Harvey Coastal Hazard Risk Management and Adaptation Plan

Coastal Hazard Assessment

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Prepared for Shire of Harvey

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1 INTRODUCTION

This document summarises coastal hazards affecting the Shire of Harvey and their potential changes over the next 100 years, to support planning for the Shire coast. It has been developed to inform the Shire's Coastal Hazard Risk Management and Adaptation Plan (CHRMAP), which provides a basis for the long-term management of coastal assets and values that are exposed to hazard.

Three documents have been prepared as part of the CHRMAP development (Figure 1-1). The information in this Coastal Hazards document was used to inform the key coastal management issues being faced by the Shire of Harvey. The CHRMAP itself has been developed as a stand-alone document, for which the Coastal Hazard Assessment and Summary of Key Issues provide reference material.

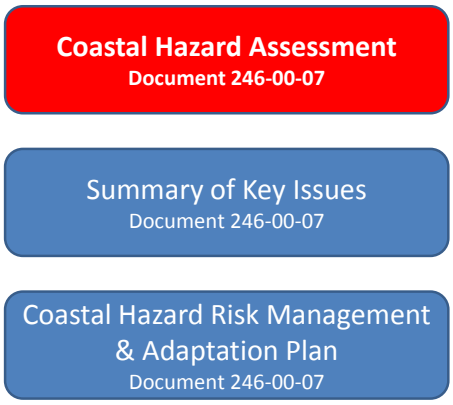

Figure 1-1: Document Context in the CHRMAP

Following guidance from the CHRMAP Guidelines [1] and the State Coastal Planning Policy SPP 2.6 [2], coastal hazards focused upon include erosion, inundation and coastal landform mobility. It is noted that movement of the coastal dunes has historically required substantial management effort along the Harvey coast, and therefore requires greater consideration than is provided by Schedule One of SPP 2.6.

The coast considered for the hazard assessment extends the entire length of the Shire coastline (Figure 1-2), from the southern tip of Leschenault Peninsula in the south, to the northern Shire boundary, which is approximately 11km south of Preston Beach. The landward extent of assessment varies spatially, depending on which coastal hazard or management is under consideration. Evaluation of erosion is considered for the open ocean coast; coastal landform mobility is considered across the coastal dune ridge and inundation is considered on the coast, on the shores of Leschenault Estuary and across the lowlands which extend between Lake Preston and Leschenault Estuary. The townsites of Binningup and Myalup are included in the assessment, along with Leschenault Peninsula Regional Park, which is managed by the Department of Parks and Wildlife (DPaW).

Figure 1-2: Shire of Harvey Coast

1.1 Background and Context

The Shire of Harvey is one of nine member councils of the Peron Naturaliste Partnership (PNP), a group of local governments who have adopted a regional, collaborative approach to monitoring and management of the coastal zone from Cape Peron to Cape Naturaliste in southwest Western Australia. Through the PNP a number of studies have been completed to identify areas where future impacts from coastal erosion and inundation may affect assets or planning along the PNP coast [3,4,5]. It was recognised that there is a need for scaling down or regional coastal hazard assessments to make the evaluation relevant to decision-making. The PNP identified the potential value of linking hazard assessments from both regional and local scales, particularly to support interagency decision-making regarding the consequences of adaptation actions.

Following from the regional-scale assessment of coastal hazards and adaptation pathways 5, the PNP selected the Shire of Harvey as an appropriate location to test in detail the process of stepping from regional coastal hazard assessment, through local hazard assessment, to implementation within the planning framework. The regional-scale erosion assessment indicated significant challenges for townsite planning for the Shire of Harvey coast due to erosion potential, suggesting that the coast requires management through a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) framework [1,2]. The Shire of Harvey has undertaken to develop a CHRMAP to assist in planning for and the management of coastal assets.

An assessment has been made of the coastal processes occurring along the Shire of Harvey coastline, to identify the sources of coastal hazards (erosion, inundation and coastal landform mobility) in the region. Evidence regarding the pathways by which these hazards may create risk for the Shire of Harvey's coastal assets has been collected, to support interpretation of possible mitigation actions. Characterisation of hazard sources and pathways includes description of their amplitude and likelihood, to support evaluation of appropriate management responses through a Source-Pathway-Receptors-Consequences framework.

2 REGIONAL DESCRIPTION OF HARVEY COAST

The Shire of Harvey coast is located approximately 180-km south of Perth, with a mainly sandy shore in front of a high coastal dune barrier seaward of Lake Preston and Leschenault Estuary. This coast is the southern part of a ridge-lagoon coastal sequence which extends from Bunbury to Mandurah, and separated from the Geographe Bay sandy coast by the natural boundary at Casuarina Point.

The continental shelf in this region is relatively broad and shallow, with shelter from the prevailing southwest ocean swells provided by the Leeuwin-Naturaliste ridge. However, the coast is not protected by the extensive limestone ridges that form shallow near shore reefs along much of the central and south west coast of Western Australia (Figure 2-1). Although minor rock features can be observed, they are typically present on the shore itself or isolated in nature. The coastal topography is dominated by a large sequence of coastal dunes, up to 50-metres elevation above sea level. Much of the foreshore is sharply scarped, with extensive blowouts present along the dune ridge.

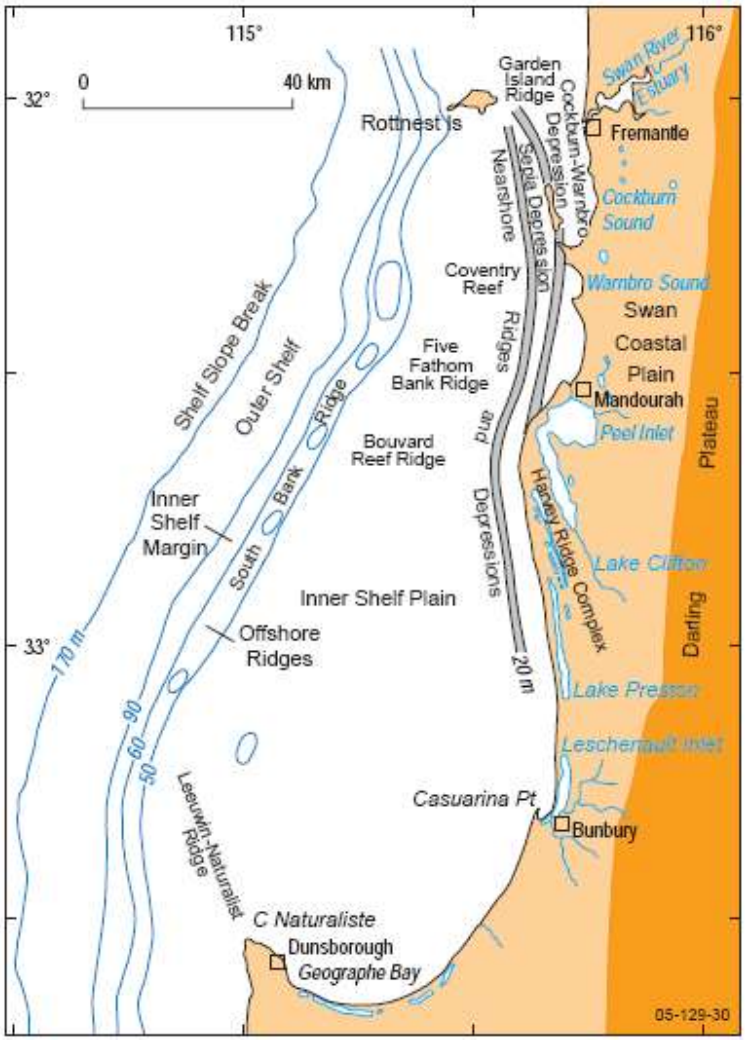

Figure 2-1: Morphology of Naturaliste to Rottnest Shelf
Extracted from Geoscience Australia [6]

3 GEOLOGY, COASTAL ORIGINS AND SEDIMENT CHARACTER

The geological and sedimentary setting determines how the existing coastal landforms developed, which may influence how they behave in the future. It contributes directly to modern coastal dynamics through the variation of material characteristics, with seabed and nearshore rock features providing an almost fixed framework underlying and retaining sand bodies including beaches and dunes.

The geology of the southwest region is divided by the Darling Scarp between the Yilgarn Block to the east (Precambrian granites) and the Perth Basin to the west, with mostly Cretaceous limestone [7]. Quaternary Tamala limestone formations are expressed along parts of the coast, nearby islands and reef chains. Below the Darling Scarp, surface sediments of the Swan Coastal Plain are comprised of a sequence of weathered coastal dune systems, generally decreasing in age westward (Figure 3-1). The sequence has resulted from sea level fluctuations in the Late Quaternary [8,9].

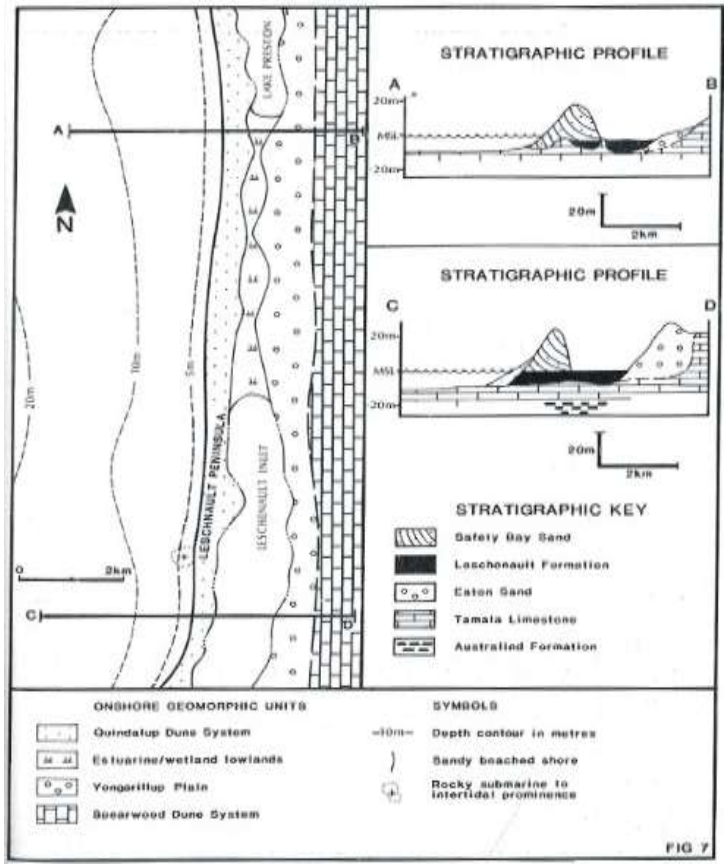

Figure 3-1: Classification of Coastal Landform Origins
Extract from Searle & Semeniuk [9]

Casuarina Point (Bunbury) marks a boundary between natural coastal sectors that are distinct for Geographe Bay to the south and the Bunbury-Mandurah coastline to the north; the southern half of the Bunbury-Mandurah coastline comprises the Shire of Harvey coast [9,10]. Exposed rock at Casuarina Point, which forms the western boundary of Koombana Bay, includes a mixture of basalt and limestone. These are expressions of the Pre-Cambrian and Pleistocene formations that define the regional geology. Elsewhere throughout Bunbury and its surrounds, these rock layers are overlain by

sands and estuarine muds, with deposition from the Preston and Collie Rivers flowing into the Leschenault Estuary from the south. South of Bunbury, the coastal region can be generally described as a thin Holocene sand sheet, overlying a gently graded Pleistocene limestone substrate, which extends out into Geographe Bay. Limestone is exposed in the nearshore region at Minninup, forming a short section of rocky coast.

The Bunbury-Mandurah coast is part of the wider lowlands and is dominated by the Quindalup Dunes, an extensive sequence of coastal dune ridges comprised of Safety Bay Sands, which have been reworked over the Holocene period; approximately the last 10,000 years [11]. Measurements of this sedimentary unit have demonstrated a very high carbonate content, from 35% to 90% by weight [12]. The dunes have extensive aeolian characteristics, including dune face blowouts and sand sheets [13] (Figure 3-5) with some highly deflated parabolic dunes overlying lagoonal sediments [14].

The evolutionary sequence of the Bunbury-Mandurah coastline has been interpreted from coastal stratigraphy [15] (Figure 3-2). Unlike the majority of southwest Australia, the coast in this region is not defined by outcropping of Pleistocene limestones (Tamala formation) but is almost solely derived from Holocene reworking of mobile sediments.

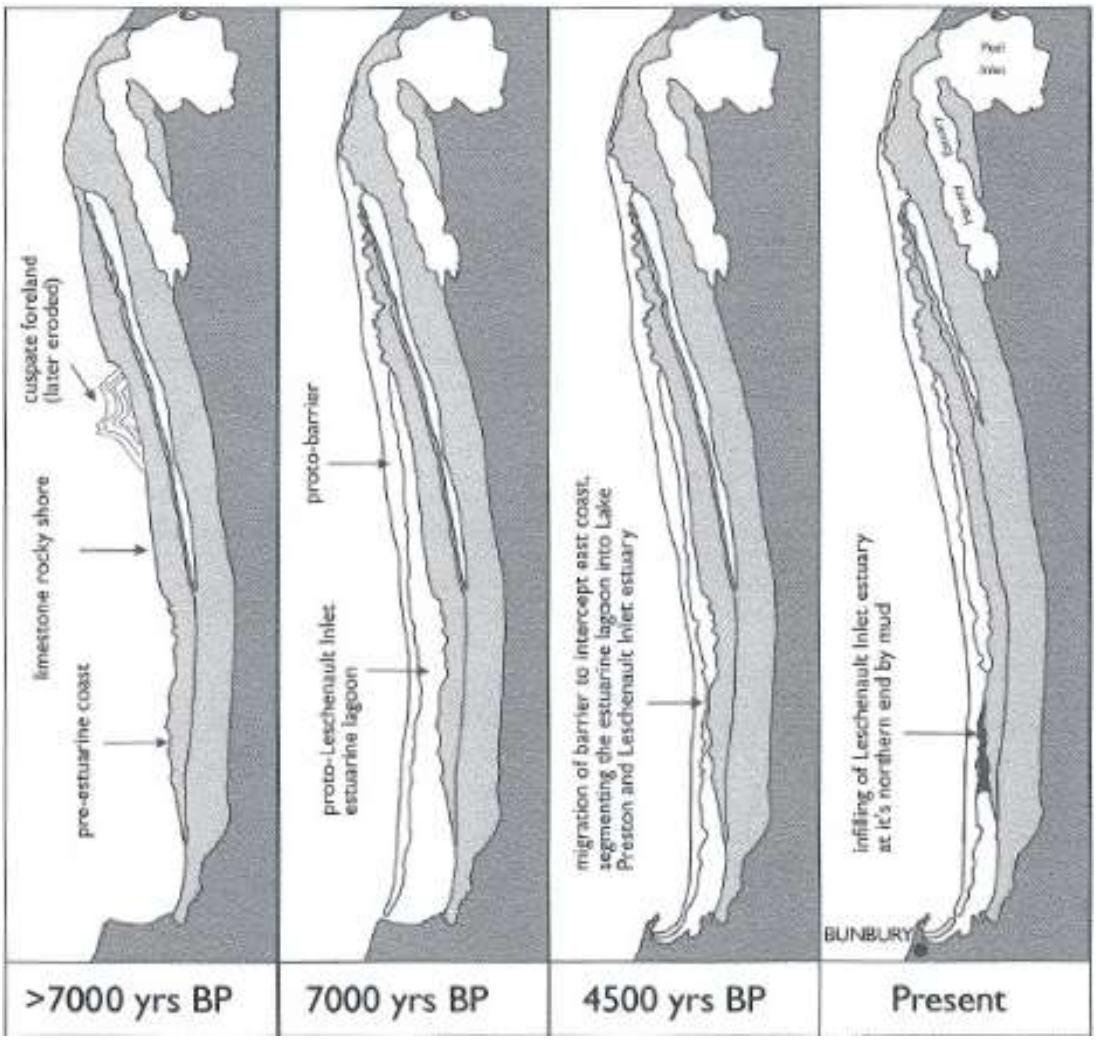

Figure 3-2: Coastal Evolutionary Sequence
Extract from Semeniuk *et al.* [15]

Further evidence regarding the mobile nature of the sediments in the region was provided through the use of boreholes, cone penetrometer and microtremor seismic data [16]. Boreholes taken through the frontal dune ridge showed no rock above -10m AHD, although isolated sampling slightly further east identified some rock between 0 and –10m AHD.

3.1 Sediment Character

Variation of sediment size and chemical composition may affect the relative mobility of the coast. It may also indicate the relative contributions of different sources (e.g. rivers compared to marine sources or rock weathering). Sediment with the same chemical properties but different size may indicate different levels of mobility due to waves and currents.

Sediment character has been described on several occasions within the Bunbury-Mandurah region. The major coastal features, including the dune barrier (Figure 3-1) have been classed as *Safety Bay Sands,* which is characterised as being fine to medium sand, with very high carbonate content. Measurements of beach sand grain size show variation across the Bunbury-Mandurah region, with apparent response to wave exposure and landform mobility.

Bunbury
- Sampling conducted as part of siltation studies for Bunbury Harbour identified a significant difference of sediment sizes either side of the main Bunbury breakwater, with 0.85mm median diameter on the western side and 0.24mm on the east side [17].
- Sediment samples from Bunbury back beach showed a mean diameter ranging from 0.35 to 0.5mm, with a carbonate analysis of approximately 17% by mass [18].

Binningup
- Local sediment sampling has been undertaken for south of Binningup town site [19]. A composite sediment sample was analysed, comprised of material from the waterline, beach berm and foredune. The sample median diameter was 0.44mm.

Mandurah
- Sediment analysis at Dawesville Channel, associated with sand bypassing operations showed a median diameter of 0.20 to 0.33mm [20].

3.2 Sediment Cells Context

Characterisation of coastal behaviour along the southwest Australian coast has been described using the concept of sediment cells [10]. Cells define areas of coast within which landform change, including the seabed, is strongly related, typically through sediment exchange between landforms (i.e. material eroded from one feature is transferred to another). The boundaries between sediment cells have been determined through the identification of structural characteristics (e.g. a large headland or change in coastal orientation) which will inhibit the transfer of sediment between adjacent cells, although a complete barrier to sediment exchange occurs rarely along the southwest coast.

A spatial hierarchy of sediment cells has been developed [10], with primary, secondary and tertiary cells (largest to smallest). Sequentially finer scales are brought about through the inclusion of boundaries which cause less substantial limitation of sediment transfer. In general, finer cell scales are more relevant to finer time scales, with tertiary cells relevant at an inter-annual time scale, secondary relevant at inter-decadal time scales and primary for longer time scales.

Sediment cells including or adjacent to the Harvey Coast have been identified (Table 3-1). As the Shire coast is located towards the southern end of the Casuarina Point to Cape Bouvard primary cell, it is likely to be influenced by the rate of sediment bypassing Casuarina Point and the Bunbury Port

facilities. A secondary cell boundary was identified near Binningup, with a reef rock platform apparently influencing coastal orientation, but providing a substantially lesser impediment to sediment movement than at Bunbury. Tertiary cell boundaries identified within the Shire coast provide relatively weak control and were more influenced by differences in exposure (and cross-shore sediment transfer) between cells. The importance of tertiary cells to the interpretation of coastal vegetation line change over inter-annual time scales has been demonstrated on the neighbouring Yalgorup Coast [21].

Table 3-1: Sediment Cells including or adjacent to the Harvey Coast

Primary Cell	Secondary Cell	Tertiary Cell
B. Casuarina Point to Cape Bouvard	8. Preston Beach North to Cape Bouvard	*Not considered to directly affect Harvey Coast*
	7. Lake Preston South to Preston Beach North	7a Lake Preston South to Preston Beach North
	6. Binningup to Lake Preston South	6b Myalup North to Preston South
		6a Binningup to Myalup North
	5. Bunbury Harbour to Binningup	5c Buffalo Road to Binningup
		5b Leschenault South to Buffalo Road
		5a Bunbury Harbour to Leschenault South
A. Cape Naturaliste to Casuarina Point	4. Capel River mouth to Bunbury Harbour	*Not considered to directly affect Harvey Coast*
	3. Norman Road to Capel River Mouth	*Not considered to directly affect Harvey Coast*
	2. Point Piquet to Norman Road	*Not considered to directly affect Harvey Coast*
	1. Cape Naturaliste to Point Piquet	*Not considered to directly affect Harvey Coast*

The sediment cells framework has been used to guide the collection and interpretation of coastal change information for the Harvey Coast (Section 5).

3.3 Rock Features

Although the majority of the coast is sandy, rock features occur extensively along the Harvey coast, particularly the seabed, providing significant influence on the way the coast changes. The complexity of the seabed revealed by nearshore LIDAR (Figure 3-3) provides supporting evidence for stratigraphic interpretation of the Leschenault Peninsula late Holocene dynamics [14], but also shows a greater presence of rock features than previously implied by geophysical assessment [16].

Sediment cell identification (Table 3-1), which is based on coastal landforms, can be related to the major seabed and coastal rock features. The relatively higher rock platform from Binningup to Buffalo Road provides sufficient coastal control to act as a secondary sediment cell boundary. More subtle changes are induced at Myalup North and Leschenault South by the sheltering from offshore reefs and Casuarina Point respectively.

The importance of limestone pavement and offshore ridges is suggested by the large-scale offshore profiles (Figure 3-4). These highlight a separation of the nearshore and offshore slopes, which may be a key mechanism to reduce the rate of progressive coastal erosion over the late Holocene. The distribution of beach rock deposits as a series of ridges across the nearshore seabed plain has been interpreted as indicating the movement of the Leschenault-Yalgorup dune barrier. Progressive net recession has occurred through phases or relative stability and phases of enhanced erosion [22].

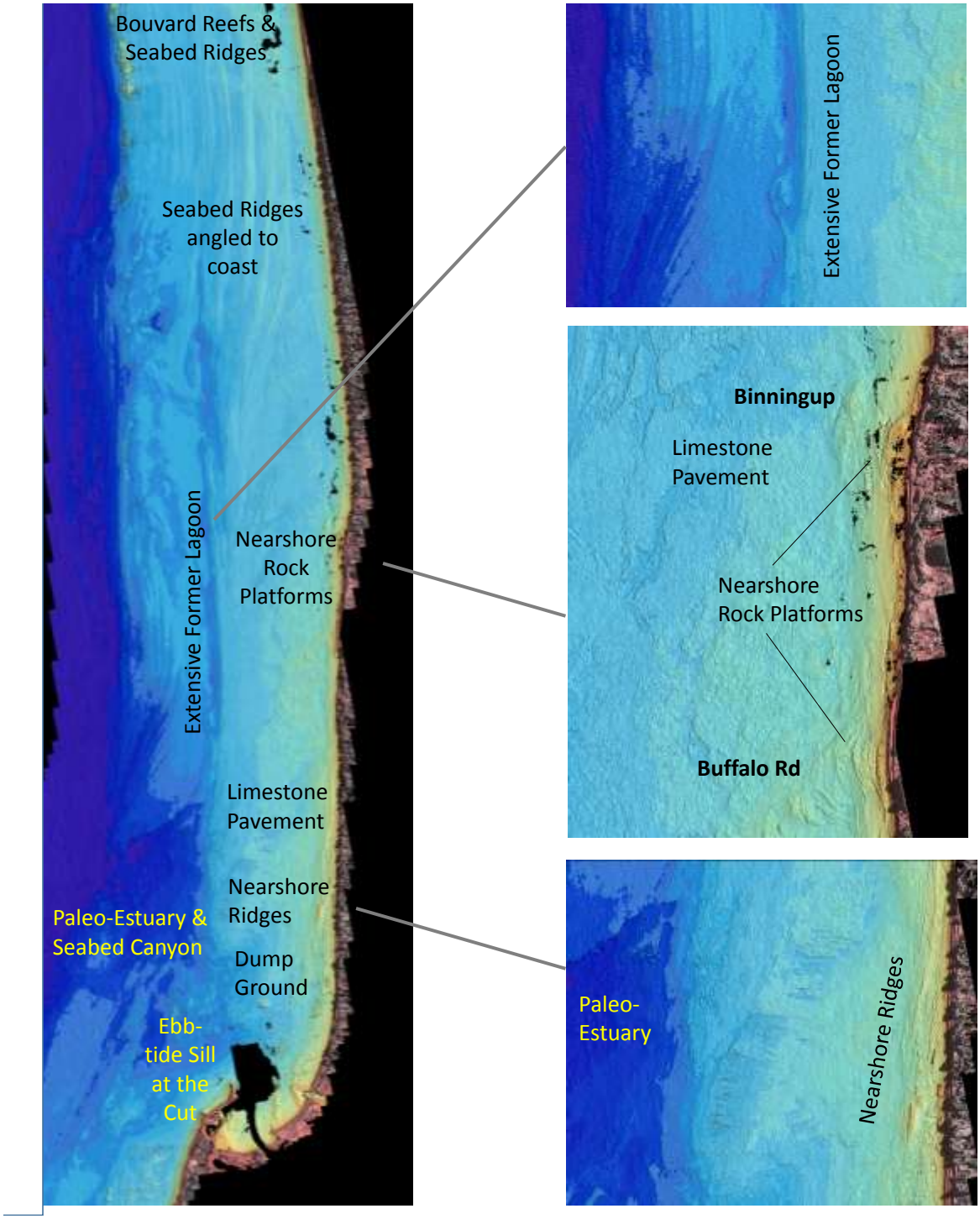

Figure 3-3: Major Seabed Features

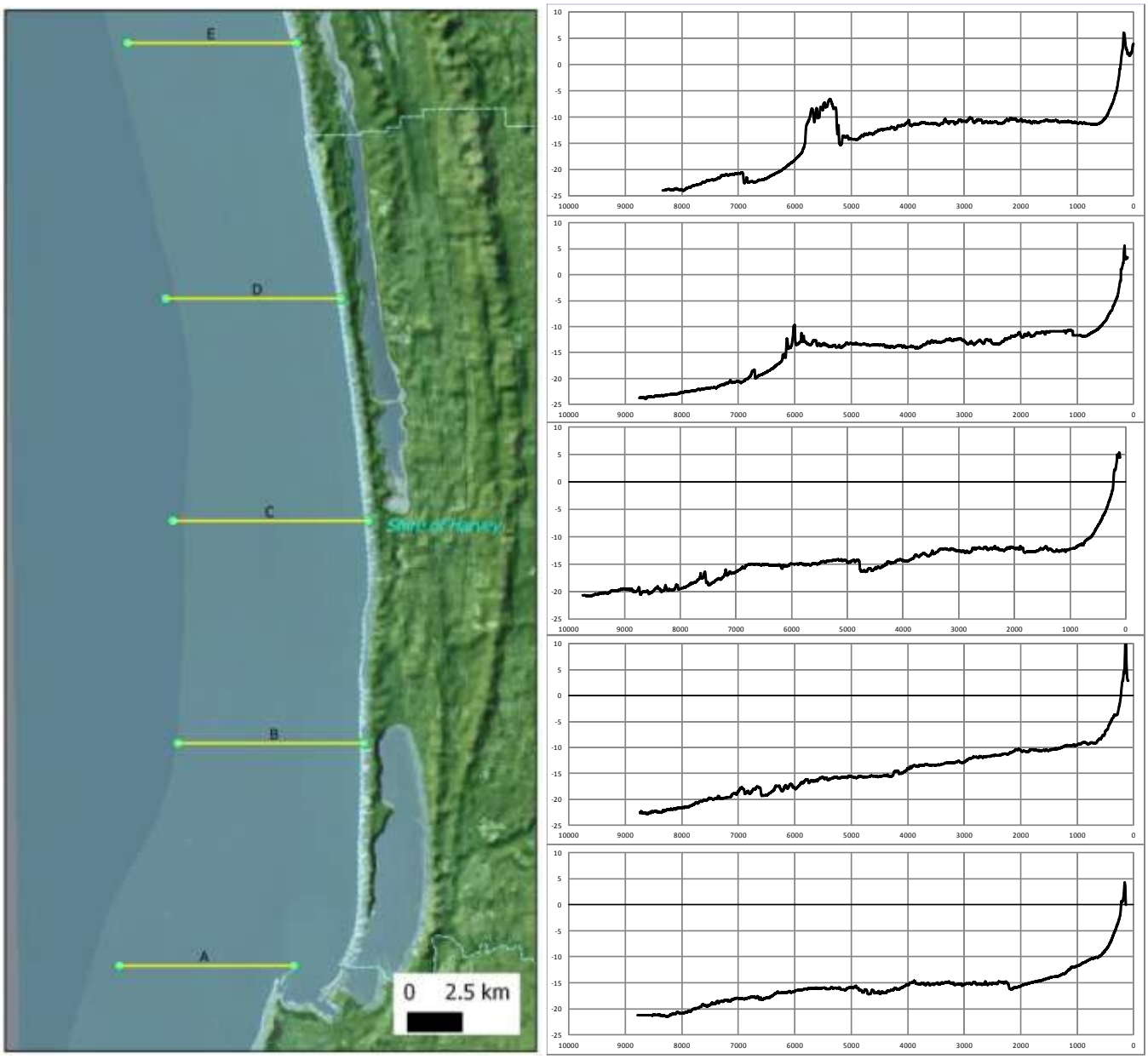

Figure 3-4: Long Cross-Shore Profiles for Harvey Coast
A near-horizontal seabed for the northern section (profiles C through E) suggests remnant structure after landward migration of the Leschenault-Yalgorup coastal dune barrier and influence of rock ridges. Profile curvature on profile D suggests mobile sediments below -20m depth.

3.4 Coastal Dunes

The coastal dunes along the Leschenault-Yalgorup coast, including Harvey coast, have been described as a high aeolian dune ridge, which has migrated landward over the late Holocene (within the last 7,000 years). The form and structure of the dunes has been evaluated using the Department of Water LIDAR topography, which shows variation along the length of the Harvey coast (Figure 3-5). The dune ridge north of Binningup is generally higher, broader and less deflated than the ridge to the south, which has partly moved over lagoonal sediments in Leschenault Estuary.

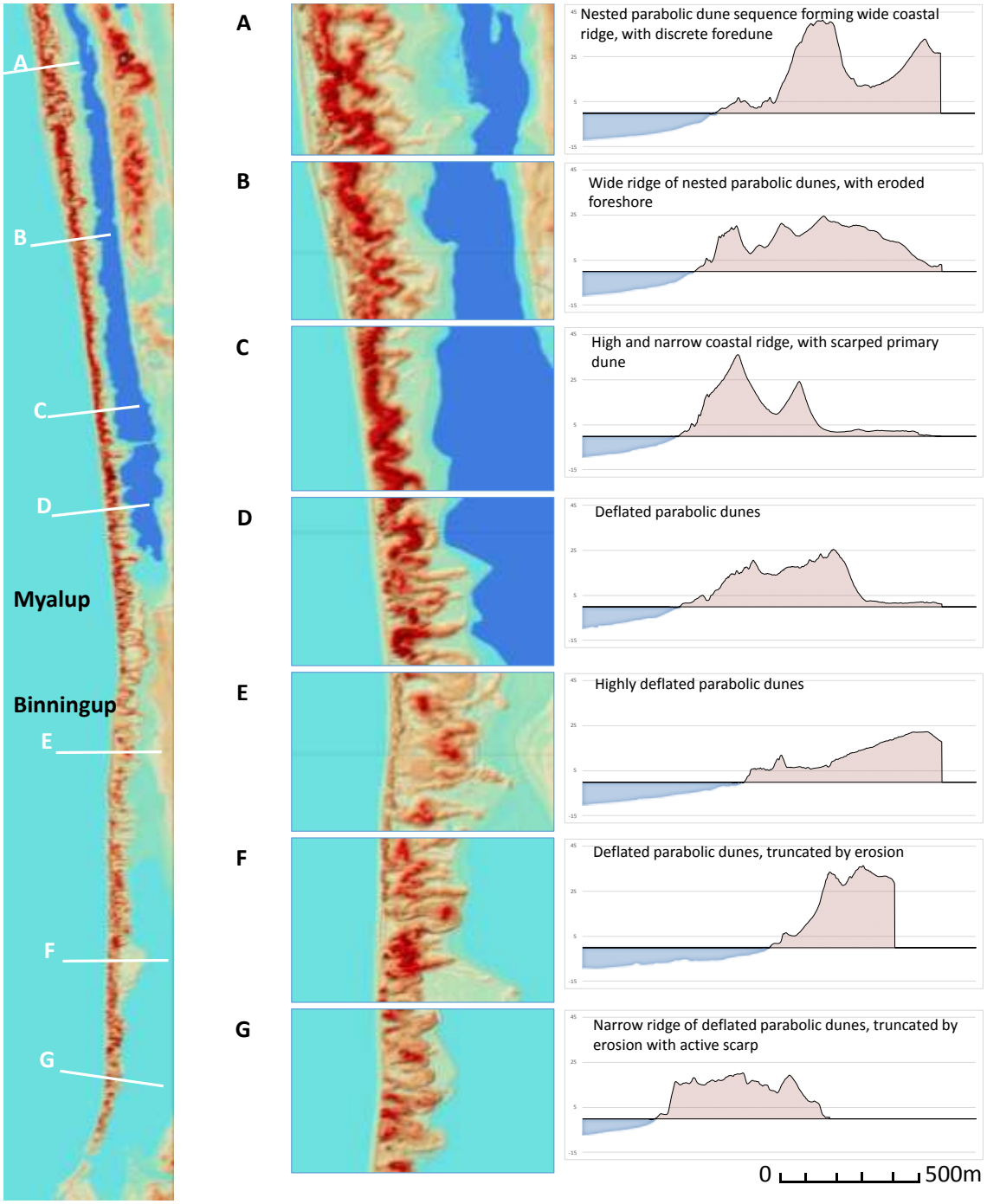

Figure 3-5: Barrier Dune Structure