



WorleyParsons[®]

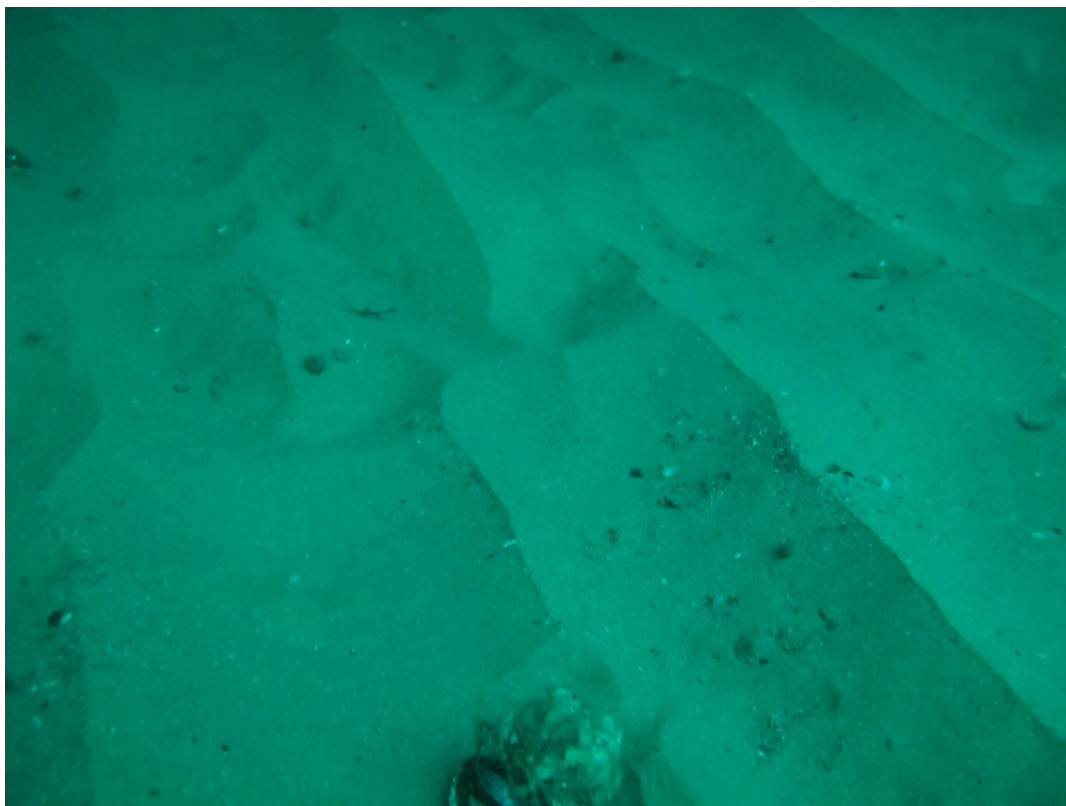
resources & energy

EcoNomics[™]

NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF
PRIMARY INDUSTRIES)

Ex-HMAS ADELAIDE Artificial Reef

Marine Sediment Quality Survey



301020-03410 – FINAL

4 July 2011

Infrastructure & Environment

3 Warabrook Blvd
Warabrook, NSW, 2304
Tel: +61 2 4985 0000
Fax: +61 2 4985 0099
www.worleyparsons.com
WorleyParsons Services Pty Ltd
ABN 61 001 279 812

© Copyright 2011 WorleyParsons Services Pty Ltd



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

Executive Summary

The Ex-HMAS ADELAIDE was scuttled off the coast of Terrigal and Avoca Beach, on the New South Wales Central Coast on 13 April 2011 for the purpose of creating an artificial reef and recreational dive site. In accordance with the Artificial Reef Permit, NSW Crown Lands (a Division of the Department of Primary Industries) must implement the approved *Long Term Management and Monitoring Plan* (LTMMP). The LTMMP includes monitoring of marine sediment quality from around the Ex-HMAS ADELAIDE Artificial Reef and from two locations within the hull of the vessel to examine how metal corrosion and degradation of protective paint layers over time may impact on the surrounding environment.

The *Sediment Quality Survey* involved the collection of marine sediments, using a remote grab, from six sites (Monitoring Sites) around the Ex-HMAS ADELAIDE Artificial Reef with three sites located on the port side of the vessel and three sites located on the starboard side. Sediments were also collected from the three Control Sites established prior to the scuttling of the Ex-HMAS ADELAIDE.

During this survey no sediments were collected from within the hull of the vessel, as at the time of sampling, there was no accumulation of sediments within the hull.

All sediment samples were analysed for a suite of metals. Individual metal concentrations from each Monitoring and Control Site were compared to the ANZECC / ARM CANZ (2000) Interim Sediment Quality Guidelines (ISQG). The metal concentrations from each Monitoring Site were also compared to the results from sediment samples collected from the site of the vessel, prior to scuttling.

The results of the analysis recorded the concentrations of metals in sediment collected from the Control Sites and the Monitoring Sites around the Ex-HMAS ADELAIDE Artificial Reef as being below the ISQG-Low values. The results indicate that one month post scuttling there is a low risk of any adverse biological effects on the surrounding environment due to the scuttling of the Ex-HMAS ADELAIDE.



NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY

Disclaimer

This report has been prepared on behalf of and for the exclusive use of NSW Crown Lands (A Division of the NSW Department of Primary Industries), and is subject to and issued in accordance with the agreement between NSW Crown Lands (A Division of the NSW Department of Primary Industries) and WorleyParsons Services Pty Ltd. WorleyParsons Services Pty Ltd accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

Copying this report without the permission of NSW Crown Lands (A Division of the NSW Department of Primary Industries) and WorleyParsons Services Pty Ltd is not permitted.

PROJECT 301020-03410 - EX-HMAS ADELAIDE ARTIFICIAL REEF

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	DRAFT Issued for internal review	<u> </u> Dr K Newton & Orla Murray	<u> </u> H Houridis	<u> </u> N/A	22 June 2011	<u> </u> N/A	
B	DRAFT Issued for client review	<u> </u> Dr K Newton	<u> </u> A Ling	<u> </u>	1 July 2011	<u> </u>	
C	FINAL	<u> </u> <i>Kate En</i> Dr K Newton	<u> </u> <i>P</i> P Moses	<u> </u>	4 July 2011	<u> </u>	



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

CONTENTS

1. INTRODUCTION 1

 1.1 Background 1

 1.2 Location of the Dive Site 1

 1.3 Project Aims & Scope 2

2. METHODS 5

 2.1 Sediment Sampling Sites 5

 2.1.1 Control Sites 5

 2.1.2 Monitoring Sites 5

 2.1.3 Sample Sites within the Hull 5

 2.2 Sediment Collection 7

 2.3 Analysis of Metals 8

 2.4 Comparison between Sites, to ANZECC Guidelines and to Previous Surveys 8

3. RESULTS 9

 3.1 Comparison with ANZECC Guidelines 9

 3.2 Comparison between Sampling Sites 10

 3.3 Comparison with Baseline Surveys 10

4. DISCUSSION 11

5. REFERENCES 12

FIGURES

Figure 1.1 Approximate location of the Ex-HMAS ADELAIDE artificial dive reef.

Figure 2.1 Locations of Control and Monitoring Sites.

Figure 2.2 The remote grab sampler used to collect marine sediments.



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

TABLES

Table 1.1 Co-ordinates of the scuttling location for the Ex-HMAS ADELAIDE.

Table 2.1 Co-ordinates of reference and impact sediment sampling sites.

Table 3.1 Comparison between metal concentrations and ANZECC Guidelines.

Table 3.2 Comparison between metal concentrations at the Monitoring and Control Sites.

Table 3.3 Comparison between previous and current survey results.

APPENDICES

Appendix 1 – Laboratory Results

Appendix 2 – Summary of Raw and Analysed Sediment Quality Data



NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY

1. INTRODUCTION

1.1 Background

The Ex-HMAS ADELAIDE was a long-range escort frigate which was scuttled off the coast of Terrigal and Avoca Beach on Wednesday 13 April 2011 for the purpose of creating an artificial reef and recreational dive site. An Artificial Reef Permit (SD2008/1062) was issued by the Department of Environment, Water, Heritage and the Arts (DEWHA), under the *Environment Protection (Sea Dumping) Act 1981*, in March 2010. In accordance with the Artificial Reef Permit, NSW Crown Lands (a division of the Department of Primary industries) must implement the approved *Long Term Management and Monitoring Plan (LTMMP)*.

The purpose of the LTMMP is to provide for the post-scuttling management and monitoring of the Ex-HMAS ADELAIDE Artificial Reef and covers monitoring for the first five years post-scuttling. The LTMMP contains provision for review, based on the results of monitoring.

The LTMMP includes requirements to undertake and report changes in the environmental conditions on and around the artificial reef. Specifically, the environmental monitoring includes the following:

- Reef communities survey;
- Sediment movement;
- Sediment quality; and
- Bioaccumulation study.

The results of the initial *Sediment Quality Survey* are provided in this report.

1.2 Location of the Dive Site

The Ex-HMAS ADELAIDE is located in Bulbararing Bay, between Avoca Beach and Terrigal Headland, on the NSW Central Coast. The ship is located approximately 1.4 km from Terrigal Headland and 1.9 km from Avoca Beach (**Figure 1.1**) with a depth of water over the main mast of 8.02 m LAT (personal communication, NSW Crown Lands 2011). **Table 1.1** provides the scuttling co-ordinates for the vessel.



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

Table 1.1 Co-ordinates of the scuttling location for the Ex-HMAS ADELAIDE.

Latitude / Longitude	Northing / Easting (MGA 94)
Latitude (south): 33°27.91'	Northing (MGA 94): 6,296,076.969
Longitude (east): 151°27.38'	Easting (MGA 94): 356,551.686

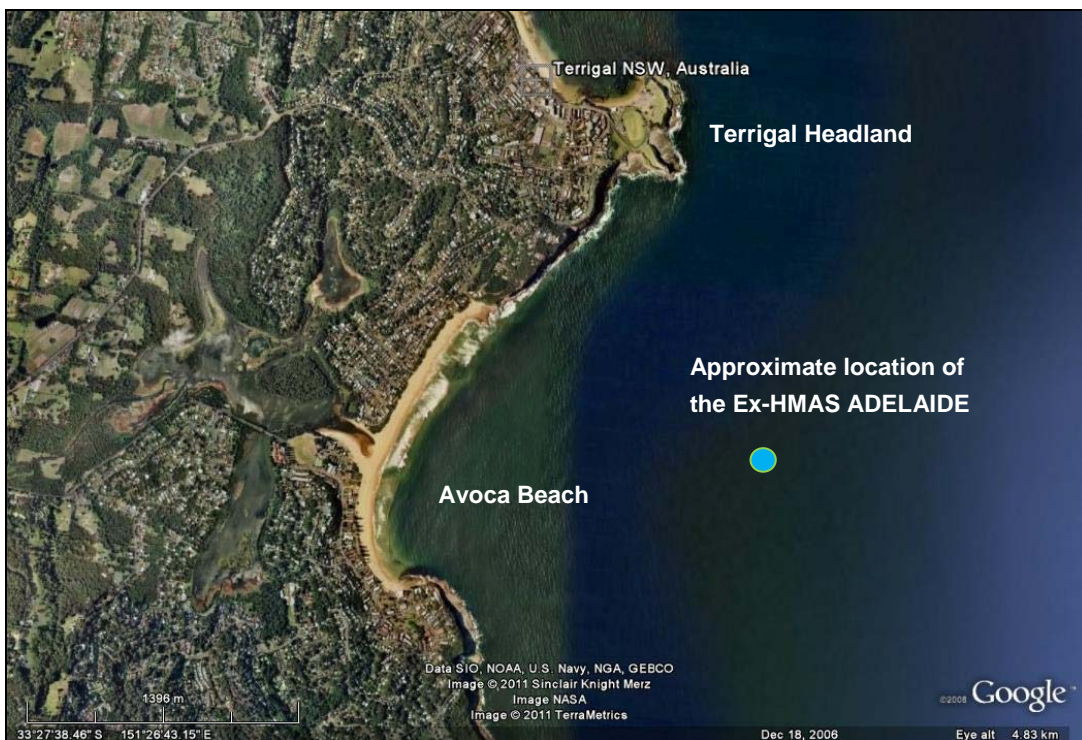


Figure 1.1 Approximate location of the Ex-HMAS ADELAIDE artificial dive reef.

1.3 Project Aims & Scope

The rationale for documenting sediment quality around the Ex-HMAS ADELAIDE is to assess how metal corrosion and degradation of protective paint layers over time may impact on the surrounding marine environment. Specifically, the LTMMP requires the following:

“Sediment quality will be analysed at one month post scuttling, six months post scuttling and 18 months post scuttling. Sediment quality will then be analysed again at 60 months post scuttling. Annual sampling and analysis is not proposed

The main aim of sediment quality monitoring is to determine whether benthic organisms would be likely to be affected by metal enrichment of sediments around the vessel. As noted previously, work



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

by MacLeod et al. (2004) indicated that after four years anti-corrosive paint systems on the Ex-HMAS SWAN were still largely intact. In addition, galvanic corrosion was only beginning to be discernable after four years. Hence it was considered unlikely that there would be any significant changes in metal enrichment of sediments over the first five years. In addition, monitoring for other ex-navy vessels in the early years following scuttling (MacLeod et al. 2004) indicated contamination levels well below ISQG-low trigger levels (i.e. where levels are below the trigger level no impact on biota is expected). Further sediment quality monitoring will be considered based on the results of initial monitoring and when the LTMMMP is reviewed after five years.

The method of collecting sediment samples will determine the distance of the sample from the hull of the ship. If sediment grab samples are taken using a stainless steel Van Veen grab-sampler, then samples may need to be taken approximately 50 m from the vessel to minimise the risk of snagging mooring lines. If divers take sediment samples manually, then samples can be taken as close as 10 m from the ship. Given the depth of the ship (at 32 m) there is some uncertainty regarding the appropriate sampling methodology. This will be determined at the first sampling one month post scuttling. Sediment samples will be obtained as close to the hull of the ship as possible in the same alignment along the length of the ship. GPS coordinates will be taken at the selected sampling sites. These locations will then become the reference points for all future sampling. The locations proposed are three each on the starboard and port sides of the vessel at the midpoint and just prior to the bow and stern. Sampling immediately adjacent to the bow and stern are not preferred to avoid areas of localised scouring. Sediment samples will also be taken from three control sites which are at different distances from the scuttling site and were previously analysed for heavy metals.

If remote testing is employed the grab sampler will be slowly lowered from the survey vessel to the seabed and retrieved following sediment capture. The collected sediment will be emptied into a clean plastic core tray and packaged separately in 150 ml glass jars (or other size required by the laboratory) for contaminant (metals) testing. All samples will be kept in the dark and on ice until delivery to the analytical laboratory.

Collection of samples by divers would be by using hand held polycarbonate cores (around 0.5 m long and 80 to 100 mm in diameter) capped at one end and pushed into and along the seabed to collect the sediment for analysis. The cores would then be capped at the other end and processed as above.

Sediment samples will be analysed for a suite of metals including aluminium and iron (primarily due to corrosion of the superstructure and hull) and chromium, copper, lead, nickel and zinc (heavy metals which may have been in paints or components of the vessel which were unable to be removed). Sediment quality results will be compared with ANZECC / ARMICANZ (2000) guidelines and previous results from control sites.

In addition, sediment from two sites within the hull is to be sampled and analysed for lead to measure any changes in sediment lead concentrations over time. The location of the monitoring sites shall be



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

in the bottom centre of the Laundry (compartment number 4-140-0-Q); and Auxiliary Machinery Room Number 3 (compartment number 5-292-0-L), as shown in the plans attached at Annex D”.

Section 2 of this report outlines the study methods and **Section 3** provides the results of the *Sediment Quality Survey*. In **Section 4** a discussion of the survey results is provided.



NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY

2. METHODS

The *Sediment Quality Survey* assessed the condition of marine sediments at six sites around the Ex-HMAS ADELAIDE (Monitoring Sites) and at three Control Sites. Sediment sampling was undertaken on the 17th May 2011, approximately one month post scuttling. An additional three samples from the Monitoring Sites were collected on the 30th May 2011 due to damages during transportation to the laboratory.

2.1 Sediment Sampling Sites

2.1.1 Control Sites

The location of the three Control Sites (identified as S2, S3 and S6) are outlined in the LTMMMP. The co-ordinates for each of the Control Sites are listed in **Table 2.1** and shown in **Figure 2.1**.

2.1.2 Monitoring Sites

Six Monitoring Sites were established around the Ex-HMAS ADELAIDE Artificial Reef (i.e. Monitoring Sites I1 – I6). Three Monitoring Sites were established on the port side of the vessel just prior to the stern (I1) at the mid-section (I2) and just prior to the bow (I3). Three Monitoring Sites were established on the starboard side of the vessel just prior to the stern (I6) at the mid-section (I5) and just prior to the bow (I4). The co-ordinates for each of the Monitoring Sites are listed in **Table 2.1** and shown in **Figure 2.1**. The Monitoring Sites have been established for all future sediment sampling adjacent to the Ex-HMAS ADELAIDE Artificial Reef.

Monitoring Sites were established as close to the Ex-HMAS ADELAIDE Artificial Reef as possible, taking into consideration the sea state and weather conditions in order to avoid entanglement of the grab sampler with the special marker buoys and dive moorings and / or with the Artificial Reef.

2.1.3 Sample Sites within the Hull

The two sediment monitoring sites within the hull of the Ex-HMAS ADELAIDE are located in the bottom centre of the Laundry (compartment number 4-140-0-Q) and auxiliary Machinery Room Number 3 (compartment number 5-292-0-L). No sediment was collected from within the hull during the survey due to the absence of any sediment at these sites.



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**



Figure 2.1 Locations of Control and Monitoring Sites.

Table 2.1 Co-ordinates of sediment sampling sites.

Sample Point	Latitude (S)	Longitude (E)
Control Site - S2	33°27.829'	151°27.416'
Control Site - S3	33°27.880'	151°27.157'
Control Site - S6	33°28.099'	151°27.347'
Monitoring Site - I1	33°27.843'	151°27.428'
Monitoring Site- I2	33°27.849'	151°27.479'
Monitoring Site - I3	33°27.864'	151°27.522'
Monitoring Site - I4	33°27.942'	151°27.449'
Monitoring Site - I5	33°27.921'	151°27.416'
Monitoring Site - I6	33°27.897'	151°27.381'



NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY

2.2 Sediment Collection

As the depth of the seabed exceeded the safe diving limit for commercial divers (see Note below), sediment samples were collected using a remote grab sampler. A Petite Ponar grab sampler (Thermo Fisher) (a smaller version of the Van Veen sampler) was used for sediment sampling. The 2.4 L Petite Ponar grab is large enough to collect the volume of sediment required for the metals analysis (i.e. 150 ml) while being more manageable in the field (**Figure 2.2**). The grab sampler was slowly lowered from the survey vessel to the seabed and retrieved following sediment capture using an electric winch. The sediment retrieved was deposited into a clean Pyrex bowl, mixed well and then transferred into 150 ml glass jars (provided by the analytical laboratory) for metals testing. All samples were kept on ice in the dark until delivery to the analytical laboratory the following day.

In addition to these, one split duplicate sample was collected at the Monitoring Site S6. A split duplicate is a single homogenised sample split into two or more containers to assess the precision (or repeatability) of the analysis.

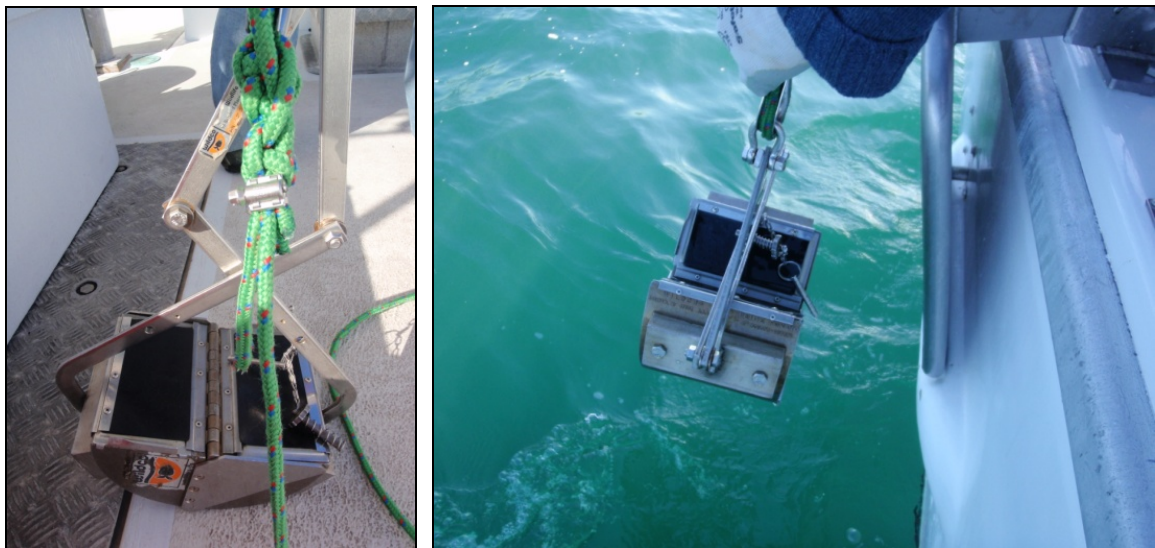


Figure 2.2 The remote grab sampler used to collect marine sediments.

NOTE: Under *Australian Standard AS 2815: Training and Certification of Occupational Divers* commercial divers using self-contained underwater breathing apparatus (SCUBA) are restricted to working underwater to depths of 30 m. While AS 2815 allows commercial divers to access depths beyond 30 m, commercial divers must use surface-supplied underwater breathing apparatus (SSBA) with surface compression chambers. The use of SSBA for commercial diving around the ex-HMAS ADELAIDE Artificial Reef for the environmental monitoring was not considered safe due to the risk of entanglements with the vessel.



NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY

2.3 Analysis of Metals

The LTMMP requires the sediment samples to be analysed by a NATA accredited laboratory for a suite of metals. The LTMMP specifically nominates aluminium, iron, chromium, copper, lead, nickel and zinc for analysis. All sediment analysis was undertaken by the NATA accredited laboratory, Advanced Analytical (North Ryde, NSW). All laboratory Sample Receipt Notifications and Reports of Analysis are provided in **Appendix 1**.

2.4 Comparison between Sites, to ANZECC Guidelines and to Previous Surveys

Metal concentrations for each site were compared to the ANZECC / ARMCANZ (2000) Interim Sediment Quality Guidelines (ISQG). The ANZECC / ARMCANZ (2000) Guidelines provide high and low ISQG trigger values, which indicate whether the concentration of a contaminant is likely to have an adverse impact on marine organisms inhabiting the sediment. Note that ANZECC / ARMCANZ (2000) ISQG trigger values have not been set for aluminium or iron.

Comparisons between sites in the current study were also undertaken, with metal concentrations from the Monitoring Sites being compared to the concentrations from the Control Sites.

The LTMMP states that the results will be *compared to previous results from control sites*. However, during the *Marine Baseline Survey* (WorleyParsons 2009b) the Control Sites were not analysed for metals. The only sites analysed for metals during the *Marine Baseline Survey* were located in the proposed scuttling location of the Ex-HMAS ADELAIDE and were labelled as V1, V2 and V3. Hence, results from Monitoring Sites in the current survey and sites V1, V2 and V3 were compared during this *Sediment Quality Survey*.



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

3. RESULTS

Sediment samples were collected from three Control Sites (S2, S3, S6) and six Monitoring Sites (I1-I6) around the Ex-HMAS ADELAIDE Artificial Reef (see **Figure 2.1**) and analysed for a suite of metals as outlined in **Section 2.3**. Original laboratory reports are provided in **Appendix 1**. In **Appendix 2** a summary of all raw and analysed data, including means, standard deviations and median values, along with the relevant ANZECC / ARMCANZ (2000) ISQG High and Low values for each metal are provided. Note that **Appendix 1** and **2** also provide data on additional metals analysed in previous surveys but which were not required for the LTMMP.

The relative percent difference (RPD) for the split duplicates at impact site I6 were less than 15% which is well within the acceptable range of 35%, indicating good laboratory precision.

3.1 Comparison with ANZECC Guidelines

Median and mean metal concentrations from each site were compared to the ANZECC / ARMCANZ (2000) ISQG-Low values. The concentrations of metals in sediment at all reference and impact sites were below the ISQG-Low values (see **Table 3.1** and **Appendix 2**) indicating that one month post scuttling there is a low risk that any adverse biological effects will occur to marine organisms living within the sediments surrounding the Ex-HMAS ADELAIDE.

While no ANZECC / ARMCANZ (2000) values are provided for aluminium and iron, the data obtained during this survey and previous surveys will act to provide a baseline condition for future sediment monitoring around the vessel.

Table 3.1 Comparison between metal concentrations and ANZECC Guidelines.

Metal	Monitoring Site Median (mg/kg)	Monitoring Site Mean (mg/kg)	Control Site Median (mg/kg)	Control Site Mean (mg/kg)	ANZECC (ISQG-Low)	ANZECC (ISQG-High)
Aluminium	1150	1183	1100	1013	Not available	Not available
Iron	9650	9567	10000	9100	Not available	Not available
Chromium	6.9	7.1	6.9	6.8	80	370
Copper	1.5	2	1.7	1.4	65	270
Lead	3.2	3.3	3.1	3.2	50	220
Nickel	2.3	2.4	2.5	2.2	21	52
Zinc	9.7	10.3	10	9.2	200	410



NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY

3.2 Comparison between Sampling Sites

A comparison between the concentrations of metals in sediments from the Control Sites and Monitoring Sites around the Ex-HMAS ADELAIDE Artificial Reef showed that mean concentrations of all of metals were slightly higher at the Monitoring than the Control Sites during the one month survey (see **Table 3.2**).

Table 3.2 Comparison between metal concentrations at the Monitoring and Control Sites.

Metal	Monitoring Site Mean (mg/kg)	Control Site Mean (mg/kg)
Aluminium	1183	1013
Iron	9567	9100
Chromium	7.1	6.8
Copper	2	1.4
Lead	3.3	3.2
Nickel	2.4	2.2
Zinc	10.3	9.2

3.3 Comparison with Baseline Surveys

During the *Baseline Marine Survey* (WorleyParsons 2009b) marine sediments were collected from three sites in the approximate location in which the Ex-HMAS ADELAIDE would be scuttled (i.e. V1, V2, V3). Concentrations of all metals in the *Marine Baseline Survey* were less than their respective ANZECC / ARM CANZ (2000) ISQG-Low values (where these had been established). **Table 3.3** provides sediment concentrations from these previous monitoring sites and the mean concentration value from Monitoring Sites during the current survey. Mean metal concentrations in sediments obtained during the previous *Baseline Marine Survey* and the *Sediment Quality Survey* are very similar (**Table 3.3**).

Table 3.3 Comparison between previous and current survey results.

Metal	V1 (mg/kg)	V2 (mg/kg)	V3 (mg/kg)	Baseline Study Mean (mg/kg)	Monitoring Site Mean (mg/kg)
Aluminium	1180	1170	1200	1183	1183
Iron	10300	8510	10000	9603	9567
Chromium	8	6.8	7.9	7.6	7.1
Copper	1.6	1.2	1.4	1.4	2
Lead	3.7	3.1	3.6	3.5	3.3
Nickel	2.8	2.2	2.6	2.5	2.4
Zinc	12.2	8	10.4	10.2	10.3



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

4. DISCUSSION

This *Marine Sediment Quality Survey* was undertaken to assess the extent, if any, of metal enrichment of marine sediments surrounding the EX-HMAS ADELAIDE Artificial Reef one month after scuttling of the vessel, in comparison to nearby Control Sites. No appreciable differences were found in the concentrations of a suite of metals from marine sediments sampled around the Ex-HMAS ADELAIDE (Monitoring Sites) and at Control sites within Bulbararing Bay one month post scuttling. Nor were there any differences detected between the concentrations of metals in sediments collected at the Monitoring Sites during this survey with metal concentrations in samples collected during previous surveys at the scuttling site. During future surveys sampling within the hull may be required; however, sampling may not be possible as the depth exceeds the permissible depth for Level 1 and 2 commercial diving guidelines.



**NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY**

5. REFERENCES

WorleyParsons (2009a). *Ex-HMAS Artificial Reef Project - Review of Environmental Factors*. Report for the Land and Property Management Authority (LPMA), WorleyParsons, 2009.

WorleyParsons (2009b). *Ex-HMAS Artificial Reef Project - Marine Survey Report*. Report for the Land and Property Management Authority (LPMA), WorleyParsons, October 2009.

ANZECC / ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand. Canberra, ACT. Australia.

MacLeod I., Morrison P., Richards V., and West N. (2004). Corrosion monitoring and the environmental impact of decommissioned naval vessels as artificial reefs. *Proceedings of Metal 4-8* October 2004.



WorleyParsons®

resources & energy

EcoNomics™

NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY

Appendix 1 – Laboratory Results

SAMPLE RECEIPT NOTIFICATION



Attention : Katie Newton

Client : Worley Parsons Pty Ltd
3 Warabrook Blvd
Warabrook NSW 2304

Telephone : 02 4985 0020

Facsimile : 02 4985 0099

Project : Ex-HMAS Adelaide Monitoring

Order Number :

Laboratory Reference : A11/2278

Completed Chain of Custody accompanied samples.	YES
Samples were received in good condition and correctly preserved for all tests.	YES
Samples were received in sufficient time to allow laboratory to meet holding times.	YES
Samples were received chilled/chilling (if required).	YES

Date samples received : 19/05/2011
Matrix : Marine Sediment
No. of samples : 10
Scheduled reporting date : 25 May 11

Client Services Manager : Daniel Um

Telephone : 02 9888 9077
Email : daniel.um@advancedanalytical.com.au

Contact your Client Services Manager for all queries and issues regarding this sample batch.

Note: Turnaround time begins at time of receipt at laboratory, surcharges may apply for fast turnaround.

Water samples will be appropriately stored for 1 month from date of receipt of samples.
Soil / Sediment samples will be appropriately stored for 3 months from date of receipt of samples.

COMMENTS:

Advanced Analytical Australia Pty Ltd
ABN 20 105 644 979
11 Julius Avenue
North Ryde NSW 2113 Australia

Ph: + 61 2 9888 9077
Fax: + 61 2 9888 9577
contact@advancedanalytical.com.au
www.advancedanalytical.com.au



REPORT OF ANALYSIS

Laboratory Reference: A11/2278 [R00]

Client: Worley Parsons Pty Ltd
3 Warabrook Blvd
Warabrook NSW 2304

Contact: Katie Newton

Order No:
Project: Ex-HMAS Adelaide Monitoring
Sample Type: Marine Sediment
No. of Samples: 10
Date Received: 19/05/2011
Date Completed: 25/05/2011

Laboratory Contact Details:

Client Services Manager: Daniel Um
Technical Enquiries: Ian Eckhard
Telephone: +61 2 9888 9077
Fax: +61 2 9888 9577
Email: daniel.um@advancedanalytical.com.au

Attached Results Approved By:

Ian Eckhard
Technical Director

Comments:

All samples tested as submitted by client. All attached results have been checked and approved for release. This is the Final Report and supersedes any reports previously issued with this batch number. This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.



Issue Date: 27 May 2011

Page 1 of 4

Advanced Analytical Australia Pty Ltd
ABN 20 105 644 979
11 Julius Avenue,
North Ryde NSW 2113 Australia

Ph: + 61 2 9888 9077
Fax: + 61 2 9888 9577
contact@advancedanalytical.com.au
www.advancedanalytical.com.au



Batch Number: A11/2278 [R00]

Project: Ex-HMAS Adelaide Monitoring

Laboratory Reference:	-	-	A11/2278/1	A11/2278/2	A11/2278/3	A11/2278/5
Client Reference:	-	-	S2	S3	S6	I2
Date Sampled:	-	-	17/05/2011	17/05/2011	17/05/2011	17/05/2011
Analysis Description	Method	Units				
Moisture Content						
Moisture Content	04-004	%	20.8	21.9	21.5	22.1
Trace Elements						
Silver	04-001	mg/kg	<0.1	0.11	0.12	<0.1
Aluminium	04-001	mg/kg	1,200	1,100	740	1,300
Arsenic	04-001	mg/kg	12	15	15	11
Cadmium	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Chromium	04-001	mg/kg	7.4	6.9	6.0	7.5
Copper	04-001	mg/kg	1.8	1.7	0.80	2.6
Iron	04-001	mg/kg	10,000	10,000	7,300	10,000
Mercury	04-002	mg/kg	<0.01	<0.01	<0.01	<0.01
Manganese	04-001	mg/kg	81	87	73	83
Molybdenum	04-001	mg/kg	<0.5	<0.5	<0.5	<0.5
Nickel	04-001	mg/kg	2.6	2.5	1.5	2.7
Lead	04-001	mg/kg	3.3	3.1	3.1	3.2
Antimony	04-001	mg/kg	<0.5	<0.5	<0.5	<0.5
Vanadium	04-001	mg/kg	17	18	15	17
Zinc	04-001	mg/kg	11	10	6.5	11
Selenium*	ICPMS	mg/kg	<0.10	<0.10	<0.10	<0.10

Issue Date: 27 May 2011

Page 2 of 4

Advanced Analytical Australia Pty Ltd
ABN 20 105 644 979
11 Julius Avenue,
North Ryde NSW 2113 Australia

Ph: +61 2 9888 9077
Fax: +61 2 9888 9577
contact@advancedanalytical.com.au
www.advancedanalytical.com.au



Batch Number: A11/2278 [R00]

Project: Ex-HMAS Adelaide Monitoring

Laboratory Reference:	-	-	A11/2278/7	A11/2278/9	A11/2278/10
Client Reference:	-	-	I4	I6	Dup
Date Sampled:	-	-	17/05/2011	17/05/2011	17/05/2011
Analysis Description	Method	Units			
Moisture Content					
Moisture Content	04-004	%	22.7	22.9	21.9
Trace Elements					
Silver	04-001	mg/kg	<0.1	<0.1	<0.1
Aluminium	04-001	mg/kg	1,100	1,100	1,200
Arsenic	04-001	mg/kg	12	13	13
Cadmium	04-001	mg/kg	<0.1	<0.1	<0.1
Chromium	04-001	mg/kg	6.9	6.5	7.1
Copper	04-001	mg/kg	1.3	1.5	1.6
Iron	04-001	mg/kg	9,400	9,200	10,000
Mercury	04-002	mg/kg	<0.01	<0.01	<0.01
Manganese	04-001	mg/kg	78	76	85
Molybdenum	04-001	mg/kg	<0.5	<0.5	<0.5
Nickel	04-001	mg/kg	2.2	2.2	2.4
Lead	04-001	mg/kg	3.2	3.1	3.2
Antimony	04-001	mg/kg	<0.5	<0.5	<0.5
Vanadium	04-001	mg/kg	16	16	17
Zinc	04-001	mg/kg	9.7	9.7	11
Selenium*	ICPMS	mg/kg	<0.10	<0.10	<0.10

Method	Method Description
04-004	Moisture by gravimetric, %
04-001	Metals by ICP-OES, mg/kg
04-002	Mercury by CVAAS, mg/kg
ICPMS	*Analysed by ICP-MS

Result Comments

[<] Less than

[INS] Insufficient sample for this test

[NA] Test not required

Solid sample results are reported on a dry weight basis.

Samples 4 (I1), 6 (I3) and 8 (I5) arrived broken. No analysis could be conducted on these samples.

- Spike recovery for Al and Fe could not be accurately determined due to a significant background analyte concentration.

Issue Date: 27 May 2011

Page 3 of 4

Advanced Analytical Australia Pty Ltd
 ABN 20 105 644 979
 11 Julius Avenue,
 North Ryde NSW 2113 Australia

Ph: +61 2 9888 9077
 Fax: +61 2 9888 9577
 contact@advancedanalytical.com.au
 www.advancedanalytical.com.au



Batch Number: A11/2278 [R00]

Project: Ex-HMAS Adelaide Monitoring

QUALITY ASSURANCE REPORT

TEST	UNITS	Blank	Duplicate Sm#	Duplicate Results	Spike Sm#	Spike Results
Silver	mg/kg	<0.1	A11/2278-1	<0.1 <0.1	A11/2278-1	115%
Aluminium	mg/kg	<5	A11/2278-1	1200 1200 RPD: 0	A11/2278-1	#
Arsenic	mg/kg	<0.4	A11/2278-1	12 12 RPD: 0	A11/2278-1	105%
Cadmium	mg/kg	<0.1	A11/2278-1	<0.1 <0.1	A11/2278-1	104%
Chromium	mg/kg	<0.1	A11/2278-1	7.4 7.2 RPD: 3	A11/2278-1	98%
Copper	mg/kg	<0.1	A11/2278-1	1.8 1.7 RPD: 6	A11/2278-1	98%
Iron	mg/kg	<5	A11/2278-1	10000 10000 RPD: 0	A11/2278-1	#
Mercury	mg/kg	<0.01	A11/2278-1	<0.01 <0.01	A11/2278-1	85%
Manganese	mg/kg	<0.5	A11/2278-1	81 82 RPD: 1	A11/2278-1	102%
Molybdenum	mg/kg	<0.5	A11/2278-1	<0.5 <0.5	A11/2278-1	100%
Nickel	mg/kg	<0.1	A11/2278-1	2.6 2.5 RPD: 4	A11/2278-1	91%
Lead	mg/kg	<0.5	A11/2278-1	3.3 3.3 RPD: 0	A11/2278-1	92%
Antimony	mg/kg	<0.5	A11/2278-1	<0.5 <0.5	A11/2278-1	102%
Vanadium	mg/kg	<0.1	A11/2278-1	17 17 RPD: 0	A11/2278-1	100%
Zinc	mg/kg	<0.5	A11/2278-1	11 11 RPD: 0	A11/2278-1	92%
Selenium*	mg/kg	<0.10	A11/2278-1	<0.10 <0.10	A11/2278-1	89%

Comments:

RPD = Relative Percent Deviation

[NT] = Not Tested

[N/A] = Not Applicable

= Spike recovery data could not be calculated due to high levels of contaminants

Acceptable replicate reproducibility limit or RPD: Results < 10 times LOR: no limits.

Results > 10 times LOR: 0% - 50%.

Acceptable matrix spike & LCS recovery limits: Trace elements 70-130%

Organic analyses 50-150%

SVOC & speciated phenols 10-140%

Surrogates 10-140%

When levels outside these limits are obtained, an investigation into the cause of the deviation is performed before the batch is accepted or rejected, and results are released.

Issue Date: 27 May 2011

Page 4 of 4

Advanced Analytical Australia Pty Ltd

ABN 20 105 644 979

11 Julius Avenue,

North Ryde NSW 2113 Australia

Ph: +61 2 9888 9077

Fax: +61 2 9888 9577

contact@advancedanalytical.com.au

www.advancedanalytical.com.au



REPORT OF ANALYSIS

Laboratory Reference: A11/2496 [R01]

Client: Worley Parsons Pty Ltd
3 Warabrook Blvd
Warabrook NSW 2304

Contact: Katie Newton

Order No:
Project: Ex-HMAS Adelaide Monitoring
Sample Type: Marine Sediment
No. of Samples: 3
Date Received: 31/05/2011
Date Completed: 21/06/2011

Laboratory Contact Details:

Client Services Manager: Daniel Um
Technical Enquiries: Ian Eckhard
Telephone: +61 2 9888 9077
Fax: +61 2 9888 9577
Email: daniel.um@advancedanalytical.com.au

Attached Results Approved By:

Ian Eckhard
Technical Director

Comments:

All samples tested as submitted by client. All attached results have been checked and approved for release. This is the Final Report and supersedes any reports previously issued with this batch number. This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.



Issue Date: 21 June 2011

Page 1 of 3

Advanced Analytical Australia Pty Ltd
ABN 20 105 644 979
11 Julius Avenue,
North Ryde NSW 2113 Australia

Ph: +61 2 9888 9077
Fax: +61 2 9888 9577
contact@advancedanalytical.com.au
www.advancedanalytical.com.au



Batch Number: A11/2496 [R01]

Project: Ex-HMAS Adelaide Monitoring

Laboratory Reference:	-	-	A11/2496/1	A11/2496/2	A11/2496/3
Client Reference:	-	-	I1	I3	I5
Date Sampled:	-	-	30/05/2011	30/05/2011	30/05/2011
Analysis Description	Method	Units			
Moisture Content					
Moisture Content	04-004	%	19.3	19.6	21.1
Trace Elements					
Silver	04-001	mg/kg	<0.1	<0.1	<0.1
Aluminium	04-001	mg/kg	1,300	1,100	1,200
Arsenic	04-001	mg/kg	11	13	13
Cadmium	04-001	mg/kg	<0.1	<0.1	<0.1
Chromium	04-001	mg/kg	8.2	6.8	6.5
Copper	04-001	mg/kg	3.4	1.4	1.5
Iron	04-001	mg/kg	10,000	8,900	9,900
Mercury	04-002	mg/kg	<0.01	<0.01	<0.01
Manganese	04-001	mg/kg	87	77	76
Molybdenum	04-001	mg/kg	<0.5	<0.5	<0.5
Nickel	04-001	mg/kg	2.9	2.3	2.3
Lead	04-001	mg/kg	3.3	3.8	3.1
Antimony	04-001	mg/kg	<0.5	<0.5	<0.5
Vanadium	04-001	mg/kg	19	16	15
Zinc	04-001	mg/kg	12	9.7	9.5
Selenium*	ICPMS	mg/kg	<0.10	<0.10	<0.10

Method	Method Description
04-004	Moisture by gravimetric, %
04-001	Metals by ICP-OES, mg/kg
04-002	Mercury by CVAAS, mg/kg
ICPMS	*Analysed by ICP-MS

Result Comments

[<] Less than

[INS] Insufficient sample for this test

[NA] Test not required

Solid sample results are reported on a dry weight basis.

*Analyte is not covered by NATA scope of accreditation.

This report supersedes Report A11-2496-[R00].pdf.

Issue Date: 21 June 2011

Page 2 of 3

Advanced Analytical Australia Pty Ltd

ABN 20 105 644 979

11 Julius Avenue,

North Ryde NSW 2113 Australia

Ph: + 61 2 9888 9077

Fax: +61 2 9888 9577

contact@advancedanalytical.com.au

www.advancedanalytical.com.au



Batch Number: A11/2496 [R01]

Project: Ex-HMAS Adelaide Monitoring

QUALITY ASSURANCE REPORT

TEST	UNITS	Blank	Duplicate Sm#	Duplicate Results	Spike Sm#	Spike Results
Silver	mg/kg	<0.1	[NT]	[NT]	A11/2468/01	106%
Aluminium	mg/kg	<5	[NT]	[NT]	A11/2468/01	#
Arsenic	mg/kg	<0.4	[NT]	[NT]	A11/2468/01	100%
Cadmium	mg/kg	<0.1	[NT]	[NT]	A11/2468/01	101%
Chromium	mg/kg	<0.1	[NT]	[NT]	A11/2468/01	98%
Copper	mg/kg	<0.1	[NT]	[NT]	A11/2468/01	101%
Iron	mg/kg	<5	[NT]	[NT]	A11/2468/01	#
Mercury	mg/kg	<0.01	[NT]	[NT]	A11/2468/01	91%
Manganese	mg/kg	<0.5	[NT]	[NT]	A11/2468/01	#
Molybdenum	mg/kg	<0.5	[NT]	[NT]	A11/2468/01	98%
Nickel	mg/kg	<0.1	[NT]	[NT]	A11/2468/01	93%
Lead	mg/kg	<0.5	[NT]	[NT]	A11/2468/01	91%
Antimony	mg/kg	<0.5	[NT]	[NT]	A11/2468/01	91%
Vanadium	mg/kg	<0.1	[NT]	[NT]	A11/2468/01	100%
Zinc	mg/kg	<0.5	[NT]	[NT]	A11/2468/01	93%
Selenium*	mg/kg	<0.10	[NT]	[NT]	A11/2468/01	108%

Comments:

RPD = Relative Percent Deviation

[NT] = Not Tested

[N/A] = Not Applicable

= Spike recovery data could not be calculated due to high levels of contaminants

Acceptable replicate reproducibility limit or RPD: Results < 10 times LOR: no limits.

Results >10 times LOR: 0% - 50%.

Acceptable matrix spike & LCS recovery limits: Trace elements 70-130%

Organic analyses 50-150%

SVOC & speciated phenols 10-140%

Surrogates 10-140%

When levels outside these limits are obtained, an investigation into the cause of the deviation is performed before the batch is accepted or rejected, and results are released.



WorleyParsons®

resources & energy

EcoNomics™

NSW CROWN LANDS (A DIVISION OF THE NSW DEPARTMENT OF PRIMARY INDUSTRIES)
EX-HMAS ADELAIDE ARTIFICIAL REEF
MARINE SEDIMENT QUALITY SURVEY

Appendix 2 – Summary of Raw and Analysed Sediment Quality Data

Sample ID	Date sampled	Silver	Aluminium	Arsenic	Cadmium	Chromium	Copper	Iron	Mercury	Manganese	Molybdenum	Nickel	Lead	Antimony	Vanadium	Zinc	Selenium*	
Unit		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	
LOR		0.1	5	0.4	0.1	0.1	0.1	5	0.01	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.1	
Aquatic Ecology	NAGD SL / ANZECC ISGQ low	1	-	20	1.5	80	65	-	0.15	-	-	21	50	2	-	200	-	
	ANZECC ISGQ high	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
REFERENCE SITES	S2	17/05/2011	0.05	1200	12	<0.1	7.4	1.8	10000	<0.01	81	<0.5	2.6	3.3	<0.5	17	11	<0.1
	S3	17/05/2011	0.11	1100	15	<0.1	6.9	1.7	10000	<0.01	87	<0.5	2.5	3.1	<0.5	18	10	<0.1
	S6	17/05/2011	0.12	740	15	<0.1	6	0.8	7300	<0.01	73	<0.5	1.5	3.1	<0.5	15	6.5	<0.1
		Mean	0.09	1013	14.0	<0.1	6.8	1.4	9100	<0.1	80.3	<0.5	2.2	3.2	<0.5	16.7	9.2	<0.1
		StDev	0.04	242	1.7	NA	0.71	0.55	1559	NA	7	NA	0.61	0.12	NA	1.5	2.4	NA
		Median	0.11	1100	15	<0.1	6.9	1.7	10000	<0.1	81	<0.5	2.5	3.1	<0.5	17	10	<0.1
		Min	0.05	740	12	<0.1	6	0.8	7300	<0.1	73	<0.5	1.5	3.1	<0.5	15	6.5	<0.1
		Max	0.12	1200	15	<0.1	7.4	1.8	10000	<0.1	87	<0.5	2.6	3.3	<0.5	18	11	<0.1
IMPACT SITES	I1	30/05/2011	<0.1	1300	11	<0.1	8.2	3.4	10000	<0.01	87	<0.5	2.9	3.3	<0.5	19	12	<0.1
	I2	17/05/2011	<0.1	1300	11	<0.1	7.5	2.6	10000	<0.01	83	<0.5	2.7	3.2	<0.5	17	11	<0.1
	I3	30/05/2011	<0.1	1100	13	<0.1	6.8	1.4	8900	<0.01	77	<0.5	2.3	3.8	<0.5	16	9.7	<0.1
	I4	17/05/2011	<0.1	1100	12	<0.1	6.9	1.3	9400	<0.01	78	<0.5	2.2	3.2	<0.5	16	9.7	<0.1
	I5	30/05/2011	<0.1	1200	13	<0.1	6.5	1.5	9900	<0.01	76	<0.5	2.3	3.1	<0.5	15	9.5	<0.1
	I6	17/05/2011	<0.1	1100	13	<0.1	6.5	1.5	9200	<0.01	76	<0.5	2.2	3.1	<0.5	16	9.7	<0.1
		Mean	<0.1	1183	12.2	<0.1	7.1	2.0	9567	<0.1	79.5	<0.5	2.4	3.3	<0.5	16.5	10.3	<0.1
		StDev	NA	98	1	NA	0.67	0.85	468	NA	4.5	NA	0.29	0.26	NA	1.4	1.0	NA
		Median	<0.1	1150	12.5	<0.1	6.9	1.5	9650	<0.1	77.5	<0.5	2.3	3.2	<0.5	16	9.7	<0.1
		Min	<0.1	1100	11	<0.1	6.5	1.3	8900	<0.1	76	<0.5	2.2	3.1	<0.5	15	9.5	<0.1
	Max	<0.1	1300	13	<0.1	8.2	3.4	10000	<0.1	87	<0.5	2.9	3.8	<0.5	19	12	<0.1	

Notes:
Where results are below LOR, half the LOR has been used in the statistical analyses (*italicised*)
ANZECC ISGQ-low - ANZECC/ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality as updated (in draft) by Simpson et al. (2008)
NAGD SL - Commonwealth of Australia (2009) National Assessment Guidelines for Dredging

QA/QC

Sample ID	Silver	Aluminium	Arsenic	Cadmium	Chromium	Copper	Iron	Mercury	Manganese	Molybdenum	Nickel	Lead	Antimony	Vanadium	Zinc	Selenium*
I6	<0.1	1100	13	<0.1	6.5	1.5	9200	<0.01	76	<0.5	2.2	3.1	<0.5	16	9.7	<0.1
Dup	<0.1	1200	13	<0.1	7.1	1.6	10000	<0.01	85	<0.5	2.4	3.2	<0.5	17	11	<0.1
Mean	-	1150	13	-	6.8	1.6	9600	-	80.5	-	2.3	3.2	-	17	10	-
% RPD	-	-8.7	0	-	-8.8	-6.5	-8.3	-	-11.2	-	-8.7	-3.2	-	-6.1	-12.6	-

Notes:

The relative percent difference (RPD) for split duplicates and the RSD for split triplicates should be within ±35%.