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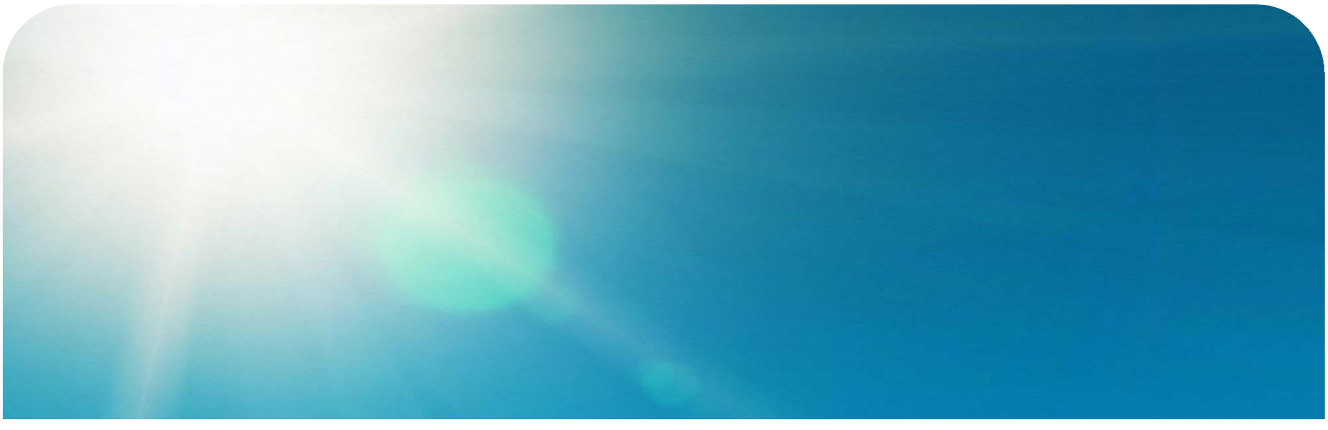
Appendix 8.3 – Sediment Sampling and Analysis Plan Implementation Report



Potential Dredging and Spoil Disposal - Sediment Sampling and Analysis Plan Implementation Report

AAP01-000-GEG-GGEN-00002

Document revision history and tracking

Document Revision

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A	For Review	11-Nov-2022	Ian Irvine	Marine Offshore Disposal Specialist
B	For Review	17-Nov-2022	Ian Irvine	Marine Offshore Disposal Specialist
C	For Use	18-Nov-2022	Ian Irvine	Marine Offshore Disposal Specialist

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Rev	Date	Description	Prepared by

Contents

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List of Abbreviations and Units

Abbreviations	Definition
Ag	Silver
Al	Aluminium
ANZECC	Australia and New Zealand Environment and Conservation Council
ANZG, 2018	Australian and New Zealand Water Quality Guidelines
AVS: SEM	Acid-volatile sulphide and simultaneously extracted metals
As	Arsenic
BaP	Benzo(a)pyrene, a carcinogenic PAH
BDL	Below Detection Limit
BHD	Backhoe Dredge
BTEX	Benzene, toluene, ethylbenzene, and xylenes
BTEXN	Benzene, toluene, ethylbenzene, xylenes, and naphthalene
Cd	Cadmium
Co	Cobalt
COC	Chain-of-Custody
CoC	Contaminant of Concern
COPC	Contaminant of Potential Concern
Cu	Copper
Cr6+	Hexavalent chromium
CRM	Certified Reference Material, i.e., a standard sample of certified composition
CSM	Conceptual site model
DAWE	Commonwealth Department of Agriculture, Water, and the Environment
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DGV	Default Sediment Quality Guideline Value (ANZG, 2018) = NAGD Screening Level
DoL	Depth of Lowering
DQI	Data Quality Indicator
DQO	Data Quality Objective
EEZ	Exclusive Economic Zone
EMP	Environmental Management Plan
NT EPA	NT Environmental Protection Authority
Fe	Iron
FID	Flame ionisation detector
GC	Gas chromatography

Abbreviations	Definition
GCMS	Gas Chromatograph - Mass Spectrometer
GV-High	ANZG (2018) Sediment Quality High Value = NAGD High Value
Guardian	Guardian Geomatics Pty Ltd
Hg	Mercury
ICP	Inductively Coupled Plasma
Investigation Area	The area that is being studied in this investigation
KP	Kilometre point, measured from the cable landing site at Murrumujuk
LOR	Limit of Reporting (also, Practical Quantitation Limit, PQL)
m	Metre
mm	millimetre
mg/kg	Milligram per kilogram (ppm)_
µg/kg	microgram per kilogram (ppm)
mg/L	milligram per litre
µg/L	microgram per litre
Mn	Manganese
MS	Mass Spectrometry
NAGD	National Assessment Guidelines for Dredging, 2009
NATA	National Association of Testing Authorities
Ni	Nickel
NMRL	Non-mobile Reference Level
OCP	Organochlorine Pesticides
OPP	Organophosphorus Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCB	Polychlorinated Biphenyls
ppb	Part per billion
ppm	Part per million
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit (also, LOR)
PR	Pollution Research Pty Ltd
Proponent, the	Australia-Asia PowerLink
PSD	Particle Size Distribution
QA/QC	Quality Assurance and Quality Control
RPD	Relative Percentage Difference

Abbreviations	Definition
ROV	Remotely Operated Vehicle
RPL	Route Position List
RSD	Relative Standard Deviation
SAP	Sampling and Analysis Plan
SAPIR	Sampling and Analysis Plan Implementation Report
SAQP	Sampling, Analysis and Quality Plan
Sb	Antimony
SDP	Sea Dumping Permit
Se	Selenium
SG	Spoil Ground
SOP	Standard Operating Procedure
SQGV	Sediment Quality Guideline Value = NAGD Screening Level = ANZG (2018) Default Value (DGV)
SRN	Sample Receipt Notice
SSC	Suspended Sediment Concentration
TBT	Tributyltin Oxide
TOC	Total organic carbon
TPH/TRH	Total petroleum hydrocarbons, now called total recoverable hydrocarbons
TSHD	Trailing Suction Hopper Dredge
UCL/95% UCL	Upper Confidence Limit/Upper 95% Confidence Limit of the Mean
USEPA	United States Environmental Protection Agency
V	Vanadium
WOE	Weight-of-evidence
WQO	Water Quality Objective
Zn	Zinc

1 Introduction and Background

1.1 Introduction

This Sampling and Analysis Plan Implementation Report (SAPIR) sets out the findings of a Sampling and Analysis Plan (SAP) implemented by the Proponent within the NT's Coastal Waters, as per the requirements of the National Assessment Guidelines for Dredging, 2009 (NAGD).

The Proponent is looking to obtain sea disposal permits for the removal of sand waves from the Subsea Cable System during marine cable installation works for Australia-Asia PowerLink (AAPowerLink; the Project) set to occur during the implementation phase.

Pre-Installation works that require removal of sand waves, loading of spoil into the marine vessel, and subsequent disposal will require sea dumping approval. These works are:

1. Potential use of a trailing suction hopper dredge (TSHD) to reduce sand waves on the seabed, or to reduce the slope of inclines.
2. Subtidal cable landfall works carried out by dredging.

The requirements for a sea dumping permit within the Commonwealth Marine Area are set out in the *Environment Protection (Sea Dumping) Act 1981* (Cwth) (Sea Dumping Act), which applies in all Australian waters, and to all Australian vessels and Australian aircraft, anywhere at sea. "Australian waters" includes any waters on the landward side of the Exclusive Economic Zone (EEZ), or the Continental Shelf of Australia where it extends beyond the EEZ, except areas determined to be Internal Waters of a state or territory.

The Sea Dumping Act implements Australia's obligations under the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (the London Protocol). The London Protocol entered into force for its parties in 2006. The National Assessment Guidelines for Dredging 2009 (NAGD) sets out the regulatory framework for the loading and offshore disposal of spoil material.

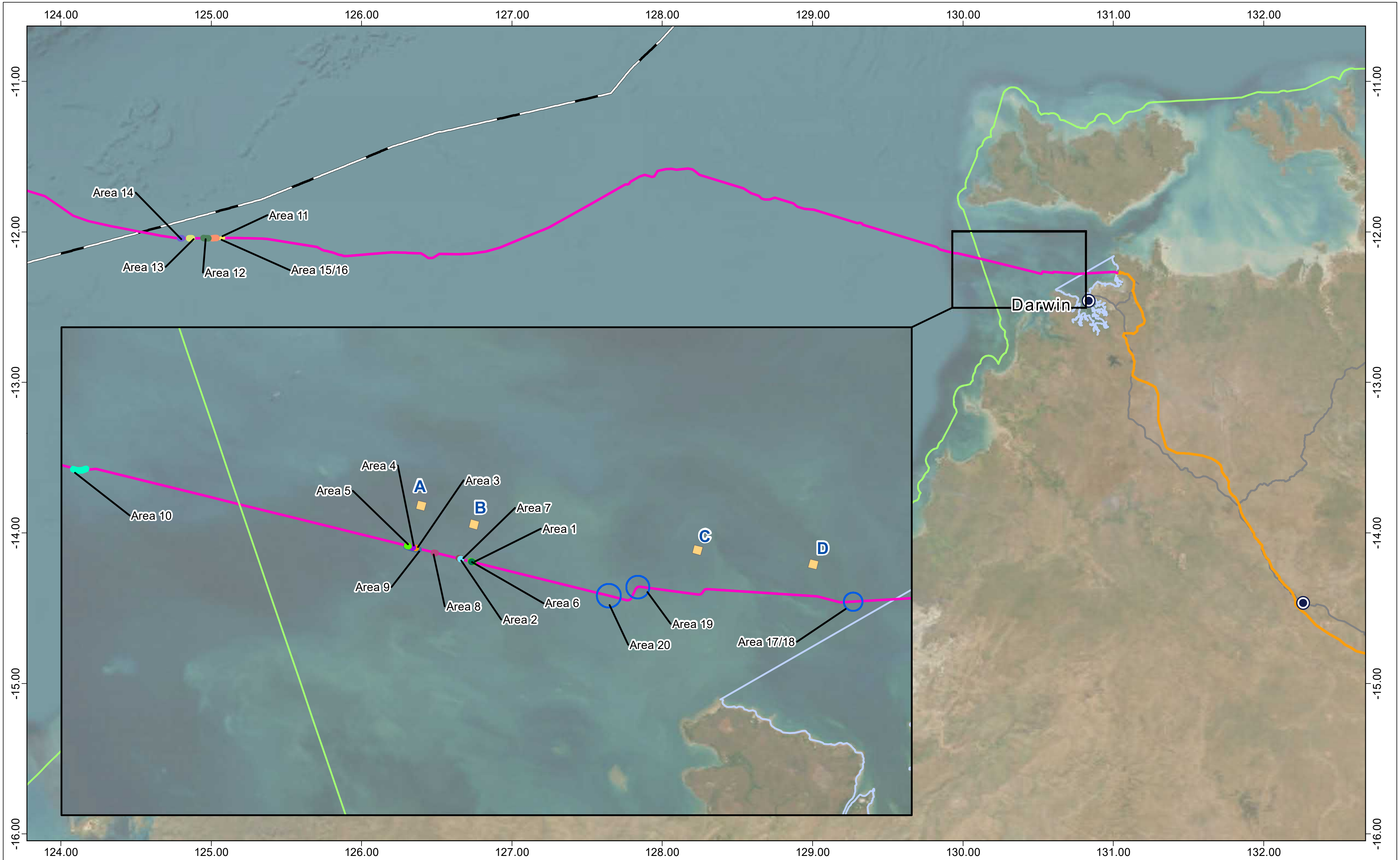
Sea dumping permits for activities in Australian waters are issued by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW), formerly DAWE. For activities in internal waters of the NT, permits are issued by the NT EPA.

The initial step in the application process is preparation of a Draft Sampling and Analysis Plan (SAP), according to NAGD 2009 requirements, to determine the chemical and physical characteristics of the marine sediment that is proposed to be removed at each of the sand waves and subtidal sites. The Proponent met with DAWE and NTEPA in May 2022 to determine their requirements for the SAP process. The SAP, prepared for dredging activities proposed to take place within the NT's Coastal Waters, was finalised in August 2022 and was implemented by Guardian Geomatics Pty Ltd (Guardian) during a survey cruise in August-September 2022. The SAP is included as Appendix 1 to this document.

Sand waves that may require dredging occur at several locations along the 740 km of the Subsea Cable System Corridor in Australian waters, from landfall at Murrumujuk to the edge of the Australian EEZ (refer to Figure 1-1). Sixteen potential dredging sites were previously identified within the Australian EEZ and NT Coastal Waters, though only Sites 1 to 5 were located within the NT's Coastal Waters (demarcated by black line on Figure 1-1) and included in the SAP. The remaining sites were located within the Australian EEZ and were not sampled as they were outside the scope of this investigation. The five locations investigated were identified from a survey to inform the Project, undertaken in 2020.

Four further sand wave sites (Sites 17-20) that may require dredging were identified and investigated during the August-September 2022 Murrumujuk survey (Figure 1-1). Other locations may be identified in subsequent surveys prior to planned installation of the cables during the implementation phase. Four potential dredge spoil disposal grounds were identified (Figure 1-1) and also investigated during the survey.

Pollution Research Pty Ltd (PR) was commissioned to prepare a Draft SAP (Appendix 1) to document the proposed sampling and analysis work for dredging and spoil disposal in NT Coastal Waters, to be carried out in August-September 2022 as part of a Subsea Cable survey (refer to Figure 1-2). The field sampling was undertaken by Guardian in August-September 2022.



Legend

- Subsea Cable System
- Land Based AAPowerlink Infrastructure
- Exclusive Economic Zone
- Coastal Waters (State and Northern Territory Powers) Act 1980
- Darwin harbour boundary
- Potential Spoil Disposal Grounds

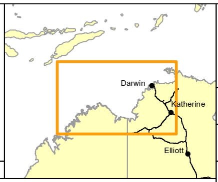


Figure 1: Australian Subsea Cable System Route, showing all identified sandwave locations and potential spoil disposal grounds

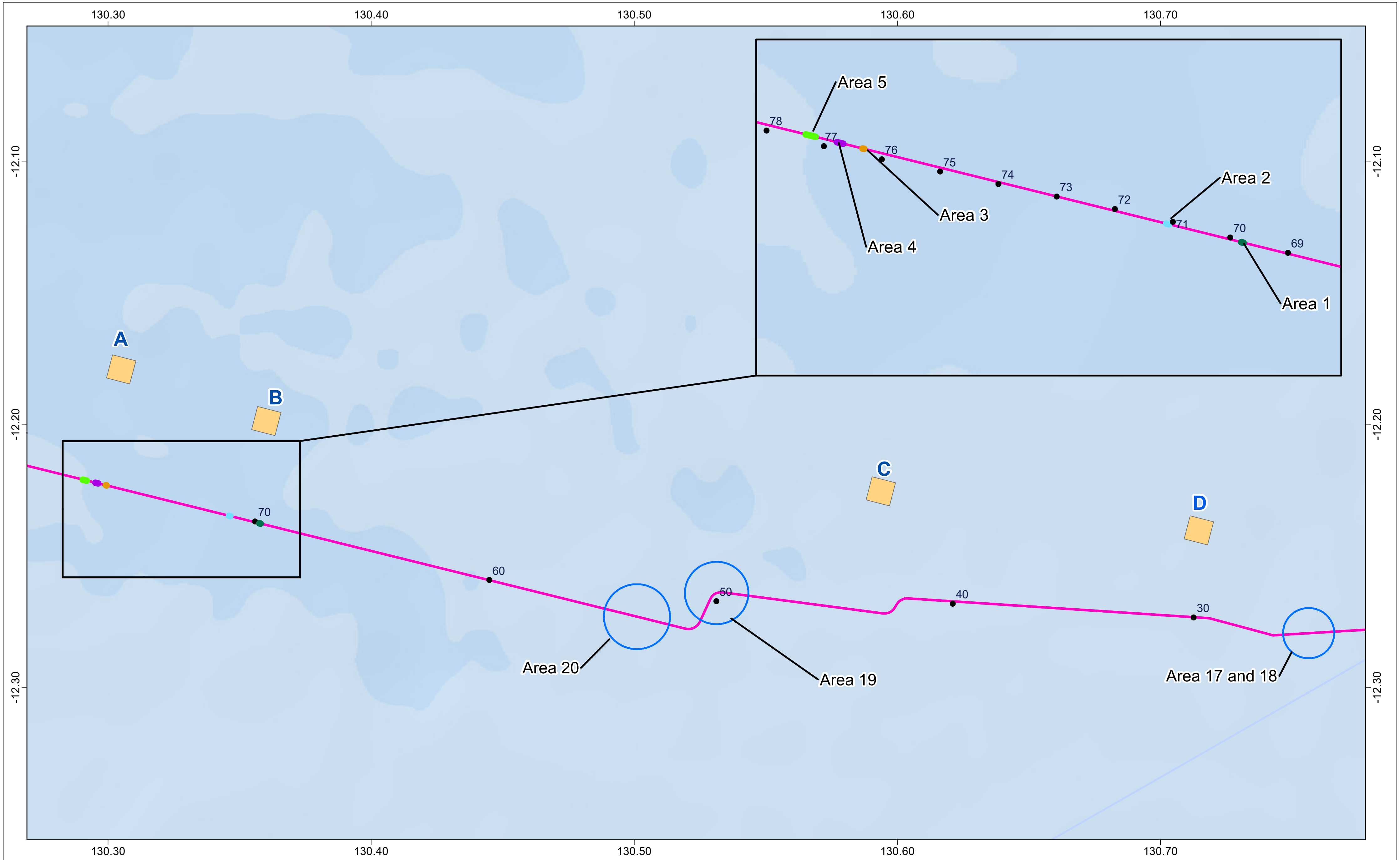
Project: Australia-Asia PowerLink	Reference #: AAPL_GNR_CTA_GEN_MAP_0450	Figure: 1 of 1	Revision: A
Coordinate System: GDA 2020	Datum: GDA 2020	Date: 18/11/2022	

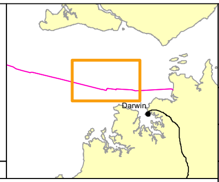
0 50 100 150 Kilometres

Scale: 1:3,500,000 A4

N

Source: NTG data - Cadastre and roads. Imagery: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community





Legend

- Kilometre Points
- Subsea Cable System
- Potential Spoil Disposal Grounds
- Sandwave Area

Sandwave

- Area 1
- Area 2
- Area 3
- Area 4
- Area 5

Source: NTG data - Cadastre and roads. Imagery: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 2: Subsea Cable System Murrumujuk Survey route showing the sandwave areas and potential spoil grounds in NT coastal waters

Project: Australia-Asia PowerLink	Reference #: AAPL_GNR_CTA_GEN_MAP_0451	Figure: 1 of 1	Revision: A
Coordinate System: GDA 2020	Datum: GDA 2020	Date: 18/11/2022	
0 2 4 6 8 Kilometres	Scale: 1:200,000	A4	

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1.2 Purpose of the Investigation

The purpose of the SAP was to:

1. Determine the physical, chemical, and biological characteristics of the sediment to be dredged from the nine sand wave areas.
2. Determine the physical, chemical, and biological characteristics of the sediment at the four potential spoil disposal grounds, to determine the suitability of these sites for unconfined sea disposal of spoil from the sand wave areas.

The purpose of this SAPIR is to:

3. Summarise the work carried out during the survey cruise and laboratory analysis of the samples obtained.
4. Assess, using the guidelines set out in the NAGD, the suitability of sand wave dredge spoil for unconfined marine disposal.
5. Assess, using the guidelines set out in the NAGD and input from other specialist consultants, the suitability of the potential disposal sites for unconfined disposal of spoil from the sand wave areas.

1.3 Scope of the Report

This SAPIR:

- Presents the methods used for sampling, analysis, and quality assurance and quality control (QA/QC), including any problems encountered or deviations from the procedures set out in the SAP.
- Presents the results of physical and chemical analysis of the sand wave areas and spoil disposal ground sediment samples.
- Carries out a QA/QC assessment of the field and laboratory data, comparison to the pre-set data quality indicators (DQIs), and data validation.
- Reviews and summarises the results obtained, assesses the data in accordance with NAGD assessment guidelines and reaches conclusions as to the acceptability of the spoil for marine disposal, and the suitability of potential disposal sites.

1.4 Limitations

This SAPIR was prepared by PR for the Proponent, solely for the purposes set out in Section 1. Reliance of other parties on this report is subject to agreement in writing by PR.

PR otherwise disclaims responsibility to any person other than the Proponent arising in connection with this SAPIR. PR also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by PR in connection with preparing this SAPIR were limited to those specifically detailed in the SAPIR and are subject to the scope limitations set out in the SAPIR.

The opinions, conclusions and any recommendations in this SAPIR are based on conditions encountered and information reviewed at the date of preparation of the report. PR has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the SAPIR was prepared.

2 Dredging and Disposal Investigation Areas

2.1 Location, Description and Volume of Proposed Dredging Works

The Proponent is proposing a HVDC submarine power cable configuration of a 525 kV XLPE bipole with metallic return. There will be three cables (i.e., pole 1, pole 2 and the metallic return). A route length of approximately 740 km has been assessed for the Project in Australian waters from landfall at Murrumujuk to the boundary of the EEZ. The route is shown on Figure 1-1 in Section 1.1 above, and the nine sand wave areas that were investigated in the current study. Sand wave Areas 1-5 had been identified previously in 2020. Sand wave Areas 17-20 were identified during the August-September 2022 survey.

2.1.1 Cable Burial

The depth of lowering cable for sea installation will vary from 0.5 – 3 m below the seabed and is dependent on the outcome of the final Marine Cable Burial Risk Assessment (CONFIDENTIAL Appendix 8.1 to the Supplement to Environmental Impact Statement (SEIS)). It is envisaged that a variety of installation techniques may be required due to the variable nature of the seabed along the marine cable route.

For the purposes of this SAPIR, cable burial using techniques such as ploughing, jet trenching and mass flow excavator are the most relevant installation technique to consider (Figure 2-1). These techniques may be used where the seabed is comprised of soft sand. Where the seabed is harder sediments, clays, limestone, and the like, alternative burial techniques such as mechanical trenching, as well as rock placement, application of concrete mattresses or installation of cast iron shells, may be required.

A study conducted for the cable burial in Australian waters, taking anthropogenic factors and sediment/seabed conditions into account, recommended a 0.6 m burial depth, where sediment burial is the chosen method. This depth is in relation to and sits below the non-mobile reference level (NMRL) or constant depth level, which can be determined by analysing the geotechnical specifications and morphology of the seabed. If seabed features such as bed waves or sand waves exist, pre-sweeping activities such as dredging are required to smooth out the slopes for cable burial machines such as trenchers to pass over, and in some cases, to avoid free spans of the cable.

Since micro-routing had not taken place at the time of this study, only the seabed along the common Route Position List (RPL) has been analysed. The three-cable system may be bundled or single laid, meaning there may be several pre-sweeping campaigns at the time of installation, however for this study it is assumed that pole 1 and the metallic return will be laid bundled, and subsequently pole 2 will be single laid. This means that the dredging volumes and areas computed may need to be multiplied as required.

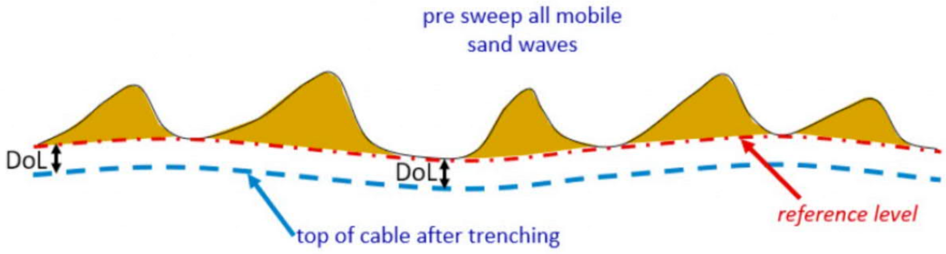

Figure 2-1: NMRL levels and sand waves, DoL (depth of lowering)

2.1.2 Dredging Level and Pre-Sweeping Methodology

To bury the cable adequately, a trenching tool may be used. The trencher can only be operated on slopes that do not exceed 12 – 15°. If seabed irregularities exist such as sand waves, they will need to be pre-swept. As sand waves tend to be mobile, their peaks and troughs move with time. This study utilises a single survey dataset available for this area and therefore, at the time of writing this report, it is impossible to determine migration rates of the bed forms and thus difficult to determine an NMRL that can be used for cable installation in 2025. Additional surveys by the Marine Contractor will seek to obtain more survey data prior to detailed micro-routeing and installation of the cable.

Pre-sweeping is typically done using a Trailing Suction Hopper Dredger (TSHD). Depending on the size of the vessel, the dredge head is a few metres wide. With each passage through the dredging area, depending on seabed conditions, it will dredge a slice of a few tens of centimetres – presenting a box cut from a cross-sectional viewpoint as shown in Figure 2-2. The process is repeated various times until the required dredging depth is needed.

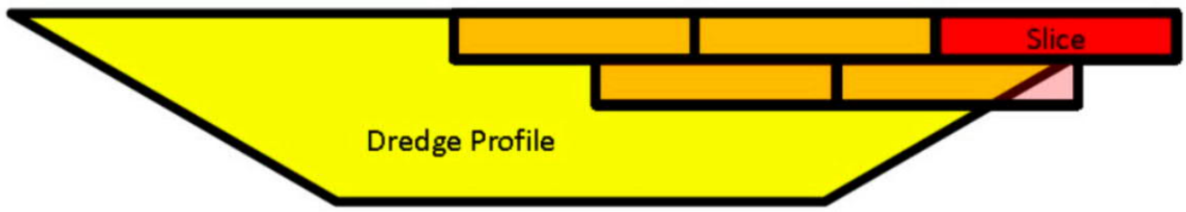

Figure 2-2: Dredge profile

2.1.3 Dredge Profile Dimensions and Dredging Volume Calculations

The dimensions assumed are a first estimate and will need to be optimised with the contractor's input. The bottom width of the trench is set at 14 m, i.e., 7 m to each side of the centre line. This is wide enough to lay the cable and allow the passage of a trencher including all tolerances. The gradient side slopes in sandy seabeds are typically 1:4. The depth of the trench is dependent on the local NMRL level, and with the parameters above, the theoretical net dredging volume can be calculated. The top width of the trench varies but will be approximately 30 m.

The calculated dredging volume for two lines is 264,932 m^3 (see Tables Table 2-1 and Table 2-2 for details).

Over-depth and Vertical Tolerances

Dredging is not a very precise operation. The drag head is large and heavy, the ship is in constant movement and the dredging process itself is sediment dependent. In practice, an over-depth will have to be dredged to realise a minimal pre-sweep profile. To ensure an adequate cable depth can be realised, over-depth can compensate for natural infilling over time, and therefore avoid maintenance between initial dredging and cable installation.

Additionally, technical tolerances must be accounted for, and have been given a 0.5 m tolerance for this study. An additional 0.5 m for over-depth results in a 1 m vertical tolerance as seen in Figure 2-3 below.

It should be noted that the seabed will change over time, meaning it will be different when pre-sweeping starts. Therefore, this study will be updated with more recent bathymetric survey data and contractor input.

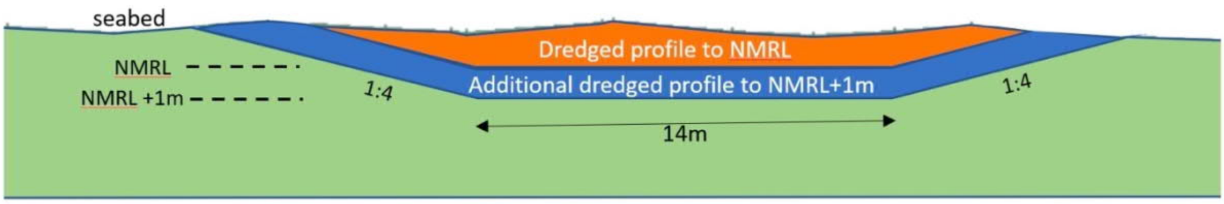

Figure 2-3: Dredge profile including tolerances

A typical calculation of the Non-mobile Reference Level (NMRL) can be seen in Figure 2-4 below, the blue line depicting the seabed level and the red line indicates the NMRL in this area. Noting the NMRL passing below the irregular features on the seabed, the volume of dredging is simply the area between the red and blue lines, accounting for tolerances, and multiplying it by the cross-sectional area.

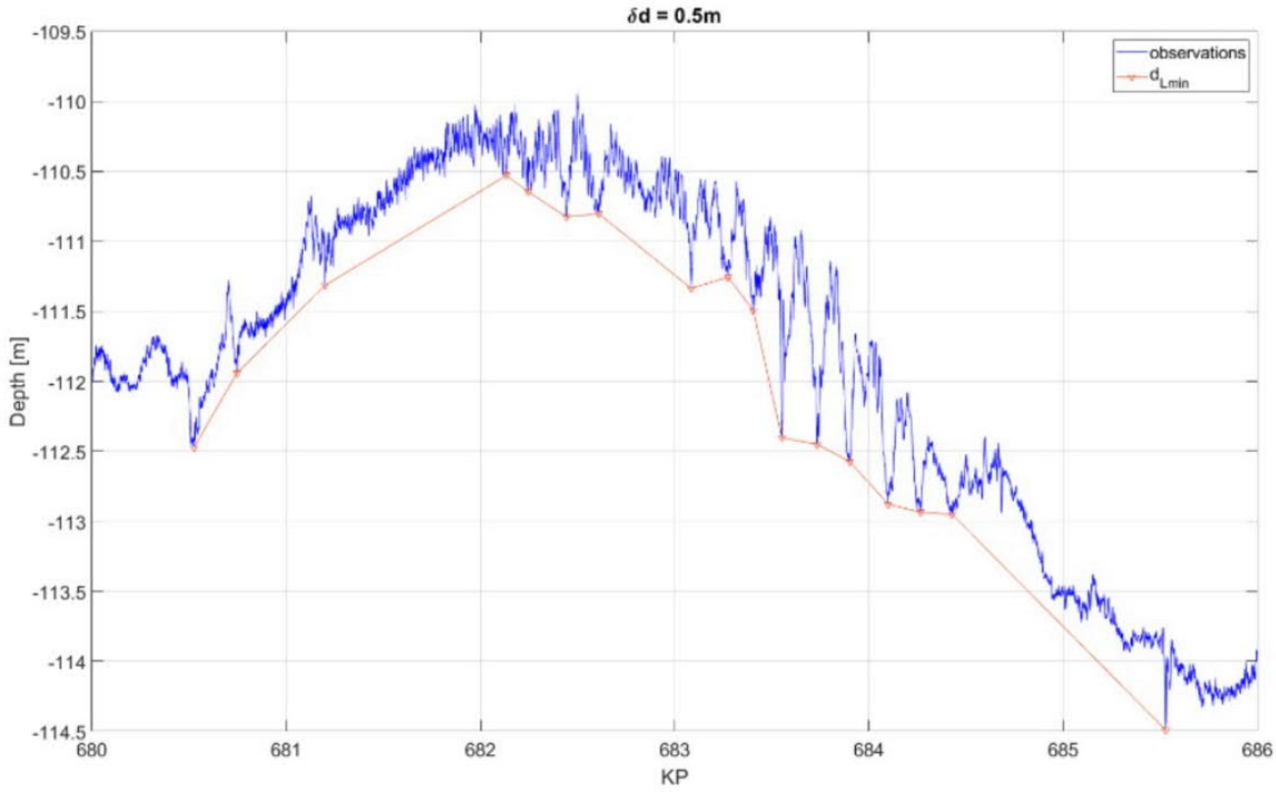

Figure 2-4: NMRL level with seabed

Location and Identification of Sand Waves

Prior to the Murrumujuk survey cruise, the locations of sand wave areas 1 to 5 were pinpointed in a post-survey burial assessment study by the subsea survey contractor (Table 2-1 and Figure 2-5 below), and the volumes calculated.

Table 2-1: Location of sand waves areas 1-5 and pre-sweep lengths

Area	From KP (km)	To KP (km)	Water depth (m)	NMR	Pre-sweep Section length (m)
1	67.269	67.587	-35.83	Constant depth level at -35	43
2	68.140	68.770	-35.20	Constant depth level at -	50
3	73.887	74.107	-35.93	Constant depth level at -	30
4	74.240	74.471	-35.03	Constant depth level at -35	113
5	74.845	75.055	-34.42	Constant depth level at -	173

Table 2-2 shows, for each of these sections, the current, indicative calculated quantities of material to be dredged, with and without considering the over depth and tolerance of 1 m. The total volume considers two lines to be dredged, being the bundled metallic return and pole 1 and subsequent single pole 2.

The above sand waves were identified from the 2020 survey. Further assessments / calculations will be required following the conclusion of the August-September 2022 Murrumujuk survey and prior to installation in 2025. The sand wave locations are shown on Figure 2-5.

Table 2-2: Indicative volume calculations, sand wave areas 1-5

Area	From KP (km)	To KP (km)	NMRL	Pre-sweep Section length (m)	Pre-sweep area (m^2)	Pre-sweep volume (m^3)	Pre-sweep area (m^2) + 1 m tolerance	Pre-sweep volume (m^3) + 1 m tolerance
1	67.269	67.587	Constant depth level at -35 m	43	766	341	1,462	1,507
2	68.140	68.770	Constant depth level at -35.2 m	50	1,039	693	1,742	2,109
3	73.887	74.107	Constant depth level at -35.4 m	30	507	207	1,055	1,027
4	74.240	74.471	Constant depth level at -35 m	113	1,840	901	3,186	3,498
5	74.845	75.055	Constant depth level at -34.6 m	173	3,231	1,412	4,865	5,459
Total (2 lines)					**14,766**	**7,108**	**24,620**	**27,200**
Total (doubled in SAP as a contingency)								**54,400**

During the Murrumujuk survey cruise, four additional sand wave areas (Sand waves 17-20) were identified. These are shown on Figure 2-6 to Figure 2-8, and listed in Table 2-3.

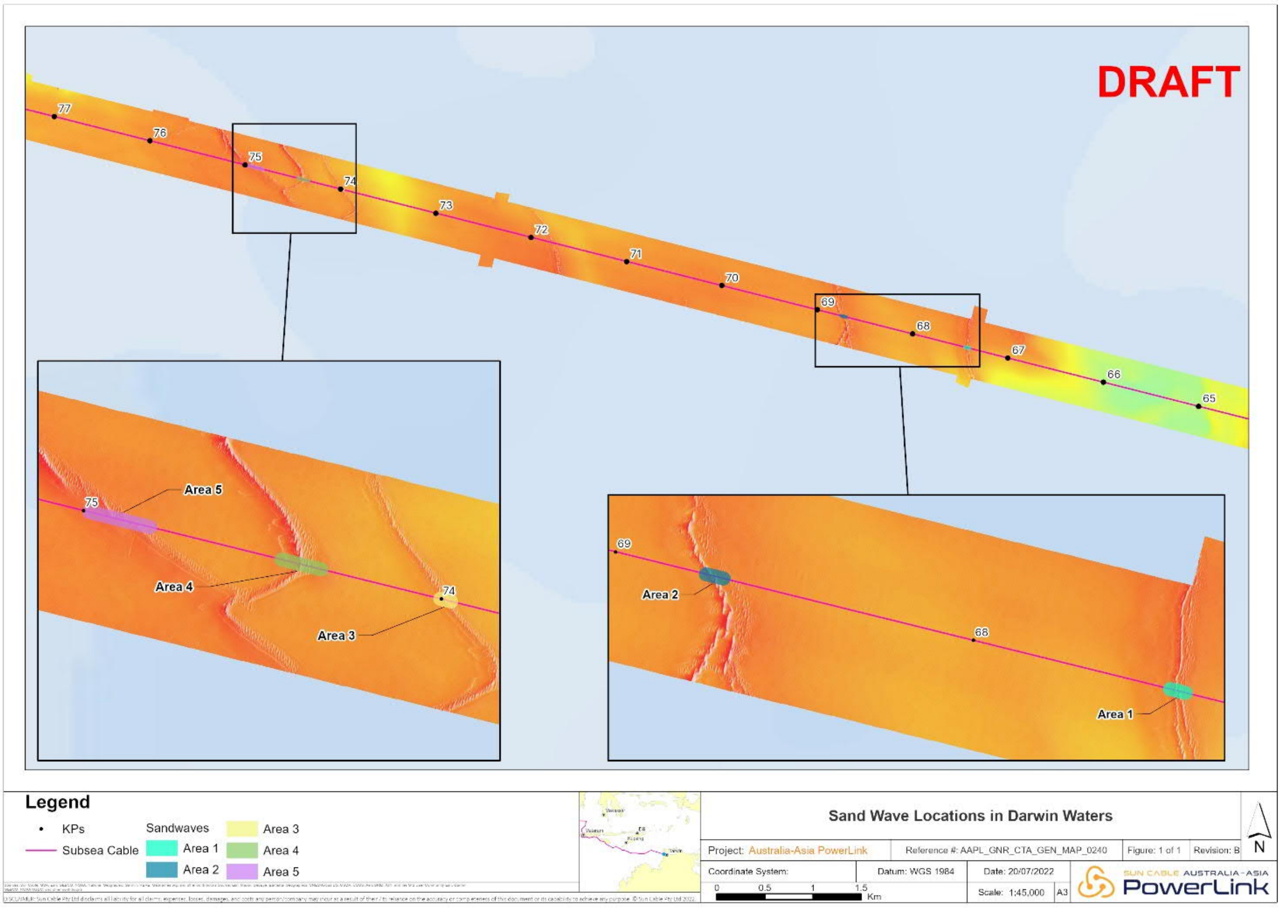

Figure 2-5: Sand wave locations 1-5 on bathymetric data from sidescan sonar

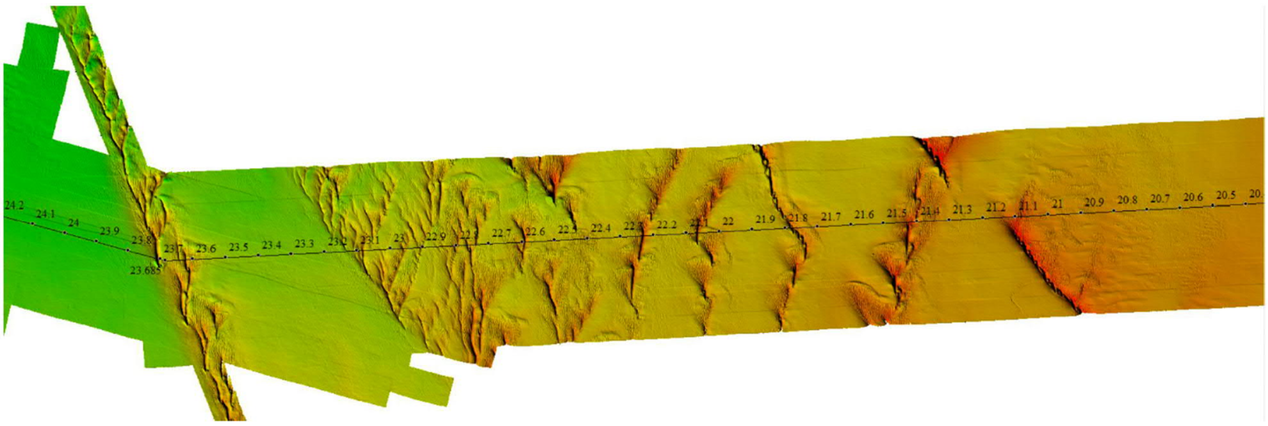

Figure 2-6: Sand wave areas 17 and 18 at KP 20-23

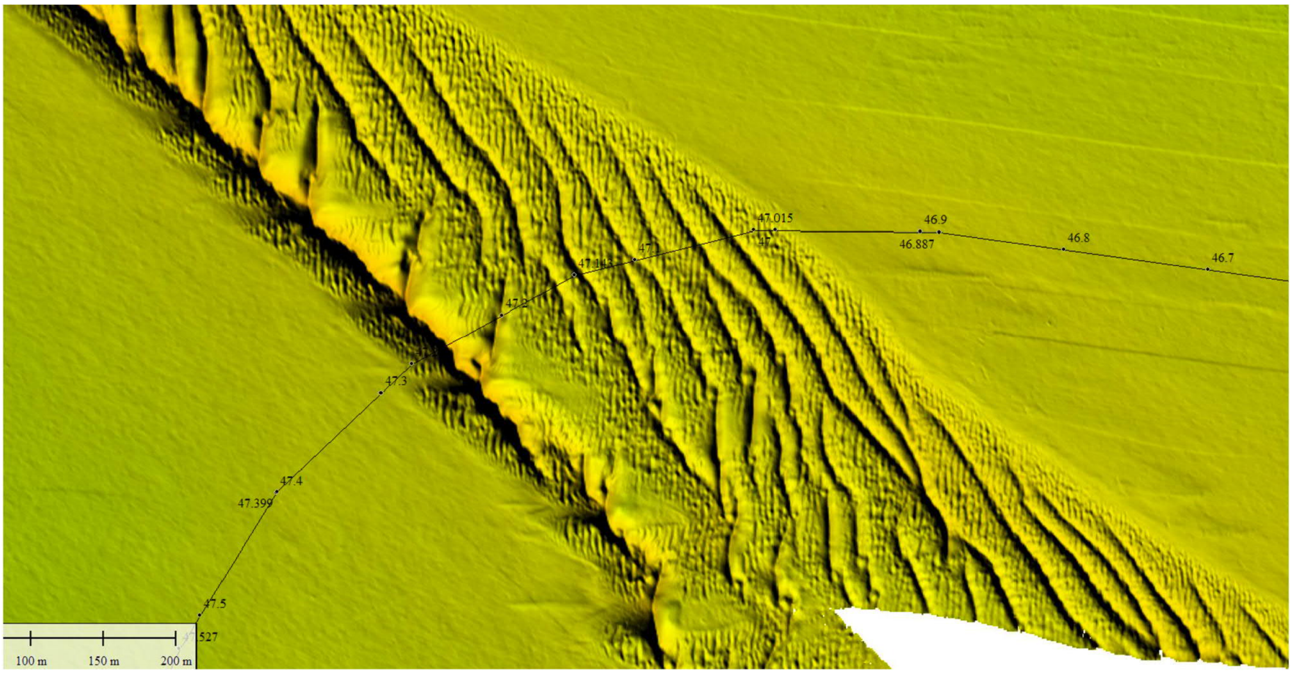

Figure 2-7: Sand wave area 19 at KP 47

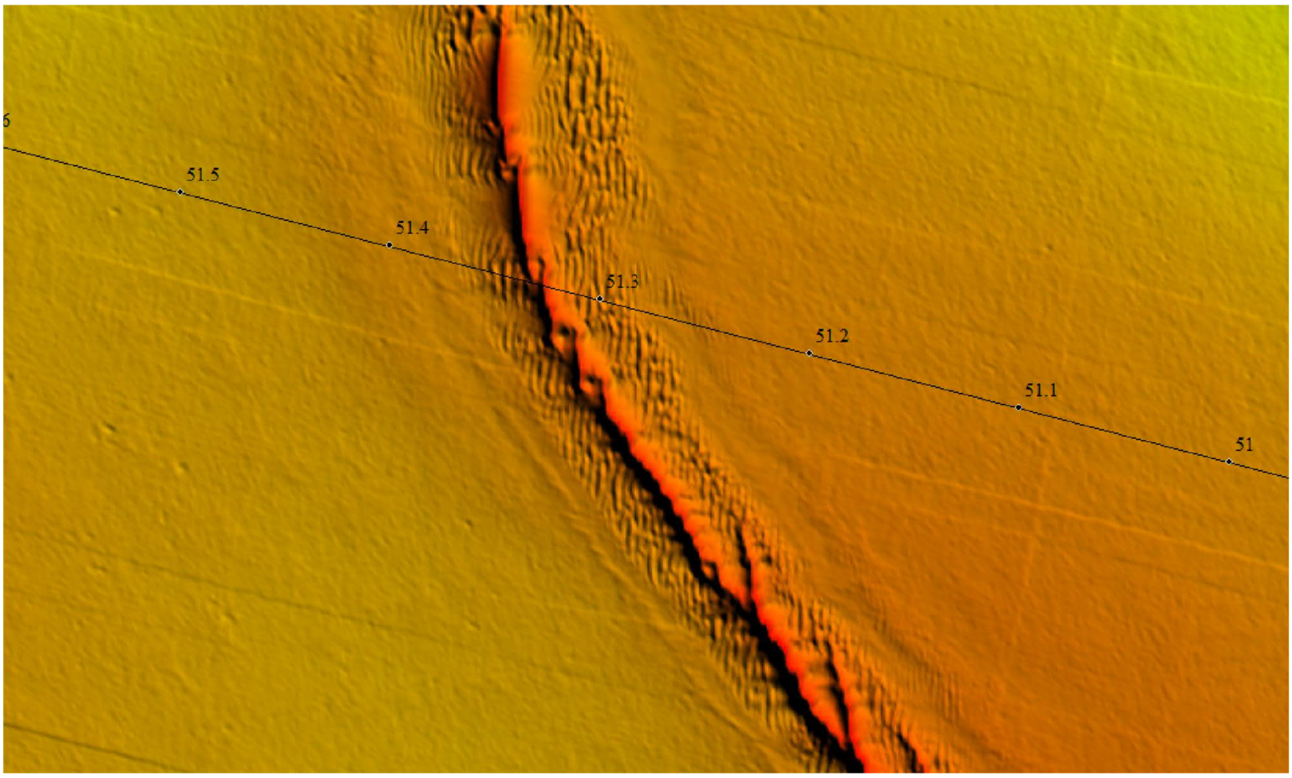

Figure 2-8: Area 20 – Updated Sand wave location at KP 51

Table 2-3: Indicative volume calculations, sand wave areas 17-20

Area	From KP (km)	To KP (km)	NMRL	Pre-sweep Section length (m)	Pre-sweep area (m^2)	Pre-sweep volume (m^3)	Pre-sweep area (m^2) + 1 m tolerance	Pre-sweep volume (m3) + 1 , tolerance
17	20.7	23.2	NA	2,500	NA	NA	NA	83,125*
18	23.55	23.75	NA	200	NA	NA	NA	6,650*
19	47.01	47.27	NA	260	NA	NA	NA	8,645*
20	51.28	51.36	NA	80	NA	NA	NA	2,660*
Subtotal				**3,040**				**101,080***
Total (2 lines)					NA	NA	NA	**202,160**

* NOTE: These areas were identified on the Murrumujuk survey cruise in late August 2022, and as sediment sampling was about to begin, there was not time for the detailed calculations to be made. Therefore, the pre-sweep volumes were determined pro-rata from the calculations in Table 2-2, and multiplied by an average factor of 33.25 (total pre-sweep volume (m3) + 1/tolerance total pre-sweep section length) from Table 2-2, above).

NA: Not available at the time.

New volume calculations have since been made (Primo Marine Pre-Sweeping Volumes and Areas, September 2022). Primo calculated the total volume of dredging required to be 132,481 m^3. This value has been doubled for two lines, as per Table 2-2 above, and thus the total dredging volume is 264,932 m^3. This Figure is close to the volume used in the SAP (54,000 m^3+ 202,160 m^3 = 256,560 m^3) to calculate NAGD sampling requirements.

2.2 Location of Potential Spoil Disposal Grounds

Two potential spoil disposal ground locations (Spoil Grounds A and B, see Section 3.1.2 and Figure 1-1) were identified prior to the Murrumujuk survey. These spoil grounds were chosen to be close to sand waves 1-5, as far as could be determined from the available bathymetric, sediment and benthic habitat data available for the area. Locations were also chosen to avoid the existing Bayu-Undan gas pipeline.

After sand wave areas 17-20 were identified during the Murrumujuk survey, two additional potential disposal areas were identified (C and D, Figure 1-1) using the same selection criteria.

3 Methodology

3.1 Sampling Design

3.1.1 Proposed Sand wave Dredging Areas

Sampling locations and numbers were determined in the SAP, based on NAGD requirements for the calculated total dredging volume. Under the NAGD, the volumes of discontinuous areas can be combined where they share the same contamination classification, in this case ‘probably clean.’

The sampling design implemented was essentially as set out in the SAP, with the true sampling locations generally being within 15 m of the planned locations. The locations of all samples are presented in Appendix 6. Several locations were moved slightly due to lack of sediment recovery. Sample site numbers for the nine potential sand wave dredging areas are listed in Table 3-1.

Table 3-1: Number of Dredge Area Sampling Locations

Area	Number of Core Sampling Sites	Number of NAGD 2009 Triplicate Cores*	Number of Field Split Triplicates*
1	2	-	-
2	2	-	1
3	2	-	-
4	3	1	-
5	4	1	-
17	17	1	1
18	1	1	
19	2	1	1
20	1	-	-
Total	34	5	3

* Triplicate samples collected at 10% of all locations and splits at 5% of locations, as per the NAGD and the SAP.

3.1.2 Potential Spoil Disposal Locations

Four potential spoil disposal grounds have been identified (Figure 1-1, orange rectangles). Spoil Grounds A and B are near dredging areas 1-5, to the north of the proposed cable route and the adjacent Bayu-Undan gas pipeline. Potential Spoil Ground C is located to the north of sand wave areas 19 and 20, and Spoil Ground D to the north of sand wave areas 17 and 18.

Each site is 1 km^2 in area, and thus has ample capacity for the volume of spoil proposed, plus a large contingency in case of a future increase in dredging volumes from these sand wave areas, or other sand waves that may be identified in future surveys.

Four surface grab samples were collected at each potential spoil ground, from the corners of each site, as set out in Table 3-2. The coordinates are listed in Table 3-3.

Table 3-2: Number of Potential Spoil Ground sampling locations

Area	Number of Grab Sampling Sites	Number of Triplicates*	Number of Field Splits*
A	4	1	-
B	4	-	1
C	4	1	-
D	4	-	1
Total	**16**	**2**	**2**

* Triplicate samples collected at 10% of all locations and splits at 5% of locations, as per the NAGD and the SAP.

3.2 Sampling Locations and Numbers

The physical/chemical sampling sites and coordinates are listed in Table 3-3, and the benthic invertebrate sample sites in Table 3-4.

Table 3-3: Number of Physical/Chemical Sampling Sites

Area	Site No.	Approx. KP*	X Coordinate MGA52	Y Coordinate MGA52	Triplicate Site	Split Site	Sub-samples #	QC Samples
Sand wave 1	Core	67.433	647676.7764	8646789.4375			2	
	Core	67.452	647658.3733	8646794.1627			2	
Sand wave 2	Core	68.729	646421.4860	8647111.7545		✓	4	
	Core	68.757	646394.3657	8647118.7181			2	
Sand wave 3	Core	73.993	641324.1178	8648420.5310			2	
	Core	74.000	641317.4842	8648422.2341			2	
Sand wave 4	Core	74.360	640968.7931	8648511.7579			2	
	Core	74.398	640931.9868	8648521.2076	✓		4	
	Core	74.435	640896.1491	8648530.4086			2	
Sand wave 5	Core	75.004	640345.1732	8648671.8675			2	
	Core	75.009	640340.3303	8648673.1109	✓		4	
	Core	75.031	640319.0215	8648678.5824			2	
	Core	75.046	640304.4928	8648682.3130			2	
Sand wave 17	Core	20.76	692474.9	8642005.5			2	
	Core	21.05	692185.3	8641990.2			2	
	Core	21.25	691985.6	8641979.6			2	
	Core	21.46	691775.8	8641968.5			2	
	Core	21.61	691626.0	8641960.6	✓		4	

Area	Site No.	Approx. KP*	X Coordinate MGA52	Y Coordinate MGA52	Triplicate Site	Split Site	Sub-samples #	QC Samples
	Core	21.68	691556.1	8641956.9			2	
	Core	21.81	691426.3	8641950.1			2	
	Core	21.87	691366.4	8641946.9			2	
	Core	22.16	691076.8	8641931.6		✓	4	
	Core	22.32	690917.1	8641923.2			4	
	Core	22.50	690737.3	8641913.7			2	
	Core	22.58	690657.4	8641909.4			2	
	Core	22.59	690647.4	8641908.9			2	
	Core	22.77	690467.7	8641899.4			2	
	Core	22.78	690457.7	8641898.9			2	
	Core	23.03	690208.0	8641885.7			2	
	Core	23.09	690148.1	8641882.5			2	
Sand wave 18	Core	23.59	689648.7	8641856.2	✓	✓	6	
Sand wave 19	Core	47.16	666536.3	8643758.3	✓		4	
	Core	47.27	666440.2	8643705.5			2	
Sand wave 20	Core	51.35	663254.3	8642789.8			2	
Disposal Site A, Samples from the 4 corners of the site	Grab	NA	641620.0756	8653910.8955			1	
	Grab	NA	642586.0014	8653652.0765	✓		3	
	Grab	NA	642327.1824	8652686.1515			1	
	Grab	NA	641361.2566	8652944.9705			1	
Disposal Site B, Samples from the 4 corners of the site	Grab	NA	647611.0586	8651711.5905			1	
	Grab	NA	648576.9844	8651452.7715		✓	3	
	Grab	NA	648318.1654	8650486.8455			1	
	Grab	NA	647352.2395	8650745.6645			1	
Disposal Site C, Samples from the 4 corners of the site	Grab	NA	673013.78	8648615.31			1	
	Grab	NA	673979.706	8648356.49	✓		3	
	Grab	NA	673720.887	8647390.56			1	
	Grab	NA	672754.961	8647649.38			1	

Area	Site No.	Approx. KP*	X Coordinate MGA52	Y Coordinate MGA52	Triplicate Site	Split Site	Sub-samples #	QC Samples
Disposal Site D, Samples from the 4 corners of the site	Grab	NA	686160.528	8646894.78			1	
	Grab	NA	687126.451	8646635.97		✓	3	
	Grab	NA	686867.65	8645670.05			1	
	Grab	NA	685901.727	8645928.85			1	
Total							110	
Rinsate blanks (assumes 4 days sampling)								16
Trip blank/spike								4
Total samples for analysis							130	

Table 3-4: Number of Benthic Invertebrate Grab Sampling Sites

Area	Site No.	Approx. KP*	X Coordinate MGA52	Y Coordinate MGA52	Triplicate Site
Sand wave 1	S1	67.433	647676.7764	8646789.4375	✓
Sand wave 2	S3	68.729	646421.4860	8647111.7545	✓
Sand wave 3	S5	73.993	641324.1178	8648420.5310	✓
Sand wave 4	S7	74.360	640968.7931	8648511.7579	✓
Sand wave 5	S10	75.004	640345.1732	8648671.8675	✓
Sand wave 17	Core S14	20.76	692474.9	8642005.5	✓
	Core S21	21.87	691366.4	8641946.9	✓
	Core S30	23.09	690148.1	8641882.5	✓
Sand wave 18	Core S31	23.59	689648.7	8641856.2	✓
Sand wave 19	Core S32	47.16	666536.3	8643758.3	✓
Sand wave 20	Core S34	51.35	663254.3	8642789.8	✓
Disposal Site A, Samples from the 4 corners of the site	Grab A1	NA	641620.0756	8653910.8955	✓
	Grab A2	NA	642586.0014	8653652.0765	✓
	Grab A3	NA	642327.1824	8652686.1515	✓
	Grab A4	NA	641361.2566	8652944.9705	✓
Disposal Site B, Samples from the 4 corners of the site	Grab B1	NA	647611.0586	8651711.5905	✓
	Grab B2	NA	648576.9844	8651452.7715	✓
	Grab B3	NA	648318.1654	8650486.8455	✓

Area	Site No.	Approx. KP*	X Coordinate MGA52	Y Coordinate MGA52	Triplicate Site
	Grab B4	NA	647352.2395	8650745.6645	✓
Disposal Site C, Samples from the 4 corners of the site	Grab C1	NA	673013.78	8648615.31	✓
	Grab C2	NA	673979.706	8648356.49	✓
	Grab C3	NA	673720.887	8647390.56	✓
	Grab C4	NA	672754.961	8647649.38	✓
Disposal Site D, Samples from the 4 corners of the site	Grab D1	NA	686160.528	8646894.78	✓
	Grab D2	NA	687126.451	8646635.97	✓
	Grab D3	NA	686867.65	8645670.05	✓
	Grab D4	NA	685901.727	8645928.85	✓
Total					**81**

3.3 Variations to the SAP

Some minor changes were made to sampling locations due to inadequate sample recovery or for operational reasons. These are detailed in Appendix 6.

3.4 Sampling, Subsampling and Logging

3.4.1 Sample collection

Core samples

At each coring site a vibrocore was collected, of sufficient length to sample the top 1 m of the sediment. If insufficient sediment was recovered a new core was collected. If suitable cores could not be collected after three attempts, the location was moved 20 m along the Subsea Cable System route and resampled. If a suitable core could still not be collected, a grab sample was collected.

At triplicate sampling locations three cores were collected at the one location.

At the locations specified in Table 3-4, triplicate grab samples were collected for benthic infauna analysis, and underwater remotely operated vehicle (ROV) imagery was taken to assess the nature of the seabed and benthic habitats (Section 4).

After recovery the core liner was removed from the core barrel and split to expose the sediment. A core plate was prepared and numbered, the core was photographed and logged, and a sample was collected from the midpoint of each 50 cm section for volatiles (see below). The core was then sampled in 50 cm sections, i.e., 0-50 cm and 50-100 cm. Each 50 cm section of the core was placed in a pre-cleaned mixing bowl and homogenised before subsampling. The core logs and photos are presented in Appendix 2.

Grab Samples

If the grab sampler was only partly full or the jaws were held open by rock, shell or other coarse material, the sample was discarded and a new sample collected. After each grab sample was recovered a sample plate was prepared and numbered, and a sample collected from the middle of the grab for volatiles (see below). The contents of the grab were placed in a pre-cleaned mixing bowl, photographed, and homogenised before subsampling. The grab photos are presented in Appendix 2.

At triplicate sampling locations, three grabs were collected at the one location.

At the locations specified in Table 3-4, triplicate grab samples were collected for benthic infauna analysis, and ROV imagery taken to assess the benthic habitat (Section 4). If the grab sampler was only partly full it was discarded, and a new sample collected.

3.4.2 Biological Sampling and Imagery

Benthic Invertebrates

Benthic invertebrates sampling procedure (EcOz 2022, Benthic macroinvertebrate sampling for proposed sand wave dredging and disposal sites):

- Use an appropriate grab sampler (Van Veen, Ekman, Ponar or similar) to collect at least 0.1 m2 of sediment from the top 10 cm of sediment.
- Empty the grab sampler contents into a metal tray
- Hose down the grab sampler with filtered (to 500 µm) seawater, or if necessary, a very small amount of freshwater, rinsing any material left inside the grab sampler into the metal tray. Do not use too much freshwater, as the macroinvertebrates may be undetectable if exposed to large quantities or for extended periods of time.
- Inspect the contents to ensure there is sufficient material for a complete sample. The sample amount needs to be consistent across sites, throughout the survey.
- Inspect the contents for fragile, visible animals. If they are small (less than 1 cm) and visible, separate them and place in the sample jar.
- If there are any large macro-invertebrates (> 1cm) (e.g., crabs, urchins etc) take a note of how many and what they are. If unsure, take a photo next to a size reference object, e.g., a pencil, and a piece of paper with the site id written on it. Dispose back into the ocean – these are too large for ethanol preservation.
- Empty the contents of the tray into the stack of sieves in order from large at the top to small at the bottom (e.g., 10 mm, 4 mm in 0.5 mm (500 µm) from top to bottom).
- Gently elutriate the sample over the sieves. This step may take up to 20 minutes depending on how muddy/sandy the sediment is. The water pressure should be low for this sampling. Freshwater should be used sparingly, and if possible, the preference is to use filtered (to 500 µm) seawater.
- If the sediment is very coarse or muddy/clayey and unable to pass through the 500 µm sieve, wash the contents of the sieve into a circular bucket, add some filtered (to 500 µm) seawater water, and elutriate by swirling around and immediately pouring off the swirling water over the 500 µm sieves. Repeat this as many times as it takes to be confident that the macro-invertebrates have been elutriated out of the sediment and water. After this, use the sieves to double check, as best as possible, that the macroinvertebrates have been captured. Do not press clayey/muddy sediment through the sieve as any macro-invertebrates present will be crushed and not be identified.
- Gently empty the macroinvertebrates remaining on the 500 µm sieve into a sealable plastic jar and preserve with 80% ethanol. If all the sample does not fit in one jar, put the remaining sample in another jar. Tighten the lid firmly.
- Write the site id clearly on a piece of paper using pencil, and place inside the jar with the sample. Label the sample jar with the site id, date, and time of collection.

- Each sample date and time will be entered on the EcOz sample record sheet, pre-filled with the site names, a dash, and the sample triplicate number e.g., S1-1, S1-2, S1-3, S2-1 etc. If there are more than two sample jars per site, they can be labelled in the same way. Note on the sample sheet the number of jars for each grab sample. If the grab sampler fails to trigger, each attempt will be indicated by adding an alphabetical identifier on the sample number e.g., S1-1-b indicates two failures to trigger before sample was taken.
- Stack the sample jars neatly inside the white buckets and keep in the shade ready for transport.
- When the sampling is over, organise transport for the samples to shore and contact EcOz to pick up the samples up. EcOz will organise transport of the samples to Benthic Australia for sorting, identification, and analysis.

Benthic Video Survey

The field work was undertaken by Guardian using a Blue Remotely Operated Vehicle (ROV2) configured with eight thrusters, recording video footage at 32 frames per second (from EcOz Memorandum- Benthic video footage analysis, 2022). At each GPS location (+/- 10 m) the ROV was deployed to the seabed. Two survey methods were used due to depth, conditions and boat types being varied between the two tasks. Both methods were in accordance with the Field Manuals for Marine Sampling to Monitor Australian Waters (Przeslawski and Foster 2020). The two methods are described as follows:

- The 35 Task 1 underwater videos were undertaken in deep water from a large geotechnical vessel. A clump-weight was used to secure the ROV to the seabed at each site, and the ROV was operated in a full-circle (~2 to 2.5 m radius) around the clump-weight.
- The 30 Task 2 underwater videos were undertaken in shallow water and in windy conditions from a small vessel. The ROV was deployed at each site and was stationary at the seabed level while the boat was allowed to drift, with tether being released at the same rate as the boat-drift, for up to ~50 m.

The operator had live visuals of the ROV footage and took care to pause and focus on features that may have been significant. Some of the dredge video footage did not record depth and is labelled 'NA' in the results tables. The video footage was cropped by Guardian Geomatics and sent to EcOz for benthic epifauna identification.

The imagery was used by specialist marine scientists to assess the sediment characteristics, bedforms and other topographic features, and benthic habitats and macrofaunal communities, including the presence or absence of seagrasses, macroalgae, corals and filter-feeder communities at the sampling locations (see Appendix 9.1 Memorandum: Benthic Video Footage Analysis of the SEIS).

3.4.3 Subsampling of Cores and Grabs

For each sample, one Whirlpac bag was collected for Particle Size Distribution (PSD), and two jars for the other analyses – Total Organic Carbon (TOC), Total Petroleum Hydrocarbons (TPH), Polycyclic Aromatic Hydrocarbons (PAH) and metals plus metalloids – filled to zero headspace. Sample volumes and storage requirements are set out in Table 3-5.

Table 3-5: Sample Volumes and Storage requirements (NAGD)

Analyte	Volume (ml)	Container	Preservation	Storage	Holding Time	
PSD	50-200	Whirlpac bag	Refrigerate	<4oC	Undetermined	50-200
TOC	Oct-50	Pre-cleaned glass jar, Teflon-lined lid	Freezer for extended storage	<20oC	Undetermined	Oct-50
TPH and PAH	250	Pre-cleaned glass jar, Teflon-lined lid	Freezer for extended storage	<20oC	14 days if refrigerated	250
Metals	100	Pre-cleaned jar, Teflon-lined lid	Freezer for extended storage, otherwise refrigerate	<4oC	Mercury – 28 days unless frozen. Other metals, 6 months.	100

Samples for the volatile hydrocarbons Benzene, Toluene, Ethylbenzene, Xylenes and Naphthalene (BTEXN) cannot be homogenised. Immediately on splitting each core or recovering each grab sample, a sample for volatiles was taken from the midpoint of each 50 cm core section, or directly from the grab sampler, and the jar filled to zero headspace.

3.4.4 Decontamination of Reused Equipment

Prior to sampling and after collection of each core or grab sample, sampling equipment in contact with the sediment (core tubes, grab samplers, mixing bowls and spoons) was decontaminated by:

- Scrubbing with a dilute solution of Decon 90
- Rinsing with seawater.

3.4.5 Sample Preservation, Storage and Transport

The sample jars were labelled clearly with a waterproof pen on the outside label and on the cap. Samples for PSD were stored in double Whirlpac bags, labelled on the outside, with an additional waterproof label inside the outer bag. Labels included the unique sample number, date, location, depth of sample and sampler's initials. Samples were refrigerated on board until ready for shipment.

Due to the duration of the survey, and the 14-day holding times for organics, samples were periodically shipped to shore and to the analytical laboratories. The subsamples were placed in Eskies containing chilled freezer blocks sufficient to keep the samples cool until delivery.

- Sample chain-of-custody

Samples were listed on the chain-of-custody (COC) forms, along with reference to the analyses and Limits of Reporting (LORs, called Practical Quantitation Limit, PQL, in the NAGD) specified in the laboratory's quote, and any special requirements noted. Samples for possible future analysis were marked 'Hold.'

Because other offshore sediment investigations in the region had shown TPH levels to be low, and frequently below LORs, Total PAHs were only to be analysed on samples where TPHs were above the LOR.

- Laboratory Analysis

Sediment samples were analysed using standard methods for marine samples, to the detection limits required. The analytical methods employed were appropriate for the analytes required, and the LORs were at or below those specified in the NAGD. Analytes are listed in Table 3-6.

No PAHs were analysed by ALS because TPHs were not detected in the great majority of samples, and in the few samples where they were detected the values were at or marginally above the LORs.

Table 3-6: List of Analytes and NAGD-specified LORs

Analyte	LOR (called PQL in the NAGD 2009)	ALS LOR	ALS ANALYSIS CODE
Basic Sediment Characteristics			
Moisture content	0.1%	0.1%	EA055
Total organic carbon	0.1%	0.02%	EP003
Particle size and settlement rate	PSD (sieve + hydrometer)	1%	EA150
Organic compounds			
Total petroleum hydrocarbons	10-50 (mg/kg)	3-5 mg/kg	EP071-SD and EP080-SD
BTEXN	200 µg/kg	200 µg/kg	EP080-SD
Total PAHs – only required on samples where TPH exceeds LOR	100 µg/kg	Not analysed	SD-02
Metals and Metalloids			
Copper	1 mg/kg	1 mg/kg	EG020-SD
Lead	1 mg/kg	1 mg/kg	EG020-SD
Zinc	1 mg/kg	1 mg/kg	EG020-SD
Chromium	1 mg/kg	1 mg/kg	EG020-SD
Nickel	1 mg/kg	1 mg/kg	EG020-SD
Cadmium	0.1 mg/kg	0.1 mg/kg	EG020-SD
Mercury	0.01 mg/kg	0.01 mg/kg	EG035T-LL
Arsenic	1 mg/kg	1 mg/kg	EG020-SD
Antimony	0.5 mg/kg	0.5 mg/kg	EG020-SD
Aluminium	200 mg/kg	50 mg/kg	EG005-SD
Iron	100 mg/kg	50 mg/kg	EG005-SD

Sources: NAGD 2009, ALS

3.5 QA/QC Procedures

3.5.1 Field QA/QC

The field QA/QC methods and data quality indicators (DQIs) to be met are summarised in Table 3-7.

Table 3-7: Field Quality Assurance and Quality Control

Procedure	Data Quality Indicators and Notes
Personnel	All samples collected and handled in accordance with the SAP, by experienced professionals.
Data collection	All sites sampled using appropriate Standard Operating Procedures (SOPs) based on the SAP. Any variations to the SAP noted and explained. Appropriate description of site conditions. Sample locations correct and adequately described. Field notes and logs complete and signed and dated each day.
Sample handling	Sediment and rinsate samples collected in laboratory supplied jars/vials, appropriately labelled, and refrigerated at <6oC until shipment. During shipment, samples stored in insulated, chilled containers with sufficient freezer bricks to maintain temperature until receipt by the analysing lab. Chain-of-custody (CoC) documentation complete, including sample numbers and types, dates, sampler name, preservation and analysis requirements, and signatures of sampler and lab. Sample receipt notice (SRN) from lab that all samples on CoCs received chilled and intact, and within holding times.
Calibration of field equipment	Not required in this study.
Intra-lab duplicates	Two samples from a field-homogenised subsample, analysed to identify variations due to handling of subsamples. Collected & analysed at a rate of 5% of the primary samples.
Inter-lab duplicates (field splits)	Two samples from a field-homogenised subsample, analysed to identify analysis variations, sent to different labs. Collected & analysed at a rate of 5% of the primary samples. Acceptance criteria, either <5 x LOR = no limit on Relative Percent Difference value (RPD) (or RSD, Relative Standard Deviation for triplicates), >5 x LOR = 0-50% RPD – or as specified on lab certificates.
Field triplicate	Three separate samples (usually cores) collected at the same location. Determines the variability in sediment physical and chemical characteristics and is an indicator of how representative samples are of the sediment.
Trip blanks and trip spikes	Trip blanks and spikes supplied by the laboratory, for BTEXN. Trip blank included in each sample shipment to assess the potential for loss of volatiles during storage and transport. Analyte concentrations should be < LOR. Trip spike included in each sample shipment to assess the potential for cross-contamination from volatiles during storage and transport. Analyte recoveries should be > 90% of the original spikes or as specified on the lab certificate.
Rinsate blanks	Rinsate or wash blanks collected from each piece of re-used equipment to determine any cross-contamination between samples or subsamples. Analyte levels should be < LORs.

3.5.2 Laboratory QA/QC

The Completeness Objective for the study (NAGD) is that a minimum of 95% of the data obtained on the samples submitted for analysis is validated as fit for purpose.

The laboratory QA/QC procedures are summarised in Table 3-8.

Table 3-8: Laboratory Quality Assurance and Quality Control

Procedure	Data Quality Indicators and Notes
Analysis	All analyses done by standard procedures for marine samples.
Holding times	Holding times for the various analytes in sediments and soils are as specified within Section 3.4.2 above and are met.
Detection limits	Laboratory LORs as specified above, to meet NAGD requirements. Ideally the LORs will be an order of magnitude lower than the lowest level to be determined in the samples.
Lab blanks	Prepared by the lab to identify cross-contamination of samples during handling, extraction, and analysis. To be analysed at a rate of 5 % of samples, with a minimum of 1 per batch. Analyte concentrations should be < LORs.
Lab duplicates	To be analysed at a rate of 5 % of samples, with a minimum of 1 per batch. Duplicates are a separate subsample taken from the sample jar. The lab mixes the sediment as best they can in the jar then takes out 2 separate subsamples. These are then carried through the whole preparation process. RPD acceptance criteria vary and are as specified on lab certificates.
Lab standard or control samples	Standard samples of known composition included in each batch to check analysis accuracy. To be analysed at a rate of 5% of samples, with a minimum of 1 per batch. Analyte concentrations should be < LORs. Control limits vary and are as specified on lab certificates.
Matrix and surrogate spikes	Matrix spikes determine interference from the sample matrix on contaminant recovery. A field sample is divided into two aliquots and spiked with identical levels of analytes, at a rate of 5% of samples. Matrix spike control limits vary and are as specified on lab certificates. The matrix spike duplicate RPDs to be met are as specified on lab certificates. Surrogate spikes (organic compounds only) are compounds similar to the target analyte, but unlikely to be present in the sample. The recovery rate indicates the lab's ability to extract the analyte from the sample matrix. Recovery rates vary and are as specified on lab certificates.

4 Results

4.1 Field Observations

4.1.1 Sediments in the Sand Wave Areas

From the Guardian field logs of the 1 m cores, sand wave area sediments were predominantly brown or grey-brown carbonate sands dominated by bioclastic material (shell debris mainly from bivalves, gastropods, echinoderms, and foraminifera), plus, commonly, rounded limestone fragments (clasts), and sometimes quartz and pebbles.

Sediments sometimes became finer with depth and often had a clayey sand or carbonate clay layer near the base of the core. The core logs are summarised in Table 4-1.

Table 4-1: Core Log Summary, Sand wave Areas

Sand wave Area & Water Depth	Core Number	Summary Description (based on Guardian Core Logs (Appendix 2))
1 39-40 m	VC-S1B	Grey-brown carbonate sand dominated by bioclastic material (shells/tests of various organism groups) and limestone clasts, becoming a grey sandy carbonate clay at depth
	VC-S2B	Grey-brown carbonate sand dominated by bioclastics, becoming finer down-core. Below 0.8 m a calcareous clay or clayey calcareous gravel.
2 37-39 m	VC-S3	Grey-brown carbonate sand dominated by bioclastics/limestone clasts (broken limestone).
	VC-S4	Grey-brown slightly clayey carbonate sand or sandy gravel, dominated by bioclastics and limestone clasts. A greenish-grey carbonate clay below 0.7 m.
3 34 m	VC-S5A	Grey-brown carbonate sand dominated by bioclastics.
	VC-S6	Grey-brown carbonate sand dominated by bioclastics to 0.82 m, below this a clayey carbonate sand.
4 34-38 m	VC-S7	Grey-brown carbonate sand dominated by bioclastics and brown limestone clasts. Below 0.8 m, clayey carbonate sand to sandy carbonate clay.
	VC-S8-1	Grey-brown carbonate sand dominated by bioclastics.
	VC-S9	Grey-brown clayey or clayey silty carbonate sand dominated by bioclasts.
5 35-39 m	VC-S10	Grey-brown carbonate sand, silty at the surface, dominated by bioclasts. Below 0.7 m a greenish-grey clayey carbonate sand.
	VC-S11-2	Red-brown to grey carbonate sand dominated by rounded limestone clasts and bioclasts. Below 0.6 m, clayey silty carbonate sand.
	VC-S11-3	Grey-brown carbonate sand, sometimes gravelly, dominated by rounded limestone clasts and bioclasts. Below 0.75 m, clayey carbonate gravel/carbonate clay, greenish-grey.
	VCS-12A	Grey-brown carbonate sand, silty at surface, dominated by rounded limestone clasts and bioclasts. Below 0.6 m, clayey silty carbonate sand.
	VC-S13	Grey carbonate sand, clayey at the surface and increasing down-core, dominated by bioclasts and rounded limestone clasts. Clayey carbonate sand below 0.63 m.
17	VC-S14	Olive-grey carbonate sand dominated by bioclasts and rounded limestone clasts interbedded with clayey carbonate sand layers. Below 0.91 m, silty carbonate clay.

Sand wave Area & Water Depth	Core Number	Summary Description (based on Guardian Core Logs (Appendix 2))
17-23 m	VC-S15	Brown carbonate sand, mainly bioclasts, becoming a silty clayey carbonate sand with depth. Below 0.67 m, alternating layers of carbonate sand and clayey carbonate sand.
	VC-S16	Grey-brown carbonate sand dominated by bioclasts and limestone clasts, becoming a silty clayey carbonate sand with depth. Below 0.75 m a dark grey silty sandy carbonate clay.
	VC-S17A	Yellow-brown carbonate sand dominated by bioclasts and limestone clasts, light grey below 0.25 m.
	VC-S18-1	Grey clayey silty carbonate sand dominated by bioclasts. Below 0.5 m a grey calcareous clay with laminated coaly/woody beds.
	VC-S18-2A	As for S18-1.
	VC-S18-3	As for S18-1.
	VC-S19	Grey-brown carbonate sand dominated by limestone clasts and bioclasts. From 0.3-0.8 m, clayey silty carbonate sand. Below 0.8 m, greenish-grey calcareous clay.
	VCS-20A	Grey-brown carbonate sand dominated by limestone clasts and bioclasts. From 0.1-0.63 m, clayey silty gravelly carbonate sand/carbonate gravel. Below 0.63 m, greenish-grey calcareous clay.
	VC-S21	Grey-brown carbonate sand dominated by bioclasts, becoming a clayey carbonate sand FROM 0.2-0.7 m. Below this an olive-brown calcareous clay.
	VC-S22	Greenish-grey clayey carbonate sand dominated by bioclasts, to 0.34 m, then a carbonate sand. Below 0.7 m an olive-brown calcareous clay.
	VC-S23	Yellow-brown carbonate sand dominated by rounded limestone clasts, to 0.34 m, then a clayey carbonate sand to 0.7 m. Below this a grey carbonate clay.
	VC-S24	Yellow-brown carbonate sand dominated by rounded limestone clasts. Below 0.9 m, grey carbonate clay.
	VC-S25	Yellow-brown carbonate sand dominated by rounded limestone clasts. Below 0.95 m, grey carbonate clay.
	VC-S26B	Yellow-brown carbonate sand dominated by rounded limestone clasts. Below 0. 5 m, grey carbonate clay.
	VC-S27	Grey-brown carbonate sand, dominated by rounded brown limestones. Below 0.9 m, silty clayey carbonate sand.
	VC-S28	Brown/greenish grey carbonate sand dominated by limestone clasts and bioclasts. Below 0.75 m, greenish-grey clayey silty carbonate sand. Below 0.9 m, dark grey carbonate clay.
	VC-S29	Yellow-brown carbonate sand, dominated by quartz and limestone clasts, becoming grey-brown with depth. Below 0.95 m, clayey carbonate sand.
	VC-S30B	Dark grey-brown carbonate sand dominated by rounded limestones and bioclasts, throughout.
18 20-21 m	VC-S31-1	Yellow-brown to grey-brown carbonate sand dominated by limestone clasts and bioclasts. Greyish-brown below 0.9 m.
	VC-S31-2	Yellow-brown carbonate sand dominated by limestone clasts and bioclasts. Greyish brown below 0.86 m.
	VC-S31-3A	As for VC-S31-2.

Sand wave Area & Water Depth	Core Number	Summary Description (based on Guardian Core Logs (Appendix 2))
19 27-30 m	VC-S32A-1	Brown carbonate sand dominated by limestone clasts and bioclasts. 0.73—0.95 m, greenish-grey clayey sandy carbonate gravel. Below 0.95 m, carbonate clay.
	VC-S32-2B	Brown carbonate sand dominated by limestone clasts and bioclasts. 0.4-0.7 m, grey-green clayey silty carbonate sand. Below 0.7 m, carbonate clay.
	VC-S32-3	Brown carbonate sand dominated by limestone clasts and bioclasts throughout.
	VC-S33	Brown carbonate sand dominated by limestone clasts and bioclasts. 0.7-0.95 m, greenish-grey gravelly clayey carbonate sand. Below 0.95 m, carbonate clay.
20 34 m	VC-S34	Brown carbonate sand dominated by limestone clasts and bioclasts. 0.3-0.99 m, greenish grey clayey gravelly carbonate sand. Below 0.99 m, carbonate clay.

4.1.2 Sediments of the Potential Spoil Disposal Grounds

From the Guardian sample photos (Appendix 2) and the underwater video observations (EcOz 2022a), the sediments were predominantly brown or grey-brown carbonate sands, or sometimes muddy sands, often containing small pebbles, whole and broken shell and coral rubble (Table 4-2).

Table 4-2: Grab Sample Summary, Potential Spoil Ground Sites

Potential Spoil Ground	Grab Sample & Water Depth (m)	Summary Description (based on Guardian sample photos (Appendix 2), underwater video observations (EcOz 2022a, Table 1) and grainsize data
A	A1, 44 m	Grey-brown sand with small pebbles, shells, and coral rubble.
	A2, 52 m	Grey-brown sand with small pebbles, shells, and coral rubble.
	A3, 48 m	Grey-brown sand with shell.
	A4, 43 m	Grey-brown sand with small pebbles, shells, and coral rubble.
B	B1, 48 m	Grey-brown muddy sand.
	B2, 40 m	Grey-brown gravelly muddy sand.
	B3, 40 m	Grey-brown muddy sand.
	B4, 40 m	Grey-brown muddy sand.
C	C1, 33 m	Grey-brown sand with small rocks, shells, and coral rubble.
	C2, 33 m	Grey-brown sand, some rocky rubble.
	C3, 31 m	Grey-brown sand, some rocky rubble.
	C4, 30 m	Grey-brown sand, some rocky rubble.
D	D1, 24 m	Brown sand with small sand waves, rocky rubble, and large shells.
	D2, 24 m	Brown sand with small sand waves, rocky rubble, and large shells.
	D3, 23 m	Brown sand with small sand waves, rocky rubble, and large shells.
	D4, 24 m	Brown sand with small pebbles, shells, and coral rubble.

4.1.3 Underwater Video

Video footage was analysed from 35 survey sites (from EcOz 2022b, Task 1). This footage provides context for interpreting survey data within the proposed dredge areas and dredge spoil disposal grounds, including benthic-macroinvertebrate sampling, sediment geochemistry and geotechnical data. Results of the video survey are summarised in Figure 4-1.

In general, benthic species and epifauna were very sparse, with footage showing mostly unconsolidated sediment as described in the core log and grab sample summaries (Table 4-1 and Table 4-2, above) with isolated occurrences of individual organisms.

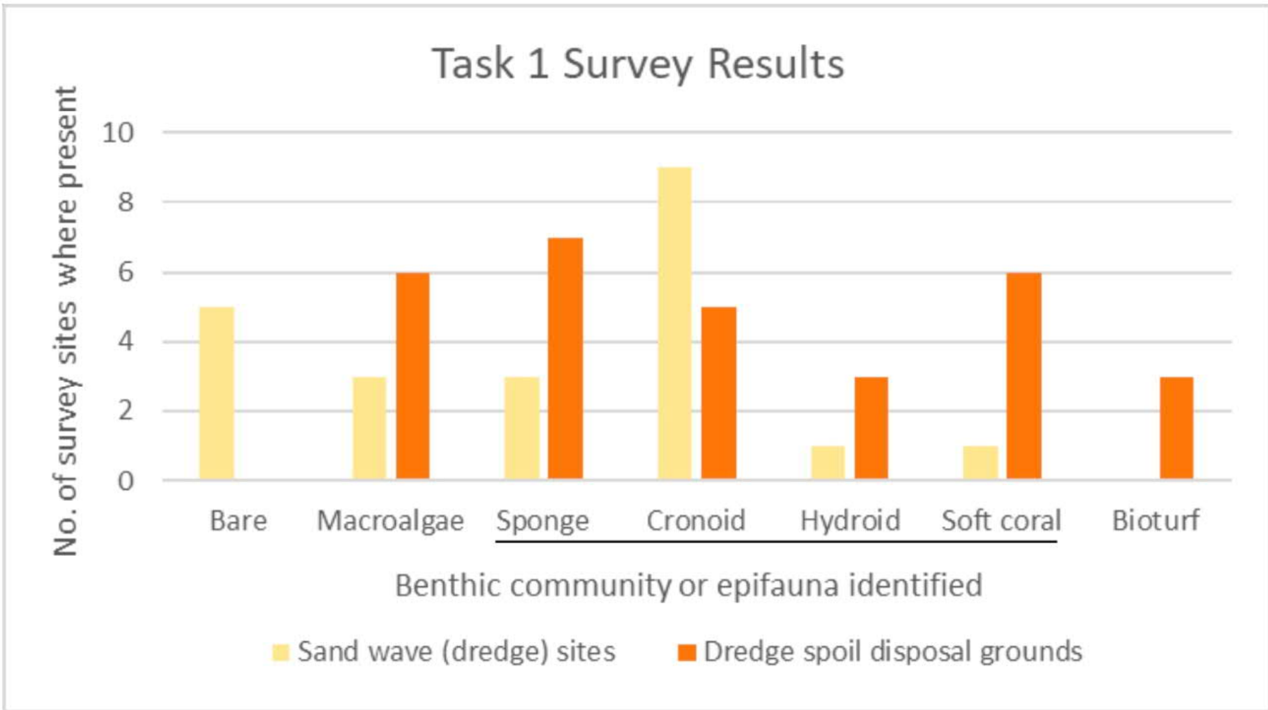

Figure 4-1: Benthic video footage analysis (source: EcOz 2022b)

4.2 Sediment Texture

The laboratory particle size analysis data for the current investigation is reviewed and summarised below.

4.2.1 Sand Wave Dredging Areas 1-5 and Potential Spoil Grounds A and B

Sediments from sand wave dredging areas 1-5 (sampling locations S1 to S13, see Table 3-3), which were sampled by coring, were predominantly sands or gravelly sands (48-95% sand-sized material, 4-33% gravel) with generally minor proportions of silt- and clay-sized material. The grainsize of the 0.5-1.0 m sample tended to be slightly finer than the 0-0.5 m sample (Figure 4-2).

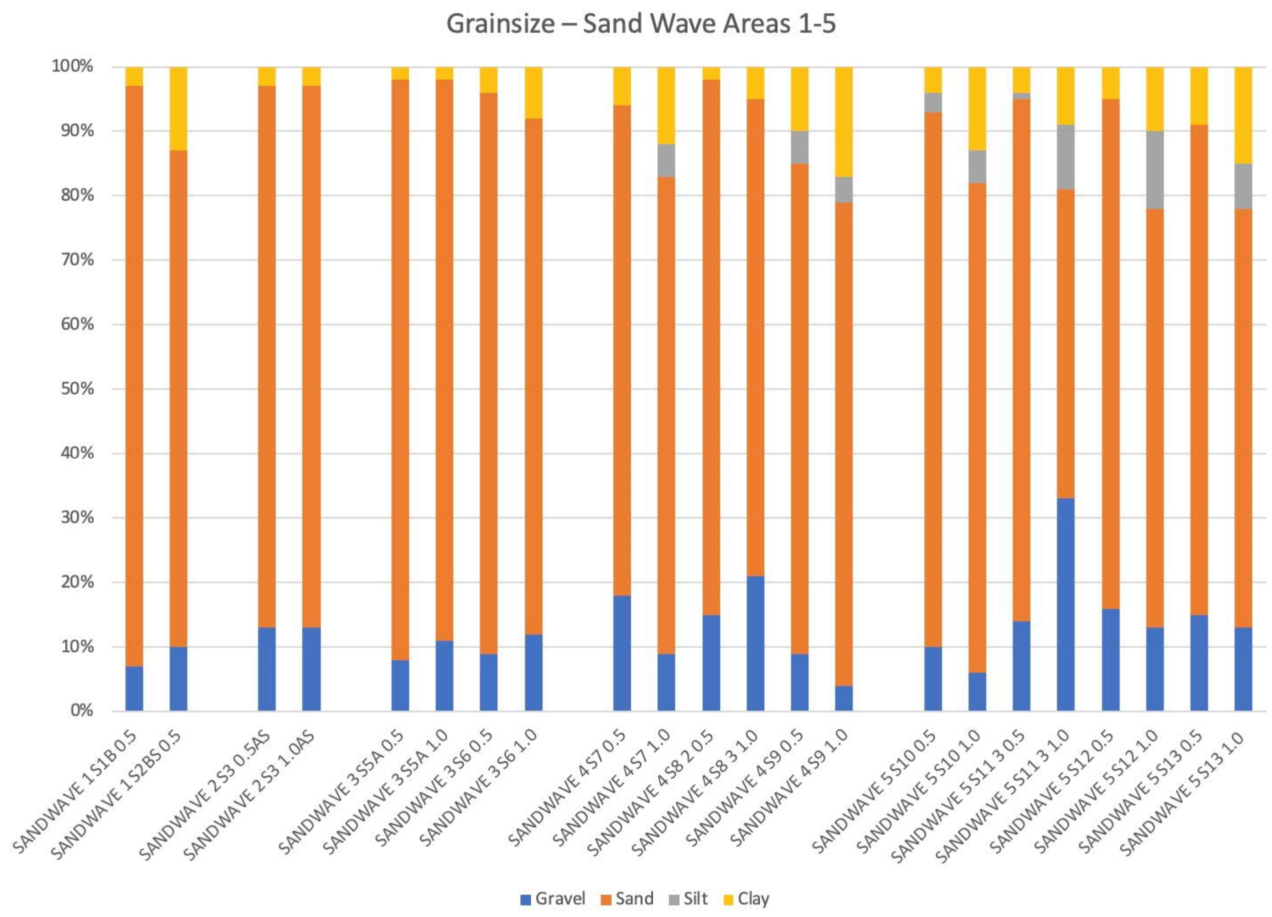

Figure 4-2: Grainsize distribution, 0.5 m and 1.0 m samples from cores, sand wave areas 1-5

Sediments from the two potential spoil grounds (Spoil Grounds A and B), which were obtained by grab sampler, were muddy sands (typically 59-75% sand-sized material), with a gravel content of 4-26% (Figure 4-3 and Figure 4-4).

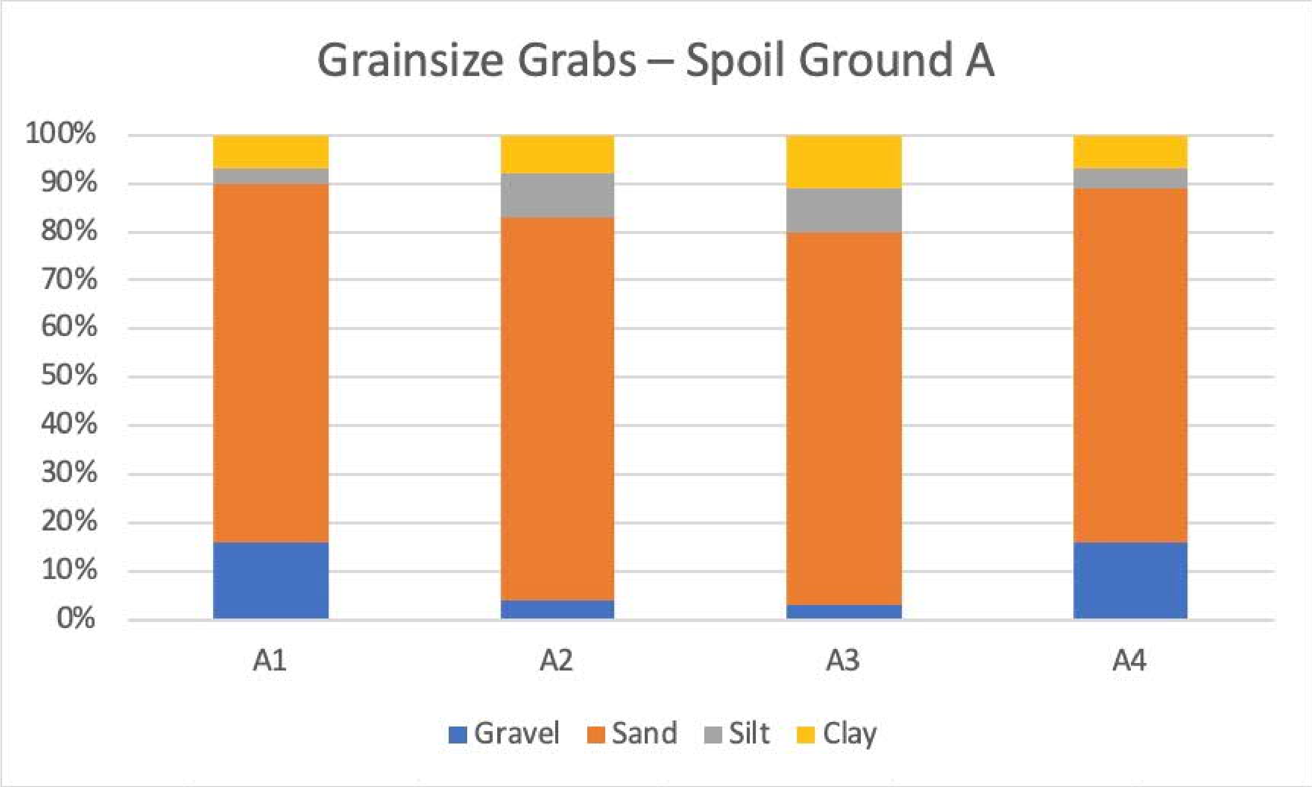

Figure 4-3: Grainsize distribution, grab samples from Spoil Ground A

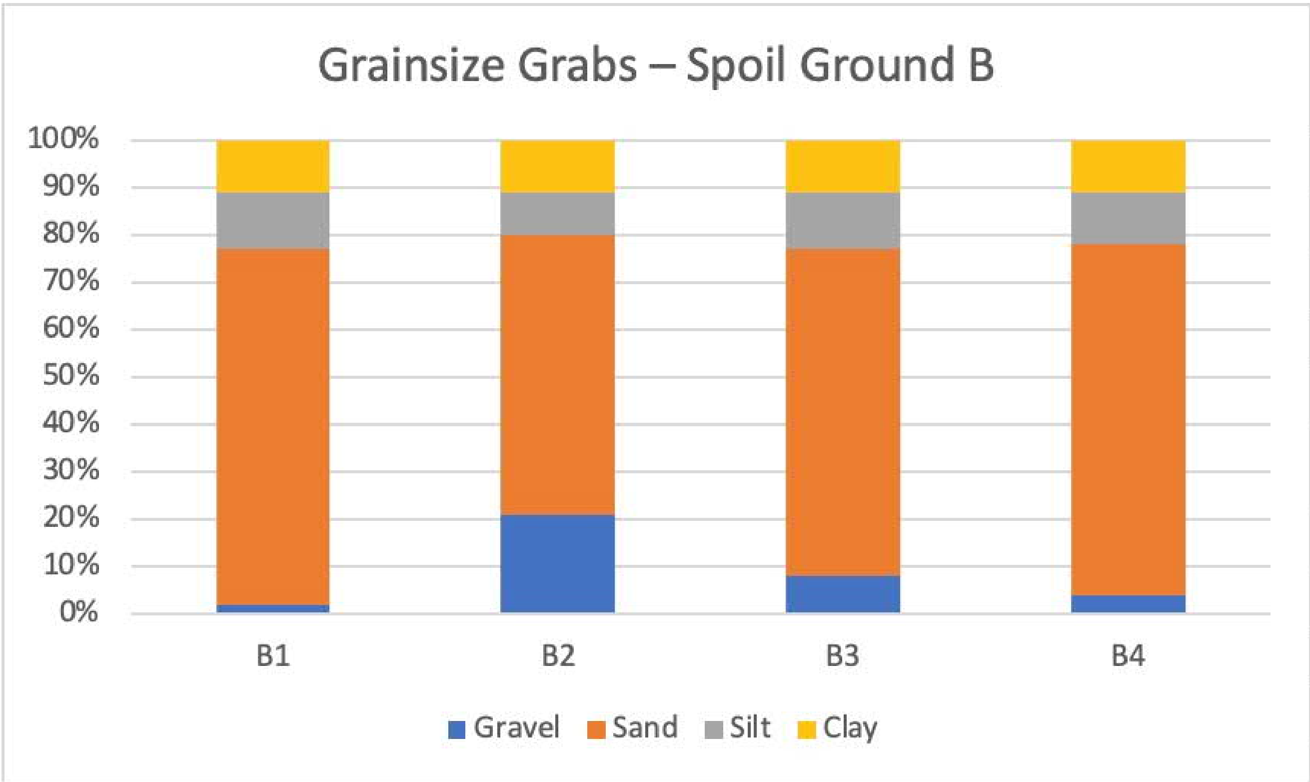

Figure 4-4: Grainsize distribution, grab samples from Spoil Ground B

4.2.2 Sand Wave Dredging Areas 17-18 and Potential Spoil Ground D

The surface and near-surface sediments from sand wave dredging areas 17-18 (sampling locations S14 to S31, Figure 4-5), were variable in texture. Most of the sediments were sands or silty sands (70-90% sand-sized material) with minor proportions of silt, clay, and gravel, with the 0.5-1.0 m sample often being slightly finer than the 0-0.5 m sample. However, in a number of cores (S18, S18 2A, S18 3, S19, S22, S24, S26B and S28) the lower sample was significantly finer than the upper sample. Some of these samples were sandy clays or sandy silty clays.

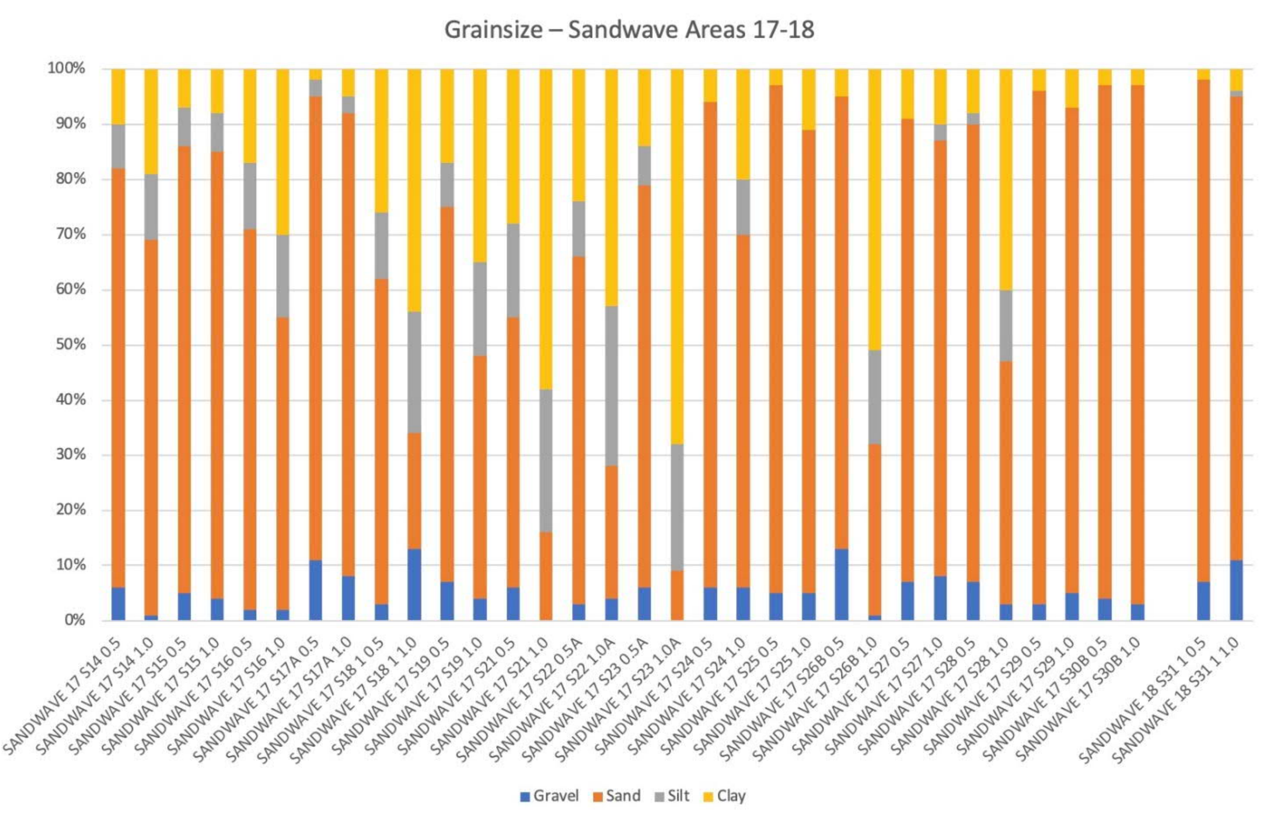

Figure 4-5: Grainsize distribution, 0.5 m and 1.0 m samples from cores, sand wave areas 17-18

Sediments from the nearby Potential Spoil Ground D were sands with approximately 90% sand-sized material and minor fines and gravel (Figure 4-6).

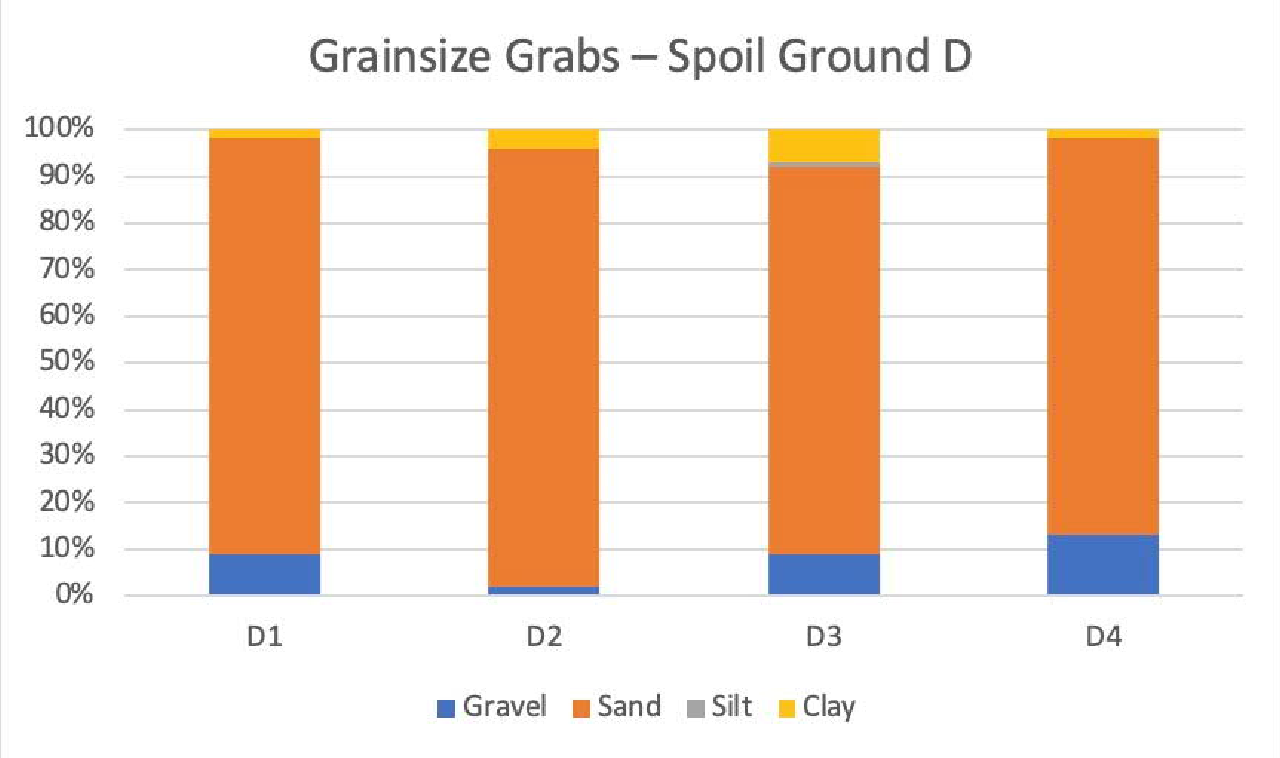

Figure 4-6: Grainsize distribution, grab samples from Spoil Ground D

4.2.3 Sand Wave Dredging Areas 19-20 and Potential Spoil Ground C

Sediments from Sand Wave Dredging Areas 19-20 (sampling locations S32 to S34) were mostly sands or gravelly sands (Figure 4-7). In cores S33 and S34 the lower sample from the core was finer than the upper half. These samples would be classified as gravelly muddy sands.

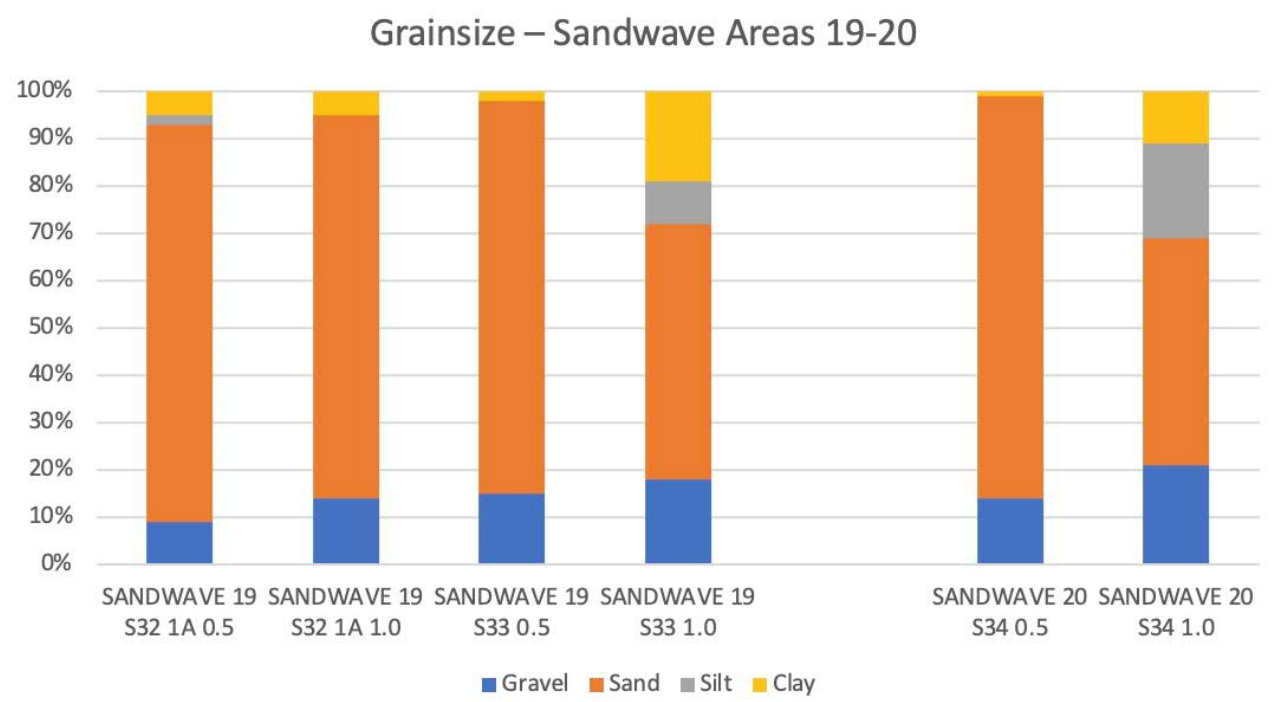

Figure 4-7: Grainsize distribution, 0.5 m and 1.0 m samples from cores, sand wave areas 19-20

Sediments from the nearby Spoil Ground C (Figure 4-8) were gravelly sands or gravelly muddy sands with a sand content of 48-74% and gravel content of 10-36%, except for sample VC8 C 1.0 which had 50% gravel and was classed as a sandy muddy gravel.

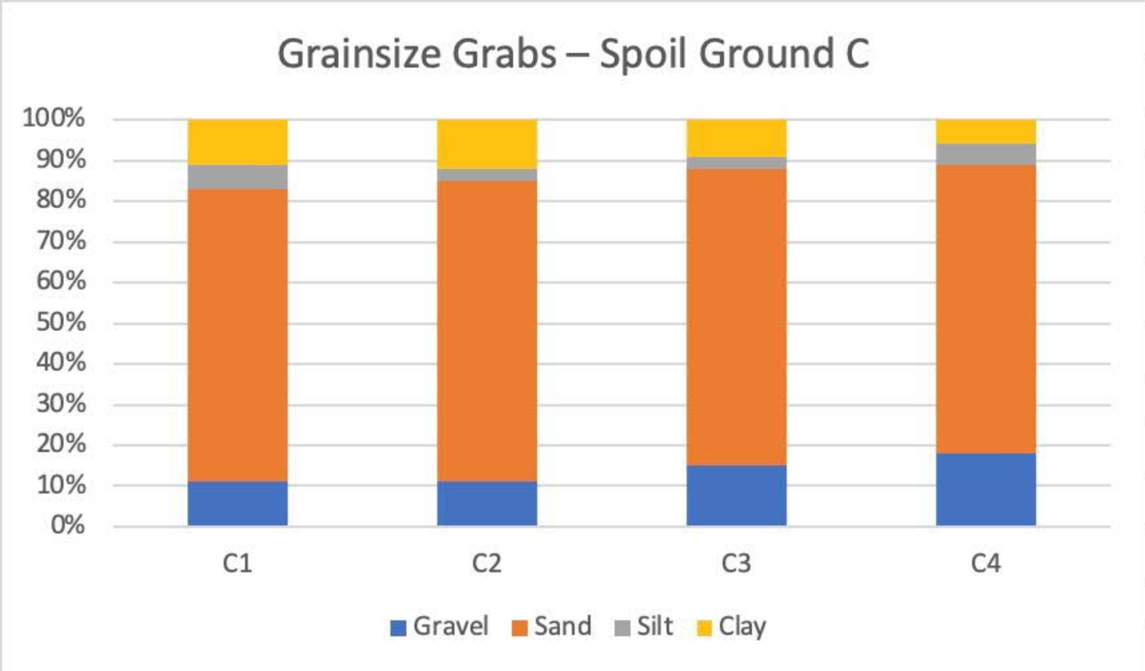

Figure 4-8: Grainsize distribution, grab samples from Spoil Ground C

4.3 Sediment Chemistry

Chemical analysis has not previously been done along the original cable route described in the Draft EIS, or the revised route to Murrumujuk. There is little chemical data in the scientific literature for the far offshore sediments in the region, but a number of studies have sampled the Darwin Outer Harbour area and Shoal Bay (Inpex, 2018; Radke et al., 2020: RPS, 2021).

4.3.1 Sand Wave Dredging Areas 1-5 and Potential Spoil Grounds A and B

Metals and Metalloids

The NAGD-specified metals analysed (cadmium, chromium, copper, lead, mercury, nickel, and zinc) were found to be at very low levels, typical of natural levels in uncontaminated marine sediments, in all samples. These metals were well below the National Assessment Guidelines for Dredging (NAGD) 2009 Screening Levels in all samples. Cadmium was seldom detected, and mercury and antimony not detected in any sample (Table 4-3). Aluminium and iron, which are not considered toxic in marine sediments, were analysed for normalising purposes and were also present at low levels. This was consistent with other investigations in the area (Inpex, 2018; Radke et al., 2020: RPS, 2021).

The metalloid arsenic was often present at levels exceeding the NAGD Screening Level of 20 mg/kg, however arsenic is known to be naturally high in marine sediments from much of Australia, including sediments of the Darwin Outer Harbour area and Shoal Bay, where the levels reported in the scientific literature are comparable to those found in the current investigation:

- Sediments at the Inpex offshore Dredge Spoil Disposal Ground were tested in 2012, prior to any spoil disposal, and at 71% of sampling sites arsenic was found to be above the Screening Level.

- Sediments in the Outer Darwin Harbour Area and eastern Shoal Bay (Radke et al., 2020) contained elevated arsenic levels similar to those found in the current study.
- Elevated arsenic levels were also reported in some samples from the Darwin Harbour Channel (RPS, 2021).

The high arsenic levels are considered to be due to elevated natural arsenic levels in the source rocks from which the marine sediments are derived (Radke et al., 2020).

The only notable difference between the dredging areas and potential spoil grounds was that arsenic was slightly elevated in the dredging areas compared to the disposal sites (Table 4-4).

Table 4-3: Summary of Metals Results for Sand wave Areas 1-5

Analyte	LOR (mg/kg)	NAGD Screening Level	Number of Samples	Number > LOR	Number > Screening Level*	Min	Max
Antimony	0.5	2	39	0	0	<0.5	-
Arsenic	1	20	39	39	17	9.9	41
Cadmium	0.1	1.5	39	1	0	<0.1	0.2
Chromium	1	80	39	39	0	4.8	18
Copper	1	65	39	15	0	<1	2.2
Lead	1	50	39	39	0	2.2	5.6
Mercury	0.01	0.15	39	0	0	<0.01	-
Nickel	1	21	39	39	0	2.2	7.4
Zinc	1	200	39	39	0	1.5	7.4

* 95% UCL values will be calculated once the remaining data has been received

Table 4-4: Summary of Metals Results for Potential Spoil Grounds A and B

Analyte	LOR (mg/kg)	NAGD Screening Level	Number of Samples	Number > LOR	Number > Screening Level*	Min	Max
Antimony	0.5	2	8	0	0	<0.5	-
Arsenic	1	20	8	8	0	4.1	16
Cadmium	0.1	1.5	8	2	0	<0.1	0.3
Chromium	1	80	8	8	0	11	18
Copper	1	65	8	8	0	1.4	2.7
Lead	1	50	8	8	0	3.8	4.7
Mercury	0.01	0.15	8	0	0	<0.01	-
Nickel	1	21	8	8	0	4.3	7.0
Zinc	1	200	8	8	0	4.4	8.9

* 95% UCL values will be calculated once the remaining data has been received

Organics

None of the samples from the dredging areas or the potential spoil grounds contained detectable total petroleum hydrocarbons (TPH). None of the volatile hydrocarbons (BTEXN), were detected in any sample. The low TPH and volatile hydrocarbons levels were consistent with the results of investigations at the Inpex Dredge Spoil Disposal Ground in 2012, prior to disposal (Inpex, 2018), in the outer Darwin Harbour and Shoal Bay study (Radke et al., 2020) and along the Barossa Gasfield Project offshore pipeline route (RPS, 2021).

Because TPHs were not detected, the samples were not analysed for polycyclic aromatic hydrocarbons (PAHs), which are found in petroleum hydrocarbons.

The TOC levels were very low, typically in the range of 0.1-0.3%, as would be expected in sandy sediments distant from land-based sources of organic matter. The highest TOC values were found in the finer sediments, which is also normal.

4.3.2 Sand Wave Dredging Areas 17-18 and Potential Spoil Ground D

Metals and metalloids

The metals and metalloid levels were similar to those reported above. Cadmium, chromium, copper, lead, mercury, nickel, and zinc were present at low levels, typical of natural levels in uncontaminated marine sediments. These metals were well below the National Assessment Guidelines for Dredging (NAGD) 2009 Screening Levels in all samples. Cadmium was seldom detected, and mercury and antimony not detected in any sample (Table 4-5 and Table 4-6). Some lab data is still to come. Once received, the upper 95% confidence limits (95% UCLs) will be calculated.

The metalloid arsenic was often present at levels exceeding the NAGD Screening Level of 20 mg/kg, however as detailed above, arsenic is known to be naturally high in marine sediments from much of Australia, including sediments of the Darwin Outer Harbour area and Shoal Bay, where the levels reported in the scientific literature are comparable to those found in the current investigation. This is considered to be due to elevated natural arsenic levels in the source rocks from which the marine sediments are derived (Radke et al., 2020).

Metal levels in the dredging areas were slightly higher than at the potential spoil grounds, though all metal levels were well below their NAGD Screening Levels in all samples, and hence the sediments are classed as uncontaminated.

Table 4-5: Summary of Metals Results for Sand Wave Areas 17-18

Analyte	LOR (mg/kg)	NAGD Screening Level	Number of Samples	Number > LOR	Number > Screening Level*	Min	Max
Antimony	0.5	2	52	0	0	<0.5	-
Arsenic	1	20	52	52	24	9.9	58
Cadmium	0.1	1.5	52	0	0	<0.1	0.1
Chromium	1	80	52	52	0	5.2	41
Copper	1	65	52	32	0	<1	7.4
Lead	1	50	52	52	0	3.7	18
Mercury	0.01	0.15	52	0	0	<0.01	-
Nickel	1	21	52	52	0	2.5	14
Zinc	1	200	52	52	0	2.3	20

* 95% UCL values will be calculated once the remaining data has been received

Table 4-6: Summary of Metals Results for Potential Spoil Ground D

Analyte	LOR (mg/kg)	NAGD Screening Level	Number of Samples	Number > LOR	Number > Screening Level*	Min	Max
Antimony	0.5	2	5	2	0	<0.5	0.95
Arsenic	1	20	5	5	3	16	48
Cadmium	0.1	1.5	5	0	0	<0.1	0.1
Chromium	1	80	5	5	0	5.4	19
Copper	1	65	5	3	0	<1	2.0
Lead	1	50	5	5	0	4.0	7.6
Mercury	0.01	0.15	5	0	0	<0.01	-
Nickel	1	21	5	5	0	2.8	5.6
Zinc	1	200	5	5	0	2.3	7.1

* 95% UCL values will be calculated once the remaining data has been received

Organics

Apart from one single sample (GS21-4) from the dredging area, which contained TPHs slightly above the LOR (though two orders of magnitude below the NAGD Screening Level), TPHs were not detected in any sample from either the dredging areas or Spoil Ground D. None of the volatile hydrocarbons, BTEXN, were detected in any sample. Accordingly, the samples were not analysed for polycyclic aromatic hydrocarbons (PAHs), which are found in petroleum hydrocarbons.

The TOC levels were very low, typically in the range of 0.1-0.2%, as would be expected in sandy sediments distant from land-based sources of organic matter.

There was no notable difference between the organics found in the dredging areas and the disposal site.

4.3.3 Sand Wave Dredging Areas 19-20 and Potential Spoil Ground C

Metals and Metalloids

The metals and metalloid levels were similar to those reported above. Cadmium, chromium, copper, lead, mercury, nickel, antimony, and zinc were present at low levels, typical of natural levels in uncontaminated marine sediments. These metals were well below the NAGD Screening Levels in all samples. Cadmium was seldom detected, and mercury not detected in any sample (Table 4-7 and Table 4-8).

The metalloid arsenic was often present at levels exceeding the NAGD Screening Level of 20 mg/kg, however as detailed above arsenic is known to be naturally high in marine sediments from much of Australia, including sediments of the Darwin Outer Harbour area and Shoal Bay, where the levels reported in the scientific literature are comparable to those found in the current investigation. This is considered to be due to elevated natural arsenic levels in the source rocks from which the marine sediments are derived (Radke et al., 2020).

Metal levels in the dredging areas were similar to those at the disposal sites. All metal levels were well below their NAGD Screening Levels in all samples, and hence the sediments are classed as uncontaminated.

Table 4-7: Summary of Metals Results for Sand wave Areas 19-20

Analyte	LOR (mg/kg)	NAGD Screening Level	Number of Samples	Number > LOR	Number > Screening Level*	Min	Max
Antimony	0.5	2	7	0	0	<0.5	-
Arsenic	1	20	7	10	4	12	36
Cadmium	0.1	1.5	7	0	0	<0.1	0.1
Chromium	1	80	7	10	0	6.6	20
Copper	1	65	7	4	0	<1	2.5
Lead	1	50	7	10	0	3.2	5.5
Mercury	0.01	0.15	7	0	0	<0.01	-
Nickel	1	21	7	10	0	3.2	7.1
Zinc	1	200	7	10	0	2.2	9.3

* 95% UCL values will be calculated once the remaining data has been received

Table 4-8: Summary of Metals Results for Potential Spoil Ground C

Analyte	LOR (mg/kg)	NAGD Screening Level	Number of samples	Number > LOR	Number > Screening Level*	Min	Max
Antimony	0.5	2	6	1	0	<0.5	0.9
Arsenic	1	20	6	6	2	13	30
Cadmium	0.1	1.5	6	0	0	<0.1	0.1
Chromium	1	80	6	6	0	13	21
Copper	1	65	6	6	0	1.8	2.9
Lead	1	50	6	6	0	4.9	6.9
Mercury	0.01	0.15	6	0	0	<0.01	-
Nickel	1	21	6	6	0	5.0	8.1
Zinc	1	200	6	6	0	5.9	10.2

* 95% UCL values will be calculated once the remaining data has been received

Organics

TPHs were not detected in any sample from the dredging areas. Four samples from Spoil Ground D contained TPHs slightly above the LOR (though two orders of magnitude below the NAGD Screening Level), None of the volatile hydrocarbons, BTEXN, were detected in any sample. The samples were not analysed for PAHs, which are found in petroleum hydrocarbons.

The TOC levels were very low, typically in the range of 0.1-0.3%, as would be expected in sandy sediments distant from land-based sources of organic matter.

There was no notable difference between the organics found in the dredging areas and the potential spoil grounds.

4.4 QA/QC and Data Validation

4.4.1 Field QA/QC

Field work was carried out by Guardian on board the survey vessel, following methods specified in the SAP. There were some issues because, due to the identification of sand wave areas 17-20 and consequently a significant additional dredging requirement during the survey, the SAP was still being updated for the many additional sample locations for several days after sampling began on August 28. However:

- Samples were collected at all locations specified in the final SAP (Rev 5), and extra (contingency) samples were collected at many locations in case follow-up analysis was required.
- Subsampling for chemical, physical, and biological testing was completed at all locations.

Compliance with field QA/QC procedures is summarised in Table 4-9. Incomplete compliance with some of the DQIs and issues with compliance are reviewed below.

Table 4-9: Field QA/QC Assessment

Procedure	Data Quality Indicators and Notes	Compliance (see Notes below)
Personnel	All samples collected and handled in accordance with the SAP, by experienced professionals	Complied with.
Data collection	All sites sampled using appropriate Standard Operating Procedures (SOPs) based on the SAP.	Complied with.
	Any variations to the SAP noted and explained.	Complied with.
	Appropriate description of site conditions.	Complied with.
	Sample locations correct and adequately described.	Complied with.
	Field notes and logs complete and signed and dated each day.	Complied with apart from signatures.
Sample handling	Sediment and rinsate samples collected in laboratory supplied jars/vials, appropriately labelled, and refrigerated at <6oC until shipment.	Complied with.
	During shipment, samples stored in insulated, chilled containers with sufficient freezer bricks to maintain temperature until receipt by the analysing lab.	Complied with.
	Chain-of-custody (CoC) documentation complete, including sample numbers and types, dates, sampler name, preservation and analysis requirements, and signatures of sampler and lab.	Some CoC issues (see discussion below).
	Sample receipt notices (SRN) from lab that all samples on CoCs received chilled and intact, and within holding times.	Holding times mostly complied with. Some Eskies had elevated internal temperature.
Calibration of field equipment	Not required in this study.	Not applicable.
Intra-lab duplicates Inter-lab duplicates (field splits)	Two samples from a field-homogenised subsample, analysed to identify variations due to handling of subsamples. Collected & analysed at a rate of 5% of the primary samples.	Complied with.

Procedure	Data Quality Indicators and Notes	Compliance (see Notes below)
	Two samples from a field-homogenised subsample, analysed to identify analysis variations, sent to different labs. Collected & analysed at a rate of 5% of the primary samples. Acceptance criteria, either <5 x LOR = no limit on RPD, >5 x LOR = 0-50% RPD – or as specified on lab certificates.	Partly complied with. Complied with.
Field triplicate	Three separate samples (usually cores) collected at the same location. Determines the variability in sediment physical and chemical characteristics.	Complied with. The chemical and physical properties of the triplicate cores and grab samples were generally similar, indicating that the samples were representative of the sediments being sampled.
Trip blanks and trip spikes for volatiles	Trip blank included in each sample shipment to assess the potential for loss of volatiles during storage and transport. Analyte concentrations should be < LOR. Trip spike included in each sample shipment to assess the potential for cross-contamination from volatiles during storage and transport. Analyte recoveries should be > 90% of the original spikes or as specified on the lab certificate.	Not fully complied with. Not fully complied with.
Rinsate blanks	Rinsate or wash blanks collected from each piece of re-used equipment to determine any cross-contamination between samples or subsamples. Analyte levels should be < LORs.	Not fully complied with.

COC Issues

There were a number of discrepancies between the samples recorded on the CoC forms and the samples received by ALS and recorded on the Sample Receipt Notices (SRNs):

- Work Order ES2230841. Forty-nine samples received that were not on the CoC. Twenty-three samples on the CoC were not supplied. Three particle size distribution (PSD) bags not supplied.
- Work Order ES2231582. two samples received that were not on the CoC. Two samples not on the CoC were received.
- Work Order ES2231586. One sample was received empty and could not be analysed.
- Work Order ES2231587. Two samples 'not received' but later in sample receipt notice listed as 'On Hold.'
- Work Order ES2231627. One sample received empty. Three water samples not received. One PSD bag not received.

The discrepancies were resolved between Guardian and ALS and all samples (apart from a few empty samples and samples not received) were analysed.

Many of the additional samples were sent in case follow-up analysis was required and were placed on hold. As it happened, follow-up analysis was not required because the sediments were classified as uncontaminated according to NAGD requirements.

The two samples for vibrocore location V20 were mislabelled, and ALS placed them on hold. Analysis of these samples has been requested and is pending.

The above issues are not considered to have affected the assessment.

SRN Issues

The Esky internal temperature reported in the SRN for Work Order ES2230841 was 13.1oC, well above the recommended maximum of 6oC. It is possible that this could have affected the volatiles in the samples, although given that none of the samples from any location contained significant hydrocarbons this is unlikely to have affected the validity of the results.

Holding Times

The four rinsate water samples analysed (RIN_3-6) had exceeded their holding times for TOC. This is not an issue as TOC was not required to be analysed on these rinsate samples. No other holding time breaches were reported on the SRNs.

Field (split) Replicates (inter-lab and intra-lab)

All the field split replicates analysed at ALS met the required RPD value for all analytes detected.

None of the split triplicate sediment samples were sent to a reference lab, as required. The split triplicates have been identified and are being sent to a second lab (SESL) for analysis, however they can only be analysed for metals and metalloids (except mercury) and TOC, because the holding times for TPH and BTEXN have expired. Once the analyses are received, the RPD values will be calculated and compared to the relevant DQIs.

Trip Blanks and Spikes for Volatiles

Three blank containers were sent to ALS for testing, but none were tested. No trip spike samples were sent. However, given that no volatiles were detected in any sample from any of the locations, the shortfall of trip blanks and spikes would not have affected the results.

Rinsate Blanks

Six rinsate blanks were sent to ALS for testing but only three were tested for the list of analytes. The metal levels were all less than the LORs. Given the very low levels of contaminants found throughout the sampling areas, this is not considered to have affected the validity of the results.

4.4.2 Laboratory QA/QC

Laboratory analysis was carried out by ALS, the main laboratory, and is being carried out by a reference laboratory for analysis of the third triplicate samples. Data from the reference lab has not yet been received.

Compliance with laboratory QA/QC procedures is summarised in Table 4-10. Incomplete compliance with the DQIs and issues with compliance are reviewed below.

Table 4-10: Laboratory QA/QC Assessment

Procedure	Data Quality Indicators and Notes	Compliance (see Notes below)
Analysis	All analyses done by standard procedures for marine samples.	Complied with.
Holding times	Holding times for the various analytes in sediments and soils are as specified above.	Mostly complied with.
Detection limits	Laboratory LORs as specified above, to meet NAGD requirements.	Complied with.
Lab blanks	Prepared by the lab to identify cross-contamination of samples during handling, extraction, and analysis. To be analysed at a rate of 5 % of samples, with a minimum of 1 per batch. Analyte concentrations should be < LORs.	Complied with.
Lab duplicates	To be analysed at a rate of 5 % of samples, with a minimum of 1 per batch. Duplicates are a separate subsample taken from the sample jar. The lab mixes the sediment as best they can in the jar then takes out 2 separate subsamples. These are then carried through the whole preparation process. Acceptance criteria vary and are as specified on lab certificates.	Complied with apart from one outlier for one analyte on one sample. Complied with.
Lab standard or control samples	Standard samples of known composition included in each batch to check analysis accuracy. To be analysed at a rate of 5% of samples, with a minimum of 1 per batch. Analyte concentrations should be < LORs. Control limits vary and are as specified on lab certificates.	Complied with. Complied with.
Matrix and surrogate spikes	Matrix spikes determine interference from the sample matrix on contaminant recovery. A field sample is divided into two aliquots and spiked with identical levels of analytes, at a rate of 5% of samples. Matrix spike control limits vary and are as specified on lab certificates. Matrix spike duplicates, RPDs as specified on lab certificates. Surrogate spikes (organic compounds only) are compounds similar to the target analyte, but unlikely to be present in the sample. The recovery rate indicates the lab's ability to extract the analyte from the sample matrix. Recovery rates vary and are as specified on lab certificates.	Complied with. Mostly complied with.
Completeness objective of study	Minimum of 95% of all data for the submitted samples validated as suitable for use for project objectives.	Complied with. More than 95% of the data was validated as suitable for use.

Review of Outliers from the ALS QC and QCI Reports for the Following Work Orders:

- ES2230841 – No QC sample outliers. One duplicate outlier. No QC sample frequency outliers.

- Duplicate RPD for aluminium exceeded control limits on one sample. This does not affect the assessment as aluminium is not a NAGD contaminant.

- ES2231582 – no QC outliers, some holding time outliers. No QC sample frequency outliers.
  - 7 samples exceeded their holding times for analysis for moisture content by one day. This does not affect the assessment as it is unlikely to have significantly changed the calculated values, and the analytes detected (metals) were all well below their NAGD Screening Levels or, in the case of arsenic, known to be naturally high in the region.
- ES2231583 – no QC outliers, no holding time outliers. No QC sample frequency outliers.
- ES2231584 – no QC outliers, no holding time outliers. No QC sample frequency outliers.
- ES2231585 – one surrogate recovery outlier. No other QC outliers, no holding time outliers. No QC sample frequency outliers.
  - Surrogate recovery was greater than the upper data quality objective on one sample for TPH and BTEX. This does not affect the assessment as TPH and BTEX were below LORs on almost all samples.
- ES2231586 – no QC outliers, no holding time outliers. No QC sample frequency outliers.
- ES2231587 – 17 surrogate recovery outliers. No other QC outliers, one holding time outlier. No QC sample frequency outliers.
  - Surrogate recovery was less than the lower data quality objective on 17 samples for TPH and BTEX. This does not affect the assessment as TPH and BTEX were below LORs on almost all samples.
  - The holding time for analysis of TOC on one rinsate sample was exceeded by 6 days. This does not affect the assessment as TOC analysis was not required on the rinsate samples.
- ES2231588 – 7 surrogate recovery outliers. No other QC outliers, no holding time outliers. No QC sample frequency outliers.
  - Surrogate recovery was less than the lower data quality objective on 7 samples for TPH and BTEX. This does not affect the assessment as TPH and BTEX were below LORs on almost all samples.
- ES2231627– 14 surrogate recovery outliers. No other QC outliers, some holding time outliers. No QC sample frequency outliers.
  - Surrogate recovery was less than the lower data quality objective on 14 samples for TPH and BTEX. This does not affect the assessment as TPH and BTEX were below LORs on almost all samples.
  - 5 samples exceeded their holding times for analysis for moisture content by 5 days. This does not affect the assessment as it is unlikely to have significantly changed the calculated values, and the analytes detected (metals) were all well below their NAGD Screening Levels or, in the case of arsenic, known to be naturally high in the region.

4.4.3 Conclusion

The chemical data quality was reviewed. Based on the data validation it is concluded that the overall analysis results were representative of the sediments sampled and were suitable for assessing the suitability of the sediments for offshore disposal, according to the requirements of the NAGD.

5 Summary and Conclusions

The SAP prepared by PR was implemented by Guardian in August-September 2022 to collect sediment samples from nine proposed sand wave dredging areas and four potential spoil grounds, for a proposed dredging volume of 264,962 m^3.

Vibrocore samples were collected at 34 locations in the dredging areas. 11 grab samples were also collected. The number of samples collected and analysed exceeds NAGD requirements for the proposed volume of dredging. The core samples were sent for physical and chemical testing, and the grab samples for chemical, physical and biological testing.

Grab samples were also collected from 16 potential spoil ground locations and sent for chemical, physical and biological testing.

Physical and chemical testing was carried out by ALS, benthic invertebrate analysis by Benthic Australia and habitat assessment of the underwater video footage by EcOz. Reference samples are being analysed by SESL Australia.

The sediment sampling was completed according to the SAP. The chemical data quality was reviewed by PR. The data validation concluded that the overall analysis results were representative and suitable for assessing the suitability of the sediments for offshore disposal, according to the requirements of the NAGD.

Conclusions of this SAPIR:

- Sediments in the proposed dredging areas and potential spoil disposal grounds were typically gravelly carbonate sands, gravelly muddy carbonate sands or muddy carbonate sands. The lower sample from cores tended to be finer than the upper sample. In sand wave areas 17 and 18 the lower sample from a number of cores was significantly finer than the upper sample. Some of these samples would be classified as sandy carbonate clays or sandy silty carbonate clays.
- The levels of all metals and metalloids except arsenic were either not detected or below their relevant NAGD Screening Levels in all samples.
- The levels of arsenic frequently exceeded the NAGD Screening Levels, however arsenic is known to be naturally elevated in the region, including the sediments of the Outer Darwin Harbour and Shoal Bay. The arsenic levels found in this investigation were comparable to those reported in the scientific literature for this region and for Shoal Bay (Inpex, 2018; Radke et al., 2020; RPS, 2021).
- The levels of BTEXN and TPH were well below the NAGD Screening Levels in all samples, and not detected in most of the samples.
- The above data indicate that the sediments are uncontaminated and meet NAGD requirements for unconfined offshore disposal.

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Appendix 1 - Sampling and Analysis Plan

This document is ‘Commercial in confidence’ and has been attached as a separate item (Appendix 5.4 of the SEIS) for the NT EPA.