Eurobodalla's Open Coast Coastal Management Plan

Geotechnical Investigation Report

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1. Introduction

This report presents the results of geotechnical services undertaken to support development of the Eurobodalla Shire Council's (Council) Open Coast Coastal Management Plan (CMP). Pells Sullivan Meynink (PSM) was engaged by Rhelm Pty Ltd (Rhelm) to undertake the geotechnical services component of work. Rhelm have been engaged by Council to finalise the Eurobodalla's Open Coast CMP as per the technical brief[1].

The geotechnical services requested relate to the investigation of three beach sites along the Eurobodalla Shire Council coast, namely, Long Beach, Surfside, and Tomakin (the sites). Results of the geotechnical investigation will be used as input for the probabilistic erosion and recession estimates within the Vulnerability Assessment stage of the open coast CMP.

This document presents the results of a desk-study and geotechnical investigation of the sites. A preliminary geotechnical model of each site is provided. Suggestions for further investigations are provided.

2. Scope of Work

The scope of work was set by Council and comprised:

- Stage 1 – Desk study
- Stage 2 – Non-Intrusive Field Investigation:
  - Engineering geological field mapping
  - Geophysical investigations.
- Stage 3 - Compilation of a simplified geotechnical model.

3. Desk Study

3.1 Introduction

A desk study forms the basis for the conceptual model of a site and considers geology, geomorphology, hydrogeology and surface processes. The conceptual models formulated for the sites in this study focus on the following:

- Coastal processes and interactions
- Review of possible subsurface conditions underlying the site based on an assessment of the terrain and landforms, and
- Identification of data gaps.

As part of the desk study, the following data and documents were reviewed:

- Geological maps and associated notes
- Geographical information systems (GIS) data, and
- Available elevation data including LiDAR and bathymetry.

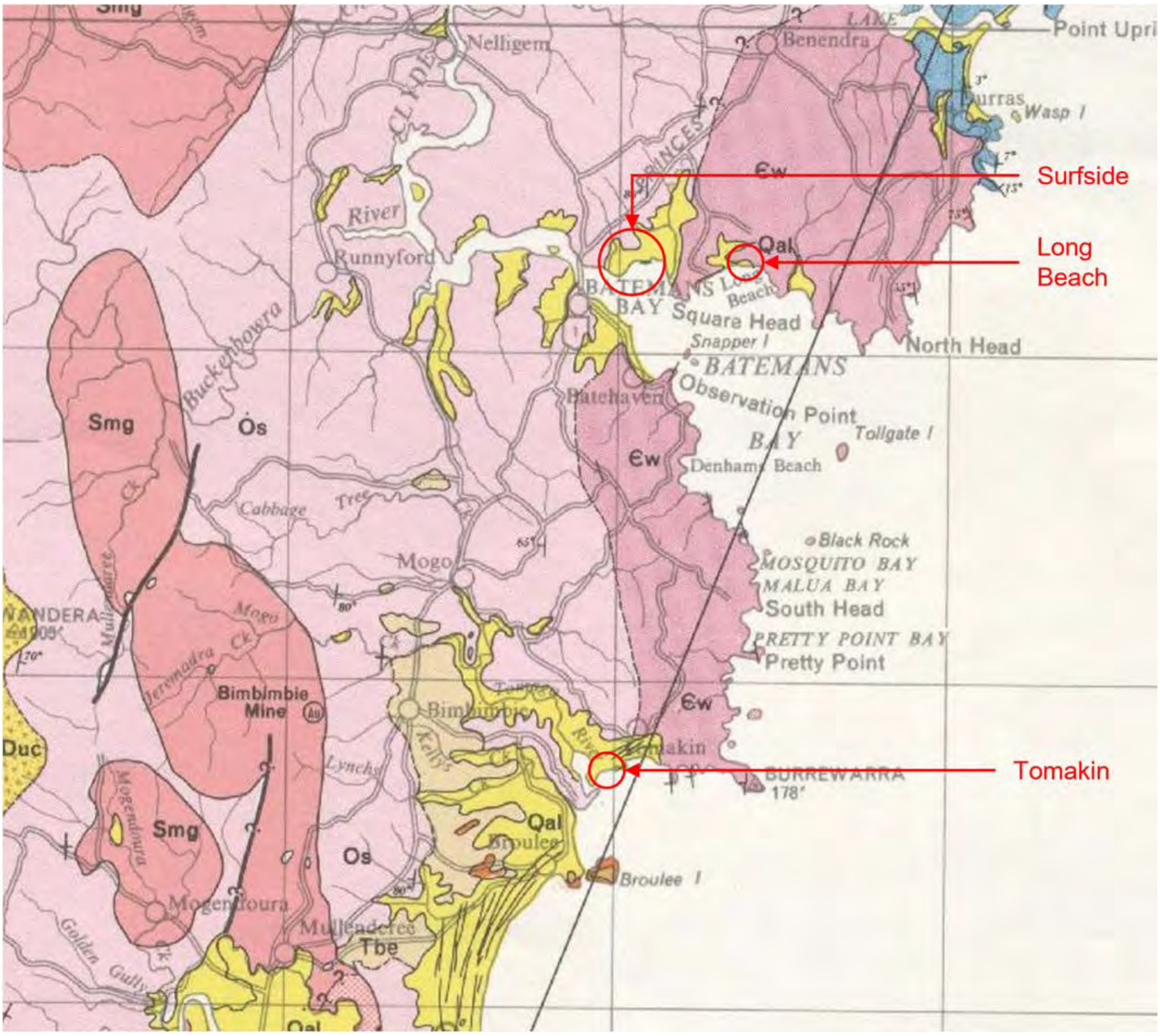
The aim of the resultant conceptual model was to guide the field mapping program, and subsequently be tested and validated against the on-site observations. Figures from the desk study are presented in Appendix A and discussed below.

3.2 Geological Setting

The 1:250,000 Ulludulla Geological Map shows that the basement geology underlying the sites encompasses rocks of the Lachlan Orogen, and described as follows, Inset 1:

- Adaminaby Group, (Os) – siltstone, claystone, sandstone, quartzite, chert
- Wagonga Group, (Ꞓw) – chert, conglomerate, agglomerate, slate, sandstone, phyllite.

[1] Eurobodalla Shire Council Technical Brief: Eurobodalla's Open Coast CMP; brief issued July 2020



Inset 1: **Ulludulla 1:250,000 (Rose, 1966). The site locations are approximated by the red circles and associated annotations.**

Both the Adaminaby and Wagonga Groups form part of the Narooma Accretionary Complex. The rocks of the Adaminaby Group have been folded along meridional axes and dips of the bedding rarely exceed 70°. The folding in these rocks has produced a slaty cleavage and bedding has substantially been obscured. Sediments of the Wagonga Group generally dip sub-vertically and strike north-south. The geological maps shows that the basement rocks are overlain by thick Quaternary deposits (Qal).

3.3 Terrain Evaluation

3.3.1 Overview

Development of a conceptual model for the sites is based on a remote sensing assessment of the terrain using GIS methods. Terrain evaluation is a form of engineering geomorphology that uses principles of mapping and classification to sub-divide the landscape into a series of smaller and more detailed hierarchical groups, typically comprising (from largest to smallest):

- Land systems
- Land facets, and
- Land elements.

These groups are assigned physical attributes based on the geomorphological processes that formed them and the underlying bedrock geology. It is a particularly useful technique where there is limited sub-surface geotechnical data.

Terrain evaluation aims to develop a conceptual engineering geological model of a site to understand the spatial distribution and relationship between each identified land facet as well as to infer the extent, thickness and engineering geological characteristics of sub-surface materials.

3.3.2 Terrain Classification

Digital elevation models (DEMs) were generated from LiDAR and bathymetry data obtained from public repositories[2], and were used to undertake the terrain mapping and classification. The mapped terrain classification plans for each respective site are shown in Insets 2 to 4, and all terrain classification figures included in Appendix A.

Three broad land systems are identified across the sites:

- Estuarine – drowned valley system comprising tidal rivers depositing into saline waters
- Marine – shoreline systems comprising sediments deposited by wind, wave, and tidal processes
- Uplands – general geomorphic system at higher elevations than the coastal plain, comprising weathered bedrock overlain by surficial deposits predominantly deposited by mass wasting processes (i.e., gravity).

A total of eight land facets are identified across the sites. Table 1 presents a description of the landforms and their anticipated engineering geological characteristics.

3.4 Publicly Available Data

Publicly available sources were reviewed to identify potential data that may supplement the conceptual models. The most useful public source was WaterNSW through their real-time data website[3]. The WaterNSW database was reviewed for borehole records proximal to each of the sites, particularly with regards to drillers logs if available.

Where boreholes contained drillers logs with notes on the materials encountered during drilling, these were used to inform the conceptual model. It is important to note that drillers logs are not technical logs, are often subjective and are based on the operator's experience. For the purposes of informing the conceptual models, the drillers logs are therefore considered as being anecdotal and assessed as having a low confidence.

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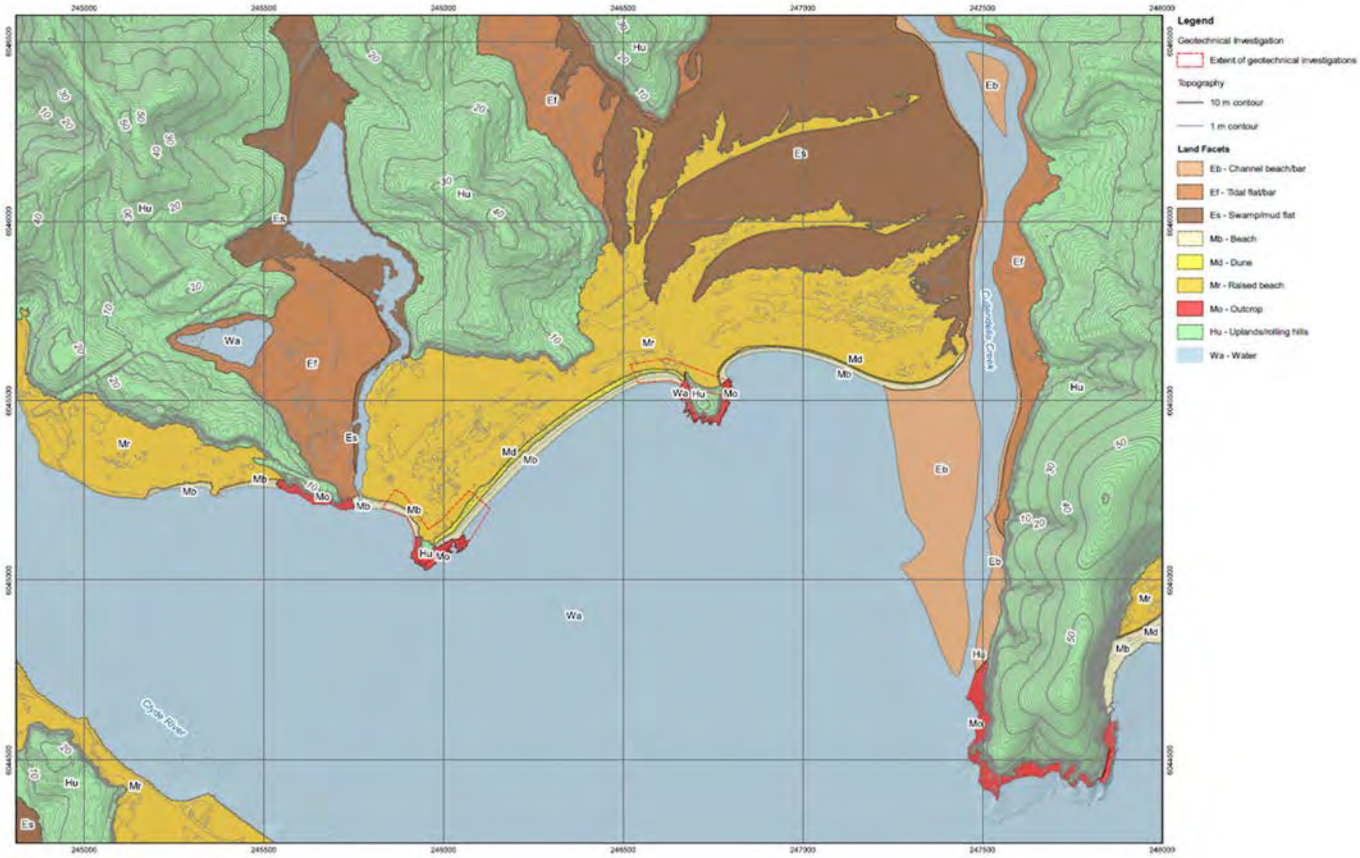
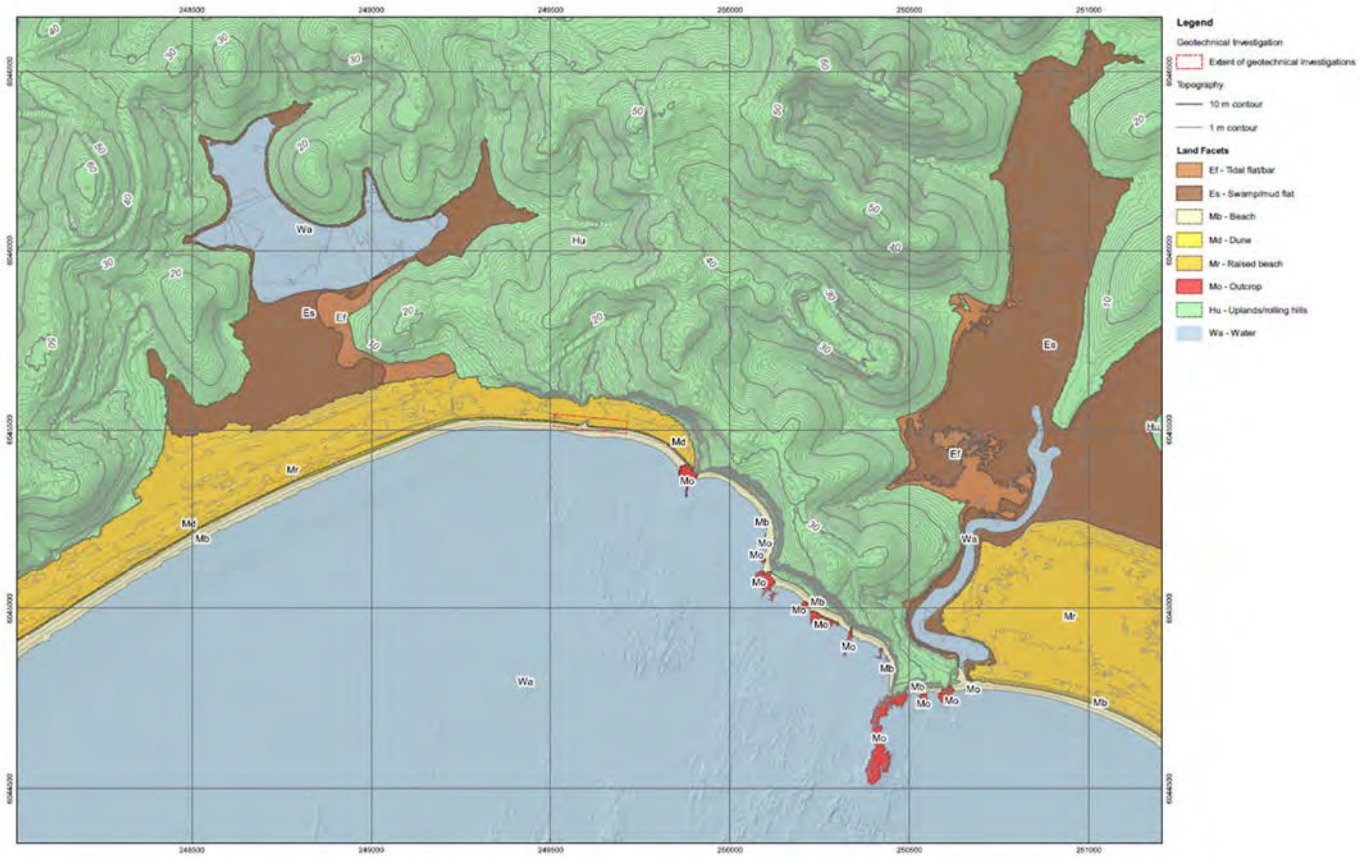
[2] Elvis – Elevation and Depth – Foundation Spatial Data, *https://elevation.fsdf.org.au/*

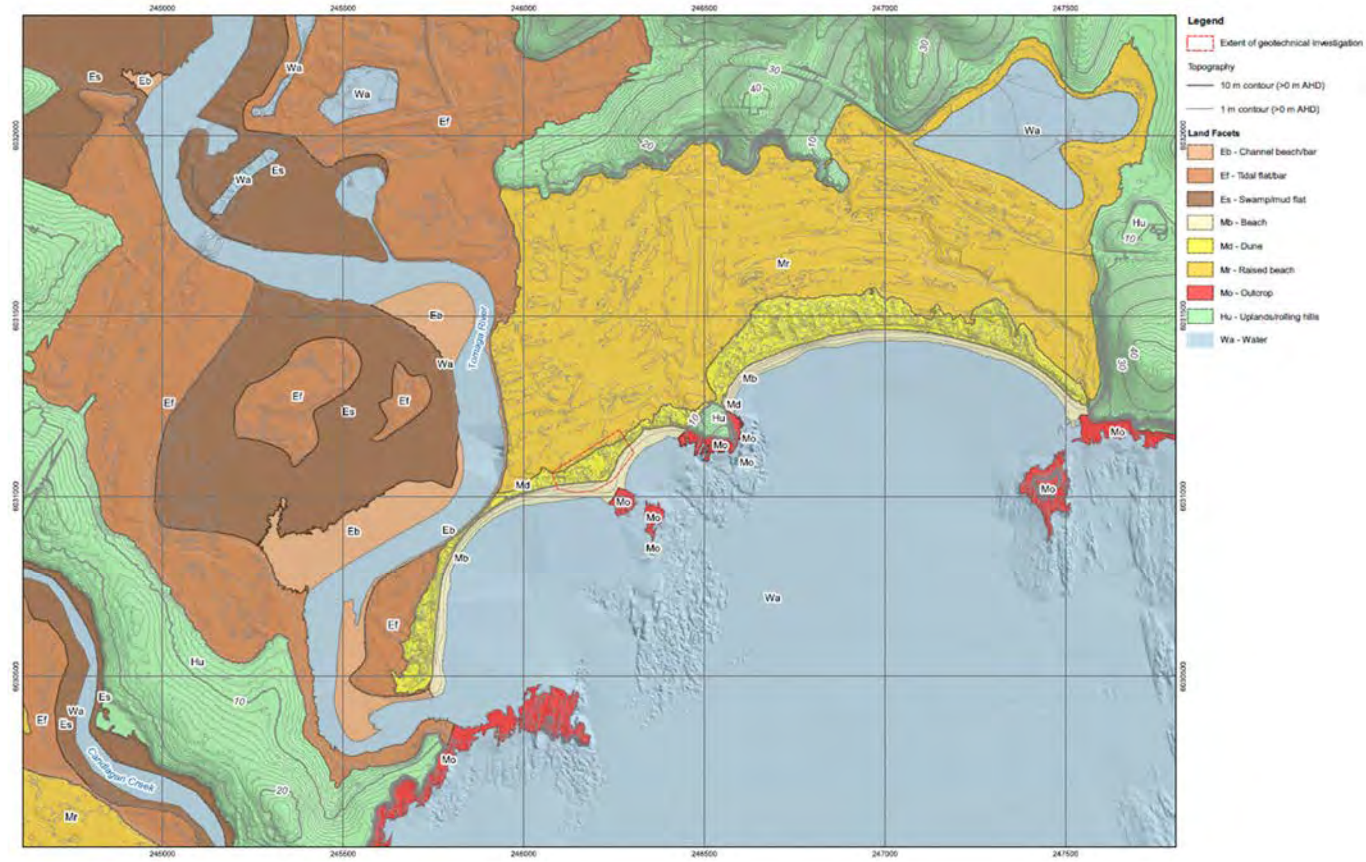
[3] WaterNSW Real Time Data, *https://realtimedata.waternsw.com.au/*



Inset 2: **Terrain classification for Surfside.**



Inset 3: **Terrain classification for Long Beach.**



Inset 4: Terrain classification for Tomakin.

Table 1 – Identified land systems and facets.

Land System	Land Facet	Symbol	Description and Anticipated Characteristics
Estuarine	Channel beach/bar	Eb	Sub-tidal bars and beaches within, and on the flanks of, active channels. Deposits typically several to tens of metres thick comprising sand with minor fines.
	Tidal flat/bar	Ef	Sub- to supratidal low slopes that are vegetated. Deposits typically several to tens of metres thick comprising sands, silts, and clays.
	Swamp/mud flat	Es	Intertidal low slopes that are waterlogged. Deposits typically several to tens of metres thick comprising clays and silts with minor sand.
Marine	Beach	Mb	Swash zone gently sloping towards coast. Typically, several to tens of metres thick comprising well-sorted sand.
	Dune	Md	Supra-tidal and back-of-beach, with rounded, shallow to moderate slopes. Typically, several metres thick comprising aeolian (wind-deposited) sands and minor silts.
	Raised beach	Mr	Perched behind beach/dune, with moderate ascending slope flanking seaward side, flat on top, and moderate descending slopes flanking landward side. Can also be terraced. Typically, several to tens of metres thick comprising well-sorted sand with minor silts and gravels.
	Intertidal outcrop	Mo	Intertidal wave-cut platform, shore platform, or coastal bench. Typically, flat but depends on underlying geology, comprising weathered bedrock and weathered subcrop covered by sand.
Uplands	Rolling hills	Hu	Terrestrial system at higher elevations, comprising concave footslopes, convex upper slopes and rounded ridges. Weathered bedrock overlain by colluvium of varying thickness.

4. Non-Intrusive Geotechnical Investigation

4.1 Introduction

The non-intrusive geotechnical investigation comprised:

- Field mapping – consisting of a site walk-over and engineering geological mapping undertaken between the 16th and 18th June 2021
- Geophysical surveys – undertaken during the week beginning 21st June 2021.

As intrusive investigations were not undertaken as originally planned, the results obtained from the non-intrusive fieldwork are the only data that is used to progress the conceptual models formulated during the desk study to observational engineering geological models.

4.2 Engineering Geological Field Mapping

4.2.1 Overview

Geotechnical ground-based mapping of exposures and geomorphological features was carried out to delineate and describe the various natural and man-made materials found in the study areas. Although this mapping focused on the study areas specifically, the regional area surrounding each site was also considered to understand the larger engineering geological setting. Field mapping sheets are attached in Appendix B.

Observations from the mapping campaign serves to inform the engineering geological models and understand the geotechnical character of the surficial soils and bedrock. Additionally, these observations compliment the non-intrusive geophysical investigations, with the aim of comparing the observed surficial materials with the geophysical profile.

Inset 5 presents an example of an observed outcrop, which was used to inform the likely bedrock profile in this geology. In this instance, the observed variability in the top of bedrock was noted as being a significant geotechnical characteristic that could be inferred to occur at depth below the soil profile.

Inset 5: Example of variability in the bedrock:soil interface (~4 m vertical drop over ~2 m horizontal) identified during the mapping campaign. In this example at Surfside North, the variable rock:soil interface is controlled by bedding structure in the rock.

4.2.2 Observed Geotechnical Units

The materials observed during the mapping campaign can largely be categorised into three geotechnical units:

- Marine/littoral deposits
- Colluvium, and
- Turbiditic bedrock.

A typical description of each geotechnical unit and associated land facets from the terrain classification is presented in Table 2 as observed during the mapping. It is expected there will likely be some variability in the geotechnical character of the units presented, however, without the benefit of the intrusive investigations, it is not possible to provide information on the nature of the geotechnical variability in each unit.

Table 2 – Typical geotechnical units and descriptions as observed in the mapping.

Geotechnical Unit	Associated Land Facets	Typical Material Description
Marine/littoral deposits	Mb – Beach Md – Dune Mr – Raised Beach	Sand, light brown, non-plastic with silt (variable proportions), slightly moist to wet, loose to medium dense, well graded.
Colluvium	Hu – Uplands	Silty gravel, low plasticity, with sand, moist, loose, poorly graded
Turbiditic bedrock	Hu – Uplands Mo – Outcrop	Turbidite (sequence of sandstone, siltstone, claystone, sandstone, chert), fine to medium grained, pale orange, brown, grey, very low to low strength, highly weathered.

4.3 Geophysical Surveys

4.3.1 Overview

Geophysical surveys were undertaken to investigate the possible distribution of material and depth to bedrock based on the observed seismic velocities. It is important to note that any geophysical investigation is an indirect method of testing the sub-surface conditions. Intrusive investigations are routinely used to ground truth and calibrate the results of geophysical investigations, which only measures the geophysical properties of the sub-surface.

4.3.2 Seismic Refraction (SRF) Survey

The seismic survey report is attached in Appendix C with the results summarised as follows:

- Marked seismic velocity contrasts were identified, increasing with depth, and providing a reasonable seismic profile across each SRF traverse
- Significantly higher velocities observed in the profile were attributed to seismic velocities associated with bedrock, although there is uncertainty in this assumption without testing from drilling
- Smaller differences in the seismic velocities in the upper profile were attributed to a possible shallow groundwater table, whereby the seismic velocities of saturated sediments (i.e., below the water table) are typically higher than dry sediments (i.e., above the water table)
- There is a degree of ambiguity in the measured seismic velocities and associated material interpretations for some layers at the Tomakin and Long Beach sites. This includes some ambiguity in the seismic velocities recorded in the vicinity of the buried seawall at Long Beach.

Overall, the results obtained from the SRF are considered reasonable for the purposes of this CMP.

5. Preliminary Engineering Geological Model

5.1 Surfside South

Based on the desk study and field mapping for Surfside South, the expected ground conditions for each land facet existing across the site comprises, Figure 1:

- Beach, dune and raised beach facets:
  - Marine/littoral deposits
  - Approximately 5 to 15 m thick, thinning out towards adjacent intertidal outcrop and rolling hill facets.
- Intertidal outcrop facets:
  - Turbiditic bedrock
  - Becoming sub-crop overlain by thin (<1 m) marine/littoral deposits adjacent to beach, dune, and raised beach facets.
- Rolling hills facets:
  - Colluvium of <1 m thickness

- Underlain by turbiditic bedrock.

The seismic section is reproduced in Figure 2, and indicates that seismic layer 2 (2,200 – 2,800 m/s) is interpreted as possibly being bedrock. Levels of this layer vary approximately between 2.3 m depth in the southeast and deepens to approximately 8 m depth towards the northwest. It is noted that this interpretation is based on typical seismic velocities only and is therefore assessed as having a low confidence.

Groundwater is expected to be close to or otherwise at surface, with several waterlogged areas noted during the field mapping. Seismic velocities of layer 1 (1,500 – 1,500 m/s) are also interpreted as being saturated sand.

5.2 Surfside North

Expected ground conditions for each land facet present at Surfside North comprises, Figure 3:

- Beach, dune and raised beach facets:
  - Marine/littoral deposits
  - At least 4 m thick (possibly up to tens of metres), and thinning out towards intertidal outcrop and rolling hill facets.
- Intertidal outcrop facet:
  - Turbiditic bedrock
  - Becoming subcrop overlain by thin (<1 m) marine/littoral deposits adjacent to beach, dune, and raised beach facets.
- Rolling hills facets:
  - Colluvium of <1 m thickness
  - Underlain by turbiditic bedrock.

The seismic section is reproduced in Figure 4, and indicates that seismic layer 3 (1,950 – 2,200 m/s) is interpreted as possibly being bedrock. Levels of this layer vary approximately between 3.5 m to 6 m depth. This interpretation is based on typical seismic velocities only and is again assessed as having a low confidence.

Groundwater is expected to be shallow, with several waterlogged areas noted during the field mapping. Seismic velocities of layer 2 (1,100 – 1,350 m/s) are also interpreted as being partially saturated to saturated sand.

5.3 Long Beach

Based on the desk study and field mapping undertaken at Long Beach, the expected ground conditions for each land facet within the area of interest comprises, Figure 5:

- Beach, dune and raised beach facets:
  - Marine/littoral deposits
  - Approximately 2 m thick in the centre of the study area (based on mapped intertidal sub-crop)
  - Thickening to several metres towards the west and east.

The location of the seawall structure at Long Beach is fairly evident at surface, being approximately 280 m in extent, as annotated in Figure 5. However, without the sub-surface intrusive investigations the depth of the seawall and its foundation conditions are not known.

The seismic section is reproduced in Figure 6 and indicates that seismic layer 4 (1,900 – 2,300 m/s) is possibly interpreted as bedrock. Levels of this layer vary approximately between 5 m to 11 m depth. Above this, the velocities associated with seismic layer 3 (1,700 – 1,950 m/s) are ambiguous and the possible materials are uncertain. The seismic velocities of this layer may either be indicative of weathered bedrock or a coarse grained soil such as gravel/sandy gravel with boulders. Intrusive investigations would be required to confirm the material type and geotechnical condition.

Groundwater is expected to be shallow, due to the proximity to the shoreline. Seismic velocities of layer 2 (600 – 1,450 m/s) are interpreted as being partially saturated sand.

5.4 Tomakin

Expected ground conditions for each land facet present within the study area at Tomakin comprises, Figure 7:

- Beach, dune and raised beach facets:
  - Marine/littoral deposits
  - At least 6 m thick (possibly up to tens of metres).

The seismic section is reproduced in Figure 8 and indicates that seismic layer 4 (2,000 – 2,100 m/s) is possibly interpreted as bedrock. Levels of this layer vary approximately between 7 m to 10 m depth. The velocities associated with seismic layer 3 (1,550 – 1,650 m/s) are ambiguous and the possible materials are uncertain. The seismic velocities of this layer may either be indicative of weathered bedrock or dense to very dense sand/gravel. Intrusive investigations are required to confirm the material type and geotechnical condition.

Groundwater is expected at moderate depths of approximately 5 to 6 m. The seismic velocities of layer 2 (600 – 950 m/s) are interpreted as being partially saturated sand at depths of 2.5 to 4 m.

6. Discussion and Recommendations

6.1 Qualifications

The work undertaken and presented in this report has provided a preliminary understanding of the geotechnical conditions at each of the four sites. The ground profile is inferred from the terrain classification, field mapping, and the seismic survey results, which includes interpretations of the possible sub-surface geological materials based on the seismic velocities only. Geophysical surveys are an indirect method of testing the sub-surface conditions and are routinely ground-truthed and calibrated by intrusive investigations. Without intrusive investigations, such as drilling and test pitting, the degree of confidence in the interpreted subsurface conditions based on the geophysical results is lower compared to interpretations that would include such intrusive investigation data. Further Investigations

To address the above qualifications and improve the preliminary engineering geological models for the sites, intrusive investigations are suggested. The amount of sub-surface geotechnical investigations can be optimised with the benefit of the work to date and to fit within the environmental and archaeological constraints of undertaking intrusive investigations. In summary the quantum of sub-surface work that could be undertaken in the future includes:

- A total of 5 no. machine-augered holes across the sites:
  - 2 no. at Surfside
  - 2 no. at Long Beach
  - 1 no. at Tomakin.
- Two (2) no. machine excavated test pits at Long Beach only, to assess the foundation conditions of the buried seawall.

Intrusive investigations would allow for the ground truthing of the geophysical results, in particular to associate the seismic velocities directly with material drilled or excavated and sampled from the sub-surface. This would allow for confirmation of the interpreted geological materials with the aim to resolve the uncertainties around ambiguous seismic velocity layers and expected variability in the sub-surface profile.

7. Closure

We trust this report provides the information you require for the CMP. We would be happy to answer any questions that may arise.

Yours Sincerely

BRENDON JONES
SENIOR ENGINEERING GEOLOGIST

MARK EGGERS
CHIEF ENGINEERING GEOLOGIST

8. References

Rose G., 1966, Ulladulla 1:250 000 Geological Sheet SI/56-13, 1st edition, Geological Survey of New South Wales, Sydney