SOUITHSHORE RESIDENTS ASSOCIAITON

SOUTHSHORE INUNDATION PROTECTION LEVEE

December 2016

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INTRODUCTION

In the Tonkin Taylor (T&T) report on the Effects of Sea Level Rise for Christchurch City for the Christchurch City Council (November 2013) the Southshore area was identified as one of several areas at risk of inundation as a consequence of climate change induced sea level rise (SLR). Southshore wasn't specifically identified as an area but was included in the assessments of SLR effects on both the Avon-Heathcote Estuary and the Christchurch Dunes. While aspects of that report were controversial and the report has been subject to further peer review the underlying premise that SLR is underway and accelerating is essentially unchallenged by other than the scientifically illiterate. SLR will occur and has to be factored into future planning.

For Southshore the immediate threat is from the Estuary side from storm tide levels, storm surge riding on top of high tide levels. While changes to the intensity of individual storm conditions are likely as a result of climate change the T&T report assumes that storm tide levels will rise only due to an increase in mean sea level (MSL). The corollary of this is that the inundation recurrence interval will decrease because the storm surge elevation is superimposed on an increasingly higher base level. One incidence of this will be enough to shake confidence in the future of Southshore if nothing is put in place to mitigate the risk.

The solution is quite simple and well known internationally, particularly to the Dutch, create a levee to protect the established houses and infrastructure on Southshore. There were 640 houses in this area prior to the earthquakes reducing to 480 in the aftermath but with new builds underway the number has recovered to close to 500, all served by the established infrastructure. Rather than write this off in one event it makes economic sense to consider what is required to protect it.

It is understood that the Christchurch City Council (CCC) has commissioned an engineering report on the provision of a levee/berm and the cost was estimated at $39 million for 3 kilometres. That corresponds to a figure of $13,000 per lineal metre. Uneconomic and unrealistic. What is required is a relatively simple berm structure similar to what the CCC has already employed around the New Brighton area to keep the Avon river from overflowing into New Brighton.

OCEL is experienced in the design and construction of coastal protection structures and small dams, including temporary works for the recently completed Beachville Road seawall protection in Redcliffs. OCEL has been approached by the Southshore Residents Association (SSRA) to look at the design of a levee/berm to protect the area from inundation from the Estuary side. The proposed berm to have more than just a protective function but to also form an elevated walk/cycle way along the Estuary shoreline linking in to other established and proposed walkways. It represents an opportunity to create an attractive walkway feature to take advantage of spectacular views across the Estuary.

SOUTHSHORE ESTUARY SHORELINE

The shoreline on the Southshore side of the Estuary is an intertidal area exposed at low tide and consisting primarily of a sand/mud seabed. OCEL has undertaken a drone flyover of the shoreline for this report. The residential area immediately behind the shoreline has been Red Zoned and cleared of houses leaving a wide grassed area between the shoreline and the remaining houses to the west of Rockinghorse Road. The shoreline itself varies from a rock armour slope at the north end, the starting point for a berm, to low gravel beaches and grassed areas and to vertical wood and concrete retaining walls at the south end. Towards the north end there are areas of sea grass out from the shoreline - reference Photograph Nos 1 and 2. The seawalls that previously fronted individual houses at the south end are still in position although badly deteriorated in many cases – reference Photograph No 3. The houses were Red Zoned and removed, the seawalls remain. Rock armour has been added in front of one property.

Photograph No 1

Photograph No 2

Photograph No 3

Where the shoreline has been left unprotected erosion and flooding has occurred, exacerbated in some cases by the work undertaken to remove the Red Zone houses. Excavations opened to remove foundations have not been filled in or brought back up to level, grass verges have been left exposed to wave action from waves generated on the Estuary wind fetches. Grassed verges are easily eroded by wave action. Closer to the northern end lack of care in the removal of foundations and failure to reinstate former ground levels has led to the penetration of water well inshore of the coastline in storm events on the Estuary. Many of the Estuary edge seawalls that previously protected now Red Zoned properties have collapsed now that the property owners who were previously there to maintain them have gone. Photograph Nos 4, 5 and 6 illustrate the problems. In addition to keeping water out a proposed berm would have to provide coastal protection against wave action.

In Photograph Nos 1 to 3 a thin green line is evident some distance back from the shoreline. This appears to be some sort of attempt at a berm, totally inadequate, low in height and with no wave protection function or ability to resist wave attack.

Photograph No 4

Photograph No 5

Photograph No 6

Figure No 1 taken from Tonkin and Taylor report shows the areas inundated by SLR around the Estuary. The construction of a berm along the Estuary shoreline would retain in excess of 50% of the Southshore area. The SLR inundation area for Redcliffs is also shown. The new seawall can be outflanked by the Estuary water flooding through the shoreline fronting Redcliffs Park.

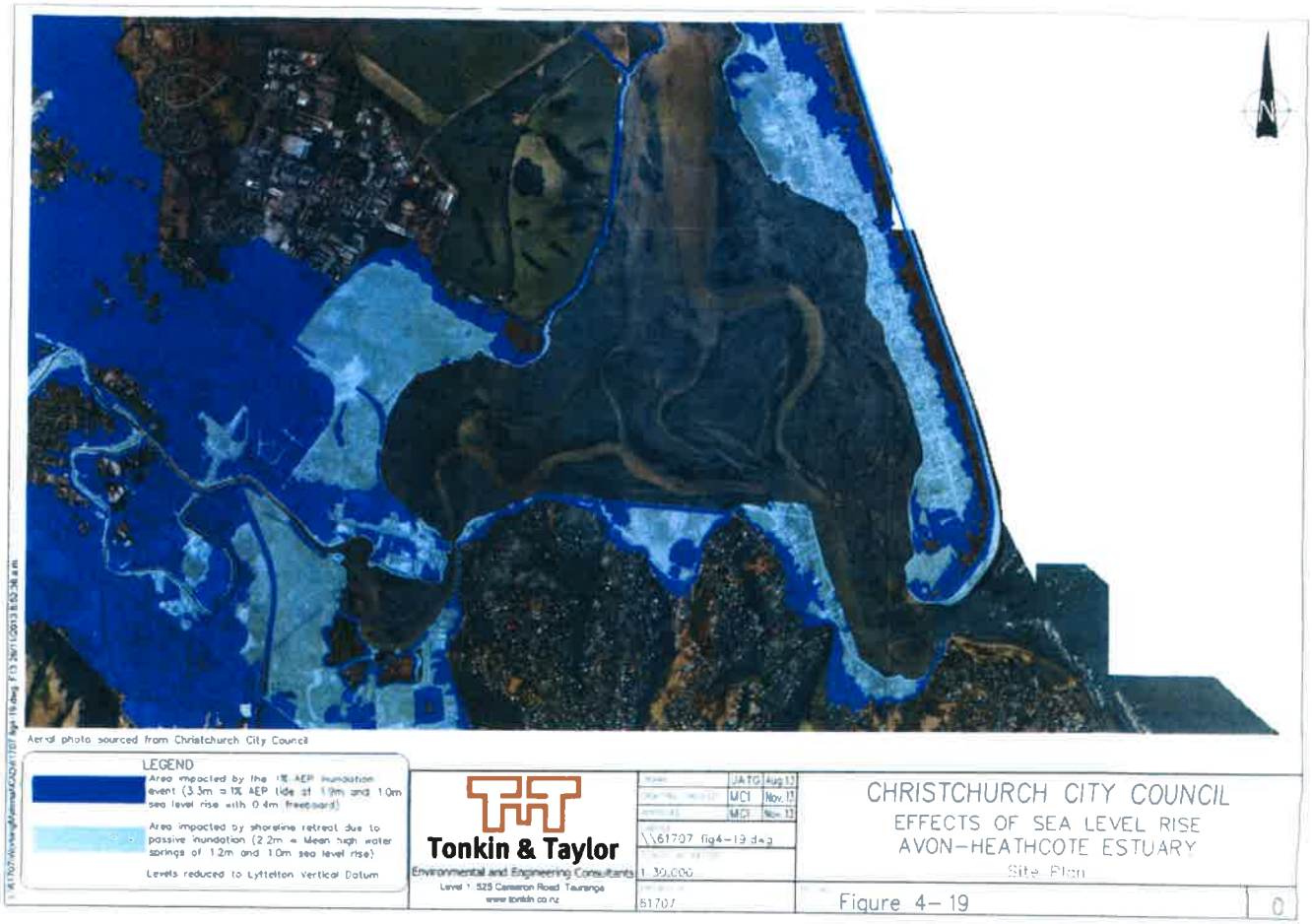


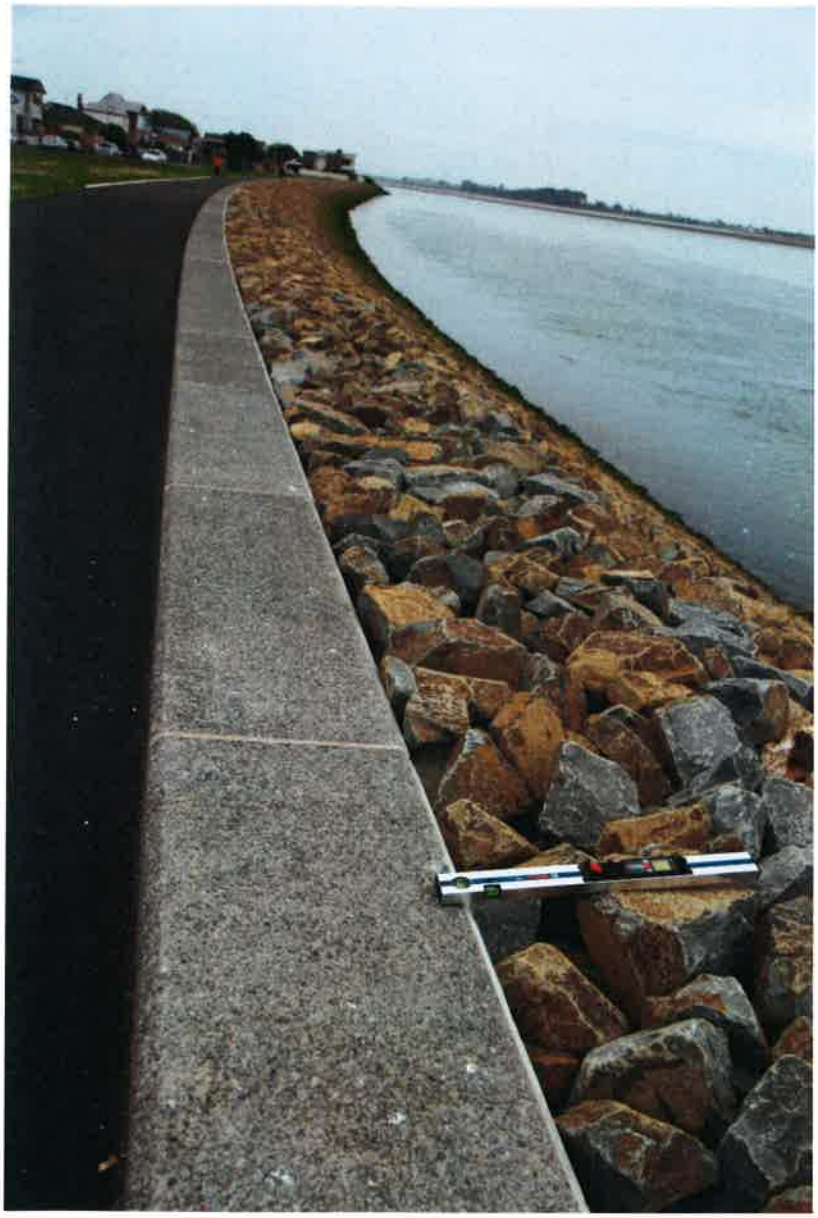
Figure No 1

BERM DESIGN

The design of a berm to protect Southshore from inundation from the Estuary side should incorporate the following features

- Be high enough to accommodate the 100 year SLR projection, currently 1 m, with sufficient base width to be able accommodate an increase in the berm height in the light of future updated SLR estimates.
- Have an additional height margin on top of the SLR height to prevent overtopping by wave runup.
- Have a 1V:3H slope on the Estuary side to promote energy dissipation by wave breaking, avoid wave reflection and thereby reduce the armouring requirement.
- The Estuary face berm surface to be designed to be stable against wave attack, either by providing an armoured surface, rock armour or Reno mattress protection, or by using a recent geofabric development, sand mattresses. Natural beach features could also be employed to give variety. There is no need for the same solution to be employed for the full 3 km length of the berm.
- Sufficient width to provide for a combined walkway/cycleway on top of the berm. Although protection against inundation of the land behind the berm in elevated high tide events – elevation due to a combination of spring tides, SLR and storm surge - is the prime design objective the berm can provide an attractive elevated pathway along the Estuary shoreline extending the network of existing and planned walkways as a bonus.
- The berm must be impermeable to resist the flow of water both through and under the berm when the water level builds up on the Estuary side.
- The berm to use readily available materials and be of simple construction to keep the construction cost down.

attack along the Southshore Estuary shoreline is limited rather than continuous and the sediment in motion during wave attack is of small size factors allowing the use of Reno mattress elements. OCEL has used Reno mattresses and gabions for coastal protection where they essentially provide backup, a last line of defence, the same as used in front of the Waimairi and New Brighton surf lifesaving clubs and the New Brighton library at the base of the Christchurch Pier. If Reno mattresses were used they can be completely covered with sand. They function as a sand trap for sand entrained by wave action.

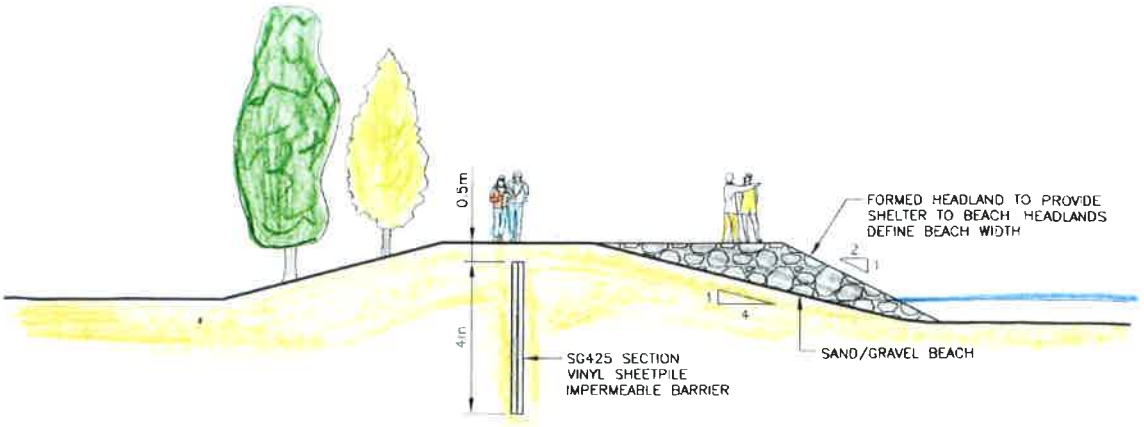


Photograph No 7

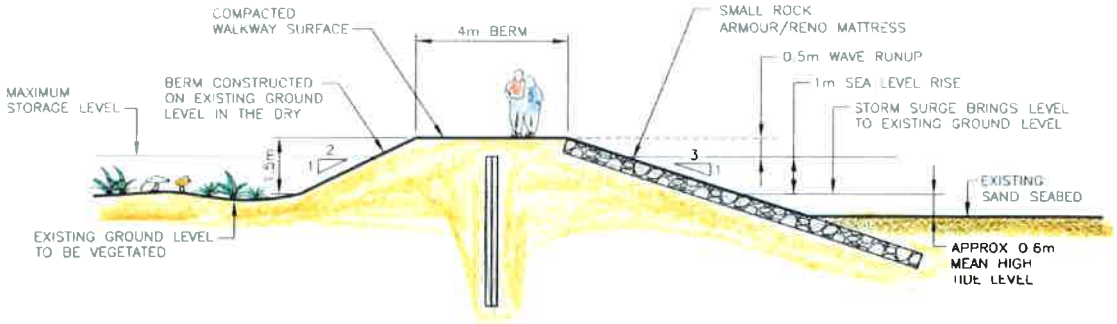
A further alternative is a sand mattress made from geofabric material with a Velcro like surface which traps sand to give the mattresses a natural sand appearance. These units are a recent development from TenCate sold in New Zealand by Geofabrics NZ Limited. In position these units look like a natural feature and allow bare foot access across them. A brochure for TenCate sand mattresses is attached as Appendix A to this report. Other options are to use sand or gravel to create a natural beach feature set at a lower slope than 1V:3H.

Given the length of the Southshore Estuary shoreline, the curves in it and the opportunity to create an attractive walkway experience rather than just a protective berm it would make sense to use a range of coastal protection methods to add variety. Rock protection could be used in front of the sea grass areas towards the north end of

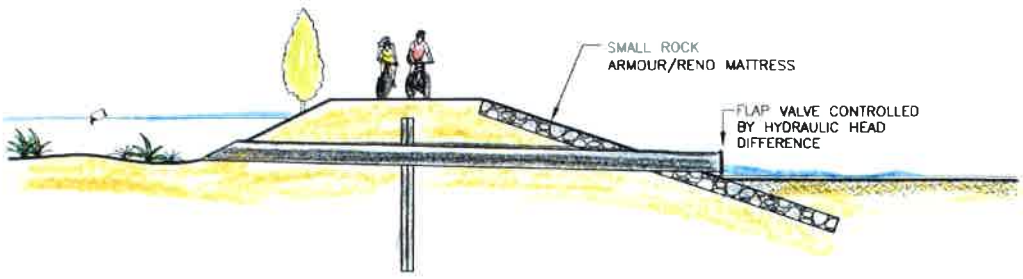
the walkway, Photograph No 2. The sea grass provides some wave protection by itself, the berm would be behind it to provide protection against elevated water levels and an elevated viewing platform. Beaches could be provided at other locations to ease access for people wanting to launch and use kayaks and paddle boards at high tide. These beaches could be defined or limited by small promontories. Figure No 3 illustrates some possible cross-sections along the berm.



SECTION THRU HEADLAND/BEACH



SECTION THRU DETENTION POND



SECTION THRU DETENTION POND OUTLET

NOTE:
LEVELS SHOWN ARE APPROXIMATE

Figure No 3

Drawing DR-STHSHR-001 shows the end of the spit and the potential to add further to the attraction of the walkway by the addition a high water roosting refuge island for godwits off the Estuary shoreline. This will provide protection from wave action in its lee (with respect to wave attack) and a sand beach could be incorporated on the Southshore shoreline.

The path of the berm could follow the shoreline sometimes set right on it sometimes back from it to leave a grassed area behind a beach for example. This feature could be lost in future as a result of SLR but would be available in the immediate future. Putting the berm on the existing shoreline would allow the Red Zoned area behind it to be used in some areas for sustainable housing. Services – sewer, power and water - are already in place to the boundary of the red Zone.

The Red Zoning implies that the land is liquefiable as well as being subject to an inundation risk. The risk of land liquefaction in a seismic event could be addressed by using floating houses – effectively the water acts as a base isolator in an earthquake and the house can rise with the water level - or by using pile foundations and screw piles with the pile auger bearing plates set at depths where the foundation sand is not susceptible to liquefaction by virtue of its density and confining pressure. Floating houses could be used on the Estuary side of the berm and the material dredged to create a shallow pond for the house so that it floats at all stages of the tide could be used to create the berm behind the house. OCEL Drawing No DR-160705-001 shows a possible concept. The Southshore area could set an example for Christchurch by pioneering sustainable and resilient housing in a coastal area. Pilot projects would add interest to the area and showcase sustainable housing, boosting confidence in the area.

All these features could contribute interest to the walkway on top of the berm. The walkway would link to the existing nature trails at the end of the Southshore spit.

COST

OCEL has design experience in the design and costing of coastal protection works, it is one of the firm's core activities.

OCEL understands that the CCC has already obtained a cost estimate for a protective berm along the Southshore Estuary shoreline - $39 million for a 3 km long berm corresponding to $13,000 per lineal metre. While the design details for this berm and the consultancy that provided it are unknown – to OCEL – it has to be a far simpler structure than the recently constructed replacement seawall at Beachville Road, Redcliffs.

OCEL had input for that seawall in the form of the design of temporary works – sheet piling design to protect the foundations from strong tidal currents and the design of lifting frames to allow the installation of Reno mattress units and the underlying geotextile sheets at the same time. The Beachville Road seawall is in relatively deep water and had to be constructed in water using diver assistance rather than being constructed in the dry. It is topped by a reinforced concrete wall. While the wall can be outflanked by water flowing around the ends of the wall the houses directly behind it are afforded some protection from SLR and high water levels in the Estuary. The cost of that seawall – the contract price paid to the firm Connell Contractors that built the wall – is understood to be $4.7 million, corresponding to a linear rate of $8,900/m for the 530 m length of the seawall. The cost given in The Press at the opening of the walkway in early November was $8 million corresponding to a price per meter of $15,100. Exactly what the $8 million cost covers in addition to the construction of the seawall itself is not known but would likely have included the cost of the asphalt walkway behind it, the cost of regrassing the area between the wall and the road and SCIRT management costs and mark-up on the seawall construction contract.

The estimated construction cost for the berm as shown in Figure No 2 is $2,500 per lineal metre, $ 7.5 million total. It features the use of SG425 section 4 m long sheet piles as an impermeable core. These sheet piles could also be used as earth retaining structures to create a quay wall if required. The berm material is compacted river run material, AP40. The cost does not allow for a paved walkway on top but assumes compacted material.

The berm construction cost does not include landscaping or beach features. The cost of a pump station and pondage area needs to be separably included because what keeps water out will also keep it in and the coincidence

of a high tide and a high rainfall event would cause flooding. The cost of a pump station and pondage area (obtained with assistance from the CCC) is approximately $6 million for budget purposes, pending further engineering work and investigation. This does not allow for SCIRT margins but there is no particular reason why they should be involved, it can be a CCC project.

The pondage area could be an attractive wetland area incorporated in the design. The soil removed to create the pondage areas could be used in the construction of the berm.

Engineering design and survey costs would also need to be added. Allow say $200K inclusive of geotechnical investigation work. If a linear cost of $3,000/m was allowed for, $9 million total for the project that could be taken to include provisions for drainage and landscaping.

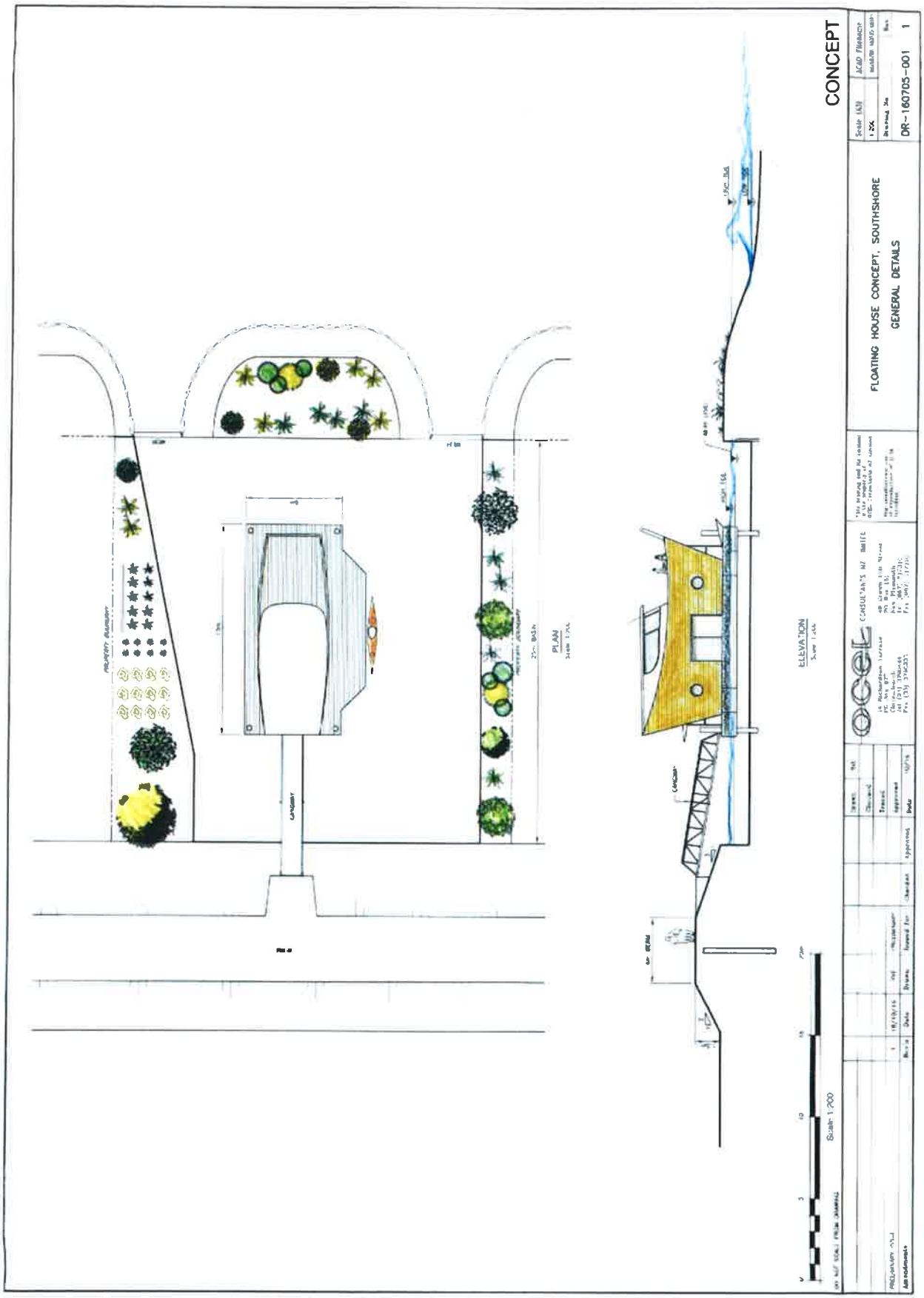
Based on the $9 million figure the berm cost per house, considering the total current number of houses, 500, would be $18,000/house.

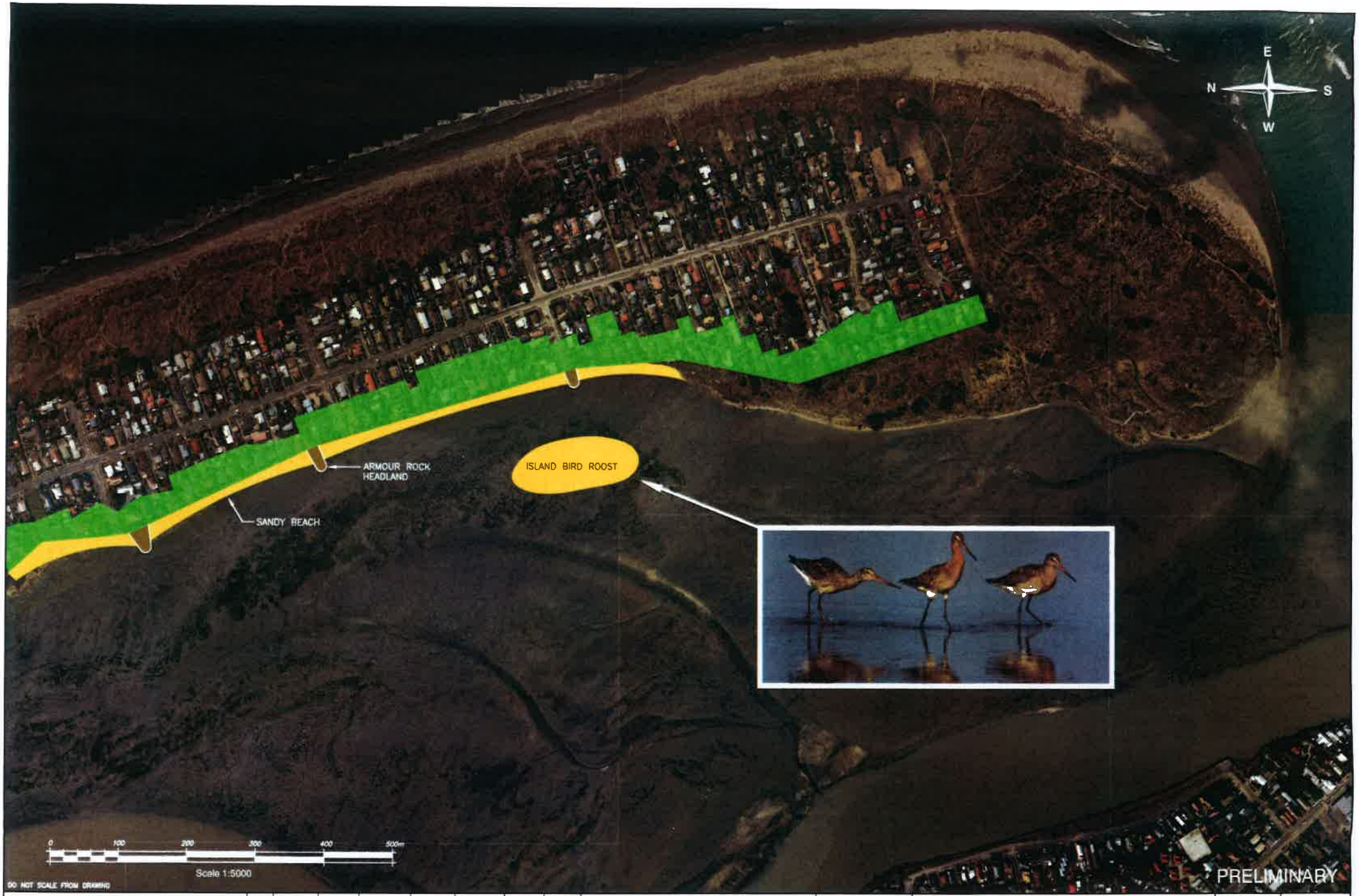
The equivalent figure for the Beachville Road seawall, $8 million/140 = $57,000/house, making the Southshore berm far more (3 x) cost effective. The costs could be offset by the sale of Red Zone land for innovative sustainable housing development.

CONCLUSION

Southshore can be protected against possible inundation from high water levels in the Estuary by the provision of a simple berm running along the Estuary shoreline. The probability/risk of inundation is increasing as a result of SLR, elevated water levels arising from storm surge effects riding on elevated tide levels. Southshore is an established and attractive housing area with 500 homes the value of which would be sharply lowered by an inundation event. It makes economic and social sense to protect a community of this size against the start of SLR, the berm height has been set to allow for the currently forecast 1m SLR in 100 years. The berm construction cost would be much less expensive than the cost of the seawall protecting Beachville Road in Redcliffs immediately across the Estuary from Southshore. The Southshore berm would also protect a lot more houses at a lower cost per house than the Redcliffs seawall with the potential to protect even more houses given the available space. Southshore could be a show case for resilient sustainable houses adopted to accommodate SLR, techniques that could be used elsewhere in the Red Zone. The case for a berm at Southshore makes economic and social sense.

In addition to its protective function the berm represents an opportunity to create an attractive elevated walkway/cycleway along the Estuary shoreline. The shoreline can be tailored to provide for a full range of activities and interests ranging from active boating sports using wind or person powered craft to bird watching. The Estuary is a food source and resting area for large numbers of birds, most notably the godwits. The attractions are readily apparent now, given the number of walkers on the red zoned land. It does not require much imagination to see what it could be if the crumbling Estuary edge can be transformed into a combination of natural and usable beach areas with spectacular views.


CONCEPT
FLOATING HOUSE CONCEPT, SOUTHSHORE
GENERAL DETAILS
DR-160705-001
PLAN
ELEVATION
CARIBBEAN
Scale 1:200



DO NOT SCALE FROM DRAWING

Amendments	Rev'n	Date	Drawn	Issued for	Checked	Approved

Drawn	RVE
Checked	
Traced	
Approved	
Date	05/16

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PROPOSED BERM FOR SOUTHSHORE

COASTAL OPTION

Scale (A3)	ACAD Filename
1:5000	160705/DR-160705-002R1
Drawing No.	Rev.
DR-160705-002	1

APPENDIX

TENCATE Geotube

METHOD STATEMENT

TenCate Geotube® Sand Filled Mattresses

Installation Guide

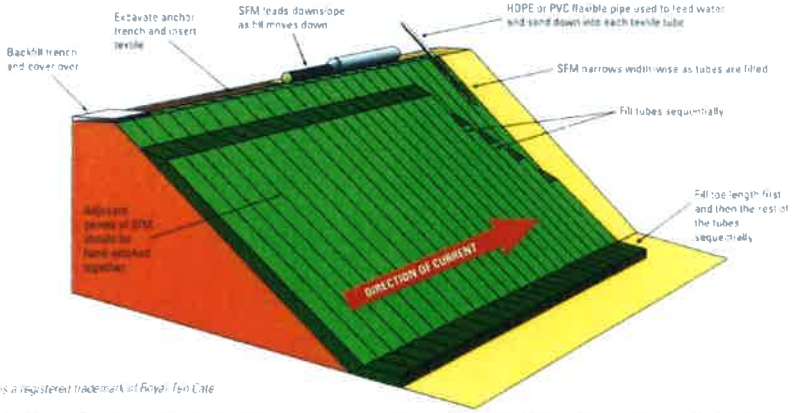
Product & Application

TenCate Geotube® Sand Filled Mattress is a containment product manufactured from two layers of engineered fabrics stitched together at regular intervals. The exposed top layer fabric is a special composite geotextile that provides excellent abrasion resistance and durability; and is capable of trapping settling sediments and particles. The range of products include:

- SFM1000G: Green solution for conditions where vegetation can establish naturally *(see Figure 1)*.
- SFM2000C: Coarse fibre solution for conditions where vegetation have difficulty establishing naturally, e.g. saline water, regular water level fluctuation zone, etc *(see Figure 1)*.

When filled with sand, the resulting mattress is an environmental revetment for the slope protection of riverbanks, lakeshores and sedimentation ponds. Figure 2 is a schematic diagram for the site installation of TenCate Geotube® Sand Filled Mattress.

Figure 1: Sand Filled Mattress (with insets of SFM1000G and SFM2000C surface finishes)



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TENCATE
materials that make a difference

Installation

Some pre-installation planning is usually necessary. This may include estimation of panel sizes as well as cutting and seaming of panels to suit site conditions. Slope preparation, trenching and other profiling may be needed before the Sand Filled Mattress is laid out according to the Engineer's instructions.

Adjacent panels of Sand Filled Mattress are sewn together to provide continuity *(see Figure 3)*. When the Sand Filled Mattress is laid out in position, sand is introduced into the internal space created in-between the two fabric layers. This is typically done using a hopper system and water is used to wash down the sand *(see Figure 4)*. The sand fill shall conform to the specifications provided by the Engineer. Figure 5 shows a completed Sand Filled Mattress revetment prior to establishment of vegetation. Figure 6 shows a completed Sand Filled Mattress revetment fully vegetated over.

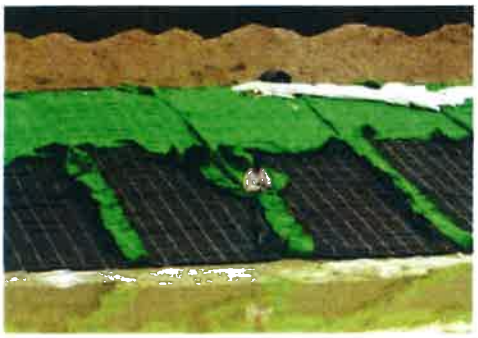

Figure 3.

Figure 4.

Figure 5.

Figure 6.

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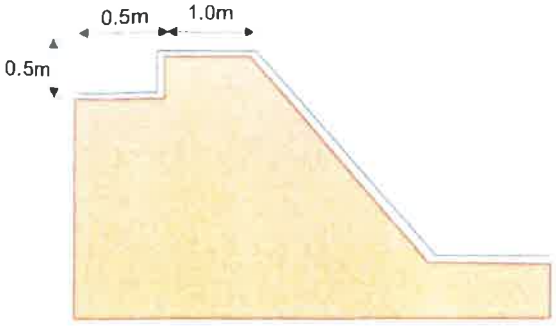
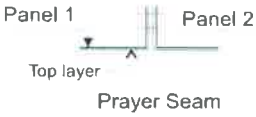
Method Statement for Sand Filled Mattress Installation



Excavate anchor trench along the slope and ensure that the slope is free from sharp protruding objects.

The sand filled mattress are supplied in panel width of 3.86m x 40m length. Precut the panel to the required length as per required with a sharp blade or scissor.

J seam method shall be used for seaming the end closure across the width. The seaming shall be carried out using a hand held portable seaming machine using thread with a breaking strength of > 20 kg.



For seaming between adjacent panels, manual seaming using Prayer seam shall be used to seam the selvage of each panels together. The thread used shall have a breaking strength of 100kg. Ensure that during the seaming the top layer (green colour) is always faced up.