EASTLAND PORT LIMITED

Eastland Port Reclamation, Wharf 8 Extension and Outer Breakwater

Engineering Report for Consent Application

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Synopsis

Eastland Port Limited are seeking consent for the development of their Wharf 8 extension Reclamation Area, Revetment and upgrade of their Outer Breakwater. Worley have undertaken engineering works to develop a concept design for this redevelopment. A summary of the design is presented within this design report.

Disclaimer

PROJECT 301015-04045 - Eastland Port Reclamation, Wharf 8 Extension and Outer Breakwater - Engineering Report for Consent Application

Rev	Description	Originator	Reviewer	Worley Approver	Revision Date	Customer Approver	Approval Date
Rev C	Draft for Client Review	C. Adamantidis	D. Aubourg	C. Thomas	30 June 2021		
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1. List of Acronyms

Acronym	Description
CD	Gisborne Port Chart Datum
CMP	Construction Management Plan
DGB20	Densely Graded Base, 20mm (road base)
DSM	Deep Soil Mixing
EPL	Eastland Port Limited
ESCP	Erosion and Sediment Control Plan
GDC	Gisborne District Council
MBES	Multibeam Echo Sounder
MHL	Manly Hydraulics Laboratory
MHWS	Mean High Water Spring Tide Level, m CD
MLWS	Mean Low Water Spring Tide Level, m CD
MPa	Mega Pascals, measure of concrete strength
PVC	Poly-vinyl chloride
RC	Reinforced Concrete
RL	Reduced level above Chart datum, m
SLY	Southern Logyard
WLY	Wharfside Logyard

2. Introduction

Eastland Port Ltd (EPL) operates Eastland Port, located in Gisborne on the east coast of New Zealand's North Island. EPL is undertaking an upgrade of its port infrastructure to allow for an expected significant increase in log exports, as part of their Twin Log Berth Project. As part of this work, there are plans to extend Wharf 8 to the south, requiring reclamation and an associated Revetment to its east. In addition, sections of the Outer Breakwater, which in places was installed over 100 years ago, have failed. All sections of the structure require refurbishment.

This report documents the concept design of the Wharf 8 Reclamation, Revetment and refurbishment of the Outer Breakwater for Consent purposes. Overall works will comprise:

- extension to Wharf 8
- capital dredging adjacent to the Wharf 8 extension (documented in a separate engineering report, 301015-04045-CS-REP-002-D, Worley, June 2021)
- reclamation works adjacent to the Wharf 8 extension area
- an armoured Revetment around the perimeter of the Reclamation Area
- refurbishment of the Outer Breakwater, comprising placement of armour units around the existing structure and raising the crest level of the Outer Breakwater.

2.1 Definitions

The following definitions apply to the water levels used in this report. CD refers to Gisborne Port Chart Datum.

Tidal plane	Water level (m CD)
Highest Astronomical Tide (HAT)	2.22
Mean High Water Springs (MHWS)	2.12
Mean High Water Neaps (MHWN)	1.74
Mean Sea Level (MSL)	1.26
Mean Low Water Neaps (MLWN)	0.79
Mean Low Water Springs (MLWS)	0.40
Lowest Astronomical Tide (LAT)	0.28

(All levels *from http://www.linz.govt.nz/hydro/tidal-info/tide-tables/tidal-levels, downloaded 18/8/21.*)

2.2 Need for Redevelopment

To enable twin berths at the port, Wharf 8 will need to be extended south by approximately 130 m to cater for larger ships. To enable truck access to the southern end of this extension, additional reclamation is required. The reclamation would need to be sealed to accommodate truck traffic and is proposed to comprise granular fill.

As the Reclamation Area is subject to an energetic wave climate, a revetment will be required to protect the area from wave action. The Revetment would comprise armour units, and the final crest levels and armour unit details have been refined with the use of physical scale wave modelling.

A review of the geotechnical conditions below the Reclamation Area and proposed Revetment has shown that there is a thin layer of soft soils (silt and sands) overlying mudstone ("papa" rock). These soft soils may need to be treated using soil stabilisation techniques, to prevent long-term settlement of the Reclamation Area and Revetment.

Sections of the existing Outer Breakwater area have failed, with parts of the existing structure now below Mean High Water Springs (MHWS). Analysis of survey data along the Breakwater has shown that parts of the structure have been subject to a significant and consistent rate of settlement since at least the late 1950s, with parts of the structure settling at rates of up to 22 mm per annum. The settlement is due to ongoing consolidation of soft alluvial sediments. Geotechnical interpretation of geophysical information has shown that the surface of the "papa" mudstone rock dips downward below the Breakwater, with the Breakwater underlain by up to 30 m of soft alluvial sediments. Further, the original construction drawings indicate that the inner structure of the Outer Breakwater was originally protected by concrete cube armour units, which have since either subsided into the surrounding seabed, or have been dislodged from the structure by wave action. The Outer Breakwater will therefore require refurbishment to enable continued protection for ships using the port area.

Refurbishment works will be required to the Outer Breakwater, comprising:

- armour units to protect the core of the Breakwater
- concrete capping doweled into the existing Breakwater crest to raise the crest level to 4.5 m above Gisborne Chart Datum.

Discussions with potential contractors were held during the design process to assess constructability constraints. These indicated that as there are numerous obstructions around the existing Outer Breakwater, including displaced concrete cube armour units, it would be difficult to undertake ground stabilisation works below the proposed armour units. The lack of ground stabilisation works may result in localised failures of the Outer Breakwater armour layers. EPL propose to manage this risk by topping up the armour layers as necessary, should localised slip failures or subsidence occur in the future.

Wharf 8 is proposed to be extended to allow for a 200 m and a 185 m ship to berth at both Wharf 7 and Wharf 8. This will involve Wharf 8 accommodating a 185 m ship, with Wharf 7 accommodating a 200 m ship, and both ships having a maximum draught of 10.8m. The reclamation will abut the existing Breakwater, which has not been designed to take the fill behind the wall or the dredging in front of the wall. Structural works will therefore be required to upgrade the existing Breakwater for these loads.

The concept design of these works is presented in Section 3 and 4 of this report. The design of the works has been refined with the use of physical scale wave modelling to optimise the sizing and hence stability of the armour units and crest levels.

3. Reclamation Area

To enable twin berths at the port, Wharf 8 will need to be extended south by approximately 130 m. To enable truck access to the southern end of this extension, additional reclamation is required. The reclamation would need to be sealed to accommodate truck traffic, and is proposed to comprise granular fill.

Figure 3-1 provides a plan showing the extent of the Reclamation Area and Revetment. The Reclamation Area would extend alongside the proposed Wharf 8 extension and be protected by an armoured revetment, with a typical section for this revetment shown in Figure 3-1. The footprint of the Reclamation Area has been designed to avoid the Heritage Boat Harbour site, with a buffer of at least 5 m provided to avoid construction impacts at the landing site.

Part of the existing rock and rubble revetment (the Southern Revetment) would be removed to accommodate the Reclamation Area. The Reclamation Area extension will grade toward the northeast at 2% to accommodate surface drainage, and will tie into the existing Southern Log Yard (SLY) stormwater system which has an existing elevation of approximately 4 m above Gisborne Chart Datum (CD).

The Reclamation Area would comprise granular fill, which is preferred over the use of silty dredge spoil material (see Section 8.1).

The elements of the reclamation would include:

- earthworks for the construction of the Reclamation, Revetment and removal of part of the existing Southern Revetment
- construction of an armoured Revetment around the perimeter of the Reclamation Area, to protect it against wave overtopping and provide vehicular access for trucks between the new revetment, existing roadway along the crest of the existing Southern Revetment, and SLY area.
- ground stabilisation below the Reclamation and Revetment area to treat unconsolidated alluvial sediments, to improve the foundations of the Revetment and Reclamation Area to prevent excessive long-term settlements.

Discussions with potential contractors were held during the design process to assess constructability constraints. These indicated that, for the construction of the revetment foundations, the risk of subsidence during construction due to the localised presence of unconsolidated alluvial sediments can be managed by placement of additional rock core material where needed to displace the soft sediment layer, as opposed to ground stabilisation works below the revetment.

3.1 Earthworks

Figure 3-1, Figure 3-2 and Figure 3-3 show the extent of the proposed earthworks for the Revetment and Reclamation Area. A long section of the proposed Revetment is provided in Figure 3-4.

The Reclamation would comprise granular fill, to the extent shown on the Figures, topped with a suitable road-base material such as DGB20. The pavement will need to be suitable for log handling equipment loads, provide adequate surface drainage and reduce maintenance costs associated with the equipment damaging the ground surface.

The pavement will be designed based on the shuttle trucks, container handling equipment and highest load log handling equipment currently utilised at the port. Design of the pavement will be conducted using pavement specific design software, based on available geotechnical data.

A section of the existing rock/rubble Southern Revetment that is within the proposed reclamation footprint area would be partially removed, with the material to be reused within the Reclamation Area. The existing geotechnical information indicates that there may be unconsolidated alluvium below the proposed Reclamation Area, though there is uncertainty with regards to the thickness of this material. To prevent long term settlement of the Reclamation and proposed Revetment, the unconsolidated alluvium may need to be removed or alternatively treated using ground stabilisation techniques.

The construction of the Reclamation Area would be preceded by construction of the Revetment core and toe protection, which would act as a “bund” around the perimeter of the Reclamation area. Revetment works would progress from east to west, to allow access to the revetment by land-based equipment. The revetment core is envisaged to comprise rock fill material and would be progressively protected from wave action by X-bloc concrete armour units as the construction progresses from east to west. It would be expected that at any one time, only the leading edges of the working platform would remain unprotected by concrete or secondary rock armour units, and it is estimated that approximately 40 m^2 of unprotected core at the leading edge of the working platform would be below MHWS. Once the revetment works have enclosed the reclamation area, the reclamation could be constructed partially from material sourced from removal of part of the existing Southern Revetment. The early Revetment works would:

- contain the Reclamation Area, forming a bund, to prevent dispersion of fine sediments from the construction into Poverty Bay
- provide protection to the construction area from wave action.

A means of sediment dispersion control from the core of the revetment during construction is likely to be required, due to the potential for fine sediments attached to the rock obtained from local quarries to be released during construction. The controls may comprise a silt curtain or series of silt curtains around the revetment core during construction, or pre-washing the proposed rock-fill to control the risk of fine sediments generated from the construction of the rock revetment from dispersing into Poverty Bay. The potential for dispersion of fine sediments generated from construction of the rock core of the revetment is being assessed separately by MetOcean Solutions Limited.

It is envisaged that, once the Reclamation Area is completely enclosed by the Revetment, the Reclamation Area would be constructed by means of a working platform for construction equipment, likely constructed of crushed rock, to allow land-based equipment to access the Reclamation Area, and incorporated within the Reclamation Area at the completion of the works. As the Reclamation Area is filled, seawater enclosed within the Reclamation Area by the Revetment would filter through the revetment, and dewatering would not be required.

Table 1 summarises the area of seabed to be reclaimed and volume of earthworks that will be required for construction of the Revetment and Reclamation Area, including volume of material to be excavated (cut), and volume of material to be filled (fill). Assuming 6 t X-bloc® armour units (or similar) are used, approximately 1300 units would be required.

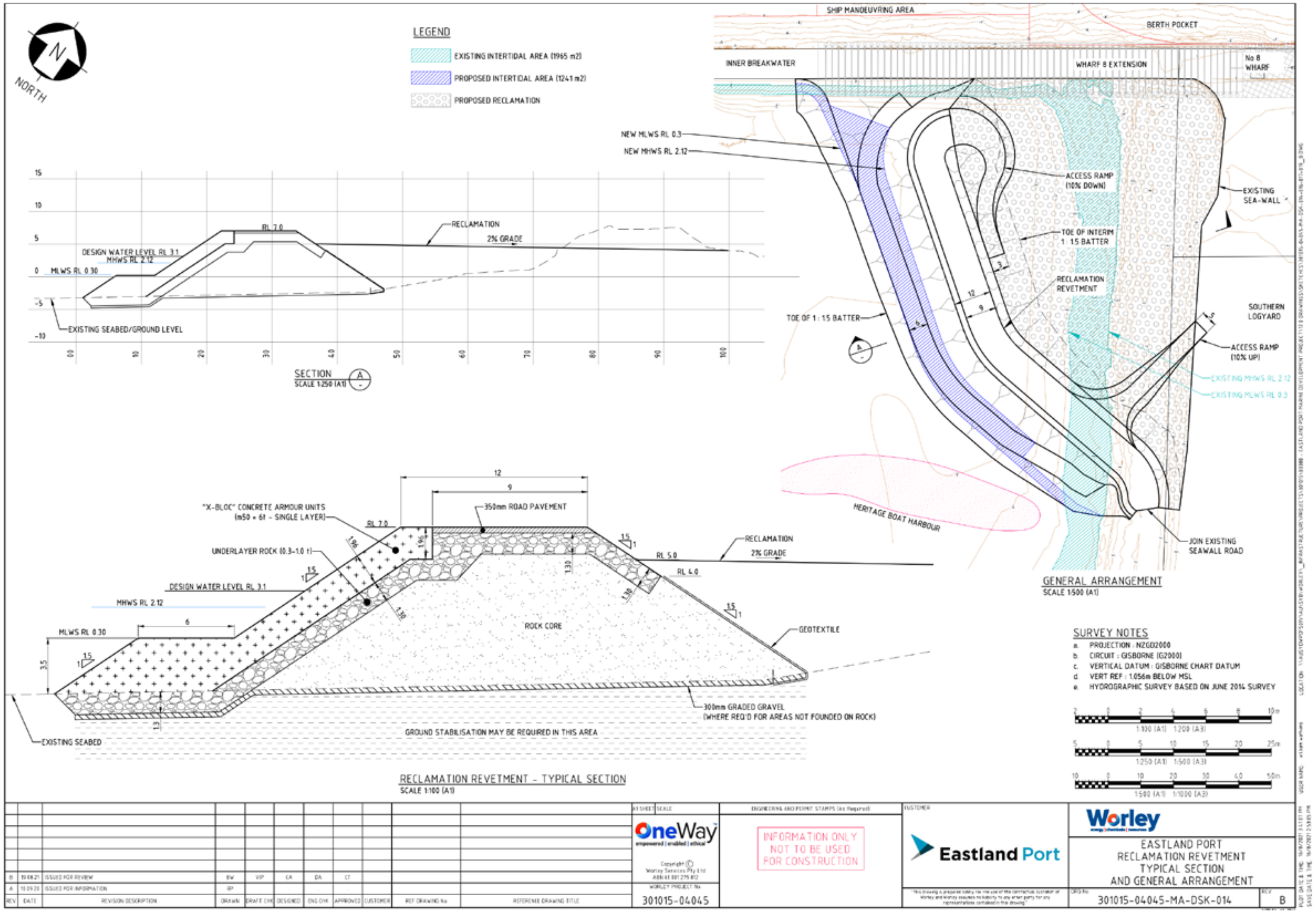

Figure 3-1 – Eastland Port Reclamation, Revetment and Typical Section

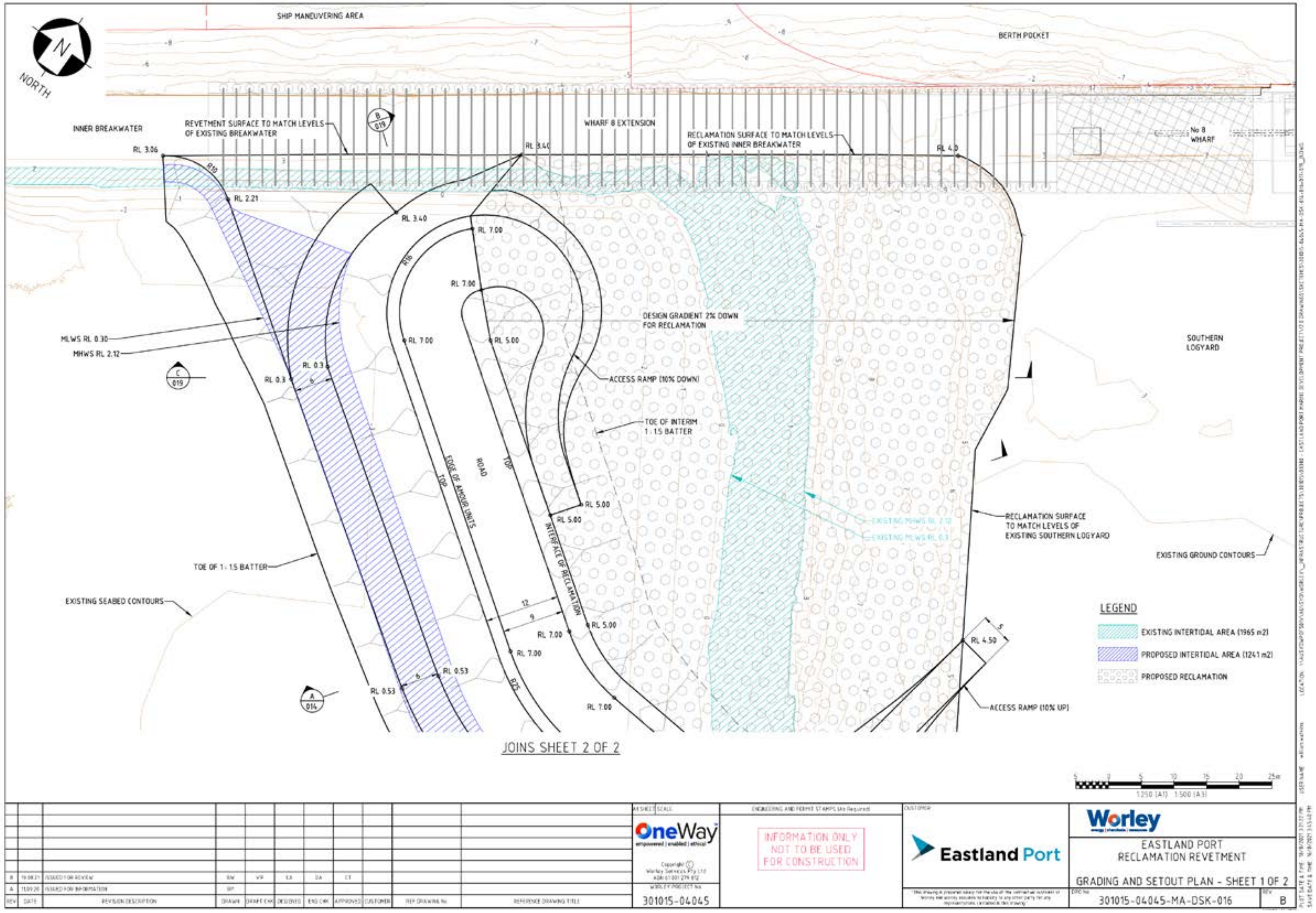

Figure 3-2 – Eastland Port Reclamation Revetment Grading and Setout Plan (Sheet 1)

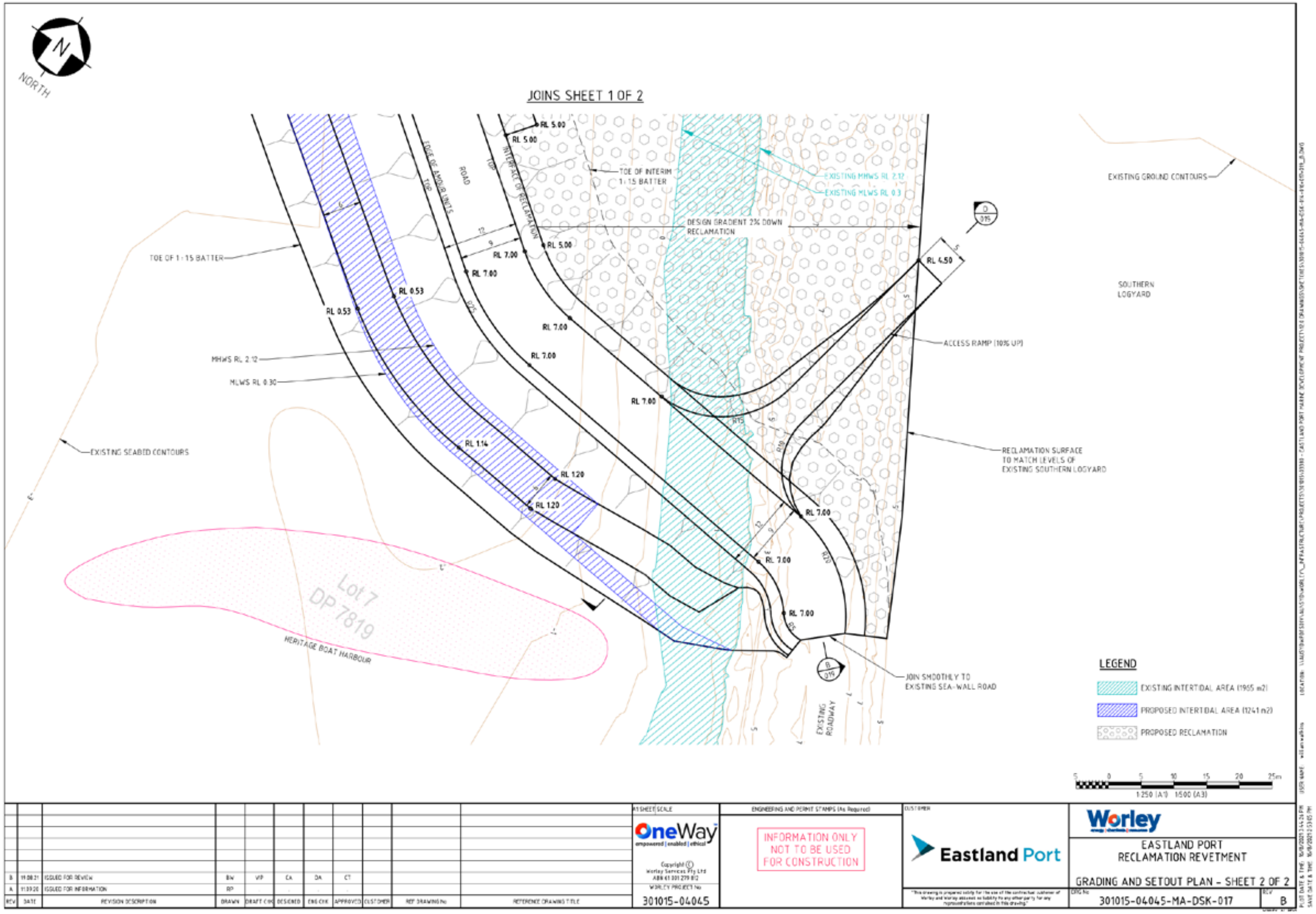

Figure 3-3 - Eastland Port Reclamation Revetment Grading and Setout Plan (Sheet 2)

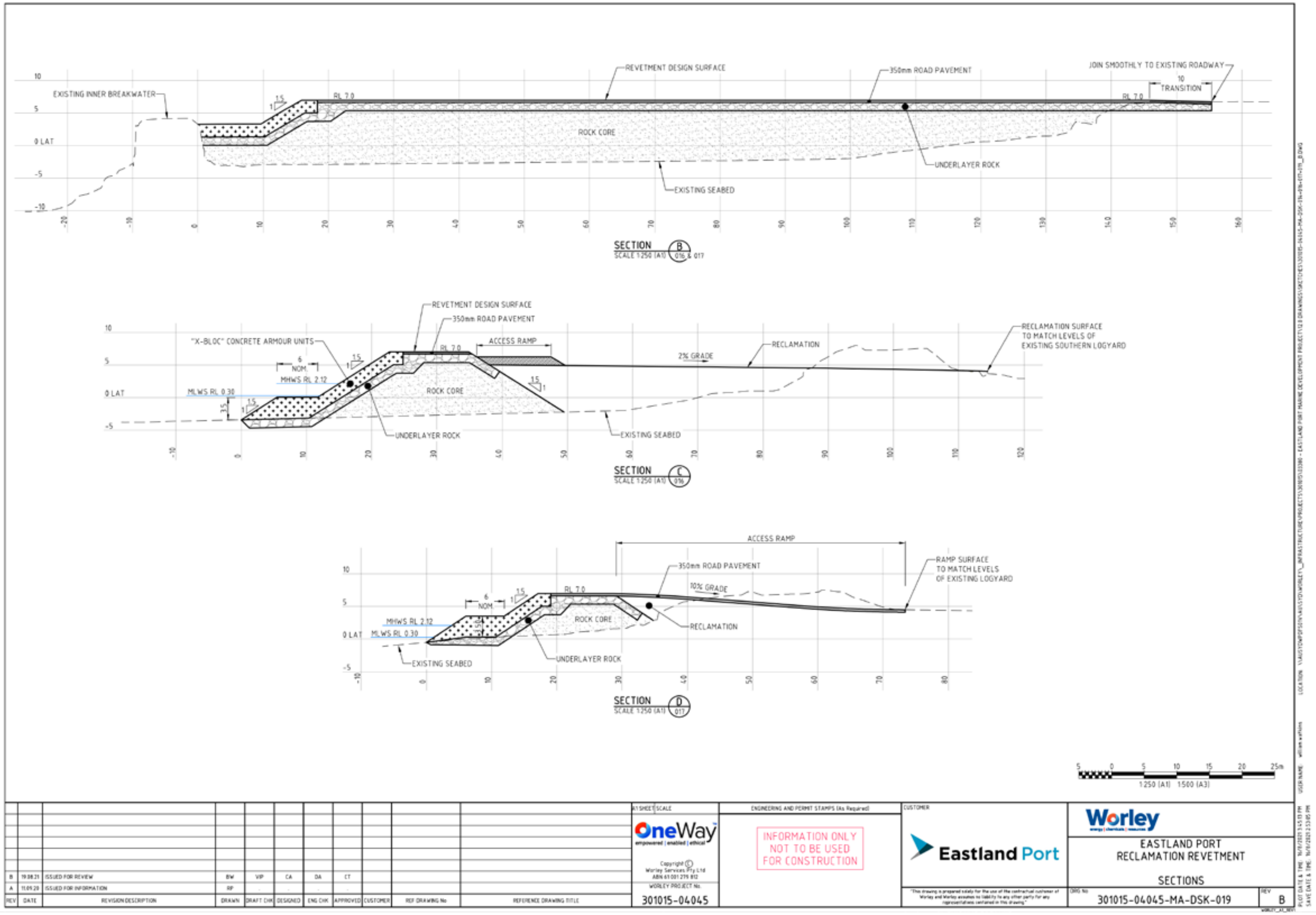

Figure 3-4 – Eastland Port Reclamation and Revetment Sections

Table 1 – Estimated earthworks quantities for Reclamation and Revetment

Zone	Cut Volume (m^3)	Fill Volume (m^3)	Area of seabed (m^2)
Reclamation footprint below MLWS (loss of seabed)			6,250
Revetment Core[1]		19,500	
Excavation for Core	2,500		
Underlayer Rock (1.3 m thick)		4,300	
Armour units (X-bloc® or similar)		7,800[2]	
Road Pavement (350 mm thick)		500	
Ramp Fill (ramp from Revetment crest to Southern Log Yard)		3,000	
300 mm gravel road base		2,000	
Reclamation – excavation	5,000		
Reclamation – fill		17,000	

3.2 Revetment

An armoured Revetment (refer Figure 3-1) will be required around the perimeter of the Reclamation Area. The function of the Revetment will be to:

- provide protection to the Reclamation Area from erosion due to wave action, and lower the risk of wave overtopping onto the Reclamation Area
- provide vehicular access from the Southern Log Yard to top of the Revetment and existing roadway located on the existing Southern Revetment.

The Revetment would include the following elements:

- a crushed-rock core
- secondary rock armour layer, nominally comprising 0.3 – 1.0 t rock boulders
- primary armour layer. This is likely to comprise interlocking concrete armour units (X-bloc® or similar), up to 6 t
- a crest level at 7.0 m Gisborne Port Chart Datum
- crest 9 m wide providing surface trafficable by trucks currently used at Eastland Port, comprising crushed rock roadbase (DGB20 or similar), nominally 300 mm thick, with asphaltic concrete seal nominally 50 mm thick, but subject to further design development.

The toe of the Revetment may require removal of material or ground stabilisation to treat the soft alluvial soils beneath the foundations. This would improve the geotechnical stability of the Revetment and prevent long-term settlement. Discussions with contractors have indicated that it would be feasible to displace soft

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[1] Additional core material may be required during construction to displace soft alluvial sediments at the foundations of the Revetment.

[2] Volume of concrete armour unit layers. Volume of concrete required is approximately 40% of this value, as the concrete armour layer has a porosity of approximately 60%.

alluvial sediments below the revetment during construction, by placement of additional core rock fill material to achieve a stable foundation.

The concept design of the armour for the revetment has been documented in Report 301015-03380-GE-REP-009 (WorleyParsons, 2018). The design of the armour and crest levels for the Revetment has been refined with physical scale modelling, undertaken at the Manly Hydraulics Laboratory (Appendix A). The physical modelling assessed areas of wave focusing, reflections, wave overtopping and armour stability.

3.2.1 Physical Scale Modelling

Due to the 3-dimensional variations in the design of the protection structures including the Breakwater head, the knuckle where it adjoins the Inner Breakwater, the form of the reclamation Revetment, its adjoining to the Inner Breakwater and the angle of wave incidence, 3-dimensional scale model testing was undertaken at the Manly Hydraulics Laboratory (MHL) wave basin. The objectives of the model studies were:

- Optimising the size of the X-bloc® (or similar) armour units for the Outer Breakwater refurbishment and for the reclamation Revetment, by determining what size armour units would be required to limit damage of the armour layers to less than 2% (i.e., defined as initial damage where only a few units are displaced)
- Determining the minimum crest level of the reclamation Revetment to limit average wave overtopping volumes to an acceptable level of 20 l/s/m, above which unacceptable damage to the structure would occur.
- Optimising the design of the Revetment where it adjoins the existing Breakwater.

The studies found that:

- Xbloc armour size at the Breakwater head could be limited to 27 t (in lieu of 34 t that was determined under the desktop design)
- Xbloc armour size at the Breakwater trunk could be limited to 18 t (in lieu of 20 t that was determined under the desktop design)
- Xbloc armour size at the logyard extension Revetment could be limited to 5.2 t (in lieu of 10 t that was determined under the desktop design)
- Xbloc armour size at the transition area between the reclamation and Outer Breakwater trunk would be 11.2 t (in lieu of 10 t that was determined under the desktop design)
- The crest level of the Revetment would be set to 7.0 m CD. At this level, considering future sea level rise, wave overtopping volumes would be limited to <20 l/s/m, which would be sufficient to prevent damage to the crest and leeward side of the Revetment due to wave overtopping. This level is the same as that of the existing Southern Log Yard Revetment, which would allow a smooth transition between both structures to be adopted and simplify the construction.

The sizing of the armour units used in the design has been determined based on the standard X-bloc® sizes listed in the X-bloc® Guidelines for Concept Design, with the next largest standard size above the sizing determined from the physical scale modelling, selected (Delta Marine Consultants, 2018). The nearest standard X-bloc size for each armour class is indicated in Table 2.

Table 2 – Standard X-bloc® sizes compared with sizes determined from physical scale modelling

Project element	Recommended armour size from 3D physical modelling (X-bloc®), t	Actual armour size based on next available standard armour size, t
Breakwater Head	27	28.8
Breakwater Trunk	18	19.2
Transition area between Reclamation Area and Breakwater trunk	11.2	12
Logyard extension Revetment	5.2	6

Protection of the leeward side of the Revetment with secondary armour rock would be required to prevent wash-off of fine material from the surface due to wave overtopping flow and rainfall/runoff down the embankment face. It is recommended that the underlayer rock be extended so that an additional class/grading of rock would not need to be sourced.

3.2.2 Armour Units for Revetment and Breakwater

The armour units considered for the design are X-bloc®. Similar units include, but are not limited to, Accropode™ and Core-loc®. These armour units comprise interlocking concrete units that can be placed either uniformly or randomly. Concrete armour units are required for this project, as rock material of sufficient quality, size and quantity is not available locally to provide erosion protection for the Revetment and Breakwater. The most efficient and economical type of armouring has been selected with respect to structural and hydraulic stability (including the risk of progressive damage); fabrication, storage, handling and placement of armour units; and maintenance and repair of armour layers (Reedjik & Muttray, 2009). Examples of these armour units are provided in Figure 3-5, with examples of placement of the X-bloc® units provided in Figure 3-6.

Figure 3-5 – Left – X-bloc® (4 m^3/9.6 t, Port Oriel, Ireland). Centre – Accropode units (6.2 m^3/14.9 t, Scarborough UK). Right – Core-loc® (15 m^3/36 t, Kaumalapau Harbor, Hawaii). (Reedjik & Muttray, 2009)

Figure 3-6 – Examples of typical random placement of X-bloc® units

3.3 Wharf 8 Extension

The Reclamation Area will comprise a new Revetment with imported fill behind it, which will abut the existing Breakwater. The existing Breakwater has not been designed to take the fill behind the wall or the dredging for the Wharf 8 berth pocket in front of the wall. The following structural works are therefore required to upgrade the existing Breakwater for these loads:

- install new walls either side of existing Breakwater
- install tierods or beam between the new walls creating a caisson[3]

[3] A caisson is a box-like structure commonly used in civil engineering projects where work is being carried out in areas submerged in water.

- supply, delivery and placement of graded gravel to fill the caisson
- placement of a concrete capping slab.

No land-based earthworks will be required, other than filling the caisson with graded gravel.

The wharf will be extended 130 m westward toward and along the Inner Breakwater, with a new pavement installed on a 30 m length on the existing wharf, effectively extending the wharf by 160 m. A new capping beam would be installed along the 160 m section (including 130 m extension), effectively creating a reclamation (or loss of seabed area) of 275 m^2 on the channel side of the wharf. The 130 m extension would be supported by piles, and pavement over the existing Inner Breakwater, rock fill bed and compacted engineered fill materials. The Wharf 8 extension will have a deck level of RL 4.1m CD (approximately 3.7 m above MLWS). The existing crane beam will need to be extended 100 m to the north-west, which will require some additional concrete works and approximately 17 piles, based on the existing Wharf 8 design. As the wharf extension will be supported on piles, no additional ground stabilisation works will be necessary. The level of the existing Inner breakwater varies, but is generally around RL 4.1 mCD. As the top finished level of the extended structure will be at 4.1mCD, sections of the existing Inner Breakwater will need to be trimmed to accommodate the proposed concrete/tie rods and new pavement.

The concept design of the Wharf 8 extension is presented in Figure 3-7. The material quantities required for the Wharf 8 extension are provided in Table 3.

Table 3 – Estimated quantities for Wharf 8 extension

Zone	No.	Fill Volume (m^3)
No. Caisson Piles	200	
No. Piles for Crane Beam	17	
Gravel fill for caisson		3,750
Concrete – crane beam		100
Concrete – capping beams		900
Reinforcing steel for capping beams		300 tonne
Tie rods and T-anchors for tie rod connections	200	
Reinforced concrete slab up to 1 m thick		3,500
40 MPa RC plug on top and front of piles		700
Reinforcing steel for pile plugs		85 tonne

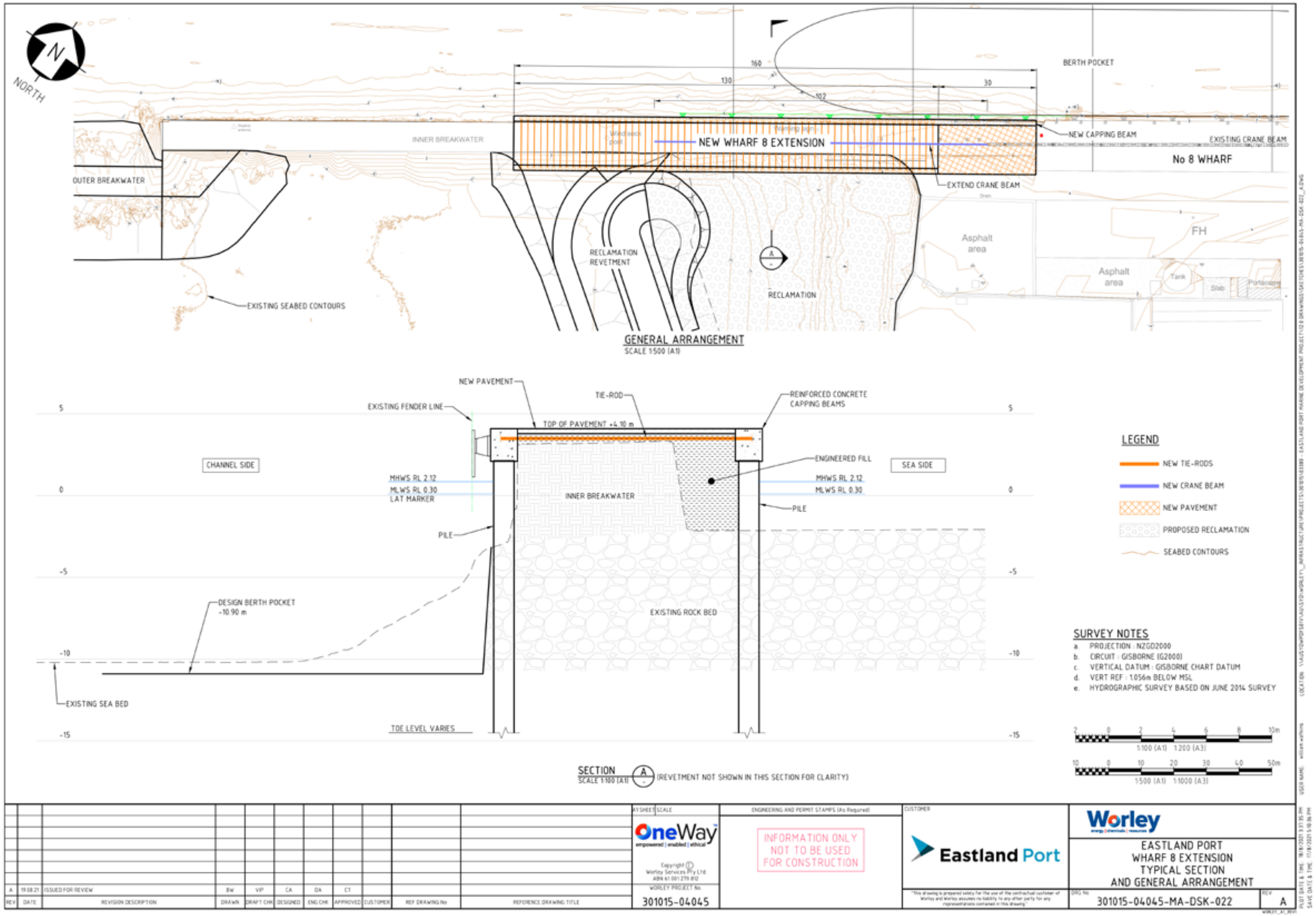


Figure 3-7 – Eastland Port Wharf 8 Extension – Typical Section and General Arrangement

4. Outer Breakwater

The Concept Design for the Outer Breakwater refurbishment (WorleyParsons, 2015) is presented in Figure 4-1 and Figure 4-2.

The features of the design include:

- filling either side solely with interlocking armour units as the crest elevation is relatively low at around RL 4.0 to 4.5 m CD
- the ocean side slope is 1V:2H and the lee side slope is 1V:1.25H to avoid the channel
- the raised cast-in-situ concrete crest will require epoxy doweling into the existing structure to accommodate horizontal shear from wave forces
- a small area of re-armouring of the Inner Breakwater will also occur in an approximately 30m long ‘transition zone’ (shown hatched in Figure 4-1) to allow construction access.

The design of the Outer Breakwater includes concrete armour units, placed in bulk around the existing Breakwater core, with 28.8 t X-bloc® (or similar) units currently proposed for the Breakwater head, and 19.2 t X-bloc® (or similar) for the Breakwater trunk. The mass of the units has been optimized with physical scale modelling as discussed in Section 3.2.1.

The geotechnical conditions below the Outer Breakwater area comprise deep soft alluvial sediments, with a preliminary geotechnical analysis indicating that soil stabilisation may be required to allow the placement of the armour units around the Breakwater core. The potential stabilisation techniques are described in Section 6.5. Discussions with potential contractors held during the design process to assess constructability constraints indicated that, as there are numerous obstructions around the existing Outer Breakwater, including displaced concrete cube armour units, it would be difficult to undertake ground stabilisation works below the proposed armour units. The lack of ground stabilisation works may result in localised slip failures of the Outer Breakwater armour layers. Ongoing settlement of the Outer Breakwater, which has been observed historically, is likely to continue.

The constructability reviews also indicated that the proposed armour units may require the use of marine-based plant for placement, as the ability of the existing Breakwater structure to support the crane loads incurred from land-based placement is likely to be limited.

It should be noted that as the existing Breakwater is founded on deep soft alluvial sediments, it is expected to require ongoing maintenance, which would comprise topping up the concrete armour units should excessive settlements occur.

4.1 Estimated Material Quantities

The estimated volume of the armour layers required for construction of the Breakwater refurbishment is approximately 40,000 m^3. At a porosity of 60%, this equates to 16,000 m^3 of concrete armour units placed in bulk around the core of the Breakwater. The total number of armour units required is estimated at:

- 28.8 t X-bloc® (or similar) – 350 units
- 19.2 t X-bloc® (or similar) – 1450 units.

- 12 t X-bloc® (or similar) – 110 units.

The volume of the concrete cap required to raise the crest of the Breakwater to 4.5 m CD is approximately 4,700 m^3. The seabed 'footprint' of the structure (above MLWS) will be increased by 3,500 m^2, from approximately 1,850 m^2 to 5,350 m^2. The volumes of each component are estimated in Table 4.

Table 4 – Estimated material quantities for Outer Breakwater upgrade

Zone	No. units	Fill Volume (m^3)	Area of seabed (m^2)
Reclamation footprint below MHWS (loss of seabed)			3,500
Rock Fill (500 – 1000 kg)		6,250	
Armour units (X-bloc® or similar)		40,000[4]	
28.8 t (12 m^3) units for Breakwater head	350	10,000	
19.2 t (8 m^3) units for Breakwater trunk	1450	28,300	
12.0 t (5 m^3) units for Breakwater knuckle	110	1,700	
Concrete cap for crest		4,700	
Road Pavement (350 mm thick)		540	

[4] Volume of concrete armour unit layers. Volume of concrete required is approximately 40% of this value, as the concrete armour layer has a porosity of approximately 60%.

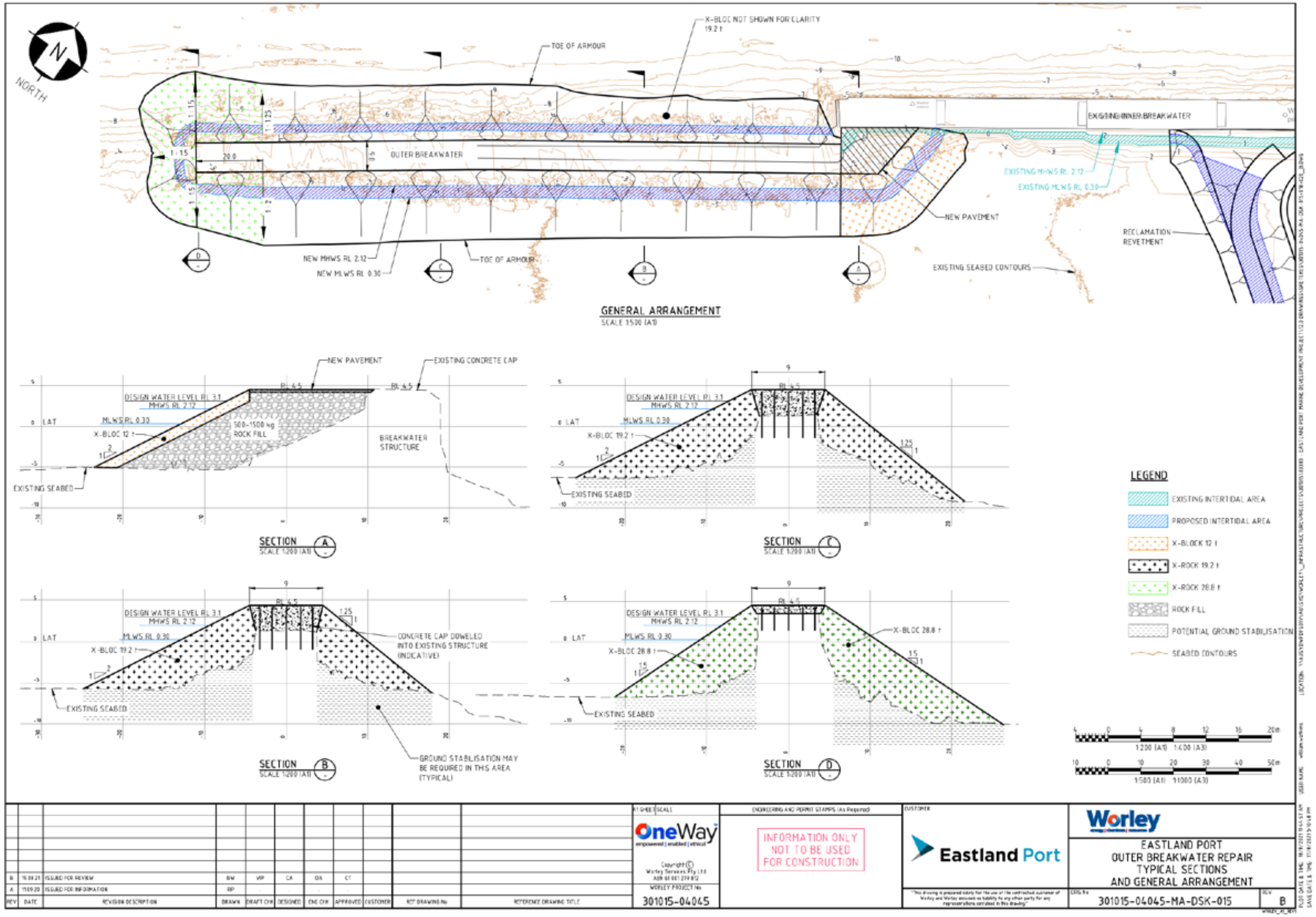


Figure 4-1 – Eastland Port Outer Breakwater Repair Typical Sections and General Arrangement

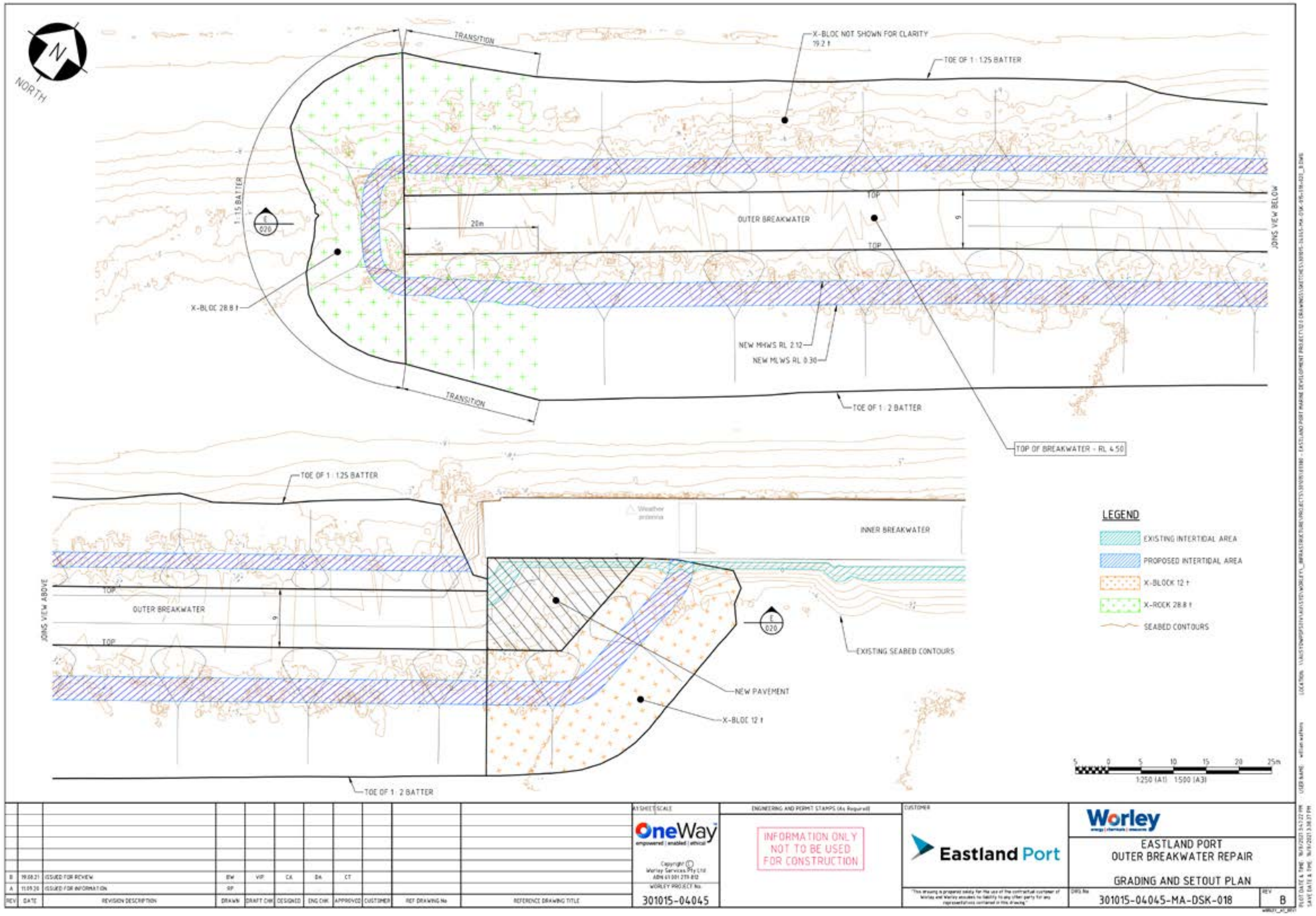


Figure 4-2 – Eastland Port Outer Breakwater Repair Grading and Setout Plan

5. Geotechnical Conditions

A range of sub-surface investigations have been conducted across the site, with boreholes drilled along the alignment of the Inner Breakwater as well as geophysical surveys and Multibeam Echo Sounder (MBES) for an area around the Breakwater. This data has been used to interpret the likely ground conditions. The stratigraphic profile prepared along the alignment of the Inner Breakwater is included in Figure 5-1.

This interpretation suggests

- The Northern (inshore) section includes a deep paleochannel infilled with soils with good geo-mechanical properties.
- The Southern (offshore) section of the Inner Breakwater, and the Outer Breakwater (which have experienced large settlements) contains soft sediments likely overlying the higher paleochannel loadbearing soils.

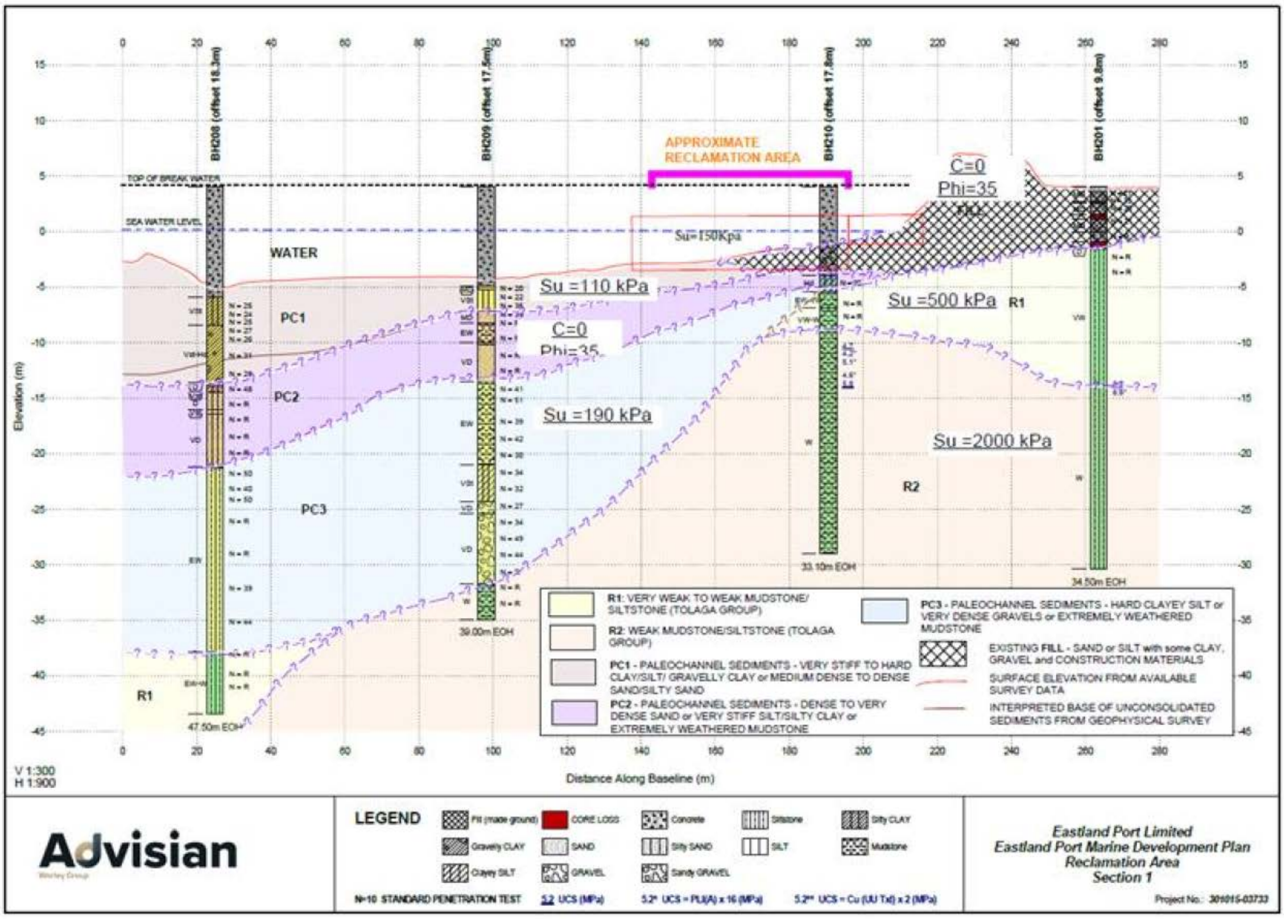


Figure 5-1 – Interpretation of sub-surface ground conditions - Inferred ground profile below Inner Breakwater

While the geotechnical design parameters of the good loadbearing paleochannel materials were derived based on correlations against in-situ testing results (i.e. standard penetration tests), the shear strength of soft marine sediments were assumed at this stage. The shear strength (magnitude and variation with depth) will need further validation via appropriate in-situ and laboratory testing of representative samples.

A preliminary assessment of the proposed Revetment design and Outer Breakwater refurbishment design was carried out against global stability and bearing capacity requirements, using the commercially available software SlopeW. The preliminary assessment found that the presence of soft sediments is likely to pose geotechnical stability concerns, and that an appropriate level of ground improvement may be required to mitigate the stability risks.

6. Design and Build Details

Contractors will be engaged to construct the proposed Outer Breakwater refurbishment, Reclamation area and Wharf 8 Extension. As the final detailed design is still to be undertaken, final design details including pavement, soil stabilisation details, armour unit details and crest levels are subject to further refinement, and will not become available until after EPL has received consent conditions and is committed to the proposed redevelopment works. This section describes the likely construction sequence and methods to achieve compliance with Gisborne District Council's (GDC) plans, of these works. Due to the size of the site, it is likely that a number of work activities will be undertaken at one time, rather than work proceeding in a linear fashion as described here.

Due to the age and unknown status of the existing Revetment, it is unlikely that all demolished material will be re-used on site. However, materials will be sorted on site and suitable materials will be reused where possible. All unsuitable material will be removed from site and disposed of at an appropriately consented facility. Note that earthworks to the existing Revetment would not extend below MHWS and would occur only once the new Revetment has enclosed the proposed Reclamation Area.

As described in Section 8.1, due to the fine nature of dredged material, it is unsuitable for use as backfill within the Reclamation Area, or as part of pavement material, and therefore unlikely to be re-used on site.

Construction is likely to require ground improvement equipment, excavators, bulldozers, piling equipment and cranes. Excavation of the existing Revetment is likely to occur using standard earthmoving equipment, followed by standard earthmoving, paving and concreting equipment to install pavement. Cranes will be required for the installation of armour units for the Revetment and Outer Breakwater.

Figure 3-1 contains a site plan of the proposed works, while Figure 3-1 and Figure 4-1 provide some typical cross sections of the work to be completed. Actual details may vary once consent conditions are available.

6.1 Expected Construction Sequence – Wharf 8 Extension

The following construction sequence is expected for the Wharf 8 extension. Construction is expected to take approximately 8 months, and would need to commence prior to construction of the Reclamation and Revetment. Piling would likely be undertaken using a "Drill and Drive" technique, whereby steel circular hollow section piles would be driven to refusal, then drilled through the pile to enable further driving of the piles to the ultimate embedment level required. Piles would be driven to an ultimate penetration depth of 11m – 19m below the seabed, depending on the nature of the seabed materials. The construction staging for the Wharf 8 Extension is shown in Figure 6-1.

- **Preliminaries**
  - Site mobilisation/setup temporary services.
- **Stage 1 – Install Piles**
  - Supply and deliver steel tube piles
  - Mobilise piling rig and install piles either side of Breakwater - some removal of existing Breakwater material may be required
- Stage **2 - Install precast concrete capping beams**

- Install tie rods (rods to be placed in settlement tubes)
- Install insitu concrete infill to capping beams

- **Stage 3 - Place engineered fill between piled walls**
- *(*Reclamation *works program can start once gravel is placed)*
- **Stage 4 - Cast insitu concrete slab/pavement makeup**
- **Site demobilisation**

Discussions with potential contractors were held during the design process to assess constructability constraints. Contractor feedback indicated that, for the Wharf 8 extension, it would be advantageous for the area to be protected from wave action to allow the piling rig to work more efficiently. This could be achieved by partial or complete construction of the Revetment initially, to partially enclose the Reclamation area and reduce the wave climate, or by fully enclosing the Reclamation area and pumping out the water such that construction of the Wharf 8 Extension can be carried out. Construction would likely be carried out from land, but may require the use of some barge-based equipment, depending on the methodology adopted by the contractor. Contractors also indicated that a minimum separation distance of 5 m is achievable between the edge of the revetment works and the northern edge of the reef at the Heritage Boat Harbour.

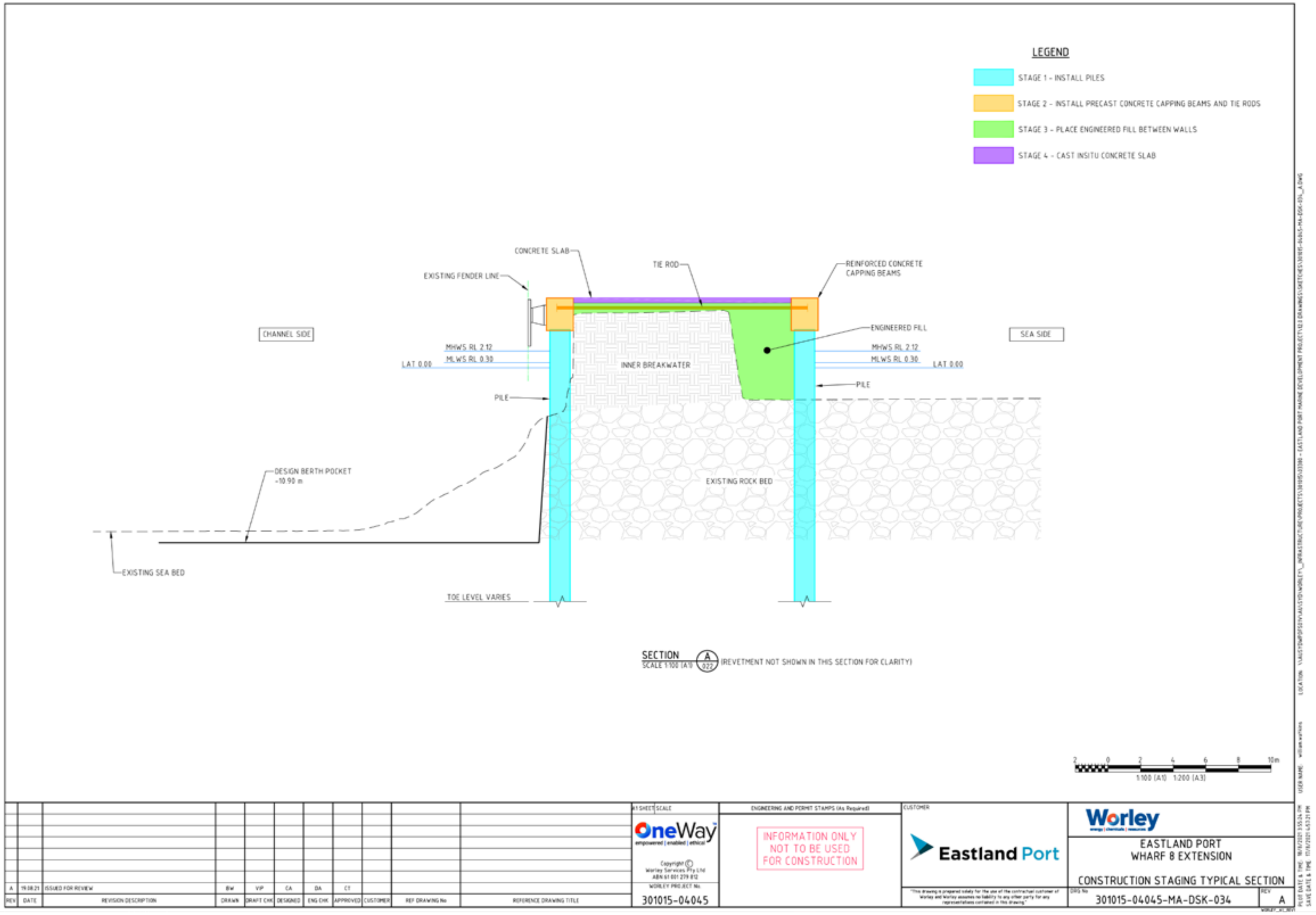


Figure 6-1 - Indicative Construction Sequence – Wharf 8 Extension

6.2 Expected Construction Sequence – Reclamation Area

The expected construction sequence for the Reclamation Area, showing the broad construction stages, is illustrated in Figure 6-2 and would be as below. Construction of the reclamation would begin following the placement of engineered fill between the piled walls for the Wharf 8 extension. Construction is likely to take approximately three years following site mobilisation, with indicative timeframes for each activity provided below. There is a possibility this could be shortened during detailed construction planning with procurement of long lead items such as Core Rock and Concrete protection units being conducted early and stored offsite. The variation in the expected construction period is related to the extent and nature of the likely ground stabilisation measures, the supply of armour units and weather conditions.

- **Preliminaries**
  - Site mobilisation/setup temporary services (1 – 2 months)
  - Remove debris and deleterious materials from existing Southern Revetment and store/dispose of appropriately (1 week).
- **Stage 1 –Construct Revetment Working Platform**
  - Construct working platform for construction equipment from existing SLY for areas not requiring ground improvement. The working platform would comprise crushed rock fill or quarry run, with suitable material from within the existing Revetment incorporated within the Reclamation Area. The working platform would be constructed to an elevation of approximately 3 m CD and would form part of the core of the Revetment. (approximately 6-12 months to build rock embankment and rock underlayer to specification, to standard required for placement of concrete armour units).
- **Stage 2 – Initiate Construction of Revetment Toe and enclose Reclamation Area (constructed concurrently with Stage 1)**
  - Construct the Revetment toe and Revetment to a level of 3.5 m CD building out from the SLY, likely beginning at the south-eastern corner and moving in a westerly direction along the Revetment footprint, for the areas where the depth of unconsolidated material is shallow. The depth of unconsolidated sediments is expected to be shallow at the eastern end but may be progressively deeper moving toward the west. Contractor feedback during the design process has indicated that the unconsolidated sediments can be displaced with placement of additional core rock where necessary to achieve a stable foundation for the revetment (3 - 4 months).
  - Progressively armour the toe with armour units, such that only a small area of the revetment core remains unprotected from wave action at any time during the construction (2 months).
  - Complete construction of the revetment toe by armouring with armour units to fully enclose the Reclamation Area, forming a bund (1 month).
- **Stage 3 – Progressively construct Revetment**
  - Construct second stage of Revetment core between approximately RL 3.5 and RL 6, and armour front face progressively, likely from east to west (4 – 6 months).
  - Construct third stage of Revetment finished crest level and armour front and rear face progressively, likely from east to west (2 – 3 months).
  - Construct pavement at crest of Revetment and Reclamation Area (1 - 2 months).
  - As construction of the revetment progresses, install geotextile fabric on the inside edge, and cover with quarry run material to prevent deterioration of the geotextile (1 – 2 months).

- **Stage 4 and Stage 5 – Construct Reclamation working platform, ground improvement works and Reclamation Area**

  Following on from construction of the Revetment, progressive construction of a rock working platform followed by ground improvement of the existing seabed works if required in front of the rock platform and construction of the Reclamation Area. The sequence would generally be as follows, working from the shoreline to the edge of the Revetment:

  - Undertake ground improvements for approximately 10 m to 15 m from the shoreline;
  - Fill over the area of ground improvement with granular material up to approximately RL 3m CD to create a working platform;
  - Use the working platform to undertake ground improvements for the next 10 m to 15 m zone of the seabed;
  - Extend the working platform over the latest section of ground improvement;
  - Continue with the abovementioned sequence of work until ground improvement works are extended to the outer edge of the Reclamation Area. (4 – 6 months)
  - Construct Reclamation Area to finished level and grade using engineered fill/crushed rock (4 – 6 months).

- **Demobilisation**

  - Fencing and other miscellaneous works will be completed as construction allows.
  - Site demobilisation.

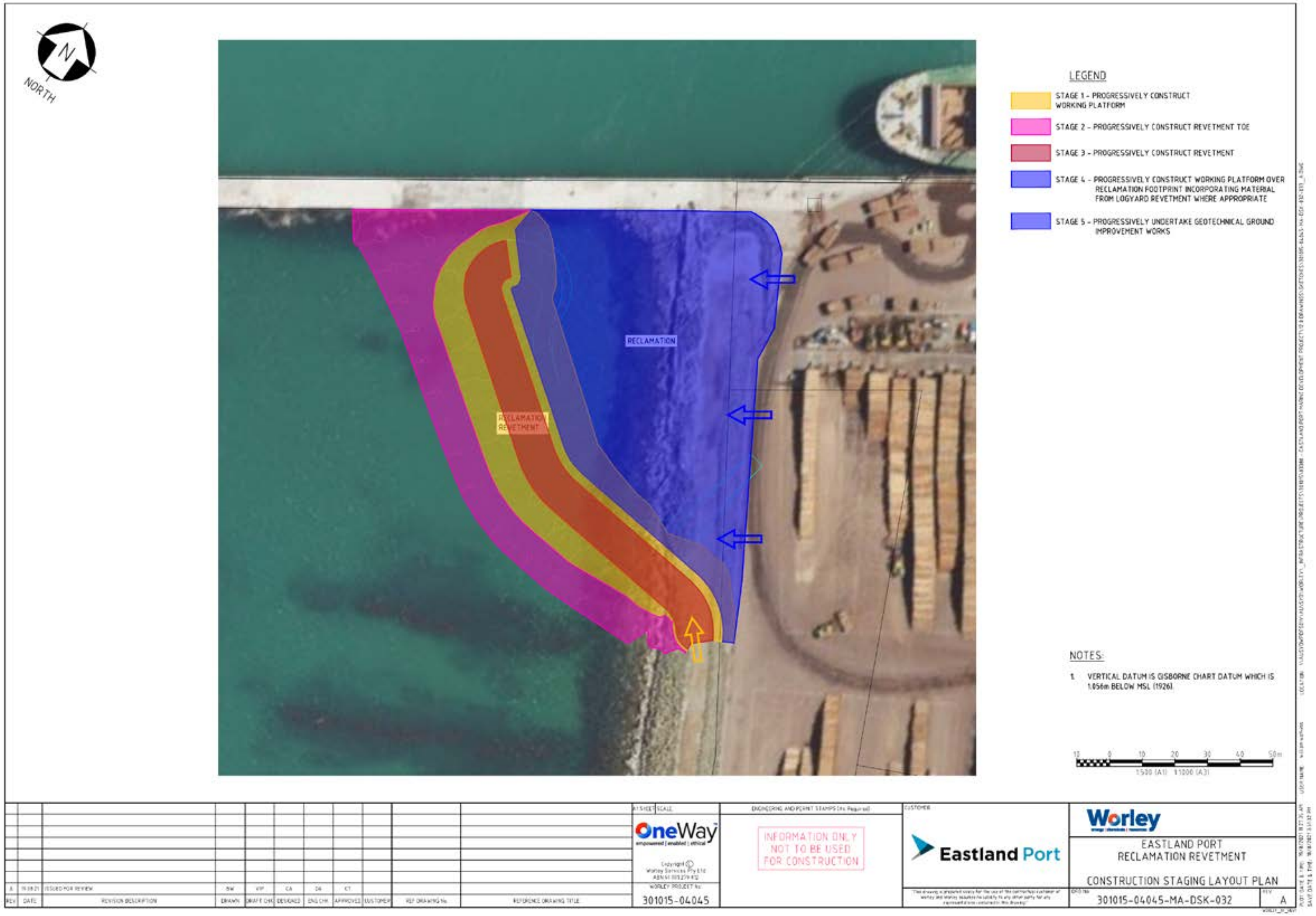


Figure 6-2 – Indicative construction sequence – Reclamation Area

6.3 Expected Construction Sequence – Outer Breakwater

Surveyed sections of the Outer Breakwater indicate the possible deterioration of the original structure with the concrete blocks and some rock infill spread within the surrounding matrix of soft marine sediments. It is also understood that historically Eastland Port may have placed additional rip-rap material around the structure, increasing the amount of buried obstructions around the Breakwater structure.

Placement of additional armour units around the Breakwater as part of the proposed works may require deep stabilisation measures of the marine sediments, in order to support the armour units. Detailed geotechnical information is not currently available but will be required to inform the extent of ground improvement works required beneath the foundations of the proposed structure.

Discussions with potential contractors held during the design process to assess constructability constraints indicated that, as there are numerous obstructions around the existing Outer Breakwater, including displaced concrete cube armour units, it would be difficult to undertake ground stabilisation works below the proposed armour units. The lack of ground stabilisation works may result in localised slip failures of the Outer Breakwater armour layers. EPL propose to manage this risk by topping up the armour layers as necessary, should localised slip failures or subsidence occur in the future.

The initial concept for the Outer Breakwater refurbishment envisaged armour units being placed by crane from the existing Outer Breakwater structure. Given the uncertain geotechnical conditions at the site and the of size of crane required to place concrete armour units up to 28.8t at a large radius, the ability of the existing structure to support the crane would need to be the subject of further geotechnical and engineering investigations. An alternative to supporting the crane on the existing structure is to construct the armour layers using marine plant. This alternative was considered to be the most feasible based on constructability feedback obtained from potential contractors. A crane for placement of the concrete armour units would be mounted on a barge or jack-up platform, which would be subject to operability constraints due to weather and swell. A third option to create a crushed rock working platform for construction plant alongside the existing structure was considered. However, the platform would be difficult to maintain during the construction period due to the high wave energy that occurs at the Outer Breakwater.

Therefore, at this stage of project development, the following construction sequence and stages, illustrated in Figure 6-3, is envisaged. The Outer Breakwater upgrade may take approximately 2 years of construction, and would likely be undertaken following the completion of the Reclamation and Wharf 8 construction. This construction period is to be spread over a number of summer seasons (5) though to allow for easier construction and the procurement of materials required. Constructability discussions with contractors indicated that the newly constructed Reclamation Area could be used as a laydown area for the armour units for the Outer Breakwater, which would assist in providing initial preloading to the Reclamation Area to prevent excessive future settlements. Indicative timeframes for each activity are provided below. The variation in the expected construction period is related to the extent and nature of the likely ground stabilisation measures, the supply of armour units and weather conditions.

- **Preliminaries**
  - Site mobilisation/setup temporary services (1 – 2 months)

- **Stage 1 – Progressively construct armour layers**
  - Manufacture the 28.8t and 19.2t armour units (either at the airport or the Matawhero Log Yard), and transport to the site as required. A local handling area for the armour units would be required, which may be a section of the SLY or the newly constructed Reclamation Area (2 – 4 months).
  - Construct the "knuckle" by placing rock fill at the transition location between the Inner and Outer Breakwater.
  - Progressively armour the area around the existing Outer Breakwater and "knuckle" transition with concrete armour units, working from east to west. Concurrently place concrete armour units on the northern side of the Breakwater (6 – 12 months).
- **Stage 2 – Progressively construct concrete capping layer.**
  - Construct dowels into existing structure, then add concrete capping to Breakwater core to required finished level (1 – 2 months).
  - Complete armour placement to required finished level (4 – 6 months).
- **Site demobilisation.**

Regardless of the construction method adopted (crane on the caisson or crane working from marine-based barge or jack-up platform), further geotechnical investigations will be required.

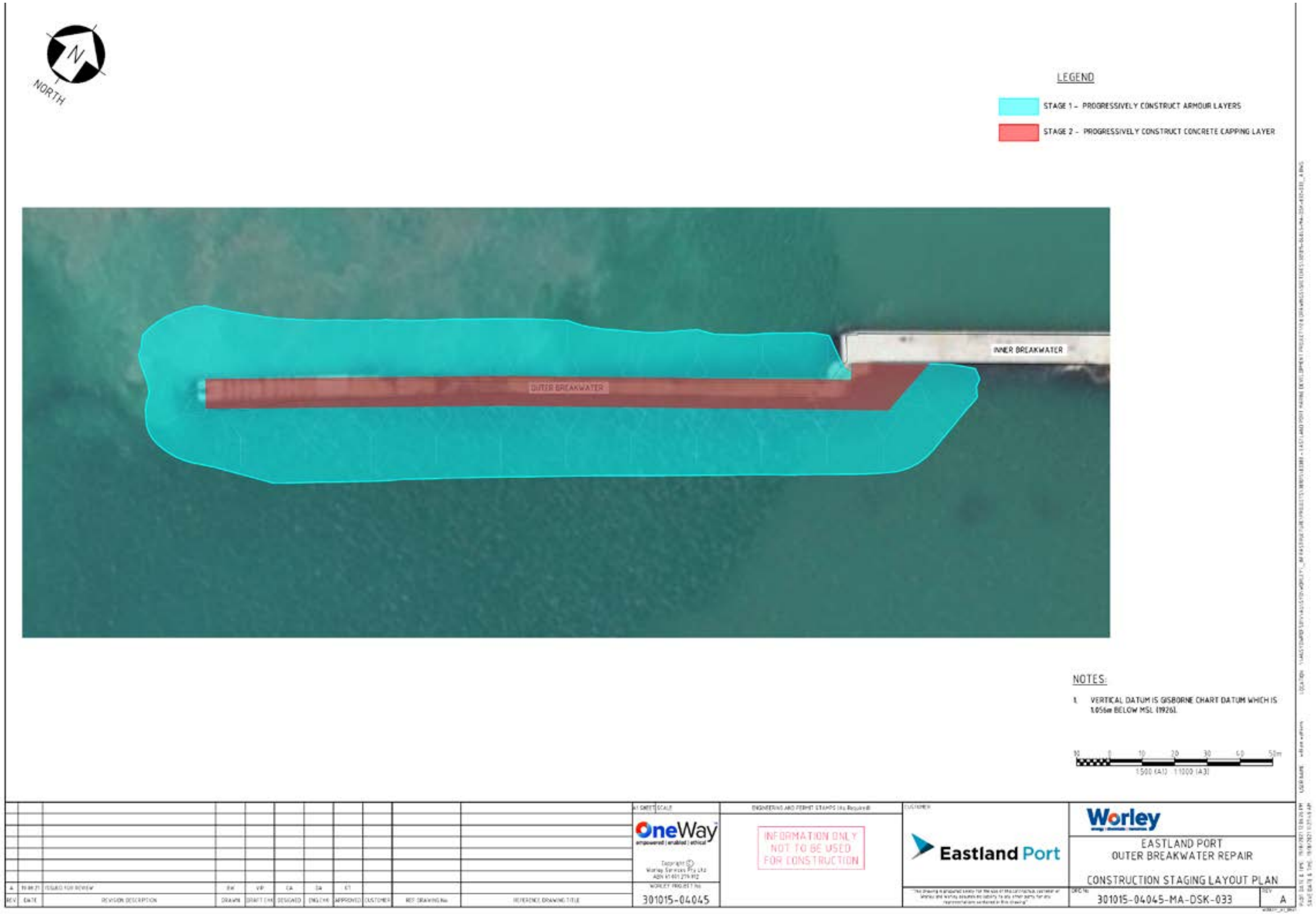


Figure 6-3 – Indicative Construction Sequence – Outer Breakwater refurbishment

6.4 Erosion and Sediment Control

During construction the contractor will be required to include runoff controls to ensure that the requirements contained within Chapter 6 of the Tairāwhiti Resource Management Plan (Gisborne District Council, 2017) are met. EPL will require the contractor to prepare an Erosion and Sediment Control Plan (ESCP) that shows how the contractor will meet these requirements. While details of the systems to be used will be determined by the contractor, it is expected that they will be similar to controls used on similar earthmoving and retaining wall projects conducted in Gisborne, such as the recent Wharfside Logyard (WLY) redevelopment.

Controls may include:

- minimising plant movement during dry conditions to minimise dust generation
- having a water cart on site during extended dry conditions to control dust
- installation of silt fences prior to stormwater discharge locations from the site
- hay bale barriers
- stormwater pit/discharge location inlet protection
- runoff diversion channels and bunds
- regular sweeping and washing of site entrance and exit points.

In addition to these controls it is expected that regular daily, weekly and post event inspections will occur to check on the operation, effectiveness and maintenance requirements of the controls.

6.5 Ground Improvement Options

Several ground improvement options for the Reclamation Area are available as described below. The appropriate solution will be determined following further geotechnical investigations.

- **Deep Soil Mixing (DSM) combined with high strength geofabric** – This involves the mixing of the grout with in-situ soil using a rotary mixing auger (Figure 6-4). The cement binder is applied under pressure with the outcome to consist of a number of interlocking column panels. In turn, this will increase the ground bearing pressure capacity and minimise the magnitude of settlement as well as reducing the risk of differential ground movements. This option would involve founding the interlocking columns on the competent paleochannel sediments below the soft sediments.
- **Mass Stabilisation -** Mass stabilisation is a ground improvement method where the soft soil mass is mechanically mixed with dry binder to improve its engineering characteristics to a maximum depth of 5.0 m to 6.0 m (Figure 6-5). In this technique, the binder is pulverised under high air pressure and then mixed with the in-situ soil using an excavator with an extension holding a special rotating head. The choice of binder depends on the soil moisture content and it could consist of either cement or mixtures of cement and lime.
- **Combination of DSM and mass stabilisation** – This involves a combination of mass stabilisation and deep soil mixing columns, with mass stabilisation over a depth of 2.0 m to 3.0 m which may be adopted to create a stable working platform with a sufficient bearing capacity to support the operating forces imposed by the deep soil-mixing equipment, followed by interlocking DSM columns to deeper depths if required.
- **Jet Grouting** - The technique of jet grouting uses rotating nozzles at the end of a hollow tube to inject binder using high pressure jets, and may be appropriate for improving the stability of the Outer Breakwater refurbishment. Pre-drilling through seabed obstructions would be required to allow insertion of the rotating nozzles for treatment to a depth suitable to provide adequate support for the

Breakwater structure. The injection pressure may be varied to create large diameter columns of in-situ soil mixed with the binder agent. Figure 6-6 shows the methodology employed during the jet grouting process.

The above options for the Reclamation Area would require the use of a stable working platform for construction equipment, and the Reclamation Area to be enclosed by the Revetment to prevent dispersion of fine material into Poverty Bay.

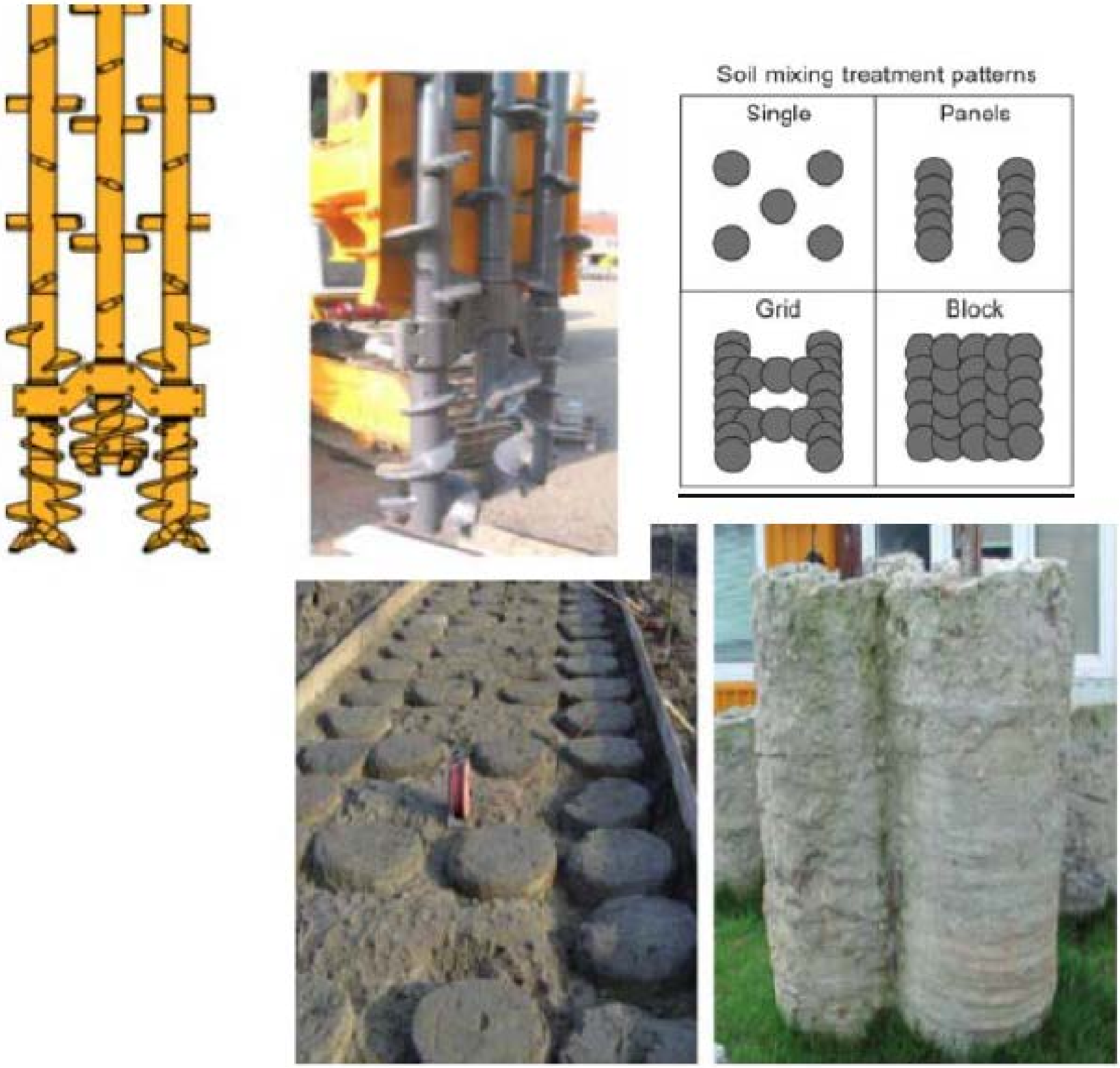


Figure 6-4 – Deep Soil Mixing (DSM) process

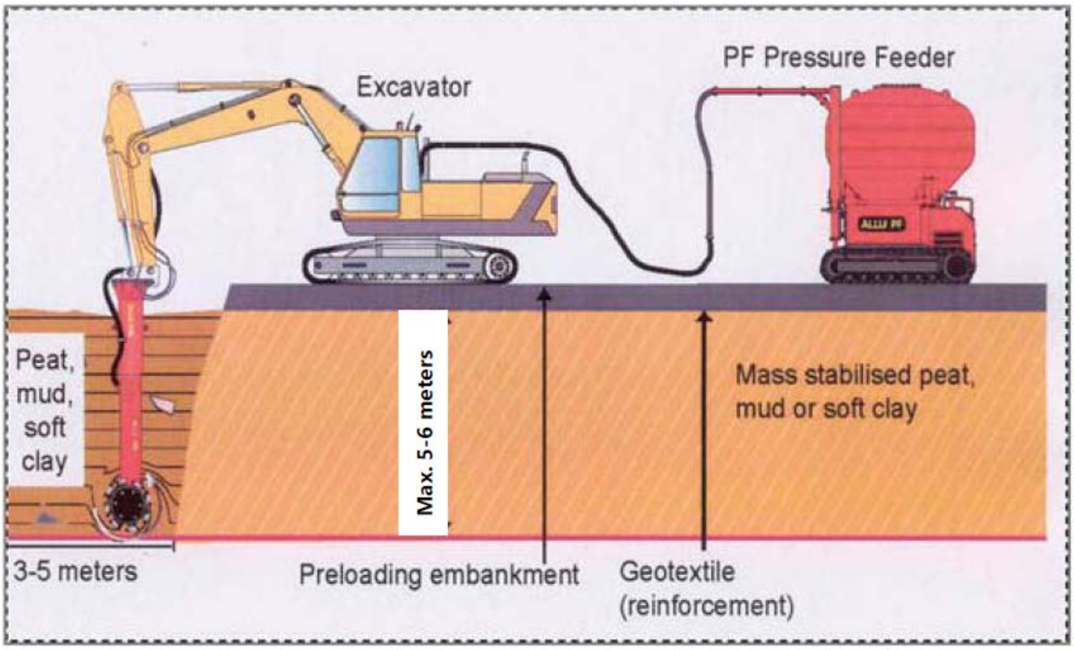


Figure 6-5 – Example of Mass Stabilisation Process

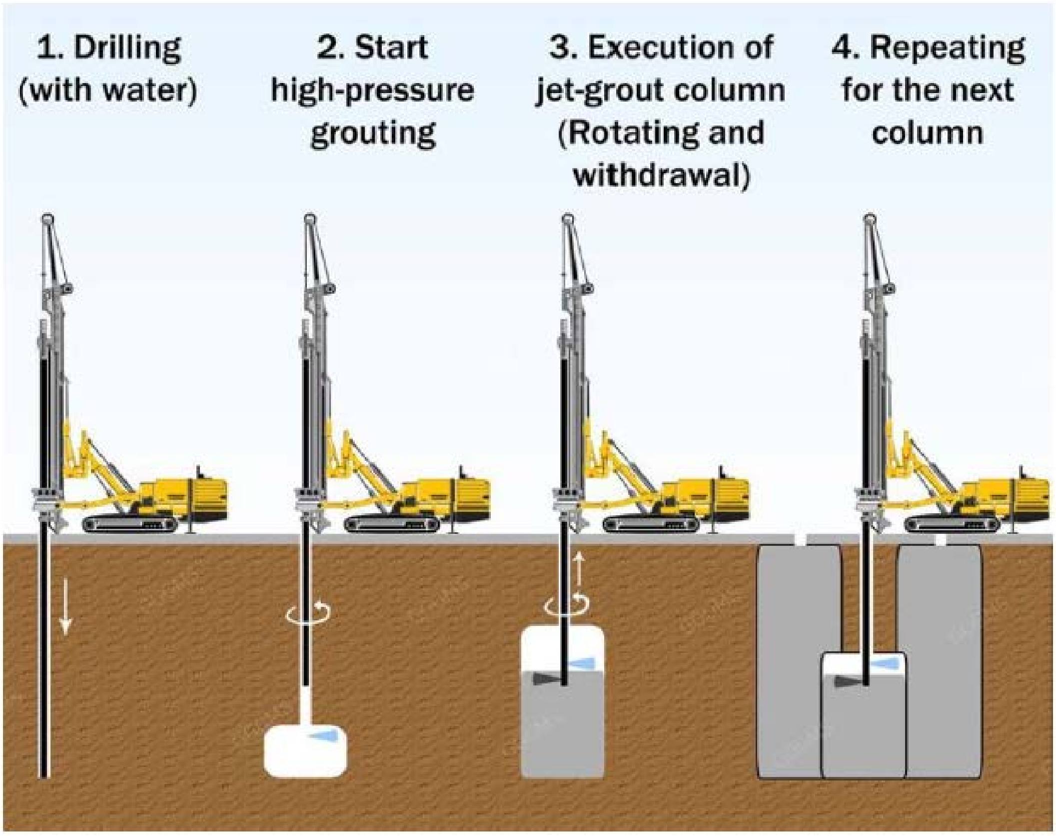


Figure 6-6 – Jet grouting process

7. Impacts

7.1 Construction Impacts

Allowing for mobilisation, demolition, construction and demobilisation, and depending on final staging, it is expected that the reclamation and Breakwater refurbishment works may take up to eight years. Construction of the Wharf 8 extension would be undertaken first, with the Reclamation and Revetment construction commencing part-way through the Wharf 8 extension construction program, and the Breakwater refurbishment being conducted at a later stage.

For the Wharf 8 extension, hammer driving of steel tubular piles will be required, which will generate associated noise and vibration. Works will be managed in accordance with New Zealand Standard NZS 6803:1999 'Acoustics – Construction Noise'. EPL will set aside space for the storage and handling of the piles and tie rods + PVC tubing during Breakwater improvements/repairs. Due to the limited space available within the port, these may need to be stored offsite.

Traffic would access the SLY via Kaiti Beach Road. It is understood that the manufacture of concrete armour units would occur offsite at the Matawhero Logyard, and trucks would deliver the units to the site via Awapuni Road, Customhouse Street, Wainui Road and Hirini Street, as indicated in Figure 7-1. There will be an increased number of vehicle movements along Awapuni Road, Customhouse Street, Wainui Road and Hirini Street during construction as concrete armour units, materials and equipment are delivered to site. An alternative would be to use the newly constructed Reclamation Area as a laydown yard for the manufacture of concrete armour units for the Outer Breakwater. An estimate of the number of vehicle movements is included within Table 5, Table 6 and Table 7. However, exact numbers will depend on the final design and the selected contractor's method of material delivery. Due to the sequencing of works and requirements to maintain safe operations on site, it is not expected that all aspects of the work will be conducted at one time, and therefore the maximum number of trucks/day is based on simultaneous construction of the Reclamation Area and Outer Breakwater extension. It is envisaged that for the 19.2 t and 28.8 t concrete armour units, a truck can only accommodate one unit at a time, with a maximum of two units able to be accommodated per truck for the 12 t units. The maximum number of trucks/day (approximately 150), is equivalent to approximately 16 trucks/hour.

It is envisaged that all construction materials will be transported to site by land, although it is possible (but not likely) that some materials may need to be delivered to site by barge.

Table 5 – Estimated Truck Movements – Revetment and Reclamation Area (return trips)

Works	Total Trucks (return trips)	Maximum Trucks/day
Supply of Fill for Revetment core	5,500	50
Supply of underlayer rock	1,300	50
Supply of concrete armour units for Revetment	2,600	30
Paving works for Revetment crest	350	20
Fill for Reclamation Area	3,750	75
Ground Improvement Works	10,000	75
General (Including mobilisation and demobilisation)	200	5
Total	**23,700**	**150**

Table 6 – Estimated Truck Movements – Wharf 8 Extension (return trips)

Works	Total Trucks (return trips)	Maximum Trucks/day
Supply of Gravel backfill	800	30
Supply of piles, T-anchors, link plates	400	30
Supply of reinforcement	500	30
Supply of concrete for capping beams, pile plugs and slab	1,800	30
General (Including mobilisation and demobilisation)	200	5
Total	**3,700**	**125**

Table 7 – Estimated Truck Movements – Outer Breakwater Refurbishment (return trips)

Works	Total Trucks (return trips)	Maximum Trucks/day
Supply of concrete armour units for Breakwater	3,800	30
Supply of concrete for capping	800	10
General (Including mobilisation and demobilisation)	200	5
Total	**4,800**	**45**

It is expected construction traffic will be routed through a one-way system in and out of the SLY to spread traffic through all available access ways. EPL will prepare a Traffic Management Plan for the construction phase of the redevelopment.

A Construction Management Plan (CMP) is to be prepared covering management of the site and compliance with relevant health and safety, noise and other requirements. This may include the requirement for a construction zone around the works, to ensure safety of all personnel operating on or in the vicinity of the project.

Figure 7-1 – Potential truck route from casting yard to site

7.2 Ongoing Operational Impacts

While it is expected that the works will improve operational efficiency of the Port, and provide additional area for storage of logs, it is not expected that there will be any ongoing operational impacts on other operations at the port or within the local area.

7.2.1 Maintenance Requirements

Ongoing maintenance of the works is expected to be required. For the Wharf 8 extension works, the following maintenance regime is expected:

- regular inspection of the piles for corrosion
- monitor upper portion of the structure (splash zone) for integrity of paint protection
- undertake regular maintenance inspections of the cathodic protection system.

For the Revetment and Outer Breakwater, maintenance would comprise topping up the Revetment and Outer Breakwater with armour units as required, should there be future settlement or dislodgement of the armour.

7.3 Impact on Coastal Marine Area

The Reclamation, Revetment and Outer Breakwater refurbishment will result in a change in the location of the Mean Low Water Spring tide level (MLWS, +0.4 m on Chart Datum) and Mean High Water Spring tide level (MHWS, 2.1 m on Chart Datum), and a change in the area of the intertidal zone between MLWS and MHWS. The existing and proposed location of these elevations is illustrated in Figure 3-1 and Figure 4-1.

The change in intertidal areas as a result of the reclamation and Breakwater refurbishment is provided in Table 8. The Reclamation footprint below MHWS for the Reclamation, Revetment, Outer Breakwater and Wharf 8 Extension are shown in Figure 7-2.

Table 8 – Estimated changes in intertidal areas – Reclamation, Revetment, Outer Breakwater refurbishment and Wharf 8 Extension

Works	Area m^2
Reclamation footprint below existing MLWS (loss of seabed)	6,250
Reclamation footprint below proposed MLWS	650
Additional land (from existing MHWS to proposed MHWS)	7,000
Intertidal area over reclamation footprint (between MHWS and MLWS), existing	2,000
Intertidal area over reclamation footprint (between MHWS and MLWS), proposed	1,250
Net loss of intertidal area (reclamation)	750
Existing SLY revetment footprint below MHWS (estimate)	2,600
Existing Outer Breakwater footprint above MLWS	1,350
Existing Outer Breakwater footprint (estimate)	8,000
Proposed Outer Breakwater footprint below proposed MLWS	5,520
Proposed Outer Breakwater footprint below existing MLWS (loss of seabed)	9,420

Works	Area m^2
Proposed Outer Breakwater refurbishment footprint above MLWS	6,600
Proposed Outer Breakwater refurbishment footprint above MHWS	3,750
Intertidal area over Outer Breakwater refurbishment footprint (between MHWS and MLWS), existing	100
Intertidal area over Outer Breakwater refurbishment footprint (between MHWS and MLWS), proposed	1,500
Net gain in intertidal area (Outer Breakwater refurbishment)	1,400
Total breakwater footprint (proposed)	10,700
Loss of seabed (Wharf 8 Extension, due to piles)	250

Note that the platform at the end of the existing Outer Breakwater will be recreated, and the existing navigation marker will be reinstalled at its current location when construction is completed.

7.3.1 Heritage Boat Harbour Site

The footprint of the Reclamation Area has been designed to provide a minimum 5 m buffer zone between the works and the Heritage Boat Harbour site, as indicated in Figure 3-1.

7.3.2 Dispersal of Fine Sediments

The Revetment would enclose the reclamation and ground improvement works during construction, to prevent dispersion of fine sediments from the construction works into Poverty Bay. Mitigation measures for dispersion of fine sediments during construction of the Revetment core and placement of armour may include pre-washing of the core and armour material. Alternatively, installation of silt curtains may be considered, however, feedback from contractors has indicated that this may be challenging due to the high-energy wave climate at the Revetment site.

In addition, the area of exposed core material during construction of the Revetment core would be minimised by progressively armouring the core material as construction of the revetment core progresses toward the north-west. The core would be armoured by a secondary rock armour layer that would be designed to act as a rock filter and prevent fines from migrating through the outer armour layers. The secondary rock armour layer would be designed so that the armour rocks are large enough to not be washed through the voids between the concrete armour unit layer.

The potential for sediment generation from the core material obtained from the Kuri Quarry has been documented in a separate memorandum in Appendix A (Worley, 2022). Two sources of core material were tested using hydrometer analysis to estimate the production of fines from the core material when placed into water, which captures fines generated from dust bonded to the grains of the core material. It was found that approximately 1.2% of the mass of the material designated as “plus 65” quarry run from the Kuri Quarry would comprise silt-sized particles that could contribute to a plume during construction. This compares with an estimate that approximately 7% of the mass of material designated as “all-in” quarry run would comprise silt-size particles that could contribute to a plume during construction, and would therefore be unsuitable for use as core material.

Figure 7-2 – Reclamation Footprint below existing MLWS for Outer Breakwater, Revetment, Reclamation and Wharf 8 Extension

For construction of the "knuckle" transition between the Inner and Outer Breakwater, clean graded rock fill would be used with the generation of fines expected to be much less than the "plus 65" quarry run material that would be used for the core of the Revetment. The rock fill would be protected with concrete armour units as construction progresses to minimise its exposure to wave action and hence minimise generation of fine sediment. Concrete units will be precast and stored on site, and would not generate any significant fines.

7.4 New Zealand Coastal Policy Considerations

Policy 10 of the New Zealand Coastal Policy statement requires that the form and design of the works have particular regard to (among other aspects that are assessed in the AEE for the project):

> *(a) the potential effects on the site of climate change, including sea level rise, over no less than 100 years;*
>
> *(c) the use of materials in the reclamation, including avoiding the use of contaminated materials that could significantly adversely affect water quality, aquatic ecosystems and indigenous biodiversity in the coastal marine area;*
>
> *(g) the ability to avoid consequential erosion and accretion, and other natural hazards.*

7.4.1 Sea Level Rise and Climate Change

The design of the structures, including the Wharf 8 extension, Reclamation and Outer Breakwater upgrade have considered the NZ Ministry for the Environment guidance for Local Government, "Coastal Hazards and Climate Change" (Government of New Zealand, 2017). For non-habitable assets with a functional need to be at the coast and which are readily adaptable (i.e. the reclamation seawall and Outer Breakwater extension), the minimum sea level rise allowance to apply is 0.65 m, as per Table 12 of the Guideline.

The design of the structures has been refined with physical scale wave modelling, which considered the full range of ocean water levels that include the required sea level rise component. The crest level of the Revetment has been set to minimise wave overtopping, and armour layers were designed based on wave conditions that included the sea level rise allowance as stipulated in the Guideline.

7.4.2 Use of materials in the reclamation

Debris and deleterious materials from the existing Southern Log Yard Revetment will be removed from site and disposed of at an appropriately consented facility. The fill to be used for reclamation would preferably be relatively non-compressible granular fill, with dredged silt or similar material unlikely to be suitable. Only clean (non-contaminated) fill would be permitted to be used within the works.

7.4.3 Avoidance of Natural Hazards

The Gisborne Port area, being located on the East Coast and facing the Pacific Ocean, is subject to a range of natural hazards, notably storm events/surges, earthquakes and tsunami. Most of the port is also built on reclaimed land and expected to be affected by liquefaction following an earthquake. Like other parts of the district the port has been, and will continue to be, affected by of sea level rise through climate change.

The design of the Reclamation, Outer Breakwater upgrade and Wharf 8 Extension has sought to avoid or account for these natural hazards. The design water levels (3.1 mCD) for the Outer Breakwater and Reclamation account for these natural hazards by including the following components:

- “Extreme” storm surge 0.46 m (Mulgor, 2005)
- Infragravity (IG) wave amplitude 0.25 m (Mulgor, 2005)
- Sea Level Rise 0.65 m (Government of New Zealand, 2017)

Physical scale modelling has been undertaken in the MHL wave basin to study the 3-dimensional variations in the design parameters for the port structures, including wave heights and water levels, to inform the design of the Breakwater head, the knuckle where it adjoins the Inner Breakwater, the form of the Reclamation Revetment, its adjoining to the Inner Breakwater and the angle of wave incidence. The concrete armour units for the Reclamation and Outer Breakwater have been designed to protect the Reclamation Area from erosion due to waves.

Given the high porosity of the armour layers, the Revetment and Outer Breakwater would absorb rather than reflect wave energy, so the risk that wave reflections from the structures would adversely impact the surrounding coastal environment would be reduced when compared with the existing situation. The orientation of the Reclamation Area has been carefully considered, and designed to be parallel to the incoming wave crests, thus minimising the potential for consequential erosion and accretion in areas outside the works footprint, including at Gisborne City Beach or Kaiti Beach. MetOcean Solutions Limited (MetOcean Solutions , 2020) have undertaken a coastal process study involving high-resolution wave transformation modelling that addresses the changes to wave climate expected in the Port as part of this project. They found that wave heights generally become larger in the close vicinity of the Reclamation structure (due to reflection) and that there was relatively larger wave energy radiating back to the southern quadrant. In contrast, wave heights are relatively reduced within a band along the southern training wall (Outer Breakwater).

A preliminary assessment of the proposed Revetment design and Outer Breakwater refurbishment design was carried out against global stability and bearing capacity requirements, using the commercially available software SlopeW, to take account of earthquake and liquefaction risks. The preliminary assessment found that the presence of soft sediments is likely to pose geotechnical stability concerns, for which ground improvement may be required. The appropriate ground improvement solution will be determined following further geotechnical investigations, with options presented in Section 6.5 of this report.

8. Alternatives Considered

A range of alternatives have been considered when preparing the design of the Reclamation, Outer Breakwater refurbishment and Wharf 8 Extension. The main alternatives considered included:

- re-use of dredged material within the Reclamation Area
- several alternative revetment and reclamation alignments
- encapsulating the existing Outer Breakwater structure with a piled wall caisson
- demolishing the existing Outer Breakwater structure and constructing a stand-alone armoured rubble mound Breakwater to the east, incorporating the spalls
- encapsulating the existing Outer Breakwater with an armoured rubble mound
- use of rock armour in lieu of concrete armour units for the Outer Breakwater refurbishment and Revetment
- use of pattern-placed concrete armour units in lieu of bulk (random)-placed units
- staging the refurbishment of the Outer Breakwater to defer construction of the Outer section.

The alternatives are described in more detail below.

8.1 Re-use of Dredged Material in Reclamation

The fill to be used for Reclamation would preferably be relatively non-compressible granular fill. If dredged silt or similar material is used, this may significantly increase the potential long-term settlement over the Reclamation Area. The silty dredged material has poor engineering qualities, with low strength, poor tillage and poor drainage characteristics. These characteristics make it unsuitable for use within the Reclamation as engineered material without significant soil improvement. If dredged material were to be considered for use within the Reclamation Area:

- relatively slow ground improvement methods such as surcharging with wick drains, would be required before the Reclamation Area can be used. These methods could take a number of years before a suitable level of improvement was achieved.
- alternative soil mixing techniques, such as the use of lime or cement dry soil mixing techniques, would not be economically viable against the use of imported clean fill. Soil mixing techniques have previously been costed at some $150 to $200 per cubic metre for EPL.

Note that any rocky material obtained from dredging would comprise slightly weathered mudstone and siltstone, which would be unsuitable for use in the proposed reclamation works, as the rock is likely to break down over time due to abrasion.

A geotechnical analysis for the Reclamation Area, assuming non-compressible granular fill, was undertaken to estimate potential long-term settlements. Estimated settlement in the area adjacent to the Southern Log Yard (where shallow rock and stiff / dense paleo channel sediments are expected) is approximately 100 mm over the life of the project, which is considered to be acceptable. Use of dredged material within the Reclamation Area would significantly increase this potential settlement to an unacceptable level.

8.2 Outer Breakwater Refurbishment

The following options for the refurbishment of the Outer Breakwater were considered (WorleyParsons, 2015a):

- Option A - Encapsulate the existing structure with a piled retaining wall caisson founded to levels that would allow channel deepening
- Option B - Demolish the existing structure and use the spalls to rebuild a new rubble mound Breakwater to the east, far enough to allow for channel deepening
- Option C - Encapsulate the existing structure with a rubble mound. For future channel deepening the channel-side toe would need to be supported by a cantilever sheet piling wall.

The alternative options A and B are shown in Figure 8-1.

Option A was discounted based on cost and construction risk. For driving the piling for a future toe support or for a caisson, the presence of dislodged blocks from the existing Outer Breakwater poses an unacceptable risk for construction, as all blocks would need to be located and removed. While removal of many of the blocks could be achieved, there would be high risk in driving piling and trimming the seabed for the placement of the existing and new blocks for a caisson solution. Divers would be involved and construction vessels would be in the navigation channel.

The rubble-mound option was adopted as it is inherently flexible, which is a significant advantage over a rigid structure in that it can suffer considerable damage but still provide protection. A rubble mound structure can be easily repaired, and the materials for the rubble mound (concrete blocks) are more durable than the steel piles and reinforced concrete that would be required for the caisson option.

Encapsulating the existing Outer Breakwater as per the proposed design, in lieu of constructing a separate rubble-mound structure, would allow the cost of upgrading the structure head (which has been subject to a lesser degree of ongoing settlement than the trunk), to be deferred into the future. The overall change of footprint of the encapsulated Outer Breakwater is also lower than would occur if a new Breakwater was constructed.

8.3 Armour Units

Interlocking concrete armour units have been selected for armouring the Revetment and Outer Breakwater structures, in lieu of rock or pattern-placed units. The reasons for this are that the available limestone rock from quarries located nearby to Eastland Port is of relatively poor quality and would be expected to degrade over time if used as armourstone. Further, rock of the appropriate size required for armouring the Outer Breakwater and Revetment is not locally available.

Pattern-placed units, such as Seabees, were discounted in favour of interlocking bulk-placed concrete armour units. The reason for this is to allow the Revetment and Outer Breakwater structure to be flexible in response to settlement and wave loadings, and for ease of construction, as pattern-placed units require very tight tolerances for placement.

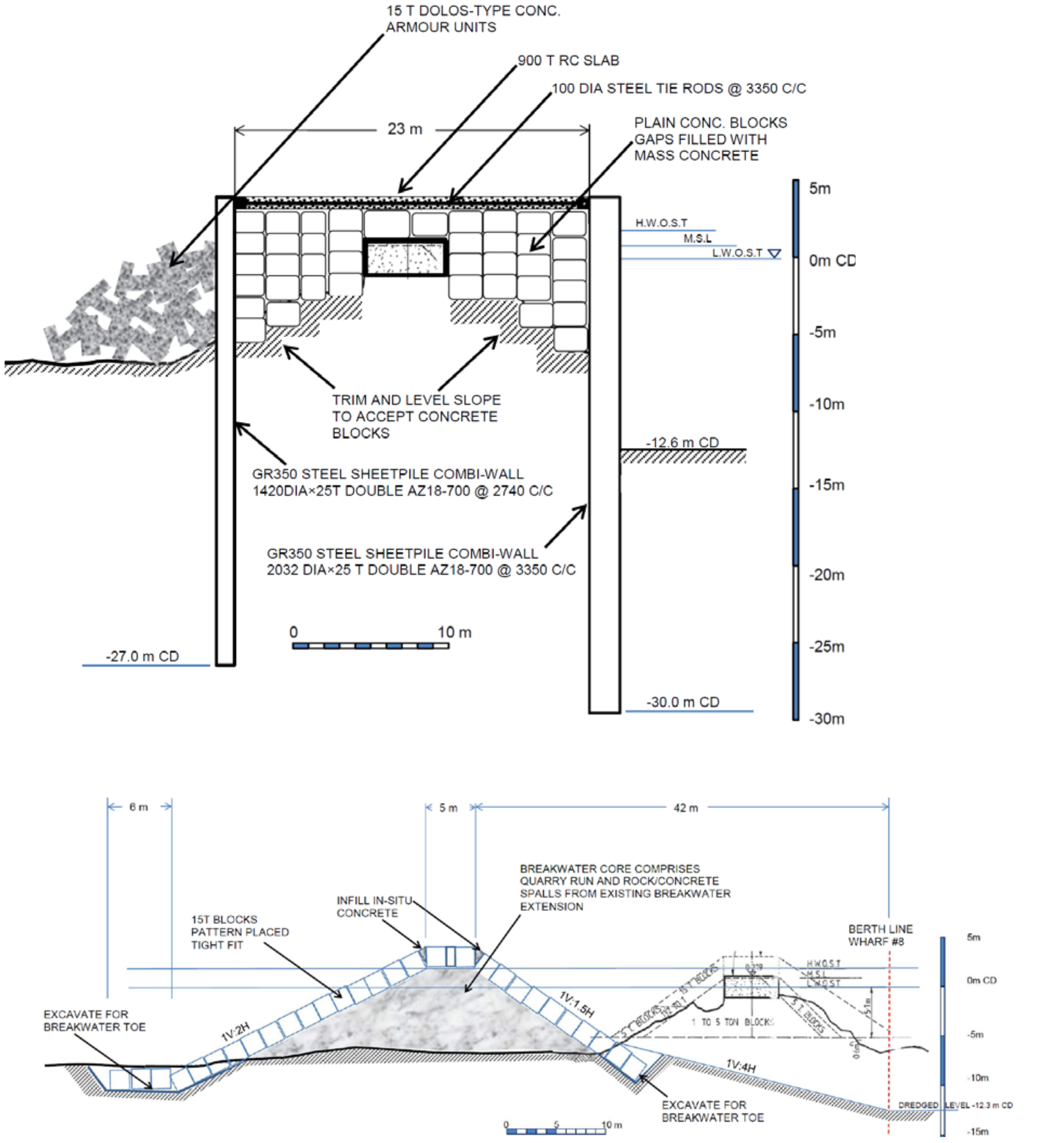


Figure 8-1 – Alternative Outer Breakwater options. Top – caisson option. Bottom – separate rubble mound structure

9. References

Delta Marine Consultants. (2018). *X-Bloc Guidelines for Concept Design.*

Gisborne District Council. (2017, 08 31). *Tairāwhiti Resource Management Plan.* Retrieved 09 20, 2017, from Gisborne District Council: http://www.gdc.govt.nz/the-tairawhiti-plan/

Gisborne District Council. (Operative 31 January, 2006). *Gisborne District Council Combined Regional Land & District Plan.* Gisborne: Gisborne District Council.

Government of New Zealand. (2017). *Coastal Hazards and Climate Change - Guidance for Local Government.* Wellington: Ministry for the Environment, Manatu Mo Te Taiao.

MetOcean Solutions . (2020). *Eastland Port Reclamation - High resolution wave modelling of existing and proposed port configurations.*

MetOcean Solutions Limited. (2011). *Eastland Port Wave Climate Study - Design Wave Statistics for a Proposed Seawall.* New Plymouth.

Mulgor. (2005). *Analysis of Sea Levels and Waves Measured at Eastland Port.* Christchurch.

Mulgor. (2018). *Sea Levels and Waves at Eastland Port.* Christchurch.

Reedjik, B., & Muttray, M. (2009). Design of Concrete Armour Layers. *Hansa International Maritime Journal. 6.*, 111 - 118.

Worley. (2022, February 8). Sediment Generation from Revetment Construction. *Memorandum*.

WorleyParsons. (2015). *Breakwater Extension - Preliminary Design.* Report no. 301015-03380-CS-REP-004.

WorleyParsons. (2015a). *Breakwater Upgrade Options.* Report no. 301015-03380-GE-REP-004.

WorleyParsons. (2018). *Eastern Breakwater and Southern Logyard Extensions Requisite Armour Mass.* North Sydney: WorleyParsons.

Appendix A. Sediment Memo

Memorandum

Subject	Sediment Generation from Revetment Construction		
Date	8 February 2022		
To	Marty Bayley	From	Chris Adamantidis
CC	Colin Thomas, David Aubourg, Max Dunn, Alexis Berthot	Doc No	120456-MMO-C0008
Project No	120456		
File Loc	Y:\Wgtn\120456\2.Controlled Docs		
Project	Wharf 8, Reclamation, Outer Breakwater		

Sediment Generation from Revetment Construction

Introduction and Background

Eastland Port Ltd (EPL) is undertaking an upgrade of its port infrastructure to allow for an expected significant increase in log exports, as part of their Twin Log Berth Project. As part of this work, there are plans to extend Wharf 8 to the south, requiring reclamation and an associated Revetment to its east.

The concept design of the Revetment allows for the construction of an armoured Revetment around the perimeter of the Reclamation Area, to protect it against wave overtopping and provide vehicular access for trucks between the new revetment, existing roadway along the crest of the existing Southern Revetment, and southern logyard area. The proposed Revetment construction sequence will involve construction of the Revetment core and toe protection, which would act as a “bund” around the perimeter of the Reclamation area. Revetment works would progress from east to west, to allow access to the revetment by land-based equipment. The revetment core is envisaged to comprise rock fill material and would be progressively protected from wave action by X-bloc concrete armour units as the construction progresses from east to west.

During the construction works, there is the potential for fine sediments to be released into Poverty Bay, with the fine sediments generated from the following activities:

- fine sediment and dust bound to the granular rock fill and underlayer rock when received from the local quarries could be released into the environment when the rock is placed in position
- release of fine sediment from the seabed upon placement of the rock core, due to displacement of the soft seabed sediments following rock core placement
- release of fine sediments due to weathering and abrasion of the individual stones, both from minor breakage upon placement and over the lifetime of the structure due to degradation of the rock material.

Of the above sources of fine material, it is considered that the release of fine sediments due to dust bound to the material received from the quarry is of the most concern as this would be released throughout the water column. Fine material displaced from the seabed would likely stay near the seabed and settle again soon after placement as the seabed comprises mainly sandy material, and the release of fine sediments due to abrasion of the armour and core stones would likely occur over a very long timeframe and would likely not cause a concern for water quality.

This Memorandum discusses recommendations for estimating the quantity of fine material (<0.075 mm) that could be released during construction of the revetment, for use in numerical modelling.

Sources of fine material

The quantity of fine material bound to the revetment core and armour rock is a function of the nature of the rock material received from the quarry, the method of extraction of the rock material from the quarry (blasting and/or excavation), the handling equipment used by the quarry and the procedures in place at the quarry used to process the extracted material (e.g. if the material is washed or screened to remove fines).

CIRIA, CUR CETMEF (2007) describes methods that can be adopted at the quarry to minimise contamination of the core and armour material with fines, including mechanical removal with a static bar or grizzly and use of dividing walls between different classes of material. Core material is often specified as “quarry run” which contains fine materials.

There are no standard tests available to estimate the quantity of fine material that is bound to armourstones produced from a quarry. Theoretical models for estimation of fines content following blasting in a quarry exist (CIRIA, CUR, METCEF 2007). However, these are quite complex to apply in practice and are not designed to estimate the distribution of the very fine material within the quarry yield that would contribute to poor water quality. The models would also not predict contamination of the quarry material with fines from sources other than derived from the blasting process. Quality control procedures can be used to minimise the contamination of rock material from fines at the quarry, during transport and at the construction site, including loading of material into trucks equipped with sprinkler systems for washing the material, or stockpiling the material for some time prior to use to allow fine sediments to leach out of them into a controlled sediment pond, either at the quarry or in a controlled area within the construction zone.

Estimating quantity of fine sediment release

Jiang *et al* (2019) describes best practice for sediment plume dispersion model application. This paper investigates *spill rates* (release of fine materials into the water column as a percentage of the mass or volume of material placed) to use for sediment plume modelling for different construction activities. These baseline spill rates have been calibrated and validated against site sediment transect measurements. For construction of the core of the revetment with an unknown quantity of fines and onto a silt/clay seabed, the recommended “spill” rate from Table 1 is 6%, which would be a conservative estimate for the core construction and considers resuspension of fine material from the seabed during construction.

To obtain a more realistic estimate of the fine sediment “spill” rate from construction of the core and armour layers due to fine sediments bound to the rock, two samples of “quarry run” material from the Kuri Quarry were tested using both *dry sieve analysis* (DSA) and hydrometer testing. The two samples included:

- A 100 kg sample of “quarry run” for material designated by the quarry as “plus 65 mm” (i.e. including larger boulders up to 300 mm diameter but with fewer fines)
- A 120 kg sample of “quarry run” for material designated by the quarry as “All-in” (i.e. a 300mm down face run of the quarry, including fines).

The DSA tests provided a particle size distribution by mass of the material “in the dry”, with an estimate of the percentage of the silt-sized fraction (<0.075 mm) provided for each of the two samples. The DSA test can be considered representative of the generation of fines from end-dumping of material prior to entering the water.

The hydrometer test was undertaken on a 1 kg subsample of the “quarry run” fraction below 4.75 mm diameter. This test provided the particle size distribution of the finer fraction of the material “in the wet”, with particle size distribution down to fine silt or finer (0.0012 mm). The hydrometer test is representative of the generation of fine material from end-dumping of the core material within the water column as it includes the fraction of fine material that would be released from the core on contact with the water (i.e. the fines do not remain bound to the larger fraction as would occur in the dry sieve analysis). The hydrometer test also provides the fall velocities for the finer fractions of material, which will be important to consider in the sediment dispersion modelling.

The full test results are provided in Appendix A, but are summarised in Table 2, Table 3, Table 4 and Table 5, together with an estimate of the mass of fine sediment that would be generated per tonne of material entering the water column.

It was found that:

- for the “all-in” material, from the hydrometer analysis, 7.01% of the mass of the material entering the water column would be silt-sized particles or finer that could contribute to a plume
- for the “plus 65” material, from the hydrometer analysis, 1.20% of the mass of the material entering the water column would be silt-sized particles or finer that could contribute to a plume.

The silt-sized fractions would settle at different rates, with settling velocities provided in Table 3 and Table 5. It should be noted that fines would only enter the water from the underwater fraction of the core, or from approximately 75% of each load of end-tipped material during the construction.

Table 1 – Spill rates for dredging and infilling operations (Jiang et al, 2019)

Table 4 Spill rates for dredging and infilling operations

Operation description	Material type	Spill layer	Spill rate (%)
TSHD (Trailing Suction Hopper Dredger)	Silt/clay	Bottom	7%
Cutter Suction Dredger (CSD)	silt/clay	Bottom	2%
Grab Dredger	silt/clay	Surface	2.5%
Overflow Allowed	silt/clay	Surface	Associated with TSS
Barge propeller wash	silt/clay	Bottom	5%
Pipe discharge	silt/clay	Surface	2%
Barge/Hopper Dumping	silt/clay	Bottom	6%
Grab Dredger Dumping	silt/clay	Bottom	6%
Any type of operations	Sand		25%

Table 2 – Summary of dry Sieve analysis for "all-in" quarry run material

Size (mm)	% Passing	Weight (Kg)	Passing Kg/ Tonne	Retained (Kg/Tonne)	% per tonne passing	% per tonne retained
300	100.0%	119.85	1,000.00	202.00	100.0%	20%
200	79.8%	95.64	798.00	145.00	79.8%	15%
100	65.3%	78.26	653.00	122.00	65.3%	12%
63	53.1%	63.64	531.00	223.00	53.1%	22%
37.5	30.8%	36.91	308.00	72.00	30.8%	7%
19	23.6%	28.28	236.00	48.00	23.6%	5%
9.5	18.8%	22.53	188.00	42.00	18.8%	4%
4.75	14.6%	17.50	146.00	18.00	14.6%	15%
2.36	12.8%	15.34	128.00	24.00		
1.18	10.4%	12.46	104.00	19.00		
0.6	8.5%	10.19	85.00	13.00		
0.3	7.2%	8.63	72.00	11.00		
0.15	6.1%	7.31	61.00	12.00		
0.075	4.9%	5.87	49.00			

Table 3 – Summary of hydrometer analysis for "all-in" quarry run material

Size (mm)	% Passing	Weight (Kg)	Passing Kg/ Tonne	Retained (Kg/Tonne)	% per tonne passing	% per tonne retained	Fall velocity cm/sec
4.75	100.0%	17.50	146.00		14.60%	1.02%	
2.36	93.0%	16.27	135.78		13.58%	1.90%	
1.18	80.0%	14.00	116.80		11.68%	1.61%	
0.6	69.0%	12.07	100.74		10.07%	0.58%	
0.425	65.0%	11.37	94.90		9.49%	0.44%	
0.3	62.0%	10.85	90.52		9.05%	0.44%	
0.212	59.0%	10.32	86.14		8.61%	0.44%	
0.15	56.0%	9.80	81.76		8.18%	1.17%	
0.075	48.0%	8.40	70.08	2.92	7.01%	0.29%	
0.063	46.0%	8.05	67.16	7.30	6.72%	0.73%	
0.0353	41.0%	7.17	59.86	4.38	5.99%	0.44%	0.11900
0.026	38.0%	6.65	55.48	2.92	5.55%	0.29%	0.06438
0.0188	36.0%	6.30	52.56	4.38	5.26%	0.44%	0.03382
0.0138	33.0%	5.77	48.18	2.92	4.82%	0.29%	0.01813
0.0103	31.0%	5.42	45.26	2.92	4.53%	0.29%	0.01010
0.0075	29.0%	5.07	42.34	5.84	4.23%	0.58%	0.00538
0.0055	25.0%	4.37	36.50	2.92	3.65%	0.29%	0.00291
0.004	23.0%	4.02	33.58	2.92	3.36%	0.29%	0.00151
0.0029	21.0%	3.67	30.66	4.38	3.07%	0.44%	0.00078
0.0022	18.0%	3.15	26.28	4.38	2.63%	0.44%	0.00047
0.0012	15.0%	2.62	21.90	21.90	2.19%	2.19%	0.00015

Table 4 – Summary of dry Sieve analysis for "plus 65" quarry material

Size (mm)	% Passing	Weight (Kg)	Passing Kg/ Tonne	Retained (Kg/Tonne)	% per tonne passing	% per tonne retained
300	100.0%	101.48	1,000.00	558.00	100.0%	56%
200	44.2%	44.85	442.00	255.00	44.2%	26%
100	18.7%	18.98	187.00	159.00	18.7%	16%
63	2.8%	2.84	28.00	-	2.8%	0%
37.5	2.8%	2.84	28.00	-	2.8%	0%
19	2.8%	2.84	28.00	1.00	2.8%	0%
9.5	2.7%	2.74	27.00	3.00	2.7%	0%
4.75	2.4%	2.44	24.00	1.00	2.4%	2%
2.36	2.3%	2.33	23.00	2.00		
1.18	2.1%	2.13	21.00	3.00		
0.6	1.8%	1.83	18.00	2.00		
0.3	1.6%	1.62	16.00	2.00		
0.15	1.4%	1.42	14.00	2.00		
0.075	1.2%	1.22	12.00			

Table 5 – Summary of hydrometer analysis for "plus 65" quarry material

Size (mm)	% Passing	Weight (Kg)	Passing Kg/ Tonne	Retained (Kg/Tonne)	% per tonne Passing	% per tonne retained	Fall velocity cm/sec
4.75	100.0%	2.44	24.00		2.40%	0.14%	
2.36	94.0%	2.29	22.56		2.26%	0.19%	
1.18	86.0%	2.09	20.64		2.06%	0.22%	
0.6	77.0%	1.88	18.48		1.85%	0.10%	
0.425	73.0%	1.78	17.52		1.75%	0.10%	
0.3	69.0%	1.68	16.56		1.66%	0.10%	
0.212	65.0%	1.58	15.60		1.56%	0.10%	
0.15	61.0%	1.49	14.64		1.46%	0.26%	
0.075	50.0%	1.22	12.00	0.72	1.20%	0.07%	
0.063	47.0%	1.14	11.28	0.72	1.13%	0.07%	
0.0353	44.0%	1.07	10.56	0.96	1.06%	0.10%	0.12253
0.026	40.0%	0.97	9.60	0.72	0.96%	0.07%	0.06763
0.0188	37.0%	0.90	8.88	0.96	0.89%	0.10%	0.03626
0.0138	33.0%	0.80	7.92	0.24	0.79%	0.02%	0.01976
0.0103	32.0%	0.78	7.68	0.96	0.77%	0.10%	0.01075
0.0075	28.0%	0.68	6.72	0.72	0.67%	0.07%	0.00581
0.0055	25.0%	0.61	6.00	0.72	0.60%	0.07%	0.00307
0.004	22.0%	0.54	5.28	0.48	0.53%	0.05%	0.00159
0.0029	20.0%	0.49	4.80	0.48	0.48%	0.05%	0.00082
0.0022	18.0%	0.44	4.32	0.72	0.43%	0.07%	0.00049
0.0012	15.0%	0.37	3.60	3.60	0.36%	0.36%	0.00015

Estimated load of material during construction

Based on discussions with EPL, it is anticipated that the Quarry material will be delivered in a bulk unit (Truck and Trailer) of 26 tonnes per load. Given the turn-around time for these units to unload both truck and trailer is a reasonable to anticipate that 1 truck will arrive every 15 minutes with the Quarry run or Plus 65 Material.

This would be equivalent to a supply load of 104 tonnes / hour at the peak of construction of the revetment core.

Recommendations

In the absence of quality control procedures from the quarry to limit the inclusion of fines in the core material, or processing/handling procedures to remove fines prior to construction, it is recommended that either:

- a conservative "spill" rate be assumed for production of fines during construction, or
- the spill rates herein estimated using the hydrometer tests on the quarry run material are used in assessing the production of fines during construction and the information on particle settling velocity be used to estimate sediment plume generation from the construction activities.

References

CIRIA, CUR CETMEF (2007) *The Rock Manual, The use of rock in hydraulic engineering (2nd edition),* C683, CIRIA, London.

Jiang, J, Hongjuan Han and Anuja Karunarathna (2019) *Best Practice for Sediment Plume Dispersion Model Application*, Proceedings Australasian Coasts & Ports 2019 Conference – Hobart, 10-13 September 2019

DRY SIEVE ANALYSIS
TEST REPORT

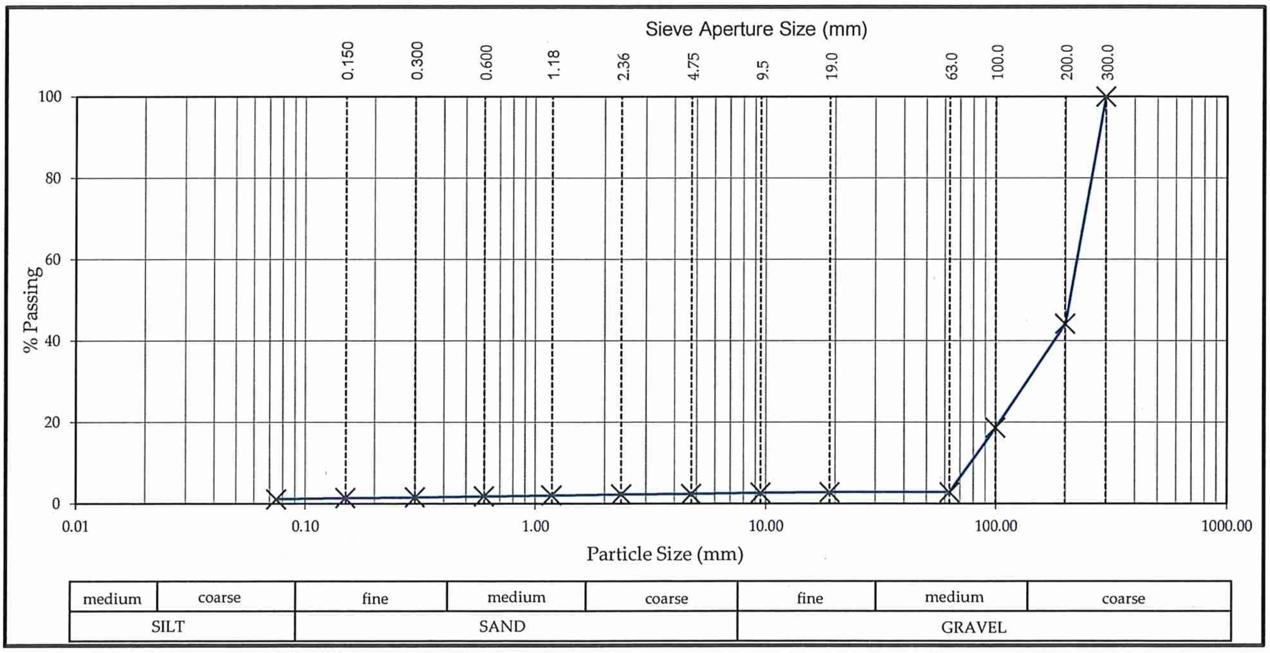
Project :	Waerengaokuri 'Face Run" Lab Scalped at 63mm
Location :	Waerengaokuri Quarry
Client :	Downer NZ, Gisborne
Contractor :	Downer NZ, Gisborne
Sampled by :	Downer NZ, Gisborne
Date sampled :	15-12-21
Sampling method :	Not Known
Sample description :	300mm down Face Run Limestone
Sample condition	Air Dry

Air Dried sample was washed. All wash water was decanted and fines air dried, then wet sieved.

Project No :	2S0534.93
Lab Ref No :	GS1893/1
Client Ref No :	Steve Petrowski

Sieve Analysis

Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing
300.00	100	19.00	2.8	4.75	2.4	0.30	1.6
200.00	44		-	2.36	2.3	0.15	1.4
100.00	19		-	1.18	2.1	0.075	1.2
63.00	2.8	9.50	2.7	0.60	1.8		-



Test Method	Notes
NZS 4407 : 2015 Test 3.8.2	All information supplied by Client

Date tested : 12-01-22
Date reported : 02-02-22

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Pete Carlyle
Designation : *Senior Civil Engineering Technician*
Date : 02-02-22

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Determination of the Particle Size Distribution Test Method NZS 4407 : 2015 Test 3.8.2 **DRY SIEVE ANALYSIS**		Project No : Lab Ref No : Client Ref No :	2S0534.93 GS1893/1 Steve Petrowski
Project :	Waerengaokuri 'Face Run" Lab Scal	Sample condition	Air Dry
Location :	Waerengaokuri Quarry		
Client :	Downer NZ, Gisborne		
Contractor :	Downer NZ, Gisborne		
Sampled by :	Downer NZ, Gisborne	Test details :	
Date sampled :	15-12-21	Fraction tested:	
Sampling method :	Not Known	Dispersant Used:	
Sample description :	300mm down Face Run Limestone	History:	

Determination of Water Content		
Container No		
Mass of container + wet soil (g)		
Mass of container + dry soil (g)		
Mass of container (g)		
Water content (%)		
Average Water Content (%)	-	

Total Dry Mass	
Container No	
Mass of dry soil (g)	101478.00
Mass of wet soil (g)	
Total dry mass of soil (g)	101478.00

Sieve Analysis					
Sieve Size (mm)	Retained (g)	Corrected Mass Retained (g)	Corrected Mass % Retained	Passing (%)	Limit (g)
300	0.0		0.0	100.0	-
200	56648.0		55.8	44.2	12000
100	25846.0		25.5	18.7	8000
63	16119.0		15.9	2.8	6000
19	17.9		0.0	2.8	4000
Passing 19	2847.1		0.0		
				2.8	3000
				2.8	2000
9.5	63.7	63.7	0.1	2.7	1500
4.75	309.0	309.0	0.3	2.4	250
Passing 4.75	2467.1	309.0			
2.36	12.66	147.5	0.1	2.3	150
1.18	19.88	231.6	0.2	2.1	100
0.600	20.34	236.9	0.2	1.8	80
0.3	17.99	209.6	0.2	1.6	70
0.150	17.13	199.5	0.2	1.4	60
0.075	22.81	265.7	0.3	1.2	40
				1.2	20
Pan	1.09	12.7	0.0		
2.36 - Pan	111.9				
Total	100307.1				

Dry Mass by difference (Passing 0.075mm sieve by washing)	
Container No	
Mass of tray + dry agg (g)	
Mass of tray (g)	
Mass of dry agg (+0.075mm) (g)	-
Mass of dry agg (-0.075mm) (g)	-

19mm Split Mass Determination	
Mass before splitting (g)	2847.1
Split mass (g)	2847
Split Ratio	1.0000

4.75mm Split Mass Determination	
Mass before splitting (g)	2467.1
Split mass (g)	211.8
Split Ratio	11.6483

Check	
Tested By	PDC
Date	12-01-21
Checked By	FM
Date	2/2/22

PF-LAB-099 (11/07/2020)

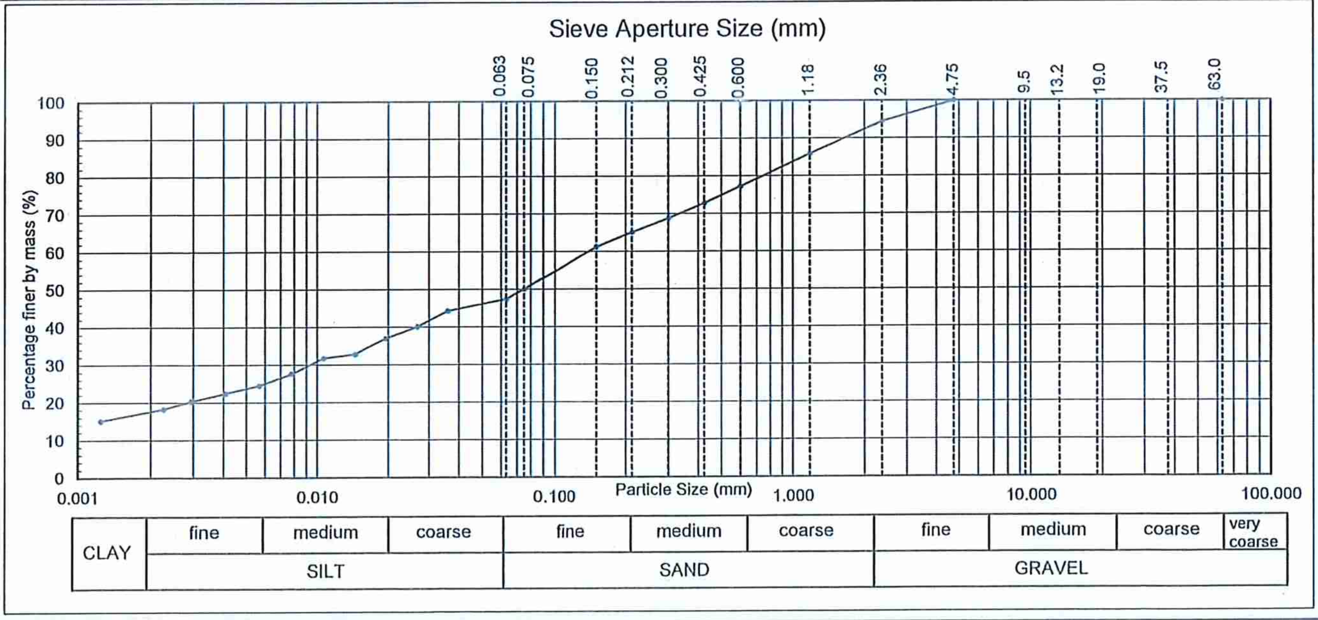
Mass of subsample passing 4.75mm for Hydrometer analysis was 1000gms.

PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Waerengaokuri 'Face Run'
Location :	Waerengaokuri
Client :	Downer NZ Ltd
Consultant :	-
Borehole No:	Sample 1 Depth: 4.75m
Sample Ref No:	Sample 1
Sampled by :	Client
Date sampled :	Not Stated
Sampling method :	Bagged
Sample condition :	As received
Sample description :	Sandy SILT, some clay, trace gravel
Solid Particle Density (t/m^3):	2.75 Assumed
Water Content (as received):	2.5 %

Project No:	2-S0534.95
Lab Ref No:	GS1893/1_Hyd
Client Ref:	

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	100	0.300	69	0.0358	44	0.0057	25
37.5	--	2.36	94	0.212	65	0.0266	40	0.0041	22
19.0	--	1.18	86	0.150	61	0.0195	37	0.0029	20
13.2	--	0.600	77	0.075	50	0.0144	33	0.0023	18
9.5	--	0.425	73	0.063	47	0.0106	32	0.0012	15
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0078	28		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 8.0 (Whatmans Full Range pH Indicator paper)
	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 01/02/22

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Date Reported: 02/02/22

IANZ Approved Signatory

Designation : *Senior Civil Engineering Technician*

Date : 02/02/22

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Test results indicated as not accredited are outside the scope of the laboratory's accreditation

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PARTICLE SIZE ANALYSIS TEST
TITLES and DATA INPUT SHEET

Project No:	2-S0534.95
Lab Ref No:	GS1893/1_Hyd
Client Ref:	

Project :	Waerengaokuri 'Face Run'				
Location :	Waerengaokuri				
Client :	Downer NZ Ltd				
Consultant :	-				
Borehole No:	Sample 1	Sample depth :	4.75	Specimen depth :	
Sample Ref No:	Sample 1	to :		to :	
Sampled by :	Client				
Date sampled :	Not Stated	Date received :	20/12/2021		
Sampling method :	Bagged				
Sample condition :	As received				
Sample description :	Sandy SILT, some clay, trace gravel				
Tested by :	ET	Date :	01/02/22		
Checked by :		Date :			

Clay	18%
Silt	29%
Sand	48%
Gravel	5%

Test Details:	Washed Grading & Hydrometer Analysis
Fraction Tested:	Whole soil
Sample Condition:	As received

Cells with RED Corner Flags contain Tips or Comments — cell with flag

Determination of Water Content

Container No	MC9	MC12
Mass of container + wet soil (g)	88.10	87.38
Mass of container + dry soil (g)	86.86	86.13
Mass of container (g)	37.16	37.16
Water content (%)	2.48	2.55
Average Water Content WC(%)	2.51	

If only one Water Content determination is done, Enter the data in cell D23 to D25 only.

Determination of Total Dry Mass

Container No		
Mass of wet soil (g)	77.49	All % Passing calcs
Total dry mass of soil (g)	75.59	<< uses this dry mass

Determination of Dry Mass (passing finest sieve by washing)

Washed through B S Sieve:	63	um
Container No	FS7	Enter '0' (zero) in
Mass container+dry soil(+63um)	114.05	<< Cells L27 & L28
Mass of container (g)	73.66	<< if not washed.
Mass dry soil (+ 63um) (g)	40.39	
Total Mass dry soil (- 63um) (g)	36.04	<Includes corrected Pan Mass
Split Mass (-4.75mm)	0.00	<<<You must Enter
Split Ratio (-4.75mm)	1.000000	'0' (zero) if not split.

N.B.: -4.75mm sample was NOT SPLIT

Sieve Analysis

Sieve Size (mm)	Mass Retained (g)	Corrected Mass	% Retained	% Passing	Max. Sieve Load(g)
63.0			--	100.0	2500
37.5			--	100.0	2500
19.0			--	100.0	2000
13.2			--	100.0	1500
9.5			--	100.0	1000
4.75	0.00	0.00	0.00	100.0	500
Mass Passing 4.75mm		*No Entries in these cells*			
2.36	4.17	4.17	5.52	94.5	150
1.18	6.50	6.50	8.60	85.9	100
0.600	6.49	6.49	8.59	77.3	80
0.425	3.37	3.37	4.46	72.8	70
0.300	3.04	3.04	4.02	68.8	60
0.212	2.78	2.78	3.68	65.1	50
0.150	2.96	2.96	3.92	61.2	40
0.075	8.46	8.46	11.19	50.0	25
0.063	1.95	1.95	2.58	47.5	20
Pan	0.84	36.04	Calibration for Hydrometer No:	5264	
Total Dry Masses	40.56	75.76	Slope (M)=	-390.0262	Y Int'cpt (C) 405.9344

Hydrometer Test Constants

Dispersant used :	Sodium Hexametaphosphate	
Hydrometer No :	5264	
Ref cylinder hydrometer rdg (r) :	1.0007	<<Leave this cell empty if the
Comp correction:x=1000(1-r)=r' :	0.70	Comp Corr (x) is manually
pH of suspension :	8.0	entered in column F51:F62.
Solid density soil particles(t/m³)	2.75	Assumed
Density of water (t/m³)	1.00	Assumed

Hydrometer SPLIT RATIO Calculation {DRY MASSES}

Mass Dry Soil in Hydrometer+ SOD HEX (g)	0.00	You must Enter '0' << (zero) in
Mass dry SODIUM HEX used in hydrom (g)	0.00	Cell M43&M44
Mass Dry soil in HYDROM test (split) (g)	0.00	if not split.
Split Ratio in terms of DRY MASS (- 63 um)	1.000	

N.B.: Hydrometer Sample was NOT SPLIT

Hydrometer Analysis

Date / Time	Elapsed Time (min)	Temp (°C)	*Hydrometer readings* Initial(HydrRdg) (R'h)	Comp.Corr.(x) 0.70 used	Corrected (R'h-x)	DynaVisc. H_2O(Ns/m²)	Hydrom. Calib H(cm)	*Particle Properties* Velocity (cm/sec)	Radius (mm)	*Test Result* Diameter (mm)	Passing (%)	
	1	20.1	22.0		21.3	0.9994	7.328	0.122252	0.01790	0.0358	44.28	-
	2	20.1	20.0		19.3	0.9994	8.108	0.067633	0.01331	0.0266	40.12	-
	4	20.1	18.5		17.8	0.9994	8.693	0.036257	0.00975	0.0195	37.00	-
	8	20.1	16.5		15.8	0.9994	9.473	0.019755	0.00719	0.0144	32.85	-
	15	20.1	16.0		15.3	0.9994	9.668	0.010753	0.00531	0.0106	31.81	-
	30	20.1	14.0		13.3	0.9994	10.448	0.005810	0.00390	0.0078	27.65	-
	60	20.1	12.5		11.8	0.9994	11.033	0.003068	0.00283	0.0057	24.53	-
	120	20.1	11.5		10.8	0.9994	11.423	0.001588	0.00204	0.0041	22.45	-
	240	20.1	10.5		9.8	0.9994	11.813	0.000821	0.00147	0.0029	20.373	-
	420	20.1	9.5		8.8	0.9994	12.203	0.000485	0.00113	0.00225	18.294	-
	1440	20.1	8.0		7.3	0.9994	12.788	0.000148	0.00062	0.0012	15.176	-

Test Method: Particle Size Distribution: NZS 4402:1986 Test 2.8.1, 2.8.2, 2.8.3


Waerengaokuri Face Run 20/12/21
OPUS
SS1893/1
63mm PLUS
After Washing

DRY SIEVE ANALYSIS
TEST REPORT

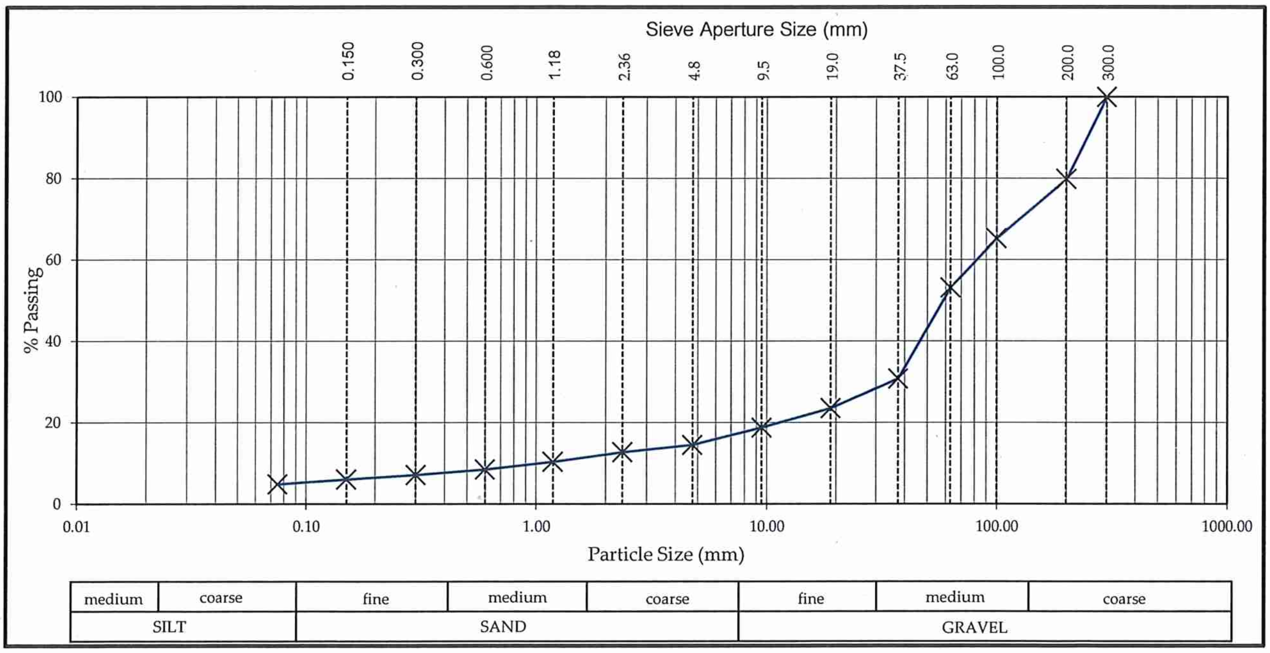
Project :	Waerengaokuri 'Face Run" ALL IN
Location :	Waerengaokuri Quarry
Client :	Downer NZ, Gisborne
Contractor :	Downer NZ, Gisborne
Sampled by :	Downer NZ, Gisborne
Date sampled :	15-12-21
Sampling method :	Not Known
Sample description :	300mm down Face Run Limestone
Sample condition	Air Dry

Project No :	2S0534.93
Lab Ref No :	GS1893/2
Client Ref No :	Steve Petrowski

Air Dried sample Dry Sieved to 4.75mm. A riffled sub-sample was Wash Sieved on a 0.075mm sieve.

Sieve Analysis

Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing	Size (mm)	% Passing
300.00	100	37.50	31		-	0.300	7
200.00	80	19.00	24	2.36	13	0.150	6
100.00	65	9.50	19	1.18	10	0.075	5
63.00	53	4.75	15	0.600	9		-



Test Method	Notes
NZS 4407 : 2015 Test 3.8.2	All information supplied by Client

Date tested : 12-01-22
Date reported : 02-02-22

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Pete Carlyle
Designation : *Senior Civil Engineering Technician*
Date : 02-02-22

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Telephone +64 6 868 1528
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Determination of the Particle Size Distribution Test Method NZS 4407 : 2015 Test 3.8.2 **DRY SIEVE ANALYSIS**		Project No :	2S0534.93
		Lab Ref No :	GS1893/2
		Client Ref No :	Steve Petrowski
Project :	Waerengaokuri 'Face Run" ALL IN	Sample condition	Air Dry
Location :	Waerengaokuri Quarry		
Client :	Downer NZ, Gisborne		
Contractor :	Downer NZ, Gisborne		
Sampled by :	Downer NZ, Gisborne	Test details :	
Date sampled :	15-12-21	Fraction tested:	
Sampling method :	Not Known	Dispersant Used:	
Sample description :	300mm down Face Run Limestone	History:	

Determination of Water Content		
Container No		
Mass of container + wet soil (g)		
Mass of container + dry soil (g)		
Mass of container (g)		
Water content (%)		
Average Water Content (%)	-	

Total Dry Mass	
Container No	
Mass of dry soil (g)	119850.00
Mass of wet soil (g)	
Total dry mass of soil (g)	119850.00

Sieve Analysis					
Sieve Size (mm)	Retained (g)	Corrected Mass Retained (g)	Corrected Mass % Retained	Passing (%)	Limit (g)
300	0.0		0.0	100.0	-
200	24160.0		20.2	79.8	12000
100	17451.0		14.6	65.3	8000
63	14556.0		12.1	53.1	6000
37.5	26726.0		22.3	30.8	4000
Passing 19	1.0		1.5		
19	8696.0	8696.0	7.3	23.6	3000
9.5	5722.0	5722.0	4.8	18.8	2000
4.75	5087.0	5087.0	4.2	14.6	1500
				14.6	250
Passing 4.75	17453.0				
2.36	26.40	2135.7	1.8	12.8	150
1.18	34.80	2815.3	2.3	10.4	100
0.600	28.00	2265.2	1.9	8.5	80
0.3	19.70	1593.7	1.3	7.2	70
0.150	16.30	1318.6	1.1	6.1	60
0.075	18.10	1464.3	1.2	4.9	40
				4.9	20
Pan	0.70	56.6	0.0		
2.36 - Pan	144				
Total	114047.4				

Dry Mass by difference (Passing 0.075mm sieve by washing)	
Container No	
Mass of tray + dry agg (g)	
Mass of tray (g)	
Mass of dry agg (+0.075mm) (g)	-
Mass of dry agg (-0.075mm) (g)	-

19mm Split Mass Determination	
Mass before splitting (g)	1
Split mass (g)	1
Split Ratio	1.0000

4.75mm Split Mass Determination	
Mass before splitting (g)	17453
Split mass (g)	215.74
Split Ratio	80.8983

Check	
Tested By	PDC
Date	12-12-21
Checked By	FM
Date	2/2/22

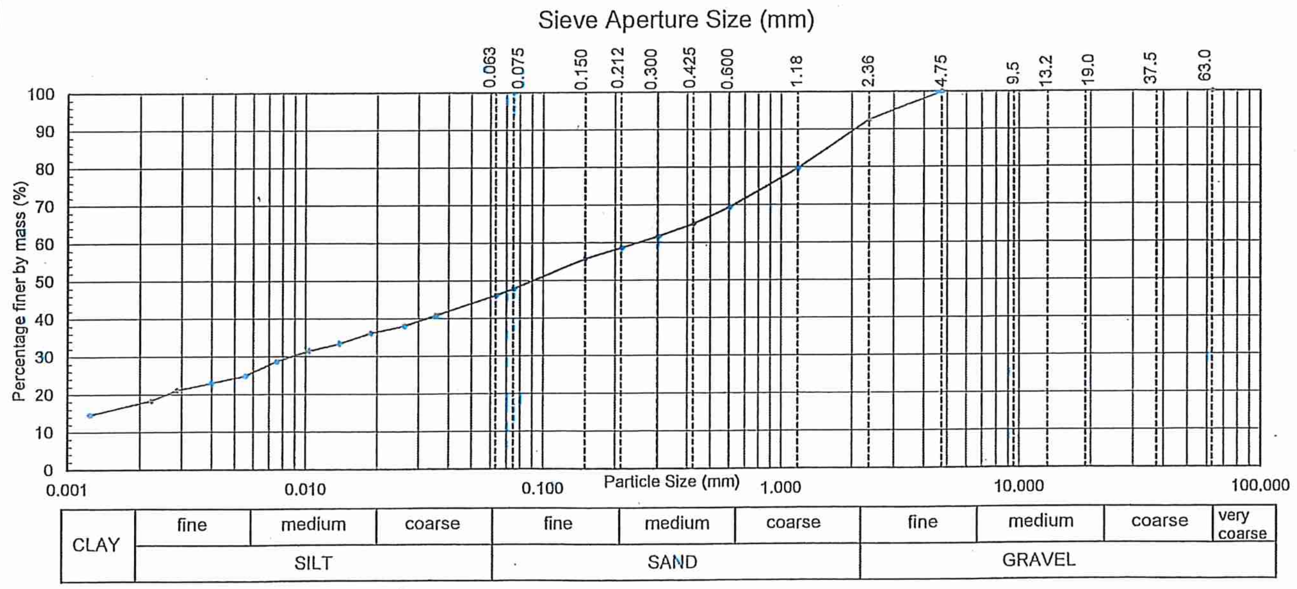
Mass of subsample passing 4.75 for Hydrometer was 1000 gms.

PARTICLE SIZE ANALYSIS (HYDROMETER METHOD)
TEST REPORT

Project :	Waerengaokuri 'Face Run'		
Location :	Waerengaokuri		
Client :	Downer NZ Ltd		
Consultant :	-		
Borehole No:	Sample 2	Depth:	4.75m
Sample Ref No:	Sample 2		
Sampled by :	Client		
Date sampled :	Not Stated		
Sampling method :	Bagged		
Sample condition :	As received		
Sample description :	Sandy SILT, some clay and minor gravel		
Solid Particle Density (t/m^3):	2.75	Assumed	
Water Content (as received):	1.5	%	

Project No:	2-S0534.95
Lab Ref No:	GS1893/2_Hyd
Client Ref:	

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	100	0.300	62	0.0353	41	0.0055	25
37.5	--	2.36	93	0.212	59	0.0260	38	0.0040	23
19.0	--	1.18	80	0.150	56	0.0188	36	0.0029	21
13.2	--	0.600	69	0.075	48	0.0138	33	0.0022	18
9.5	--	0.425	65	0.063	46	0.0103	31	0.0012	15
Note:	"--" denotes sieve not used and/or hydrometer analysis not tested					0.0075	29		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Washed Grading & Hydrometer Method)	pH of suspension : 8.0 (Whatmans Full Range pH Indicator paper
	All information supplied by Client

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.

Date Tested: 01/02/22

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Date Reported: 02/02/22

IANZ Approved Signatory

Designation : *Senior Civil Engineering Technician*

Date : 02/02/22

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Test results indicated as not accredited are outside the scope of the laboratory's accreditation

PF-LAB-100 (11/07/2020)

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PARTICLE SIZE ANALYSIS TEST
TITLES and DATA INPUT SHEET

Project No:	2-S0534.95
Lab Ref No:	GS1893/2_Hyd
Client Ref:	

Project :	Waerengaokuri 'Face Run'				
Location :	Waerengaokuri				
Client :	Downer NZ Ltd				
Consultant :	-				
Borehole No:	Sample 2	Sample depth :	4.75	Specimen depth :	
Sample Ref No:	Sample 2	to :		to :	
Sampled by :	Client				
Date sampled :	Not Stated	Date received :	20/12/2021		
Sampling method :	Bagged				
Sample condition :	As received				
Sample description :	Sandy SILT, some clay and minor gravel				
Tested by :	ET	Date :	01/02/22		
Checked by :		Date :			

Clay	17%
Silt	29%
Sand	46%
Gravel	8%

Test Details:	Washed Grading & Hydrometer Analysis
Fraction Tested:	Whole soil
Sample Condition:	As received

Cells with RED Corner Flags contain Tips or Comments | cell with flag

Determination of Water Content

Container No	MC14	MC18
Mass of container + wet soil (g)	98.13	109.00
Mass of container + dry soil (g)	97.25	107.94
Mass of container (g)	37.26	37.40
Water content (%)	1.46	1.50
Average Water Content WC(%)	1.48	

If only one Water Content determination is done, Enter the data in cell D23 to D25 only.

Sieve Analysis

Sieve Size (mm)	Mass Retained (g)	Corrected Mass	% Retained	% Passing	Max. Sieve Load(g)
63.0			--	100.0	2500
37.5			--	100.0	2500
19.0			--	100.0	2000
13.2			--	100.0	1500
9.5			--	100.0	1000
4.75	0.00	0.00	0.00	100.0	500
Mass Passing 4.75mm		*No Entries in these cells*			
2.36	6.27	6.27	7.48	92.5	150
1.18	10.74	10.74	12.81	79.7	100
0.600	8.73	8.73	10.41	69.3	80
0.425	3.60	3.60	4.29	65.0	70
0.300	2.84	2.84	3.39	61.6	60
0.212	2.50	2.50	2.98	58.6	50
0.150	2.43	2.43	2.90	55.7	40
0.075	6.60	6.60	7.87	47.9	25
0.063	1.46	1.46	1.74	46.1	20
Pan	0.59	38.62	Calibration for Hydrometer No:		5264
Total Dry Masses	45.76	83.79	Slope (M)=		-390.0262

Y Int'cpt (C) 405.9344

Determination of Total Dry Mass

Container No		
Mass of wet soil (g)	85.10	All % Passing calcs
Total dry mass of soil (g)	83.86	<< uses this dry mass

Determination of Dry Mass (passing finest sieve by washing)

Washed through B S Sieve:	63	um
Container No	FS8	Enter '0' (zero) in
Mass container+dry soil(+63um)	119.27	<< Cells L27 & L28
Mass of container (g)	73.45	<< if not washed.
Mass dry soil (+ 63um) (g)	45.82	
Total Mass dry soil (- 63um) (g)	38.62	<Includes corrected Pan Mass
Split Mass (-4.75mm)	0.00	<<<You must Enter
Split Ratio (-4.75mm)	1.000000	'0' (zero) if not split.

N.B.: -4.75mm sample was NOT SPLIT

Hydrometer Test Constants

Dispersant used :	Sodium Hexametaphosphate	
Hydrometer No :	5264	
Ref cylinder hydrometer rdg (r) :	1.0007	<<Leave this cell empty if the
Comp correction:x=1000(1-r)=r' :	0.70	Comp Corr (x) is manually
pH of suspension :	8.0	entered in column F51:F62.
Solid density soil particles(t/m³)	2.75	Assumed
Density of water (t/m³)	1.00	Assumed

Hydrometer SPLIT RATIO Calculation {DRY MASSES}

Mass Dry Soil in Hydrometer+ SOD HEX (g)	0.00	You must Enter '0' << (zero) in
Mass dry SODIUM HEX used in hydrom (g)	0.00	Cell M43&M44
Mass Dry soil in HYDROM test (split) (g)	0.00	if not split.
Split Ratio in terms of DRY MASS (- 63 um)	1.000	

N.B.: Hydrometer Sample was NOT SPLIT

Hydrometer Analysis

Date / Time	Elapsed Time (min)	Temp (°C)	*Hydrometer readings* Initial(HydrRdg) (R'h)	Comp.Corr.(x) 0.70 used	Corrected (R'h-x)	DynaVisc. H_2O(Ns/m²)	Hydrom. Calib H(cm)	*Particle Properties* Velocity (cm/sec)	Radius (mm)	*Test Result* Diameter (mm)	Passing (%)	
	1	20.1	22.5		21.8	0.9994	7.133	0.118998	0.01766	0.0353	40.85	-
	2	20.1	21.0		20.3	0.9994	7.718	0.064379	0.01299	0.0260	38.04	-
	4	20.1	20.0		19.3	0.9994	8.108	0.033816	0.00941	0.0188	36.17	-
	8	20.1	18.5		17.8	0.9994	8.693	0.018128	0.00689	0.0138	33.36	-
	15	20.1	17.5		16.8	0.9994	9.083	0.010102	0.00514	0.0103	31.48	-
	30	20.1	16.0		15.3	0.9994	9.668	0.005376	0.00375	0.0075	28.67	-
	60	20.1	14.0		13.3	0.9994	10.448	0.002905	0.00276	0.0055	24.92	-
	120	20.1	13.0		12.3	0.9994	10.838	0.001507	0.00199	0.0040	23.05	-
	240	20.1	12.0		11.3	0.9994	11.228	0.000781	0.00143	0.0029	21.175	-
	420	20.1	10.5		9.8	0.9994	11.813	0.000469	0.00111	0.00222	18.364	-
	1440	20.1	8.5		7.8	0.9994	12.593	0.000146	0.00062	0.0012	14.616	-

PF-LAB-100 (11/07/2020)

Test Method: Particle Size Distribution: NZS 4402:1986 Test 2.8.1, 2.8.2, 2.8.3


Waerengaokuri Face Run
20/12/21
OPUS
Lab Ref GS1893/2
Subsample #1
With Fines


Waerengaokuri Face Run 20/12/21
Sample As Delivered
OPUS