DEFINITION OF EROSION HAZARD LINES
CLARK'S BEACH - BYRON BAY

by
D.N. Foster
and
S.J. Foster

Technical Report No. 83/08
July, 1983
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<table>
<thead>
<tr>
<th>BIBLIOGRAPHIC DATA SHEET</th>
<th>1. REPORT No.</th>
<th>TR 83-08</th>
<th>2. I.S.B.N.</th>
<th>0/85824/234/6</th>
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</thead>
<tbody>
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<td>3. TITLE AND SUBTITLE</td>
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<td>DEFINITION OF EROSION HAZARD LINES</td>
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<td>4. REPORT DATE</td>
<td></td>
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<td>July, 1983</td>
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<td>5. AUTHOR(S)</td>
<td>D.N. Foster and S.J. Foster</td>
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<td>6. SPONSORING ORGANISATION</td>
<td>N.S.W. Department of Public Works</td>
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<td>7. SUPPLEMENTARY NOTES</td>
<td>The work reported was carried out by the Water Research Laboratory and is published under the direction of the Officer-in-Charge of the laboratory acting on behalf of Unisearch Ltd. and the N.S.W. Department of Public Works.</td>
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<td>8. ABSTRACT</td>
<td>This investigation looks at the long term stability of Clark's Beach, Byron Bay with the objective of defining a suitable coastal erosion hazard line if the existing sea wall adjacent to the town centre is maintained as a permanent control structure in perpetuity.</td>
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<td>9. DISTRIBUTION STATEMENT</td>
<td>At the time of publication this report is available only by permission of N.S.W. Department of Public Works and the Officer-in-Charge of the University of N.S.W. Water Research Laboratory.</td>
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<td>10. KEY WORDS</td>
<td>Beach erosion, coastal engineering, groynes.</td>
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<td>11. DESCRIPTORS</td>
<td>Clark's Beach, Byron Bay</td>
<td></td>
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<tr>
<td>12. CLASSIFICATION</td>
<td>Restricted</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>13. NUMBER OF PAGES</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. PRICE</td>
<td>$10.00</td>
<td></td>
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Preface

The work reported herein was carried out and is published under the direction of the Officer-in-Charge of the Water Research Laboratory, acting on behalf of the client, N.S.W. Department of Public Works.

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Associate Professor of Civil Engineering,
Officer-in-Charge
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1. **INTRODUCTION**

In April, 1983, the Water Research Laboratory of The University of New South Wales, through Unisearch Ltd., was commissioned by the N.S.W. Public Works Department to:

i. assess the long term stability of Clark's Beach, Byron Bay if the present groyne and seawall system adjacent to the swimming pool in the town centre is maintained as a permanent feature thereby providing a fixed headland control to the beach at that point;

ii. provide guidelines to the Department for the modification of the present erosion hazard lines along Clark's Beach if a permanent control structure is maintained in perpetuity;

iii. assess any effect that such action would have on the beaches to the north.

The results of this investigation are outlined in this report.

2. **DEFINITION OF BEACH AREAS**

There is some confusion as to just where Clark's Beach stops and Main Beach starts. As the rock seawall and groyne system at the town centre now forms an artificial barrier to beach processes it is convenient to separate the beach systems at this location. In this report the beach system to the south of this location is referred to as Clark's Beach whilst that to the north is referred to as Main Beach. This is consistent with the terms of reference as set out in the introduction.

3. **DATA SOURCES**

The conclusions reached in this report are largely based on existing data for the area. The principal data sources referred to were:


iii. The University of New England Department of Geography 1975 report by B. Caton entitled "New Brighton Erosion" (Reference 3).

iv. The report to Byron Bay Shire Council by D. Hopley 1967 entitled "A statistical approach to the relationship between coastal erosion and changes in wind patterns at Byron Bay, N.S.W." (Reference 4).

v. The hydrographic chart of 1883 as surveyed by Commander Howard.

vi. The hydrographic chart of 1921 as surveyed by Department of Public Works.
vii. The orthophoto map showing the 1977 topography (Scale 1:4000) as prepared by the Central Mapping Authority N.S.W.

viii. Aerial photography since 1947 from various sources.

ix. Photogrammetric surveys of dune erosion escarpments from aerial photography since 1947 prepared by Department of Public Works.

x. Beach profile data taken by Department of Public Works since 1972.

4. DEFINITION OF EROSION HAZARD LINES

Following a comprehensive study of beach processes between Byron Bay and Hastings Point undertaken by the Department of Public Works in 1977-1978 (Reference 1), initial guidelines to coastal erosion hazard limits in the vicinity of Clark's Beach were set down in Reference 1 as shown in Figure 1.

The basis for these limits was a buffer zone of 100 m plus twice the average rate of shoreline recession as predicted by a mathematical model of the area.

In comparing these limits with that given in this report it should be noted that:

a. The 1977-78 study was by its very nature a broad overview of the area between Byron Bay and Hastings Point and consequently did not examine in detail local areas such as Clark's Beach. Consequently in relation to local regions it should be looked upon as the starting rather than the end point for the investigation of local problems.

b. Prediction of shoreline recessions rates using the mathematical model was based on the assumption of no foreshore protective works. The terms of reference of this report are that the present seawall and groyne system, adjacent to the town centre and swimming pool, is to be maintained as a permanent feature.

c. Since completion of the 1977-78 study more detailed analysis of erosion in the area has been undertaken by the Department of Public Works.

d. Since completion of the 1977-78 study the basic guidelines for erosion hazard limits have been reviewed by the Department of Public Works and are now set down as follows:

i. For developed areas the erosion hazard line will be set back a suitable distance from the top of the existing erosion escarpment to provide a buffer zone to allow for short term variations in the shoreline resulting from storm action and to provide for the establishment of coastal vegetation for dune and foreshore protection. In the case of Byron Bay this has been set at 50 m. Added to this is an allowance for long term erosion as indicated by the best estimate of the likely long term average erosion rate over the next 50 years.
ii. For undeveloped areas the same conditions apply except that
the allowance for long term erosion rate is increased to 100
years.

Variations to these zones in local areas may be accepted provided they
can be justified by the coastal processes pertaining to a particular site
(e.g. limitations to erosion by rock outcrops, local protection by coastal
protection devices such as groynes or seawalls etc.). For the purpose of
this report Clark’s Beach has been classified as a developed area.

5. HISTORICAL EROSION

5.1 Past Studies

Studies of historical erosion along both Clark’s Beach and Main Beach
have been undertaken by Hopley (Reference 4), Caton (Reference 3), Rendel
and Partners (Reference 2) and P.W.D. (Reference 1). The principal data
sources for these studies were the vegetation lines as shown on the hydro­
graphic charts of 1883 and 1921, aerial photographs post 1947 and beach
profile data (Main Beach) post 1972.

All of these studies looked at discrete locations only, and indicate a
variation in erosion rates of between 0.5 to 3.0m/year at the town centre
(Figure 2). This is not unexpected as apparent erosion rates may vary con­
siderably over only a short distance because of short term changes result­
ing from individual storms.

A further estimate of erosion rates was made in Reference 1 using a
numerical model based on a coastal transport equation of the form:

\[ q_L = K H_b^2 \sin 2 \alpha_b \]

where \( q_L \) = the longshore transport rate

\( H_b \) = breaker wave height

\( \alpha_b \) = breaker angle relative to the shoreline

\( K \) = empirical coefficient

The results of this study indicated erosion rates of between 2 and
3m/year at the town centre and along Main Beach.

It should be noted that the accuracy of the prediction from a model of
this type depends on a number of factors such as the magnitude and vari­
ability of the coefficient \( K \), the accuracy to which the variability of
offshore wave heights, period and direction can be defined and the accuracy
of the data against which the model is calibrated. At present many of
these factors are poorly defined.

An important result of the numerical model is that unless some form of
coastal defence is undertaken (e.g. seawalls, groynes, beach nourishment
etc.) the past erosion is likely to continue unabated for at least the next
100 years.
5.2 Historical Erosion as Indicated by Vegetation Lines

Vegetation lines are shown on the 1883 and 1921 hydrographic surveys and can be abstracted from aerial photographs post 1947. A plot of these data is given in Figures 3 to 4.

Care should be exercised in the interpretation of these data as vegetation lines may be quite misleading for many reasons such as:

i. Definition of vegetation line is subjective and varies between different investigators.

ii. The location of the erosion escarpment and vegetation line can vary considerably because of short term changes resulting from storm events, blowouts, mining, building construction, grazing etc.

For these reasons they tend to be a qualitative rather than a quantitative indicator of coastal erosion.

Examination of Figure 3 would suggest that there have been only minor changes since 1883 to the shoreline along the southern half of Clark’s Beach except at the extreme southern end where the 1921 vegetation line is considerably landwards of either the 1883 or 1977 vegetation lines. This is not considered to be indicative of erosion as the area is based on rock and is more likely the result of a local blowout. Along the northern half of Clark’s Beach continuous and consistent erosion is indicated. In this area the 1977 vegetation line corresponds closely to the erosion escarpment (as indicated by the contours on the base plan) whilst the 1883 and 1921 vegetation lines are significantly seaward. The location of the erosion escarpment on these charts is not known but if anything is likely to be further seaward of the vegetation line. This is also the case in 1947 as can be seen by comparing Figures 3, 4, 5 and 6.

The break between little change and significant erosion is quite distinct and appears to be related to offshore reefs and local rock outcrops some of which are visible on Figure 8.

5.3 Historical Erosion from Photogrammetry

Since 1947 evidence of coastal erosion can be obtained from aerial photography. From these data estimates of erosion can be made by comparing the erosion escarpments of the frontal dunes over a range of time periods. Because of local variations in erosion rates as a result of individual storms it is essential that such a study be undertaken photogrammetrically so that the whole region of interest is covered rather than isolated sections of the coast. Since the completion of the 1978 study (Reference 1) the Public Works Department has undertaken such studies. The erosion escarpments in 1947 and 1977 and the corresponding erosion or accretion rates over this period are shown in Figures 5 and 6.

Reference to Figures 5 and 6 indicates that in the region of the town centre the erosion rates are of the order of 1.5 to 2.0 m/yr which is somewhere between the estimated rates based on historical records (Section 5.1) and that estimated by numerical methods (Section 5.2) in Reference 1.

In relation to Clark’s Beach, Figures 5 and 6 indicate the same sharp division between significant erosion and little shoreline change as was indicated from the vegetation surveys (Section 5.2). Over the southern
half of the beach there has been essentially no significant change. Over the northern half of the beach continual erosion of between 1.0 and 1.5 m/yr has occurred except in the immediate vicinity of the swimming pool where the shoreline location is fixed by the rock seawall.

6. COASTAL PROCESSES IN VICINITY OF CLARK'S BEACH

There has been no attempt in this study to undertake a detailed analysis of the coastal processes pertaining to Clark's Beach, which are very complex. However, some aspects of these processes which have relevance in arriving at the conclusions given in this report are discussed below.

i. From Reference 1 a graph has been prepared showing the variation of wave height and wave energy in relation to deep water wave conditions (Figure 7). This indicates that wave conditions are extremely sensitive to the offshore wave direction. For a S.E. approach the beach is very sheltered by Cape Byron. For a N.E. approach, waves can enter the bay almost unabated. Consequently, beach behaviour will be very sensitive to the direction of storm approach and is likely to suffer more damage from tropical cyclones than from extra-tropical cyclones.

ii. As discussed in Reference 1, sand transport past Cape Byron is sensitive to weather conditions. Under certain conditions of waves and currents there is a substantial loss of sand offshore and a corresponding reduction of sand supply to Clark's Beach. Because of this and the sensitivity of wave conditions along Clark's Beach to the offshore wave direction sand tends to be supplied to the coastline in slugs. At some times this will result in a wide beach profile which provides substantial protection against storms whilst at other times the beach is narrow and the backshore highly susceptible to storm damage.

Figures 8 and 9 illustrate this point. In 1883 and 1967 there is a relatively narrow beach berm along the southern half of Clark's Beach and a relatively broad beach berm to the north. In 1921 and 1977 the position has been reversed with substantial sand storage to the south and a relatively narrow beach berm to the north. Under the latter conditions the northern end of the beach would be susceptible to storm damage, particularly under an east to north-east direction of storm waves. Figure 10 plots the variability of sand storage as indicated by aerial photographs and indicates that significant changes are continuously going on as a result of the changing weather patterns. It can be concluded that Clark's Beach is highly dynamic and is likely to show greater variability than other beaches. This is an argument for maintaining a substantial buffer zone in this area as proposed by the Department of Public Works.

7. EFFECT OF SEA WALL AT TOWN CENTRE

In the early 1960's a short rock seawall was constructed to protect the town centre. Whilst to date this has been successful, erosion of the shoreline has continued to both the north and the south, and the seawall is presently being outflanked by this erosion. Continued erosion in the future will allow waves of larger height to reach the wall and will increase the size of rock required to prevent failure. At the same time action will have to be undertaken to prevent failure by outflanking.
It has been suggested that the seawall is now acting as a groyne and will therefore reduce the future erosion of Clark's Beach. However, Figures 5 and 6 would suggest that any such effect has been very limited. To the south of Fletcher Street erosion rates between 1947 and 1977 have continued unabated and have not been significantly affected by the seawall.

A further indication that there has been little long term groyne effect is the erosion along Main Beach where accelerated erosion would be expected if significant interruption to sand bypassing was occurring. Erosion rates are shown in Figure 6. With the exception of the area immediately to the north of the wall erosion rates are of a similar magnitude to that experienced on Clark's Beach. The locally high erosion immediately to the north is normal as a result of wave reflection from the seawall.

Beach profiles taken in front of the seawall (Figure 11) also indicate little effect of the wall on sand bypassing. For a groyne to have a significant effect on the beaches it would need to project well seaward of the low tide level, that is an increase of some 100 or more metres. For this reason it is considered that, except for the area very adjacent to it, there will be no significant groyne action over the next 50 years unless action is taken to build a groyne at this location much further seaward as part of a coastal defence strategy.

An antithesis to this conclusion is that the seawall has had no significant long term effect on the erosion of Main Beach except in the local areas immediately adjacent to the seawall.

8. RECOMMENDED HAZARD LINES

Based on the criteria set down by the Department (refer Section 4) revised erosion hazard lines for Clark's Beach are shown in Figure 12. These are based on the following criteria:

i. Historical erosion over the period 1947 to 1977 as indicated by aerial photography provides the most reliable estimate of past and future erosion in the area.

ii. Over the northern half of Clark’s Beach (except immediately adjacent to the seawall) the recommended rate of long term erosion is 1.5 m/yr. This corresponds to the envelope of maximum erosion over this period and therefore is probably conservative. However, in view of the highly dynamic nature of the beach and the beach processes and the relatively short period of reliable record, adoption of a lower value (e.g. the average rate) is not recommended.

iii. The southern half of Clark’s Beach has been stable over the past 100 years. Whilst the reason for the sudden change between the northern and southern end of the beach has not been identified (although it is believed to be related to bed rock levels) the period of record is sufficiently long to justify a conclusion of negligible erosion.

iv. The buffer zone immediately to the south of the seawall has been increased from 50 m to 75 m. This is considered necessary to provide for locally high erosion which can occur as a result of wave reflection and increased turbulence levels in the vicinity of the wall. The long term erosion has, however, been taken as zero because of local groyne action to the north of Fletcher Street.
Optional Groyne for protection of Globetrotter's Development

Material excavated from entrance to stabilise dune infront of Globetrotter's

Belongil Creek entrance
Training wall

Material excavated from entrance to stabilise dune infront of Globetrotter's

Note: Initial nourishment of groyne field necessary to avoid interruption of littoral drift. Maintenance nourishment as required.

Erosion hazard zone is twice predicted shoreline position from fig. 131 plus moveable 100 metre buffer zone.

GROYNE MANAGEMENT OPTION - BYRON BAY - WITH DESIGN EROSION HAZARD ZONES (FROM REFERENCE 1.)
AVERAGE EROSION RATES
CAPE BYRON TO HASTINGS POINT 1947-1977
(FROM REFERENCE 1.)

FIGURE 2.
Vegetation Lines

--- 1883 Survey
--- 1921 Survey
--- 1947 WML

FIGURE 4.
VARIATION OF WAVE HEIGHT AND WAVE ENERGY WITH OFFSHORE WAVE DIRECTION

FIGURE 7.
SAND BAR LOCATIONS 1883 AND 1967

FIGURE 8
FIGURE 10

LEGEND:

- - - - - 1966
- - - - - 1967
- - - - - 1973
- - - - - 1977
- - - - - 1980

OSCILLATION OF SAND BAR AT CLARKS BEACH
LEGEND:

- - 5.6.72
- - - 23.7.76
- - - 2.3.77
- - - 1.5.78
- - - 22.6.78

SELECTED BEACH PROFILES (TOWN CENTRE)
1972 - 1979
ESTIMATED EROSION ESCARPMENT YEAR 2030—
NO PROTECTION EXCEPT BY EXISTING SEA WALL

MODIFIED DESIGN
EROSION HAZARD LINES
CLARKS BEACH, BYRON BAY
FIGURE 12.