

Shire of Harvey
Coastal Hazard Risk Management
and Adaptation Plan
November 2016

Prepared for Shire of Harvey



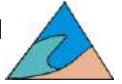
Report 246-00-09 Rev1

Damara WA Pty Ltd





Content	Page
1 Introduction.....	1
1.1 Background and Context	3
1.2 CHRMAP Framework and Objectives	4
2 Coastal Hazards and Assets	5
2.1 Coastal Hazards	5
2.2 Coastal Assets and Amenity	8
2.3 Interaction of Hazards with Assets.....	9
3 Management Framework.....	13
3.1 Coastal Management Approach.....	14
3.2 Existing Tenure	14
3.3 Existing Infrastructure	15
3.4 Community Attitudes	16
3.5 Financial Considerations.....	16
4 Recommended Planning Approach	17
4.1 Implementation Considerations.....	21
4.2 Special Control Area	23
5 Coastal Hazard Decision-Making.....	24
5.1 Coastal Erosion Monitoring and Decision-Making	25
5.2 Dune Mobility Monitoring and Decision-Making	28
5.3 Coastal Inundation Monitoring and Decision-Making.....	29
6 Asset-Based Adaptation Assessment	33
6.1 Binningup Town Site.....	35
6.2 Binningup Road Access.....	39
6.3 Myalup Town Site	44
6.4 Other Residential Areas.....	49
6.5 Dune Vegetation.....	54
6.6 On-Beach Activities.....	57
6.7 Coastal 4WD Access Points.....	62
6.8 Binningup Seawall	64
6.9 Desalination Plant.....	71
6.10 Harvey Diversion Drain	73
6.11 The Cut.....	77
6.12 Sedgeland.....	80



7	Summary of Overall Management	82
7.1	Regional Management Context.....	82
7.2	Policy and Tenure Revision.....	83
7.3	Community Education	83
7.4	Investigations.....	83
7.5	Monitoring.....	84
7.6	Management Actions	86
8	Implementation	88
8.1	Implementation Plan (2016-2020)	88
8.2	CHRMAP Evaluation and Revision	90
9	References.....	91



Figure	Page
Figure 1-1: Document Context	1
Figure 1-2: Shire of Harvey Coast	2
Figure 1-3: Elements of CHRMAP Development	3
Figure 1-4: CHRMAP Components Recommended by WAPC	4
Figure 2-1: Sea Level Rise and Coastal Recession Scenarios	7
Figure 2-2: Hazard-Consequence Matrices by Asset	12
Figure 3-1: Some Factors Involved in Coastal Management Decision-Making	13
Figure 4-1: Proposed Planning Response across Shire Coast	18
Figure 4-2: Proposed Planning Response for Binningup	19
Figure 4-3: Proposed Planning Response for Myalup	20
Figure 5-1: Combination of Episodic and Progressive Behaviour.....	24
Figure 5-2: Beach Width Monitoring Sites and Sediment Cell Boundaries	26
Figure 5-3: Schematic of CMAP Monitoring Data Coverage	27
Figure 5-4: Trend Aliasing due to Sampling Rates and Acute Erosion.....	27
Figure 5-5: Dune Buffer Management Sequence for an Eroding Coast	28
Figure 5-6: Water Level Classification Scheme.....	30
Figure 5-7: Using Threshold Exceedance to Monitor Change in Risk.....	31
Figure 5-8: Knowledge-Base for Inundation Processes.....	31
Figure 6-1: WAPC Preferred Adaptation Hierarchy.....	33
Figure 6-2: Binningup Town Site.....	35
Figure 6-3: Exposed Beach Rock at Northern End of Binningup Town Site.....	38
Figure 6-4: Harvey Coast Inundation Hazard Zones	39
Figure 6-5: Binningup Road Extreme Flood Event Mapping	40
Figure 6-6: Myalup Town Site.....	44
Figure 6-7: Myalup Dune Cross-Section	45
Figure 6-8: Dune Buffer Management Sequence for an Eroding Coast	46
Figure 6-9: Properties and Historic Dune Mobility North of Myalup	51
Figure 6-10: Schematic Illustrating Dune Management Phases.....	53
Figure 6-11: Variability of Dune Management along Harvey Coast.....	54
Figure 6-12: Typical Development of Informal Paths due to Pinch Points.....	58
Figure 6-13: Interpretation of Beach Widths Relative to Rock Features.....	59
Figure 6-14: Binningup Seawall and Adjacent Facilities	64
Figure 6-15: Beach Width Variability at Binningup Seawall	65
Figure 6-16: Exposure of Seawall Southern End Following September 2013 Storm.....	66
Figure 6-17: Concept for Fixed Facility Based on Existing Layout	68
Figure 6-18: Harvey Diversion Drain Ocean Entrance Plan Form.....	73
Figure 6-19: Harvey Diversion Drain Ocean Entrance Oblique View.....	74
Figure 6-20: Note Regarding Bathymetry at The Cut	77
Figure 6-21: Change to Tidal Prism & Flows at the Cut from a Simple Flux Model.....	78
Figure 6-22: Oblique Aerial View of 700m Long Interdunal Basin	80
Figure 7-1: Exposed rocky coast, north of Binningup, February 2015	84



Tables	Page
Table 2-1: Hazard Scenarios	6
Table 2-2: Summary of Assets and Values.....	8
Table 2-3: Assets and Existing Management Thresholds	9
Table 2-4: Impact to Assets for Hazard Scenarios	11
Table 4-1: Provisions and Explanation for the Coastal Management Zone	22
Table 4-2: Recommended Provisions for Townsite Special Control Areas.....	23
Table 6-1: Resource Requirement Levels for Management Actions	34
Table 6-2: Recession Impacts on Binningup Town Site	36
Table 6-3: Anticipated Timeline of Changing Hazard Management Approach at Binningup.....	37
Table 6-4: Management Triggers and Actions for Binningup Town Site.....	38
Table 6-5: Change in Annual Flood Probability Due to Sea level Rise	40
Table 6-6: Coastal Flooding Impacts on Binningup Road Access	41
Table 6-7: Comparison of Flood Barrage Options	42
Table 6-8: Impacts, Responses and Management Triggers for Binningup Rd Access	43
Table 6-9: Recession and Dune Mobility Impacts on Myalup Town Site	45
Table 6-10: Anticipated Timeline of Changing Hazard Management Approach at Myalup.....	48
Table 6-11: Management Triggers and Actions for Myalup Town Site	48
Table 6-12: Management Triggers and Actions for Dune Mobility outside Townsites.....	52
Table 6-13: Dune Instability, Key Processes and Typical Management Tools.....	55
Table 6-14: Basis for Dune Management Priority	56
Table 6-15: Determining Access Requirements based on Rock Exposure and Beach Use.....	60
Table 6-16: Access Management Actions based on Obstruction Length and Beach Use	61
Table 6-17: Resources Required for Identified Beach Access Management Tools	61
Table 6-18: Recession Impacts on Binningup Seawall.....	66
Table 6-19: Alternate Pathways for Management of Binningup Seawall	69
Table 6-20: Resources Required for Management of Binningup Seawall.....	70
Table 6-21: Adaptation Hierarchy Applied to Desalination Plant Pipelines	72
Table 6-22: Desalination Plant Pipeline Management Sequence for Progressive Erosion	72
Table 6-23: Anticipated Timeline for Changing Management Approach at Harvey Diversion Drain..	75
Table 6-24: Monitoring and Management Triggers Relevant to Harvey Diversion Drain	76
Table 7-1: Recommended Investigations	83
Table 7-2: Monitoring Program Outlined by PNP CMAP	84
Table 7-3: Summary of Management Actions.....	87
Table 8-1: Actions Required in the Next 5 Years	88
Table 8-2: Resources Required for Management Actions	89



Document Classification

EXTERNAL DOCUMENT

DOCUMENT CONTROL

Date	Document Manager	Summary of Document Revision	Client Signoff
14 Oct 2015	MJE	Draft CHRMAP	N/R
05 Jul 2016	MJE	Revision for External Release	
27 Sep 2016	MJE	Revision for Final Draft	
31 Oct 2016	MJE	Inclusion of Planning, Transport & PNP Edits	
21 Nov 2016	MJE	Inclusion of Shire Comments	



Abbreviations

2WD	Two Wheel Drive
4WD	Four Wheel Drive
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BoM	Bureau of Meteorology
CD	Chart Datum
CHRMAP	Coastal Hazard Risk Management and Adaptation Plan
CMAp	Coastal Monitoring Action Plan
DER	Department of Environment and Regulation
DPaW	Department of Parks and Wildlife
GBRS	Greater Bunbury Regional Scheme
LPS	Local Planning Scheme
MSL	Mean Sea Level
PNP	Peron Naturaliste Partnership
RL	Reduced Level
SLR	Sea Level Rise
SPP	State Planning Policy
UCL	Unallocated Crown Land
WAPC	Western Australian Planning Commission



1 INTRODUCTION

This Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) is the third of a set of documents (Figure 1-1) prepared for the Shire of Harvey, to support long-term coastal management and planning for the Shire's coastal assets. The Plan has been developed following the CHRMAP framework outlined by the Western Australian Planning Commission ¹, with consideration of local attributes. This CHRMAP considers the Shire of Harvey coast (Figure 1-2), which extends from the southern tip of Leschenault Peninsula to the northern Shire boundary, approximately 11km south of Preston Beach. The town centres at Binningup and Myalup are included.

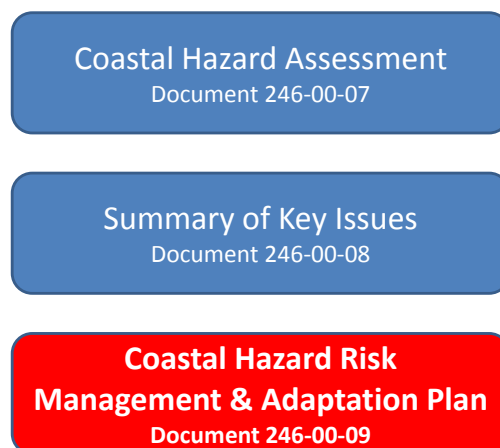


Figure 1-1: Document Context

Evaluation of the potential impacts of coastal hazards, particularly those of erosion, inundation and coastal landform mobility is described in Section 7 of the Harvey CHRMAP *Coastal Hazards Assessment* (Document 246-00-07).

Key coastal planning and management issues that may result from potential coastal hazards have been identified through consideration of stakeholder values. Identification of values included community liaison through workshops and discussion with the project steering group, in their roles as representatives of key stakeholder interest groups. Information regarding the identification and analysis of key issues is reported separately in Section 3 of Harvey CHRMAP *Summary of Key Issues* (Document 246-00-08).

The Plan acknowledges present-day coastal management issues faced by the Shire and considers how possible coastal change may affect town site and strategic planning over the next 100 years. Adaptation strategies are recommended to mitigate adverse consequences related to future coastal hazards. The CHRMAP is intended to support and extend the coastal management practices outlined in the Shire of Harvey Coastal Management Plan ².



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 of 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 inter-agency decision making regarding the consequences of adaptation actions.

The regional-scale erosion and inundation assessment⁴ indicated significant challenges for town site planning for the Shire of Harvey. The combination of a historic erosion trend with projected sea level rise was modelled to produce significant erosion of the Leschenault Peninsula, with increased inundation of the lowlands north of Leschenault Estuary further anticipated to constrain the narrow strip of coastal development that includes Binningup and Myalup. As a consequence of these forecast potential impacts, 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 Shire of Harvey and PNP determined that the appropriate setting for the hazard assessment and the interpreted consequences for coastal planning and management is through a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) framework. This approach is consistent with the State Coastal Planning Policy⁶ (SPP 2.6), which acknowledges that potential hazards caused by climate change and sea level rise should not necessarily preclude present-day coastal use. Non-statutory guidelines for CHRMAP preparation have been developed¹, which suggest the use of a risk-based management framework, incorporating community and stakeholder consultation.

The process followed to develop this CHRMAP for the Shire of Harvey coast is outlined in Figure 1-3.

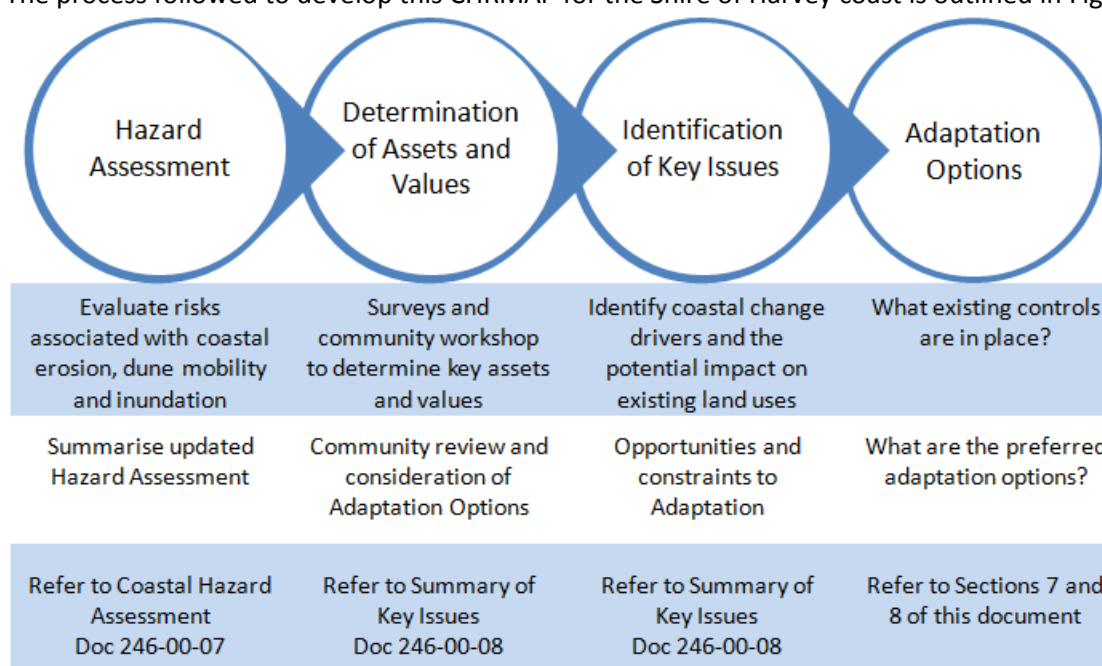
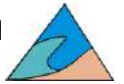


Figure 1-3: Elements of CHRMAP Development



1.2 CHRMAP Framework and Objectives

Guidelines for developing a CHRMAP have been prepared by WAPC, using risk management principles to help prioritise the need for management actions. The content of a CHRMAP, as outlined in the guidelines, incorporates assessment of hazards and values to guide identification of a plan for coastal management, which is supported by monitoring and review (Figure 1-4). Due to the complexity of coastal situations and the wide range of possible applications, there is no definitive content, or approach towards developing a CHRMAP, although common elements include identification of Objectives, Assets, Hazards, Performance Criteria, Risk Management Options, Monitoring and Triggers. The WAPC guidelines encourage communication and consultation with stakeholders and community throughout the CHRMAP development and implementation.



Figure 1-4: CHRMAP Components Recommended by WAPC
Extracted from CHRMAP Guidelines

Key objectives of the CHRMAP framework are to assist statutory decision makers to:

- Consider coastal hazard and to evaluate the risk for specific assets;
- Identify realistic and effective management and adaptation responses to those risks; and
- Prioritise the management and adaptation responses.

The CHRMAP is a non-statutory document, intended to provide guidance to the Shire and other decision-makers over time in regards to the consideration of coastal risk and management when decisions are being made regarding:

- Development, subdivision, rezoning or other planning and environmental approvals;
- The prioritisation of coastal management efforts;
- Provision of support to the community to ensure that recreational needs are maintained;
- Property, infrastructure and beach user/resident safety.

Within this context the CHRMAP should be taken into account when regional and local planning instruments are reviewed; when capital works programs are being considered; and in the more immediate term, to provide a context for the consideration of day-to-day functions of the Shire (including the consideration of planning/building applications).



2 COASTAL HAZARDS AND ASSETS

2.1 Coastal Hazards

Coastal hazards affecting the Harvey coast and relevant to coastal planning are described in the Harvey CHRMAP *Coastal Hazards Assessment* (Document 246-00-07). The most significant hazards include erosion, coastal inundation and landform mobility (dunes and estuary entrance). All three of these hazards have been historically active on the Harvey coast and are projected to have increased future impact with projected climate change, mainly through sea level rise ⁷.

For each of the hazards, the severity of impact and extent of affected area are predicted to increase progressively. Consequently, although there are considerable uncertainties regarding how each hazard may change over time, management thresholds are likely to be reached with increasing recurrence. Where use of these thresholds is affected by recurrence (e.g. safety or cost-benefit), then it is more a question of when the threshold is reached rather than its likelihood. The situation suggests that adaptive, trigger-based decision-making is likely to be required for effective management of the Shire of Harvey coast. Following the principles of SPP 2.6, consideration of a wide range of possible outcomes provides a practical basis for management.

Erosion has occurred progressively on the Shire of Harvey coast for thousands of years with an estimated average rate of 0.5 to 1.0 m/yr, through alternating phases of rapid erosion and relative stability. Historic periods of erosion occurred in the 1970s to 1980s and from 2008 to 2015, although their role as part of a sustained trend is obscured by human activities, alongshore movements of sand and partial recovery of beach sediment. The effect of sea level rise is projected to increase the opportunity for erosive phases, with the average erosion rate increasing by up to 3.0 m/yr over the next 100 years; notably with this severe estimate based on very conservative assumptions.

Historic observations of coastal change have suggested that the sections of rock underlying the dune barrier locally affect how erosion occurs along the Harvey coast. This may substantially influence the relative stability along the coast, with higher stability possible between Binningup and Buffalo Road. Geotechnical assessment is required to determine the relative presence of rock and improve the capacity for effective coastal management.

Coastal Landform Mobility has been observed on the Harvey coast over the historic record, including dune movement and estuary entrance instability. Dune movement is the main form of mobility, with evidence of landward sand drift over the last 6,000 years. Estuary entrance movement is wholly modern, after construction of a diversion drain near Myalup and relocation of the Leschenault Estuary entrance in the 1950s.

Dune mobility is influenced by a range of factors, including stress due to vehicles or pedestrians (through damage to vegetation), coastal erosion, drought and bushfires. On the Harvey coast, it has also been affected historically by industrial waste disposal and concerted dune restoration and revegetation works. At its most degraded state in the early 1990s, approximately 50% of the Harvey coast was subject to active dune mobility. The area of mobile sand sheets and dune blowouts has been substantially reduced through the combined effects of restoration works and comparatively few severe storms.



Sensitivity of the dunes to erosion or sea level rise has been assessed based upon the dune cross-sections. This indicated that the foredunes present along most of the coast north of Binningup contribute substantially to stability of the main dunes. Erosion of approximately 20m, which can occur during a single severe winter, is sufficient to lose the majority of foredune along the Harvey coast. This would likely create widespread dune blowouts and sand sheet formation equivalent to the situation of the 1980s and early 1990s.

Projected sea level rise is expected to amplify the net rate of erosion, increasing the opportunity for dune destabilisation.

The instability of estuary entrances has been demonstrated at the two artificial entrances for Harvey Diversion Drain and Leschenault Estuary (The Cut), where shoreline movement is much greater than the adjacent coast. Projected change will increase the dynamics at these locations, due to increased dune mobility and the potential for an increased volume of sediment in the flood delta and ebb sill.

Coastal Inundation has been a relatively infrequent coastal hazard over the history of the Shire, with limited flooding of Australind foreshore area and the lowlands at the northern end of Leschenault Estuary. The effect of runoff flooding has been more significant, with repeated flooding and water-logging of the lowlands between Leschenault Estuary and Lake Preston prompting management through an open-channel drainage network. Road access to Binningup and the Southern Seawater Desalination Plant is raised above the adjacent land, and drainage culverts pass under Springhill and Buffalo roads. The drainage network and the lands it drains are presently susceptible to coastal flooding due to very extreme ocean water levels, estimated to have 100 to 500 year average recurrence interval (ARI).

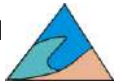
Projected sea level rise is expected to progressively increase the likelihood of coastal flooding affecting parts of the Harvey coast. This will occur through increased recurrence of flooding at the existing hotspots (Australind and the lowlands north of Leschenault Estuary), and extension of the area affected by floods. For a projected sea level rise of 0.9m, the 100 year ARI coastal flood is estimated to reach as far north as Taranto Road, whilst typical high tides (10-12 times per year) would be above the present-day level of Buffalo Road.

Hazard Scenarios

A range of projected hazard levels has been used to define three hazard scenarios, which each include changes to erosion, landform mobility and sea level rise (Table 2-1). The progressively changing nature of coastal hazard is suggested by time frames over which the scenario is considered likely to be valid, with the moderate scenario expected to occur sometime after 2045 and the high scenario expected to occur after 2075. The high level of uncertainty associated with the hazard projections is indicated by the broad and overlapping time frames for the different scenarios.

Table 2-1: Hazard Scenarios

	Existing Conditions	Moderate Scenario	High Scenario
Erosion	Up to 20m	Up to 50m	Up to 150m
Landform (Dune) Mobility	25% Increase	50% Increase	100% Increase
Sea Level Rise	0.0-0.2m	0.2-0.5m	0.5-0.9m
Time Frame	2016-2065	2045-2115 ⁺	2075-2115 ⁺



Projected time series for sea level rise and recession are illustrated in Figure 2-1. The sea level rise time series follows State Government recommended projection, which is a moderately high interpretation of IPCC projections ⁷ (Figure 2-1a). The combination of recession and acute erosion provides a time series band of possible coastal position, with actual coastal position anticipated to vary within this band (Figure 2-1b). Comparison of the projected recession associated with different combinations of acute erosion, progressive change and response to sea level rise (Figure 2-1c) highlights the relative sensitivity of the projection to the response to sea level rise. However, it also shows that even with extreme response (300:1 ratio), the recession allowance developed using SPP 2.6 will give a number of decades for identification and response.

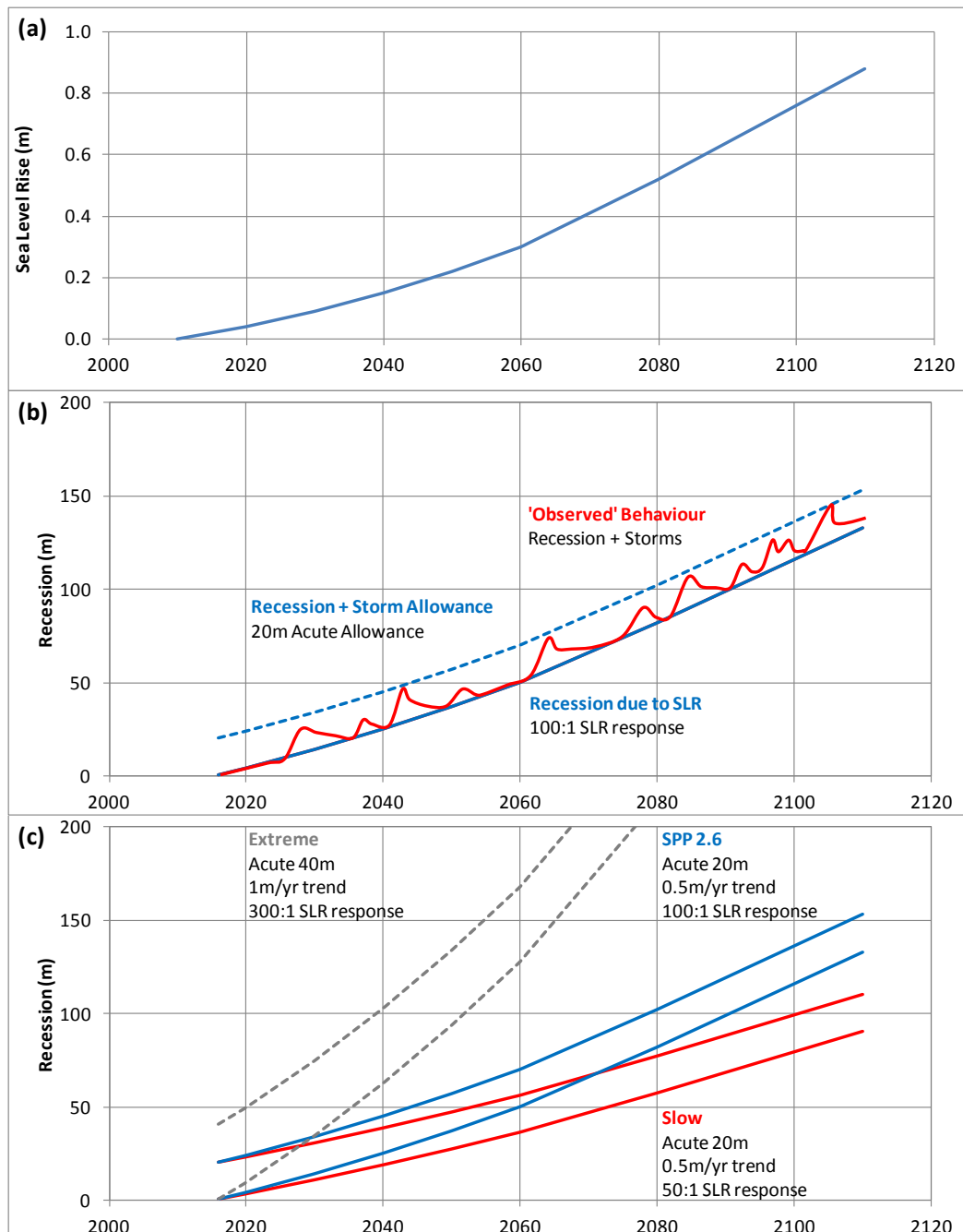


Figure 2-1: Sea Level Rise and Coastal Recession Scenarios



2.2 Coastal Assets and Amenity

Community and stakeholder consultation was used to identify the key assets and amenity of the Harvey coast (Table 2-2). The process of identification and valuation is described in the Harvey CHRMAP *Summary of Key Issues* (Document 246-00-08). For each identified asset or amenity, relative sensitivity to different coastal hazards and the major impacts were considered as part of the valuation.

Table 2-2: Summary of Assets and Values

Coastal Asset or Amenity	Sensitivity	Impacts	Community Importance
Residential			
Binningup Town Site	Erosion / Dune Mobility	Damage to property, infrastructure; management costs	High
Binningup Road Access	Inundation	Minor flood risk, management costs	High
Myalup Town Site	Erosion / Dune Mobility	Management costs	High
Other Residential Areas	Erosion / Dune Mobility	Management costs	Medium
Industrial			
Harvey Diversion Drain	Erosion / Dune Mobility	Management costs	High
Desalinisation Plant	Erosion / Dune Mobility	Management costs	Medium
Recreational			
On-beach activities	Erosion	Loss of beach amenity	High
Coastal 4WD Access Points	Erosion	Management costs	High
Informal Launching Sites	Erosion	Maintenance	Low
Binningup Seawall	Erosion	Structural damage, infrastructure loss	High
Professional fishing	Erosion	Loss of access	High
Rural			
Agricultural Land	Inundation / Salinity	Loss of productive agricultural land	High
Heritage			
Aboriginal Heritage	Erosion / Dune Mobility	Affected by 4WDs	Low
European Heritage	Erosion / Dune Mobility	Management costs	Low
Environmental			
Sedgelands	Dune Mobility / Salinity	Habitat loss	High
Dune Vegetation	Dune Mobility	Management costs	High
Coastal Woodlands	Dune Mobility	Habitat loss	High

The process of valuation highlighted the diversity of community interests, consequently providing a high valuation for the majority of identified assets or amenity. A very strong sense of value was clearly placed on access to and use of the coast, with a stronger interest in the management of present-day conditions than in possible future issues.

Interpretation of the valuation also recognises that any community and stakeholder engagement process cannot be wholly or proportionally representative of the community.



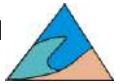
2.3 Interaction of Hazards with Assets

Interaction of coastal hazards with the assets and amenity is a key focus for coastal planning and adaptation. Coastal planning typically aims to use the spatial (and temporal) characteristics of the hazards and assets to avoid interaction. Adaptation is required when the levels of hazard are intolerable for the existing assets and management framework (i.e. have unacceptable likelihood of adverse physical, financial, social or environmental impacts).

Coastal management (both formal and informal) within the Shire of Harvey shows strong recognition of coastal hazards, with typically wide coastal setbacks and layout of infrastructure to minimise the impact of dune mobility or erosion. As a consequence, the existing management framework has generally created moderate to large thresholds for change before significant adverse outcomes are likely to occur (Table 2-3), which would prompt adaptation. Exceptions occur at Binningup Seawall, recreational activities directly linked to the beach and for the sedgeland north of Myalup.

Table 2-3: Assets and Existing Management Thresholds

Coastal Asset or Amenity	Threat	Threshold	Outcome when threshold reached
(A) Residential			
Binningup Town Site	Dune Mobility	>30m	Road smothering, then houses
	Erosion	>50m	Loss of road
Binningup Road Access	Inundation	>0.5m	Town access restricted once/year
Myalup Town Site	Dune Mobility	Any	Caravan park or houses smothered
	Erosion	>170m	Caravan park lost
Other Residential Areas	Dune Mobility	>10m	Isolated residences smothered
	Erosion	>150m	Isolated residences lost
(B) Industrial			
Harvey Diversion Drain	Dune Mobility	>70m	Blocking of Diversion ocean entrance
	Erosion	>30m	Increased wind drift blocks entrance
Desalination Plant	Dune Mobility	>150m	Smothering of building
	Erosion	>280m	Loss of building
(C) Recreational			
On-beach activities	Erosion	>15m	Loss of amenity
Coastal 4WD Access Points	Erosion	>20m	Reduced accessibility
Informal Launching Sites	Erosion	>20m	Reduced accessibility
Binningup Beach Ramp	Erosion	>15m	Loss of accessibility
(D) Rural			
Agricultural Land	Inundation	>0.3m	Salt water flooding once/decade
(E) Heritage			
Aboriginal Heritage	Dune Mobility	Not Identified	
	Erosion		
European Heritage	Dune Mobility	Not Identified	
	Erosion		
(F) Environmental			
Sedgeland	Erosion	>10m	Marine incursion to sedgeland
	Inundation	Unknown	Saline intrusion
Dune Vegetation	Dune Mobility	Any	Reduced dune vegetation
	Erosion	>20m	Reduced dune vegetation
Coastal Woodlands	Dune Mobility	>40m	Reduced woodland area
	Erosion	>70m	Reduced woodland area



Interaction of coastal hazards with assets notionally provides a basis for risk-assessment using a consequences-likelihood matrix. This is a widely applied approach for assigning risk levels, with examples presented in the WAPC CHRMAP guidelines¹. A preliminary assessment was developed from the valuation and hazard scenarios (Table 2-4), with heritage assets excluded due to the community's low valuation.

Application of the consequences-likelihood matrix through the CHRMAP framework is primarily to provide a basis for prioritisation of management and adaptation efforts. The relative value of this approach is diluted by several factors for the Shire of Harvey coast:

- Community-based valuation gave strong values for the majority of assets, making it indiscriminate on a consequence-likelihood basis;
- All assets require management, and are ultimately likely to have a need for adaptation in the future. It is always appropriate to ensure that resources used for management are commensurate with the value of each asset;
- There are few trade-offs between assets which are likely to occur due to management, meaning adaptation paths should be assessed discretely for each asset (and its corresponding governance) rather than a combined assessment. This practicality is further developed in situations where episodic factors contribute to coastal impacts (for example, funding is almost certain to be committed to a low value asset that has been damaged by a storm compared to a high value asset that is exposed to possibility of hazard that is higher than desired); and
- Coastal hazards of erosion and inundation are both expected to progressively amplify over time, and there are large elements of uncertainty in their forecast. Consequently, a CHRMAP that provides triggers to management actions along the hazard continuum effectively offsets the importance of establishing hazard likelihood.

The community expressed strong interest in continuing the use of existing management techniques, which are considered to be practical and effective for the immediate planning horizon (<20 years). Lower interest was placed on longer-term planning horizons for which alternate techniques may be necessary.

Maximising the effective use of existing management frameworks (Section 3) and developing adaptation pathways for individual assets (Section 6) are key factors influencing the structure of this CHRMAP and its supporting analyses.

Despite limited use of the consequence-likelihood matrix for prioritising resources on the Shire of Harvey coast, the approach yields information about potential changes to management pressure. Figure 2-2 shows the relative impact to each asset for the three hazard scenarios (Table 2-1). In each case, the 'constraint to asset' represents the viability of the asset or amenity of itself (i.e. how much the hazard may restrict use, require maintenance or need replacement) and therefore 'constraints' are not directly comparable on a resource basis.



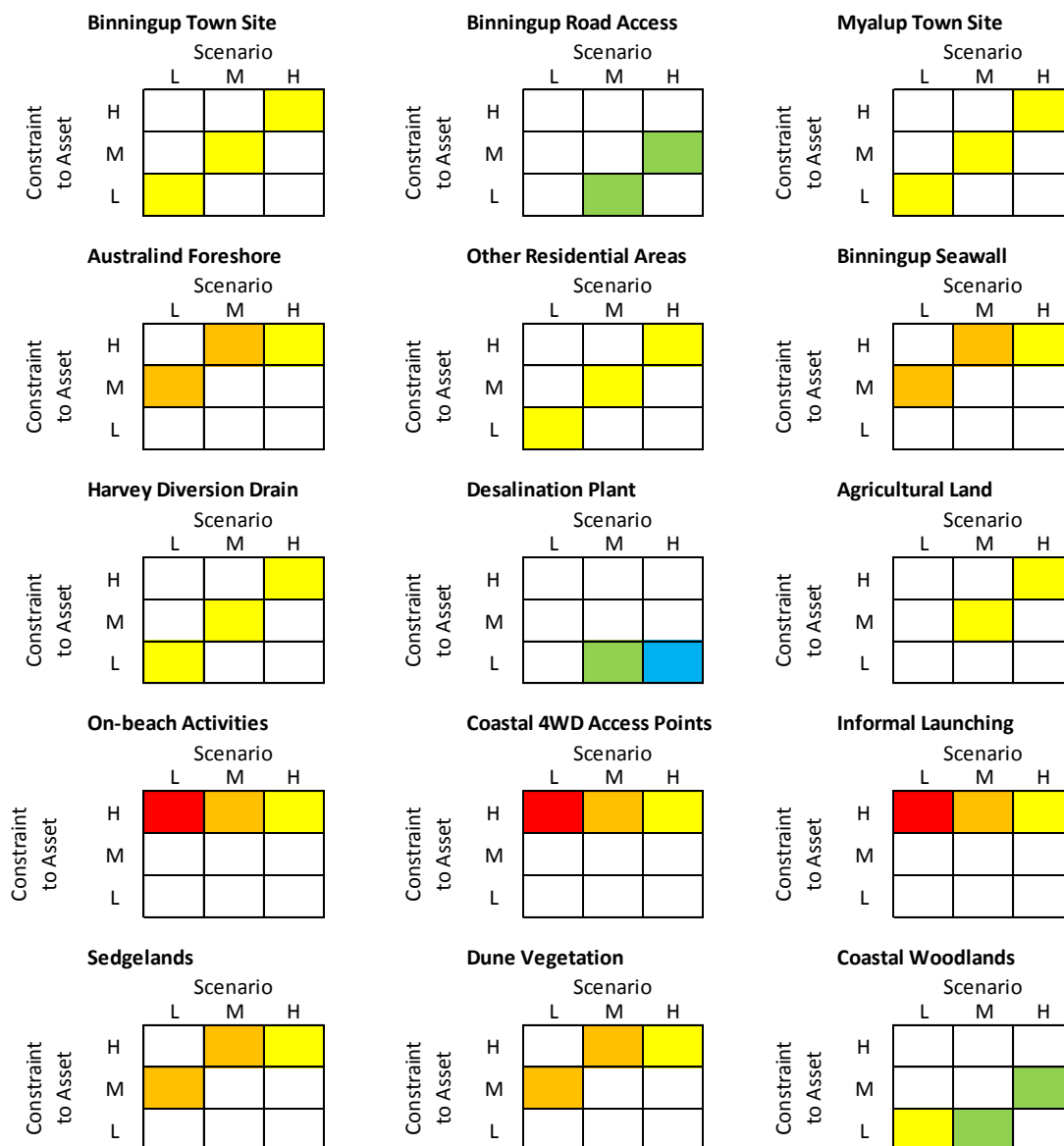
Table 2-4: Impact to Assets for Hazard Scenarios

Hazard	Erosion			Inundation			Landform Mobility		
Hazard Scenario	Existing	Moderate	High	Existing	Moderate	High	Existing	Moderate	High
Coastal Asset or Amenity									
<i>Residential</i>									
Binningup Town Site	–	M	H	–	–	–	L	L	L
Binningup Road Access	–	–	–	–	L	M	–	–	–
Myalup Town Site	–	L	M	–	–	–	L	M	H
Australind Foreshore	–	–	–	M	H	H	–	–	–
Other Residential Areas	–	–	–	–	–	–	L	M	H
<i>Industrial</i>									
Harvey Diversion Drain	L	M	M	–	–	–	–	L	H
Desalinisation Plant	–	–	–	–	–	–	–	L	L
<i>Recreational</i>									
On-beach activities	H	H	H	–	–	–	–	–	–
Coastal 4WD Access Points	H	H	H	–	–	–	M	M	H
Informal Launching Sites	H	H	H	–	–	–	–	–	–
Binningup Seawall	M	H	H	–	–	–	–	–	–
<i>Rural</i>									
Agricultural Land	–	–	–	–	M	H	–	–	–
<i>Environmental</i>									
Sedgeland	M	H	H	L	M	H	M	M	M
Dune Vegetation	–	L	M	–	–	–	M	H	H
Coastal Woodlands	–	–	–	–	–	–	L	L	M

Impacts to assets, including constraint to their use, are described as Low (L), Medium (M) or High (H), based on three forecast scenarios (existing, moderate or high) and the associated hazards of erosion, inundation or landform mobility.



The consequence-likelihood matrices (which are also implicitly consequence-timeline matrices) all show a tendency for increased constraint to the asset with increased severity of the scenario. The most common pattern is for Low constraint with a Low scenario, Medium constraint with a Medium scenario and High constraint with a High scenario. Consequently, matrices have been colour coded to indicate deviation from this behaviour. Assets for which a high constraint to the asset may result from a small scenario of coastal change are those which are (perceptibly) most sensitive to change, which is strongly reflected in concerns expressed by the residents for different aspects of recreational beach use, including on-beach activities, 4WD access and informal launching. Other assets susceptible to greater than 'common' constraint are Australind foreshore (subject to flooding), Binningup Seawall, the sedgeland north of Myalup and general stability of dune vegetation.



Colour-coding refers to the relative constraint to the asset, compared with the Scenario
i.e. moderate rating is given where a low Scenario causes low constraint, or a high scenario causes high constraint

Extreme
 High
 Moderate
 Low
 Negligible

Figure 2-2: Hazard-Consequence Matrices by Asset



3 MANAGEMENT FRAMEWORK

Coastal managers for the Harvey coast include:

- The Shire of Harvey;
- The Department of Parks and Wildlife (via the Leschenault Regional Park);
- Private landowners; and
- State Government (through unallocated Crown land, the desalination plant and Harvey Diversion Drain).

Decision-making is different for each coastal manager. However, the four key management factors involved in decision-making are usually governance, ownership, financial capacity and community (plus stakeholder) attitudes (Figure 3-1). In many cases, it is also the interactions between these factors that ultimately determine decisions, either by providing an 'external' control (e.g. governance controlling land owner responsibilities), or by creating a trade-off.

Disconnection between the four main factors can provide a barrier to effective coastal management, particularly if management responsibilities (determined by governance) are not supported by a corresponding financial capacity. This has importance on the Harvey coast due to the diversity of land ownership boundaries and the difficulties of implementing a simple management approach.

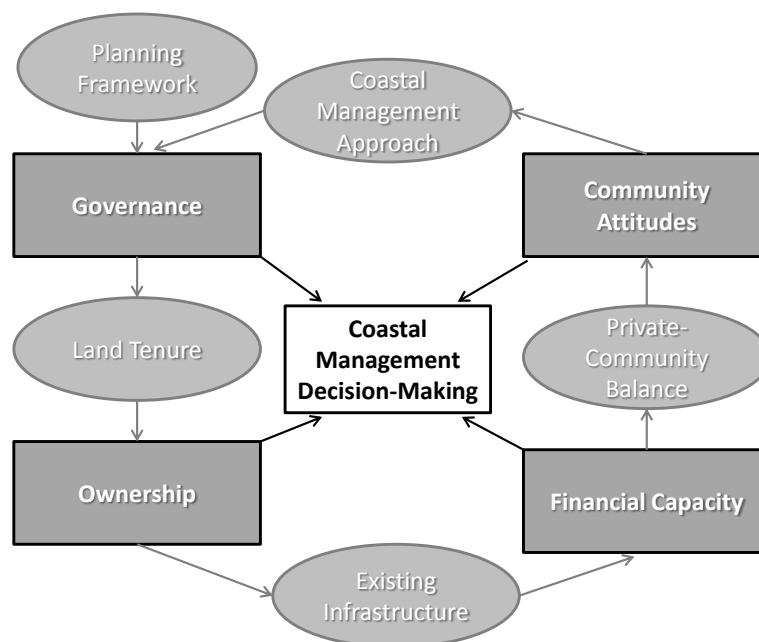


Figure 3-1: Some Factors Involved in Coastal Management Decision-Making

The management framework for the Shire of Harvey has been described through some of the key management factors and their interactions:

- Coastal Management Approach;
- Existing Tenure;
- Existing Infrastructure;
- Community Attitudes; and
- Financial Considerations.



3.1 Coastal Management Approach

Until recently, the approach for all coastal managers along the Harvey coast has been similar, with a focus upon low cost and low infrastructure. Progressive coastal erosion and instability of the dune systems were considered in the practices of each of the coastal managers, with setbacks established to infrastructure; careful road and building placement; and implementation of revegetation works. These practices were largely related to avoiding direct costs caused by coastal hazards, which corresponds to the primary coastal management strategy recommended by the State Coastal Planning Policy SPP 2.6⁶.

The overall strategy of coastal hazard avoidance excludes Binningup Seawall. This facility was developed as a coastal node in response to a perceived need for improved beach access and marine safety. Additional functions for recreational, social and services (stormwater management) have been incorporated into the facility design.

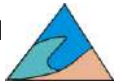
3.2 Existing Tenure

Large portions of the coastal dunes are held in private ownership or State Government stewardship (Section 5.2 of *Harvey CHRMAP Summary of Key Issues*, Document 246-00-08), which constrains Shire management of these areas. Apart from Binningup and Myalup townsites, the majority of the coastal areas are privately owned to high water mark, or comprise areas of Conservation Park with management being undertaken by DPaW. The Greater Bunbury Region Scheme does not provide for future reservation and acquisition of significant coastal foreshore reserves within the Shire. This is particularly apparent north of Myalup where, for the purposes of coastal management, the GBRS reserves are inadequate and affect only land comprising mainly UCL. Where existing lots extend to high water mark the GBRS reserve is particularly thin, covering beaches only.

The lack of GBRS reserves limits the ability of the Shire to seek management orders for coastal areas and effectively manage these areas via the region scheme provisions. Alternative mechanisms will need to be found.

The privately owned land proposed for Regional Open Space in the GBRS has the option to be acquired by the State Government. Should this occur, the land will be vested in the Crown and the details of the vesting in relation to its management will be clarified at that stage. Typically, coastal foreshore areas under existing Region Schemes are managed by the relevant Local Government, with management funded through State Government grants. Unfortunately, the GBRS does not propose Regional Open Space reserves over many coastal dune areas, and thus an opportunity for future acquisition and management of these areas may have been lost. The GBRS does, however, propose the inclusion of all beach areas within a Regional Open Space reserve.

When subdivision abutting the coast is proposed, a portion of the coastal land is allocated as foreshore reserve and can be ceded to the Crown free of cost if included as a condition of subdivision approval. This is likely to occur as part of any future subdivision proposals along the Shire's coastal areas, however at present it is understood that the Shire's draft Local Planning Strategy is only promoting future development of land south of Binningup which is subject to Structure Plan provisions in the local planning scheme. As part of finalising the Structure Plan for this area, foreshore reserves of appropriate widths should be investigated and ideally incorporated



into either regional or local reserves. Localised Foreshore Management Plans are generally prepared in these circumstances and this practice should continue.

South of Buffalo Road, the Department for Parks and Wildlife implement management plans for Leschenault Peninsula and Yalgorup National Park^{8,9}. DPaW is continuing to implement the 1998 management plan for ongoing management and rehabilitation of this area. The Department are also continuing to implement the Yalgorup National Park Management Plan for areas affected by that Plan, including Lake Preston. The Shire should seek to support the work being undertaken by DPaW and consider assisting in specific management proposals where there would be a shared gain, such as the cost-sharing arrangement to upgrade and bituminise the Buffalo Beach access road.

3.3 Existing Infrastructure

Comparison of the threat posed by coastal dynamics to existing infrastructure (asset classes A, B or C in Table 4-8 of *Harvey CHRMAP Summary of Key Issues*) suggests that:

- Dune mobility provides a potential hazard to the majority of coastal assets over the next 100 years;
- Erosion hazard for the next 100 years is mainly avoided for the existing infrastructure. Local exceptions occur at Binningup, Myalup and Harvey Diversion. It is recognised that the major reason for avoidance outside the town sites relates to the difficulties of constructing adjacent to potentially mobile and steep-topography dunes; and
- Coastal inundation is likely to affect existing agricultural practices and access to Binningup town site within the next 100 years.

Appropriate management strategies to deal with these threats (per infrastructure unit) have been considered in the context of the preferred adaptation hierarchy.

Dune Mobility

It is considered unfeasible to wholly avoid the threat of dune mobility. The relative uncertainty associated with dune mobility and the comparative success of dune management locally at Binningup and Myalup suggest that Accommodation through dune management may be practical in some situations.

The cost of dune stabilisation varies from \$25,000 to \$500,000 for a single blowout, requiring repeated works over the time, with increasing recurrence on an eroding coast. This provides a strong financial incentive for low intensity development to be located well landward of mobile dune areas.

Coastal Erosion

Two major pieces of infrastructure that are subject to erosion threat are the Harvey Diversion Drain and the Binningup Seawall. Each of these facilities has a purpose that is directly related to their position relative the shore (being drainage to the ocean and beach access respectively). This characteristic suggests that a management strategy of Accommodation may be appropriate for these facilities, although there may be constraints to the practicality of this strategy at Binningup Seawall (Section 2).

Although other recreational assets are subject to coastal erosion, they represent relatively low cost facilities, with a short service life. Car parks at Myalup and Buffalo Rd are presently setback behind a narrow dune buffer, supporting a management strategy of Retreat.



There is a limited amount of fixed residential infrastructure within Binningup that is subject to erosion hazard, as result of development when State policy definition of the coastal zone was less stringent. The town site layout potentially supports limited Retreat, with only a small portion of land adjacent to the town that is not in private ownership or low-lying. Only a small number of sites may be made available for land swap, requiring an increased proportion of land buy-back if a Retreat strategy is used, becoming increasingly convoluted and costly (per metre erosion) as retreat progresses landward. Coastal limestone in this vicinity tentatively suggests that the existing buffer may be adequate to Avoid coastal erosion threat – this requires physical assessment to determine.

Myalup Caravan Park is potentially subject to coastal erosion within the next 100 years. The existing caravan park use represents an appropriately low cost infrastructure investment, which may be removed or relocated.

Coastal Inundation

Coastal inundation threats to agricultural land and Binningup road access cannot be 'Avoided', as the coastal lowland is continuous between Leschenault Estuary and Lake Preston. The fixed spatial nature of the agricultural land also means that a true strategy of 'Retreat' is not possible, as land that becomes untenable due to coastal flooding will not be replaced. Consequently, management strategies to be considered are 'Accommodation' or 'Contraction'.

3.4 Community Attitudes

The community displays a strong sense of value and interest in the coast, with a willingness of community members to participate in dune restoration and monitoring. Community representatives indicated desires to retain or improve existing levels of beach access and to maintain the ecological values of the Harvey coast.

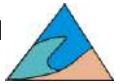
The strong interest in improved beach access is further displayed by community support when the beach ramps at Binningup Seawall were proposed. This facility directly addressed the difficulties of beach access, improving the speed and reliability of 4WD access to the beach for small boat launching.

3.5 Financial Considerations

The scale of and options for future adaptation requires careful consideration of financial viability. The Shire of Harvey, including the coastal communities of Binningup and Myalup, has a small population to support any form of significant adaptation infrastructure or ongoing coastal management. Costs for coastal management are presently incurred by:

- Maintenance of Binningup Seawall and launching ramp;
- Maintenance of Myalup car park and beach access;
- Dune restoration; and
- Beach access tracks.

Staff resources for the Shire of Harvey are also presently limited.



4 RECOMMENDED PLANNING APPROACH

As discussed in the *Harvey CHRMAP Summary of Key Issues* (Document 246-00-08), there are several challenges to effective coastal management which may need to be addressed through modification of the planning framework. This section outlines one *possible* pathway towards improved coastal management. However, it is suggested that a substantially greater degree of planning assessment and dialogue with the State Government is required to develop a fully functional approach. Further refinement of the planning approach is recommended over the next few years (Section 7.2).

It is recommended that a two-level approach to planning, policy and tenure be adopted by the Shire. These provisions will complement the existing *Precinct Policy Area Statements* (1, 7 and 10) as outlined in *Local Planning Scheme No. 1*.

1. Regional Planning: Regional Open Space

The Regional Open Space Reservation of the Greater Bunbury Region Scheme needs to be more extensive along the Harvey coast, recognising its regional significance and the implications that actions outside the Shire can have on this section of coast. The actual extent of reservation needs to be agreed between the Shire, affected landowners and the Western Australian Planning Commission, however it is recommended that as a minimum the mobile dune is reserved.

2. Local Planning: Local Planning Scheme

The Shire has significant ability to influence land use planning at a local level. the Shires Local Planning Scheme may consider the following mechanisms to provide the appropriate planning response:

- Coastal Management Zone ^a to cover all lots with frontage to the coast;
- Coastal management Special Control Area within Binningup and Myalup to a line 150m landward of the existing coast; and
- Specific requirement for Structure Plans prepared in accordance with Scheme Provisions to consider coastal processes.

The recommended extent of planning instruments are outlined for the whole Shire coast (Figure 4-1), in the vicinity of Binningup (Figure 4-2) and in the vicinity of Myalup (Figure 4-3).

^a The actual name of the zone will be determined by the Shire following discussion with the Department of Planning.

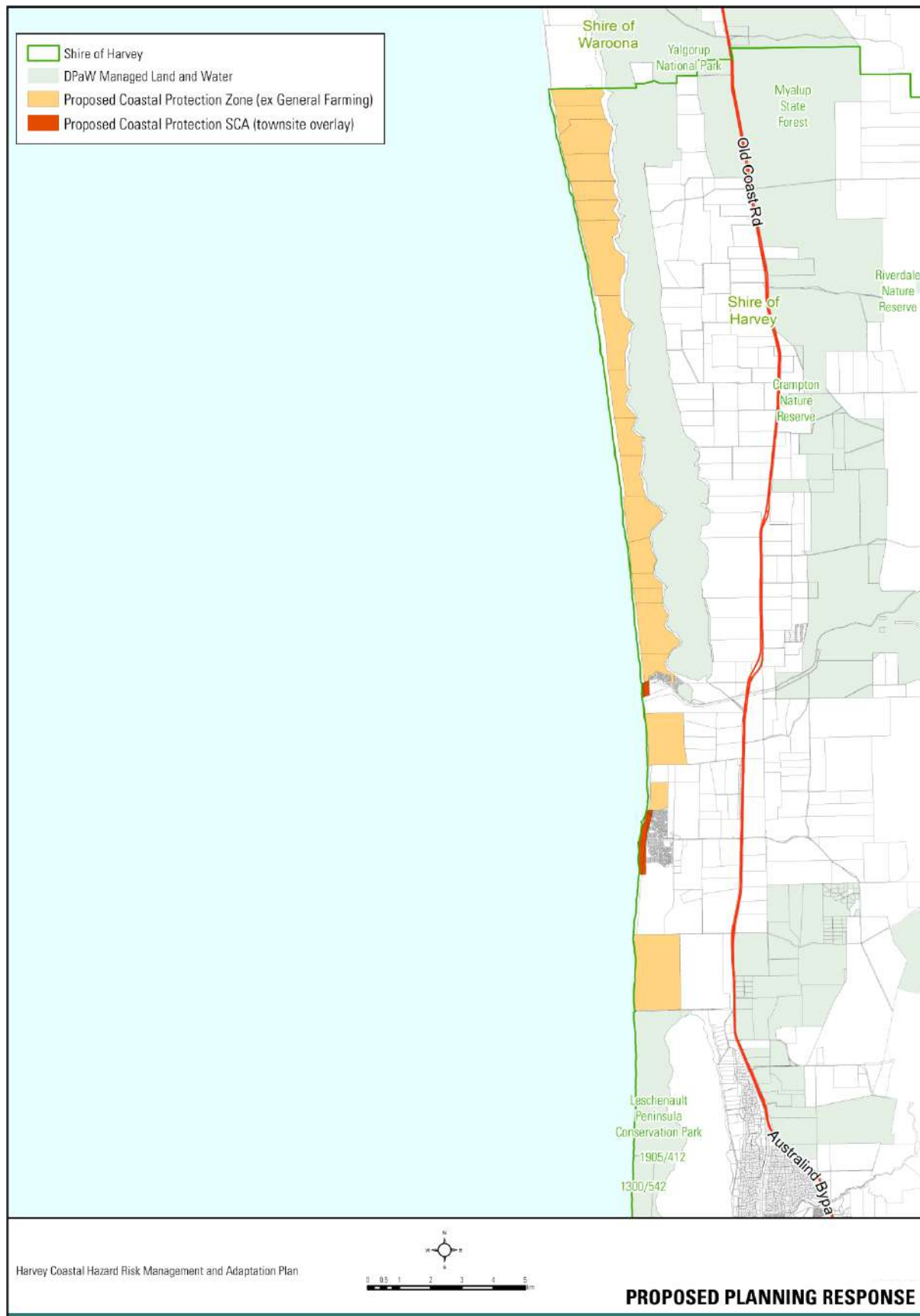


Figure 4-1: Proposed Planning Response across Shire Coast

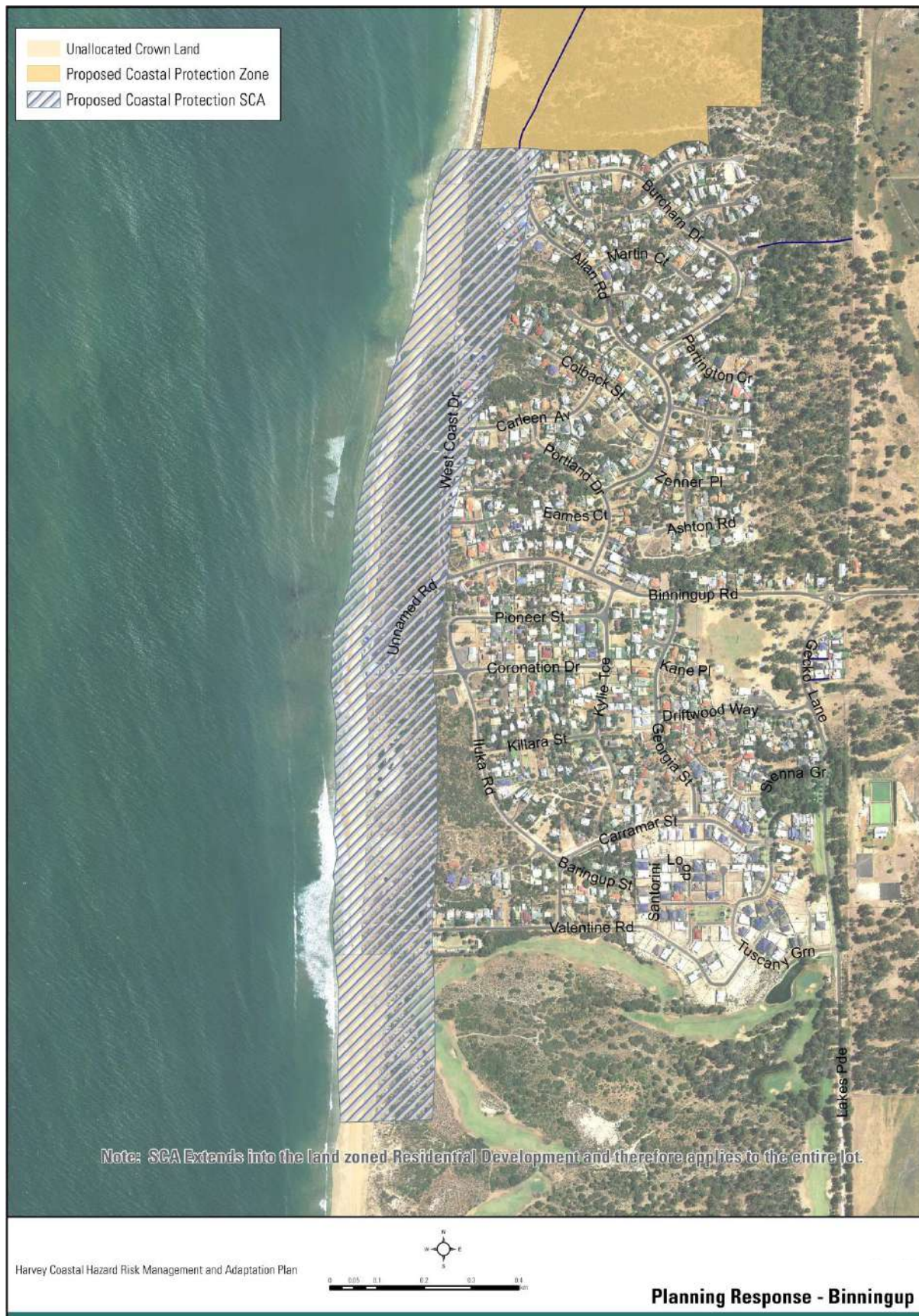
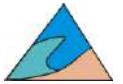


Figure 4-2: Proposed Planning Response for Binningup

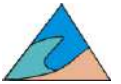
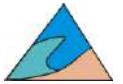


Figure 4-3: Proposed Planning Response for Myalup



4.1 Implementation Considerations

Options are provided as an example of how the planning system could respond within the Shire, however further consideration will be required prior to them being determined as an appropriate mechanism.

Greater Bunbury Region Scheme

The suggested extent of the eventual GBRS should encompass as a minimum the mobile dunes, although ultimately could be brought landward to reflect other environmental or cadastral features. The actual extent will be determined following further investigation and discussion.

Coastal Management Zone

The Coastal Management Zone should cover all existing lots fronting the coast, and in addition any lots likely to be subject to coastal processes. The inclusion of the zone highlights the importance of managing the privately-owned areas of the Shire's coastline in an appropriate manner. In most cases the zone would replace the current *General Farming* zone, which does not appropriately address matters of coastal management and protection.

Suggested objectives of the Coastal Management Zone include:

- To provide for development that is compatible with, and that will preserve, the coastal environs;
- To prevent development that may be susceptible to future impact from coastal processes;
- To limit subdivision of coastal land;
- To ensure that relevant notifications are placed on Certificates of Title; and
- To promote coastal management works.

A range of additional provisions may relate to the zone that specifically relate to coastal management (Table 4-1).



Table 4-1: Provisions and Explanation for the Coastal Management Zone

<i>Additional Provisions^b</i>	<i>Explanatory Comment (not to be included in scheme)</i>
Planning Approval	
Notwithstanding any other requirement of the Scheme for any lot within the Coastal Protection Zone, planning approval is required for all development including a Single House.	The regulations can permit single houses in some zones without the need for planning approval. This provision requires Planning Approval for all development,
On approving any Development in the zone, the Local Government shall require the placement of a notification on the Certificate of Title pertaining to the potential impacts of Coastal Processes.	This clause provides the Shire the opportunity to review implications of coastal processes and to place a notification on the relevant Certificate of Title in accordance with Clause 5.5(ii) of SPP2.6.
Variation to Development Standards	
<p>The Local Government may permit variations to the building setback, where it is satisfied that the modification:</p> <ul style="list-style-type: none"> • Is consistent with the objectives for the zone; • Preserves areas of remnant vegetation, coastal dunes and other areas of environmental significance; • Provides sufficient area for the development of any low fuel zone and/or hazard separation area on the lot; • Is required due to the topography or shape of the lot; and • Will have no adverse impact on the amenity of existing residences on adjoining lots. 	Provides flexibility for the Shire to work with landowners to deliver improved design outcomes on individual lots.
Fencing	
The Local Government will encourage fencing of dunes and other sensitive areas for the purposes of improving coastal/environmental management.	This clause provides an opportunity for the Shire to support landowners in managing coastal or environmental features of their properties. It may also assist in the application of grant funding for on-ground works.
Keeping of Animals	
The keeping of livestock, animals or any rural pursuit activity is not permitted within the zone.	This is to ensure environmental features and coastal dunes are protected.

^b Note: the wording of these provisions is for example only. Further consideration will need to be given to eventual wording to ensure consistency with the Shire's Local Planning Strategy and Model Scheme Text requirements.



4.2 Special Control Area

A Special Control Area is proposed within the existing townsites of Binningup and Myalup. The Special Control Area will apply to relevant residential/commercial/infrastructure reserves in existing urban areas of Myalup and Binningup ^c and will identify additional provisions related to coastal processes (Table 4-2).

Table 4-2: Recommended Provisions for Townsite Special Control Areas

Name of area	Purpose	Additional provisions
Coastal Protection	To protect development within the townsites of Binningup and Myalup from coastal processes associated with coastal recession over a 100-year timeframe.	<ol style="list-style-type: none"> 1. The Local Government will refuse applications for residential land use or development of any other incompatible uses which would, in the opinion of the Local Government, suffer adverse impacts from identified coastal processes using best available information at the time and taking into account the expected life of the development being proposed. 2. The Local Government will not recommend to the Western Australian Planning Commission the further subdivision of residential zoned land within the Special Control Area. 3. Where development is approved within the Special Control Area, a notification shall be placed on the title in accordance with Clause 5.5 (ii) of SPP2.6. 4. The Local Government will require a detailed assessment of coastal processes, appropriate design and management measures to be incorporated into any Structure Plan prepared for land affected by the Special Control Area.

Note: These mechanisms and provisions require further analysis and assessment under the current Planning framework relevant to the locality to interpret the implications on existing statutory planning controls.

^c It should be noted that the suggested extent of the SCA currently aligns with the recession line shown on Figure 5-2. This line may be modified following more detailed geotechnical investigations on the Binningup coast. The extent of the SCA should be reviewed in line with this information as it becomes available.



5 COASTAL HAZARD DECISION-MAKING

This section presents a basis for coastal hazard decision-making typically applied to planning⁶. Information relevant to the Shire of Harvey is presented for the hazards of erosion (Section 5.1), inundation (Section 5.2) and mobility of coastal landforms (Section 5.3).

Threats posed by coastal hazards vary over time and are influenced by weather conditions, the shore conditions, the assets (infrastructure or environmental) or amenity which may be affected and human interventions. A key characteristic of coastal hazards relevant to decision-making is that they typically combine episodic and progressive behaviour (Figure 5-1). Environmental risk management frameworks¹⁰ provide a suitable basis for decision-making to accommodate hazards changing over time. Practical management methods can either be to adopt a conservative initial position or to use an adaptive management approach, where monitoring helps to identify the most appropriate suite of management actions. As demonstrated for the Peron-Naturaliste coast¹¹, the approach used is strongly influenced by the perceived assets at risk and the resulting ease or difficulty of obtaining funding to provide ongoing monitoring to support adaptive management.

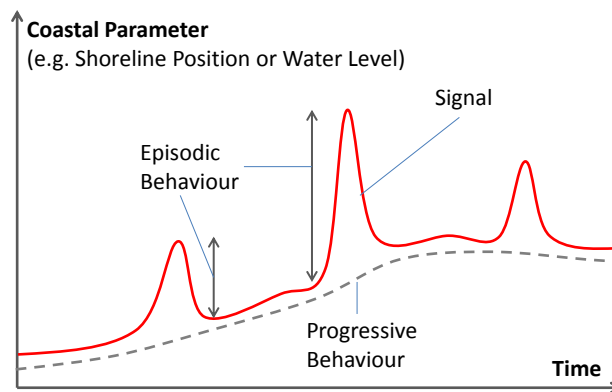
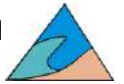


Figure 5-1: Combination of Episodic and Progressive Behaviour

The State Coastal Planning Policy SPP 2.6⁶ recommends the application of development setbacks and minimum ground or floor levels to provide a conservative initial coastal management position, but acknowledges that a number of existing sites and facilities are presently exposed to coastal hazards or may be threatened at a later date. SPP 2.6 recommends that a risk management framework be applied to these sites, incorporating coastal monitoring as part of adaptive management through a CHRMAP¹.

Risk management application to decision-making typically considers *consequence* of a hazard impacting on an asset, combined with the *likelihood* of that impact. The consequence and likelihood for impacts on assets is the overall risk associated with the hazard. This framework may be used for efficient identification of appropriate hazard mitigation and management effort.

Changing conditions over time are typically identified by monitoring of progressive behaviour, with episodic behaviour considered a 'random' variable. In most situations the effects of uncertainty associated with either episodic or progressive behaviour incorporated in the assessment of risk to achieve a conservative outcome (e.g. episodic hazard is evaluated towards the upper limit of confidence envelopes, or progressive hazard is assumed to follow a 'worst-case' pattern over time).



5.1 Coastal Erosion Monitoring and Decision-Making

Characteristics of historic coastal change along the Shire of Harvey coast include:

- Substantial seasonal variation in beach width;
- Moderate to large erosion during severe storm events;
- Local influence of rock platforms and beach rock when they are uncovered;
- Local retention or erosion adjacent to cross-shore rock and reef features due to reversals of alongshore transport (compartmentalised behaviour);
- Focused erosion during severe storm events (north of Binningup) being subsequently distributed alongshore over a number of years (transferred recession);
- Initial recession at Leschenault Estuary entrance (The Cut) following excavation, followed by substantial local shoreline variability on the adjacent coast; and
- Overall net coastal recession, occurring progressively over millennia.

In order to adequately interpret coastal change, distinguishing between the causes and pathways of change is likely to be required.

The approach towards coastal erosion monitoring for the Shire of Harvey is outlined in the PNP Coastal Monitoring Action Plan¹¹, which distinguishes between monitoring for acute erosion hazard and monitoring for erosion trend (recession). Monitoring for acute erosion hazard is targeted toward identifying the likelihood associated with severe acute erosion (typically storm-driven), and is therefore most relevant when assets are located near to the shore. For the Shire of Harvey, historic acute erosion has typically been less than 20m, but decadal phases of severe progressive erosion and dune mobility have occurred (see *Harvey CHRMAP Coastal Hazard Assessment*, Document 246-00-07). The Shire of Harvey coast has been planned with consideration of both rapid and progressive erosion. As a consequence, very few assets are subject to an acute erosion hazard, except Binningup Seawall (Section 6.8) and the amenity of the beach and foredune area itself (Sections 6.6 and 6.7). Monitoring for acute erosion hazard (i.e. likelihood) is not proposed for the Harvey coast, although it remains necessary to monitor coastal change with suitable frequency to distinguish an acute response from more progressive changes.

In contrast to the relative insensitivity to acute erosion, an understanding of the overall coastal trend has ramifications for coastal planning and adaptation. The most widespread and immediate issue is related to the potential for dune mobilisation following coastal retreat. Potential future recession, particularly due to projected sea level rise, has the capacity to affect discrete assets, including existing residential dwellings (Sections 6.1 and 6.3) and the Harvey Diversion Drain (Section 6.9).

The 10-year monitoring program recommended within the CMAP involves:

- Monthly photographic monitoring for indicator sites;
- Annual or twice yearly measurement of beach widths (see Figure 5-2);
- Oblique aerial imagery annually or twice yearly (captured by PNP);
- Capture of vertical aerial imagery every 5 to 10 years with photogrammetric interpretation of vegetation line and shoreline (captured by Landgate);
- Annual dune monitoring.

This monitoring framework is intended to allow identification of relatively high frequency change such as storm response and seasonal beach change, but is mainly qualitative (Figure 5-3).



Figure 5-2: Beach Width Monitoring Sites and Sediment Cell Boundaries

Temporal Coverage

Vertical Aerial Imagery

Oblique Aerial Imagery

Beach Widths

Site Photographs

Time

NB: Relative Timing is not to scale

Data Quality

Quantitative

Full Coverage

Qualitative

Full Coverage

Quantitative

Part Coverage

Qualitative

Part Coverage

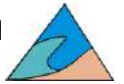
Quantitative

Coverage

L H

Vertical aerial imagery provides the main quantified basis for evaluating coastal trend and therefore making decisions. However, vegetation lines (derived from aerial imagery) are a proxy for coastal position, as considerable beach change can occur without affecting the vegetation line. Due to the potentially high amplitude of short-term variations, it is also necessary to use photographic monitoring to provide a high frequency indicator of change, identifying whether a phase of storm erosion and recovery has contributed to the perceived trend (Figure 5-4).





5.2 Dune Mobility Monitoring and Decision-Making

Dune mobility has historically been a substantial coastal management issue for the Shire of Harvey, the Department of Parks and Wildlife and local land-owners. It is anticipated that the management effort required will increase substantially in the future, particularly if progressive recession due to sea level rise causes widespread loss of existing narrow foredunes and form erosion scarps that destabilise existing dune faces up to 100m in width. A typical sequence of development is:

1. Erosion event undermines foredune vegetation, forming a scarp;
2. Exposed foredune blown out by wind or water, creating sand sheet to landward;
3. Sand sheet mobility smothers adjacent dune vegetation and undercuts laterally;
4. Blowout and sand sheet advance landward.

Techniques for the management of mobile coastal dunes are well established¹³, with intervention at an early stage of dune mobility being significantly less expensive than stabilisation at a later date, largely due to the physical area requiring stabilisation. In many cases, dune instability is enhanced by uncontrolled 4WD access (Section 6.7).

Early intervention involves construction of a vegetated or brushed dune buffer, which provides a wind barrier and prevents the movement of foredune sand into a sand sheet. When a buffer is present, the management requirements may generally be indicated by the width of existing buffer, which is therefore the main parameter to be monitored. On an eroding coast, management actions associated with dune stabilisation typically follow a sequence indicated by Figure 5-5. A new buffer should be established landward using earthworks, brushing and planting when the management effort is considered to be excessive. Appropriate buffer width is determined by the height of the scarp to seaward, as it should typically be five to six times the scarp height.

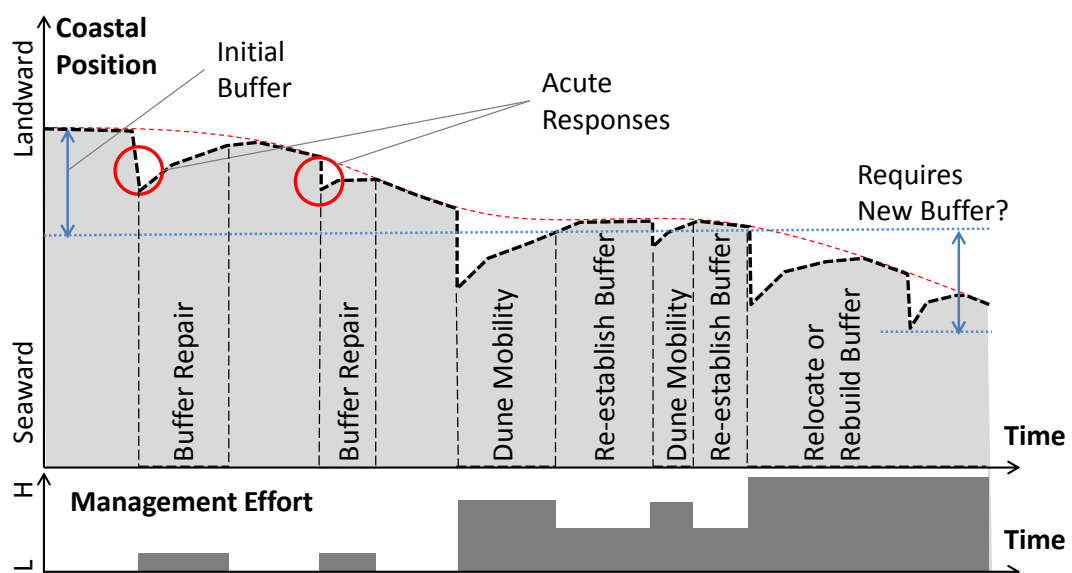
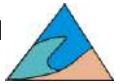


Figure 5-5: Dune Buffer Management Sequence for an Eroding Coast

Monitoring is typically used to characterise the increase in area and the horizontal movement of the sand sheet for mobile dunes that are not stabilised early. Two approaches used are:

- Vertical aerial imagery to measure change in sand sheet area;



- Installation of survey posts to measure movement of the sand sheet's leading edge when there is a short distance for sand sheet movement to affect amenity or assets, as outlined in the CMAP.

Approaches towards the management of advanced dune mobility (i.e. active sand sheets) typically vary according to the density and perceived value of the assets potentially affected. Approaches include:

- Locating (or relocating) assets to reduce the likelihood of being affected by sand drift;
- Monitoring the advance rate of the sand sheet compared with the projected time of use for the asset;
- Providing assets with structural characteristics that reduce sensitivity to drift; or
- Stabilising the sand sheet (for high value assets).

These approaches broadly parallel the adaptation hierarchy suggested in SPP 2.6 for the management of coastal erosion and inundation hazards.

5.3 Coastal Inundation Monitoring and Decision-Making

The key parameter for monitoring of coastal inundation hazard is coastal water level. However, as with coastal erosion, there is a high level of uncertainty regarding process attribution which may need to be evaluated when making coastal management decisions in regards to inundation risk.

Coastal inundation is developed through a wide range of water level processes, with at least 20 processes identified from scientific research in the Peron-Naturaliste region¹⁴. The micro-tidal nature of the region determines that many of these processes have comparable amplitude. Therefore a different set of processes may be influential for any particular inundation management issue, depending on recurrence, timing or interaction of processes. Some of the inundation issues faced by the Shire of Harvey include:

- Movement of the wetted foreshore fringe, affecting amenity and access temporarily;
- Foreshore change in response to water levels, particularly beach adjustments;
- Stability of drains and channels subject to occasional, intermittent or regular coastal flows;
- Change to hydrodynamic stresses affecting foreshore infrastructure, including throughflow and overtopping; and
- Flood damage caused by water that reaches assets (typically infrastructure or environmental assets) that are not water tolerant.

Each of these issues requires consideration of a different range of water levels, which may be loosely classified as ambient, high or extreme. These classifications can be described relative to the set of processes most likely to contribute to water level recurrence (Figure 5-6). Significantly, because of the small tides along the Harvey coast, the effect of mean sea level change is projected to cause substantial shifts in the relative recurrence of water levels at or above existing thresholds. Assets affected by present day extreme levels (i.e. subject to flooding only during extreme storms) will be subject to ambient conditions (i.e. inundation on a day-to-day basis) with a sea level rise of approximately 0.5m, projected to occur by 2080 (Section 2.1). Even small changes may substantially affect flood recurrence, with a 0.1m sea level rise approximately doubling the occurrence of flooding at thresholds around +1.2mCD.

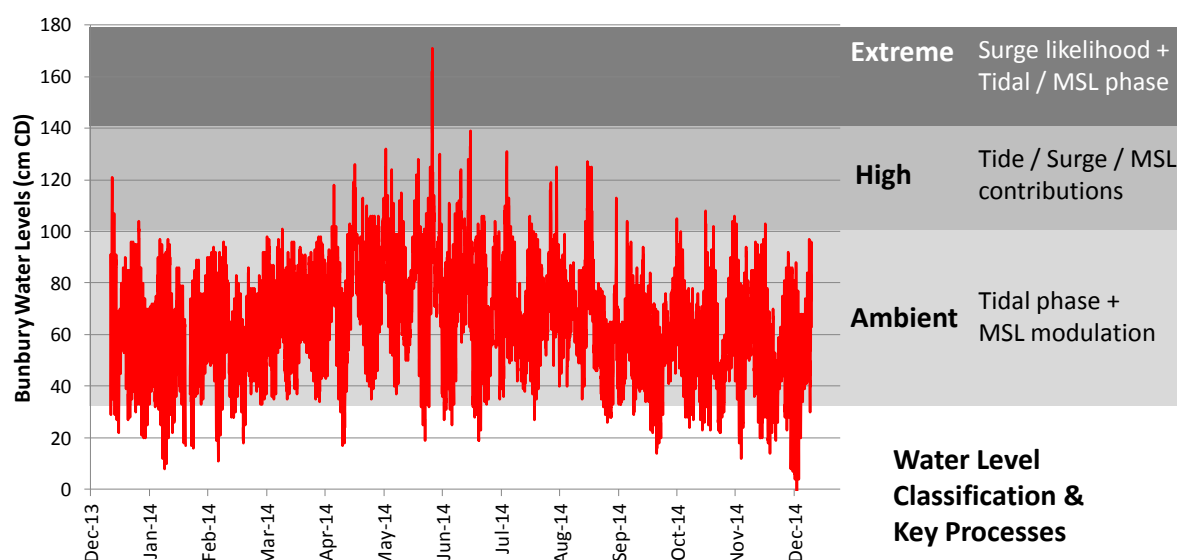


Figure 5-6: Water Level Classification Scheme

The nature of coastal flood events commonly creates a wide range of risk-tolerant to risk-averse behaviour in relation to coastal management. A key factor is that flood perception is largely determined by damaging events. As small flood events can often occur with zero or limited impact, often only extreme events are recognised. However, there is potential to have extended periods between critical events or clusters of critical events, which is only partly dependent on the underlying preconditions of mean sea level or tidal phase. A key result of this mainly episodic behaviour is that observations of extreme or high flooding ($>+1.6\text{m CD}$) are not good predictors of risk. Instead, observation of low-moderate level flood events ($+1.2$ to $+1.6\text{m CD}$) is considered to provide a better measure of progressive change to inundation risk and therefore is a better parameter to be monitored and used for decision-making.

A difficulty with identifying a particular threshold for decision-making is that the occurrence in any year may vary significantly due to either storminess or inter-annual variability (tides or MSL). This produces wide levels of uncertainty when using annual threshold exceedance to infer a present level of risk (Figure 5-7a). Interpretation can be improved by the use of a wider observation period, say $>5+$ years, over which exceedance is averaged (Figure 5-7b).

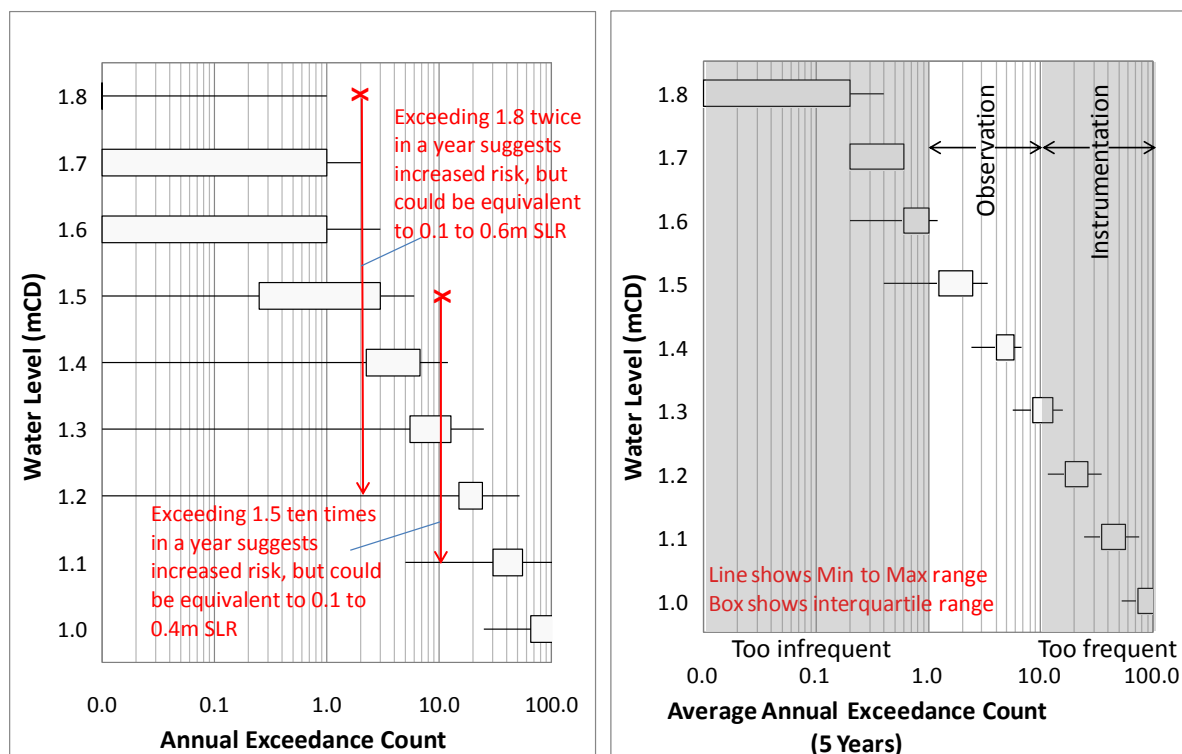


Figure 5-7: Using Threshold Exceedance to Monitor Change in Risk
Using a longer data set (>5+ years) to describe behaviour improves confidence.

In addition to the difficulty of inferring risk levels from observations due to the episodic nature of ocean surges, establishing the likelihood of threat to the lowlands north of the Leschenault Estuary from coastal inundation requires an understanding of overland propagation of surge events. This is presently poorly informed compared to knowledge about other water level phenomena (Figure 5-8).

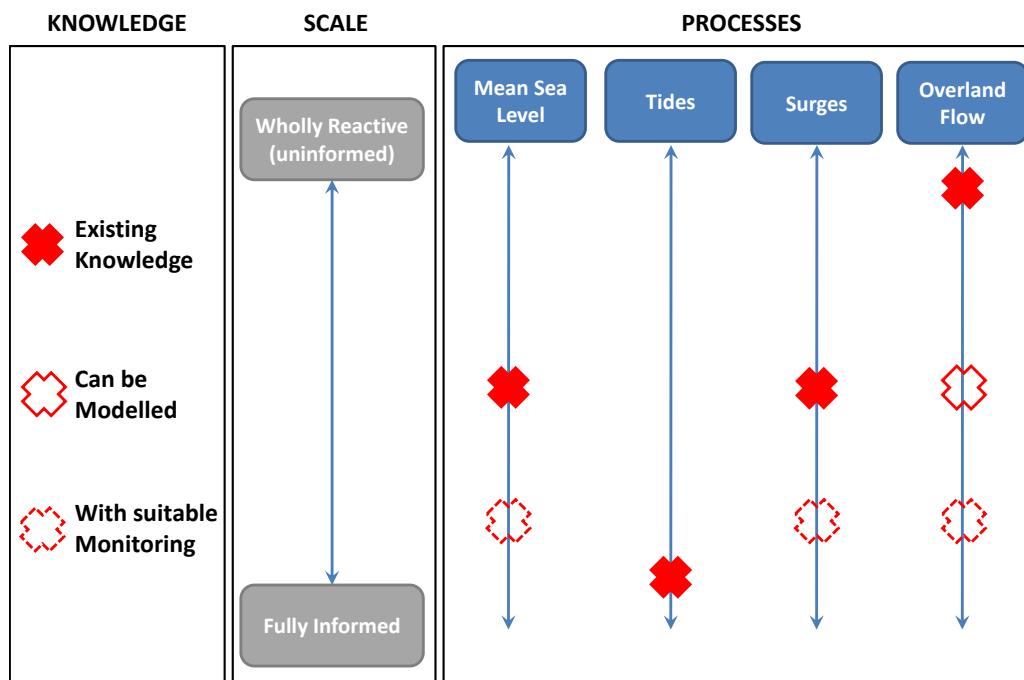
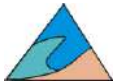


Figure 5-8: Knowledge-Base for Inundation Processes



Evaluation of coastal inundation likelihood requires knowledge of:

1. 'Background' ocean water levels (tides and mean sea level);
2. Meteorological conditions producing storm surge; and
3. Capacity for an oceanic flood event to propagate through Leschenault Estuary and overland to Binningup.

The components of tide and mean sea level are effectively measured by the Bunbury Port tide gauge. This exhibits characteristics similar to the Fremantle record, with high water level events mainly restricted to May through July due to tide and seasonal mean sea level processes. Inter-annual variability is mainly introduced by the El Niño-La Niña phase, further influenced by year-to-year storminess and the 18.6-year lunar nodal cycle ¹⁴.

With interpretation, the Bunbury gauge record also provides a history of storm surge events that supports identification of the meteorological conditions producing severe storm surges ¹⁵. Parameterisation of the storm characteristics can therefore be used to estimate surge likelihood. It is notable that the likelihood of flooding due to tropical cyclone-induced surge has not yet been established, although a modelling scenario based upon impact of Tropical Cyclone Alby has been used to consider Bunbury flood risk ¹⁶.

Although the tide gauge record is viable to develop an understanding of inundation factors (1) and (2) listed above, decision-making for Binningup may also require an understanding of factor (3). A preliminary estimate can be established through numerical modelling, and undertaking a flood study is recommended (Section 7.1). However, to correctly validate the model requires observations. It is therefore considered appropriate to implement a monitoring program that supports both model validation and adaptive decision-making. The recommended approach follows the PNP Coastal Monitoring Action Plan ¹¹, using a combination of flood frequency analysis and flood mapping ¹⁷.

Recommended sites to undertake flood frequency analysis include:

- Australind shore, landward of the scientific observation causeway;
- The small wetland north of Crimp Crescent;
- Buffalo Road;
- Wetlands on the western side of Leschenault Estuary (along Harris Track);
- Springhill Road; and
- Binningup Road.

Flood mapping should be undertaken for events which exceed +1.8m CD on the Bunbury tide gauge. The limit of flooding should be determined, generally by survey of levels and positions of flood debris or water marking. Consideration should be given to storm surge events which are simultaneous with heavy rainfall, where a distinction between runoff flooding and coastal inundation may be obscured.