NSW GOVERNMENT

Manly Hydraulics Laboratory

WAMBERAL BEACH
TERMINAL PROTECTION STRUCTURE
ENGINEERING DESIGN REQUIREMENTS

Report MHL2872
21 September 2022

Prepared for:

Central Coast Council

Central Coast Council

Department of Planning and Environment

Cover Photograph: Post-storm drone survey Wamberal Beach 29 June 2020. Source: MHL

Wamberal Beach
Terminal Protection Structure
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Foreword

These Engineering Design Requirements (hereafter termed Requirements) were developed by Manly Hydraulics Laboratory for Central Coast Council to assist developers, professional engineering designers and Council in the preparation and evaluation of development applications for coastal protection works at Wamberal Beach.

These Requirements are issued as Final and are classified as publicly available.

Feedback from public exhibition (July 2022) has been considered in the development of these Requirements.

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1 Introduction

1.1 Why were these Requirements developed?

The implementation of coastal protection works at Wamberal Beach is complex and requires informed co-ordination of various interested parties to improve on the ad-hoc and inadequate present situation, and to achieve appropriate protection against coastal erosion hazards while enhancing environmental and public amenity outcomes.

These Engineering Design Requirements (hereafter termed Requirements) were developed for Central Coast Council to assist developers, professional engineering designers and Council in the preparation and evaluation of development applications for coastal protection works at Wamberal Beach.

1.2 How should these Requirements be used?

This document provides Engineering Design Requirements to inform coastal protection development applications at Wamberal Beach. The Requirements will be used by Central Coast Council in-conjunction with the Environmental Planning and Assessment Act 1979, Section 27 of the Coastal Management Act 2016 and Chapter 2 (Coastal Management) of the State Environmental Planning Policy (Resilience and Hazards) 2021 to ensure legislative requirements are satisfied when assessing and granting consent for coastal protection development applications at Wamberal Beach. Development applications for coastal protection works at Wamberal Beach should demonstrate the use of these Requirements in detailed design drawings, technical specifications and construction management.

Development applications shall adhere to additional requirements under Council's Local Environmental Plan and Development Control Plan, and be developed in accordance with the Gosford Beaches Coastal Zone Management Plan (WorleyParsons, 2017), Coastal Management Act 2016 and the State Environmental Planning Policy (Resilience and Hazards) 2021. Council is preparing a Coastal Management Program (CMP) in accordance with the NSW Coastal Management Framework that will supersede the Coastal Zone Management Plan (2017) when certified.

It is noted that the NSW Department of Planning and Environment recently released in draft the *NSW Coastal Design Guidelines – For a thriving and resilient coast.* At the time of preparing the present Requirements, the document was unavailable and has not been explicitly considered in the development of these Requirements.

1.3 What do these Requirements contain?

These Requirements contain:

- Key criteria for seawall design (Section 2)
- Engineering Design Requirements for development applications for coastal protection works at Wamberal Beach (Section 3)

- Structural alignment requirements and alongshore considerations for coastal protection works at Wamberal Beach (Section 4)
- Closing remarks (Section 5)
- Appendices providing a list of relevant standards (Appendix A), geotechnical data review (Appendix B) and requirements for potential unexpected finds (Appendix C).

1.4 Further background and information

For further background and information please refer to the Wamberal Terminal Coastal Protection Assessment technical reports (Couriel et al., 2021, see Section 6 References).

2 Key criteria for terminal protection design

Following a review of the Wamberal Terminal Coastal Protection Assessment (Couriel et.al, 2021), community consultation and consideration of Council's role in relation to coastal erosion, Central Coast Council have developed key criteria for terminal protection (i.e., seawall) design at Wamberal Beach as shown in Table 2.1.

Table 2.1: Key criteria for seawall design at Wamberal Beach (Central Coast Council, 2022)

Criteria	Description
1	The seawall is to be located as far landward as possible, to reduce interaction with coastal processes and maximise available beach width
2	The seawall is to be located wholly on private property where possible
3	The seawall is to be constructed, owned and maintained by property owners
4	The seawall is to have the least sand nourishment requirements practicable to maintain beach amenity, both upfront and over the serviceable life of the structure.
5	The seawall is to include landscaping and materials that blend into the coastal environment and be designed to have a reduced vertical relief following the natural cross section of the foreshore.

All development applications for coastal protection works shall demonstrate that they meet Council's key criteria outlined in Table 2.1 and provide justification where deviation from these criteria is proposed.

These criteria have been considered in developing these Engineering Design Requirements.

In addressing these criteria and Requirements for engineering design listed in subsequent Sections of this document, coastal protection works must seek to enhance recreational and visual amenity on Wamberal Beach, demonstrating synergies with the natural backshore foredune environment.

3 Engineering Design Requirements

The following table provides Engineering Design Requirements for coastal protection development applications at Wamberal Beach. These Requirements must be demonstrated in development application submissions unless refined alternatives that are appropriately justified using evidence-based analysis are proposed by a suitably experienced and qualified professional engineer.

Table 3.1: Engineering Design Requirements for coastal protection works at Wamberal Beach

Item	Design requirement
Primary engineering standards and guideline references for seawall detailed design	• Coastal Engineering Manual (USACE, 2006) • Shore Protection Manual (CERC, 1984) • The Rock Manual: The use of rock in hydraulic engineering (CIRIA, 2007) • EurOtop: Manual on wave overtopping of sea defences and related structures (Pullen et al., 2018) • AS 4997-2005 Guidelines for the design of maritime structures • Design of Coastal Revetments, Seawall and Bulkheads (USACE, 1995)
Preferred seawall design configuration	All seawall designs should demonstrate that they meet Council's key criteria for seawall design preferences as outlined in Table 2.1 and design aspects covered in these Requirements.
Cross-shore positioning	All seawall elements are to be located at or landward of the seaward limit of the structure footprint shown in Figures 4.2 to 4.5. Any alternative alignment must demonstrate requirements outlined in Section 4.2. The seawall shall be located as far landward as practicable to minimise impact on coastal processes and beach amenity and shall be located fully on private land wherever feasible. The practicability of further landward adjustment to the alignment should be evaluated where the crest of an existing foredune erosion scarp is situated landward of the structure. Alignment requirements and alongshore considerations are further discussed Section 4.
Minimum initial design life	50 years (must be demonstrated/certified by design engineer)
Minimum design average recurrence interval (ARI)	Initial damage for non-rigid structures: 100–200 year ARI Failure for non-rigid structures or rigid structures: 500–2000 year ARI Any variation to minimum design ARI should be justified by the design engineer.

<table>
<tr><th>Item</th><th>Design requirement</th></tr>
<tr><td>Minimum serviceability criteria</td><td>Minimum serviceability criteria of structure including non-structural components as per table below. Detailed design drawings and specifications must specify procedures for routine seawall inspections following major storm events to assess damage and condition of the seawall with provision for maintenance works as required.

Detailed design drawings and specifications are to include explicit triggers and details to cater for sea level rise (SLR; see Criteria for addressing sea level rise and Adaptation to future sea level rise).

<table>
<tr><th rowspan="2">Average recurrence interval (ARI, years)</th><th rowspan="2">Encounter probability over 50-year period</th><th colspan="2">Minimum Maintenance / Serviceability Criteria</th></tr>
<tr><th>Non-rigid structure</th><th>Rigid Structure</th></tr>
<tr><td>≤20</td><td>≥92%</td><td>Damage to non-structural components.</td><td>Damage to non-structural components.</td></tr>
<tr><td>20-100</td><td>39-92%</td><td>Minor maintenance/repairs</td><td>Minor maintenance /repairs</td></tr>
<tr><td>100-500</td><td>10-39%</td><td>Damage affecting serviceability but not immediate integrity</td><td>Damage necessitating maintenance /repairs but not affecting immediate integrity</td></tr>
<tr><td>≥500</td><td>≤10%</td><td>Failure of structure</td><td>Failure of structure</td></tr>
</table>
</td></tr>
<tr><td>Maintenance Management</td><td>A Maintenance Management Plan (MMP) is to be prepared for the maintenance of the coastal protection works for the intended design life. The MMP is to be prepared by a suitably qualified coastal engineer and be approved by Council in writing prior to issue of the construction certificate.

The MMP is to include methods and location for access for periodic and post-storm maintenance. The applicant must provide a maintenance schedule for periodic inspections and demonstrate how post-storm damage will be assessed. Where major maintenance such as structural repairs is carried out, a copy of the compliance certification is to be provided to Council.

The MMP may be modified by the agreement of all landowners to which a particular section of contiguous coastal protection works apply and with the approval of Council.</td></tr>
</table>

<table>
<tr><th>Item</th><th>Design requirement</th></tr>
<tr><td>Concept design ocean conditions</td><td>Offshore ocean conditions adopted for seawall concept designs are provided in the table below and are values derived from MHL2780 (Couriel et al., 2021) and Watson (2022). Adopted detailed design ocean parameters must be specified and may be refined to account for alongshore variability in wave exposure and depth-limited design conditions at the toe of the structure in accordance with the Coastal Engineering Manual (USACE, 2012) and physical modelling.
<table>
<tr><th colspan="2">Parameter</th><th>Concept design value</th></tr>
<tr><td colspan="2">Annual Recurrence Interval (ARI) for initial damage of non-rigid structures and serviceability of rigid structures</td><td>100 year ARI[a]</td></tr>
<tr><td rowspan="3">Design conditions for initial damage of non-rigid structures</td><td>Offshore wave height for 3h duration (Hs)</td><td>8.7 m</td></tr>
<tr><td>Peak spectral offshore wave period (Tp)</td><td>13 s [b]</td></tr>
<tr><td>Ocean water level (excluding wave setup & SLR)</td><td>+1.46 mAHD [d]</td></tr>
<tr><td colspan="2">Annual Recurrence Interval (ARI) design failure of rigid and non-rigid structures</td><td>500 year ARI[a]</td></tr>
<tr><td rowspan="3">Design conditions for failure of non-rigid and rigid structures</td><td>Offshore wave height for 3h duration (Hs)</td><td>9.8 m [c]</td></tr>
<tr><td>Peak spectral offshore wave period (Tp)</td><td>13 s [b]</td></tr>
<tr><td>Ocean water level (excluding wave setup & SLR)</td><td>+1.51 mAHD [d]</td></tr>
</table>
[a] Joint probability of adopted wave and water level conditions not considered.
[b] Based on Hs-Tp joint occurrence analysis of Sydney wave buoy data from March 1992 to December 2019
[c] Extrapolated from Fort Denison water level and Sydney wave height exceedance curves.
[d] From Determining Extreme Still Water Levels for Design and Planning Purposes Incorporating Sea Level Rise: Sydney, Australia. (Watson, 2022)</td></tr>
<tr><td>Criteria for addressing sea level rise (SLR)</td><td>Sea level rise (SLR) projections adopted in design should be specified and be consistent with the Council’s latest SLR policy at the time of detailed design works being undertaken.

In the absence of Council having a prescribed sea level rise policy, it is recommended that SSP5-8.5 sea level projections are used for the time horizon of interest from the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (Fox-Kemper et al., 2021).

Variations to the above sea level rise projections may be considered. Where a variation is proposed, it shall be supported by a report prepared by a suitably experienced and qualified professional engineer.

A Bruun recession factor of 43 (that is that horizontal shoreline recession due to sea level rise of 43 times the magnitude of sea level rise will be considered) was determined for Wamberal Beach as part of the Hazard Definition Study (WorleyParsons, 2014).</td></tr>
<tr><td>Underlying recession rate</td><td>An underlying recession rate of 0.2 m/year was determined for Wamberal Beach as part of the Hazard Definition Study (WorleyParsons, 2014).</td></tr>
<tr><td>Adaptation to future sea level rise</td><td>Detailed designs shall specify an adaption pathway to future sea level rise and environmental conditions beyond the design life of the structure (see also Minimum Serviceability Criteria above).</td></tr>
</table>

<table>
<tr><th>Item</th><th>Design requirement</th></tr>
<tr><td>Seawall crest level and wave overtopping thresholds.</td><td>
Crest levels adopted in prior detailed design for a sloped Seabee structure ranged from 6 to 8 m AHD dependent on the seawall make-up and alongshore distribution of design wave and water level conditions (Couriel et al., 1998).

Detailed design shall specify crest levels along the structure commensurate with adjacent seawall serviceability and be determined by a suitably experienced and qualified professional engineer. Crest levels shall consider alongshore variability in design wave exposure, wave runup and overtopping, safety to property and people, adjoining foreshore/dune and/or berm slopes, elevations and crest levels of any adjoining structures.

Physical modelling shall be undertaken to confirm the final design crest level unless it can be explicitly demonstrated that adequate factors of safety are built into the design.

Wave return features may be incorporated in detailed designs to reduce wave overtopping hazards to people and property. Wave return designs and foreshore drainage systems should be validated and optimised for performance using physical modelling.

Safe overtopping thresholds for various hazard types are provided below from EurOtop (2018).

<table>
<tr><th>Hazard type</th><th>Mean overtopping q
(l/s per m)</th><th>Max Volume V_{max}
(l per m)</th></tr>
<tr><td>People at structures with possible violent overtopping, mostly vertical structures</td><td>No access for any predicted overtopping</td><td>No access for any predicted overtopping</td></tr>
<tr><td>People at seawall / dike crest. Clear view of the sea.
H_{m0} = 3 m
H_{m0} = 2 m
H_{m0} = 1 m
H_{m0} < 0.5 m</td><td>
0.3
1
10-20
No limit</td><td>
600
600
600
No limit</td></tr>
<tr><td>Building structure elements; H_{m0} = 1-3 m</td><td>≤1</td><td><1,000</td></tr>
<tr><td>Damage to equipment set back 5-10m</td><td>≤1</td><td><1,000</td></tr>
<tr><td>Grass covered crest and landward slope; maintained and closed grass cover; H_{m0} = 1 – 3 m</td><td>5</td><td>2,000-3,000</td></tr>
<tr><td>Damage to paved or armoured promenade behind seawall</td><td>< 200</td><td>Not provided</td></tr>
</table>
</td></tr>
<tr><td>Design scour level</td><td>An adopted design scour depth shall not be above -2 m AHD unless geotechnical investigation or coastal engineering studies support alternative design scour depth and/or scour protection design.</td></tr>
<tr><td>Wave overtopping, runoff and property drainage</td><td>Detailed design shall account for return flow drainage including wave overtopping return flows, rainfall runoff and interactions with adjacent property drainage.</td></tr>
</table>

Item	Design requirement
Rock armour and/or toe structure elements	General • individual rocks shall be free from cracks, cleavage planes, seams, defects and the like, which would result in the breakdown of the rock in a marine environment • rock shall be rough and angular • the ratio of the maximum dimension of any rock to the minimum dimension, measured at right angles to the maximum dimension, shall not exceed 2.5 • armour rock shall be individually placed, not rolled or dropped into position • placed rocks shall be wedged and locked together such that they are not free to move and have at least three points of contact Sandstone • minimum dry density 2,300 kg/m³ • water absorption less than 1.5% • saturated point load strength index (Is50) greater than 1.5 MPa sodium soundness weight loss less than 9% • wet/dry strength variation less than 30% Igneous • minimum dry density 2,650 kg/m³ • saturated point load strength index (Is50) greater than 5.0 MPa • sodium soundness weight loss less than 12% • no more than 15% (by volume) olivine and no zones of secondary alteration such as chloritisation • no signs of stress relief All rock armour should be tested for durability to assess its ability to retain physical and mechanical properties throughout a serviceable design life in an open coast marine environment. Refer to CEM Part VI (2006) and CIRIA (2007) for rock armour element design guidance. See list of standards in Appendix A
Concrete elements	All concrete elements shall be designed in accordance with AS 4997-2005 Guidelines for the design of maritime structures and be tested to provide sufficient engineering properties throughout a serviceable design life in an open coast marine environment. Refer to CEM Part VI (USACE, 2006) for further design guidance. See list of standards in Appendix A
Steel elements	All steel elements shall be designed in accordance with AS 4997-2005 Guidelines for the design of maritime structures and be tested to provide sufficient engineering properties throughout a serviceable design life in the open coast marine environment. Refer to CEM Part VI (USACE, 2006) for further design guidance. See list of standards in Appendix A

Item	Design requirement
Rock filled bags elements	All rock filled bag elements shall be designed in accordance with AS 4997-2005 Guidelines for the design of maritime structures and be tested to provide sufficient engineering properties throughout a serviceable design life in an open coast marine environment. Durability and engineering design performance of rock filled bag elements shall be verified and certified by a suitably experienced and qualified professional engineer. See list of standards in Appendix A
Other elements	All other elements shall be designed in accordance with AS 4997-2005 Guidelines for the design of maritime structures (where relevant) and be demonstrated and certified to provide sufficient engineering properties throughout its serviceable design life in an open coast marine environment without creating environmental or public health or amenity hazards. See list of standards in Appendix A
Physical modelling for design verification and optimisation	Detailed design can benefit greatly from physical modelling to verify and optimise details. Physical modelling is recommended for all designs; however, it is mandatory when seawall designs comprise innovative and untested rigid elements such as wave return walls, integrated access stairways, balustrading or composite structures. Where designers elect not to undertake physical modelling, adequate factors of safety in design must be demonstrated. The value of physical modelling to minimise factors of safety, verify design performance and identify / mitigate any unexpected hydrodynamic effects and consequences is well recognised in the international coastal engineering community and supported by all authoritative coastal engineering references.
Terminal end controls	Where works are undertaken in staged approach (during and after construction), temporary and in some cases permanent terminal end controls to protect adjacent properties in regions of end-erosion shall be accounted for in detailed design and be undertaken by a suitably experienced and qualified professional engineer. Design of terminal end controls shall specify a design level of protection and design life. This includes all staged construction works including those contributing to a staged completion of a lagoon-to-lagoon structure. Design of coastal protections works including terminal end controls must comply with legislative requirements under Section 27 of the Coastal Management Act 2016.

Item	Design requirement
Lagoon end termination	Detailed designs situated at the southern and northern extremities of a lagoon-to-lagoon structure shall be undertaken in-conjunction with detailed design of seawall end termination structures (at 1 Pacific St and Wamberal SLSC). Transitions to termination structures should demonstrate alongshore uniformity and be correctly designed with smoothed transitions between any changes in seawall configuration. Termination of seawall structures in the vicinity of lagoon entrances shall examine structural stability during rare to extreme flood events as well as design coastal events and account for potential interactions with lagoon entrance processes. Detailed design of termination points at Lagoon ends should minimise encroachment impact on both coastal and lagoon entrance processes and be sufficiently designed to mitigate or limit the potential for outflanking.
Alongshore uniformity	The design should demonstrate alongshore (lagoon to lagoon) uniformity and be correctly designed with smoothed transitions between any changes in seawall configuration. Transitions in seawall configurations should be guided by engineering design integration between adjacent structures and should also consider synergies with existing (or enhanced) backshore landscapes and interaction with coastal processes during design conditions.
Interaction with adjoining properties or works	The seawall design shall integrate with adjacent seawall structures and shall not adversely affect the performance of adjacent seawall works. Seawall works should specify suitable terminal end controls to mitigate the risk of end erosion to adjacent properties (see *Terminal end controls*). Design of coastal protections works shall consider potential interaction with adjacent beach or properties and must comply with legislative requirements under Section 27 of the Coastal Management Act 2016.

Item	Design requirement
Sand nourishment for beach amenity	Construction of any seawall shall be accompanied by a sand nourishment program to maintain sandy beach amenity in accordance with the Gosford Beaches CZMP (WorleyParsons, 2017) and Section 27 of the Coastal Management Act 2016. Sand nourishment shall account for: • projected sea level rise recession and historical underlying recession over the design life of the structure • any seawall encroachment impacts on available beach area (not required for seawall works located at or landward of the structure footprint limit shown in Figures 4.2 to 4.5). Ongoing beach monitoring shall be adopted to inform and optimise repeat nourishment works. Any sand brought to the beach from outside the native beach system as part of the works should conform to the *Sand nourishment sediment properties* specified in these Requirements. Sand nourishment activities shall be undertaken in accordance with appropriate legislation and environmental impact assessment requirements. Council will be responsible for developing and implementing a sand nourishment program in the future and may introduce a coastal protection charge as part of funding it. The sand nourishment triggers and replenishment volumes to maintain beach amenity are to be reviewed periodically.
Sand nourishment sediment properties	Any sand brought to the beach from outside the native beach system as part of the works should conform to the properties below: Median grain size D50 (mm): 0.35 to 0.55 mm (medium grained sand) Sorting: Well-sorted (uniformity coefficient < 2). No more than 5% by weight fines (<0.075 mm), less than 10% by weight of grain sizes larger than 1.0 mm, and no material larger than 5 mm grain size. Foreign matter: The total proportion of silt, clay vegetation or other foreign matter, shall not exceed 5% by weight. Mineral composition: Quartz sand with low carbonate fraction Colour: Dull yellow See Guidelines for Sand Nourishment (Carley and Cox., 2017) for further design guidance.

Item	Design requirement
Ongoing structure and beach monitoring requirements	Construction of any seawall shall be accompanied by an ongoing monitoring program by asset owners that includes: • structure condition inspections after events with high wave exposure at the structure to maintain serviceability and identify repairs to potential damages. • beach monitoring by Council to inform of the condition of the beach over the life of the structure including regions fronting and adjacent to the structure. • beach monitoring by Council shall also be undertaken to determine requirements for sand nourishment to maintain beach amenity.
Access for maintenance	The seawall design shall include consideration of the need for access for future maintenance. This should be undertaken via a corridor with minimum width of 3 m between the rear crest of the structure and adjacent buildings. This maintenance corridor is required to be kept unimpeded by structures (except for minor landscaping) and consist of compacted granular material to support loading of maintenance plant and design drainage. If this cannot be achieved, alternative access for seawall maintenance must be specified by the design engineer as part of the development application.
Minimum level of geotechnical investigation prior to design	A geotechnical investigation shall be conducted at the property as part of the seawall design process to confirm, among other things, the extent of existing rock/ad-hoc materials and geotechnical properties of the dune substrate including the geotechnical properties of any bedrock units present. The investigation shall be carried out by a suitably qualified engineer. The investigation shall include, as a minimum, excavation of three test pits along the proposed seawall alignment, with the pits generally aligned perpendicular to the seaward property boundary. A review of the adequacy of available geotechnical knowledge of the proposed location for detailed design should be undertaken and used to inform of any further geotechnical investigations required. A summary of available geotechnical information for Wamberal Beach is provided in Appendix B (from MHL2780, 2021).
Sand excavation and placement	All sand excavated during the construction of the seawall shall be screened (to remove any oversized materials, sediment greater than 5mm grain size, foreign matter and vegetation) and placed seaward of the works with any necessary fill landward of the seawall comprised of the separated materials (if suitable) and/or suitable clean fill that would be imported to the site. This will maximise the amount of sand added to the beach area as a result of the works. Sand won from the works shall be placed on the beach immediately seaward of the seawall above 0.0 m AHD and spread uniformly along and across the beach.

Item	Design requirement
Seawall burial and revegetation	In areas of the beach that are naturally wider with established foredunes (see Figures 4.2 to 4.5), seawall works are to be buried and covered by sand won during excavation (screened as per *Sand excavation and placement*) and revegetated with native foredune flora. Reburial of the seawall should aim to achieve a similar topographic profile (within +/-0.25 m) to that prior to works as measured via a pre-works survey of the foredune. In narrower areas of the beach where maintenance of a buried seawall is not feasible, landscaping and design configuration should seek to enhance beach amenity and demonstrate synergies with the native backshore foredune environment. Re-vegetation is to be undertaken in accordance with Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques (DLWC, 2001).
Requirements for contamination assessment and remediation	There is potential to encounter hazardous materials (such as asbestos) and other non-native materials (such as dilapidated building materials) along the entire foreshore of the works. Refer to Appendix B for a summary of previous documentation on materials present in beach substrate (from MHL2780, 2021). Management of contaminated lands shall be undertaken in accordance with the NSW Environmental Protection Authority (EPA) requirements including the Contaminated Land Management Act 1997, State Environmental Planning Policy (Resilience and Hazards) 2021 Chapter 4 Remediation of land, NSW EPA Waste classification guidelines and, Managing Land Contamination - Planning Guidelines. A waste management plan must be prepared for the development. The Plan must be in accordance with the Council's Development Control Plan. The plan is to outline: 1. Estimated volume and type of waste material(s) 2. Identify volume and type of material to be used for re-use 3. Identify method to separate, screen and ensure compliance for material reuse 4. Address how waste will be managed onsite and methods for disposal at licensed waste handling facility 5. Identify process for unexpected finds (aboriginal artifacts). Refer to Appendix C for potential unexpected finds protocol requirements. The plan should include procedures for handling, disposal and remediation of asbestos or any other contamination. Implementation of the plan should ensure that any demolition and construction waste, including excavated material is reused, recycled or disposed of in an environmentally friendly manner.

Item	Design requirement
Removal/reuse of foreign materials in beach and dune substrate	All existing foreign material and rock present in the beach substrate seaward of the seawall must be removed or reused (where suitable) during seawall construction and be replaced by an equivalent volume of sand nourishment and graded to the level of the natural beach berm or foredune seaward of the seawall as specified under S*and excavation and placement*. Depending on the seawall design, suitable existing ad-hoc and emergency rock protection present in the beach and dune substrate may be incorporated as part of the seawall design where practicable. Suitability of reused material should be determined by an experienced and qualified professional engineer. Any reused rock material is to be placed landward of the seaward limit of structure footprint shown in Figures 4.2 to 4.5. Any rock placed seaward of this limit will be required to demonstrate requirements outlined in Section 4.2. Where not suitable for reuse, any existing ad-hoc material and emergency rock protection works seaward of the seawall must be removed during construction to enhance beach amenity. Properties of sand sources shall conform to nourishment characteristics as provided under *Sand nourishment sediment properties*. Management of contaminated lands shall be undertaken in accordance with the NSW Environmental Protection Authority requirement. See *Requirements for contamination assessment and remediation*. The reuse, recycle or dispose of all materials shall be undertaken in accordance with the Waste Management Plan submitted with the subject application. Geotechnical investigation prior to works should confirm the nature and extent of foreign material in the beach substrate. Refer to Appendix B for a summary of previous documentation on materials present in beach substrate (from MHL2780, 2021). Refer to Appendix C for potential unexpected finds protocol requirements.
Environmental impact assessment	All development applications shall undertake environmental impact assessments in accordance with appropriate environmental legislation.
Other environmental aspects	All development applications shall minimise impacts to the environment and demonstrate beneficial environmental outcomes and enhanced backshore ecology where possible (e.g., environmentally friendly design and landscaping). Designs that demonstrate beneficial environmental outcomes are preferred. Refer also to *Seawall burial and revegetation.*

Item	Design requirement
Public safety	All development applications shall minimise impacts to beach user safety during construction and over the serviceable life of the structure. Development applications shall facilitate safe beach user activities and shall not impede safe access to the beach, safe beach user area, private homeowner safety, safe water entry and surf life saving activities. Beach user safety impacts of any proposed seawall structure should be assessed during post-storm eroded and accreted beach conditions. Design of seawall structures shall mitigate safety hazards associated with vertical relief. See *Mitigating impacts of vertical relief.*
Beach accessways	Beach access shall be incorporated into the design at existing public beach accessways and at designated private accessway locations to be determined as part of detailed design. Private beach access must be wholly located within the private boundary. Private beach access must be designed by a suitably qualified engineer during the detailed design phase and demonstrate the structure can withstand wave interactions during design conditions. Design of private accessway locations should evaluate the benefits of neighbour-shared accessways in consultation with private homeowners. Any rights of access will need to be determined and agreed upon as part of the development application. Post-construction of private beach access may not be considered. Design of accessways shall maintain safe beach access during both post-storm eroded and accreted conditions with consideration of changing sand levels and vertical relief, dune scarping and public safety. Structures with rock placement at the toe should not impede on safe beach access. In regions of wider beach (Figures 4.2 to 4.5) with buried seawalls, designs shall maintain public sand accessways similar to those existing prior to works. During narrow beach conditions the design shall accommodate emergency landings and egress for beach users, providing safety from wave runup hazards. For rigid structures accessways should be incorporated via integrated staircase designs that have been assessed for their hydraulic efficacy and interactions with beach processes under design conditions. Timber staircase may be included in designs for non-rigid structures or composite designs. Any public accessways that have been disturbed/removed or otherwise as a result of the Works shall be restored prior to the completion of the Contract. Safe private and public access should be maintained over the serviceable life of the structure.

Item	Design requirement
Mitigating impacts of vertical relief	Vertical seawall designs shall mitigate safety and visual amenity impacts associated with vertical relief (i.e., the vertical distance from crest of the structure to the fluctuating natural sand level fronting the seawall). Design considerations to mitigate impacts of vertical relief shall consider one or more of the following (not limited to): • Tiering (or cascading) of the seawall every 2 m (or less) rise in elevation for levels at and above 4 m AHD. • Composite design incorporating a sloped region (e.g., rock armour, rock bag or Seabee units) in the upper portion of the structure above 4 m AHD. • Landscaping / vegetation in the upper portion of the structure above 4 m AHD. • Maintaining a buried seawall by sand and vegetation covering where feasible (particularly in wider regions of the beach as per Figures 4.2 to 4.5). Seawall configuration features to mitigate vertical relief should be designed by a suitably experienced and qualified engineer and provide adequate engineering performance during design storm conditions.
Landscaping, Aesthetics and Amenity	Landscaping must be incorporated into the design to enhance visual amenity and to blend the seawall structure to the natural backshore foredune topography and environment. A landscape plan shall be submitted which specifies: • Design components which assist to blend the design into the natural environment. For rigid structures, this should consider design aspects such as seawall geometry, concrete tinting and/or finishes, and features to enhance visual aesthetics. • Any flora species to be planted. Note, species cannot be planted that: compromise the seawall integrity, identified as state prohibited species or will have a visual impact to neighbouring properties. Re-vegetation is to be undertaken in accordance with Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques (DLWC, 2001). Seawall designs along existing public accessways shall also incorporate access with provision where possible of public beach user facilities such as viewing platforms, seating, shower facilities and rubbish disposal. The design shall mitigate visual amenity impacts of large vertical relief (see *Mitigating impacts of vertical relief*), include provision of sand burial/vegetation covering where possible and not impede on safe public access. The design of the seawall should be located as far landward as practicable and with structural footprints that do not adversely encroach into the active beach region and public land. Non-native materials existing within the beach and dune substrate seaward of the seawall must be reused or removed and correctly disposed of during construction. See *Removal/reuse of foreign materials in beach and dune substrate*. Shadow modelling diagrams shall be included as part of the development application to assess shadowing impacts of the development relative to the existing environment.

Item	Design requirement
Construction impacts and schedule	A construction management plan must be prepared. The plan shall include as a minimum the following: a) Proposed method of access to and egress from the site for demolition, excavation and construction vehicles, including routes through Council owned or managed land and the location and type of temporary vehicular crossing for the purpose of minimising traffic congestion and noise in the area, with no access across public parks or reserves being allowed without Councils Consent being granted. b) The proposed method of loading and unloading. demolition, excavation and construction machinery, excavation and building material, formwork and the erection of any part of the structure within the site including temporary fencing. c) The location and operation of any onsite crane. d) Proposed method for sand bunding/construction buffers. Must include: location, extent of area, materials used and demonstrate negating impacts to tidal processes. Must also describe how the bunding will be managed during and post-storm event. e) Construction schedule outlining construction time frames demonstrating effort to minimise time on the beach. f) Outline method to address customer enquiries/complaints i.e., onsite signage with project manager contact details. g) Vegetation plan for protection of existing flora, for e.g., barriers around mature trees (Norfolk Island Pines) to avoid damage during construction. The construction management plan should ensure appropriate measures have been considered for site access, storage and the operation of the site during all phases of the construction process in a manner that respects adjoining owners' property rights and protects amenity in the locality, without unreasonable inconvenience to the community.
Drawings and visual aids	The Development Applications shall provide detailed design drawings that as a minimum include a plan view, cross-sectional views, and artistic render impressions of the proposed works. All drawings and renders should show the beach in both post-storm eroded and typical accreted conditions, with references to beach survey datasets and dates used. Artistic renders shall include fly-over impressions from a beach user perspective of the development to visualise proposed works in both post-storm eroded and typical accreted beach conditions.
Certification requirements	The Applicant shall submit a suitably qualified Civil Engineer's certification that the design drawings and completed works have been constructed in accordance with the Development Application consent, Central Coast Council's DCP (Former Gosford Council DCP) and the approved Construction Certificate plans. The development is required to be carried out in accordance with all relevant Australian Standards. Details demonstrating compliance with the relevant Australian Standards are to be submitted to the Certifying Authority. The coastal protection works must be maintained in accordance with development consent, conditions approved plans and specifications. Maintenance must be to a standard that does not compromise the protection or integrity of the adjoining land.
Certification post	The construction of the seawall shall be certified by a suitably experienced and qualified professional engineer.

Item	Design requirement
Basis of design statement	A Basis of Design (BoD) statement shall be prepared as part of the seawall design process and submitted with the Development Application. The BoD shall clearly state all of the design factors, assumptions and qualifications adopted in the design, including specific reference to the above design criteria.
Surveying	Seawall construction must include surveys of the site (including beach and foredune) prior to works, during works (including structure specifications toe and crest positions) and within 4 days after completion of works.
Work-as-executed drawings	The developer(s) must supply to Council one electronic set of the Drawings upon which the developer shall mark all alterations to the work other than those covered by amended or new drawings issued to and approved by Council. Drawings should also be provided and marked in AutoCAD formats showing work as executed details.
Relevant Legislation	The development is required to be carried out in accordance with all relevant legislation. A list of relevant legislation to the development shall be submitted as part of the development application.

4 Alignment requirements and alongshore considerations

4.1 Basis of alignment requirements

This section provides alignment requirements and alongshore considerations for coastal protection development applications at Wamberal Beach. The alignment requirements and alongshore considerations have been developed based on:

- a primary objective to align the seawall as far landward as practicable to minimise encroachment into the active beach profile and lessen impacts on amenity, while maintaining whole of embayment uniformity within the constraints of adjacent existing developments and setback requirements to provide sufficient maintenance and adaptation space.
- the landward (rear-of-structure) crest alignment adopted in the detailed design of the former Seabee seawall design for Wamberal Beach (Couriel et al., 1998; MHL, 2004). Extensive work was undertaken in determining the former design alignment including detailed design assessment of wave overtopping, detailed design of terminal ends, community consultation and negotiations with individual property owners, detailed design refinement using physical model testing (Couriel et al., 1998) and certified environmental impact statement assessments (MHL, 2003).
- a recent review of the former rear-of-structure design alignment (Couriel et al., 1998; MHL, 2004) for updated seawall concept design development as documented in MHL2780 (Couriel et al., 2021) and assessment of amenity impacts in MHL2779 (Couriel et al., 2021).
- Council's key criteria for seawall design as provided in Table 2.1.

A seaward limit of the structure footprint was determined based on the toe alignment of a vertical seawall concept design (MHL2780 Couriel et al., 2021), located approximately 0.9 m seaward of the former rear-of-structure alignment. A recent coastal protection amenity impact assessment undertaken by Couriel et al. (MHL2779, 2021) found this alignment to have the least encroachment impacts on active beach processes and available beach use area, improving on the existing state of ad-hoc materials and emergency works at Wamberal Beach.

No seawall works are to be located seaward of this alignment unless exemption requirements outlined in Section 4.2 are provided.

The following factors have not been considered in determining alignment requirements and warrant further consideration in detailed design:

- Detailed design setback requirements for wave overtopping with design crest level refinements.
- Detailed design implications to ensure structural stability and safety (including vertical relief – particularly during and immediately after major coastal erosion events).

- Private homeowner consultation and detailed property-by-property assessment including implications of alignment on other structures such as decks, patios, beach access, fences, walls and awnings located in the structure footprint.
- Detailed design setback requirements for structure maintenance.
- Detailed design implications on alignment of localised bedrock outcrops and geotechnical considerations.
- Detailed design of termination points at Lagoon ends to minimise encroachment and impact on both coastal and lagoon entrance processes.
- Future sand nourishment programs to maintain beach width for amenity and public use purposes.

4.2 Exemptions to alignment requirements

The alignment requirements and alongshore considerations must be demonstrated in development applications unless refined alternatives are proposed that are appropriately justified using evidence-based analysis by a suitably experienced and qualified professional engineer.

Any alternative alignments should include an assessment and appropriate mitigation measures (where required) of any encroachment impacts of the structure into the active beach region and beach user area over the design life of the structure. Any alternative alignment proposals must adopt an integrated approach with all adjacent properties that deviate from the seaward limit of structure footprint presented in these Requirements.

Evidence and justification for alternative alignments will be reviewed as part of the development application assessment process.

4.3 Divisions for staged seawall construction

Staged construction of a lagoon-to-lagoon structure should be done in a co-ordinated manner that maintains alongshore uniformity of design, includes sufficiently designed end erosion control measures during staged works and is supported and agreed to by all affected individual property owners.

Three divisions for staged seawall construction have been specified by Central Coast Council and are shown in Figure 4.1 and Table 4.1.These include:

A. Northern region (1 Calais Rd to Wamberal SLSC)

B. Central region (27 to 109 Ocean View Dr)

C. Southern region (1 Pacific St to 25 Ocean View Dr)

Private property owners are responsible for preparing and lodging development applications and this shall generally comprise no more than one application for each of the three divisions outlined above. This is to support the coordination of a lagoon-to-lagoon structure that maintains alongshore design uniformity in accordance with the Requirements outlined in Section 3.

Alignment requirements and alongshore considerations are outlined for each of the divisions in the following sections. It is acknowledged that some flexibility with development applications with construction sequencing may need to be applied to each of the divisions.

Figure 4.1: Divisions for staged seawall construction

Table 4.1: Properties included in divisions for staged seawall construction

Section	Properties
A	End termination at Wamberal SLSC. Public beach accessway Dover Rd. Numbers 1, 3, 5, 7, 9, 11, 13, 15 & 17 Calais Rd. Public beach accessway Surfers Rd.
B	Numbers 2 & 4 Surfers Rd. Numbers 27, 29, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59-61, 63, 65, public beach accessway, 67, 69 -71 (DPE lots), 73, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 101, 103A & 105 Ocean View Drive.
C	Public beach accessway Ocean View Dr. Numbers 23A, 23B, 23C, 25B & 25A & 25 (DPE lots) Ocean View Drive. Numbers 1, 3, 5, 7-9, 11, 13, 15, 17, 19, 21, 23A, 23, 25, 29, 31 & 33 Pacific St. End termination at 1 Pacific St.

4.3.1 A) Northern region (1 Calais Rd to Wamberal SLSC)

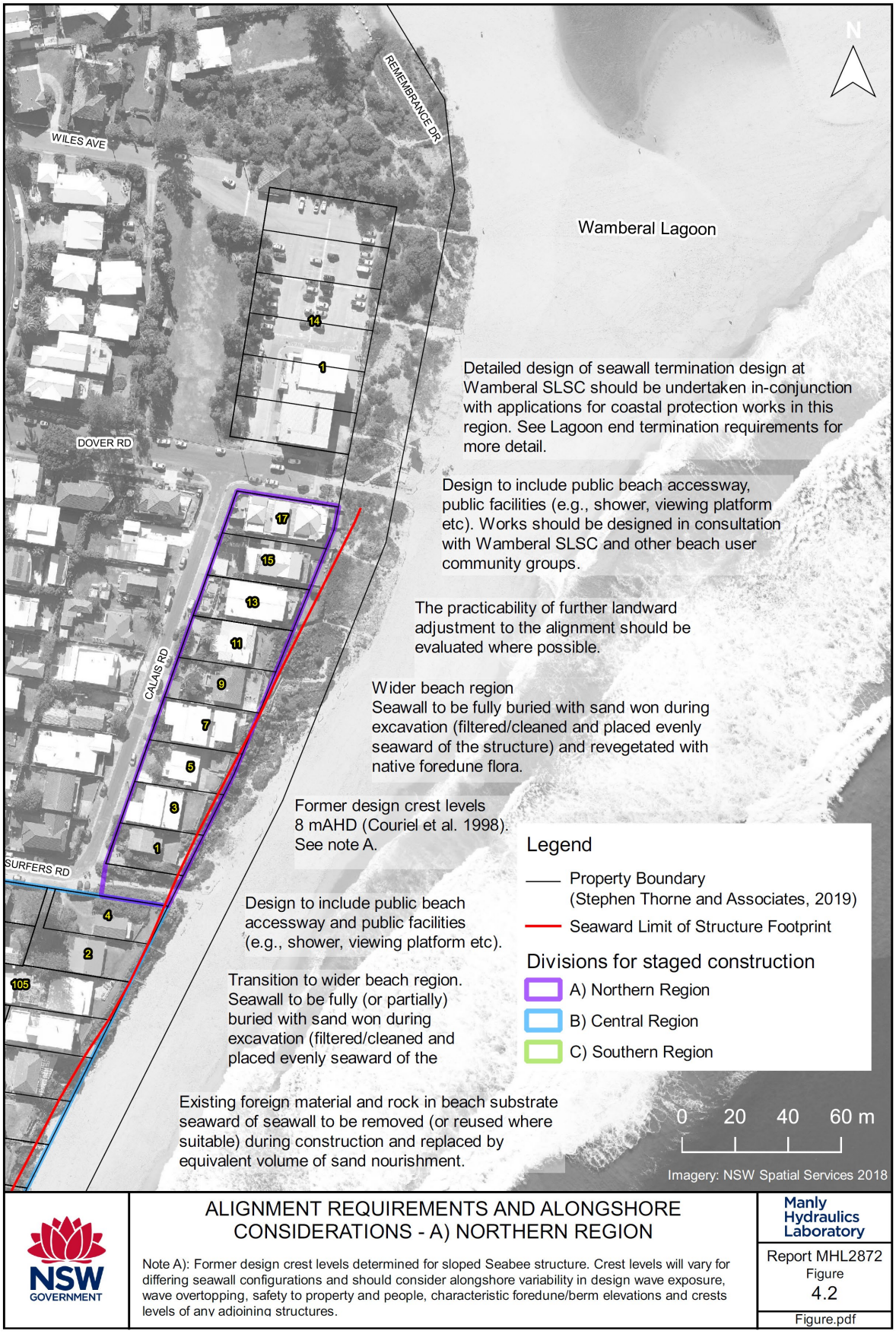

Figure 4.2: Alignment requirements and alongshore considerations - Division A

4.3.2 B) Central region (27 to 109 Ocean View Dr)

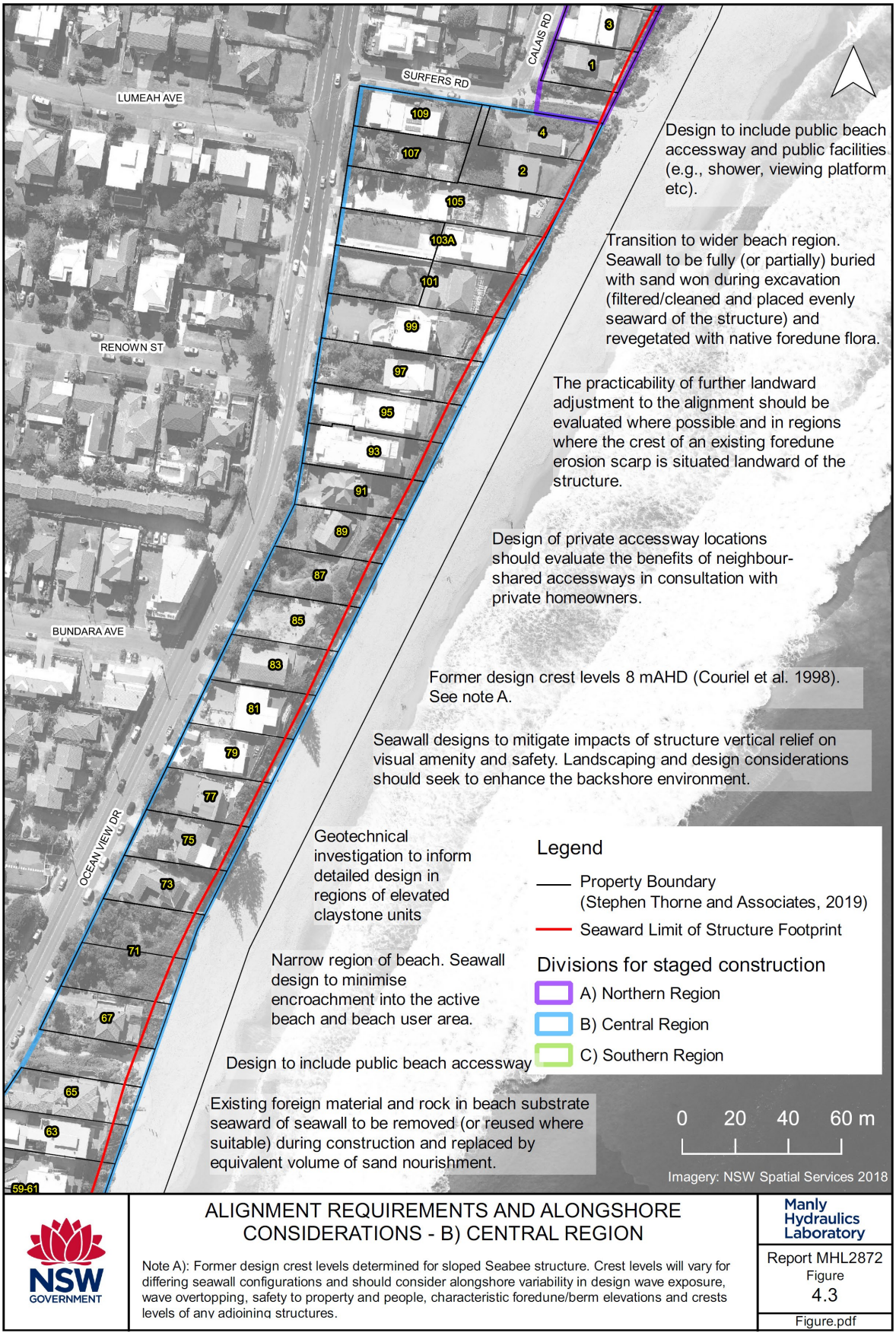

Figure 4.3: Alignment requirements and alongshore considerations – Division B (north)

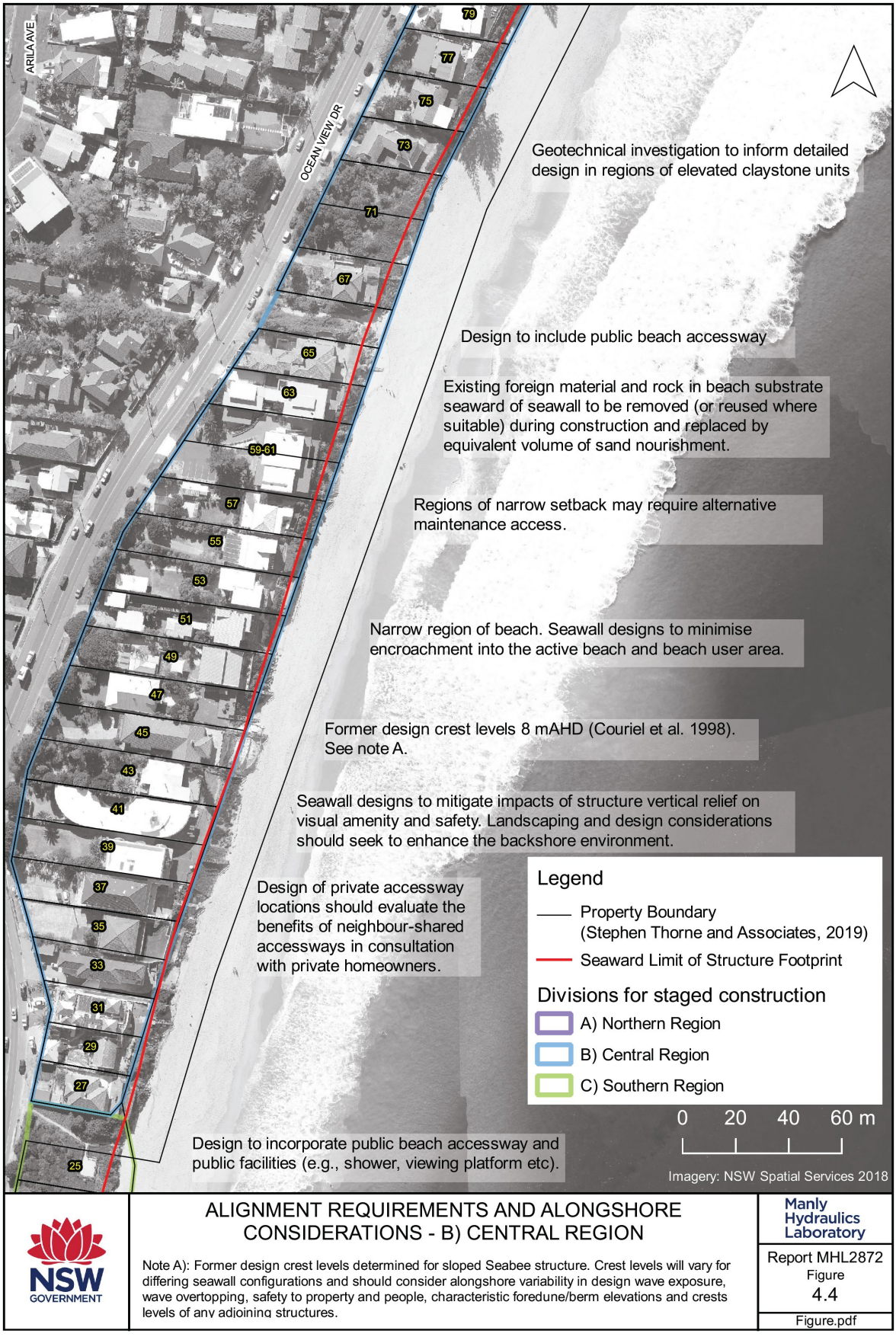

Figure 4.4: Alignment requirements and alongshore considerations – Division B (south)

4.3.3 C) Southern region (1 Pacific St to 25 Ocean View Dr)

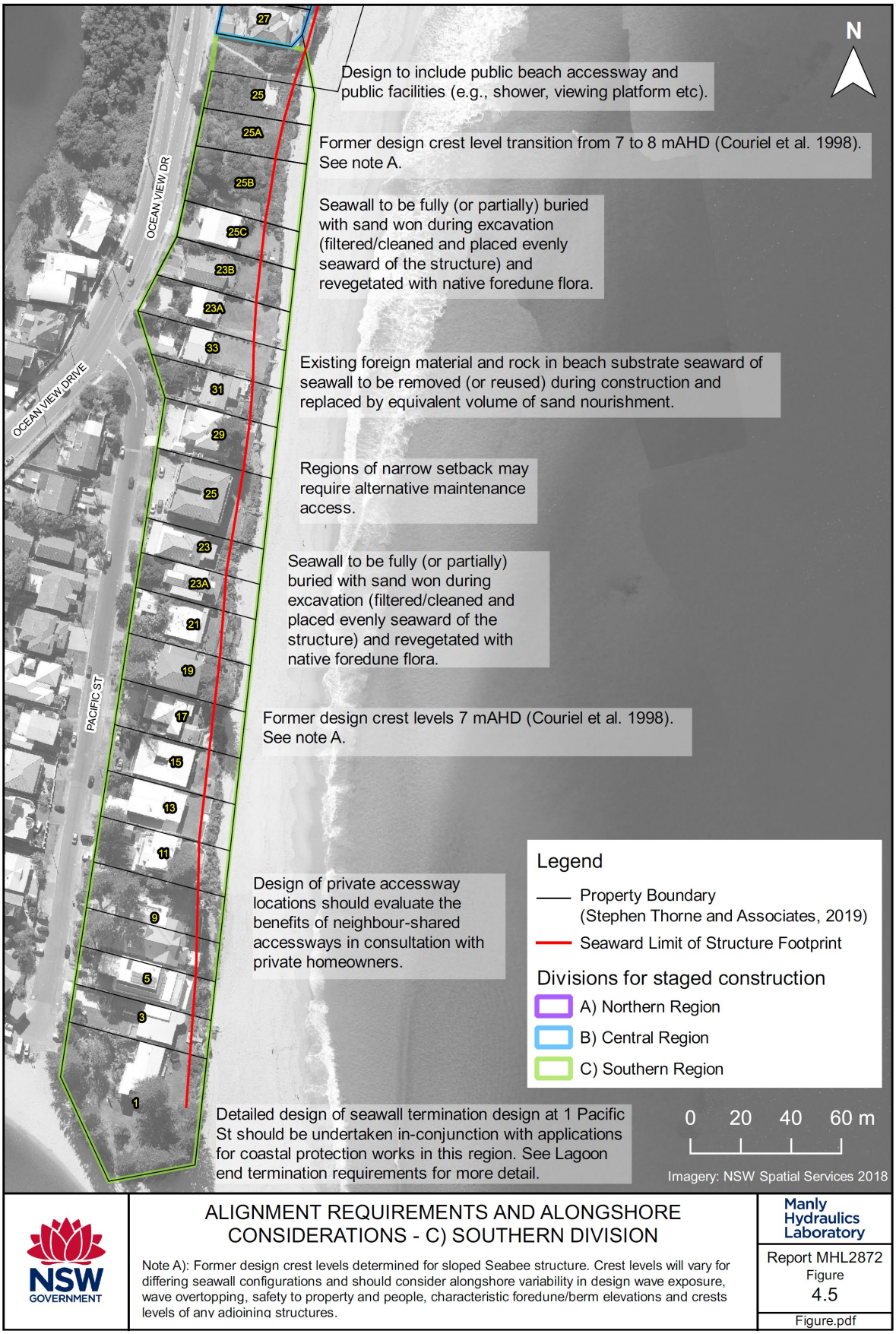

Figure 4.5: Alignment requirements and alongshore considerations – Division C

5 Closing remarks

The implementation of coastal protection works at Wamberal Beach is complex and requires informed co-ordination of various interested parties to improve on the ad-hoc and inadequate present situation, and achieve appropriate protection against coastal erosion hazards while enhancing environmental and public amenity outcomes (an important unifying objective).

These Requirements were developed for Central Coast Council to assist developers, professional engineering designers and Council in the preparation and evaluation of development applications for coastal protection works at Wamberal Beach.

Development applications shall adhere to additional requirements under Council's Local Environmental Plan and Development Control Plan, and be developed in accordance with the Gosford Beaches Coastal Zone Management Plan (WorleyParsons, 2017), Coastal Management Act 2016 and the State Environmental Planning Policy (Resilience and Hazards) 2021.

The Requirements specified in this document are subject to future revision and refinements.

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7 Glossary and definitions

adaptation pathway	A strategy based on implementation of specific actions or works at future times as and when required to mitigate the ongoing impacts of changing climate or receding foreshores. The objective is to achieve the most economic use of land which will be increasingly at risk, without sterilising it unnecessarily. The pathway provides economic certainty to all stakeholders.
annual exceedance probability (AEP)	The probability (expressed as a percentage) of an exceedance (e.g. large wave height or high water level) in a given year.
annual recurrence interval (ARI)	The average time between exceedances (e.g., large wave height or high water level) of a given value, also known as Return Period.
armour	Relates to the individual elements placed on the upper surface of a seawall or revetment to resist the forces of waves and currents on the seaward face.
armour size	Increasing armour size relates to dimensions or submerged weight of units, commonly rocks.
assets	Commonly used to mean built assets or infrastructure (e.g., houses, roads, sewer lines) but also applied to recognised environmental and recreational attributes considered of value.
beach state	The condition of a beach at a point in time (e.g., eroded, accreted) and usually defined by survey or photographic information. Will significantly affect the quantum of erosion and wave penetration at the back of the beach when a storm occurs.
briefing process	The technical letter engaging a professional to undertake a specific task or to provide specific advice, e.g., an engineer certifying a seawall.
certification	The written provision to an authority by a suitably qualified and experienced professional that an action has been undertaken or a structure built in accordance with the original design objectives and is fit for that purpose (e.g., an engineer signs a certificate stating that a seawall has been constructed in accordance with the design).
crest level	Refers to the highest point on a seawall or the front top edge of a natural sand dune. This level determines the extent of wave overtopping and inundation that will occur to landward.
design life	The period of time that a structure is designed to meet the design objectives. Usually, seawalls are typically designed for 40-60 years but may be longer. Maintenance is required over the design life.

design failure	Occurs when either the structure as a whole, including its foundation, or individual structure components cannot withstand load conditions within the design criteria
encounter probability	The chance of an event being equalled or exceeded over the design life of a project life.
end erosion	At the end of a seawall or where gaps exist in a discontinuous seawall, during storm events waves and erosion can penetrate behind the exposed ends of the seawall, causing collapse of the structure from the landward side.
geotechnical	Pertaining specifically to soils and foundation stability.
mass gravity	Relating to a seawall which relies on the weight of the structure and frictional resistance at the base to resist any applied lateral loading.
minor structures	Term used within this report to describe that group of seawalls and revetments that have not been approved and/or where the details of the construction and materials used are not known. Commonly the definition is used to describe small structures placed to protect individual properties or assets by persons unknown.
revetment	An armoured sloping structure which protects the natural sloping land surface from erosion, designed to resist wave erosion and scour. See also seawall.
remote, remote sensing	Applies to data collection using sensors or methods not attached to the object being monitored (e.g., air photos, radar, echo sounding).
rip-rap	Layers of small rocks randomly placed to armour a slope or surface and protect from erosion or scour of the underlying soil mass.
rock mattress / rock bag	Layer of (usually) smaller sized rock placed along an exposed surface at the crest or toe of a seawall to resist erosion and scour. May be retained in mesh containers. See also rip rap.
scour	Erosion of sand by the flow of water, usually adjacent to a hard strata or structure. Commonly refers to the depth of erosion at the base of a seawall below the normal seabed level.
serviceability	The ability of being able to provide an intended service or design objectives
seawall	A structure separating land and water areas, designed to prevent erosion of the land by waves and currents and to retain the fill to the landward side. As used, also includes ‘revetments’ throughout this project report.

slope	Usually relating to the angle in cross-section of the beach face or the front surface of a seawall or revetment. The slope will contribute to the dissipation of incoming wave energy, affecting the wave runup levels which occur and the extent of wave overtopping.
structure footprint	The area of land which a structure (including all rigid and non-rigid elements) occupies.
trigger	Where a decision is not implemented until a particular event occurs or condition is met
toe	Refers to the lowest seaward edge of a seawall or revetment. Failure of the toe by undermining by waves and current is the most common cause of failure of coastal protection works along the coast that are not properly designed.
water table	The top surface level of groundwater within a soil mass. This water exerts a pressure on the back of a seawall or revetment unless adequate drainage is provided through the seawall to relieve it.

Appendix A List of Standards

Standards that are generally relevant to the Works (based on concept designs 3 and 4 of MHL2780; 2021) and relevant to these Requirements are listed below.

AS 1000-1979	The International System of Units (SI) and its application
AS 1012.1-2014	Methods of testing concrete – Sampling of concrete
AS 1141.6.1-2000	Methods for sampling and testing aggregates – Particle density and water absorption of coarse aggregate – Weighing-in-water method
AS 1141.23-2009	Method for sampling and testing aggregates – Los Angeles value
AS 1141.24-2013	Method for sampling and testing aggregates – Aggregate soundness – Evaluation by exposure to sodium sulphate solution
AS 1170 (Parts 0 to 4)	Minimum design loads on structures (SAA Loading Code – Australian Standard)
AS 1302-2005	Geometrical product specifications (GPS) – Indication of surface texture in technical product documentation
AS 1304-1991	Welded wire reinforcing fabric for concrete
AS 1379-2007	Specification and supply of concrete
AS 1428.1-2009	Design for access and mobility – General requirements for access – New building work
AS 1478.1-2000	Chemical admixtures for concrete, mortar and grout – Admixtures for concrete
AS 1479-1973	Code of practice for the use of chemical admixtures in concrete
AS 1554.1-2011	Structural steel welding – Welding of steel structures
AS 1650-1989	Hot-dipped galvanized coating on ferrous articles (dependent on final design)
AS 1657-2018	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS 2001.2.4-1990	Method of test for textiles – Physical tests – Determination of bursting pressure of textile fabrics – Hydraulic diaphragm method
AS 2159-2009	Piling- Design and Installation
AS 2350.0-1999	Methods of testing Portland and blended cements – General introduction and list of methods
AS 2758.1-2014	Aggregates and rock for engineering purposes – Concrete aggregates
AS 2758.6-2008	Aggregates and rock for engineering purposes – Part 6: Guidelines for the specification of armourstone

AS 3582.1-3-1998	Supplementary cementitious materials for use with Portland and blended cement – Fly ash, silica flume, slag
AS 3600-2009	Concrete structures
AS 3610-1995	Formwork for concrete
AS 3700-2011	Masonry Structures
AS 3706.2-2012	Geotextiles – Methods of test – Determination of tensile properties – Wide-strip method (concept design 4)
AS 3706.3-2012	Geotextiles – Methods of test – Determination of tearing strength – Trapezoidal method
AS 3706.4-2012	Geotextiles – Methods of test – Determination of burst strength – California bearing ratio (CBR) - Plunger method
AS 3706.5-2014	Geotextiles – Methods of test – Determination of puncture resistance – Drop cone method
AS 3706.6-2012	Geotextiles – Methods of test – Determination of seam strength
AS 3904.3-1994	Quality management and quality system elements – Guidelines for processed materials
AS 3962-2001	Guidelines for design of marinas
AS 3972-2010	General purpose and blended cements
AS 4024.1303-2014	Safety of machinery – Risk assessment – Practical guidance and examples of methods
AS 4100-1998	Steel structures
AS 4671-2001	Steel reinforcing materials
AS 4678-2002	Earth-retaining structures
AS 4997-2005	Guidelines for the design of maritime structures
AS 5334-2013	Climate change adaptation for settlements and infrastructure – A risk based approach
AS 9001-2016	Quality management systems-Requirements

International and other standards:

BS 6349 (Part 1 & 7)	British Standard Code of Practice for Maritime Structures
ISO 21650:2007	Actions from Waves and Currents on Coastal Structures

Appendix B Geotechnical data review (from MHL2780, 2021)

B.1. Preamble

The geotechnical conditions of the study site are an important component in the detailed design and assessment of foundations of a coastal protective structure. Building on the investigations of previous studies, the following sections provided an outline of the broader coastal geomorphology setting and review of geotechnical data available for the study site.

B.2. Coastal Geomorphology Setting

Terrigal-Wamberal Beach is a sandy embayment situated within the Central Coast sediment compartment. The coastal geomorphology and topography of the embayment is described by Hudson (1997) and MHL (2003) and illustrated in Figure B.1Figure . The sandy embayment is classified as stationary-receded coastal barrier system containing two entrances at Wamberal and Terrigal Lagoons (Hudson, 1997). The embayment is composed of fine to medium grained quartz sand with a carbonate fraction deposited during the mid-Holocene with stabilising sea levels and backed by estuaries infilled with fluvial sediments (Thom and Roy, 1985). Dune elevations reaching typically up to +8 to +10 m AHD increase from south to north in the embayment with increasing exposure to the predominant south to south-easterly wave climate. Much larger transgressive cliff-top dunes reaching up to +100 m AHD are also present north of Wamberal Point and are believed to be deposited during earlier geological time (Hudson, 1997).

The embayment is bounded by interbedded sandstone and shale (Terrigal Formation) headlands at Terrigal in the south and Wamberal Point in the north. Rocky reefs are situated offshore of the embayment in water depths of 20 – 25 m (MHL, 2003). The offshore reefs are relatively shallow compared with those of neighbouring embayments, suggested to have a more pronounced impact on sediment transport processes by trapping offshore storm deposits and containing embayment sediment in a relatively closed system (NSW OEH, in draft ; MHL, 2003). Rock outcrops are also prevalent north of Wamberal Lagoon entrance with smaller outcrops located offshore of the Terrigal Lagoon entrance. Figure B.2 shows a claystone outcrop temporarily exposed during storms, situated just above mean sea level on the beach in front of 73 -87 Ocean View Dr.

The entrances of Wamberal and Terrigal Lagoons act as sediment sinks in the embayment, intermittently closing with the infilling of marine sand and beach growth depending on catchment rainfall and ocean wave conditions.

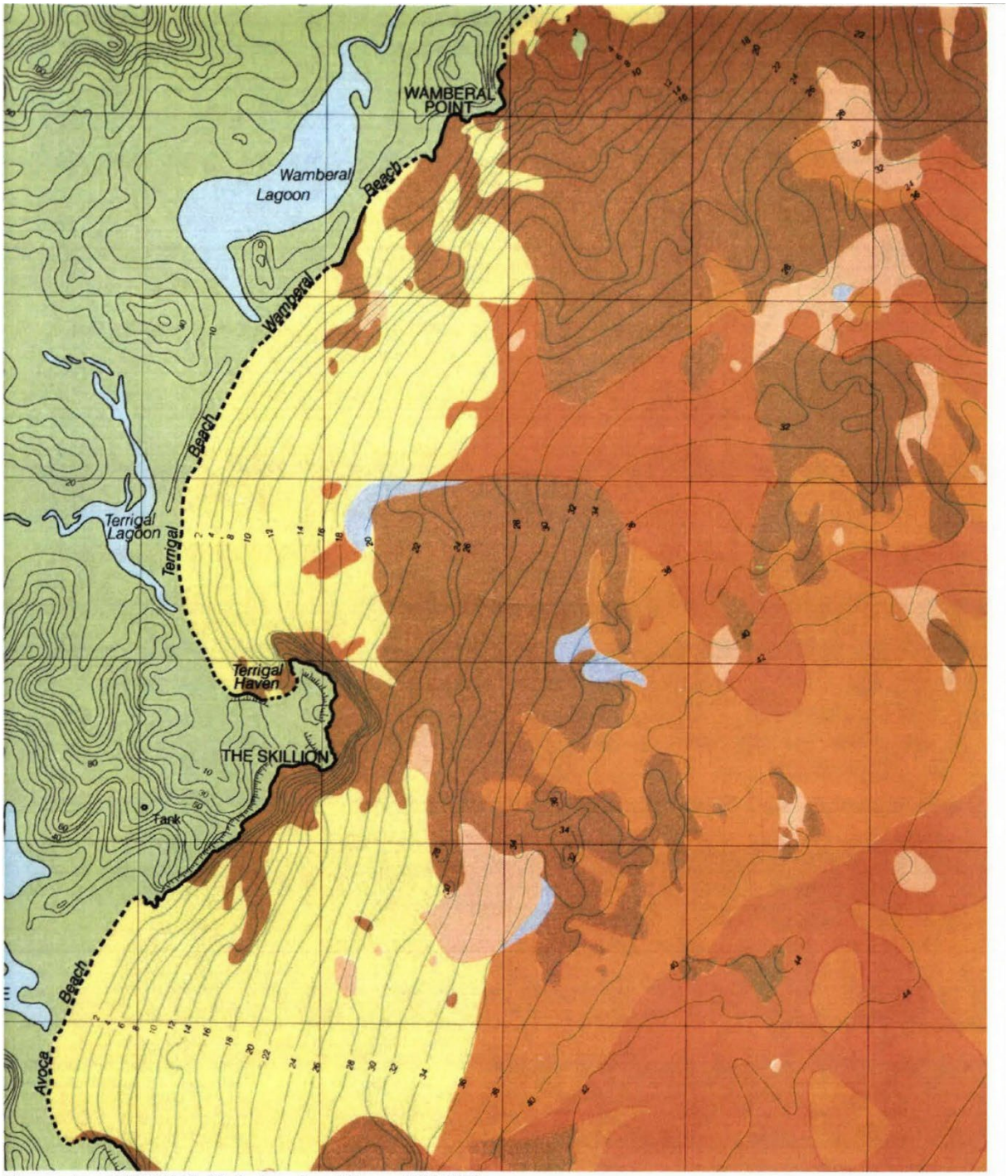


Figure B.1: Terrigal-Wamberal Beach coastal geomorphology. From PWD (1984).

Figure B.2: Claystone outcrop located between 73-87 Ocean View Dr. Imagery from 19 Jul 2020 Drone Survey.

B.3. Geotechnical data

Geotechnical studies of the study area have been undertaken by Hudson (1997) and as part of various development applications (DAs) for private land owners within the study area.

Hudson (1997) carried out geotechnical investigations at Avoca, Wamberal and Forresters Beach for Gosford City Council to identify physical constraints such as bedrock to inform estimates of dune recessions and coastal erosion hazard zones. The study included conductivity measurements along the beach and dune, and drilling samples in the beach face. Additionally, studies undertaken for private residents as part of development applications have typically used drilling samples in the incipient foredune underlying private lots (NSW OEH, in draft). Post-storm georeferenced drone surveys in 2020 undertaken by MHL for NSW Engineering Emergency Management also capture exposed bedrock units in certain sections of the beach.

The geotechnical information from these studies presented in Figure B.3 and described in Table B.1. Typical stratigraphy is characterised by:

- Underlying weathered sandstone; overlaid by
- Cohesive very stiff to hard silt and clay deposits of varying thickness including siltstone, claystone and ferruginous sandstone. Classified by Hudson (1997) as weathered to fresh bedrock basement (Pleistocene); overlaid by
- Fine to medium grained quartz sand (Holocene) with thin layers of gravelly sand and sandy clay typically near the underlying siltstone/claystone boundary.

Borehole stratigraphy from Hudson (1997) is presented in Figure B.4 and Figure B.5. Similar stratigraphy is described for the Wamberal barrier in the Gosford 1:25,000 Geological Map Sheet Series.

Typical depths to the siltstone/claystone unit have been found to vary along the study site as shown in Figure B.5 and Table B.1. In the south section of the study site (south of 73 Ocean View Dr, Figure B.3), this is situated between -2 to below -10 m AHD. In the mid-north of the site, a 400 m section of elevated siltstone/claystone is situated north of 73 Ocean View Dr with shallower depths of -2 to +1 m AHD. This unit is shown in Figure B.2 and is temporarily exposed during erosion event. The claystone bedrock returns to lower depths in the north of the study site. The geotechnical data indicates that the foredune is predominantly unconsolidated quartz sand from the surface to below 0 m AHD other than a small region between Bundara Ave and Renown St where elevated siltstone/claystone of up to +6 to +8 m AHD has been identified.

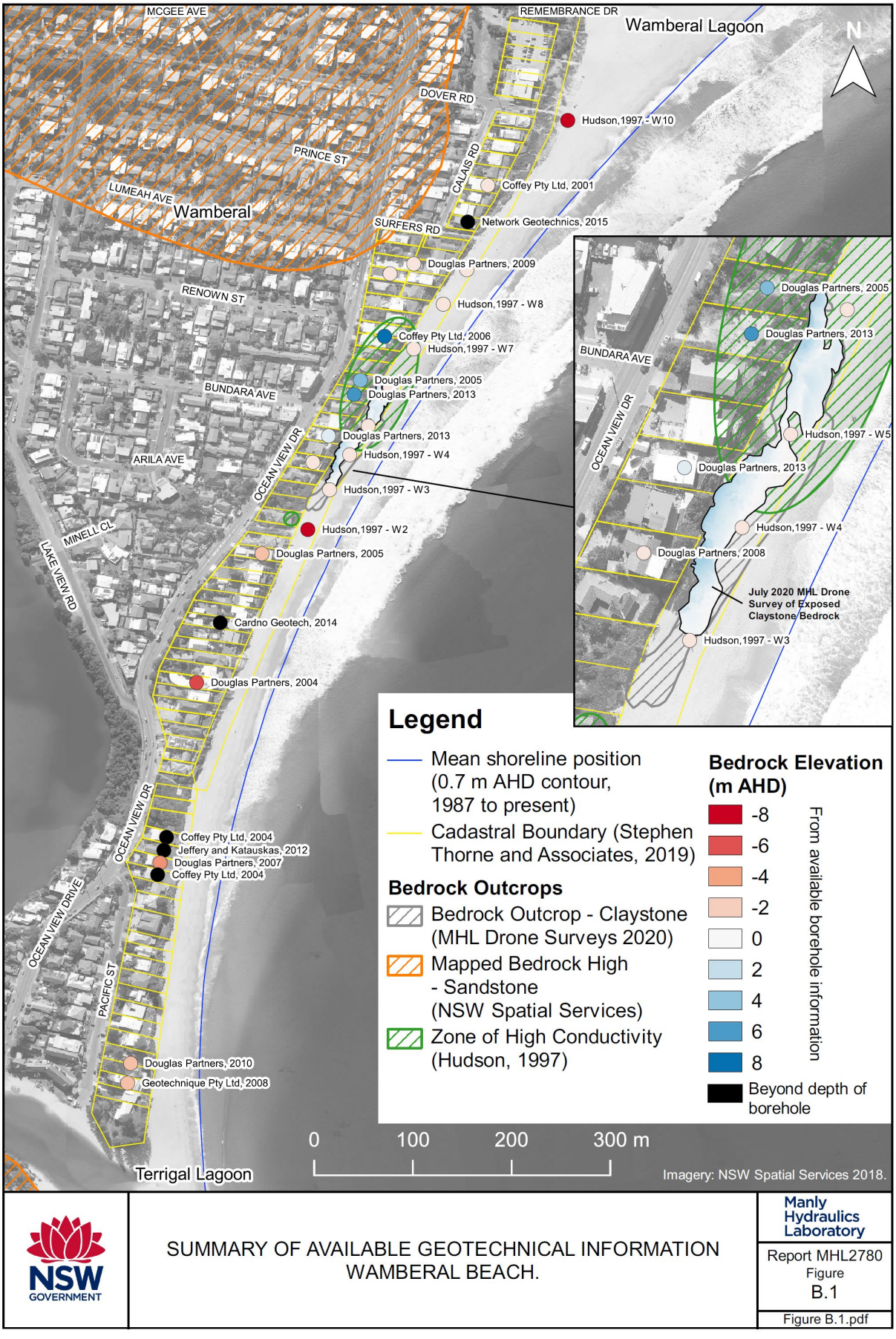


Figure B.3: Geotechnical information summary. From MHL2780 (2021)

Table B.1: Borehole information from private property development applications. From (NSW OEH, in draft)

Property	Date	Geotech Firm	Details
Lot 73 DP13304 (7 Calais Rd)	30/05/2001	Coffey Pty Ltd	Bore logs indicate soil profile typically consists of medium dense Aeolian and marine sands to at least -1.5 m AHD (at BH 1), overlying very stiff to hard residual clays and weathered sandstone.
1 Calais Rd	25/01/2015	Network Geotechnics	2 Bore holes, deepest to approx. RL 3.5 m AHD where medium dense/dense marine sand encountered. Only marine sand encountered.
105 Ocean View Drive	6/04/2009	Douglas Partners	Loose to medium dense sand down to -0.6 m AHD. Stiff clay becoming hard from -0.6 to -1.3 m AHD with cemented bands. Weathered bedrock at depth of -1.9 m AHD.
103 Ocean View Drive	31/10/2007	Jeffery and Katauskas	Sand to 0 m AHD. Sandy clay zero to -1.5 m AHD, sandstone below -1.5 m AHD.
93 and 95 Ocean View Drive	20/03/2006	Coffey Pty Ltd	Sand from surface to RL 8.9 m AHD. Clay between RL 8.9 and 8.4 m AHD. Silty Clay between RL 8.4 and 8.4 m AHD. Ironstone banding at around 4.4 m AHD.
87 Ocean View Drive	1/04/2005	Douglas Partners	Sand above RL 6.0 m AHD, underlain by very stiff to hard clay with weathered rock inferred below -3.1 m AHD.
85 Ocean View Drive	4/12/2013	Douglas Partners	Sand above RL 6.4 m AHD. Very stiff to hard clay between -2 and 6.4 m AHD. Weathered rock inferred below -2.0 m AHD.
79 Ocean View Drive	26/09/2013	Douglas Partners	Sand above RL 0.5 m AHD, underlain by very stiff to hard clay to -3.8 m AHD (limit of investigation). Bedrock inferred below.
75 Ocean View Drive	10/07/2008	Douglas Partners	Sand above RL zero m AHD. Very stiff to hard clay between zero and -10.8 m AHD. Weathered rock inferred below -10.8 m AHD.
63 Ocean View Drive	11/11/2005	Douglas Partners	Sand above RL -3.0 m AHD, underlain by very stiff to hard clay.
51 Ocean View Drive	11/09/2014	Cardno Geotech	Loose to medium dense, fine to medium grained sand.
41 Ocean View Drive	10/05/2004	Douglas Partners	Sand above RL -7.4 m AHD, underlain by very stiff to hard clay.
33 Pacific Street	2/11/2004	Coffey Pty Ltd	Sand from surface to RL zero m AHD where borehole terminated. No information below this level.
25C Ocean View Drive	10/12/2004	Coffey Pty Ltd	Sand from surface to RL 0.85 m AHD where borehole terminated. No information below this level.
23B Ocean View Drive	10/01/2012	Jeffery and Katauskas	Thick layer of silty sand and silty clay over relatively clean sandy soils to termination depth (approx. -6.5 m AHD)
23A Ocean View Drive	26/09/2007	Douglas Partners	Sand from surface to -4 m AHD, underlain by stiff clay to -9 m AHD then apparent rock.
7-9 Pacific Street	18/11/2010	Douglas Partners	Sand from surface to -2 m AHD, underlain by stiff to very stiff clay to -15 m AHD (limit of investigation).
5 Pacific Street	24/11/2008	Geotechnique Pty Ltd	Sand from surface to -3 m AHD, underlain by stiff to very stiff clay to -5 m AHD (limit of investigation).

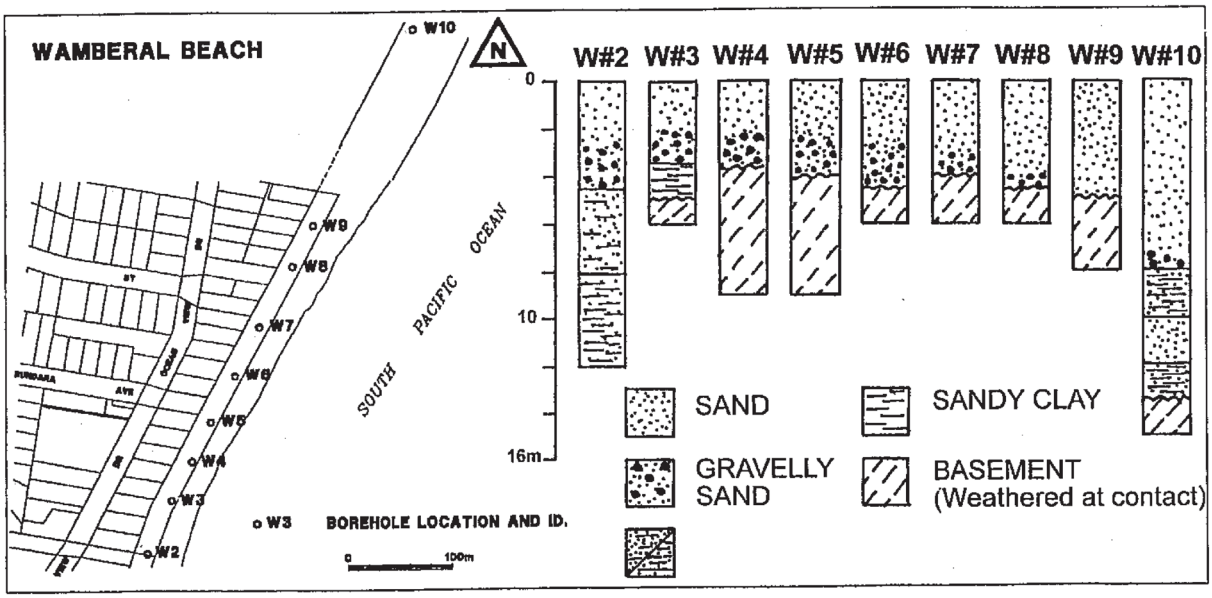
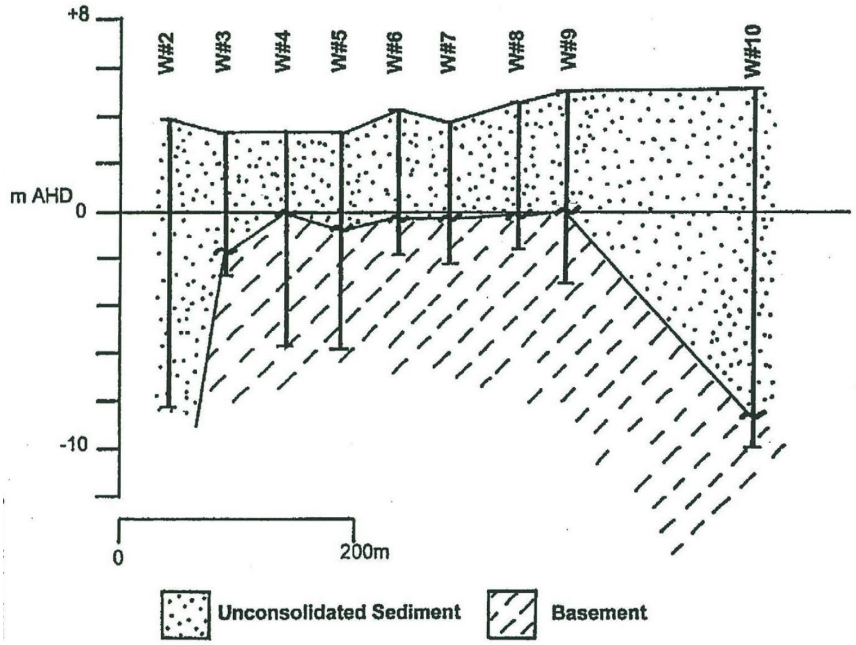


Figure B.4: Wamberal Beach borehole samples from Hudson (1997). Siltstone/claystone unit interpreted as bedrock.



Borehole ID	Ground Level (m. AHD)	Interpreted Depth to Bedrock (m. AHD)
W#2	3.95	-8.05 (NE)
W#3	3.30	-1.70
W#4	3.36	-0.14
W#5	3.34	-0.66
W#6	4.24	-0.26
W#7	3.72	-0.28
W#8	4.41	-0.19
W#9	5.00	0.00
W#10	5.03	-8.47

NE: Bedrock not encountered to depth shown

Figure B.5: Wamberal Beach Geological Section from Hudson (1997). Siltstone/claystone unit interpreted as bedrock.

B.5. Other material in beach and foredune substrate

It is also noted that various ad-hoc material exists in the beach and foredune substrate. In 2017 WorleyParsons described existing materials located on Wamberal beach noted in previous studies and from field inspections at the time (WorleyParsons, 2017). These are listed in Table B.2.

Table B.2: Materials in beach and foredune substrate as documented by WorleyParsons (2017)

Material	Known locations
1974 Rock Protection	43-45, 51-67, 73-75, 81-83, 87-103 and 105 Ocean View Drive. 2 and 4 Surfers Road; 1-9 Calais Road.
1978 Rock Fill and Ballast	23a-b Ocean View Drive
Rock fill/rubble/bricks	9,13-19 Pacific St. 55, 65, 67, 69-71, 75, 81, 85, 91, 97, 101, 103, 105 Ocean View Drive.
Large rock (0.7-2 m diameter)	25, 33 Pacific St 25c, 27, 49, 57, Ocean View Drive
Concrete walls (various)	19 Pacific St 35, 53 Ocean View Drive 1 Calais Rd
Terracotta Seabee with rock wire basket toe	59-61 Ocean View Drive
Concrete capping/pieces	29 Pacific St. 37 Ocean View Drive
Corrugated iron	Not specified
Rubber tyres	7 Calais Rd
Septic Tanks fill with sand/gravel	25 Pacific St
Timber retaining walls	21-23,31 Pacific St 27, 31, 41, 75, 79, 81, 83, 93, 95, 97 Ocean View Drive 3, 5, 7 Calais Rd

Additional material was recently placed as part of emergency protection works following substantial storm erosion in July 2020. The works were placed on the beach over a period extending from 26 July to early August 2020. The emergency protection works are summarised in Table B.3. At total of 2660 tonnes of rock armour and 2120 tonnes of rock bags armour was placed on the beach as part of the works. Concrete blocks were also placed by a resident in front of 73 Ocean View Dr.

Materials visible on the beach following the July 2020 storm erosion were mapped by MHL drone surveys and are presented in Figure B.6. Materials included emergency rock protection and rock bags outlined in Table B.3 as well as ad-hoc materials existing in the beach prior to the July 2020 storm including former rock protection works, failed concrete structures and rubble, gabion rock mattresses, terracotta seabee units and other objects.

All existing foreign material and rock present in the beach substrate seaward of the seawall must be removed (or reused where suitable) during seawall construction and be replaced by an equivalent volume of sand nourishment.

Table B.3: Emergency protection works at Wamberal Beach July-Aug 2020 as of 8 Aug 2020 (per comms, Royal Haskoning 2020). Source MHL2780

Material	Approximate tonnes placed (t)	Locations
Stage 1A Rock armour	Total: 1080t 60t per property 120t at 51 Ocean View Dr	25B-45, 51, 55-63 Ocean View Dr
Stage 1A Kyowa Rock Bags (2t)	Total: 520t 20-70 bags per property	47, beach access adjacent to 65, 69-71 Ocean View Dr
Stage 1B Rock armour	Total: 1580t 60t per property 100t at 95-97 Ocean View Dr 120t at 51 Ocean View Dr	27-45, 49-51, 55-65, 67, 81-83, 93-97 Ocean View Dr
Stage 1B Rock bags (4t)	Total: 1600t 30 bags per property 10 bags at 75 Ocean View Dr	47, beach access adjacent to 65, 69-79, 85-91 Ocean View Dr

Figure B.6 Materials present on beach post-July 2020 storm erosion (Source MHL2780, 2021)

Appendix C Potential unexpected finds

Central Coast Council stipulates that the developer shall have a procedure within the overall environmental management guidelines for the construction regarding an Unexpected Contamination Finds Protocol (UFP). The UFP is required to document the management procedures and controls to mitigate potential environmental and human health impacts associated with unexpected contamination and asbestos finds that may be encountered during construction works.

The objective of this UFP is to document the management responsibilities, controls and procedures tomitigate potential environmental and human health impacts associated with unexpected contamination such as asbestos and rock finds that may be encountered during construction works.

C.1. Potential unexpected finds characteristics

A summary and description of the types of unexpected finds that may be encountered during construction work in the project area are presented in Table C.1 below. The developer's Site Manager will retain the overall responsibility for implementing the unexpected finds procedure for all construction works undertaken within, or near, the project area.

Table C.1 Unexpected finds and characteristics of contamination

Potential unexpected find	Observed characteristic	Type of contaminant/ issues
Petroleum hydrocarbons (e.g. fuels, oils and lubricants)	May be identified by either odour and/or visual indications ofcontamination. Petroleum hydrocarbon contamination may be identified by characteristic petrol, diesel or 'oily' odours (e.g. hydraulic oil) whichmay vary in strength from weak (just detectable) to very strong (easily detectable at a distance from the source). In soils, the odour may or may not be accompanied by specific areasof dark staining (black-grey) or larger scale discolouration of strata from a previously identified 'natural colour' (e.g. staining of orange and brown clay to dark grey and green.) May also be visible as a distinct coloured sheen on water within anexcavation.	TRH, BTEX, PAH, lead
Buried dry waste materials	May include a variety of construction and demolition waste materials including wood, plastic, metal fragments, building rubble (e.g. concrete, brick, asphalt, asbestos containing materials etc.)	Asbestos, heavy metals

Potential unexpected find	Observed characteristic	Type of contaminant/ issues
Buried or surface bonded ACM, asbestos fines/friable asbestos	Cement-bound asbestos containing material (ACM) (e.g. compressed cement sheeting) may be present in building waste or pipes. Friable forms of asbestos including lagging and insulation. Textured coatings and vinyl floor tiles may also contain asbestos. Asbestos fines and asbestos fibres are not typically visible to the unaided eye. Laboratory analysis is required to identify asbestos in soil. Removal of asbestos shall be undertaken in accordance with appropriate legislation and NSW EPA requirements. Asbestos can be disposed of at Council's Buttonderry and Woy Woy Waste Management Facilities. Handy Links: https://www.safework.nsw.gov.au/hazards-a-z/asbestos Code of Practice How to Safely Remove Asbestos Aug 2019 https://www.epa.nsw.gov.au/your-environment/waste/industrial-waste/asbestos-waste	Asbestos
Buried organic materials	Such materials may be associated with decomposed plant matter found within the natural alluvial soils. Although this process is generally naturally occurring, by-products of the decomposing natural material should be considered if encountered.	Nutrients (ammonia, sulphates, phosphates), gaseous emissions (CH4, CO2, H2S)
Structures or conduits containing possible hazardous materials	Could be identified as follows: • A buried storage tank or former pipelines (typically metal, concrete or plastic). • Deeper sand fill sometimes with visual/olfactory indications of contamination. Presence of small concrete footings surrounding by odorous or visually impacted soils and/or groundwater.	TPH, BTEX, PAH, lead, asbestos
Ash or slag deposits	Ash materials are typically light weight, grey and white sand and gravel sized particles (1mm to 10mm). Slag materials can be varied in consistency and colour and may comprise pale grey to blue/green/grey and be loose or cemented. Slag gravels can be very angular and appear to have a vesicular (i.e. 'honeycomb') texture.	PAH, heavy Metals, can generate alkaline leachate
Landfill type material	Could include a combination of the other categories detailed in this table along with domestic (e.g. rag, clothing), clinical (e.g. sharps, human tissue or hair, laboratory specimens or culture), and/or putrescible waste (e.g. food scraps, nappies, animal waste).	Heavy metals, acids,ammonia, sulfides

Potential unexpected find	Observed characteristic	Type of contaminant/ issues
Other unusual odours	Other unusual odours that are different from surrounding soils, e.g. a sweet odour could indicate the presence of chlorinated hydrocarbon contamination.	Various
Per- and polyfluoralkyl substances (PFAS)	Foaming in waters (e.g. in excavations, dewatering sumps or discharge) with little agitation and minimal dissipation.	PFAS
Buried Drums	Metal or plastic drums containing potentially unknown hazardous substances. It is noted that management of drum contents may require specialist hazmat contractors. Drums should not be opened to inspect contents until a qualified hazmat contractor has been engaged to assessed potential risks.	Various

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