ASSESSMENT OF COASTAL PROCESSES AND COASTAL HAZARDS AT RIVERSDALE BEACH, WAIRARAPA

*

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WAYNE HASTIE

WELLINGTON REGIONAL COUNCIL

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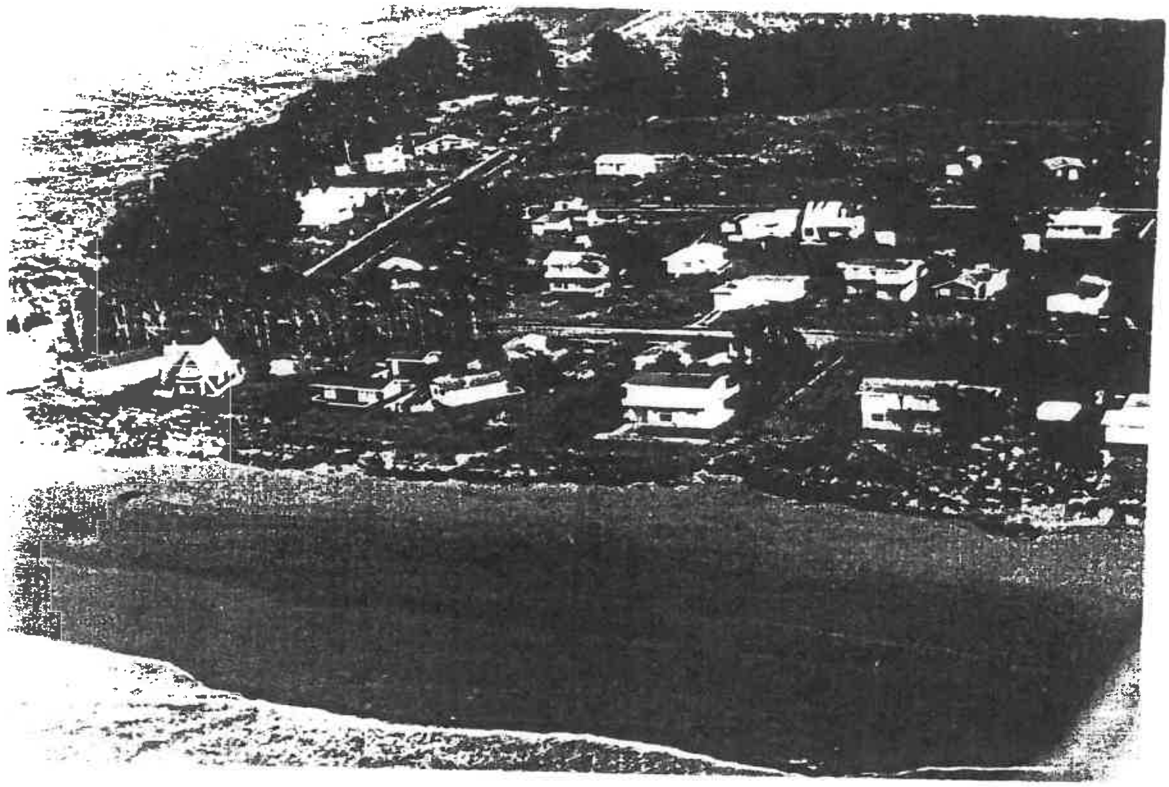


PLATE 1: Debris from the sea left lying on Sunrise Way up to Blue Pacific Parade after the July 1985 storm.

Assessment of Coastal Processes and Coastal Hazards at Riversdale Beach, Wairarapa

Introduction

Riversdale Beach resort is located on the Wairarapa east coast about 115 km NE from Wellington City and about 40 km SE of Masterton in terms of straight line distances (Figure 1). The resort was first subdivided in 1953 followed by extensions southward and westward in 1960, 1965 and 1970. There are now 87 beach front properties fronting 1.8 km of the 4 km long sandy Riversdale Beach. In total, the present-day capital value of these properties is about $8.81 million, the average price of a property being $102,441 but ranging up to $189,000 (1990 Valuation figures).

Many of the beach front properties are susceptible to the hazards of coastal erosion and inundation from the sea. During the winter of 1974, severe S-SE storms removed 15-20 m of foredune from the beach front. A further reminder of the vulnerability of the beach front properties to coastal erosion and inundation from the sea occurred during a severe storm on 26-27 July 1985. The July 1985 storm eroded most if not all of the coastline in the area. Slabs of sandstone up to 1 m in length were smashed off shore platforms by storm waves and deposited on the upper beach and foredune at Uriti Point, a very exposed area. At Riversdale a storm tide of unknown magnitude resulted in overtopping and breaching of the foredune causing extensive flooding of dune swales and structural damage to at least two houses. Flooding extended back to Blue Pacific Parade, a distance of some 100 m from the beach (Plates 1,2 & 3). Properties at the northern end of the beach suffered the most damage and the Motels had 50 mm to 80 mm of seawater around them which seeped under doors soaking carpets. By comparison houses at the southern end of Riversdale suffered little or no damage apart from minor flooding.

The beach front properties at Riversdale remain susceptible to the hazards, and the threat may increase due to the predicted rise in sea levels as a result of the Greenhouse Effect.

Following the 1974 storm events, the Wairarapa Catchment Board (now Wellington Regional Council (WRC)), commenced beach-profile surveys at the southern end of Riversdale Beach. In November 1976 the WRC established three beach-profile sites at southern Riversdale and commenced monitoring the beach and foredune approximately on a monthly basis. Following discussions in 1981 with Dr Jeremy Gibb, of the Water and Soil Directorate of the Ministry of Works and Development, the beach-profile survey was extended in April 1982 to cover the present 13 sites shown in Figure 1. Additional investigations were carried out by WRC staff during 1983 and 1985 under the guidance of the Dr Gibb who subsequently compiled a report titled "Preliminary Assessment of Coastal Processes and Coastal Hazards At Riversdale Beach, Wairarapa East Coast, North Island, New Zealand" (1986). Apart from monitoring beach and dune movements the main object of the investigation was to assess hazards and develop an appropriate management strategy.

This current report completes the preliminary work undertaken by Dr Gibb. Potential hazards are assessed, and recommendation made for future management of the area, including both physical measures and planning standards.

PLATE 2: Foredunes truncated at Riversdale Beach after the 1985 storm

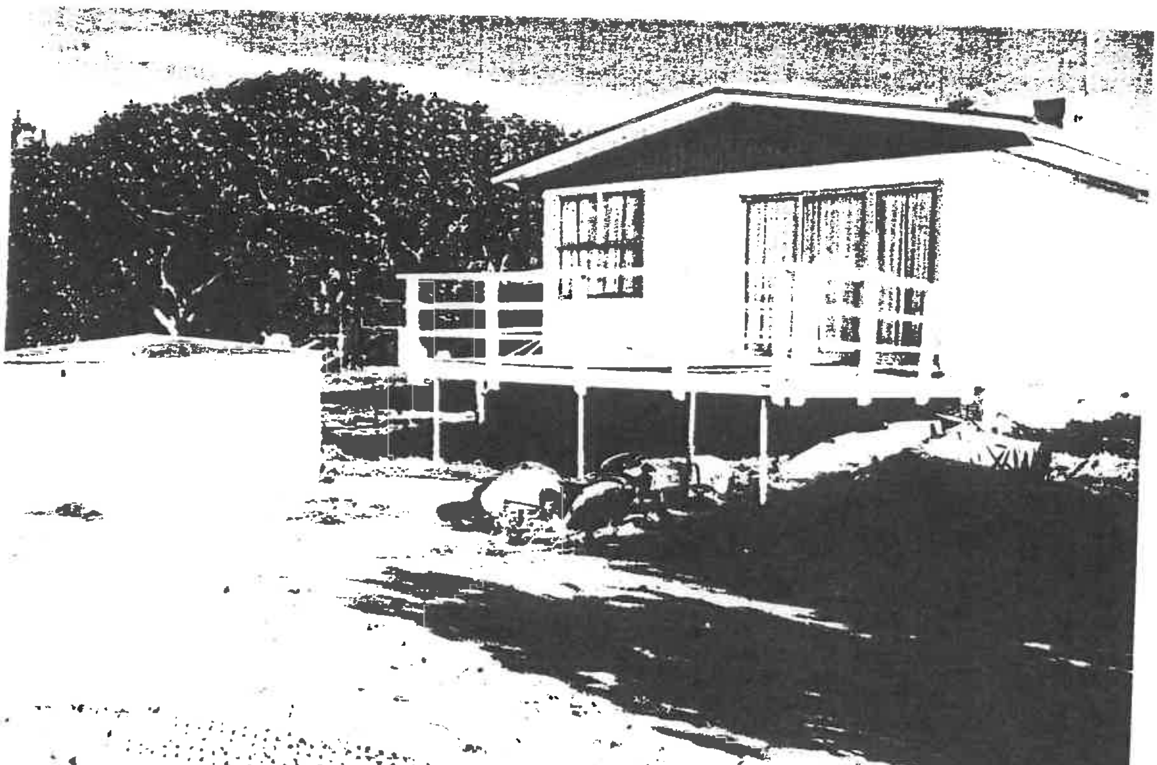
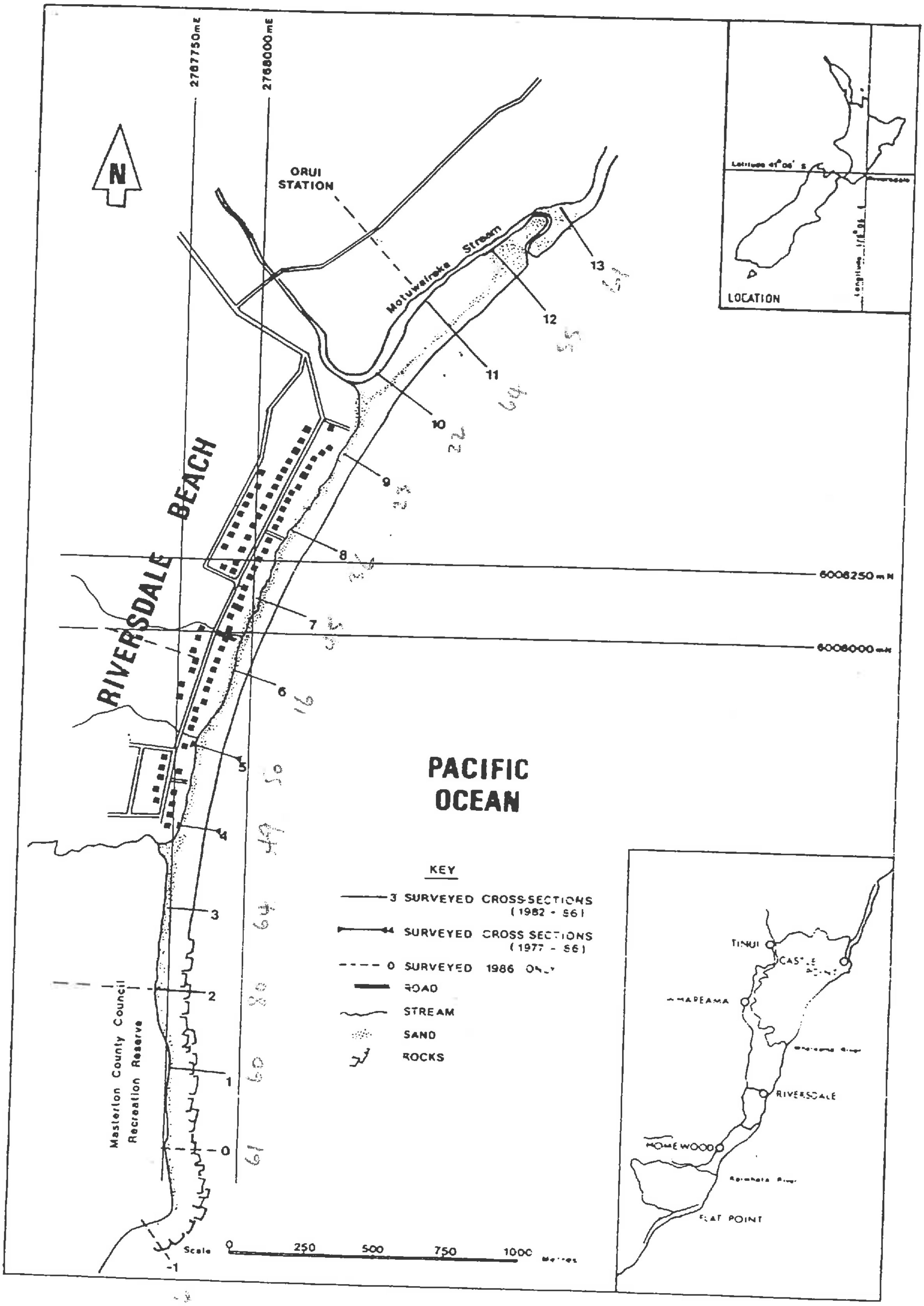


PLATE 3: Tractor inundated by the sea and buried by sand after the 1985 storm

FIGURE 1


N
2787750mE
2788000mE
ORUI STATION
Motuwaireka Stream
RIVERSDALE BEACH
PACIFIC OCEAN
6008250mN
6008000mN
-1
0
1
2
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4
5
6
7
8
9
10
11
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13
Masterton County Council Recreation Reserve
Scale 0 250 500 750 1000 Metres
KEY
3 SURVEYED CROSS-SECTIONS (1982 - 86)
SURVEYED CROSS SECTIONS (1977 - 86)
0 SURVEYED 1986 ONLY
ROAD
STREAM
SAND
ROCKS
LOCATION
TINUI
CASTLE POINT
WHAREAMA
RIVERSDALE
HOMEWOOD
FLAT POINT

2. Hazard Assessment

As noted previously, the main coastal hazards at Riversdale Beach are inundation from the sea and coastal erosion.

2.1 Inundation

Assessments of the potential inundation hazard at Riversdale have been based on a knowledge of the general topography of the area, and on past inundation events. Low spots in the frontal dunes enable seaward penetration of sea water, making all of the land seaward of Blue Pacific Parade potentially at risk. Roads such as Sunrise Way and Karaka Ave have been cut through the foredunes. In July 1985 the sea washed up these roads, almost to Blue Pacific Parade. The first photograph (plate 1) shows the debris left on Sunrise Way which runs off Blue Pacific Parade.

Inundation is likely when high spring tides coincide with a storm surge accompanying southerly storm events, such as during the July 1985 storm. Stationary storm events can increase water levels by 0.01 m for a decrease in atmospheric pressure of 1 mb (Heath 1979). This effect coupled with onshore winds can increase water levels by 0.6 m plus around the New Zealand coast.

2.2 Coastal Erosion

Potential coastal erosion at Riversdale has been assessed using the Coastal Hazard Mapping Technique promoted in New Zealand by Dr Gibb. The basis of this technique is an extrapolation of past trends into the future, with allowance being made for expected increases in sea level.

The technique of Coastal Hazard Mapping was first introduced into New Zealand during a study of natural hazards such as erosion, flooding, and landslip along the 147 km Waiapu County coastline. East Cape region (Gibb, 1981). Following the Waiapu study and the acceptance of the coastal hazard mapping techniques by both central and local government. catchment authorities, and the planning tribunal, more than 600 km of New Zealand's 13,000 km long coastlines were mapped between 1980 and 1986.

The method requires an assessment of three factors. These are: i) the long-term (historic) rate of erosion or accretion. and ii) the maximum short-term erosion or accretion, and iii) the rate of shore retreat caused by predicted sea-level rise.

i) *The long-term (historic) rate of erosion or accretion.*

The long term rate of erosion or accretion at Riversdale is estimated principally by comparing the historic coast lines from aerial photographs from 1902 to 1991.

ii) *The maximum short-term erosion or accretion.*

The maximum short-term erosion or accretion at Riversdale is measured by calculating the extent of foreshore erosion or accretion from an isolated storm event or events over a short period of time.

iii) *The rate of shore retreat caused by predicted sea-level rise.*

An estimate of shore retreat caused by sea level rise at Riversdale was calculated using the Bruun Rule (Bruun 1962). This requires information on both on-shore and off-shore beach profiles, and the predicted rate of sea-level rise. Data on the latter were obtained from the International Panel on Climate Change (Warrick and Oerlemans 1990).

Details of the Coastal Hazard Mapping technique are found in Appendix B; whilst further details on the geology, coastal processes, and weather, including storm events, can be found in the report by Gibb (1986).

3. Results of Coastal Erosion Assessment

The maps in the back pocket (Maps 1-3) show a Coastal Hazard Zone within which assets will potentially be placed at risk by 2050. There are two components to the Zone. Firstly, the area extending 30 m inland from the seaward toe of the foredune is at risk from short term erosion events which may occur at any time. Secondly, long term changes in the location of the shoreline up until 2050 have been assessed based on past trends and predicted changes in sea level.

In some localities the area currently subject to short term erosion extends further inland than the area subject to coastal erosion in the year 2050 A.D. This is because long term trends at these localities are not one of erosion. Rather, they are areas where dunes have been advancing seaward. If the present trends continue some buildings in these localities may become landward of the Coastal Hazard Zone.

The Coastal Hazard Zone predicted for Riversdale should be periodically reviewed as information is updated. This may require reassessment of the Coastal Hazard Zone if any major changes to the erosion or accretion trends at Riversdale occur, or any major changes to predicted sea level rise.

4. Recommendations

The current planning standards in the Masterton Transitional District Plan (Appendix A) do not adequately provide for the hazards as identified in this Report. The Wellington Regional Council recommends the following protection measures and planning standards to decrease the risk to beach front properties from coastal erosion and inundation from the sea.

Objective 1

The foredune at Riversdale Beach will be maintained and enhanced.

Policies

(1) To protect dune vegetation from pedestrians, trail bikes, dune buggies and other potentially destructive vehicles.

(2) To eliminate low spots in the foredune.

(3) To consider the instalment of dune building fences to trap windblown sand and increase dune elevations.

(4) To provide specially designed slatted vehicle access tracks if vehicles are required to gain access to the beach across the foredune.

(5) To provide specially designed pedestrian access tracks to give access across the dunes to the beach.

Methods

(1) Masterton District Council to enforce bylaws which prohibit destruction of dune vegetation.

(2) Masterton District Council with technical support from the Wellington Regional Council to work jointly to eliminate low spots in the foredunes, to consider the construction of a sand trapping fence, and to provide specially designed access tracks for pedestrians and vehicular traffic as required.

Justification

The "best" protection for Riversdale from both erosion and inundation is a well formed and maintained foredune system that is able to function as a natural element of the coastal system. A healthy foredune system is dependent of well established dune vegetation. Dune vegetation is particularly susceptible to damage from pedestrians and vehicles of all kinds.

Maintenance of dune vegetation will also help to minimise the hazard or nuisance of landward blowing sand.

Elimination of the low spots in the foredune will provide good protection from inundation during storm events.

Objective 2

The assets exposed to the risk of coastal erosion will be minimised.

Policies

(1) No subdivision of land will be allowed within the Coastal Hazard Zone.

(2) No construction of new dwellings will be allowed within the Coastal Hazard Zone.

(3) No expansion of existing dwellings within the Coastal Hazard Zone will be allowed.

(4) Construction of accessory buildings within the Coastal Hazard Zone will be considered on their merits.

(5) The Coastal Hazard Zone will be reviewed by the Wellington Regional Council every 10 years, or sooner if the Wellington Regional Council deems it necessary.

Methods

Policies 1 - 4 will be implemented through the Masterton District Plan. Policy 5 will be implemented by the Masterton District Council through the District Plan and through the administration of the Building Act 1991.

Policy 5 will be implemented by the Wellington Regional Council through the Annual Plan process.

Justification

The Coastal Hazard Zone has been assessed using an accepted methodology and the best data available. All of the land within the Zone is potentially at risk from coastal erosion by 2050. Limiting development is the area will limit the potential loss and damage to property from this erosion.

Perhaps of greater importance, past experience indicates that once assets are threatened by erosion, there is pressure to provide physical protective works. The greater the value of assets at risk, the greater the pressure for protective works. The only type of protective work that is environmentally friendly is beach renourishment, and the cost is usually prohibitive. Other physical protection works such as groins and seawalls have substantial adverse effects on the environment, as outlined below. All physical structure detract from the natural character of the coastal environment. The preservation of this character and protection of the coast from inappropriate development is a matter of national importance under section 6 of the Resource Management Act 1991

Groynes interfere with the natural longshore sediment transport process. Material trapped by a groyne is then unavailable for nourishing the adjacent downstream section of coast which may then exhibit increased erosion. This can lead to the construction of an additional groyne to combat the new erosion and so the effects may be shifted further along the coast. It is a rule of thumb that groynes never solve an erosion problem but merely transfer it to another location along the coast. The proliferation of groynes further detracts from the natural character of the coast.

Seawalls also have adverse effects on beach systems. Firstly, walls increase the reflection of storm wave energy seaward and hence reduce beach level in front of the wall. This will also inhibit the deposition of sand in front of the wall. As a result, the high tide line will often reach the base of the wall resulting in a loss of beach amenity. Secondly, walls can deflect part of the wave energy onto adjacent sections of beach thereby increasing the wave energy in these areas and increasing the potential for erosion. This is known as the "end effect". Thirdly, building a wall isolates the remaining dunes from behind the beach and prevents the natural process of supply of this material to the beach system during times of sediment deficit (for example, during storm events). Finally, if the adjacent shoreline retreats the wall will become outflanked and may act as a groyne inhibiting the longshore transfer of sand. Outflanking can also have serious consequences for the integrity of the wall because it exposes the ends to wave attack.

In addition to the above adverse effects, an effective physical structures such as walls and groynes must be properly designed and constructed making them very expensive options. The cost of "simple" riprap protection may exceed $1000 per lineal metre. The effect of the high cost may result in calls for "cheaper" construction options which will require substantial maintenance and have a high risk of failure.

All of the proposed policies are consistent with the recently released Draft New Zealand Coastal Policy Statement. A particularly relevant section of the Draft policy is Outcome 3.4, "Recognition of and Provision for the Mitigation of Coastal Hazards". A copy of the section is provided in Appendix C.

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Acknowledgements

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APPENDIX A: Provisions relevant to Riversdale Beach contained in the Masterton Transitional District Plan (1992)

1. DEFINITION

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"coastal hazard zone" means that area of land within 60m of the toe of the foredune for the General Rural Zone and that area within 30m of the toe of the foredune in the Coastal Resort Zone.

2. PLANNING STRATEGY

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GOAL 7: To ensure the preservation of the natural character of the coastal environment and to protect it from subdivision and development which is detrimental to the environment.

3. OBJECTIVES

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Objective 5: Rural Subdivision

(c) To prevent unnecessary subdivision along the coastal fringe...

Objective 7: Protection of the Coastal Environment

(a) To protect the existing natural environment against unnecessary development, and to protect, preserve and enhance all aspects of the coastal environment.

(b) To consolidate development within existing coastal resort areas.

4. CODE OF ORDINANCES

Pages 22 & 23 - Zoning (Ordinance 3)

Clause 3: Coastal Resort Area

3.1 Permitted Uses: Predominant Uses

The uses listed below are permitted as of right in the Coastal Resort zone...provided that no new development may occur within the coastal hazard zone. Reconstruction of any existing building in the coastal hazard zone will require conditional use consent.

3.2 Permitted Uses: Conditional Uses

(q) Reconstruction of any existing building in the coastal hazard zone.

Page 34 - Subdivision (Ordinance 4)

Clause 4: Coastal Management Area

All general subdivision standards shall apply within the Coastal Management Area except in the following matters:

(a) Proposed use of lots to conform with zoning: The applicant shall produce sufficient information to satisfy Council that the intended use of the proposed lots is for a permitted use under the district scheme.

Subdivision will not be granted consent unless the proposed use is either permitted as of right, or prior consent for the use has been granted.

(b) Special Policy Requirements: No subdivision shall be permitted unless the Council is satisfied that:

(i) Subsequent development on any allotment created would not generate any adverse impact on the coastal environment.

(ii) That development within the 30 m Coastal Hazard zone (Coastal Resort zone) or within the 60 m Coastal Hazard zone (General Rural Azone) will not occur.

(iii) The site is capable of being self-sufficient in, or is adequately serviced for, water supply and sewage disposal.

(iv) Adequate protection of any coastal feature within the subdivision is proposed.

Page 53 - Performance Standards (Ordinance 6)

Clause 9: Maintenance of Land and Buildings

9.2 Coastal Management Area: Protection of Foredunes

All uses shall provide for adequate protection or preservation of any foredunes (a sand dune immediately adjacent to the foreshore). Failure to do so shall represent an offence and the owner or occupier of the site may be required to restore the land to its original condition or to undertake such action to prevent further damage to the foredune.

All proposed protection and preservation of the foredunes should be carried out in consultation with the Wairarapa Catchment Board.

APPENDIX B: Coastal Hazard Zone Assessment Technique

1. Introduction

Gibb (1985) and Gibb and Aburn (1986) have derived the following equation to assess the width of a Coastal Hazard Zone (CHZ) along unconsolidated sedimentary coastlines:

Equation 1

$$\text{CHZ} = [X + R]\ T + S$$

Where X is the rate of shore retreat caused by relative sea-level rise, R is the long-term (historic) rate of erosion or accretion, T is an assessment period, and S is the maximum short-term erosion-accretion. The technique is essentially based on the principles embodied in Figures 2 and 3 below and predicts the likely position of the shoreline at specific times into the future.

The variables shown in equation 1 have been calculated at Riversdale using methods described below.

2. Variable *X*

To calculate for *X* Gibb (1985) and Gibb and Aburn (1986) have used the Bruun Rule (Bruun 1962; 1983) which states that "for a shore profile in equilibrium, as sea-level rises, beach erosion takes place in order to provide sediments to the nearshore so that the nearshore seabed can be elevated in direct proportion to the rise in sea level" (Bruun 1962). Bruun (1983) determined the practical approximation of shoreline movement *X* to be:

Equation 2

$$X = \frac{la}{h}$$

Where *X* is the rate of shore retreat, *l* is the length of profile of exchange, *a* is rate of sea-level rise, and *h* is the maximum depth of exchange (closure depth) between nearshore and offshore sediments (Figure 3)

2.1 Determination of *X* (shore retreat)

To solve for *X* in:

$$X = \frac{la}{h}$$

Estimates on *l*, *a*, and *h* were obtained using the methods below.

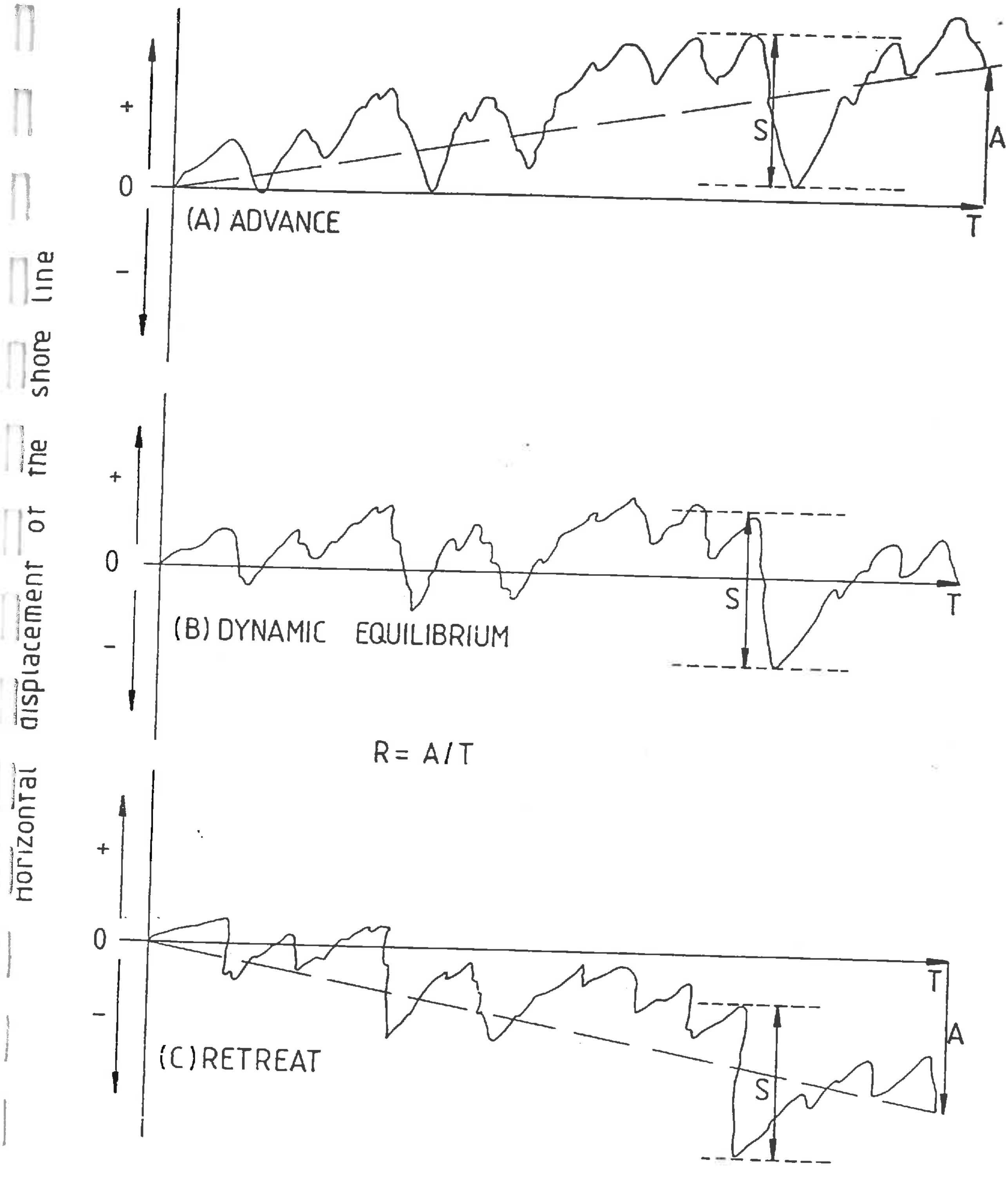
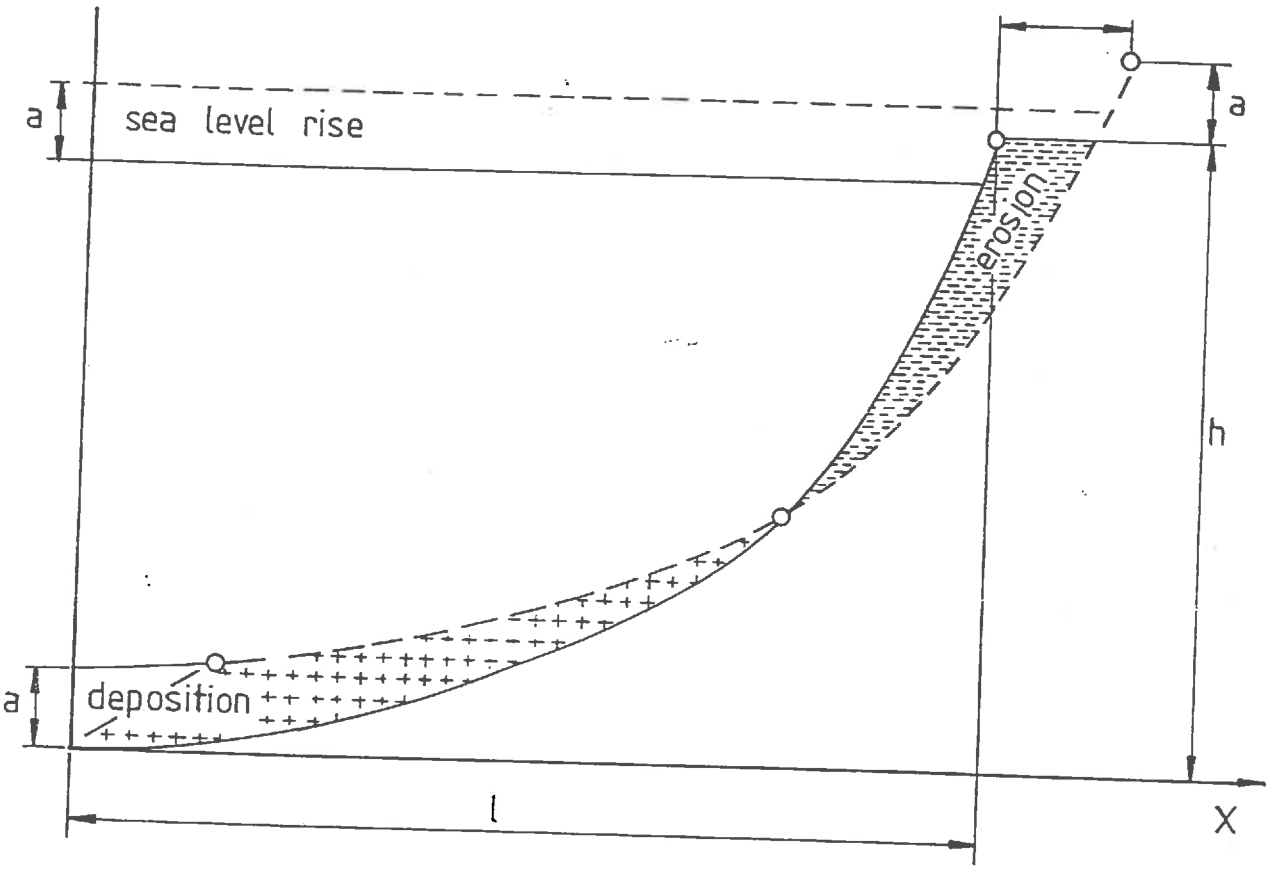


FIGURE 2 Diagrams showing short-term fluctuation S in the position of the shoreline (seaward toe of foredune), and long-term trend, R, where R is the net rate of movement in m/year calculated by dividing the horizontal distance, A, by the survey time interval, T. (A) is advance seaward from net accretion. (B) is fluctuating about a mean position indicating dynamic equilibrium. (C) is retreat landward from net erosion.

FIGURE 3 Diagram showing the Bruun's effect-translation of the beach profile, resulting in shore erosion and deposition of sediments (adapted from Bruun 1983, figure 1), a = sea level rise ; h = limiting depth of beach sediments ; l = distance to limiting depth and X = erosion amount.



i) h = maximum depth of exchange (closure depth) between nearshore and offshore sediments

Closure Depth was estimated using two methods; the first method from Weggel (1979) and the second from Hallermier (1981a).

The first method of Weggel (1979) uses an exponential decay equation to determine the closure depth averaged offshore profiles.

Data from the five off-shore profiles at Riversdale (Figure 4), surveyed in 1985, were averaged and then applied to Weggel's equation using semilogarithmic paper as outlined in Weggels paper (1979). The closure depth was calculated at **21m**.

The second method of Halliemier (1981a) determines the closure depth by examining the wave pattern ie.

$$di = (\bar{H}s - 0.3\sigma)\ \bar{T}s(g/5000D)^{0.5}$$

where

di = water depth at the seaward bound of shoal zone (ft)
$\bar{H}s$ = annual mean significant wave height (ft)
σ = annual standard deviation of significant wave height (ft)
$\bar{T}s$ = annual mean significant wave period (s)
g = acceleration of gravity (ft s^{-2})
D = median sand grain diameter (ft)

Unfortunately not all the necessary wave data was available at Riversdale work; however. work completed at Lake Ferry by Matthews (1982) was used as an approximation. Sediment dredged from the off-shore profiles was dominated by fine sand to very fine sand fraction. This was used in the equation.

The results gave a closure depth of **23m**, extremely close to the first estimation using Weggels method.

The closure depth (d) was averaged between the two methods and estimated to be **22m**.

ii) l = length of profile exchange

The length of profile exchange was estimated by comparing the 5 profiles surveyed in 1985 (eg. Figure 4). Because the off-shore survey did not go out to a closure depth of 22m the profile exchange length had to be extrapolated. Estimated profile exchange lengths varied from 1800 to 2600m; an average of **2000m** was taken.

iii) a = sea level rise

An estimated sea level rise rate of **0.005m/yr** was used. This figure was derived from best estimate predictions for rates in sea rise until 2050 AD by the International Panel on Climate Change (Warrick and Oerlemans, 1990).

Therefore an estimate for shore retreat (X) at Riversdale is:

$$X = \frac{20000.005}{25} = 0.4\ m/yr$$

2.1.1 Sensitivity of the CHZ to sea level rise predictions

To test the sensitivity of the CHZ to sea level rise predictions, both the low and high predictions from the International Panel on Climate Change (Warrick and Oerlemans, 1990) were calculated for each section. In section 1, for example, a low sea level prediction gave a value of 0.2 metres/year for X. A high sea level prediction gave a value of 0.64 metres/year for X.

However as X is only one of the factors in:

$$\text{CHZ} = /X + R/\ T + S$$

the actual change is less significant at section 1.

For example, the CHZ would be 48 metres from the current seaward toe of the foredune rather than the present calculation of 60 metres for a low sea level prediction. Conversely, if the high prediction for sea level rise is used the CHZ at section 1 would be 84 metres rather than 60 metres.

2.2 Variables R and S

The long term rate (R) of erosion or accretion at Riversdale is estimated by:

i) estimating erosion or accretion trends using aerial photographs since 1902;

ii) calculating short term fluctuations and long term trends in the volume of beach sands;

iii) calculating short term fluctuations and long term trends in the volume of foredune sands;

iv) estimating the rate of tectonic uplift verses erosion of the coastal platforms;

v) sedimentological analysis detailing sediment sources and longshore drift;

vi) collation of meterological data, including wind-wave roses and ocean-swell roses.

Short-term (*S*) storm induced erosion and inundation from the sea has been estimated by collating records since 1902. This has shown that up to 30m of erosion has resulted at Riversdale from storms.

Further details of *R* and *S* can be found in Gibb (1986).

2.4 Variable *T*

A period of 60 years was used for *T* (time interval). This period was decided as a useful life for the existing dwellings.

THE CALCULATIONS TO DETERMINE THE COASTAL HAZARD ZONE ARE SUMMARISED IN TABLE 1 ALONG WITH THE RESULTS USED TO DEFINE THE ZONE.

Table 1: Calculation of the CHZ

The calculation of the Coastal Hazard Zone (CHZ) given in the table below is calculated from the following equation:

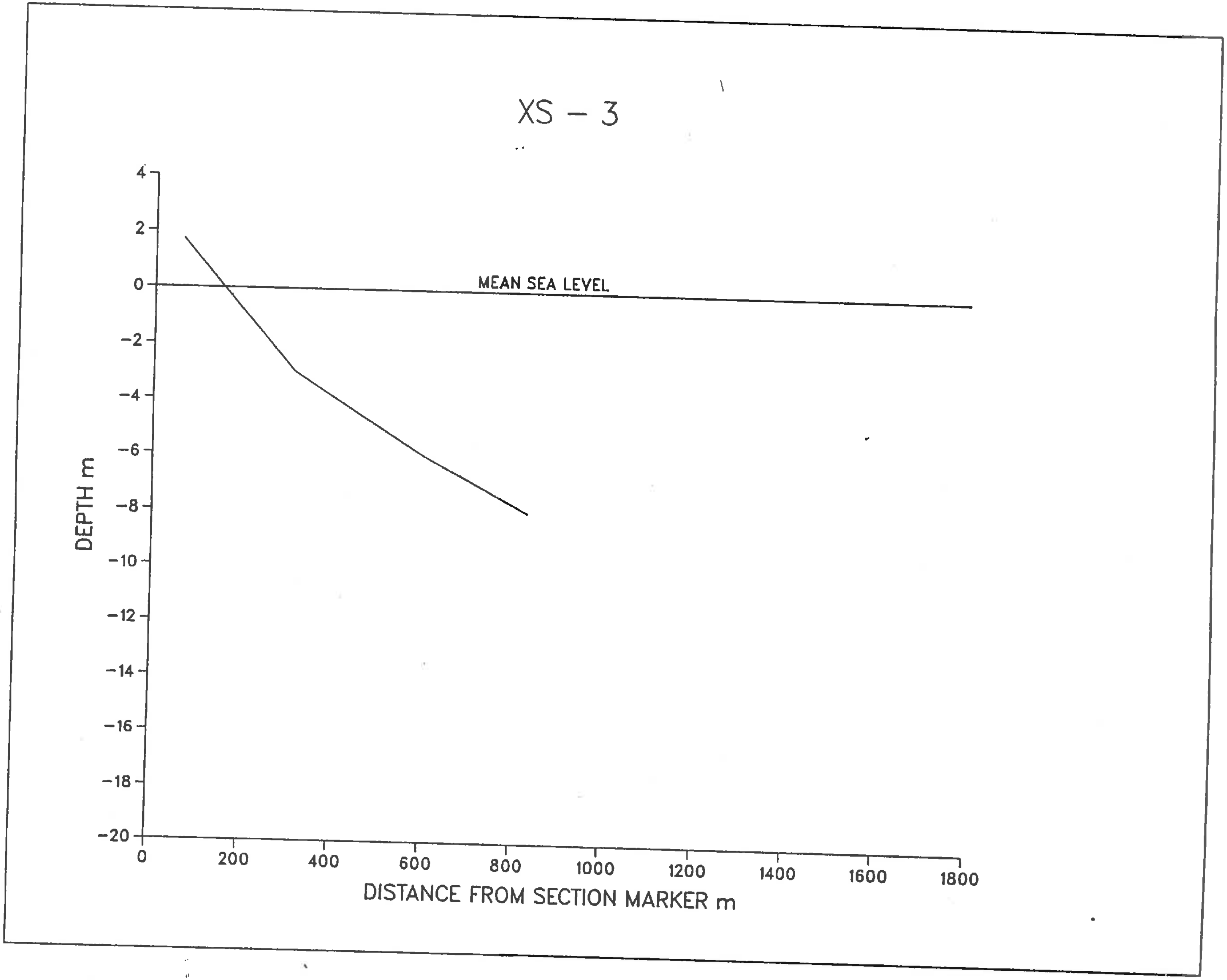
CHZ = $[X + R]\ T + S$

To calculate the CHZ the long-term (historic) rate of erosion or accretion at Riversdale (*R*) and the rate of shore retreat caused by predicted sea-level rise at Riversdale (*X*) are added together and then multipled by the approximate average lifespan of a dwelling, in this case 60 years (*T*).

The maximum short-term erosion or accretion at Riversdale (*S*) is added to the equation. This takes into account any further short-term erosion that may occur over and above the predicted shore line at 2050 A.D. calculated from other factors eg. $[X + R]\ T$.

Cross sections No.	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
X	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
R	-0.37	-0.12	-0.10	-0.42	-0.17	0.08	0.06	0.63	0.15	0.30	0.52	0.53	-0.16	-0.02	-0.12
T	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
S	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
CHZ	76	61	60	80	64	49	50	16	45	36	23	22	64	55	61

* All figures are in metres


XS – 3
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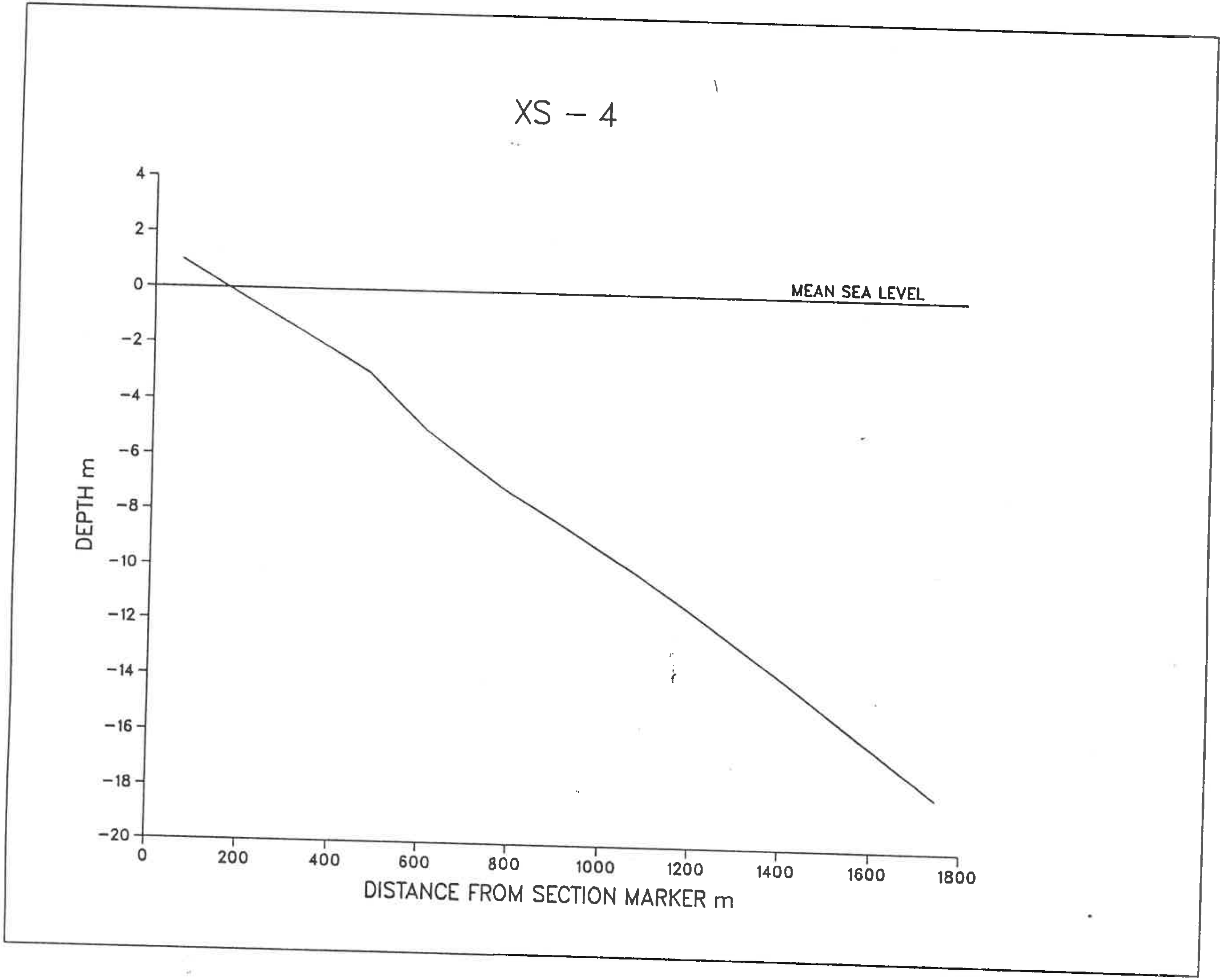
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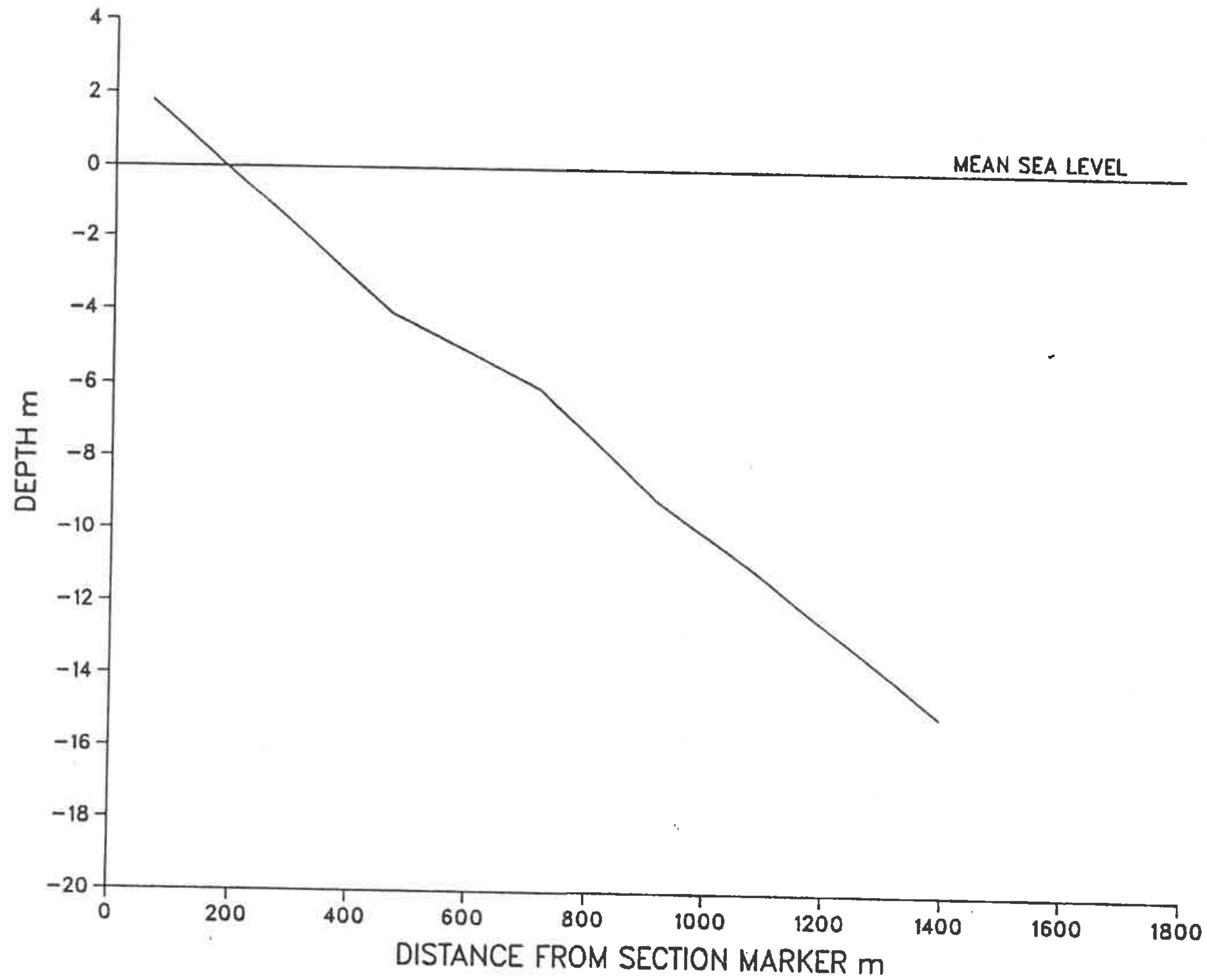

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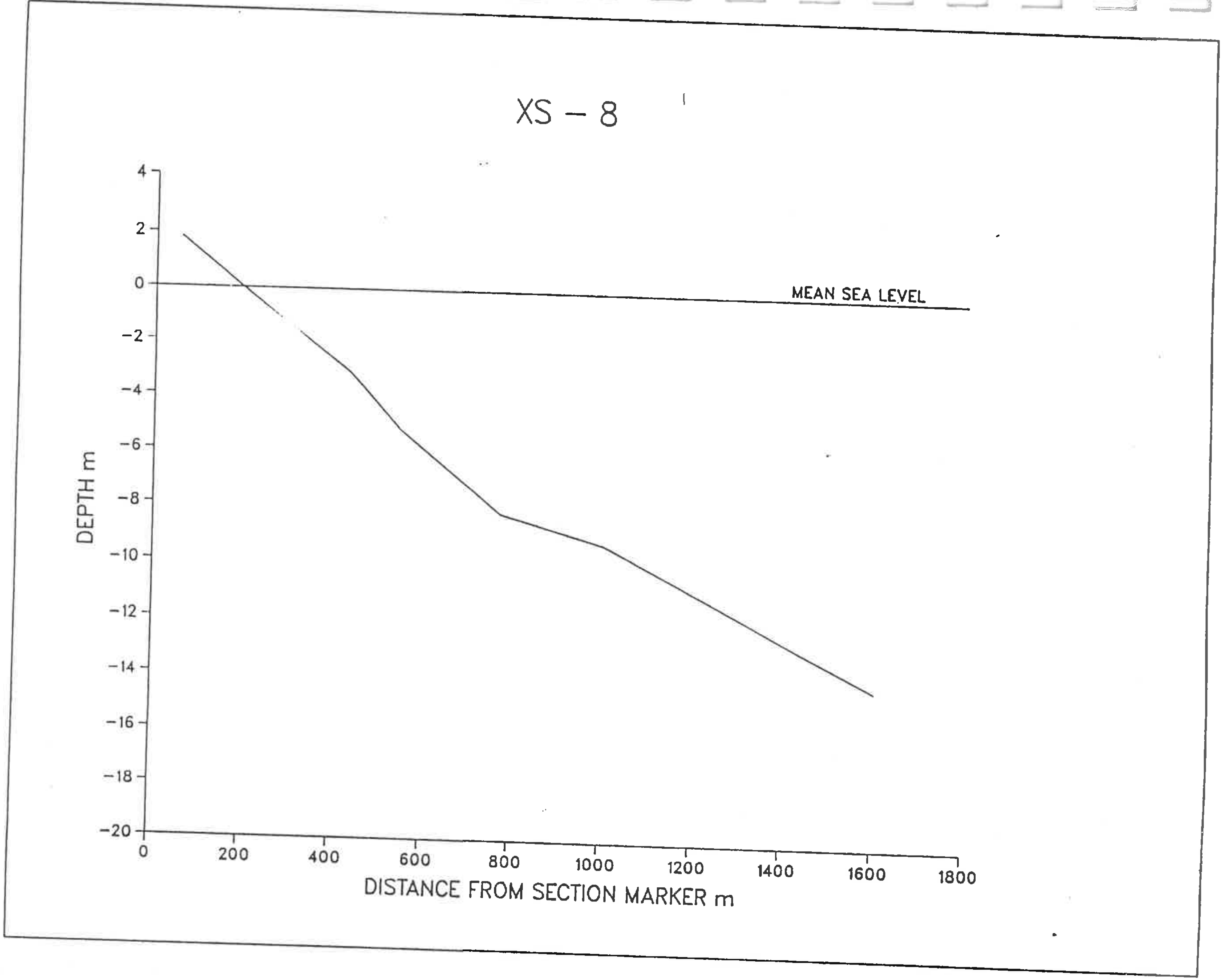
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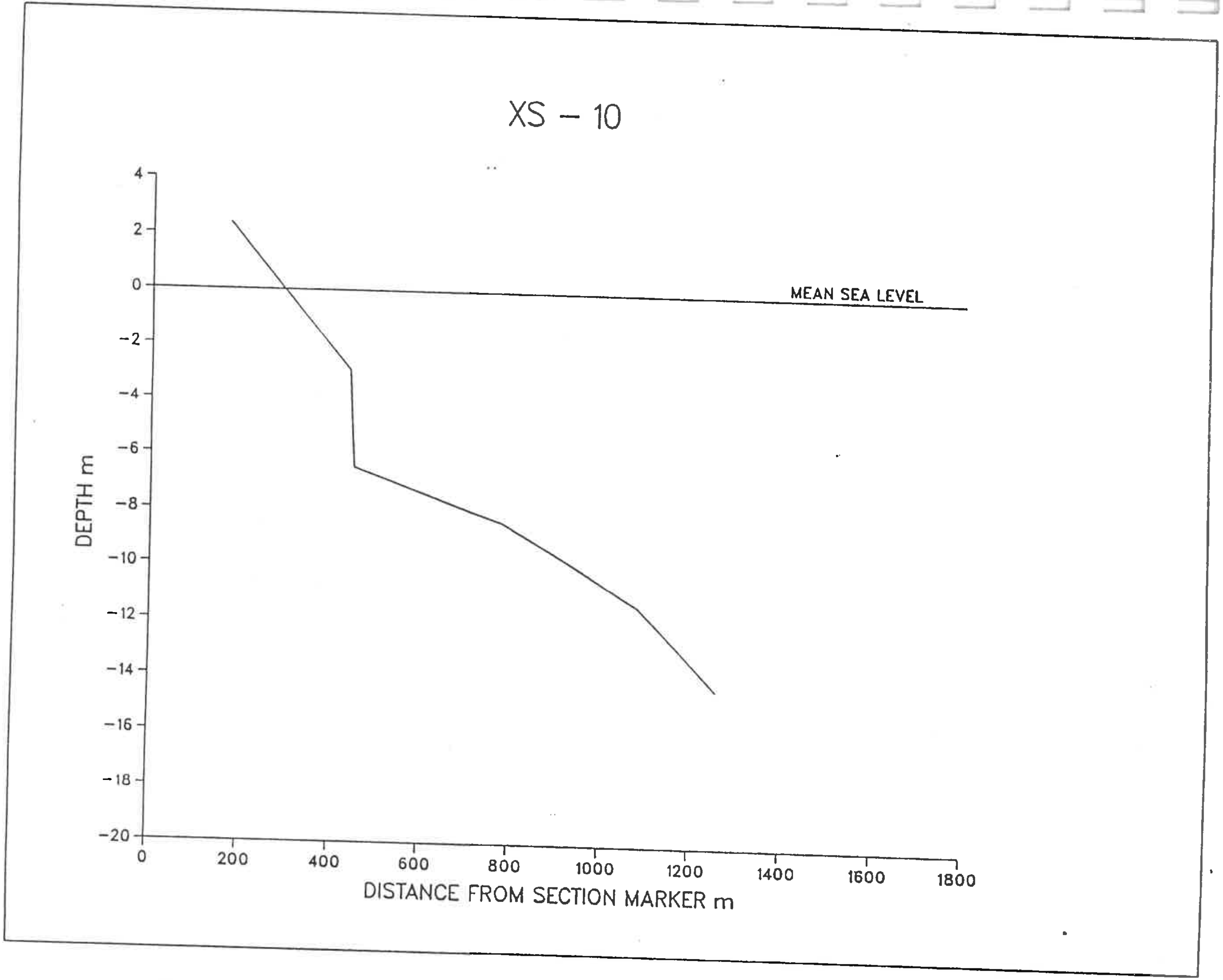

XS – 10
DEPTH m
4
2
0
−2
−4
−6
−8
−10
−12
−14
−16
−18
−20
MEAN SEA LEVEL
0
200
400
600
800
1000
1200
1400
1600
1800
DISTANCE FROM SECTION MARKER m

APPENDIX C: Draft New Zealand Coastal Policy Statement

OUTCOME 3.4

Recognition of and Provision for the Mitigation of Coastal Hazard

3.4.0 When considering subdivision, use or development of the coastal environment provision shall be made, as far as practicable, to avoid, remedy or mitigate the actual or potential adverse effects of natural hazards, including: wind, sea and river erosion, landslips, flooding, subsidence, sedimentation, sea-level rise, tsunami, and storms and cyclones.

3.4.1 Provision shall be made to recognise the potential impacts of likely changes in sea level. This may include:

(a) identifying and avoiding development in areas prone to inundation or accelerated erosion:

(b) ensuring that the integrity of natural systems and their buffers is not unduly affected; and

(c) protecting human lives, essential facilities, and economic activities.

3.4.2 Provision shall be made to identify areas where potential use and development will be prone to natural hazards.

3.4.3 Provision should be made to conserve and enhance resilient natural features which have the capacity to protect subdivision, use, or development such as beaches, sand dunes, mangroves, wetlands and barrier islands.

3.4.4 Provision should be made for likely changes in sea level by controlling subdivision, use or development, in ways that allow for the natural inland migration of estuaries and wetlands and the re-establishment of natural margins for these areas where practicable and appropriate.

3.4.5 Provision should be made to ensure that new structures are located to avoid the need for coastal hazard protection works in the future, and that the form, location and design of coastal hazard protection works will avoid adverse environmental effects, to the extent practicable.

3.4.6 Provision should be made to avoid adverse effects of coastal hazard protection works by relocating where practicable existing structures that are exposed to natural coastal hazards.

Explanation

Locating activities such as subdivisions or industry in areas vulnerable to coastal hazards should be avoided. Appropriate decisions about the location of structures should be possible with the collation of an information base on areas vulnerable to hazards. A common past reaction to natural hazards such as the movement of river mouths, eroding cliff faces, or storm conditions has been to construct elaborate and expensive protective structures. When poorly designed these can fail completely or cause major impacts to another area of coast. If relocation of a coastal activity is not feasible it is important to ensure that any protection structures are soundly designed.

Efforts should also be made to retain features such as sand dunes and wetlands which provide a buffer from natural hazards.

Local authorities need to consider the potential effects of sea level rise when planning for coastal development. Sea levels appear to be rising naturally at present, but predictions about climate change indicate that the rate may increase. The inland boundaries of naturally protective features such as sand dunes and wetlands will move further landward as sea levels rise. Inhibiting this movement could mean loss of areas that are essential natural protective features, breeding and feeding sites for birds and fish, and habitat for coastal vegetation, marine animals and wading bird species.