COASTAL MANAGEMENT CONSULTANCY LIMITED

SECTION 32 ANALYSIS OF CRITERIA TO BE INCLUDED IN THE REGIONAL COASTAL ENVIRONMENT PLAN FOR ASSESSING COASTAL HAZARD AREAS IN THE GISBORNE DISTRICT

Report prepared for Gisborne District Council

October 1994

C.R. 1994/16

200 Rangitane Road
RD1, Kerikeri 0294
New Zealand

Telephone (64) 09 401 6493
Mobile 021 150 0754
Facsimilie (64) 09 401 6463
Email jgibbcmc@ihug.co.nz

DISCLAIMER

Coastal Management Consultancy Limited (the Service Provider) shall have no liability;

i. to any person other than the client to whom the Service Provider's report is addressed; nor,

ii. in the event that the Service Provider's report is used for any purpose other than the specific purpose stated in the report.

TABLE OF CONTENTS

SECTION 32 ANALYSIS OF CRITERIA TO BE INCLUDED IN THE REGIONAL COASTAL ENVIRONMENT PLAN FOR ASSESSING COASTAL HAZARD AREAS IN THE GISBORNE DISTRICT

by

Jeremy G Gibb

1 INTRODUCTION

On 27 June 1994, Gisborne District Council commissioned the author to evaluate the criteria chosen by Council for assessing Coastal Hazard Areas (Appendix I) in order to satisfy the requirements of Section 32 of the Resource Management Act 1991 (S.32 of the Act). Under S.32, Council has a duty to *"consider alternatives, assess benefits and costs, etc... before adopting any objective, policy, rule, or other method"*. For this evaluation the focus is principally on the benefits, limitations and costs of alternative *"methods"*.

Section 32 of the Act requires that a local authority should demonstrate that it has evaluated the chosen criteria with the "principal alternative means available" including the option of "taking no action". The evaluation of alternatives, should include the "reasons for and against" each option, the "likely benefits and costs" and the likely "implementation and compliance costs".

For this analysis, the criteria adopted by Gisborne District Council for assessing Coastal Hazard Areas (Appendix I) are used as the basis for evaluating the potential alternatives according to the general requirements of S.32 of the Act. For the evaluation, the relevant provisions of The New Zealand Coastal Policy Statement 1994 (NZCPS-94) set out below are used as a guideline. Because of its relevance, a brief history is given of Coastal Hazard Mapping in the Gisborne District.

2 COASTAL HAZARD MAPPING IN THE GISBORNE DISTRICT

Coastal Hazard Mapping techniques for New Zealand were conceived, developed, tested and standardised in the then Waiapu County between 1979 and 1980, an area featuring most if not all known natural coastal hazards in New Zealand (Gibb 1981a). Identified hazards included sea and wind erosion, flooding from storm wave runup, tsunami and coastal rivers, and landslip. The standardised Coastal Hazard Mapping techniques, including those for calculating widths of Coastal Hazard Zones, were adopted as policy by the Soil Conservation and Rivers Control Council in March 1981 for the National Water and Soil Conservation Organisation (NWASCO), for nationwide application.

The Coastal Hazard Mapping techniques identified and quantified coastal hazards mostly from existing information supported by field investigations. Criteria were recognised at the time as being different for each section of the New Zealand coast because of the different factors involved. Coastal Hazard Zones were measured as a horizontal distance inland from the seaward toe of a seacliff or foredune, whichever reference shoreline was the most clearly defined along each section of coast. The coastal hazard lines so defined were then fixed in terms of the existing cadastral survey system with respect to property boundaries. For some areas of New Zealand the Coastal Hazards Zones were shown on district planning maps in District Schemes.

In December 1980, the then Cook County Council commissioned the author to assess a Coastal Hazard Zone for Wainui Beach. Using a comprehensive database, a 25 to 55m-wide Coastal Hazard Zone was assessed which comprised a 15m-wide *"Zone of Immediate Risk"* and a 10 to 40m-wide "Zone of Ultimate Risk". The "Zone of Immediate Risk" was extremely susceptible to adverse effects from short-term storm induced sea erosion whereas, the *"Zone of Ultimate Risk"* was susceptible to the long-term rate of retreat. The landward extent of the hazard zone so determined *"represents the line beyond which the shoreline (seaward limit of land vegetation) is not expected to lie in the next 100 years. Any assets within the hazard zone may be destroyed by coastal erosion during the next 100 years (1981-2081)"* (Gibb 1981b).

After a process of public consultation, Cook County Council included the Coastal Hazard Zone on the planning maps of the first review of its District Planning Scheme released in September 1982, which became operative on 1 June 1989. Within the 25 to 55m-wide Coastal Hazard Zone, which was designated as the "Wainui Erosion Hazard Area (WEHA)", the scheme statement prohibited further subdivision of the land and restricted building in accordance with the provisions of Section 641(A) of the Local Government Act 1974. The same restrictions were applied to the "Makorori Erosion Hazard Area (MEHA)" which was delineated on the planning maps of the Cook County District Planning Scheme.

2.1 COMMENT

The all important point to emerge from the above is that the practise of identifying Coastal Hazard Areas in statutory plans is not new to the Gisborne District. Coastal Hazard Zones have been used as instruments since 1980, to both inform the public of the existence and relative intensity of natural hazards, and to control subdivision and development of land subject to, or likely to be subject to, adverse effects from actual and potential coastal hazards.

3 THE NEW ZEALAND COASTAL POLICY STATEMENT 1994

On 5 May 1994, The New Zealand Coastal Policy Statement 1994 (NZCPS-94) was issued by notice in the Gazette (Doc 1994) as part of the statutory functions of the Minister of Conservation under S.28 of the Act. The NZCPS-94 has policies for the recognition of natural hazards and provision for avoiding or mitigating their effects. With respect to natural hazards the NZCPS-94 states on pages 2 and 3 amongst other matters that, "regard shall be had to the following general principles.....":

> *"(7) The coastal environment is particularly susceptible to the effects of natural hazards.*
>
> *(12) The ability to manage activities in the coastal environment sustainably is hindered by the lack of understanding about coastal processes and the effects of activities.*

Therefore, an approach which is precautionary but responsive to increased knowledge is required for coastal management".

The policies in the NZCPS-94 that are particularly relevant for making provision for the assessment of coastal hazard areas and stated on page 9 and are:

Policy 3.4.1

"Local authority policy statements and plans should identify areas in the coastal environment where natural hazards exist.

Policy 3.4.2

Policy statements and plans should recognise the possibility of a rise in sea level, and should identify areas which would as a consequence be subject to erosion or inundation. Natural systems which are a natural defence to erosion and/or inundation should be identified and their integrity protected.

Policy 3.4.3

The ability of natural features such as beaches, sand dunes, mangroves, wetlands and barrier islands, to protect subdivision, use, or development should be recognised and maintained, and where appropriate, steps should be required to enhance that ability.

Policy 3.4.4

In relation to future subdivision, use and development, policy statements and plans should recognise that some natural features may migrate inland as the result of dynamic coastal processes (including sea level rise)."

3.1 COMMENT

In order to satisfy the provisions of both the Act and the NZCPS-94, Local Authority policy statements and plans should make provision for "identifying areas in the coastal environment where coastal hazards exist", or have the potential to exist. Where there is a lack of knowledge and understanding of coastal processes a "precautionary approach" is necessary. Furthermore, it is important to identify and protect natural systems and features "such as beaches, sand dunes, mangroves, wetlands and barrier islands" that act as a "natural defence" from coastal hazards and which may "migrate inland as the result of dynamic coastal processes (including sea-level rise)".

4 EVALUATION OF ALTERNATIVES

For the criteria set out in Appendix I, a minimum of two alternatives is considered ranging from the "principal alternative means available" to the option of "taking no action".

4.1 SEA-LEVEL RISE

Four potentially possible options are considered.

Option I: The Intergovernmental Panel on Climate Change (IPCC) *"high estimate"* of +1.10m by 2100 A.D.

Option II: The IPCC *"best estimate"* of +0.66m by 2100 A.D.

Option III: Projection of the historical rate of sea-level rise for New Zealand of 1.7mm/year to give +0.18m by 2100 A.D.

Option IV: Exclude sea-level rise.

4.1.1 Option I - High Estimate of +1.10m

The major benefit of adopting this option is to completely "err on the side of caution" as suggested by the NZCPS-94. The IPCC "high estimate" recognises the uncertainties surrounding the potential response of the large ice sheets of Antarctica and Greenland and local and regional sea-level effects. The benefits that would accrue from adopting the high estimate would mostly be that potentially large future damage and disruption costs to human subdivision and development would be minimized.

In terms of limitations, the IPCC high estimate, lies at the upper limit of uncertainty in the global projections and therefore, has a relatively low probability of occurrence. To adopt such an uncertain projection could "lock up" desirable land from subdivision and development. There would be lost opportunity costs from restricting land uses and economic activities on such land.

4.1.2 Option II - Best estimate of +0.66m

The major benefit of adopting this option is to acknowledge that it is recognised by international and national scientific experts as being the *"best estimate"* for projected sea-level rise for next century. For the year 2050 A.D. the IPCC best estimate of +0.30m is in close agreement with the NZCCC mid range estimate of +0.26m for the New Zealand region. Such a projection could be considered to have a relatively high probability of occurrence. To adopt the best estimate would also be *"erring on the side of caution"* in compliance with the NZCPS-94, in the light of the best information available. Adequate provision would be made for the protection of future subdivision and development from the potential effects of sea-level rise.

The major limitation is that the linearity of the historical rate of sea-level rise for New Zealand at 1.7mm/year since 1900 suggests there is still an uncertainty as to when the rate will undergo a three-fold acceleration to the projected "best estimate" rate of about 6mm/year. To adopt the best estimate could also lead to lost opportunity costs for the use of coastal lands for intensive land uses such as residential subdivision and development.

4.1.3 Option III - Historical projection of +0.18m

The major benefit of adopting this option is to acknowledge and accept on the basis of a very excellent historical record for New Zealand, that the present historic trend of sea-level rise will continue at the same rate into the future. On this basis more coastal land could be made available for intensive land uses such as subdivision and development.

The costs that could occur from adopting Option III are potentially considerable. The overwhelming scientific consensus on global warming and sea-level rise would be duly ignored on the implicit assumption that the "status quo" climate and sea-levels of the past and present would continue unaffected into the future. The precautionary principle would not be exercised and subdivision and development would be allowed in areas with a potential high probability of suffering adverse effects from a projected accelerated sea-level rise in response to global warming.

4.1.4 Option IV - Exclude Sea-Level Rise

The major reason to adopt this option is to attempt to make a case on the basis of both scientific uncertainty and that periods of major global cooling (Glacial Periods) follow periods like the present of temperate climate (Interglacial Periods). Global cooling would eventually result in a fall in sea-level as the sea became locked up as ice in Antarctica and Greenland. The major benefit of adopting this option would be to utilize relatively more coastal land for subdivision and development and other intensive land uses.

The potential costs of adopting this option could be considerable. The "hard evidence" of both the historic rate of sea-level rise for New Zealand and the international and national scientific consensus by experts for sea-level rise next century would have to be completely ignored. The consequences of ignoring such expert opinion could be disastrous leading to an ever increasing loss of development and infrastructure as time went by and ever increasing costs to be shouldered by the entire community to protect threatened coastal property and assets.

4.1.5 Conclusion

On the basis of the benefits, costs and limitations Option II is recommended for adoption by Gisborne District Council.

4.2 LONG-TERM SHORELINE TREND

Three possible options are considered.

Option I: Assume uniform coastal retreat at some arbitrary rate for all sites.

Option II: Determine the long-term trend from historical surveys data for each site.

Option III: Exclude the long-term shoreline trend.

4.2.1 Option I - Assume Uniform Coastal Retreat

The major benefit of adopting this option would be significant savings on carrying out analyses of historic surveys of the coast. The requirements of the NZCPS-94 could be satisfied by adopting a relatively large erosion rate that would "err on the side of caution". Hazard assessments could be expedited at greater speed and more coastline covered during the time available.

The major limitation would be to ignore the actual long-term shoreline trend at each site. Coasts with a history of advance from accretion or in a state of dynamic equilibrium would be wrongly classified as having a trend of erosion. For eroding coasts the rates range from a few decimetres a year to metres per year. To adopt an arbitrary rate would possibly grossly overestimate a hazard area on very slowly eroding coasts and greatly underestimate the area on very rapidly eroding coasts. Either way, there would be considerable lost opportunity costs or considerable costs to be shouldered by the community.

4.2.2 Option II - Determine the Long-Term Trend

The major benefit of adopting this option is that the assessment of Coastal Hazard Areas would be based on site specific information. This would have greater acceptance by local inhabitants who have witnessed the trend over a long period. There is also a relatively high probability that such a trend will continue and that coasts either advancing, retreating, or in a state of dynamic equilibrium will be confidently identified and accurate long-term rates determined.

The major limitation would be the time and costs spent analysing early cadastral plans, vertical aerial photographs and historical information. Some of the data may be unreliable, especially where there is no record of the reference line adopted by early surveyors to define Mean High Water mark (MHWS). Under these circumstances the rates of shoreline movement may prove to be unreliable.

4.2.3 Option III - Exclude the Long-Term Trend

the major benefit of this option would be cost savings in researching early survey records. There would be an implicit assumption that the coast was totally stable. Subdivision and development could be allowed within close proximity of the beach utilising all available land.

The limitations and costs would be potentially massive. Ignoring the long-term trend on moderate to rapidly eroding coasts would sooner or later result in the damage and destruction of property and assets. There would be ever increasing costs to the ratepayers to protect threatened development. Such development would have to be either relocated or protection works constructed and continually maintained. There would be a high probability of loss of the amenity value of the beach. The requirements of the Act and the NZCPS-94 would be ignored.

4.2.4 Conclusion

On the basis of the benefits, limitations and costs, it is recommended that Option II be adopted by Gisborne District Council.

4.3 TERM SHORELINE FLUCTUATIONS

Three possible options are considered.

Option I: Assume a uniform distance for short-term shoreline fluctuations for every site.

Option II: Determine the short-term fluctuations at each site.

Option III: Exclude the short-term fluctuation.

4.3.1 Option I - Assume Uniform Fluctuation

The major benefit of this option would be to provide significant savings in the time taken to analyse survey data and make field investigations. Adopting a moderately large value would "err on the side of caution", thus satisfying the NZCPS-94. A greater length of coastline could be covered with the funds available.

The major limitation would be to implicitly ignore the extensive variability in short-term shoreline fluctuations known to occur from site to site around the New Zealand coast. On this basis a uniform value could grossly underestimate the true value for some sites and grossly overestimate the value of others. For the former, subdivision and development could be lost as a result leading to a greater burden of cost on the shoulders of the community.

4.3.2 Option II - Determine the Short-Term Fluctuation

The major benefit of this option would utilise site specific information. This would be more readily accepted by the property owners affected by the hazard assessment.

In terms of costs, there would be an outlay to conducting the necessary research. There is always a measure of uncertainty that the short-term fluctuation revealed by such research will occur again. Should the value be overestimated there would be lost opportunity costs for subdivision and development.

4.3.3 Option III - Exclude the Short-Term Fluctuation

The major benefit of this option would be to result in cost savings in research. As above there would be an implicit assumption that the coast was totally stable and without any movement. On this basis, subdivision and development could be allowed within close proximity to the beach.

Adopting this option could be costly in every respect. The fact that most if not all unconsolidated sedimentary shorelines fluctuate in position by a few tens to a few hundred metres would be ignored irrespective of whether they are advancing, retreating or in dynamic equilibrium. By ignoring such movements subdivision and development could extend into the hazard area, thus incurring considerable costs to the community.

4.3.4 Conclusion

On the balance of the benefits, limitations and costs, it is recommended that Option II for each site be adopted by Gisborne District Council.

4.4 DUNE SCARP STABILITY

Three possible options are considered:

Option I: Adopt a uniform value for every site.

Option II: Determine the dune scarp stability factor for each site.

Option III: Exclude the dune scarp stability factor.

4.4.1 Option I - Adopt Uniform Value

The major benefit would be a small savings in survey costs to determine the dune scarp stability factor at each site. The major limitation would be to ignore the fact that there are site specific variations, particularly in the heights of sand dunes and the angle of repose of different grades of sand. This could lead to either an underestimation or overestimation of the hazard area from this factor. Both could lead to lost opportunity costs or to increased costs to the community.

4.4.2 Option II - Determine the Dune Scarp Stability

The major benefit of this option is that this factor would be based on site specific measurements that would reflect local variability. The data required on the heights of the dunes could be utilised for the other factors to be considered for the hazard assessment. In terms of costs, there would be a relatively small amount of time spent conducting the necessary surveys.

4.4.3 Option III - Exclude the Dune Scarp Stability Factor

The major benefit would be a saving in survey costs. Provision to include this factor could simply be made by projecting the entire dune profile landward for the hazard assessment. Similarly the Coastal Hazard Area could be defined by measuring from the dune crest or top seaward edge of the scarp as the reference "shoreline".

In terms of costs, not to take account of the dune scarp stability factor would be to reduce the hazard area by several metres. Such a reduction could result in a small but significant risk to subdivision and development.

4.4.4 Conclusions

On the balance of the benefits, limitations and costs it is recommended that Option II be adopted by Gisborne District Council.

4.5 STORM WAVE RUNUP

Three possible options are considered:

Option I: Determine storm wave runup by empirical methods.

Option II: Determine storm wave runup from field evidence.

Option III: Exclude storm wave runup.

4.5.1 Option I - Determine Storm Wave Runup Empirically

Frisby and Goldberg (1981) developed an empirical method to calculate storm wave runup levels for Onepoto Bay near the East Cape. Runup levels were calculated using 5 components consisting of the predicted astronomical tide, barometric set-up, wind set-up, wave set-up, and wave runup. A prerequisite of using this approach is to have good data for the "design storm" and the gradient of the nearshore and offshore seabed profiles.

The benefits of using this technique are that it is reasonably well established and can provide good estimates provided there are good data. If the data do not exist then assumptions need to be made about the 5 components which may or may not equate with reality. Inevitably, such estimates need to be verified by observations and field evidence. Should reliable field evidence not exist then the technique is useful as a first approximation.

4.5.2 Option II - Determine Actual Storm Wave Runup

The major benefit of this option is that it is based on site specific observations either directly during a severe onshore storm, or indirectly from the levels of flotsam and other material deposited during maximum storm wave runup from past storms. The flood heights attained during such events can usually be discerned as a contour height for flood hazard assessments.

The major limitation of this approach is that the magnitude of storm wave runup from the one-in-100 year storm is likely to be underestimated. This is likely to happen if driftwood marking the effects of such a storm has rotted away over time leaving no evidence. It is thought that hardwoods may have a life of approximately 30 years as driftwood before rotting away.

4.5.3 Option III - Exclude Storm Wave Runup

The benefits of this option would be to allow subdivision and development in low-lying coastal areas thus utilising prime land as close to the coast as practically possible. There would be the implicit assumption that the risk from flooding from the sea would be minimal and would not pose a threat to development.

The likely costs of this option could be potentially large as the East Coast is extremely susceptible to storm wave runup. Developing flood prone areas would inevitably create an ongoing burden of cost on the shoulders of the community.

4.5.4 Conclusions

On the balance of the likely benefits, costs and methodologies it is recommended that Option II be adopted by Gisborne District Council.

4.6 TSUNAMI WAVE RUNUP

Three possible options are considered.

Option I: Adopt a uniform value for all sites.

Option II: Determine Tsunami wave runup from field and historic evidence for each site.

Option III: Exclude Tsunami wave runup.

4.6.1 Option I - Adopt Uniform Height

The benefits of this method would be cost savings on research and field investigations. The worst case scenario could be adopted to determine a flood contour level. If there is a lack of information for a particular site such an approach could be seen to "err on the side of caution", thus satisfying NZCPS-94.

Like similar options discussed above the major limitation of this option would be to either overestimate or underestimate the tsunami wave runup height along the East Coast where there is a history of tsunami erosion and inundation. To ignore the historical record could be to endanger subdivision and development at a cost to the community.

4.6.2 Option II - Determine Tsunami Wave Runup

The major benefit of adopting this option is that it would be based on site specific historical observations. An appropriate contour could be adopted and land uses restricted below such a contour level.

The major limitation of this approach is the historical record which may lack precision. This could lead to a relatively large tsunami being underestimated with severe consequences for development.

4.6.3 Option III - Exclude Tsunami Wave Runup

This option could be justified on the grounds of uncertainty and lack of solid evidence. The major benefit would be to allow subdivision and development in low-lying land close to the coast.

The potential costs of adopting this option could be considerable if low lying areas were inundated during a tsunami.

4.6.4 Conclusions

On the balance of likely benefits, limitations and costs, it is recommended that Option II be adopted by Gisborne District Council.

4.7 WIND EROSION

Three possible options are considered:

Option I:	Assume all sand dune complexes are extremely sensitive to wind erosion.
Option II:	Determine the extent of wind erosion for specific sites from observations.
Option III:	Exclude wind erosion.

4.7.1 Option I - Assume All Sand Dunes Are Wind Erosion Prone

The major benefit of adopting this option is that the extent of dune sands on the coast could be uniformly mapped from vertical aerial photographs. Implicit in this option is the assumption that at some stage all the dunes will be subject to wind erosion.

The major limitation of adopting this method is that there are other factors that significantly reduce potential wind erosion. These include soil development, vegetation cover and land use. To adopt such a simplistic approach could result in severe restrictions on potential intensive land uses thereby denying the realisation of the economic potential of the land.

4.7.2 Option II - Determine Extent of Wind Erosion

The major benefit of adopting this option is that the extent of bare ground representing wind eroded areas can be mapped. Having such information managerial practices can be easily costed and implemented to mitigate such areas.

The major limitation is that such an approach is only a snapshot in time. The aerial photographs from which the "snapshot" was taken may well be out of date by several years.

4.7.3 Option III - Exclude Wind Erosion

Provided no other hazards apply, the major benefit of adopting this option would be to make all sand dunes available for a range of intensive land uses and development. The major cost would be if inappropriate development instigated severe wind erosion. Such erosion could damage and destroy property and assets creating a significant cost to the community.

4.7.4 Conclusion

On the balance of likely benefits, costs and methodologies it is recommended that Option II be adopted by Gisborne District Council.

4.8 NATURAL COASTAL FEATURES AND LITHOLOGY

Two possible options are considered.

Option I: Determine the Extent of Natural Coastal Features and the Lithology.

Option II: Exclude Natural Coastal Features and Lithology.

4.8.1 Option I - Determine Extent of Natural Coastal Features and Lithology

The major benefit of this option is to provide a record of coastal features and lithologies that are important at either protecting land from the effects of natural hazards or contribute to them though inherent structural weaknesses. Knowing the extent of these features and lithologies is useful for determining appropriate land uses that allow the natural functioning of the coast to continue.

The potential costs would not be high as most of the mapping and recording would be based on existing information including aerial photographs.

4.8.2 Option II - Exclude Natural Features and Lithology

The only benefit for adopting this option is a minor savings in costs to record the extent of the natural features and lithologies. To adopt this option would be to ignore the requirements of the NZCPS-94 and the contributions such features make toward the stability of the coast and protection of the coastal hinterland.

4.8.3 Conclusions

On the balance of the likely benefits and costs it is recommended that Option I be adopted by Gisborne District Council.

4.9 SAFETY FACTOR

Three possible options are considered.

Option I: Determine a safety factor that allows for uncertainties in all factors used to assess Coastal Hazard Areas.

Option II: Determine safety factors for selected factors used to assess Coastal Hazard Areas.

Option III: Exclude the safety factor.

4.9.1 Option I - Determine Safety Factor for all Factors

The major benefit of adopting this option is that judgement can be clearly separated from factual observation for each factor used to assess a Coastal Hazard Area. Such practice would allow likely auditing of the basis of Coastal Hazard Area assessments. It also provides both consistency and flexibility for making such assessments for various coastal sites. Where data have either strengths or deficiencies, the safety factor will reflect these so that the hazard areas will be proportionately smaller or larger.

The major limitation is that the impression could be given that there is uncertainty for all the factors used in the Coastal Hazard Area assessment. In terms of cost a minor amount of time would be required to calculate the relative errors of each factor to determine the safety factor. Another possible limitation is that the relative safety factor value given to each of the factors used to assess the hazard area would be smoothed and lost into one final value.

4.9.2 Option II - Determine Safety Factor for Selected Factors

The major benefit of adopting this option is that a safety factor could be applied to selected factors used to assess Coastal Hazard Areas where uncertainty existed. For other factors with a relatively high degree of reliability a safety factor would not be applied, thus making the relative reliability of each factor very clear at the outset.

The major limitation is the lack of consistency and subjective choice of which factors the safety factor should be applied to. This could lead to a tendency to favour one factor ahead of all others. There would be the implicit assumption that those factors to which no safety factor had been applied were extremely reliable with insignificant variability.

4.9.3 Option III - Exclude the Safety Factor

The major benefit of this option is to simplify the coastal hazard assessment. It would also give a clear impression to the public that the factors for the Coastal Hazard Area assessments were extremely reliable with no significant variability.

The major limitation is that this is simply not the case. Previous assessments have revealed considerable variations in the reliability of data used for each of the factors. Also there is a high probability of considerable variations from site to site. By not including a safety factor there is a high probability of poorly judged estimates of hazard areas which could ultimately result in greater costs to the community.

4.9.4 Conclusions

On the balance of benefits and limitations it is recommended that Option 1 be adopted by Gisborne District Council.

4.10 REFERENCE SHORELINE

Three possible options are considered.

Option I: Adopt Mean High Water Springs (MHWS).

Option II: Adopt a natural feature.

Option III: No reference shoreline.

4.10.1 Option I - Adopt MHWS

The major benefit of adopting this boundary as the reference shoreline for Coastal Hazard Area assessments is that it is consistent with the Resource Management Act 1991. It also has the advantage of complying with professional survey standards by adopting the MHWS elevation relevant to a particular site and then surveying this contour along the coast. On this basis, the option is internally consistent.

The major limitations are the survey costs and the inherent instability in the line of MHWS. The costs would involve registered surveyors carrying the MHWS level from a known benchmark to the site and then surveying that level along a selected part of the coast subject to considerable wave action and other coastal processes. Such a method would be extremely time consuming particularly on difficult terrain such as rocky shorelines. There are considerable uncertainties in the exact level of MHWS around New Zealand which make it difficult to justify the survey costs. Also, the line of MHWS is very unstable, changing daily from a few metres to many tens of metres. The effect of such changes could be to diminish the width of Coastal Hazard Areas significantly.

4.10.2 Option II - Adopt a Natural Feature

This option involves adopting the seaward toe of the foredune or seacliff or seaward edge of the berm crest for a gravel beach ridge. The major benefit of this option is that the reference shoreline can be easily defined in the field by staff with relatively little expertise resulting in major cost savings. Another benefit is that these natural features are relatively stable and not subject to the same degree of horizontal movement as MHWS.

The major limitations are in areas where these natural features are not clearly defined in the field or on aerial photographs. In such cases judgements are likely to lead to significant errors in positioning these reference shorelines. Notwithstanding, where such difficulties exist provision for accommodating the errors can be made in the safety factor.

4.10.3 Option III - No reference Shoreline

There are no known benefits associated with this option. However, there are many limitations the most obvious of which is that without a reference shoreline it is impossible to define a Coastal Hazard Area.

4.10.4 Conclusions

On the basis of benefits and limitations it is recommended that Option II be adopted by the Gisborne District Council.

4.11 PLANNING HORIZON

Three options are considered.

Option I: Planning horizon of 100 years.

Option II: Planning horizon of 50 years.

Option III: Exclude the planning horizon

4.11.1 Option I - 100 Years

The major benefits of adopting this option are that a 100 year period generally encompasses the minimum period of occupation of property on the coast and the minimum useful life of residential buildings and services provided they are regularly maintained. It also allows for the cumulative effects of a slowly accelerating rise in sea-level, recurrence of severe onshore storms with a one-in-100 year frequency, long-term fluctuations in sediment supply and the recurrence of episodic short-term shoreline fluctuations.

The major limitation is that scientific uncertainty in factors such as sea-level rise, storminess and other coastal processes increases with time. There are also uncertainties with coastal developments in terms of potential changes in land use. Adopting a period of 100 years means that a Coastal Hazard Area will have a proportionately greater width than adopting a lesser period. A consequence of these limitations is lost opportunity costs for developing coastal land.

4.11.2 Option II - 50 Years

The major benefit of adopting this option is that it is at the limit of what could be considered acceptable scientific uncertainty by some members of the science profession. A 50-year period could also be perceived as being reasonable in terms of the requirements of Resource Management Act 1991 for sustainable management.

The major limitation is that history has shown that a planning horizon of 50 years falls well short of the reality of the actual occupation life of coastal developments. Many were developed last century and still exist today. The other limitation is that this option duly ignores the fact that the international scientific community has adopted the year 2100 A.D. for its assessments of climate change and associated impacts on the coast.

4.11.3 Option III - Exclude Planning Horizon

There are no known benefits associated with this option. Implicit in the assessment of Coastal Hazard Areas is the process of forecasting likely positions in the shoreline next century. To exclude a planning horizon would be to negate the planning process in total.

4.11.4 Conclusions

On the basis of the benefits and limitations it is recommended that Option I be adopted by the Gisborne District Council.

4.12 RISK ZONATION

Three options are considered.

Option I: Determine Extreme, High and Moderate risk zones, and Safety Buffer Zone.

Option II: Determine Immediate and Ultimate risk zones.

Option III: Exclude risk zonation.

4.12.1 Option I - Extreme, High and Moderate Risk Zones and Safety Buffer Zone

The major benefit of this option is to provide a refined planning and management tool for selectively controlling subdivision, development and use of coastal land in a Coastal Hazard Zone and to inform property owners of the relative risk to their properties and assets from coastal hazards. A wider range of policies and strategies would be available to coastal planners and managers to remedy, mitigate or avoid the actual and potential adverse effects of coastal hazards within each of the risk zones.

The major limitation is the potential to create alarm in the minds of the public, especially those living in the zones of Extreme and High risk. Within these zones properties are likely to be devalued significantly causing frustration to property owners. There may also be potential difficulties with insuring assets at reasonable premiums in Extreme and High risk zones owing to the high probability of damage or destruction to buildings at some time within their economic life.

4.12.2 Option II - Immediate and Ultimate Risk Zones

The major benefit of this option is that it was adopted by the Cook County Council in 1981 for the Wainui Coastal Hazard Area. As such, the precedent set could be adopted elsewhere. The use of just two risk zones separates an area of high probability of exposure to risk from an area of moderate probability of such exposure.

The major limitation of this option is that it ignores the evolution of Coastal Hazard Mapping in New Zealand which now includes the risk zones defined in Option I.

4.12.3 Option III - Exclude Risk Zonation

The major benefit of this option is to have one simple Coastal Hazard Line defining a Coastal Hazard Area. Within such an area various restrictions can be applied to subdivision and development and appropriate land uses adopted. The line can easily be shown at low cost on the planning maps.

The major limitation of this option is that it ignores the fact that the land included in a Coastal Hazard Zone is subject to, or is likely to be subject to various degrees of risk from coastal hazards, the greatest degree of risk being closest to the sea. This option removes the opportunity to provide appropriate policies, rules and restrictions to property and assets at relative degrees of risk within a Coastal Hazard Zone.

4.12.4 Conclusions

On the basis of the benefits, limitations and costs it is recommended that Option I be adopted by the Gisborne District Council.

5 CONCLUSION

On the balance of the benefits, costs and limitations the criteria chosen by the Gisborne District Council for assessing Coastal Hazard Areas, described in Appendix I of this report, are found to be the most reasonable and practical alternatives for the types of natural hazards encountered along the Gisborne District coast.

6 REFERENCES

DoC, 1994: New Zealand Coastal Policy Statement 1994. *Department of Conservation, Wellington:* 26p.

Frisby, R.B. and Goldberg, E., 1981: Storm wave run-up levels at Onepoto Bay, East Coast, North Island, New Zealand. *In*: Gibb, J.G. Coastal hazard mapping as a planning technique for Waiapu County. *Water & Soil Technical Publication, 21*: 63p.

Gibb, J.G., 1981a: Coastal hazard mapping as a planning technique for Waiapu County, East Coast, North Island, New Zealand. *Water & Soil Technical Publication 21*: 63p.

Gibb, J.G., 1981b: *Assessment of a Coastal Hazard Zone for Wainui Beach, Gisborne.* Unpublished Water & Soil Directorate report to Cook County Council: 40p.

IPCC. 1990: *Scientific Assessment of Climate Change*. WMO/UNEP Intergovernmental Panel on Climate Change, Geneva.

NZCCC, 1990: *"Climate Change: Impacts on New Zealand"*: New Zealand Climate Change Programme, Ministry for the Environment, Wellington.

APPENDIX I

STANDARDS AND CRITERIA FOR ASSESSING COASTAL HAZARD AREAS ALONG THE GISBORNE DISTRICT COAST

Coastal Hazard Areas within the Gisborne District will be assessed in two stages. First, an initial assessment of *Areas Sensitive to Coastal Hazards* for medium priority sections of coast. Second, a detailed assessment of *risk* within *Coastal Erosion Hazard Zones,* for *high* priority sections of coast. Priority ranking will be determined by Council staff according to the level of existing development at risk and/or the attractiveness, potential or suitability of the coastal area for future development.

A. INITIAL ASSESSMENT OF AREAS SENSITIVE TO COASTAL HAZARDS

For *medium* priority sections of coast, an initial assessment of *Areas Sensitive to Coastal Hazards* (ASCH) will be made for the major identified natural hazards of *erosion, landslip and flooding*. The basis for the assessment will be a *Coastal Hazards Database* incorporating a standardised *Coastal Sensitivity Index* (CSI) technique for ranking sections of coast with different sensitivities to coastal hazards. The CSI is determined by integrating information from the following 8 physical variables.

CSI = **elevation + storm wave runup + gradient + tsunami runup + lithology + landform + horizontal trend + short-term fluctuation**.

The 8 physical variables that comprise the Coastal Hazards Database including CSI values from 1 to 5 are set out in the following Table:

CLASS VARIABLE	**1 Very Low**	**2 Low**	**3 Medium**	**4 High**	**5 Very High**
Elevation above MHWS (m)	>20.0	20.0-10.1	10.0-5.1	5.0-2.0	<2.0
Max. Storm Wave Runup Level above MHWS (m)	<1.0	1.0-1.5	1.6-2.5	2.6-5.0	>5.0
Gradient (deg)	>20	20-11	10-6	5-2	<2
Max. Tsunami Wave Runup Level above MHWS (m)	<0.5	0.5-1.5	1.6-4.0	4.1-10.0	>10
Lithology					
Igneous	Plutonics. Intrusives.				
Metamorphic	Metamorphics (high to medium grade).	Low grade metamorphics.	Sheared metamorphics.		
Volcanic	Volcanics (lava, dikes).	Very densely & densely welded ignimbrites. Volcanic breccia.	Partially welded ignimbrite.	Non-welded ignimbrite. Consolidated volcanic ash. Lahars.	Unconsolidated volcanic ash.
Sedimentary		Densely indurated sedimentary rocks (greywacke, solid argillite). Well cemented, sedimentary rocks (limestones, quartzite).	Moderately indurated sedimentary rocks (sandstones argillite, conglomerate).	Weakly indurated sedimentary rocks (mudstones, weak argillite, weak conglomerates). Relict sands. Lignite. Loess.	Unconsolidated sediments (colluvium, alluvium, gravels, sands, silts, muds). Peat. Swelling bentonites.
Natural Landform	Very hard rock platforms & sea cliffs	hard rock platforms & sea cliffs	Moderately hard rock platforms & sea cliffs Moraines	Soft rock platforms & sea cliffs. Alluvial deltas. Saltmarsh/ mangroves.	Sand barriers, beaches, dunes & spits. Gravel barriers, beach ridges & spits. River mouths. Cuspate forelands.
Long-term Trend (m/year)	>+0.50 Advance	+0.50 to -0.02	-0.03 to -0.49	-0.50 to -2.00	>-2.00 Retreat
Short-term Fluctuation (m)	<2	2-5	6-10	11-30	>30

The CSIs will be derived by numerically integrating the 8 variables and ranking the number so obtained into one of the 5 sensitivity classes listed in the following Table:

Very Low	Low	Medium	High	Very High
8-13	14-20	21-27	28-34	35-40

Flooding

The extent of land subject to inundation by the sea and/or coastal rivers will be delineated by the contour above MSL, below which land has a high probability of being flooded by of either maximum *storm wave runup* during a one-in-100 year storm or maximum *tsunami wave runup*, coupled with rising sea-levels.

Storm Wave Runup

Is the *Maximum* elevation above MHWS of wave runup attained during a severe onshore storm with a frequency of occurrence of approximately one-in-100 years, determined by:

- Measurements made from field, anecdotal and historical evidence.

Tsunami Wave Runup

Is the *maximum* elevation above MHWS of runup attained during a local or distantly generated tsunami observed during the last century, determined by:

- Measurements recorded in published scientific papers and anecdotal evidence.

Landslip

The extent of coastal slopes subject to landslip will be identified on vertical aerial photographs and used as a basis to define ASCH widths.

Photomaps

ASCH widths will be defined on GDC Photomaps at 1:5,000 Scale, based on aerial surveys made in May 1993.

B. COASTAL EROSION HAZARD ZONE ASSESSMENT

Coastal Erosion Hazard Zones (CHZ) subdivided into *Risk Zones* and a *Safety Buffer Zone* will be assessed for the high priority areas known to be adversely affected by the identified natural hazard of sea and wind erosion, and will be based, where appropriate, on the following combination of factors:

CHZ = [(X + R) T + S + D] F + L

Where:

Factor X

Is the *Rate* in metres per year of shore retreat in response to local relative sea-level rise, determined by:

- The standardised Bruun Rule.
- Standardised estimates for potential sea-level rise by 2050 and 2100 A.D. by the New Zealand Climate Change Committee (NZCCC) and the Intergovernmental Panel on Climate Change (IPCC).
- Subtraction of local and regional effects from the projections of global sea-level rise by the NZCCC and IPCC.
- Identification of the seaward limit of onshore-offshore beach sediment movement from field evidence.

Factor R

Is the *Rate* in metres per year of long-term (historic) net shoreline advance, retreat or dynamic equilibrium for sand and gravel shores and seacliffs, determined from:

- Coastal Resource maps at 1:5,000 and 1:2,500 Scales.
- Analysis of Cadastral and Vertical Aerial surveys spanning the last century for areas not covered by the Coastal Resource maps.

Factor T

Is the *Planning Horizon* in years extending from the present up to the year 2100 A.D. for which CHZ assessments will be made.

Factor S

Is the *Magnitude* in metres of either the *maximum* recorded short-term historic shoreline fluctuation along coasts of sand or gravel, or the *maximum* extent of land that has failed from past or present landslides along seacliffs of relatively consolidated rock, determined from:

- Coastal Resource maps at 1:5,000 and 1:2,500 Scales and Photomaps at 1:5,000 Scale.
- Analysis of survey, anecdotal and historical records.

Factor D

Is the *Magnitude* in metres of retreat of the top seaward edge of the erosion scarp cut into sand dunes as a result of slumping to attain a stable slope, determined by:

- The angle of repose of dry loose dune sand.
- The height of the dunes above Mean Sea Level (MSL).

Factor F

Is the *Safety Factor* that is expressed on a scale from 1.0 (0%) to 2.0 (100%), determined by:

- Averaging the sum of the errors for Factors **R**, **X**, **S** and **D**.

Factor L

Is the *Horizontal* distance of representative, relatively unmodified natural features such as the beach, shore platform, foredune complex or primary gravel beach ridge. Such features provide a natural protection of the land from coastal hazards and will be determined by:

- Measurements made in the field and from sequential vertical aerial photographs.

Risk Zonation

The CHZ will be subdivided into *Extreme, High and Moderate Risk Zones* and a *Safety Buffer Zone*. The *Extreme Risk Zone* lies adjacent to the coast and encompasses the area subject to high impact short-term shoreline fluctuations. The *High Risk Zone* lies adjacent and landward of the Extreme Risk Zone and encompasses the area subject to potential sea and wind erosion, flooding or landslip with a high probability of occurring between now and the year 2050 A.D. The *Moderate Risk Zone* lies adjacent and landward of the High Risk Zone and encompasses the area subject to potential sea and wind erosion, flooding and landslip with a high probability of occurring during the period 2050 to 2100 A.D. The *Safety Buffer Zone* lies adjacent and landward of the *Moderate Risk Zone* and allows for uncertainties in the CHZ assessment.

Reference Shorelines

The CHZ width will be measured landward from the seaward toe of the foredune or seacliff, top seaward edge of the storm berm on gravel beach ridges, or the line of MHWS were precisely defined by standard survey methods.

Wind erosion

The extent of sand dune complexes subject to wind erosion will be determined from sequential vertical aerial photographs by mapping the degree of wind erosion expressed on a scale from 0 (None) to 5 (Extreme), on the basis of percentage area of bare ground defined as follows:

Degree of Erosion		**Percentage of Bare Ground**
None	0	No significant erosion
Slight	1	1 – 10
Moderate	2	11 – 20
Severe	3	21 – 40
Very Severe	4	41 – 60
Extreme	5	>60