Hydrosphere Consulting

Ballina Shire Council

Shaws Bay Dredging
Baseline Surveys and Data Analysis

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Cover Photo: Area 1 East Arm depostion delta

Hydrosphere Consulting
Suite 6, 26-54 River Street
PO Box 7059, BALLINA NSW 2478
www.hydrosphere.com.au

18-012 – SHAWS BAY DREDGING

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APPENDICES

1. INTRODUCTION

Shaws Bay is a modified tidal embayment that was once part of the Richmond River channel. It consists of 3 main sections referred to in this report as the East Arm, the Main Section as well as the Northern Section (Figure 1). It was created by construction of the northern river training wall and reclamation of land for urban development. The Bay is hydrologically connected to the Richmond River and tidal flows enter and exit through the rockwork of the training wall. Whilst the upper sections of the training wall are highly porous and allow the high tide to pass through relatively unobstructed, the lower portions are less so and this produces a weir-like effect resulting in water being ponded above the level of the adjoining estuary on the receding tide. The resulting tidal regime in the Bay has approximately equivalent high tides to the main estuary, but low tides are truncated to a minimum of around -0.2m AHD in the main part of the Bay and -0.3m AHD within the East Arm.

The bulk of the tidal exchange appears to occur through the wall within the East Arm and hence efficient tidal flow through this area is vital in maintaining good water quality within the Bay. Ensuring effective tidal exchange to maintain good water quality in the Bay is a consistent theme that has been raised by numerous community members. Tidal exchange with the Northern Section is significantly less that the East Arm as it is most removed from the source at the training wall, and the shape and bathymetry of the Bay somewhat isolates the Northern Section from the main embayment.

Dredging of the Bay was undertaken in the mid-1970s to form sandy beaches along the western side of the Bay. Dredging was also carried out twice in the 1980s. Wind generated waves gradually transported this sand back into the deeper sections of the Bay, generally in a northerly direction. A long-reach excavator was used in the early 1990s to again pull sand back onto the beach areas. No dredging of the Bay has occurred since this time.

The Shaws Bay Coastal Zone Management Plan was adopted by Council in 2015 and certified in 2016. The CZMP contains a number of recommended management actions to address key issues and protect and enhance the values of the Bay. The overall management goal for the Shaws Bay CZMP is: "*to improve the recreational amenity of Shaws Bay and to ensure that the habitat and ecological values of the Bay are maintained within an acceptable range*." Siltation/shoaling in Shaws Bay was one of the key management issues identified by the CZMP which is an underlying cause of several other issues. During the preparation of the CZMP, numerous community members expressed concern that dredging had not been undertaken for many years and that the ecological health and public amenity of the Bay was being compromised. After consideration of numerous options to achieve the desired outcomes, the CZMP recommended dredging of the Main Section of Shaws Bay with the primary aims of:

- Reducing siltation. There are numerous areas within the Bay that have become significantly shallower over time, with many areas becoming dominated by seagrass which further promotes settlement of silt. Such accelerated siltation ultimately results in areas which become too shallow for efficient tidal flow, resulting in die-off of seagrass, poor quality sediments and reduced ecological value. Dredging will reduce the opportunity for expansion of areas prone to siltation and maintain open water for the benefit of swimmers and maintenance of environmental values;
- Improving tidal flushing and reducing water quality risks. Full tidal exchange in the East Arm occurs on a daily basis, however the residence time of water further into the Bay generally increases. Dredging of key areas is anticipated to reduce restriction of tidal circulation within the Bay and allow for better overall flushing;
- Maintaining foreshore access to deep water. Shallowing of the foreshore margins, combined with continued growth of seagrass and mangroves, has restricted the areas of the Bay that allow easy access to the main waterbody, particularly at low tide, without needing to traverse through seagrass and the associated silt, shells and organic debris; and
- Improving foreshore beaches, through nourishment using dredged material, which will provide a greater area of sandy beach to cater for ever-increasing numbers of Bay users and allow better access to the main area of the Bay and the better water quality therein.

In doing this, there are several significant anticipated benefits and it is important that any future dredging is undertaken in a way that maximises these benefits, whilst balancing numerous technical, ecological, legislative and financial factors.

Figure 1. Shaws Bay

As part of the implementation of the Shaws Bay CZMP, Ballina Shire Council has received funding from the Office of Environmental and Heritage on a 50/50 basis for investigations into the feasibility of the recommended dredging. The scope of work is divided into three broad stages:

1. Baseline Surveys and Data Analysis (this report) which aims to better define the dredging proposal through provision of an updated hydrographic survey, definition of the target dredging area, characterisation of the target sediments and the suitability for beach nourishment within the Bay as well as survey of target areas for the presence of seagrass which may influence the feasibility of dredging;
2. Dredging Options Assessment and Detailed Plan (to be completed in early 2018) to identify and evaluate the best detailed methodology for dredging, considering agency stakeholder input, environmental, technical and financial constraints; and
3. Preparation of documentation required for works approval (June 2018). This will include identification of the approvals pathway, preparation of assessment documentation and applications for permits required. This stage of work is intended to progress the project to the point where tenders for the physical works can be requested.

This report only documents the outcomes of stage 1. Subsequent documentation for the other stages will be developed as appropriate at completion of those milestones.

2. HYDROGRAPHIC SURVEY & VOLUMENTRIC ANALYSIS

Previous hydrographic survey information for Shaws Bay is available from June/July 1999 and July 2013 and has been discussed in the Shaws Bay CZMP. As part of the current project, an additional hydrographic survey was undertaken in April 2017 to supplement this data set and provide up to date information regarding infill areas and for the planning and estimation of dredging volumes.

2.1 Method

The hydrographic survey of the entire bay was undertaken 26-27 April 2017 utilising a combination of ground-based survey in shallow and shoreline areas, as well as boat-based hydrosurvey. In both cases a Topcon HiPerSR RTK GPS linked to the CORSnet signal correction service (Ballina TS 12089) was used to provide accurate (typically ± 15mm) position in the vertical and horizontal planes. For boat-based survey, the GPS was coupled to a CeeEcho survey grade (±10mm accuracy) echo sounder. Calibration was achieved through adjustment of the unit's sound velocity parameter to match physically measured depth within the Bay. Sounding lines were selected to match the hydrographic survey undertaken in 2013, and hence are intended to be directly comparable with this previous survey. Additional sounding lines (see Drawing 1, Appendix 1) were also added to increase resolution in key areas and to provide cross-line checks at different tidal states.

AutoCAD Civil3D was utilised to display, analyse and edit survey data. Editing was mainly necessary where echo soundings returned the elevation of the top of seagrass instead of the underlying substrate. This was generally evident when evaluating the cross-section of each sounding line and in comparison to recent aerial photography. Points which appeared to suddenly rise more than 0.3m in elevation compared to the surrounding bathymetry and were in close proximity to seagrass visible on aerial photography, were deemed to be erroneous returns and were deleted from the data set.

Triangulation of survey data, contouring (Appendix 1, Drawings 2 and 3) and analysis of volume change (Appendix 1, Drawing 4) between the current and previous (2013) hydrographic surveys were also undertaken utilising Civil3d.

2.2 Results and Discussion

The 2017 hydrosurvey corresponded very well with the 2013 survey and there was very little broad-scale change in bathymetry of the waterway (Appendix 1, Drawing 4). Minor random variations between the derived 2013 and 2017 bathymetry were evident, which is expected with single beam hydrographic surveys due the inability to exactly replicate survey points and that the 2017 survey included more detailed survey of shorelines and other key areas. The new data in concert with the sediment investigations undertaken for this report provide and excellent basis for dredge sediment volume estimation.

The notable areas of difference between the 2013 and 2017 surveys were as follows (refer Appendix 1, Drawing 4):

1. Localised changes in the channel form and depth within the East. For instance a significant scour hole that was present in 2013 has infilled in 2017 and there appears to have been some increase in channel depth along the east arm, which is assumed to have contributed to the additional sediment deposited at the East Arm delta. The effect of continued erosion of the northern bank of the East Arm is also apparent. Apart from broad changes it should be noted that the spatial resolution of bathymetric data in the East is significantly reduced due to deletion of false sonar returns over dense seagrass in this area.
2. There was increased north-westerly extension of the currently active sand lobe on the East Arm delta (i.e. around sediment sampling location C, Appendix 1, Drawing 5). The additional volume of sediment within this localised infill area since 2013 is around 2,500 m^3, which is over half of the 3,600 m^3 targeted for dredging at the delta.
3. There also appears to have been increased sedimentation from the delta area along the western side of the Main Bay. There is continuing settlement of silt within the seagrass south of this area, which is leading to degradation of the quality of seagrass in this location, as well as offshore recruitment of juvenile mangroves. Further towards the west, the sediment is sandy and it is assumed that sand from the eastern (active) side of the delta is being redistributed in westwards particularly during strong north-easterly winds.
4. Numerous high points were identified within the northern section of the Main Bay. Similar high points were also identified in the 2013 survey, however the slight discrepancy in the boat tracks between the two surveys has resulted in apparent differences in this location depending on which survey lines intersected with the isolated high spots. Subsequent investigation of several of these high areas in 2017, determined that at least some are associated with underwater rock outcrops up to 1m above the surrounding sediment.
5. Water depth in the vicinity of the choke point between the Main Bay and Northern Section appears to have increased. Tidal flows are concentrated in this area and some scour of the channel is expected at this location. This may be exacerbated by the minor accretion in the vicinity of the rock outcrops, which would result in minor additional constriction/concentration of tidal flows within the ebb-tide channel(s).
6. Overall, excluding the areas highlighted above, there was little detectable change in bed level, with the nett volume change due to minor variations (±0.25m) being negligible. Apparent significant variations between the 2013 and 2017 surveys near the survey margins (e.g. along the training wall) are not shown in Appendix 1, Drawing 4 and are considered (as was also noted in the 1999 to 2013 comparison) to be artefacts of minor survey differences.

3. DREDGING TARGET AREAS

Dredging is planned to achieve three key aims:

1. Promote water exchange and tidal flushing to maintain water quality;
2. Win sand to utilise for beach nourishment to improve public amenity;
3. Ensure that priority swimming areas subject to siltation/shallowing remain suitable for these activities.

Two target areas have been identified based on information available to date, although additional investigations during later stages of this study may result in modification of the proposal. The areas are indicated in Appendix 1, Drawing 4 and are discussed below:

3.1 Area 1 – East Arm deposition delta

This depositional delta is located on the southern margin of the Main Bay and has formed from sediments eroded from the East Arm. Sand is transported by the incoming tide from erosion in the East Arm and deposited into the main section of Shaws Bay. The delta is intruding into the deepest part of the Bay (around -6.5m AHD) and has formed as a series of sand lobes, corresponding to the location of the active tidal flow channel at various times over the years. Dredging is proposed to address the build-up of this eroded sediment and provide a sand resource for re-nourishment of foreshore beaches in Shaws Bay.

The proposed dredging, in concert with the stabilisation works to be undertaken within the East Arm, will arrest the continued growth of the delta, and prevent the likely subsequent seagrass/mangrove colonisation and resulting siltation of this vital tidal exchange pathway. The western part of the target dredge area extends along the training wall and is important to ensure that any tidal exchange that is occurring along this section of the wall remains unimpeded. This addresses a concern raised by some stakeholders during the CZMP consultation process and ensures that open water remains adjacent to the concrete steps along the wall at this location. Similarly, the eastern extent of this dredge area was raised as an area of concern by stakeholders, where it was recalled that the beach in this location previously allowed unimpeded access to deep water for swimming, but is gradually filling with sediment.

Overall, it is estimated that up to 3,600 m^3 of sand is available for dredging in this location, although this will be subject to the studies and approvals to be undertaken in later stages of this project. This volume is based on a target bed level of -2.5m AHD, although additional sand immediately offshore of the target area, which forms the toe of the delta, is available at deeper elevations. This additional volume has not been included at this stage as it is considered that the majority of the benefit of dredging will be realised with the proposed arrangement.

Batters of 1 in 4 have been incorporated into the dredge design. This slope is significantly less than existing natural bed slopes at the delta, but has been selected as a trade-off between maximising bed stability post-dredging and minimising the dredging footprint and proximity of works to the nearby seagrass beds.

3.2 Area 2 – Main Bay shallows

This is a large area toward the northern end of the Main Bay that was identified in the CZMP as concern for efficient tidal exchange and flushing of the Northern Section. It has been previously identified that sand from the East Arm delta is generally pushed northwards along the eastern shoreline, resulting in a general shallowing of that shoreline as well as leading to a build-up of sand towards the northern end.

Dredging of this area will:

- Promote more efficient tidal exchange with the Northern Section of Shaws Bay;
- Address the build-up of sediment at this location and reduce the sediment supply that is available for further in-filling of the Northern Section, particularly the narrow channel joining this section to the Main Bay;
- Remove the possibility that this area is colonised by marine vegetation in the future, which would exacerbate siltation, shallowing and reduction of tidal exchange. This factor was a concern raised by regular swimmers in Shaws Bay, who value the open, but safe, nature of this waterway.

Historical dredging of this area appears to have been incomplete and it is possible that rock outcrops, which were identified in the current study, are partially responsible for this. Despite the presence of rock at some points, the sediment coring undertaken for this project (see section 4) revealed that there is substantial depth of sediment overlaying most of this area.

A Dial-Before-You-Dig query identified a submarine telecommunications line extending across the narrowest part of the Bay at the northern extreme of the proposed dredge area. Subsequent discussions with local cable locating services as well as with Telstra representatives indicated that there is no live cable in this location and there is uncertainty whether a cable ever existed in this location. In any case, this does not appear to be a constraint to dredging at this location.

It is currently considered that dredging of this area would be feasible utilising a suction style dredge and it is estimated that up to 5,500 m³ of sand may be accessible from this area. Similar to Area 1, this volume is based on a target bed elevation of -2.5m AHD. Given a minimum low tide level of -0.3m AHD, this will result in water depths in generally in excess of 2m, although no removal of rock is proposed. Design batters in this section have been set at 1 in 6, in keeping with bathymetry of this lower-energy section of the Bay.

4. SEDIMENT CHARACTERISTICS

4.1 Method

Sediment coring was undertaken within the target dredging areas in order to characterise the sediments in these locations. Ten coring locations were pre-selected based on the intended dredging footprint, proposed depth of cut and to adequately characterise the sediments to be dredged. During field work, it was decided to add an additional core to extend the spatial information available, providing a total of 11 coring sites, designated A to K as indicated in Appendix 1, Drawing 5.

Coring was undertaken utilising a 60mm vibracoring system deployed from Hydrosphere's work vessel 'Mudskipper'. With this method, an aluminium tube is vibrated mechanically and driven vertically downwards, typically 1.5 to 2.5m, into the sediment. A food-grade plastic liner and core catcher/cone assembly is utilised to retain the sediment within the tube. The tube is extracted from the sediment using an on-board crane, and once aboard, the plastic lining and sediment core are extracted and the core is then available for further processing (Figure 2). Although the vibration of the tube leads to some minor disturbance of the core periphery, this method generally yields an excellent representation of the sub-surface strata allowing photography, logging and sub-sampling of specific depths/strata from the sediment core.

Figure 2: Extracted cores within plastic liners prior to splitting and core logging

Cores were logged and sub-sampled at Hydrosphere's workshop, with multiple samples taken per core for analysis of sediment particle size distribution and chemical contaminants. Sub-sample depths are shown in core logs presented in Appendix 2. Sub-samples were placed on ice and submitted to Southern Cross University's Environmental Analysis Laboratory for NATA accredited analysis. Samples were taken for four suites of analysis as follows. The abbreviations correspond with the codes of the core logs presented in Appendix 2.

- PSD – Particle dry sieving classification in accordance with the Wentworth grain size classification (>2mm – gravel and organic matter, 1-2mm – very coarse sand, 500µm-1mm – coarse sand, 250-500µm – medium sand, 125-250µm – fine sand, 63-125µm – very fine sand, <63µ - silt and clay);

- ASS – Testing for Acid Sulphate Soils (ASS) which involved a full analysis of chromium reducible sulphur, actual and potential acidity and neutralising capacity;
- ENM – Corresponding the EAL's analysis suite for excavated natural material which included testing for pH, moisture content, electrical conductivity, foreign material (rubber, plastic, bitumen, paper, cloth, painted wood etc.), metals, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (C10-C40) and BTEX (C6-C10); and
- PEST – Corresponding to EAL's analysis suite for pesticides which included testing for Organo-chlorines (OC), Organo-phosphates (OP) and Polychlorinated Biphenyls (PCB).

These four suites were selected as they cover all common urban, industrial and agricultural contaminants potentially in the Shaws Bay sediments, and are commonly utilised for the classification of excavated material including waste classification under *Protection of the Environment Operations Act 1997*. The goal of this analysis was to determine any risk to the suitability of potential dredge targets for beach nourishment within Shaws Bay.

4.2 Results and Discussion

Core logs for locations A to K (see Drawing 5 in Appendix 1) are presented in Appendix 2. These provide a summary of the appearance of sediments encountered, the depths and analyses applied to sub-samples and physical/aesthetic characteristics.

4.2.1 Grain size

Particle size distribution (PSD) results (Figure 3 and also see Appendix 3) show that the Shaws Bay sediments are dominated by sand-sized fractions, predominantly 250-500µm (medium sand), sometimes overlain by a layer of silty/organic material. This is consistent with field observations and inspection of the recovered cores that indicate a relatively homogenous sediment profile consisting of marine sands but often with a relatively thin but distinct 'sludgy' surface layer. Laboratory results show that even this relatively dirty material contained less than 1% of mud by weight.

Generally, sand quality improved with depth, with several cores displaying very clean yellow sand at depth, with gradually darker (anoxic) sediments towards the surface. Only one core (D) had a silty layer at depth. This core is at the head of a historical sand lobe corresponding to a previous tidal flow channel. It is likely that the silt layer was deposited at a time when the path of the tidal channel changed and there was infilling of the channel by surrounding, dislodged silt from the up-current seagrass beds.

It is concluded that the vast majority of sediment within the areas targeted for dredging is marine sand, consistent with the intended use for beach nourishment on the Shaws Bay foreshores and agrees with historical accounts of the use of dredged material for beach formation in the Bay.

The overlying silt encountered on many of the cores is likely to a result of the lack of significant physical disturbance for nearly 20 years. Silty material enters the system from both storm water input direct to the Bay and primarily through tidal exchange of silt-laden floodwaters following heavy rains in the Richmond River catchment. Previous regular dredging would have served to disperse and integrate silt in the Shaws Bay environment, resulting in relatively clean bed sediments in these areas of activity. Given that the silt has been allowed to build up in this fashion, re-establishment of dredging in Shaws Bay should consider methods for separation and removal of this material in order to maximise the quality of the desired clean sand for beach nourishment.

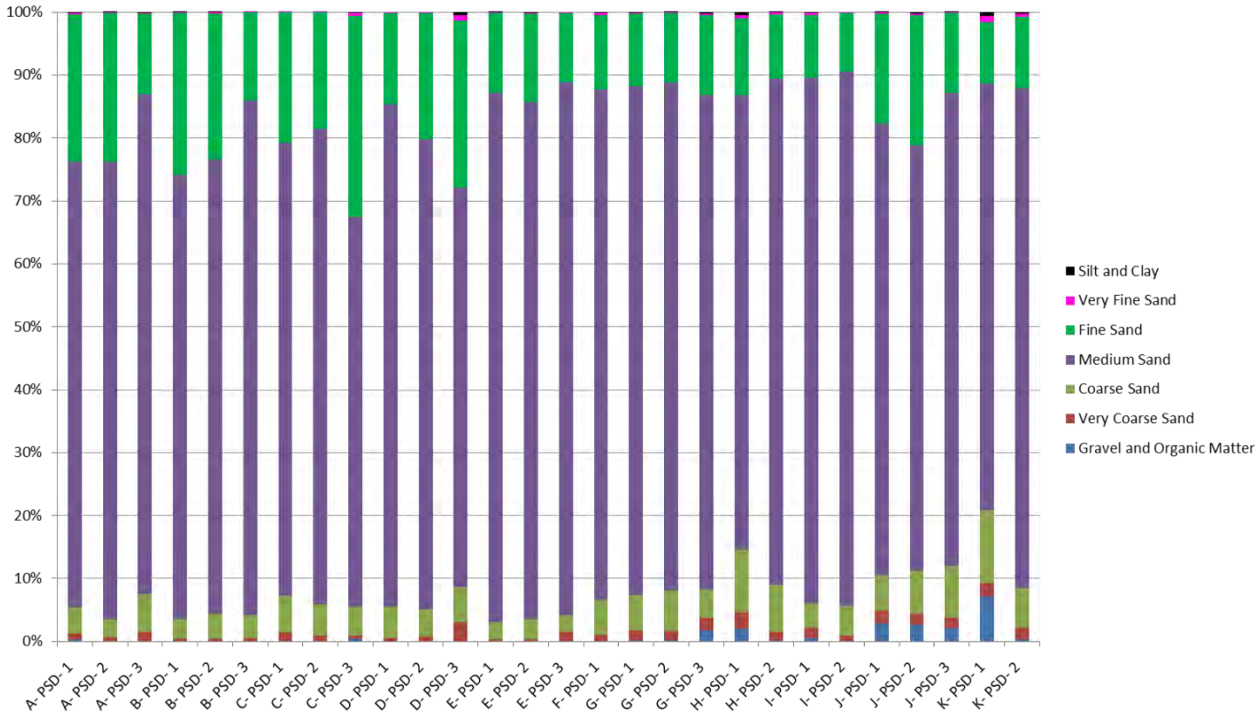


Figure 3. Particle size distribution of sediment samples (Wentworth grain size classification

4.2.2 Acid Sulphate Soil

Acid sulfate soils (ASS) are sediments or soils which contain iron sulphides which, when exposed to oxygen form sulphuric acid (Ahern, 1998). Actual ASS (AASS) are soils or sediments that are highly acidic (generally <pH4) due to the oxidation of sulphides in the material. Potential ASS (PASS) is soil or sediment containing sulfidic material that has not been oxidised, however, if oxidised will have a high acid generating potential. Disturbance of such soils that fall under these classifications pose a risk in the form of the release or generation of sulphuric acid which could result in fish kills and other environmental impacts if acid runoff enter waterways.

All samples for Shaws Bay were analysed using the detailed laboratory chromium suite analysis to identify the level of PASS and evaluate any risk associated with PASS. Chromium Reducible Sulfur (Scr) analysis measures actual acidity (AASS), reducible inorganic sulfur (PASS) and acid neutralising capacity from which the net acidity is calculated. For coarse materials such as sand, an action threshold of 0.03% Scr is considered to indicate the presence of PASS. Under the NSW *ASSMAC Acid Sulfate Soils Assessment Guidelines (1998)* an ASS Management Plan should be prepared (for works disturbing >1000 tonnes of soil) if the oxidisable sulfur content of the material is >0.03%.

Appendix 3 provides the ASS results for the Shaws Bay sediments and indicates that all cores contained appreciable, although not consistent, levels of oxidisable sulphur. Sulphidic content was highest with the silty/organic material, but elevated levels (>0.03%) were also detected in clean sands. In all cases, the analysis detected that there was sufficient natural carbonaceous material present to provide excess 'self-neutralising' capacity, although this does not remove the requirement to develop an acid sulphate soil management plan to be implemented during dredging works.

ASS can also be problematic from an administrative perspective. Dredged material can be considered a 'waste' under the POEO Act and exemptions for 'recovery' of ASS material for beneficial use (e.g. beach nourishment) are not granted by the EPA when moving material off site. In this case, as long as the dredged material is to be utilised 'on site' at Shaws Bay, this issue is unlikely to arise.

Although management of ASS is not a trivial manner, it is considered that appropriate methods to address ASS risks are available and that these should be evaluated and detailed as part of later stages of this project.

4.2.3 Chemical contaminants

The results of all chemical contaminates analysed are displayed in Appendix 3. The sediments were tested for a large suite of chemical contaminants in order to cover the potential urban, industrial and agricultural contaminants that could impact the beneficial use of dredged material.

The results indicate that all pesticide compounds analysed including PCBs were below detection limit for all samples. The majority of metals analysed for, including arsenic, lead, chromium, copper, nickel, and zinc were detected at low levels in a number of samples, although well below relevant guideline values (DEWHA, 2009; ANZECC/ARMCANZ, 2000) for each analyte. For all samples, both cadmium and mercury fell below detection limits. All PAHs, total petroleum hydrocarbons and BTEX tested for fell below detection limits and relevant guideline values (ANZECC/ARMCANZ, 2000). No physical contaminants, in the form of rubber, plastic, bitumen, paper, cloth, painted wood, were detected in any of the samples tested although a single scrap of plastic was observed towards the bottom of core D.

All material sampled is considered to be uncontaminated with all test results being either undetectable or significantly below relevant guideline values.

4.2.4 Aesthetic considerations

During the collection of sediment cores and sub-sampling all soils were examined for aesthetic consideration. This took into account feel, odour and visual nature of the sediment to determine if this material was appropriate for beach nourishment within Shaws Bay. All samples collected were comprised of sand varying in texture and colour. This ranged from yellow clean sand at depth to gradually darker (anoxic) sand closer to the surface. Although the yellow clean sand is considered ideal for beach nourishment the grey sands will bleach over time and are consistent with the texture and feel of sand currently at the proposed target beach nourishment areas. Visual assessment of the sediment cores also identified that dredging Area 2 (north) contains varying depths of overlying sludge, which was confirmed during a visual assessment of the area. The sludge did not give off a strong odour but did display a consistency and feel not desirable for beach nourishment. It is recommended that a technique for separating and removing this small component is considered in the dredging methodology.

5. SEAGRASS COMPOSITION AND DISTRIBUTION

Numerous estuarine habitat features are present in Shaws Bay including rock walls, submerged boulders and bedrock outcrops, inter-tidal and sub-tidal sand flats, mangroves and woody debris as well as saltmarsh and seagrass. Potential impacts of dredging on all these habitats should be considered in the environmental assessment for the project which is to be undertaken during Stage 3 of this project (refer to Section 1) and should consider (particularly) the likely impacts to macroinvertebrate and fish communities.

The presence of healthy seagrass is considered the single-most important factor influencing habitat value within shallow sub-tidal sections of the Bay which are most likely to be affected by dredging. It is well established that diversity of estuarine fish generally increases at seagrass margins and this is a results of numerous factors including the presence of shelter, increased primary productivity, increased diversity of habitats and food resources for macroinvertebrates and the fact that seagrass grows best in areas of good water quality.

Aside from the inherent ecological value of seagrass and associated faunal community, seagrass (along with other marine vegetation) is protected under the *Fisheries Management Act 1994* and presence of seagrass is a key constraint to dredging. For these reasons, evaluating the extent of seagrass within the Bay was seen as a key information priority to inform subsequent stages of this project.

Two main seagrass communities occur in Shaws Bay:

- Beds of *Zostera capricorni* which typically occur at elevations between 0 and –1.1m AHD within the Bay, although the depth range varies according to location. These beds typically have distinct margins and the dark colouration of the beds means they are readily identifiable and able to be mapped from aerial imagery. The outer margin of the beds is sometimes blurred by the presence of heavy deposits of the *Microdictyon* as discussed below in Section 5.2.2;

- Areas of *Halophila ovalis*. This smaller species occurs in protected areas of good light exposure/water clarity. It has previously been observed to occur both inshore and offshore of fringing *Zostera*. This seagrass tends to form a low 'carpet' on the sediment, which can range from sparse to dense coverage. The variable coverage, short growth form (typically 1-3cm) and low-contrast light green colouration means that it is not able to be discerned with any accuracy from aerial photography.

5.1 Method

Aerial photography from 2017 was evaluated in GIS to determine the boundaries of *Zostera* seagrass in the vicinity of the target dredge and potential deposition areas. Aerial photography geo-rectification was confirmed with reference to RTK GPS survey of several locations around the Bay, thus enabling a high degree of confidence in the location of this mapping. In addition to the readily discernible *Zostera*, numerous other features (darker areas) were identified on the aerial image and were flagged for field inspection and verification. These areas were suspected as potential areas of Microdictyon or organic debris accumulation, change in sediment composition or could also indicate *Halophila*, and were inspected during the field survey component of this work.

Field surveys consisted of snorkelling surveys along transects established approximately perpendicular to the shoreline (for fringing sites) and parallel to visual markers (overhead power lines and shore features) within the shallow, central, open water section of the Bay. The open water transects were reconnoitred by a two-person snorkelling team to determine presence/absence of any seagrass, and if present, it was intended that a formal transect line was to marked out by measuring tape and the position of seagrass boundaries, species, relative density and condition noted. To supplement the snorkelers' field assessment, one of the team used a GoPro camera on extendable pole to record the length of each transect to allow peer review of any features of interest. The other snorkeler dived to bed level along the transect for close-up inspection of the bed in deeper water.

For shore-based transects. A RTK GPS position was plotted on the offshore boundary of the *Zostera* bed and then a snorkelling transect was swum usually perpendicular to the bank for a distance of typically 20-25m. Once again, the approach was to initially reconnoitre the transect, and then follow up with detailed transect measurements if any seagrass was detected. The GPS points taken as transect start points were compared to the boundaries mapped from aerial photography to allow verification of position, particularly where offshore *Microdictyon* deposits, which become darker with decay, can be confused with *Zostera* on the imagery.

5.2 Results and Discussion

5.2.1 Seagrass

Seagrass is marine vegetation protected under the *Fisheries Management Act 1994* and destruction of seagrass increases approval risk for dredging and also adds the financial burden of compensatory habitat payments which equates to around $108/m² of seagrass.

Whilst *Zostera* is readily identifiable on aerial imagery and can be quickly verified in the field, a key concern for this project was that the less visible *Halophila* seagrass could have been present within the dredging footprint and therefore have a significant bearing on the dredging proposal.

None of the open water or shore-based transect surveys detected any seagrass beyond that identified remotely by aerial photography. *Halophila* was always located in very close proximity and virtually always inshore of the mapped *Zostera*. The mapped *Zostera* beds are therefore considered to accurately represent the offshore extent of all seagrass.

The nominated dredge areas have been designed to incorporate batters and have been offset to generally avoid direct impacts on the *Zostera* beds mapped from aerial photography. One area of seagrass of less than 50 m² has been included in the intended dredging footprint. This small section of patchy *Zostera* protrudes into a sand lobe on the East Arm delta and inclusion of this patch in the dredging allows removal of significantly more sand at this location.

Figure 4. *Halophila* growth in close proximity to *Zostera* seagrass

5.2.2 Macroalgae (seaweed)

A key finding of the surveys was that much of the bed of Shaws Bay is blanketed in dense growth of the green macroalga *Microdictyon umbilicatum*. The species is superficially similar to the sea lettuce *Ulva*, but grows significantly larger. It forms large thin lobate plates up to 45cm in diameter, which although seeming unattached, generally grow on the bed in protected areas and within seagrass beds (Figure 5). This alga tends to smother seagrass, and forms thick blankets of live and dead *Microdictyon* on the bed of the estuary. Blanket thickness of up of 80cm was observed during the seagrass surveys and it is considered likely that deeper deposits of this material, along with terrestrial vegetative matter as well seagrass, brown algae debris and some organic material from mangroves is likely to have accumulated to greater levels in the deepest part of the Bay, which was not surveyed.

Although native, the presence of *Microdictyon* in bloom proportions is considered to be detrimental to the ecological health of Shaws Bay. There is direct visual evidence of this species smothering *Zostera*, and as well as degrading the value of large areas of sub-tidal sandflat for popular recreationally important fish species such as whiting and flathead. Although not assessed, the breakdown of dead algae would release nutrients into the water column and is likely to be contributing to the sludgy surface sediments encountered during sediment coring.

Removal of *Microdictyon* during dredging of otherwise bare substrates is not likely to have any detrimental effect on the Shaws Bay system and is likely to reduce the risk of nutrient enrichment and continued algal bloom. The dredging methodology for Shaws Bay should consider the most efficient way to separate this material from the beneficial sediments and will also need to develop methods to protect water quality and efficiently dispose of this unwanted material. It should be noted that trials have been undertaken in other studies in the use of this species as a terrestrial mulch/fertiliser, and such beneficial end uses should be considered for this project.

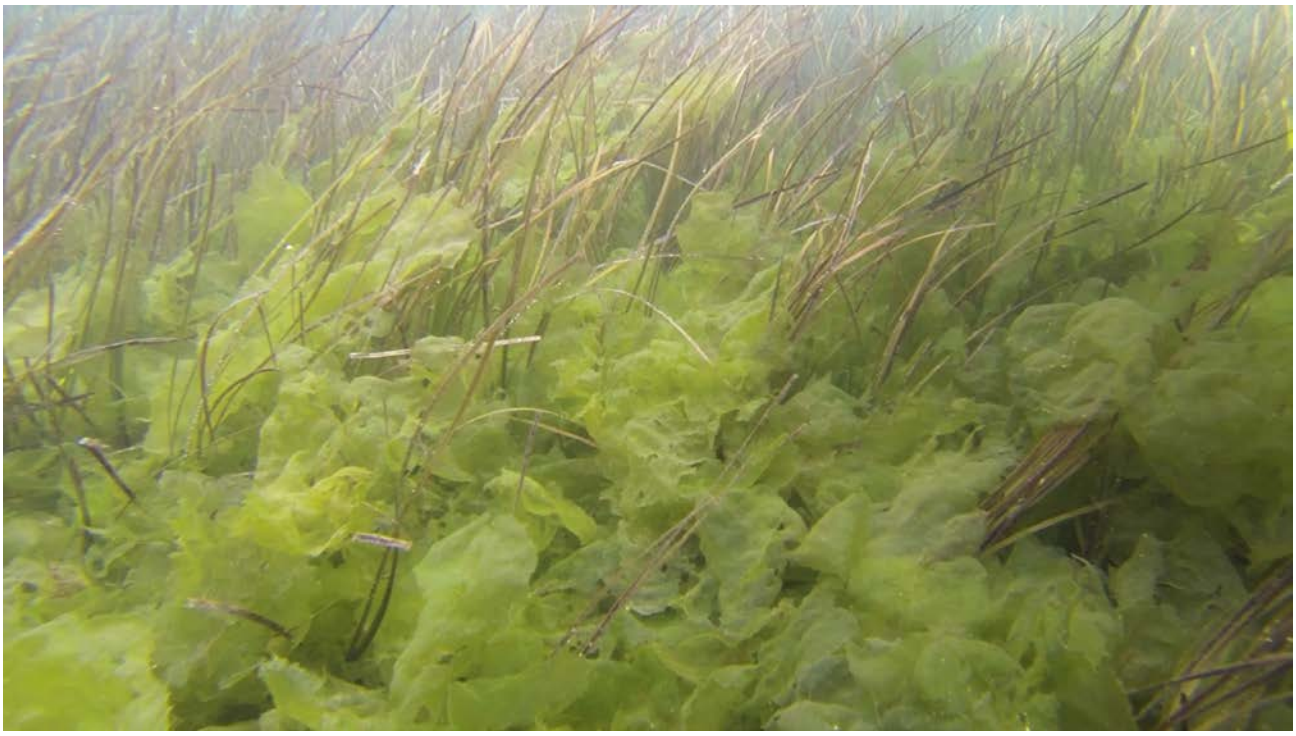


Figure 5. Typical growth of *Microdictyon* within *Zostera* seagrass

Some brown macroalgae (tentatively identified as *Dictyota sp*.) was encountered in traversing eastern shoreline transects and appeared to be growing from the sandy bed of the Bay. Close inspection revealed no dedicated holdfast and it appeared that the algae was semi-buried, with the buried parts in various stages of decay. It is currently unknown if this macro algae was dislodged from elsewhere (e.g. the rock wall and steps at the southern end of the bay) or growing *in situ*. This alga was in small isolated patches and is likely to form similar habitat value to other organic debris within the Bay. This macroalgae was not observed within the identified dredging footprint and its presence is not considered likely to influence approval requirements for dredging.

6. ADDITIONAL INVESTIGATIONS

Though the course of the current study, two additional aspects were identified that warrant further consideration as part of this project.

6.1 Removal of *Microdictyon* and surface silt

Sediment sampling and marine vegetation snorkelling transects identified that the Main Bay and to a lesser extent the Northern Section has large amounts of the blooming macroalga *Microdictyon umbilicatum* which forms extensive blanketing deposits of both live and decaying matter on the bed of the estuary. It is known to be more likely to bloom during cooler weather. This alga was reported by community members in winter 2016 however it is not known whether this alga has persisted since that time, or has re-bloomed in winter 2017. *Microdictyon* was not present in any appreciable amounts in March 2013 when seagrass surveys were undertaken for the CZMP, however it was raised as a potential issue (misidentified as *Ulva*) in the 1999 EMP.

The ecological and water quality implications of bloom conditions of *Microdictyon* are currently unknown, however it is suspected that this material is contributing significantly to nutrient recycling within the Bay. Researchers from Southern Cross University have previously undertaken research into nutrient cycling within Shaws Bay (not directly related to *Microdictyon*) and have found that the microbial community is Shaws Bay functions to recycle, rather than remove, the plant nutrient nitrogen from the system and that nitrogen loss rates are diminished in Shaws Bay relative to other coastal areas.

The surface layering of silt is also likely to be contributing to nutrients within Shaws Bay. High nutrient flood waters from the Richmond River estuary are known to be a key source of silt to Shaws Bay. This silt appears to be retained in the surface sediments and bioturbation into lower strata does not appear to be a significant factor. This silty material is therefore exposed to the water column and is more likely to be contributing to nutrients in the system. Previous, regular dredging activities would have served to mix and integrate silt into the beach and bed sediments, however the lack of large-scale physical disturbance has resulted in a more defined and deeper layer of silt than was likely to have existed previously.

These aspects, combined with reduced flushing from continued siltation and vegetative growth along the training wall increases the risk of eutrophication of the Bay. It is recommended that further research into the likely persistence and impacts of *Microdictyon* is undertaken and that a better understanding is developed, through liaison with Southern Cross University researchers, of how this algae and the sediments in Shaws Bay are affecting the nutrient status of the Bay. The Options Assessment phase of the current project should consider methods to remove and dispose of both silt and excessive organic matter from the target dredging, and possibility wider areas of the Bay.

6.2 Increasing tidal exchange through the training wall

Tidal exchange through the training wall is vital to the on-going health and enjoyment of Shaws Bay. A general trend within the East Arm has been observed whereby northern bank of the East Arm has been eroding and the tidal flow channel has been gradually migrating northwards following the retreating bank. As this occurs, the main tidal currents are concentrated towards the northern side, and siltation occurs on the southern side of the East Arm. This area is then colonised by seagrass, and later by mangrove seedlings.

A mature stand of mangroves exists along a substantial section of the East Arm training wall, and there is continued activity by Council, under a NSW Fisheries permit, to remove juvenile mangroves emerging in the remaining section. During the development of the CZMP there was significant community interest in removing the mature mangroves to encourage increased water flushing, however this option (discussed as Option 10 in the CZMP Vol 2) was not recommended due to uncertainty that a successful outcome could be achieved and the need to undertake a detailed assessment of removal methodologies and environmental impact assessment. This lack of confidence meant that the considerable expense and ecological impact of the works could not be justified as part of the plan.

Since the finalisation of the CZMP, there continues to be stakeholder interest in evaluating this option, and site observations have shown that there is continued silt deposition and mangrove seedling recruitment in this area. In considering this issue further it is has been identified that there is scope to implement a small-scale field trial which would help to address some of the uncertainties listed above. It is recommended that the opportunity for such as trial is pursued further and given that part of such a trial would involve some sediment removal and similar considerations to other dredging in the Bay, planning of this work should consider the outcomes of next stage of the current project and seek to address issues raised in the CZMP.

7. SUMMARY AND CONCLUSIONS

The investigations to date have determined that there is continued infilling of some areas of Shaws Bay and that concerns raised by stakeholders during the CZMP community consultation are still valid. Key areas of sediment accumulation are at the East Arm delta and the north-central portion of the Main Bay. Accumulation in both locations has the potential to restrict tidal exchange, particularly if these areas are colonised by marine vegetation, which would lead to isolation and stagnation of other areas of seagrass, accelerate overall siltation and reduce the amenity of the Bay for swimming and associated activities.

Two corresponding dredging areas have been identified as the initial focus for the re removal of accumulated sediment:

1. The active sand lobe and historical accumulation at the toe of the East Arm delta should be dredged to address ongoing infilling of the Bay and to reduce the possibility of continued seagrass and ultimately mangrove colonisation within this important tidal exchange area and westwards along the main training wall. As an extension to this component, further investigation of increasing tidal flow through the wall within the mangrove forest should also be considered in the dredging options assessment; and
2. As identified in the CZMP, the shallow nature of the northern section of the Main Bay has the potential to restrict tidal exchange to the north arm of Shaws Bay and also reduce amenity for swimmers utilising the upgraded beaches of the Western Foreshore and Pop Denison Park. Although there are some rock outcrops in this area as identified during hydrographic and snorkelling surveys, removal of sediment is still recommended and currently considered feasible.

These areas were selected to avoid major known constraints such as large meadows of existing seagrass and were considered likely to be feasibly dredged with minimal environmental impact whilst providing significant contribution to the overall aims of the CZMP.

Coring within these target dredging areas indicated that the sediments of the Bay are dominated by marine sands and the aesthetic quality of that sand generally increases with depth through the profile. Both sediment investigations and subsequent snorkeler surveys showed that some of the bed of Shaws Bay is capped by a layer of silty material, often with a high level of organic coverage by the blooming green algae *Microdictyon umbilicatum*. This is resulting in degradation of surface sediments and is inconsistent with clean sand environment desired by community stakeholders.

The underlying sand resource is considered ideal for beach nourishment as planned for numerous locations in Shaws Bay, however separation and removal of the surface silt and organic material prior to placement is recommended and the options assessment should determine how this is best achieved. It should also be noted that most of the sediment, including the clean sandy layers, has elevated oxidisible sulphur levels and is therefore considered as potential acid sulphate soil, despite having significant self-neutralising capacity. The options assessment will need to consider this factor and an acid sulphate soil management plan will need to be developed and implemented as part of the actual dredging works. Aside from PASS/ASS there were no other contaminants of concern detected in the Shaws Bay sediments.

No insurmountable barriers to dredging have been identified and it is recommended that continued evaluation of feasibility of dredging is undertaken as per the project scope, with the addition of the following:

- Consideration of a broader silt/organic/sludge removal component to be included in the dredging scope
- Investigation into the feasibility of a trial to enhance tidal exchange through the training wall.

8. REFERENCES

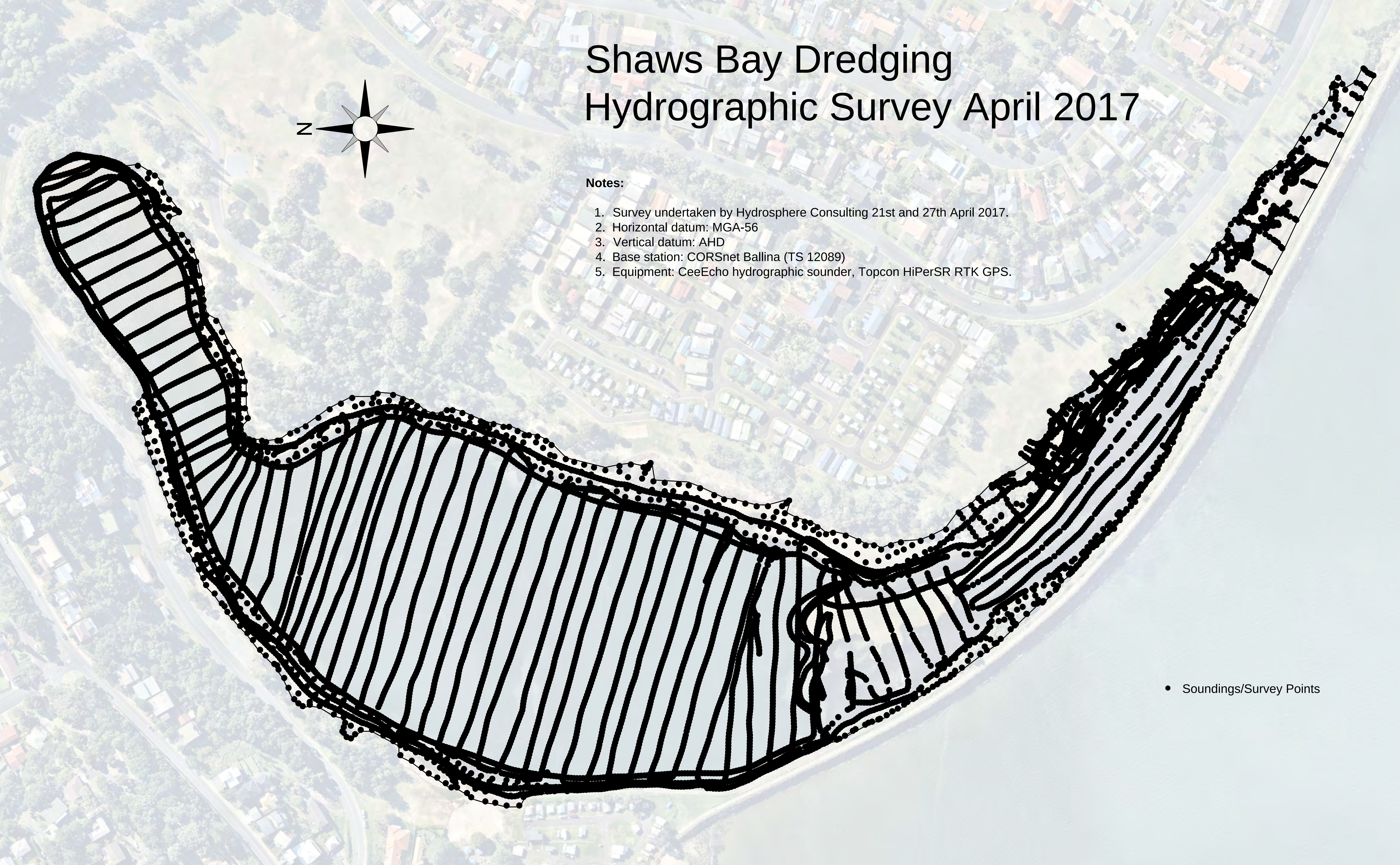
Ahern C R, Stone, Y, and Blunden B (1998). Acid Sulfate Soils Assessment Guidelines Published by the Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

ANZECC/ARMCANZ (2000). Australian and New Zealand guidelines for fresh and marine water quality. Volume 1, The Guidelines.

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

Hydrosphere Consulting (2013) Coastal Zone Management Plan for Shaws Bay. Report for Ballina Shire Council.

Appendix 1



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SCALES

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Metres

CLIENT: BALLINA SHIRE COUNCIL

SHAWS BAY DREDGING
HYDROGRAPHIC SURVEY 2017

JOB NUMBER: 18-012

REVISION	DATE	DESCRIPTION	DRAWN
	2017-11-04	REV 0	MH

DRAWING NUMBER

DRAWING 1

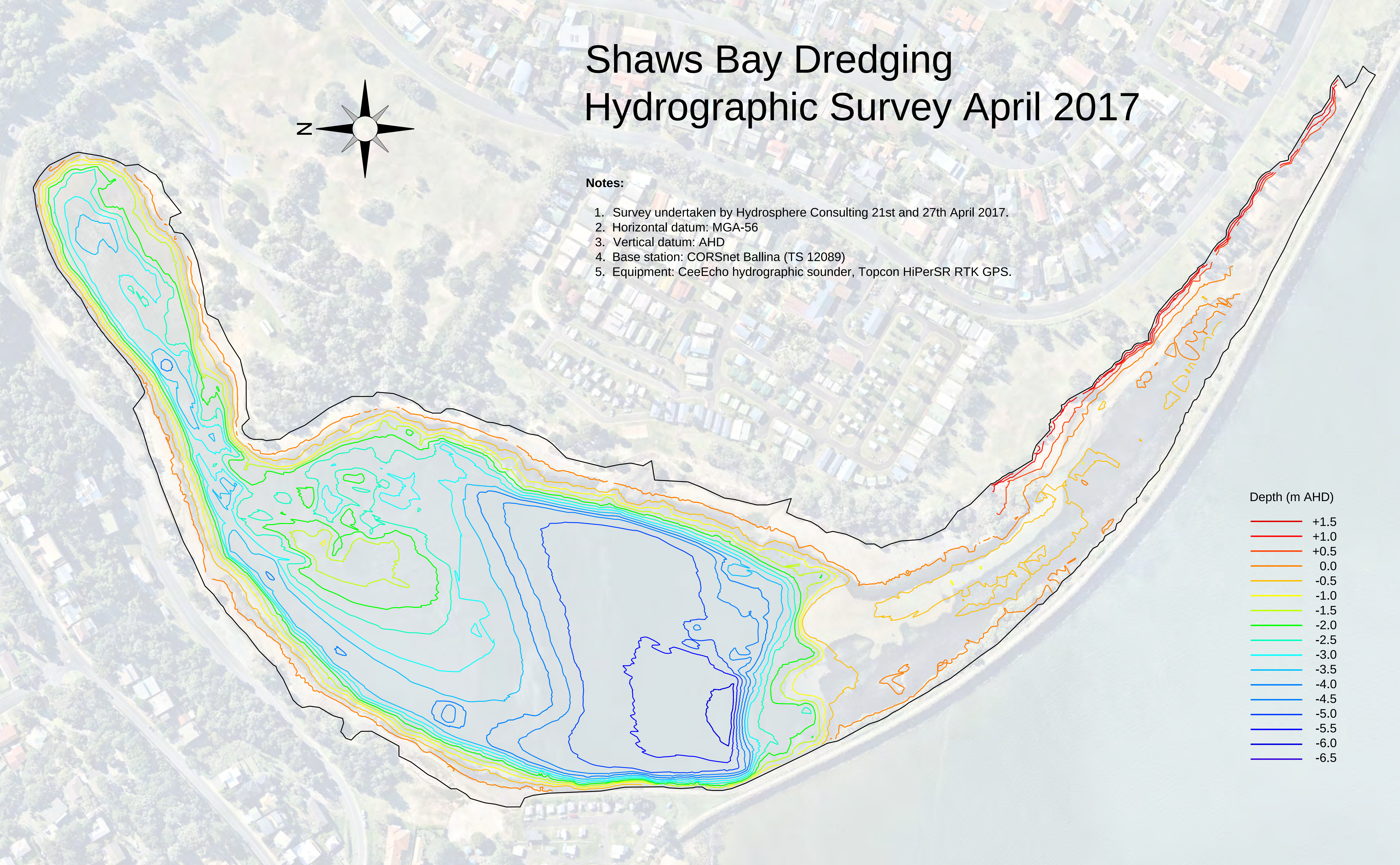
SHEET 1 OF 1

Y:\18-012 Shaws Bay Dredging\Drawings\Shaws Hydrosurvey 2017-04-27 rev2.dwg

Shaws Bay Dredging
Hydrographic Survey April 2017

Notes:

1. Survey undertaken by Hydrosphere Consulting 21st and 27th April 2017.
2. Horizontal datum: MGA-56
3. Vertical datum: AHD
4. Base station: CORSnet Ballina (TS 12089)
5. Equipment: CeeEcho hydrographic sounder, Topcon HiPerSR RTK GPS.



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Contour interval: 0.5m

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SHAWS BAY DREDGING HYDROGRAPHIC SURVEY 2017	

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	2017-11-04	REV 0	MH

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DRAWING 2
SHEET 1 OF 1

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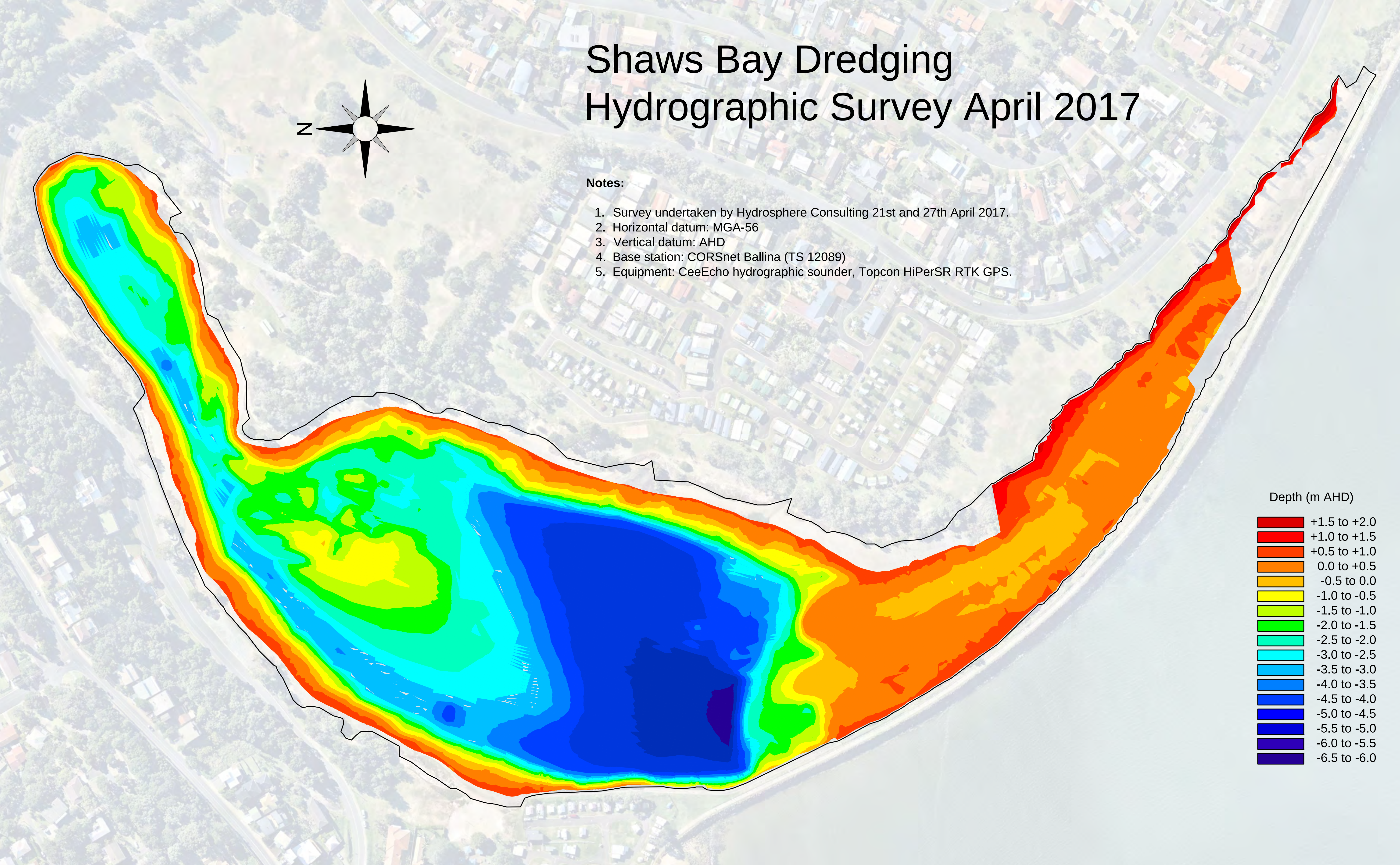
Shaws Bay Dredging
Hydrographic Survey April 2017

Notes:

1. Survey undertaken by Hydrosphere Consulting 21st and 27th April 2017.
2. Horizontal datum: MGA-56
3. Vertical datum: AHD
4. Base station: CORSnet Ballina (TS 12089)
5. Equipment: CeeEcho hydrographic sounder, Topcon HiPerSR RTK GPS.



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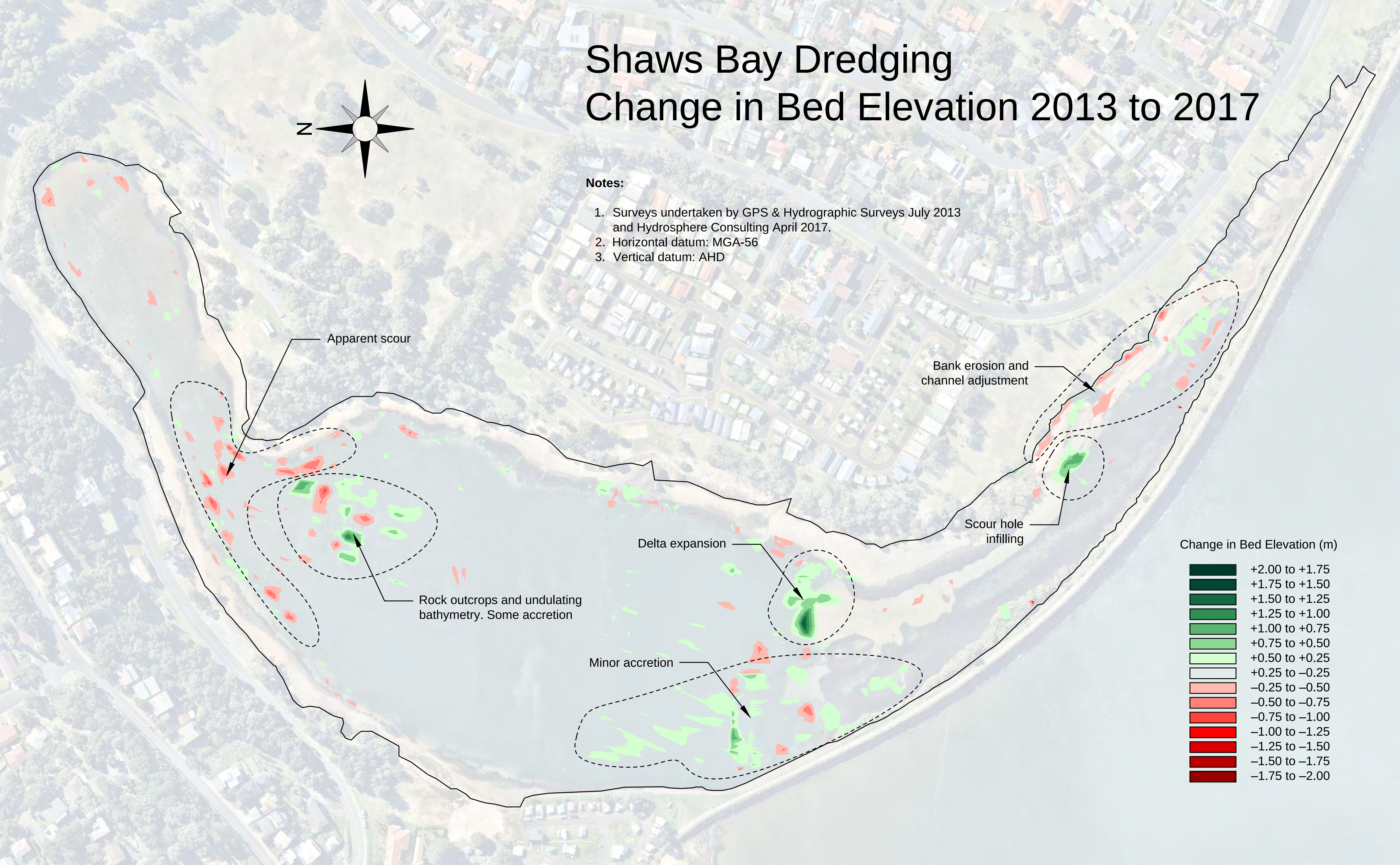
Y:\18-012 Shaws Bay Dredging\Drawings\Shaws Hydrosurvey 2017-04-27 rev2.dwg

Shaws Bay Dredging
Change in Bed Elevation 2013 to 2017

Notes:

1. Surveys undertaken by GPS & Hydrographic Surveys July 2013 and Hydrosphere Consulting April 2017.
2. Horizontal datum: MGA-56
3. Vertical datum: AHD



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SCALES
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SHAWS BAY DREDGING
BED ELEVATION CHANGE 2013-2017

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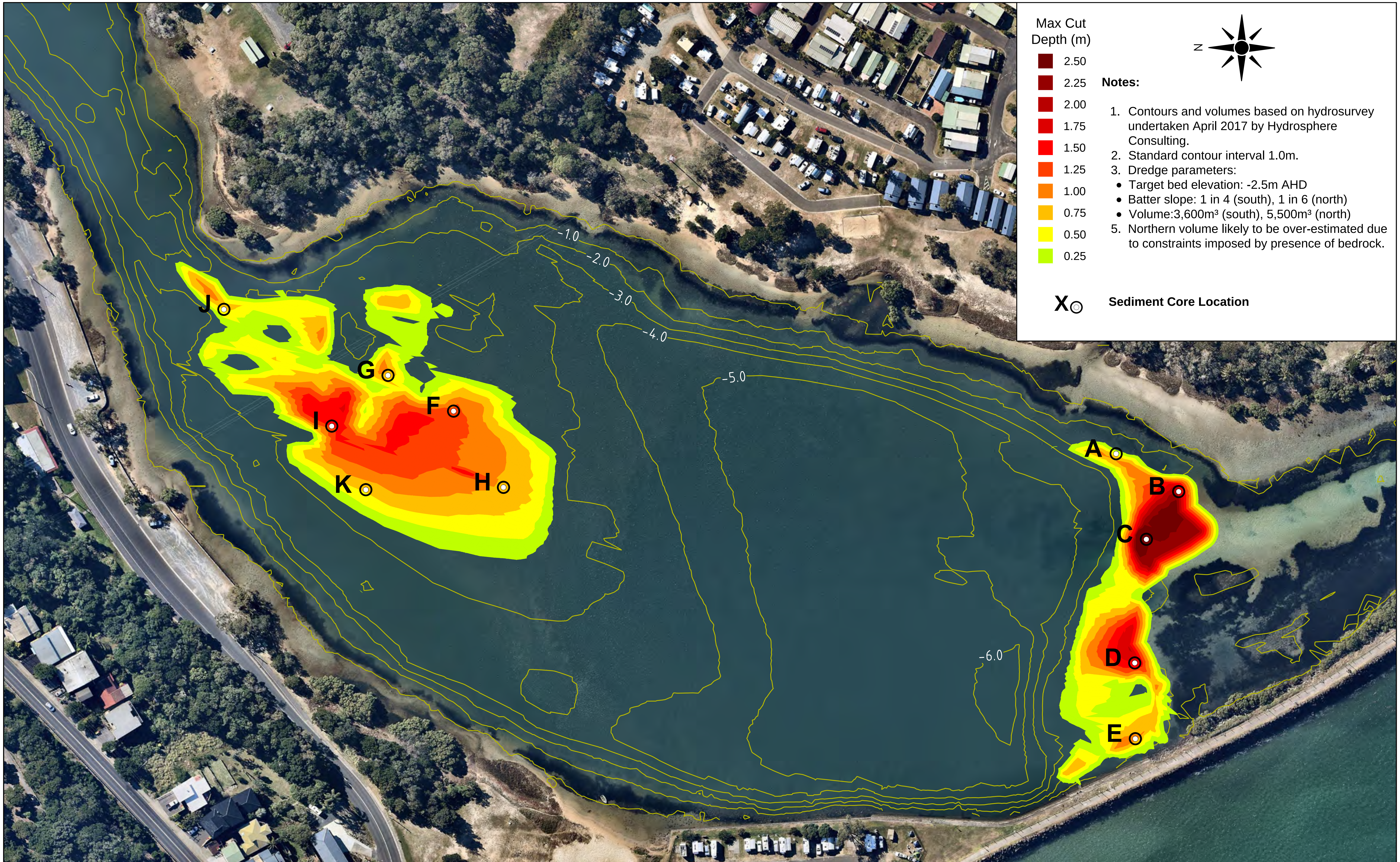

Max Cut Depth (m)

- 2.50
- 2.25
- 2.00
- 1.75
- 1.50
- 1.25
- 1.00
- 0.75
- 0.50
- 0.25

N

Notes:

1. Contours and volumes based on hydrosurvey undertaken April 2017 by Hydrosphere Consulting.
2. Standard contour interval 1.0m.
3. Dredge parameters:
   - Target bed elevation: -2.5m AHD
   - Batter slope: 1 in 4 (south), 1 in 6 (north)
   - Volume:3,600m³ (south), 5,500m³ (north)
5. Northern volume likely to be over-estimated due to constraints imposed by presence of bedrock.

X◎ **Sediment Core Location**

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SHAWS BAY DREDGING TARGET AREAS AND SEDIMENT CORING LOCATIONS

REVISION	DATE	DESCRIPTION	DRAWN
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DRAWING NUMBER

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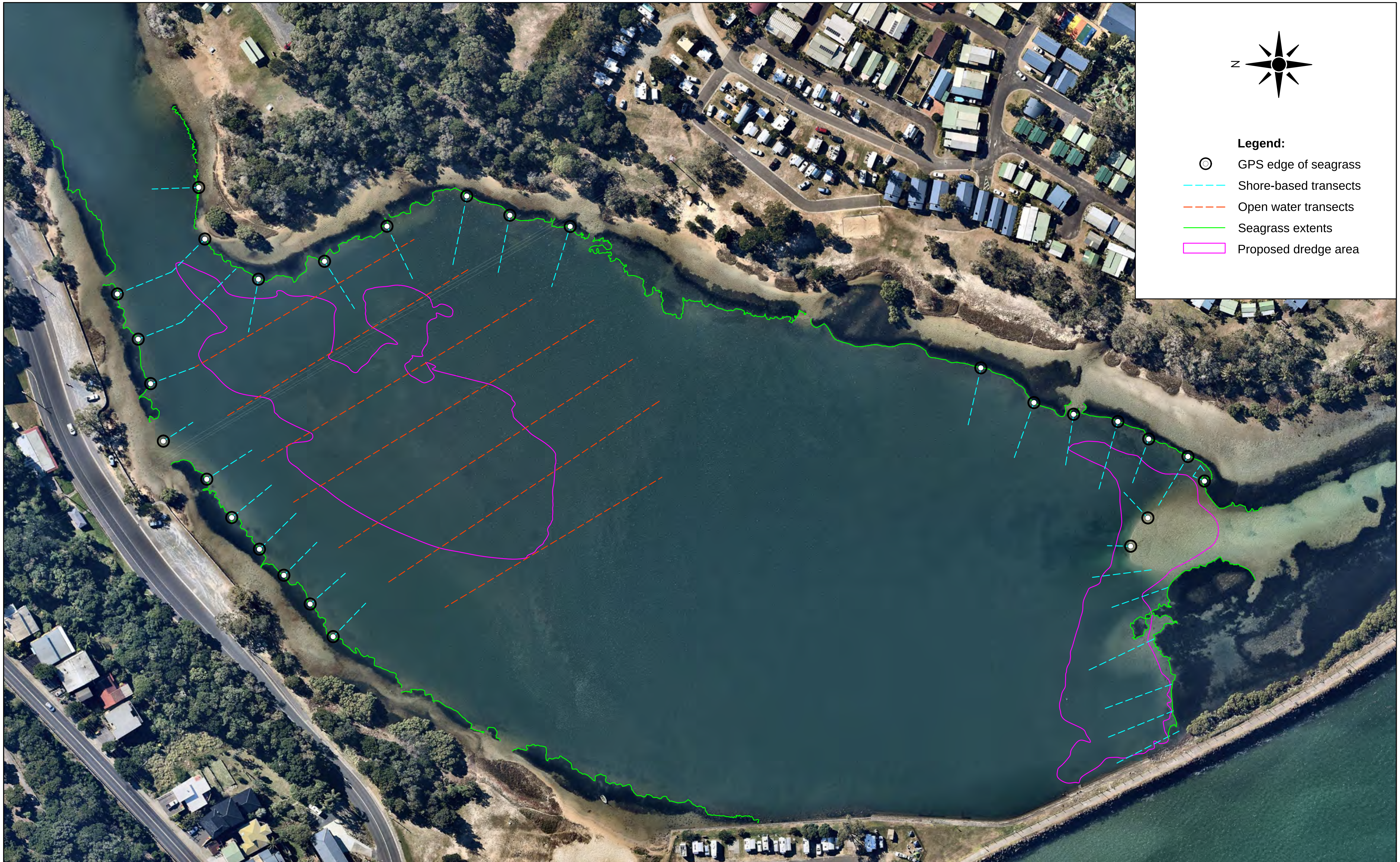
SHEET 1 OF 1

Y:\18-012 Shaws Bay Dredging\Drawings\Shaws Dredging Targets.dwg



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SHAWS BAY DREDGING
SEAGRASS TRANSECTS AND MAPPING

REVISION	DATE	DESCRIPTION	DRAWN
	2017-11-04	REV 0	MH
	2017-11-09	REV 1	MH

DRAWING NUMBER

DRAWING 6

SHEET 1 OF 1

Y:\18-012 Shaws Bay Dredging\Drawings\Shaws Dredging Seagrass.dwg

Appendix 2: Sediment core logs

Borehole Log

Project Number:	18-012	Core identifier:	A
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556863 6806408
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.53
Vertical Datum:	Australian Height Datum	Core length:	2.37
Notes:			

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Photo log	Graphic	Texture	Colour	Comments
A-PSD-1 A-ASS-1	■	■			-1.6	0.0 – 0.1			Silty Sand	Dark Grey	Sludgy consistency. No odour. No shell
A-ENM-1 A-PEST-1			■	■	-1.7 – -2.4	0.1 – 1.0			Sand	Light Grey	Clean marine sand. No odour. No shell
A-ASS-2 A-PSD-2 A-ENM-2 A-PEST-2 A-ASS-3 A-PSD-3	■	■	■	■	-2.5 – -3.8	1.0 – 2.37			Sand	Slightly Mottled Light Grey - Yellow	Clean marine sand. No odour. No shell
					-3.9 – -4.5	2.4 – 3.0	Core terminated in dense sand				

Datum Elevation scale: -1.6, -1.7, -1.8, -1.9, -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2, -3.3, -3.4, -3.5, -3.6, -3.7, -3.8, -3.9, -4.00, -4.1, -4.2, -4.3, -4.4, -4.5

Depth scale: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

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REVISION DATE	DESCRIPTION	DRAWN
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Y:\18-012 Shaws Bay Dredging\Core Logs\Core A.dwg

Borehole Log

Project Number:	18-012	Core identifier:	B
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556847 6806381
Horiztontal Datum:	MGA-56	Bed Elevation:	-0.53
Vertical Datum:	Australian Height Datum	Core length:	1.94
Notes:			

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Texture	Colour	Comments
B-PSD-1 B-ASS-1	■	■			-0.6 to -0.7	0.0 to 0.18	Sand	Yellow	Clean marine sand. No odour. No shell
B-ENM-1 B-PEST-1			■	■	-0.7 to -1.6	0.18 to 1.07	Sand	Medium Grey	Clean marine sand. No odour. No shell
B-ASS-2 B-PSD-2	■	■							
B-ENM-2 B-PEST-2			■	■	-1.6 to -2.4	1.07 to 1.84	Sand	Yellow	Clean marine sand. No odour. No shell
B-ASS-3 B-PSD-3	■	■							

Core terminated in dense sand

Datum Elevation scale: -0.6, -0.7, -0.8, -0.9, -1.00, -1.1, -1.2, -1.3, -1.4, -1.5, -1.6, -1.7, -1.8, -1.9, -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2, -3.3, -3.4, -3.5

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REVISION	DATE	DESCRIPTION	DRAWN
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Y:\18-012 Shaws Bay Dredging\Core Logs\Core B.dwg

Borehole Log

Project Number:	18-012	Core identifier:	C
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556826 6806395
Horiztontal Datum:	MGA-56	Bed Elevation:	-0.21
Vertical Datum:	Australian Height Datum	Core length:	2.19

Notes:

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Texture	Colour	Comments
C-PSD-1 C-ASS-1	■	■			-0.21 to -0.4	0.0 – 0.24	Sand	Yellow	Clean marine sand. No odour. No shell
C-ENM-1 C-PEST-1			■	■	-0.45 to -1.7	0.24 – 1.5	Sand	Medium Grey	Clean marine sand. No odour. No shell
C-ASS-2 C-PSD-2	■	■							
C-ENM-2 C-PEST-2			■	■	-1.7 to -2.4	1.5 – 2.19	Sand	Light Grey	Clean marine sand. No odour. No shell
C-ASS-3 C-PSD-3	■	■							

Photo log:

Core terminated in dense sand

Datum Elevation scale: -0.3, -0.4, -0.5, -0.6, -0.7, -0.8, -0.9, -1.00, -1.1, -1.2, -1.3, -1.4, -1.5, -1.6, -1.7, -1.8, -1.9, -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2

Depth scale: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

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REVISION	DATE	DESCRIPTION	DRAWN
	2017-10-22	REV 0	MH

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Y:\18-012 Shaws Bay Dredging\Core Logs\Core C.dwg

Borehole Log

Project Number:	18-012	Core identifier:	D
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556773 6806400
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.02
Vertical Datum:	Australian Height Datum	Core length:	1.95
Notes:			

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Photo log	Graphic	Texture	Colour	Comments
D-PSD-1 D-ASS-1 D-ENM-1 D-PEST-1	■	■	■	■	-1.1 to -1.8	0.0 to 0.8			Sand	Light Grey	Clean marine sand. No odour. No shell
D-ASS-2 D-PSD-2 D-ENM-2 D-PEST-2	■	■	■	■	-1.9 to -2.5	0.9 to 1.5			Sand	Medium Grey	Clean marine sand. No odour. No shell
					-2.6 to -2.7	1.6 to 1.7			Silty Sand	Dark Grey	Muddy sand. No odour.Shell evident. Scrap of plastic
D-ASS-3 D-PSD-3	■	■			-2.8 to -2.9	1.8 to 1.9			Sand	Medium Grey	Clean marine sand. No odour. No shell
					-3.00 to -4.00	2.0 to 3.0		Core terminated in dense sand			

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Hydrosphere Consulting

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Borehole Log

Project Number:	18-012	Core identifier:	E
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556741 6806399
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.76
Vertical Datum:	Australian Height Datum	Core length:	1.64
Notes:			

Sample	PSD	ASS	ENM	PEST	Photo log	Graphic	Texture	Colour	Comments
E-PSD-1 E-ASS-1 E-ENM-1 E-PEST-1							Sand	Light Grey	Clean marine sand. No odour. No shell
E-ASS-2 E-PSD-2 E-ENM-2 E-PEST-2							Sand	Mottled Light Grey - Yellow	Clean marine sand. No odour. One shell
E-ASS-3 E-PSD-3							Sand	Yellow	Very clean marine sand. No odour. No shell
					Core terminated in dense sand				

Datum Elevation: -1.8, -1.9, -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2, -3.3, -3.4, -3.5, -3.6, -3.7, -3.8, -3.9, -4.00, -4.1, -4.2, -4.3, -4.4, -4.5, -4.6, -4.7

Depth: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

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Y:\18-012 Shaws Bay Dredging\Core Logs\Core E.dwg

Borehole Log

Project Number:	18-012	Core identifier:	F
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556881 6806692
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.65
Vertical Datum:	Australian Height Datum	Core length:	1.48
Notes:			

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Texture	Colour	Comments
F-ASS-1		■	■		-1.65 to -1.8	0.0–0.14	Silty Sand	Dark Grey	Sand with sludgy consistency
F-ENM-1			■		-1.8 to -2.15	0.14–0.5	Sand	Medium Grey	Clean marine sand. No odour. Some fine shell
F-PSD-1 F-PEST-1	■			■	-2.15 to -2.75	0.5–1.1	Sand	Mottled Light Grey - Yellow	Clean marine sand. No odour. No shell
F-ASS-2		■			-2.75 to -3.13	1.1–1.48	Sand	Yellow	Clean marine sand. No odour. No shell

Core terminated at suspected rock

Datum Elevation scale: -1.7, -1.8, -1.9, -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2, -3.3, -3.4, -3.5, -3.6, -3.7, -3.8, -3.9, -4.00, -4.1, -4.2, -4.3, -4.4, -4.5, -4.6

Depth scale: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

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Y:\18-012 Shaws Bay Dredging\Core Logs\Core F.dwg

Borehole Log

Project Number:	18-012	Core identifier:	G
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556896 6806720
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.80
Vertical Datum:	Australian Height Datum	Core length:	2.20
Notes:			

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Graphic	Texture	Colour	Comments
G-PSD-1 G-ASS-1	■	■			-1.8 to -1.9	0.0 – 0.1		Sand	Mottled Lt. G-Y	Clean marine sand. No odour. No shell
					-1.9 to -1.95	0.1 – 0.15		Sand	Dark Grey	Organics, dead vegetative matter
G-ENM-1 G-PEST-1			■	■	-1.95 to -2.55	0.15 – 0.75		Sand	Light Grey	Clean marine sand. No odour. Some fine shell
G-ASS-2 G-PSD-2	■	■			-2.55 to -3.25	0.75 – 1.45		Sand	Mottled Light Grey - Yellow	Clean marine sand. No odour. Some fine shell
G-ENM-2 G-PEST-2 G-ASS-3 G-PSD-3	■	■	■	■	-3.25 to -4.00	1.45 – 2.2		Sand	Yellow	Clean marine sand. No odour. Some fine shell

Core terminated in dense sand

Datum Elevation scale: -1.8, -1.9, -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2, -3.3, -3.4, -3.5, -3.6, -3.7, -3.8, -3.9, -4.00, -4.1, -4.2, -4.3, -4.4, -4.5, -4.6, -4.7, -4.8

Depth scale: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

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Borehole Log

Project Number:	18-012	Core identifier:	H
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556848 6806670
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.88
Vertical Datum:	Australian Height Datum	Core length:	1.94
Notes:			

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Photo log	Graphic	Texture	Colour	Comments
H-PSD-1 H-ASS-1	■	■			-1.9 to -2.1	0.0 to 0.2			Sand	Medium Grey	Clean marine sand. No odour. Some fine shell
	■	■	■	■	-2.1 to -2.5	0.2 to 0.6			Sand	Light Grey	Clean marine sand. No odour. Some fine shell
H-ASS-2 H-PSD-2 H-ENM-1 H-PEST-1	■	■	■	■	-2.5 to -3.8	0.6 to 1.94			Sand	Yellow	Clean marine sand. No odour. Some fine shell
					-3.8 to -4.8	2.0 to 3.0	Core terminated at suspected rock				

Datum Elevation scale: -1.9, -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2, -3.3, -3.4, -3.5, -3.6, -3.7, -3.8, -3.9, -4.00, -4.1, -4.2, -4.3, -4.4, -4.5, -4.6, -4.7, -4.8

Depth scale: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

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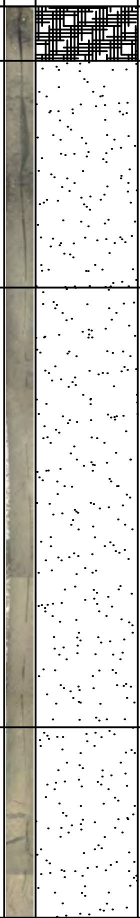
Borehole Log

Project Number:	18-012	Core identifier:	I
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556875 6806744
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.28
Vertical Datum:	Australian Height Datum	Core length:	2.01

Notes:

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Photo log	Graphic	Texture	Colour	Comments
I-PEST-1				▮	-1.3 – -1.4	0.0 – 0.1			Silty Sand	Dark Grey	Dead organic material
I-ASS-1	▮	▮	▮		-1.4 – -1.9	0.1 – 0.6			Sand	Light Grey	Clean marine sand. No odour. Some shell fragmer
I-ASS-2 I-PSD-1 I-ENM-1 I-PEST-2	▮	▮	▮	▮	-1.9 – -2.9	0.6 – 1.6			Sand	Yellow	Clean marine sand. No odour. No shell
I-PSD-2	▮	▮	▮	▮	-2.9 – -3.3	1.6 – 2.0			Sand	Yellow	Very clean marine sand. No odour. No shell



Core terminated in dense sand

Datum Elevation: -1.3, -1.4, -1.5, -1.6, -1.7, -1.8, -1.9, -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2, -3.3, -3.4, -3.5, -3.6, -3.7, -3.8, -3.9, -4.00, -4.1, -4.2

Depth: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

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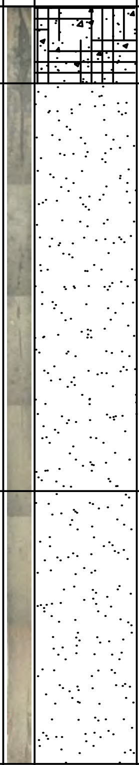
Borehole Log

Project Number:	18-012	Core identifier:	J
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556925 6806790
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.88
Vertical Datum:	Australian Height Datum	Core length:	1.67

Notes:

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Texture	Colour	Comments
J-PSD-1 J-ASS-1	■	■			-1.9 to -2.0	0.0 – 0.17	Sand	Medium Grey	Some organic material. Large shell fragments
J-PSD-2 J-ASS-2 J-ENM-1 J-PEST-1	■	■	■	■	-2.0 to -2.9	0.17 – 1.07	Sand	Light Grey	Clean marine sand. No odour. Some large and small shell
J-PSD-3 J-ASS-3	■	■	■	■	-3.0 to -3.5	1.07 – 1.67	Sand	Yellow	Clean marine sand. No odour. Some small shell



Core terminated in dense sand

Datum Elevation scale: -1.9 to -4.8; Depth scale: 0.0 to 3.0

Photo log | Graphic

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Borehole Log

Project Number:	18-012	Core identifier:	K
Client:	Ballina Shire Council	Date:	18/10/17
Project Name	Shaws Bay Dredging Investigation	Method:	Vibrocore 60mm
Location:	Shaws Bay Ballina, NSW	Position:	556847 6806729
Horiztontal Datum:	MGA-56	Bed Elevation:	-1.99
Vertical Datum:	Australian Height Datum	Core length:	1.80
Notes:			

Sample	PSD	ASS	ENM	PEST	Datum Elevation	Depth	Texture	Colour	Comments
K-PSD-1 K-ASS-1	■	■	■	■	-2.00 to -2.2	0.0 to 0.2	Silty Sand	Dark Grey	Sludgy consistency. Large shells
K-ASS-2 K-PSD-2 K-ENM-1 K-PEST-1	■	■	■	■	-2.2 to -3.55	0.2 to 1.55	Sand	Light Grey	Clean marine sand. No odour. Some small shell
	■	■	■	■	-3.55 to -3.8	1.55 to 1.8	Sand	Yellow	Clean marine sand. No odour. Some small shell

Photo log:

Core terminated in dense sand

Datum Elevation scale: -2.00, -2.1, -2.2, -2.3, -2.4, -2.5, -2.6, -2.7, -2.8, -2.9, -3.00, -3.1, -3.2, -3.3, -3.4, -3.5, -3.6, -3.7, -3.8, -3.9, -4.00, -4.1, -4.2, -4.3, -4.4, -4.5, -4.6, -4.7, -4.8, -4.9, -5.00

Depth scale: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0

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Y:\18-012 Shaws Bay Dredging\Core Logs\Core K.dwg

Appendix 3: Laboratory analysis results

RESULTS OF ACID SULFATE SOIL ANALYSIS

29 samples supplied by HydroSphere Consulting Pty Ltd on 20/10/2017. Lab Job No.G4204

Analysis requested by Rod Conroy .Your Job: Shaws Bay Sediment

PO Box 7059 BALLINA NSW 2478

Sample Identification	EAL Lab Code	Texture	Moisture Content		Potential Sulfidic Acidity (Chromium Reducible Sulfur - CRS)		Actual Acidity (Titratable Actual Acidity - TAA)		Retained Acidity ($\% S_{HCl} - \% S_{KCl}$)		Acid Neutralising Capacity (ANC_{BT})		Net Acidity (based on S_{CR})	Lime Calculation
			(% moisture of total wet weight)	(g moisture / g of oven dry soil)	(% S_{cr})	(mol H^+/t)	pH_{KCl}	(mol H^+/t)	(% S_{NAS})	(mol H^+/t)	(% $CaCO_3$)	(mol H^+/t)	(mol H^+/t)	(kg $CaCO_3$/t DW)
Method Info.		**	**		(In-house method S20)		(In-house method 16b)		**		(In-house method S14)		**	**
A- ASS- 1	G4204/1	Medium	31.3	0.46	0.219	136	8.92	0	..	..	1.56	312	-71	-4
A- ASS- 2	G4204/2	Coarse	17.2	0.21	<0.005	0	9.47	0	..	..	0.24	47	-32	-2
A- ASS- 3	G4204/3	Coarse	16.7	0.20	0.015	9	9.44	0	..	..	0.72	144	-86	-4
B- ASS- 1	G4204/4	Coarse	18.6	0.23	0.008	5	9.42	0	..	..	0.34	67	-40	-2
B- ASS- 2	G4204/5	Coarse	17.7	0.22	0.047	29	9.33	0	..	..	0.29	58	-10	0
B- ASS- 3	G4204/6	Coarse	18.0	0.22	0.008	5	9.48	0	..	..	0.26	53	-30	-1
C- ASS- 1	G4204/7	Coarse	18.0	0.22	0.006	4	9.53	0	..	..	0.72	144	-92	-5
C- ASS- 2	G4204/8	Coarse	17.3	0.21	0.027	17	9.57	0	..	..	0.62	123	-65	-3
C- ASS- 3	G4204/9	Coarse	18.5	0.23	0.154	96	9.18	0	..	..	0.81	163	-13	-1
D- ASS- 1	G4204/10	Coarse	18.5	0.23	0.020	12	9.57	0	..	..	0.83	165	-98	-5
D- ASS- 2	G4204/11	Coarse	17.8	0.22	0.045	28	9.48	0	..	..	0.69	138	-64	-3
D- ASS- 3	G4204/12	Coarse	19.4	0.24	0.248	155	9.17	0	..	..	1.69	337	-70	-4
E- ASS- 1	G4204/13	Coarse	19.1	0.24	0.012	8	9.46	0	..	..	0.22	44	-22	-1
E- ASS- 2	G4204/14	Coarse	17.1	0.21	0.011	7	9.42	0	..	..	0.29	58	-32	-2
E- ASS- 3	G4204/15	Coarse	18.5	0.23	<0.005	0	9.23	0	..	..	0.50	99	-66	-3
F- ASS- 1	G4204/16	Coarse	23.0	0.30	0.114	71	9.23	0	..	..	1.66	331	-150	-7
F- ASS- 2	G4204/17	Coarse	17.6	0.21	<0.005	0	9.65	0	..	..	1.72	344	-229	-11
G- ASS- 1	G4204/18	Coarse	19.2	0.24	0.050	31	9.48	0	..	..	1.92	383	-225	-11
G- ASS- 2	G4204/19	Coarse	17.6	0.21	<0.005	0	9.65	0	..	..	1.38	276	-184	-9
G- ASS- 3	G4204/20	Coarse	18.0	0.22	<0.005	0	9.69	0	..	..	3.17	634	-423	-21
H- ASS- 1	G4204/21	Coarse	19.5	0.24	0.140	87	9.39	0	..	..	2.02	404	-182	-9
H- ASS- 2	G4204/22	Coarse	17.5	0.21	0.006	4	9.67	0	..	..	2.04	408	-268	-13
I- ASS- 1	G4204/23	Coarse	18.8	0.23	0.069	43	9.49	0	..	..	1.00	199	-90	-4
I- ASS- 2	G4204/24	Coarse	17.7	0.22	<0.005	0	9.57	0	..	..	1.27	253	-169	-8
J- ASS- 1	G4204/25	Coarse	20.0	0.25	0.042	26	9.48	0	..	..	1.53	306	-178	-9
J- ASS- 2	G4204/26	Coarse	18.8	0.23	0.045	28	9.52	0	..	..	1.55	309	-178	-9
J- ASS- 3	G4204/27	Coarse	17.9	0.22	<0.005	0	9.74	0	..	..	2.92	583	-388	-19
K- ASS- 1	G4204/28	Coarse	25.8	0.35	0.207	129	9.24	0	..	..	2.17	433	-160	-8
K- ASS- 2	G4204/29	Coarse	17.7	0.21	0.012	7	9.65	0	..	..	1.81	362	-234	-12

NOTES:

1. All analysis is reported on a dry weight (DW) basis, unless wet weight (WW) is specified.
2. Samples are dried and ground immediately upon arrival (unless supplied dried and ground).
3. Analytical procedures are sourced from Ahern CR, McElnea AE and Sullivan LA (2004). *Acid sulfate soil laboratory method guidelines* . Queensland Department of Natural Resources, Mines and Energy: Indooroopilly, Qld, Australia.
4. The Acid Base Accounting Equation is **Net Acidity = Actual Acidity + Retained Acidity + Potential Sulfidic Acidity (S_{cr} or S_{ox}) — Acid Neutralising Capacity/Fineness Factor** (Ahern et al. 2004 - full reference above).
5. Retained Acidity is required when the pH_{KCl} < 4.5 or where jarosite has been visually observed. Acid Neutralising Capacity is required when the Potential Sulfidic Acidity is greater than the texture dependent trigger and the pH_{KCl} is ≥ 6.5.
6. **An acid sulfate soil management plan is triggered by Net Acidity results greater than the texture dependent criterion: coarse texture ≥ 0.03% S or 19 mol H^+/t; medium texture ≥ 0.06% S or 37 mol H^+/t; fine texture ≥ 0.1% S or 62 mol H^+/t)** (Ahern *et al.* 2004 - full reference above)
7. For projects that disturb > 1000 tonnes of soil, the coarse trigger of ≥ 0.03% S must be applied in accordance with Ahern CR, Stone Y and Blunden B (1998). *Acid sulfate soils assessment guidelines* . Acid Sulfate Soil Management Advisory Committee: Wollongbar, NSW, Australia.
8. Acid sulfate soil texture triggers can be related to standard soil textures: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays (Ahern et al. 1998 - full reference above).
9. Bulk density is required to convert liming rates to soil volume based results. Field bulk density rings can be submitted to EAL for bulk density determination.
10. **The lime calculation includes a Fineness Factor of 1.5 as a safety margin for acid neutralisation (Ahern et al. 2004). This is only applied to positive values. An increased safety factor may be required in some cases.**
11. A negative Net Acidity result indicates an excess acid neutralising capacity.
12. .. is reported where a test is either not requested or not required. Where pH_{KCl} is < 4.5 or > 6.5, zero is reported for S_{NAS} and ANC in Net Acidity calculations, respectively.
13. Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.
14. ** NATA accreditation does not cover the performance of this service.

Accreditation No. 14960 Accredited for compliance with ISO/IEC 17025

checked: ....
Graham Lancaster
Laboratory Manager

GRAIN SIZE ANALYSIS (sieving technique) (Page 1 of 1)

28 soil samples supplied by HydroSphere Consulting Pty Ltd on 20th October, 2017. Lab Job No. G4205
Analysis requested by Rod Conroy. **Your Reference: Shaws**
PO Box 7059 BALLINA NSW 2478

SAMPLE ID	Lab Code	>2mm Gravel/ Organic Matter	1 - 2mm Very Coarse Sand	500μm - 1mm Coarse Sand	250 - 500μm Medium Sand	125 - 250μm Fine Sand	63 - 125μm Very Fine Sand	<63μm Mud (Silt/Clay)
A- PSD- 1	G4205/1	0.23%	1.02%	4.12%	70.9%	23.4%	0.25%	0.08%
A- PSD- 2	G4205/2	0.03%	0.58%	2.95%	72.7%	23.6%	0.09%	0.04%
A- PSD- 3	G4205/3	0.00%	1.55%	5.94%	79.4%	12.8%	0.23%	0.07%
B- PSD- 1	G4205/4	0.00%	0.37%	3.19%	70.6%	25.8%	0.10%	0.01%
B- PSD- 2	G4205/5	0.00%	0.36%	4.07%	72.2%	23.1%	0.25%	0.01%
B- PSD- 3	G4205/6	0.00%	0.53%	3.67%	81.7%	14.1%	0.02%	0.00%
C- PSD- 1	G4205/7	0.04%	1.35%	5.83%	72.0%	20.7%	0.01%	0.00%
C- PSD- 2	G4205/8	0.03%	0.89%	5.00%	75.5%	18.5%	0.03%	0.00%
C- PSD- 3	G4205/9	0.36%	0.61%	4.50%	62.0%	31.9%	0.48%	0.11%
D- PSD- 1	G4205/10	0.08%	0.40%	5.05%	79.8%	14.6%	0.05%	0.00%
D- PSD- 2	G4205/11	0.02%	0.76%	4.33%	74.7%	20.1%	0.06%	0.00%
D- PSD- 3	G4205/12	0.09%	2.88%	5.62%	63.5%	26.5%	0.91%	0.48%
E- PSD- 1	G4205/13	0.03%	0.30%	2.75%	84.1%	12.7%	0.11%	0.05%
E- PSD- 2	G4205/14	0.00%	0.34%	3.18%	82.2%	14.1%	0.13%	0.10%
E- PSD- 3	G4205/15	0.00%	1.54%	2.60%	84.7%	11.1%	0.07%	0.00%
F- PSD- 1	G4205/16	0.09%	0.92%	5.61%	81.1%	11.9%	0.26%	0.17%
G- PSD- 1	G4205/17	0.12%	1.69%	5.61%	80.8%	11.6%	0.15%	0.09%
G- PSD- 2	G4205/18	0.19%	1.47%	6.52%	80.6%	11.2%	0.04%	0.01%
G- PSD- 3	G4205/19	1.83%	1.90%	4.51%	78.5%	12.7%	0.28%	0.20%
H- PSD- 1	G4205/20	1.99%	2.64%	10.03%	72.2%	12.2%	0.59%	0.42%
H- PSD- 2	G4205/21	0.21%	1.30%	7.48%	80.5%	10.2%	0.30%	0.01%
I- PSD- 1	G4205/22	0.51%	1.59%	3.93%	83.5%	10.0%	0.37%	0.08%
I- PSD- 2	G4205/23	0.00%	0.92%	4.71%	84.9%	9.5%	0.05%	0.00%
J- PSD- 1	G4205/24	2.95%	1.93%	5.58%	71.8%	17.5%	0.18%	0.04%
J- PSD- 2	G4205/25	2.59%	1.76%	6.85%	67.7%	20.6%	0.27%	0.20%
J- PSD- 3	G4205/26	2.14%	1.61%	8.27%	75.2%	12.7%	0.07%	0.03%
K- PSD- 1	G4205/27	7.09%	2.12%	11.59%	67.9%	9.7%	0.95%	0.60%
K- PSD- 2	G4205/28	0.31%	1.86%	6.35%	79.4%	11.4%	0.51%	0.21%

Note:
1: The Dry and Wet Sieving Analysis method was used for this grain size determination (Method of: Lewis and McConchie, 1994. Analytical Sedimentology. Chapman and Hall, USA.)

checked: ....
Graham Lancaster
Laboratory Manager

RESULTS OF SOIL ANALYSIS

18 soil samples supplied by HydroSphere Consulting Pty Ltd on 20th October, 2017 - Lab Job No. G4206
Analysis requested by Rod Conroy. Your Job: Shaws Bay
PO Box 7059 BALLINA NSW 2478

ANALYTE	METHOD REFERENCE	Sample 1 A- PEST-1	Sample 2 A- PEST-2	Sample 3 B- PEST-1	Sample 4 B- PEST-2	Sample 5 C- PEST-1	Sample 6 C- PEST-2	Sample 7 D- PEST-1	Sample 8 D- PEST-2	Sample 9 E- PEST-1	Sample 10 E- PEST-2	Sample 11 F- PEST-1	Sample 12 G- PEST-1	Sample 13 G- PEST-2	Sample 14 H- PEST-1	Sample 15 I- PEST-1	Sample 16 I- PEST-2	Sample 17 J- PEST-1	Sample 18 K- PEST-1
	Job No.	*G4206/1*	*G4206/2*	*G4206/3*	*G4206/4*	*G4206/5*	*G4206/6*	*G4206/7*	*G4206/8*	*G4206/9*	*G4206/10*	*G4206/11*	*G4206/12*	*G4206/13*	*G4206/14*	*G4206/15*	*G4206/16*	*G4206/17*	*G4206/18*
MOISTURE %	** c	18	17	18	18	17	18	17	19	18	18	17	19	18	18	20	17	17	17
PESTICIDE ANALYSIS SCREEN																			
DDT+DDE+DDD (mg/Kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin + Dieldrin (mg/kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlordane (mg/kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan (mg/kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin (mg/kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor (mg/kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
HCB (mg/kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor (mg/kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other Organochlorine Pesticides (mg/Kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyrifos (mg/kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other Organophosphate Pesticides (mg/Kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PCB's (mg/Kg)	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

METHODS REFERENCE

a. [1:3]Nitric/HCl digest - APHA 3125 ICPMS
b. [1:3]Nitric/HCl digest - APHA 3120 ICPOES
c. Analysis sub-contracted - Envirolab report no. 178348
*** denotes these test procedure or calculation are as yet not NATA accredited but quality control data is available*

Accreditation No. 14960.
Accredited for compliance with ISO/IEC 17025.

NOTES

DW = Dry Weight. na = no guidelines available

Organochlorine pesticide (OC's) screen: (HCB, alpha-BHC, gamma-BHC, Heptachlor, delta-BHC, Aldrin, Heptachlor Epoxide, gamma-Chlordane, alpha-chlordane, Endosulfan 1, pp-DDE, Dieldrin, Endrin, pp-DDD, Endosulfan 2, pp-DDT, Endrin Aldehyde, Endosulfan Sulphate, Methoxychlor)

Organophosphorus pesticide (OP's) screen: (Azinphos-methyl (Guthion), Bromophos-ethyl, Chlorpyriphos, Chlorpyriphos-methyl, Diazinon, Dichlorvos, Dimethoate, Ethion, Fenitrothion, Malathion, Parathion, Ronnel)

PCB's = Polychloriniated Biphenyls (Arochlor 1016, 1232, 1242, 1248, 1254, 1260)

checked:...............

RESULTS OF ENM SOIL ANALYSIS

17 samples supplied by HydroSphere Consulting Pty Ltd on the 20th October, 2017. Job Number: G4207
Analysis requested by Rod Conroy. **Your Project: Shaws Bay**
PO box 7059 BALLINA NSW 2478

	ENM Number	Method	*EAL Detection Limits*	Sample 1 A- ENM- 1	Sample 2 A- ENM- 2	Sample 3 B- ENM- 1	Sample 4 B- ENM- 2	Sample 5 C- ENM- 1
		Job No.		*G4207/1*	*G4207/2*	*G4207/3*	*G4207/4*	*G4207/5*
Moisture Content (% moisture)	..	Inhouse - 110˚C	*<0.1*	16	17	18	18	19
METALS								
Arsenic (mg/Kg)	4	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<1*	2	2	2	2	2
Lead (mg/Kg)	3	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<0.5*	1	<1	2	1	<1
Cadmium (mg/Kg)	2	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium (mg/Kg)	5	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<1*	1	1	3	2	1
Copper (mg/Kg)	6	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<1*	<1	<1	1	1	<1
Nickel (mg/Kg)	7	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<1*	1	1	2	1	1
Zinc (mg/Kg)	8	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<1*	2	2	8	4	2
Mercury (mg/Kg)	1	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<0.05*	<0.05	<0.05	<0.05	<0.05	<0.05
Soil Conductivity (1:5 water dS/m)	9	Rayment and Higginson 4B1	*<0.01*	2.23	2.45	3.37	2.90	2.76
Soil pH (1:5 water)	10	Rayment and Higginson 4A1	*..*	8.83	8.93	8.56	8.73	8.90
Polycyclic Aromatic Hydrocarbons (PAH)								
Naphthalene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Benz(a)anthracene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene (mg/Kg)	..	*c*	*<0.05*	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(b)&(k)flouranthene (mg/Kg)	..	*c*	*<0.2*	<0.2	<0.2	<0.2	<0.2	<0.2
Indeno(1,2,3-c,d)pyrene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenz(a,h)anthracene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,I)perylene (mg/Kg)	..	*c*	*<0.1*	<0.1	<0.1	<0.1	<0.1	<0.1
Sum of reported PAHs (mg/Kg)	11	*c*	*..*	..	..	..	..	..
Benzo(a)pyrene TEQ calc (PQL) (mg/Kg)	12	*c*	*<0.5*	<0.5	<0.5	<0.5	<0.5	<0.5
HYDROCARBON ANALYSIS RESULTS								
BTEX								
Benzene (mg/Kg)	13	*c*	*<0.2*	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene (mg/Kg)	14	*c*	*<0.5*	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene (mg/Kg)	15	*c*	*<1*	<1	<1	<1	<1	<1
m+p-Xylene (mg/Kg)	16	*c*	*<2*	<2	<2	<2	<2	<2
o-Xylene (mg/Kg))		*c*	*<1*	<1	<1	<1	<1	<1
Naphthalene (mg/Kg)	..	*c*	*<1*	<1	<1	<1	<1	<1
Total Recoverable Hydrocarbons								
C10-C14 Fraction (mg/Kg)	..	*c*	*<50*	<50	<50	<50	<50	<50
C15-C28 Fraction (mg/Kg)	..	*c*	*<100*	<100	<100	<100	<100	<100
C29-C36 Fraction (mg/Kg)	..	*c*	*<100*	<100	<100	<100	<100	<100
C10-C16 Fraction (mg/Kg)	..	*c*	*<50*	<50	<50	<50	<50	<50
C10-C16 less Naphthalene Fraction (mg/Kg)	..	*c*	*<50*	<50	<50	<50	<50	<50
C16-C34 Fraction (mg/Kg)	..	*c*	*<100*	<100	<100	<100	<100	<100
C34-C40 Fraction (mg/Kg)	..	*c*	*<100*	<100	<100	<100	<100	<100
Contaminants (Physical - rubber, plastic, bitumen, paper, cloth, paint wood) (%)	18	*** As per RTA T276*	*<0.01*	<0.01	<0.01	<0.01	<0.01	<0.01

METHODS REFERENCE

a. $^{1:3}$Nitric/HCl digest - APHA 3125 ICPMS
b. $^{1:3}$Nitric/HCl digest - APHA 3120 ICPOES
c. Analysis sub-contracted - Envirolab Report No. 178513

NATA
Accreditation No. 14960.
Accredited for compliance with ISO/IEC 17025.

NOTES

1. *DW = Dry Weight. na = no guidelines available*
2. *NSW EPA ENM Guidelines - Protection of the Environment Operations (Waste) Regulation 2014*
   (The Excavation Natural Material Order 2014 - Resource Recovery Order under Part 9, Clause 93)
3. *For statistical purposes, half detection limit replaced with samples NOT DETECTED*
4. ** denotes these test procedures are as yet not NATA accredited but quality control data is available

checked: ....
Graham Lancaster (Nata signatory)
Laboratory Manager

RESULTS OF ENM SOIL ANALYSIS

17 samples supplied by HydroSphere Consulting Pty Ltd on the 20th October, 2017. Job Number: G4207
Analysis requested by Rod Conroy. **Your Project: Shaws Bay**
PO box 7059 BALLINA NSW 2478

	ENM Number	Method	Sample 6 C- ENM- 2	Sample 7 D- ENM- 1	Sample 8 D- ENM- 2	Sample 9 E- ENM- 1	Sample 10 E- ENM- 2	Sample 11 F- ENM- 1
		Job No.	*G4207/6*	*G4207/7*	*G4207/8*	*G4207/9*	*G4207/10*	*G4207/11*
Moisture Content (% moisture)	..	Inhouse - 110˚C	18	17	17	17	17	20
METALS								
Arsenic (mg/Kg)	4	1:3Nitric/HCl digest - APHA 3125 ICPMS	2	2	2	1	2	2
Lead (mg/Kg)	3	1:3Nitric/HCl digest - APHA 3125 ICPMS	1	1	2	1	1	1
Cadmium (mg/Kg)	2	1:3Nitric/HCl digest - APHA 3125 ICPMS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium (mg/Kg)	5	1:3Nitric/HCl digest - APHA 3125 ICPMS	1	1	3	1	1	2
Copper (mg/Kg)	6	1:3Nitric/HCl digest - APHA 3125 ICPMS	<1	<1	1	<1	<1	1
Nickel (mg/Kg)	7	1:3Nitric/HCl digest - APHA 3125 ICPMS	1	1	2	1	1	1
Zinc (mg/Kg)	8	1:3Nitric/HCl digest - APHA 3125 ICPMS	3	2	8	2	3	5
Mercury (mg/Kg)	1	1:3Nitric/HCl digest - APHA 3125 ICPMS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Soil Conductivity (1:5 water dS/m)	9	Rayment and Higginson 4B1	2.59	1.84	3.09	2.77	2.71	3.19
Soil pH (1:5 water)	10	Rayment and Higginson 4A1	8.86	8.96	8.73	8.87	8.87	8.60
Polycyclic Aromatic Hydrocarbons (PAH)								
Naphthalene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benz(a)anthracene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene (mg/Kg)	..	*c*	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(b)&(k)flouranthene (mg/Kg)	..	*c*	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Indeno(1,2,3-c,d)pyrene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenz(a,h)anthracene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,I)perylene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sum of reported PAHs (mg/Kg)	11	*c*	..	..	..	..	..	..
Benzo(a)pyrene TEQ calc (PQL) (mg/Kg)	12	*c*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
HYDROCARBON ANALYSIS RESULTS BTEX								
Benzene (mg/Kg)	13	*c*	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene (mg/Kg)	14	*c*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene (mg/Kg)	15	*c*	<1	<1	<1	<1	<1	<1
m+p-Xylene (mg/Kg)	16	*c*	<2	<2	<2	<2	<2	<2
o-Xylene (mg/Kg))		*c*	<1	<1	<1	<1	<1	<1
Naphthalene (mg/Kg)	..	*c*	<1	<1	<1	<1	<1	<1
Total Recoverable Hydrocarbons								
C10-C14 Fraction (mg/Kg)	..	*c*	<50	<50	<50	<50	<50	<50
C15-C28 Fraction (mg/Kg)	..	*c*	<100	<100	<100	<100	<100	<100
C29-C36 Fraction (mg/Kg)	..	*c*	<100	<100	<100	<100	<100	<100
C10-C16 Fraction (mg/Kg)	..	*c*	<50	<50	<50	<50	<50	<50
C10-C16 less Naphthalene Fraction (mg/Kg)	..	*c*	<50	<50	<50	<50	<50	<50
C16-C34 Fraction (mg/Kg)	..	*c*	<100	<100	<100	<100	<100	<100
C34-C40 Fraction (mg/Kg)	..	*c*	<100	<100	<100	<100	<100	<100
Contaminants (Physical - rubber, plastic, bitumen, paper, cloth, paint wood) (%)	18	*** As per RTA T276*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

METHODS REFERENCE

a. 1:3Nitric/HCl digest - APHA 3125 ICPMS
b. 1:3Nitric/HCl digest - APHA 3120 ICPOES
c. Analysis sub-contracted - Envirolab Report No. 178513

Accreditation No. 14960.
Accredited for compliance with ISO/IEC 17025.

NOTES

1. *DW = Dry Weight. na = no guidelines available*
2. *NSW EPA ENM Guidelines - Protection of the Environment Operations (Waste) Regulation 2014*
   (The Excavation Natural Material Order 2014 - Resource Recovery Order under Part 9, Clause 93)
3. *For statistical purposes, half detection limit replaced with samples NOT DETECTED*
4. ** denotes these test procedures are as yet not NATA accredited but quality control data is available

checked: ....
Graham Lancaster (Nata signatory)
Laboratory Manager

RESULTS OF ENM SOIL ANALYSIS

17 samples supplied by HydroSphere Consulting Pty Ltd on the 20th October, 2017. Job Number: G4207
Analysis requested by Rod Conroy. **Your Project: Shaws Bay**
PO box 7059 BALLINA NSW 2478

	ENM Number	Method	Sample 12 G- ENM- 1	Sample 13 G- ENM- 2	Sample 14 H- ENM- 1	Sample 15 I- ENM- 1	Sample 16 J- ENM- 1	Sample 17 K- ENM- 1
		Job No.	*G4207/12*	*G4207/13*	*G4207/14*	*G4207/15*	*G4207/16*	*G4207/17*
Moisture Content (% moisture)	..	Inhouse - 110˚C	17	17	17	18	17	16
METALS								
Arsenic (mg/Kg)	4	1:3Nitric/HCl digest - APHA 3125 ICPMS	2	2	2	3	2	2
Lead (mg/Kg)	3	1:3Nitric/HCl digest - APHA 3125 ICPMS	1	1	1	1	1	1
Cadmium (mg/Kg)	2	1:3Nitric/HCl digest - APHA 3125 ICPMS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium (mg/Kg)	5	1:3Nitric/HCl digest - APHA 3125 ICPMS	1	2	1	2	2	2
Copper (mg/Kg)	6	1:3Nitric/HCl digest - APHA 3125 ICPMS	<1	1	1	1	1	1
Nickel (mg/Kg)	7	1:3Nitric/HCl digest - APHA 3125 ICPMS	1	1	1	1	1	2
Zinc (mg/Kg)	8	1:3Nitric/HCl digest - APHA 3125 ICPMS	3	4	5	5	5	3
Mercury (mg/Kg)	1	1:3Nitric/HCl digest - APHA 3125 ICPMS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Soil Conductivity (1:5 water dS/m)	9	Rayment and Higginson 4B1	3.15	2.54	2.80	2.78	2.76	2.98
Soil pH (1:5 water)	10	Rayment and Higginson 4A1	8.77	8.76	8.84	8.77	8.75	8.79
Polycyclic Aromatic Hydrocarbons (PAH)								
Naphthalene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benz(a)anthracene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene (mg/Kg)	..	*c*	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(b)&(k)flouranthene (mg/Kg)	..	*c*	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Indeno(1,2,3-c,d)pyrene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenz(a,h)anthracene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,l)perylene (mg/Kg)	..	*c*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sum of reported PAHs (mg/Kg)	11	*c*	..	..	..	..	..	..
Benzo(a)pyrene TEQ calc (PQL) (mg/Kg)	12	*c*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
HYDROCARBON ANALYSIS RESULTS								
BTEX								
Benzene (mg/Kg)	13	*c*	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene (mg/Kg)	14	*c*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene (mg/Kg)	15	*c*	<1	<1	<1	<1	<1	<1
m+p-Xylene (mg/Kg)	16	*c*	<2	<2	<2	<2	<2	<2
o-Xylene (mg/Kg))		*c*	<1	<1	<1	<1	<1	<1
Naphthalene (mg/Kg)	..	*c*	<1	<1	<1	<1	<1	<1
Total Recoverable Hydrocarbons								
C10-C14 Fraction (mg/Kg)	..	*c*	<50	<50	<50	<50	<50	<50
C15-C28 Fraction (mg/Kg)	..	*c*	<100	<100	<100	<100	<100	<100
C29-C36 Fraction (mg/Kg)	..	*c*	<100	<100	<100	<100	<100	<100
C10-C16 Fraction (mg/Kg)	..	*c*	<50	<50	<50	<50	<50	<50
C10-C16 less Naphthalene Fraction (mg/Kg)	..	*c*	<50	<50	<50	<50	<50	<50
C16-C34 Fraction (mg/Kg)	..	*c*	<100	<100	<100	<100	<100	<100
C34-C40 Fraction (mg/Kg)	..	*c*	<100	<100	<100	<100	<100	<100
Contaminants (Physical - rubber, plastic, bitumen, paper, cloth, paint wood) (%)	18	*** As per RTA T276*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

METHODS REFERENCE
a. 1:3Nitric/HCl digest - APHA 3125 ICPMS
b. 1:3Nitric/HCl digest - APHA 3120 ICPOES
c. Analysis sub-contracted - Envirolab Report No. 178513

Accreditation No. 14960. Accredited for compliance with ISO/IEC 17025.

NOTES
1. *DW = Dry Weight. na = no guidelines available*
2. *NSW EPA ENM Guidelines - Protection of the Environment Operations (Waste) Regulation 2014 (The Excavation Natural Material Order 2014 - Resource Recovery Order under Part 9, Clause 93)*
3. *For statistical purposes, half detection limit replaced with samples NOT DETECTED*
4. ** denotes these test procedures are as yet not NATA accredited but quality control data is available

checked: ....
Graham Lancaster (Nata signatory)
Laboratory Manager

RESULTS OF ENM SOIL ANALYSIS

17 samples supplied by HydroSphere Consulting Pty Ltd on the 20th October, 2017. Job Number: G4207
Analysis requested by Rod Conroy. **Your Project: Shaws Bay**
PO box 7059 BALLINA NSW 2478

	ENM Number	Method	*MIN*	*MAX*	*AVERAGE*	*ENM - Col 2 AVERAGE*	*ENM - Col 3 MAX*
		Job No.				*see note 2*	*see note 2*
Moisture Content (% moisture)	..	Inhouse - 110˚C	*16*	*20*	*17*	..	..
METALS							
Arsenic (mg/Kg)	4	1:3Nitric/HCl digest - APHA 3125 ICPMS	*1*	*3*	*2*	*20*	*40*
Lead (mg/Kg)	3	1:3Nitric/HCl digest - APHA 3125 ICPMS	*1*	*2*	*1*	*50*	*100*
Cadmium (mg/Kg)	2	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<0.1*	*<0.1*	*<0.1*	*0.5*	*1.0*
Chromium (mg/Kg)	5	1:3Nitric/HCl digest - APHA 3125 ICPMS	*1*	*3*	*2*	*75*	*150*
Copper (mg/Kg)	6	1:3Nitric/HCl digest - APHA 3125 ICPMS	*1*	*1*	*1*	*100*	*200*
Nickel (mg/Kg)	7	1:3Nitric/HCl digest - APHA 3125 ICPMS	*1*	*2*	*1*	*30*	*60*
Zinc (mg/Kg)	8	1:3Nitric/HCl digest - APHA 3125 ICPMS	*2*	*8*	*4*	*150*	*300*
Mercury (mg/Kg)	1	1:3Nitric/HCl digest - APHA 3125 ICPMS	*<0.05*	*<0.05*	*<0.05*	*0.5*	*1.0*
Soil Conductivity (1:5 water dS/m)	9	Rayment and Higginson 4B1	*1.84*	*3.37*	*2.76*	*1.5*	*3.0*
Soil pH (1:5 water)	10	Rayment and Higginson 4A1	*8.56*	*8.96*	*8.80*	*5 - 9*	*4.5 - 10*
Polycyclic Aromatic Hydrocarbons (PAH)							
Naphthalene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Acenaphthylene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Acenaphthene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Fluorene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Phenanthrene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Anthracene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Fluoranthene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Pyrene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Benz(a)anthracene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Chrysene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Benzo(a)pyrene (mg/Kg)	..	*c*	*<0.05*	<0.05	..	..	..
Benzo(b)&(k)flouranthene (mg/Kg)	..	*c*	*<0.2*	<0.2	..	..	..
Indeno(1,2,3-c,d)pyrene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Dibenz(a,h)anthracene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Benzo(g,h,I)perylene (mg/Kg)	..	*c*	*<0.1*	<0.1	..	..	..
Sum of reported PAHs (mg/Kg)	11	*c*	*<0.1*	..	*<1.0*	*20*	*40*
Benzo(a)pyrene TEQ calc (PQL) (mg/Kg)	12	*c*	*<0.5*	<0.5	*<0.5*	*0.5*	*1.0*
<u>HYDROCARBON ANALYSIS RESULTS</u>							
<u>BTEX</u>							
Benzene (mg/Kg)	13	*c*	<0.2	<0.2	..	..	*0.5*
Toluene (mg/Kg)	14	*c*	<0.5	<0.5	..	..	*65*
Ethylbenzene (mg/Kg)	15	*c*	<1	<1	..	..	*25*
m+p-Xylene (mg/Kg)	16	*c*	<2	<2	..	..	*15*
o-Xylene (mg/Kg))		*c*	<1	<1	..	..	
Naphthalene (mg/Kg)	..	*c*	<1	<1	..	..	..
<u>Total Recoverable Hydrocarbons</u>							
C10-C14 Fraction (mg/Kg)	..	*c*	*<50*	<50	..	..	..
C15-C28 Fraction (mg/Kg)	..	*c*	*<100*	<100	..	..	..
C29-C36 Fraction (mg/Kg)	..	*c*	*<100*	<100	..	..	..
C10-C16 Fraction (mg/Kg)	..	*c*	*<50*	<50	..	..	..
C10-C16 less Naphthalene Fraction (mg/Kg)	..	*c*	*<50*	<50	..	..	..
C16-C34 Fraction (mg/Kg)	..	*c*	*<100*	<100	..	..	..
C34-C40 Fraction (mg/Kg)	..	*c*	*<100*	<100	..	..	..
Contaminants (Physical - rubber, plastic, bitumen, paper, cloth, paint wood) (%)	18	*** As per RTA T276*	*<0.01*	<0.01	*<0.01*	*<0.05*	*<0.1*

<u>METHODS REFERENCE</u>

a. [1:3]Nitric/HCl digest - APHA 3125 ICPMS
b. [1:3]Nitric/HCl digest - APHA 3120 ICPOES
c. Analysis sub-contracted - Envirolab Report No. 178513

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<u>NOTES</u>

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(The Excavation Natural Material Order 2014 - Resource Recovery Order under Part 9, Clause 93)
3. For statistical purposes, half detection limit replaced with samples NOT DETECTED
4. ** denotes these test procedures are as yet not NATA accredited but quality control data is available

Environmental Analysis Laboratory, Southern Cross University,
Tel. 02 6620 3678, website: scu.edu.au/eal

checked: ....
Graham Lancaster (Nata signatory)
Laboratory Manager