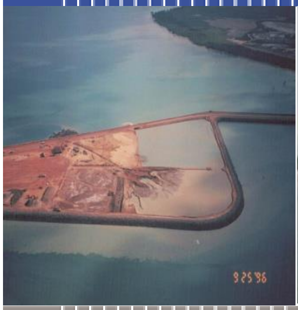


Report

Tug Pen and Small Vessel Berths

Dredging Sampling and Analysis Plan

10 FEBRUARY 2014

Prepared for

Darwin Port Corporation

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Abbreviations

Abbreviation	Description
ANC	Acid neutralising capacity
ANZECC	Australian and New Zealand Environment Conservation Council
ASS	acid sulphate soils
CBD	Central Business District
CD	Chart Datum
DHAC	Darwin Harbour Advisory Committee
DLP	(NT former) Department of Lands and Planning
DoE	Commonwealth Department of the Environment (formerly DSEWPaC)
DPC	Darwin Port Corporation
EAW	East Arm Wharf
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPBC	Environment Protection and Biodiversity Conservation
HSEP	Health, Safety and Environment Plan
ISQG – Low	Interim Sediment Quality Guidelines – low
LNG	liquefied natural gas
MSB	Marine Supply Base
MUBF	Multi User Barge Ramp Facility
NAGD	National Assessment Guidelines for Dredging
NATA	National Association of Testing Authorities
NT	Northern Territory
NTG	Northern Territory Government
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PQL	Practical quantification limit
PSD	Particle size distribution analyses
PSV	Platform support vessel
PWC	Power and Water Corporation
QA/QC	Quality assurance/quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SAP	Sampling and Analysis Plan
SCr	Chromium reducible sulphur
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate [Suite]
TAA	Total actual acidity
TBT	Tributyltin
TOC	Total Organic Carbon
TPH	Total petroleum hydrocarbons
UCL	Upper Confidence Limit
URS	URS Australia Pty Ltd

Abbreviations

Units of Measurement

Abbreviation / Symbol	Description
%	percent
-	minus
>	greater than
°C	degrees Celsius
x	times
bq/kg	Becquerel per kilogram
g	gram/s
ha	hectare/s
kg	kilogram/s
km	kilometre/s
km^2	square kilometre/s
m	metre/s
m^3	cubic metre/s
mg	milligram/s
mg/kg	milligram/s per kilogram
ml	millilitre/s
t	tonne/s

Introduction

1.1 Background

The Northern Territory Government (NTG) has proposed an expansion of the East Arm Wharf (EAW) in Darwin Harbour to accommodate the requirements of existing and prospective wharf users. The major features of the project (refer **Figure 1-1**) are as follows:

- Developing a Marine Supply Base (MSB), primarily to service the existing and developing oil and gas industries in the Timor Sea, Browse Basin and adjacent areas.
- Constructing a Multi User Barge Facility (MUBF) including a barge ramp and hardstand area, berthing for barges and facilities for loading and unloading.
- Development of tug pen and small vessel berths to accommodate tugs, customs boats and other smaller vessels.

Increased traffic at East Arm is necessitating a greater number of tug boats and other small vessels, requiring the construction of a dedicated mooring facility suitable for tugs and other small craft. The facility will be situated on the northern side of the EAW groyne and is within the restricted access area of the EAW, owned by the Darwin Port Corporation (DPC), with land-based access to the wharf via Berrimah Road.

The EAW Expansion Project was subject to an Environmental Impact Assessment (EIA) and an Environmental Impact Statement (EIS) was developed to investigate the potential impacts of the development on the surrounding marine and terrestrial environments (DLP 2011a; DLP 2011b). The EIS was submitted to the Northern Territory (NT) Environmental Protection Agency (EPA)[1] and the Department of Environment (DoE)[2] for consideration.

The project received approval under the NT *Environmental Assessment Act 1982* in December 2011 and conditional approval by DoE under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) in March 2012 in the form of Approval EPBC 2010/5304.

Figure 1-1 displays the East Arm Wharf Expansion components.

This sampling and analysis plan (SAP) has been developed for the tug pen and small vessel berths, for which design and siting options are still being finalised. The potential dredge footprint used for the determination of the sampling area in this SAP (as shown in **Figure 1-2**) has been developed to ensure that all potential tug pen design and siting options along the northern face of the EAW groyne are appropriately included in the coverage of sampling (refer Section 1.3 for further details).

The SAP addresses the requirements set out in Conditions 24 and 25 of the Commonwealth project approval (EPBC 2010/5304) under sections 130(1) and 133 of the EPBC Act.

1.2 Proposed dredging

The bathymetry surrounding the tug pen and small vessel berth location is detailed on **Figure 1-2.**

The dredge volume proposed within the EIS was 181,000 cubic metres (m^3); however current calculations indicate that this is likely to be significantly reduced to between 30,000 m^3 and 115,000 m^3. The maximum dredge depth has been reduced from -7 m Chart Datum (CD) to -6 m CD. Depending on the design configuration selected, the actual dredge footprint may be less than the concept area included in the EIS.

[1] Formerly the Department of Natural Resources, Environment, the Arts and Sport (NRETAS)
[2] Formerly Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC)

Geotechnical drilling was undertaken in early 2011 and reported on by Aurecon Australia Pty Ltd at the nine borehole locations shown on **Figure 1-2.** The thickness of unconsolidated sediment encountered varied considerably, with a minimum thickness of 1.8 m at borehole T1 (located well to the west of the proposed dredging footprint) and a maximum thickness of 8.4 m in borehole T22. The Burrell Creek Formation was encountered at a level of -8.47 to -10.59 m CD.

Predominantly fine grained deposits were encountered, with granular content of less than 40%. Gravel was found in only one sample. In general, the alluvial material in this area was described as silty clay with trace sand. The majority of Atterberg limits indicated that the sediment is clay of high plasticity (Aurecon, 2011). The relevant section of the Aurecon Report is attached as **Appendix A**.

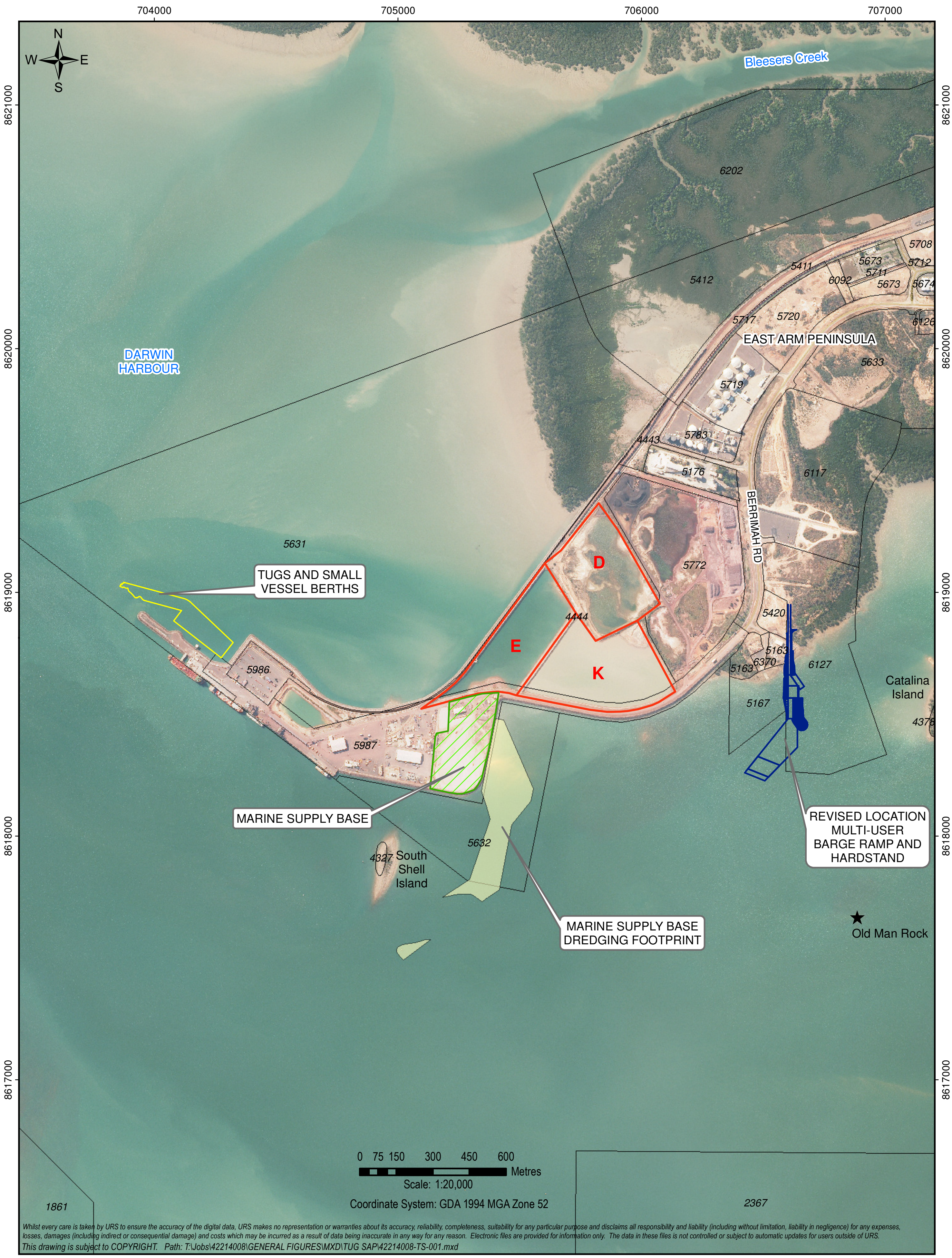
Given the above information, this SAP has been prepared on the basis that all material to be dredged is unconsolidated sediments (silts, clays and sand).

1.3 Proposed investigation

URS Australia Pty Ltd (URS) has been commissioned by the DPC to develop this SAP with reference to the *National Assessment Guidelines for Dredging* (NAGD) (Commonwealth of Australia 2009), hereafter 'NAGD (2009)'. The SAP assesses the proposed dredging options and available historical data on the physical and chemical characteristics of sediments in the vicinity of the tug pen facility (Phase I assessment). In addition, the sampling and analysis of sediments for contaminants listed on the Contaminants List (Section 3.2) and a comparison to Screening Levels (Phase II assessment) are detailed in the Sampling Methods (Section 5).

Elutriate and bioavailability testing (Phase III) and assessment of toxicity and bioaccumulation (Phase IV) may not be required, depending on the outcomes of the Phase II assessments. However, if necessary, Phase III and Phase IV assessments will be undertaken in the event that the upper 95% confidence limit of mean concentrations of contaminants in sediment exceed NAGD (2009) Screening Levels.

Geochemical testing of sediments in the sampling zone is proposed to assess the distribution and variability of contaminant concentrations and to compare these concentrations to Screening Level values in the NAGD (2009). The data can be used to classify the sediments in a single dredge management unit or, if required, to define several distinct dredge management units, dependent on the final dredging plan.



EAW EXPANSION PROJECT COMPONENTS

URS

TUG PEN FACILITY DREDGING SAP

Figure: **1-1**

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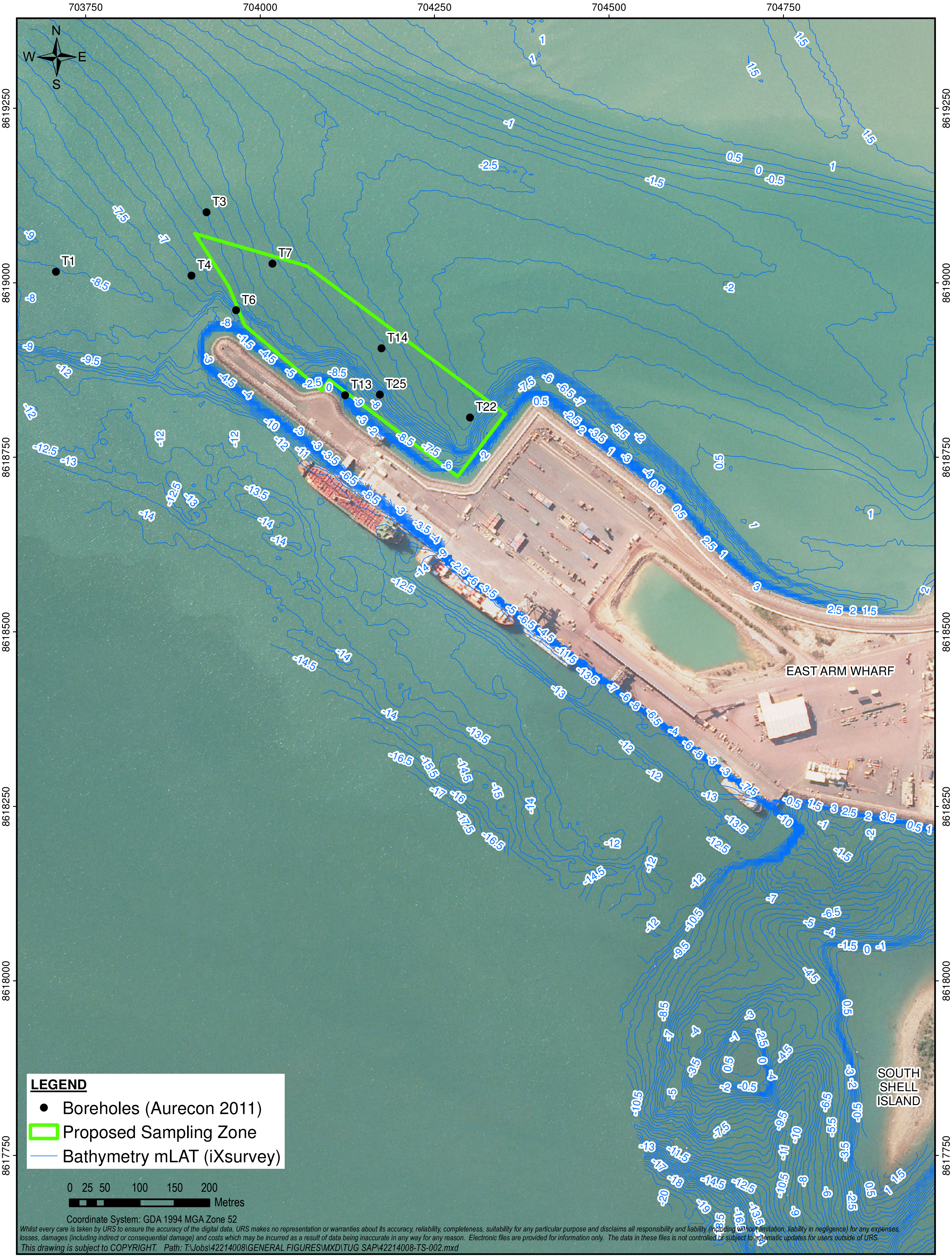

LOCATION OF PROPOSED SEDIMENT SAMPLING PROGRAM

URS

TUG PEN FACILITY DREDGING SAP

Figure: 1-2

File: **42214008-TS-002.mxd** Drawn: **JD** Approved: **JVR** Date: **10/02/2014** Rev. **A** A4

1.4 Objectives

The purpose of this SAP is to describe the location and number of seafloor sediment samples, the sampling methodology, analytical and sample transport procedures to assess the physical and chemical characteristics of the sediments proposed to be dredged and to assess their suitability for disposal.

Specifically, investigations to support the proposed dredging program at EAW have the following objectives:

- Complete a field sampling and analytical program of sediment proposed for dredging in accordance with guidance provided in the NAGD (2009).
- Determine whether the quality and quantity of data gathered are sufficient to adequately characterise the contamination status of the sediments to assess disposal and re-use options.

Data quality objectives for the program are:

- To collect and retain, in accordance with the SAP procedures, the required number of cores and samples to assess contamination levels in accordance with the NAGD (2009).
- To collect and retain, in accordance with the SAP procedures, the required number of quality assurance/quality control (QA/QC) samples to assess data quality in accordance with the NAGD (2009).
- For analysis of the samples to be undertaken at a National Association of Testing Authorities (NATA) accredited laboratory in accordance with laboratory QA/QC procedures and NAGD (2009) analysis procedures.
- For the SAP report to undergo independent detail checks and technical reviews before the results are provided to DoE and utilised in the Water Quality Management Plan for the project, as detailed in Conditions 26 and 28 of the Commonwealth project approval (EPBC 2010/5304).

1.5 SAP review and approval

This SAP has been reviewed and approved for release to the client by Ian Baxter of URS, who is a member of the Consultancy Panel for DoE, for whom reviews are undertaken of documents submitted in support of applications for the disposal of dredged material (under the *Environment Protection [Sea Dumping] Act 1981*).

For ease of review of this SAP by the Commonwealth DoE, **Appendix B** of the SAP details in which sections of the SAP that the relevant guidance provided in Appendix B of the NAGD (2009) has been addressed.

1 Introduction

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Environmental Setting

2.1 Darwin Harbour

2.1.1 Physical characteristics

Darwin Harbour is a large ria system, or drowned river valley, formed by post-glacial marine flooding of a dissected plateau. The harbour was formed by rising sea levels about 6000-8000 years ago and has a surface area variously described as between 500 and 1,000 square kilometres (km^2), depending upon the boundaries applied (e.g. Padovan 2001, Darwin Harbour Advisory Committee [DHAC] 2003; INPEX 2010; DLP 2011). In its southern and south-eastern portions, the harbour has three main components: East, West and Middle Arms which merge into a single unit, along with the smaller Woods Inlet, before opening into Beagle Gulf to the north.

The harbour extends for more than 30 kilometres (km) along this north-north-east – south-south-westerly oriented axis. The Elizabeth River flows into East Arm, while the Darwin and Blackmore rivers flow into Middle Arm. During the dry season (May to September) the estuary is typically well mixed, but freshwater inflow from rivers during the wet season can lead to stratification of salinity in the water column in the arms of the harbour (Drewry et al. 2010).

The Darwin Harbour catchment is some 2,417 km^2, which is relatively small when compared to its estuary area of some 810 km^2 (DHAC 2003; Wolanski et al. 2005). The relatively low catchment to estuary ratio (when compared to other major Australian estuaries) was considered by DHAC (2003) to indicate that there is less potential for disturbance from runoff to the estuary than in estuaries with proportionally larger catchments.

2.1.2 Land use and contaminant loads

DHAC (2003), based on the data of Owen and Meakin (2003), determined that there was a wide diversity of land uses within the Darwin Harbour region, though almost 70% of the region was occupied by non-polluting uses (e.g. remnant native vegetation, surface water supply, conservation areas).

The Elizabeth River has the second largest catchment of the rivers entering Darwin Harbour [the largest is the Blackmore River that enters Middle Arm (Padovan 2001)]. In the late 1990s, rural land use accounted for approximately 75% of the catchment area. This is likely to have increased over the past decade, being primarily comprised of rural residential areas and small-scale horticultural developments in the upper reaches of the river. Undeveloped land (predominantly mangrove communities) fringes the river over a distance of some 25 km between the rural land use areas and East Arm, has the potential to act as a buffer to reduce the amounts of contaminants reaching East Arm from sources in the upper catchment. Padovan (2001) calculated the mean annual contaminant loads contributed to the harbour from the Elizabeth River catchment in the mid-1990s to be 69 tonnes (t) of nitrogen, 3.5 t of phosphorous, 70 kilograms (kg) of arsenic, 14 kg of cadmium, 156 kg of chromium, 373 kg of copper, 132 kg of lead, 138 kg of nickel and 1,638 kg of zinc.

Approximately 6 km upstream of EAW, the Palmerston Wastewater Treatment Plant discharges treated effluent into Myrmidon Creek, which enters the lower reaches of the Elizabeth River where it enters East Arm. The mass loadings of the release from the Plant in 2005/06 were 40 t of ammonia, 69 t of Kjeldahl nitrogen and 18 t of phosphorus (Power and Water Corporation [PWC] 2006).

Some 5 km upstream of the tug pen and small vessel berths dredging area is Hudson Creek, which supports livestock export facilities and other light industrial uses. The Hudson Creek catchment also includes rural and urban land. All of these land uses represent potential sources of contaminants that may accumulate in the tug pen and small vessel berths dredging area. In the mid-1990s, the mean annual contaminant loads contributed to the Harbour from the Hudson Creek catchment were calculated by Padovan (2001) to be 15 t of nitrogen, 3 t of phosphorous, 40 kg of arsenic, 6 kg of cadmium, 220 kg of chromium, 189 kg of copper, 327 kg of lead, 43 kg of nickel and 1,860 kg of zinc.

The Bleesers Creek catchment, directly to the north-east of the tug pen dredging area, contains a large motorsport complex, sewage treatment ponds and the Darwin Train Station as well as the industrial lots located along Berrimah Road, all of which represent potential sources of contaminants that may accumulate in the tug pen dredging area. The Charles Darwin National Park is located directly to the north of the tug pen dredging area and is considered an unlikely source of contamination due to its limited infrastructure.

Based on a number of previous studies (Section 3.1), arsenic is present in the region at concentrations potentially above screening levels as a result of the local geology, however bioavailable levels are low (refer Table 3-1).

2.1.3 Distribution of contaminants

Environmental factors that may potentially affect the distribution of contaminants within Darwin Harbour, and hence could influence the concentrations of contaminants in the sediments of the tug pen and small vessel berths dredging area, include:

- Strong tidal currents that readily mobilise seafloor sediments on flood and ebb tides, especially during spring tide periods.
- Eddies in water flows that enhance the settlement of sediments from the water column in certain areas.
- Wind-driven water circulation that can redistribute large amounts of seafloor sediments, particularly during tropical storms and cyclones.

Each of these factors would primarily influence the distribution of fine sediment fractions, to which metals are typically bound at higher densities (Batley 1995).

2.2 East Arm Wharf

EAW is located approximately 4.5 km south east of the Darwin Central Business District (CBD). Opened in 2000, the existing wharf has a continuous 754 m berth face located parallel to the main shipping channel, and incorporates a dry bulk materials handling facility featuring a ship loader designed to load Panamax class vessels and is currently used to export iron ore, manganese, and copper concentrate. EAW occupies a land area of approximately 18 hectares (ha) of sealed hard stand surface with 4,000 m² of undercover cargo handling facility, and a further 18 ha of bunded area for future reclamation. A single rail spur from the Australasia Railway runs over a 16 m wide railway causeway, linking to three rail lines to the wharf (including a 4 ha intermodal container terminal), with road access provided over the causeway from Berrimah Road (NTG 2011).

The primary role of EAW is to facilitate the movement of goods via rail, road and shipping to international markets. EAW currently services vessels handling general cargoes, live cattle exports, dry bulk imports, containerised / break bulk and specialised heavy lift cargoes, plus offshore rig tender service vessels (AECOM 2009). It is utilised by oil and gas, mining, agriculture, horticulture, bulk minerals and construction industries (DPC 2010).

2 Environmental Setting

The types and tonnages of cargo imported and exported from Darwin Port in 2012/2013 are detailed in **Table 2-1** (DPC 2013). Of note with reference to potential impacts on sediment quality are ores, minerals, chemicals and petroleum. These have historically influenced the sediment quality in the EAW area, most notably after copper concentrate spills occurred while loading in 2010 (AIMS 2010).

Table 2-1 Trade through Darwin Port in 2012/2013

Commodity	Export tonnage	Import tonnage
Beverages	22	4,921
Building supplies	238	47,731
Chemicals	1,780	200,496
Iron ore and concentrates	1,668,432	0
Manganese	888,767	0
Other dry bulk	3,163	232,298
Food Products	18	332
Glass	0	376
Livestock	118,712	0
Livestock feed	13,399	17
Machinery and equipment	4,967	18,072
Metal Products	7,173	49,208
Metal Waste	12,017	28
Motor Vehicles and Parts	403	15,804
Other	45,220	120,960
Paper	575	1,469
Petroleum	35,508	806,483
Timber	14	404
Grand Total	2,800,408	1,498,600

2 Environmental Setting

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Existing Data

3.1 Previous investigations

The NAGD (2009) state that existing chemical or toxicity data for the sediments of the area to be dredged have a maximum currency of five years, where there is no reason to believe that the contamination status has changed significantly, after which new data are required. The EAW area was subject to copper concentrate spills in 2010 (AIMS 2010), so in accordance with the guidelines, all data from 2010 and earlier are to be used for historical comparison only and cannot be used to characterise the current contaminant status of the sediments to be dredged.

Previous investigations that were conducted in the vicinity of EAW include the following:

- URS, 2012, East Arm Wharf Dredging Sampling and Analysis Plan and report, prepared for NTG Department of Lands and Planning (DLP) in April 2012.
- AIMS 2010, Investigation of Copper Concentrate Loadout at East Arm Port: Water and Sediment Quality, prepared for NTG Department of Natural Resources, Environment, the Arts and Sports, Darwin, Northern Territory.
- URS, 2009. Ichthys Gas Field Development Project: Nearshore Marine Water Quality and Sediment Study. Prepared for INPEX Browse, Ltd, 11 August 2009.
- Fortune, J, 2006. The grainsize and heavy metal content of sediment in Darwin Harbour. Report No. 14/2006D of the Aquatic Health Unit, Environmental Protection Agency, Department of Natural Resources, Environment and the Arts, Darwin, Northern Territory.

The findings of the previous investigations will assist in consideration of the potential sources of contaminants to the EAW area. Selected findings (sediment quality exceedances only) from these studies are summarised in **Table 3-1**.

Table 3-1 Sediment Sampling Results from Selected Previous Studies in the East Arm Wharf Area

Study	Analyte	Screening Level (mg/kg)	95% UCL	Comment
URS 2012	Arsenic	20	42.2	Bioavailability = low
AIMS 2010	Arsenic	20	Not calculated	Screening Level exceeded at some sites near EAW
	Copper	270	Not calculated	Exceeded at some sites near EAW. One site exceeded ANZECC bioavailability criteria.
URS 2009	Arsenic	20	37.2	Bioavailability = low
	Chromium	80	45.1	Screening Level exceeded at some sites near EAW
	Mercury	0.15	0.018	
	Nickel	21	5.9	
Fortune 2006	Arsenic	20	Not calculated	Screening Level exceeded at two sites near EAW

These studies found that although the NAGD (2009) Screening Levels were exceeded at some individual sites, the only 95% Upper Confidence Limit (UCL) level to exceed a Screening Level was arsenic in the URS (2009) study (in which elutriate testing showed that arsenic was present in a form with only low bioavailability) . Other analytes investigated in these studies did not exceed Screening Levels at any site. The URS (2012) study results showed a 95% UCL level for arsenic above the Screening Level but the distribution of arsenic within the sediment profile suggests the elevated levels are still attributable to the local geology.

3.2 Contaminants list

Taking into consideration port activities, potential catchment inputs and data from previous sediment sampling programs in East Arm, **Table 3-2** presents a list of contaminants which it is considered could be present at elevated levels in the sediments within the tug pen and small vessel berths dredging area. In addition to the listed contaminants, samples will also be tested for acid sulfate soils potential, as required by the conditions of the Commonwealth project approval.

Table 3-2 Contaminants List for Sampling in Tug Pen and Small Vessels Berths Dredging Area

Analytical Parameter	Rationale for Analysis
Particle Size Distribution Analysis (PSD)	Standard sediment analysis tool.
Total Organic Carbon (TOC)	For normalisation of organics
Antimony	Potentially found at ore export loading facilities
Aluminium	Useful for normalising elements
Arsenic	Known to be naturally high background levels
Cadmium	Common pollutant in port areas
Chromium	Elevated concentrations detected by URS (2009)
Copper	AIMS (2010) indicated the presence of elevated concentrations in port sediments
Iron	Exported from EAW
Lead	Common pollutant in port areas
Manganese	Exported from EAW
Mercury	Elevated concentrations detected by URS (2009)
Nickel	Elevated concentrations detected by URS (2009)
Silver	Common pollutant in port areas
Zinc	Common pollutant in port areas
Total polycyclic aromatic hydrocarbons (PAHs)	Common pollutant in port areas
Total petroleum hydrocarbons (TPHs)	Common pollutant in port areas
Total nitrogen	Bleesers Creek and Palmerston wastewater treatment

3 Existing Data

Analytical Parameter	Rationale for Analysis
	outfalls located upstream
Total phosphorus	Phosphate rock exported from EAW
Tributyltin (TBT)	No longer used as an antifoulant, but still potentially present in port environments.
Radionuclides	Uranium and thorium exported from EAW

It should be noted that not all of the “typical sediment contaminants” listed in Table 1 of the NAGD (2009) appear in Table 3-2 of this SAP. Contaminants for which there are considered to be no significant sources of input to the tug pen and small vessel berths dredging area (e.g. from imports or exports, or from the surrounding catchment) have been excluded from Table 3-2. For example, while organochlorine pesticides (mainly dieldrin) were detected in some samples of Darwin stormwater in the mid-1990s by Padovan (2001), these pesticides have been progressively phased out over the subsequent decades. Therefore it is considered that the potential for organochlorine pesticides to be present in the tug pen and small vessel berths dredging area sediments is sufficiently low to justify their exclusion from the contaminants list.

3 Existing Data

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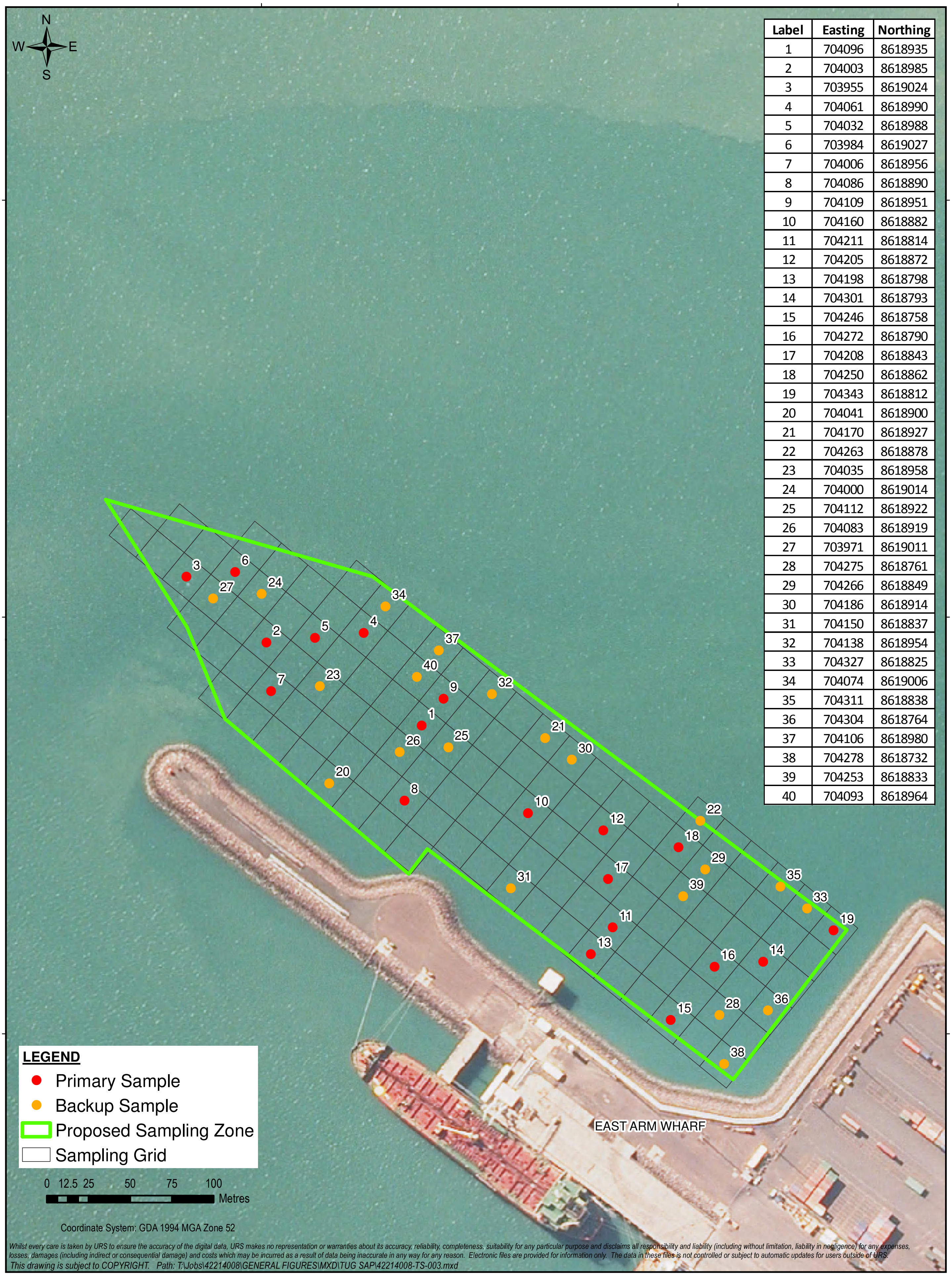
Sampling Locations

The required number of sample locations, calculated in accordance with Appendix D of the NAGD (2009), is 19. This was based on the maximum estimated volume of sediment to be dredged (115,000 m^3) derived by the EAW Expansion Project design contractor.

For the purpose of calculating the number of sampling locations:

- All of the material to be dredged is assumed to be unconsolidated. The geotechnical survey information (Appendix A) indicates that the depth of unconsolidated sediments is likely to extend below the maximum dredging depth across most of the dredging footprint.
- All of the material to be dredged is classified (in accordance with the NAGD [2009]) as ‘potentially contaminated’. As there are no data upon which to classify the sediments as ‘probably clean’ or ‘probably contaminated’ there are no grounds upon which the number of sampling locations can be halved.

The locations were selected by overlaying a 20.7 m x 20.7 m grid over the dredging area (to provide a total of 121 cells, more than the 95 cells [5 x 19 sample locations] needed to meet the requirements of Appendix D of the NAGD [2009]), then generating random numbers to determine the cells within which samples are to be collected. The sampling locations and coordinates (in geodetic datum GDA94) are shown in **Figure 4-1**. An additional 21 locations and coordinates are also shown; these will be sampled as required in the event that any of the initial 19 locations do not have a surface layer of unconsolidated sediments.



Label	Easting	Northing
1	704096	8618935
2	704003	8618985
3	703955	8619024
4	704061	8618990
5	704032	8618988
6	703984	8619027
7	704006	8618956
8	704086	8618890
9	704109	8618951
10	704160	8618882
11	704211	8618814
12	704205	8618872
13	704198	8618798
14	704301	8618793
15	704246	8618758
16	704272	8618790
17	704208	8618843
18	704250	8618862
19	704343	8618812
20	704041	8618900
21	704170	8618927
22	704263	8618878
23	704035	8618958
24	704000	8619014
25	704112	8618922
26	704083	8618919
27	703971	8619011
28	704275	8618761
29	704266	8618849
30	704186	8618914
31	704150	8618837
32	704138	8618954
33	704327	8618825
34	704074	8619006
35	704311	8618838
36	704304	8618764
37	704106	8618980
38	704278	8618732
39	704253	8618833
40	704093	8618964

SEDIMENT SAMPLING LOCATIONS AND GPS COORDINATES

URS | TUG PEN FACILITY DREDGING SAP | Figure: **4-1**

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Sampling Methods

5.1 Sterilisation procedures

Prior to commencement of sampling operations, an area on the vessel will be designated for sample handling. Potential contaminant sources in the vicinity of this area (e.g. galvanised or oily surfaces) are to be covered to reduce the potential for sample contamination.

Field personnel will wear sterile disposable nitrile gloves during sampling to minimise the potential for sample contamination by residues (e.g. hydrocarbons, sunscreen, etc.). Gloves will be changed between samples. Sterile plastic and stainless steel spatulas will be used where direct contact with the sediment sample is necessary (e.g. during splitting of the cores): stainless steel will be used for samples to be analysed for organic compounds, and plastic for samples to be analysed for metals. Smoking is not permitted in the vicinity of, or upwind from, the designated sample processing area. Sample processing will be undertaken upwind of generators and any other engines that are unable to be turned off for safety reasons.

The polycarbonate core tubing to be used for sample collection (see Section 5.2) will be cleaned with dilute acid, then rinsed with deionised water and a suitable solvent before the commencement of the sampling program. Sampling equipment will be decontaminated between sites by thorough cleaning in seawater. If clayey sediments are encountered, then a Decon solution will be used to clean the cores, with the cores rinsed in seawater prior to use at the next site.

5.2 Sampling methods

All sampling will be undertaken using a vibrocore. This will be installed on a vessel fitted with appropriate lifting equipment, power generation, deck space, shallow draft, adequate station-holding capability and other specifications to be finalised by the coring equipment supplier. The equipment will be manned by suitably qualified and experienced personnel, and the field operations supplemented by geotechnical staff from the contractor. The cores, with polycarbonate liners, are driven into the seabed from the vessel, then recovered to the vessel.

Aboard the support vessel, the sediment will be extruded from the core and photographed. The depth and visual descriptions of the sediment will be recorded, including colour, predominant grain size, presence of shell fragments and depth of any distinct horizons (changes in colour or grain size). Composite samples will be taken from every 0.5 m horizon, i.e. 0–0.5 m; 0.5–1.0 m, etc. Any intermediate horizons of soft sediments >0.5 m in thickness will be sampled separately.

5.3 Sample handling, preservation and transport

Table 5-1 details the containers, holding times and possible analysing laboratories for each analyte. Sediment samples will be placed in 250 ml laboratory supplied glass jars (for hydrocarbons and TBT analyses) and plastic whirlpak bags (for metals, PSD and acid sulfate soils analyses). The use of plastic, rather than glass, storage containers is recommended for metals, as metals tend to adsorb onto glass surfaces, potentially leading to underestimates of metal concentrations. An additional whirlpak of sediment will be retained at each site for archiving purposes.

All samples (whirlpaks and jars) will be placed inside labelled plastic self-seal bags for protection, stored on ice or refrigerated in the field and frozen at the earliest opportunity. Samples will be delivered, with accompanying Chain of Custody forms, to Australian Laboratory Services (ALS) in Darwin. ALS will forward the samples, under appropriate Chain of Custody procedures and preservation conditions, to their NATA-accredited laboratories in other capital cities.

5 Sampling Methods

Table 5-1 Practical Quantification Limit (PQLs) and Analytical Methods

Analyte	PQL	Method	Container / sediment weight	Holding time	Lab
Total Petroleum Hydrocarbons (TPH)	2 – 100 mg/kg	GC-FID-EP071	Teflon Lined 250 ml Glass Jar 100-250 g	14 days chilled to $4^{o}C$ Extended if frozen	ALS
Total Polycyclic Aromatic Hydrocarbons (PAH)	0.004-0.005 mg/kg	USEPA 3640/8270	Teflon Lined 250 ml Glass Jar 100-250 g	14 days	ALS
Metals					
Antimony	0.5mg/kg	USEPA 6020 ICP/MS and EG020SDH	Whirlpak 10-100 g	180 days chilled to $4^{o}C$ Extended if frozen	ALS
Arsenic	0.5 mg/kg				
Cadmium	0.1 mg/kg				
Chromium	0.5 mg/kg				
Copper	0.5 mg/kg				
Lead	1 mg/kg				
Nickel	1 mg/kg				
Zinc	0.5 mg/kg				
Iron	2 mg/kg				
Aluminium	5 mg/kg				
Mercury	0.01 mg/kg	APHA 3112 Hg-B CV/FIMS			
Tributyltin (TBT)	1 µg Sn/kg	GCMS-EP090	Teflon Lined 250 ml Glass Jar 100-250 g	14 days chilled to $4^{o}C$ 120 days if frozen	ALS
Total Organic Carbon (TOC)	0.1%	LECO after acid treatment – EP005	Teflon Lined 250 ml Glass Jar 10-50 g	Undetermined-extended storage if frozen	
Particle Size Distribution (PSD)	-	Wet sieving and laser diffraction	Whirlpak 50-200 g	No specific holding time – chilled to $4^{o}C$	ALS
Radionuclides	500 bq/kg	ISO9696 & ISO9697	Teflon Lined 250 ml Glass Jar 50-200 g	6 months	ALS
Total Nitrogen	20 mg/kg	NT-11	Teflon Lined 250 ml Glass Jar 50-200 g	6 months	ALS
Total Phosphorus	2 mg/kg	NT-11	Teflon Lined 250 ml Glass Jar 50-200 g	6 months	ALS

Analyte	PQL	Method	Container / sediment weight	Holding time	Lab
Acid sulfate soils	Action criteria dependent on clay content.[1]	Chromium suite: Total actual acidity (TAA), Chromium Reducible Sulfur (SCr) and Acid Neutralising Capacity (ANC).[2]	Whirlpak 100-250 g	Lab in 24 hours and frozen as soon as possible	ALS

1 Refer to Section 8.1 in Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes, WA Department of Environment and Conservation Acid Sulfate Soils Guideline Series May 2009.
2 10 % of samples will also be analysed using the Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) Suite.

5.4 Sample numbers

The total number of samples to be collected cannot be calculated at this juncture, as the number of samples from each location will depend on the depth of unconsolidated sediment at that location.

Following Quality Assurance / Quality Control (QA/QC) practice recommended in the Guidelines, the following samples will be collected:

- Field triplicate samples of sediments at 10% of locations (typically those with plentiful unconsolidated sediments). This will involve collecting and processing three separate samples at one location.
- Field splits at 5% of locations (i.e. one location). The sample will be homogenised and split into three subsamples, two of which will be processed separately by the primary analysing laboratory, with the third subsample sent to an alternate (reference) laboratory for analysis.

Field triplicate samples and splits will be labelled so as to be identifiable by the field environmental contractor, yet unrecognisable as replicates by the analysing laboratory.

As sediment samples will be collected over a number of days, samples will potentially be sent to the receiving laboratory in batches. If this occurs, one sample from the previous batch, an inter-batch duplicate, will be re-sampled to determine analytical variation between batches.

5.5 Laboratory analysis of samples

Analysis of sediments will be undertaken by NATA accredited ALS laboratories in Sydney, Newcastle and Brisbane. The methods and analytical PQLs for the analyses are provided in **Table 5-1**; the latter are at or below those recommended in Table 1 of the NAGD (2009).

Laboratory QA/QC procedures will be consistent with those described in Appendix F of the NAGD (2009). That is, for each batch (10-20 samples) or part batch, the following samples will be analysed.

- One laboratory blank sample.
- For metals, one Standard Reference Material, i.e. a sample of certified composition such as MESS-1 or BCSS-1, or BEST-1 (for mercury), or a suitable internal laboratory standard calibrated against a Standard Reference Material. The laboratory standard will be a ground sediment sample, not a liquid sample, to test both the recovery of the extraction procedure and the analysis.

- For organics, one sample spiked with the parameters being determined (or a surrogate spike for certain organics) at a concentration within the linear range of the method being employed. This will determine whether the recovery rate of the analytical method is adequate or not (i.e. that all the chemicals present in the sample are actually being found in the analysis.
- One replicate sample to determine the precision of the analysis; the standard deviation and coefficient of variation will be documented.

Recoveries of surrogate spikes will be documented and daily calibration data reviewed. The laboratory will review the quality control data and quality assurance documentation and a statement will be made in their report that the data meet the quality objectives specified by the method for that analysis. These will be presented in the laboratory analytical report - i.e. the acceptable recovery range for spikes and Standard Reference Materials and the acceptable range of relative percentage difference (RPD) on duplicates. All of the quality assurance data (blanks, laboratory duplicates, spikes and Standard Reference Materials) will be reported with the analytical data for each batch of samples analysed. As soon as the analyses are completed the results will be emailed to URS for review so that any unusual values can be queried and, if necessary, reanalysis carried out before the holding time for the samples has expired.

The laboratory QA/QC procedures will be appropriate for the low concentrations expected in marine sediments, which are frequently lower than those required for contaminated site investigations. A clear statement will be made on the Chain of Custody forms accompanying the samples that they are comprised of marine sediments.

5.6 Field records

Field notes will include the manual recording of field conditions (weather, tides and currents), site locations, sampling methods, handling and storage methods, field sample numbers, date, time and identity of sampler.

Field description of sediments will include the physical appearance, texture, colour, and presence of foreign material, presence of shell fragments and or biota and stratification. Where multiple samples are collected at a site, notes will be made on the variability between samples. Records will also be made detailing the unique sample identifier for each sample collected.

Chain of Custody forms accompany all samples to the analysing laboratories. Each sample will appear as a separate line item on the form, with the required analyses clearly identified. The consignments will be checked against the Chain of Custody forms by the laboratories and their completeness confirmed by return e-mail.

5.7 Health, safety and environment

Prior to the start of fieldwork, a scope specific risk-based health, safety and environment plan (HSEP) will be prepared and reviewed by key project personnel to address potential risks to the health and safety of project personnel and to their operating environment. Factors specific to East Arm include:

- Strong currents
- Large tidal variations (potential vessel grounding)
- Marine wildlife (e.g. crocodiles, stingers)
- Vessel traffic (commercial and recreational)

These factors will be considered with reference to both sampling efficiency and potential health and safety risks. The HSEP will also include issues such as handling and storage of chemicals used in fieldwork, and management of waste.

Safety planning will include job hazard analyses to identify the personnel and equipment requirements of all survey tasks, vessel navigation duties and responsibilities, the use of routine and emergency communication channels, and the development of an Emergency Response Plan to be followed in the event of a serious accident. On-site vessel inductions and other 'tool-box' safety meetings will be conducted before the start of each sampling task.

5.8 Contingency plan

In the event of adverse weather conditions or critical equipment failure rendering the sampling programme unsafe, there will be a downtime contingency. If the sampling programme has commenced, then the survey team will return to shore and assess the likely duration of the adverse weather conditions or equipment repair/replacement times. Alternative equipment/vessel suppliers will be identified in Darwin (in addition to the selected contractor) prior to works commencing, so that if possible, equipment/vessels can be replaced in the event of equipment/vessel issues.

5.9 Data management and reporting

Validation of analytical data will be undertaken as soon as results are received from the analytical laboratory. The relative standard deviation (RSD) will be determined for field triplicates and duplicates and the relative percentage difference (RPD) will be determined for laboratory duplicates. In accordance with the NAGD (2009) laboratory duplicates that have a RPD of greater than ± 35% will be reanalysed, if possible, prior to the expiry of the analytical holding time. Likewise, field triplicates and duplicates that have an RSD of greater than ± 50% will be reanalysed. An interpretive quality control report will be provided by the analysing laboratory, highlighting any outliers to quality control procedures.

ProUCLT statistical software will be used to analyse the data. The reporting of the field and analytical data will comprise:

- documentation of all field procedures and data including core photographs and logs
- data validation
- comparison of the 95% Upper Confidence Limit (UCL) of contaminant concentrations in sediment in the dredge area with NAGD (2009) Screening Levels (as per Appendix A of the NAGD [2009])
- mean sediment contaminant concentrations will be compared with background concentrations, if NAGD (2009) Screening Levels are exceeded.

5.10 Sampling and Analysis Plan Report

A SAP report will be submitted to DoE to comply with Condition 25 of the Commonwealth project approval (EPBC 2010/5304). The report will be used by the NTG as input into the Water Quality Management Plan (in accordance with the approval conditions detailed in Section 1.4).

The report will include a description of actual sampling locations and numbers, results including QA/QC assessment of both field and laboratory data, and an assessment of the results in accordance with the NAGD (2009). The original laboratory certificates will also be included.

5 Sampling Methods

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7 Limitations

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Appendix A Excerpt from Darwin East Arm Wharf Near Shore Factual Geotechnical Investigation Report for the Northern Territory Government, May 2011, by Aurecon Australia Pty Ltd, P31-32

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7.2.6 Tug, customs and small vessels area (T-Series)

A total of nine boreholes were drilled in this area (see Drawing 41840-SK-091 in Appendix B). The thickness of sediment encountered in this area varied considerably, with a minimum thickness of 1.8 m at borehole T1 and a maximum thickness of 8.4 m in borehole T22 (see Table 7.6). Sketches showing the thickness of sediment and interpolated contours are given in Appendix B. The Burrell Creek Formation was encountered at a level of -8.47 to -10.59 m.

Predominantly fine grained deposits were encountered in this area, with granular content of less than 40%. Gravel was found in only one sample (see Figure 7.6). In general, the alluvial material in this area can be described as silty CLAY with trace sand. The majority of Atterberg limits indicate that the sediment is clay of high plasticity (see Figure 7.7).

Table 7.6 Depth of marine alluvial sediments encountered – T-series boreholes

Borehole	Thickness of marine alluvial sediments (metres)	Maximum depth of marine alluvial sediments (metres Chart Datum)	Nature of Marine Sediments (Logged Description)	SPT Results
T1	1.8	-10.59	Sandy clay, silty sand, gravelly sand	SPT “N” = 0 blows (0.0m)
T3	4.55	-10.11	Sandy silt, clayey silt, sandy silty clay	SPT “N” = 0 blows (0.0m)
T4	2.0	-9.21	Clayey silt	SPT “N” = 0 blows (0.0m)
T6	2.1	-8.47	Clayey silt	SPT “N” = 0 blows (0.0m)
T7	4.5	-8.8	Clayey silt, sandy silt	SPT “N” = 0 blows (0.0m)
T13	4.2	-10.05	Clayey silt, silt, gravel	SPT “N” = 0 blows (0.0m) SPT “N” = 2 blows (3.0m)
T14	6.0	-9.24	Silty clay, sandy clayey silt, silty sand	SPT “N” = 0 blows (0.0m) SPT “N” = 0 blows (2.5m)
T22	8.4	-10.11	Clayey silt, silty sand, sandy silt	SPT “N” = 0 blows (0.0m) SPT “N” = 0 blows (1.5m)
T25	3.1	-9.17	Clayey silt, silty sand, sandy silt	SPT “N” = 0 blows (0.0m)

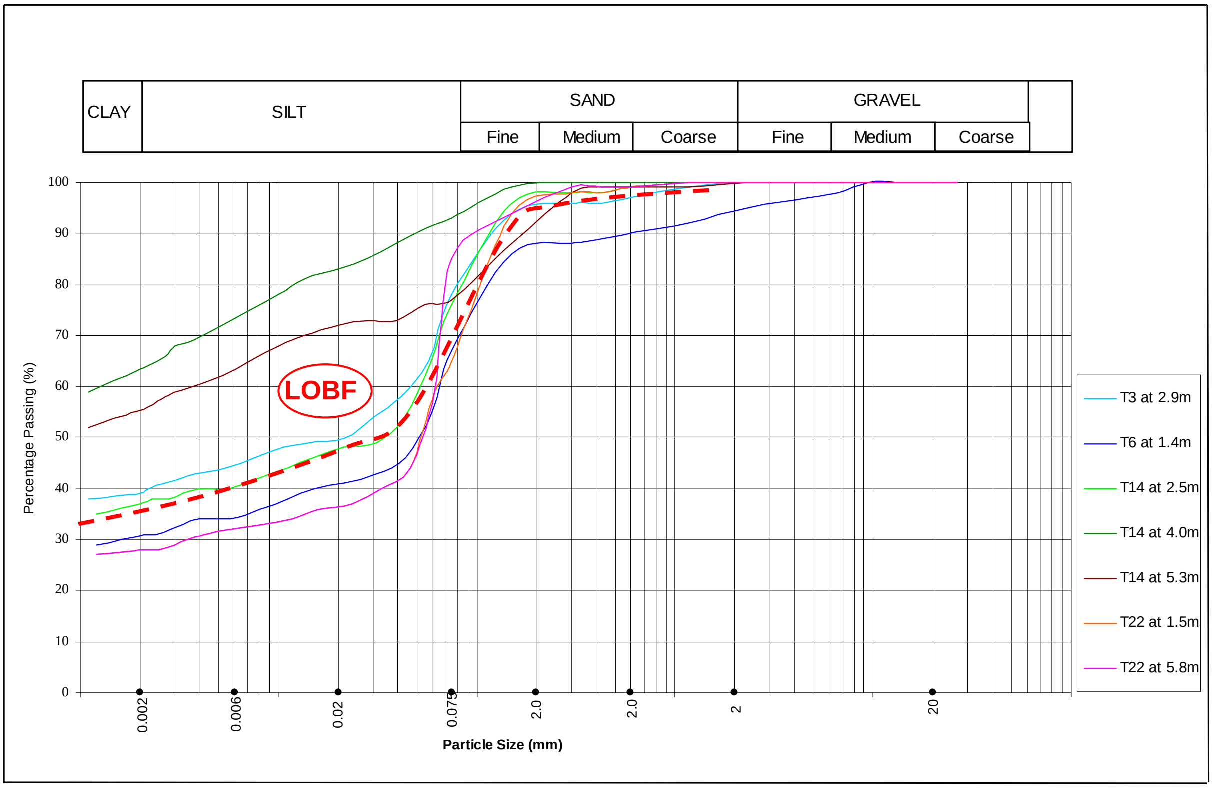

Figure 7.6 Particle size distributions - T-Series boreholes

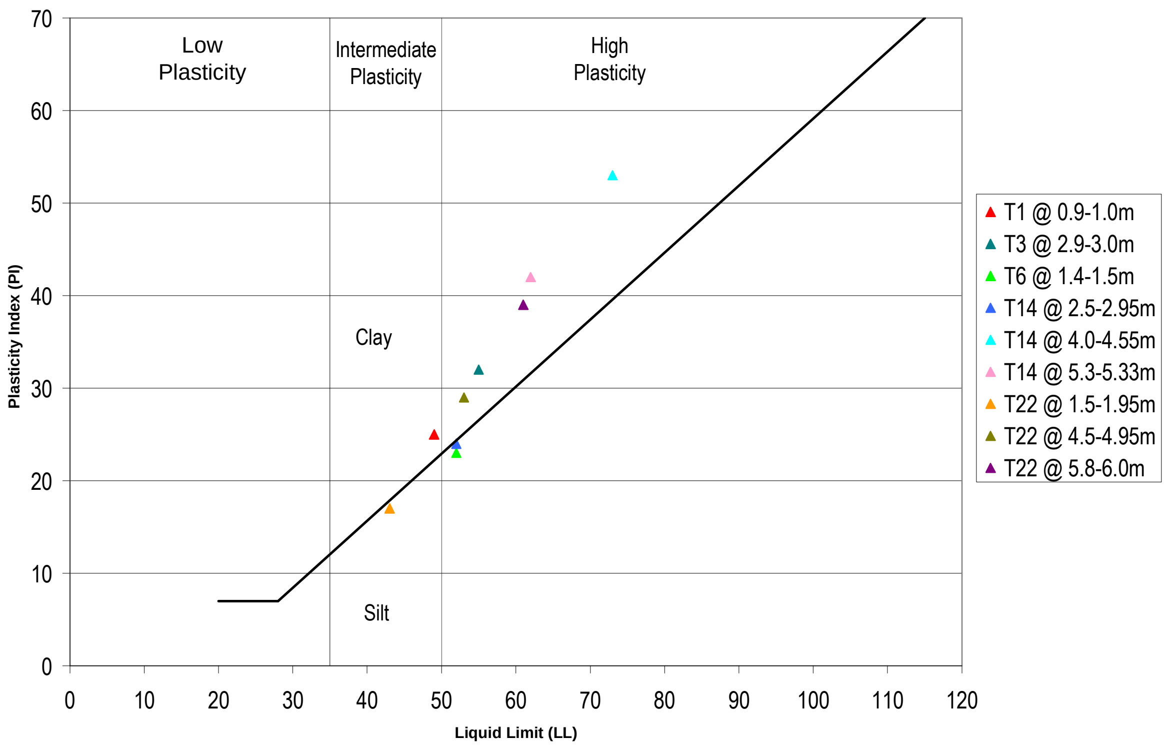

Figure 7.7 Atterberg limits - T-Series boreholes

Appendix B Cross reference of this Sampling and Analysis Plan to NAGD (2009) Appendix B

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NAGD Guidance	SAP Section
The objectives of the SAP, including data quality objectives.	1.4
A brief description of the dredging proposal, including the planned dredging area or areas, the dredging depths, the types of sediments involved and the final volume of material to be removed (in cubic metres) for sea disposal.	1.2
An evaluation of the history of the dredge area and its catchment, and available data on the sediments to be dredged.	2.1.2 2.2 3.1
A table showing the amounts to be dredged for each separate dredge area, as well as differentiating between clean, contaminated and potentially contaminated materials. *(As the dredge footprint is treated as a single area, and all of the material is considered 'potentially contaminated', this is covered in text rather than in a table*)	4
The *Contaminants List*, based on the history of the catchment and any previous sediment sampling.	3.23.2
Consideration of environmental factors potentially affecting contamination in the sediments (such as currents, bathymetry, grain-size) or which may limit or hinder the sampling program (for example depth, currents or waves, rocky bottom, weather, wildlife such as sharks, crocodiles or stingers, remoteness).	2.1.3 5.7
A rationale for the proposed sampling design, including maps showing the dredging area/s and the proposed sampling locations.	4
A contingency plan in case of adverse weather or critical failure of equipment.	5.8
The equipment (vessel, sampling, sub-sampling and testing gear, positioning equipment, sample containers, reports, charts and data forms) and personnel needed to implement the SAP, and a list of field measurements to be carried out.	5.2
A list of sample numbers, including field replicates and quality assurance samples, the approximate sampling locations and details of the position-fixing method, the proposed length of cores and depths of sub-samples from cores.	4 5.2 5.4
Step-by-step procedures for sampling and sub-sampling consistent with Appendix D of the Guidelines; the volume of sample required for analysis and the types and numbers of containers; procedures to ensure that samples are not contaminated from pollution sources on the survey boat.	5.1 5.2 5.3
Step-by-step procedures for sample handling, preservation, storage and QA/QC.	5.3
The laboratories to be used, a list of analyses required, the proposed analytical methods, the detection limits of the proposed methods, whether the methods will achieve the specified Practical Quantitation Limits (PQLs) in Table 1 of the Guidelines, laboratory replicates, certified reference materials, and QA/QC procedures.	5.3 5.5
Procedures for data management, data quality validation and any statistical routines proposed used.	5.9




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