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Natural Hazards, Sea Level Rise and the New Auckland Unitary Plan: Implications for Low Lying Coastal Communities

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Abstract

This paper uses the objectives and policies inherent in the New Zealand Coastal Policy Statement 2010 as a template for benchmarking the adaptation strategies contained in the Unitary Plan for Auckland City, New Zealand's largest coastal municipal centre. The research analyses the stakeholder feedback from the public submission section devoted to coastal hazards, and assesses through selected criteria and a rating system, developed in conjunction with literature studies and stakeholder contribution, the degree to which the plan aligns with the policies of adaptation required by this Coastal Policy Statement. A case study tests the effectiveness of the adaptation requirements. Results indicate an appropriate degree of compliance with the relevant adaptation criteria, but that, in order to minimise future disruption, more attention should be given to the long-term planned withdrawal of housing from hazardous coastal situations.

Keywords: Building regulations; Coastal inundation; Sea level rise; Adaptation strategies

Introduction

New Zealand is a small island country with a 15,000 kilometre long coastline. With 65 per cent of its inhabitants living within five kilometres of the sea, the country's wellbeing remains vulnerable to a range of hazard events. These include earthquake and volcanic eruption, but also hazards which are the focus of this paper: increased risk of flooding, land instability and coastal inundation caused by tidal surges exacerbated by rising sea levels as a result of climate change.

Research studies into the effects of global warming and its anticipated effect on sea level rise (SLR) have undergone a significant increase in the last 15 years [1]. These studies have a particular relevance to the New Zealand context. Hall et al., for example, suggests present day sea levels in the United Kingdom could rise by up to 0.69 metres by the year 2080 [2] with damage depending on size and frequency of surge event [3,4]. Studies emanating from Latin America suggest population rise and building development in coastal areas is set to continue alongside rising sea levels and changes to extreme sea levels associated with storms, thereby adding to the risk level [5] and, of course, the cost [6] Peer-reviewed publications such as Rahmstorf (2007), using techniques that relate sea level to historical average temperatures, suggest a rise of 0.55 metres to 1.25 metres, depending upon emission scenarios [7]. Vermeer, Rahmstorf, Horton et al., Grinsted et al., Pfeffer et al., and others range in their estimates of a sea rise level from a low 0.18 metres to a high of 1.6 metres by the year 2100 [8], depending upon the methods used and the various emission scenarios [9-11]. Research studies in New Zealand by the Commissioner for the Environment suggest similar increasing frequencies of 100-year exceedences over time, with Auckland's rise lagging that of other New Zealand cities due to tidal differences [12]. Golledge and Naish et al. suggest the upper limit of SLR projections could be too conservative, with ice sheet melt from Antarctica alone estimated in their modelling to contribute a base sea rise of as much as 0.40 metres by the year 2100 if a maximum global temperature rise of 2 degrees is not maintained. This would result in a significant increase in the Intergovernmental Panel on Climate Change (IPCC) report estimates, which in 2013 estimated a SLR range from a low 0.26 metres to as high as 0.98 metres, depending on the Representative Concentration Pathway chosen [13] Golledge's scenario, (a projection that has a present IPCC low confidence rating due to levels of uncertainly in the modelling of these process-based projections), would, if borne out, result in Antarctic sea-ice melt, ice shelf erosion (and subsequent melt) and a resultant SLR of several metres [13-15].

The environmental, economic and social changes facing cities located near coastlines or major water flows will challenge urban planners and engineers to rethink traditional attitudes to planning the future urban environment. Initiatives are required that both mitigate the increased emissions that exacerbate global climate conditions, and allow the adaptation of policies that minimise the harmful consequences of inadequate mitigation [16]. Studies suggest approaches to infrastructure planning, particularly in the area of water management [17] and in the energy sector [18] that rely on assumptions from the past, are no longer sufficient to meet the increased volatility and risk associated with the supply and demand of essential services. Urban density considerations in the formation of the recently implemented Auckland Unitary Plan (AUP) [19] are but one example of a city trying to mitigate the effects of urban sprawl with new polices that reward increased development density. Studies in Alberta, Canada suggest sustainability benefits and many billions of dollars could be saved both in future capital costs and maintenance costs with such policies [20] provided the proper frameworks for achieving such policies were in place [21].

The AUP was brought about subsequent to the amalgamation of Auckland's seven municipal centres and a regional council into one large "super city" in 2010 (operating under the name "Auckland Council"), and is but a further step in the assimilation process that has

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seen local boroughs merged into small cities, and cities again merge into large metropolitan cities, which Auckland now is. Auckland is to date is the only city to have undertaken such a merger. Other councils continue to debate the benefits of following Auckland's lead. Whilst amalgamation holds some efficiency benefits, research suggests they can be offset by organisational costs and increased detachment from the citizens they seek to represent [22]. The advantages of amalgamation require matching against the United Nation principle of subsidiarity, where "public responsibilities should be exercised by those elected authorities, which are closest to the citizens" [23]. Measures, such as the public submission process, largely obligatory as a consultation process for amended or new legislation at both local and central government level in New Zealand, are an important consideration that should form an integrated part of any local government adaptation process [24] Stakeholder engagement and adaption is a bulwark against detachment and an opportunity for the local populace to have their say in legislative changes that may affect their everyday living. Whilst local government responses to implementing adaptation objectives can vary considerably [25] the findings of Sayce et al. [26] and Pomeroy and Douvere [27] suggest public participation and collaboration processes, at the very least, help to inform and involve a diverse public audience, deepen mutual understanding and assist in ensuring that planning and decision-making is informed by the "needs and interests of the affected communities", whatever they may be. This is particularly the case where the public is included in the consultation process from an early stage [28] as it helps to build local knowledge over time, an important task in the community acceptance of climate change, and which in turn, with sufficient funding and leadership, helps through increased interaction with the policymakers to underpin the legitimacy of the mitigation and adaptation policies adopted [29].

The AUP, which became operative in-part on 15 November 2016 is, like other local authority planning documents, a series of plans that detail how the city or municipal centre will deal with managing the "use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety" [30]. It is, in effect, a single document combining a Regional Policy Statement, a Regional Coastal Plan, a Regional Plan and a District Plan combined into a single document. It is the primary document through which the Unitary Authority meets its obligations under New Zealand's overriding legislation, the Resource Management Act 1991 (RMA), to protect community health and wellbeing from any negative environmental effects arising from poor air quality, excessive noise or vibration, poor quality landfills or earthworks, and the like, and including the main focus of this paper, natural hazards. The AUP, for example, the subject of this benchmarking study, defines its task in the natural hazards section as mitigating in its planning processes "the adverse effects of natural hazards on human life, property, infrastructure and the environment, while minimising the adverse effects of measures implemented to reduce the risks of natural hazards" [31] In the specific areas of coastal management, the RMA requires, amongst other things, local and regional government to give effect to the objectives and policies stated in the New Zealand Coastal Policy Statement 2010 (NZCPS). Within this document are the specific objectives and policies that pertain to coastal hazards local government is required to give effect to. They will in this paper become the base criteria against which the respective natural hazard policies of the AUP are compared [32].

Comparative policy analysis is the systematic study and comparison of public policies and policy-making in different jurisdictions "to better understand the factors and processes that underpin similarities and differences in policy choices." [33]. Effective comparisons can elicit clarity about the determining factors that make for the variations in policy and hence "serve as a foundation for theory-building." [34]. They enable policy makers to draw inferences from the experience of other jurisdictions, and thus help improve the overall quality of adaptation policies across the local government spectrum. Adaptation policies, by their very nature, are dealing with the unknown in an incremental way such that a region's vulnerability, or susceptibility to "negative climate-related impacts" is reduced [35]. All local governments have some scope for formulating localised policy choices, in spite of common restraints such as a lack of capacity, scarce resources and central government placed limitations to their authority. The choices they make provide fertile grounds for comparison [36].

This paper firstly analyses the stakeholder feedback from the public submission section devoted to coastal hazards, and assesses through selected criteria and a rating system the degree to which the AUP aligns with the policies of adaptation required by the NZCPS. A case study tests the effectiveness of the adaptation requirements in mitigating the hazards of climate change for the low-lying coastal urban settlement area selected.

Methods

They are as outlined in Table 1.

Rating system

A four-point (0,1,2,3) rating system outlined in Table 2 assesses the coastal hazard adaptation plan against each of the four outcome criteria. Scores reflect the amount of quantifiable detail present and its relevance to the local area and loosely follow, in format, a more extensive plan evaluation analysis undertaken for the southeast Queensland regional area. The criteria values rate the degree of specificity of a policy to a particular hazard or locality. The more generic or global the objective or policy, the less its assessed value. The more focused the policy on geographically specific risk, the higher the rating. This approach is supported by academic research that suggests good adaptation processes include working with coastal communities to achieve change, understanding existing local risks and vulnerabilities to coastal hazards and identifying and mitigating the most adverse in a flexible process that is open to change through on-going monitoring (Table 2) [37,38].

The comparison evaluates just one section of a multi-sectioned document. The assigned values were the final determination of the writer, but were subject to check and discussion with planners and engineers familiar with critiquing adaptation policies. Whilst the

Criteria	Description
Criterion 1	Significant coastal hazard issues clearly identified and defined.
Criterion 2	New (sub-divisional) developments are located away from areas prone to coastal hazard risks.
Criterion 3	Coastal hazard risks are managed by considered responses, including managed retreat, for existing development in these areas.
Criterion 4	Natural defences to coastal hazards are protected or restored.

Table 1: Outcome criteria.

Rating Value	Description
0	No evidence of criterion in the natural hazard section of the plan.
1	Criterion acknowledged, but lack detail and definition.
2	Criterion mentioned with moderate level of detail, however entirely descriptive and lack local application and analysis.
3	Detailed analysis of criterion is provided addressed in a manner that can be interpreted locally, using a variety of tools such as vulnerability, exposure or risk assessments, maps, fieldwork or GIS analysis.

Table 2: Criteria evaluation system.

values are numerical the evaluation is qualitative in nature. A level of subjectivity within the evaluation process is however, inevitable and is acknowledged.

The findings are organized as follows. Firstly, stakeholder feedback from the public submissions on coastal hazards is presented. This information reveals the substance of the issues that are foremost in the public mind and is a gauge in assessing the level of public support or otherwise for the proposals that are intended to shape the coastal adaptation policies within the AUP. Secondly, the AUP adaptation objectives are compared to the relevant objectives outlined in the New Zealand Coastal Policy Statement 2010. Thirdly, a case study tests the effectiveness of the adaptation requirements in mitigating the hazards of climate change for the low-lying coastal urban settlement area selected.

Results and Discussion

Stakeholder feedback: Natural hazards and flooding

As part of the process to develop the AUP for implementation, Auckland Council created a proposed AUP for public consultation. A range of stakeholder communities and mana whenua (indigenous population) were consulted through a variety of online, face-to-face meetings and media bulletins, with the express aim of soliciting feedback about the proposed AUP. Some 9400 submissions were received across an 11 week consultation period between 15th March and the end of May 2013. Subsequent submissions totaled 3800. Feedback covered aspects of the natural environment such as air quality, noise, vibration, landfills, earthworks, forestry, storm-water and wastewater, to name but a few. Within this feedback, 182 submissions were received against the natural hazards section of the AUP, a small number when considered against the total number of submissions, but considering the size and scope of the plan and the numerous themes, and the fact that climate and climate change is a new emerging issue for most people, a significant number nonetheless. Within this general theme an estimated number of 100 were focused on hazards specifically related to coastal inundation and flooding as a consequence of climate change and predicted SLR [39].

Most submissions accepted the science around climate change was not precise but were nevertheless concerned that future planning takes the science into account. Some were more strident around at-risk land than others, insisting that the AUP be amended simply to "…avoid new development in natural hazard areas." The Auckland Regional Public Health Service took a similarly hard line to new developments:

"Add a policy of managed retreat from areas subject to inundation risks and that new developments not be built in these locations."

New Zealand's Department of Conservation, a government department, took a more 'middle of the road' approach, suggesting subdivision be permitted only where:

"… Subdivision, use and development does not exacerbate the long term risks to people, property and the environment from natural hazards or their effects, taking into account the effects of climate change."

Others were more accommodating, but wanted greater acknowledgement of the dangers coastal inundation posed and a system set in place that ensured the impact was minimised:

"Amend policy 14 as follows: 'Require the finished floor levels of: a. new dwellings and habitable rooms of non-dwellings b. substantial additions, modifications or extensions to existing dwellings c. located in coastal inundation areas to be above the mapped 1 per cent AEP coastal storm tide event plus 1 metre projected sea level rise.' "

All of the major conservation groups that submitted, including the Department of Conservation, the Environmental Defence Society (a non-government organisation) and The Royal Forest and Bird Society of New Zealand (a non-government organisation) expressed the need to avoid hard engineering solutions wherever possible in mitigating the effects of coastal development in land subject to natural hazards and flooding:

"Amend Objective 2 so that it explicitly refers to discouraging the use of hard engineering solutions."

The Environmental Defence Society also supported this objective:

"Add an additional policy which indicates that any residual adverse effects of hard engineering solutions which cannot be avoided, mitigated or remedied will be offset through restoration and enhancement actions that achieve no net loss and preferably a net gain in terms of impacts on natural heritage values of the coastal environment."

Some submissions recognised the rapid pace of change to the science of climate change and emphasised the need for regular review of policies relating to coastal inundation over time:

"Ensure the maps for coastal inundation and flooding areas apply climate change predictions for the next 100 years."

Submissions from individuals focused on climate change and flooding from coastal inundation also reflected the new awareness emerging in the community that the change in the world environment would have a lasting impact on the more vulnerable of New Zealand's coastal regions.

"Adopt policies that will allow buildings to be easily shifted from the site or lifted over the next 50 years if sea levels rise as predicted relates to coastal inundation mapping at Tindalls Beach, Manly and Orewa."

"Adopt policies that will allow a private property owner to contract the council out of any liability or responsibility if sea level rises as predicted [relates to coastal inundation mapping at Tindalls Beach, Manly and Orewa]. This could include registration of a caveat or similar over the title."

Not all submissions were in favour of the natural hazards objectives or policies suggested by the proposed AUP. Some business groupings close to water, such as the Warkworth Area Business Association were apprehensive about the effect the new policies would have on their activities.

"Delete the provisions relating to coastal inundation unless it can be demonstrated by a detailed S32 analysis that application of rules is necessary to manage a resource management issue."

The Ports of Auckland, a key industry within the new Auckland Council, wanted exemption from the policy relating to visual effects on coastal landscape and amenity values

"Amend Policy 8 to replace 'coastal protection works' with 'new coastal protection works', and amend clause (g) as follows long-term adverse visual effects on coastal landscape and amenity values, except in the case of the construction and operation of significant infrastructure."

A summary of the feedback provided within submissions can be illustrated by reference to the following Table 3. A range of Government departments, commercial and professional entities, voluntary organisations and private individuals were among the submitters on coastal hazards Table 4. Most made multiple submissions.

Whilst an overall majority of submitters (approximately 70 per cent) supported the general thrust of the Auckland Council's approach to land subject to natural hazards, particularly with respect to coastal inundation, a proportion of these, approximately 20 per cent, identified as "strong supporters" in Table 3, were critical of what they regarded as an overly timid approach by the Auckland Council in its treatment of development proposals. Many wanted more direct intervention in coastal mitigation to limit future damage and cost to the vulnerable parts of the coastal environment than the Auckland Council was prepared or able to concede. This limitation is discussed further in the commentary associated with Criterion 3 in the evaluation that follows.

Comparative policy analysis: AUP

As stated, the assessment phase of the research included measuring outcomes against the criteria selected in the NZCPS objectives pertaining to the management of key coastal hazard risks as a result of climate change. The criteria selected are summarized in Table 3 with a rating value identified in Table 4.

Criterion 1: Significant issues outlined and hazard identification clearly stated: The AUP natural hazard policies acknowledge the risks associated with their locality, including coastal erosion, coastal inundation, tsunami, land instability, flooding, earthquake and volcanic eruption. A detailed definition of land that may be subject to natural hazards is provided. More specifically, this is land defined as:

a. Within a horizontal distance of 20m from the top of any cliff with a slope angle steeper than 1:3 (18 degrees);

System	Value
Strong support	20%
Support	50%
Neutral	5%
Not supportive	20%
Strong Antipathy	5%

Table 3: Public submission support of AUP adaptation policies.

Type	Number
Government, central and local	9
Commercial and Professional	28
Private Organisations	7
Individual	12

Table 4: Submission demographics.

b. On any slope with an angle greater than or equal to 1 in 2 (26 degrees);

At an elevation less than 3 meters above Mean High Water Spring (MHWS) if the activity is within 20 meters of MHWS.

Any natural hazard area identified with the Council's natural hazard register, database, GIS viewer or commissioned natural hazard study [40].

A base requirement of planning schemes is to augment written information with maps or databases that identify the location and scale of the hazard. In the AUP, the Auckland Council has taken the map technology one step further, with New Zealand's National Institute of Water and Atmospheric Research (NIWA) assigned to instigate a series of digital overlay maps based on cadastral level information which, when overlaid over any base zone map, provide information about the projected extent of coastal inundation within a zoned area. These GIS inundation maps, hazard registers and any additional reports make up the information that identifies land that is subject to natural hazards. The GIS maps provide an instant aerial picture for planners, architects, engineers and the public of the extent of coastal inundation and SLR expected in the housing area so chosen. It represents a considerable advance in digital plan technology (Figure 1).

Criterion 2: New (subdivisional) developments are located away from areas prone to coastal hazard risks: The AUP's policy allows subdivision in certain limited circumstances, contrary to NZCPS objectives, but in all cases requires a full risk assessment of each sub-divisional proposal. Eleven specific criteria are outlined against which the subdivision proposal is measured. These include type, frequency and scale of the natural hazard, type of activity, design and scale, effects on public safety, exacerbation of an existing natural hazard, ease of movement for the building should it be required by severe shoreline retreat and the use and retention of natural landform buffers over hard engineering solutions. All such land requires an engineering assessment to confirm whether the land is, or will be, subject to erosion, inundation or instability over the next 100 years. Such criteria should, if assessed correctly, ensure this Criterion set by the NZCPS is followed.

Criterion 3: Coastal hazard risks are managed by considered responses, including managed retreat, for existing development in these areas: Development of existing land and building in the AUP is subject to the same restrictions as subdivision and new development, namely, an engineering assessment to assess its hazard free status. Failing that, a resource consent is required (special planning permission from the local authority) in which the risk criteria outlined in Criterion Two and applicable to Criterion Three are examined. Should planning consent be given, finished floor levels for dwellings, alterations or extensions to the dwelling(s) located in coastal inundation areas are required to be above the mapped 1 percent AEP storm tide event plus 1.0 metre projected SLR. The issue of "planned retreat" for existing communities is not addressed to any degree of resolution in either scheme, even though consideration is a part of the NZCPS objective and a logical outcome of the RMA focus to "avoid, remedy and mitigate adverse effects" from planning decisions. The prospect of later building removal as a result of future coastal erosion and inundation is implicit in the AUP in that the ability of a building proposal to be relocated in the future would be one of the factors influencing permission to develop or subdivide land [40]. However there is no specific requirement in the present planning scheme for buildings in coastal hazard areas to be relocatable. Absent as a specific policy is the concept of managed retreat, where communities and local government discuss and agree on a long-

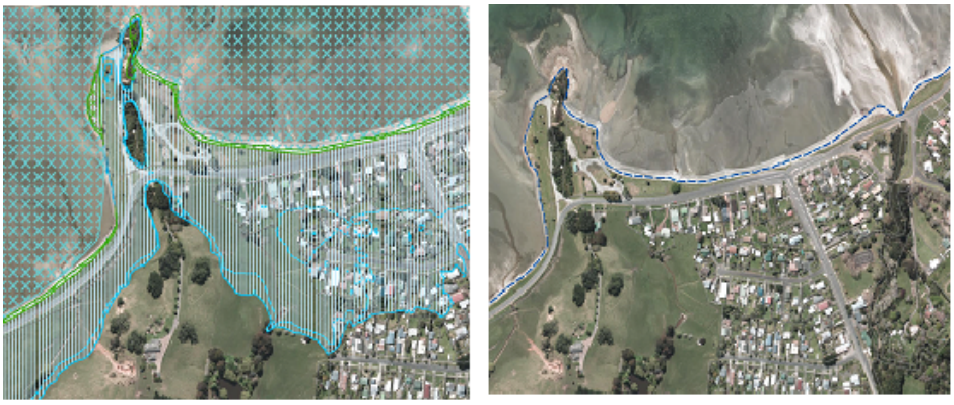

Figure 1: Digital overlay (left) to part Kawakawa Bay map (right) showing extent of coastal inundation predicted for a 1 per cent AEP+1 metre SLR event.

Criteria	New Zealand Coastal Policy Statement 2010	Max Rating	Auckland Unitary Plan	Rating
One	Significant issues outlined and hazard identification clearly stated. Definition of coastal hazard identified.	4	Coastal hazard issues identified and defined. Detailed GIS inundation maps relevant to any stated locality. Floor height formula.	4
Two	New (sub-divisional) developments are located away from areas prone to coastal hazard risks.	4	Subdivision development permitted in hazard situations although subject to risk assessment analysis. Criteria for these outlined. Detailed requirements listed within Ch5.12.of the AUP.	3
Three	Coastal hazards risks are managed by considered responses, including managed retreat, for existing development in these areas.	4	Existing development: New extensions or alterations allowed in restricted circumstances or with Engineer's certificate. Risk assessment analysis required with detailed requirements listed. Floor height defined, general formula. Planned retreat issues *not* addressed for existing buildings.	2
Four	Natural defences to coastal hazards are protected or restored.	4	Hard engineering solutions are permitted to protect development in hazardous coastal areas, contrary to NZCPS criteria. However there are considerable restrictions on what is permitted within these types of solutions.	3
Total Value		16/16 (100%)		12/16 (75%)

Table 5: Comparison summary.

term action strategies to remove building stock from inundation and erosion prone areas. Studies, such as the New Zealand Climate Change Research Institute (CCRI) report, have expressed concern that coastal management at a local authority level in New Zealand, particularly in relation to SLR and its effects is even now, not taken seriously enough, in spite of recent internationally published estimates from researchers such as Rahmstorf [7] and Prefer et al. [11]. CCRI's report expresses the view that existing settlements in low lying coastal areas, as exist in many parts of New Zealand, may have already accepted the inevitability of a coastal adaptation approach that depends on hard engineering stabilization. This approach, whilst it may be appealing in the short-term, will in their view, "decrease community resilience and increase vulnerability in the long term" [41].

Criterion 4: Natural defences to coastal hazards are protected or restored: The AUP requirements allow "non-natural" defences around development in hazardous coastal situations but are quite specific in what is *not* acceptable as a hard engineering solution. For example, such solutions must not "undermine the foundations at the base of the structure, cause erosion in front of, behind or around the ends of the structure, cause settlement or loss of foundation material, movement or dislodgement of individual structural elements, long term loss of sediment from the immediate vicinity or long term adverse visual effects on coastal landscape and amenity values." [40]. Whilst the requirements fall short of the NZCPS criterion, there are safeguards stated about what is acceptable as a hard engineering solution.

Comparison policy analysis summary: The comparison analysis exercise, with the criterion ratings summarised in Table 5, is a first step evaluation to identify both strengths and weaknesses of the natural hazards section of the scheme plan. Such benchmarking may assist in the development of more rigorous adaptation-planning outcomes. The criteria values contained in Table 5 rated the degree of specificity of a policy to a particular hazard or locality. The more generic or global the objective or policy, the less its assessed value. The more focused the policy on geographically specific risk, the higher the rating.

The AUP plan was assessed as meeting Criterion One requirements adequately. Criterion Two and Four fell short of meeting the full intent of the NZCPS requirements, but had sufficient procedures in place as to ensure any deviation from NZCPS requirements was carefully analysed and assessed prior to development approval. Criterion Three required the adaptation policy to consider the issue of managed retreat of existing housing from erosion prone low lying areas future inundation was considered a significant risk. Whilst AUP policy hinted at the need for building typology to take into account this future scenario, there appeared to be no specific policy aimed at any long term resolution of this issue Table 5.

Case Study

The photo on the left in Figure 1 illustrates the calculated extent of coastal inundation in a portion of Kawakawa Bay, a small South Auckland coastal community and the subject of this case study. The area in question was chosen for two reasons. Firstly, a building site within the settlement was the subject of a housing development by the

Operative Plan	Requirement	Minimum Finished Floor Level RL.
Existing Manukau District Scheme Rules Sec 9.9.1.2	0.5 metres above Land and Survey Datum RL 2.90 metres	3.40 metre
AUP Requirements	0.5 metres above 1 per cent AEP plus 1 metre SLR equals 0.5 metre plus RL 2.24 metres plus 1.00 metre	3.74 metre

Table 6: Floor level comparison between legacy district scheme and AUP.

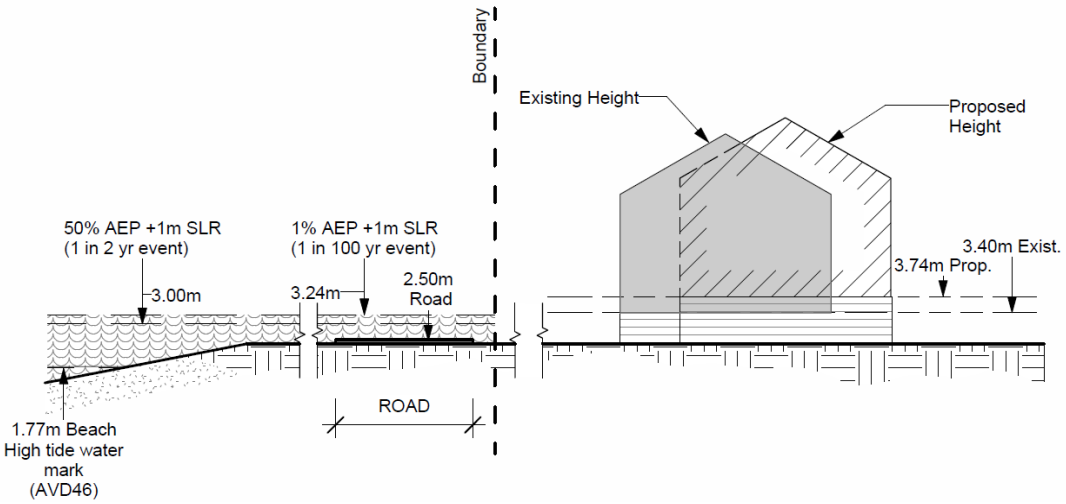

Figure 2: Sea level height comparison: Existing Legacy District Scheme and AUP.

author and secondly, the area surrounding the site in question is typical of a significant number of settlements in Auckland and elsewhere in New Zealand that border low-lying coastal land, differing parts of which are susceptible to natural hazards such as coastal inundation and flooding Figure 1. It is largely flat with a ground level on average at a reduced level (RL) of RL 2.50 metres. Table 3 compares the allowable floor heights under the old legacy plan (Manukau City) [41,42] with the new requirements set by the AUP. This formula sets the new required floor level at a height of RL 1.24 metres above the surrounding land, this height being some 0.33 metres higher than the acceptable floor level height in the old legacy plan.

This formula however takes no account of the foreshore context in which the building site is located. At the site in question in Kawakawa Bay (Figure 2), no buffer exists between sea and section. The road levels remain at RL 2.50 metres above the adopted reference datum, with a small coastal strip then falling away to the beach and tide level. The physical implications of this geography is that even AEP 50 per cent events (i.e. 1 in 2 year storms) with a 1 metre SLR would likely see water levels at RL 3.00 metres, half a metre above the road and the section in question. Hazards unrelated to SLR, such as flooding across overland flow paths coinciding with major storm events, may further exacerbate the extent and depth of flooding, particularly where developments are close to the coast (as is this case study) and the mouths of streams (Table 6 and Figure 2) [43].

Conclusion

The comparative examination undertaken has discussed policy content and scored policy quality within the natural hazards policy section of the AUP planning scheme. The AUP natural hazards section is easy to follow and interpret, with supporting information concise, contained and easily extracted, particularly the GIS mapping feature. Results from the public submission data indicate a moderately high level of public support for the policies. There is close alignment with the NZCPS coastal hazard objectives in most of the rated criterion, the exception being, a lack of community policy connected to the need for long term "managed retreat" from coastal areas where erosion or the low lying nature of the terrain make them particularly vulnerable to inundation. The case study also bears out this conclusion. It suggests that, for Kawakawa Bay and low-lying coastal urban settlement areas elsewhere, there is a gap in the effectiveness of the AUP adaptation requirements in mitigating the long-term hazards associated with climate change. New Zealand has many low-lying coastal settlements that would be affected to a similar degree as that outlined in the case study. The AUP research has shown that for adaptation policies to follow fully the "precautionary approach" required NZCPS, there is a need for a more pro-active stance on the need for long-term coastal retreat measures for the housing sites within this case study and such similar low-lying localities in other parts of New Zealand. It is hence recommended that, in order to minimise future disruption, more attention should be given to further planning and research to ascertain more accurately the strategies required to best assist the long-term planned withdrawal of housing from identified hazardous coastal situations. These strategies should include a greater emphasis on the development of more design-appealing re-locatable dwellings and research to investigate techniques to move building structures free of concrete pads and hence enhance for existing dwellings the possibility of re-location. Above all, there is a need to structure advice and communication at a local authority level to better prepare exposed settlements for anticipated changes to coastal land, and to plan for these. Sustainable solutions to these issues present considerable challenges to local and national government in their quest to enable people and communities to provide for their social, economic, cultural wellbeing and for their health and safety.

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