REPORT

Tonkin+Taylor

Nelson Regional Coastal Plan Update:

Review of coastal erosion studies and recommendations to inform policy review

Prepared for
Nelson City Council
Prepared by
Tonkin & Taylor Ltd
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1 Introduction

Nelson City Council (NCC), a unitary council, is currently developing a second generation combined district and regional plan and regional policy statement, the Nelson Plan. This includes the regional coastal plan, which needs to be prepared in accordance with the New Zealand Coastal Policy Statement (NZCPS). The Plan is expected to be released as a draft for public input early in 2017, and then publicly notified in mid-2017.

Much of the Nelson City coastline (refer to extent in Figure 1) has either experienced, is periodically subject to, or is projected to be at risk from coastal erosion (NCC pers. comm. 2016). Particular areas that have been found to be at risk include the Tahunanui Beach Reserve, Tahunanui campground, Nelson golf course, Nelson airport and associated peninsula, and the residential area of Monaco (Figure 2).

To date, several studies have been commissioned or written by NCC in-house regarding erosion management and potential responses to manage this hazard, that include recommendations for further work. To date, very few of the recommendations have been acted upon and it is not clear what areas of further work should be pursued and if pursued, how they should be scoped, prioritised, or sequenced.

1.1 Scope

NCC has commissioned Tonkin + Taylor (T+T) to identify what works are required for NCC to align itself with the objective and policy direction required by the NZCPS in reviewing the Nelson Plan, with particular regard to managing coastal erosion risk. The specific scope of works is as follows:

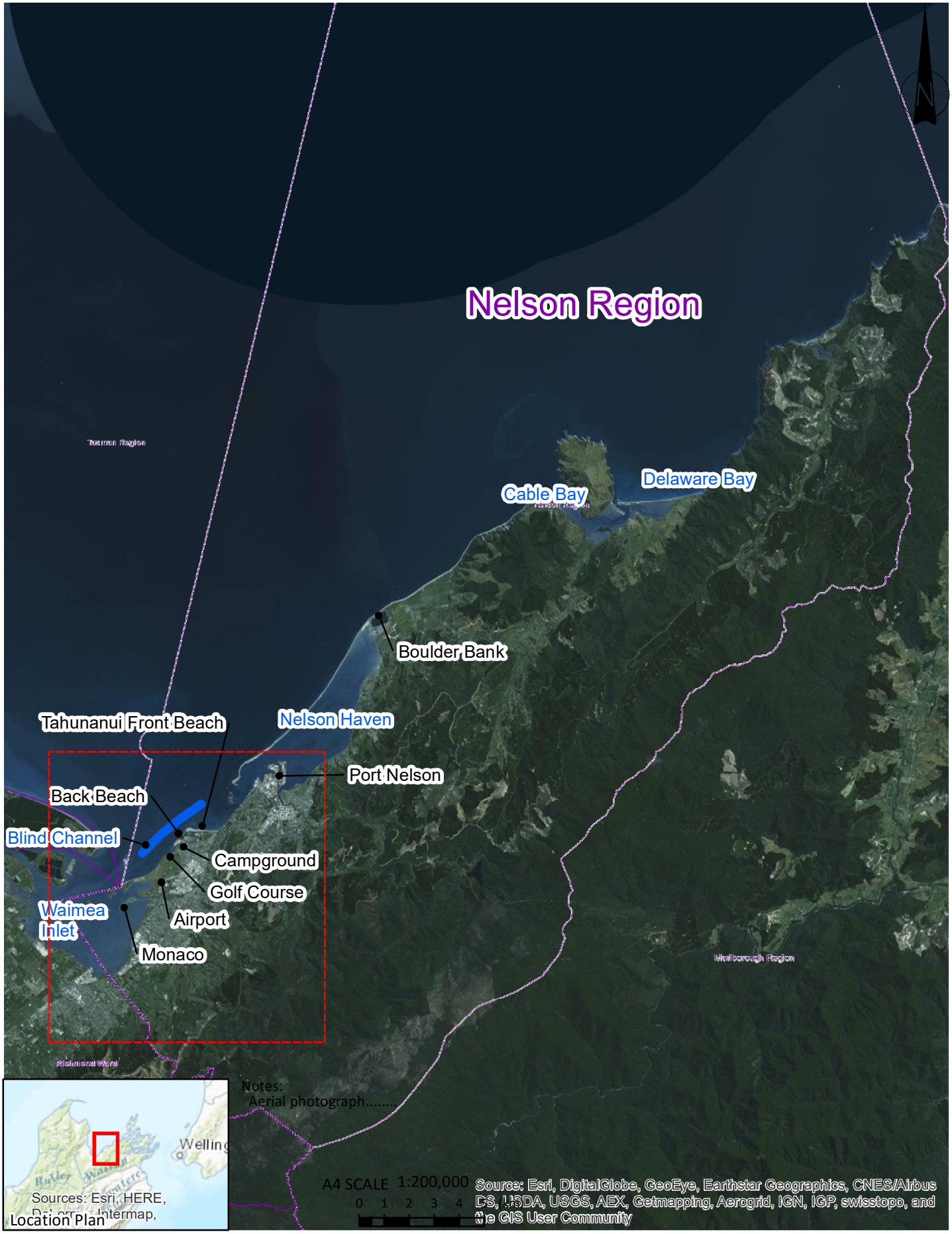
1 Briefly review provisions around coastal erosion in the existing Nelson Plan and identify any deficiencies with respect to the objective and policy direction required by the NZCPS.

2 Review previous studies on the extent and management of erosion hazard around the NCC coastline

3 Identify information gaps which need to be addressed for NCC to update policy around coastal erosion

4 Scope works required to address gaps including required expertise, likely methodology, deliverables, timing, likely cost and priority/sequencing.

5 Summarise findings in a concise report and discuss at meeting with Council officers.



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NELSON CITY COUNCIL

Coastal Erosion Advice to Inform Policiy Review

Nelson City overview

Site Map

FIGURE No. Figure 1

Rev. 0

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Coastal Erosion Advice to Inform Policiy Review

Nelson City overview

Detailed Site Map

FIGURE No. Figure 2

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2 RMA planning process for natural hazards

The RMA planning process for the consideration of natural hazard within a district or regional plan requires technical assessment of the hazards and the risk posed by those hazards; and a robust process for developing and testing plan provisions (including objectives, policies and rules) intended to manage the hazard risk to suit the needs of the community. Figure 3 outlines the staged process, beginning with a technical risk assessment which is further developed within Figure *4*.

2.1 Technical Risk Assessment

The New Zealand Coastal Policy Statement (2010) Policy 24 requires the identification of areas that are potentially affected by coastal hazards.

"Identify areas in the coastal environmental that are potentially affected by coastal hazards (including tsunami), giving priority to the identification of areas at high risk of being affected. Hazard risks, over at least 100 years, are to be assessed…" NZCPS (2010) Policy 24.

This is essentially a technical risk assessment process (Kenderdine et al., 2016). It comprises two-level assessment. A "*first-pass"* assessment should take into account the various drivers of hazard as outlined in the NZCPS Policy 24 (1) (a) – (h). It should be undertaken at a high level and generally, at a regional-scale; using existing information and a high sea level rise estimate. Results will likely be conservative due to the assumptions made during calculations. Mapping should be undertaken to identify areas potentially exposed to the effects of coastal hazards. A preliminary screening exercise of what is contained within those areas identified can then be applied to identify area at high risk of being affected. This screening would include identifying areas and features that are valued, such as areas of existing development, proposed new development, natural or man-made defences, and significant ecological, social or cultural sites. This screening exercise will assist in prioritising areas which may be most exposed to adverse effects for which more detailed "*second pass"* assessment can be completed.

These more detailed, second-pass assessments of high risk areas can be undertaken to more thoroughly understand the likelihood of hazard occurrence, uncertainties and the effects of different future sea level rise scenarios. These assessments will assist stakeholders in understanding the consequence and risk posed by the hazard and as a basis for decision-making in the land use and adaptation planning processes.

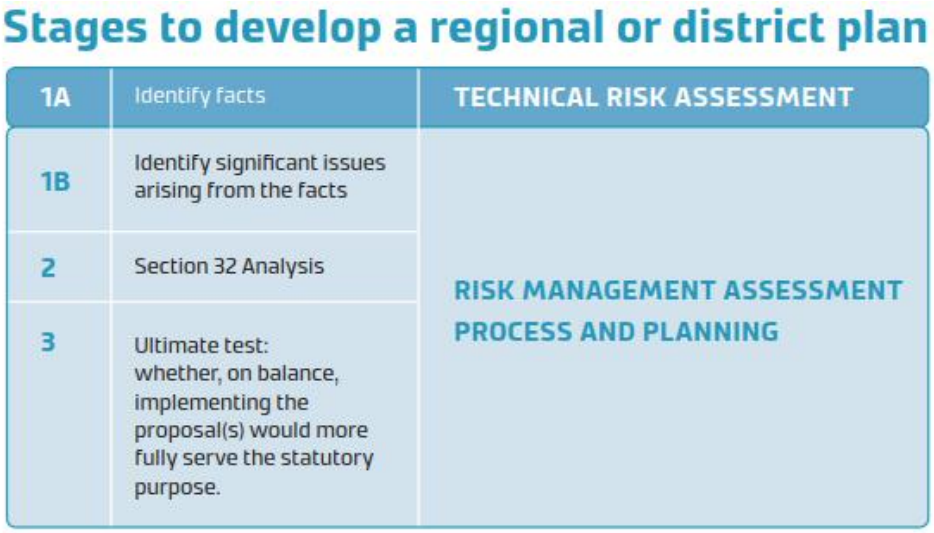

Figure 3 Stages to develop a regional or district plan flow diagram

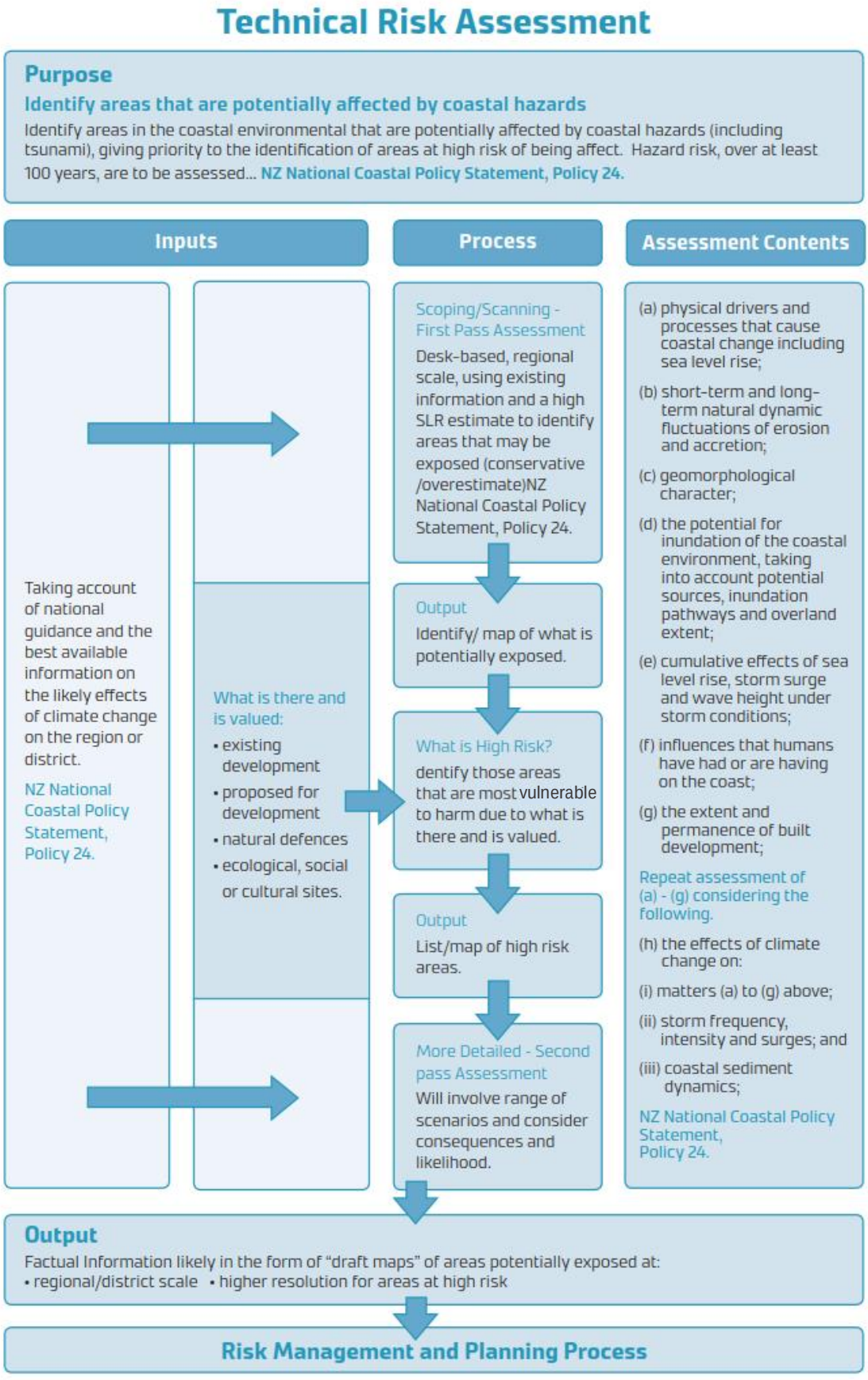

Figure 4 Technical Risk Assessment flow diagram

2.2 Risk management assessment and planning process

Following the risk management process there are the processes involved in engaging with the community and the formal statutory planning process. Engagement should begin with enabling stakeholder and communities of interest to understand the technical assessment and the consequences this information may have on what they value, their expectations and aspirations. This is the process of establishing community attitude to risk. Ideally this process should be concurrent with exploring options for management responses to the risks and effects of natural hazards and developing draft proposals for Plan provisions. It should precede the formal statutory processes required for plan preparation and consultation.

In the case of coastal hazards and the NCC Plan review process, there will be a need to explore the technical assessment outputs and identify the specific stakeholder groups that should be engaged in understanding this information and its significance. There may be additional engagement processes required to those already planned for the overall Plan review process.

3 Review of existing plan and statutory documents

Provisions on coastal hazards in the existing Nelson Resource Management Plan (2006) and Draft Regional Policy Statement (2016) have been reviewed to understand alignment with and identify any inconsistencies with respect to the objectives and policy direction required by the New Zealand Coastal Policy Statement (2010). An analysis, comparing the objectives and policies of the NZCPS to provisions in the Plans is provided in Appendix B, but the main inconsistencies identified include:

Nelson Resource Management Plan (2007)

It is important to note that the operative Plan was made operative before the current version of the NZCPS and therefore has a low level of alignment with the NZCPS 2010. It also predates the Ministry for the Environments 2008 guidance, for example:

- Policy CM8.1 of current RM plan deals with 0.6m SLR over next 100 years. This value is low compared to current guidance (i.e. MfE, 2008)
- Areas potentially affected by coastal hazards as required under NZCPS (2010) Policy 24 are not specifically identified (other than some inundation areas, which are not clearly defined) and some information on reserve requirements.

Draft Regional Policy Statement (2016)

The draft Regional Policy Statement provides a more aligned framework to implement the NZCPS, but still requires further development, for example:

- Areas potentially affected by coastal hazards as required under NZCPS (2010) Policy 24 are not specifically identified, although Issue 5.1 refers to general locations subject to coastal erosion.
- There is some inconsistency over use of a '100 year planning timeframe' (i.e. as described in Policy 5.4) and consideration of hazard to 2100 (i.e. Issue 5.1 and the anticipated Environmental Results). This should be made consistent with NZCPS Policy 24 which requires consideration of hazard over at least 100 years (i.e. to at least 2116).
- Issue 5.1 notes that "Natural events become hazardous when they may adversely affect human lives." However, this is not consistent with the definition in the RMA which includes property and other aspects of the environment. Policies address cultural values but not other important environmental values.
- There are important principles associated with resilience identified (Objective 5.3) and regarding engagement (policy 5.5) that can be built upon.

4 Review of previous coastal hazard studies

The Nelson coastline is complex, being located between steep, tectonically uplifted ranges to the east and flat Waimea River Floodplain to the west. The coastline is exposed to both local wind-waves generated within Tasman Bay and swell originating in the Tasman Sea and South Taranaki Bight and has a spring tidal range is almost 4 m. Sediments are derived from local coastal cliff erosion and river systems bringing materials from inland. The coastline is defined by cliff, sand and gravel beaches, spits and barriers, boulder banks and finer estuarine environments within Waimea Inlet. The shoreline is also extensively man-modified, particularly around Nelson City with many coastal roads running adjacent to artificially armoured shorelines. The dominant coastal processes will vary depending on the primary drivers changing from wave-dominated in the north and tidally dominated in the southwest.

Figure 5 Aerial view of Tahunanui Beach and Nelson in the background (source: Boffa Miskell, 2015)

This section sets out a review of existing studies related to coastal hazards for Nelson City and surrounding areas. These coastal hazards include:

- Coastal erosion
- Coastal inundation including coastal water level effects on
  - Terrestrial flooding
  - Liquefaction
- Tsunami

A bibliography including a brief summary for each available report is presented in Appendix A. The following sections summarise the studies including the specific assessments undertaken, area covered, data used and findings. Table 1 provides a summary of the available assessments related to coastal erosion that have been completed for the Nelson City region.

A gap analysis is undertaken to determine how the hazard assessments undertaken for Nelson City align with the considerations set out in the New Zealand Coastal Policy Statement (2010) as summarised in Figure *4* and best practice guidelines (MfE, 2008; Ramsey et al., 2013).

4.1 Coastal erosion

Coastal erosion refers to the landward movement of the shoreline by action of natural forces. On a beach, this movement may be related to periodic storms and cyclic changes in wave height and direction, changes in sediment supply and, in the longer term, by changes in the mean sea level. However, movement may occur in both direction, with accretion and seaward movement of the shoreline often occurring following significant storms or changes in sediment supply (Figure 6).

On a consolidated cliffed shoreline, the movement is generally only in a landward direction and is driven by both gradual weathering and slumping of cliff face as it becomes over-steepened by erosion at the cliff toe. This toe erosion is driven by wave height, water level and the presence of accumulated talus or beach material in front of the toe. The rate of erosion and susceptibility to changes in sea level is highly dependent on the cliff material.

Figure 6 Coastal types susceptible to erosion at Delaware Bay spit (left; source: NIWA, 2014) and cliff south of Cable Bay (right; source: NZ Frenzy 2013)

4.1.1 Previous studies

Gibb (1978) first attempted to quantify rates of coastal erosion and accretion in New Zealand using analysis of historic cadastral plans, vertical aerial photographs and field measurements. For Tahunanui Beach, Gibb found 445 m of accretion between 1850 and 1969 (+3.74m/year) and erosion of 73 m between 1948 and 1971 (-3.17 m/year). The Bounder Bank was found to be accreting at rates of up +5 to 10 m/year over short periods in the 40s and 50s.

The Nelson Catchment and Regional Water Board (1984) assessed historical rates of coastal erosion (based on previous studies by Gibb) to produce coastal hazard maps for the Tasman Bay and Golden Bay areas to define areas which are threatened by coastal erosion over the following 50 to 100 years. It recommends that the whole of the developable coastline from Delaware Bay to Separation Point in Tasman Bay should be subject to planning requirements. However, the analysis of historical erosion rates appears to be limited to south of Tahunanui Beach and projected future hazard areas did not include allowance for future changes in sea level.

Previous coastal erosion assessments for the Nelson region have been undertaken between 2000 and 2015. These assessments have tended to focus on the Tahunanui Beach area (Ocel, 2000, 2010; Opus, 2015), which has historically been prone to coastal erosion due to the eastward migration of Blind Channel (Sissons, 2003) however a more wide-ranging assessment has been undertaken by NIWA (2014).

NIWA (2014b) undertook a qualitative assessment of coastal erosion along the Nelson City coastline based on site inspection, literature and discussions. The erosion potential at several locations (typically higher use beaches) between Delaware Bay to Monaco was assessed; erosion at Tahunanui being identified as the main erosion issue. Monitoring at most locations was recommended including beach profiles and monitoring of the informal coastal protection between the camp ground and Monaco. Additional economic investigation of the assets at risk at Tahunanui was recommended to inform risk and options assessments and advanced numerical modelling to predict future shoreline change investigated.

OCEL (2000) undertook an assessment of coastal erosion rates at Tahunanui Beach based on historic vegetation lines and bathymetric survey. They found ongoing erosion close to Rocks Road, on the Back Beach and in front of the camp ground and recommend construction of protection measures. In 2010, OCEL re-assessed coastal erosion rates and coastal erosion processes at Tahunanui Beach following completion of seawall and drain modifications along Rocks Road and the installation of rock protection along the camp ground shoreline on back beach by NCC as recommended by OCEL (2000). Further options to deal with the erosion risk were discussed including doing nothing and shoreline armouring and channel realignment options.

In 2015, OPUS assessed the historic coastal erosion rates for Tahunanui Beach (Front and Back Beach) and the Campground coastline. OPUS reviewed the Tahunanui Reserve Management Plan, its change for the separate coastal zones over time, and give recommendations to prepare a Shoreline Management Plan. Recommendations on improving existing coastal protection structures, shoreline monitoring and further investigations to assess erosion at Tahunanui Beach are also presented.

4.1.2 Gap analysis

Early studies of coastal erosion (Gibb, 1978; Nelson Catchment Board, 1984) assessed only limited sites with limited data and did not account for future sea level rise in assessing future coastal hazard. Coastal processes have been assessed qualitatively for select locations from Delaware Bay to Monaco (NIWA, 2014). This assessment has given regard to some of the criteria identified in NZCPS (2010) Policy 24 including the physical drivers and processes that cause coastal change, the geomorphological character and influences that humans have had, but has not quantified the potential extent of the erosion at a region-wide scale. This has therefore not allowed a screening of the hazard-exposure to take place to identify high risk areas.

In spite of this, coastal erosion has been studied in detail for discrete areas such as the Tahunanui Beach area (i.e. OCEL, 2000, 2010; OPUS, 2015) which is likely to arise as a high risk site. Existing studies have been primarily based on review of historic information with little prediction of future expected erosion extents, although it is acknowledged that the complex natural system being driven by large-scale bathymetric changes makes such forecasts difficult.

4.2 Coastal inundation

Inundation from the sea occurs when sea levels are super elevated and encroach onto land. Key components that determine sea levels include astronomical tides, barometric and wind effects, generally referred to as storm surge, medium term fluctuations, including El Niño-Southern Oscillation (ENSO) and Inter-decadal Pacific Oscillation (IPO) effects and long-term changes in sea level. Wave breaking can also contribute to water level through wave set-up and run-up. Areas affected by coastal inundation are not necessarily subject to increased coastal erosion if the inundation is temporary (i.e not permanent such as a change in the tidal position).

4.2.1 Previous studies

Several coastal inundation studies have been completed by NIWA between 2009 and 2015. NIWA (2009) assessed the 1% AEP coastal water levels for Nelson City for the present day and allowing for

sea level rise up to 1 m. These extreme levels were later mapped overlaying aerial photographs in 2013 (NIWA, 2013a). A joint-probability analysis of extreme significant wave heights and storm tide levels for Tasman Bay was undertaken by NIWA in 2012. Mean High Water Spring (MHWS) levels including allowance for several sea level rise scenarios were derived for 8 locations along the NCC coastline. A synthesis of the previous four reports was set out by NIWA in 2014 for The Wood, Stoke, Tahunanui Beach and Glenduan including storm-tide elevations, allowance for sea level rise and freeboard.

A larger scale coastal inundation assessment including wave effects for open coast shorelines was undertaken by NIWA in 2014 covering both Tasman Bay and Golden Bay. In 2015, NIWA updated their joint-probability analysis from 2012 for Nelson City to include 8 years of overlapping storm tide and wave data compared to 4 years in 2012.

4.2.2 Gap analysis

In summary, the coastal inundation reports completed by NIWA provide detailed water level information in keeping with technical and statutory guidance, although is based on a relatively short record length and so will likely continue to change as additional data becomes available. Earlier mapping (NIWA, 2013) of inundation extents has not likely used the most up to date values (i.e. NIWA, 2015), and so should be reassessed, particularly to identify the potential extent of the inundation hazard at a region-wide scale using high SLR scenarios. This will allow identification of higher risk areas and more detailed assessment where required.

4.3 Tsunami

Tsunami are a series of waves generated when a large volume of water is rapidly displaced. Events capable of generating hazardous tsunami include: earthquakes (normally >M5) and their associated fault ruptures (especially dip-slip faulting of the seabed), volcanic eruptions, coastal landslides and submarine slides and meteor impact (Marlborough Civil Defence, 2011). Typical tsunami damage includes (GNS, 2005):

- The impact of the tsunami bore either on land or in shallow waters and the outward return flow as the tsunami recedes
- Impact of debris carried in the tsunami flow
- Fire and contamination
- Inundation of salt water on land.

Areas affected by Tsunami are not necessarily subject to increased erosion risk but can be depending on the nature of the tsunami flow.

4.3.1 Existing studies

GNS (2014) undertook a tsunami hazard assessment for Tasman Bay and Golden Bay including analysis of historic tsunami runup events. Potential tsunami amplitudes at the coast caused by maximum credible tsunami events (<2500 years) were estimated at up to 8 m. These values were doubled and high tide added to define a maximum run up potential and were mapped using simple attenuation rules with distance inland to define tsunami evacuation zones.

4.3.2 Gap analysis

This method of identifying tsunami extents, although coarse and likely very conservative, does allow identification of areas potentially affected by the hazard (i.e. Figure 7). Analysis of risk has not yet been undertaken but, given the extent of the hazard, this risk is likely to be very high and likely warrants more detailed assessment on a local scale. This may include assessing inundation extents

under a range of return period scenarios and using more advanced hydrodynamic techniques. Note that Council has advised that Tsunami risk is to be managed by Civil Defence and Emergency Management (CDEM) rather than a planning response. To be consistent with the NZCPS Policy 24, any assessment and mapping should consider the risk of different tsunami likelihoods and the effect of sea level rise on inundation.

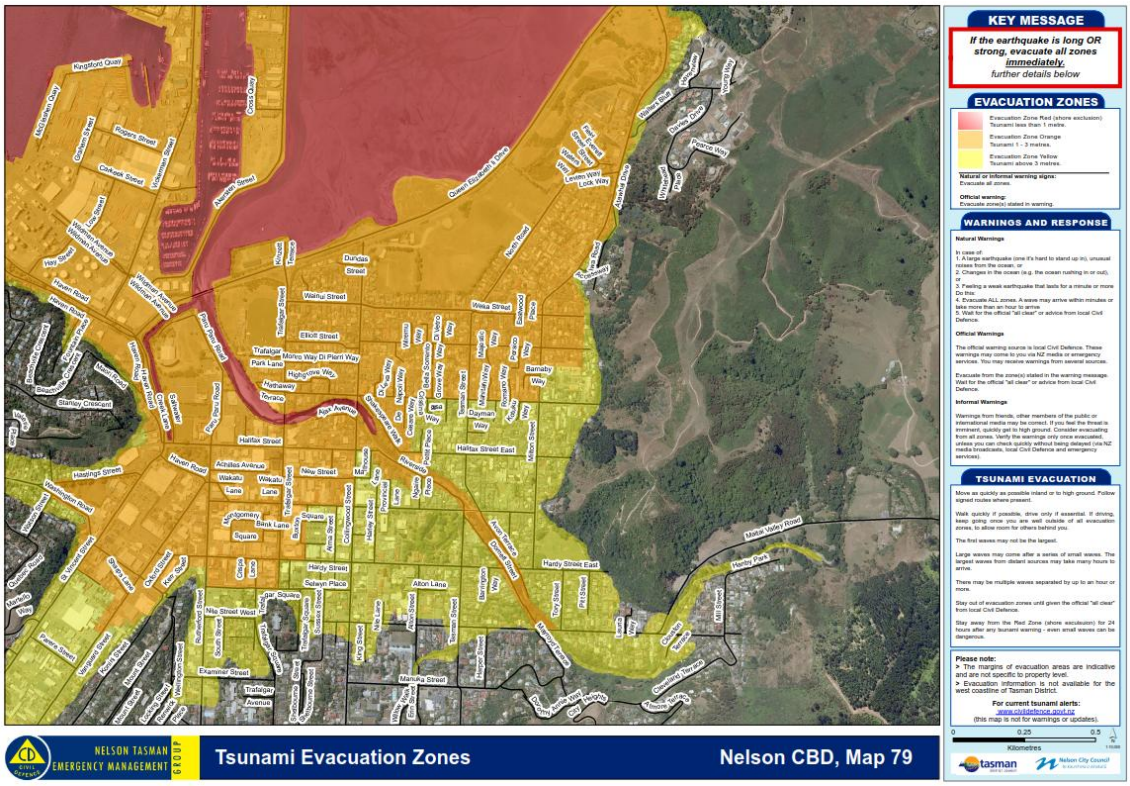

Figure 7 Tsunami Evacuation Zones for Nelson CBD (source: Nelson-Tasman CDEM group)

4.4 Terrestrial flooding

Terrestrial flooding refers to flooding of the land by rainfall-induced events. The coastal water level (the *tailwater* level) at the time of flooding can affect the ability of the flood waters to drain from the land and therefore the flooding level attained, especially in the lower reaches adjacent the coastline. Sea level rise may result in increased terrestrial flooding by raising the tailwater level. Areas affected by terrestrial flooding are not necessarily subject to increased erosion risk but can be depending on the nature of the flood flow.

4.4.1 Existing studies

A number of terrestrial flooding assessments have been undertaken in the Nelson district. Tonkin + Taylor (2013) produced flood hazard maps for Nelson City for 1% AEP rainfall events in the Maitai River catchment allowing for several future sea level rise scenarios including up to 1 m SLR to 2100. Results show that Nelson city can expect significant flooding across the lower portion of the urban area under a 1% AEP event in the year 2100.

Tonkin + Taylor (2015) developed hydrological and hydraulic models for the Wakapuaka Floodplain and catchment to complete floodplain and flood hazard mapping. In addition to catchment flooding, the Wakapuaka Floodplain has been assessed as being prone to coastal inundation due to overtopping of the Boulder Bank along the open coast during extreme tide events. The assessment considered the effects of sea level rise (0.5 m for 2065 and 1 m for 2115), storm tide (incl. 1% AEP)

and wave height predictions based on NIWA (2013), and utilised combinations of coastal and rainfall extremes to derive inundation mapping for a particular design return event.

4.4.2 Gap analysis

Terrestrial flooding assessments undertaken for the Nelson District including Tonkin + Taylor (2013; 2015) have utilised future sea level rise scenarios of up to 1 m to identify areas affected by terrestrial flooding. This is consistent with requirements under NZCPS (2010).

4.5 Liquefaction

Liquefaction of soil comprising sand or silty sand can occur in response to earthquake shaking resulting in significant and rapid loss of strength until such time that elevated water pressures generated by the shaking subside. Soil needs to be saturated for it to liquefy and full saturation generally occurs in the soils located beneath the groundwater level (Quilter et al., 2015). Increases in sea level have the potential to increase groundwater levels in coastal plains and reclaimed areas, increasing the susceptibility of soils to liquefaction.

Figure 8 Surface ejection of soil and water as sand boils

4.5.1 Previous studies

Tonkin + Taylor (2014) undertook an assessment of liquefaction potential of soils across the low-lying flat to gently sloping land at Tahunanui (north-eastern part). Measured ground water levels including allowance of 0.3 m, 0.5 m and 0.8 m future increased ground water levels have been used to calculate liquefaction severity. The future increased ground water level of 0.5 m represents sea level rise to 2050. Investigations indicated variable gravel strength underlain by highly liquefiable sand consistent with Tahunanui Sands.

4.5.2 Gap analysis

Studies such as T+T (2014) have considered the effects of 0.5 m SLR to 2065. To align with NZCPS (2010), consideration of 1 m SLR to 2116 should be considered.

Table 1 Summary of available recent reports related to coastal erosion

Report reference	Assessment undertaken	Data used	Area
OPUS (2015)	• Qualitative review of coastal erosion risk management strategy (strategic coastal policy) • Quantitative assessment of erosion rates • Recommendations on repairing existing structures, monitoring shorelines, policy and management plans and further investigations	• OCEL (2000, 2010) digital shorelines	• From Tahunanui Beach to the Campground
NIWA (2014b)	• Qualitative assessment of coastal erosion processes • Qualitative assessment of structure (hard and soft) condition and performance • Recommended coastal protection measures including additional investigations and monitoring	• Field visit and literature review	• Delaware Bay • The Boulder Bank • Tahunanui Front and Back Beaches • Tahunanui Campground and Golf Course • Nelson airport • Monaco
OCEL (2010)	• Review of coastal erosion following protection measures installed by NCC • Qualitative and quantitative assessment of erosion rates • Digitised shorelines • Proposed further protection measures	• OCEL (2000) • Historic aerial photographs (2006, 2007) • GPS survey of vegetation line (2010) • Bathymetric survey of Blind Channel (2004)	• Tahunanui Beach
OCEL (2000)	• Qualitative assessment of coastal processes • Quantitative assessment of erosion rates • Digitised shorelines • Proposed protection measures	• Bathymetric survey of Blind Channel (2000) • GPS survey of vegetation line (2000) • Cross-shore beach profile surveys (2000; locations indicated in report) • Historic aerial photographs (1948, 1966, 1970, 1975, 1981, 1987, 1999) • Drogue tracking information (Blind Channel)	• Tahunanui Beach (Front Beach and Back Beach)

Report reference	Assessment undertaken	Data used	Area
		• Current measurement information (Blind Channel) • Sediment sampling information (exact locations unspecified)	
NIWA (2015a)	• Updated quantitative joint-probability analysis from NIWA (2012) - Joint probability extreme water levels and wave heights - Extreme wave set-up and run-up levels	• Discontinuous 31-year water level data (incl. large gaps) – Nelson gauge • 8-year overlapping wave height – water level dataset	• Tasman Bay
NIWA (2014c)	• Coastal inundation levels along the open coast - Extreme wave height - Extreme water level • Coastal Calculator	• 4-5 year wave data • 9 year water level data from Little Kaiteriteri and Tarakohe gauges • SWAN model for Cook Strait	• Tasman Bay • Golden Bay
NIWA (2014a)	• Storm tide elevations based on the 4 previous reports for NCC to include in their land development plan	• NIWA (2009, 2012, 2013a, 2013b)	• The Wood • Stoke • Tahunanui Beach • Glenduan
NIWA (2013b)	• Derivation of MHWS levels for the Nelson region incl. 0.7 m and 1 m SLR scenarios	• Discontinuous 28-year water level data (incl. large gaps) – Nelson gauge	• 8 locations along Nelson City coastline
NIWA (2013a)	• Inundation maps for a 1% AEP storm tide + 0, 0.3, 0.5, 1.0m SLR	• Results from NIWA (2009)	• Nelson City
NIWA (2012)	• Quantitative joint-probability analysis of extreme significant wave heights and storm tide levels - *quantitative*	• Discontinuous 28-year water level data (incl. large gaps) – Nelson gauge • 4-year overlapping wave height – water level dataset • SWAN model for Cook Straight	• Tasman Bay
NIWA (2009)	• Present day and future extreme water levels (incl. SLR) • Minimum ground levels	• Discontinuous 25-year water level data (incl. large gaps) – Nelson gauge	• Nelson City

5 Recommendations

In order to update policy around coastal erosion in the second generation Nelson Plan, the following process is recommended to enable completion of a Technical Risk Assessment (Figure *4*) consistent with principals of the NZCPS:

1 Information gathering
2 First pass assessment
3 Identify high risk areas
4 Detailed assessment of high risk or vulnerable areas.

5.1 Information gathering

Description: This stage gathers available information related to coastal erosion including historic maps, aerial photographs and cadastral surveys, digitised shorelines, LiDAR, wave height, water levels and additional anecdotal information.

Likely methodology: Thorough review of literature and previous studies

Required expertise: N/A

External peer review: N/A

Timing: Immediate

Deliverables: Based on this review, Council have LiDAR, georeferenced aerial photographs and limited georeferenced shorelines (Tahananui Beach). Data on extreme wave height, water levels and inundation mapping is also available.

Likely cost: Based on the review of previous studies, this stage is largely complete, although the electronic versions of digitised shorelines, wave height and water level data should be compiled by Council if not already available.

5.2 First pass assessment

Description: Region-wide hazard exposure screening to assess potential erosion hazard across entire Nelson coast.

Likely methodology: Should be undertaken on a regional scale for current/50/100 year timeframes and should consider both existing processes and response to high end sea level rise scenarios (i.e. RCP 8.5 95%). The coastline would be broken into cells depending on coastal processes and the shoreline response with simple erosion models derived for each. The assessment would be based on existing data, previous assessment and expert judgement to provide a continuous mapped extent across the region.

Required expertise: Coastal engineer or scientist with specific expertise in coastal erosion hazard

External peer review: External reviewer or experienced internal natural hazards officer to be involved in planning stages and review of report.

Timing: Likely 4-6 weeks. Begin as soon as data compiled

Deliverables: Summary report, maps of areas potentially affected by coastal erosion hazard for entire region.

Likely cost: 30-50K depending on availability of data. Allow 5K for external peer review.

5.3 Identify high risk areas

Description: This identify what is located and valued within the areas potentially affected by erosion hazard (or any other hazard).

Likely methodology: Assess areas potentially affected against the following criteria:

- Existing development (buildings, assets, infrastructure)
- Proposed development
- Natural or artificial defences
- Ecological, social or cultural values.

This is largely a desk-based and high level assessment, using Information already available and consultation with Council staff. Information sources would include:

- maps in existing planning documents (e.g. showing identified areas of natural or heritage value, areas of existing development or identified for future development);
- national heritage/archaeological register;
- Council GIS or other reports prepared to support planning processes, reserve management plans and asset management;
- aerial photographs.

Required expertise: Consultant with expertise in natural hazard risk assessment including hazard consequence planning.

External peer review: Not likely required.

Timing: Likely 1-2 weeks depending on data availability. Begin as soon as first-pass assessment is completed.

Deliverables: Report, maps of high risk areas, recommendations for areas requiring detailed assessment and effort required

Likely cost: 10-15K.

5.4 Development of engagement strategy

Description: An engagement strategy should be developed based on the early results of the first-pass and risk assessment.

Likely methodology: This will explore the technical assessment outputs and identify the specific stakeholder groups that should be engaged in understanding this information and its significance. This will guide the future risk management assessment and planning process and may be initiated while detailed assessments are underway.

Required expertise: Resource management specialist with expertise in natural hazards, risk and community consultation.

External peer review: Not likely required.

Timing: Likely 1-2 weeks.

Deliverables: Engagement strategy

Likely cost: 5-10K.

5.5 Detailed assessment

Description: Detailed assessment of identified high risk or vulnerable areas.

Likely methodology: Use of advanced numerical or statistical models to assessed likelihood of erosion hazard in discrete areas, with extents likely defined based on coastal compartments subject to similar processes (i.e. The Boulder Bank, Tahunanui front and back beach, campground to airport). Assessment detail will depend on level of risk identified in first-pass assessment. Statistical uncertainty should be incorporated and multiple future SLR scenarios should be considered. The consequence of the hazard should be considered to enable risk to be quantified and used to inform decision-making.

Required expertise: Coastal engineer or scientist with specific expertise in coastal processes and erosion hazard.

External peer review: External reviewer involved in planning stages, review of methods, findings and report.

Timing: Number of areas dependent on outcomes of first-pass risk assessment but each local area likely 4-6 weeks.

Deliverables: Probabilistic maps of areas likely to be affected by coastal erosion hazard

Likely cost: Dependent on size and complexity of area but likely to range upward of 30-50K per area, and potentially significantly higher if additional data or complex numerical modelling required. For preliminary budgeting purposes, three areas could be assumed at $50K per areas = $150K total. Allow 5-10K/site for peer review, 25-30K total.

5.5.1 Note on modelling of Tahunanui Beach and the Waimea Inlet

OCEL (2000) considered that advanced numerical models could be used to predict the effects of sea level rise on coastal morphology but discounted at the time based on cost. NIWA (2014) likewise consider that such modelling could be used to better predict future shoreline trends and manage risk but also acknowledge the expense (several $100,000).

We consider that long-term morphological modelling remains in a research and academic domain and that application to the Waimea Inlet for long term (decadal to century) simulations would likely yield results with greater degrees of uncertainty than extrapolation of historic trends and simple beach-response methods utilising sensitivity assessments.

However, such numerical models can be useful for assessing shorter-term changes in wave, current and sediment transport if structural responses (groynes, channel dredging) were being seriously considered as long-term management strategies.

Overall, the development of advanced morphological model models for the Nelson/ Waimea Inlet area is not likely a priority or feasible for this current plan update but may yield some insight into the current coastal processes and, with sufficient calibration, potentially into future trends. The modelling could therefore be supported and potentially partially funded in an academic research context (i.e. sponsorship of a PhD) with results potentially being utilised in subsequent plan updates.

5.6 Overall timing

Based on tendering of first-pass hazard and risk assessment work in late December 2016 and starting work in Jan 2017, we believe it would be possible to complete the first pass assessment and identification of high risk areas by mid- to late-March 2017.

Following this assessment, a decision around whether to undertake further detailed assessment could be made. If this is not required, then the risk management and planning process (Stages 1B, 2 and 3) could begin. If detailed assessments are required, this could take 2-4 months, and should be completed as an input to the planning processes.

In our view, it is likely that at least some detailed assessment will be required, better to understand the range of potential future impacts that could occur in those areas at most risk. Depending on the level of engagement with communities of interest that has already occurred and the approach Council wishes to take to this engagement, this could involve 6-12 months. As mapping information will present a range of possible future scenarios and include conservative options (some extreme case assumptions) a reasonable period of time and number of workshops with affected parties and the community are likely to be required to build an understanding of the risk that may need to be managed. Some of the mapping information will be challenging for communities to come to terms with. Early workshops would need to focus on understanding what the future may look like and how people, property and the environment could be impacted. They should also test community attitude to these effects. Subsequent workshops should explore potential response/planning options and run concurrent with Section 32 evaluation processes. Several iterations of option generation/refinement and evaluation are likely to be required. On this basis we anticipate that the Council's mid 2017 date for notifying a proposed plan is unlikely to be achievable...

6 Applicability

This report has been prepared for the exclusive use of our client Nelson City Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:

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Dr Tom Shand
Senior Coastal Engineer

Authorised for Tonkin & Taylor Ltd by:

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Richard Reinen-Hamill
Project Director

Marje Russ
Resource Management Specialist

Patrick Knook
Coastal Engineer

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Appendix A: Coastal Hazard Bibliography

Boffa Miskell (2014) - Nelson Coastal Study

Description of the coastal environment along the NCC shoreline including:

1 definition of Coastal Marine Area (CMA), Coastal Terrestrial Areas (CTA) and Coastal Significance Zone
2 subdivision of the NCC shoreline in separate CMA areas and CTA areas (mapped)
3 land types for each subdivided CTA area including coastal profiles (cross-sections)
4 coastal natural character ratings including Key Values for each CTA area (e.g. impressive sequence of coastal landforms or sand spit is significant ecological site at Delaware Bay)

Boffa Miskell (2015) - Nelson Coastal Study – Pressures and threats to Nelson's highly values parts of the Coastal Enironment

Following the Nelson Coastal Study report (Boffa Miskell, 2014) this report addresses the vulnerability of the coastal environment to a variety of human activities (e.g. earthworks, constructing structures, removal of vegetation and land reclamation). General characteristics, key natural character values, key sensitivities to identified values and corresponding likely and possible threats for each CTA area are tabulated (e.g. for Cape Soucis a key natural character value is 'steep, erosion prone cliff face', 'intact indigenous forest and coastal cliff vegetation').

Cawthron (2009) - Effects of climate change on the Nelson-Tasman Region

Assessment of climate change effects for Nelson City including effects of flooding due a sea level rise of 1.9 m. Areas that would be flooded during the 1.9 m sea level rise are identified, described and mapped.

Cawthron Institute (2014) - Port Nelson and Nelson Haven long-term monitoring programme: report on compiled data 1996-2014

Long-term monitoring programme (LTMP) for Port Nelson and Nelson Haven to provide a continuing record of environmental quality in benthic areas of Port and Haven areas, and a basis for formulating any mitigation measures that may be required in the future. The report comments among other things on analyses of sediment contaminants measured at 12 subtidal monitoring stations.

Eliot Sinclair and Partners Ltd. (2013) - Survey Report for Blind Channel, Nelson for Port Nelson Ltd, Tasman District Council and Nelson City Council

Gibb (1998) Rates of coastal erosion and accretion in New Zealand. N.Z Journal of Marine and Freshwater Research 12 (4) 429-56.

Gibb quantifies rates of coastal erosion and accretion around New Zealand using analysis of historic cadastral plans, vertical aerial photographs and field measurements. For the Nelson Region, rates at Tahunanui Beach and the Boulder Bank are assessed with large accretional changes found at both sites since 1850, although Tahunanui Beach had changed to an erosion trend after 1948.

GNS (2014) - Tsunami modelling and evacuation zone mapping for Tasman Bay and Golden Bay

Tsunami hazard assessment for Tasman Bay and Golden Bay including analysis of historic tsunami and derivation of potential run-up levels caused by most probable and maximum credible tsunami events. GNS recommend to undertake further work required to refine the estimates of wave height at the coast in Tasman Bay and consequent tsunami evacuation zones.

Kenderdine, SE; Hart, DE; Cox, RJ; de Lange; WP; Smith, MH. (2016) Peer review of the Christchurch Coastal Hazards Assessment Report. Review report produced for the Christchurch City Council, 18 August 2016, 74pp.

Nelson Catchment and Regional Water Board (1984) Coastal Hazard Planning in Nelson. Unpub. report, 21pp., May 1984.

The Nelson Catchment Board uses a Coastal Mapping Planning for establishing the extent of the coastal zone in the Tasman Bay and Golden Bay areas which are threatened by coastal erosion over the following 50 to 100 years. The study is based on historical shoreline change. Generalised net rates of longshore drift and some yearly erosion and accretion rates are shown. It recommends that the whole of the developable coastline from Delaware Bay to Separation Point in Tasman Bay and from Separation Point to Port Puponga should be subject to planning requirements.

NIWA (2009) - Review of Nelson City minimum ground level requirements in relation to coastal inundation and sea level rise

Assessment of Average Recurrence Interval (ARI) storm tide levels for Nelson, including wave component for Monaco, to assess extreme coastal water levels (0.5% AEP adopted) including an allowance for sea level rise (0.5m, 0.8m and 1.0m). Minimum ground levels to 2100 were derived for sheltered coastal areas and for Monaco (incl. 0.2m for waves). Recommendations are made to assess wave setup/runup component to derive extreme water levels for open-coast environments (Monaco, Glenhaven, Glenduan, Delaware Bay, Tahunanui Spit and exposed low-lying parts at Rocks Road). The report includes evaluation of extreme water levels/minimum ground levels in relation to S32 matters and long-term planning.

NIWA (2012) - Combined wave and storm tide hazard for southern Tasman Bay

Assessment of extreme significant wave heights along the Nelson and Tasman District coastline, and assessment of joint-probability relationship between extreme wave conditions and coincident storm tide sea levels. Extreme water levels and wave heights including several sea level rise scenarios based on IPCC (2000) are also included.

NIWA (2013a) - Storm-tide Potential Inundation Maps: Nelson City

Inundation maps for Nelson City (city centre) generated using storm-tide elevations from NIWA (2009) for the present day sea level and 0.3 m, 0.5 m, 0.8 m and 1 m sea level rise.

NIWA (2013b) - Mean High Water Springs (MHWS) levels including sea-level rise scenarios: Envirolink Small Advice Grant (1437-NLCC80)

MHWS levels and projected future MHWS levels are provided for 8 locations, with future predicted levels including 0.7 m and 1 m of sea level rise. Levels are presented in terms of MSL and NVD-55.

NIWA (2014a) - Extreme sea level elevations from storm tides and waves: Tasman and Golden Bay Coastlines

Assessment of coastal inundation elevations and likelihoods for the present day as a result of combinations of elevated storm tide, wave setup and wave runup along the open coast of the Tasman Bay and Golden Bay coastlines for Tasman District Council (TDC).

NIWA (2014b) - Erosion along the Nelson City coastline

Assessment of coastal erosion along Nelson City shoreline at Delaware bay, the Boulder Bank, the Tahunanui Front and Back Beaches, the Tahunanui campground and golf course, Nelson airport, and Monaco. Coastal erosion processes for these sites are described including recommendations for coastal protection and additional investigations/monitoring. Especially for Tahunanui Beach it is recommended undertake an economic assessment of the value of and return from the assets in the

Tahunanui Reserve and to undertake further investigation to predict long-term migration of Blind Channel to assess likely consequences including sea level rise scenarios. It is recommended to monitor the coastal protection structures along the shoreline extending from the golf course to Monaco on a regular basis and to install additional protection as sea level rises.

NIWA (2014c) - Nelson City storm-tide synthesis

Derivation of storm-tide elevations for The Wood, Stoke, Tahunanui Beach and Glenduan adopting a sea level rise allowance of 1 m and free board of 0.4 m. These storm-tide elevations are derived based on NIWA (2009, 2012, 2013a and 2013b) with the purpose for NCC to include in their land development manual.

NIWA (2015a) - Climate change and variability – Tasman District

Description of changes in the climate over the next 100 years for Tasman District including sea level rise scenarios, temperature and rainfall intensity changes, expected increase in storm surge and wave height.

NIWA (2015b) - Nelson extreme storm tide plus wave setup and run-up

Updated joint-probability analysis of storm tide and waves (updated from NIWA, 2012). The Coastal Calculator was developed for NCC to calculate extreme water levels (both static and dynamic) including allowance for sea level rise.

OCEL (2000) - Tahunanui Beach erosion study

Assessment of coastal erosion along Tahunanui Beach including proposed management options. This report identifies coastal erosion occurring at the east end of Tahunanui Beach (adjacent to Rocks Road) and the west end of the beach (Back Beach), and describes coastal processes at Tahunanui Beach. Long-term erosion is assessed based on historical information and analysis of dominant coastal processes. Protection works are proposed based on this analysis.

OCEL (2010) - Tahunanui Beach erosion review

Review of Tahunanui Beach erosion including review of actions undertaken by NCC following the OCEL (2000) report. It was found that the structures that were installed by NCC have enhanced the beach. OCEL further assessed erosion of the back beach and migration of Blind Channel based on historic information and recommend bathymetric surveys to be repeated to monitor shoreline changes. Options to reduce erosion are presented in the report.

OPUS (2015) - Tahunanui Coastal Erosion Study

Review of the managed retreat policy for the shoreline from Tahunanui Beach to the Campground adjacent to the Airport. This was done by assessing coastal processes (erosion rates were assessed based on review of historic shorelines/vegetation lines mapped on an aerial photograph) and reviewing the Policy Development, its impact and application for each coastal management zone. The potential risk management policies by zone and change over time are summarised including recommendations on long-term policies and management measures.

Sissons, D. (2003) – A Brief History of Tahunanui Beach.

Review of changes to the Tahunanui Beach area over time including geomorphological changes from 1850s to present based on analysis of bathymetry and aerial photos, anthropogenic development over this period and projections of future trends. The key points are that the Tahunanui Beach area is a relatively young depositional feature, created when the channel that discharged the Waimea Inlet into Tasman Bay, and which originally ran along the coastline adjacent to Rocks Road, breached the Waimea Bank to the west. The bank tip then welded to the eastern coastline creating the beach

feature. The Blind Channel as it is now known, has been migrating east since towards its original position and eroding the western end of Tahunanui Beach.

Tonkin + Taylor (2013) - Maitai River Flood Hazard Mapping Modelling Report

Tonkin + Taylor have produced flood hazard maps of the Maitai River including a series of 1% AEP rainfall events and a series of hypothetical sunny day dambreak events of the Maitai Dam. Flood hazard maps have been produced using existing LiDAR data and are based on hydraulic model results. The overall model is a combination of a 1D model from the Maitai Dam to the city, and a coupled 1D and 2D model within the urban environment. Flood hazard maps have been produced including flood depths for 1% AEP rainfall events allowing for several future sea level rise scenarios (incl. 1 m SLR to 2100). Results show that Nelson city can expect significant flooding across the lower portion of the urban area purely as a result of the estimated 100% AEP tide event in the year 2100.

Tonkin + Taylor (2014) - Tahunanui Liquefaction Assessment Stage 2 – Assessment of Eastern Margin

Assessment of liquefaction potential of soils across the low-lying flat to gently sloping land at Tahunanui (north-eastern part). This stage follows Stage 1, which indicated the presence of surficial gravel deposits and a reduced thickness of sediments with a high liquefaction potential. Measured ground water levels including allowance of 0.3 m, 0.5 m and 0.8 m future increased ground water levels have been used to calculate liquefaction severity. The future increased ground water level of 0.5 m represents sea level rise to 2050. Machine auger, CPT testing and scala penetrometer investigations indicate variable gravel strength underlain by highly liquefiable sand consistent with Tahunanui Sands. The soils that are predicted to liquefy generally comprise sands to non-plastic silt materials. Visual assessment of samples recovered from the machine auger holes indicates that none of these potentially liquefiable soils are likely to have sufficient plasticity to resist liquefaction.

Tonkin + Taylor (2015) - Nelson City Council – Wakapuaka Floodplain Modelling

Tonkin + Taylor have developed hydrological and hydraulic models for the Wakapuaka Floodplain and catchment to complete floodplain and flood hazard mapping. In addition to catchment flooding, the Wakapuaka Floodplain has been assessed as being prone to coastal inundation due to overtopping of the Boulder Bank along the open coast during extreme tide events. The assessment has considered the effects of sea level rise (0.5 m for 2065 and 1 m for 2115), storm tide (incl. 1% AEP) and wave height predictions, and have determined appropriate combinations of coastal and rainfall extremes to derive inundation mapping for a particular design return event. The coastal overtopping model shows some overtopping during present day 100% AEP events increasing to significant overtopping over the next 100 year and for more extreme events.

Appendix B: Comparison of NZCPS and Nelson Plan

NZCPS (2010)	NCC Draft RPS 2016 and current RM Plan 2007
Objective 5 To ensure that coastal hazard risks taking account of climate change, are managed by: • locating new development away from areas prone to such risks; • considering responses, including managed retreat, for existing development in this situation; and • protecting or restoring natural defences to coastal hazards.	Issue 5.1 notes increasing pressure from urban growth and issue with new and existing development Resource Management Issues R19: identifies risks related to people and property from flooding (river source), coastal erosion and Tsunami. Also mentions SLR noting that this is still a widely debated phenomenon. Issues limited to risk to property and human life and accentuated risk from land disturbance.
Policy 24: Identification of coastal hazards (1) Identify areas in the coastal environment that are potentially affected by coastal hazards (including tsunami), giving priority to the identification of areas at high risk of being affected. Hazard risks, over at least 100 years, are to be assessed having regard to: (a) physical drivers and processes that cause coastal change including sea level rise; (b) short-term and long-term natural dynamic fluctuations of erosion and accretion; (c) geomorphological character; (d) the potential for inundation of the coastal environment, taking into account potential sources, inundation pathways and overland extent; (e) cumulative effects of sea level rise, storm surge and wave height under storm conditions; (f) influences that humans have had or are having on the coast; (g) the extent and permanence of built development; and (h) the effects of climate change on: (i) matters (a) to (g) above; (ii) storm frequency, intensity and surges; and (iii) coastal sediment dynamics; taking into account national guidance and the best available information on the likely effects of climate change on the region or district	Areas potentially affected by coastal hazards are not identified in either the draft RPS or current RM Plan. Tsunami is mentioned as one of the three most potentially damaging hazard events in issue 5.1. Some specific locations (Delaware Bay, Boulder Bank, Monaco and Tahunanui Back Beach) are identified as areas subject to coastal erosion or inundation (Issue 5.1) Appendix 6 The RM Plan has riparian and coastal margin overlays that apply along all coastal margins excluding the port). One of the values of these is hazard mitigation which is described as including flooding, ponding and the low impact management of stormwater. The RM Plan also has an inundation overlay, but it is not clear what this captures (f) Issue 5.1 observes people's actions in putting up defences (sea walls etc.) can have localised effects. (h) issue 5.1 notes this can increase intensity and frequency of events and impact biodiversity. Objective 5.3 planning and development to recognise implications of climate change
Policy 25: Subdivision, use, and development in areas of coastal hazard risk	Objective 5.2 – development to reduce or mitigate risk

NZCPS (2010)	NCC Draft RPS 2016 and current RM Plan 2007
In areas potentially affected by coastal hazards over at least the next 100 years: (a) avoid increasing the risk of social, environmental and economic harm from coastal hazards; (b) avoid redevelopment, or change in land use, that would increase the risk of adverse effects from coastal hazards; (c) encourage redevelopment, or change in land use, where that would reduce the risk of adverse effects from coastal hazards, including managed retreat by relocation or removal of existing structures or their abandonment in extreme circumstances, and designing for relocatability or recoverability from hazard events; (d) encourage the location of infrastructure away from areas of hazard risk where practicable; (e) discourage hard protection structures and promote the use of alternatives to them, including natural defences; and (f) consider the potential effects of tsunami and how to avoid or mitigate them.	Policy 5.2 avoid new subdivision, development and regionally significant infrastructure and community assets in areas of high risk with exceptions (no reasonable alternative for infrastructure, avoidance is impossible/impractical, boundary adjustments) Policy 5.3 mitigate effects on subdivision and developing in non high risk areas – some measures in explanation (e.g. floor levels…) Policy 5.4 for land potentially affected by coastal erosion or inundation over next 100 years, no land use change or redevelopment that would increase risk and encourage that which reduces risk. Objective CM8 is to minimise risk to people, property or other aspect of the environment, through avoidance and mitigation of natural hazards within the coastal environment. CM8.1 applies to activities and structures in the coastal environment, requiring them to be located and designed to take into account - any existing natural hazards - the potential to exacerbate natural hazards - implications of climate change (inc SLR of 06 m and increasing severity storms) Explanation limits scope of concern to people and property. Refers to rules on floor levels CM8.2 Protection works allowed only where they are the best practicable option and positive effects greater than adverse, considering: - probability of them achieving stated purpose - public benefit form use or development protected - regional and national significance of use and development protected - effects of the work on environment, including rate of erosion - effects of not proceeding - measures previously taken, including to avoid the need for works - alternatives to the development and reasons these not proceeded with. Explanation says works a last resort. Likely for existing development, New development should avoid need for works. CM8.4 and CM8.5 on structures and disturbance should not intercept movement or remove so as to increase risk of coastal erosion or accretion. District wide policy DO 2.1.3 not aggravate known or potential hazard on site or other site.

NZCPS (2010)	NCC Draft RPS 2016 and current RM Plan 2007
	District wide policy DO7.1.6 coastal activities, including structure located and designed to take into account - existing natural hazards - potential to exacerbate - implication of future climate change - policy CM8.2 District wide policy DO13A.5.1 environmentally responsive – subdivision and development should consider….responding to SLR
Policy 26: Natural defences against coastal hazards (1) Provide where appropriate for the protection, restoration or enhancement of natural defences that protect coastal land uses, or sites of significant biodiversity, cultural or historic heritage or geological value, from coastal hazards. (2) Recognise that such natural defences include beaches, estuaries, wetlands, intertidal areas, coastal vegetation, dunes and barrier islands.	Policy 5.6 where appropriate protect, re-create or enhance natural features and landforms of regional significance and where they provide protection from natural hazards. Policy 5.7 cultural heritage areas are protected from natural hazards where appropriate. District Wide DO6 notes that riparian and coastal margins may be subject to rapid erosion and accretion and inundation
Policy 27: Strategies for protecting significant existing development from coastal hazard risk (1) In areas of significant existing development likely to be affected by coastal hazards, the range of options for reducing coastal hazard risk that should be assessed includes: (a) promoting and identifying long-term sustainable risk reduction approaches including the relocation or removal of existing development or structures at risk; (b) identifying the consequences of potential strategic options relative to the option of 'do-nothing'; (c) recognising that hard protection structures may be the only practical means to protect existing infrastructure of national or regional importance, to sustain the potential of built physical resources to meet the reasonably foreseeable needs of future generations; (d) recognising and considering the environmental and social costs of permitting hard protection structures to protect private property; and (e) identifying and planning for transition mechanisms and timeframes for moving to more sustainable approaches.	Explanation for Policy 5.2 notes it is not practical to relocate central city and need to adopt a risk tolerance approach. CM8.2 Protection works allowed only where they are the best practicable option and positive effects greater than adverse, considering: - probability of them achieving stated purpose - public benefit form use or development protected - regional and national significance of use and development protected - effects of the work on environment, including rate of erosion - effects of not proceeding - measures previously taken, including to avoid the need for works - alternatives to the development and reasons these not proceeded with. Explanation says works a last resort. Likely for existing development, New development should avoid need for works. CM8.3 temporary works (<5 years) allowed if removable, no permanent adverse effects and are temporary to provide time to prepare and implement a plan to remove or reduce coastal erosion risk without the use of further protection works.

NZCPS (2010)	NCC Draft RPS 2016 and current RM Plan 2007
(2) In evaluating options under (1): (a) focus on approaches to risk management that reduce the need for hard protection structures and similar engineering interventions; (b) take into account the nature of the coastal hazard risk and how it might change over at least a 100-year timeframe, including the expected effects of climate change; and (c) evaluate the likely costs and benefits of any proposed coastal hazard risk reduction options. (3) Where hard protection structures are considered to be necessary, ensure that the form and location of any structures are designed to minimise adverse effects on the coastal environment. (4) Hard protection structures, where considered necessary to protect private assets, should not be located on public land if there is no significant public or environmental benefit in doing so	
Policy 3 Precautionary Approach 1. Adopt a precautionary approach towards proposed activities whose effects on the coastal environment are uncertain, unknown, or little understood, but potentially significantly adverse. 2. In particular, adopt a precautionary approach to use and management of coastal resources potentially vulnerable to effects from climate change, so that: a. avoidable social and economic loss and harm to communities does not occur; b. natural adjustments for coastal processes, natural defences, ecosystems, habitat and species are allowed to occur; and c. the natural character, public access, amenity and other values of the coastal environment meet the needs of future generations.	Coastal Marine Area Policy CM5.1 adopt a precautionary approach to proposed activities, particularly those where the effects of coastal processes on activities or the effects of the activities themselves are as yet unknown or little understood.
natural hazard means any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire, or flooding) the action of which adversely	Issue 5.1 notes that "Natural events become hazardous when they may adversely affect human lives." This is not consistent with the definition in the RMA which includes property and other aspects of the environment.

NZCPS (2010)	NCC Draft RPS 2016 and current RM Plan 2007
affects or may adversely affect human life, property, or other aspects of the environment.	Issue 5.3 identifies impact on Iwi cultural heritage areas. District Wide Objective DO2.1 – adverse effects of hazards on people, property and the environment are avoided or mitigated.
Meaning of effect In this Act, unless the context otherwise requires, the term effect includes— (a) any positive or adverse effect; and (b) any temporary or permanent effect; and (c) any past, present, or future effect; and (d) any cumulative effect which arises over time or in combination with other effects—regardless of the scale, intensity, duration, or frequency of the effect, and also includes— (e) any potential effect of high probability; and (f) any potential effect of low probability which has a high potential impact.	Policy 5.1 – risk-based approach for use, development. Explanation notes focus on consequences and that land use control may be needed for low likelihood events Resource Management Issues R19: identifies risks related to people and property from flooding (river source), coastal erosion and Tsunami. Also mentions SLR noting that this is still a widely debated phenomenon. Issues limited to risk to property and human life and accentuated risk from land disturbance. Objective CM8 is to minimise risk to people, property or other aspect of the environment, through avoidance and mitigation of natural hazards within the coastal environment.

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