Appendix I

Economic Report (Rhelm)

I.1 Economic Analysis - Technical Report

engineering | environmental | economics | engagement

Shire of Murray: Coastal Hazard Risk Management and Adaptation Planning

Economic Assessment

Prepared for: **Baird**

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Cover Image: *Properties on Ballee Island (CNES / Airbus Maxar Technologies, Google Maps, 2022)*

Executive Summary

Overview

The community of the Shire of Murray (SoM) are facing the adverse impacts of coastal erosion and inundation on their coastlines. The vulnerability of land use and development within the estuarine and tidally influenced riverine zone from physical process hazards is expected to increase in the future with the impacts of climate change. The shoreline areas in the SoM are currently impacted by erosion and inundation processes with loss of nature reserves, foreshore parkland and residential properties.

Objectives & Methodology

In order to ensure that the coastal hazard is factored into decision-making for future planning requirements, a Coastal Hazard Risk Management and Adaptation Planning (CHRMAP) is being undertaken. The CHRMAP process is a risk-based approach to ensure that the coastal hazard is factored into decision-making for future planning requirements. The overall objective of the study is to forecast inundation and erosion paths between 2020 to 2120, in order to cost estimate necessary actions by council or other government bodies to protect both public and private assets.

The assessment has been undertaken for erosion and inundation across five timeline scenarios associated with sea level rise (SLR):

- 2020: no SLR
- 2030: +0.1m SLR
- 2050: +0.2m SLR
- 2070: +0.4m SLR
- 2120: +0.9m SLR.

The assessment has focused on a part of the overall Shire of Murray CHRMAP study area, being:

- North Yunderup
- South Yunderup
- Murray Delta Islands
- Kooljerrenup Nature Reserve

Assessment Scenarios

The economic cost benefit analysis (CBA) assesses various scenarios against a “base case” scenario. In this case, a “do-minimum” scenario was adopted for the base case condition. Under this scenario, no mitigation is undertaken to protect foreshore areas or property, and erosion and inundation will continue to worsen and impact the study area.

Mitigation options are then compared with the base case scenario, to determine the overall economic viability of implementing these mitigation measures. Two key types of mitigation measures were assessed:

- Hard engineering option, which would include typical foreshore treatments like revetments;
- Nature based solutions, which include a combination of vegetation and softer engineering solutions to provide protection.

A separate option was considered for Kooljerrenup Nature Reserve as a part of the CHRMAP. Under this option, an adaption strategy of purchasing land on the eastern side of the reserve is considered, to

mitigate the loss of land due to erosion on the shoreline side. This option has not been explicitly assessed as a part of the CBA, but the base case economic loss of land has been estimated to assist in informing this option.

Further discussion on these is provided in the overall CHRMAP report.

Costs estimates for these mitigation options were provided by Baird and include both the capital costs and maintenance costs.

Base Case Economic Impacts

Under the base case, economic impacts from both erosion and inundation were considered. A summary of these various impacts is provided in Table i.

Table i. Base Case Impacts

Location	Mitigation Option	Inundation	Erosion
Yunderup Island	Hard	$510,258	$65,782
	Nature Based	$510,258	$65,782
Ballee Island	Hard	$400,968	$89,853
	Nature Based	$400,968	$89,853
Coolenup Island	Hard	$2,108,132	$154,764
	Nature Based	$2,108,132	$154,764
Nth Yunderup Shoreline	Hard	$102,238	$5,181,221
	Nature Based	$102,238	$5,181,221
South Yunderup	Hard	$110,807	$1,624,422
	Nature Based	$110,807	$1,624,422
Kooljerrenup Nature Reserve		$0	$5,091,392

Cost Benefit Analysis

The benefits for the mitigation options were considered in terms of the protection provided for both erosion, as well as inundation of properties. Economic values were estimated for both the base case condition, as well as the mitigation option, to determine an overall net benefit. These were compared against the estimated costs for the project. A summary of the economic results is shown in Table ii.

Climate change results in a non-stationary environment, where risks and impacts on the community are expected to change over time. For inundation and erosion, with sea level rise these are anticipated to worsen. From an economic viewpoint, while a project may not be viable to implement today, it may be viable in the future as climate change continues to worsen. Understanding when this will occur can assist in SoM planning into the future. A summary of an estimate of when this would occur, based on the sea level rise projections, is provided in Table ii.

Table ii. Summary of Economic Results

Location	Mitigation Option	Total Costs	Total Benefits	NPV[1]	BCR	Timeframe for Viability[2]
Yunderup Island	Hard	4.16	0.58	-3.58	0.14	30 – 50 years
	Nature Based	0.47	0.04	-0.43	0.08	30 – 50 years
Ballee Island	Hard	1.72	0.49	-1.23	0.29	20 – 40 years
	Nature Based	0.09	0.05	-0.03	0.61	10 – 20 years
Coolenup Island	Hard	12.81	2.26	-10.55	0.18	>50 years
	Nature Based	0.66	0.09	-0.57	0.14	20 – 40 years
Nth Yunderup Shoreline	Hard	5.69	5.28	-0.40	0.93	5 – 10 years
	Nature Based	0.64	3.11	2.46	4.82	current
Sth Yunderup Shoreline	Hard	5.45	1.74	-3.72	0.32	10 – 30 years
	Nature Based	0.62	0.97	0.36	1.74	current

A distributional analysis is a useful tool for understanding the key beneficiaries for a mitigation option. It is undertaking by assessing the beneficiaries for each of the net benefits identified. For the Shire of Murray, the key beneficiaries are private landowners, as well as the Shire of Murray (though the public assets such as reserves). A summary of the distributional analysis is provided in Table iii.

Table iii. Distributional Analysis

Location	Mitigation Option	Private Landowners	Shire of Murray
Yunderup Island	Hard	100%	0%
	Nature Based	100%	0%
Ballee Island	Hard	100%	0%
	Nature Based	100%	0%
Coolenup Island	Hard	100%	0%
	Nature Based	100%	0%
Nth Yunderup Shoreline	Hard	100%	0%
	Nature Based	100%	0%
Sth Yunderup Shoreline	Hard	90%	10%
	Nature Based	88%	12%

[1] Net Present Value (the difference between the net benefits and net costs)
[2] Indicative timeframe at which the project may have a BCR > 1 in the future.

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Acronyms

AAD	Annual Average Damage
ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
AWE	Average Weekly Earnings
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CHRMAP	Coastal Hazard Risk Management and Adaptation Planning
CMU	Coastal Management Units
FYRR	First Year Rate of Return
IA	Infrastructure Australia
IRR	Internal Rate of Return
LGA	Local Government Area
NPV	Net Present Value
NPVI	Net Present Value per Dollar of Capital Investment
NSW	New South Wales
PV	Present Value
SoM	Shire of Murray
SLR	Sea Level Rise

1 Introduction

The community of the Shire of Murray (SoM) are facing the adverse impacts of coastal erosion and inundation on their coastlines. The vulnerability of land use and development within the estuarine and tidally influenced riverine zone from physical process hazards is expected to increase in the future with the impacts of climate change. The shoreline areas in the SoM are currently impacted by erosion and inundation processes with loss of fringing vegetation in some areas of the Peel Harvey Estuary, the Murray and Serpentine River entrances experiencing erosion events and the delta islands being periodically affected by high water levels and erosive conditions. The influence of climate change and sea level rise is anticipated to exacerbate the erosion and high-water levels.

The Shire of Murray is located 80km South of Perth in Western Australia with a population of approximately 18,000. An overview of the locality is shown in Figure 1-1. The focus of this economic assessment is on four key areas within the study area, namely North Yunderup, South Yunderup, the Yunderup delta islands, and Koolijerrenup Nature Reserve (Figure 1-2 and Figure 1-3). These four areas were selected through the CHRMAP process, due to their vulnerability to both erosion and inundation events in the future and their containment of highly valued or protected lands.

The economic assessment undertaken as part of this report refines the evaluation of a number of options by quantifying the economic value of the various adaptation options considered to mitigate against hazards associated with coastal erosion. The Cost Benefit Analysis (CBA) was performed to consider the economic costs and benefits of the protection options, along with the implications of the Base Case for the study areas.

As part of this CHRMAP economic assessment, five sea level rise (SLR) scenarios were modelled:

- 2020: no SLR
- 2030: +0.1m SLR
- 2050: +0.2m SLR
- 2070: +0.4m SLR
- 2120: +0.9m SLR.

Figure 1-1. Locality

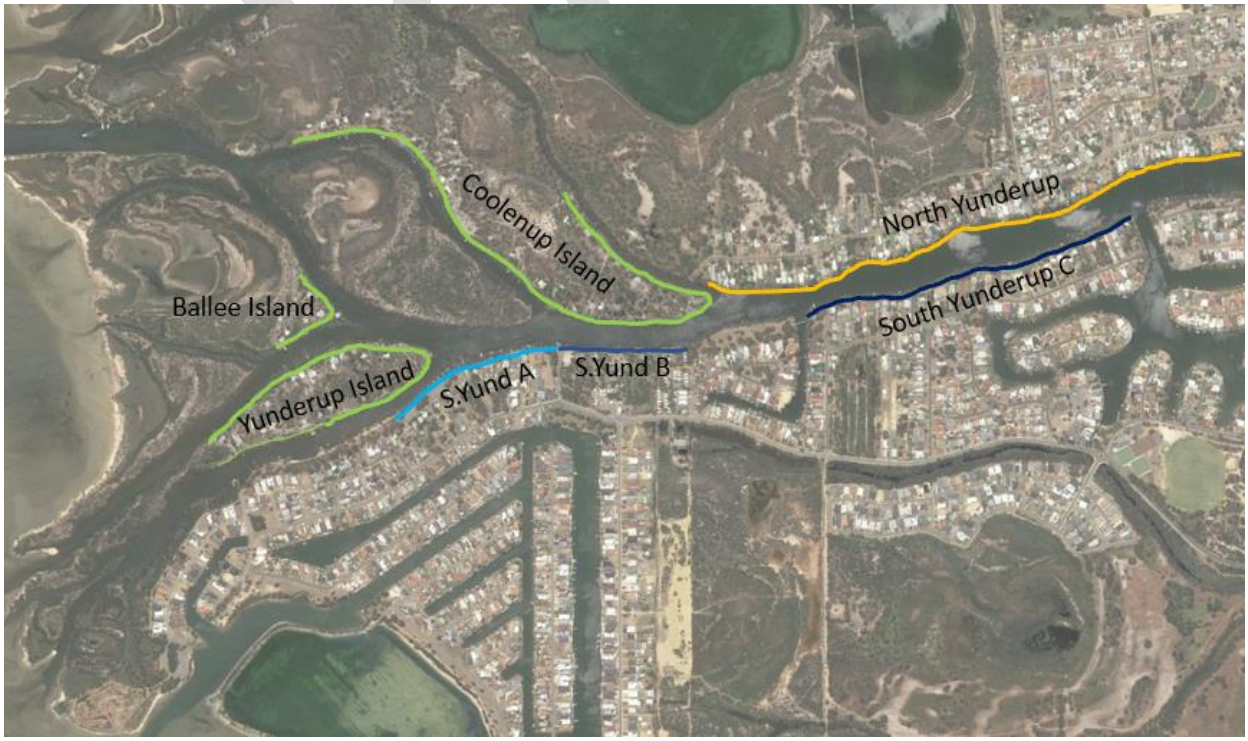

Figure 1-2. Key Areas of Investigation

Figure 1-3. Kooljerrenup Nature Reserve

2 Economic Assessment

The economic assessment considers the comparative costs and benefits of the proposed mitigation options against a base case scenario.

The economic merit of the individual projects was determined by comparing the present value (PV) of the change in net economic benefits (compared with the Do-Minimum base case) less the change in capital and maintenance costs. The key benefits incorporated within this Cost Benefit Analysis (CBA) assessment were in the form of savings in inundation damages and erosion loss.

Standard evaluation metrics of Net Present Value (NPV), Net Present Value of Investment (NPVI), and Internal Rate of Return (IRR), have been determined to support the assessment of viability.

2.1 Assumptions

For the purposes of this assessment, a number of assumptions have been made to facilitate estimation of economic values. These include:

- 2021/22 was utilised as the base year of assessment
- 2026 is the 'year of opening', i.e. the commencement of project benefits
- Capital expenditure costs for each project were deemed to be expended in 2025, and include the works associated with upgrading and maintaining public assets
- The length of the economic assessment period is 50 years (i.e. 2026 to 2075)
- A primary discount rate of 7% p.a. has been applied and sensitivities of 4% and 10% p.a. have also been calculated.

Realistically, if multiple options were implemented, these would likely be staggered over a number of years. However, the same 'year of opening' of the various options considered was adopted to provide a consistent base against which to compare the various options.

Where other alternative parameters or other assumptions were used in the identification and evaluation of relevant costs and benefits, these are documented in the following subsections.

2.2 Scenarios

A cost benefit analysis compares mitigation options against a base case. The definition of these scenarios is outlined below.

2.2.1 The Base Case

In the absence of the project, it is assumed that a 'do-minimum' approach would be adopted. The Council would be assumed to take no action to mitigate against the forecast inundation and erosion and a planned retreat approach would be adopted. This scenario and the assessment has been further discussed in Section 3.

2.2.2 Mitigation Options

The overall CHRMAP has considered a number of options to mitigate the effects of erosion and inundation, as well as climate change. This long list of options was then evaluated through a Multi-Criteria Assessment (MCA), and shortlisted options were identified for further assessment. The details of these option are discussed in the CHRMAP report.

Of the short-listed options, the following options have been assessed as part of this economic assessment:

- "Hard" engineering solution – this involves the construction of a revetment/ seawall on the foreshore, to provide protection to properties and land against erosion. By raising the crest of the revetment, these solutions also provide protection against inundation as well.
- Nature based solutions – similar to above, these use vegetation and "softer" engineering approaches to provide protection against erosion. These options are not considered to provide significant benefits for inundation.

Examples of these solutions are shown in Figure 2-1.

Figure 2-1. Example of "Hard" Engineering Solution (left)[3] and Nature Based Solution (right)[4]

A separate option was considered for Kooljerrenup Nature Reserve as a part of the CHRMAP. Under this option, an adaption strategy of purchasing land on the eastern side of the reserve is considered, to mitigate the loss of land due to erosion on the shoreline side. This option has not been explicitly assessed as a part of the CBA, but the base case economic loss of land has been estimated to assist in informing this option.

[3] https://cirtexcivil.co.nz/case-studies/tauranga-sea-wall-rock-revetment-terratex-k-geotextile/
[4] Syrinx Environmental (2018), Lower Murray River, Foreshore Stabilisation Guidelines. Prepared for the Shire of Murray, November 2018.

3 Base Case

The base case scenario considers an assessment of the impacts of inundation and erosion under current conditions as well as under the forecast impacts due to climate change.

3.1 Erosion

The erosion assessment under the base case assumes that no mitigating actions are undertaken to limit the erosion. The economic loss associated with the erosion includes:

- Loss of Private Land;
- Loss of Public Reserves and Nature Reserves;
- Loss of Public Assets (such as roads, parking areas etc).

The economic loss was quantified through the loss of land area or asset over time. Spatial analysis provided by Baird, predicts the percentage of land lost for each property lot and reserve within the CHRMAP study area for the five representative periods in time – 2020, 2030, 2050, 2070 and 2120.

3.1.1 Private Land

The valuation of properties was based on an assessment of the current property market conditions and the sales in the market across the previous decade. Land values were estimated based on property sale prices and deducting an estimate of the value of the house on the structure. This analysis was undertaken for 20 representative properties in the study area.

The intention is to derive a representative average land value for each of the key parts of the study area. It is not intended to be a precise property by property estimate, but rather than overall average to provide an indication of the economic loss.

The analysis estimated:

- North Yunderup foreshore properties have a value of $600 per square metre;
- South Yunderup foreshore properties have a value of $350 per square metre;

The Murray delta islands provided additional challenges in estimating land values. There was significant variation in property sale prices across the islands. Property sale prices ranged from $50,000 to over $800,000. Further, as the assessment areas adopted for each of the islands only have a few properties, the influence of land value can have a significant effect on the economic assessment.

Reviewing the sale values suggest that some of the higher prices may be associated with the infrastructure (house and other infrastructure) on the property, as much as the land value itself. Reviewing the various sales, an estimated land value of $80,000 per property was adopted. However, a sensitivity analysis was undertaken on this value to understand its influence on the results.

Using the above values, the loss of land was estimated at each snapshot period in time from the erosion estimates from Baird. A linear loss rate was assumed between these periods.

A further assumption was included in the analysis, where the property area falls below 500 square metres. At this point, it was assumed that the lot was no longer viable, and therefore the property would be completely lost. At this lot size, while it would be possible to reconstruct a house on the lot, the continual erosion would make that reconstruction not feasible. When this occurred on the property, the remainder of the property value is assumed as a loss.

3.1.2 Private Houses

In addition to the loss of land, as erosion continues it can result in a loss of the house as well. When the erosion reaches the house, a loss of the asset is assumed (and the house is assumed to be reconstructed on the remainder of the residential lot).

The following was assumed for the building values:

- Murray Delta Islands: $198,000
- North Yunderup: $330,000
- South Yunderup: $330,000.

The cost for North Yunderup and South Yunderup has been derived from *Rawlinsons Construction Cost Guide 2019*. It is recognised that there is significant variance in building types within these areas, but these were adopted to provide a representative average.

The types of houses on the Murray delta islands are highly variable, with relatively modest structures to large houses. In general, the houses are of a smaller and or/ simpler construction type. In the absence of more precise valuations, an estimate of 60% of the North and South Yunderup was assumed.

3.1.3 Public Assets

The foreshore and parkland areas within the Yunderup and Murray Delta Islands study area, incurred erosion damages to not only private land areas, but also to public assets. Public assets were inclusive, but not limited to; boat ramps, bollards, carparks, footpaths, park utilities, reserves and signage.

The value for most assets were based on Shire of Murray Asset Database and were assigned to each component. Baird provided estimates of the periods of time when each of these assets would be lost to erosion.

The economic value of the reserves includes both the benefit that it provides to the community through their use of the asset, together with a "non-use" value, which is the amenity that is gained from the existence of the asset. The key public reserve areas are in South Yunderup and include foreshore sections of land as well as some parks.

Pascoe et al (2017) provides non-market values for a number of coastal areas but does not include estimates for parkland or bushland. While there are some similar studies on parkland values, most require some estimate of the usage of the parkland. Anecdotal information suggests a relatively low usage of the reserve assets, and therefore this was not included in the overall estimate. This will provide a lower bound estimate of the economic value.

Hence, for the purposes of this study, a non-use value per square metre was derived from a scaled value of Pascoe's shrubland valuation for the Byron Bay area in northern NSW. The shrubland valuation for Byron Bay was chosen as a basis due to the similarities to Yunderup's environmental and geographical characteristics, being both regional and coastal locations. Moreover, through research using *.id* (Informed Decisions) and the Australian Bureau of Statistics (ABS), it was found that both areas showed similar socio-economic characteristics with almost identical weekly household incomes and mortgage repayments. Hence, with such similarities, Pascoe's initial valuation of $73 per square metre was able to be scaled down to $24.41 per square metre through the weighting of the population of Byron Bay (9,246) and Yunderup (3,092).

3.1.4 Kooljerrenup Nature Reserve

The reserve is listed as a strictly protected nature reserve under the International Union for Conservation of Nature (IUCN) since 1975 in the 1a category. This categorisation allows the Western Australia Department of Biodiversity, Conservation and Attractions to protect biodiversity and geomorphic features through strict controls and limitation of human visitation and use.

Without undertaking more complex willingness-to-pay or other detailed economic assessments, it is difficult to provide an economic value for these types of natural assets. However, there are a number of studies that investigate the value of environmental assets, and some of these can be translated to the local area to provide an indication of the value. However, it is recognised that there are a number of local factors and community values that can result in an alternative valuation. Therefore, any estimates provided in this report should be considered indicative.

The valuation for Kooljerrenup Nature Reserve has been derived from weighted adaptation of Pascoe et al (2017) non-market values for Scrubland, Marshlands and Estuaries. An estimate of $68.30 per square metre. Although this valuation derives from literature relating to coastal assets, it is argued that the reserve provides benefits for biodiversity and the conservation of geological structures which have a high value.

Baird provided estimates of the land area loss under the different time horizons is shown Table 3-1 and in Figure 3-1.

Table 3-1 Kooljerrenup Nature Reserve: forecast land lost to erosion

Year	SLR (m)	Total Area Lost (m^2)
2020	-	0
2030	+ 0.1	61,786
2050	+ 0.2	196,525
2070	+ 0.4	338,138
2120	+ 0.9	665,712

Figure 3-1 Kooljerrenup Nature Reserve forecast erosion

3.2 Flood Inundation and Damages

The depth of inundation at properties across the study area was modelled for the five SLR scenarios listed in Section 1. The water level in each of these scenarios is presented in Table 3-2 and illustrated in Figure 3-2.

Table 3-2 Water levels (m AHD) for each ARI in each modelled year (SLR scenario)

Year	SLR (m)	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr
2020	-	0.60	0.78	0.87	0.91	0.96	1.04	1.09	1.44
2030	+ 0.1	0.70	0.88	0.97	1.01	1.06	1.14	1.19	1.54
2050	+ 0.2	0.80	0.98	1.07	1.11	1.16	1.24	1.29	1.64
2070	+ 0.4	1.00	1.18	1.27	1.31	1.36	1.44	1.49	1.84
2120	+ 0.9	1.50	1.68	1.77	1.81	1.86	1.94	1.99	2.34

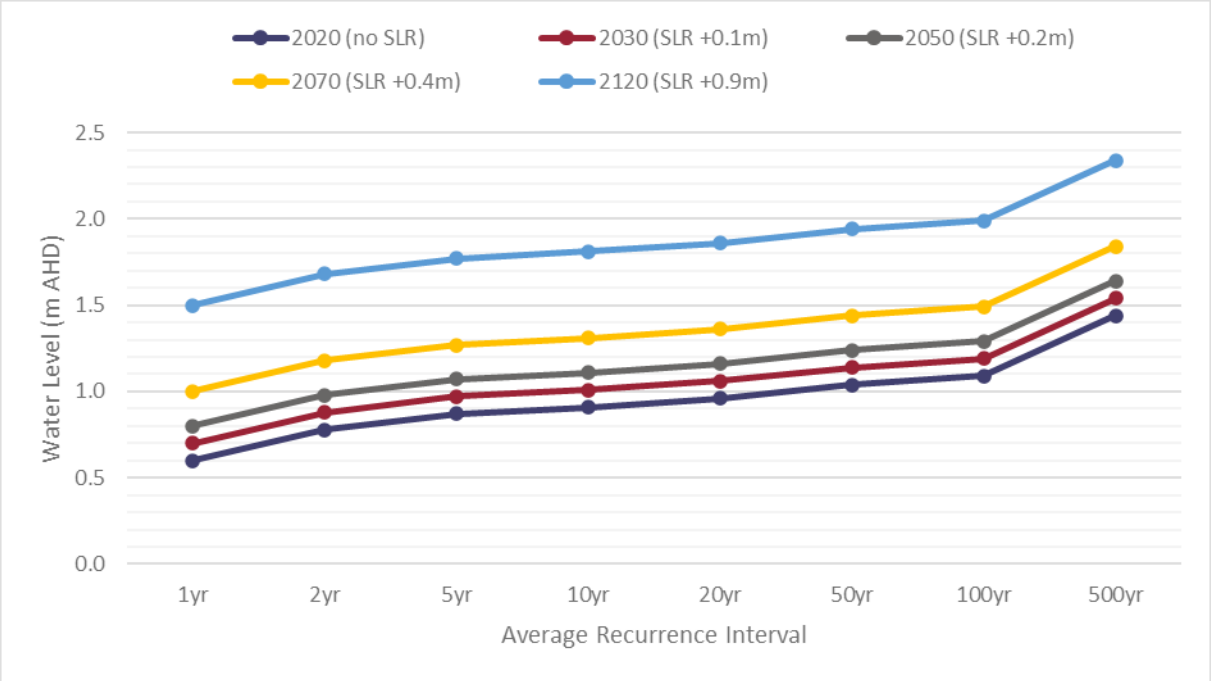

Figure 3-2 Water levels (m AHD) for each ARI in each modelled year (SLR scenario)

Baird provided information for the properties in the study area include:

- Estimated ground level at the house;
- Estimated floor level of the house, based on an assumed 0.3 metres above ground;
- The over floor flooding depth for different AEP events and under the different SLR scenarios.

Flood damages were calculated using the *Flood Damage Estimation Tool FD01* (DPE, 2022), which forms part of the NSW Floodplain Development Manual Update. This tool represents the culmination of the most recent research in flood damages in both Australian and Internationally. It is not specifically focused on NSW and can be adapted to other states in Australia. The tool facilitates the calculation of structural, internal (contents) and external damages for each property, as a function of the depth of inundation in each AEP event. In the absence of detailed property data, it was assumed that the majority of residential properties were single storey with a floor area of 240 square metres (categorised as 'large'). Some properties on some of the Murray Delta Islands were re-classified as small or medium based on an inspection of the aerial imagery.

A summary of the key model inputs is described in Table 3-3.

Table 3-3 Flood damage estimation tool: user inputs

Input	Value	Justification / Threshold
Replacement value	$2,000 per m^2	Default recommendation
Average value of contents	$490 per m^2	Default recommendation
External damages	$15,000 per property	If overfloor flooding is present
Clean-up costs	$4,000 per property	If overfloor flooding is present
Actual-to-potential ratio	0.9	Default recommendation

The base year of dollar values within the tool is 2019. As a result, in line with DPE guidance, Average Weekly Earnings (AWE)[5] has been used to inflate values to present day – the second quarter of the 2021/22 financial year – by a rate of 4.75%.

External damages were only incorporated when overfloor flooding occurred.

The residential damage curve used in the analysis, based on the above inputs, is displayed in Figure 3-3. It is noted that it is inclusive of structural, internal and external damages at a given overfloor flood depth.

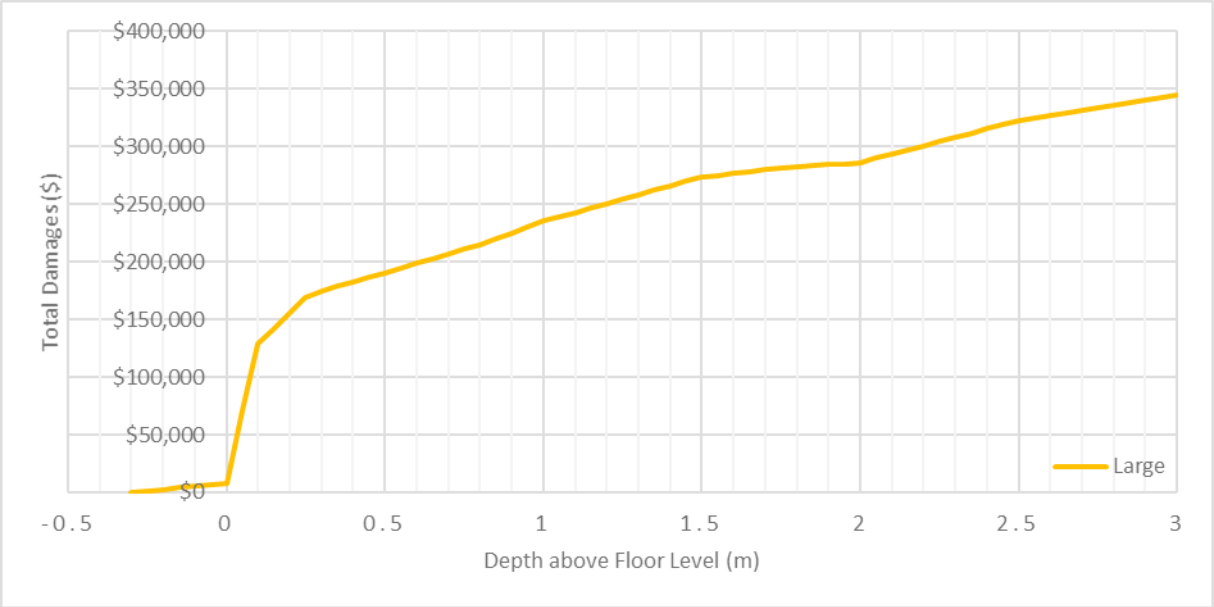

Figure 3-3 Residential damage curve adopted for the analysis

3.3 Other Considerations

The economic analysis focuses on the erosion and inundation impacts. However, there are a number of other considerations that are not directly included within this analysis:

- Tidal inundation – under sea level rise, tidal levels will increase, which will result in inundation of areas that were previously above the normal tidal limit. Regular tidal inundation of a residential property limits its potential viability, and may lead to a property needing to be abandoned if no mitigating actions are undertaken. A preliminary assessment was undertaken which suggests that the impact of this on properties was less than the influence of erosion, and therefore this was conservatively not included within the analysis.
- Groundwater Impacts – Increases in sea level rise will influence groundwater levels, particularly in the delta islands. This can result in impacts in building foundations, services etc.

[5] ABS Series ID - A85002148L

4 Mitigation Options

As identified in Section 2.2.2, two key options were considered; a hard engineering option and a nature-based option.

4.1 Option Performance

Following discussion with Baird, the following as assumed in terms of the performance of these options in terms of erosion and flood inundation protection. The assumed protection (and hence reduction in loss) under the different options is shown in Table 4-1

Table 4-1 Mitigation Option Protection Levels

Project	Inundation	Erosion
Hard Engineering	100%	100%
Nature Based Solution	0%	60%

4.2 Mitigation Option Costs

Capital and maintenance costs were provided by Baird for both option types, and for the different parts of the study area. Baird provided a low range and high range estimate for the capital costs. Based on these, a middle range estimate was adopted for the economics.

The annual maintenance cost of all projects is estimated to be 2% of the undiscounted capital cost for the life of the project, based on information provided by Baird. A summary of the capital and maintenance costs, together with the present value equivalent, is shown in Table 4-2.

Table 4-2. Summary of Mitigation Option Costs

Area	Mitigation Option	Maintenance Costs		Capital Costs	
		Annual	PV (7% p.a.)	Cost	PV (7% p.a.)
Yunderup Island	Hard	$79,800	$898,988	$3,990,000	$3,257,029
	Nature Based	$9,044	$101,885	$452,200	$369,130
Ballee Island	Hard	$33,000	$371,762	$1,650,000	$1,346,891
	Nature Based	$1,700	$19,151	$85,000	$69,385
Coolenup Island	Hard	$246,000	$2,771,318	$12,300,000	$10,040,464
	Nature Based	$12,648	$142,486	$632,400	$516,227
Nth Yunderup	Hard	$109,200	$1,230,195	$5,460,000	$4,456,986
	Nature Based	$12,376	$139,422	$618,800	$505,125
Sth Yunderup	Hard	*$104,700*	*$1,179,500*	*$5,235,000*	*$4,273,319*
	Nature Based	$11,866	$133,677	$593,300	$484,310

5 Economic Results

5.1 Benefit Summary

A summary of the base case impacts to the study area, both in terms of inundation and erosion, are summarised in Table 5-1. The mitigation works target a reduction in these costs. Table 5-1 provides a summary of the mitigation residual cost under the mitigation scenario (for erosion and inundation) and the associated net benefit.

There are several key points to note from the estimated benefits:

- The inundation damages for Coolenup Island are high. This is a function of the number of residential properties on this island together with the low-lying nature of the terrain. However, as no floor level information was available, it is possible that the floor levels are higher than the assumed 0.3m above ground. If the floor levels are higher, then this would result in a different outcome. This is a similar outcome for the remainder of the Murray Delta Islands. The economic estimate could be refined with floor levels survey and more detailed information on each of the properties.
- Erosion damages for North Yunderup are relatively high. This is reflective of the higher density development in this area, the proximity of both the properties and the houses to the river edge and the higher value of land. By comparison, South Yunderup is lower as it has greater buffer in front of most properties as well as larger residential lots and generally a lower value.
- Based on the estimates provided here, an estimated erosion loss of around $5.1M for the Kooljerrenup Reserve is estimated.

Table 5-1. Benefit Summary (present values based on discount rate of 7%pa)

Location	Mitigation Option	Inundation Damages			Erosion Damages		
		Base Case	Project Case	Difference	Base Case	Project Case	Difference
Yunderup Island	Hard	$510,258	$0	$510,258	$65,782	$0	$65,782
	Nature Based	$510,258	$510,258	$0	$65,782	$26,313	$39,469
Ballee Island	Hard	$400,968	$0	$400,968	$89,853	$0	$89,853
	Nature Based	$400,968	$400,968	$0	$89,853	$35,941	$53,912
Coolenup Island	Hard	$2,108,132	$0	$2,108,132	$154,764	$0	$154,764
	Nature Based	$2,108,132	$2,108,132	$0	$154,764	$61,905	$92,858
Nth Yunderup Shoreline	Hard	$102,238	$0	$102,238	$5,181,221	$0	$5,181,221
	Nature Based	$102,238	$102,238	$0	$5,181,221	$2,072,488	$3,108,733
South Yunderup	Hard	$110,807	$0	$110,807	$1,624,422	$0	$1,624,422
	Nature Based	$110,807	$110,807	$0	$1,624,422	$649,769	$974,653
Kooljerrenup Nature Reserve		$0	N/A	N/A	$5,091,392	N/A	N/A

5.2 Cost Benefit Analysis

The relative costs and benefits of the Project Case in comparison to the Base Case were compared through a Cost Benefit Analysis (CBA). The results of the CBA are summarised in Table 5-2. A positive NPV and BCR greater than one support a claim for the project to be considered as economically feasible.

Climate change results in a non-stationary environment, where risks and impacts on the community are expected to change over time. For inundation and erosion, with sea level rise these are anticipated to worsen. From an economic viewpoint, while a project may not be viable to implement today, it may be viable in the future as climate change continues to worsen.

An economic analysis was undertaken by "shifting" the start of the assessment forward in time to the point at which the BCR reaches 1. This represents the time at which the project is likely to be economically viable. This can provide useful information from a planning perspective, to allow for SoM to plan for future mitigation that might be required.

The time periods indicated here are based on the sea level rise rates that have been adopted in the study. A variation in those rates will result in a change to these timeframes. Therefore, these should be considered to be indicative.

A summary of the periods where each of the mitigation options and associated study areas will become viable is shown in Table 5-2.

For the Murray Delta Islands, the mitigation options have a BCR less than 1, suggesting that the options are presently not economically viable. This is a function of the low density of development on the islands and the large lots leading to relatively high mitigation option costing relative to the benefit. While that is the case at present, nature-based solutions on Ballee Island would become viable in the next 10 – 20 years based on current SLR projections. This is largely due to the larger erosion risk on this island and the relatively small area for the number of houses protected.

For North Yunderup, the nature-based solutions perform well, with a BCR of 4.8. This is due to the density of properties in this area and their proximity to the river. However, there may be practical challenges in implementing nature-based solutions within the available space in this area. A hard engineering solution, while having a BCR less than 1, is expected to be viable within 5 – 10 years, and therefore could also be considered given the likely planning horizons.

South Yunderup performs well with nature-based solutions. These solutions may also suit this area given that there is generally greater land buffer in this location compared with the northern side.

Table 5-2 Economic assessment results: individual projects ($M, present value at 7% p.a.)

Location	Mitigation Option	Total Costs	Total Benefits	NPV[6]	BCR	Timeframe for Viability[7]
Yunderup Island	Hard	4.16	0.58	-3.58	0.14	30 – 50 years
	Nature Based	0.47	0.04	-0.43	0.08	30 – 50 years
Ballee Island	Hard	1.72	0.49	-1.23	0.29	20 – 40 years
	Nature Based	0.09	0.05	-0.03	0.61	10 – 20 years

[6] Net Present Value (the difference between the net benefits and net costs)
[7] Indicative timeframe at which the project may have a BCR > 1 in the future.

Coolenup Island	Hard	12.81	2.26	-10.55	0.18	>50 years
	Nature Based	0.66	0.09	-0.57	0.14	20 – 40 years
Nth Yunderup Shoreline	Hard	5.69	5.28	-0.40	0.93	5 – 10 years
	Nature Based	0.64	3.11	2.46	4.82	current
Sth Yunderup Shoreline	Hard	5.45	1.74	-3.72	0.32	10 – 30 years
	Nature Based	0.62	0.97	0.36	1.74	current

5.3 Distributional Analysis

A distributional analysis is a useful tool for understanding the key beneficiaries for a mitigation option. It is undertaking by assessing the beneficiaries for each of the net benefits identified.

For the Shire of Murray, the key beneficiaries are private landowners, as well as the Shire of Murray (though the public assets such as reserves). A summary of the distributional analysis is provided in Table 5-3.

Table 5-3. Distributional Analysis

Location	Mitigation Option	Private Landowners	Shire of Murray
Yunderup Island	Hard	100%	0%
	Nature Based	100%	0%
Ballee Island	Hard	100%	0%
	Nature Based	100%	0%
Coolenup Island	Hard	100%	0%
	Nature Based	100%	0%
Nth Yunderup Shoreline	Hard	100%	0%
	Nature Based	100%	0%
Sth Yunderup Shoreline	Hard	90%	10%
	Nature Based	88%	12%

5.4 Sensitivity Analysis

A sensitivity analysis was undertaken to understand the relative robustness of the economic outcomes for a selection of the locations and mitigation scenarios. A sensitivity analysis was undertaken on the cost estimate, together with the discount rate, to understand the relative sensitivity of the options. This is summarised in Table 5-4.

Table 5-4. Sensitivity Analysis - BCR

Location	Mitigation Option	Base	Upper Range Cost Estimates	4% Discount Rate	10% Discount Rate
Yunderup Island	Hard	0.14	0.09	0.28	0.08
	Nature Based	0.08	0.05	0.22	0.03
Ballee Island	Hard	0.29	0.19	0.54	0.17
	Nature Based	0.61	0.35	1.56	0.24
Nth Yunderup Shoreline	Hard	0.93	0.63	1.76	0.56
	Nature Based	4.82	2.75	9.13	2.91

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