Derwent River Foreshore Coastal Hazards Project - FINAL

Prepared for Brighton Council

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OFFICES IN CANBERRA, HOBART, MELBOURNE, AND SYDNEY ON THE COUNTRY OF THE NGAMBRI/NGUNNAWAL/NGARIGO, MUWININA, WURUNDJERI, AND GADIGAL PEOPLES.

Front cover image Old Beach by Sam Shelly photographers 2019.

Contents

List of Figures

List of Tables

Acronyms

AEP	Annual Exceedance Probability
CBA	Cost Benefit Analysis
DEM	Digital elevation model
IPCC	International Panel on Climate Change
LGA	Local Government Authority
LiDAR	Light detection and ranging
LISTmap	Land Information System Tasmania map
mAHD	Australian Height Datum mean
MHT	Mean high tide
MNHLUP	Mitigating Natural Hazards through Land Use Planning
RCP	Representative concentration pathways
SLR	Sea level rise
SLRPA	Sea Level Rise Planning Allowance
SSP	Shared Socio-economic Pathway
TCAP	Tasmanian Costal Adaptation Pathways
TSPA	Threatened Species Protection Act

Glossary

Term	Definition
Annual exceedance probability (AEP)	The probability that a flood of a given (or larger) magnitude will occur within a period of one year.
Coastal erosion	Coastal erosion, sometimes referred to as shoreline retreat, occurs when a net loss of sediment or bedrock from the shoreline results in landward movement of the high-tide mark.
Coastal inundation	The temporary or permanent flooding of land by the sea due to storm surge, tides or sea-level rise.
Ecosystem services	Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as (1) supporting services such as productivity or biodiversity maintenance, (2) provisioning services such as food or fibre, (3) regulating services such as climate regulation or carbon sequestration and (4) cultural services such as tourism or spiritual and aesthetic appreciation.
Freeboard	The height difference between the 100-year flood level and the floor level of a building.
Radiative forcing	Radiative forcing is what happens when the amount of energy that enters the Earth's atmosphere is different to the amount of energy that leaves it.
Representative concentration pathways (RCP)	RCPs portray possible future greenhouse gas and aerosol emissions scenarios. The four RCPs range from very high (RCP8.5) through to very low (RCP2.6) future concentrations. The numerical values of the RCPs (2.6, 4.5, 6.0 and 8.5) refer to the concentrations in 2100.[1]
Scenario RCP8.5	Scenario RCP8.5 is the highest baseline future greenhouse gas and aerosol emissions scenario. It is generally referred to as the basis for the 'worst case' climate change scenarios based on current policies and practices.
Shared Socio-economic Pathway (SSP)	SSPs expand on RCPs to allow for a standardised comparison of society's choices and their resulting levels of climate

[1] CoastAdapt, (n.d), 'What are the RCPs?', accessed at: https://coastadapt.com.au/infographics/what-are-rcps

Term	Definition
	change. Unlike RCPs, SSPs include socioeconomic narratives and trends to indicate a range of plausible futures. The SSPs are based on five narratives: 1.a world of sustainability-focused growth and equality (SSP1) 2. a “middle of the road” world where trends broadly follow their historical patterns (SSP2) 3. a fragmented world of “resurgent nationalism” (SSP3) 4. a world of ever-increasing inequality (SSP4); and 5. a world of rapid and unconstrained growth in economic output and energy use (SSP5).
Scenario SSP5-8.5	Scenario SSP5-8.5 is the highest baseline future greenhouse gas and aerosol emissions scenario and correlates to Scenario RCP8.5.

Source: IPCC, 2022

Executive summary

Climate change is expected to exacerbate coastal hazards in the Derwent River Foreshore, increasing the frequency and severity of storm events, flooding and erosion. Brighton Council identified three sites of most concern:

1. Sunrise Avenue (Site A),
2. Riverside Drive (Site B), and
3. Old Beach (Site C).

The aim of this project is to understand and plan for coastal hazards at these three sites along the Derwent River foreshore and in doing so, build the capacity of Brighton Council and the community to make key decisions. To build this capacity, this project is expected to provide information about the risks and adaptation options and improve community understanding about risk reduction. The project broadly reflects the Tasmanian Coastal Adaptation Pathways (TCAP) process to provide an assessment of existing and projected coastal hazards, an assessment of risk and values, indicate adaptation pathways and conduct a Cost Benefit Analysis (CBA) of the pathways.

The Brighton Council Derwent River Foreshore Coastal Hazards Project has been funded, in part, by the Australian Government's, *Preparing Australian Communities – Local Stream Program*. This project responds to the issues of coastal inundation along the Derwent River Foreshore where it is reported that residential backyards regularly flood, rare saltmarsh communities experience habitat restriction, and government assets and infrastructure are impacted.

Coastal hazard management and land use planning

The Tasmanian Government initiated the *Mitigating Natural Hazards through Land Use Planning* (MNHLUP) project in 2011 to help mitigate risks from natural hazards. Through the MNHLUP, the State Government adopted a hazard treatment approach, where stakeholders collectively define the hazard, consider available evidence and identify options for mapping areas that might be exposed to hazards. Then further define the boundaries of hazard bands, and develop planning, building, and emergency management outcomes that apply within each hazard band.

In 2012, the Tasmanian Government implemented Sea Level Rise Planning Allowances (SLRPAs) across the state so that sea level rise (SLR) could be considered in planning decisions, and to reduce uncertainty around sea level rise management in coastal areas. In 2016, the State Government commissioned coastal hazard modelling. In response to this modelling, the Tasmanian Government identified and implemented hazard bands for erosion and inundation. The bands are based on hazard planning matrices[2], which describe hazard exposure, control intent (whether planning or building

[2] Tasmanian Government Department of Premier and Cabinet 2016, *Coastal Hazards in Tasmania – Summary Report of Coastal Hazards Technical Report*, https://www.dpac.tas.gov.au/__data/assets/pdf_file/0027/63855/Coastal_Hazards_report_Version_7_20161201_-_Summary_report.pdf

controls are necessary) and strategic planning considerations for each hazard band. The *C10.0 Coastal Erosion Hazard Code* and *C11.0 Coastal Inundation Hazard Code* of the Brighton Planning Scheme outline the purpose and application of the coastal hazard bands, as well as use and development standards.

This report utilises the SES 2016 coastal hazard modelling. At the time of this project, an update of coincidental flood modelling for the Derwent River was being undertaken. A request for this flooding information was made but the modelling had not concluded in time to be included in this project. To counter this, the SES 2016 coastal hazard modelling was verified using Climatics modelling which mostly aligns with the current coastal hazard mapping available.

Values at risk from erosion and inundation

The three study sites encompass public and private infrastructure, Aboriginal heritage items as well as natural assets. Understanding these values is critical to determine the nature and magnitude of risks, and to inform appropriate adaptation pathways in line with protecting what the community values.

Coastal erosion

Across the three sites, modelling indicates that there are no properties currently at risk of coastal erosion. By 2050, 22 residential properties may be at medium risk of land erosion. These properties have a combined building value of $6.6 million, with most (18) of these properties being in Site B – Riverside Drive. By 2100, 51 residential properties across the three sites may be at risk of erosion with a combined capital value of $23.2 million (low risk hazard band). 30 of these properties are within Site C – Old Beach.

TABLE 1: SUMMARY OF RESIDENTIAL PROPERTIES POTENTIALLY AT RISK – COASTAL EROSION[3]

	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Site A	0	0	0	0	0	0
Site B	0	0	6,607,500	18	7,290,000	21
Site C	0	0	2,180,000	4	15,907,500	30
Total	**0**	**0**	**8,787,500**	**22**	**23,197,500**	**51**

Source: SGS Economics and Planning, 2023

[3] Value is the adjusted capital value of a property after deducting land value, which includes improvements to the property over time. SGS has only considered the impact of coastal hazards on properties and has excluded where only land parcels or additional infrastructure (i.e. greenhouses/sheds) are at risk.

Additional assets at risk across the three sites are:

- Site A: The erosion risk mainly affects the foreshore area. Seven additional residential plots of land (not buildings) are at risk of erosion.
- Site B: coastal erosion is likely to be relatively mild. No residential properties are currently at risk. The boat ramp and some public lands zoned for utilities and open space, are at risk of present-day and future coastal erosion. A small level of risk of erosion has been indicated for the railway track and playground area.
- Site C: By 2050, projected erosion could lead to a recession of up to 110 meters inland. A boat ramp, a minor section of a vehicle track, and segments of a hiking trail are likely to be affected. Open space, especially the foreshore adjacent to the hiking trail, is also expected to be at risk.
- Across all three sites, 18 identified Aboriginal Heritage items are at risk of erosion. 12 of these are in Site C, while the remaining six are in Site B.

Inundation

The modelling indicates that there is no immediate threat of inundation to properties across the three sites. However, the risk of inundation intensifies significantly, as areas become susceptible to a 1% storm event by 2050, and/or face the prospect of a 0.8m sea level rise by 2100. A total of 22 residential properties, valued at approximately $9.3 million, will be susceptible to these hazards. Notably, residential homes situated in the south of Site C are particularly susceptible to inundation. As the risk progresses, categorised within the low-risk hazard band, the number of properties at risk is anticipated to quadruple in impact. This escalation will result in $38.2 million worth of properties, or a total of 89 homes at risk of inundation caused by storm events in 2100.

TABLE 2: SUMMARY OF RESIDENTIAL PROPERTIES POTENTIALLY AT RISK – INUNDATION[4]

	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Site A	0	0	0	0	0	0
Site B	0	0	900,000	3	2,540,000	8
Site C	0	0	8,400,000	19	35,680,800	81
Total	**0**	**0**	**9,300,000**	**22**	**38,220,800**	**89**

Source: SGS Economics and Planning, 2023

[4] Value is the adjusted capital value of a property after deducting land value, which considers for improvements to the property over time. SGS has only considered the impact of coastal hazards on properties and have excluded where only land parcels or additional infrastructure (greenhouses/sheds) are at risk.

Across all the sites, other assets at risk of inundation are:

- Site A: Modelling indicates present risk to other assets is minimal. By 2050, a proportion of the marshland could become inundated. This risk would be limited to the area below the railway track. By 2100, inundation risk will increase and affect some areas beyond the railway track boundary, primarily open space and railway tracks with limited existing uses.
- Site B: At present, the anticipated inundation risk to public infrastructure is minimal. The level of risk is anticipated to rise in the medium term. Assets at risk in the medium term include the disused boat ramp, playground, open space and roads (1% AEP in 2050). In the long term (1% AEP in 2100), there is an increased risk to additional roads and sections of the hiking track.
- Site C: In the area south of Site C, the risk of inundation is significantly higher and could substantially impact the community in the medium to long term. Open space and parts of the hiking trail are at risk in the present day. As the risk increases, more of these areas could become inundated, along with other assets, including several roads and the boat ramp.
- Across all three sites, 25 identified Aboriginal Heritage items are at risk of inundation. 21 of these are in Site C, while the remaining four are in Site B.

This assessment will inform stakeholder engagement across the three sites to determine acceptable risk, the value the community places on those assets at risk and how the community may choose to respond (informing the development of adaptation pathways).

Stormwater

There are no stormwater hazards present in Site A

The majority of Site B is vulnerable to stormwater drainage hazards. Several hundred houses and other buildings are at a very low risk from stormwater. The area of stormwater hazard overlaps with areas assessed with natural values ranging from lowest to high priority along the coastline. Notably there is a small pocket of open space that is of moderate-to-high priority. There are six Aboriginal Heritage items that are at very low risk of stormwater damage.

A significant area of land in Site C is vulnerable to stormwater hazards. For Site C, several hundred houses and buildings are at very low risk of stormwater. About 11 Aboriginal Heritage items are at a very low risk from Stormwater hazards. The area of stormwater hazard overlaps with areas assessed with natural values ranging from lowest to moderate priority along the coastline. There are 11 Aboriginal Heritage items that are at very low risk of stormwater damage.

Adaptation pathways

Adaptation pathways consist of complementary options that can be implemented simultaneously and consecutively over time to manage coastal risk and protect values. Adaptation pathways may vary from ‘protect at all cost’ to ‘planned retreat’ and anything in between.

Three pathways were assessed:

- Business as usual or ‘do nothing’
- Pathway 1 - minimal intervention
- Pathway 2 – protect the coast

Each of these pathways has associated costs, implications highlighting the trade-offs associated with choosing a certain pathway.

Cost Benefit Analysis

A Cost Benefit analysis compared the costs and benefits associated with each pathway to inform decision making about what may be the best overall outcome for the community. The results of which are shown in the table below. A number of values, such as Aboriginal culture and foreshore recreation and amenity, could not be expressed in dollar values. As a result, the key performance indicators (NPV and BCR) which only include the monetised values, cannot be solely relied on when assessing the options.

TABLE 3: COST-BENEFIT ANALYSIS RESULTS FOR EACH ADAPTATION PATHWAY, ALL SITES

Incremental costs ($ millions)	Pathway 1			Pathway 2		
	Site A	Site B	Site C	Site A	Site B	Site C
Adaptation costs	1.68	0.97	1.15	11.00	4.16	5.17
Incremental benefits ($ millions)						
Avoided cost of risk	0.16	0.57	0.58	0.31	3.18	1.50
Land value uplift	0	0	0	0	0	3.40
Improved community wellbeing	+	0.02	0.02	++	0.03	0.04
Retention of natural values	+++		+++	-		-
Retention of Aboriginal cultural heritage	-	+	+	-	++	++
Retention of foreshore recreation and amenity	++	++	+	+	++	+
Reduced emergency services expenditure	+	+	+	+	++	++
Subtotal	0.16	0.59	0.48	0.31	3.21	4.94
Net present value (NPV) ($ millions)	-1.52	-0.38	-0.32	-10.69	-0.95	-0.23
Benefit-Cost ratio (BCR)	0.09	0.61	0.60	0.03	0.77	0.96

Source: SGS Economics and Planning, 2023
Figures are in millions

The CBA results indicate that Pathway 2 - protect the coast, would return the most benefits per dollar spent at Sites B and C (i.e. for every dollar spent in Site C, $0.96 of quantified benefits would result). While Pathway 2 would be more expensive, the associated intensive interventions would protect more properties and also be beneficial for some of the qualitative values, such as Aboriginal culture and recreational value of the foreshore. At Site A however, there are no private properties that fall within the coastal inundation or erosion hazard bands, and thus the larger expenditure in pathway 2 would not return as much of a benefit as it would for Sites B and C. At Site A, pathway proves to be the superior investment decision.

The CBA results only include the monetised costs and benefits and should be considered in tandem with the additional impacts of each pathway that could not be costed (i.e. preservation of Aboriginal heritage items, community wellbeing and social cohesion). Traditionally, an investment decision would be made based on these results alone, however the pathway of choice should not be solely based on economic appraisal, but also the preferences of the community given other, non-monetised benefits.

Next steps

For each site, a preferred pathway has been identified through this report. The following are recommended:

- Engage with the community to seek feedback on the preferred pathway
- Once confirmed, initiate the process for concept designs, engineering considerations and implementation. The community should continue to be engaged throughout.
- Engage with TasRail to understand their considerations for the rail line sections at risk, and options to accommodate culverts for wetland migration (Site A).

1. Introduction

1.1 Purpose of this report

Climate change is expected to exacerbate coastal hazards within the Derwent River Foreshore. This includes increases in the frequency and severity of storm events, rainfall flooding and sea level rise. Using the LIST-map coastal hazard layer, Brighton Council has identified three sites where exposure and vulnerability to coastal hazards is most acute: Sunrise Avenue (Site A), Riverside Drive (Site B), and Old Beach (Site C).

The aim of this project is to understand and plan for coastal hazards at these three sites along the Derwent River foreshore and in doing so, build the capacity of Brighton Council and the community to make key decisions. To build this capacity, this project is expected to provide information about the risks and adaptation options and improve community understanding about risk reduction. The project broadly reflects the Tasmanian Costal Adaptation Pathways (TCAP) process to provide an assessment of existing and projected coastal hazards, an assessment of risk and values, indicate adaptation pathways and conduct a Cost Benefit Analysis (CBA) of the pathways.

The Brighton Council Derwent River Foreshore Coastal Hazards Project has been funded, in part, by the Australian Government's, *Preparing Australian Local Communities Program*. This project responds to the issues of coastal inundation along the Derwent River Foreshore where residential backyards regularly flood, rare saltmarsh communities experience habitat restriction, and government assets and infrastructure are impacted.

To build Brighton Council's capacity to respond and adapt to existing and projected coastal hazards, this report provides:

- **Hazard mapping and assessments** of each of the three sites to generate consistent and clear maps of coastal hazards at present and projected changes to 2050, 2075 and 2100[5].
- **Assessment of Values at Risk, and the cost of doing nothing to manage the risk.** This considers the private, public, and natural land, assets, infrastructure, and services that are, or will be, at risk in the three sites if nothing is done to manage the risk[6].

This report represents **Stage 1** of the project, the findings of which will feed into Stage 2 (community engagement) and Stage 3 (adaptation planning) to provide a better understanding of the issues and possible responses.

[5] Spatial layers have been produced by SGS that map out the study areas based on pdf illustrations. As such, it should be noted that there may be a small margin of difference.

[6] The impact on Crown/State owned land has been considered as this may be managed by Brighton Council.

1.2 Project approach

This project has three stages. Stage 1 – Coast hazards and risk assessment. The outcomes of this stage, were to identify risks and assets at risk to inform Stage 2 - community and stakeholder engagement. The engagement subsequently informed Stage 3 - the development of adaptation pathways. The cost benefit analysis assessed the costs and benefits of different options of how Council, the community and infrastructure and property owners may choose to respond and adapt to identified risks. Figure 1 gives an overview of project method.

Within Stage 1, the hazard mapping and risk assessment has utilised LIST, LiDAR data and related GIS layers to indicate sea level rise impacts and erosion impacts across the three sites. Despite updated modelling by the IPCC, the LISTmap projections have been deemed sufficient. The current coastal hazard mapping has been verified using Climatics modelling which mostly aligns with the current coastal hazard mapping available.

The asset risk assessment considers the public assets, infrastructure, essential services and other values that are or will be at risk if nothing is done. This assessment utilised Council's rates database, asset and infrastructure database, data on natural and recreation assets and values. SGS estimated the value of infrastructure from *Rawlinson (2022): Australian Construction Handboo*k and escalated figures to represent 2023 costs and additional expenses associated with regional locations.

FIGURE 1 PROJECT METHOD

Stage 1 Coastal hazards and risk assessment

- Coastal hazards
- Risk assessment

Stage 2 Community and stakeholder engagement

- Engagement plan
- Engagement (incl. workshops)

Stage 3 Adaptation Planning

- Planning Scheme review
- Adaptation pathways with options and indicative costs
- Cost Benefit Analysis

1.3 Study areas

Brighton Council has identified the following three key sites where assets and residential properties are most affected using LIST-map coastal hazard layers.

Site A: Sunrise Avenue

Site A includes the foreshore/marshlands area around Sunrise Avenue north of Bridgewater Bridge. The area is low-lying in nature with numerous foreshore properties. Brighton Council maintains the road of Sunrise Avenue. The Derwent Valley Railway line runs along the foreshore area.

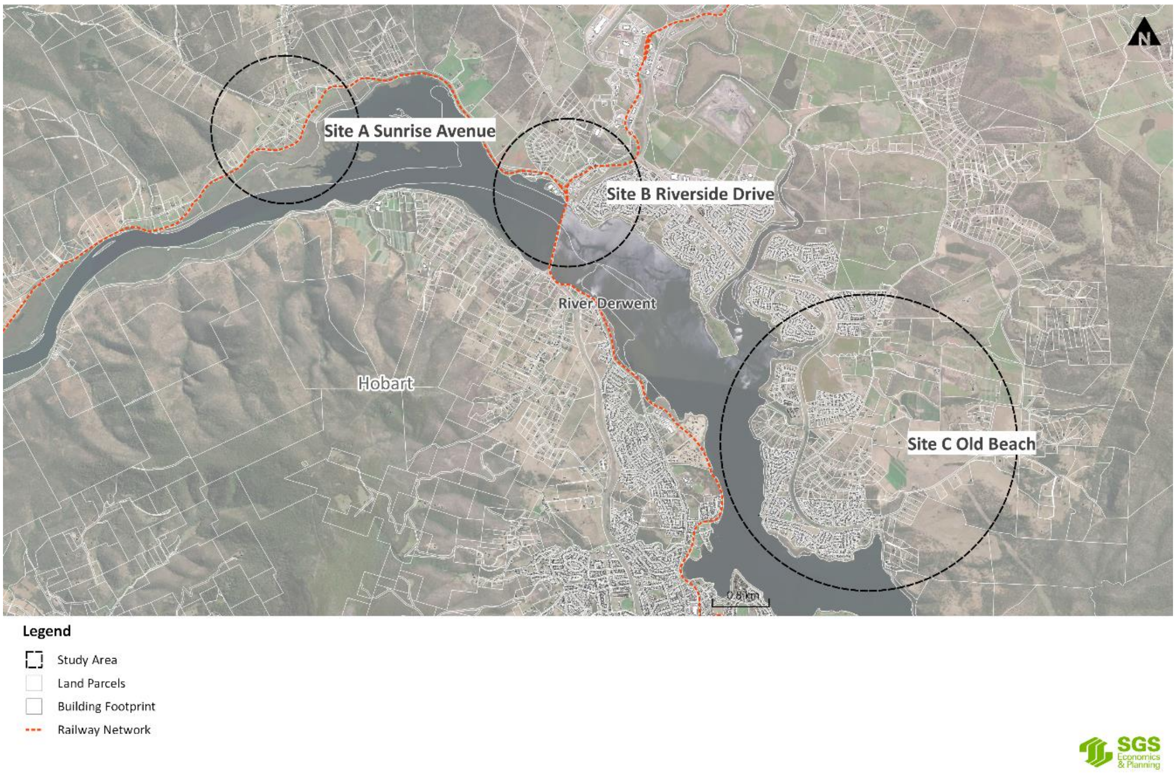
Site B: Riverside Drive

Site B includes the foreshore area around Riverside Drive, a road maintained by Brighton Council. The site is subject to frequent inundation of the road area and some foreshore properties. The site is located immediately adjacent to Bridgewater Bridge. An upgrade of the Bridge is underway. This Project ***does not*** include an assessment of the land and infrastructure associated with the upgrade of the Bridgewater Bridge – climate change impact assessments are a separate piece of work being carried out by Brighton Council (see Appendix A – Bridgewater Bridge for a summary of works and potential impacts).

Site C: Old Beach

Site C includes the foreshore area between the north end of Morrisby Road, Old Beach and the southern boundary of the Brighton municipality (see Figure 2). It also includes the Jetty and the end of Jetty Road and East Derwent Highway, which is a primary route of entry/exit to the municipality. The site is subject to frequent inundation of the walking paths, the foreshore (Crown Land), and some private properties. Brighton Council maintains the walking track and has a licence to conduct maintenance works in an approximately one metre area surrounding the walking track.

FIGURE 2: STUDY SITES



Source: SGS Economics and Planning, 2023

2. Coastal Hazard Planning in Tasmania

2.1 Overview

The Tasmanian Government initiated the Mitigating Natural Hazards through Land Use Planning (**MNHLUP**) project in 2011 to help managing risks from natural hazards. Through the MNHLUP, the State Government intends to adopt a hazard treatment approach, where stakeholders:

- Collectively define the hazard
- Consider available evidence and identify options for mapping areas that might be exposed to hazards
- Define the boundaries of hazard bands; and
- Develop planning, building, and emergency management outcomes that apply within each hazard band.

In 2012, the Tasmanian Government implemented Sea Level Rise Planning Allowances (**SLRPAs**) across the state so that sea level rises (**SLR**) are considered in planning decisions, and to reduce uncertainty around sea level rise management in coastal areas. The State Government then commissioned CSIRO in 2016 to model hazards in coastal council areas in line with Scenario RCP8.5 - the highest baseline future greenhouse gas and aerosol emissions scenario – set out in the International Panel on Climate Change (**IPCC**)'s Fifth Assessment Report (**AR5**).

In response to this modelling, the Tasmanian Government's hazard planning matrices[7] for both coastal erosion and coastal inundation were created that describe hazard exposure, control intent (whether planning or building controls are necessary) and strategic planning considerations for each hazard band.

> Hazard bands indicate the risk posed in specific locations and determine what planning and building controls are needed. They do not indicate that land *will* be inundated or eroded, only that the land is *susceptible*.[8]

This report utilises the SES 2016 coastal hazard modelling. At the time of this project, an update of coincidental flood modelling for the Derwent River was being undertaken. A request for this flooding information was made but the modelling had not concluded in time to be included in this project. To counter this, the SES 2016 coastal hazard modelling was verified using Climatics modelling which mostly aligns with the current coastal hazard mapping available.

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[7] Tasmanian Government Department of Premier and Cabinet 2016, *Coastal Hazards in Tasmania – Summary Report of Coastal Hazards Technical Report*, https://www.dpac.tas.gov.au/__data/assets/pdf_file/0027/63855/Coastal_Hazards_report_Version_7_20161201_-_Summary_report.pdf

[8] Tasmanian Government Department of Justice (2021), 'State planning provisions – coastal hazards'.

2.2 Coastal Erosion Hazards

The Tasmanian Government's 2016 *Coastal Hazards Technical Report*[9] defines coastal erosion as:

> 'the wearing away of coastal land by water, wind, general weather conditions or human intervention'.

Coastal erosion may take the form of:

- hazardous erosion (short-term erosion of sandy or soft shorelines),
- coastal recession (long-term erosion of sandy or soft shorelines) and
- landslides (downslope movement of land usually caused by storms or waves removing material at the foot of the landslide).

Areas along Tasmania's coastline have been classified into coastal erosion hazard bands using coastal geomorphology and sea level rise data. The bands describe susceptibility to coastal erosion and shoreline recession when considering current and anticipated conditions by 2100.

The coastal erosion bands are:

- **Acceptable** – area is unaffected by coastal recession until after 2100; not subject to controls,
- **Low** – areas vulnerable to coastal recession by 2100 or is protected by coastal defences,
- **Medium** – areas vulnerable to coastal recession by 2050,
- **High** – areas is currently vulnerable to coastal recession; typically on sand dunes.

In addition, areas without erosion risk are identified as 'acceptable', and areas with unknown hazard exposure due to limited data on geomorphological conditions, are identified as 'coastal erosion investigation areas'.

The Coastal Erosion Hazard Code applies to land that is either in a low, medium, high or unknown hazard band. The code requires that planning application submissions include a Coastal Erosion Hazard Report for properties in these bands. If a site within a Coastal Erosion Investigation Area is assessed and determined to be in a low, medium or high hazard band area, a Coastal Erosion Investigation Area Report will be required in addition to a Coastal Erosion Hazard Report when submitting a planning application.

2.3 Coastal Inundation Hazards

Coastal inundation occurs when low-lying coastal land is flooded by the sea and can be either temporary or permanent. Temporary coastal inundation is caused by floods, tides, storm surge and

[9] Tasmanian Government Department of Premier and Cabinet 2016, *Coastal Hazards Technical Report*, https://www.dpac.tas.gov.au/__data/assets/pdf_file/0025/63853/Coastal_Hazards_Report_version_7_-_20161201.pdf

storm events, which is usually measured by annual exceedance probability (**AEP**). Whereas permanent coastal inundation is a result of sea level rise (**SLR**) and measured from the mean high tide (**MHT**) line.[10]

A range of data was used to assess coastal inundation in Tasmania, including sea level rise planning allowances (**SLRPAs**), storm tide event information, the median high tide line, 10m contour line and the LiDAR digital elevation model (**DEM**). Areas along the coastline were also classified into coastal inundation hazard bands according to their vulnerability to coastal inundation when considering current and anticipated conditions by 2100:

- **Acceptable** – area is unaffected by coastal inundation until after 2100
- **Low** – area is vulnerable to a 1% AEP storm event by 2100; medium-term flooding issue
- **Medium** – area is vulnerable to a 1% AEP storm event by 2050; will be impacted by a 0.8m SLR by 2100
- **High** – area will be within 0.2m SLR from MHT line by 2050; currently impacted by the Highest Astronomical Tide; or
- **Coastal Inundation Investigation Areas** – area is not covered by LiDAR and is below the 10m contour line and within the coastal zone; yet to be classified due to incomplete or unavailable elevation data.

The Coastal Inundation Hazard Code applies to land that is either in a low, medium, or high hazard band, and requires a Coastal Inundation Hazard Report for planning application submissions. If a site within a Coastal Inundation Investigation Area is assessed and determined to be in a low, medium, or high hazard band area, results from the assessment will be required to accompany the Coastal Inundation Hazard Report when submitting a planning application.

2.4 Brighton Planning Scheme

Hazard Codes

The *C10.0 Coastal Erosion Hazard Code* and *C11.0 Coastal Inundation Hazard Code* of the Brighton Planning Scheme outline the purpose and application of the coastal hazard bands, as well as use and development standards.

Table 4 shows the coastal inundation hazard bands and the projected water level heights of different localities in the Brighton municipality. Hazard bands and areas are then visualised in the Land Information System Tasmania map (**LISTmap**).

These areas are subject to the planning requirements set out for each band by State Planning Provisions. The Brighton Planning Scheme does not currently contain any additional local provisions relevant to coastal hazards.

[10] Ibid.

Hazard bands indicate the risk posed in particular locations and determine what planning and building controls are needed. They do not indicate that land *will* be inundated or eroded, only that the land is *susceptible*.[11]

TABLE 4: BRI-C11.1 COASTAL INUNDATION HAZARD BANDS AND PROJECTED SEA HEIGHTS (AHD LEVELS)

Locality	High Hazard Band (mAHD)	Medium Hazard Band (mAHD)	Low Hazard Band (mAHD)	Defined Flood Level (mAHD)
	Sea Level Rise 2050	1% annual exceedance probability 2050 with freeboard	1% annual exceedance probability 2100 (design flood level) with freeboard	1% annual exceedance probability 2100
Bridgewater (Site B)	0.9	2.0	2.6	2.3
Dromedary (Site A)	0.9	1.9	2.6	2.3
Gagebrook (Site C)	0.9	2.0	2.6	2.3
Old Beach (Site C)	0.9	2.0	2.6	2.3
All other locations	0.9	2.0	2.6	2.3

Source: Brighton Planning Scheme, Tasmanian Government n.d.

Notes: Freeboard is the height difference between the 100-year flood level and the floor level of a building.

[11] Tasmanian Government Department of Justice (2021), 'State planning provisions – coastal hazards'.

2.5 Local Strategies and Plans

Analysis of Brighton Council's strategies and plans indicates how the Council is responding to current, and future, coastal hazards. In Table 5, the following documents are summarised:

- Brighton Climate Change Resilience Strategy 2017
- Open Space Strategy 2012
- Bridgewater Parkland 2016-2026
- Weed Management Strategy 2021-2026
- Greening Brighton Strategy 2016-2021

TABLE 5: SUMMARY OF COUNCIL PLANS AND STRATEGIES

Plans and Strategies	Summary
Brighton Climate Change Resilience Strategy 2019	The Climate Change and Resilience Strategy is Council's framework to help mitigate and plan for climate change, with directions to achieve greater sustainability and resilience. In this strategy, Council recognises the need to manage climate related risks and prepare the community for climate change. As part of this, Council is helping to develop the Regional Coastal Hazards Strategy, which will be relevant to the study areas in this project. Council's objectives that are relevant to coastal hazards are to: 4. improve Council's understanding of climate change risks and opportunities, and 5. improve the resilience of Council infrastructure. The strategy identifies a key action to achieve these objectives, which is to *ensure future asset maintenance and replacement programs consider climate change, including coastal hazards and inundation modelling*. This project gives effect to the strategy in helping Council to understand the risk impacts of the study area.
Open Space Strategy 2012	The Open Space Strategy intends to guide Council with the planning, development and management of open space in the LGA. Open space (including coastal fore dunes) has been identified as a means to mitigate climate change adaptation and mitigation through its role as a foreshore buffer to rising sea levels and ability to absorb impacts of storm surge. This strategy lists opportunities to improve gaps in the provision of local parks, which fall outside of the study areas of this project and are unlikely to be impacted by coastal recession and coastal inundation.

Plans and Strategies	Summary
Bridgewater Parkland 2016-2026	This masterplan of Bridgewater Parkland provides an idea of what the parkland could look like, to improve its current usage. It includes a section of study area Site B, which is proposed to be an extension of a foreshore trail upon development of the land. The area is likely to be affected by coastal erosion and inundation in the future.
Weed Management Strategy 2021-2026	The Weed Management Strategy guides priority weed management and investment in Brighton Council. Sites A and B are part of the foreshore-walking trail weed eradication zone, and weeds will need to be removed for native vegetation to help combat rising sea levels.
Greening Brighton Strategy 2016-2021	The Greening Brighton Strategy sets a framework for Council to increase the number of trees across urban areas of the LGA, which will improve amenity and help tackle climate change. The strategy identifies high, medium, and low priority streets to be planted with trees in Bridgewater, Gagebrook and Herdsman's Cove. As these priority areas do not fall into the costal erosion or costal inundation hazard bands, they are unlikely to be impacted by coastal recession and coastal inundation.
Natural Resource Management Strategy 2023	The Natural Resource Management (NRM) Strategy provides strategic direction to enable Brighton Council and other stakeholders to work collaboratively to improve NRM. It outlines directions for climate, natural resources, cultural landscapes, water, biodiversity, people and context for delivering NRM. Relevant to this study is incorporating NRM into managing risks and planning adaptation pathways.

Source: SGS Economics and Planning, 2022

The development of adaptation pathways (Stage 3 of this project) will take into consideration Council's existing policies and strategies.

2.6 Natural hazard and climate projections used in this report

Principles

The natural hazard data on present day and projected future risks that informed the coastal hazard bands (inundation and erosion) were developed some years ago (between 2014 and 2016 indicatively). The projections are based on the Fifth Assessment Report from 2014. While unavailable, it should be noted that the climate modelling under the hazard layers is due to be updated as per the Tasmanian Climate Change Action Plan Tasmania's Draft Climate Change Action Plan 2023-25.

Since, new climate change projections have been published by the ICCP as part the Sixth Assessment Report from 2022. In general terms, this report confirms the earlier projections and adds further detail. It does appear that the rate of climate change assessed in the latest publication is higher than the earlier version.

In consultation with the Department of Premier and Cabinet, it was suggested that while the rate of sea level rise is faster, the implications in terms of the accuracy and applicability of the existing hazard bands is small. Similarly, the information for decision makers climate modelling undertaken by Climate Futures, University of Tasmania for local government in 2019, outlines sea level rise figures consistent with other comments on accuracy and applicability of hazard bands.

Further, in 2022, State Emergency Services embarked on a project to undertake flood modelling for all main rivers in Tasmania, including the Derwent River. This work is currently underway, and the full results are not yet available.

To gain a better understanding of the accuracy of the coastal risk data, SGS therefore decided to use an alternate source of information: Climatics, which is a comprehensive database of historical to present day severe weather events. Climatics is a product from the Early Warning Network, and its data can be used to identify changes in the intensity and severity of weather events in specific locations.

A verification process was applied to understand if the present-day risks (i.e., likelihood of inundation) as recorded by Climatics align with the hazard bands. Please note that the Climatics data only refer to present-day risk, and therefore the verification process is limited to confirming whether locations are within the 'high hazard band' or not. The process enables to identify for the locations whether they are correctly identified as being in or outside the high hazard band.

Where the verification process identified discrepancies, this is incorporated into the report. Overall, the differences were small: areas identified as being in the high hazard band were confirmed by the data, and some areas identified as being in the medium hazard band were deemed to at risk today and should therefore be in the high hazard band.

While the results largely confirm the hazard bands are applicable and suitable to the current situation, it also shows that coastal risks are worsening. It should be noted that the hazard bands as used by the planning system, when they refer to 'present-day' it refers to the baseline year of 2010. It is therefore logical that now, in 2023, the high hazard band starts to shift as it includes 13 more years of climate change.

In conclusion, the hazard bands as used in the planning system remain largely accurate. In some areas, risk levels have increased since the base-year of the hazard bands, which is 2010.

3. Site A – Sunrise Avenue

3.1 Site overview

Site A is located in Dromedary, approximately 14 kilometres west of the suburb of Brighton. The following features as described are shown in Figure 3 overleaf. The site contains land zoned Rural Living. There are numerous dwellings, some situated in the low-lying land abutting the foreshore marshlands (see Figure 3). There are no commercial businesses located in Site A.

There is one Aboriginal Heritage item on Site A, inland from the Derwent River (see Figure 3).[12]

The site includes a substantial foreshore area around Sunrise Avenue which consists of marshlands, much of the area is classified threatened native vegetation and is a designated environmental management zone. Two waterways flow into the site from the north, Dean Brook and Millvale Creek. Both waterways, the marshlands and the Derwent River foreshore, are covered by a waterway and coastal protection area overlay. Figure 4 shows the coastal vegetation while Natural values refer to the variety of life-forms, including plants, animals, and micro-organisms, and the ecosystems they belong to, including land forms, soils, and water. One of the crucial natural values in Site A are the wetlands to the south of the rail line, which, the Derwent Estuary Natural Values dataset (see Figure 5) lists the majority of the wetlands as a high priority site, the highest importance rating. Similarly, the wetlands, are deemed to have a Very High integrated conservation value, as determined by the Conservation of Freshwater Ecosystem Values (CFEV). This is the highest classification which expresses the relative importance of an ecosystem.

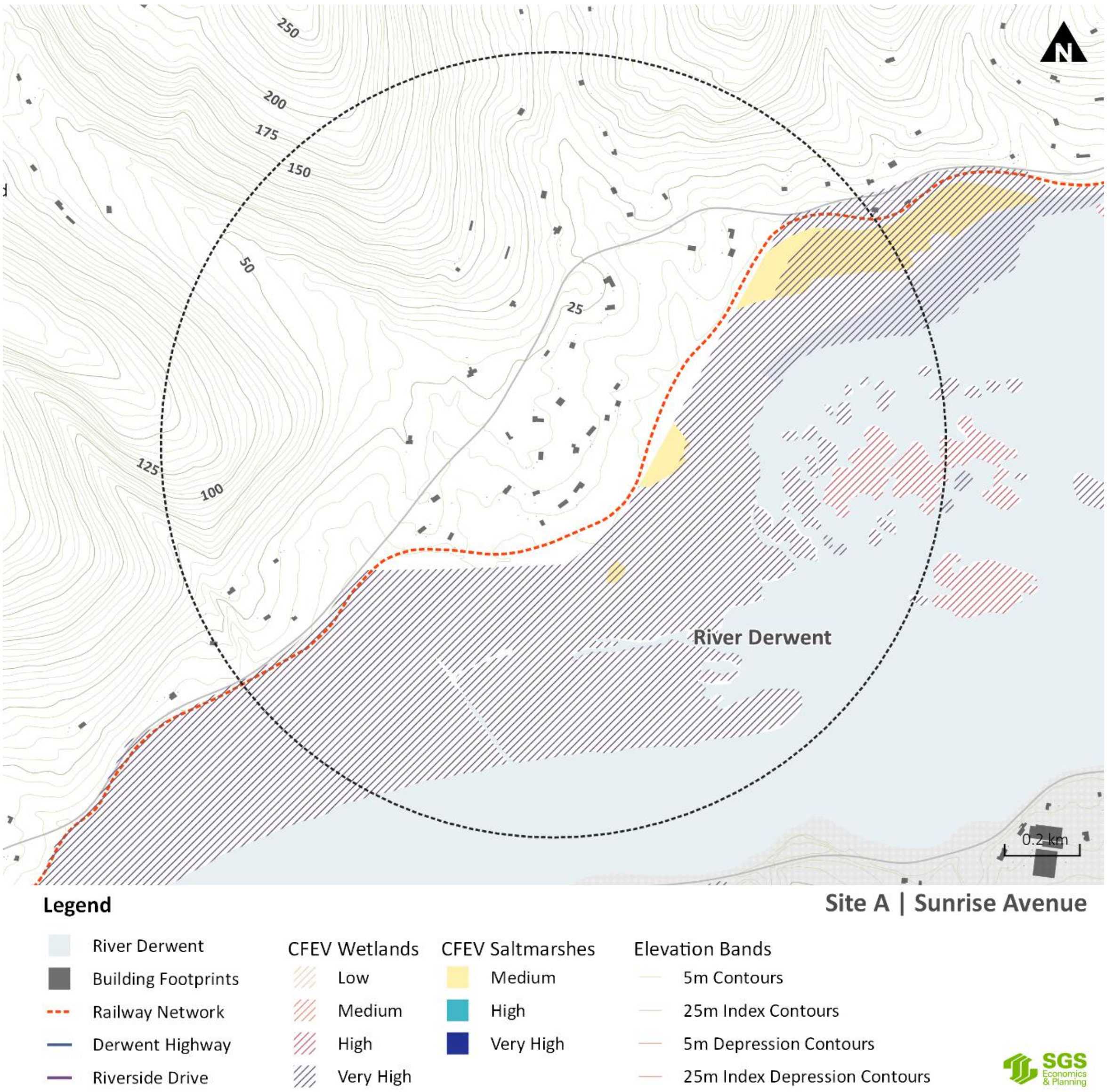
Figure 5 shows the natural values of the site.

A state road, B10 (Boyer Road), passes through the site from south-east to south-west. At the centre of the site is Sunrise Avenue, a road maintained by Brighton Council. The Derwent Valley Railway line also runs through the site, dividing the private land and foreshore on either side. The railway line is currently an in-operational heritage line, having closed its service in 2005. The railway line has been in government ownership since 2006, however a non-profit group (The Derwent Valley Railway) is actively campaigning to gain access to the railway and fundraise to refurbish the tracks and sleeper carriages. with the aim of re-establishing the railway line to service the tourist industry.[13]

[12] Brighton Council (2022), Aboriginal Heritage Tasmania Sunrise Avenue Map.

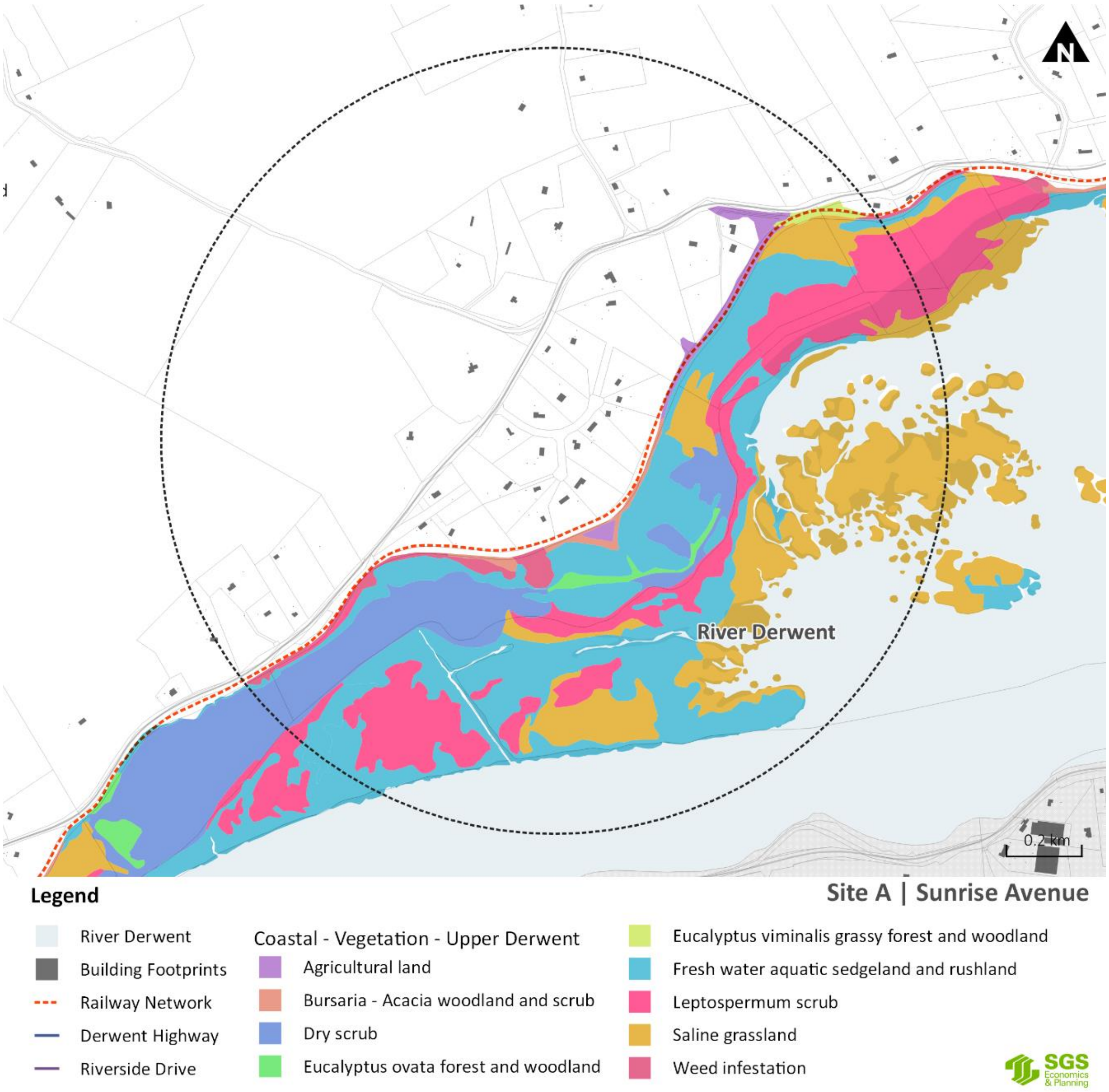
[13] Derwent Valley Railway (2023), https://www.dvr.org.au/

FIGURE 3: SITE A CONTEXT MAP



Source: SGS Economics and Planning, 2023

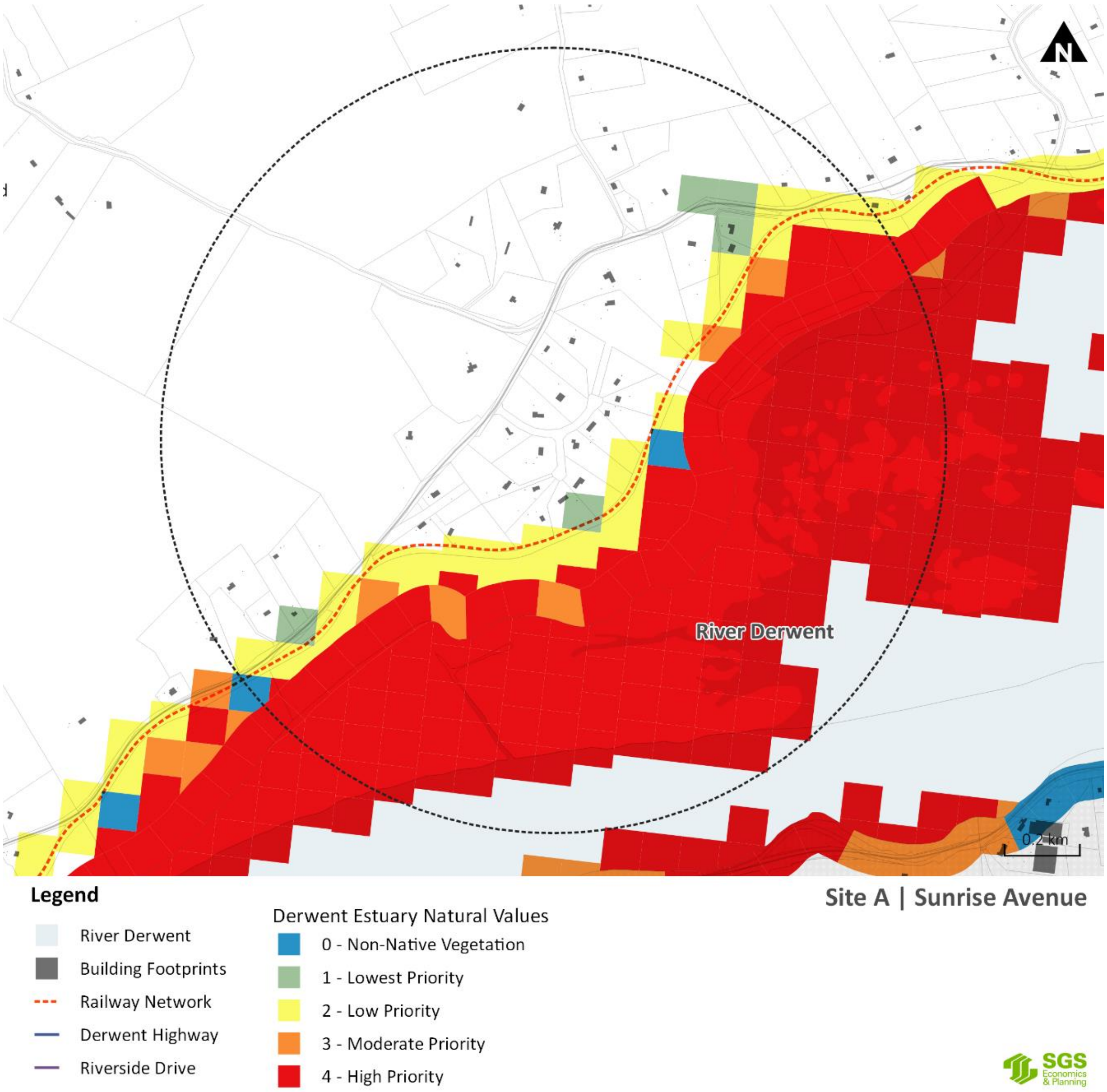
FIGURE 4: SITE A CONTEXT - COASTAL VEGETATION



Source: SGS Economics and Planning, 2023

Natural values refer to the variety of life-forms, including plants, animals, and micro-organisms, and the ecosystems they belong to, including land forms, soils, and water. One of the crucial natural values in Site A are the wetlands to the south of the rail line, which, the Derwent Estuary Natural Values[14] dataset (see Figure 5) lists the majority of the wetlands as a high priority site, the highest importance rating. Similarly, the wetlands, are deemed to have a Very High integrated conservation value, as determined by the Conservation of Freshwater Ecosystem Values[15] (CFEV). This is the highest classification which expresses the relative importance of an ecosystem.

FIGURE 5: SITE A CONTEXT - NATURAL VALUES



Source: SGS Economics and Planning, 2023

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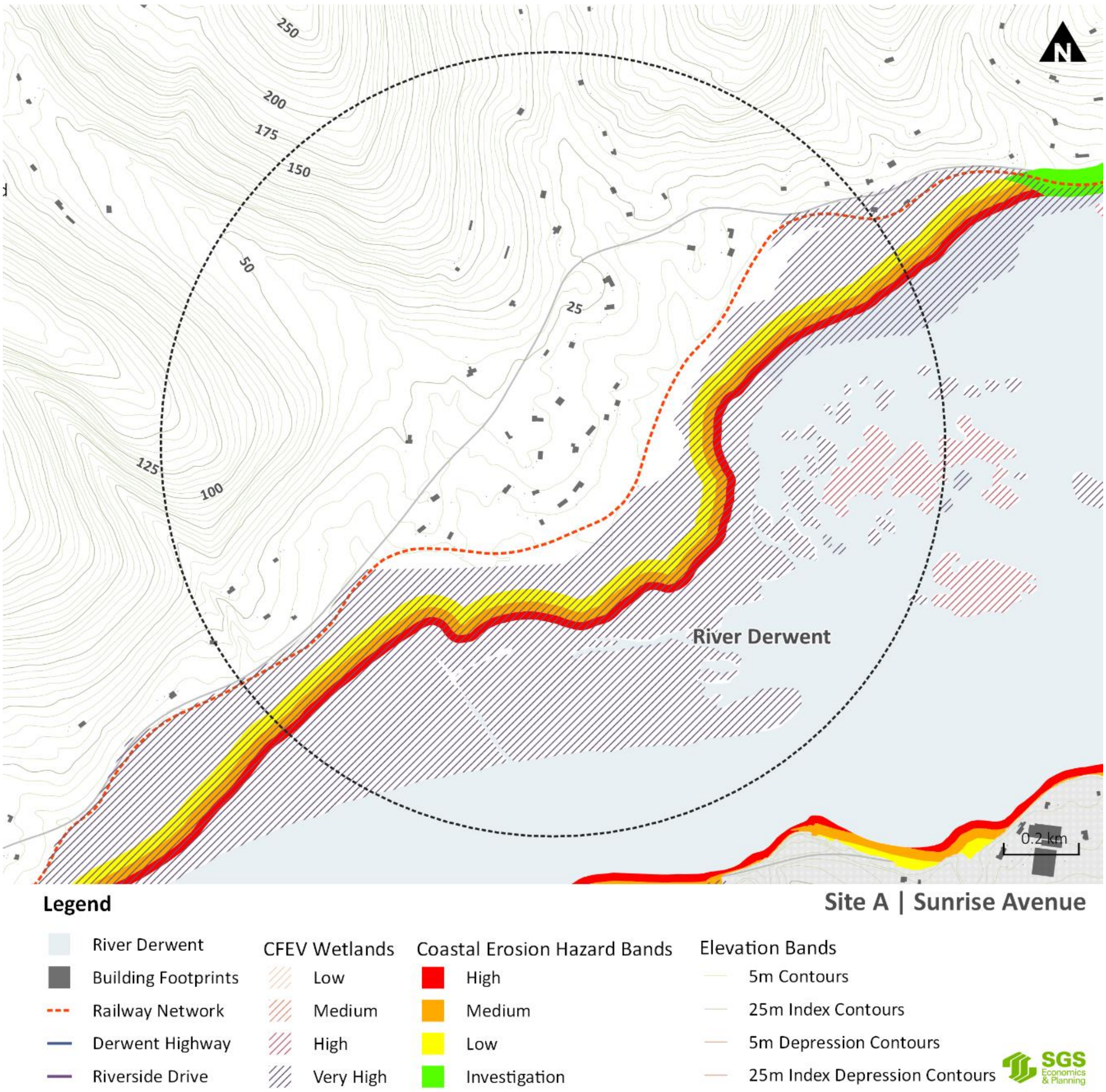
[14] https://services.thelist.tas.gov.au/arcgis/rest/services/Public/NaturalEnvironment/MapServer/106
[15] https://services.thelist.tas.gov.au/arcgis/rest/services/Public/NaturalEnvironment/MapServer/60

3.2 Coastal Erosion Hazards

The potential coastal erosion susceptibility hazard bands for the study area are shown in Figure 6. The map shows that there are areas within the high, medium, and low coastal erosion hazard bands:

- **High hazard band**: the area along the low-lying public land of the Derwent River foreshore is *currently* vulnerable to coastal recession, that is without further sea level rise.
- **Medium hazard band**: directly abutting the area defined as a high hazard band, moving inland. This land is vulnerable to coastal recession to 2050 as sea level rise progresses to 0.2m.
- **Low hazard band:** set back from the medium hazard band, moving inland, the area is vulnerable to coastal recession to 2100 as sea level rise progresses to 0.8m.

FIGURE 6: SITE A - COASTAL EROSION



Source: SGS Economics and Planning, 2023

3.3 Coastal Erosion Assets at Risk

The modelling indicates that no residential properties are directly at risk of erosion at present or in the future. Seven residential plots of land may be susceptible to some level of erosion but at these sloping properties, where the dwellings are located at higher ground away from the foreshore. The houses themselves are not at risk, now or in the future to 2100. No risk to public infrastructure has been identified.

Some of the foreshore is at risk. Most of the area classified at risk is crown land; a small amount is privately owned. The size of the open space at risk is indicated in Table 6.

TABLE 6: NON-VALUED ASSETS AT RISK - EROSION

	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	6.49	10.96	13.09

Source: SGS Economics and Planning, 2023

The Aboriginal Heritage item located inland in Site A is not expected to be affected by coastal erosion.

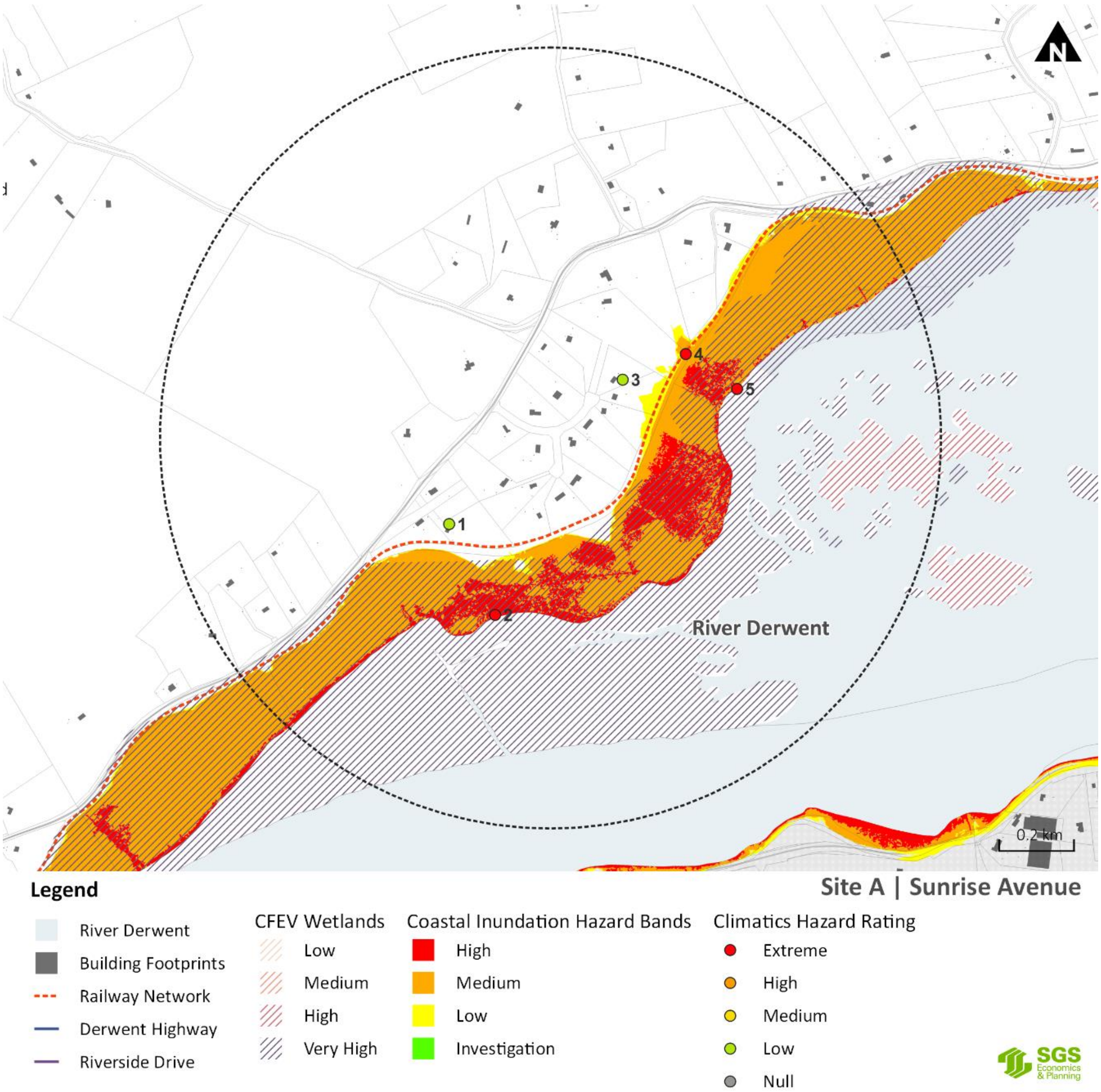
The wetlands which are classified as Very High CFEV classifications extend up to the rail line, where the risk of coastal erosion intersects this critical ecosystem, as shown in Figure 6. This indicates that the wetlands area located in the high-risk hazard band and beyond are currently vulnerable to recession, while the areas at risk of recession will encroach further inland by 2100.

3.4 Coastal Inundation Hazards

Future coastal inundation risks will increase as climate change leads to sea levels rising. Coastal sea level rise mapping of Site A (Figure 7) reveals areas with low, medium, and high coastal inundation hazard bands:

- High hazard band: a significant area of land between the Derwent Valley Railway line and the marshlands will be within 0.2m SLR from MHT line by 2050 and is currently impacted by the Highest Astronomical Tide.
- Medium hazard band: all land between the Derwent Valley Railway line and the marshlands is classified as a medium hazard band (where it is not classified as 'high'), meaning the area is vulnerable to a 1% AEP storm event in 2050 and will be impacted by a 0.8m SLR by 2100. In some areas, the medium hazard band applies to the Derwent Valley Railway line.
- Low hazard band: land abutting the medium hazard band, inland and adjacent to the Derwent Valley Railway line, is vulnerable to a 1% AEP storm event in 2100 and medium-term flooding issues. In some areas, the low hazard band applies to the Derwent Valley Railway line.

FIGURE 7: SITE A – COASTAL INUNDATION HAZARDS AND WETLANDS CONSERVATION VALUE



Source: SGS Economics and Planning, 2023

Verification with Climatics

SGS used Climatics data to verify the coastal inundation risk ratings identified by the Department of Premier and Cabinet (DPAC) by distinguishing several representative locations within the site to assess their exposure to fluvial flooding. In Figure 7 above, five sites are listed showing risk ratings for fluvial flooding at these locations from Climatics. Overall the risk analysis from Climatics at site A broadly aligns with the Coastal Inundation Hazard bands, which demonstrates that most of the wetlands to the south of the railway are at medium to high risk of inundation. However, specifically at location 4, Climatics does predict a higher risk of flooding than the coastal inundation hazard band at that location. North of the rail line, the risk of fluvial flooding is low, while there are no coastal inundation hazard bands applicable to this area. Table 7 below summarises the alignment between the two risk rating systems.

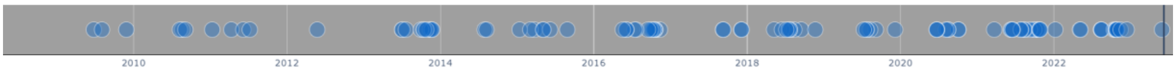
TABLE 7: RISK RATING ALIGNMENT BETWEEN CLIMATICS AND DPAC, SITE A

Location	Climatics risk rating	DPAC Hazard band	Alignment
1	Low: no direct impact on this site from river flooding	Null	Both predict no direct impact from flooding
2	Extreme: Flooding impact on this site with 5% AEP	High	Both fall into respective highest risk category.
3	Low: no direct impact on this site from river flooding	Null	Both predict no direct impact from flooding
4	Extreme: Flooding impact on this site with 5% AEP	Medium	Climatics (5% AEP currently) predicts greater risk than DPAC (1% AEP by 2050)
5	Extreme: Flooding impact on this site with 5% AEP	High	Both fall into respective highest risk category.

Source: Climatics; DPAC; SGS Economics and Planning, 2023

Throughout site A, Climatics generally predicts a somewhat higher risk of fluvial flooding at these locations than DPAC does for coastal inundation. The hazards being assessed are not identical and this may cause some of the misalignment in risk ratings between the two datasets, rather than one systematically overstating or understating risk. In any case, the outlook for the wetlands to the south of the rail line is poor, with both datasets assigning their respective highest risk ratings to areas within the wetlands for each hazard. Figure 8 below shows the incidence of flood events at site A and demonstrates a trend of increasing frequency, even in the last decade.

FIGURE 8: TIMELINE OF FLOOD EVENTS AT SITE A



Source: Climatics

3.5 Coastal Inundation Assets at Risk

No dwellings are projected to be affected by coastal inundation up to 2100. However, eight residential plots of land are likely to be at risk of partial inundation. These are sloping properties, where the dwellings are located at higher ground away from the foreshore. The houses themselves are not at risk, now or in the future to 2100.

With climate change and sea level rise, the marshlands will increasingly be at risk of inundation. Most of the marshland is at risk of inundation during extreme storm events by 2050. As sea levels continue to rise, the marshlands will become more permanently wet as the drainage capacity deteriorates and will become more frequently inundated towards 2100. If nothing is done to manage the marshlands, the character will change, and its ecosystem values diminish. Marshlands are often important as breeding and nursery grounds for bird and fish species. The presence of the rail line may prevent the marshlands from moving landward (if nothing is done to manage the risks).

By 2100, a larger area will be at risk of inundation due to extreme storm events including areas beyond the railway track boundary. Inundation would likely affect open space and railway tracks. The railway tracks may become overtopped or undermined if nothing is done to manage the risk.

TABLE 8: NON-VALUED ASSETS AT RISK - INUNDATION

Asset	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	18.59	40.67	40.67
Railway network (m)	0	162	689

Source: SGS Economics and Planning, 2023

The Aboriginal Heritage item which is located inland in Site A is not expected to be affected by coastal inundation.

The wetlands to the south of the rail line have a Very High integrated conservation value. Throughout Site A, this Very High classifications extends up to the rail line, overlapping almost entirely with the medium and high-risk hazard bands for coastal inundation, suggesting that these wetlands are potentially wholly at risk from sea level rise by 2100, if not damaged or destroyed by 1% AEP events before then. These wetlands are also considered to be a threatened native vegetation community, a state-wide mapping layer showing the indicative extent of these vegetation communities[16]. The same mapping layer shows that there is a pocket of Eucalyptus ovata forest and woodlands to the south of the rail line within the wetlands, which is covered by the high-risk coastal inundation hazard band. There are salt marshes adjacent to the rail line which are part of the wetlands, which are likewise at risk of coastal inundation, predominantly medium risk.

There are no flora or fauna species for conservation significance within Site A.

3.6 Stormwater Hazards

There are no stormwater hazards present in Site A.

3.7 Summary

Many of the land and assets at risk are exposed to both natural hazards, but inundation is the most predominant risk. There is a substantial foreshore area in Site A that is expected to be at risk of erosion, storm events and inundation[17], along with parts of the Derwent Valley Railway network. While this has not been valued in monetary terms due to limited data, the area impacted by risk has been summarised in the following table.

TABLE 9: NON-VALUED ASSETS AT RISK – OF INUNDATION AND/OR EROSION

Asset	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	18.66	40.67	40.67

[16] https://services.thelist.tas.gov.au/arcgis/rest/services/Public/NaturalEnvironment/MapServer/2

Railway network (m)	0	162	689

Source: SGS Economics and Planning, 2023

The Aboriginal Heritage item in Site A is unlikely to be affected by coastal erosion, inundation or stormwater.

The wetlands to the south of the rail line are entirely covered by coastal inundation hazards bands Medium and High, while having a Very High integrated conservation value, the highest importance classification. These critical wetlands are in areas that will likely be entirely inundated by sea-level rise alone (if not storm-tide events), by 2100. The threat of coastal erosion already affects some of the wetlands, with parts of them already vulnerable to coastal recession, while by 2100, wetland area further inland will also be vulnerable to encroachment.

4. Site B – Riverside Drive

4.1 Site overview

Site B, Riverside Drive, is in Bridgewater, a suburb approximately 19 kilometres north of Hobart. The site contains a diverse range of land uses, including grazing pastures, rural residential, urban residential, horticulture, transport and communication, and nature conservation. There are 614 residential properties within the site. These consist of a mix of rural living and general residential areas. A parcel of land to the east of the site, is zoned for future urban development and contains a heritage registered property (Genappe - 50 Boyer Road).

There are also numerous businesses that form a small activity centre in the mixed-use zone along Old Main Road and the Midland Highway and a high school (Northern Christian School) is situated to the north of the site.

The site has several open space and recreational areas, including the Nielsen Esplanade Park and Bridgewater Memorial Reserve. Abutting Riverside Drive Road along the Derwent River is an area of marshlands that are managed according to a waterway and coastal protection overlay. At the end of Riverside Drive is a popular fishing jetty and parking area. The jetty located in Nielsen Esplanade is to be replaced in a similar location as part of the Bridgewater Bridge project. It also marks the start of the Riverside Drive Foreshore Trail, a 2.7-kilometre trail which stretches west towards Boyer.[18]

The site is located directly adjacent to the Bridgewater Bridge which is a crucial transport link connecting the area to Granton in the south via the Midland Highway. The construction of the new Bridgewater Bridge is currently underway, and its impacts on erosion and inundation appear to be negligible according to a technical report[19] prepared as part of the new bridge project. The South Line railway also runs across the bridge and north through the site, however the line is no longer operational since the purpose-built Brighton Transport Hub. The Derwent Valley Line, not in operation intersects the site.

Also contained within the site are six Aboriginal Heritage items (see Figure 9). [20]

The site contains threatened wetland vegetation (see Figure 9). The environment contains natural values as illustrated in Figure 10.

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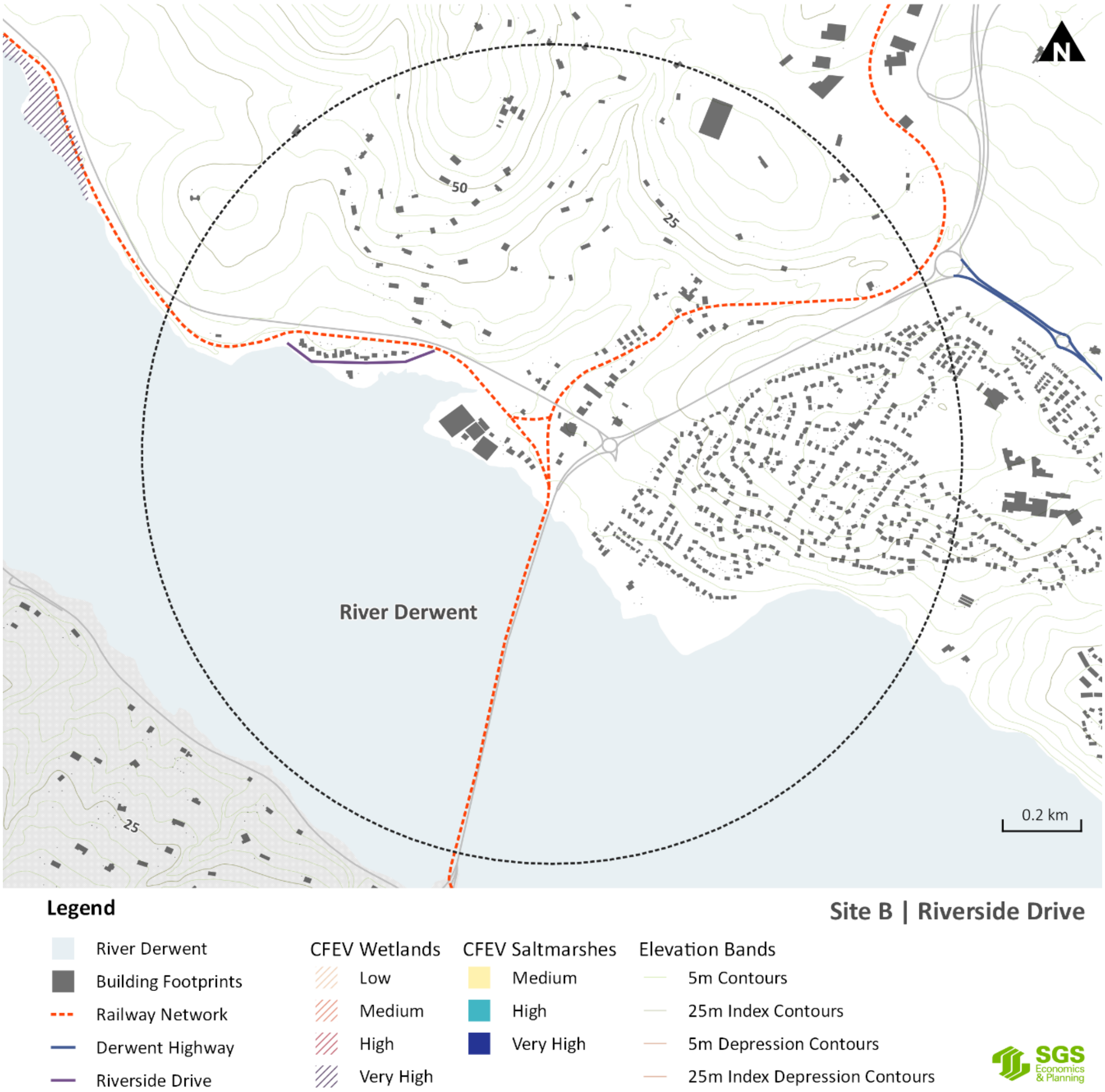
[18] Great Hobart Trails (2023) https://www.greaterhobarttrails.com.au/tracks/riverside-drive-foreshore-trail

[19] Hydo-Electric Corporation, 2021, New Bridgewater Bridge Flood Hazard Report.

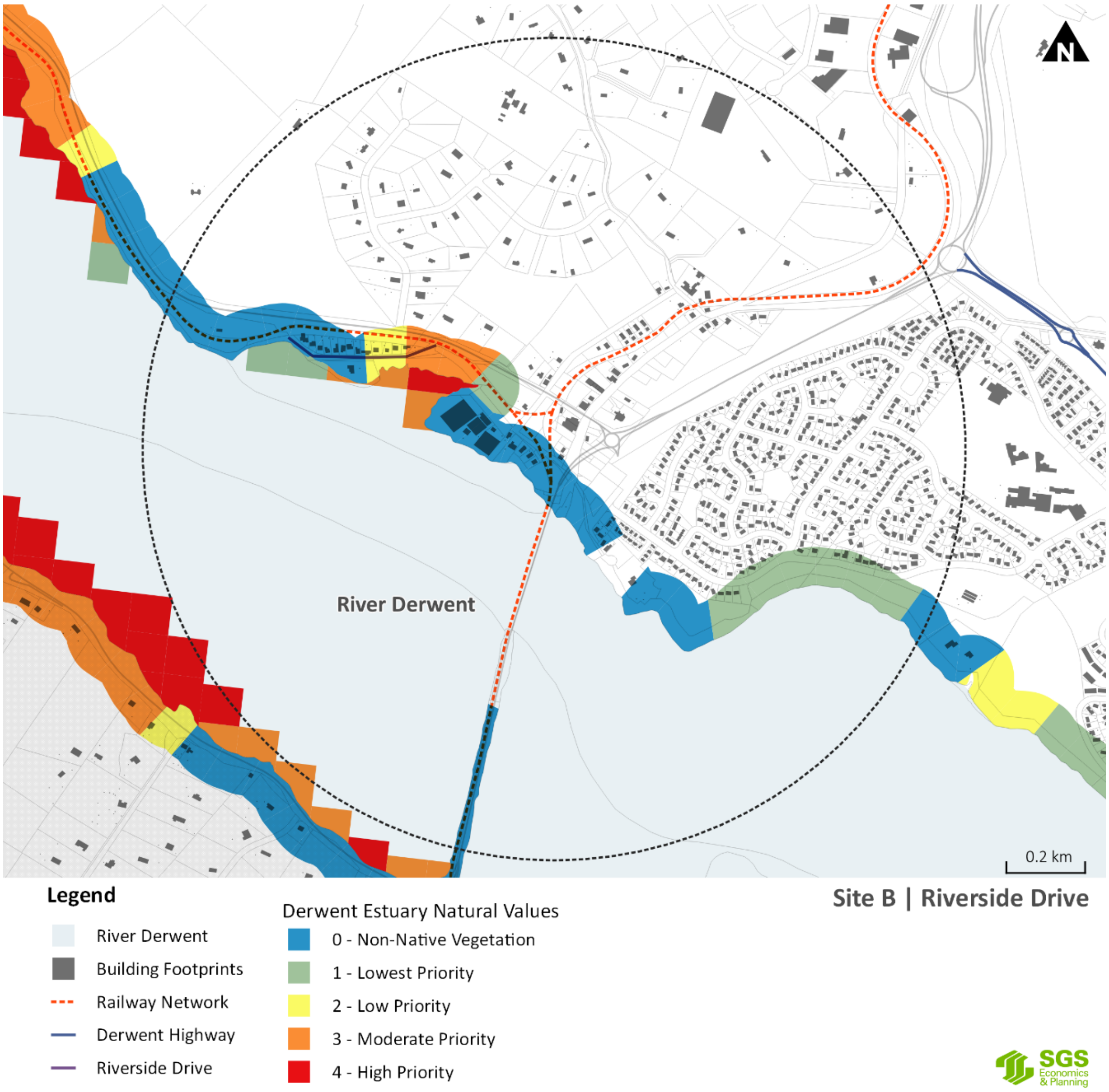
[20] Brighton Council (2022), Aboriginal Heritage Tasmania Riverside Drive Map.

FIGURE 9: SITE B CONTEXT MAP



Source: SGS Economics and Planning, 2023

FIGURE 10: SITE B CONTEXT - NATURAL VALUES



Source: SGS Economics and Planning, 2023

4.2 Coastal Erosion Hazards

Erosion modelling and spatial data enable the identification of areas that are at risk of erosion. The potential coastal erosion susceptibility hazard bands for the study area are shown in Figure 11. The map shows that there are high, medium, low and investigation coastal erosion hazard bands all present in Site B:

- High hazard band: a significant area of public land to the north west of the Bridgewater Bridge along the low-lying land of the Derwent River foreshore is *currently* vulnerable to coastal erosion.

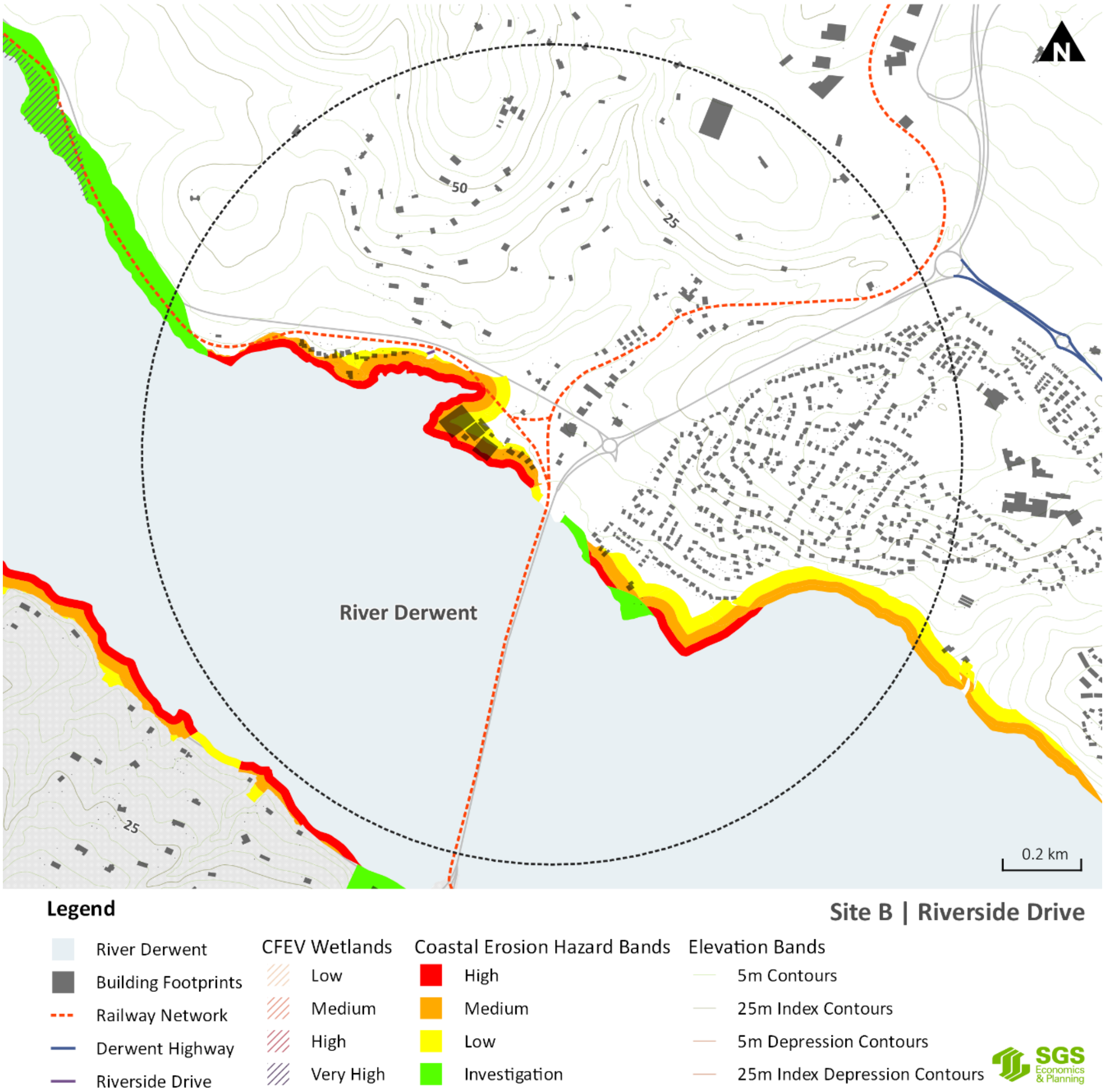
This includes private properties on Wallace Street. A smaller area along Nielsen Esplanade along the foreshore, south of the bridge, is also classified as a high coastal erosion hazard band.

- **Medium hazard band**: Along Riverside Drive and Wallace Street, north of the Bridgewater Bridge, several private properties are within the medium hazard band, exposing them erosion risk by 2050. South of the bridge, an area to the east of the site boundary is also within the medium erosion band, including Bridgewater Parkland.
- **Low hazard band:** set back from the medium hazard band, moving inland, the area is vulnerable to coastal erosion to 2100 as sea level rise progresses to 0.8m.

Investigation hazard band: two areas within Site B contain an investigation hazard band, the first to the north east along the Derwent River foreshore and Dromedary walking path, the second to the south of the Bridgewater Bridge. These areas are adjacent to coastlines but yet to be classified due to incomplete or unavailable landform data.

The map shows that the primary area of concern are the private properties along Wallace Street. As sea levels rise, the properties are at increasing risks, to the extent that a high tide could lead to erosion by 2100 (if nothing is done to manage the risk).

FIGURE 11: SITE B - COASTAL EROSION



Source: SGS Economics and Planning, 2023

4.3 Coastal Erosion Assets at Risk

While at present no buildings are at risk of erosion, with climate change and associated sea level rise, this is set to change towards 2050. By then, approximately 18 buildings (dwellings and greenhouses) with a total capital value of $6.6 million will be at risk if nothing is done to manage the risk. As sea levels continue to rise, buildings on another 21 properties may be at risk if nothing is done to manage the risk.

TABLE 10: CAPITAL VALUES OF BUILDINGS AT RISK – EROSION RISK

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Private properties	0	0	6,607,500	18	7,290,000	21

Source: SGS Economics and Planning, 2023

The boat ramp, a small section of the hiking track and the playground are currently at risk of erosion. Sections of road and the track are likely to be exposed to erosion as sea levels rise. Overall, the capital values at risk, is estimated to be $112,585 in 2050, to increasing to $482,482 in 2100.

TABLE 11: VALUES OF PUBLIC INFRASTRUCTURE AT RISK – EROSION RISK

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Boat Ramp	$37,433	1	$37,433	1	$37,433	1
Roads	$4,917	0.0km	$21,552	0.1km	$334,749	0.8km
Hiking Track	$22,300	0.2km	$53,600	0.5km	$110,300	1.1km
Total	**$64,650**	**N/A**	**$112,585**	**N/A**	**$482,482**	**N/A**

Source: SGS Economics and Planning, 2023
Note: Boat Ramp derived from costs of land backed wharve (precast concrete interlocking piles and reinforced concrete ground slab) (no electrical and water services), Roads based on composite price of suburban road with in situ concrete kerbs (6m wide), Trail calculated based on paved footpath (1500mm wide)

Overtime, an increasing amount of open space is likely to be at risk of erosion including the playground.

TABLE 12: NON-VALUED ASSETS AT RISK – EROSION RISK

Asset	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	1.42	3.76	4.81

Source: SGS Economics and Planning, 2023

Four Aboriginal Heritage items are located within the High Erosion Hazard Band, while a further two straddle the High/Medium Erosion Hazard band, indicating that all six items are at high risk of erosion.

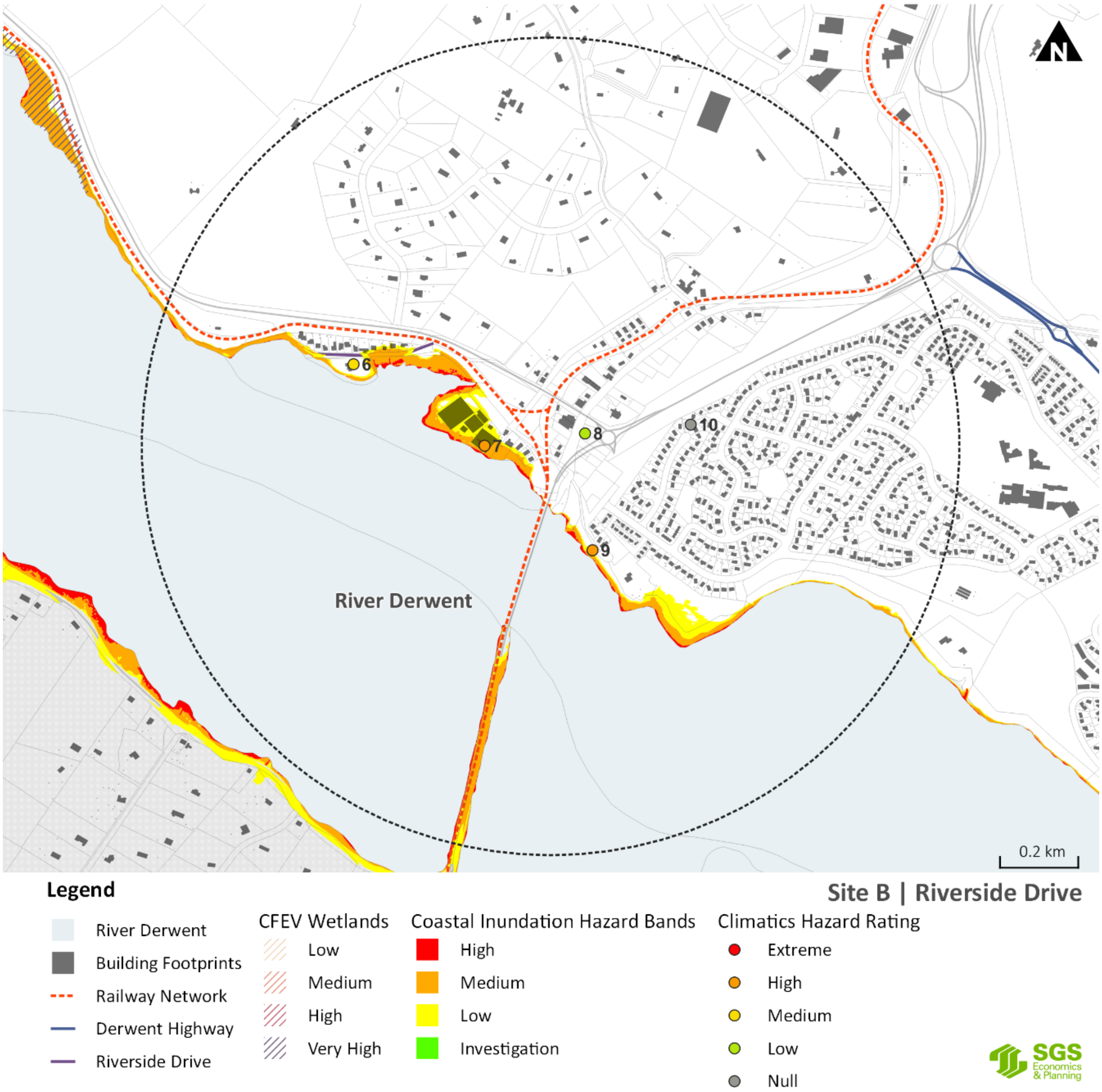
Much of the natural value in Site B is identified by the Derwent Estuary Natural Values dataset to be either non-native vegetation or the in the lowest priority band. There is a pocket of moderate and high priority natural value to the south of the intersection between Riverside Drive and Boyer Road, at the mouth of Derwent River. The entire shoreline of Site B is vulnerable to coastal erosion of low to high risk. This natural value site is on the shoreline and therefore overlaps with the high-risk hazard band for coastal erosion, indicating that this pocket of high priority vegetation is currently at risk of coastal recession.

4.4 Coastal Inundation Hazards

Future coastal inundation risks will increase as climate change leads to sea levels to rise. Coastal sea level rise mapping of Site B (Figure 12) shows areas with low, medium and high coastal inundation hazard bands:

- High hazard band: Several properties on Riverside Drive and Wallace Street (including private properties), and south side of the Bridgewater Bridge. The width of the high hazard band is limited, meaning there are no direct threats to buildings on the land parcels identified.
- Medium hazard band: all land along the Derwent River foreshore in Site B is within the medium hazard band, meaning the area is vulnerable to a 1% AEP storm event by 2050 and will be inundated at a regular basis by 2100. The medium hazard band encompasses private properties on Wallace Street and Riverside Drive, as well as the south side of the Bridgewater Bridge. By 2050, some of the buildings on these parcels will be at risk.
- Low hazard band: land abutting the medium hazard band, inland, is vulnerable to a 1% AEP storm event in 2100 and medium-term flooding issues. In some areas, the low hazard band applies to private properties on Wallace Street and Riverside Drive.

FIGURE 12: SITE B - COASTAL INUNDATION



Source: SGS Economics and Planning, 2023

Verification with Climatics

SGS has analysed several representative locations within Site B using Climatics to assess their exposure to fluvial flooding. As Figure 12 shows, the coastal land surrounding Bridgewater Bridge is at risk of coastal inundation, as well as from fluvial flooding, represented by the numbered locations on the map. Land immediately adjacent to the bridge entrance is at high risk of fluvial flooding, which is to say that these sites have a predicted 2% AEP for a direct impact from the Derwent River flooding. One site identified is a greenhouse to the northwest of the Bridge entrance, while on the other side, the foreshore walk south of Gunn Street is at the same risk level. Both sites are directly on the foreshore, while locations further inland are at medium, low or no risk. This aligns with the high-risk rating along the foreshore identified by DPAC, while the drop off in risk further inland also holds. Nevertheless, certain locations analysed in Climatics are shown to be at some level of risk from flooding, with no coastal inundation hazard band coverage. This is summarised in Table 13 below.

TABLE 13: RISK RATING ALIGNMENT BETWEEN CLIMATICS AND DPAC, SITE B

Location	Climatics risk rating	DPAC Hazard band	Alignment
6	Medium: flooding impact on this site with 1% AEP	Null	Climatics identifies flooding risk at this site while DPAC does not.
7	High: Flooding impact on this site with 2% AEP	Medium	Both fall into respective second highest risk category, but Climatics risk rating is more severe.
8	Low: no direct impact on this site from river flooding	Null	Both predict no direct impact from flooding
9	High: Flooding impact on this site with 2% AEP	Low	Climatics (2% AEP currently) predicts greater risk than DPAC (1% AEP by 2100).
10	Null	Null	Both datasets identify no flooding or inundation risk at this location.

Source: Climatics; DPAC; SGS Economics and Planning, 2023

The coastal inundation hazard bands from DPAC do not extend far inland but do suggest that there is a high risk on the coast around Bridgewater Bridge. Climatics analysis of locations within site B predicts that the risk of fluvial flooding extends somewhat further inland, with medium and high-risk ratings applying to locations not covered by the DPAC hazard bands. Figure 13 below shows a timeline of flood events at the coastline of site B. It demonstrates that flood events are becoming more frequent, even within the last decade.

FIGURE 13: TIMELINE OF FLOOD EVENTS AT SITE B

Source: Climatics

4.5 Coastal Inundation Assets at Risk

Inundation risk is contained mainly in areas also facing coastal erosion risk. The present risk of inundation is very minimal, with an impact on one greenhouse. The extent exacerbates when the risk moves to medium risk, with the risk of a 1% AEP storm event in 2050, or 0.8m sea level rise by 2100 developing up 50m from the riverbanks, at its most vulnerable point. Three properties will be at risk in this scenario. As the risk of 1% AEP storm event approaches in 2100, there may be a further five properties at risk of inundation and will inundate the large parcel of land at the end of Wallace Street.

TABLE 14: VALUES OF PROPERTIES AT RISK (ADJUSTED CAPITAL, EXCLUDING LAND VALUES) – INUNDATION RISK

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Private properties	0	0	900,000	3	2,540,000	8

Source: SGS Economics and Planning, 2023

Similarly, with coastal erosion, the disused boat ramp and roads may be marginally affected on Site B. Impact of potential inundation on public infrastructure is likely to be negligible with present-day risk. However, this impact is expected to grow by approximately four folds in the medium term (1% AEP in 2050). More roads and parts of the walking track will be at risk of inundation in the long term (1% AEP storm event in 2100).

TABLE 15: VALUES OF PUBLIC INFRASTRUCTURE AT RISK – INUNDATION RISK

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Boat Ramp	$0	0	$37,433	1	$37,433	1
Roads	$8,820	0.2km	$158,572	0.4km	$726,694	1.8km
Hiking Track	$461	0.0km	$183,173	1.8km	$218,086	2.2km
Total	**$9,281**	**N/A**	**$379,178**	**N/A**	**$982,213**	**N/A**

Source: SGS Economics and Planning, 2023
Note: Boat Ramp derived from costs of land backed wharve (precast concrete interlocking piles and reinforced concrete ground slab) (no electrical and water services), Roads based on composite price of suburban road with in situ concrete kerbs (6m wide), Trail calculated based on paved footpath (1500mm wide)

The likelihood of inundation risk affecting open space is expected to be low across various inundation hazard bands, although it may have an impact on the local playground.

TABLE 16: NON-VALUED ASSETS AT RISK – INUNDATION RISK

Asset	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	0.32	1.64	1.64

Source: SGS Economics and Planning, 2023

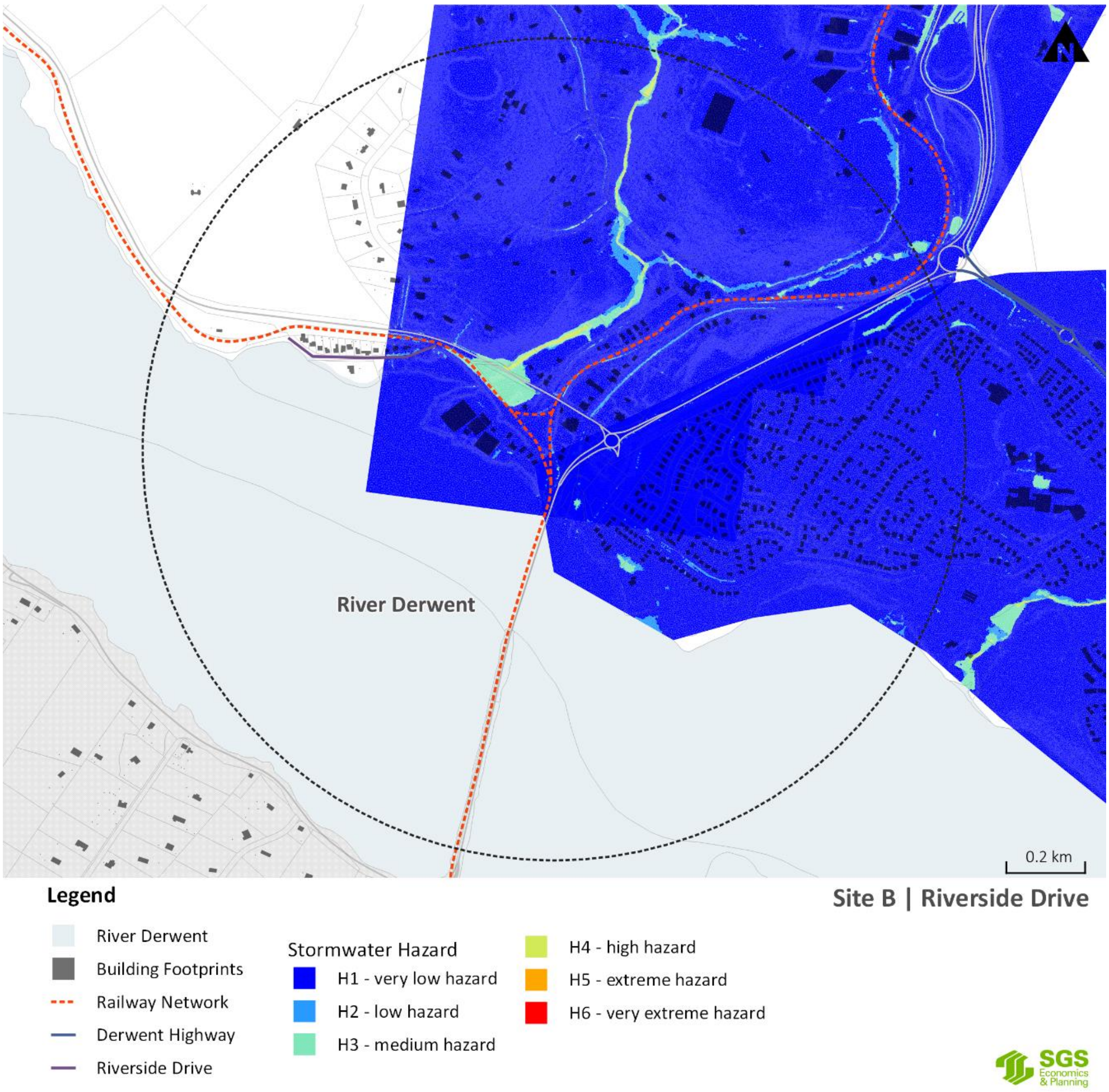
In total, four Aboriginal Items are at risk of inundation. Three Aboriginal Heritage Items are located within the Medium Inundation Hazard Band (774, 1384, 1381), one straddles the High/Medium Inundation Hazard band (7776). Two items (7775, and 1383) appear to not be at risk of inundation.

Coastal inundation proves to be less threatening to the vegetation in Site B than at Site A, due to a more severe slope from the banks of the river. Nevertheless, the area to the south of Riverside Drive and Boyer Road, which is considered moderate to high priority in the Derwent Estuary Natural Values dataset, is also covered by medium to high-risk hazard bands for coastal inundation. This means that this pocket of open space is vulnerable to sea-level rise by 2100, and parts of it will be vulnerable by 2050, if not already damaged or destroyed by a 1% AEP storm event before then.

4.6 Stormwater Hazards

The majority of Site B is vulnerable to stormwater drainage hazards (Figure 14). This area includes recreation and urban uses. With sea level rise it is reasonable to assume that stormwater drainage issues, such as the need to manage stormwater via the overflow, will gradually increase over time. Contributing factors are an increased water table and higher storm surges.

FIGURE 14: SITE B - STORMWATER HAZARDS



Source: SGS Economics and Planning, 2023

A few hundred houses and other buildings are at a very low risk from stormwater.

All six Aboriginal Heritage items are at very low risk from stormwater hazards.

As Figure 14 shows, the majority of land within Site B is vulnerable to stormwater hazards, predominantly low to very low risk. However, there is a pocket of medium to high risk which intersects with the high priority area identified in the Derwent Estuary Natural Values dataset. This is shown in Figure 14 at the intersection between the railway network, Riverside Drive and Boyer Road. With sea level rise and increasing storm surge resulting from climate change, the vulnerability of this site will likely increase over time.

4.7 Summary

Site B is susceptive to coastal hazards, however, both inundation and coastal erosion are likely to be relatively mild due to the geographical location of the study area, as well as due to land utilisation. Similar to Site A, the land is relatively low density and is characterised by limited land uses.

Most assets are likely to be exposed to both coastal erosion and inundation risks.

Currently, no residential properties are at risk of coastal hazards. As the potential for erosion and inundation escalates to the medium hazard band, approximately 18 residential properties may be at risk, with a total value of about $6.6 million. This value is expected to grow with a low-risk hazard band, whereby, a total of 22 properties are potentially at risk of erosion and inundation due to extreme events. The total value of these properties is around $7.5 million.

TABLE 17: VALUES OF PROPERTIES AT RISK (ADJUSTED CAPITAL, EXCLUDING LAND VALUES)

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Private properties	0	0	6,607,500	18	7,535,000	22

Source: SGS Economics and Planning, 2023

Built public infrastructure are also at risk of coastal hazards, such as roads and footpaths. Infrastructure in the study area that carries some level of risk include a hiking trail, roads, boat ramp and a local playground[21].

TABLE 18: VALUES OF PUBLIC INFRASTRUCTURE AT RISK

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Boat Ramp	37,433	1	37,433	1	37,433	1
Roads	197,475	0.5km	421,935	1.0km	599,888	1.5km
Hiking Track	22,761	0.1km	184,550	0.7km	243,382	0.7km
Total	**257,668**	**N/A**	**643,918**	**N/A**	**880,702**	**N/A**

Source: SGS Economics and Planning, 2023
Note: Boat Ramp derived from costs of land backed wharve (precast concrete interlocking piles and reinforced concrete ground slab)

[21] Note: Playgrounds have not been measured as this has not been detailed in Rawlinson's.

(no electrical and water services), Roads based on composite price of suburban road with in situ concrete kerbs (6m wide), Trail calculated based on paved footpath (1500mm wide)

There is also foreshore area in Site B that is expected to be at risk of erosion, storm events and inundation[22], along with parts of the Derwent Valley Railway and the South Line network. While this has not been valued due to limited data, the area impacted has been summarised in the following table.

TABLE 19: NON-VALUED ASSETS AT RISK

Asset	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	1.42	3.76	4.82

Source: SGS Economics and Planning, 2023

All six Aboriginal Heritage items in Site B are at very low risk from stormwater hazards, and high/medium risk of erosion. Four of the items are at risk of inundation.

The urban development at Site B extends towards the shore line across much of its river banks, meaning that there are relatively fewer natural values at risk from coastal hazards. However, a small pocket of open space that is considered moderate to high priority is at risk particularly from coastal inundation, as a low-lying area on the banks of the Derwent River. It is vulnerable to sea level rise by 2050 to 2100, if not storm events before then. This site is also currently at the intersection of low to medium stormwater hazard risk.

[22] Willingness to pay (WTP) through comparable studies can suggest the value of public-owned foreshores, through the benefit transfer approach. However, this has not been valued at this stage as it is unclear about the significance of the marshlands that reside in this study area and whether this WTP value can be applied. This will be informed and investigated through stakeholder engagement in a later stage of the study.

5. Site C – Old Beach

5.1 Site overview

Situated on the southern boundary of Brighton LGA, Site C (Old Beach) is the largest of the three sites. The site has a diversity of land uses close to the river foreshore, mostly residential and open space. An electricity transmission corridor also runs through the site.

The Derwent River foreshore stretches along the site from the south of Herdsman's Cove to Old Beach at the boundary of the LGA and is covered by a waterway and coastal protection overlay. The popular council-maintained Old Beach walking track lines the foreshore. This area is Crown land and maintained according to its waterway and coastal protection overlay. The site boasts natural assets including the Clarrie's Creek and Gagebrook tributary, saltmarshes, and numerous open spaces. There is threatened native vegetation within the site (see Figure 17). The natural values within the site are shown in Figure 18.

The site also contains 25 known Aboriginal Heritage Shell Middens[23] and several Artefact Scatters[24] predominantly along the Old Beach walking track[25] (Figure 16).

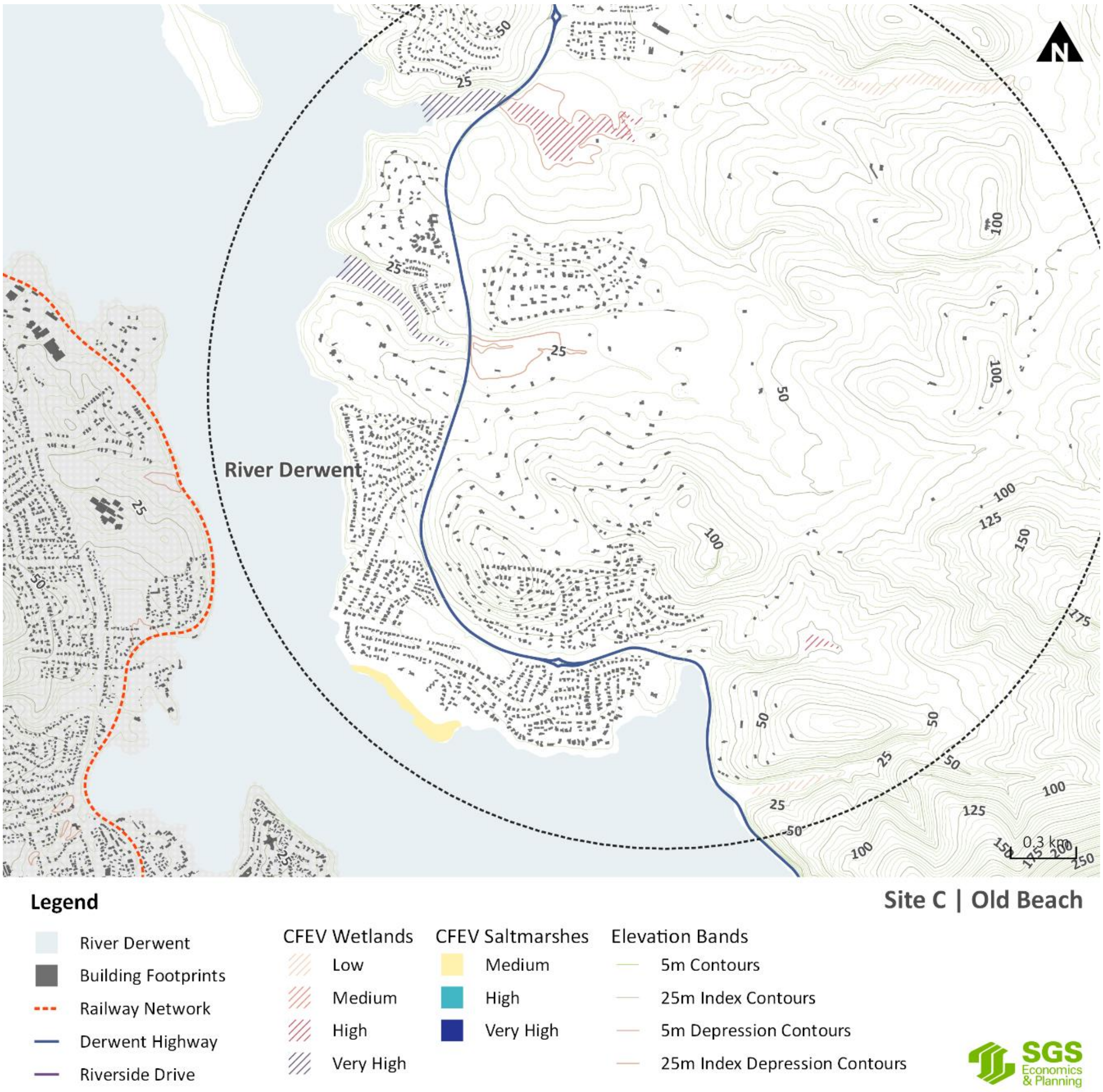
FIGURE 15: FORESHORE WALKWAY AT OLD BEACH

Source: SGS Economics and Planning, 2023

[23] Distinct concentrations of discarded shell that have accumulated as a result of past Aboriginal camping and food processing activities.
[24] A stone artefact is any stone or rock fractured or modified by Aboriginal people to produce cutting, scraping or grinding implements.
[25] Brighton Council (2022), Aboriginal Heritage Tasmania Old Beech Map.

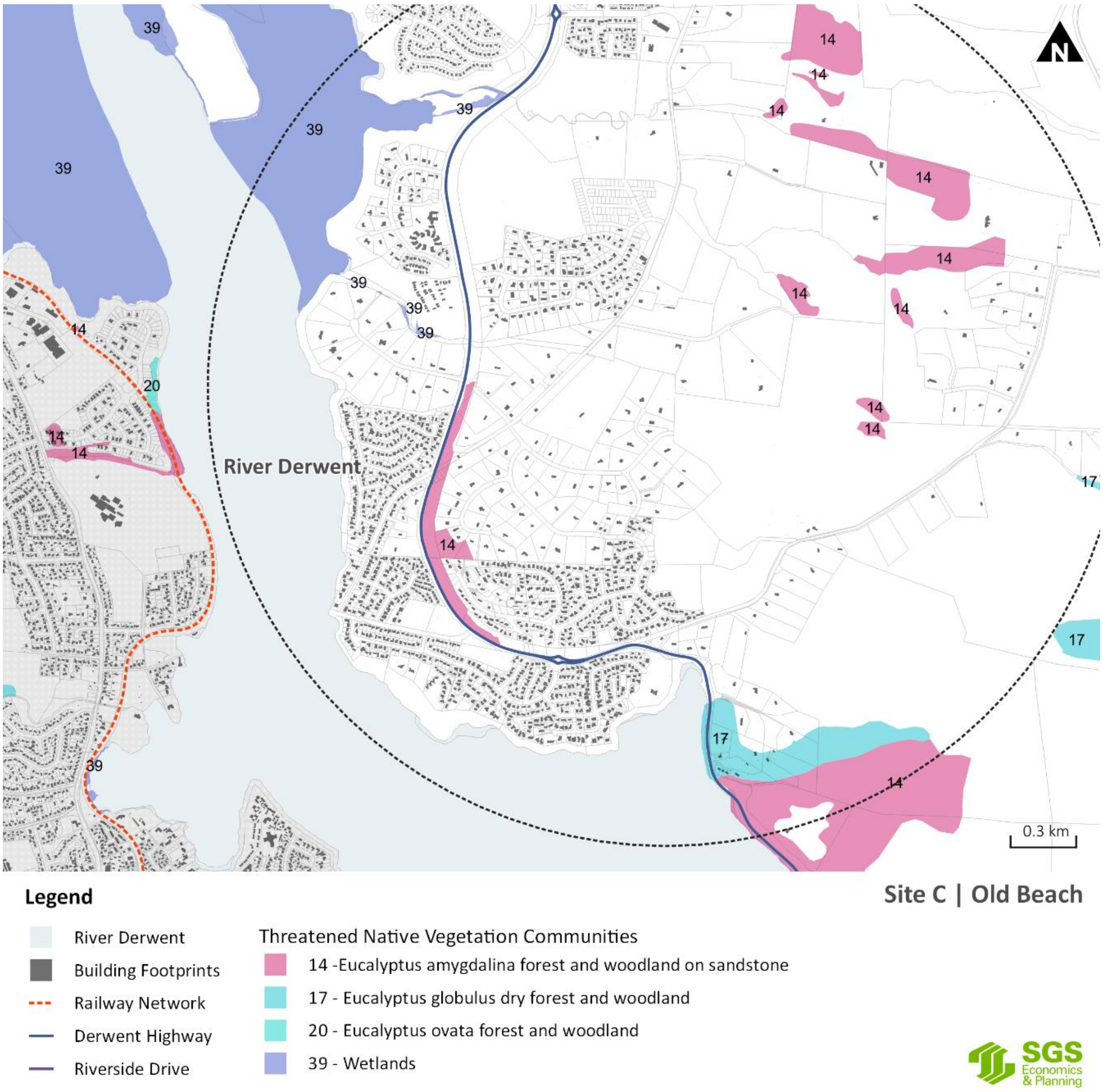
The East Derwent Highway is the primary route of entry/exit to the municipality and Jetty Road provides boat access to the Derwent River via the Old Beach Jetty. There is a walkway planned (currently a sand footpath) for the north of the Jetty.

FIGURE 16: SITE C CONTEXT MAP



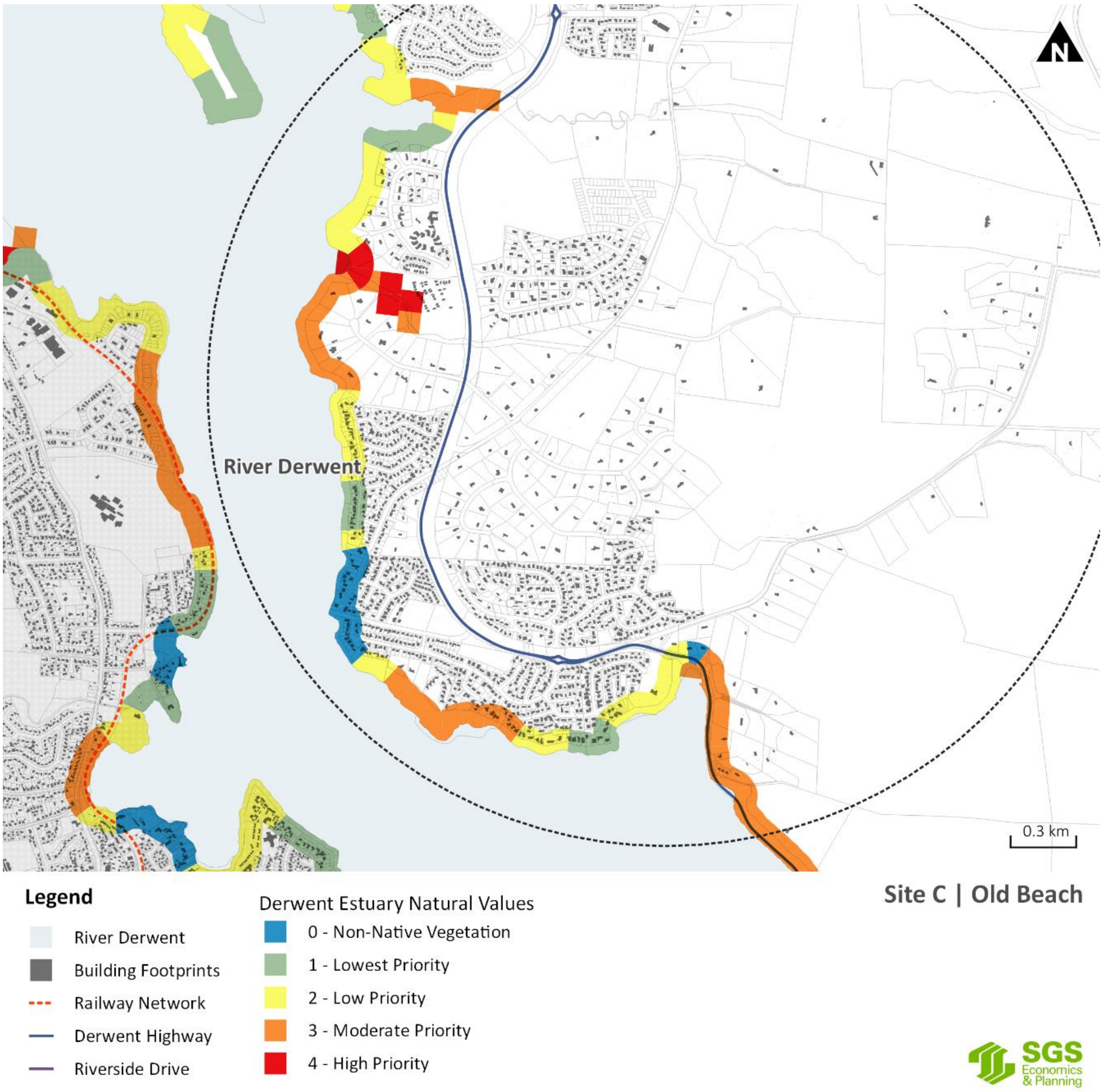
Source: SGS Economics and Planning, 2023

FIGURE 17: SITE C CONTEXT - THREATENED NATIVE VEGETATION



Source: SGS Economics and Planning, 2023

FIGURE 18: SITE C CONTEXT - NATURAL VALUES



Source: SGS Economics and Planning, 2023

5.2 Coastal Erosion Hazards

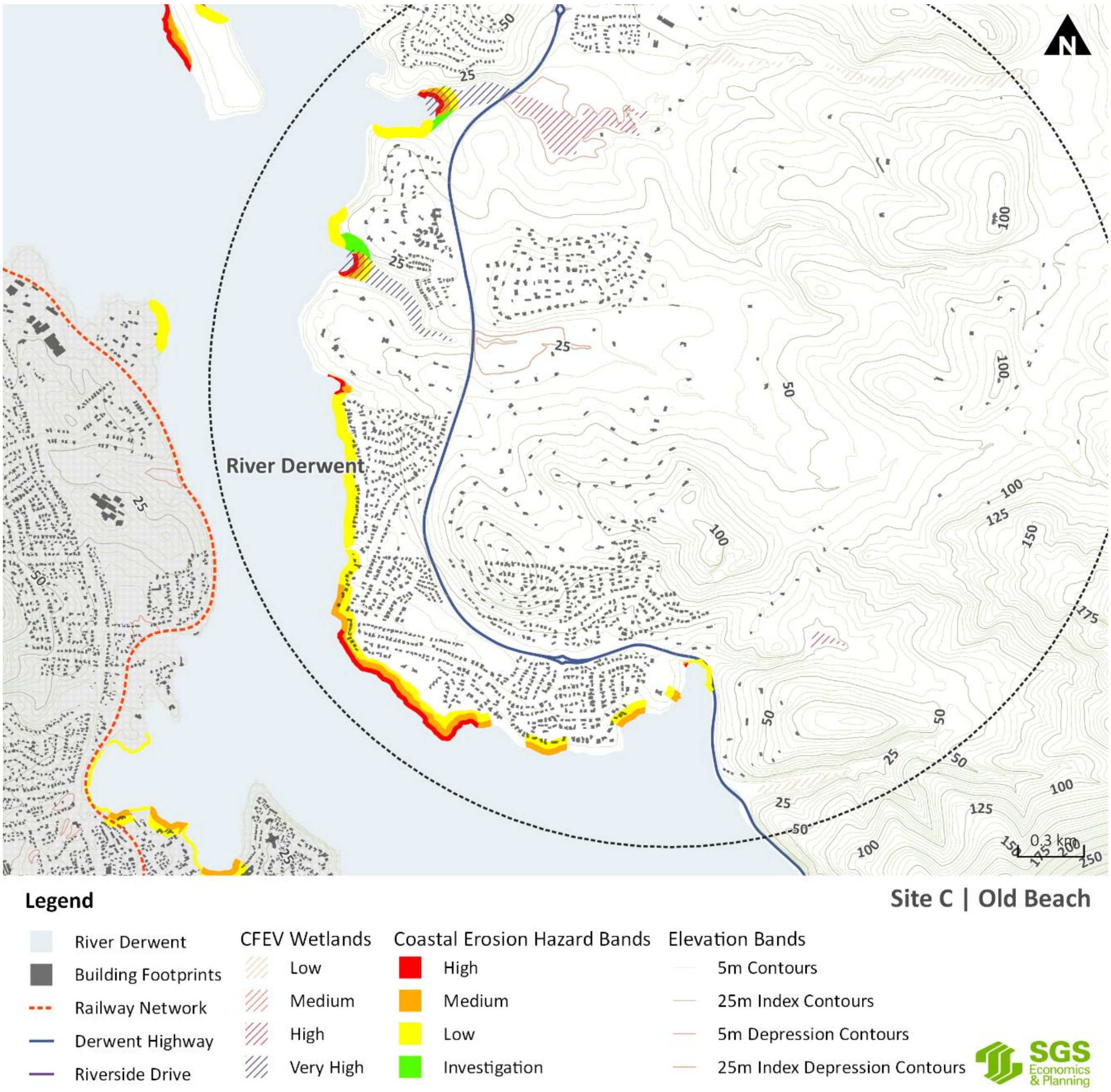
The coastal erosion susceptibility hazard bands for the study area are shown in Figure 19. The map shows that there are high, medium, low and investigation coastal erosion hazard bands all present in Site C:

- High hazard band: four sections of land along the Derwent River foreshore are *currently* vulnerable to coastal recession. The most significant of these is the open space south of the boat ramp (off Jetty Road) and along the Old Beach walking track. Over time, with sea level rise, erosion will increasingly become a risk, if nothing is done to manage the risk.

- **Medium hazard band**: directly abutting the area defined as a high hazard band, moving inland, is vulnerable to coastal recession to 2050 as sea level rise progresses to 0.2m. Most significantly, the medium coastal erosion hazard band encompasses the Old Beach walking track itself, several private properties and the boat ramp on Jetty Road.
- **Low hazard band:** set back from the medium hazard band, moving inland, the area is vulnerable to coastal erosion by 2100 as sea level rise progresses to 0.8m. There is also a significant stretch of land along the River Derwent foreshore, north of the boat jetty, that is classified as a low hazard band. This area captures private properties on Morrisby Road.

Investigation hazard band: two areas to the north of Site C contain an investigation hazard band, two of which encompasses the Clarries Creek tributary and Gage Brook tributary. These areas are adjacent to coastlines yet to be classified due to incomplete or unavailable landform data.

FIGURE 19: SITE C - COASTAL EROSION



Source: SGS Economics and Planning, 2023

5.3 Coastal Erosion Assets at Risk

In terms of present-day risk, coastal erosion is relatively sparse, primarily limited to marshlands located south of the Jetty Road Boat Ramp or within a small section of Site C's coves. A small section of the East Derwent Highway (State Government owned) at the southern end of the Old Beach site is within the low erosion hazard band.

Currently, the land is expected to recede by approximately 20 meters from the riverbanks. However, by 2050, this recession is projected to grow, affecting not only these areas but also other parts of the study area. With the potential erosion, the land may recede by up to 30 meters inland. As a result of this progression, three residential properties, a boat ramp, a minor section of a vehicle track, and a few segments of a hiking trail are likely to be impacted.

The projected impact in 2100 suggests that not only the current areas but also additional regions will be negatively affected, with exacerbated risk. The land may recede by 60 meters inland at its most vulnerable point. As a result, the community will experience significant consequences, particularly as 30 residential properties face long-term risks.

TABLE 20: VALUES OF BUILDINGS AT RISK – EROSION RISK

Assets	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Private properties	0	0	2,180,000	4	15,907,500	30

Source: SGS Economics and Planning, 2023

TABLE 21: VALUES OF PUBLIC INFRASTRUCTURE AT RISK – EROSION RISK

Assets	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Boat Ramp	$0	0	$126,294	1	$126,294	1
Roads	$4,917	0.0km	$21,552	0.1km	$334,749	0.8km
Hiking Track	$22,300	0.2km	$53,600	0.5km	$110,300	1.1km
Total	**$64,650**	**N/A**	**$201,446**	**N/A**	**$571,343**	**N/A**

Source: SGS Economics and Planning, 2023
Note: Boat Ramp derived from costs of land backed wharve (precast concrete interlocking piles and reinforced concrete ground slab) (no electrical and water services), Roads based on composite price of suburban road with in situ concrete kerbs (6m wide), Trail calculated based on paved footpath (1500mm wide)

The foreshore area is likely to see a moderate impact from erosion, which is expected to increase as land recession risk develops in the future.

TABLE 22: NON-VALUED ASSETS AT RISK – EROSION RISK

Asset	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	5.13	8.02	15.53

Source: SGS Economics and Planning, 2023

Two shell middens appear to lie in land marked in high erosion hazard band, three are in the medium risk band, while seven are in the low hazard band. Altogether this indicates that twelve items in Site C are at risk of erosion.

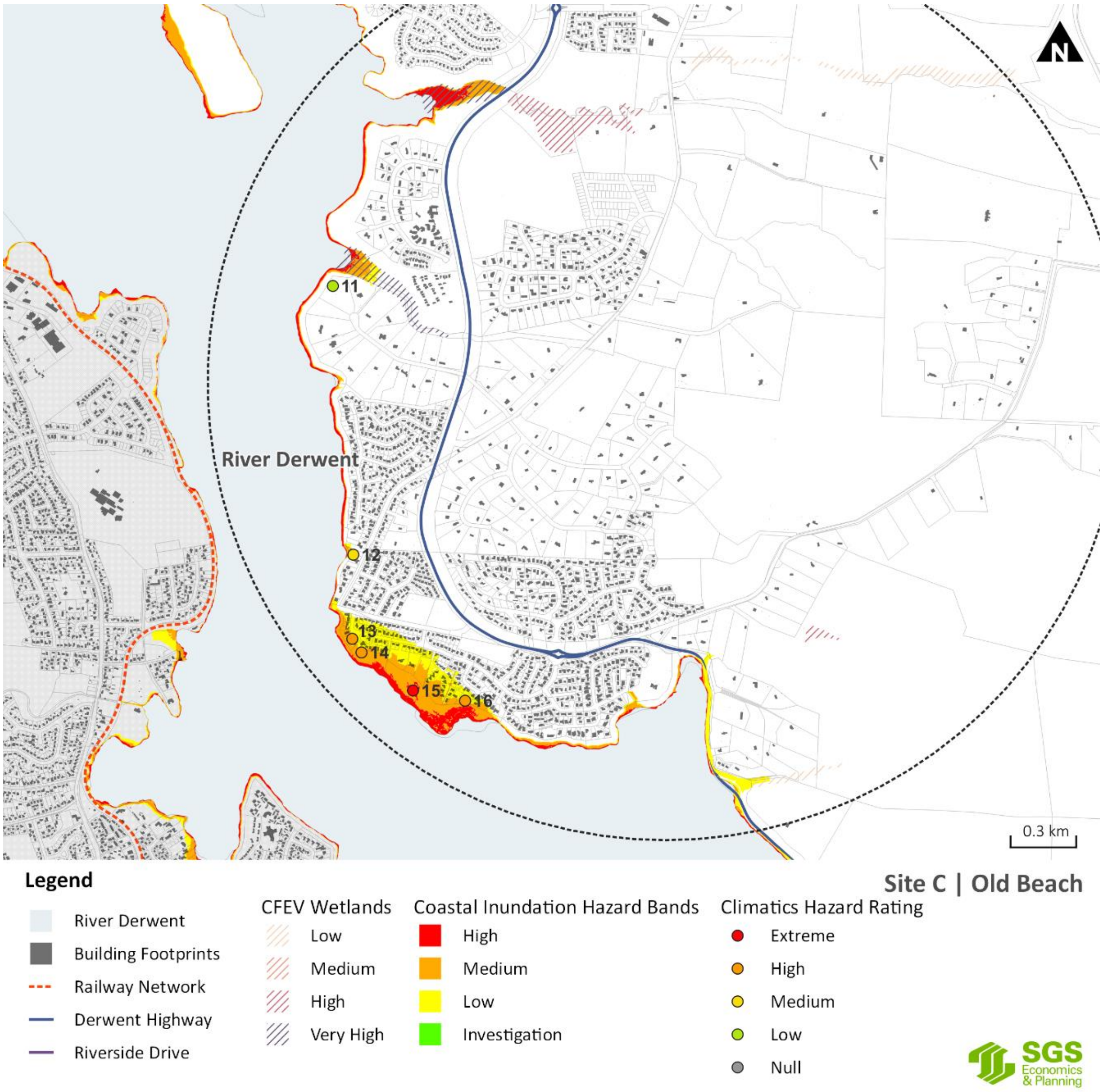
Most of the shoreline at Site C is vulnerable to coastal erosion to some degree, while there are a variety of natural values with which these hazard bands intersect. There are multiple inlets along the shoreline, the northernmost two of which are considered to have Very High integrated conservation value by CFEV. These inlets also have high risk hazard band coverage for coastal erosion, suggesting that they are currently vulnerable to coastal recession. These sites are also considered to have moderate to high priority in the Derwent Estuary natural values dataset. There are also multiple threatened native vegetation communities, including wetlands which incorporate the above-mentioned vulnerable inlets, along the northern coast of Site C, which is vulnerable to coastal erosion. This is shown in Figure 17, which also highlights pockets of threatened Eucalyptus amygdalina and Eucalyptus globulus dry forest and woodland, at the southern end of Site C's coastline. However currently, these natural values are not at risk of coastal erosion.

5.4 Coastal Inundation Hazards

Future coastal inundation risks will increase as climate change leads to sea levels to rise. Coastal sea level rise mapping of Site C (Figure 20) reveals areas with low, medium and high coastal inundation hazard bands:

- High hazard band: the entire length of the foreshore along the Derwent River is classified as a high coastal inundation hazard band and will be within 0.2m SLR from MHT line by 2050 and is currently impacted by the Highest Astronomical Tide. During extreme events, inundation affects land across the walking track, and in some cases, water has already flowed over the track without causing (substantial) damage.
- Medium hazard band: set back from the medium hazard band along the Derwent River foreshore, moving inland, land is classified as a medium hazard band, meaning the area is vulnerable to a 1% AEP storm event in 2050 and will be impacted by a 0.8m SLR by 2100. Most significantly, the medium hazard band encompasses private properties on Sun Valley Drive and Fouche Avenue, south of the boat ramp. The medium hazard band also covers the Gage Brook tributary, to the north of the site, and stretches inland to the East Derwent Highway.
- Low hazard band: land abutting the medium hazard band, inland, is vulnerable to a 1% AEP storm event in 2100 and medium-term flooding issues. Most significantly, the low hazard band encompasses private properties on Jetty Road, Sun Valley Drive and Fouche Avenue, south of the boat ramp.

FIGURE 20: SITE C - COASTAL INUNDATION



Source: SGS Economics and Planning, 2023

Verification with Climatics

As Figure 20 shows, effectively the entire foreshore of Site C is at some level of risk from coastal inundation. The worst affected area is the council-maintained Old Beach foreshore walk, where the inundation risk extends inland further than along the rest of the foreshore. SGS used Climatics data to verify these hazard risks, by identifying several representative locations within Site C to assess their exposure to range of climate hazards. The open space to the south of the foreshore walk is assessed to be at extreme risk, or that there is a theoretical direct impact from a 1-in-20-year flooding event. Elsewhere along the foreshore, areas are at medium to high risk, including residential land near the foreshore walk. This aligns with the coastal inundation hazard bands identified by DPAC, some of which cover residential land adjacent to the foreshore walk.

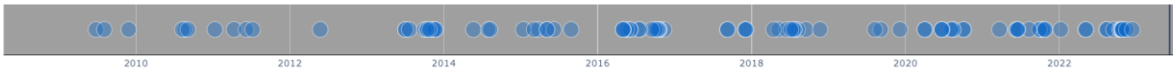
TABLE 23: RISK RATING ALIGNMENT BETWEEN CLIMATICS AND DPAC, SITE C

Location	Climatics risk rating	DPAC Hazard band	Alignment
11	Low: flooding impact on this site with 1% AEP	Null	Both predict no direct impact from flooding
12	Medium: Flooding impact on this site with 1% AEP	Low	Climatics (1% AEP currently) predicts greater risk than DPAC (1% AEP by 2100).
13	High: Flooding impact on this site with 2% AEP	Medium	Climatics (2% AEP currently) predicts greater risk than DPAC (1% AEP by 2050).
14	High: Flooding impact on this site with 2% AEP	Medium	Climatics (2% AEP currently) predicts greater risk than DPAC (1% AEP by 2050).
15	Extreme: Flooding impact on this site with 5% AEP	Medium	Climatics (5% AEP currently) predicts greater risk than DPAC (1% AEP by 2100). This is the biggest deviation across all locations.
16	High: Flooding impact on this site with 2% AEP	Medium	Climatics (2% AEP currently) predicts greater risk than DPAC (1% AEP by 2050).

Source: Climatics; DPAC; SGS Economics and Planning, 2023

The Derwent River foreshore walk is an area of particular concern, identified by both datasets. The coastal inundation hazard bands extend further inland in this area than along the rest of the foreshore, and the sites analysed using Climatics data all demonstrated high to extreme risk. Figure 21 below demonstrates a trend of increasing frequency of flood events over the last decade along the Derwent River foreshore walk.

FIGURE 21: TIMELINE OF FLOOD EVENTS AT SITE C



Source: Climatics

5.5 Coastal Inundation Assets at Risk

Inundation is the most significant risk to this study area, and over time will increasingly expose both public assets and private dwellings, if nothing is done to manage the risk. Especially the number of dwellings at risk in the future is a point of concern. Initially Crown land and public assets such as the walking track will be at risk, but as sea levels continue to rise, these risks will also affect dwellings. Notably, a small section of the East Derwent Highway (State Government owned) at the southern end of the Old Beach site is also at risk.

Currently, the extent of inundation is very limited and does not affect existing residential dwelling, although parts of the land of properties is at a low-level risk (i.e., gardens). There are several vacant land parcels that will need to consider inundation risk in their design to withstand 1%AEP events in the future. However, as the risk increases, it is anticipated that 19 properties may face the possibility of being inundated by a 1% AEP storm event in 2050. And these properties would be regularly inundated by 2100 or a sea level rise of 0.8m.

Over the long term, the risk of a 1% AEP storm event in 2100 will continue to escalate, leading to a significant number of additional houses being at risk of inundation, which include an additional 62 properties. As well, a larger amount of public infrastructure will also be susceptible to inundation as the timeframe progresses.

TABLE 24: VALUES OF PROPERTIES AT RISK (ADJUSTED CAPITAL, EXCLUDING LAND VALUES) – INUNDATION RISK

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Private properties	0	0	8,297,500	18	35,577,500	79
Government-owned properties	0	0	102,500	1	103,300	2
Total	**0**	**0**	**8,400,000**	**19**	**35,680,800**	**81**

Source: SGS Economics and Planning, 2023
Note: Includes 20 properties that may be affected by a low risk of inundation on Morrisby Rd. Values have been estimated based on average prices for Site C.

Certain parts of the hiking trail are at risk at present day, and this will increase substantially over time with greater parts of the Crown land and public infrastructure at risk.

TABLE 25: VALUES OF PUBLIC INFRASTRUCTURE AT RISK – INUNDATION RISK

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Boat Ramp	$0	0	$37,433	1	$37,433	1
Roads	$0	0	$110,934	0.27km	$489,050	1.19km
Hiking Track	$0	0	$26,144	0.3km	$26,144	0.3km
Total	**$0**	**N/A**	**$174,511**	**N/A**	**$552,627**	**N/A**

Source: SGS Economics and Planning, 2023
Note: Boat Ramp derived from costs of land backed wharve (precast concrete interlocking piles and reinforced concrete ground slab) (no electrical and water services), Roads based on composite price of suburban road with in situ concrete kerbs (6m wide), Trail calculated based on paved footpath (1500mm wide)

The study area has a relatively large parcel of foreshore Crown land which is particularly vulnerable to inundation, particularly the area adjacent to the hiking trail. Most highlighted in the table below is that inundation from a 1% AEP storm event poses a high risk to the present day.

TABLE 26: NON-VALUED ASSETS AT RISK – INUNDATION RISK

Asset	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	12.55	15.03	15.03

Source: SGS Economics and Planning, 2023

Approximately, 21 Aboriginal Heritage items are covered by high coastal inundation hazard bands in Site C. About four items are not at risk of inundation.

The northern inlets which are considered to have Very High integrated conservation values are also at risk from coastal inundation, high and medium hazard bands. This suggests that these wetlands and other natural values at these locations are vulnerable to sea level rise by between 2050 and 2100, if not affected by storm events prior. The threatened native vegetation clusters containing eucalyptus globulus and eucalyptus amygdalina dry forest and woodland communities are threatened by low to medium hazard bands for coastal inundation, indicating vulnerability to sea level rise by the end of the century. At the Derwent River foreshore walk, there is a pocket of medium integrated conservation value saltmarsh identified by CFEV that are covered by medium to high coastal inundation hazard bands.

5.6 Stormwater hazards

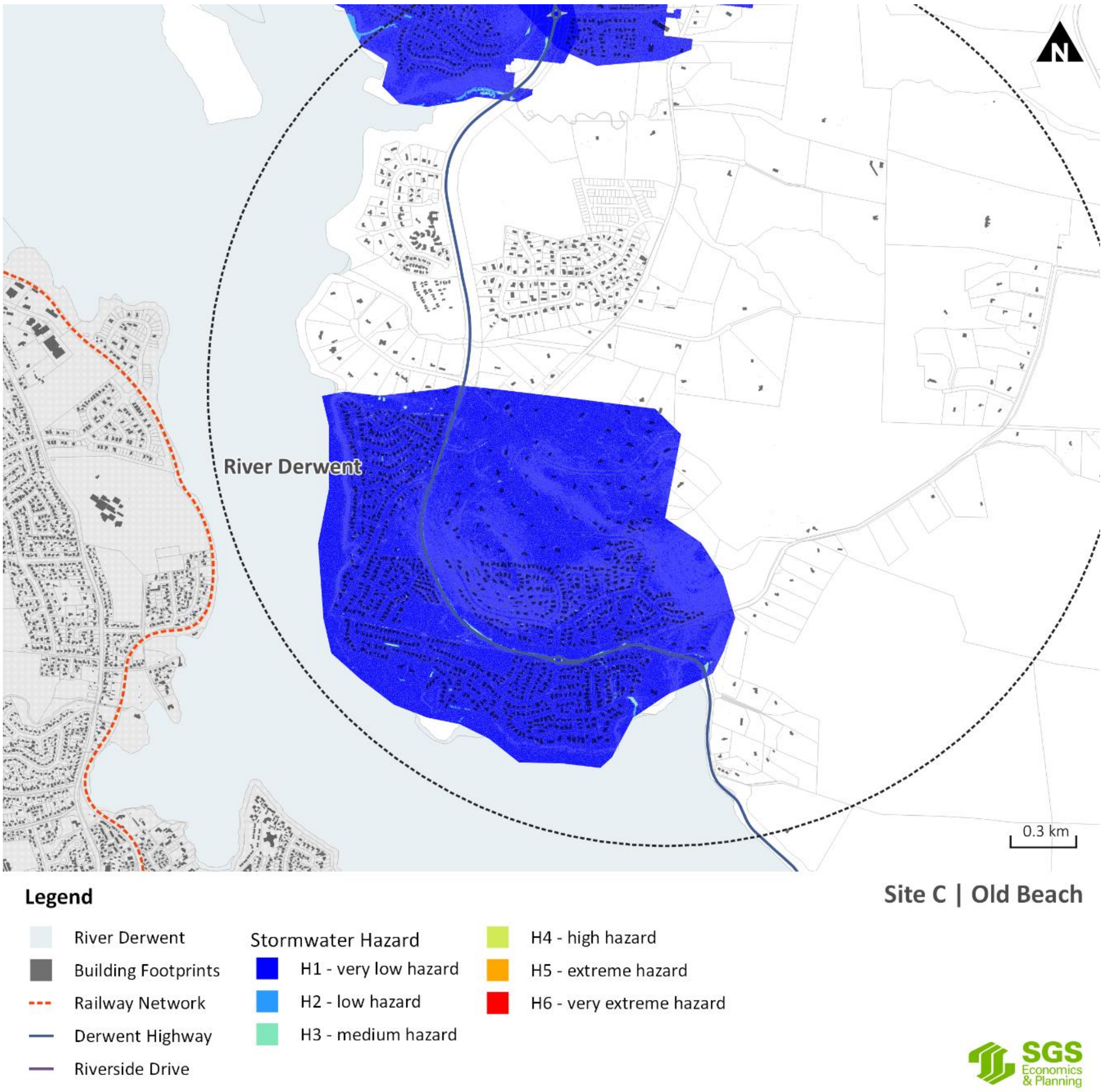
A significant area of land in Site C is vulnerable to stormwater drainage hazards (Figure 22). This area includes residential, recreational, and private uses. With sea level rise it is reasonable to assume that stormwater drainage issues, such as the need to manage stormwater via the overflow, will gradually increase over time. Contributing factors are increased water table and higher storm surges.

Several hundred houses and other buildings are at very low risk. Public infrastructure at very low risk includes the East Derwent Highway (State Government owned) and the Old Beach Jetty.

About 11 Aboriginal Heritage items are at a very low risk from Stormwater hazards.

The area of stormwater hazard overlaps with areas assessed with natural values ranging from lowest to moderate priority along the coastline, including the Old Beach saltmarshes.

FIGURE 22: SITE C - STORMWATER HAZARDS



Source: SGS Economics and Planning, 2023

5.7 Summary

Site C stands out as the most concentrated and densely populated area compared to the other sites and is home to a relatively larger community. Consequently, the risk of both coastal erosion and inundation, although primarily confined to the vicinity of the riverbank, is projected to have a more significant impact on the community residing in Site C. Despite numerous businesses and organisations located here, they are unlikely to be affected by coastal hazards as they are located inland away from hazards.

At present day, there are no residential properties potentially at risk of either erosion or inundation. As the potential for erosion and inundation escalates to the medium hazard band, approximately 20 residential properties may be impacted, with a total value of about $9.6 million. This value is expected to grow with a low-risk hazard band, whereby, a total of 101 properties is potentially at risk of erosion and inundation due to extreme events. The total value of these properties is around $47.1 million.

TABLE 27: VALUES OF PRIVATE PROPERTIES AT RISK (ADJUSTED CAPITAL, EXCLUDING LAND VALUES)

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Private properties	0	0	9,500,000	20	46,998,300	100
Government-owned properties	0	0	102,500	1	103,300	1
Total	**0**	**0**	**9,602,500**	**21**	**47,101,600**	**101**

Source: SGS Economics and Planning, 2023

Site C is also home to public assets that is expected to be at risk of erosion, storm events and inundation, including roads, footpaths and a boat ramp.

TABLE 28: VALUES OF PUBLIC INFRASTRUCTURE AT RISK

Asset	High Risk Hazard Band		Medium Risk Hazard Band		Low Risk Hazard Band	
	Capital Value ($)	Count	Capital Value ($)	Count	Capital Value ($)	Count
Boat Ramp	0	0	126,294	1	126,294	1
Roads	4,917	0.0km	93,343	0.2km	1,079,989	2.6km
Track	22,761	0.2km	184,550	1.8km	243,382	2.4km
Total	**153,971**	**N/A**	**404,187**	**N/A**	**1,449,664**	**N/A**

Source: SGS Economics and Planning, 2023
Note: Boat Ramp derived from costs of land backed wharve (precast concrete interlocking piles and reinforced concrete ground slab) (no electrical and water services), Roads based on composite price of suburban road with in situ concrete kerbs (6m wide), Trail calculated based on paved footpath (1500mm wide)

The foreshore is expected to be at risk of erosion, storm events and inundation, summarised in the following table.

TABLE 29: NON-VALUED ASSETS AT RISK

Asset	High Risk Hazard Band	Medium Risk Hazard Band	Low Risk Hazard Band
Open space (ha)	12.83	15.61	19.65

Source: SGS Economics and Planning, 2023

12 Aboriginal Heritage items are at varying risks from coastal erosion, while 21 are at high risk from inundation. About 11 Aboriginal Heritage items are at a very low risk from stormwater hazards.

Site C is home to a variety of natural values, including threatened native vegetation communities, in particular wetlands in the north of the site, which include inlets that are considered to have Very High integrated conservation value. These natural values are particularly vulnerable to both coastal erosion – being at risk of coastal recession currently – and coastal inundation, with sea level rise posing the risk of submerging the sites by between 2050 and 2100.

6. Adaptation pathways

6.1 Overview

Adaptation pathways consist of complementary options that can be implemented simultaneously and consecutively over time to manage coastal risk and protect values. Adaptation pathways may vary from 'protect at all cost' to 'planned retreat' and anything in between. Each pathway has its own consequences. For example, the construction of levees may protect property from floods and erosion but reduce the recreation and natural values of the foreshore. A retreat pathway could mean that an area at risk may no longer be suitable for residential or recreational purposes but natural values may be retained.

Pathways are described further in the following section.

6.2 Pathways considered

Business as usual

This pathway may also be referred to as the 'do nothing' pathway, however it would be an active decision to follow it. Doing nothing comes with its own costs and consequences, such as the forced retreat of housing, infrastructure and services from the affected coastline, as well as any damage caused to the natural and built environments as a result of the increasing severity of coastal hazards. Recurrent repair costs for affected properties would build up without the intervention of adaptation measures.

Pathway 1 – minimum intervention

This pathway allows maximum freedom for natural foreshore processes to unfold with a minimum of intervention from existing or new development, or flood and erosion protection works. Where erosion threatens structures with failure in the short term, they would be removed. Likewise, where inundation repeatedly impacts a property, it would eventually become not worth repairing and would likely be abandoned. Little to no development would be allowed in hazard areas, and there would be no intensification in existing at-risk areas.

Property owners would be allowed to take action that extends the life of their existing structures, within their own property boundary if it has no impact on adjacent properties or areas. Filling and raising land would generally not be allowed, nor would hardening shorelines with rocks or concrete or even dune or beach nourishment.

Implications and Costs under pathway 1

The most significant costs would be the loss of the foreshore walkway and of residential land as a result of retreat (in the ballpark of $16 million). Management options, for which the costs are uncertain, include vegetation management, emergency management planning, managed retreat (deconstruction and decommissioning structures and services) and the fact that (infill) development would no longer be allowed, which could result in an opportunity cost for some properties.

Specifically, the potential implications and costs of pathway 1 are:

- Flood/erosion damages to the walkway
- Flood/erosion damage expenses to dwellings, sheds and other structures. The amount depends upon level of reinvestment/maintenance of property in hazard areas, degree of investment in protection, effectiveness of warnings and community response
- Land value lost to current owners
- Emergency services expenditure (limited if residents leave before major event- unlikely; higher if leave after major event, but depending on effectiveness of emergency planning)
- Some other infrastructure reconfiguration
- Reduced community use and sense of place due to loss of walkway and foreshore access.
- Psychological impact of 'decline' of a coastal community

Pathway 2 – protecting the coast

This pathway concentrates on protecting the existing future community and property. It assumes that the rate and extent of change in erosion and inundation hazards will be manageable using any necessary protection and adaptation options. This includes some of the adaptation measures not permitted under the previous pathway, including filling and raising land, rock revetment and seawall construction. It is assumed that these adaptation measures would be paid for, at least in part by the beneficiaries; the property owners.

Intensification is permitted where it does not compromise community values for the suburb, and can be proven to be safe given the adaptation measures taken. Intensification of residential development enables more parties to contribute to the costs of protection. While natural areas may be affected, they will adapt in their own way or become modified in ways that the community accepts.

How might things proceed with this pathway?

The foreshore public open space area will be made more amenable and have higher recreation values. The foreshore along the Old Beach Foreshore Trail will need, in addition to vegetation management, to be hardened with a rock revetment to prevent ongoing erosion, which is likely needed around 2030.

Hardening of the shore would protect the community from shoreline erosion and recession for a long time (but not indefinitely). A revetment would reduce the need for individual properties to address erosion hazards. The costs of the revetment, to be borne by those who benefit from it, are substantial. Significant intensification of development would be a means to reduce the burden of costs per property owner. This would change the character of the neighbourhood. The foreshore around the Old Beach Boat Ramp and to the north along Jetty Road, may need armouring to prevent undermining of foreshore properties.

New development and redevelopment/major extensions would be required to be built in a way to withstand erosion risks for the lifetime of the asset and/or with the floor above the expected maximum annual high tide for the lifetime of the structure plus a freeboard allowance.

The low-lying land that is susceptible to inundation, now and in the future, would need to be filled and infrastructure and services would need to be raised as they become exposed to inundation risks. To prevent adverse effects on adjoining residential properties there will be a need for a stormwater drainage plan which allows parts of the neighbourhood to be filled and raised gradually over time. Consistent filling of land will also minimise overflowing issues with septic systems.

Areas potentially becoming wetlands (if not filled) would be filled to allow for intensification of development in the community. This could have impacts on flood risks from stormwater due to rainfall. There would be a need to invest in stormwater drainage channels/pipes as flow dynamics may be altered due to the filling of land. The reclamation of wetland areas increases the value of land from what is typically for environmental land to the value of low and medium density residential land. The cost of filling the land may be offset by rezoning and related value uplift.

Likely options within this pathway

The main options within this pathway are: vegetation management, revetment wall and raising land and infrastructure assets.

FIGURE 23: EXAMPLES OF OPTIONS ALLOWABLE UNDER PATHWAY 2

Armouring river banks

Rock revetment that is aesthetically pleasing, Hawkesbury River NSW

Fill to raise land levels

Improved stormwater drainage

Other implications and costs include:

- Reduced flood/erosion direct and indirect damage expenses (private and public property)
- Much less property lost

- Reduced emergency services expenditure
- Community value of enhanced foreshore recreation value
- Some other infrastructure reconfiguration.

6.3 Community feedback on pathways

Through a community workshop held on 7th November 2023, participants explored the consequences of following the above pathways, including the positive and negatives and how would the pathway happen?

Participants were generally more supportive of Pathway 2 that protects the existing and future assets and community values, especially for site C where there are a greater number of assets to protect. Participants were receptive to Pathway 1 for Site A, where there are fewer built assets to protect. Table 30 summarises discussions on each pathway.

TABLE 30: COMMUNITY FEEDBACK ON PATHWAYS 1 & 2

	Adaptation pathway 1	Adaptation pathway 2
Description	Maximum freedom of natural foreshore processes is allowed to unfold with minimum intervention or resistance	Protecting existing and future community and property using any necessary protection and adaptation options
Pros	▪ It allows current residents to take action ▪ Less impact on wildlife (compared to pathway 2) ▪ It provides an opportunity for community to work together, demonstrating collective responsibility ▪ Aboriginal Middens are left as they are ▪ Brighton Council would be invested in planning to find solutions (prevention before crisis)	▪ Properties and the foreshore would be protected ▪ Allow for intensification of development, therefore enabling more participants to contribute to the costs of protection works ▪ Protection works could help to stabilize insurance costs ▪ IT would protect community values of shared, recreational spaces such as the river path and jetty ▪ Costs could be shared more easily between stakeholders (including state and local government) ▪ It provides an opportunity to invest in stormwater waste management for all of Brighton municipality ▪ It is an opportunity for Bright Council to be 'ground-breakers' and leaders of climate action along with property owners
Cons	▪ The foreshore walkway and recreation areas would be lost ▪ Loss of saltwater marshes ▪ There would be a risk of flooding ▪ Homeowners would be liable ▪ There would be cost implications for some residents ▪ It would not address stormwater issues ▪ Properties may lose value and/or become unsellable	▪ The cost of protection works ▪ The inconvenience of protection works caused to residents ▪ There are potential unknown consequences in this pathway, such as, the consequences of protection works on the environment. The protection works could result in changed to the river which may impact the saltmarshes and river flow ▪ It may take too long to formulate solutions

	Adaptation pathway 1	Adaptation pathway 2
	▪ Residents may not have the opportunity to stay in their homes ▪ There would be limited opportunity for residents to protect their property ▪ Other stakeholders (organisations, local government) may install infrastructure and not share it with the community	▪ There is potential for lobby groups, or others, to influence the outcomes of this pathway ▪ The protection works rely on expert advice, which may be inconsistent and result in different strategies to mitigate issues
Further considerations and requirements	▪ Further community consultation would be required to meet a consensus on the pathway ▪ Who gets to determine property value? ▪ What level of government assistance is expected? ▪ What recreation spaces will replace the loss of the walkway and/or jetty? ▪ Council would need to be transparent, continually updating the community on the process ▪ There should be research on how other local areas are addressing similar issues ▪ Council and government could formulate policy and guidelines for homeowners to take action ▪ A federal strategy could provide greater guidance ▪ There could be a land swap incentive for affected properties	▪ A levy and/or rates ▪ Tas Rail should pay to protect existing rail infrastructure ▪ There needs to be continuous community engagement and stakeholder engagement, whereby everyone is given an equal voice ▪ The wellbeing areas of the riverfront should be promoted to the broader community to help them understand why it is important to protect

Source: SGS Economics and Planning, 2023

7. Cost benefit analysis

7.1 Overview

To understand which pathway may generate the best overall outcomes to the community, a Cost-Benefit Analysis (CBA) is a useful economic appraisal tool. CBAs compare the costs and benefits of a base case against a project case(s). The Net Present Value (NPV) represents the incremental benefits generated in the project case less the incremental costs incurred. That is, the benefits and costs realised above what would have been realised in the base case. Likewise, the Benefit-Cost Ratio (BCR) represents the incremental benefits divided by the incremental costs, otherwise, the return on investment.

- Base Case: Business as Usual (BaU) or doing nothing (i.e. not managing the risk)
- Project Case 1: Adaptation pathway 1
- Project Case 2: Adaptation pathway 2

While performance indicators like BCR and NPV are relevant, it should be stressed that not all costs and benefits can be expressed in dollar terms. Community wellbeing, social cohesion and preservation of Aboriginal heritage are just a few values that have not been expressed in dollar terms in this study, which is not an indication that they are less important than those benefits that have been monetised. The performance indicators should be interpreted in combination with the qualitative valuation of these important attributes.

In addition, planning for adaptation is subject to a range of uncertainties:

- The rate and level of climate change induced impacts, i.e. sea level rise and coastal erosion. Climate change and its impacts are now fairly well understood. But the exact amount of change by for instance 2050 and 2100 is still somewhat uncertain.
- The interaction with other changes, climate related or not, such as a trend towards more extreme rainfall events and its impact on drainage and flows in streams.
- The effectiveness of adaptation options and the costs.
- Changes in the world around us in terms of economic growth, demographic change and technological change.

The adaptation actions examined in this CBA have been derived by a literature review, but more accurate results could be derived with an engineer making site-specific estimates.

Our sensitivity analysis shows how adaptation options and their effectiveness may be impacted by these uncertainties.

7.2 Costs and Benefits

This section describes the costs and benefits of the two adaptation pathways for each of the three sites; and makes recommendations in relation to the preferred way forward.

The Types of Costs and Benefits

TABLE 31: COST ITEMS FOR BASE CASE AND ADAPTATION PATHWAYS

Base Case – Do nothing	Pathway 1: Foreshore increasingly erodes and community retreats early	Pathway 2: Protect development and support intensification as long as possible
Emergency management planning	Emergency management planning	Filling low-lying land to raise land levels and relocation of infrastructure and services
	Vegetation management	Investment in stormwater drainage infrastructure
	Property owners acting withing their property boundaries	Rock revetment OR Seawall construction to prevent erosion
	Installation of Culverts	Installation of Culverts
		Vegetation management

Source: SGS Economics and Planning, 2023

For the purposes of this CBA, the cost items presented Table 31 above have been grouped into a single item called adaptation costs for each of the base case and adaptation pathways. This is in order to examine the incremental costs incurred in each pathway above that which would have been incurred in the base case.

TABLE 32: BENEFIT ITEMS FOR BASE CASE AND ADAPTATION PATHWAYS

Pathway 1: Foreshore increasingly erodes and community retreats early	Pathway 2: Protect development and support intensification as long as possible
Avoided damage costs from reduced hazards	Avoided damage costs from reduced hazards
Retained natural values	Retained natural values
Improved community wellbeing	Land value uplift
	Improved community wellbeing

Source: SGS Economics and Planning, 2023

Details about the valuation of these costs and benefits are covered in Appendix D.

Costs – Site A

Base case

The base case is the 'do-nothing' scenario, and therefore, there are no adaptation costs relating to the prevention of the impacts of coastal erosion and inundation. However, it is assumed that investment in emergency management planning would occur in the form of a community awareness and evacuation program. This would not prevent any damage to the land or structures that are threatened, but would allow residents to safely evacuate in the event of flooding in particular, which will become more common over the remainder of the century. This costs $139,130 to establish (assumed to be in 2030), and $6,956 a year to maintain from then on. This is presented in Table 33 below.

TABLE 33: ADAPTATION COSTS UNDER THE BASE CASE, SITE A, 2024-2100

Adaptation	Lifecycle cost*	Present value*
Community awareness and evacuation program	$626,000	$158,000

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Pathway 1

As above, there is an investment in a community awareness and evacuation program to protect residents. Given that this cost is incurred in both the base case and pathway 1, it would be excluded from the analysis of this pathway as it is not an *incremental* cost. Other adaptation actions aimed at preventing damage from coastal inundation and erosion are applicable in this pathway, which are incremental costs to the base case. Across all sites, this includes, vegetation management, which would occur along the coast that is vulnerable to coastal erosion. The entire coastline in Site A is currently exposed to the high hazard band of coastal erosion. Wetlands would need to move landward. The installation of culverts would enable this. In Pathway 1, this has been assumed to occur in 2030, until which, some of the natural values of the wetlands may be lost. The total cost of adaptation pathway 1 is presented in Table 34 below.

TABLE 34: ADAPTATION COSTS UNDER PATHWAY 1, SITE A, 2024-2100

Adaptation	Lifecycle cost*	Present value*
Community awareness and evacuation program	$626,000	$158,000
Vegetation management	$3,687,000	$747,000
Installation of culverts	$2,087,000	$934,000
Incremental costs	**$5,774,000**	**$1,681,000**

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Pathway 2

Pathway 2 is focussed on protecting private property. While there are no private properties that fall within the respective hazard bands for coastal erosion and inundation, the severe risk posed to the wetlands that are the backyard of these properties suggests that in this pathway, houses would still opt for protection. This means that the land of these properties is filled and raised above flood levels, as well as to fortify it against coastal erosion. Likewise, foreshore hardening would occur along the affected coastline. This would mean that the wetlands would be completely lost, while the properties would be protected. The costs are presented in Table 35 below.

TABLE 35: ADAPTATION COSTS UNDER PATHWAY 2, SITE A, 2024-2100

Adaptation	Lifecycle cost*	Present value*
Community awareness and evacuation program	$626,000	$158,000
Vegetation management	$461,000	$369,000
Filling and raising land	$1,316,000	$924,000
Foreshore hardening	$14,567,000	$9,707,000
Incremental costs	**$16,344,000**	**$11,000,000**

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Benefits – Site A

This section describes the benefits of the adaptation pathways for Site A against the base case, i.e. the do nothing scenario.

Avoided damage costs

Pathway 1

In pathway 1, it is assumed that as sea level rises and the wetlands slowly becomes wetter, the culverts are installed, and that the wetlands have the ability to move landward, channelled to safer, higher ground, north of the railway track. Other benefits, such as community wellbeing and land value uplift are not applicable to Site A as there are no private properties at risk. The rail line between the wetlands and private properties is at risk, however. It is assumed that the installation of culverts as well as other techniques like vegetation management have some mitigating effect on damage to the railway line, and so half of potential damage to it has been modelled to be avoided.

The natural values of the wetlands at Site A have not been specifically valued, although wetlands can be of significant monetary value in certain contexts. A 2014 US study[26] found that the median value which

[26] Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S. J., Kubiszewski, I., ... & Turner, R. K. (2014). Changes in the global value of ecosystem services. Global environmental change, 26, 152-158.

is $12,163 per hectare per year (A25,343 today). However, there is no detailed understanding of the ecological values of the wetlands at Site A. The benefit is shown in Table 36 below.

TABLE 36: AVOIDED COST OF RISK UNDER PATHWAY 1, SITE A 2024-2100

Avoided cost of risk	Lifecycle cost*	Present value*
Avoided cost of risk (rail line)	$1,467,000	$157,000

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Pathway 2

In pathway 2, interventions are taken to protect private property, rather than the wetlands. This means that the potential loss of natural values is not avoided, as the wetlands would be inundated and lost while protections would be implemented further inland, where there are private properties.

As there are no private dwellings at risk, the only asset at risk to inundation is the rail line in the medium to long term. The benefit of the avoided damage is presented in Table 37 below. However, as SGS has been unable to consult with TasRail, the cost of risk may be under- or overestimated.

TABLE 37: AVOIDED COST OF RISK UNDER PATHWAY 2, SITE A, 2024-2100

Avoided cost of risk	Lifecycle cost*	Present value*
Avoided cost of risk (rail line)	$2,834,000	$313,000

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Improved community health and wellbeing

With no private properties or community infrastructure at risk at site A, there is a negligible impact on community health and wellbeing.

Retention of foreshore amenity

There is significant foreshore amenity in Site A, due the presence of the wetlands and salt marshes on the banks of the River Derwent. The loss of wetlands would likely reduce the amenity of the foreshore for residents, in a similar way as the base case.

Costs – Site B

Base case

The base case in Site B is the same as the base case in Site A, as it is the ‘do-nothing’ scenario.

Pathway 1

As above, there is an investment in an community awareness and evacuation program to protect residents. In addition, adaptation actions are aimed at preventing damage from coastal inundation and erosion. This includes, most notably, vegetation management. Under pathway 1, all coastline exposed to erosion.

Both north and south of the bridge several private properties are at risk of erosion and inundation in the short, medium and long term. 18 are at risk by 2050, and 21 are at risk by 2100.

Property owners would be able to act within their property boundaries to protect their assets from the coastal hazards under this pathway. They would not be allowed to harden foreshore under this pathway. Rather, they would be allowed to undertake vegetation management, raise buildings, move buildings out of harm's way and/or protect them with flood skirts. The total cost of adaptation pathway 1 is presented in Table 38 below, and estimated to have a present value of approximately $1 million.

TABLE 38: ADAPTATION COSTS UNDER PATHWAY 1, SITE B, 2024-2100

Adaptation	Lifecycle cost*	Present value*
Community awareness and evacuation program	$626,000	$158,000
Vegetation management	$3,461,000	$611,000
Property owners' adaptation	$1,171,000	$363,000
Incremental costs	**$4,632,000**	**$974,000**

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Pathway 2

Pathway 2 involves a series of more capital-intensive adaptation measures aimed at protecting the private property at risk of erosion and inundation.

There are 18 properties directly on the foreshore north of Bridgewater Bridge, intersected by medium-to-high hazard bands. To the south of it, a further three properties are at low-to-medium risk. Table 45 below presents the cost estimates for the options. Given that there are more intensive protective measures in place in pathway 2 for site B, it is assumed that there would not be a need for a community awareness and evacuation program, as the intention of this pathway would be to prevent damage to residential property.

Low lying areas will be filled and provided with improved stormwater drainage. The rock revetment will be placed along the foreshore areas that are susceptible to erosion once the erosion risk becomes too high. Until that time, erosion will be managed through vegetation management. Foreshore hardening would be implemented at the sites of most acute need. In site B, this would be to the north of Bridgewater Bridge and has been assumed to occur in 2030, due to several properties being at high risk already. These cost items are demonstrated in Figure 24 in Appendix D, while the cost items are shown in Table 39 below.

TABLE 39: ADAPTATION COSTS UNDER PATHWAY 2, SITE B, SITE B, 2024-2100

Adaptation	Lifecycle cost*	Present value*
Property owners' adaptation	$1,171,000	$363,000
Foreshore hardening	$8,170,000	$3,169,000
Stormwater drainage investment	$2,446,000	$352,000
Vegetation management	$2,265,000	$368,000
Incremental costs	**$13,501,000**	**$4,165,000**

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Benefits – Site B

Avoided damages

Pathway 1

In pathway 1, shoreline recession will result in some loss of land over time similar to the base case. Adaptation does enable private properties to be occupied for longer resulting in avoided damages compared to the base case. The present value of avoided damages is around $573,000 (Table 40).

TABLE 40: AVOIDED DAMAGES UNDER PATHWAY 1, SITE B 2024-2100

Avoided cost of risk	Lifecycle cost*	Present value*
Avoided cost of risk (capital value)	$13,573,000	$573,000

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Pathway 2

In pathway 2, it is assumed that where foreshore hardening occurs, all damage from coastal erosion and inundation is able to be prevented, provided there is adequate expenditure on maintenance and repairs of the preventative infrastructure. This means that residents would be protected from being forced to demolish or relocate their dwellings. Therefore, the benefit exists of avoided damages and avoided need to demolish and relocate. The present value of avoided costs is approximately $3.2 million compared to the base case. This is shown in Table 41.

TABLE 41: AVOIDED COST OF RISK UNDER PATHWAY 2, SITE B, 2024-2100

Avoided cost of risk	Lifecycle cost*	Present value*
Avoided cost of risk (capital value)	$20,583,000	$886,000
Avoided loss of property value	$2,612,000	$66,000
Avoided relocation costs	$26,996,000	$2,231,000
Incremental benefit	**$50,191,000**	**$3,183,000**

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Avoided cost of risk represents the damage that would be avoided by the adaptation measures taken. For example, if filling and raising a property successfully protects it from a coastal inundation event, then the damage avoided would be avoided cost of risk.

Avoided loss of property value refers to those properties that would not be abandoned under pathway 2 as they have been successfully protected from coastal erosion by the adaptation measures taken. Likewise, when properties would be abandoned under the base case, the residents would also have to relocate. Avoided relocation costs represents the benefit of not being forced to relocate away from the coast.

Land value uplift

There are no vacant lots in Site B that would be able to be developed under either pathway. Development should be discouraged along the coast in this highly constrained area.

Improved community health and wellbeing

The mental health impacts of repeated exposure to climate hazards has been quantified by NSW Treasury in their flood CBA tool technical note[27]. The cumulative mental health cost for a flood event that is less than 30cm above floor level is $5,331 per household. For a flood event between 30cm and 1 metre above floor level, this cost rises to $8,586, and for floods over 1 metre, $11,651. SGS has assumed the middle figure of $8,586 to represent the mental health impacts of a flood on each household.

The improvement in terms of avoided mental health costs is the highest for pathway 2, as more property is protected. This is presented in Table 48 below with a mental health benefit for pathway 2 of $33,000 (present value), and $19,000 for pathway 1 (Table 42).

[27] https://www.treasury.nsw.gov.au/sites/default/files/2023-10/20231030_flood-cost-benefit-analysis-tool_technical_note.pdf

TABLE 42: IMPROVED COMMUNITY WELLBEING - MENTAL HEALTH - IN EACH PATHWAY, SITE B, 2024-2100

Benefit	Lifecycle cost*	Present value*
Pathway 1	$659,000	$19,000
Pathway 2	$997,000	$33,000

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Aboriginal Cultural heritage

Shell middens are collections of remains of meals of shellfish once gathered and eaten by Aboriginal people on the foreshore. Though they have not been quantified, they are protected by law, by the *Aboriginal Heritage Act 1975*, and therefore protection of this Tasmanian Aboriginal cultural heritage should be considered when determining the best adaptation pathway. It is important to understand the preferred methods of preservation of these shell middens, which do not necessarily entail protecting the physical materials. In fact, some of the more intensive adaptation actions like rock revetment could actually redirect damage to other parts of the coast which could contain other sites of cultural importance.

There are six known Aboriginal cultural heritage items that are intersected by the coastal inundation hazard bands in Site B. Under the base case, these shell middens would inevitably be destroyed. Under pathway 1, these shell middens may be protected from the impacts of coastal inundation, however as sea level rise continues to increase over the rest of the century, these sites would inevitably be inundated. Under pathway 2, rock revetment would protect these sites, and their loss may be slowed by the interventions taken. Given that there are likely to be undiscovered shell middens, it is also possible that the interventions themselves could damage some sites. However, this would still be the best scenario for physically protecting these sites.

Reduced emergency services expenditure

Emergency services expenditure after a natural disaster will vary depending on the severity and spread of the impacts, as well as what type of response is required, which cannot be predicted accurately over a long period of time. The Australia Government Disaster Recovery Payment (AGDRP) provides a single payment for residents adversely affected by the floods that affected Tasmania in October 2022, of $1,000 per adult and $400 per child, which can be taken as a proxy for disaster recovery expenditure.

However, the NSW treasury guidelines for flood CBAs suggest that emergency management - including the cost of evacuations, rescue and supply of essential goods and services – should not be included[28], and therefore, this benefit has not been quantified.

[28] https://www.treasury.nsw.gov.au/sites/default/files/2023-10/20231030_flood-cost-benefit-analysis-tool_technical_note.pdf, table 11

Costs – Site C

Base case

The base case in Site C is the same as the base case in Sites A and B, as it is the 'do-nothing' scenario.

Pathway 1

As above, there is an investment in a community awareness and evacuation program to protect residents. In Site C, there is an area of rocky shore that is already relatively protected from coastal hazards as shown in Figure 25 in Appendix D. Vegetation management would mostly occur along the along the foreshore walkway, as well as at some high risk inlets in the north of the site. Property owners would also be able to act within their own boundaries to protect their assets from the coastal hazards. The total cost of adaptation pathway 1 is presented in Table 43 below, and is estimated to be close to a present value of $800,000.

TABLE 43: ADAPTATION COSTS UNDER PATHWAY 1, SITE C, 2024-2100

Adaptation	Lifecycle cost*	Present value*
Community awareness and evacuation program	$626,000	$158,000
Vegetation management	$3,254,000	$498,000
Property owners' adaptation	$2,211,000	$296,000
Incremental costs	**$5,464,000**	**$794,000**

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Pathway 2

In pathway 2 Low lying areas will be filled and provided with improved stormwater drainage. The rock revetment will be placed along the foreshore areas that are susceptible to erosion once the erosion risk becomes too high. Until that time, erosion will be managed through vegetation management. As Figure 25 in Appendix D shows, the coastline along which the foreshore walkway runs, is predominantly covered by high hazard band for coastal erosion, and this is where foreshore hardening such as rock revetment would be implemented, assumed to occur first in 2030. It would be further extended around 2050 to cover areas exposed to the medium hazard band. The cost items presented in Table 44 below.

TABLE 44: ADAPTATION COSTS UNDER PATHWAY 2, SITE C, 2024-2100

Adaptation	Lifecycle cost*	Present value*
Property owners' adaptation	$2,211,000	$296,000
Rock revetment	$9,964,000	$4,196,000

Adaptation	Lifecycle cost*	Present value*
Stormwater drainage investment	$2,446,000	$352,000
Vegetation management	$232,000	$123,000
Incremental costs	**$14,227,000**	**$4,809,000**

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Benefits Site C

Avoided damages

Pathway 1

In pathway 1, some damage to the properties is avoided, while the land is eventually lost due to erosion. Impacted houses will have to be abandoned and demolished or relocated. The avoided damages have a present value of $578,000 (Table 45).

TABLE 45: AVOIDED COST OF RISK UNDER PATHWAY 1, SITE C, 2024-2100

Avoided cost of risk	Lifecycle cost*	Present value*
Avoided cost of risk (capital value)	$20,565,000	$578,000

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000
** Not included as the value of wetlands is unknown

Pathway 2

In pathway 2, it is assumed that the interventions can prevent all damage from coastal erosion and inundation, provided there is adequate expenditure on maintenance and repairs of the preventative infrastructure. It also means that residents would be protected from being required to demolish or relocate their dwellings. The benefit is shown Table 46 below.

TABLE 46: AVOIDED COST OF RISK UNDER PATHWAY 2, SITE C, 2024-2100

Avoided cost of risk	Lifecycle cost*	Present value*
Avoided cost of risk	$35,697,000	$1,224,000
Avoided loss of property value	$4,548,000	$109,000
Avoided relocation costs	$20,766,000	$168,000

Avoided cost of risk	Lifecycle cost*	Present value*
Incremental benefit	$61,011,000	$1,502,000

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Land value uplift

There is no land value uplift in the base case or under pathway 1.

Pathway 2

Pathway 2 would enable 11 currently undeveloped lots to be developed without substantial protection or engineering works to reduce risk exposure.

Assuming these lots would gradually be developed over time under pathway 2, there is a land value uplift of $423,498[29] per lot compared to the base case. The cumulative net benefit is around $3.4 million as presented in Table 47.

TABLE 47: LAND VALUE UPLIFT UNDER PATHWAY 2, 2024-2100

Benefit	Lifecycle benefit	Present value
Value of developed land	$4,658,000	$3,398,000

Source: SGS Economics and Planning, 2023
* rounded to the nearest $1,000

Improved community health and wellbeing

Both pathway 1 and 2 would reduce the repeated exposure of the community to floods. As explained earlier, this helps preventing mental health and wellbeing costs. The avoided health costs are greater for pathway 2 as private property is protected and adds up to $39,715 to 2100. For pathway 1 it is estimated to be lower around $17,637. This is presented in Table 48 below.

TABLE 48: IMPROVED COMMUNITY WELLBEING - MENTAL HEALTH - IN EACH PATHWAY, 2024-2100

Benefit	Lifecycle cost	Present value
Base Case	$0	$0
Pathway 1	$524,356	$17,637
Pathway 2	$1,251,175	$39,715

Source: SGS Economics and Planning, 2023

[29] The average capital improved value of houses along the Brighton foreshore – data provided by Brighton Council

* rounded to the nearest $1,000

Retained natural values

Due to the additional vegetation management, both pathways generate benefits in terms of improved natural values, compared to BaU. Under pathway 1, the saltmarsh would be able to migrate landward and its values may be retained in the long term. Under pathway 2, the saltmarshes would not be able to migrate landward as a result of rock revetments.

Aboriginal Cultural heritage

There are 25 known Aboriginal cultural heritage items within Site C at risk of inundation between now and 2100, and 10 that are at risk from erosion by 2100.

Under the base case, these shell middens would inevitably be lost. Under pathway 1, some of these shell middens would be protected from the impacts of coastal inundation, however as foreshore recession continues to worsen over the rest of the century, the 10 known sites would eventually be lost in the same way as the base case.

Under pathway 2, while erosion may be slowed by the interventions taken, shell middens would still be threatened if they are between the shore and the foreshore hardening (assuming foreshore hardening itself would avoid damaging the middens).

Retention of foreshore amenity

The Derwent foreshore walkway along Old Beach anecdotally provides significant amenity to local residents and is an important part of Brighton's character. Given that there is no available data on visitation and use of the foreshore walkway, it was not possible to monetise the recreation and wellbeing benefit of the continued use of the foreshore walkway. It is clear from consultation that this walkway is highly valued. The benefits of walking are estimated to be $4.40 per person per kilometre[30], which could be substantial, depending on the level of use of the foreshore walkway.

Under pathway 1, as well as the base case, the foreshore walkway would by 2050, be susceptible to a 1% AEP flood event, and it would be reasonable to conclude that the amenity of the foreshore walkway would have been reduced to some degree by mid-century, and entirely lost by the end of the century.

Under pathway 2 however, while the foreshore walkway would be protected and the benefits of its prolonged use would be enjoyed by the entire community.

Reduced emergency services expenditure

Emergency services expenditure after a natural disaster will vary depending on the severity and spread of the impacts, as well as what type of response is required, which cannot be predicted accurately over a long period of time.

7.3 Results

The costs and benefits included in this analysis are high-level and should be taken as indicative. Nevertheless, the results of the analysis provide useful insight into the relative performance of each

[30] Australian Transport Assessment and Planning Guidelines, M4 Active Travel, Table 6

pathway. That is, the return on investment in adaptation pathways, the benefits of which manifest predominantly as avoided damage from coastal hazards up to 2100. Further planning stages would require site-specific designs and engineering appraisals and costings.

There are also many unquantified benefits, because they cannot be monetised appropriately, or because of a lack of data. However, they are of equal weight to the quantified benefits and should be considered in addition to the results presented in Table 49 below.

For some benefits that have not been quantified, qualitative assessments have been made for each pathway, with more '+'s representing a relatively better outcome. A '-' represents a neutral outcome, i.e., no difference from the base case.

Neither pathway provides a positive NPV or a BCR greater than 1 at any of the three sites. However, this does not imply that the adaptation pathways are unsuitable investments. The NPV does not include the benefits that could not be monetised, including retention of natural values and foreshore amenity.

It is critical to understand that the negative NPV's of each pathway at each site do not mean that the pathways represent worse outcomes than the base case. In the base case, not only would there be no avoided cost of risk, all of the non-monetised benefits would also not be realised, undoubtedly leading to worse outcomes for the Brighton community. It is the lack of quantitative values for these benefits that leads to the negative NPV, rather than poor investments.

Pathway 2 provides greater benefits to sites B and C, given the significant presence of private property at risk in these sites, while at Site A, it is primarily the wetlands that are at risk. It suggests that the higher intensity adaptations pursued in pathway 2 are better suited to those areas where private property is at risk. Pathway 1 is the preferred option at Site A, not only because of its much lower cost, but also because it would facilitate the retention of the wetlands, which has not been quantified. Had the wetlands economic value been quantified, it would only strengthen the case for pathway 1 as the preferred option for site A. Table 49 below presents these results.

TABLE 49: COST-BENEFIT ANALYSIS RESULTS FOR EACH ADAPTATION PATHWAY, ALL SITES

Incremental costs ($ millions)	Pathway 1			Pathway 2		
	Site A	Site B	Site C	Site A	Site B	Site C
Adaptation costs	1.68	0.97	1.15	11.00	4.16	5.17
Incremental benefits ($ millions)						
Avoided cost of risk	0.16	0.57	0.58	0.31	3.18	1.50
Land value uplift	0	0	0	0	0	3.40
Improved community wellbeing	+	0.02	0.02	++	0.03	0.04
Retained natural values	+++		+++	-		-

Incremental costs ($ millions)	Pathway 1			Pathway 2		
	Site A	Site B	Site C	Site A	Site B	Site C
Retained Aboriginal cultural heritage	-	+	+	-	++	++
Retention of foreshore amenity	++	++	+	+	++	+
Reduced emergency services expenditure	+	+	+	+	++	++
Subtotal	0.16	0.59	0.48	0.31	3.21	4.94
Net present value (NPV) ($ millions)	-1.52	-0.38	-0.32	-10.69	-0.95	-0.23
Benefit-Cost ratio (BCR)	0.09	0.61	0.60	0.03	0.77	0.96

Source: SGS Economics and Planning, 2023
Figures are in millions and discounted to present day values

The present value of the incremental costs and benefits is the result of a discounted cash flow (DCF) analysis, whereby future costs and benefits are expressed in present values, using a discount rate of 7%. This has the effect of reducing the impact of costs and benefits that are incurred far into the future, meaning that the temporal distribution of these items has a material impact on the results of the analysis. As such, sensitivity tests which adjust this discount rate have been undertaken and the results provided in Table 50 and Table 51 in the following section.

Sensitivity testing

As Table 50 below shows, reducing the discount rate significantly improves the results of the CBA across all sites and pathways, which is due to the long timeframe of the analysis, and the clustering of many of the effects towards the end of the CBA, as the impacts of climate change become more severe. However, it does not change the preferred options, with pathway 1 being stronger at Site A, and pathway 2 remaining the better investment choice at Sites B and C.

TABLE 50: COST-BENEFIT ANALYSIS RESULTS WITH 4% DISCOUNT RATES

Incremental costs	Pathway 1			Pathway 2		
	Site A	Site B	Site C	Site A	Site B	Site C
NPV ($ millions)	-2.06	0.26	0.19	-12.32	2.96	3.06
BCR	0.14	1.17	1.10	0.05	1.53	1.43

Source: SGS Economics and Planning, 2023

Likewise, Table 51 demonstrates the extreme impact of changing the discount rate. In this sensitivity test, increasing the discount rate reduces the long term benefits of these adaptation measures drastically, as most of them are concentrated towards the end of the century, and are therefore being discounted heavily. Nevertheless, as above, the preferred options do not change.

TABLE 51: COST-BENEFIT ANALYSIS RESULTS WITH 10% DISCOUNT RATES

Incremental costs	Pathway 1			Pathway 2		
	Site A	Site B	Site C	Site A	Site B	Site C
NPV ($ millions)	-1.22	-0.45	-0.60	-9.19	-1.92	-0.57
BCR	0.07	0.39	0.28	0.02	0.43	0.86

Source: SGS Economics and Planning, 2023

8. Next steps

The CBA provides an evidence base of the costs and benefits associated with taking a particular course of action in response to coastal hazards. During community consultation, community members called for further community engagement about the adaptation pathways to reach more residents and other groups who may be impacted by inundation, erosion, and stormwater risks.

Participants also suggested that the project would benefit from greater communication about what is at stake. For the broader community, who may not have property at risk, it is important that they understand the community values of the areas that are at risk such as the foreshore and walking track. This will ensure that the community broadly understands what is being protected and what is at stake if no action is taken.

It is recommended to engage with TasRail, to understand how it may seek to protect the rail line through Site A and how TasRail could potentially contribute to the broader adaptation pathways being sought. This is likely to also require engineering advice regarding the feasibility of culverts in this location.

For Site B, the assets at risk are mainly private property and would likely require contributions from property owners. Specific consultation and contribution plans should be undertaken for pathways associated with Site B.

Through further engagement with the community and key stakeholders, once a preferred pathway has been established, in keeping with the principles of TCAP, the community should be brought along with further engagement on the concept designs and implementation. This will contribute to broader understanding and shared ownership.

Appendix A: Bridgewater Bridge

Bridgewater Bridge

The Bridgewater Bridge (the bridge) is Tasmania's largest transport project.

This Project ***does not*** include an assessment of the land and infrastructure associated with the upgrade of the Bridgewater Bridge – climate change impact assessments are a separate piece of work being carried out by Brighton Council.

The bridge, which will replace an existing crossing and will be completed by the end of 2024. It is a critical part of the transport and freight link between the northern and southern regions of Tasmania. The bridge will consist of a four-lane road for vehicles and crossing for pedestrian and cyclists.

The new bridge crosses the Derwent River, a major freshwater inflow to the Derwent Estuary. As such, the following marine and coastal works associated with the project include:

- Temporary works including access structures, hardstands and piled structures for the construction of the bridge substructure and superstructure
- Formation of new bridge abutments landside of the river (Granton and Bridgewater)
- Piling works within the waterways including concrete pile caps and piers
- Demolition of the existing bridge and rehabilitation of areas
- Land reclamation on coastal areas for construction access and temporary works
- Modifications to existing and creation of new stormwater infrastructure
- Barge and work boats for construction activities
- New load out ramps and structures for construction access from land to river.[31]

The Department of State Growth commissioned a series of assessments to assess the implications of the project on coastal hazards, the key findings are summarised in the table below.

TABLE 52: BRIDGEWATER BRIDGE COSTAL HAZARDS

Assessment	Implications for coastal hazards
Coastal Inundation Assessment	– The bridge extents are generally outside the inundation and erosion risk areas.

[31] Burbury Consulting, 2021, 'New Bridgewater Bridge Costal Inundation Assessment', Department of State Growth, pp. 4-6.

Assessment	Implications for coastal hazards
	– The bridge will not increase the risk of inundation to the upstream or downstream causeway areas or banks.
Coastal Erosion Assessment	– There will be no measurable increase risk in erosion of the coastal areas the planned works are constructed on or adjacent to due to the construction or operation of the bridge. – The bridge will not lead to worsening of the flow regime of the Derwent River and consequent erosion. – Any new shoreline reclamation or building pads constructed into the waterways should be armoured with appropriate rock protection to minimise the risk of erosion from waves,, stormwater or flooding.
Aquatic Risk Assessment	– The construction of the bridge poses considerable risks to the aquatic environment. The key risks are through sediment disturbance and changes to hydrodynamics. – The project will cause an unavoidable loss of a relatively large area of *Ruppia megacarpa* (TSPA-listed rare plant species) directly beneath the bridge. It is possible that this plant may also be lost further downstream as a result. – Plants and animals may be impacted by the project due to elevated metal concentrations, reduced light through suspended sediment, reduced dissolved oxygen and epiphytic algal overgrowth. – If construction follows mitigation measures, the aquatic risk and long-term impact of the project can be considered 'low'.
Flood Hazard Report	– The bridge will not significantly alter the water levels in the Derwent River. – Future flooding caused by 1% AEP events and exacerbated by climate change water-level and rain intensity increases, is expected to cause increased flooding throughout the Derwent Estuary and River system regardless of the development. – The design of the new bridge should include provision for water level rises anticipated due to climate change and, additionally, for flooding associated with 1% AEP events.
Hydrodynamic Modelling	– The impacts of the project on water quality are mostly confined to be close to the works, and mainly to the southern shore of the Derwent River downstream to the confluence with the Jordan River.

Source: Burbury Consulting (2021), Marine Solutions (2021), Entura (2021).

Notes: Annual Exceedance Probability (AEP) 1% translates to a 1 in 100-year occurrence.

Appendix B: Community Engagement Report

11 / 2023

Stakeholder Engagement Summary

SGS Economics & Planning

Certified B Corporation

Derwent River Coastal Hazards Project
Brighton Council

Contents

SGS Economics and Planning Pty Ltd
ACN 007 437 729
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01

Project Overview

Project aims and overview

The aim of the project is to understand and plan for coastal hazards at three locations along the Derwent River foreshore. With climate change, many natural hazards, including coastal hazards, are expected to exacerbate. With this project, Council and the community intend to build capacity for decision making.

To build this capacity, this project will provide information about the risks and adaptation options and improve community understanding about risk reduction. The project is expected to broadly reflect the Tasmanian Coastal Adaptation Pathways (TCAP) process.

The project involves a coastal hazards assessment, a risk assessment, community values assessment, adaptation pathways and a cost-benefit analysis of the pathways. In addition, SGS will provide input into Council presentations, and project communication materials like brochures and documents.

As part of the project, the SGS Economics and Planning team will support Council to undertake stakeholder engagement with landowners and asset managers in the three study areas (depicted overleaf). The benefits and an overview of stakeholder engagement for a TCAP-style project are outlined at the end of this section.

The project will be undertaken in three stages, with completion anticipated by the end of December 2023:

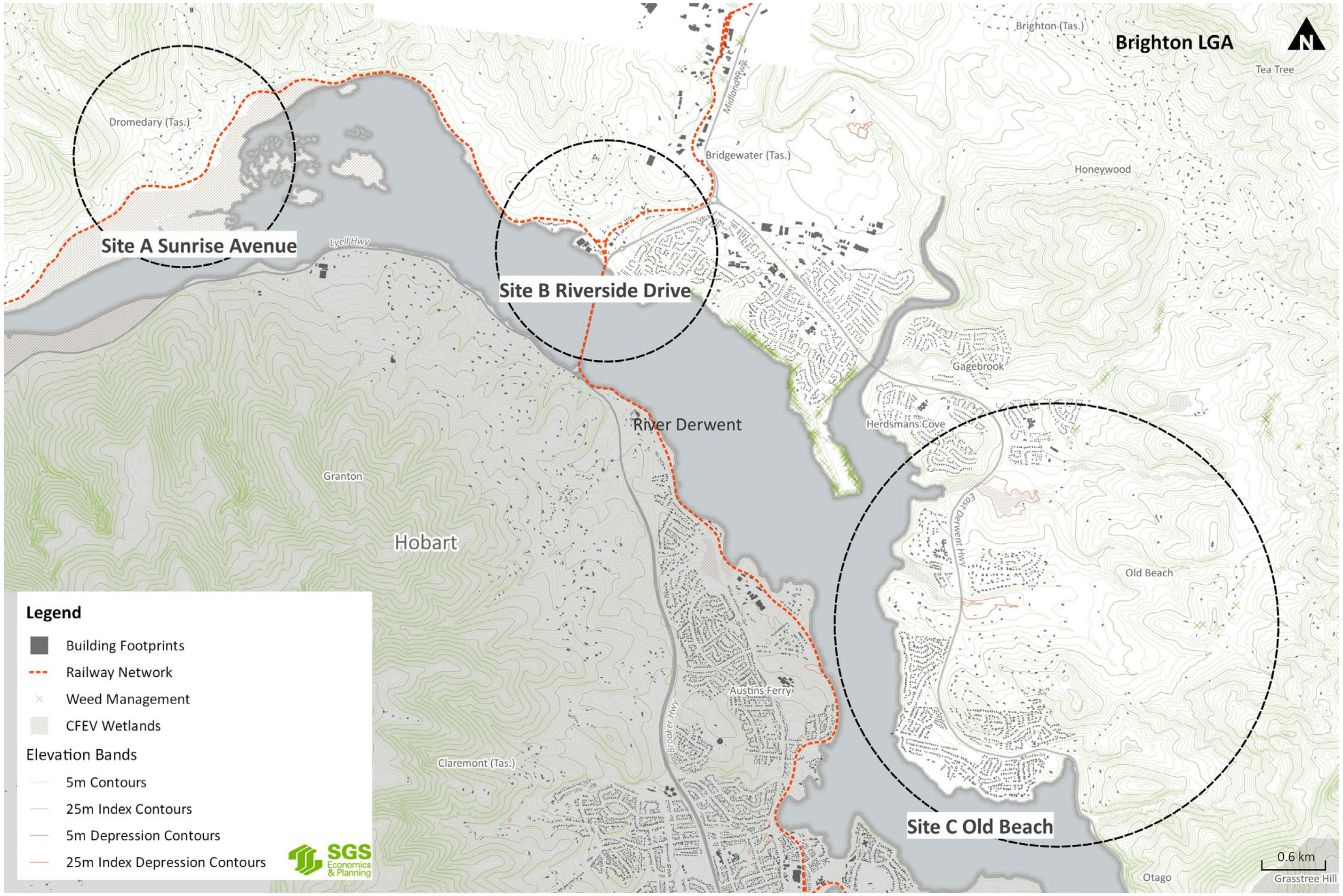
- Stage 1: Coastal Hazards and Values and Risk Assessment.
- Stage 2: Community and Stakeholder Engagement.
- Stage 3: Adaptation Planning.

At the time of engagement, SGS have prepared the first report from Stage 1 of the analysis. The information and analysis uncovered in Stage 1 informed discussion with stakeholders (including community members/landowners), regarding:

- Preliminary hazard mapping
- Values at risk
- Planning scheme context
- Preliminary adaptation pathways for further discussion with stakeholders.

This document outlines the findings of the Stakeholder and Community Engagement.

Study areas



Brighton LGA
N
Brighton (Tas.)
Tea Tree
Dromedary (Tas.)
Bridgewater (Tas.)
Honeywood
Midland Hwy
Lyell Hwy
Site A Sunrise Avenue
Site B Riverside Drive
Gagebrook
Herdsmans Cove
River Derwent
East Derwent Hwy
Granton
Hobart
Old Beach
Austins Ferry
Brooker Hwy
Claremont (Tas.)
Site C Old Beach
0.6 km
Otago
Grasstree Hill
Legend
Building Footprints
Railway Network
Weed Management
CFEV Wetlands
Elevation Bands
5m Contours
25m Index Contours
5m Depression Contours
25m Index Depression Contours
SGS Economics & Planning

02

Engagement approach

Stakeholder engagement

One of the most recognised benefits of a TCAP approach is the effective inclusion of stakeholder engagement in the true sense of the word. Adaptation is a long-term and ongoing process, and in some ways this type of project is one of the first marked steps to engage the community.

A robust and transparent engagement approach is crucial and contributes to trust and confidence-building among the community, and between the community, Council, and other levels of Government. It provides a steppingstone for future decision-making processes.

The engagement process is based on communicating clearly and honestly about the projected changes, engaging communities to explore how their futures may look, what their preferences are, and the steps involved to achieve a preferred future state.

A targeted stakeholder workshop was held with interested/affected community members and landowners, to explore different pathways to adapt to the risks associated with foreshore coastal hazards along the Derwent River. Feedback on the pathways was also gained from Essential Services via email and from Council's online consultation 'Have Your Say'.

During the workshop, participants were split into two groups to explore the two adaptation pathways. For each adaptation pathway, the following questions were discussed:

- "What are the positives? The negatives?
- What does the overall balance feel like?
- Is it 'desirable'? Is it a plausible scenario? Can I imagine this actually happening? Is it likely to happen? If not, why not? Could it be made to happen and if so, what would be required? Would that be desirable or acceptable?
- What if changes occur more slowly or more rapidly than expected?
- Who decides to implement options and when?
- Who pays, and how?"

Extent of stakeholder engagement and involvement

A targeted approach to stakeholder engagement has been undertaken for this project, both with landowners/residents and business owners, as relevant to each study area.

A core function of the engagement activities for the TCAP process is to improve community understanding of environmental hazards, and to work together to identify a preferred way of managing and adapting to hazards in the future. A focus of discussions was to enhance community appreciation that business as usual (BAU) is a decision with consequence just as choosing a different path is.

With this project, Council and the community intend to build capacity for decision making. To build capacity, the project is expected to provide information about the risks and adaptation options and improve community understanding about risk reduction.

Engagement in the project was undertaken according to the Core Values for the Practice of Public Participation (International Association for Public Participation – IAP2). Public participation:

- Is based on the belief that those who are affected by a decision have a right to be involved in the decision-making process.
- Includes the promise that the public's contribution will influence the decision.
- Promotes sustainable decisions by recognizing and communicating the needs and interests of all participants, including decision makers.
- Seeks out and facilitates the involvement of those potentially affected by or interested in a decision.
- Seeks input from participants in designing how they participate.
- Provides participants with the information they need to participate in a meaningful way.
- Communicates to participants how their input affected the decision.

03

Key findings

Community workshop – Adaptation pathway 1

Participants explored pathway 1 – the pathway whereby maximum freedom of natural foreshore processes is allowed to unfold with minimum intervention or resistance – answering 'What are the positives and negatives?' and 'How would it happen?'.

Participants identified the positives and negatives associated with pathway 1, however, the negatives outweighed the positives. The positive factors included:

- The pathway allows current residents to take action
- Less impact on wildlife (compared to pathway 2)
- It provides an opportunity for community to work together, demonstrating collective responsibility
- Aboriginal Middens are left as they are
- Brighton Council would be invested in planning to find solutions (prevention before crisis)

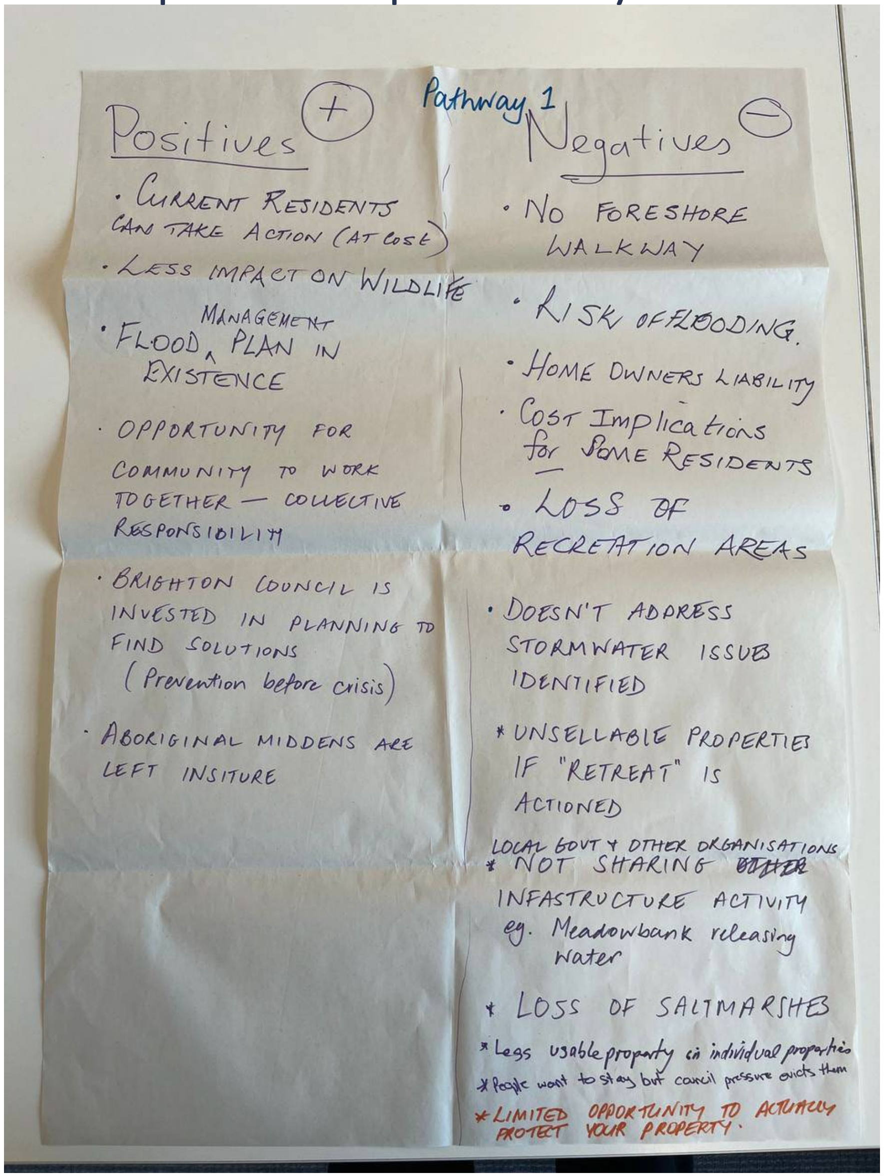
Negative factors of pathway 1 identified by the community included:

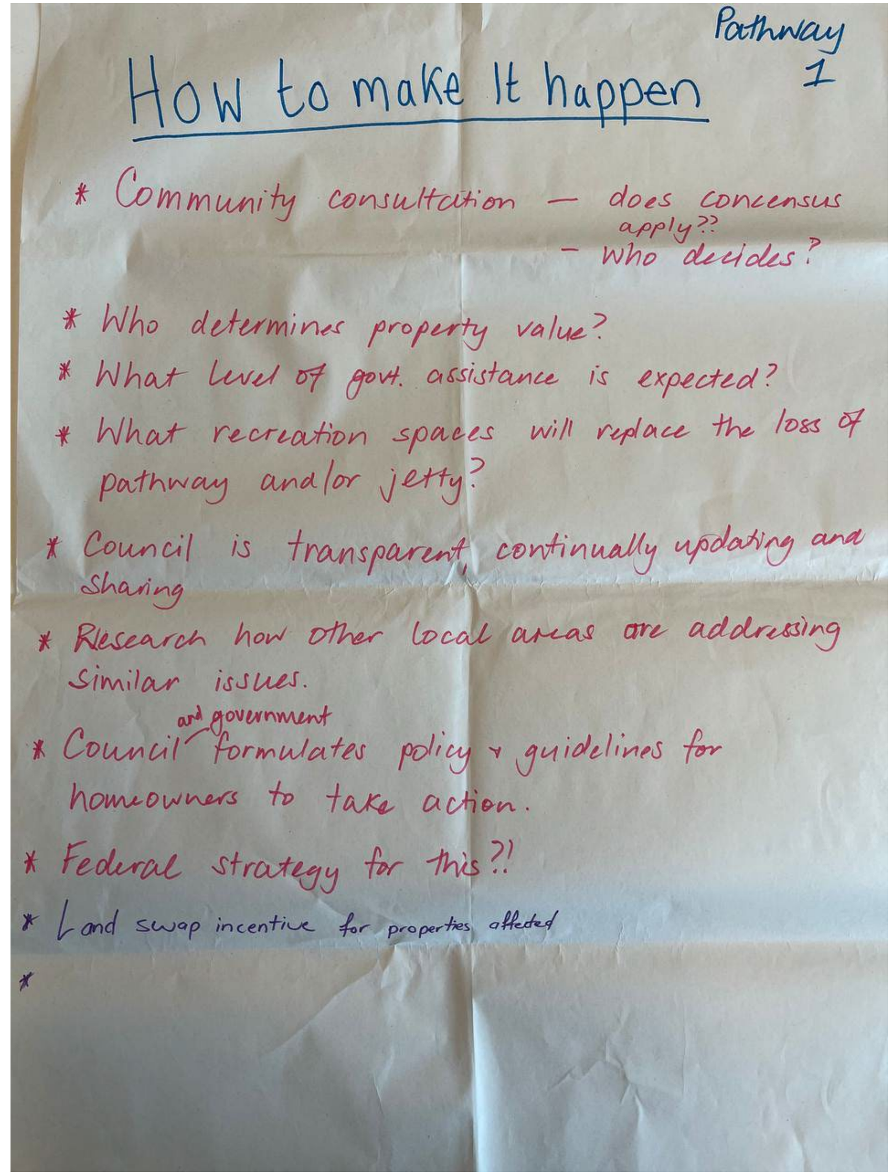
- The foreshore walkway and recreation areas would be lost
- Loss of saltwater marshes
- There would be a risk of flooding
- Homeowners would be liable
- There would be cost implications for some residents
- The pathway would not address stormwater issues
- Properties may lose value and/or become unsellable
- Residents may not have the opportunity to stay in their homes
- There would be limited opportunity for residents to protect their property
- Other stakeholders (organisations, local government) may install infrastructure and not share it with the community

Participants identified the following requirements and considerations to make pathway 1 happen:

- Further community consultation would be required to meet a consensus on the pathway
- Who gets to determine property value?
- What level of government assistance is expected?
- What recreation spaces will replace the loss of the walkway and/or jetty?
- Council would need to be transparent, continually updating the community on the process
- There should be research on how other local areas are addressing similar issues
- Council and government could formulate policy and guidelines for homeowners to take action
- A federal strategy could provide greater guidance
- There could be a land swap incentive for affected properties

Adaptation pathway 1 workshop





Community workshop – Adaption pathway 2

Participants explored pathway 2 – the pathway that concentrates on protecting existing and future community and property using any necessary protection and adaptation options – answering 'What are the positives and negatives?' and 'How would it happen?'.

Participants identified positives and negatives with pathway 2, with many of the positives focused on the protection of assets and community values and the key negative being the cost. The positive factors included:

- Properties and the foreshore would be protected
- The pathway would allow for intensification of development, therefore enabling more participants to contribute to the costs of protection works
- Protection works could help to stabilize insurance costs
- The pathway would protect community values of shared, recreational spaces such as the river path and jetty
- Costs could be shared more easily between stakeholders (including state and local government)
- The pathway provides an opportunity to invest in stormwater waste management for all of Brighton municipality
- The pathway is an opportunity for Bright Council to be 'ground-breakers' and leaders of climate action along with property owners

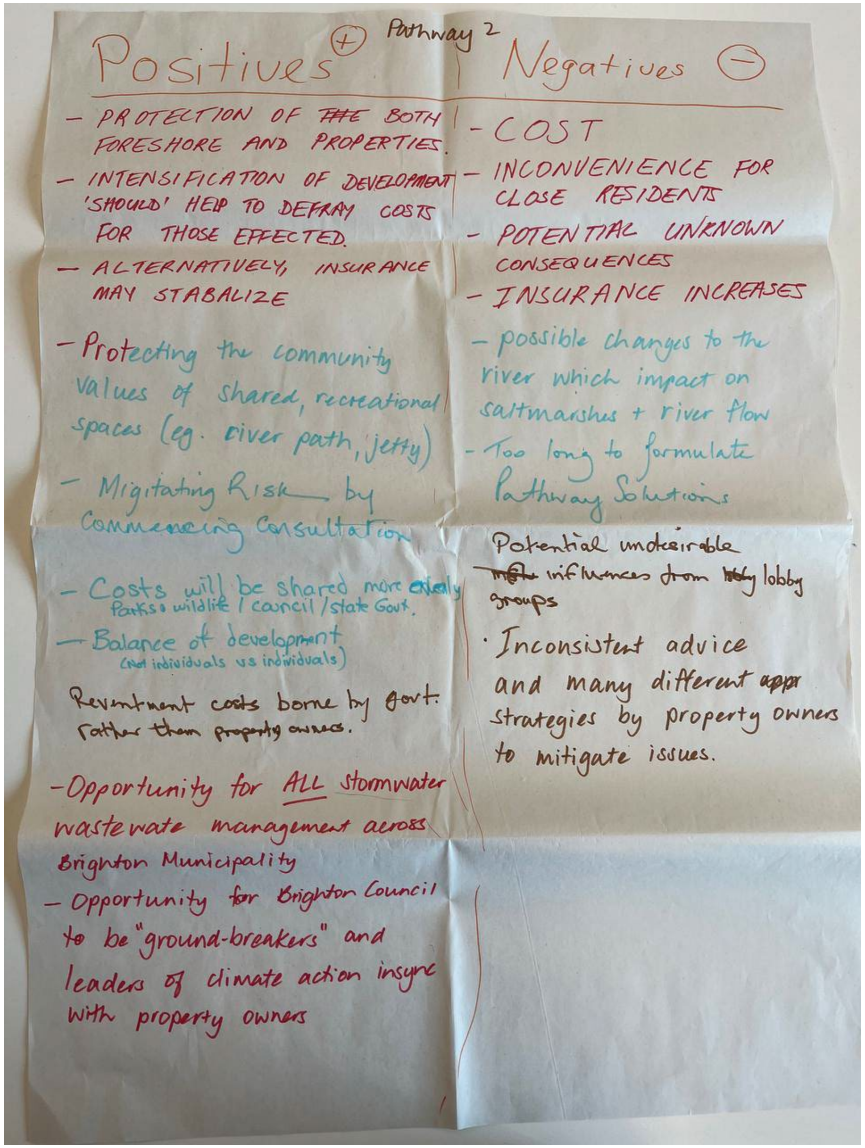
The Negative factors of pathway 2 identified by the community included:

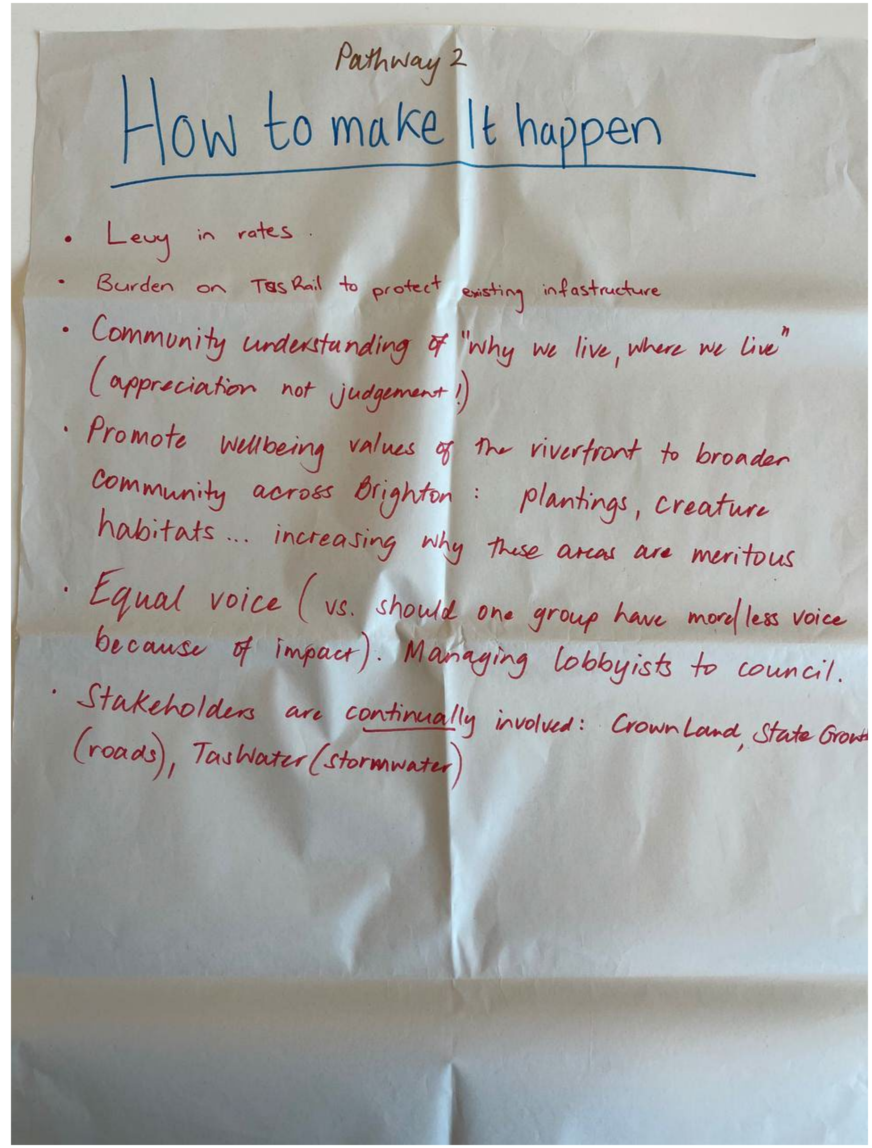
- The cost of protection works
- The inconvenience of protection works caused to residents
- There are potential unknown consequences in this pathway, such as, the consequences of protection works on the environment. The protection works could result in changed to the river which may impact the saltmarshes and river flow
- It may take too long to formulate solutions
- There is potential for lobby groups, or others, to influence the outcomes of this pathway
- The protection works rely on expert advice, which may be inconsistent and result in different strategies to mitigate issues

Participants identified the following requirements and considerations to make pathway 2 happen:

- A levy and/or rates
- Tas Rail should pay to protect existing rail infrastructure
- There needs to be continuous community engagement and stakeholder engagement, whereby everyone is given an equal voice
- The wellbeing areas of the riverfront should be promoted to the broader community to help them understand why it is important to protect

Adaptation pathway 2 workshop





Community workshop – Summary

The community workshop revealed positives and negatives with both adaptation pathways. However, participants typically responded positively to a pathway that protects the existing and future assets and community values. The workshop also raised further considerations for the next steps of the project.

Key findings from the engagement included:

- Participants were more supportive of adaptation pathway 2, especially on site C where there are a greater number of assets to protect.
- Participants were receptive to pathway 1 for site A, where there are fewer built assets to protect.

Key considerations for the next steps included:

- Participants called for more community engagement on the adaptation pathways to reach everyone in the community and other groups who would be impacted by inundation, erosion and stormwater risks, such as the boating community.

- Participants also suggested that the project would benefit from greater communication about what is at stake. For the broader community, who may not have property at risk, it is important that they understand the community values of the area that are at risk so that they understand what we are trying to protect and what is at stakes if we don't take action.
- Tas Rail have not responded to requests for consultation. It will be important for future stages of this project, as participants were keen to understand how Tas Rail seek to protect the rail line on site A and how they would potentially contribute to the adaptation pathways.

Appendix C: CBA Methodology

Cost of risk

In order to determine the cost of risk, understanding the likelihood of hazard events occurring was required. According to Climate Futures for Tasmania, a 1% AEP coastal flood event in the baseline year (2010), would become a 5-10% AEP event by 2030. A growth factor was applied to the risk of flooding that each hazard band is exposed to, such that a 1% AEP flood event in 2010, would become a 7.5% AEP (mid-range) flood event in 2030. The impacts of risk for each hazard band are shown in Table 53 below. It assumes that value lost is replaced by residents until such time where it is no longer viable to do so, which is assumed to be when the risk reaches 100%, or alternatively that the property would be expected to be impacted by a hazard event every year.

A hazard event is not expected to wipe out the entire property every time, rather a proportion of the capital value is expected to be wiped out. For this study, 20% was assumed to be the value of capital wiped out by each incident. This means that cost of risk is the cumulative product of the probabilities of a hazard event occurring in each hazard band with the total value at risk in each hazard band, all multiplied by 20%. The progressive increase in risk is demonstrated in Table 53 below.

TABLE 53: PROBABILITY OF HAZARD EVENT OCCURRING OVER TIME FOR EACH HAZARD BAND

Hazard band	2010	2024	2030	2050	2090	2100
High	1.00%	5.55%	7.50%	15.00%	20.00%	21.00%
Medium	0.02%	0.07%	0.13%	1.00%	15.00%	16.25%
Low	0.00%	0.00%	0.00%	0.01%	0.37%	1.00%

Source: SGS Economics and Planning, 2023

Cost benefit analysis

One of the main costs of BaU is the escalating risk of floods and erosion damaging property and other values: this is referred to as the cost of risk. Cost of risk calculations consider the likely damages of extreme events and the probabilities of these extreme events over time. The total cost of risk is the sum of the (discounted) annual expected damages for various extreme events over time (2010-2100). For the purposes of this CBA, avoided cost of risk – that is, the cost of damage avoided by choosing one of the adaptation pathways – will be treated as a benefit.

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In line with convention and recommendations from Infrastructure Australia[32], we have applied a 7% discount factor to the stream of costs and benefits in this analysis.

Performance indicators

The costs and benefits are then compared utilising discounted cashflow analysis (DCF). DCF involves comparing all the costs and benefits over time, with future costs and benefits discounted (converted) to today's dollar values. The DCF produces performance measures which allow the project to be considered in terms of the scale of benefits generated in comparison with the costs.

In line with convention, the CBA has been undertaken on an 'incremental' basis. This measures the performance of the project against the base case by subtracting costs and benefits that would have occurred regardless of investment.

Two performance measures are subsequently generated:

- Net Present Value (NPV) and
- Benefit Cost Ratio (BCR).

Details on how these measures are calculated and how they should be interpreted are summarised in Table 54 below.

TABLE 54: INTERPRETATION OF PEROFMANCE INDICATORS

Performance measure	Estimation method	Decision rule
Net Present Value (NPV)	A number generated by deducting the present value of the stream of costs from the present value of the stream of benefits (with the present value of costs and benefits determined by using an appropriate discount rate)	▪ Accept options with a positive NPV ▪ Reject options with a negative NPV ▪ The greater the NPV, the better.
Benefit Cost Ratio (BCR)	The ratio of the present value of the stream of benefits to the present value of the stream of costs	▪ Accept options with a BCR > 1 ▪ Reject options with a BCR < 1 ▪ The greater the BCR, the better.

Source: SGS Economics and Planning (2023)

[32] Infrastructure Australia (2021) Infrastructure Australia Assessment Framework, Box 12: Discount rates

Appendix D: CBA Inputs and assumptions

The costs presented in the following sections have not been provided by an engineering assessment and should be taken as indicative only.

Assumptions

Emergency management planning

This adaptation measure is applicable to the base case and pathway 1.

According to the Department of Climate Change, Energy, the Environment and Water's (DCCEEW) 2010 report, the upfront capital costs associated with setting up an early flood warning system and an awareness campaign are assumed to cost around $140,000, with recurrent costs of approximately $7,000 per annum, indexed to 2023 Australian Dollars[33]. In the event of a pending flood, households and businesses are expected to incur some loss of productive time in order to prepare for a flood. An additional day per person per household and a day of lost trade for business has been included as an inconvenience cost[34].

This cost is incurred in the base case and under pathway 1, while under pathway 2, the more intensive adaptation measures are assumed to supersede the need for an early flood warning system.

Vegetation management

This adaptation measure is applicable to pathways 1 and 2.

Vegetation management is expected to occur along the affected coastline as necessary. That is, for the coastline that is in the high hazard band, or at risk today, vegetation management should already be being considered. For the coastline intersected by the medium hazard band, vegetation management would occur by 2050, and by 2100 for the coastline intersected by the low hazard band. For Old Beach, almost the entire coastline is affected by 2100.

Unless already protected by another more intensive intervention – in the case of pathway 2, such as foreshore hardening – vegetation management is assumed to be applied to the part of the foreshore that is exposed to the high hazard band. For Site A, the entire shoreline is exposed to the high hazard band. In site B, there is a large length of coast exposed to the high hazard band north of Bridgewater Bridge, as well as two smaller pockets south of the bridge. Likewise, In site C, much of the foreshore walkway along Old Beach is exposed to the coastal erosion high hazard band, as well as along inlets north of the foreshore walkway. The exposure within each site is shown in Table 55 below.

[33] DCCEEW (2010) Coastal Inundation at Narrabeen Lagoon

[34] Average wages have been used as a proxy for a lost day for residences and average profit as a proxy for a lost day for commercial businesses.

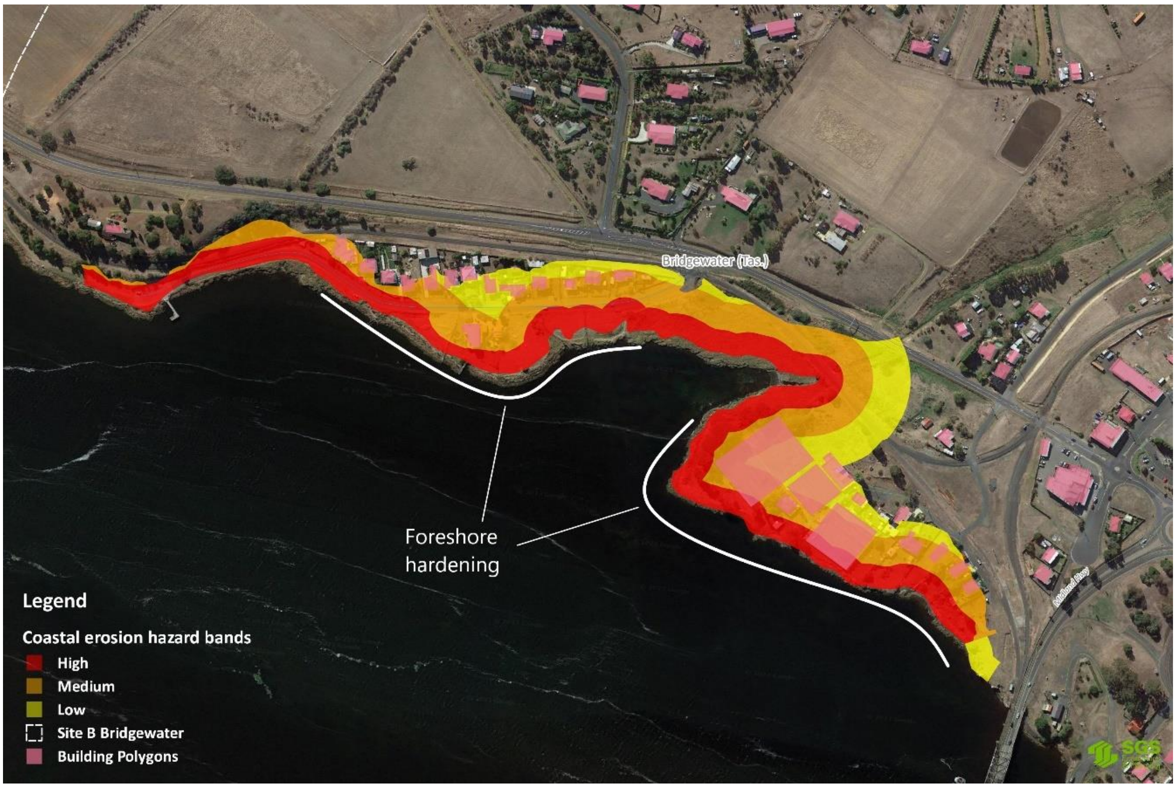
TABLE 55: COASTAL EROSION HAZARD BANDS EXPOSURE BY SITE

Hazard band	Site A	Site B	Site C	Total
High	1,423 metres	1,836 metres	2,369 metres	5,629 metres
Medium	854 metres	560 metres		1,414 metres
Low	1,292 metres	44 metres		1,335 metres

Source: SGS Economics and Planning (2023)

The area highlighted in Figure 24 below shows the parts of the coastline that would be subject to foreshore hardening under pathway 2, and therefore where vegetation management would not be required under this scenario. In Site B, two stretches of coastline that have both commercial and residential development adjacent to the shoreline, would be protected by foreshore hardening, while vegetation management would occur across the rest of the exposed coastline. These two developed areas account for about 770 metres.

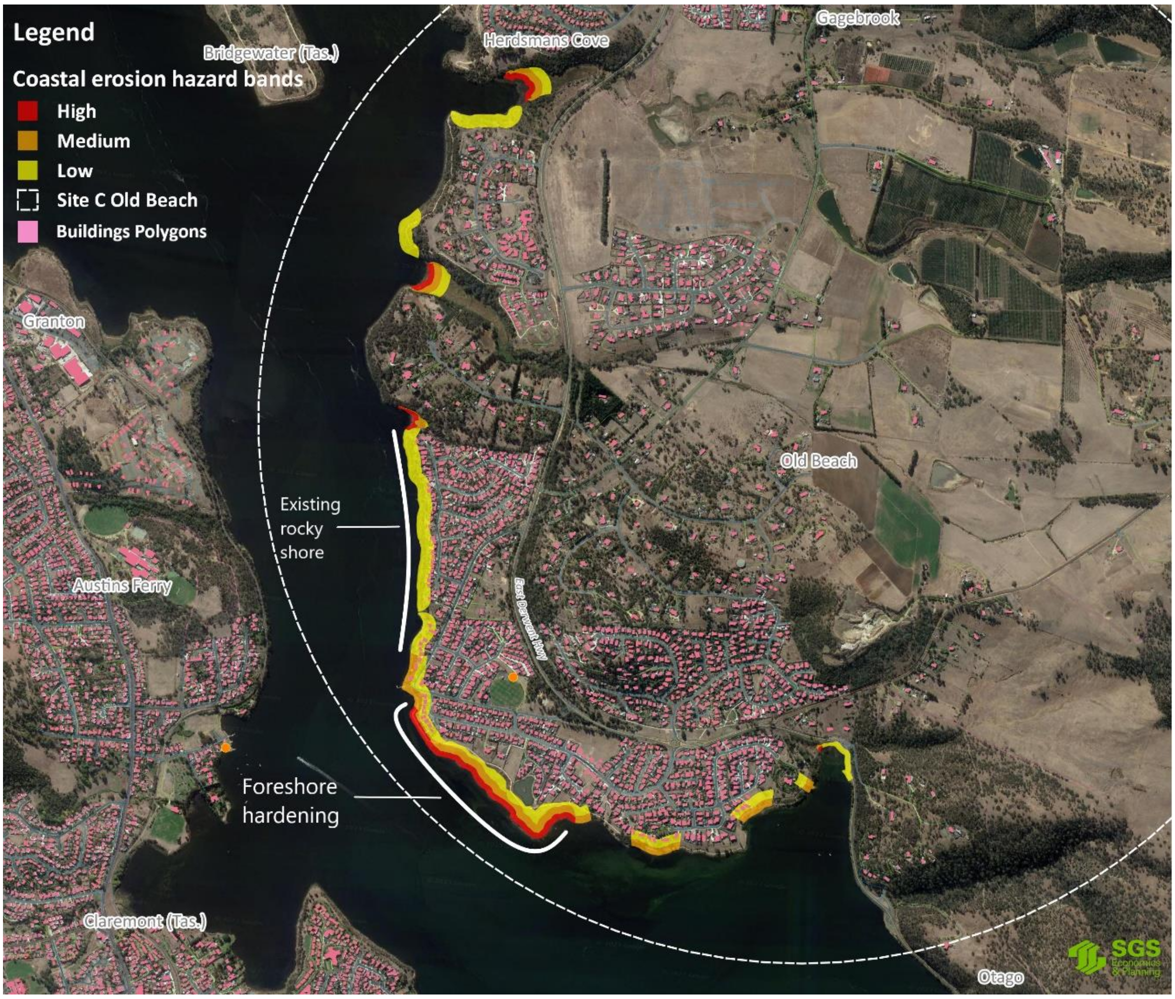
FIGURE 24: COASTAL EROSION HAZARD BANDS AND THE APPLICATION OF FORESHORE HARDENING IN SITE B



Source: SGS Economics and Planning, 2023

So, in pathway 2, vegetation management is assumed to only be required along the 478 metres of coastline exposed to the high hazard band, beyond the foreshore walkway stretch. Figure 25 shows where foreshore hardening would occur in Site C.

FIGURE 25: COASTAL EROSION HAZARD BANDS AND THE APPLICATION OF FORESHORE HARDENING IN SITE C



Source: SGS Economics and Planning, 2023

Vegetation management costs about $50 per linear metre, depending on a range of factors including the width of planting, and also assuming that planting is undertaken by volunteer members of the community[35]. In New Zealand, the Bay of Plenty dune restoration had over 1,500 volunteer members contribute to the planting process. However this is not a reliable assumption, and SGS has assumed that the cost would be double this, assuming that the custodians of the vegetation management are paid, particularly over the long timeframe that it is needed. Dune management can be highly effective however it relies on community knowledge and limited access so that the vegetation is not trampled. Given that vegetation management will occur along the popular foreshore walkway, community understanding of how to protect the vegetation is critical. Taking this into consideration, it has been assumed that revegetation and maintenance works would need to occur every 5 years, in line with other Australian councils' analysis[36].

[35] https://www.igci.org.nz/dunes/costs
[36] https://www.noosa.qld.gov.au/downloads/file/3287/fact-sheet-dune-beach-management

Under pathway 1, all exposed coastline would be managed with vegetation. However under pathway 2, Table 56 shows how much coastline would be protected with vegetation, given that other parts of exposed coastline would be protected by foreshore hardening.

TABLE 56: VEGETATION MANAGEMENT IN PATHWAY 2

Hazard band	Site A	Site B	Site C	Total
High	478 metres	1,067 metres	2,369 metres	**3,915 metres**
Medium	1,040 metres	1,628 metres	2,369 metres	**5,037 metres**
Low	1,423 metres	1,671 metres	2,369 metres	**5,463 metres**

Source: SGS Economics and Planning (2023)

Protection of individual properties

This adaptation measure is applicable to pathway 1.

Protecting individual properties from erosion and inundation can be done in different ways:

- Piles or foundations to resist loss of foundation stability by erosion
- Elevated substructures (raised slab or floor, poles, non-inhabited ground floor) above flood levels
- Moveable dwellings
- Water proof or resistant construction not affected by temporary flooding
- Floatable dwellings.

These actions are permissible under pathway 1 as long as they do not impact on neighbouring properties, which rules out some of the points above, particularly moveable and floatable dwellings.

Flood barriers either placed directly against the structures wall or free standing barriers can be used to protect existing dwellings. Most of the other options apply for new construction but could be used on extensions or where a building undergoes extensive renovation.

The cost per built structure would vary considerably with the extent of exposure, and the size and design of the building. Protections against coastal inundation have been assumed to cost about $13,000 per property, while the cost to protect a property from coastal erosion is assumed to be about double the cost. More properties are exposed to coastal inundation hazards than coastal erosion, with none exposed to the high hazard band of either. SGS has modelled the homes exposed to the medium hazard bands of each hazard engage in this adaptation measure in 2030, and those exposed to the low hazards band do so in 2075, as it assumed that residents would want to protect their homes before they become acutely at risk.

Foreshore hardening and seawall construction

This adaptation measure is applicable to pathway 2.

Foreshore hardening refers to a range of adaptation measures that are predominantly substitutable, and therefore only one such measure would be needed. It is assumed the cheapest method would be chosen. They include rock revetment, rock groynes, and seawall construction. All of these measures are relatively expensive compared to the other adaptation measures for pathways 1 and 2. One of the more sustainable and long-lasting foreshore hardening techniques involves rip-rap rock revetment, which can cost between $3000[37] – 11,000 per linear metre[38]. Figure 26 overleaf shows the total length of foreshore exposed to the high hazard band across all sites. The length of this stretch is 5,629 metres, while an additional (not directly behind high hazard band) 1,414 metres is exposed to the medium hazard band. SGS has taken an average of several estimates for rock revetment of about $6,000 per metre. Applying this across the entire foreshore exposed to the high hazard band would cost nearly $35 million.

However, with the availability of more cost-effective and less intensive interventions like vegetation management, it is assumed that foreshore hardening would only be invested in at the sites of most acute need, as presented in Figure 24 and Figure 25 above. If rock revetment was undertaken only to protect those highlighted areas, and this would cost over $10 million. It would then cost an additional nearly $2 million in 2050 to upgrade the rock revetment to cover the parts of the foreshore walkway that would become vulnerable to coastal recession, i.e., the medium hazard band. The stretch of the foreshore walkway shoreline exposed to the medium hazard band is 292 metres long.

A recent case study is in Collaroy-Narrabeen beach in Sydney which was impacted by a June 2016 storm surge with a return period of 50-60 years (~2% AEP). It caused severe damage primarily from erosion but also likely in part due to inundation impacts. Following the storm, a seawall has begun being constructed, with the benefitting residents contributing 80% of the cost. On average, the cost to residents for the seawall is $230,000 per property[39], meaning the total cost was $287,500 per resident. The wall extends across 250 metres of coastline, and cost a total of $25 million, or $100,000 per metre, protecting 49 private properties and 11 public land parcels[40]. Building a sea wall at this cost along the entire coastline exposed to the coastal erosion high hazard band would cost $142 million. Building one that protects the foreshore walkway would cost $95 million, making it a less financially viable option than other foreshore hardening techniques. Even more conservative estimates from a review of cost estimates for flood adaptation in the publication *Water* demonstrate that seawalls are potentially prohibitively expensive. A seawall in the United States could cost between $13.8-29.3 million USD per kilometre in 2016, equivalent to $42.1 million AUD per kilometre in 2023[41]. With a near kilometre stretch of the foreshore walkway shoreline already exposed to the high hazard band, it would cost nearly $40 million to construct a seawall to protect it at this more conservative price.

Much of Site C's foreshore, specifically the area to the north of the Old Beach Jetty and boat ramp, is already made up of rocky foreshore that does not require hardening. However, there are high and medium coastal erosion hazard bands effective to the south of the boat ramp and other isolated pockets of hazardous areas. These areas have been assumed to progressively require foreshore hardening if pathway 2 were to be chosen, as extensions and repairs are required to maintain the efficacy of this adaptation.

The Collaroy Narrabeen seawall has been a controversial project and even been referred to as the 'ugliest wall in Australia'[42] and this adaptation measure may reduce the amenity of the Brighton

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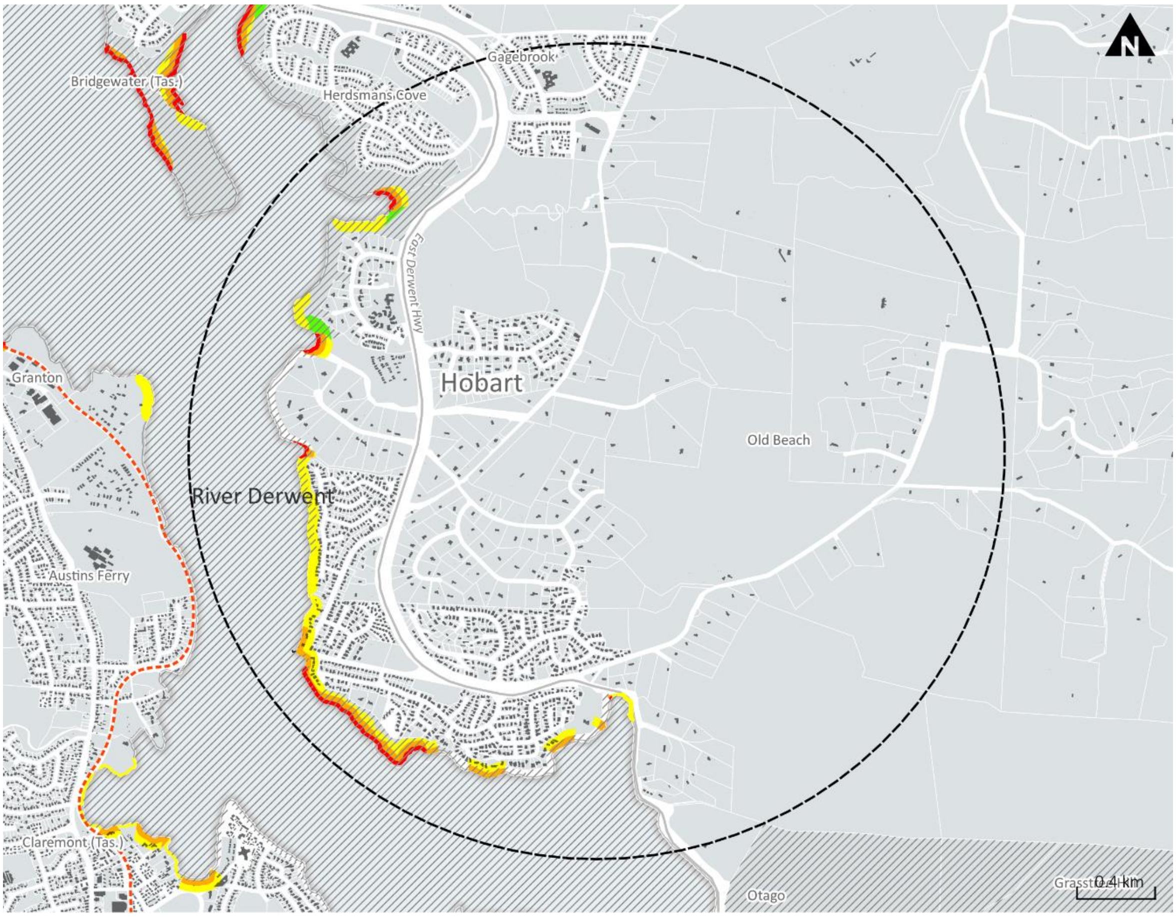
[37] https://assets.publishing.service.gov.uk/media/6034ee168fa8f5432c277c23/Cost_estimation_for_coastal_protection.pdf
[38] White Lake Dock & Dredge Inc (2023), Rip Rap Shoreline Protection. $2,200 USD per linear foot converted to $AUD per linear metre
[39] ICA (2021), Climate Change Impact Series: Actions of the Sea and Future Risks, Insurance Council of Australia
[40] Sydney Morning Herald (2021), Construction begins on Northern Beaches sea wall despite 'vexed' funding issues
[41] Aerts JCJH. A Review of Cost Estimates for Flood Adaptation. Water. 2018; 10(11):1646. https://doi.org/10.3390/w10111646
[42] The Guardian (2022) Beachfront homeowners push to extend Collaroy seawall to protect property from erosion

foreshore walkway. As there is no data on the visitation and use of the foreshore walkway, this potential consequence has not been quantified.

FIGURE 26: SITE C COASTAL EROSION HAZARD BANDS



Site C | Old Beach

Legend

- Study Area
- Building Footprint
- Property Boundary
- Public Land
- Railway Network

Coastal Erosion Hazard Bands

- High
- Medium
- Low
- Investigation

SGS Economics & Planning

Source: SGS Economics and Planning, 2023

Filling and raising land

This adaptation measure is applicable to pathway 2.

The cost of raising land levels will depend on the availability and cost of suitable fill. Sometimes fill material may be available for free. Costs of placing and grading may be quite modest, with higher costs for the load bearing area under the structure where consolidation and suitable material is required. An indicative cost to raise land level by up to one metre may be $13 - $40 per square metre. A midpoint of $26 has been assumed. For existing development there would be additional cost if these structures have to be lifted. In general, one would time the raising of the land to coincide with the redevelopment of a structure or normal rebuilding cycle for roads or other infrastructure.

The recommended average household size for flood risk management measures from the NSW Department of Planning and Environment is 220 square meters[43].

Roads can be raised above flood levels, or at least to depths that allow continued access during flood events. Raising roads may be necessary to provide access to properties that are not directly affected by coastal hazards but depend upon roads in the flood hazard area for access.

In low lying areas, raising roads implies continued commitment to maintaining a community in an area that is expected to be exposed to current or future flood hazards. Indicative cost to raise roads for suburban roads is $526 per metre to raise 0.5 metres[44]. It is most cost effective to raise roads at the time of significant maintenance. Raising roads may have significant effects on drainage patterns and could affect low lying properties adversely.

If the filling is done in stages there may be issues where filled land could increase the flooding of adjacent unfilled land. Such a patchwork filling approach may create problems with drainage unless some considerable thought and planning is put in place to anticipate and manage this issue. An overall filling and drainage plan would be required to avoid the worst foreseeable problems. A patchwork approach to filling will enable properties, infrastructure and land to be filled at the time it is (re)developed, thereby minimising the additional cost of adaptation.

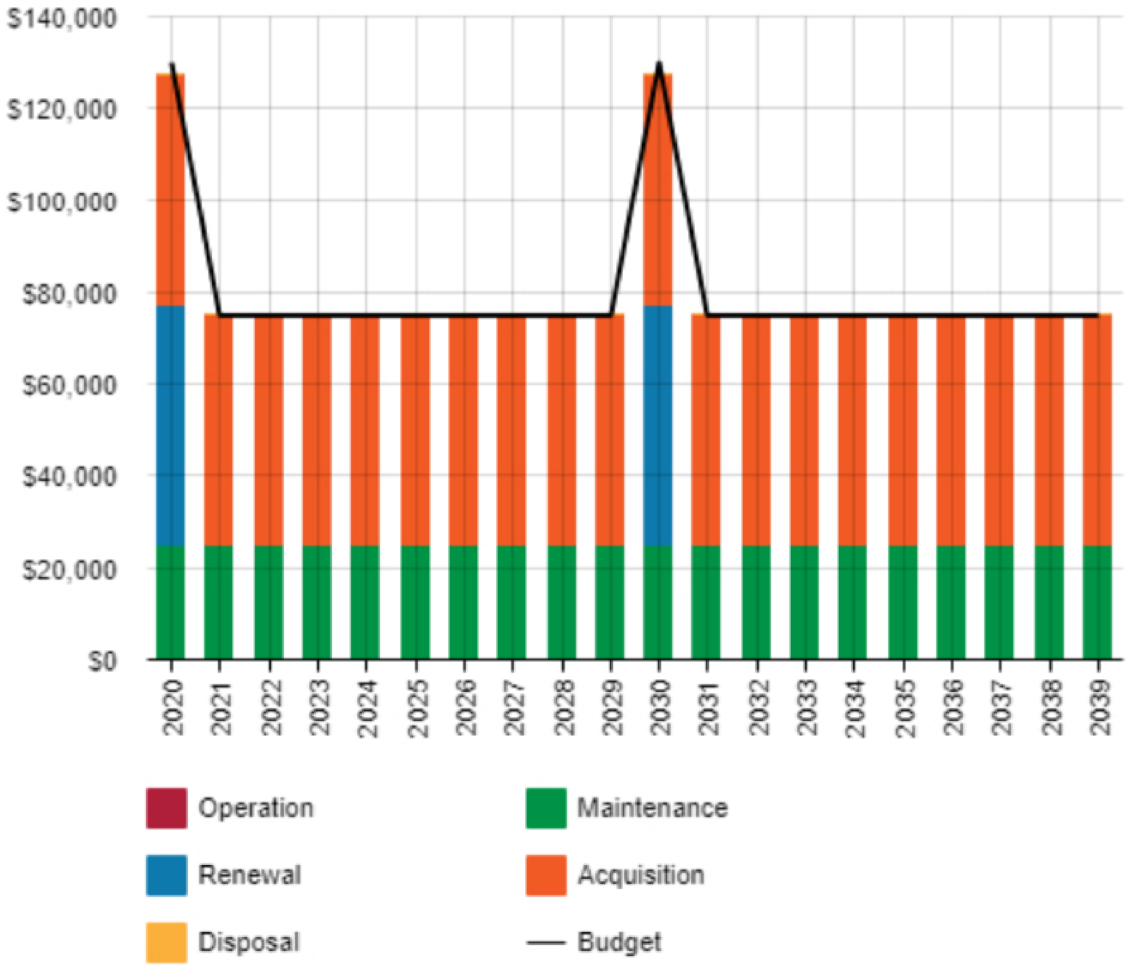
Stormwater drainage investment

This adaptation measure is applicable to pathway 2.

Brighton Council's stormwater management plan sets out the budget for stormwater infrastructure at $80,500 a year for two decades (from 2020 to 2039), with renewal works worth about $50,000 occurring at the start of each decade[45], as shown in below. A simple assumption that investment in stormwater infrastructure is doubled from 2030 onwards has been applied, however the distribution of this investment is not provided in the budget. Therefore, it has been assumed that about 40% of this additional investment would occur within site C, worth $32,200 every year, with an additional $20,000 spent at the beginning of each decade on renewal. The costs in Section 7 represent the *additional* investment in stormwater infrastructure, above that which would occur without intervention.

[43] DPE NSW (2023), Flood risk management measures, table 13
[44] SGS (2013) TCAP Garden Island Creek
[45] https://www.brighton.tas.gov.au/wp-content/uploads/2021/08/Stormwater-Management-Plan-Final-December-2020.pdf

FIGURE 27: FORECAST LIFECYCL COSTS AND PLANNED BUDGETS FOR STORMWATER INFRASTRUCTURE



Source: Brighton Council, 2020

Cost of relocation

A case study in the town of Tangier in Chesapeake Bay in America provides insight into the potentially prohibitive costs of relocation. The town has lost 62% of its inhabitable land since 1967, and much of its population too. It is estimated that the cost to relocate the 436 remaining residents would be between $100-200 million USD. The midpoint of this estimate is equivalent to $229 million AUD, or $524,450 per resident. Taking the average household size in Brighton of 2.6, this would equate to almost $1.4 million to relocate a household. However, as this relates to the relocation of an entire town, it is likely that this figure overstates the cost to relocate an individual house as needed. A review of cost estimates for flood adaptation in the publication *Water*, suggests that the cost to relocate an average building is $349,000 in 2015 US dollars[46]. This is equivalent to $692,203 AUD in 2023.

As the risk increases over time for the households in each hazard band, so too does the probability of a house needing to be relocated, which is reflected in the assessment of the benefits of each pathway.

[46] Aerts JCJH. A Review of Cost Estimates for Flood Adaptation. Water. 2018; 10(11):1646. https://doi.org/10.3390/w10111646

Land value uplift

This adaptation measure is applicable to pathway 2.

Under the base case and pathway 1, there would eventually need to be retreat from the foreshore as coastal erosion and inundation make the area unliveable, while allowing natural processes to run their course. The adaptation measures available under pathway 2 however, would protect the foreshore from coastal erosion and inundation, which would make it viable for infill development. In fact, the cost of these adaptation measures may be offset by the value uplift of the land as a result of allowing it to be developed for residential use. To determine the value uplift of infill development, the average capital value of homes in Site C – Old Beach was taken as a proxy. That is, the total value of land parcels with residential structures on them, less the value of the land itself. This value is $423,498.

Cost to install culverts

As part of the Brown Hill Keswick Creek Stormwater Project, in South Australia, a section of Brown Hill Creek in Forestville was diverted by the Department of Planning, Transport and Infrastructure in 2013. The creek was diverted to into underground culverts such as this one.

FIGURE 28: UNDERGROUND CULVERT IN BROWNHILL CREEK, SOUTH AUSTRALIA

Source: Brown Hill Keswick Creek Stormwater Project

Another part of the project that was not completed was for 102 culverts spread across the length Malcolm Street to Victoria Street in Brownhill Creek. The total cost of this was nearly A$25 million[47], or about A$304,000 each in present-day values. As this was not completed, and the appendix does not include the distance along which the culverts would have been spread, another estimate for how spread apart these culverts must be.

[47] https://bhkcstormwater.com.au/wp-content/uploads/2014/09/Appendix-17-estimated-costs-of-high-flow-bypass-culverts-A4.pdf

The Oakajee Port and Rail: Surface Water Management report prescribes that culverts along Oakajee River, north of Perth should have 1.5 to 2 culverts per kilometre of railway track[48]. This means that along the railway track, which is where culverts would be installed, would require up to 5 culverts along its 2.4 km stretch within the bounds of site A. A 1% annual maintenance cost has been assumed too.

Value of wetlands

A 2014 study updating the value of ecosystem services in the wake of worsening climate change placed the average annual value of US wetlands at $140,174 per hectare in 2011 USD (A$292,069 present value). However this is likely skewed by several extremely high value wetlands and Brighton's is more likely closer to the median value which is $12,163 per hectare per year (A25,343 present value)[49].

Additional inputs

Coastal hazard risks

TheLIST map provides resources on coastal hazards threatening Tasmania's coastline. These include hazard bands which correspond to probabilities of impacts now and in the future[50]. The hazard bands are defined as follows in Table 57 and Source: SGS Economics and Planning (2023)

Table 58 below. These are important as they are a key input into the cost of risk calculations, by defining the probability that the value at risk is actually damaged or destroyed.

TABLE 57: COASTAL INUNDATION HAZARD BANDS DEFINITIONS

Hazard band	Implication
High	Areas vulnerable to a 1% AEP storm event, or a mean high tide by 2050
Medium	Areas vulnerable to a 1% AEP storm event in 2050
Low	Areas vulnerable to a 1% AEP storm event in 2100

Source: SGS Economics and Planning (2023)

TABLE 58: COASTAL EROSION HAZARD BANDS DEFINITIONS

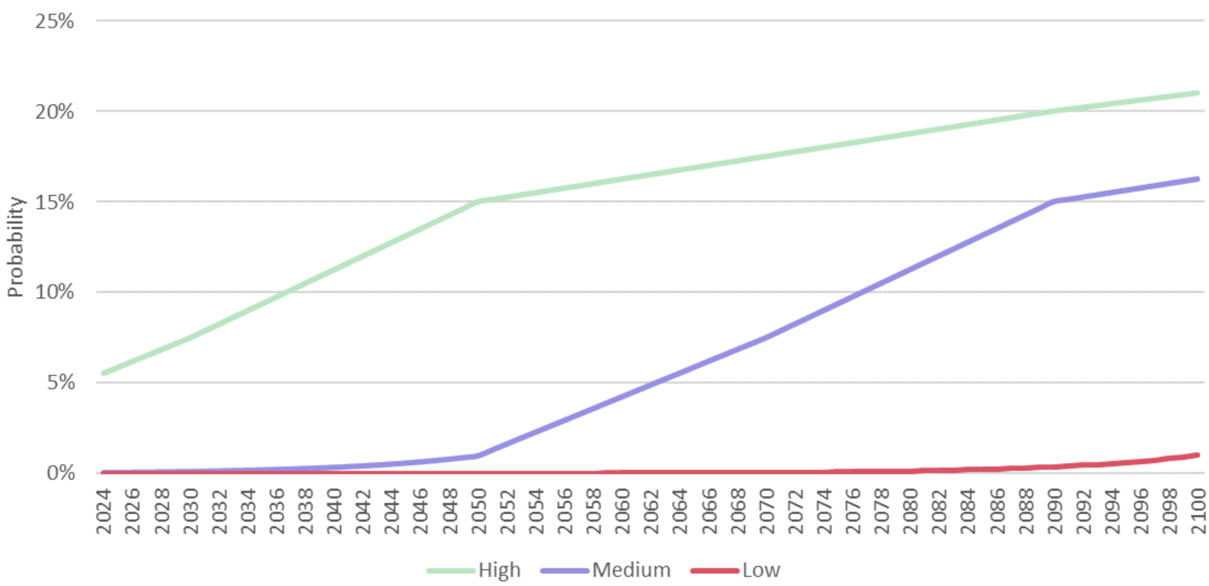
Hazard band	Implication
High	Areas currently vulnerable to coastal recession, typically sand dunes
Medium	Areas vulnerable to coastal recession by 2050
Low	Areas vulnerable to coastal recession by 2100, or protected by coastal defences

[48] https://www.epa.wa.gov.au/sites/default/files/PER_documentation/1881-PER-Appendix%203%20-%20Surface%20Water%20Assessment.pdf
[49] Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S. J., Kubiszewski, I., ... & Turner, R. K. (2014). Changes in the global value of ecosystem services. Global environmental change, 26, 152-158.
[50] https://listdata.thelist.tas.gov.au/public/outgoing/sif/metadata/Coastal_Inundation_Mapping_Stage4_1.pdf

Source: SGS Economics and Planning (2023)

However, these risks are not stagnant over time. Climate Futures for Tasmania provides an understanding of how the likelihood of a 1% AEP flood event in the baseline year (2010) will evolve over time. It is expected that such an event would be a 5-10% AEP event in 2030, and a 20% AEP in 2090. From these three points, a relationship between the probability of an event occurring over time can be extrapolated, and this relationship is demonstrated in Figure 29 below.

FIGURE 29: PROBABILITY OF COASTAL HAZARD BY HAZARD BAND OVER TIME



Source: SGS Economics and Planning, 2023

Value at risk

One of the key inputs into the CBA is value at risk (VaR), which is the total value of the land and structures (i.e. capital improved value) threatened by coastal erosion and inundation hazards over the rest of the century. To find this value, we used the cadastral parcel information within Site C – Old Beach, including the land and capital value of all private parcels, and overlayed them with the coastal erosion and inundation hazard bands from theLIST map. This represents the total possible damages of a sufficiently severe hazard event represented by the hazard bands, and therefore appear substantial. However, the probability of such an event occurring is often quite low and therefore, the total risk (in $) is likely to be considerably lower than the *potential* damages of an extreme event.

Cost of risk

Cost of risk was one of the key inputs in this CBA as it defines what is at stake in the base case, and what could be saved under each pathway. In other words, one of the key benefits of each adaptation pathway is the cost of risk avoided as a result of the adaptation measures taken.

It is important to note that the likelihood of extreme events is an area of adaptation planning that is still developing, and future weather conditions are still very difficult to predict accurately. Therefore, cost of risk calculations should be interpreted as indicative estimates only. The total cost of risk calculations are summarised in Table 59 below.

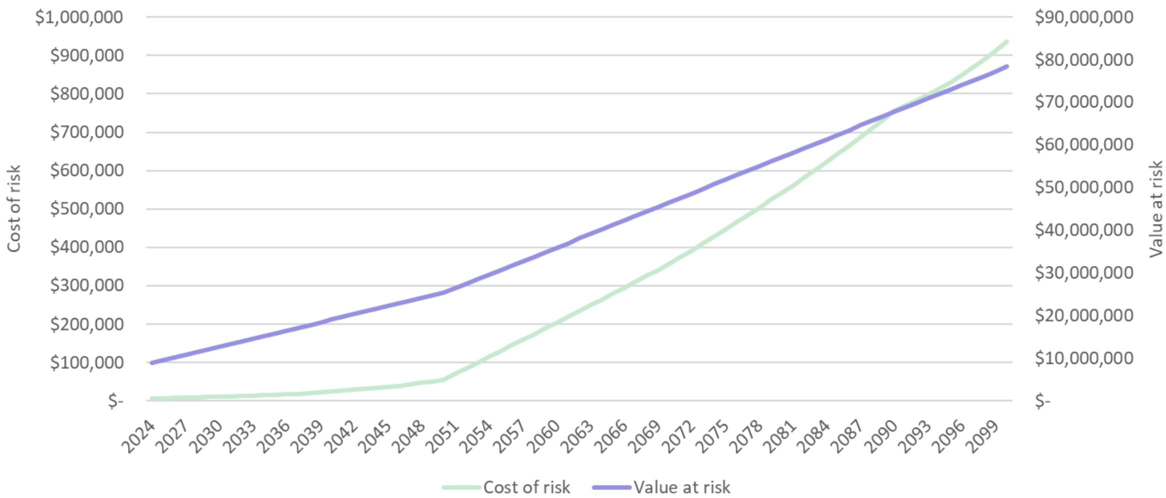
TABLE 59: COST OF RISK FROM INUNDATION AND EROSION – ALL SITES

	Baseline (2010)	By 2050	By 2100
Value at risk – properties	$0	$24,586,380	$76,372,950
Value at risk – transport	$231,652	$769,473	$1,997,203
Subtotal	$231,652	$25,355,853	$78,370,152
Cost of risk*	**$6,648**	**$56,222**	**$936,704**

Source: SGS Economics and Planning, 2023
* Hazard bands represent vulnerability to 1% AEP (1-in-100 year event), so cost of risk is 1% of cumulative value at risk

Cost of risk is derived by multiplying the proportion of value at risk by the probability of an event occurring in that hazard band, as described in Figure 29 above. The cost of risk overtime escalates gradually, however as the properties firstly exposed to the high hazard band are eventually abandoned, they are no longer counted in cost of risk – they are simply lost value, which leads to a less smooth temporal distribution of cost of risk. This is demonstrated in Figure 30 below.

FIGURE 30: VALUE AT RISK AND COST OF RISK – ALL SITES



Source: SGS Economics and Planning, 2023

An additional cost of risk that does not relate to the property values at risk is the replacement value of personal property such as vehicles and home contents. The NSW Department of Planning and Environment provides guidance on these costs, which include $15,000 for external damage, $3,750 for vehicle damage and $490 for damage to contents[51]. This has been included in the CBA.

[51] https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Water/Floodplains/flood-risk-management-measures-230282

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