attachment 1

to

item 168

Investigations to Dredge Parts of the Hawkesbury River

date of meeting: 27 August 2013
location: council chambers
time: 6:30 p.m.

Hawkesbury City Council

WorleyParsons
resources & energy

EcoNomics™

HAWKESBURY CITY COUNCIL

Hawkesbury River Dredging Investigations

Pilot Sediment Investigation

301015-02986

22 May 2013

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PROJECT 301015-02986 – HAWKESBURY CITY COUNCIL – HAWKESBURY RIVER PILOT SEDIMENT INVESTIGATION

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for client review	Carsten Matthai	NLC Nicole Cowlishaw	Sofie Mason-Jones	1 May 2013	Hawkesbury City Council	20 May 2013
0	Final		Carsten Matthai	Sofie Mason-Jones	22 May 2013	Hawkesbury City Council	

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1. INTRODUCTION

The Hawkesbury River flows from the confluence of the Nepean and Gross Rivers, north of Penrith, for around 120 km to Broken Bay, where it enters the ocean. The river forms part of the greater Hawkesbury-Nepean River System, which effectively encircles metropolitan Sydney and provides its primary water source. The Hawkesbury River is navigable from Windsor to the ocean and supports numerous recreational and commercial boating activities.

The area for the sampling and analysis pilot study (the pilot study) described in this Sampling and Analysis Plan (SAP) is represented by the 32 km tidal stretch of the river from “The Breakaway” (upstream of the Windsor Bridge) to the Sackville Ferry river crossing (the Project Area). The Project Area is important for recreational boat users and a thoroughfare for vessels travelling to and from destinations further upstream (**Figure 1**).

Apart from a small section of river just north of the Windsor Bridge and potentially an area around the Sackville Ferry, it is understood that the Project Area has not been dredged previously.

Concerns from users of the river have been raised over a number of years in relation to the navigability of the Project Area. On 29 March 2011, Hawkesbury City Council resolved to present a report on dredging investigations to the Hawkesbury City Council Floodplain Risk Management Committee and requested that the Committee identify and prioritise potential locations for investigation along the Hawkesbury River between Windsor and Sackville that would provide the most cost benefit to the community.

On 18 April 2011, the Hawkesbury City Council Floodplain Risk Management Committee identified and prioritised seven (7) locations within the Project Area for investigation:

1. Sackville Ferry (SF);
2. Sackville Gorge (SG);
3. Ebenezer Church (EC);
4. Pitt Town Bottoms (PTB);
5. Sandy Point (SP);
6. Cattai Creek (CC); and
7. Bens Point (BP).

The seven priority locations on the Hawkesbury River are shown **in Figure 2**

Sediment quality investigations undertaken downstream of the Project Area in the lower Hawkesbury-Nepean River (Matthai et al., 2009) suggested an impact from booster biocides used in antifoulants on sediments in areas of high boating activity. Regionally, only few heavy metals and no organic contaminants were shown to exceed ANZECC/ARMCANZ (2000) sediment quality guideline trigger values in sediments of the lower Hawkesbury-Nepean River. However, sediments near marinas and riverside settlements in upper Berowra and Cowan Creeks also contained elevated concentrations of tributyltin (TBT) (Matthai et al., 2009).

Acid sulphate soils (ASS) planning maps for the Hawkesbury River show that the whole of the Project Area is mapped as Class 1 ASS, which are defined as areas with the highest probability of ASS being present. Any works on lands of this class are considered to present an environmental risk (Ahern et al., 1998).

On 6 February 2013, Hawkesbury City Council advised that it would like to test for Nitrogen-15 isotopes in the Project Area to provide an indication of the spatial influence of sewage treatment plant (STP) discharges.

This Pilot Sediment Investigation Report includes the following elements:

- Objectives of the Pilot Sediment Investigation;
- Maps showing the actual sediment sample locations;
- Number of sediment samples, including quality control and quality assurance (QA/QC) samples;
- Methods and procedures for sampling;
- Details of methods for sample handling, storage and QC/QA;
- List of chemical analyses; and
- Normalization of results for organic analytes to 1% TOC (within a range of 0.2-10%).

The findings of the pilot sediment investigation that are documented in this Report are in accordance with the approved “Hawkesbury River Dredging Investigations - Project Variation Request for Sampling and Analysis Pilot Study” project variation request dated 4 March 2013.

This Report provides

- a summary of the pilot sediment sampling and analysis work undertaken in the Hawkesbury River,
- an indicative baseline assessment of the dredge material at the seven priority sample locations for onshore reuse or probable waste material classification, and
- an indicative assessment of the suitability of the dredge material for offshore disposal.

The pilot study comprises whole sediment concentration testing of composite core samples only and it excludes toxicity characteristic leaching procedure (TCLP) testing, elutriate and other testing, which may be required in future, more detailed, sediment investigations to determine the potential for onshore reuse or a waste disposal classification. In addition, the number of samples per area recommended in the relevant guidelines (NAGD (e.g. Commonwealth of Australia, 2009); NSW Waste Guidelines (DECC, 2009)) was not met by the collection of one core sample at each of the seven priority sample locations.

Within the limitations of the scope of the pilot study sediment assessment, this Report provides conclusions as to the possible acceptability or unacceptability of the sediments for land based reuse, sea disposal or land disposal at the seven priority sample locations and it provides recommendations as to further work required.

2. PILOT SEDIMENT INVESTIGATION REPORT OBJECTIVES

This Report describes the physical and chemical characteristics of sediments at the seven identified priority sampling locations and it comprises a pilot study sediment investigation. The investigation obtained baseline data to assess potential dredge material disposal options, which may include the suitability of dredge material for beneficial reuse, on land disposal or sea disposal. Chemical results of sediment analyses were compared to the relevant guidelines including:

- Acid Sulfate Soils Assessment Guidelines (Ahern et al., 1998) published by the NSW Acid Sulfate Soils Management Advisory Committee (ASSMAC);
- National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009);
- NSW Waste Classification Guidelines – Part 1: Classifying Waste: Table 1 (DECC, 2009); and
- National Environmental Protection Council document National Environmental Protection (Assessment of Site Contamination) Measure 1999 (NEPC Guidelines).

While the number of samples per area and subsamples per sample location that are recommended in the assessment guidelines above was not met by the collection and chemical testing of sediment samples from one core at each of the seven priority locations, the pilot study sediment sampling provides baseline data which will be used by Hawkesbury City Council to guide future decisions on the dredging and disposal options of the material to be dredged at the seven priority locations. A detailed assessment and classification of sediments would:

a) require additional sediment sampling to meet the required minimum number of samples specified in the relevant guidelines (e.g. NAGD);

b) be dependent on the volume of dredge material and the number of dredge management areas; and

c) provide a more detailed spatial and vertical coverage of each proposed dredge management area.

A secondary objective of the pilot sediment investigation is to undertake a preliminary indicative sewage tracing assessment and characterisation through analysis of Nitrogen-15 ($\delta^{15}N$) stable isotopes in surficial sediments at six sample locations that are potentially impacted by STP discharges. The stable isotope data from these six sample locations was compared to data from two reference locations where potential sewage contributions to surficial sediments are likely to be negligible (**Figure 3**).

The fifteen sample locations (i.e. seven priority core sample locations, six sewage tracing grab sample locations and two sewage tracing reference locations) are shown in **Table 1**.

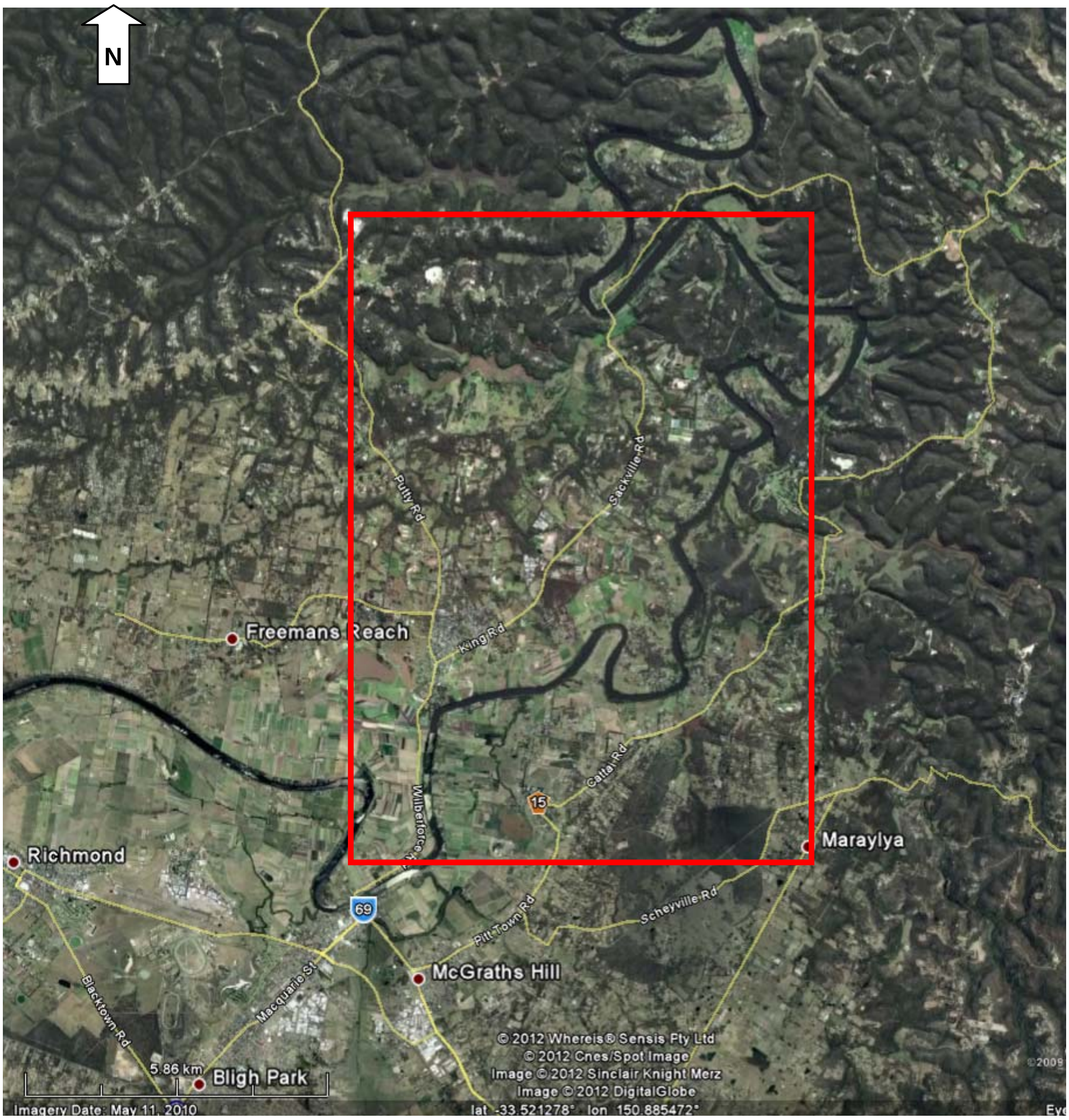

Figure 1. Hawkesbury River Pilot Sediment Investigation Project Area (Source: Google Earth and WorleyParsons, 2013).

Figure 2. Seven Priority Locations on the Hawkesbury River (Source: Google Earth and Hawkesbury City Council, 2013).

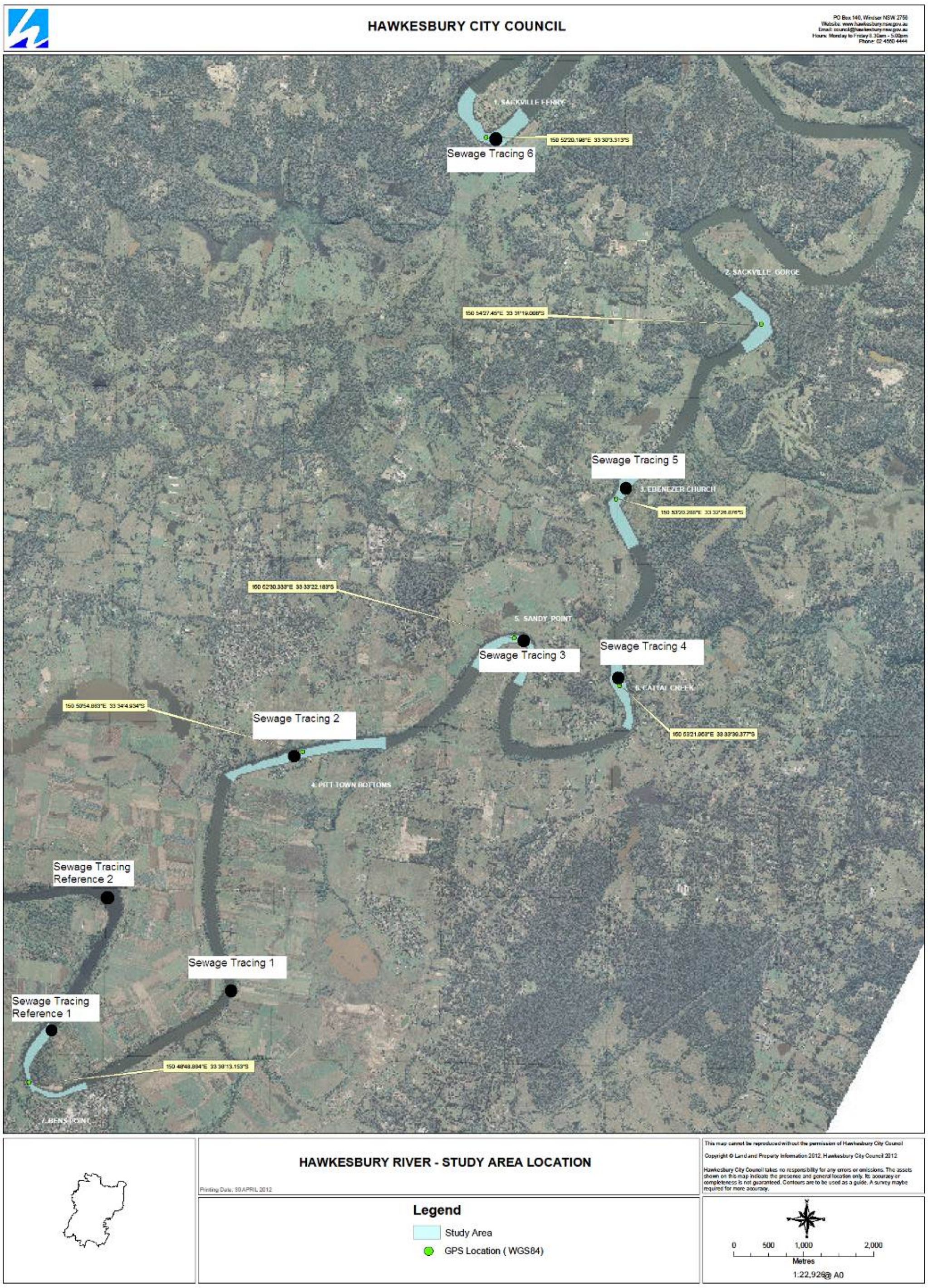

Figure 3. Six Sewage Tracing Sample Locations and Two Reference Locations on the Hawkesbury River (Source: Google Earth and Hawkesbury City Council, 2013).

Table 1. Coordinates of Priority Sample Locations, Sewage Tracing Locations and Reference Locations.

Sample Location	Sample ID	No. of Subsamples	Latitude (S)*	Longitude (E)*
1. Sackville Ferry	SF	1	33^0 30' 30.2"S	150^0 52' 25.7"E
2. Sackville Gorge	SG	1	33^0 31' 19.0"S	150^0 54' 27.5"E
3. Ebenezer Church	EC	1	33^0 32' 27.0"S	150^0 53' 22.0"E
4. Pitt Town Bottoms	PTB	1	33^0 34' 01.5"S	150^0 51' 04.5"E
5. Sandy Point	SP	1	33^0 33' 22.2"S	150^0 52' 30.3"E
6. Cattai Creek	CC	1	33^0 33' 29.5"S	150^0 53' 24.0"E
7. Bens Point	BP	1	33^0 36' 12.7"S	150^0 48' 49.9"E
8. Sewage Tracing 1	ST1	1	33^0 35' 36.4''	150^0 50' 20.2''
9. Sewage Tracing 2	ST2	1	33^0 34' 01.5''	150^0 51' 04.5''
10. Sewage Tracing 3	ST3	1	33^0 33' 22.2''	150^0 52' 30.3''
11. Sewage Tracing 4	ST4	1	33^0 33' 29.5''	150^0 53' 24.0''
12. Sewage Tracing 5	ST5	1	33^0 32' 27.0''	150^0 53' 22.0''
13. Sewage Tracing 6	ST6	1	33^0 30' 03.2''	150^0 52' 25.7''
14. Sewage Tracing Reference 1	STR1	1	33^0 35' 47.5''	150^0 49' 01.3''
15. Sewage Tracing Reference 2	STR2	1	33^0 35' 12.6''	150^0 49' 25.8''
Total Number of Sediment Samples		**15**		

*All coordinates are in WGS84; Coordinates for all sample locations were recorded in the field.

3. METHODOLOGY

3.1 Sediment Sampling (Cores and Grab samples)

Sediment cores were collected at the seven priority sample locations by Geochemical Assessments Pty Ltd (GA), using a piston push corer and surficial sediment grab samples were collected at eight sewage tracing sample locations (including two reference locations). The GA sampling vessel, a purpose built aluminium hull trailer boat 5 m in length, was used as a working platform for sediment core and grab sampling and on-board sample processing.

A handheld GPS with an accuracy of +/-5 m was used to record each sample location. Cores and grab samples were collected as close as possible to the sample locations that were proposed in the Sampling and Analysis Plan (**Appendix 1**), however, sediment core samples at Pitt Town Bottoms (PTB) and Cattai Creek (CC) were collected about 0.4 nautical miles and 0.1 nautical miles from the sample locations indicated in the SAP, as the proposed sample locations plotted on land. The sample location map provided by Hawkesbury City Council, shown as Figure 2 in the SAP (**Appendix 1**), was used to obtain the sediment core samples as close as practicable to the location indicated on the map and the coordinates of the actual sample locations were recorded in the field log book, as shown in **Table 1**.

A log was kept by a WorleyParsons Senior Environmental Scientist to record the sampling date, time, water depth, sample location coordinates, and the depth of core and grab sampler penetration at each sample location. Prior to sampling, the vessel was thoroughly inspected and washed down. Any evident sources of contamination were cleaned and covered in plastic to avoid accidental contamination of sediment samples.

Sediment cores were collected using a custom-fabricated piston push corer with a 50 mm outer diameter (OD) stainless steel core tube. Cores were driven to a total depth of up to 2.0 m or refusal.

Grab samples of the upper 10 cm of sediment were collected at the eight sewage tracing sample locations (including two reference locations) using a stainless steel Ponar grab sampler.

A WorleyParsons Senior Environmental Scientist determined the acceptability of each sediment core following collection. The criteria for acceptance of a core included:

- No obvious loss of surficial sediment;
- The core must have entered the sediment profile vertically;
- There must be no visible disturbance or gaps in the sediment stratigraphy; and
- The core must reach the depth of dredging or refusal at rock or dense sand or clay.

Composite core samples at the seven designated priority sample locations and grab samples at eight sewage tracing sample locations (including two reference locations) were collected over two days of field sampling on 2 and 3 April 2013. In addition, QA/QC split duplicate samples were collected on 10% of primary samples and analysed for all analytes that were analysed in the primary samples (i.e. one QC split duplicate sample for the seven core samples and one QC split duplicate sample for the eight grab samples). The split duplicate samples were used to assess variations associated with subsample handling and chemical analyses.

3.2 Sample Processing

All sample handling and processing was performed to minimise contamination and sample mix-ups. The workspace on the sampling vessel was washed down regularly with ambient river water to clean all surfaces and minimise dust contamination of samples. New powder-free nitrile gloves were worn by the sampler for the processing of each sample from each location. Subsampling was undertaken using stainless steel implements that were decontaminated between each sample using Decon 90, followed by an ambient river water rinse.

Piston cores were extruded from the core tube and placed on a sampling tray for subsequent logging, photographing and subsampling. A homogenised composite core sample was collected from the surface to a depth of 2.0 m (or the end of the core, if refusal occurred above 2.0 m) and samples were stored appropriately for chemical testing. Composite core samples and the upper 10 cm of sediment from grab samples were transferred into a stainless steel bowl to be homogenized prior to transferring the sample to laboratory-supplied clean and pre-labelled sample containers. Samples for chemical testing were placed with zero headspace in appropriate sampling containers that were provided by the analytical laboratory. Samples for physical testing (Particle Size Distributions (PSD) analysis) and acid sulphate soil (ASS) testing were placed in plastic zip lock bags.

Sample identifiers included the sample location initials (**Table 1**). For example, SF indicates that the sediment sample was collected from sample location 1 (Sackville Ferry). QA/QC samples were numbered consecutively (i.e. QC1, QC2) with the type of the QA/QC sample and the key for the primary sample it relates to being recorded on a separate QA/QC identification log sheet that was not revealed to the analytical laboratory.

The following sediment volumes were retained from each composite core sample for the different analyses required:

- Two 125 ml glass jars for analysis of trace metals, polycyclic aromatic hydrocarbons (PAHs), tributyltin (TBT) and total organic carbon (TOC);
- One 500 ml ziplock bag for Particle Size Distribution (PSD) analysis; and
- One 200 ml ziplock bag for Acid Sulfate Soil (ASS) analysis.

The following sediment volumes were retained from each sediment grab sample for the different analyses required:

- One 125 ml glass jar for analysis of trace metals; and

- One 125 ml glass jar for stable isotope analysis of Nitrogen-15.

3.3 Sample Preservation, Shipment and Analysis

Samples for geochemical analysis were packed in ice in an esky immediately after sampling to maintain the temperature below 4°C. Samples for physical analysis were stored at ambient temperatures. Samples were then submitted to the NATA-accredited analytical laboratory (Advanced Analytical Australia) following the completion of fieldwork under WorleyParsons Chain-of-Custody (CoC) protocols. Sediment samples for stable isotope Nitrogen-15 were forwarded to Environmental Isotopes Pty Ltd (EA) in Sydney by Advanced Analytical Australia for analysis.

Samples for possible future analyses were archived in refrigerated storage by the analytical laboratory for up to three months after sampling.

3.4 Analysis Schedule

All laboratory data, including CoCs and Reports/Certificates of Analysis (CoA) are provided in **Appendix 2**.

3.4.1 Chemical Analysis

The primary laboratory that undertook the chemical testing was the NATA registered Advanced Analytical Australia (AAA). The contaminants and the detection limit of the proposed analytical methods are outlined in the following sections and summarized in **Table 2**.

Environmental Isotopes Pty Ltd undertook the analysis of N isotope analyses on eight surfical sediment grab samples, including two reference samples (i.e. samples ST1-ST6, STR1 and STR2). The environmental isotope analysis report and a summary of the analytical methodology are provided in **Appendix 2**.

3.4.2 Physical Analysis

The seven primary composite core samples were analysed for PSD to provide an indication of the physical characteristics of the proposed dredge material at each priority sample location. Physical testing comprised a determination of PSD by wet sieving, using geological size fractions and a determination of the fine fraction content (hydrometer) to determine clay (<4 μm) and silt (4 to 63 μm) fraction contents.

3.4.3 Total Number of Sediment Samples

The number of sediment samples was one composite sample per core and one homogenized sample per grab sample, totaling seven core samples and eight grab samples (including two samples from reference locations). Therefore a total of fifteen primary sediment samples were analyzed.

In addition, two split duplicate samples were collected, comprising split samples from one of the composite core samples and one of the grab samples, respectively. The total number of chemical analyses is summarised in **Table 2**.

Table 2. Chemical Analytes for Pilot Sediment Investigation (seven composite core samples and eight grab samples)

Test Parameter	Limit of Reporting	Units	Core Sample Analyses	Grab Sample Analyses[3]	Split Duplicate Sample Analyses[2]	Total Number of Analyses
Silver (Ag)	0.1	mg/kg	7	8	2	17
Cadmium (Cd)	0.1	mg/kg	7	8	2	17
Copper (Cu)	0.1	mg/kg	7	8	2	17
Lead (Pb)	0.5	mg/kg	7	8	2	17
Zinc (Zn)	0.5	mg/kg	7	8	2	17
Chromium (Cr)	0.1	mg/kg	7	8	2	17
Nickel (Ni)	0.1	mg/kg	7	8	2	17
Arsenic (As)	0.4	mg/kg	7	8	2	17
Mercury (Hg)	0.01	mg/kg	7	8	2	17
PAHs (each individual species)	5[1]	µg/kg	7	0	1	8
TBT	0.5	µgSn/kg	7	0	1	8
TOC	0.01	%	7	0	1	8
Acid sulphate soil (Cr-reducible suite)	3	mole H+/tonne	7	0	1	8
ASS Field Screening	0.1	pH	7	0	1	8
Nitrogen-15 Isotope[4]	N/A	N/A	0	8	1	9

Notes

1. The laboratory strived to reach this PQL but matrix interference prevented the laboratory reaching this very low detection limit for Benzo(b)&(k)-fluor-anthene and Coronene (LOR: 10 μg/kg).
2. All primary and QA/QC sediment samples were analysed for all analytes.
3. The eight sediment grab samples were analysed for trace metals Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn and Nitrogen 15 stable isotope concentrations only.
4. Nitrogen isotope analyses were undertaken by Environmental Isotopes Pty Ltd.

3.5 QA/QC Procedures

3.5.1 Field QA/QC Procedures

Field QA/QC procedures included the following:

- Sample Location: A handheld GPS position fixing system with an accuracy of +/-5 m was used to locate each sample location;
- Decontamination of Sampling Equipment: Prior to use, the survey vessel was thoroughly inspected and washed down. All surfaces used for sample handling were also covered in

plastic sheeting prior to sub-sampling. All sampling equipment that could come into contact with the sediment samples was decontaminated using Decon 90 prior to each sampling event;

- Field Documentation: Each sample location was numbered on a sampling plan in the field logbook. All other observations including time, date of sampling, water depth, and depth of core penetration were noted in the field logbook. Time, date, and appearance of the sediments (e.g. texture, colour, odour) were also reported in the field logbook during sub-sampling;
- Cross Contamination: Each sample jar was washed with ambient river water following sub-sampling to remove sediment on the outside of the sample containers and to minimise cross-contamination;
- Split duplicates: At two sample locations two split duplicate samples were taken and submitted to the analytical laboratory for geochemical analysis. The split results were analysed to assess variability in sub-sampling; and
- Sample Control: Each sample has a unique identification number that was recorded in the field log book, and on the CoC form. A CoC form accompanied the sediment samples at all times, and included the analyses required for each sample.

3.5.2 Laboratory QA/QC Procedures

Laboratory QA/QC procedures for the geochemical analyses included the following:

- Analysis Blanks: One per analytical run or one in every 20 samples, whichever is the smaller;
- Laboratory Duplicate: One in every 10 samples or batch, whichever is the smaller;
- Laboratory Control Standard: One per analytical run or one in every 20 samples, whichever is the smaller;
- Laboratory Matrix Spike: One in every 20 samples or batch, whichever is the smaller;
- Surrogate Spike: For determinations that are appropriate, surrogate spikes will be added to all samples for analysis; and
- Calibration Blank: One per analytical run or one in every 20 samples, whichever is the smaller.

4. DATA VALIDATION

4.1 Field QA/QC

Split Duplicates

The relative per cent difference (RPD) of the geochemical testing of split duplicate sample pairs SF and QC1 and ST6 and QC2 is less than 25% for all parameters tested (**Table 3**). Concentrations of organic contaminants are below or near the analytical. Concentrations of organic contaminants in split duplicate samples were below or near the analytical LOR and RPD values were not calculated.

The variability of the data as a result of laboratory testing is below the 35% data quality objectives (DQO) for the analysis of duplicate samples stipulated in the National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009).

4.2 Laboratory QA/QC

The laboratory interpretive QA/QC report for laboratory duplicates, method blanks, laboratory control samples and matrix spikes is shown in **Appendix 2** and indicates that:

- for all matrices
    - no Method Blank value outliers occur;
    - no Duplicate outliers occur (RPD <10% - **Table 3**);
    - no Laboratory Control outliers occur;
    - no Matrix Spike outliers occur; and
- for all regular sample matrices, no surrogate recovery outliers occur.

Based on the laboratory QA/QC assessment the analytical data are acceptable for the environmental interpretation outlined in this report.

Table 3. Relative Per Cent Differences of Concentrations of Trace metals in Laboratory Duplicates samples (SF and ST6) and in Field Split Duplicate samples (SF/QC1 and ST6/QC2).

Sample ID		As	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn
	Unit	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	LOR	0.4	0.1	0.1	0.1	0.5	0.01	0.1	0.1	0.5
SF		0.55	<0.1	1.7	0.71	1.4	<0.01	1.7	<0.1	6.4
SF (lab duplicate)		0.6	<0.1	1.7	0.71	1.3	<0.01	1.7	<0.1	6.4
RPD(%)		-8.7	nc	0	0	7.4	nc	0	nc	0
ST6		0.86	<0.1	2.5	0.89	2.2	<0.01	2.5	<0.1	17
ST6 (lab duplicate)		0.91	<0.1	2.5	0.86	2	<0.01	2.5	<0.1	17
RPD(%)		-5.6	nc	0	3.4	9.5	nc	0	nc	0
SF		0.55	<0.1	1.7	0.71	1.4	<0.01	1.7	<0.1	6.4
QC1		0.53	<0.1	1.7	0.58	1.3	<0.01	1.7	<0.1	7.3
RPD(%)		3.7	nc	0	20.2	7.4	nc	0	nc	-13.1
ST6		0.86	<0.1	2.5	0.89	2.2	<0.01	2.5	<0.1	17
QC2		0.96	<0.1	2.8	1.1	2.2	<0.01	2.6	<0.1	16
RPD(%)		-11.0	nc	-11.3	-21.1	0	nc	-3.9	nc	6.1

LOR - limit of reporting; nc - not calculated

5. PHYSICAL AND GEOCHEMICAL CHARACTERISTICS OF SEDIMENTS IN THE HAWKESBURY RIVER

5.1 Physical Characteristics

Composite core samples comprised more than 80% and up to 100% sand-sized sediment at the seven sediment core locations, with composite fine fraction contents comprising between 0% and 16% (**Table 4**).

Sediment texture in surficial sediments at sample locations ST1 to ST6 and at the two reference locations STR1 and STR2 (water depth: 1.5 m to 4.5 m) varied from dark olive brown quartzose sand with nil fine fraction (<63 μm fraction) to dark olive slightly sandy mud with about 80% fine fraction content (**Table 5**). Similarly, the sediment in core samples varied from brown quartzose sands to dark olive-gray sandy muds.

Field photos of the sediment cores and sediment grab samples collected at each sample location are shown in **Appendix 3**.

Table 4. Gravel, Sand, Silt and Clay Content in Composite Core Samples

Sample ID	Gravel (>2 mm) (%)	Sand (0.060-2 mm) (%)	Silt (0.002-0.060 mm) (%)	Clay (<0.002 mm) (%)
SF	1	98	1	
SG	0	100	0	0
EC	0	86	10	4
PTB	4	80	12	4
SP	0	93	4	3
CC	3	96	1	
BP	1	99	0	0

Table 5. Summary of field sampling log.

Sample Location ID	Sample Location	Latitude	Longitude	Sampling Date and Time	Water Depth (m)	Sample Type	Core Length (m)	Sample Collected	Sediment Description	Additional Comments
SF	Sackville Ferry	33^0 30' 03.2"	150^0 52' 25.7"	2 April 2013, 11.45am	2.2	Piston core	2.0	0.0-2.0 m	light brown quartzose sand, homogeneous downcore to 2.0 m depth, black organic-rich layers with decomposing leaves and charcoal at 1.50-1.52 m depth and 1.70-1.71 m depth, end of core in unconsolidated sand	Sample collected 20 m west (downstream of ferry crossing; Collected split duplicate sample QC1
SG	Sackville Gorge	33^0 31' 19.0"	150^0 54' 27.5"	2 April 2013, 12.45pm	2.6	Piston core	2.0	0.0-2.0 m	dark brown-gray sand, homogeneous downcore to depth of 2.0 m, no fines, some lithic grains (dark), fine- to medium-grained, end of core in unconsolidated sand	
EC	Ebenezer Church	33^0 32' 27.0"	150^0 53' 22.0"	2 April 2013, 1.55pm	3.0	Piston core	2.0	0.0-2.0 m	dark olive slightly sandy mud (0-0.6 m; 80% visual fine fraction) overlying quartzose dark brown to gray medium- to fine-grained sand (0.6-2.0 m; 5% visual fine fraction), end of core in unconsolidated sand	
PTB	Pitt Town Bottoms	33^0 34' 01.5"	150^0 51' 04.5"	3 April 2013, 10.15am	3.5	Piston core	1.9	0.0-1.9 m	olive-gray hydrous layer overlying sandy mud (0-0.5 m depth; 60% visual fine fraction); olive-gray quartzose slightly muddy sand (0.5-0.8 m depth; 20% visual fine fraction and 5% gravel); dark gray to brown slightly gravelly quartzose sand, medium- to coarse grained (0.8-1.9 m depth); refusal on rock at 1.9 m depth	core refusal at 1.9 m
SP	Sandy Point	33^0 33' 22.2"	150^0 52' 30.3"	2 April 2013, 10.00am	1.5	Piston core	2.0	0.0-2.0	dark olive-brown sandy mud (0-0.3 m depth; 60% visual fine fraction) overlying light brown medium-grained quartzose sand (0.3-2.0 m depth; nil visual fine fraction), end of core in unconsolidated sand	
CC	Cattai Creek	33^0 33' 29.5"	150^0 53' 24.0"	2 April 2013, 3.05pm	2.7	Piston core	2.0	0.0-2.0	gray-brown quartzose medium- to coarse-grained sand with black organic-rich decomposing wood interspersed (0-0.5 m depth; 5% visual fine fraction; 5% visual gravel) overlying medium- to coarse-grained quartzose sand (0.5-2.0 m depth; nil visual fine fraction content), end of core in unconsolidated sand	
BP	Bens Point	33^0 36' 12.7"	150^0 48' 49.9"	3 April 2013, 11.45am	2.9	Piston core	1.8	0.0-1.8	light brown medium- to coarse-grained slightly gravelly quartzose sand (0.0-2.0 m depth; nil visual fine fraction; 5% visual gravel), homogeneous downcore, refusal on rock at 1.8 m depth	core refusal at 1.8 m
ST1	Midway between BP and PTB	33^0 35' 36.4"	150^0 50' 20.2"	3 April 2013, 9.15am	2.7	Grab sample	-	composite sample	dark brown quartzose sand with a thin hydrous layer, 5% visual fine fraction	
ST2	at PTB site	33^0 34' 01.5"	150^0 51' 04.5"	3 April 2013, 10.00am	3.5	Grab sample	-	composite sample	dark olive brown muddy sand with a thin dark brown hydrous layer, 40% visual fine fraction, 10% visual gravel (decomposing organic matter)	
ST3	at SP site	33^0 33' 22.2"	150^0 52' 30.3"	2 April 2013, 9.30am	1.5	Grab sample	-	composite sample	dark olive green to brown slightly muddy sand (<5% visual fine fraction)	
ST4	at CC site	33^0 33' 29.5"	150^0 53' 24.0"	2 April 2013, 3.00pm	2.7	Grab sample	-	composite sample	dark brown medium-grained quartzose sand (nil visual fine fraction), no hydrous layer	
ST5	at EC site	33^0 32' 27.0"	150^0 53' 22.0"	2 April 2013, 1.50pm	3.0	Grab sample	-	composite sample	dark olive slightly sandy mud with mud 'lumps' of 1-2 cm in size, dark brown hydrous layer in upper 1 cm, 80% visual fine fraction	
ST6	at SF site	33^0 30' 03.2"	150^0 52' 25.7"	2 April 2013, 11.40am	2.4	Grab sample	-	composite sample	light brown quartzose sand, homogeneous, nil visual fine fraction	Collected split duplicate sample QC2
STR1	ca .750m upstream of BP	33^0 35' 47.5"	150^0 49' 01.3"	3 April 2013, 12.35pm	2.3	Grab sample	-	composite sample	light brown medium-grained clean quartzose sand with a trace viusal gravel content and nil visual fine fraction content	
STR2	Upstream of STR1	33^0 35' 12.6"	150^0 49' 25.8"	3 April 2013, 1.25pm	4.5	Grab sample	-	composite sample	dark olive-brown slightly muddy quartzose sand with some organic plant material (10% visual fine fraction)	sample collected 10 m downstream of barrier spanning across the river, unable to proceed further upstream

5.2 Acid Sulfate Soils

Acid sulfate soils (ASS) planning maps for the Hawkesbury River show that the whole of the Project Area is mapped as Class 1 ASS, which are defined as areas with the highest probability of ASS being present. Any works on lands of this class are considered to present an environmental risk (Ahern et al., 1998; WorleyParsons, 2012).

It is understood that the scope of work of testing and analysis of sediments in the pilot sediment investigation does not meet the minimum requirements stipulated in the Acid Sulfate Soils Manual guidelines (Ahern et. al, 1998), such as sub-sampling and testing of sediments in 0.5 m intervals. However, the pilot sediment investigation provides an indicative assessment of acid generating risk in sediments at the seven priority locations in the Hawkesbury River through the sampling and testing of composite core samples at each of these locations.

Results of the acid sulfate soil testing are provided in **Table 6** and in **Appendix 2**.

The acid sulfate soil assessments involved two stages. The first stage of testing involved laboratory screen testing of seven primary and one field split duplicate composite core samples collected during the investigation to identify the presence and severity of actual acid sulfate soils and the likely presence of potential acid sulfate soil (PASS). The laboratory screening test reported that pH_f prior to oxidation ranged from 6.2 to 6.9 indicating that no actual acid sulfate soils (AASS) (i.e. $pH_f \leq 4$) are likely to be present though this should be confirmed through further testing. From the laboratory testing undertaken, the presence of PASS can be indicated (though not confirmed) through one or more of the following:

- Release of hydrogen sulfide (H_2S) during oxidation;
- Effervescence and release of heat during oxidation;
- A pH following oxidation (pH_{fox}) <3.5; and
- A drop in pH following oxidation of 1 or more (i.e. $pHf - pH_{fox} \geq 1$).

Analysis of the results of the field screen indicated that PASS may be present in all samples, as $pHf - pH_{fox} \geq 1$ in all seven samples tested.

Detailed laboratory analysis was carried out using the more rigid Chromium Reducible Sulfur (CRS) suite on each of the seven primary composite core samples, including those with the highest drop in pH following oxidation or those with the greatest reaction rate. A summary of results for the selected samples is provided in **Table 6**.

The Titratable Actual Acidity (TAA) results indicate that AASS is not present in any of the seven sediment samples prior to disturbance of the sediments.

The potential sulfidic acidity of each sample was determined using the Chromium Reducible Sulfur (S_{Cr}) test which is a direct measure of reduced inorganic sulfur and therefore allows distinction between inorganic sulfur such as pyrite and sulfur from organic sources. One of the seven samples (sample PTB: S_{Cr} 53 mol H^+/t) reported a potential sulfidic acidity greater than the “action criteria” specified in the Acid Sulfate Soils Manual guidelines (Ahern et. al, 1998). These results indicate a high potential for acid generating conditions to develop in the dredge material from that sample location, following disturbance and oxidation.

Generally, where action criteria are exceeded, an acid sulfate soil management plan (ASSMP) is required for the disturbance of these sediments, unless mitigating factors such as sufficient ANC are established. Such factors are accounted for by determining the net acidity of each sample using the acid base accounting equation:

Net acidity = potential sulfidic acidity + existing acidity – acid neutralising capacity

The acid neutralising capacity (ANC) of a soil is the ability of the soil to neutralise any acid that may be produced on oxidation and maintain the pH above 5.5. Organic matter, calcium carbonates (i.e. shell) and magnesium carbonates are common naturally occurring neutralising agents. The effectiveness of these agents varies depending on particle size, coatings on the agent and kinetic factors which affect the rate at which they dissolve and become available. To account for these limitations, the acid neutralising capacity is divided by a minimum fineness factor of 1.5.

As shown in **Table 6**, the net acidity did not exceed the action criteria provided in the Acid Sulfate Soils Manual (Stone et. al, 1998) in any of the seven composite sediment core samples. Preliminary liming rates for the neutralisation of the samples vary from <0.75 kg $CaCO_3$/t to 4.3 kg $CaCO_3$/t of sediment.

An ASSMP may not be required if the proposed works are expected to result in the oxidation of the dredged material during removal, transportation, reuse or disposal, however, additional sediment sampling and assessment would be required to fulfil the minimum sampling criteria, including sampling at a minimum of 0.5 m downcore sample intervals. In addition, sampling would be required at a minimum number of sampling locations, depending on the area of dredging.

Table 6. Summary of Acid Sulfate Soil Testing

		ASS Screen Test				Laboratory Result of Chromium Suite Testing																	
						Actual Acidity			Potential Acidity		Acid Neutralising Capacity			Retained Acidity				Acid Bas	Acid Base Accounting				
		pH_F	pH_{Fox}	Drop in pH	Reaction Rate	pH_{KCl}	TAA	s-TAA	S_{CR}		ANC	a - ANC_{BT}	s - ANC_{BT}	a-S_{NAS}	s-S_{NAS}	S_{KCL}	S_{HCL}	Net Acidity				Liming Rate	Liming Rate without ANCE
		pH Unit	pH Unit			pH Unit	mole H+/t	% S	% S	mole H+/t	% $CaCO_3$	mole H+/t	% S	mole H+/t	% S	% S	% S	% S acid trail	% S sulfur trail	mole H+/t	mole H+/t acid trail	kg $CaCO_3$/t	kg $CaCO_3$/t
Core	**Depth**	**0.1**	**0.1**			**0.1**	**5**	**0.01**	**0.005**	**3**	**0.05**	**10**	**0.05**	**0.005**	**0.005**	**0.005**	**0.005**	**Calculated**		**Calculated**			
SF	**0.0-2.0**	6.5	2.4	**4.1**	1	5.5	<5	<0.01	<0.005	<3	<0.05	<10	<0.05	<0.005	<0.005	<0.005	<0.005	-0.01	<0.02	<10	<10	<0.75	<0.75
SG	**0.0-2.0**	6.5	4.2	**2.3**	1	5.5	<5	<0.01	<0.005	<3	<0.05	<10	<0.05	<0.005	<0.005	<0.005	<0.005	-0.01	<0.02	<10	<10	<0.75	<0.75
EC	**0.0-2.0**	6.9	3.7	**3.2**	**3**	5.5	<5	<0.01	0.01	6	<0.05	<10	<0.05	<0.005	<0.005	<0.005	<0.005	-0.01	<0.02	6	<10	<0.75	<0.75
CC	**0.0-2.0**	6.3	**3**	**3.3**	1	5.5	<5	<0.01	<0.005	<3	<0.05	<10	<0.05	<0.005	<0.005	<0.005	<0.005	-0.01	<0.02	<10	<10	<0.75	<0.75
SP	**0.0-2.0**	6.6	3.3	**3.3**	1	5.1	<5	<0.01	<0.005	3	<0.05	<10	<0.05	<0.005	<0.005	<0.005	<0.005	-0.01	<0.02	<10	<10	<0.75	<0.75
BP	**0.0-1.8**	6.2	4.7	**1.5**	1	5.8	<5	<0.01	<0.005	<3	<0.05	<10	<0.05	<0.005	<0.005	<0.005	<0.005	-0.01	<0.02	<10	<10	<0.75	<0.75
PTB	**0.0-1.9**	6.7	3.1	**3.6**	1	5.1	<5	<0.01	**0.08**	**53**	<0.05	58	<0.05	<0.005	<0.005	<0.005	<0.005	0.06	0.06	14	14	4.3	4.3

Notes: Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Vigorous; 4 - Very Vigorous **BOLD** - pHfox (<3.5), drop in pH (≥1) or reaction rate (≥2) indicates PASS Acid neutralising capacity not effective where pH_{KCL} <6.5

* Liming rate using Ag Lime (ENV = 98%), Safety Factor = 1.5

5.3 Geochemical Characteristics of Sediments

The concentrations of all chemical parameters tested in the sampled sediments (composite core and surface grab samples) are shown in **Table 7**.

Concentrations of Ag and Cd were below the analytical limit of reporting (LOR) of 0.1 mg/kg in all sediment samples tested.

Concentrations of As varied from 0.55 to 5.3 mg/kg, with the highest concentration of As at sample location ST5 (EC).

Concentrations of Cr varied between 1.7 and 15 mg/kg, with the highest concentration of Cr at sample location ST5 (EC).

Cu concentrations in sediments varied from 0.68 to 17 mg/kg, with the highest concentration at sample location ST5 (EC).

Concentrations of Pb in sediments varied from 1.4 to 17 mg/kg and the highest concentration of Pb was present at sample location ST5 (EC).

Hg concentrations in sediments varied from <0.01 to 0.04 mg/kg, with the highest concentration in sediments from sample location ST5 (EC).

Concentrations of Ni in sediments varied from 1.7 to 14 mg/kg, with the highest concentration in sediments at sample location ST5 (EC).

Concentrations of Zn varied from 6.4 to 87 mg/kg, with the highest concentration in sediments from sample location ST5 (EC).

Concentrations of PAHs were mostly near or below the analytical LOR for individual PAHs, with the exception of:

- Phenanthrene (68 μg/kg), Fluoranthene (17 μg/kg), Pyrene (24 μg/kg), Benz(a)anthracene (13 μg/kg), Chrysene (46 μg/kg), Benzo(b)&(k)-fluor-anthene (21 μg/kg), Benzo(e)pyrene (21 μg/kg) and Perylene (11 μg/kg) in sediment from sample location SF;
- Phenanthrene (10 μg/kg), Fluoranthene (12 μg/kg), Pyrene (12 μg/kg), Benzo(b)&(k)-fluor-anthene (15 μg/kg) and Perylene (140 μg/kg) in sediment from sample location EC;
- Phenanthrene (16 μg/kg), Fluoranthene (10 μg/kg), Benzo(b)&(k)-fluor-anthene (10 μg/kg) and Perylene (58 μg/kg) in sediment from sample location PTB; and
- Perylene (89 μg/kg) in sediment from sample location SP.

Total PAH concentrations varied from <100 μg/kg to 250 μg/kg, with three of the seven composite sediment core samples containing more than 100 μg/kg of total PAHs (i.e. samples SF, SG, PTB). Concentrations of total PAHs normalized to 1 per cent organic carbon varied from <100 μg/kg to 595 μg/kg at sample location SF.

Concentrations of TBT were below the analytical LOR in all sediment samples tested.

Total organic carbon contents in sediments varied from 0.05% to 0.70%.

Table 7. Concentrations of Chemical Parameters in Sediments.

Sample ID		Moisture Content	As	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn	Naphthalene	1-Methyl-naphthalene	2-Methyl-naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)&(k)-fluoranthene	Benzo(a)-pyrene	Indeno(1,2,3-cd)-pyrene	Dibenz(a,h)-anthracene	Benzo(g,h,i)-perylene	Coronene	Benzo(e)-pyrene	Perylene	Total PAHs	Total PAHs (normalized to 1% TOC	MBT
	Unit	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µgSn/k
	LOR	0.1	0.4	0.1	0.1	0.1	0.5	0.01	0.1	0.1	0.5	5	5	5	5	5	5	5	5	5	5	5	5	10	5	5	5	5	10	5	5	100	-	0.5
NAGD Screening Level			20	1.5	80	65	50	0.15	21	1	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10000	-
NSW Waste Guidelines (General Solid Waste - CT1)			100	20	100	-	100	4	40	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	800	-	-	-	-	-	-	-	-	-
NEPM HIL/HSL C (developed open space or recreational areas)			300	100	240	20000	600	400	800	-	30000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	400000	-	-
NEPC - Ecological Investigation Level (EILS) Interim Urban			50	3	400	100	270	1	30	-	200	170000	-	-	-	-	-	-	-	-	-	-	-	-	700	-	-	-	-	-	-	-	-	-
SF		19.3	0.55	<0.1	1.7	0.71	1.4	<0.01	1.7	<0.1	6.4	<5	8	<5	<5	<5	<5	68	<5	17	24	13	46	21	9	<5	<5	8	<10	21	11	250	595	<0.5
SG		20.1	0.66	<0.1	2.5	0.83	2	<0.01	2.1	<0.1	9.4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<10	<5	5	<100	<100	<0.5
EC		25.8	2	<0.1	5.9	5.3	6.2	0.01	5.1	<0.1	30	<5	<5	<5	<5	<5	<5	10	<5	12	12	6	9	15	8	6	<5	8	<10	8	140	240	343	<0.5
PTB		14.7	1.7	<0.1	5.2	3.6	3.7	<0.01	4.7	<0.1	16	6	<5	6	<5	<5	<5	16	<5	10	9	6	9	10	<5	<5	<5	<5	<10	<5	58	130	500	<0.5
SP		23.6	1.4	<0.1	4.4	3.8	4.9	<0.01	4	<0.1	23	<5	<5	<5	<5	<5	<5	5	<5	5	6	<5	<5	<10	<5	<5	<5	<5	<10	<5	89	100	370	<0.5
CC		18.4	0.79	<0.1	2.7	1.4	2	<0.01	2.2	<0.1	9.1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<10	<5	7	<100	<100	<0.5
BP		19.8	0.62	<0.1	2.1	0.68	1.7	<0.01	1.9	<0.1	7.8	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<10	<5	<5	<100	<100	<0.5
ST1		32.6	2.5	<0.1	7.9	7.7	8.3	0.02	7.8	<0.1	47	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
ST2		31.9	2.1	<0.1	6.9	5.7	7.2	0.01	6.6	<0.1	33	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
ST3		25.3	1.3	<0.1	4.1	3.5	4.3	<0.01	4.4	<0.1	23	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
ST4		19	0.63	<0.1	2	0.89	2	<0.01	1.9	<0.1	9.4	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
ST5		58.3	5.3	<0.1	15	17	17	0.04	14	<0.1	87	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
ST6		18.1	0.86	<0.1	2.5	0.89	2.2	<0.01	2.5	<0.1	17	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
STR1		21	0.65	<0.1	2.1	0.76	1.7	<0.01	2	<0.1	8.9	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
STR2		26.1	1.4	<0.1	5.2	3.7	4.9	0.01	5.4	<0.1	26	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Min		14.7	0.55	<0.1	1.7	0.68	1.4	<0.01	1.7	<0.1	6.4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5	<10	<5	<5	<100	343	<0.5
Max		58.3	5.30	<0.1	15.0	17.0	17.0	0.04	14	<0.1	87.0	6	8	6	<5	<5	<5	68	<5	17	24	13	46	21	9	6	<5	8	<10	21.0	140	250	595	<0.5
Mean		24.9	1.50	<0.1	4.7	3.8	4.6	0.02	4.4	<0.1	23.5	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	45	124	280	<0.5

Notes:

Total PAHs and TBT are normalised to 1% TOC (within 0.2% to 10% range). Where results are below LOR, half the LOR has been used in the statistical analy na - not analysed nc - not calculated "-" - no value provided

NEPC - National Environmental Protection Council (NEPC) (1999) National Environmental Protection (Assessment of Site Contamination) Measure NAGD - National Asessment Guidelines for Dredging (Commonwealth of Australia, 2009)

6. COMPARISON OF CHEMICAL CONCENTRATIONS TO GUIDELINE LEVELS

Chemical results of sediment analyses were compared to relevant guidelines including:

- NSW Waste Classification Guidelines – Part 1: Classifying Waste: Table 1 (DECC, 2009);
- National Environmental Protection Council document National Environmental Protection (Assessment of Site Contamination) Measure 1999 (NEPC Guidelines); and
- National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009);

6.1 Comparison of Results to DECC (2009) Waste Classification Guidelines

Individual results were compared to the NSW DECC (2009) Waste Classification Guidelines: Part 1 – Classifying Waste for the purpose of assessing the proposed dredge material for on land disposal.

Individual results for all contaminants were below the CT1 levels, indicating that the material from all seven priority locations may be suitable for disposal as general Solid Waste (**Table 7**).

However, due to the insufficient number of samples collected for each priority area in the pilot sediment investigation, there may be additional sampling and testing requirements and restrictions applied to the offsite disposal of the sediments at a licensed landfill. If dewatering of material is required prior to any onshore disposal, consideration would also need to be given to the quality of the return water and any specific treatment or disposal requirements. These matters would need to be addressed in an environmental assessment for any future proposed dredging and disposal works.

6.2 Comparison of Results to Contamination Criteria for Reuse

The draft variation to the National Environment Protection (Assessment of Site Contamination) Measure (the NEPM) was released in September 2010. The NEPM comprises an overarching framework for the assessment of site contamination and its relationship to the management of site contamination.

Changes to the NEPM made in the draft variation incorporate new scientific information and technological improvements. The changes allow for the setting of protection levels for the environment and levels of site management on a site specific basis. The changes are expected to reduce the level of costly and sometimes unnecessary site remediation undertaken based on the use of generic criteria.

The NEPM are relevant should the dredge material be considered for reuse on land such as on playing fields or as beach nourishment material. The relevant NEPM criteria that apply to the Hawkesbury River dredging project include:

- Health Investigation Levels (HIL's[1]) and Health Screening Levels (HSL's[2]) Category C developed open space or recreational areas; and
- Ecological Investigation Levels (EIL's[3]) for urban residential and open public spaces.

Individual results and the mean concentration of each contaminant for each of the seven priority sample locations were found to be below the HILs and HSLs Category C. While no reuse criteria are available for TBT, the concentrations of TBT below the analytical LOR in all sediment core samples at all sample locations suggests that TBT is unlikely to be a contaminant of potential concern in sediments in the Project Area (**Table 7**).

Due to the insufficient number of samples collected for each priority area in the pilot sediment investigation, there may be additional sampling and testing requirements and restrictions applied to the dredging and beneficial reuse of the sediments. Additional sampling and testing requirements would need to be addressed in an environmental assessment for any future proposed dredging and disposal works.

6.3 Comparison of Results to NAGD Sediment Quality Guidelines for Sea Disposal

Results for organic analytes, including TBT and total PAHs, were normalised to 1% TOC (within limits of 0.2% to 10% TOC) and results for each contaminant were compared to the NAGD Screening Levels. Where concentrations were below the analytical laboratory limit of reporting (<LOR), a value of half the LOR was used in the statistical analysis of the results and the calculation of the mean concentrations.

The concentrations of chemical parameters tested, and for which there is an available corresponding guideline level, were below the NAGD Screening Levels in all sediment samples and for all chemicals tested (**Table 7**).

A full characterisation of sediments for sea disposal under the NAGD would require additional sediment sampling and testing under a Sampling and Analysis Plan (SAP) approved by the Department of Sustainability, Environment, Water, Populations and Communities (SEWPAC).

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[1] HILs - Health investigation levels are generic and apply across Australia to all soil types generally to a depth of 3 m below surface.

[2] HSLs - Health screening levels for petroleum hydrocarbons depend on physicochemical properties of soil as it affects hydrocarbon vapour movement in soil and the characteristics of building structures. They apply to different soil types, land uses and depths below surface to >4 m and have a range of limitations.

[3] EILs - Ecological investigation levels depend on specific soil physicochemical properties and land use scenarios and generally apply to the top 2m of soil.

7. ASSESSMENT OF NITROGEN ISOTOPES AS TRACER OF SEWAGE PARTICULATE MATTER

Previous studies published in the international scientific literature have shown that it is possible to exploit the isotopic distinction of untreated or primary-treated sewage organic matter (OM) that carries an isotopically-depleted terrestrial signal relative to marine, estuarine or fluvial OM to delineate sewage influence and to demonstrate that sewage particles are incorporated into marine food webs (Savage, 2005).

A physical stable isotope mixing model, which utilizes sewage particulate matter and “clean” sediments from reference locations in the Hawkesbury River that are located upstream of South Creek as end members, would require a substantially greater sampling density and a greater inter- and intra-site replication of analyses, both at reference sampling locations and at sample locations downstream of the inferred sewage source (i.e. South Creek). In addition, it would be necessary to sample sediments with similar physical characteristics that are preferentially fine-grained (‘muddy’) and organic-rich (i.e. containing >1% organic carbon), as these sediments would be more suited to N Nitrogen (N) isotope analyses.

Testing of surficial sediments in the Project Area for N-isotopes was undertaken to provide an indication of the spatial influence of sewage treatment plant (STP) discharges downstream of South Creek, which is the likely source of sewage particulate matter to sediments in the Hawkesbury River. Surficial sediment sampling of the upper 10 cm of sediments was undertaken at six sample locations located between South Creek and Sackville Ferry (ST1-ST6). In addition, two reference locations (STR1-STR2) were selected upstream of South Creek to compare the N isotope data to the sampling locations downstream of South Creek (**Figure 3**).

The pilot sediment investigation required sediment sampling at sample locations downstream of South Creek and at or near sediment core locations, where sediments were found to be substantially sands to muddy sands, with fine fraction (<0.060 mm fraction) contents of <20% at all seven priority locations. Therefore analysis and quantification of N isotopes was not possible in samples from sample locations ST4 and ST6, and at reference location STR1. However, the N isotope concentrations ($\delta^{15}N$) were determined for sediment samples from locations ST1 (approximately mid-way between Bens Point (BP) and Pitt Town Bottoms (PTB)), ST2 (Pitt Town Bottoms (PTB)), ST3 (Sandy Point (SP)) and ST5 (Ebenezer Church (EC)) and from reference location STR2 (upstream of South Creek).

7.1 Nitrogen Isotope Mixing Model

Linear mixing models can be used to partition two sources with a single isotopic signature. Two conditions must be met to exploit mixing models for source partitioning in isotopic studies. Firstly, the contributing sources (end-members) must have distinctive isotopic signals. Secondly, if diagenetic alteration of the isotopic signature occurs, it must do so in a predictable way. This report includes estimates of the relative contribution of possible sewage-derived and ‘natural’ estuarine N based on calculations using simple $\delta^{15}N$ two-source mixing models of the form:

$$\delta^{15}N_x = X(\delta^{15}N_{sewage}) + (1 - X)\delta^{15}N_y$$

where X is the percent sewage contribution, $\delta^{15}N_x$ is the estimated (from the literature, refer to Savage, 2005) mean $\delta^{15}N$ value of sewage particulate matter derived from sources in South Creek, $\delta^{15}N_{sewage}$ is the $\delta^{15}N$ signature of the sediment samples in the Hawkesbury River, and $\delta^{15}N_y$ is the reference $\delta^{15}N$ value at reference location STR2 upstream of South Creek.

This mixing model does not consider other terrestrial sources because the sewage N is assumed to overwhelm other terrestrial inputs of N to Hawkesbury River. The relative estimated contribution of sewage N and the end-member source values used in the calculations are presented in **Table 8**. For additional details on the assumptions of the mixing models refer to Savage (2005).

It is important to note that the mixing model does not have well-defined end members and that it would require substantial additional verification and sampling to generate a greater level of reliability and certainty regarding the likely contribution of sewage particulate-matter derived organic carbon that has been assimilated in surficial sediments.

Table 8. Per cent sewage N (X) that is assimilated in fluvial organic matter and deposited in sediments is estimated using a stable isotopic mixing model.

Sample location	$\delta^{15}N_x$ *	Reference Location (STR2) $\delta^{15}N_y$	$\delta^{15}N_{sewage}$ **	X (% sewage)
ST1	6.2	4.6 ‰	38 ‰	4.8
ST2	6	4.6 ‰	38 ‰	4.2
ST3	5.7	4.6 ‰	38 ‰	3.3
ST4	na	4.6 ‰	38 ‰	na
ST5	8.5	4.6 ‰	38 ‰	11.7
ST6	na	4.6 ‰	38 ‰	na
**Sewage Particulate matter (after Savage, 2005)				
na - not analysed (insufficient organic carbon in sample)				

7.2 Sewage Contributions to Organic Matter in Surficial Sediments

The estimated sewage particulate matter content in organic matter in surficial sediments varies from 3.3% at sample location ST3 (Sandy Point) to 11.7% at sample location ST5 (Ebenezer Church). While the estimated sewage content decreases with greater distance from South Creek from 4.8% at sample location ST1 (approximately mid-way between BP and PTB), which is nearest to South Creek, to 3.3% at sample location ST3 (Sandy Point), the estimated sewage content at sample location ST5 downstream of ST3 exceeds 10% (**Table 8**).

The surficial sediment sampled at ST5 (Ebenezer Church) contains the highest concentrations of trace metals of the eight surface sediment samples collected, which reflects the depositional nature of the sediment at that location compared to the other sample locations. Surficial sediment at ST5 comprises 80% visual fine fraction and dark olive slightly sandy mud in the upper 0.6 m of sediment. Therefore it is likely that sewage organic matter that originates upstream from areas in the South Creek catchment would be transported downstream and be deposited in a lower energy section of the river at location ST5 (EC). In contrast, the relative contributions of sewage particulate matter decrease with greater distance from the inferred source in South Creek from sample locations ST1 to ST3, reflecting a higher energy environment and a consequently greater dilution of sewage-derived organic carbon with distance from the likely source in South Creek.

The concentrations of trace metals, PAHs and TBT in sediments at the seven priority sample locations in the Hawkesbury River are low, which is generally consistent with the low concentrations of trace metals in sediments in the Lower Hawkesbury River downstream of the Sackville Ferry up to the Moonee Moonee Bridge. Therefore the empirical geochemical data obtained by the pilot sediment investigation are consistent with the geochemical characterisation of sediments in the Lower Hawkesbury River observed in published literature (Matthai et al., 2009) and the area geochemistry of the Hawkesbury River sediments with regards to trace metals, PAHs and TBT is homogeneous.

The generally low concentrations of trace metals, PAHs and TBT in sediments at all sample locations indicates that the concentrations of trace metals in the Hawkesbury River, including the Lower Hawkesbury River downstream of the Sackville Ferry are similar laterally (spatially) and vertically (downcore to a depth of up to 2 m). This supports the premise that the requirements for additional geochemical characterisation of sediments at the seven priority sampling locations for an assessment of sediments for sea disposal or on land disposal may be reduced, if approved by the relevant regulatory authorities (i.e. state and/or Federal authorities), and using the empirical chemical data obtained by the pilot sediment investigation.

However, additional geochemical and ecotoxicological assessments such as bioavailability of contaminants, sediment toxicity, and acid generating potential of the dredge material, if required, may have to be undertaken separately and at a greater lateral and vertical sample density in future, as these additional investigations were not included in the pilot sediment investigation.

8. CONCLUSIONS

The pilot sediment investigation provides baseline physical and geochemical data at seven priority locations in the Hawkesbury River. The outcomes of the investigation may be summarised as follows:

- Sediment texture in surficial sediments at sample locations ST1 to ST6 and at two reference locations STR1 and STR2 varied from dark olive brown quartzose sand (nil fine fraction content) to dark olive slightly sandy mud (~80% fine fraction content). Sediment in core samples varied from brown quartzose sands to dark olive-gray sandy muds;
- Net acidity did not exceed action criteria provided in the Acid Sulfate Soils Manual (Stone et. al, 1998) in any of the seven composite sediment core samples. Preliminary liming rates for the neutralisation of the samples vary from <0.75 kg $CaCO_3$/t to 4.3 kg $CaCO_3$/t of sediment;
- Estimated sewage particulate matter contents in organic matter in surficial sediments vary from 3.3% to 11.7%. While the estimated sewage content decreases with greater distance from South Creek from 4.8% near South Creek to 3.3% at sample location ST3 (Sandy Point), the estimated sewage content at sample location ST5 downstream of ST3 exceeds 10%.
- Concentrations of all chemical parameters tested, and for which there is an available guideline level, were below the NAGD Screening Levels, the NSW Waste Guidelines CT1 Level (Solid Waste) and the NEPC Guidelines (Ecological Investigation Level) in all sediment samples and for all chemicals tested;
- Based on the laboratory QA/QC assessment the analytical data are acceptable for the environmental interpretation outlined in this report; and
- The pilot study sediment sampling has generated baseline geochemical data that provides an indicative geochemical characterisation of sediments at each of the seven priority locations. The geochemical data can be used by Hawkesbury City Council to guide future decisions on the dredging and disposal options of sediments (i.e. sea disposal, land based re-use or land disposal). While the baseline geochemical data for the sediments at the seven priority locations that was obtained during the pilot sediment investigation do not indicate contamination above environmental guideline concentrations (i.e. NAGD, NSW Waste Guidelines, NEPC Guidelines) for any of the contaminants tested, additional sediment sampling and assessment would be required to fulfil the minimum sampling criteria, including sampling at a minimum of 0.5 m downcore sampling intervals and at a minimum number of sampling locations, depending on the size of the area of dredging. However, it may be possible, if approved by the relevant government regulatory authorities, for the number of additional sample locations to be reduced, based on the outcomes of the pilot sediment assessment and the low overall contaminant concentrations in sediments at the seven priority locations.

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Appendix 1 Sampling and Analysis Plan

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HAWKESBURY CITY COUNCIL

Hawkesbury River Dredging Investigations

Sampling and Analysis Pilot Study

Sampling and Analysis Plan

301015-02986

26 March 2013

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HAWKESBURY CITY COUNCIL
HAWKESBURY RIVER DREDGING INVESTIGATIONS
SAMPLING AND ANALYSIS PLAN

Disclaimer

This document has been prepared for the sole purpose of documenting our Sampling and Analysis Plan (SAP) to undertake sediment sampling in the Hawkesbury River. This SAP has been prepared on behalf of and for the exclusive use of Hawkesbury City Council, and is subject to and issued in accordance with the agreement between Hawkesbury City Council and WorleyParsons. WorleyParsons accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

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PROJECT - HAWKESBURY RIVER DREDGING INVESTIGATIONS - SAMPLING AND ANALYSIS PILOT STUDY

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	C Matthai	N Cowlishaw	N/A	18-Mar-13	N/A	
B	Issued for client review	C Matthai	N Cowlishaw	N/A	18-Mar-13		
0	Issued to client	C Matthai	N Cowlishaw	N Cowlishaw	26-Mar-13		

CONTENTS

1 INTRODUCTION

The Hawkesbury River flows from the confluence of the Nepean and Gross Rivers, north of Penrith, for around 120 km to Broken Bay, where it enters the ocean. The river forms part of the greater Hawkesbury-Nepean River System, which effectively encircles metropolitan Sydney and provides its primary water source.

The Hawkesbury River is navigable from Windsor to the ocean and supports numerous recreational and commercial boating activities. The area for the sampling and analysis pilot study (the pilot study) described in this Sampling and Analysis Plan (SAP) is represented by the 32 km tidal stretch of the river from “The Breakaway” (upstream of the Windsor Bridge) to the Sackville Ferry river crossing (the Project Area). The Project Area is important for recreational boat users and a thoroughfare for vessels travelling to and from destinations further upstream (**Figure 1**).

Apart from a small section of river just north of the Windsor Bridge and potentially an area around the Sackville Ferry, it is understood that the Project Area has not been dredged previously.

Concerns from users of the river have been raised over a number of years in relation to the navigability of the Project Area. On 29 March 2011, Hawkesbury City Council resolved to present a report on dredging investigations to the Hawkesbury City Council Floodplain Risk Management Committee and requested that the Committee identify and prioritise potential locations for investigation along the Hawkesbury River between Windsor and Sackville that would provide the most cost benefit to the community.

On 18 April 2011, the Hawkesbury City Council Floodplain Risk Management Committee identified and prioritised seven (7) locations within the Project Area for investigation: 1. Sackville Ferry; 2. Sackville Gorge; 3. Ebenezer Church; 4. Pitt Town Bottoms; 5. Sandy Point; 6. Cattai Creek; and 7. Bens Point (**Figure 2**).

Sediment quality investigations undertaken downstream of the Project Area in the lower Hawkesbury-Nepean River (Matthai et al., 2009) suggested an impact from booster biocides used in antifoulants on sediments in areas of high boating activity. Regionally, only few heavy metals and no organic contaminants were shown to exceed ANZECC/ARMCANZ (2000) sediment quality guideline trigger values in sediments of the lower Hawkesbury-Nepean River. However, sediments near marinas and riverside settlements in upper Berowra and Cowan Creeks also contained elevated concentrations of tributyltin (TBT) (Matthai et al., 2009).

Acid sulphate soils (ASS) planning maps for the Hawkesbury River show that the whole of the Project Area is mapped as Class 1 ASS, which are defined as areas with the highest probability of ASS being present. Any works on lands of this class are considered to present an environmental risk (Ahern et al., 1998).

On 6 February 2013, Hawkesbury City Council advised that it would like to test for Nitrogen-15 isotopes in the Project Area to provide an indication of the spatial influence of sewage treatment plant (STP) discharges.

This SAP includes the following elements:

- Objectives of the SAP;
- Maps showing the proposed sediment sample locations;
- Number of sediment samples, including quality control and quality assurance (QA/QC) samples;
- Methods and procedures for sampling;
- Details of methods for sample handling, storage and QC/QA; and
- List of chemical analyses.

1.1 Objectives

This SAP describes the pilot study sediment investigation at the seven identified priority sampling locations to describe the physical and chemical characteristics of sediments. The investigation will also obtain baseline data to assess potential dredge material disposal options, which may include the suitability of dredge material for beneficial reuse, on land disposal or sea disposal. Chemical results of sediment analyses will be compared to the relevant guidelines including:

- Acid Sulfate Soils Assessment Guidelines (Ahern et al., 1998) published by the NSW Acid Sulfate Soils Management Advisory Committee (ASSMAC);
- National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009);
- NSW Waste Classification Guidelines – Part 1: Classifying Waste: Table 1 (DECC, 2009); and
- National Environmental Protection Council document National Environmental Protection (Assessment of Site Contamination) Measure 1999 (NEPC Guidelines).

While the number of samples per area and subsamples per sample location that are recommended in the assessment guidelines above will not be met by the collection and chemical testing of sediment samples from one core at each of the seven priority locations, the pilot study sediment sampling is considered to provide baseline data which will be used to guide future decisions on the dredging and disposal options of the material to be dredged at the seven priority sample locations. A detailed assessment and classification of sediments would:

a) require additional sediment sampling to meet the required minimum number of samples specified in the relevant guidelines (e.g. NAGD);

b) be dependent on the volume of dredge material and the number of dredge management areas; and

c) provide a better spatial and vertical coverage of each proposed dredge area.

A secondary objective of the pilot study is a preliminary sediment investigation to assess sewage tracing and characterisation through analysis of Nitrogen-15 stable isotopes in surficial sediments at six (6) sample locations that are potentially impacted by STP discharges. The stable isotope data from these six sample locations will be compared to data from two (2) reference locations where potential sewage contributions to surficial sediments are likely to be negligible (**Figure 3**).

The fifteen (15) sample locations (i.e. seven priority locations, six sewage tracing sample locations and two sewage tracing reference locations) are summarized in **Table 1**.

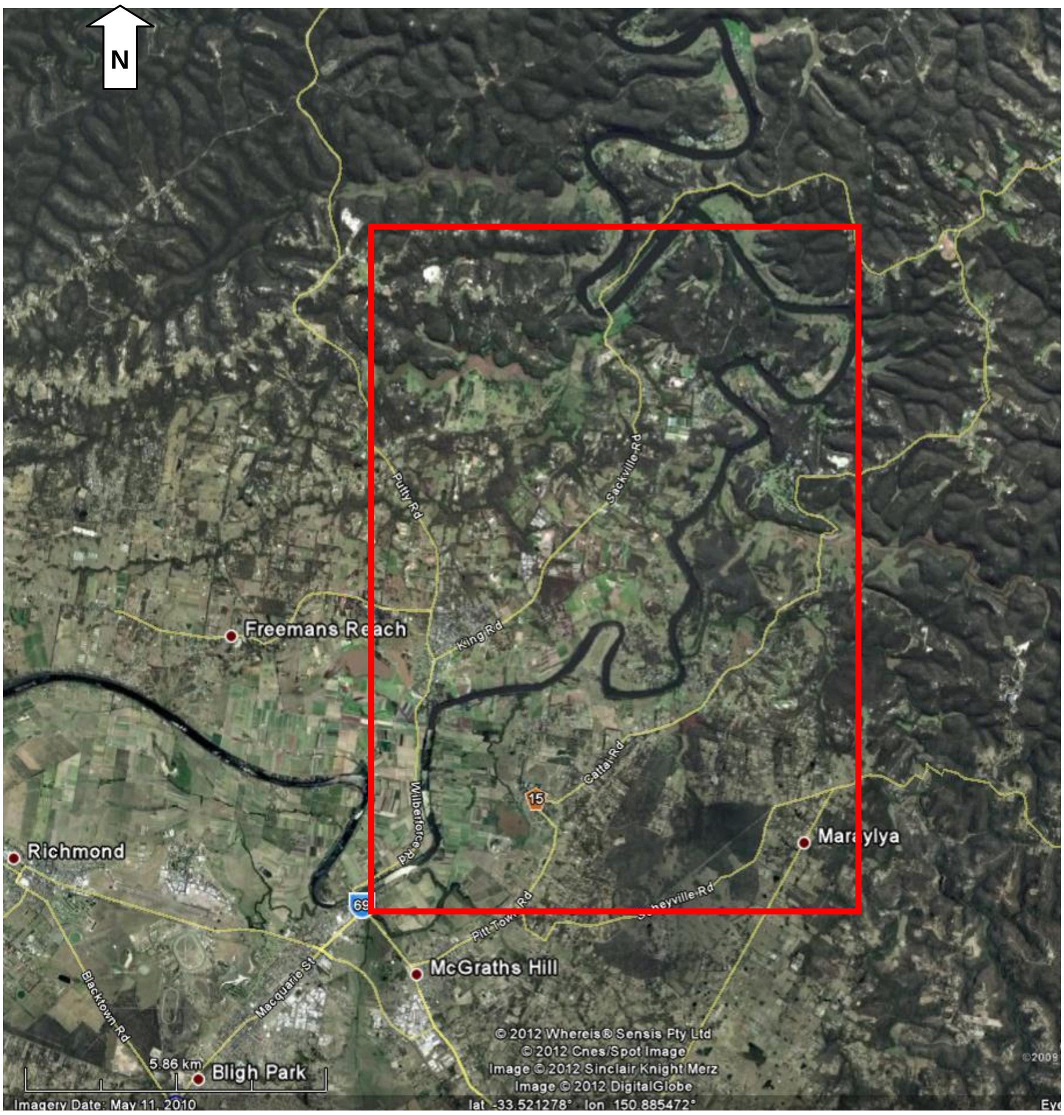

Figure 1. Hawkesbury River dredging investigation Project Area (Source: Google Earth and WorleyParsons, 2012).

Figure 2. Seven Priority Locations on the Hawkesbury River (Source: Google Earth and Hawkesbury City Council).

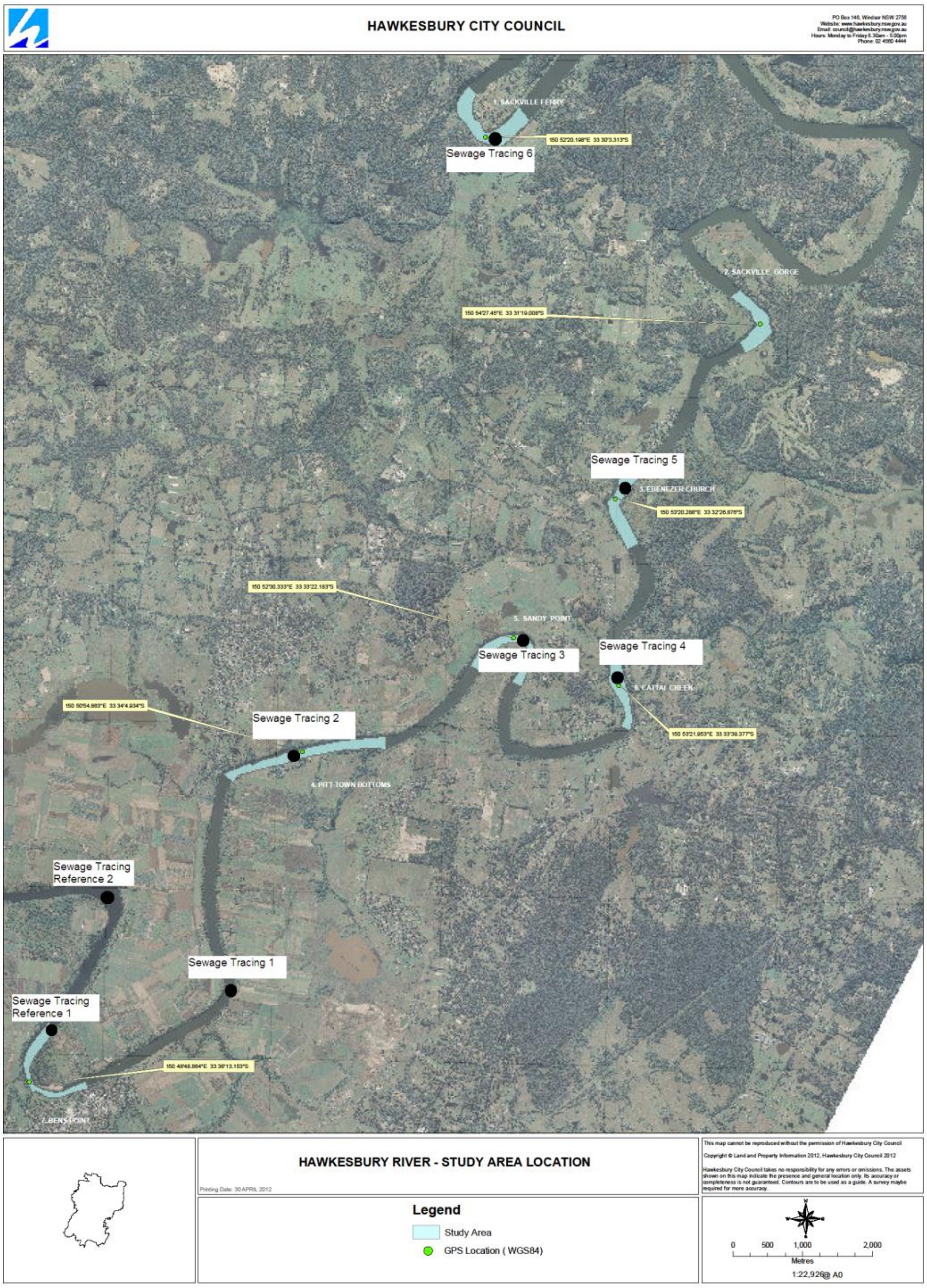

Figure 3. Six Sewage Tracing Sample Locations and Two Reference Locations on the Hawkesbury River (Source: Google Earth and Hawkesbury City Council).

Table 1. Coordinates of pilot study priority sediment sample locations, sewage tracing locations and reference locations.

Sample Location	Sample ID	No. of Subsamples	Latitude (S)*	Longitude (E)*
1. Sackville Ferry	SF	1	33 30'30.313"S	150 52'20.198"E
2. Sackville Gorge	SG	1	33 31'19.008"S	150 54'27.450"E
3. Ebenezer Church	EC	1	33 32'26.876"S	150 53'20.288"E
4. Pitt Town Bottoms	PTB	1	33 34'40.934"S	150 50'54.863"E
5. Sandy Point	SP	1	33 33'22.183"S	150 52'30.333"E
6. Cattai Creek	CC	1	33 33'39.377"S	150 53'21.953"E
7. Bens Point	BP	1	33 36'13.153"S	150 48'48.864"E
8. Sewage Tracing 1	ST1	1	TBC	TBC
9. Sewage Tracing 2	ST2	1	TBC	TBC
10. Sewage Tracing 3	ST3	1	TBC	TBC
11. Sewage Tracing 4	ST4	1	TBC	TBC
12. Sewage Tracing 5	ST5	1	TBC	TBC
13. Sewage Tracing 6	ST6	1	TBC	TBC
14. Sewage Tracing Reference 1	STR1	1	TBC	TBC
15. Sewage Tracing Reference 2	STR2	1	TBC	TBC
Total Number of Samples		**15**		

*All coordinates are in WGS84; TBC: to be confirmed. Coordinates for Sewage Tracing Sample Locations 1 to 6 and Sewage Tracing Reference Locations 1 and 2 will be recorded in the field. Ideally, the sample locations will have similar textural characteristics to enable a comparison of the isotope and trace metal data and an effort will be made to obtain samples with similar textural characteristics from accumulatory areas, which may necessitate relocation of a sewage tracing location or sewage tracing reference location.

2 SEDIMENT SAMPLING (CORES AND GRAB SAMPLES)

Geochemical Assessments Pty Ltd (GA) will be engaged to collect sediment cores using a vibrocorer and/or a piston push corer at the seven priority sample locations and surficial sediment grab samples at eight sewage tracing sample locations (including two reference locations). The GA sampling vessel, a purpose built aluminium hull trailer boat 5 m in length, will be used as a working platform for sediment core and grab sampling and on-board sample processing.

Cores and grab samples will be collected as close as possible to the proposed sample locations. A handheld GPS with an accuracy of +/-5 m will be used to record each sample location.

A log will be kept by a WorleyParsons Senior Environmental Scientist (Dr Carsten Matthai) to record the sampling date, time, water depth, sample location coordinates, and the depth of core and grab sampler penetration at each sample location. Prior to sampling, the vessel will be thoroughly inspected and washed down. Any evident sources of contamination will be cleaned and covered in plastic to avoid accidental contamination of sediment samples.

Sediment cores will be collected using a custom-fabricated piston push corer with a minimum 50 mm outer diameter (OD) polycarbonate core tube, or a light weight vibrocorer with a minimum 50 mm steel or polycarbonate core tube. Core catchers may be used to prevent sediment loss from the core barrel during sample retrieval. Cores will be driven to a total depth of up to 2.0 m or refusal. Wherever possible, the piston corer will be used to enable a time-efficient collection of sediment cores to 2.0 m or refusal. If piston core refusal occurs in sandy sediment above 2.0 m, the vibrocorer will be deployed to obtain a core sample to 2.0 m or core refusal in consolidated clay or rock.

Grab samples of the upper 10 cm of sediment will be collected at the eight sewage tracing sample locations (including two reference locations) using a stainless steel Ponar grab sampler.

Multiple sediment cores or grab samples will be collected at each sample location, if required, to provide sufficient volume of sediment for the required geochemical analyses.

A WorleyParsons Senior Environmental Scientist (Dr Carsten Matthai) will determine the acceptability of each sediment core following collection. The criteria for acceptance of a core include:

- No obvious loss of surficial sediment;
- The core must have entered the sediment profile vertically;
- There must be no visible disturbance or gaps in the sediment stratigraphy; and
- The core must reach the depth of dredging or refusal at rock or dense sand or clay.

Composite core samples at the seven designated priority sample locations and grab samples at eight sewage tracing sample locations (including two reference locations) will be collected over two days of field sampling on 2 and 3 April 2013, assuming negligible interference from unscheduled boating activities or severely adverse weather conditions.

In addition, QA/QC split duplicate samples will be collected on 10% of primary samples and analysed for all analytes that are analysed in the primary samples (i.e. one QC split duplicate sample for the seven core samples and one QC split duplicate sample for eight grab samples). The split duplicate samples will be used to assess variations associated with subsample handling and chemical analyses.

2.1 Sample Processing

All sample handling and processing will be performed to minimise contamination and sample mix-ups. The workspace on the sampling vessel will be washed down regularly with ambient river water to clean all surfaces and minimise dust contamination of samples. New powder-free nitrile gloves will be worn by the sampler for the processing of each sample from each location. Subsampling will be undertaken using stainless steel implements that will be decontaminated between each sample using Decon 90, followed by an ambient river water rinse.

Piston cores and/or vibrocores will be extruded from the core tube and placed on a sampling tray for subsequent logging, photographing and subsampling. A homogenised composite core sample will be collected from the surface to a depth of 2.0 m (or the end of the core, if refusal occurs above 2.0 m) and samples will be stored appropriately for chemical testing. Composite core samples and the upper 10 cm of sediment from grab samples will be transferred into a stainless steel bowl to be homogenized prior to transferring the sample to laboratory-supplied clean and pre-labelled sample containers. Samples for chemical testing will be placed with zero headspace in appropriate sampling containers that are provided by the analytical laboratory. Samples for physical testing (Particle Size Distributions (PSD) analysis) and acid sulphate soil (ASS) testing will be placed in plastic zip lock bags.

Sample identifiers will include the sample location initials (**Table 1**). For example, SF indicates that the sediment sample was collected from sample location 1 (Sackville Ferry). QA/QC samples will be numbered consecutively (i.e. QC1, QC2) with the type of the QA/QC sample and the key for the primary sample it relates to being recorded on a separate QA/QC identification log sheet that will not be revealed to the analytical laboratory.

The following sediment volumes will be retained from each composite core sample for the different analyses required:

- Two 125 ml glass jars for analysis of trace metals, polycyclic aromatic hydrocarbons (PAHs), TBT and total organic carbon (TOC);
- One 500 ml ziplock bag for PSD analysis; and
- One 200 ml ziplock bag for ASS analysis.

The following sediment volumes will be retained from each sediment grab sample for the different analyses required:

- One 125 ml glass jar for analysis of trace metals; and
- One 125 ml glass jar for stable isotope analysis of Nitrogen-15.

2.2 Sample Preservation, Shipment and Analysis

Samples for geochemical analysis will be packed in ice in an esky immediately after sampling to maintain the temperature below 4°C. Samples for physical analysis will be stored at ambient temperatures. Samples will then be submitted to the NATA-accredited analytical laboratory (Advanced Analytical Australia) following the completion of fieldwork under WorleyParsons Chain-of-Custody (CoC) protocols. Sediment samples for stable isotope Nitrogen-15 will be forwarded to Environmental Isotopes Pty Ltd (EA) in Sydney by Advanced Analytical Australia for analysis.

WorleyParsons will coordinate the analysis of the samples. Samples for possible future analyses will be archived in refrigerated storage by the analytical laboratory for up to three months after sampling.

2.3 Analysis Schedule

2.3.1 Chemical Analysis

The primary laboratory selected to undertake the chemical testing is the NATA registered Advanced Analytical Australia (AAA). The contaminants and the detection limit of the proposed analytical methods are outlined in the following sections and summarized in **Table 2**.

2.3.2 Physical Analysis

The seven primary composite core samples will be analysed for PSD to provide an indication of the physical characteristics of the proposed dredge material at each priority sample location. Physical testing will comprise a determination of PSD by wet sieving, using geological size fractions and a determination of the fine fraction content (hydrometer) to determine clay (<4 μm) and silt (4 to 63 μm) fraction contents.

2.3.3 Total Number of Sediment Samples

The number of sediment samples will be one composite sample per core and one homogenized sample per grab sample, totaling seven core samples and eight grab samples (including two samples from reference locations). Therefore there will be a total of fifteen primary sediment samples for analysis.

In addition, two split duplicate samples will be collected, comprising split samples from one of the composite core samples and one of the grab samples, respectively. The total number of chemical analyses is summarised in **Table 2**.

Table 2. Chemical analytes for pilot study sediment sampling (seven cores and eight grab samples)

Test Parameter	Limit of Reporting	Units	Core Sample Analyses	Grab Sample Analyses	Split Duplicate Sample Analyses	Total Number of Analyses
Silver (Ag)	0.1	mg/kg	7	8	2	17
Cadmium (Cd)	0.1	mg/kg	7	8	2	17
Copper (Cu)	1	mg/kg	7	8	2	17
Lead (Pb)	1	mg/kg	7	8	2	17
Zinc (Zn)	1	mg/kg	7	8	2	17
Chromium (Cr)	1	mg/kg	7	8	2	17
Nickel (Ni)	1	mg/kg	7	8	2	17
Arsenic (As)	1	mg/kg	7	8	2	17
Mercury (Hg)	0.01	mg/kg	7	8	2	17
PAHs (each individual species)	4 to 5[1]	µg/kg	7	0	1	8
TBT	0.5	µgSn/kg	7	0	1	8
TOC	0.02	%	7	0	1	8
Acid sulphate soil (Cr-reducible suite)	2	mole H+/tonne	7	0	1	8
ASS Field Screening	0.1	pH	7	0	1	8
Nitrogen-15 Isotope	N/A	N/A	0	8	1	9

Notes

1. The laboratory will strive to reach this PQL but previous sampling and testing indicates that matrix interference may prevent the laboratory reaching this very low detection limit.
2. All primary and QA/QC sediment samples will be analysed for all analytes.
3. The eight sediment grab samples will be analysed only for trace metals Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn and Nitrogen-15 stable isotope concentrations.

2.4 Data Management Procedure

Statistical analysis and tabulation of data will be undertaken following data validation. Validation of data will include evaluating the results from laboratory QC samples, including laboratory blanks and laboratory surrogate samples and split duplicate sample analyses.

2.5 Equipment List

The following equipment will be required to undertake the pilot study sediment sampling program:

- Handheld differential GPS;
- Sampling vessel (length: 5 m) (owned and operated by GA);
- Light-weight vibrocorer;
- Minimum of 50 mm OD stainless steel or polycarbonate core tubes with stainless steel core catcher (if required);
- Tray table for subsampling;
- Stainless steel piston push corer (custom-fabricated);
- Core extrusion devices;
- Digital camera;
- Measuring tape;
- Deck wash;
- Eskies and ice;
- Decontamination equipment (Decon 90, brushes, buckets);
- Laboratory-supplied sample containers and zip lock bags;
- Sampling trays, stainless steel mixing bowls and subsampling equipment, spoons;
- Permanent markers and other stationary;
- CoC forms;
- Log book and logging sheets; and
- Personal protection equipment (weather protection, hats, nitrile powder-free gloves, steel capped boots, appropriate work clothes).

A WorleyParsons Senior Environmental Scientist (Dr Carsten Matthai) will coordinate the sampling program and assist GA in carrying out the sampling. GA personnel will operate the sampling vessel, vibrocorer and piston push corer and undertake the core extraction with the assistance of GA technical staff.

2.6 Health and Safety Precautions

The sampling program will adhere to health, safety and environment (HSE) systems of GA and Safe Work Method Statements (SWMS) for the proposed works prepared by GA, and forwarded and approved by WorleyParsons.

Prior to the commencement of fieldwork involving coring, Hawkesbury City Council will provide authorisation to undertake the proposed sampling and analysis program.

Geochemical Assessments (GA) will observe all warning signs at and in the vicinity of each sampling location to minimise any latent risk of underwater services being damaged. There will be no sampling within 60 m of any warning sign for underwater infrastructure and cables.

2.7 Sampling Contingency Plans

2.7.1 Adverse Weather

The proposed sampling will be undertaken in the relatively protected waters of the Hawkesbury River. In the case of predicted severe weather, sampling would be discontinued and rescheduled. The sampling program will be completed over two days, however a longer sampling period may result from inclement weather. WorleyParsons personnel will continue working in rain, provided conditions remain calm and no occupational health and safety risks arise. If adverse weather makes sampling unsafe or impractical due to high winds or waves, the sampling team, coring subcontractor and vessel operator would remain on stand-by.

2.7.2 Equipment Failure

Equipment used on the sampling program is highly specialised but many replacement parts for the vibrocorer and piston push corer would be provided on standby by the subcontractor. Repairs to critical equipment would be undertaken as soon as practicable, although equipment failure would result in a delay to sample collection.

2.8 QA/QC Procedures

2.8.1 Field QA/QC Procedures

Field QA/QC procedures will include the following:

- Sample Location: A handheld GPS position fixing system with an accuracy of +/-5 m will be used to locate each sample location;
- Decontamination of Sampling Equipment: Prior to use, the survey vessel will be thoroughly inspected and washed down. Any evident sources of contamination will be cleaned and covered in plastic to avoid accidental contamination of any samples. All surfaces used for sample handling will also be covered in plastic sheeting prior to subsampling. All sampling equipment that may come into contact with the sediment samples will be decontaminated using Decon 90 prior to each sampling event;
- Field Documentation: Each sample location will be numbered on a sampling plan in the field logbook. All other observations including weather, time, date of sampling, water depth, and

depth of core penetration will be noted in the field logbook. Time, date, and appearance of the sediments (e.g. texture, colour, odour) will also be reported in the field logbook during sub-sampling;

- Cross Contamination: Each sample jar will be washed with ambient river water following subsampling to remove sediment on the outside of the sample containers and to minimise cross-contamination;
- Split duplicates: At two sample locations two split duplicate samples will be taken and submitted to the analytical laboratory for geochemical analysis. The split results will be analysed to assess variability in sub-sampling; and
- Sample Control: Each sample will have a unique identification number that will be recorded in the field log book, and the CoC form. A CoC form will accompany the sediment samples at all times, and will include the analysis required for each sample and each laboratory.

2.8.2 Laboratory QA/QC Procedures

Laboratory QA/QC procedures for the geochemical analyses will include the following:

- Analysis Blanks: One per analytical run or one in every 20 samples, whichever is the smaller;
- Laboratory Duplicate: One in every 10 samples or batch, whichever is the smaller;
- Laboratory Control Standard: One per analytical run or one in every 20 samples, whichever is the smaller;
- Laboratory Matrix Spike: One in every 20 samples or batch, whichever is the smaller;
- Surrogate Spike: For determinations that are appropriate, surrogate spikes will be added to all samples for analysis; and
- Calibration Blank: One per analytical run or one in every 20 samples, whichever is the smaller.

3 REPORTING

The findings of the pilot study sediment investigation will be documented in a Letter Report, in accordance with the approved “Hawkesbury River Dredging Investigations - Project Variation Request for Sampling and Analysis Pilot Study” project variation request dated 4 March 2013. The Letter Report will provide a summary of the pilot study sediment sampling and analysis work undertaken in the Hawkesbury River, and provide an indicative baseline assessment of the dredge material at the seven priority sample locations for onshore reuse, and an indicative assessment of the suitability of the dredge material for offshore disposal or probable waste material classification.

The pilot study comprises whole sediment concentration testing of composite core samples only and it excludes toxicity characteristic leaching procedure (TCLP) testing, elutriate and other testing, which may be required in future, more detailed, sediment investigations to determine the potential for onshore reuse or a waste disposal classification. In addition, the number of samples per area recommended in the relevant guidelines (e.g. NAGD, NSW Waste Guidelines) will not be met by collection of one core only at each of the seven priority sample locations.

Chemical testing results will be validated by statistically analysing quality control/quality assurance (QC/QA) data and a comparison to the relevant guidelines (i.e. NAGD, ASS guidelines, NSW Waste Guidelines, NEPC Guidelines). In addition, the results of the pilot study will also be used to assess sewage tracing and characterisation through analysis of Nitrogen-15.

The Letter Report will also detail the completed sampling and analysis work and present an assessment of the results, including the following:

- A description of the sampling carried out and the actual sample locations, sample numbers (including replicate and QA samples), completed CoC forms, field logs and descriptions of the sediments;
- A description of any problems encountered or deviations from the procedures set out in the SAP (including justifications for deviations);
- Normalization of results for organic analytes to 1% TOC (within a range of 0.2-10%);
- Reporting of all QA/QC data;
- Presentation and review of the results, including QA/QC assessment of field and laboratory data and data validation;
- Within the limitations of the scope of the pilot study sediment assessment, provide conclusions as to the possible acceptability or unacceptability of the sediments at the seven priority sample locations for land based reuse, sea disposal or land disposal and recommendations as to further work required. Additional assessments such as bioavailability of contaminants, sediment toxicity, and acid generating potential of the dredge material at a greater lateral and vertical sample density may be recommended but would have to be undertaken separately in

future, as these additional investigations are not included in the pilot study sediment assessment; and

- Appendices, including all laboratory and field data.

4 REFERENCES

Ahern C R, Stone, Y, and Blunden B (1998). *Acid Sulfate Soils Assessment Guidelines.* Published by the Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

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

Commonwealth of Australia (2009). National Assessment Guidelines for Dredging, Commonwealth of Australia, Canberra, 2009.

DECC (2009). NSW Wast Classification Guidelines. NSW Department of Environment, Climate Change and Water, NSW. December 2009.

Matthai, C., Guise, K., Coad, P., McCready, S. and Taylor, S. (2009) *Environmental status of sediments in the lower Hawkesbury-Nepean River, New South Wales*. Australian Journal of Earth Sciences (2009) 56, (225–243).

WorleyParsons (2012). Hawkesbury River Dredging Investigations – Summary Report. Report for Hawkesbury City Council, 30 August 2012.

Appendix 2 Laboratory Data

REPORT OF ANALYSIS

Laboratory Reference: A13/1651-A [R01]

Client:	WorleyParsons Services Pty Ltd Level 12, 141 Walker Street North Sydney NSW 2060	**Order No:**	301015-02986
		Project:	Hawkesbury River Pilot Study
		Sample Type:	Sediment
		No. of Samples:	19
Contact:	Nicole Cowlishaw	**Date Received:**	3/04/2013
		Date Completed:	22/04/2013

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.

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Laboratory Reference: **Client Reference:** **Date Sampled:** **Analysis Description**	**-** **-** **-** **Method**	**-** **-** **-** **Units**	**A13/1651-A/1** **SF** **02/04/2013**	**A13/1651-A/2** **SG** **02/04/2013**	**A13/1651-A/3** **EC** **02/04/2013**	**A13/1651-A/4** **CC** **02/04/2013**
Moisture Content						
Moisture Content	04-004	%	19.3	20.1	25.8	18.4
Trace Elements						
Arsenic	04-001	mg/kg	0.55	0.66	2.0	0.79
Cadmium	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Chromium	04-001	mg/kg	1.7	2.5	5.9	2.7
Copper	04-001	mg/kg	0.71	0.83	5.3	1.4
Lead	04-001	mg/kg	1.4	2.0	6.2	2.0
Mercury	04-002	mg/kg	<0.01	<0.01	0.01	<0.01
Nickel	04-001	mg/kg	1.7	2.1	5.1	2.2
Silver	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Zinc	04-001	mg/kg	6.4	9.4	30	9.1
Poly Aromatic Hydrocarbons						
Naphthalene	04-022	µg/kg	<5.0	<5.0	<5.0	<5.0
1-Methylnaphthalene	04-022	µg/kg	8.0	<5.0	<5.0	<5.0
2-Methylnaphthalene	04-022	µg/kg	<5.0	<5.0	<5.0	<5.0
Acenaphthylene	04-022	µg/kg	<5.0	<5.0	<5.0	<5.0
Acenaphthene	04-022	µg/kg	<5.0	<5.0	<5.0	<5.0
Fluorene	04-022	µg/kg	<5.0	<5.0	<5.0	<5.0
Phenanthrene	04-022	µg/kg	68	<5.0	10	<5.0
Anthracene	04-022	µg/kg	<5.0	<5.0	<5.0	<5.0
Fluoranthene	04-022	µg/kg	17	<5.0	12	<5.0
Pyrene	04-022	µg/kg	24	<5.0	12	<5.0
Benz(a)anthracene	04-022	µg/kg	13	<5.0	6.0	<5.0
Chrysene	04-022	µg/kg	46	<5.0	9.0	<5.0
Benzo(b)&(k)fluoranthene	04-022	µg/kg	21	<10	15	<10
Benzo(a)pyrene	04-022	µg/kg	9.0	<5.0	8.0	<5.0
Indeno(1,2,3-cd)pyrene	04-022	µg/kg	<5.0	<5.0	6.0	<5.0
Dibenz(a,h)anthracene	04-022	µg/kg	<5.0	<5.0	<5.0	<5.0
Benzo(g,h,i)perylene	04-022	µg/kg	8.0	<5.0	8.0	<5.0
Coronene	04-022	µg/kg	<10	<10	<10	<10
Benzo(e)pyrene	04-022	µg/kg	21	<5.0	8.0	<5.0
Perylene	04-022	µg/kg	11	5.0	140	7.0

Laboratory Reference:	**-**	**-**	**A13/1651-A/1**	**A13/1651-A/2**	**A13/1651-A/3**	**A13/1651-A/4**
Client Reference:	**-**	**-**	**SF**	**SG**	**EC**	**CC**
Date Sampled:	**-**	**-**	**02/04/2013**	**02/04/2013**	**02/04/2013**	**02/04/2013**
Analysis Description	**Method**	**Units**				
Total PAHs (as above)	04-022	µg/kg	250	<100	240	<100
Surrogate 1 Recovery	04-022	%	94	93	103	90
Surrogate 2 Recovery	04-022	%	103	98	107	102
Surrogate 3 Recovery	04-022	%	101	101	104	100
Date Extracted	04-022	-	5/04/2013	5/04/2013	5/04/2013	5/04/2013
Date Analysed	04-022	-	15/04/2013	15/04/2013	15/04/2013	15/04/2013
Organotins						
Monobutyl tin	04-026	µgSn/kg	<0.50	<0.50	<0.50	<0.50
Dibutyl tin	04-026	µgSn/kg	<0.50	<0.50	<0.50	<0.50
Tributyl tin	04-026	µgSn/kg	<0.50	<0.50	<0.50	<0.50
Surrogate 1 Recovery	04-026	%	85	88	83	91
Date Extracted	04-026	-	17/04/2013	17/04/2013	17/04/2013	17/04/2013
Date Analysed	04-026	-	19/04/2013	19/04/2013	19/04/2013	19/04/2013
Subcontract Analysis						
Total Organic Carbon	SUB	%	0.42	0.05	0.70	0.27

Laboratory Reference:	**-**	**-**	**A13/1651-A/5**	**A13/1651-A/6**	**A13/1651-A/7**	**A13/1651-A/8**
Client Reference:	**-**	**-**	**SP**	**QC1**	**QC2**	**ST3**
Date Sampled:	**-**	**-**	**02/04/2013**	**02/04/2013**	**02/04/2013**	**02/04/2013**
Analysis Description	**Method**	**Units**				
Moisture Content						
Moisture Content	04-004	%	23.6	19.3	17.8	25.3
Trace Elements						
Arsenic	04-001	mg/kg	1.4	0.53	0.96	1.3
Cadmium	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Chromium	04-001	mg/kg	4.4	1.7	2.8	4.1
Copper	04-001	mg/kg	3.8	0.58	1.1	3.5
Lead	04-001	mg/kg	4.9	1.3	2.2	4.3
Mercury	04-002	mg/kg	<0.01	<0.01	<0.01	<0.01
Nickel	04-001	mg/kg	4.0	1.7	2.6	4.4
Silver	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Zinc	04-001	mg/kg	23	7.3	16	23
Poly Aromatic Hydrocarbons						
Naphthalene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
1-Methylnaphthalene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
2-Methylnaphthalene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Acenaphthylene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Acenaphthene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Fluorene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Phenanthrene	04-022	µg/kg	5.0	<5.0	[NA]	[NA]
Anthracene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Fluoranthene	04-022	µg/kg	5.0	<5.0	[NA]	[NA]
Pyrene	04-022	µg/kg	6.0	<5.0	[NA]	[NA]
Benz(a)anthracene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Chrysene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Benzo(b)&(k)fluoranthene	04-022	µg/kg	<10	<10	[NA]	[NA]
Benzo(a)pyrene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Indeno(1,2,3-cd)pyrene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Dibenz(a,h)anthracene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Benzo(g,h,i)perylene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Coronene	04-022	µg/kg	<10	<10	[NA]	[NA]
Benzo(e)pyrene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Perylene	04-022	µg/kg	89	8.0	[NA]	[NA]

Laboratory Reference: **Client Reference:** **Date Sampled:** **Analysis Description**	**-** **-** **-** **Method**	**-** **-** **-** **Units**	**A13/1651-A/5** **SP** **02/04/2013**	**A13/1651-A/6** **QC1** **02/04/2013**	**A13/1651-A/7** **QC2** **02/04/2013**	**A13/1651-A/8** **ST3** **02/04/2013**
Total PAHs (as above)	04-022	µg/kg	100	<100	[NA]	[NA]
Surrogate 1 Recovery	04-022	%	100	95	[NA]	[NA]
Surrogate 2 Recovery	04-022	%	107	103	[NA]	[NA]
Surrogate 3 Recovery	04-022	%	102	100	[NA]	[NA]
Date Extracted	04-022	-	5/04/2013	5/04/2013	[NA]	[NA]
Date Analysed	04-022	-	15/04/2013	15/04/2013	[NA]	[NA]
Organotins						
Monobutyl tin	04-026	µgSn/kg	<0.50	<0.50	[NA]	[NA]
Dibutyl tin	04-026	µgSn/kg	<0.50	<0.50	[NA]	[NA]
Tributyl tin	04-026	µgSn/kg	<0.50	<0.50	[NA]	[NA]
Surrogate 1 Recovery	04-026	%	91	88	[NA]	[NA]
Date Extracted	04-026	-	17/04/2013	17/04/2013	[NA]	[NA]
Date Analysed	04-026	-	19/04/2013	19/04/2013	[NA]	[NA]
Subcontract Analysis						
Total Organic Carbon	SUB	%	0.27	0.34	[NA]	[NA]

Laboratory Reference:	**-**	**-**	**A13/1651-A/9**	**A13/1651-A/10**	**A13/1651-A/11**	**A13/1651-A/13**
Client Reference:	**-**	**-**	**ST4**	**ST5**	**ST6**	**ST1**
Date Sampled:	**-**	**-**	**02/04/2013**	**02/04/2013**	**02/04/2013**	**03/04/2013**
Analysis Description	**Method**	**Units**				
Moisture Content						
Moisture Content	04-004	%	19.0	58.3	18.1	32.6
Trace Elements						
Arsenic	04-001	mg/kg	0.63	5.3	0.86	2.5
Cadmium	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Chromium	04-001	mg/kg	2.0	15	2.5	7.9
Copper	04-001	mg/kg	0.89	17	0.89	7.7
Lead	04-001	mg/kg	2.0	17	2.2	8.3
Mercury	04-002	mg/kg	<0.01	0.04	<0.01	0.02
Nickel	04-001	mg/kg	1.9	14	2.5	7.8
Silver	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Zinc	04-001	mg/kg	9.4	87	17	47
Poly Aromatic Hydrocarbons						
Organotins						
Subcontract Analysis						

Laboratory Reference: **Client Reference:** **Date Sampled:** **Analysis Description**	- - - **Method**	- - - **Units**	**A13/1651-A/14** **BP** **03/04/2013**	**A13/1651-A/15** **PTB** **03/04/2013**	**A13/1651-A/16** **ST2** **03/04/2013**	**A13/1651-A/17** **STR1** **03/04/2013**
Moisture Content						
Moisture Content	04-004	%	19.8	14.7	31.9	21.0
Trace Elements						
Arsenic	04-001	mg/kg	0.62	1.7	2.1	0.65
Cadmium	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Chromium	04-001	mg/kg	2.1	5.2	6.9	2.1
Copper	04-001	mg/kg	0.68	3.6	5.7	0.76
Lead	04-001	mg/kg	1.7	3.7	7.2	1.7
Mercury	04-002	mg/kg	<0.01	<0.01	0.01	<0.01
Nickel	04-001	mg/kg	1.9	4.7	6.6	2.0
Silver	04-001	mg/kg	<0.1	<0.1	<0.1	<0.1
Zinc	04-001	mg/kg	7.8	16	33	8.9
Poly Aromatic Hydrocarbons						
Naphthalene	04-022	µg/kg	<5.0	6.0	[NA]	[NA]
1-Methylnaphthalene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
2-Methylnaphthalene	04-022	µg/kg	<5.0	6.0	[NA]	[NA]
Acenaphthylene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Acenaphthene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Fluorene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Phenanthrene	04-022	µg/kg	<5.0	16	[NA]	[NA]
Anthracene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Fluoranthene	04-022	µg/kg	<5.0	10	[NA]	[NA]
Pyrene	04-022	µg/kg	<5.0	9.0	[NA]	[NA]
Benz(a)anthracene	04-022	µg/kg	<5.0	6.0	[NA]	[NA]
Chrysene	04-022	µg/kg	<5.0	9.0	[NA]	[NA]
Benzo(b)&(k)fluoranthene	04-022	µg/kg	<10	10	[NA]	[NA]
Benzo(a)pyrene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Indeno(1,2,3-cd)pyrene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Dibenz(a,h)anthracene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Benzo(g,h,i)perylene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Coronene	04-022	µg/kg	<10	<10	[NA]	[NA]
Benzo(e)pyrene	04-022	µg/kg	<5.0	<5.0	[NA]	[NA]
Perylene	04-022	µg/kg	<5.0	58	[NA]	[NA]

Laboratory Reference: **Client Reference:** **Date Sampled:** **Analysis Description**	**-** **-** **-** **Method**	**-** **-** **-** **Units**	**A13/1651-A/14** **BP** **03/04/2013**	**A13/1651-A/15** **PTB** **03/04/2013**	**A13/1651-A/16** **ST2** **03/04/2013**	**A13/1651-A/17** **STR1** **03/04/2013**
Total PAHs (as above)	04-022	µg/kg	<100	130	[NA]	[NA]
Surrogate 1 Recovery	04-022	%	91	98	[NA]	[NA]
Surrogate 2 Recovery	04-022	%	101	104	[NA]	[NA]
Surrogate 3 Recovery	04-022	%	101	99	[NA]	[NA]
Date Extracted	04-022	-	5/04/2013	5/04/2013	[NA]	[NA]
Date Analysed	04-022	-	15/04/2013	15/04/2013	[NA]	[NA]
Organotins						
Monobutyl tin	04-026	µgSn/kg	<0.50	<0.50	[NA]	[NA]
Dibutyl tin	04-026	µgSn/kg	<0.50	<0.50	[NA]	[NA]
Tributyl tin	04-026	µgSn/kg	<0.50	<0.50	[NA]	[NA]
Surrogate 1 Recovery	04-026	%	93	95	[NA]	[NA]
Date Extracted	04-026	-	17/04/2013	17/04/2013	[NA]	[NA]
Date Analysed	04-026	-	19/04/2013	19/04/2013	[NA]	[NA]
Subcontract Analysis						
Total Organic Carbon	SUB	%	0.08	0.26	[NA]	[NA]

Laboratory Reference: A13/1651-A [R01]

Project: Hawkesbury River Pilot Study

Laboratory Reference: **Client Reference:** **Date Sampled:** **Analysis Description**	**-** **-** **-** **Method**	**-** **-** **-** **Units**	**A13/1651-A/18** **STR2** **03/04/2013**
Moisture Content			
Moisture Content	04-004	%	26.1
Trace Elements			
Arsenic	04-001	mg/kg	1.4
Cadmium	04-001	mg/kg	<0.1
Chromium	04-001	mg/kg	5.2
Copper	04-001	mg/kg	3.7
Lead	04-001	mg/kg	4.9
Mercury	04-002	mg/kg	0.01
Nickel	04-001	mg/kg	5.4
Silver	04-001	mg/kg	<0.1
Zinc	04-001	mg/kg	26
Poly Aromatic Hydrocarbons			
Organotins			
Subcontract Analysis			

Method	Method Description
04-004	Moisture by gravimetric, %
04-001	Metals by ICP-OES, mg/kg
04-002	Mercury by CVAAS, mg/kg
04-022	PAHs & Phenols by GCMS
04-026	Organotins by GCMS, µgSn/kg
SUB	Subcontracted Analyses

Result Comments

[<]	Less than
[INS]	Insufficient sample for this test
[NA]	Test not required

Sample #1 is heterogeneous for PAHs, possibly due to the presence of small black pieces in the sample.

Analysis was subcontracted to Sydney Analytical Laboratories (NATA Number 1884);
reference SAL report number SAL24576B.

ASS analysis was subcontracted to Envirolab Services (NATA Number 2901);
reference Envirolab certificate number 88404.

Nitrogen Isotope analysis was subcontracted to Environmental Isotopes;
reference Environmental Isotopes certificate dated April9, 2013.

PSD analysis was subcontracted to Golder Associates (NATA Number 1446); Golder Job Number 127634002.

This report supersedes Report A12-1651-A-[R00].pdf.

QUALITY ASSURANCE REPORT

TEST	UNITS	Blank	Duplicate Sm#	Duplicate Results	Spike Sm#	Spike Results
Arsenic	mg/kg	<0.4	A13/1651-A-1	0.55||0.60||RPD: 9	A13/1651-A-1	85%
Cadmium	mg/kg	<0.1	A13/1651-A-1	<0.1||<0.1	A13/1651-A-1	101%
Chromium	mg/kg	<0.1	A13/1651-A-1	1.7||1.7||RPD: 0	A13/1651-A-1	103%
Copper	mg/kg	<0.1	A13/1651-A-1	0.71||0.71||RPD: 0	A13/1651-A-1	103%
Lead	mg/kg	<0.5	A13/1651-A-1	1.4||1.3||RPD: 7	A13/1651-A-1	98%
Mercury	mg/kg	<0.01	A13/1651-A-1	<0.01||<0.01	A13/1651-A-1	108%
Nickel	mg/kg	<0.1	A13/1651-A-1	1.7||1.7||RPD: 0	A13/1651-A-1	100%
Silver	mg/kg	<0.1	A13/1651-A-1	<0.1||<0.1	A13/1651-A-1	85%
Zinc	mg/kg	<0.5	A13/1651-A-1	6.4||6.4||RPD: 0	A13/1651-A-1	98%

TEST	UNITS	Blank	Duplicate Sm#	Duplicate Results	Spike Sm#	Spike Results
Naphthalene	µg/kg	<5.0	A13/1651-A-1	<5.0||6.0	A13/1651-A-1	106%
1-Methylnaphthalene	µg/kg	<5.0	A13/1651-A-1	8.0||<5.0	A13/1651-A-1	98%
2-Methylnaphthalene	µg/kg	<5.0	A13/1651-A-1	<5.0||<5.0	A13/1651-A-1	100%
Acenaphthylene	µg/kg	<5.0	A13/1651-A-1	<5.0||<5.0	A13/1651-A-1	96%
Acenaphthene	µg/kg	<5.0	A13/1651-A-1	<5.0||<5.0	A13/1651-A-1	100%
Fluorene	µg/kg	<5.0	A13/1651-A-1	<5.0||<5.0	A13/1651-A-1	102%
Phenanthrene	µg/kg	<5.0	A13/1651-A-1	68||6.0||RPD: 168	A13/1651-A-1	99%
Anthracene	µg/kg	<5.0	A13/1651-A-1	<5.0||<5.0	A13/1651-A-1	101%
Fluoranthene	µg/kg	<5.0	A13/1651-A-1	17||<5.0	A13/1651-A-1	92%
Pyrene	µg/kg	<5.0	A13/1651-A-1	24||<5.0	A13/1651-A-1	92%
Benz(a)anthracene	µg/kg	<5.0	A13/1651-A-1	13||<5.0	A13/1651-A-1	94%
Chrysene	µg/kg	<5.0	A13/1651-A-1	46||<5.0	A13/1651-A-1	98%
Benzo(b)&(k)fluoranthene	µg/kg	<10	A13/1651-A-1	21||<10	A13/1651-A-1	87%
Benzo(a)pyrene	µg/kg	<5.0	A13/1651-A-1	9.0||<5.0	A13/1651-A-1	89%
Indeno(1,2,3-cd)pyrene	µg/kg	<5.0	A13/1651-A-1	<5.0||<5.0	A13/1651-A-1	81%
Dibenz(a,h)anthracene	µg/kg	<5.0	A13/1651-A-1	<5.0||<5.0	A13/1651-A-1	79%
Benzo(g,h,i)perylene	µg/kg	<5.0	A13/1651-A-1	8.0||<5.0	A13/1651-A-1	78%
Coronene	µg/kg	<10	A13/1651-A-1	<10||<10	A13/1651-A-1	88%
Benzo(e)pyrene	µg/kg	<5.0	A13/1651-A-1	21||<5.0	A13/1651-A-1	97%
Perylene	µg/kg	<5.0	A13/1651-A-1	11||10||RPD: 10	A13/1651-A-1	85%
Total PAHs (as above)	µg/kg	<100	A13/1651-A-1	250||<100	A13/1651-A-1	[NA]
Surrogate 1 Recovery	%	101	A13/1651-A-1	94||96||RPD: 2	A13/1651-A-1	90%
Surrogate 2 Recovery	%	101	A13/1651-A-1	103||99||RPD: 4	A13/1651-A-1	95%
Surrogate 3 Recovery	%	107	A13/1651-A-1	101||100||RPD: 1	A13/1651-A-1	90%

Laboratory Reference: A13/1651-A [R01]

Project: Hawkesbury River Pilot Study

TEST	UNITS	Blank	Duplicate Sm#	Duplicate Results	Spike Sm#	Spike Results
Monobutyl tin	µgSn/kg	<0.50	A13/1651-A-1	<0.50||<0.50	A13/1651-A-1	83%
Dibutyl tin	µgSn/kg	<0.50	A13/1651-A-1	<0.50||<0.50	A13/1651-A-1	90%
Tributyl tin	µgSn/kg	<0.50	A13/1651-A-1	<0.50||<0.50	A13/1651-A-1	86%
Surrogate 1 Recovery	%	106	A13/1651-A-1	85||86||RPD: 1	A13/1651-A-1	92%

TEST	UNITS	Blank
Total Organic Carbon	%	<0.01

TEST	Units	Blank	Duplicate Sm#	Duplicate Results
Arsenic	mg/kg	[NT]	A13/1651-A-11	0.86||0.91||RPD: 6
Cadmium	mg/kg	[NT]	A13/1651-A-11	<0.1||<0.1
Chromium	mg/kg	[NT]	A13/1651-A-11	2.5||2.5||RPD: 0
Copper	mg/kg	[NT]	A13/1651-A-11	0.89||0.86||RPD: 3
Lead	mg/kg	[NT]	A13/1651-A-11	2.2||2.0||RPD: 10
Mercury	mg/kg	[NT]	A13/1651-A-11	<0.01||<0.01
Nickel	mg/kg	[NT]	A13/1651-A-11	2.5||2.5||RPD: 0
Silver	mg/kg	[NT]	A13/1651-A-11	<0.1||<0.1
Zinc	mg/kg	[NT]	A13/1651-A-11	17||17||RPD: 0

TEST	Units	Blank	Duplicate Sm#	Duplicate Results	Spike Sm#	Spike Results
Monobutyl tin	µgSn/kg	[NT]	[NT]	[NT]	External	101%
Dibutyl tin	µgSn/kg	[NT]	[NT]	[NT]	External	99%
Tributyl tin	µgSn/kg	[NT]	[NT]	[NT]	External	96%
Surrogate 1 Recovery	%	[NT]	[NT]	[NT]	External	97%

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.

CHAIN OF CUSTODY

WorleyParsons
resources & energy

ATTENTION: Daniel Um
DELIVERY ADDRESS: Advanced Analytical
11 Julius Ave, North Ryde, NSW 2133
CLIENT: WorleyParsons
OFFICE: Lv12, 141 Walker St, North Sydney NSW 2060

COC SEQUENCE NUMBER (Circle)
COC: [✓ 1] 2 3 4 5 6 7
OF: 1 [✓ 2] 3 4 5 6 7

RELINQUISHED BY: Carsten Matthai
DATE/TIME: 3-4-13

RECEIVED BY: Dana Mackenzie
DATE/TIME: 3/4/13 7°C

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY:
DATE/TIME:

PROJECT: [redacted] ~~Maintenance Dredging~~ Hawkesbury River Pilot Study
PROJECT NUMBER: 301015-02986

PROJECT MANAGER: Nicole Cowlishaw
CONTACT PH: (02) 8456 7209
EMAIL RESULTS AND INVOICE TO: nicole.cowlishaw@worleyparsons.com; carsten.matthai@worleyparsons.com

SAMPLER: Carsten Matthai
CONTACT PH: 8456 6798/ 0411331112

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Forward samples to be analysed for Nitrogen-15 isotope analysis to Environmental Isotopes.

LAB USE ONLY	SAMPLE DETAILS			CONTAINER INFORMATION		ANALYSIS REQUIRED								Additional Information
						A				B		C	D	
LAB ID A13/1651	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE	TOTAL CONTAINERS	Trace metals (Ag, Cd, Cu, Pb, Zn, Cr, Ni, As, Hg)	PAHs	TBT	TOC	Acid sulphate soil (Cr-reducible suite)	ASS field Screening	Nitrogen Isotope (see Notes)	PSD (wet sieving and hydrometer)	
1	SF	2-4-13	Sediment	Jars and bags	4	✓	✓	✓	✓	✓	✓		✓	
2	SG	2-4-13	〃		4	✓	✓	✓	✓	✓	✓		✓	
3	EC	2-4-13	〃		4	✓	✓	✓	✓	✓	✓		✓	
4	CC	2-4-13	〃		4	✓	✓	✓	✓	✓	✓		✓	
5	SP	2-4-13	〃		4	✓	✓	✓	✓	✓	✓		✓	
6	QC1	2-4-13	〃		4	✓	✓	✓	✓	✓	✓			
7	QC2	2-4-13	〃		2	✓						✓		
8	ST3	2-4-13	〃		2	✓						✓		
9	ST4	2-4-13	〃		2	✓						✓		
10	ST5	2-4-13	〃		2	✓						✓		
11	ST6	2-4-13	〃		2	✓						✓		
12	Cattai Ck	2-4-13	〃		2	✓						✓		HOLD
				TOTAL	36									

CHAIN OF CUSTODY

WorleyParsons
resources & energy

ATTENTION: Daniel Um **DELIVERY ADDRESS:** Advanced Analytical 11 Julius Ave, North Ryde, NSW 2133 **CLIENT:** WorleyParsons	**COC SEQUENCE NUMBER (Circle)** COC: 1 [✓ 2] 3 4 5 6 7 OF: 1 [✓ 2] 3 4 5 6 7	**RELINQUISHED BY:** Carsten Matthai **DATE/TIME:** 3-4-13	**RECEIVED BY:** Dana Mackenzie **DATE/TIME:** 3/4/13 7°C	**RELINQUISHED BY:** **DATE/TIME:**	**RECEIVED BY:** **DATE/TIME:**

OFFICE: Lv12, 141 Walker St, North Sydney NSW 2060

PROJECT: [redacted] Hawkesbury River Pilot Study

PROJECT NUMBER: 301015-02986

PROJECT MANAGER: Nicole Cowlishaw

CONTACT PH: (02) 8456 7209

EMAIL RESULTS AND INVOICE TO: nicole.cowlishaw@worleyparsons.com; carsten.matthai@worleyparsons.com

SAMPLER: Carsten Matthai

CONTACT PH: 8456 6798/ 0411331112

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Forward samples to be analysed for Nitrogen-15 isotope analysis to Environmental Isotopes.

LAB USE ONLY	SAMPLE DETAILS			CONTAINER INFORMATION		ANALYSIS REQUIRED A				B		C	D	Additional Information
LAB ID A13/1651	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE	TOTAL CONTAINERS	Trace metals (Ag, Cd, Cu, Pb, Zn, Cr, Ni, As, Hg)	PAHs	TBT	TOC	Acid sulphate soil (Cr-reducible suite)	ASS field Screening	Nitrogen Isotope (see Notes)	PSD (wet sieving and hydrometer)	
13	ST1	3-4-13	Sediment	Jars and bags	2	✓						✓		
14	BP	3-4-13	"		4	✓	✓	✓	✓	✓	✓		✓	
15	PTB	3-4-13	"		4	✓	✓	✓	✓	✓	✓		✓	
16	ST2	3-4-13	"		2	✓						✓		
17	STR1	3-4-13	"		2	✓						✓		
18	STR2	3-4-13	"		2	✓						✓		
19	South CK	3-4-13	"		2	✓						✓		HOLD
				TOTAL	18									

Reference	Description	Sample Description	Sample No.	Replicate	Date sampled	Moisture Content	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)&(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene
Units						%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PQL						0.1	0.4	0.1	0.1	0.1	0.5	0.01	0.1	0.1	0.5	5	5	5	5	5	5	5	5	5	5	5	5	10	5	5	5
Method						04-004	04-001	04-001	04-001	04-001	04-001	04-002	04-001	04-001	04-001	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022
A13/1651-A	Hawkesbury River Pilot Study	SF	1	0	2/04/2013	19.3	0.55	<0.1	1.7	0.71	1.4	<0.01	1.7	<0.1	6.4	<5	8	<5	<5	<5	<5	68	<5	17	24	13	46	21	9	<5	<5
A13/1651-A	Hawkesbury River Pilot Study	SF	1	1	2/04/2013	20.2	0.6	<0.1	1.7	0.71	1.3	<0.01	1.7	<0.1	6.4	6	<5	<5	<5	<5	<5	6	<5	<5	<5	<5	<5	<10	<5	<5	<5
A13/1651-A	Hawkesbury River Pilot Study	SG	2	0	2/04/2013	20.1	0.66	<0.1	2.5	0.83	2	<0.01	2.1	<0.1	9.4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5
A13/1651-A	Hawkesbury River Pilot Study	EC	3	0	2/04/2013	25.8	2	<0.1	5.9	5.3	6.2	0.01	5.1	<0.1	30	<5	<5	<5	<5	<5	<5	10	<5	12	12	6	9	15	8	6	<5
A13/1651-A	Hawkesbury River Pilot Study	CC	4	0	2/04/2013	18.4	0.79	<0.1	2.7	1.4	2	<0.01	2.2	<0.1	9.1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5
A13/1651-A	Hawkesbury River Pilot Study	SP	5	0	2/04/2013	23.6	1.4	<0.1	4.4	3.8	4.9	<0.01	4	<0.1	23	<5	<5	<5	<5	<5	<5	5	<5	5	6	<5	<5	<10	<5	<5	<5
A13/1651-A	Hawkesbury River Pilot Study	QC1	6	0	2/04/2013	19.3	0.53	<0.1	1.7	0.58	1.3	<0.01	1.7	<0.1	7.3	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5
A13/1651-A	Hawkesbury River Pilot Study	QC2	7	0	2/04/2013	17.8	0.96	<0.1	2.8	1.1	2.2	<0.01	2.6	<0.1	16																
A13/1651-A	Hawkesbury River Pilot Study	ST3	8	0	2/04/2013	25.3	1.3	<0.1	4.1	3.5	4.3	<0.01	4.4	<0.1	23																
A13/1651-A	Hawkesbury River Pilot Study	ST4	9	0	2/04/2013	19	0.63	<0.1	2	0.89	2	<0.01	1.9	<0.1	9.4																
A13/1651-A	Hawkesbury River Pilot Study	ST5	10	0	2/04/2013	58.3	5.3	<0.1	15	17	17	0.04	14	<0.1	87																
A13/1651-A	Hawkesbury River Pilot Study	ST6	11	0	2/04/2013	18.1	0.86	<0.1	2.5	0.89	2.2	<0.01	2.5	<0.1	17																
A13/1651-A	Hawkesbury River Pilot Study	ST6	11	1	2/04/2013	18.1	0.91	<0.1	2.5	0.86	2	<0.01	2.5	<0.1	17																
A13/1651-A	Hawkesbury River Pilot Study	ST1	13	0	3/04/2013	32.6	2.5	<0.1	7.9	7.7	8.3	0.02	7.8	<0.1	47																
A13/1651-A	Hawkesbury River Pilot Study	BP	14	0	3/04/2013	19.8	0.62	<0.1	2.1	0.68	1.7	<0.01	1.9	<0.1	7.8	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5	<5	<5
A13/1651-A	Hawkesbury River Pilot Study	PTB	15	0	3/04/2013	14.7	1.7	<0.1	5.2	3.6	3.7	<0.01	4.7	<0.1	16	6	<5	6	<5	<5	<5	16	<5	10	9	6	9	10	<5	<5	<5
A13/1651-A	Hawkesbury River Pilot Study	ST2	16	0	3/04/2013	31.9	2.1	<0.1	6.9	5.7	7.2	0.01	6.6	<0.1	33																
A13/1651-A	Hawkesbury River Pilot Study	STR1	17	0	3/04/2013	21	0.65	<0.1	2.1	0.76	1.7	<0.01	2	<0.1	8.9																
A13/1651-A	Hawkesbury River Pilot Study	STR2	18	0	3/04/2013	26.1	1.4	<0.1	5.2	3.7	4.9	0.01	5.4	<0.1	26																

Reference	Description	Sample Description	Sample No.	Replicate	Date sampled	Benzo(g,h,i)perylene	Coronene	Benzo(e)pyrene	Perylene	Total PAHs (as above)	Surrogate 1 Recovery	Surrogate 2 Recovery	Surrogate 3 Recovery	Date Extracted	Date Analysed	Monobutyl tin	Dibutyl tin	Tributyl tin	Surrogate 1 Recovery	Date Extracted	Date Analysed	Total Organic Carbon
Units						µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	%	%	%	-	-	µgSn/kg	µgSn/kg	µgSn/kg	%	-	-	%
PQL						5	10	5	5	100	-	-	-	-	-	0.5	0.5	0.5	-	-	-	0.01
Method						04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-022	04-026	04-026	04-026	04-026	04-026	04-026	SUB
A13/1651-A	Hawkesbury River Pilot Study	SF	1	0	2/04/2013	8	<10	21	11	250	94	103	101	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	85	17/04/2013	19/04/2013	0.42
A13/1651-A	Hawkesbury River Pilot Study	SF	1	1	2/04/2013	<5	<10	<5	10	<100	96	99	100	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	86	17/04/2013	19/04/2013	
A13/1651-A	Hawkesbury River Pilot Study	SG	2	0	2/04/2013	<5	<10	<5	5	<100	93	98	101	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	88	17/04/2013	19/04/2013	0.05
A13/1651-A	Hawkesbury River Pilot Study	EC	3	0	2/04/2013	8	<10	8	140	240	103	107	104	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	83	17/04/2013	19/04/2013	0.7
A13/1651-A	Hawkesbury River Pilot Study	CC	4	0	2/04/2013	<5	<10	<5	7	<100	90	102	100	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	91	17/04/2013	19/04/2013	0.27
A13/1651-A	Hawkesbury River Pilot Study	SP	5	0	2/04/2013	<5	<10	<5	89	100	100	107	102	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	91	17/04/2013	19/04/2013	0.27
A13/1651-A	Hawkesbury River Pilot Study	QC1	6	0	2/04/2013	<5	<10	<5	8	<100	95	103	100	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	88	17/04/2013	19/04/2013	0.34
A13/1651-A	Hawkesbury River Pilot Study	QC2	7	0	2/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	ST3	8	0	2/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	ST4	9	0	2/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	ST5	10	0	2/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	ST6	11	0	2/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	ST6	11	1	2/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	ST1	13	0	3/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	BP	14	0	3/04/2013	<5	<10	<5	<5	<100	91	101	101	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	93	17/04/2013	19/04/2013	0.08
A13/1651-A	Hawkesbury River Pilot Study	PTB	15	0	3/04/2013	<5	<10	<5	58	130	98	104	99	5/04/2013	15/04/2013	<0.5	<0.5	<0.5	95	17/04/2013	19/04/2013	0.26
A13/1651-A	Hawkesbury River Pilot Study	ST2	16	0	3/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	STR1	17	0	3/04/2013																	
A13/1651-A	Hawkesbury River Pilot Study	STR2	18	0	3/04/2013																	

Envirolab Services Pty Ltd
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CERTIFICATE OF ANALYSIS 88404

Client:

Advanced Analytical Aust. Pty Ltd
11 Julius Ave
North Ryde
NSW 2113

Attention: Daniel Um

Sample log in details:

Your Reference:	**A13/1651**		
No. of samples:	8 Waters		
Date samples received / completed instructions received	04/04/2013	/	04/04/2013

This report supersedes R00 due to a revision in the project ID.

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	11/04/13	/	12/04/13
Date of Preliminary Report:	Not Issued		

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

M. Mansfield
Matt Mansfield
Approved Signatory

NATA
ACCREDITED FOR
TECHNICAL
COMPETENCE

Chromium Suite						
Our Reference:	UNITS	88404-1	88404-2	88404-3	88404-4	88404-5
Your Reference	-------------	A13/1651/1	A13/1651/2	A13/1651/3	A13/1651/4	A13/1651/5
Date Sampled	------------	2/04/2013	2/04/2013	2/04/2013	2/04/2013	2/04/2013
Type of sample		Soil	Soil	Soil	Soil	Soil
pH $_{kcl}$	pH units	5.5	5.5	5.5	5.5	5.1
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
TAA pH 6.5	moles H$^+$/t	<5	<5	<5	<5	<5
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	0.01	<0.005	0.005
a-Chromium Reducible Sulfur	moles H$^+$/t	<3	<3	6	<3	3
S_{HCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	<0.05	<0.05	<0.05	<0.05	<0.05
s-ANC_{BT}	%w/w S	<0.05	<0.05	<0.05	<0.05	<0.05
s-Net Acidity	%w/w S	<0.01	<0.01	0.01	<0.01	<0.01
a-Net Acidity	moles H$^+$/t	<10	<10	<10	<10	<10
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	<0.75	<0.75	<0.75
a-Net Acidity without ANCE	moles H$^+$/t	<10	<10	<10	<10	<10
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	<0.75	<0.75	<0.75	<0.75

Chromium Suite				
Our Reference:	UNITS	88404-6	88404-7	88404-8
Your Reference	-------------	A13/1651/6	A13/1651/14	A13/1651/15
Date Sampled	------------	2/04/2013	3/04/2013	3/04/2013
Type of sample		Soil	Soil	Soil
pH $_{kcl}$	pH units	5.4	5.8	5.1
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01
TAA pH 6.5	moles H$^+$/t	<5	<5	5
Chromium Reducible Sulfur	%w/w	0.006	<0.005	0.08
a-Chromium Reducible Sulfur	moles H$^+$/t	4	<3	53
S_{HCl}	%w/w S	<0.005	<0.005	<0.005
S_{KCl}	%w/w S	<0.005	<0.005	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	<0.05	<0.05	<0.05
s-ANC_{BT}	%w/w S	<0.05	<0.05	<0.05
s-Net Acidity	%w/w S	<0.01	<0.01	0.09
a-Net Acidity	moles H$^+$/t	<10	<10	58
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	4.3
a-Net Acidity without ANCE	moles H$^+$/t	<10	<10	58
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	<0.75	4.3

sPOCAS field test Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	88404-1 A13/1651/1 2/04/2013 Soil	88404-2 A13/1651/2 2/04/2013 Soil	88404-3 A13/1651/3 2/04/2013 Soil	88404-4 A13/1651/4 2/04/2013 Soil	88404-5 A13/1651/5 2/04/2013 Soil
pH_F (field pH test)*	pH Units	6.5	6.5	6.9	6.3	6.6
pH_{FOX} (field peroxide test)*	pH Units	2.4	4.2	3.7	3.0	3.3
Reaction Rate*	-	Slight	Slight	High	Slight	Slight

sPOCAS field test Our Reference: Your Reference Date Sampled Type of sample	UNITS ------------- ------------	88404-6 A13/1651/6 2/04/2013 Soil	88404-7 A13/1651/14 3/04/2013 Soil	88404-8 A13/1651/15 3/04/2013 Soil
pH_F (field pH test)*	pH Units	6.4	6.2	6.7
pH_{FOX} (field peroxide test)*	pH Units	2.3	4.7	3.1
Reaction Rate*	-	Slight	Slight	Slight

Method ID	Methodology Summary
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.

QUALITY CONTROL Chromium Suite	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
pH $_{kcl}$	pH units		Inorg-068	[NT]	88404-1	5.5 || 5.3 || RPD: 4	LCS-1	95%
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	88404-1	<0.01 || <0.01	LCS-1	96%
TAA pH 6.5	moles H^+/t	5	Inorg-068	<5	88404-1	<5 || <5	[NR]	[NR]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	88404-1	<0.005 || <0.005	LCS-1	112%
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3	88404-1	<3 || <3	[NR]	[NR]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	88404-1	<0.005 || <0.005	[NR]	[NR]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	88404-1	<0.005 || <0.005	LCS-1	93%
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	88404-1	<0.005 || <0.005	[NR]	[NR]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	88404-1	<0.05 || <0.05	[NR]	[NR]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	88404-1	<0.05 || <0.05	[NR]	[NR]
s-Net Acidity	%w/w S	0.01	Inorg-068	<0.01	88404-1	<0.01 || <0.01	[NR]	[NR]
a-Net Acidity	moles H^+/t	10	Inorg-068	<10	88404-1	<10 || <10	[NR]	[NR]
Liming rate	kg $CaCO_3$ /t	0.75	Inorg-068	<0.75	88404-1	<0.75 || <0.75	[NR]	[NR]
a-Net Acidity without ANCE	moles H^+/t	10	Inorg-068	<10	88404-1	<10 || <10	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$ /t	0.75	Inorg-068	<0.75	88404-1	<0.75 || <0.75	[NR]	[NR]

QUALITY CONTROL sPOCAS field test	UNITS	PQL	METHOD	Blank
pH_F (field pH test)*	pH Units		Inorg-063	[NT]
pH_{FOX} (field peroxide test)*	pH Units		Inorg-063	[NT]

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batched of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable.

Reference	Description	Sample Description	Sample No.	Replicate	Date Sampled	Type of Sample	pH $_{kcl}$	s-TAA pH 6.5	TAA pH 6.5	Chromium Reducible Sulfur	a-Chromium Reducible Sulfur	S_{HCl}	S_{KCl}	S_{NAS}	ANC_{BT}	s-ANC_{BT}	s-Net Acidity	a-Net Acidity
Units							pH units	%w/w S	moles H^+/t	%w/w	moles H^+/t	%w/w S	%w/w S	%w/w S	% $CaCO_3$	%w/w S	%w/w S	moles H^+/t
PQL								0.01	5	0.005	3	0.005	0.005	0.005	0.05	0.05	0.01	10
Method							Inorg-068	Inorg-068	Inorg-068	Inorg-068	Inorg-068	Inorg-068	Inorg-068	Inorg-068	Inorg-068	Inorg-068	Inorg-068	Inorg-068
88404	A13/1651	A13/1651/1	1	0	2/04/2013	Soil	5.5	<0.01	<5	<0.005	<3	<0.005	<0.005	<0.005	<0.05	<0.05	<0.01	<10
88404	A13/1651	A13/1651/1	1	1	2/04/2013	Soil	5.3	<0.01	<5	<0.005	<3	<0.005	<0.005	<0.005	<0.05	<0.05	<0.01	<10
88404	A13/1651	A13/1651/2	2	0	2/04/2013	Soil	5.5	<0.01	<5	<0.005	<3	<0.005	<0.005	<0.005	<0.05	<0.05	<0.01	<10
88404	A13/1651	A13/1651/3	3	0	2/04/2013	Soil	5.5	<0.01	<5	0.01	6	<0.005	<0.005	<0.005	<0.05	<0.05	0.01	<10
88404	A13/1651	A13/1651/4	4	0	2/04/2013	Soil	5.5	<0.01	<5	<0.005	<3	<0.005	<0.005	<0.005	<0.05	<0.05	<0.01	<10
88404	A13/1651	A13/1651/5	5	0	2/04/2013	Soil	5.1	<0.01	<5	0.005	3	<0.005	<0.005	<0.005	<0.05	<0.05	<0.01	<10
88404	A13/1651	A13/1651/6	6	0	2/04/2013	Soil	5.4	<0.01	<5	0.006	4	<0.005	<0.005	<0.005	<0.05	<0.05	<0.01	<10
88404	A13/1651	A13/1651/14	7	0	3/04/2013	Soil	5.8	<0.01	<5	<0.005	<3	<0.005	<0.005	<0.005	<0.05	<0.05	<0.01	<10
88404	A13/1651	A13/1651/15	8	0	3/04/2013	Soil	5.1	<0.01	5	0.08	53	<0.005	<0.005	<0.005	<0.05	<0.05	0.09	58

Reference	Description	Sample Description	Sample No.	Replicate	Date Sampled	Type of Sample	Liming rate	a-Net Acidity without ANCE	Liming rate without ANCE	pH_F (field pH test)*	pH_{FOX} (field peroxide test)*	Reaction Rate*
Units							kg $CaCO_3$/t	moles H^+/t	kg $CaCO_3$/t	pH Units	pH Units	-
PQL							0.75	10	0.75			
Method							Inorg-068	Inorg-068	Inorg-068	Inorg-063	Inorg-063	Inorg-063
88404	A13/1651	A13/1651/1	1	0	2/04/2013	Soil	<0.75	<10	<0.75	6.5	2.4	Slight
88404	A13/1651	A13/1651/1	1	1	2/04/2013	Soil	<0.75	<10	<0.75			
88404	A13/1651	A13/1651/2	2	0	2/04/2013	Soil	<0.75	<10	<0.75	6.5	4.2	Slight
88404	A13/1651	A13/1651/3	3	0	2/04/2013	Soil	<0.75	<10	<0.75	6.9	3.7	High
88404	A13/1651	A13/1651/4	4	0	2/04/2013	Soil	<0.75	<10	<0.75	6.3	3	Slight
88404	A13/1651	A13/1651/5	5	0	2/04/2013	Soil	<0.75	<10	<0.75	6.6	3.3	Slight
88404	A13/1651	A13/1651/6	6	0	2/04/2013	Soil	<0.75	<10	<0.75	6.4	2.3	Slight
88404	A13/1651	A13/1651/14	7	0	3/04/2013	Soil	<0.75	<10	<0.75	6.2	4.7	Slight
88404	A13/1651	A13/1651/15	8	0	3/04/2013	Soil	4.3	58	4.3	6.7	3.1	Slight

Environmental Isotopes Pty. Ltd.

May 22, 2013

Advanced Analytical Australia Pty Ltd
11 Julius Ave
North Ryde NSW
AUSTRALIA 2113
Attn: Daniel Um

Dear Daniel:

Enclosed is an amended written report of the N and C isotope and concentration analysis of sediment. Some of the samples ware clean sands and do not contain sufficient organic matter for N isotope analysis – our detection limit is about 0.02 wt%.

For future sampling your client should focus on mud-rich samples, which will have higher organic matter concentrations. If further advice on sampling is required please get them to contact me.

Sincerely,

Dr Anita S. Andrew

Director

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Environmental Isotopes Pty. Ltd.

Environmental Isotopes Analysis Report

Samples

Advanced Analytical Australia Pty Ltd provided 9 wet sediment samples for N isotope analysis. Because the concentrations of N in the samples were unknown we also analysed C isotope values as well as C and N concentrations as part of the analysis. A small subsample of the sediment was dried overnight at 50°C. The samples were not pretreated to remove carbonate but the C isotope values measured show that carbonate is not present in the samples.

Nitrogen in sediments is overwhelmingly contained in organic matter and some of the samples are clean sands with very low organic C contents. An attempt was made to get data by handpicking dark composite grains from 2 samples (marked “c”). One of these samples contained no C and the other was C-rich but contained no N.

Methods

Carbon and nitrogen isotope analysis

Dried sediment were accurately weighed into tin cups for analysis of $\delta^{15}N$ and $\delta^{13}C$ and N and C concentrations using a modified Europa Roboprep CN Elemental Analyser (EA) attached to a Finnigan Mat Conflo III and Finnigan 252.

Samples were analysed relative to internal gas standards that were calibrated using international nitrogen isotope standards (IAEA-N1 ($\delta^{15}N = 0.43$ ‰ AIR) and IAEA-N2 ($\delta^{15}N = 20.41$ ‰ AIR); Bohlke & Coplen 1995) and carbon isotope standards (NBS-22 ($\delta^{13}C = -30.03$ ‰ VPDB; Coplen *et al.* 2006) and ANU SUCROSE ($\delta^{13}C = -10.3$ ‰ VPDB).

Solid standards laboratory (LGA: $\delta^{15}N = -5.40$ ‰ AIR; $\delta^{13}C = -14.6$ ‰ VPDB) and international standards (NBS-22 and IAEA-N-2) were analysed in the analytical runs and use to correct the data. Microanalysis standard B2105 was run to calibrate for concentration and as an unknown.

All analyses were undertaken by Dr Anita Andrew.

Data Presentation

Nitrogen isotope data are expressed using the δ notation where:

$$\delta^{15}N = \frac{{}^{15}N/{}^{14}N_{sample} - {}^{15}N/{}^{14}N_{reference}}{{}^{15}N/{}^{14}N_{reference}} * 1000$$

and reported in permil relative to the AIR scale defined by IAEA standard IAEA-N-1 (+0.43‰) (Bohlke & Coplen 1995).

Carbon isotope data are also expressed using the δ notation where:

$$\delta^{13}C = \frac{{}^{13}C/{}^{12}C_{sample} - {}^{13}C/{}^{12}C_{reference}}{{}^{13}C/{}^{12}C_{reference}} * 1000$$

Values are reported in permil (‰) relative to the international standard VPDB which is defined by the International Atomic Energy Agency standard, IAEA-NBS19 (δ^{13}C = +1.95‰; Coplen *et al.* 1995).

Errors

Errors are estimated using laboratory standards run regularly as unknowns. These micro analytical standards are used to calibrate the instrument for measurement of concentration of C and N but have proven to be useful material for monitoring errors. These micro analytical standards give standards deviations of better than ±0.15 for C and N isotope values.

Table 1 Isotope results for standard run as unknown compared with results since 2004.

Anal. No.	Sample No.	Date	δ^{15}N ‰ AIR	δ^{13}C ‰ VPDB
EA24836	B2105	8/4/2013	–4.92	–28.26
	Mean		–5.11	–28.41
	Std dev.		0.14	0.17
	Count		164	152

Results

Nitrogen and carbon isotope values and concentrations are listed in Table 2. The N and C concentration data are reported as analyzed on a carbonate-free basis but also calculated as the weight % of the original dried sediment. A C/N ratio is calculated on a molar basis.

Nitrogen isotope and concentration data were not possible for the samples of clean sand and analyses with low peak heights and therefore lower precision are marked in italics. Mud rich samples provided good results and it is recommended that any future sampling focuses on mud-rich sediments that represent low-energy environments and retain organic matter.

References

Bohlke & Coplen 1995. IAEA TECDOC-825 Proceedings of a consultants meeting held in Vienna Austria, 1–3 Dec 1993.

Coplen T. B. 1995. Reporting of stable hydrogen, carbon, and oxygen isotopic abundances – (Technical Report) *Geothermics* 24, 708–712.

Coplen T. B., Brand W. A., Gehre M., Groning M., Meijer H. A. J.,Toman B. & Verkouteren R. M. 2006. New Guidelines for δ^{13}C Measurements. *Analytical Chemistry* 78, 2439–2441.

Schoell M., Faber E. & Coleman M. L. 1983. Carbon and hydrogen isotopic compositions of the NBS 22 and NBS 21 stable isotope reference materials: An inter-laboratory comparison. *Organic Geochemistry* 5, 3–6.

Dr Anita S Andrew
Director
Environmental Isotopes P/L

Table 2 Nitrogen and carbon isotope values and concentrations.

Anal. No.	AAA Lab ID	Client ID	Sample Date	Analysis Date	Sample wgt (mg)	δ^{15}N ‰ AIR	δ^{13}C ‰ VPDB	N wgt %	C wgt %	C/N*
EA24844	A13/1651-C/7 QC2	QC2	2/4/2013	8/04/2013	59.25		*–26.4**		0.10	
EA24843	A13/1651-C/7 QC2 c	QC2	2/4/2013	8/04/2013	2.92		–26.2		16.44	
EA24837	A13/1651-C/8 ST3	ST3	2/4/2013	8/04/2013	20.70		*–26.7**		0.35	
EA24838	A13/1651-C/8 ST3	ST3	2/4/2013	8/04/2013	66.55	*5.7**	–27.2	0.03	0.35	13.61
EA24842	A13/1651-C/8 ST3 c	ST3	2/4/2013	8/04/2013	1.10					
EA24845	A13/1651-C/9 ST4	ST4	2/4/2013	8/04/2013	67.40		*-27.1**		0.07	
EA24839	A13/1651-C/10	ST5	2/4/2013	8/04/2013	42.75	8.5	–27.4	0.20	2.46	14.35
EA24846	A13/1651-C/11 ST6	ST6	2/4/2013	8/04/2013	57.33		–26.6		0.06	
EA24840	A13/1651-C/13 ST1	ST1	3/4/2013	8/04/2013	65.15	6.2	–27.2	0.05	0.69	16.10
EA24841	A13/1651-C/16 ST2	ST2	3/4/2013	8/04/2013	62.05	6.0	–26.6	0.07	1.07	17.83
EA24847	A13/1651-C/17 STR1	STR1	3/4/2013	8/04/2013	57.95					
EA24848	A13/1651-C/18 STR2	STR2	3/4/2013	8/04/2013	69.22	*4.6**	–28.6	0.01	0.18	21.00

*Small peak height

c handpick concentration of dark composite grains

Golder Associates

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TEST RESULTS

Client : Advanced Analytical Australia
Project : Delivered Samples
Project Ref. : A13/1651-D

Job No. : 127634002
Date Received : 09/04/2013
Sampled by : Client

PARTICLE SIZE SUMMARY

Reg'n No.	Sample ID	Sample No.	Percent Gravel (+ 2 mm)	Percent Sand (2 mm - 0.060 mm)	Percent Silt (0.060 mm - 0.002 mm)	Percent Clay (-0.002 mm)
13301395	SF 02/04/2013	1	1	98	1	
13301396	SG 02/04/2013	2	0	100	0	
13301397	EC 02/04/2013	3	0	86	10	4
13301398	CC 02/04/2013	4	3	96	1	
13301399	SP 02/04/2013	5	0	93	4	3
13301400	BP 03/04/2013	14	1	99	0	
13301401	PTB 03/04/2013	15	4	80	12	4

Remarks :

Test Procedures : AS1289.3.6.1 & AS1289.3.6.3

Prepared by :

Checked by

Golder Associates

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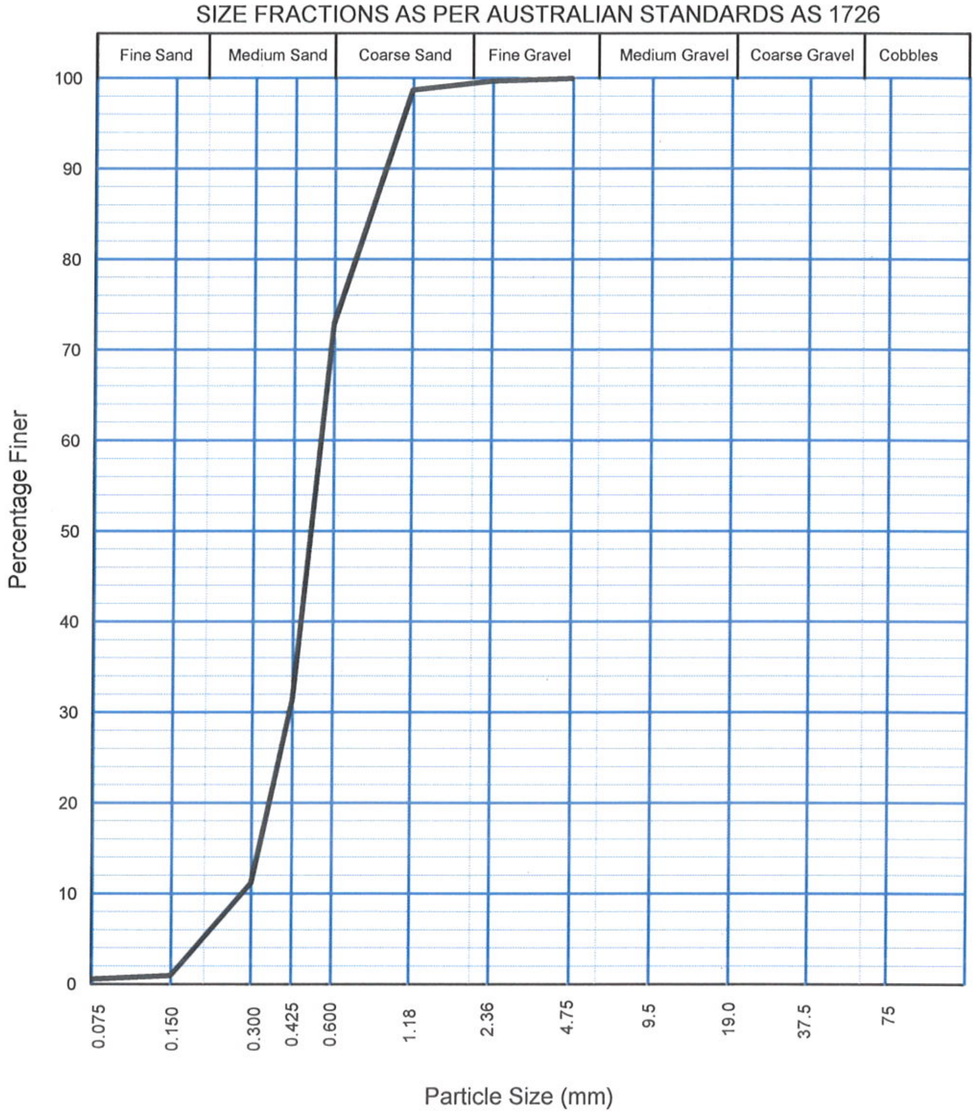
PARTICLE SIZE DISTRIBUTION

Client :	Advanced Analytical Australia	Report No. :	R15174
Address :	PO Box 153, Hamilton 4007	Job No. :	127634002
Project :	Delivered Samples	Reg'n No. :	13301395
Location/Sample ID :	SF 02/04/2013	AAA Lab. ID :	A13/1651-D/1
		Date Received :	9-Apr-13
		Sampled By :	Client

Sieve Size (mm)	Percent Passing
150	
75	
37.5	
19.0	
9.5	
4.75	100.0
2.36	99.7
1.18	98.7
0.600	73.0
0.425	31.4
0.300	11.2
0.150	1.0
0.075	0.6



Remarks :

Test Procedure : AS 1289 3.6.1

Prepared by : nf

Checked by : GH

This document is issued in accordance with NATA's accreditation requirements.

NATA

17/4/13

Nick Farrer
Approved Signatory

Senior Technical Officer
NATA Accred. No. : 1961

Golder Associates

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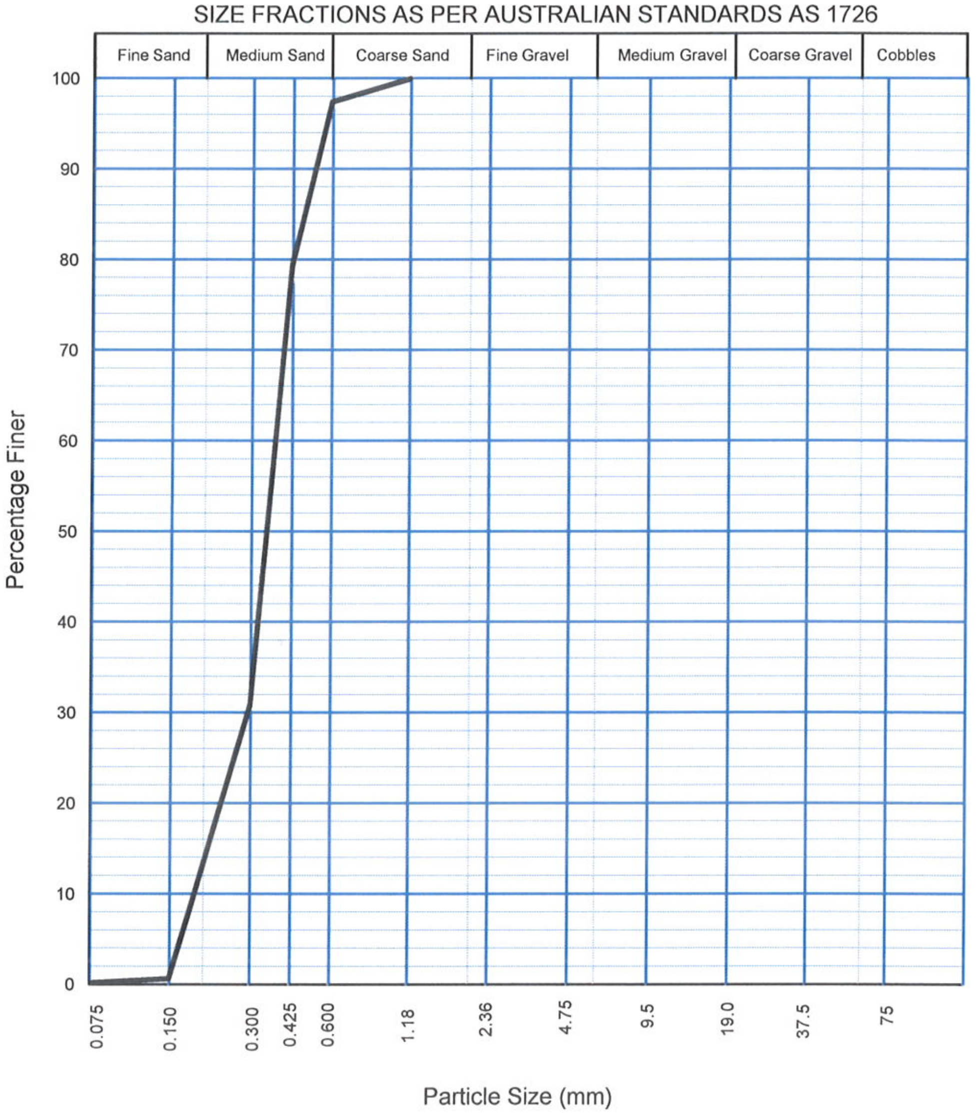
PARTICLE SIZE DISTRIBUTION

Client :	Advanced Analytical Australia	Report No. :	R15175
Address :	PO Box 153, Hamilton 4007	Job No. :	127634002
Project :	Delivered Samples	Reg'n No. :	13301396
Location/Sample ID :	SG 02/04/2013	AAA Lab. ID :	A13/1651-D/2
		Date Received :	9-Apr-13
		Sampled By :	Client

Sieve Size (mm)	Percent Passing
150	
75	
37.5	
19.0	
9.5	
4.75	
2.36	
1.18	100.0
0.600	97.4
0.425	79.4
0.300	30.8
0.150	0.7
0.075	0.2



Remarks :			
Test Procedure :	AS 1289 3.6.1		
Prepared by :		Checked by :	

This document is issued in accordance with NATA's accreditation requirements.

NATA

17/4/13

Nick Farrer
Approved Signatory

Senior Technical Officer
NATA Accred. No. : 1961

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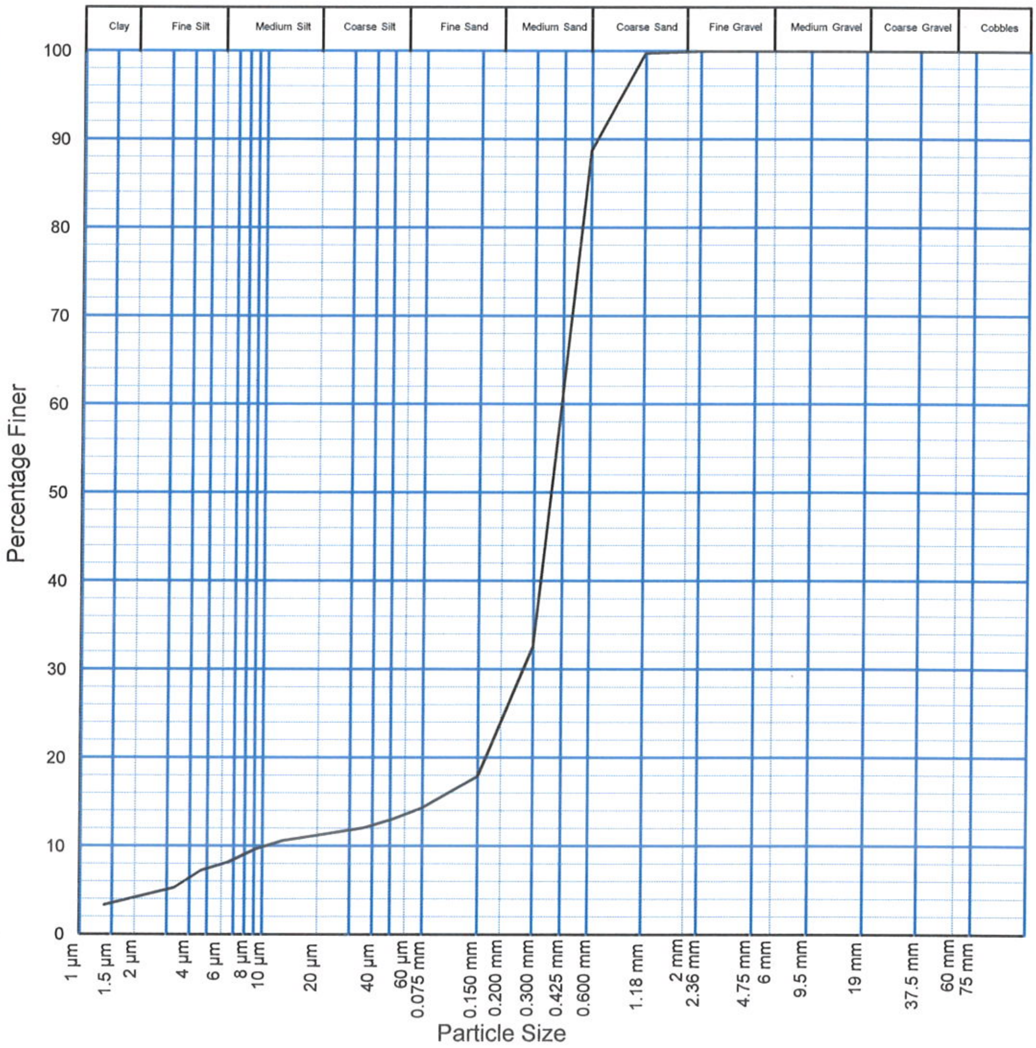
PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	Advanced Analytical Australia	Report No. :	R15176
Address :	PO Box 153, Hamilton 4007	Job No. :	127634002
Project :	Delivered Samples	Reg'n No. :	13301397
Sample ID :	EC 02/04/2013	AAA Lab. ID :	A13/1651-D/3
		Date Received :	9/04/2013
		Sampled By :	Client

Particle Size (mm)	Percent Passing
150	
75	
37.5	
19.0	
9.5	
4.75	
2.36	100.0
1.18	99.8
0.600	88.7
0.425	60.9
0.300	32.6
0.150	17.9
0.075	14.4
Particle Size (Microns)	**Percent Passing**
51.2	13.1
36.4	12.1
25.8	11.6
13.0	10.6
9.2	9.7
6.6	8.2
4.7	7.2
3.3	5.3
1.4	3.4

SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726



Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70 t/m³
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		

Test Procedure : AS 1289.3.6.3 - Variations to test method a)assumed particle density used b) testing up to 24 hours

Prepared by :

Checked by :

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NATA

17/4/13

Nick Farrer
Approved Signatory

Senior Technical Officer
NATA Accred. No. : 1961

Golder Associates

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Phone : (07) 3840 9500
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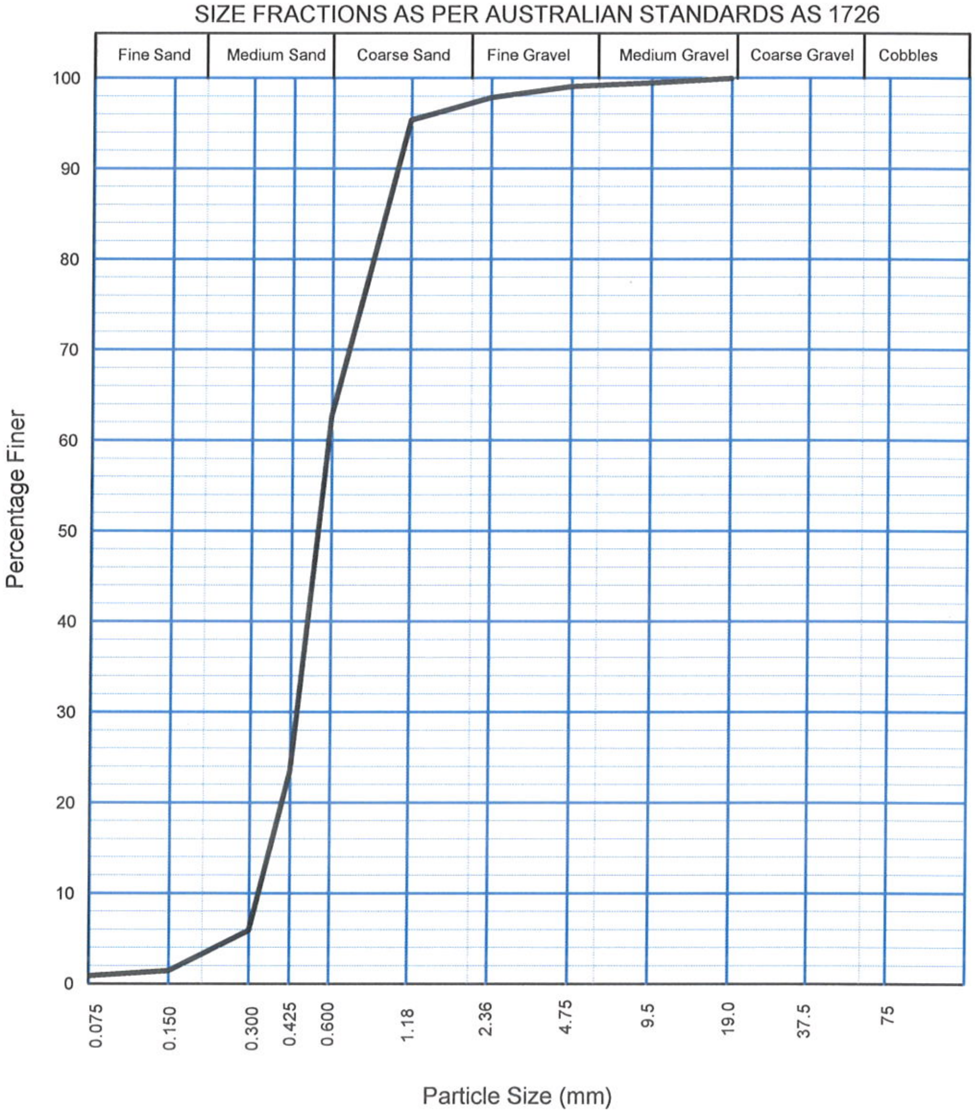
PARTICLE SIZE DISTRIBUTION

Client :	Advanced Analytical Australia	Report No. :	R15177
Address :	PO Box 153, Hamilton 4007	Job No. :	127634002
Project :	Delivered Samples	Reg'n No. :	13301398
Location/Sample ID :	CC 02/04/2013	AAA Lab. ID :	A13/1651-D/4
		Date Received :	9-Apr-13
		Sampled By :	Client

Sieve Size (mm)	Percent Passing
150	
75	
37.5	
19.0	100.0
9.5	99.5
4.75	99.1
2.36	97.9
1.18	95.4
0.600	62.7
0.425	23.5
0.300	5.9
0.150	1.5
0.075	0.9



Remarks :			
Test Procedure :	AS 1289 3.6.1		
Prepared by :		Checked by :	

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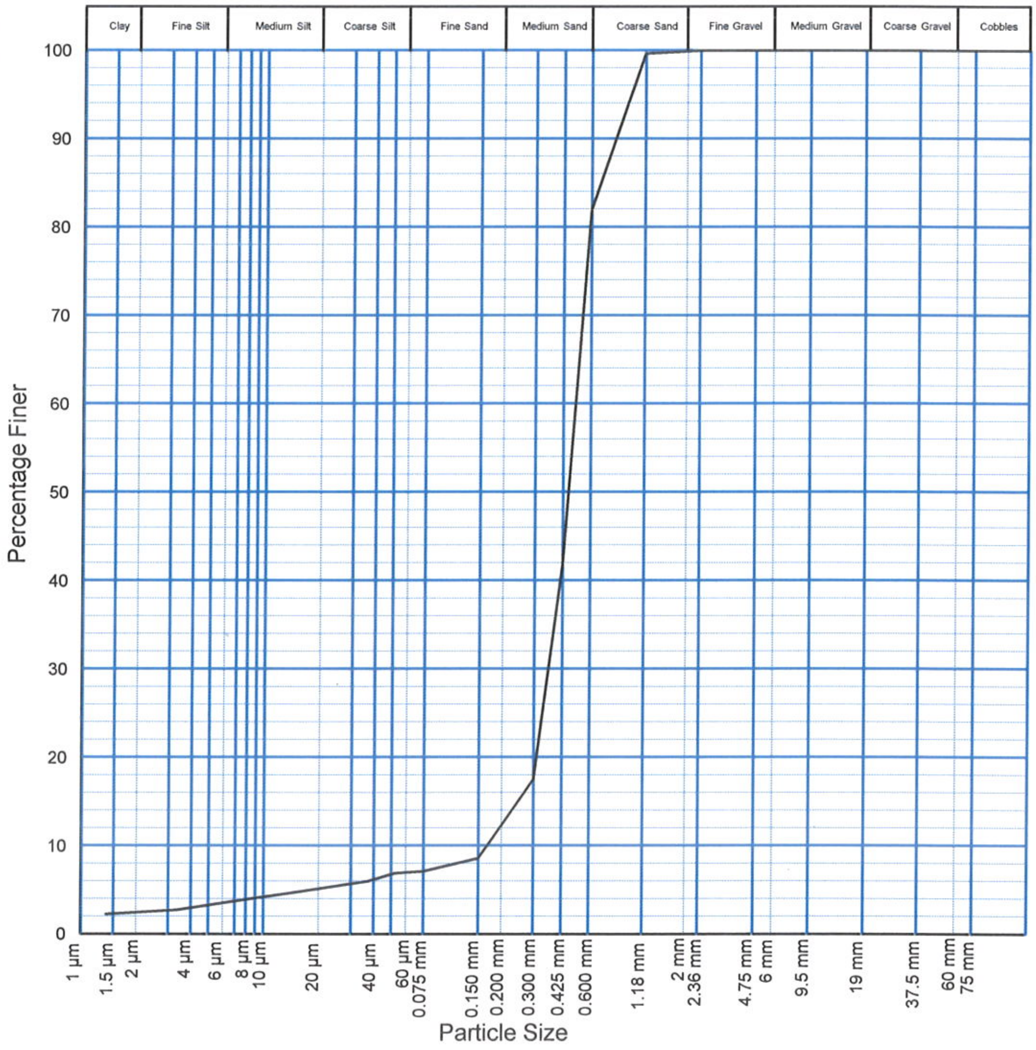
PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	Advanced Analytical Australia	Report No. :	R15178
Address :	PO Box 153, Hamilton 4007	Job No. :	127634002
Project :	Delivered Samples	Reg'n No. :	13301399
Sample ID :	SP 02/04/2013	AAA Lab. ID :	A13/1651-D/5
		Date Received :	9/04/2013
		Sampled By :	Client

Particle Size (mm)	Percent Passing
150	
75	
37.5	
19.0	
9.5	
4.75	
2.36	100.0
1.18	99.7
0.600	82.0
0.425	41.9
0.300	17.6
0.150	8.6
0.075	7.1
Particle Size (Microns)	**Percent Passing**
52.6	6.9
37.3	6.0
26.4	5.5
13.3	4.6
9.4	4.1
6.7	3.7
4.7	3.2
3.4	2.7
1.4	2.3

SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726



Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70 t/m³
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		
Test Procedure : AS 1289.3.6.3	- Variations to test method a)assumed particle density used b) testing up to 24 hours		
Prepared by : NF		Checked by : GH	

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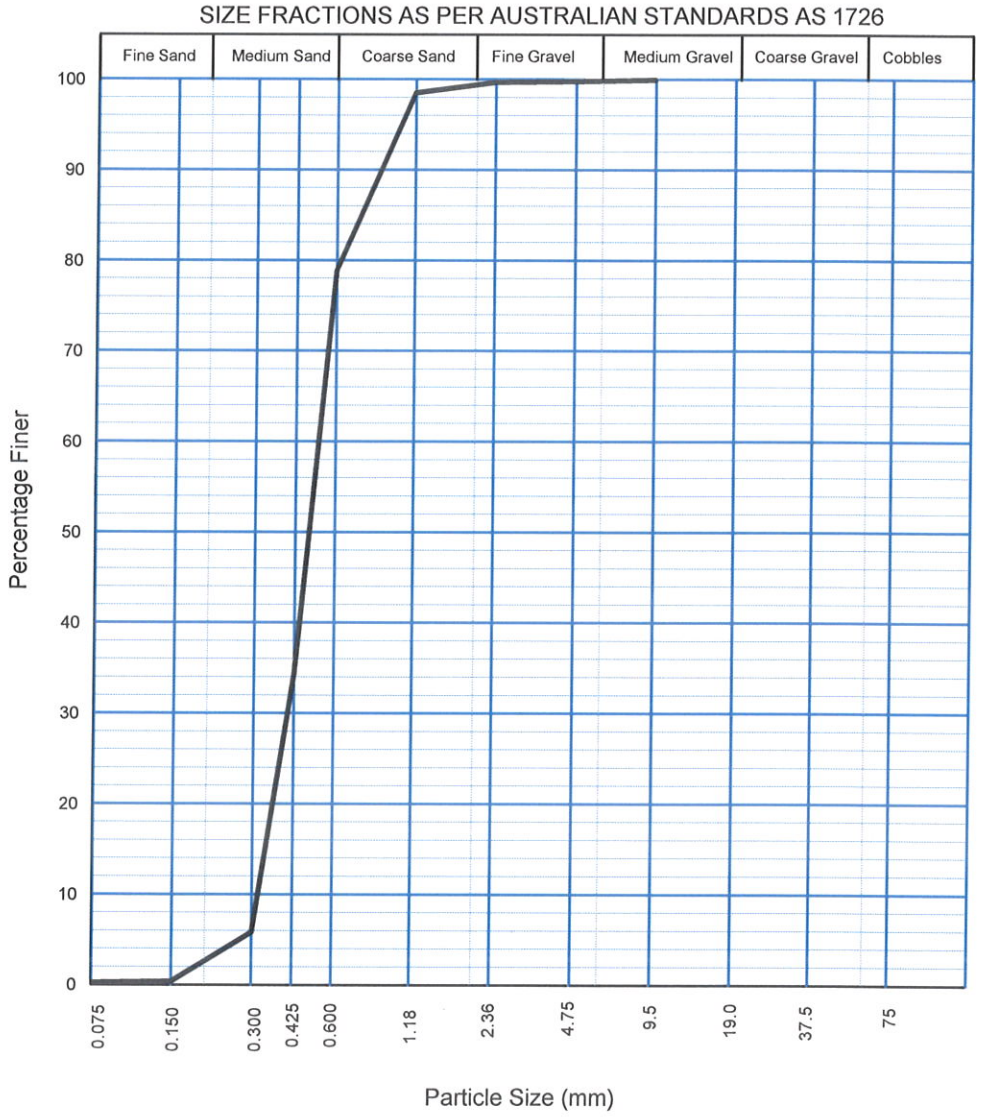
PARTICLE SIZE DISTRIBUTION

Client :	Advanced Analytical Australia	Report No. :	R15179
Address :	PO Box 153, Hamilton 4007	Job No. :	127634002
Project :	Delivered Samples	Reg'n No. :	13301400
Location/Sample ID :	BP 03/04/2013	AAA Lab. ID :	A13/1651-D/14
		Date Received :	9-Apr-13
		Sampled By :	Client

Sieve Size (mm)	Percent Passing
150	
75	
37.5	
19.0	
9.5	100.0
4.75	99.8
2.36	99.7
1.18	98.5
0.600	78.9
0.425	34.3
0.300	5.8
0.150	0.4
0.075	0.2



Remarks :		
Test Procedure :	AS 1289 3.6.1	
Prepared by : NF		Checked by : GH

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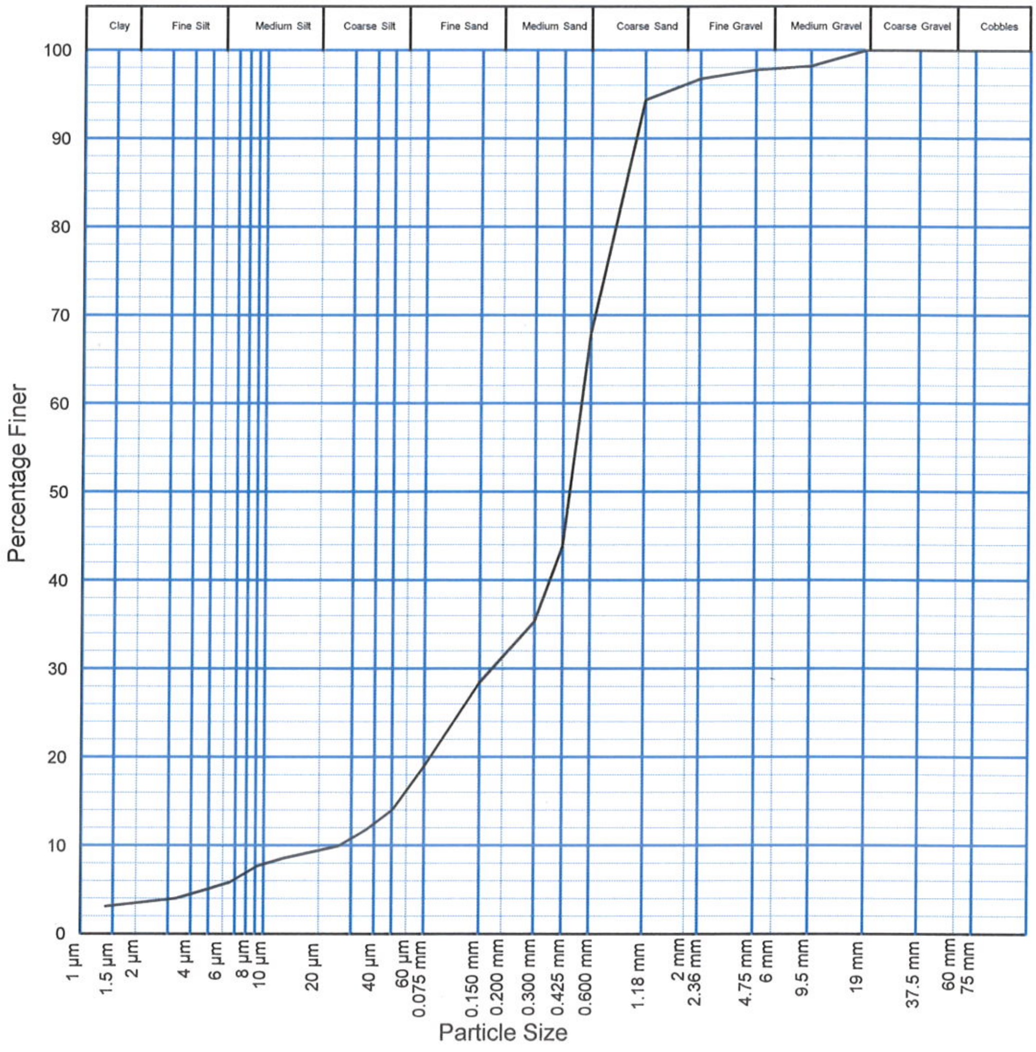
PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	Advanced Analytical Australia	Report No. :	R15180
Address :	PO Box 153, Hamilton 4007	Job No. :	127634002
Project :	Delivered Samples	Reg'n No. :	13301401
Sample ID :	PTB 03/04/2013	AAA Lab. ID :	A13/1651-D/15
		Date Received :	9/04/2013
		Sampled By :	Client

Particle Size (mm)	Percent Passing
150	
75	
37.5	
19.0	100.0
9.5	98.2
4.75	97.8
2.36	96.8
1.18	94.4
0.600	67.9
0.425	43.9
0.300	35.4
0.150	28.5
0.075	18.9
Particle Size (Microns)	**Percent Passing**
50.8	14.1
36.3	11.8
25.9	10.0
13.1	8.6
9.3	7.7
6.6	5.9
4.7	5.0
3.3	4.1
1.4	3.1

SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726



Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70 t/m³
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		
Test Procedure : AS 1289.3.6.3	- Variations to test method a)assumed particle density used b) testing up to 24 hours		
Prepared by : NF		Checked by : GN	

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TEST RESULTS

Client :	Advanced Analytical Australia	Job No. :	127634002
Project :	Delivered Samples	Date Received :	09/04/2013
Project Ref. :	A13/1651-D	Sampled by :	Client

PARTICLE SIZE SUMMARY

Reg'n No.	Sample ID	Sample No.	Percent Gravel (+ 2 mm)	Percent Sand (2 mm - 0.060 mm)	Percent Silt (0.060 mm - 0.002 mm)	Percent Clay (-0.002 mm)
13301395	SF 02/04/2013	1	1	98	1	
13301396	SG 02/04/2013	2	0	100	0	
13301397	EC 02/04/2013	3	0	86	10	4
13301398	CC 02/04/2013	4	3	96	1	
13301399	SP 02/04/2013	5	0	93	4	3
13301400	BP 03/04/2013	14	1	99	0	
13301401	PTB 03/04/2013	15	4	80	12	4

Remarks :

Test Procedures : AS1289.3.6.1 & AS1289.3.6.3

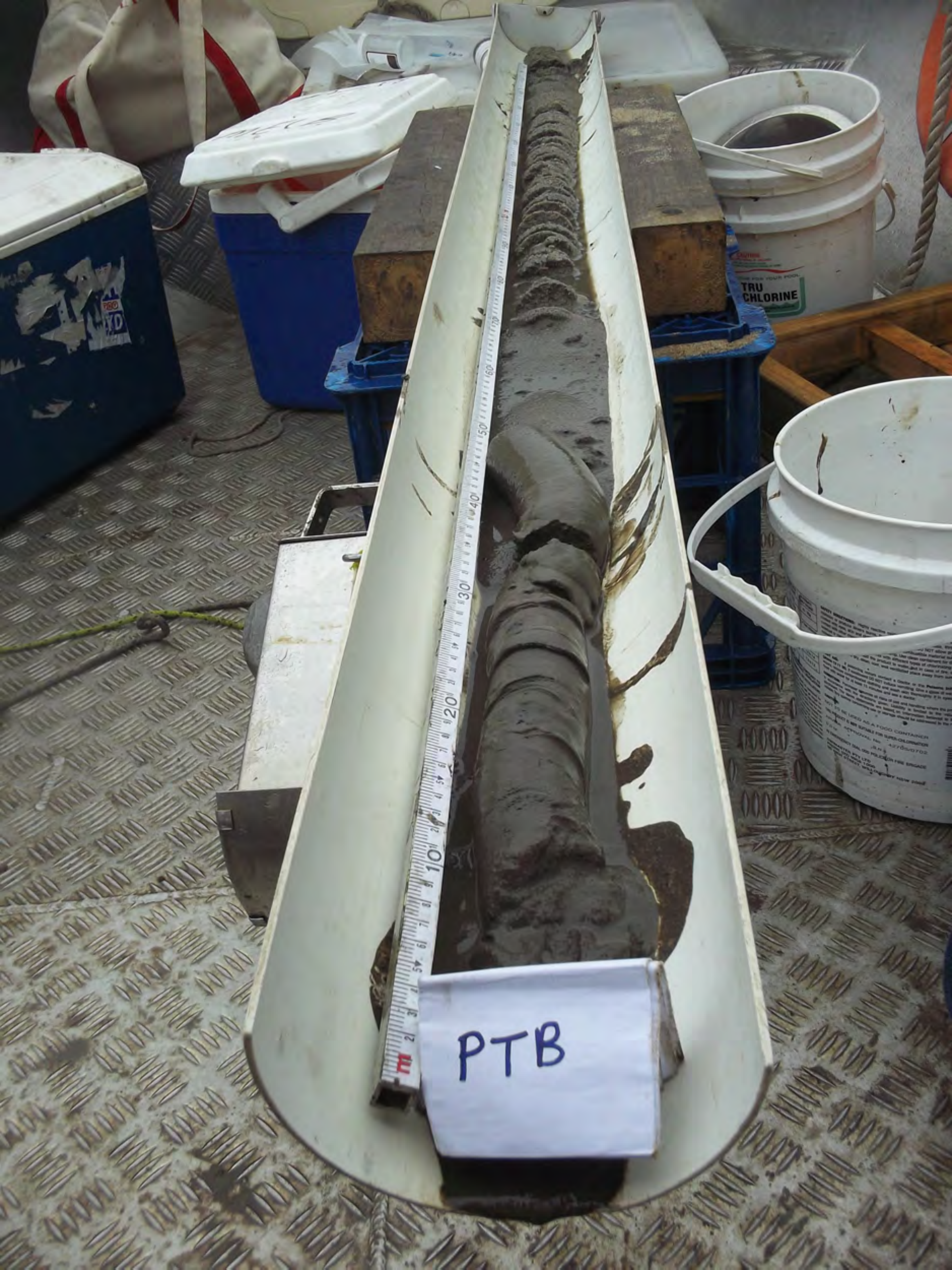
Prepared by : NF Checked by GH

Appendix 3 Field Sample Photos


BP
MELB
10
20
30
40
50
60


EC
60
50
40
30
20


TRU
POOL CHLORINE
418
EC


PTB


SF
ASSIFICATION OF ROCKS
70
60
50
40
30
20
TRU
POOL CHLORINE


SG
TRU
POOL CHLORINE
10kg NET


SP
ASSIFICATION OF ROCKS
10
20
30
40
50
60
70

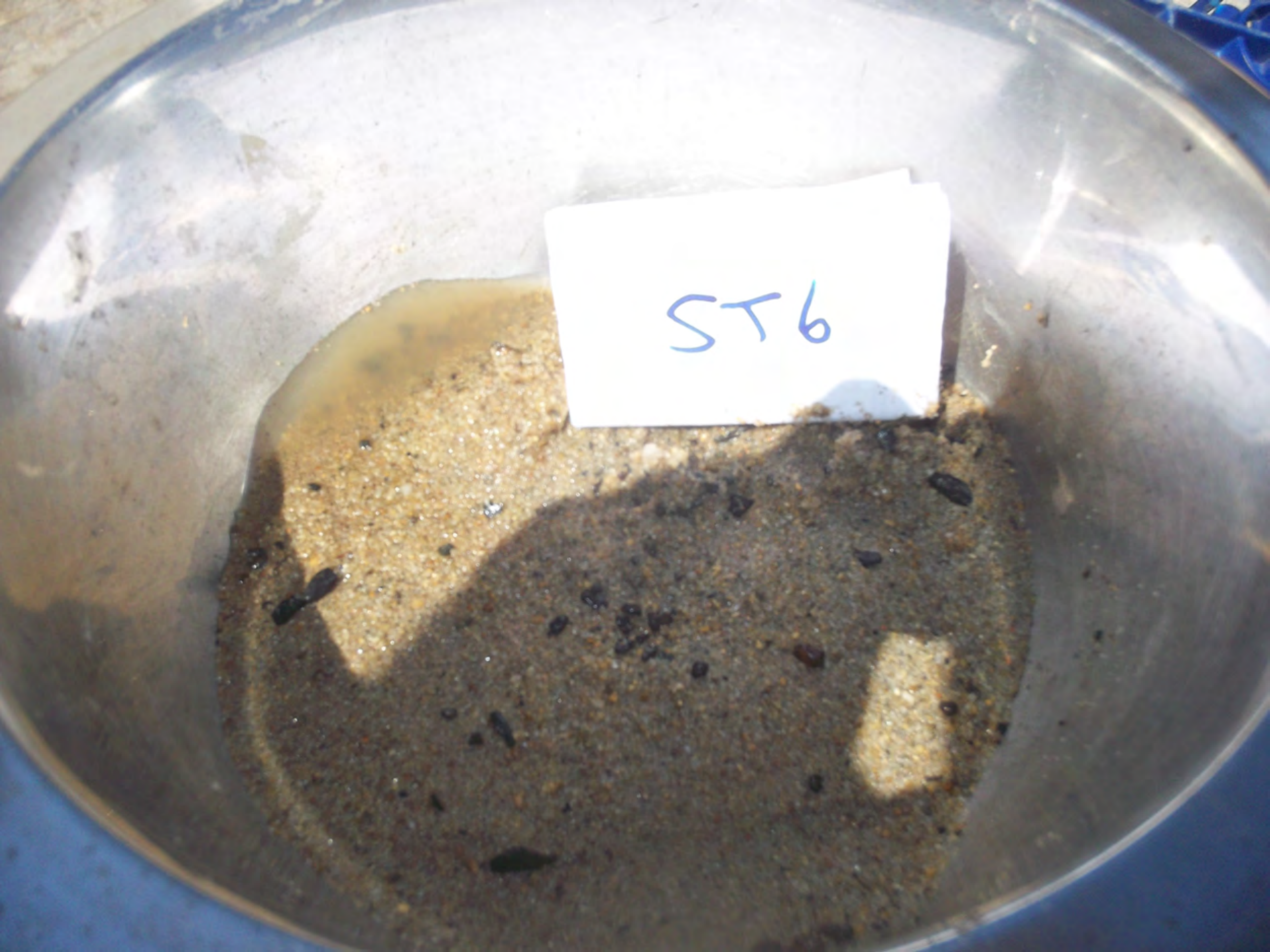

ST1


ST2


ST3
60
70
80


ST4


ST5


ST6


STR1


5TR2