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Kurnell Revetment Wall Peer Review

1. Background

The Kamay Botany Bay National Park (KBBNP) is located on the southern foreshore of Botany Bay, covering an area of 492 hectares. The study area is a 220m length of foreshore on the southern peninsular of the entrance to Botany Bay (Figure 1).

Figure 1 - Overview of Botany Bay showing the Kamay Study Site (BMT, 2024)

In its current state, the north-west facing foreshore is protected by a combination of rock and temporary sandbag seawalls, protecting assets like the walking path and the electricity service line. These assets are at risk from inundation from storm tide and wave run-up based on a 10-year ARI storm. In 2022, BMT recommended upgrading these seawalls to mitigate the coastal erosion hazard at the site. In 2024, BMT expanded on the coastal process assessment from the 2022 report and addressed the RFI questions raised by the South Sydney Planning Panel (SSPP) related to coastal hazards and seawall design. This has been documented in the *DA240290 Revised 2 Coastal Hazard and Process Report 2024 11 07*.

The new stepped sandstone seawall was designed by Consult Marine, running from the recently constructed wharf to the edge of Commemoration Flat (Figure 2), in front of the existing sandbag wall. The topmost layer of sandbags will be removed, and the rest buried underneath sandstone blocks (Figure 4). These sandbags currently provide a temporary protection to the dune, mitigating the damages caused by the 2018 major storm event. Consult Marine's design drawing list has been documented in the *DA240290 Original Structural Design Drawin*gs.

Figure 2 ***Nearmap image showing the approximately 220 metres in length proposed seawall area on the seaward side of the Norfolk Island Pines (BMT, 2024)***

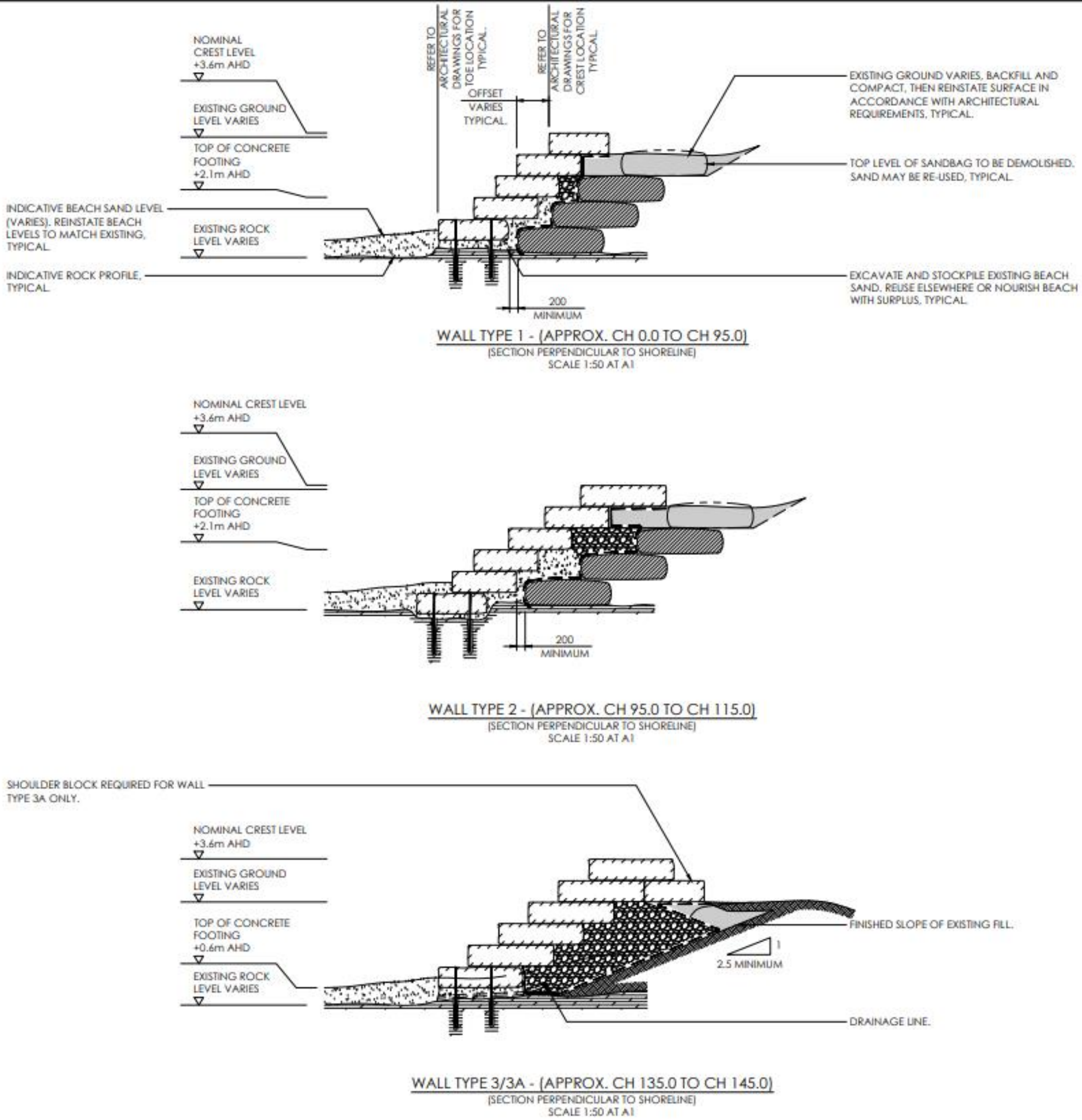

Figure 3 Cross sections of the proposed seawall (Consult Marine, 2023)

DA for construction of the seawall and adjacent landscaping works (DA24/0290) was submitted to the Sutherland Shire Council (SSC) by the NSW National Parks & Wildlife Service on 13 September 2024.

GHD has been engaged by SSC to review the coastal engineering components of the DA and provide comments to assist SSC in evaluating the proposed design solution.

The review considers the *DA240290 Revised 2 Coastal Hazard and Process Report 2024 11 07* and the *DA240290 Original Structural Design Drawings*.

1.1 Purpose of this Letter

The purpose of this report is to document the findings of GHD's peer review in order to assist Council in evaluating the risk of coastal hazards impacting the proposed infrastructure.

1.2 Scope of Works

The objective of the review is to assist SSC in evaluating the likely residual coastal risks associated with the design proposed by the Consult Marine's design from coastal hazards, inundation and coastal structural integrity perspectives based on the information available to GHD and studies undertaken by BMT.

GHD's advice is documented within this brief letter report and is limited to providing advice regarding the following:

- Data gaps in the information used to inform Consult Marine's design and BMT's report
- Limitations of Consult Marine's and BMT's approach
- Whether Consultant Marine's and BMT's interpretation in relation to coastal vulnerability and hazards aligns with GHD's interpretation
- Check if alternative options were sufficiently discussed and reviewed by Consult Marine.
- Commentary regarding the proposed design, including considerations such as location and extent, use of sandbags and retaining of the existing coastal protection, appropriate filter layers, toe and crest details, rock sizing, specification, etc. based on GHD's experience in delivering similar projects and relevant guidelines such as the CIRIA Rock Manual, USACE Coastal Engineering Manual and Shoreline Protection Manual.
- Commentary on how the proposed design is likely to reach the intended design life.
- Commentary on overall performance of sandstone wall
- A review of how and if impacts of sea level rise are sufficiently considered.
- Recommendations regarding any additional field work, numerical modelling, empirical analysis, redesign or proposed management measures during construction or over the design life to align BMT's approach with that which would typically be adopted by GHD when designing similar infrastructure.

GHD's scope of works is limited in accordance with the following:

- Documents to be reviewed by GHD are limited to the following:
  - *DA240290 Revised 2 Coastal Hazard and Process Report 2024 11 07*
  - *DA240290 Original Structural Design Drawings*.
- GHD's review is solely focused on the review of the Coastal Hazards and integrity of the coastal protection elements and how the Consult Marine design has accounted for these hazards. GHD's scope of works does not include checking calculations, undertaking design verification or design validation services, nor undertaking a parallel design process. Similarly, GHD's scope of works does not include provision of review advice regarding broader design and delivery considerations such as structural design, durability, sustainability, safety and accessibility, social, environmental or heritage considerations, tender or construction phase considerations.
- GHD's scope of works does not include issuing of any certificates or certifications and Consult Marine remains solely responsible for their design.
- GHD's scope of works does not include undertaking independent calculations. Review of other forms of instability, such as geotechnical stability is based on the information contained in the design report and limited to risk based assessment of suitability of assumptions and procedures.

2. Peer Review findings

2.1 Design approach and documentation

- The Drawing set prepared by Consult Marine aligns with GHD's expectations for a project of this type and scale, including detailed notes, existing conditions, general arrangements, sections and details. Given that some elements of the design intent are documented within the associated set of Architects plans and Architect's specifications, it is recommended that the tender and construction contracts, clearly establish the order of precedence for the various documents.
- The information provided to GHD does not include a standalone basis of design report or design criteria report however the drawing notes stipulate the criteria shown in Figure 4. These criteria have been adopted as the basis for GHD's review:

Design Criteria:

- Maximum vertical live load (on or within 4m behind wall):
  - Uniformly Distributed Load: 5kPa, or
  - Point Load: 4.5kN.
  - N.B. A 4.5kN Point Load is approximately equivalent to a wheel load from a light vehicle of GVM ≤ 1.8t.
- Structure Classification: Class B to AS4678-2002
- Design Working Life: 50 years with periodic inspection and maintenance.
- Sea Level Rise: 0.4m allowance.
- Design Waves (Breaking):
  - 1:1yr Swell Wave (North): Hb = 0.8m, Ts = 15s
  - 1:1yr Wind Wave (WNW): Hb = 1.3m, Ts = 3.5s
  - 1:200yr Swell Wave (North): Hb = 1.3m, Ts = 15s
  - 1:200yr Wind Wave (WNW): Hb = 1.6m, Ts = 3.5s

Figure 4 Drawing extract – Design Criteria (Consult Marine, 2021)

- Safety in Design (SiD) report or SiD register has not been provided to GHD, though drawings notes make reference to high risk activities identified in the Safety in Design review. It is recommended that tender documentation clearly sets out the responsibilities of the successful Contractor in relation to Safety in Design.
- The drawings include specifications of materials, including concrete, rebars, and dowels. While the specifications are provided, the documentation does not include a durability design report or plan, and it is not clearly indicated if the specified materials can achieve the desired design life of 50 years. For instance, for the dowels, reference to material alloy specifications identifies materials with different levels of corrosion resistance, with no indication of any impact if the lower level is adopted.
- The BMT Report Kamay Revetment DA Advice - Coastal Hazard and Process includes the findings coastal process assessment and provides responses to RFI questions raised by the South Sydney Planning panel including information provided by Consult Marine relating to the detailed design methodology and assumptions. Although this information was documented within the BMT Report, the responses provided by Consult Marine provide the information generally expected in a detailed design report for a project of this type and scale.

2.2 Seawall design review findings

2.2.1 Design summary

The design documentation proposes a sloped sandstone block wall constructed over the existing sandbag seawall, running from the Kamay Ferry Wharf to the edge of Commemoration Flat, with rock revetment transition structures for integration with existing coastal structures. The topmost layer of sandbags is to be removed. The design also includes a sandstone block staircase leading from the pathway to the beach. Commentary regarding the key design considerations for a project of this nature is provided in Sections 2.2.2 to 2.2.10.

2.2.2 Toe stability

Toe stability is the structure's resistance to erosion at its base caused by wave action and the movement of sand and sediment from around the base of the foundation. If the foundation is undermined, the structure may become unstable.

The design notes a concrete mass is to be cast over bedrock beneath the toe blocks to prevent undermining. Toe block anchors are to be installed at every fourth block along the length of the structure, with two anchors per block, as shown in Figure 5.

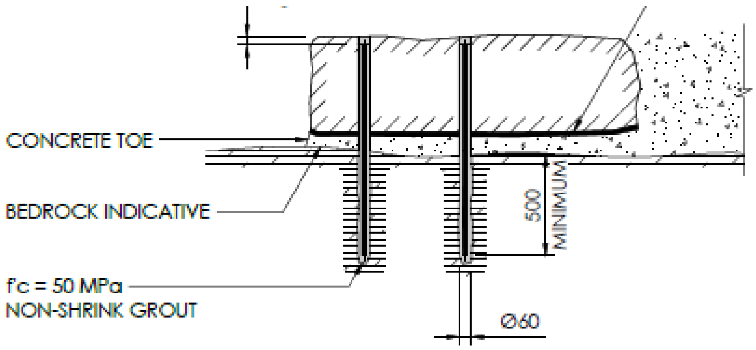

Figure 5 Toe block anchor detail

Noting the aesthetic, recreational and constructability requirement is to adopt a relatively uniform block height, the proposed approach generally aligns with GHD's expectations and appears appropriate for the intended purpose of enhancing the existing shoreline.

It is expected that the core drilling of anchor holes will be undertaken once the blocks are placed. The specifications do not include any requirement for the contractor to minimise the risk of cracking of the sandstone blocks during coring. The 25 MPa UCS is roughly in the range of a medium-strength rock which, while it can be drilled, may require special methods including low-pressure drilling to minimise cracking especially for a drill hole of 60mm. The risk is also increased when drilling through thinner sandstone blocks (as shown in some areas) or thin layers of insitu placed concrete.

The length of the anchor blocks are not provided and requirement is limited to specification of the minimum depth of embedment in rock. It is not clear how the anchor rods are to be measured and installed on site and how the cover depth at top of the anchors are to be ensured. Consideration should also be given to access to the toe of the structure for core drilling equipment.

2.2.3 Foundations

The foundation is the base of the structure that supports and distributes the weight, to ensure the structure is stable. Weak or unstable foundations can lead to settling, tilting, or collapse of the structure. Ensuring a stable base is crucial to maintaining the structure's integrity against wave action.

The toe of the structure is specified to be constructed on a mass concrete foundation overlying bedrock, with the existing sandbags directly overlying bedrock, providing a high bearing capacity base in comparison to overlying sands. The underlayers are to be comprised of concrete, backfill and drainage material made of ballast or aggregate, placed over the existing sandbags (refer Figure 8).

SSPP RFI 5 states *“Commentary on the suitability of the proposal having a design life of 50 years, when built on top of existing sandbags, which have a limited design life and will degrade over time, potentially leading to loss of sand and integrity of the sandstone blocks”,* identifying concern of using sandbags as foundations.

The proposed construction over sandbags may pose concerns if the sandbags degrade, resulting in potential loss of material and formation of voids beneath the structure should fines be washed out. However, the potential for fines to be washed out is reduced by the inclusion of formal drainage paths and the containment of finer materials within geotextile and concrete. Additionally, the blockwork structure is specified to have a 0-3 mm gap between blocks, meaning underlying foundation material is unlikely to be lost through the structure. As noted elsewhere in this review, the risk of piping can be further reduced by ensuring that the geotextile membrane remains intact throughout the design life. Given the incremental cost of a higher grade and stronger geotextile, application of a thicker and stronger geotextile may reduce the risk of material loss.

The drawings allow the contractor to vary the dimensions of the sandstone blocks "as required" to satisfy architectural and structural design intent. It is not clear where these intents are clarified and how the contractor is expected to confirm that without providing a detailed design review or report. We therefore recommend a limited range of variability in size is imposed including an allowable limit of size (i.e. as a percentage of length/width/height) for individual blocks and in aggregate for a number of consequent blocks.

The proposed approach generally aligns with GHD’s expectations and appears appropriate for the intended design life.

2.2.4 Armour layer and underlayers

An armour layer is the outer protective layer of the structure capable of resisting wave energy and preventing erosion and damage to the underlayers. Improperly designed armour layer may fail to withstand wave forces, leading to excessive damage, frequent maintenance or structural failure.

The armour layer for the block wall structures has been designed using large (500x500x2000mm), interlocked sandstone blocks along the length of the structure. The underlayer is comprised of concrete at the base of the structure, followed by a drainage layer and overlain with backfill. Geotextile is shown as wrapped between the sandbags and the underlayers.

The armour layer for the rock revetment transition structures has been designed using two layers of sandstone (D50 = 650 mm), with a 100-200 mm sandstone underlayer underlain by compacted fill. A layer of geotextile runs underneath the underlayer and compacted fill layer, anchoring in the armour layer. Evidence of calculations has not been provided however the BMT Report states that the filtration has been designed as per the Coastal Engineering Manual Part IV.

The proposed approach generally aligns with typical industry practice for this type of structure. Ordinarily, an allowable level of damage during the design event would be specified in order to allow the asset owner to plan for an appropriate level of maintenance over the design life. GHD recommends the armour and underlayer of the rock revetment be monitored over the design life and maintenance be undertaken when required to ensure the structure performs as intended over the design life.

2.2.5 Outflanking and end effects

Outflanking and end effects refer to localised impacts at the ends of the structure or excessive levels of damage at interfaces between different types of shoreline protection.

There are several interfaces along the proposed shoreline design, comprising:

– Kamay Ferry Wharf to transition revetment structure (west)
– Transition revetment structure to blockwork wall

– Transition revetment structure to existing sloped rock wall
– Transition revetment structure to existing sloped sandstone wall
– Transition revetment structure to blockwork staircase
– Blockwork staircase to blockwork wall

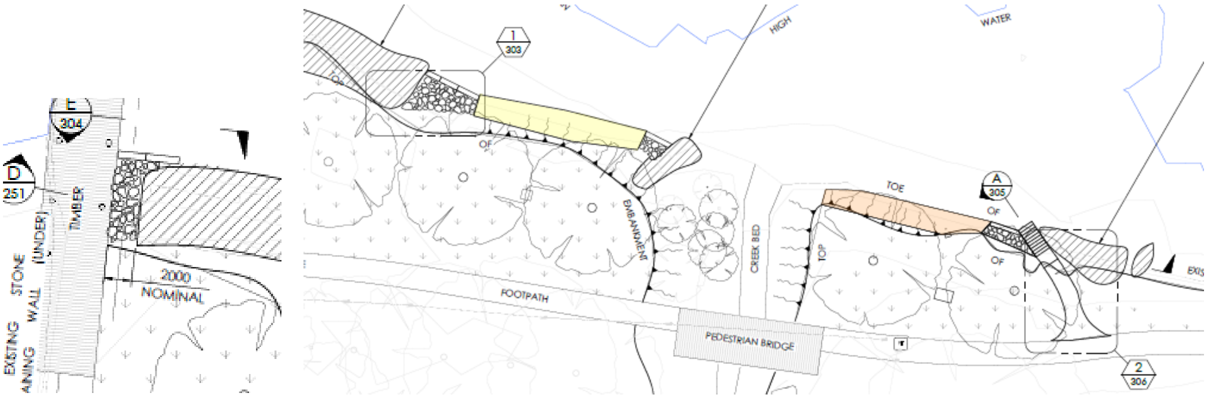

Figure 6 ***Interfaces between structure types***

Consult Marine specified the transition plan from the blockwork structure to the existing block wall, comprising a transition structure of rock armour revetment and toe blocks. The rock revetment will align with each side, transitioning linearly from the proposed structure to the existing block wall, and the toe will align with the existing wall, with two anchors per block (Figure 7).

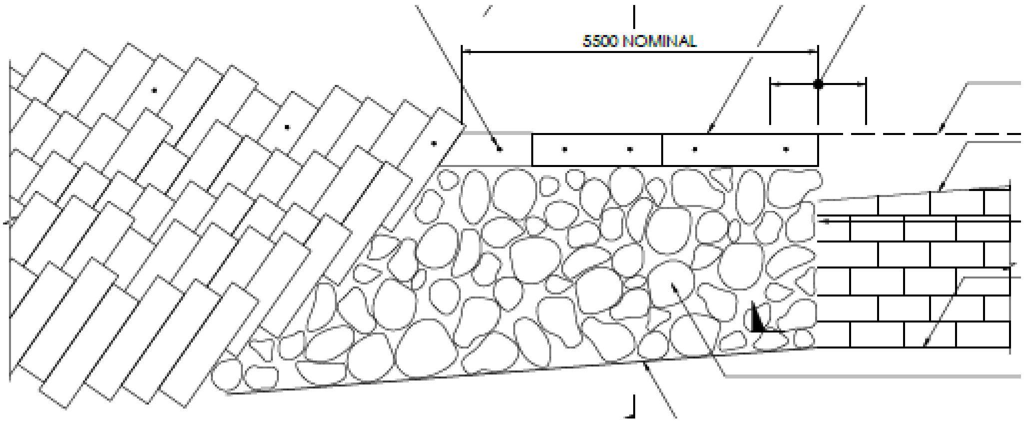

Figure 7 ***Transition plan detail (east)***

Whilst the proposed structure would typically extend beyond the area's most at risk to reduce potential for outflanking, it is understood BMT and Consult Marine have taken into consideration the aesthetic and heritage aspects of the site by preserving existing shoreline protection. This is documented in response to SSPP RFI 2, *"An assessment of the proposal under Part 2.2, Division 2 - Coastal Vulnerability of the SEPP, to ensure that the works are engineered to withstand current and projected coastal hazards for the design life of the works"*, where BMT have outlined that, *"The revetment transition structure should ideally continue from the existing wall into the western bank of the stream mouth. The adopted position was to retain the blockwork structure at the stream mouth for aesthetic reasons, primarily to preserve the heritage value of the adjoining stone block seawall structures. This approach involves accepting the risk later in the structure's life, with repairs and maintenance to be undertaken locally as required".*

The interfaces appear to have been considered by Consult Marine and are documented by several detailed sections in Drawings 303 and 304. The proposed approach generally aligns with typical industry practice and appears appropriate given the site constraints. GHD recommends the interfaces between the existing and proposed shoreline protection be monitored over the design life and maintenance be undertaken when required to ensure the structure performs as intended over the design life.

2.2.6 Material Degradation

Material degradation relates to the potential for deterioration of the sandstone blocks, geotextile fabric, or other materials used in the construction due to exposure to saltwater, wave action, UV radiation, and other environmental factors. Over time, these factors can cause the sandstone to erode, the geotextile to break down, or the sandbags to degrade, potentially compromising the stability and effectiveness of the coastal protection system.

BMT has specified differing sandstone material properties for the revetment armour rock and the remaining blocks, billets and stair treads. Sandstone blocks are also noted to require a protective coating to reduce ingress of moisture and salts, which is intended to improve durability.

SSPP RFI 8 questions the differences in sandstone material properties, *"…This should include an explanation as to why the required sodium sulfate loss is less than 10% for the sandstone blocks but is relaxed to less than 25% for the sandstone armour and underlayer"*.

The BMT Report notes that the sandstone blocks will be subject to more severe environments due to periodic cleaning and have an increased difficulty of replacement as opposed to the armour, requiring the better material properties. The underlayer is not exposed to as severe conditions and as such, does not require equivalent material properties.

The proposed geotextile Texcel 400R is a non-woven geotextile designed for coastal applications, with a resistance to environmental factors such as saltwater. It restricts the migration of fine soil particles while remaining permeable to water, thereby preventing fines washout. Along the length of the structure, the geotextile is to be cut in line with the top block and consideration has been given to its exposure to erosion and overtopping. However, given the low frequency and magnitude of overtopping rates, GHD would consider this to be a reasonable approach.

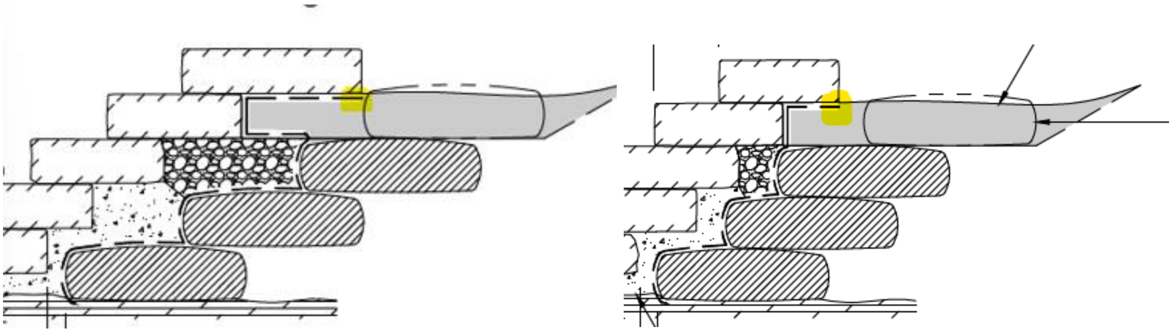

Figure 8 ***Geotextile ends in Type 1 and Type 2 structure sections***

The concrete specification in the drawings identifies C1 with reference to AS3600 for the stairs. However, the stairs are in fact in a tidal area and should be specified as C2 in order to comply with AS3600.

The specifications for rebar and dowels reference Duplex stainless steel alloy grades of 2304 and 2205. It is typically possible to specify references to the relevant AS/NZS code: AS/NZS 4671 is applicable for reinforcing steel, and while it generally covers carbon steel, manufacturers and designers can refer to AS/NZS 4671 in conjunction with the relevant ASTM codes for stainless steel rebar. This provides specifications for deformed and plain stainless-steel bars for concrete reinforcement. We also note that these materials have different corrosion resistance characteristics and, if in the designer's view the lower resistance is adequate, it is not clear why a higher resistance is provided. There appears to be a duplication of stainless-steel material specification with some inconsistent requirements on 014 and 012 drawings.

2.2.7 Overtopping

Overtopping refers to when wave action and storm surges cause waves to flow over the top of the structure, potentially damaging the landside assets including the footpath and other assets.

Considering the predicted maximum wave runup levels over the lifespan of the structure, the proposed crest height will reduce overtopping under current conditions. Towards the end of the design life, the structure may have overtopping in some areas, similar to current conditions. Whilst overtopping may occur in extreme weather events, the inclusion of the drainage layer may reduce the impacts on landside assets.

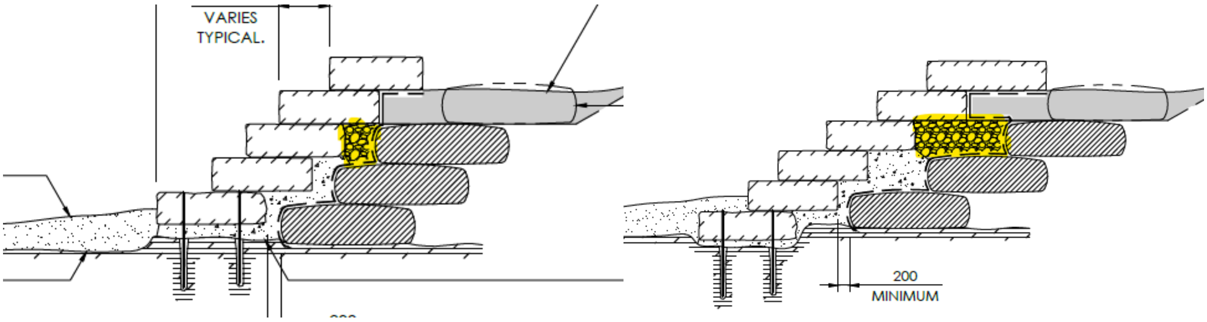

Figure 9 Drainage layer

Preserving existing shoreline protection means that exposure to wave overtopping will remain at current levels. This approach appears appropriate given the site constraints. GHD recommends monitoring of the structure following extreme weather events to ensure overtopped water is being effectively drained and no pooling of water is identified.

2.2.8 Drainage

Drainage refers to the management of water flow behind the structure. Poor drainage can raise water levels behind the structure, leading to an increase in pressure on the structure. Increases in water levels also leads to drainage through unintended flow paths, which may result in loss of fines from “piping” or “washout”, and in some cases can cause geotechnical instability and failure.

The proposed design includes a drainage layer as shown in Figure 9 however there is no drainage behind the concrete footing (up to +2.1 mAHD) resulting in potential increases in groundwater levels which may cause potential impacts to slope stability and nearby trees, and create unintended flow paths (Figure 10).

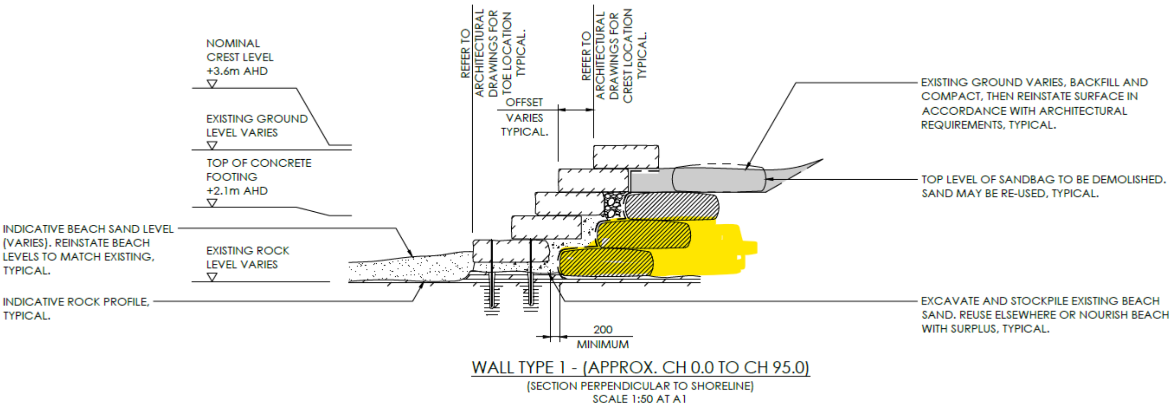

Figure 10 No drainage outlet behind concrete footing leading to increases in groundwater levels

The concrete stair area, as detailed in Section A, Drawing 305, shows consideration of a drainage pipe and rock profile. However, the rock profile is not extended to the level of pavement. The type and permeability of the underlying material are unknown. We would recommend that the drainage design be reviewed and full continuity of drainage pathways to the open water or adjacent drainage system be confirmed.

GHD recommends that consideration be given to potential impacts associated with the obstruction of groundwater flow paths.

2.2.9 Wave Reflection Issues

Reflection of wave energy occurs when a wave strikes the structure and is reflected back towards the sea or along the shoreline. Reflected waves can intensify erosion in front of the structure or damage adjacent areas.

The blockwork design is more reflective of wave energy than a natural sandy foreshore, and is therefore expected to have some impact on natural erosion and accretion cycles. However, the BMT report notes that the proposed solution is comparable to the existing conditions and is not expected to cause adverse impacts to coastal processes.

The area in front of the structure is underlain by an intertidal rock platform with transient sand. Whilst this sand may be susceptible to minor erosion due to reflection, with consideration to the beach uses outlined by BMT, it is not expected to significantly impact amenity and beach stability.

GHD notes that whilst a less reflective solution could be developed, this would come at a cost in terms of durability, footprint of the structure and encroachment into landside middens or the intertidal zone. Accordingly, the proposed approach generally aligns with GHD's expectations and appears appropriate given the site constraints.

2.2.10 Settlement or Deformation

Settlement or deformation may occur when the structure exhibits uneven downward movement or shifting due to poor soil conditions or insufficient compaction. This can lead to structural instability, misalignment and localised stresses.

The weight of the sandstone blocks has potential to cause the sandbags to compress, which, combined with potential degradation of sandbags, may lead to uneven settling. However, the design has arranged blocks in an interlocking placement that will distribute the weight and may reduce potential movement.

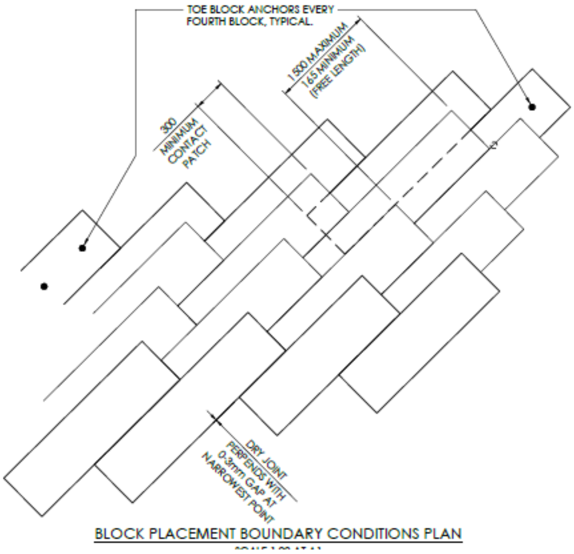

Figure 11 Interlocking placement of sandstone blocks

There is also a risk that the top sandstone block may be subject to uneven settlement when placed on the compacted backfill (Figure 12). However, Consult Marine has proposed that the fill material is subject to 95% compaction and as a result, any settlement is expected to be minimal and gradual over the design life.

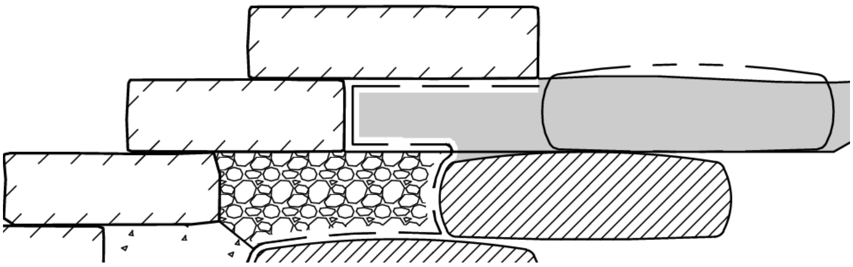

Figure 12 Settlement risk of top sandstone block

GHD recommends periodic monitoring of the top sandstone block and fill layer and undertaking maintenance if any issues are identified.

3. Summary and conclusion

GHD considers that BMT and Consult Marine's proposed sloped sandstone block wall constructed over the existing sandbag seawall is an appropriate design solution given the site constraints.

In addition to the specific comments provided above, GHD recommends the following monitoring and maintenance measures be undertaken to ensure the long-term stability and performance of the structure, as outlined in Table 1 below.

Table 1 Summary of monitoring and maintenance recommendations

Item	Project element	Recommendation
1	Armour and underlayers	Periodic monitoring of armour and underlayer of rock revetment over design life. Maintenance undertaken when required.
2	Overtopping	Event monitoring of the structure following extreme weather events to ensure overtopped water is being effectively drained and no pooling of water is identified.
3	Settlement or deformation	Periodic monitoring of the top sandstone block and fill layer. Maintenance undertaken when required.

We trust that the information presented above is of assistance to Council in evaluating the likely residual coastal risks associated with the design proposed by Consult Marine. Should you have any questions or require clarifications, please do not hesitate to contact the undersigned.

Regards

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