Coastal erosion and inundation project

DTec Consulting Ltd
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Executive summary

DTec Consulting Ltd was contracted by the Christchurch City Council to identify and delineate key coastal constraints around the Akaroa Harbour Basin Settlement Study Areas. In particular, the work addresses:

(a) existing and anticipated susceptibility to coastal erosion;
(b) coastal inundation (including storm surge) and erosion risks associated with climate change and potential sea-level rise; and
(c) coastal inundation risks associated with tsunami.

A technical report, including maps, has been prepared.

Methodology

The methodology employed by DTec included:

- A review of existing information (ie previous studies on coastal processes in the harbour basin).
- Mapping coastal protection works.
- Measuring past shoreline movements over the last 60 years from aerial photographs.
- Calculating the extent and effect of possible extreme water levels, storm wave generation and wave run-up elevations on shoreline stability, taking into account potential sea-level rise.

Key findings:

Coastal erosion since 1941

Except for a few localised areas around stream mouths, there has been very little change in shoreline position over the last 60 years (based on aerial photograph interpretations for 1941, 1975 and 2000-2004). The likely reasons for this are:

- that large tracts of the shoreline have been protected by seawalls and revetments for long periods of time;
- that the harbour shoreline is not exposed to a high energy swell environment; and
- that the shorelines of most of the bays are protected by a wide and shallow inter-tidal foreshore, where ongoing sedimentation occurs.

Anticipated susceptibility to coastal erosion (due to sea-level rise)

An assessment of future coastal erosion over the next 50 years was undertaken. This was based solely on the potential effects on sea-level rise only, as the shoreline mapping (above) identified no long-term shoreline retreat. This assessment was carried out using the "Brunn rule" approach, which assumes that the beaches and hinterland areas are composed of sand and there are no existing coastal protection works. Hence, the actual extent of future shoreline retreat is likely to be less than predicted.

The highest levels of shoreline retreat due to sea-level rise were predicted to occur in areas where there is little hinterland relief behind the shoreline. The following maximum shoreline retreats were estimated:

- in the order of 20m on the flats at Robinsons Bay and Barrys Bay; and
- in the order of 15m on flats at French Farm and Takamatua. Similar shoreline retreat distances were predicted at Duvauchelle, however the presence of existing protection structures should reduce erosional impacts; and
- in the order of 2-8m at Wainui and Akaroa.

Although existing coastal protection structures may reduce future coastal erosion, lowering of the beach profile due to sea-level rise will increase the potential of toe failure for some of these structures.

Coastal protection structures

There is approximately 8 km of coastal protection structures around the harbour basin settlement areas. These structures have been mapped and assessed in terms of their condition, and are ranked on a scale from 'very poor' to 'very good'. Up to 15% (1.25 km) of these structures have been assessed as being in

'poor' or 'very poor' condition, and will almost certainly require major maintenance or replacement over the next 30-50 years.

Many roads in the harbour basin are located immediately behind the shoreline, and hence the erosion and/or failure of coastal protection structures would have a significant adverse effect on transport corridors. For example, 450 metres of Wainui Main Road through French Farm is likely to be affected over a 50-year time frame.

Storm surges and sea-level rise

Existing coastal structures which have elevations of less than 1m could be overtopped in current spring high tide conditions, with only moderate storm surge or wave energy. The greatest length of these low structures is in Duvauchelle (approximately 430m), which is exposed to potentially the greatest southerly wave heights.

The combination of sea-level rise (as predicted by the Intergovernmental Panel for Climate Change) and storm surges has been predicted to be able to produce extreme water levels up to 0.8m above the current Mean High Water Springs (MHWS). However, local conditions (including water depths and wave refraction) significantly alters the likely effect between within each bay and even within different parts of each bay.

Around 50% of coastal protection structures are estimated to currently be inefficient at preventing overtopping by wave run-up in extreme conditions. This will increase with predicted sea-level rise. Frequent overtopping would lead to these structures being less effective at restriction future erosion.

Tsunami inundation

It is estimated that a tsunami between 2m-4m high would have a return period of approximately 100 years in the harbour basin area. Therefore, an indicative assessment of tsunami hazard was carried out by mapping elevations below the 2m and 4m contour (the 'bath-type' approach).

Areas below the 2m contour are at the highest risk of a tsunami within the next 50 years. This covers about 10.8 ha of the coastal hinterland at Wainui, French Farm, Duvauchelle, Takamatua and Akaroa. The greatest area at this level of risk is the area of reclamation at Childrens Bay, Akaroa. A further 50 ha within the harbour settlements areas are at lower risk, having elevations of between 2m and 4m; the largest areas being in Duvauchelle and Akaroa.

Mitigation options for future coastal hazards

As the coastal hinterland is dominated by roads immediately behind the shoreline, any erosion or failure of shoreline structures could have a major impact on roading infrastructure, particularly where there is little or no room to relocate the road corridor. Options for mitigation against future coastal hazards include:

- a thorough monitoring and maintenance programme to ensure that new or repaired coastal protection structures are properly designed to withstand additional toe scour and overtopping associated with sea-level rise. This may include:
    - raising the elevation of structures prone to over-topping;
    - when replacing vertical concrete structures, consider using rock where possible; and
    - the use of earth bunds in low lying areas where protection works to coastal erosion are not warranted. The use of shrub type vegetation to reduce overland flow could also be considered.
- where there is room to locate the road corridor further inland, a setback from future development landward of the existing road corridor. This should take into account on-going shoreline retreat over a 100-year timeframe and would include land within 70-80m of the shoreline in low-lying areas.
- If floor-level heights of new buildings was to be considered, a height of 3m above MSL should be sufficient for both tsunami and storm surge inundation hazards.

Mapping

The following maps are included in this report:

- the location and type of coastal protection works;
- shoreline positions in 1941, 1975, and 2000-2004; and
- areas potentially at risk from coastal hazards:
    - 2m and 4m tsunami inundation areas,
    - 50-yr erosion potential with sea-level rise,
    - Indicative storm surge inundation with sea-level rise, and
    - Structures that will be overtopped with storm surges and sea-level rise.