Coastal-Burwood Community Board
SUPPLEMENTARY AGENDA

Notice of Meeting:

An ordinary meeting of the Coastal-Burwood Community Board will be held on:

Date: **Monday 4 September 2017**
Time: **4.30pm**
Venue: **Boardroom, Corner Beresford and Union Streets, New Brighton**

Membership

Chairperson	Kim Money
Deputy Chairperson	Tim Sintes
Members	Tim Baker
	David East
	Glenn Livingstone
	Linda Stewart

4 September 2017

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12 Resolution to Include Supplementary Reports

1. Background

1.1 Approval is sought to submit the following report to the Coastal-Burwood Community Board meeting on 04 September 2017:

13. Southshore Floodplain Management Short Term Options Feedback

1.2 The reason, in terms of section 46A(7) of the Local Government Official Information and Meetings Act 1987, why the report was not included on the main agenda is that it was not available at the time the agenda was prepared.

1.3 It is appropriate that the Coastal-Burwood Community Board receive the report at the current meeting.

2. Recommendation

2.1 That the report be received and considered at the Coastal-Burwood Community Board meeting on 04 September 2017.

13. Southshore Floodplain Management Short Term Options Feedback

Christchurch City Council

13. Southshore Floodplain Management Short Term Options Feedback

Reference: 17/954966
Contact: Keith Davison Keith.davison@ccc.govt.nz 03 941 8999

Item 13

1. Purpose of Report

1.1 The purpose of this report is for the Coastal-Burwood Community Board to provide feedback on the staff report to the Council meeting on 31 August 2017 (adjourned from the 24 August 2017) on Southshore Floodplain Management Short Term Options (Attachment 1). The Council resolved at that meeting to seek feedback from the Community Board and for staff to report back on this feedback to the Council on 28 September 2017.

2. Staff Recommendations

That the Coastal-Burwood Community Board:

1. Receive the information in the Southshore Floodplain Management Short Term Options Report with attachments.
2. Provide feedback to staff on the next steps for Southshore Floodplain Management Short Term Options to inform a subsequent report to Council.

3. Key Points

3.1 The Council resolved on the 31 August 2017 to:

1. Receive the Southshore Floodplain and Management Short Term Options report with attachments

2. Approve option 2 to establish emergency works to construction.

3. Refer the remainder of the report to the next Coastal-Burwood Community Board meeting for the Board's comment and request staff report back to the Council meeting 28 September 2017.

3.2 The Southshore Floodplain Management Short Term Options Report is provided to the Board in the attached document (Attachment 1).

Attachments

No.	Title	Page
A ⇩	Southshore Floodplain Management Short Term Options Report	7

Signatories

Author	Thomas Parsons - Surface Water Engineer
Approved By	Keith Davison - Manager Land Drainage Richard Osborne - Head of Planning and Strategic Transport John Mackie - Head of Three Waters and Waste David Adamson - General Manager City Services

Council
24 August 2017

42. Southshore Floodplain Management Short Term Options

Reference: 17/793802
Contact: Keith Davison Keith.davison@ccc.govt.nz 03 941 8999

1. Purpose and Origin of Report

Purpose of Report

1.1 The purpose of this report is to inform the Council of the initial feasibility of the OCEL proposal and of potential short term measures to address tidal flooding and rainfall flooding in the area south of Bridge Street along the estuary side of the Brighton Spit.

Origin of Report

1.2 This report is being provided to fulfil Council resolution CAPL/2017/00022 passed on 20 June 2017, being to:

1.2.1 *Direct the Chief Executive to report back to Council by 30 August 2017 with an initial evaluation of the feasibility of the OCEL Consultants Ltd's proposal for the Estuary Edge Protection at Southshore, and whether there are any other alternative options for short-term measures to address concerns raised by the community. The report back from the Chief Executive should include what statutory, planning or consenting mechanisms may be required to allow estuary edge protections (of any form) to be legally constructed; and should also include any assessment of the OCEL proposal undertaken by Regenerate Christchurch.*

1.3 Council also resolved on 3 August 2017 (CNCL/2017/00176) following the flood event of 21 July 2017 to:

1.3.1 *Seek urgent approval for resource consent to continue and complete to a robust standard the bund work created on Friday 21 July to Sunday 23 July 2017 and to extend this work as necessary to prevent seawater inundation along the estuary side of Southshore and the South Brighton Domain to the jetty.*

1.4 This report will present options for short term measures that will address both rainfall flooding and seawater inundation (tidal flooding). It will also present management options to address risks of erosion of any short term works constructed to manage flood risk.

2. Significance

2.1 The options in this report are of medium significance in relation to the Christchurch City Council's Significance and Engagement Policy.

2.1.1 The level of significance was determined by the impact that natural hazards could have on the local community and the potential implications for Council of decisions made in this area for other areas within the city also affected by the natural hazards.

2.1.2 Given the very limited time available the community engagement and consultation outlined in this report has been limited to discussions with other agencies, including Environment Canterbury, Regenerate Christchurch and Land Information New Zealand (LINZ). The views of some members of the community have been expressed via correspondence from the local Southshore Residents Association and through the petition received by Council on 26 July 2017.

3. Staff Recommendations

That the Council:

1. Receive the Southshore Floodplain Management Short Term Options Report with attachments.
2. Approve Option 1 - a short term, temporary intervention to reduce flooding risks south of Bridge Street on the estuary side of Brighton Spit, and instruct staff to undertake the work identified in the report to progress this option into construction (noting the need to report back on implementation timeframes and any issues under resolution 4.).

   Note: The Council is currently working on a long term Regeneration Strategy for Southshore and South New Brighton in collaboration with Regenerate Christchurch.
3. That staff engage with Land Information New Zealand (LINZ) and Environment Canterbury to clarify roles and responsibilities in this coastal environment and funding options, noting that the timeframe of this report did not allow staff to fully explore these issues.
4. Report back to Council at the earliest opportunity the outcomes of these discussions, the implementation timeframes for Option 1 and any issues that arise with pursuing Option 1.

4. Key Points

4.1 This report supports the Council's Long Term Plan (2015 - 2025):

4.1.1 Activity: Flood Protection and Control Works

- Level of Service: 14.1.5 Implement Land Drainage Recovery Programme works to reduce flooding

4.2 The Southshore Inundation Protection Levee Report (OCEL Consultants NZ Limited, December 2016) has been considered and the option presented in the report:

- Is a typical hard engineered approach to management of tidal flooding
- Would need further investigation before confirming feasibility
- Would necessitate other engineering works, such as stormwater management and groundwater management systems, to effectively manage other sources of flooding
- Would be likely to fail in a future earthquake if not set back from the estuary edge in the order of 50 m – 100 m (as far as Rocking Horse Road in places) or constructed with engineered foundations to reduce risk of failure (with consequential cost impacts)
- Is useful for the development of options to inform floodplain management plans as part of the multi-hazard investigation

4.3 Approaches other than hard engineering may also be feasible, viable, more adaptable and provide a wider range of benefits.

4.4 Tidal flooding on 21 July 2017 overtopped the estuary edge and flowed through gaps in the existing landscape feature on residential red zoned land. Emergency works were undertaken to fill low points to reduce the extent of flooding predicted on the following tide.

4.5 There are a range of concerns that have been raised by some members of the community through the Southshore Residents Association, correspondence received by Council staff and the petition to Council that was received on 27 July 2017 (CNCL/2017/00160) including:

- Coastal flooding
- Coastal erosion
- Ecological impacts of emergency works

- Estuary edge access
- Maintenance of roads within the Residential Red Zone (RRZ)

4.6 There are a number of different statutory and non-statutory plans that are applicable in the area adjoining the Ihutai / Avon-Heathcote Estuary edge. Options for physical works will need to consider the regulatory requirements set out within those plans. Resource consents for the emergency works are needed and any future works would also need a consent. Access to private land is required to undertake further works in some areas.

4.7 The following short term options have been developed, to a preliminary stage, to address flooding (and consequential stormwater management), coastal erosion and ecological impacts of the emergency works:

- Option 1 – Stabilise Emergency Works and Extend to Bridge Street
- Option 2 – Stabilise Emergency Works (Do Minimum)
- Option 3 – Stabilise Emergency Works and Extend to the Jetty

4.8 These options are short term and have a design life of 20 years. They would not address groundwater seepage or provide earthquake resilience. A 20 year period will enable sufficient time for long term planning and adaptation planning to progress without unduly burdening later decision making with significant capital costs. Any short term works may not be consistent with long term plans that will be developed over the coming years and by enacting the works Council could be tied to ongoing maintenance of the works and additional considerations before it could later remove such works. Ongoing work on the multi-hazard analysis will inform floodplain management plans. These plans may suggest alternative alignments or management options.

4.9 Further work is required to:

- Evaluate the risks associated with enacting the works, for example, further geotechnical assessment is required to understand the risk posed by future earthquakes
- Discuss with other agencies the potential for assisting with the works
- Understand how any further defence works fit within Council climate change policies and other projects that will engage with the community around the adaptive management responses to coastal hazards and the effects of sea level rise. This includes the Coastal Futures project and regeneration planning for South New Brighton and Southshore
- Improve the costs associated with the works
- Undertake floor level surveys and hydraulic modelling to better understand the benefits of the works

4.10 Further investigation is required to provide robust advice on any proposed works in this area. The time required to develop this work will allow discussions with ECan on roles and responsibilities on coastal inundation and erosion.

5. Context/Background

5.1 The Brighton Spit is formed by southward migration of sands within Pegasus Bay and has been in various states of deposition and erosion over time. The spit has sand dunes on the seaward side that are elevated above sea level. The western side of Brighton Spit is formed of estuarine deposits and is very low lying, particularly along parts of Rocking Horse Road.

5.2 Prior to the Canterbury Earthquake Sequence starting in 2010 ('the earthquakes') numerous private properties extended to the Ihutai / Avon-Heathcote Estuary (the 'Estuary) edge. These properties were subject to risk of coastal flooding and erosion. The response of the individual

property owners was to erect varying forms of coastal defences in an ad hoc manner. Many of these defences were constructed on an unformed legal road, most of which is located within the coastal marine area.

5.3 As a result of land damage from the earthquakes many of these properties were purchased by the Crown, commonly known as the residential red zone (RRZ). The RRZ varies in width but is continuous along the spit to as far north as the Council-owned camp ground at Halsey Street, excluding two privately owned properties. It has been reported that the clearance of these properties and the de-habitation of the land left many residents feeling exposed to coastal hazards. The existing ad hoc defences are in varying states of dilapidation.

5.4 LINZ formed a low landscaping feature of topsoil as part of ongoing management of the RRZ. This feature was discontinuous as it did not extend through privately owned land or Council roads. As a result it was not effective at managing tidal flooding risks. Figure 1 provides a map of the general area and the extent of options described later in this report.

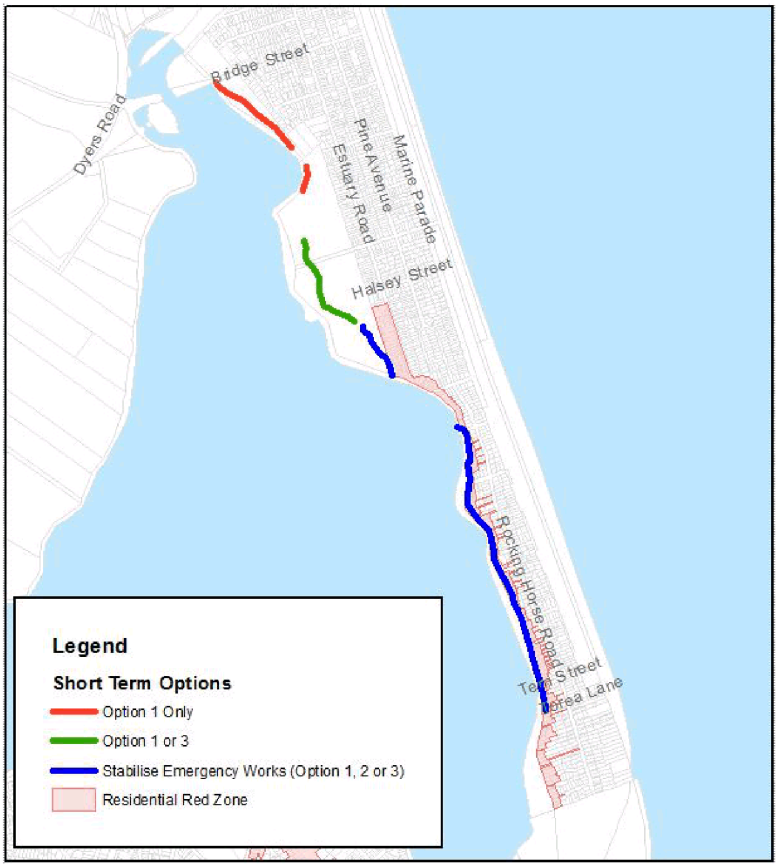

Figure 1 Map of Project Area Southshore and South New Brighton (North to top)

5.5 Widespread tidal flooding occurred on 21 July 2017 due to overtopping of the Estuary edge as flow passed through the gaps in the landscaping feature and around existing coastal defences at Ebbtide Street. This included (Figure 2):

- Areas of Rocking Horse Road between Caspian Street and Tern Street
- Estuary Road south of Halsey Street

- Private properties, outbuildings and garages on these and adjoining roads
- One permanent private residence and one temporary private residence were flooded above habitable floor level
- Foundations of many properties with some very close to habitable floor level

Figure 2 Flooding of Rocking Horse Road (above) and Debris Showing Overtopping of the Estuary Edge at Penguin Street on 21 July 2017

5.6 Water levels of near to 11 m Christchurch District Datum (CDD) in height were recorded in the Estuary. This level is the highest ever in the 20 years of record at Bridge Street and the 43 years of record at Ferrymead Bridge. The water level resulted from a combination of king tides, long period offshore waves and a significant storm surge.

5.7 In response to the tidal flooding of 21 July 2017 emergency works were constructed that aimed to significantly reduce the extent of the flooding predicted to occur on the following tide (22 July 2017). The following low points were filled along Southshore (Figure 3):

- Council owned roads (heads of cul-de-sacs) at Penguin Street, Heron Street and Tern Street
- Over privately owned land at 44A and 78 Rocking Horse Road
- Through South New Brighton Park in the vicinity of the Estuary Road RRZ

Figure 3 Emergency Works Near to Penguin Street during Event of 22 July 2017

5.8 In conjunction with temporary pumping these emergency works significantly reduced flooding that might have otherwise occurred on 22 July 2017. A higher astronomical tide level and wind set up across the Estuary was offset by lower storm surge on 22 July. The resulting water levels were elevated almost as high as recorded on 21 July 2017.

5.9 Since the 21 July 2017 the works have been partially stabilised with additional compaction, levelling and widening (Figure 4). Silt fences have been erected to help minimise environmental impact. Some vegetation loss has occurred due to the works in areas of ecological significance through vehicle movements, placement of the bund and other construction activities.

Figure 4 Emergency Works in South New Brighton Park

5.10 The purpose of the emergency works was not to address erosion of the Estuary edge within South New Brighton Park (Figure 5). Prior to the earthquakes attempts had been made to manage erosion of the Estuary edge using engineered coastal defences (reno mattresses). These defences failed in some areas during the earthquakes through slumping or lateral spreading. This lowered the top of the mattresses and exposed the bank in areas below high tide level to wave action. Landward migration of the top of bank is now occurring with some tree loss and the formation of beaches behind the mattresses. With time these beaches could stabilise and be colonised by plants. The options described in this report include trial planting areas to assess if areas where beaches have formed (Figure 6) can be stabilised effectively.

5.11 Ongoing monitoring (site observations and survey) to assess geomorphological changes is needed.

Figure 5 Estuary Edge Erosion within South New Brighton Park

Figure 6 Beach Formation within South New Brighton Park behind Reno Mattress around Park Bench

5.12 There is an area of slightly elevated bank to the north of the campground. There is a longitudinal crack well back from the top of the bank (Figure 7) indicating instability of the land immediately adjacent to the estuary edge.

Figure 7 Cracking in the high bank within South New Brighton Park

5.13 Other works are currently underway within South New Brighton Park, including reconstruction of the jetty and boardwalk areas with engineered erosion structures along the Estuary edge to reduce risk of erosion damaging or isolating the newly built Council assets.

Community Concerns

5.14 There are a range of concerns that have been raised by some members of the community prior to and after the recent flooding via the Southshore Residents Association, correspondence received by Council staff and a petition to Council that was received on 27 July 2017:

- Coastal flooding
- Coastal erosion
- Ecological impacts of emergency works
- Estuary edge access
- Maintenance of roads within the RRZ

5.15 The wording of the petition was that:

The residents of Southshore write to express our anger and disappointment at the late and inadequate response from Council in relation to flood risk.

The flood events of this weekend highlight what we have been saying to the Council for six and a half years since the earthquake. The previous flood defences on Red Zoned property were demolished and the land scraped and lowered by Red Zone clearance and not reinstated. A new storm water system has been installed to half the community but this inadequate provision is a point of flooding as witnessed in the last few days. Water from the estuary comes up through the drains and floods the street during high tide. Once the high tide has receded the outlets do not allow water to drain out. The temporary bund had gaps in it which lo and behold caused us to flood.

This is a man-made and negligence issue and one that the Council have continued to ignore and deliberately obstruct. We have even offered a solution to try and help which has been met with yet more obstruction. Turning up with diggers after we have flooded is appalling. The time for action is now. As residents of Christchurch we urgently need the City Council to show some long overdue leadership on this issue and we seek urgent, effective remedial action rather than "bandaids".

The council talk of resilient cities - yet the lack of action by the council is resulting in exactly the opposite and causing immense social upset, mental health issues and stress.

OCEL Initial Feasibility

5.16 OCEL Consultants NZ Ltd was approached by the Southshore Residents Association to prepare a report on a levee / berm to protect Southshore from tidal flooding over the Estuary edge. OCEL proposed (OCEL 2016) a compacted, engineered fill embankment with erosion protection and a plastic sheet pile wall at its core to reduce fluctuations in groundwater level due to the tide (Figure 8).

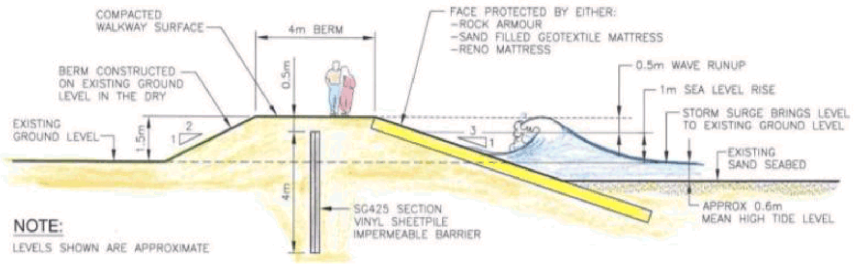

Figure 8 Levee / Berm Proposed within OCEL Report (Replicated from Figure 2 OCEL 2016)

5.17 Aurecon New Zealand Limited were engaged by Council to consider the OCEL report (Attachment A – Southshore Inundation Protection Levee Report Evaluation). Aurecon's investigation found that OCEL's proposed levee:

- Is a hard engineered approach to manage tidal flooding
- Would need further development and investigation before confirming feasibility
- Would necessitate other engineering works, such as stormwater management and groundwater management systems, to effectively manage other sources of flooding
- Would be likely to fail in a future earthquake if not set back from the estuary edge in the order of 50 m – 100 m (as far as Rocking Horse Road in places) or constructed with engineered foundations to reduce risk of failure (with consequential cost impacts)

5.18 The information presented in the OCEL report will be useful for Council in the development of options to inform floodplain management plans as part of the multi-hazard study. The multi-hazard study will consider a range of potential intervention options, including engineered options (as presented to Council on 27 July 2017). The OCEL proposal is an example of an engineered option that may be considered in the wider multi-hazard study. The OCEL option will also inform longer term options for adaption for the effects of climate change and sea level rise to be considered as part of the South New Brighton and Southshore Regeneration Strategy, being developed by Regenerate Christchurch. Other options and approaches may also be feasible, viable, more adaptable and provide a wider range of benefits.

5.19 Council resolved to continue with the multi-hazard study (CNCL/2017/00175) that will help inform decision on long term floodplain management options. Any decision to progress with long term options without full consideration of the range of hazards present in this area could lead to maladaptive and perverse outcomes for the community, particularly if hard engineering interventions are pursued.

5.20 Regenerate Christchurch has not independently evaluated the OCEL proposal.

Planning and Consenting Requirements to Enable Estuary Edge Protection Options

5.21 The area adjoining the Southshore estuary edge is within a complex planning environment. This complexity recognises that the area has multiple values based around the natural and cultural environment, particularly in terms of its coastal location. The relevant statutory documents that apply, include:

- the Christchurch District Plan
- Canterbury Regional Coastal Environment Plan
- Canterbury Regional Policy Statement
- the New Zealand Coastal Policy Statement

5.22 Depending on the exact location and type of works, these documents will influence the processes to enable any estuary edge works to be legally constructed.

5.23 The Regional Coastal Environment Plan will apply to any works within the coastal marine area (the area below mean high water springs tide). This may apply given that the area of any potential works is located in close proximity of the estuary edge. The Avon-Heathcote Estuary is recognised as an area of significant natural value under the plan. Activities that are likely to require consent in the coastal marine area include any new structures, destruction, damage or disturbance of the foreshore and seabed, occupation of the coastal marine area and deposition of material.

5.24 On the landward side, the area is affected by a number of zones and overlays under the Christchurch District Plan, including:

- Zones : Specific Purpose Flat Land Recovery, Open Space Coastal, Open Space Community Park and Residential Suburban;
- Natural Hazard Overlays: Liquefaction Management Area, Fixed Minimum Floor Level Overlay within Flood Management Area, High Flood Hazard Management Area;
- Natural and Cultural Heritage Overlays: Outstanding Natural Feature, Area of at least High Natural Character in the Coastal Environment, Natural Character in the Coastal Environment, Ngāi Tahu Sites of Cultural Significance (Ngā Tūranga Tupuna and Ngā Wai Coast), Coastal Environment.

5.25 Attachment B (Christchurch District Plan Analysis) an analysis of these zones and overlays. Resource consent will be required for any works as a result of a number of overlays and the open space zones. The application will require assessments in relation to ecological, cultural and landscape values and the risks from natural hazards.

5.26 The schematic diagram in Attachment B illustrates the relationship between the different planning environments, broadly showing the relevant plans, zones and overlays.

5.27 The New Zealand Coastal Policy Statement 2010 (NZCPS) will be a relevant consideration for any resource consent, as both the Regional Coastal Environment Plan and the Christchurch District Plan do not fully give effect to the NZCPS. The Regional Coastal Environment Plan pre-dates the current NZCPS, while the coastal hazard provisions were removed from the replacement Christchurch District Plan process.

5.28 Being a higher order statutory document, the NZCPS provides direction for the management of and responses to coastal hazards. There are a number of objectives and policies that would be of particular relevance to any resource consent for estuary edge works. Policies relating to coastal hazard risk (Policies 24 to 27) discourage hard protection structures and promote use of alternatives including natural defences. While any strategies for reducing coastal hazard risks in areas of significant existing development promote taking a long-term risk reduction approach when considering options.

5.29 It is noted that, while it will not affect consenting requirements in the near future, there are projects underway to determine future adaptation pathways with coastal communities. The Coastal Futures project will engage with the community around the adaptive management responses to coastal hazards and the impacts of climate change on coastal settlements and infrastructure across the district. The South New Brighton and Southshore regeneration planning project, being undertaken with Regenerate Christchurch, will be the 'pilot' for the wider project

Alternative Short Term Measures and Other Options to Address Natural Hazards

5.30 Council's resolution of 20 June 2017 (CAPL/2017/00022) requires an evaluation of alternatives for short-term measures to address community concerns. There are three areas of concern that relate to natural hazards (or arise from addressing tidal flood risk): tidal flooding, rainfall flooding and erosion.

5.31 It is possible to consider these issues separately. For example, works to reduce the risk of tidal flooding can be constructed away from the estuary edge so erosion of the Estuary edge can be treated separately, except in cases where the erosion puts at risk the tidal flooding measures. Erosion reduction measures can be carried out independently of tidal and rainfall flooding works. However, works to reduce tidal flooding will have an impact on rainfall flooding / stormwater management, primarily, blocking of overland flow paths. These impacts will need to be managed in order to avoid adverse effects. Also, any works to address rainfall flooding may not be completely effective if tidal flooding is not managed.

5.32 Measures to address these three issues are the topic of a report prepared for Council by CH2M Beca Ltd (Attachment C – Southshore Short Term Floodplain Management Options) (Beca 2017).

5.33 The options to address the tidal flooding concerns were in development when the flooding event of 21 July 2017 occurred. The emergency works enacted as a result of this flooding are very similar in nature to the short term measures being considered. The subsequent Council resolution on 3 August 2017 (CNCL/2017/00176) provides approval to extend the emergency works to the jetty within South New Brighton Park and to complete the bund to a robust standard.

5.34 The options presented in this report to address tidal flooding are based upon varying lengths of northward extension of the emergency works. In all options some work would be required to stabilise and enhance the emergency works through landscape treatment of the exposed fill. Covering the bunds with top soil and grass will reduce the risk of erosion of the bund and limit sediment laden runoff from discharging to the Estuary. A walking track of a similar nature to the Te Ara Ōtākaro Avon Trail would be proposed in areas where pedestrian access is expected and where reasonable transitions can be made to other areas with walking tracks, for example, adjoining the Jellicoe Marsh but not necessarily in areas south of Ebbtide Street as the tracks would be discontinuous. Tree removals would be required in the extension areas. The number and location of trees affected would be established in subsequent design stages but is likely to include mature trees.

5.35 The design for any extension would be similar to the new lengths of stopbank being constructed alongside the Avon River as part of the Land Drainage Recovery Programme Avon River Temporary Stopbank Management Project. The design is for an engineered fill bund with topsoil and grass cover on top of a shallow foundation that would be constructed to a height of no less than 11.2 m CDD (the water level recorded in the Estuary during the 21 July event was approximately 11m CDD). As with the Avon stopbank project the design life would be approximately 20 years and would not provide groundwater control beneath the stopbank. The bund would not be designed to resist ground movement, e.g. lateral spread. It is expected that significant remedial works would be required following a seismic event.

5.36 Further investigations are required to understand the likely earthquake event that would initiate lateral spread or cause settlement of any extension works. This would inform an assessment of the likelihood of this event occurring during the functional life of the works and the risks associated with failure of the works. It is possible that remedial works could be enacted to repair any earthquake damage following a seismic event and prior to a significant storm event or that the design could provide some earthquake resilience. These investigations are required to enable the provision of robust advice on the options as the cost of inclusion of earthquake resilience within the design could significantly increase costs of the works. Earthquake resilient designs could include features such as geotextile wrapping of layers of fill within the embankment or lateral spread resistant foundations.

5.37 Providing infrastructure with a short term design life would allow the long term planning process to proceed and also provide time for funding for long term works to be considered. A low capital expenditure reduces the risk of the capital cost associated with this decision prohibitively restricting any future options however further work is required to understand potential failure modes and the risks that these present to the communities benefited by the works, such as groundwater seepage or earthquake related land damage.

5.38 Although these works will have a short term design life, there is a risk that expectations of permanent tidal flood defence will result from a decision to proceed with these works. This may impact on future options and decisions to alter or introduce a new adaptation pathway that shifts away from solely engineering defence as would be delivered with the extension of the emergency works. Council has powers under the Christchurch District Drainage Act 1951 in relation to the construction and maintenance of defences against water (and drainage infrastructure). This legislation will impact on decisions and options around any new flood defences. Environment Canterbury also has powers in relation to minimising and preventing damage within its district by floods and erosion, under the Soil Conservation and Rivers Control Act 1941, and the Council should discuss future measures with them.

5.39 Monitoring and management of coastal erosion is also required to reduce the risk of the tidal flooding works being eroded. The nature and extent of management activities can vary with distance between the Estuary edge and the bund.

5.40 North of Ebbtide Street there is a large distance between the potential bund alignment and the Estuary edge. Given that the intervening distance is part of the park a potential approach is to establish an Estuary edge monitoring and management programme to provide an effective and adaptive way of managing the erosion risk. Existing reno mattresses could be retained and some tree loss would be expected with time. Pilot planting areas would be required to confirm the viability of beach formation in the local environment. The existing path would have to be relocated in short sections if the erosion progresses beyond the existing alignment. The general principle would be for a natural estuary edge and this would result in some landward migration of the top of bank. This approach is in accordance with the South New Brighton Reserves Management Plan and Development Plan that was consulted on and adopted by a hearings panel on 31 March 2014 and resolved by the Burwood-Coastal Community Board on 3 June 2014.

5.41 A slightly different approach to risk of erosive failure of the bund is possible south of Ebbtide Street. Additional planting in areas where the berm between the bund and the Estuary edge is narrow is an alternative to more hard engineering. Some additional erosion management works would be required at the ends of the cul-de-sacs where the bunds are very close to the Estuary edge. This is likely to require a geotextile layer being placed beneath the existing rock armouring.

5.42 Erosion management works would be required to reduce the risk of the bund being eroded and in large areas a naturalised edge would be preferred.

5.43 The construction of a bund will interfere with overland flow paths between Rocking Horse Road and the Estuary that will activate in extreme rainfall events. To remediate this impact and maintain the existing level of flood risk it would be preferred to excavate areas of the emergency bund and install structures with stop logs. The stop logs can be removed if flood levels become elevated behind the bund. Temporary pumping will need to be installed if there is rainfall at the same time as elevated Estuary water levels. Construction of pump laydown areas and some new stormwater manholes will be undertaken to facilitate the temporary pumping activities.

5.44 Remedial works will be required in areas where enacting the emergency work caused significant vegetative loss, particularly in areas adjoining the Jellicoe Salt Marsh (on the southern end of the South New Brighton Park).

5.45 Two longer term options were also considered by Beca (CH2M Beca 2017): rebuild and realignment. These options include significantly greater works with construction of a new bund along much of the study area either along a similar alignment or an alignment near to the back of the RRZ. The additional costs for these options are large and they are not considered to be short term measures. As with the OCEL proposal there is a risk of perverse or maladaptive outcomes with investment of this scale prior to completion of long term planning. It is proposed to pass this information to Regenerate Christchurch so that they can consider these options within their South New Brighton and Southshore regeneration planning process.

5.46 Detailed hydraulic modelling and floor level surveys have not been undertaken to inform the assessment of options within this report. Further work is required to give greater certainty on the benefits of the potential options.

Addressing Other Community Concerns

5.47 Other concerns raised by the community, including:

- The condition of road related assets within some streets adjoining the RRZ
- Maintenance of side roads

- Ineffective vehicle barriers and prolonged surface water ponding on Ebbtide Street
- Public access along the entire Southshore Estuary frontage.

5.48 Council resolved on 10 December 2015 (Item 14) to alter the status of some roads adjoining the RRZ to limit maintenance costs in areas where full service was no longer required. Many streets were classified as 'Out of Service – Decommissioned'. As a result, this street is not being maintained at a full service level. The state of Ebbtide Street and Tern Street, in particular, are a cause of concern for some residents. Long term planning for the Southshore RRZ is underway and the future of these roads will be considered as part of that process. Any repair of streets and footpaths in areas that service only RRZ could be wasted if the future use of the land is altered. It is not recommended that repair of these assets be undertaken until the long term planning process is completed.

5.49 Minor repair of any damage caused during the enacting of the emergency works will be undertaken in the short term.

5.50 Issues related to maintenance of side roads have been forwarded to the Council operations team to consider. Issues relating to vehicle access barriers have been identified to LINZ.

5.51 Public access along the Estuary frontage is currently restricted at two locations where privately owned land extends to the Estuary edge. It may be possible to create public paths on the unformed legal road on which the Estuary edge currently sits. The aim of these paths would be to permit pedestrian access past these points, however this would require works within the Coastal Marine Area, with subsequent consenting challenges. Further concept design and investigative work, including discussions with LINZ, would be required prior to making a recommendation on this matter. As with road maintenance in the RRZ any works of this type may be inconsistent with long term plans.

6. Option 1 - Stabilise Emergency Works and Extend to Bridge Street

Option Description

6.1 This option would see the emergency bund span low points in the existing topography within South New Brighton Park (pink line in Figure 9) and stabilisation of the emergency works. This would provide a reduction in risk of tidal flooding for properties within South New Brighton and Southshore. Extending the bund would offer a uniform approach to tidal flood risk that would be consistent with upstream areas of the Ōtākaro / Avon River. Construction of a bund with a design life of up to 20 years will allow time for long term planning processes to develop. Future decisions on floodplain management could require moving or abandoning the bund if a differing adaptation pathway is found to be preferred.

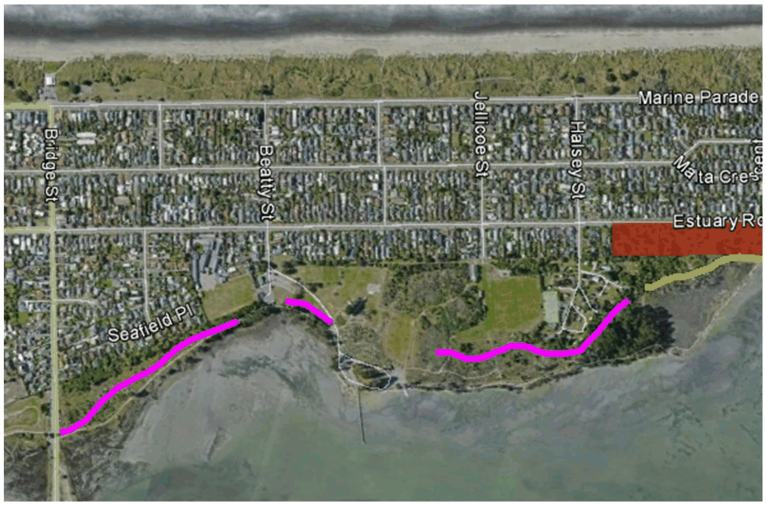

Figure 9 Potential Extension of Emergency Bund in Parts of South New Brighton Park (North approximately to the left)

6.2 It is estimated that there are a large number of low lying homes and properties within South New Brighton and Southshore (Table 1). Approximately 36 houses with floor levels estimated below 10.8 m RL are within the area benefited with this option. This does not represent the total numbers of houses and properties at risk as it is unlikely that there would be sufficient volume of tidal inundation overtopping the estuary edge to fill to this level. Debris marks from the 21 July 2017 event have been surveyed at levels between 10.62 m CDD and 10.87 m CDD. The floor levels have been estimated based upon building age and have not been surveyed. Floor level surveys and detailed hydraulic modelling would improve the assessment of benefits.

Table 1 Estimated Number of Benefited Houses and Properties

Level (m Christchurch District Datum)	Number at Risk	
	Estimated Houses with Floor Level at Risk	Estimated Properties at Risk (Land not Houses)*
10.8	36	343
11	161	633

* Based upon estimate average level of the land within a property.

6.3 This option also includes the monitoring and management of the Estuary edge erosion to varying degrees and the rainfall flooding approach as outlined above. A summary of the option is presented in Table 2.

6.4 The total budget for this option has been estimated at approximately $2.0 million +/- 40%. The confidence in the cost estimates will increase as the design develops.

Table 2 Option 1 Components

Item	Northern Area	Southern Area
Tidal Flooding	▪ Build a new bund through park behind Campground connecting to high ground near jetty ▪ Build a new bund behind Seafield Pl	▪ Landscape treatment existing only - topsoil, grass and crusher dust top in some areas

Item	Northern Area	Southern Area
	▪ Bund alignments as per South New Brighton Reserves Management Plan and Development Plan ▪ Both bunds finishing similar to Avon temporary stopbanks (topsoil, grass with crusher dust top), minimum level RL11.2 m ▪ Landscape works to existing bund in saltmarsh area	
Bund Erosion	▪ Monitor and maintain to protect bund ▪ Keep existing reno mattresses ▪ Remove trees as required ▪ Move path in future if required ▪ Pilot planting areas in existing beach formation areas	▪ Monitor and maintain to protect bund ▪ Geotextile and rock on bund at road ends ▪ Additional planting in areas where berm between bank and bund is narrow
Rainfall Flooding	▪ Stop logs to allow drain down ▪ Construct new manholes where existing sumps/manholes aren't suitable for temporary pumping ▪ Formalise temporary pump locations	▪ Stop logs to allow drain down ▪ Formalise temporary pump locations ▪ Swale in Residential Red Zone draining to road ends

Significance

6.5 The level of significance of this option is medium and is consistent with section 2 of this report.

6.6 Engagement with the community was undertaken to inform the South New Brighton Reserves Management Plan and Development Plan. Feedback from the community prompted this report. Consultation with the community might be required to inform resource consent applications for these works.

Impact on Mana Whenua

6.7 This option does involve a significant decision in relation to ancestral land or a body of water or other elements of intrinsic value, therefore this decision does specifically impact Ngāi Tahu, their culture and traditions. Engagement with Ngāi Tahu would be required to inform resource consenting of the works. The area is of high cultural significance.

Community Views and Preferences

6.8 A large proportion of the local community are specifically affected by this option as illustrated above in Table 1. Some of the community's views have been expressed through their local residents association, within the petition and other correspondence received by Council. There are a range of views within the community on the various values of the area.

Alignment with Council Plans and Policies

6.9 This option is largely consistent with Council's Plans and Policies, and Community Outcomes, including the South New Brighton Reserves Management Plan. This option may be inconsistent in part with some policies in the Christchurch District Plan. These do not require amendment as the option would be assessed against the provisions of the plan through the resource consent process under the Resource Management Act.

Financial Implications

6.10 Cost of Implementation – The construction cost for this option has been estimated at $1.6 million. A budgetary provision of $2.0 million +/- 40% which provides for project contingency, design costs and project management / support costs. Costs for contaminated land, access to

and restoration of private land, groundwater seepage and ground improvement is not provided for within the budget. Costs would be re-estimated at the completion of detailed design.

6.11 Approximately half the cost estimate is for the extension of the bund through South New Brighton Park. The remaining costs are associated with stabilising and mitigating the adverse effects of the emergency works. Landscaping and planting of the bund through Jellicoe Marsh, providing a walking trail, planting areas for erosion risk reduction, rock armouring at the road ends, construction of stop logs and stormwater manholes to facilitate stormwater pumping are the key components of these potential works that contribute to the cost estimate. The costs of top soiling and grassing of the emergency works is only a small component of the cost estimate.

6.12 There is cost risk associated with the findings of compaction testing of the emergency works. Some lengths of the emergency works may require additional compaction to meet the required design life.

6.13 Maintenance / Ongoing Costs – Ongoing monitoring and management of the Estuary edge is required in this option. This would require ongoing funding but will be dependent on the frequency and severity of storm events. As such ongoing costs are reactive in nature and very difficult to quantify.

6.14 Funding source – Capital costs would be met from within the Land Drainage Recovery Programme. This project is not currently specified as a line item within the Long Term Plan. Some budgetary balancing will be required in order to fund the capital investment. There is potential to utilise budget from the LDRP508 Lower Avon River Stopbanks Preliminary Design project, LDRP521 Avon Floodplain Management Implementation and LDRP524 EQ Waterway and Retic Repair to fund these works.

6.15 The proposed expenditure on these projects would have otherwise delivered planning and design associated with the Avon River Floodplain Management project in advance of decisions on the Ōtākaro / Avon River Corridor RRZ. There will be a period of time next financial year where this design work could be progressed in advance of the planned final decision on future use of the RRZ. It is likely that construction of any Ōtākaro / Avon River permanent stopbanks will take many years and any delay in starting their construction will be immaterial in comparison to other programme risks. Also the current works on the temporary stop banks will increase their longevity beyond a likely construction completion date.

6.16 A cost share agreement of some description with LINZ may be possible with regards to the works within crown-owned land.

6.17 Ongoing monitoring and maintenance costs will fall within existing operational budgets for park, roading and land drainage maintenance.

Legal Implications

6.18 Resource consents will be required to enact the works from Council. A determination on works within the Coastal Marine Area is being sought from Canterbury Regional Council (ECan). Emergency works were enacted on private and crown owned land. Access agreements will be sought from those parties.

6.19 Roles and responsibilities for coastal erosion and inundation management need clarification with ECan. The governing acts include the Land Drainage Act 1908 (LDA), Christchurch District Drainage Act 1951 (CDDA), the Soil Conservation and Rivers Control Act 1941 and the Local Government Acts 1974 and2002. These acts set out the responsibilities of the Council as a Drainage Board and ECan as a Catchment Board. ECan has responsibility to "minimise and prevent damage within its district by floods and erosion" within Christchurch and to exercise a general supervision of Drainage Board (i.e. the Council) with respect to the powers conferred under the CDDA. The Council's powers under the CDDA (and LDA) can be exercised in relation to watercourses and drains, but also banks and defences against water. Engagement with ECan

is required as to how these various acts have been interpreted historically and presently, and how they could impact the options presented in this report, presently and in the future.

Risks and Mitigations

6.20 There are a number of risks associated with enacting these works from both engineering and social standpoints.

6.21 Risk of flooding caused by system failure, overtopping during events that are larger than the design capacity, storm event erosion or operational deficiency (e.g. the stop logs are not removed) remains. This will result in flooding of streets, properties and potentially some homes.

6.21.1 Treatment: Ongoing operational management of the network is fundamental to ongoing flood management. Response plans are already in place and will need to be continued.

6.21.2 Residual risk rating: the rating of the risk is low given the nature of the potential system.

6.22 Failure of the works could occur during an earthquake or through a groundwater seepage induced geotechnical failure (i.e. a piping failure) as the design options discussed in this report do not mitigate these risks. Regular inundation of the toe of the works will not occur within the design life of the short term works so failures resulting from groundwater seepage are low.

6.22.1 Treatment: Ongoing monitoring of seepage beneath the works and maintenance of the works following an earthquake. Monitoring during extreme storm events will be a method to identify seepage paths beneath the works. This could identify areas where remedial works are necessary. Extension of the current stopbank inspection procedure would be an important tool to confirm any change in crest height over time or during an earthquake. Remedial works could be undertaken to top up the works, if required.

6.22.2 Residual risk rating: Given the infrequent required operation of the works it is likely that there will be sufficient time following an earthquake to enact remedial works, however, further investigative effort is required to understand the residual risk associated with this approach.

6.23 There is a risk that long term planning is not resolved (e.g. plans are not agreed or funding is not available) within the design life of the works or the outcomes of the plans diverge from the outcomes of this decision.

6.23.1 Treatment: Ongoing maintenance of the works will be required and a detailed risk assessment will be needed if the temporary works are to remain beyond 20 years.

6.23.2 Residual risk rating: the rating of the risk is low given the specified design life.

6.24 It is possible that exposure to other hazards will diminish the benefits achieved through these works. For example, is it possible that groundwater levels could rise with sea levels and that properties will suffer from groundwater water inundation.

6.24.1 Treatment: Hazard assessments continue within the LDRP 97 Multi-Hazard project and long term decision making be progressed within the 20 year design life.

6.24.2 Residual risk rating: the rating of the risk is low given the specified design life.

Implementation

6.25 Implementation dependencies - There are no dependencies with starting the design and consenting work. Resource consents would be required prior to starting physical works.

6.26 Implementation timeframe – Delivery of the project would be dependent on the determination of the resource consent level of notification. It is expected that the project could be completed this financial year.

Option Summary - Advantages and Disadvantages

6.27 The advantages of this option include:

- Able to be delivered in the short term
- Is adaptive as it can easily be modified in the future
- Consistency with the Council resolution of 3 August 2017 (CNCL/2017/00176)
- Reduces the risk of tidal flooding in extreme events to up to an estimated 343 properties and 36 homes
- Consistency with the South New Brighton Reserves Management Plan and Development Plan
- Provides a consistent treatment of flooding risks to all properties on the spit

6.28 The disadvantages of this option include:

- The budget has been estimated at approximately $2.0 million +/- 40%
- Greater cost than the Stabilise Emergency Works (Do Minimum) Option
- Reliant on ongoing maintenance and wet weather responses
- Tree removals and vegetation clearance would be required
- Risk of limiting future decisions on floodplain management or necessitating ongoing maintenance from Council beyond the original design life

7. Option 2 - Stabilise Emergency Works (Do Minimum)

Option Description

7.1 This option includes only the stabilisation of the emergency works as they stand today. This option does not extend the works to the north through South New Brighton Park. Stabilisation of the bund with a design life of up to 20 years would allow time for long term planning processes to develop.

7.2 It is estimated that there are a large number of low lying homes and properties within South New Brighton and Southshore (Table 3). Approximately 17 houses with floor levels estimated below 10.8 m RL are within the area benefited by these works. This is 19 houses fewer than Option 1.

Table 3 Estimated Number of Benefited Houses and Properties

Level (m Christchurch District Datum)	Number at Risk	
	Estimated Houses with Floor Level at Risk	Estimated Properties at Risk (Land not Houses)*
10.8	17	202
11	93	308

* Based upon estimate average level of the land within a property.

7.3 This option also includes the monitoring and management Estuary edge erosion to varying degrees and the rainfall flooding approach as outlined above. A summary of the option is presented in Table 4.

7.4 The total budget for this option has been estimated at approximately $1.0 million +/- 40%. The confidence in the cost estimates will increase as the design develops.

Table 4 Option 2 Components

Tidal Flooding	▪ Landscape works to existing bund in saltmarsh area	▪ Landscape treatment existing only - topsoil, grass and crusher dust top in some areas
Bund Erosion	▪ Monitor and maintain to protect bund	▪ Monitor and maintain to protect bund ▪ Geotextile and rock on bund at road ends ▪ Additional planting in areas where berm between bank and bund is narrow
Rainfall Flooding	▪ None	▪ Stop logs to allow drain down ▪ Formalise temporary pump locations ▪ Swale in Residential Red Zone draining to road ends

Significance

7.5 The level of significance of this option is medium and is consistent with section 2 of this report.

7.6 This option would leave a section of the community exposed between the areas of tidal flooding works. Consultation with the community might be required to inform resource consent applications for the potential works.

Impact on Mana Whenua

7.7 The Impacts on Mana Whenua associated with Option 1 apply to this option.

Community Views and Preferences

7.8 A large proportion of the local community are specifically affected by this option as illustrated above in Table 1. Their views have been expressed through their local residents association and within the petition received by Council. Reducing the extent to less than Option 1 may cause some concern amongst residents who are not offered the same level of service.

Alignment with Council Plans and Policies

7.9 The commentary associated with Option 1 applies to this options.

Financial Implications

7.10 Cost of Implementation – The construction cost for this option has been estimated at $0.8 million. A budgetary provision of $1.0 million +/- 40% which provides for project contingency, design costs and project management / support costs. Costs for contaminated land, access to and restoration of private land, groundwater seepage and ground improvement is not provided for within the budget. Costs would be re-estimated at the completion of detailed design.

7.11 The costs are associated with stabilising and mitigating the adverse effects of the emergency works. Landscaping and planting of the bund through Jellicoe Marsh, providing a walking trail, planting areas for erosion risk reduction, rock armouring at the road ends, construction of stop logs and stormwater manholes to facilitate stormwater pumping are the key components of these works that contribute to the cost estimate. The costs of top soiling and grassing of the emergency works is only a small component of the cost estimate.

7.12 The other commentary on financial implications associated with Option 1 applies to this option.

Legal Implications

7.13 The legal implications associated with Option 1 apply to this option.

Risks and Mitigations

7.14 The risks associated with Option 1 apply to this option.

Implementation

7.15 Implementation dependencies - There are no dependencies with starting the design and consenting work. Resource consents would be required prior to starting physical works.

7.16 Implementation timeframe – Delivery of the project would be dependent on the determination of the resource consent level of notification. It is expected that the project could be completed this financial year. The construction period for this option would be less than Options 1 and 3.

Option Summary - Advantages and Disadvantages

7.17 The advantages of this option include:

- Able to be delivered in the short term
- Is adaptive as it can easily be modified in the future
- Reduces the risk of tidal flooding in extreme events to up to an estimated 202 properties and 17 homes
- Consistency with the South New Brighton Reserves Management Plan and Development Plan
- This is the lowest cost option

7.18 The disadvantages of this option include:

- Inconsistency with the Council resolution of 3 August (CNCL/2017/00176)
- Does not provide a uniform approach to all properties within the study area
- The budget has been estimated at approximately $1.0 million +/- 40%
- Reliant on ongoing maintenance and wet weather responses
- Tree removals and vegetation clearance would be required

8. Option 3 - Stabilise Emergency Works and Extend to the Jetty

Option Description

8.1 This option includes stabilisation of the emergency works as they stand today and extending these works as far north as the Jetty within South New Brighton Park (pink line in Figure 10). Stabilisation of the bund with a design life of up to 20 years will allow time for long term planning processes to develop.

Figure 10 Potential Extension of Emergency Bund in Parts of South New Brighton Park (North approximately to the left)

8.2 It is estimated that there are a large number of low lying homes and properties within South New Brighton and Southshore (Table 5). Approximately 21 houses with floor levels estimated below 10.8 m RL are within the area benefited by the potential works. This is 15 houses fewer than Option 1 and 4 more than Option 2.

Table 5 Estimated Number of Benefited Houses and Properties

Level (m Christchurch District Datum)	Number at Risk	
	Estimated Houses with Floor Level at Risk	Estimated Properties at Risk (Land not Houses)*
10.8	21	252
11	109	437

* Based upon estimate average level of the land within a property.

8.3 This option also includes the monitoring and management Estuary edge erosion to varying degrees and the rainfall flooding approach as outlined above. A summary of the option is presented in Table 6.

8.4 The total budget for this option has been estimated at approximately $1.4 million +/- 40%. The confidence in the cost estimates will increase as the design develops.

Table 6 Option 2 Components

Tidal Flooding	▪ Build a new bund through park behind Campground connecting to high ground near jetty ▪ Bund alignments as per South New Brighton Reserves Management Plan and Development Plan ▪ Both bunds finishing similar to Avon temporary stopbanks (topsoil, grass with crusher dust top), minimum level RL11.2 m	▪ Landscape treatment existing only - topsoil, grass and crusher dust top in some areas

	▪ Landscape works to existing bund in saltmarsh area	
Bund Erosion	▪ Monitor and maintain to protect bund ▪ Keep existing reno mattresses ▪ Remove trees as required ▪ Move path in future if required ▪ Pilot planting areas in existing beach formation areas	▪ Monitor and maintain to protect bund ▪ Geotextile and rock on bund at road ends ▪ Additional planting in areas where berm between bank and bund is narrow
Rainfall Flooding	▪ Stop logs to allow drain down ▪ Construct new manholes where existing sumps/manholes aren't suitable for temporary pumping ▪ Formalise temporary pump locations	▪ Stop logs to allow drain down ▪ Formalise temporary pump locations ▪ Swale in Residential Red Zone draining to road ends

Significance

8.5 The level of significance of this option is medium and is consistent with section 2 of this report.

8.6 This option would leave a section of the community exposed between areas of tidal flooding works. Consultation with the community might be required to inform resource consent applications for these works.

Impact on Mana Whenua

8.7 The Impacts on Mana Whenua associated with Option 1 apply to this option.

Community Views and Preferences

8.8 A large proportion of the local community are specifically affected by this option as illustrated above in Table 1. Their views have been expressed through their local residents association and within the petition received by Council. Reducing the extent to less than Option 1 may cause some concern amongst residents who are not offered the same level of service.

Alignment with Council Plans and Policies

8.9 The commentary associated with Option 1 applies to this option.

Financial Implications

8.10 Cost of Implementation – The construction cost for this option has been estimated at $1.1 million. A budgetary provision of $1.4 million +/- 40% which provides for project contingency, design costs and project management / support costs. Costs for contaminated land, access to and restoration of private land, groundwater seepage and ground improvement is not provided for within the budget. Costs will be re-estimated at the completion of detailed design.

8.11 The other commentary on financial implications associated with Option 1 applies to this option.

Legal Implications

8.12 The legal implications associated with Option 1 apply to this option.

Risks and Mitigations

8.13 The risks associated with Option 1 apply to this option.

Implementation

8.14 Implementation dependencies - There are no dependencies with starting the design and consenting work. Resource consents would be required prior to starting physical works.

8.15 Implementation timeframe – Delivery of the project would be dependent on the determination of the resource consent level of notification. It is expected that the project could be completed this financial year. The construction period for this option would be less than Options 1 and greater than Option 2.

Option Summary - Advantages and Disadvantages

8.16 The advantages of this option include:

- Able to be delivered in the short term
- Is adaptive as it can easily be modified in the future
- Consistency with the Council resolution of 3 August (CNCL/2017/00176)
- Reduces the risk of tidal flooding in extreme events to up to an estimated 252 properties and 21 homes
- Consistency with the South New Brighton Reserves Management Plan and Development Plan
- Lower costs than the Option 1

8.17 The disadvantages of this option include:

- Does not provide a uniform approach to all properties within the study area
- The budget has been estimated at approximately $1.4 million +/- 40%
- Reliant on ongoing maintenance and wet weather responses
- Tree removals and vegetation clearance would be required
- Risk of limiting future decisions on floodplain management or necessitating ongoing maintenance from Council beyond the original design life

Attachments

No.	Title	Page
A	Southshore Inundation Protection Levee Report Evaluation	
B	Christchurch District Plan Analysis	
C	Southshore Short Term Floodplain Management Options	

Confirmation of Statutory Compliance

Compliance with Statutory Decision-making Requirements (ss 76 - 81 Local Government Act 2002).
(a) This report contains:
(i) sufficient information about all reasonably practicable options identified and assessed in terms of their advantages and disadvantages; and
(ii) adequate consideration of the views and preferences of affected and interested persons bearing in mind any proposed or previous community engagement.
(b) The information reflects the level of significance of the matters covered by the report, as determined in accordance with the Council's significance and engagement policy.

Signatories

Authors	Thomas Parsons - Surface Water Engineer Debbie Hogan - Team Leader City Planning
Approved By	Keith Davison - Manager Land Drainage John Mackie - Head of Three Waters and Waste Richard Osborne - Head of Planning and Strategic Transport Peter Langbein - Finance Business Partner David Adamson - General Manager City Services

A. Southshore Inundation Protection Levee Report Evaluation

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10 August 2017

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Dear Sylvia

Southshore Inundation Protection Levee Report Evaluation

1 Introduction

Aurecon was commissioned by CCC to carry out a review of the following document:

"*Southshore Inundation Protection Levee*" prepared by OCEL in December 2016.

The agreed scope of works was as follows:

- Site walkover to obtain an understanding of the local environment and conditions.
- Review report and comment on assessment methodology, assumptions, and proposed design solutions.
- Provide comment on any geotechnical issues or gaps identified that could affect feasibility. Consultation with OCEL to be considered if data information gaps are identified or where methodology needs clarification.
- Provide recommendations for further investigation or work required to enable the project to proceed.
- Summarise findings on coastal and geotechnical engineering aspects in a brief letter report.
- Review meeting with Council.

We note that the review provides a high level feasibility check and does not include any quantitative analysis or assessment of flood and inundation levels or erosion processes. Comments on the proposed design are also qualitative and need confirmation following further investigation and analysis.

The following information is based on a site walkover carried out on 1 August 2017 and a review of the OECL report referencing specific report sections.

The scope of work and terms and conditions of our engagement are as set out in our proposal letter – Southshore Flood Protection Proposal dated 20 July 2017.

2 Southshore Estuary Shoreline

A walkover of the site on 1 August 2017 confirms the description of the existing shoreline by OCEL as a fair representation of the characteristics of the area. The risk of flooding, although not confirmed by modelling or quantitated in terms of flood elevation levels, in the area is considered realistic. Evidence of erosion is clearly visible and is expected to deteriorate if no action is undertaken.

We agree that the small berm (refer page 3, last paragraph of OCEL report) is considered inadequate to provide long term flood and erosion protection. However, it does provide some flood protection in the interim.

3 Coastal Engineering Comments

3.1 General Comments

We agree with OCEL that Sea Level Rise (SLR) is imminent and should be considered for any long term remedial work proposed to protect Southshore from flood inundation and coastal erosion. The main threat is from coastal inundation during high storm tides, while exposure to waves is considered relatively benign (i.e. no direct exposure to large waves from coastal storms) compared with more exposed areas on the other side of the estuary at Moncks Bay (properties along Main Road) and Redcliffs (properties along and Beachville Road).

OCEL recommends installing a berm to protect Southshore from inundation, which we believe is appropriate to minimise coastal inundation risk for this location.

The report notes that the berm should be *"high enough to accommodate the 100 year SLR projection, currently 1m, with sufficient base width to be able to accommodate an increase in berm height in the light of future updated SLR estimates."* This is considered a sensible approach to ensure flexibility and future proofing in case sea level rise predictions are underestimated.

Three different berm surfaces are proposed in the report, being:

- Rock armour;
- Reno-mattress;
- Sand mattress.

We agree that different options should be considered as the long shoreline has varying levels of exposure to the elements and would require different levels of protection. It also is likely to provide a more aesthetically pleasing overall design.

Figure 1 of the OCEL report provides a concept design for a flood berm, which is considered appropriate for the respective site. We consider that the provided dimensions for storm surge and wave run up, although to be further analysed during detailed design, are of the right order of magnitude.

The proposed vinyl sheet piling is expected to be a feasible option as long as ground conditions do not prevent penetration into the ground. It is expected to minimise the impact of groundwater flows during periods of temporarily elevated sea levels associated high tide or storm surge conditions. The effectiveness depends on geohydrological conditions of the soil.

The current stormwater runoff system at Southshore consists of multiple outlets with duckbill backflow prevention installed. OCEL notes that these *"duckbills have not been particularly effective because of their size and stiffness and the limited head available to drive them"*. OCEL suggests to provide for ponds to collect stormwater runoff and discharge it during periods of low tide.

We agree that the existing duckbills do require driving head to open compared with a simple flap gate, however they are considered more robust and therefore more effective at preventing backflow. It will depend on stormwater runoff design flows and levels if the system is adequate and suitable for the long term when allowing for climate change impacts (i.e. both increased rainfall and sea level rise). Maintenance is still required to ensure that the outlet does not get blocked by beach sand deposits.

It is not fully clear from the report how much space is required for the proposed ponds and how it interacts with the existing stormwater network. Ponds could be a challenge considering the low-lying land and effects associated with predicted sea level rise, such as global groundwater rise and higher outlet conditions. The long term stormwater strategy for Southshore will need to be considered and integrated into design of any inundation protection solution.

The second to last paragraph on page 6 in the report provides dimensions regarding the berm design level. It notes that *"The berm has been set at 1.5m above existing ground level which is approximately 1m above mean high tide level for much of the Estuary shoreline but is less in some places toward the*

north end." We presume that the berm height will be the same for the entire shoreline and will not be set off the existing ground level. To prevent any confusion we recommend that OCEL confirms the proposed berm height to either Lyttelton Vertical Datum 1937 or CCC Drainage Datum.

3.2 Comments on proposed Erosion Protection

The OECL report contains recommendations on three methods to protect the shoreline from ongoing erosion from wave and storm surge protection. Detailed comments on the three methods are presented below.

3.2.1 Rock armour

OCEL proposes *"rock armour of the same type and size as used along the Estuary causeway and the Beachville Road seawall, … but at a lower slope"*. Considering the exposure to waves and currents (expected to be less at Southshore) and reduced slope, we expect a smaller rock size could be considered. This can be analysed during detailed design.

We note that the rock grading at Beachville Road is well graded, while for absorption of wave energy and minimising wave run up a uniformly graded rock is preferable. We recommend considering a more uniform rock grading.

3.2.2 Reno mattress

We do have reservations regarding the use of Reno-mattresses in the coastal environment due to the risk of damage from floating objects and/or corrosion. Figure 1 below shows damaged Reno-mattress observed during our walk-over. It is unknown to us when this was installed. The suitability of Reno mattresses to provide the minimum design life time required for the coastal environment will need to be determined before this option is adopted.

Figure 1 Damaged Reno-mattress

3.2.3 Sand mattress

The third armour option is a sand mattress made from geofabric material. This is a new material and as such there are limited examples on which to assess the long term durability within a New Zealand context. However, the information provided by TenCate suggest that it is a suitable option. Further investigation is recommended to confirm that the proposed material provides the minimum design life time for the coastal protection.

3.3 Proposed Extent of works

Although the total shoreline is approximately 3 km long, we do not believe that protection is required over the entire length. Discussion of potential exceptions are outlined below:

- ***Section from Bridge Street to jetty near Beatty Street:***
  This area is less exposed and somewhat protected by the shallow foreshore and vegetation. Scour protection may not be required and monitoring of this section could be an acceptable alternative.
- ***Section from jetty near Beatty Street and Holiday Park:***
  Protection from flood inundation is required, however a lower level of scour protection could be considered.
- ***Holiday Park to Ebbtide Street:***
  This is a natural low lying inundation area with a boardwalk along the shoreline that is currently being repaired / upgraded. We believe that erosion protection of this area is not required. An existing bund provides flood protection, which may be considered adequate for current climate conditions.
- ***Ebbtide Street:***
  This section currently consists of a concrete wall topped up with rock armour. We understand the rock armour was provided by Council as an interim measure until a more comprehensive flood protection scheme for Southshore was developed. Despite the condition of the concrete wall not being great in places and the rock armour being thin (one layer of rock with areas of geotextile being exposed – refer Figure 2 below), it could be suitable for the near future following some maintenance. The existing height of the berm (about 1.6m above Mean High Water) is expected to be adequate for sea conditions up to 0.5m SLR.

Figure 2 Existing scour protection along Ebbtide Street

The remaining 1.5 km long section between Ebbtide Street and the southern dunes will require protection or controlled management to prevent further erosion of the coastline and to protect from flood inundation. The options presented in the OCEL report could be one way of achieving this.

4 Geotechnical Comments

Our geotechnical comments are presented below:

4.1 Lateral Spread Risk

The Southshore area west of Rocking Horse Road was classified as Red Zone due to extensive lateral spreading during the September 2010 and February 2011 earthquakes with movements of several hundred millimetres in place indicated on crack maps on the NZ Geotechnical Database (NZGD). The berm option proposed by OCEL does not allow for the effects of lateral spreading and/or liquefaction induced settlement following a moderate to major seismic event. We note that constructing the berm close to the shore would locate it in a high hazard area with a significant likelihood of damage in future large earthquakes. For example, the Alpine Fault has a 30% probability of occurrence within the next 50 years and is likely to cause ground damage in excess of recent earthquakes due to its likely duration.

Hence, we recommend that consideration is given to locating the berm as far back from the edge of the Estuary as practicable, say 50m to 100m (i.e. as far from the sea as practicable without encroaching on private property).Possibly the alignment could be adjusted based on the crack patterns mapped on the NZGD with the berm located upslope (east) of the worst of the cracked areas. It may be possible to slightly reduce the berm height if the berm moves eastward as the ground rises slightly to the east.

It should be noted that it may be difficult to locate the berm sufficiently eastward to avoid the areas of potential lateral sliding. It is also possible that while the berm would presently be out of a lateral spread zone, erosion over the next years or decades could create a lateral spread potential. The risk of damage to the berm from future large earthquakes would therefore have to be considered when assessing the economics of the new berm.

We note that the current proposal has stormwater detention ponds on the landward side of the berm. Depending on their depth and the depth of the water table, there could be a lateral spread hazard into

the ponds with the banks of the pond sliding into the pond excavation. There is also the potential for stormwater ponds to increase the lateral spread hazard to houses as lateral spreading due to the pond may be closer to private property than lateral spreading into the Estuary.

Where locating the berm as far back from the currently shoreline is not acceptable and/or resilience is required, consideration should be given to use of lateral spreading and/or liquefaction mitigation measures to minimise the effects of lateral spreading and/or liquefaction induced settlements likely to reduce the effectiveness of proposed embankment solution. The lateral spreading mitigation measures could involve use of a number of different ground improvement techniques some of which can be modified to act as low permeability 'wall' curtains beneath the embankments to negate the need for vinyl sheet piles beneath the embankment.

4.2 Construction Material

The idea of using local soils for the berm has been suggested although construction costs appear to be based on importing AP40mm gravel. The use of local sandy soils would likely be acceptable but flatter slopes may be required to minimise erosion by wind and rain. It may also be possible to zone the fill with say more expensive gravel fill on the seaward side of the berm and lower cost, local sandy soils on the landward side.

4.3 Sheet Piles

The proposed design has vinyl sheet piles to 3m depth. Based on the inferred stratigraphy of sandy and silty soils, and the fact that there was large scale liquefaction in the area during the recent earthquakes, we anticipate that driving, or vibrating in, the sheets would be feasible.

We are unsure of the adequacy of the proposed sheet pile depth and some analyses would be required to confirm that a 3m deep sheet pile in sandy soils would limit water inflows for say 12 hours, or however long the high tide/storm surge would be "operating".

There is a large amount of information from the Southshore area on the NZGD. However, some additional investigations may be required to assess foundation soil permeabilities as part of assessing leakage potential.

5 Summary and Further Considerations

We have reviewed the report and the proposed solution and agree that design concept is sensible to prevent coastal flood inundation and erosion. We found no technical reasons to discount the presented options, but note that there is insufficient technical information to determine if the options will be feasible. Any solution will need to be integrated with a long term stormwater management strategy allowing for climate change impacts. It is likely that with further investigation, this option or similar technical solutions will be possible.

We note that there are some decisions that will need to be made about the design life and level of risk that Council is willing to accept, as this could significantly influence the final form of the design solution.

We believe the following aspects should be considered further during subsequent phases of the project:

- Carry out a detailed wave assessment for the area to enable selection/design of appropriate erosion protection measures and confirmation on design berm height
- Integration of flood protection design with a long term stormwater management strategy for the Southshore area to ensure that any solution is robust and can be adapted as required for effects associated with sea level rise
- Consideration of the optimal location and extent of the berm balancing erosion, flood and geotechnical/seismic risk
- Confirmation of design life for the berm and erosion protection measures

- Refine extent and form of protection required
- Further investigation and analysis to confirm the depth of sheet piles required to sufficiently limit water inflow beneath the berm

Please note that the above bullet points are not an exhaustive list but will assist decision makers with better information.

Yours faithfully

René van Lierop
Senior Civil Engineer

Ian McPherson
Technical Director

B. Christchurch District Plan Analysis

Appendix: Christchurch District Plan provisions relevant to the Southshore estuary edge

Activity	Zones					Overlays								
						Natural Hazard		Ngāi Tahu Sites of Cultural Significance		Indigenous biodiversity	Landscape	Natural Character in the coastal environment		
	Specific Purpose Flat Land Recovery	*Open Space Natural*	*Open Space Coastal**	*Open Space Community Parks*	*Residential Suburban*	*Fixed Minimum Floor Level Overlay within Flood Management Area*	*High Flood Hazard Management Area*	*Ngā Turanga Tupuna (ID44)*	*Ngā Wai Coast (ID78 & ID96)**	*Sites of Ecological Significance (SES/LP/6 & SES/LP14)**	*Outstanding Natural Feature (ONF36.0)**	*Coastal Environment*	*Areas of at least high natural character in the Coastal Environment (HNC33.0, HNC34.0)**	*Natural character in the Coastal Environment*
Maintenance and repair of flood protection and bank erosion protection works	Permitted (Also allows for relocation and removal)	Permitted	Non-complying (not provided for)	Permitted	Non-complying	Permitted - Filling or excavation associated with maintenance of existing flood protection		Where resource consent is required through other overlays or zone provisions additional matters will be considered, including objectives and policies. A Cultural Impact Assessment will be required.		Exempt where works undertaken by Council or ECan in accordance with appropriate Flood and Drainage bylaw	Non-complying (not provided for)	Where resource consent is required through other overlays or zone provisions additional matters will be considered, including objectives and policies.	Non-complying (not provided for)	
						Restricted discretionary - For new works								
Hazard management or mitigation works (includes river control and drainage works) carried out by a local authority under certain legislation	Permitted - If undertaken outside SES, outstanding natural feature and any areas of natural character				Non-complying					n/a				
	Restricted Discretionary if involves areas listed above									n/a				
New buildings/structures (includes new flood protection/mitigation)	n/a			Controlled	Non-complying		Permitted - For replacement or repair of buildings			n/a				
							Non-complying for new buildings							
Indigenous vegetation clearance	n/a		Restricted discretionary	n/a	n/a	n/a	n/a			Non-complying	n/a		n/a	

Assumptions:

1. Any works undertaken of substantial nature involving bunds or stop banks will be considered to be a building for the purposes of the District Plan i.e. will exceed the exemption of less than $6m^2$ in area and less than 1.8m in height.
2. Exemption for earthworks associated with the maintenance, upgrade or construction of hazard mitigation and protection works undertaken by the Council, the Canterbury Regional Council and the Crown will apply.
3. Parts of the Open Space Coastal Zone, SES/LP/14, HNC34.0 and ONF36.0 (noted with * in the table) are below mean high water springs. Consents will not be triggered under the Christchurch District Plan in those parts beyond the jurisdictional responsibilities of the CCC.

CH2M Beca

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Report

Southshore Short Term Floodplain Management Options

Prepared for Christchurch City Council

Prepared by CH2M Beca Ltd

11 August 2017

C. Southshore Short Term Floodplain Management Options

Revision History

Revision N°	Prepared By	Description	Date
A	**Kate Purton / Marcus Gibson**	Draft for Client Review	7/8/2017
1	**Kate Purton / Marcus Gibson**	Final	11/8/2017

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Kate Purton / Marcus Gibson**		11/8/2017
Reviewed by	**Graham Levy**		11/8/2017
Approved by	**Graham Levy**		11/8/2017
on behalf of	CH2M Beca Ltd		

Executive Summary

The Southshore Short Term Floodplain Management Options study assesses concept level options for flood risk reduction along the Southshore Spit estuary coastline south of Bridge Street. The assessment has considered options that can be implemented over various time-frames and of various durability. This study was initiated in response to a resolution of the Council meeting of 20 June 2017 (CAPL/2017/00022).

An existing landscaping soil bund and Council bunds are present along sections of the Estuary edge. On the afternoon of 21 July 2017 an extreme event in the Estuary, led to extensive flooding of roads and private properties in Southshore. Additional bunds were formed to fill critical gaps within the existing bund network to reduce tidal flooding.

The study area is split into two sections at the existing rock armouring along Ebbtide Street, being; the Northern Area that largely comprises the South New Brighton Park and the Jellico Salt Marsh along the Estuary edge with residential property set back behind, and the Southern Area of residential land along the spit (including the Residential Red Zone) to the south up to the Estuary edge.

Options considered the mitigation of effects associated with:

- Estuary tidal flooding. This includes construction of a bund to reduce flood risk to residential property associated with extreme water levels within the Estuary.
- Rainfall flooding. When the water level in the Estuary is normal or low, the existing stormwater system can discharge to the Estuary via the primary piped system and (if there is no bund) secondary overland flow. With a bund in place between the land and the Estuary, this blocks the overflow points which could make flooding worse. Options developed are to provide a level of service for rainfall flooding that is no less than what was provided prior to the emergency works.
- Erosion of the Estuary edge. Options have been considered to protect strategic Council assets and infrastructure from Estuary edge erosion, with a primary focus on protecting the bund. Measures considered include monitoring and maintenance, hard engineering solutions such as localised treatment with walls or rock armouring, and soft engineered solutions with landscaping to reduce the rate of Estuary edge erosion and to buffer wave energy against the bund. Re-grading and naturalisation of the Estuary edge are also explored at a high level only.

Long term issues and options, including effects of climate change and sea level rise, groundwater change, permanent floodplain management works and/or land use changes, are not part of this study, and would be addressed through more comprehensive Regeneration studies and long term planning processes.

A long list of options and outcomes was developed, which was consolidated into a short list through a workshop and meetings with Council staff. The short list of options for assessment and development of cost estimates is presented in Table 2 within this report. The short list considered three risk mitigation philosophies, these being broadly described as:

1. Stabilising the emergency works and existing bunds (Option 1)
2. Rebuild of bunds (Option 2)
3. Realignment of bunds (Option 3)

The scope, cost and feasible lifetime of the bunds is lowest for Option 1 and highest for Option 3. In the limited timeframes of this study, feasibility, concept design and cost estimates for Option 3 cannot be reliability assessed without further investigation, and as a result it is has not been possible to carry out a full options comparison. However, advantages, disadvantages and risks have been considered for each of the

options and are described in the report. High level capital cost estimates for Options 1 and 2 have been developed.

This study identified and recommends the options presented in Table A. The estimated combined capital cost of the recommended concept options is $1,610,000.

Table A – Summary of recommended options to be progressed

Item	Northern Area	Southern Area
Tidal Flooding	**Option 1: $1,080,000** ▪ Build new bund through park behind the campground connecting to high ground near jetty ▪ Build new bund behind Seafield Pl ▪ Bund alignments as per South New Brighton Reserves Development Plan ▪ Both bunds finishing similar to Avon temporary stopbanks (topsoil, grass with crusher dust top), minimum level RL11.2 m ▪ Landscape works to existing bund in saltmarsh area	**Option 1: $20,000** ▪ Landscape treatment existing only - topsoil, grass and crusher dust top in some areas
Bund Erosion	**Option 1: $30,000** ▪ Monitor and maintain to protect bund ▪ Keep existing reno mattresses ▪ Remove trees as required ▪ Move path in future if required ▪ Pilot planting areas in existing beach formation areas	**Option 1: $175,000** ▪ Monitor and maintain to protect bund ▪ Geotextile and rock on bund at road ends ▪ Additional planting in areas where berm between bank and bund is narrow
Rainfall Flooding	**Option 2: $90,000** ▪ Stop logs to allow drain down ▪ Construct new manholes where existing sumps/manholes are not suitable for temporary pumping ▪ Formalise temporary pump locations	**Option 2: $215,000** ▪ Stop logs to allow drain down ▪ Formalise temporary pump locations ▪ Swale in Residential Red Zone draining to road ends

Note: Concept cost estimates are for capital works only. Operations and maintenance costs for monitoring and remediation for erosion and temporary pumping costs are not included in estimates. There is a contingency allowance of 25%. On costs are included for Preliminaries and General, environmental management, consenting, professional fees, and CCC direct project-related costs. These high level estimates are intended for options comparison.

It is also recommended that:

- The existing rock armouring at Ebbtide Street is surveyed to confirm the minimum level along its length, and topped up to a minimum of RL 11.2 m.
- Planting of Estuary berm slopes is investigated further.
- Further investigation is carried out into Option 3 Realignment (Tidal Flooding, Erosion and Rainfall Flooding) to determine feasibility, and if feasible develop concept design and cost estimates. This should be carried out in conjunction with regeneration planning for the area and Council's LDRP97 Multi-hazards Analysis project.

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C. Southshore Short Term Floodplain Management Options

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Appendix A
Maps from South New Brighton Reserves Development Plan

Appendix B
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Cost Estimates

1 Introduction

CH2M Beca Ltd (Beca) has been engaged by Christchurch City Council (Council) to investigate short term options for managing flood risk in Southshore and South New Brighton.

The purpose of this study is to identify options for flood risk mitigation that can be implemented immediately, and options that can be maintained for up to 20 years. These options include management of:

- Tidal Flooding
- Rainfall flooding
- Erosion of the Estuary edge.

Long term issues and options, including effects of climate change and sea level rise, permanent flood mitigation works and/or land use changes, are not part of this study.

2 Project Location

The project area is from Bridge Street south to the bottom of the spit as shown in Figure 1.

Figure 1 - Project area

3 Background

Christchurch City Council has commissioned Beca to assess immediate and short term options in response to a resolution of the Council meeting of 20 June 2017, item 5.2.22, (emphasis added):

> *"Direct the Chief Executive to report back to Council by 30 August 2017 with an initial evaluation of the feasibility of the OCEL Consultants Ltd's proposal for the Estuary Edge Protection at Southshore, and* ***whether there are any other alternative options for short-term measures to address concerns raised by the community****. The report back from the Chief Executive should include what statutory, planning or consenting mechanisms may be required to allow estuary edge protections (of any form) to be legally constructed; and should also include any assessment of the OCEL proposal undertaken by Regenerate Christchurch."*

The peer review of the OCEL report and the statutory/planning/consenting assessment referred to above are not included in the scope of this report and are being carried out by others.

This report has been completed within a limited timeframe to assist Council staff in preparing a report to Council to meet the deadline above.

The flood event of 21/22 July 2017 and the associated emergency works occurred while this study was underway.

4 Project Stages & Report Structure

The project includes two stages.

- Stage 1 – Background information, options identification and short-listing workshop.
- Stage 2 – Develop options, cost estimates, options assessment and reporting.

This report summarises both stages.

Sections 5 to 10 of this report summarise the background information, issues, long list options and outcomes of the options short-listing.

Sections 11 to 13 summarise the concept design of the short-listed options, cost estimates and options assessment.

Recommendations are included in Sections 14.

5 Information Provided

The following information has been provided by Council and relied upon for this study:

- AECOM New Zealand Ltd, *Technical Specification for Southshore Landscaping Bund, Southshore, Christchurch*, prepared for CERA, dated 20 November 2015.

- City Design, Christchurch City Council, *Estuary Eastern Foreshore Erosion*, prepared for Water Services Unit, Christchurch City Council, dated May 1995
- Christchurch City Council, *Waterways, Wetlands and Drainage Guide, Part B: Design*, amended December 2011.
- Christchurch City Council, *South New Brighton Reserves Development Plan - Blighs Garden, Bridge Reserve, South New Brighton Park*, dated April 2014.
- Christchurch City Council, *South New Brighton Reserves Management Plan - Blighs Garden, Bridge Reserve, South New Brighton Park*, dated March 2014.
- Christchurch City Council, 2015 LiDAR data
- Christchurch City Council/GHD Ltd, Construction Drawings, *Temporary Stopbank Management (LDRP507)*, dated April 2017
- GHD Ltd, *Draft Christchurch City Council Temporary Stopbank Management Operation and Maintenance Manual*, dated December 2016
- GHD, *Avon-Heathcote Tidal Barrier Pre-Feasibility Study*, 14/15-185, dated July 2015
- OCEL Consultants NZ Ltd, *Southshore Inundation Protection Levee*, prepared for Southshore Residents Association, dated October 2016.
- SCIRT, *Detailed Design Report NE1 NE2 Southshore South of Beatty St (RD,SW,WS), 11109-DE-GE-RP-0001, Revision 2*, dated 9 September 2014
- SCIRT, *Detailed Design Report Main Road 3 Laning Seawall), 10655-DE-RW-RP-001,* dated 28 February 2013
- SCIRT, *Detailed Design Report PS229 Blake Street New SW Pump Station, 11070-DE-SW-RP-0001, dated 18 December* 2013
- SCIRT, *Detailed Design Report NE3 New Brighton (RD/SW/WS), 11110-DE-GE-RP-0001, d*ated 13 December 2013
- SCIRT, *Detailed Design Report Beachville (SW,RD), 11200-DE-GE-RP-0001*, dated 15 April 2015
- SCIRT, *Northern Seawall Design Report Beachville (SW,RD), 11200-DE-GE-RP-0002*, dated 15 April 2015
- SCIRT, *Eastern Seawall Design Report Beachville (SW,RD), 11200-DE-GE-RP-0003*, dated 15 April 2015
- Tonkin & Taylor, *Coastal Hazard Assessment Report, Stage 2*, prepared for Christchurch City Council, dated July 2015.

6 Other Information Used

The following other information was also used for this study:

- Brown L. J, Weeber J. H., Geology of the Urban Area, Geological Map 1, Scale 1:25,000, Institute of Geological & Nuclear Sciences, 1992.
- Canterbury Geotechnical Database "*LiDAR and Digital Elevation Models", Map Layer CGD0500 - 20 July 2015*, retrieved July 2017 from https://www.nzgd.org.nz
- Canterbury Geotechnical Database "*EQC Liquefaction and Lateral Spreading Observations", Map Layer CGD0300 - 23 July 2012*, retrieved July 2017 from https://www.nzgd.org.nz
- Canterbury Geotechnical Database "*EQC Vertical Ground Movements", Map Layer CGD0600 - 23 July 2012*, retrieved July 2017 from https://www.nzgd.org.nz
- Canterbury Geotechnical Database "*GNS Science Median Water Table Elevations (Version 2)", Map Layer CGD065160 - 9 June 2014*, retrieved July 2017 from https://www.nzgd.org.nz
- Canterbury Geotechnical Database "*Conditional PGA for Liquefaction Assessment", Map Layer CGD05110 - 11 February 2013*, retrieved July 2017 from https://www.nzgd.org.nz
- New Zealand Geotechnical Database geotechnical investigation logs, from https://www.nzgd.org.nz.

- New Zealand Standards, NZS1170.0:2002, Structural design actions, Part 0 – General principles, 2002.
- New Zealand Standards, NZS1170.5:2004, Structural design actions, Part 5 – Earthquake Actions New Zealand, 2004.

7 Existing Environment

7.1 General

The study area includes residential land, Residential Red Zone, parks/reserves (Bridge Reserve and South New Brighton Park), and South New Brighton School. The existing land use is shown in Figure 2.

Figure 2 – Existing land use in study area

C. Southshore Short Term Floodplain Management Options

The existing Estuary edge within the study area comprises (moving from north to south):

- From Bridge Street to Ebbtide Street, through the parks/reserves, a mixture of a natural edge and engineered erosion mitigation (gabions/reno mattresses)
- At Ebbtide Street, rock armouring of the Estuary edge
- From Ebbtide Street to the bottom of the Southshore spit, a mixture of natural edge, old sea walls and informal rock armouring.

Estuary tidal flooding risk mitigation comprises:

- Temporary stopbanks along the Avon River from north of the project area to Bridge Street, at RL 11.2 m. These are being extended as part of the Avon temporary stopbanks project (currently in construction phase) to just south of Bridge Street.
- There are some naturally higher areas in South New Brighton Park that are high enough to provide natural mitigation of tidal flooding.
- At Ebbtide Street, the rock armouring which varies from approximately RL 10.9 m to RL 11.5 m (levels need to be confirmed by survey).
- CERA/LINZ landscaping bund in Residential Red Zone from Godwit Street to south of Tern Street nominally at RL 11.2 m. This had gaps at each of the road ends, but in response to the flooding on 21/22 July 2017 emergency works were undertaken and :
  - The gaps at the road ends have been filled to approximately RL 11.3 m
  - The bund has been extended into South New Brighton Park to tie into high land just south of the camping ground at approximately RL 11.3 m.

The location of the existing bund and Ebbtide St rock armouring is shown in Figure 3. Photos of the emergency works to the bund are included in Figure 4 and Figure 5.

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Southshore Short Term Floodplain Management Options

Figure 3 - Existing bunds

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Figure 4 - Emergency bund at Penguin Street

Figure 5 - Emergency bund at Plover Street.

Figure 6 – Emergency bund through reserve

7.2 Ground Levels and Lie of the Land

Within the study area:

- There are high sand dunes to the east which separate the spit from the sea.
- North of Caspian Street the land west of the dunes generally falls towards the west (i.e. park), with local low areas at the roads.
- The levels within the park/reserve vary, with some areas of higher land towards the park.
- South of Caspian Street the residential land generally falls towards Rocking Horse Road and the side streets, with the Estuary edge and Residential Red Zone land generally slightly higher than Rocking Horse Road.
- At the southern end of spit the Estuary edge rises to dunes around the bottom of the spit.

Ground levels (from LiDAR) are shown in Figure 7.

C. Southshore Short Term Floodplain Management Options

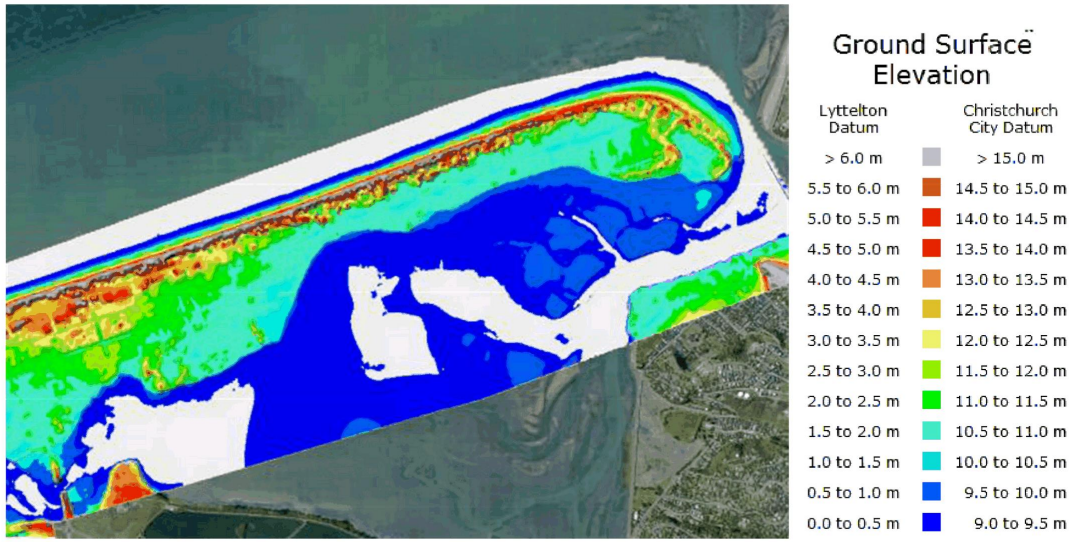

Figure 7 - Ground surface elevation from LiDAR (2012), Source New Zealand Geotechnical Database

C. Southshore Short Term Floodplain Management Options

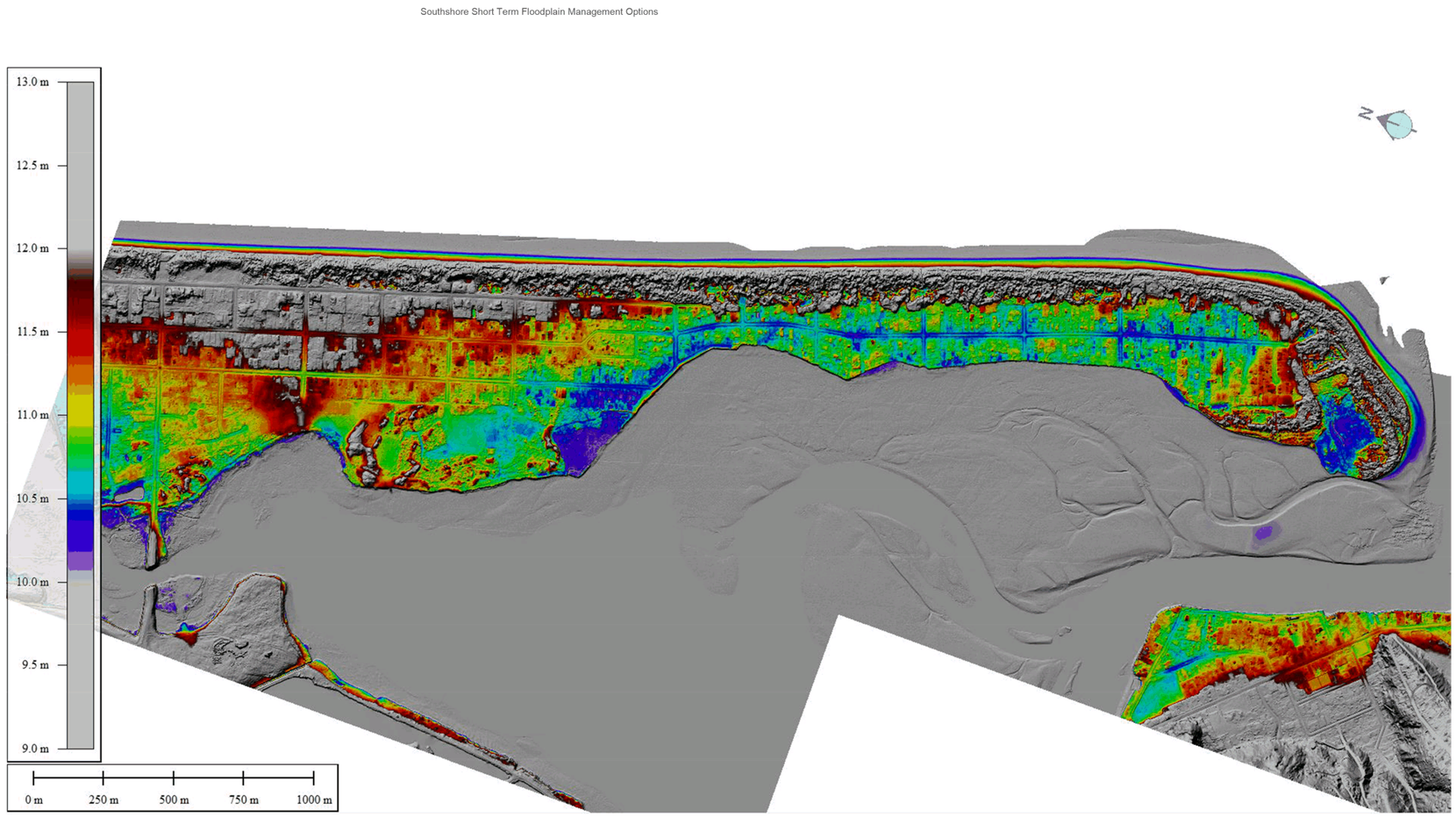

Figure 8 - Detailed ground surface elevations in m RL, from CCC 2015 LiDAR

7.3 Stormwater System

The primary stormwater system is a kerb and channel, sump and pipe system in the roads with number of outfalls to the Estuary. The outfalls have non-return valves (flap gates) to prevent backflow from the Estuary. A photo of an outfall with a "duckbill" style non-return valve is shown in Figure 9

Figure 9 - Stormwater outlet with "duckbill" non-return valve in Southshore.

The secondary stormwater system, which would operate once the capacity of the primary system is reached or when the primary system is unable to discharge, is overland flow along the roads and through the park/reserve, and ponding in the roads and park/reserve, eventually spilling to the Estuary once overflow levels are reached at approximately RL 10.7 m. The extent of ponding with water up to RL 10.7 m is shown in Figure 10.

C. Southshore Short Term Floodplain Management Options

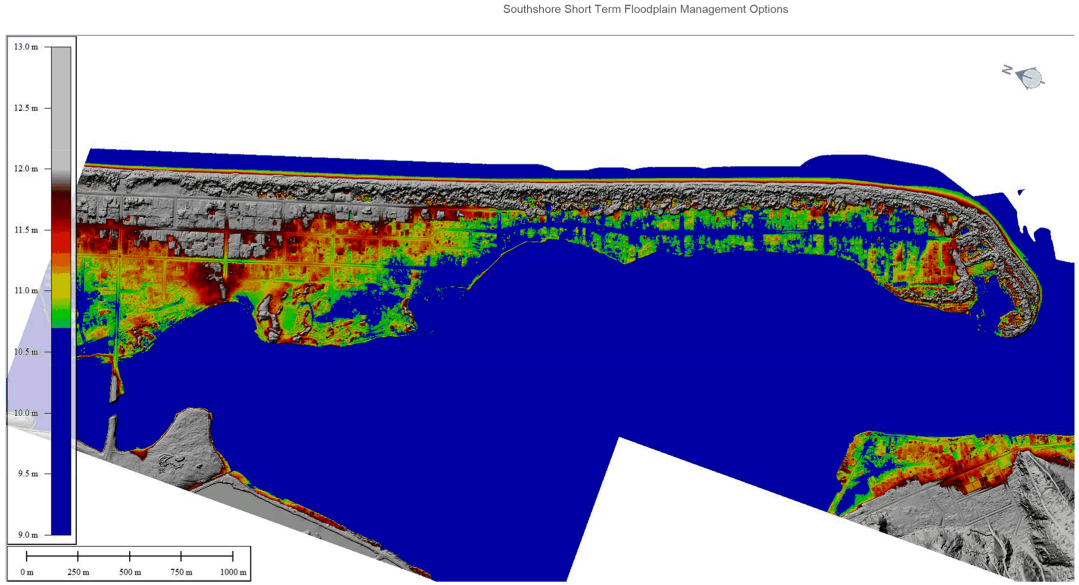

Figure 10 - CCC 2015 LiDAR with water up to RL 10.7 m

7.4 Ground Conditions

Geology within the study area comprises dominantly sand of fixed and semi fixed dunes and beaches (Brown & Weeber, 1992). Fine sands deposited along the estuarine environment of the spit are loose to medium dense and are prone to liquefaction in an earthquake. The fine to medium sands deposited in the active coastal environment on the eastern side of the spit are more typically dense, exhibiting improved resistance to liquefaction and lateral spread.

7.5 Groundwater Conditions

A desktop review has been carried out of publically available groundwater data from the EQC piezometers used for groundwater monitoring post-earthquake. The groundwater is shallow, typically 0.5 m to 1 m below the ground surface, varying with both season and daily tides.

The Riccarton Gravels (first artesian aquifer) is located at approximately 40 m to 50 m depth below ground surface.

7.6 Geotechnical Hazards

7.6.1 Seismic Performance During Recent Earthquakes

The 2010-2011 Canterbury earthquake sequence induced land damage in South New Brighton and Southshore, inducing liquefaction and lateral spread, which was more dominant along the Estuary margins west of Rocking Horse Road.

- **4 September 2010 M_w7.1 Earthquake**: Liquefaction was induced along the Estuary margin, and pockets of lateral spread ground deformation was observed extended back into residential land. The earthquake had an approximate strong ground motion intensity equivalent to an earthquake with an annual probability of exceedance (AEP) of 1/250 (NZS1170.5).
- **22 February 2011 M_w6.2 Earthquake**: The strong ground motion was in the order of 0.56g to 0.61g peak ground acceleration (PGA) (New Zealand Geotechnical Database (NZGD) – conditional PGA). This is approximately equivalent to a 1/1000 earthquake scenario. The February event induced liquefaction across most of the spit, being more prominent along the Estuary margin west of Rocking Horse Road. Lateral spread resulted along the Estuary edge along the Southshore spit extending further inland compared to the February earthquake
- **13 June 2011 M_w6.0 Earthquake**: The earthquakes on the 13 June 2011 resulted in further liquefaction of soils along the Estuary margins. EQC road based surveys of land damage recorded liquefaction along the spit, however obvious lateral spread was not observed (NZGD). However some ground deformation is expected to have occurred along the Estuary edge and within adjacent residential property considering the estimated peak ground accelerations of 0.34-0.42g, equating to a seismic event with an approximate AEP of 1/250.

Earthquakes of the 23 December 2011 and 14 February 2015 both induced strong ground motion at a level marginally above serviceability limit state (SLS) for design of structures. This induced minor surface observation of liquefaction ejecta adjacent to the Estuary, however no lateral spread was observed.

C. Southshore Short Term Floodplain Management Options

Figure 11 provides a summary of land damage during the 4 September 2010 and 22 February 2011 earthquake that clearly shows the relative vulnerability of land within the study area to earthquake ground motion.

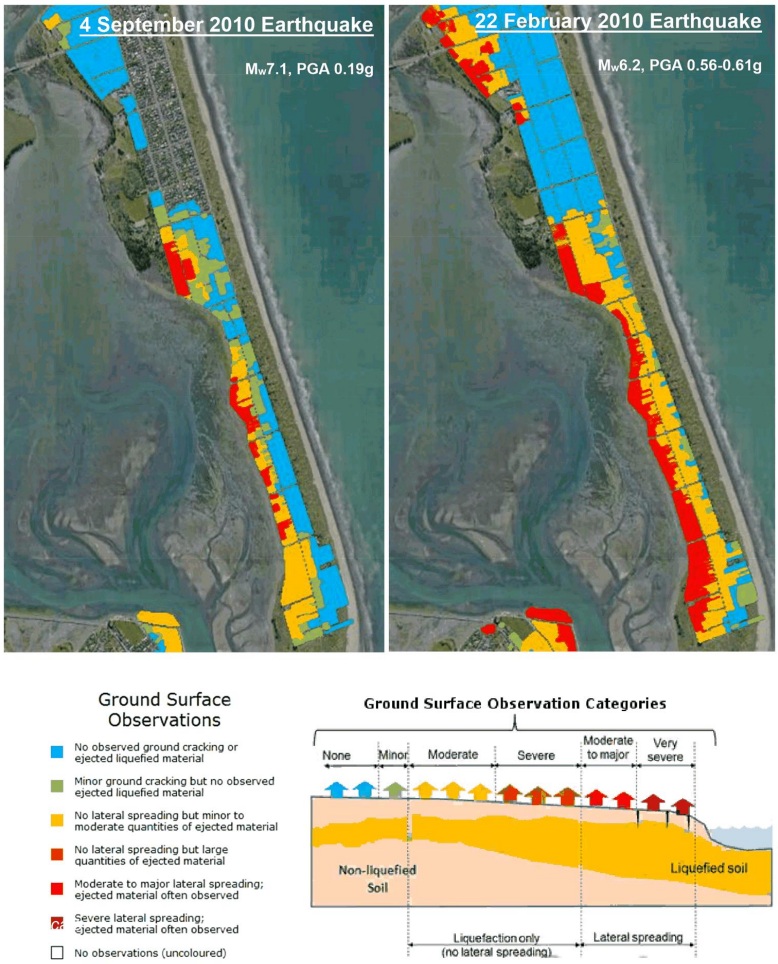

Figure 11 – Liquefaction and lateral spread field observations – 4 September 2010 and 22 February 2011 Earthquake (EQC property observations, source New Zealand Geotechnical Database)

C. Southshore Short Term Floodplain Management Options

7.6.2 Discussion

Recent earthquakes have demonstrated vulnerability of the land to liquefaction triggering and consequential lateral spread, which results in both land settlement and stretch/translation of land adjacent to the Estuary. Engineered structures such as bunds to reduce Estuary tidal flooding risk could experience elevated risk of breach post-earthquake, through settlement of the bund crest and/or loosening or cracking of the embankment leading to possible piping failure. In the event of a significant earthquake inducing damage, bunds would potentially require crest top up and remedial work to reinstate embankment integrity. Bunds are most vulnerable when located adjacent to the Estuary edge. Moving the alignment inland away from the Estuary reduces the severity of possible earthquake induced damage through; providing separation to the Estuary edge reduces the magnitude of lateral spread deformations experienced, and improves resistance of soils to liquefaction when moving east towards the coastal foreshore.

Minor static bund crest settlement can occur, however is anticipated to occur over a short time following construction due to cohesionless sandy soils within the study area.

Groundwater levels will rise with any future sea level rise, reducing depth to groundwater. This will influence future land use and increase the vulnerability of the land to damage during future earthquakes through a reduced thickness of non-liquefiable crust. The effect of changing ground water levels has not been considered for this study due to the short term nature of the solutions.

8 Issues

8.1 Estuary flooding

The existing ground levels along the eastern boundaries of the residential land vary from approximately RL 10.5 m to 11.9 m (from 2015 LiDAR), with no higher land in between in most areas. Estuary levels for extreme events, with current climate, are summarised in Table 1.

Table 1 - Extreme Estuary water levels (Goring, 2011 from CCC WWDG Appendix 1)

Location	MLOS	20% AEP (5 year)	10% AEP (10 year)	2% AEP (50 year)	1% AEP (100 year)	0.5% AEP (200 year)
Bridge St	9.363	10.780	10.829	10.910	10.936	10.958

Note: Levels include tide, storm surge, annual cycle and residual mean level of sea. To adjust for sea level rise add the predicted sea level rise relative to 2011 MLOS.

It can be seen from above that the extreme Estuary water levels are higher than the ground levels at the residential areas.

On the afternoon of 21 July 2017 an extreme event in the Estuary, peaking at RL 10.963 m, led to extensive flooding of roads and private properties and in Southshore. At least one house on Rocking Horse Road was flooded above floor level. Emergency works were carried out to join the existing bunds to reduce the risk of flooding on the next high tide.

If Southshore is to be protected from tidal flooding from the Estuary in extreme events, a bund is required.

8.2 Rainfall flooding

When the water level in the Estuary is normal or low, the existing stormwater system can discharge to the Estuary via the primary piped system and (if there is no bund) secondary overland flow. Once the capacity of the primary system is reached, water will be conveyed via overland flow along the roads and through the park/reserve, and will pond in the roads and park/reserve, eventually spilling out to the Estuary once the lowest overflow points are reached (at Penguin Street and South New Brighton Reserve) at approximately RL 10.7 m.

When a bund is constructed between the land and the Estuary, this blocks the overflow points, preventing secondary overland flow from draining out to the Estuary. Without any stormwater works to offset this loss of secondary flow path, this would increase the flood risk of rainfall related flooding. For this reason, temporary pumps were installed with the emergency bund works.

The existing pipe system would not be affected by bunds (which would be constructed over the top of the existing pipes).

8.3 Erosion

There are number of areas where the Estuary edge is currently eroding. These include:

- Various locations within the park/reserve (including natural edge and behind existing reno mattresses)
- Various locations adjacent to the Residential Red Zone (including behind existing sea walls and rock armouring and the natural edge).

Photos of examples of erosion are included in Figure 12 to Figure 15.

A study into Estuary Eastern Foreshore Erosion along the Southshore spit was completed by Council in 1995 (Walter, 1995). The detailed review of historical knowledge, interpretation of aerial photographs and digital models, has highlighted that the extent and topography of the spit has changed with time. This has been the result of both natural coastal and fluvial process, Christchurch urbanisation, and progressive development on the spit.

Walter (1995) highlights that the introduction of marram grass, that is more efficient in trapping sand to form dunes than native grasses, resulted in accelerated accretion of the coastal dune system and expansion of the spit through the 1920s to 1940s. Furthermore, urbanisation of Christchurch led to large quantities of sediment being washed into the rivers that migrated into the Estuary from the late 1920s. Digital terrain model analysis that was performed for the erosion study indicated that the gently sloping estuary mudflats then experienced a period of erosion through 1962 to 1975, followed by accretion until 1988. Ongoing development of Southshore has further modified the Estuary edge through construction of informal coastal defences and filling, with defences potentially influencing local erosion and accretion of the Estuary edge.

The Estuary appears to be experiencing a period of erosion. LINZ is currently monitoring erosion at two locations along the Residential Red Zone: 100B and 108B Rocking Horse Rd.

Council currently has projects underway (to protect its infrastructure) in the park/reserve at the boardwalk, the carpark and the boat ramp.

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Figure 12 - Erosion in park behind existing reno mattresses

Figure 13 - Erosion behind rock armouring / old wall at Residential Red Zone on Rocking Horse Road

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Figure 14 - Erosion behind old wall at Residential Red Zone on Rocking Horse Road

Figure 15 - Erosion of natural Estuary edge near south end of spit

8.4 Area Specific Issues

In addition to the project wide issues described above there are a number of area specific issues.

The project area can be split into three areas:

- Northern area – north of existing Ebbtide Street rock armouring of Estuary edge
- Ebbtide Street – existing Ebbtide Street rock armouring
- Southern area – south of existing Ebbtide Street rock armouring.

8.4.1 Northern area

The following issues need to be considered north of Ebbtide Street:

- Flooding – residential (roads, private properties and houses) and campground
- Landscape and ecology
- Recreation and paths
- South New Brighton Reserve Development Plan
- The space for erosion
- Tree loss due to erosion
- Existing reno mattresses.

8.4.2 Ebbtide Street

There is an existing rock armouring sea wall along Ebbtide Street. From LiDAR it appears that the average of about RL 11.3 m, but varies from approximately RL 11.5 m to 10.9 m. This wall should be surveyed to confirm the lowest level and topped up if required to a minimum of RL 11.2 m.

8.4.3 Southern area

The following issues need to be considered south of Ebbtide Street:

- Flooding – roads, private properties and houses.
- Longevity of emergency bund
- Landowner access for new bund (privately owned properties in Residential Red Zone)
- Vulnerability of earlier LINZ bund
- Landscaping of emergency bund
- Foreshore erosion and degradation of existing defences
- Tree loss due to erosion.

8.5 Other issues

Other issues which have been raised by residents but are outside the scope of this study include:

- Road maintenance
- Residential Red Zone maintenance
- Access along the Estuary.

Groundwater management is also a potential issue, particularly with future sea level rise, but is outside of the scope of this study due to these being temporary works.

9 Options

9.1 Estuary tidal flooding

As noted in Section 8.1, if the risk of tidal flooding of Southshore from tidal flooding from the Estuary in extreme events is to be reduced, some form of bund is required.

There are a number of options for a bund:

- Bund from site materials, as per the existing LINZ bund
- Engineered bund from imported materials with foundation, as per the bunds being constructed under the Avon temporary stopbanks project north of Bridge Street
- More permanent engineered bund or easily adapted to a permanent (e.g. with additional foundation works or geogrid reinforcement; or potential to add sheet piles later).

The seismic performance and erosion resistance of an engineered bund would be greater than that of a bund constructed from site materials, however the cost would also be higher.

There are also options for the location of a bund:

- At the Estuary edge
- Set back from the Estuary edge within the Residential Red Zone or park/reserve (e.g. similar to the existing LINZ bund)
- Set back further within the Residential Red Zone or park/reserve, close to the residential boundary.

Seismic performance of the land (and therefore of a bund built on the land) improve with distance from the Estuary edge/closer to the residential boundary. Erosion risk also reduces with distance from the Estuary edge.

However closer to the residential boundary increases the risk of aesthetic and privacy issues for adjacent properties. Space is also required between the residential boundary and the bund to provide for drainage of runoff from the adjacent land and from the bund (e.g. a swale along the toe of the bund), A setback for the swale of at least 5 m to adjacent private property is required to reduce potential increase of earthquake induced ground deformations associated with the swale on residential land.

9.2 Rainfall flooding

As noted in Section 7.2, when a bund is constructed between the land and the Estuary, this blocks the overflow points, preventing secondary overland flow from draining out to the Estuary. Without any stormwater works to offset this loss of secondary flow path, this would increase the flood risk of rainfall related flooding.

There are a number of options for mitigating this rainfall flooding:

- No secondary flow stormwater works/do nothing
- Stoplogs in the bund to allow release of water if required
- Storage (e.g. stormwater basins) behind the bund
- Larger gravity pipes under the bunds
- Temporary pumping
- Permanent pump stations.

Stop logs could be built into the bund and opened when the Estuary level was low to drain out surface ponding from the landward side of the bund. This would be a relatively low cost solution, but would require manual intervention.

Creating storage would require excavation on the landward side of the bund. Secondary flow could drain into this storage and then drain out slowly via pipework under the bund when Estuary water level was lower. There is limited space to do this in the Residential Red Zone. The storage would need to be created below the level of the area to be drained but above the groundwater level. Also, excavation of basins close to property boundaries may increase the lateral spread risk to those properties.

Larger gravity pipes under the bund would be costly, have less capacity than the existing overland flow paths and would still only be able to operate when levels in the Estuary were low.

Temporary surface pumps could be used to pump over the bund, and would be able to discharge regardless of the level in the Estuary. However they would have less capacity than the existing overland flow paths. Temporary pumps could be set up in response to forecasts of rainfall events, and an emergency operations plan developed setting out when, where and how they would be used. Careful planning would be required to ensure the pumps were available when required.

Permanent pump stations could also be constructed to pump water over the bund. These would be able to discharge regardless of the level in the Estuary and could be designed to match or exceed the capacity of the existing overland flow paths. They would be a relatively high cost.

9.3 Erosion management

There are a number of options for managing erosion. The Estuary edge has moved over time and will continue to do so. For the purposes of this study it is proposed that the erosion management would be aimed at protecting infrastructure (e.g. bunds, roads and services) rather than the holding the Estuary edge in its existing location.

- No erosion management/do nothing
- Monitor erosion and repair as necessary
- Planting to reduce wave energy and erosion
- Monitor erosion and proactively treat evolving problem areas
- Engineering mitigation over a wider area.

For all approaches the existing erosion needs to be monitored. Targeted repairs could be undertaken either reactively or proactively.

Planting the area between the Estuary edge and the bund (the Estuary berm) would reduce wave energy and therefore erosion, and could also provide for landscape and ecology. This would require selection of appropriate plant species and successful establishment of plants.

Widespread engineering mitigation (e.g. rock revetment along the whole Estuary edge) would be the highest cost option. It would also impact on ecology, landscape and recreation.

Further discussion, with examples of possible conceptual application of erosion management strategy is presented in Appendix D.

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10 Options Short-Listing

An Options Workshop was held on Friday 21 July, attended by Council staff and Beca staff. Some of the Council staff at the workshop were called away to deal with immediate issues of flooding in Southshore. Further discussions and meetings were held with Council staff and Beca staff following the workshop to agree the short-listed options.

The short-listed options are set out in Table 2. These are separated into “northern area” and “southern area” for the areas north and south of Ebbtide Street. It is assumed that the existing rock armouring at Ebbtide Street, which provides erosion mitigation will remain, and the bund be maintained at a minimum level of RL 11.2 m to reduce risk of tidal flooding.

Note that the options in Table 2 can be mixed and matched. For each area there are three options for each of tidal flooding, erosion and rainfall flooding. Some combinations of options would be complimentary to each other.

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Table 2 - Short-listed options

Option	Northern area (north of Ebbtide St)			Southern area (south of Ebbtide St)		
	Tidal Flooding	**Bund Erosion**	**Rainfall Flooding**	**Tidal Flooding**	**Bund Erosion**	**Rainfall Flooding**
Option 1 **Stabilise emergency works**	▪ Build new bund through park behind Campground connecting to high ground near jetty ▪ Build new bund behind Seafield Pl ▪ Bund alignments as per South New Brighton Reserves Development Plan ▪ Both bunds finishing similar to Avon temporary stopbanks (topsoil, grass with crusher dust top), minimum level RL11.2 m ▪ Landscape works to existing bund in saltmarsh area	▪ Monitor and maintain to protect bund ▪ Keep existing reno mattresses ▪ Remove trees as required ▪ Move path in future if required ▪ Pilot planting areas in existing beach formation areas	▪ Stop logs to allow drain down ▪ Construct new manholes where existing sumps/manholes aren't suitable for temporary pumping	▪ Landscape treatment existing only - topsoil, grass and crusher dust top in some areas	▪ Monitor and maintain to protect bund ▪ Geotextile and rock on bund at road ends ▪ Additional planting in areas where berm between bank and bund is narrow	▪ Stop logs to allow drain down ▪ Temporary pumping at existing sumps/manholes
Option 2 **Rebuild**	▪ Build new bund through park behind Campground connecting to high ground near jetty ▪ Build new bund behind Seafield Pl ▪ Bund alignments as per South New Brighton Reserves Development Plan ▪ All bunds Avon temporary stopbanks type (topsoil, grass with crusher dust top), minimum level RL11.2 m ▪ Landscape works to existing bund in saltmarsh area ▪ Landscape all works and include relocation of path within domain	▪ Monitor and maintain to protect bund, paths and trees ▪ Keep existing reno mattresses ▪ Place rock and new reno mattresses as required	▪ Stop logs to allow drain down ▪ Construct new manholes where existing sumps/manholes aren't suitable for temporary pumping ▪ Formalise temporary pump locations	▪ Rebuild bund just behind existing alignment ▪ Avon temporary stopbanks type bund with topsoil, grass with crusher dust top, minimum level RL11.2 m	▪ Monitor and maintain, with proactive localised works as required to protect bund ▪ Geotextile and rock on bund at road ends ▪ Plant large areas of berm between bund and Estuary bank	▪ Stop logs to allow drain down ▪ Formalise temporary pump locations ▪ Swale in Residential Red Zone draining to road ends
Option 3 **Realignment**	▪ Build new bund through park behind Campground connecting to high ground near jetty ▪ Build new bund behind Seafield Pl ▪ Bund alignments as per South New Brighton Reserves Development Plan. ▪ Rebuild saltmarsh section of bund on new alignment in Residential Red Zone ▪ All bunds Avon temporary stopbanks type (topsoil, grass with crusher dust top), minimum level RL11.2 m ▪ Landscape all works and include relocation of path within domain ▪ Open saltmarsh to sea	▪ Remove reno mattresses where there is no infrastructure to protect ▪ Naturalise Estuary edge ▪ Batter existing Estuary bank and extensive planting ▪ Remove existing at risk trees and replant ▪ Move existing path	▪ Permanent pump stations ▪ Network capacity upgrades ▪ Relocate manholes as required	▪ Rebuild bund on new alignment further back in Residential Red Zone ▪ Avon temporary stopbanks type bund with topsoil, grass and wide crusher dust top, minimum level RL11.2 m ▪ Remove road ends beyond bund ▪ Extensive landscape treatment	▪ Naturalise Estuary edge ▪ Remove existing walls / rock armouring ▪ Batter existing Estuary bank and extensive planting	▪ Permanent pump stations ▪ Network capacity upgrades ▪ Relocate manholes as required ▪ Swale in Residential Red Zone draining to road ends

11 Concept Designs

Concept designs have been developed from the short-listed options as follows.

11.1 Tidal Flooding Options

The location of the proposed bund alignments for each option are shown in Appendix B.

11.1.1 Northern area– Tidal Flooding Option 1

- Building new bunds through the park to close existing gaps:
  - Behind camping ground connecting to high ground near jetty, protecting the camping ground and residential land behind it.
  - Behind Seafield Place, protecting Seafield Place and the surrounding low area.
- The bund alignments would be as per the South New Brighton Reserves Development Plan (refer Appendix A).
- Avon temporary stopbanks type bund with topsoil, grass and wide crusher dust top, minimum level RL11.2 m
- Landscape works to existing bund in saltmarsh area, including filling over the haul road to create a naturalised slope and planting.

11.1.2 Northern area– Tidal Flooding Option 2

- Mostly the same as Option 1.
- Plus landscape all works and relocate path within domain.

11.1.3 Northern area – Tidal Flooding Option 3

- Building new bunds as per Option 1 and 2.
- Plus replace the saltmarsh section of the bund on new alignment in the Residential Red Zone, removing the bund through the saltmarsh area so that this can be landscaped and open to the sea.
- Plus landscape all works and relocate path within domain.

11.1.4 Southern area – Tidal Flooding Option 1

- Landscape treatment existing only - topsoil, grass and crusher dust top.

11.1.5 Southern area – Tidal Flooding Option 2

- Rebuild bund immediately behind existing alignment for the entire length. This would allow a more robust bund to be constructed on be approximately same alignment as the existing, but without removing the existing bund during construction. It would also allow the topsoil from the existing bund to be reused.
- Avon temporary stopbanks type bund with topsoil, grass with crusher dust top, minimum level RL11.2 m.

11.1.6 Southern area – Tidal Flooding Option 3

- Rebuild bund on new alignment further back in Residential Red Zone. This would make the bund more robust and reduce the erosion risk.

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- Avon temporary stopbanks type bund with topsoil, grass and wide crusher dust top, minimum level RL11.2 m.
- Remove road ends beyond bund, so that road ends are further from Estuary edge at less risk from erosion.
- Extensive landscape treatment.

11.2 Erosion Options

11.2.1 Northern area – Erosion Option 1

- Monitor erosion and maintain to protect bund.
- Keep existing reno mattresses.
- Remove trees as required (for safety).
- Move path in future if required due to erosion damage.
- Pilot planting areas in existing beach formation areas, to trial plants in this environment.

11.2.1.1 Northern area – Erosion Option 2

- Monitor erosion and maintain to protect bund, paths and trees.
- Keep existing reno mattresses.
- Place rock and new reno mattresses as required.

11.2.2 Northern area – Erosion Option 3

- Remove reno mattresses where there is no significant infrastructure to protect
- Naturalise Estuary edge including
  - Batter existing Estuary bank
  - Extensive planting to stabilise and naturalise
  - Remove existing at risk trees and replant
- Move existing path.

11.2.3 Southern area – Erosion Option 1

- Monitor erosion and maintain as required to protect the bund.
- Geotextile and rock on bund at road ends, to provide additional erosion risk mitigation where the bund is closer to the Estuary edge.
- Additional planting in areas where berm between bank and bund is narrow.

11.2.4 Southern area– Erosion Option 2

- Mostly same as Option 1.
- Plus plant large areas of berm between bund and Estuary edge.

11.2.5 Southern area – Erosion Option 3

- Naturalise Estuary edge including
  - Remove existing walls, armouring and reno mattresses, and dispose of material off-site.
  - Batter existing Estuary bank
  - Plant extensively from the Estuary edge to the bund.

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11.3 Rainfall Flooding Options

11.3.1 Northern area – Rainfall Flooding Option 1

- Install stop logs within the bund, which can be opened when the Estuary level was low to drain out surface ponding from the landward side of the bund.
- Construct new manholes where existing sumps/manholes aren't suitable for temporary pumping. This would provide for suitable sumps/manholes for temporary pumps to draw from, discharging to the Estuary.

11.3.2 Northern area – Rainfall Flooding Option 2

- Install stop logs within the bund, which can be opened when the Estuary level was low to drain out surface ponding from the landward side of the bund.
- Construct new manholes where existing sumps/manholes aren't suitable for temporary pumping. This would provide for suitable sumps/manholes for temporary pumps to draw from, discharging to the Estuary.
- Formalise temporary pump locations, with compacted aggregate set-down areas for pumps.

11.3.3 Northern area – Rainfall Flooding Option 3

- Construct permanent stormwater pump stations, instead of using temporary pumps. There would be a number of pump stations, spread throughout the project area, including at road ends and in the park. These would be below ground reinforced concrete structures housing permanent pumps, with electrical kiosks above ground.
- Carry out pipe network upgrades (inlets and pipes) to covey stormwater to the new permanent pump stations.
- Relocate/construct new manholes as required to fit with new arrangement of stormwater pipe network and pump stations.

11.3.4 Southern area – Rainfall Flooding Option 1

- Install stop logs within the bund, which can be opened when the Estuary level was low to drain out surface ponding from the landward side of the bund.
- Temporary pumping from existing sumps/manholes, over the bund to the Estuary.

11.3.5 Southern area – Rainfall Flooding Option 2

- Install stop logs within the bund, which can be opened when the Estuary level was low to drain out surface ponding from the landward side of the bund.
- Formalise temporary pump locations, with compacted aggregate set-down areas for pumps.
- Swale in Residential Red Zone, on the landward side of the bund to collection the local runoff, draining to the road ends.

11.3.6 Southern area – Rainfall Flooding Option 3

- Construct permanent stormwater pump stations, instead of using temporary pumps. There would be a number of pump stations, spread throughout the project area, including at road ends and in the park. These would be below ground reinforced concrete structures housing permanent pumps, with electrical kiosks above ground.
- Carry out pipe network upgrades (inlets and pipes) to covey stormwater to the new permanent pump stations.

- Relocate/construct new manholes as required to fit with new arrangement of stormwater pipe network and pump stations.
- Swale in Residential Red Zone, on the landward side of the bund to collection the local runoff, draining to the road ends.

12 Cost Estimates

High-level capital cost estimates for Options 1 and 2 have been prepared. These are summarised in Table 3, with a breakdown presented in Appendix E. Due to the limited timeframe, confirmation of feasibility and concept designs for Option 3 (and therefore also cost estimates for Option 3) have not been carried out as part of this study.

Table 3 - Short-listed options

Option	Northern area (north of Ebbtide St)			Southern area (south of Ebbtide St)		
	Tidal Flooding	Bund Erosion	Rainfall Flooding	Tidal Flooding	Bund Erosion	Rainfall Flooding
Option 1 Stabilise emergency works	$1,080,000	$30,000	$70,000	$20,000	$175,000	$55,000
Option 2 Rebuild	$1,535,000	$220,000	$90,000	$1,680,000	$215,000	$215,000

These high level estimates are intended for options comparison. Contingency allowance of 25% is included within the conceptual estimates. Additional cost is included for preliminary and general, environmental management, consenting, professional fees, and CCC direct project-related costs.

Estimates do not include allowance for temporary pumps, or for ongoing erosion maintenance to protect the bunds, as these are an operational cost.

13 Options Assessment

In the limited timeframes of this study, and without the Option 3 feasibility, concept design and cost estimates, it is not possible to carry out a full options comparison. However, advantages, disadvantages and risks have been considered for each of the options and are summarised below.

13.1 Tidal Flooding Options

13.1.1 Northern area

There are gaps in the existing high ground high ground in this area which mean some residential areas and the camping ground are currently at risk of Estuary tidal flooding.

Option 1, building a new Avon temporary stopbanks type bund to close the gaps through the park (behind the camping ground and Seafield Place), would protect this area from Estuary tidal flooding.

Option 2 would reduce risk of inundation of this area from the Estuary. It also provides improved landscaping and relocation of the path within the domain.

Option 3 involves the building new Avon temporary stopbanks type bund to close the same gaps through the park as Options 1 and 2, but also includes replacing the bund through the saltmarsh area with a new bund in the Residential Red Zone. This would improve the seismic and erosion resilience of this section of bund and allow the saltmarsh to be re-planted and opened to the sea. It also includes the same landscaping as Option 2. Option 3 would also be the highest cost of the three options, and would involve further investigation and concept design work.

Tidal flooding Option 1 is recommended for the northern area, provided erosion is also managed. This is on the basis of it being the lowest cost short term option that can be implemented relatively quickly. It achieves the same level of tidal inundation protection as the other options.

13.1.2 Southern area

Option 1, landscaping the existing emergency bund, provides the least disruption and lowest cost option. However the existing LINZ bund (which was built from site material) is more vulnerable to erosion from wave action and settlement than a new engineered bund.

Option 2, construction of a new Avon temporary stopbanks type bund on approximately the same alignment (just behind the emergency bund), would provide a more robust bund (due to its construction), but with a higher cost.

Option 3, building a new Avon temporary stopbanks type bund further back towards the Residential Red Zone boundary, would provide for improved seismic resilience and erosion risk mitigation. Further investigation and concept design would be required for this option. This investigation and design work could be carried out in conjunction with Regeneration planning for the area and Council's LDRP97 Multi-Hazards project.

Tidal flooding Option 1 is recommended for the southern area, provided erosion is also managed. This is on the basis of it having a significantly lower cost, and being a short term option that can be implemented relatively quickly. It achieves a similar level of tidal inundation protection as the other options.

13.2 Erosion Options

13.2.1 Northern area

Option 1, monitor and maintain to protect bund only, is the lowest interference and lowest cost of the three options. It includes keeping the existing reno mattresses, but removing trees and moving the path as required to provide for recreational use of the reserve and includes pilot planting in existing beach areas for natural reduction of erosion risk.

Option 2, monitor and maintain to protect bunds, paths and trees, involves more engineering intervention than Option 1. It involves keeping the existing reno mattresses and adding more reno mattresses and rock as required to protect the paths and trees, as well as the bund. This would involve more disruption and would cost more than Option 1, but may be able to maintain the existing trees and paths.

Option 3, naturalise the Estuary edge, involves removing the existing reno mattresses, battering back the bank to a stable slope and extensive planting from the Estuary edge to the bund. This would require the removal and replanting of trees, and moving the existing path, which is not consistent with the Reserve Development Plan. The planted flatter Estuary berm slopes would dissipate wave energy, reducing erosion.

This would be the highest cost option. There is a risk that the naturalised slope would continue to erode before suitable plants became established.

Further investigation would be required to confirm that Option 3 is feasible, followed by concept design to understand the extent of reserve which would be affected, and cost estimates. This investigation and design work could be carried out in conjunction with Regeneration planning for the area and Council's LDRP97 Multi-Hazards project.

Erosion Option 1 is recommended for the northern area. This is on the basis of it being the lowest cost short term option that can be implemented relatively quickly. It has similar performance and similar monitoring requirements to Option 2.

13.2.2 Southern area

Option 1, monitor and maintain to protect the bund only, is the lowest interference and lowest cost of the three options. It includes placing geotextile and rock on the bund at the road ends (which are close to the Estuary) and local planting in areas where the berm is narrow, to reduce the increased erosion risk due to these locations being closer to the Estuary edge.

Option 2 is as per Option 1, plus increased proactive localised works as required to protect the bund, and planting larger areas of berm between the Estuary edge and the bund. It would provide some improved erosion risk mitigation than Option 1, but with more engineered works and a higher cost.

The existing informal rock armouring and remnant sea walls would stay in place for both Options 1 and 2.

Option 3, naturalise the Estuary edge, involves removing the existing informal rock armouring and remnant sea walls, battering back the bank to a stable slope and extensive planting from the Estuary edge to the bund. The planted flatter Estuary berm slopes would dissipate wave energy, reducing erosion. This would be the highest cost option. There is a risk that the naturalised slope would continue to erode before suitable plants became established.

Further investigation would be required to confirm that Option 3 is feasible, followed by concept design to understand the extent of Residential Red Zone land which would be affected, and cost estimates. This investigation and design work could be carried out in conjunction with Regeneration planning for the area and Council's LDRP97 Multi-Hazards project.

Erosion Option 1 is recommended for the southern area. This is on the basis of it being the lowest cost short term option that can be implemented relatively quickly.

13.3 Rainfall Flooding Options

13.3.1 Northern area

The key driver for the rainfall flooding options is not making the flood risk worse than it was pre-earthquake, once continuous bunds are in place which block the overflow path out to the Estuary.

Option 1, stop logs and temporary pumping, allows for overflow points to be opened when the Estuary water level is low, with temporary pumps to provide discharge even when the Estuary is high. It includes new sumps/manholes where needed to establish accessible locations to pump from. Temporary pumps provide a flexible and low capital cost option (although there are hiring costs). However temporary pumps have limited capacity and need to be set-up and operational at time of the rainfall event.

Option 2 is as per Option 1, but with compacted aggregate set-down areas for pumps, making it easier and tidier to set-up the temporary pumps. This would be a slighter higher cost than Option 1.

Option 3, permanent pump stations and stormwater network upgrades, includes constructing new permanent below ground pump stations and associated new inlets, pipes and manholes to convey stormwater to the pump stations. Permanent pump stations can have much higher capacity than temporary pumps. They are also less visually intrusive than temporary pumps, with only electrical kiosks above ground. Option 3 could include improving the stormwater system performance for the area (i.e. reducing the flood risk from rainfall rather than just making it no worse).

Option 3 would be a much higher cost option than Option 1 and 2. Further investigation and concept design work would be required for Option 3.

Rainfall flooding Option 2 is recommended for the northern area. This is on the basis of it being only slightly more expensive than Option 1, but more robust, and it is a short term option that can be implemented relatively quickly.

13.3.2 Southern area

The key driver for the rainfall flooding options is not making the flood risk worse now with continuous bunds that are in place along the Residential Red Zone which block the overflow paths to the Estuary at the road ends.

Option 1, stop logs and temporary pumping, allows for overflow points to be opened when the Estuary water level is low, with temporary pumps to provide discharge even when the Estuary is high. It includes new sumps/manholes where needed to establish accessible locations to pump from. Temporary pumps provide a flexible and low capital cost option (although there are hiring costs). However temporary pumps have limited capacity and need to be set-up and operational at time of the rainfall event.

Option 2 is as per Option 1, but with compacted aggregate set-down areas for pumps and a swale in the Residential Red Zone on the landward side of the bund. The pump set-down areas would make it easier and tidier to set-up the temporary pumps. The swale behind the bund would collect the local runoff and convey it to the road ends (where it would discharge to the stormwater pipe system). This would be a more effective option than Option 1, but at a slightly higher cost.

Option 3, permanent pump stations and stormwater network upgrades, includes constructing new permanent below ground pump stations and associated new inlets, pipes and manholes to convey stormwater to the pump stations. Permanent pump stations can have much higher capacity than temporary pumps. They are also less visually intrusive than temporary pumps, with only electrical kiosks above ground. Option 3 could include improving the stormwater system performance for the area (i.e. reducing the flood risk from rainfall rather than just making it no worse).

Option 3 would be a much higher cost option than Option 1 and 2. Further investigation and concept design work would be required for Option 3.

Rainfall flooding Option 2 is recommended for the southern area. This is on the basis of it being a cost-effective short term option that can be implemented relatively quickly. The swale also adds value relative to Option 1 as a means of avoiding undrained ponding area due to poor drainage of RRZ land.

C. Southshore Short Term Floodplain Management Options

14 Recommendations

It is recommended that the following options, as described in the previous Sections, are progressed:

- Tidal flooding Option 1 for the northern area
- Tidal flooding Option 1 for the southern area
- Erosion Option 1 for the northern area
- Erosion Option 1 for the southern area
- Rainfall flooding Option 2 for the northern area
- Rainfall flooding Option 2 for the southern area

The concept capital cost estimate for the recommended options is $1,610,000

It is also recommended that

- The existing rock armouring at Ebbtide Street is surveyed to confirm the minimum level along its length, and topped up to a minimum of RL 11.2 m.
- Planting of Estuary berm slopes is investigated further.
- Further investigation is carried out into Option 3 Realignment (Tidal Flooding, Erosion and Rainfall Flooding) to determine feasibility, and if feasible develop concept design and cost estimates. This should be carried out in conjunction with Regeneration planning for the area and Council's LDRP97 Multi-hazards assessment.

Appendix A

Maps from South New Brighton Reserves Development Plan

C. Southshore Short Term Floodplain Management Options

Figure 3 Bridge Reserve Concept Plan

C. Southshore Short Term Floodplain Management Options

Figure 4 South New Brighton Park Concept Plan

C. Southshore Short Term Floodplain Management Options

Appendix B

Options Bund Alignment Plans

C. Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options

Figure B1 - Bund alignment Option 1

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C. Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options

Figure 16 - Bund alignment Option 2

C. Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options

Figure 17 - Bund alignment Option 3

CH2M Beca

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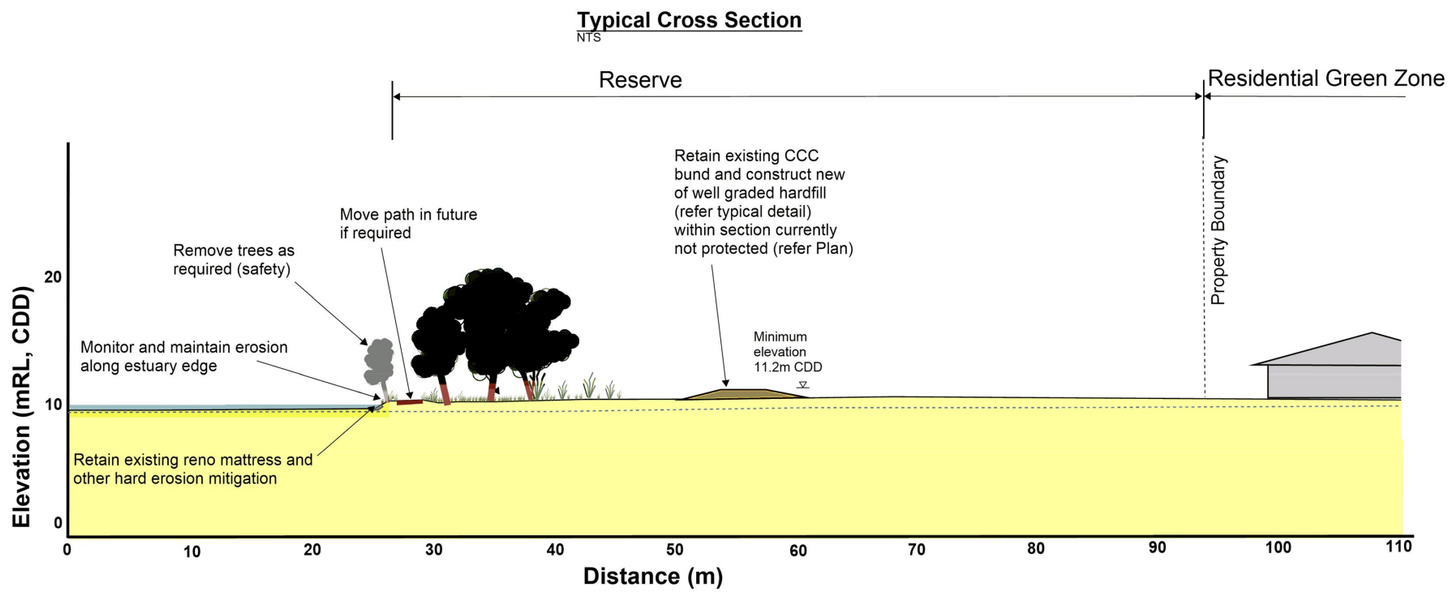
Appendix C

Options Concept Design Diagrams

Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options – North – Option 1: Stabilise Emergency Works

Typical Cross Section
NTS



Typical Alignment Plan
NTS

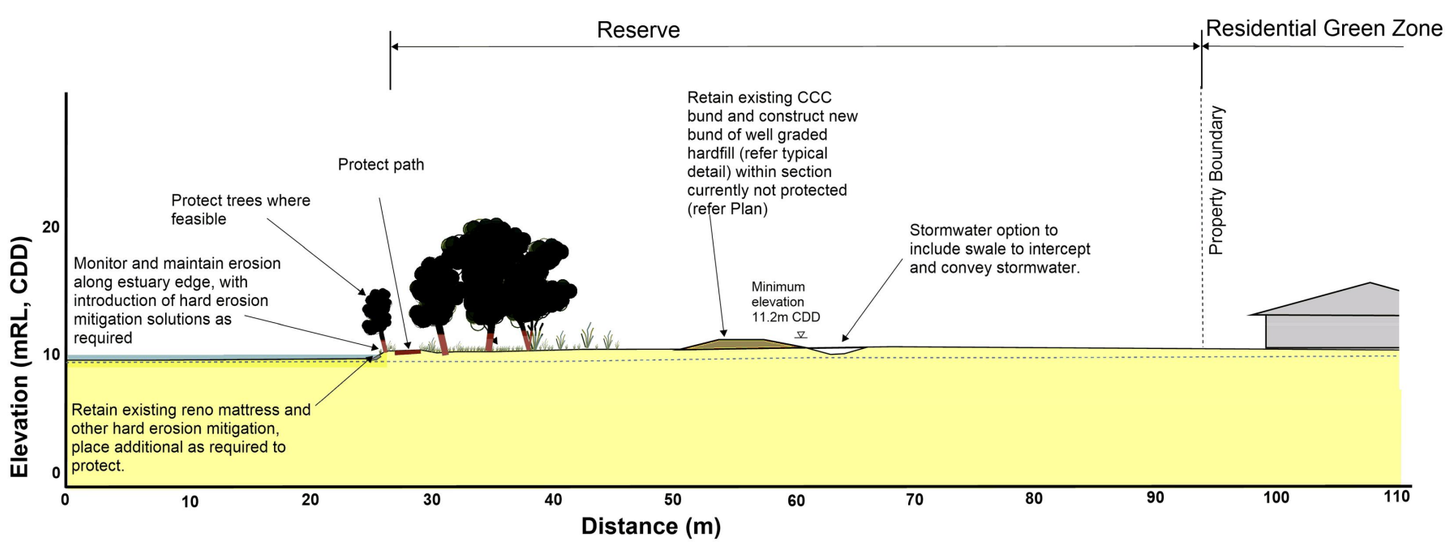
Bund Alignments as per South New Brigthon Reserves Development Plan

6514422, MFG, 7/8/2017

Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options – North – Option 2: Rebuild

Typical Cross Section
NTS



Typical Alignment Plan
NTS

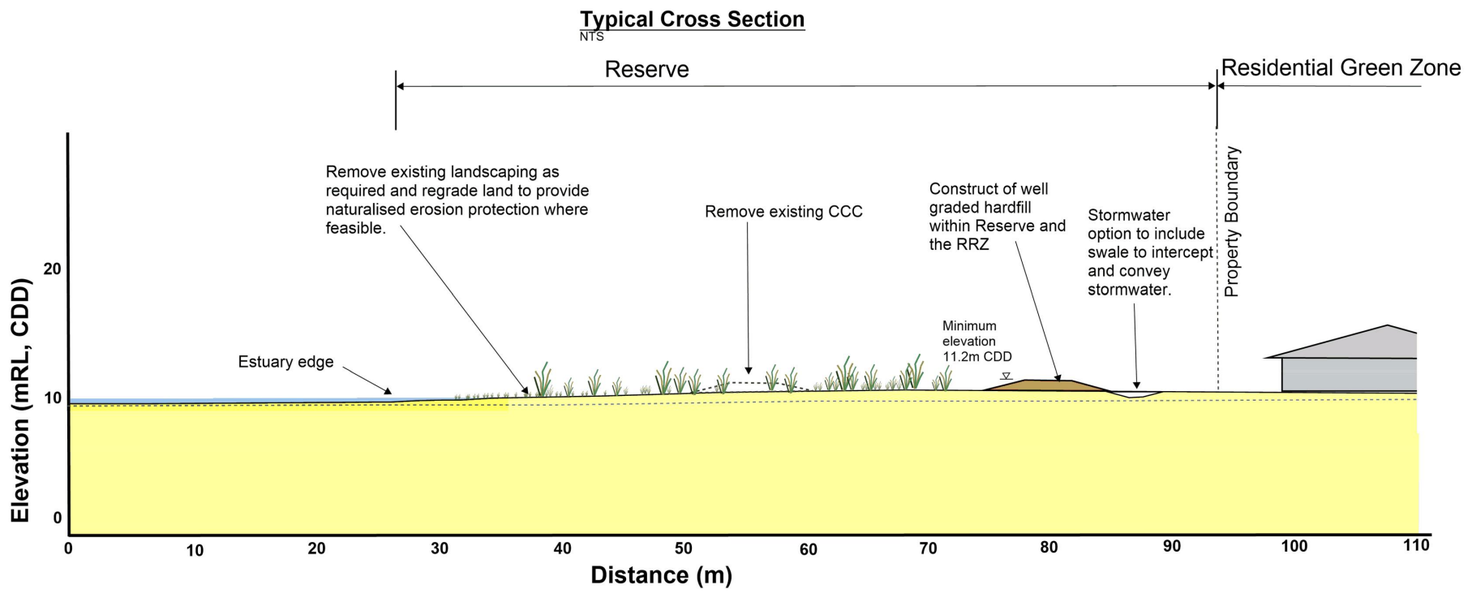
Bund Alignments as per South New Brigthon Reserves Development Plan

6514422, MFG, 7/8/2017

Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options – North – Option 3: Realignment

Typical Cross Section
NTS



Typical Alignment Plan
NTS

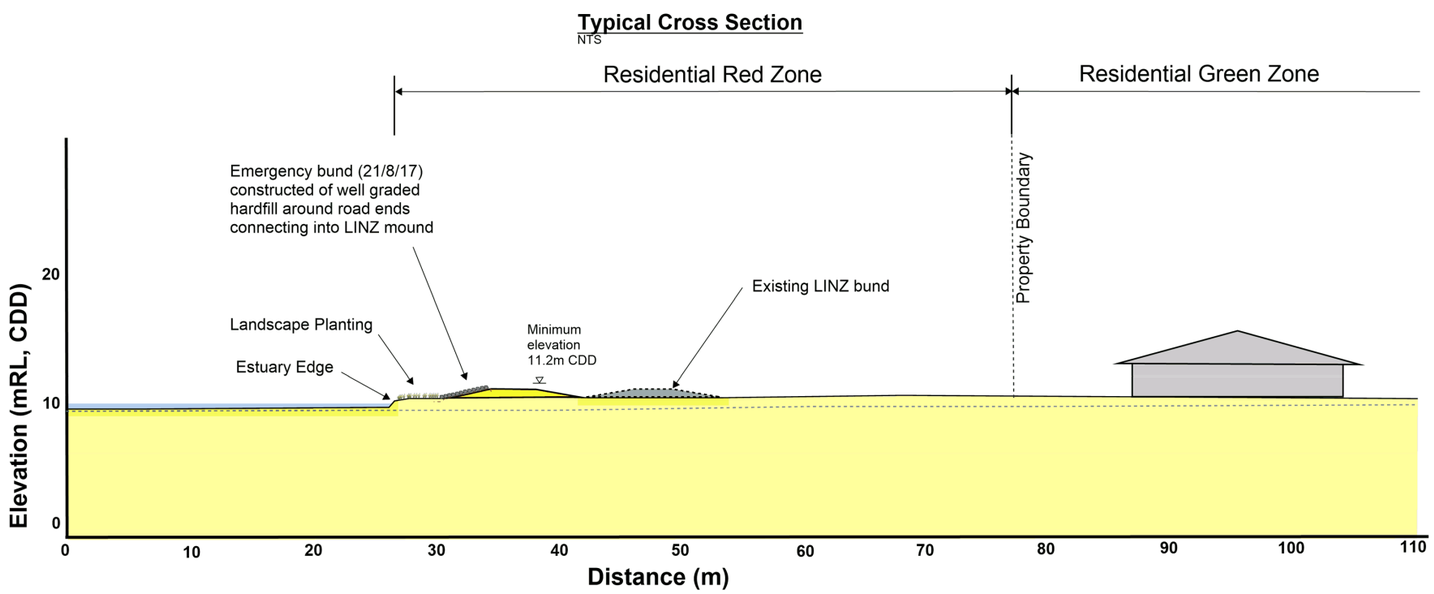
Bund Alignments as per South New Brigthon Reserves Development Plan

6514422, MFG, 4/8/2017

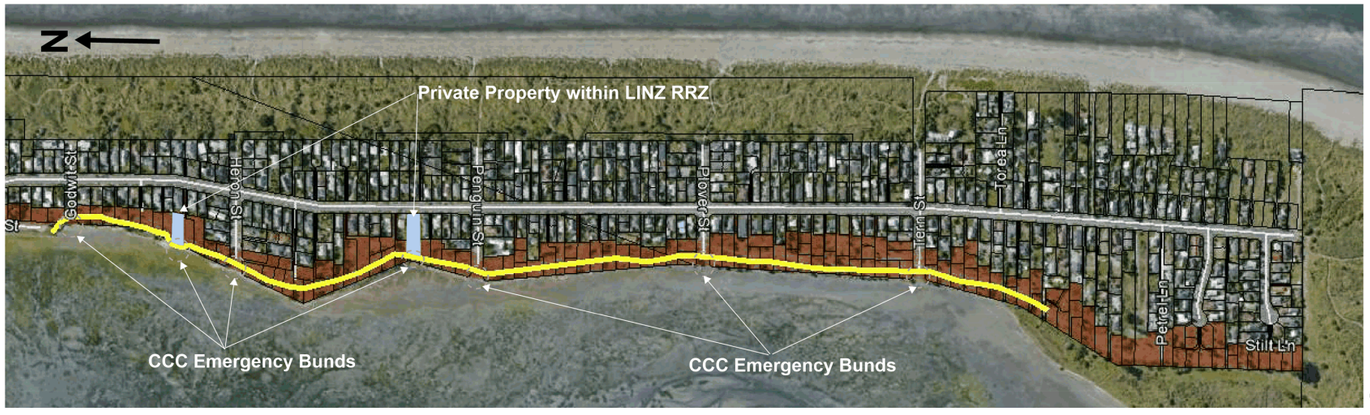
Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options – South – Option 1: Stabilise Emergency Works

Typical Cross Section
NTS



Typical Alignment Plan
NTS

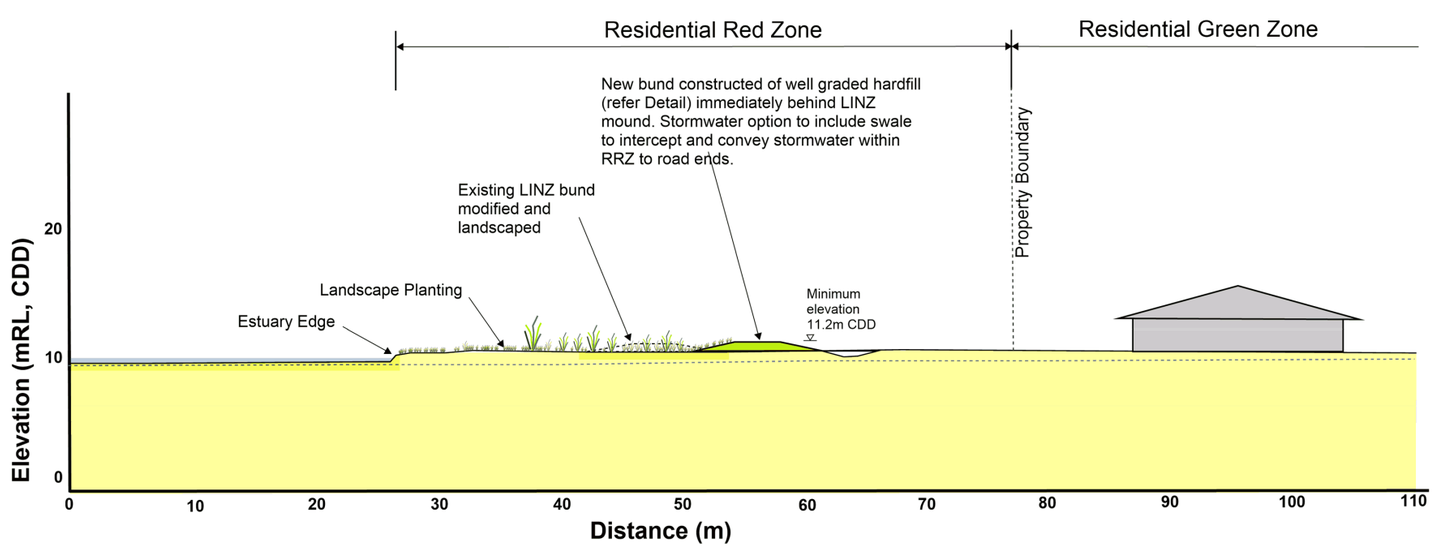


6514422, MFG, 7/8/2017

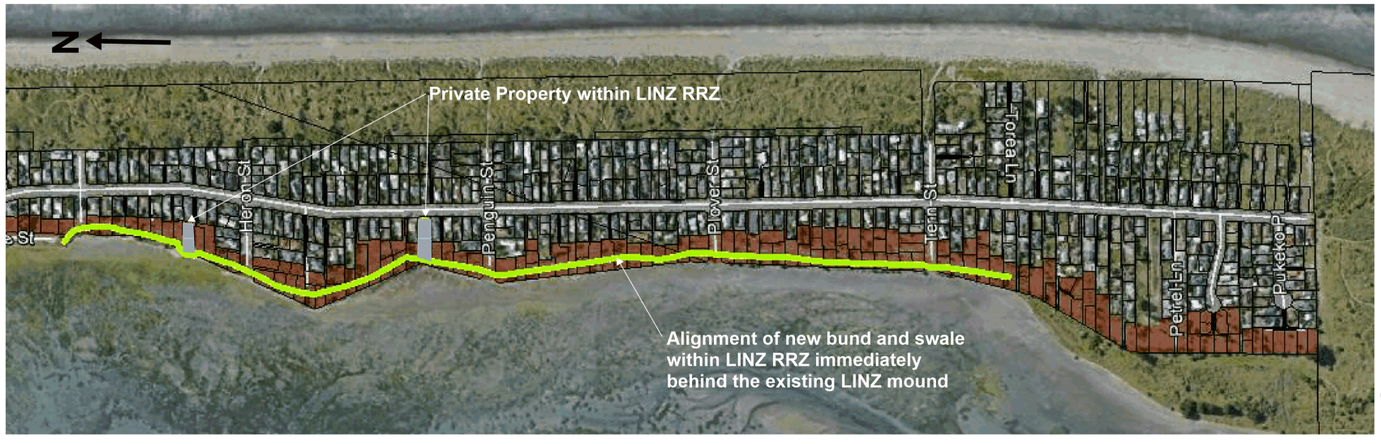
Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options – South – Option 2: Rebuild

Typical Cross Section
NTS



Typical Alignment Plan
NTS

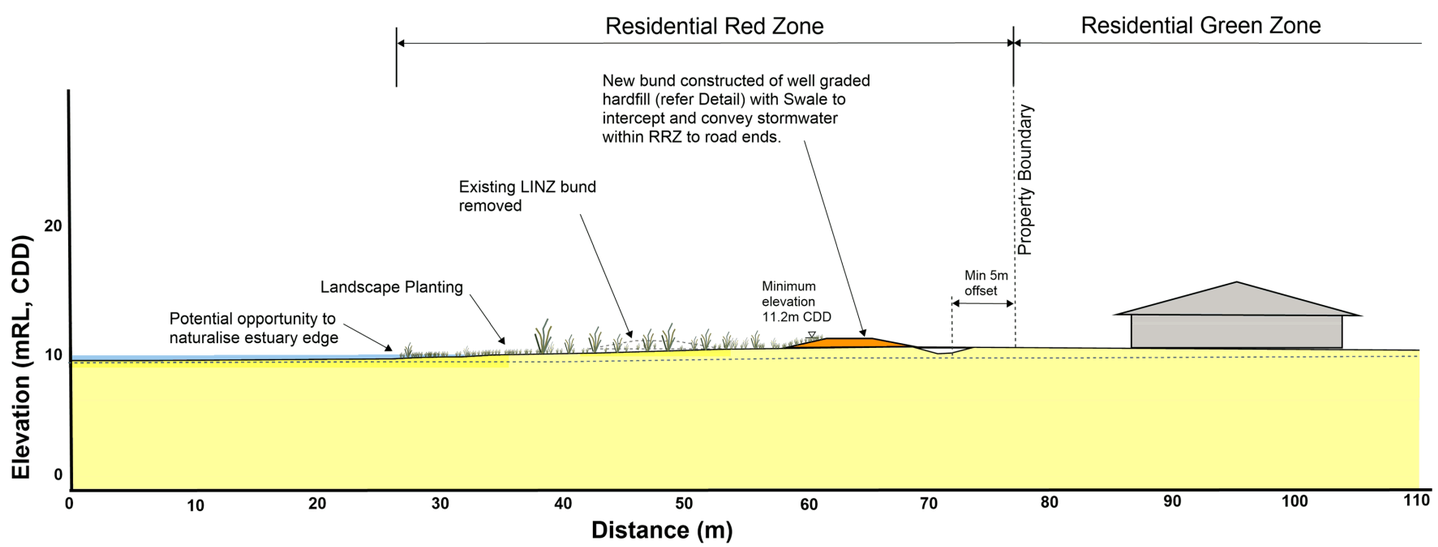


6514422, MFG, 7/8/2017

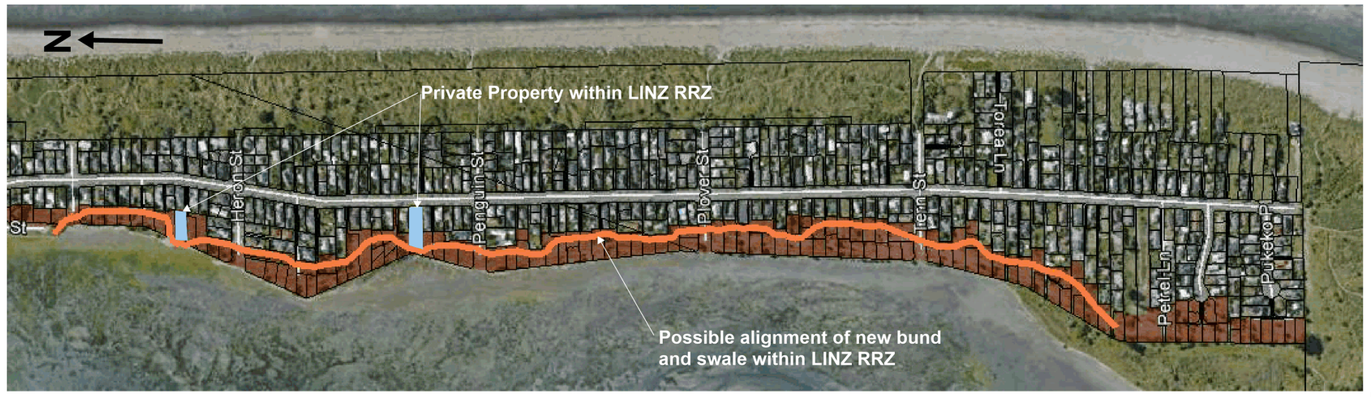
Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options – South – Option 3: Realignment

Typical Cross Section
NTS



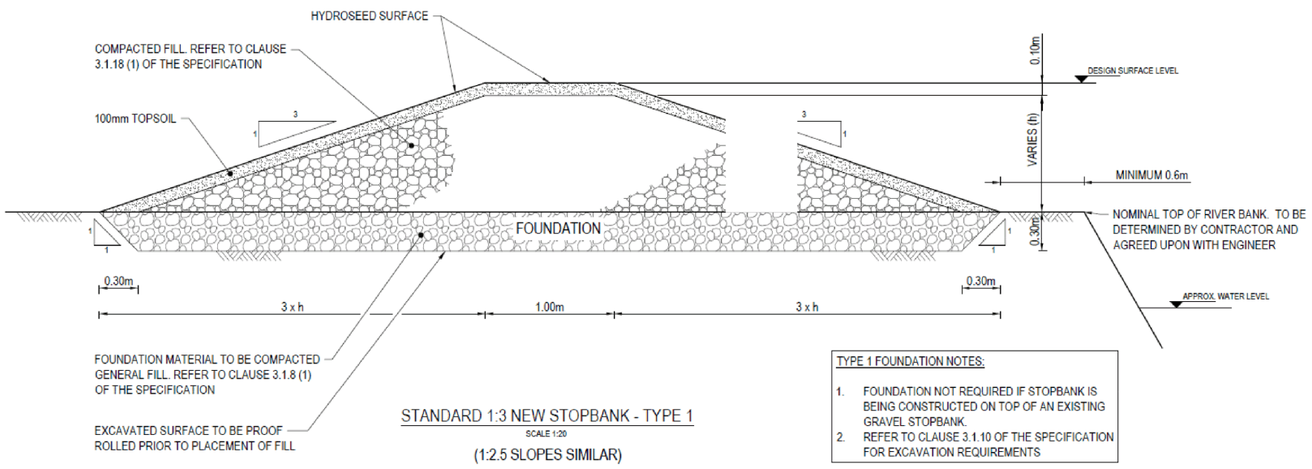
Typical Alignment Plan
NTS



6514422, MFG, 7/8/2017

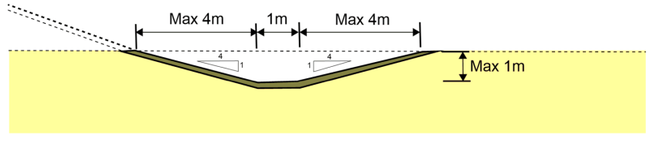
Southshore Short Term Floodplain Management Options

Typical New Bund Construction Detail
NTS



Detail sourced for the Avon River Temporary Stopbank Project (GHD) DWG C501, Issue 0 For Construction

Swale behind bund in Stormwater Options 2 and 3, Typical Swale Construction Detail
NTS



6514422, MFG, 7/8/2017

Appendix D

Erosion Management

Erosion Management Concepts

This section describes generic erosion management concepts applicable to the South New Brighton and Southshore Estuary edge which include; do nothing and monitor, removal and relocation, maintenance and repair and soft and hard techniques.

Do nothing and monitor

'Do nothing' involves no physical alterations to the shoreline to reduce coastal erosion. If there are locations along the Estuary edge that do not exhibit any significant signs of erosion and/or the upland value does not warrant any intrusive action to be carried out, doing nothing may be the best solution.

In addition to doing nothing, it may be considered to implement a coastline monitoring system to provide details for development of future management options (if required).

Removal and relocation

It may be considered to remove a structure and/or vegetation if it is redundant or facilitating coastal erosion. For example, at several locations between Bridge Street and the southern end of spit reserve, there are seawalls that are no longer affording mitigation of erosion risk along the Estuary edge. It should be considered to remove these structures as they no longer serve a purpose.

Additionally, as sea level rise will continue to move the shoreline landward, it may also be considered to relocate structures that are in close proximity to the shoreline.

Maintenance and repair of existing structures

There are locations along the Estuary edge that have been armoured with informal rock armouring, gabions and seawalls. It is believed that some of these structures may not have been designed and constructed using a formal design code and as a result have endured significant levels of deterioration. Repairing and upgrading these assets by taking a formal approach is a possible solution to reduce risk of erosion. This method may require the removal and replacement of some existing structures/vegetation where sufficient deterioration has been observed.

Soft techniques

Re-grade and plant

In a low energy environment vegetation can be used to reduce shoreline erosion by planting in the intertidal and supratidal substrate. The roots from plants bind soils to form a barrier against erosion. This strategy is typically limited to locations with shorter fetch. In areas with larger fetch the implementation of a marsh fringe may require sand fill and/or a stone sill to attenuate wave action (Figure 18). Additionally, this technique may also require the supratidal substrate to be re-graded to provide a suitable location for planting.

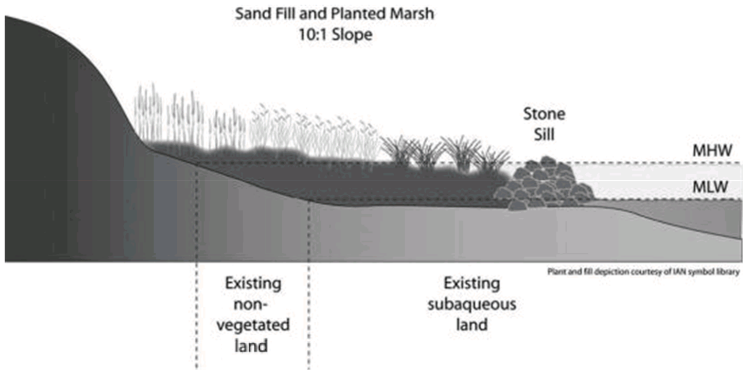


Figure 18 - Typical cross section of a marsh sill with sand fill and tidal planted marsh vegetation.

As the Estuary edge is a low energy environment planting and regrading is a viable solution to coastal erosion. In locations where there is no existing coastal defence system in place this approach could be implemented.

Beach nourishment

Beach nourishment involves the placement of sediment nearshore to advance the shoreline seaward (Figure 19). In a storm event, the sediment acts as a 'buffer' to protect the land behind from erosion. Beach nourishment can be used in combination with other coastal erosion concepts, such as re-grading and planting, groyne systems and revetments.

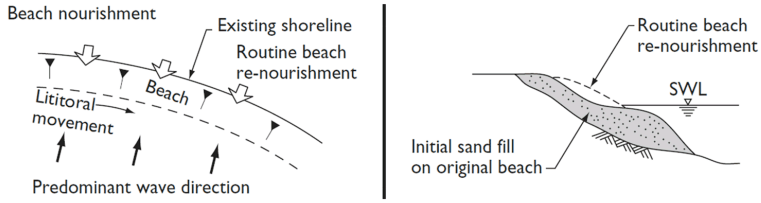


Figure 19 – Typical plan view and cross section illustrating beach nourishment.

The economic viability of beach nourishment depends on a range of factors including: the value of the land that is to be protected, the background erosion rate and the availability of low cost quality sediment. Generally, beaches that are most suited to beach nourishment have substantial upland value and the background erosion rate is low.

As the background erosion rate is predicted to be low along the South New Brighton and Southshore Estuary edge beach nourishment could be a viable solution to reduce coastal erosion.

Hard techniques

Groynes

Groynes are structures used to influence the nearshore sediment transport process. The purpose of a groyne is to retain the volume of beach material by reducing the longshore drift. Groynes typically extend perpendicular to the shoreline and are made from stone, concrete or timber as shown in Figure 20.

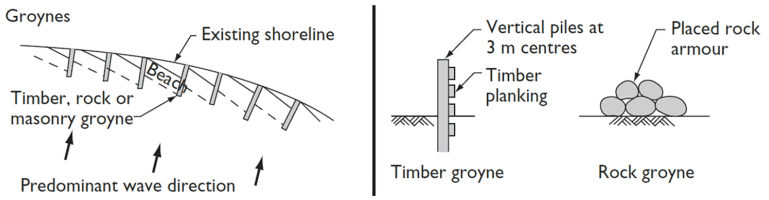


Figure 20 – Typical plan view and cross section illustrating a pile and rock armour groyne system.

For a groyne to be viable the beach site must have high longshore transport rates and the downstream affects must be known.

Due to the unpredictable nature of a groyne system and the low longshore transport rates along the South New Brighton and Southshore Estuary edge this concept is not considered to be a preferred solution.

Rubble mound breakwaters

A rubble mound breakwater serves the purpose of dissipating wave energy. Rubble mound breakwaters are typically constructed from rip rap and comprise of an armour layer and a core and a geotextile layer. Depending on the environment a rubble mound breakwater can include several different layers. These structures are suited to both high and low energy environments and locations subject to a constant wave climate i.e not storm dominated.

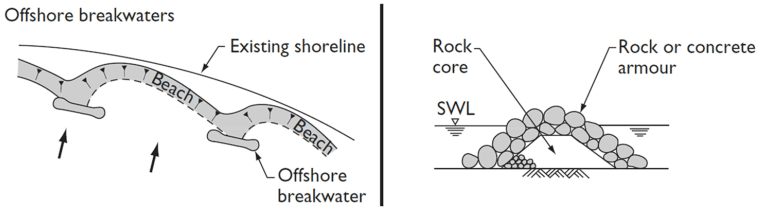


Figure 21 – Typical plan view and cross section illustrating a detached breakwater system.

A detached breakwater (salient) in conjunction with sand replenishment may be useful in providing an added buffer against wave attack in critical areas along the Estuary Edge.

Revetment/seawall

A revetment/seawall is a structure that is usually placed along the shoreline to protect the land behind from erosion and waves. These structures are generally suitable for areas subject to high energy waves and sites with existing hard shoreline structures. A typical cross section of a riprap revetment is shown in Figure 22.

C. Southshore Short Term Floodplain Management Options

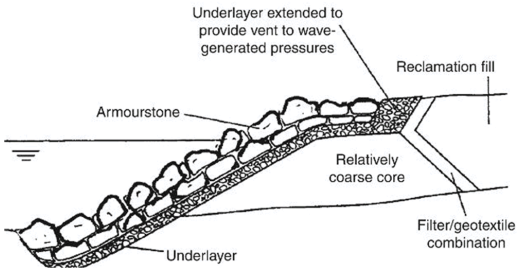


Figure 22 – Typical cross section illustrating a riprap revetment system.

As a revetment/seawall is a robust solution, it is considered appropriate for high value land and critical infrastructure under immediate threat. In locations where there is already existing revetments/seawalls maintenance and repair maybe considered.

Conceptual Erosion Management Application

This section highlights the most applicable erosion management concepts for three different circumstances (discussed below) at different locations along the South New Brighton and Southshore Estuary edge based on a desktop inspection. The preferred approach would be to adopt a risk based erosion management plan to provide a complete picture of the mitigation works required.

It must be noted that the erosion management concepts discussed below are general in nature and are only intended to give an idea of the likely works required. Additionally, they are selected assuming that there is significant infrastructure that is worth protecting, and to reduce the risk of the bunds eroding.

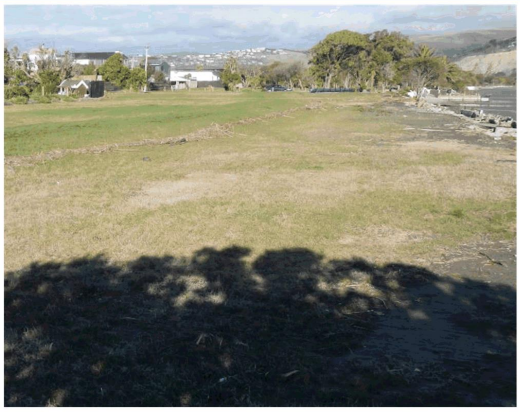
The erosion management concepts discussed are generally in accordance with the Option 2 erosion management Strategies discussed within Section 9.2 and 10.0 of the main body of this report.

Circumstance one - Immediate action

Circumstance one considers the following:

- Immediate action is carried out;
- Erosion mitigation is provided for the LINZ grassed bund only.

Table 3 – Circumstance one

Description/approach	General view
Description: LINZ grassed bund. **Approach:** Do nothing and monitor. (There is sufficient erosion mitigation of the LINZ grassed bund buffer strip of land provided by the grass covering.)	

Circumstance Two - Action < one year

Circumstance two considers the following:

- Action is carried out within a one year period;
- Erosion mitigation for general locations along the Estuary edge.

Table 4 – Circumstance two

Description/approach	General view
Description: Eroding shoreline **Approach:** Monitor, removal of intrusive vegetation and re-grade and plant.	
Description: Eroding shoreline **Approach:** Monitor, removal of intrusive vegetation and re-grade and plant.	

C. Southshore Short Term Floodplain Management Options

Description: Eroding shoreline above reno mattress. **Approach:** Monitor, removal of intrusive vegetation and re-grade and plant. If it is needed maintenance and repair of the reno mattress may also be considered.	
Description: Eroding shoreline **Approach:** Monitor and re-grade and plant.	

C. Southshore Short Term Floodplain Management Options

Description: Eroding shoreline **Approach:** Monitor, relocation of seating, re-grade and plant.	
Description: Eroding shoreline **Approach:** Monitor and re-grade and plant.	

C. Southshore Short Term Floodplain Management Options

Description: Eroding shoreline and deteriorated stone sill. **Approach:** Monitor, removal of existing stone sill and re-grade and plant.	
Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, removal of existing construction material and re-grade and plant.	

C. Southshore Short Term Floodplain Management Options

Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair or structure removal and re-grade and plant.	
Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair or structure removal and re-grade and plant.	

C. Southshore Short Term Floodplain Management Options

Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair or structure removal and re-grade and plant.	

C. Southshore Short Term Floodplain Management Options

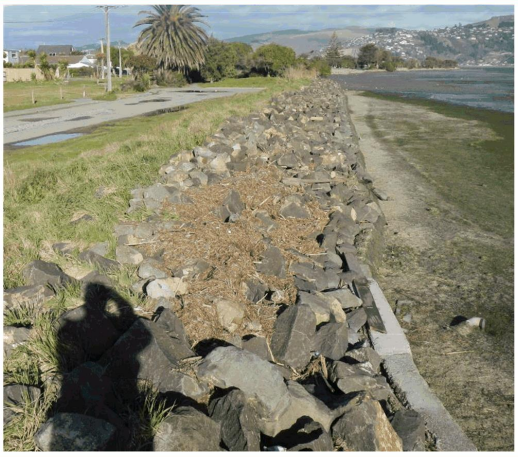
Circumstance three - Action < two years

Circumstance three considers the following:

- Action is carried out within a two year period;
- Erosion risk reduction is considered for general locations along the South New Brighton and Southshore Estuary Edge.
- Pre-emptive erosion risk mitigation is considered for critical locations along the Estuary edge.

Note: The following pre-emptive works would be carried out in addition to what is discussed above. In this case a critical location is defined as an area where erosion poses a risk to critical Council infrastructure.

Table 5 – Circumstance three

Description/approach	General view
Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair using current design standards	

C. Southshore Short Term Floodplain Management Options

Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair using current design standards	
Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair using current design standards.	

C. Southshore Short Term Floodplain Management Options

Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair using current design standards.	
Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair using current design standards.	

C. Southshore Short Term Floodplain Management Options

Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair using current design standards.	
Description: Eroding shoreline and deteriorated sea defence structure. **Approach:** Monitor, maintenance and repair using current design standards.	

Appendix E

Cost Estimates

C. Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options

Concept Cost Estimates

Summary

(A)	Northern Area (north of Ebbtide St)	Total Estimate
1.0	**Inundation**	
1.1	***Option 1: Stabilised emergency works***	
1.1.1	New Bund through Park behind campground	**$360,000**
1.1.2	New Bund behind Seafield Place	**$400,000**
1.1.3	New Bund south of Beatty St	**$80,000**
1.1.4	Filling on estuary side of the CCC bund over access track	**$180,000**
1.1.5	Landscape Works to existing bund in saltmarsh area (2250m2)	**$60,000**
1.2	***Option 2: Rebuild***	
1.2.1	New Bund through Park behind campground	**$360,000**
1.2.2	New Bund behind Seafield Place	**$400,000**
1.2.3	New Bund south of Beatty St	**$80,000**
1.2.4	Landscape Works to existing bund in saltmarsh area (1200m2)	**$55,000**
1.2.5	Replace existing CCC bund	**$640,000**
2.0	**Erosion**	
2.1	***Option 1: Stabilised emergency works***	
2.1.1	Monitor and maintain to protect bund	excluded
2.1.2	Remove trees as required	excluded
2.1.3	Move path in future if required	excluded
2.1.4	Pilot planting area in existing beach formation areas (600m2)	**$30,000**
2.2	***Option 2: Rebuild***	
2.2.1	Monitor and maintain to protect bund, paths and trees	excluded
2.2.2	Place rock and new reno mattresses as required (600m2)	**$220,000**
3.0	**Stormwater**	
3.1	***Option 1: Stabilised emergency works***	
3.1.1	Stop Logs at low points within bunds to facilitate drain down (4No.)	**$45,000**
3.1.2	New manholes (3No.)	**$25,000**
3.2	***Option 2: Rebuild***	
3.2.1	Stop Logs at low points within bunds to facilitate drain down (4No.)	**$45,000**
3.2.2	New manholes (3No.)	**$25,000**
3.2.3	Formalise temporary pump locations (3No.)	**$20,000**

C. Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options

Concept Cost Estimates

Summary

(B)	Southern Area (South of Ebbtide St)	Total Estimate
1.0	**Inundation**	
1.1	***Option 1: Stabilised emergency works***	
1.1.1	Landscape treatment of existing bund (CCC works and LINZ)	**$20,000**
1.2	***Option 2: Rebuild***	
1.2.1	Remove Existing LINZ and CCC bund and replace with new engineered bund	**$1,680,000**
2.0	**Erosion**	
2.1	***Option 1: Stabilised emergency works***	
2.1.1	Monitor and maintain to protect bund	excluded
2.1.2	Placement of geotextile and armour rocks on coastal face of CCC bunds at road ends to: Godwit St, Heron St, Penguin St, Plover St, Tern St (5No. Locations, allow 2 x 50m2 each)	**$140,000**
2.1.3	Additional planting in areas where berm between estuary edge and bund is narrow.	**$35,000**
2.2	***Option 2: Rebuild***	
2.2.1	Monitor and maintain to protect bund, paths and trees	excluded
2.2.2	Placement of geotextile and armour rocks on coastal face of CCC bunds at road ends to: Godwit St, Heron St, Penguin St, Plover St, Tern St (5No. Locations, allow 2 x 50m2 each)	**$140,000**
2.2.3	Additional planting in areas where berm between estuary edge and bund is narrow.	**$35,000**
2.2.4	Place rock and new reno mattresses as required (100m2)	**$40,000**
3.0	**Stormwater**	
3.1	***Option 1: Stabilised emergency works***	
3.1.1	Stop Logs at low points within bunds to facilitate drain down (5No.)	**$55,000**
3.2	***Option 2: Rebuild***	
3.2.1	Stop Logs at low points within bunds to facilitate drain down (5No.)	**$55,000**
3.2.2	New manholes (5No.)	**$40,000**
3.2.3	Formalise temporary pump locations (5No.)	**$30,000**
3.2.4	Swale in Residentual Red Zone draining to roads, with catchpit and pipework to connect into the existing stormwater system (5No.)	**$90,000**

C. Southshore Short Term Floodplain Management Options

Southshore Short Term Floodplain Management Options

Concept Cost Estimates

Summary

Note:

These high level estimates are intended for options comparison.

General Assumptions:
Measurements are subject to validation of existing layout and structures.
The estimates assumes continuity of work and unobstructed access to site.
Estimate assumes project will be procured as a traditional, competitive Lump Sum tender with at least 3 suitable tenderers.

Specific Assumptions:
Estimates are based on Beca concept design information received 7 August 2017.
All excavation spoil to be disposed off site.
All bund aggregate material is assumed to be imported material.
On Costs include:
- Main Contractor's Preliminaries & General allowance - 15%; Margin is deemed included in the rates.
- Main Contractor's Environmental Management allowance - 5%.
- Contingency allowance of 25%.
- Professional fees for design, project management, construction monitoring - 15%.
- Allowance for Client project-related direct costs - 2%.
- Allowance for Consenting - 5%.

General Exclusions:
Goods and Services Tax (GST).
Staging / phasing of the works.
Works outside normal hours.
Costs to date.
Cost escalation beyond date of estimate.

Specific Estimate Exclusions:
Land purchase and access costs.
Creating temporary access and making good (e.g. into estuarine areas).
Contaminated soil and hazardous materials (e.g. asbestos).
Ground improvement.
Tree removal and tree planting.