MARINE AND ESTUARINE ENVIRONMENTAL ASSESSMENT IN BRIDPORT, TASMANIA

Report to

Burbury Consulting

March, 2019

www.marinesolutions.net.au

Version	Author	Date reviewed	Reviewed by
1 of 1	Annie Ford	15/03/2019	Matt Cameron

Note: Location maps throughout this report are representative only; for precise GPS coordinates, see the appendices.
All satellite imagery used throughout is sourced from The Land Information System Tasmania (LIST).

[1] Cover photo, the "Second Solution" moored alongside the Bridport Boat Ramp (photo Marine Solutions, 8/11/2018).

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1 Executive Summary

Marine Solutions were contracted by Burbury Consulting to provide a field and desktop assessment of a proposed development site at Bridport on Tasmania's north-eastern coast. The proposed development will improve marina facilities and vessel operations by deepening and re-routing Hurst Creek rivermouth through the sand dunes adjacent to the fisheries wharf.

The scope of this document includes a desktop review of the marine environment and field assessment. These were used to identify potential construction and operational impacts and inform development recommendations.

A desktop search identified a number of threatened or protected species that occur, or are likely occur, within the study area. It is recommended a management plan is developed to ensure threatened species are considered during construction processes, specifically including Australian grayling, cetaceans and marine reptiles. Surveys for Gunn's screw shell and the red handfish should also be considered prior to the commencement of approvals for any marine-based disturbances within the region.

Bathymetric mapping in the Anderson Bay study area found the region is relatively shallow, with depth increasing uniformly with increasing distance from shore. A series of patchy intertidal rocks were identified in the south-eastern side of the Anderson Bay study area. Hurst Creek is a meandering and narrow waterway with extensive shallow sand flats to the south. The creek varied from 0.0 m to -2 m Australian Height Datum (AHD), with the deepest sections at the fisheries wharf and at the rivermouth.

The benthic habitat throughout Anderson Bay was primarily coarse-grained ridged sand with shell grit, organic debris and drift algae. Patchy rocky reef with mixed macroalgae communities occur in the northern inshore regions, however no rocky reef was identified in the southern regions of Anderson Bay. Notably, seagrass habitat likely occurs within the area however no beds were identified in towed video transects.

Jet probing in the channel leading between the existing fishing wharf and the proposed rivermouth adjustment (at site SQ03) identified bedrock refusal from 1.6 m to 2 m below the sediment surface which could be an isolated rock outcrop or more extensive bedrock formation. At other sites within

Hurst Creek and Anderson Bay the sediment depths are likely to exceed 2 m but more extensive geotechnical surveys would be required to adequately determine the full extent of the underlying bedrock and possible impediments to proposed dredging alignment.

Acid sulphate soils testing identified the presence of acid sulphates in sediments within the proposed dredging alignment. However, due to naturally high levels of calcium carbonate (likely in the form of marine shell deposits) sediments also exhibit a high acid neutralising capacity and correspondingly a low liming rate requirement to render them a minimal environmental risk.

Levels of contaminants, including tributyltin and copper, were all below ANZECC ISQG low trigger values, at all sites tested, except for alongside the existing fishing wharf (site SQ04), which had an elevated level of zinc above the ISQG high trigger value. Although zinc concentrations are considered moderately high at this site relative to natural background levels, a large fraction of this is likely not bioavailable and most species are tolerant of higher zinc levels.

2 Introduction

2.1 Background

Marine Solutions was invited by Burbury Consulting to conduct a marine environmental assessment in the vicinity of a proposed development in Bridport (**Error! Reference source not found.**).

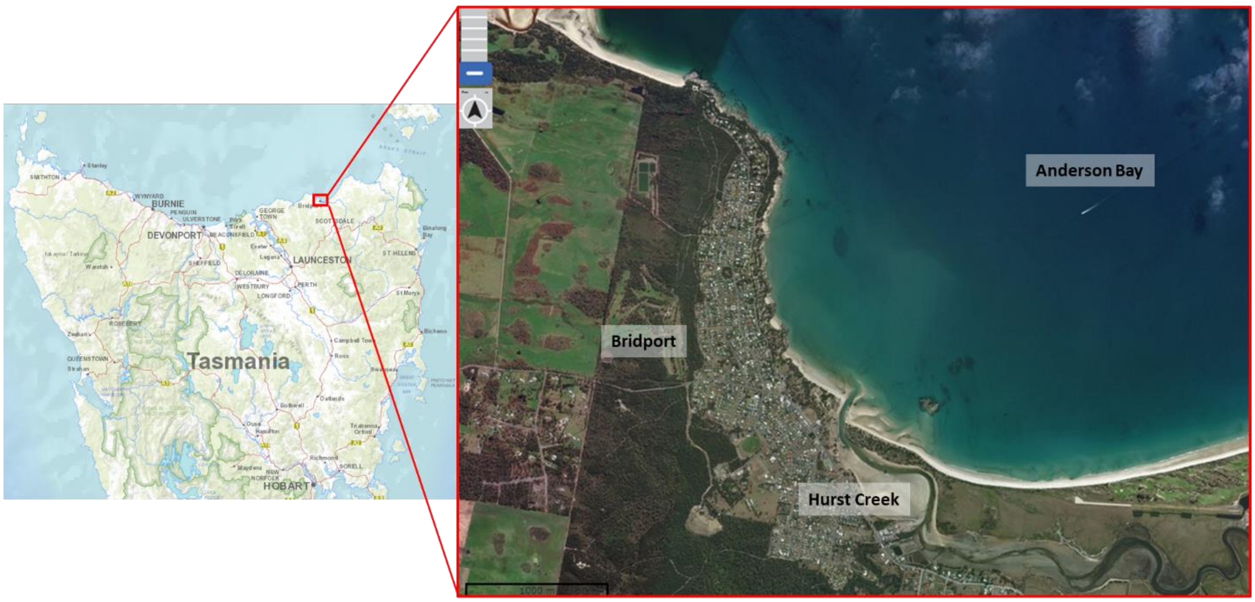


Figure 1 Location of environmental assessment in relation to Bridport township

Burbury Consulting are investigating options to improve marina facilities and vessel operations within Bridport, north-eastern Tasmania. One option Burbury Consulting are considering, to facilitate improved vessel operations includes an adjustment of the Hurst Creek rivermouth by re-routing Hurst Creek through the sand dunes adjacent to the fisheries wharf (Figure 2).

Figure 2 Potential zone for Hurst Creek rivermouth adjustment

To understand potential impacts of this proposed development, an environmental assessment was conducted to identify sensitive receptors in the region, benthic habitat types, and the seabed throughout the study area.

2.2 Purpose and Scope

The purpose of this report is to assess sensitive receptors, benthic habitat types, and bathymetry in the vicinity of the proposed development.

The scope of this report extends to a detailed summary of available information regarding natural values and the ecology of the area. Please note that the scope does not extend to terrestrial ecology.

Specifically, the project includes the following:

- Desktop survey of sensitive receptors
- Detailed summarization of benthic habitat types
- Interpretation of Anderson Bay and Hurst Creek bathymetric maps

- Provision of data (corrected to MGA94 horizontal datum, GDA94 bearing datum and AHD vertical) as contour maps in JPG, and as a DXF file
- Sediment and bedrock depth investigation
- Sediment assessment, including Acid Sulphate and contaminant testing

3 Desktop Protected Matters Summary

The *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* Protected Matters Search Tool (PMST) is a tool managed by the Department of the Environment to help determine whether Matters of National Environmental Significance (MNES) or other matters protected by the *EPBC Act 1999* are likely to occur in a given area of interest (Table 1). The PMST was used to identify protected matters relating the study area, with a buffer of 5000 m. The full report is available upon request from Marine Solutions. Marine threatened and protected species, migratory species and invasive species are discussed in further detail in Section 3.1 below.

Table 1 Summary of findings of the *EPBC Act* PMST.

	Item	# ID'd by PMST	Notes
Matters of National Environmental Significance	World Heritage Properties	None	
	National Heritage Places	None	
	Wetlands of International Importance	None	
	Great Barrier Reef Marine Park	None	
	Commonwealth Marine Area	None	
	Listed Threatened Ecological Communities	1	
	Listed Threatened Species	54	Includes 6 marine species
	Listed Migratory Species	42	
Other Matters Protected by EPBCA	Commonwealth Land	1	
	Commonwealth Heritage Places	None	
	Listed Marine Species	73	(Refer to section 3.1.1)
	Whales and Other Cetaceans	10	(Refer to section 3.1.1.2)
	Critical Habitats	None	
	Commonwealth Reserves Terrestrial	None	
	Australian Marine Parks	None	
Extra Information	State and Territory Reserves	3	
	Regional Forest Agreements	1	
	Invasive Species	27	Does not include any marine species
	Nationally Important Wetlands	None	
	Key Ecological Features (Marine)	None	

3.1 Aquatic Flora and Fauna

3.1.1 Threatened and Protected Species/Ecological Communities

There are a number of marine species listed as threatened that may occur in the vicinity of the proposed development. Threatened species are protected under the *Threatened Species Protection (TSP) Act 1995* (Tasmanian state legislation) and/or the *EPBC Act* (Australian Government legislation).

Under the *TSP Act*, no listed species can be collected, disturbed, damaged or destroyed without a permit. Under the *EPBC Act*, any action with significant impact on a listed threatened species and/or community is prohibited without approval (*EPBC Act* Section 18 and 18A).

In addition to threatened species legislation, the *Fisheries (General and Fees) Regulations 2006* under the *Living Marine Resources Management (LMRM) Act 1995* prohibits the taking/possession of various marine species, including Syngnathids (seahorses, seadragons and pipehorses), Handfish, Threefin Blennies, Limpets/False Limpets of three superfamilies, and five species of shark. Additional species are protected by the schedules of the *Wildlife (General) Regulations 2010* (Regulations under the *Nature Conservation Act 2002* [NCA]), under which a person must not take, buy, sell or have possession of any protected wildlife or any product of any protected wildlife without a permit. Threatened species that could potentially occur within the vicinity of the study area are discussed in greater detail in this section.

In a search of the Natural Values Atlas (NVA, 2018) and EPBC PMST (2018), 10 threatened marine species were identified as possibly occurring in the area or known to occur in the area (Table 2). Verified records of 4 threatened species within a 5000 m radius of the study area were found (NVA, 2018; Table 2).

Table 2 Summary of threatened marine species identified in a search of the NVA and the EPBC PMST. Note that the scope of the current report does not extend to freshwater, terrestrial or avian biota.

	Listing			
Species	EPBC Act	TSP Act	NVA findings	EPBC PMST findings
Australian Grayling (*Prototroctes maraena*)	Vulnerable	Vulnerable	May occur within 500 m (based on range boundaries)	Species or species habitat known to occur within area
Blue Whale *(Balaenoptera musculus)*	Endangered	Endangered		Species or species habitat likely to occur within area
Southern Right Whale (*Eubaleena australis*)	Endangered	Endangered	Verified record within 5000 m	Species or species habitat known to occur within area
Humpback Whale (*Megaptera novaeangliae*)	Vulnerable	Endangered		Species or species habitat known to occur within area
Green Turtle (*Chelonia mydas*)	Vulnerable			Breeding likely to occur within area
Leatherback Turtle (*Dermochelys coriacea*)		Vulnerable	Verified record within 5000 m	-
Gunn's Screw Shell (*Gazameda gunnii*)	Vulnerable	Vulnerable	Verified record within 5000 m	-
Red handfish (Thymichthys politus)	Critically endangered	Critically endangered	Verified record within 5000 m	-
Great White Shark (*Carcharodon carcharias*)	Vulnerable	Vulnerable	-	Species or species habitat known to occur within area
Giant Kelp Marine Forests of South Eastern Australia	Endangered	-		Community likely to occur within area

3.1.1.1 Australian grayling

The Australian grayling is native to Tasmania and southeast mainland Australia. Australian grayling have a diadromous lifecycle, inhabiting fresh water streams as adults, and migrating to coastal seas as larvae. Spawning takes place in late spring/early summer (Bryant and Jackson, 1999). Larvae are transported to sea in stream/river currents and return as migrating juveniles approximately 4-6 months later (Bryant and Jackson, 1999).

The main threats to Australian grayling are the construction of dams and weirs restricting migration to and from the sea (Backhouse et al. 2008). Although the proposed development will not introduce a barrier to migration, a management plan should be developed to ensure Australian grayling are considered for any construction processes that may impact water quality.

3.1.1.2 Cetaceans

Whale populations have been recovering steadily since the post whaling era and are likely to migrate along the surrounding coastline in the autumn and spring months. Baleen whales are making a slow recovery in numbers post whaling and the number of females migrating to Australia to calve in spring has also been steadily increasing (DSEWPC, 2012a).

The main threats to cetaceans are interactions with fishing operations, vessel strike, acoustic disturbance and climate change (DEWHA, 2009). Given the inshore nature of the proposed development, interactions with cetaceans are unlikely. Despite the low likelihood of interaction, a management plan should be developed to ensure cetaceans are considered for any construction processes that may cause acoustic disturbances.

3.1.1.3 Turtles

Sea turtle sightings in Tasmanian waters are rare and commonly indicative of poor animal health (Edgar, 2008). Green and leatherback turtles are considered a tropical species, and therefore their presence in the vicinity of the port is considered unlikely. The main processes threatening turtles are harvesting of their eggs, hunting of the adults, bycatch, wildlife trade, plastic pollution and loss of nesting beaches. No turtle species are known to nest on Tasmanian Beaches.

Despite the low likelihood of interaction, a management plan should be developed to ensure turtles are considered for any construction processes that may cause water quality impacts or acoustic disturbances.

3.1.1.4 Gunn's screw shell

The Gunn's screw shell is an eastern Australian endemic which lives benthically on sand habitats (Grove, 2011). Due to the benthic nature of the species, any activities disturbing sediments or affecting sediment chemistry and biota are likely to impact the species.

Given verified records of Gunn's screw shells have been identified within 5000 m of the proposed development, a targeted search may be required prior to the commencement of the approvals process and a management plan should be developed to ensure Gunn's screw shells are considered for any construction processes that may disturb sediments or affect sediment chemistry and biota.

3.1.1.5 Red handfish

The preferred habitat of red handfish is on top of rocks, amongst macro-algae, in sandy areas between rocks and the reef-sand interface and on sediments with weed clumps near reefs, with a depth distribution ranging from 1 to 20 metres (DEE, 2015).

Given verified records of red handfish have been identified within 5000 m of the proposed development, a targeted handfish search may be required prior to the commencement of the approvals process for marine construction and a management plan should be developed to ensure Red handfish are considered for any construction processes that may disturb potential handfish habitat.

3.1.1.6 White shark

White sharks are known to occur within the study area. The main process threatening white sharks is commercial fishing (DSEWPC, 2013). The species is epipelagic and exhibits a highly mobile life history, frequently travelling long distances in offshore waters (Edgar, 2008). As such, any appearance of white sharks within the area of Bridport is likely to be highly transitory.

Given the inshore nature of the proposed development, it is unlikely to cause any impacts to white sharks.

3.1.1.7 Giant kelp forests

Giant kelp forests of *Macrocystis pyrifera* are variable in their distribution and abundance through space and time. The extent and density of this ecological community have been greatly reduced in Tasmania over recent decades (DSEWPC, 2012; Edyvane, 2003). This is driven by interacting factors including entrainment of the nutrient poor, warm waters of the East Australian Current (Vergés et al., 2016). Effective as of late 2012, *Giant Kelp Marine Forests of South East Australia* is listed under the *EPBC Act 1999* as an Endangered Ecological Community.

While no known populations of giant kelp are known to exist within the development footprint, suitable substrate does exist in the region. Giant kelp extent varies greatly, spatially and temporally, in response to a range of known and unknown variables in the marine environment and therefore the environment in the vicinity of the proposed development may hold the potential to be giant kelp habitat. However, no negative impacts to the ecological community are foreseen due to the distance between the proposed development and suitable substrate for giant kelp populations.

3.1.1.8 Other

Although freshwater species are outside the scope of this report, it should be noted that verified records of the giant freshwater crayfish (*Astacopsis gouldi*) were identified within 5000 m of the study area and the eastern dwarf galaxias (*Galaxiella pusilla*) likely occurs in within the area (based on range boundaries). These species should be considered prior to the commencement of the approvals process for any construction activities.

4 Field Investigation

4.1 Benthic Characterisation

4.1.1 Methods

Video tow transects were conducted within the subtidal zone of Anderson Bay on the 8th of November 2018 (see Appendix 2 for positional information). Footage was captured to obtain information on habitat types, habitat viscosity and benthic features. Four video tows were conducted throughout the study area, from the dunes adjacent to Hurst Creek to the old-pier boat ramp (Figure 3). Transects commenced at approximately 1 m depth at the shoreline, and extended, perpendicular to the shoreline for approximately 100 m.

Video footage was stamped with date, time and positional information. Towed video footage was captured with a Scielex single CCD camera recording to a portable hard drive Archos PMA 400 unit at resolution of 440Tv lines and 512 x 582 pixels and is available as separate AVI files (available on request from Marine Solutions).

Figure 3 Location of video tows

4.1.2 Results

Two major benthic habitat types were present in Anderson Bay, including 1) soft sediments (fine-grained and coarse-grained sand) and 2) rocky reef with mixed macroalgae communities. Disconnected and varying extents of reef habitat were interspersed throughout sand habitat (i.e. patchy reef), however the benthic habitat was primarily uniform sand throughout the study area.

The benthic habitat adjacent to Hurst Creek (transect B1) included different variations of sand habitat (Figure 4). The seabed was primarily ridged coarse-grained sand with shell grit, organic debris and drift algae. Notably, visibility at the seabed was occasionally reduced due to highly mobile suspended sediments. The suspension of fine sediments may be due to the incoming tide experienced during the towed video transects or strong westerly wind and subsequent water movement. No rocky reef or seagrass was observed throughout this transect, however seagrass was observed within drift algae and likely occurs in the region.

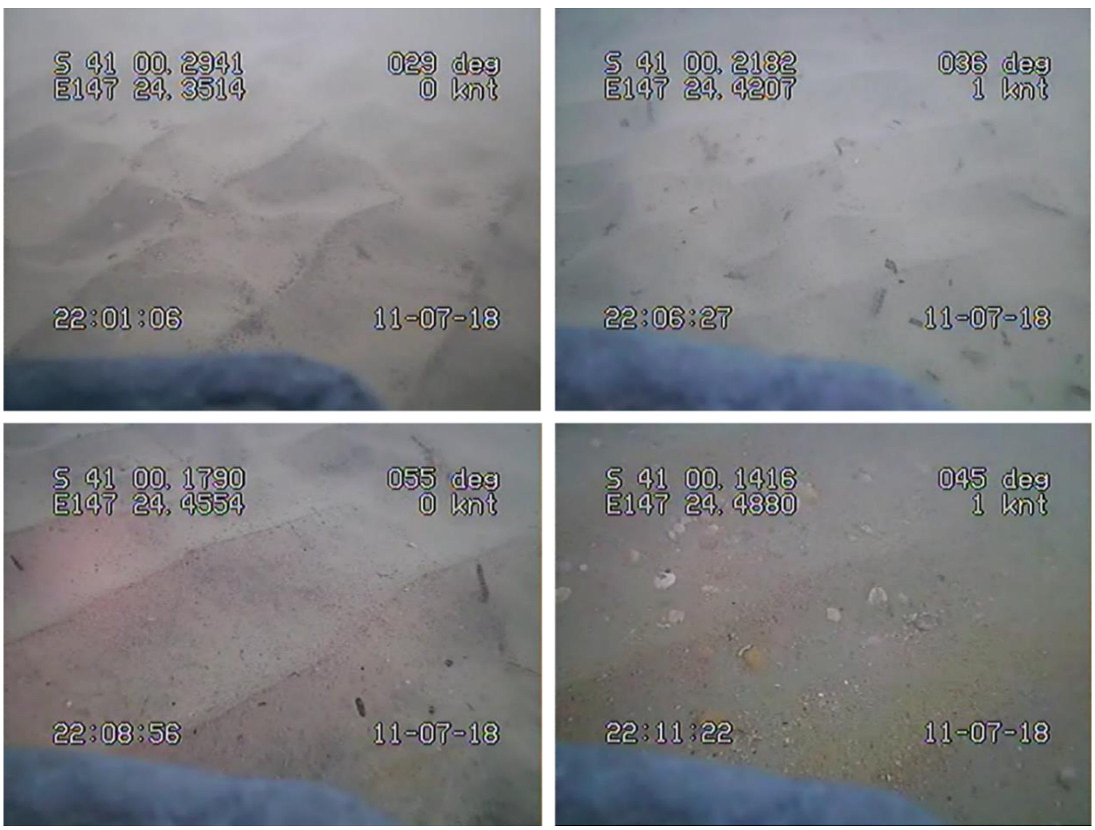


Figure 4 Dominant habitat types along transect B1

The benthos adjacent to Hurst Creek rivermouth (transect B2) was primarily ridged sand with sparse drift algae and organic debris (Figure 5). Similar to transect B1, visibility at the seabed was intermittently reduced due to highly mobile suspended sediments. No rocky reef or seagrass was observed throughout this transect.

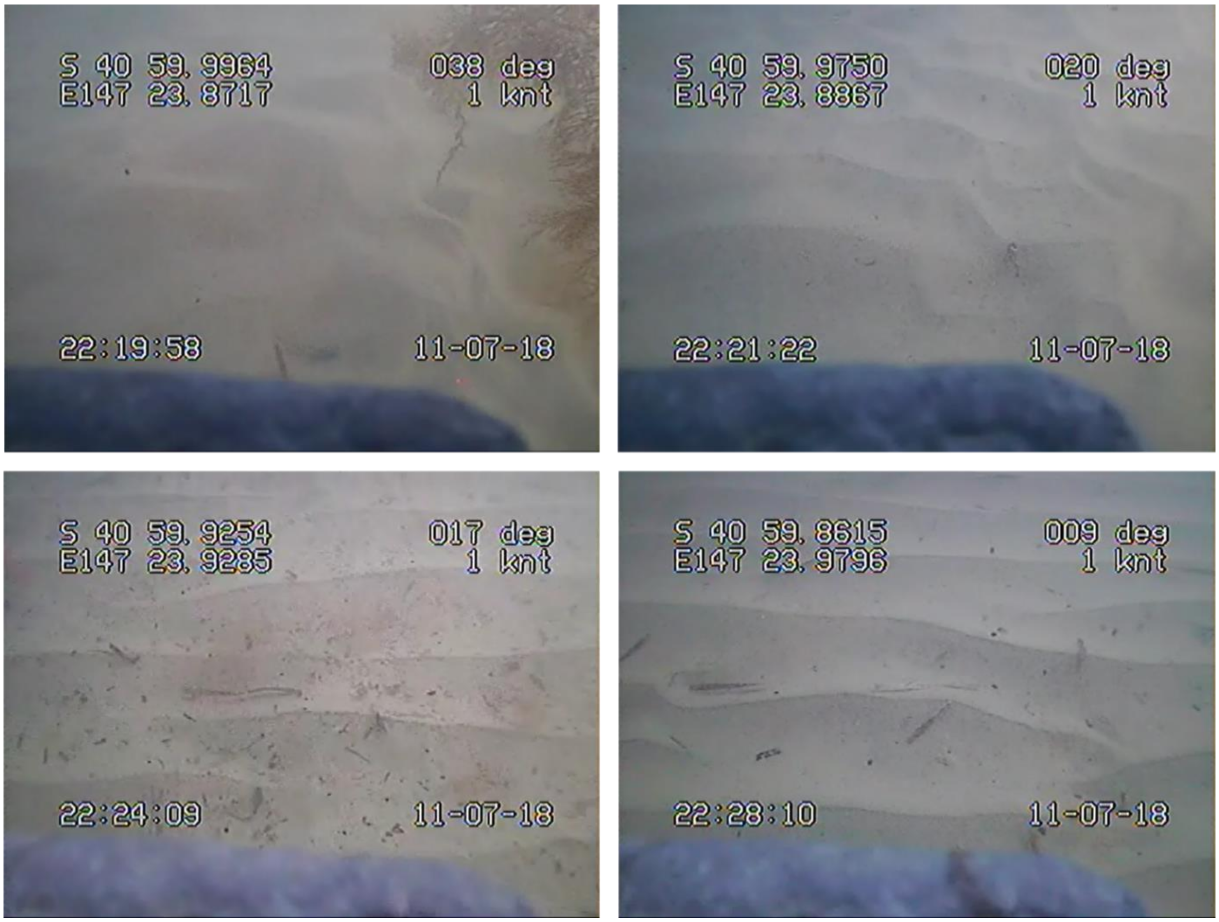


Figure 5 Dominant habitat types along transect B2

The benthic habitat along transect B3 varied from mixed macroalgae communities (potentially attached to rocky reef) inshore, to uniform coarse-grained sand with ridges offshore (Figure 6). The dominant inshore macroalgae communities transitioned to uniform sand with no benthic features. Drift algae and debris was commonly observed on the sand habitat. Given the poor visibility inshore, it was not identified whether inshore macroalgae was attached to patchy reef or unattached drift algae.

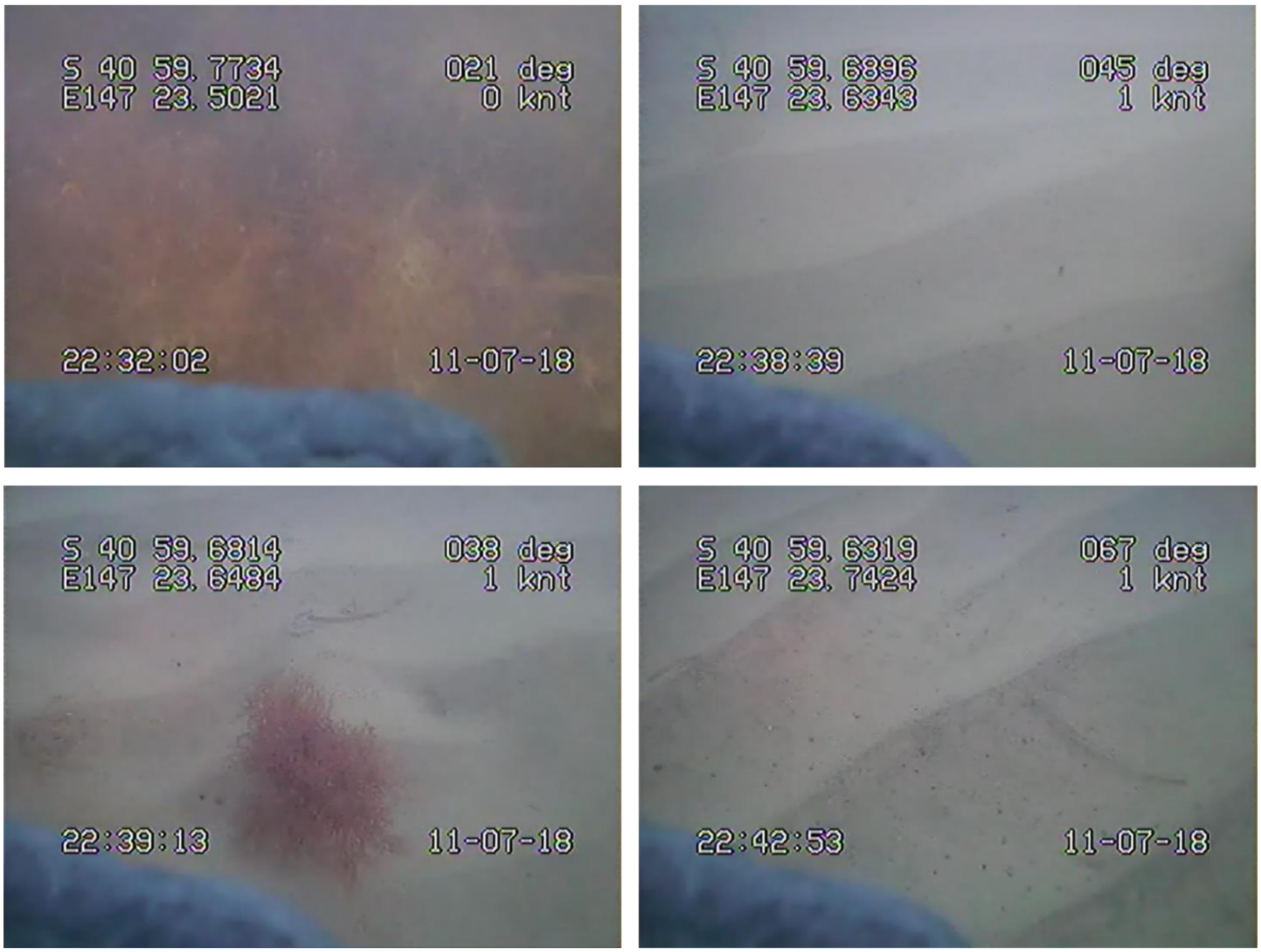


Figure 6 Benthic habitat types along transect B3

The benthic habitat adjacent to the old pier boat ramp (transect B4) transitioned between rocky reef with mixed macroalgae communities and uniform ridged sand with organic debris (Figure 7). The visibility near the seabed was poor, with suspended sediments creating a cloudy layer throughout the water column for the majority of the transect.

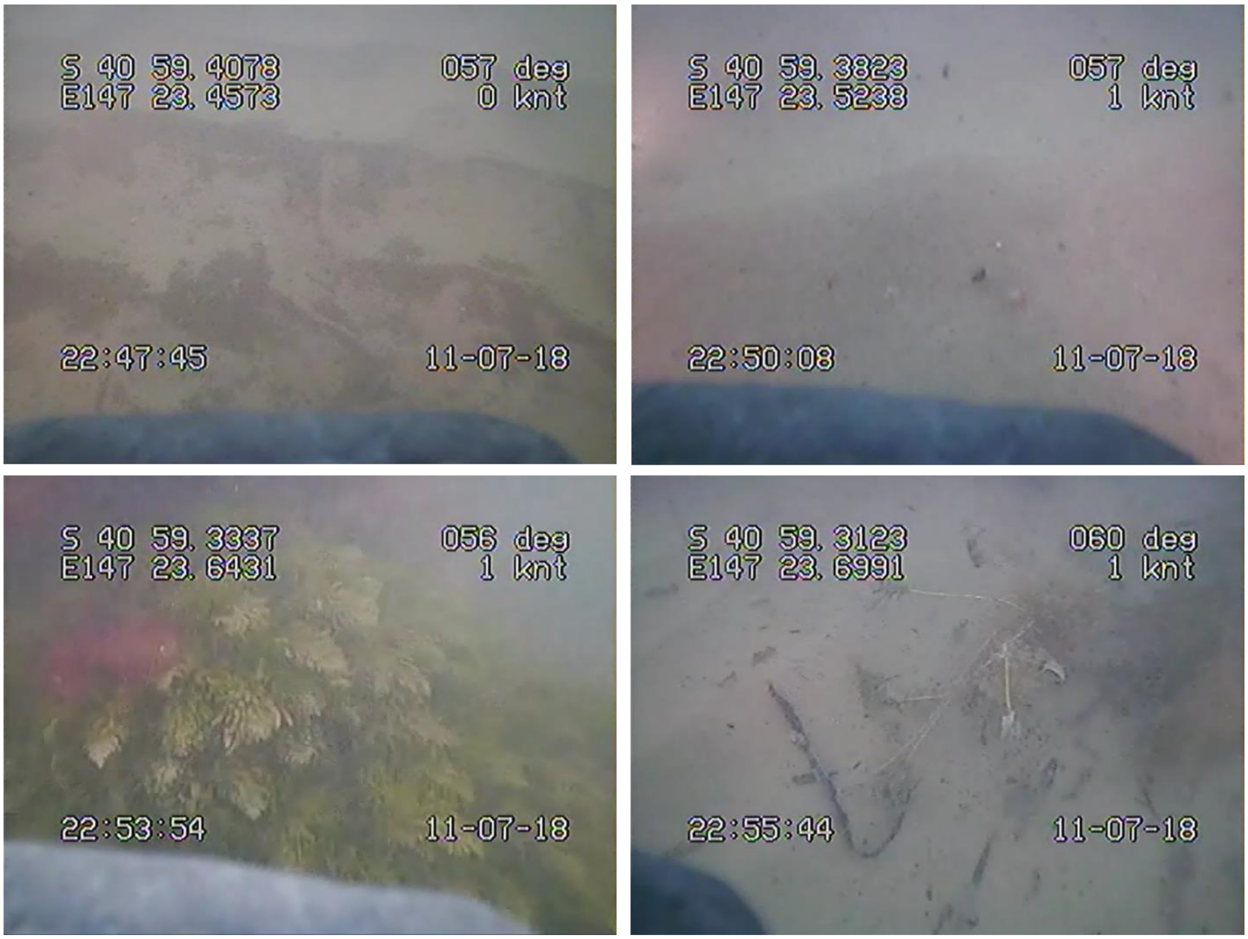


Figure 7 Benthic habitat types along transect B4

4.2 Bathymetric Mapping

4.2.1 Methods

Two zones were mapped within the study area, including 1) Anderson Bay and 2) Hurst Creek (Figure 8). A 3 km stretch of shoreline was mapped within Anderson Bay, extending to 1 km offshore at the furthest extent. Anderson Bay was mapped from the shoreline (0.5 m depth AHD) to approximately 10 m depth AHD. Approximately 1.5 km of Hurst Creek was mapped from the rivermouth to the fishery wharf upstream.

Figure 8 Bathymetric mapping zones, including Anderson Bay (denoted in red) and Hurst Creek (denoted in yellow)

Bathymetric mapping was conducted using two vessels: "The Second Solution" and "The Small Solution" (Figure 9). Anderson Bay was mapped using "The Second Solution" using a CHIRP enabled broadband sounder Simrad NSS9 evo2 chart plotter. GPS position and water depth were logged every 2 seconds to *Seabed Mapper* run on a laptop computer. Due to restrictive depths, Hurst Creek was mapped in our smaller vessel, “The Small Solution” using a CHIRP enabled broadband sounder Garmin EchoMAP plotter, also logging GPS positions and water depth every two seconds.

Figure 9 Vessels used for bathymetric mapping, including “The Second Solution” (left) and “The Small Solution”

The depths were measured to the nearest tenth of a meter, and tidally and barometrically corrected for Chart Datum using Low Head tide charts and observations from the Low Head Bureau of Meteorology (BoM) station. The resultant file was interpolated using GIS software *Surfer 11.0*, thus creating a bathymetric profile of the area. Bathymetric data was mapped with contour lines at maximum intervals of 1 m.

4.2.2 Results

Metadata Report

Projection:	UTM GRS80 Ellipsoid GDA-1994-MGA-Zone55
Vertical datum:	Nautical Chart Datum and Australian Height Datum
Date of capture:	08/11/2018
Corrections*:	Low Head Gauge and BoM station
Grid nodes:	1417x839 (1,188,863 nodes), grid spacing: X:1.99, Y:1.99
Interpolation algorithm:	Kriging

Bathymetry

Bathymetry within Anderson Bay is typical of a shallow coastal bay, with a gradual increase in depth with increasing distance from shore (Figure 10, Figure 11). The depth within Anderson Bay is relatively shallow, with a uniform increase in depth adjacent to the shoreline with the exception of the Hurst Creek rivermouth and the eastern section of the study area. The Hurst Creek rivermouth is deeper than adjacent waters, with depths of 1 m extending seawards of the training wall for approximately 250 m. East of the Hurst Creek rivermouth, a series of patchy shallow rocks extend from approximately 250 m from the shore to 750 m from the shore.

Hurst Creek is a narrow waterway with extensive shallow sand flats to the south. The deepest section of the creek (-2 m AHD) extends from the boat ramp to the rivermouth, where water movement was also strongest during field works. The creek becomes shallow (0.0 m – -2 m AHD) from the boat ramp to the fisheries wharf. A deeper section (2 m) also exists near the fisheries wharf where fishing vessels are berthed and launched. A number of benthic features exist within Hurst Creek, including steep channel gradients, numerous shallow sections at the rivermouth and fisheries wharf, and fluctuating depths within the channel.

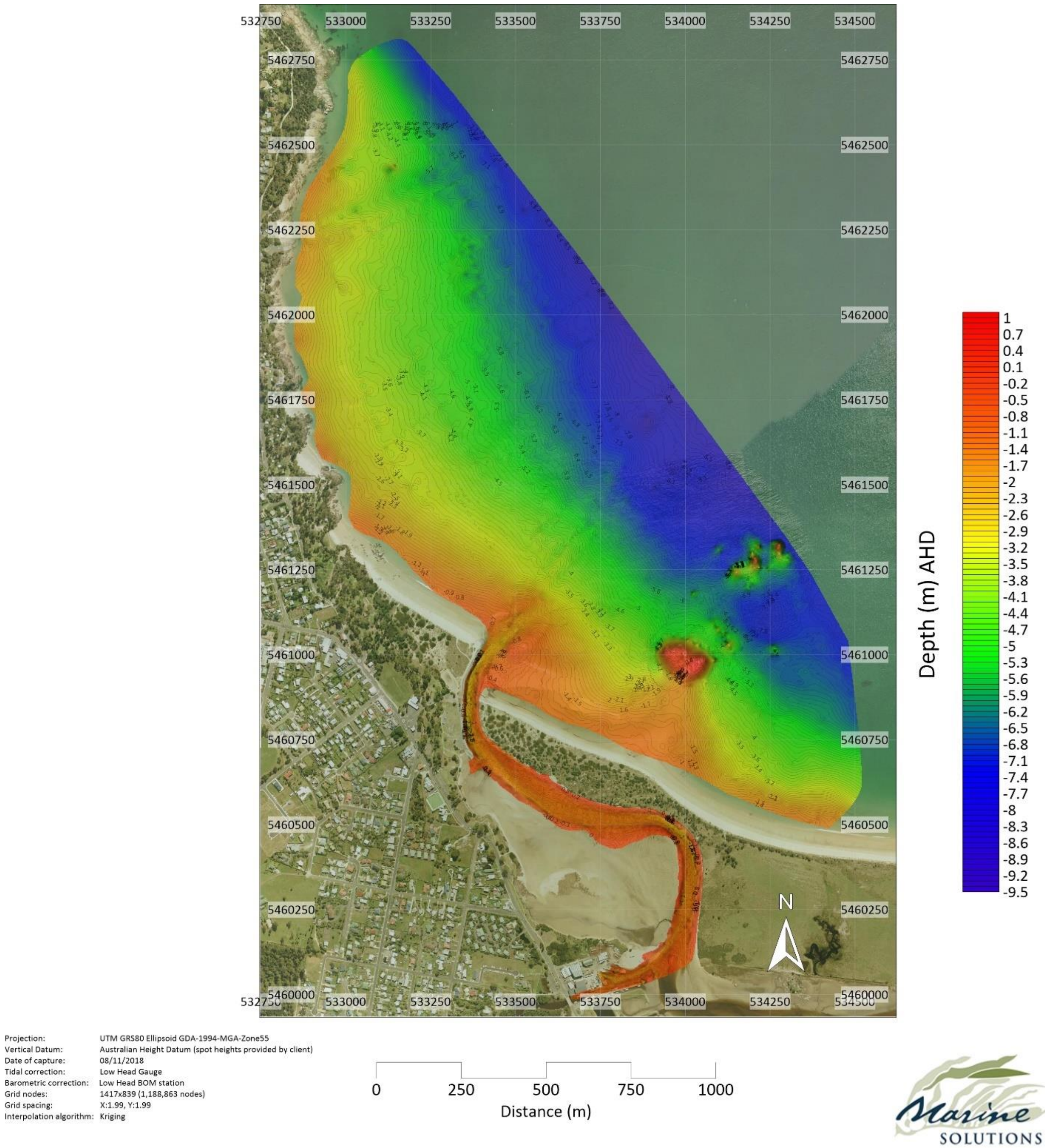
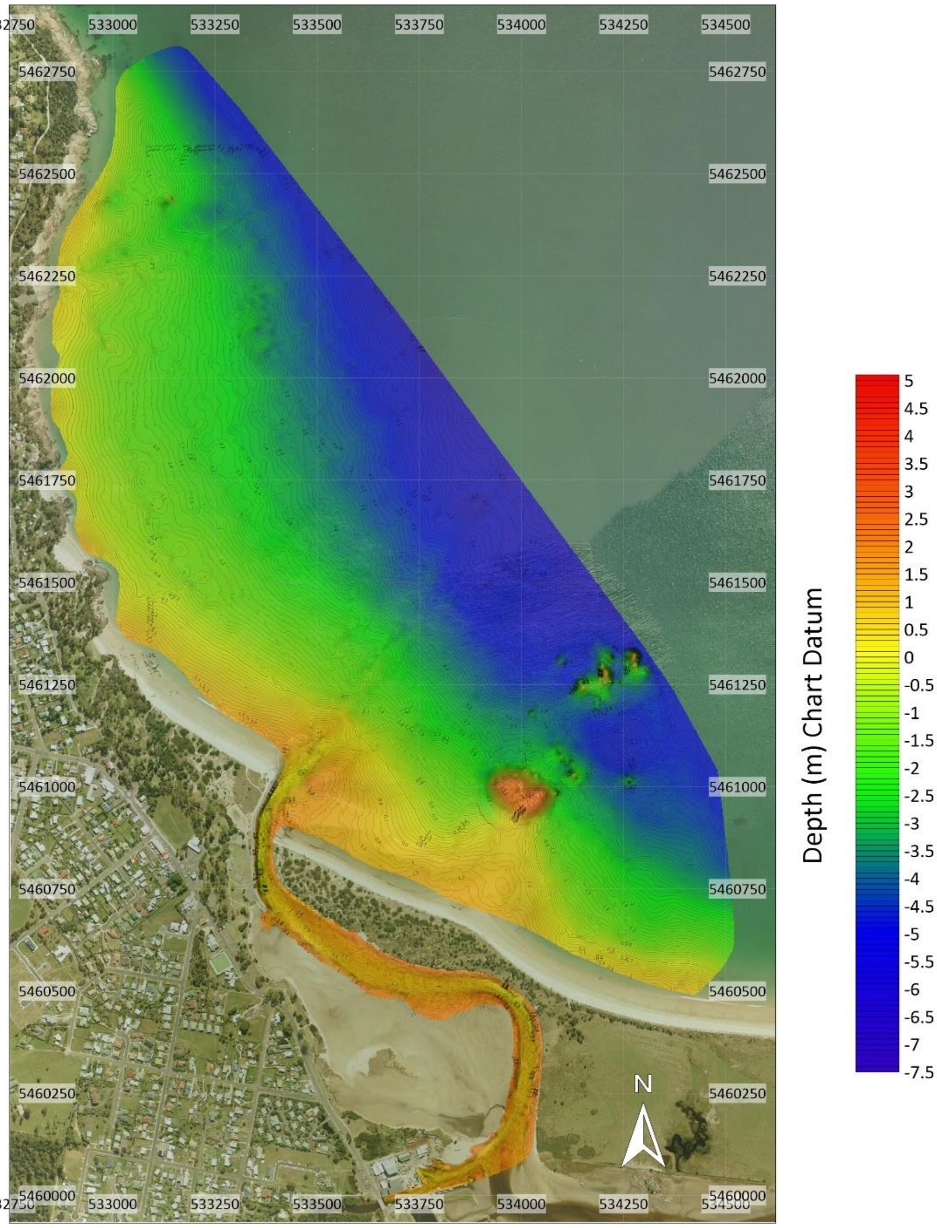


Figure 10 Bathymetry in Anderson Bay and Hurst Creek corrected to AHD



Projection: UTM GRS80 Ellipsoid GDA-1994-MGA-Zone55
Vertical Datum: Chart Datum
Date of capture: 08/11/2018
Tidal correction: Low Head Gauge
Barometric correction: Low Head BOM station
Grid nodes: 1417x839 (1,188,863 nodes)
Grid spacing: X:1.99, Y:1.99
Interpolation algorithm: Kriging

0 250 500 750 1000
Distance (m)

Figure 11 Bathymetry in Anderson Bay and Hurst Creek corrected to CD

4.3 SEDIMENT ANALYSIS

To characterise the sediments, and subsequent environmental risk of dredging at Bridport, sediments were sampled at a total of 5 sampling sites (see Figure 12 and Appendix 2).

Figure 12 Sediment sample sites throughout Hurst Creek and Anderson Bay for jet probing, ASS testing, contaminant testing and particle size testing.

4.3.1 Jet Probing

Sediment depth information was collected from 5 jet probe points along the proposed dredging alignment (Figure 12). Jet probing found variable sediment depth along the alignment, with hard bedrock refusal found at site SQ03. Sediment depth was over 2 m at sites SQ02 and SQ04, with depth likely also greater than 1.8 m at SQ01 (Table 3). Jet probing was not completed at site SQ05 due to an incoming tide.

Table 3 Jet probe refusal

Site	Depth of Refusal (m)	Type of Refusal	Observations
SQ01	1.8	Compacted shell grit	Mobile sand in top layers, base included coarse reworked sediments and shell. Hard to penetrate through bottom layer of compacted shell grit. No rock refusal found.
SQ02	+ 2	Shell grit	Black surface sediments with no shell. Shell grit in base of core.
SQ03	1.6 - 2	Hard rock	Multiple jet probes at site with depths reaching 1.6m, 1.7m, 1.8m and + 2m. All hard rock refusal. Sediments included shell and grit that graded to mobile river sand.
SQ04	+ 2	Soft sediment	Highly compacted with fibrous matter throughout. Fine surface sediments. Medium grained sediments with some shell grit at the base.
SQ05	*Not obtained*	*Not obtained*	-

4.3.2 Acid Sulphate Soils

Acid sulphate soils (ASS) are sediments that occur naturally in waterlogged environments (Thornton 2010). These sediments contain iron sulphides, most commonly in the form of iron pyride (Thornton 2010). ASS occur in two main forms: potential acid sulphate soils (PASS), where the pyride is retained in a reduced state (not oxidised), and actual acid sulphate soils (AASS), where the pyride is oxidised by exposure to air. The oxidation of ASS results in the formation of sulphuric acid (Thornton 2010). ASS are harmless when undisturbed on the seafloor (DEP 2009), however, dredging activities that expose PASS to air can result in destructive leaching of acid into the environment (DEP 2009; Thornton 2010). To characterise the ASS-related risk of dredging this site, both field and laboratory testing was conducted.

4.3.2.1 Field tests

Field pH (pH_F) and field pH peroxide (pH_{FOX}) ASS Screening Tests were conducted at a single depth of cores taken from sites SQ02 – SQ04. These tests assist in determining the likelihood of soils being AASS or PASS and are simple and low-cost. PASS/AASS testing was conducted at the depths of the cores that appeared most likely to be PASS or AASS, as determined by field-based stratigraphical examination including a visual/odour assessment of sediments in each core.

To conduct the pH_F tests a half-teaspoon of sediment was placed in a glass jar. Approximately 2ml of deionised water was added to sediment samples and vigorously mixed with a stirrer to a smooth paste. The pH of the sediment paste was immediately measured (once stabilised) using a pH spear point probe and recorded. The pH_{FOX} tests were conducted simultaneously using a half-teaspoon of sediment from exactly the same core position as the pH_F tests. Approximately 2 ml of buffered hydrogen peroxide was added to sediment samples and mixed to a smooth paste. Samples were then gently heated in order to speed up the reaction process. The reaction of the sediment with the hydrogen peroxide was rated using a scale of 0-4 (0 being no reaction and 4 being a vigorous reaction – see Appendix 3 for a scale of soil reaction rating). Once the reaction had visibly slowed (between 1 and 10 minutes following hydrogen peroxide addition), the pH was recorded. The difference between the pH_{FOX} and pH_F was recorded as $\triangle$pH.

A combination of three factors is required to constitute a positive field sulphide identification (Ahern *et al.* 1998):

1) A relatively strong soil reaction with hydrogen peroxide, i.e. a soil reaction rating > 3;
2) A $\triangle$pH of at least 1 unit; and
3) A pH_{FOX} of < 3.0.

4.3.2.2 Field results

No field test was conducted on the sediment core from SQ01. Based on field observations and stratigraphy of the core, it was determined that the core was composed of loosely packed mobile sediments with no odor that posed negligible risk of ASS. No field test was conducted for site SQ05 due to access difficulties with the tide. However, samples were collected at both sites for laboratory investigation.

Two tests were conducted on the core from SQ04 due to stratigraphic differences between the surface and bottom of the core.

Field tests from cores sampled (SQ02, SQ03, SQ04 top and SQ04 bottom) indicated a strong likelihood of ASS. Samples showed a reduction in pH of >1 unit after the addition of hydrogen peroxide (Table 4). This was accompanied by moderate to vigorous reactions. All samples showed evidence of fizzing and bubbling. After 2-3 minutes of gentle heating samples from sites SQ02 and SQ04 top and bottom continued to produce strong to vigorous reactions that foamed and bubbled over the tops of the 250ml jars that were used for the testing (**Error! Reference source not found.**). Sulphur odor was evident for cores from sites SQ02, SQ03 and SQ04.

Figure 13 The early stages of pH_{FOX} reaction at site 3 (left) and a vigorous pH_{FOX} reaction foaming over the jar at site 4 (right)

Table 4 AASS/PASS field testing results from sediment cores collected at Bridport

Core ID	Photo	pH_F	pH_{FOX}	ΔpH	Reaction
SQ01		No field test	No field test	N/A	N/A
SQ02		7.7	5.8	1.9	3 – strong reaction
SQ03		7.8	6.6	1.2	2 – moderate reaction
SQ04 bottom		7.3	5.8	1.5	4 – vigorous reaction
SQ04 top	As above	7.9	6.2	1.7	3 – strong reaction
SQ05	No core	No field test	No field test	N/A	N/A

4.3.2.3 Laboratory results

Following ASS field screening tests three site samples (SQ01 – SQ04) were retained and sent for further laboratory testing to identify potential acidity, acid neutralizing capacity and required liming rates.

ASS were present within the sediments at the three sites tested, however due to high natural acid neutralising capacity of the sediments, low liming rates of less than 1 kg CaCO3/t were identified for all three sites (Table 5).

Table 5. ASS Laboratory test results.

	SQ2	SQ3	SQ4
Potential Acidity (% CRS)	0.738	0.064	0.729
Acid Neutralising Capacity (as % CaCO3)	28.8	13.6	11.4
Liming Rate (kg CaCO3/t)	<1	<1	<1

4.3.3 Particle size analysis

Sediment quality is closely linked to particle size, with fine, organic-rich clays and silts typically significantly enriched in contaminants such as nutrients, hydrocarbons and heavy metals, due to their high binding capacity. In general, deeper waters with less water movement will exhibit finer silt and mud sediments (depositional areas), while shallower waters tend to have coarser sand and shell based sediments (erosional areas). The sediment size also is indicative of the speed of settlement of disturbed particles, with larger sediment sizes typically settling rapidly.

A sample of the top ~10 cm of sediment was collected by divers into sterile screw top glassware for each site and analyzed post-hoc for particle size distribution by Marine Solutions. Particle size distribution was assessed volumetrically for sediments taken from 5 sites (SQ01-SQ05), by washing samples through a series of sieves (4 mm, 2 mm, 1 mm, 500 µm, 250 µm, 125 µm and 63 µm). The content of each sieve was drained completely of water and transferred to a measuring cylinder, beginning with the coarsest sediment fraction (4 mm) and working down to the finest (63 µm). The volume of sediment measured in the measuring cylinder was recorded for each sieve size. The sediment fraction <63 µm was assumed to be the total volume of the sample minus the combined volume of all other size classes.

Analysis indicated that sediments at the proposed development site mostly consisted of medium grained particles between 0.5mm – 0.125mm in the surface layer (Figure 14). This reflects the mobile nature of the surface sediments due to strong tidal movements throughout Hurst Creek and along the oceanic beach. Sites SQ04 and SQ05 showed higher proportions of fine particles (0.063mm). These sites are located near the fisheries wharf and would receive less tidal influence than the fast-flowing creek sites, and reflective of silt depositional areas.

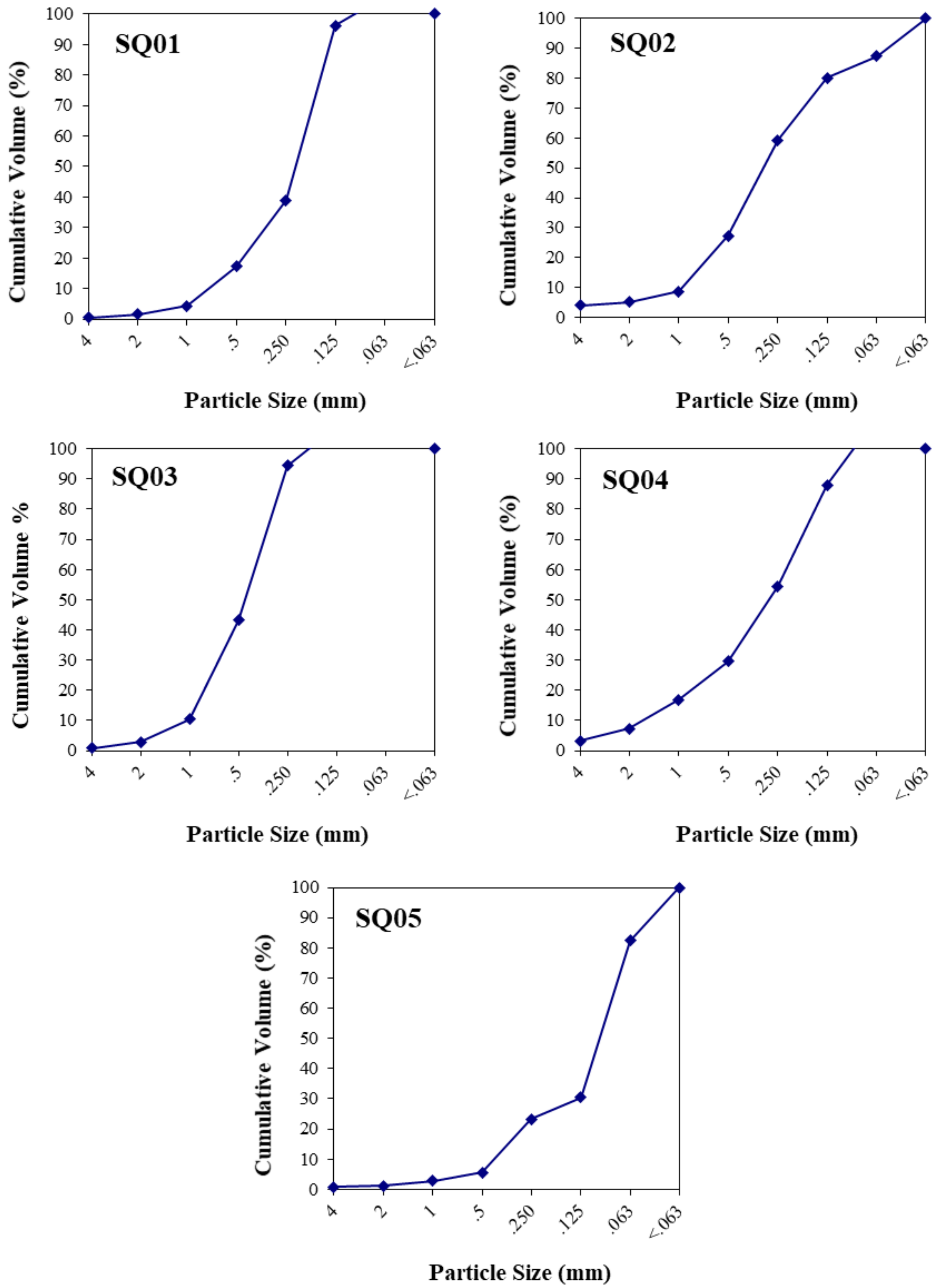


Figure 14 Particle size distribution of sediments at the proposed development area

4.3.4 Sediment contaminant analysis

Samples from Sites SQ01 – SQ05 were collected for contaminant analysis and tested for a variety of analytes. Results were compared against Interim Sediment Quality Guidelines (ISQGs) from the Australian and New Zealand Environment Conservation Council (ANZECC) Water Guideline (2000) trigger values for Southeast Australian estuaries that have 'slightly to moderately disturbed ecosystems'.

Levels of contaminants were below ANZECC ISQG low trigger values for all contaminants, at all sites except SQ04 which had an elevated level of zinc above the ISQG high trigger value (Table 6). Concentrations of contaminants appeared slightly elevated at SQ04 relative to the other sites, particularly for copper, manganese and zinc. Tributyltin was detectable at SQ04 but still below the ANZECC ISQG low trigger value. Levels of Cobalt and Manganese at SQ04, for which there are no available ISQGs, were slightly elevated relative to the other sites but unlikely to be at concentrations to cause any ecological impacts.

Concentrations of zinc in marine and estuarine sediments vary widely, however for a nearshore coastal environment, concentrations of 476 mg/kg, as detected at SQ04, would be considered moderately high relative to expected natural background levels (Neff, 2002). A large fraction of this zinc may be in a residual form in the mineral lattice of sediments particles or present in heavy metals, rendering it not bioavailable. Zinc is only moderately toxic to some marine species; fish appear to be most tolerant, whilst phytoplankton and some larval crustaceans and mollusks are most sensitive.

Table 6 Contaminants for analysis within sediments

Parameter	ISQG – Low	ISQG – High	SQ1	SQ2	SQ3	SQ4	SQ5
Arsenic (mg/kg)	**20**	**70**	3	2	2	5	4
Cadmium (mg/kg)	**1.5**	**10**	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium (mg/kg)	**80**	**370**	5	9	2	16	10
Cobalt (mg/kg)	**-**	**-**	<1	1	<1	3	1
Copper (mg/kg)	**65**	**270**	<1	1	<1	17	3
Manganese (mg/kg)	**-**	**-**	35	38	7	70	42
Lead (mg/kg)	**50**	**220**	<1	1	<1	6	2
Nickel (mg/kg)	**21**	**52**	2	4	<1	8	5
Zinc (mg/kg)	**200**	**410**	4	9	3	476	19
Tributyltin (ng Sn/g)	**5**	**70**	<2	<2	<2	2	<2

5 RECOMMENDATIONS & CONCLUSIONS

Based on a desktop survey, a number of threatened species were identified to occur, or likely occur, within the study area. It is recommenced a management plan is developed to ensure threatened species are considered during construction processes, including Australian grayling, cetaceans and marine reptiles. Surveys for Gunn's screw shell and the red handfish should also be considered prior to the commencement of approvals for any marine-based disturbances within the region.

The benthic habitat throughout the survey area was primarily coarse-grained ridged sand with shell grit, organic debris and drift algae. Patchy rocky reef with mixed macroalgae communities occur in the northern inshore regions of Andersons Bay, however no inshore rocky reef was identified in the southern regions of Andersons Bay. Notably, seagrass likely occurs within the area however no beds were identified in towed video transects. Anderson Bay is relatively shallow, with depth increasing uniformly with increasing distance from shore. A series of offshore, patchy intertidal rocks were identified in the south-eastern side of the Anderson Bay study area. Hurst Creek is a meandering and narrow waterway with extensive shallow sand flats to the south. The creek varied from 0.0 m to 2 m AHD, with the deepest sections at the fisheries wharf and at the rivermouth.

Multiple jet probes at site SQ03 identified hard bedrock refusal from 1.6 m to 2 m which could be an isolated rock outcrop or more extensive bedrock formation. At sites SQ01, SQ02 and SQ04 sediment depths are likely to exceed 2 m. More extensive geotechnical surveys would be required to determine the full extent of the underlying bedrock and possible impediments to the proposed dredging alignment.

ASS testing identified the presence of acid sulphates in benthic sediments within the proposed dredging alignment. However, due to naturally high levels of calcium carbonate (likely in the form of marine shell deposits) sediments exhibit a high acid neutralising capacity and correspondingly a low liming rate requirement to render them a minimal environmental risk.

Levels of contaminants, including tributyltin and copper, were all below ANZECC ISQG low trigger values, at all sites tested, except SQ04, which had an elevated level of zinc above the ISQG high trigger value.

Although zinc concentrations are considered moderately high at this site relative to natural background levels, a large fraction of this is likely not bioavailable and most species are tolerant of higher zinc levels.

In conclusion, no sensitive benthic habitats exist in the direct footprint of the proposed development or dredging alignment, however a number of additional species-specific surveys and management plans are recommended prior to commencement of the approvals process for a marine development.

6 REFERENCES

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7 APPENDICES

Appendix 1. Operational Summary

Date	Personnel	Time (start)	Time (end)	Cloud	Rain	Swell	Wind	Tide	Works conducted
8/11/2018	I. Cooksey A. Ford	08:30	14:00	4/8	None	0	25 knots W	Mid, high, mid	- Bathymetric mapping - Towed video
27/02/2018	S. Ibbott	11:30	15:30	6/8	None	0	5 knots Variable	Mid falling, low	- Sediments

Appendix 2. GPS Positions of sampling locations

Name	Zone	Easting	Northing	Notes
B1 Start	55G	534125.7	5460628.36	
B1 End	55G	534406.82	5461000.27	
B2 Start	55G	533457.83	5461169.73	
B2 End	55G	533679.59	5461458.9	
B3 Start	55G	532945.25	5461589.01	
B3 End	55G	533315.85	5461872.53	
B4 Start	55G	532886.71	5462266.44	
B4 End	55G	533276.93	5462471.61	
SQ01	55G	534065.87	5460636.10	
SQ02	55G	534012.50	5460464.25	
SQ03	55G	533984.20	5460235.81	
SQ04	55G	533821.58	5460021.31	
SQ05	55G	533898.25	5460070.69	

Appendix 3. Soil reaction rating scale for the pH_{FOX} test

Reaction Scale	Reaction Description
0	No reaction.
1	Slight reaction. Small amount of gas evolution. Temperature change negligible.
2	Moderate reaction. Noticeable gas evolution. Temperature change detectable to touch through glass container.
3	Strong reaction. Considerable gas evolution causing audible fizzing. Temperature warm to touch through glass container.
4	Very vigorous reaction. Considerable gas evolution causing audible fizzing and possibly spitting. Heat generation commonly >80 °C

Appendix 4. Summary of field pH and field pH peroxide test results

Site	Date Sampled	Time Sampled	Water depth over site (cm)	Core depth (cm)	Approx. sample depth (cm)	pH_F	pH_{FOX}	△pH	Reaction Rating
1	27/02/2019	11:30	Nil	150	145	No field test conducted	-	-	-
2	27/02/2019	11:45	Nil	200	195	7.7	5.8	1.9	3
3	27/02/2019	12:25	20 cm	160	155	7.8	6.6	1.2	2
4 bottom	27/02/2019	15:00	Nil	180	175	7.3	5.8	1.5	4
4 surface	27/02/2019	15:00	Nil	180	30	7.9	6.2	1.7	3
5	27/02/2019	15:30	Nil	No core	-	-	-	-	-

Appendix 5. Laboratory results of AASS/PASS testing

See laboratory AASS/PASS results attached.