



Bedrock Based Coastal Hazard Revision for Blueys and Boomerang Beach

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Bedrock Based Coastal Hazard Revision for Blueys and Boomerang Beach

Prepared for: Great Lakes Council

Prepared by: BMT WBM Pty Ltd (Member of the BMT group of companies)

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<p>Synopsis: This report makes recommendations to revise the WorleyParsons (2011) hazard definition for Bluey and Boomerang Beaches to incorporate the presence of bedrock substrate (i.e. 'bedrock control' on coastal hazards). As part of this study, the bedrock control for Blueys and Boomerang Beaches has been mapped based on a range of geological / geotechnical, Ground Penetrating Radar and geomorphic information. The methods applied for this purpose are also documented.</p> <p>This report follows on from the GPR Investigation of Blueys and Boomerang Beaches (BMT WBM, 2014) into the local coastal geological system. The outcomes of this assessment will facilitate the development of the Coastal Zone Management Plan also being prepared by BMT WBM at present.</p>		

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Contents**Contents**

1	Introduction	1
1.1	Objectives and Scope	1
2	Geological Control on Coastal Hazards	2
3	Physical Setting of Blueys and Boomerang Beaches	4
3.1	Introduction	4
3.2	Regional Setting	4
3.2.1	Overview	4
3.2.2	Bedrock Geology	4
3.2.3	Coastal Sedimentary Landforms	6
3.3	Coastal Hazard Geological Controls	6
3.4	Blueys Beach	7
3.4.1	Southern Blueys Beach	7
3.4.2	Northern Blueys Beach	10
3.5	Boomerang Beach	10
3.5.1	Southern Boomerang Beach	12
3.5.2	Northern Boomerang Beach	12
4	Hazard Line Amendments	15
5	Conclusions and Recommendations	20
5.1	Geological Limits to Coastal Hazards	20
5.2	Revised Coastal Hazard Lines	20
5.3	Recommendations	20
6	References	21
Appendix A	Southern Blueys Beach Geotechnical Excavation Investigation	A-1

List of Figures

Figure 2-1	Conceptual Model: Maximum recession limits, as controlled by underlying bedrock topography, applied to coastal hazard definition (modified from Sharples and Donaldson, 2012)	3
Figure 3-1	Blueys and Boomerang Beaches, Great Lake Council	5
Figure 3-2	Blueys Beach (looking south), showing the bedrock outcrops through the beach in the far southern corner	8
Figure 3-3	Cohesive clayey gravelly substrate, Southern Blueys Beach	8

Contents

Figure 3-4	Bedrock Control on Coastal Hazards, Blueys Head (southern Blueys Beach)	9
Figure 3-5	Bedrock Control on Coastal Hazards, Boomerang Point (northern Blueys and southern Boomerang Beaches)	11
Figure 3-6	Bedrock Control on Coastal Hazards, Charlotte Head (northern Boomerang Beach)	14
Figure 4-1	Bedrock Revised Beach Erosion and Shoreline Recession Hazard Map, Blueys Beach	16
Figure 4-2	Bedrock Revised Beach Erosion and Shoreline Recession Hazard Map, Boomerang Beach	17
Figure 4-3	Bedrock Revised Zone of Reduced Foundation Capacity, Blueys Beach	18
Figure 4-4	Bedrock Revised Zone of Reduced Foundation Capacity, Boomerang Beach	19
Figure A-1	Pit 1: Excavation Photographs (Geoff Love, Great Lakes Council)	A-1
Figure A-2	Pit 1: Excavation Geotechnical Log (Geoff Love, Great Lakes Council)	A-2
Figure A-3	Pit 2: Excavation Photograph (Geoff Love, Great Lakes Council)	A-3
Figure A-4	Pit 2: Excavation Geotechnical Log (Geoff Love, Great Lakes Council)	A-4

Introduction

1 Introduction

This report outlines recommendations to the Great Lakes Council (Council) regarding the existing coastal hazard zones defined for Blueys and Boomerang Beaches which relate to the beach erosion and shoreline recession hazard, and the zone of reduced foundation capacity hazard (herein referred to as 'coastal hazards'). Coastal hazards were previously defined by WorleyParsons in the 'Boomerang Beach and Blueys Beach Coastal Processes and Hazard Definition Study', July 2011. Recommendations are made to Council to incorporate the local geomorphology and bedrock geology into the existing WorleyParsons (2011) hazard definition, such that the hazard lines extend to (and not beyond) the stable coastal substrate located at the ends of each both beaches.

This letter reports follows on from the Ground Penetrating Radar (GPR) coastal geology investigation of Blueys and Boomerang Beaches previously undertaken by BMT WBM, 2014.

1.1 Objectives and Scope

The aim of this report is to outline the proposed amendments to the alongshore extent of the existing Blueys and Boomerang Beaches hazard zones (as per WorleyParsons, 2011), based on the distribution of erodible (i.e. soft sediments) and non-erodible, or 'stable' (i.e. bedrock) coastal geological substrate.

This assessment has synthesised the available geological and geomorphological (i.e. 'geotechnical') information available for the study site, primarily comprising the following three sources (in order relevance):

- A Ground Penetrating Radar Investigation of Blueys and Boomerang Beaches (BMT WBM, 2014, referred to herein as the 'GPR study'), which included:
 - A GPR investigation of the coastal geology;
 - A review of the PWD (1985) geotechnical borehole information (see below); and
 - Geomorphological interpretation of the landscape.
- Blueys Beach (south) geotechnical excavation investigation, as conducted by Council on 14th May, 2014 (referred to herein as GLCC, 2014); and
- Blueys Beach and Boomerang Beach - Coastal Engineering Advice (PWD, 1985).

No assessment is made within this report in relation to the coastal engineering approach taken by WorleyParsons (2011) to determine the cross shore (i.e. landwards) hazard extents, as they applied industry standard methods that are widely accepted in NSW. Thus, amendments to the inland extent of the WorleyParsons (2011) hazard zone are only made where stable, non-erodible coastal substrate have been identified.

2 Geological Control on Coastal Hazards

The coastal hazards of beach erosion and shoreline recession are specific to erodible sediment landforms that fringe coastal shorelines, such as a beach and dune system. Stable coastal substrates, namely bedrock, are largely resistant to wave erosion, and thus the presence of non-erodible material in the coastal zone essentially forms a limit to erosion and recession, and the associated zone of reduced foundation capacity hazard. Bedrock control on coastal hazards can be present in an alongshore and / or cross shore (inland) direction.

Typical examples of geological control on coastal hazards are as follows. In a scenario where a beach and dune sedimentary system adjoins a rocky (e.g. cliffed) shoreline, the alongshore limits to coastal hazards occur at the beach / dune – cliff interface. Additionally, in the case of a pocket beach (for example) where the dune system mantles a buried backshore rocky slope in a cross shore direction, the maximum inland potential of erosion and recession occurs at the bedrock – sediment interface. Specifically, this occurs where the bedrock slopes become elevated to a level high enough to protect the overlying sediments from wave erosion.

For high energy – open coast environments this coastal hazard boundary is likely to occur at around the 4 m AHD bedrock contour. In low energy estuarine environments, this boundary would more likely occur around the 2 m AHD bedrock contour.

The concept of bedrock control on shoreline recession is presented in Figure 2-1. Geological controls on coastal hazards are best incorporated into hazard definitions by identifying the limits to which an erodible shoreline can *in principle* recede to, prior to undertaking any hazard estimations. This is best achieved by mapping out the potential recession limit for a coastal compartment, which can be either exposed at the surface or buried beneath backbeach / dune sediments. A ~4 metre bedrock elevation has been identified as an appropriate level for limiting coastal hazards, as it is expected that coastal conditions over the next 100 years will allow wave action during large storms events to readily erode shoreline sediments up to this height (taking into consideration to wave setup, wave run-up and incremental sea level rise).

As such, coastal hazard definitions undertaken for areas of varied coastal geology can only be comprehensively assessed if the bedrock control on coastal hazards is considered. Detailed geological / geomorphological investigations are therefore warranted for complex coastal geological systems that include important coastal fringing assets and infrastructure. Blueys and Boomerang Beaches fit the above criteria.

Depending on the nature of the coastal system being assessed, the geological limit to coastal hazards can be adequately mapped out for many coastal landscapes through interpretation of the surrounding geological landscape. A good understanding of coastal Quaternary evolution and coastal sedimentary facies models is required for this purpose (e.g. Roy *et al*, 1994). However, for more complex geological systems, a targeted subsurface geotechnical / borehole investigation and / or a non-invasive geophysical survey of the coastal geology (for example, by applying Ground Penetrating Radar survey) may also be required.

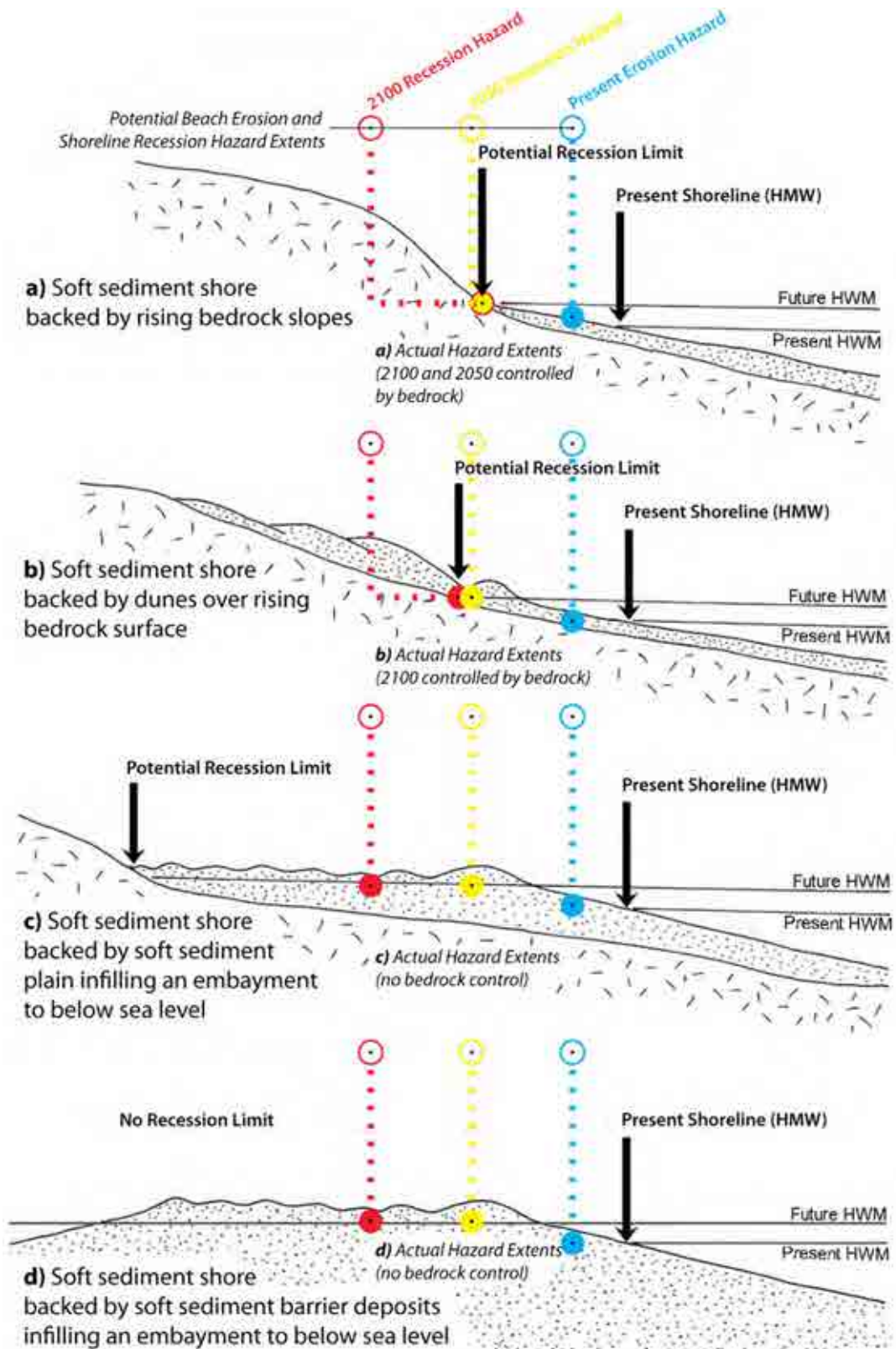


Figure 2-1 Conceptual Model: Maximum recession limits, as controlled by underlying bedrock topography, applied to coastal hazard definition (modified from Sharples and Donaldson, 2012)

3 Physical Setting of Blueys and Boomerang Beaches

3.1 Introduction

The following section provides an overview of the coastal geomorphology and geology of both Blueys and Boomerang Beaches, before describing in detail the local bedrock controls affecting actual hazard extents at the beaches.

3.2 Regional Setting

3.2.1 Overview

The physical setting of Blueys and Boomerang Beaches has been well described in PWD (1985), WorleyParsons (2011) and BMT WBM (2014). In summary, Blueys Beach and Boomerang Beach form high energy beaches that are bound by three steep bedrock headlands: Bluey Beach terminates at Blueys Head in the south; Boomerang Beach terminates at Charlotte Head in the north; and Boomerang Point is the prominent headland feature that separates the two adjacent beaches (refer to Figure 3-1). Both beaches are primarily sandy, relatively short in length and backed by dune systems that include composite barrier deposits comprising a relic – Pleistocene dune core overlain by modern Holocene dune sands. A mostly continuous incipient dune fronts the barrier dunes at both beaches.

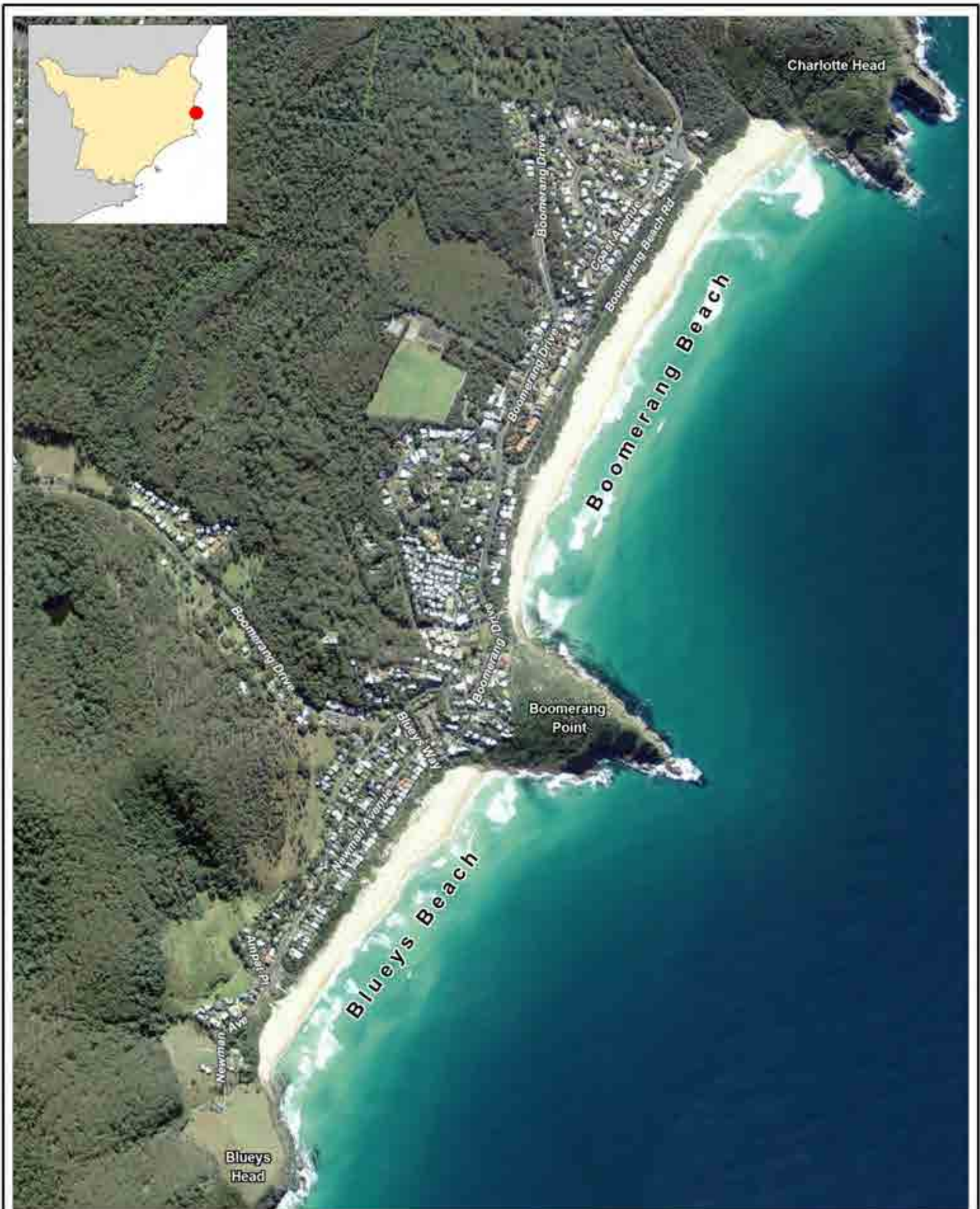
Blueys Beach barrier dune stretches southward from Boomerang Point towards the small creek entrance located near the southern corner of the beach. The barrier dune height decreases notably towards the creek entrance. A small local catchment is located behind the barrier dune, which drains the surrounding steeply rising vegetated bedrock slopes.

A continuous barrier dune at Boomerang Beach adjoins a transgressive dunefield that comprises locally high dunes towards the centre and north and a depression hollow towards the south. The lowland / swampy backbarrier area drains in a north-westerly direction towards Elizabeth Beach.

Sandmining of the incipient dunes and beach berms occurred at both beaches throughout the early to mid-1970's. A good overview of the sand mining history of Blueys and Boomerang Beaches is provided in PWD (1985).

3.2.2 Bedrock Geology

The bedrock geology of the region comprises Yagon Siltstone, a carboniferous aged sedimentary unit that is moderately metamorphosed and deformed (Roberts et al., 1991). Upturned sedimentary beds of this geological unit broadly trend to the southeast, which are seen outcropping in the form of coastal cliffs and wave-cut rocky shore platforms at the ends of Blueys and Boomerang Beaches. This predominant southeast-northwest geological structure of the local bedrock has strongly controlled the cliff morphology and embayment planform of both beaches. Field inspection of the cliffs and rocky platforms at southern Blueys Beach found the local geology to primarily comprise tilted meta-sedimentary beds that mostly comprise dark grey-brown siltstones with the occasional sandstone interbeds, which is consistent with the lithological description provided by Roberts et al. (1991) for the Yagon Siltstone formation. Tubridites, breccias, chaotic mudstones and conglomerates have also been noted within this geological formation (Roberts et al., 1991).

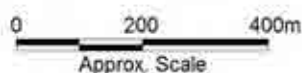


Title:
Blueys and Boomerang Beaches
Great Lakes Council

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Physical Setting of Blueys and Boomerang Beaches

3.2.3 Coastal Sedimentary Landforms

Based on the existing information, namely the PWD (1985) geotechnical investigation and the field observation during the GPR study (BMT WBM, 2014), the sediment types of the Blueys and Boomerang Beaches sedimentary landforms are provided below:

- *Beaches*
 - Predominately comprised of modern-Holocene clean marine sands; and
 - But also include **localised buried boulder deposits** towards the far ends of both beaches, notably at southern end of Boomerang Beach but also at the northern end of Blueys Beach;
- *Incipient Dunes*
 - **Clean sands**, of Holocene-age.
- *Barrier Dune*
 - Comprise an outer shell of **clean dune sands**, most likely Holocene in age; underlain by
 - An inner core of relic – Pleistocene **dune sands / silty sands**, that are **variably indurated** in places;

It is noted that neither the PWD (1985) borehole investigation, nor the GPR investigation found evidence of the buried boulder beach deposits extending significantly landward beneath the barrier dune at northern Boomerang Beach or southern Blueys Beach. However, photographic evidence in PWD (1985) and BMT WBM (2014) show that the boulders may superficially extend beneath the barrier dune.

Stiff clays and clayey sediments located beneath the barrier dune at Blueys Beach (i.e. at the base of the PWD (1985) boreholes) at around mean sea level, likely comprise relic Pleistocene-age estuarine / lagoonal sediments.

3.3 Coastal Hazard Geological Controls

The following sections describe the coastal geology of Blueys and Boomerang Beaches as it relates to coastal hazards. This description is based largely on the outcomes of the GPR study (BMT WBM, 2014).

In general, it was found that the geological limits to coastal hazards occur at the far ends of both beaches only. The erosion and recession limits that bound the active beaches are located at the toe of the adjacent coastal cliffs (i.e. at the alongshore limits of both sandy beaches). Within the immediate backbeach areas, the GPR and borehole data indicate that the modern coastal cliffs extend inland to form relic coastal cliffs and slopes (i.e. bluffs) that have subsequently become overlain by (relatively younger) barrier dune sediments. Thus the backshore geological limits to coastal hazard comprise buried coastal bluffs, within the coastal zone.

Physical Setting of Blueys and Boomerang Beaches

3.4 Blueys Beach

Blueys Beach is a southeast facing pocket beach that is bound by rocky headlands. The following description of Blueys Beach relates specifically to the geological limits to coastal hazards that are present within this pocket beach coastal system.

Both the BMT WBM GPR Study (2014) and the PWD geotechnical investigation (1985) show the middle stretch of Blueys Beach and its immediate backbeach area to comprise soft sediment landforms that are vulnerable to coastal hazards. The beach and incipient dunes are built from clean, unconsolidated sands. Behind here, the barrier dune forms a composite sedimentary landform comprised of modern clean dunes sands that overlay a relic dune deposit. The relic dune core is Pleistocene in age and primarily includes clean sands that become interbedded towards its base with silty sand layers that are softly indurated. Borehole data also shows the barrier dune to overlie a clay deposit at around sea level (PWD, 1985), which is likely coastal (i.e. estuarine / lagoonal) in origin.

The geological limit to coastal hazards for the central length of beach is located significantly landward of the coastal hazard envelopes (at least 150 metres landward of the shoreline, but often greater distances than this), at the base of the backing bedrock hinterland.

Bedrock only becomes an important control on coastal hazards towards the far ends of Blueys Beach.

3.4.1 Southern Blueys Beach

The geology of southern Blueys Beach is complex. The beach is formed mostly of sand but becomes underlain by a rocky shore platform at the far end of the beach. The barrier dune is a composite landform, comprising both modern sands and a variable indurated Pleistocene core. A creek mouth dissects the barrier dune some 150 metres from the end of the beach. Adjacent to here, dune sediments are underlain by clayey sands (PWD, 1985). South of the creek mouth, the dunes reduce significantly in height (relative to the middle and north sections of beach) and indurated sands become exposed at the toe of the dunes under eroded beach conditions (BMT WBM, 2014).

A short section of shoreline abruptly changes orientation towards the southern end of the beach, to trend in a north – south direction. A moderately rising vegetated slope immediately backs this shoreline segment. Limited exposures of bedrock at the base of vegetated embankment, in the form of tilted sedimentary beds (at around 4 m AHD), is considered to be the local geological control on coastal erosion and recession (see Figure 3-2 and Figure 3-4). The single photogrammetric profile for this section of shoreline (as shown in WorleyParsons (2014); Block A501, Profile 1) shows that the beach has not receded landwards into the backing vegetated slopes. This further indicates that the rock outcrops at the back of the southern Blueys Beach form a landward limit to erosion and recession. South of here, the beach terminates against the exposed rocky cliffs and shore platforms of Blueys Head.



Figure 3-2 Blueys Beach (looking south), showing the bedrock outcrops through the beach in the far southern corner

The moderately rising slopes described above may have a coastal slope instability hazard that warrants further investigation. Outcropping above the bedrock base to these slopes is a poorly sorted and cohesive mix of boulders and gravels held within a clay rich matrix (refer to Figure 3-3). A subtle topographic feature that is not indicative of bedrock landform, is also located immediately landward of this exposure (see Figure 3-2). The origin and extent of this uncharacteristic landform feature has not been investigated in detail here (as it is not relevant to the beach erosion and shoreline recession hazard definition), however a cursory geomorphic interpretation suggests that it may form a relic mass movement deposit¹. A more detailed assessment would be required to confirm this interpretation.

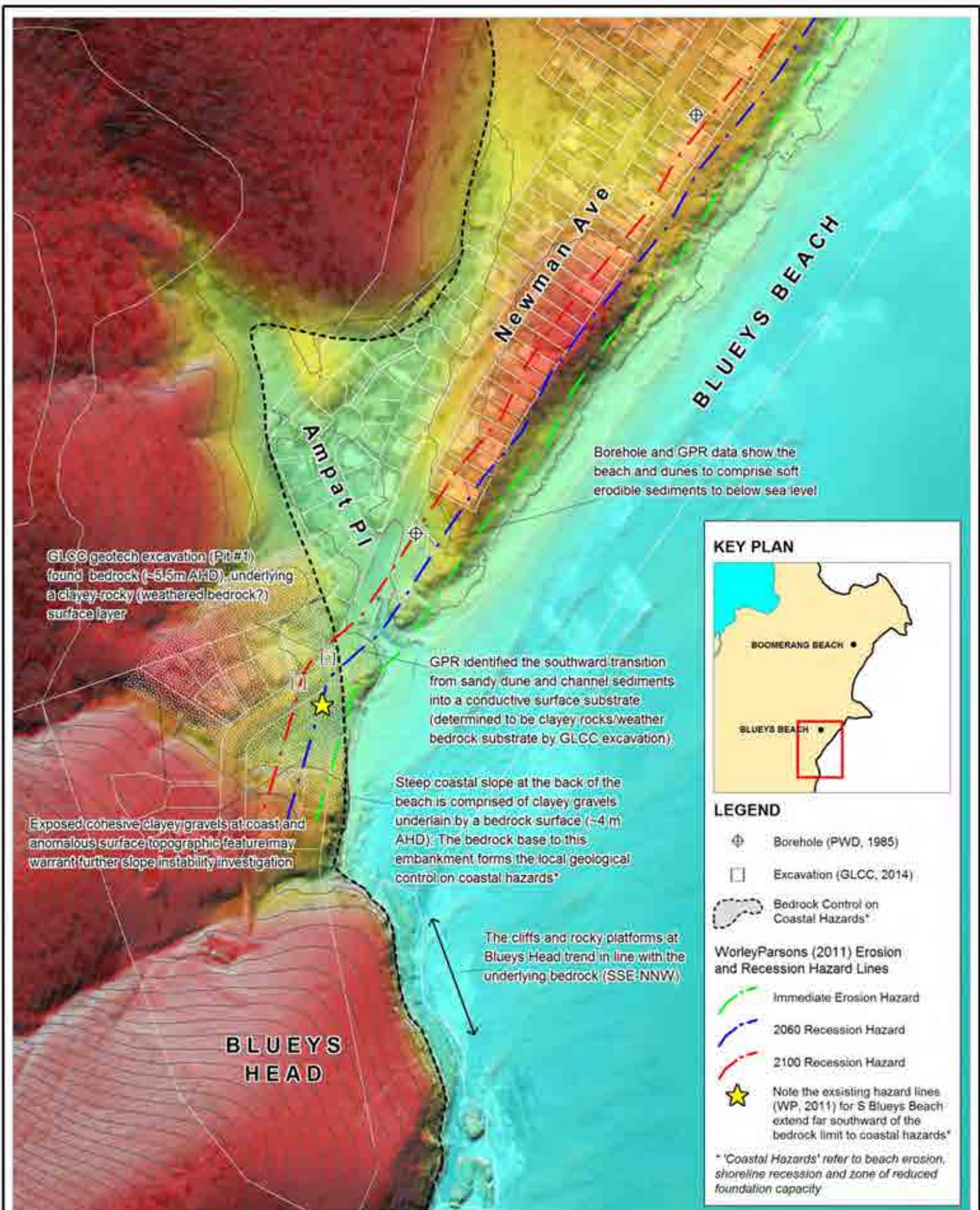


Figure 3-3 Cohesive clayey gravelly substrate, Southern Blueys Beach

¹ The sedimentology and geomorphology of this anomalous surficial feature suggests it may comprise a mass movement (landslide?) deposit, based on the following:

- Poorly sorted nature of sediments exposed at coastal margins of the feature;
- Fan-like shape of the anomalous topographic feature, which is also bounded by erosion gullies; and
- Possible relation between this feature and an inferred underlying bedrock fault (which would cause a plane of weakness that could potentially triggered such an event); note that although no faults have been previously mapped at this location, examination of the high resolution (LiDAR) DEM as part of this assessment identified a relationship between adjacent bedrock incised creek on Blueys Head and bedrock fault lines (as noted from bedding discontinuities in the LiDAR along a number of northeast striking linear features).

Further investigation is required into the geotechnical nature of this feature, as an associated cliff / slope instability coastal hazard may exist if this landform feature is indeed a mass movement deposit (refer to Figure 3-2).



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**Bedrock Control on Coastal Hazards, Blueys Head
 (Southern Blueys Beach)**

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Physical Setting of Blueys and Boomerang Beaches

Landward of the southern beach / dune system, the geological limit to coastal hazards is interpreted to continue in a northerly direction from the rock exposures described above (refer to Figure 3-4). The nature of this geological limit to coastal hazards likely forms a relic rocky shoreline, which is presently covered by the adjacent dune sediments. The trend of this limit matches with the adjacent Blueys Heads cliffs (and underlying local bedrock structure). This interpretation is consistent with both the GPR data for southern Blueys Beach and the geotechnical excavation conducted by Great lakes Council: where the GPR survey shows obvious sedimentary bedding located to the immediate east of this inferred boundary (refer BMT, WBM, 2014; Figure B-1 and B-2); and the geotechnical excavation investigation which located stable bedrock substrate at 5.4 m AHD to the west of this boundary (refer to Appendix A).

3.4.2 Northern Blueys Beach

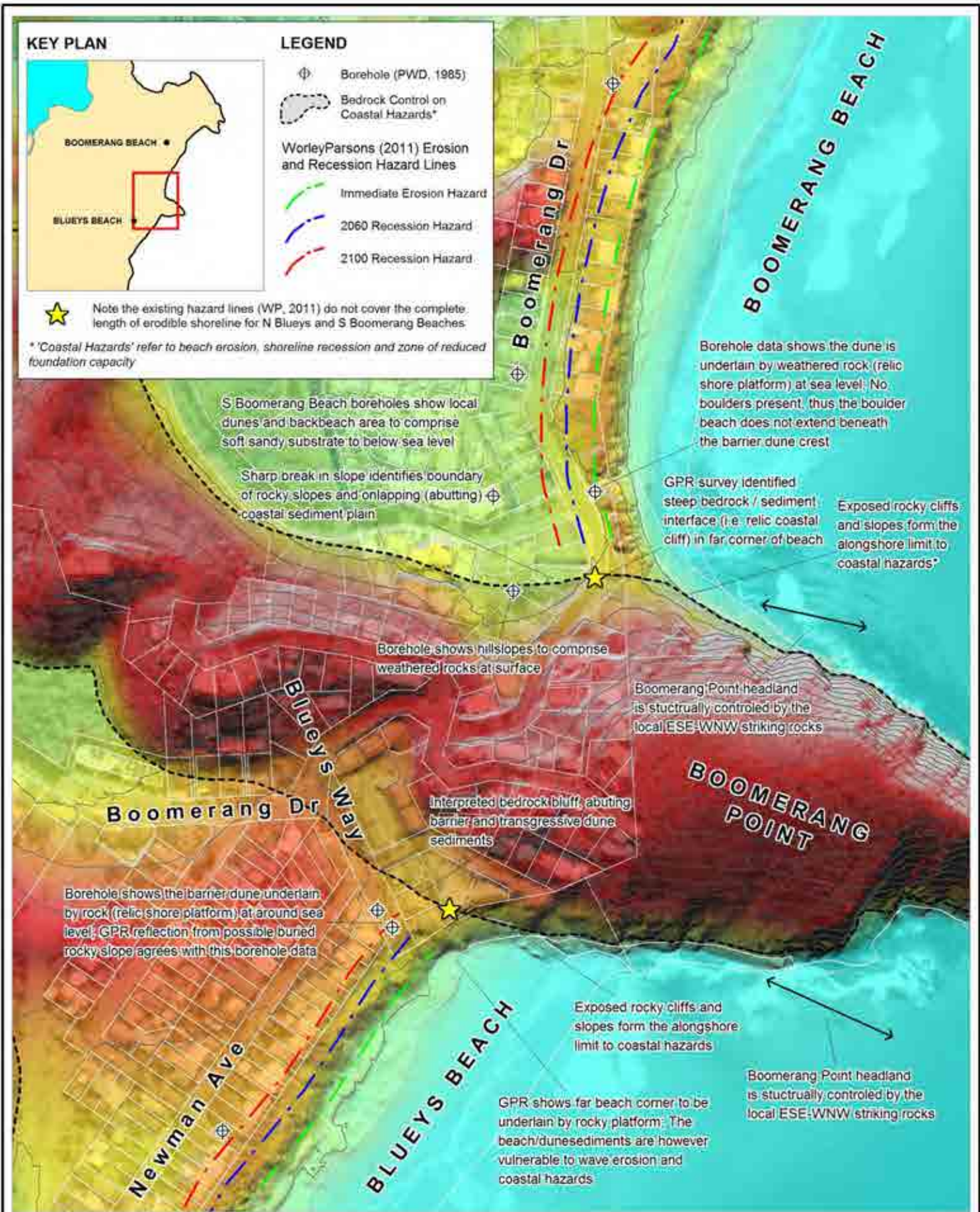
Similarly, the GPR and borehole data show that the coastal geology of northern Blueys Beach to be variable (PWD, 1985; BMT WBM, 2014). The beach is mostly sandy with the exception of the far northern corner where a partially buried boulder deposit is located at the base of the Boomerang Point cliffs. Beneath here, a rocky shore platform is thought to extend southwards a short distance from the toe of the cliffs, based on a dipping GPR surface surveyed beneath the beach (BMT WBM, 2014). Bedrock found at around sea level in northern Blueys Beach boreholes (PWD, 1985) indicates that a relic rocky shore platform also extends beneath the barrier dune (BMT WBM, 2014). The buried rocky shore platform is however not sufficiently elevated to provide any significant protection to the overlying beach and dune sediment from wave erosion and shoreline recession.

The backbeach geological limit to recession at northern Blueys Beach is controlled by the buried bedrock slopes that adjoin the Boomerang Point ridge line. The bedrock boundary located here likely takes the form of a relic coastal cliff that would have developed prior to the deposition of the Bluey Beach barrier dune landform. Considering the now active coastal cliffs are strongly controlled by the underlying bedrock structure (which has a local south easterly trend), the bedrock limit to coastal hazards is interpreted to extend inland and in-line with this geological trend. The interpreted geological recession limit as shown in Figure 3-5 is consistent with PWD (1985) borehole data and GPR surveys for this location.

3.5 Boomerang Beach

Boomerang Beach is an east-southeast facing barrier beach that is laterally bound by bedrock. The following description of this beach relates specifically to the geological limits to coastal hazards that are located within the Boomerang Beach coastal system.

The existing coastal geological studies of Boomerang Beach show that the bedrock limits to coastal hazards are located towards the far ends of the beach only (PWD, 1985; BMT WBM, 2014). These are detailed below. The middle stretch of beach is comprised of soft sediment landforms that extend below sea level and are therefore erodible by wave action and vulnerable to coastal hazards. The beach and incipient dunes are built from clean, unconsolidated sands and the backing barrier dune is formed of a modern dune sand capping that is variable and underlain by relic dunes. Similar to Blueys Beach, the barrier dune core is Pleistocene in age and formed of both clean sands and variably indurated silty sands that extend below sea level.



Title:
Bedrock Control on Coastal Hazards, Boomerang Point (Northern Blueys and Southern Boomerang Beaches)

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Physical Setting of Blueys and Boomerang Beaches

3.5.1 Southern Boomerang Beach

The geological limit to coastal hazards (i.e. the bedrock-sediment interface) in southern Boomerang Beach was identified in the GPR surveys of the area (BMT WBM, 2014). These data show the beach and dune sediments to abut onto a steeply dipping bedrock surface in the far corner of the beach. The bedrock surface is interpreted to form a buried coastal rocky cliff / slope.

Inland of the area surveyed by GPR study, the limit to coastal hazards has been mapped by geomorphic interpretation of the landscape. A distinct break in slope in back beach topography adjacent to Boomerang Point was used for this purpose. The surface features here show that the interface where the low lying coastal sediments that back Boomerang Beach abut the adjacent rocky slopes of Boomerang Point (refer Figure 3-5). The interpreted bedrock boundary also trends in line with the underlying geological structure (which strikes east-west), thus providing confidence in the topographic based geomorphic interpretation.

Other features of interest from the southern Boomerang Beach coastal system that do not constrain coastal hazards include a buried rocky shore platform and a periodically exposed boulder beach. These are briefly discussed below.

The weathered bedrock located at 0 m AHD beneath the southern Boomerang Beach barrier dune (refer PWD, 1985; B.H. Boom 5) is interpreted to form a part of a wide rocky shore platform that extends northward from the buried bedrock bluff as described above. Based on the borehole data, and common form of wave cut shore platforms, it is expected that this bedrock feature has a sub-horizontal profile at around mean sea level. As such, the buried rocky platform at southern Boomerang Beach, as interpreted from the PWD (1985) borehole data, will not limit the landward migration of coastal hazards with future sea level rise.

An extensive boulder beach is located at southern Boomerang Beach. This feature is often overlain by sand, but become variable and exposed under eroded conditions. Boomerang Beach boreholes drilled landward of the boulder beach deposits show that it does not extend behind the barrier dune crest. This may indicate that the boulder beach is Holocene in age. Regardless of the age and exact landward extent of this feature, the morphology of the deposit, and roundness of the boulders indicates that it is indeed a wave deposited landform. The origin of this feature indicates that the boulders can therefore be reworked and transported by wave action. Thus the boulder beach is not considered to form a stable shoreline feature that would halt the landward migration of coastal hazards with sea level rise. In addition, the eroded beach conditions observed during the GPR field investigation noted that the backing barrier dune sediments were recently eroded by wave action, indicating that wave uprush over the boulders during storm conditions is capable of eroding the backing barrier dune sands. Thus the boulder beach has been largely ignored in the processes of determining the geological limits to coastal hazards at southern Boomerang Beach.

3.5.2 Northern Boomerang Beach

The coastal hazard bedrock control for the northern Boomerang Beach has been estimated based on a geomorphic interpretation of the coastal geological system as neither the GPR study or borehole investigations were able to survey the far northern limits of the barrier dune due to dense vegetation ground cover. It is however likely that the central-northern limits of the beach and dunes are vulnerable to coastal hazards based on the GPR study output and geotechnical information

Physical Setting of Blueys and Boomerang Beaches

(available up to the northern carpark facilities). These data show the soft sediment coastal landforms to extend below mean sea level (PWD, 1985; BMT WBM, 2014). As such, the central-northern sections of Boomerang Beach are vulnerable to coastal hazards.

As detailed in the GPR study (BMT WBM, 2014) and mapped in Figure 3-6 , the bedrock control at the far northern end of Boomerang Beach likely extends landward of Charlotte Head beneath the beach and vegetated backshore slopes. The bedrock boundary is interpreted to continue onshore from the modern rocky cliff line in a north-westerly direction, in line with the local geological structure. Immediately south of here, the beach is assumed to be backed by high vegetated sand dunes that overly a buried rocky shore platform (at, or just below mean sea level). As such, the immediate backshore area of northern Boomerang Beach (between the car park and Charlotte Head) is vulnerable to coastal hazards.

KEY PLAN

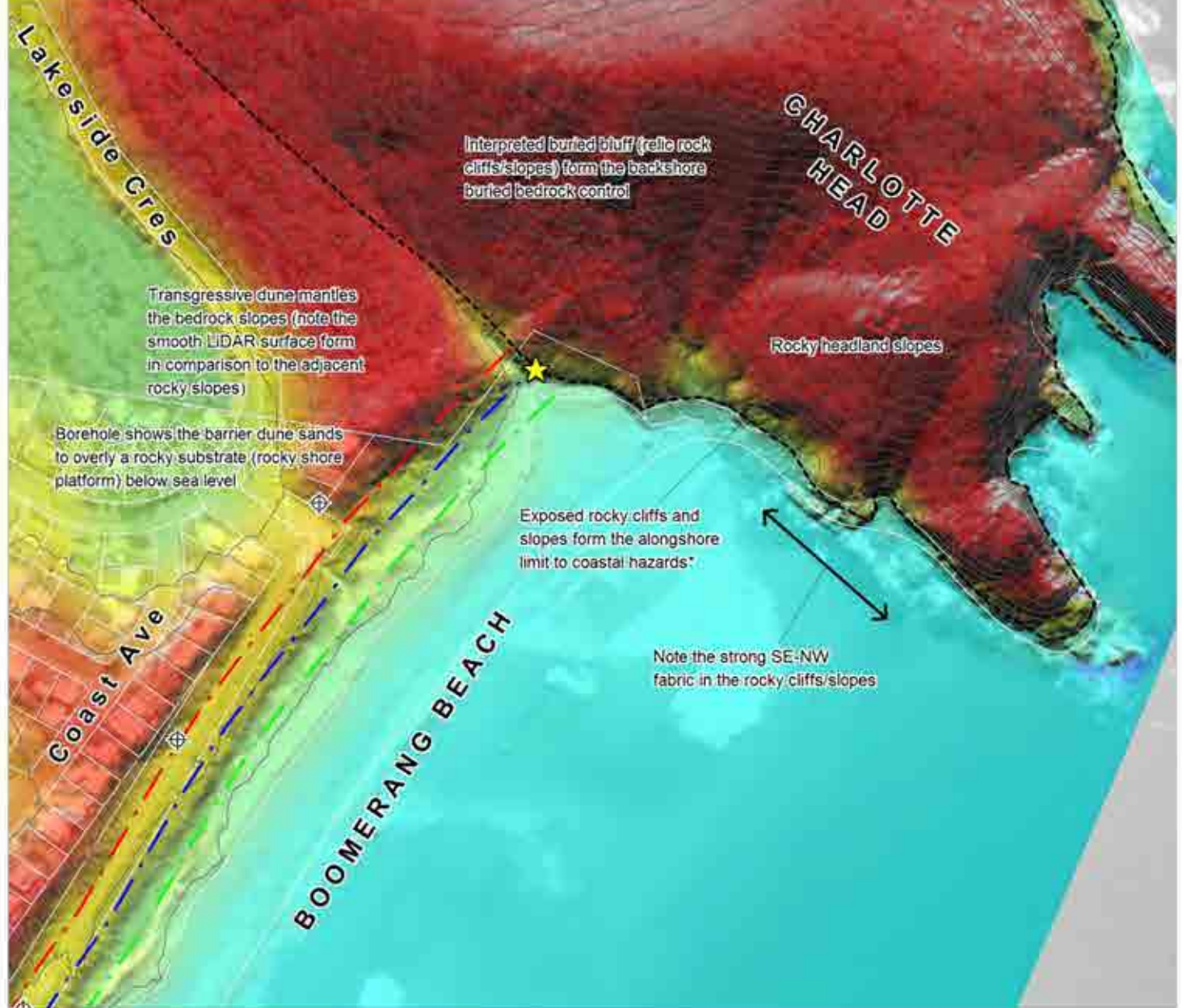


LEGEND

- Borehole (PWD, 1985)
- Bedrock Control on Coastal Hazards*
- WorleyParsons (2011) Erosion and Recession Hazard Lines**
- Immediate Erosion Hazard
- 2060 Recession Hazard
- 2100 Recession Hazard

Note the existing hazard extent (WP, 2011) for N Boomerang Beach is consistent with the length of erodible shoreline

* 'Coastal Hazards' refer to beach erosion, shoreline recession and zone of reduced foundation capacity

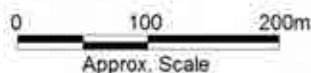


Title:
Bedrock Control on Coastal Hazards, Charlotte Head (Northern Boomerang Beach)

Figure:
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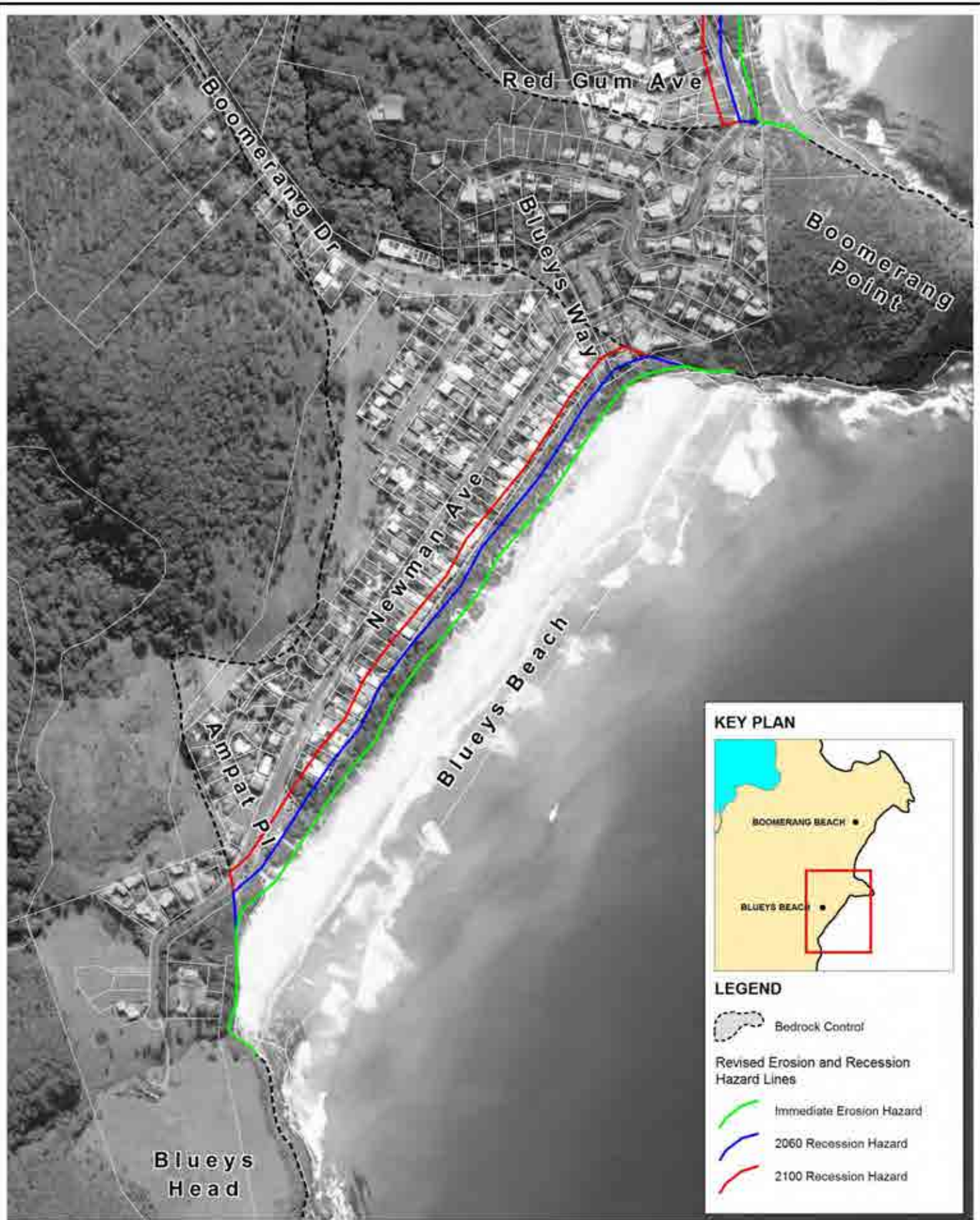


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4 Hazard Line Amendments

It is recommended that the beach erosion, shoreline recession and zone of reduced foundation capacity hazards definition for Blueys and Boomerang Beaches be revised to incorporate the bedrock control on coastal hazards as synthesised in Section 3. As noted in Section 2, such revisions do not make any recommendations with regard to the coastal engineering methods applied to determine the landward hazard extents, but rather just extends and / or limits the current hazard definition estimate to encompass the alongshore extent of erodible coastal sediment bodies. As such, the recommended hazard line revision detailed below is considered to be representative of local coastal bedrock controls present at the two beaches. The mapped recommended hazard revisions are provided in the figures below, which include the following changes:

- The southern limit of Blueys Beach coastal hazard definition has been shortened to account for the backshore bedrock substrate that underlies the far southern vegetated embankment and adjoins Blueys Head to the south (refer Figure 4-1);
- The alongshore limits of coastal hazard definition for northern Blueys Beach and southern limit of Boomerang Beach has been extended to the flanks of Boomerang Point and now encompass the entire length of erodible shoreline in those areas (refer Figure 4-2 and Figure 4-3); and
- The coastal hazard mapping for northern Boomerang Beach remains largely unchanged, however the hazard lines are now tied into the Charlotte Head bedrock control (refer Figure 4-4).



KEY PLAN

LEGEND

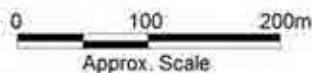
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- Revised Erosion and Recession Hazard Lines
 - Immediate Erosion Hazard
 - 2060 Recession Hazard
 - 2100 Recession Hazard

Title:
**Bedrock Revised - Beach Erosion and Shoreline
 Recession Hazard Map, Blueys Beach**

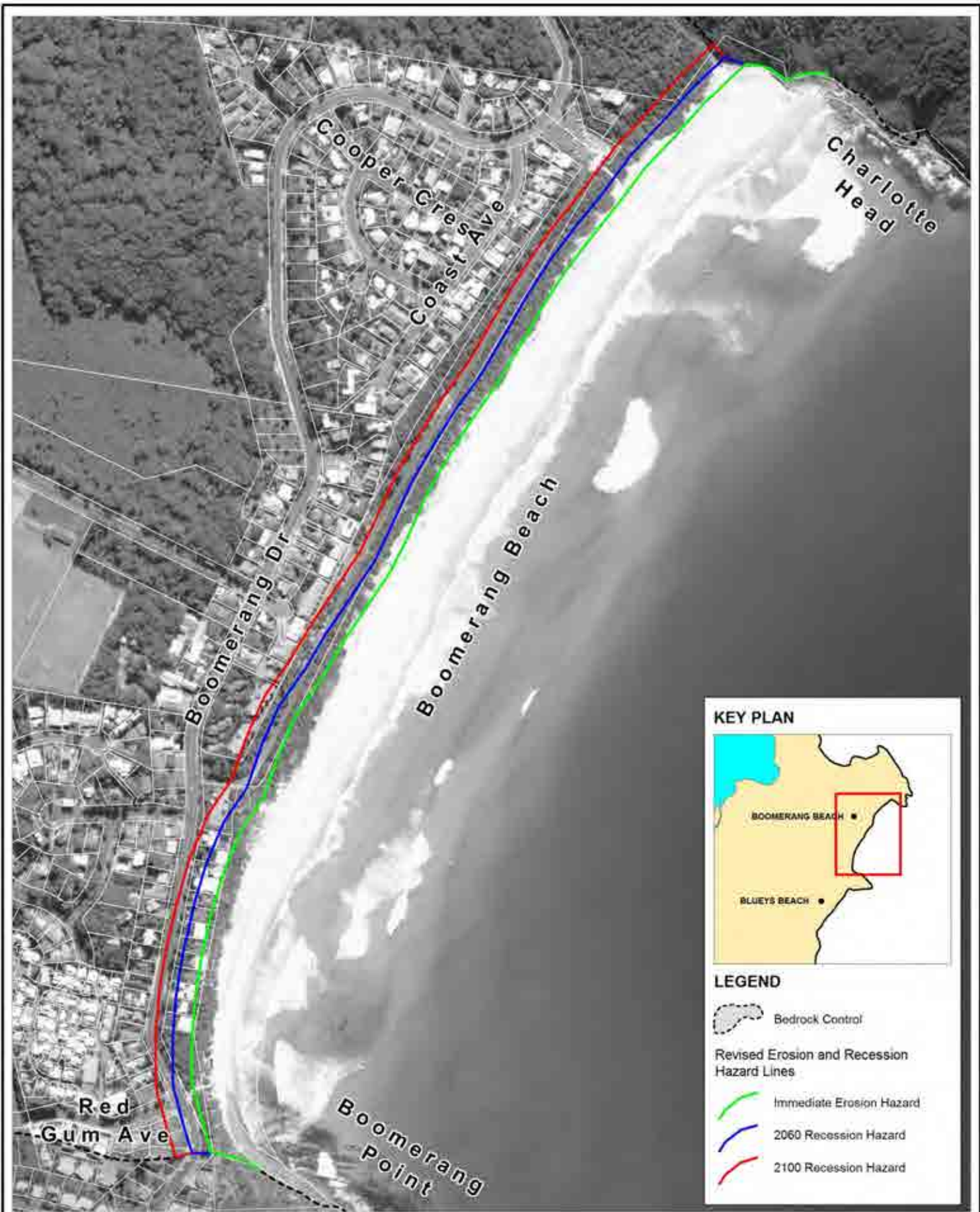
Figure:
4-1

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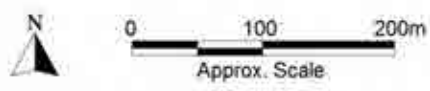
- Bedrock Control
- Revised Erosion and Recession Hazard Lines**
 - Immediate Erosion Hazard
 - 2060 Recession Hazard
 - 2100 Recession Hazard

Title:
**Bedrock Revised - Beach Erosion and Shoreline
 Recession Hazard Map, Boomerang Beach**

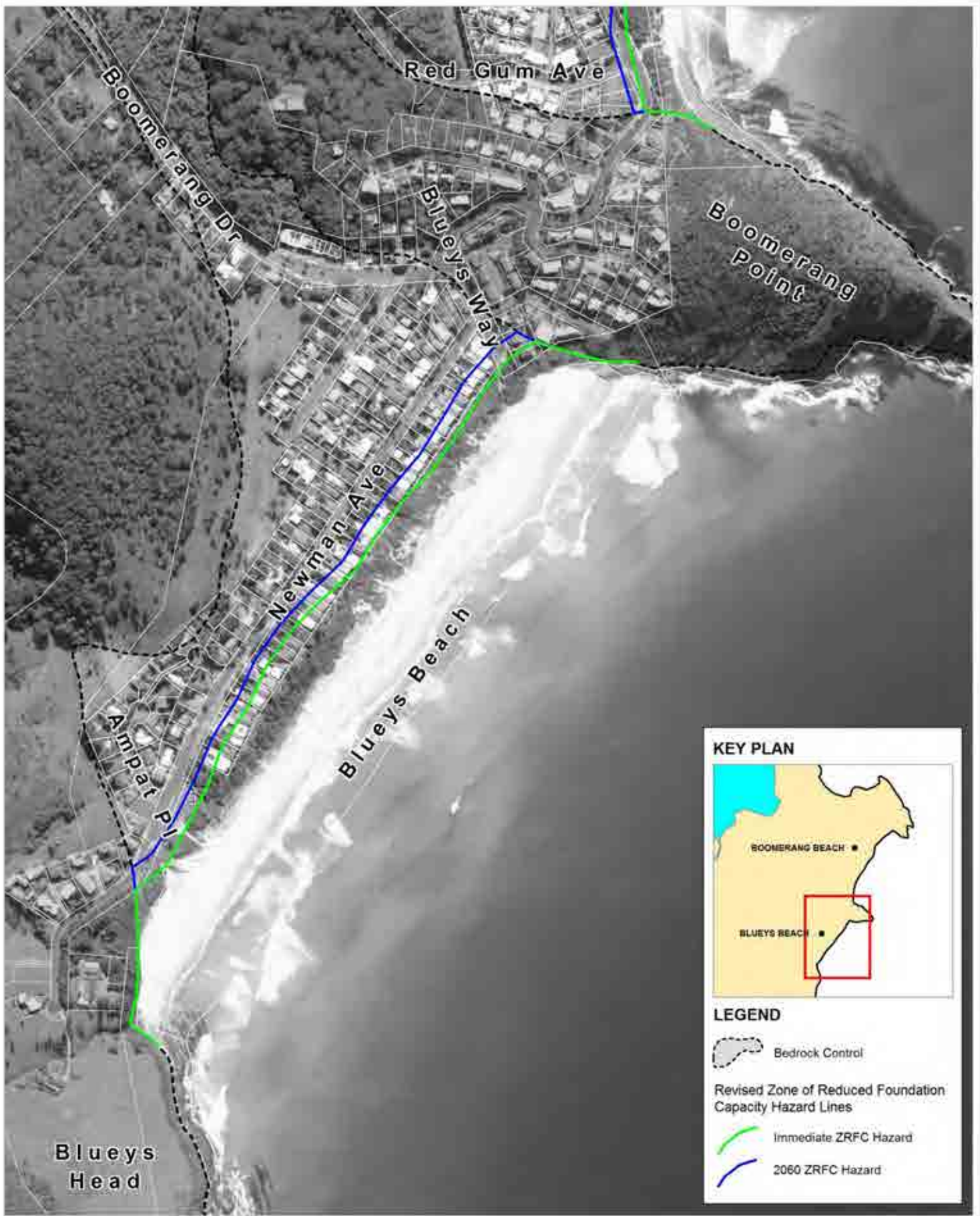
Figure:
4-2

Rev:
A

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KEY PLAN

LEGEND

- Bedrock Control
- Revised Zone of Reduced Foundation Capacity Hazard Lines**
 - Immediate ZRFC Hazard
 - 2060 ZRFC Hazard

Title:
Bedrock Revised - Zone of Reduced Foundation Capacity Hazard, Blueys Beach

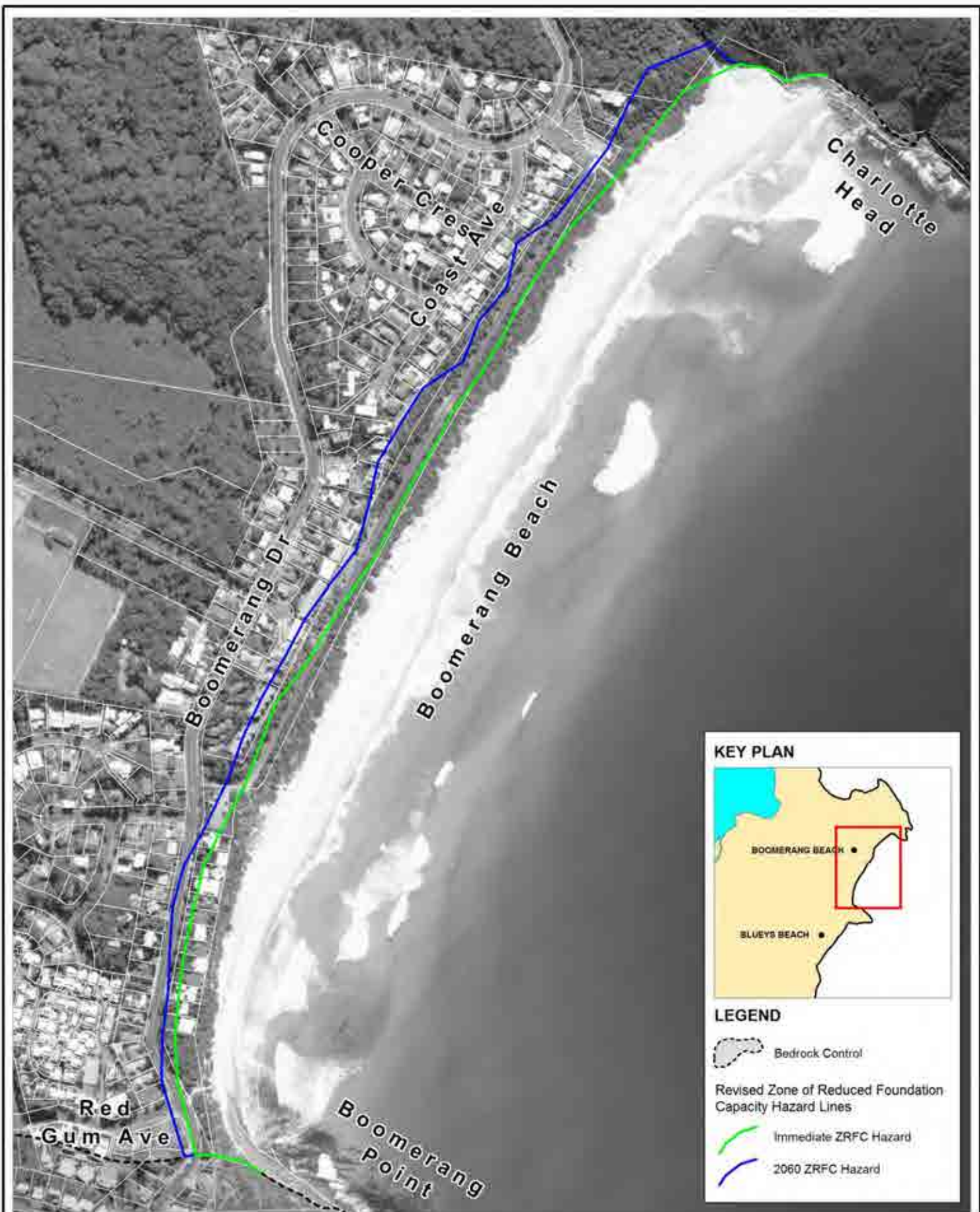
Figure:
4-3

Rev:
A

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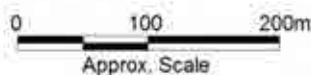
- Bedrock Control
- Revised Zone of Reduced Foundation Capacity Hazard Lines**
- Immediate ZRFC Hazard
- 2060 ZRFC Hazard

Title:
Bedrock Revised - Zone of Reduced Foundation Capacity Hazard, Boomerang Beach

Figure:
4-4

Rev:
A

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5 Conclusions and Recommendations

5.1 Geological Limits to Coastal Hazards

The beach and dune landforms at Blueys and Boomerang Beaches comprise erodible sediments that are vulnerable to coastal hazards. These soft sediment landforms adjoin steep rocky cliffs and buried bluffs, which are resistant to coastal hazards, at the far ends of both beaches. It is this geological boundary that forms the alongshore limit to beach erosion, shoreline recession and the zone of reduced foundation capacity hazards. The bedrock-sediment boundary at both beaches was found to be strongly controlled by the underlying bedrock structure, which plays an important role in the development of the local rocky shorelines.

The geological limits to coastal hazard are defined and mapped in Section 3.3.

5.2 Revised Coastal Hazard Lines

By mapping of the geological controls to coastal hazards, it is evident that previous coastal hazard lines were overestimated for the alongshore extent of hazard at southern Blueys Beach and underestimated for the alongshore hazard extents towards Boomerang Point (i.e. north Blueys and south Boomerang Beaches).

Based on these findings, the Blueys and Boomerang Beaches hazard definition has been revised to:

- extend (and limit) the alongshore hazard extents to encompass the entire lengths of erodible shorelines; and
- tie the hazard lines into the bedrock cliffs and buried bluffs that laterally bound the alongshore extent of erodible shoreline (refer to Section 4).

The coastal engineering methods applied by WorleyParsons (2011) to determine the landwards hazard extents are current industry standard, and as such, no revision to the cross shore hazard extents have been made.

5.3 Recommendations

Based on the finding of the GPR study, and the additional geomorphic and geotechnical analysis detailed in this report, it is recommended that the revised beach erosion, shoreline recession and zone of reduced foundation capacity hazard definitions be adopted by Council, as detailed in Section 4.

It is also recommended that Council ensures that future coastal hazard definition studies give due consideration to near shore bedrock control.

6 References

BMT WBM (2014) *Ground Penetrating Radar Investigation of Blueys and Boomerang Beaches*. Final Report prepared for the Great Lake Council.

PWD (1985) *Boomerang Beach and Blueys Beach Coastal Engineering Advice*. Public Works Department Civil Engineering Division.

Roy, P.S., Cowell, P.J., Ferland, M.A. and Thom, B.G., 1994. Wave-dominated coasts. In: R.W.G. Carter and C.D. Woodroffe (Editors), *Coastal Evolution: Late Quaternary Shoreline Morphodynamics*. Cambridge University Press, Cambridge, pp 121-186.

WorleyParsons (2011) *Boomerang Beach and Blueys Beach Coastal Processes and Hazard Definition Study*. Final Report prepared for the Great Lake Council.

Appendix A Southern Blueys Beach Geotechnical Excavation Investigation

Two geotechnical excavation pits were investigated by Geoff Love from Great Lakes Council at southern Blueys Beach on the 14th May, 2014. The investigation was conducted to a) clarify the inconclusive results received from the GPR investigation at this location (BMT WBM, 2014); and b) ultimately help define the coastal substrate at this location. It should be noted that the poor GPR results returned from southern Blueys Beach and south of the creek mouth, was due to the clayey nature of the coastal substrate as shown below.

Investigation Pit 1 is located at -32.3543° south, 152.5339° east, with a ground surface RL of 6.7 m AHD.

Investigation Pit 2 is located at -32.3545° south, 152.5336° east, with a ground surface RL of 9.0 m AHD.

Photos and engineering logs from the excavation pits are provided below. These are followed by a map detailing the pit locations.

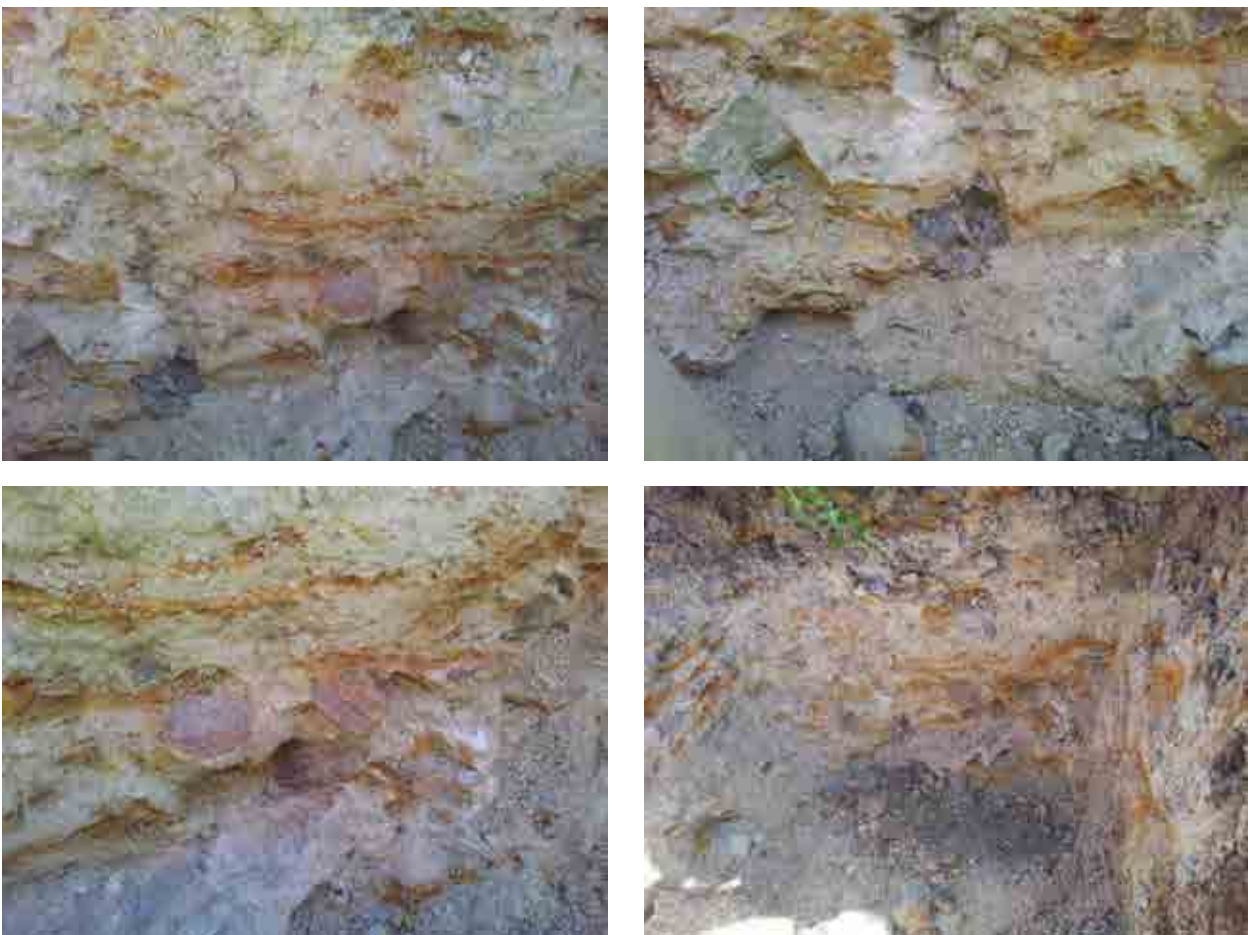


Figure A-1 Pit 1: Excavation Photographs (Geoff Love, Great Lakes Council)

Pit 1# = 32.3543; 152.5339
 GL RL 6.7m AHD

Great Lakes Council
 ENGINEERING LOG - EXCAVATING

Logged by:		GEOFF LOVE		Date:	14/05/2014	
Principal:		GLC				
Project:		BOOMERANG/BLUEYS CZMP - HAZARD LINES				
Pit Location:		PIT 1# 89 NEWMAN AVE BLUEY BEACH				
Equipment Type & Model:		EXCAVATOR		RL Surface:		
Excavation Dimensions:		1200 Long	1200 wide	N orientation		Datum
METHOD	WATER	SAMPLES, TESTS, ETC YES	RL DEPTH (m)	MATERIALS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX
			0.1	MIXED TOPSOIL	RL 6.7m AHD	
			0.2		MOIST	
			0.3	MIXED SOIL & ROCK TO 150 MLD	SL. MOIST	
			0.4			
			0.5	WEATHERED ROCK		
			0.6	ORANGE 'IRONSTONE' VEINS, EASILY BROKEN	DRY	
			0.7	SILTSTONE MATRIX		
			0.8	+ SEDIMENTARY INCL.		
			0.9	DURABLE ROCK	RL 5.9m AHD	
			1.0	SLIGHTLY WEATHERED		
			1.1	ORANGE VEINING	DRY	
			1.2	OLD SEDIMENTARY INCLUSIONS, VEINS & SILTSTONE		
			1.3	BOTTOM OF PIT	DRY RL 5.4m AHD	
			1.4	EXCAVATOR REFUSAL		
			1.5			
			1.6			
			1.7			
			1.8			
			1.9			
			2.0			

Page of

Figure A-2 Pit 1: Excavation Geotechnical Log (Geoff Love, Great Lakes Council)



Figure A-3 Pit 2: Excavation Photograph (Geoff Love, Great Lakes Council)

PIT 2# - 32.3545°; 152.5336°
 CL RL 9.0m AHD

Great Lakes Council
 ENGINEERING LOG - EXCAVATING

Logged by:		GEOFF LOVE		Date:	14/05/2014	
Principal:		GLC				
Project:		BOOMERANG/BLUEYS CZMP - HAZARD LINES.				
Pit Location:		PIT 2# OFF ST. NEWMAN AVE, BLUEYS BEACH				
Equipment Type & Model				RL Surface:		
Excavation Dimensions:		800 long	600 wide	NE orientation	Details	
METHOD	WATER	SAMPLES, TESTS, ETC NO	RL DEPTH (m)	MATERIALS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX
			0.1	TOPSOIL + FILL		
			0.2		DRY	
			0.3			
			0.4	ORIG. TOPSOIL	DRY	
			0.5	WHITE/GREY CLAY RED MOTTLES 30% (SANDY)		
			0.6		DRY	
			0.7	BROWN CLAY SANDY SILTY RED MOTTLES 30%		
			0.8		SLIGHT. MOIST	
			0.9			
			1.0			
			1.1			
			1.2			
			1.3			
			1.4			
			1.5	TRANSITION TO GREY CLAY MOTTLED	SL. MOIST.	
			1.6	BOTTOM OF PIT		RL 7.5m AHD
			1.7	No ROCK FD.		
			1.8			
			1.9			
			2.0			

Figure A-4 Pit 2: Excavation Geotechnical Log (Geoff Love, Great Lakes Council)



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