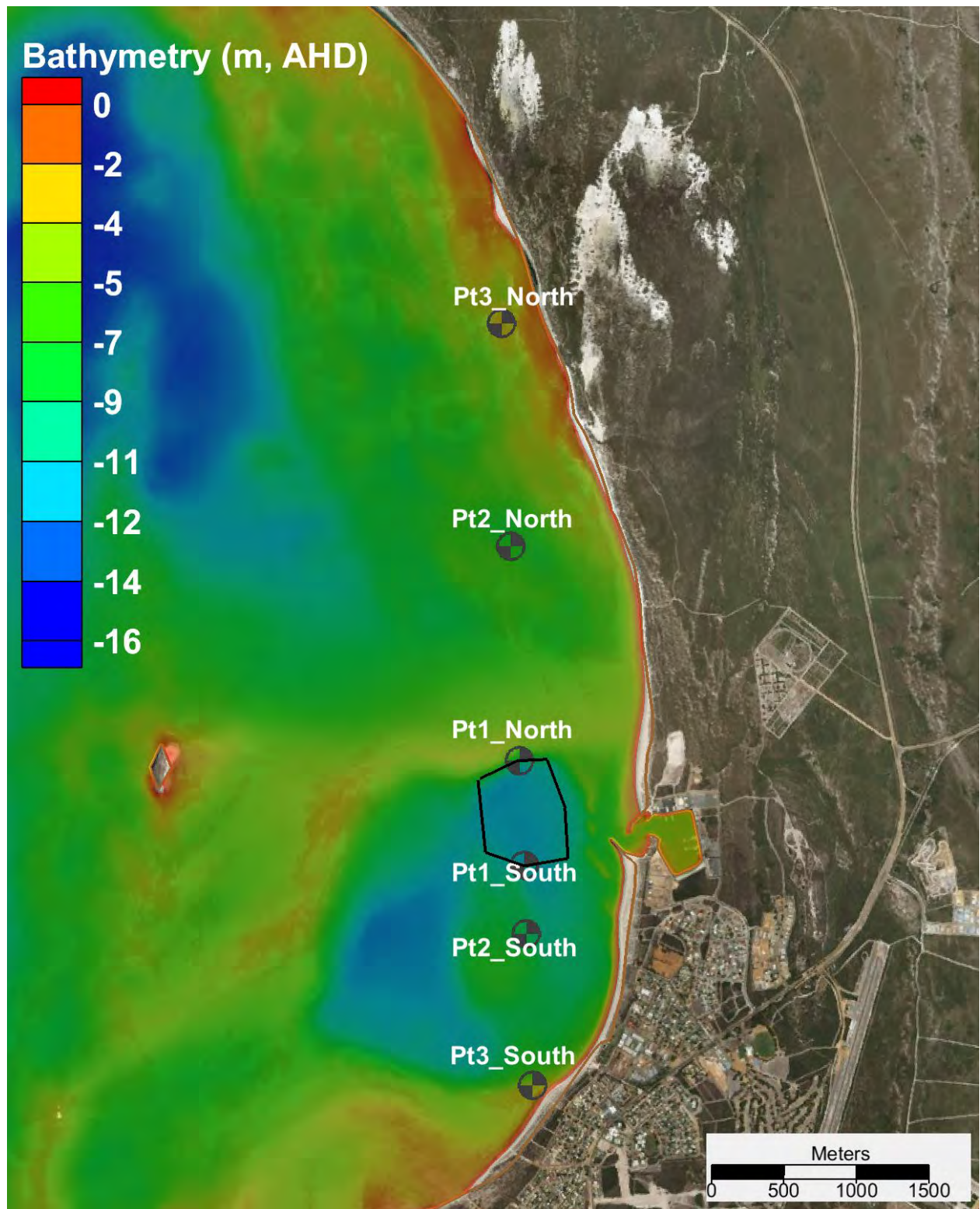


Figure 3-4 Locations of extracted TSS time series north and south of the disposal area

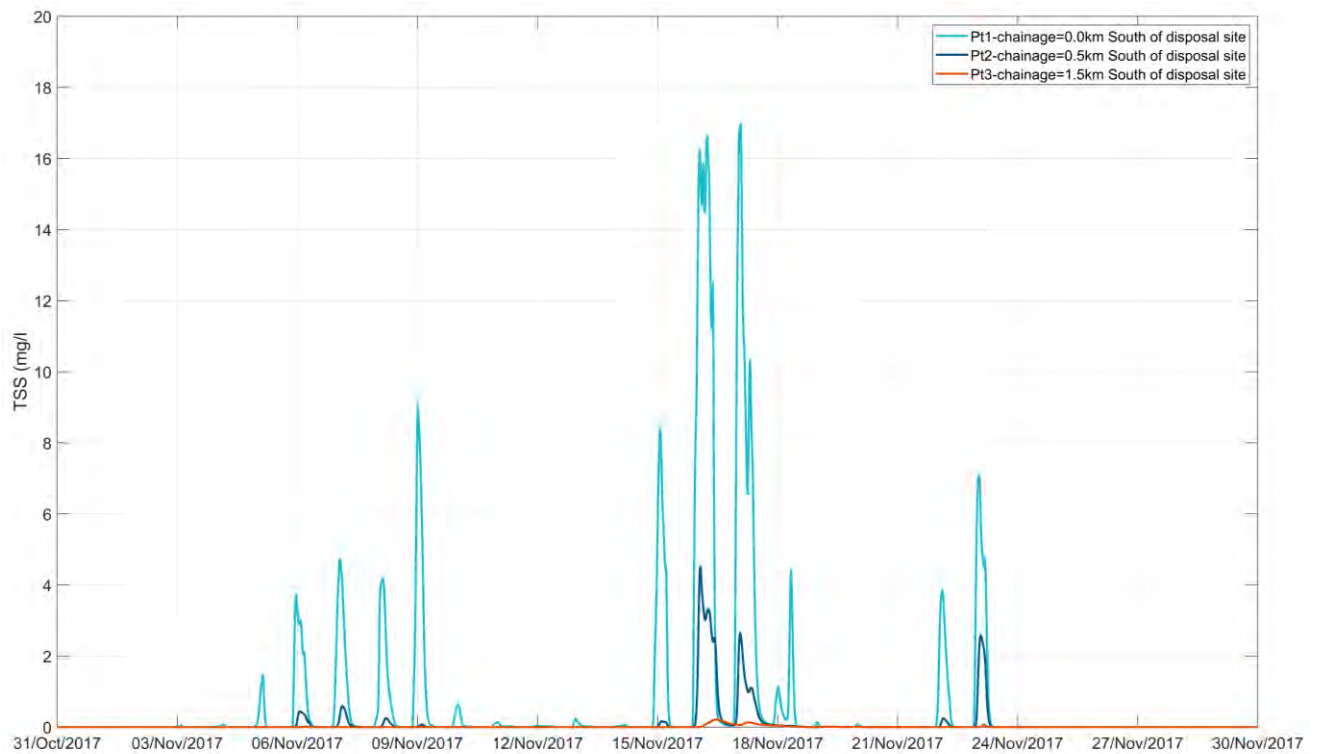


Figure 3-5 Modelled total suspended solids time series at points south of the disposal area during the plume modelling period (location of the points demonstrated in Figure 3 4)

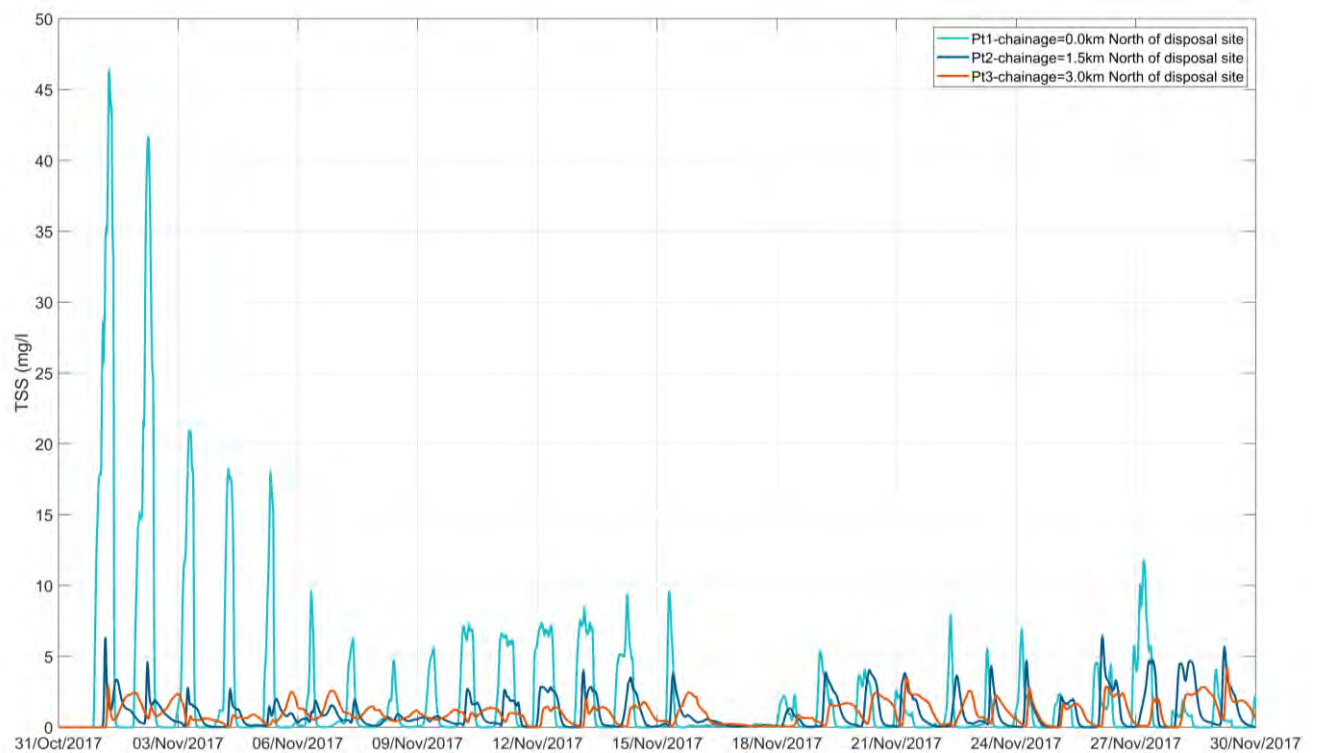


Figure 3-6 Modelled total suspended solids time series at points north of the disposal area during the plume modelling period (location of the points demonstrated in Figure 3 4)

3.1.2 Disposal area stability

The result of the acute storm simulation indicated that the filled disposal area is stable under both the northerly and southerly severe storm conditions. The storm simulations resulted in no erosion or change to the bed levels of the disposal area. The resuspension of the fine materials from the disposal area due to the storm activities is minimal with TSS from resuspended sediment being less than 0.1 mg/L at both the at northern and southern boundaries (Figure 3-7 and Figure 3-8).

The model results demonstrated that the natural shallow areas in the vicinity of the disposal area, including the sand bar and beaches in the Jurien Bay are experiencing significantly higher bed shear stress compared with the filled disposal area and therefore, are more prone to erosion and sediment mobility. This suggests that the proposed offshore disposal area may still remain stable if the design fill level is raised above -8 mCD, providing additional capacity for disposal of maintenance dredging material in future. If required, the model can be used to assess the maximum fill level at which the disposal area is stable, and the resuspension level of the sediments is yet below the trigger level of the receptors.

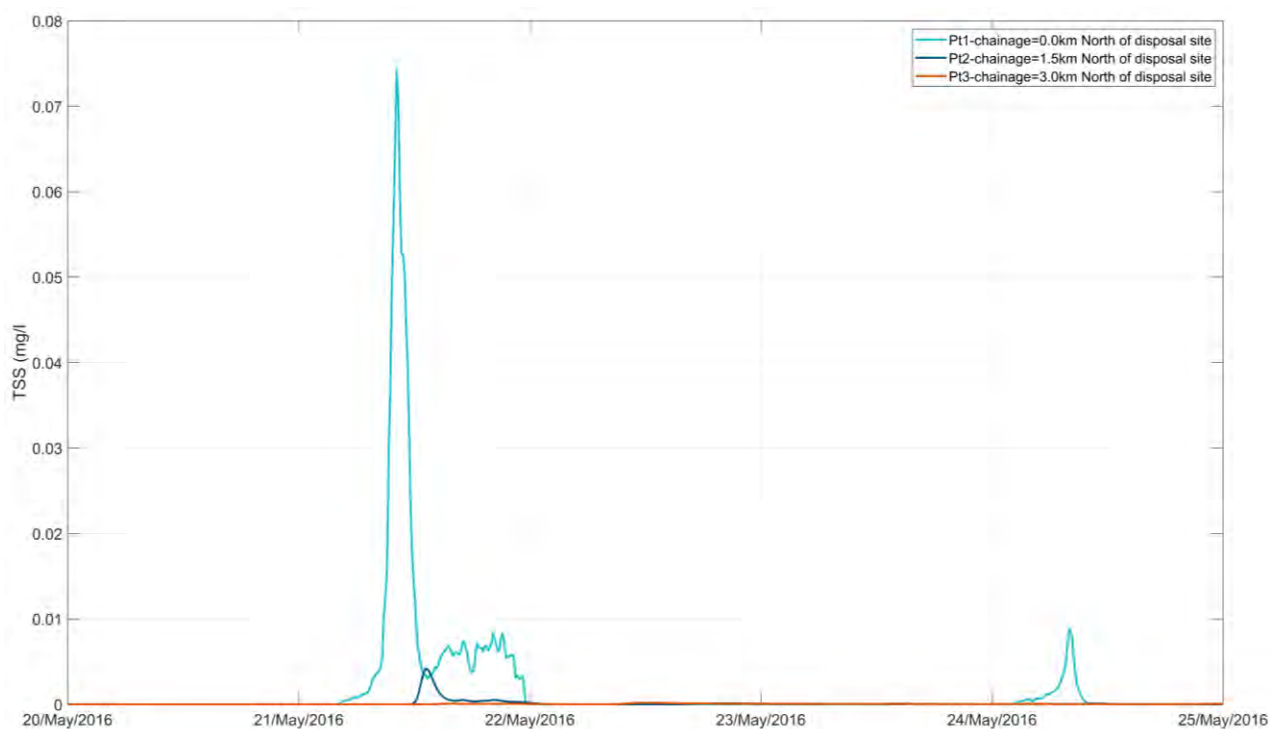


Figure 3-7 Time series plot at the northern boundary of the disposal area over the acute storm event (location of the points demonstrated in Figure 3-4)

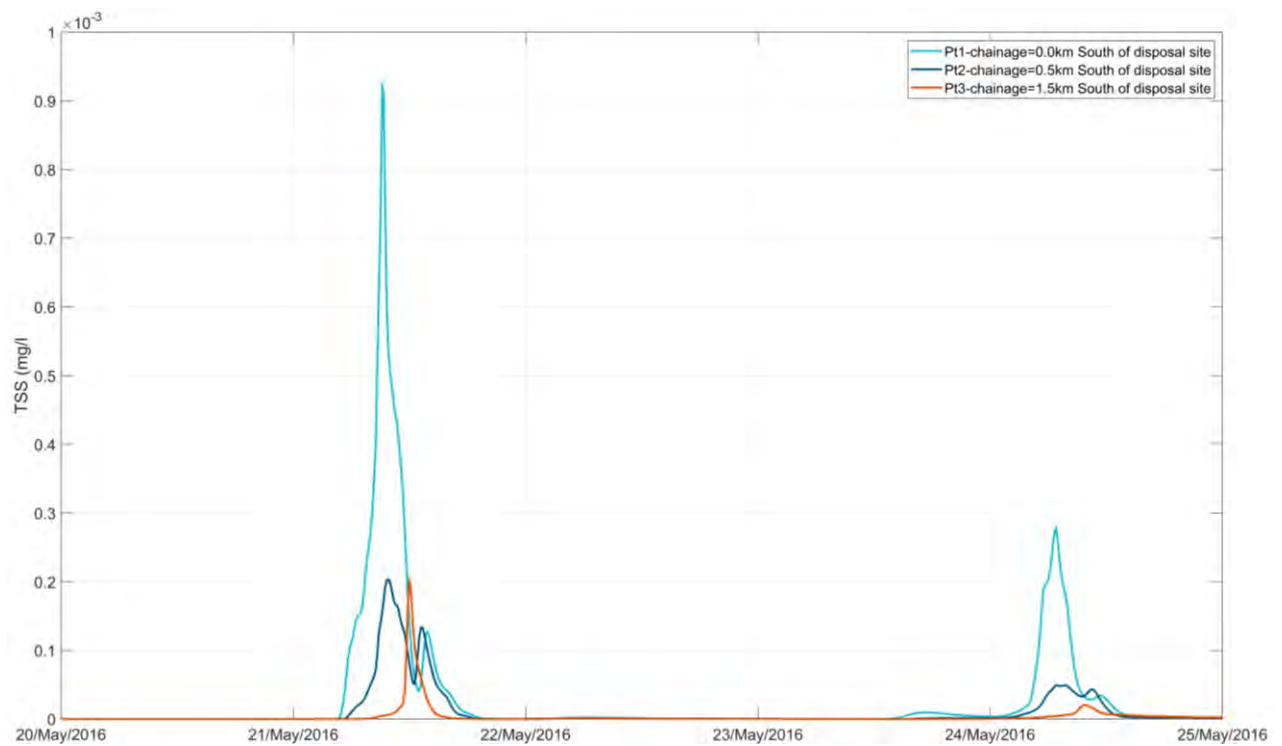


Figure 3-8 Time series plot at the southern boundary of the dredge disposal over the acute storm event (location of the points demonstrated in Figure 3-4)

4 Summary

A numerical modelling study was carried out to assess the likely dredge plume dispersion and stability of the filled disposal area. BMT previously calibrated wave and hydrodynamic modelling framework was used for this study. A representative period of one month was simulated to assess the likely dredge plume fate dispersion. The particle size distributions for materials to be dredged were obtained from the environmental sampling report and used to define the dredge disposal release source.

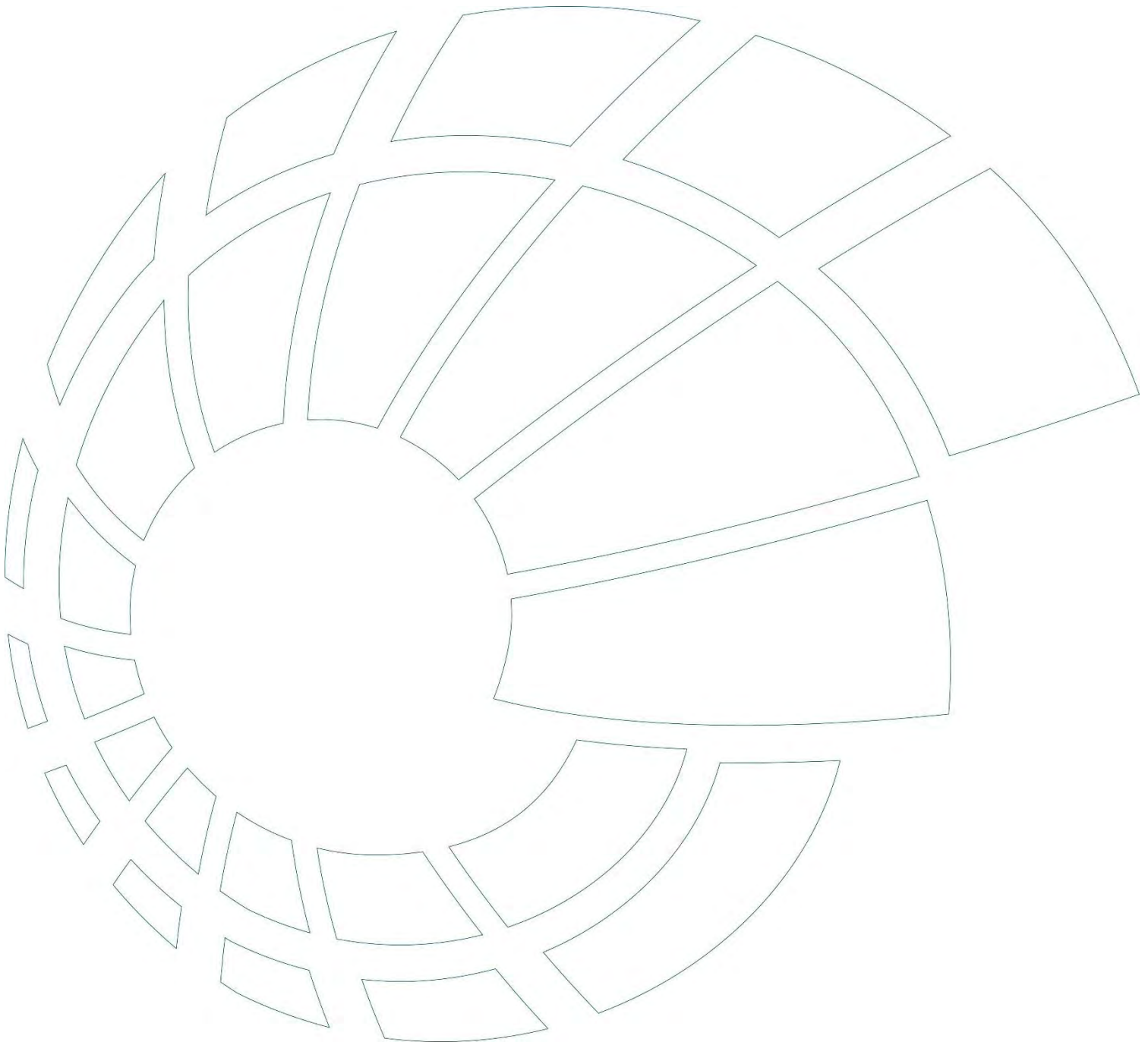
The dredge plume simulation results demonstrated that TSS level every day reduces below 5 mg/L a few hours after stopping the daily dredging operation (12 hours/day). Most of the suspended solids settle to the seabed overnight and the remaining TSS level in the water column is minimal (below 1 mg/L) prior the dredging operation start on the next day. The model results were used to prepare spatial exceedance maps of TSS and identifying the likely area of impact due to the dredge disposal.

Stability of the dredge disposal area under acute storm conditions was also assessed using the above noted sediment transport modelling framework. The stability assessment was carried out over acute storm conditions which cover the main storm characteristics at Jurien Bay (Including northerly, westerly and southerly storm winds). The modelling results demonstrated that the filled disposal area to the design level of -8 mCD was stable over the simulated acute storm conditions. The storm simulations resulted in no erosion or change to the bed levels of the disposal area. The resuspension of the fine materials from the disposal area was minimal due to the storm activities. The model results demonstrated that the natural shallow areas away from the disposal area, including the sand bar and beaches of Jurien Bay experience significantly higher bed shear stress compared with the filled disposal area (filled to -8 mCD) and therefore are more prone to erosion and sediment mobility.

5 References

- BMT (2017) Jurien Bay Boat Harbour long term dredging and disposal strategy investigation, prepared for the Department of Transport, Ref R-J16001_07-01, June 2017
- BMT (2018) Jurien Bay Boat Harbour Reference, Evaluation of Options to Decrease Wrack Ingress, R-J17026.00-01, December 2018
- BMT (2019) Jurien Bay Boat Harbour – Long-term Maintenance Dredging Sediment Sampling and Analysis Plan Implementation Report. Prepared for Department of Transport by BMT, Report No. R-1454_01-2Rev/0, Perth, Western Australia, July 2019
- BMT WBM (2013) TUFLOW FV Science Manual.
- Booij, N., Ris, R.C., and Holthuijsen, L.H. (1999) A third-generation wave model for coastal regions. 1. Model Description and Validation. *Journal of Geophysical Research-Oceans*, Vol. 104(C4), 7649-7666.
- Chua, J. (2002) Oceanographic Modelling of Jurien Bay, Western Australia, Unpublished Engineering Honours Thesis, The University of Western Australia.
- Damara WA Pty Ltd (2012) The Coast of the Shires of Gingin and Dandaragan, Western Australia: Geology, Geomorphology and Vulnerability.
- Delft University of Technology (2006) SWAN Technical Documentation, Faculty of Civil Engineering and Geosciences, Environmental Fluid Mechanics Section, Delft, Netherlands.
- Holloway, K. (2008) Characterising the Hydrodynamics of Jurien Bay, Western Australia. Unpublished Engineering Honours Thesis, The University of Western Australia.
- NOAA WWIII, NOAA Wave Watch III global model, National Weather Service Environmental Modelling Center, U.S Department of Commerce.
- Sun C, Shimizu K, Symonds G (2016) Numerical modelling of dredge plumes: a review. WAMSI Dredging Science Node Report, Theme 3/ Project 3.1.3, June 2016.
- TUFLOW FV, User Manual, Flexible Mesh Modelling (2014) BMT WBM.
- Woods and Gilkes, (1982) Investigations into sedimentation, soil development and coastal history at Jurien. Prepared by P.J. Woods and R.J. Gilkes, University of Western Australia, May 1982.

Appendix A Drawings



Appendix B Jurien Bay Boat Harbour Maintenance Dredging Sediment Sampling and Analysis Plan

Jurien Bay Boat Harbour – Long-term Maintenance Dredging Sediment Sampling and Analysis Plan

R-1454_01-1/Rev1

March 2019



Jurien Bay Boat Harbour – Long-term Maintenance Dredging Sediment Sampling and Analysis Plan

Prepared for

Department of Transport

Prepared by

BMT

March 2019

Report No. R-1454_01-1/Rev1

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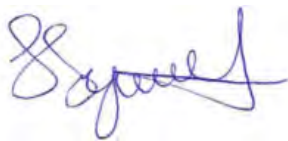
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Acronyms

ALS	Australian Laboratory Services Pty Ltd
ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ASS	Acid sulfate soils
BCH	Benthic communities and habitat
BTEX	Benzene, toluene, ethylbenzene, and xylene
C°	Degrees celsius
CALM Act	<i>Western Australian Conservation and Land Management Act</i>
CA	Commonwealth of Australia
CD	Chart datum
CoC	Chain of Custody
COPC	Contaminants of potential concern
CPC	Conservation and Parks Commission
CSD	Cutter suction dredge
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions
DEIA	Dredging environmental impact assessment
DoEE	Commonwealth Department of Energy and Environment
DQOs	Data quality objectives
DOC	Dissolved organic carbon
DoT	Western Australian Department of Transport
DVG	Default guideline value
DWER	Western Australian Department of Water and Environmental Regulation
EDM	Environmental data management
EMF	Department of Transport's Maintenance Dredging – Environmental Management Framework
EP Act	<i>Western Australian Environmental Protection Act 1986</i>
EPSD Act	<i>Commonwealth Environment Protection (Sea Dumping) Act 1981</i>
FRP	Filterable reactive phosphate
GC–ICPMS	Gas chromatography inductively coupled plasma mass spectrometry
GF–AAS	Graphite Furnace Atomic Absorption Spectrometry
GIS	Geographical information systems
GPS	Geographical positioning system
H ₂ S	Hydrogen sulfide
ha	Hectare
IC	Inorganic carbon
ICP–AES	Inductively coupled plasma atomic emission spectroscopy
ICP–MS	Inductively coupled plasma mass spectrometry
ICP–OES	Inductively Coupled Plasma-Optical Emission Spectrometer
ID	Sample identifier
JHA	Job hazard analysis

JBMP	Jurien Bay Marine Park
km	Kilometre
km/h	Kilometre per hour
L	Litre
LoR	Limit of reporting
LTMMP	Long-term monitoring and management plan
m	Metre
m ³	Cubic metre
mg/kg	Milligrams per kilogram
mm	Millimetre
Mm ³	Million cubic metres
m/s	Metres per second
MCM	Million cubic metres
MAFRL	Marine and Freshwater Research Laboratory
MLEP	Maximum Level of Ecological Protection
NH ₃ /NH ₄	Ammonia/ammonium
NO ₃	Nitrate
NAGD	National Assessment Guidelines for Dredging
PAHs	Polyaromatic hydrocarbons
PQL	Practical quantitation limits
PPE	Personal protective equipment
PSD	Particle size distribution
QA/QC	Quality assurance / quality control
RPD	Relative Percent Difference
RPM	Revolutions per minute
RSD	Relative Standard Deviation
SAP	Sampling and analysis plan
TBT	Tributyltin
TN	Total nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TPHs	Total petroleum hydrocarbons
TRHs	Total recoverable hydrocarbons
UCL	Upper confidence limit
µm	Micrometre
USEPA	United States Environmental Protection Authority
WA	Western Australia

1. Introduction

1.1 Background

Jurien Bay is located ~225 km north of Perth in the Wheatbelt region of Western Australia (WA; Figure 1.1). The Jurien Bay Boat Harbour (hereafter 'the Boat Harbour') is ~2 km north of Jurien Bay townsite, and was initially constructed in 1986 to provide a refuge and service facilities for the fishing industry (Figure 1.1). The Boat Harbour water area occupies ~14 ha and has a volume of ~369,000 m³ (BMT Oceanica 2015). The Boat Harbour comprises an entrance channel leading into a large basin area containing service jetties and boat maintenance facilities on the northern boundary, and on the eastern boundary, jetty pens and public boat ramps (Figure 1.1). Also available are toilets, a public beach and car parking facilities (Figure 1.1). The Boat Harbour provides for a range of community uses, including recreational tourism and commercial developments, with a number of land-backed facilities. Jurien Bay Marine Park (JBMP) surrounds the Boat Harbour and is popular for fishing and recreational activities including swimming, diving, snorkelling and water sports (Figure 1.1).

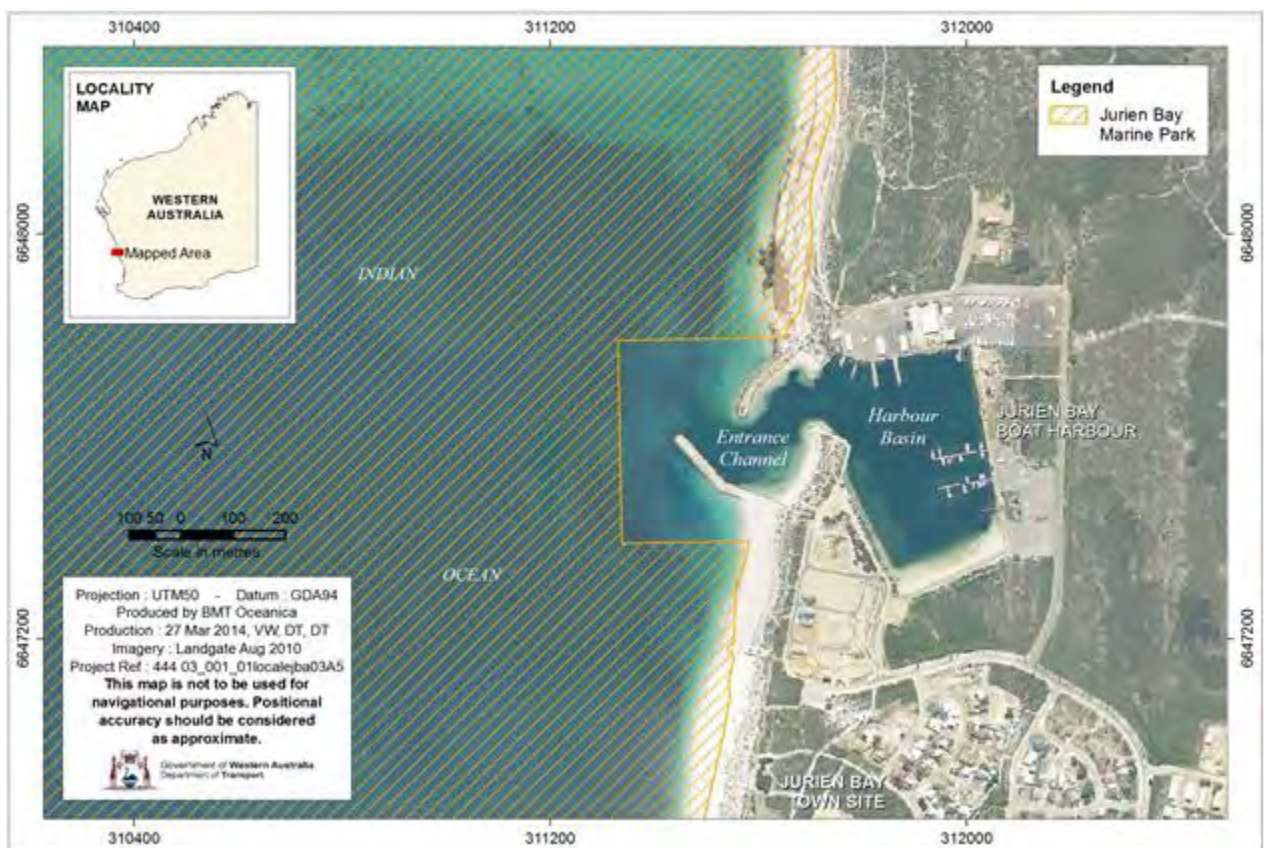


Figure 1.1 Jurien Bay Boat Harbour and surrounding Marine Park, Western Australia

The Boat Harbour lease area is vested with the Minister for Transport under the *Marine and Harbours Act 1981* for 'harbour purposes' and is managed by the WA Department of Transport (DoT). Sediment and wrack (detached seagrass and macroalgae) typically accumulate in the Boat Harbour, more frequently within the entrance channel, affecting navigable depths for safe vessel access. Decomposition of wrack accumulation has occasionally led to deoxygenation in the Boat Harbour waters, resulting in fish kills and odour concerns (BMT Oceanica 2013a).

DoT is required to undertake maintenance dredging for the life of the Boat Harbour under the *Marine and Harbours Act 1981* to maintain navigable depths and reduce sediment and wrack ingress. Maintenance dredging has been completed ~biennially in the last 5 years, with dredge volumes of ~70,000 m³ per campaign. Disposal has typically been onshore within the Boat Harbour

reserve (Figure 4.3), however; this area has limited capacity and DoT propose to dispose future dredged material to an offshore disposal area (Section 2.2). Sediment sampling and analyses was last completed in 2014 and is required prior to future maintenance dredging campaigns to assess potential impacts of dredging and disposal and determine monitoring and management requirements.

1.2 Document purpose

This document outlines the sediment sampling and analysis plan (SAP) to complete Boat Harbour sediment sampling in support of a 10-year sea dumping permit application under the *Environment Protection Sea Dumping Act 1981* (EPSD Act), and future sampling requirements for the permit duration as determined by approval conditions. Sediment investigations within the Boat Harbour are required to adequately characterise the physical and chemical properties of dredge and disposal area sediments. This SAP provides an overview of proposed sampling in-line with requirements of the National Assessment Guidelines for Dredging (NAGD; CA 2009) five phases of assessment for ocean disposal suitability:

- Phase I assessment involves the review of “existing information on the material proposed for ocean disposal, to determine which contaminants need investigation and to assess whether existing information sufficiently characterises the sediments without further testing” (CA 2009; Section 4.3).
- Phase II assessment involves “identifying and investigating the list of contaminants which could be present at elevated levels in the sediments of the dredge area and therefore require analysis” (CA 2009; this document and Sections 5 and 6.4.1).
- Phase III assessment involves elutriate and bioavailability testing (Section 6.4.2).
- Phase IV assessment involves toxicity and bioaccumulation testing (Section 6.4.3).
- Phase V assessment involves weight of evidence assessment (Section 6.4.4).

2. Project Description

2.1 Dredging

The Boat Harbour entrance channel and basin design depths are outlined in Table 2.1 and Figure 2.1. Maintenance dredging campaigns involve the removal of marine sediments and wrack accumulation to restore design depths from discrete areas (Areas A, B, D-F and H-J in Figure 2.1). Accretion of a large volume of marine sands around entrance channel breakwaters may also require maintenance dredging: one area immediately north of the northern breakwater (Areas C and K, Figure 2.1) and another area immediately south of the southern breakwater (Area G; Figure 2.1).

The depth of sediment accretion above design depths varies seasonally and is dependent on the rate of natural siltation; however, the maximum estimated dredging thickness is anticipated ~5 m below the current seabed surface (Table 2.1). Dredge areas, target dredge depths and estimated dredge volumes including over-dredge are shown in Table 2.1. The maximum dredging volume (inclusive of the over-dredge volume) per maintenance campaign is anticipated to be ~210,100 m³ with an estimated duration of 40 weeks (Table 2.1). The dredge volumes are conservative and represent upper estimates for target volumes and areas for the proposed 10-year permit duration and will vary prior to each maintenance campaign depending on siltation rates. It is also unlikely there will be available funding from DoT's state-wide maintenance dredging program to achieve all target areas, volumes and depths in an individual maintenance campaign, and the anticipated volume per campaign are more likely to be ~80,000 m³ based on historical dredging volumes and an anticipated campaign duration of 18 weeks (Table 4.2). Areas within the Boat Harbour that are still at or below the declared design depths will require minimal or no dredging. These areas will be determined from pre-dredge hydrographic surveys prior to each maintenance campaign.

Table 2.1 Target dredge depths and estimated dredge volumes for the proposed Jurien Boat Harbour maintenance dredging campaigns

Dredge area	Target dredge depth (m CD)	Dredge design volume (m ³)	Dredge design and over-dredge (0.3 m) volume (m ³)
A	-5.0	9340	12,120
B	-4.0	5700	8020
CI	-5.0	0	40
CII	-4.0	5880	7250
CIII	-3.0	8350	9340
CIV	-2.0	7390	8210
DI	-3.0	3880	4950
DII	-2.0	3670	4780
E*	-1.0	710	1560
F	-4.0	1100	2490
G*	-3.5	27,360	31,120
H*	-3.5	2810	7380
I*	-3.0	4650	12,970
J*	-2.0	860	3220
K*	Varies	86,050	96,650
Total	N/A	167,750	210,100

Notes:

1. Refer to Figure 2.1 for explanation of dredge areas
2. *= Provisional areas and volumes
3. Volumes are conservative and represent upper estimates within each dredging area and will vary for each maintenance campaign depending on natural siltation rates
4. m = metre, CD = chart datum, m³ = cubic metre, N/A = not applicable

It is anticipated that dredging will be completed with a small cutter suction dredge (CSD). The use of a CSD should limit turbid plumes and sedimentation to the dredge area, though this depends on sediment characteristics and local hydrodynamics (Ports Australia 2014).

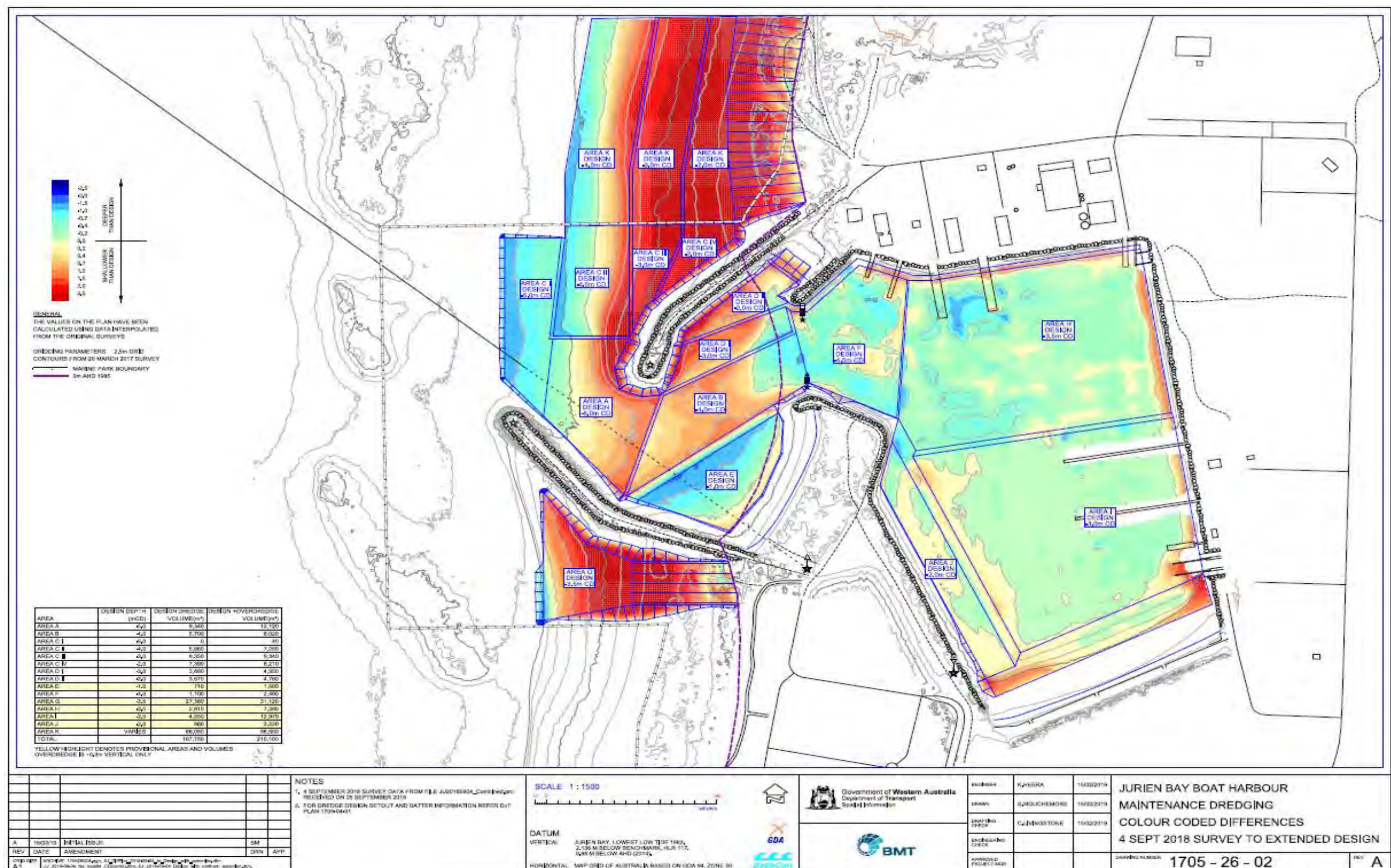


Figure 2.1 Jurien Bay Boat Harbour proposed dredging areas and volumes

2.2 Disposal

For maintenance dredging campaigns it is proposed that marine sediments from the Boat Harbour will be disposed offshore. The proposed offshore disposal area is located ~1 km northwest of the Boat Harbour in ~12 m water depth (Figure 2.2). Dredged material from the Boat Harbour will be hydraulically pumped via floating or submerged pipeline. The offshore disposal area is ~36 ha and has the capacity to receive dredged material from over the next 10 years to a maximum volume of ~1.1 Mm³. The overall depth of the offshore disposal area will be reduced to -8.0 chart datum (CD). The offshore disposal area is in the JBMP (Section 4.1.5) and disposal of material is subject to additional approvals from Department of Biodiversity, Conservations and Attractions (DBCA). Several alternative disposal options have been previously considered for the placement of dredged material for Boat Harbour maintenance campaigns (BMT Oceanica 2017). Offshore placement was prioritised over the onshore alternatives, due to the shorter pumping distance reduced potential for dredged material to be re-distributed back into the Boat Harbour, to retain sediments within the natural marine system, to avoid clearing of onshore native vegetation within the Harbour Reserve (Figure 2.2), and in consideration of the principles of waste avoidance and promotion of resource recovery.

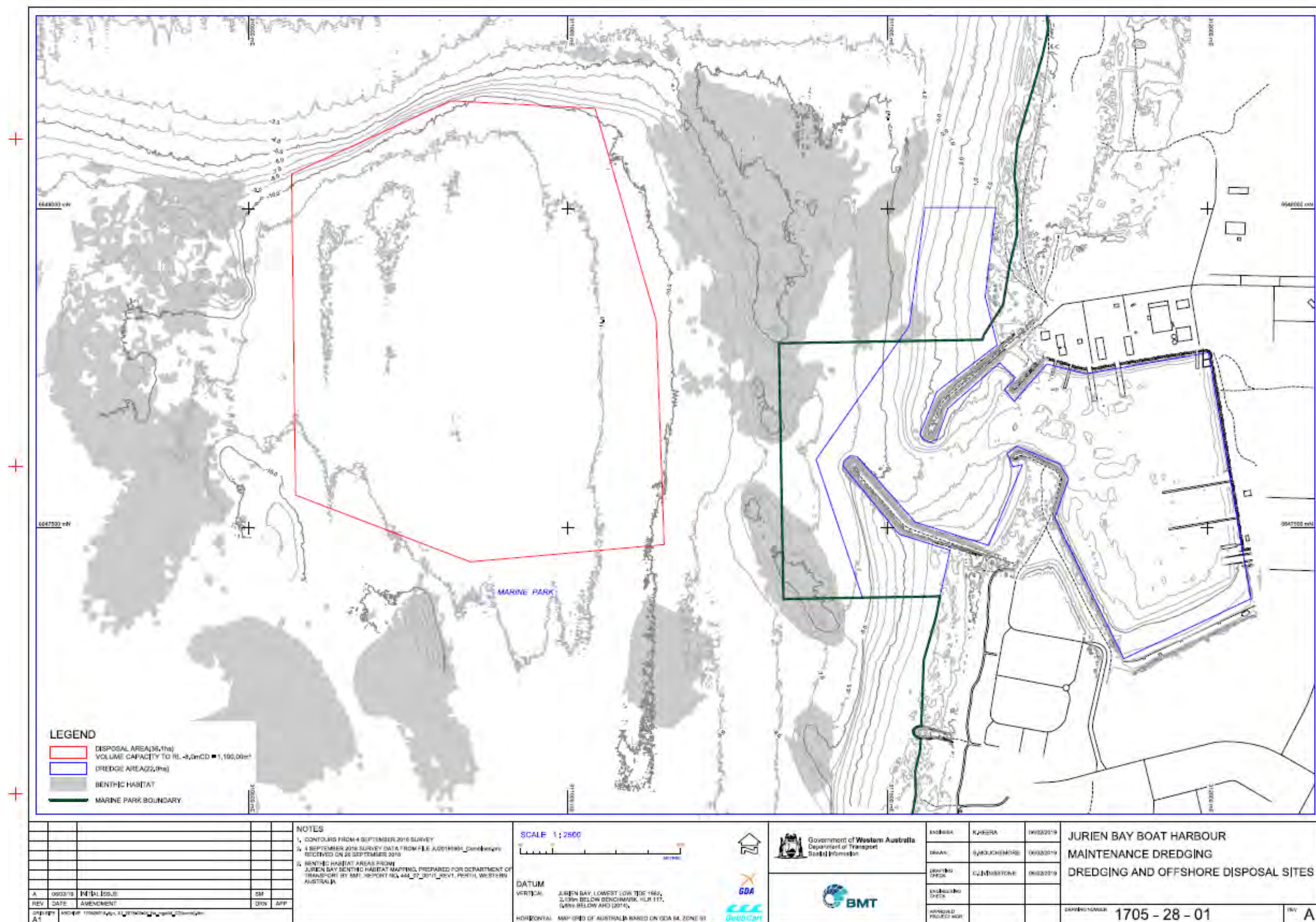


Figure 2.2 Jurien Bay Boat Harbour maintenance campaigns proposed offshore disposal area, underlying benthic habitat and Jurien Bay marine park excision boundary

3. Regulatory Overview

The legislation and guidelines relevant to defining this SAP are detailed in Sections 3.1 to 3.2. Application of other relevant legislation and guidelines with greater consideration to the offshore disposal area occurring within JBMP (Figure 2.2) will be assessed during preparation of a long-term monitoring and management plan (LTMMP). The LTMMP will be submitted with the sea dumping permit application and include the results of proposed sediment sampling outlined herein.

3.1 Environmental Protection (Sea Dumping) Act 1981

The EPSD Act applies to disposal of controlled materials in Australian Waters other than waters within the limits of the State or of the Northern Territory. Department of Energy and Environment (DoEE) assesses environmental impacts, permits proposals to load and dump materials seaward of low water mark to the limits of the Exclusive Economic Zone, and sets conditions of approval to mitigate and manage environmental impacts.

3.1.1 National Assessment Guidelines for Dredging

The NAGD (CA 2009) provides supporting information to the EPSD Act. The regulatory framework set out in the NAGD is applied to ensure the impacts of dredged material loading and disposal are adequately assessed and, if permitted, that impacts are managed responsibly and effectively. The NAGD (CA 2009) sets out methods for:

- evaluating alternatives to ocean disposal
- assessing sediment quality
- assessing dredging and disposal sites
- assessing potential impacts on the marine environment and other users
- determining management and monitoring requirements.

3.1.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Contaminants in sediments that exceed NAGD Screening Levels (CA 2009) require bioavailability and elutriate testing (Section 6.4.2) to assess the bioavailable fractions for uptake by marine organisms, and potential impacts to marine water quality from release of contaminants during dredging and disposal (CA 2009). The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) are applied to assess water quality impacts from physical/chemical stressors and/or toxicants.

Default guidelines values (DGV) for physical and chemical stressors are available for marine geographic regions from regional reference site data in surface and bottom waters. The DGV for toxicants are derived for differing levels of species protection, with the level of protection determined through the current or desired condition of the ecosystem that is assigned. The 99% species protection will be applied to Boat Harbour dredging and disposal given it is proposed to dispose material into JBMP.

3.2 Department of Transport Maintenance Dredging Environmental Management Framework

Department of Transport has an Environmental Management Framework (EMF; BMT 2018a) that provides guidance for environmental management and monitoring of state-wide maintenance dredging operations. The intention of the EMF is to ensure that DoT's maintenance dredging activities are:

- completed with consideration of environmental factors and environmental regulatory requirements

- protection of the environment
- clear, relevant and practical identification of potential environmental impacts
- open engagement with stakeholders
- effective environmental monitoring and management.

The EMF is updated annually, ensuring that best practice environmental management is applied to maintenance dredging. This SAP has been designed and implemented in accordance with the latest revision of the EMF (BMT 2018a) to ensure that the above objectives are achieved.

3.3 Anticipated environmental approvals

Approvals for the Boat Harbour maintenance dredging campaigns are likely to include:

- Sea Dumping Permit under the EPSD Act
- issuance of a lawful authority under the *Conservation and Land Management Act 1984* (CALM Act) through DBCA and with consideration from the Conservation and Parks Commission (CPC)
- possible referral under the *Environmental Protection Act 1986* (EP Act). This will be determined through consultation with Department of Water and Environmental Regulation (DWER)

4. Background Information

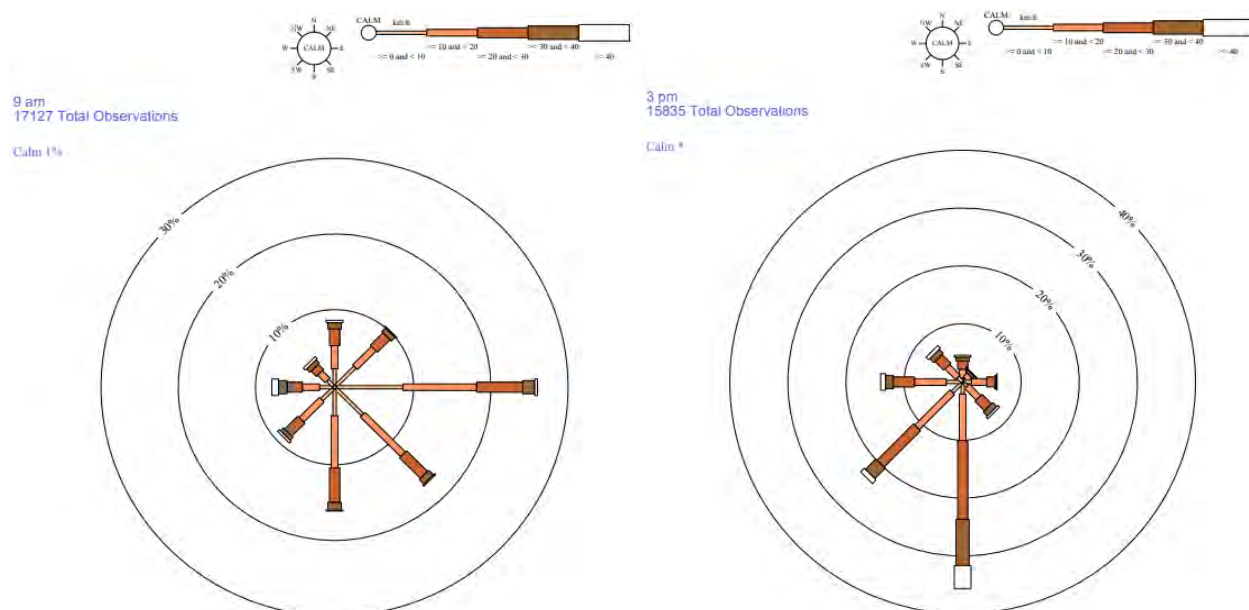
4.1 Physical environment

The Boat Harbour is located within the greater South-West Marine Region, which is divided further into seven bioregions, as defined by the Integrated Marine and Coastal Regionalisation of Australia Version 4.0 (DEWHA 2007). The Southwest Shelf Transition bioregion comprises the continental shelf between Perth in the south and Kalbarri in the north. This bioregion extends from nearshore areas to the edge of the continental shelf, the majority of which is under Commonwealth jurisdiction. With a maximum depth of 200 m, this nearshore bioregion is characterised by a high level of marine biodiversity, including sub-tropical, tropical and temperate marine species (DEWHA 2007).

4.1.1 Climate

Jurien Bay experiences a Mediterranean climate with hot, dry summers and mild, wet winters. During summer, mean monthly temperature ranges between ~16–31°C and during winter between ~9–21°C (BoM 2019). Rainfall in Jurien Bay is highly variable throughout the year, with an annual rainfall average of ~549 mm (BoM 2019). Seasonal rainfall levels range from a maximum monthly average of ~114 mm in July to a minimum monthly average of ~7 mm in December (BoM 2019).

Wind data recorded between 1969 and 2018 indicates that winds are predominantly from the east and south-east in the morning (0900) and from the south and south-west in the afternoon (1500) (BoM 2019; Figure 4.1). Mean annual wind speed was 17.2 and 22.8 km/h at 0900 and 1500 respectively, rarely exceeding 40 km/h (BoM 2019; Figure 4.1).



Source: BoM (2019)

Notes:

1. Wind speed recorded at Jurien bay between 1969 and 2018 at 0900 (left) and 1500 (right)
2. * = calm is <0.5%

Figure 4.1 Jurien Bay wind speed and direction

4.1.2 Geology and geomorphology

The Southwest Shelf Transition bioregion includes a narrow continental shelf (40–80 km wide) that is characterised by complex physical features (DEWHA 2007). Nearshore, eroded limestone reefs and pinnacles form ridges, depressions and inshore lagoons. The inner shelf is a smooth plain with a series of ridges that develop into a tropical reef in the northern area of the bioregion (e.g. Houtman Abrolhos Islands). The greater Gingin-Dandaragan coastline is characterised by Safety

Bay Sand from the Quindalup Dune systems. The coastal areas of the Jurien Bay region consist of curved beaches backed by low dunes. The shoreline in the Jurien Bay area consists of a continuous beach that is more exposed in the north and sheltered in the south (Eliot et al. 2012). Onshore, parabolic dunes in the south migrate north, forming mobile sand sheets with vegetation cover.

Beaches are separated by sand promontories or points, rocky headlands and low limestone cliffs. A series of elongated limestone reefs run parallel to the shore and provide the shoreline with some shelter from offshore waves (Oceanica & JFA 2005). Associated with these reefs are numerous emergent rocks and islands (CALM 2005).

4.1.3 Hydrodynamics

Hydrodynamics of the continental shelf are influenced by the Leeuwin and Capes currents, and seasonal variations in wind regimes (Gallop et al. 2012). The Leeuwin Current drives the offshore currents along the shelf break; whereas coastal currents are mostly wind-driven (DEWHA 2007). The Leeuwin Current is a warm, narrow and shallow current that transports tropical waters southward with low nutrients and salinity levels, predominantly during the Autumn and Winter months (March–August) (Gersbach et al. 1999, DEWHA 2007). The Leeuwin Current forms eddies in several predictable locations in this bioregion, including Jurien Bay. These eddies occur as cross-shelf currents that mix nutrient-rich, deep waters with the shallower water from the continental shelf, thereby enhancing the overall biological productivity for the region.

The Capes Current is a cool, counter-current that flows northward close inshore, resulting in localised upwelling and cooler water on the upper continental shelf (Pearce & Pattiaratchi 1999). In the Southwest Shelf Transition bioregion, the Capes Current also transports temperate species larvae from the southern regions to the northern areas along the inner, nearshore shelf (DEWHA 2007). The Capes Current is present mostly in the summer months (December–February)

Coastal currents are predominantly wind-driven by the strong south-westerly sea breezes occurring each afternoon (DEWHA 2007). This sea breeze system generates winds generally in excess of 50 km/h (Pattiaratchi et al. 1997), thus creating diurnal changes to wave heights, wave periods, nearshore currents and sediment levels and transport (Masselink & Pattiaratchi 1998). Under ambient conditions, the winter wind regime is generally calm and south-westerly, with a weaker sea breeze component. Winter storms (mid-latitude depressions) may generate strong winds, usually from the north-west (Lemme et al. 1999).

4.1.4 Coastal processes

Sand along the Jurien Bay coastline is transported via several coastal processes. Wind influences sand movement in the ocean (with the nearshore waves and currents) and on land, forming transgressive dunes (Ecoscape 2005). In winter, storm events generally transport nearshore sand in a southerly direction; whereas in summer, prevailing winds tend to transport nearshore sand in a northerly direction. In addition, waves and tides generate longshore currents that result in the littoral drift and cross-shelf transport of sand.

Onshore of Jurien Bay, unstable landforms are highly susceptible to changes from weather and metocean processes (Eliot et al. 2012). This coastal risk is evident in exposed beaches, mobile sand sheets and active blowouts in the sand dune complexes. Historically, wind and rainfall changes increased the coastal activity in the area, causing substantial fluctuations in sand dunes and blowouts.

4.1.5 Jurien Bay Marine Park

In 2003, the JBMP was designated a Class A Marine Park under the CALM Act. Located adjacent to the Boat Harbour, the JBMP comprises marine waters between Wedge Island and Green Head, WA. The JBMP's offshore boundary extends to the WA State limit (three nautical miles offshore) and encompasses an area over 82 000 ha (CALM 2005). The Marine Park includes offshore islands that are vested as Class A nature reserves under the CALM Act, as well as sea lion and seabird breeding grounds, seagrass meadows which serve as nursery areas for western rock lobsters and the migratory path of several whale species (CALM 2005). Management of the environment within the JBMP is administered by DBCA, through the JBMP Management Plan (CALM 2005).

4.2 Biological environment

The Southwest Shelf Transition bioregion contains a unique mixture of both tropical and temperate marine species, including a high number of endemic fauna as well as the highest seagrass species diversity globally (DEWHA 2007). In the nearshore areas (<50 m deep), the biological environment is characterised by Australia's largest, continuous limestone reef with numerous rocks and islands creating sheltered environments for diverse mixture of temperate and tropical species of marine flora and fauna (CALM 2005, Eliot et al. 2012).

4.2.1 Benthic communities and habitats

To inform long-term dredging and disposal options, and marine environmental monitoring and management for the Boat Harbour maintenance dredging campaigns, BMT completed benthic habitat mapping of Jurien Bay in November 2017 (BMT 2018b). The specific objectives of the mapping project were to:

- i. collect digital baseline data on the spatial extent and characteristics of benthic habitats in the mapping area, and
- ii. qualitatively characterise the extent of benthic communities and habitat (BCH) surrounding the Boat Harbour and develop a mapping product of suitable quality to meet multiple purposes (including informing dredging operations and potential future environmental approvals applications, if necessary).

A total of 3667.2 ha of BCH were mapped during the project and the following dominant habitat types were identified (Table 4.1):

- bare sand (57.9%),
- sand inundated platform reef with macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.) (18.3%)
- sand inundated platform reef with macroalgae and perennial seagrass (*Amphibolis* spp.) (13.9%)
- reef dominated by macroalgae (6.1%)

Comparatively, a small proportion of mapped benthic habitat is inhabited by mixed perennial seagrass (*Amphibolis* spp. and *Posidonia* spp.; 2.6%) and even less by mono-specific perennial and ephemeral seagrass meadows (~1.0% for *Amphibolis* spp., *Posidonia* spp. and *Halophila* spp. combined). Filter feeders such as corals and sponges within the mapped area represented only a small proportion (0.3%).

The nearshore area north of the Boat Harbour is mostly comprised of a mixed assemblage of macroalgae and perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.) overlying a sand inundated platform reef, extending ~500 m to 1 km offshore (Figure 4.2). South of the Boat

Harbour, benthic habitat is less vegetated and is dominated by mobile sands with small scattered meadows of perennial seagrass (mixed assemblages of *Posidonia* spp. and *Amphibolis* spp. and mono-specific assemblages of *Posidonia* spp.) and ephemeral seagrass (*Halophila* spp.; Figure 4.2). This predominantly sandy area surrounding the Boat Harbour extends ~3 km offshore.

Further offshore, benthic habitat is dominated by a mixed assemblage of macroalgae and perennial seagrass (*Amphibolis* spp.) on sand inundated platform reef (Figure 4.2). Next to the dominant offshore benthic habitat, areas containing a mixed assemblage of macroalgae and mixed perennial seagrass (*Amphibolis* spp. and *Posidonia* spp.) also occur (Figure 4.2). In the north-west offshore region of the mapped area there is an expansive area of reef dominated by macroalgae (Figure 4.2).

Inside the Boat Harbour entrance channel, benthic habitat is predominantly characterised by wrack overlying bare sand. Directly adjacent to the Boat Harbour entrance channel, wrack and sparse meadows of seagrass (*Posidonia* spp.) covered in sand and epiphytic growth by calcareous algae was observed. These seagrass meadows appeared partially dead and flattened on the seafloor, and therefore were classified as wrack for mapping purposes. It is noted that areas of wrack have been classified as bare sand in Figure 4.2.

The selection of a suitable offshore disposal area was based on the findings of the mapping project. The proposed offshore disposal area is described in Section 2.2 and is located over bare sand (Figure 4.2).

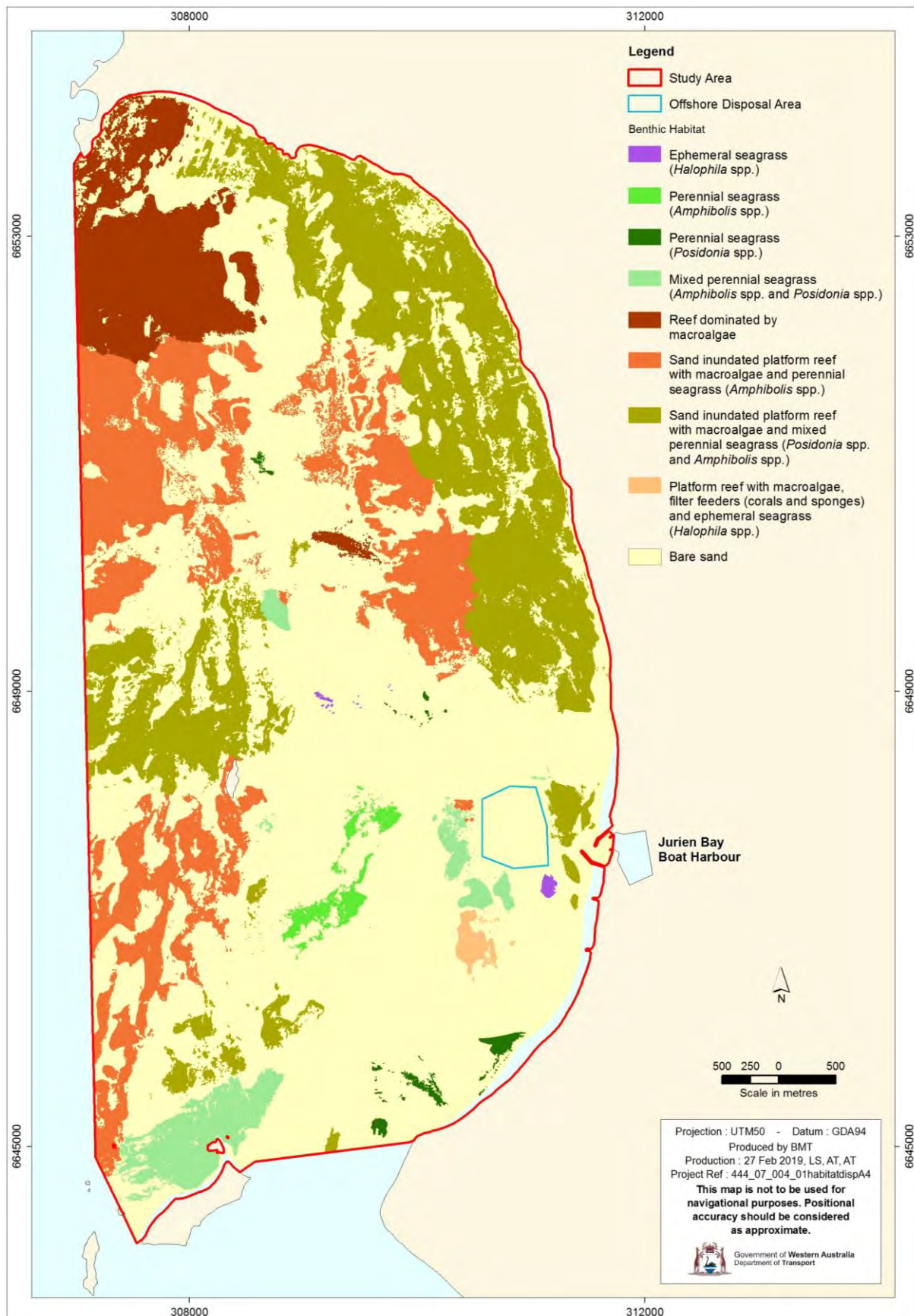
Table 4.1 Area and proportion occupied by benthic habitat categories

Benthic habitat type	Area (ha)	Proportion ¹ (%)
Ephemeral seagrass (<i>Halophila</i> spp.)	2.6	0.1
Perennial seagrass (<i>Amphibolis</i> spp.)	23.4	0.6
Perennial seagrass (<i>Posidonia</i> spp.)	12.2	0.3
Mixed perennial seagrass (<i>Amphibolis</i> spp. and <i>Posidonia</i> spp.)	94.5	2.6
Reef dominated by macroalgae	222.1	6.1
Sand inundated platform reef with macroalgae and perennial seagrass (<i>Amphibolis</i> spp.)	508.2	13.9
Sand inundated platform reef with macroalgae and mixed perennial seagrass (<i>Posidonia</i> spp. and <i>Amphibolis</i> spp.)	670.2	18.3
Platform reef with macroalgae, filter feeders (corals and sponges) and ephemeral seagrass (<i>Halophila</i> spp.)	11.5	0.3
Bare sand	2122.5	57.9
Total	3667.2	100

Source: BMT (2018b)

Note:

1. Percentages do not add up to exactly 100% due to rounding.



Source: BMT (2018b)

Figure 4.2 Classification of Jurien Bay benthic communities and habitat and distribution

4.3 Review of previous sampling and analysis

The proposed disposal area (Figure 2.2) has not been previously sampled, however; the water and sediment of the JBMP are considered pristine (CALM 2005). Boat Harbour sediments have been characterised on several occasions and the results are outlined below.

4.3.1 Sediment sampling and analysis 2005

In 2005, six cores were obtained from within the Boat Harbour entrance channel and one core from within the basin. Sediments were analysed for particle size distribution (PSD), total organic carbon (TOC), total and elutriate nutrients and total metals (Oceanica & JFA 2005). Results showed sediments within the dredge area were comprised of clean medium/fine sands interspersed with decomposing seagrass wrack layers. There was no evidence of acid sulfate soils (ASS; Oceanica & JFA 2005). Sediment PSD showed material was predominantly medium to fine marine sands (83–96%) with some silt (<15%) and clay (<3.0%) and rapid settling velocity (Oceanica & JFA 2005). Total metal results were below relevant ANZECC/ARMCANZ (2000) sediment quality guidelines (Oceanica & JFA 2005). Sediments had low TOC and elutriate nutrient concentrations (where no guidelines were available for comparison) were considered typical for a sandy textured sediment with low TOC. Elutriate ammonia exceeded the relevant ANZECC/ARMCANZ (2000) guideline at one site; however; this was attributable to the decomposing seagrass entrained within the sediments. Elutriate nutrient results were considered over conservative of potential water quality impacts given the dilution within the receiving environment and water to sediment mix during dredging is sufficient to reduce concentrations below relevant guidelines.

4.3.2 Sediment sampling and analysis 2014

In April 2014 seven sites were sampled within the Boat Harbour inner northern breakwater sand trap (BMT Oceanica 2014a). Sediments were analysed for PSD, TOC, total nutrients, organotins, total recoverable hydrocarbons (TRHs), polycyclic aromatic hydrocarbons (PAHs), total and elutriate metals and elutriate hydrogen sulfide (H₂S). Sediments were mostly comprised of medium grained sands, with small amounts of organic material. Particle size distribution results showed sediments were predominantly sands (96–100%), with some silt (<4%), clay (<0.2%) and gravel (<1%) and short settling times (<2.5 minutes for 90% of particles) across all sample sites. All contaminants of potential concern (COPC) were below the NAGD Screening Levels (CA 2009), with the exception of mercury at one site that recorded a low-level exceedance at depth (0.2 mg/kg). Remaining sediment samples within the dredge area tested for mercury were below the laboratory limit of reporting (LoR). Elutriate analysis of mercury at the individual site that exceeded was below the LoR. The results of the sediment sampling are presented in full in the Dredging Environmental Impact Assessment (DEIA; BMT Oceanica 2014a).

Sediments were sampled within the Boat Harbour basin and entrance channel in August 2014 for COPC including total metals, tributyltin (TBT), PAHs, TRHs, ASS and total and elutriate nutrients. All COPC met the relevant NAGD Screening Levels (CA 2009). High concentrations of elutriate nutrients were recorded within the sediment samples that exceeded ANZECC/ARMCANZ (2000) water quality guidelines and were attributed to the decomposing seagrass that accumulates in parts of the Boat Harbour. During dredging monitoring for all maintenance dredging campaigns completed within the Boat Harbour (Table 4.2) have demonstrated there are no observable nutrient related impacts, despite elevated concentrations. This indicates dilution is sufficient within the receiving environment and nutrients within dredged material present a low-risk of causing significant environmental impacts.

Boat Harbour sediments were below the DEC (2013) ASS Action Criteria for all but one sample. The sample exhibited overall net negative acidity following acid base accounting indicating the risk of ASS generation during dredging and disposal is low.

Results from the combined sediment surveys indicate there a low risk of contaminant release during dredging and ocean disposal, and any associated potential impacts to the environment.

4.3.3 Wrack sampling and analysis 2011

In November 2011, wrack trawled from the entrance channel of the Boat Harbour was sampled and analysed for COPC including TOC, total metals, total nutrients, TBT, TRHs, benzene, toluene, ethylbenzene and xylene (BTEX), PAHs and H₂S. There are currently no specific guidelines to assess COPC within wrack, and results were compared to the NAGD Screening Levels for sediment quality (CA 2009). Results were below the NAGD Screening Levels (CA 2009) for all COPC within wrack, except cadmium that recorded a low-level exceedance (1.7 mg/kg), and TPHs. Analysis of TPHs identified both petroleum-based and nonpetroleum-based hydrocarbons, which are typically associated with vegetable and animal products (including oils, sugars and fatty acids). To remove any interference from these nonpetroleum based compounds, a silica gel clean-up of the samples should be performed. It was determined that the laboratory did not perform a silica-gel clean up. It is therefore likely that the TPHs concentration was unlikely to be petroleum-based hydrocarbons, but were organics from biogenic matter instead (BMT Oceanica 2013b).

4.3.4 Wrack sampling and analysis 2014

In April 2014, wrack samples were collected at six sites within the Boat Harbour entrance channel to support a DEIA completed for pre-emptive wrack trawling in 2014 (Section 4.4.3). The results are presented in full in BMT Oceanica (2014a). All wrack samples had a sulfurous odour and COPC (total metals, TBT, TPHs, PAHs, BTEX) were below the NAGD Screening Levels (CA 2009). Wrack samples consisted of mostly *Amphibolis* spp. stems, with some *Posidonia* spp (BMT Oceanica 2014c). Elutriate H₂S and nutrient concentrations within wrack samples were elevated, however; there are no available marine guidelines for comparison to assess potential impacts, and nutrients are naturally elevated in marine flora given the organic constituents (BMT Oceanica 2014a). Dilution within the receiving marine environment was anticipated to reduce nutrient concentrations below relevant guidelines and no impacts were expected given wrack naturally accretes and resuspends from natural processes within the marine system (BMT Oceanica 2014a).

4.4 Historical dredging and disposal

The Boat Harbour design depths and navigability have historically been maintained through operations involving cutter suction dredging, wrack trawling and land-based excavation. Historical maintenance campaigns and volumes are outlined in Table 4.2.

Table 4.2 Historical maintenance dredging campaigns completed at Jurien Bay Boat Harbour

Year	Volume ¹	Comments
2016/17	~62,000	Maintenance dredging and disposal to cleared onshore disposal area
2015	~79,500 ~4700 (wrack)	Maintenance dredging and disposal to cleared onshore disposal area, Wrack trawling
2014	~8500 ~4100 tonnes (wrack)	Sand excavation near Fisheries jetty using land-based plant, wrack trawling
2013	~7100	Wrack trawling
2011	~45 tonnes	Wrack trawling
2005/2006	~41,000	Maintenance dredging and disposal to dunes, wrack disposal options considered
1988	~550,000	Capital construction of the Boat Harbour. Majority of the material removed from the Boat Harbour was re-used for land reclamation in the south and south-east of the Boat Harbour for residential development. A portion of the material was also disposed to the north of the site.

Note:

1. Volume is m³ unless otherwise indicated

4.4.1 Capital dredging

Capital dredging to construct the Boat Harbour was carried out in 1985 and completed in 1986 (Table 4.2). The basin was dry excavated to ~ -3 m CD and the entrance channel to ~-3.5–4 m CD. The harbour entrance was dredged to ~ -5–6 m CD (JFA 2006). Majority of the material removed from the Boat Harbour was placed to the south and south-east of the Boat Harbour for residential development. However, a portion of the material was also disposed north of the site (JFA 2006). The total volume of material removed during the Boat Harbour construction was ~550,000 m³.

4.4.2 Maintenance dredging

Since construction, the Boat Harbour has required several maintenance campaigns (Table 4.2). Dredged material from the 2005/06 campaign was disposed onshore to sand dunes north of the Boat Harbour (and subsequently re-vegetated). Dredged material from the 2015/16 and 2016/17 campaigns was disposed of into cleared areas onshore within the Harbour Reserve (Figure 4.3).

4.4.3 Wrack trawling

Wrack trawling in the Boat Harbour entrance channel has been completed in 2011, 2013 and 2014 (Table 4.2). The 2011 campaign was a trial that involved the removal of ~100 tonnes of wrack (JFA 2012). Prolonged stormy weather conditions in winter 2013 led to substantial wrack ingress into the Boat Harbour and along the nearby beaches. Wrack trapped within the entrance channel led to poor navigability and decomposition resulted in localised fish kills. As a result, emergency trawling works removed ~2000 tonnes of wrack from the Boat Harbour in October/November 2013 (BMT Oceanica 2013b). Similar works were completed in June/July 2014 when 4500 tonnes of wrack was removed pre-emptively to reduce the amount of wrack in the Boat Harbour entrance channel ahead of winter storms.

During each campaign, wrack was removed from the entrance channel using a beam trawl and a heavy-duty net. The wrack was placed within the DoT Harbour Reserve (Figure 4.3) and later used as mulch by local Jurien Bay residents. Minor turbidity was observed during the trawling campaigns, but the turbid plume was not seen to extend beyond the Boat Harbour breakwaters.

4.4.4 Sand excavation

Excavation of sediments adjacent to the Boat Harbour inner northern sand trap was completed in 2014 (Table 4.2). The works involved the removal of ~8500 m³ of material to improve navigability in the entrance channel and allow access to the Boat Harbour jetties. The material was placed on the inner northern sand trap for the construction of the onshore bunded disposal area in the 2014/2015 dredging campaign. Turbidity generated during the sand excavation campaign did not extend beyond the Boat Harbour breakwaters.

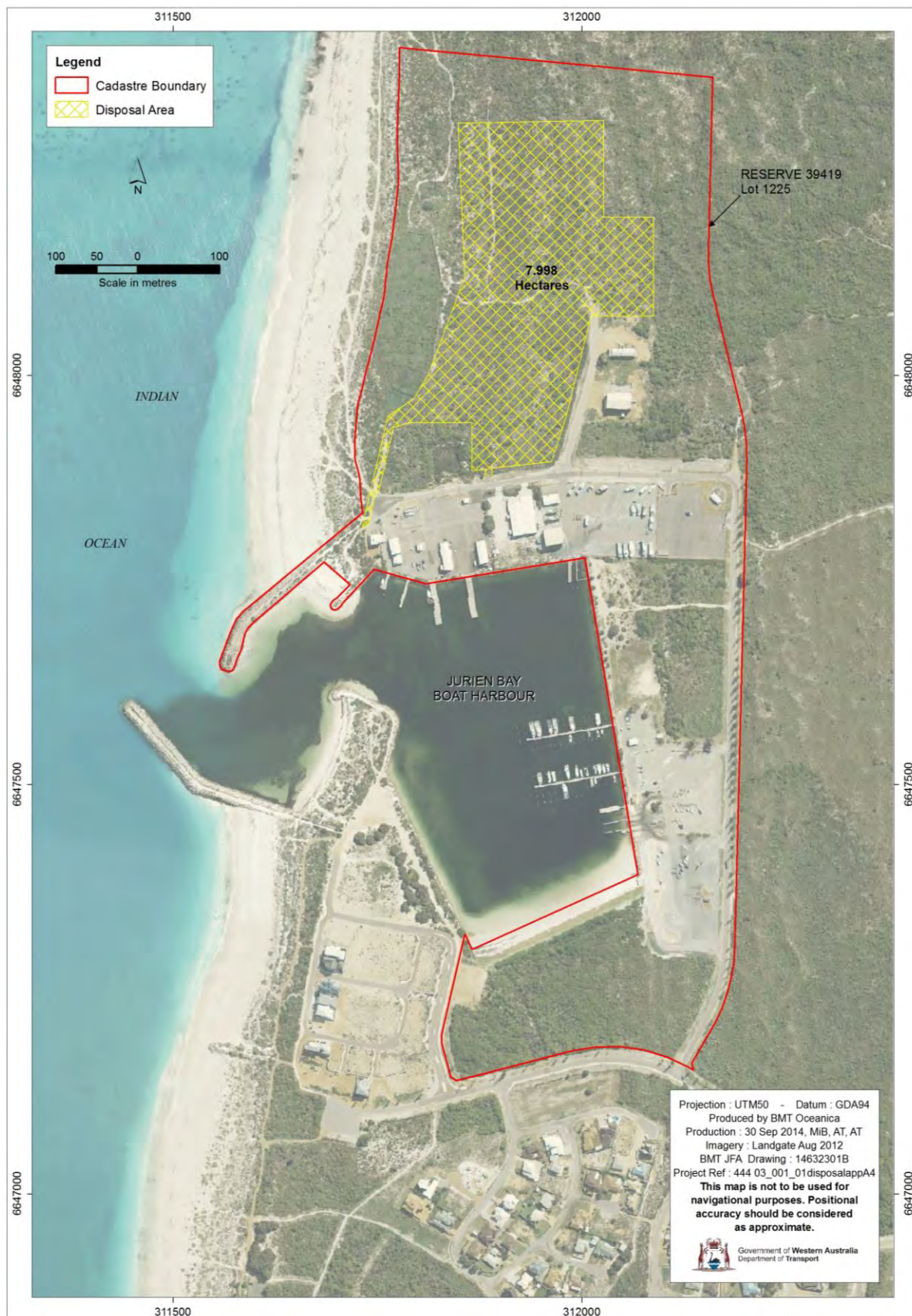


Figure 4.3 Jurien Bay Boat Harbour Reserve and onshore disposal area for the 2014-2017 maintenance dredging campaigns

5. Sampling and Analysis Plan

5.1 Contaminants of potential concern

The Boat Harbour is a small boating facility constructed along an arid stretch of rural coastline. Clean marine sands and wrack are transported into the Boat Harbour from the JBMP via longshore sediment drift processes and typically accrete seasonally around the breakwaters and entrance channel (Figure 1.1). Maintenance dredging is required frequently to remove sediment and wrack accretion to maintain Boat Harbour design depth for navigability.

5.1.1 Dredging

Review of sediment quality data within the last 5 years and combined results from 2005–2014 indicate material within the Boat Harbour is suitable for dredging and ocean disposal (Section 4.3). It is acknowledged results from 2005 and 2014 sampling are older than, or approaching, five years. However; it is considered the results are appropriate for review and selection of potential contaminants in future campaigns for the following reasons:

- the usage patterns of the Boat Harbour have not changed since the 2005 sampling, so the likelihood for significant variation in results is low
- there are no historical contaminated sites that require monitoring and management
- the sampling sites were within the same dredge areas as for the proposed 2014/2015 dredging campaign
- there are no historical reported contaminant spills within the Boat Harbour.

The Boat Harbour is not considered susceptible to potential contamination from agricultural sources such as pesticides, or manufacturing sources such as polychlorinated biphenyls. Organotins were globally banned in 2008 and previous sediment sampling results indicate a low risk of organotin contamination (Section 4.3). Review of DWER (2019) ASS risk area maps relevant to the Boat Harbour location and previous sediment quality data (Section 4.3) indicates the risk of generating ASS during dredging and disposal is unlikely. Therefore, the dredge areas are classified as 'probably clean' for the purposes of sediment sampling based on likely cause effect pathways and review of historical data (Section 4.3). The potential sediment contaminant sources in the dredge area have been reviewed in Table 5.1 and sediments within the dredging area will not be sampled for pesticides, herbicides, organotins and ASS. A reduced analyte suite is proposed, and it is recommended that sediments sampled within the proposed dredge areas be analysed for:

- key metals and metalloids (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc; p.29 CA 2009)
- organics (TPHs, BTEX and PAHs)
- elutriate nutrients – total nitrogen (TN), total phosphorus (TP), ammonia ($\text{NH}_3 + \text{NH}_4$), filterable reactive phosphate (FRP) and nitrate/nitrite (NO_x)¹

Sediments will also be analysed for moisture and TOC for normalisation as a measure of bioavailability for organic contaminants (CA 2009). Samples will be analysed for PSD to estimate plume dispersion and to calculate settling velocity to provide an indication of plume intensity.

¹ There are no guidelines for total nutrients in sediments, therefore only elutriate nutrient concentrations will be analysed to assess potential impacts from nutrient release during dredging and disposal

Table 5.1 Potential sources of contamination risk at Jurien Bay Boat Harbour

Potential sediment contamination	Risk rating	Reason for risk rating	Assessment required (Y/N)
Metals	Medium	Vessels, anti-foulant paints, shipping operations, marine structures made from metals, storm water inputs	Y
Hydrocarbons	Medium	Potential source from refuelling vessels within the dredge areas	Y
Tributyltin (antifoulant paint applied to vessels prior to 2008)	Very Low	Vessels moored in the vicinity of the dredge area but not detected in sediment quality results (Section 4.3). Given the global ban in 2008, the risk of organotin contamination is considered low.	N
Pesticides/herbicides	Very Low	No river catchment run-off near the dredge area and 2014 sediment quality results indicate low risk of contamination.	N
Elutriate nutrients (leading to eutrophication)	Low	Sediment quality results from 2014 showed elevated concentrations of elutriate nutrients likely from high wrack content within the Boat Harbour. It is considered dilution is sufficient within the dredging and disposal areas and the risk of potential eutrophication impacts are considered low based on results from historical monitoring and management. Given the previous elevated concentrations, elutriate nutrients will be risk assessed.	N
Acid sulfate soils	Very Low	Sediment quality results from 2014 (Section 4.3) showed the risk of acid generation during dredging and disposal is unlikely. The dredging and disposal areas are not located in an ASS risk area (DWER 2019) or within a high-risk environment (e.g. near a riverine/estuarine environments). The dredging method will also limit aerial exposure of dredged material.	N

5.1.2 Disposal

The proposed offshore disposal area (Figure 2.2) is located within JBMP and a Maximum Level of Ecological Protection (MLEP) and requires activities to be managed to ensure no changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota. There are no surrounding land uses or likely cause effect pathways with potential contaminant source inputs. A reduced analyte suite is proposed for the offshore disposal area and sediments will be sampled for PSD to inform plume dispersion, TOC and a basic metal suite should alternative disposal options be required.

5.2 Sampling design and rationale

5.2.1 Sampling design

The maximum dredging volume for an individual maintenance campaign is ~210 100 m³ (inclusive of over-dredge; Table 2.1) and the total cumulative dredge volume is expected to be ~1.1 Mm³ over the proposed 10-year permit duration (Section 2). As the proposed dredging volume for an individual campaign is less than 500 000 m³ and the distribution of potential contaminants is likely to be uniform, the entire dredging area has been treated as a single site (CA 2009).

In accordance with the NAGD (Table 2.1; CA 2009), a minimum of 29 sites are required to be sampled in the dredge areas. Given material is classified as 'probably clean' for the purposes of sediment sampling based on recent good quality data, sample numbers will be halved to 15 sites

as per the NAGD (CA 2009; Section 4.3). The sampling numbers are developed from individual campaign volumes given the low risk of contamination (Section 4.3), frequency of maintenance dredging, and commitment to re-sample the Boat Harbour five years into the permit duration.

There is a low risk of potential contamination within the offshore disposal area (Section 5.1.2). In accordance with the NAGD (CA 2009), seven sites will be sampled within the proposed offshore disposal area to establish ambient baseline concentrations (metals and TOC) for comparison of data between dredge and disposal area sediments, assess plume dispersion from PSD data, and provide results for assessment of alternative disposal options, if required (Section 4.3). A drop camera will be used to re-assess habitat characteristics within the disposal area since the completion of the Jurien Bay benthic habitat survey in 2018 (BMT 2018b).

5.2.2 Sampling sites

Sediment sampling sites have been randomly distributed throughout the dredging and disposal area footprints using ArcGIS 10 software (Figure 5.1). Some sites were manually re-positioned to ensure adequate sample depth and coverage, and adjacent to areas with the highest risk of potential contaminants. The coordinates of the proposed sediment sampling sites are listed in Table 5.2. Quality assurance and quality control (QA/QC) samples as described in NAGD (CA 2009) and Section 5.2.4 will be collected as required during the field survey.

5.2.3 Sampling depth

Boat Harbour sediments are considered to be relatively well mixed, given the moderate to high levels of vessel activity and frequency of maintenance dredging campaigns (Section 5.2.1). Sediments within the Boat Harbour are considered representative of clean marine sands accumulated between maintenance campaigns, and previous results have demonstrated there was no contamination at depth in high risk areas (Section 4.3). As sediments are long-term accumulators of contaminants, it is not anticipated that recent accretion of marine sands between maintenance campaigns will present a contamination risk in surface layers or at depth. Therefore, a grab sampler, which collects the surface ~20 cm of sediment is considered appropriate to collect representative samples within the Boat Harbour.

Surface layer sediments within the proposed dredging and disposal areas will be sampled at each site listed in Table 5.2.

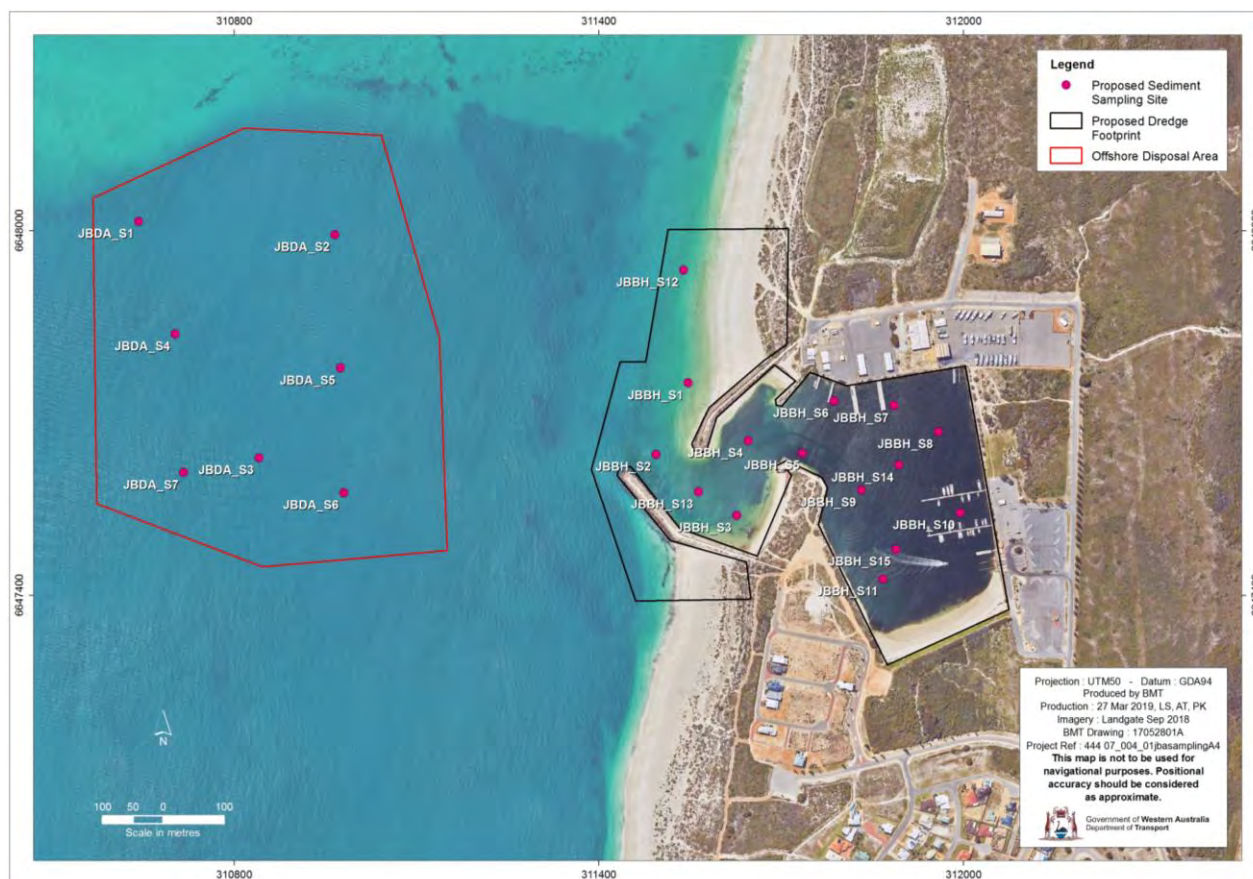


Figure 5.1 Proposed sediment sampling locations within the Jurien Bay Boat Harbour dredge areas

Table 5.2 Proposed site coordinates and target sampling depths within the Jurien Bay Boat Harbour and the offshore disposal site

Sediment sampling site ¹	Sampling area	Coordinates (UTM51 GDA94)		Target sampling depth (m)
		Easting	Northing	
JBBH_S1	Dredge area	311547	6647749	0.2
JBBH_S2*		311494	6647632	0.2
JBBH_S3		311627	6647531	0.2
JBBH_S4		311646	6647654	0.2
JBBH_S5		311734	6647634	0.2
JBBH_S6*		311787	6647720	0.2
JBBH_S7		311886	6647712	0.2
JBBH_S8		311958	6647669	0.2
JBBH_S9		311832	6647574	0.2
JBBH_S10*		311995	6647536	0.2
JBBH_S11		311867	6647427	0.2
JBBH_S12		311540	6647935	0.2
JBBH_S13		311564	6647570	0.2
JBBH_S14		311894	6647614	0.2
JBBH_S15		311889	6647476	0.2
JBDA_S1	Disposal area	310643	6648015	0.2
JBDA_S2		310966	6647993	0.2
JBDA_S3		310841	6647626	0.2
JBDA_S4		310703	6647830	0.2

JBDA_S5		310975	6647774	0.2
JBDA_S6		310980	6647569	0.2
JBDA_S7		310717	6647602	0.2

Notes:

1. Refer to Figure 5.1 for sediment sampling site locations
2. JBBH = Jurien Bay Boat Harbour, JBDA = Jurien Bay Disposal Area
3. * = QA/QC sampling sites

5.2.4 Sampling QA/QC

The NAGD (CA 2009) recommends two types of QA/QC samples:

- Triplicate: at 10% of sampling sites, three separate grabs shall be taken at the same sampling site, to determine the variability of the physical and chemical sediment characteristics at the scale of sampling.
- Split sample: at 5% of sampling sites, the samples shall be thoroughly mixed then split into three containers to assess laboratory variation, with two of the three samples analysed at the primary laboratory (intra-laboratory splits) and the third sample analysed by a reference laboratory (inter-laboratory split).

One rinsate blank will be completed for each item of reused equipment per day to assess decontamination among samples meets relevant data quality objectives (Section 6.3.6).

For the proposed sampling design (Section 5.2.1), two triplicate sample (sites JBBH_S6 and JBBH_S10) and one split sample (site JBBH_S2) will be collected. Analysis for PSD will be completed on the triplicate sample, but not on the split sample.

A total of 15 samples will be analysed from the proposed dredging area (Table 5.3). A further seven samples will be collected from the disposal area (Table 5.3). Six QA/QC samples will be collected (in addition to primary samples; Table 5.3).

Table 5.3 Proposed number of samples to be analysed at Jurien Bay Boat Harbour dredging and disposal areas

Sampling area	Total number of samples collected
Dredging area	15
Disposal area	7
QA/QC	6
Total	28

5.3 Field operations and procedures

The field procedures used during the sampling are consistent with NAGD (CA 2009) and are detailed in the following sections.

5.3.1 Health and safety

Prior to the commencement of the field survey, a Field Plan and a Job Hazard Analysis (JHA) shall be completed to identify and address the workplace health and safety associated with the survey. All field personnel shall be required to review and sign the Field Plan and JHA.

There is a low risk of personal injury from the use of the sampling equipment. Similarly, the sediments to be sampled are considered to pose little risk to the health of field personnel. Decon 90 (a detergent) will be used in the field for cleaning sampling equipment among sites. No other chemicals will be used in the field. Decon 90 is a biodegradable concentrate that combines anionic

and non-anionic surface active agents with stabilising agents, alkalis and non-phosphate detergent builders to produce a highly effective cleaning compound. Nitrile gloves will be worn by personnel involved in the handling of sediments and appropriate personal protection equipment (PPE) will be worn by all field personnel.

5.3.2 Equipment and personnel

Two personnel are required to complete the sediment sampling during a two-day field campaign. No diving or snorkelling is required, and sediment sample collection will be vessel based within the dredging and disposal areas using a grab sampler. The following equipment will be used during the sampling program:

- 2 x hand-held geographical positioning system (GPS) units
- vessel GPS
- Van Veen grab
- rinsed sample containers provided by the laboratory
- ziplock bags
- Munsell soil colour chart and scale bar
- eskies and ice bricks
- inert nitrile gloves
- pyrex glass bowls
- white plastic spoons
- Decon 90
- plastic tubs and brushes for washing
- digital camera
- drop camera
- field and sediment logs
- chain of custody (CoC) forms
- JHA
- daily operations reports
- first aid kit
- PPE (steel-cap boots, sunglasses, sunscreen, long trousers, long-sleeved high-visibility shirts, wide-brimmed hats and gloves)
- field mobile phone
- electrical tape
- permanent markers
- waterproof pens
- spare batteries for camera and GPS.

5.3.3 Contingency

In the event of delays due to bad weather or critical equipment failure, sampling will be continued as soon as safely possible. In case of extended delays, any samples already collected will be submitted to the laboratory for testing rather than being held until the completion of the entire sampling program. Any deviation from the procedures outlined in this document will be noted in the implementation report, and records of sample delivery to the laboratories will be filed and supplied on request.

The recommended sample holding times, storage and transport, as defined within the NAGD (CA 2009; Section 5.3.8), will be adhered to.

5.3.4 Sediment collection

A hand-held GPS will be used to locate the proposed sediment sampling sites (Figure 5.1). The 'actual' location of each site will be recorded on the GPS (accuracy ± 5 m) to mark and confirm the sampled location. Actual sediment sampling locations will be recorded with a GPS unit for presentation in the implementation report.

Sediment samples from the dredge and disposal areas will be collected using a Van Veen grab to a depth of ~ 0.2 m. One grab sample will be collected from most sampling sites, with three grabs collected from the triplicate sampling site (Table 5.2). A drop camera will be used to confirm the habitat at the disposal area (Section 5.2.1).

5.3.5 Seawater collection

Approximately 20 L of seawater will be collected for elutriate analysis (if required). The seawater will be collected on the last day of sampling and as close to transportation time as possible to ensure it arrives at the laboratory as soon as possible after sampling. Local seawater from Jurien Bay will be collected from an area away from potential sources of contamination and turbidity.

5.3.6 Sample processing and labelling

Each sample will be placed directly into a glass bowl. Before placing the sediment into laboratory sample containers, the following data and metadata will be entered onto a field log:

- date and time of sampling
- sampling site number
- sample identifier (ID)
- coordinates of each location at which samples are taken (recorded on a GPS)
- identity of personnel
- water depth of sampling location
- sediment characteristics including Munsell colour, texture, angularity, odour, sediment type, grain size, presence of foreign material, organics and shell fragments
- local weather conditions at time of sampling, such as tides, swells and currents
- a photograph of each sediment sample

At each site following collection sediment grabs will be photographed and sediment descriptions recorded. Samples for volatile substances (TPH, PAH and BTEX) will be collected immediately into the appropriate vials directly from the grab to limit the exposure of volatiles. The remaining sample will be homogenised within a Pyrex glass bowl using a plastic spoon until the colour and texture is uniform. The mixing of the sample will be limited to avoid oxygenation of the sample. An appropriate volume will be collected for each analyte as described in Section 5.3.8 and placed into the appropriate sample containers provided by the laboratory. Excess sediment will be disposed on-site at the time of sampling. Sampling equipment will be cleaned with Decon 90 and rinsed thoroughly with clean seawater between each sampling site.

All sample containers will be clearly labelled in two locations with a unique ID, the date of collection, and the BMT project number. A field sediment inventory log will also be kept to ensure that each sample can be identified, and a photograph of each field log will be taken as a back-up, as often as required. The field log will record:

- date of sampling
- sampler
- sampling location and GPS coordinates
- sample containers collected.

5.3.7 Cross-contamination control

To avoid cross-contamination between sampling at the individual sites, all sampling equipment will be washed in Decon 90 after each sampling site and rinsed with fresh seawater. One rinsate blank will be collected for each item of reused equipment per day to assess decontamination among samples. Field personnel handling the samples will wear a pair of inert gloves, changing these between sample collection at each site.

5.3.8 Sample storage and transport

The recommended sample volumes and sample container types for each analyte are outlined in Table 5.4, along with preservation techniques and storage conditions. Glass pre-cleaned sample containers will be used to store sediments other than PSD samples, which will be stored in double Ziploc bags. The samples will be kept in an esky with ice until they can be transported to a refrigerator or freezer on completion of the day's sampling. The samples will remain in storage until transported to the laboratories in eskies with ice blocks to ensure that the samples remain cool.

Table 5.4 Recommended volumes, preservation, storage and holding times for sediment samples and analytes

Analyte	Typical sample size	Sample container	Preservation technique	Storage condition	Storage holding time ¹	Reference
Metals	400 ml ²	Pre-cleaned glass jar with Teflon-lined lid	Refrigerate (or freezer for extended storage) ⁴	≤4°C	6 months (Hg 28 days unless frozen)	CA (2009)
Moisture ³	50 ml		Refrigerate (or freezer for extended storage)	<6°C	14 days	NEPC (2013)
Total organic carbon	50 ml		Refrigerate (or freezer for extended storage)	<6°C	28 days, unless frozen	NEPC (2013)
Elutriate nutrients ⁴	100 ml		Refrigerate	<4°C	14 days	CA (2009)
Organics (TPHs, PAHs, BTEX)	250 ml ²	Solvent-rinsed glass jar with Teflon-lined lid, filled with zero headspace	Refrigeration	≤4°C, in the dark	14 days if refrigerated	CA (2009)
Elutriate seawater ⁴	1 L per sample	White plastic drums	Refrigerate	4°C, in the dark	14 days	CA (2009)
Particle size distribution	200 ml	Ziploc bag or equivalent resealable plastic bag	Refrigerate	<4°C	Undetermined	CA (2009)

Notes:

- Represents holding time prior to sample extraction by the laboratory, extract holding times also apply
- Includes sample for whole sediment, elutriate and bioavailable analysis
- No holding time applies for moisture content if the results are used for dry weight reporting and performed on the same day as the chemical analytes of interest
- Sediments for elutriate analysis cannot be frozen and have a holding time of 14 days
- ml millilitre, L = litre, ≤ = less than or equal to, C° = degrees celsius, metals = arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc elutriate nutrients = total nitrogen, total phosphorus, ammonia/ammonium, filterable reactive phosphate, nitrate/nitrite, TPHs = total petroleum hydrocarbons, PAHs = polycyclic aromatic hydrocarbons, BTEX = benzene, toluene, ethylbenzene, xylene

5.3.9 Chain of custody forms

A detailed CoC form will be prepared and will accompany samples to designated laboratories. The CoC forms allow tracking of individual samples, ensure correct analysis and storage, and that the recommended holding times are being adhered to, where possible. The CoC forms must be signed by the laboratories on receipt of the sample and returned to BMT. The CoC forms will include:

- place of sampling
- sample site ID, client name and BMT project number
- sampling date
- requested analysis
- sample storage request
- appropriate PPE requirements for sample handling
- sample transport details including date of dispatch.

6. Analysis Plan

6.1 Laboratory analysis and quality assurance, quality control

In recognition of the low-risk of contamination within sediments (Section 4.3), a risk-based approach has been adopted in selecting analytes within the dredge and disposal areas for analyses based on likely contaminant cause effect pathways (Table 5.1). The sediment samples from the proposed dredging and disposal areas will therefore be tested for a range of different analytes (Table 6.1) based on the COPC from review of historical data and recent facility usage (Section 4.3).

Table 6.1 Selected analyte analysis plan for Jurien Bay Boat Harbour dredging and disposal areas

Area	Site	Metals	Elutriate nutrients	TOC ⁴	TRHs	PAHs	BTEX	PSD ⁴
Dredge areas	JBBH_S1	✓	✓	✓	✓	✓	✓	✓
	JBBH_S2	✓	✓	✓	✓	✓	✓	✓
	JBBH_S3	✓	✓	✓	✓	✓	✓	✓
	JBBH_S4	✓	✓	✓	✓	✓	✓	✓
	JBBH_S5	✓	✓	✓	✓	✓	✓	✓
	JBBH_S6	✓	✓	✓	✓	✓	✓	✓
	JBBH_S7	✓	✓	✓	✓	✓	✓	✓
	JBBH_S8	✓	✓	✓	✓	✓	✓	✓
	JBBH_S9	✓	✓	✓	✓	✓	✓	✓
	JBBH_S10	✓	✓	✓	✓	✓	✓	✓
	JBBH_S11	✓	✓	✓	✓	✓	✓	✓
	JBBH_S12	✓	✓	✓	✓	✓	✓	✓
	JBBH_S13	✓	✓	✓	✓	✓	✓	✓
	JBBH_S14	✓	✓	✓	✓	✓	✓	✓
	JBBH_S15	✓	✓	✓	✓	✓	✓	✓
Disposal area ⁴	JBDA_S1	✓		✓	✓	✓	✓	✓
	JBDA_S2	✓		✓	✓	✓	✓	✓
	JBDA_S3	✓		✓	✓	✓	✓	✓
	JBDA_S4	✓		✓	✓	✓	✓	✓
	JBDA_S5	✓		✓	✓	✓	✓	✓
	JBDA_S6	✓		✓	✓	✓	✓	✓
	JBDA_S7	✓		✓	✓	✓	✓	✓
QA/QC	Triplicate	✓	✓	✓	✓	✓	✓	✓
	Split	✓	✓	✓	✓	✓	✓	

Notes:

1. Refer to Figure 5.1 for sediments sampling site locations
2. JBBH = Jurien Bay Boat Harbour, JBDA = Jurien Bay Disposal Area
3. Elutriate nutrients = total nitrogen, total phosphorus, ammonia/ammonium, filterable reactive phosphorus and nitrate/nitrite, metals = arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, TOC = total organic carbon, TRHs = total recoverable hydrocarbons, PAHs = poly-aromatic hydrocarbons, BTEX = benzene, toluene, ethylbenzene and xylene, CEC = cation exchange capacity, PSD = particle size distribution
4. Analysis required for normalisation as a measure of bioavailability for organic contaminants

6.1.1 Dredging areas sample analysis

All sediment samples within the dredge areas will be analysed for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc), elutriate nutrients (total nitrogen, total phosphorus, ammonia/ammonium, filterable reactive phosphorus and nitrate/nitrite), TOC, hydrocarbons

(PAHs, TPHs, BTEX) and PSD in recognition of the low-risk of contamination and the likely COPC (Section 4.3; Table 6.1). The PSD data will assess plume dispersion and calculate particle settling times to provide an indication of potential turbidity generated from dredging and disposal. TOC will provide a measure of contaminant mobility within the sediment for assessment against the NAGD (CA 2009)

6.1.2 Disposal area sample analysis

There is a low risk of contamination at the offshore disposal area and sediment samples will be analysed for PSD to inform plume dispersion, TOC and a metal suite (Section 5.1.2).

6.1.3 Analysis laboratories

It is proposed² that Australian Laboratory Services (ALS) will be the primary laboratory for chemical analysis of sediment samples and ChemCentre will be the reference laboratory for chemical analysis. Murdoch University's Marine and Freshwater Research Laboratory (MAFRL) will complete PSD analysis; no reference laboratory is required for PSD analysis. Limits of reporting of laboratories used in this study are listed and compared to practical quantitation limits (PQL) in Table 6.2. There are no relevant guidelines for BTEX and the primary samples will be analysed to the required PQL.

Samples will be consigned using CoC forms to the laboratories for analysis. As part of their procedures, both the primary laboratory and the reference laboratory will test blanks, spikes and standards and complete laboratory duplicates as required by the NAGD (CA 2009) and to the satisfaction of the National Association of Testing Authorities requirements.

Table 6.2 Practical quantitation limits and limits of reporting for analysis laboratories and relevant contaminants concern with Jurien Bay dredging and disposal areas

Parameter (mg/kg)		PQL	NAGD Screening Level ¹	ALS	ChemCentre	MAFRL	PQL limit met
Arsenic		1	20	1	0.2	n/a	Y
Cadmium		0.5	1.5	0.1	0.05	n/a	Y
Chromium		1	80	1	0.05	n/a	Y
Copper		1	65	1	0.1	n/a	Y
Lead		1	50	1	0.5	n/a	Y
Mercury		0.01	0.15	0.01	0.01	n/a	Y
Nickel		1	21	1	0.1	n/a	Y
Zinc		1	200	1	0.25	n/a	Y
TPH	C ₆ –C ₉	n/a	n/a	3	25	Y	n/a
	C ₁₀ –C ₁₄	n/a	n/a	3	50	Y	n/a
	>C ₁₅ –C ₂₈	n/a	n/a	3	50	Y	n/a
	>C ₁₆ –C ₃₅ (aromatics)	n/a	n/a	90	200	Y	n/a
	>C ₁₆ –C ₃₅ (aliphatics)	n/a	n/a	100	100	Y	n/a
	> C ₃₅ (aliphatics)	n/a	n/a	100	100	Y	n/a
	C ₂₉ –C ₃₆	n/a	n/a	5	n/a	Y	n/a

² Analysis laboratories will be NATA accredited and subject to change

Parameter (mg/kg)		PQL	NAGD Screening Level ¹	ALS	ChemCentre	MAFRL	PQL limit met
	Total	n/a	550	–	n/a	Y	n/a
BTEX		0.2	n/a	0.2	0.2	n/a	Y
PAHs		0.005	10 000	0.004–0.005	0.005	n/a	Y
Elutriate nutrients (mg/L)		n/a	n/a	0.005–0.05	0.005–0.01	n/a	n/a
Moisture content (%)		0.1	n/a	0.03	0.1	n/a	Y
Total organic carbon (%)		0.1	n/a	0.02	0.05	n/a	Y
Particle size distribution (unit as stated)		Size distribution and rates of settlement after 50% and 90% of settlement	Size distribution and rates of settlement after 50% and 90% of settlement	n/a	n/a	Wet sieving (>106 µm), and laser diffraction (106–0.3 µm)	Y

Note:

1. National Assessment Guidelines for Dredging (CA 2009) PQL = practical quantitation limit, ALS = Australian Laboratory Services, MAFRL = Marine and Freshwater Research Laboratory, TPH = total petroleum hydrocarbons, BTEX = benzene, toluene, ethylnzene, xylene, PAH = polycyclic aromatic hydrocarbons, elutriate nutrients = total nitrogen, total phosphorus, ammonia/ammonium, filterable reactive phosphorus and nitrate/nitrite n/a = not applicable, Y = yes, N = no, – = not supplied

6.2 Proposed laboratory analytical methods

6.2.1 Metals

Whole sediment

Analytical methods for total metals will consist of a strong acid digest and then analysing for metals with either Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) or Graphite Furnace Atomic Absorption Spectrometry (GF-AAS) (mercury only) by both ALS and ChemCentre laboratories.

Elutriate

Elutriate testing will be conducted by shaking a representative sediment sample with four times the volume of seawater (ratio of 1:4). Samples will be placed on an end-over-end-shaker at room temperature for 30 minutes and then allowed to settle for 1 hour. The supernatant will be centrifuged at 3000 revolutions per minute for 3 minutes and then filtered through 0.45 µm disposable syringe filters. Ultra trace metal analysis will be performed with an Agilent 770 x ICP-MS (Inductively Coupled Plasma – Mass Spectrometry) to achieve the lowest reporting levels possible. The elutriate water will also be tested as a blank by the same methods and subtracted from the elutriate test results.

6.2.2 Total recoverable hydrocarbons and benzene, toluene, ethylbenzene and xylene

Sediment extraction will be completed using a dichloromethane/hexane solution. The extract will be analysed via gas chromatography – mass spectrometry. The method follows the United States Environmental Protection Authority (USEPA) methods (5030A, 8020, 8000A and 8260).

6.2.3 Polycyclic aromatic hydrocarbons

Sediment will be extracted with dichloromethane/acetone solution and injected into a gas chromatograph with detection by a mass selective detector (USEPA method 8270).

6.2.4 Elutriate nutrients

Elutriate testing is carried out by shaking a representative sediment sample with four times the volume of seawater (ratio of 1:4). Samples are placed on an end-over-end shaker at room temperature for 30 minutes and then allowed to settle for 1 hour. The supernatant is centrifuged at 3000 rpm for 3 min and then filtered through 0.45 µm disposable syringe filters. The filtered supernatant is measured for dissolved nutrients using the following methods: filterable reactive phosphorus analysed by the ascorbic acid method; nitrate and nitrite by copper-cadmium reduction; and ammonium by the alkaline phenate method. All nutrient analyses are carried out using a Lachat Quick-Chem 8500 Automated Flow Injection Analyser. The elutriate water is also tested as a blank by the same methods and subtracted from the elutriate test results.

6.2.5 Total organic carbon

Total organic carbon (TOC) will be determined from a sample pre-treated with acid to remove inorganic carbon (IC) (carbonates and bicarbonates). The residue is filtered, washed and collected on a glass fibre filter. The filter with residue is placed into a crucible and is dried in an oven at 40°C for several hours. The organic carbon (OC) in the dried sample in the crucible is determined using a total carbon analyser. The dissolved organic carbon (DOC) in the acid solution is determined using ICP-AES after purging to remove any dissolved inorganic carbon (carbon dioxide). The final TOC result will be the sum of the OC in the solid residue and the DOC in the solution.

6.2.6 Particle size distribution

Sediment samples will be analysed for PSD by laser diffraction to categorise particle sizes between 0.02 and 500 µm. The particle size distribution for particles >500 µm will be measured by wet sieving. Particle size fractions will be reported to the Wentworth (1922) scale (Table 6.3).

Table 6.3 Wentworth scale particle size fractions

Size class	Particle size (µm)
Clay	<4
Fine silt	4–16
Medium silt	16–31
Course silt	31–62
Fine sand	62–250
Medium sand	250–500
Coarse sand	500–2000
Pebbles/Cobbles/Boulders	>2000

6.3 Data analysis

6.3.1 Particle settling times

The PSD data from samples in the proposed dredging and disposal areas (Figure 5.1) will be used to inform plume dispersion and calculate particle settling times to give an indication of the turbidity duration during dredging and disposal. Information on the method used to calculate particle settling times is provided in Section 6.2.6. Particle settling times will be calculated using Stoke's Law, which estimates the particle settling velocity based on the diameter and density of the particles. The settling velocities will then be used to estimate the time taken for sediment to settle through 1 m of water. Settling times will not be calculated for sediment samples that are >45% silt and clay as Stoke's Law is not applicable for material with this high a proportion of fine sediment.

6.3.2 Normalisation

As TOC is the main binding constituent for organic substances in marine sediments, the NAGD (CA 2009) requires organics (e.g. TPHs, BTEX, PAHs) to be normalised to 1% TOC for comparison with the NAGD Screening Levels (CA 2009). Normalisation is only appropriate over a TOC range of 0.2–10%. For TOC <0.2% or TOC >10%, the maximum and minimum values of 0.2 and 10% TOC will be used for normalisation, respectively. In accordance with the NAGD, if the organic data are below LoR, half the LoR value will be used for normalisation purposes (CA 2009).

6.3.3 Calculation of 95% upper confidence limit

Concentrations of contaminants in sediment samples will be compared to the NAGD Screening Levels and Sediment Quality Guideline High Values (CA 2009). Comparison of sediment contaminant concentrations to the NAGD Screening Levels requires calculation of the 95% Upper Confidence Limit (UCL) of the mean (CA 2009). The data will firstly be tested for normality using the software ProUCL 4.0 (USEPA 2007). This software determines the most appropriate method for calculating the 95% UCL depending on the distribution of the data and the size of the dataset, including the proportion of values below the LoR (which introduce statistical complexities into the analysis). These may include parametric (such as Student's t-UCL) or nonparametric (such as bootstrap) methods. A 95% UCL will then be calculated if there are enough replicate sediment samples.

The 95% UCL of the mean will not be calculated when more than 25% of the contaminant concentration data are below the LoR (Section 6.3.4). This is because bias can be introduced if a large proportion of data are below the LoR, leading to under-estimation of contamination at certain sites.

6.3.4 Analysis of analyte concentrations below the limit of reporting

Analyte concentrations that are too low to be detected using laboratory methods will be recorded as below the LoR. Generally, half the laboratory LoR value will be used as a substitute for data below the LoR, in accordance with the NAGD (CA 2009). However, a large proportion of the data below the LoR has the capacity to bias subsequent analyses. USEPA (2007) does not consider a 95% UCL of the mean calculated based upon few detected values to be reliable. Therefore, where the data contain values below the LoR, the following protocol will be applied (based on ANZECC & ARMCANZ 2000):

- Where >25% of values are below the LoR, descriptive statistics (means and percentiles) or inferential analysis (including the calculation of confidence limits) will not be calculated. Instead, individual results will be compared to the triggers and discussed accordingly.
- Where ≤25% but >0% of values are below the LoR, confidence limits will be calculated via two methods; once using the normalised estimate based on half the LoR as the replacement value and once using zero as a replacement value. This will then inform the interpretation of the results, in particular, whether the choice of replacement value affects the outcome of the analysis.

6.3.5 Quality assurance and quality control assessment

The results of the field QA/QC sampling will be analysed as described in the NAGD (CA 2009) by calculating the Relative Percent Difference (RPD) between two samples, and Relative Standard Deviation (RSD) between three samples. The results should agree within an RPD or RSD of ±50%, although the NAGD (CA 2009) notes that this may not always be the case where the sediments are very heterogeneous.

6.3.6 Data management procedures

All data will be validated prior to reporting (Appendix A). Data will be checked for completeness and compared against the submitted CoC forms delivered to the laboratories. Data will be analysed for outliers and these will be processed as per page 35 of NAGD (CA 2009). All laboratory reports will be included in appendices to the SAP implementation report. This will include laboratory QA/QC data (blanks, laboratory duplicates, and spikes) and all original data received. All original field sediment grab log sheets will also be put in appendices along with appropriate photographs.

6.3.7 Systems

The data management system has the following components:

- procedures for recording results of analysis and field observations
- procedures for systematic screening and validation of data
- secure storage of information
- a data retrieval system
- data analysis protocols
- flexibility to accommodate additional information, e.g. metadata.

6.3.8 Data entry protocols

Appropriate protocols for entering data will be implemented to reduce error in data entry:

- Templates for standardising datasheet formats (sediment field log, method statement) that are provided to field staff prior to sampling to ensure all information required will be collected.
- Data are electronically transferred to the database where possible to prevent transcription errors.
- The collector(s) of the data to ensure that only correct and validated data are provided to the database manager for uploading into the database.

6.3.9 Responsibility for data management

A dedicated geographical information system (GIS) and Environmental Data Management (EDM) team are responsible for producing maps and managing spatial data, to ensure adherence to data management protocols and accurate mapping. The EDM team adhere to a QA/QC protocol, and any changes to the data and/or the database are appropriately implemented and tracked.

6.3.10 Archive and back-up data

Archives of all original data files and associated metadata are maintained for future reference. This includes archiving of:

- raw data sheets from field and laboratory measurements and analyses
- electronic copies of verified data files prior to uploading into the database.

Regular backing up of the monitoring database occurs so that data are not lost in the case of system or file failures.

6.4 Assessment of dredged material for ocean disposal

The suitability of the dredge material for unconfined ocean disposal will be determined by following the procedure as outlined within Figure 3 (p.12) of the NAGD (CA 2009).

6.4.1 Phase II assessment

The 95% UCL for COPC will be calculated for sediment samples, unless there are instances where the sample size is insufficient (i.e. $n \leq 6$), to yield statically robust results. In such cases, individual site data will be compared to NAGD Screening Levels (CA 2009).

Further sample analysis

If results for all analytes from each distinct sediment layer (sampling increment) fall below the NAGD Screening Levels (CA 2009), no further testing will be undertaken and the material in that area will be considered suitable for unconfined ocean disposal. Results may also be compared to ambient baseline levels for sediments of comparable grain size, as per NAGD (CA 2009). If contaminant concentrations are found to be dissimilar to the concentrations occurring at the disposal area, then further sampling and testing will be required.

6.4.2 Phase III assessment

If contaminant concentrations still exceed NAGD Screening Levels (CA 2009), then elutriate and bioavailability analysis of the relevant analyte will be completed on samples collected at the site that exceeded the guideline to: 1) simulate the potential release of contaminants from the sediment during dredging and disposal; and 2) determine the bioavailability of the contaminant (CA 2009). If the bioavailable concentrations³ still exceed relevant guidelines toxicity and bioaccumulation testing may be considered (as described in Section 4.2.3 of the NAGD; CA 2009). This will be done in consultation with the determining authority (DoEE).

Elutriate testing

If concentrations of metals are above the relevant NAGD Screening Levels (CA 2009) elutriate testing of the relevant sediment samples will be completed within 14 days to meet recommended holding times (Section 5.3.8). Given there are no guidelines for total nutrients in marine sediments, only elutriate nutrients will be analysed to assess potential eutrophication impacts. Selecting the samples from the sites that have exceeded the NAGD Screening Levels is consistent with the NAGD (CA 2009) protocols whereby a defined sub-area can be selected if the most contaminated locations are captured. The sites that have exceeded the NAGD Screening Levels (CA 2009) are assumed to be the most contaminated.

Elutriate testing will be undertaken at a dilution ratio of 1:4 (CA 2009; p. 40). The results of the 1:4 dilutions will be compared directly with ANZG (2018) or ANZECC/ARMCANZ (2000)⁴ water quality trigger values for 99% species protection, with concentrations below the trigger values considered unlikely to adversely impact benthic organisms. If an exceedance occurs, the laboratory will apply a correction factor to the concentrations measured from the 1:4 dilution extraction, since this ratio greatly overestimates concentrations that will be present within the water column following disposal (NAGD; p. 40). These correction factors will be calculated using initial dilution estimations based on disposal method and oceanographic data (where available). The corrected concentrations will then be compared against ANZG (2018) trigger values for 99% species protection marine water quality.

Bioavailability testing

If concentrations of metals are above the relevant NAGD Screening Levels (CA 2009) bioavailable testing of the relevant sediment samples will be completed within 14 days to meet recommended holding times (Section 5.3.8). Further bioavailability testing of metals will be completed using a dilute acid extraction to estimate the bioavailable fraction. The bioavailable concentration (95% UCL) will then be compared to the NAGD Screening Levels (CA 2009) and, if exceeded, ecotoxicity

³ Elutriate results may be used to estimate bioavailable concentrations where pore water samples can't be obtained (NAGD; CA 2009).

⁴ Where guidelines for nutrients are not available in the revised ANZG (2018), ANZECC/ARMCANZ (2000) guidelines will be applied.

testing may then be implemented or alternative design and/or disposal methods may be investigated.

6.4.3 Phase IV assessment

Toxicity

If elutriate concentrations of contaminants are below the ANZG (2018) water quality guidelines, but the bioavailable fractions are above relevant criteria, toxicity testing is required. Toxicity and bioaccumulation testing will require fresh representative sediment samples to be collected. Acute and chronic toxicity and bioaccumulation testing will be undertaken in accordance with the NAGD (CA 2009) in consultation with the determining authority (DoEE).

Bioaccumulation

If contaminants of concern prove to be bioavailable, a desktop study of the bioaccumulation potential will be undertaken for those contaminants. If a specific contaminant is identified as bioavailable and having a potential to bioaccumulate, a bioaccumulation study may be undertaken.

6.4.4 Phase V assessment

A Phase V 'weight-of-evidence' assessment will only be necessary if further testing is inconclusive. If necessary, all relevant data will be assessed, including field results/ecology, chemistry (bioavailability and desorption), laboratory ecotoxicity and bioaccumulation, to compile information to assist determination of the suitability for ocean disposal.

7. References

- ANZECC, ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1: The Guidelines. 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. Available from www.waterquality.gov.au/anz-guidelines [Accessed 17 February 2019]
- BMT (2018a) Department of Transport Maintenance Dredging – Environmental Management Framework. Prepared for Department of Transport by BMT Western Australia Pty Ltd, Report No. 1368_00_001/1_Rev1, Perth, Western Australia, February 2018
- BMT (2018b) Jurien Bay Benthic Habitat Mapping. Prepared for Department of Transport by BMT Western Australia Pty Ltd, Report No. 444_07_001/1_Rev1, Perth, Western Australia, March 2018
- BMT Oceanica (2013a) Jurien Bay Boat Harbour Wrack and Water Quality Management. Discussion Paper prepared for Department of Transport by BMT Oceanica Pty Ltd, Perth, Western Australia, November 2013
- BMT Oceanica (2013b) Jurien Bay Boat Harbour Emergency Wrack Removal – Environmental Impact Assessment. Prepared for the Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd. Report No 444_02_001/1_Rev0, Perth, Western Australia, November 2013
- BMT Oceanica (2014a) Jurien Bay Sediment Dredging and Wrack Trawling – Environmental Impact Assessment. Prepared for the Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd. Report No 444_03_002/2_Rev0, Perth, Western Australia, May 2014
- BMT Oceanica (2014b) Jurien Bay Boat Harbour – Dredging Environmental Impact Assessment. Prepared for Department of Transport and BMT JFA Consultants Pty Ltd by BMT Oceanica Pty Ltd, Report No. 444_03_001/2_Rev1, Perth, Western Australia, December 2014
- BMT Oceanica (2014c) Wrack Species Identification and Percent Composition at Jurien Bay Boat Harbour – Memorandum. Prepared for the Department of Transport, by BMT Oceanica Pty Ltd, Perth, Western Australia, August 2014
- BMT Oceanica (2015) Jurien Bay Boat Harbour – Synthesis of Available Information and Assessment of Processes Leading to Periods of Low Oxygen and Fish Kills. Prepared for Department of Transport by BMT Oceanica Pty Ltd, Report No. 444_03_003/1_Rev1, Perth, Western Australia, June 2015
- BMT Oceanica (2017) Jurien Bay Long Term Disposal Options Approvals Pathways – Internal Memorandum. Prepared for Department of Transport by BMT Oceanica Pty Ltd, Perth, Western Australia, May 2017
- BoM (2019) Climate Statistics for Australian Locations. Bureau of Meteorology, Canberra, Australian Capital Territory. Available at http://www.bom.gov.au/climate/averages/tables/cw_009131.shtml [Accessed 19 February 2019]
- CA (2009) National Assessment Guidelines for Dredging. Commonwealth of Australia, Canberra, ACT

- CALM (2005) Jurien Bay Marine Park Management Plan 2005–2015. Management Plan Number 49. Department of Conservation and Land Management, Government of Western Australia, Perth, Western Australia
- DEC (2013) Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes: Acid Sulfate Soils Guideline Series. Department of Environment and Conservation, Perth, Western Australia, March 2013
- DEWHA (2007) The South-west Marine Bioregional Plan – Bioregional Profile. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra, Australian Capital Territory
- DWER (2019) Acid Sulfate Soil Risk Map, Geraldton (DWER-051) Available from https://catalogue.data.wa.gov.au/dataset/acid-sulfate-soil-risk-map-geraldton-dwer-051/resource/1a429748-3910-3a25-856c-744311741709?view_id=13a89436-a1f6-45c6-9ad8-1ec3022b6be2 [Accessed 12 February 2019]
- Ecoscape (2005) Lancelin foreshore land-use and management plan. Prepared by Ecoscape (Australia) Pty Ltd for the Shire of Gingin, North Fremantle, WA, June 2005
- Eliot I, Gozzard JR, Eliot M, Stul T, McCormack G (2012) The Coast of the Shires of Gingin and Dandaragan, Western Australia: Geology, Geomorphology and Vulnerability. Prepared by Damara WA Pty Ltd and Geological Survey of Western Australia for the Department of Planning and Department of Transport, Perth, Western Australia, March 2012
- Gallop SL, Verspecht F, Pattiaratchi CB (2012) Sea breezes drive currents on their inner continental shelf off southwest Western Australia. *Ocean Dynamics* 62:569–583
- Gersbach GH, Pattiaratchi CB, Ivey GN, Cresswell GR (1999) Upwelling on the south-west coast of Australia – source of the Capes Current? *Continental Shelf Research* 19:363–400
- JFA (2006) Jurien Boat Harbour maintenance dredging 2005–2006 contract closeout report. Prepared for the Department for Planning and Infrastructure, Government of Western Australia by JFA Consultants Pty Ltd, Perth, Western Australia, January 2006
- JFA (2012) 2011 Jurien Bay Boat Harbour Weed Trawling Trial – Closeout Report 2011 Session. Prepared for the Department of Transport by JFA Consultants Pty Ltd, Perth, Western Australia, January 2012
- Lemme AJ, Hegge BJ, Masselink G (1999) Offshore wave climate, Perth (Western Australia), 1994–96. *Marine and Freshwater Review* 50:95–102
- Masselink G, Pattiaratchi C (1998) The effect of sea breeze on beach morphology, surf zone hydrodynamics and sediment resuspension. *Marine Geology* 146:115–135
- NEPC (2013) National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) National Environment Protection Council, 2013
- Oceanica, JFA (2005) Maintenance Dredging Jurien Boat Harbour Environmental Impact Assessment. Prepared for the Department for Planning & Infrastructure by Oceanica Consulting Pty Ltd and JFA Consultants Pty Ltd, Report No 444/01, Perth, Western Australia, June 2005
- Pattiaratchi C, Hegge B, Gould J, Eliot I (1997) Impact of sea-breeze activity on nearshore and foreshore processes in southwestern Australia. *Continental Shelf Research* 17:1539–1560
- Pearce AF, Pattiaratchi CB (1999) The Capes Current: A summer countercurrent flowing past Cape Leeuwin and Cape Naturaliste, Western Australia. *Continental Shelf Research* 19:401–420
- Ports Australia (2014) Dredging and Australian Ports: Subtropical and Tropical Ports. Prepared by Ports Australia, Sydney, New South Wales, April 2014

USEPA (2007) ProUCL version 4.0. Available from <<http://www.epa.gov/esd/tsc/software.htm>>.
United States Environmental Protection Authority

Appendix A

Data Validation

Table 1 Field Data Quality Indicators

Indicator	Frequency	Acceptance Criteria
PRECISION (a quantitative measure of the data variability)		
Sampling methodologies	All samples	Appropriate and complied with
Intra-lab duplicates/splits	5% of samples	<+/- 50% RPD*
Inter-lab duplicates/splits	5% of samples	<+/- 50% RPD*
Trip blanks/spikes (volatiles only)	1 per sampling	<= LOR for blanks, as per lab spec for spikes
ACCURACY (a quantitative measure of the closeness of reported data to the true value)		
Collection of rinsate blanks for re-used sampling or subsampling equipment	Where equipment re-used, one sample per day per item of equipment	CoCs below detection limit
Sampling methodologies	All samples	Appropriate and complied with
REPRESENTATIVENESS (qualitative confidence that data obtained are representative of each sampled medium)		
Sampling, subsampling, sample handling and storage appropriate for the history and contamination status of the sediments, the study objectives and the media/analytes	All media & all analytes	All samples collected and handled according to SAQP
COMPARABILITY (qualitative confidence that data collected in separate sampling events is equivalent)		
SAQP for sample collection, subsampling and handling. Same methods used each day; same types of samples collected	All samples	All samples collected and handled in accordance with SAQP, by experienced professionals
COMPLETENESS (the amount of useable data, as a % of total data collected. Goal is 95% or more valid data)		
Chain-of-Custody forms (COCs), sample descriptions and sample location data complete	All samples	All samples
All critical locations sampled; all samples collected	All samples	All samples collected & analysed according to SAQP
Completeness objective met (ie percentage of data suitable for use, 95% of all data)	All data	Minimum 95% of all data on submitted samples validated as suitable for use
Methodologies	All samples	Sampling in accordance with NEPM, 2011 and/or NAGD, 2009, and other relevant standards for marine sampling, as appropriate

* Contaminant concentrations become increasingly uncertain as they approach the method detection limit, and therefore DQOs may not be met for analytical values close to LORs. Laboratories often use the following approach (or a variation of it) to assess replicates:

- Result < 5 times the LOR – no limit to RPD or RSD.
- Result > 5 times the LOR – RPD or RSD should be <= 50%.

Table 2 Laboratory Data Quality Indicators

Objective	Frequency	Acceptance Criteria
PRECISION (a quantitative measure of the data variability)		
Lab duplicates (separate subsamples from jar, not aliquot splits)	1 per batch or 20 samples	<5 x LOR = no limit on RPD. >5 x LOR = 0-50% RPD *
ACCURACY (a quantitative measure of the closeness of reported data to the true value)		
Matrix spikes	1 per lab batch or 20 samples	Recovery 70% - 130% for inorganics/metals, 60-140% for organics, or as per lab requirement## RPDs should be less than 35%
Matrix spike duplicates	1 per lab batch or 20 samples	
Surrogate spikes	All organic analyses	Recovery 70% - 130% for inorganics/metals, 60-140% for organics, or as for lab requirement##
Lab method and reagent blanks	1 each per batch	<= LOR
Control samples	1 per lab batch or 20 samples	Recovery 70% - 130% or as for lab requirement##
Analysis of CRMs (for metals) or in-house standards certified against CRMs	All sediment metal analyses, 1 per batch	<+/- 35% RPD, recovery 70% - 130% or as per lab requirement
REPRESENTATIVENESS (qualitative confidence that data obtained are representative of each medium sampled)		
Sample handling and storage appropriate for media/analytes	All media, all analytes	All samples
Holding times (HTs)	All samples	All samples extracted and analysed within HTs
COMPARABILITY (qualitative confidence that data collected in separate sampling events can be directly compared)		
Standard analysis methods	All samples	All samples subsampled, extracted/digested & analysed at NATA-certified labs, by standard methods
LORs consistent between labs and batches	All samples	All samples
LORs met for all analytes**@	All samples	All samples
Outliers and inter-lab discrepancies resolved	Affected samples	Affected samples re-extracted and analysed in replicate.
COMPLETENESS (the amount of useable data, as a % of total data collected – minimum of 95%)		
All critical locations sampled, all required samples collected, and all samples analysed according to this SAQP	All samples	All required data obtained
Chain-of-Custody forms (COCs), field logs, sample descriptions and sample location data complete	All samples	All samples
Samples received at laboratory as specified on COC forms	All samples	All bottles and jars received and unbroken, seals intact and samples cool
QC samples sufficient, and acceptable results	All QC/QAs	100%
SENSITIVITY (ability of analysis methods to reliably determine the analytes at lowest environmental concentrations)		
Analysis methods and LORs appropriate for media, expected background levels of analytes and adopted site assessment criteria	All media, all analytes	All samples
SECONDARY DATA (quality assessment of any pre-existing data to be used in this project)		
All secondary data	All pre-existing data	Establish DQIs and assess data quality

Certain inhomogeneous samples, eg fine, clayey or organic-rich sediments, samples through mangrove root zones, algal mats etc, as well as samples for analysis of volatiles and semi-volatiles, must not be homogenised in the field prior to subsampling. Therefore, sample replicates are distinct samples rather than splits. Such replicates may not meet this DQI.

Lower recoveries may be recorded for some semi-volatile organics, such as phenols. Recoveries may also be lower, and the spread wider, on some sediments and soils due to matrix interference from high water content, high salinity, plant waxes, sterols, lipids etc.

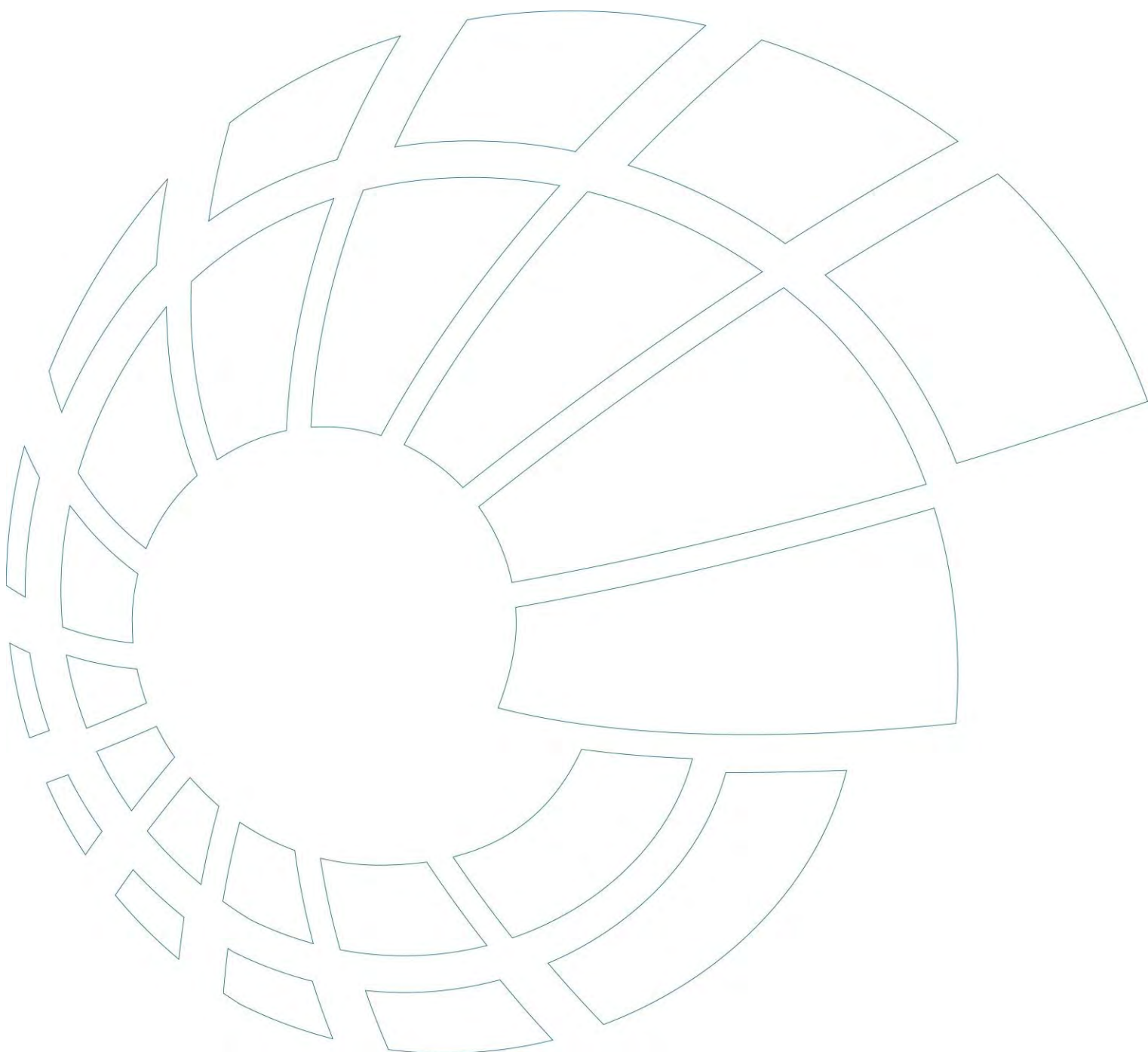
* Contaminant concentrations become increasingly uncertain as they approach the method detection limit. Criteria:

- Result < 5 times the LOR – no limit to RPD or RSD.
- Result > 5 times the LOR – RPD or RSD should be $\leq 50\%$ (or $\leq 35\%$ for lab replicates).

** Occasionally, matrix effects may prevent this. Any such incidences must be documented by lab.



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Appendix C Jurien Bay Boat Harbour Sediment Sampling and Analysis Plan 2019 Implementation Report



Jurien Bay Boat Harbour – Long-term Maintenance Dredging Sediment Sampling and Analysis Plan Implementation Report

R-1454_01-2

June 2019



Document Control Sheet

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Quality Assurance



BMT Western Australia Pty Ltd has prepared this report in accordance with our Integrated Management System, in compliance with OHSAS18001, ISO14001 and ISO9001

Status

This report is 'Draft' until approved for final release by the Project Director (or their authorised delegate) as indicated below by signature. A Draft report may be issued for review with intent to generate a 'Final' version but must not be used for any other purpose.

Approved for final release:



Project Director
Date: 25 June 2019

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List of Abbreviations and Terms

ALS	Australian Laboratory Services
ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand
BTEX	Benzene, toluene, ethylbenzene and xylene
CA	Commonwealth of Australia
CEC	Cation exchange capacity
cm	Centimetre
DER	Department of Environment Regulation
DoT	Western Australian Department of Transport
EILs	Ecological Investigation Levels
EMF	Department of Transport's Maintenance Dredging – Environmental Management Framework
ESLs	Ecological Screening Levels
EPSD Act	<i>Environment Protection Sea Dumping Act 1981</i>
FRP	Filterable reactive phosphorus
g	Gram
GDA	Geodetic Centre of Australia
GIS	Geographical information systems
HILs	Health Investigation Levels
LoR	Limit of reporting
LTMMP	Long-term Monitoring and Management Plan
m	Metre
MAFRL	Murdoch University's Marine and Freshwater Research Laboratory
mEq	Moles of electric charge
mg/kg	Milligrams per kilogram
NAGD	National Assessment Guidelines for Dredging
NATA	National Association of Testing Authorities
NEPC	National Environmental Protection Council
NO _x	Nitrate+nitrite
PAHs	Polycyclic aromatic hydrocarbons

PSD	Particle size distribution
QA/QC	Quality assurance and quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SAP	Sampling and analysis plan
TOC	Total organic carbon
TKN	Total kjeldahl nitrogen
TN	Total nitrogen
TP	Total phosphorus
TPHs	Total petroleum hydrocarbons
TRHs	Total recoverable hydrocarbons
UCL	Upper confidence limit
µg/L	Micrograms per litre
µm	Micrometre
USEPA	United States Environmental Protection Agency
UTM	Universal trans-mercator

1 Sampling and Analysis

1.1 Sampling methods

Sediments from Jurien Bay Boat Harbour (hereafter; the Boat Harbour) were sampled 16–17 April 2019. The purpose of the sediment sampling was to adequately characterise the physical and chemical properties of proposed dredge and disposal area sediments to:

1. Support a 10-year Sea Dumping Permit application under the *Environment Protection Sea Dumping Act 1981* (EPSD Act), and future sampling requirements for the permit duration as determined by approval conditions.
2. Inform a Long-term Monitoring and Management Plan (LTMMMP) for maintenance dredging at the Boat Harbour over the period 2019–2029, to be submitted with the Sea Dumping Permit application; LTMMMPs are a statutory requirement for the issue of a long-term Sea Dumping Permit under the EPSD Act.

Sampling methods were in-line with the requirements of the National Assessment Guidelines for Dredging (NAGD; CA 2009) and Department of Transport's (DoT) Maintenance Dredging – Environmental Management Framework (EMF; BMT 2018a). These methods are detailed the approved sediment sampling and analysis plan (SAP; BMT 2019).

Surface sediment samples were collected from 15 sites within the proposed dredge area and from seven sites within the proposed offshore disposal area (Table 1.1; Figure 1.1). For further detail on sampling design and rationale, refer to the SAP (BMT 2019).

Surface sediment samples were also collected from three sites onshore (Table 1.1; Figure 1.1). It is noted that the results of sampling and analysis of sediments from the onshore area have been included in this report but are not relevant for assessing offshore disposal of dredge area sediments for future Boat Harbour maintenance dredging campaigns.

All sampling sites were randomly distributed throughout the relevant areas, as required by NAGD (CA 2009), using ArcGIS 10 software. The coordinates of the sediment sampling sites are listed in Table 1.1.

It is noted that drop camera imagery to re-assess habitat characteristics within the offshore disposal area since the completion of the Jurien Bay benthic habitat survey in 2018 (BMT 2018b), as stipulated in the SAP (BMT 2019), was unable to be completed due to unfavourable weather conditions.

Table 1.1 Sediment sampling site coordinates and target sampling depths within the Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Site ¹	Sampling area ¹	Coordinates (UTM51; GDA94)		Target sampling depth (m)
		Easting	Northing	
JBBH_S1	Dredge area	311663	6647812	0.2
JBBH_S2*		311553	6647626	0.2
JBBH_S3		311623	6647531	0.2
JBBH_S4		311605	6647685	0.2
JBBH_S5		311727	6647625	0.2
JBBH_S6*		311779	6647714	0.2
JBBH_S7		311886	6647712	0.2
JBBH_S8		311974	6647712	0.2
JBBH_S9		311827	6647579	0.2
JBBH_S10*		312024	6647471	0.2
JBBH_S11		311873	6647429	0.2
JBBH_S12		311654	6647907	0.2
JBBH_S13		311568	6647509	0.2
JBBH_S14		311896	6647615	0.2
JBBH_S15		311895	6647486	0.2
JBDA_S1	Offshore disposal area	310641	6648017	0.2
JBDA_S2		310969	6648003	0.2
JBDA_S3		310847	6647627	0.2
JBDA_S4		310691	6647826	0.2
JBDA_S5		310975	6647777	0.2
JBDA_S6		310974	6647566	0.2
JBDA_S7		310719	6647607	0.2
JBODA_1	Onshore disposal area	311982	6648234	0.2
JBODA_2		312072	6648190	0.2
JBODA_3		312019	6648121	0.2

Notes:

1. Refer to Figure 1.1 for sediment sampling site locations.
2. * = Quality assurance and quality control sampling site (Section 1.1.1).



1.1.1 Sampling quality assurance and quality control

As recommended by the NAGD (CA 2009), the following two types of quality assurance and quality control (QA/QC) samples were collected:

- Triplicate: at 10% of sampling sites, three separate samples taken at the same site to determine the variability of the physical and chemical sediment characteristics at the scale of sampling.
- Split: at 5% of sampling sites, single samples were thoroughly mixed then split into three containers to assess intra- and inter-laboratory variation, with two of the three samples analysed at the primary laboratory (intra-laboratory splits) and the third sample analysed by a reference laboratory (inter-laboratory split).

For the proposed sampling design (Section 1.1), two triplicate samples (from sites JBBH_S6 and JBBH_S10) and one split sample (from site JBBH_S2) were collected.

All sampling equipment was washed with Deacon 90 between sampling sites, and at the beginning of each sampling area. Field staff wore nitrile gloves while handling sampling equipment. Samples were stored and transported as per the SAP (BMT 2019) and NAGD (CA 2009) requirements.

One rinsate blank was completed for each item of reused equipment per day to assess if potential decontamination among samples meets relevant data quality objectives.

1.2 Sediment analysis methods

1.2.1 Sediment analytes and rationale

Samples collected in-field were sent to the relevant laboratories for analyses (as detailed in the SAP; BMT 2019) to characterise physical and chemical properties of sediments within the dredge area, offshore disposal area and onshore disposal areas. Samples were analysed for the potential contaminants of concern listed in the SAP (BMT 2019). A summary of the sample areas and contaminants analysed is provided in Table 1.2. For further information on the justification for the sampling regime, testing for each analyte and laboratory methods, refer to the SAP (BMT 2019).

Table 1.2 Selected analyte analysis plan for sediment samples from the Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Area ¹	Site ¹	Total metals ²	Elutriate metals ²	Elutriate nutrients ³	TOC ^{4,5}	TRH/TPHs ⁴	PAHs ⁴	BTEX ⁴	PSD ^{4,6}	CEC ^{4,6}	pH ⁶
Dredge area	JBBH_S1	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S2	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	JBBH_S4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	JBBH_S5	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S6	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S7	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	JBBH_S9	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S10	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	JBBH_S12	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S13	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S14	✓	✓	✓	✓	✓	✓	✓	✓		
	JBBH_S15	✓	✓	✓	✓	✓	✓	✓	✓		
Offshore disposal area	JBDA_S1	✓			✓	✓	✓	✓	✓		
	JBDA_S2	✓			✓	✓	✓	✓	✓		
	JBDA_S3	✓			✓	✓	✓	✓	✓		
	JBDA_S4	✓			✓	✓	✓	✓	✓		
	JBDA_S5	✓			✓	✓	✓	✓	✓		
	JBDA_S6	✓			✓	✓	✓	✓	✓		
	JBDA_S7	✓			✓	✓	✓	✓	✓		
Onshore disposal area	JBODA_1	✓ ⁷			✓				✓		
	JBODA_2	✓ ⁷			✓				✓		
	JBODA_3	✓ ⁷			✓				✓		
QA/QC ⁸	Triplicate	✓	✓	✓	✓	✓	✓	✓	✓		
	Split	✓	✓	✓	✓	✓	✓	✓			

Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. Total/elutriate metals = arsenic, cadmium, total chromium, copper, lead, mercury (inorganic), nickel and zinc.
3. Elutriate nutrients = total phosphorus (TP), filterable reactive phosphorus (FRP), total nitrogen (TN), nitrate+nitrite (NO_x), ammonium (NH₄⁺), ammonia (NH₃), nitrite (NO₂⁻), nitrate (NO₃⁻), and total kjeldahl nitrogen (TKN).

4. TOC = total organic carbon; TRHs = total recoverable hydrocarbons; TPHs = total petroleum hydrocarbons; PAHs = polycyclic aromatic hydrocarbons; BTEX = benzene, toluene, ethylbenzene and xylene; PSD = particle size distribution; CEC = cation exchange capacity.
5. Analysis required for normalisation as a measure of bioavailability for organic contaminants (Section 1.3.2).
6. Analysis required to calculate the range of Ecological Investigation Levels for "urban residential/public open space" for onshore disposal of dredged sediments (NEPC 2013; Section 1.3.3.2).
7. Onshore disposal area sediment samples were analysed for selected total metal analytes (total chromium, copper, nickel, zinc) to provide ambient background concentrations to calculate Ecological Investigation Levels for "urban residential/public open space" (NEPC 2013; Section 1.3.3.2).
8. QA/QC = quality assurance and quality control (Section 1.1.1).

1.2.2 Particle size analysis

Sediment samples were analysed for particle size distribution (PSD) by laser diffraction to categorise particle sizes between 0.02–500 µm. The PSD for particles >500 µm was measured by wet sieving.

1.2.3 Contaminant analysis

Concentrations of contaminants within the sediment samples were determined via chemical analyses using standard methods by National Association of Testing Authorities (NATA) accredited laboratories. The primary laboratory used for chemical analysis of sediment samples was Australian Laboratory Services (ALS) and the secondary laboratory was ChemCentre. Murdoch University's Marine and Freshwater Research Laboratory (MAFRL) completed PSD analysis; no reference laboratory was required for PSD analysis.

1.2.4 Laboratory QA/QC

Laboratory testing of blanks, spikes, standards and duplicates were completed as required by NATA and NAGD (CA 2009).

1.3 Data analysis methods

1.3.1 Particle settling times

Stokes law was used to calculate the particle settling velocities of the time required for 50% and 90% of suspended particles to settle in 1 m of water for each sediment sample. Settling velocity was not calculated for sediment samples >45% silt and clay content as Stokes' Law is not applicable for material with high fines content.

1.3.2 Normalisation of organics

Total organic carbon (TOC) is the main binding constituent for organic substances in marine sediments. The NAGD (CA 2009) requires organics (total recoverable hydrocarbons [TRHs], total petroleum hydrocarbons [TPHs], polycyclic aromatic hydrocarbons [PAHs] and benzene, toluene, ethylbenzene and xylene [BTEX]) to be normalised to 1% TOC for appropriate comparison to Screening Levels. The normalised results allow for comparison of different sediment samples and provide an indication of the bioavailability of organic analytes. A TOC greater than 1% increases the binding capacity of organics to become less biologically available, therefore normalisation will reduce the measured value proportionally (the reverse also applies). Normalisation is appropriate over a TOC range of 0.2–10%. For TOC <0.2% or TOC >10%, the maximum and minimum values of 0.2 and 10% TOC are used for normalisation, respectively. Where the organic data were below the laboratory limit of reporting (LoR) normalisation was not completed.

1.3.3 Assessment against guidelines

1.3.3.1 NAGD Screening Levels

Contaminant concentrations in dredge and offshore disposal area sediment samples were compared to the NAGD Screening Levels (CA 2009). In accordance with the NAGD (CA 2009), contaminant concentrations from the area to be dredged requires calculation of the 95% upper confidence limit (UCL) of the mean (CA 2009). The data was first tested for normality using the software ProUCL 4.0 (USEPA 2007). The software determines the appropriate method for calculating the 95% UCL depending on the distribution of the data and dataset size, including the proportion of values below the LoR (which introduces statistical complexities into analyses). These methods may include parametric (such as Student's t-UCL) or nonparametric (such as bootstrap) methods. For offshore disposal area sediments, the individual sample concentrations were compared to the Screening Levels.

1.3.3.2 Ecological investigation levels, ecological screening levels and health investigation levels¹

Contaminant concentrations in dredge area sediment samples were assessed against Ecological Investigation Levels (EILs), Ecological Screening Levels (ESLs), and Health Investigation Levels (HILs) from the NEPC (2013) guidelines as referenced in DER (2014) contaminated sites guidelines. Calculation of EILs (for chromium III, copper, nickel and zinc) require the addition of ambient background analyte concentrations (from reference site data) to define contaminant limits for ecological investigation. These calculations also factor the physical sediment properties affecting mobility of metals (i.e. TOC, cation exchange capacity [CEC], pH and % clay) as per DER (2014) and NEPC (2013).

The maximum and the 95% UCL of the arithmetic mean of sediment contaminant concentrations were compared to the appropriate EILs and ESLs for “urban residential/public open space areas” and HIL “C” which is appropriate for public open spaces (NEPC 2013). For assessment against the relevant EILs, ESLs and HILs, the following criteria are specified in NEPC (2013):

- standard deviation of the sample data must be less than 50% of the relevant value
- no single value must exceed 250% of the relevant value.

1.3.3.3 Australian & New Zealand Guidelines for Fresh and Marine Water Quality

Mean elutriate contaminant concentrations were compared to ANZECC/ARMCANZ (2000)² marine water quality guidelines as per NAGD (CA 2009). The species level of protection applied to contaminants reflects the level of disturbance within the surrounding marine environment. The dredge area experiences a high level of recreational vessel traffic and is representative of a moderately disturbed system; therefore, a 90% species level of protection applies. The offshore disposal area is located within Jurien Bay Marine Park waters and is representative of a high ecological value system; therefore, a species protection level of 99% applies.

1.3.4 Analysis of analyte concentrations below the limit of reporting

Generally, half the laboratory LoR value was used as a substitute for data below the LoR in accordance with the NAGD (CA 2009). A large proportion of data below the LoR has the capacity to bias subsequent analyses leading to underestimation of contamination. USEPA (2007) does not consider a 95% UCL of the mean calculated based upon few detected values to provide reliable estimates. Therefore, where the data contain values below the LoR, the following protocol was applied (based on CA 2018):

- Where >25% of concentrations were below the LoR, descriptive statistics (means and percentiles) or inferential analysis (including the calculation of confidence limits) were not calculated. Instead, individual sample results were compared to the triggers and discussed accordingly.
- Where ≤25% but >0% of concentrations were below the LoR, confidence limits were calculated via two methods; once using the normalised estimate based on half the LoR as the replacement value and once using zero as a replacement value. This information was used to inform the interpretation of results, in particular, whether the choice of replacement value affected the outcome of the analysis.

1.3.5 QA/QC data analysis

The accuracy of sediment analyses was determined by quantifying the differences between the concentrations of analytes in the QA/QC samples, using the methods outlined in NAGD (CA 2009).

¹ Comparison of contaminant concentrations to EILs, ESLs and HILs is only appropriate to assess onshore disposal of dredge area sediments.

² At the time of preparing this report, the ANZG (2018) marine water quality guidelines were not available for application due to resolving issues/inconsistencies on the website, and it was recommended to refer to the ANZECC/ARMCANZ (2000) marine water quality guidelines in the interim.

The relative percent difference (RPD) was calculated for the analyte concentrations in the split samples (both inter-laboratory and intra-laboratory splits) and the relative standard deviation (RSD) was calculated for analyte concentrations in the triplicate samples.

The RPD was calculated as follows:

$$RPD (\%) = \frac{(\text{difference between sample splits}) \times 100}{(\text{average of sample splits})}$$

The acceptable RPD range of split samples depends upon the concentration levels detected relative to the LoR as follows (Australian Department of the Environment, pers. comm. 12 August 2014):

- 0–100% RPD when the average concentration is <5 times the LoR
- 0–75% RPD when the average concentration is 5 to 10 times the LoR
- 0–50% RPD when the average concentration is >10 times the LoR.

If the RPD for a measured analyte falls outside of these limits, the value of the measured analyte is flagged as an estimate rather than a precise value (CA 2009).

The RSD was calculated as follows:

$$RSD (\%) = \frac{(\text{standard deviation of triplicate samples}) \times 100}{(\text{average of triplicate samples})}$$

The triplicate samples should agree within an RSD of $\pm 50\%$. RSDs greater than 50% may indicate that the sediments are heterogeneous or greatly differ in grain size (CA 2009). The RPD and RSD was only calculated if all QA/QC sample concentrations were above the LoR. If one or more of the analyte concentrations were below the LoR, the individual concentrations were compared to assess the magnitude of the differences between them.

2 Sediment Analysis Results

2.1 Physical sediment characteristics

2.1.1 Visual and odour characterisation

Sediments from the dredge area were predominantly grey/brown coloured and very well sorted medium to coarse sands (Table 2.1). Some dredge area sediment samples contained considerable portions of organic matter (0–30%) and debris (0–20%) and exhibited a sulfidic odour (Table 2.1).

Offshore disposal area sediments were characterised by grey/brown coloured and very well sorted coarse sands that contained a small (<5%) amount of organic matter (Table 2.1).

At the onshore disposal area, sediments were predominately dark grey/brown coloured and very well sorted medium to coarse sands (Table 2.1). Considerable amounts of organic matter (50%) and small amounts of debris (10%) were observed in the onshore disposal area sediment samples (Table 2.1).

The original field inventory of sediment samples and relevant photos are provided in Appendix A.

Table 2.1 Inventory of sediment samples from the Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Sample ¹	Core horizon interval (m)	Munsell colour ²	Texture	Sorting	Sulfidic odour	Organic matter (%)	Debris (%)	Other comments
Dredge area¹								
JBBH_S1	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	0	
JBBH_S2	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	0	
JBBH_S3	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	0	
JBBH_S4	0–0.2	10YR 7/1		Medium to coarse sand	Very well sorted	No	30	Site moved as first grab was all wrack
JBBH_S5	0–0.2	10YR 7/2		Medium to coarse sand	Very well sorted	No	20	Site moved as first grab was all wrack
JBBH_S6_1	0–0.2	10YR 6/7		Medium to coarse sand	Very well sorted	No	20	
JBBH_S6_2	0–0.2	10YR 6/7		Medium to coarse sand	Very well sorted	No	20	
JBBH_S6_3	0–0.2	10YR 6/7		Medium to coarse sand	Very well sorted	No	20	
JBBH_S7	0–0.2	10YR 5/1		Medium to coarse sand	Very well sorted	No	20	Large piece of gaffer tape in sample
JBBH_S8	0–0.2	10YR 7/2		Medium sand	Very well sorted	Yes	20	Algal mat present
JBBH_S9	0–0.2	10YR 7/2		Medium sand	Very well sorted	Yes	20	Algal mat present
JBBH_S10_1	0–0.2	10YR 6/7		Medium sand	Very well sorted	Yes	10	
JBBH_S10_2	0–0.2	10YR 6/7		Medium sand	Very well sorted	Yes	10	
JBBH_S10_3	0–0.2	10YR 6/7		Medium sand	Very well sorted	Yes	10	
JBBH_S11	0–0.2	10YR 7/2		Medium to coarse sand	Very well sorted	No	20	Some <i>Halophila</i> spp. present
JBBH_S12	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	0	
JBBH_S13	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	0	Site moved as first grab was all wrack
JBBH_S14	0–0.2	10YR 7/2		Medium sand	Very well sorted	Yes	20	Algal mat present
JBBH_S15	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	10	
Offshore disposal area¹								
JBDA_S1	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	5	
JBDA_S2	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	5	
JBDA_S3	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	5	
JBDA_S4	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	5	
JBDA_S5	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	5	
JBDA_S6	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	5	
JBDA_S7	0–0.2	10YR 7/2		Coarse sand	Very well sorted	No	5	
Onshore disposal area¹								
JBODA_1	0–0.1	10YR 6/2		Medium to coarse sand	Well sorted	No	50	
JBODA_2	0–0.1	10YR 5/2		Medium to coarse sand	Very well sorted	No	50	
JBODA_3	0–0.1	10YR 4/2		Medium to coarse sand	Very well sorted	No	50	

Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. The colours presented in the table above are intended to provide visual comparison between the samples and are not intended to take the place of a Munsell Soil Colour Chart (colours were determined using BabelColor).

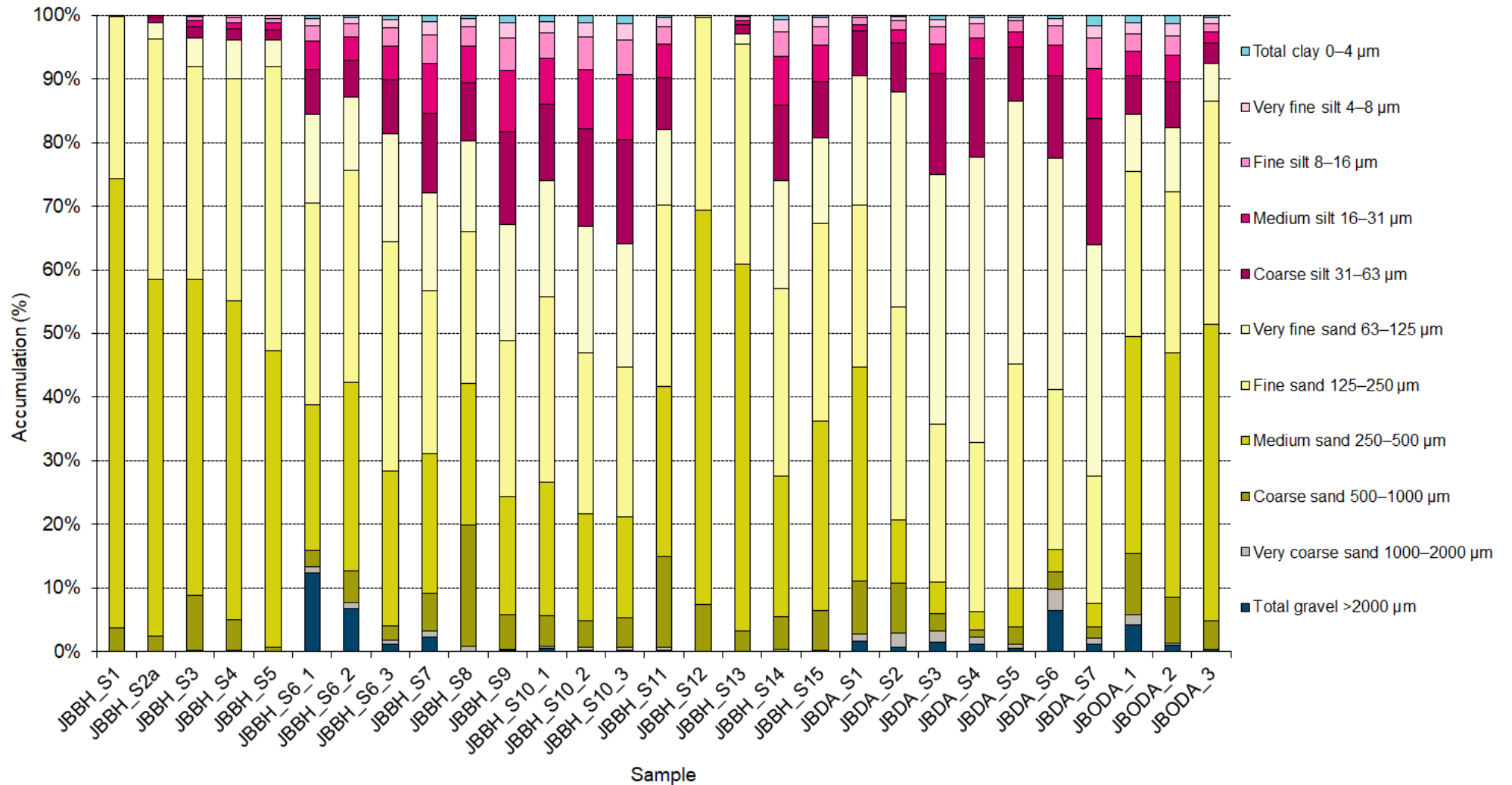
2.1.2 Particle size distribution

Dredge area sediments were predominantly characterised by fine (125–250 µm) to medium (500–100 µm) grained sands (Figure 2.1; Table 2.2). Small portions of gravel (>2000 µm), silt (4– 63 µm) and clay (<4 µm) were present in dredge area sediments, particularly for sediments from inside the Boat Harbour basin (Figure 2.1; Table 2.2).

At the offshore disposal area, sediments were dominated by very fine (63–125 µm) to fine (125–250 µm) grained sands, with small portions of gravel (>2000 µm), silt (4– 63 µm) and clay (<4 µm) present (Figure 2.1; Table 2.2).

Onshore disposal area sediments were mostly fine (125–250 µm) to medium (500–100 µm) grained sands, with small portions of gravel (>2000 µm), silt (4– 63 µm) and clay (<4 µm) present (Figure 2.1; Table 2.2).

The complete laboratory reports are provided in Appendix B.



Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. JBBH_S1–S15 = dredge area; JBDA_S1–S7 = offshore disposal area; JBODA_1–3 = onshore disposal area.

Figure 2.1 Particle size distributions (%) of sediment samples from the Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Table 2.2 Particle size distributions (%) of sediment samples from the Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Category	Size	Dredge area ¹																			Offshore disposal area ¹							Onshore disposal area ¹		
		JBBH_S1	JBBH_S2a	JBBH_S3	JBBH_S4	JBBH_S5	JBBH_S6_1	JBBH_S6_2	JBBH_S6_3	JBBH_S7	JBBH_S8	JBBH_S9	JBBH_S10_1	JBBH_S10_2	JBBH_S10_3	JBBH_S11	JBBH_S12	JBBH_S13	JBBH_S14	JBBH_S15	JBDA_S1	JBDA_S2	JBDA_S3	JBDA_S4	JBDA_S5	JBDA_S6	JBDA_S7	JBODA_1	JBODA_2	JBODA_3
Total gravel	>2000 µm	0.0	0.0	0.0	0.0	0.0	12.4	6.8	1.2	2.2	0.0	0.1	0.5	0.2	0.2	0.1	0.0	0.0	0.0	0.1	1.6	0.7	1.4	1.2	0.5	6.4	1.1	4.1	0.9	0.3
Very coarse sand	1000–2000 µm	0.0	0.0	0.1	0.1	0.0	0.9	0.9	0.6	1.0	0.8	0.3	0.4	0.4	0.4	0.6	0.0	0.0	0.3	0.2	1.0	2.3	1.8	1.0	0.7	3.4	1.0	1.7	0.5	0.1
Coarse sand	500–100 µm	3.6	2.4	8.8	4.9	0.6	2.6	4.9	2.3	5.9	19.0	5.4	4.8	4.2	4.7	14.2	7.3	3.2	5.1	6.1	8.3	7.8	2.8	1.2	2.7	2.7	1.8	9.7	7.1	4.4
Medium sand	250–500 µm	70.8	56.0	49.6	50.2	46.5	22.8	29.7	24.2	21.9	22.3	18.7	20.9	16.7	15.9	26.8	62.0	57.7	22.2	29.8	33.8	10.0	4.9	2.8	6.0	3.5	3.7	34.0	38.5	46.7
Fine sand	125–250 µm	25.5	37.8	33.5	34.9	44.7	31.7	33.2	36.1	25.6	23.9	24.4	29.2	25.4	23.6	28.5	30.3	34.7	29.4	31.2	25.5	33.4	24.9	26.7	35.2	25.1	19.9	26.0	25.4	35.1
Very fine sand	63–125 µm	0.1	2.6	4.4	6.1	4.3	14.1	11.6	17.0	15.5	14.3	18.3	18.3	19.9	19.3	11.9	0.4	1.6	17.1	13.4	20.3	33.8	39.2	44.8	41.3	36.4	36.5	9.0	10.0	6.0
Total sand	63–2000 µm	100	98.8	96.4	96.1	96.2	72.1	80.4	80.3	69.9	80.3	67.0	73.5	66.6	63.9	82.0	100	97.1	74.1	80.7	88.9	87.3	73.6	76.5	86.0	71.1	62.9	80.4	81.4	92.3
Coarse silt	31–63 µm	0.0	0.8	1.8	1.8	1.5	7.0	5.8	8.5	12.4	9.1	14.6	12.0	15.3	16.4	8.1	0.0	1.4	11.9	8.9	7.0	7.7	15.9	15.6	8.6	13.0	19.8	6.2	7.3	3.2
Medium silt	16–31 µm	0.0	0.4	1.1	1.0	1.2	4.5	3.7	5.3	8.0	5.8	9.5	7.3	9.4	10.2	5.3	0.0	0.8	7.6	5.7	1.0	2.2	4.6	3.2	2.4	4.8	7.9	3.7	4.1	1.7
Fine silt	8–16 µm	0.0	0.0	0.6	0.7	0.7	2.3	2.0	2.8	4.4	3.0	5.2	3.9	5.0	5.5	2.8	0.0	0.6	4.0	2.9	1.1	1.4	2.8	2.3	1.7	2.9	4.7	2.8	3.1	1.3
Very fine silt	4–8 µm	0.0	0.0	0.2	0.3	0.5	1.2	1.0	1.4	2.1	1.3	2.4	1.8	2.3	2.5	1.3	0.0	0.2	1.8	1.4	0.4	0.6	1.1	0.8	0.6	1.1	2.0	1.7	1.8	0.9
Total silt	4–63 µm	0.0	1.2	3.6	3.9	3.8	15.0	12.5	17.9	26.8	19.2	31.8	25.0	32.0	34.6	17.5	0.0	2.9	25.2	18.9	9.4	11.8	24.4	21.9	13.3	21.9	34.5	14.4	16.4	7.1
Total clay	0–4 µm	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.6	1.0	0.5	1.1	0.9	1.2	1.3	0.4	0.0	0.0	0.7	0.4	0.0	0.2	0.6	0.4	0.3	0.6	1.6	1.2	1.4	0.3

Notes:
1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. Blue text indicates the dominant fraction in each sample.

2.1.3 Settling times

The settling times were variable depending on the silt and clay content in each sample (Section 2.1.2). The settling time for 50% of particles to settle through 1 m of water was <3 minutes for all sediment samples (Table 2.3). The settling times for 90% of particles to settle through 1 m of water ranged from <1 minute to ~1.2 hours for all sediment samples (Table 2.3).

The complete laboratory reports are provided in Appendix B.

Table 2.3 Settling times of sediment samples from the Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Sample ¹	Time for 50% of particles to settle through 1 m (minutes)	Time for 90% of particles to settle through 1 m (minutes)
Dredge area¹		
JBBH_S1	0.20	0.51
JBBH_S2a	0.27	0.84
JBBH_S3	0.26	1.09
JBBH_S4	0.28	1.29
JBBH_S5	0.34	1.14
JBBH_S6_1	0.51	14.99
JBBH_S6_2	0.42	9.95
JBBH_S6_3	0.71	21.35
JBBH_S7	0.85	47.65
JBBH_S8	0.49	23.38
JBBH_S9	1.39	63.15 (~1 hour)
JBBH_S10_1	0.96	39.52
JBBH_S10_2	1.55	59.51 (~1 hour)
JBBH_S10_3	1.82	70.38 (~1.2 hours)
JBBH_S11	0.45	20.44
JBBH_S12	0.22	0.59
JBBH_S13	0.26	0.81
JBBH_S14	0.89	38.86
JBBH_S15	0.55	22.59
Offshore disposal area¹		
JBDA_S1	0.41	4.84
JBDA_S2	1.13	6.06
JBDA_S3	2.05	17.91
JBDA_S4	2.09	11.48
JBDA_S5	1.47	6.62
JBDA_S6	1.74	18.53
JBDA_S7	2.92	56.40 (~1 hour)
Onshore disposal area¹		
JBODA_1	0.33	17.76
JBODA_2	0.36	23.54
JBODA_3	0.31	2.08

Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. Hours shown in parentheses.

2.2 Total organic carbon, cation exchange capacity and pH

The TOC content was generally low and ranged from 0.08–1.31% for dredge area sediments, 0.25–3.79% for offshore disposal area sediments and 0.40–0.82% for onshore disposal area sediments (Table 2.4).

The CEC and pH of dredge area sediments ranged from 4.7–13.4 mEq/100g and 8.1–8.6, respectively (Table 2.4).

The complete laboratory reports are provided in Appendix C.

Table 2.4 Total organic carbon content, cation exchange capacity and pH of sediment samples from the Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Site ¹	Total organic carbon (%)	Cation exchange capacity (mEq/100g)	pH
Dredge area¹			
JBBH_S1	0.10	na	na
JBBH_S2*	0.11	na	na
JBBH_S3	0.19	4.7	8.6
JBBH_S4	0.11	4.7	8.6
JBBH_S5	0.14	na	na
JBBH_S6*	0.68	na	na
JBBH_S7	0.89	na	na
JBBH_S8	0.51	13.4	8.4
JBBH_S9	1.31	na	na
JBBH_S10*	0.76	na	na
JBBH_S11	0.20	9.9	8.1
JBBH_S12	0.08	na	na
JBBH_S13	0.09	na	na
JBBH_S14	0.85	na	na
JBBH_S15	0.43	na	na
Offshore disposal area¹			
JBDA_S1	0.26	na	na
JBDA_S2	0.25	na	na
JBDA_S3	0.67	na	na
JBDA_S4	0.50	na	na
JBDA_S5	0.32	na	na
JBDA_S6	3.79	na	na
JBDA_S7	0.74	na	na
Onshore disposal area¹			
JBODA_1	0.56	na	na
JBODA_2	0.82	na	na
JBODA_3	0.40	na	na

Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. 'na' = data not available (refer to Section 1.2 for analyte analysis plan and rationale).
3. '**' = quality assurance and quality control sample; results of the two split samples from JBBH_S2 analysed by the primary laboratory were averaged to provide a single value at the site, and results from triplicate samples collected at JBBH_S6 and JBBH_S10 were averaged to provide a single value at each site.

2.3 Metals

2.3.1 Total metals

Test statistics (95% UCL, standard deviation and maximum) were calculated for concentrations of total metals in sediments from the dredge area (Table 2.5). The 95% UCLs, maximums and individual site concentrations of total metals in sediments from the dredge area were below the relevant NAGD Screening Levels (CA 2009) and below or within the range of EILs and HILs (NEPC 2013; Table 2.5).

At the offshore disposal area, concentrations of total metals in sediments from all individual sites were below the relevant NAGD Screening Levels (CA 2009; Table 2.5).

The complete laboratory reports are provided in Appendix C.

Table 2.5 Total metal concentrations of sediment samples from Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Site ¹	Total metals (mg/kg)							
	Arsenic	Cadmium	Total chromium	Copper	Lead	Mercury (inorganic)	Nickel	Zinc
NAGD Screening Level²	20	1.5	80	65	50	0.15	21	200
EIL^{2,3,4}	50	–	65–70	85	270	–	35	130–140
HIL^{2,3}	300	90	300⁶	17 000	600	80	1200	–
Dredge area¹								
JBBH_S1	<1.0	0.1	12.0	<1.0	<1.0	<0.01	<1.0	<1.0
JBBH_S2*	<1.0	<0.1	10.6	<1.0	<1.0	<0.01	<1.0	1.3
JBBH_S3	1.1	0.1	11.2	<1.0	<1.0	<0.01	<1.0	2.3
JBBH_S4	1.1	0.1	9.8	<1.0	<1.0	<0.01	<1.0	1.6
JBBH_S5	1.1	0.1	10.3	2.1	<1.0	<0.01	<1.0	4.5
JBBH_S6*	2.6	0.2	10.4	14.4	1.6	<0.01	<1.0	28.8
JBBH_S7	6.3	0.3	14.1	59.9	3.0	<0.01	2.7	78.7
JBBH_S8	1.5	0.2	11.8	33.8	1.1	<0.01	1.2	26.4
JBBH_S9	2.7	0.2	14.3	64.2	1.9	<0.01	2.5	50.2
JBBH_S10*	2.6	0.2	10.8	35.4	1.9	<0.01	1.2	46.9
JBBH_S11	1.3	0.1	9.9	16.6	<1.0	<0.01	<1.0	13.4
JBBH_S12	<1.0	0.1	12.5	<1.0	<1.0	<0.01	<1.0	<1.0
JBBH_S13	1.2	<0.1	10.8	<1.0	<1.0	<0.01	<1.0	1.4
JBBH_S14	1.5	0.1	10.1	16.8	<1.0	<0.01	<1.0	19.7
JBBH_S15	1.1	0.1	12.2	19.0	<1.0	<0.01	<1.0	13.8
Dredge area test statistics								
95% UCL (LoR/2)	2.5	0.2	12.0	n/d	n/d	n/d	n/d	29.9
95% UCL (LoR = 0)	3.4	0.2	12.0	n/d	n/d	n/d	n/d	29.9
Mean (LoR/2)	1.7	0.1	11.4	n/d	n/d	n/d	n/d	19.3
Mean (LoR = 0)	1.6	1.2	11.4	n/d	n/d	n/d	n/d	19.3
St dev (LoR/2)	1.5	0.1	1.4	n/d	n/d	n/d	n/d	23.3
St Dev (LoR = 0)	1.6	0.1	1.4	n/d	n/d	n/d	n/d	23.4
Maximum	6.3	0.3	14.3	64.2	3.0	<0.01	2.7	78.7
Offshore disposal area¹								
JBDA_S1	3.7	<0.1	9.8	<1.0	<1.0	<0.01	<1.0	1.4
JBDA_S2	1.4	<0.1	6.7	<1.0	<1.0	<0.01	<1.0	1.0

Site ¹	Total metals (mg/kg)							
	Arsenic	Cadmium	Total chromium	Copper	Lead	Mercury (inorganic)	Nickel	Zinc
JBDA_S3	2.53	0.1	8.5	<1.0	<1.0	<0.01	1.0	2.0
JBDA_S4	2.56	<0.1	8.1	<1.0	<1.0	<0.01	<1.0	1.4
JBDA_S5	1.26	<0.1	8.1	<1.0	<1.0	<0.01	<1.0	<1.0
JBDA_S6	3.99	0.1	8.0	<1.0	<1.0	<0.01	1.0	1.9
JBDA_S7	2.90	0.1	8.6	<1.0	<1.0	<0.01	1.6	2.3
Onshore disposal area^{1,5}								
JBODA_1	na	na	10.0	1.0	na	na	<1.0	1.5
JBODA_2	na	na	9.7	3.9	na	na	<1.0	3.4
JBODA_3	na	na	11.0	3.6	na	na	<1.0	2.7

Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. NAGD = National Assessment Guideline for Dredging (CA 2009); EIL = Ecological Investigation Levels for “urban residential/public open space” (NEPC 2013); HIL = Health Investigation Level “C” for “public open space” (NEPC 2013).
3. Comparisons to EILs and HILs are only applicable for assessing onshore disposal of dredge area sediments.
4. EILs were derived using ambient background concentrations of chromium III (total chromium was conservatively applied for EIL calculations), copper, nickel and zinc in onshore disposal area sediments and the sediment specific % clay, total organic carbon, pH and cation exchange capacity in dredge area sediments, where required (NEPC 2013). Selected sites were sampled for total organic carbon, pH and cation exchange capacity (Section 1.2.1) and averaged to calculate EILs, where required. For nickel and copper, a range of EILs is provided to assess onshore disposal of dredge area sediments. For total chromium and zinc, absolute values are provided for EILs due to little variation in data inputs.
5. Total metal concentrations of sediments from the onshore area are included for information but do not require assessment against guideline values (their analysis is for use in calculating EILs; NEPC 2013).
6. HIL “C” for “public open space” for chromium VI was conservatively applied in the absence of a guideline value for total chromium.
7. ‘-’ = no guideline value available; ‘nd’ = statistic not determined because the dataset contains >25% of values below the laboratory limit of reporting (Section 1.3.4); ‘UCL’ = upper confidence limit; ‘st dev’ = standard deviation; ‘na’ = data not available (refer to Section 1.2 for analyte analysis plan and rationale); ‘LoR’ = laboratory limit of reporting.
8. ‘**’ = quality assurance and quality control sample; results of the two split samples from JBBH_S2 analysed by the primary laboratory were averaged to provide a single value at the site, and results from triplicate samples collected at JBBH_S6 and JBBH_S10 were averaged to provide a single value at each site.

2.3.2 Elutriate metals

Mean concentrations of elutriate copper and zinc from dredge area sediments exceeded the relevant ANZECC/ARMCANZ (2000) trigger values for toxicants at the 90% and 99% species levels of protection (Table 2.6). An individual site exceedance of the relevant ANZECC/ARMCANZ (2000) trigger value for toxicants at the 99% species protection level was reported for concentrations of elutriate cadmium (JBBH_S6; Table 2.6). Concentrations of elutriate arsenic, total chromium, lead and nickel were below the relevant ANZECC/ARMCANZ (2000) trigger values for toxicants at the 99% species protection level (Table 2.6).

The complete laboratory reports are provided in Appendix C.

Table 2.6 Elutriate metal concentrations of sediment samples from Jurien Bay Boat Harbour dredge area, offshore disposal area and onshore disposal area

Site ¹	Elutriate metals (µg/L)						
	Arsenic	Cadmium	Total chromium	Copper	Lead	Nickel	Zinc
90% species level of protection ²	–	14	48.6 ⁶	3	6.6	200	23
99% species level of protection ²	–	0.7	7.7 ⁶	0.3	2.2	7	7
Dredge area¹							
JBBH_S5	5.8	<0.2	<0.5	1.2	<0.2	<0.5	<5.0
JBBH_S6	16.9	0.8	<0.5	4.8	0.2	1.1	46.0
JBBH_S7	5.3	0.3	<0.5	2.6	<0.2	1.0	71.0
JBBH_S8	17.5	0.6	<0.5	4.4	<0.2	0.8	56.0
JBBH_S9	12	0.7	<0.5	5.4	<0.2	1.0	47.0
JBBH_S10	15.9	0.6	<0.5	5.6	0.2	1.4	135.3
JBBH_S11	10.5	0.3	<0.5	7.7	<0.2	1.3	27.0
JBBH_S14	17.1	0.4	<0.5	4.7	<0.2	1.0	28.0
JBBH_S15	5.8	<0.2	<0.5	5.5	<0.2	0.8	15.0
Mean³	11.9	0.4	nd	4.6	nd	1.0	47.5

Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. ANZECC/ARMCANZ (2000) trigger values for toxicants at the 90% (applicable to dredge area) and 99% (applicable to offshore disposal area) species levels of protection.
3. Where data was below the laboratory limit of reporting half of the value was used to calculate the mean value.
4. '–' = no guideline value available; 'nd' = statistic not determined because the dataset contains >25% of values below the laboratory limit of reporting (Section 1.3.4).
5. '**' = quality assurance and quality control sample; results of the two split samples from JBBH_S2 analysed by the primary laboratory were averaged to provide a single value at the site, and results from triplicate samples collected at JBBH_S6 and JBBH_S10 were averaged to provide a single value at each site.
6. ANZECC/ARMCANZ (2000) trigger values for chromium III conservatively applied in the absence of a guideline values for total chromium.
7. **Orange text** indicates an exceedance of the relevant ANZECC/ARMCANZ (2000) trigger values for toxicants at the 99% species level of protection.
8. **Red text** indicates an exceedance of the relevant ANZECC/ARMCANZ (2000) trigger values for toxicants at the 90% species level of protection.

2.4 Nutrients

2.4.1 Elutriate nutrients

Mean concentrations of elutriate total phosphorus (TP), filterable reactive phosphorus (FRP), total nitrogen (TN), nitrate+nitrite (NO_x) and ammonium (NH_4^+) from dredge area sediments exceeded the relevant ANZECC/ARMCANZ (2000) default trigger values for physical and chemical stressors for south-west Australia for slightly disturbed marine inshore ecosystems (Table 2.7). Mean concentrations of elutriate ammonia (NH_3) from dredge area sediments exceeded the relevant ANZECC/ARMCANZ (2000) trigger value for toxicants at the 90% and 99% species levels of protection (Table 2.7).

The complete laboratory reports are provided in Appendix C.

Table 2.7 Elutriate nutrient concentrations of sediment samples from Jurien Bay Boat Harbour dredge area

Site ¹	Elutriate nutrients (µg/L)								
	TP ²	FRP ²	TN ²	NO _x ²	NH ₄ ⁺ ²	NH ₃ ²	Nitrite	Nitrate	TKN ²
Default trigger values for south-west Australia marine inshore waters ³	20	5	230	5	5	–	–	–	–
90% species level of protection ⁴	–	–	–	–	–	1200	–	–	–
99% species level of protection ⁴	–	–	–	–	–	500	–	–	–
Dredge area¹									
JBBH_S1	17	19	159	39	6	7	<2	39	120
JBBH_S2*	9	11	357	<2	166	177	<2	<2	357
JBBH_S3	62	42	1220	5	694	739**	2	3	1220
JBBH_S4	23	8	847	<2	455	485	<2	<2	847
JBBH_S5	80	37	1900	4	1100	1170**	3	<2	1900
JBBH_S6*	147	101	6113	11	4753	5063	<2	11	6103
JBBH_S7	47	27	3660	7	2930	3120	<2	7	3650
JBBH_S8	74	49	2480	12	1860	1980	<2	12	2470
JBBH_S9	185	145	3090	10	2300	2450	<2	10	3080
JBBH_S10*	63	28	3260	16	2483	2643	7	14	3243
JBBH_S11	114	79	2220	12	1470	1570	2	10	2210
JBBH_S12	76	68	344	63	76	81	<2	63	281
JBBH_S13	19	9	1280	5	853	909**	<2	5	1280
JBBH_S14	113	81	2780	8	2250	2400	<2	8	2770
JBBH_S15	128	91	1620	17	1240	1320	<2	17	1600
Mean⁵	77	53	2089	14	1509	1608	nd	13	2075

Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. TP = total phosphorus; FRP = filterable reactive phosphorus; TN = total nitrogen; NO_x = nitrate+nitrite; NH₄⁺ = ammonium; NH₃ = ammonia; TKN = total kjeldahl nitrogen.
3. ANZECC/ARMCANZ (2000) default trigger values for physical and chemical stressors applicable to south-west Australia for slightly disturbed marine inshore ecosystems.
4. ANZECC/ARMCANZ (2000) trigger values for toxicants at the 90% (applicable to dredge area) and 99% (applicable to offshore disposal area) species levels of protection.
5. Where data was below the laboratory limit of reporting half of the value was used to calculate the mean value.
6. '–' = no guideline value available; 'nd' = statistic not determined because the dataset contains >25% of values below the laboratory limit of reporting (Section 1.3.4).
7. '*' = Quality assurance and quality control sample; results of the two split samples from JBBH_S2 analysed by the primary laboratory were averaged to provide a single value at the site, and results from triplicate samples collected at JBBH_S6 and JBBH_S10 were averaged to provide a single value at each site.
8. **Red text** indicates an exceedance of the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values.
9. ****** = indicates exceedance of the relevant ANZECC/ARMCANZ (2000) trigger values for toxicants at the 99% species level of protection but is below the relevant ANZECC/ARMCANZ (2000) trigger values for toxicants at the 90% species level of protection.

2.5 Hydrocarbons

Concentrations of hydrocarbons (TPHs, TRHs, PAHs and BTEX) in sediments from the dredge area were below the relevant NAGD Screening Levels (CA 2009) and/or below or within the range of relevant EILs, ESLs and HILs (NEPC 2013), where applicable.

Sediments from the offshore disposal area had concentrations of hydrocarbons (TRHs, TPHs, PAHs and BTEX) below the relevant NAGD Screening Levels (CA 2009).

The complete laboratory reports are provided in Appendix C.

2.6 QA/QC results

The results of QA/QC analyses are summarised in Table 2.8. Analytes that are not included had concentrations that were below the LoR in all QA/QC samples and the calculation of RPD and RSD values was not appropriate (Section 1.2.4).

Acceptable RPD limits were calculated as outlined in Section 1.3.5. The RPD values exceeding assigned limits were for inter-laboratory splits of elutriate NH_4^+ and NH_3 (Table 2.8). Exceedances can be caused by heterogeneity between split samples or from variability between the laboratory methods for sample preparation and analysis. Therefore, the concentrations of analytes with RPD values exceeding assigned limits should be considered as estimates rather than precise measurements.

The RSD values for elutriate TP and elutriate FRP exceeded the $\pm 50\%$ limit recommended by NAGD (CA 2009) suggesting small scale (cm) spatial variability in the distribution of these analytes at site JBBH_S10 (Table 2.8).

The analysis laboratories completed the required testing of blanks, spikes and standards and completed laboratory duplicates, as required by NAGD (CA 2009), and passed the relevant QA/QC assessments. All results from field rinsate blanks and trip blanks were below the LoR, indicating that there was no contamination among samples (Appendix C).

The complete reference laboratory reports are provided in Appendix D.

Table 2.8 Quality assurance and quality control data of sediment samples from Jurien Bay Boat Harbour dredge area

QA/QC sample type	Intra-laboratory splits	Inter-laboratory splits		Field triplicates	
Test statistic (CA 2009)	RPD (%)			RSD (%)	
Site ¹	JBBH_S2			JBBH_S6	JBBH_S10
QA/QC samples analysed	a,b	a,c	b,c	1,2,3	1,2,3
TOC	9.52	124.14	129.82	12.39	27.77
Arsenic	na	na	na	11.92	13.32
Cadmium	na	na	na	0.00	34.64
Total chromium	2.84	22.92	20.11	7.81	4.19
Copper	na	na	na	7.21	17.58
Lead	na	na	na	28.93	8.18
Nickel	na	na	na	na	9.36
Zinc	0.00	35.29	35.29	6.29	14.22
TRH >C10–C16	na	na	na	11.98	17.68
TRH >C10–C16 less naphthalene	na	na	na	11.98	17.68
TRH >C16–C34	na	na	na	27.00	3.16
TRH >C34–C40	na	na	na	na	2.02
TPH C10–C14	na	na	na	2.47	17.68
TPH C15–C28	na	na	na	22.65	8.02
TPH C29–C36	na	na	na	36.78	3.32
Elutriate TP	35.29	na	na	34.53	66.65
Elutriate FRP	0.00	na	na	40.63	72.70
Elutriate TN	5.89	21.65	15.81	10.27	29.15
Elutriate NO _x	na	nd	na	30.99	49.49
Elutriate ammonium	14.46	84.64	72.40	12.63	44.95
Elutriate ammonia	14.69	87.67	75.41	12.54	44.96
Elutriate nitrate	na	na	na	30.99	50.00
Elutriate TKN	5.89	na	na	10.29	29.45

Notes:

1. Refer to Table 1.1 and Figure 1.1 for explanation of sediment sampling areas and sites.
2. 'QAQC' = quality assurance and quality control; 'RSD' = relative standard deviation; 'RPD' = relative percent difference; 'na' = value not appropriate for determination where the analyte had QA/QC values below the laboratory limit of reporting; 'TOC' = total organic carbon; 'TRH' = total recoverable hydrocarbon; 'TPH' = total petroleum hydrocarbon; 'TP' = total phosphorus; 'FRP' = filterable reactive phosphorus; 'TN' = total nitrogen; 'NO_x' = nitrate+nitrite; 'TKN' = total kjeldahl nitrogen.
3. Values in red text indicate exceedances of RPD/RSD limits specified by NAGD (CA 2009).

3 Summary and Conclusion

The physical characteristics of sediments sampled from the dredge area were slightly different to the offshore disposal area, predominantly characterised by fine to medium sands compared to very fine to fine sands. Concentrations of total metals and hydrocarbons from dredge area sediments were below NAGD Screening Levels (CA 2009). Mean concentrations of elutriate metals (copper and zinc) and elutriate nutrients (TP, FRP, TN, NO_x, NH₄⁺ and NH₃) from dredge area sediments exceeded the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values. In accordance with the NAGD (CA 2009), elutriate concentrations should be scaled to account for initial dilution at the discharge area for appropriate assessment against the relevant ANZECC/ARMCANZ (2000) marine water quality trigger values; results of this additional requirement are to be presented in the LTMMMP. Based on the results presented in this report, dredge area sediments are considered suitable for unconfined ocean disposal under the EPSD Act.

4 References

- 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. Available from www.waterquality.gov.au/anz-guidelines [Accessed 15 May 2019]
- ANZECC & ARMCANZ (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
- BMT (2018) Department of Transport Maintenance Dredging – Environmental Management Framework. Prepared for Department of Transport by BMT Western Australia Pty Ltd, Report No. 1368_00_001/1_Rev1, Perth, Western Australia, February 2018
- BMT (2019) Jurien Bay Boat Harbour – Long-term Maintenance Dredging Sediment Sampling and Analysis Plan. Prepared for Department of Transport by BMT Western Australia Pty Ltd, Report No. R-1454_01-1/Rev1, Perth, Western Australia, March 2019
- CA (2009) National Assessment Guidelines for Dredging, Prepared by Commonwealth of Australia, Canberra, ACT
- DER (2014) Assessment and management of contaminated sites. Contaminated sites guidelines. Department of Environment Regulation, Perth, Western Australia, December 2014
- NEPC (2013) National Environment Protection (Assessment of Site Contamination) Measure Amendment 2013 (No. 1), National Environment Protection Council, Schedule 201
- USEPA (2007) ProUCL Version 4.0. United States Environmental Protection Authority. Available from <http://www.epa.gov/esd/tsc/software.htm> [Accessed 15 May 2019]

Appendix A Field inventory of sediment samples and photos

	F8.3.9 Sediment Core Description	BMT0-CD-147
		Rev 0
		13/07/2016

Field conditions					
Date & Time	16,17 April 2019	Tidal state (SELECT)			
Field personnel	BD, LS	Wave heights (direction/he	2m SW		
Project # & name	1454_01	Winds (direction/speed)	Light, variable		
Project location	Jurien Bay Boat Harbour	Underwater visibility (m)	2 m		

Site details						
Site name	GPS waypoint (#)	Water depth	Time	No. grabs per sample	Benthic habitat present and photos	Core photos? (SELECT)
JBBH_S1	10	0	1600	1	No	Yes
JBBH_S2_A	29	2	1145	2	No	Yes
JBBH_S3	30	3	1150	2	No	Yes
JBBH_S4	28	1	1130	1	Yes	Yes
JBBH_S5	27	1	1125	1	Yes	Yes
JBBH_S6_1	13	3	810	2	Yes	Yes
JBBH_S6_2	13	3	810	2	Yes	Yes
JBBH_S6_3	13	3	810	2	Yes	Yes
JBBH_S7	12	4	748	2	Yes	No
JBBH_S8	26	3	1120	3	Yes	Yes
JBBH_S9	24	3	1108	2	Yes	Yes
JBBH_S10_1	14	3	857	2	Yes	Yes
JBBH_S10_2	14	3	857	2	Yes	Yes
JBBH_S10_3	14	3	857	2	Yes	Yes
JBBH_S11	22	2	1057	1	Yes	Yes
JBBH_S12	11	1	1615	1	No	Yes
JBBH_S13	31	3	1200	1	No	Yes
JBBH_S14	25	3	1115	3	Yes	Yes
JBBH_S15	23	2	1100	1	Yes	Yes
JBDA_S1	15	12	1030	1	Yes	No
JBDA_S2	16	12	1030	1	Yes	No
JBDA_S3	17	12	1030	1	Yes	Yes
JBDA_S4	18	12	1030	1	Yes	Yes
JBDA_S5	19	12	1030	1	Yes	Yes
JBDA_S6	20	12	1030	1	Yes	Yes
JBDA_S7	21	12	1030	1	Yes	Yes
JBODA_1	9	0	1320	1	Yes	Yes
JBODA_2	7	0	1320	1	Yes	Yes
JBODA_3	8	0	1320	1	Yes	Yes

Description									
Site name	Horizon (cm)	Munsell	Texture (SELECT & COMMENTS)		Sorting (SELECT)	Sulfidic Odour (SELECT)	Organic Matter (%)	Debris (%)	Other Comments
JBBH_S1	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	0	0	
JBBH_S2_A	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	0	0	
JBBH_S3	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	0	0	
JBBH_S4	0–0.2	10YR 7/1	Medium to coarse sand		Very well sorted	No	30	0	Site moved as first grab was all wrack
JBBH_S5	0–0.2	10YR 7/2	Medium to coarse sand		Very well sorted	No	20	10	Site moved as first grab was all wrack
JBBH_S6_1	0–0.2	10YR 6/7	Medium to coarse sand		Very well sorted	No	20	10	
JBBH_S6_2	0–0.2	10YR 6/7	Medium to coarse sand		Very well sorted	No	20	10	
JBBH_S6_3	0–0.2	10YR 6/7	Medium to coarse sand		Very well sorted	No	20	10	
JBBH_S7	0–0.2	10YR 5/1	Medium to coarse sand		Very well sorted	No	20	20	Large piece of gaffer tape in sample
JBBH_S8	0–0.2	10YR 7/2	Medium sand		Very well sorted	Yes	20	10	Algal mat present
JBBH_S9	0–0.2	10YR 7/2	Medium sand		Very well sorted	Yes	20	10	Algal mat present
JBBH_S10_1	0–0.2	10YR 6/7	Medium sand		Very well sorted	Yes	10	10	
JBBH_S10_2	0–0.2	10YR 6/7	Medium sand		Very well sorted	Yes	10	10	
JBBH_S10_3	0–0.2	10YR 6/7	Medium sand		Very well sorted	Yes	10	10	
JBBH_S11	0–0.2	10YR 7/2	Medium to coarse sand		Very well sorted	No	20	10	Some Halophila spp. Present
JBBH_S12	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	0	0	
JBBH_S13	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	0	0	Site moved as first grab was all wrack
JBBH_S14	0–0.2	10YR 7/2	Medium sand		Very well sorted	Yes	20	10	Algal mat present
JBBH_S15	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	10	10	
JBDA_S1	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	5	0	
JBDA_S2	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	5	0	
JBDA_S3	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	5	0	
JBDA_S4	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	5	0	
JBDA_S5	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	5	0	
JBDA_S6	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	5	0	
JBDA_S7	0–0.2	10YR 7/2	Coarse sand		Very well sorted	No	5	0	
JBODA_1	0-0.1	10YR 6/2	Medium to coarse sand		Well sorted	No	50	10	
JBODA_2	0-0.1	10YR 5/2	Medium to coarse sand		Very well sorted	No	50	10	
JBODA_3	0-0.1	10YR 4/2	Medium to coarse sand		Very well sorted	No	50	10	

Sample	Photo	Sample	Photo	Sample	Photo	Sample	Photo
JBBH_S1		JBBH_S7		JBBH_S13		JBDA_S6	
JBBH_S2		JBBH_S8		JBBH_S14		JBDA_S7	
JBBH_S3		JBBH_S9		JBBH_S15		JBODA_1	
JBBH_S4		JBBH_S10_1		JBDA_S1	No image available	JBODA_2	
JBBH_S5		JBBH_S10_2		JBDA_S2	No image available	JBODA_3	

Sample	Photo	Sample	Photo	Sample	Photo	Sample	Photo
JBBH_S6_1		JBBH_S10_3		JBDA_S3			
JBBH_S6_2		JBBH_S11		JBDA_S4			
JBBH_S6_3		JBBH_S12		JBDA_S5			

Appendix B Particle Size Analysis Laboratory Reports (Marine and Freshwater Research Laboratory)

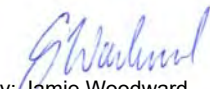


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S1	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	16/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	2/05/2019	
Wentworth Size Classifications		Calculations D50 (µm)318.26 Minimum settling velocity of 50% of particles (mm s ⁻¹)83.52 Time for 50% of particles to settle over 1 m (hours)0.003 D10 (µm)199.42 Minimum settling velocity of 90% of particles (mm s ⁻¹)32.79 Time for 90% of particles to settle over 1 m (hours)0.008 Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Total Clay % (0-4µm)	0.00	
Very Fine Silt % (4-8µm)	0.00	
Fine Silt % (8-16µm)	0.00	
Medium Silt % (16-31µm)	0.00	
Course Silt % (31-63µm)	0.00	
Total Silt (4-63µm)	0.00	
Very Fine sand % (63-125µm)	0.11	
Fine sand % (125-250µm)	25.49	
Medium sand % (250-500µm)	70.79	
Coarse sand % (500-1000µm)	3.59	
Very Coarse sand % (1000-2000µm)	0.02	
Total Sand (63-2000µm)	99.99	
Total Gravels (>2000µm)	0.01	
Extended range by sieving		
Extended size, µm	Extended percent retained at size	
	5003.59	
	10000.02	
	20000.01	
	40000.00	
	80000.00	
	160000.00	


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

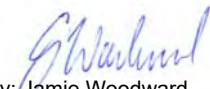


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S2_A	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	17/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	2/05/2019	
Wentworth Size Classifications		Calculations D50 (µm)274.66 Minimum settling velocity of 50% of particles (mm s ¹)62.21 Time for 50% of particles to settle over 1 m (hours)0.004 D10 (µm)155.32 Minimum settling velocity of 90% of particles (mm s ¹)19.89 Time for 90% of particles to settle over 1 m (hours)0.014 Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Total Clay % (0-4µm)	0.00	
Very Fine Silt % (4-8µm)	0.00	
Fine Silt % (8-16µm)	0.00	
Medium Silt % (16-31µm)	0.37	
Course Silt % (31-63µm)	0.80	
Total Silt (4-63µm)	1.16	
Very Fine sand % (63-125µm)	2.61	
Fine sand % (125-250µm)	37.81	
Medium sand % (250-500µm)	56.02	
Coarse sand % (500-1000µm)	2.37	
Very Coarse sand % (1000-2000µm)	0.03	
Total Sand (63-2000µm)	98.84	
Total Gravels (>2000µm)	0.00	
Extended range by sieving		
Extended size, µm	Extended percent retained at size	
	5002.37	
	10000.03	
	20000.00	
	40000.00	
	80000.00	
	160000.00	


Signatory: Jamie Woodward
Date: 13/05/2019

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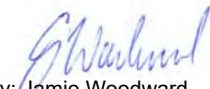


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S3	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	3/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.00	D50 (µm)	279.37
Very Fine Silt % (4-8µm)	0.18	Minimum settling velocity of 50% of particles (mm s ¹)	64.36
Fine Silt % (8-16µm)	0.58	Time for 50% of particles to settle over 1 m (hours)	0.004
Medium Silt % (16-31µm)	1.06	D10 (µm)	136.28
Course Silt % (31-63µm)	1.78	Minimum settling velocity of 90% of particles (mm s ¹)	15.32
Total Silt (4-63µm)	3.60	Time for 90% of particles to settle over 1 m (hours)	0.018
Very Fine sand % (63-125µm)	4.36		
Fine sand % (125-250µm)	33.53	Settings	
Medium sand % (250-500µm)	49.64	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	8.78	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.09	Result Units	Volume
Total Sand (63-2000µm)	96.40	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.00	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	8.78	Sample visual assessment	
1000	0.09	Sand with no other noticeable sediment types present.	
2000	0.00		
4000	0.00		
8000	0.00		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

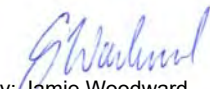


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S4	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	3/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.00	D50 (µm)	267.67
Very Fine Silt % (4-8µm)	0.34	Minimum settling velocity of 50% of particles (mm s ¹)	59.08
Fine Silt % (8-16µm)	0.73	Time for 50% of particles to settle over 1 m (hours)	0.005
Medium Silt % (16-31µm)	1.03	D10 (µm)	125.19
Course Silt % (31-63µm)	1.79	Minimum settling velocity of 90% of particles (mm s ¹)	12.92
Total Silt (4-63µm)	3.89	Time for 90% of particles to settle over 1 m (hours)	0.021
Very Fine sand % (63-125µm)	6.07		
Fine sand % (125-250µm)	34.85	Settings	
Medium sand % (250-500µm)	50.20	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	4.90	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.09	Result Units	Volume
Total Sand (63-2000µm)	96.11	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.00	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
	500 4.90		
	1000 0.09	Sample visual assessment	
	2000 0.00	Sand with no other noticeable sediment types present.	
	4000 0.00		
	8000 0.00		
	16000 0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.




PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S5	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p) (g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	17/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	3/05/2019	
Wentworth Size Classifications		Calculations D50 (µm)242.71 Minimum settling velocity of 50% of particles (mm s ⁻¹)48.58 Time for 50% of particles to settle over 1 m (hours)0.006 D10 (µm)132.89 Minimum settling velocity of 90% of particles (mm s ⁻¹)14.56 Time for 90% of particles to settle over 1 m (hours)0.019 Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Total Clay % (0-4µm)	0.00	
Very Fine Silt % (4-8µm)	0.47	
Fine Silt % (8-16µm)	0.69	
Medium Silt % (16-31µm)	1.15	
Course Silt % (31-63µm)	1.53	
Total Silt (4-63µm)	3.84	
Very Fine sand % (63-125µm)	4.25	
Fine sand % (125-250µm)	44.70	
Medium sand % (250-500µm)	46.53	
Coarse sand % (500-1000µm)	0.64	
Very Coarse sand % (1000-2000µm)	0.04	
Total Sand (63-2000µm)	96.16	
Total Gravels (>2000µm)	0.00	
Extended range by sieving		
Extended size, µm	Extended percent retained at size	
	500 0.64	
	1000 0.04	
	2000 0.00	
	4000 0.00	
	8000 0.00	
	16000 0.00	


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

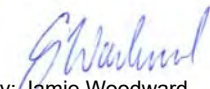


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S6_1	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	17/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	3/05/2019	
Wentworth Size Classifications		Calculations D50 (µm)199.29 Minimum settling velocity of 50% of particles (mm s ⁻¹)32.75 Time for 50% of particles to settle over 1 m (hours)0.008 D10 (µm)36.72 Minimum settling velocity of 90% of particles (mm s ⁻¹)1.11 Time for 90% of particles to settle over 1 m (hours)0.250
Total Clay % (0-4µm)	0.49	
Very Fine Silt % (4-8µm)	1.19	
Fine Silt % (8-16µm)	2.33	
Medium Silt % (16-31µm)	4.47	
Course Silt % (31-63µm)	7.03	
Total Silt (4-63µm)	15.01	
Very Fine sand % (63-125µm)	14.06	
Fine sand % (125-250µm)	31.74	
Medium sand % (250-500µm)	22.82	
Coarse sand % (500-1000µm)	2.55	Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Very Coarse sand % (1000-2000µm)	0.93	
Total Sand (63-2000µm)	72.10	
Total Gravels (>2000µm)	12.39	
Extended range by sieving		
Extended size, µm	Extended percent retained at size	
500	2.55	
1000	0.93	
2000	2.04	
4000	2.59	
8000	7.77	
16000	0.00	
		Sample visual assessment Sand with some mud, shell and plant material present.


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

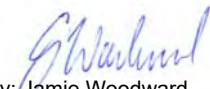


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S6_2	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	17/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	3/05/2019	
Wentworth Size Classifications		Calculations D50 (µm)218.51 Minimum settling velocity of 50% of particles (mm s ¹)39.37 Time for 50% of particles to settle over 1 m (hours)0.007 D10 (µm)45.08 Minimum settling velocity of 90% of particles (mm s ¹)1.68 Time for 90% of particles to settle over 1 m (hours)0.166 Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Total Clay % (0-4µm)	0.32	
Very Fine Silt % (4-8µm)	1.02	
Fine Silt % (8-16µm)	1.97	
Medium Silt % (16-31µm)	3.74	
Course Silt % (31-63µm)	5.77	
Total Silt (4-63µm)	12.50	
Very Fine sand % (63-125µm)	11.63	
Fine sand % (125-250µm)	33.23	
Medium sand % (250-500µm)	29.72	
Coarse sand % (500-1000µm)	4.89	Sample visual assessment Sand with some mud, shell and plant material present.
Very Coarse sand % (1000-2000µm)	0.92	
Total Sand (63-2000µm)	80.39	
Total Gravels (>2000µm)	6.78	
Extended range by sieving		
Extended size, µm	Extended percent retained at size	
500	4.89	
1000	0.92	
2000	0.80	
4000	0.92	
8000	1.84	
16000	3.22	


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

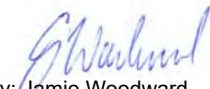


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S6_3	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	3/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.60	D50 (µm)	169.06
Very Fine Silt % (4-8µm)	1.40	Minimum settling velocity of 50% of particles (mm s ¹)	23.57
Fine Silt % (8-16µm)	2.76	Time for 50% of particles to settle over 1 m (hours)	0.012
Medium Silt % (16-31µm)	5.31	D10 (µm)	30.77
Course Silt % (31-63µm)	8.46	Minimum settling velocity of 90% of particles (mm s ¹)	0.78
Total Silt (4-63µm)	17.93	Time for 90% of particles to settle over 1 m (hours)	0.356
Very Fine sand % (63-125µm)	17.04		
Fine sand % (125-250µm)	36.15	Settings	
Medium sand % (250-500µm)	24.24	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	2.25	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.64	Result Units	Volume
Total Sand (63-2000µm)	80.31	Instrument	Mastersizer3000
Total Gravels (>2000µm)	1.15	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
	500 2.25		
	1000 0.64	Sample visual assessment	
	2000 0.25	Sand with some mud, shell and plant material present.	
	4000 0.81		
	8000 0.09		
	16000 0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

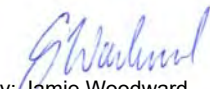


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S7	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	3/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	1.02	D50 (µm)	153.93
Very Fine Silt % (4-8µm)	2.10	Minimum settling velocity of 50% of particles (mm s ¹)	19.54
Fine Silt % (8-16µm)	4.35	Time for 50% of particles to settle over 1 m (hours)	0.014
Medium Silt % (16-31µm)	7.96	D10 (µm)	20.60
Course Silt % (31-63µm)	12.41	Minimum settling velocity of 90% of particles (mm s ¹)	0.35
Total Silt (4-63µm)	26.82	Time for 90% of particles to settle over 1 m (hours)	0.794
Very Fine sand % (63-125µm)	15.50		
Fine sand % (125-250µm)	25.58	Settings	
Medium sand % (250-500µm)	21.93	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	5.92	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	1.00	Result Units	Volume
Total Sand (63-2000µm)	69.93	Instrument	Mastersizer3000
Total Gravels (>2000µm)	2.22	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	5.92	Sample visual assessment	
1000	1.00	Sand with some mud, shell and plant material present.	
2000	0.59		
4000	0.39		
8000	1.24		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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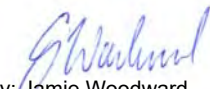


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S8	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	3/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.49	D50 (µm)	202.13
Very Fine Silt % (4-8µm)	1.34	Minimum settling velocity of 50% of particles (mm s ¹)	33.69
Fine Silt % (8-16µm)	2.97	Time for 50% of particles to settle over 1 m (hours)	0.008
Medium Silt % (16-31µm)	5.77	D10 (µm)	29.40
Course Silt % (31-63µm)	9.09	Minimum settling velocity of 90% of particles (mm s ¹)	0.71
Total Silt (4-63µm)	19.17	Time for 90% of particles to settle over 1 m (hours)	0.390
Very Fine sand % (63-125µm)	14.30		
Fine sand % (125-250µm)	23.88	Settings	
Medium sand % (250-500µm)	22.30	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	19.01	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.85	Result Units	Volume
Total Sand (63-2000µm)	80.34	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.00	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
	500 19.01	Sample visual assessment	
	1000 0.85	Sand with some mud present.	
	2000 0.00		
	4000 0.00		
	8000 0.00		
	16000 0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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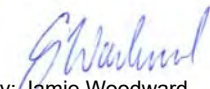


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S9	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1544_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	6/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	1.11	D50 (µm)	120.45
Very Fine Silt % (4-8µm)	2.39	Minimum settling velocity of 50% of particles (mm s ¹)	11.96
Fine Silt % (8-16µm)	5.24	Time for 50% of particles to settle over 1 m (hours)	0.023
Medium Silt % (16-31µm)	9.49	D10 (µm)	17.89
Course Silt % (31-63µm)	14.64	Minimum settling velocity of 90% of particles (mm s ¹)	0.26
Total Silt (4-63µm)	31.75	Time for 90% of particles to settle over 1 m (hours)	1.052
Very Fine sand % (63-125µm)	18.33		
Fine sand % (125-250µm)	24.39	Settings	
Medium sand % (250-500µm)	18.65	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	5.40	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.27	Result Units	Volume
Total Sand (63-2000µm)	67.04	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.09	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	5.40	Sample visual assessment	
1000	0.27	Sand with mud and some plant material present.	
2000	0.03		
4000	0.00		
8000	0.03		
16000	0.02		


Signatory: Jamie Woodward
Date: 13/05/2019

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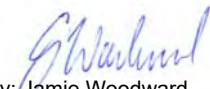


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S10_1	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1544_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	6/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.93	D50 (µm)	145.31
Very Fine Silt % (4-8µm)	1.84	Minimum settling velocity of 50% of particles (mm s ¹)	17.41
Fine Silt % (8-16µm)	3.92	Time for 50% of particles to settle over 1 m (hours)	0.016
Medium Silt % (16-31µm)	7.31	D10 (µm)	22.62
Course Silt % (31-63µm)	11.97	Minimum settling velocity of 90% of particles (mm s ¹)	0.42
Total Silt (4-63µm)	25.04	Time for 90% of particles to settle over 1 m (hours)	0.659
Very Fine sand % (63-125µm)	18.32		
Fine sand % (125-250µm)	29.19	Settings	
Medium sand % (250-500µm)	20.86	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	4.79	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.40	Result Units	Volume
Total Sand (63-2000µm)	73.55	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.48	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	4.79	Sample visual assessment	
1000	0.40	Sand with mud and some shell and plant material present.	
2000	0.07		
4000	0.40		
8000	0.00		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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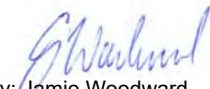


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S10_2	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C	
Sampling Date:	17/04/2019		
Sample Type:	Sediment		
MAFRL Job Code:	BMT19-22		
Client Reference:	1544_01_002		
Analysis Date	6/05/2019		
Wentworth Size Classifications		Calculations D50 (µm)114.36 Minimum settling velocity of 50% of particles (mm s ¹)10.78 Time for 50% of particles to settle over 1 m (hours)0.026 D10 (µm)18.43 Minimum settling velocity of 90% of particles (mm s ¹)0.28 Time for 90% of particles to settle over 1 m (hours)0.992 Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300	
Total Clay % (0-4µm)	1.16		
Very Fine Silt % (4-8µm)	2.29		
Fine Silt % (8-16µm)	4.99		
Medium Silt % (16-31µm)	9.39		
Course Silt % (31-63µm)	15.34		
Total Silt (4-63µm)	32.01		
Very Fine sand % (63-125µm)	19.85		
Fine sand % (125-250µm)	25.43		
Medium sand % (250-500µm)	16.73		
Coarse sand % (500-1000µm)	4.19		
Very Coarse sand % (1000-2000µm)	0.40		
Total Sand (63-2000µm)	66.61		
Total Gravels (>2000µm)	0.23		
Extended range by sieving			
Extended size, µm	Extended percent retained at size		
	500	4.19	Sample visual assessment Sand with mud and some shell and plant material present.
	1000	0.40	
	2000	0.15	
	4000	0.07	
	8000	0.00	
	16000	0.00	


Signatory: Jamie Woodward
Date: 13/05/2019

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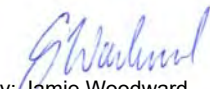


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S10_3	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1544_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	6/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	1.34	D50 (µm)	105.50
Very Fine Silt % (4-8µm)	2.53	Minimum settling velocity of 50% of particles (mm s ¹)	9.18
Fine Silt % (8-16µm)	5.47	Time for 50% of particles to settle over 1 m (hours)	0.030
Medium Silt % (16-31µm)	10.21	D10 (µm)	16.95
Course Silt % (31-63µm)	16.38	Minimum settling velocity of 90% of particles (mm s ¹)	0.24
Total Silt (4-63µm)	34.59	Time for 90% of particles to settle over 1 m (hours)	1.173
Very Fine sand % (63-125µm)	19.35		
Fine sand % (125-250µm)	23.56	Settings	
Medium sand % (250-500µm)	15.88	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	4.70	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.40	Result Units	Volume
Total Sand (63-2000µm)	63.89	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.18	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	4.70	Sample visual assessment Sand with mud and some shell and plant material present.	
1000	0.40		
2000	0.18		
4000	0.00		
8000	0.00		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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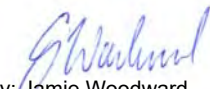


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S11	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	17/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1544_01_002	
Analysis Date	6/05/2019	
Wentworth Size Classifications		Calculations D50 (μm)211.02 Minimum settling velocity of 50% of particles (mm s ¹)36.72 Time for 50% of particles to settle over 1 m (hours)0.008 D10 (μm)31.45 Minimum settling velocity of 90% of particles (mm s ¹)0.82 Time for 90% of particles to settle over 1 m (hours)0.341
Total Clay % (0-4μm)	0.40	
Very Fine Silt % (4-8μm)	1.33	
Fine Silt % (8-16μm)	2.82	
Medium Silt % (16-31μm)	5.31	
Course Silt % (31-63μm)	8.08	
Total Silt (4-63μm)	17.55	
Very Fine sand % (63-125μm)	11.86	
Fine sand % (125-250μm)	28.55	
Medium sand % (250-500μm)	26.76	
Coarse sand % (500-1000μm)	14.19	Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Very Coarse sand % (1000-2000μm)	0.59	
Total Sand (63-2000μm)	81.95	
Total Gravels (>2000μm)	0.11	
Extended range by sieving		
Extended size, μm	Extended percent retained at size	
500	14.19	
1000	0.59	
2000	0.08	
4000	0.03	
8000	0.00	
16000	0.00	
		Sample visual assessment Sand with mud and some shell and plant material present.


Signatory: Jamie Woodward
Date: 13/05/2019

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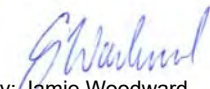


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S12	Settling Velocity calculations using Stokes Law	
Sampling Date:	16/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1544_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	6/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.00	D50 (µm)	305.87
Very Fine Silt % (4-8µm)	0.00	Minimum settling velocity of 50% of particles (mm s ¹)	77.15
Fine Silt % (8-16µm)	0.00	Time for 50% of particles to settle over 1 m (hours)	0.004
Medium Silt % (16-31µm)	0.00	D10 (µm)	185.50
Course Silt % (31-63µm)	0.00	Minimum settling velocity of 90% of particles (mm s ¹)	28.37
Total Silt (4-63µm)	0.00	Time for 90% of particles to settle over 1 m (hours)	0.010
Very Fine sand % (63-125µm)	0.39		
Fine sand % (125-250µm)	30.26	Settings	
Medium sand % (250-500µm)	62.03	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	7.31	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.02	Result Units	Volume
Total Sand (63-2000µm)	100.00	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.00	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	7.31	Sample visual assessment	
1000	0.02	Sand with no other noticeable sediment types present.	
2000	0.00		
4000	0.00		
8000	0.00		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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Spare test items will be held for two months unless otherwise requested.

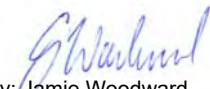


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S13	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	16/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1544_01_002	
Analysis Date	6/05/2019	
Wentworth Size Classifications		Calculations D50 (µm)281.41 Minimum settling velocity of 50% of particles (mm s ¹)65.30 Time for 50% of particles to settle over 1 m (hours)0.004 D10 (µm)158.34 Minimum settling velocity of 90% of particles (mm s ¹)20.67 Time for 90% of particles to settle over 1 m (hours)0.013
Total Clay % (0-4µm)	0.00	
Very Fine Silt % (4-8µm)	0.19	
Fine Silt % (8-16µm)	0.57	
Medium Silt % (16-31µm)	0.76	
Course Silt % (31-63µm)	1.37	
Total Silt (4-63µm)	2.89	
Very Fine sand % (63-125µm)	1.59	
Fine sand % (125-250µm)	34.66	
Medium sand % (250-500µm)	57.68	
Coarse sand % (500-1000µm)	3.15	Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Very Coarse sand % (1000-2000µm)	0.03	
Total Sand (63-2000µm)	97.11	
Total Gravels (>2000µm)	0.00	
Extended range by sieving		
Extended size, µm	Extended percent retained at size	
500	3.15	
1000	0.03	
2000	0.00	
4000	0.00	
8000	0.00	
16000	0.00	
		Sample visual assessment Sand with no other noticeable sediment types present.


Signatory: Jamie Woodward
Date: 13/05/2019

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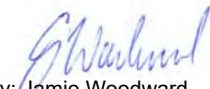


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBH_S14	Settling Velocity calculations using Stokes Law	
Sampling Date:	16/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1544_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	6/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.70	D50 (µm)	150.62
Very Fine Silt % (4-8µm)	1.82	Minimum settling velocity of 50% of particles (mm s ¹)	18.71
Fine Silt % (8-16µm)	3.96	Time for 50% of particles to settle over 1 m (hours)	0.015
Medium Silt % (16-31µm)	7.58	D10 (µm)	22.81
Course Silt % (31-63µm)	11.88	Minimum settling velocity of 90% of particles (mm s ¹)	0.43
Total Silt (4-63µm)	25.23	Time for 90% of particles to settle over 1 m (hours)	0.648
Very Fine sand % (63-125µm)	17.10		
Fine sand % (125-250µm)	29.41	Settings	
Medium sand % (250-500µm)	22.18	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	5.10	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.28	Result Units	Volume
Total Sand (63-2000µm)	74.06	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.00	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	5.10	Sample visual assessment	
1000	0.28	Sand with mud and some plant material present.	
2000	0.00		
4000	0.00		
8000	0.00		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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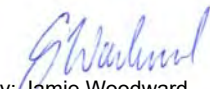


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name: JBBH_S15		Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³) 2.65 Liquid density (ρ_f) (g/cm ³) 1.025 Acceleration due to Gravity (g) (ms ⁻²) 9.81 Liquid viscosity (η) (cp) 1.074 *Liquid parameters based on seawater of 35ppt @ 20°C	
Sampling Date: 17/04/2019			
Sample Type: Sediment			
MAFRL Job Code: BMT19-22			
Client Reference: 1454_01_002			
Analysis Date: 7/05/2019			
Wentworth Size Classifications		Calculations D50 (µm) 191.95 Minimum settling velocity of 50% of particles (mm s ¹) 30.38 Time for 50% of particles to settle over 1 m (hours) 0.009 D10 (µm) 29.91 Minimum settling velocity of 90% of particles (mm s ¹) 0.74 Time for 90% of particles to settle over 1 m (hours) 0.377 Settings SOP Name SOP-LV-3REPS-default.msop Analysis Model General Purpose Result Units Volume Instrument Mastersizer3000 RI/ABS: 2.74 / 1 Dispersant Water Additives 10mL Sodium Hexametaphosphate Sonication (s) 300	
Total Clay % (0-4µm) 0.39			
Very Fine Silt % (4-8µm) 1.37			
Fine Silt % (8-16µm) 2.94			
Medium Silt % (16-31µm) 5.69			
Course Silt % (31-63µm) 8.88			
Total Silt (4-63µm) 18.88			
Very Fine sand % (63-125µm) 13.35			
Fine sand % (125-250µm) 31.22			
Medium sand % (250-500µm) 29.80			
Coarse sand % (500-1000µm) 6.13			
Very Coarse sand % (1000-2000µm) 0.17			
Total Sand (63-2000µm) 80.67			
Total Gravels (>2000µm) 0.05			
Extended range by sieving			
Extended size, µm	Extended percent retained at size		
500	6.13		
1000	0.17		
2000	0.05		
4000	0.00		
8000	0.00		
16000	0.00		
Sample visual assessment Sand with mud and some plant material present.			


 Signatory: Jamie Woodward
 Date: 13/05/2019

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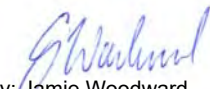


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBHODA_1	Settling Velocity calculations using Stokes Law	
Sampling Date:	16/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p)(g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	8/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	1.18	D50 (µm)	247.54
Very Fine Silt % (4-8µm)	1.71	Minimum settling velocity of 50% of particles (mm s ¹)	50.53
Fine Silt % (8-16µm)	2.80	Time for 50% of particles to settle over 1 m (hours)	0.005
Medium Silt % (16-31µm)	3.71	D10 (µm)	33.73
Course Silt % (31-63µm)	6.15	Minimum settling velocity of 90% of particles (mm s ¹)	0.94
Total Silt (4-63µm)	14.37	Time for 90% of particles to settle over 1 m (hours)	0.296
Very Fine sand % (63-125µm)	9.02		
Fine sand % (125-250µm)	25.96	Settings	
Medium sand % (250-500µm)	34.02	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	9.66	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	1.69	Result Units	Volume
Total Sand (63-2000µm)	80.35	Instrument	Mastersizer3000
Total Gravels (>2000µm)	4.09	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	9.66	Sample visual assessment Sand with some shell, mud and plant material present.	
1000	1.69		
2000	1.75		
4000	2.26		
8000	0.08		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBHODA_2	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	16/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	9/05/2019	
Wentworth Size Classifications		Calculations D50 (µm)236.34 Minimum settling velocity of 50% of particles (mm s ¹)46.06 Time for 50% of particles to settle over 1 m (hours)0.006 D10 (µm)29.30 Minimum settling velocity of 90% of particles (mm s ¹)0.71 Time for 90% of particles to settle over 1 m (hours)0.392
Total Clay % (0-4µm)	1.37	
Very Fine Silt % (4-8µm)	1.83	
Fine Silt % (8-16µm)	3.09	
Medium Silt % (16-31µm)	4.14	
Course Silt % (31-63µm)	7.30	
Total Silt (4-63µm)	16.36	Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Very Fine sand % (63-125µm)	9.96	
Fine sand % (125-250µm)	25.37	
Medium sand % (250-500µm)	38.50	
Coarse sand % (500-1000µm)	7.09	
Very Coarse sand % (1000-2000µm)	0.46	
Total Sand (63-2000µm)	81.38	
Total Gravels (>2000µm)	0.90	
Extended range by sieving		
Extended size, µm	Extended percent retained at size	
	5007.09	Sample visual assessment Sand with some shell, mud and plant material present.
	10000.46	
	20000.25	
	40000.30	
	80000.00	
	160000.35	


Signatory: Jamie Woodward
Date: 13/05/2019

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PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBBHODA_3	Settling Velocity calculations using Stokes Law	
Sampling Date:	16/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	9/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.35	D50 (µm)	255.09
Very Fine Silt % (4-8µm)	0.90	Minimum settling velocity of 50% of particles (mm s ⁻¹)	53.66
Fine Silt % (8-16µm)	1.32	Time for 50% of particles to settle over 1 m (hours)	0.005
Medium Silt % (16-31µm)	1.74	D10 (µm)	98.51
Course Silt % (31-63µm)	3.16	Minimum settling velocity of 90% of particles (mm s ⁻¹)	8.00
Total Silt (4-63µm)	7.13	Time for 90% of particles to settle over 1 m (hours)	0.035
Very Fine sand % (63-125µm)	5.97		
Fine sand % (125-250µm)	35.06	Settings	
Medium sand % (250-500µm)	46.67	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	4.44	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.13	Result Units	Volume
Total Sand (63-2000µm)	92.27	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.26	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	4.44	Sample visual assessment	
1000	0.13	Sand with some shell, mud and plant material present.	
2000	0.08		
4000	0.16		
8000	0.03		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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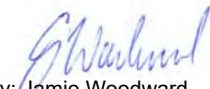


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name: JBDA_S1		Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³) 2.65 Liquid density (ρ_f) (g/cm ³) 1.025 Acceleration due to Gravity (g) (ms ⁻²) 9.81 Liquid viscosity (η) (cp) 1.074 *Liquid parameters based on seawater of 35ppt @ 20°C	
Sampling Date: 17/04/2019			
Sample Type: Sediment			
MAFRL Job Code: BMT19-22			
Client Reference: 1454_01_002			
Analysis Date: 7/05/2019			
Wentworth Size Classifications			
Total Clay % (0-4µm) 0.00		Calculations D50 (µm) 222.14 Minimum settling velocity of 50% of particles (mm s ¹) 40.69 Time for 50% of particles to settle over 1 m (hours) 0.007 D10 (µm) 64.59 Minimum settling velocity of 90% of particles (mm s ¹) 3.44 Time for 90% of particles to settle over 1 m (hours) 0.081	
Very Fine Silt % (4-8µm) 0.36			
Fine Silt % (8-16µm) 1.11			
Medium Silt % (16-31µm) 1.01			
Course Silt % (31-63µm) 6.96			
Total Silt (4-63µm) 9.44			
Very Fine sand % (63-125µm) 20.31			
Fine sand % (125-250µm) 25.48			
Medium sand % (250-500µm) 33.80			
Coarse sand % (500-1000µm) 8.33			
Very Coarse sand % (1000-2000µm) 1.02		Settings SOP Name SOP-LV-3REPS-default.msop Analysis Model General Purpose Result Units Volume Instrument Mastersizer3000 RI/ABS: 2.74 / 1 Dispersant Water Additives 10mL Sodium Hexametaphosphate Sonication (s) 300	
Total Sand (63-2000µm) 88.93			
Total Gravels (>2000µm) 1.63			
Extended range by sieving			
Extended size, µm	Extended percent retained at size		
500	8.33		
1000	1.02		
2000	0.70		
4000	0.24		
8000	0.24		
16000	0.46		
Sample visual assessment Sand with some mud, shell and plant material present.			


 Signatory: Jamie Woodward
 Date: 13/05/2019

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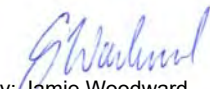


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBDA_S2	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	17/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	7/05/2019	
Wentworth Size Classifications		Calculations D50 (µm)133.92 Minimum settling velocity of 50% of particles (mm s ¹)14.79 Time for 50% of particles to settle over 1 m (hours)0.019 D10 (µm)57.76 Minimum settling velocity of 90% of particles (mm s ¹)2.75 Time for 90% of particles to settle over 1 m (hours)0.101 Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Total Clay % (0-4µm)	0.23	
Very Fine Silt % (4-8µm)	0.58	
Fine Silt % (8-16µm)	1.43	
Medium Silt % (16-31µm)	2.17	
Course Silt % (31-63µm)	7.65	
Total Silt (4-63µm)	11.83	
Very Fine sand % (63-125µm)	33.78	
Fine sand % (125-250µm)	33.43	
Medium sand % (250-500µm)	10.00	
Coarse sand % (500-1000µm)	7.77	
Very Coarse sand % (1000-2000µm)	2.30	
Total Sand (63-2000µm)	87.29	
Total Gravels (>2000µm)	0.65	
Extended range by sieving		
Extended size, µm	Extended percent retained at size	
	5007.77	
	10002.30	
	20000.56	
	40000.07	
	80000.02	
	160000.00	
Sample visual assessment Sand with some mud, shell and plant material present.		


Signatory: Jamie Woodward
Date: 13/05/2019

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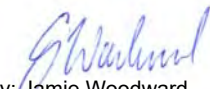


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBDA_S3	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p)(g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	7/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.60	D50 (µm)	99.36
Very Fine Silt % (4-8µm)	1.11	Minimum settling velocity of 50% of particles (mm s ¹)	8.14
Fine Silt % (8-16µm)	2.82	Time for 50% of particles to settle over 1 m (hours)	0.034
Medium Silt % (16-31µm)	4.64	D10 (µm)	33.59
Course Silt % (31-63µm)	15.87	Minimum settling velocity of 90% of particles (mm s ¹)	0.93
Total Silt (4-63µm)	24.44	Time for 90% of particles to settle over 1 m (hours)	0.299
Very Fine sand % (63-125µm)	39.19		
Fine sand % (125-250µm)	24.88	Settings	
Medium sand % (250-500µm)	4.94	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	2.78	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	1.79	Result Units	Volume
Total Sand (63-2000µm)	73.58	Instrument	Mastersizer3000
Total Gravels (>2000µm)	1.38	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	2.78	Sample visual assessment Sand with mud and some shell and plant material present.	
1000	1.79		
2000	0.89		
4000	0.14		
8000	0.00		
16000	0.34		


Signatory: Jamie Woodward
Date: 13/05/2019

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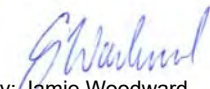


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBDA_S4	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	17/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	7/05/2019	
Wentworth Size Classifications		Calculations D50 (μm)98.28 Minimum settling velocity of 50% of particles (mm s ¹)7.96 Time for 50% of particles to settle over 1 m (hours)0.035 D10 (μm)41.95 Minimum settling velocity of 90% of particles (mm s ¹)1.45 Time for 90% of particles to settle over 1 m (hours)0.191 Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Total Clay % (0-4μm)	0.41	
Very Fine Silt % (4-8μm)	0.83	
Fine Silt % (8-16μm)	2.30	
Medium Silt % (16-31μm)	3.24	
Course Silt % (31-63μm)	15.58	
Total Silt (4-63μm)	21.95	
Very Fine sand % (63-125μm)	44.82	
Fine sand % (125-250μm)	26.65	
Medium sand % (250-500μm)	2.79	
Coarse sand % (500-1000μm)	1.18	
Very Coarse sand % (1000-2000μm)	1.02	
Total Sand (63-2000μm)	76.46	
Total Gravels (>2000μm)	1.18	
Extended range by sieving		
Extended size, μm	Extended percent retained at size	
500	1.18	
1000	1.02	
2000	0.76	
4000	0.42	
8000	0.00	
16000	0.00	
Sample visual assessment Sand with mud and some shell and plant material present.		


Signatory: Jamie Woodward
Date: 13/05/2019

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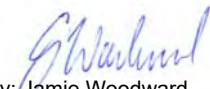


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
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Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBDA_S5	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p) (g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	7/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	0.26	D50 (µm)	117.33
Very Fine Silt % (4-8µm)	0.62	Minimum settling velocity of 50% of particles (mm s ¹)	11.35
Fine Silt % (8-16µm)	1.67	Time for 50% of particles to settle over 1 m (hours)	0.024
Medium Silt % (16-31µm)	2.40	D10 (µm)	55.25
Course Silt % (31-63µm)	8.60	Minimum settling velocity of 90% of particles (mm s ¹)	2.52
Total Silt (4-63µm)	13.29	Time for 90% of particles to settle over 1 m (hours)	0.110
Very Fine sand % (63-125µm)	41.33		
Fine sand % (125-250µm)	35.23	Settings	
Medium sand % (250-500µm)	5.98	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	2.74	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.72	Result Units	Volume
Total Sand (63-2000µm)	86.00	Instrument	Mastersizer3000
Total Gravels (>2000µm)	0.45	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	2.74		
1000	0.72	Sample visual assessment	
2000	0.23	Sand with some mud, shell and plant material present.	
4000	0.22		
8000	0.00		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

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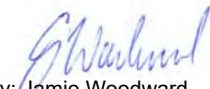


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBDA_S6	Settling Velocity calculations using Stokes Law Parameters Particle density (ρ_p)(g/cm ³)2.65 Liquid density (ρ_f) (g/cm ³)1.025 Acceleration due to Gravity (g) (ms ⁻²)9.81 Liquid viscosity (η) (cp)1.074 *Liquid parameters based on seawater of 35ppt @ 20°C
Sampling Date:	17/04/2019	
Sample Type:	Sediment	
MAFRL Job Code:	BMT19-22	
Client Reference:	1454_01_002	
Analysis Date	7/05/2019	
Wentworth Size Classifications		Calculations D50 (μm)107.91 Minimum settling velocity of 50% of particles (mm s ⁻¹)9.60 Time for 50% of particles to settle over 1 m (hours)0.029 D10 (μm)33.03 Minimum settling velocity of 90% of particles (mm s ⁻¹)0.90 Time for 90% of particles to settle over 1 m (hours)0.309 Settings SOP NameSOP-LV-3REPS-default.msop Analysis ModelGeneral Purpose Result UnitsVolume InstrumentMastersizer3000 RI/ABS:2.74 / 1 DispersantWater Additives10mL Sodium Hexametaphosphate Sonication (s)300
Total Clay % (0-4μm)	0.56	
Very Fine Silt % (4-8μm)	1.12	
Fine Silt % (8-16μm)	2.95	
Medium Silt % (16-31μm)	4.81	
Course Silt % (31-63μm)	13.04	
Total Silt (4-63μm)	21.92	
Very Fine sand % (63-125μm)	36.42	
Fine sand % (125-250μm)	25.13	
Medium sand % (250-500μm)	3.47	
Coarse sand % (500-1000μm)	2.74	Sample visual assessment Sand with mud and some shell and plant material present.
Very Coarse sand % (1000-2000μm)	3.37	
Total Sand (63-2000μm)	71.12	
Total Gravels (>2000μm)	6.41	
Extended range by sieving		
Extended size, μm	Extended percent retained at size	
500	2.74	
1000	3.37	
2000	2.68	
4000	3.28	
8000	0.45	
16000	0.00	


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

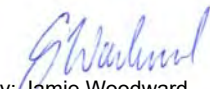


PARTICLE SIZE ANALYSIS REPORT

Contact: Ben Davis
Customer: BMT
Address: Level 4, 20 Parkland Ave, Osborne Park 6017

Date of Issue: 13/05/2019
Date Received: 17/04/2019
Our Reference: BMT19-22

Sample Name:	JBDA_S7	Settling Velocity calculations using Stokes Law	
Sampling Date:	17/04/2019	Parameters	
Sample Type:	Sediment	Particle density (ρ_p)(g/cm ³)	2.65
MAFRL Job Code:	BMT19-22	Liquid density (ρ_f) (g/cm ³)	1.025
Client Reference:	1454_01_002	Acceleration due to Gravity (g) (ms ⁻²)	9.81
Analysis Date	7/05/2019	Liquid viscosity (η) (cp)	1.074
		*Liquid parameters based on seawater of 35ppt @ 20°C	
Wentworth Size Classifications		Calculations	
Total Clay % (0-4µm)	1.58	D50 (µm)	83.15
Very Fine Silt % (4-8µm)	2.03	Minimum settling velocity of 50% of particles (mm s ¹)	5.70
Fine Silt % (8-16µm)	4.71	Time for 50% of particles to settle over 1 m (hours)	0.049
Medium Silt % (16-31µm)	7.88	D10 (µm)	18.93
Course Silt % (31-63µm)	19.84	Minimum settling velocity of 90% of particles (mm s ¹)	0.30
Total Silt (4-63µm)	34.46	Time for 90% of particles to settle over 1 m (hours)	0.940
Very Fine sand % (63-125µm)	36.48		
Fine sand % (125-250µm)	19.91	Settings	
Medium sand % (250-500µm)	3.72	SOP Name	SOP-LV-3REPS-default.msop
Coarse sand % (500-1000µm)	1.77	Analysis Model	General Purpose
Very Coarse sand % (1000-2000µm)	0.98	Result Units	Volume
Total Sand (63-2000µm)	62.85	Instrument	Mastersizer3000
Total Gravels (>2000µm)	1.10	RI/ABS:	2.74 / 1
		Dispersant	Water
Extended range by sieving		Additives	10mL Sodium Hexametaphosphate
Extended size, µm	Extended percent retained at size	Sonication (s)	300
500	1.77	Sample visual assessment Sand with mud and some shell and plant material present.	
1000	0.98		
2000	0.53		
4000	0.58		
8000	0.00		
16000	0.00		


Signatory: Jamie Woodward
Date: 13/05/2019

The results only apply to the sample as received and to the sample tested.
Spare test items will be held for two months unless otherwise requested.

Appendix C Primary Laboratory Reports (ALS Environmental)

CERTIFICATE OF ANALYSIS

Work Order : **EB1911615**
Client : **BMT WESTERN AUSTRALIA PTY LTD**
Contact : **MR BEN DAVIS**
Address : **LEVEL 4 20 PARKLAND ROAD**
OSBORNE PARK WA, AUSTRALIA 6017
Telephone : **+61 08 6272 0000**
Project : **Jurien Bay BH Sediment Sampling 2019**
Order number :
C-O-C number :
Sampler :
Site : **Jurien Bay**
Quote number : **1453_01 (EP/175/19 V2)**
No. of samples received : **21**
No. of samples analysed : **14**

Page : 1 of 8
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 08-May-2019 12:29
Date Analysis Commenced : 15-May-2019
Issue Date : 22-May-2019 08:50



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

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>
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



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.

- EN68: This analysis in accordance with National Ocean Disposal Guidelines, Commonwealth of Australia, 2002 - (modified). Results reported are those determined on a 1:4 sediment/seawater elutriate without blank correction.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.



Analytical Results

Sub-Matrix: ELUTRIATE
 (Matrix: WATER)

Client sample ID

				JBBH_S5	JBBH_S6_1_0.00_0.1 0	JBBH_S6_2_0.00_0.1 0	JBBH_S6_3_0.00_0.1 0	JBBH_S7_0.00_0.10
Client sampling date / time				08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00
Compound	CAS Number	LOR	Unit	EB1911615-006	EB1911615-007	EB1911615-008	EB1911615-009	EB1911615-010
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Arsenic	7440-38-2	0.5	µg/L	5.8	17.8	15.6	17.4	5.3
Cadmium	7440-43-9	0.2	µg/L	<0.2	1.1	0.3	1.0	0.3
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	0.6	<0.5
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.4	<0.2	<0.2
Nickel	7440-02-0	0.5	µg/L	<0.5	1.6	0.8	0.8	1.0
Zinc	7440-66-6	5	µg/L	<5	60	34	44	71
EG093T_LL: Total Metals in Saline Water by ORC-ICPMS								
Copper	7440-50-8	0.2	µg/L	1.2	5.8	3.2	5.3	2.6



Analytical Results

Sub-Matrix: ELUTRIATE
 (Matrix: WATER)

Client sample ID

				JBBH_S8	JBBH_S9	JBBH_S10_1_0.00_0.10	JBBH_S10_2_0.00_0.10	JBBH_S10_3
Client sampling date / time				08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00
Compound	CAS Number	LOR	Unit	EB1911615-011	EB1911615-012	EB1911615-013	EB1911615-014	EB1911615-015
				Result	Result	Result	Result	Result
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Arsenic	7440-38-2	0.5	µg/L	17.5	12.0	13.4	20.4	13.8
Cadmium	7440-43-9	0.2	µg/L	0.6	0.7	0.4	1.1	0.3
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.6	<0.5	<0.5
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.3	<0.2	<0.2
Nickel	7440-02-0	0.5	µg/L	0.8	1.0	1.4	1.6	1.1
Zinc	7440-66-6	5	µg/L	56	47	109	128	169
EG093T_LL: Total Metals in Saline Water by ORC-ICPMS								
Copper	7440-50-8	0.2	µg/L	4.4	5.4	3.9	8.0	4.8



Analytical Results

Sub-Matrix: ELUTRIATE
 (Matrix: WATER)

Client sample ID

				JBBH_S11	JBBH_S14	JBBH_S15	Elutriate Control	----
Client sampling date / time				08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1911615-016	EB1911615-019	EB1911615-020	EB1911615-021	-----
				Result	Result	Result	Result	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Arsenic	7440-38-2	0.5	µg/L	10.5	17.1	5.8	2.2	----
Cadmium	7440-43-9	0.2	µg/L	0.3	0.4	<0.2	<0.2	----
Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	0.4	----
Nickel	7440-02-0	0.5	µg/L	1.3	1.0	0.8	0.5	----
Zinc	7440-66-6	5	µg/L	27	28	15	<5	----
EG093T_LL: Total Metals in Saline Water by ORC-ICPMS								
Copper	7440-50-8	0.2	µg/L	7.7	4.7	5.5	0.8	----

Page : 6 of 8
 Work Order : EB1911615
 Client : BMT WESTERN AUSTRALIA PTY LTD
 Project : Jurien Bay BH Sediment Sampling 2019



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Client sample ID

				JBBH_S5	JBBH_S6_1_0.00_0.1 0	JBBH_S6_2_0.00_0.1 0	JBBH_S6_3_0.00_0.1 0	JBBH_S7_0.00_0.10
Client sampling date / time				08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00
Compound	CAS Number	LOR	Unit	EB1911615-006	EB1911615-007	EB1911615-008	EB1911615-009	EB1911615-010
				Result	Result	Result	Result	Result
EN68: Seawater Elutriate Testing Procedure								
Seawater Sampling Date	----	-	-	16/05/2019	16/05/2019	16/05/2019	16/05/2019	16/05/2019



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Client sample ID

				JBBH_S8	JBBH_S9	JBBH_S10_1_0.00_0.10	JBBH_S10_2_0.00_0.10	JBBH_S10_3
Client sampling date / time				08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00
Compound	CAS Number	LOR	Unit	EB1911615-011	EB1911615-012	EB1911615-013	EB1911615-014	EB1911615-015
				Result	Result	Result	Result	Result
EN68: Seawater Elutriate Testing Procedure								
Seawater Sampling Date	----	-	-	16/05/2019	16/05/2019	16/05/2019	16/05/2019	16/05/2019

Page : 8 of 8
 Work Order : EB1911615
 Client : BMT WESTERN AUSTRALIA PTY LTD
 Project : Jurien Bay BH Sediment Sampling 2019



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Client sample ID

				JBBH_S11	JBBH_S14	JBBH_S15	Elutriate Control	----
Client sampling date / time				08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	08-May-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1911615-016	EB1911615-019	EB1911615-020	EB1911615-021	-----
				Result	Result	Result	Result	----
EN68: Seawater Elutriate Testing Procedure								
Seawater Sampling Date	----	-	-	16/05/2019	16/05/2019	16/05/2019	16/05/2019	----

QUALITY CONTROL REPORT

Work Order	: EB1911615	Page	: 1 of 3
Client	: BMT WESTERN AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR BEN DAVIS	Contact	: Customer Services EB
Address	: LEVEL 4 20 PARKLAND ROAD OSBORNE PARK WA, AUSTRALIA 6017	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 08 6272 0000	Telephone	: +61-7-3243 7222
Project	: Jurien Bay BH Sediment Sampling 2019	Date Samples Received	: 08-May-2019
Order number	:	Date Analysis Commenced	: 15-May-2019
C-O-C number	: ----	Issue Date	: 22-May-2019
Sampler	: ----		
Site	: Jurien Bay		
Quote number	: 1453_01 (EP/175/19 V2)		
No. of samples received	: 21		
No. of samples analysed	: 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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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>
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 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
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG093T: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2355749)									
EB1911615-006	JBBH_S5	EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	0.2	0.00	No Limit
		EG093A-T: Arsenic	7440-38-2	0.5	µg/L	5.8	5.6	3.48	0% - 50%
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-T: Zinc	7440-66-6	5	µg/L	<5	<5	0.00	No Limit
EB1911615-016	JBBH_S11	EG093A-T: Cadmium	7440-43-9	0.2	µg/L	0.3	0.3	0.00	No Limit
		EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	0.00	No Limit
		EG093A-T: Arsenic	7440-38-2	0.5	µg/L	10.5	10.2	3.09	0% - 50%
		EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	<0.5	0.00	No Limit
		EG093A-T: Nickel	7440-02-0	0.5	µg/L	1.3	1.6	16.4	No Limit
		EG093A-T: Zinc	7440-66-6	5	µg/L	27	25	8.94	No Limit
EG093T_LL: Total Metals in Saline Water by ORC-ICPMS (QC Lot: 2355748)									
EB1911615-006	JBBH_S5	EG093A-T_LL: Copper	7440-50-8	0.2	µg/L	1.2	1.2	0.00	No Limit
EB1911615-016	JBBH_S11	EG093A-T_LL: Copper	7440-50-8	0.2	µg/L	7.7	7.8	0.00	0% - 20%



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result			Low	High
EN68: Seawater Elutriate Testing Procedure (QCLot: 2347166)								
EN68a: Seawater Sampling Date	----	----	-	16/05/2019	----	----	----	----

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result			Low	High
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2355749)								
EG093A-T: Arsenic	7440-38-2	0.5	µg/L	<0.5	10 µg/L	116	89	125
EG093A-T: Cadmium	7440-43-9	0.2	µg/L	<0.2	10 µg/L	119	82	122
EG093A-T: Chromium	7440-47-3	0.5	µg/L	<0.5	10 µg/L	103	85	123
EG093A-T: Lead	7439-92-1	0.2	µg/L	<0.2	10 µg/L	95.2	85	125
EG093A-T: Nickel	7440-02-0	0.5	µg/L	<0.5	10 µg/L	114	85	125
EG093A-T: Zinc	7440-66-6	5	µg/L	<5	10 µg/L	91.5	82	128
EG093T_LL: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2355748)								
EG093A-T_LL: Copper	7440-50-8	0.2	µg/L	<0.2	10 µg/L	97.5	85	115

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG093T: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2355749)							
EB1911615-007	JBBH_S6_1_0.00_0.10	EG093A-T: Arsenic	7440-38-2	50 µg/L	120	70	130
		EG093A-T: Cadmium	7440-43-9	12.5 µg/L	114	70	130
		EG093A-T: Chromium	7440-47-3	50 µg/L	103	70	130
		EG093A-T: Lead	7439-92-1	50 µg/L	98.7	70	130
		EG093A-T: Nickel	7440-02-0	50 µg/L	118	70	130
		EG093A-T: Zinc	7440-66-6	50 µg/L	92.6	70	130
EG093T_LL: Total Metals in Saline Water by ORC-ICPMS (QCLot: 2355748)							
EB1911615-007	JBBH_S6_1_0.00_0.10	EG093A-T_LL: Copper	7440-50-8	50 µg/L	101	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1911615	Page	: 1 of 4
Client	: BMT WESTERN AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR BEN DAVIS	Telephone	: +61-7-3243 7222
Project	: Jurien Bay BH Sediment Sampling 2019	Date Samples Received	: 08-May-2019
Site	: Jurien Bay	Issue Date	: 22-May-2019
Sampler	: ----	No. of samples received	: 21
Order number	:	No. of samples analysed	: 14

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- **NO** Matrix Spike outliers occur.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- **NO** Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- **NO** Quality Control Sample Frequency Outliers exist.



Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EN68: Seawater Elutriate Testing Procedure							
Non-Volatile Leach: 180 day HT (e.g. PFAS, metals ex.Hg) (EN68a)							
JBBH_S5, JBBH_S6_2_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S9, JBBH_S10_2_0.00_0.10, JBBH_S11, JBBH_S15,	JBBH_S6_1_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S8, JBBH_S10_1_0.00_0.10, JBBH_S10_3, JBBH_S14, Elutriate Control	08-May-2019	15-May-2019	04-Nov-2019	✔	----	----

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG093T: Total Metals in Saline Water by ORC-ICPMS							
Clear HDPE (U-T ORC) - Unfiltered; Lab-acidified (EG093A-T)							
JBBH_S5, JBBH_S6_2_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S9, JBBH_S10_2_0.00_0.10, JBBH_S11, JBBH_S15,	JBBH_S6_1_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S8, JBBH_S10_1_0.00_0.10, JBBH_S10_3, JBBH_S14, Elutriate Control	15-May-2019	20-May-2019	11-Nov-2019	✔	20-May-2019	11-Nov-2019
EG093T_LL: Total Metals in Saline Water by ORC-ICPMS							
Clear HDPE (U-T ORC) - Unfiltered; Lab-acidified (EG093A-T_LL)							
JBBH_S5, JBBH_S6_2_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S9, JBBH_S10_2_0.00_0.10, JBBH_S11, JBBH_S15,	JBBH_S6_1_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S8, JBBH_S10_1_0.00_0.10, JBBH_S10_3, JBBH_S14, Elutriate Control	15-May-2019	20-May-2019	11-Nov-2019	✔	20-May-2019	11-Nov-2019



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB)							
Seawater Elutriate Testing Procedure	EN68a	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Low Level Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T_LL	2	17	11.76	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	2	20	10.00	9.52	✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Low Level Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T_LL	1	17	5.88	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	20	5.00	4.76	✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Low Level Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T_LL	1	17	5.88	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	20	5.00	4.76	✔	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Low Level Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T_LL	1	17	5.88	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	1	20	5.00	4.76	✔	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Low Level Total Metals in Saline Water Suite A by ORC-ICPMS	EG093A-T LL	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
Digestion for Total Recoverable Metals - ORC	EN25-ORC	SOIL	In house: Referenced to USEPA SW846-3005. This is an Ultrapure Nitric acid digestion procedure used to prepare surface and ground water samples for analysis by ORC- ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Seawater Elutriate Testing Procedure	EN68a	SOIL	USEPA Evaluation of Dredged Material Proposed for Ocean Disposal - Testing Guide, 1991, EPA-503/8-91/001, USEPA and US Army Corps of Engineers. ANZECC Interim Ocean Disposal Guidelines, December, 1998 This Procedure outlines the preparation of leachate designed to simulate release of contaminants from sediment during the disposal of dredged material. Release can occur by physical processes or a variety of chemical changes such as oxidation of metal sulphides and release of contaminants adsorbed to particles or organic matter.

CERTIFICATE OF ANALYSIS

Work Order : **EP1903737**
Client : **BMT WESTERN AUSTRALIA PTY LTD**
Contact : **MR BEN DAVIS**
Address : **LEVEL 4 20 PARKLAND ROAD**
OSBORNE PARK WA, AUSTRALIA 6017
Telephone : **+61 08 6272 0000**
Project : **Jurien Bay BH Sediment Sampling 2019**
Order number : **1454_01_002**
C-O-C number : **834**
Sampler : **BEN DAVIS, LOUISE SYNNOT**
Site : **Jurien Bay**
Quote number : **1453_01 (EP/175/19 V2)**
No. of samples received : **37**
No. of samples analysed : **37**

Page : 1 of 29
Laboratory : Environmental Division Perth
Contact : Customer Services EP
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : +61-8-9406 1301
Date Samples Received : 18-Apr-2019 11:30
Date Analysis Commenced : 23-Apr-2019
Issue Date : 07-May-2019 09:26



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.

Signatories	Position	Accreditation Category
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
David Viner	SENIOR LAB TECH	Perth Organics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD
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.

- Elutriate and TOC conducted by ALS Brisbane, NATA Site No. 818.
- It is recognised that EK267PA-SW (Total Phosphorus as P) is less than EK271A-SW (Reactive Phosphorous as P) for some samples. However, the difference is within experimental variation of the methods.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- EP132-SD: LOR has been raised for EP1903737-013 due to suspected matrix effects and interferences. Chromatogram has been reviewed.
- EP132-SD: LOR raised for EP1903737-015 due to high moisture content.
- EP080: C6-C9 and C6-C10 matrix spike recovery not determined due to possible matrix effects and interferences.
- EN68: This analysis in accordance with National Ocean Disposal Guidelines, Commonwealth of Australia, 2002 - (modified). Results reported are those determined on a 1:4 sediment/seawater elutriate without blank correction.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity ($H^+ + Al^{3+}$).



Analytical Results

Sub-Matrix: ELUTRIATE
 (Matrix: WATER)

Client sample ID

				JBBH_S1	JBBH_S2_A	JBBH_S2_B	JBBH_S3	JBBH_S4
Client sampling date / time				16-Apr-2019 16:12	17-Apr-2019 11:40	17-Apr-2019 11:42	17-Apr-2019 11:49	17-Apr-2019 11:27
Compound	CAS Number	LOR	Unit	EP1903737-004	EP1903737-005	EP1903737-006	EP1903737-007	EP1903737-008
				Result	Result	Result	Result	Result
EK255A: Ammonia								
Ammonia as N	7664-41-7	0.005	mg/L	0.007	0.164	0.190	0.739	0.485
EK255A-NH4: Ammonium								
Ammonium as N	14798-03-9_N	0.005	mg/L	0.006	0.154	0.178	0.694	0.455
EK257A: Nitrite								
Nitrite as N	14797-65-0	0.002	mg/L	<0.002	<0.002	<0.002	0.002	<0.002
EK258A: Nitrate								
Nitrate as N	14797-55-8	0.002	mg/L	0.039	<0.002	<0.002	0.003	<0.002
EK259A: Nitrite and Nitrate (NOx)								
Nitrite + Nitrate as N	----	0.002	mg/L	0.039	<0.002	<0.002	0.005	<0.002
EK261A: Total Kjeldahl Nitrogen								
Total Kjeldahl Nitrogen as N	----	0.050	mg/L	0.120	0.346	0.367	1.22	0.847
EK262A: Total Nitrogen								
Total Nitrogen as N	----	0.050	mg/L	0.159	0.346	0.367	1.22	0.847
EK267A: Total Phosphorus (Persulfate Digestion)								
Total Phosphorus as P	----	0.005	mg/L	0.017	0.010	0.007	0.062	0.023
EK271A: Reactive Phosphorus								
Reactive Phosphorus as P	14265-44-2	0.001	mg/L	0.019	0.011	0.011	0.042	0.008



Analytical Results

Sub-Matrix: ELUTRIATE
 (Matrix: WATER)

Client sample ID

				JBBH_S5	JBBH_S6_1_0.00_0.1 0	JBBH_S6_2_0.00_0.1 0	JBBH_S6_3_0.00_0.1 0	JBBH_S7_0.00_0.10
Client sampling date / time				17-Apr-2019 11:19	17-Apr-2019 08:07	17-Apr-2019 08:19	17-Apr-2019 08:23	17-Apr-2019 07:41
Compound	CAS Number	LOR	Unit	EP1903737-009	EP1903737-010	EP1903737-011	EP1903737-012	EP1903737-013
				Result	Result	Result	Result	Result
EK255A: Ammonia								
Ammonia as N	7664-41-7	0.005	mg/L	1.17	5.43	4.33	5.43	3.12
EK255A-NH4: Ammonium								
Ammonium as N	14798-03-9_N	0.005	mg/L	1.10	5.10	4.06	5.10	2.93
EK257A: Nitrite								
Nitrite as N	14797-65-0	0.002	mg/L	0.003	<0.002	<0.002	<0.002	<0.002
EK258A: Nitrate								
Nitrate as N	14797-55-8	0.002	mg/L	<0.002	0.011	0.015	0.008	0.007
EK259A: Nitrite and Nitrate (NOx)								
Nitrite + Nitrate as N	----	0.002	mg/L	0.004	0.011	0.015	0.008	0.007
EK261A: Total Kjeldahl Nitrogen								
Total Kjeldahl Nitrogen as N	----	0.050	mg/L	1.90	6.51	5.38	6.42	3.65
EK262A: Total Nitrogen								
Total Nitrogen as N	----	0.050	mg/L	1.90	6.52	5.39	6.43	3.66
EK267A: Total Phosphorus (Persulfate Digestion)								
Total Phosphorus as P	----	0.005	mg/L	0.080	0.094	0.195	0.151	0.047
EK271A: Reactive Phosphorus								
Reactive Phosphorus as P	14265-44-2	0.001	mg/L	0.037	0.061	0.143	0.099	0.027



Analytical Results

Sub-Matrix: ELUTRIATE
 (Matrix: WATER)

Client sample ID

				JBBH_S8	JBBH_S9	JBBH_S10_1_0.00_0.10	JBBH_S10_2_0.00_0.10	JBBH_S10_3
Client sampling date / time				17-Apr-2019 11:16	17-Apr-2019 11:05	17-Apr-2019 08:48	17-Apr-2019 08:51	17-Apr-2019 08:53
Compound	CAS Number	LOR	Unit	EP1903737-014	EP1903737-015	EP1903737-016	EP1903737-017	EP1903737-018
				Result	Result	Result	Result	Result
EK255A: Ammonia								
Ammonia as N	7664-41-7	0.005	mg/L	1.98	2.45	1.65	2.32	3.96
EK255A-NH4: Ammonium								
Ammonium as N	14798-03-9_N	0.005	mg/L	1.86	2.30	1.55	2.18	3.72
EK257A: Nitrite								
Nitrite as N	14797-65-0	0.002	mg/L	<0.002	<0.002	<0.002	0.007	<0.002
EK258A: Nitrate								
Nitrate as N	14797-55-8	0.002	mg/L	0.012	0.010	0.021	0.014	0.007
EK259A: Nitrite and Nitrate (NOx)								
Nitrite + Nitrate as N	----	0.002	mg/L	0.012	0.010	0.021	0.021	0.007
EK261A: Total Kjeldahl Nitrogen								
Total Kjeldahl Nitrogen as N	----	0.050	mg/L	2.47	3.08	2.28	3.26	4.19
EK262A: Total Nitrogen								
Total Nitrogen as N	----	0.050	mg/L	2.48	3.09	2.30	3.28	4.20
EK267A: Total Phosphorus (Persulfate Digestion)								
Total Phosphorus as P	----	0.005	mg/L	0.074	0.185	0.031	0.110	0.047
EK271A: Reactive Phosphorus								
Reactive Phosphorus as P	14265-44-2	0.001	mg/L	0.049	0.145	0.009	0.050	0.026



Analytical Results

Sub-Matrix: ELUTRIATE (Matrix: WATER)				Client sample ID	JBBH_S11	JBBH_S12_0.10	JBBH_S13	JBBH_S14	JBBH_S15
Client sampling date / time					17-Apr-2019 10:55	16-Apr-2019 16:17	17-Apr-2019 12:01	17-Apr-2019 11:11	17-Apr-2019 10:57
Compound	CAS Number	LOR	Unit		EP1903737-019	EP1903737-020	EP1903737-021	EP1903737-022	EP1903737-023
					Result	Result	Result	Result	Result
EK255A: Ammonia									
Ammonia as N	7664-41-7	0.005	mg/L		1.57	0.081	0.909	2.40	1.32
EK255A-NH4: Ammonium									
Ammonium as N	14798-03-9_N	0.005	mg/L		1.47	0.076	0.853	2.25	1.24
EK257A: Nitrite									
Nitrite as N	14797-65-0	0.002	mg/L		0.002	<0.002	<0.002	<0.002	<0.002
EK258A: Nitrate									
Nitrate as N	14797-55-8	0.002	mg/L		0.010	0.063	0.005	0.008	0.017
EK259A: Nitrite and Nitrate (NOx)									
Nitrite + Nitrate as N	----	0.002	mg/L		0.012	0.063	0.005	0.008	0.017
EK261A: Total Kjeldahl Nitrogen									
Total Kjeldahl Nitrogen as N	----	0.050	mg/L		2.21	0.281	1.28	2.77	1.60
EK262A: Total Nitrogen									
Total Nitrogen as N	----	0.050	mg/L		2.22	0.344	1.28	2.78	1.62
EK267A: Total Phosphorus (Persulfate Digestion)									
Total Phosphorus as P	----	0.005	mg/L		0.114	0.076	0.019	0.113	0.128
EK271A: Reactive Phosphorus									
Reactive Phosphorus as P	14265-44-2	0.001	mg/L		0.079	0.068	0.009	0.081	0.091



Analytical Results

Sub-Matrix: ELUTRIATE (Matrix: WATER)			Client sample ID	Elutriate	----	----	----	----
Client sampling date / time				17-Apr-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP1903737-037	-----	-----	-----	-----
Result				----	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.06	----	----	----	----
EK255A: Ammonia								
Ammonia as N	7664-41-7	0.005	mg/L	<0.005	----	----	----	----
EK255A-NH4: Ammonium								
Ammonium as N	14798-03-9_N	0.005	mg/L	<0.005	----	----	----	----
EK257A: Nitrite								
Nitrite as N	14797-65-0	0.002	mg/L	<0.002	----	----	----	----
EK258A: Nitrate								
Nitrate as N	14797-55-8	0.002	mg/L	<0.002	----	----	----	----
EK259A: Nitrite and Nitrate (NOx)								
Nitrite + Nitrate as N	----	0.002	mg/L	<0.002	----	----	----	----
EK261A: Total Kjeldahl Nitrogen								
Total Kjeldahl Nitrogen as N	----	0.050	mg/L	0.199	----	----	----	----
EK262A: Total Nitrogen								
Total Nitrogen as N	----	0.050	mg/L	0.199	----	----	----	----
EK267A: Total Phosphorus (Persulfate Digestion)								
Total Phosphorus as P	----	0.005	mg/L	0.017	----	----	----	----
EK271A: Reactive Phosphorus								
Reactive Phosphorus as P	14265-44-2	0.001	mg/L	<0.001	----	----	----	----



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	JBBH_S1	JBBH_S2_A	JBBH_S2_B	JBBH_S3	JBBH_S4
Client sampling date / time					16-Apr-2019 16:12	17-Apr-2019 11:40	17-Apr-2019 11:42	17-Apr-2019 11:49	17-Apr-2019 11:27
Compound	CAS Number	LOR	Unit		EP1903737-004	EP1903737-005	EP1903737-006	EP1903737-007	EP1903737-008
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		----	----	----	8.6	8.6
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		6.8	33.8	30.1	31.9	31.8
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		----	----	----	3.8	3.8
Exchangeable Magnesium	----	0.1	meq/100g		----	----	----	0.6	0.6
Exchangeable Potassium	----	0.1	meq/100g		----	----	----	<0.1	<0.1
Exchangeable Sodium	----	0.1	meq/100g		----	----	----	0.2	0.2
Cation Exchange Capacity	----	0.1	meq/100g		----	----	----	4.7	4.7
Exchangeable Sodium Percent	----	0.1	%		----	----	----	4.3	4.5
EG020-SD: Total Metals in Sediments by ICPMS									
Arsenic	7440-38-2	1.00	mg/kg		<1.00	<1.00	<1.00	1.15	1.09
Cadmium	7440-43-9	0.1	mg/kg		0.1	<0.1	0.1	0.1	0.1
Chromium	7440-47-3	1.0	mg/kg		12.0	10.7	10.4	11.2	9.8
Copper	7440-50-8	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Lead	7439-92-1	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg		<1.0	1.3	1.3	2.3	1.6
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		<0.01	<0.01	<0.01	<0.01	<0.01
EN68: Seawater Elutriate Testing Procedure									
Seawater Sampling Date	----	-	-		1/5/2019	1/5/2019	1/5/2019	1/5/2019	1/5/2019
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.10	0.11	0.10	0.19	0.11
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
>C10 - C16 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3
>C16 - C34 Fraction	----	3	mg/kg		<3	<3	<3	<3	15
>C34 - C40 Fraction	----	5	mg/kg		<5	<5	<5	<5	<5
>C10 - C40 Fraction (sum)	----	3	mg/kg		<3	<3	<3	<3	15
>C10 - C16 Fraction minus Naphthalene (F2)	----	3	mg/kg		<3	<3	<3	<3	<3
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3
C10 - C14 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	JBBH_S1	JBBH_S2_A	JBBH_S2_B	JBBH_S3	JBBH_S4
Client sampling date / time					16-Apr-2019 16:12	17-Apr-2019 11:40	17-Apr-2019 11:42	17-Apr-2019 11:49	17-Apr-2019 11:27
Compound	CAS Number	LOR	Unit		EP1903737-004	EP1903737-005	EP1903737-006	EP1903737-007	EP1903737-008
					Result	Result	Result	Result	Result
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons - Continued									
C15 - C28 Fraction	----	3	mg/kg		<3	<3	<3	4	15
C29 - C36 Fraction	----	5	mg/kg		<5	<5	<5	<5	<5
^ C10 - C36 Fraction (sum)	----	3	mg/kg		<3	<3	<3	4	15
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons									
C6 - C10 Fraction	C6_C10	3	mg/kg		<3	<3	<3	<3	<3
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg		<3.0	<3.0	<3.0	<3.0	<3.0
EP080-SD: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	108-88-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Ethylbenzene	100-41-4	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
ortho-Xylene	95-47-6	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
^ Total Xylenes	----	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of BTEX	----	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Naphthalene	91-20-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
EP132B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	5	µg/kg		<5	<5	<5	<5	<5
2-Methylnaphthalene	91-57-6	5	µg/kg		<5	<5	<5	<5	<5
Acenaphthylene	208-96-8	4	µg/kg		<4	<4	<4	<4	<4
Acenaphthene	83-32-9	4	µg/kg		<4	<4	<4	<4	<4
Fluorene	86-73-7	4	µg/kg		<4	<4	<4	<4	<4
Phenanthrene	85-01-8	4	µg/kg		<4	<4	<4	<4	<4
Anthracene	120-12-7	4	µg/kg		<4	<4	<4	<4	<4
Fluoranthene	206-44-0	4	µg/kg		<4	<4	<4	<4	<4
Pyrene	129-00-0	4	µg/kg		<4	<4	<4	<4	<4
Benz(a)anthracene	56-55-3	4	µg/kg		<4	<4	<4	<4	<4
Chrysene	218-01-9	4	µg/kg		<4	<4	<4	<4	<4
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg		<4	<4	<4	<4	<4
Benzo(k)fluoranthene	207-08-9	4	µg/kg		<4	<4	<4	<4	<4
Benzo(e)pyrene	192-97-2	4	µg/kg		<4	<4	<4	<4	<4
Benzo(a)pyrene	50-32-8	4	µg/kg		<4	<4	<4	<4	<4
Perylene	198-55-0	4	µg/kg		<4	<4	<4	<4	<4
Benzo(g,h,i)perylene	191-24-2	4	µg/kg		<4	<4	<4	<4	<4



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	JBBH_S1	JBBH_S2_A	JBBH_S2_B	JBBH_S3	JBBH_S4
Client sampling date / time					16-Apr-2019 16:12	17-Apr-2019 11:40	17-Apr-2019 11:42	17-Apr-2019 11:49	17-Apr-2019 11:27
Compound	CAS Number	LOR	Unit		EP1903737-004	EP1903737-005	EP1903737-006	EP1903737-007	EP1903737-008
					Result	Result	Result	Result	Result
EP132B: Polynuclear Aromatic Hydrocarbons - Continued									
Dibenz(a,h)anthracene	53-70-3	4	µg/kg		<4	<4	<4	<4	<4
Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg		<4	<4	<4	<4	<4
Coronene	191-07-1	5	µg/kg		<5	<5	<5	<5	<5
^ Sum of PAHs	----	4	µg/kg		<4	<4	<4	<4	<4
^ Benzo(a)pyrene TEQ (zero)	----	4	µg/kg		<4	<4	<4	<4	<4
^ Benzo(a)pyrene TEQ (half LOR)	----	4	µg/kg		5	5	5	5	5
^ Benzo(a)pyrene TEQ (LOR)	----	4	µg/kg		10	10	10	10	10
EP080-SD: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	0.2	%		115	85.9	103	106	120
Toluene-D8	2037-26-5	0.2	%		101	74.5	89.5	92.2	109
4-Bromofluorobenzene	460-00-4	0.2	%		100	75.6	89.7	92.8	111
EP132T: Base/Neutral Extractable Surrogates									
2-Fluorobiphenyl	321-60-8	10	%		83.9	84.6	82.0	85.1	86.8
Anthracene-d10	1719-06-8	10	%		103	77.3	70.1	72.6	71.4
4-Terphenyl-d14	1718-51-0	10	%		86.4	78.5	80.6	81.8	79.1



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				JBBH_S5	JBBH_S6_1_0.00_0.1 0	JBBH_S6_2_0.00_0.1 0	JBBH_S6_3_0.00_0.1 0	JBBH_S7_0.00_0.10
Client sampling date / time				17-Apr-2019 11:19	17-Apr-2019 08:07	17-Apr-2019 08:19	17-Apr-2019 08:23	17-Apr-2019 07:41
Compound	CAS Number	LOR	Unit	EP1903737-009	EP1903737-010	EP1903737-011	EP1903737-012	EP1903737-013
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	35.4	44.5	42.3	45.4	51.8
EG020-SD: Total Metals in Sediments by ICPMS								
Arsenic	7440-38-2	1.00	mg/kg	1.11	2.27	2.88	2.54	6.35
Cadmium	7440-43-9	0.1	mg/kg	0.1	0.2	0.2	0.2	0.3
Chromium	7440-47-3	1.0	mg/kg	10.3	11.0	9.5	10.8	14.1
Copper	7440-50-8	1.0	mg/kg	2.1	13.6	14.1	15.6	59.9
Lead	7439-92-1	1.0	mg/kg	<1.0	2.0	1.1	1.8	3.0
Nickel	7440-02-0	1.0	mg/kg	<1.0	<1.0	<1.0	1.0	2.7
Zinc	7440-66-6	1.0	mg/kg	4.5	29.1	30.5	26.9	78.7
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EN68: Seawater Elutriate Testing Procedure								
Seawater Sampling Date	----	-	-	1/5/2019	1/5/2019	1/5/2019	1/5/2019	1/5/2019
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.14	0.73	0.58	0.72	0.89
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
>C10 - C16 Fraction	----	3	mg/kg	<3	5	5	6	11
>C16 - C34 Fraction	----	3	mg/kg	8	27	37	43	106
>C34 - C40 Fraction	----	5	mg/kg	<5	<5	<5	6	21
>C10 - C40 Fraction (sum)	----	3	mg/kg	8	32	42	55	138
>C10 - C16 Fraction minus Naphthalene (F2)	----	3	mg/kg	<3	5	5	6	11
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	3	mg/kg	<3	<3	<3	<3	<3
C10 - C14 Fraction	----	3	mg/kg	<3	6	5	6	11
C15 - C28 Fraction	----	3	mg/kg	8	21	26	31	69
C29 - C36 Fraction	----	5	mg/kg	<5	8	14	15	48
^ C10 - C36 Fraction (sum)	----	3	mg/kg	8	35	45	52	128
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons								
C6 - C10 Fraction	C6_C10	3	mg/kg	<3	<3	<3	<3	<3
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg	<3.0	<3.0	<3.0	<3.0	<3.0
EP080-SD: BTEXN								
Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				JBBH_S5	JBBH_S6_1_0.00_0.1 0	JBBH_S6_2_0.00_0.1 0	JBBH_S6_3_0.00_0.1 0	JBBH_S7_0.00_0.10
Client sampling date / time				17-Apr-2019 11:19	17-Apr-2019 08:07	17-Apr-2019 08:19	17-Apr-2019 08:23	17-Apr-2019 07:41
Compound	CAS Number	LOR	Unit	EP1903737-009	EP1903737-010	EP1903737-011	EP1903737-012	EP1903737-013
				Result	Result	Result	Result	Result
EP080-SD: BTEXN - Continued								
Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Naphthalene	91-20-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	<5	<5	<5	<5	80
2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	<5	<5	40
Acenaphthylene	208-96-8	4	µg/kg	<4	<4	<4	<4	<5
Acenaphthene	83-32-9	4	µg/kg	<4	<4	<4	<4	<40
Fluorene	86-73-7	4	µg/kg	<4	<4	<4	<4	<40
Phenanthrene	85-01-8	4	µg/kg	<4	<4	<4	<4	<60
Anthracene	120-12-7	4	µg/kg	<4	<4	<4	<4	<5
Fluoranthene	206-44-0	4	µg/kg	<4	<4	<4	<4	<40
Pyrene	129-00-0	4	µg/kg	<4	<4	<4	<4	<40
Benz(a)anthracene	56-55-3	4	µg/kg	<4	<4	<4	<4	<40
Chrysene	218-01-9	4	µg/kg	<4	<4	<4	<4	<5
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	<4	<4	<4	<5
Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	<4	<4	<5
Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	<4	<4	<5
Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	<4	<4	<5
Perylene	198-55-0	4	µg/kg	<4	<4	<4	<4	<5
Benzo(g,h,i)perylene	191-24-2	4	µg/kg	<4	<4	<4	<4	<5
Dibenz(a,h)anthracene	53-70-3	4	µg/kg	<4	<4	<4	<4	<5
Indeno(1,2,3-cd)pyrene	193-39-5	4	µg/kg	<4	<4	<4	<4	<5
Coronene	191-07-1	5	µg/kg	<5	<5	<5	<5	<5
^ Sum of PAHs	----	4	µg/kg	<4	<4	<4	<4	120
^ Benzo(a)pyrene TEQ (zero)	----	4	µg/kg	<4	<4	<4	<4	<5
^ Benzo(a)pyrene TEQ (half LOR)	----	4	µg/kg	5	5	5	5	<5
^ Benzo(a)pyrene TEQ (LOR)	----	4	µg/kg	10	10	10	10	10
EP080-SD: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	107	109	108	98.0	116



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Client sample ID

				JBBH_S5	JBBH_S6_1_0.00_0.1 0	JBBH_S6_2_0.00_0.1 0	JBBH_S6_3_0.00_0.1 0	JBBH_S7_0.00_0.10
Client sampling date / time				17-Apr-2019 11:19	17-Apr-2019 08:07	17-Apr-2019 08:19	17-Apr-2019 08:23	17-Apr-2019 07:41
Compound	CAS Number	LOR	Unit	EP1903737-009	EP1903737-010	EP1903737-011	EP1903737-012	EP1903737-013
				Result	Result	Result	Result	Result
EP080-SD: TPH(V)/BTEX Surrogates - Continued								
Toluene-D8	2037-26-5	0.2	%	94.7	96.1	90.7	86.6	94.6
4-Bromofluorobenzene	460-00-4	0.2	%	97.6	95.7	93.2	86.0	97.4
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	92.2	91.5	91.0	89.0	87.1
Anthracene-d10	1719-06-8	10	%	79.0	74.1	70.3	82.7	75.7
4-Terphenyl-d14	1718-51-0	10	%	88.3	85.5	77.9	85.3	83.7



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	JBBH_S8	JBBH_S9	JBBH_S10_1_0.00_0.10	JBBH_S10_2_0.00_0.10	JBBH_S10_3
Client sampling date / time					17-Apr-2019 11:16	17-Apr-2019 11:05	17-Apr-2019 08:48	17-Apr-2019 08:51	17-Apr-2019 08:53
Compound	CAS Number	LOR	Unit		EP1903737-014	EP1903737-015	EP1903737-016	EP1903737-017	EP1903737-018
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		8.4	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		44.8	59.1	44.1	42.7	43.2
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		9.6	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g		3.3	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g		<0.1	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g		0.4	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		13.4	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%		3.4	----	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS									
Arsenic	7440-38-2	1.00	mg/kg		1.47	2.71	2.26	2.73	2.95
Cadmium	7440-43-9	0.1	mg/kg		0.2	0.2	0.1	0.2	0.2
Chromium	7440-47-3	1.0	mg/kg		11.8	14.3	10.3	10.8	11.2
Copper	7440-50-8	1.0	mg/kg		33.8	64.2	28.9	36.0	41.3
Lead	7439-92-1	1.0	mg/kg		1.1	1.9	1.7	1.9	2.0
Nickel	7440-02-0	1.0	mg/kg		1.2	2.5	1.1	1.3	1.3
Zinc	7440-66-6	1.0	mg/kg		26.4	50.2	39.2	50.1	51.3
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		<0.01	<0.01	<0.01	<0.01	<0.01
EN68: Seawater Elutriate Testing Procedure									
Seawater Sampling Date	----	-	-		1/5/2019	1/5/2019	1/5/2019	1/5/2019	1/5/2019
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.51	1.31	0.57	0.73	0.99
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
>C10 - C16 Fraction	----	3	mg/kg		5	13	4	4	5
>C16 - C34 Fraction	----	3	mg/kg		42	129	46	57	75
>C34 - C40 Fraction	----	5	mg/kg		8	23	9	12	16
>C10 - C40 Fraction (sum)	----	3	mg/kg		55	165	59	73	96
>C10 - C16 Fraction minus Naphthalene (F2)	----	3	mg/kg		5	13	4	4	5
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				JBBH_S8	JBBH_S9	JBBH_S10_1_0.00_0.10	JBBH_S10_2_0.00_0.10	JBBH_S10_3
Client sampling date / time				17-Apr-2019 11:16	17-Apr-2019 11:05	17-Apr-2019 08:48	17-Apr-2019 08:51	17-Apr-2019 08:53
Compound	CAS Number	LOR	Unit	EP1903737-014	EP1903737-015	EP1903737-016	EP1903737-017	EP1903737-018
				Result	Result	Result	Result	Result
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons - Continued								
C10 - C14 Fraction	----	3	mg/kg	5	12	4	4	5
C15 - C28 Fraction	----	3	mg/kg	29	86	31	36	46
C29 - C36 Fraction	----	5	mg/kg	17	55	20	26	37
^ C10 - C36 Fraction (sum)	----	3	mg/kg	51	153	55	66	88
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons								
C6 - C10 Fraction	C6_C10	3	mg/kg	<3	<3	<3	<3	<3
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg	<3.0	<3.0	<3.0	<3.0	<3.0
EP080-SD: BTEXN								
Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Naphthalene	91-20-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	<5	<5	<5	<5	<5
2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	<5	<5	<5
Acenaphthylene	208-96-8	4	µg/kg	<4	<5	<4	<4	<4
Acenaphthene	83-32-9	4	µg/kg	<4	<5	<4	<4	<4
Fluorene	86-73-7	4	µg/kg	<4	<5	<4	<4	<4
Phenanthrene	85-01-8	4	µg/kg	<4	<5	<4	<4	<4
Anthracene	120-12-7	4	µg/kg	<4	<5	<4	<4	<4
Fluoranthene	206-44-0	4	µg/kg	<4	<5	<4	<4	<4
Pyrene	129-00-0	4	µg/kg	<4	<5	<4	<4	<4
Benz(a)anthracene	56-55-3	4	µg/kg	<4	<5	<4	<4	<4
Chrysene	218-01-9	4	µg/kg	<4	<5	<4	<4	<4
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	<5	<4	<4	<4
Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<5	<4	<4	<4
Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<5	<4	<4	<4
Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<5	<4	<4	<4
Perylene	198-55-0	4	µg/kg	<4	<5	<4	<4	<4



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				JBBH_S8	JBBH_S9	JBBH_S10_1_0.00_0.10	JBBH_S10_2_0.00_0.10	JBBH_S10_3
Client sampling date / time				17-Apr-2019 11:16	17-Apr-2019 11:05	17-Apr-2019 08:48	17-Apr-2019 08:51	17-Apr-2019 08:53
Compound	CAS Number	LOR	Unit	EP1903737-014	EP1903737-015	EP1903737-016	EP1903737-017	EP1903737-018
				Result	Result	Result	Result	Result
EP132B: Polynuclear Aromatic Hydrocarbons - Continued								
Benzo(g,h,i)perylene	191-24-2	4	µg/kg	<4	<5	<4	<4	<4
Dibenz(a,h)anthracene	53-70-3	4	µg/kg	<4	<5	<4	<4	<4
Indeno(1,2,3-cd)pyrene	193-39-5	4	µg/kg	<4	<5	<4	<4	<4
Coronene	191-07-1	5	µg/kg	<5	<5	<5	<5	<5
^ Sum of PAHs	----	4	µg/kg	<4	<5	<4	<4	<4
^ Benzo(a)pyrene TEQ (zero)	----	4	µg/kg	<4	<5	<4	<4	<4
^ Benzo(a)pyrene TEQ (half LOR)	----	4	µg/kg	5	<5	5	5	5
^ Benzo(a)pyrene TEQ (LOR)	----	4	µg/kg	10	10	10	10	10
EP080-SD: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	110	100	119	90.5	127
Toluene-D8	2037-26-5	0.2	%	104	85.0	107	126	104
4-Bromofluorobenzene	460-00-4	0.2	%	102	86.1	109	122	108
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	85.2	79.3	72.1	89.3	79.7
Anthracene-d10	1719-06-8	10	%	71.8	78.3	72.4	76.6	74.5
4-Terphenyl-d14	1718-51-0	10	%	88.6	79.1	76.3	81.6	76.7



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	JBBH_S11	JBBH_S12_0.10	JBBH_S13	JBBH_S14	JBBH_S15
Client sampling date / time					17-Apr-2019 10:55	16-Apr-2019 16:17	17-Apr-2019 12:01	17-Apr-2019 11:11	17-Apr-2019 10:57
Compound	CAS Number	LOR	Unit		EP1903737-019	EP1903737-020	EP1903737-021	EP1903737-022	EP1903737-023
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		8.1	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		41.2	11.5	27.8	43.7	41.1
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		8.0	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g		1.6	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g		<0.1	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g		0.3	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		9.9	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%		2.9	----	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS									
Arsenic	7440-38-2	1.00	mg/kg		1.31	<1.00	1.24	1.46	1.08
Cadmium	7440-43-9	0.1	mg/kg		0.1	0.1	<0.1	0.1	0.1
Chromium	7440-47-3	1.0	mg/kg		9.9	12.5	10.8	10.1	12.2
Copper	7440-50-8	1.0	mg/kg		16.6	<1.0	<1.0	16.8	19.0
Lead	7439-92-1	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg		13.4	<1.0	1.4	19.7	13.8
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		<0.01	<0.01	<0.01	<0.01	<0.01
EN68: Seawater Elutriate Testing Procedure									
Seawater Sampling Date	----	-	-		1/5/2019	1/5/2019	1/5/2019	1/5/2019	1/5/2019
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.20	0.08	0.09	0.85	0.43
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
>C10 - C16 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3
>C16 - C34 Fraction	----	3	mg/kg		25	<3	<3	27	22
>C34 - C40 Fraction	----	5	mg/kg		<5	<5	<5	<5	<5
>C10 - C40 Fraction (sum)	----	3	mg/kg		25	<3	<3	27	22
>C10 - C16 Fraction minus Naphthalene (F2)	----	3	mg/kg		<3	<3	<3	<3	<3
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3
C10 - C14 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	JBBH_S11	JBBH_S12_0.10	JBBH_S13	JBBH_S14	JBBH_S15
Client sampling date / time					17-Apr-2019 10:55	16-Apr-2019 16:17	17-Apr-2019 12:01	17-Apr-2019 11:11	17-Apr-2019 10:57
Compound	CAS Number	LOR	Unit		EP1903737-019	EP1903737-020	EP1903737-021	EP1903737-022	EP1903737-023
					Result	Result	Result	Result	Result
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons - Continued									
C15 - C28 Fraction	----	3	mg/kg		19	<3	4	18	16
C29 - C36 Fraction	----	5	mg/kg		8	<5	<5	11	7
^ C10 - C36 Fraction (sum)	----	3	mg/kg		27	<3	4	29	23
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons									
C6 - C10 Fraction	C6_C10	3	mg/kg		<3	<3	<3	<3	<3
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg		<3.0	<3.0	<3.0	<3.0	<3.0
EP080-SD: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	108-88-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Ethylbenzene	100-41-4	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
ortho-Xylene	95-47-6	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
^ Total Xylenes	----	0.5	mg/kg		<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of BTEX	----	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Naphthalene	91-20-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
EP132B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	5	µg/kg		<5	<5	<5	<5	<5
2-Methylnaphthalene	91-57-6	5	µg/kg		<5	<5	<5	<5	<5
Acenaphthylene	208-96-8	4	µg/kg		<4	<4	<4	<4	<4
Acenaphthene	83-32-9	4	µg/kg		<4	<4	<4	<4	<4
Fluorene	86-73-7	4	µg/kg		<4	<4	<4	<4	<4
Phenanthrene	85-01-8	4	µg/kg		<4	<4	<4	<4	<4
Anthracene	120-12-7	4	µg/kg		<4	<4	<4	<4	<4
Fluoranthene	206-44-0	4	µg/kg		<4	<4	<4	<4	<4
Pyrene	129-00-0	4	µg/kg		<4	<4	<4	<4	<4
Benz(a)anthracene	56-55-3	4	µg/kg		<4	<4	<4	<4	<4
Chrysene	218-01-9	4	µg/kg		<4	<4	<4	<4	<4
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg		<4	<4	<4	<4	<4
Benzo(k)fluoranthene	207-08-9	4	µg/kg		<4	<4	<4	<4	<4
Benzo(e)pyrene	192-97-2	4	µg/kg		<4	<4	<4	<4	<4
Benzo(a)pyrene	50-32-8	4	µg/kg		<4	<4	<4	<4	<4
Perylene	198-55-0	4	µg/kg		<4	<4	<4	<4	<4
Benzo(g,h,i)perylene	191-24-2	4	µg/kg		<4	<4	<4	<4	<4



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				JBBH_S11	JBBH_S12_0.10	JBBH_S13	JBBH_S14	JBBH_S15
Client sampling date / time				17-Apr-2019 10:55	16-Apr-2019 16:17	17-Apr-2019 12:01	17-Apr-2019 11:11	17-Apr-2019 10:57
Compound	CAS Number	LOR	Unit	EP1903737-019	EP1903737-020	EP1903737-021	EP1903737-022	EP1903737-023
				Result	Result	Result	Result	Result
EP132B: Polynuclear Aromatic Hydrocarbons - Continued								
Dibenz(a,h)anthracene	53-70-3	4	µg/kg	<4	<4	<4	<4	<4
Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	<4	<4	<4	<4
Coronene	191-07-1	5	µg/kg	<5	<5	<5	<5	<5
^ Sum of PAHs	----	4	µg/kg	<4	<4	<4	<4	<4
^ Benzo(a)pyrene TEQ (zero)	----	4	µg/kg	<4	<4	<4	<4	<4
^ Benzo(a)pyrene TEQ (half LOR)	----	4	µg/kg	5	5	5	5	5
^ Benzo(a)pyrene TEQ (LOR)	----	4	µg/kg	10	10	10	10	10
EP080-SD: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	119	127	119	125	101
Toluene-D8	2037-26-5	0.2	%	102	103	105	108	86.3
4-Bromofluorobenzene	460-00-4	0.2	%	105	106	107	109	90.0
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	81.0	85.0	84.1	88.4	81.5
Anthracene-d10	1719-06-8	10	%	72.0	79.4	71.6	71.1	71.6
4-Terphenyl-d14	1718-51-0	10	%	81.5	89.7	81.8	82.7	79.3



Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	JBDA_S1	JBDA_S2	JBDA_S3	JBDA_S4	JBDA_S5
Client sampling date / time					17-Apr-2019 09:40	17-Apr-2019 09:42	17-Apr-2019 09:43	17-Apr-2019 09:59	17-Apr-2019 10:32
Compound	CAS Number	LOR	Unit		EP1903737-024	EP1903737-025	EP1903737-026	EP1903737-027	EP1903737-028
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		35.2	33.0	44.3	39.9	38.4
EG020-SD: Total Metals in Sediments by ICPMS									
Arsenic	7440-38-2	1.00	mg/kg		3.67	1.41	2.53	2.56	1.26
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg		9.8	6.7	8.5	8.1	8.1
Copper	7440-50-8	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Lead	7439-92-1	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	1.0	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg		1.4	1.0	2.0	1.4	<1.0
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		0.26	0.25	0.67	0.50	0.32
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
>C10 - C16 Fraction	----	3	mg/kg		<3	<3	<3	3	<3
>C16 - C34 Fraction	----	3	mg/kg		13	15	19	24	10
>C34 - C40 Fraction	----	5	mg/kg		<5	<5	<5	<5	<5
>C10 - C40 Fraction (sum)	----	3	mg/kg		13	15	19	27	10
>C10 - C16 Fraction minus Naphthalene (F2)	----	3	mg/kg		<3	<3	<3	3	<3
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	3	mg/kg		<3	<3	<3	<3	<3
C10 - C14 Fraction	----	3	mg/kg		<3	<3	<3	5	<3
C15 - C28 Fraction	----	3	mg/kg		12	12	15	15	9
C29 - C36 Fraction	----	5	mg/kg		<5	<5	6	10	<5
^ C10 - C36 Fraction (sum)	----	3	mg/kg		12	12	21	30	9
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons									
C6 - C10 Fraction	C6_C10	3	mg/kg		<3	<3	<3	<3	<3
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg		<3.0	<3.0	<3.0	<3.0	<3.0
EP080-SD: BTEXN									
Benzene	71-43-2	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	108-88-3	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2
Ethylbenzene	100-41-4	0.2	mg/kg		<0.2	<0.2	<0.2	<0.2	<0.2



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				JBDA_S1	JBDA_S2	JBDA_S3	JBDA_S4	JBDA_S5
Client sampling date / time				17-Apr-2019 09:40	17-Apr-2019 09:42	17-Apr-2019 09:43	17-Apr-2019 09:59	17-Apr-2019 10:32
Compound	CAS Number	LOR	Unit	EP1903737-024	EP1903737-025	EP1903737-026	EP1903737-027	EP1903737-028
				Result	Result	Result	Result	Result
EP080-SD: BTEXN - Continued								
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Naphthalene	91-20-3	0.2	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	<5	<5	<5	<5	<5
2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	<5	<5	<5
Acenaphthylene	208-96-8	4	µg/kg	<4	<4	<4	<4	<4
Acenaphthene	83-32-9	4	µg/kg	<4	<4	<4	<4	<4
Fluorene	86-73-7	4	µg/kg	<4	<4	<4	<4	<4
Phenanthrene	85-01-8	4	µg/kg	<4	<4	<4	<4	<4
Anthracene	120-12-7	4	µg/kg	<4	<4	<4	<4	<4
Fluoranthene	206-44-0	4	µg/kg	<4	<4	<4	<4	<4
Pyrene	129-00-0	4	µg/kg	<4	<4	<4	<4	<4
Benzo(a)anthracene	56-55-3	4	µg/kg	<4	<4	<4	<4	<4
Chrysene	218-01-9	4	µg/kg	<4	<4	<4	<4	<4
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	<4	<4	<4	<4
Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	<4	<4	<4
Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	<4	<4	<4
Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	<4	<4	<4
Perylene	198-55-0	4	µg/kg	<4	<4	<4	<4	<4
Benzo(g,h,i)perylene	191-24-2	4	µg/kg	<4	<4	<4	<4	<4
Dibenz(a,h)anthracene	53-70-3	4	µg/kg	<4	<4	<4	<4	<4
Indeno(1,2,3-cd)pyrene	193-39-5	4	µg/kg	<4	<4	<4	<4	<4
Coronene	191-07-1	5	µg/kg	<5	<5	<5	<5	<5
^ Sum of PAHs	----	4	µg/kg	<4	<4	<4	<4	<4
^ Benzo(a)pyrene TEQ (zero)	----	4	µg/kg	<4	<4	<4	<4	<4
^ Benzo(a)pyrene TEQ (half LOR)	----	4	µg/kg	5	5	5	5	5
^ Benzo(a)pyrene TEQ (LOR)	----	4	µg/kg	10	10	10	10	10
EP080-SD: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	87.8	128	88.2	90.2	104
Toluene-D8	2037-26-5	0.2	%	76.2	123	76.5	78.3	88.2
4-Bromofluorobenzene	460-00-4	0.2	%	85.1	130	86.2	88.0	99.4

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 Work Order : EP1903737
 Client : BMT WESTERN AUSTRALIA PTY LTD
 Project : Jurien Bay BH Sediment Sampling 2019



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Client sample ID

				JBDA_S1	JBDA_S2	JBDA_S3	JBDA_S4	JBDA_S5
Client sampling date / time				17-Apr-2019 09:40	17-Apr-2019 09:42	17-Apr-2019 09:43	17-Apr-2019 09:59	17-Apr-2019 10:32
Compound	CAS Number	LOR	Unit	EP1903737-024	EP1903737-025	EP1903737-026	EP1903737-027	EP1903737-028
				Result	Result	Result	Result	Result
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	82.7	93.4	80.9	91.8	93.8
Anthracene-d10	1719-06-8	10	%	79.1	73.1	72.8	71.2	72.6
4-Terphenyl-d14	1718-51-0	10	%	78.8	80.8	96.6	78.4	78.2



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				JBDA_S6	JBDA_S7	JBODA_1_0.00_0.10	JBODA_2_0.00_0.10	JBODA_3_0.00_0.10
Client sampling date / time				17-Apr-2019 10:35	17-Apr-2019 10:35	17-Apr-2019 13:43	03-Apr-2019 07:37	16-Apr-2019 13:14
Compound	CAS Number	LOR	Unit	EP1903737-029	EP1903737-030	EP1903737-031	EP1903737-032	EP1903737-033
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	----	----	0.7	0.9	1.0
Moisture Content	----	1.0	%	41.5	47.7	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS								
Arsenic	7440-38-2	1.00	mg/kg	3.99	2.90	----	----	----
Cadmium	7440-43-9	0.1	mg/kg	0.1	0.1	----	----	----
Chromium	7440-47-3	1.0	mg/kg	8.0	8.6	10.0	9.7	11.0
Copper	7440-50-8	1.0	mg/kg	<1.0	<1.0	1.0	3.9	3.6
Lead	7439-92-1	1.0	mg/kg	<1.0	<1.0	----	----	----
Nickel	7440-02-0	1.0	mg/kg	1.0	1.6	<1.0	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg	1.9	2.3	1.5	3.4	2.7
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	3.79	0.74	0.56	0.82	0.40
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
>C10 - C16 Fraction	----	3	mg/kg	<3	<3	----	----	----
>C16 - C34 Fraction	----	3	mg/kg	15	16	----	----	----
>C34 - C40 Fraction	----	5	mg/kg	<5	<5	----	----	----
>C10 - C40 Fraction (sum)	----	3	mg/kg	15	16	----	----	----
>C10 - C16 Fraction minus Naphthalene (F2)	----	3	mg/kg	<3	<3	----	----	----
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	3	mg/kg	<3	<3	----	----	----
C10 - C14 Fraction	----	3	mg/kg	<3	3	----	----	----
C15 - C28 Fraction	----	3	mg/kg	13	14	----	----	----
C29 - C36 Fraction	----	5	mg/kg	<5	<5	----	----	----
^ C10 - C36 Fraction (sum)	----	3	mg/kg	13	17	----	----	----
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons								
C6 - C10 Fraction	C6_C10	3	mg/kg	<3	<3	----	----	----
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	3.0	mg/kg	<3.0	<3.0	----	----	----
EP080-SD: BTEXN								
Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	----	----	----
Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	----	----	----



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				JBDA_S6	JBDA_S7	JBODA_1_0.00_0.10	JBODA_2_0.00_0.10	JBODA_3_0.00_0.10
Client sampling date / time				17-Apr-2019 10:35	17-Apr-2019 10:35	17-Apr-2019 13:43	03-Apr-2019 07:37	16-Apr-2019 13:14
Compound	CAS Number	LOR	Unit	EP1903737-029	EP1903737-030	EP1903737-031	EP1903737-032	EP1903737-033
				Result	Result	Result	Result	Result
EP080-SD: BTEXN - Continued								
Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	<0.2	----	----	----
ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	----	----	----
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	----	----	----
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	----	----	----
Naphthalene	91-20-3	0.2	mg/kg	<0.2	<0.2	----	----	----
EP132B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	5	µg/kg	<5	<5	----	----	----
2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	----	----	----
Acenaphthylene	208-96-8	4	µg/kg	<4	<4	----	----	----
Acenaphthene	83-32-9	4	µg/kg	<4	<4	----	----	----
Fluorene	86-73-7	4	µg/kg	<4	<4	----	----	----
Phenanthrene	85-01-8	4	µg/kg	<4	<4	----	----	----
Anthracene	120-12-7	4	µg/kg	<4	<4	----	----	----
Fluoranthene	206-44-0	4	µg/kg	<4	<4	----	----	----
Pyrene	129-00-0	4	µg/kg	<4	<4	----	----	----
Benzo(a)anthracene	56-55-3	4	µg/kg	<4	<4	----	----	----
Chrysene	218-01-9	4	µg/kg	<4	<4	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	<4	----	----	----
Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	----	----	----
Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	----	----	----
Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	----	----	----
Perylene	198-55-0	4	µg/kg	<4	<4	----	----	----
Benzo(g,h,i)perylene	191-24-2	4	µg/kg	<4	<4	----	----	----
Dibenz(a,h)anthracene	53-70-3	4	µg/kg	<4	<4	----	----	----
Indeno(1,2,3-cd)pyrene	193-39-5	4	µg/kg	<4	<4	----	----	----
Coronene	191-07-1	5	µg/kg	<5	<5	----	----	----
^ Sum of PAHs	----	4	µg/kg	<4	<4	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	4	µg/kg	<4	<4	----	----	----
^ Benzo(a)pyrene TEQ (half LOR)	----	4	µg/kg	5	5	----	----	----
^ Benzo(a)pyrene TEQ (LOR)	----	4	µg/kg	10	10	----	----	----
EP080-SD: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	93.0	87.2	----	----	----
Toluene-D8	2037-26-5	0.2	%	81.1	75.6	----	----	----



Analytical Results

Sub-Matrix: **SEDIMENT**
 (Matrix: **SOIL**)

Client sample ID

				JBDA_S6	JBDA_S7	JBODA_1_0.00_0.10	JBODA_2_0.00_0.10	JBODA_3_0.00_0.10
Client sampling date / time				17-Apr-2019 10:35	17-Apr-2019 10:35	17-Apr-2019 13:43	03-Apr-2019 07:37	16-Apr-2019 13:14
Compound	CAS Number	LOR	Unit	EP1903737-029	EP1903737-030	EP1903737-031	EP1903737-032	EP1903737-033
				Result	Result	Result	Result	Result
EP080-SD: TPH(V)/BTEX Surrogates - Continued								
4-Bromofluorobenzene	460-00-4	0.2	%	90.0	84.7	----	----	----
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	10	%	78.7	84.9	----	----	----
Anthracene-d10	1719-06-8	10	%	76.5	70.1	----	----	----
4-Terphenyl-d14	1718-51-0	10	%	81.2	78.3	----	----	----



Analytical Results

Sub-Matrix: SEDIMENT
 (Matrix: SOIL)

Client sample ID

				Trip Blank TBS 063	Trip Blank TBS 064	Trip Blank TBS 065	Elutriate	----
Client sampling date / time				16-Apr-2019 08:31	16-Apr-2019 08:31	16-Apr-2019 08:31	17-Apr-2019 00:00	----
Compound	CAS Number	LOR	Unit	EP1903737-034	EP1903737-035	EP1903737-036	EP1903737-037	-----
				Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	----	----
EN68: Seawater Elutriate Testing Procedure								
Seawater Sampling Date	----	-	-	----	----	----	1/5/2019	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	10	mg/kg	<10	<10	<10	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	<10	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg	<10	<10	<10	----	----
EP080: BTEXN								
Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	<0.2	----	----
Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	<0.5	----	----
Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	<0.5	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	<0.5	<0.5	----	----
ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	<0.5	----	----
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	<0.2	----	----
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	<0.5	----	----
Naphthalene	91-20-3	1	mg/kg	<1	<1	<1	----	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	88.0	94.3	79.0	----	----
Toluene-D8	2037-26-5	0.2	%	85.9	91.1	76.5	----	----
4-Bromofluorobenzene	460-00-4	0.2	%	88.5	93.5	77.5	----	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				RinsateBlank_1	RinsateBlank_2	RinsateBlank_3	----	----
Client sampling date / time				18-Apr-2019 08:47	18-Apr-2019 08:48	18-Apr-2019 08:49	----	----
Compound	CAS Number	LOR	Unit	EP1903737-001	EP1903737-002	EP1903737-003	-----	-----
				Result	Result	Result	----	----
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	<1	<1	<1	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	<0.5	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	----	----
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	----	----
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	RinsateBlank_1	RinsateBlank_2	RinsateBlank_3	----	----
Client sampling date / time					18-Apr-2019 08:47	18-Apr-2019 08:48	18-Apr-2019 08:49	----	----
Compound	CAS Number	LOR	Unit		EP1903737-001	EP1903737-002	EP1903737-003	-----	-----
					Result	Result	Result	----	----
EP080/071: Total Petroleum Hydrocarbons - Continued									
C29 - C36 Fraction	----	50	µg/L		<50	<50	<50	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		<50	<50	<50	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	<20	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	<20	<20	----	----
>C10 - C16 Fraction	----	100	µg/L		<100	<100	<100	----	----
>C16 - C34 Fraction	----	100	µg/L		<100	<100	<100	----	----
>C34 - C40 Fraction	----	100	µg/L		<100	<100	<100	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L		<100	<100	<100	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		<100	<100	<100	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	<1	<1	----	----
Toluene	108-88-3	2	µg/L		<2	<2	<2	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	<2	<2	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	<2	<2	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	<2	<2	----	----
^ Total Xylenes	----	2	µg/L		<2	<2	<2	----	----
^ Sum of BTEX	----	1	µg/L		<1	<1	<1	----	----
Naphthalene	91-20-3	5	µg/L		<5	<5	<5	----	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		16.6	20.4	12.3	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%		49.8	59.7	46.7	----	----
2,4,6-Tribromophenol	118-79-6	1.0	%		58.1	69.7	64.3	----	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		48.2	59.4	53.7	----	----
Anthracene-d10	1719-06-8	1.0	%		82.6	93.1	93.0	----	----
4-Terphenyl-d14	1718-51-0	1.0	%		93.0	99.1	100	----	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		90.1	97.1	87.8	----	----
Toluene-D8	2037-26-5	2	%		97.2	96.4	97.2	----	----
4-Bromofluorobenzene	460-00-4	2	%		100.0	98.2	99.0	----	----



Surrogate Control Limits

Sub-Matrix: SEDIMENT		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	63	132
Toluene-D8	2037-26-5	66	125
4-Bromofluorobenzene	460-00-4	60	124
EP080-SD: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	70	130
Toluene-D8	2037-26-5	70	130
4-Bromofluorobenzene	460-00-4	70	130
EP132T: Base/Neutral Extractable Surrogates			
2-Fluorobiphenyl	321-60-8	70	130
Anthracene-d10	1719-06-8	70	130
4-Terphenyl-d14	1718-51-0	70	130

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	67
2-Chlorophenol-D4	93951-73-6	29	120
2,4,6-Tribromophenol	118-79-6	10	131
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	34	131
Anthracene-d10	1719-06-8	43	127
4-Terphenyl-d14	1718-51-0	41	142
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

QUALITY CONTROL REPORT

Work Order	: EP1903737	Page	: 1 of 20
Client	: BMT WESTERN AUSTRALIA PTY LTD	Laboratory	: Environmental Division Perth
Contact	: MR BEN DAVIS	Contact	: Customer Services EP
Address	: LEVEL 4 20 PARKLAND ROAD OSBORNE PARK WA, AUSTRALIA 6017	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: +61 08 6272 0000	Telephone	: +61-8-9406 1301
Project	: Jurien Bay BH Sediment Sampling 2019	Date Samples Received	: 18-Apr-2019
Order number	: 1454_01_002	Date Analysis Commenced	: 23-Apr-2019
C-O-C number	: 834	Issue Date	: 07-May-2019
Sampler	: BEN DAVIS, LOUISE SYNNOT		
Site	: Jurien Bay		
Quote number	: 1453_01 (EP/175/19 V2)		
No. of samples received	: 37		
No. of samples analysed	: 37		



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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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>
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
David Viner	SENIOR LAB TECH	Perth Organics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD
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

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
 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
 RPD = Relative Percentage Difference
 # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2315717)									
EP1903737-004	JBBH_S1	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EP1903737-014	JBBH_S8	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2315719)									
EP1903737-024	JBDA_S1	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EA002: pH 1:5 (Soils) (QC Lot: 2309246)									
EP1903590-002	Anonymous	EA002: pH Value	----	0.1	pH Unit	8.4	8.4	0.00	0% - 20%
EP1903702-010	Anonymous	EA002: pH Value	----	0.1	pH Unit	9.0	9.0	0.00	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2315730)									
EP1903737-004	JBBH_S1	EA055: Moisture Content	----	0.1	%	6.8	7.1	3.72	No Limit
EP1903737-013	JBBH_S7_0.00_0.10	EA055: Moisture Content	----	0.1	%	51.8	49.6	4.26	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2315731)									
EP1903737-024	JBDA_S1	EA055: Moisture Content	----	0.1	%	35.2	33.5	5.07	0% - 20%
EP1903737-033	JBODA_3_0.00_0.10	EA055: Moisture Content	----	0.1	%	1.0	0.8	19.1	0% - 50%
ED008: Exchangeable Cations (QC Lot: 2308794)									
EP1903590-002	Anonymous	ED008: Exchangeable Sodium Percent	----	0.1	%	2.3	2.3	0.00	0% - 20%
		ED008: Exchangeable Calcium	----	0.1	meq/100g	9.0	10.0	10.5	0% - 20%
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	2.0	2.2	10.5	0% - 20%
		ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.1	0.00	No Limit
		ED008: Exchangeable Sodium	----	0.1	meq/100g	0.2	0.3	0.00	No Limit
		ED008: Cation Exchange Capacity	----	0.1	meq/100g	11.3	12.5	10.2	0% - 20%
EP1903737-014	JBBH_S8	ED008: Exchangeable Sodium Percent	----	0.1	%	3.4	3.2	5.28	0% - 20%
		ED008: Exchangeable Calcium	----	0.1	meq/100g	9.6	9.9	2.89	0% - 20%
		ED008: Exchangeable Magnesium	----	0.1	meq/100g	3.3	3.3	0.00	0% - 20%
		ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	<0.1	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED008: Exchangeable Cations (QC Lot: 2308794) - continued									
EP1903737-014	JBBH_S8	ED008: Exchangeable Sodium	----	0.1	meq/100g	0.4	0.4	0.00	No Limit
		ED008: Cation Exchange Capacity	----	0.1	meq/100g	13.4	13.6	1.48	0% - 20%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2315718)									
EP1903737-004	JBBH_S1	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	0.1	0.1	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	<1.00	0.00	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	12.0	12.0	0.00	0% - 50%
		EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	1.1	0.00	No Limit
EP1903737-014	JBBH_S8	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	0.2	0.2	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	1.47	1.55	5.50	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	11.8	11.6	1.75	0% - 50%
		EG020-SD: Copper	7440-50-8	1	mg/kg	33.8	34.2	1.08	0% - 20%
		EG020-SD: Lead	7439-92-1	1	mg/kg	1.1	1.1	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	1.2	1.2	0.00	No Limit
		EG020-SD: Zinc	7440-66-6	1	mg/kg	26.4	26.5	0.624	0% - 20%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2315720)									
EP1903737-024	JBDA_S1	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.1	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	3.67	3.78	2.97	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	9.8	10.7	9.05	0% - 50%
		EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	<1.0	0.00	No Limit
		EG020-SD: Zinc	7440-66-6	1	mg/kg	1.4	1.6	9.86	No Limit
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2317353)									
EP1903737-004	JBBH_S1	EP003: Total Organic Carbon	----	0.02	%	0.10	0.10	0.00	No Limit
EP1903737-014	JBBH_S8	EP003: Total Organic Carbon	----	0.02	%	0.51	0.53	4.80	0% - 20%
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2317354)									
EP1903737-024	JBDA_S1	EP003: Total Organic Carbon	----	0.02	%	0.26	0.28	7.12	0% - 50%
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2309530)									
EP1903733-001	Anonymous	EP080: C6 - C9 Fraction	----	10	mg/kg	<10	<10	0.00	No Limit
EP1903739-001	Anonymous	EP080: C6 - C9 Fraction	----	10	mg/kg	<10	<10	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2309530)									
EP1903733-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	0.00	No Limit
EP1903739-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	0.00	No Limit
EP080: BTEXN (QC Lot: 2309530)									
EP1903733-001	Anonymous	EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
		EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP080: BTEXN (QC Lot: 2309530) - continued									
EP1903733-001	Anonymous	EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Naphthalene	91-20-3	1	mg/kg	<1	<1	0.00	No Limit
EP1903739-001	Anonymous	EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	No Limit
		EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	0.00	No Limit
		EP080: Naphthalene	91-20-3	1	mg/kg	<1	<1	0.00	No Limit
		EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QC Lot: 2309547)							
EP1903737-004	JBBH_S1	EP080-SD: C6 - C9 Fraction	----	3	mg/kg	<3	<3	0.00	0% - 3%
EP1903737-014	JBBH_S8	EP080-SD: C6 - C9 Fraction	----	3	mg/kg	<3	<3	0.00	0% - 3%
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QC Lot: 2309549)									
EP1903737-004	JBBH_S1	EP071-SD: C10 - C14 Fraction	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: C15 - C28 Fraction	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: C10 - C36 Fraction (sum)	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: C29 - C36 Fraction	----	5	mg/kg	<5	<5	0.00	No Limit
EP1903737-014	JBBH_S8	EP071-SD: C10 - C14 Fraction	----	3	mg/kg	5	4	38.5	No Limit
		EP071-SD: C15 - C28 Fraction	----	3	mg/kg	29	25	13.9	No Limit
		EP071-SD: C10 - C36 Fraction (sum)	----	3	mg/kg	51	42	19.4	0% - 50%
		EP071-SD: C29 - C36 Fraction	----	5	mg/kg	17	13	24.4	No Limit
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QC Lot: 2309551)									
EP1903737-024	JBDA_S1	EP080-SD: C6 - C9 Fraction	----	3	mg/kg	<3	<3	0.00	0% - 3%
EP1903737-030	JBDA_S7	EP080-SD: C6 - C9 Fraction	----	3	mg/kg	<3	<3	0.00	0% - 3%
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QC Lot: 2309558)									
EP1903737-024	JBDA_S1	EP071-SD: C10 - C14 Fraction	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: C15 - C28 Fraction	----	3	mg/kg	12	17	34.6	No Limit
		EP071-SD: C10 - C36 Fraction (sum)	----	3	mg/kg	12	17	34.5	No Limit
		EP071-SD: C29 - C36 Fraction	----	5	mg/kg	<5	<5	0.00	No Limit
EP1903737-030	JBDA_S7	EP071-SD: C10 - C14 Fraction	----	3	mg/kg	3	<3	0.00	No Limit
		EP071-SD: C15 - C28 Fraction	----	3	mg/kg	14	14	0.00	No Limit
		EP071-SD: C10 - C36 Fraction (sum)	----	3	mg/kg	17	21	21.0	No Limit
		EP071-SD: C29 - C36 Fraction	----	5	mg/kg	<5	7	35.1	No Limit
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QC Lot: 2309547)									
EP1903737-004	JBBH_S1	EP080-SD: C6 - C10 Fraction	C6_C10	3	mg/kg	<3	<3	0.00	0% - 3%
EP1903737-014	JBBH_S8	EP080-SD: C6 - C10 Fraction	C6_C10	3	mg/kg	<3	<3	0.00	0% - 3%

Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QC Lot: 2309549)									
EP1903737-004	JBBH_S1	EP071-SD: >C10 - C16 Fraction	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: >C16 - C34 Fraction	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: >C10 - C40 Fraction (sum)	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: >C34 - C40 Fraction	----	5	mg/kg	<5	<5	0.00	No Limit
EP1903737-014	JBBH_S8	EP071-SD: >C10 - C16 Fraction	----	3	mg/kg	5	4	32.1	No Limit
		EP071-SD: >C16 - C34 Fraction	----	3	mg/kg	42	35	16.4	0% - 50%
		EP071-SD: >C10 - C40 Fraction (sum)	----	3	mg/kg	55	44	22.2	0% - 50%
		EP071-SD: >C34 - C40 Fraction	----	5	mg/kg	8	5	31.4	No Limit
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QC Lot: 2309551)									
EP1903737-024	JBDA_S1	EP080-SD: C6 - C10 Fraction	C6_C10	3	mg/kg	<3	<3	0.00	0% - 3%
EP1903737-030	JBDA_S7	EP080-SD: C6 - C10 Fraction	C6_C10	3	mg/kg	<3	<3	0.00	0% - 3%
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QC Lot: 2309558)									
EP1903737-024	JBDA_S1	EP071-SD: >C10 - C16 Fraction	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: >C16 - C34 Fraction	----	3	mg/kg	13	18	32.1	No Limit
		EP071-SD: >C10 - C40 Fraction (sum)	----	3	mg/kg	13	18	32.2	No Limit
		EP071-SD: >C34 - C40 Fraction	----	5	mg/kg	<5	<5	0.00	No Limit
EP1903737-030	JBDA_S7	EP071-SD: >C10 - C16 Fraction	----	3	mg/kg	<3	<3	0.00	No Limit
		EP071-SD: >C16 - C34 Fraction	----	3	mg/kg	16	20	21.2	No Limit
		EP071-SD: >C10 - C40 Fraction (sum)	----	3	mg/kg	16	20	22.2	No Limit
		EP071-SD: >C34 - C40 Fraction	----	5	mg/kg	<5	<5	0.00	No Limit
EP080-SD: BTEXN (QC Lot: 2309547)									
EP1903737-004	JBBH_S1	EP080-SD: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: meta- & para-Xylene	108-38-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
			106-42-3						
		EP080-SD: ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Total Xylenes	----	0.2	mg/kg	<0.5	<0.5	0.00	0% - .2%
		EP080-SD: Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
EP1903737-014	JBBH_S8	EP080-SD: Naphthalene	91-20-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: meta- & para-Xylene	108-38-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
			106-42-3						
		EP080-SD: ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Total Xylenes	----	0.2	mg/kg	<0.5	<0.5	0.00	0% - .2%
EP080-SD: BTEXN (QC Lot: 2309551)									



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP080-SD: BTEXN (QC Lot: 2309551) - continued									
EP1903737-024	JBDA_S1	EP080-SD: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Total Xylenes	----	0.2	mg/kg	<0.5	<0.5	0.00	0% - .2%
		EP080-SD: Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Naphthalene	91-20-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
EP1903737-030	JBDA_S7	EP080-SD: Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Toluene	108-88-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Total Xylenes	----	0.2	mg/kg	<0.5	<0.5	0.00	0% - .2%
		EP080-SD: Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
		EP080-SD: Naphthalene	91-20-3	0.2	mg/kg	<0.2	<0.2	0.00	0% - .2%
EP132B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2309548)									
EP1903737-004	JBBH_S1	EP132B-SD: Acenaphthylene	208-96-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Acenaphthene	83-32-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Fluorene	86-73-7	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Phenanthrene	85-01-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Anthracene	120-12-7	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Fluoranthene	206-44-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Pyrene	129-00-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benz(a)anthracene	56-55-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Chrysene	218-01-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(b+j)fluoranthene	205-99-2 205-82-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Perylene	198-55-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(g,h,i)perylene	191-24-2	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Dibenz(a,h)anthracene	53-70-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Sum of PAHs	----	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Naphthalene	91-20-3	5	µg/kg	<5	<5	0.00	No Limit
		EP132B-SD: 2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP132B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2309548) - continued									
EP1903737-004	JBBH_S1	EP132B-SD: Coronene	191-07-1	5	µg/kg	<5	<5	0.00	No Limit
EP1903737-014	JBBH_S8	EP132B-SD: Acenaphthylene	208-96-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Acenaphthene	83-32-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Fluorene	86-73-7	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Phenanthrene	85-01-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Anthracene	120-12-7	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Fluoranthene	206-44-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Pyrene	129-00-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benz(a)anthracene	56-55-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Chrysene	218-01-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(b+j)fluoranthene	205-99-2	4	µg/kg	<4	<4	0.00	No Limit
			205-82-3						
		EP132B-SD: Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Perylene	198-55-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(g,h,i)perylene	191-24-2	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Dibenzo(a,h)anthracene	53-70-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Sum of PAHs	----	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Naphthalene	91-20-3	5	µg/kg	<5	<5	0.00	No Limit
		EP132B-SD: 2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	0.00	No Limit
		EP132B-SD: Coronene	191-07-1	5	µg/kg	<5	<5	0.00	No Limit
EP132B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2309559)									
EP1903737-024	JBDA_S1	EP132B-SD: Acenaphthylene	208-96-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Acenaphthene	83-32-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Fluorene	86-73-7	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Phenanthrene	85-01-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Anthracene	120-12-7	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Fluoranthene	206-44-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Pyrene	129-00-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benz(a)anthracene	56-55-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Chrysene	218-01-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(b+j)fluoranthene	205-99-2	4	µg/kg	<4	<4	0.00	No Limit
			205-82-3						
		EP132B-SD: Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Perylene	198-55-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(a,h,i)perylene	191-24-2	4	µg/kg	<4	<4	0.00	No Limit



Sub-Matrix: SOIL				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP132B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2309559) - continued									
EP1903737-024	JBDA_S1	EP132B-SD: Dibenz(a,h)anthracene	53-70-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Sum of PAHs	----	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Naphthalene	91-20-3	5	µg/kg	<5	<5	0.00	No Limit
		EP132B-SD: 2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	0.00	No Limit
		EP132B-SD: Coronene	191-07-1	5	µg/kg	<5	<5	0.00	No Limit
EP1903737-030	JBDA_S7	EP132B-SD: Acenaphthylene	208-96-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Acenaphthene	83-32-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Fluorene	86-73-7	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Phenanthrene	85-01-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Anthracene	120-12-7	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Fluoranthene	206-44-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Pyrene	129-00-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benz(a)anthracene	56-55-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Chrysene	218-01-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(b+j)fluoranthene	205-99-2	4	µg/kg	<4	<4	0.00	No Limit
			205-82-3						
		EP132B-SD: Benzo(k)fluoranthene	207-08-9	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(e)pyrene	192-97-2	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(a)pyrene	50-32-8	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Perylene	198-55-0	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Benzo(g,h,i)perylene	191-24-2	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Dibenz(a,h)anthracene	53-70-3	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Indeno(1.2.3.cd)pyrene	193-39-5	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Sum of PAHs	----	4	µg/kg	<4	<4	0.00	No Limit
		EP132B-SD: Naphthalene	91-20-3	5	µg/kg	<5	<5	0.00	No Limit
		EP132B-SD: 2-Methylnaphthalene	91-57-6	5	µg/kg	<5	<5	0.00	No Limit
		EP132B-SD: Coronene	191-07-1	5	µg/kg	<5	<5	0.00	No Limit
Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA005P: pH by PC Titrator (QC Lot: 2322829)									
EB1910980-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.19	7.23	0.555	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 2322178)									
EP1903846-006	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.006	0.006	0.00	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.004	0.004	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.021	0.020	0.00	No Limit

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 Project : Jurien Bay BH Sediment Sampling 2019



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG020T: Total Metals by ICP-MS (QC Lot: 2322178) - continued									
EP1903588-009	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0005	<0.0005	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.008	0.006	33.4	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.026	<0.026	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2322205)									
EP1903588-009	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EP1903941-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EK255A: Ammonia (QC Lot: 2323770)									
EP1903737-004	JBBH_S1	EK255A-SW: Ammonia as N	7664-41-7	0.005	mg/L	0.007	0.006	24.8	No Limit
EP1903737-014	JBBH_S8	EK255A-SW: Ammonia as N	7664-41-7	0.005	mg/L	1.98	1.96	1.31	0% - 20%
EK255A: Ammonia (QC Lot: 2323774)									
EP1903737-037	Elutriate	EK255A-SW: Ammonia as N	7664-41-7	0.005	mg/L	<0.005	<0.005	0.00	No Limit
EK257A: Nitrite (QC Lot: 2323769)									
EP1903737-004	JBBH_S1	EK257A-SW: Nitrite as N	14797-65-0	0.002	mg/L	<0.002	<0.002	0.00	No Limit
EP1903737-014	JBBH_S8	EK257A-SW: Nitrite as N	14797-65-0	0.002	mg/L	<0.002	<0.002	0.00	No Limit
EK257A: Nitrite (QC Lot: 2323773)									
EP1903737-037	Elutriate	EK257A-SW: Nitrite as N	14797-65-0	0.002	mg/L	<0.002	<0.002	0.00	No Limit
EK259A: Nitrite and Nitrate (NOx) (QC Lot: 2323771)									
EP1903737-004	JBBH_S1	EK259A-SW: Nitrite + Nitrate as N	----	0.002	mg/L	0.039	0.038	0.00	0% - 50%
EP1903737-014	JBBH_S8	EK259A-SW: Nitrite + Nitrate as N	----	0.002	mg/L	0.012	0.012	0.00	No Limit
EK259A: Nitrite and Nitrate (NOx) (QC Lot: 2323776)									
EP1903737-037	Elutriate	EK259A-SW: Nitrite + Nitrate as N	----	0.002	mg/L	<0.002	<0.002	0.00	No Limit
EK262A: Total Nitrogen (QC Lot: 2323799)									
EP1903737-004	JBBH_S1	EK262PA-SW: Total Nitrogen as N	----	0.025	mg/L	0.159	0.184	14.6	No Limit
EP1903737-014	JBBH_S8	EK262PA-SW: Total Nitrogen as N	----	0.025	mg/L	2.48	2.42	2.45	0% - 50%
EK262A: Total Nitrogen (QC Lot: 2323802)									
EP1903737-037	Elutriate	EK262PA-SW: Total Nitrogen as N	----	0.025	mg/L	0.199	0.215	7.73	No Limit
EK267A: Total Phosphorus (Persulfate Digestion) (QC Lot: 2323800)									
EP1903737-004	JBBH_S1	EK267PA-SW: Total Phosphorus as P	----	0.005	mg/L	0.017	0.022	27.5	No Limit
EP1903737-014	JBBH_S8	EK267PA-SW: Total Phosphorus as P	----	0.005	mg/L	0.074	0.077	3.44	0% - 50%
EK267A: Total Phosphorus (Persulfate Digestion) (QC Lot: 2323801)									
EP1903737-037	Elutriate	EK267PA-SW: Total Phosphorus as P	----	0.005	mg/L	0.017	0.020	14.9	No Limit
EK271A: Reactive Phosphorus (QC Lot: 2323772)									
EP1903737-004	JBBH_S1	EK271A-SW: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	0.019	0.023	16.7	0% - 20%
EP1903737-014	JBBH_S8	EK271A-SW: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	0.049	0.049	0.00	0% - 20%

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Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK271A: Reactive Phosphorus (QC Lot: 2323775)									
EP1903737-037	Elutriate	EK271A-SW: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	<0.001	0.002	0.00	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 2310314)									
EP1903466-009	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	<1	<1	0.00	No Limit
EP1903805-027	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	<1	<1	0.00	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2311500)									
EP1903724-016	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EP1903788-007	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 2311500)									
EP1903724-016	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EP1903788-007	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EP080: BTEXN (QC Lot: 2311500)									
EP1903724-016	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
EP1903788-007	Anonymous	EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit
		EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	<2	0.00	No Limit
			106-42-3						
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit



Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2315717)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	2.154 mg/kg	119	80	120
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2315719)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	2.154 mg/kg	112	80	120
EA002: pH 1:5 (Soils) (QCLot: 2309246)								
EA002: pH Value	----	----	pH Unit	----	4 pH Unit	100	70	130
				----	7 pH Unit	99.4	70	130
ED008: Exchangeable Cations (QCLot: 2308794)								
ED008: Exchangeable Calcium	----	0.1	meq/100g	<0.1	22.13 meq/100g	90.4	84	112
ED008: Exchangeable Magnesium	----	0.1	meq/100g	<0.1	1.558 meq/100g	91.8	84	114
ED008: Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.913 meq/100g	101	92	112
ED008: Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.377 meq/100g	111	80	120
ED008: Exchangeable Sodium Percent	----	0.1	%	<0.1	----	----	----	----
ED008: Cation Exchange Capacity	----	0.1	meq/100g	<0.1	24.98 meq/100g	91.2	85	111
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2315718)								
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	21.62091 mg/kg	107	74	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	4.6838 mg/kg	102	97	113
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	33.904 mg/kg	116	72	152
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	33.782 mg/kg	102	76	116
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	40.33169 mg/kg	119	74	124
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	51.10088 mg/kg	111	81	135
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	61.70999 mg/kg	119	81	143
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2315720)								
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	21.62091 mg/kg	106	74	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	4.6838 mg/kg	102	97	113
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	33.904 mg/kg	116	72	152
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	33.782 mg/kg	93.2	76	116
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	40.33169 mg/kg	111	74	124
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	51.10088 mg/kg	110	81	135
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	61.70999 mg/kg	114	81	143
EN68: Seawater Elutriate Testing Procedure (QCLot: 2320158)								
EN68a: Seawater Sampling Date	----	----	-	1/5/2019	----	----	----	----
EN68: Seawater Elutriate Testing Procedure (QCLot: 2320159)								
EN68a: Seawater Sampling Date	----	----	-	1/5/2019	----	----	----	----

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) LowHigh	
Method: Compound	CAS Number	LOR	Unit	Result				
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2317353)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.44 %	97.7	70	130
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2317354)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	1.94 %	103	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2309530)								
EP080: C6 - C9 Fraction	----	10	mg/kg	<10	32 mg/kg	87.5	66	122
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2309530)								
EP080: C6 - C10 Fraction	C6_C10	10	mg/kg	<10	37 mg/kg	86.1	66	122
EP080: BTEXN (QCLot: 2309530)								
EP080: Benzene	71-43-2	0.2	mg/kg	<0.2	2 mg/kg	90.4	72	122
EP080: Toluene	108-88-3	0.5	mg/kg	<0.5	2 mg/kg	91.2	75	119
EP080: Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	2 mg/kg	90.8	73	121
EP080: meta- & para-Xylene	108-38-3	0.5	mg/kg	<0.5	4 mg/kg	94.6	74	122
	106-42-3							
EP080: ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	2 mg/kg	93.5	75	121
EP080: Naphthalene	91-20-3	1	mg/kg	<1	0.5 mg/kg	112	64	126
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 2309547)								
EP080-SD: C6 - C9 Fraction	----	3	mg/kg	<3	32 mg/kg	102	70	130
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 2309549)								
EP071-SD: C10 - C14 Fraction	----	3	mg/kg	<3	252 mg/kg	108	70	130
EP071-SD: C15 - C28 Fraction	----	3	mg/kg	<3	634 mg/kg	105	70	130
EP071-SD: C29 - C36 Fraction	----	5	mg/kg	<5	99 mg/kg	97.8	70	130
EP071-SD: C10 - C36 Fraction (sum)	----	3	mg/kg	<3	----	----	----	----
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 2309551)								
EP080-SD: C6 - C9 Fraction	----	3	mg/kg	<3	32 mg/kg	92.8	70	130
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 2309558)								
EP071-SD: C10 - C14 Fraction	----	3	mg/kg	<3	252 mg/kg	112	70	130
EP071-SD: C15 - C28 Fraction	----	3	mg/kg	<3	634 mg/kg	109	70	130
EP071-SD: C29 - C36 Fraction	----	5	mg/kg	<5	99 mg/kg	102	70	130
EP071-SD: C10 - C36 Fraction (sum)	----	3	mg/kg	<3	----	----	----	----
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309547)								
EP080-SD: C6 - C10 Fraction	C6_C10	3	mg/kg	<3	37 mg/kg	104	70	130
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309549)								
EP071-SD: >C10 - C16 Fraction	----	3	mg/kg	<3	404 mg/kg	109	70	130
EP071-SD: >C16 - C34 Fraction	----	3	mg/kg	<3	567 mg/kg	98.0	70	130
EP071-SD: >C34 - C40 Fraction	----	5	mg/kg	<5	33 mg/kg	92.8	70	130
EP071-SD: >C10 - C40 Fraction (sum)	----	3	mg/kg	<3	----	----	----	----
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309551)								



Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309551) - continued								
EP080-SD: C6 - C10 Fraction	C6_C10	3	mg/kg	<3	37 mg/kg	91.4	70	130
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309558)								
EP071-SD: >C10 - C16 Fraction	----	3	mg/kg	<3	404 mg/kg	113	70	130
EP071-SD: >C16 - C34 Fraction	----	3	mg/kg	<3	567 mg/kg	102	70	130
EP071-SD: >C34 - C40 Fraction	----	5	mg/kg	<5	33 mg/kg	96.7	70	130
EP071-SD: >C10 - C40 Fraction (sum)	----	3	mg/kg	<3	----	----	----	----
EP080-SD: BTEXN (QCLot: 2309547)								
EP080-SD: Benzene	71-43-2	0.2	mg/kg	<0.2	2 mg/kg	126	70	130
EP080-SD: Toluene	108-88-3	0.2	mg/kg	<0.2	2 mg/kg	96.9	70	130
EP080-SD: Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	2 mg/kg	99.8	70	130
EP080-SD: meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	4 mg/kg	101	70	130
EP080-SD: ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	2 mg/kg	99.6	70	130
EP080-SD: Total Xylenes	----	0.2	mg/kg	<0.2	----	----	----	----
EP080-SD: Sum of BTEX	----	0.2	mg/kg	<0.2	----	----	----	----
EP080-SD: Naphthalene	91-20-3	0.2	mg/kg	<0.2	0.5 mg/kg	91.6	70	130
EP080-SD: BTEXN (QCLot: 2309551)								
EP080-SD: Benzene	71-43-2	0.2	mg/kg	<0.2	2 mg/kg	107	70	130
EP080-SD: Toluene	108-88-3	0.2	mg/kg	<0.2	2 mg/kg	95.4	70	130
EP080-SD: Ethylbenzene	100-41-4	0.2	mg/kg	<0.2	2 mg/kg	99.4	70	130
EP080-SD: meta- & para-Xylene	108-38-3 106-42-3	0.2	mg/kg	<0.2	4 mg/kg	93.7	70	130
EP080-SD: ortho-Xylene	95-47-6	0.2	mg/kg	<0.2	2 mg/kg	95.6	70	130
EP080-SD: Total Xylenes	----	0.2	mg/kg	<0.2	----	----	----	----
EP080-SD: Sum of BTEX	----	0.2	mg/kg	<0.2	----	----	----	----
EP080-SD: Naphthalene	91-20-3	0.2	mg/kg	<0.2	0.5 mg/kg	88.6	70	130
EP132B: Polynuclear Aromatic Hydrocarbons (QCLot: 2309548)								
EP132B-SD: Naphthalene	91-20-3	5	µg/kg	<5	25 µg/kg	103	55	131
EP132B-SD: 2-Methylnaphthalene	91-57-6	5	µg/kg	<5	----	----	----	----
EP132B-SD: Acenaphthylene	208-96-8	4	µg/kg	<4	25 µg/kg	101	64	110
EP132B-SD: Acenaphthene	83-32-9	4	µg/kg	<4	25 µg/kg	99.5	62	112
EP132B-SD: Fluorene	86-73-7	4	µg/kg	<4	25 µg/kg	102	64	118
EP132B-SD: Phenanthrene	85-01-8	4	µg/kg	<4	25 µg/kg	97.8	59	117
EP132B-SD: Anthracene	120-12-7	4	µg/kg	<4	25 µg/kg	78.8	69	111
EP132B-SD: Fluoranthene	206-44-0	4	µg/kg	<4	25 µg/kg	104	66	118
EP132B-SD: Pyrene	129-00-0	4	µg/kg	<4	25 µg/kg	99.5	70	116
EP132B-SD: Benz(a)anthracene	56-55-3	4	µg/kg	<4	25 µg/kg	82.8	59	121
EP132B-SD: Chrysene	218-01-9	4	µg/kg	<4	25 µg/kg	99.6	68	116

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) LowHigh	
Method: Compound	CAS Number	LOR	Unit	Result				
EA005P: pH by PC Titrator (QCLot: 2322829)								



Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EA005P: pH by PC Titrator (QCLot: 2322829) - continued								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	100	98	102
				----	7 pH Unit	99.7	98	102
EG020T: Total Metals by ICP-MS (QCLot: 2322178)								
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	105	85	120
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	99.7	84	120
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	97.2	85	120
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	99.1	83	120
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	98.1	86	120
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	102	83	120
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	102	84	120
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2322205)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	100	87	115
EK255A: Ammonia (QCLot: 2323770)								
EK255A-SW: Ammonia as N	7664-41-7	0.005	mg/L	<0.005	0.1 mg/L	90.2	80	120
EK255A: Ammonia (QCLot: 2323774)								
EK255A-SW: Ammonia as N	7664-41-7	0.005	mg/L	<0.005	0.1 mg/L	98.4	80	120
EK257A: Nitrite (QCLot: 2323769)								
EK257A-SW: Nitrite as N	14797-65-0	0.002	mg/L	<0.002	0.5 mg/L	102	80	120
EK257A: Nitrite (QCLot: 2323773)								
EK257A-SW: Nitrite as N	14797-65-0	0.002	mg/L	<0.002	0.5 mg/L	103	80	120
EK259A: Nitrite and Nitrate (NOx) (QCLot: 2323771)								
EK259A-SW: Nitrite + Nitrate as N	----	0.002	mg/L	<0.002	0.1 mg/L	105	80	120
EK259A: Nitrite and Nitrate (NOx) (QCLot: 2323776)								
EK259A-SW: Nitrite + Nitrate as N	----	0.002	mg/L	<0.002	0.1 mg/L	107	80	120
EK262A: Total Nitrogen (QCLot: 2323799)								
EK262PA-SW: Total Nitrogen as N	----	0.025	mg/L	<0.025	1 mg/L	100	80	120
EK262A: Total Nitrogen (QCLot: 2323802)								
EK262PA-SW: Total Nitrogen as N	----	0.025	mg/L	<0.025	1 mg/L	98.3	80	120
EK267A: Total Phosphorus (Persulfate Digestion) (QCLot: 2323800)								
EK267PA-SW: Total Phosphorus as P	----	0.005	mg/L	<0.005	0.42 mg/L	101	80	120
EK267A: Total Phosphorus (Persulfate Digestion) (QCLot: 2323801)								
EK267PA-SW: Total Phosphorus as P	----	0.005	mg/L	<0.005	0.42 mg/L	109	80	120
EK271A: Reactive Phosphorus (QCLot: 2323772)								
EK271A-SW: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	<0.001	0.1 mg/L	95.7	84	120
EK271A: Reactive Phosphorus (QCLot: 2323775)								
EK271A-SW: Reactive Phosphorus as P	14265-44-2	0.001	mg/L	<0.001	0.1 mg/L	93.6	84	120



Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low High	
Method: Compound	CAS Number	LOR	Unit	Result				
EP005: Total Organic Carbon (TOC) (QCLot: 2310314)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	110	79	111
				<1	100 mg/L	108	79	111
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 2309202)								
EP075(SIM): Naphthalene	91-20-3	1	µg/L	<1.0	10 µg/L	56.2	42	99
EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	10 µg/L	63.4	36	113
EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	10 µg/L	66.4	36	102
EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	10 µg/L	73.2	34	113
EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	10 µg/L	68.7	37	115
EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	10 µg/L	76.4	46	109
EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	10 µg/L	94.5	40	124
EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	10 µg/L	79.8	40	123
EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	10 µg/L	103	40	126
EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	10 µg/L	91.9	46	121
EP075(SIM): Benzo(b+j)fluoranthene	205-99-2	1	µg/L	<1.0	10 µg/L	79.8	43	123
	205-82-3							
EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	10 µg/L	68.3	47	121
EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	10 µg/L	78.0	45	123
EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	10 µg/L	85.5	39	120
EP075(SIM): Dibenz(a,h)anthracene	53-70-3	1	µg/L	<1.0	10 µg/L	85.7	39	119
EP075(SIM): Benzo(g,h,i)perylene	191-24-2	1	µg/L	<1.0	10 µg/L	73.2	40	123
EP075(SIM): Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2309201)								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	385 µg/L	51.3	35	95
EP071: C15 - C28 Fraction	----	100	µg/L	<100	385 µg/L	60.2	34	111
EP071: C29 - C36 Fraction	----	50	µg/L	<50	380 µg/L	56.4	34	105
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2311500)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	320 µg/L	89.8	74	113
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2309201)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	398 µg/L	52.2	37	99
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	597 µg/L	57.6	35	108
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	168 µg/L	49.1	11	117
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2311500)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	370 µg/L	88.7	74	115
EP080: BTEXN (QCLot: 2311500)								
EP080: Benzene	71-43-2	1	µg/L	<1	20 µg/L	86.2	84	114
EP080: Toluene	108-88-3	2	µg/L	<2	20 µg/L	99.9	81	115
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	20 µg/L	100	84	113

Sub-Matrix: **WATER**

Sub-Matrix: WATER				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike Concentration	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result		LCS	Low	High
EP080: BTEXN (QCLot: 2311500) - continued								
EP080: meta- & para-Xylene	108-38-3	2	µg/L	<2	40 µg/L	98.7	84	114
	106-42-3							
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	20 µg/L	99.1	87	111
EP080: Naphthalene	91-20-3	5	µg/L	<5	5 µg/L	104	77	118

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

Sub-Matrix: SOIL				Matrix Spike (MS) Report			
				Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low High	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number				
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2315717)							
EP1903737-005	JBBH_S2_A	EG035T-LL: Mercury	7439-97-6	10 mg/kg	91.0	70	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2315719)							
EP1903737-025	JBDA_S2	EG035T-LL: Mercury	7439-97-6	10 mg/kg	92.1	70	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2315718)							
EP1903737-005	JBBH_S2_A	EG020-SD: Arsenic	7440-38-2	50 mg/kg	112	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	101	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	105	70	130
		EG020-SD: Copper	7440-50-8	50 mg/kg	97.5	70	130
		EG020-SD: Lead	7439-92-1	50 mg/kg	109	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	102	70	130
		EG020-SD: Zinc	7440-66-6	50 mg/kg	105	70	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2315720)							
EP1903737-025	JBDA_S2	EG020-SD: Arsenic	7440-38-2	50 mg/kg	106	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	102	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	98.2	70	130
		EG020-SD: Copper	7440-50-8	50 mg/kg	95.6	70	130
		EG020-SD: Lead	7439-92-1	50 mg/kg	108	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	99.4	70	130
		EG020-SD: Zinc	7440-66-6	50 mg/kg	101	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2309530)							
EP1903733-002	Anonymous	EP080: C6 - C9 Fraction	----	24 mg/kg	85.7	69	135
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2309530)							
EP1903733-002	Anonymous	EP080: C6 - C10 Fraction	C6_C10	29 mg/kg	73.7	69	135
EP080: BTEXN (QCLot: 2309530)							

Matrix Spike (MS) Report

				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP080: BTEXN (QCLot: 2309530) - continued							
EP1903733-002	Anonymous	EP080: Benzene	71-43-2	2 mg/kg	76.8	76	118
		EP080: Toluene	108-88-3	2 mg/kg	77.9	67	112
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 2309547)							
EP1903737-005	JBBH_S2_A	EP080-SD: C6 - C9 Fraction	----	600 mg/kg	# Not Determined	70	130
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 2309549)							
EP1903737-005	JBBH_S2_A	EP071-SD: C10 - C14 Fraction	----	252 mg/kg	114	70	130
		EP071-SD: C15 - C28 Fraction	----	634 mg/kg	113	70	130
		EP071-SD: C29 - C36 Fraction	----	99 mg/kg	107	70	130
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 2309551)							
EP1903737-025	JBDA_S2	EP080-SD: C6 - C9 Fraction	----	32 mg/kg	79.5	70	130
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons (QCLot: 2309558)							
EP1903737-025	JBDA_S2	EP071-SD: C10 - C14 Fraction	----	252 mg/kg	104	70	130
		EP071-SD: C15 - C28 Fraction	----	634 mg/kg	101	70	130
		EP071-SD: C29 - C36 Fraction	----	99 mg/kg	95.7	70	130
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309547)							
EP1903737-005	JBBH_S2_A	EP080-SD: C6 - C10 Fraction	C6_C10	725 mg/kg	# Not Determined	70	130
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309549)							
EP1903737-005	JBBH_S2_A	EP071-SD: >C10 - C16 Fraction	----	404 mg/kg	115	70	130
		EP071-SD: >C16 - C34 Fraction	----	567 mg/kg	106	70	130
		EP071-SD: >C34 - C40 Fraction	----	33 mg/kg	106	70	130
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309551)							
EP1903737-025	JBDA_S2	EP080-SD: C6 - C10 Fraction	C6_C10	37 mg/kg	72.9	70	130
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons (QCLot: 2309558)							
EP1903737-025	JBDA_S2	EP071-SD: >C10 - C16 Fraction	----	404 mg/kg	104	70	130
		EP071-SD: >C16 - C34 Fraction	----	567 mg/kg	94.3	70	130
		EP071-SD: >C34 - C40 Fraction	----	33 mg/kg	93.5	70	130
EP080-SD: BTEXN (QCLot: 2309547)							
EP1903737-005	JBBH_S2_A	EP080-SD: Benzene	71-43-2	2 mg/kg	96.8	70	130
		EP080-SD: Toluene	108-88-3	2 mg/kg	75.8	70	130
EP080-SD: BTEXN (QCLot: 2309551)							
EP1903737-025	JBDA_S2	EP080-SD: Benzene	71-43-2	2 mg/kg	98.4	70	130
		EP080-SD: Toluene	108-88-3	2 mg/kg	86.8	70	130
EP132B: Polynuclear Aromatic Hydrocarbons (QCLot: 2309548)							



Sub-Matrix: **WATER**

Sub-Matrix: WATER				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 2322178) - continued							
EP1903588-010	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	118	70	130
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	116	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	106	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	112	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	127	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	112	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	116	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2322205)							
EP1903588-012	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	106	70	130
EK255A: Ammonia (QCLot: 2323770)							
EP1903737-005	JBBH_S2_A	EK255A-SW: Ammonia as N	7664-41-7	0.25 mg/L	73.6	70	130
EK257A: Nitrite (QCLot: 2323769)							
EP1903737-006	JBBH_S2_B	EK257A-SW: Nitrite as N	14797-65-0	0.1 mg/L	97.5	70	130
EK259A: Nitrite and Nitrate (NOx) (QCLot: 2323771)							
EP1903737-005	JBBH_S2_A	EK259A-SW: Nitrite + Nitrate as N	----	0.1 mg/L	100	70	130
EK262A: Total Nitrogen (QCLot: 2323799)							
EP1903737-005	JBBH_S2_A	EK262PA-SW: Total Nitrogen as N	----	0.5 mg/L	94.6	70	130
EK267A: Total Phosphorus (Persulfate Digestion) (QCLot: 2323800)							
EP1903737-005	JBBH_S2_A	EK267PA-SW: Total Phosphorus as P	----	0.5 mg/L	102	70	130
EK271A: Reactive Phosphorus (QCLot: 2323772)							
EP1903737-005	JBBH_S2_A	EK271A-SW: Reactive Phosphorus as P	14265-44-2	0.25 mg/L	115	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 2310314)							
EP1903466-010	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	110	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2311500)							
EP1903724-017	Anonymous	EP080: C6 - C9 Fraction	----	240 µg/L	108	77	137
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 2311500)							
EP1903724-017	Anonymous	EP080: C6 - C10 Fraction	C6_C10	290 µg/L	113	77	137
EP080: BTEXN (QCLot: 2311500)							
EP1903724-017	Anonymous	EP080: Benzene	71-43-2	20 µg/L	85.5	77	122
		EP080: Toluene	108-88-3	20 µg/L	123	74	126

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EP1903737	Page	: 1 of 18
Client	: BMT WESTERN AUSTRALIA PTY LTD	Laboratory	: Environmental Division Perth
Contact	: MR BEN DAVIS	Telephone	: +61-8-9406 1301
Project	: Jurien Bay BH Sediment Sampling 2019	Date Samples Received	: 18-Apr-2019
Site	: Jurien Bay	Issue Date	: 07-May-2019
Sampler	: BEN DAVIS, LOUISE SYNNOT	No. of samples received	: 37
Order number	: 1454_01_002	No. of samples analysed	: 37

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- **NO** Matrix Spike outliers occur.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA055: Moisture Content (Dried @ 105-110°C)						
Soil Glass Jar - Unpreserved JBODA_2_0.00_0.10	----	----	----	26-Apr-2019	17-Apr-2019	9

Matrix: **WATER**

Method	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural Elutriate	----	----	----	01-May-2019	30-Apr-2019	1

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	0	13	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	0	15	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
Ammonia as N - Ultra-Trace in Saline Waters	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N - Ultra-Trace in Saline Waters	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Ultra-Trace in Saline Waters	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	0	13	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace in Saline Water	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen/Persulfate Digestion/Ultra-Trace/Saline	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus/Persulfate Digestion/ Ultra Trace /Saline	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	0	15	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
Container / Client Sample ID(s)							



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002: pH 1:5 (Soils)								
Soil Glass Jar - Unpreserved (EA002)								
JBBH_S3,	JBBH_S4,	17-Apr-2019	24-Apr-2019	24-Apr-2019	✓	24-Apr-2019	24-Apr-2019	✓
JBBH_S8,	JBBH_S11							
EA055: Moisture Content (Dried @ 105-110°C)								
Soil Glass Jar - Unpreserved (EA055)								
JBODA_2_0.00_0.10		03-Apr-2019	----	----	----	26-Apr-2019	17-Apr-2019	✗
Soil Glass Jar - Unpreserved (EA055)								
JBBH_S1,	JBBH_S12_0.10,	16-Apr-2019	----	----	----	26-Apr-2019	30-Apr-2019	✓
JBODA_3_0.00_0.10,	Trip Blank - TBS 063,							
Trip Blank - TBS 064,	Trip Blank - TBS 065							
Soil Glass Jar - Unpreserved (EA055)								
JBBH_S2_A,	JBBH_S2_B,	17-Apr-2019	----	----	----	26-Apr-2019	01-May-2019	✓
JBBH_S3,	JBBH_S4,							
JBBH_S5,	JBBH_S6_1_0.00_0.10,							
JBBH_S6_2_0.00_0.10,	JBBH_S6_3_0.00_0.10,							
JBBH_S7_0.00_0.10,	JBBH_S8,							
JBBH_S9,	JBBH_S10_1_0.00_0.10,							
JBBH_S10_2_0.00_0.10,	JBBH_S10_3,							
JBBH_S11,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
JBDA_S1,	JBDA_S2,							
JBDA_S3,	JBDA_S4,							
JBDA_S5,	JBDA_S6,							
JBDA_S7,	JBODA_1_0.00_0.10							
ED008: Exchangeable Cations								
Soil Glass Jar - Unpreserved (ED008)								
JBBH_S3,	JBBH_S4,	17-Apr-2019	26-Apr-2019	15-May-2019	✓	26-Apr-2019	15-May-2019	✓
JBBH_S8,	JBBH_S11							



Matrix: **SOIL**

Evaluation: * = Holding time breach ; ✓ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG020-SD: Total Metals in Sediments by ICPMS								
Soil Glass Jar - Unpreserved (EG020-SD)		03-Apr-2019	29-Apr-2019	30-Sep-2019	✓	30-Apr-2019	30-Sep-2019	✓
JBODA_2_0.00_0.10								
Soil Glass Jar - Unpreserved (EG020-SD)		16-Apr-2019	29-Apr-2019	13-Oct-2019	✓	30-Apr-2019	13-Oct-2019	✓
JBBH_S1,	JBBH_S12_0.10,							
JBODA_3_0.00_0.10								
Soil Glass Jar - Unpreserved (EG020-SD)		17-Apr-2019	29-Apr-2019	14-Oct-2019	✓	30-Apr-2019	14-Oct-2019	✓
JBBH_S2_A,	JBBH_S2_B,							
JBBH_S3,	JBBH_S4,							
JBBH_S5,	JBBH_S6_1_0.00_0.10,							
JBBH_S6_2_0.00_0.10,	JBBH_S6_3_0.00_0.10,							
JBBH_S7_0.00_0.10,	JBBH_S8,							
JBBH_S9,	JBBH_S10_1_0.00_0.10,							
JBBH_S10_2_0.00_0.10,	JBBH_S10_3,							
JBBH_S11,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
JBDA_S1,	JBDA_S2,							
JBDA_S3,	JBDA_S4,							
JBDA_S5,	JBDA_S6,							
JBDA_S7,	JBODA_1_0.00_0.10							
EG035T: Total Recoverable Mercury by FIMS								
Soil Glass Jar - Unpreserved (EG035T-LL)		16-Apr-2019	29-Apr-2019	14-May-2019	✓	30-Apr-2019	14-May-2019	✓
JBBH_S1,	JBBH_S12_0.10							
Soil Glass Jar - Unpreserved (EG035T-LL)		17-Apr-2019	29-Apr-2019	15-May-2019	✓	30-Apr-2019	15-May-2019	✓
JBBH_S2_A,	JBBH_S2_B,							
JBBH_S3,	JBBH_S4,							
JBBH_S5,	JBBH_S6_1_0.00_0.10,							
JBBH_S6_2_0.00_0.10,	JBBH_S6_3_0.00_0.10,							
JBBH_S7_0.00_0.10,	JBBH_S8,							
JBBH_S9,	JBBH_S10_1_0.00_0.10,							
JBBH_S10_2_0.00_0.10,	JBBH_S10_3,							
JBBH_S11,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
JBDA_S1,	JBDA_S2,							
JBDA_S3,	JBDA_S4,							
JBDA_S5,	JBDA_S6,							
JBDA_S7								



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EN68: Seawater Elutriate Testing Procedure								
Non-Volatile Leach: 28 day HT(e.g. Hg, CrVI) (EN68a)	JBBH_S1,	JBBH_S12_0.10	16-Apr-2019	30-Apr-2019	14-May-2019	✓	----	----
Non-Volatile Leach: 28 day HT(e.g. Hg, CrVI) (EN68a)	JBBH_S2_A, JBBH_S3, JBBH_S5, JBBH_S6_2_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S9, JBBH_S10_2_0.00_0.10, JBBH_S11, JBBH_S14, Elutriate	JBBH_S2_B, JBBH_S4, JBBH_S6_1_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S8, JBBH_S10_1_0.00_0.10, JBBH_S10_3, JBBH_S13, JBBH_S15,	17-Apr-2019	30-Apr-2019	15-May-2019	✓	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Soil Glass Jar - Unpreserved (EP003)	JBODA_2_0.00_0.10		03-Apr-2019	29-Apr-2019	01-May-2019	✓	29-Apr-2019	01-May-2019
Soil Glass Jar - Unpreserved (EP003)	JBBH_S1, JBODA_3_0.00_0.10	JBBH_S12_0.10,	16-Apr-2019	29-Apr-2019	14-May-2019	✓	29-Apr-2019	14-May-2019
Soil Glass Jar - Unpreserved (EP003)	JBBH_S2_A, JBBH_S3, JBBH_S5, JBBH_S6_2_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S9, JBBH_S10_2_0.00_0.10, JBBH_S11, JBBH_S14, JBDA_S1, JBDA_S3, JBDA_S5, JBDA_S7,	JBBH_S2_B, JBBH_S4, JBBH_S6_1_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S8, JBBH_S10_1_0.00_0.10, JBBH_S10_3, JBBH_S13, JBBH_S15, JBDA_S2, JBDA_S4, JBDA_S6, JBODA_1_0.00_0.10	17-Apr-2019	29-Apr-2019	15-May-2019	✓	29-Apr-2019	15-May-2019
EP080/071: Total Petroleum Hydrocarbons								
Soil Glass Jar - Unpreserved (EP080)	Trip Blank - TBS 063, Trip Blank - TBS 065	Trip Blank - TBS 064,	16-Apr-2019	24-Apr-2019	30-Apr-2019	✓	24-Apr-2019	30-Apr-2019

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Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
Soil Glass Jar - Unpreserved (EP080) Trip Blank - TBS 063, Trip Blank - TBS 065	Trip Blank - TBS 064,	16-Apr-2019	24-Apr-2019	30-Apr-2019	✓	24-Apr-2019	30-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP071-SD) JBBH_S1,	JBBH_S12_0.10	16-Apr-2019	26-Apr-2019	30-Apr-2019	✓	29-Apr-2019	05-Jun-2019	✓
Soil Glass Jar - Unpreserved (EP071-SD) JBBH_S2_A, JBBH_S3, JBBH_S5, JBBH_S6_2_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S9, JBBH_S10_2_0.00_0.10, JBBH_S11, JBBH_S14, JBDA_S1, JBDA_S3, JBDA_S5, JBDA_S7	JBBH_S2_B, JBBH_S4, JBBH_S6_1_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S8, JBBH_S10_1_0.00_0.10, JBBH_S10_3, JBBH_S13, JBBH_S15, JBDA_S2, JBDA_S4, JBDA_S6,	17-Apr-2019	26-Apr-2019	01-May-2019	✓	29-Apr-2019	05-Jun-2019	✓
EP080: BTEXN								
Soil Glass Jar - Unpreserved (EP080) Trip Blank - TBS 063, Trip Blank - TBS 065	Trip Blank - TBS 064,	16-Apr-2019	24-Apr-2019	30-Apr-2019	✓	24-Apr-2019	30-Apr-2019	✓



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP080-SD / EP071-SD: Total Petroleum Hydrocarbons								
Soil Glass Jar - Unpreserved (EP071-SD)								
JBBH_S1,	JBBH_S12_0.10	16-Apr-2019	26-Apr-2019	30-Apr-2019	✓	29-Apr-2019	05-Jun-2019	✓
Soil Glass Jar - Unpreserved (EP080-SD)								
JBBH_S1,	JBBH_S12_0.10	16-Apr-2019	29-Apr-2019	30-Apr-2019	✓	29-Apr-2019	30-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP071-SD)								
JBBH_S2_A,	JBBH_S2_B,	17-Apr-2019	26-Apr-2019	01-May-2019	✓	29-Apr-2019	05-Jun-2019	✓
JBBH_S3,	JBBH_S4,							
JBBH_S5,	JBBH_S6_1_0.00_0.10,							
JBBH_S6_2_0.00_0.10,	JBBH_S6_3_0.00_0.10,							
JBBH_S7_0.00_0.10,	JBBH_S8,							
JBBH_S9,	JBBH_S10_1_0.00_0.10,							
JBBH_S10_2_0.00_0.10,	JBBH_S10_3,							
JBBH_S11,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
JBDA_S1,	JBDA_S2,							
JBDA_S3,	JBDA_S4,							
JBDA_S5,	JBDA_S6,							
JBDA_S7								
Soil Glass Jar - Unpreserved (EP080-SD)								
JBBH_S2_A,	JBBH_S2_B,	17-Apr-2019	29-Apr-2019	01-May-2019	✓	29-Apr-2019	01-May-2019	✓
JBBH_S3,	JBBH_S4,							
JBBH_S5,	JBBH_S6_1_0.00_0.10,							
JBBH_S6_2_0.00_0.10,	JBBH_S6_3_0.00_0.10,							
JBBH_S7_0.00_0.10,	JBBH_S8,							
JBBH_S9,	JBBH_S10_1_0.00_0.10,							
JBBH_S10_2_0.00_0.10,	JBBH_S10_3,							
JBBH_S11,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
JBDA_S1,	JBDA_S2,							
JBDA_S3,	JBDA_S4,							
JBDA_S5,	JBDA_S6,							
JBDA_S7								



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP080-SD / EP071-SD: Total Recoverable Hydrocarbons								
Soil Glass Jar - Unpreserved (EP080-SD)								
JBBH_S1,	JBBH_S12_0.10	16-Apr-2019	29-Apr-2019	30-Apr-2019	✓	29-Apr-2019	30-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP080-SD)								
JBBH_S2_A,	JBBH_S2_B,	17-Apr-2019	29-Apr-2019	01-May-2019	✓	29-Apr-2019	01-May-2019	✓
JBBH_S3,	JBBH_S4,							
JBBH_S5,	JBBH_S6_1_0.00_0.10,							
JBBH_S6_2_0.00_0.10,	JBBH_S6_3_0.00_0.10,							
JBBH_S7_0.00_0.10,	JBBH_S8,							
JBBH_S9,	JBBH_S10_1_0.00_0.10,							
JBBH_S10_2_0.00_0.10,	JBBH_S10_3,							
JBBH_S11,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
JBDA_S1,	JBDA_S2,							
JBDA_S3,	JBDA_S4,							
JBDA_S5,	JBDA_S6,							
JBDA_S7								
EP080-SD: BTEXN								
Soil Glass Jar - Unpreserved (EP080-SD)								
JBBH_S1,	JBBH_S12_0.10	16-Apr-2019	29-Apr-2019	30-Apr-2019	✓	29-Apr-2019	30-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP080-SD)								
JBBH_S2_A,	JBBH_S2_B,	17-Apr-2019	29-Apr-2019	01-May-2019	✓	29-Apr-2019	01-May-2019	✓
JBBH_S3,	JBBH_S4,							
JBBH_S5,	JBBH_S6_1_0.00_0.10,							
JBBH_S6_2_0.00_0.10,	JBBH_S6_3_0.00_0.10,							
JBBH_S7_0.00_0.10,	JBBH_S8,							
JBBH_S9,	JBBH_S10_1_0.00_0.10,							
JBBH_S10_2_0.00_0.10,	JBBH_S10_3,							
JBBH_S11,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
JBDA_S1,	JBDA_S2,							
JBDA_S3,	JBDA_S4,							
JBDA_S5,	JBDA_S6,							
JBDA_S7								



Matrix: **SOIL**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EP132B: Polynuclear Aromatic Hydrocarbons								
Soil Glass Jar - Unpreserved (EP132B-SD)								
JBBH_S1,	JBBH_S12_0.10	16-Apr-2019	26-Apr-2019	30-Apr-2019	✓	29-Apr-2019	05-Jun-2019	✓
Soil Glass Jar - Unpreserved (EP132B-SD)								
JBBH_S2_A,	JBBH_S2_B,	17-Apr-2019	26-Apr-2019	01-May-2019	✓	29-Apr-2019	05-Jun-2019	✓
JBBH_S3,	JBBH_S4,							
JBBH_S5,	JBBH_S6_1_0.00_0.10,							
JBBH_S6_2_0.00_0.10,	JBBH_S6_3_0.00_0.10,							
JBBH_S7_0.00_0.10,	JBBH_S8,							
JBBH_S9,	JBBH_S10_1_0.00_0.10,							
JBBH_S10_2_0.00_0.10,	JBBH_S10_3,							
JBBH_S11,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
JBDA_S1,	JBDA_S2,							
JBDA_S3,	JBDA_S4,							
JBDA_S5,	JBDA_S6,							
JBDA_S7								

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) Elutriate	30-Apr-2019	----	----	----	01-May-2019	30-Apr-2019	✖
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-T) RinsateBlank_1, RinsateBlank_2, RinsateBlank_3	18-Apr-2019	01-May-2019	15-Oct-2019	✔	01-May-2019	15-Oct-2019	✔
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) RinsateBlank_1, RinsateBlank_2, RinsateBlank_3	18-Apr-2019	----	----	----	02-May-2019	16-May-2019	✔

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Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK255A: Ammonia							
Clear Plastic - Filtered & Frozen (AS/ISO) - UT Nu (EK255A-SW) JBBH_S1, JBBH_S2_A, JBBH_S2_B, JBBH_S3, JBBH_S4, JBBH_S5, JBBH_S6_1_0.00_0.10, JBBH_S6_2_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S8, JBBH_S9, JBBH_S10_1_0.00_0.10, JBBH_S10_2_0.00_0.10, JBBH_S10_3, JBBH_S11, JBBH_S12_0.10, JBBH_S13, JBBH_S14, JBBH_S15, Elutriate	30-Apr-2019	----	----	----	02-May-2019	28-May-2019	✓
EK257A: Nitrite							
Clear Plastic - Filtered & Frozen (AS/ISO) - UT Nu (EK257A-SW) JBBH_S1, JBBH_S2_A, JBBH_S2_B, JBBH_S3, JBBH_S4, JBBH_S5, JBBH_S6_1_0.00_0.10, JBBH_S6_2_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S8, JBBH_S9, JBBH_S10_1_0.00_0.10, JBBH_S10_2_0.00_0.10, JBBH_S10_3, JBBH_S11, JBBH_S12_0.10, JBBH_S13, JBBH_S14, JBBH_S15, Elutriate	30-Apr-2019	----	----	----	02-May-2019	04-May-2019	✓
EK259A: Nitrite and Nitrate (NOx)							
Clear Plastic - Filtered & Frozen (AS/ISO) - UT Nu (EK259A-SW) JBBH_S1, JBBH_S2_A, JBBH_S2_B, JBBH_S3, JBBH_S4, JBBH_S5, JBBH_S6_1_0.00_0.10, JBBH_S6_2_0.00_0.10, JBBH_S6_3_0.00_0.10, JBBH_S7_0.00_0.10, JBBH_S8, JBBH_S9, JBBH_S10_1_0.00_0.10, JBBH_S10_2_0.00_0.10, JBBH_S10_3, JBBH_S11, JBBH_S12_0.10, JBBH_S13, JBBH_S14, JBBH_S15, Elutriate	30-Apr-2019	----	----	----	02-May-2019	28-May-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK262A: Total Nitrogen								
Clear Plastic Bottle - Frozen (AS) (EK262PA-SW)		30-Apr-2019	02-May-2019	28-May-2019	✓	02-May-2019	28-May-2019	✓
JBBH_S1,	JBBH_S2_A,							
JBBH_S2_B,	JBBH_S3,							
JBBH_S4,	JBBH_S5,							
JBBH_S6_1_0.00_0.10,	JBBH_S6_2_0.00_0.10,							
JBBH_S6_3_0.00_0.10,	JBBH_S7_0.00_0.10,							
JBBH_S8,	JBBH_S9,							
JBBH_S10_1_0.00_0.10,	JBBH_S10_2_0.00_0.10,							
JBBH_S10_3,	JBBH_S11,							
JBBH_S12_0.10,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
Elutriate								
EK267A: Total Phosphorus (Persulfate Digestion)								
Clear Plastic Bottle - Frozen (AS) (EK267PA-SW)		30-Apr-2019	02-May-2019	28-May-2019	✓	02-May-2019	28-May-2019	✓
JBBH_S1,	JBBH_S2_A,							
JBBH_S2_B,	JBBH_S3,							
JBBH_S4,	JBBH_S5,							
JBBH_S6_1_0.00_0.10,	JBBH_S6_2_0.00_0.10,							
JBBH_S6_3_0.00_0.10,	JBBH_S7_0.00_0.10,							
JBBH_S8,	JBBH_S9,							
JBBH_S10_1_0.00_0.10,	JBBH_S10_2_0.00_0.10,							
JBBH_S10_3,	JBBH_S11,							
JBBH_S12_0.10,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
Elutriate								
EK271A: Reactive Phosphorus								
Clear Plastic - Filtered & Frozen (AS/ISO) - UT Nu (EK271A-SW)		30-Apr-2019	----	----	----	02-May-2019	28-May-2019	✓
JBBH_S1,	JBBH_S2_A,							
JBBH_S2_B,	JBBH_S3,							
JBBH_S4,	JBBH_S5,							
JBBH_S6_1_0.00_0.10,	JBBH_S6_2_0.00_0.10,							
JBBH_S6_3_0.00_0.10,	JBBH_S7_0.00_0.10,							
JBBH_S8,	JBBH_S9,							
JBBH_S10_1_0.00_0.10,	JBBH_S10_2_0.00_0.10,							
JBBH_S10_3,	JBBH_S11,							
JBBH_S12_0.10,	JBBH_S13,							
JBBH_S14,	JBBH_S15,							
Elutriate								



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP005: Total Organic Carbon (TOC)								
Amber TOC Vial - Sulfuric Acid (EP005) RinsateBlank_1, RinsateBlank_3	RinsateBlank_2,	18-Apr-2019	----	----	----	23-Apr-2019	16-May-2019	✓
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) RinsateBlank_1, RinsateBlank_3	RinsateBlank_2,	18-Apr-2019	24-Apr-2019	25-Apr-2019	✓	26-Apr-2019	03-Jun-2019	✓
EP080/071: Total Petroleum Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP071) RinsateBlank_1, RinsateBlank_3	RinsateBlank_2,	18-Apr-2019	24-Apr-2019	25-Apr-2019	✓	26-Apr-2019	03-Jun-2019	✓
Amber VOC Vial - Sulfuric Acid (EP080) RinsateBlank_1, RinsateBlank_3	RinsateBlank_2,	18-Apr-2019	26-Apr-2019	02-May-2019	✓	26-Apr-2019	02-May-2019	✓
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
Amber Glass Bottle - Unpreserved (EP071) RinsateBlank_1, RinsateBlank_3	RinsateBlank_2,	18-Apr-2019	24-Apr-2019	25-Apr-2019	✓	26-Apr-2019	03-Jun-2019	✓
Amber VOC Vial - Sulfuric Acid (EP080) RinsateBlank_1, RinsateBlank_3	RinsateBlank_2,	18-Apr-2019	26-Apr-2019	02-May-2019	✓	26-Apr-2019	02-May-2019	✓
EP080: BTEXN								
Amber VOC Vial - Sulfuric Acid (EP080) RinsateBlank_1, RinsateBlank_3	RinsateBlank_2,	18-Apr-2019	26-Apr-2019	02-May-2019	✓	26-Apr-2019	02-May-2019	✓



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected		Evaluation
Laboratory Duplicates (DUP)							
Exchangeable Cations with pre-treatment	ED008	2	11	18.18	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	4	33	12.12	10.00	✓	NEPM 2013 B3 & ALS QC Standard
PAHs in Sediments by GCMS(SIM)	EP132B-SD	4	31	12.90	10.00	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	3	27	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	3	30	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	3	30	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TPH - Semivolatile Fraction	EP071-SD	4	31	12.90	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	2	12	16.67	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX in Sediments	EP080-SD	4	31	12.90	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Exchangeable Cations with pre-treatment	ED008	1	11	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAHs in Sediments by GCMS(SIM)	EP132B-SD	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	2	27	7.41	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	2	30	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	2	30	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TPH - Semivolatile Fraction	EP071-SD	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX in Sediments	EP080-SD	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Exchangeable Cations with pre-treatment	ED008	1	11	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAHs in Sediments by GCMS(SIM)	EP132B-SD	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Seawater Elutriate Testing Procedure	EN68a	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	2	27	7.41	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	2	30	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	2	30	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TPH - Semivolatile Fraction	EP071-SD	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX in Sediments	EP080-SD	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
PAHs in Sediments by GCMS(SIM)	EP132B-SD	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	2	27	7.41	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	2	30	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TPH - Semivolatile Fraction	EP071-SD	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: **SOIL**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Matrix Spikes (MS) - Continued							
TRH Volatiles/BTEX in Sediments	EP080-SD	2	31	6.45	5.00	✔	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Ammonia as N - Ultra-Trace in Saline Waters	EK255A-SW	3	21	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N - Ultra-Trace in Saline Waters	EK259A-SW	3	21	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Ultra-Trace in Saline Waters	EK257A-SW	3	21	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	13	0.00	10.00	✗	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	1	8	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace in Saline Water	EK271A-SW	3	21	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	13	15.38	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen/Persulfate Digestion/Ultra-Trace/Saline	EK262PA-SW	3	21	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	11	18.18	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus/Persulfate Digestion/ Ultra Trace /Saline	EK267PA-SW	3	21	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	15	0.00	10.00	✗	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	2	16	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N - Ultra-Trace in Saline Waters	EK255A-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N - Ultra-Trace in Saline Waters	EK259A-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Ultra-Trace in Saline Waters	EK257A-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	8	25.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace in Saline Water	EK271A-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen/Persulfate Digestion/Ultra-Trace/Saline	EK262PA-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	11	18.18	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus/Persulfate Digestion/ Ultra Trace /Saline	EK267PA-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N - Ultra-Trace in Saline Waters	EK255A-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N - Ultra-Trace in Saline Waters	EK259A-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Ultra-Trace in Saline Waters	EK257A-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace in Saline Water	EK271A-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Total Metals by ICP-MS - Suite A	EG020A-T	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen/Persulfate Digestion/Ultra-Trace/Saline	EK262PA-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	11	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus/Persulfate Digestion/ Ultra Trace /Saline	EK267PA-SW	2	21	9.52	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N - Ultra-Trace in Saline Waters	EK255A-SW	1	21	4.76	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N - Ultra-Trace in Saline Waters	EK259A-SW	1	21	4.76	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Nitrite as N - Ultra-Trace in Saline Waters	EK257A-SW	1	21	4.76	5.00	✗	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	13	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P - Ultra-Trace in Saline Water	EK271A-SW	1	21	4.76	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Nitrogen/Persulfate Digestion/Ultra-Trace/Saline	EK262PA-SW	1	21	4.76	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	11	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus/Persulfate Digestion/ Ultra Trace /Saline	EK267PA-SW	1	21	4.76	5.00	✗	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	15	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
pH by PC Titrator	EA005-P	SOIL	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Exchangeable Cations with pre-treatment	ED008	SOIL	In house: Referenced to Rayment & Higginson (2011) Method 15A2. Soluble salts are removed from the sample prior to analysis. Cations are exchanged from the sample by contact with Ammonium Chloride. They are then quantitated in the final solution by ICPAES and reported as meq/100g of original soil. This method is compliant with NEPM (2013) Schedule B(3) (Method 301)
Total Metals in Sediments by ICPMS	EG020-SD	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector. Analyte list and LORs per NODG.
Total Mercury by FIMS (Low Level)	EG035T-LL	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N - Ultra-Trace in Saline Waters	EK255A-SW	SOIL	In house: Referenced to APHA 4500-NH ₃ H. Ammonia is determined by direct colorimetry by FIA. This method is compliant with NEPM (2013) Schedule B(3)
Ammonium as N	EK255A-SW-NH ₄	SOIL	Ammonium in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH and Temperature. Ammonia is determined by direct colorimetry by Flow Injection Analyser according to APHA 4500-NH ₃ G. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N - Ultra-Trace in Saline Waters	EK257A-SW	SOIL	In house: Referenced to APHA 4500-NO ₂ - B. Nitrite is determined by direct colourimetry by FIA.
Nitrate as N - Ultra-Trace in Saline Waters	EK258A-SW	SOIL	In house: Referenced to APHA 4500-NO ₃ - I. Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by FIA. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results.
Nitrite and Nitrate as N - Ultra-Trace in Saline Waters	EK259A-SW	SOIL	In house: Referenced to APHA 4500-NO ₃ - I. Combined oxidised Nitrogen (NO ₂ +NO ₃) is determined by Cadmium Reduction and direct colourimetry by FIA.
TKN (Total N - NO _x -N). (FIA - UT) in Saline Waters	EK261PA-SW	SOIL	In house: Referenced to APHA 4500-P J. & 4500-NO ₃ - I. Calculated by difference from total Nitrogen and NO _x . Contributing method parameters are determined by FIA. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Total Nitrogen/Persulfate Digestion/Ultra-Trace/Saline	EK262PA-SW	SOIL	In house: Referenced to APHA 4500-P J. Persulfate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus. As sample is digested with persulfate under alkaline conditions yielding orthophosphate and nitrate. Following digestion, analytes are determined by flow injection analysis. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus/Persulfate Digestion/ Ultra Trace /Saline	EK267PA-SW	SOIL	In house: Referenced to APHA 4500-P J. Persulfate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus. As sample is digested with persulfate under alkaline conditions yielding orthophosphate and nitrate. Following digestion, analytes are determined by flow injection analysis. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P - Ultra-Trace in Saline Water	EK271A-SW	SOIL	In house: Referenced to APHA 4500-P E Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by FIA. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP003	SOIL	In house C-IR17. Dried and pulverised sample is reacted with acid to remove inorganic Carbonates, then combusted in a LECO furnace in the presence of strong oxidants / catalysts. The evolved (Organic) Carbon (as CO2) is automatically measured by infra-red detector.
TPH - Semivolatile Fraction	EP071-SD	SOIL	In house: Referenced to USEPA SW 846 - 8270D. Extracts are analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3) (Method 504)
TRH Volatiles/BTEX	EP080	SOIL	In house: Referenced to USEPA SW 846 - 8260B. Extracts are analysed by Purge and Trap, Capillary GC/MS. Quantification is by comparison against an established 5 point calibration curve. Compliant with NEPM amended 2013.
TRH Volatiles/BTEX in Sediments	EP080-SD	SOIL	In house: Referenced to USEPA SW 846 - 8260B Extracts are analysed by Purge and Trap, Capillary GC/MS. Quantification is by comparison against an established 5 point calibration curve.
PAHs in Sediments by GCMS(SIM)	EP132B-SD	SOIL	In house: Referenced to USEPA 8270D GCMS Capillary column, SIM mode using large volume programmed temperature vaporisation injection.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
TRH - Semivolatile Fraction	EP071	WATER	In house: Referenced to USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
TRH Volatiles/BTEX	EP080	WATER	In house: Referenced to USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
Exchangeable Cations Preparation Method	ED007PR	SOIL	In house: Referenced to Rayment & Higginson (1992) method 15A1. A 1M NH4Cl extraction by end over end tumbling at a ratio of 1:20. There is no pretreatment for soluble salts. Extracts can be run by ICP for cations.
Persulfate Digestion for UT Dissolved TN and TP for FIA fin	EK262/267PA-SW Prep	SOIL	In house: Referenced to APHA 4500 P - J. This method is compliant with NEPM (2013) Schedule B(3)
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Seawater Elutriate Testing Procedure	EN68a	SOIL	USEPA Evaluation of Dredged Material Proposed for Ocean Disposal - Testing Guide, 1991, EPA-503/8-91/001, USEPA and US Army Corps of Engineers. ANZECC Interim Ocean Disposal Guidelines, December, 1998 This Procedure outlines the preparation of leachate designed to simulate release of contaminants from sediment during the disposal of dredged material. Release can occur by physical processes or a variety of chemical changes such as oxidation of metal sulphides and release of contaminants adsorbed to particles or organic matter.
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (2013) Schedule B(3) (Method 202)
Dry and Pulverise (up to 100g)	GEO30	SOIL	#
Methanolic Extraction of Soils for Purge and Trap	ORG16	SOIL	In house: Referenced to USEPA SW 846 - 5030A. 5g of solid is shaken with surrogate and 10mL methanol prior to analysis by Purge and Trap - GC/MS.
Tumbler Extraction of Solids for LVI (Non-concentrating)	ORG17D	SOIL	In house: 10g of sample, Na2SO4 and surrogate are extracted with 50mL 1:1 DCM/Acetone by end over end tumbling. An aliquot is concentrated by nitrogen blowdown to a reduced volume for analysis if required.
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

Appendix D Reference Laboratory Reports (ChemCentre)



ChemCentre
Inorganic Chemistry Section
Report of Examination



Accredited for compliance with ISO/IEC 17025 testing, Accreditation No. 8

Purchase Order: 1454_01_002

ChemCentre Reference: 18S4167 R0

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Attention: Louise Synnot

Report on: 1 sample received on 18/04/2019

<u>LAB ID</u>	<u>Material</u>	<u>Client ID and Description</u>
18S4167 / 001	sediment	JBBH_S2_C

LAB ID	001
Client ID	JBBH_S2_C

Sampled	17/04/2019
----------------	------------

Analyte	Method	Unit	
Total Organic Carbon	(combs)	%	0.47
Arsenic	iMET2SAMS	mg/kg	0.8
Cadmium	iMET2SAMS	mg/kg	0.08
Chromium	iMET2SAICP	mg/kg	8.5
Copper	iMET2SAICP	mg/kg	<0.1
Lead	iMET2SAMS	mg/kg	<0.5
Nickel	iMET2SAMS	mg/kg	0.4
Zinc	iMET2SAMS	mg/kg	0.91
Benzene*	ORG002SL	mg/kg	<0.1
Ethylbenzene*	ORG002SL	mg/kg	<0.1
m,p-Xylene*	ORG002SL	mg/kg	<0.2
o-Xylene*	ORG002SL	mg/kg	<0.1
Toluene*	ORG002SL	mg/kg	<0.1
Aliphatic fraction C10-C35*	ORG007SS	mg/kg	<250
Aromatic fraction C16-C35*	ORG007SS	mg/kg	<250
TPH C6-C9	ORG015S	mg/kg	<25
TPH C10-C14 in soil	ORG007S	mg/kg	<25
TPH C15-C28 in soil	ORG007S	mg/kg	<100
TPH C29-C36 in soil	ORG007S	mg/kg	<100
Total TRHs	ORG007SPTC	mg/kg	<250
TRH >C10-C16	ORG007S	mg/kg	<25
TRH >C16-C34	ORG007S	mg/kg	<100
TRH >C34-C40	ORG007S	mg/kg	<100
TRH C6-C10	ORG015S	mg/kg	<25
Total TPHs	ORG007S	mg/kg	<250
Naphthalene*	ORG020SL	mg/kg	<0.001
1-methylnaphthalene*	ORG020SL	mg/kg	<0.001
2-Methylnaphthalene*	ORG020SL	mg/kg	<0.001
Acenaphthylene*	ORG020SL	mg/kg	<0.001
Acenaphthene*	ORG020SL	mg/kg	<0.001

LAB ID 001
Client ID JBBH_S2_C

Sampled 17/04/2019

Analyte	Method	Unit	
Fluorene*	ORG020SL	mg/kg	<0.001
Phenanthrene*	ORG020SL	mg/kg	<0.001
Anthracene*	ORG020SL	mg/kg	<0.001
Fluoranthene*	ORG020SL	mg/kg	<0.001
Pyrene*	ORG020SL	mg/kg	<0.001
Benz(a)anthracene*	ORG020SL	mg/kg	<0.001
Chrysene*	ORG020SL	mg/kg	<0.001
Benzo(b)fluoranthene*	ORG020SL	mg/kg	<0.001
Benzo(k)fluoranthene*	ORG020SL	mg/kg	<0.001
Benzo(a)pyrene*	ORG020SL	mg/kg	<0.001
Indeno(1,2,3-cd)pyrene*	ORG020SL	mg/kg	<0.001
Dibenzo(a,h)anthracene*	ORG020SL	mg/kg	<0.001
Benzo(g,h,i)perylene*	ORG020SL	mg/kg	<0.001
Moisture, loss at 105C.	ORG160	%	34

Date Extracted ORG007S 24/04/2019 12:0
Date Analysed (combs) 9/5/2019
iMET2SAICP 8/5/2019
iMET2SAMS 8/5/2019
ORG002SL 26/4/2019
ORG007S 29/4/2019
ORG007SPTC 29/4/2019
ORG007SS 29/4/2019
ORG015S 26/4/2019
ORG020SL 13/5/2019
ORG160 29/4/2019
Sample Condition Cold

Method	Method Description
(combs)	Total carbon, total organic carbon (acid pretreatment), total inorganic carbon (calculation) and Sulfur in soils by combustion, in-house method S57.
iMET2SAICP	Acid digestable metals (dry wt basis) by digestion and ICPAES.
iMET2SAMS	Acid digestable metals (dry wt basis) by ICPMS.
ORG002SL	BTEX in soil with low LORs
ORG007S	Total Recoverable Hydrocarbons in Soil
ORG007SPTC	Sum of TRHs in Soils with C6-C10 by Purge and Trap
ORG007SS	Aromatic Aliphatic Fractions of TRH in Soils
ORG015S	BTEX and C6 - C10 in soil
ORG020SL	PAHs in soil by GC-MS with low LOR
ORG160	Determination of Loss on Drying

Elutriate nutrients and low level Mercury were subcontracted to NMI, 105 Delhi Road, North Ryde, NSW, 2133. NATA accreditation 198.
Report attached.

These results apply only to the sample(s) as received. Unless arrangements are made to the contrary, these samples will be disposed of after 30 days of the issue of this report.
This report may only be reproduced in full.



Elena Mcconville-Wolfe
Chemist
SSD Inorganic Chemistry
16-May-2019



Ibrahim Jambol
Senior Chemist and Research Officer
SSD Organic Chemistry



Hanna May
Team Leader
SSD Inorganic Chemistry



Quality Assurance Report



Client : BMT Western Australia Pty Ltd
Client Ref No : Jurien Bay Sediment Sampling
CoC No :
QA Report No : 18S4167-QA R 0

Analyte	Method	Unit	LoR	Blank	Sample Duplicates			Acceptable RPD	Recoveries		Acceptable Recovery
					Sample	Duplicate	RPD		LCS	Matrix Spike	
							%	%	%	%	%
Scientific Services Division											
Sample Matrix : sediment											
18S4167/000											
Arsenic	iMET2SAMS	mg/kg	0.2	<0.2	-	-	-	20%	101%	-	75% - 125%
Cadmium	iMET2SAMS	mg/kg	0.05	<0.05	-	-	-	20%	97%	-	75% - 125%
Chromium	iMET2SAICP	mg/kg	0.05	<0.05	-	-	-	20%	103%	-	75% - 125%
Copper	iMET2SAICP	mg/kg	0.1	<0.1	-	-	-	20%	106%	-	75% - 125%
Nickel	iMET2SAMS	mg/kg	0.1	<0.1	-	-	-	20%	99%	-	75% - 125%
Lead	iMET2SAMS	mg/kg	0.5	<0.5	-	-	-	20%	99%	-	75% - 125%
Zinc	iMET2SAMS	mg/kg	0.25	<0.25	-	-	-	20%	93%	-	75% - 125%
18S4167/001											
TRH >C10-C16	ORG007S	mg/kg	25	<25	<25	<25	<1%	20%	91%	91%	63% - 130%
TRH >C16-C34	ORG007S	mg/kg	100	<100	<100	<100	<1%	20%	124%	74%	54% - 130%
TRH >C34-C40	ORG007S	mg/kg	100	<100	<100	<100	<1%	20%	112%	80%	49% - 122%
1-methylnaphthalene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
2-Methylnaphthalene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Acenaphthylene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Acenaphthene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	84%	60% - 130%
Anthracene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Benz(a)anthracene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Benzo(a)pyrene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%



Quality Assurance Report

Analyte	Method	Unit	LoR	Blank	Sample Duplicates			Acceptable RPD	Recoveries		Acceptable Recovery
					Sample	Duplicate	RPD		LCS	Matrix Spike	
							%	%	%	%	%
Benzo(b)fluoranthene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Benzo(k)fluoranthene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Benzo(g,h,i)perylene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
TPH C10-C14 in soil	ORG007S	mg/kg	25	<25	<25	<25	<1%	20%	-	-	50% - 160%
Aliphatic fraction C10-C35	ORG007SS	mg/kg	250	<250	<250	<250	<1%	20%	-	-	75% - 125%
TPH C15-C28 in soil	ORG007S	mg/kg	100	<100	<100	<100	<1%	20%	-	-	46% - 160%
Aromatic fraction C16-C35	ORG007SS	mg/kg	250	<250	<250	<250	<1%	20%	-	-	75% - 125%
TPH C29-C36 in soil	ORG007S	mg/kg	100	<100	<100	<100	<1%	20%	-	-	12% - 160%
Chrysene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Dibenzo(a,h)anthracene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Fluoranthene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Fluorene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Moisture, loss at 105C.	ORG160	%	0.1	<0.1	34	34	<1%	10%	-	-	75% - 125%
Indeno(1,2,3-cd)pyrene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Naphthalene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Phenanthrene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	-	60% - 130%
Pyrene	ORG020SL	mg/kg	0.001	<0.001	<0.001	<0.001	<1%	30%	-	88%	60% - 130%
Total Organic Carbon	(combs)	%	0.05	<0.05	0.47	0.53	12%	20%	-	-	75% - 125%
Total TPHs	ORG007S	mg/kg	250	<250	<250	<250	<1%	20%	-	-	49% - 124%

Definitions:

RPD = Relative Percentage Difference

LCS = Laboratory Control Sample

LoR = Limit of Reporting



Quality Assurance Report



Quality Control Acceptance Criteria

Waters:

Lab Dups RPD <10% for results greater than 5 X LOR.

For results less than 5 x LOR no acceptance criteria for RPD.

Matrix spikes, LCS and Surrogate recoveries: Generally 75% - 125% for inorganics/metals, 60% - 140% for organics (+/- 50% surrogates) and 10% - 140% for labile SVOCs (including labile surrogates) unless other values are stated above.

Soils:

Soils: Lab Dups RPD<20% for results greater than 5 X LOR.

For results less than 5 x LOR no acceptance criteria for RPD.

Matrix spikes, LCS and Surrogate recoveries: Generally 75% - 125% for inorganics/metals, 60% - 140% for organics (+/- 50% surrogates) and 10% - 140% for labile SVOCs (including labile surrogates) unless other values are stated above.

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Elena Mcconville-Wolfe
Chemist

14-May-2019

Hanna May
Team Leader

Ibrahim Jambol
Senior Chemist and Research Officer



Australian Government
Department of Industry,
Innovation and Science

National Measurement Institute



REPORT OF ANALYSIS

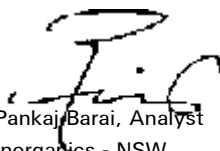
Page: 1 of 5

Report No. RN1232259

Client :	CHEMCENTRE CORNER MANNING ROAD AND SOUTH ENTRANCE OF CURTIN UNIVERSITY	Job No. :	CHEM06/190424/2
Attention :		Quote No. :	QT-02027
Project Name :		Order No. :	18S4167
Your Client Services Manager :	Richard Coghlan	Date Received :	24-APR-2019
		Sampled By :	CLIENT
		Phone :	02 9449 0161

Lab Reg No.	Sample Ref	Sample Description
N19/010863	.	SOIL 18S4167/001_JBBH_S2_C

Lab Reg No.		N19/010863				
Date Sampled		17-APR-2019				
Sample Reference		.				
	Units					Method
Total Recoverable Mercury by CV-AAS						
Mercury	mg/kg	0.0029				NT249_244
Trace Elements						
Total Solids	%	68.9				NT2_49


Pankaj Barai, Analyst
Inorganics - NSW
Accreditation No. 198

15-MAY-2019

All results are expressed on a dry weight basis.

REPORT OF ANALYSIS

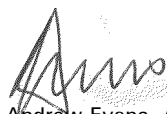
Page: 2 of 5

Report No. RN1232259

Client :	CHEMCENTRE CORNER MANNING ROAD AND SOUTH ENTRANCE OF CURTIN UNIVERSITY	Job No. :	CHEM06/190424/2
Attention :		Quote No. :	QT-02027
Project Name :		Order No. :	18S4167
Your Client Services Manager :	Richard Coghlan	Date Received :	24-APR-2019
		Sampled By :	CLIENT
		Phone :	02 9449 0161

Lab Reg No.	Sample Ref	Sample Description
N19/010863/1	.	SOIL ELUTRIATE 18S4167/001_JBBH_S2_C

Lab Reg No.			N19/010863/1				
Date Sampled			17-APR-2019				
Sample Reference			.				
		Units					Method
Total Recoverable Trace Elements by ICP							
Phosphorus Total	mg/L		<0.05				NT2_47



Andrew Evans, Analyst
Inorganics - NSW
Accreditation No. 198

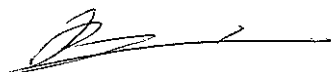
15-MAY-2019

Lab Reg No.			N19/010863/1				
Date Sampled			17-APR-2019				
Sample Reference			.				
		Units					Method
Miscellaneous							
Ammonia-N	mg/L		0.42				NWD17
Ammonium-N (calculated)	mg/L		0.38				NW_D8
Nitrogen - Total	mg/L		0.43				NW_B23
NOx	mg/L		0.02				NW_B19
Orthophosphate-P	mg/L		<0.005				NW_D9
pH	pH_unit		8.3				NW_S11
TCLP							
Volume of Elutriate water	ml		160				NW_SL17
Volume of Elutriate water plus sample			200				NW_SL17
Elutriate water used			N19/008333/				NW_SL17

REPORT OF ANALYSIS

Page: 3 of 5
Report No. RN1232259

Lab Reg No.		Units	N19/010863/1				
Date Sampled			17-APR-2019				
Sample Reference			.				Method



Wei Huang, Analyst
Inorganics - NSW
Accreditation No. 198

15-MAY-2019

Total = acid extractable elements

REPORT OF ANALYSIS

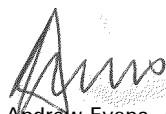
Page: 4 of 5

Report No. RN1232259

Client :	CHEMCENTRE CORNER MANNING ROAD AND SOUTH ENTRANCE OF CURTIN UNIVERSITY	Job No. :	CHEM06/190424/2
Attention :		Quote No. :	QT-02027
Project Name :		Order No. :	18S4167
Your Client Services Manager :	Richard Coghlan	Date Received :	24-APR-2019
		Sampled By :	CLIENT
		Phone :	02 9449 0161

Lab Reg No.	Sample Ref	Sample Description
N19/008333/1	.	WATER 18S3747/002-ELUTRIATE H2O

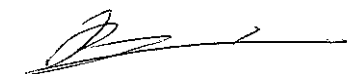
Lab Reg No.			N19/008333/1				
Date Sampled			21-MAR-2019				
Sample Reference			.				
		Units					Method
Total Recoverable Trace Elements by ICP							
Phosphorus Total	mg/L		<0.05				NT2_47



Andrew Evans, Analyst
Inorganics - NSW
Accreditation No. 198

15-MAY-2019

Lab Reg No.			N19/008333/1				
Date Sampled			21-MAR-2019				
Sample Reference			.				
		Units					Method
Miscellaneous							
Ammonia-N	mg/L		0.013				NWD17
Ammonium-N (calculated)	mg/L		0.013				NW_D8
Nitrogen - Total	mg/L		0.15				NW_B23
NOx	mg/L		0.01				NW_B19
Orthophosphate-P	mg/L		<0.005				NW_D9
pH	pH_unit		7.7				NW_S11



Wei Huang, Analyst
Inorganics - NSW
Accreditation No. 198

15-MAY-2019

REPORT OF ANALYSIS

Page: 5 of 5
Report No. RN1232259

Total = acid extractable elements



Accredited for compliance with ISO/IEC 17025 - Testing.
This report shall not be reproduced except in full.
Results relate only to the sample(s) tested.

This Report supersedes reports: *RN1231949* *RN1232255*

Measurement Uncertainty is available upon request.



Australian Government
National Measurement Institute

QUALITY ASSURANCE REPORT

Client: CHEMCENTRE

NMI QA Report No: CHEM06/190424/2 T1

Sample Matrix: Soil

Analyte	Method	LOR	Blank	Duplicates			Recoveries	
				Sample	Duplicate	RPD	LCS	Matrix Spike
		mg/kg	mg/kg	mg/kg	mg/kg	%	%	%
Inorganics Section								N19/008332
Mercury	NT2.44	0.01	<0.01	0.0029	0.0028	4	106	101

Filename = K:\Inorganics\Reporting\Water\Water 2019\CSV Upload\

Legend:

Acceptable recovery is 75-120%.

Acceptable RPDs on duplicates is 44% at concentrations >5 times LOR. Greater RPD may be expected at <5 times LOR.

LOR = Limit Of Reporting

ND = Not Determined

RPD = Relative Percent Difference

NA = Not Applicable

LCS = Laboratory Control Sample.

#: Spike level is less than 50% of the sample's concentration, hence the recovery data is not reliable.

**: reference value not available

Comments:

Results greater than ten times LOR have been rounded to two significant figures.

This report shall not be reproduced except in full.

Signed:

Dr Andrew Evans
Inorganics, NMI-North Ryde
8/05/2019

Date:



QUALITY ASSURANCE REPORT

Client: CHEMCENTRE

NMI QA Report No: CHEM06/190424/2 T1

Sample Matrix: Water

Analyte	Method	LOR	Blank	Duplicates			Recoveries	
				Sample	Duplicate	RPD	LCS	Matrix Spike
		ug/L	ug/L	ug/L	ug/L	%	%	%
Inorganics Section								
Phosphorus Total	NT2.47	0.05	<0.05	NA	NA	NA	94	NA

Filename = K:\Inorganics\Quality System\QA Reports\TE\QAR2019\Water\

Legend:

Acceptable recovery is 75-120%.

Acceptable RPDs on duplicates is 44% at concentrations >5 times LOR. Greater RPD may be expected at <5 times LOR.

LOR = Limit Of Reporting

ND = Not Determined

RPD = Relative Percent Difference

NA = Not Applicable

LCS = Laboratory Control Sample.

#: Spike level is less than 50% of the sample's concentration, hence the recovery data cannot be reported.

Comments:

Results greater than ten times LOR have been rounded to two significant figures.

This report shall not be reproduced except in full.

Signed:

Dr Andrew Evans
Inorganics , NMI-North Ryde
14/05/2019

Date:



QUALITY ASSURANCE REPORT

Client: ChemCentre

NMI QA Report No: CHEM06/190424/2 QA

Sample Matrix: Elutriate

Analyte	Method	LOR	Blank	Duplicates			Recoveries	
		mg/L	mg/L	Sample mg/L	Duplicate mg/L	RPD %	Matrix spk %	LCS %
Waters Section				N19/010863/1			N19/010863/1	
Nitrogen - Total	NW_B23	0.05	<0.05	0.43	NA	NA	NA	100
Ammonia-N	NWD17	0.001	<0.001	0.42	NA	NA	NA	108
NOx	NW_B19	0.01	<0.01	0.02	NA	NA	NA	105
Orthophosphate-P	NWD9	0.005	<0.005	<0.005	<0.005	ND	NA	97
pH (pH units)	NW_S11	NA	NA	8.3	NA	NA	NA	101

Filename = K:\Inorganics\WATER SECTION\NH4\

Legend

Acceptable recovery is 80-120%.

Acceptable RPDs on duplicates is 30% at > 5 times LOR. Greater RPD may be expected at < 5 LOR.

LOR = Limit Of Reporting

ND = Not Determined

RPD = Relative Percent Difference

NA = Not Applicable

LCS = Laboratory Control Sample.

Comments

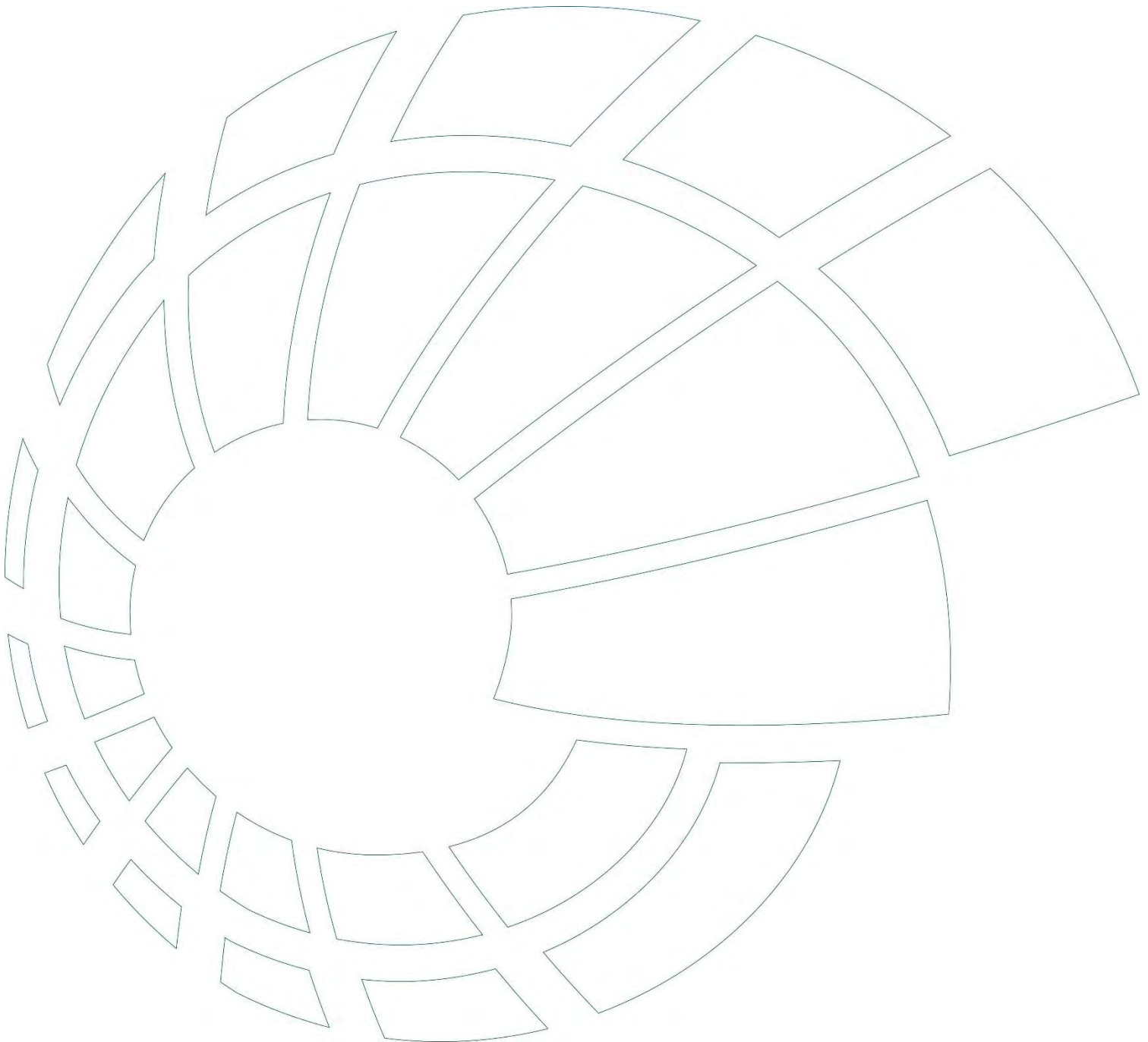
This report shall not be reproduced except in full.

Results greater than ten times LOR have been rounded to two significant figures.

Signed:

Dr Andrew Evans
Inorganics Manager, NMI-Pymble
15/05/2019

Date:



Appendix D Jurien Bay Boat Harbour Benthic Habitat Mapping Study

Jurien Bay Benthic Habitat Mapping

444_07_001/1_Rev1

March 2018



Jurien Bay Benthic Habitat Mapping

Prepared for

Department of Transport

Prepared by

BMT

March 2018

Report No. 444_07_001/1_Rev1

Client: Department of Transport

Document history

Distribution

Revision	Author	Recipients	Organisation	No. copies & format	Date
A	M Capill	B Davis	BMT	1 x .docm	17/01/18
B	M Capill	L Synnot	BMT	1 x .docm	29/01/18
C	M Capill	M Bailey	BMT	1 x .docm	01/02/18
0	M Capill	L Clarke	BMT	1 x .pdf	02/02/18
1	M Capill	B Davis L Clarke	BMT	1 x docm	20/03/18

Review

Revision	Reviewer	Intent	Date
A	B Davis	Technical review	17/01/18
B	L Synnot	Client manager/editorial review	31/01/18
C	M Bailey	Director review	01/02/18
0	L Clarke	Project engineer	02/02/18

Quality Assurance



BMT Western Australia Pty Ltd (trading as BMT) has prepared this report in accordance with our Health Safety Environment Quality Management System, certified to OHSAS 18001, AS/NZS 4801, ISO 14001 and ISO 9001..

Status

This report is 'Draft' until approved for final release, as indicated below by inclusion of signatures from: (i) the author and (ii) a Director of BMT Western Australia Pty Ltd (trading as BMT) or their authorised delegate. A Draft report may be issued for review with intent to generate a 'Final' version, but must not be used for any other purpose.

Approved for final release:

Author

Date: 20/03/18

Director (or delegate)

Date: 20/03/18

Disclaimer

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Acronyms

BPPH	Benthic primary producer habitat
DoT	Western Australian Department of Transport
ha	Hectares
km	Kilometres
m	Metres
m ²	Square metre
TCS	Towed camera system

1. Introduction

Jurien Bay Boat Harbour (hereafter, the Boat Harbour) is located north of the Jurien Bay town site, ~250 km north of Perth, Western Australia (Figure 1.1). The Boat Harbour services a range of government, recreational and commercial vessels and is managed by Department of Transport (DoT).

Wrack and marine sediments accumulate in the Boat Harbour on a frequent basis resulting in several negative impacts affecting the navigability, environment and aesthetic quality. To manage these impacts, routine maintenance dredging of the Boat Harbour is undertaken by DoT.

To inform future dredging requirements and marine environmental management of the Boat Harbour, BMT undertook benthic habitat mapping of Jurien Bay in November 2017. The specific objectives of the mapping project were to:

- i. collect digital baseline data on the spatial extent and characteristics of benthic habitats in the mapping area, and
- ii. qualitatively characterise the extent of benthic primary producer habitat (BPPH) surrounding the Boat Harbour, and develop a mapping product of suitable quality to meet multiple purposes (including informing dredging operations and potential future environmental approvals applications, if necessary).

This report provides an overview of the scope of work, methods and mapping products from the Jurien Bay benthic habitat mapping project.

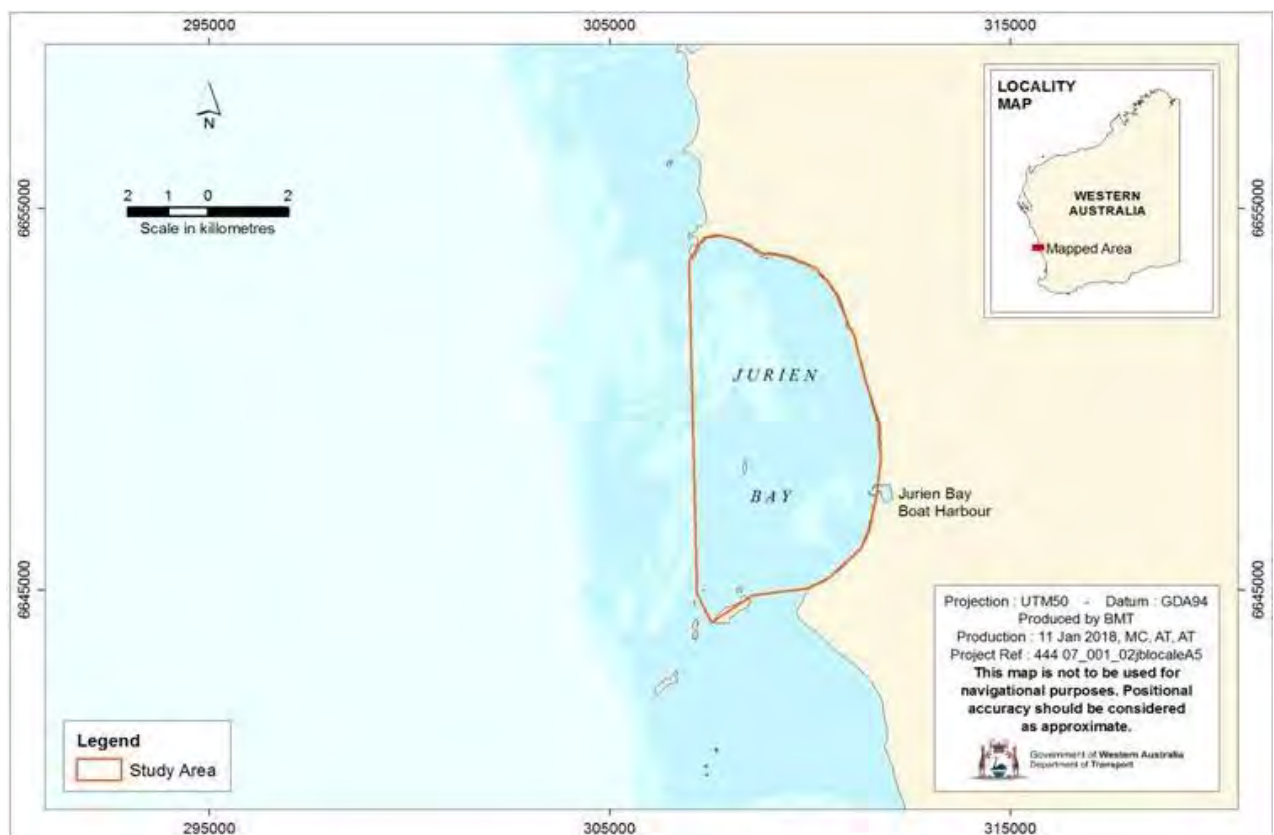


Figure 1.1 Location of the Jurien Bay Boat Harbour and study area

2. Description of the Marine Environment

2.1 General setting

The study area is located inside the Jurien Bay Marine Park (hereafter, the Marine Park) within the Central West Coast marine bioregion. The marine environment experiences a Mediterranean climate, low tidal range (maximum of ~0.7 m; Chua 2002), and predominantly wind driven currents (Holloway 2006). The marine flora and fauna of this region is comprised of a mixture of temperate and tropical species. Temperate species are transported north by the Capes Current from cool southern temperate waters, and tropical species are transported south by the Leeuwin Current from tropical northern waters (CALM 2005).

The near shore seabed topography of the region is complex, containing a series of shallow elongate limestone reefs that run parallel to shore. The numerous emergent rocks and islands associated with these reefs provide the coast with protection from swell waves, and result in the development of deep (>10 m depth) and shallow (<10 m depth) lagoonal environments. The shallow lagoons are interspersed with sandbars that run approximately perpendicular to shore (CALM 2005).

2.2 Marine flora and fauna

Marine Park waters are characterised by several BPPH types including (CALM 2005):

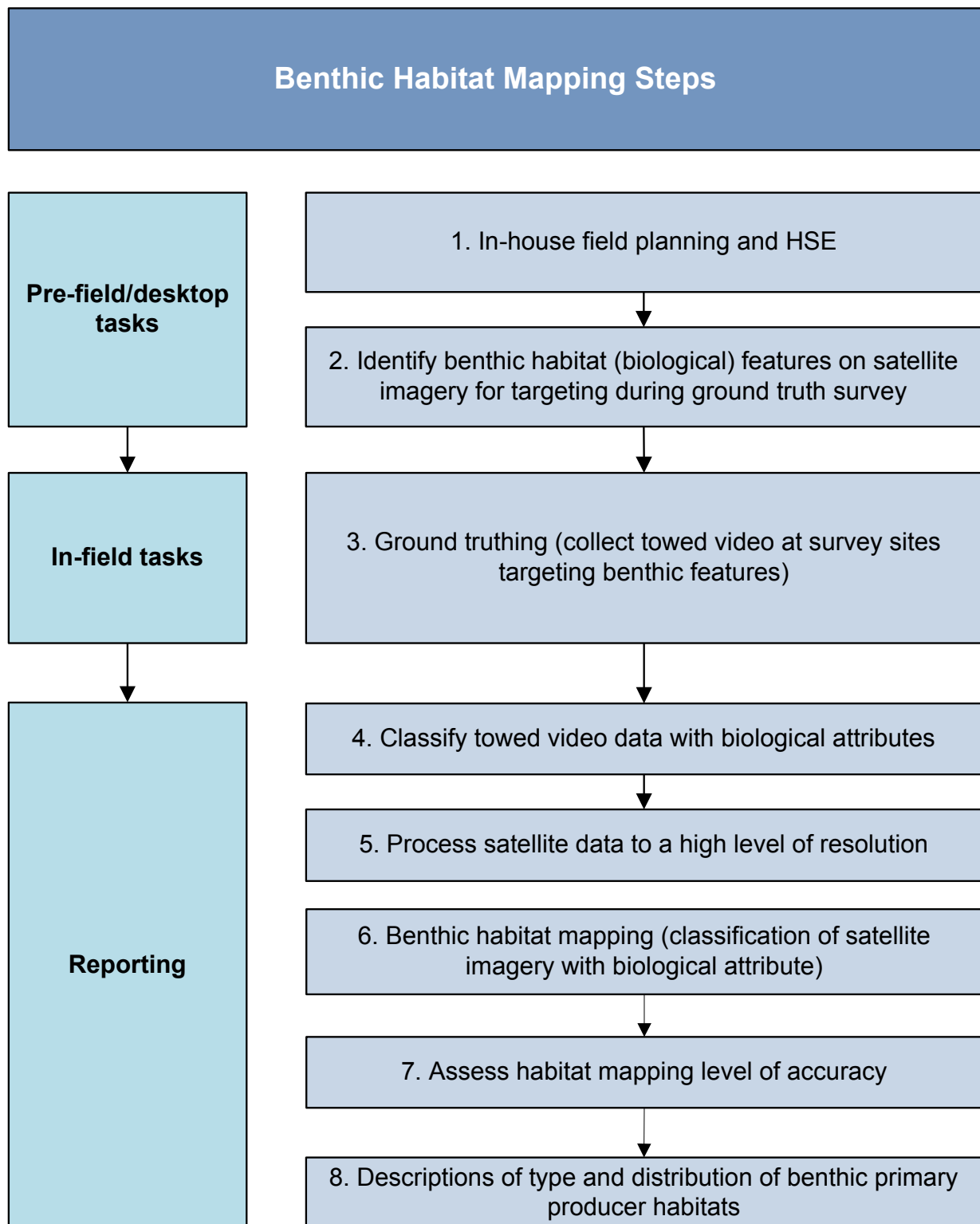
- seagrass meadows
- bare or sparsely vegetated mobile sand
- shoreline and offshore intertidal reef platforms
- subtidal limestone reefs
- reef pavement

These BPPH support diverse seagrass assemblages, with nine species of seagrass recorded in the Marine Park, and mixed macroalgal assemblages (CALM 2005). Although small coral communities are relatively common in the Jurien Bay region, there are no coral reefs (CALM 2005).

These local BPPHs in turn provide habitat and food for diverse fin-fish assemblages, with up to 127 species recorded in the Jurien Bay region (Atlas of Living Australia 2018). Examples include Western Australian dhufish (*Glaucosoma hebraicum*), pink snapper (*Chrysophrys auratus*) and baldchin groper (*Choerodon rubescens*). The commercially fished western rock lobster (*Parulirus cygnus*) is also common to the region and has the highest economic value of any single species commercial fishery in Australia. In addition, the Marine Park supports several species of marine mammals, including 14 species of cetaceans (five of which are listed as rare or likely to become extinct), and a large sea lion population (CALM 2005).

3. Benthic Habitat Mapping Methods

The steps involved to prepare the benthic habitat map are presented in Figure 3.1. In summary, satellite imagery was used to identify benthic habitat features to be ground truthed by towed video. Video footage was classified with biological attributes and combined with satellite imagery to create classified BPPH maps of an area offshore of the Boat Harbour.



Note:

1. HSE = Health, Safety and Environment

Figure 3.1 Steps undertaken to complete Jurien Bay benthic habitat mapping

3.1 Remote data collection

Satellite imagery collected over the study area in the last two years was assessed to determine the most suitable image for mapping. Multispectral satellite imagery from 24 August 2017 was used to identify benthic habitat assemblages for mapping the study area (Figure 3.2). Panchromatic (grey-scale) and multispectral (8 spectral bands) satellite imagery was acquired from the DigitalGlobe WorldView-2 sensor with a resolution of 2 m. The image selected had the clearest water and highest visibility of benthic features in the area of primary interest. Some turbidity was evident over the northern part of the image, but the visibility over these areas was considered sufficient to allow for spectral separation of habitat categories. Prior to commencing the habitat mapping, the satellite imagery was assessed for possible artefacts or sun-glint, but due to the high image quality, no corrections were required.

3.2 Ground truth survey

Ground truth data were collected using towed video camera surveys on 9 and 11 November 2017 and on 1 March 2018. The ground truth data were used to augment the spatial data from the satellite image analysis, and to enable definition of benthic habitat assemblages within the study area. The survey design, collection techniques and methods used to capture and classify video data are described below.

3.2.1 Survey design

In total, 60 transects were surveyed with towed video (Figure 3.2). Transect lengths varied from ~100 m to ~1.6 km, with a total survey transect distance of ~27.5 km. Transect positions were stratified to target areas of particular benthic features (sediments, reefs, seagrass, macroalgae habitats) prior to field mobilisation. Most video frames covered a ~1–2 m wide band of substrate, resulting in ~4.1 hectares (ha) (or 0.11% of the mapping area) of benthic habitat surveyed. Within this survey area, the video data analysis produced ~47 690 units of classified habitat data (with each unit corresponding to ~1.0 m² of mapping area).

3.2.2 Collection of towed video data

Towed video data were collected using a towed camera system (TCS). The TCS was configured for the project with two digital cameras (one standard definition and one high definition) mounted in a water proof sled/housing. The primary camera was mounted to a sled on a 45° angle, pointing forward. The system was connected to the vessel via an umbilical that could be let out to 50 m.

High definition footage from the camera was recorded onto the device's internal storage (128 GB) or external SD cards (up to 128 GB), while standard definition footage was used by the field team to navigate the sled. Footage was backed up at least daily throughout the survey.

During the towed video surveys, a track log was created in real-time within positioning software. The track log contained local date, local time, easting, northing, latitude and longitude, updated every 1 second. A single track log was generated for all towed video transects at the end of the survey.

3.2.3 Classification of video footage

Video footage was analysed and classified according to the benthic habitat categories outlined in Table 3.1. Analysis and classification of video footage was undertaken using TransectMeasure (SeaGIS 2013). The number of points from video tow that were classified for each benthic habitat category is provided in Table 3.2; each point represents ~1 m² of benthic habitat. Following classification, the time vs. classification log was merged with the position vs. time log to

provide a single file with a classification for every position where valid video footage was obtained; this process was automated.

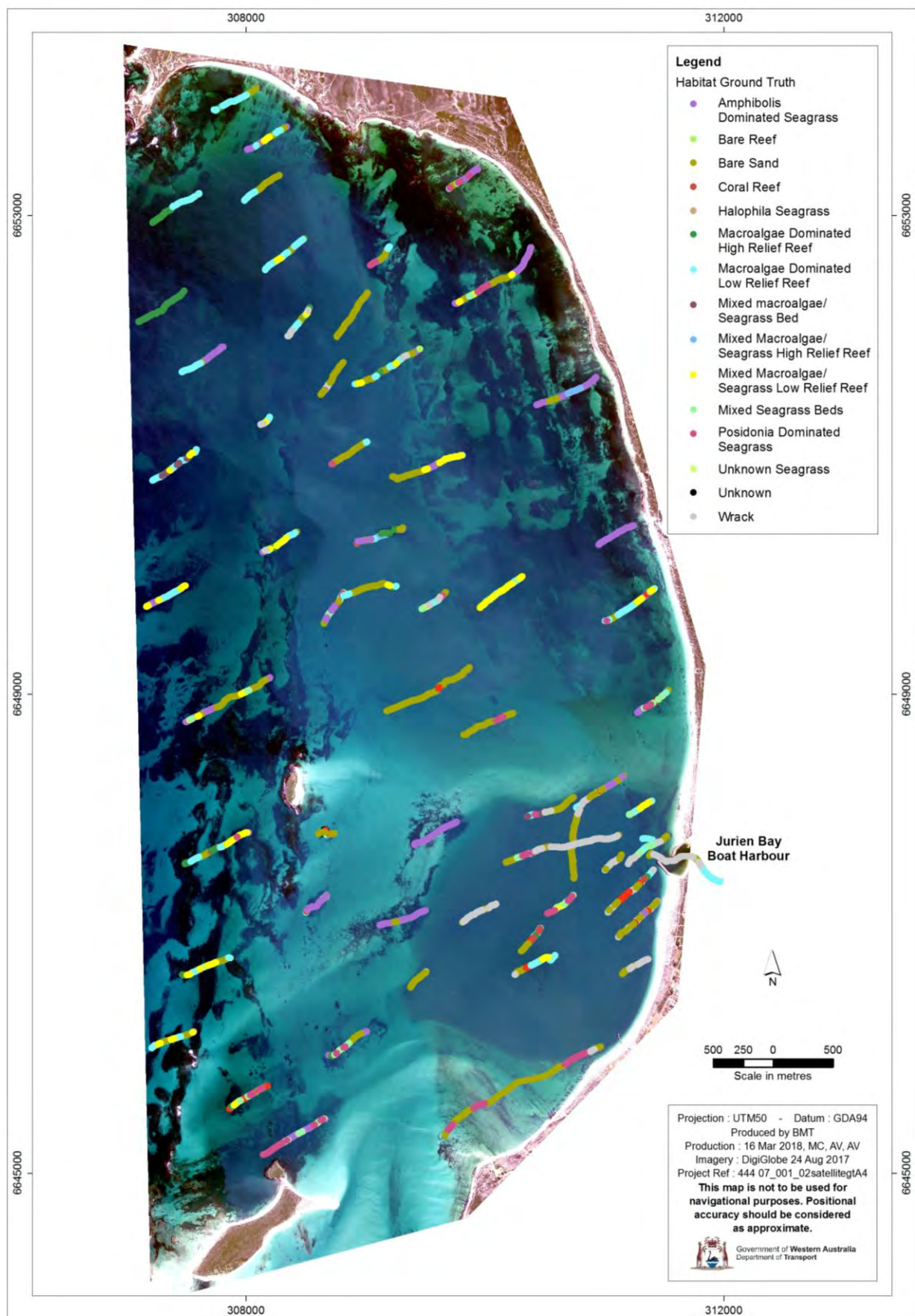
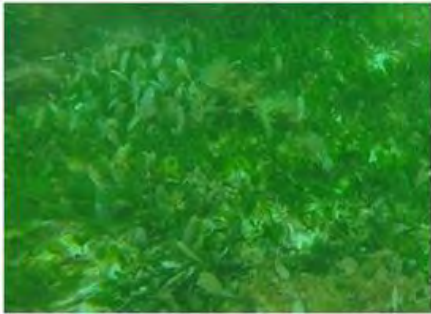

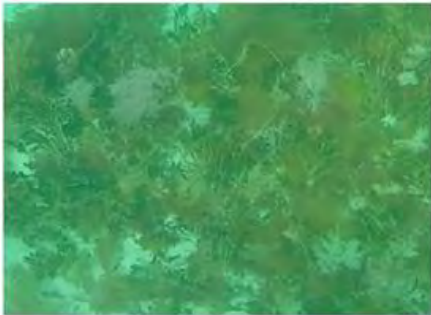






















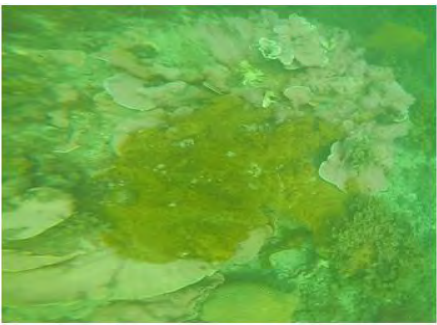



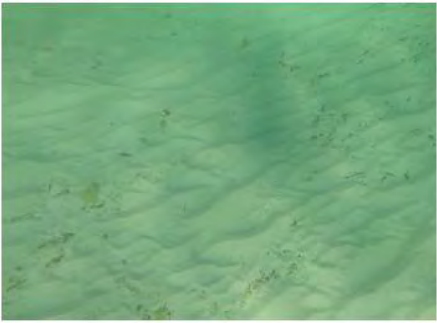
Figure 3.2 Jurien Bay benthic habitat mapping transect locations and habitat type

Table 3.1 Jurien Bay benthic habitat mapping categories and example images from video classification

Benthic habitat categories	Example images		
Seagrass bed dominated by <i>Halophila</i> spp.			
Seagrass bed dominated by <i>Amphibolis</i> spp.			
Seagrass bed dominated by <i>Posidonia</i> spp.			

Mixed seagrass bed			
Macroalgae dominated low relief reef			
Macroalgae dominated high relief reef			

Mixed macroalgae/seagrass bed			
Mixed macroalgae/seagrass low relief reef			
Mixed macroalgae/seagrass high relief reef			

Coral			
Bare reef			
Bare sand			



Wrack	
Unknown seagrass	
Unknown	Feature does not fit into any of the above categories, and/or, cannot be determined.

Table 3.2 Benthic habitat categories points classified and proportion

Benthic habitat categories	Points classified	Proportion ¹ (%)
Seagrass bed dominated by <i>Halophila</i> spp.	1094	2.3
Seagrass bed dominated by <i>Amphibolis</i> spp.	6108	12.8
Seagrass bed dominated by <i>Posidonia</i> spp.	1728	3.6
Mixed seagrass bed	1227	2.6
Macroalgae dominated low relief reef	8374	17.6
Macroalgae dominated high relief reef	1936	4.1
Mixed macroalgae/seagrass bed	332	0.7
Mixed macroalgae/seagrass low relief reef	3134	6.6
Mixed macroalgae/seagrass high relief reef	358	0.8
Coral	93	0.2
Bare reef	350	0.7
Bare sand	17154	36.0
Wrack	5645	11.8
Unknown seagrass	13	0.0
Unknown	144	0.3
Total	47690	100

Note:

1. Percentages do not add up to exactly 100 due to rounding.
2. Example images of classification categories are provided in Table 3.1.

3.3 Classification and mapping procedures

3.3.1 Classification procedures

Habitat mapping was performed using a supervised Maximum Likelihood classifier to classify the images using ERDAS IMAGINE 2015 (Hexagon Geospatial 2016). Training areas were based on ground truthing collected in the field using towed video (Section 3.2.3). A random split was applied to the ground truthing points to split them into classification (70%) and validation (30%) data. The 70% withheld classification ground truthing data were used to generate spectral signatures for the classification. Habitats could be reliably divided into vegetated cover of varying density, and non-vegetated areas, but could not be further classified into seagrass and reef categories as a result of high spectral similarity between seagrass and other vegetated areas (e.g. macroalgae, turfing algae). Therefore, the following categories were mapped:

- vegetated
- non-vegetated areas.

Vegetated areas included all regions with sparse to dense seagrass or macroalgal cover, while non-vegetated areas combined sand and bare rock pavement/reef. Seagrass and macroalgal categories were manually assigned at a later stage. Vegetated areas were defined as either dense (having no obvious gaps in the vegetation cover based on visual assessment of the imagery) or sparse vegetation (containing areas of bare sand or reef in between the vegetation cover). After the supervised classification had been performed, the classified images were visually assessed for consistency across the study area using ArcGIS 10.2. Bathymetric charts were also used to help delineate reef and non-reef areas based on visual assessment of the depth differences between features. The bathymetric information was then integrated with the habitat classification to allow for the separation of vegetated areas, according to reef or non-reef substrate.

3.3.2 Development of final habitat map

Ground truthing data (Figure 3.2) were used to manually define seagrass and macroalgal habitats over the vegetated reef and non-reef areas using ArcGIS 10.2, resulting in the categories described in (Table 3.1). Post-processing was then applied to improve the classification over areas of noise in the data, or misclassification resulting from spectral similarities between the categories, especially in more sparsely vegetated areas, and smooth the boundary between classified habitats. Areas affected by remaining turbidity were improved by applying additional image assessments and contrast stretches to maximise the visibility and confirm the extent of habitats. A minimum mapping unit of ~36 m² was considered suitable to remove small classified areas and merge with neighbouring polygons.

3.3.3 Assessment of accuracy

An accuracy assessment was performed on the habitat classification using the 30% withheld validation ground truthing data for the vegetated and non-vegetated categories. No accuracy assessment could be performed for the detailed habitat categories, as these were derived manually with no supervised classification approach and final categories deviated slightly from the final ground truth categories. However, a visual assessment showed good agreement between the detailed categories and the imagery and ground truthing.

The assessment of vegetated and non-vegetated categories achieved a very high overall accuracy of 93.40% and Kappa statistic of 0.87. The accuracies for the individual categories are reflected in Table 3.3. The Kappa value measures agreement between the classification of categorical data, and recognises the agreement that could occur by chance. Kappa values over 0.40 have been considered as representing moderate to strong agreement (Congalton 1991, 2001).

Table 3.3 Accuracy assessment of the benthic habitat classification

Habitat type		Reference Data			User's accuracy ¹
		Vegetated	Non-vegetated	Total	
Classified Data	Vegetated	58	5	63	92.06%
	Non-vegetated	2	41	43	95.35%
	Total	60	46	106	N/A
	Producer's accuracy²	96.67%	89.13%	N/A	N/A

Note:

1. User's accuracy, or reliability, indicates the probability that a pixel classified in the image actually represents that class on the ground (error of commission). It is calculated by dividing the total number of correct pixels in a class by the total number of pixels that were classified in that class (Congalton 1991).
2. Producer's accuracy indicates the probability of a reference pixel being correctly classified (error of omission). It is calculated by dividing the total number of correct pixels in a class by the total number of pixels of that class as derived from the reference data.

4. Distribution of Benthic Habitats

A total of 3667.2 ha of benthic habitat was mapped during the project (Table 4.1). Within this area, the dominant habitat types are (Table 4.1):

- bare sand (57.9%),
- sand inundated platform reef with macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.) (18.3%)
- sand inundated platform reef with macroalgae and perennial seagrass (*Amphibolis* spp.) (13.9%)
- reef dominated by macroalgae (6.1%)

Comparatively, a small proportion of mapped benthic habitat is inhabited by mixed perennial seagrass (*Amphibolis* spp. and *Posidonia* spp.) (2.6%) and even less by mono-specific perennial and ephemeral seagrass meadows (~1.0% for *Amphibolis* spp., *Posidonia* spp. and *Halophila* spp. combined). There is also little habitat within the mapping area occupied by filter feeders such as corals and sponges (0.3%). One area containing filter feeders was identified within a mixed assemblage of macroalgae and ephemeral seagrass (*Halophila* spp.) located south-west of the Boat Harbour approximately 750 m offshore (Figure 4.1).

The nearshore area north of the Boat Harbour is mostly comprised of a mixed assemblage of macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.). This occurred on sand inundated platform reef, extending ~500 m to 1 km offshore (Figure 4.1). South of the Boat Harbour, benthic habitat is less vegetated and is dominated by mobile sands with small scattered meadows of perennial seagrass (mixed assemblages of *Posidonia* spp. and *Amphibolis* spp. and mono-specific assemblages of *Posidonia* spp.) and ephemeral seagrass (*Halophila* spp.; Figure 4.1). This predominantly sandy area surrounding the Boat Harbour extends ~3 km offshore.

Further offshore, benthic habitat is dominated by a mixed assemblage of macroalgae and perennial seagrass (*Amphibolis* spp.) on sand inundated platform reef (Figure 4.1). Next to the dominant offshore benthic habitat, areas containing a mixed assemblage of macroalgae and mixed perennial seagrass (*Amphibolis* spp. and *Posidonia* spp.) also occur (Figure 4.1). In the north-west offshore region of the mapping area, there is an expansive area of reef dominated by macroalgae (Figure 4.1).

Inside the Boat Harbour Entrance Channel, benthic habitat is predominantly characterised by wrack overlying bare sand. Directly adjacent to the Boat Harbour Entrance Channel, wrack and sparse meadows of seagrass (*Posidonia* spp.) covered in sand and epiphytic growth by calcareous algae was observed. These seagrass meadows appeared partially dead and flattened on the seafloor, and therefore were classified as wrack for the purpose of the mapping project. It is noted that areas which comprised wrack have been classified as bare sand in Figure 4.1.

Table 4.1 Area and proportion occupied by benthic habitat categories

Benthic habitat type	Area (ha)	Proportion1 (%)
Ephemeral seagrass (<i>Halophila</i> spp.)	2.6	0.1
Perennial seagrass (<i>Amphibolis</i> spp.)	23.4	0.6
Perennial seagrass (<i>Posidonia</i> spp.)	12.2	0.3
Mixed perennial seagrass (<i>Amphibolis</i> spp. and <i>Posidonia</i> spp.)	94.5	2.6
Reef dominated by macroalgae	222.1	6.1
Sand inundated platform reef with macroalgae and perennial seagrass (<i>Amphibolis</i> spp.)	508.2	13.9
Sand inundated platform reef with macroalgae and mixed perennial seagrass (<i>Posidonia</i> spp. and <i>Amphibolis</i> spp.)	670.2	18.3
Platform reef with macroalgae, filter feeders (corals and sponges) and ephemeral seagrass (<i>Halophila</i> spp.)	11.5	0.3
Bare sand	2122.5	57.9
Total	3667.2	100

Note:

1. Percentages do not add up to exactly 100 due to rounding.

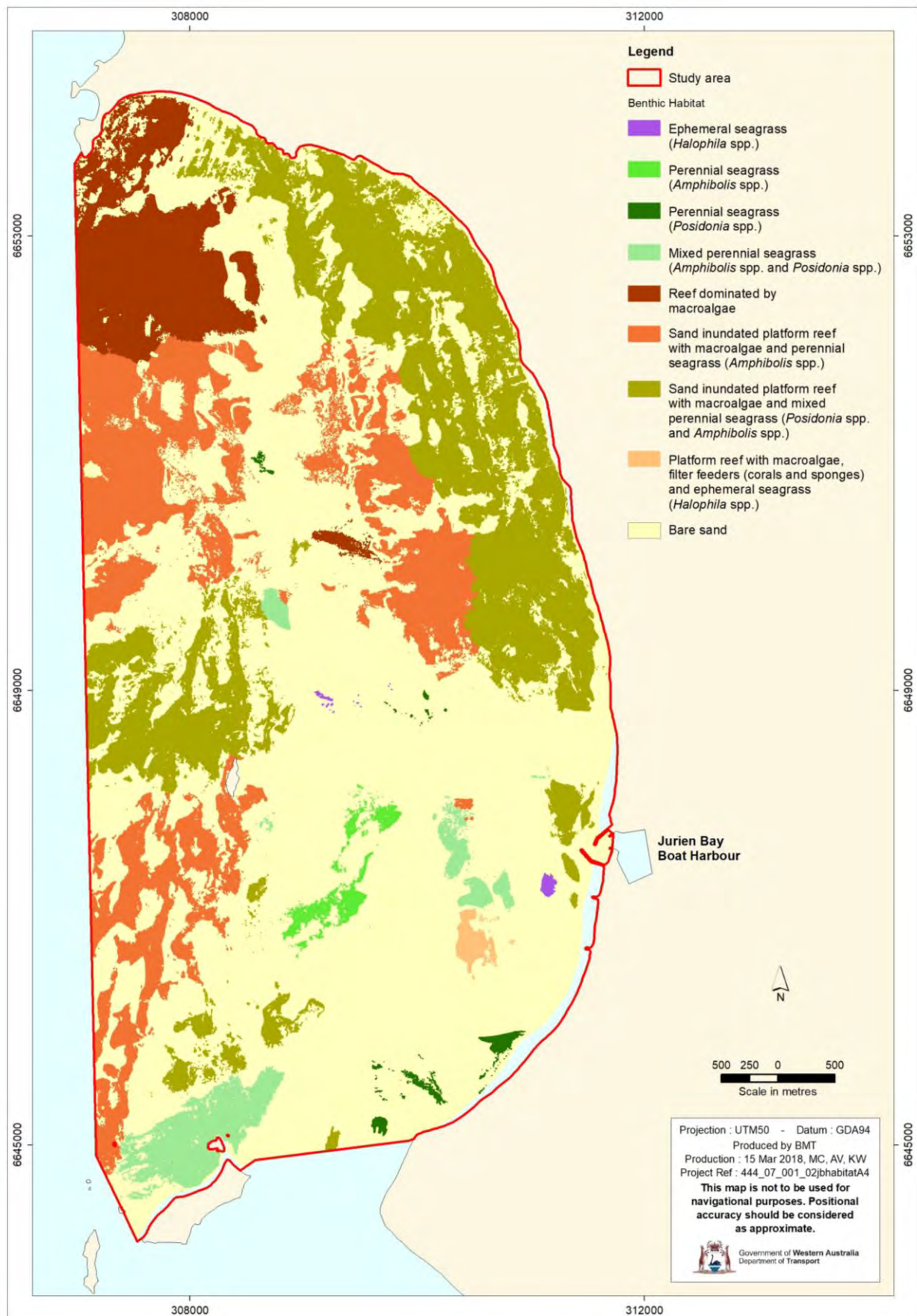


Figure 4.1 Classification of Jurien Bay benthic primary producer habitat extent and distribution

5. Conclusions

Benthic habitats of Jurien Bay were successfully mapped using satellite images and ground truthing data. The survey methods and approaches used to generate the benthic habitat map employed accepted scientific techniques that are repeatable.

Habitats primarily consisted of bare sand, sand inundated platform reef with macroalgae and mixed perennial seagrass (*Posidonia* spp. and *Amphibolis* spp.), sand inundated platform reef with macroalgae and perennial seagrass (*Amphibolis* spp.) and reef dominated by macroalgae. The mapped benthic habitats were representative of known regional and local habitats, and no new BPPH assemblages were observed.

This report and associated mapping products provide a high quality representation of the benthic habitats within the mapping area. All maps are suitable for environmental approvals processes with State and Federal regulatory authorities, and for facilitating future monitoring and management in the region.

6. References

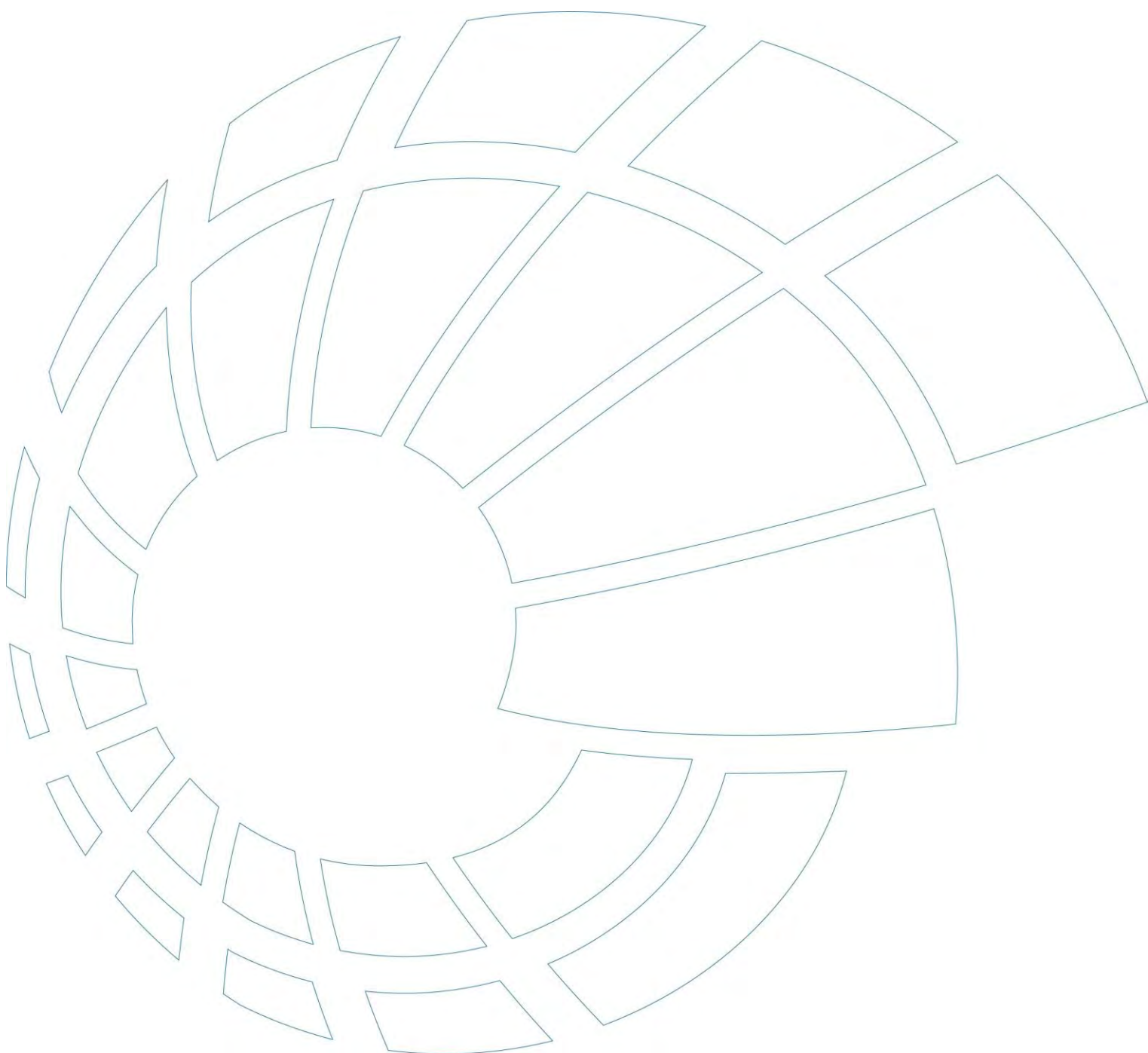
- Atlas of Living Australia (2018) Atlas of Living Australia website. Available at <http://www.ala.org.au> [Accessed 17 January 2018]
- CALM (2005) Jurien Bay Management Plan 2005–2015. Department of Conservation and Land Management, Report No. 49, Perth, Western Australia
- Chua J (2002) Oceanographic Modelling of Jurien Bay, Western Australia. University of Western Australia, Perth, Western Australia
- Congalton RG (1991) A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sensing of Environment* 37:35–46
- Congalton RG (2001) Accuracy assessment and validation of remotely sensed and other spatial information. *International Journal of Wildland Fire* 10:321–8
- Hexagon Geospatial (2016) ERDAS Imagine Classification Supervised Classification. Available at <https://hexagongeospatial.fluidtopics.net/reader/~P7L4c0T_d3pauwS98oGQ/r3McCpL65xdeQ0Mcu5SfzA> [Accessed on 11 October 2017]
- Holloway K (2006) Characterizing the Hydrodynamics of Jurien Bay, Western Australia. University of Western Australia, Perth, Western Australia
- SeaGIS (2013) Transect Measure – single camera biological analysis tool. SeaGIS Pty Ltd, Bacchus Marsh, Victoria, Australia. Available at <http://www.seagis.com.au/transect.html> [Accessed 15 May 2013]

Appendix A

Electronic data

The following data were supplied electronically to Department of Transport for the Jurien Bay mapping project:

- Towed video
- Transect locations and time stamp data
- TransectMeasure classifications – raw data
- Raw satellite imagery (2017)
- Ground truth video overlay
- Mapping products – final BPPH map



Appendix E EPBC Act Protected Matter Search Tool Report – April 2022



EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 25-Apr-2022

[Summary](#)

[Details](#)

[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

[Acknowledgements](#)

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	40
Listed Migratory Species:	44

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at <http://www.environment.gov.au/heritage>

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	66
Whales and Other Cetaceans:	11
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	1
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	1
Key Ecological Features (Marine):	None
Biologically Important Areas:	10
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities

[Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community may occur within area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community may occur within area

Listed Threatened Species

[Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.

Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Zanda latirostris listed as Calyptorhynchus latirostris Carnaby's Black Cockatoo, Short-billed Black-cockatoo [87737]	Endangered	Species or species habitat likely to occur within area
FISH		
Thunnus maccoyii Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
MAMMAL		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat known to occur within area
PLANT		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Eucalyptus argutifolia Yanchep Mallee, Wabling Hill Mallee [24263]	Vulnerable	Species or species habitat may occur within area
Hemiandra gardneri Red Snakebush [7945]	Endangered	Species or species habitat may occur within area
REPTILE		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
SHARK		

Scientific Name	Threatened Category	Presence Text
Carcharias taurus (west coast population)		
Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sphyrna lewini		
Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat likely to occur within area

Listed Migratory Species	[Resource Information]	
Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Diomedea amsterdamensis		
Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea epomophora		
Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Hydroprogne caspia Caspian Tern [808]		Foraging, feeding or related behaviour known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Sternula albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
Eubalaena australis as Balaena glacialis australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area
Mobula alfredi as Manta alfredi Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat known to occur within area
Mobula birostris as Manta birostris Giant Manta Ray [90034]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species	[Resource Information]	
Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Ardenna carneipes as Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hydroprogne caspia as Sterna caspia Caspian Tern [808]		Foraging, feeding or related behaviour known to occur within area
Larus pacificus Pacific Gull [811]		Foraging, feeding or related behaviour known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Phoebastria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Puffinus assimilis Little Shearwater [59363]		Foraging, feeding or related behaviour known to occur within area
Rostratula australis as Rostratula benghalensis (sensu lato) Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Sternula albifrons as Sterna albifrons Little Tern [82849]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thinornis cucullatus as Thinornis rubricollis Hooded Dotterel, Hooded Plover [87735]		Species or species habitat known to occur within area overfly marine area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammal		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat known to occur within area
Reptile		
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and Other Cetaceans		[Resource Information]
Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area

Current Scientific Name	Status	Type of Presence
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves			[Resource Information]
Protected Area Name	Reserve Type	State	
Jurien Bay	Marine Park	WA	

EPBC Act Referrals				[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status	
Not controlled action				
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed	

Biologically Important Areas			
Scientific Name		Behaviour	Presence
Seabirds			
Ardenna pacifica Wedge-tailed Shearwater [84292]		Foraging (in high numbers)	Known to occur
Hydroprogne caspia Caspian Tern [808]		Foraging (provisioning young)	Known to occur
Larus pacificus Pacific Gull [811]		Foraging (in high numbers)	Known to occur

Scientific Name	Behaviour	Presence
Puffinus assimilis tunneyi Little Shearwater [59363]	Foraging (in high numbers)	Known to occur
Sterna dougallii Roseate Tern [817]	Foraging	Known to occur
Sternula nereis Fairy Tern [82949]	Foraging (in high numbers)	Known to occur
Seals		
Neophoca cinerea Australian Sea Lion [22]	Foraging (male and female)	Known to occur
Sharks		
Carcharodon carcharias White Shark [64470]	Foraging	Known to occur
Whales		
Balaenoptera musculus brevipinna Pygmy Blue Whale [81317]	Distribution	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration (north and south)	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [-Office of Environment and Heritage, New South Wales](#)
- [-Department of Environment and Primary Industries, Victoria](#)
- [-Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [-Department of Environment, Water and Natural Resources, South Australia](#)
- [-Department of Land and Resource Management, Northern Territory](#)
- [-Department of Environmental and Heritage Protection, Queensland](#)
- [-Department of Parks and Wildlife, Western Australia](#)
- [-Environment and Planning Directorate, ACT](#)
- [-Birdlife Australia](#)
- [-Australian Bird and Bat Banding Scheme](#)
- [-Australian National Wildlife Collection](#)
- [-Natural history museums of Australia](#)
- [-Museum Victoria](#)
- [-Australian Museum](#)
- [-South Australian Museum](#)
- [-Queensland Museum](#)
- [-Online Zoological Collections of Australian Museums](#)
- [-Queensland Herbarium](#)
- [-National Herbarium of NSW](#)
- [-Royal Botanic Gardens and National Herbarium of Victoria](#)
- [-Tasmanian Herbarium](#)
- [-State Herbarium of South Australia](#)
- [-Northern Territory Herbarium](#)
- [-Western Australian Herbarium](#)
- [-Australian National Herbarium, Canberra](#)
- [-University of New England](#)
- [-Ocean Biogeographic Information System](#)
- [-Australian Government, Department of Defence](#)
- [Forestry Corporation, NSW](#)
- [-Geoscience Australia](#)
- [-CSIRO](#)
- [-Australian Tropical Herbarium, Cairns](#)
- [-eBird Australia](#)
- [-Australian Government – Australian Antarctic Data Centre](#)
- [-Museum and Art Gallery of the Northern Territory](#)
- [-Australian Government National Environmental Science Program](#)
- [-Australian Institute of Marine Science](#)
- [-Reef Life Survey Australia](#)
- [-American Museum of Natural History](#)
- [-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania](#)
- [-Tasmanian Museum and Art Gallery, Hobart, Tasmania](#)
- [-Other groups and individuals](#)

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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Appendix F Jurien Bay Boat Harbour Marine Fauna Log Sheets

Marine fauna observation log (to be completed after any observations of marine fauna within 300 m from the dredge)

Date:		Observer name:		Dredge operator name:	
Were there any marine fauna interactions during this shift?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, how many interaction logs were completed?			
Were any injured or dead marine fauna sighted during this shift?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, was notification provided to BMT?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, was the notification record completed?	<input type="checkbox"/> Yes <input type="checkbox"/> No

Time of observation	Operation in progress during the observation*	Dredge position		Pod information							Weather Conditions				Outcome of observation and management*	<p>*Key</p> <p>Operation in progress during observation: DO = dredge in operation; DNO = dredge not in operation</p> <p>Marine fauna type: W = whale; D = dolphin; P = pinniped; T = turtle; U = unknown; O = other</p> <p>Relative bearing from dredge bow: assume bow of the dredge is 0°</p> <p>Actual swim direction: where the fauna is heading based on true north (e.g. N, S, E, W)</p> <p>Marine fauna condition: N = normal; I = injured; D = dead; U = unknown</p> <p>Waves: 0 = flat to ripples with crest; 1 = small wavelets; 2 = large wavelets; 3 = small waves; 4 = moderate to long waves</p> <p>Visibility: 0 = no visibility; 1 = limited visibility; 2 = visibility ok; 3 = visibility perfect</p> <p>Outcome of observation and management:</p> <p>Scenario 1 = not able to resight marine fauna – suspended dredging until 20 minutes after the last marine fauna was observed in the monitoring zone (within 300 m from the dredge)</p> <p>Scenario 2 = marine fauna moved outside of the monitoring zone (within 300 m from the dredge) – dredging continued afterwards</p> <p>Scenario 3 = dredge moved to another position where a minimum distance of 300 m between the dredge and marine fauna could be maintained – dredging continued afterwards</p> <p>Scenario 4 = other (provide further comments to explain)</p>
		Latitude	Longitude	Marine fauna type*	Number of marine fauna	Relative bearing from dredge bow (°)*	Distance from dredge (m)	Actual swim direction*	Interaction with dredge/equipment (Y/N)	Marine fauna condition*	Wind speed (km/h)	Wind direction	Waves (0–4)*	Visibility (0–3)*		

Notification record (to be completed after any observations or interactions with injured/dead marine fauna)

Date and time of notification:	
Name of person providing the notification:	
Name of BMT person notified:	
Instructions received from BMT:	

Marine fauna interaction log (to be completed after any interaction between marine fauna and dredge or dredge equipment)

Date/time of interaction:		Observer name:		Dredge operator name:	
Location of dredge during interaction:					
Marine fauna type:	<input type="checkbox"/> Whale <input type="checkbox"/> Dolphin <input type="checkbox"/> Pinniped <input type="checkbox"/> Turtle <input type="checkbox"/> Unknown <input type="checkbox"/> Other:				
Marine fauna species/notable features:					
Operation in progress during interaction:	<input type="checkbox"/> Dredge in operation <input type="checkbox"/> Dredge not in operation <input type="checkbox"/> Other:				
Type of interaction:	<input type="checkbox"/> Interaction with dredge <input type="checkbox"/> Interaction with dredge equipment <input type="checkbox"/> Other:				
Detailed comments for type of interaction:					
Outcome of interaction and management:	<input type="checkbox"/> No injury apparent for marine fauna – not able to resight marine fauna – suspended dredging until 20 minutes after the last marine fauna was observed in the monitoring zone (within 300 m from the dredge) <input type="checkbox"/> No injury apparent for marine fauna – marine fauna moved outside of the monitoring zone (within 300 m from the dredge) – dredging continued afterwards <input type="checkbox"/> No injury apparent for marine fauna – dredge moved to another position where a minimum distance of 300 m between the dredge and marine fauna could be maintained – dredging continued afterwards <input type="checkbox"/> Injured marine fauna – suspended dredging and notified BMT of the injured marine fauna <input type="checkbox"/> Dead marine fauna – suspended dredging and notified BMT of the dead marine fauna <input type="checkbox"/> Other (provide further comments to explain):				
Detailed comments for outcome of interaction and management:					

Appendix G Jurien Bay Boat Harbour Plume Sketch Template

DREDGE AREA

OBSERVATIONS (within the past 24 hours)

- Y N N/A
- Evidence of excessive algal growth? ☐ ☐ ☐
 - Evidence of oil or other films on water surface? ☐ ☐ ☐
 - Evidence of litter or other debris in water? ☐ ☐ ☐
 - Observations of marine fauna within 300m from dredge while operating (if yes, marine fauna observation log to be completed)? ☐ ☐ ☐
 - Interaction (e.g. collision) with marine fauna and dredge while operating (if yes, marine fauna interaction log to be completed)? ☐ ☐ ☐

(Note that "marine fauna" includes whales, dolphins, pinnipeds and turtles).

(Photos to be taken of any items reported)

Notes & Comments:

DREDGE AREA**Maintenance Dredging Plume Sketch**
Use Black Felt Tip Pen

Date:

Time:

Observer Name:

Dredge Operator Name:

Y N N/A

Dredging Area Plume Sketched ☐ ☐ ☐

Dredging Area Photo(s) Taken ☐ ☐ ☐

Draw Wind Direction (From):



WIND SPEED (kn) WAVE

- | | | |
|---------|----------------------------|--------------------------|
| <1 - 2 | Flat - Ripples with Crests | <input type="checkbox"/> |
| 3 - 6 | Small Wavelets | <input type="checkbox"/> |
| 7 - 10 | Large Wavelets | <input type="checkbox"/> |
| 11 - 15 | Small Waves | <input type="checkbox"/> |
| 16 - 26 | Moderate to Long Waves | <input type="checkbox"/> |

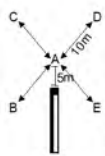
TIDE High ☐ Mid ☐ Low ☐

Flood ☐ Slack ☐ Ebb ☐

Notes & Comments:

DISPOSAL PIPELINE OUTLET

	Latitude	Longitude	Dip	Tide	RL
A					
B					
C					
D					
E					

**DISPOSAL AREA**

OBSERVATIONS (within the past 24 hours)

- Y N N/A
- Evidence of excessive algal growth? ☐ ☐ ☐
 - Evidence of oil or other films on water surface? ☐ ☐ ☐
 - Evidence of litter or other debris in water? ☐ ☐ ☐
- (Photos to be taken of any items reported)

Notes & Comments:

DISPOSAL AREA**Maintenance Dredging Plume Sketch**
Use Black Felt Tip Pen

Date:

Time:

Observer Name:

Dredge Operator Name:

Y N N/A

Disposal Area Plume Sketched ☐ ☐ ☐

Disposal Area Photo(s) Taken ☐ ☐ ☐

Draw Wind Direction (From):



WIND SPEED (kn) WAVE

- | | | |
|---------|----------------------------|--------------------------|
| <1 - 2 | Flat - Ripples with Crests | <input type="checkbox"/> |
| 3 - 6 | Small Wavelets | <input type="checkbox"/> |
| 7 - 10 | Large Wavelets | <input type="checkbox"/> |
| 11 - 15 | Small Waves | <input type="checkbox"/> |
| 16 - 26 | Moderate to Long Waves | <input type="checkbox"/> |

TIDE High ☐ Mid ☐ Low ☐

Flood ☐ Slack ☐ Ebb ☐

Notes & Comments:

Legend

- Navigation Marker
- Disposal Area
- Dredge Area

Projection : UTM50 - Datum : GDA94

Produced by BMT

Production : 01 Dec 2020, MeC, AV, PK

Imagery : Landgate Nov 2019

Project Ref : 179_01_002_01_tempjbaportA4

This map is not to be used for navigational purposes. Positional accuracy should be considered as approximate.

Government of Western Australia
Department of Transport

**Appendix H Jurien Bay Boat Harbour Weekly Environmental
Checklist Template**



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BMT Western Australia Pty Ltd
ACN: 093 752 811

DRAFT TEMPLATE

WEEKLY ENVIRONMENTAL MONITORING 20XX JURIE BAY BOAT HARBOUR MAINTENANCE DREDGING CAMPAIGN – WEEK #X

Environmental monitoring of the 20XX Jurie Bay Boat Harbour maintenance dredging campaign between XX–XX MONTH 20XX is to be in accordance with the associated Dredging Environmental Management Plan (BMT 2019). See table and comments below for results of the required environmental monitoring tasks.

Environmental Monitoring Checklist

Monitoring task	Monday (DD/MM/YY)		Tuesday (DD/MM/YY)		Wednesday (DD/MM/YY)		Thursday (DD/MM/YY)		Friday (DD/MM/YY)		Saturday (DD/MM/YY)	
	Received?	Correct?	Received?	Correct?	Received?	Correct?	Received?	Correct?	Received?	Correct?	Received?	Correct?
Plume sketch												
Remote imagery (Boat Harbour)												
Remote imagery (dredge vessel)												
Site photograph (disposal area)												
Marine mammal observation log												
Dredge track log												

Notes:

1. Red text indicates a non-conformance with conditions outlined in the DEMP (BMT 2019)
2. Red italicised text indicates partial non-conformance with conditions outlined in the DEMP (BMT 2019)

3. Black bold text indicates that data was collected but not yet provided and/or no data was collected for a valid reason e.g. non-operational machinery, poor weather

Relevant Nautilus link(s):

Comments on environmental monitoring non-conformances:

Comments on other environmental issues (i.e. results from light loggers, water quality monitoring, aerial imagery, public complaints register):

Environmental monitoring data still to be received:

Reference

BMT (2019) Jurien Bay Boat Harbour Maintenance Dredging Long Term Monitoring and Management Plan. Prepared for Department of Transport by BMT Western Australia Pty Ltd, Report No. R-1454_01-3/Rev0, Perth, Western Australia, July 2019

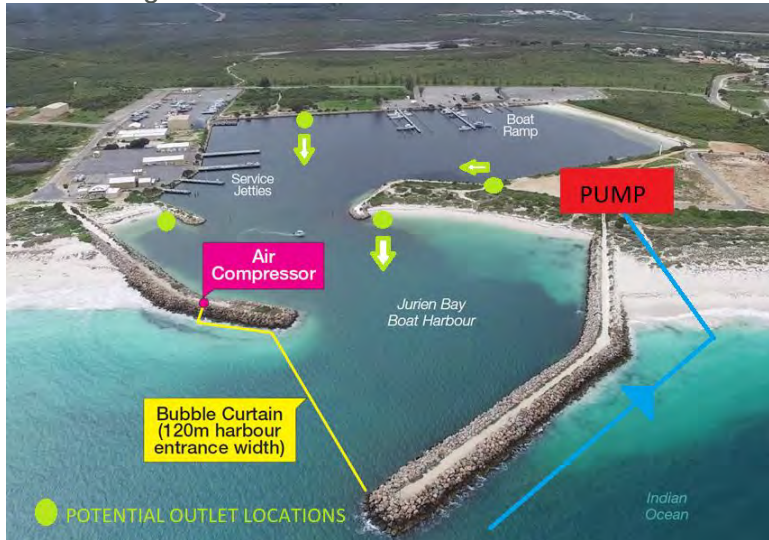
Appendix I Summary of Stakeholder Consultation

Date	Stakeholder type	Stakeholder comment	DoT comment
20/08/2019	Resident	<p>In todays business world all projects revolve around MONEY. This ongoing contamination issue within Jurien marina has cost the tax payer an enormous amount of money, while the problem continues year after year. In short, an extremely expensive band aid. Another reason dredging may not be the wisest idea is that any natural depressions in the marine environment may well be there for a reason, and messing with nature may well come back and bite you on the rear end, and then we are back into the money outlay - again! Not to mention the scourge of any government - the Green "people".</p> <p>And still the marina problem exists.</p> <p>Surely the most positive solution to the problem has to be one that is effective, permanent and cost effective. This would be to either protect the current entrance from the W/NW weather by a means to be determined by people smarter than me, or to completely alter access to the marina by way of a W/SW orientated entrance. Either way the solution is final, as is the money outlay.</p>	<p>The comment received does not relate to offshore disposal of dredged material. Long-term planning and/or engineering solutions for the future of Jurien Bay Boat Harbour is beyond the scope of this report and stakeholder consultation process.</p> <p>DoT notes that sediments tested in both 2014 and 2019 are not contaminated and are suitable for unconfined offshore disposal under the NAGD (CA 2009) framework.</p>
23/08/2019	Resident	<p>Thanks for the opportunity to comment on this problem . Perhaps now it is a good time to stand back and assess design and cost for future management of this infrastructure, a forward twenty year plan might be a good plan .</p> <p>The current design is best suited to a stable shoreline and perhaps because it's initial cost ,was given approval for its</p>	<p>The comment received does not relate to offshore disposal of dredged material. Long-term planning and/or engineering solutions for the future of Jurien Bay Boat Harbour is beyond the scope of this report and stakeholder consultation process</p>

Date	Stakeholder type	Stakeholder comment	DoT comment
		<p>construction, but without delving back in historical evidence , the first jetty built is some distance inland now.</p> <p>This dynamic ,has of recent times , accelerated , causing the problem of silting in the marina . This can be attributed to the rapid erosion of the south point of Jurien Bay . This erosion , driven by the predominant prevailing wind , the southerly , has caused the distance between the point and Long Island to get greater and so the volume of water driven by the wind carries greater volumes of sand into the bay which is evidenced by beach accretion and problems in the marina .</p> <p>Solutions may involve a groin at the point to arrest the water flow or looking further ahead , designing a marina , using the current groins , to establish the marina in the ocean with a bridge for access so that foreshore dynamics could occur naturally without ending up in an inland marina like now .</p> <p>No cheap option seems likely but I believe good engineering and cost benefit analysis could have a good chance for long term success . Otherwise continual costs will make expenses blow out to mind blowing numbers in the current situation.</p>	
24/08/2019	Pen Holder Resident	Being a keen surfer, amateur fisherman, scuba diver & generally interested in all things related to the ocean & foreshore, I am surprised there is not a plan in place to fix the seaweed build up problem!	Long-term planning and/or engineering solutions for the future of Jurien Bay Boat Harbour is beyond the scope of this report and stakeholder consultation process

Date	Stakeholder type	Stakeholder comment	DoT comment
		<p>My visual observations over the past 7 years tell me the bay flushes from north to south, this is evident by the build-up of beach wrack on the north side of the marina breakwater & a clean wrack free beach on the south side.</p> <p>Extension of the north breakwater wall will prevent the sea grass/weed from entering the marina after a storm or large swell event.</p> <p>My comments are not meant to offend anyone or discredit any studies undertaken but I feel there is no substitution for practical experience & observation.</p> <p>Conversations with local professional fishermen seem to back my assessment of the seaweed issue.</p> <p>Dumping the dredging spoil back into the ocean is not a good idea, fix the problem & you most likely won't need to dredge.</p>	<p>Offshore disposal has been identified and assessed as the most ecologically sustainable solution for disposal of dredged material at Jurien Bay. Capital works to prevent further incursion of sand and wrack into the harbour will not remove the requirement to dredge in the short-medium term.</p>
24/08/2018	MAG member Resident	<p>As a long time advocate of the Jurien Bay Marine Park, me being the diving supervisor for the initial CALM benthic survey of the Marine Park in the 1990's and then a member of the JBMP consultative committee that established the Marine Park afterwards, I see no impediment with placing dredge spoil from the Jurien Marina into the natural depression just offshore. Having dived that area I have found nothing of significance on the seabed there.</p> <p>I believe that decreasing the depth of water in the depression it will reduce the cost of a groyne that will</p>	<p>DoT appreciates the support for proposed offshore placement of dredged material.</p>

Date	Stakeholder type	Stakeholder comment	DoT comment
		eventually be installed to protect the entrance of the Jurien Marina.	
27/08/2019	Resident	<p>I admit I am not an engineer and can't back this suggestion with scientific evidence but why not pump water into the marina to create an outflow of water and material that would prevent the build up.</p> <p>The principal is similar to the bubble curtain. Create eddies and currents that prevent the seagrass from entering the marina. By pumping water into the marina, oxygen levels would increase and overall health would be improved. Just like a fish tank, by circulating the water, the tank remains healthy. The benefit of this is by pumping sufficient quantities of water into the marina, there would be an outflow through the mouth.</p> <p>When water is flowing out through the mouth it would seem to prevent seagrass and weed from flowing inward.</p> <p>It is a simple suggestion and there would need to be a fair bit of scientific research to assess viability. As with the bubble curtain there would need to be several trial locations for the outlet, to ensure effective outflow. Ideally the outlet would be in the back of the marina to maximise the outflow potential, however erosion and deposits of sand will need to be considered through some sort of initial modelling to investigate this.</p> <p>Consideration would need to be given to the swimming areas and the impact currents would have on these. There</p>	<p>The comment received does not relate to offshore disposal of dredged material.</p> <p>Pumping of water into the Boat Harbour has been previously assessed by DoT as a solution to reduced dissolved oxygen levels, however; proved economically un-viable. Bubble curtain trials proved ineffective at preventing wrack from entering the Boat Harbour.</p> <p>Long-term planning for the future of Jurien Bay Boat Harbour is beyond the scope of this report and stakeholder consultation process.</p>

Date	Stakeholder type	Stakeholder comment	DoT comment
		<p>would be the potential to only run the pumps overnight or during storms so currents would not impact the swimming and boating activities</p> 	
02/04/2019	Department of Water and Environmental Regulation (DWER) mid-west Gascoyne office	<p>Thank you for the opportunity to comment on the dredging operation at Jurien Bay Boat Harbour. The Mid West Gascoyne office will not be providing a response direct to Department of Transport, feedback and comments will be directed through the departments head office.</p>	<p>DoT has provided project information to the DWER EPA Services Division on 02/08/2019 and no reply has been received to date (04/09/2019)</p>



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