Appendix A

Stakeholder and Community Engagement Plan

A.1 SCEP

Shire of Murray CHRMAP

Stakeholder and Community Engagement Plan

May 2021

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Issue	Date	Status	Prepared by		Approved by	
			Name	Initials	Name	Initials
1	15/09/2020	DRAFT	Hayley Campbell	HC	Cath Blake-Powell	CBP
2	8/10/2020	DRAFT	Hayley Campbell	HC	Catherine Atoms	CA
3	24/11/2020	DRAFT	Hayley Campbell	HC	Cath Blake-Powell	CBP
4	14/12/2020	DRAFT	Hayley Campbell	HC	Cath Blake-Powell	CBP
5	5/5/2021	DRAFT	Hayley Campbell	HC	Cath Blake-Powell	CBP

Contents

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1. Introduction

1.1 Project background and context

The Shire of Murray has appointed the project team of Baird Australia, **element**, Rhelm and Seashore Engineering to collaboratively produce a Coastal Hazard Risk Management Adaptation Plan (CHRMAP) consistent with Western Australian Planning Commission (WAPC) 2019 guidelines.

This Stakeholder and Community Engagement Strategy (SCEP) has been prepared to guide the engagement process and ensure that the community and stakeholders are effectively and actively involved in the CHRMAP preparation process.

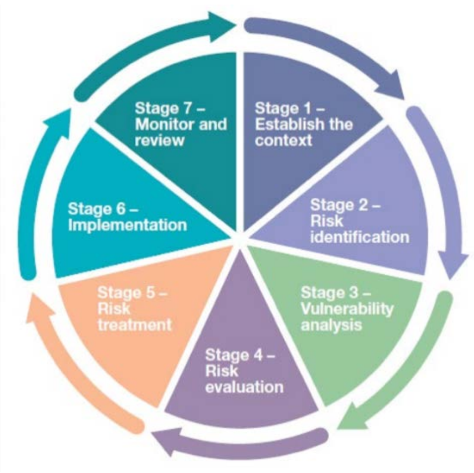
The purpose of the project is to undertake the necessary tasks required to complete the CHRMAP process for the study area in accordance with the coastal hazard risk management and adaptation planning guidelines (WAPC, 2019).

The CHRMAP project delivery will utilise the background studies that the Shire of Murray has previously completed and build on this work to develop a risk assessment framework consistent with WAPC 2019 guidelines. This process will identify the key areas and timeline for coastal hazard risk and guide the identification of adaptation options that will address the short and long-term management of the within the hazard areas.

Adaptation options for the shoreline will consider a full range of planning instruments and be developed in a manner consistent with the views of the stakeholders and community. Identification of preferred options will be guided by a rigorous economic assessment of alternatives, with the final recommendations reviewed by the Steering Committee and presented to the Council for final endorsement. An open and effective community and stakeholder engagement process will contribute to the success of the project.

The CHRMAP process will be completed in 7 stages, where the community will review the draft prepared at the end of each stage. In this way, community and stakeholder involvement will guide the preparation process. See the below diagram for a breakdown of the 7 stages.

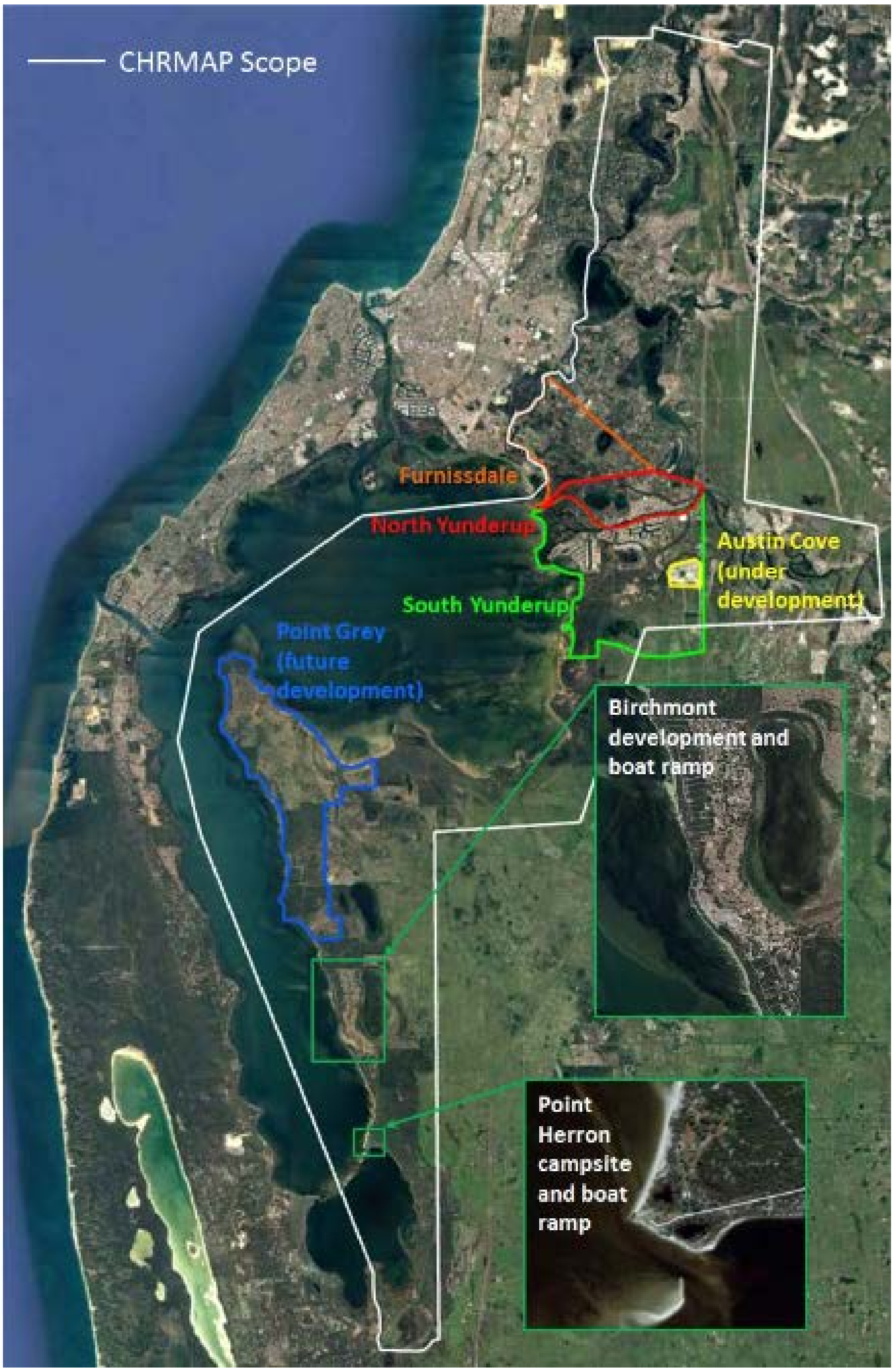
Figure 1 Diagram of the CHRMAP stages



1.2 Scope

The CHRMAP for the Shire of Murray will be carried out for the region encompassing the low-lying estuarine reaches of the Peel Harvey, and the tidally influenced reaches of the Murray and Serpentine Rivers, focusing on natural assets along the length of the estuarine and relevant riverine foreshores, as well as built assets indicated in the below.

Figure 2 CHRMAP study area



2. Objectives

2.1 Project objectives

The specific objectives of the project are to:

- Improve understanding of the Peel–Harvey estuarine coastal and Murray and Serpentine riverine features, processes, and erosion and inundation hazards in the study area.
- Gain an understanding of asset vulnerability in the Peel–Harvey estuarine coastal and Murray and Serpentine riverine zones that includes the areas of water and land that are predominately influenced by coastal processes.
- Identify significant asset vulnerability trigger points and respective timeframes to mark the need for implementation of immediate or medium-term risk management action.
- Identify assets (natural and man-made) and the services and functions they provide situated in the Peel – Harvey estuarine coastal and Murray and Serpentine riverine zones.
- Identify the value at risk of the assets that are vulnerable to adverse impacts from erosion and inundation hazards.
- Determine the likelihood and consequence of the adverse impacts of erosion and inundation hazards on the assets and assign a level of risk.
- Identify risk management measures and actions and how these shall be incorporated into short- and longer-term decision-making.
- Engage stakeholders and the community in the planning and decision-making process.

2.2 Engagement objectives

The engagement plan will detail the key stages of the project and guide stakeholders and the wider community on the CHRMAP process and how they will be involved in the determination of the final outcomes. Following the project objectives, the engagement objectives are to:

- Promote local knowledge sharing through citizen science – the practice of public participation and collaboration in scientific research and data collection to increase scientific knowledge.
- Create a shared sense of ownership for the estuarine environment.
- Clearly communicate project information and scope to community and stakeholders to acquire feedback.
- Inform, consult and involve the community in identifying suitable adaptation options.
- Collect and collate the community and stakeholders' coastal values and aspirations for the long term.
- Understand the level of tolerance of specific risks within the community for specific assets, or groups of assets.

2.3 Key messaging

Supporting the engagement approach, a series of key messages will form an integral component of this project. These key messages are reviewed through the project's duration and as new information comes to light. The key messages are as follows:

- In collaboration with the project team, the Shire of Murray will be producing a CHRMAP for the low-lying estuarine reaches of the Peel Harvey, and the tidally influenced reaches of the Murray and Serpentine Rivers. They will also focus on natural and built assets along the length of the estuarine and relevant riverine foreshores.
- Coastal hazards including erosion and inundation are impacting these systems, and with their increasing extent and frequency may pose even greater risks into the future.
- In order to protect our environment and mitigate these risks, we need to develop a deeper understanding of these hazards and establish an effective framework and plan.
- A collaborative, objective and comprehensive process, including on-the-ground citizen involvement, will assist in preparing the CHRMAP.
- The CHRMAP project will be undertaken in 7 stages, with stakeholder and community engagement happening early in the process under Stage 1 'Establish the Context'.
- The project will be delivered in accordance with State Coastal Planning Policy 2.6 (SPP 2.6) and WAPC, CHRMAP guidelines.
- We will be engaging with a range of stakeholders including Aboriginal Traditional Owners, industry and specialist stakeholders as well as the local community. We will do so through a range of methods both face-to-face and online.
- The local community will also be involved in the CHRMAP process through a Community Reference Group (CRG) and access to project updates through the Shire of Murray 'Your Say' page, available from https://yoursay.murray.wa.gov.au/murray-chrmap
- The project will inform stakeholders and the community about potential risks arising from hazards in the estuarine and tidally influenced river zones, community and cultural values of the zone and adaptation pathways and management options that the Shire of Murray can pursue over time.

2.4 Key issues and approach

It is common that there are a number of issues and opportunities that may relate to engaging with community and key stakeholders for a project of this type. We would like to identify all possible issues or opportunities early in the planning process and find an approach suitable within the SCEP. We will work with the Shire of Murray and the project team to identify all possible issues/opportunities and the associated approach in the following table.

Table 1 Potential issues and plan to mitigate through engagement.

Issue	Potential Impact	Approach (opportunity)
Community and stakeholders misunderstand the project scope and objectives.	The community are unsure of what can be achieved by the CHRMAP.	We will create a clear set of project key messages and negotiables and non-negotiables which will define the scope of the CHRMAP to be used throughout the engagement communications. Briefings, communications collateral etc will be produced to minimise misunderstandings.

Issue	Potential Impact	Approach (opportunity)
Some members of the community feel they are underrepresented.	Community unable to engage within project timeframe.	Ensure we have an equitable number of community and stakeholder representatives involved in the engagement process. Ensure all key stakeholders are identified by the project team and the Shire of Murray. Use a range of methods to engage with the community and stakeholders.
We ask too much of the community.	Participants in the engagement process become fatigued and/or uncertain in the engagement process.	A clear and concise set of key messages will be agreed upon in the SCEP to guide all communications and engagement collateral will be simple and informative. Project team members will be available at each engagement activity to provide further guidance with project information.
Community and stakeholder apprehension to engage and disappointment in the outcomes.	Community and stakeholders may be sceptical that they can meaningfully influence the project and may become disappointed if the engagement process does not lead to action that reflects their input.	Forming part of the key messages, negotiables and non-negotiables of the project will be defined within the SCEP and communicated to all participants in the engagement process so that they understand which parts of the project they will be able to influence.
There is lack of interest within the community.	There is low community and stakeholder participation and therefore the project team has limited feedback and information from the process.	We will create interesting and effective communications collateral and advertise the engagement process through multiple channels. We will be nimble and flexible in the engagement process and be ready to change direction if needed.
Certain stakeholders are tempted to push a solution that does not serve the community as a whole.	The solution pushed by these stakeholders does not support a long-term solution for everyone. Other 'quiet' stakeholder groups are disadvantaged by the outcome.	A layered approach to the engagement activities on offer and identifying the reason of interest of each stakeholder group to understand their motivation. Ensuring the reach of engagement is broad and at the whole community level, using citizen science to get as much involvement as possible.

3. Stakeholder Identification and Analysis

Understanding project stakeholders is a critical consideration of any engagement and communications program. By understanding who these groups or individuals are, we may better understand and analyse their degree of influence and interest, and therefore the involvement they are likely to request and require.

We have worked in collaboration with the project team and the Shire of Murray to compile a full stakeholder list. The following table summarises a non-exhaustive list of key stakeholders, grouped into broad categories.

Table 2 Key stakeholders and analysis

Stakeholder	Level of engagement	Method to engage
Shire of Murray staff and Councillors	Inform and collaborate	All
South West Aboriginal Land and Sea Council	Involve	Traditional Owner Engagement
Department of Primary Industries and Regional Development	Collaborate and inform	Stakeholder memo
Department of Planning, Lands & Heritage	Collaborate	Steering Group
Department of Transport	Collaborate	Steering Group
Department of Water and Environmental Regulation	Collaborate	Steering Group
Peel Harvey Catchment Council	Collaborate	Steering Group
Department of Biodiversity, Conservation and Attractions	Collaborate	Steering Group
Peron Naturaliste Partnership	Collaborate	Steering Group
City of Mandurah	Collaborate and inform	Steering Group
Local groups, such as Chamber of Commerce, Progress Associations etc	Inform, consult, involve	CRG, online survey, online information webinars.
Schools, colleges and youth groups	Consult	Online survey, information webinars.
Landowners shown in the hazard areas predicted to be affected by erosion and inundation over the planning timeframe	Inform, consult, involve.	CRG, online survey, online information webinars
The broader Shire of Murray community	Inform and consult	CRG, online survey, online information webinars.
Interested recreational visitors	Inform	Online survey
Local media	Inform	Media release
Politicians	Inform	Stakeholder memo

3.1 Negotiables and non-negotiables

It is important to keep the community and stakeholders informed about which aspects of the projects are able to be influenced by their input and which are not. The negotiables and non-negotiables of the project will be collaboratively defined here by the project team and the Shire of Murray.

Table 3 Project negotiables and non-negotiables

Negotiables	Non-negotiables
• Asset identification, coastal values and significant places identified by the community • Consequence scale based on community and stakeholder input • Levels of risk deemed acceptable, tolerable and intolerable by the community • Risk treatment - Adaptation options • Risk management pathways (timeframe for adaptation and mitigation)	• State Planning Policy, Coastal Planning SPP2.6 (WAPC 2013) • Allowance for sea level rise in future planning periods (DoT 2010) • Coastal Hazard Risk Management and Adaptation Planning Guidelines (WAPC 2019)

4. Engagement Methodology

4.1 Level of Engagement

We will encourage community and stakeholder engagement on the **inform**, **consult**, **involve** and **collaborate** levels, which will guide the design of the engagement activities. The goals of each level of engagement are described in the table below.

Table 4 Levels of Engagement

Level	Inform	Consult	Involve	Collaborate
Goal	To provide balanced and objective information in a timely manner.	To obtain feedback on analysis, issues, alternatives and decisions.	To work with the public to make sure that concerns and aspirations are considered and understood.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.
Promise	"We will keep you informed."	"We will listen to and acknowledge your concerns."	"We will work with you to ensure your concerns and aspirations are directly reflected in the decisions made."	"We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible."

4.2 Engagement tools

Steering group

A project steering group (Technical Advisory Group) has been formed to involve key stakeholders throughout the CHRMAP process.

Traditional owner engagement

We recognise that Aboriginal engagement requires a specialised set of skills in order to deliver appropriate engagement methods for meaningful insights. The project team will sub-contract an Aboriginal engagement professional to conduct interviews using questions provided by the Shire. The project team will interpret the data for input into the engagement outcomes report. The project team will take direction from the Shire and SWALSC as to whom we shall invite to interview, which may likely include local elders or family group representatives.

Community reference group

Given the high level of interest from the community to date and the diverse range of stakeholders already identified by the project team, we are establishing a Community Reference Group (CRG) for the duration of the engagement activities and delivery of the draft CHRMAP. By engaging the local knowledge and insights of a CRG, the project will demonstrate a greater level of transparency, collaboration and willingness to take on board concerns, values and ideas of the community, via selected representatives.

The CRG will meet at key milestones in the project to provide feedback of the engagement approach prior to implementation as well as an additional point of review of each chapter report. CRGs will help to generate community buy-in and good will and help in the dissemination of key information through their networks.

We will work with the Shire to identify key criteria of CRG membership (whether open, invite-only or a combination of both). The project team shall prepare associated documentation such as information packages and terms of reference for the group, as well as run facilitated workshop discussions.

Information event

Early in the CHRMAP process the consultant team will facilitate a public information event, which will inform interested stakeholders and the community on the CHRMAP process including, but not limited to the following:

- What is a CHRMAP?
- Why does a CHRMAP need to be prepared?
- Project aims and delivery process?
- Key issues and Coastal Hazard Mapping.
- FAQ (e.g. queries on insurance premiums, planning considerations).
- Key proposed delivery dates and project milestones.

Our team will invite community members broadly to attend an informal information event, which will include a public display with interactive display boards. The consultant team will be available for stakeholder and community questions and feedback with project leads from the team present to advise on coastal hazard and adaptation (Matt Elliot, Jim Churchill) planning (Mike Davis) and engagement (Cath Blake-Powell).

During the information event:

- The consultant team will display the outcomes of hazard mapping (developed in Stage 2) to the participants to promote understanding of coastal hazard risk for the community now and into the future (over the next 100 years with projected sea level rise).
- Planning considerations, which are influenced by coastal hazard will be described in broad outlines (e.g. setting design floor levels for inundation).
- Environmental impacts for the Peel estuary associated with projected sea level rise will be presented at a high level.

All materials on display in the information event, such as FAQ, will be available for download from the project webpage after the event for those who cannot attend. Any questions taken on notice will be available on the next project webpage update.

The consultant team will be available to respond to and record stakeholder and community questions and feedback. The information event will assist the community and stakeholders in understanding coastal hazard issues affecting their coastal areas, recognising the role the CHRMAP process plays in developing future coastal planning activities and gauging the main concerns of the community. This will enable the consultant team to tailor the engagement to follow in later stages of the project.

Coastal values assessment (online survey and mapping tool)

We will assess the community's coastal values through an online survey and mapping tool, which will be advertised through the following:

- Distributing letters of invitation either mailed, emailed or hand delivered to key project stakeholders.
- Flyers posted to residents/homeowners residing on and adjacent to affected coastal land.
- Posters displayed at various venues across the Shire.
- Shire Facebook posts and targeted social media advertising campaigns.
- Targeted social media advertising and media releases.
- Shire website banner and CHRMAP Your Say page.
- Face-to-face invitations extended by staff members in Shire buildings (i.e. flyer distribution).

At the opening of the online survey and mapping tool, community and stakeholders will have access to information online, which they will be encouraged to read while completing the survey.

An online survey and mapping tool will be prepared by the project team, as follows.

- An online survey and map (using Your Say platform) will be published on the Shire's website. The format will be reviewed by the Shire, and include questions around:
    - whether the participant is a local, visitor, tourist or other within the Shire of Murray;
    - coastal regions where individuals frequent in the study area;
    - identifying environmental, social and economic assets they value in the area and explore why these assets are of value;
    - identify the coastal assets which are most important to them; and
    - understanding tolerance to coastal issues.
- The survey will be promoted via the Shire's webpage and social media platforms. Additionally, the survey will be directly sent to identified stakeholders and known interested parties, as well as encouraging these individuals and organisations to distribute amongst their networks. We will use the Shire's existing databases to identify all relevant stakeholders.
- The survey will be collected via the Shire's survey account, the Shire will collate the survey responses and provide to the consultant team for review.

Scenario workshop

A scenario workshop will be undertaken to gain community input and feedback into the hazard and risks to which the community is exposed. The scenario workshop will be used to provide an overview of the hazard mapping and risk assessment completed in the Stage 1 to 4 and give participants an opportunity to comment on the identified high-level risks.

The workshops will use a multi-criteria analysis (MCA) to compare and contrast an identified list of adaptation options. The analysis will incorporate criteria related to economic, social and environmental impacts.

The MCA workshop will work through alternatives in a 'live' setting, to first establish the weighting criteria for the MCA and then rank each adaptation option according to the scoring across the general categories.

At the conclusion of the workshop, a ranked list of options at each critical location will be agreed by the participants.

4.3 Communications collateral

Effective communication is essential to the engagement process. We will use the following communications collateral to promote and encourage participation in a citizen science program. We will prepare information about the project to community and stakeholders.

Broadly, the communications collateral package will include:

- FAQs: In collaboration with the Shire, element will prepare a set of FAQs which will be used on key communication platforms such as the Your Say webpage and
- Flyers: element will work with the Shire to prepare the flyer content and graphic design. The Shire will then coordinate the printing and distribution of the flyers.
- Posters: Posters will be used to advertise the engagement process including key dates and events. With Shire approval, element will prepare the poster content and graphic design and the Shire will coordinate the printing and distribution of the posters.
- Newspaper advertisements: In collaboration with the Shire, element will prepare the contentment for newspaper advertisements of key engagement dates and activities. The Shire will coordinate logistics of the advertisement.
- Messages for social media: Using the key messages and FAQs as a guide for content, the Shire will coordinate messages for social media and targeted posts.
- Shire 'Your Say' online engagement platform: alongside the project team, element will prepare the online survey questions, for the Shire to review and publish via their Your Say webpage.

Appendix B

Engagement Outcomes Summary

B.1 Engagement Outcomes Summary

Shire of Murray CHRMAP

Engagement Outcomes Summary

July 2021

Document ID: 20-154 / Project Work / Engagement / Outcomes						
Issue	Date	Status	Prepared by		Approved by	
			Name	Initials	Name	Initials
1	2.07.21	Draft	Hayley Campbell	HC	Cath Blake-Powell	CBP

Contents

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1. Introduction

1.1 Project background and context

The Shire of Murray appointed the project team of Baird Australia, **element**, Rhelm and Seashore Engineering to collaboratively produce a Coastal Hazard Risk Management Adaptation Plan (CHRMAP) consistent with Western Australian Planning Commission (WAPC) 2019 guidelines.

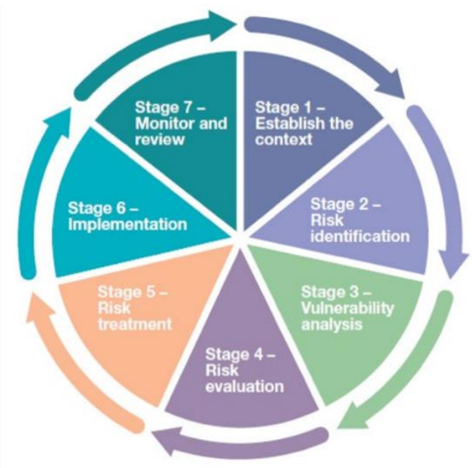
A Stakeholder and Community Engagement Strategy (SCEP) was prepared to guide the engagement process and ensure that the community and stakeholders were effectively and actively involved in the CHRMAP preparation process.

The CHRMAP project delivery utilises background studies that the Shire of Murray previously completed and will build on this work to develop a risk assessment framework consistent with WAPC 2019 guidelines. This process will identify the key areas and timeline for coastal hazard risk and guide the identification of adaptation options that will address the short and long-term management within the hazard areas.

Adaptation options for the shoreline will consider a full range of planning instruments and be developed in a manner cognisant of the views of the stakeholders and community as outlined in the findings of this report. Identification of preferred options will be guided by a rigorous economic assessment of alternatives, with the final recommendations reviewed by the Steering Committee and presented to the Council for final endorsement.

The CHRMAP process is being completed in 7 stages, where the community will review the draft prepared at the end of each stage. In this way, community and stakeholder involvement will guide the preparation process. See the below diagram for a breakdown of the 7 stages.

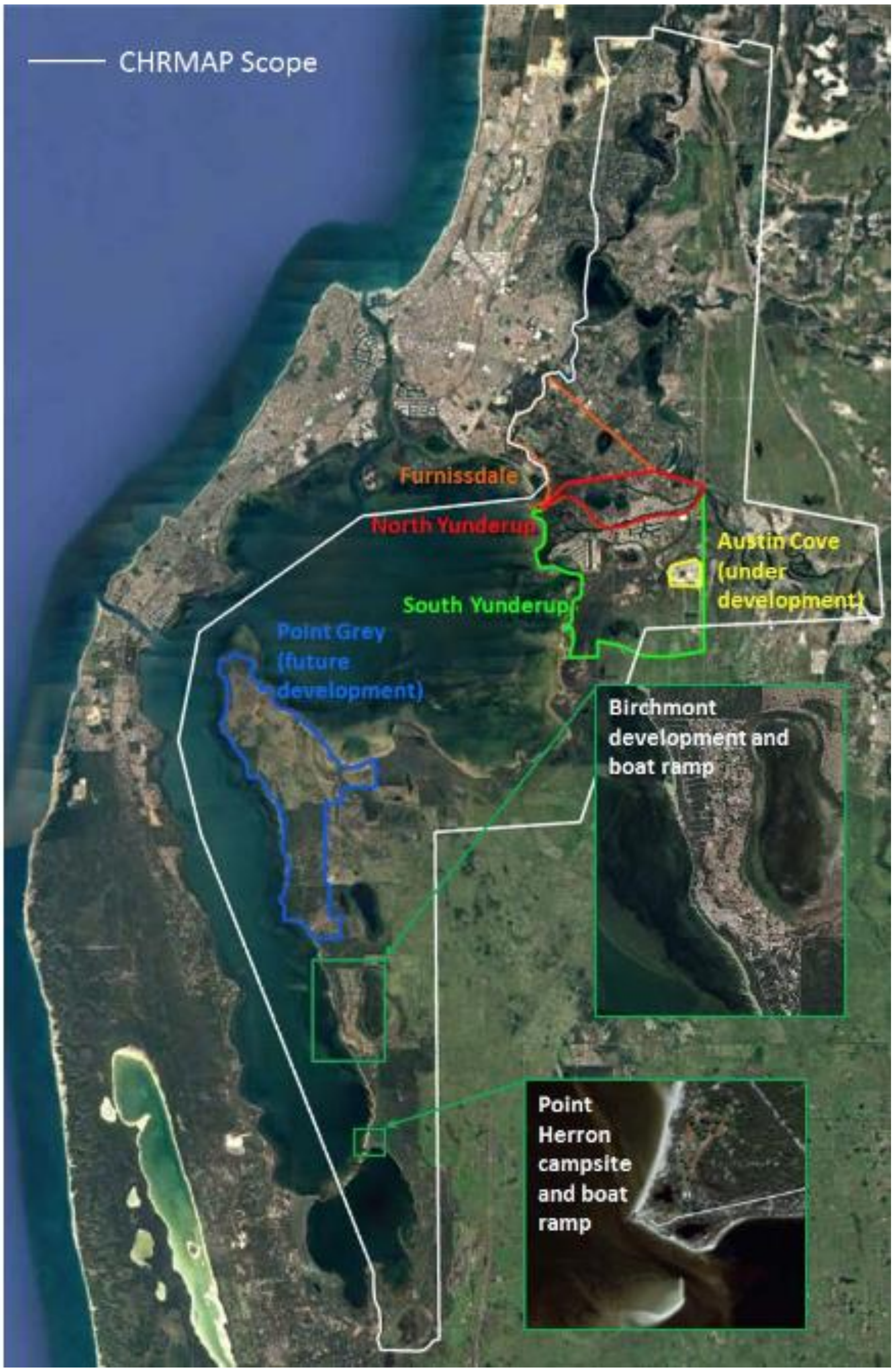
Figure 1 Diagram of the CHRMAP stages



1.2 Scope

The CHRMAP for the Shire of Murray is being carried out for the region encompassing the low-lying estuarine reaches of the Peel Harvey, and the tidally influenced reaches of the Murray and Serpentine Rivers, inclusive of natural assets along the length of the estuarine and relevant riverine foreshores, however with a focus on built assets as indicated below.

Figure 2 CHRMAP study area



2. Objectives

2.1 Project Objectives

The specific objectives of the project were to:

- Improve understanding of the Peel–Harvey estuarine coastal and Murray and Serpentine riverine features, processes, and erosion and inundation hazards in the study area.
- Gain an understanding of asset vulnerability in the Peel–Harvey estuarine coastal and Murray and Serpentine riverine zones that includes the areas of water and land that are predominately influenced by coastal processes.
- Identify significant asset vulnerability trigger points and respective timeframes to mark the need for implementation of immediate or medium-term risk management action.
- Identify assets (natural and man-made) and the services and functions they provide situated in the Peel – Harvey estuarine coastal and Murray and Serpentine riverine zones.
- Identify the value at risk of the assets that are vulnerable to adverse impacts from erosion and inundation hazards.
- Determine the likelihood and consequence of the adverse impacts of erosion and inundation hazards on the assets and assign a level of risk.
- Identify risk management measures and actions and how these shall be incorporated into short- and longer-term decision-making.
- Engage stakeholders and the community in the planning and decision-making process.

2.2 Engagement Objectives

Following the project objectives, the engagement objectives were to:

- Promote local knowledge sharing through citizen science – the practice of public participation and collaboration in scientific research and data collection to increase scientific knowledge.
- Create a shared sense of ownership for the estuarine environment.
- Clearly communicate project information and scope to community and stakeholders to acquire feedback.
- Inform, consult and involve the community in identifying suitable adaptation options.
- Collect and collate the community and stakeholders' coastal values and aspirations for the long term.
- Understand the level of tolerance of specific risks within the community for specific assets, or groups of assets.

3. Methodology

3.1 Engagement tools

A number of engagement tools have been used throughout the CHRMAP project process, these are identified below. Each of these were designed to inform key CHRMAP project stages

Information event

Early in the project, two drop-in sessions were held to introduce the CHRMAP project and provide information about the project including:

- What is a CHRMAP?
- Why does a CHRMAP need to be prepared?
- Project aims and delivery process?
- Key issues and Coastal Hazard Mapping.
- FAQ (e.g. queries on insurance premiums, planning considerations).
- Key proposed delivery dates and project milestones.

These were attended by the project team and Shire staff and held at the Pinjarra Court House and the local Pinjarra Shopping Centre with approximately 50 local attendees over both events.

Online engagement tool

Through the Shire's YourSay portal, a CHRMAP project webpage was created, hosting information about the CHRMAP process and project, an up-to-date timeline of project milestones, and an online mapping tool via Social Pinpoint.

The online mapping tool has been live, collecting 'citizen science', or spatial and values information from the following prompt: "Within the study area (yellow boundary), let us know about:

- An area and how you use it
- A place and how you value it
- An environmental observation"

Community Reference Group

Given the high level of interest from the community to date and the diverse range of stakeholders identified, we established a Community Reference Group (CRG) for the duration of the engagement activities and delivery of the draft CHRMAP. By engaging the local knowledge and insights of a CRG, the project demonstrates a greater level of transparency, collaboration and willingness to take on board concerns, values and ideas of the community, via selected representatives.

The CRG met at key milestones in the project to provide feedback of the engagement approach prior to implementation as well as an additional point of review of each chapter report. CRGs help to generate community buy-in and good will and help in the dissemination of key information through their networks.

The CRG is still ongoing for the remainder of the CHRMAP project.

Coastal values survey

A short coastal values survey was held via the YourSay webpage for 5 weeks between 16 April and 18 June 2021.

A summary of the survey questions are as follows:

About you

- What age bracket do you fall under?
- Please select the location you live from one of the following
  - Birchmont
  - West Coolup
  - Murray Delta Islands
  - South Yunderup
  - North Yunderup
  - Furnisdale
  - Ravenswood
  - Other location in Shire of Murray not listed above
  - City of Mandurah
  - Shire of Waroona
  - Outside of project area (e.g. Perth, please specify)
- How familiar are you with the CHRMAP project currently being undertaken by the Shire of Murray?
- Do you think there should be additional information available on the project YourSay page?

Visitation and coastal values

- How do you interact with the estuary?
- Where do you most frequently participate in the following activities?
- How often do you participate in the activities?
- Why do you choose these locations as opposed to other areas?
- Why do you choose these locations as opposed to other areas?

Values

- What do you value in your coastline and estuarine area?

Thank you

- Please register your details to stay up to date

Scenario workshops

Two scenario workshops were held in May at the Yunderup Sports and Recreation Club, the first workshop on Tuesday 25 May 2021 and the second workshop on Saturday 29 May. The workshops were advertised to the local community and had the purpose of delving deeper into assets, values and adaptation and mitigation strategies.

Across the workshop and total of 23 people attended.

The workshop agenda was as follows:

Introductions and Welcome
Project introduction
Project Background
Task One: Coastal Assets Identification
Consequence Scale Overview
Task Two: Consequence Scale
Task Three: Asset Priorities
Preliminary Adaptation Options Presentation
Task Four: Adaptation Strategy
Wrap up and Next Steps

3.2 Communications channels

A range of communications channels have been utilised to reach the local Shire of Murray community and specific stakeholder groups. These include:

- Shire of Murray YourSay webpage – a home for all project information and communications
- FAQs – providing information about the project, hosted on the YourSay webpage
- Social media advertisements – promoting the survey and workshop registrations
- Letterbox drops – to specific community areas promoting the survey and workshop registrations
- Signage at the South Yunderup Sport and Recreation Club (location of the workshops)
- Word of mouth communications via CRG members

4. Key findings

4.1 Online map tool

There were 28 contributors to the online map tool who made a total of 114 contributions in the form of comments about a place they love, how they use and environmental observations.

The contributions noted a range of environmental features and recreational uses within the study area, providing some context to the values and assets of the area.

The comments have been summarised by spatial area in the following table.

Location with study area	Summary of comments
Peel inlet	• Sight of sea grass "Forrest". Care should be taken when anchoring and scoop netting • Great spot for King George whiting until limestone outcrops were destroyed to accommodate the channel constructed for the canals in the early 70's
Harvey Estuary	• (Used for) wading for crabs and whiting fishing
Serpentine River	• (Used for) Bream fishing • Serpentine River end of Woodland Parade access to foreshore and river for kayaking and fishing • (Used for) Kayaking down Serpentine River • Used to see long necked turtles here but have not done so for several years
Murray River	• Severe bank erosion should have been rectified as part of the freeway bridge engineering (Pinjarra Road, Ravenswood Western). • Bright green Bank reeds seen in front of caravan park were common right up to the estuary – very effective against tide and boat erosion, unfortunately cant handle the influx of salt water • Osprey nest- can be observed from the intersection opposite (1996 Angus Place, Ravenswood Western). • Dolphins, particularly mothers with calf, stop and feed in this shallow wide stretch of river daily (due to the

	bathymetry, and deeper hole at the bend) when heading up and down the Murray River. Many species of fish inhabit this area year-round. Blue swimmer crabs can be found in high abundances here in the warmer months of the year. Adult black bream feed on the flats and shallows opposite Murray Bend and Ravenswood Road. Prawns are observed at night. In May each year, flocks of little black cormorants (n- 1000 strong) accompanied by pelicans and white herons can be seen feeding on schools of baitfish (possibly spawning Atherinids). Ospreys and whistling kites live and feed here. In Blue swimmer crab season, they can be seen approximately 5km below Pinjarra, in addition to juvenile tailor, juvenile tarwhine and garfish. Very high abundances of small yellowtail grunter inhabit the stretch of river between Ravenswood and Pinjarra, in addition to Sea mullet (adult and juveniles) and masses of Atherinids (baitfish) (7 Ravenswood Road, Ravenswood). • Important feeding area for black bream (conditioning for spawning) in winter. Dolphins observed using deeper drop -off on opposite bank for ambushing bream and mullet (6206, Ravenswood)
Harvey River	
Murray Islands	• Used as a weekend getaway from the city • Urgent need to stabilise banks at end of Yunderup Island Some erosion here due to tide and boat wash. Nice wildflowers. • Islands and other local bush walk around the whole of Yunderup Islands. • Lots of dog walkers use this area (101 Rivergum Esplanade, South Yunderup)
Point Grey	• The Dawesville Cut and the deep dredging of the Mandurah Channel has made a significant difference to the estuary and rivers environment. Has had some beneficial effects on water quality, but in general for the east side of the estuary the environmental impact has been mostly negative. Water levels through major tidal variations mean flooding can occur at any time of the year and at the other extreme the water can be so low as to make accessing jetties and boat sheds near on impossible. This tidal variation will see half of the Delta islands disappear if sea level rise predictions are right. This is a national disgrace as one of the most important

	delta island river systems in Australia is disappearing before our very eyes.
Birchmont boat ramp	• Crabbing and estuary access (Birch Drive, Birchmont) • Bird Watching (166 Birch Drive)
Herron point boat ramp	• Herron Pt has been local crabbing and net fishing place for many years.
Yunderup canals	• High tides and boat wash removing natural reeds from shoreline • Issues: poor water quality and mosquitos • Algal blooms are bad this year (2021) • North Yunderup boat ramp would be more useable with floating jetty • Along the riverfront is a beautiful place to enjoy. It needs erosion management and care of the water. (212 Culeenup Road, North Yunderup) • There has been a noticeable increase in speeding vessels in the Murray River. The resulting bank erosion, potential threat to swimmers and wildlife, and damage to moored vessels is increasing rapidly. There is an immediate need for increased signage, monitoring, a easy to use public reporting process, education and enforcement. (198 Culeenup Road, North Yunderup)

4.2 Coastal values survey

A coastal values survey ran for 5 weeks from Friday 14 May until Friday 18 June and collected a total of **186 responses** (182 online and 4 hard copy).

Who did we reach?

Respondents were mostly aged between 30-65 years with 41% being aged between 30-49 years. Half of the survey respondents were either form the City of Mandurah or from Shire locations outside of the Study area, indicating that the area is regarded by not only immediate residents. Other respondents included those from nearby locations including Warnbro, Rockingham and West Pinjarra.

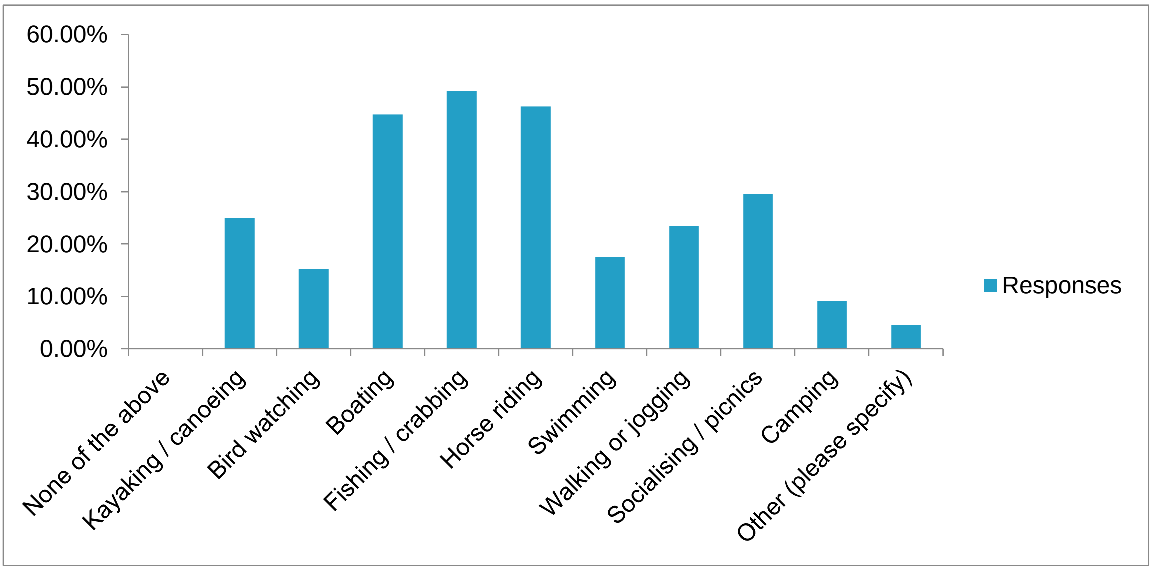
CHRMAP awareness

Most respondents (90%) were either unaware (53%) or only somewhat aware (37%) of the CHRMAP process. 91% of respondents believe there should be additional information available on the Shire's YourSay page, indicating a keenness to learn about the CHRMAP process from the community.

Interaction with the estuary

Survey respondents noted that fishing/crabbing, horse-riding and boating were the top 3 reasons they interacted with the estuary, as shown in figure 3 below.

Figure 3 How do you interact with the estuary? Select your 3 most common interaction options.



The most common places for each activity are as follows.

Activity	Location
Boating	Peel inlet (n=20), Murray River (n=11)
Fishing/crabbing	Peel inlet (n=23), Birchmont Boat Ramp (n=9), Herron Point Boat Ramp (n=10)
Horse riding	Herron Point Boat Ramp (n=26)
Swimming	Murray River (n=11) Herron Point Boat Ramp (n=9)
Walking and jogging	All locations mentioned
Camping	Herron Point Boat Ramp (n=11), Point Grey (n=5)
Socialising / picnics	Herron Point Boat Ramp (n=7)

Respondents mostly participate in all activities once or twice per month. Camping, swimming, and canoeing/kayaking were participated in less frequently.

Values

Respondents chose the above locations for the following reasons:

- Natural beauty of the area
  - "Beautiful place to swim and use the boat, also river fishing"
  - "Nice environment"
  - "It's beautiful"
  - "Peaceful"
- Proximity to their home
  - "Close to home"
  - "On my doorstep"
  - "Close to home, familiarity with the waterway"
- Great conditions and amenities available for the activity (example: nearby trails, horse float parking facilities, boat ramp access).
  - "Playground, toilet BBQ, history"
  - "Close to home, good car park and camping grounds"
  - "Good parking and nice water to ride horses"

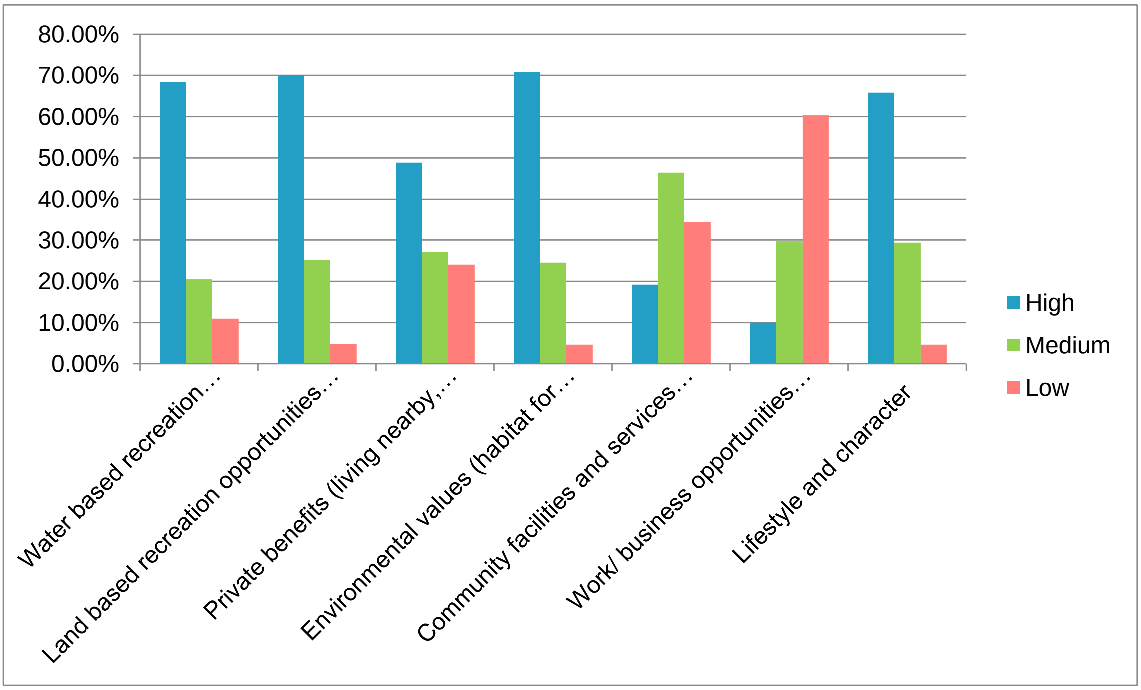
The **highest** respondent values were:

- Environmental values (habitat for wildlife, protection from storms, water/nutrient filtration) (71%)
- Land based recreation opportunities (dog walking, picnicking, fishing, exercising etc near the coastline) (70%)
- Water based recreation opportunities (boating, kayaking etc) (88.5%)

The **lowest** respondent values were:

- Work/ business opportunities (related to coastline and estuarine area) (9%)
- Community facilities and services (events, festivals) (19%)

Figure 4 What do you value in your coastline and estuarine area? Rate each category from high to low.



4.3 Scenario workshops

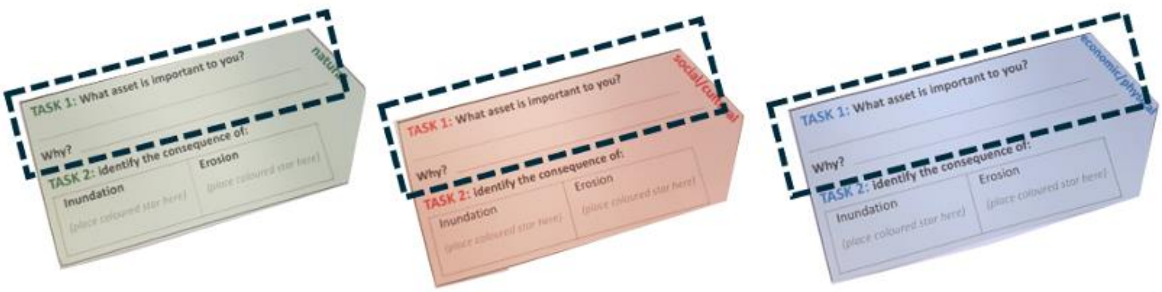
Both workshops were structured to provide information and collaborate with attendees to identify assets, priorities and adaptation options.

Task 1 – Coastal Asset Identification

Following a presentation from Baird on the project background, key findings of the Coastal Hazard Report and an overview the study area, participants were then asked to identify three different classifications of coastal assets (social, environmental and economic) within the study area boundary using the tags pictured below.

They were asked to name the asset and state why it was important.

Figure 5 Coastal Asset Tags



Task 2 – Consequence Scale

The next task asked participants to then rate each of their assets they had identified in two ways:

1. Level of inundation

2. Level of erosion

These rating were informed by the following consequence scale provided in the presentation prefacing the activity.

Consequence	Physical / Economic Impact	Environmental Impact	Social / Cultural Impact
Insignificant	Permanent loss or damage <$20k	Negligible to no loss of flora and fauna – strong recovery	Minimal short-term inconvenience <$5% of community affected
Minor	Permanent loss or damage $20k - $200k	Short term loss of flora and fauna – strong recovery	Small to medium disruption of function <10% of community affected
Moderate	Permanent loss or damage $200k - $2 million	Medium term loss of flora and fauna – recovery likely	Minor long term or major short-term loss of function <25% of community affected
Major	Permanent loss or damage $2 million - $5 million	Long-term loss of flora and fauna – limited chance of recovery	Medium term or permanent loss of function <50% of community affected
Catastrophic	Permanent loss or damage >$5 million	Permanent loss of flora and fauna – will not recover	Long-term or permanent loss of function >75% of community affected

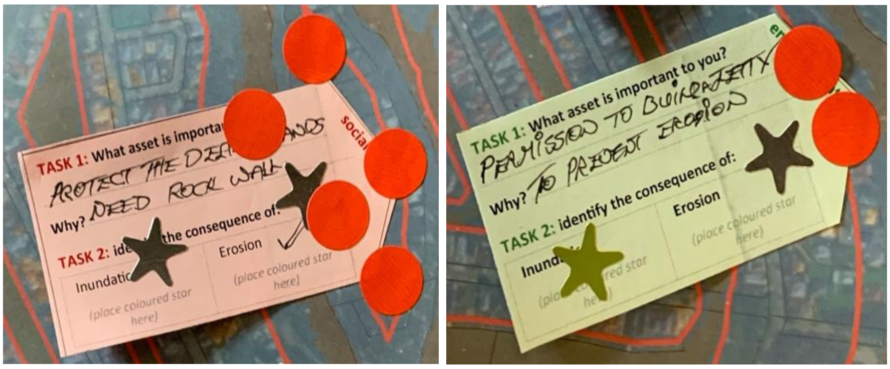
Figure 6 Consequence rating sticker sheet

Task 3 – Asset Prioritisation

Once the consequences of erosion and inundation were determined, participants were asked to re-examine the coastal assets identified on the sticky notes attached to the map on their table.

Working individually, each participant was given five dots and asked to stick one dot beside each of the five assets they valued most. However, if they believed one or more assets to be more important than another, they were able to place more than one dot beside these assets until all five dots were used.

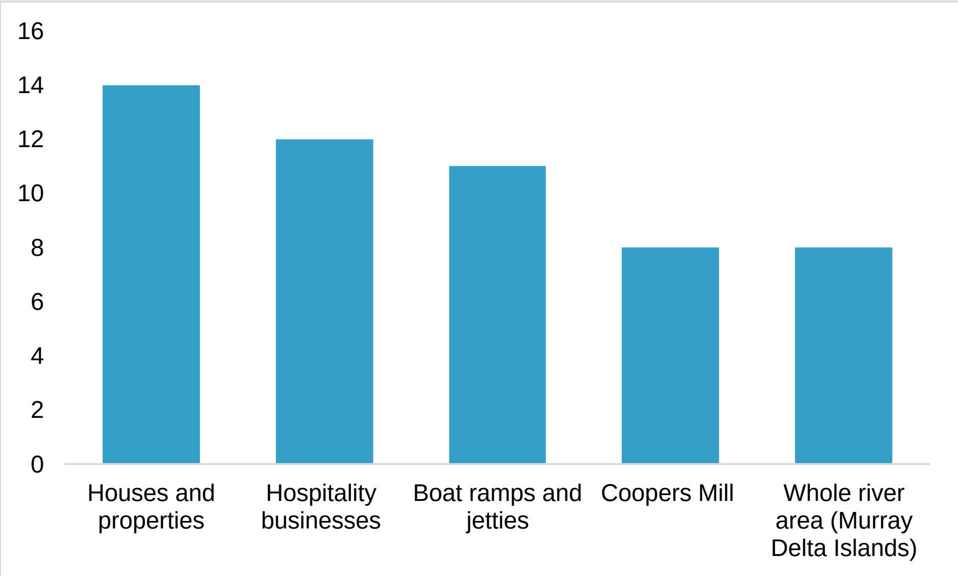
Figure 7 Example of asset prioritisation on asset tags



Results of Tasks 1, 2 and 3

Common themes amongst assets

Overall, 92 valid assets were captured over both workshops. The following graph highlights the range of assets that were named numerous times, including:



The results of the assets have been consolidated into tables based on coastal locations within the study area. The assets identified were relatively evenly spread between social (n=31), environmental (n=32) and economic (n=29).

The results show that generally, the impact of erosion is perceived to have a more severe consequence than the impact of inundation on the coastal location in the study area, particularly in the Murray Delta Islands.

While the asset group 'Houses and Properties' had the most mentions, they also had by far the highest priority ranking with 35 dots.

It is important to note that the workshop attendees were predominantly residents of the Murray Delta Islands.

Figure 8 Results of Tasks 1, 2 and 3 based on coastal location

Murray Delta Island Assets	Classification	No. of sticky notes	No. of dots (priority)	Average inundation score	Average erosion score
Whole river area	Social	5	2	5	2
Why it is important: recreation, fishing, flora and fauna, shallow waters	Environmental	3	4	5	2
Houses and properties	Economic	10	23	3	2
Why it is important: livelihood, shelter, personal financial investment, holiday house	Social	4	12	2	2
Fauna *Why it is important: protect endangered species, peace, retreat, recreation, complete ecosystem*	Environmental	8	9	3	2
Hospitality business (e.g., restaurants, cafes, pubs, school, shops)	Economic	9	3	3	3
Why it is important: provides jobs, serves community, recreation for holidays	Environmental	2	0	1	2
	Social	1	0	3	1
Boating channels / waterways	Environmental	2	3	4	1
Why it is important: for boating access, recreation, swimming, crabbing	Social	3	1	5	2
	Economic	1	1		
Coopers Mill	Social	5	8	3	2
Why it is important: historical value, tourist attraction, culture,	Economic	1	0	4	2
Fishing and crabbing	Social	1	1	3	3
Why it is important: children's development, fun, recreation,	Environmental	1	0	5	1

Boat ramps and jetties	Economic	8	7	4	2
Why it is important: island access, community use for boating/fishing, adds value to properties	Social	3	2	5	3
Riverbanks / wetlands / beaches	Environmental	4	5	4	2
Why it is important: swimming, fishing, dolphin watching, bird watching,	Social	1	1	5	2
Trees and vegetation *Why it is important: nature reserve, important to environment and fauna, prevents erosion*	Environmental	3	4	2	1
Infrastructure, bridges and roads	Economic	2		4	3
Why it is important: Access	Social	1	2	1	1
Coodanup foreshore *Why it is important: dog walking, bird watching*	Environmental	2		4	4
Cricket oval *Why it is important: social asset, historical and community value.*	Social	3	1	5	5

Peel Inlet Assets	Classification	No. of sticky notes	No. of dots (priority)	Average inundation score	Average erosion score
Estuary *Why it is important: recreation, swimming, crabbing, boating, fishing*	Environmental	2	0	4	4

Point Grey Assets	Classification	No. of sticky notes	No. of dots (priority)	Average inundation score	Average erosion score
Shallow waters *Why it is important: crabbing*	Social	1	0	5	4

Harvey Estuary Assets	Classification	No. of sticky notes	No. of dots (priority)	Average inundation score	Average erosion score
Whole area *Why it is important: lifestyle, social/family recreation, heritage*	Environmental	2	1	4	3
	Social	1	1	4	2

Birchmont Assets	Classification	No. of sticky notes	No. of dots (priority)	Average inundation score	Average erosion score
Whole Eastern Shoreline *Why it is important: no reasons given.*	Environmental	1	0	5	4

Herron Point Assets	Classification	No. of sticky notes	No. of dots (priority)	Average inundation score	Average erosion score

Shallow waters *Why it is important: crabbing*	Social	1	0	5	4
Campgrounds *Why it is important: tourism*	Social	1	0	4	2

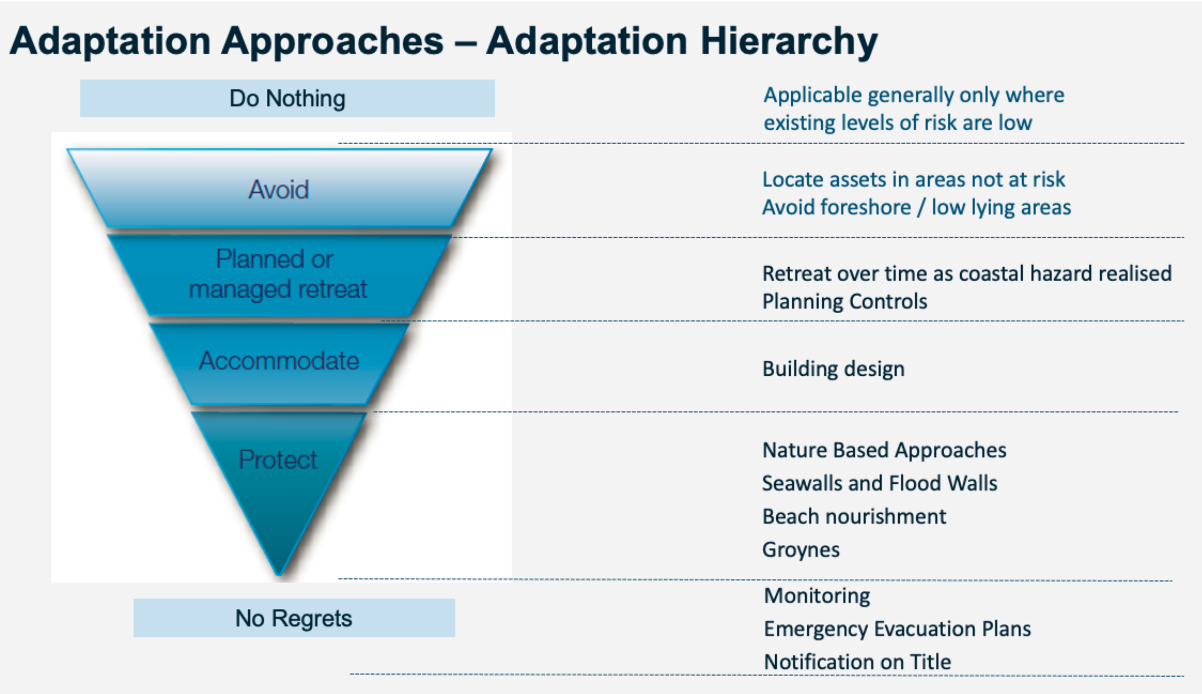
Task 4 Priority Areas Adaptation Ideas

The final workshop task involved developing adaptation strategies and preferred options for prioritised assets. Adaptation approaches and examples were presented to assist with this task, although it was made clear participants could also suggest other adaptation strategies.

The first step was for participants at the table to identify the priority asset (the one with the most dots) and then come to a consensus on which of the four adaptation strategies they wanted to implement to mitigate the risk of erosion and inundation.

They then had to identify an adaptation option or idea they preferred be implemented. They could either choose one of the options presented or develop their own.

Figure 9 Adaptation options presented at the workshop



Task 4 results

Coastal Location: The Whole Estuary	
What is your preferred adaptation strategy?	Protect
What are your table's adaptation option ideas?	• Seawalls and flood walls

Coastal Location: Coopers Mill	
What is your preferred adaptation strategy?	Protect
What are your table's adaptation option ideas?	• Bank stabilisation • Sea walls • Flood walls • Drainage • Rock Wall

	• Backfill in to build dry wall around it

Coastal Location: Estuary, Riverside Island	
What is your preferred adaptation strategy?	Protect
What are your table's adaptation option ideas?	• Provide signs to redirect boats along naval base corner • Provide rock protection • The corner focal points of the islands • Pieces of rocks

Coastal Location: Island Houses	
What is your preferred adaptation strategy?	Protect, Accommodate, Avoid
What are your table's adaptation option ideas?	• Erosion protection based on guidelines • Protect banks, revegetation, bioengineering revetment • Accommodate for new development and renovation • Planning controls • Riverbank vegetation • Rock walls • Restrict water traffic • Technology to dissipate water energy from waves • Control sea entering estuary • Nature based approaches • Sea walls and flood walls • Not to allow managed retreat for residents • Change planning rules to allow more flexible plans and to protect river banks rock walling and provide to build jetties opposite each property • Allow modification by changing planning scheme including building and sanitations • Evaluate current situation and adopt changes as sea level rises over time • Incorporate changes to height of properties and removal of septics as likelihood of occupancy increases • Adopt a measured approach • Planning controls and building design • Some cases avoid based on circumstance • Fill/block drainage and fill • Stilt build

	• Setbacks • Technology solutions (e.g., sewage)

Coastal Location: Jetty / Boat ramps	
What is your preferred adaptation strategy?	Protect, Accommodation, Planned retreat
What are your table's adaptation option ideas?	• Building design – floating erosion protection walls / banks) • Reposition and rebuild as above • Sea walls and flood walls

Coastal Location: Point Grey / Herron	
What is your preferred adaptation strategy?	Managed retreat
What are your table's adaptation option ideas?	• Monitoring • Revegetation

Coastal Location: Businesses	
What is your preferred adaptation strategy?	Protect
What are your table's adaptation option ideas?	• Planning control • Building design • Sea wall / rock wall • Limit speed limits for boat patrons • Salt tolerant plants along water edge (Sedge Grass) • Salt tolerant trees planted along bank • Mangroves

Coastal Location: Foreshore erosion	
What is your preferred adaptation strategy?	Protect
What are your table's adaptation option ideas?	• Where there is boat traffic – use of rocks • Other areas – natural protections

Coastal Location: Waterways (dredging)	
What is your preferred adaptation strategy?	No regrets
What are your table's adaptation option ideas?	• Monitoring (sulphur) environmental • Adapting dredging strategy

Coastal Location: Murray River estuary and banks	
What is your preferred adaptation strategy?	Protect

What are your table's adaptation option ideas?	• Protect the environment and housing and assets • Retain banks through managed environmental and physical retaining walls, including a Tide Wall in the Cut

Coastal Location: All Murray River Delta	
What is your preferred adaptation strategy?	Protect, Accommodate
What are your table's adaptation option ideas?	• Protect riverbanks through sea walls, river bank protection • Work with landowner to assist, protect and supply materials to stabilise banks to reduce erosion, protect vegetation • Bank preservation and vegetation re-planting • Preservation of Murray Delta environment • Keep Dawesville closed until it's needed to be flushed because of a "bloom" • Preserve the riverbanks now! • We need to protect the banks so that there is minimal extra degradation – act on things we can control • Lock system on Dawesville cut first, and then river mouth if necessary – this solves many long term and short term issues such as salinity as well as sea levels rising in the future • Revetment/erosion control – coir logs, non-woven geofabric / textile bags / logs and replanting. Use of softer, natural solutions in keeping with environment • Dike system / sea walls / flood walls • Research vegetation and best planning strategies

Coastal Location: Coolenup Island	
What is your preferred adaptation strategy?	Protect, Accommodate
What are your table's adaptation option ideas?	• Adaptation model presented shows retreat as a preferred option to accommodate. There is no way that moving people out of their homes would be a higher priority that applying mitigation. • Use natural materials where available to create bank protection as an immediate measure ie. fallen trees turned to align with the bank and staked in place then.

	• Control water at the Dawesville Cut • Make more permanent revetment wall? • Protect the riverbanks from boat wake-initiated erosion • Accommodate with planning • Riverbanks need planning and protection from salt water • Work with Council do not approve of managed retreat

The workshop concluded with a ‘thank you’ to all participants for their active engagement during both session and encouraged them to take the online survey if they hadn’t already, as well as sharing the online survey with family, friends and neighbours.

5. Next steps

This findings from this report will inform the draft CHRMAP report and be included as an appendix.

B.2 Coastal Values Survey

Shire of Murray Coastal Values Survey

- Designed to be a quick quantitative survey supplemented by workshop activity.
- To gain a better idea of the local community's coastal values within the CHRMAP study area.
- To provide a communications opportunity to grow interest in the project, and
- Capture people's registration details to grow the project data base

Welcome

As you may be aware, the Shire of Murray is currently in the process of creating a Coastal Hazard Risk Management Adaptation Plan (CHRMAP) for the coastal and estuarine regions within its boundaries. Similar CHRMAPs are currently being undertaken, or have been completed, for many coastal areas around Western Australia.

An important part of the CHRMAP process is understanding the context of the study area, including the values that the community hold for the coastal and estuarine areas.

We invite you to take part in this quick survey to understand YOUR coastal values within the Shire of Murray. This should take you approximately 5 minutes to complete.

If you would like more information on the project, head to our Your Say page at https://yoursay.murray.wa.gov.au/murray-chrmap and please register your details to stay updated about upcoming events and project updates.

Respondent Details

Age Bracket

- 5 to 14
- 15 to 29
- 30 to 49
- 50 to 64
- 65 or older

Please select the location you live from one of the following:

- Birchmont
- West Coolup
- Murray Delta Islands
- South Yunderup
- North Yunderup
- Furnissdale
- Ravenswood
- Other location in Shire of Murray not listed above
- City of Mandurah
- Shire of Waroona
- Outside of project area (eg Perth)

Awareness

How familiar are you with the CHRMAP project currently being undertaken by the Shire of Murray ? Select one option.

- Highly aware
- Somewhat aware
- Unaware

Do you think there should be additional information available on the project YourSay page? Select one option.

- Yes
- No

Visitation and Coastal Values

How do you interact with the estuary? Select your 3 most common interaction options.

- Kayaking / canoeing
- Bird watching
- Boating
- Fishing / crabbing
- Horse Riding
- Swimming
- Walking or jogging
- Socialising/ Picnics
- Camping
- Other (please specify)

<u>3 DROP DOWN sub questions for each option above.</u>

<u>A Map will be included to designate the location of the Activity based on number system (eg 1=Murray Islands, 2=Serpentine River, 3=Herron Point, 4=Birchmont etc)</u>

1. Where do you most frequently do the activity – indicate number from map

2. How often do you participate in the activity?

- (more than once per week, once per week, once to twice per month, less frequently)

3. Why do you choose to use the above locations as opposed to other areas? (can tick more than one)

- Proximity and ease of access
- Environmental values
- Good public facilities/ picnic areas/ boat ramps etc
- Quality of experience
- Social aspects and community
- Other (please specify)

Values

What do you value in your coastline and estuarine area? Rate each category (High, medium, Low)

- Water based recreation opportunities (boating, kayaking etc);
- Land based recreation opportunities (dog walking, picnicking, fishing, exercising etc near the coastline)

- Private benefits (living nearby, property values)
- Environmental values (habitat for wildlife, protection from storms, water/nutrient filtration)
- Community facilities and services (events, festivals)
- Work/ business opportunities (related to coastline and estuarine area)
- Lifestyle and character
- Other (please specify)

Project updates

Please register your details to stay up to date with the project here:

Email address: _____________

Appendix C

Coastal Hazard

C.1 Coastal Hazard Report (Seashore 2021)

Appendix A

Coastal Hazard Report

A.1 Coastal Hazard Report (Seashore 2021)

Shire of Murray
Coastal Hazard Assessment

Seashore Engineering
August 2021

Report SE111-01-Rev 1

Prepared for
Shire of Murray

Executive Summary

Coastal hazards affecting the Shire of Murray foreshores have been assessed, to support development of a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP). The Shire is located on the eastern sides of Peel Inlet and Harvey Estuary, with foreshore along the banks of the lower Murray and Serpentine Rivers. The Shire's foreshore is substantially undeveloped, with urban development at Yunderup along the lower Murray, including South Yunderup Canal Estate, and a low-density semi-rural development at Birchmont, adjacent to Harvey Estuary.

Evaluation has focused on the coastal hazards of erosion and inundation, which are the two principal hazards requiring assessment under the State Coastal Planning Policy SPP 2.6. General methods used for coastal assessment have been modified to account for the estuarine setting, including consideration of extremely low-lying land present in the lower Murray River and southern parts of Harvey Estuary. A further complication has been brought about due to opening of Dawesville Channel in 1994, which caused an abrupt change in estuarine water levels and consequently modified foreshore evolution. It is noted that the method is intended to provide 'best-estimate' hazard lines suitable for management triggers (i.e. CHRMAP application) rather than a conservative estimate of the coastal hazard zone, corresponding to Schedule One of SPP 2.6.

Erosion hazard has been assessed for 2020, 2030, 2050, 2070 & 2120 using:

- Modelling of cross-shore response to a severe storm, based upon the May 2003 storm, extrapolated to have extreme water levels and winds corresponding to a 100-year average recurrence interval (ARI).
- Extrapolation of shoreline trends based upon historical aerial imagery, generally from 2005-2017 to reduce the influence of Dawesville Channel opening. Shoreline change has historically been small, except in the vicinity of the Murray River delta, where the low-lying berms and islands have progressively folded landward into the wetlands behind them.
- Allowance for erosion in response to sea level rise, using the projected sea level curve described in Transport (2010). This includes an allowance of 0.5m per 0.01m of sea level rise for the whole foreshore, plus a geometric based allowance for low-lying areas where higher water levels will cause narrow foreshore features (berms and islands) to collapse landward. The latter process has been observed for parts of the Murray River delta after opening of Dawesville Channel.

These processes define an erosion hazard zone that varies around the Shire's foreshore, generally with a greater erosion hazard where there is low-lying land and smaller erosion hazard where the shore is higher. Erosion allowances vary from 70 to 120m by 2120.

Potential for an extreme erosion scenario has been identified in response to sea level rise, if tidal flows can cause substantial wetland infilling, with landward collapse of berms and islands up to 1.6km from the existing shore. This mechanism is not presently active, as demonstrated by the extensive intertidal wetland area, but tidal flows will increase with sea level rise. Local management of breaks through the foreshore berm may be used to mitigate the risk of significant sediment wetland infilling.

Total Erosion Allowance Along Shire of Murray Foreshore

Erosion hazard along channel margins for the lower Murray and Serpentine Rivers has been treated separately, acknowledging the differences in foreshore dynamics between the ocean, estuary, and river channels. Distinction has been made based on observed active processes, including 'switching' of channels experiencing flow within the Islands, and local influences of foreshore vegetation. In the absence of detailed measurements of channel change, allowances for erosion hazard have been based upon indicative setback requirements for estuary and river foreshores described in WAPC SPP 2.9 and DC 2.3. These have been distinguished for three sections, considering the likelihood of different erosion mechanisms being active:

- Channels within the Islands area have been defined with an erosion hazard of 50m by 2120, accounting for higher tidal flows and potential for channel switching.
- An erosion hazard allowance of 30m by 2120 has been defined where there is a single main channel for the Murray River (adjacent to Yunderup) and within the Serpentine River.
- Within the secondary channels and small lakes adjacent to the Murray River, an erosion hazard of 15m by 2120 has been defined. These waterbodies typically receive only a small quantity of flow, usually under extreme water level or flood overflow conditions.

Existing foreshore protection structures within Yunderup provide land retention, including canal estate walling and a bund around the man-made lake south of Yunderup. These features have been assumed to be maintained to provide the existing standard of protection. For canal walling, additional upkeep is likely required with higher water levels, but existing wall heights are sufficient for walling to provide protection against erosion. The bund around the man-made lake presently has a crest height of +1.1 to +1.5mAHD, which is likely to require enhancement prior to 2070 to prevent collapse due to frequent overtopping.

Inundation hazard has been identified through analysis of the Peel-Harvey tide gauge record, accounting for changes to flooding that have occurred since opening of Dawesville Channel. The upper limit of 'typical tides' is presently +0.6mAHD, defining wetland areas, and providing an effective limit for land-use. Wetland areas will increase with sea level rise, with a threshold of +1.5mAHD by 2120 based on a projected 0.9m sea level rise. The present-day 100-year ARI storm water level is estimated as +1.09mAHD, which will increase with sea level rise to +1.99mAHD by 2120.

The maximum extent of coastal inundation hazard has been evaluated through consideration of an extreme event based upon 'worst-case' impact of a tropical cyclone similar to TC Alby, but with +10% storm intensity and a track shifted to maximise flooding along the Mandurah coast, to approximate an event with 500yr recurrence. This scenario would produce a high water level of +1.44mAHD under present day conditions, increasing with sea level rise to +2.34mAHD by 2120. This upper limit level of flooding is similar to the potential flood risk area derived for the lower Murray River based upon 100-year ARI rainfall and 0.9m sea level rise.

Extreme Inundation Hazard for Present Day (+1.44mAHD)

Table of Contents

List of Figures

List of Tables

Limitations of this Report

Document Control

Index	Author	Date	Review	Date	Comment
Rev A	M.Eliot	18.12.2020	Baird	22.12.2020	Issued for Review
Rev B	M.Eliot	23.12.2020	DOT	22.02.2021	
Rev C	M.Eliot	12.04.2021	DOT/DPLH	28.04.2021	
Rev 0	M.Eliot	06.05.2021			
Rev 1	M.Eliot	09.08.2021			Address Public Comments

1. Introduction

This document summarises coastal hazards affecting the Shire of Murray foreshore, providing a contributing study for the Shire's Coastal Hazard Risk Management and Adaptation Plan (CHRMAP). The Shire of Murray is located along the eastern margins of the Peel-Harvey Estuarine System, which includes the mouths of the Murray and Serpentine Rivers.

The Shire's foreshore is substantially undeveloped, with predominantly rural land-use. Austin Bay Nature Reserve, Mealup Nature Reserve, Lake McLarty Nature Reserve and Kooljerrenup Nature Reserve occupy almost 25km of the Shire's foreshore, which includes narrow foreshore reserves in Austin Bay and at Birchmont (Figure 1-1). There are two existing communities, with urban development in Yunderup and low density semi-rural development at Birchmont. A third development area has been proposed for Point Grey (RPS 2009).

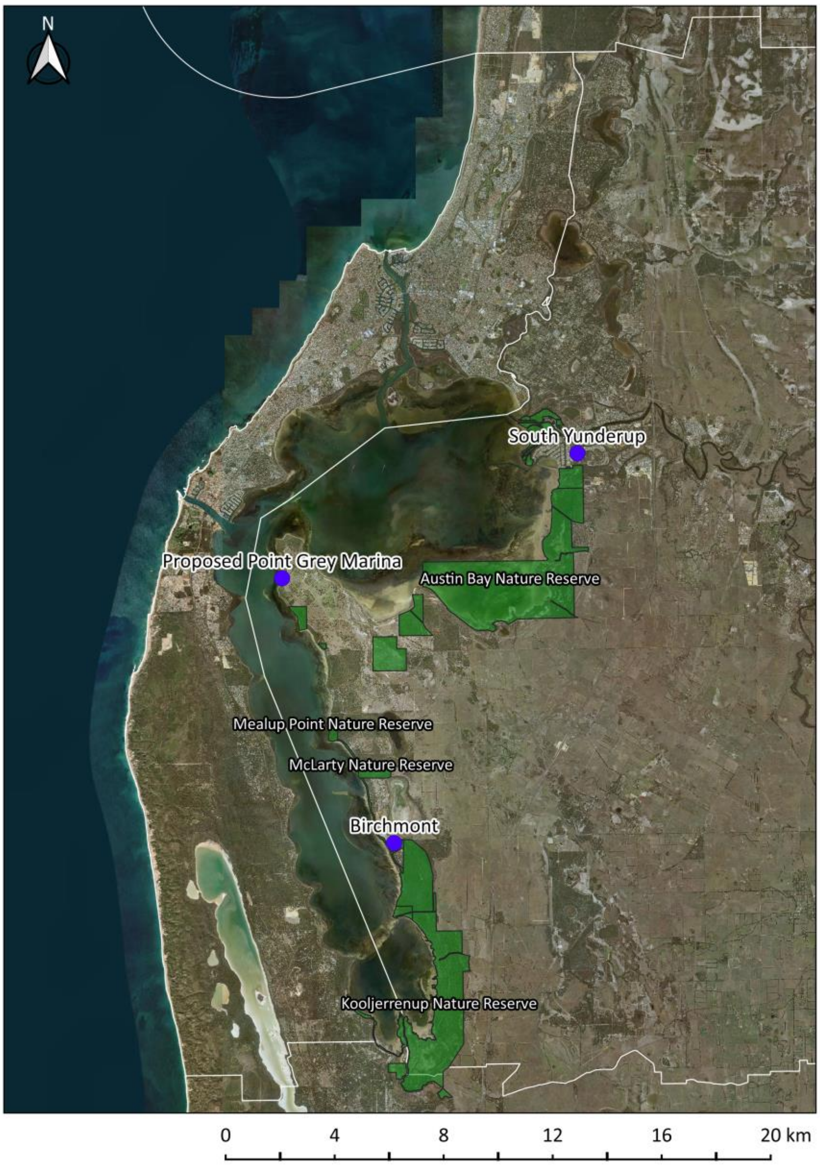


Figure 1-1: Location Diagram

1.1. COASTAL HAZARDS

Coastal hazards occur when coastal processes at the interface between the ocean (or estuary) and the adjacent land can provide physical, environmental, or social loss. For the most part, this is commonly associated with excursion of ocean waters (through waves, tides or storm surges) onto land area, particularly where it adversely affects land use. The two most investigated coastal processes are:

- Erosion, where oceans waters, including wave action, move sediment away from their existing position along the coast, removing a previous area of land.
- Coastal inundation, where land that was typically outside the influence of ocean waters, becomes submerged, typically for minutes to hours (i.e. typically excluding wave action).

Neither erosion nor inundation are a hazard unless they adversely affect an asset.

Management of coastal hazards is a key objective of the State Coastal Planning Policy SPP2.6 (WAPC 2013, 2020). This policy outlines a framework for management, combining land-use zoning and foreshore reserves as the primary tool for mitigation of coastal hazards. The policy recommends consideration of coastal hazards over a time frame of 100 years, including extreme events and projected impacts of climate change, such as sea level rise.

For areas where existing land-use may potentially be affected by coastal processes within the next 100 years, SPP 2.6 recommends development and implementation of a CHRMAP, for identification and ongoing management of coastal hazards. Guidelines regarding CHRMAP development have been published (WAPC 2019).

This coastal hazard assessment has been prepared as a step in the development of a CHRMAP for the Shire of Murray.

1.2. SUMMARY OF HAZARD ASSESSMENT APPROACH

The assessment has followed a conventional approach for forecasting coastal hazards, using observations to identify active processes, which are subsequently extrapolated, with consideration of extreme events and sea level rise (Figure 1-2). However, this is complicated by the Shire of Murray foreshore being located within the Peel-Harvey Estuarine System, which has been substantially modified by opening of Dawesville Channel in 1994.

The estuarine setting challenges the use of ‘standard’ interpretation of coastal drivers (e.g. waves & tides) and responses that are commonly used in coastal modelling, with the comparatively low-energy setting altering the relative significance of waves, tides and river flows (Harris & Heap 2002) with the structure of each estuary being affected by its origins and degree of infilling (Ryan *et al*. 2005). Consequently, estuarine morphology has been used to supplement interpretation of active processes.

The effect of Dawesville Channel complicates interpretation of active processes, as it represents a secular change in conditions, with a comparatively large increase in tidal range. Because of the low-energy conditions within the estuary, its impacts can potentially affect observed trends for decades. Although these are permanent changes, the effect of 'step changes' needs to be considered carefully when extrapolating trends for the next 100 years.

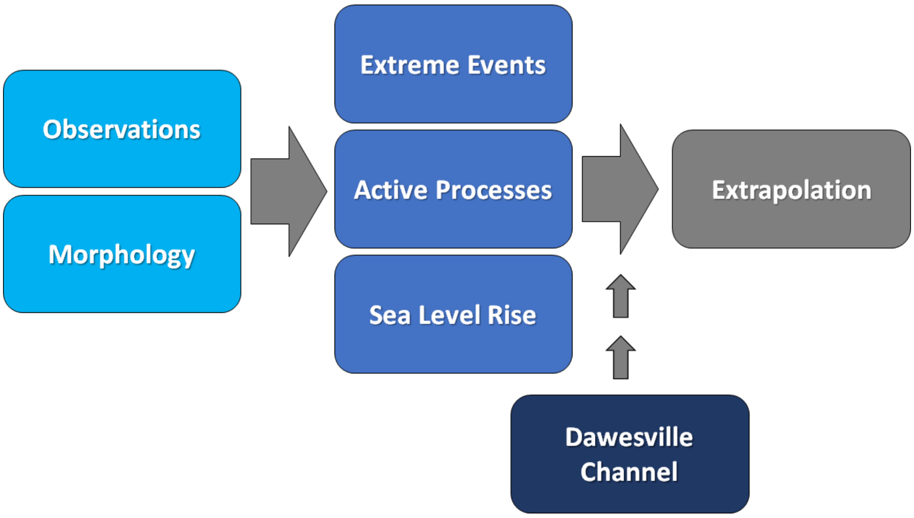


Figure 1-2: Framework of Assessment Approach

Evaluation of inundation hazard has been based upon analyses of extreme water level records and modelling for south-west Western Australia (e.g. Haigh *et al*. 2010; Eliot 2012), including the derived relationship between water levels inside and outside Peel-Harvey system (Eliot & McCormack 2019). Components of the inundation assessment include evaluation of estuary water levels, modelling of ocean extreme events and transfer of the ocean signal through to the estuary using a spectral admittance function.

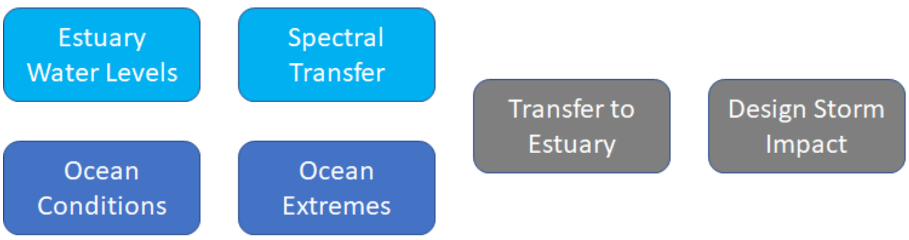


Figure 1-3: Components of Inundation Assessment

The assessment approach for the Shire of Murray foreshore dynamics has been built from previous evaluations in the southwest of Western Australia (Eliot *et al*. 2006; Damara WA 2008, 2009, 2016, 2019; Travers *et al*. 2010), within the wider context of estuarine and low-energy beach literature (Nordstrom & Roman 1992, Jackson *et al*. 2002; Ton *et al*. 2020). For the main basin of the estuaries, foreshore dynamics are strongly related to the directional wave climate and water level variability. Components of the assessment consequently involve directional analysis of winds, fetch analysis based on the estuarine structure and wave hindcasting (Figure 1-4).

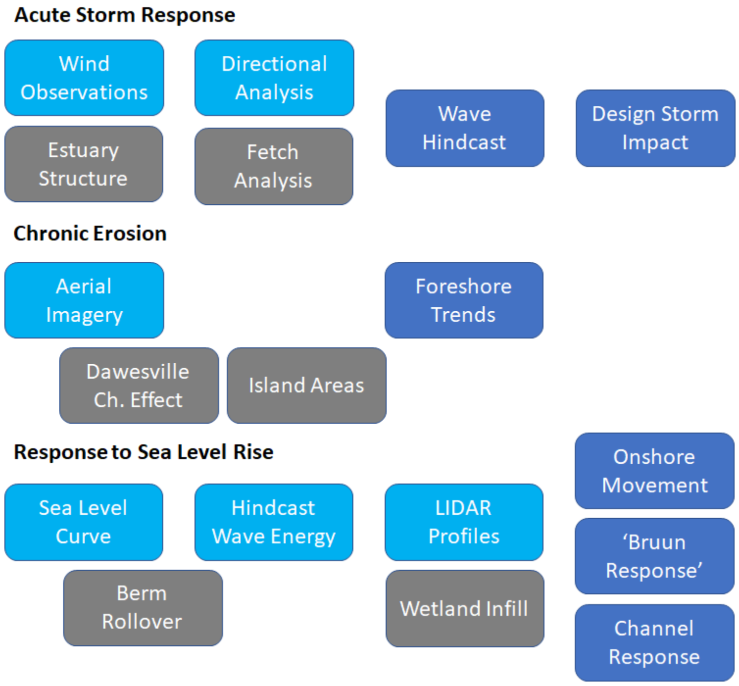


Figure 1-4: Components of Erosion Assessment

2. Peel-Harvey Foreshore Dynamics

2.1. EXISTING ORIGINS AND STRUCTURE

Peel-Harvey Estuarine System is a large waterbody, comprised of two shallow basins, the elongated Harvey Estuary, and the more rounded Peel Inlet, with input from the Harvey, Murray and Serpentine River systems, along with local catchment drainage. The estuarine system is a geologically modern feature on the greater Swan coastal floodplain, which has developed its modern form over the last 2,000 years, when sea levels have remained approximately constant, declining 1-2 m (Wyrwoll *et al*. 1995). Land surrounding the estuary has correspondingly been shaped by coastal, alluvial or lagoonal processes (Figure 2-1):

- Coastal features are prevalent on the west side of the estuarine system, with a narrow strip of dunes along the east side of Harvey Estuary.
- Alluvial features mark the previous limit of estuarine processes, which intuitively suggest an approximate limit of expected foreshore response to sea level rise up to the level of the previous highstand.
- Lagoonal deposits are present along the east and south side of Peel Inlet, along with the south end of Harvey Estuary. These include sediment supply from the Murray and Harvey Rivers, with reworking through estuarine foreshore dynamics. There has apparently been low sediment supply from the shallow grade Serpentine River.

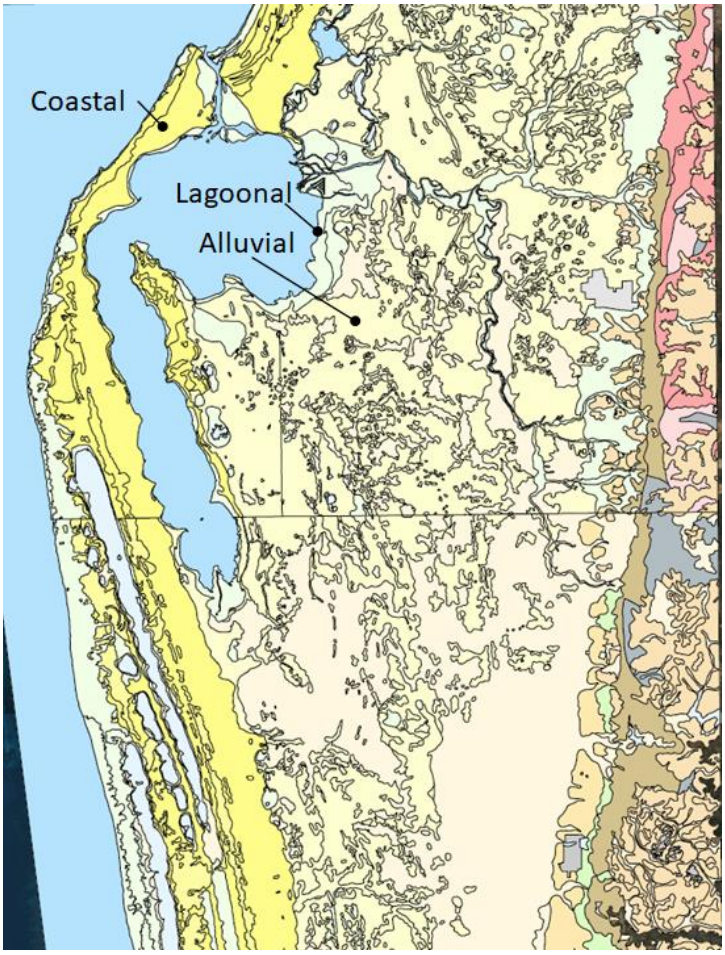


Figure 2-1: Extract from 1:50,000 Surface Geology (GSWA)

The mix of land forming processes has created several different morphotypes along the Shire of Murray foreshore (Figure 2-2). These indicate active processes and influence pathways by which the foreshore can potentially change over time.

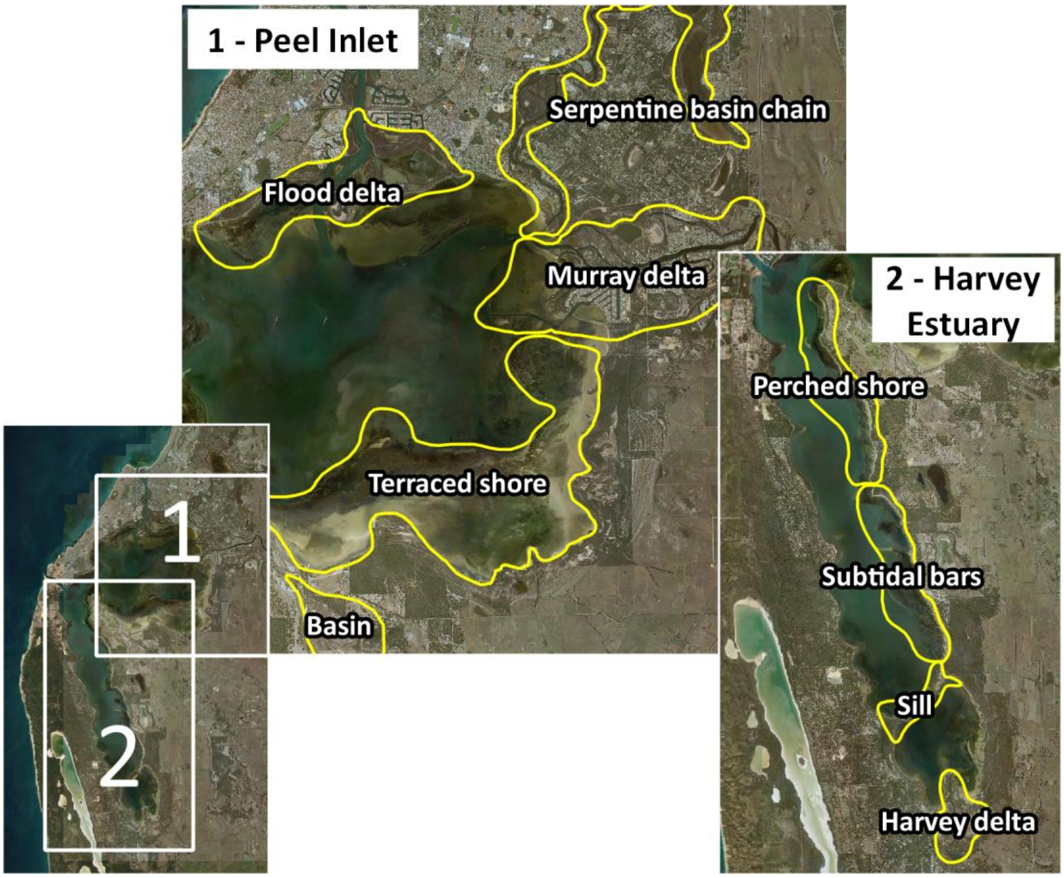


Figure 2-2: Major Foreshore Features

Active and future behaviour can be distinguished between the foreshore of the estuary basins, which is strongly influenced by wave conditions, and foreshore along channel margins, which are affected by flows and sediment supply (Table 2-1). Separate approaches have consequently been used to estimate erosion hazard in Section 4.

Table 2-1: Active & Future Processes Indicated by Key Features

Feature	Active Processes	Future Processes
Flood Delta	Historic marine sediment supply	Increased tidal exchange
Serpentine Basin Chain	Limited river sediment supply Tidal exchange	Increased tidal exchange
Murray Delta	Historic river sediment supply	Increased tidal exchange
Terraced Shore	Shallow depth limits waves	Reduced sheltering (wave)
Perched Shore	Rock control	Reduced control (wave)
Subtidal Bars	Alongshore transport	Modified transport (wave)
Sill	Tidal exchange / overwash	Increased overwash
Harvey Delta	Historic river sediment supply	Increased overwash

2.2. MORPHODYNAMICS

Identification of foreshore dynamics has been undertaken through evaluation of aerial imagery, including comparison of shoreline change, and measurement of bathymetric change, based upon hydrographic surveys. Aerial Imagery suitable to assess dynamics of the Shire of Murray foreshore is available from:

- 1974 (Sep) North Peel Inlet only City of Mandurah
- 1975 Peel Inlet only Department of Transport
- 1979 (Sep) Department of Transport
- 1985 (Jun) Peel & North Harvey City of Mandurah
- 1994 (Apr) Department of Transport
- 1995 (Feb) City of Mandurah
- 2000 City of Mandurah
- 2001 City of Mandurah
- 2002 City of Mandurah
- 2004 City of Mandurah
- 2005 City of Mandurah
- 2006 City of Mandurah
- 2007 City of Mandurah
- 2008 City of Mandurah
- 2009 City of Mandurah
- 2010 City of Mandurah
- 2011 Shire of Murray
- 2012 Shire of Murray
- 2013 (Jan) City of Mandurah
- 2014 (Feb) City of Mandurah
- 2015 (Feb) Shire of Murray
- 2015 (Nov) Shire of Murray
- 2016 Shire of Murray
- 2017 (Feb) City of Mandurah
- 2017 (Apr) Shire of Murray

Assessment of historic behaviour provides an evidential basis for the estimation of future shoreline trends. Initial interpretation of foreshore change was conducted through comparison of oldest and most recent imagery (generally 1979-2017). This indicated that much of the estuary foreshore has experienced limited net change of vegetation line, including areas that are geomorphically considered highly sensitive, such as birdsfoot delta formations (Figure 2-3). The Murray delta area provided a marked exception, with some areas of significant change.

Subsequently, historic imagery was used to evaluate foreshore processes and project future shoreline trends. Although there is almost 40 years of aerial imagery, projection of future trends based on historic behaviour is complicated by construction of Dawesville Channel. Shoreline adjustment to higher tidal range after 1994 suggests pathways of response to higher sea levels, and therefore is a useful indicator of expected response to sea level rise, particularly over the next 20-30 years.

Figure 2-3: Observed Change at Austin Bay Birdsfoot Delta

Periods 1994-2005, 2005-2011 and 2011-2017 (reported in Appendix C) were used to check the relative influence of Dawesville Channel on shoreline trends, using the logic sequence shown in Figure 2-4. Overall behaviour is indicated by Figure 2-5, noting there is little difference between the 2005 shoreline (black dash) and the 2017 shoreline (imagery) except at the Murray River delta. Low-lying areas are indicated where the 2017 HSD (pink) is set back from the 2017 shore, in the Murray River delta and along the southern shore of Peel Inlet.

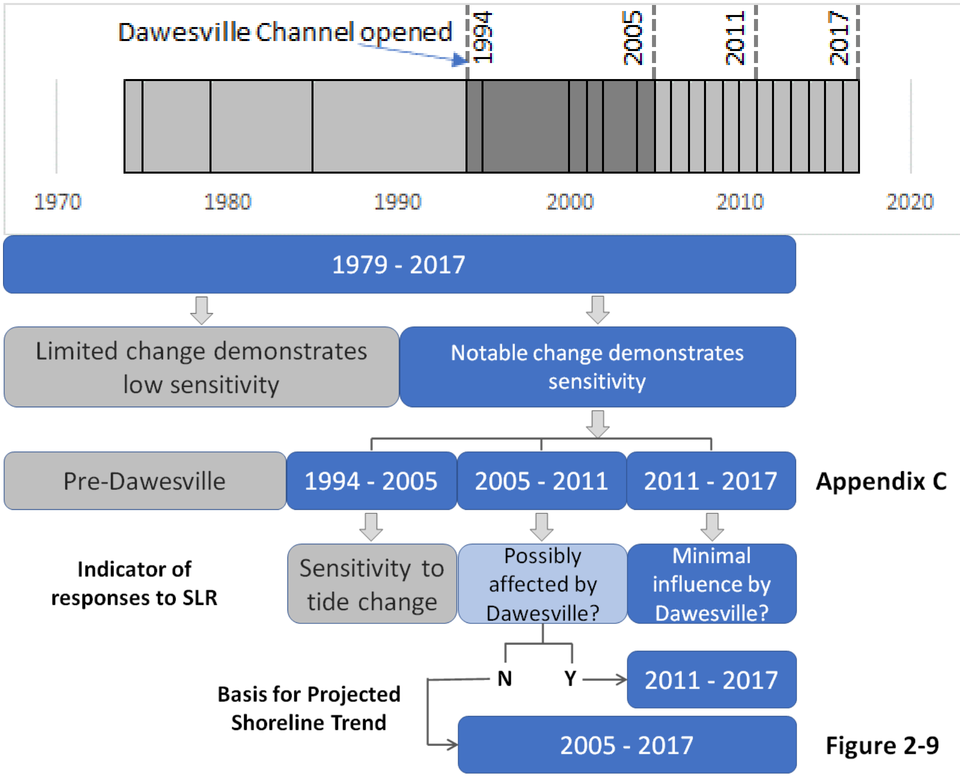


Figure 2-4: Available Imagery Dates and Flow-Diagram to Estimate Shoreline Trends

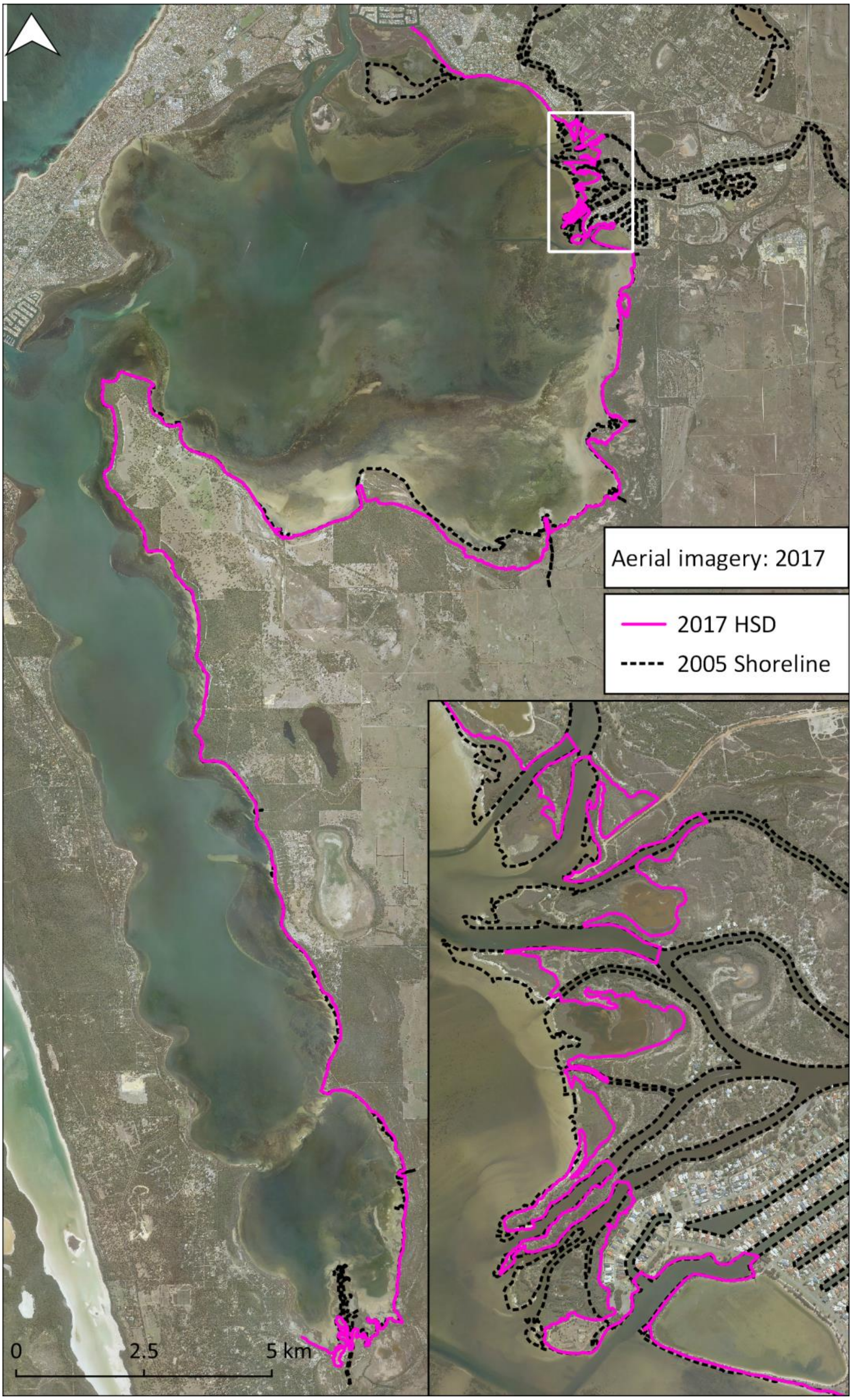


Figure 2-5: Areas of identified vegetation line change (2005-2017)

The full time series was examined for areas where substantial change had occurred, to help identify driver-response patterns, particularly if several alternative mechanisms for change were evident.

Examined at a local scale, movement of the vegetation line has been significant, particularly at the northern end of Meeyip Island (Figure 2-6). However, the nature of change has been the landward collapse of ridges and spits, with spits developed through flood deposition gradually collapsing back on to the islands (Figure 2-7). Consequently, this is not erosion (sediment volume loss) *per se*, although this movement needs to be considered in the definition of erosion hazards. Consequently, evaluation of foreshore trend has considered the change to island areas (Figure 2-8), averaged along the active foreshore length. This gives a rate of erosion of 0.5 to 1.6 m/yr, increasing from the Murray River mouth to the north, greatest at Meeyip Island.

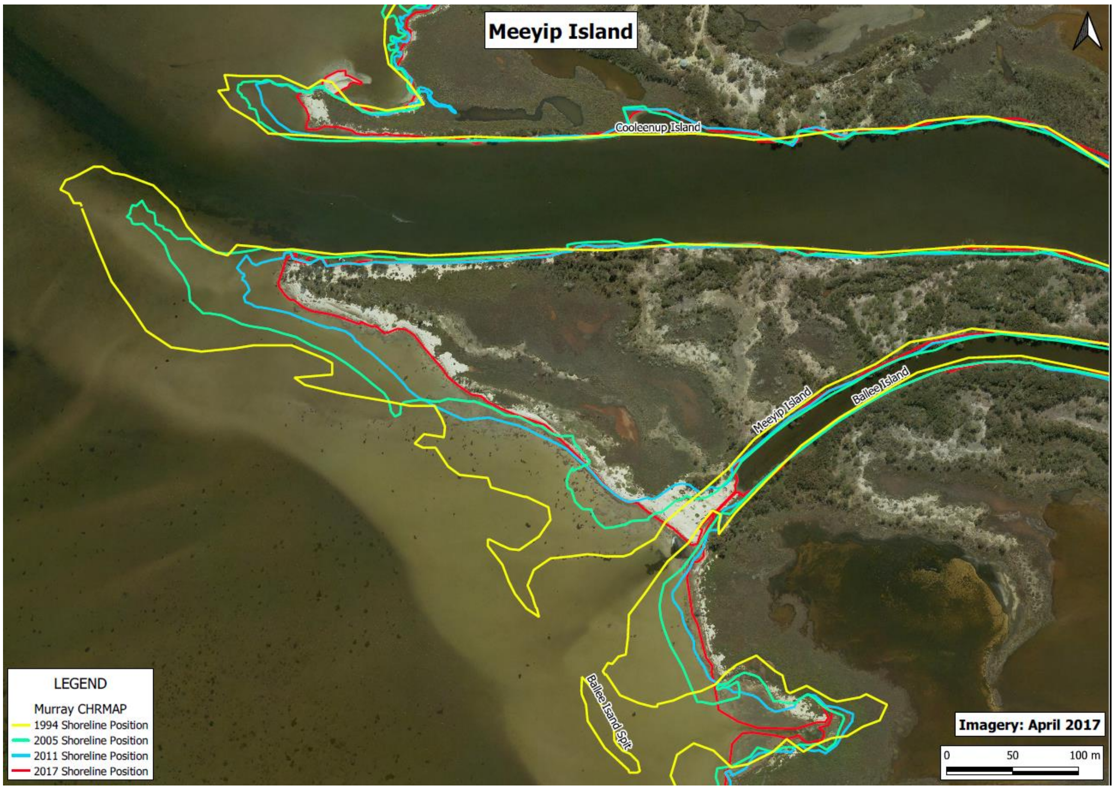


Figure 2-6: Meeyip Island Vegetation Line Change

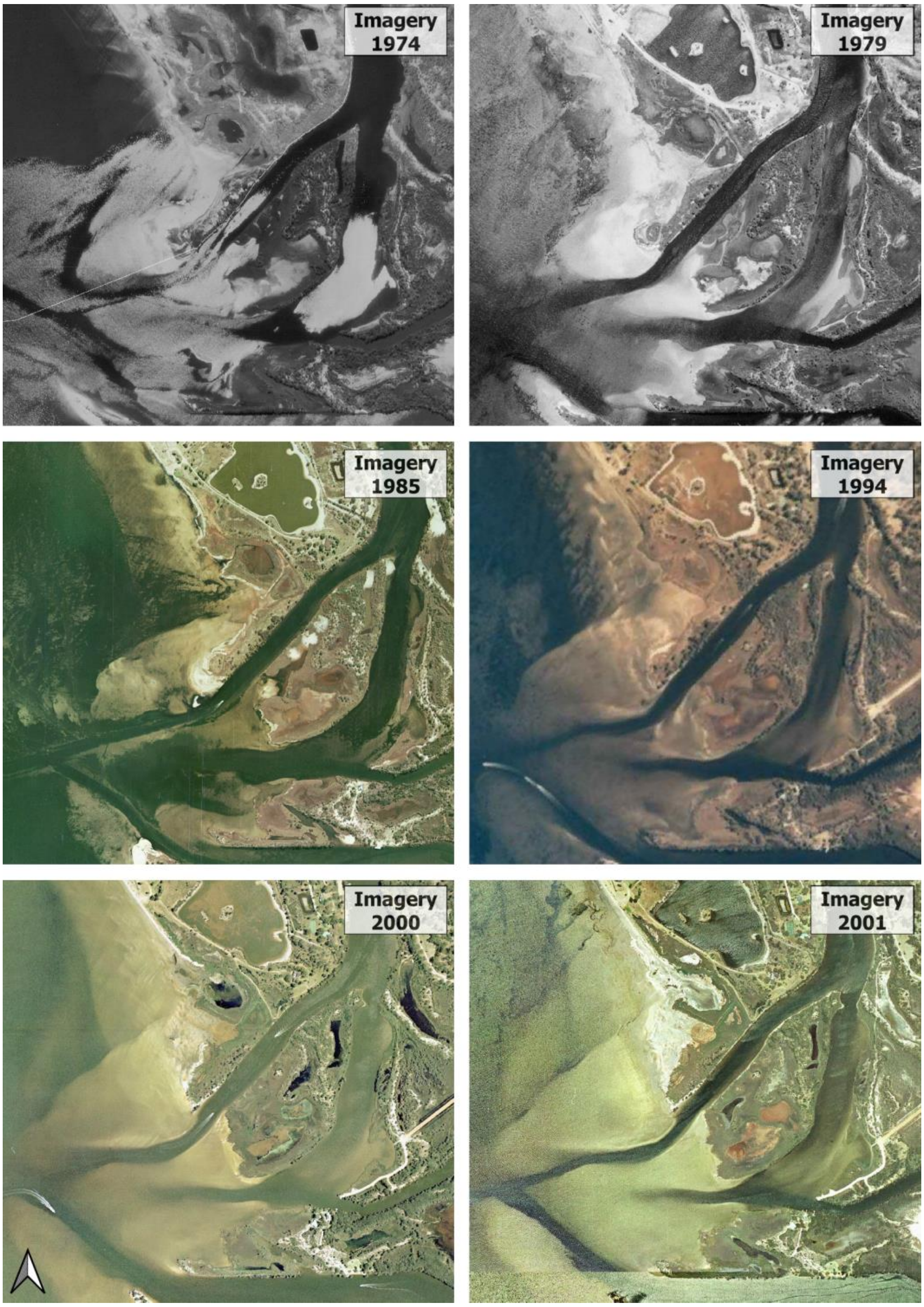


Figure 2-7: Imagery Sequence 1994-2001 for Murray Delta Area (North)

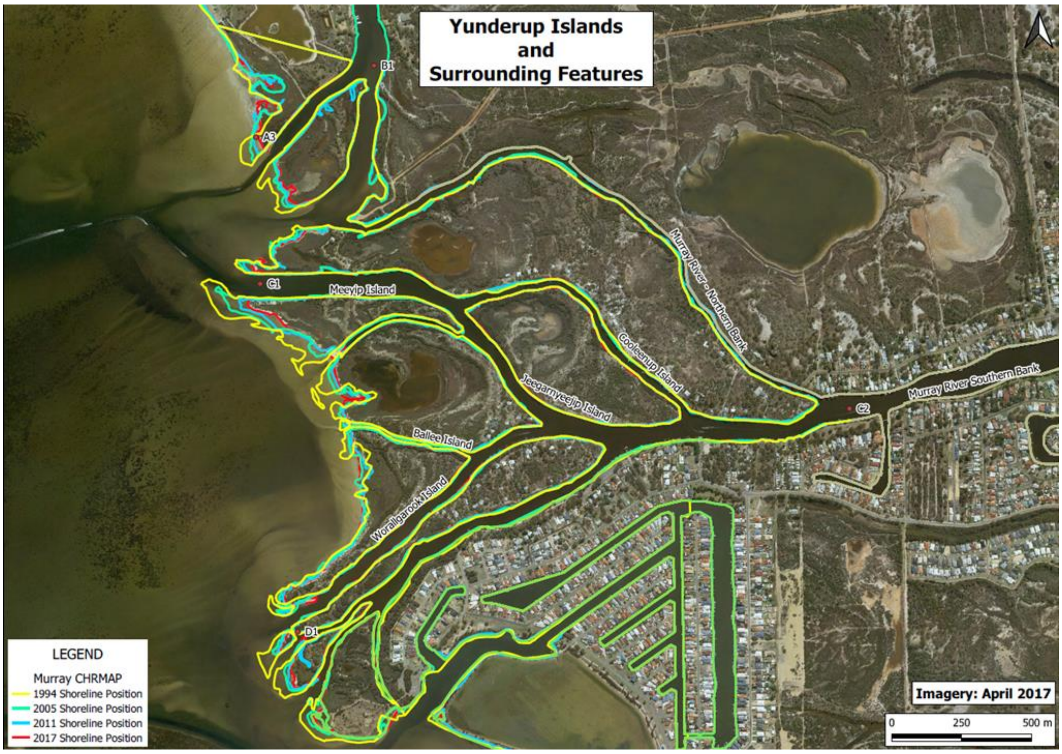


Figure 2-8: Vegetation Line Changes for Murray Delta 1994-2017

Complex foreshore dynamics were also identified at Harvey Estuary Sill, toward the southern end of Harvey Estuary. Significant disruption of the sill and adjacent transverse bars occurred following opening of Dawesville Channel, with associated 'straightening' of the shore north of Herron Point. However, substantial change was delayed until around 2012, which corresponded to a period of elevated mean sea levels during strong La Niña conditions. Changes included increased coverage of benthic vegetation, development of a single main tidal channel through the sill, further breakdown of the sill sand bar chain and degradation of the transverse bars. Local shoreline erosion is mainly a consequence of losing feed from the bars, and therefore has not been extrapolated as a future trend.

However, other sections of shore have also been subject to variability of beach and benthic conditions, without corresponding change to the shoreline itself. This is illustrated along the shore south of Point Grey, with fluctuations in beach width, nearshore bars and terrace structure (Figure 2-9). This has occurred with negligible change to the vegetation line position.

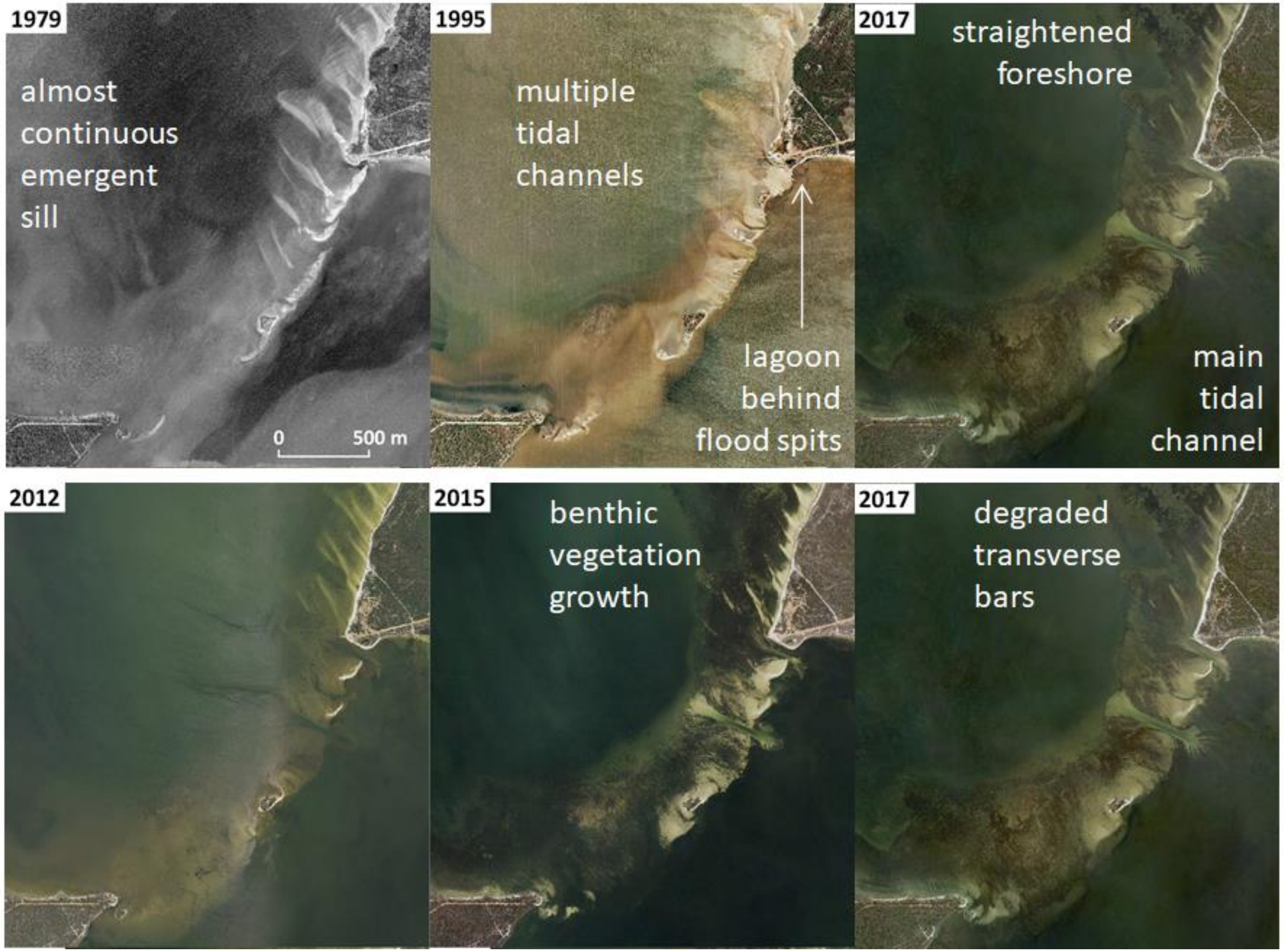


Figure 2-9: Dynamics of Harvey Estuary Sill (1979-2017)

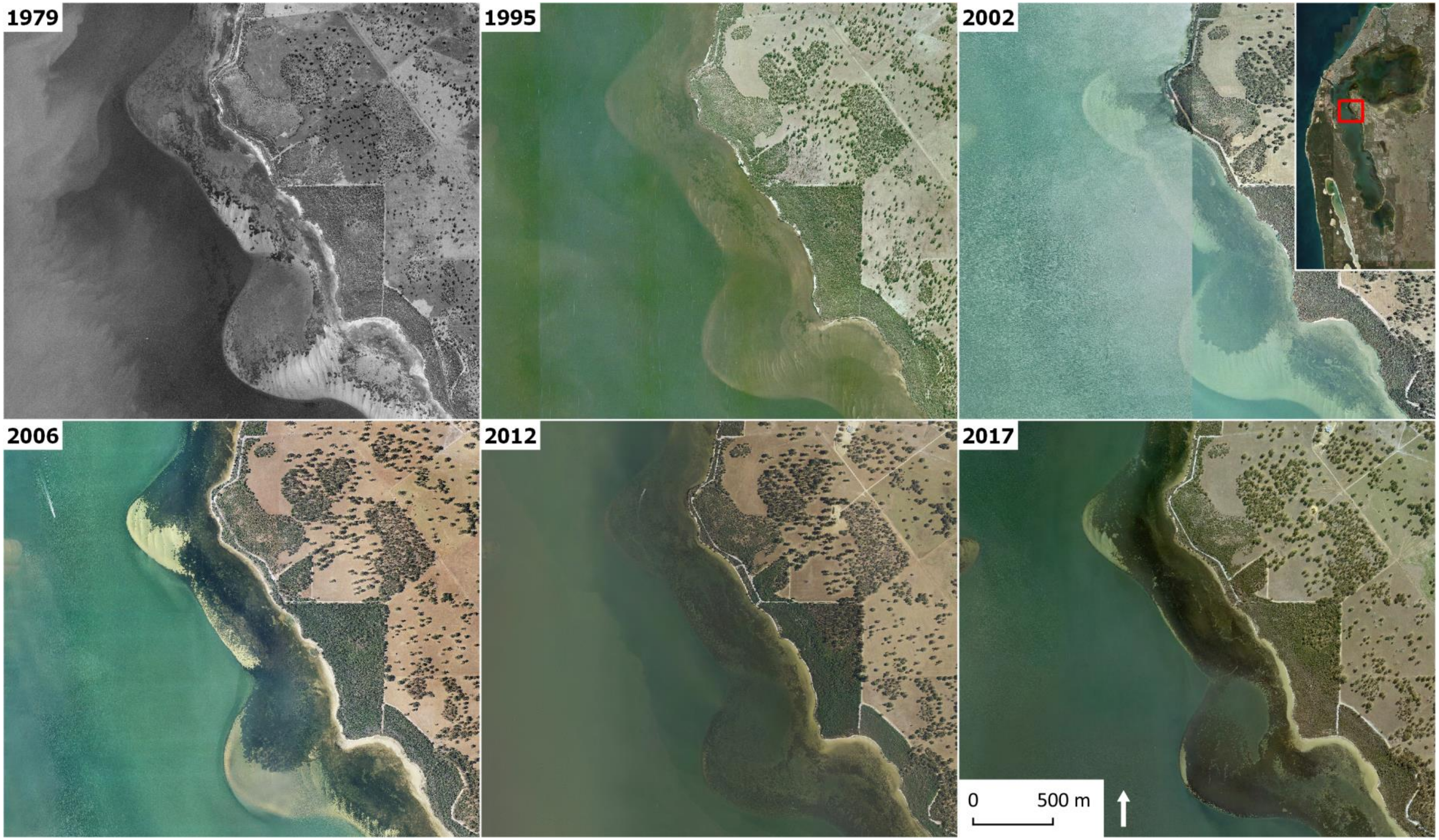


Figure 2-10: Beach and Benthic Variability on Stable Shoreline South of Point Grey

3. Inundation Hazard

Inundation hazard has been considered based upon previous studies of extreme water levels in the southwest of Western Australia (Haigh *et al*. 2010; Eliot 2012, 2018). These have identified that the relative role of different storm types in the generation of high water levels:

- Mid-latitude storms occur all year round but are most frequent and severe during winter months. Coincidence of storms with high mean sea level and the winter solstice tidal peak determines that high water levels mainly occur between May and July (Eliot 2012).
- Tropical storms occur in northerly latitudes mainly between December and March. These storms are highly mobile and occasional late season storms pass into southerly locations, where they may experience extra-tropical transition, interacting and eventually merging with extra-tropical systems. These storms can generate large surges, but they typically occur during a period of low mean sea level and moderate tides, reducing their capacity to generate extreme water levels (Eliot 2010).
- Thunderstorms occur throughout Western Australia. The local pressure drop associated with thunderstorms can generate a travelling surge that can, when travelling at certain speeds and directions, be amplified by the resonant characteristics of coastal bathymetry (Pattiaratchi & Wijeratne 2014). This provides opportunity for high amplitude but rapidly oscillating surges.

Historically, the tide gauge records of almost all southwest stations show that the most frequent cause of high water levels is developed by mid-latitude winter storms. However, the highest total water levels are typically associated with either tropical cyclones or meteotsunami. The most significant event on record was caused by TC Alby in April 1978, which caused extensive flooding from Mandurah through to Busselton (MacPherson *et al*. 2011).

Evaluation of water levels within the Peel-Harvey system has demonstrated that the estuary acts like a spectral filter, with the channel and basin structure modifying how tides, storm surges and other ocean sea level signals are transferred through into the estuarine systems (Eliot & McCormack 2019). This analysis has shown that tide is reduced to 70-90% of the ocean signal and mean sea level variation is unchanged. The effect on surges is variable, according to the time scale of the surge process, with 85% of 'typical' storm surges passing through, with reduced transfer for shorter duration signals.

The likelihood of inundation for events below 100-year ARI has been estimated based upon data from the permanent tide gauge established in Peel Inlet since 1985 (Figure 3-1). A sub-set of the dataset has been used, considering only data since April 1994, following opening of Dawesville Channel.

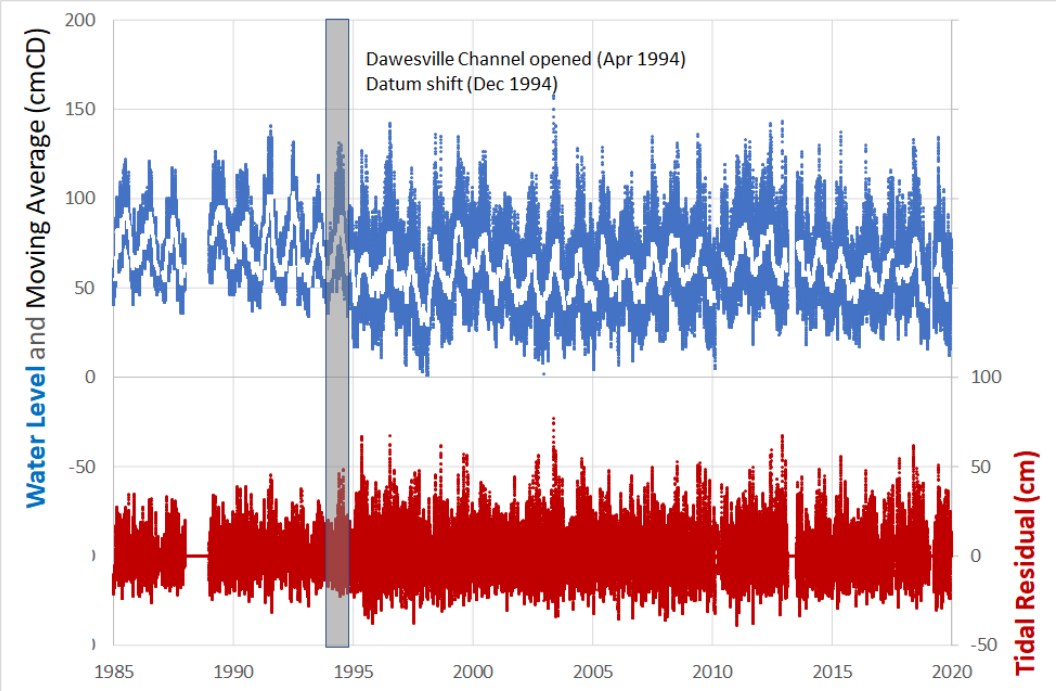


Figure 3-1: Peel Inlet Tide Gauge Observations & Residuals 1985-2019

Evaluation of inundation hazard has been based upon ground levels derived from the 2009 LIDAR land surface, captured by Fugro, on behalf of the Department of Water. It is noted that although LIDAR has capacity to collect topography with fine vertical and horizontal resolutions, there was limited vertical datum control available within the Shire of Murray (John Mullally, DOT Senior Hydrographic Surveyor, pers comm.). Hence, it is estimated that ground levels might have systematic errors in the order of 0.3m, which represents a substantial change in relative flooding incidence. Despite this potential limitation, checking of broad-scale patterns did not identify inconsistencies, and the LIDAR topography has been considered the most accurate available information for use in this assessment.

For land-use planning, water levels are distinguished between those causing 'tidal inundation' and higher levels producing 'flood inundation'. Tidal inundation occurs frequently, limiting the vegetation able to survive, and is typically characterised as wetland. The limit of present-day tidal inundation is approximately level of +0.6m (Figure 3-2), which will increase with sea level rise. Wetland areas are generally unsuitable for typical 'land-use' requiring consideration of inundation, potential erosion hazard and effects of salinity. Identification of adaptive mitigation principles is an objective for the overall CHRMAP supported by this document. Rising tidal inundation is also associated with increased salinisation of the wetlands fringing the Murray River, causing changes to the riparian vegetation, which may locally affect foreshore stability.

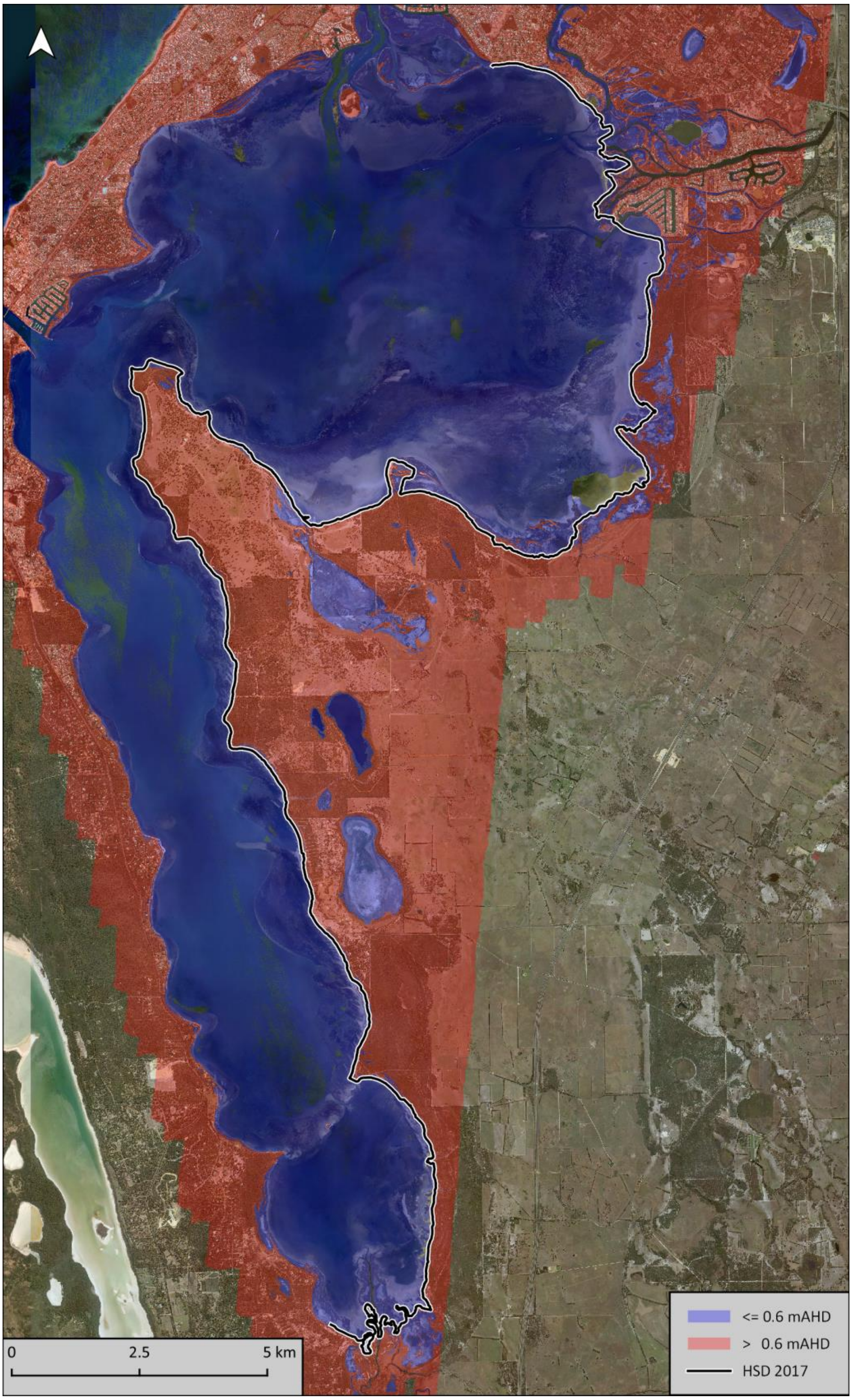


Figure 3-2: Areas Below 0.6mAHD

Note: HSD2017 is defined in front of wetland areas below 0.6mAHD where a largely continuous barrier has been identified.

Exposure of parts of the Shire of Murray foreshore to relatively low levels of inundation is demonstrated by flooded areas observed from satellite imagery, as assessed by Digital Earth Australia (Mueller *et al*. 2019). The south and west fringes of Peel Inlet is suggested to be inundated 5-20% of the time (Figure 3-3), including a large wetland connected to Roberts Bay through a narrow channel. Wetlands adjacent to Harvey Estuary (Lake McLarty and Birchmont) are not directly connected, with inundation patterns suggesting influence of near-surface groundwater (Figure 3-4).

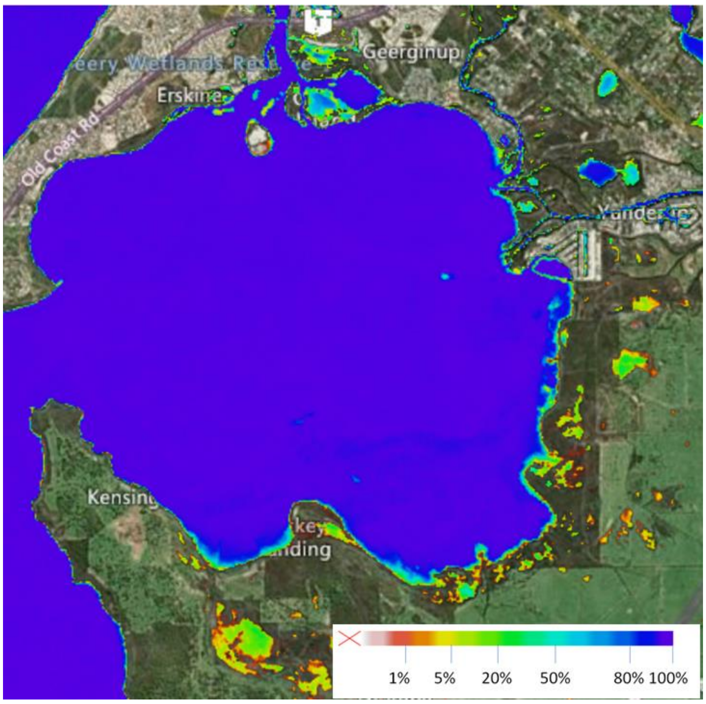


Figure 3-3: Inundation Frequency of Wetlands Fringing Peel Inlet

Flood inundation occurs with lower frequency for high levels. The impacts of flooding depend on the type of land-use, with tolerably rare flooding usually considered nuisance flooding. Incidence of tolerable flooding usually varies from once per year (affecting ground covers) to 1% likelihood per year (possibly tolerable for housing). Flood inundation levels will increase with sea level rise.

Characterisation of flood recurrence was undertaken by identifying maxima, with a minimum window of two days between events, to avoid including the same storm event twice. The highest 24 events within the data set (i.e. approximately 1 per year of data) were then ascribed ranking positions, following the method of Petrauskas & Aagard (1971). Fitting of alternative extreme distribution curves suggested a best fit with Weibull k = 1.1, which is nearly equivalent to a log-linear fit (Figure 3-5 and Table 3-1).

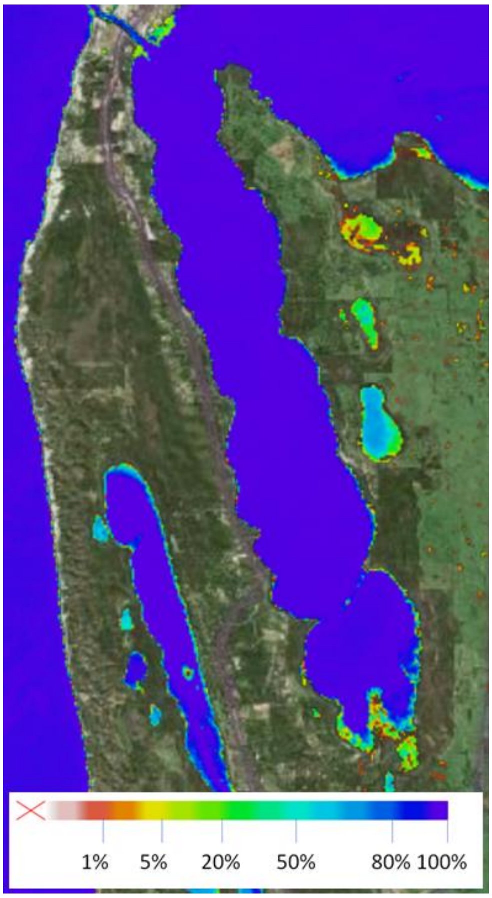


Figure 3-4: Inundation Frequency of Wetlands Fringing Harvey Estuary

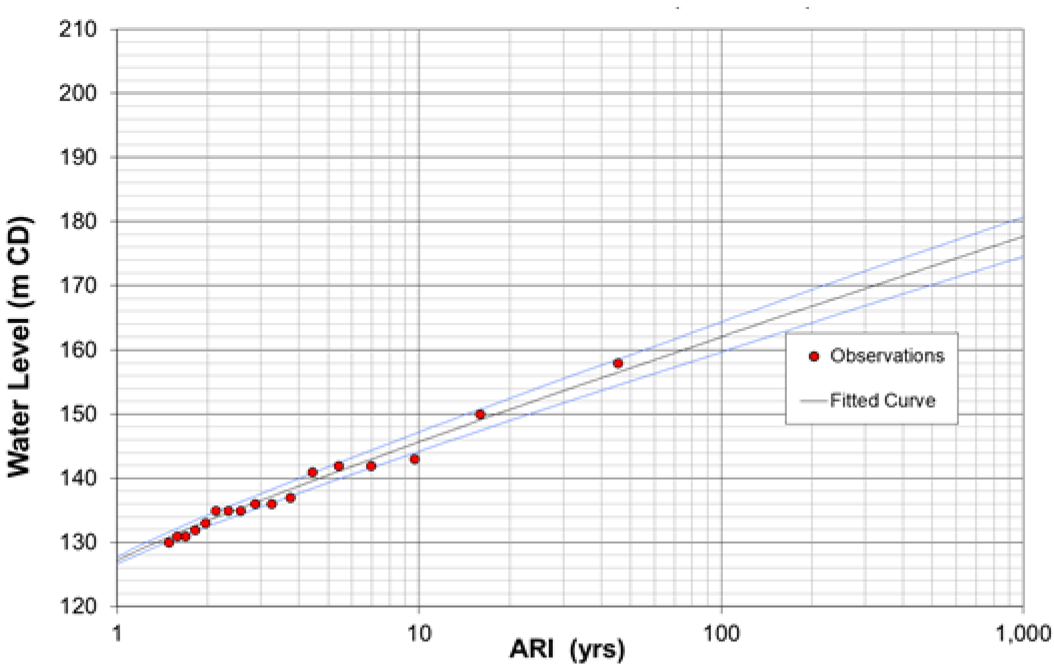


Figure 3-5: Peel Inlet Extreme Water Level Best Fit
Derived from 1994-2020 tide gauge data

Event Recurrence	2 yr ARI	5 yr ARI	10 yr ARI	20 yr ARI	50 yr ARI	100 yr ARI
Water Level (mCD)	1.33mCD	1.42mCD	1.46mCD	1.51mCD	1.59mCD	1.64mCD
Water Level (mAHD)	0.78mAHD	0.87mAHD	0.91mAHD	0.96mAHD	1.04mAHD	1.09mAHD

Table 3-1: Peel Inlet Extreme Water Level Best Fit

The potential for higher water levels associated with passage of a tropical cyclone was evaluated as an 'upper limit' estimate for inundation, following the State Coastal Planning Policy SPP 2.6 (WAPC 2013). Two design storm scenarios were developed, based upon historic events from TC Alby (April 1978) and TC Ned (March 1991).

Following the design storms approach, the storm events were modified through track shifting and varying storm intensity, to achieve a combination that approximates a 500-yr ARI event. For TC Alby, this involved increasing intensity by 10%, and shifting the storm passage such that the radius of maximum winds passed over Mandurah.

Modelling of ocean water levels at the mouth of Mandurah Channel indicated that the surge peak associated with the Alby-based design storm has a relatively short duration of approximately 18 hours (Appendix I). Based upon spectral admittance, the surge within Peel inlet was estimated to be within 60-80% of the ocean surge (Figure 3-6). It is recognised that the level of damping observed during TC Alby was substantially greater with negative surges observed in parts of the estuary. However, opening of Dawesville Channel has significantly increased the opportunity for ocean surges to enter the estuary, and the damping response observed during TC Alby will not occur for the present configuration.

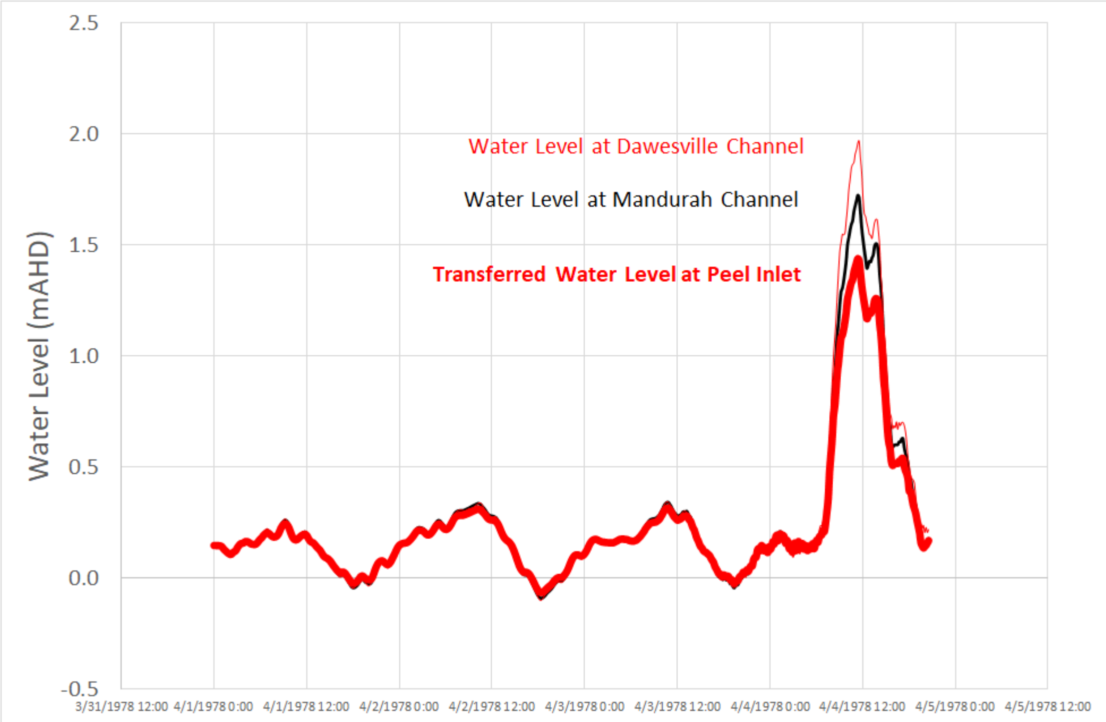


Figure 3-6: Simulated Ocean and Estuarine Water Levels for Design Storm

Using the upper limit of tide and surge transfer rates, the estimated maximum water level associated with the design storm was +1.44mAHD. This extreme storm has synoptic and tidal characteristics approximating a 500-year ARI storm event. The extent of flooding, using a bath-tub approach, covers wide areas of wetland (Figure 3-7), significantly reducing the influence of wave runup, which has consequently been neglected.

Figure 3-7: Extent of Foreshore below Design Inundation Level

The effect of projected sea level rise is to increase all levels of flooding hazard, with a recommended curve for coastal planning in Western Australia (Figure 3-8). The change to flooding levels with sea level rise has been assumed as additive (Table 3-2).

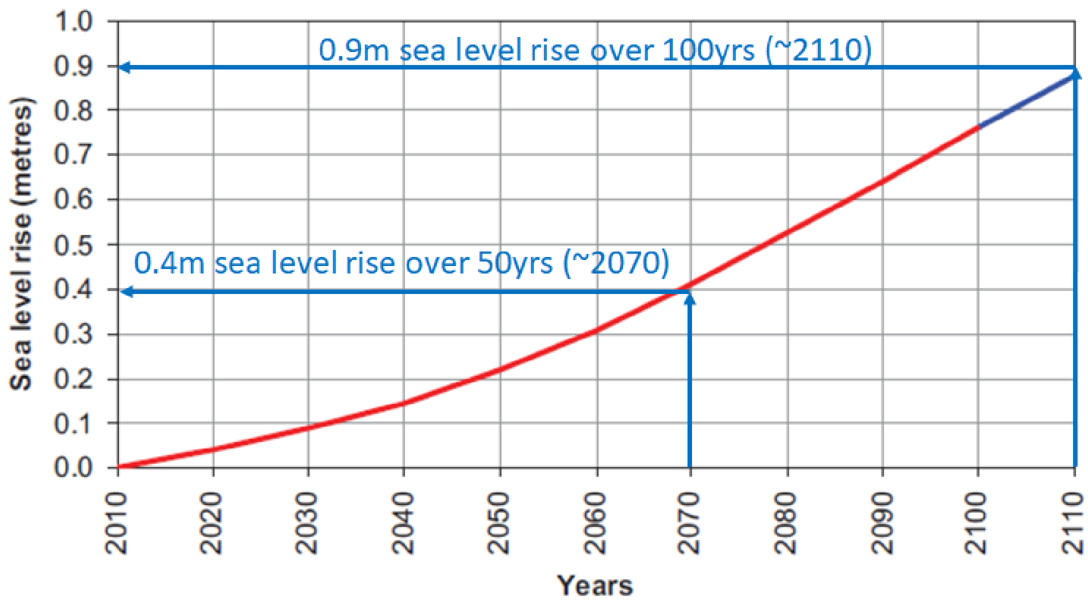


Figure 3-8: Sea Level Forecast Curve Used for WA Coastal Planning (Transport 2010)

Table 3-2: Change to Inundation Levels with Projected Sea Level Rise

Year	Projected Sea Level Rise	Tidal Inundation Limit	10yr ARI Coastal Flooding	100yr ARI Coastal Flooding	Extreme Coastal Flooding
2020	0.0m	+0.60mAHD	+0.91mAHD	+1.09mAHD	+1.44mAHD
2030	+0.07m	+0.67mAHD	+0.98mAHD	+1.16mAHD	+1.51mAHD
2050	+0.15m	+0.75mAHD	+1.06mAHD	+1.24mAHD	+1.59mAHD
2070	+0.50m	+1.10mAHD	+1.41mAHD	+1.59mAHD	+1.94mAHD
2120	+0.90m	+1.50mAHD	+1.81mAHD	+1.99mAHD	+2.34mAHD

Use of a projected sea level curve for modelling of future coastal change is a simplification. The historic record of water levels from Fremantle demonstrates that south-west Western Australia experiences significant inter-annual variability, including the effects of storminess, oceanographic variability (ENSO-related) and tidal modulation (Eliot 2012). These components determine that effects of sea level rise may be felt sooner or later than projection time frames, increasing importance of using adaptive management, which is part of the CHRMAP framework.

The relative significance of changes due to Dawesville Channel is indicated by increase of the 10yr ARI flooding level by 0.37m from pre-1994 to post-1994, acknowledging that around 0.1-0.2m of this difference is due to variability of storminess and higher mean sea level during the 2011-2013 La Niña phase (Eliot & McCormack 2019).

4. Present-day Erosion Hazard

Evaluation of erosion hazard has followed the general form of schedule one of SPP2.6 (WAPC 2013), varied to account for apparently different mechanisms causing response to sea level rise (see Section 4.4). Erosion hazard components are therefore comprised of:

- Acute Storm Erosion Allowance
- Chronic Erosion Allowance
- Response to Sea Level Rise Allowance

4.1. COASTAL EROSION POLICY

SPP2.6 requires a coastal hazard zone to be identified for greenfield development sites using 'Schedule One', which includes allowances for acute erosion (S1), chronic shoreline trend (S2) and response to sea level rise (S3). There is an additional factor for inundation (S4) which does not represent an erosive process. Although erosion allowances are similar to processes evaluated in this section, the required approach differs, as erosion hazard definition under SPP2.6 is prescriptively defined, with an objective to conservatively estimate the area subject to future foreshore change. In contrast, erosion allowances presented in this report are based on 'best-estimate' values, simulating active and projected geomorphic processes to predict change, supporting their use to guide management triggers within a CHRMAP.

4.2. ACUTE STORM EROSION ALLOWANCE

The prescribed approach for evaluating storm erosion is to model the impacts of a severe storm, with an approximate 100-year ARI recurrence. For coastal settings, this is typically undertaken using a profile-based storm response model, plus allowance for alongshore response where there are headlands, protective structures, or changes in shoreline orientation. However, validation for profile models has typically been developed for ocean coasts, where a significant mechanism for erosion is developed by the transition from spilling to plunging waves, with flattening of the beach face resulting in offshore transfer of sediment. In contrast, wave conditions within estuaries rarely experience this transition, and often remain spilling under storm conditions – erosion response is more typically associated with (i) an expansion of the hydraulic zone or (ii) alongshore sediment transfer. Application of a profile model along the Shire of Murray foreshore was therefore expected to require validation and interpretation.

4.2.1. Process Validation Event

A severe storm event occurring on 24 May 2020 provided an opportunity to evaluate the applicability of the SBEACH profile model for the Shire of Murray foreshore. This storm caused strong winds (Figure 4-1) and occurred near to the annual peak predicted tide, resulting in the second highest water level on record inside Peel Inlet.

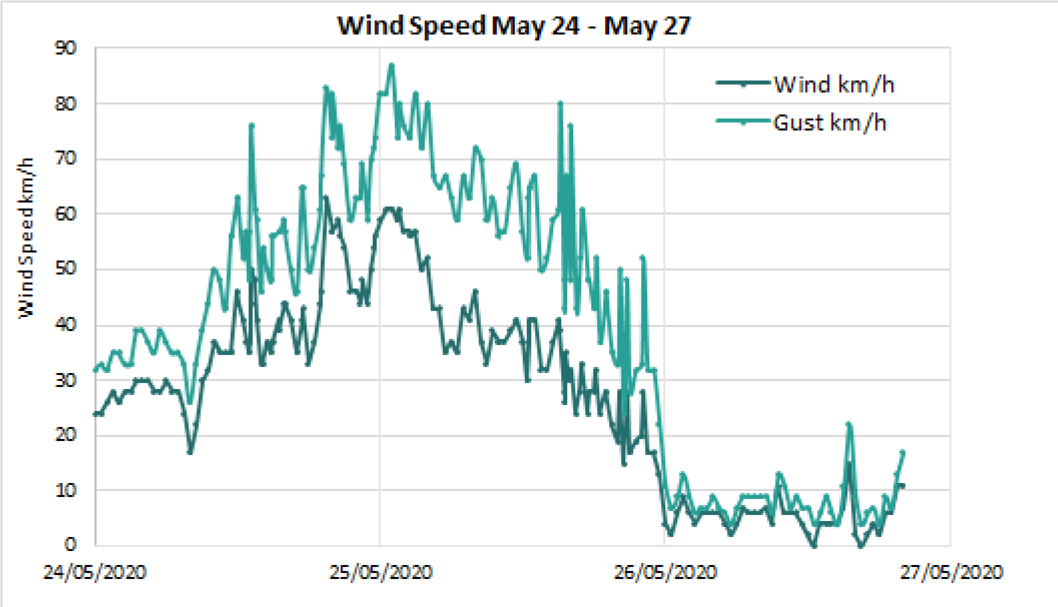


Figure 4-1: May 2020 Storm Wind Record

During site visit in June 2020, impacts to the Murray River delta foreshore were observed, which included foreshore retreat and development of storm bar to landward. This corresponds to the foreshore rollover sequence described by Davidson-Arnott (2015).

Figure 4-2: Observed Response to May 2020 Storm at Old Mill

SBEACH modelling was conducted using a hindcast derived from the wind record, combined with the measured water levels. A median sediment size of 0.15mm was assumed, although field assessment using visual grading indicated highly variable sizing. Model outcomes suggested landward transfer of a similar volume of material, although the depositional structure was steeper, with a sharp back-slope. This response is a consequence of SBEACH's formulation, which includes an empirical estimate of cross-shore sediment transport rates but does not include the process of overwash (Larson & Kraus 1989). Consequently, the total cross-sectional area of change derived from profile response modelling was converted to a horizontal erosion allowance.

4.2.2. Design Storm Definition

Development of a design storm to examine acute erosion involved evaluation of previous storm events. The storm of 16 May 2003 was identified as an outstanding event, with the highest water level on record in Peel Inlet (Figure 4-3) and sustained strong winds for nearly two days. Wind and water levels have been used to hindcast wave conditions for the 2003 and 2020 storms.

A synthetic design storm was developed, by scaling up the 2003 storm winds and water levels to correspond to 100-year ARI levels (Figure 4-4), with hindcast outputs developed for each of 73 profiles (Figure 4-5). The design storm was then applied as a sequence of three storms – this approach was applied to cater for potential underestimation of cross-shore transport rates simulated by SBEACH.

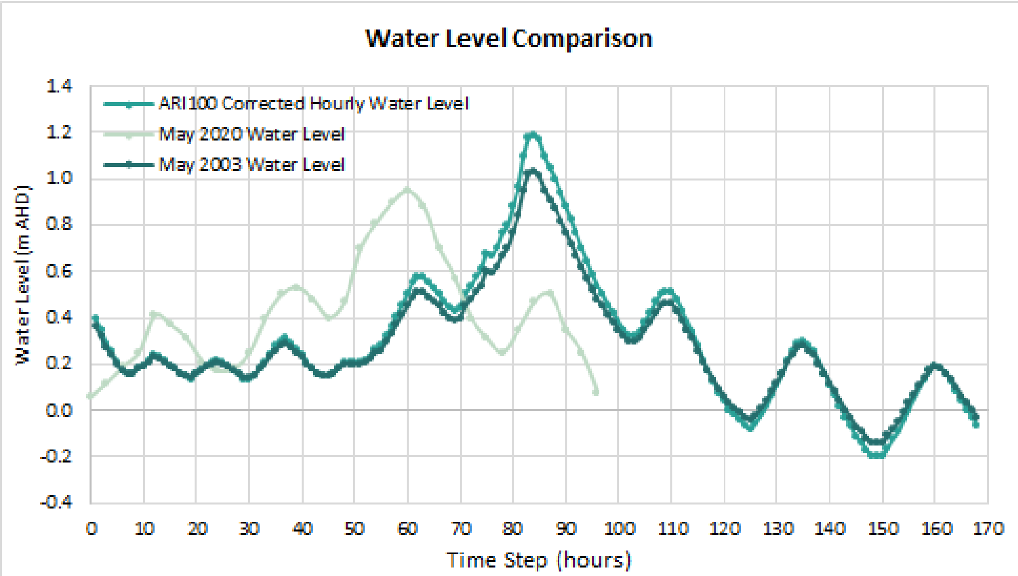


Figure 4-3: Water Levels for 2003 & 2020 Storms & Synthesised 100-year ARI Storm

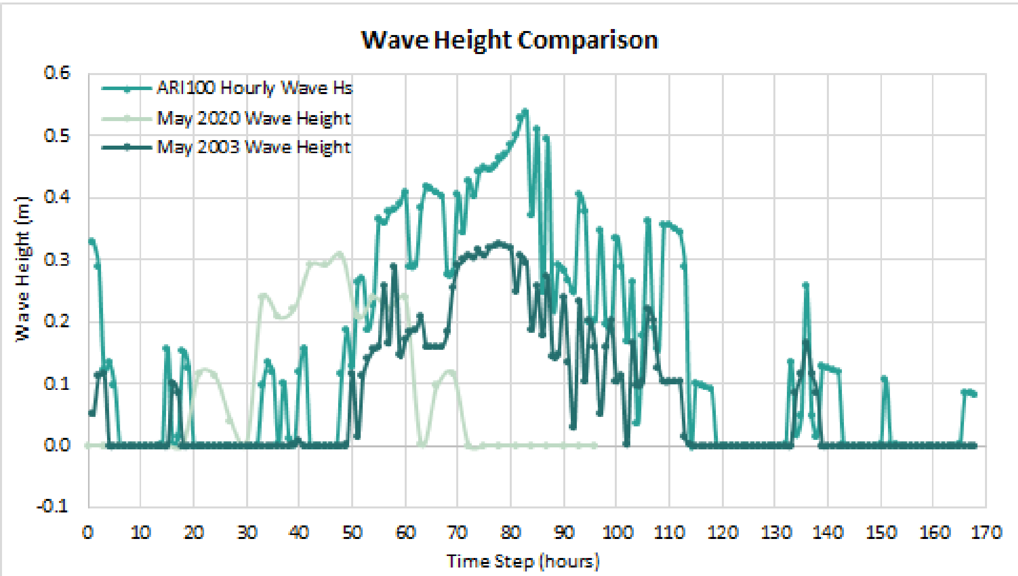


Figure 4-4: Hindcast Wave Heights for 2020, 2003 and 100-year ARI storms

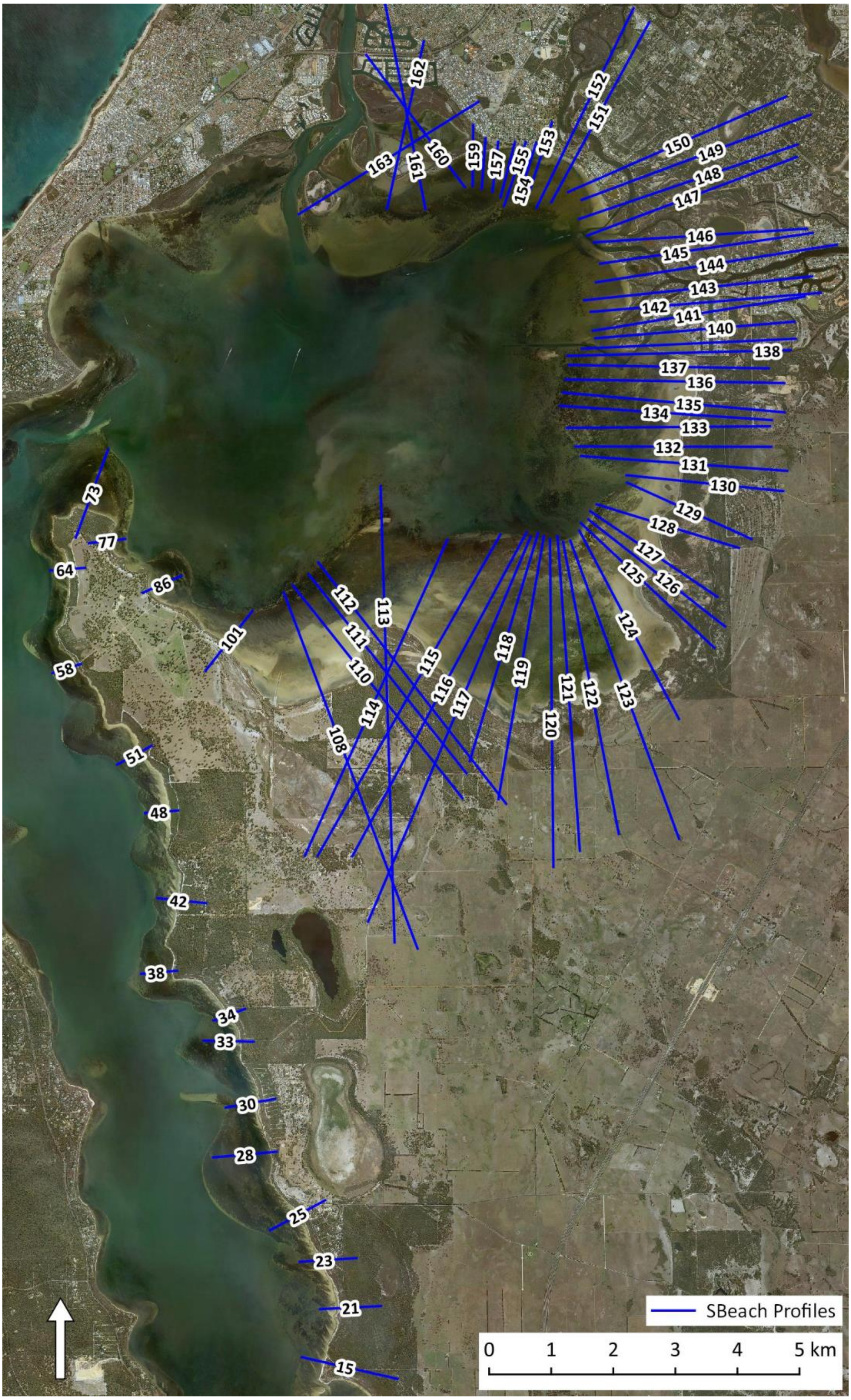


Figure 4-5: Profile Lines used for SBeach Modelling

4.2.3. Profile Response Modelling

SBEACH modelling was conducted for all profiles along the Shire of Murray foreshore (Figure 4-5). As had been suggested by trial modelling for the May 2020 storm, use of the semi-empirical model SBeach is challenged by the low elevation of the foreshore profiles, with profile change modelled to occur wherever a steep gradient is subject to wetting (Figure 4-6). At the shoreline itself, predicted profile change more typically corresponds to the main process used within SBEACH, which is movement toward an 'equilibrium profile' (Figure 4-7).

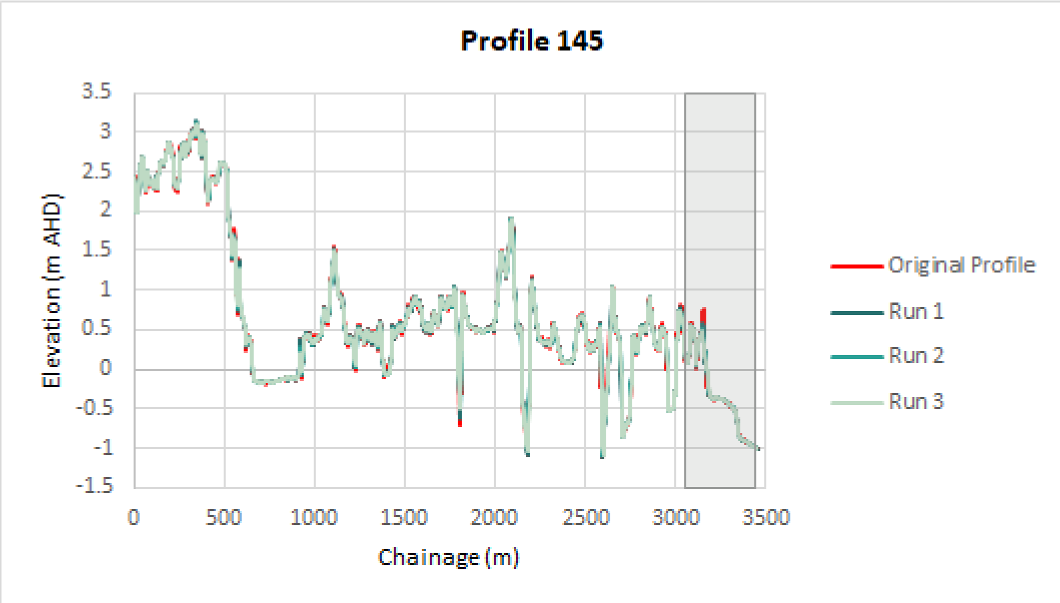


Figure 4-6: SBeach outcomes over full profile

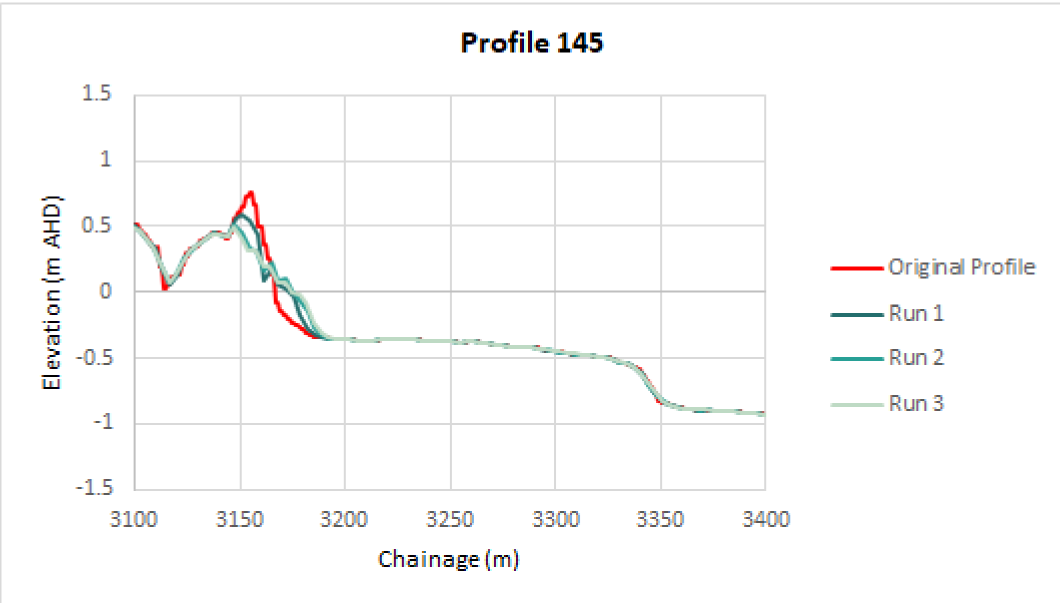


Figure 4-7: SBeach outcomes over part-profile

Estimated erosion response to a storm was developed by summing cross-section change over the whole profile, and then applying this change solely to the front face of the profile. This provided outcomes ranging from 4m to 22m erosion response, with the largest response modelled at Roberts Bay wetlands (Figure 4-13). Variation of response occurs through a range of factors, including the width of the subtidal terrace (causing damping), the beach face gradient and the elevation of the nearshore land.

Riparian vegetation can also substantially modify the foreshore response, with well-established vegetation able to resist short-term erosion pressure from waves up to 0.3-0.5m (Shafer *et al*. 2003). This resistance has not been incorporated in the SBEACH modelling.

4.3. CHRONIC EROSION ALLOWANCE

Observations of foreshore change, summarised in Appendix C, demonstrated that much of the estuary foreshore has been subject to small changes, with the clear exception of the Murray River mouth and the Islands. However, these islands have demonstrated 'roll over' behaviour (see Section 4.4.1), where low elevation spits and berms are gradually pushed landward, rather than the processes of offshore or alongshore loss which cause loss of sediment volume and are more typically considered as 'erosion'.

Determination of a chronic erosion allowance used the overall change in area for the Islands, divided by the active foreshore length, to calculate a trend. For other locations, although some variability was identified, changes were not characteristic of trends. Following SPP 2.6, a rate of 0.2m/yr was used as the minimum allowance for potential future change, which allows for the 'uncertainty' associated with shoreline trend estimation (Figure 4-13).

4.4. PROJECTED EROSION DUE TO SEA LEVEL RISE

The effect of projected sea level rise is to modify wave energy distribution along the estuary shore, causing reconfiguration of existing foreshore landforms. Response may occur through a number of pathways (Figure 4-8), including offshore, onshore or alongshore sediment transport, as well as shift in the foreshore profile.

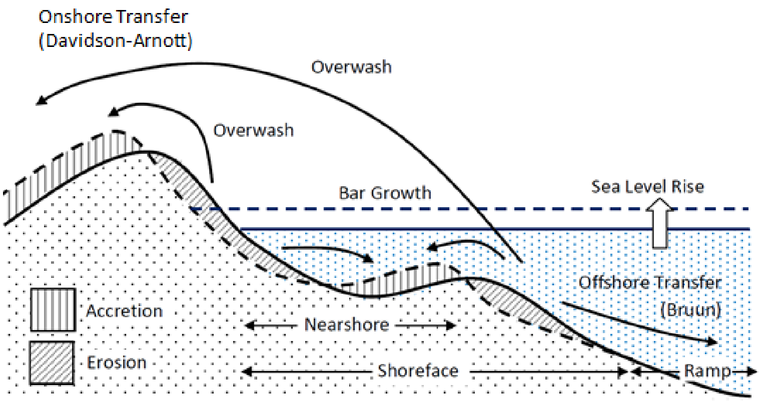


Figure 4-8: Typical Models of Cross-Shore Response to Sea Level Rise
Diagram adapted from Dubois (1992)

Localised response to sea level rise is also expected where coastal landforms facilitate sediment supply or storage. Estuaries will generally experience increased marine sediment influx, however if this is insufficient to keep up with sea level rise the estuary will ‘drown’ (Leuven *et al*. 2019). For the Peel-Harvey system, there is limited opportunity for marine sediments to enter the estuarine basin, with the ebb-delta occupying only a small part of Peel Inlet’s northwest shore. Consequently, most of the estuary is expected to respond at a local scale, where adjustment is caused through foreshore rollover and transfer to the adjacent shore.

Areas of low-lying foreshore provide enhanced opportunity for onshore sediment movement. Occurrence of this mechanism is indicated by the topography, with a low berm providing a narrow barrier to extensive wetland located to landward (Figure 4-9).

SPP2.6 describes a simple allowance for response to sea level rise on the open coast, using 1m horizontal erosion per 0.01m sea level rise. This is often considered to occur through offshore loss (described by Bruun). However, a uniform treatment would not capture the enhanced erosion hazard along low-lying sections of the Murray foreshore. It was consequently determined to determine erosion response to sea level rise by combining a derived erosion allowance for onshore sediment movement with a fixed erosion allowance for offshore or alongshore sediment transfer.

Figure 4-9: Complexity of Low-Level Topography

4.4.1. Onshore Sediment Transfer

Shoreline adjustment through onshore sediment transfer is affected by the topography formed along the shore. Where mild conditions occur, which is consistent alongshore and subject to limited disturbance under ambient conditions (e.g. seasonal variability of alongshore transport), a small berm is created along the shore with a gently sloped back face (Figure 4-10 top). This requires a moderate amount of sediment to build, which must be supplied from the shore, creating retreat. A smaller amount of sediment is required if the back slope of the berm can be steeper, such as a constructed dune, or a vegetated berm.

Response of a low-berm foreshore to sea level rise occurs through two mechanisms:

- *Berm Rollover*, where mild overtopping of the berm causes it the crest to move landward. Erosion from the front face of the berm enables the crest height to rise.
- *Wetland infill*, where large overtopping or tidal currents through a breach cause sediment to dispersed through the wetland area behind the berm.

A considerably larger amount of sediment is required if wetland infill occurs over the entire area behind the berm, which may occur if a storm-built berm becomes unstable. This sequence has been illustrated on the Murray delta islands.

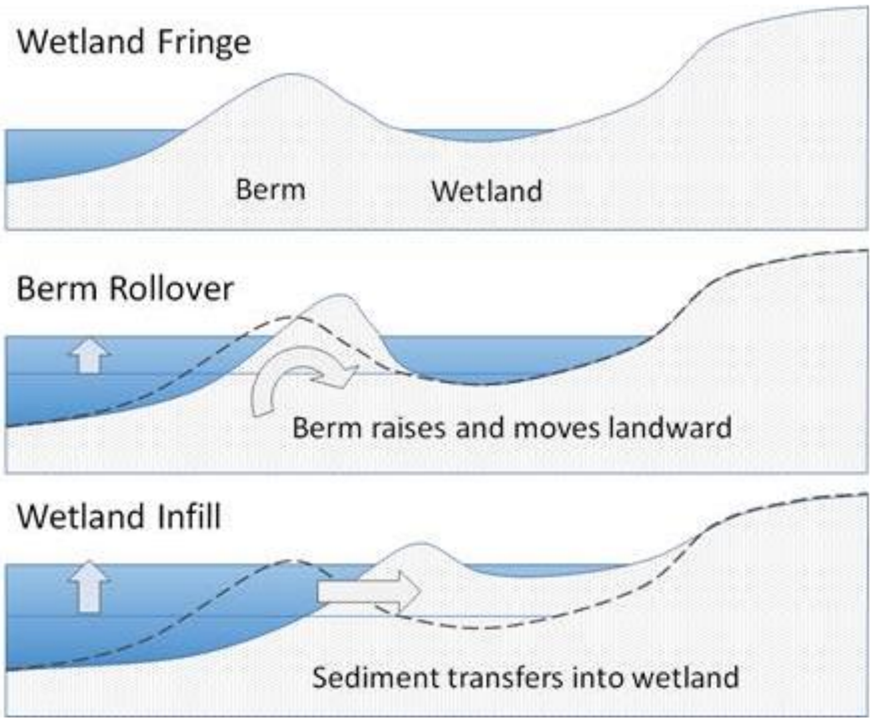


Figure 4-10: Definitions of Rollover and Infill

Instability of berm features increases the higher the berm is above the adjacent land level, with a general progression from occasional overwash, foredune building and then berm collapse and infilling. This results in an exponential increase in sediment demand and shoreline retreat with sea level rise.

Evaluation of potential erosion along the Murray foreshore has been conducted using profiles extracted from LIDAR survey (Appendix E), with aggregated behaviour considered within each of the foreshore segments. Estimation of the potential for wetland infill was calculated for each profile by the cross-sectional area below SLR + 0.6mAHD (i.e. +1.5m AHD by 2120, after 0.9m sea level rise). This provides a significant sediment demand, which has the potential to cause substantial erosion, in the order of 1800m for the Murray River delta area and approximately 400m for Roberts Bay (by 2120).

However, individual profiles highlighted significant low-lying areas, where a narrow berm prevents complete infilling. This suggests that wetland infill is not presently active widely, and that berm rollover is the most likely response to sea level rise, at least in the next 10-50 years. Because berm rollover requires a substantially smaller quantity of sediment, the potential erosion response to sea level is strongly linked to berm stability.

Evaluation of berm rollover was undertaken considering typical profile changes modelled under the design storm, compared with associated storm wave energy, parameterised by the sum of H^2T over the storm period. However, wave energy is only capable of causing overtopping when it occurs simultaneous to high water levels (relative to the berm crest). The long-term hindcast (Appendix B) has been used to derive a cumulative distribution of wave energy with water level (i.e. a berm crest at +0.3mAHD will experience all wave energy for conditions exceeding +0.3mAHD, but will have negligible wave energy input during lower water level conditions. Equating the modelled rate of berm rollover to the available wave energy, potential infill rates for different berm crest levels have been estimated (Figure 4-11). These demonstrate a substantial increase for lower berm levels, with negligible rollover for berm crest levels typically identified along the Murray foreshore of +0.6mAHD to +1.0AHD.

Response to sea level rise has been considered as equivalent to having a lower(ing) berm. This suggests that existing rates of berm rollover will remain relatively low for the next 10-30 years but have the capacity to substantially accelerate with greater sea level rise. In addition to the influence of wave energy, low-lying areas behind foreshore berms are subject to tidal influences, with increasing opportunity for berms to collapse as the difference between the estuary water level and the bed level of the landward basin increases, potentially creating the mechanism of wetland infill.

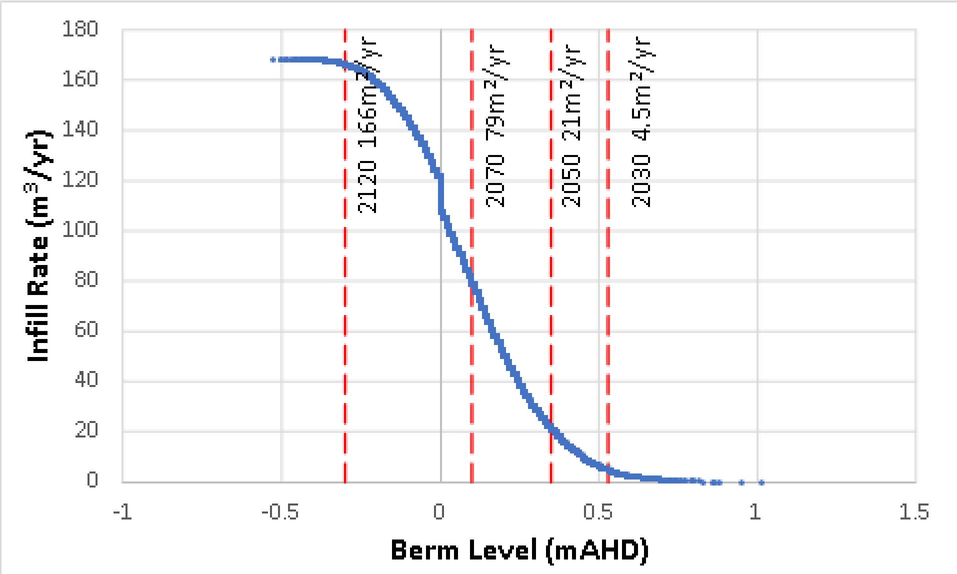


Figure 4-11: Berm Rollover Rates due to Wave Energy and Sea Level Rise

Evaluation of the potential foreshore erosion associated with sea level rise has been conducted – with a ***critical assumption*** that berm rollover will remain the major mechanism for foreshore change. The high alongshore variability results in large differences between nearshore processes – to correct for spatial connectivity, a moving average has been used to estimate the allowance for response to sea level rise.

A small response to sea level rise is expected along the majority of Harvey foreshore due to the height of the existing foreshore. Larger responses are expected towards Herron Point and Roberts Bay, where their lower profile topography is modelled to experience greater rollover. Modelled response to sea level increases from Austin Cove towards the Murray and Serpentine. A small amount of response is estimated for the section of City of Mandurah foreshore where a revetment has been built and the foreshore has been raised above +1.6mAHD.

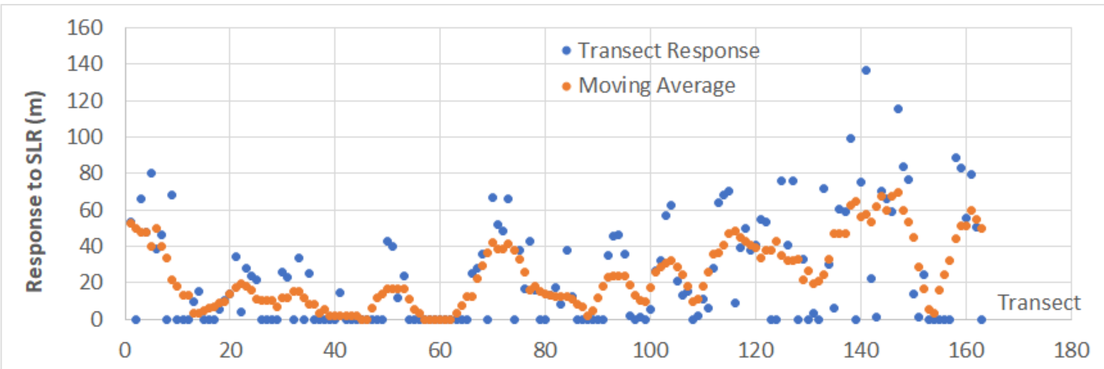


Figure 4-12: 2120 Berm Rollover Estimates by Profile (Locations in Figure 4-5)

The mechanism of wetland infilling is critical to the long-term foreshore dynamics for the Yunderup area. If the foredune berms are unable to keep pace with sea level rise, the intertidal area of the wetlands has a potential infill volume that is an order of magnitude greater than the volume required for a foreshore berm. Implicitly, this means that the projected response to sea level rise could increase to the scale of 1-2 kilometres.

4.4.2. Offshore or Alongshore Sediment Transfer

Although onshore sediment transfer has potential to be extremely significant for parts of the Shire of Murray foreshore, response to sea level rise may also occur through other transfers, including offshore or alongshore sediment transfers. It is expected that offshore loss is likely to occur where the foreshore is perched, such as near Point Grey, and alongshore loss is likely to occur where existing features suggest alongshore transport, such as north of Herron Point. However, as identified by aerial imagery, these areas have experienced small foreshore change over the historic period, limiting the capacity to project future response.

A fixed allowance of 50m has been assumed as a response to offshore or alongshore sediment transfer for all of the estuary foreshore.

4.5. TOTAL ESTUARINE FORESHORE EROSION ALLOWANCES

Influences of storm erosion, chronic change and response to sea level rise have been added horizontally to develop erosion allowances for the Shire of Murray foreshore for time frames of 2030, 2050, 2070 and 2120 (Figure 4-14). Erosion allowances for 2120 are also presented as a table according to foreshore segments (Table 4-1). Erosion distances have been mapped by buffering the erosion distances landward from a nominal shoreline at +0.6mAHD, which was treated as a horizontal setback datum (HSD) using the terminology of SPP 2.6. This is the approximate upper level at which present-day shoreline erosion is observed.

Erosion allowances are comparatively small along the Harvey Estuary foreshore, including the Birchmont area (Figure 4-15), where the relatively higher foreshore resists substantial response to sea level rise and limited historic shoreline change has been observed.

Larger erosion allowances have been determined for Austin Cove and in the vicinity of the Murray and Serpentine Rivers (Figure 4-16), developed mainly due to the low-lying topography and projected response due to sea level rise.

It is reiterated that the process of wetland infilling, which has not been incorporated in derived erosion allowances, has the capacity to massively increase the response of the foreshore to sea level rise.

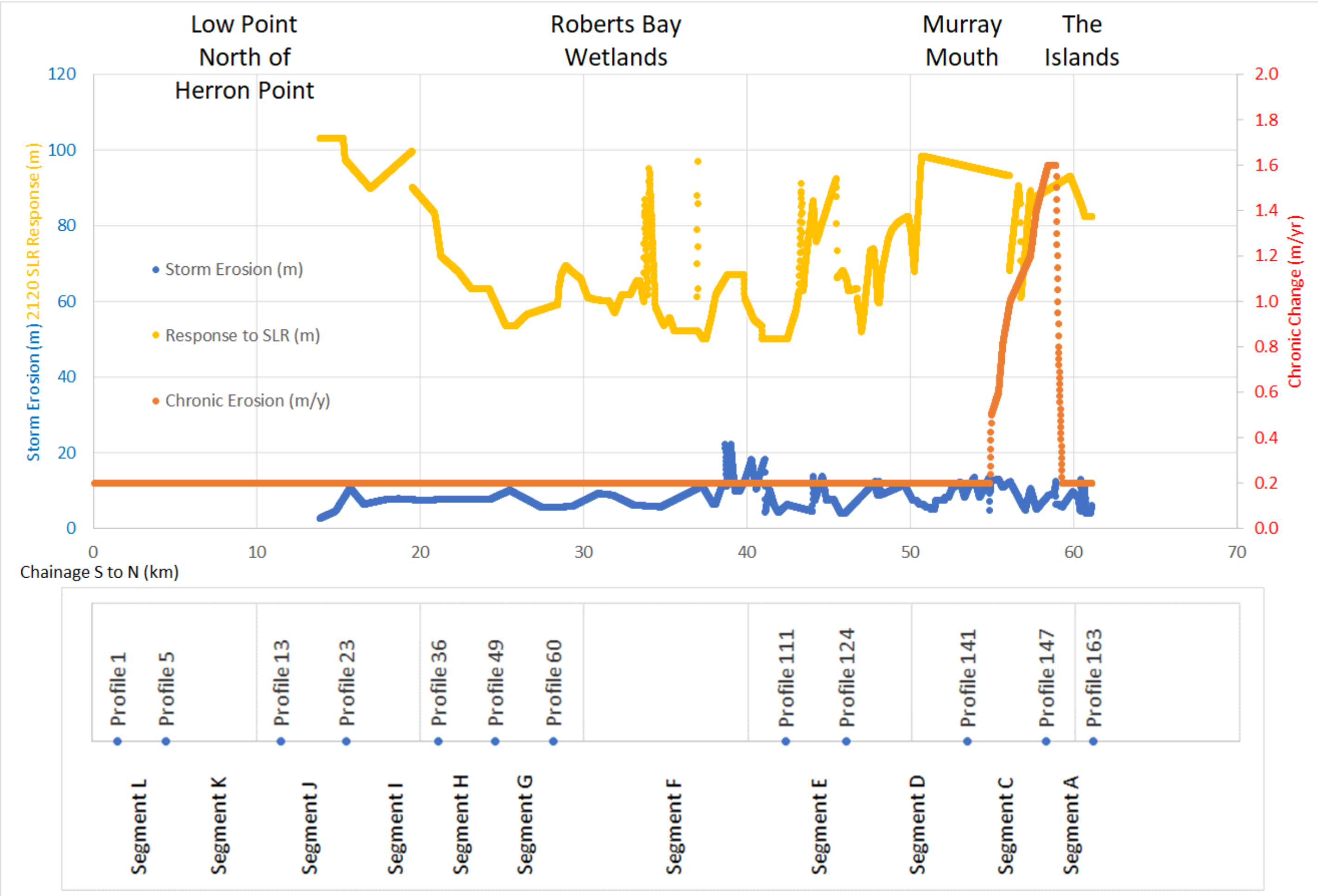


Figure 4-13: Modelled Profile Responses to Design Storm, Chronic Trend and SLR

Note that 'spikes' in the response to sea level rise occur where there is a local low point

Table 4-1: Total Erosion Allowances Table for 2120

Segment	Profiles	S1 (m)	S2 (m/yr)	S3 (m)	Total (m)
A	148-163	4-13	0.2-1.6	54-100	78-261
C	142-147	5-14	0.2-1.5	95-118	139-256
D	125-141	4-12	0.2	70-112	95-141
E	112-124	4-14	0.2	61-93	87-123
F	61-111	4-22	0.2	50-98	76-139
G	50-60	6-10	0.2	50-67	75-97
H	37-49	7-8	0.2	50-97	78-125
I	24-36	6-11	0.2	54-95	81-122
J	14-23	3-9	0.2	54-69	76-97
K	6-13	2-3	0.2	54-100	76-122
L	1-5	2-3	0.2	90-102	112-125

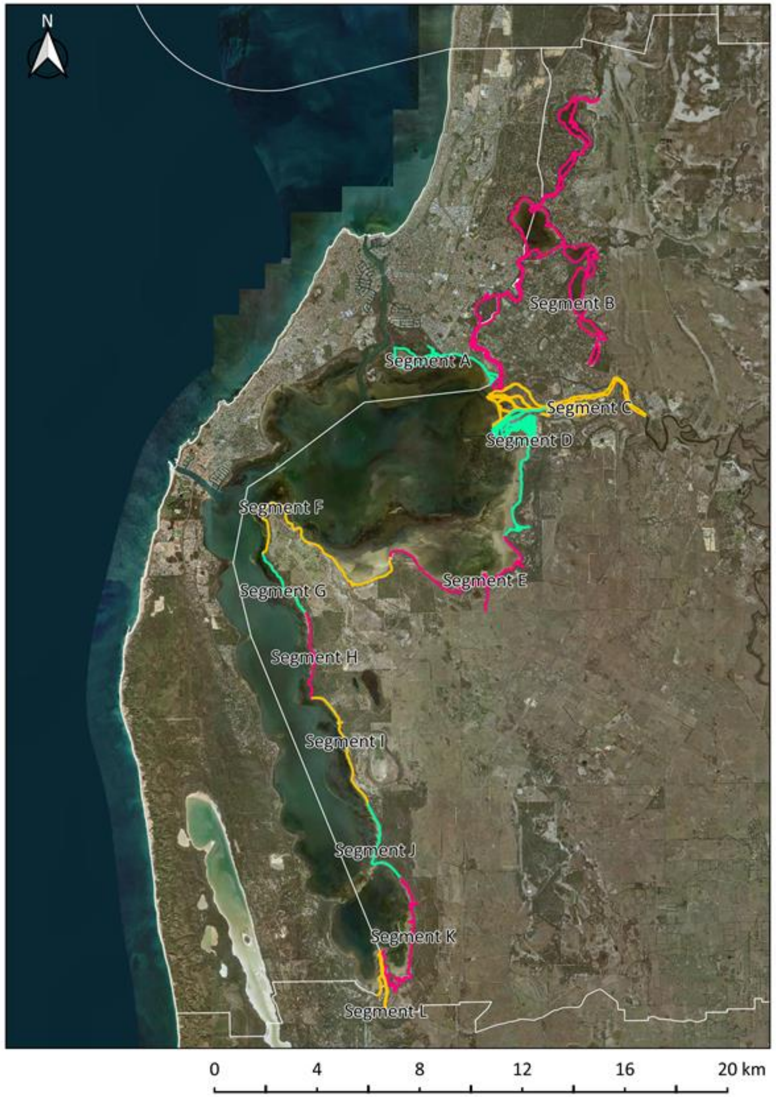


Figure 4-14: Total Erosion Allowances (Whole Foreshore)

Figure 4-15: Total Erosion Allowances (Birchmont Area)

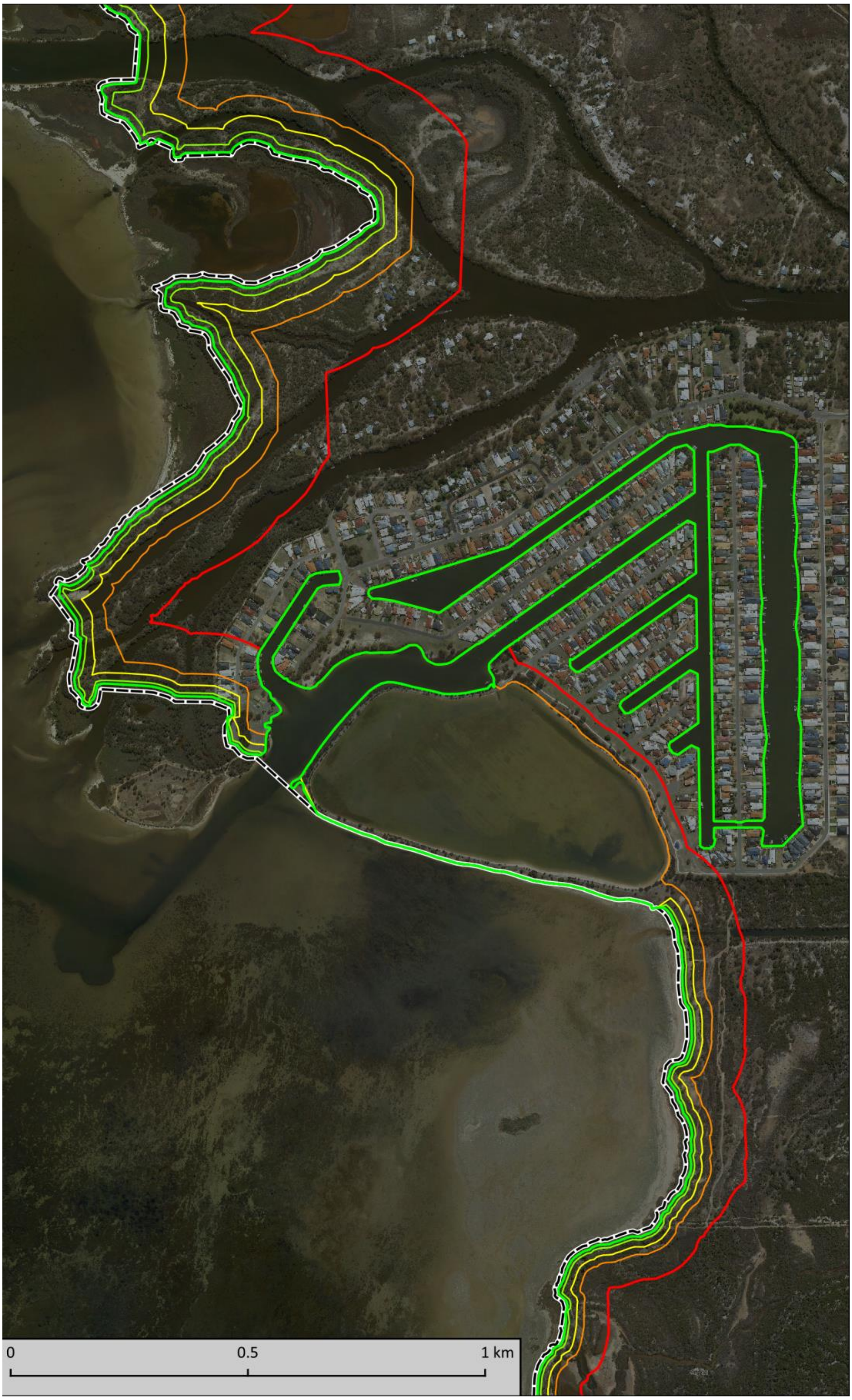


Figure 4-16: Total Erosion Allowances (South Yunderup Area)

4.6. CHANNEL EROSION ALLOWANCES

Erosion pressure has been identified along river channel sections in the lower Murray and Serpentine Rivers (Syrinx Environmental 2019). Sensitivity to erosion hazard is high along the lower Murray River due to active recreational and residential use, substantial presence of foreshore infrastructure and occurrence of high water mark freehold titles. Small scale erosion can cause jetties to disconnect from shore, or the undermining or riparian vegetation, which are perceived as substantial impacts, often prompting reactive works.

Erosion pressure has perceptibly increased due to large-scale hydraulic changes (currents and water levels) after opening of Dawesville Channel. However, the lower section of the river channels also has a history of natural channel evolution, and there have been extensive examples of local transfers of erosion pressure due to foreshore infrastructure. Erosion pressure is expected to increase further due to sea level rise.

The ability to suitably project future erosion hazard (i.e. to define foreshore setbacks) is challenged by a diversity of potential contributing mechanisms (Table 4-2). There is a limited evidence base with which to distinguish between mechanisms or parameterise the scale of response to each mechanism. The PNP Regional Coastal Monitoring Program (Damara WA 2016) provides a recommended monitoring framework for estuaries that may assist with future distinction of active drivers.

Table 4-2: Potential Erosion Mechanisms for Lower Murray River

Erosion Mechanisms	Monitoring	Distinction
Macro-scale:		
• Channel avulsion[1]	Channel widths	Different channels expand/contract
• Dawesville Channel impacts	Channel widths	After 1994, all channels responding
• Sediment supply variability	Flow record	Following flood / low flow periods
Meso-scale:		
• Hydraulic variability	Tide record	All channels responding
• Siltation / deposition	Hydrosurvey	Widespread bed shallowing
• Bed mobility	Hydrosurvey	Adjacent to known bed features
• Boat wakes	Visual inspection	Wide impact
• Channel migration	Thalweg	Local bed deepening
• Bank undermining	Visual inspection	Nearshore deepening
Micro-scale:		
• Instability of riparian vegetation (e.g. trampling)	Visual inspection	Local impact
• Erosion pressure transfer from structures	Visual inspection	Updrift trapping / downdrift erosion

[1] Avulsion is the process where hydraulic flows are redistributed between two or more channels. Typically this involves expansion of one channel and corresponding contraction of another.

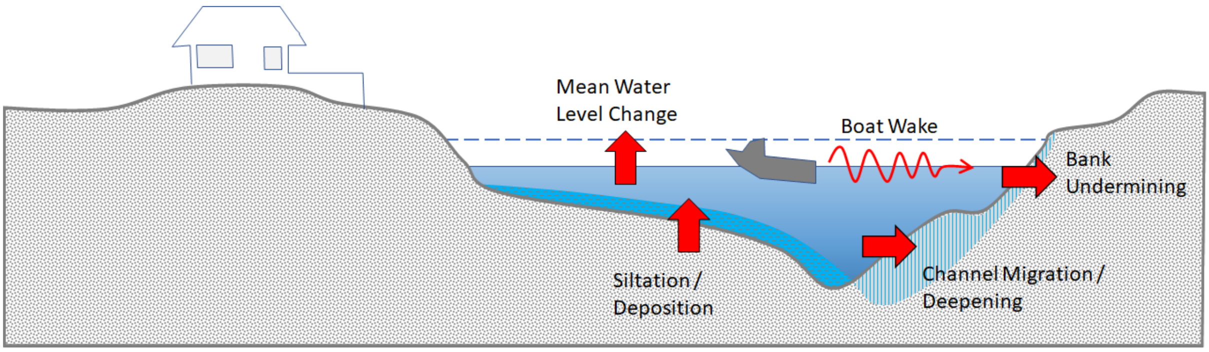


Figure 4-17: Schematic Indicating Meso-scale drivers of Channel Foreshore Change

Identification of erosion hazard along the most developed section of the lower Murray River is partly challenged by a limited ability to measure foreshore change using remote-sensing techniques commonly used for erosion assessment. In particular, the transition from a well-established riparian foreshore through to a degraded foreshore (Figure 4-18) is often obscured by tree canopy. In many cases, the root mass of trees is capable of resisting erosion stress for a considerable period, withstanding deepening of the adjacent foreshore. Change in vegetation can therefore be 'sudden' once the tree is lost, although stress may have been occurring over a much longer period.

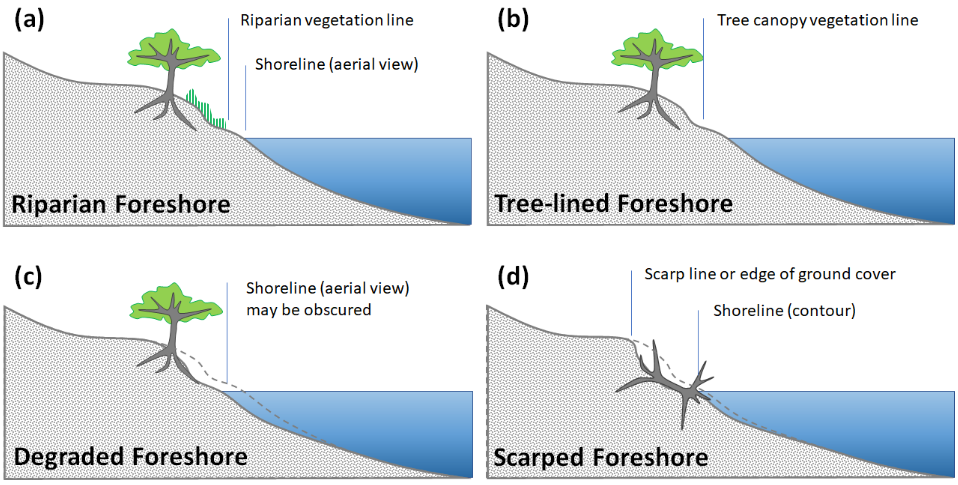


Figure 4-18: Typical Eroding Foreshore Sequence

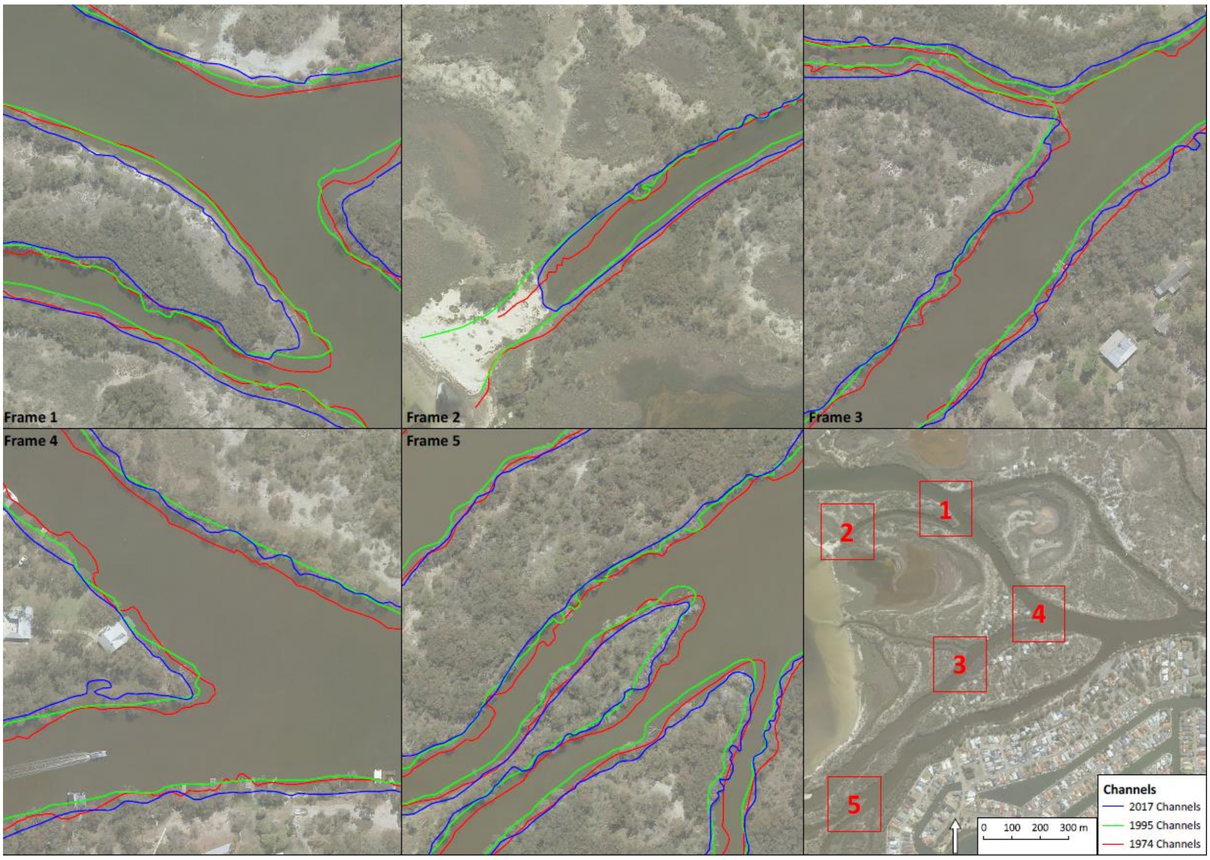


Figure 4-19: Channel Changes Within the Murray River Delta

Shorelines mapped from aerial imagery from 1974, 1995 and 2017 illustrates that the Islands foreshores have been historically dynamic. Overall, there has been general expansion of the channels, with occasional, typically local reversals. A significant change was apparent for the smaller channels 'cutting through' Meeyip Island, with the northern channel contracting after its entrance was plugged by sediment (Figure 4-19 Frame 2), and the southern channel consequently expanding (i.e. local scale channel avulsion).

Although all channels have generally widened over time, particularly following opening of Dawesville Channel, a wider scale avulsion appears to be occurring across the Islands. The northern channels have generally expanded less than those to the south, suggesting that a greater portion of flow (tidal and riverine) is passing through the southern channels.

The lower Serpentine River is comprised of a series of basins, connected by channels. Observed change within this area is small, mainly characterised by sill development near the entrance or exit of channels, which indicates tidal flows are active. Potential response to sea level rise has been evaluated using geometry of the basins and channels. As the percentage increase of channel cross-section is larger than the percentage increase of basin area with sea level rise, it is expected that the lower Serpentine River will have comparatively low sensitivity to sea level rise.

Figure 4-20: Channel Classification

Erosion hazard along channel margins for the lower Murray and Serpentine Rivers has been defined as three separate classes (Figure 4-20), acknowledging the differences in foreshore dynamics between the ocean, estuary, and river channels. Distinction has been made based on observed active processes, including 'switching' of channels, experiencing flow within the Islands, and local influences of foreshore vegetation. In the absence of detailed measurements of channel change, allowances for erosion hazard have been based upon likelihood for different mechanisms for erosion being active, distinguished for three sections, with transition between estuary and wetland buffers outlined in DC 2.3 (WAPC 2002) and SPP 2.9: Water Resources (WAPC 2006):

- Channels within the Islands area have been defined with an erosion hazard of 50m by 2120, accounting for higher tidal flows and potential for channel switching.
- An erosion hazard allowance of 30m by 2120 has been defined where there is a single main channel for the Murray River (adjacent to Yunderup) and within the lower Serpentine River.
- Within the secondary channels and small lakes adjacent to the Murray River, an erosion hazard of 15m by 2120 has been defined. These waterbodies typically receive only a small quantity of flow, usually under extreme water level or flood overflow conditions.

Variation of the erosion allowance over time has been scaled with sea level rise (Table 4-3).

Table 4-3: Erosion Allowances for River Channels

Date	2020	2030	2050	2070	2120
Sea Level Rise	0.00m	0.07m	0.15m	0.50m	0.90m
% Allowance	10%	17%	25%	60%	100%
Murray Delta	5.0m	8.5m	12.5m	30m	50m
Primary Channels	3.0m	5.1m	7.5m	18m	30m
Secondary Channels	1.5m	2.1m	3.8m	9m	15m

4.7. MAN-MADE STRUCTURES

Existing foreshore protection structures within Yunderup provide land retention, including canal estate walling, a bund around the man-made lake south of Yunderup and a containment bund at the southern entrance to the Murray River. These features have been assumed to be maintained to provide the existing standard of protection. For canal walling, additional upkeep is likely required with higher water levels, but existing wall heights are sufficient for walling to provide protection against erosion, illustrated by the extent of land above the present-day severe flood level (Figure 3-7). The bund around the man-made lake presently has a crest height of +1.1 to +1.5mAHD (Figure 4-21), which will require enhancement prior to 2070 to prevent collapse through frequent overtopping.

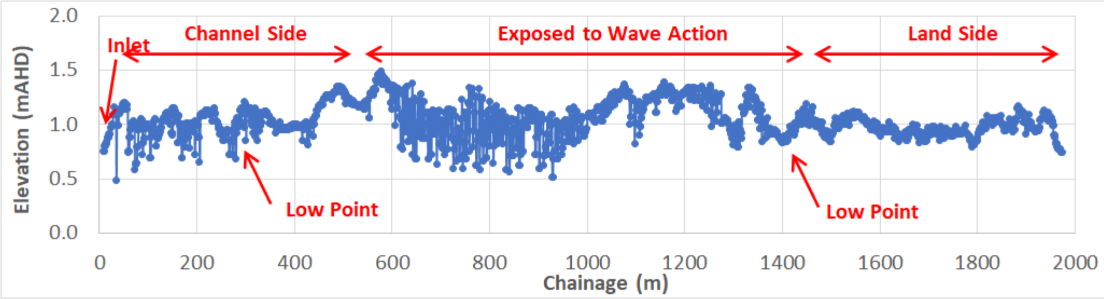


Figure 4-21: Variation of bund crest levels for Yunderup Lake

4.8. EXTREME EROSION (WETLAND INFILL) SCENARIO

Potential for wetland infill to cause extreme erosion hazard has been identified. Mapping of the potential extent of erosion under a 'full infill' scenario for a sea level rise of 0.9m by 2120 has been undertaken (Figure 4-22). This shows significant potential for erosion along the east side of Peel Inlet, of 1-2km width. Wetland infill may also occur along the south and southwest foreshore areas, with 0.4-0.8km potential erosion. A smaller potential for wetland infill was identified toward the southern end of Harvey Estuary. The extent of potential erosion due to wetland infill approximately corresponds to the boundaries of modern foreshore landforms, which developed during the present sea level era.

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Figure 4-22: Wetland Infill Scenario for 2120

5. Conclusions

Analysis of the Shire of Murray foreshore has been undertaken, to support development of a Coastal Hazard Risk Management and Adaptation Plan. Evaluation has included characterisation of estuarine morphology, determination of historic foreshore dynamics and analysis of tide gauge records. This observational basis has been supplemented by hindcast modelling of wave conditions within the estuary, to determine potential erosion response to severe storms.

Inundation characteristics were determined from the Peel Inlet tide gauge, including extreme distribution fitting for water levels of 2 to 100-year ARI, corresponding to +0.78m to +1.09mAHD. The potential for more severe inundation associated with the passage of a tropical cyclone was evaluated by modelling coastal conditions, with the transfer into the estuary modulated by the spectral characteristics of the storm surge. Simulation of a design storm based upon TC Alby, with intensity increased by 10% and an approximate 'worst-case' track gave a flooding level of +1.44mAHD. This approximates an event of recurrence 500-year ARI.

Erosion modelling was based upon modelling of a synthetic storm, developed from the May 2003 storm, which is the most severe storm on record. Wind speeds and water levels were scaled up to 100-year ARI conditions, to provide an approximation for a storm event with recurrence of approximately 100 years. Modelled erosion due to the synthetic storm was in the range of 8-22m, with larger response occurring on lower-lying foreshore areas.

Assessment of aerial imagery from 1977-2017 identified that historic foreshore changes have been large in the vicinity of the Murray River mouth and generally small (<0.2m/yr) in other locations. Movement has generally been characteristic of foreshore rollover, where narrow spits and berms collapse landward (i.e. although there are large changes in area, they represent small changes in volume). Estimated rates of change, when projected landward, are in the order of 0.8-1.6m/yr around the Murray River mouth.

Future response to sea level rise has been modelled, based upon a critical assumption that the mechanism of foreshore rollover continues to be active, with moderate infill of the wetland located to landward. Rollover can potentially cause erosion in the range of 10-160m, with greater erosion expected where the foreshore is lower. The process of wetland infilling, which has not been incorporated into the modelling, has the potential to increase substantially under projected sea level rise.

Appendix A – Peel Harvey Estuary Context

Appendix B – Meteorology and Oceanography

Appendix C – Vegetation Line Change Summary

Appendix D – Murray Delta Imagery Sequences

Appendix E – Profiles Used to Evaluate of Response to SLR

Appendix F – Peel-Harvey Bathymetric Change

Appendix G – Variability of Benthic Coverage

Appendix H – Wave Hindcast Modelling Report

Appendix I – Extreme Surge Flooding Assessment

References

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Appendix A – Peel Harvey Estuary Context

GEOLOGY & SURFACE SEDIMENTS

Geology of the Swan Coastal Plain, which includes the Mandurah Region, is divided by the Darling Scarp between the Yilgarn Block to the east (Precambrian granites) and the Perth Basin to the west, with mostly Cretaceous limestone (Gozzard 2011). The shelf margin is characterised by calcareous material, including limestone reefs from relict shorelines, extensive limestone pavement across the inner shelf and a veneer of mobile sediments transitioning to landward as a series of substantial dunes (Searle & Semeniuk 1985; Collins 1988). Three distinct ages are apparent in the superficial sediments of the Swan Coastal Plain, with a sequence of weathered coastal dune systems, including the Bassendean, Spearwood and Quindalup sands, listed in order of decreasing age and proximity to the coast (McArthur & Bettenay 1974; McArthur & Bartle 1980). Peel-Harvey Estuary is situated between the Spearwood and Bassendean dune systems.

Surface geology adjacent to the east side of Peel Inlet and Harvey estuary is characterised as coastal, lagoonal and alluvial (Figure A-1):

- Coastal landforms occur along the northern margin of Harvey Estuary, to Point Grey. This is parallel to the series of limestone ridges and waterbodies occurring in the Yalgorup region, including Lake Clifton and Leschenault Estuary.
- Lagoonal landforms are present along the southern and eastern margins of Peel Inlet, formed by active reworking by estuary waves and tides.
- Alluvial landforms, formed through floodplain processes are dominant for much of the Shire of Murray, including both active modern channels and older floodplain deposits.

Evaluation of sediments throughout the Peel-Harvey estuarine system has previously been conducted using a network of boreholes (Robertson 1972; Logan *et al*. 1976; Treloar 1978; Brown *et al*. 1980; Semeniuk & Semeniuk 1990). Interpretation indicated that:

- Underlying sediments are low permeability muds and silts.
- An intermediate layer of silts, sands and organic material is expressed on much of the estuary bed. This material is subject to wave scour and redistribution, with limited capacity for further deposition.
- An upper layer of sand, characteristic of marine origin, fringes much of the two basins. This material is swept by wave action, forming relatively broad inter-tidal terraces along the margins of Harvey Estuary.
- Zones of fluvial deposition are located at the bay-head deltas for the Murray-Serpentine system and Harvey River.
- An extensive area of marine sand and shell fragments is present in the vicinity of Mandurah Channel, suggesting a significant supply of marine sediment over geomorphic time scales (thousands of years).

Depositional behaviour inferred from boreholes is largely supported by modern observations, although there are clear differences in the rates of deposition. Aerial photography since 1973 has shown active deposition at the mouth of the Murray River, with lesser accretion in the Harvey birdsfoot delta, particularly since diversion and damming works on the Harvey River. Gradual accumulation within Mandurah Channel and growth of Fairbridge Bank has been measured through hydrographic survey, with more gradual accumulation in Sticks Channel.

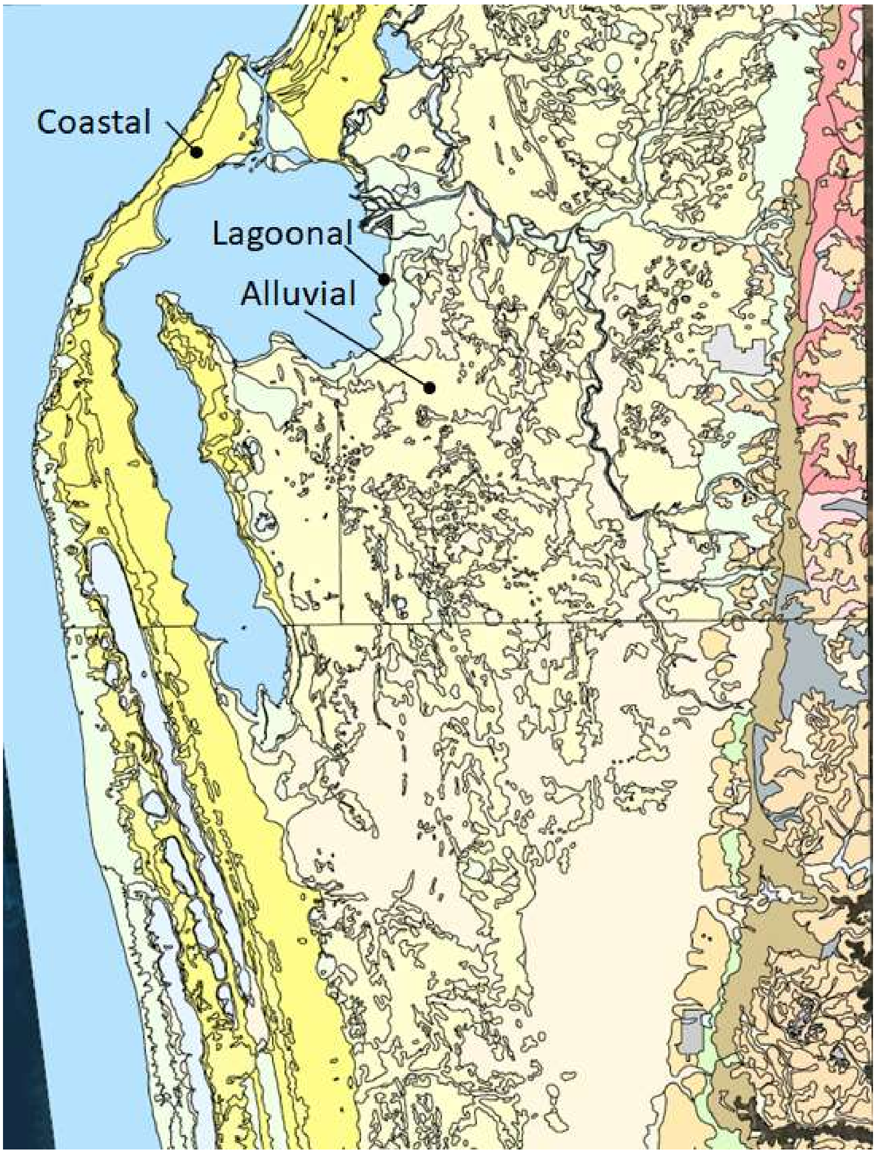


Figure A-1: Extract from 1:50,000 Surface Geology (GSWA)

There has been limited previous description of bed sediment mobility within the estuary, although most of the boating channels requiring minor maintenance dredging (APASA 2010; BMT Oceanica 2015). The entrance to South Yunderup Canals is an exception to this, with significantly increased accretion following a loss of benthic vegetation after Dawesville Channel was opened (Damara WA 2008). Aerial photography indicates that events causing benthic vegetation to be stripped also occurred prior to construction of the Channel, and in recent years well after the Channel (see Appendix E).

ESTUARINE DRIVERS, CONTROLS AND FORESHORE DYNAMICS

Peel-Harvey estuarine foreshore is generally comprised of sedimentary material, subject to forcing from wave and current hydrodynamics of the estuary water body. As with other geomorphic structures, this sediment takes on a form that responds and interacts with the hydrodynamic forcing and is influenced by the composition and supply of the sedimentary material (Wright & Thom 1977). However, estuarine systems, particularly those with shallow basins, have several characteristics influencing their behaviour (Figure A-3):

- Hydrodynamics of the estuary are low energy, allowing contributions from waves, tides and wind-generated currents to variously influence estuary morphology. Variation of these drivers, such as caused by weather events or seasonality, may cause behaviour to switch, particularly when acting in different directions.
- Hydrodynamic influence on the bed may vary over short spatial scales, due to differences in fetch length, or flow structure changes with water depth.
- The relatively small spatial scale gives variation in foreshore aspect, affecting alongshore sediment mobility due to waves or currents.
- Riparian and benthic vegetation may locally modify bed stress or stability.
- Limited tidal range inside the estuary may enhance the significance of flood conditions, whether driven by runoff or coastal flooding, i.e. a small flood event can cause water levels outside the range occurring during ambient tidal conditions.
- The modern (in a geomorphic sense) and depositional nature of estuaries (Dalrymple *et al*. 1992) supports spatial variability in the composition of material within the estuary. Differences in material mobility may influence behaviour.

Consequently, in an estuarine setting, variability of drivers typically interacts with a wider range of controls (geometry, vegetation or material) than in a coastal setting. For this reason, foreshore dynamics may effectively respond over several different temporal and spatial scales.

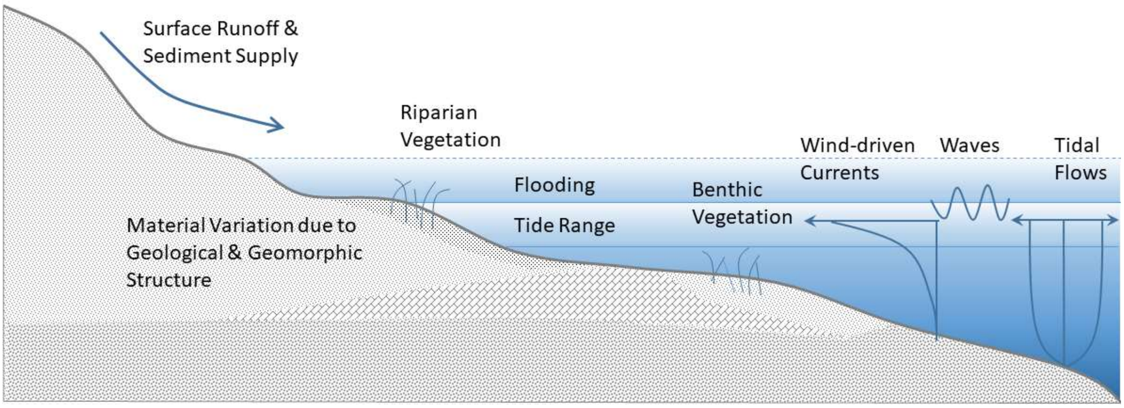


Figure A-2: Schematic of Foreshore Influences

ESTUARINE STRUCTURE & GEOMORPHOLOGY

Peel-Harvey Estuarine System is a large waterbody, draining a catchment of 11,930 km^2. It includes input from the Harvey, Murray and Serpentine River systems, along with local catchment drainage. The estuarine system is a geologically modern feature on the greater Swan coastal floodplain and is likely to have evolved from a floodplain structure towards its current form following Post-glacial inundation over the late Holocene (Robertson 1972; Logan *et al.* 1976; Treloar 1978; Brown *et al*. 1980). Although parts of its structure may be considerably older, the present structure is likely to have developed over the last 2,000 years, when sea levels have remained approximately constant, possibly declining 1-2 m (Wyrwoll *et al*. 1995).

The modern estuary has two distinct but connected estuarine basins, with a relatively narrow channel extending from Peel Inlet to the Indian Ocean. In 1994, Dawesville Channel was opened, providing an artificial connection from Harvey Estuary to the ocean. This excavation has artificially caused foreshore morphodynamics, beyond the general pattern of accretion normally expected in a modern estuarine system (Dyer 1973; Perillo 1995a, 1995b; Ryan *et al.* 2003). Further up-stream the shallow Peel Inlet has an irregularly shaped area of approximately 70km^2, and the slightly deeper Harvey Estuary an elongated structure with an area of approximately 50 km^2 (Figure A-3). The Murray and Serpentine Rivers debouch into the northeast of Peel Inlet, and the Harvey River flows into the southern end of Harvey Estuary, although much of the catchment flow is abstracted through Harvey Diversion Drain. Both basins are substantially sheltered from the direct influence of ocean waves, notably the prevailing swell.

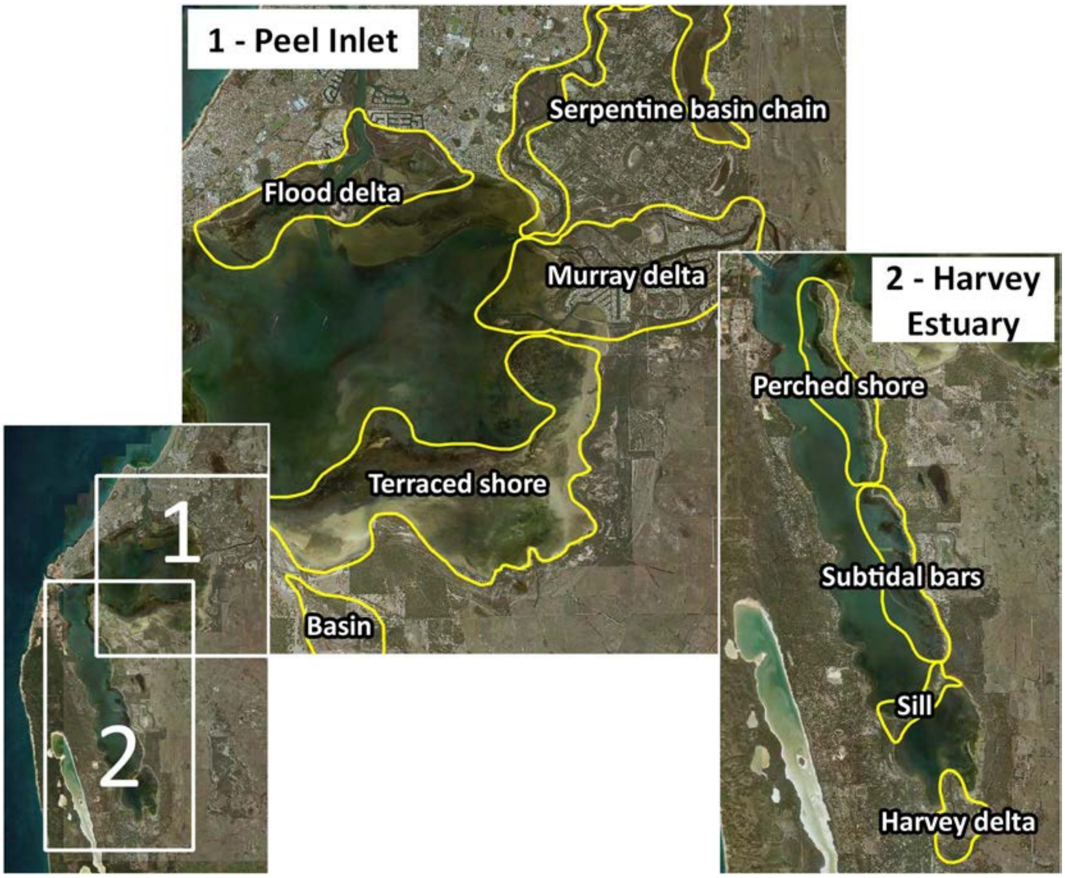


Figure A-3: Major Foreshore Features

Importantly, the low energy dynamics of sheltered estuarine beaches such as the Peel-Harvey system differ from those on the open coast; as has been reported from a wide variety of estuarine environments around the world (Davidson-Arnott & Fisher 1992; Nordstrom & Roman 1992; Makaske & Augustinus 1998; Jackson *et al*. 2002; Eliot *et al*. 2006; Travers *et al*. 2010). Key factors include:

- Absence of prevailing swell.
- Fetch limits for wind-wave generation, and
- Frequent presence of sub-tidal terraces.

These factors should be considered in any appraisal of estuarine shoreline change in the estuaries of Southwestern Australia. Their significance in the Peel-Harvey system is described below.

Peel Inlet

Peel Inlet is a nodular shaped basin, approximately 8-10 km across from any direction, and generally 1-2 m deep throughout. Extensive sub-tidal terraces are present along the southern, eastern and northern shores of the inlet, including large areas of samphire marshes (McComb *et al*. 1995). The Murray and Serpentine rivers debouch along the northeast shore of the inlet, with the Murray forming a complex prograding delta. Much of the land surrounding Peel Inlet is very low relief, reflecting its floodplain origins, and the geologically recent development of the inlet during a period of nearly stable sea levels.

Until opening of the Dawesville Channel, Peel Inlet was connected to the Indian Ocean only through Mandurah Channel, a narrow waterway which substantially restricted the transmission of ocean tides into the estuary basins. Mobility of channel sediments was evident throughout Mandurah Channel, with shoals occurring at the ocean entrance and wetlands with shallow inter-braided channels occurring at the entrance to Peel Inlet. The structure of the estuary, with its large basin and narrow entrance channel is characteristic of a wave-dominated estuary (Ryan *et al*. 2003). This classification is further supported by a ternary classification based on waves, tides and run-off (Harris *et al*. 2002) although it is recognised that the existing structure is substantially influenced by geology, with a limestone ridge forming the western boundary of the estuary (Section 2.2) and sheltering the estuarine basins.

Absence of background swell means that there is limited energy to define a 'prevailing' configuration and the shores are instead forced by wind-waves. Due to fetch limitation, there is an effective wave limit, such that there is little difference between the waves generated by moderately strong or extreme winds. For the purpose of driving sediment transport, this determines that above a characteristic threshold, the persistence of wind is of greater significance than the speed.

For those foreshore areas with subtidal terraces, which are common in the Peel-Harvey system, the terrace provides separation between sediment transport mechanisms along the outer and inner margins of the flats. Transport on the shoreward margin is limited by depth limitation and friction except under high water level conditions. This discrepancy inhibits the 'recovery' phase typically observed on open coast beaches after storm erosion, and is part of the mechanisms sustaining the terrace structure. As a consequence, estuarine beaches may exhibit relict features from severe events for many years, if not decades.

Prior to opening of Dawesville Channel, historically observed dynamics along the Peel Inlet shore mainly occurred in the vicinity of the Murray-Serpentine delta, and Mandurah Channel. In general, the delta area experienced ongoing accretion as fluvial sediments were deposited in the basin. Mandurah Channel experienced a mixture of accretion and erosion, but the pattern is obscured by human intervention, including dredging, construction of shore structures and boat wakes. Subsequent to opening Dawesville Channel, much of Peel Inlet shore showed erosive characteristics including scarping and the loss of fringing saltmarsh areas (Calvert 2002). These were anticipated results of the increased water level ranging and tidal flows caused by the channel excavation. Aerial photographs of the inlet also show zones of benthic vegetation loss, but it is noted that such events also occurred intermittently prior to Dawesville Channel (Damara WA 2008).

It is important to recognise that the historical stability of the estuarine shorelines may understate the active dynamics. The extensive sub-tidal terraces act to dissipate wave energy, and hence the majority of sediment transport is likely to occur along the edge and surface of the sub-tidal terrace, except during extreme water level events (Nordstrom & Roman 1992). Evolution of the sub-tidal terrace therefore may occur without a corresponding shoreline change until an extreme event occurs, and consequently can result in a relatively sudden shoreline movement.

The expected pattern of evolution is determined by the fetch-limited nature of the estuary basin, which may provide variation of the wave climate over relatively short distances. This determines dependence of shore stability upon the distribution of wind directions and enables the formation of extensive cross-shore features such as bars and spits, which are capable of episodic change during storm events (Niederoda & Tanner 1970; Prats 2003). The formation or collapse of ephemeral features can allow localised erosion or deposition over relatively short periods of time, and consequently, allowance for coastal setbacks should consider any reliance upon such ephemeral features. Erosion potential is enhanced where there is variability of alongshore transport, such as caused by a change in shore aspect, a difference in riparian vegetation or soils. Drainage systems including streams and river channels may also provide erosion potential due to seasonal variability of flow.

Harvey Estuary

Harvey Estuary is an elongated cigar-shaped basin with crenulated shores, roughly 20 km long, and 2-3 km wide, and typically about 3 m deep towards the centre of the estuary. A shallow sill defines a small basin at the southern end, which has provided sufficient shelter for an unusual birdsfoot delta to form where the Harvey River enters the estuary (Figure A-4). The sides of the estuary are characteristic of coastal barrier dune systems from previous eras, and provide high relief compared to the floodplain east of Peel Inlet. Low relief land is restricted to a narrow fringe along the shore, and salients where the crenulated shores project further into the estuary.

Figure A-4: Birdsfoot delta in Harvey Estuary

Processes Influencing Peel-Harvey Morphology

The relative influence of different driving processes varies substantially across the estuary, including local-scale influences of landform and bedform structures on hydrodynamics. Features indicative of difference types of forcing and land forming processes include:

- A flood delta present at the southern end of Mandurah Channel, indicates high tidal flows through the channel, with flow speeds reducing as they enter Peel Inlet. This depositional area includes the series of low-lying wetlands and intertidal flats of the Creery wetlands.
- The lower Serpentine River is a very gently graded river system comprised of a series of basins, with interconnected flood channels. These basins provide hydraulic detention, which reduces the capacity for riverine floods to convey sediment to the estuary. Basins to the east of the present mouth potentially suggest a previous flow path, which may act as a breakout pathway under extreme events. Historic modification of the Serpentine catchment included excavation of trenches between basins to drain wetlands and increase the agricultural area.
- A 'bay head delta' occurs at the mouth of the Murray River. This landform is characteristic of high sediment supply from upstream and indicates potential for relatively high flows.
- The east and southeast shores of Peel Inlet have extremely wide subtidal terraces, particularly south of Yunderup, Austin Bay and Robert Bay. These are typical of low energy estuarine shores.

- Foreshore terraces with transverse bars occur on the east side of Harvey estuary, indicating low wave energy conditions, frequently occurring from a southerly direction.
- A 'birdsfoot delta' occurs at the mouth of Harvey River. Such landforms are characteristic of sediment supply from upstream and very low energy conditions within the estuary basin.

These features largely suggest the estuarine basins provide separation between runoff processes active in the river channels and the tidal flows active in Mandurah Channel, Grey Channel between the two basins, and Dawesville Channel. Transition between flow dominated behaviour and wave dominated behaviour occurs near channel entrances and is likely to vary spatially over time.

In addition to broad-scale structural features associated with the rivers and channels, there are smaller-scale convex foreshore features at locations around both estuarine basins (e.g. Sandy Point). Some of these features are potentially underpinned by natural rock formations, but for most, active foreshores include mobile sedimentary features, with retention enhanced by either vegetation or constructed edge treatments. Modelling of Harvey Estuary hydrodynamics has suggested that local-scale convexities may induce gyres in estuary circulation, reinforcing the structure through sediment transport (Hearn & Lukatelich 1990).

RIPARIAN VEGETATION

Sheltered conditions within an estuarine setting provide increased opportunity for the sustained presence of riparian vegetation, ranging from sedges and saltbush through to salt tolerant trees, such as melaleuca. Vegetation typically provides a stabilizing role on estuary foreshores, whether through binding of sediment to the root mass, enhancement of dune-building processes, or wave sheltering from fallen logs, and therefore the presence of riparian vegetation is influential in foreshore dynamics.

The capacity for different species to establish and subsequently thrive is a function of ecological and geomorphic conditions. Influencing factors include surface water and groundwater chemistry; inundation frequency; soil type; nutrient supply; traffic; undercutting pressure; or sediment smothering (Trudgeon 1988). Different species, sometimes at various stages of maturity, are affected by different factors. Consequently, the effects of inundation and sediment dynamics often result in characteristic cross-shore zonation of vegetation species (Figure A-5). Changing conditions may cause pressure on this zonation to migrate, subject to resilience of the vegetation, which may result in phases of dieback and recolonization.

Mechanisms affecting riparian vegetation include:

- Plant life cycles, including developing maturity and response to seasonal pressures;
- Substantial variation of environmental conditions, such flooding or drought cycles, or anthropogenic factors such as nutrient loads or major engineering works;

- Foreshore dynamics, including seasonal or longer-term movements of foreshore sediments, which may build or erode spits, beaches or estuarine berms (these are sometimes described as foreshore 'dunes');
- Micro-climate variation, such as pond-channel structure within a wetland, or nutrient load associated with stormwater management and debris. There is often feedback between vegetation species development and microclimate, as more established vegetation is typically capable of stabilizing larger features such as dunes or banks.

These mechanisms are often inter-related, limiting identification of cause and effect and therefore obscuring appropriate management responses in situations where it is considered appropriate.

Within Peel-Harvey Estuarine System, characteristic forms of riparian vegetation include marshlands, wetlands and estuarine woodlands, which may occur singly, or in a sequence related to species eco-geomorphological capacity (Figure A-5):

- Estuarine marshlands, including samphire and *halosarcia* communities are extensive near the southern end of Mandurah Channel (Creery Wetland), Robert Bay, Murray-Serpentine and Harvey river mouths, (McComb *et al*. 1995). These are very flat, intertidal areas.
- Fringing estuarine wetlands, typically populated by sedge species such as *juncus krausii* occur adjacent to marshlands, but also intermittently along segments of Peel Inlet and Harvey Estuary shores (Calvert 2002).
- Estuarine woodlands, with *melaleuca* common (Calvert 2002).

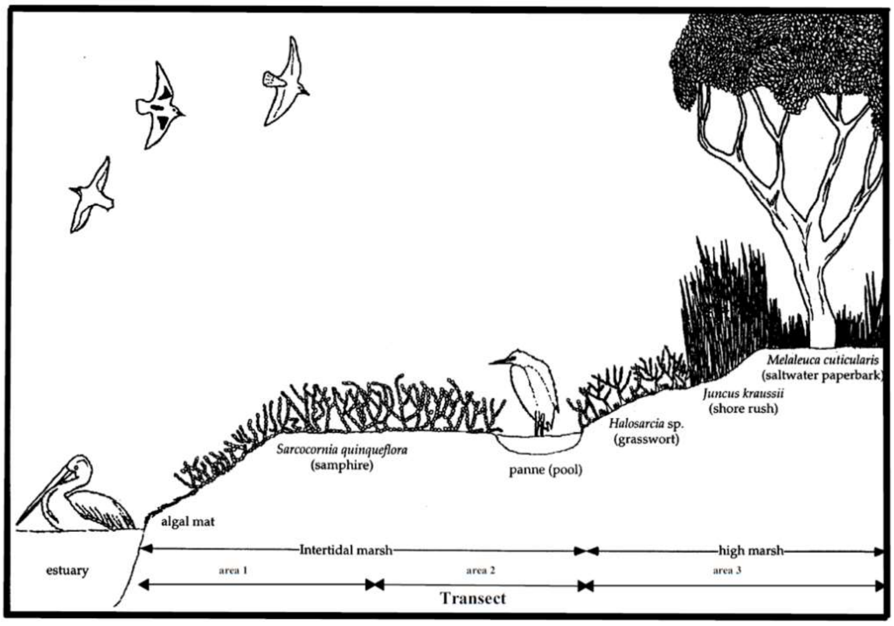


Figure A-5: Characteristic Riparian Zonation for Peel-Harvey Wetlands

(From McComb *et al*. 1995)

Development of the estuary has resulted in a complex geomorphic arrangement, including basin-channel structures and ridge-swale sequences that have developed under varying conditions, resulting in a mixture of active and relict riparian basins (Semeniuk & Semeniuk 1990). This arrangement enables substantial ecological change to occur in the foreshore zone, with switching between 'dry' and 'inundated' conditions able to occur with relatively subtle changes in hydrology or sea level. Riparian vegetation has been observed to respond to such changing conditions with migration of riparian zones (McComb *et al*. 1995). Species death may occur if adverse conditions are sustained for a critical period – this may vary from days through years, depending on robustness.

Opening of Dawesville Channel caused a substantial change to both inundation frequencies and seasonal salinity variation. Of particular importance, there was no longer a coincidence between winter high water levels and brackish conditions (Young 1986), with a result of saline stress and dieback for less tolerant species (Gibson 2001; Calvert 2002; Carter *et al*. 2006).

ESTUARY MODIFICATIONS

Peel-Harvey Estuarine System has been substantially modified since European settlement in Western Australia. Initial modifications largely involved land clearing and drainage to support agricultural use of the catchment. This was followed by substantial modification of the ocean entrance and Mandurah Channel, to improve the reliability of small craft navigation and improve estuary-ocean water exchange (DMH 1985).

Foreshore infrastructure has been progressively installed as residential and recreational pressure adjacent to the estuary has increased. This has included walling to stabilize foreshore parks and road reserves, and boat ramps to support small craft use of the estuary. Construction of canal estates commenced in the 1970s at Yunderup, with subsequent proliferation of facilities along Mandurah Channel from the 1980s. Additional canal estates were developed following opening of Dawesville Channel in 1994, and Mandurah Ocean Marina was opened in 2001.

Between the 1900s and 1970s, the hydrology of Harvey and Serpentine Rivers was modified, for reasons of land drainage, flood management and water supply. Major works included construction of a southward-draining network from Kwinana and de-snagging along the Serpentine, damming of the Harvey River and construction of Harvey Diversion Drain. In addition, agricultural drains were established for land along the eastern side of Harvey Estuary.

Changes to the hydrology and land-use altered estuarine water chemistry, resulting in progressive eutrophication of the waterway (Hodgkin *et al*. 1980). Holistic assessment of Peel-Harvey catchment was undertaken, ultimately leading to a set of management actions (DCE 1984b, 1985; Gorham *et al*. 1988). The action with the most profound consequences for Peel-Harvey foreshore dynamics was construction of Dawesville Channel, opened in 1994, which substantially increased tidal exchange into the estuary to enhance water quality.

Dawesville Channel

As of 1985, more than half the phosphorus discharged into the Peel-Harvey estuary system came through Harvey River into the south of Harvey Estuary, where there was very little exchange with ocean waters due to the isolation of these waters from Mandurah Channel. High levels of phosphorus input with limited oceanic exchange resulted in the reported *Nodularia* blooms (DCE 1984a). Initially observed in the Harvey Estuary by DEC in 1978, *Nodularia* was subsequently carried into Peel Inlet after which blooms were reported in both water bodies (DCE 1984a).

Options to manage the increasingly eutrophic state of the Estuary were evaluated, with Peel Inlet and Harvey Estuary Management Strategy (CALM 1985) developed to enhance Estuary water quality through short and long term measures. The strategy included an engineering intervention to excavate a channel between Harvey Estuary and the Indian Ocean. The proposed Dawesville Channel was intended to enhance tidal flushing and create a more marine environment, inhibiting growth of *Nodularia*. This measure was coupled with continued harvesting of nuisance weed and modified agricultural practices, to reduce nutrient input to the Estuary.

Predictions associated with the Dawesville Channel (Paul & Hutton 1985, Tong 1985, Gorham *et al*. 1988, Ryan 1993) include:

- The estuarine coastline between the Dawesville Channel and Mandurah Channel would not be eroded.
- Siltation in Mandurah Channel would not increase detrimentally.
- Training walls and entrance cross-section could be designed in tidal equilibrium, such that the channel would flush out sediment entering the channel.
- Tidal range inside the Estuary would increase from 15-20% of oceanic levels to 45-50% following construction of the Channel. This approximately corresponds to an increase of average daily tidal range from 0.1m to 0.3m.
- The altered tidal regime was predicted to create a greater number of areas conducive to saltwater mosquito breeding (saline wetlands/marshes).
- Estuary flushing time was predicted to decrease from 90 to 30 days in Peel Inlet and from 150 to 50 days in Harvey Estuary.
- Water exchange per tidal cycle during typical summer conditions was predicted to increase from 5.5×10^6 m^3 to 6.3×10^6 m^3 through Mandurah Channel, and from 3.3 $\times 10^6$ m^3 to 6.4 $\times 10^6$ m^3 through Grey Channel between the two estuary basins. Water exchange through Dawesville Channel was predicted to be 16.5 $\times 10^6$ m^3.
- Clearer water was expected with enhanced mixing due to increased tidal movement and greater flushing of organic matter.
- An ecological transition in species was predicted, from those that could withstand the variation from fresh to hypersaline water, to predominantly marine species. This was considered likely to impact commercial fisheries, reducing resident species numbers but creating a higher diversity in marine species.
- Increased quality of the overall estuary environment was expected to lead to increased recreational use of the Estuary by the public.

In 2003, a report was released demonstrating the progress and compliance with Environmental Conditions (EPA 2003). This report listed predicted changes and corresponding observations following Dawesville Channel construction. Predictions include:

Factor	**Predicted change following Dawesville Channel Construction**	**Observed change following Dawesville Channel Construction**
Tidal	Daily tidal range increase from 17% to 45-50% of ocean tide in the Peel, and from 15% to 60-70% of ocean tide in the Harvey. Decreased duration of tidal inundation/exposure. Increased frequency of tidal inundation/exposure.	Increase to 48% of ocean tide in the Peel, and to 55% of ocean tide in the Harvey. As predicted As predicted
Flooding	Transition to being driven predominantly by river flow to an influence from daily or storm surge tides affecting the eastern estuary edge. Transition from average water level decrease of 0.4m in 10 days to average water level decrease of 0.4m in 3 days.	As predicted As predicted
Hydraulic Characteristics	Decrease in average residence time from 30 days to 10 days in the Peel, and from 50 days to 17 days in the Harvey. Increase in water exchange per tidal cycle from $5.5x10^6 m^3$ to $6.3x10^6 m^3$ in the Mandurah Channel, and from $3.5 x10^6 m^3$ to $6.4 x10^6 m^3$ in the Grey Channel. Water exchange through the Dawesville Channel expected to be $16.5 x10^6 m^3$. Period of stratified conditions to reduce by approx. 2 months, with stratification to be more intense.	As predicted As predicted As predicted
Sediment Characteristics	Non-apatite phosphorus stores in estuarine sediment expected to gradually deplete, with subsequent reduced periods of anoxia and less release of phosphorus from sediments to the water column	Assessment incomplete in 2003
Water Quality	Transition from salinity extremes towards marine salinity prevailing for most of the year, with associated strong stratification. Hypersalinity to end. Reduced frequency and duration of deoxygenation periods, reduced turbidity (reduction in *Nodularia blooms)* and more rapid return to low nutrient levels, associated with estuarine flushing.	As predicted, except for some occurrence of hypersaline conditions (less extreme than previously). As predicted, except for summer turbidity in the Harvey due to winds resuspending sediment.

Modified from EPA (2003)

Impacts of Dawesville Channel that are important for foreshore dynamics include:

- A step change in the character of water level variability within the Estuary. This extended the foreshore's hydraulic zone, over which surface waves provide bed stress and may mobilise sediment.
- Substantial modification of tidal currents. and
- Alteration of ecological conditions, affecting riparian and benthic vegetation.

Distinguishing the impact of Dawesville Channel upon the estuarine system has been partly obscured by climate variability, including decadal-scale rainfall decline, and anthropogenic development of the estuary (Elliott *et al*. 2016).

Other Anthropogenic Factors

In addition to Dawesville Channel, land use change has occurred along the Shire of Murray, affecting the foreshore. The most substantial change adjacent to the shore is development of Yunderup Canals and the Islands, at the mouth of the Murray River, which includes a dredged navigation channel (Figure A-6.

Figure A-6: Land use change near Yunderup demonstrating land development and waterway modification since 1974.

Semi-rural development at Birchmont has been established with a foreshore reserve of approximately 65m width (Figure A-7).

Figure A-7: Land use change near Birchmont demonstrating semi-rural development and pasture change

Other anthropogenic activities include construction of agricultural drains and small boat ramps at Birchmont and Herron Point. Some foreshore response to the drains is apparent, with development of sediment fans at the drain mouths in Austin Bay and Robert Bay. However, these features have remained relatively stable since the 1970s.

GEOMORPHIC UNITS

The foreshore has been divided into geomorphic units, approximately corresponding to length scales of 1-2km, characterising sections of the foreshore that behave in related ways or are affected by similar stresses (Figure A-8). Divisions were based on apparent points of substantial change, including foreshore morphology and separation between embayments. This corresponds to the 'Segment' scale used for classification of City of Mandurah and Swan River foreshores.

Embayment structure and morphology was used to split the foreshore into segments, mapped at a scale of 1:30,000. Segments were defined by locating sediment splits:

- Where a substantial change to landform processes is apparent, specifically separation between deltaic and foreshore landforms.
- Where a significant barrier to alongshore sediment transport was identified.
- If the shore changed aspect by more than 45°.
- Where a perceptible change in active stresses is apparent (e.g. at tidal channels).

At this scale, the finite volume of mobile sediment determines that foreshore change is developed through a coherent combination of erosion and accretion (i.e. change is related but may not be in the same direction). For example, embayment structure may support changes to shore alignment or variation of total sediment volume without corresponding effect on adjacent segments, although these are typically not wholly disconnected, as they experience similar environmental forcing, and are connected by sediment bypassing between segments.

The segments provide a basis for spatial 'smoothing' of erosion estimates, which have been determined at individual profiles along the length of the Murray foreshore. Morphology was evaluated using the Department of Water LIDAR, collected in 2008/09. (Figure A-9). Transects were extracted from the LIDAR from approximately -1m AHD to +3mAHD landward, resulting in profiles of varying length.

Inconsistent return from the LIDAR intermittently results in a 'rough' profile. This is a mixture of data issues and complex low level topography, as illustrated by the ridges and basins present across the Islands in the elevation band of 0.5-1.5mAHD (Figure A-10). Features in this band are presently subject to low rates of overtopping, which will increase with projected sea level rise, providing a significant mechanism for coastal change.

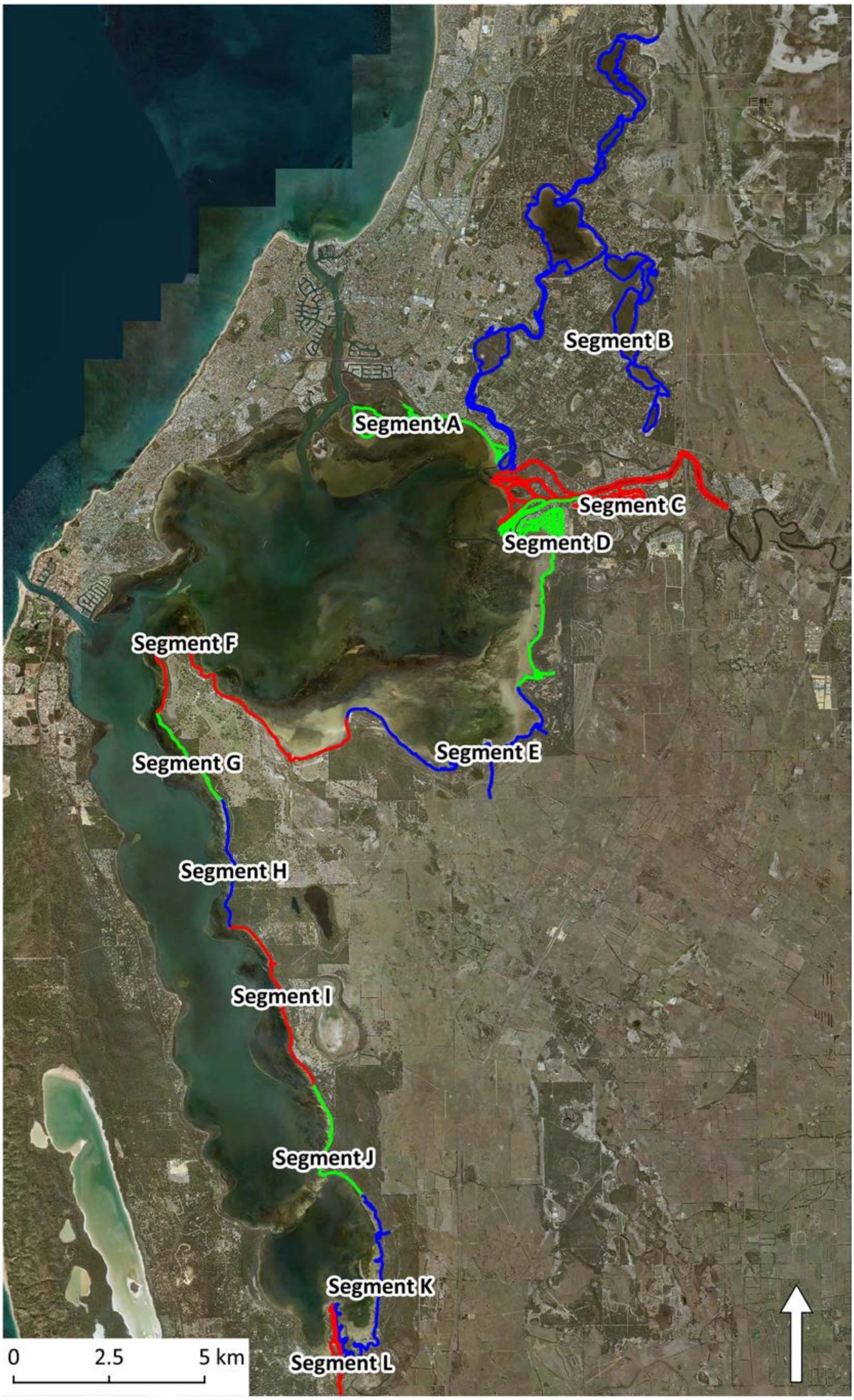


Figure A-8: Shire of Murray Foreshore Segments

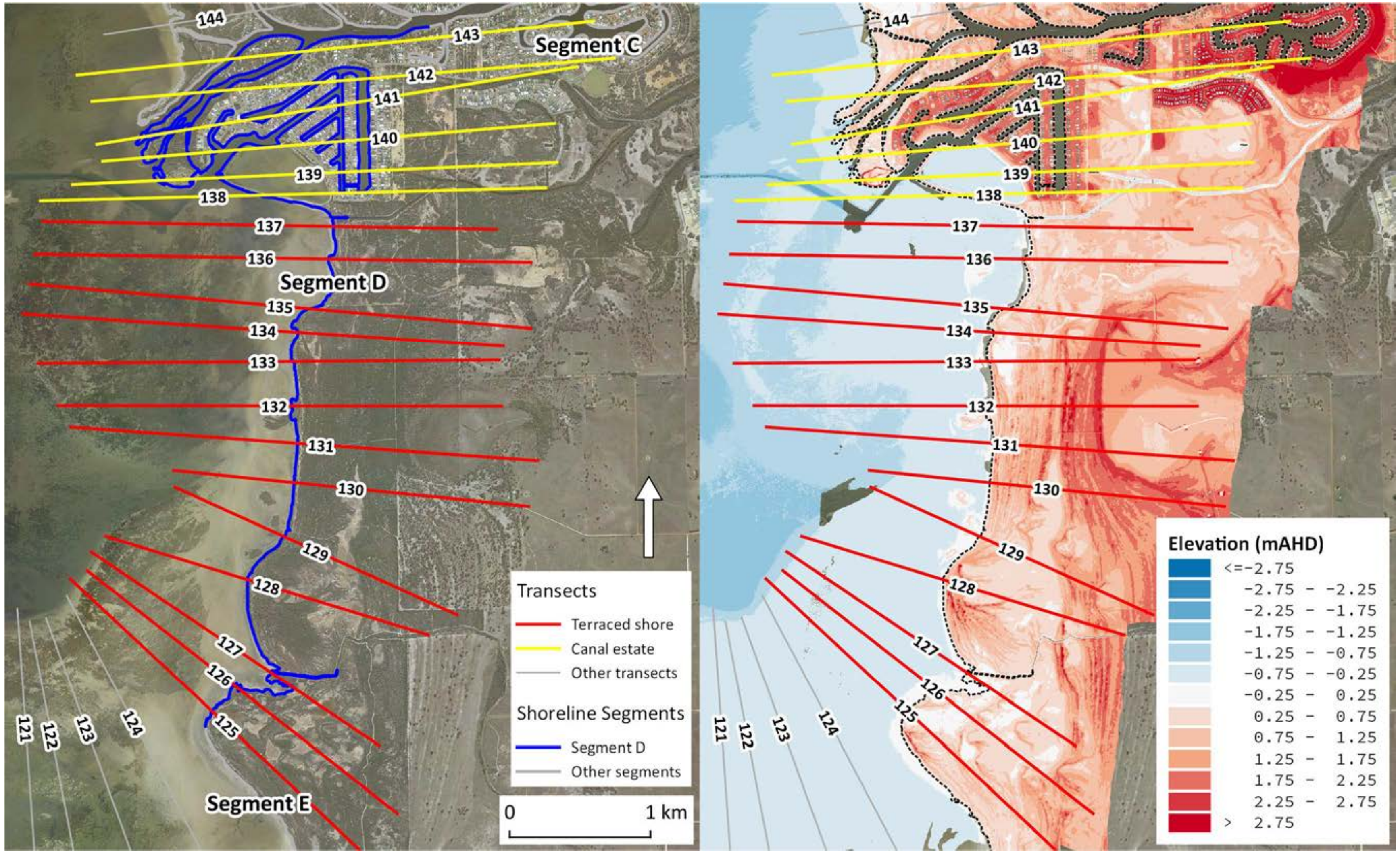


Figure A-9: Location of Segment D and Profiles 125 – 143 with shoreline variability

Figure A-10: Complexity of Low-Level Topography

Appendix B – Meteorology and Oceanography

Meteorologic and oceanographic conditions determine the hydrodynamics (water levels, waves and currents) of Peel-Harvey Estuarine system, and therefore are drivers of foreshore dynamics. Mandurah region has been historically well instrumented, using a mix of permanent and temporary installations. Information used for this assessment includes wind records measured by the Bureau of Meteorology and water levels measured by the Department of Transport (Figure B-1). Other available information includes river flow information measured by the Department of Water and Environmental Regulation.

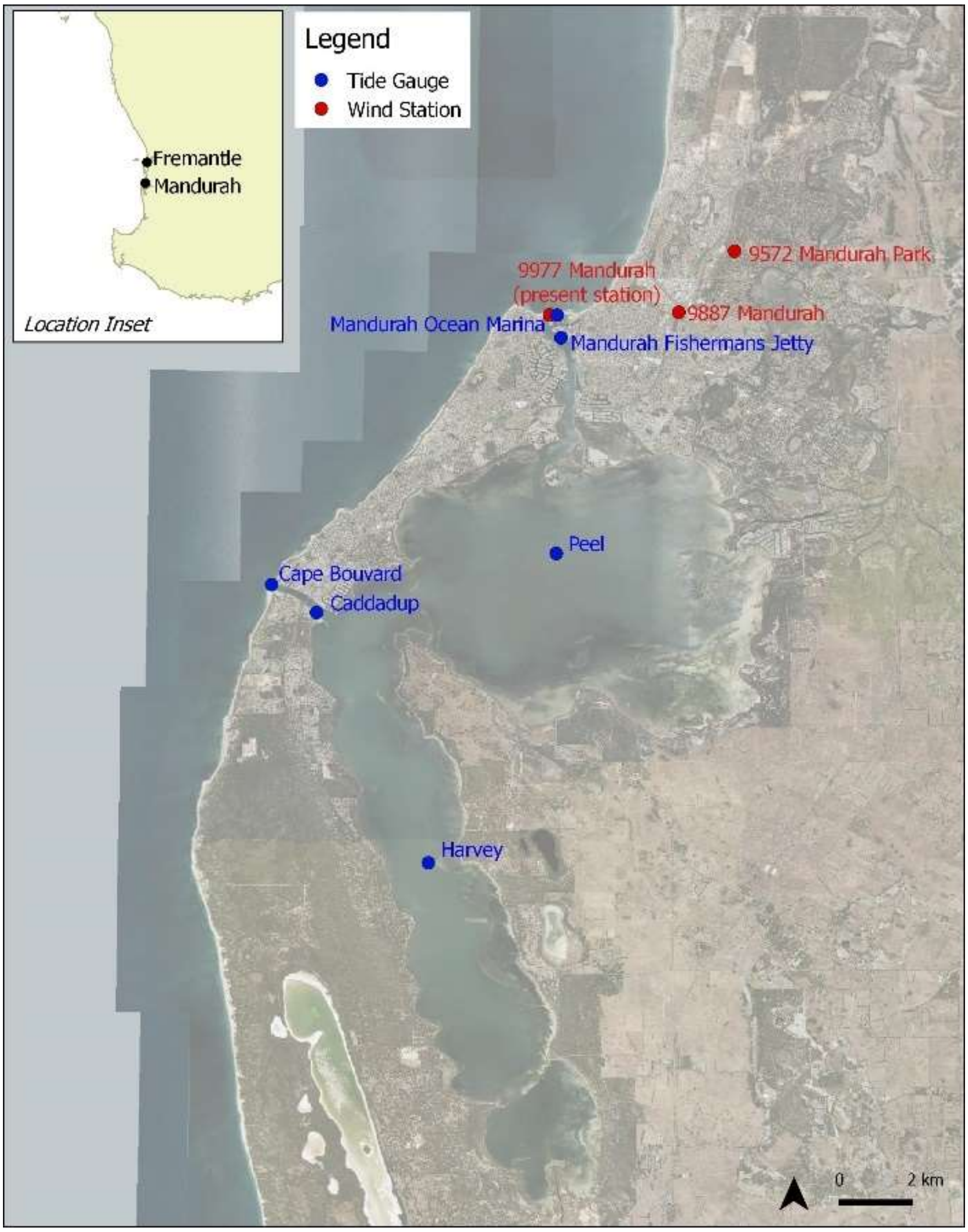


Figure B-1: Meteorological and Oceanographic Measurement Locations

Winds

Wind is significant in the Peel-Harvey Estuarine System due to its role in generation of waves and currents, with both wind speed and direction having influence. Wind observations in the Peel-Harvey region are historically available from three Bureau of Meteorology weather stations, with one Automatic Weather Station presently operating (Table B-1).

Table B-1: Summary of Mandurah BOM Weather Stations

Station	Name	Location	Operation	Elevation	Frequency of Observations
WS 9572	Mandurah Park	32.5031°S 115.7664°E	Jan-1965 to Dec-1985	15m	9am & 3pm only
WS 9887	Mandurah	32.5211°S 115.7500°E	Nov-1987 to Oct-2001	21m	3-hourly
WS 9977	Mandurah	32.5219°S 115.7119°E	Oct-2001 to present	3m	3-hourly

Comparison of wind records from the three stations at Mandurah showed:

- geographic and topographic effects of measurements from different locations.
- differences in frequency of observations.
- differences in velocity and direction scales

These have contributed to differences evident in a wind speed time series (Figure B-2), and speed and direction frequency plots (Figure B-3) for the three stations.

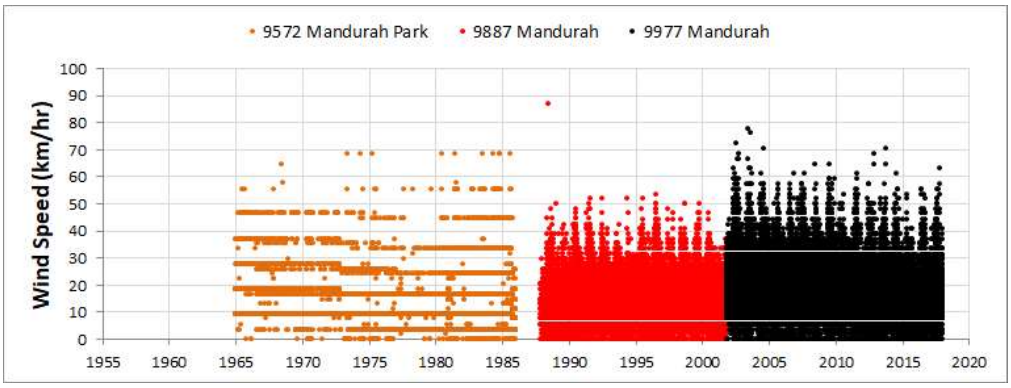


Figure B-2: Mandurah Wind Speed Time Series (All Stations)

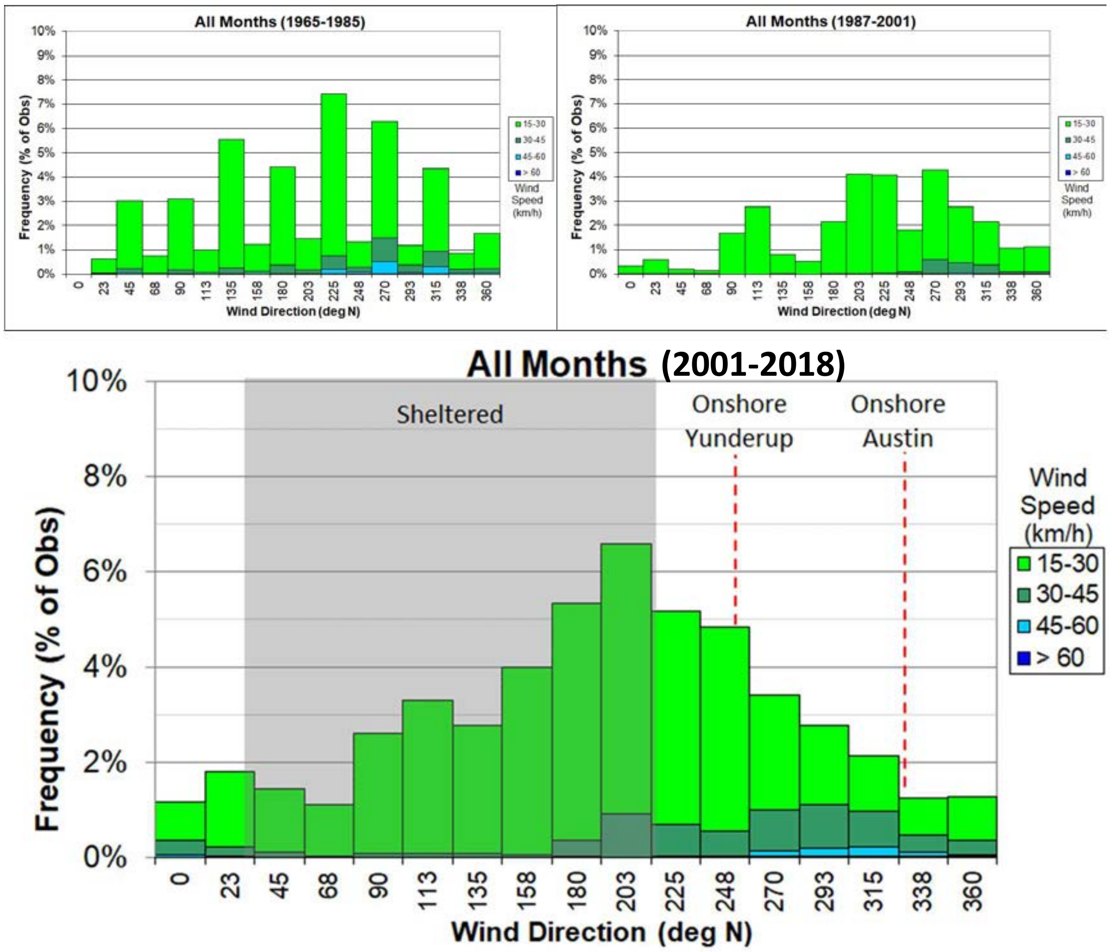


Figure B-3: Mandurah Speed and Direction Frequency Plots (All Stations)

Observations from the present station (WS 9977) located at Mandurah Ocean Marina, immediately adjacent to the shore provides a consistent set of coastal observations since 2001. This station is considered to provide a reasonable representation of winds occurring in the study area, with some minor discrepancies possible due to differences in overland sheltering and changes in exposure of winds (i.e. across the Peel Inlet and Harvey Estuary).

Monthly wind speed and direction frequency plots from the present station illustrate the seasonal shift in wind patterns (Figure B-4). Southerly sea breezes are prevalent from October through to April, with easterlies mainly occurring in February and March. Between May and September, westerlies are dominant, with strong winds generally from the west to northwest. From May to July, northeast winds have a significant secondary occurrence.

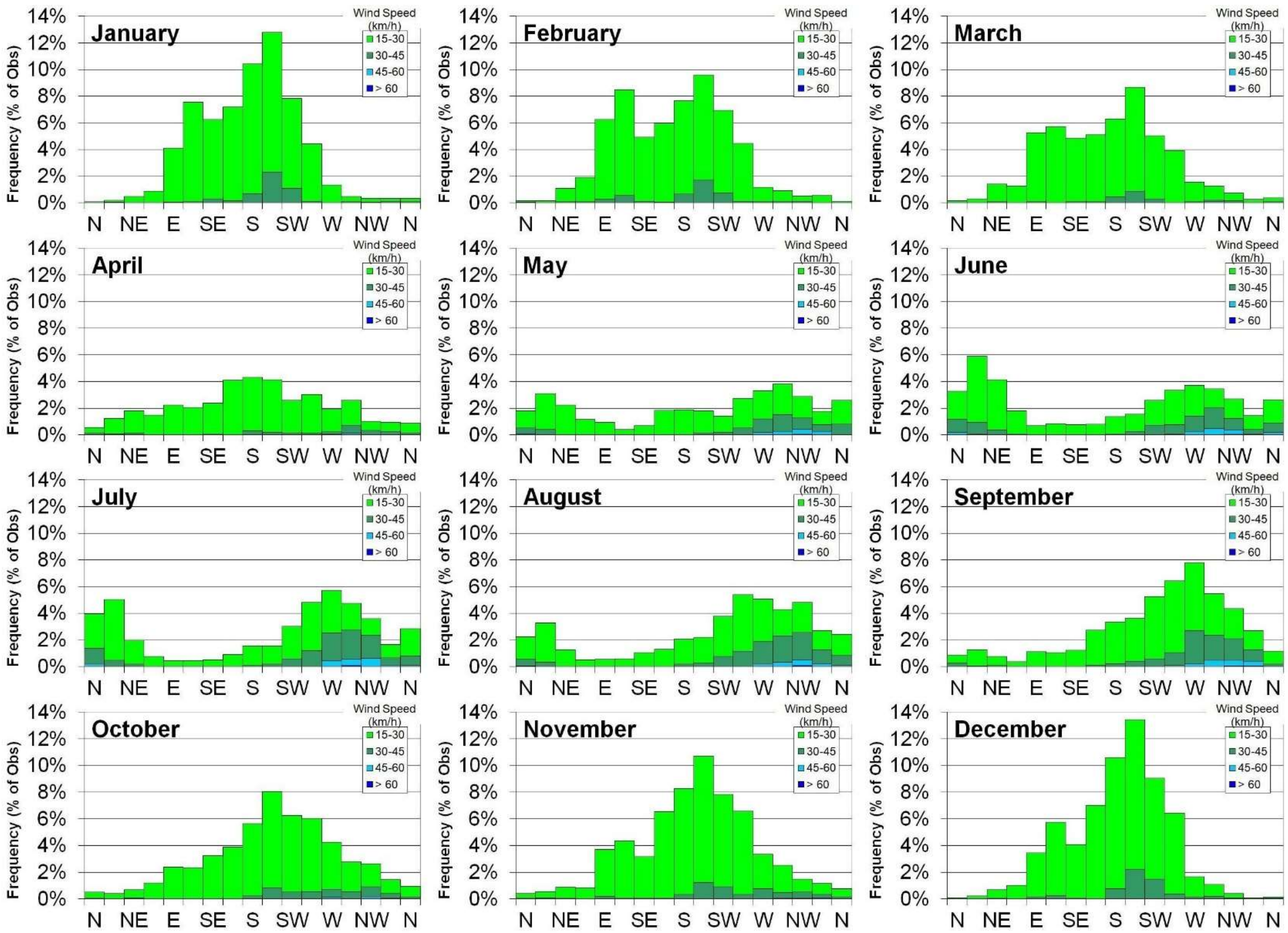


Figure B-4: Monthly Speed and Directional Frequency (Station 9977 – 2001 to 2018)

A speed and directional frequency plot for wind speeds above 45km/hr shows that strong winds are generally limited to from the northwest quadrant (Figure B-5). Low incidence of strong winds from the southwest quadrant may partly be due to sheltering adjacent to the weather station. The Shire of Murray foreshores experience onshore winds from the west through northwest directions, although modal winds arrive at an angle to the shore, suggesting a tendency for alongshore transport.

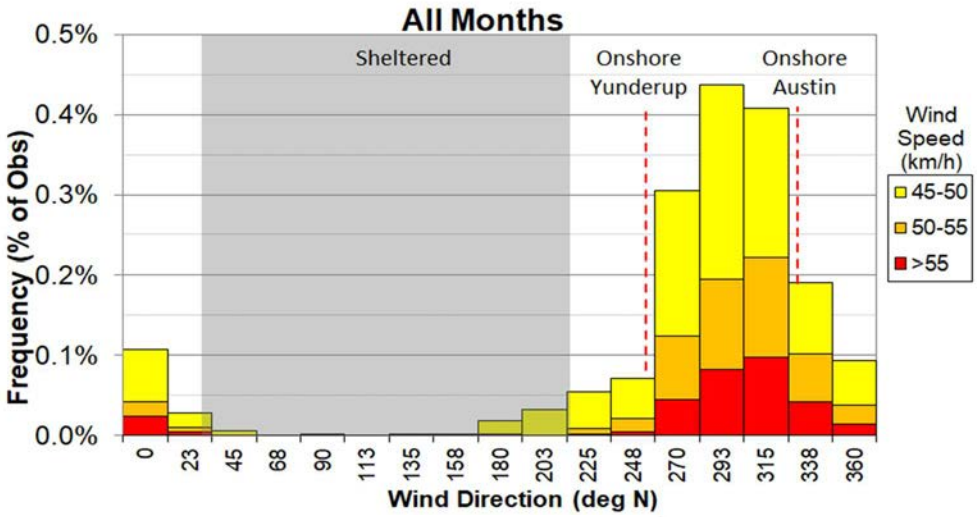


Figure B-5: Speed and Directional Frequency of Strong Winds (BOM Station 9977– 2001 to 2018)

Prevailing / frequent (Figure B-3) and dominant / strong (Figure B-5) onshore winds have the opposite directional distribution on Yunderup and Birchmont foreshores. This suggests capacity for alongshore reversal. For Austin and Robert Bay, modal prevailing and dominant winds are both west of onshore, however there is a weaker association of wind direction to waves because of the very wide shallow terrace.

Variation of wind speed with direction has been examined through evaluation of the Mandurah 2001-2018 wind record, to generate a directional extreme wind distribution (Figure B-6). Analysis steps involved:

1. Separating the wind record into 45° bands, overlapping by 22.5°.
2. Estimating the wind speed relative to the middle of the directional band using the function $U' = U \cos(\phi-\phi')$ where U is measured wind from direction ϕ and U' is the component of wind in direction ϕ'.
3. Identify maxima that occur with a minimum of 2 days separation between wind events.
4. Using a rank-based plotting probability, undertake extreme value curve fitting within each directional band, using the method of Petrauskas & Aagaard (1971).

This analysis demonstrates the significant difference in extreme wind speeds from the east-southeast compared with the west-northwest.

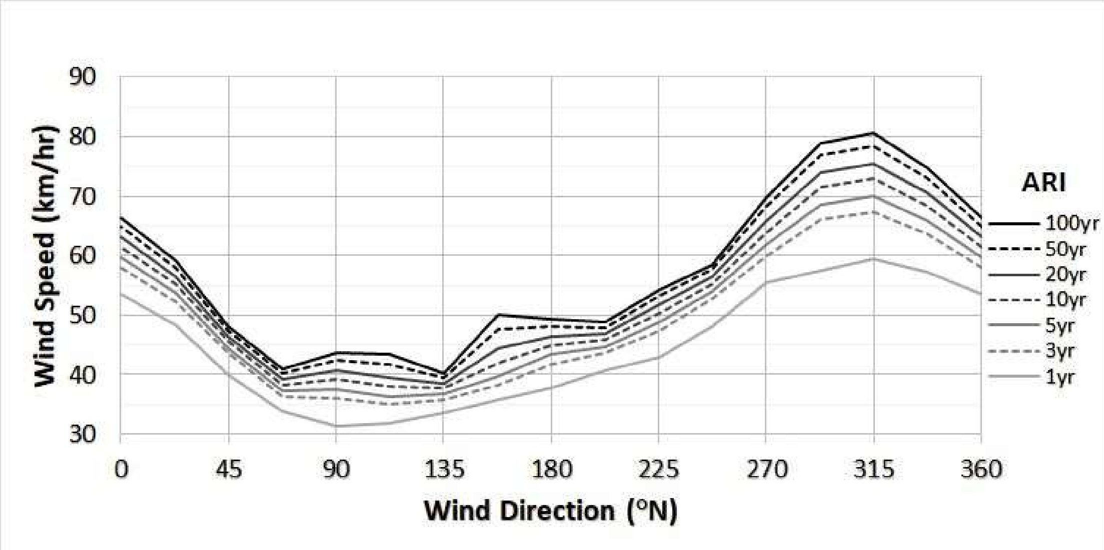


Figure B-6: Directional Extreme Wind Analysis

Annual cumulative summations of the 9am wind speed cardinal components (E-W and N-S) have been used to examine whether there are any apparent patterns of change or standout years. By summing wind vector measured at the same time for each day over a year, a 'wind drift' is calculated. This provides a directional tendency of the wind over the time considered: i.e. a positive net annual easterly wind drift value, for a specific year, indicates that for that year there was a tendency towards stronger easterly winds than during average conditions (Figure B-7). Periods where different weather stations have been used are marked by the dashed vertical lines. The observations are generally partitioned by these breaks, with mild differences between each of the sites.

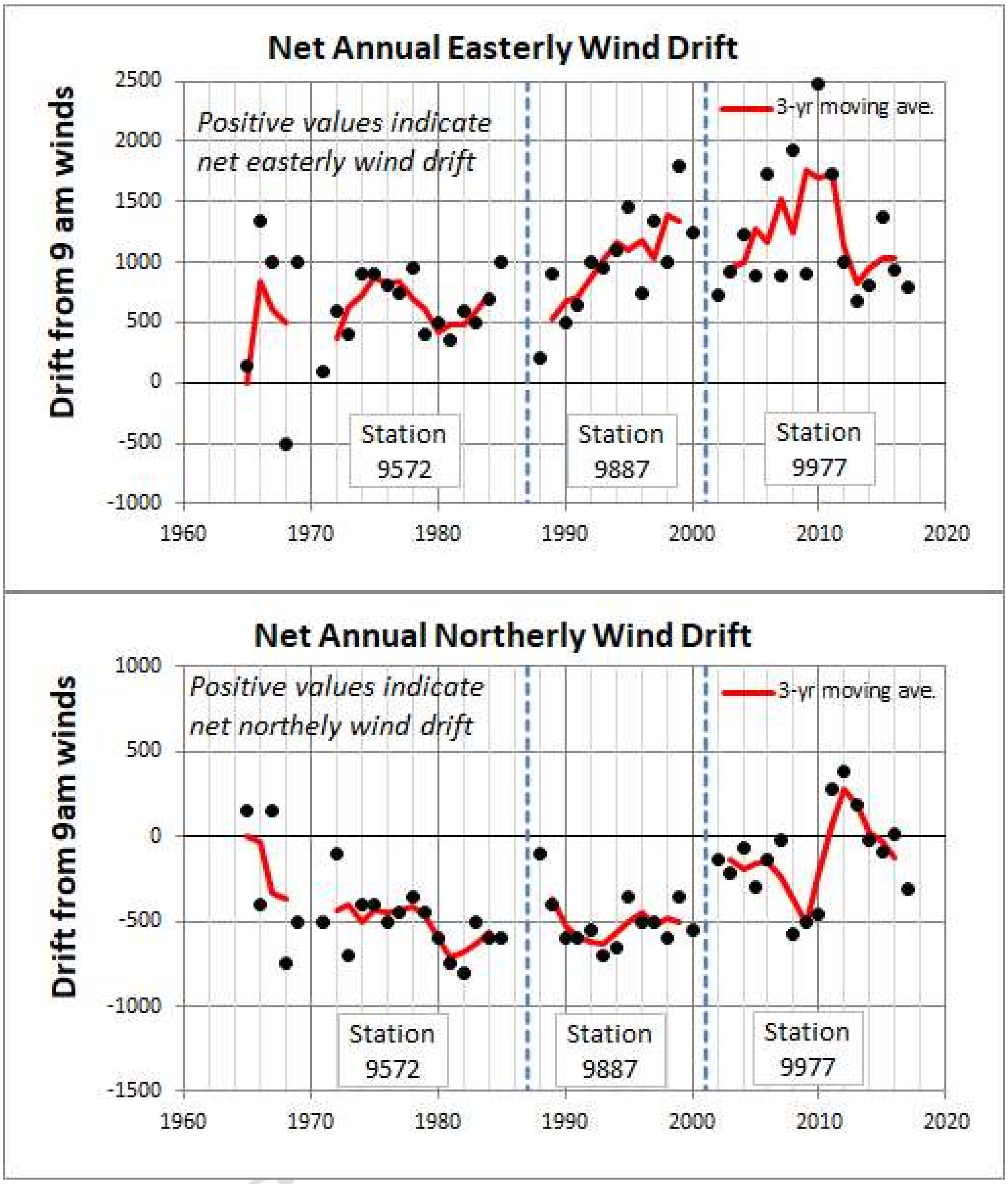


Figure B-7: Mandurah Annual Net 9am Wind Drift

These plots show considerable inter-annual variability, with peaks in the 3-year moving average for the E-W and N-S components in 2009-2011 and 2011 respectively. Standout years in the present record (WS 9977) for each cardinal direction (N,S,E,W) are shown in Figure B-8. A "Strong Year" is defined by the magnitude of the *Wind Drift* relative to the average; hence, a "Strong East Year" is characterized by the easterly cumulative wind run (Red) being consistently above the easterly average (top black line). Conversely, a "Strong West Year" would have a cumulative wind run consistently below the average.

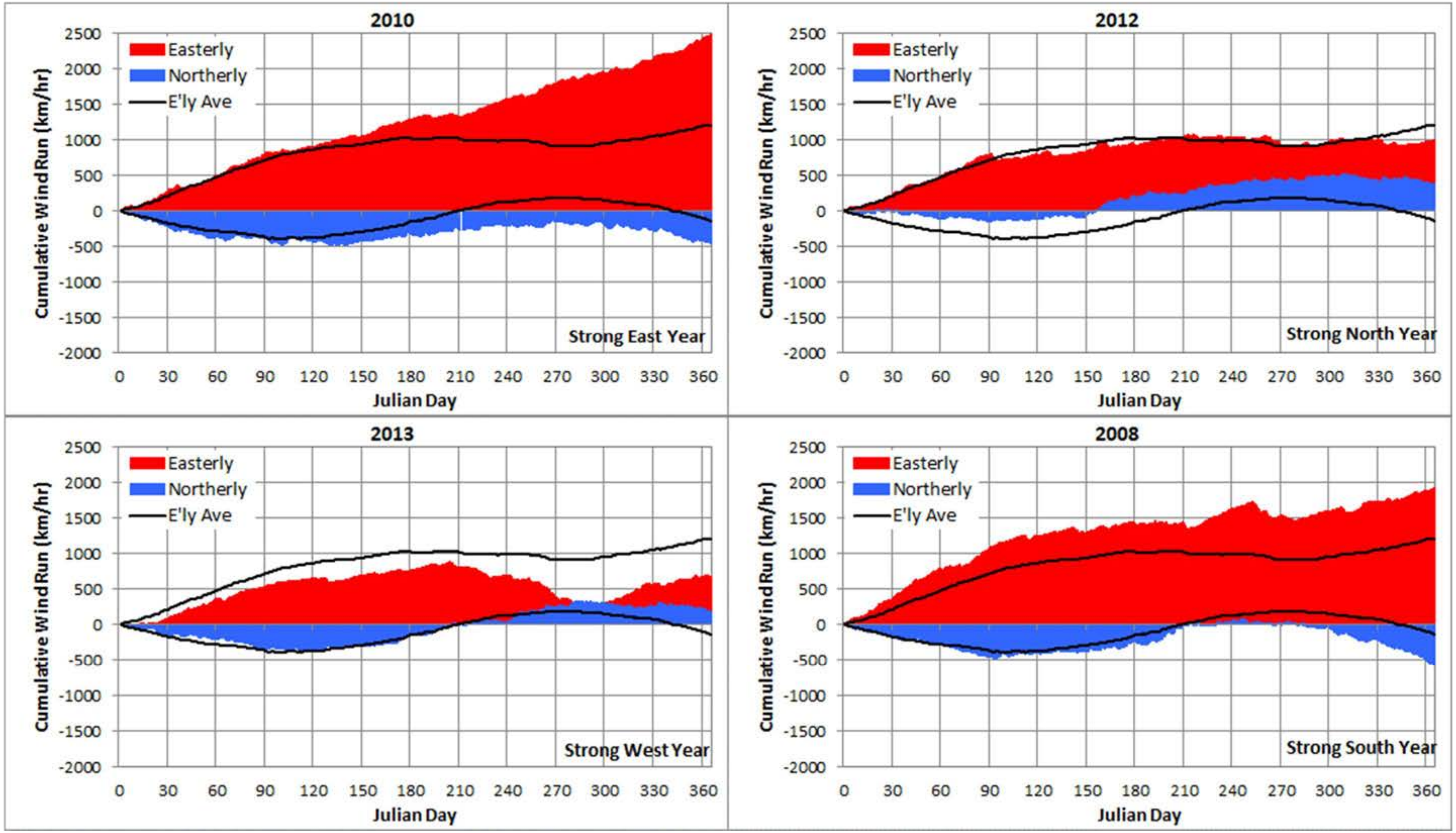


Figure B-8: Strong and Weak Annual 9am Wind Cumulative Summations

Water Levels

Water level observations from five tidal stations throughout the Mandurah region have previously been shown to have high coherence, with a reduction in tidal range from the coast to the estuary basins (Damara WA 2009). There was a significant change in character of water levels in the Peel-Harvey basins due to opening of Dawesville Channel in 1994 (Eliot & McCormack 2018). Key features affecting the water level in the study area include:

- A micro-tidal, mainly diurnal climate with solstitial tidal peaks in June and December. Tidal planes have been derived for three tide gauges in Peel-Harvey Estuary (Table B-2).

Table B-2: Tidal Planes for Peel-Harvey Tide Gauges

Derived from Harmonic Analysis of 1995-2016 records

		Mandurah	Peel	Harvey
Highest Astronomical Tide	HAT	1.14mCD	1.02mCD	1.07mCD
Mean Higher High Water	MHHW	0.78mCD	0.70mCD	0.73mCD
Mean Lower High Water	MLHW	0.71mCD	0.68mCD	0.70mCD
Mean Sea Level	MSL	0.55mCD	0.55mCD	0.55mCD
Australian Height Datum	AHD	0.54mCD	0.54mCD	0.54mCD
Mean Higher Low Water	MHLW	0.39mCD	0.42mCD	0.40mCD
Mean Lower Low Water	MLLW	0.32mCD	0.39mCD	0.37mCD
Lowest Astronomical Tide	LAT	-0.04mCD	0.08mCD	0.03mCD

- Significant meteorological surges, associated with low barometric pressure and westerly storm events, with depressed water levels during sustained easterly winds or high barometric pressure (Hamon 1966). This influences the joint occurrence of winds and water levels.
- Minor, occasional surges associated with the passage of continental shelf waves (i.e. not directly associated with local meteorological conditions), including remote generation from tropical and sub-tropical zones by tropical cyclones (Eliot & Pattiaratchi 2010).
- Seasonal mean sea level range of approximately 0.3m, peaking in June, apparently related to pressure belt latitudinal movement and variation of Leeuwin Current structure and intensity (Pattiaratchi & Buchan 1991).
- Inter-annual mean sea level variability, correlated with the El Niño-Southern Oscillation (ENSO) phenomenon, also correlated with variability of Leeuwin Current structure and intensity (Feng *et al.* 2004). High mean sea levels occur during the la Niña phase.
- An 18.6-year cycle of daily tide range, with the annual tidal range varying by approximately 20% (~0.2m). The lunar nodal cycle last peaked around 2006, with the next peak due in 2025 (Eliot 2010).
- Local wind set-up associated with strong winds across basins. The influence of wind set up was evident during the passage of TC Alby in April 1978 when strong north-

northwest winds across the Harvey Estuary resulted in an increase in water levels from north to south of almost 0.6m (Damara WA 2009).

Hourly water levels observations from the Peel tide gauge, along with the 30 day running mean, are shown in Figure B-9. The largest event observed occurred on 16 May 2003, when maximum water levels of 1.55m CD to 1.61m CD were recorded during the passage of a significant winter storm. There were several high water level events (exceeding 1.20m CD) during a peak in mean sea level associated with a strong la Niña event over 2011-2013.

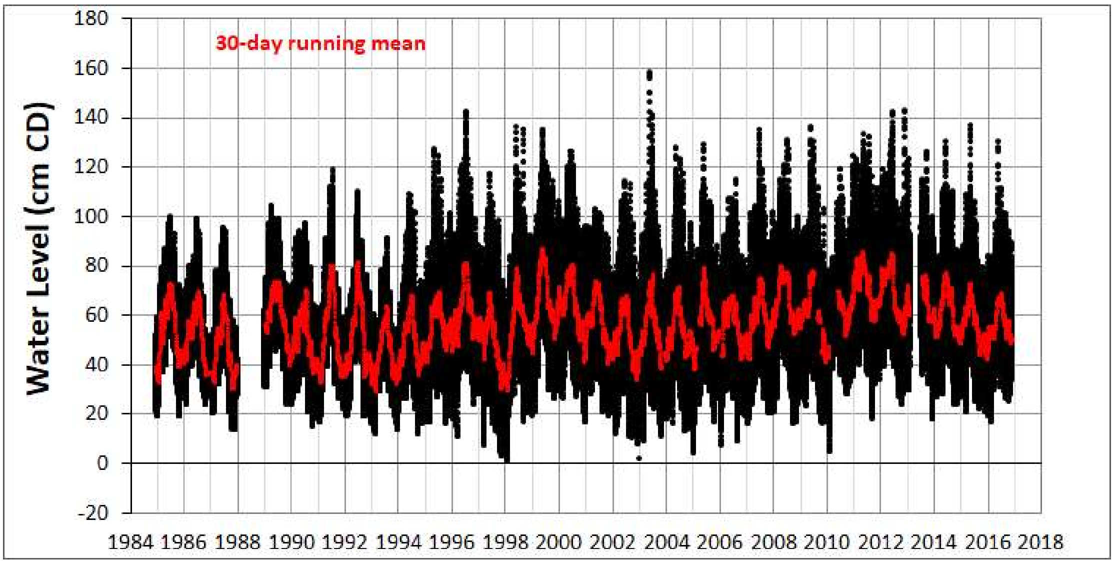


Figure B-9: Peel Inlet Water Levels (1984-2016)

Although storm events may occur all year, extreme water levels are generally restricted to between May-July, when seasonal peaks for mean sea level, surge and tide are in phase (Table B-3).

Table B-3: Summary of Seasonal Changes in Water Level Processes

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tide	Peak		Low			Peak			Low		Peak	
Surge		Low*				Peak					Low*	
MSL	Low					Peak					Low	

**Occasional tropical cyclone shelf waves during summer months (December-March)*

The frequency and magnitude of high water level events are particularly influenced by sources of inter-annual variability, in combination with variation between individual storms (Eliot 2012). Identified sources of variability include:

- Up to 0.3m of variability in the mean sea level signal between high and low years, largely corresponding to ENSO phenomenon; and

- Up to 0.15m of variability in the *oceanic* tidal signal between high and low years attributed to the 18.6-year lunar nodical cycle. A smaller influence occurs within the estuary. The latest peak in the cycle occurred in 2006.

The likelihood of high water level events increases during periods of elevated mean sea levels (la Niña) and highs in the lunar nodical tidal cycle and particularly when the two are in phase.

The nature of the water level change due to opening of Dawesville Channel is illustrated by the distinct change observed during 1994 (Figure B-10). The water level signature clearly became more ‘spiky’ after opening of the channel, with greater variation over short time scales.

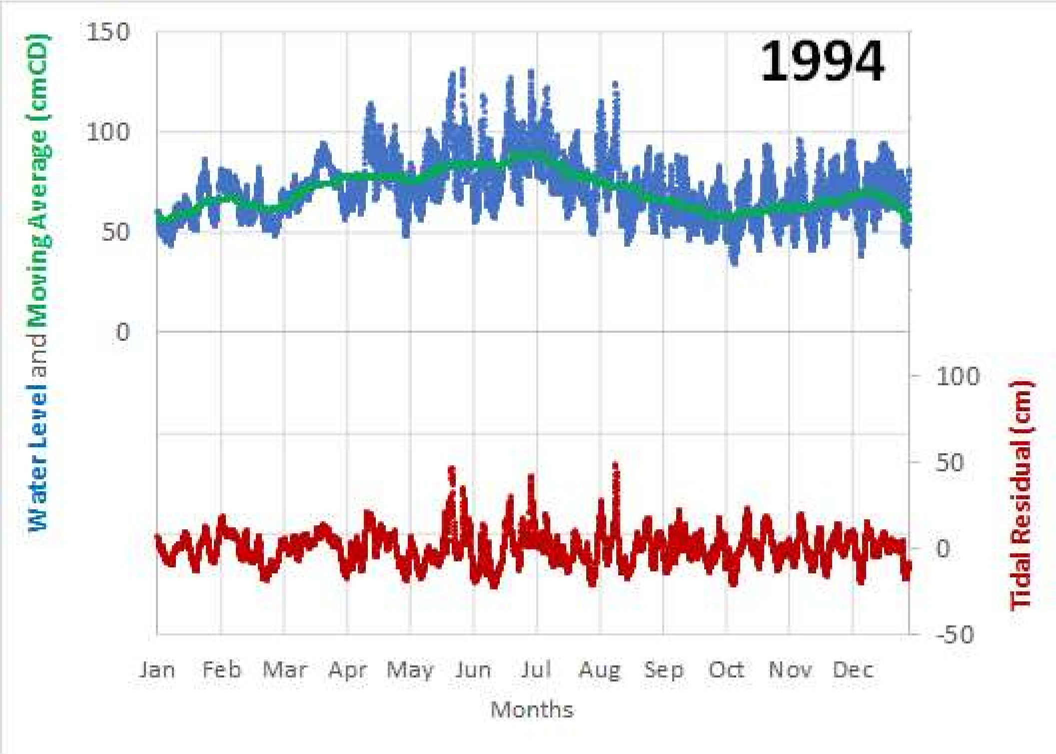


Figure B-10: Observed Water Level and Tidal Residual in Peel Inlet 1994

Harmonic analysis of the water level record has been used to further explore the changes, with separation into mean sea level, tidal and tidal residual components (Figure B-11, Figure B-12). Two large changes are demonstrated by the tidal signal, including (i) a datum shift; and (ii) large-scale increase in the tidal signal.

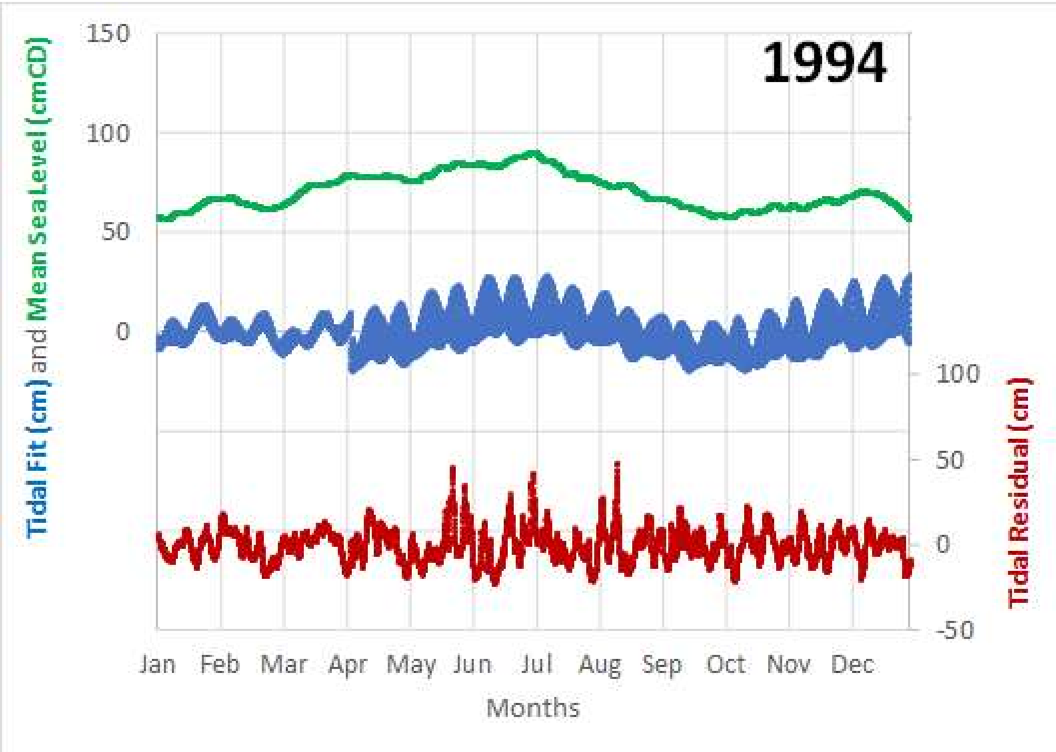


Figure B-11: Change to Water Level Processes after Dawesville Channel Opening

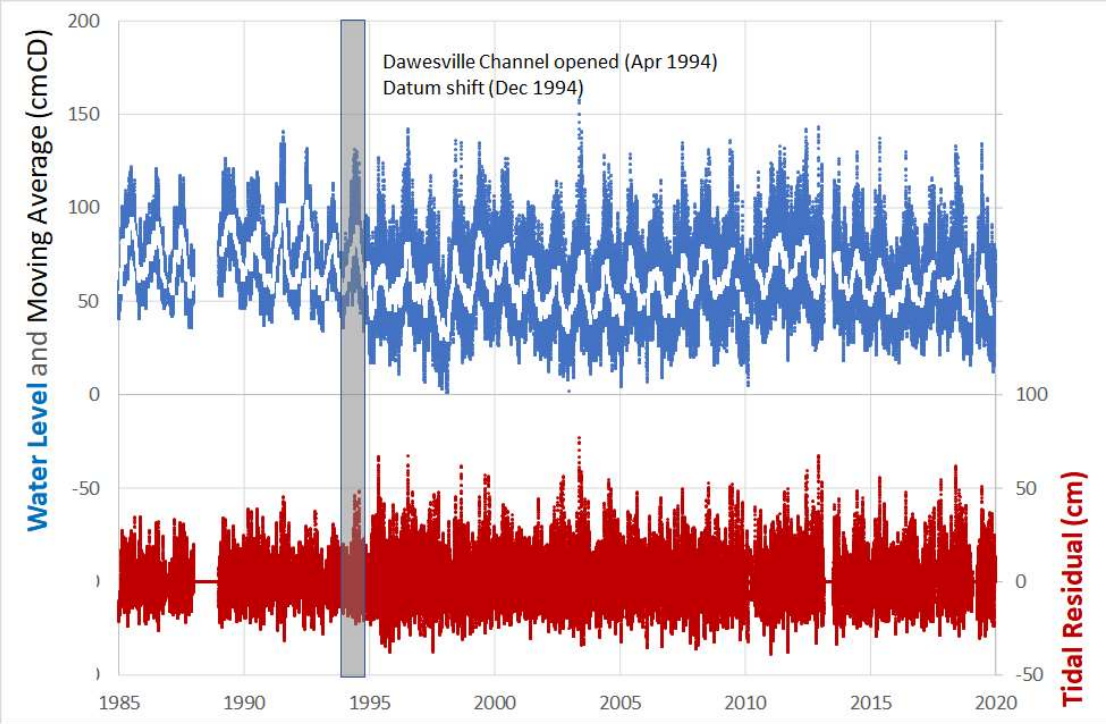


Figure B-12: Water Level Record and Tidal Residuals from Peel Tide Gauge

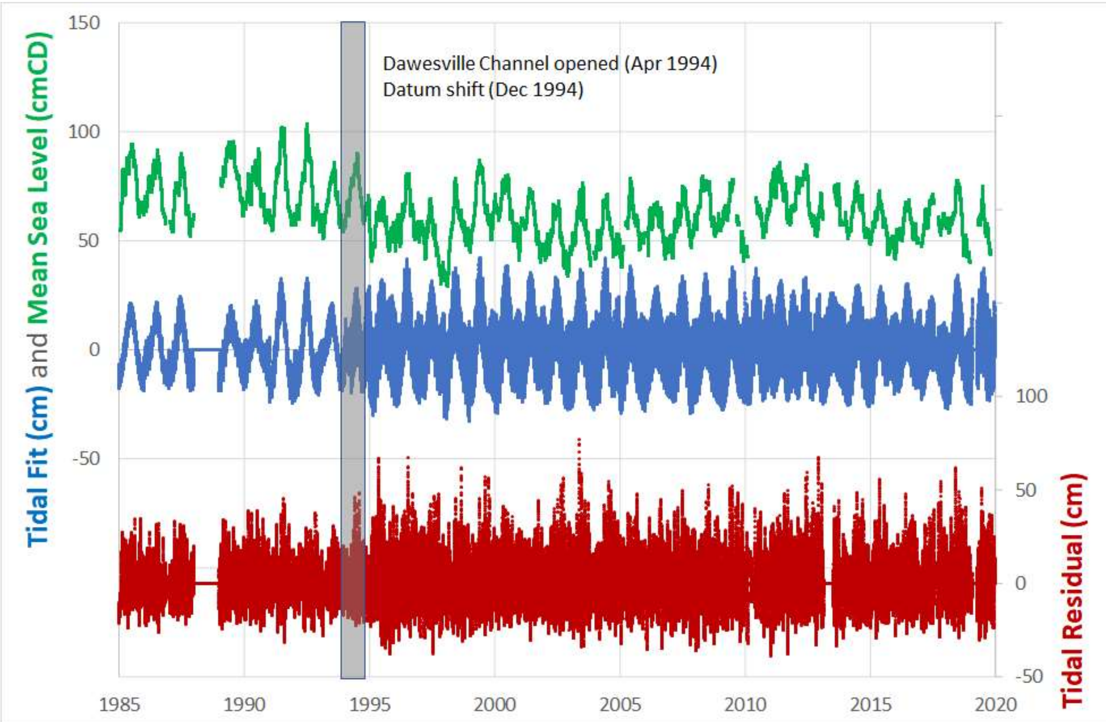


Figure B-13: Water Level Decomposition from Peel Tide Gauge

Winds and Water Levels

Relative timing of strong winds and high water levels influences spatial variation of nearshore processes in Peel-Harvey Estuarine System, including foreshore erosion-recovery patterns and wave overtopping. Specifically, foreshores with a westerly aspect are likely to experience more severe conditions due to potential for coincident high wave and water level conditions associated with westerly storms. These are the major cause of extreme wind speeds (Steedman & Associates 1982; Lemm *et al*. 1999) and cause positive storm surge through onshore wind and wave set-up and lower central pressure.

The joint probability of high wave and water levels for all directions has been assessed using a cross-plot of strong winds at and water levels from Mandurah for the available overlapping data period of 2001-2019 (Figure B-14). Maximum water level envelopes have been derived for wind speeds above 30km/hr and 50km/hr, representing reasonable upper limits.

This assessment indicates exposure of Peel-Harvey foreshores to waves is:

- Greatest along south-west to north facing foreshores, with all wind speeds above 50km/hr observed from 180°N clockwise through to 22.5°N (Figure 6 1). The most extreme wind and water level combination occurred during a severe winter storm on 16 May 2003, when a maximum water level of 1.55m AHD coinciding with a 52km/hr wind from 259°N. For these foreshores, beaches are likely to be dominated by waves.
- Lowest along east to southeast facing foreshores. For these foreshores, beaches will display a mixture of responses to wave and tide processes, with beach berm formation during high water levels potentially playing an important role in beach recovery.

This simple assessment helps explain the relationship between foreshore aspect and wave exposure within the Peel-Harvey Estuarine System. It also informs selection of flood risk scenarios and required foreshore walling design criteria.

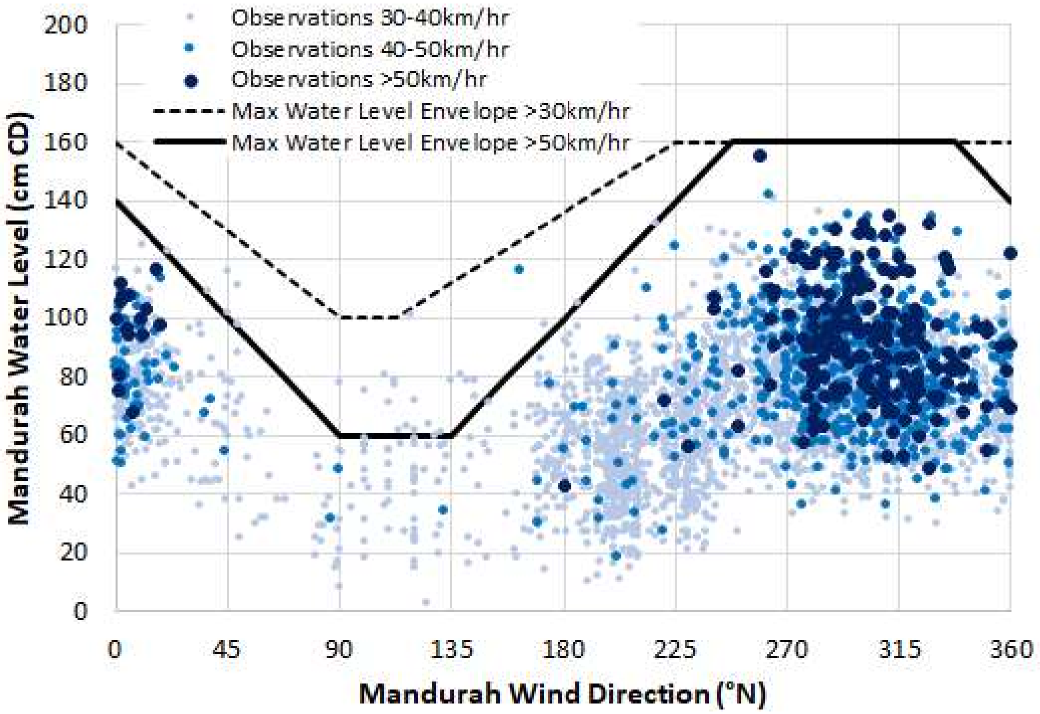


Figure B-14: Joint Occurrence of Winds and Water Levels

Spectral Admittance

Detailed evaluation of the changes in water level associated with opening of Dawesville Channel has demonstrated that both tides and surges inside the Peel-Harvey Estuarine System were increased (Eliot & McCormack 2019). The change to residuals was demonstrated to be spectrally related (Figure B-15), with negligible increase to long-period water level fluctuations (e.g. 30 days) and substantial enhancement of shorter period fluctuations (e.g. 6-12 hours).

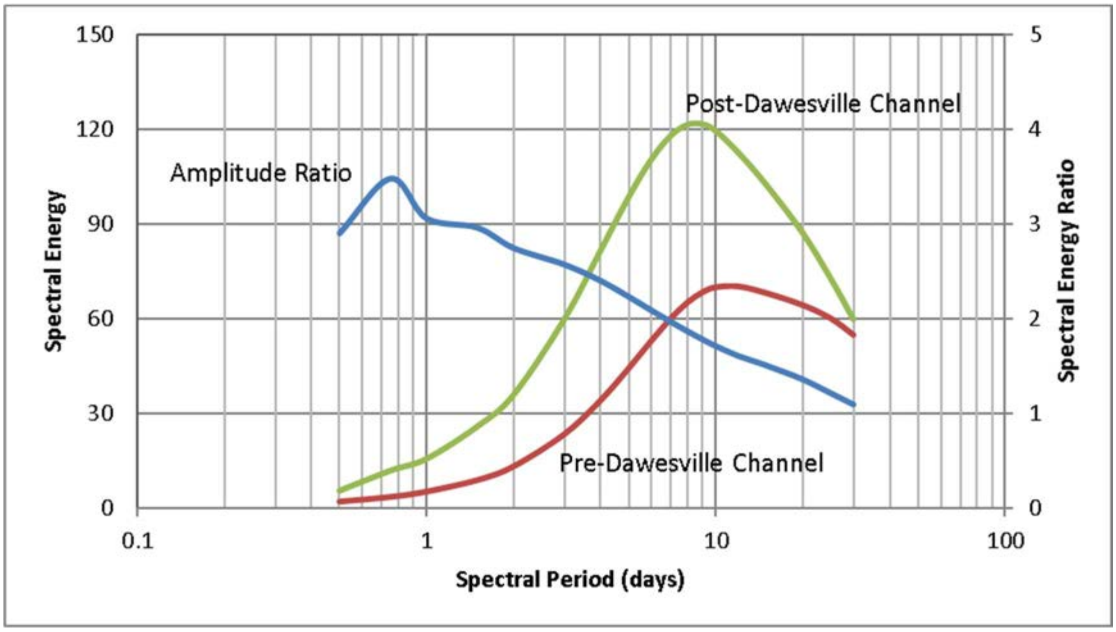


Figure B-15: Spectral Change of Tidal Residuals in Peel Inlet after Dawesville Channel

The pattern of spectral enhancement was also illustrated by the changes in tides (Figure B-16). However, this process is less well defined, as harmonic analysis may effectively transfer energy between modes of a similar frequency – such that the change needs to be considered as a combined function of multiple near-period constituents.

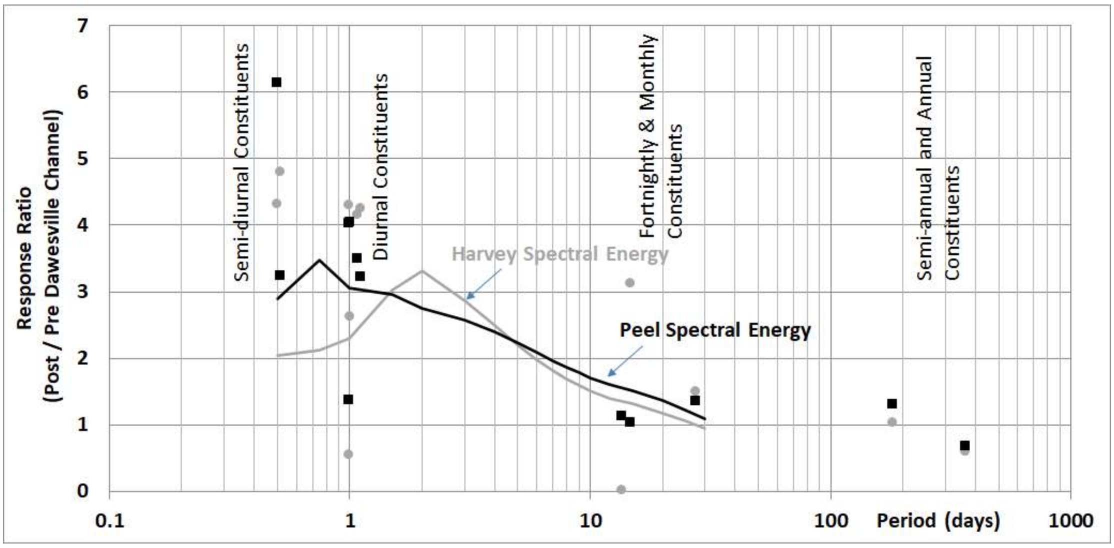


Figure B-16: Spectral Change of Tides and Residuals after Dawesville Channel

The conclusion that the estuary acts similarly to a spectral filter was consequently considered as a basis for transfer from ocean conditions to flood levels within the estuary. Harmonic analysis of the Mandurah tide gauge record from 2015 was compared with that of Peel Inlet, to assess transfer through into the estuary. This analysis was conducted for tidal harmonics, to enable identification of finer time scales. Ratios of tidal constituents demonstrated the effects of near-period constituents, plus enhancement of small-scale overtides, caused by distortion of the tidal signal entering shallow water.
An approximately log-linear response function was developed, which has been used for determination of the extreme coastal flooding condition (Report Section 3**Error! Reference source not found.**).

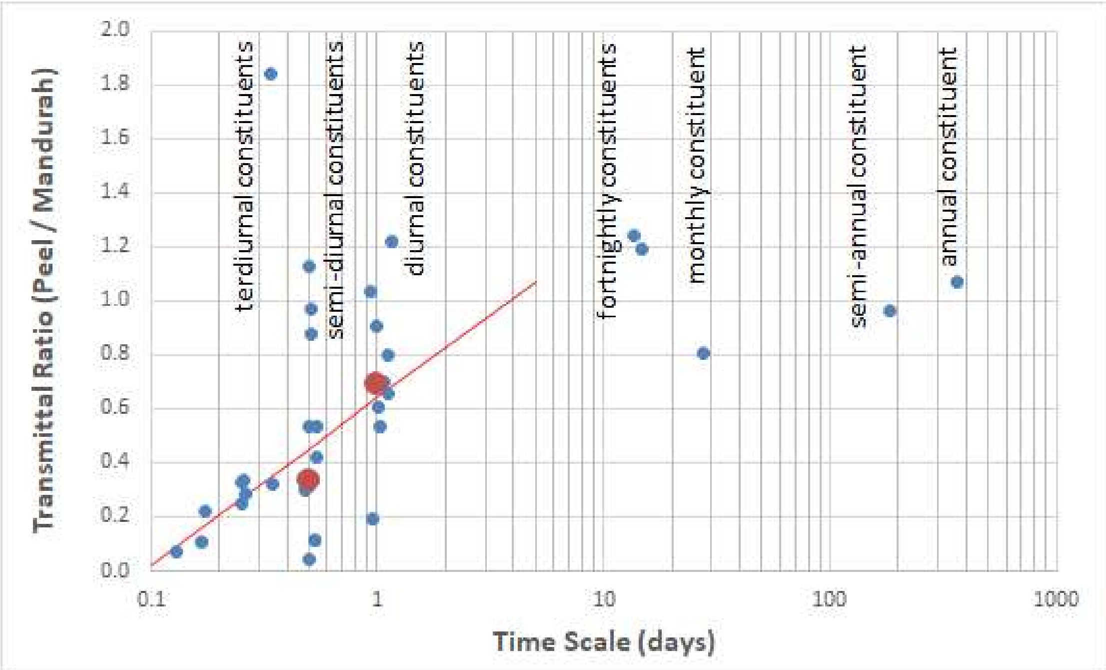


Figure B-17: Ocean-Estuary Admittance of Tidal Constituents 2015: Mandurah to Peel Inlet

Wave Conditions

There are no long-term measurements of waves within Peel-Harvey Estuary, with conditions expected to be highly affected by the position within the estuary due to wind fetch limitation (Travers *et al*. 2010). Consequently, numerical modelling has been used to explore potential wave conditions within the estuary (refer to Appendix H).

The SWAN (Surface Wave and Nearshore) model has been used to hindcast wave conditions within the estuary. Hindcasting was undertaken using a matrix of 10-minute average wind speeds and directions, covering the range measured from the Mandurah anemometer (Figure B-3). Modelling was unvalidated, as no suitable wave measurements were identified. However, this is a conventional application of SWAN, where use of typical parameters is likely to produce a fair representation, suitable for spatially comparative analysis. The model bathymetry and indicative mesh is based on the 20m gridded surface derived from 2016 LIDAR (Figure B-18).

Outputs corresponding to each wind speed and direction ‘bin’ have been used to hindcast wave conditions at each of ~900 points at approximately 100m intervals around the estuary margin. This has been used to create an equivalent wave height-direction-frequency matrix for each point (Figure B-19). Conversion from wind conditions observed from 2001-2018 to estimated wave conditions allows development of a hindcast time series for each point around the estuary (Figure B-20). It is noted that this approach neglects the time for waves to reach steady state under sustained wind conditions, however this is typically rapid for the relatively short fetches across the estuary (generally less than 30 minutes).

Some known limitations of the wave hindcasting approach are caused by local topographic influences on the wind observations and the requirement for waves to be described at some distance from the shore, such that they are not constrained by water depth. For the hindcast undertaken, expected biases include:

- Wave conditions from the south and east are expected to be slightly underestimated due to damping in the wind data set from the local topography at Mandurah Ocean Marina, where the Bureau of Meteorology anemometer is located. For the Peel-Harvey Estuarine System, some topographic sheltering is provided by the large ridge running along the western side of Harvey Estuary. These effects are acknowledged but have not been accounted for in the wave hindcast.
- Wave hindcast outputs have been provided at an approximate depth of 1.0m during mean sea level conditions, which can be up to 1km offshore along the western foreshore and is almost 2km in Austen Bay. The width of the estuarine margin may provide substantial damping to incident wave conditions, therefore affecting conclusions from the hindcast.

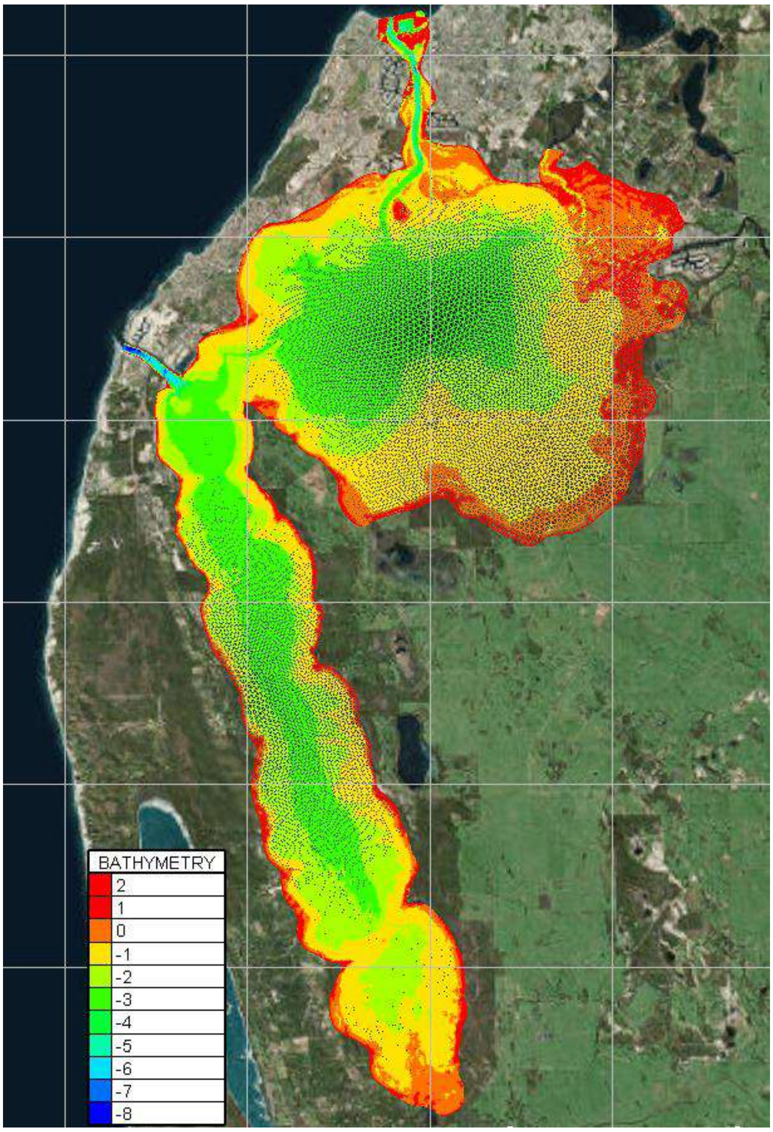


Figure B-18: Wave Hindcast Model Bathymetry

Wind Speed (m/s)	Wind Direction (deg)																
Wind Frequency	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
100yr	19.5	17.6	14.6	12.3	11.4	11.7	12.2	13.0	13.8	14.8	15.7	17.6	20.2	21.0	21.7	20.9	19.5
30yr	18.7	16.8	13.9	11.8	10.9	11.2	11.7	12.5	13.2	14.2	15.0	16.8	19.3	20.1	20.7	19.7	18.7
10yr	17.8	16.0	13.3	11.2	10.4	10.6	11.1	11.9	12.5	13.5	14.3	16.0	18.4	19.1	19.7	19.0	17.8
3yr	16.7	15.1	12.5	10.6	9.8	10.0	10.5	11.2	11.8	12.7	13.5	15.1	17.3	18.0	18.6	17.9	16.7
1yr	15.6	14.0	11.6	9.8	9.1	9.3	9.7	10.4	11.0	11.8	12.5	14.0	16.1	16.7	17.2	16.6	15.6
0.003	14.2	12.8	10.6	8.9	8.3	8.4	8.9	9.4	10.0	10.8	11.4	12.7	14.6	15.2	15.7	15.1	14.2
0.01	12.5	11.3	9.3	7.9	7.3	7.5	7.8	8.3	8.8	9.5	10.0	11.2	12.9	13.4	13.9	13.3	12.5
0.03	10.4	9.4	7.8	6.6	6.1	6.2	6.5	6.9	7.3	7.9	8.4	9.4	10.8	11.2	11.5	11.1	10.4
0.1		6.9	5.7	4.8	4.4	4.5	4.8	5.1	5.4	5.8	6.1	6.8	7.9	8.2	8.4		

Wave Height (m)	Wind Direction (deg)																
Wind Frequency	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
100yr	0.19	0.18	0.18	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.19	0.18	0.18	0.20	0.21	0.21	0.19
30yr	0.19	0.17	0.17	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.18	0.18	0.17	0.19	0.20	0.19	0.19
10yr	0.19	0.17	0.16	0.16	0.15	0.16	0.17	0.17	0.17	0.18	0.17	0.17	0.17	0.17	0.19	0.19	0.19
3yr	0.16	0.16	0.16	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.17	0.16	0.16	0.17	0.17	0.18	0.16
1yr	0.14	0.15	0.15	0.14	0.14	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.16	0.18	0.10	0.14
0.003	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.16	0.15	0.15	0.15	0.07	0.08	0.13
0.01	0.11	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.14	0.13	0.15	0.15	0.15	0.15	0.07	0.03	0.11
0.03	0.10	0.12	0.13	0.12	0.10	0.11	0.13	0.14	0.14	0.13	0.12	0.15	0.15	0.13	0.02	0.02	0.10
0.1		0.07	0.11	0.01	0.02	0.03	0.05	0.07	0.10	0.12	0.11	0.09	0.07	0.04	0.02		

Wave Period (s)	Wind Direction (deg)																
Wind Frequency	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
100yr	1.20	1.28	1.30	1.26	1.25	1.30	1.33	1.35	1.34	1.31	1.29	1.26	1.20	1.10	1.07	1.10	1.20
30yr	1.19	1.27	1.28	1.24	1.24	1.28	1.31	1.34	1.33	1.29	1.27	1.25	1.19	1.08	1.06	1.09	1.19
10yr	1.13	1.26	1.25	1.22	1.21	1.25	1.29	1.32	1.31	1.27	1.26	1.23	1.18	1.08	1.03	1.08	1.13
3yr	1.13	1.24	1.23	1.19	1.19	1.22	1.27	1.30	1.29	1.25	1.24	1.22	1.17	1.07	1.02	1.01	1.13
1yr	1.14	1.21	1.20	1.15	1.16	1.19	1.25	1.28	1.27	1.22	1.22	1.20	1.15	1.04	0.98	1.04	1.14
0.003	1.14	1.18	1.16	1.11	1.11	1.17	1.21	1.25	1.24	1.20	1.19	1.18	1.14	1.04	0.97	0.99	1.14
0.01	1.11	1.14	1.12	1.05	1.11	1.08	1.12	1.17	1.20	1.18	1.13	1.14	1.11	1.02	0.93	1.15	1.11
0.03	1.02	1.10	1.07	1.05	0.95	0.95	0.98	1.04	1.10	1.14	1.11	1.06	1.04	0.96	1.10	1.25	1.02
0.1		0.91	1.05	0.87	0.84	0.83	0.82	0.86	0.91	0.96	0.98	1.02	1.03	1.04	1.08		

Wave Dir (deg)	Wind Direction (deg)																
Wind Frequency	0.0	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
100yr	39	67	78	89	106	123	138	152	162	181	195	211	230	275	320	1	39
30yr	39	68	78	89	106	123	139	152	162	181	196	211	228	270	315	8	39
10yr	38	68	77	88	106	123	139	152	162	180	196	211	227	258	316	9	38
3yr	51	68	76	87	105	124	139	152	162	180	197	211	226	255	289	5	51
1yr	58	68	75	86	105	124	140	152	162	178	198	211	226	252	298	49	58
0.003	60	67	74	83	105	122	142	152	163	178	198	212	225	244	241	56	60
0.01	62	67	73	81	99	139	145	155	165	176	197	213	226	236	227	81	62
0.03	64	66	71	77	142	143	148	160	169	175	186	209	224	225	201	93	64
0.1		72	68	138	141	146	150	166	175	179	179	181	192	184	180		

Figure B-19: Wave Matrix for Yunderup (Location 407)

Box defines points that would be used for hindcast under wind of 10.5m/s from 165°

Wave modelling was conducted for steady wind conditions corresponding to each of the wind speed and direction combinations in the upper table. Model outputs of significant wave height, period and wave direction are plotted in each of the subsequent tables. The relationship between wind and wave estimates allows estimation of waves. For example, wind conditions of 10.5 m/s from a direction of 165° are within the box marked inside the upper table. The corresponding box in the lower three tables indicates the interpolation space for significant wave height, wave period and wave direction, respectively.

For each location around the estuary margin, the wave matrices have been used as look-up tables, combined with the 17 years of wind observations to provide wave hindcast time series (Figure B-20). Water level variation was included in the hindcast, through consideration of the modelled MSL +/-0.3m cases. Wave conditions within the estuary are generally low energy, with average wave heights of 0.2-0.3m and annual maxima of 0.4-0.6m. These conditions are suitable for development of riparian vegetation (Shafer *et al*. 2003), with disturbance such as undercutting expected when waves are above ~0.5m.

Time series illustrate seasonal differences in hindcast wave conditions:

- The greatest seasonal variation of wave height occurs where there are the largest northwesterly fetches (e.g. Austin Cove). Smaller seasonality is apparent where fetches are generally shorter, or there is a narrow directional over which waves could be generated (e.g. Birchmont).
- Seasonality of wave conditions is similar for each year, suggesting limited inter-annual variability. This is unsurprising, as fetch limitation within the estuary means that there is typically only a small increase in wave height even for large differences in wind speeds.

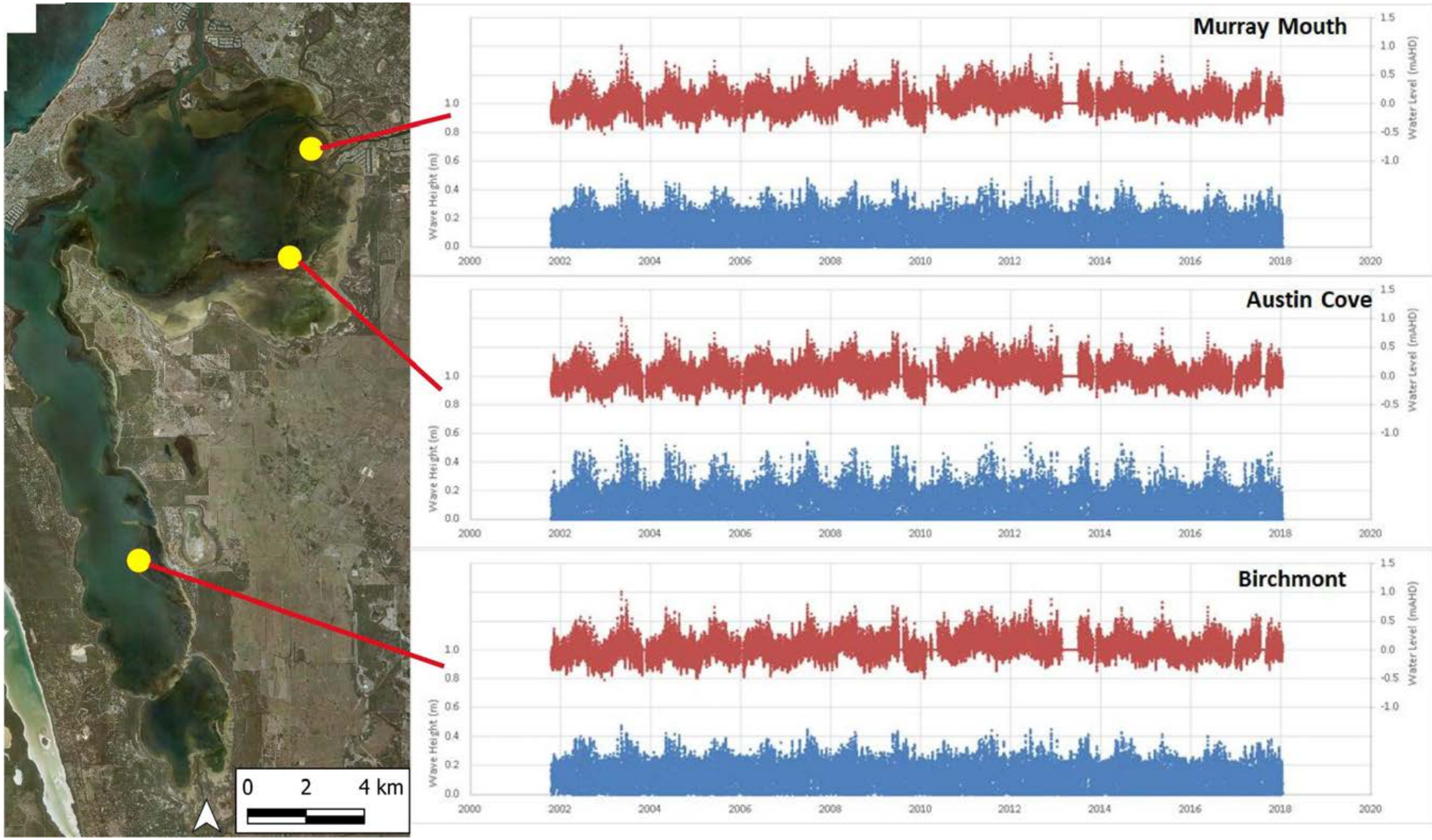
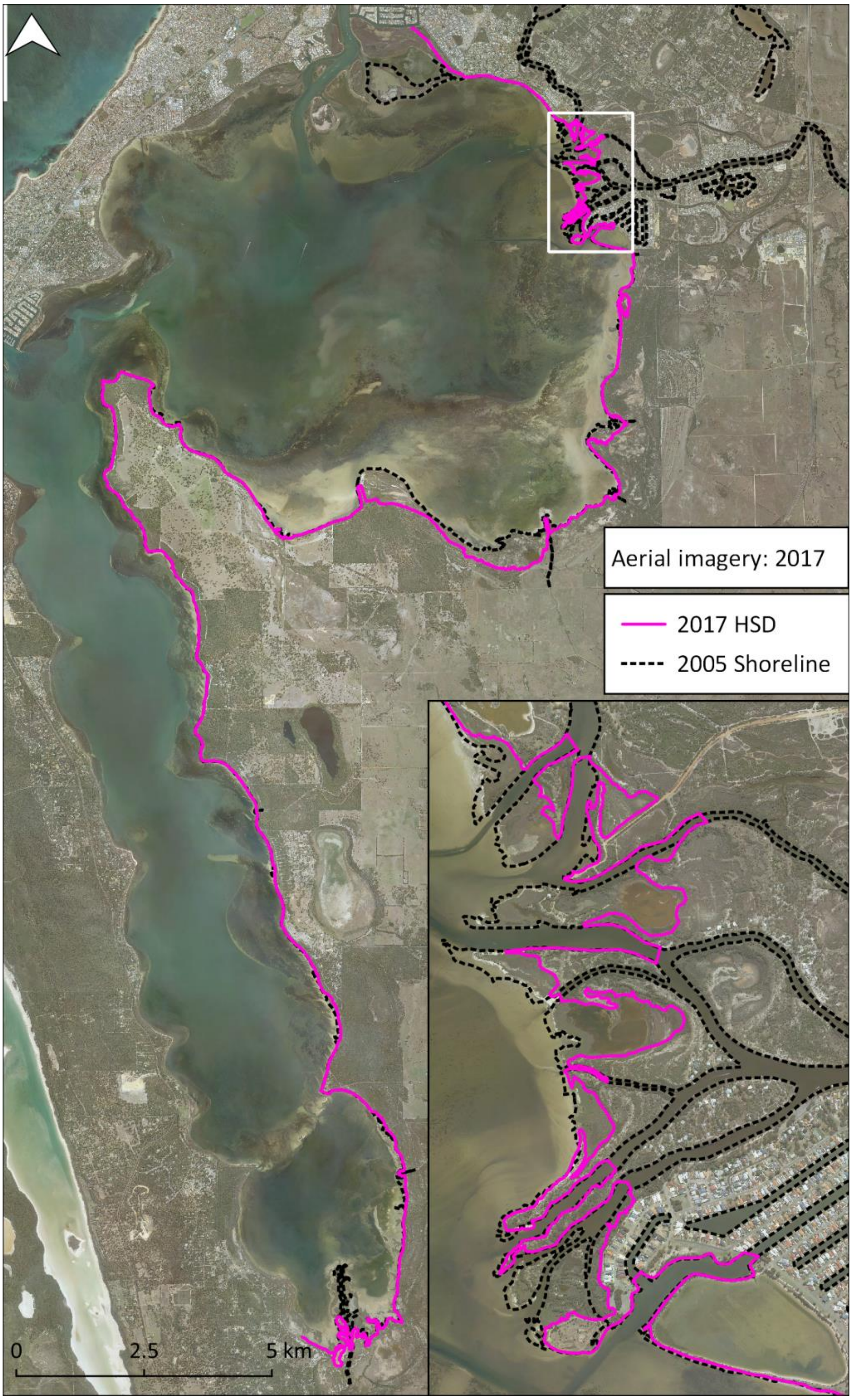


Figure B-20: Hindcast Time Series for Three Sites & Corresponding Wind Components

Appendix C – Vegetation Line Change Summary



Areas of identified vegetation line change (2005-2017)

A0 to A1 - Minor Change

1994 to 2005

1994 Imagery

1994 - Yellow Line

2005 - Green Line

Little change, some seasonal variation to sand spit at eastern end of Creery Island, although little movement of vegetation line.

Little change around Peel Parade near A1.

Variations in submerged features.

1994 to 2005

2005 Imagery

1994 - Yellow Line

2005 - Green Line

2005 to 2011

2011 Imagery

2005 - Green Line

2011 - Blue Line

Little change, more submerged features due to higher average water levels in 2011.

2005 to 2017

Little change, some retreat of vegetation on Creery Island towards 2017.

2017 Imagery

2005 - Green Line

2017 - Red Line

A1 to A2 - Minor Change

1994 to 2005

1994 Imagery

1994 - Yellow Line

2005 - Green Line

2005 Imagery

1994 - Yellow Line

2005 - Green Line

Some minor movement of shoreline. Variations in submerged features; historic dredge scars evident in 1994 imagery.

2005 to 2011

2011 Imagery

2005 - Green Line

2011 - Blue Line

Little change, submerged features due to higher average water levels in 2011.

2005 to 2017

Minor change, seawalls installed along much of this foreshore between 2011 and 2017. These seawalls have pushed shoreline south by between 4.0m and 8.5m in some locations, removing the high tide sandy beach.

2017 Imagery

2005 - Green Line

2017 - Red Line

A2 to A3 - Minor Change North End, Seawall Refurbished, Major Change at Point north of Serpentine River Entrance

1994 to 2005

1994 Imagery

1994 - Yellow Line

2005 - Green Line

2005 Imagery

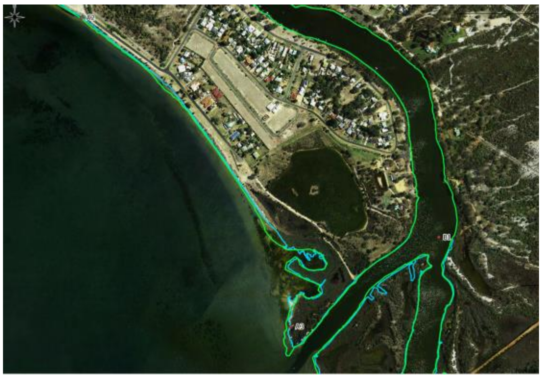
1994 - Yellow Line

2005 - Green Line

Minor recession of shoreline in northern part of segment.

Reshaping of point feature on northern side of Serpentine River entrance, with 18m of erosion at tip of point, and 45m of erosion adjacent to this. The sand appears to have shifted to a new vegetated area on this point, with an increase in width of 27m due to accretion - **major change**.

2005 to 2011



2011 Imagery

2005 - Green Line

2011 - Blue Line

Shoreline recession up to 10m along the northern part of this foreshore section skewed by high water levels of 2011.

Rock armouring installed along northern section of foreshore between 2005 and 2011, presumedly to protect adjacent asphalt road. This seawall discontinues at parkland with inland lake.

Further erosion of point feature at northern side of Serpentine River Entrance. Point tip has receded 28m, northern edge of point has receded between 19m and 13m, small spit of length 26m has accreted in the middle of this point feature, in a NW direction - **major change**.

2005 to 2017

2017 Imagery

2005 - Green Line

2017 - Red Line

Upgraded seawall installed along northern part of this segment between 2011 and 2017. This seawall has reclaimed eroded foreshore since 2011, but shoreline is still between 2m and 8m landward of 2005 position.

Note refurbished seawall is from A2 point, in a southerly direction to 1/3 of the way along John Street.

Erosion at parkland with lake up to 17m landward of its 2005 position in its most affected part, however it has accreted from the 2011 high water level position.

At the point north of the Serpentine River entrance, erosion of 50m from the 2005 position has been experienced. This is 24m of erosion between 2011 and 2017 - **major erosion**.

The spit that was forming on the NW side of this point in 2011 imagery has migrated further north, and has stabilised with the growth of vegetation. It is 36m from the 2005 shoreline position at its longest point - **major change**.

A3 to C1 (not including the inner banks of the Serpentine River) - Major Change

1994 to 2005

1994 Imagery
1994 - Yellow Line
2005 - Green Line

2005 Imagery
1994 - Yellow Line
2005 - Green Line

Erosion of the NW and SE points on the SW end of Jennala Island. Between 1994 and 2005, the NW point's vegetation line has eroded approximately 70m, while the SE point's vegetation line has eroded approximately 30m. The centre section of the SW end of Jennala Island has eroded by between 16m and 20m - **major erosion**.

The point that the vehicle barge docking area at the end of Tonkin Drive is located on, has eroded by between 5m and 7m during this time period.

Erosion has impacted Cooleenup Island's western end between 1999 and 2005, with its southern point eroding by 6m, northern point eroding 8m and variable erosion along the shoreline.

2005 to 2011

2011 Imagery
2005 - Green Line
2011 - Blue Line

The rate of erosion at the SW end of Jennala Island has decreased; 3m of erosion at its N part, 11m in its middle section and 13m erosion at the W corner.

The point which has the barge dock at the end of Tonkin Dr, has eroded a further 2m to 4m, with scalloping of foreshore experienced.

The W end of Cooleenup Island has eroded; its point has receded by 13m and its protruding features have receded by 3m to 17m - **major erosion**.

2005 to 2017

2017 Imagery

2005 - Green Line

2017 - Red Line

The rate of erosion at the SW end of Jennala Island has remained steady from 2005 to 2011 to 2017. Erosion from 2005 to 2017 amounts to 7m of erosion at its N part, 15m in its middle section and 27m erosion at the W corner. This can be considered as **major erosion**.

Between 2005 and 2017, approximately 5m of erosion has been experienced around the point which has the barge dock at the end of Tonkin Dr.

Further erosion at the W end of Cooleenup Island. The point has receded 44m between 2005 and 2017, the majority of this erosion (32m) occurring between 2011 and 2017 - **major erosion**. A new spit has formed between 2011 and 2017 on the northern side of the Point, it is 11m in length. The western shoreline of Cooleenup Island has eroded at a rate of 25 and 2m from 2005 to 2017, with 8m of this erosion experienced between 2011 and 2017 - **major change**.

C1 to D1 (not including the inner banks of the Murray River) - Major Change

1994 to 2005

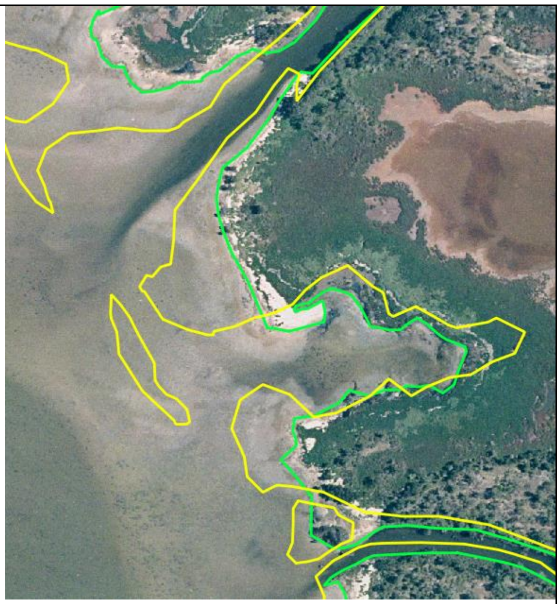
1994 Imagery
1994 - Yellow Line
2005 - Green Line

2005 Imagery
1994 - Yellow Line
2005 - Green Line

Major change with **major erosion** experienced along the western sides of all of the Murray River delta islands, being Meeyip, Ballee, Worallgarook and Little Yunderup Islands.

Major change per island:

Meeyip Island (western side, 2005 Imagery): **Major erosion** at the northern end, with an area of 150m long and 35-50 m wide eroded. 176m long section from the centre to the southern end has eroded, with an entire "T-head" spit removed from 76m landward erosion.



Ballee Island (western side, 2005 Imagery): **major erosion** including the loss of a small sand island at the northern end. The vegetation line has receded 50m at the northern end and 33m at the southern end. Some repositioning of the natural channel of Worallgarook Branch with reforming of a small vegetated feature at the SW corner of Ballee Island.

Worallgarook Island (western end, 2005 imagery):
Major erosion on the NW corner, reshaping of the centre of this foreshore, with an area 85m long and over 15m wide eroded. The centre section has accreted some 19m, and the south western point end has reshaped with the shrinkage of a small island by 40m in length.

Little Yunderup Island (south-western end, 2005 Imagery):
Major erosion to much of this small island, (note the poor resolution of the 1994 imagery reduces confidence in the position of the 1994 vegetation line). There may have been over 60m eroded from the SW end of this island between 1994 and 2005.

2005 to 2011

2011 Imagery
2005 - Green Line
2011 - Blue Line

Major erosion at the NW tip of **Meeyip Island** between 2005 and 2011, this point receded by 90m and experienced a 17m reduction in width along the north half of its SW facing beach. The remaining half of the SW facing beach, experienced **major change** with the formation of a sand bar and a thing long lagoon feature running parallel to the beach. The southern corner of the island experienced accretion from 2011 to 2017, essentially closing the 15m wide entrance to the natural channel of Meeyip Branch. This was a reversal of the erosion trend in this area from 2005 to 2011.

	Ballee Island eroded by up to 15m on its NW and SW areas, with a small accretion zone in its centre - **major change**. **Worallgarook Island** eroded by up to 15m on its NW half, and reshaped with minor accretion in the middle of its westerly facing centre beach. The SW point had areas that eroded between 24m and 14m - **major change**. **Little Yunderup Island**'s NW facing side eroded some 9m, with this eroded sand presumedly accreting between this small island and the larger Yunderup Island, fusing the two islands together.
2005 to 2017  **2017 Imagery** 2005 - Green Line 2017 - Red Line	The **major erosion** trend continued at the NW tip of **Meeyip Island** between 2011 and 2017, this point receded by a further 30m (totalling 120m of recession 2005 to 2017). An area of 200m length by average width of 15m eroded from 2011 to 2017 (total width of shoreline lost 2005 to 2017 is 25m to 40m along this beach. The southern corner of the island also eroded, with a range of 11m to 23m. Erosion on **Ballee Island** continued on the northern and southern corners sections, with the accreted beach in the centre moving slightly, and the intertidal marsh in the centre of the island's eastern side building up in elevation - **major change**. **Worallgarook Island** appears to have had accretion along the intertidal marshes of its western side. Some erosion has towards the southern end of this beach, and protruding features that were previously located on the SW point in 2005 and 2001 have eroded away. A small sand spit of width 18m, has accreted on Worallgarook Island's side of the Yunderup Branch natural channel - **major change**.

Little Yunderup Island's NW facing side eroded some 9m from 2011 to 2017, bring the total eroded width up to 18m (2005 to 2017). The sand bank fusion between the smaller and larger Yunderup Islands (forming 2005 to 2011) accreted further from 2011 to 2017.

D1 to D2 (not including the inner banks of the Murray River) - Major Change

1994 to 2005

1994 Imagery

1994 - Yellow Line

2005 - Green Line

2005 Imagery

1994 - Yellow Line

2005 - Green Line

Erosion of the SW end of **Goongoolup Island** occurred, with the vegetation line receding at least 26m between 1994 and 2005. On the mainland of South Yunderup, the SW section receded by 20m - **major change**.

Within the artificial canal system, the non-armoured shoreline (no seawall) near the South Yunderup boat ramp and at Marma Way/Moyup Way has eroded slightly during this timeframe. Aside from an additional canal arm being constructed parallel to Batavia Quays, the canal system has not eroded due to its artificial hard walling.

Some erosion has been experienced around the reclaimed bund/pond area that is located opposite the South Yunderup Boat Ramp. The perimeter of this bund is not armoured with a seawall; its SW corner eroded by 20m between 1994 and 2005 - **major change.** The remainder of the southerly facing bund wall experienced minor erosion during this timeframe - **minor change**.

2005 to 2011

2011 Imagery

2005 - Green Line

2011 - Blue Line

Elevated water levels in 2011 combined with erosional pressures between 2005 and 2011 to cause an overall recession of the SW end of **Goongoolup Island**. Between 13m and 6m of vegetated shoreline was removed. Two spits also formed, one on each side of this island. Each of the spits extend past the 2005 shoreline position by approximately 18m - **major change**.

On the mainland of South Yunderup, SW section receded by 13m, with recession decreasing around to the southern section to 7m of vegetated shoreline removed. Reshaping of the spit system at the Murray River delta occurred. At the entrance to the Canal System, the shoreline has evolved to form an additional spit some 220m SE of South Yunderup Boat Ramp - **major change.**

Erosion within the artificial canal system, near the South Yunderup boat ramp and at Marma Way/ has been experienced, with around 10m eroded from both sides of the Batavia Quays canal entrance corners and the adjacent vegetated canal banks(along Moyup Way (these canal banks are not armoured) - **major change**.

On the opposite side of the main entrance canal, the non-armoured canal banks have

	eroded by 6m to 2m. Around the perimeter of the pond bund all the way to its intersection with the historic shoreline, similar rates of erosion have been experienced, while up to 10m of shoreline has been removed from the bund wall's SW corner - **localised major change**.
2005 to 2017  **2017 Imagery** 2005 - Green Line 2017 - Red Line	The 2017 imagery shows that erosion at the SW end of **Goongoolup Island** has continued - **major change**. The breakthrough penetration of the beach into a small lagoon between 2011 and 2017 has then morphed into shoreline erosion exceeding 20m in this immediate area. The spits on either side of the island have also accreted by approximately 10m during this timeframe (overall both new spits accreted by approximately 30m from 2005 to 2017). On the mainland section of South Yunderup, the 2005 to 20011 trend of foreshore erosion has continued, , but at a slightly lesser rate. A tidal lagoon has formed on the SW corner of this area, with accretion closing off the existing spit. On the eastern side, just south of South Yunderup boat ramp, another intertidal lagoon and mud flat has been formed through accretion of sediment - **major change**.

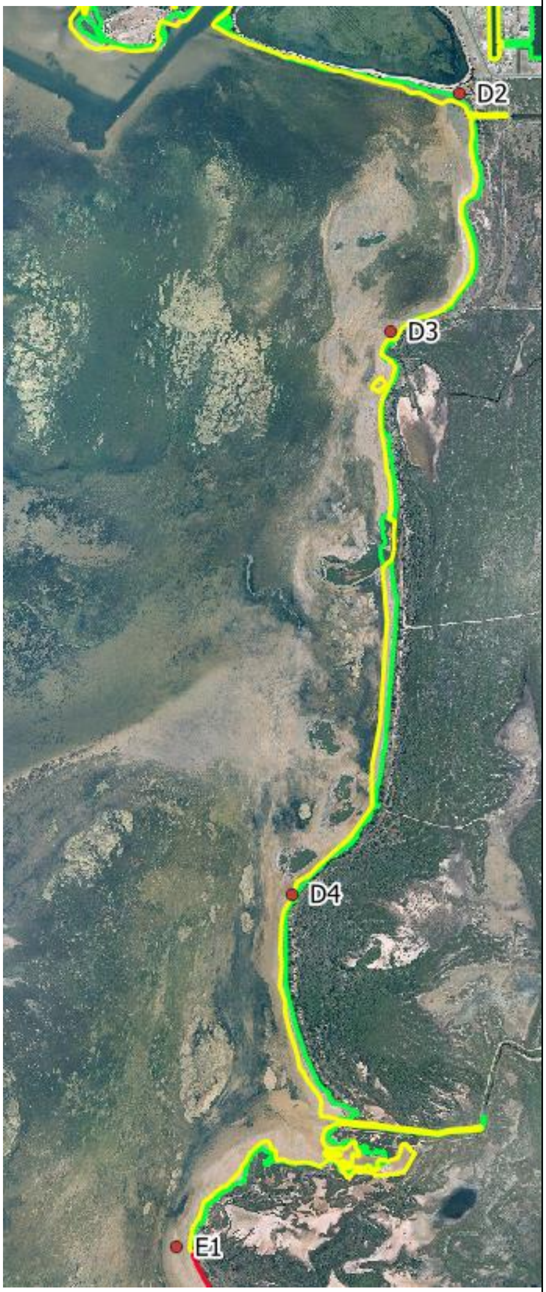
	Erosion has continued along the non-armoured parts of the main navigation channel into South Yunderup Canals - **minor change**. The shoreline around the bunded pond has stabilised since 2011, due to the lower water levels up to 2017 - **minor change**.

D2 to E1 - Minor Change

1994 to 2005

1994 Imagery
1994 - Yellow Line
2005 - Green Line

Minor change along this stretch of foreshore between 1994 and 2005.



2005 Imagery
1994 - Yellow Line
2005 - Green Line

2005 to 2011

2011 Imagery

2005 - Green Line

2011 - Blue Line

Minor change along this stretch of foreshore between 2005 and 2011.

2005 to 2017

2017 Imagery

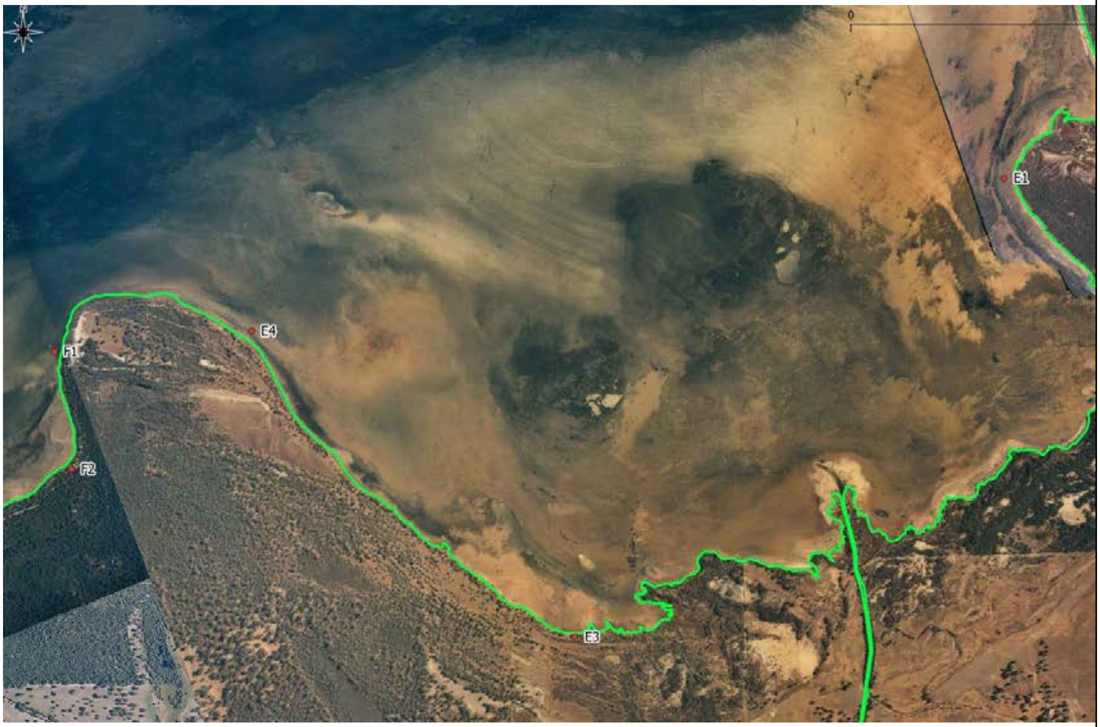
2005 - Green Line

2017 - Red Line

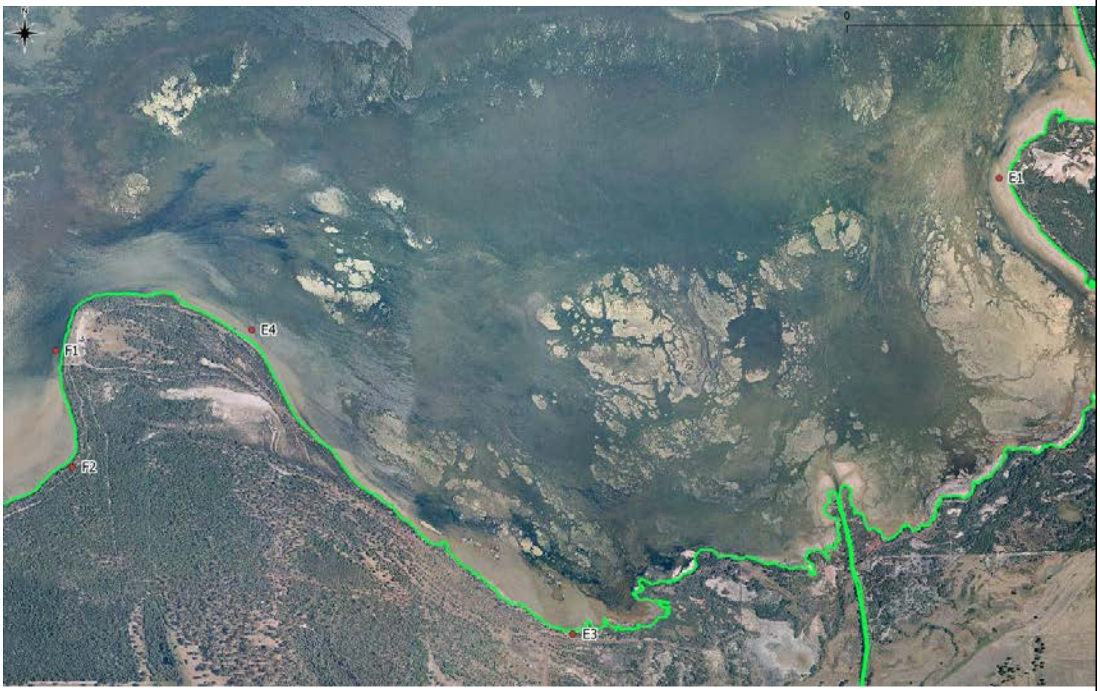
Minor change along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little vegetation retreat.

E1 to F1 - Minor Change

1994 to 2005



1994 Imagery
2005 - Green Line

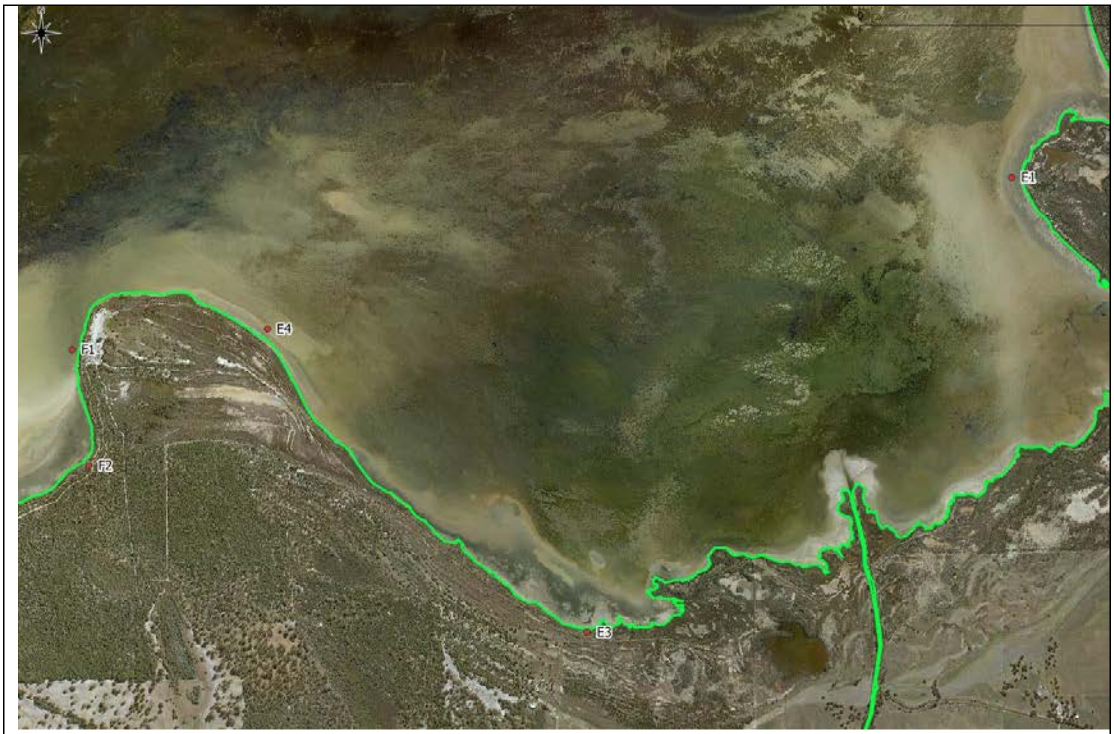


2005 Imagery
2005 - Green Line

Minor change along this stretch of foreshore between 1994 and 2005.

2005 to 2011

2011 Imagery 2005 - Green Line **Minor change** along this stretch of foreshore between 2005 and 2011.
2005 to 2017



2017 Imagery
2005 - Green Line

Minor change along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little vegetation retreat.

F1 to G1 - Minor Change

1994 to 2005

1994 Imagery
2005 - Green Line

2005 Imagery
2005 - Green Line

Minor change along this stretch of foreshore between 1994 and 2005.

2005 to 2011

2011 Imagery

2005 - Green Line

Minor change along this stretch of foreshore between 2005 and 2011.

2005 to 2017

2017 Imagery

2005 - Green Line **Minor change** along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little vegetation retreat.

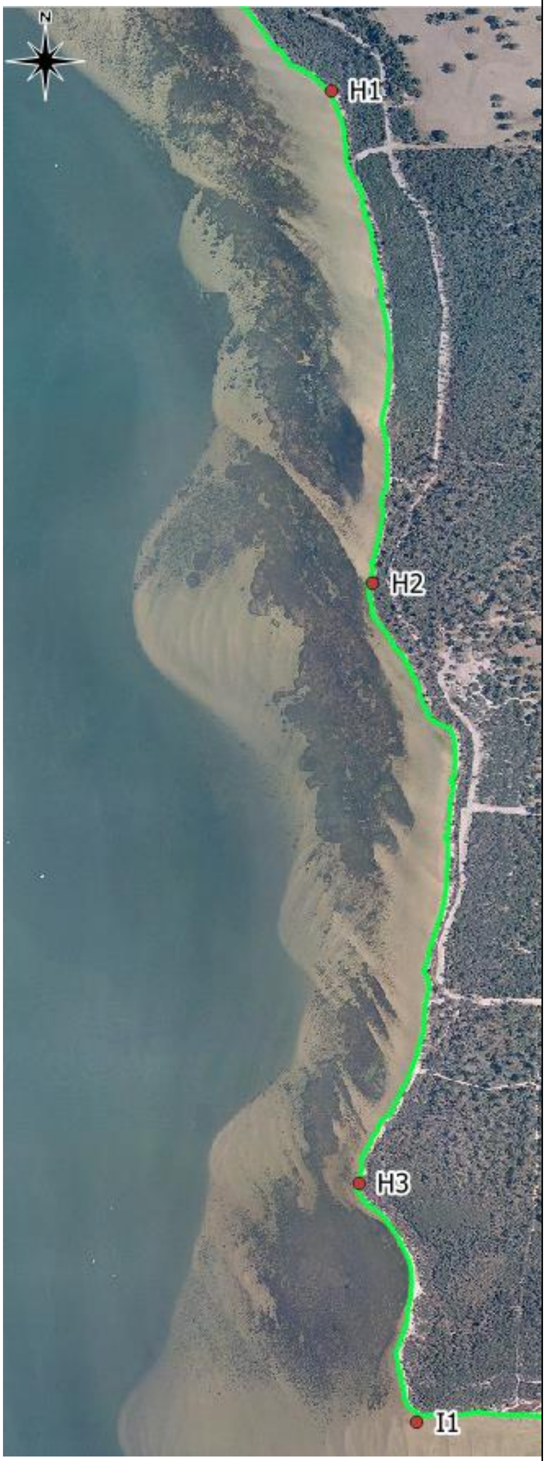
G1 to H1 - Minor Change

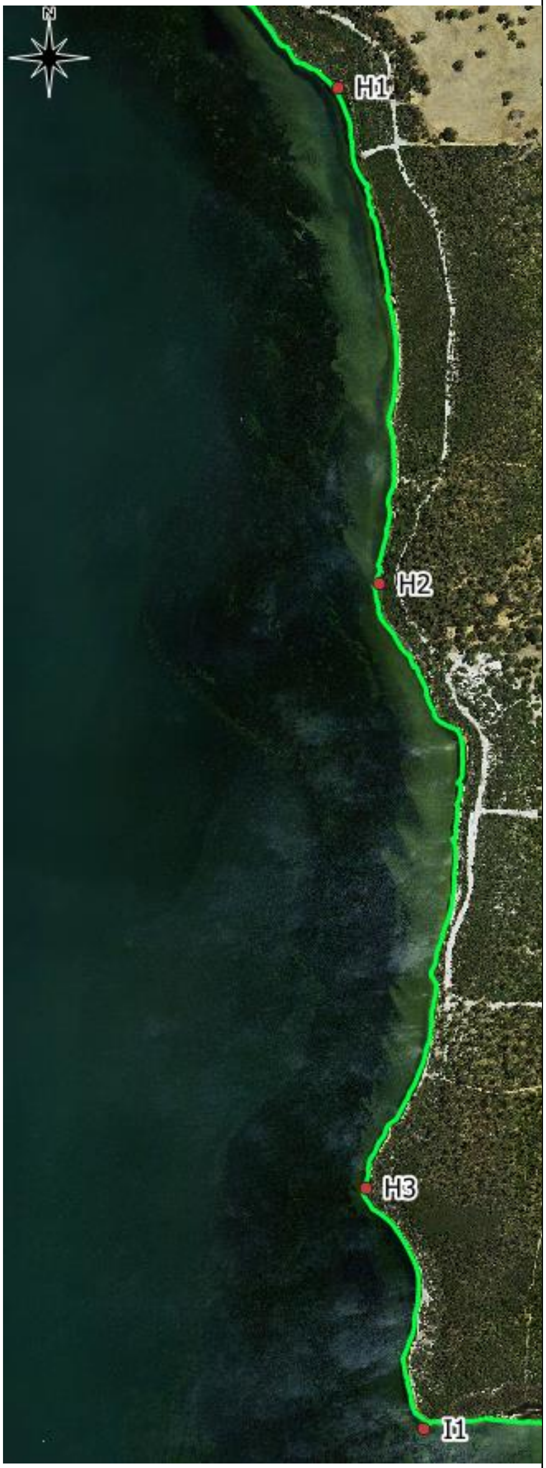
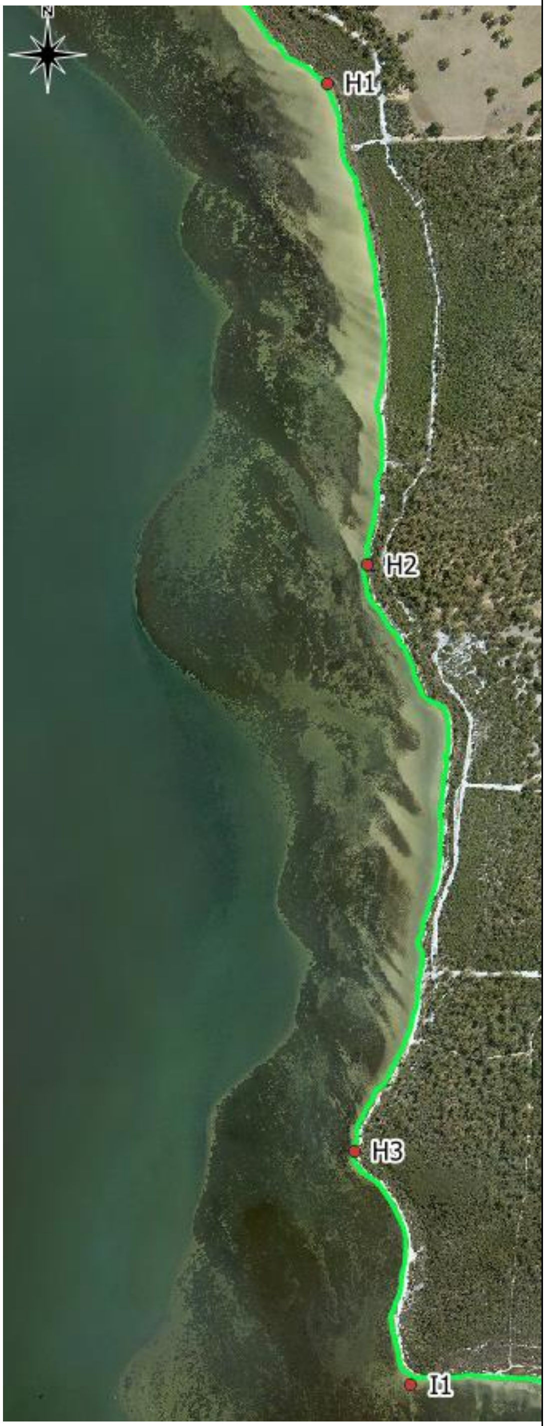
<table>
<tr><td>1994 to 2005
1994 Imagery
2005 - Green Line</td>
<td>1994 to 2005
2005 Imagery
2005 - Green Line

Minor change along this stretch of foreshore between 1994 and 2005.</td></tr>
</table>

2005 to 2011	2005 to 2017
 **2011 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 2005 and 2011.	 **2017 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little permanent vegetation line retreat.

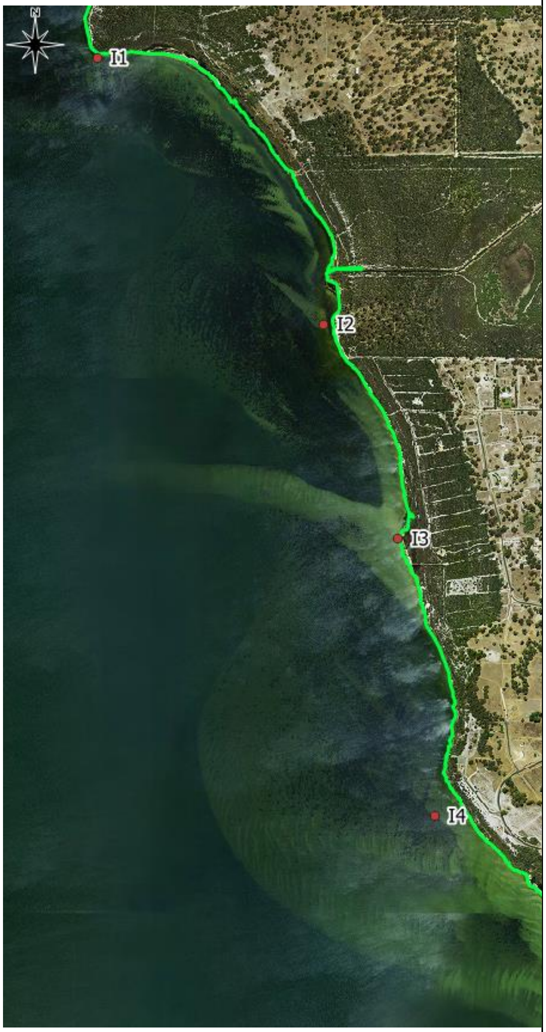
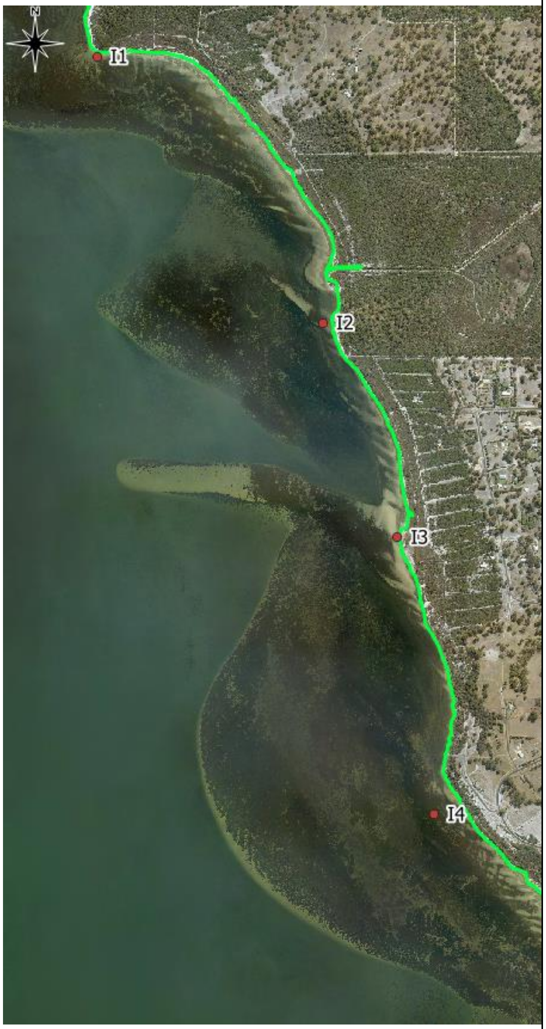
H1 to I1 - Minor Change

1994 to 2005	1994 to 2005
	
1994 Imagery 2005 - Green Line	**2005 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 1994 and 2005.

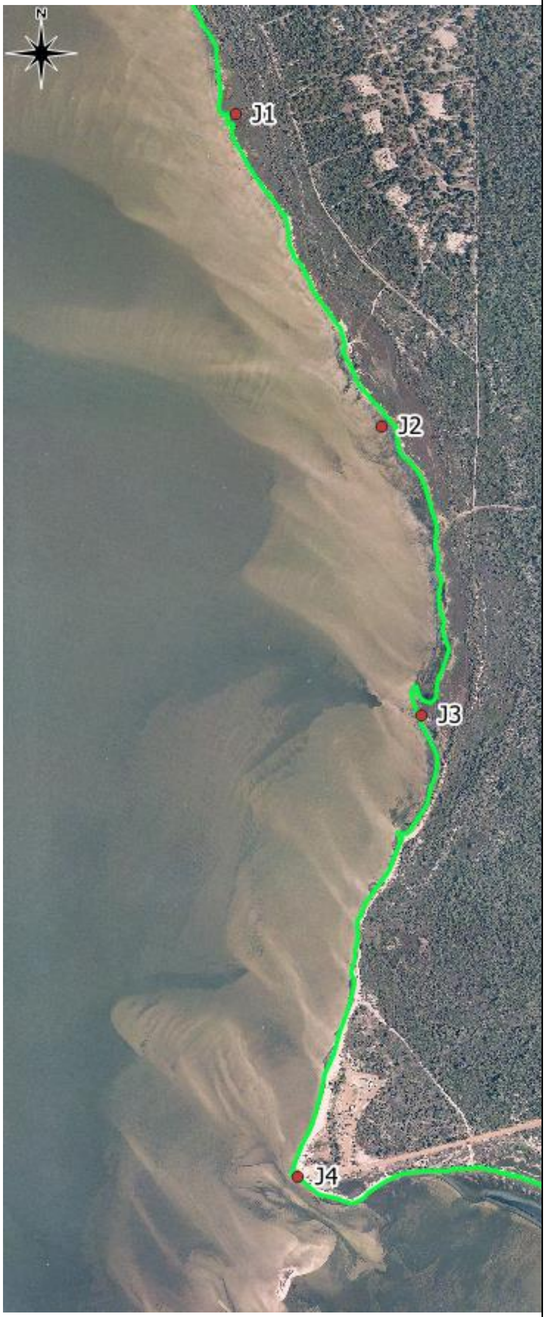
2005 to 2011	2005 to 2017
	
2011 Imagery 2005 - Green Line **Minor change** along this stretch of foreshore between 2005 and 2011.	**2017 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little permanent vegetation line retreat.

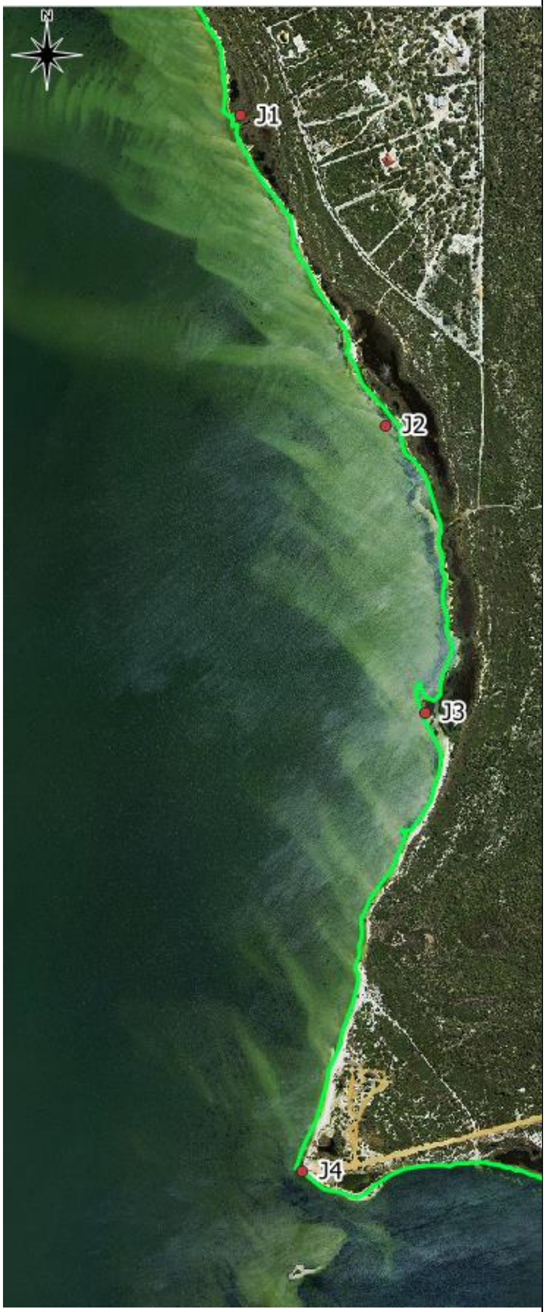
I1 to J1 - Minor Change

1994 to 2005	1994 to 2005
	
1994 Imagery 2005 - Green Line	**2005 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 1994 and 2005.

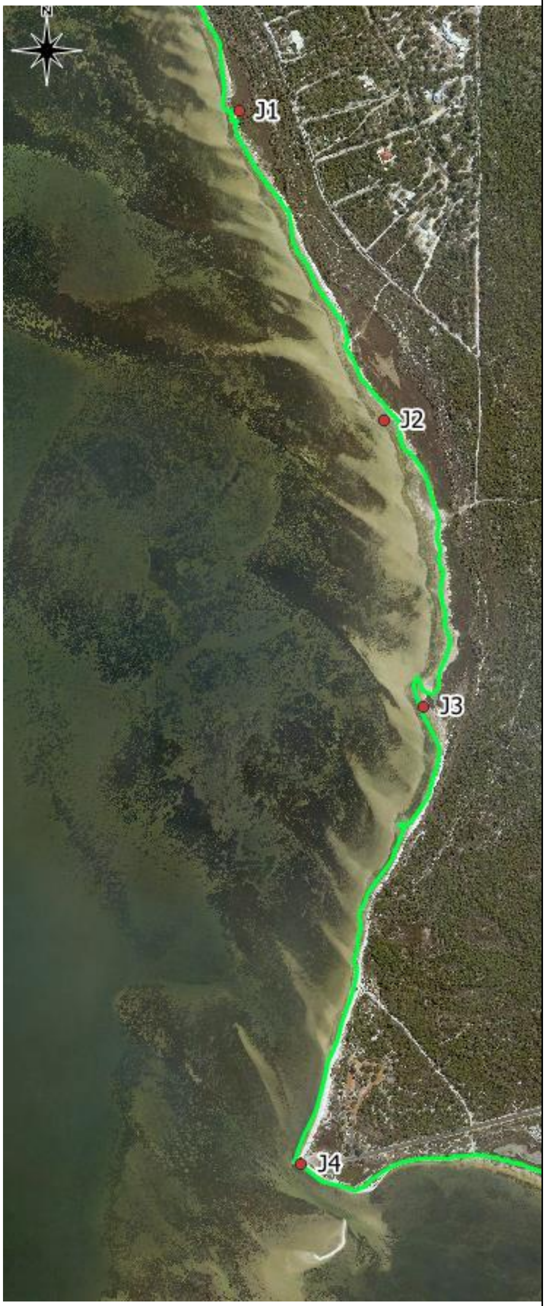
2005 to 2011	2005 to 2017
	
2011 Imagery 2005 - Green Line **Minor change** along this stretch of foreshore between 2005 and 2011.	**2017 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little permanent vegetation line retreat.

J1 to J4 - Minor Change

1994 to 2005	1994 to 2005
 2005 - Green Line **1994 Imagery*** (* 1994 Imagery digitisation error around J4)	 **2005 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 1994 and 2005.

<table>
<tr><th>2005 to 2011</th><th>2005 to 2017</th></tr>
<tr><td>

2011 Imagery
2005 - Green Line

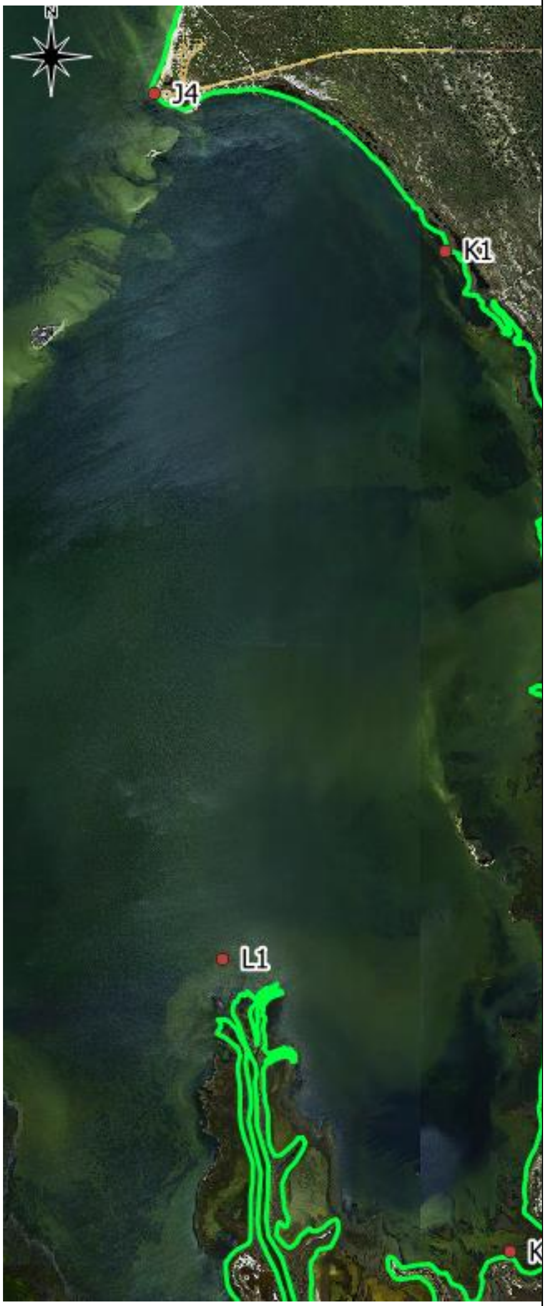
Minor change along this stretch of foreshore between 2005 and 2011.</td>
<td>

2017 Imagery
2005 - Green Line
Minor change along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little permanent vegetation line retreat.</td></tr>
</table>

J4 to K3 - Minor Change

1994 to 2005	1994 to 2005
	
1994 Imagery* 2005 - Green Line (* 1994 Imagery digitisation error around J4)	**2005 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 1994 and 2005.

2005 to 2011



2011 Imagery

2005 - Green Line

Minor change along this stretch of foreshore between 2005 and 2011.

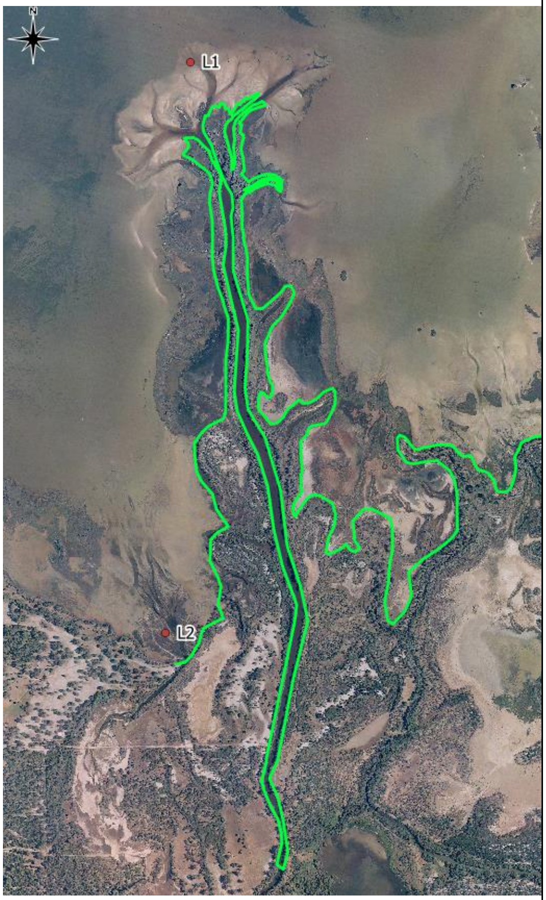
2005 to 2017

2017 Imagery

2005 - Green Line

Minor change along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little permanent vegetation line retreat.

K3 to L2 - Minor Change

1994 to 2005	1994 to 2005
	
1994 Imagery* 2005 - Green Line (* 1994 Imagery digitisation error around J4)	**2005 Imagery** 2005 - Green Line **Minor change** along this stretch of foreshore between 1994 and 2005.

<table>
<tr><td>

2005 to 2011

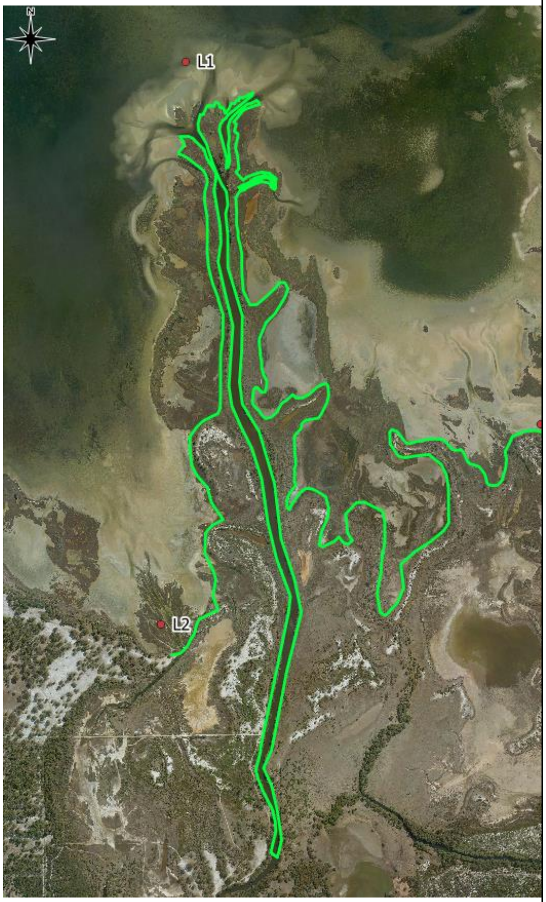
2011 Imagery

2005 - Green Line

Minor change along this stretch of foreshore between 2005 and 2011.

</td><td>

2005 to 2017



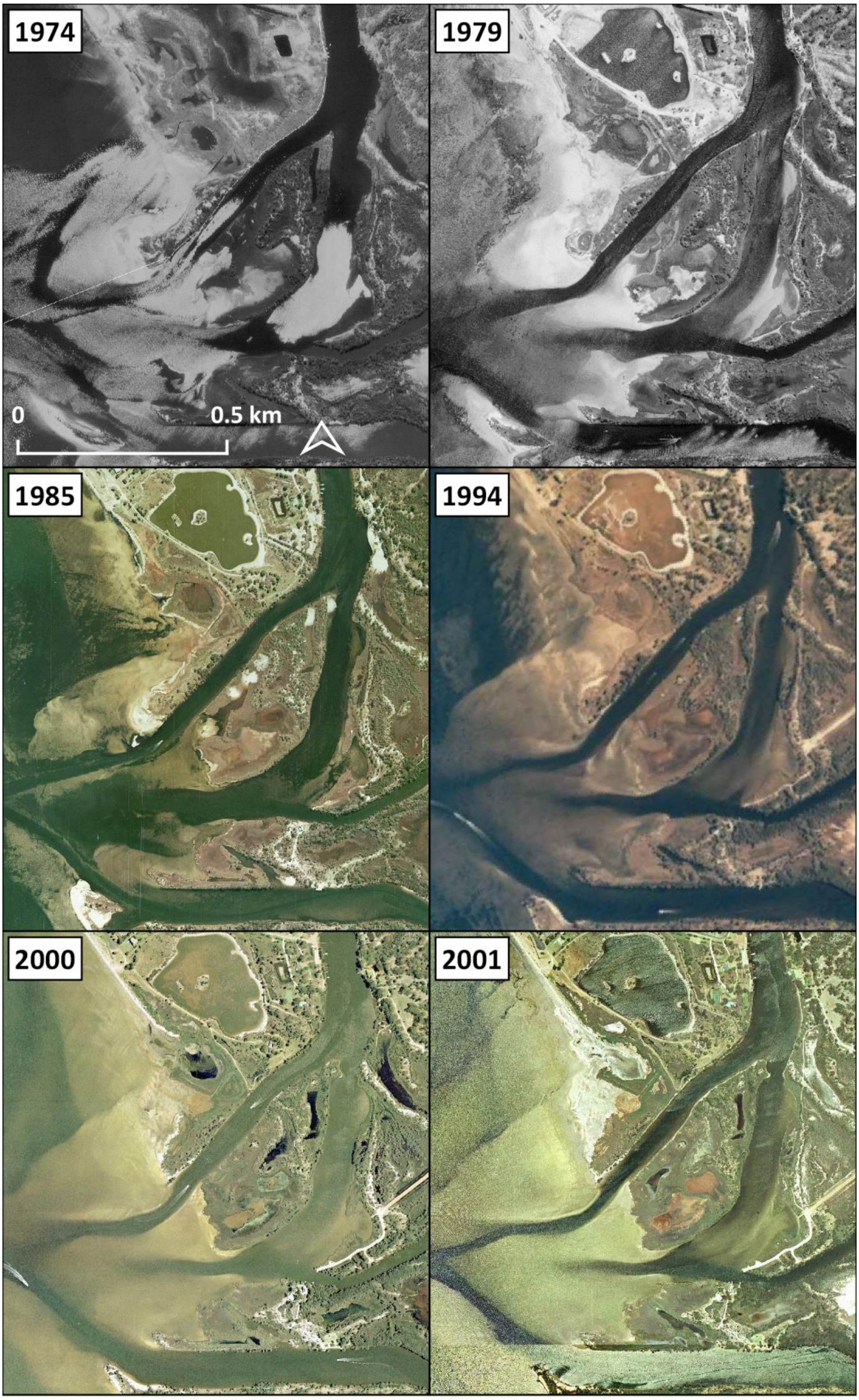
2017 Imagery

2005 - Green Line

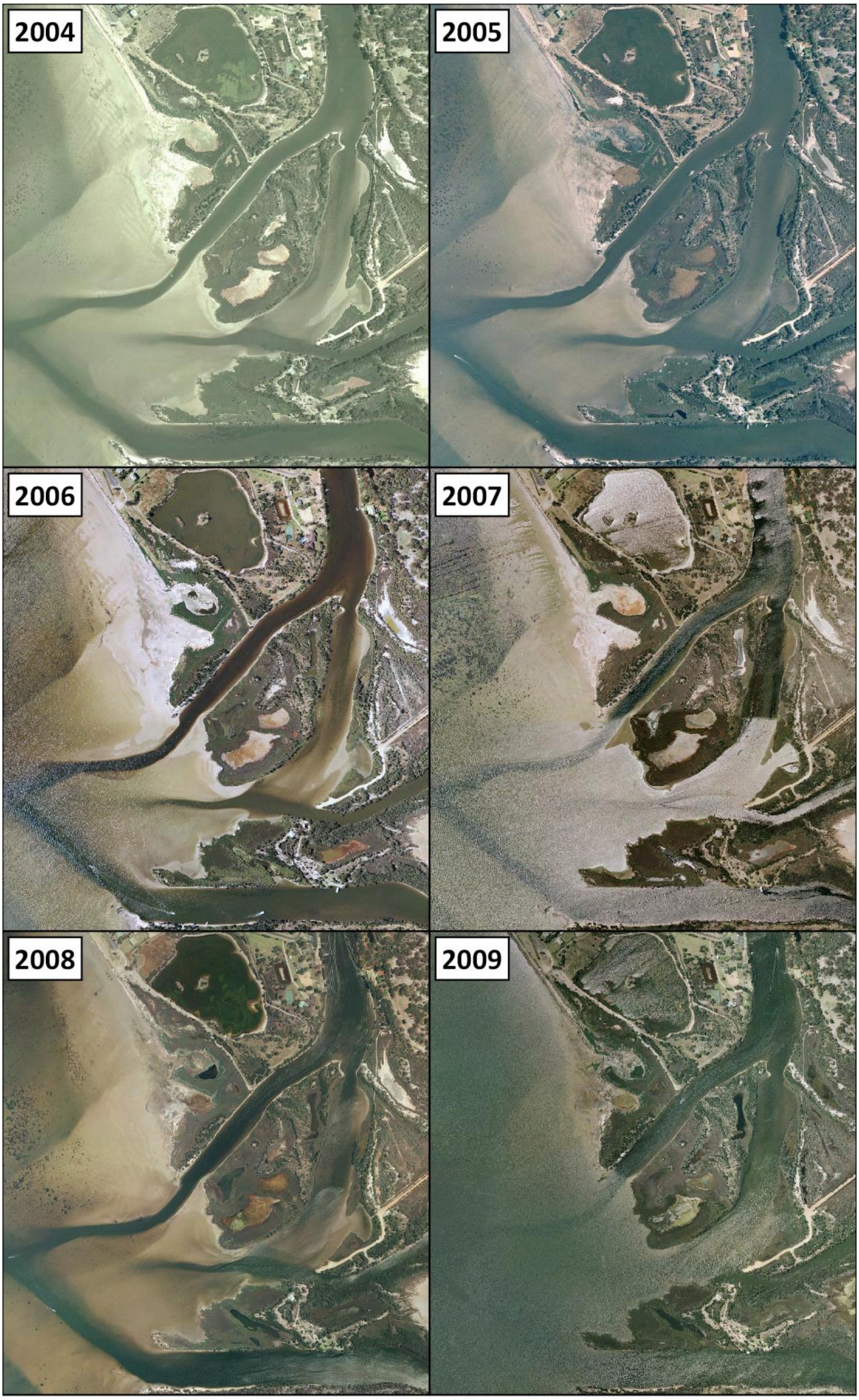
Minor change along this stretch of foreshore between 2005 and 2017. Elevated water levels in 2011 caused little permanent vegetation line retreat.

</td></tr>
</table>

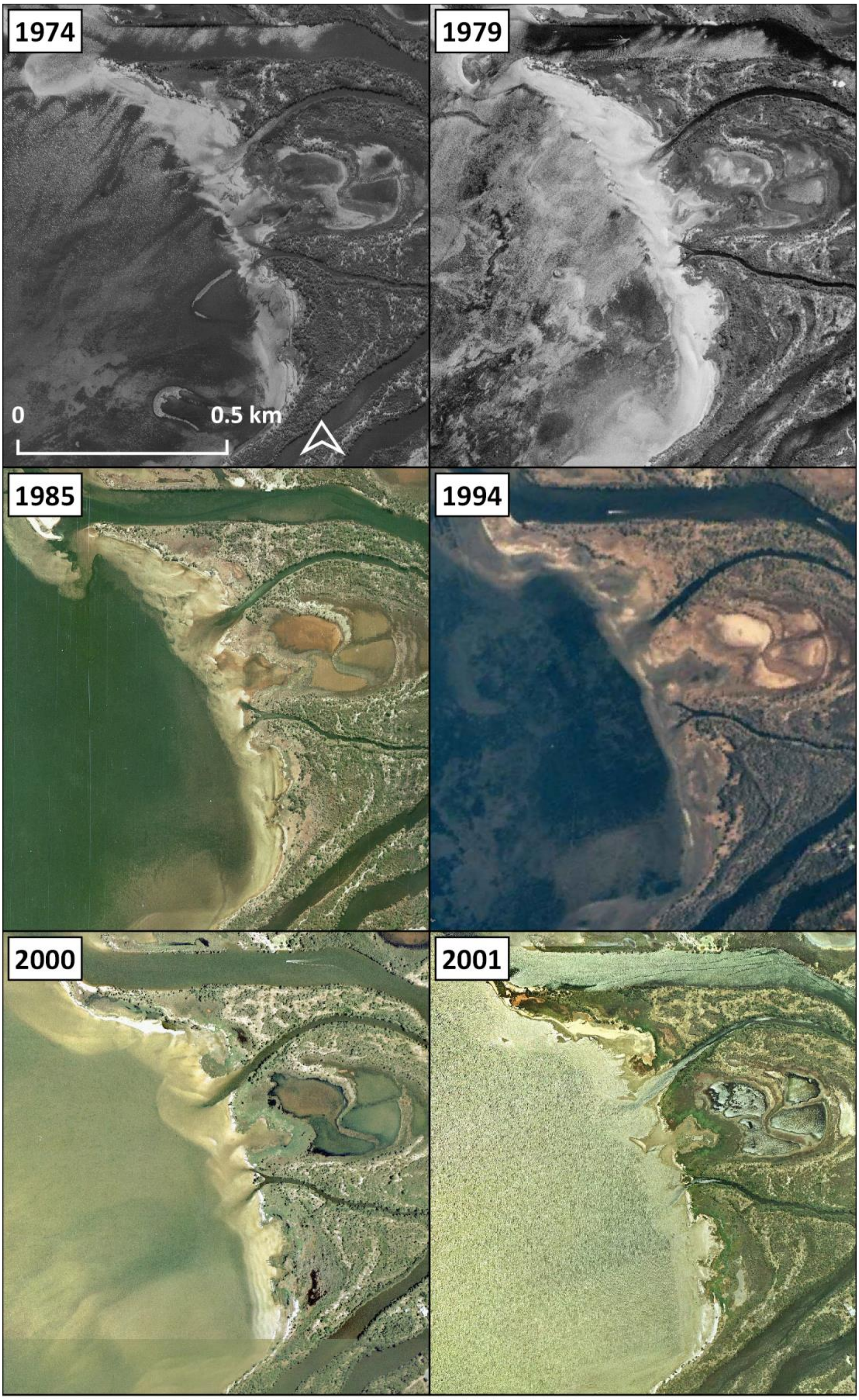
Appendix D – Murray Delta Imagery Sequences



1974
0
0.5 km
1979
1985
1994
2000
2001

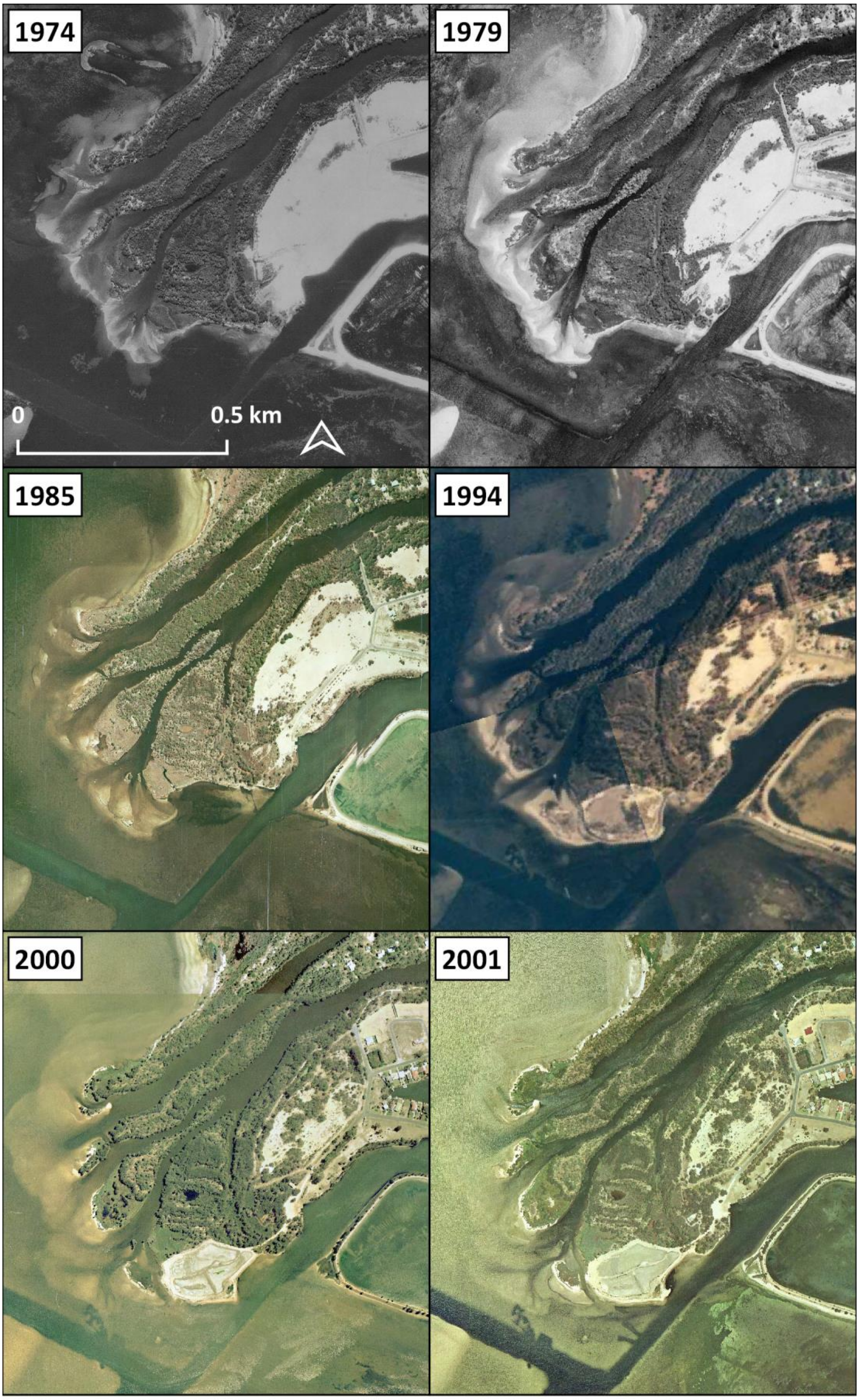

2004
2005
2006
2007
2008
2009


2010
2011
2012
2015
2016
2017


1974
1979
1985
1994
2000
2001
0
0.5 km


2004
2005
2006
2007
2008
2009

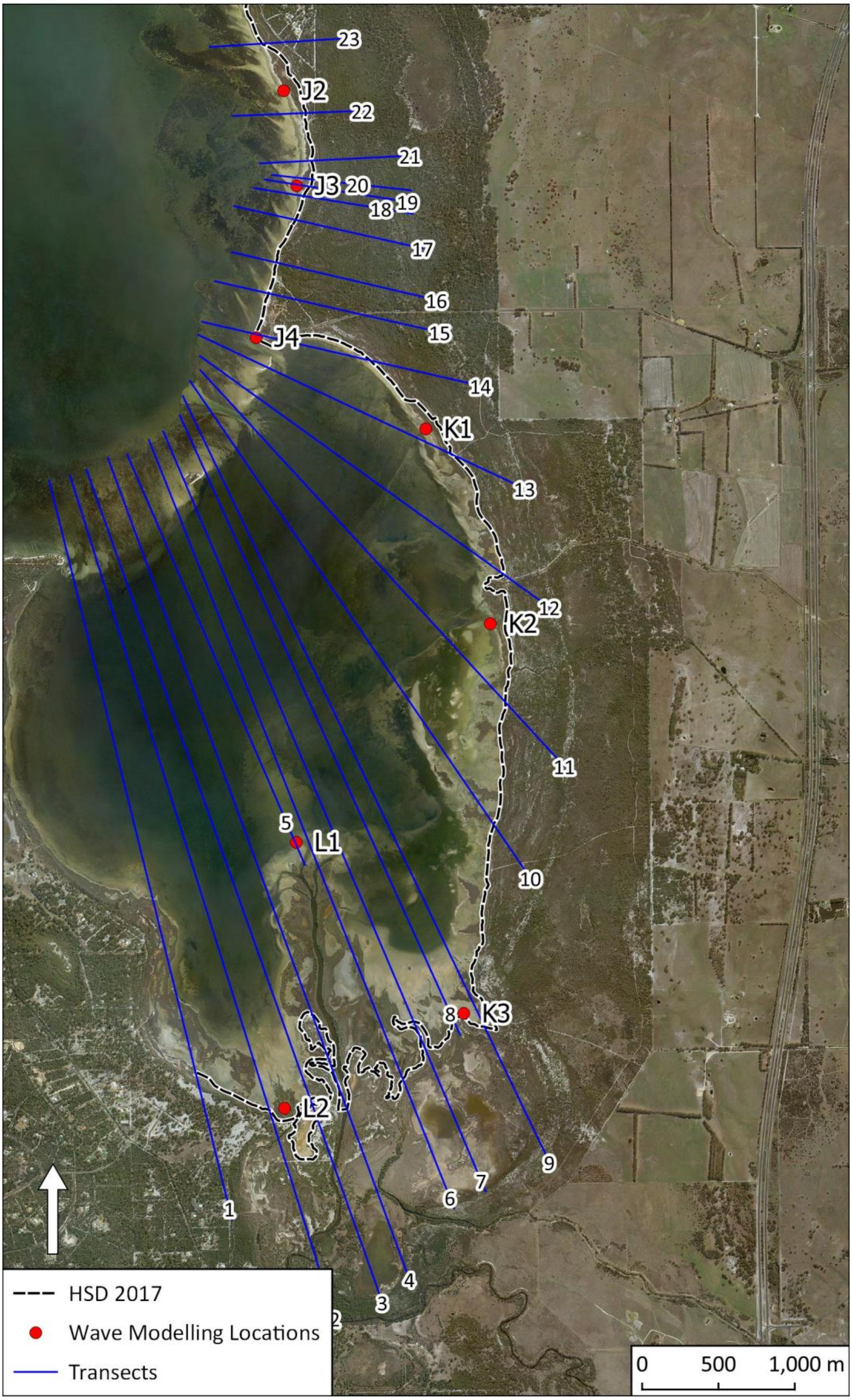

2010
2011
2012
2015
2016
2017

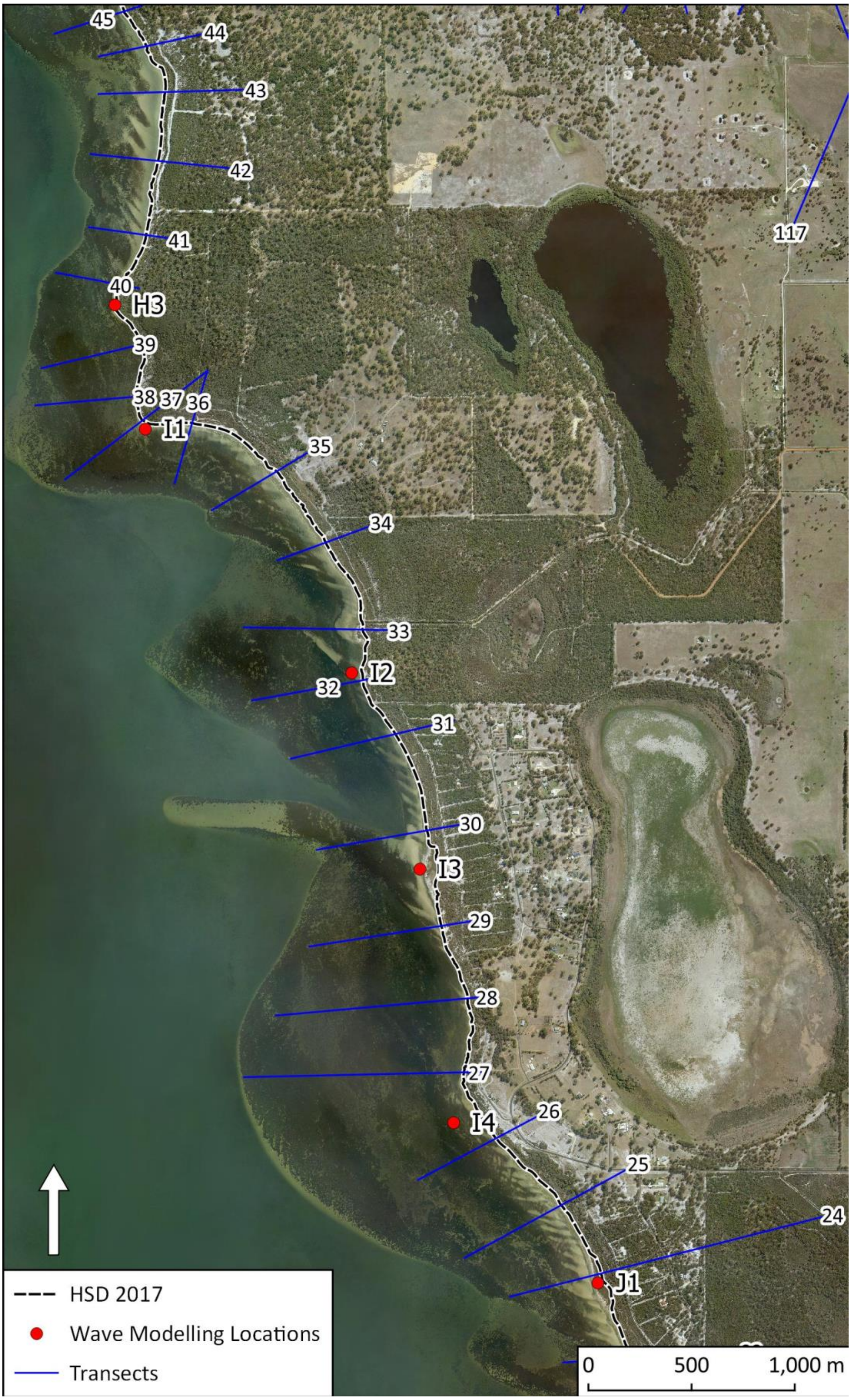

1974
0
0.5 km
1979
1985
1994
2000
2001

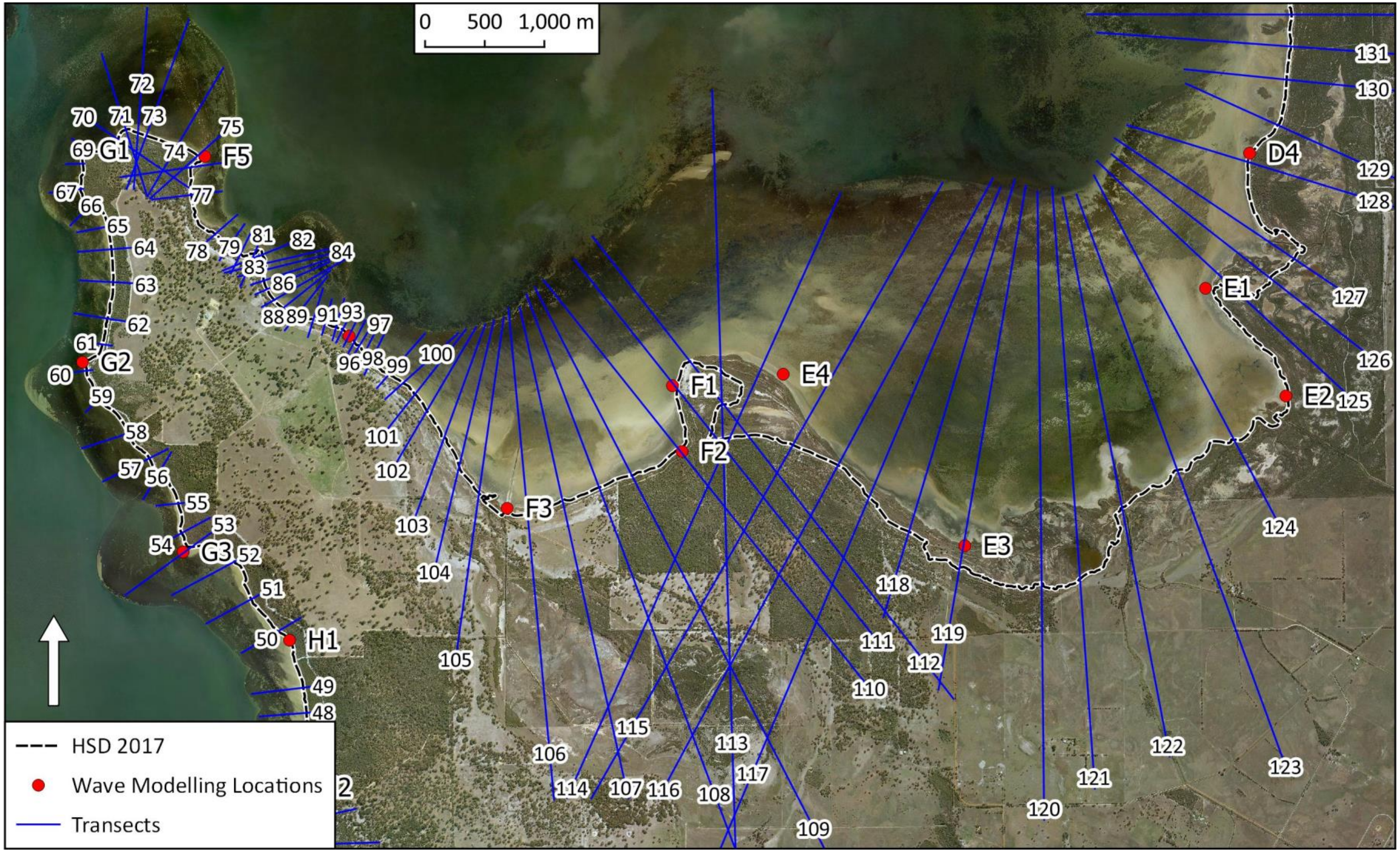

2004
2005
2006
2007
2008
2009

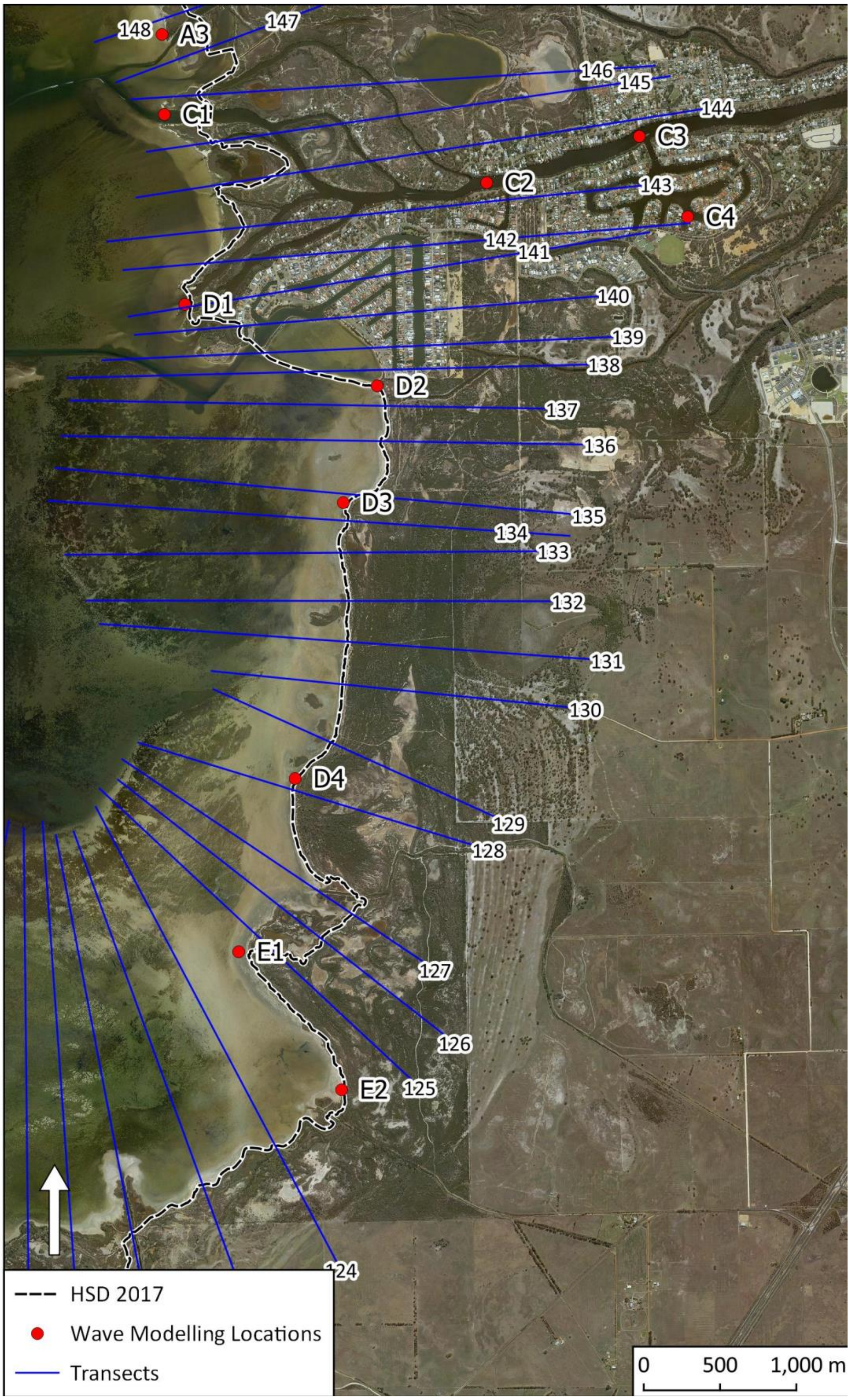

2010
2011
2012
2015
2016
2017

Appendix E – Profiles Used to Evaluate Response to SLR




45
44
43
42
41
40
H3
39
38
37
36
I1
35
34
33
I2
32
31
30
I3
29
28
27
I4
26
25
24
J1
117
HSD 2017
Wave Modelling Locations
Transects
0
500
1,000 m


0 500 1,000 m
HSD 2017
Wave Modelling Locations
Transects
G1
G2
G3
F1
F2
F3
F5
E1
E2
E3
E4
D4
H1



Note: Profiles 138 to 143 include oblique angles to parts of the shore, which will bias local determination of storm erosion & response to sea level rise. However, these effects were refined locally, due to influences of structures and low-lying topography.


HSD 2017
Wave Modelling Locations
Transects
0 500 1,000 m
B5
B4
B3
B2
B1
A0
A1
A2
A3
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163

Appendix F – Peel-Harvey Bathymetric Change

Evaluation of large-scale estuarine bed change within Peel Inlet and Harvey Estuary was reported previously in Damara WA (2019) and has been included here.

Measurement of the whole estuary bed has been conducted twice:

1. Through a set of leadline surveys in the 1970s, prior to undertaking substantial dredging works for navigation. This set of surveys, along with post-dredging surveys, was later collated by the Department of Marine and Harbours to support numerical modelling for the proposed Dawesville Channel.
2. Detailed LIDAR bathymetry survey conducted in 2016, on behalf of the Department of Water.

Comparison of estuary bed levels between the two surveys summarises estuarine change over more than 40 years, including changes that resulted from Dawesville Channel construction. However, differences in survey techniques constrain this comparison, with the earlier set of surveys having coarse coverage and relatively lower vertical precision.

For comparative analysis, two surfaces were developed with a grid spacing of 20m. The 1970s surface was generated through automated interpolation between coarse survey lines. The 2016 surface was generated through kriging, which develops a weighted average of the levels within each cell. A consequence of the different surveys and surface generation was a very smooth 1970s surface, including planar sections across areas of sparse data. By contrast, even after averaging over the grid cells, the 2016 surface retains substantial texture, indicating ripples, ridges, splays and other bedforms.

A difference plot was generated by subtracting the levels of the 1970s surface from those of the 2016 surface. Initial comparison of net change highlighted that the overall change was inconsistent with reporting to the relative vertical datums (i.e. the difference plot indicated a massive bed lowering across most of the estuary, which does not reflect observations). Identification of bed change was subsequently developed by assuming near zero volume change. The resulting vertical difference was approximately 0.21m, which matches a datum jump identified in Peel inlet tide gauge record (Appendix A).

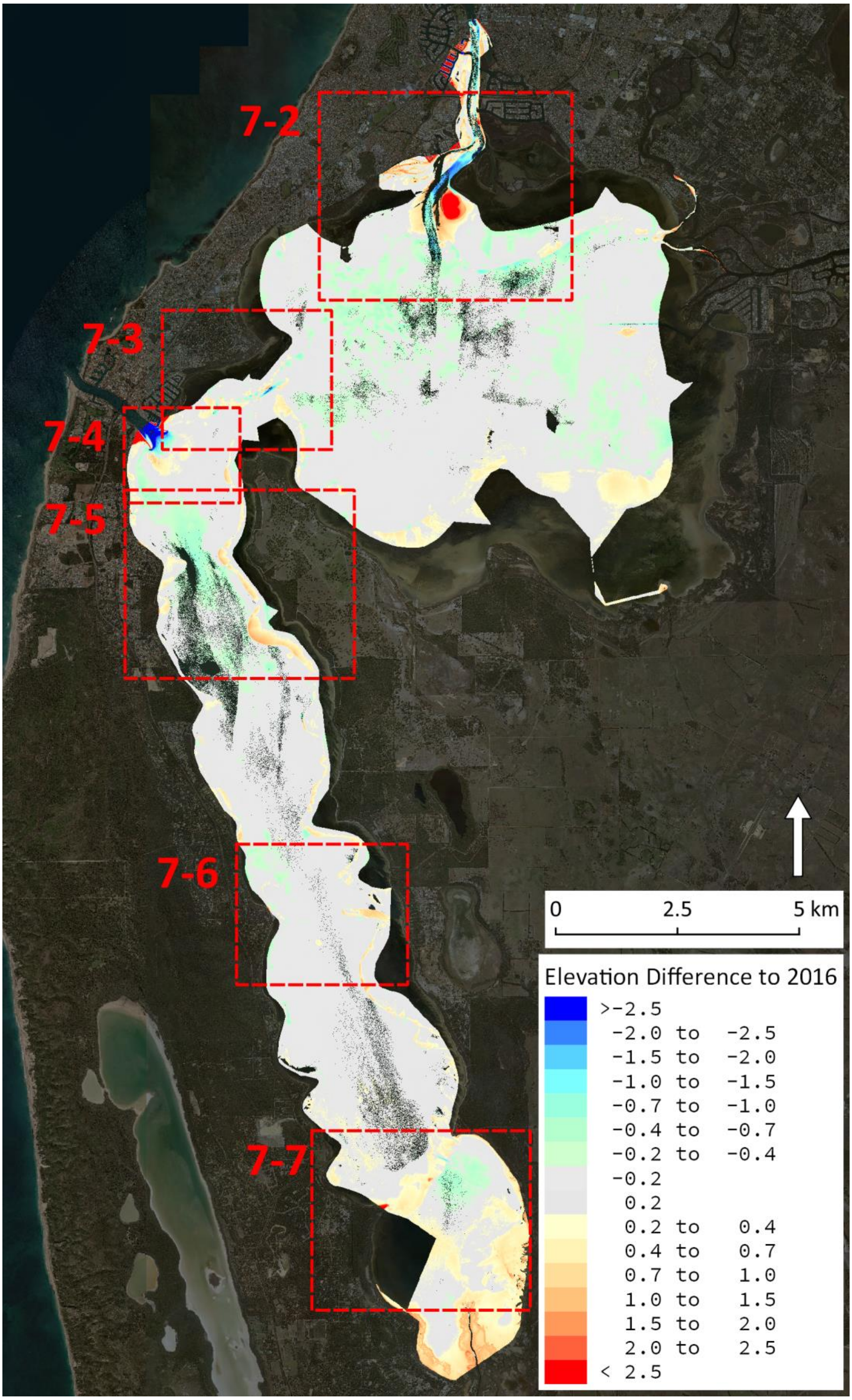


Figure F-1: Bathymetric Comparison

The survey comparison shows six areas of substantial change:

1) Sticks Channel and Channel Island (Figure F-2) were developed through dredging and reclamation in the 1980s (Paul & Hutton 1985).

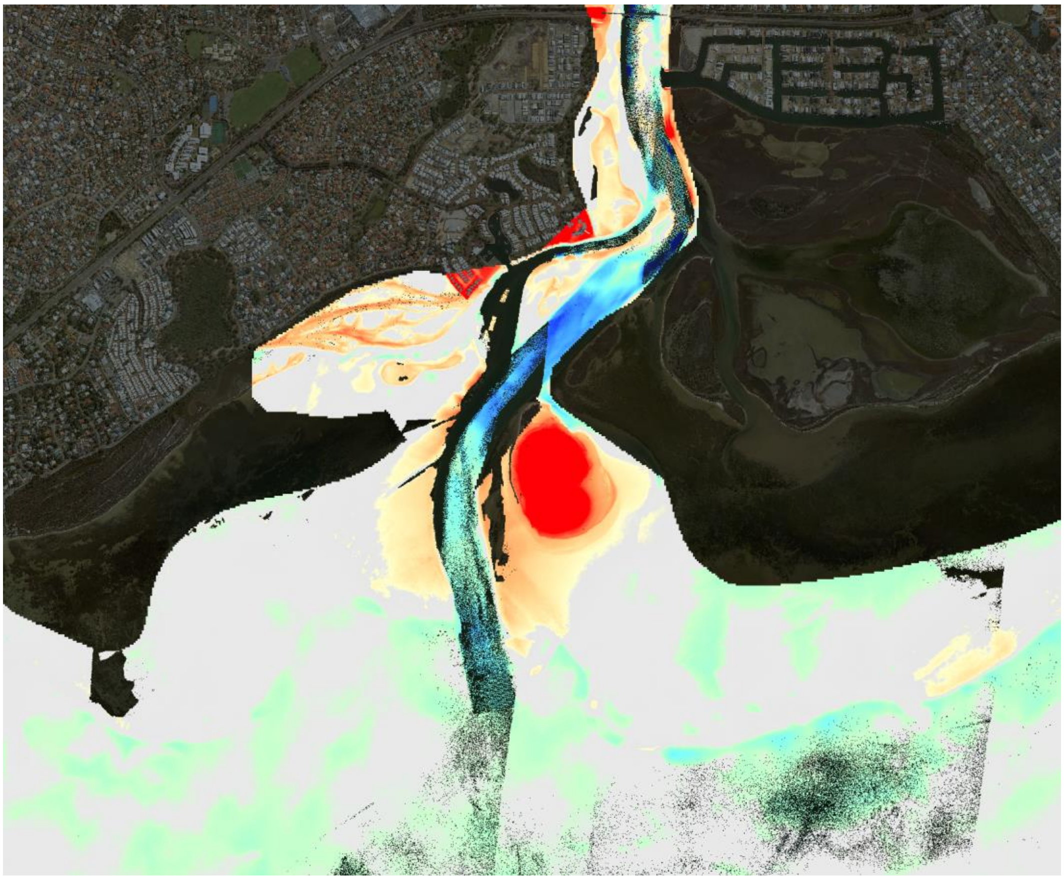


Figure F-2: Bathymetric Change near Sticks Channel

2) Grey Channel, between Peel Inlet and Harvey Estuary has experienced deepening, with some minor sedimentation of adjacent areas. This pattern is consistent with predictions of increased flow speeds through Grey Channel predicted as a response to construction of Dawesville Channel.

   A broad area of minor deepening was indicated east of Grey Channel, for approximately the western third of Peel Inlet. The cause of this pattern is unclear, as it may plausibly be a result of bed scour following construction of Dawesville Channel, loss of benthic vegetation; or a systematic vertical difference due to the difference between survey techniques.

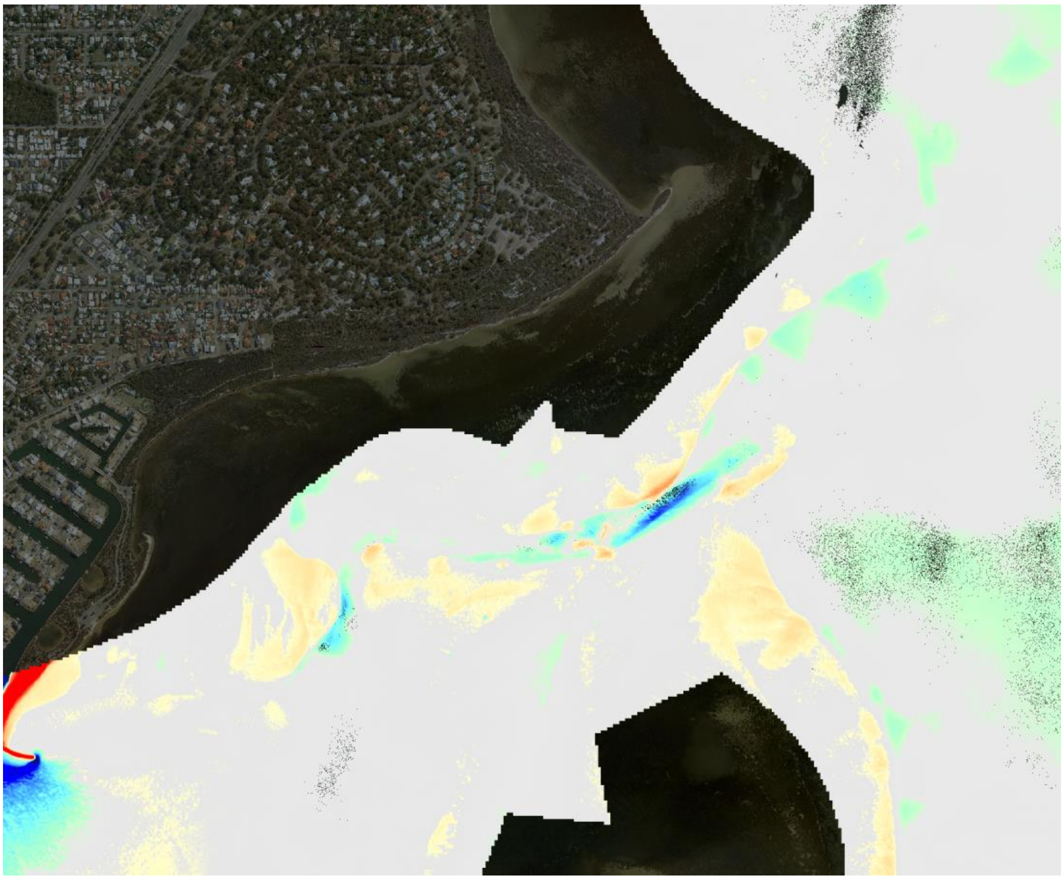


Figure F-3: Bathymetric Change near Grey Channel

The eastern end of Dawesville Channel exhibits characteristics of construction and subsequent evolution. The major 'bell mouth' feature that was constructed is now surrounded by a raised arc typical of flood sill. Secondary features occur inside the channel, including a sand shoal on the southern side, with a series of ridges connected to the shoal running part way across the channel. This creates a rippled bed structure for the flow in and out of the channel.

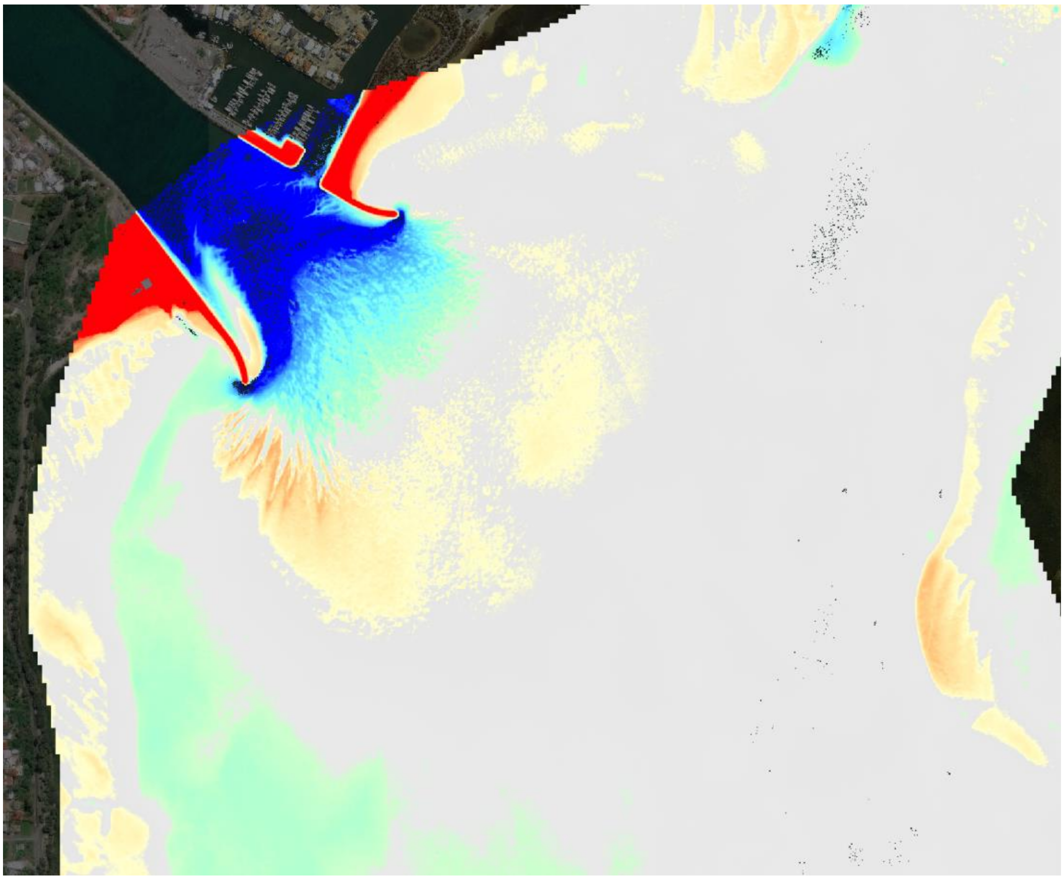


Figure F-4: Bathymetric Change near Dawesville Channel

3) South of Dawesville Channel, an area of bed lowering is indicated at the slight constriction across Harvey Estuary developed between two forelands. This is consistent with locally increased tidal currents following excavation of Dawesville Channel. The survey comparison also indicates deposition along the intertidal terrace east of the eroded area. Although this deposition is possibly where the eroded sediment was moved towards, it is also possible that this feature is created due to differences between the surveys, as coverage was extremely sparse on the terrace during the 1970s survey.

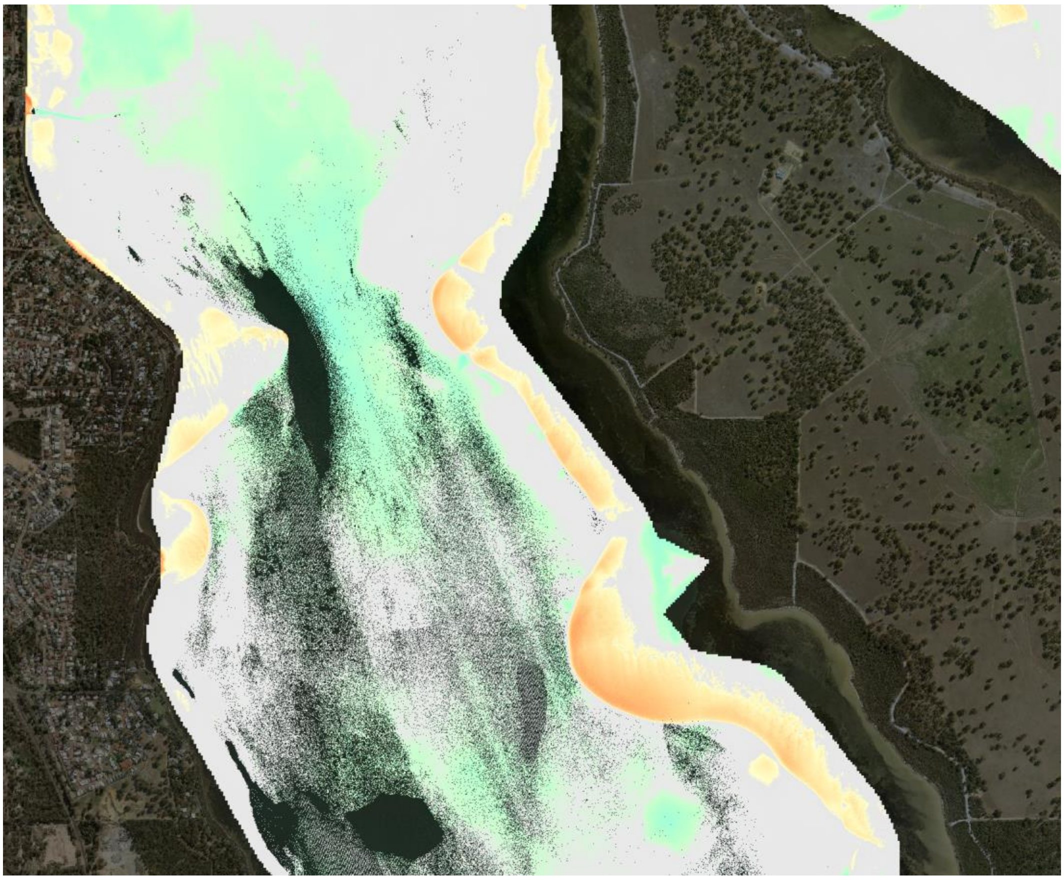


Figure F-5: Bathymetric Change south of Dawesville Channel

4) An extended linear shoal has developed on the eastern side of Harvey Estuary, which is also evident in aerial imagery. This feature started to develop in the 1980s and consequently its origin is unrelated to Dawesville Channel. The orientation of the shoal is similar to smaller transverse bars nearby along the eastern shore of Harvey Estuary. These are typically developed through a combination of wave action and tidal flows. Extended transverse bars normally occur where there is regular sediment supply such as a drainage outlet, however no such drain has been identified at this shoal.

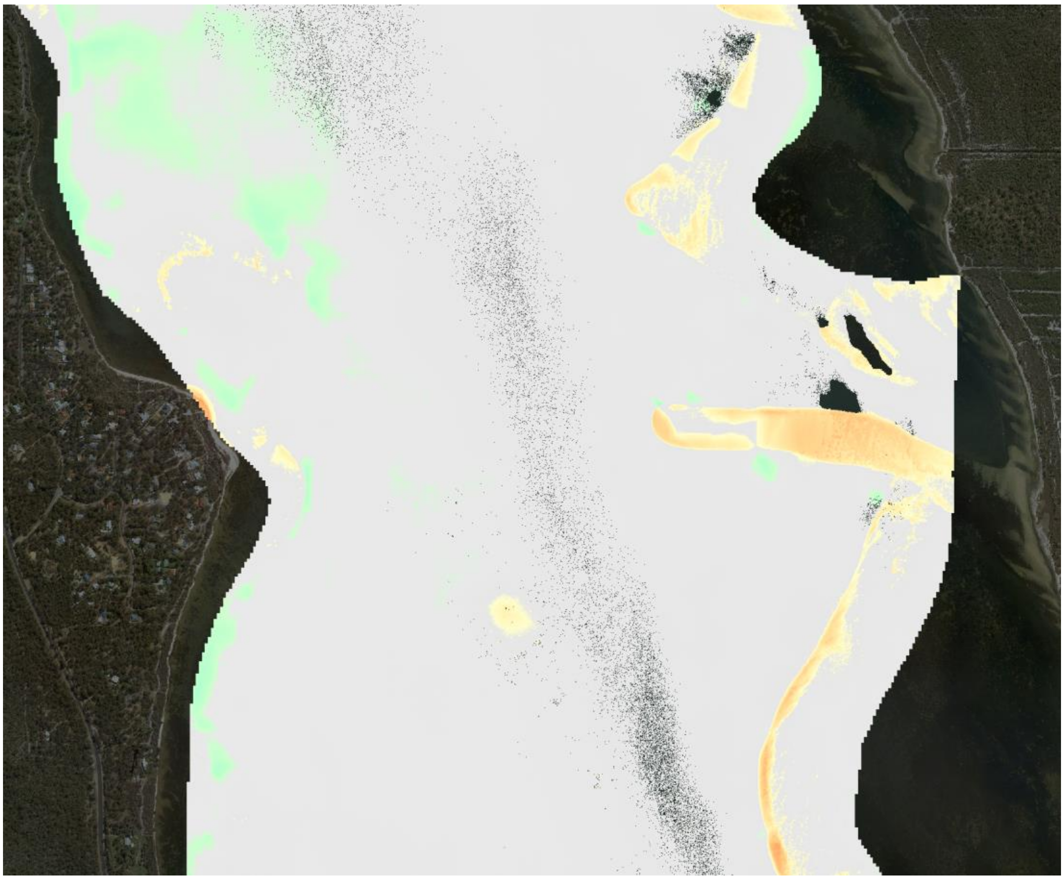


Figure F-6: Bathymetric Change near Birchmont

5) The ‘Ford’ between Island Point and Herron Point is a tidal sill, with survey comparison showing areas of erosion and accretion. Some of this change is due to survey differences, as the 1970s surveys had limited resolution of the channels. However, the dynamic nature of the sill feature is apparent from aerial imagery, with changes in the width of the sill and channel positions. Surveys should therefore be considered snapshots, rather than indicative of a long-term trend.

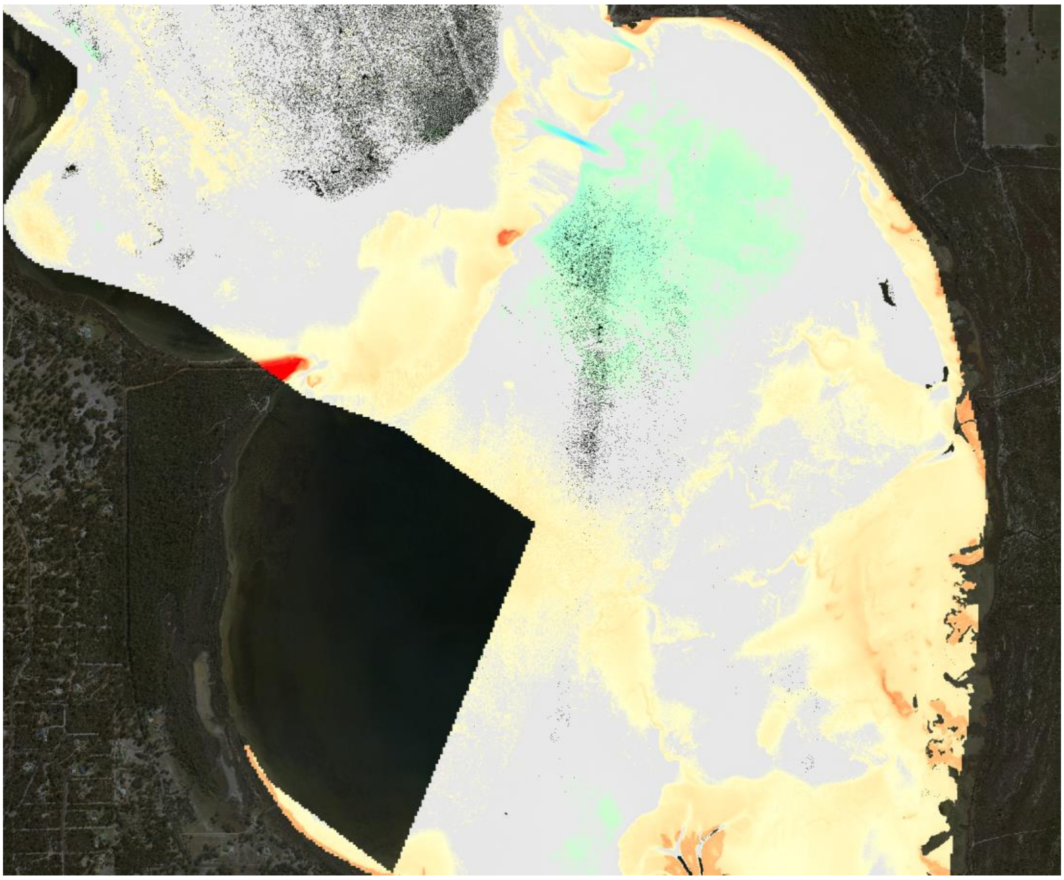
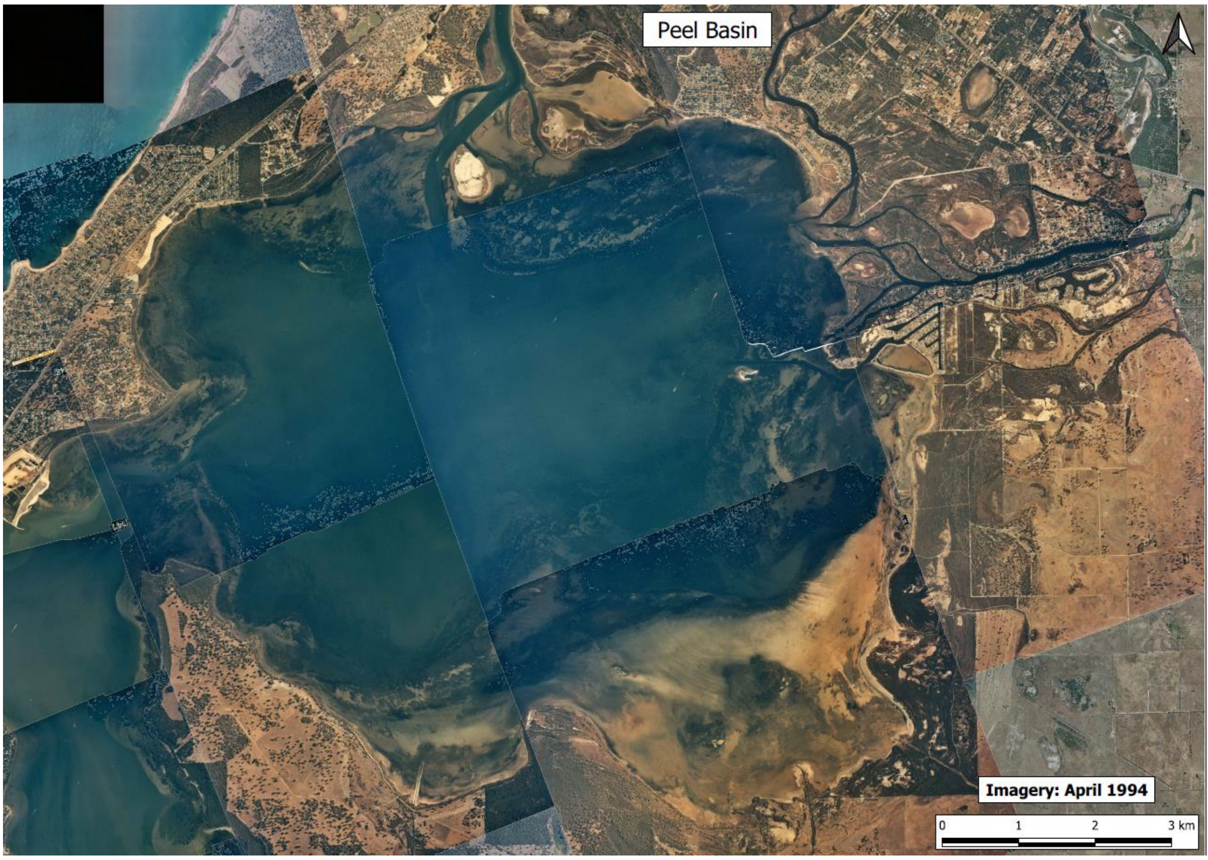
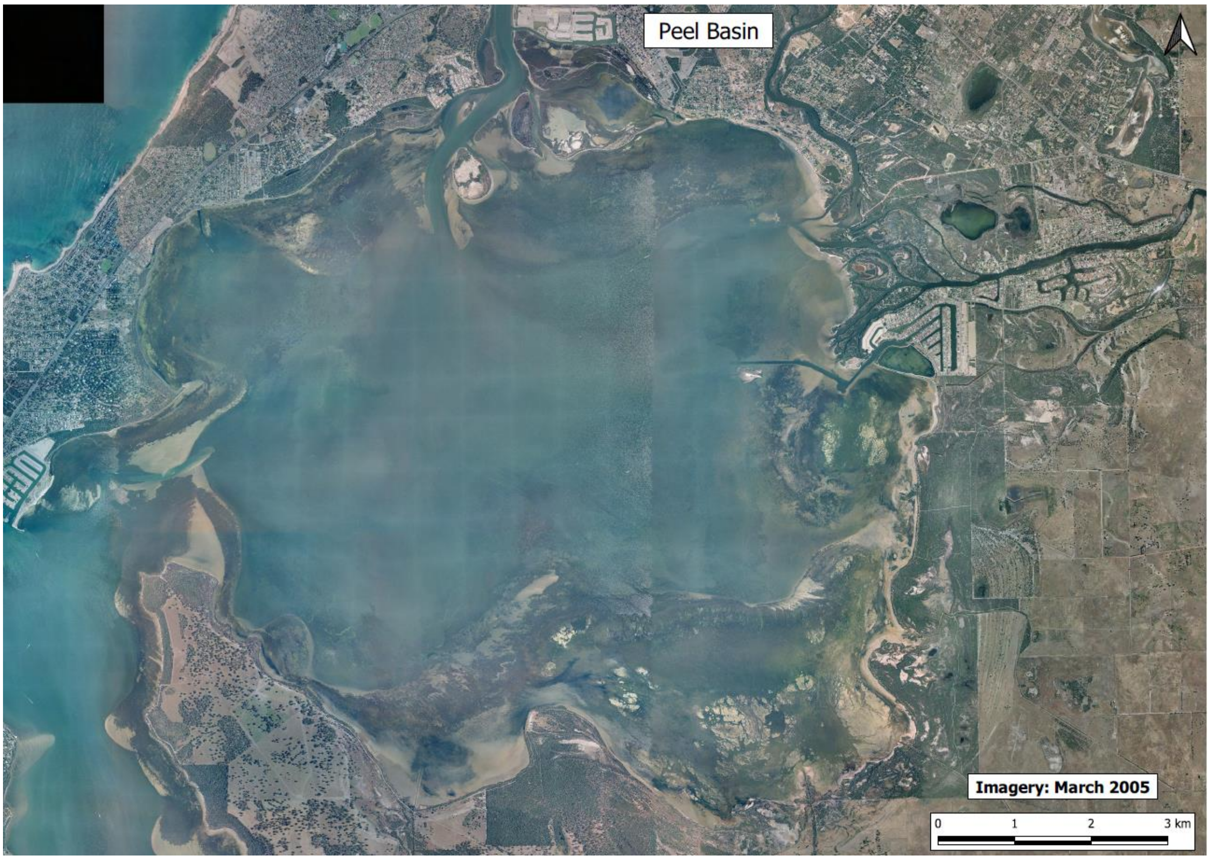
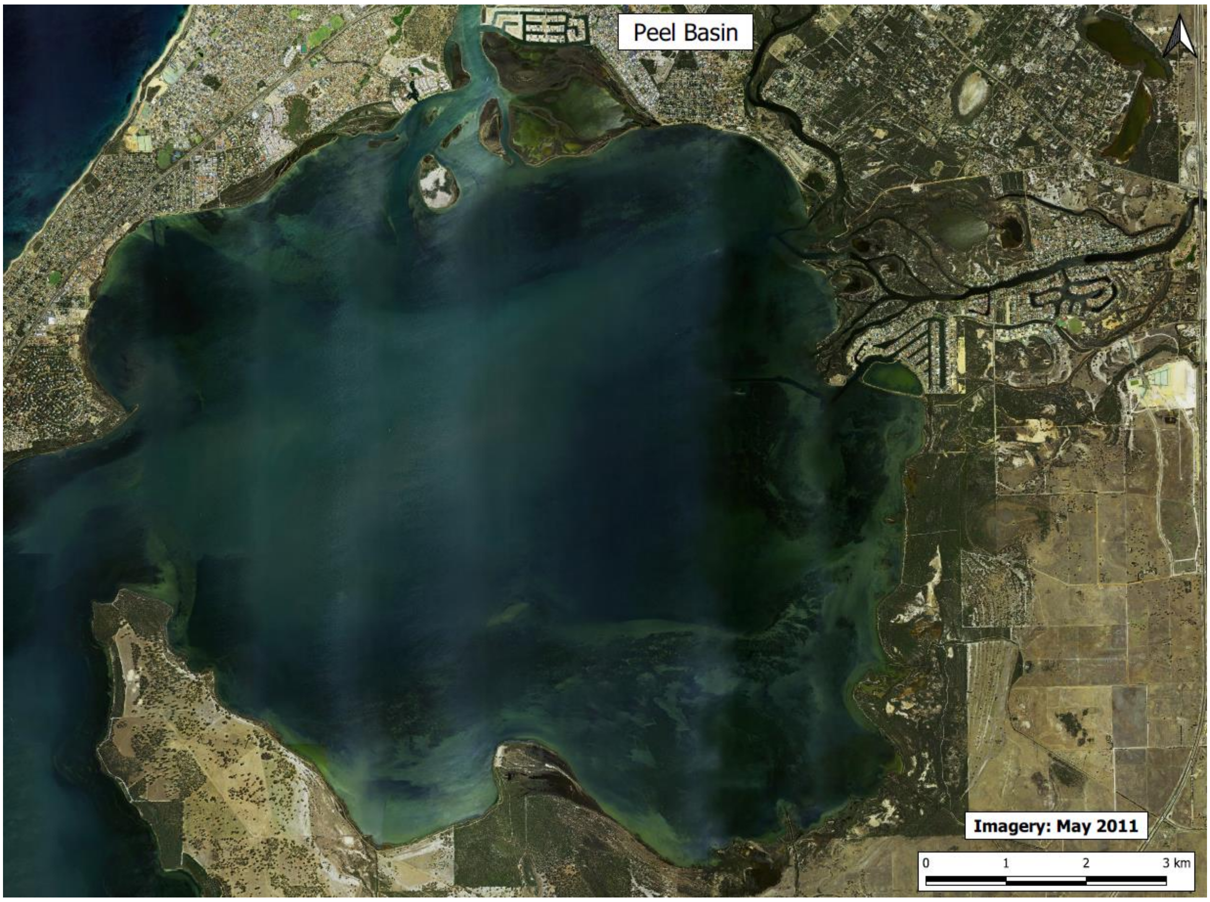


Figure F-7: Bathymetric Change near Island Point

Appendix G – Variability of Benthic Coverage






Peel Basin
Imagery: May 2011
0
1
2
3 km


Peel Basin
Imagery: May 2012
0
1
2
3 km

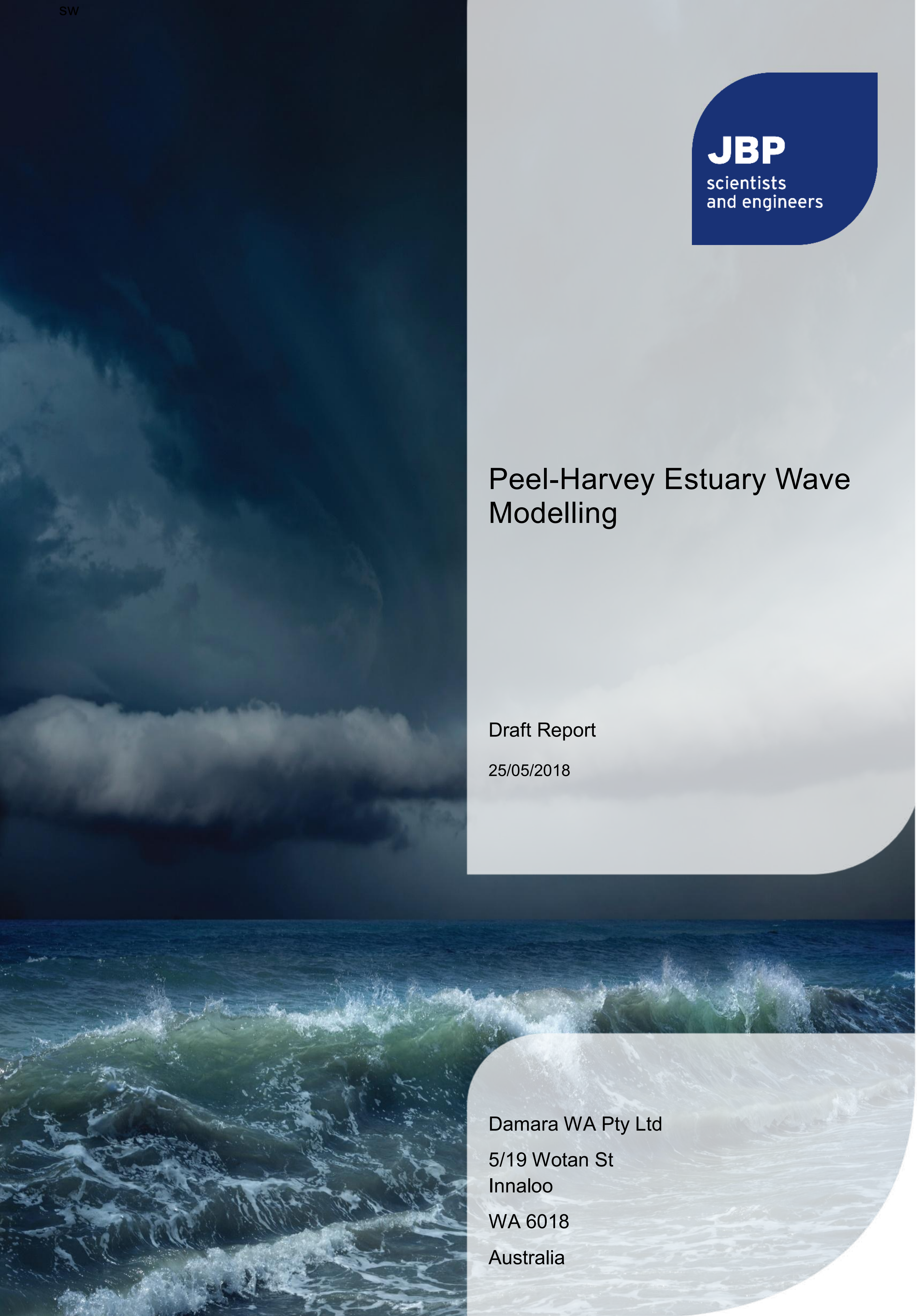

Peel Basin
Imagery: November 2015
0
1
2
3 km


Peel Basin
Imagery: October 2016
0
1
2
3 km


Peel Basin
Imagery: April 2017
0
1
2
3 km

Appendix H – Wave Hindcast Modelling Report

SW



JBP
scientists
and engineers

Peel-Harvey Estuary Wave Modelling

Draft Report

25/05/2018

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
1.0 (Draft) / 25 May 2018	-	ME

Contract

This report describes work commissioned by Matt Eliot, on behalf of Damara WA Pty Ltd, by an email from Matt Eliot on the 3rd of April 2018. Damara WA Pty Ltd's representative for the contract was Matt Eliot. Johnny Coyle and Daniel Rodger of JBP carried out this work.

Prepared by .... Johnny Coyle BSc MSc
Assistant Analyst

Approved by .... Daniel Rodger BSc MEng CEng CMarEng MIEAust MICE IMarEST
RPEQ 17794

Director

Purpose

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JBP has no liability regarding the use of this report except to Damara WA Pty Ltd.

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Executive Summary

JBP has been commissioned by Damara WA Pty Ltd to undertake wave modelling of the Peel-Harvey estuary to produce nearshore wave estimates along the shoreline for a range of scenarios. The modelling has used SWAN (Simulating WAves Nearshore), a third-generation wave model incorporating various wave transformation processes including wave-wave growth, propagation, shoaling, refraction, and breaking. The wave model was then used to simulate 224 design scenarios with varying wind speeds, directions and water levels, producing outputs at 964 locations.

Contents

List of Figures

List of Tables

1 Introduction

1.1 Background

JBP has been commissioned by Damara WA Pty ltd to produce a wave model of the Peel-Harvey Estuary near Mandurah, in Western Australia. The wave model was used to estimate nearshore wave conditions along the shoreline for a range of wind speed, wind direction and water level scenarios.

1.2 Site under investigation

The Peel-Harvey Estuary is a tidal water body in Western Australia, 60km south of Perth. It is relatively shallow, with depths rarely exceeding 3m below AHD. Described in terms of its component areas, the Harvey estuary is 21km long and 3km wide orientated north-north-east, and the Peel estuary is 7-10km wide (refer to Figure 1-1).

Figure 1-1: Peel-Harvey Estuary

2 Wave transformation modelling

Numerical wave modelling was undertaken to estimate wave growth and transformation within the estuary. The modelling approach, assumptions and results are described in this chapter.

2.1 Approach

Modelling has been undertaken using the SWAN (Simulating WAves Nearshore) wave model. SWAN is a third-generation wave model incorporating complex physics for the description of wave growth and transformation processes. It is an open source package and is capable of simulating various wave transformation processes in 2D, including, shoaling, refraction, wind-wave interaction, breaking and dissipation.

The following assumptions have been made:

1. Uniform still water levels exist throughout the estuaries.

The modelling assumed a uniform water level throughout the estuary. No information on water level gradients was available, and given the small scale of the model domain, was deemed appropriate.

2. No influence of ocean generated swell waves:

Only waves generated from wind within the estuary was considered. No additional boundary conditions were applied to consider ocean swell.

3. Uniform wind field:

The model assumed a uniform wind speed and direction throughout the domain.

2.2 Computational mesh

The mesh was constructed as an ADCIRC grid in SMS, with the landward boundary extending to the 2-3mAHD contours adjacent to the estuary.

Mesh spacing was varied around the model boundary, with higher mesh resolution in Mandura, Dawesville, Brunswick Island and Point Grey. Maximum node spacing along the shoreline was approximately 200m at the southern estuary, increasing to a 20m resolution at the Dawesville Channel, Mandura Channel and Serpentine River. The computational mesh is shown in Figure 2-1.

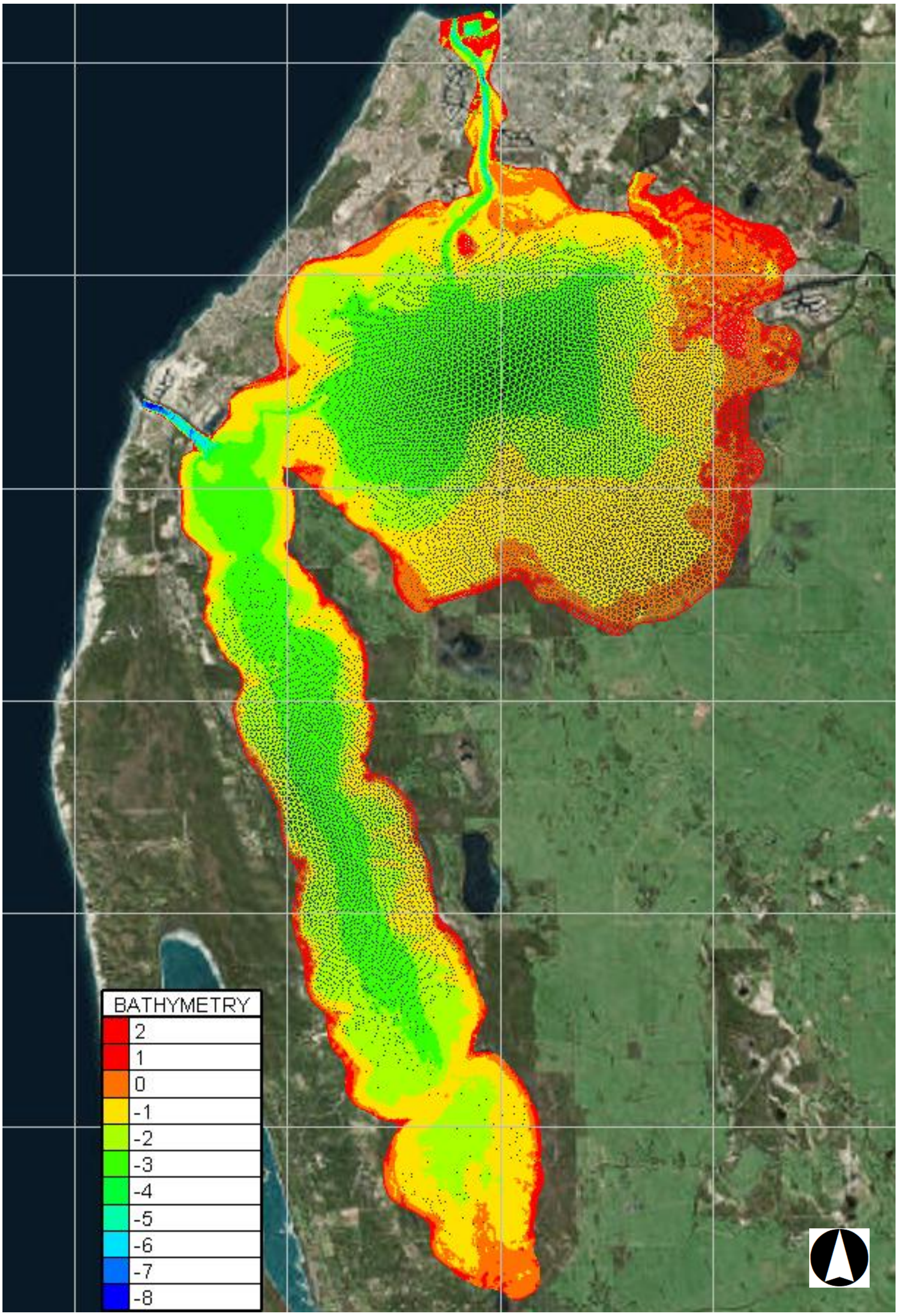

Figure 2-1: Model mesh and bathymetry

2.3 Model setup

2.3.1 Bathymetry

Model bathymetry was obtained from a 20m resolution point-cloud containing X,Y,Z data, supplied by the client. This was integrated into the model by sampling the depth at the mesh node locations.

2.3.2 Water level

A constant water level was applied throughout the domain.

2.3.3 Calibration

No observed wave parameters were available within the estuary for use in calibration. As a result, no formal calibration wave undertaken against observed data, and default model parameters were adopted for wave growth and bottom friction schemes (JONSWAP and Komen, respectively).

2.3.4 Convergence

Testing of the default parameters under a range of wind conditions was undertaken, with the model shown to converge to 99 or 99.5%. This was deemed acceptable for the model purpose.

2.3.5 Model sensitivity

The sensitivity of the model to different model parameters was tested at a location in the middle of the Harvey estuary at -2.27mAHD (374422E , 6386530S MGA zone 50, SWAN Node 13564). A constant water level, wind speed and direction were applied across the domain, and a range of physics and bottom friction terms altered. The resulting change in wave conditions are presented in Table 2-1.

Table 2-1: Model sensitivity to bottom friction and physics parameters

Physics	Bottom Friction	Hs (m)	Tp (sec)	Peak Direction
***JONSWAP**	***Komen et al.**	0.71	2.63	355
Janssen	*Komen et al.*	0.83	2.62	005
Westhuysen	*Komen et al.*	0.77	2.59	355
JONSWAP	*Collins*	0.72	2.65	355
JONSWAP	*Madsen et al.*	0.54	2.16	355
* Default				

2.4 Model simulations

The wave model was run for 224 iterations of wind and water level. The Mean Sea Level MSL (-0.17mAHD) was used for 144 simulations, with an additional 40 simulations under a high water level (+0.13m) and low water level (-0.47m) condition. The forcing conditions for these runs are displayed in Table 2-2 to Table 2-3.

Output wave conditions have been produced at of 964 locations situated around the shoreline of the estuary. These locations were all situated at approximately -1mAHD contour.

Outputs were supplied as 964 CSV datasheets, listing the toe number, output coordinates, input conditions, and estimated wave conditions.

Table 2-2: Modelled wind speeds and directions for Mean Sea Level simulations

Direction (Deg/N)	Windspeed (Km/hr)									
	10% of year	*3.0% of year*	*1.0% of year*	*0.3% of year*	*0.1% of year*	*1-yr ARI*	*3-yr ARI*	*10-yr ARI*	*30-yr ARI*	*100-yr ARI*
000.0			37.5	45.0	51.0	56.0	60.3	64.0	67.4	70.3
022.5		24.7	33.7	40.5	45.9	50.4	54.3	57.6	60.6	63.3
045.0		20.4	27.9	33.5	38.0	41.7	44.9	47.7	50.2	52.4
067.5		17.3	23.7	28.4	32.2	35.4	38.1	40.4	42.5	44.4
090.0		16.0	21.9	26.3	29.8	32.7	35.2	37.4	39.3	41.1
112.5		16.4	22.4	26.8	30.4	33.4	36.0	38.2	40.2	42.0
135.0	7.6	17.1	23.4	28.1	31.9	35.0	37.7	40.0	42.1	44.0
157.5	8.1	18.3	25.0	30.0	34.0	37.4	40.2	42.7	44.9	46.9
180.0		19.3	26.4	31.7	35.9	39.4	42.5	45.1	47.4	49.5
202.5		20.8	28.5	34.2	38.7	42.5	45.8	48.6	51.1	53.4
225.0		22.0	30.1	36.1	41.0	45.0	48.4	51.4	54.1	56.5
247.5		24.7	33.7	40.5	45.9	50.4	54.2	57.6	60.6	63.3
270.0		28.3	38.7	46.5	52.7	57.9	62.3	66.2	69.6	72.7
292.5		29.4	40.2	48.3	54.7	60.1	64.7	68.7	72.3	75.5
315.0		30.4	41.5	49.9	56.5	62.1	66.8	71.0	74.6	78.0
337.5			40.0	48.0	54.4	59.8	64.3	68.3	71.9	75.1

Table 2-3: Modelled wind speeds and directions for high and low sea level simulations (+/- 0.3m)

Direction (Deg/N)	Windspeed (Km/hr)				
	1.0% of year	*0.1% of year*	*1-yr ARI*	*10-yr ARI*	*100-yr ARI*
000.0	37.48	51.00	55.99	64.02	70.34
045.0	27.94	38.02	41.74	47.73	52.44
067.5	23.66	32.20	35.36	40.43	44.42
090.0	21.88	29.78	32.70	37.38	41.08
112.5	22.35	30.41	33.39	38.18	41.95
135.0	23.42	31.87	35.00	40.01	43.96
157.5	25.00	34.01	37.35	42.70	46.92
180.0	26.39	35.91	39.43	45.08	49.53

3 Summary

A wave model was developed for the Peel-Harvey Estuary to estimate nearshore wave conditions along the shoreline for a range of wind speed, wind direction and water level scenarios.

Output wave conditions have been produced at of 964 locations situated around the shoreline of the estuary. These locations were all situated at approximately -1mAHD contour.

A Appendix A: SWAN output samples

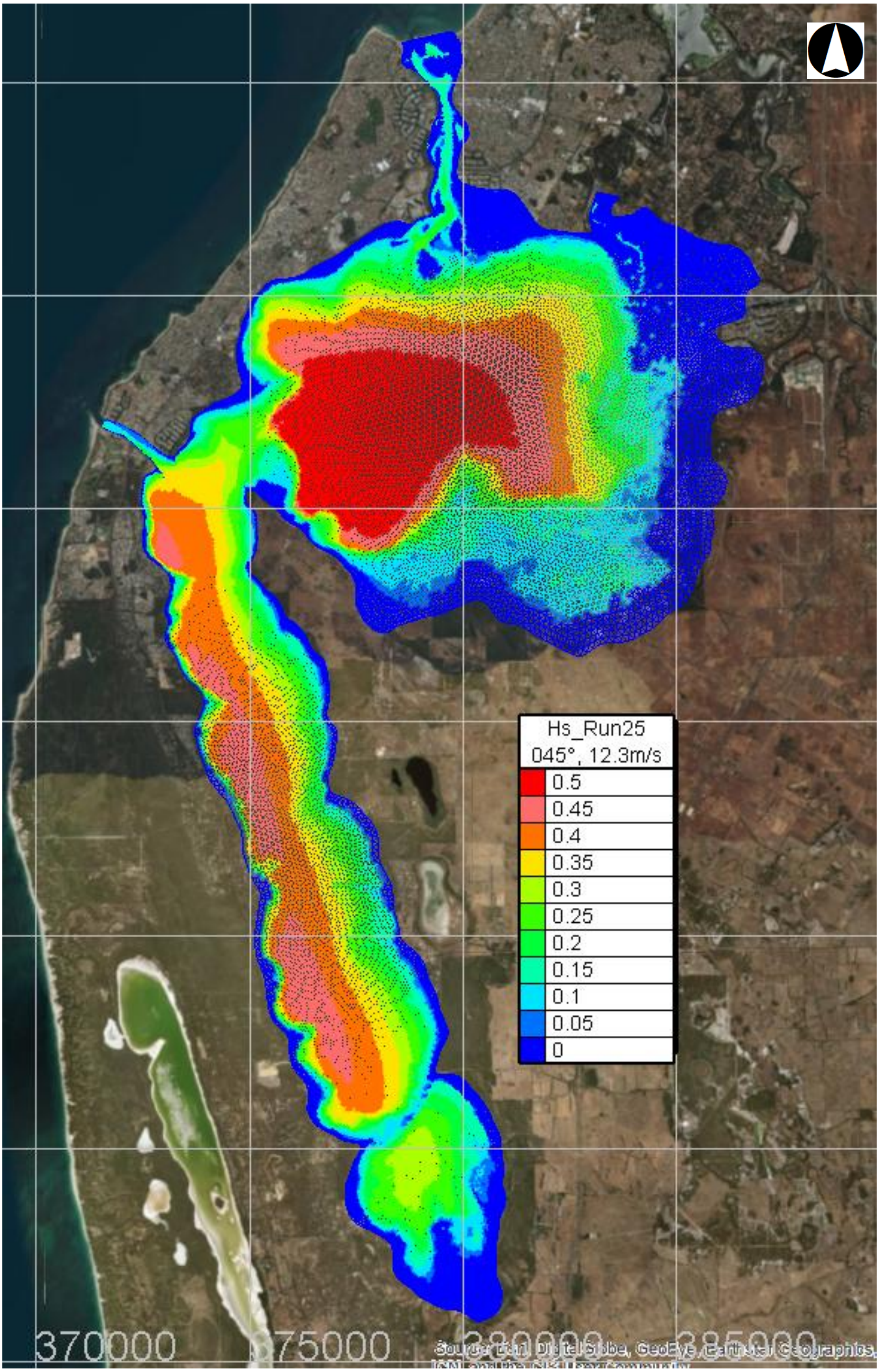

Figure A-1: Significant Wave Height for run 25 using a 12 m/s wind from 045º

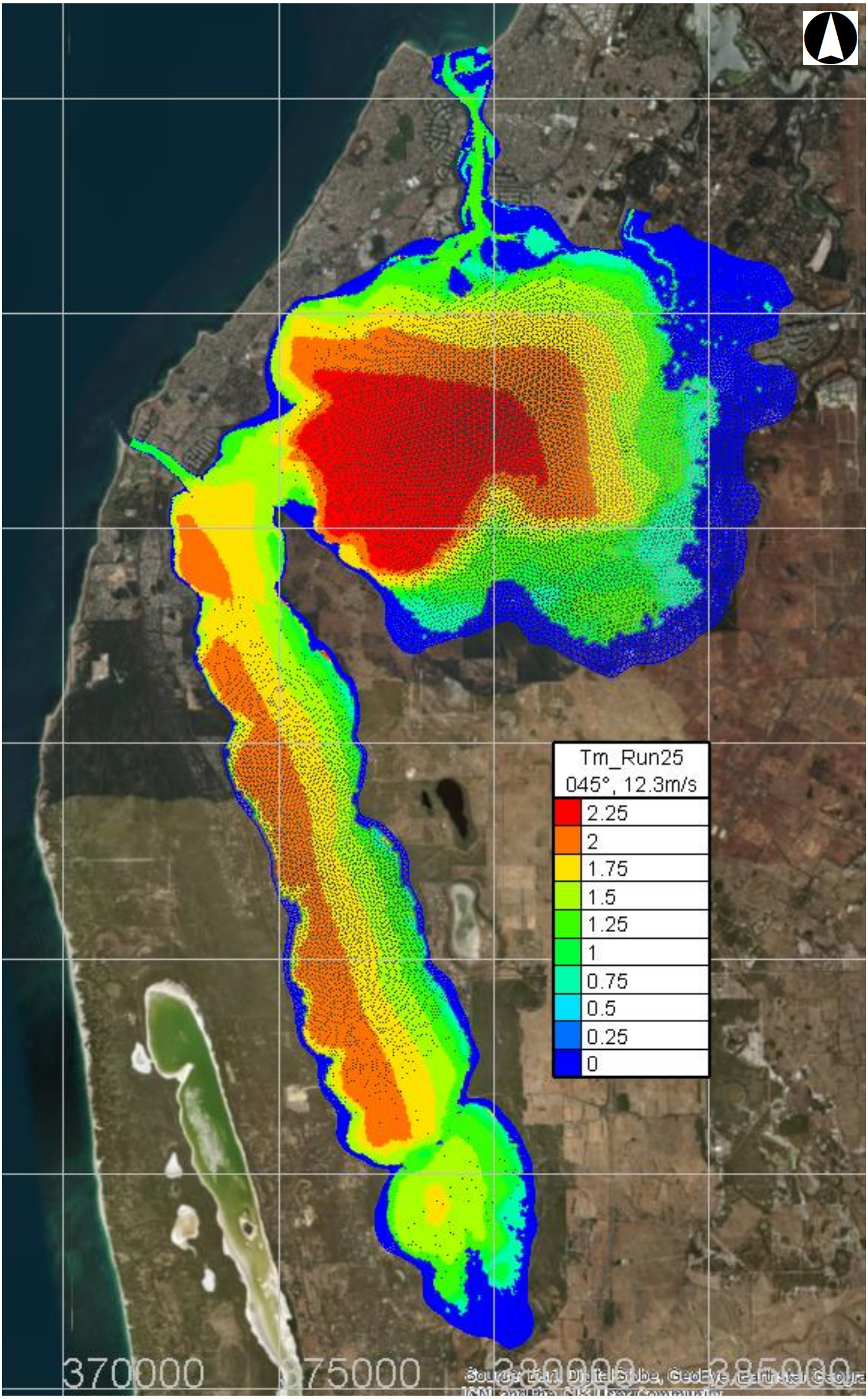

Figure A-2: Mean wave period for run 25 using a 12 m/s wind from 045°

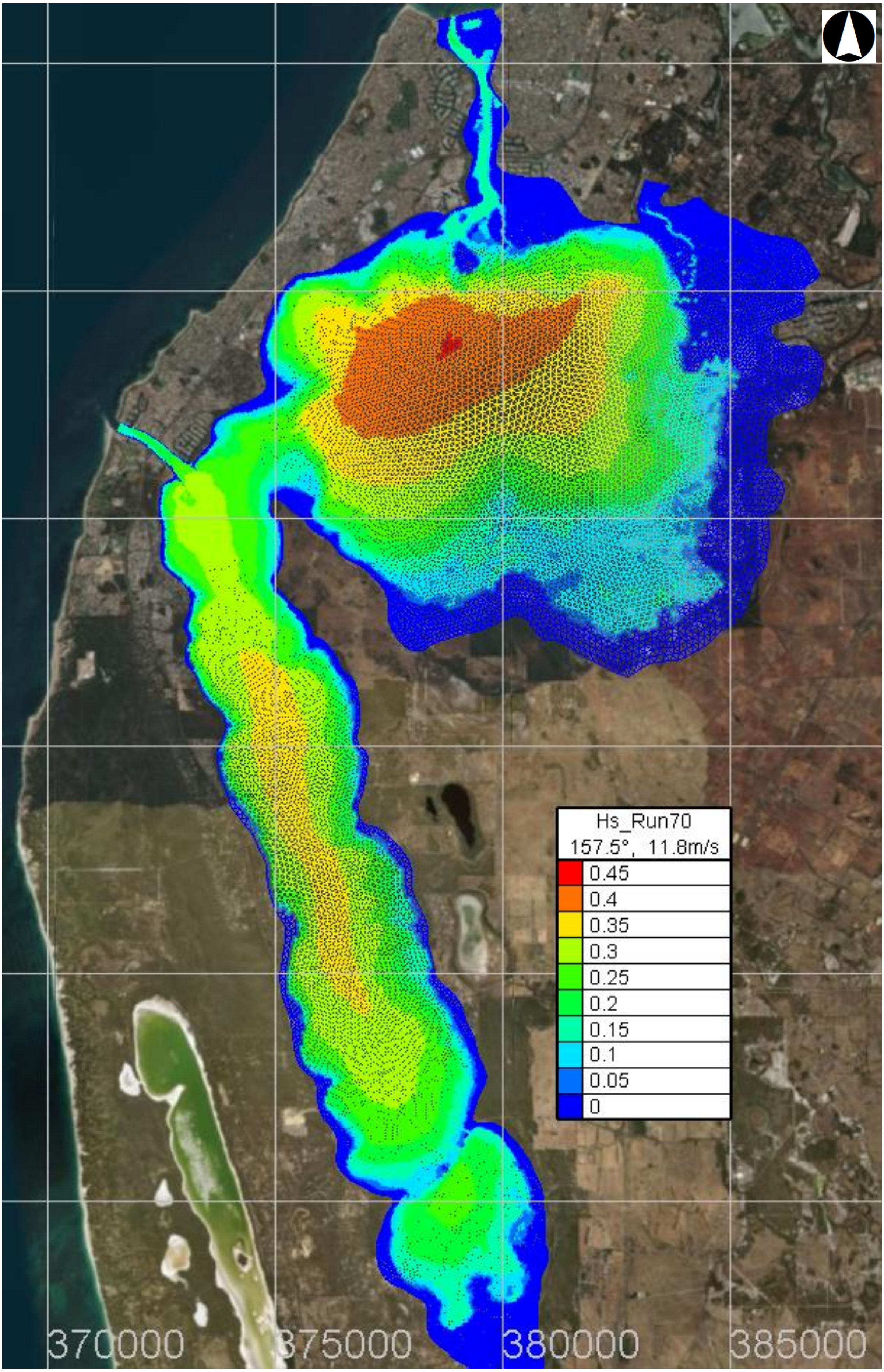

Figure A-3: Significant Wave Height for run 70 using a 11.8 m/s wind from 157.5º

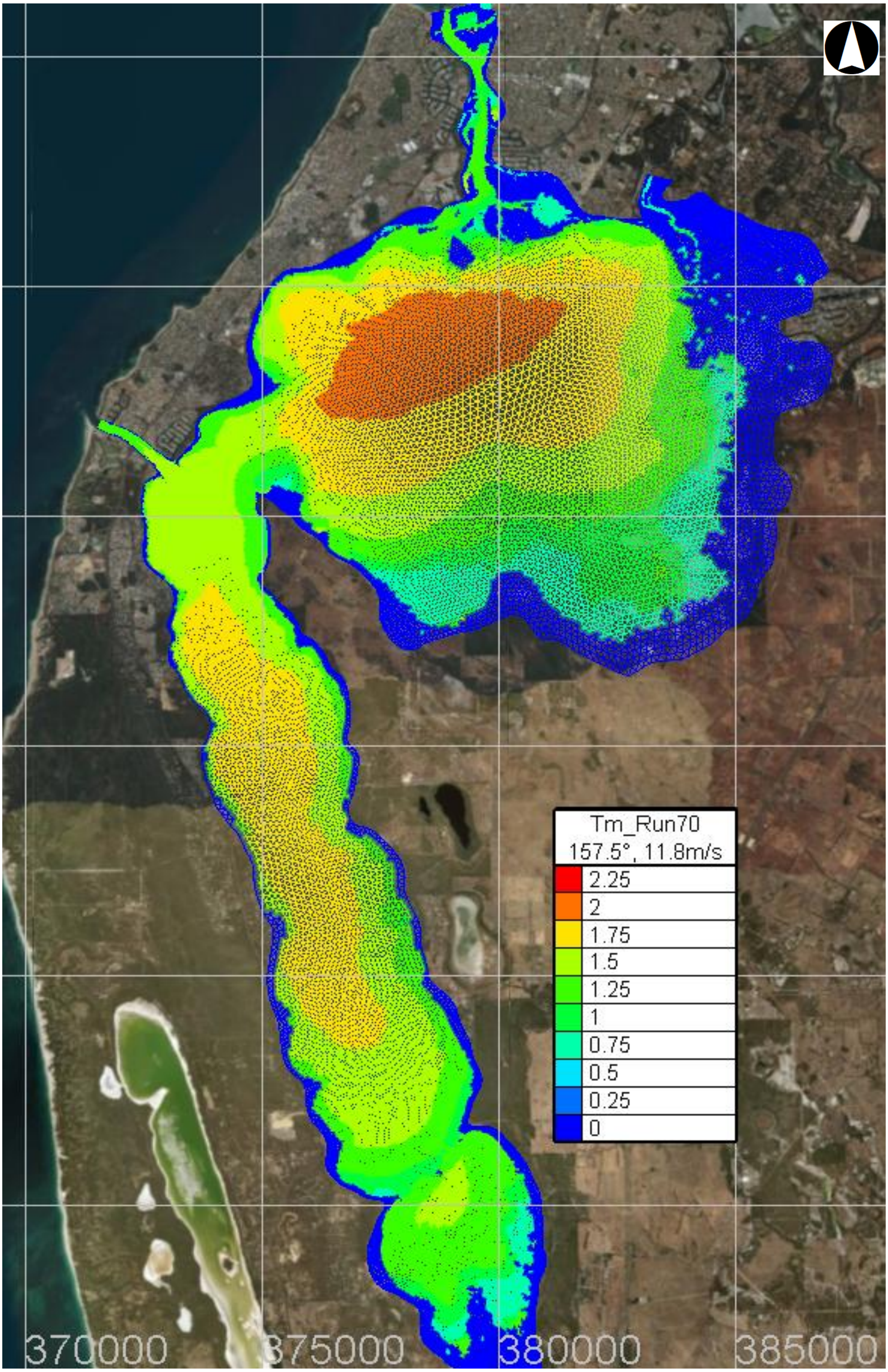

Figure A-4:: Mean Wave period for run 70 using a 11.8 m/s wind from 157.5º

B Appendix B: Sample output data

RunID	SWAN Node	Output Node	X	Y	Hs	Tm	PkDir	Dir	Wave length	Bottom Level	dHS	WL	Wdir	WSpeed_m/s
1	6737	16	378999	6377094	0.30	1.94	305	311	2.85	1.17	0.00	-0.17	0	12.5
2	6737	16	378999	6377094	0.33	2.03	295	308	3.05	1.17	0.00	-0.17	0	14.2
3	6737	16	378999	6377094	0.35	2.09	295	307	3.12	1.17	0.00	-0.17	0	15.6
4	6737	16	378999	6377094	0.36	2.12	295	306	3.16	1.17	0.00	-0.17	0	16.7
5	6737	16	378999	6377094	0.36	2.14	295	306	3.15	1.17	0.00	-0.17	0	17.8
6	6737	16	378999	6377094	0.37	2.15	295	306	3.14	1.17	0.00	-0.17	0	18.7
7	6737	16	378999	6377094	0.37	2.15	295	307	3.15	1.17	0.00	-0.17	0	19.5
8	6737	16	378999	6377094	0.14	1.36	315	330	1.52	1.17	0.00	-0.17	23	6.9
9	6737	16	378999	6377094	0.20	1.54	315	332	1.87	1.17	0.00	-0.17	23	9.4
10	6737	16	378999	6377094	0.23	1.67	315	329	2.16	1.17	0.00	-0.17	23	11.3
11	6737	16	378999	6377094	0.26	1.76	315	328	2.35	1.17	0.00	-0.17	23	12.8
12	6737	16	378999	6377094	0.28	1.83	305	326	2.53	1.17	0.00	-0.17	23	14.0
13	6737	16	378999	6377094	0.30	1.88	305	324	2.61	1.17	0.00	-0.17	23	15.1
14	6737	16	378999	6377094	0.31	1.93	305	323	2.74	1.17	0.00	-0.17	23	16.0
15	6737	16	378999	6377094	0.32	1.96	305	322	2.79	1.17	0.00	-0.17	23	16.8
16	6737	16	378999	6377094	0.33	1.98	305	321	2.79	1.17	0.00	-0.17	23	17.6
17	6737	16	378999	6377094	0.07	1.13	315	324	1.06	1.17	0.00	-0.17	45	5.7
18	6737	16	378999	6377094	0.12	1.25	325	342	1.27	1.17	0.00	-0.17	45	7.8
19	6737	16	378999	6377094	0.16	1.34	335	349	1.47	1.17	0.00	-0.17	45	9.3
20	6737	16	378999	6377094	0.18	1.42	335	352	1.68	1.17	0.00	-0.17	45	10.6
21	6737	16	378999	6377094	0.20	1.47	335	352	1.76	1.17	0.00	-0.17	45	11.6
22	6737	16	378999	6377094	0.21	1.50	335	352	1.80	1.17	0.00	-0.17	45	12.5

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Appendix I – Extreme Storm Flooding Assessment

Working Note

Baird.
Innovation Engineered.

Project/Proposal Number :	13064.101	**Date**	7 October 2020
Staff Member :	RLW		
Title :	Shire of Murray Design Storm Summary		
Summary / Description :	Overview of the modelling carried out to define a water level under design storm conditions at Mandurah, WA, for defining a design storm water level within the Peel-Harvey Estuary		
File Reference :	13064.101.W.RLW.RevA_ShireofMurrayDesignStormSummary		

Model Setup

Baird's established and validated numerical model of the West Australian coast, developed and validated for a recent inundation study for the Shire of Gingin, has been utilised for modelling of the design storm water level outside of the Peel-Harvey Estuary. The Delft-FM model extent covers the entire west coast of Western Australia from Northwest Cape to Cape Leeuwin as shown in Figure 1. There is varying model resolution, highest along the coastline areas, with Figure 2 showing resolution and observation points used in the modelling outside of the Peel-Harvey Estuary.

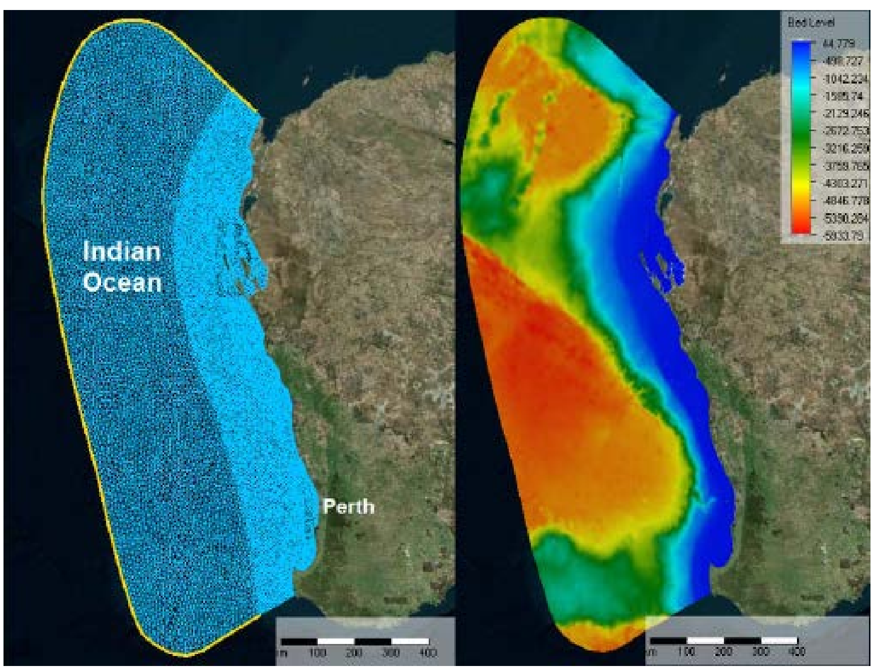

Figure 1: Model resolution and bathymetry

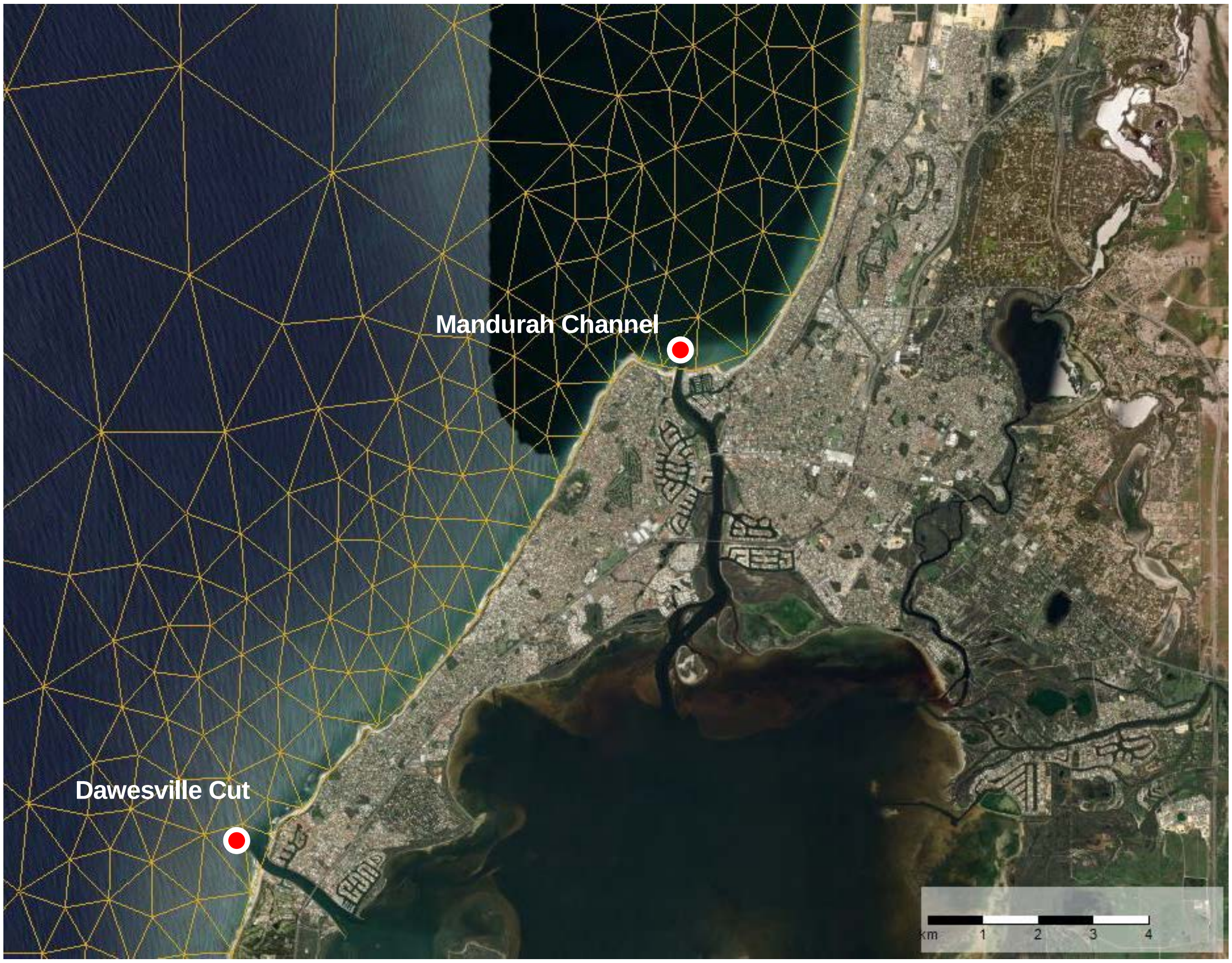

Figure 2: Model resolution outside of the Peel-Harvey Estuary, with observation points used in the modelling

Wave Model

The wave model adopted for the simulation of wave conditions in this assessment is the industry standard SWAN wave model (Simulating Waves Near Shore) developed at Delft University of Technology in the Netherlands. SWAN is a third-generation spectral wave model which computes wave propagation, wave generation by wind, non-linear wave-wave interactions and dissipation, for a given bottom topography, wind field, water level and current field (Deltares 2019).

The SWAN model accounts for (refractive) propagation due to current and depth and represents the processes of wave generation by wind, dissipation due to whitecapping, bottom friction and depth-induced wave breaking and non-linear wave-wave interactions (both quadruplets and triads) explicitly with state-of-the-art formulations. Wave blocking by currents is also explicitly represented in the model (Deltares 2019).

For the Gingin study, a coupled SWAN model was established across the same extent as the hydrodynamic model, comprised of five nested grids which increase in resolution approaching the Gingin Study area at 5km, 1km, 500m, 100m and 50m resolutions. For this study, the outer grid, covering the coast down to Mandurah, has been used to model the waves (Figure 3). It should be noted that this outer grid resolution is low to accurately estimate wave setup. In line with this, it is likely that the wave setup is being overestimated by the model as the wave model resolution is too low to define the breaking zone in detail. This model limitation should be taken into consideration when assessing model results.

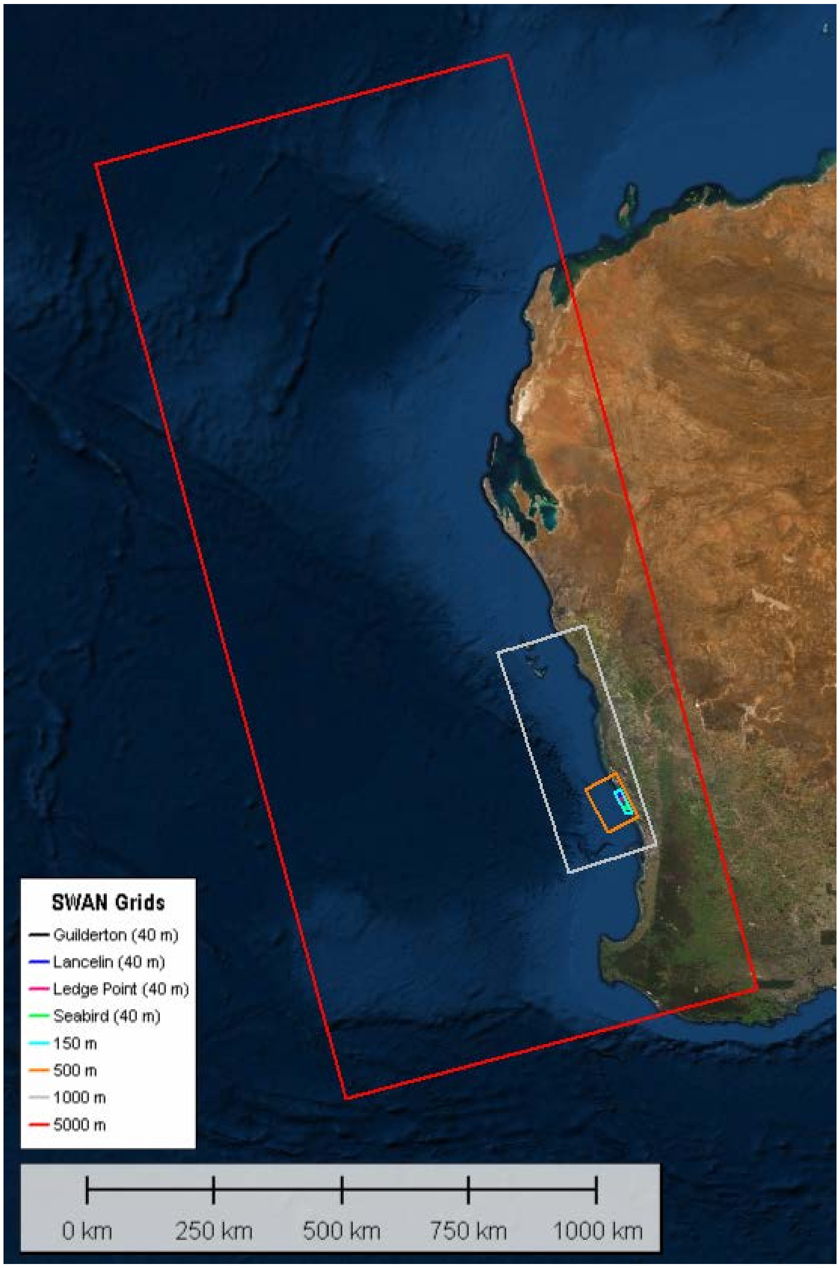

Figure 3: SWAN Model Grid extending across entire D-FM Model Domain (5000m grid size)

Wind Model

The wind model adopted in this study is Baird's Cycwind model system that adopts a Holland (2010) spatial cyclone vortex model. The cyclone wind field has adopted track parameters from the BoM's best track database (BoM, 2019) with adjustment of the Radius to Gales (R34) and Radius to Outer Closed Isobar (ROCI) parameters to better describe the windfield along the coastal waters of southwestern WA as the system track south. The design cyclone tracks for the Peel study area presented in Seashore Engineering (2020) are based on the TC Ned track and the TC Alby Track. Further information on the cyclone wind field model including validation for historical events is presented in Baird (2020b).

Maximum winds experienced for the Peel region during the passage of the design cyclones are detailed in Table 1.

Table 1: Maximum wind speeds across the Peel Region during passage of Seashore Engineering Design Cyclones

Design Cyclone	Peel Region Maximum Wind Speed (m/s)
TC Alby	39.5
TC Ned	43

Design Storms

Design storms based on Tropical Cyclone Ned (Figure 4) and Tropical Cyclone Alby (Figure 5) are presented below, including the central pressure associated with the cyclone track. Table 2 and Table 3 tabulate the central pressure and radius to maximum winds associated with each design storm.

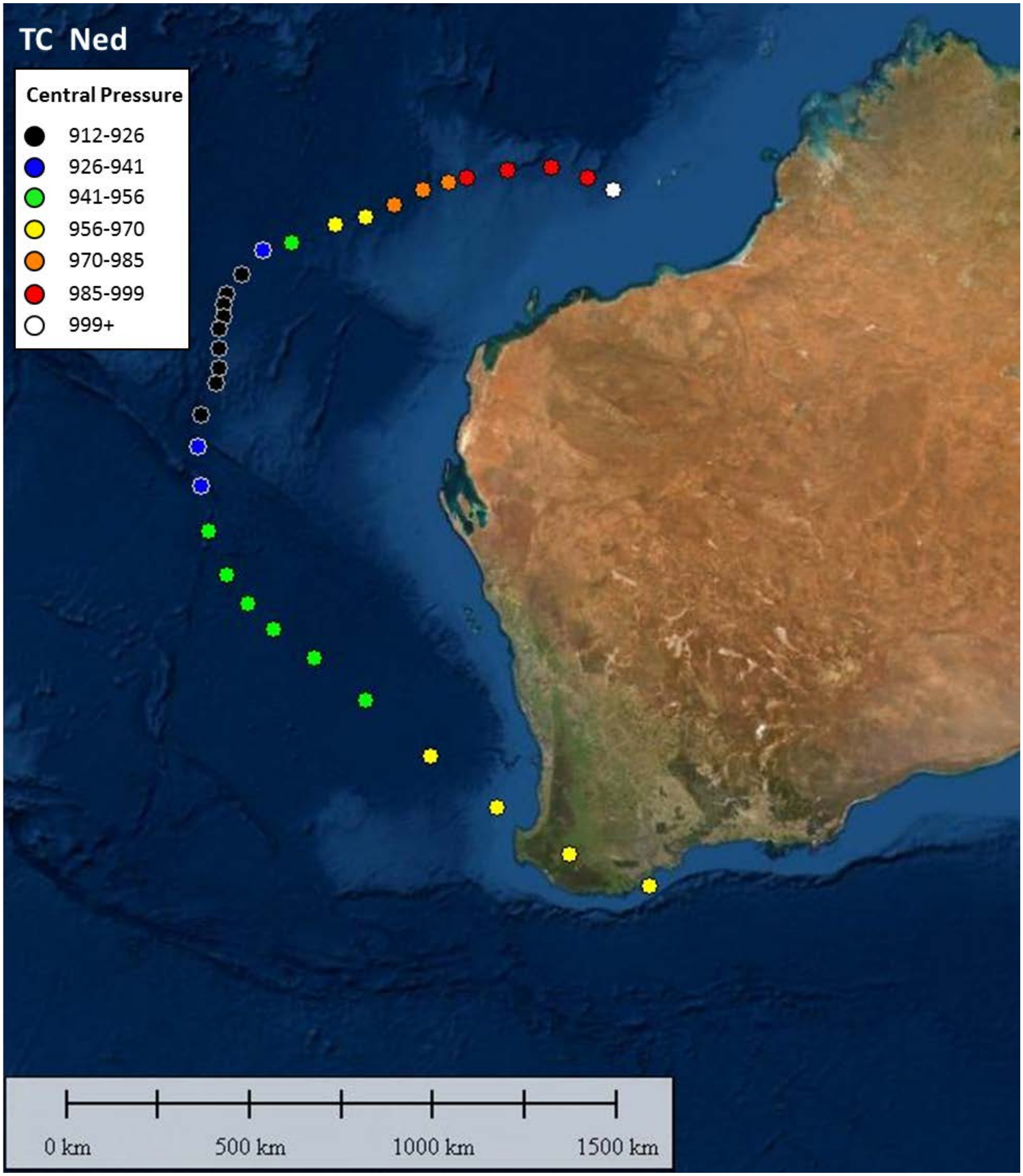

Figure 4: Path of Design Storm for Peel, based on Tropical Cyclone Ned, showing a scale of central pressure

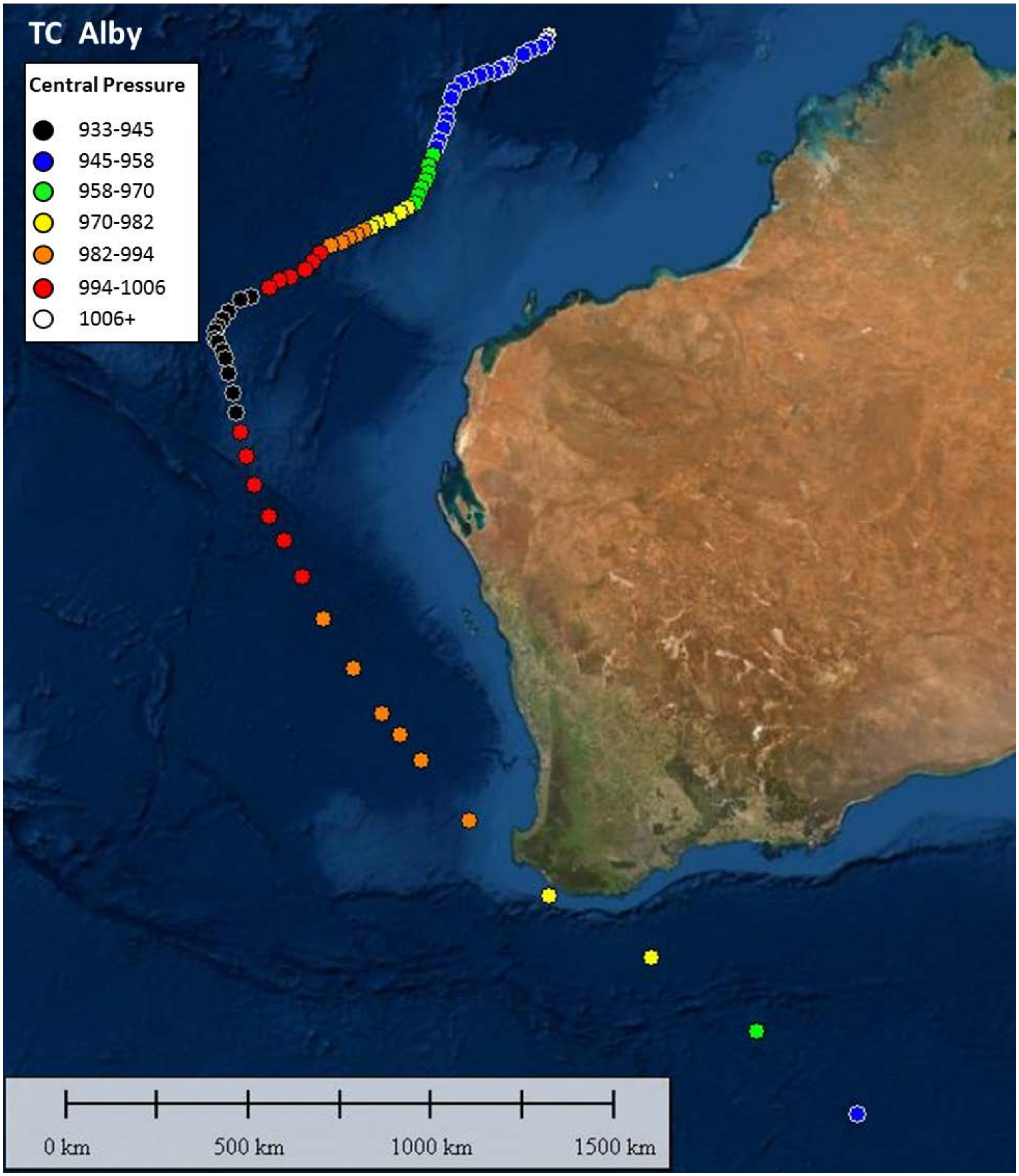

Figure 5: Path of Design Storm for Peel, based on Tropical Cyclone Ned, showing a scale of central pressure

Table 2: Central Pressure and Radius to Maximum Winds for the Design Storm for Peel Based on TC Alby

Date / Time	Long	Lat	CP	Rmax
27/03/1978 1:00	116.0	13.6	1006.3	54
27/03/1978 4:00	115.9	13.7	1006.3	54
27/03/1978 7:00	115.9	13.8	1005.4	54
27/03/1978 10:00	115.8	13.9	1005.4	54
27/03/1978 13:00	115.5	14.0	1004.4	54
27/03/1978 16:00	115.3	14.1	1004.4	54
27/03/1978 19:00	114.9	14.4	1004.4	54
27/03/1978 22:00	114.8	14.5	1003.5	54
28/03/1978 1:00	114.7	14.5	1002.5	54
28/03/1978 4:00	114.5	14.6	1001.5	54
28/03/1978 7:00	114.3	14.6	1000.6	54
28/03/1978 10:00	114.1	14.7	998.7	54
28/03/1978 13:00	113.8	14.8	998.7	54
28/03/1978 16:00	113.6	14.9	998.7	54
28/03/1978 19:00	113.4	15.1	997.7	54
28/03/1978 22:00	113.3	15.3	997.7	54
29/03/1978 1:00	113.2	15.7	997.7	54
29/03/1978 4:00	113.2	15.9	996.8	54
29/03/1978 7:00	113.1	16.1	995.8	54
29/03/1978 10:00	113.0	16.4	995.8	54
29/03/1978 13:00	112.9	16.6	994.9	54
29/03/1978 16:00	112.8	16.8	993.9	54
29/03/1978 19:00	112.7	17.1	993.0	54
29/03/1978 22:00	112.7	17.3	992.0	54
30/03/1978 1:00	112.6	17.5	991.0	54
30/03/1978 4:00	112.5	17.7	988.2	54
30/03/1978 7:00	112.4	17.9	985.3	54
30/03/1978 10:00	112.3	18.1	983.4	54
30/03/1978 13:00	112.1	18.2	981.5	54
30/03/1978 16:00	111.9	18.3	978.6	54
30/03/1978 19:00	111.6	18.5	975.8	54
30/03/1978 22:00	111.3	18.6	973.9	54
31/03/1978 1:00	111.1	18.7	972.0	54
31/03/1978 4:00	110.9	18.8	969.1	54
31/03/1978 7:00	110.7	18.9	967.2	54
31/03/1978 10:00	110.5	19.0	964.3	54
31/03/1978 13:00	110.3	19.1	962.4	54

31/03/1978 16:00	110.0	19.2	959.5	54
31/03/1978 19:00	109.7	19.4	957.6	54
31/03/1978 22:00	109.5	19.6	954.8	54
1/04/1978 1:00	109.3	19.8	952.9	54
1/04/1978 4:00	108.9	20.0	950.0	54
1/04/1978 7:00	108.6	20.1	948.1	54
1/04/1978 10:00	108.3	20.3	946.2	54
1/04/1978 13:00	107.8	20.5	943.3	54
1/04/1978 16:00	107.5	20.6	940.5	54
1/04/1978 19:00	107.2	20.9	937.6	54
1/04/1978 22:00	107.0	21.1	935.7	54
2/04/1978 1:00	106.9	21.3	933.8	54
2/04/1978 4:00	106.8	21.4	934.7	54
2/04/1978 7:00	106.8	21.6	935.7	54
2/04/1978 10:00	106.9	21.7	936.6	54
2/04/1978 13:00	107.0	21.9	938.5	54
2/04/1978 16:00	107.1	22.1	939.5	54
2/04/1978 19:00	107.2	22.5	940.5	54
2/04/1978 22:00	107.3	23.0	941.4	54
3/04/1978 1:00	107.4	23.5	943.3	54
3/04/1978 4:00	107.5	24.0	945.2	54
3/04/1978 7:00	107.7	24.6	947.1	54
3/04/1978 10:00	107.9	25.3	950.0	55
3/04/1978 13:00	108.3	26.1	952.9	65
3/04/1978 16:00	108.7	26.7	954.8	75
3/04/1978 19:00	109.2	27.6	957.6	85
3/04/1978 22:00	109.8	28.6	959.5	100
4/04/1978 1:00	110.6	29.8	962.4	120
4/04/1978 4:00	111.4	30.9	964.3	160
4/04/1978 6:00	111.9	31.4	965.3	190
4/04/1978 7:00	112.5	32.0	967.2	220
4/04/1978 10:00	113.8	33.4	969.1	240
4/04/1978 13:00	116.0	35.1	972.0	280
4/04/1978 16:00	118.8	36.5	979.6	360
4/04/1978 19:00	121.7	38.1	990.1	360
4/04/1978 22:00	124.5	39.9	1000.6	360

Table 3: Central Pressure and Radius to Maximum Winds for the Design Storm for Peel Based on TC Ned

Date / Time	Long	Lat	CP	Rmax
25/03/1989 6:00	117.7	17.8	999.0	54
25/03/1989 12:00	117.0	17.5	996.2	54
25/03/1989 18:00	116.0	17.2	993.4	54
26/03/1989 0:00	114.8	17.3	990.6	54
26/03/1989 6:00	113.7	17.5	987.8	54
26/03/1989 12:00	113.2	17.6	983.6	54
26/03/1989 18:00	112.5	17.8	979.4	54
27/03/1989 0:00	111.7	18.2	975.2	54
27/03/1989 6:00	110.9	18.5	969.6	54
27/03/1989 12:00	110.1	18.7	962.6	54
27/03/1989 18:00	108.9	19.2	948.6	54
28/03/1989 0:00	108.1	19.4	930.4	54
28/03/1989 6:00	107.5	20.0	922.0	54
28/03/1989 12:00	107.1	20.5	917.8	54
28/03/1989 18:00	107.0	20.8	913.6	54
29/03/1989 0:00	107.0	21.1	912.2	54
29/03/1989 6:00	106.9	21.4	915.0	54
29/03/1989 12:00	106.9	21.9	920.6	54
29/03/1989 18:00	106.9	22.4	922.0	54
30/03/1989 0:00	106.8	22.8	922.0	54
30/03/1989 6:00	106.4	23.6	926.2	54
30/03/1989 12:00	106.3	24.4	931.8	61
30/03/1989 18:00	106.4	25.4	936.0	68
31/03/1989 0:00	106.6	26.5	943.0	75
31/03/1989 6:00	107.1	27.6	947.2	90
31/03/1989 9:00	107.7	28.3	947.2	100
31/03/1989 12:00	108.4	28.9	950.0	110
31/03/1989 15:00	109.5	29.6	954.2	120
31/03/1989 18:00	110.9	30.6	954.2	140
31/03/1989 21:00	112.7	31.9	961.2	180
1/04/1989 0:00	114.5	33.1	961.2	230
1/04/1989 3:00	116.5	34.2	964.0	250
1/04/1989 6:00	118.7	34.9	968.2	270

Model Validation

The hydrodynamic model has been validated against predicted water levels at key locations in southwest WA as reported in Baird Australia (2020a and 2020b). The model validation is shown in Figure 6 and Figure 7and and shows excellent agreement with time series and validation statistics for modelled and predicted tides from the model at Hillary's, Jurien Bay, Lancelin and Two Rocks Marina. The validation metrics are excellent with little bias and RMS error of about 0.01-0.02 m between Fremantle and Bunbury. The model validation provides confidence the hydrodynamic model can be applied as a basis for the study in the phases to follow. Model validation for storm surge is presented in Baird (2020a and 2020b).

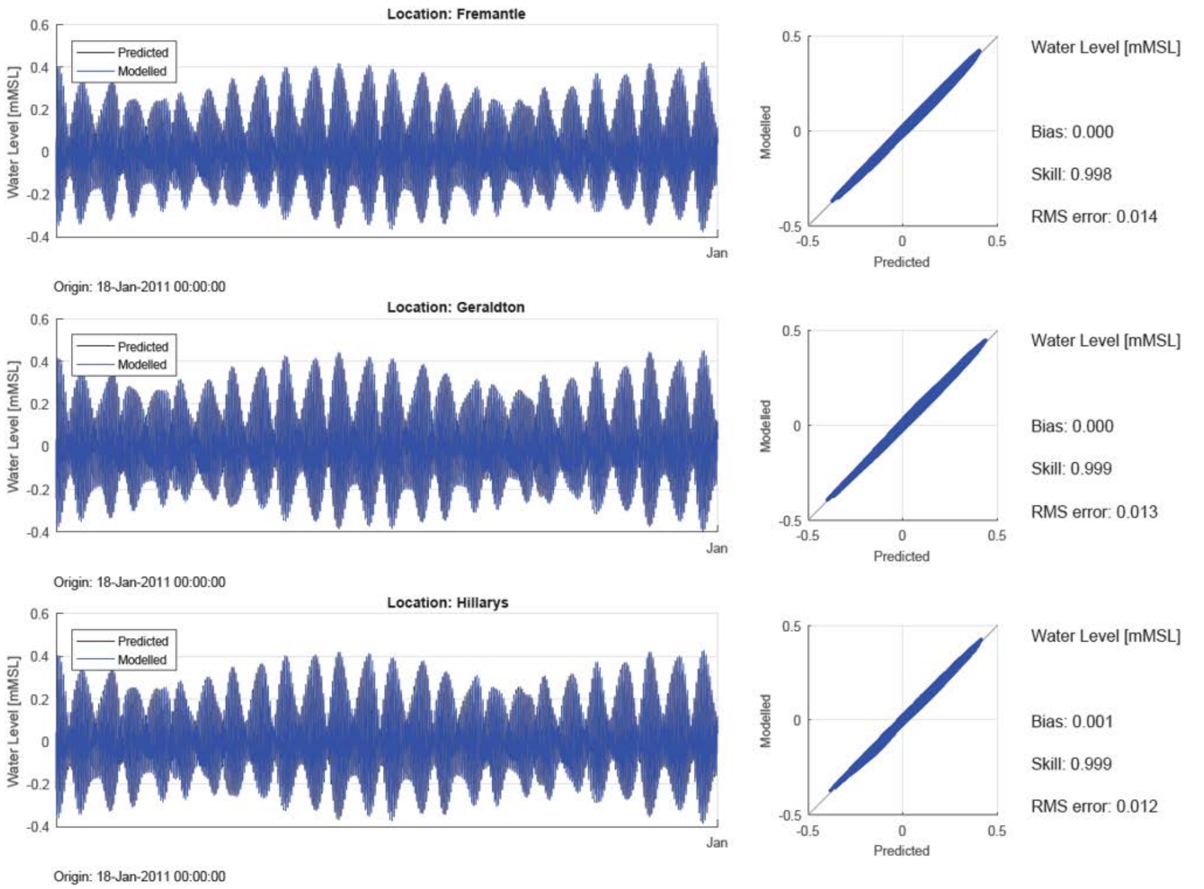

Figure 6: Time series comparisons of predicted (black), and simulated (blue) water levels for Fremantle, Geraldton, and Hillarys in 2011

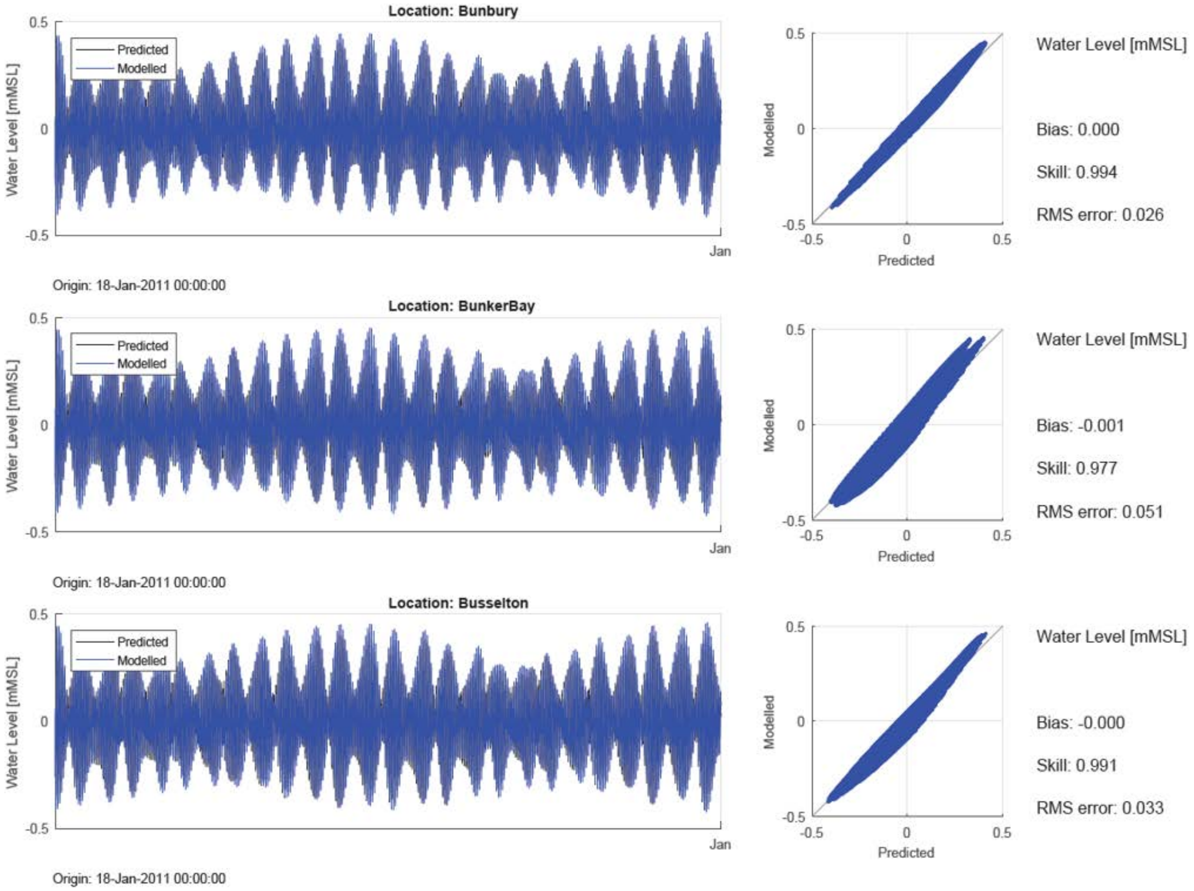

Figure 7: Time series comparisons of predicted (black), and simulated (blue) water levels for Bunbury, Bunker Bay, and Busselton in 2011.

Model Results

Model results were taken from just outside of Mandurah Channel and just outside of the Dawesville Cut, as seen in Figure 2. Results are presented from Figure 8 Figure 11, with the top panel showing the influence on water levels due to changes to water level (tide) only, as well as due to changes in wave conditions and the bottom panel showing the associated significant wave height.

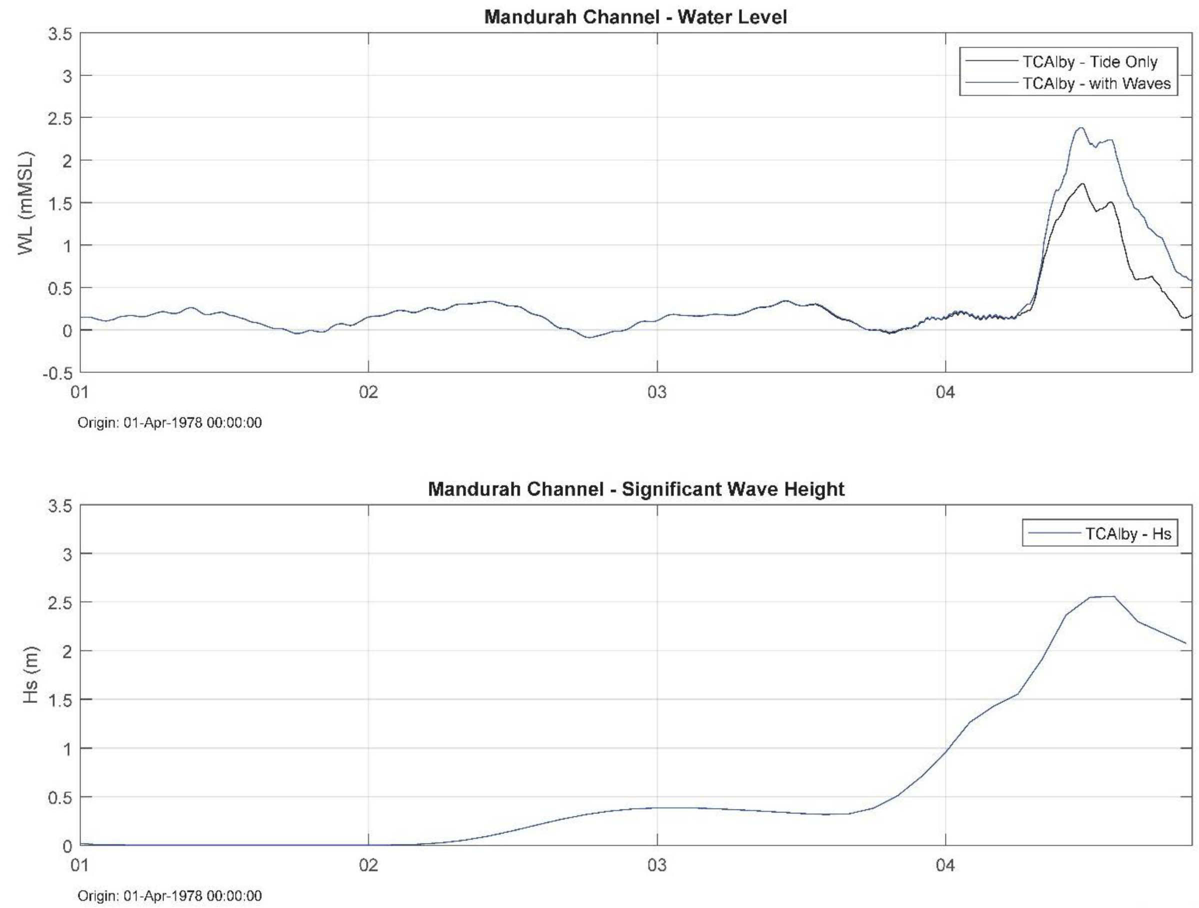

Figure 8: Water level and significant wave height modelled offshore of Mandurah Channel during a design storm based on Tropical Cyclone Alby

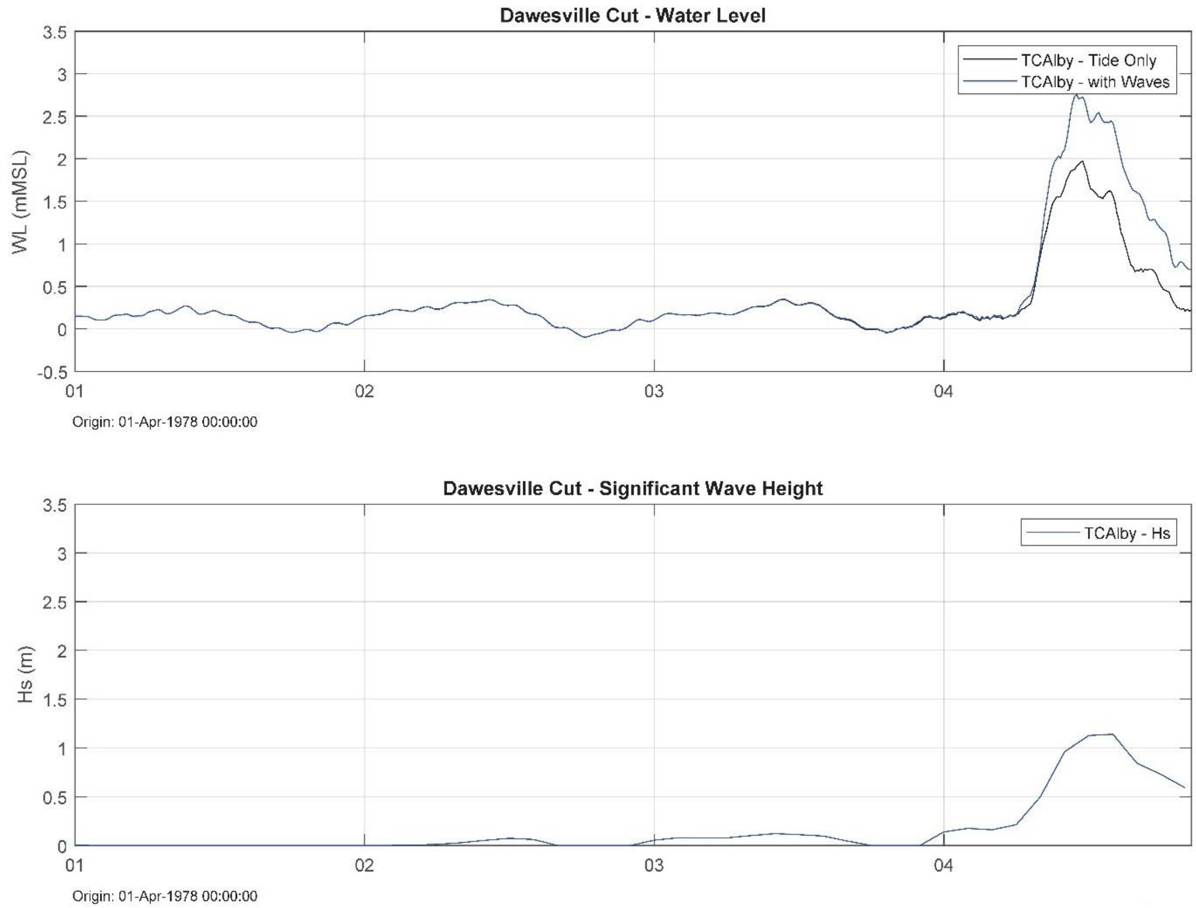

Figure 9: Water level and significant wave height modelled offshore of Dawesville Cut during a design storm based on Tropical Cyclone Alby

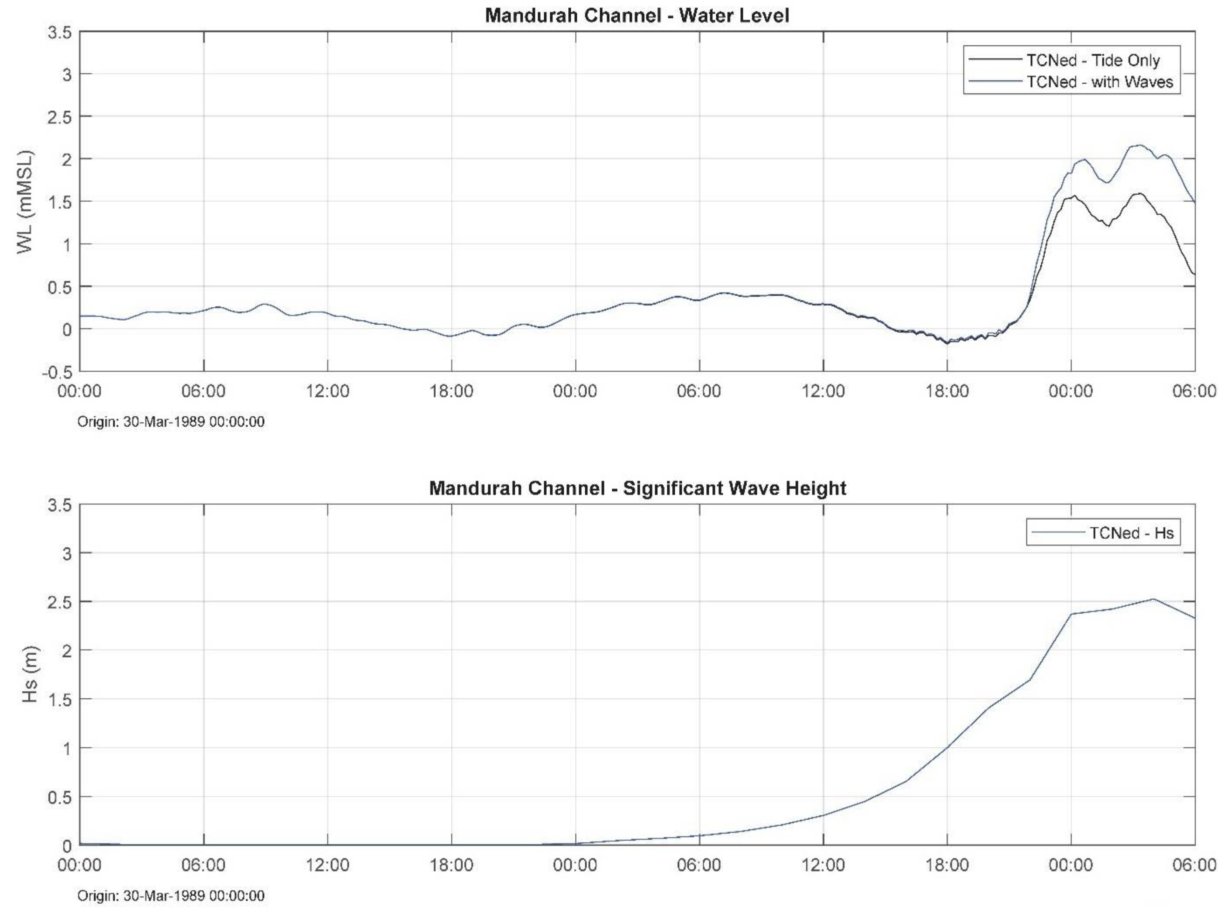

Figure 10: Water level and significant wave height modelled offshore of Mandurah Channel during a design storm based on Tropical Cyclone Ned

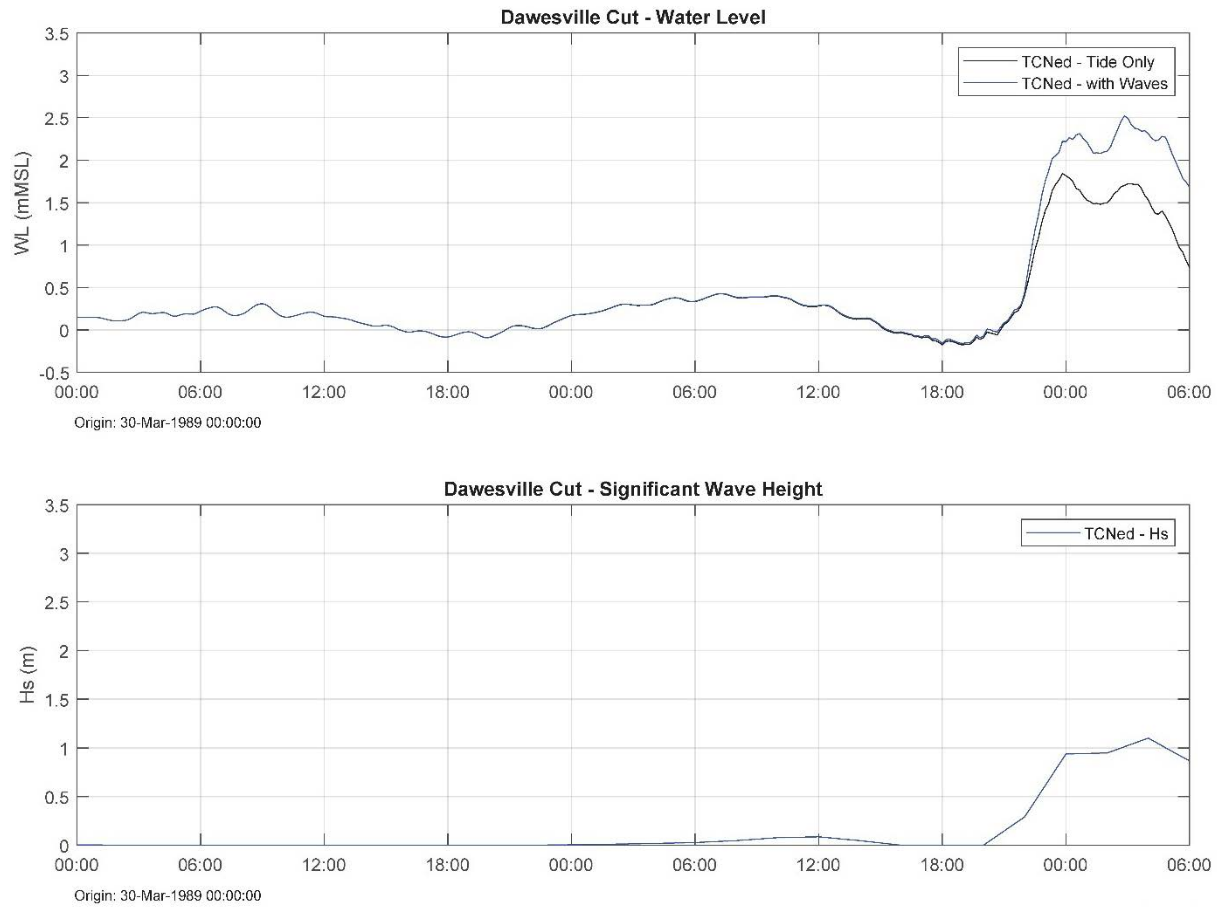

Figure 11: Water level and significant wave height modelled offshore of Dawesville Cut during a design storm based on Tropical Cyclone Ned

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C.2 Coastal Processes Allowance. Erosion Allowance for Peel-Harvey Shorelines

Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances (Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
- 2050
- 2070
- 2120

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

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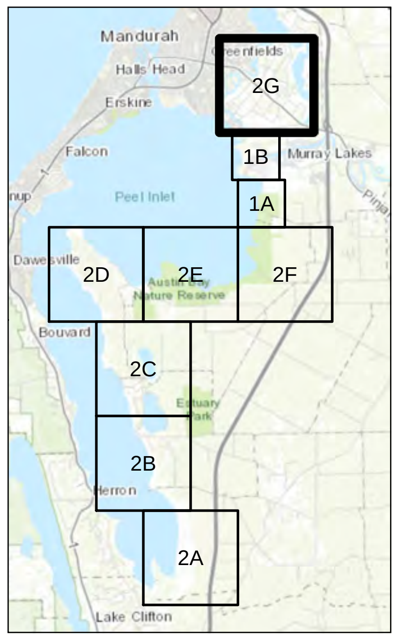
Basemap Image: ESRI World Imagery © 2021.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

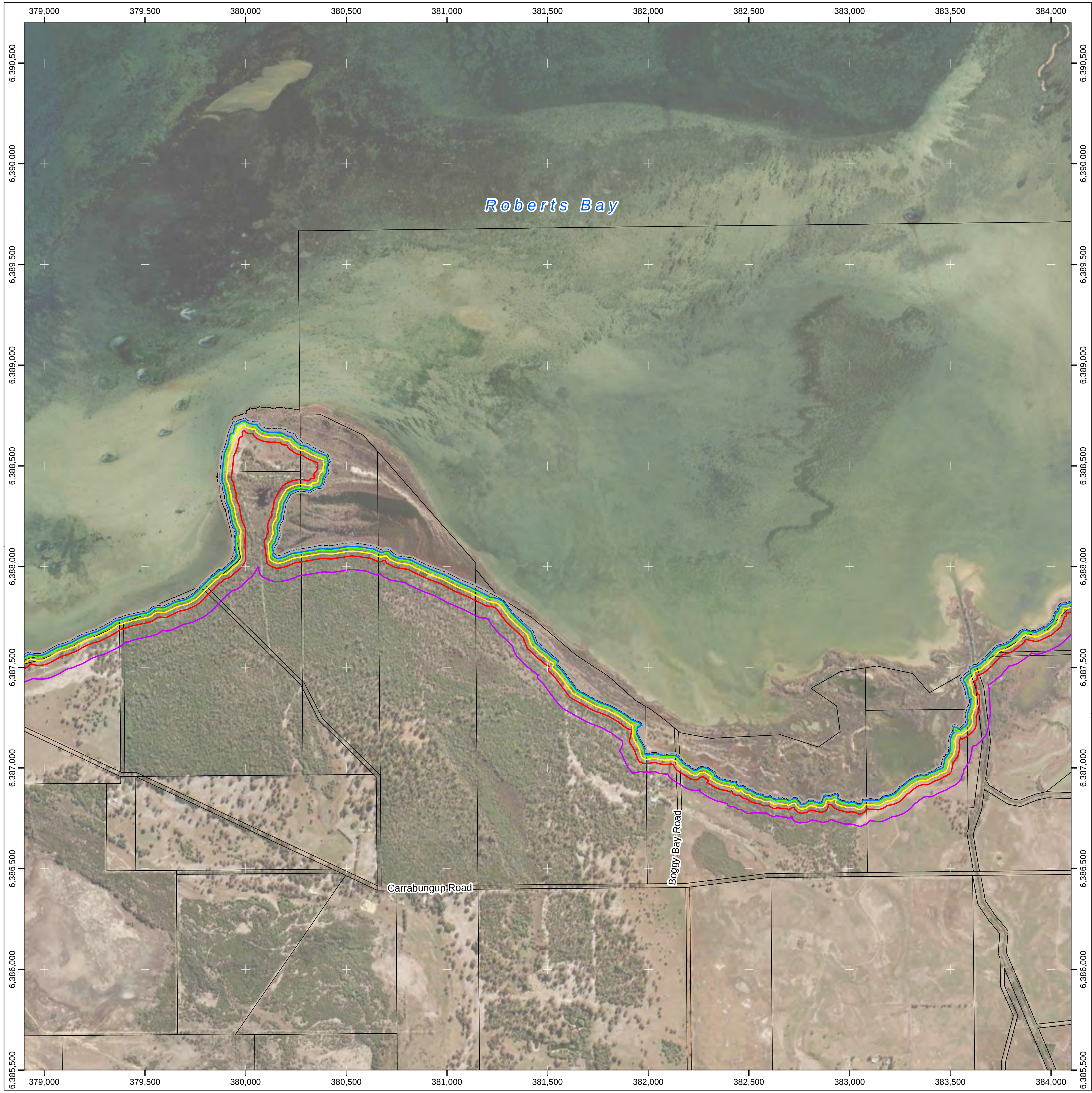
1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 20 Apr. 2021

Mapsheet: 2G



Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances (Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
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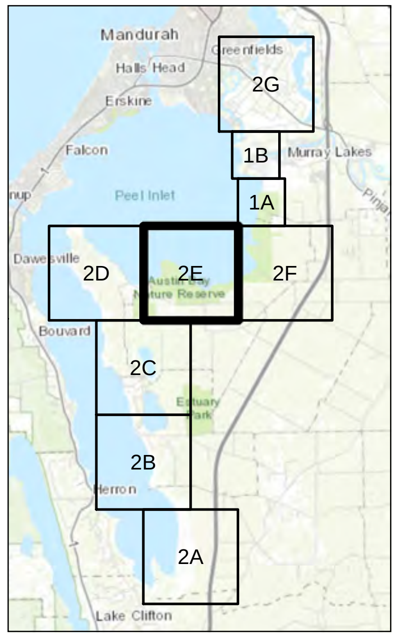
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 20 Apr. 2021

Mapsheet: 2E

Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances (Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
- 2050
- 2070
- 2120

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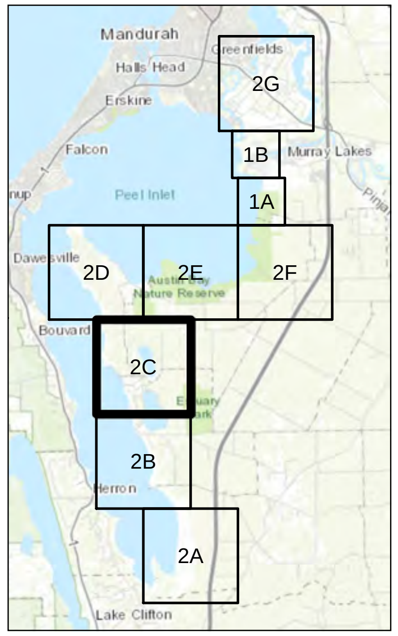
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 20 Apr. 2021

Mapsheet: 2C

Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances (Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
- 2050
- 2070
- 2120

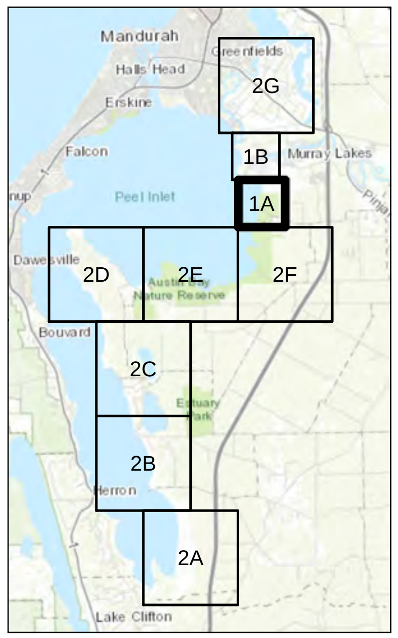
This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2021.
Spatial Reference: GDA 1994 MGA Zone 50

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 20 Apr. 2021

Mapsheet: 1A

Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances (Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
- 2050
- 2070
- 2120

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

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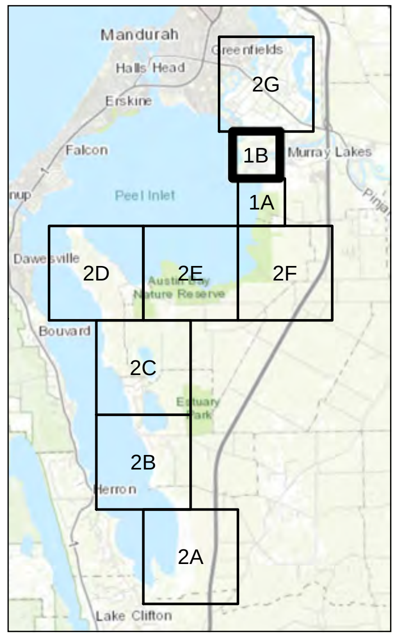
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

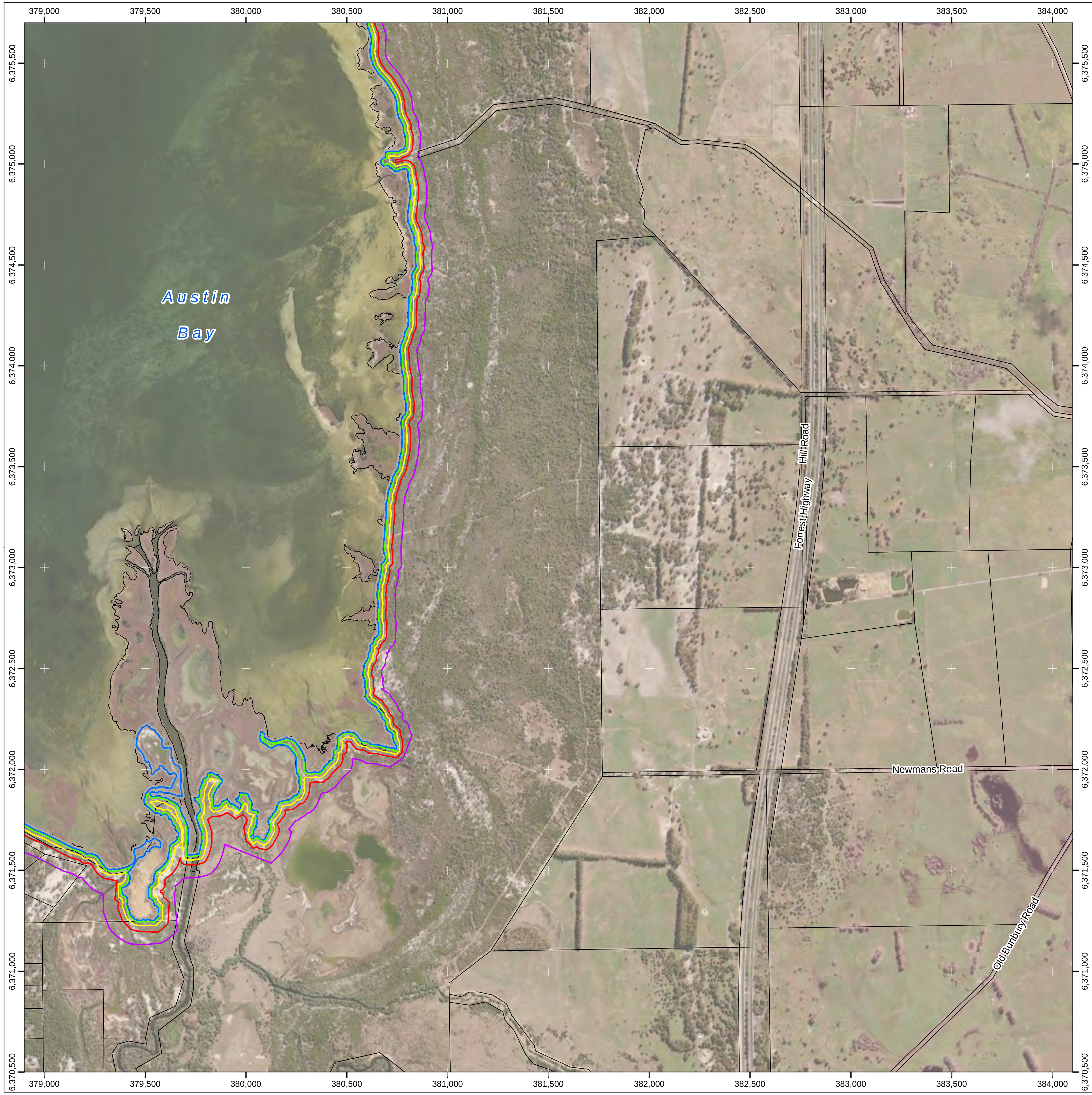


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 20 Apr. 2021

Mapsheet: 1B



Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances (Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
- 2050
- 2070
- 2120

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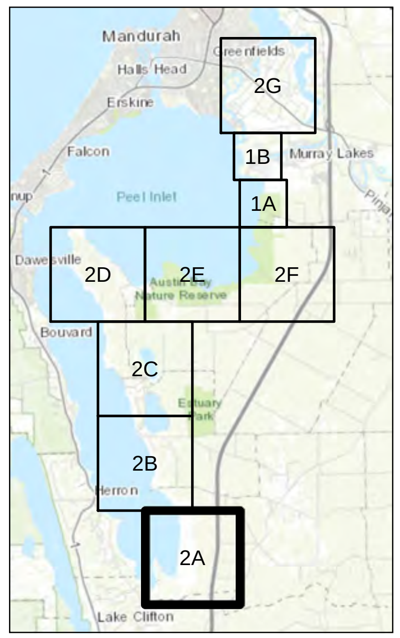
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2021.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 20 Apr. 2021

Mapsheet: 2A

Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances (Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
- 2050
- 2070
- 2120

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

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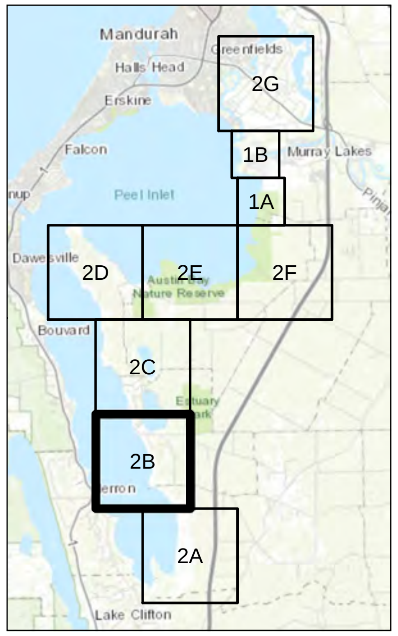
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2021.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 20 Apr. 2021

Mapsheet: 2B

Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances (Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
- 2050
- 2070
- 2120

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

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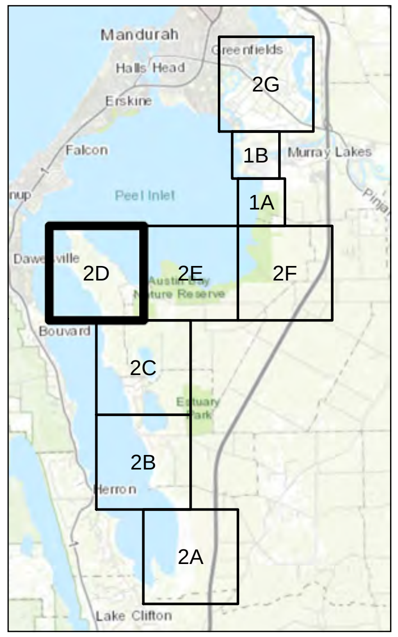
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 20 Apr. 2021

Mapsheet: 2D

Shire of Murray
Coastal Hazard Flood Mapping

Coastal Processes Allowances
(Erosion Setback)

Horizontal Setback Datum

Setbacks

- 2020
- 2030
- 2050
- 2070
- 2120

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

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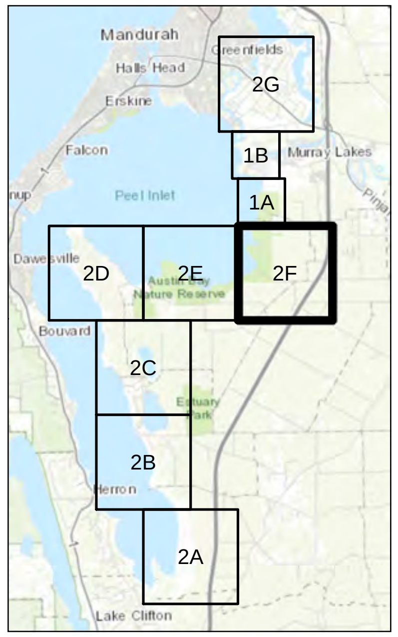
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

N W E S

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

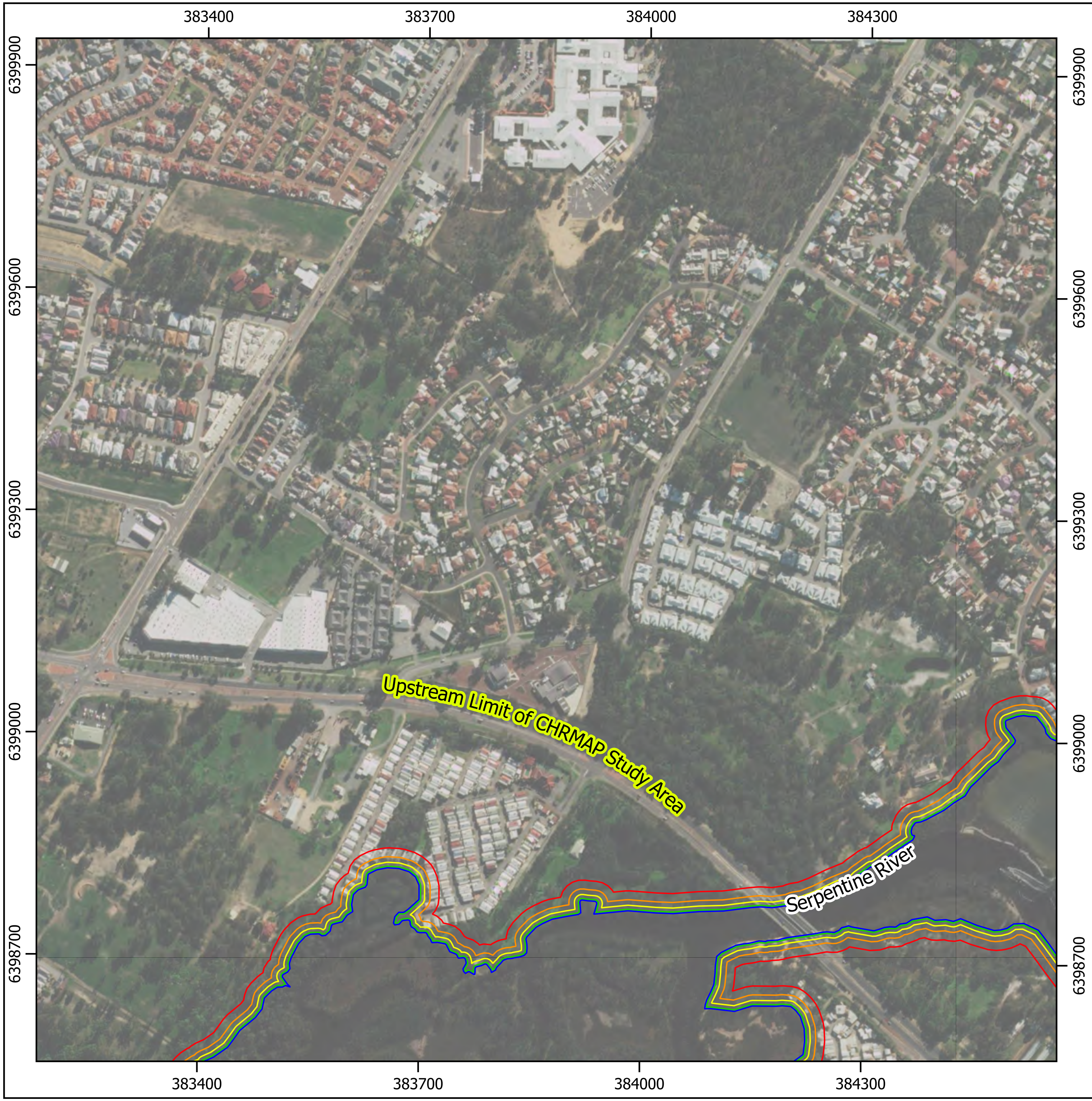
Map Published: 20 Apr. 2021

Mapsheet: 2F

C.3 Erosion Hazard for Lower Murray and Serpentine Rivers

Shire of Murray

Coastal Processes Allowances
(Erosion Setback - Rivers)



Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks used to create the erosion likelihoods have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

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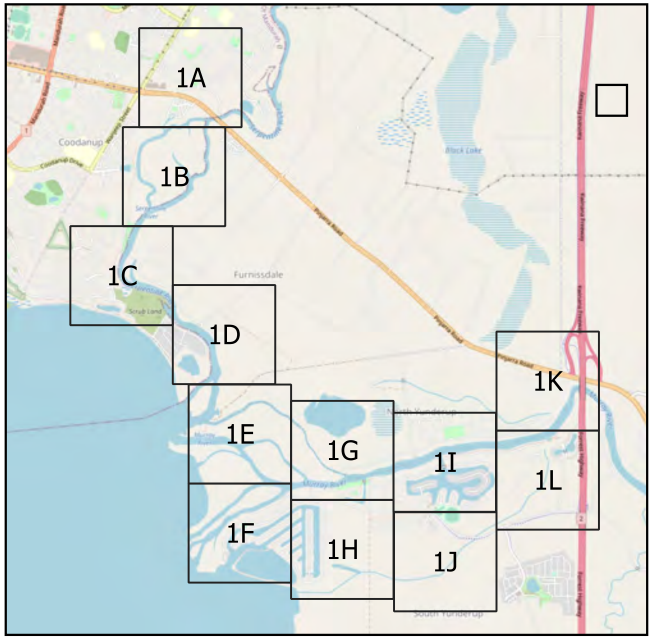
Shire of Murray

Baird.

Map 1A



Shire of Murray
Coastal Processes Allowances
(Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks used to create the erosion likelihoods have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

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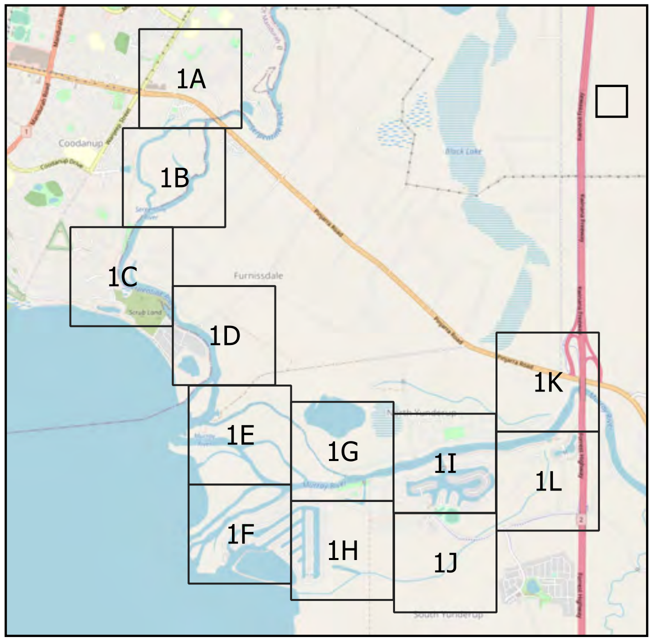
Shire of Murray
Baird.

Map 1B



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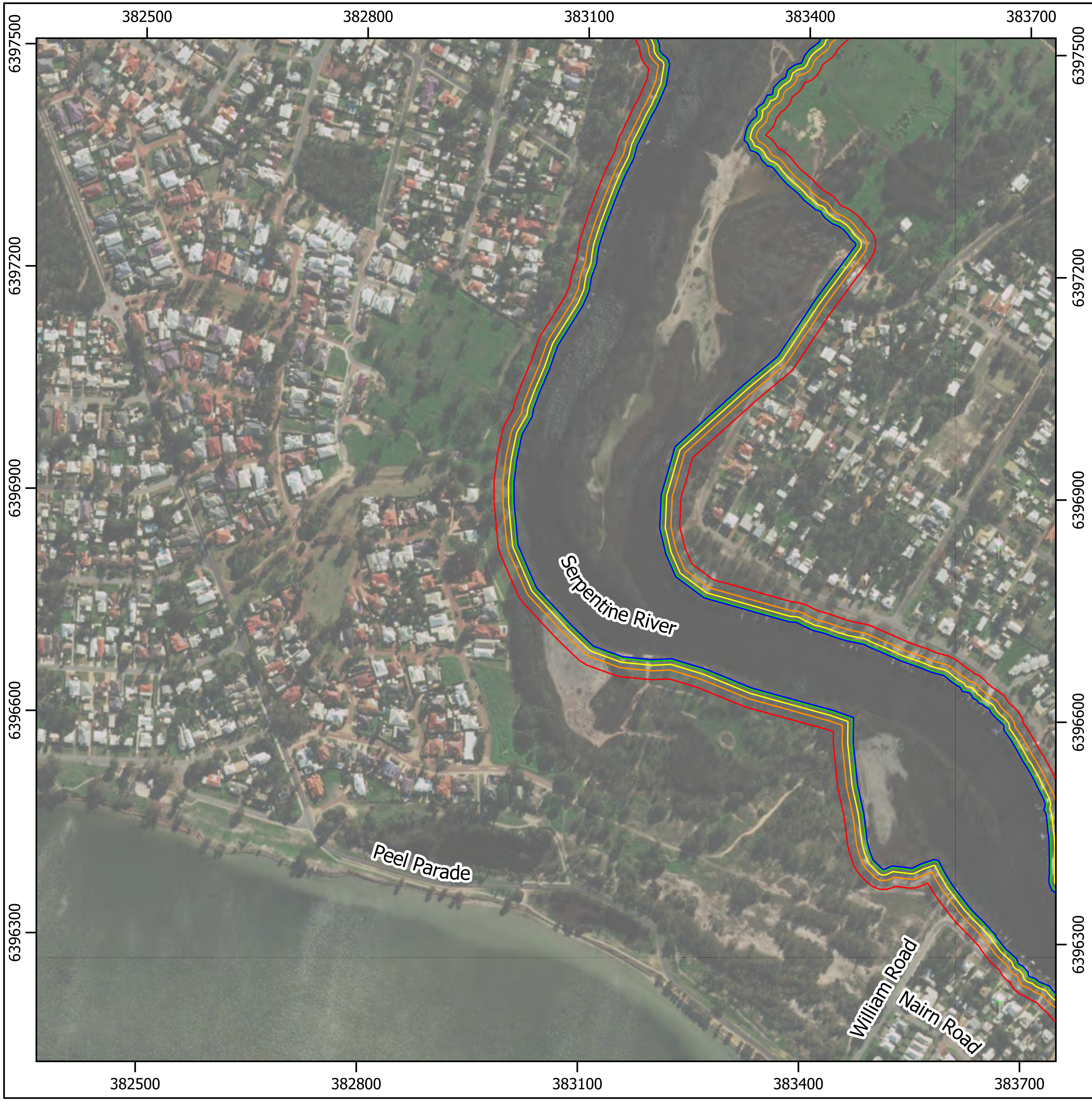

Shire of Murray

Coastal Processes Allowances
(Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

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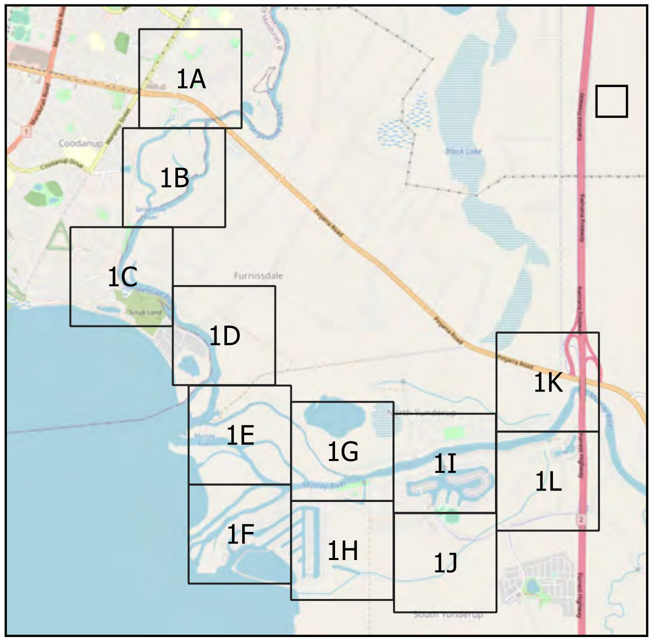
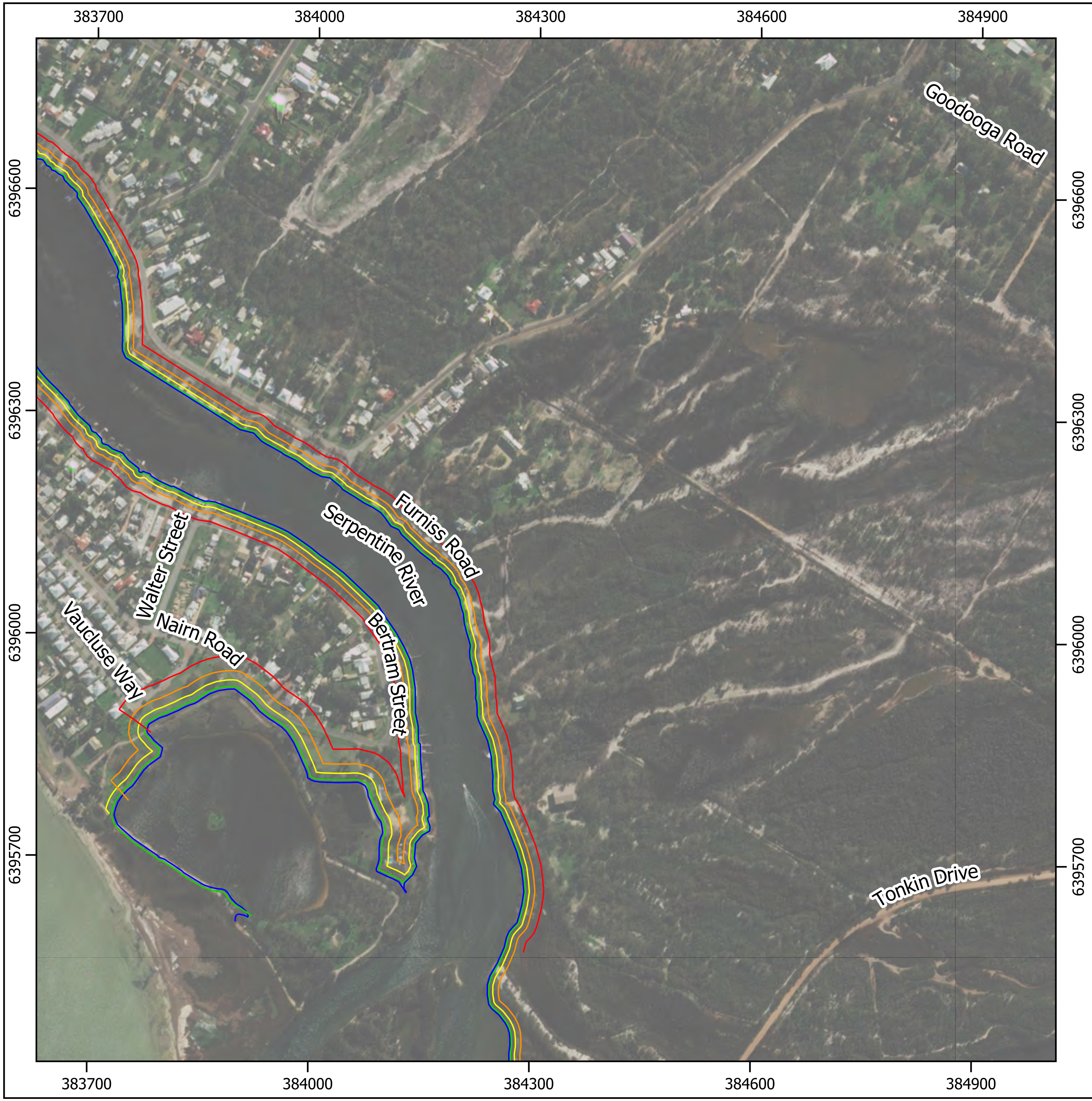
Shire of Murray Baird.

Map 1C



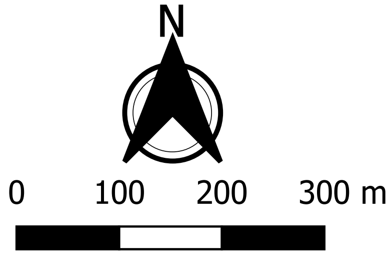


Shire of Murray

Coastal Processes Allowances (Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020



13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

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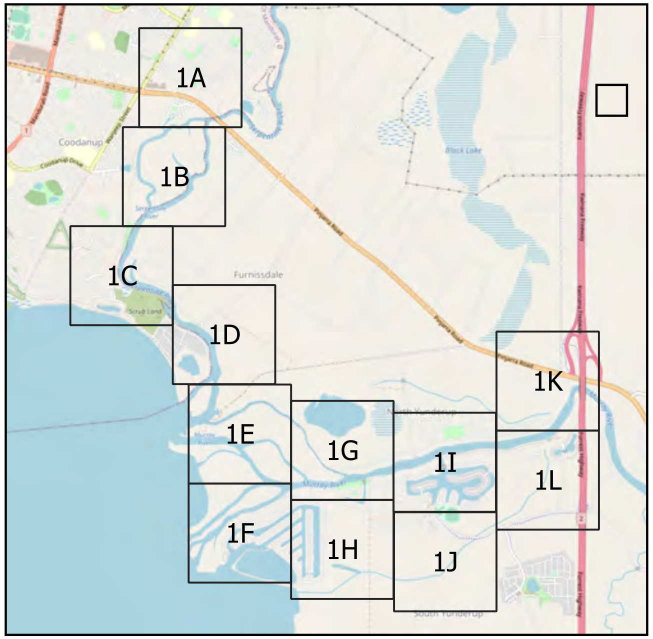
Shire of Murray Baird.

Map 1D



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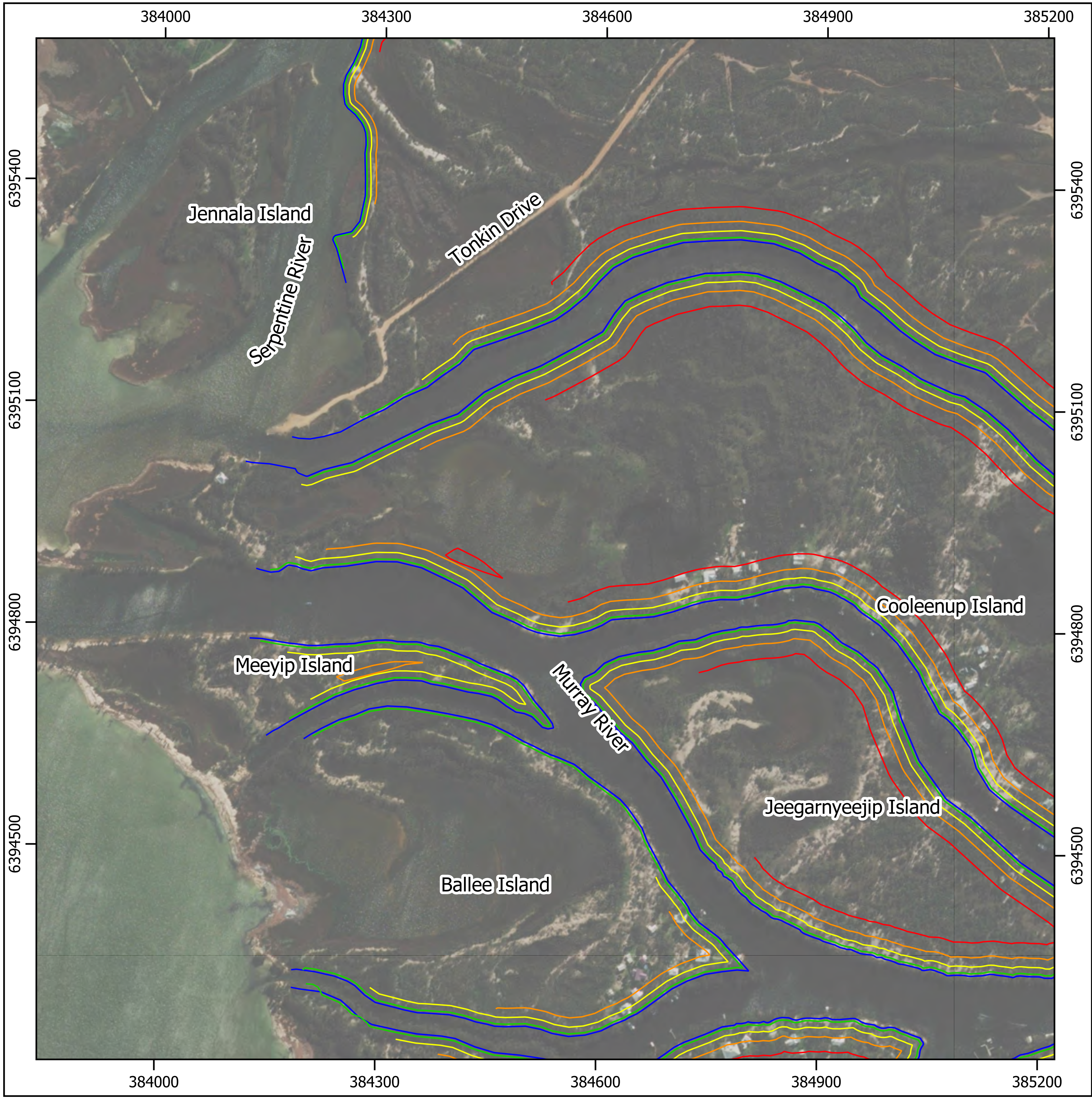

Shire of Murray

Coastal Processes Allowances (Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks used to create the erosion likelihoods have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

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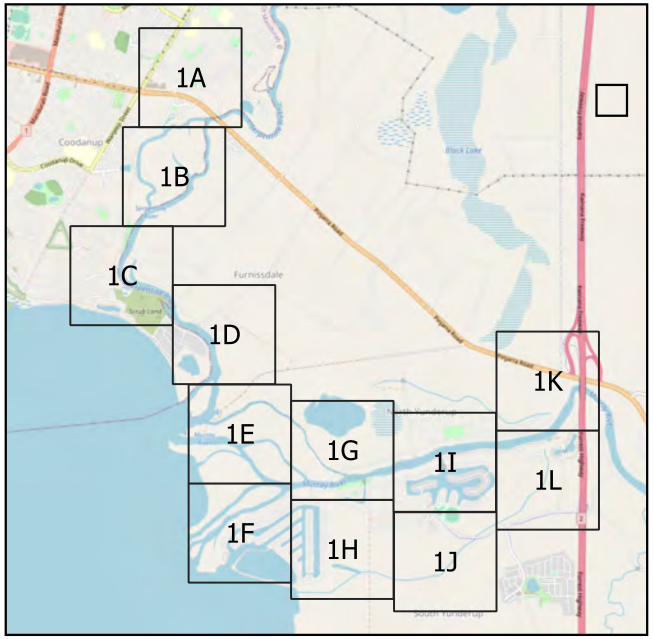
Shire of Murray

Baird.

Map 1E



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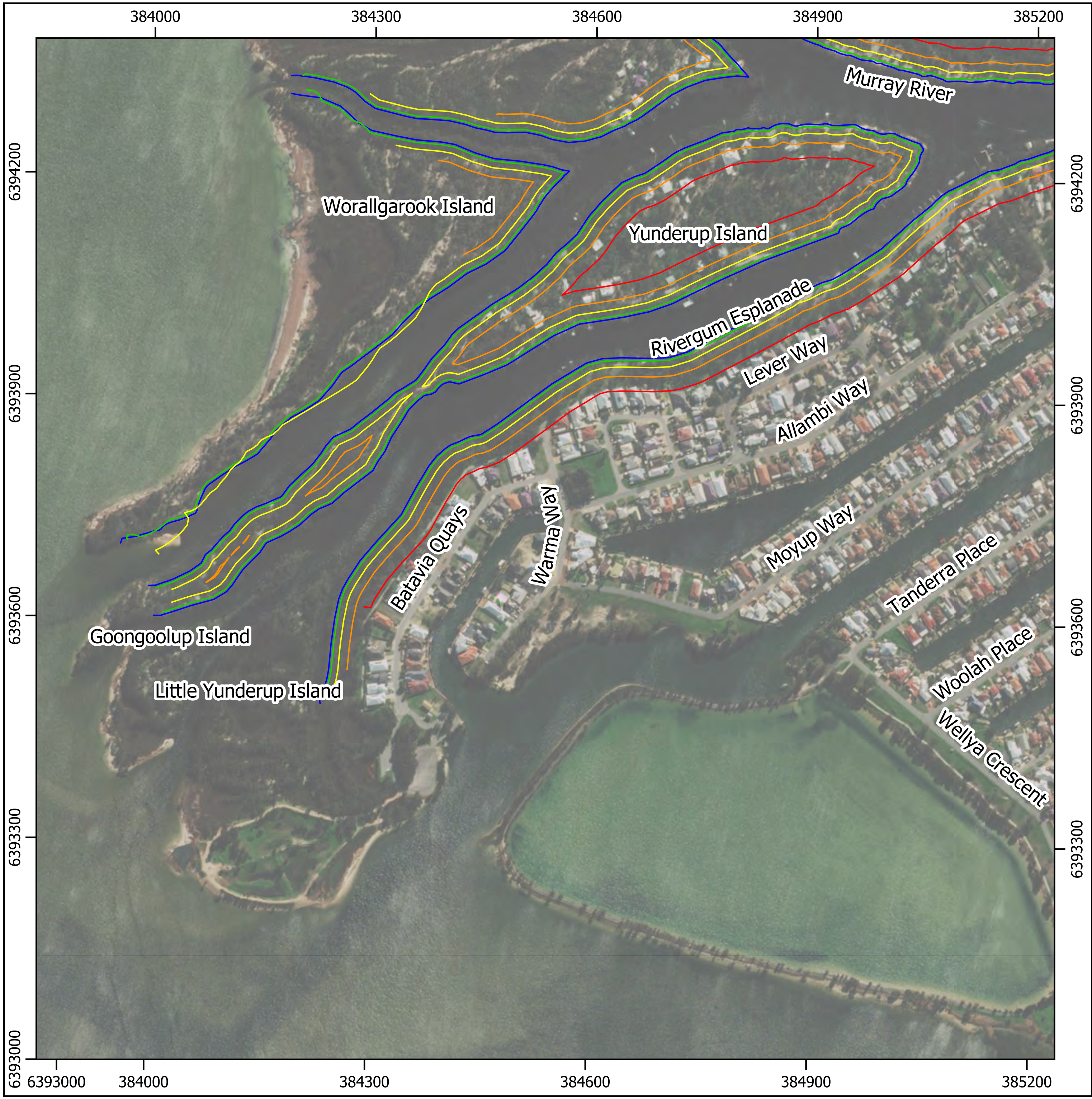

Shire of Murray

Coastal Processes Allowances

(Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

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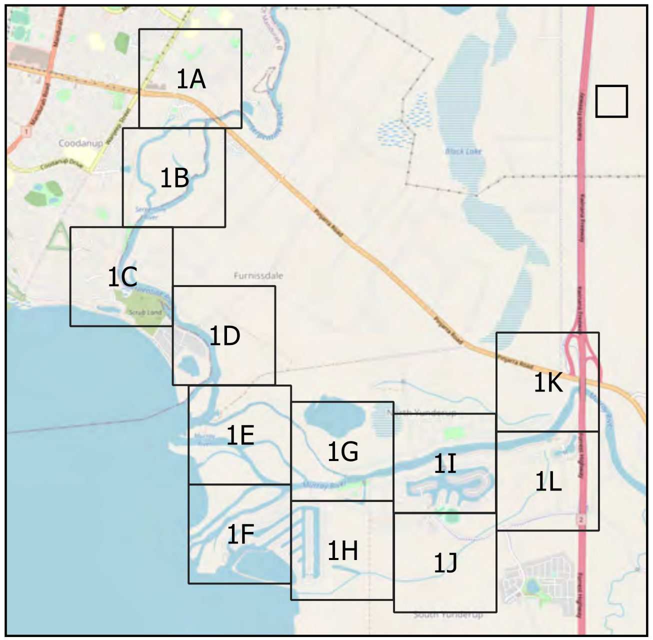
Shire of Murray
Baird.

Map 1F



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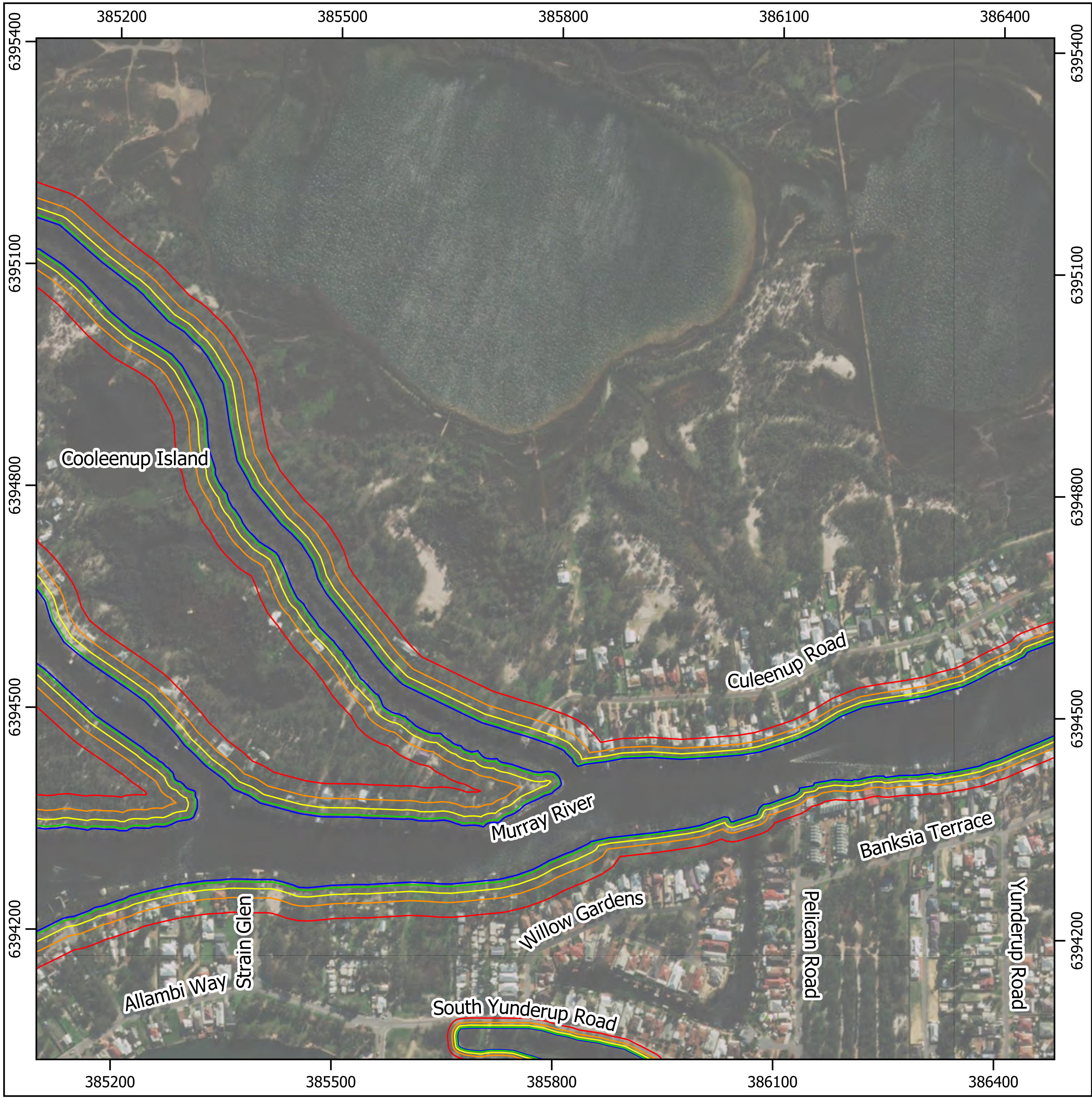

Shire of Murray

Coastal Processes Allowances (Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

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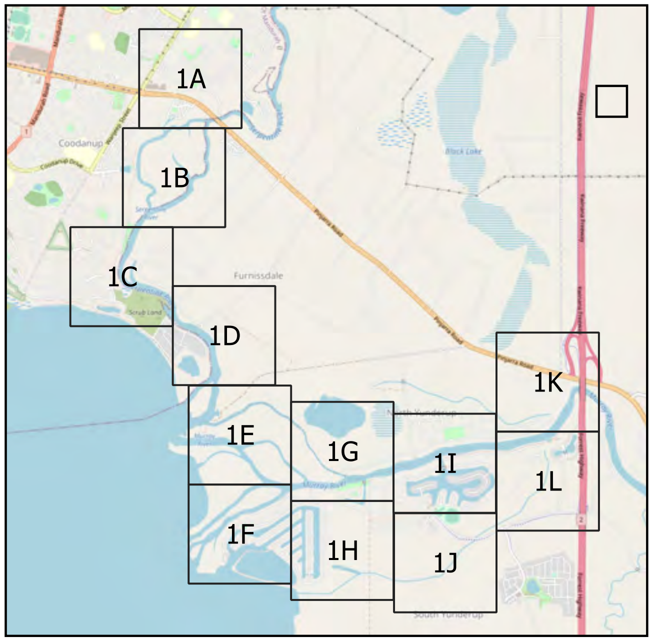
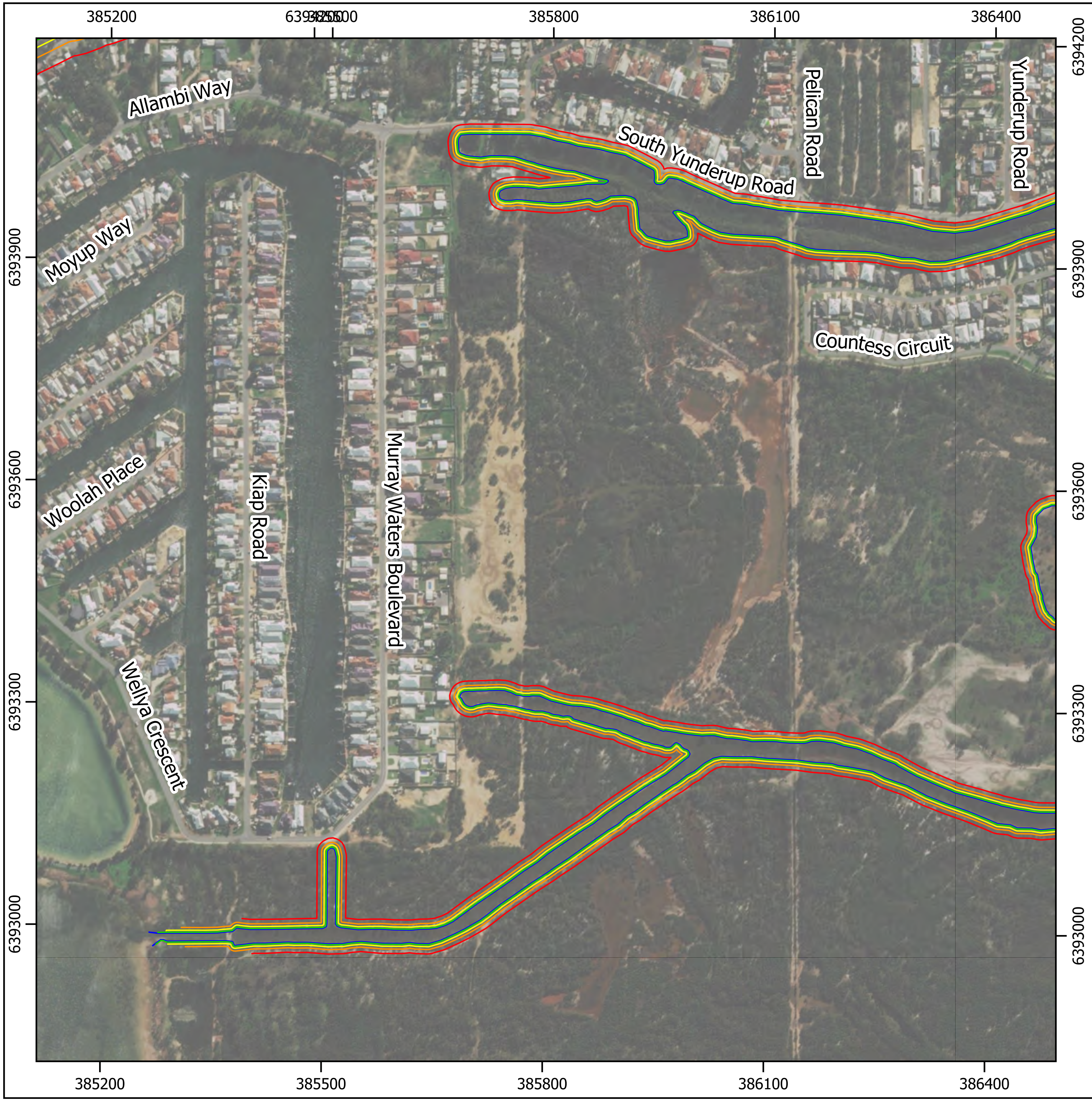
Shire of Murray Baird.

Map 1G





Shire of Murray

Coastal Processes Allowances (Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

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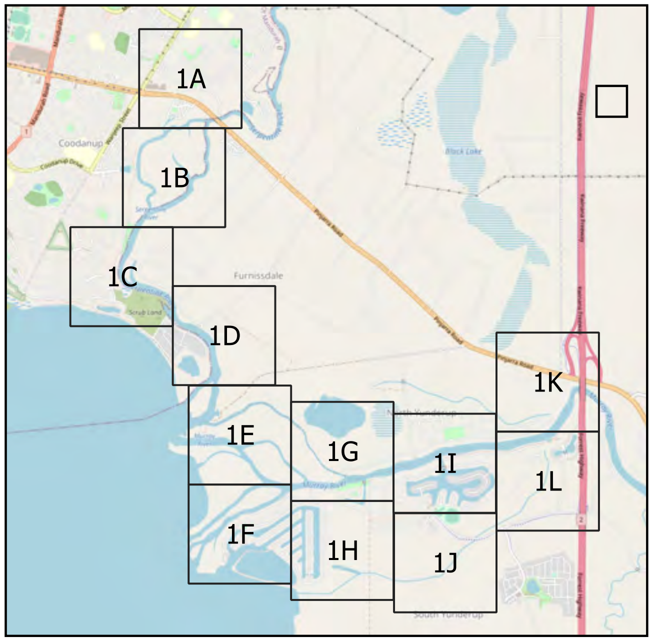
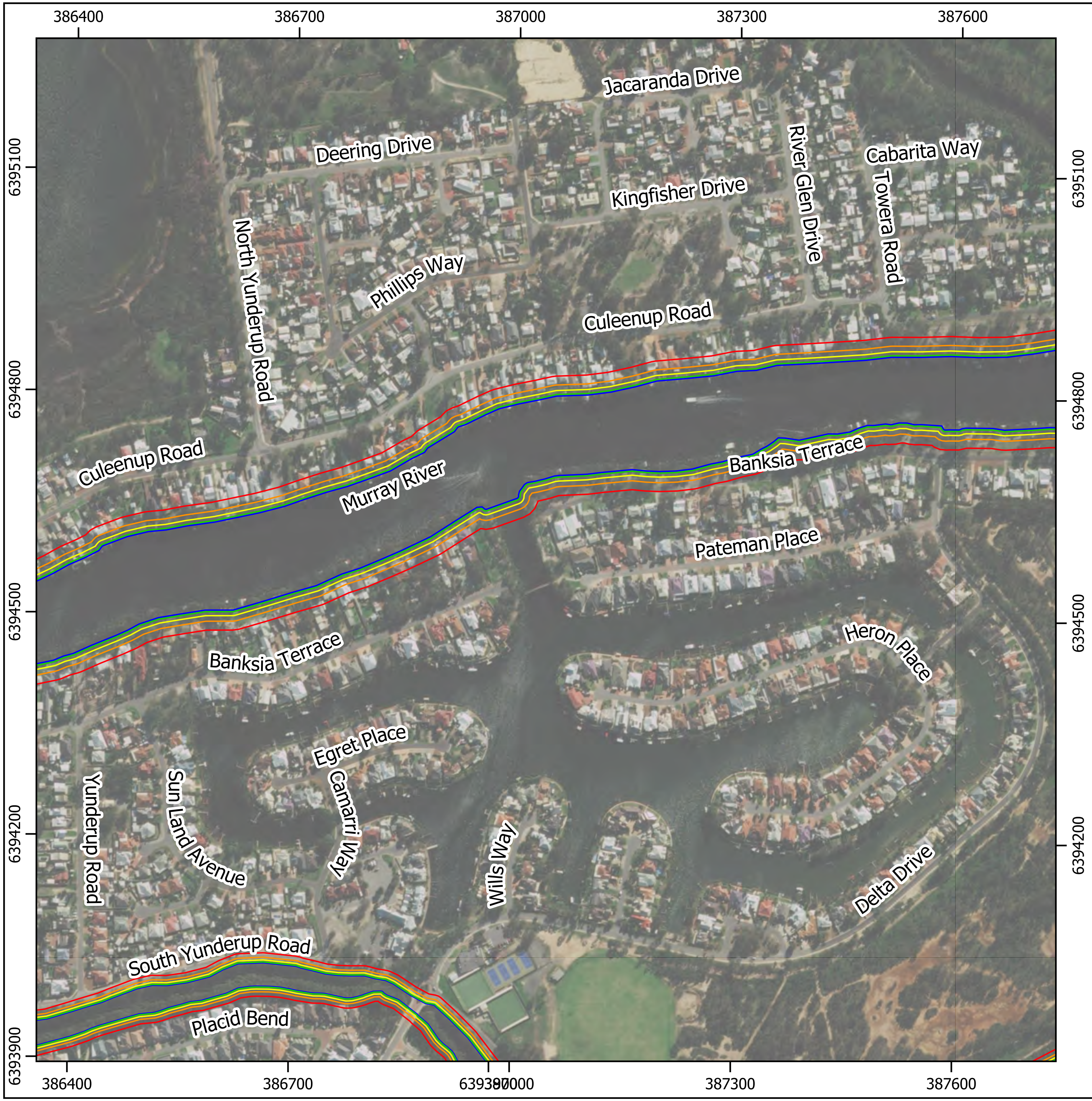
Map 1H

Shire of Murray
Baird.





Shire of Murray

Coastal Processes Allowances (Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

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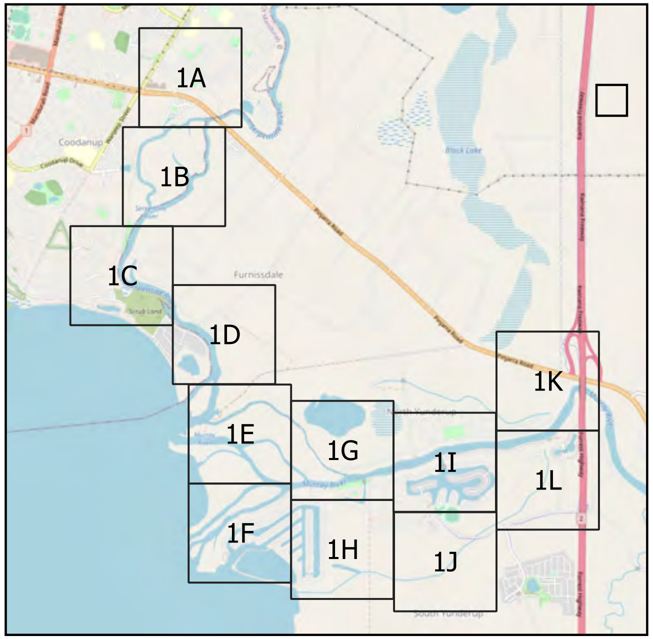
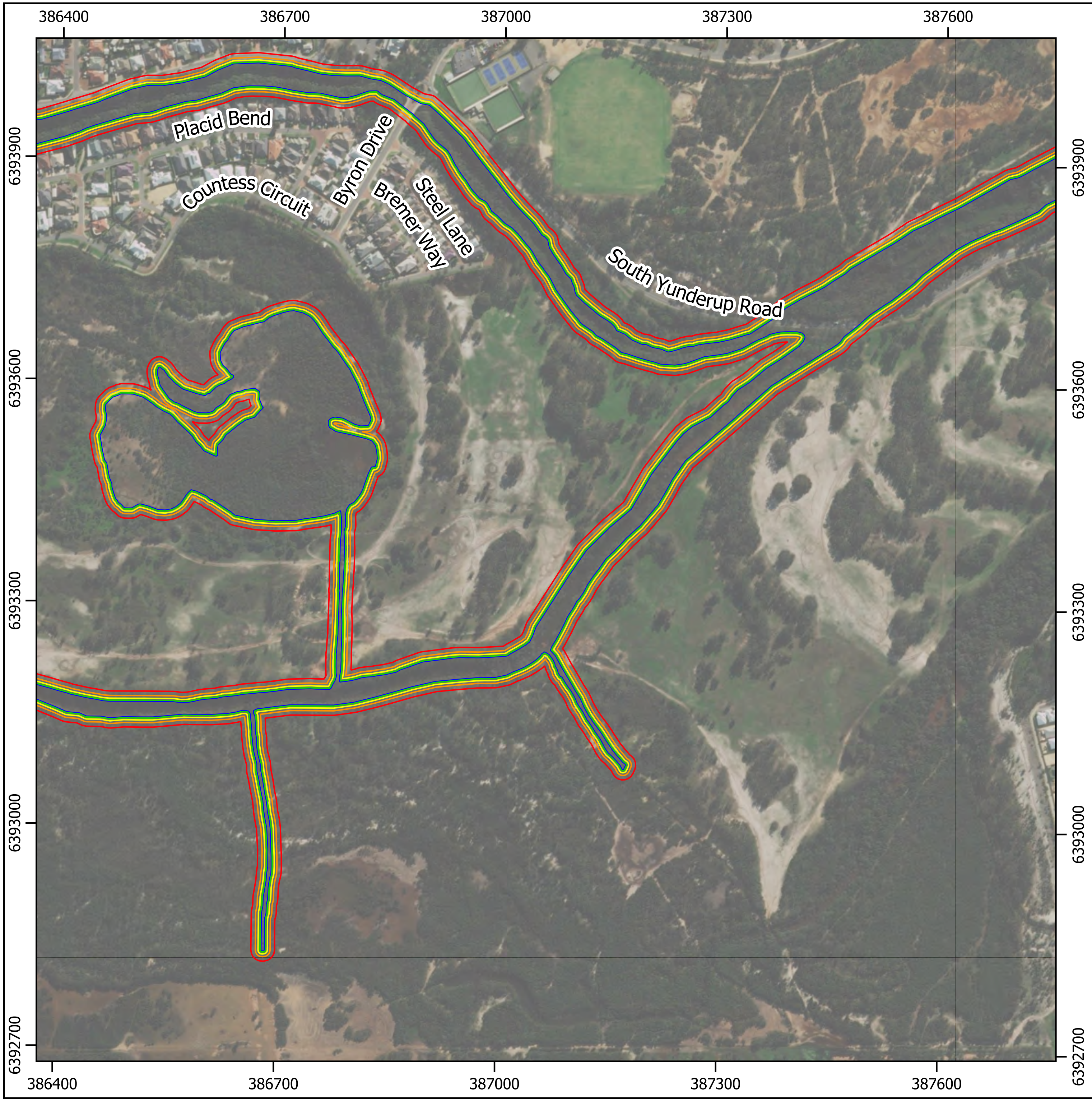
Shire of Murray

Baird.

Map 1I





Shire of Murray
Coastal Processes Allowances
(Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

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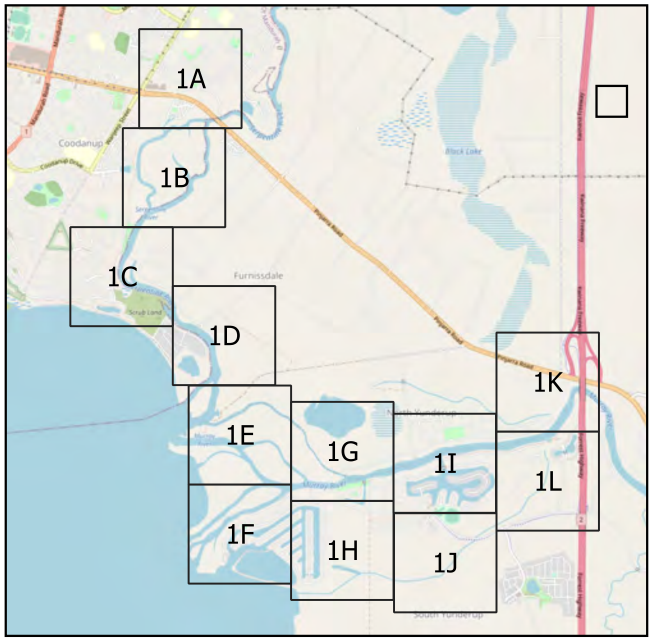
Shire of Murray Baird.

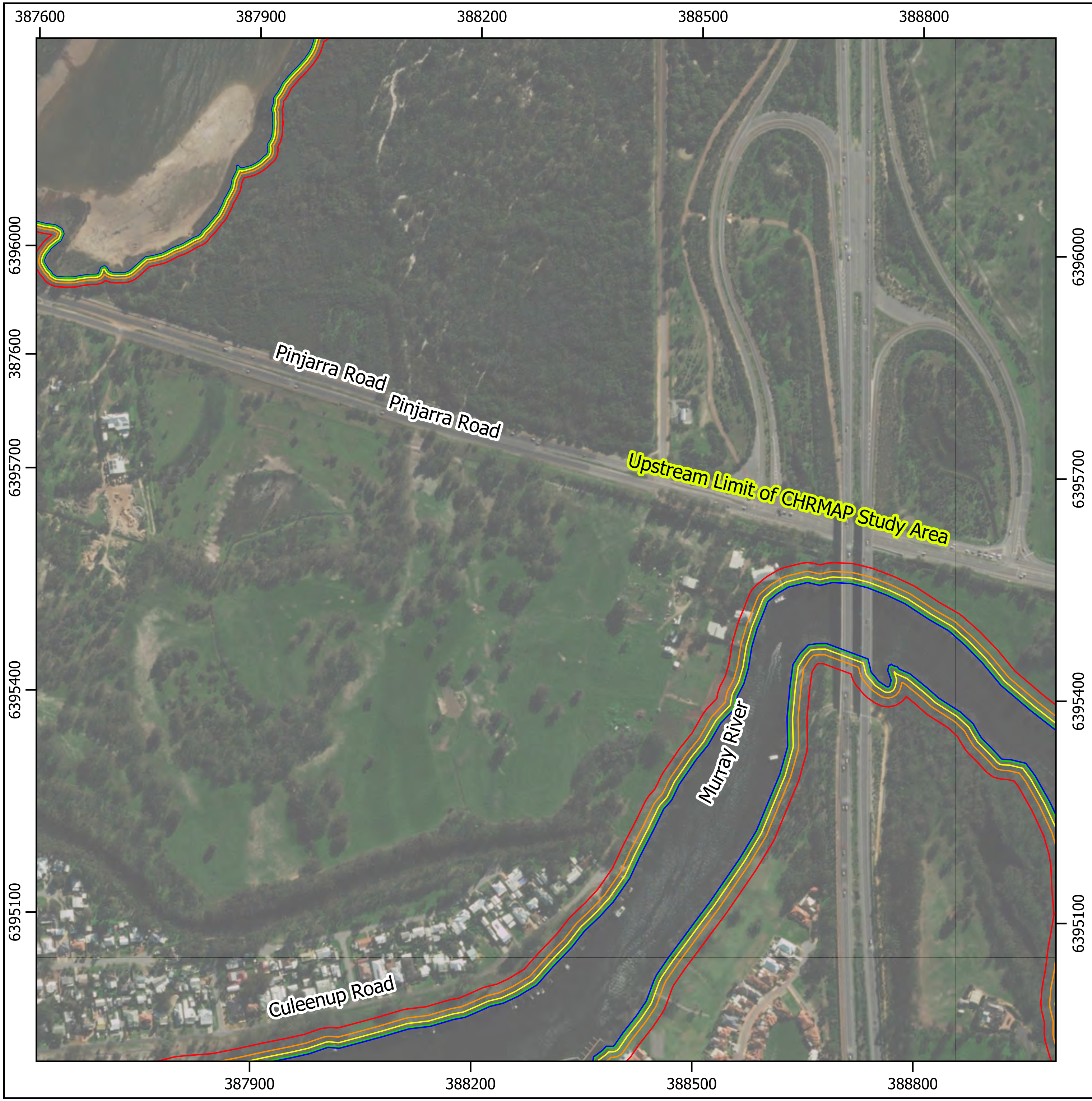
Map 1J



N:\Projects\13064.101_ShireMurrayCHRMAP\09_GIS\11_QGIS\Figures\ShireofMurray_RiverErosionHazard.pdf

Shire of Murray

Coastal Processes Allowances (Erosion Setback - Rivers)



Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

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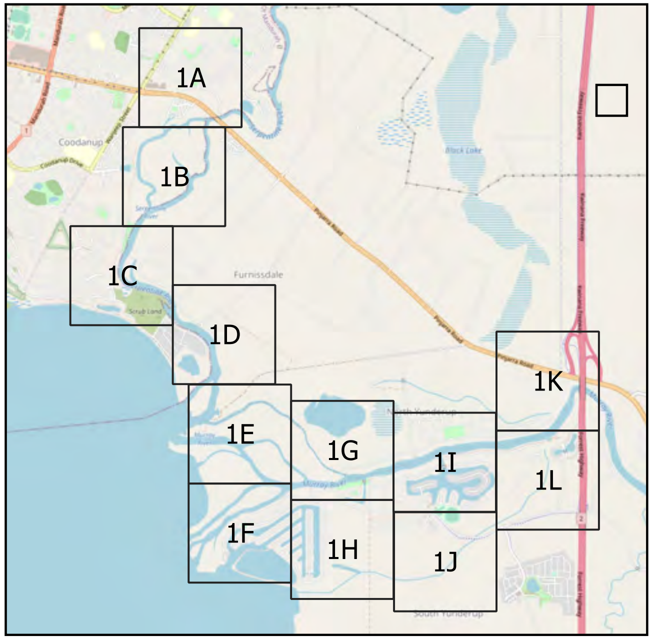
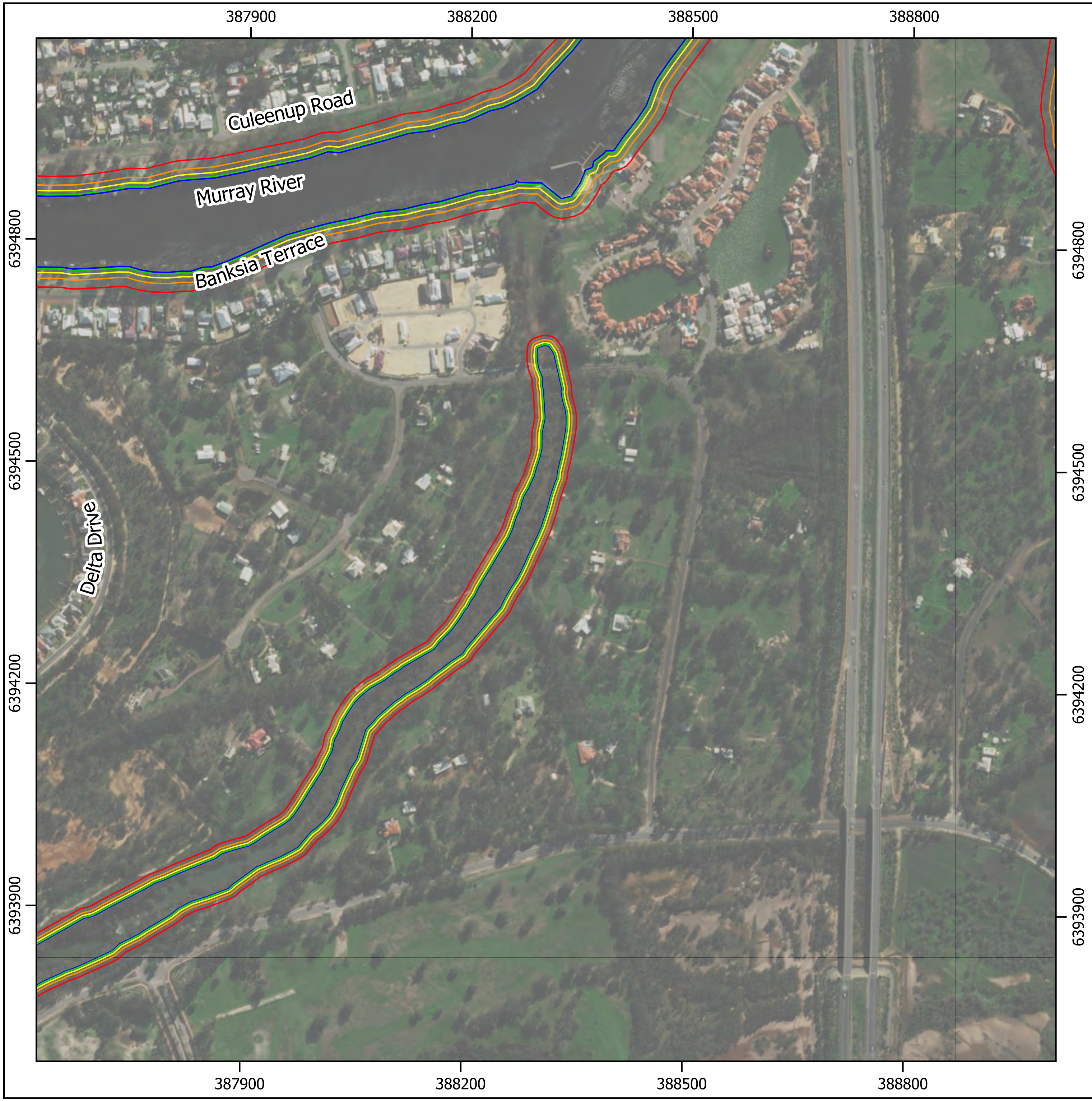
Shire of Murray Baird.

Map 1K





Shire of Murray

Coastal Processes Allowances

(Erosion Setback - Rivers)

Erosion Hazard

- 2120
- 2070
- 2050
- 2030
- 2020

N

0 100 200 300 m

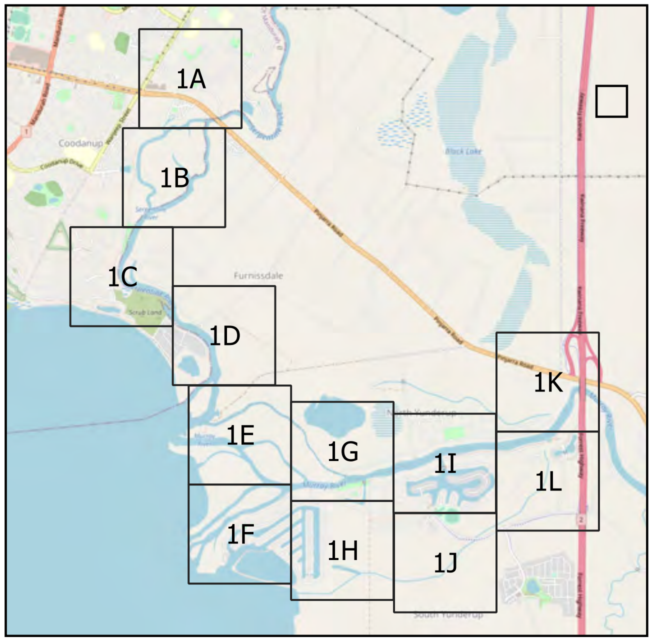
13064.101 | May-2021
Imagery: ESRI Basemap
Street Name Data: © OpenStreetMap contributors
Spatial Reference: GDA 2020 MGA Zone 50

This map has been prepared by Baird Australia on behalf of the Shire of Murray as part of the Shire of Murray Coastal Hazard Risk Management and Adaptation Planning Project. The coastal setbacks used to create the erosion likelihoods have been adopted from the Coastal Hazard assessment completed for the Shire of Murray by Seashore (2021).

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Shire of Murray Baird.

Map 1L



C.4 Coastal Inundation Hazard

C.4.1 Coastal Inundation Hazard – 100yr ARI Scenario, Planning Year 2020 (No Sea Level Rise)

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

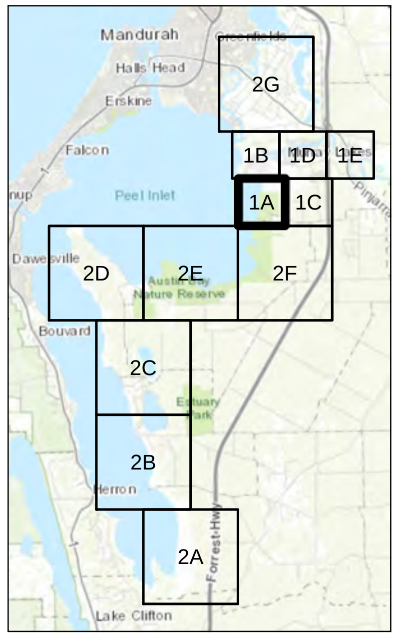
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1A

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

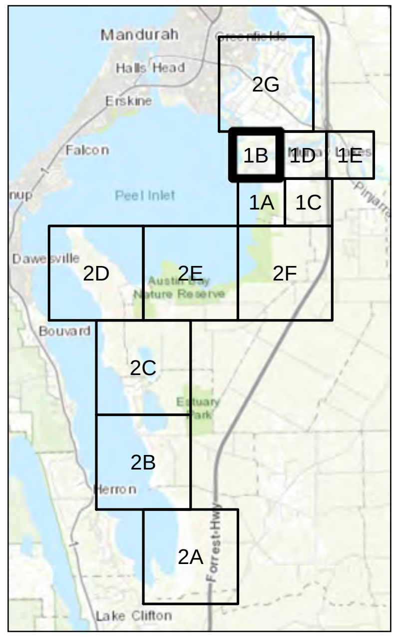
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1B

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

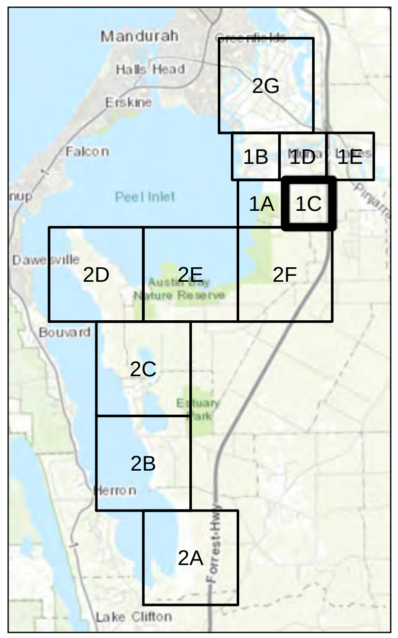
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1C

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

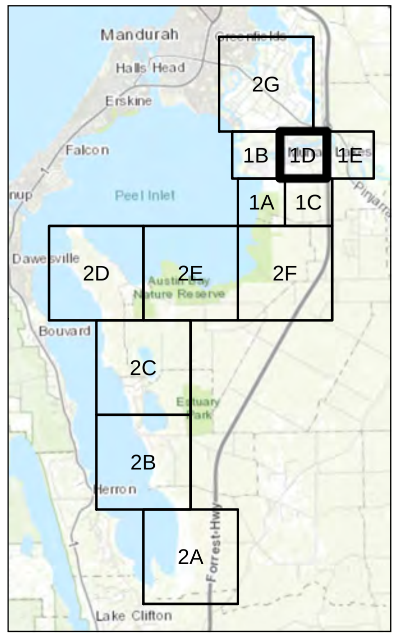
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1D

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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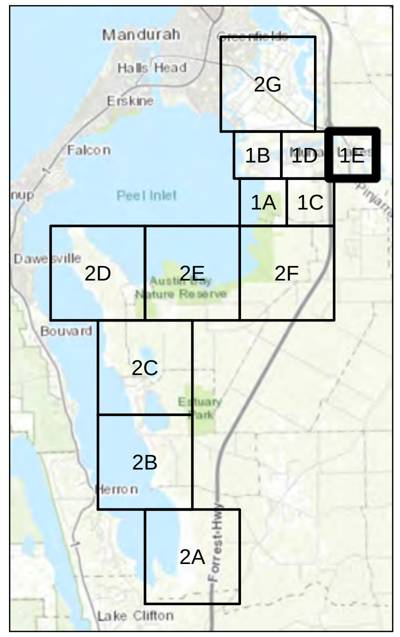
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



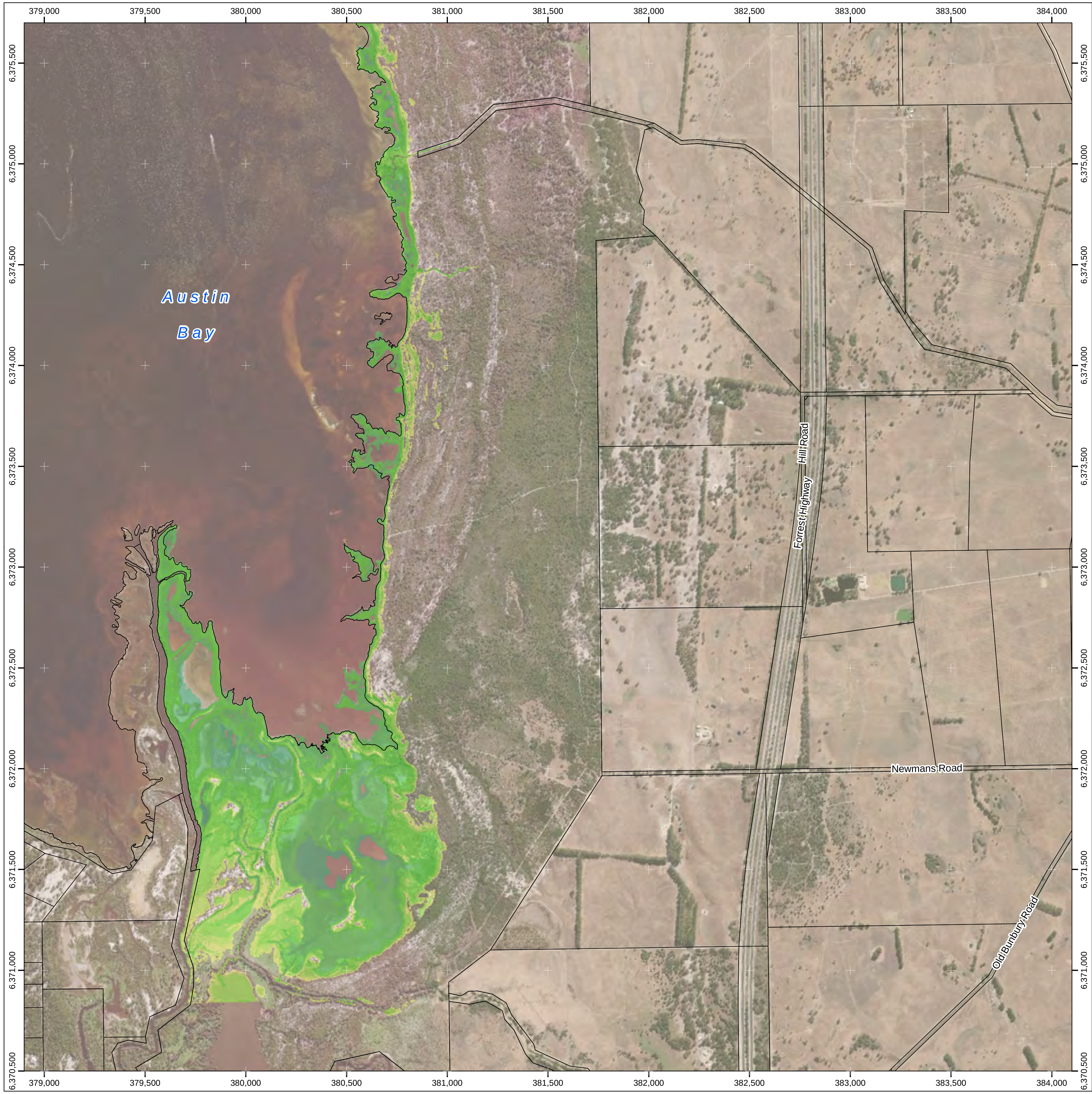
Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1E



Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

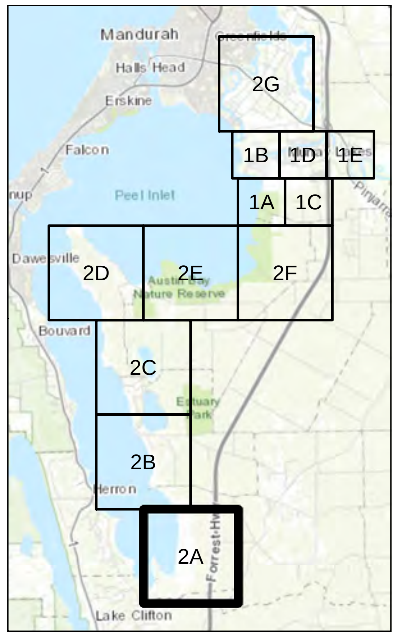
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2A

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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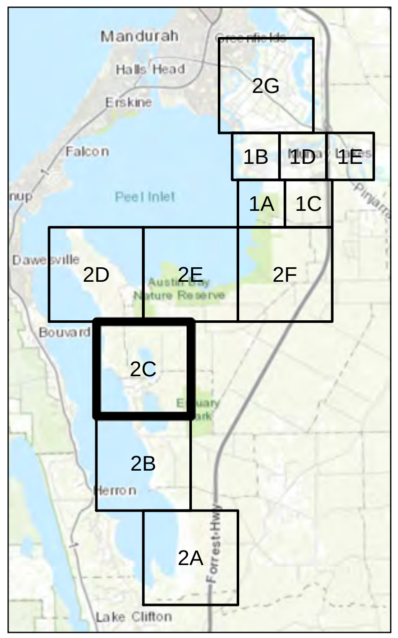
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2C

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

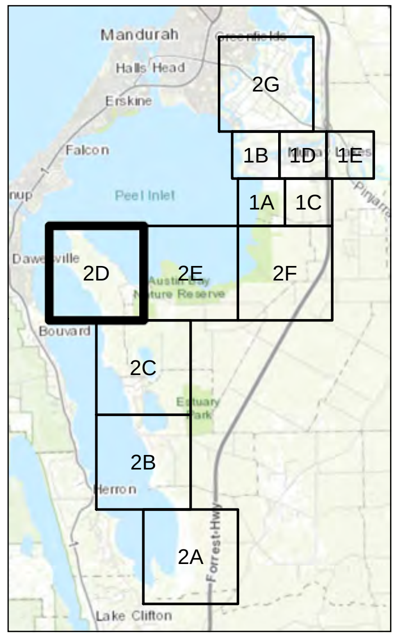
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

N W E S

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

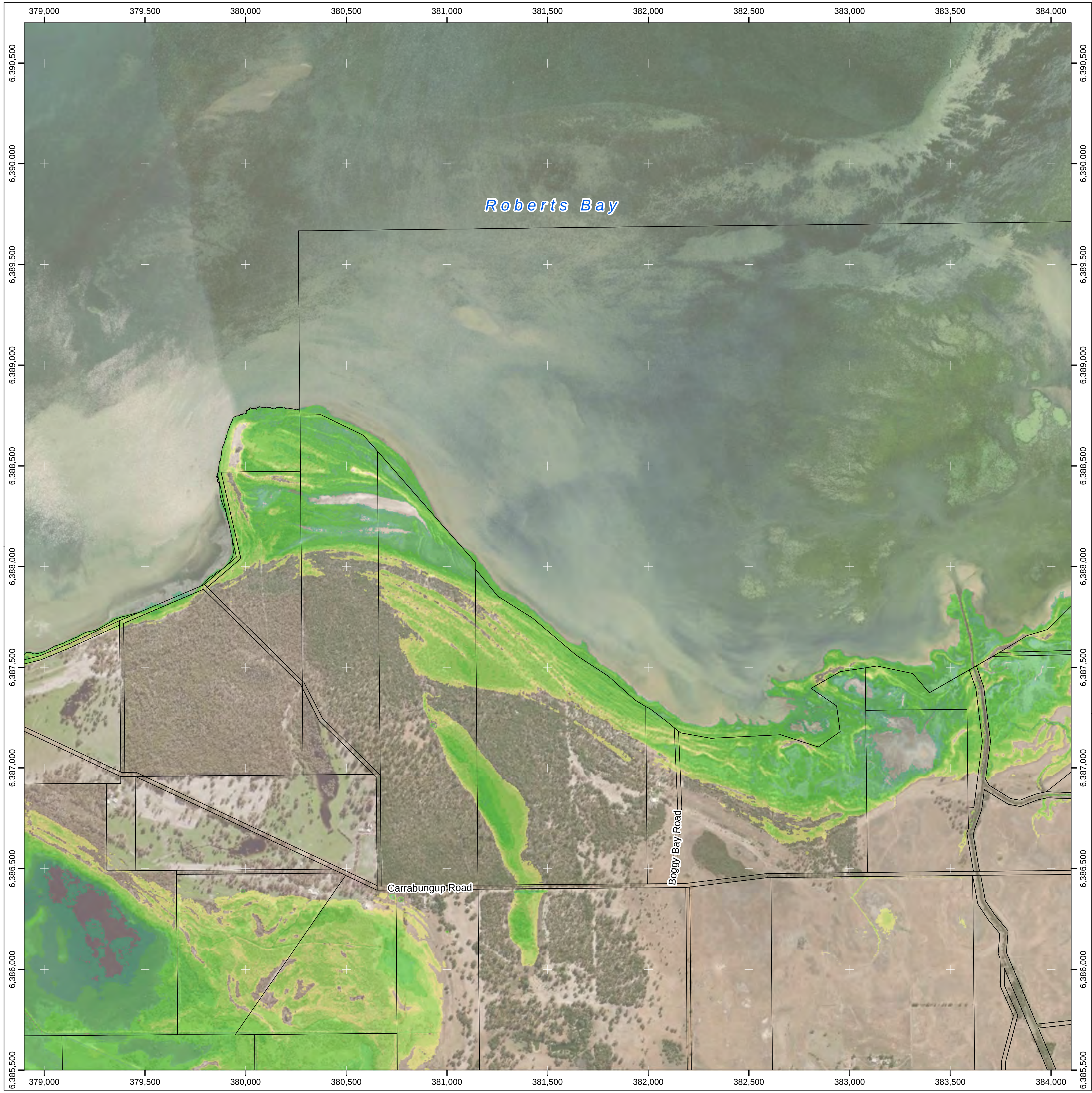


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2D



Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

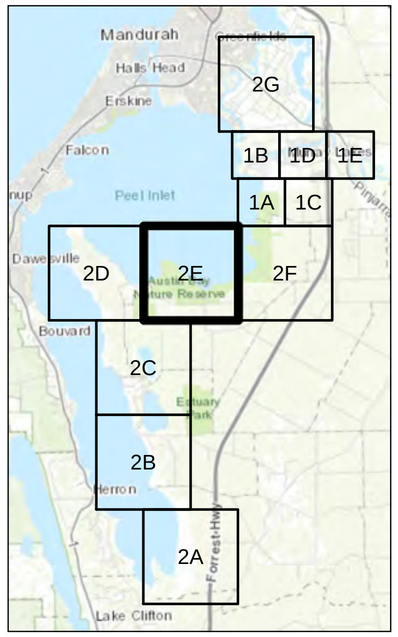
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2E

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

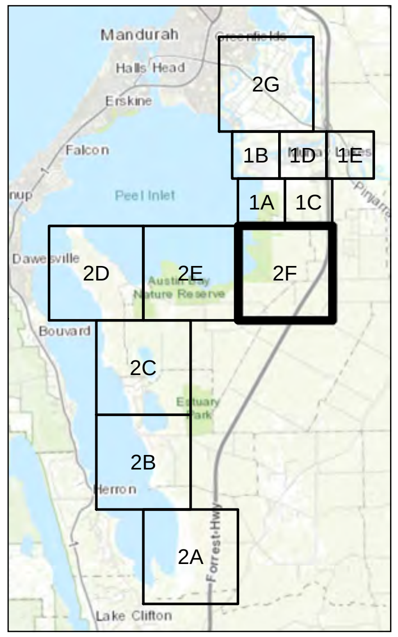
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2F

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.09m AHD (no Sea Level Rise)

Inundation Depth (m)

- > 1.0
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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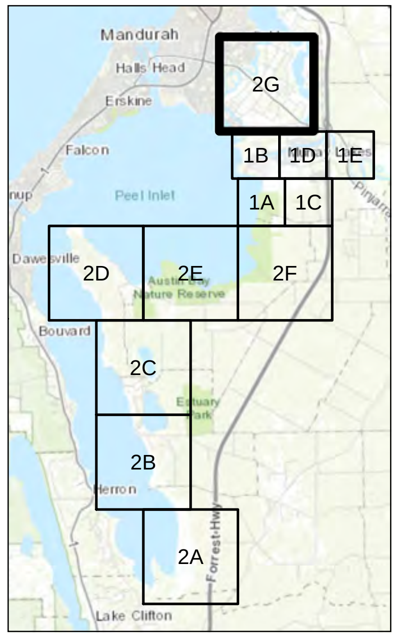
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2G

C.4.2 Coastal Inundation Hazard – 100yr ARI Scenario, Planning Year 2070 (Includes 0.4m Sea Level Rise)

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm
in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

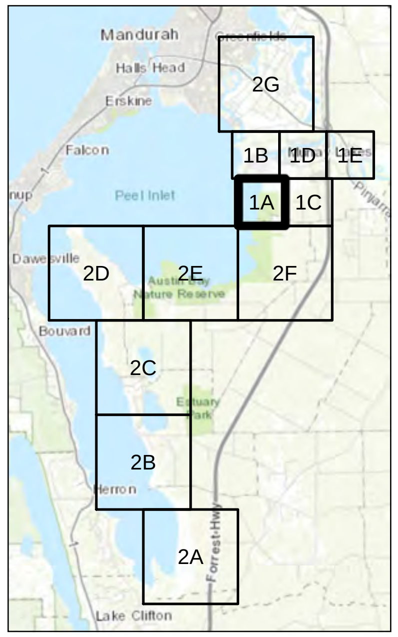
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1A

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

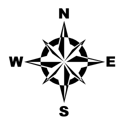
- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Spatial Reference: GDA 1994 MGA Zone 50



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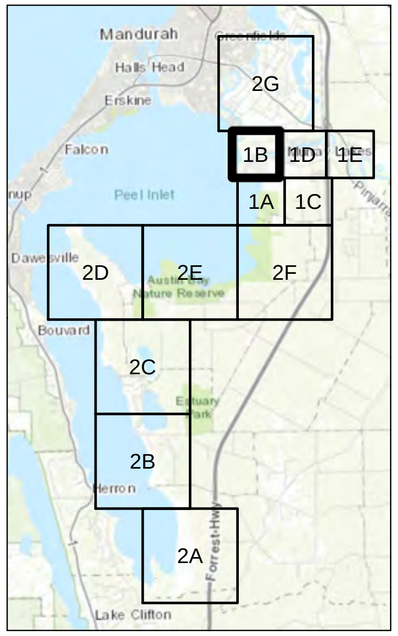
Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1B

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

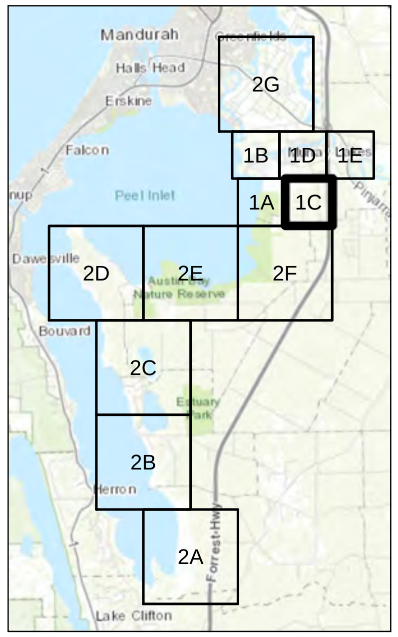
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

N W E S

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1C

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

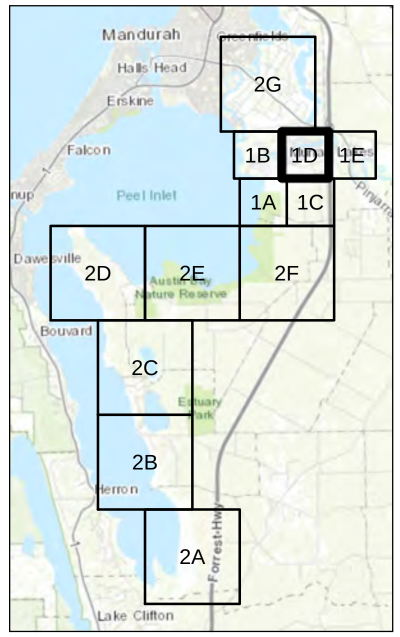
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1D

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

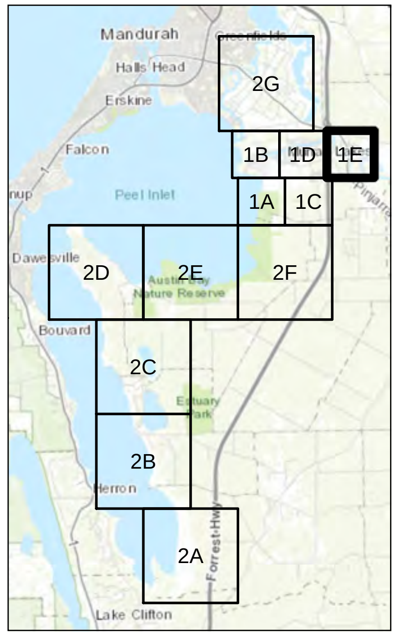
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

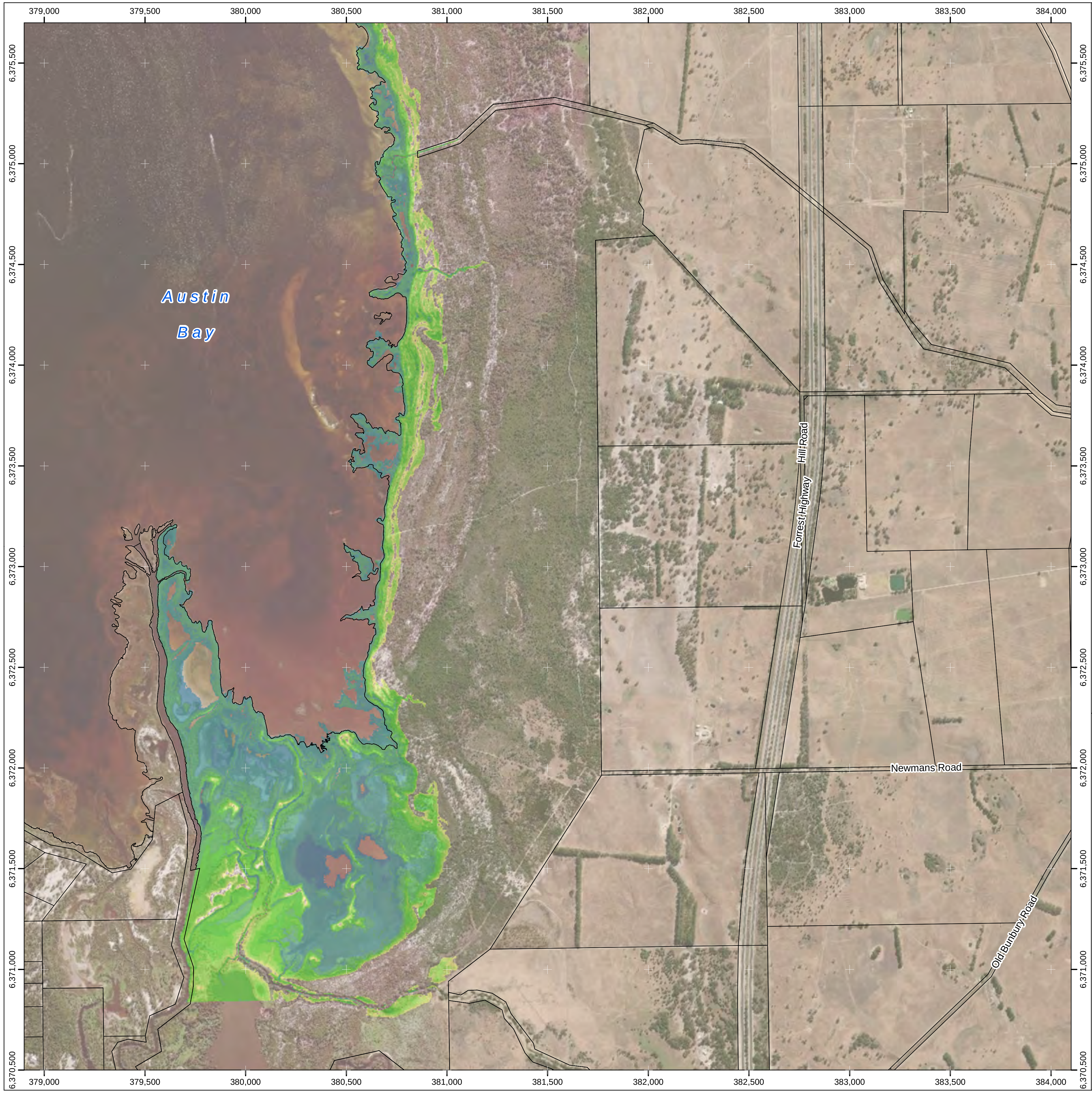
1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1E



Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

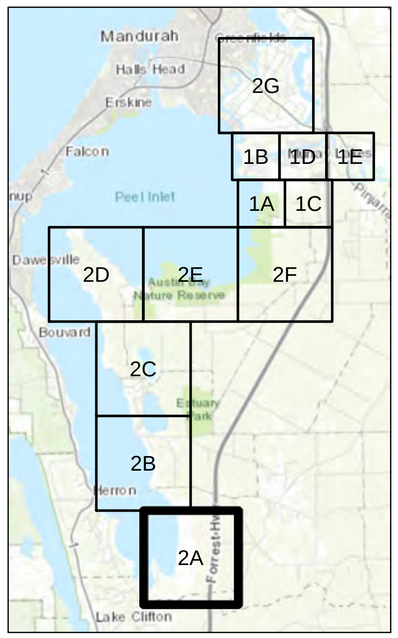
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2A

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

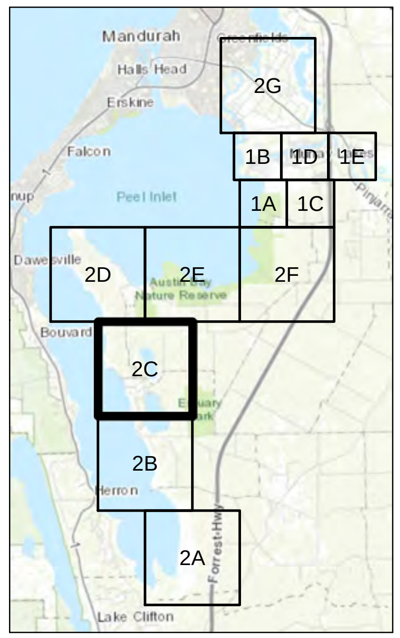
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2C

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

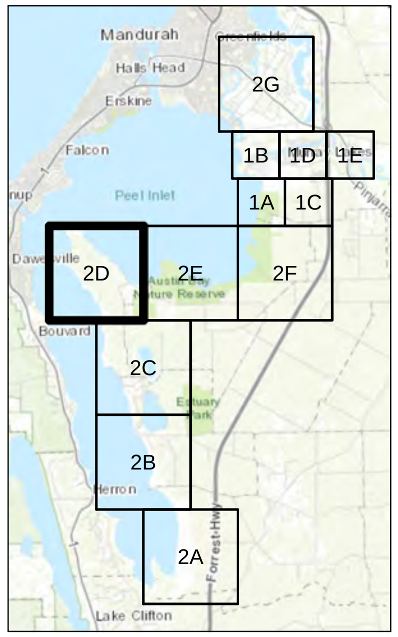
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

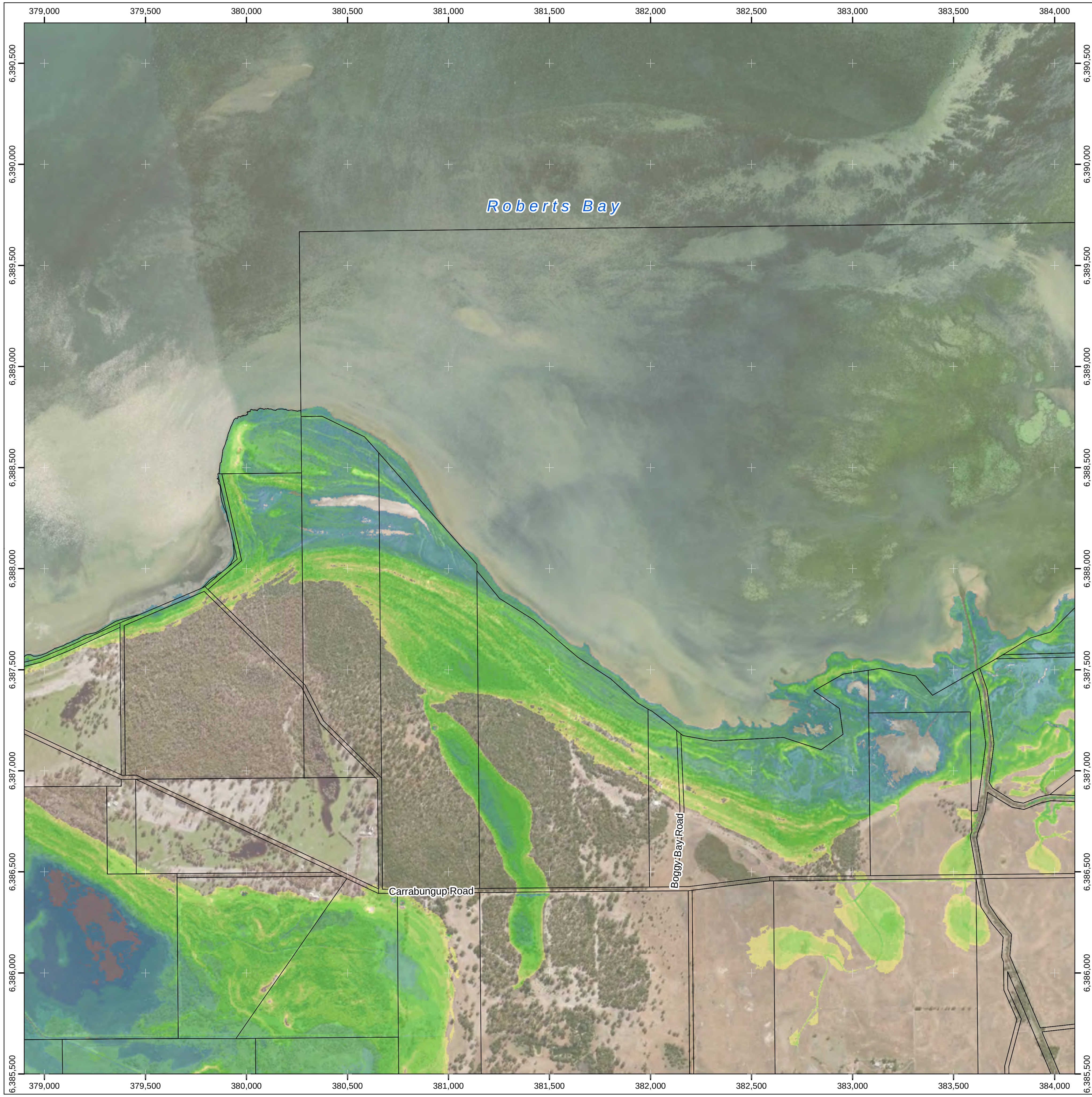
1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2D



Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

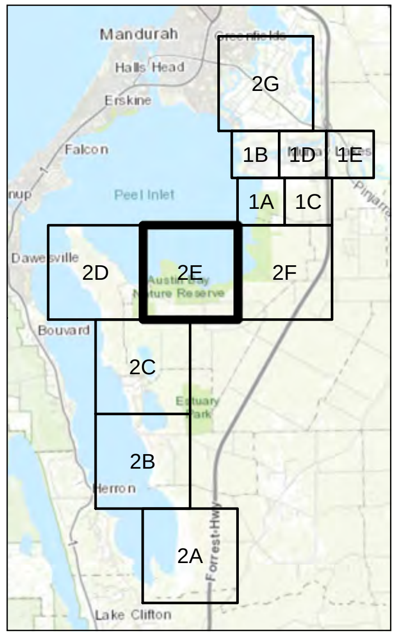
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2E

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

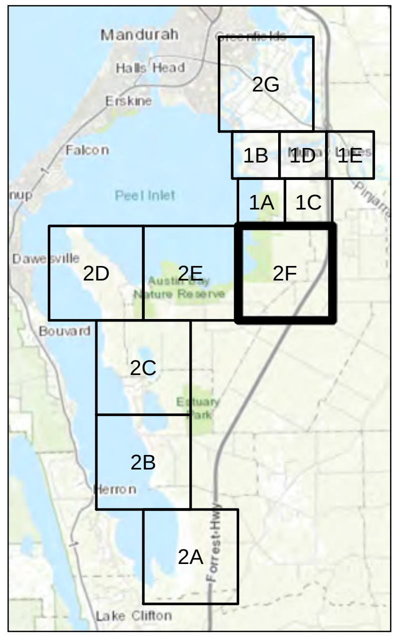
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

N W E S



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2F

Shire of Murray
Coastal Hazard Flood Mapping

100yr ARI Design Storm in Planning Year 2070

Inundation Depth Based on Peak Water level of 1.49m AHD (includes 0.4m Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

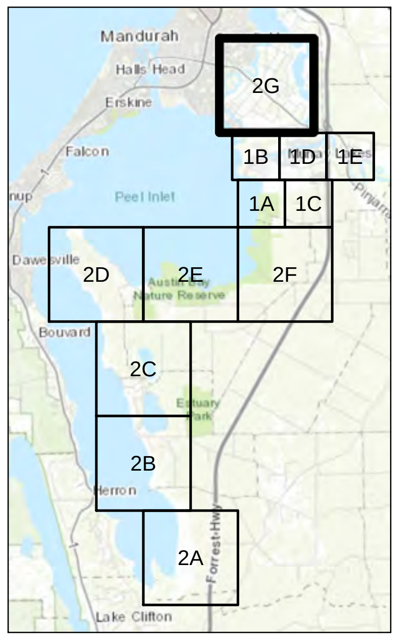
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2G

C.4.3 Coastal Inundation Hazard – 500yr ARI Scenario, Planning Year 2020 (No Sea Level Rise)

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

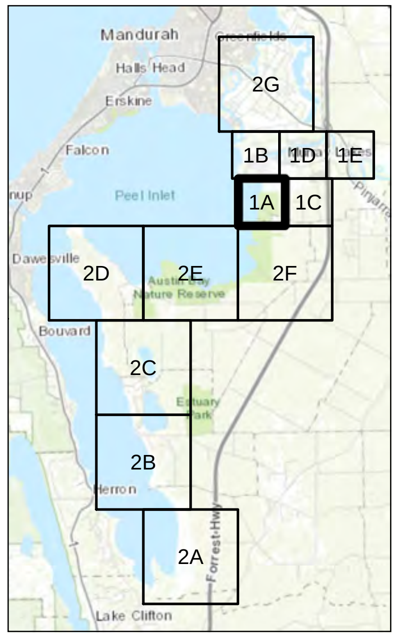
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1A

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

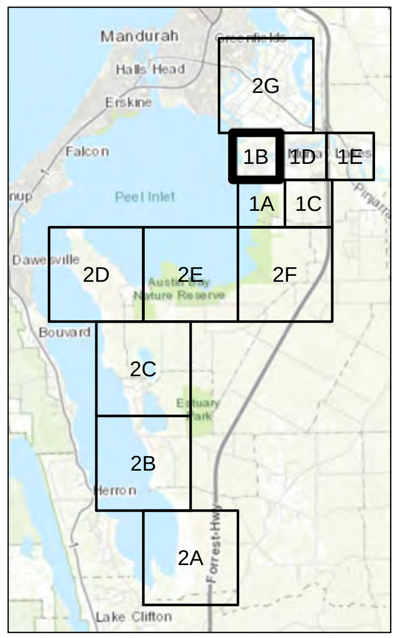
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1B

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

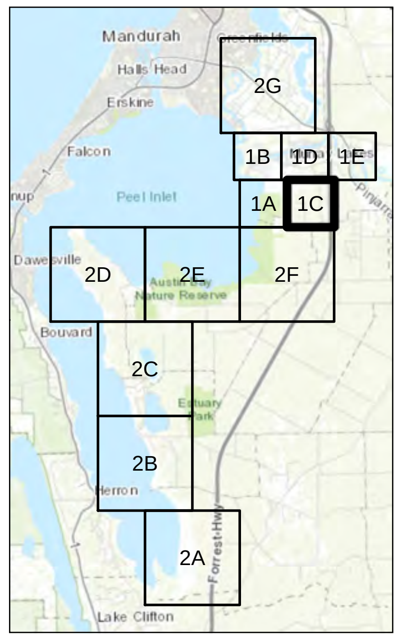
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1C

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

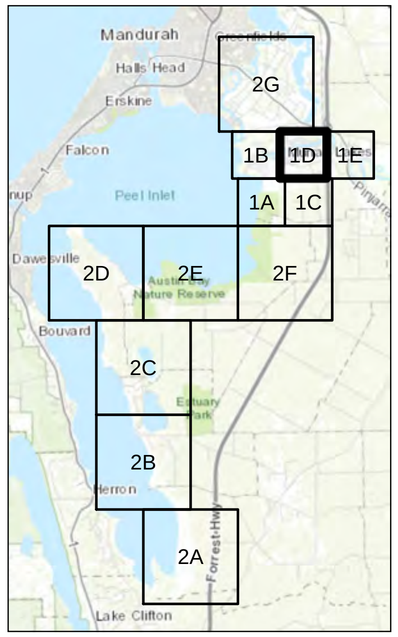
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 1D

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

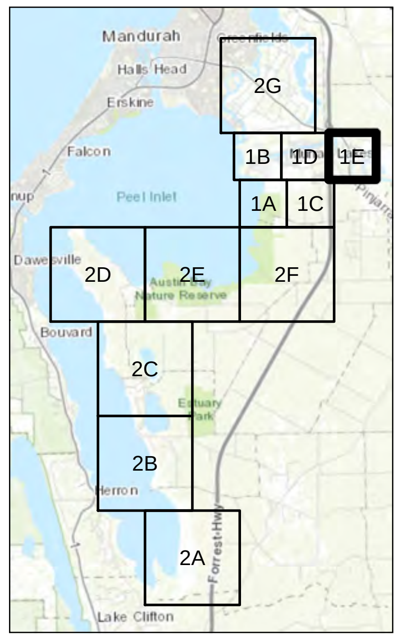
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

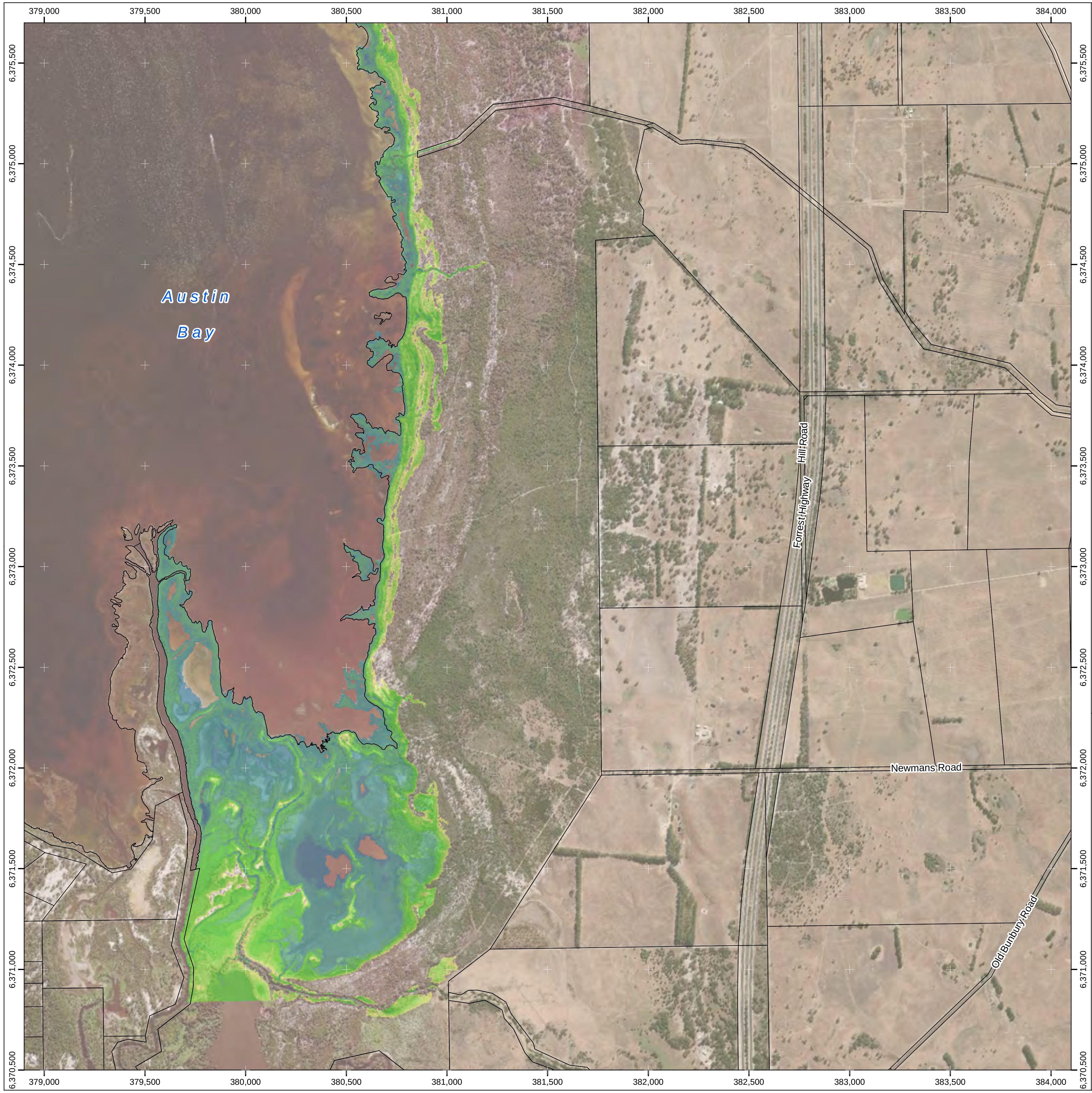
Map Published: 19 Nov. 2020

Mapsheet: 1E

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)



Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

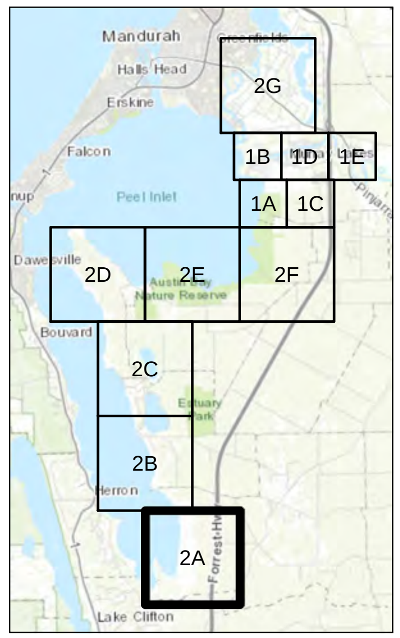
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2A

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

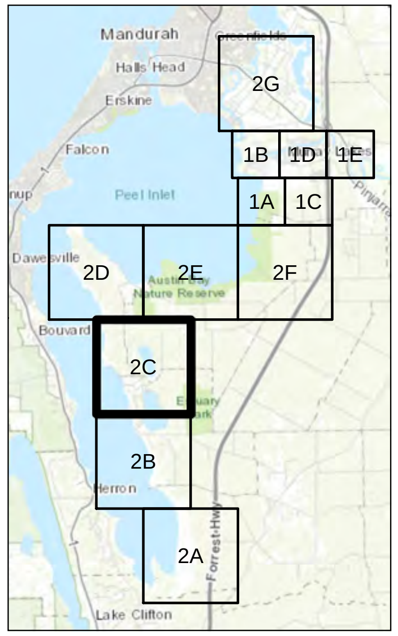
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2C

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

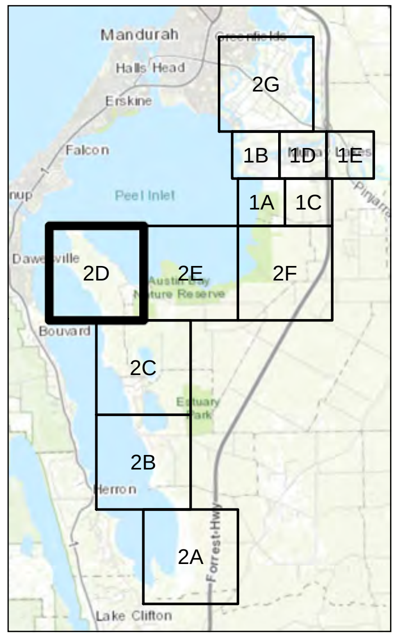
Street name data © OpenStreetMap contributors. Basemap Image: ESRI World Imagery © 2020. Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

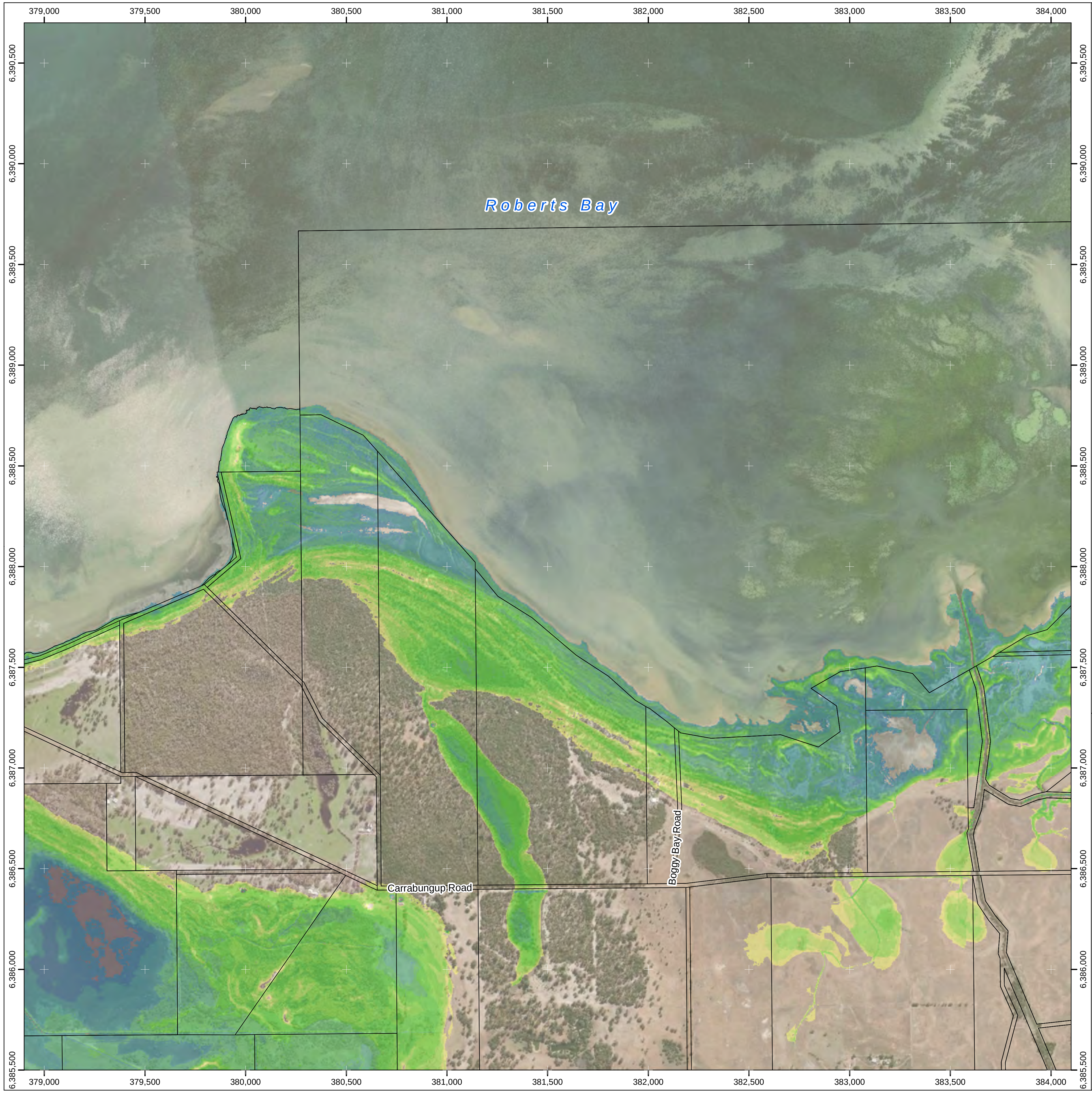


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2D



Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

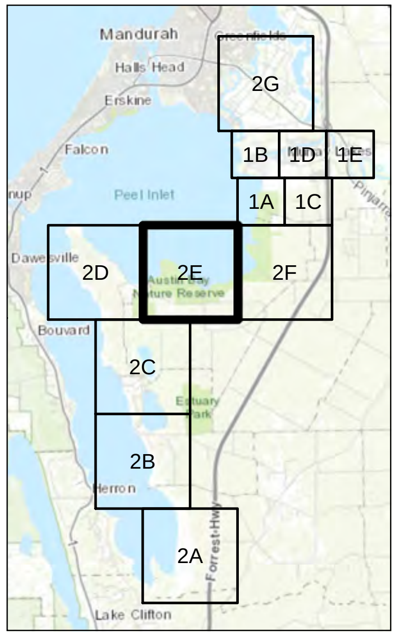
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2E

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

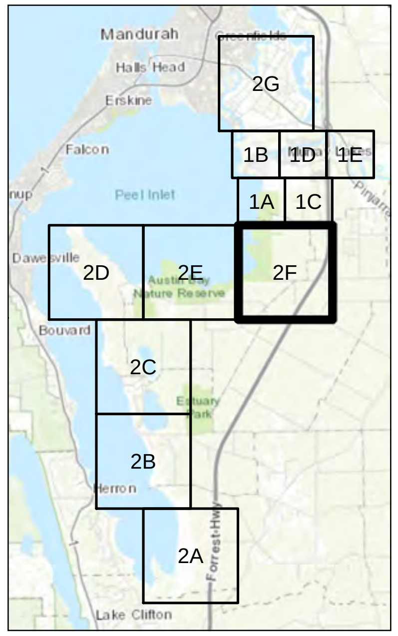
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

N W E S

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2F

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning Year 2020

Inundation Depth Based on Peak Water level of 1.44m AHD (No Sea Level Rise)

Inundation Depth (m)

- > 1.4
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- 0 - 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.

Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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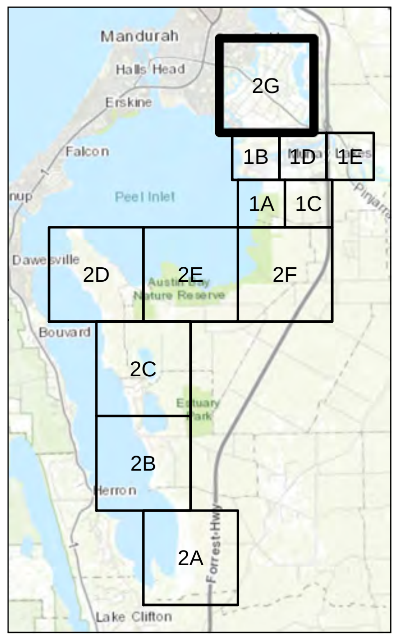
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



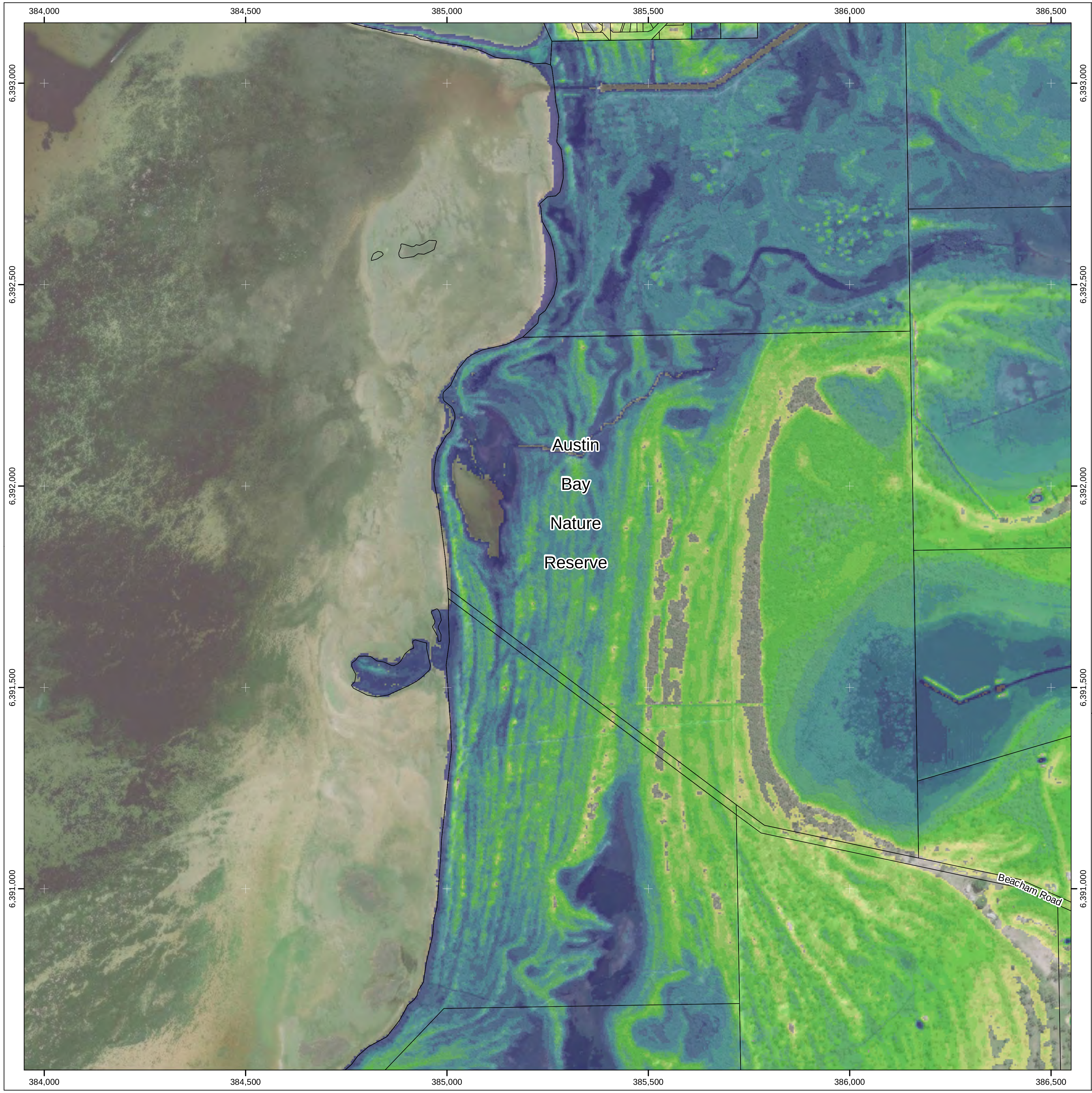
Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 19 Nov. 2020

Mapsheet: 2G

C.4.4 Coastal Inundation Hazard – 500yr ARI Scenario, Planning Year 2120 (Includes 0.9m Sea Level Rise)



Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

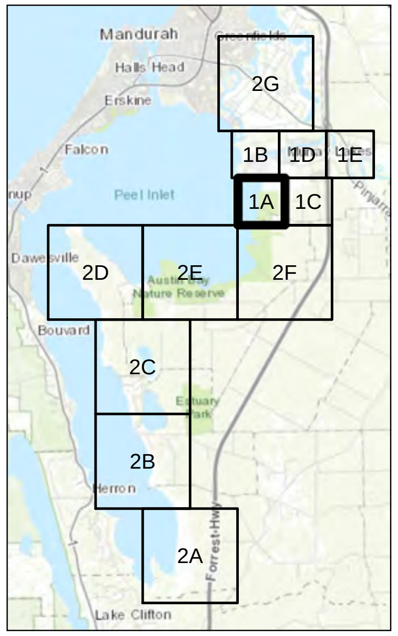
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors. Basemap Image: ESRI World Imagery © 2020. Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

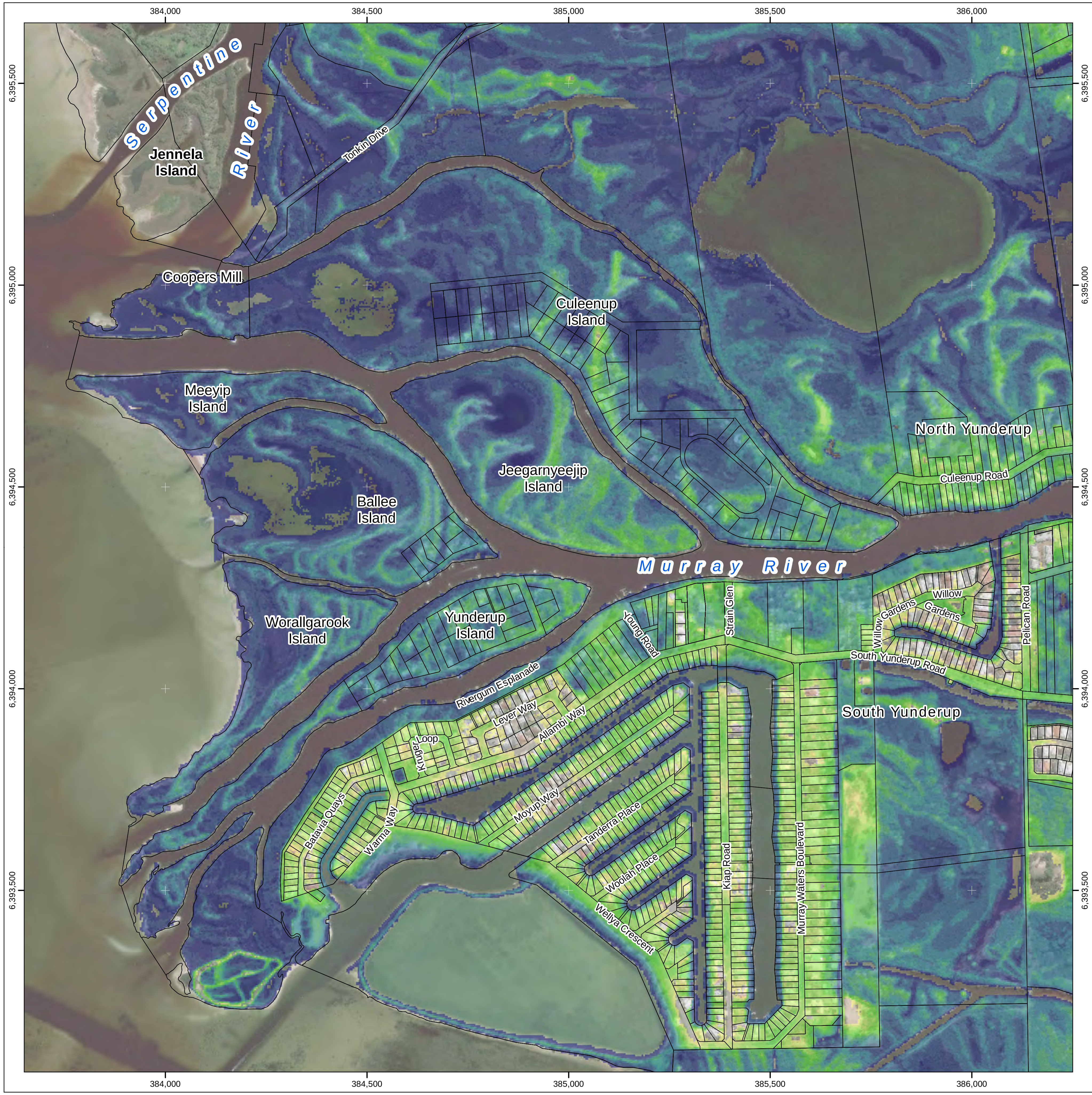


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 1A



Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

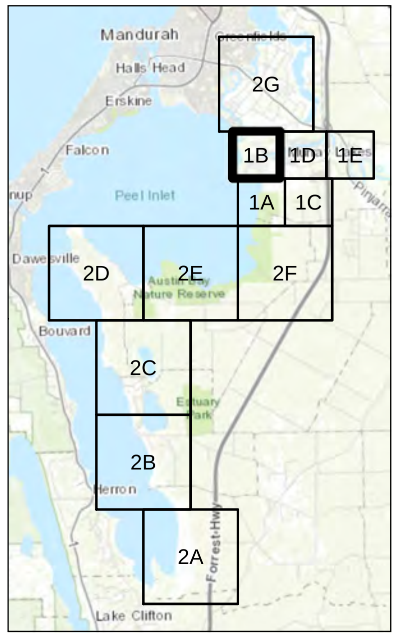
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

N W E S

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 1B

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

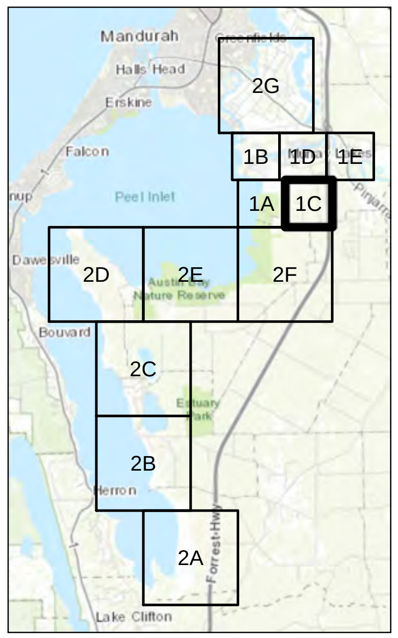
Street name data © OpenStreetMap contributors. Basemap Image: ESRI World Imagery © 2020. Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 1C

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

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Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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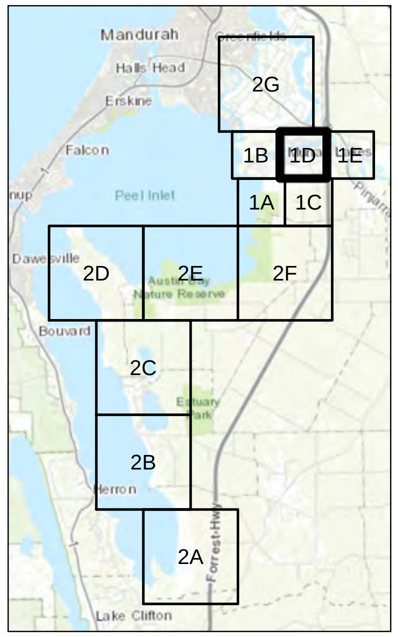
Street name data © OpenStreetMap contributors. Basemap Image: ESRI World Imagery © 2020. Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

N W E S

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 1D

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
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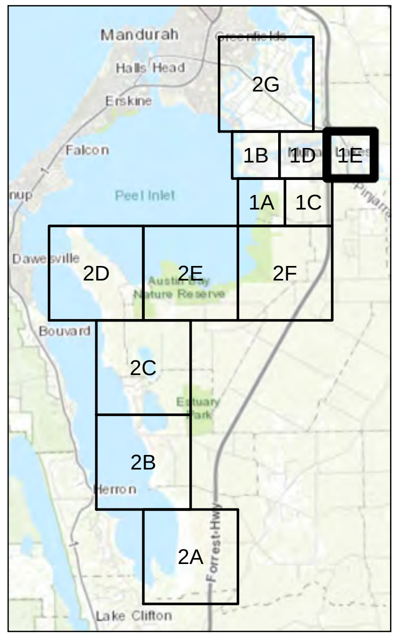
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 100 200 300 400 500 m

1:10,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

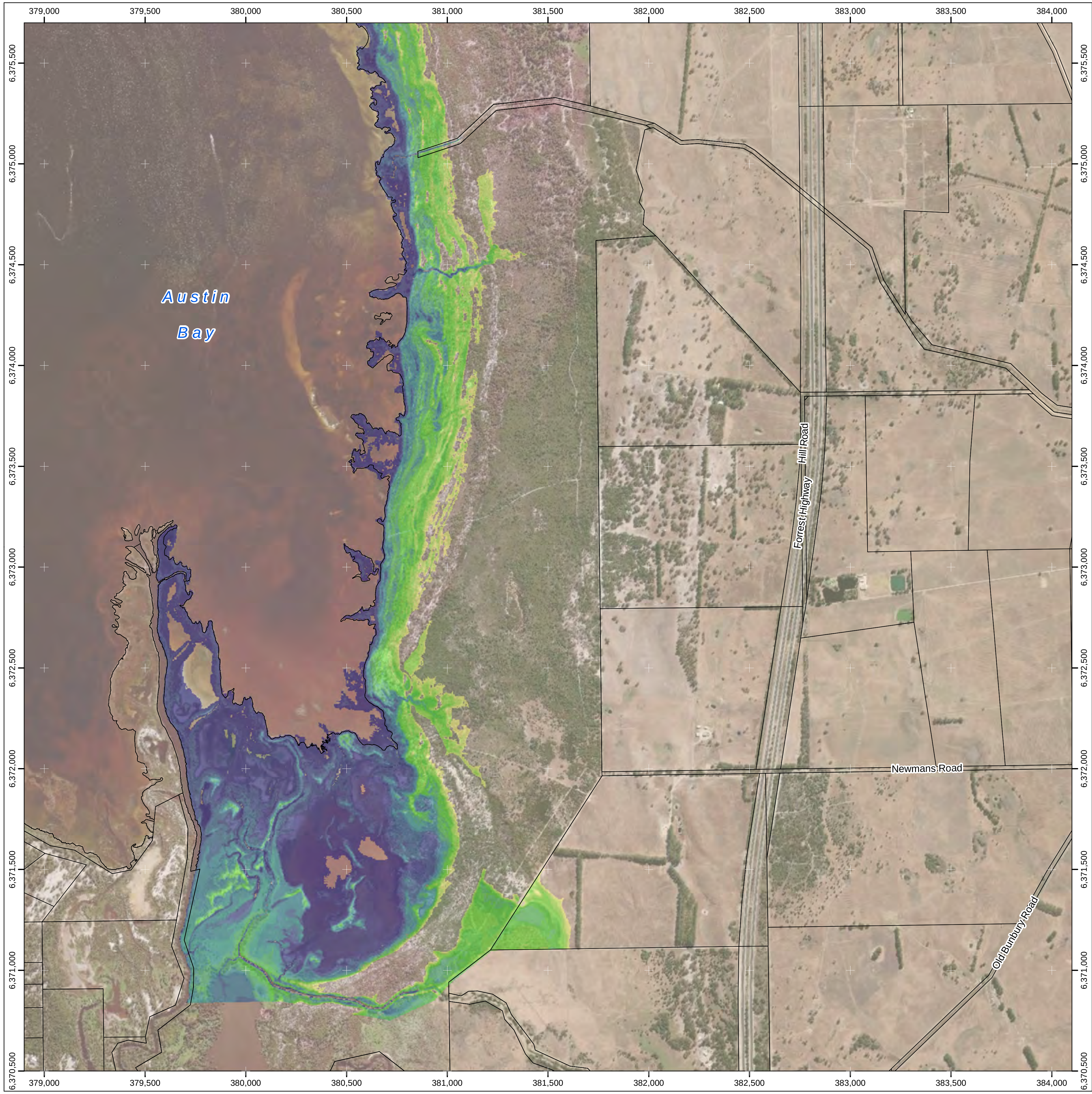


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 1E



Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

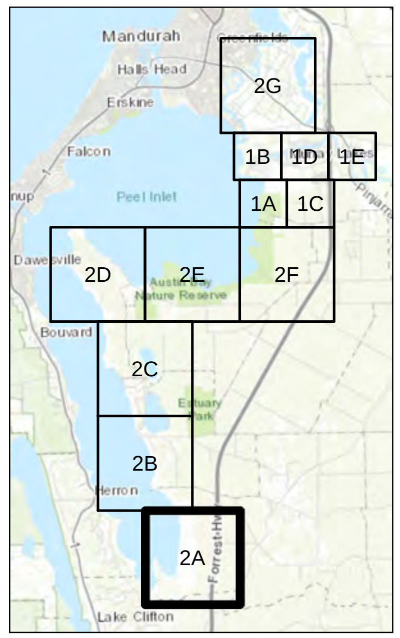
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

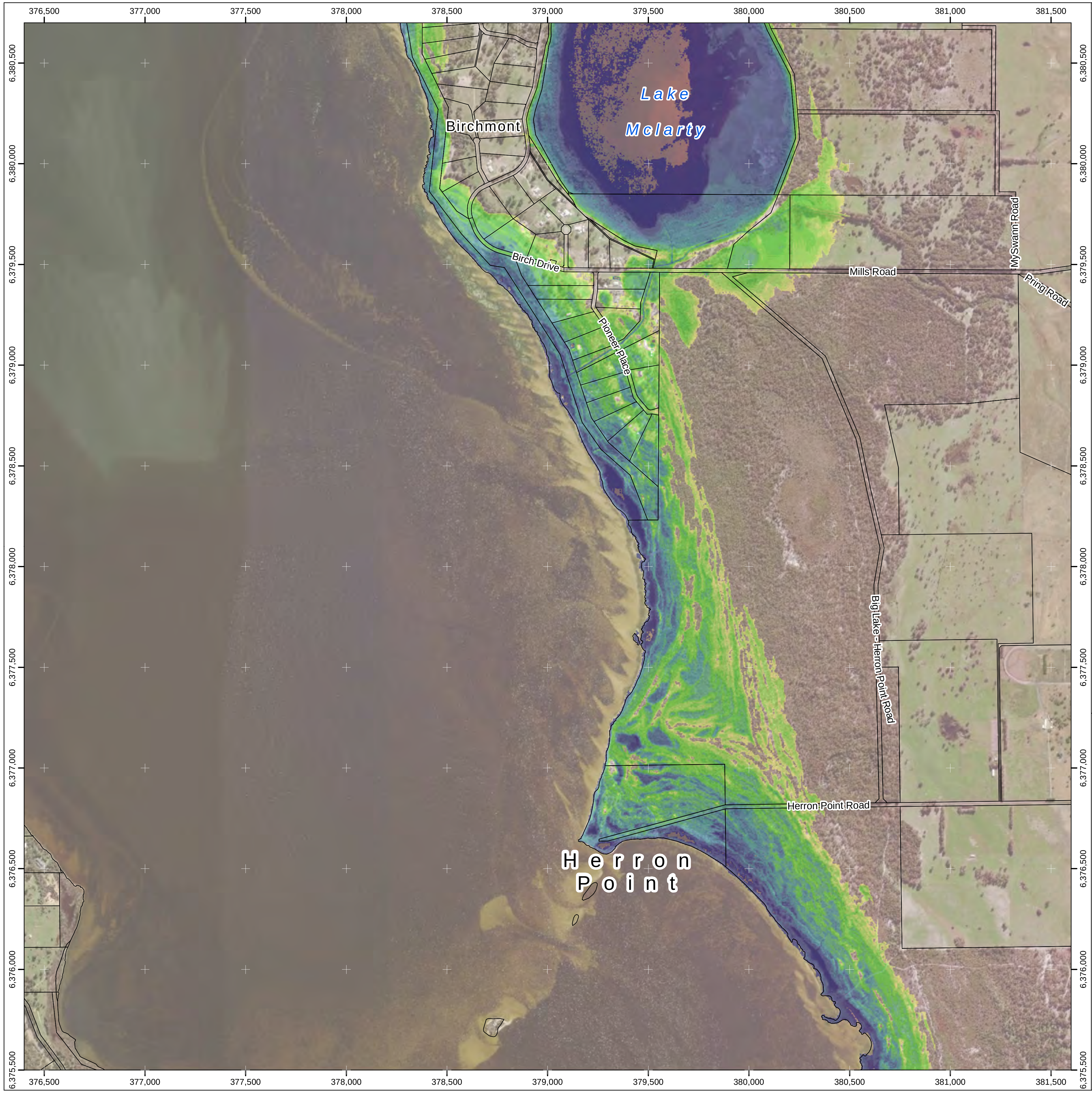


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 2A



Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

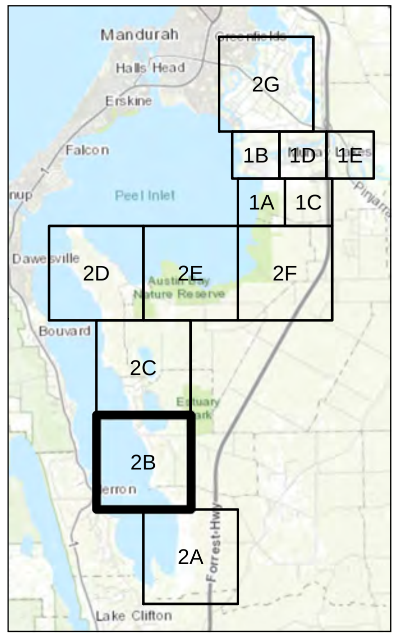
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

N W E S

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 2B

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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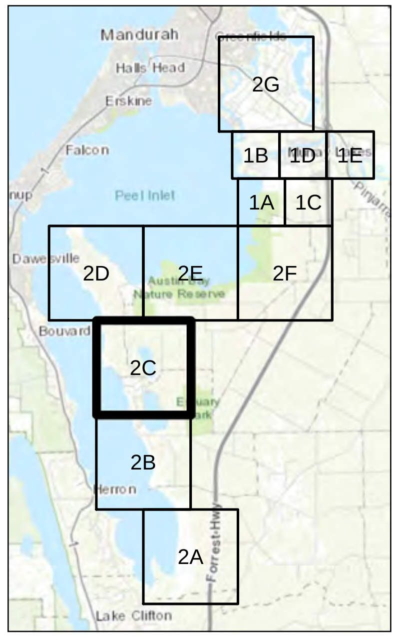
Street name data © OpenStreetMap contributors. Basemap Image: ESRI World Imagery © 2020. Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 2C

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

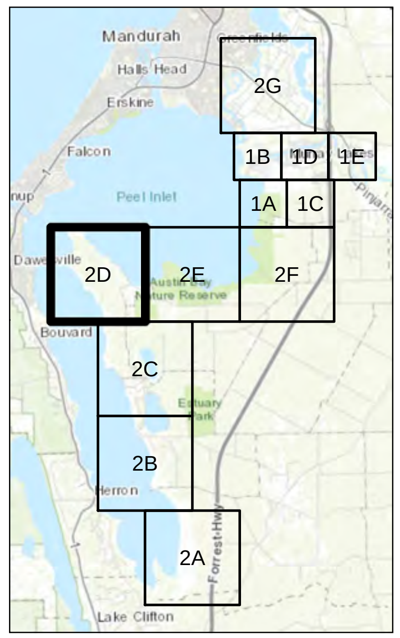
Street name data © OpenStreetMap contributors. Basemap Image: ESRI World Imagery © 2020. Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

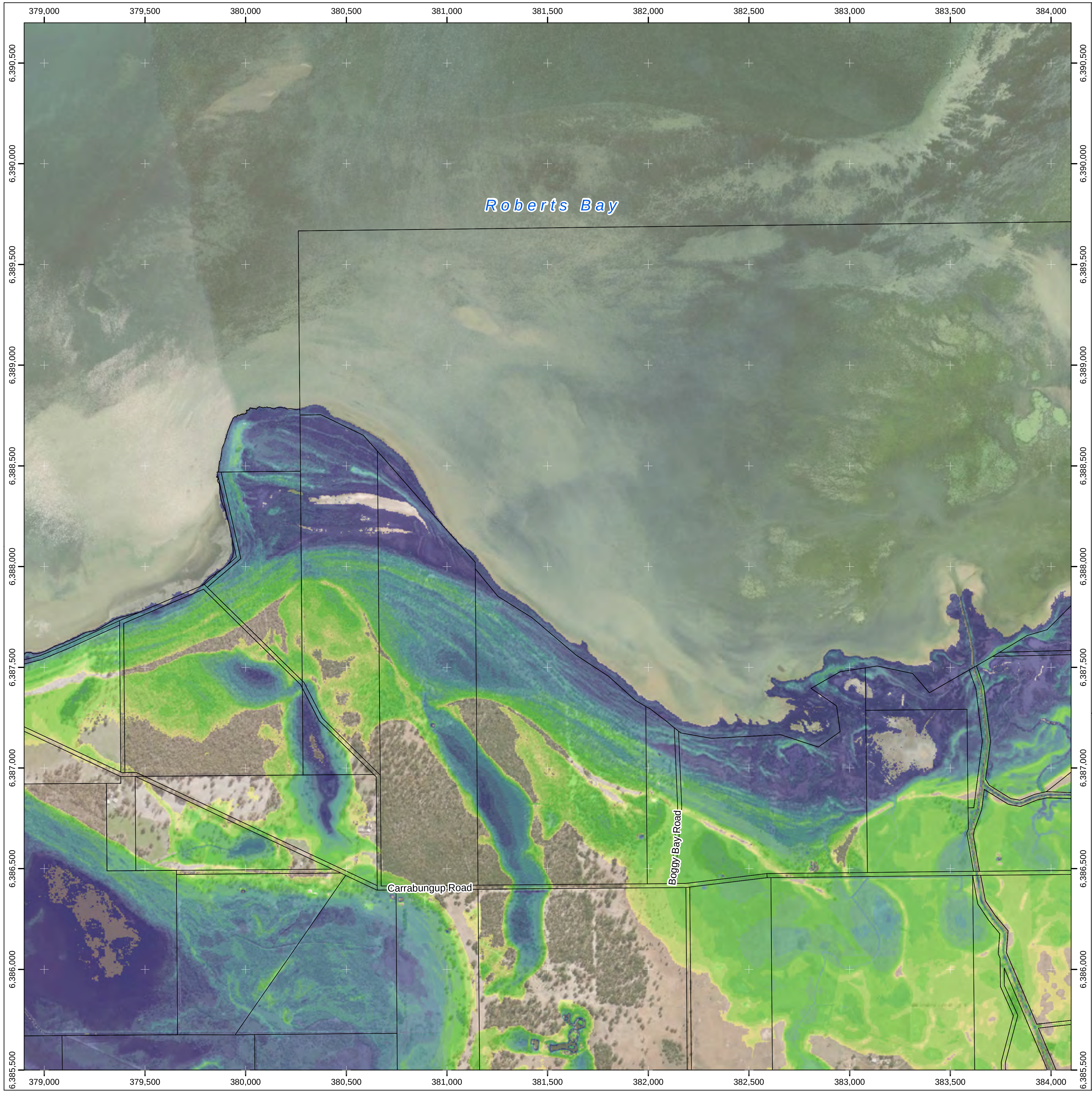


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 2D



Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

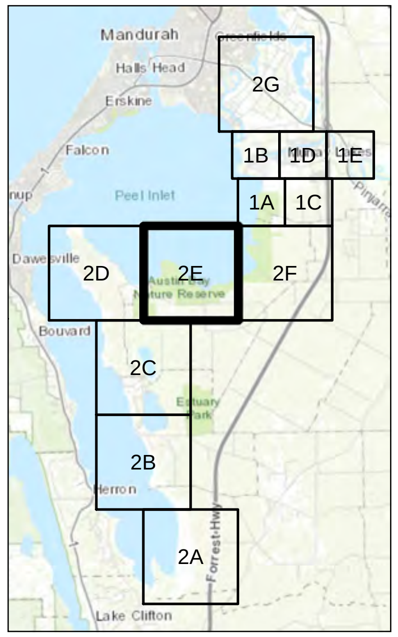
Street name data © OpenStreetMap contributors.
Basemap Image: ESRI World Imagery © 2020.
Spatial Reference: GDA 1994 MGA Zone 50

N W E S

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

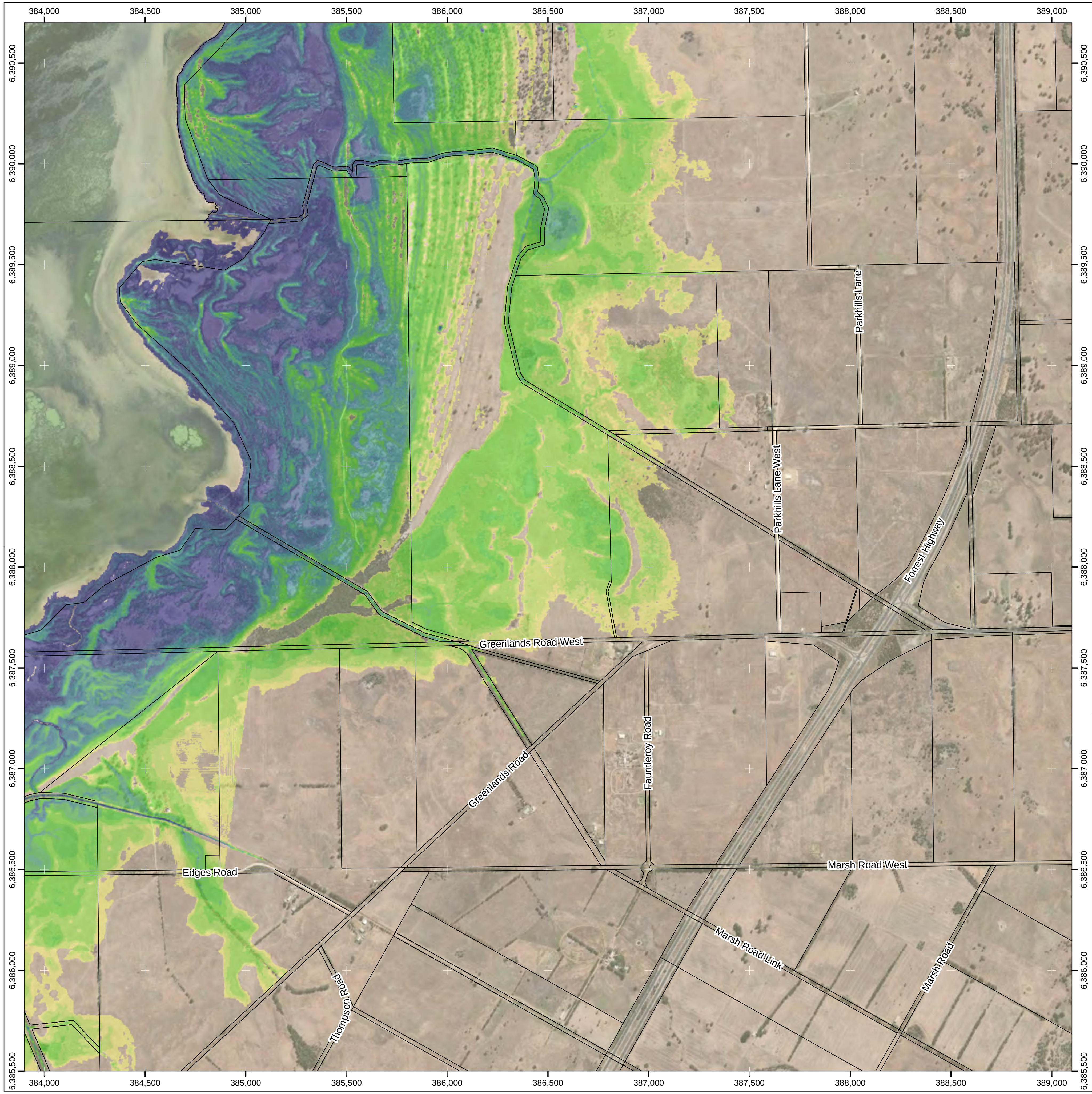


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 2E



Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Inundation Depth (m)

- > 2.0
- 1.81 - 2.0
- 1.61 - 1.8
- 1.41 - 1.6
- 1.21 - 1.4
- 1.01 - 1.2
- 0.81 - 1.0
- 0.61 - 0.8
- 0.41 - 0.6
- 0.21 - 0.4
- 0.11 - 0.2
- < 0.1

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Street name data © OpenStreetMap contributors. Basemap Image: ESRI World Imagery © 2020. Spatial Reference: GDA 1994 MGA Zone 50

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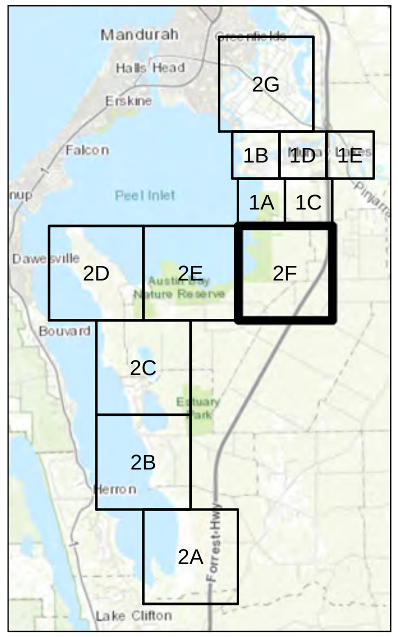
1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).

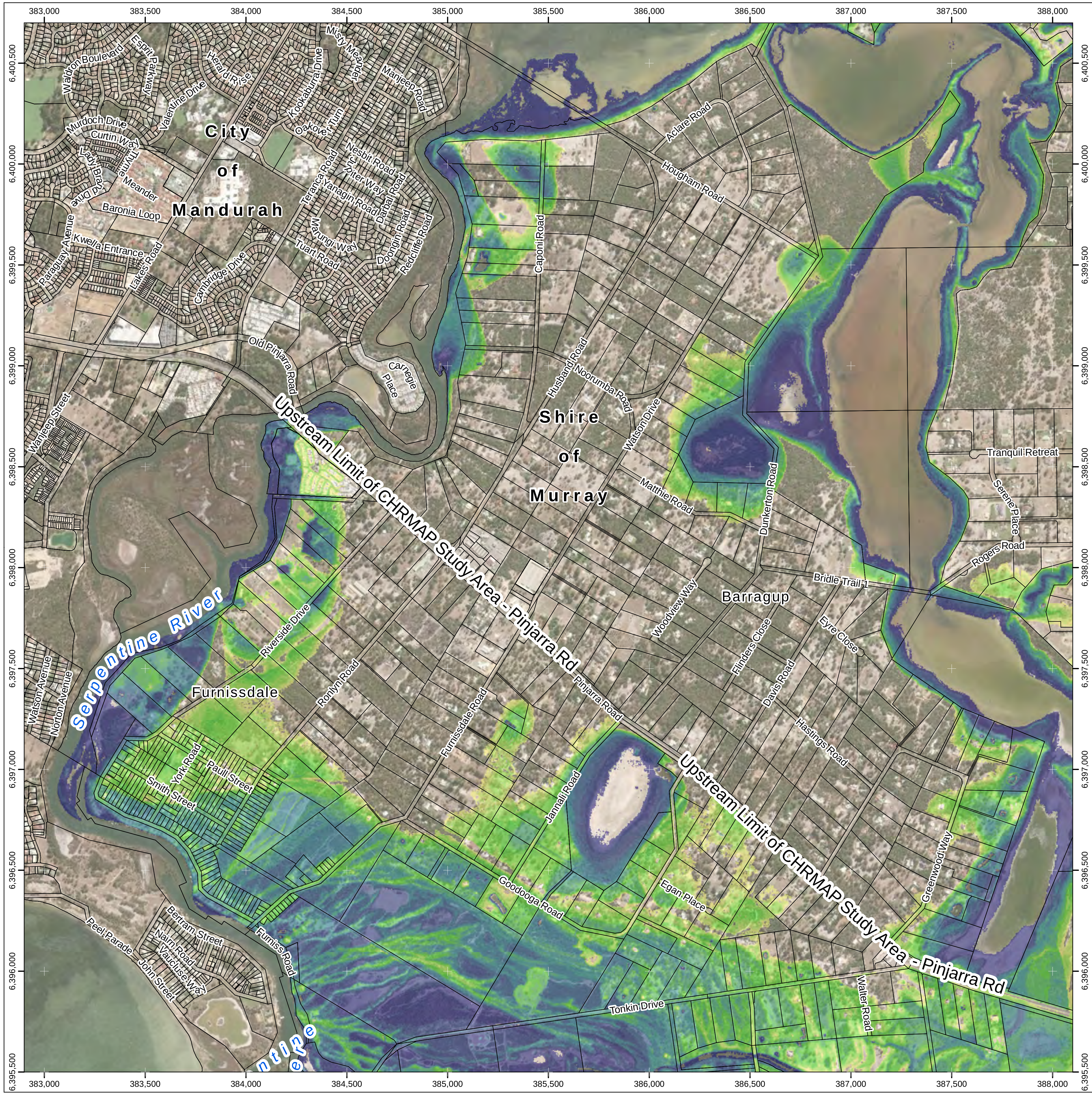


Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 2F



Shire of Murray
Coastal Hazard Flood Mapping

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Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray.
Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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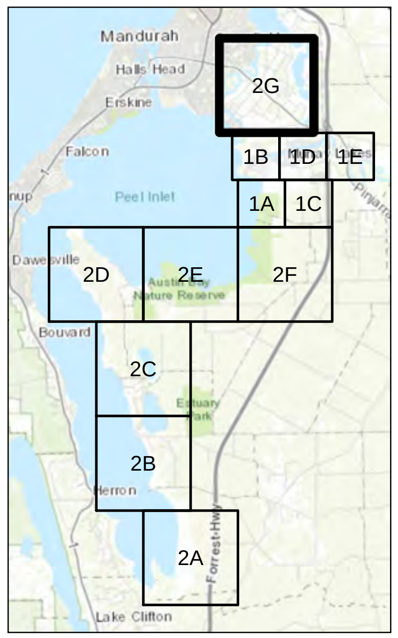
Spatial Reference: GDA 1994 MGA Zone 50

0 200 400 600 800 1,000 m

1:20,000

Map scale representative fraction when printed on A3 page size (420x297 mm).



Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208

https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 16 Nov. 2020

Mapsheet: 2G

Appendix D

Vulnerability Assessment by Shoreline Management Unit

D.1 Vulnerability – Erosion

					Likelihood Category				Erosion Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	General Cat.	Consequence	Adaptive Cap.	2030	2050	2070	2120	2030	2050	2070	2120	2030	2050	2070	2120
1	Beach areas	Environmental	Major	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	VH	VH
1	Foreshore Nature Reserve	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
1	Harvey Drain	Environmental	Minor	Good	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
1	Kooljerrenup Nature Reserve	Environmental	Major	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	VH	VH
1	Herron Point Camping Ground	Social	Moderate	Average	Rare	Unlikely	Possible	Almost Certain	L	M	M	H	L	M	M	H
1	Herron Point Foreshore	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
1	Coastal Pathways / Bridle Paths	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
1	Carpark at Herron Boat Ramp	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
1	Herron Point Boat Ramp	City Infrastructure	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
1	Herron Point Reserve Camping Ground Toilet / Showers	City Infrastructure	Minor	Poor	Rare	Rare	Unlikely	Possible	L	L	L	M	M	M	M	H
1	Infrastructure (Signage, shelters, fencing)	City Infrastructure	Insignificant	Good	Possible	Likely	Almost Certain	Almost Certain	L	L	M	M	L	L	L	L
1	Herron Point Road, Roads in Campground	City Infrastructure	Moderate	Poor	Rare	Unlikely	Possible	Likely	L	M	M	H	M	H	H	VH

					Likelihood Category				Erosion Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	General Cat.	Consequence	Adaptive Cap.	2030	2050	2070	2120	2030	2050	2070	2120	2030	2050	2070	2120
2	Beach areas	Environmental	Major	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	VH	VH
2	Foreshore Nature Reserve	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
2	Lake McLarty and McLarty Nature Reserve	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
2	Lake Mealup and Mealup Point Nature Reserve	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
2	Foreshore Reserve at Birchmont Boat Ramp	Social	Moderate	Average	Unlikely	Possible	Likely	Almost Certain	M	M	H	H	M	M	H	H
2	Coastal Pathways / Bridle Paths	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
2	Residential Properties	Private Asset	Major	Poor	Rare	Rare	Unlikely	Possible	L	L	M	H	M	M	H	VH
2	Carpark at Birchmont Boat Ramp	City Infrastructure	Moderate	Poor	Rare	Unlikely	Possible	Almost Certain	L	M	M	H	M	H	H	VH
2	Birchmont Boat Ramp	City Infrastructure	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
2	Infrastructure (signage, fencing, bus shelter)	City Infrastructure	Minor	Good	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	L	L	L
2	Drainage features (NOT Impacted by Erosion)	City Infrastructure	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M
2	Roads (Birch Drive, Mills Rd, Pioneer Place, Numbat Place, Kangaroo Loop)	City Infrastructure	Moderate	Poor	Rare	Rare	Unlikely	Possible	L	L	M	M	M	M	H	H

SMU	Description	General Cat.	Consequence	Adaptive Cap.	Likelihood Category 2030	Likelihood Category 2050	Likelihood Category 2070	Likelihood Category 2120	Erosion Risk Rating 2030	Erosion Risk Rating 2050	Erosion Risk Rating 2070	Erosion Risk Rating 2120	Vulnerability - Incl. Adaptive Capacity 2030	Vulnerability - Incl. Adaptive Capacity 2050	Vulnerability - Incl. Adaptive Capacity 2070	Vulnerability - Incl. Adaptive Capacity 2120
3	Beach area	Environmental	Major	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	VH	VH
3	Foreshore Reserve	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
3	Austin Bay Nature Reserve	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
3	Foreshore Reserve	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
3	Coastal Pathways / Bridle Paths	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
3	Residential Properties	Private Asset	Major	Poor	Rare	Rare	Unlikely	Possible	L	L	M	H	M	M	H	VH
3	Agricultural Properties	City Infrastructure	Moderate	Poor	Rare	Unlikely	Possible	Almost Certain	L	M	M	H	M	H	H	VH
3	Minor Infrastructure (signage, fencing)	City Infrastructure	Minor	Good	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
3	Drainage features	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
3	Roads (Carabunga Road).	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH

SMU	Description	General Cat.	Consequence	Adaptive Cap.	Likelihood Category 2030	Likelihood Category 2050	Likelihood Category 2070	Likelihood Category 2120	Erosion Risk Rating 2030	Erosion Risk Rating 2050	Erosion Risk Rating 2070	Erosion Risk Rating 2120	Vulnerability - Incl. Adaptive Capacity 2030	Vulnerability - Incl. Adaptive Capacity 2050	Vulnerability - Incl. Adaptive Capacity 2070	Vulnerability - Incl. Adaptive Capacity 2120
4	Beach area - Peel Inlet facing beach Batavia Quays	Environmental	Major	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	E	E	E	H	VH	VH	VH
4	Riverbank - Murray River	Environmental	Major	Average	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	H	H	VH	VH
4	Austin Bay Nature Reserve	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
4	Batavia Quays Wetland	Environmental	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
4	Batavia Quays Headland Feature - Acid Sulphate Soil Site	Environmental	Major	Poor	Likely	Almost Certain	Almost Certain	Almost Certain	H	E	E	E	VH	VH	VH	VH
4	South Yunderup Canal Bund - Water Quality Management	Environmental	Major	Poor	Rare	Rare	Unlikely	Possible	L	L	M	H	M	M	H	VH
4	Coastal Pathway - Bund in front of South Yunderup canals	City Infrastructure	Moderate	Average	Rare	Rare	Unlikely	Possible	L	L	M	M	L	L	M	M
4	Coastal Pathway - Wellya Crescent Park)	City Infrastructure	Moderate	Average	Rare	Rare	Unlikely	Possible	L	L	M	M	L	L	M	M
4	Foreshore Reserve (Tatham Rd, Rivergum Esplanade, Centenary Park)	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
4	Coastal Pathways Murray River (Tatham Rd, Rivergum Esplanade)	City Infrastructure	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
4	Coastal Pathways Batavia Quays Headland	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
4	Residential Properties South Yunderup Canal Estate	Private Asset	Major	Poor	Rare	Rare	Unlikely	Possible	L	L	M	H	M	M	H	VH
4	Residential Properties Placid Bend, Chipper Way, Countess Circuit	Private Asset	Major	Poor	Rare	Rare	Unlikely	Possible	L	L	M	H	M	M	H	VH
4	Residential Properties Batavia Quay	Private Asset	Major	Poor	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	VH	VH	VH	VH
4	Residential Properties Warma Way to Young Rd	Private Asset	Major	Poor	Rare	Rare	Unlikely	Possible	L	L	M	H	M	M	H	VH
4	Residential Properties Young Rd to Strain Glen	Private Asset	Major	Poor	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	H	VH	VH	VH
4	Residential Properties Pelican Rd, Banksia Terrace	Private Asset	Major	Poor	Unlikely	Possible	Almost Certain	Almost Certain	M	H	E	E	H	VH	VH	VH
4	Tathams Caravan Park, Murray River Caravan Park	Private Asset	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
4	Jetties and Moorings along River Privately Held	Private Asset	Minor	Average	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	M	M	M	M
4	Minor Roads (Rivergum Esplanade, Young Rd, Strain Glen, Pelican Rd, Banksia Tce)	City Infrastructure	Moderate	Poor	Unlikely	Possible	Likely	Almost Certain	M	M	H	H	H	H	VH	VH
4	Shire Jetties - Tatham Rd, Pelican Rd, Centenary Park	City Infrastructure	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
4	Boat Launch - Rivergum Esplanade Foreshore	City Infrastructure	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
4	Boat Launch - Batavia Quays Launch Facility	City Infrastructure	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
4	Batavia Quays Club Shed	City Infrastructure	Moderate	Poor	Rare	Rare	Unlikely	Possible	L	L	M	M	M	M	H	H
4	Toilets - Batavia Quays	City Infrastructure	Minor	Poor	Rare	Rare	Unlikely	Possible	L	L	L	M	M	M	M	H
4	Toilets - Pelican Road	City Infrastructure	Minor	Poor	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	M	H	H	H
4	Car Park - Batavia Quays	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
4	Car Park - Rivergum Esplanade Foreshore	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
4	Car Park - Centenary Park	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
4	Car Park - Pelican Road	City Infrastructure	Moderate	Poor	Unlikely	Possible	Likely	Almost Certain	M	M	H	H	H	H	VH	VH
4	Park Furniture - Centenary Park	City Infrastructure	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	M	M	M
4	Playground Equipment - Centenary Park	City Infrastructure	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	M	M	M
4	Park Furniture- Wellya Crescent Park	City Infrastructure	Minor	Average	Rare	Rare	Unlikely	Possible	L	L	L	M	L	L	L	M
4	Playground Equipment - Wellya Crescent Park	City Infrastructure	Minor	Average	Rare	Rare	Unlikely	Possible	L	L	L	M	L	L	L	M
4	Park Furniture - Pelican Rd Park	City Infrastructure	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	M	M	M
4	Playground Equipment - Pelican Rd Park	City Infrastructure	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	M	M	M
4	Park Furniture- South Yunderup Foreshore	City Infrastructure	Minor	Average	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	M	M	M	M
4	Footpaths	City Infrastructure	Minor	Good	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	L	L	L
4	Minor Infrastructure (Signage, fencing, lighting, bus shelter)	City Infrastructure	Minor	Good	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Drainage features (pits, pipes, culverts)	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
4	WaterCorp Infrastructure	Utilities	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH

					Likelihood Category				Erosion Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	**Description**	**General Cat.**	**Consequence**	**Adaptive Cap.**	**2030**	**2050**	**2070**	**2120**	**2030**	**2050**	**2070**	**2120**	**2030**	**2050**	**2070**	**2120**
5	Beach - Peel Inlet facing beaches on Cooleenup, Meeyip, Ballee, Woolgarook, Yunderup Islands	Environmental	Major	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	E	E	E	H	VH	VH	VH
5	Riverbank - Delta Islands and Murray River	Environmental	Major	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	E	E	E	H	VH	VH	VH
5	Nature Reserve, West end Yunderup Island	Environmental	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
5	Ballee Island Wetland	Environmental	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
5	Foreshore Pathway - Culeenup Rd east of Towerup St	City Infrastructure	Moderate	Average	Unlikely	Possible	Likely	Almost Certain	M	M	H	H	M	M	H	H
5	Foreshore Reserve - Culeenup Rd east of Towerup St	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
5	Foreshore Reserve - Yunderup Island, Ballee Island, Cooleenup Island	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
5	Residential Properties North Yunderup, Culeenup Rd	Private Asset	Major	Poor	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	VH	VH	VH	VH
5	Residential Properties Thomasfield Pl, Ravenswood	Private Asset	Major	Poor	Rare	Unlikely	Possible	Likely	L	M	H	H	M	H	VH	VH
5	Residential Properties Yunderup Island	Private Asset	Major	Poor	Rare	Unlikely	Possible	Likely	L	M	H	H	M	H	VH	VH
5	Residential Properties Ballee Island	Private Asset	Major	Poor	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	H	VH	VH	VH
5	Residential Properties Cooleenup Island	Private Asset	Major	Poor	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	H	VH	VH	VH
5	Jetties and Moorings along River Privately Held	Private Asset	Minor	Average	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	M	M	M	M
5	Minor Roads (Culeenup Rd - Western end)	City Infrastructure	Moderate	Poor	Unlikely	Possible	Likely	Almost Certain	M	M	H	H	H	H	VH	VH
5	Major Roads (Forrest Highway) No Erosion	City Infrastructure	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M
5	Shire Jetties - Culeenup Rd, Coopers Mill Precinct, North Yunderup Launch Facility. Swimming pontoon at swim beach	City Infrastructure	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
5	Boat Launch - North Yunderup Launch Facility	City Infrastructure	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
5	Toilets - Kingfisher Park (No Erosion Impact)	City Infrastructure	Minor	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M
5	Toilets - Coopers Mill Precinct	City Infrastructure	Minor	Poor	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	H	H	H	H
5	Toilets - North Yunderup Launch Facility (No Erosion Impact)	City Infrastructure	Minor	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M
5	Car Park - North Yunderup Launch Facility	City Infrastructure	Moderate	Poor	Rare	Unlikely	Possible	Likely	L	M	M	H	M	H	H	VH
5	Park Furniture - North Yunderup Foreshore Reserve	City Infrastructure	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	M	M	M
5	Park Furniture- North Yunderup Launch Facility	City Infrastructure	Minor	Average	Rare	Rare	Unlikely	Possible	L	L	L	M	L	L	L	M
5	Park Furniture - Coopers Mill Precinct	City Infrastructure	Minor	Average	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	M	M	M	M
5	Playground Equipment - Coopers Mill Precinct	City Infrastructure	Minor	Average	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	M	M	M	M
5	Park Furniture- Kingfisher Park (No Erosion Impact)	City Infrastructure	Minor	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
5	Playground Equipment - Kingfisher Park (No Erosion Impact)	City Infrastructure	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	M	M	M
5	Footpaths	City Infrastructure	Minor	Good	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	L	L	L
5	Minor Infrastructure (Signage, fencing, lighting, bus shelter)	City Infrastructure	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Drainage features (pits, pipes, culverts)	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
5	WaterCorp Infrastructure	Utilities	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
5	Coopers Mill	Cultural / Heritage	Major	Poor	Possible	Likely	Almost Certain	Almost Certain	H	H	E	E	VH	VH	VH	VH
5	Coopers Mill Caretakers House	Cultural / Heritage	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H

					Likelihood Category				Erosion Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	**Description**	**General Cat.**	**Consequence**	**Adaptive Cap.**	**2030**	**2050**	**2070**	**2120**	**2030**	**2050**	**2070**	**2120**	**2030**	**2050**	**2070**	**2120**
6	Riverbank - Serpentine River	Environmental	Major	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	E	E	E	H	VH	VH	VH
6	Foreshore Reserve - Furnissdale Foreshore	Social	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
6	Residential Properties Riverside Drive along Furnissdale Foreshore (No Erosion impacts)	Private Asset	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M
6	Residential Properties along Serpentine River, Tonkin Drive to Furnissdale Road	Private Asset	Major	Poor	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	H	VH	VH	VH
6	Residential Properties Riverside Drive Smith St to Paull St	Private Asset	Major	Poor	Rare	Unlikely	Possible	Likely	L	M	H	H	M	H	VH	VH
6	Residential Properties Riverside Drive NE of Paull St	Private Asset	Major	Poor	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	H	VH	VH	VH
6	Caravan Park (No Erosion Impact)	Private Asset	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
6	Riverglades Resort	Private Asset	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
6	Jetties and Moorings along River - Privately Held	Private Asset	Minor	Average	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	M	M	M	M
6	Minor Roads (Riverside Drive Near Smith St)	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
6	Minor Roads (Furnissdale Rd, Ronlyn Rd) No Erosion Impacts	City Infrastructure	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M
6	Major Roads (Pinjarra Rd) No Erosion	City Infrastructure	Major	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M
6	Shire Jetties - Furnissdale Launch Facility, Floating Jetty	City Infrastructure	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
6	Shire Jetties - Furnissdale Launch Facility, Timber Jetty	City Infrastructure	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
6	Shire Jetties - Tonkin Drive Foreshore Timber Jetty	City Infrastructure	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
6	Boat Ramp - Furnissdale Launch Facility	City Infrastructure	Moderate	Average	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	M	H	H	H
6	Toilets - York Road (No Erosion Impacts)	City Infrastructure	Minor	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M
6	Car Park - Furnissdale Launch Facility	City Infrastructure	Moderate	Poor	Unlikely	Possible	Likely	Almost Certain	M	M	H	H	H	H	VH	VH
6	Car Park - Riverside Drive	City Infrastructure	Moderate	Poor	Rare	Rare	Unlikely	Possible	L	L	M	M	M	M	H	H
6	Car Park - Tonkin Drive Foreshore	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
6	Car Park - Furnissdale Bridge Foreshore	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
6	Park Furniture - Furnissdale Launch Facility Foreshore Reserve	City Infrastructure	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	M	M	M
6	Playground Equipment - Furnissdale Foreshore	City Infrastructure	Minor	Average	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	M	M	M
6	Park Furniture- York Road Park. No Erosion Impacts	City Infrastructure	Minor	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
6	Playground Equipment - York Road Park. No Erosion Impacts	City Infrastructure	Minor	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
6	Footpaths	City Infrastructure	Minor	Good	Rare	Rare	Unlikely	Possible	L	L	L	M	L	L	L	L
6	Minor Infrastructure (Signage, fencing, lighting, bus shelter)	City Infrastructure	Minor	Good	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Drainage features (pits, pipes, culverts)	City Infrastructure	Moderate	Poor	Possible	Likely	Almost Certain	Almost Certain	M	H	H	H	H	VH	VH	VH
6	WaterCorp Infrastructure	Utilities	Moderate	Poor	Rare	Unlikely	Possible	Almost Certain	L	M	M	H	M	H	H	VH
6	York Road Clubrooms and Sports Courts (No Erosion)	City Infrastructure	Moderate	Poor	Rare	Rare	Rare	Rare	L	L	L	L	M	M	M	M

D.2 Vulnerability Assessment - Inundation

		m AHD				Likelihood Category				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	Elevation	General Cat.	Consequence	Adaptive Cap.	2030	2050	2070	2120	2030	2050	2070	2120	2030	2050	2070	2120
1	Beach areas	0.7	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
1	Foreshore Nature Reserve	1.2	Environmental	Minor	Good	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	L	L	L
1	Harvey Drain	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
1	Kooljerrenup Nature Reserve	1.2	Environmental	Major	Average	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	M	H	H	VH
1	Herron Point Camping Ground	1.4	Social	Minor	Average	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	M	M
1	Herron Point Foreshore	1.1	Social	Minor	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
1	Coastal Pathways / Bridle Paths	1.2	Social	Minor	Good	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	L	L	L
1	Agricultural Properties	2.2	Private Asset	Minor	Good	Rare	Rare	Rare	Unlikely	L	L	L	L	L	L	L	L
1	Carpark at Herron Boat Ramp	0.95	City Infrastructure	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
1	Herron Point Boat Ramp	0.5	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
1	Herron Point Reserve Camping Ground Toilet / Showers	2.4	City Infrastructure	Minor	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
1	Infrastructure (Signage, shelters, fencing)	0.8	City Infrastructure	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
1	Roads in Campground	1.2	City Infrastructure	Moderate	Average	Unlikely	Possible	Likely	Almost Certain	M	M	H	H	M	M	H	H
1	Herron Point Road	1.1	City Infrastructure	Moderate	Average	Possible	Possible	Almost Certain	Almost Certain	M	M	H	H	M	M	H	H

		m AHD				Inundation Likelihood				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	Elevation	General Cat.	Consequence	Adaptive Cap.	2030	2050	2070	2120	2030	2050	2070	2120	2030	2050	2070	2120
2	Beach areas	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
2	Foreshore Nature Reserve	1.2	Environmental	Minor	Good	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	L	L	L
2	Lake McLarty	1.5	Environmental	Major	Poor	Rare	Unlikely	Unlikely	Almost Certain	L	M	M	E	M	H	H	VH
2	Lake Mealup	1.5	Environmental	Major	Poor	Rare	Unlikely	Unlikely	Almost Certain	L	M	M	E	M	H	H	VH
2	Foreshore Reserve at Birchmont Boat Ramp	1.1	Social	Minor	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
2	Coastal Pathways / Bridle Paths	1.1	Social	Minor	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
2	Residential Properties	1.1	Private Asset	Moderate	Average	Possible	Possible	Almost Certain	Almost Certain	M	M	H	H	M	M	H	H
2	Carpark at Birchmont Boat Ramp	1.6	City Infrastructure	Minor	Good	Rare	Rare	Unlikely	Almost Certain	L	L	L	M	L	L	L	L
2	Birchmont Boat Ramp	0.5	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
2	Infrastructure (signage, fencing, bus shelter)	1.2	City Infrastructure	Insignificant	Good	Unlikely	Possible	Likely	Almost Certain	L	L	L	M	L	L	L	L
2	Drainage features	5	City Infrastructure	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
2	Roads (Birch Drive, Mills Rd, Pioneer Place, Numbat Place, Kangaroo Loop)	1.5	City Infrastructure	Moderate	Average	Rare	Unlikely	Unlikely	Almost Certain	L	M	M	H	L	M	M	H

		m AHD				Likelihood Category				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	**Description**	**Elevation**	**General Cat.**	**General**	**Adaptive Cap.**	**2030**	**2050**	**2070**	**2120**	**2030**	**2050**	**2070**	**2120**	**2030**	**2050**	**2070**	**2120**
3	Beach area	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
3	Foreshore Reserve	0.7	Social	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
3	Austin Bay Nature Reserve	1.1	Environmental	Minor	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
3	Robert Bay Swamp	1.2	Environmental	Major	Poor	Unlikely	Possible	Likely	Almost Certain	M	H	H	E	H	VH	VH	VH
3	Coastal Pathways / Bridle Paths	0.8	Social	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
3	Agricultural Properties	2.2	Private Asset	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
3	Agricultural Land	1.4	Private Asset	Minor	Good	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	L	L
3	Minor Infrastructure (signage, fencing)	0.6	City Infrastructure	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
3	Drainage features	0.6	City Infrastructure	Moderate	Average	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
3	Roads (Carabunga Road).	0.7	City Infrastructure	Moderate	Average	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H

		m AHD				Likelihood Category				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	Elevation	General Cat.	Consequence	Adaptive Cap.	2030	2050	2070	2120	2030	2050	2070	2120	2030	2050	2070	2120
4	Beach area - Peel Inlet facing beach Batavia Quays	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Riverbank - Murray River	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Austin Bay Nature Reserve	1.1	Environmental	Minor	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Batavia Quays Wetland	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Batavia Quays Headland Feature - Acid Sulphate Soil Site. Height of top of Revetment	2.4	Environmental	Catastrophic	Poor	Rare	Rare	Rare	Rare	M	M	M	M	H	H	H	H
4	South Yunderup Canal Bund - Water Quality Management	1.1	Environmental	Major	Average	Possible	Possible	Almost Certain	Almost Certain	H	H	E	E	H	H	VH	VH
4	Coastal Pathway - Bund in front of South Yunderup canals	1.1	City Infrastructure	Moderate	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
4	Coastal Pathway - Wellya Crescent Park)	1	City Infrastructure	Minor	Good	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Foreshore Reserve (Tatham Rd, Rivergum Esplanade, Centenary Park)	0.9	Social	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Coastal Pathways Murray River (Tatham Rd, Rivergum Esplanade)	0.85	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Coastal Pathways Batavia Quays Headland	2.2	City Infrastructure	Minor	Good	Rare	Rare	Rare	Unlikely	L	L	L	L	L	L	L	L
4	Residential Properties South Yunderup Canal Estate	2.2	Private Asset	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
4	Residential Properties Placid Bend, Chipper Way, Countess Circuit	2.2	Private Asset	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
4	Residential Properties Batavia Quay	2.2	Private Asset	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
4	Residential Properties Warma Way to Young Rd	1.8	Private Asset	Moderate	Average	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	M
4	Residential Properties Young Rd to Strain Glen	1.7	Private Asset	Moderate	Average	Rare	Rare	Unlikely	Likely	L	L	M	H	L	L	M	H
4	Residential Properties Pelican Rd, Banksia Terrace	1.7	Private Asset	Moderate	Average	Rare	Rare	Unlikely	Likely	L	L	M	H	L	L	M	H
4	Residential Properties Murray River Drive, Leander Way, Pericho Close	1.8	Private Asset	Moderate	Average	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	M
4	Agricultural / Vacant Land - Beacheam Rd to Austin Cove	1.8	Private Asset	Moderate	Average	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	M
4	Tathams Caravan Park, Murray River Caravan Park	1.1	Private Asset	Moderate	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	H	H	L	L	M	M
4	Jetties and Moorings along River Privately Held	0.6	Private Asset	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Minor Roads (Rivergum Esplanade, Young Rd, Strain Glen, Pelican Rd, Banksia Tce)	1.3	City Infrastructure	Moderate	Average	Unlikely	Unlikely	Possible	Almost Certain	M	M	M	H	M	M	M	H
4	Major Roads (South Yunderup Road, Forrest Highway) No Erosion	1.5	City Infrastructure	Moderate	Average	Rare	Unlikely	Unlikely	Almost Certain	L	M	M	H	L	M	M	H
4	Canal Network (No Erosion)	0.5	City Infrastructure	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Shire Jetties - Tatham Rd, Pelican Rd, Centenary Park	0.7	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Boat Launch - Rivergum Esplanade Foreshore	0.6	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Boat Launch - Batavia Quays Launch Facility	0.6	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Batavia Quays Club Shed	1.6	City Infrastructure	Moderate	Good	Rare	Rare	Unlikely	Almost Certain	L	L	M	H	L	L	L	M
4	South Yunderup Fire Station (No Erosion Impact)	2.1	City Infrastructure	Major	Good	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	L
4	Toilets - Centenary Park (No Erosion Impact)	1.5	City Infrastructure	Minor	Average	Rare	Unlikely	Unlikely	Almost Certain	L	L	L	M	L	L	L	M
4	Toilets - Batavia Quays	1.6	City Infrastructure	Minor	Average	Rare	Rare	Unlikely	Almost Certain	L	L	L	M	L	L	L	M
4	Toilets - Pelican Road	2.5	City Infrastructure	Minor	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
4	Car Park - Batavia Quays	1.2	City Infrastructure	Minor	Good	Unlikely	Possible	Likely	Almost Certain	L	M	M	M	L	L	L	L
4	Car Park - Rivergum Esplanade Foreshore	1.1	City Infrastructure	Minor	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Car Park - Centenary Park	1.3	City Infrastructure	Minor	Good	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	L	L
4	Car Park - Pelican Road	1.3	City Infrastructure	Minor	Good	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	L	L
4	Car Park - Willow Gardens (No Erosion Impact)	1.8	City Infrastructure	Minor	Good	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	L
4	Car Park - Fire Station (No Erosion Impact)	1.8	City Infrastructure	Minor	Good	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	L
4	Park Furniture - Centenary Park	1.4	City Infrastructure	Minor	Good	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	L	L
4	Playground Equipment - Centenary Park	1.4	City Infrastructure	Minor	Good	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	L	L
4	Park Furniture- Wellya Crescent Park	1.4	City Infrastructure	Minor	Good	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	L	L
4	Playground Equipment - Wellya Crescent Park	1.6	City Infrastructure	Minor	Good	Rare	Rare	Unlikely	Almost Certain	L	L	L	M	L	L	L	L
4	Park Furniture - Pelican Rd Park	1.7	City Infrastructure	Minor	Good	Rare	Rare	Unlikely	Likely	L	L	L	M	L	L	L	L
4	Playground Equipment - Pelican Rd Park	1.3	City Infrastructure	Minor	Good	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	L	L
4	Park Furniture- Lucie Hunter Park (No Erosion Impact	0.9	City Infrastructure	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Park Furniture- South Yunderup Foreshore	0.9	City Infrastructure	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Footpaths	0.8	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Minor Infrastructure (Signage, fencing, lighting, bus shelter)	0.9	City Infrastructure	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
4	Drainage features (pits, pipes, culverts)	0.8	City Infrastructure	Moderate	Average	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
4	WaterCorp Infrastructure	0.9	Utilities	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H

NOTE: Residential Properties. LiDAR Level + 0.3m Freeboard

		m AHD				Likelihood Category				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	Elevation	General Cat.	Consequence	Adaptive Cap.	2030	2050	2070	2120	2030	2050	2070	2120	2030	2050	2070	2120
5	Beach - Peel Inlet facing beaches on Cooleenup, Meeyip, Ballee, Woolgarook, Yunderup Islands	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Riverbank - Delta Islands and Murray River	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Nature Reserve, West end Yunderup Island	0.9	Environmental	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Ballee Island Wetland	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Foreshore Reserve - Culeenup Rd east of Towerup St	0.9	Social	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Foreshore Reserve - Yunderup Island, Ballee Island, Cooleenup Island	0.9	Social	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Residential Properties North Yunderup, Culeenup Rd	1.8	Private Asset	Moderate	Average	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	M
5	Residential Properties Thomasfield Pl, Ravenswood	2.0	Private Asset	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
5	Rural Properties Pinjarra Rd, Tonkin Drv, Walter Rd	1.9	Private Asset	Moderate	Average	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	M
5	Residential Properties Thomasfield Pl, Ravenswood	2.0	Private Asset	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
5	Residential Properties Yunderup Island	1.0	Private Asset	Mod. / Maj [2]	Average / Low[2]	Possible	Likely	Almost Certain	Almost Certain	M	H	H	E	M	H	H	VH
5	Residential Properties Ballee Island	1.0	Private Asset	Mod. / Maj [2]	Average / Low[2]	Possible	Likely	Almost Certain	Almost Certain	M	H	H	E	M	H	H	VH
5	Residential Properties Cooleenup Island	0.9	Private Asset	Mod. / Maj [2]	Average / Low[2]	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	E	H	H	H	VH
5	Septic Sytems Yunderup Island	0.7	Private Asset	Major	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	E	E	E	E	H	H	H	H
5	Septic Sytems Ballee Island	0.7	Private Asset	Major	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	E	E	E	E	H	H	H	H
5	Septic Sytems Cooleenup Island	0.6	Private Asset	Major	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	E	E	E	E	H	H	H	H
5	Jetties and Moorings along River Privately Held	0.6	Private Asset	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Minor Roads (Culeenup Rd - Western end)	1.5	City Infrastructure	Moderate	Average	Rare	Unlikely	Unlikely	Almost Certain	L	M	M	H	L	M	M	H
5	Major Roads (Pinjarra Rd, Forrest Hwy)	2.2	City Infrastructure	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
5	Shire Jetties - Culeenup Rd, Coopers Mill Precinct, North Yunderup Launch Facility. Swimming pontoon at swim beach	0.5	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Boat Launch - North Yunderup Launch Facility	0.5	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Toilets - Kingfisher Park (No Erosion Impact)	2.3	City Infrastructure	Minor	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
5	Toilets - Coopers Mill Precinct	1.4	City Infrastructure	Minor	Average	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	M	M
5	Toilets - North Yunderup Launch Facility (No Erosion Impact)	1.8	City Infrastructure	Minor	Average	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	M
5	Car Park - North Yunderup Launch Facility	1.8	City Infrastructure	Minor	Good	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	L
5	Park Furniture - North Yunderup Foreshore Reserve	0.9	City Infrastructure	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Park Furniture- North Yunderup Launch Facility	1.8	City Infrastructure	Minor	Good	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	L
5	Park Furniture - Coopers Mill Precinct	0.9	City Infrastructure	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Playground Equipment - Coopers Mill Precinct	0.9	City Infrastructure	Minor	Good	Likely	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Park Furniture- Kingfisher Park (No Erosion Impact)	2.0	City Infrastructure	Minor	Good	Rare	Rare	Rare	Unlikely	L	L	L	L	L	L	L	L
5	Playground Equipment - Kingfisher Park (No Erosion Impact)	2.3	City Infrastructure	Minor	Good	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
5	Footpaths	1.0	City Infrastructure	Minor	Good	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Minor Infrastructure (Signage, fencing, lighting, bus shelter)	0.8	City Infrastructure	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
5	Drainage features (pits, pipes, culverts)	0.8	City Infrastructure	Moderate	Average	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
5	WaterCorp Infrastructure	0.9	Utilities	Moderate	Average	Likely	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
5	Coopers Mill	0.7	Cultural / Heritage	Moderate	Average	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
5	Coopers Mill Caretakers House	1.4	Cultural / Heritage	Moderate	Average	Unlikely	Unlikely	Possible	Almost Certain	M	M	M	H	M	M	M	H

NOTE : for all Residential Properties the level is finished floor level = LiDAR Level + 0.3m Freeboard

2. For depth of flooding >1.0m over the Finished Floor level the consequence is Major and adaptive capacity is rated as low.

		m AHD				Likelihood Category				Inundation Risk Rating				Vulnerability - Incl. Adaptive Capacity			
SMU	Description	Elevation	General Cat.	Consequence	Adaptive Cap.	2030	2050	2070	2120	2030	2050	2070	2120	2030	2050	2070	2120
6	Riverbank - Serpentine River	0.5	Environmental	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Foreshore Reserve - Furnissdale Foreshore	0.7	Social	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Residential Properties Riverside Drive along Furnissdale Foreshore	1.4	Private Asset	Moderate	Average	Unlikely	Unlikely	Possible	Almost Certain	M	M	M	H	M	M	M	H
6	Residential Properties along Serpentine River, Tonkin Drive to Furnissdale Road	1.8	Private Asset	Moderate	Average	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	M
6	Residential Properties Riverside Drive Smith St to Paull St	1.5	Private Asset	Moderate	Average	Rare	Unlikely	Unlikely	Almost Certain	L	M	M	H	L	M	M	H
6	Residential Properties Riverside Drive NE of Paull St	1.5	Private Asset	Moderate	Average	Rare	Unlikely	Unlikely	Almost Certain	L	M	M	H	L	M	M	H
6	Rural Properties Pinjarra Rd to Goodooga Rd	2	Private Asset	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M
6	Caravan Park	1.7	Private Asset	Minor	Good	Rare	Rare	Unlikely	Likely	L	L	L	M	L	L	L	L
6	Riverglades Resort	2.5	Private Asset	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
6	Jetties and Moorings along River - Privately Held	0.5	Private Asset	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Minor Roads (Riverside Drive Near Smith St)	0.7	City Infrastructure	Moderate	Average	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
6	Minor Roads (Riverside Drive foreshore, Furnissdale Rd, Ronlyn Rd)	1.2	City Infrastructure	Moderate	Average	Unlikely	Possible	Likely	Almost Certain	M	M	H	H	M	M	H	H
6	Major Roads (Pinjarra Rd)	3	City Infrastructure	Moderate	Average	Rare	Rare	Rare	Rare	L	L	L	L	L	L	L	L
6	Shire Jetties - Furnissdale Launch Facility, Floating Jetty	0.5	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Shire Jetties - Furnissdale Launch Facility, Timber Jetty	0.5	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Shire Jetties - Tonkin Drive Foreshore Timber Jetty	0.5	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Boat Ramp - Furnissdale Launch Facility	0.5	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Toilets - York Road	2	City Infrastructure	Minor	Average	Rare	Rare	Rare	Unlikely	L	L	L	L	L	L	L	L
6	Car Park - Furnissdale Launch Facility	1.3	City Infrastructure	Minor	Good	Unlikely	Unlikely	Possible	Almost Certain	L	L	M	M	L	L	L	L
6	Car Park - Riverside Drive	0.7	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Car Park - Tonkin Drive Foreshore	1	City Infrastructure	Minor	Good	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Car Park - Furnissdale Bridge Foreshore	1	City Infrastructure	Minor	Good	Possible	Likely	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Park Furniture - Furnissdale Launch Facility Foreshore Reserve	1.1	City Infrastructure	Minor	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Playground Equipment - Furnissdale Foreshore	1.1	City Infrastructure	Minor	Good	Possible	Possible	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Park Furniture- York Road Park.	1.8	City Infrastructure	Minor	Good	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	L
6	Playground Equipment - York Road Park.	1.8	City Infrastructure	Minor	Good	Rare	Rare	Rare	Possible	L	L	L	M	L	L	L	L
6	Footpaths	0.7	City Infrastructure	Minor	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Minor Infrastructure (Signage, fencing, lighting, bus shelter)	0.7	City Infrastructure	Insignificant	Good	Almost Certain	Almost Certain	Almost Certain	Almost Certain	M	M	M	M	L	L	L	L
6	Drainage features (pits, pipes, culverts)	0.8	City Infrastructure	Moderate	Average	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
6	WaterCorp Infrastructure	0.7	Utilities	Moderate	Average	Almost Certain	Almost Certain	Almost Certain	Almost Certain	H	H	H	H	H	H	H	H
6	York Road Clubrooms and Sports Courts	2.1	City Infrastructure	Moderate	Average	Rare	Rare	Rare	Unlikely	L	L	L	M	L	L	L	M

NOTE: Residential Properties. LiDAR Level + 0.3m Freeboard

Appendix E

Planning Instruments Review

E.1 Review of Planning Instruments

Shire of Murray

Coastal Hazard Risk Management Adaptation Plan

December 2020

Document ID:					
Issue	Date	Status	Prepared by	Approved by	
			Name	Name	Signature
V1	27/10/20	Draft	Mike Davis	Draft	
V2	14/12/20	Final	Mike Davis	MD	

Contents

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1. Community Profile Overview

The Shire of Murray is located within the Peel region approximately 80 kilometres south of the Perth City Centre. The Shire includes the Harvey Estuary and is located adjacent to the Peel Inlet. The Murray River and Serpentine River both flow into the estuary.

The original inhabitants of the Murray area are the Binjareb Aboriginal people.

The Shire recorded a population of 17,911 people in 2019 (ABS, 2019). The Shire is predominantly zoned for rural purposes however includes the main township of Pinjarra and other settlements of Ravenswood, Dwellingup, North Dandalup and other smaller settlements. A number of canal developments have been built on the Murray River and Estuary.

Notable transport routes that run through the Shire include the Kwinana Freeway, Forrest Highway, the Southern Western Highway and the Perth-Bunbury railway line. It is noted that the Forrest Highway traverses the Murray River near the intersection with Pinjarra Road.

According to Population.ID, the Shire's population has grown from 12,522 in 2006 to 17,911 in 2019, representing an average growth rate of 1.43% during this period (Population.Id, 2020).

Approximately 89% of the Shire's population lived in a separate (single) dwelling as at 2016 (Population.Id, 2020).

It is noted that there are approximately 5,368 jobs generated within the Shire, of which, 2,351 employed persons (43.8%) also live in the Shire (Population.Id, 2020).

2. Existing Planning Framework

This section outlines the existing planning controls applicable to land use and development within the Shire with a particular focus on coastal planning and management to inform the identification of issues relating to the preparation of this CHRMAP. The following documents are included in this review.

Table 1 – Relevant Planning Framework

Corporation Strategic Planning • Murray 2030 Strategic Community Plan • Corporate Business Plan 2020 - 2024 • Emergency Risk Management Report 2013
Relevant Legislation • Planning and Development (Local Planning Schemes) Regulations 2015
State Planning Framework • Perth and Peel @ 3.5 Million • Peel Region Scheme • State Planning 2.1: Peel-Harvey coastal plain catchment • State Planning Policy 2.6: State Coastal Planning • State Planning Policy 2.6: State Coastal Planning Policy Guidelines • Coastal hazard risk management and adaptation planning guidelines • State Planning Policy 3.4: Natural Hazards and Disasters • Development Control Policy 1.8: Canal Estates and Artificial Waterway Development
Local Planning Framework • Shire of Murray Local Planning Scheme No. 4 • Boating Facilities and Moorings Local Planning Policy • General Development Requirements for Properties Abutting an Artificial Canal Waterway • Canal Walls – Yunderup State One Canals, Local Planning Policy Structure Plans • Lot 803 North Yunderup Road Structure Plan Map • Lots 1, 2 and 49 Banksia Terrace, South Yunderup Masterplans • Murray River Foreshore Masterplan

2.1 Corporate Governance Framework

2.1.1 Murray 2030 Strategic Community Plan

The Shire of Murray 2030 Strategic Community Plan (SCP) is the overarching strategy which guides the future governance of the local government over the next 10 years. The SCP establishes the following vision for the Shire:

"By 2030, the Shire of Murray will be a place where business thrives, we protect our environment, and all people enjoy an outstanding quality of life".

The SCP establishes a range of strategies to address facets of community, the environment, the economy and governance, with the following strategies relevant to planning for coastal processes"

- Ensure the safety of our community;
- Connect the natural assets, waterways, parks and reserves to the community;
- Upgrade the amenity of the Murray River Square, foreshore reserve and Glebe Land;
- Ensure Town Planning Scheme and Local Planning Strategy facilitates quality and diverse planning outcomes;
- Continually review and enhance public boating facilities and environmental sustainability within our waterways; and
- Undertake a risk assessment of the impact of climate change.

These strategies inform the Shire's Corporate Business Plan and expenditure on programs relevant to foreshore and coastal planning.

2.1.2 Corporate Business Plan 2020 – 2024

The Corporate Business Plan (CBP) is the Shire's four year business plan which informs the Shire's annual budget to deliver the priorities of the community. The CBP identifies a range of projects and actions, of which, the following are relevant to the preparation of this CHRMAP:

- Progressively improve and activate family friendly foreshore reserves;
- Progressively implement the Murray River Foreshore Masterplan;
- Review and implement the Sandy Cover South Yunderup Reserve Masterplan;
- Prepare and implement the Shire of Murray Reserve Management Plans;
- Implement the Herron Point Management Plan;
- Implement Waterways Management Plans;
- Progress the development of recreational boating facilities to meet community needs;
- Undertake a feasibility study for boat launching improvements at Batavia Quays; and
- Complete the Coastal Hazard Risk Management and Adaptation Planning Strategy and consider outcomes within the planning framework.

2.1.3 Emergency Risk Management Report 2013

The Shire has prepared an Emergency Risk Management Report which identifies the effects of storm surge and flooding as a risk that is present within the Shire. The document incorporates a Community Emergency Risk Assessment tool which can be used to correlate the likelihood and consequence to identify a risk rating similar to what is required as part of the CHRMAP process.

2.2 Relevant Legislation

2.2.1 Planning and Development (Local Planning Schemes) Regulations 2015

The *Planning and Development (Local Planning Schemes) Regulations 2015* (the regulations) were introduced by the State government to ensure a consistent structure, format and approach to local planning schemes across the state of Western Australia.

The regulations have recently been amended to introduce additional measures in response to the COVID-19 pandemic. These additional measures and exemptions to certain development and land use are temporary in nature and do not have any specific relevance to this study.

The State government is currently progressing further amendments to the Regulations which may amend the terminology and planning instruments referenced below.

The regulations contain 'deemed provisions' being Schedule 2 of the Regulations and these provisions automatically apply to all local government planning schemes throughout the state and supersede corresponding provisions of these schemes.

Schedule 2 of the Regulations contain provisions relating to various planning mechanisms which have varying degrees of application to implementing adaptation approaches for coastal processes. The planning mechanisms available in the Regulations are examined below.

<u>Local Planning Policy</u>

Part 2: Division 2 of the deemed provisions relates to the preparation of local planning policies. A local planning policy may apply generally to the Scheme area or deal with a specific class or classes of matters.

In making a determination under the scheme, the authority responsible for determining a planning application must have due regard to each relevant local planning policy, to the extent that the policy is consistent with the scheme. In addition to introducing new policy measures, a local planning policy may also vary existing deemed-to-comply provisions of the Residential Design Codes, where it is considered appropriate. In the context of coastal hazard and risk planning, a local planning policy could introduce additional design requirements for development, such as elevated habitable floor levels, additional required setback requirements and other relevant matters to ensure coastal hazard issues are appropriately responded to within the planning framework.

<u>Structure Plans and Activity Centre Plans</u>

Part 4 of the deemed provisions relates to the preparation of structure plans while Part 5 relates to the preparation of Activity Centre Plans. A structure plan (or Activity Centre Pan) may be prepared for a specific area if:

(a) The area is:

   i. All or part within a zone that is identified by the scheme as being suitable for urban or industrial development; and

   ii. Identified in this scheme as an area requiring a structure plan to be prepared before any future subdivision or development is undertaken; or

(b) A State Planning Policy requires a structure plan to be prepared for the area; or

(c) The Commission considers that a structure plan for the area is required for the purposes of orderly and proper planning.

The relevant decision maker of subdivision and development applications within a structure plan area must have due regard to but is not bound by a structure plan. A structure plan therefore does not have the full force and effect of the scheme. Once adopted, a structure plan which identifies zoning and land use permissibility, would need to be normalised within a scheme by way of a scheme amendment, if the zoning and land use permissibility is to have statutory weight.

It is noted that this section of the deemed provisions is currently the subject of a proposed amendment to the Regulations, whereby it is proposed to delete reference to 'Activity Centre Plans' in favour of 'Structure Plans' and 'Precinct Structure Plans'.

Local Development Plans

Part 6 of the Regulations provides for the preparation of local development plans (LDP), which states:

'A local development plan in respect of an area of land in the Scheme area may be prepared if –

(a) The Commission has identified the preparation of a local development plan as a condition of approval of a plan of subdivision of the area; or

(b) A structure plan requires a local development plan to be prepared for the area; or

(c) An activity centre plan requires a local development plan to be prepared for the area; or

(d) The Commission and the local government considers that a local development plan is required for the purposes of orderly and proper planning.'

It is considered that the LDP as a statutory instrument will have limited application within the Shire for responding to coastal hazards and processes and that there are more appropriate mechanisms (i.e. Scheme provisions and/or local planning policy) to address such matters.

Special Control Areas

Special Control Areas (SCA) may be established as set out within Part 5 of the model scheme provisions (Schedule 1 of the Regulations). SCAs are typically put in place to establish special provisions to target a single issue or related set of issues often overlapping zone and reserve boundaries. The provisions of an SCA would establish the purposes and objectives of the SCA, specific development requirements and, if applicable, referral requirements to relevant agencies. A SCA could therefore be established within a scheme to comprehensively address the specific development issues associated with land prone to coastal hazard and risk issues.

A SCA would be delineated on the scheme maps by way of line work, which could follow the extent of mapped areas known to be prone to storm surge and or coastal physical processes (erosion, sea level rise allowance).

General Development Provisions

Part 4 (Clause 32) of the model scheme has provisions for the establishment of additional site and development requirements in addition to those set out in the R-Codes, activity centre/structure plans, local development plans or State and local planning policies. General development provisions could technically set out general development requirements relating to areas subject to coastal flooding and / or coastal processes. However, it is considered that given the specific nature of coastal issues, including the varied locational extent to which it may affect land within a district, specific development requirements would more appropriately be established within a Special Control Area as opposed to general provisions within the scheme.

Supplemental Provisions

The Regulations provide for local planning schemes to establish provisions that supplement the provisions set out in Schedule 1 and 2 of the Regulations, or provisions that vary a provision established in Schedule 1. Such supplemental provisions are typically contained within a Schedule within the scheme. This section could be used to introduce additional provisions and requirements in relation to coastal planning matters.

Exemptions from planning approval

Regulation 61 of the deemed provisions specifies works and land uses that are exempt from the requirement to obtain development approval.

This is an important consideration of the CHRMAP process, as the specified exemptions may provide for certain situations where certain development may be established within an area affected by storm surge or coastal processes without the requirement to obtain planning approval. However, there are ways of addressing this issue. For instance, a local planning policy or local development plan could vary the deemed-to-comply requirements of the R-Codes to put in place additional design requirements that may trigger the requirement for planning approval. Secondly, a Special Control Area could be established over land affected by coastal processes or storm surge, which would trigger the requirement for the prior planning approval to be obtained from the responsible authority, including the requirement for the prior planning approval to be obtained for exempted development.

2.3 State Planning Framework

2.3.1 Perth and Peel @ 3.5 Million and Sub-regional Planning Framework

Perth and Peel @ 3.5 Million was released by the State government 2018 and provides the overarching framework to deliver four sub-regional strategies to guide future growth and development across the Perth and Peel metropolitan area through to the year 2050.

The Shire of Murray is located within the South Metropolitan Peel sub-regional area. The document plans for the provision of an additional 302,180 dwellings within this sub-region by 2050.

It is noted that the South Metropolitan Peel Sub-regional Planning Framework identifies a Planning Investigation Area around the Ravenswood settlement in proximity to the Murray River. Planning Investigation Areas are areas that may be suitable for rezoning and development subject to further detailed investigations. The Ravenswood Planning Investigation Area is subject to a number of investigations, including the need to understand inundation and flood management implications.

2.3.2 Peel Region Scheme

The Peel Region Scheme (PRS) is the principal region scheme which applies to the study area and zones and reserves land. The PRS reserves a majority of the coastal and river foreshores within the study area as ‘Parks and Recreation’ however there are some areas, such as the existing canal developments, which are zoned ‘Urban’.

2.3.3 State Planning 2.1: Peel-Harvey Coastal Plain Catchment

State Planning Policy 2.1: Peel-Harvey Coastal Plain Catchment (SPP 2.1) establishes land use and development requirements for land contained within the Peel-Harvey coastal plain catchment area. A primary objectives of SPP 2.1 is to prevent land uses that are likely to result in excessive nutrient export into the Peel-Harvey system. This policy does not have any direct implications for this CHRMAP.

2.3.4 State Planning Policy 2.6: State Coastal Planning

State Planning Policy 2.6: State Coastal Planning Policy (SPP 2.6) and associated guidelines have been prepared to guide decision making policy in relation to planning along the state’s coastline.

SPP2.6 provides policy on the determination of an appropriate foreshore reserve, which acts as a coastal buffer to accommodate coastal processes as a result of coastal erosion and risk or storm surge inundation in future planning periods.

SPP2.6 seeks to ensure coastal hazard risk management and adaptation planning is established to guide the location and form of development along the coast. The policy establishes a hierarchy for undertaking coastal hazard and risk adaptation planning. The adaptation measures of Avoid, Planned or Managed Retreat, Accommodate and Protect are to operate on a sequential and preferential basis starting with avoid as part of the coastal hazard risk management adaptation planning process.

This CHRMAP has been prepared to respond to the requirements of SPP 2.6.

2.3.5 State Coastal Planning Policy No. 2.6: State Coastal Planning Policy Guidelines

The State Coastal Planning Policy guidelines were introduced to provide guidance on the application of SPP 2.6. These guidelines identify a range of ongoing risk management and adaptation planning measures that may be considered in the assessment of development proposals located within an area known to be subject to storm surge risk or coastal erosion hazard. The guidelines establish a process for undertaking CHRMAP, as follows:

1. Establish a context;

2. Undertake a risk vulnerability assessment;
3. Determine the likelihood of the hazard occurring;
4. Determine the consequences;
5. Evaluate the risks;
6. Set in place adaptation management measures; and
7. Undertake monitoring and review.

This CHRMAP has generally been prepared in accordance with the above defined process.

Adaptation planning may be implemented through a range of mechanisms including decision-making on zoning, structure plans, subdivision and development applications.

2.3.6 Planned or Managed Retreat Guidelines

The Planned or Management Retreat Guidelines form an attachment the CHRMAP Guidelines and provide guidance on how to implement a policy of planned or managed retreat, and is applicable to 'Brownfield' and 'Infill' development, as it is these locations that are currently, and increasingly, vulnerable to coastal hazards with limited opportunities to introduce less vulnerable forms of use or development through planning control. The policy is based on principles of social, environmental and economic sustainability and adheres to objectives set out in State Planning Policy No. 2.6: State Coastal Planning Policy (discussed above). The approach ensures ongoing protection and provision of a coastal foreshore reserve and beach amenity and continuing undiminished public access to beaches. The policy directly references the completion of a comprehensive CHRMAP process, in order to outline necessary guidelines.

Key principles identified are as follows:

- To ensure land in the coastal zone is continuously provided for coastal foreshore management public access, recreation and conservation;
- To ensure public safety and reduce risk associated with coastal erosion and inundation;
- To avoid inappropriate land use and development of land at risk from coastal erosion and inundation; and
- To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves.

The guidelines outline the approach for implementing the Planned or Managed Retreat Policy, outlining planning mechanisms and their associated levels. Structure planning, local planning scheme amendment and taking of land is the first, second and third (respectively) planning mechanism for the policy.

<u>Structure Planning:</u>

Structure planning is identified as the first mechanism, requiring the consideration of risks identified in the CHRMAP process to feed into subdivision conditions of coastal areas where some degree of comprehensive redevelopment of land remains an option.

<u>Local Planning Scheme Amendment:</u>

A local planning scheme amendment is the second mechanism and is required to give statutory weight to the proposed Planned or Management Retreat Policy.

A scheme amendment is to be informed by SPP2.6 and such an amendment should classify areas vulnerable to coastal processes within a Special Control Area (SCA). An SCA may establish specific land use and development controls which may include preventing certain land use and development in areas at risk of coastal processes, incorporating adaptation development requirements (i.e. building above the known storm surge level) or requiring development to retreat from the risk at specific trigger points.

<u>Taking of Land:</u>

Taking of land is the third planning mechanism and occurs when it is assumed that land has not been transferred or committed to the public realm through structure planning processes, and that coastal processes have advanced to the point where there is no further economic or social utility in land due to coastal changes.

Where land is reserved under the relevant planning scheme, options to move this land from private to the public realm include:

- Purchase of the land by the responsible authority if the owner is willing to sell it by ordinary sale pursuant to s 190 of the PD Act; or
- Compulsory taking by the responsible authority without agreement pursuant to s 191 of the PD Act.

If land cannot be acquired under the above options (land not reserved under local planning scheme), in order to move this land from the private to public realm, it can be argued that the land is acquired for a 'public work' (that is, for the protection of foreshores). Options available for acquiring land for a 'public work' include:

- Taking by agreement under the *Land Administrative Act 1997* (LA Act); or
- Compulsory acquisition by the Minister for Lands for the purpose of a 'public work' under the LA Act.

It is the preferred approach that the land be purchased by the responsible authority by agreement under the relevant acts above.

2.3.7 State Planning Policy 3.4: Natural Hazards and Disasters

State Planning Policy 3.4: Natural Hazards and Disasters (SPP 3.4) was prepared to ensure that land use planning appropriately considers the risk of natural hazards and disasters. It addresses storm surge as well as a range of other hazards, including overland flooding. With respect to overland flooding events, SPP 3.4 requires that the 100-year average recurrence interval overland flood event by used as the defined flood event in relation to the assessment of proposals.

While SPP 3.4 identifies a 100-year ARI (average recurrence interval) event for storm surge, the policy also references SPP 2.6, which requires regard to be given to a 500 year ARI storm surge event.

With respect to storm surge, SPP 3.4 further states with respect to cyclonic activity and storm surge:

- Where storm surge studies have been undertaken and show inundation may occur, new permanent buildings should be constructed to take account of the effects of storm surge (including wind and wave set up).
- In areas where storm surge studies have not been undertaken, but evidence is available to demonstrate vulnerability to inundation, any development proposals should be supported by studies that demonstrate inundation will not occur.

2.3.8 Development Control Policy 1.8: Canal Estates and Artificial Waterway Development

Development Control Policy 1.8: Canal Estates and Artificial Waterway Development establishes development requirements for canal estates and other artificial waterway development. This policy requires decision making to have regard to State Planning Policy 2.6 as well as sea level rise and tidal and storm surge levels.

2.4 Local Planning Framework

2.4.1 Local Planning Scheme No. 4

The Shire's Local Planning Scheme No. 4 (LPS4) is the principal statutory planning document which applies land use and development controls within the Shire at a local level.

A specific objective of LPS4 is to 'preserve the special environment associated with the lakes and waterways within the Scheme Area'.

While a majority of the estuary and Murry River foreshore are reserved for Parks and Recreation under the PRS, there are also substantial private landholdings zoned for various purposes including land zoned 'Rural', 'Residential', 'Canal Development' and other purposes.

Also of particular note to this study are the following specific localities:

- Murray Delta Island Development: Zoned 'Canal Development', 'Residential' and located within the 'Floodprone Special Control Area'.
- Point Grey: Zoned 'Special Development' with a marina proposal previously lodged but refused by the Shire with the Shire's decision upheld by the State Administrative Tribunal.

Part XII of LPS4 establishes requirements for land located within river flood plains. Amongst these requirements are the following:

- A plan of subdivision shall not be approved for land within a flood fringe in the Residential or Canal Development zones unless that part of the land behind the minimum setbacks from street and rear boundaries is not less than 300mm above the flood level.
- A plan of subdivision shall not be approved for land within a flood fringe in the Special Rural zone unless part of the land in each lot has an area of not less than 2,000sqm at or above the flood level and is suitable for the erection of a dwelling in accordance with the provisions of this Scheme.
- Building levels within flood fringe land shall be a minimum of 150mm above the 1 in 100 year flood level for all existing subdivisions and for new subdivisions 500mm above the 1 in 100 year flood level.

2.4.2 Boating Facilities and Moorings Local Planning Policy

This Local Planning Policy establishes requirements for boating facilities within the Shire's artificial canal waterways. It establishes requirements in relation to visual amenity, setback requirements, clearance of navigation channels and interface with public areas and public access to canal waterways.

The policy does not establish requirements in relation to sea level rise or coastal processes and could perhaps benefit from a review following the completion of this CHRMAP.

2.4.3 General Development Requirements for Properties Abutting an Artificial Canal Waterway

This Local Planning Policy establishes objectives and requirements for various types of development that interface with the canal frontage area to ensure visual amenity along the canal waterways is maintained. Specifically, the policy relates to the construction of a dwelling, patio, verandah, shade sail structure, deck, retaining wall or outbuilding on property that abuts an artificial canal waterway.

The policy does not consider the implications of sea level rise or coastal processes.

2.4.4 Canal Walls – Yunderup Stage One Canals, Local Planning Policy

This Local Planning Policy has been prepared in response to the issue of overtopping of local tidal events over the original canal walls constructed in stage 1 of the Yunderup Canals estate. The policy notes that the sea level is projected to rise 0.15m in the coming 25 to 30 years, thus further exacerbating the issue.

This policy requires that all proposed canal wall replacements and modifications require the planning approval of the Shire. The principal objective of the policy is to ensure that replacement canal walls are replaced to a height that is above the current local tidal range to reduce the frequency of overtopping caused by storm surge and sea level rise.

The policy requires that the canal wall replacement shall have a top of wall height of 0.7m AHD.

It is recommended that this policy be reviewed following the findings of this CHRMAP.

2.4.5 Lot 803 North Yunderup Road Structure Plan Map

The Lot 803 North Yunderup Road Structure Plan proposes residential (R20-R40) on vacant land adjacent to Regional Open Space associated with the Wilgie Creek foreshore just north of the intersection of North Yunderup Road and Deering Drive. Due to the proximity to Wilgie Creek, there is the potential that the land may be subject to coastal inundation processes.

2.4.6 Lots 1, 2 and 49 Banksia Terrace, South Yunderup Structure Plan

The Structure Plan relating to Lots 1, 2 and 49 Banksia Terrace provides for the further subdivision of the subject lots which are located adjacent to the artificial canal waterway. The land is currently vacant and the structure plan provides for a 3m setback to the foreshore reserve within the private lots.

2.4.7 Murray River Foreshore Masterplan

The Murray River Foreshore Masterplan seeks to create an attractive and sustainable foreshore precinct which is centred around the Murray River Square. The masterplan identifies a number of foreshore improvements including an upgraded path network, landscaping and informal amphitheatre, a formal town square and event space and upgrades to the existing Exchange Hotel.

2.5 Summary of Existing Controls

2.5.1 Summary of options

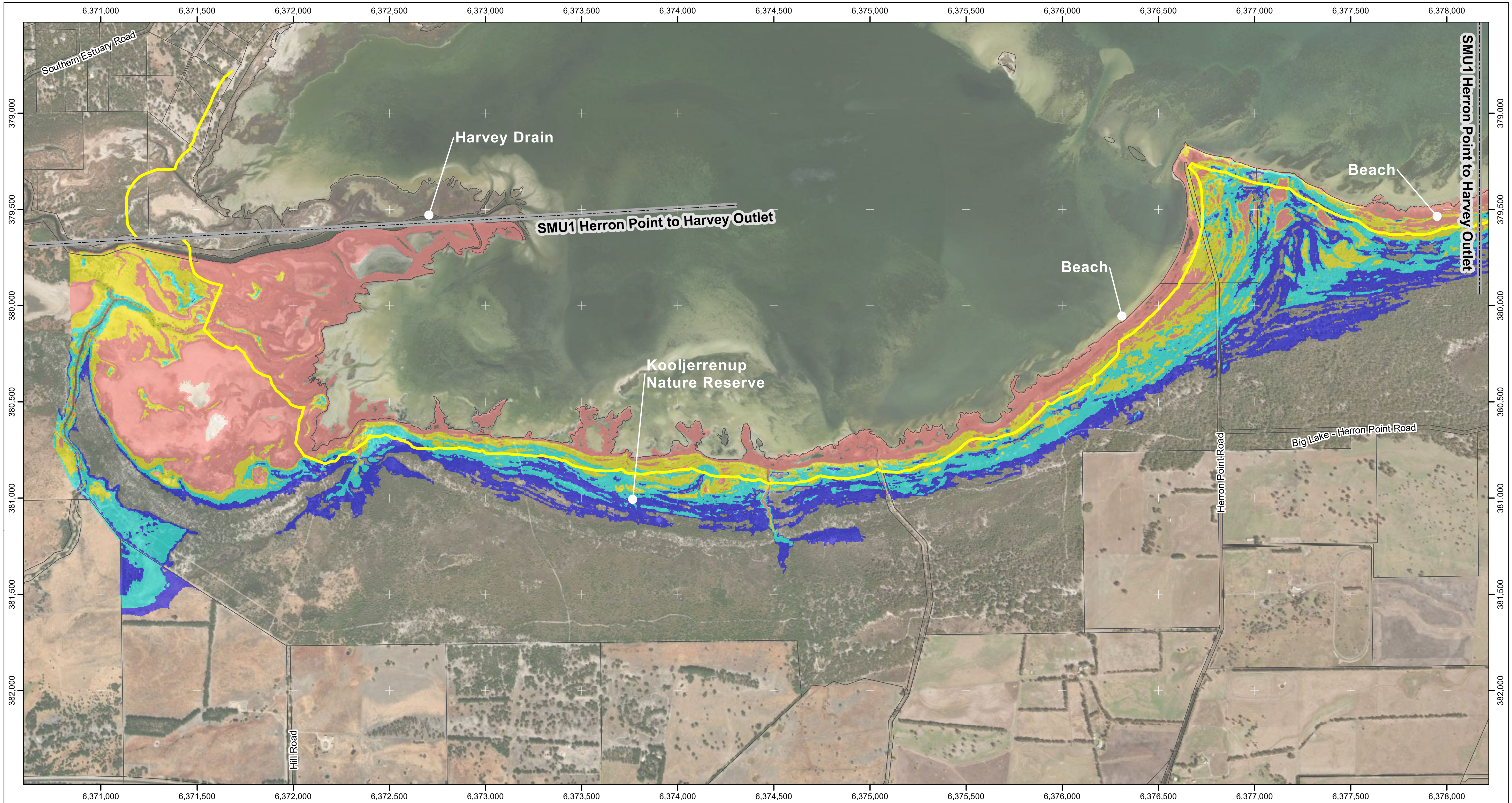
The statutory planning mechanisms that may be available to address coastal hazards within the Shire of Murray are considered in the following table which outlines the advantages and disadvantages of each option.

Statutory Measure	Advantages	Disadvantages
Structure Plan / Activity Centre Plan	Can address location specific issues i.e. identification of coastal physical setbacks and areas affected by storm surge.	Does not have the force and effect of the Scheme. Decision makers to have due regard only. Structure Plan cannot specify / enforce built form requirements. Location specific only and therefore cannot address coastal hazard issues on a broad scale. Generally, requires the land to be appropriately zoned to require the preparation of a structure plan.
Local Development Plan	Can specify built form requirements to address location specific coastal hazard issues i.e. increased setbacks, minimum habitable floor levels etc. Has statutory weight of the local planning scheme. Can vary 'deemed-to-comply' development requirements.	Location specific only and therefore cannot address coastal hazard issues on a broad scale.
Local Planning Policy	Can address coastal hazard and risk issues at a district (broad) level and/or at a location specific level. Can include mapping of coastal hazard issues with flexibility to update mapping as and when amendments are required to be undertaken.	Is only a 'due regard' document and does not have the full force and effect as provisions contained in a local planning scheme

	Can vary 'deemed-to-comply' development requirements. Can be amended relatively quickly (compared to local planning scheme amendment as new coastal studies are completed.	
Special Control Area	SCAs may establish specific provisions to address a specific issue such as storm surge and or coastal processes. SCAs can broadly address unique issues that extend across multiple zones and/ or reserves. SCAs can be used to require development approval for otherwise normally 'exempted' development. In this regard, SCAs are the preferred mechanism to identify where and what type of development requires development approval to allow for appropriate consideration of the risk of coastal processes.	A scheme amendment would potentially need to be progressed every time mapping of the coastal issue is amended and/or updated. This may be avoided if the Special Control Area refers to a separate Local Planning Policy which may contain reference to mapping of coastal hazards.
General Development Provisions (Part 4; Clause 32 of the model scheme provisions)	Can establish provisions which broadly address coastal hazards. Can introduce provisions which relate to a local planning policy addressing coastal hazards and which may contain coastal hazard mapping.	Given the specific nature of coastal issues, including the varied locational extent to which it may affect land within a district, specific development requirements would more appropriately be established within a Special Control Area as opposed to general provisions within the scheme.
Supplemental Provisions to Schedule 1 and 2 of the Regulations	May be used to supplement the standard scheme provisions set out in Schedule 1 and 2 of the Regulations to address specific coastal process issues.	Given the specific nature of coastal issues, including the varied locational extent to which it may affect land within a district, specific development requirements would more appropriately be established within a Special Control Area as opposed to the supplemental provisions of a scheme.

Appendix F

Asset Mapping and Coastal Hazard Area



Legend

Water Depth (m)

- 1.6 - 2
- 1.1 - 1.5
- 0.6 - 1
- 0 - 0.5
- 2120 Coastal Processes Line

0 200 metres

Source Data
Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.
Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Disclaimer
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SMU 1 - Herron Point to Harvey Outlet

Shire of Murray
Coastal Hazard Flood Mapping

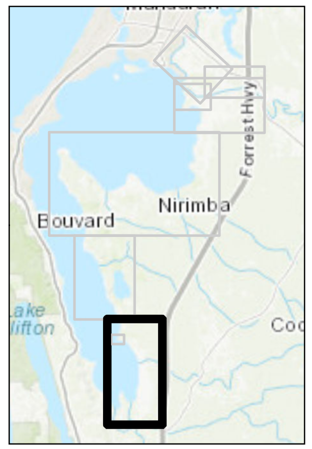
500yr ARI Design Storm
in Planning year 2120

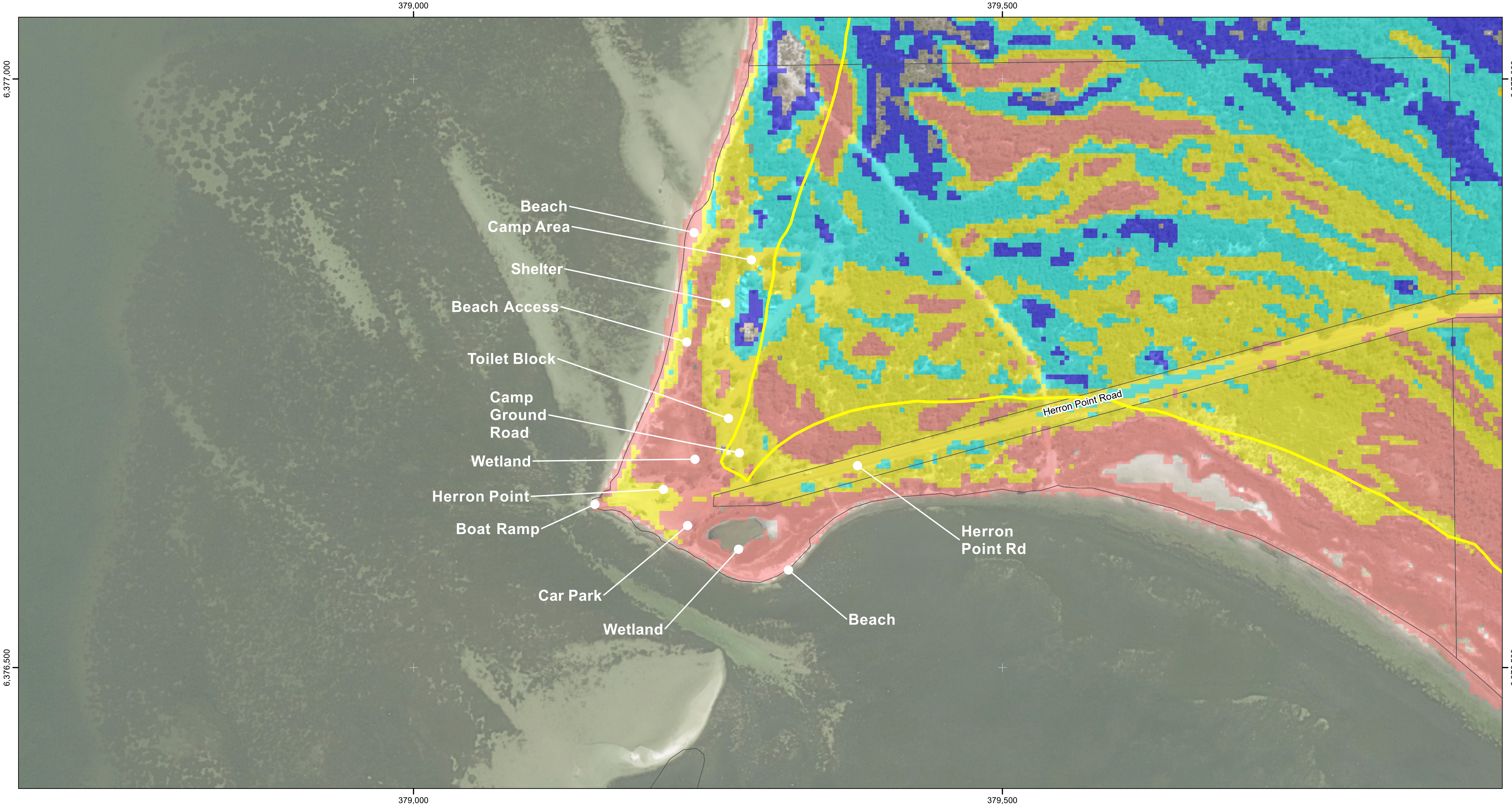
Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 10 Nov. 2021





Legend

Water Depth (m)

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- 0.6 - 1
- 0 - 0.5
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0 200 metres

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Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning year 2120

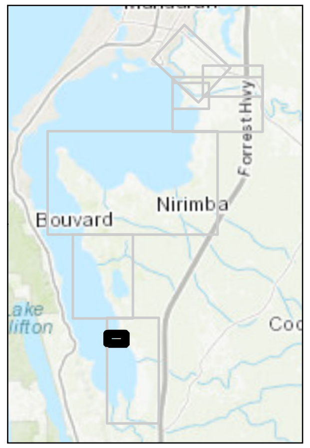
Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

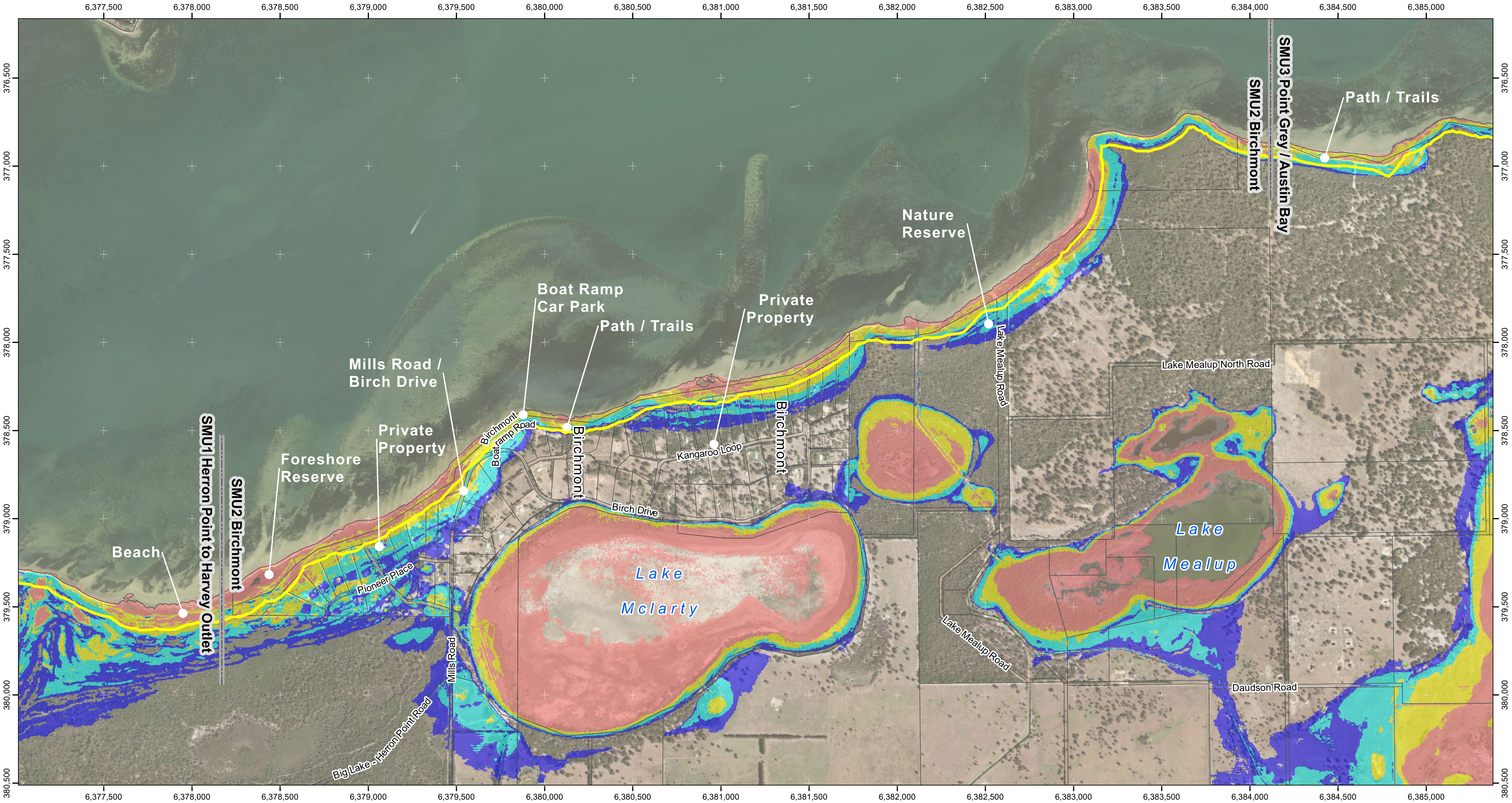
Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 10 Nov. 2021





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Water Depth (m)

- 1.6 - 2
- 1.1 - 1.5
- 0.6 - 1
- 0 - 0.5
- 2120 Coastal Processes Line

0 200 metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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SMU 2 – Birchmont

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning year 2120

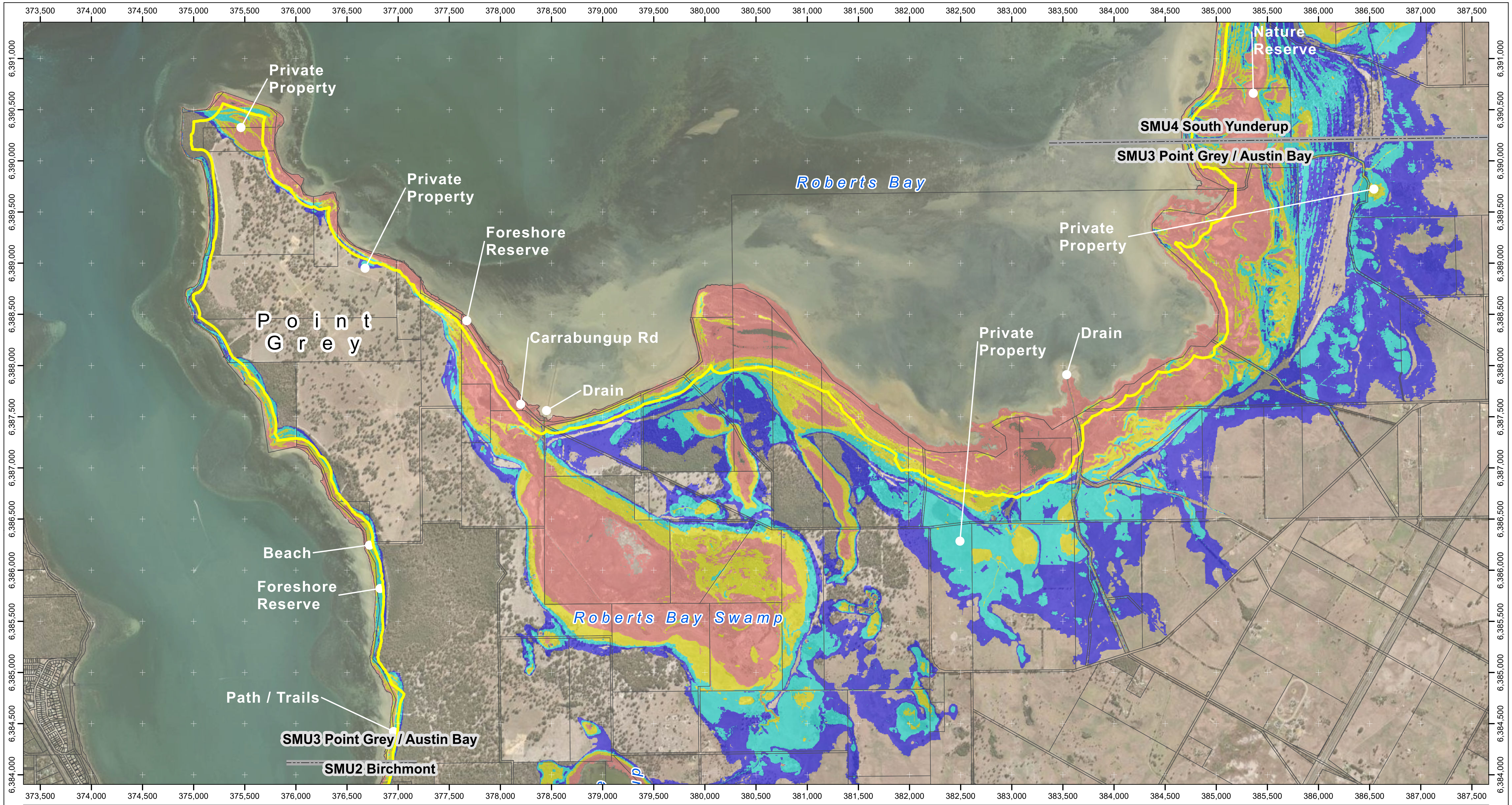
Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 10 Nov. 2021



Legend

Water Depth (m)

- 1.6 - 2
- 1.1 - 1.5
- 0.6 - 1
- 0 - 0.5
- 2120 Coastal Processes Line

N W E S

0 200 metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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SMU 3 – Point Grey / Austin Bay

Shire of Murray
Coastal Hazard Flood Mapping

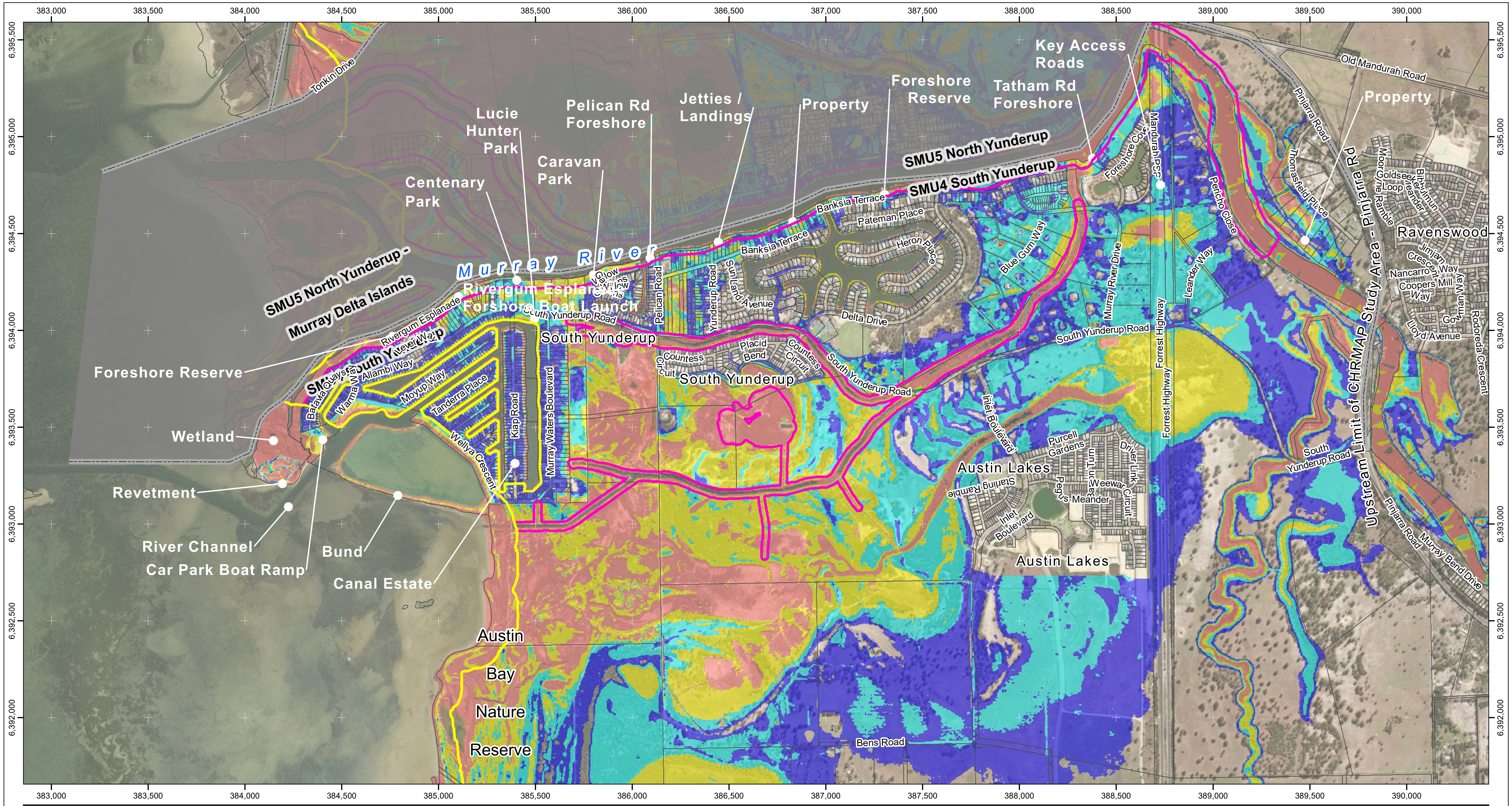
500yr ARI Design Storm in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 10 Nov. 2021



Legend

Water Depth (m)

- 1.6 - 2
- 1.1 - 1.5
- 0.6 - 1
- 0 - 0.5
- 2120 Coastal Processes Line
- 2120 Erosion River Banks

N W E S

0 200 metres

Source Data

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SMU 4 – South Yunderup

Shire of Murray Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

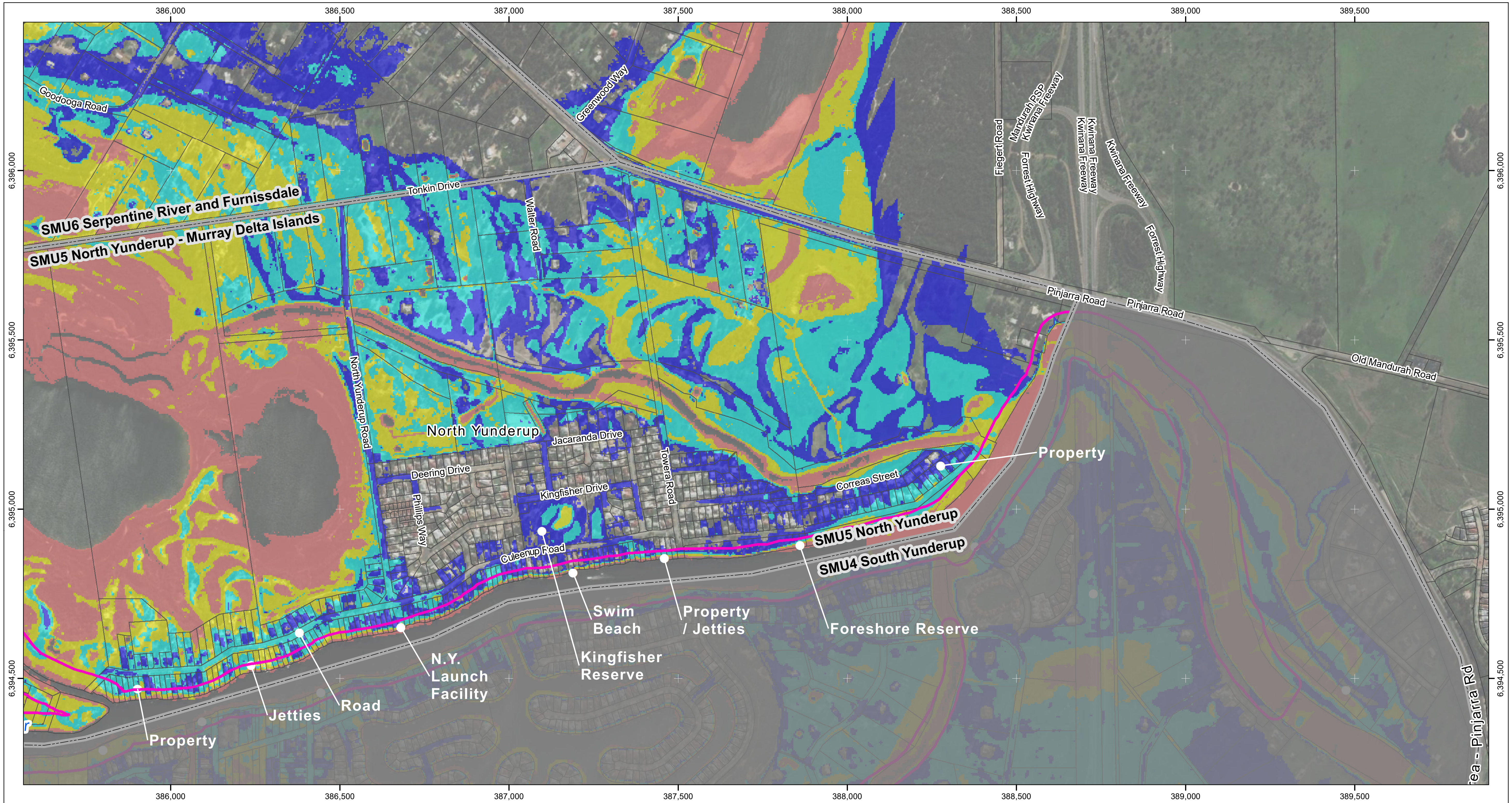
Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Shire of Murray

1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 10 Nov. 2021



Legend

Water Depth (m)

- 1.6 - 2
- 1.1 - 1.5
- 0.6 - 1
- 0 - 0.5
- 2120 Coastal Processes Line
- 2120 Erosion River Banks

N W E S

0 200 metres

Source Data
Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.
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Disclaimer
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SMU 5 – North Yunderup

Shire of Murray
Coastal Hazard Flood Mapping

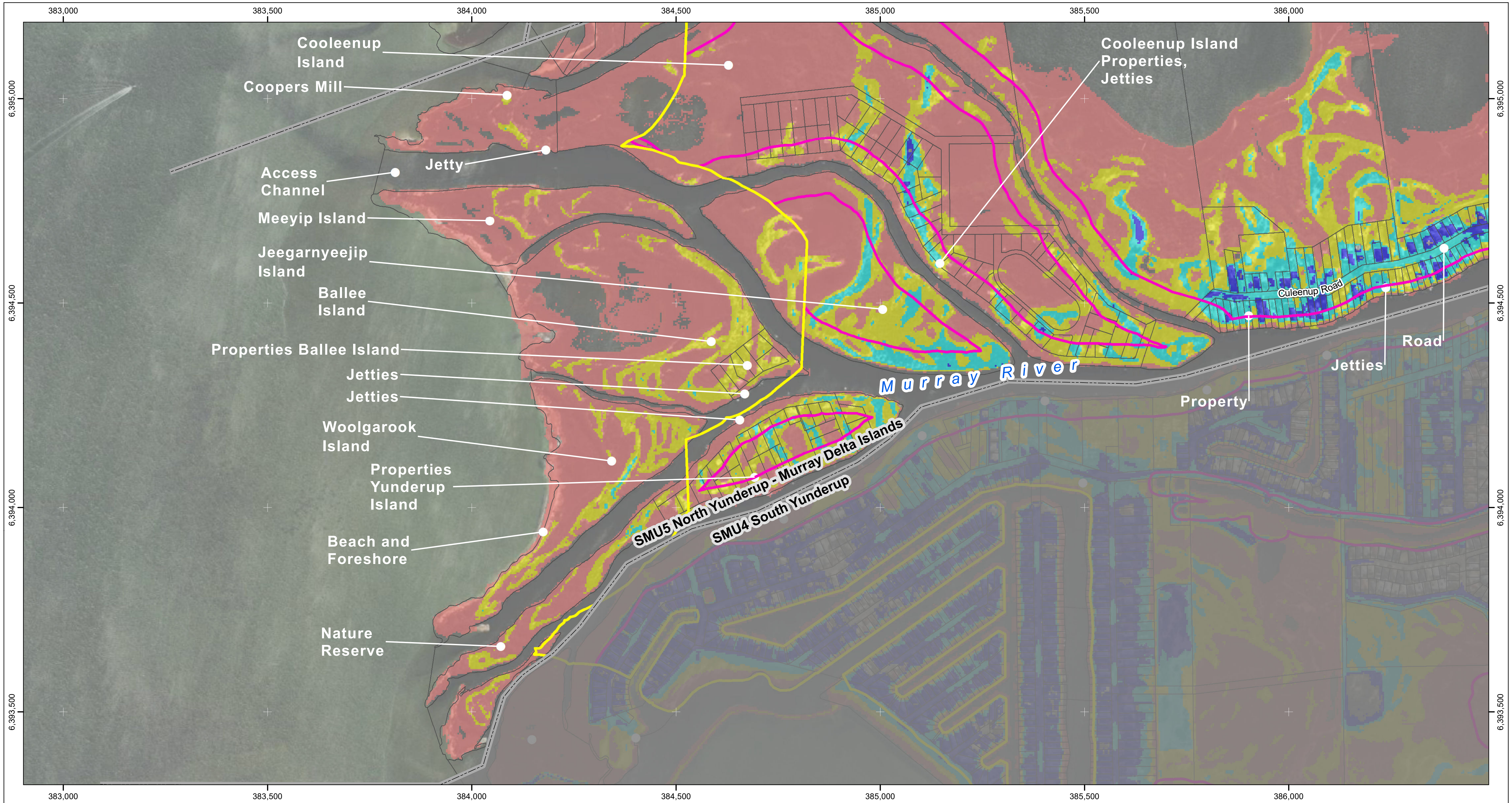
500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 10 Nov. 2021



Legend

Water Depth (m)

- 1.6 - 2
- 1.1 - 1.5
- 0.6 - 1
- 0 - 0.5
- 2120 Coastal Processes Line
- 2120 Erosion River Banks

N W E S

0 200 metres

Source Data
Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.
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SMU 5 – North Yunderup – Murray Delta Islands

Shire of Murray
Coastal Hazard Flood Mapping

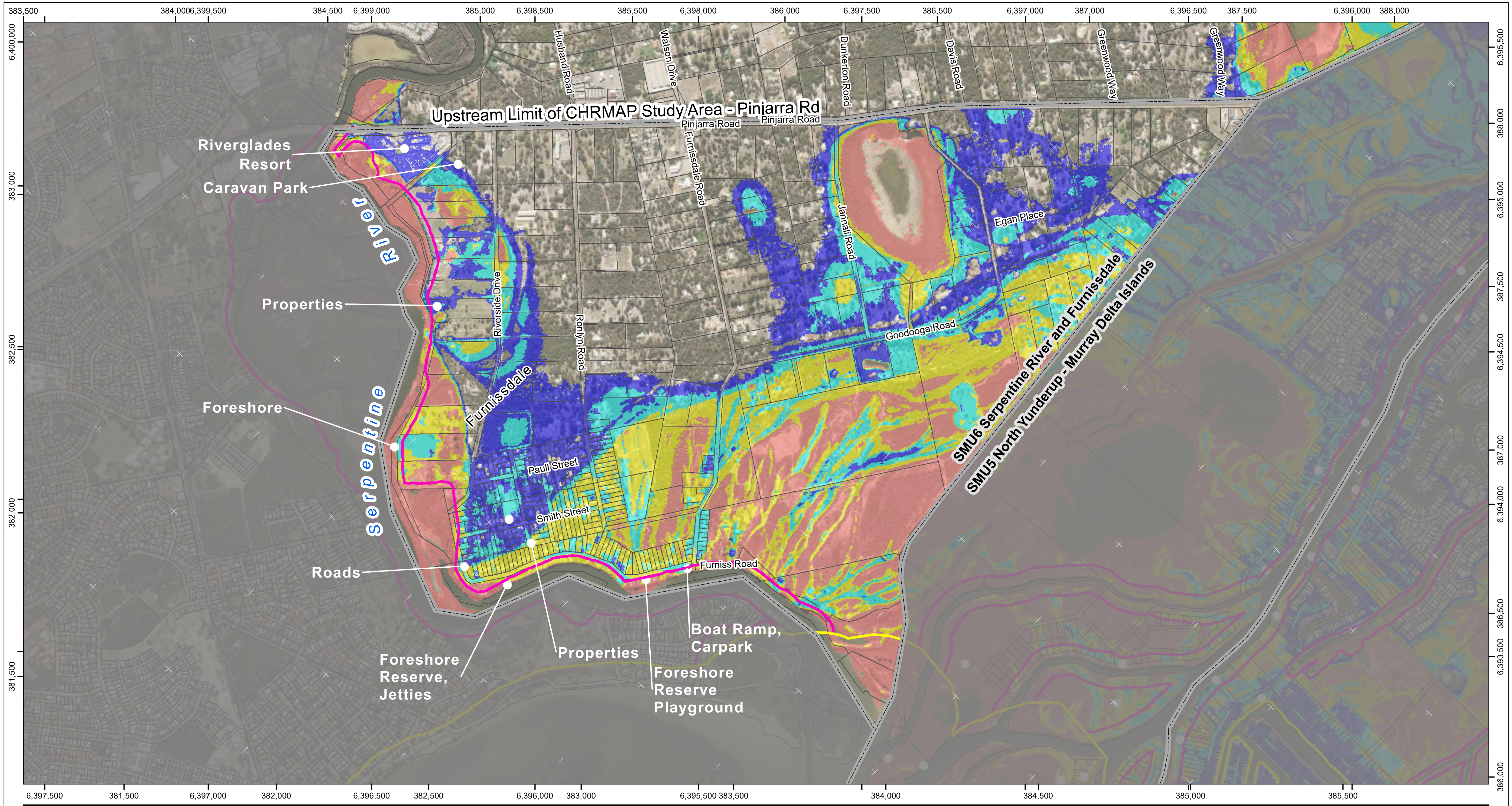
500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 11 Nov. 2021



Legend

Water Depth (m)

- 1.6 - 2
- 1.1 - 1.5
- 0.6 - 1
- 0 - 0.5
- 2120 Coastal Processes Line
- 2120 Erosion River Banks

0 200 metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site.

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SMU 6 – Serpentine River and Furnissdale

Shire of Murray
Coastal Hazard Flood Mapping

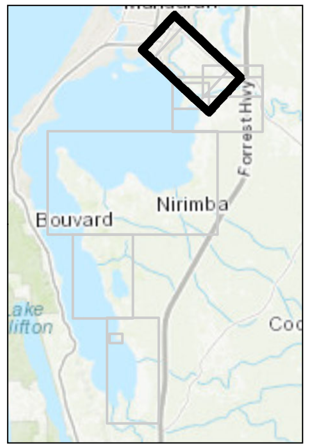
500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level of 2.34m AHD (includes 0.9m Sea Level Rise)

Shire of Murray
1915 Pinjarra Rd
Pinjarra WA 6208
https://www.murray.wa.gov.au/

Mapping prepared by Baird.

Map Published: 11 Nov. 2021



Appendix G

Adaptations Option Workshop Summary

G.1 Summary Slides Presented in the Workshop

Shire of Murray CHRMAP

- Examines the processes of erosion and inundation within the study area to understand coastal hazard risk affecting the shoreline areas today and the forecast impacts over the next 100 years (to 2120) associated with projected climate change and sea level rise.
- Developed in consultation with SoM, the local community, and a range of stakeholders in accordance with local and national guidelines. Delivered through a multi-discipline approach incorporating science, engineering, community engagement, land use planning and economic expertise.
- Aims to improve the understanding of coastal hazard risk for the community and stakeholders and to develop coastal adaptation approaches and pathways which can mitigate risk over the short to medium term (next 10-20 years) and provide management and adaptation strategies to mitigate hazard in future planning periods (next 100 years).

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Rhelm

Workshop Overview

- A number of options identified to deal with several key issues
  - Erosion / Inundation of Nature Reserves
  - Inundation of Island Properties
  - Erosion of Islands/ River Banks
  - Septic Tanks
- Seeking input from key stakeholders
- The outcomes of this workshop will then provide input to further evaluation and assessment by the team for the preparation of the CHRMAP

B. 19 81

Rhelm

Agenda

- Introductions
- Overview of MCA process
- Erosion – Nature Reserves
- Inundation – Island Properties
- Erosion – Islands and Riverbanks
- Septic Tanks
- Workshop Wrap-up

Multi-Criteria Assessment (MCA)

- An MCA is a tool to compare various alternatives or options
  - Provides a structured way to compare and contrast options
  - Uses a number of criteria, and scoring of those criteria, to compare options
  - Criteria are assigned a “score” based on the expected performance against those criteria
- Three key categories adopted for Shire of Murray
  - Technical
  - Social
  - Environmental
- These are then compared against the cost score for the option

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MCA Categories and Criteria

- **Technical**
  - Feasibility – the feasibility of designing and implementing the option
  - Effectiveness – how effective the option is at achieving the outcome
  - Climate Change Adaptation – how adaptable the option is to meet the likely changes due to climate change
  - Construction and Maintenance – ease of construction and associated maintenance
- **Social**
  - Community – impacts on the community
  - Public Amenity – impacts on the recreational use of areas, access to areas etc
- **Environmental**
  - Natural Environment – impacts on the natural environment
  - Visual Amenity – visual impacts associated with the option

MCA Scoring

Score	Technical	Social and Environmental
-2	Very Poor Performance	High negative impact
-1	Poor Performance	Medium Negative Impact
0		Low to no impact
1	Good Performance	Medium positive impact
2	Very Good Performance	High positive impact

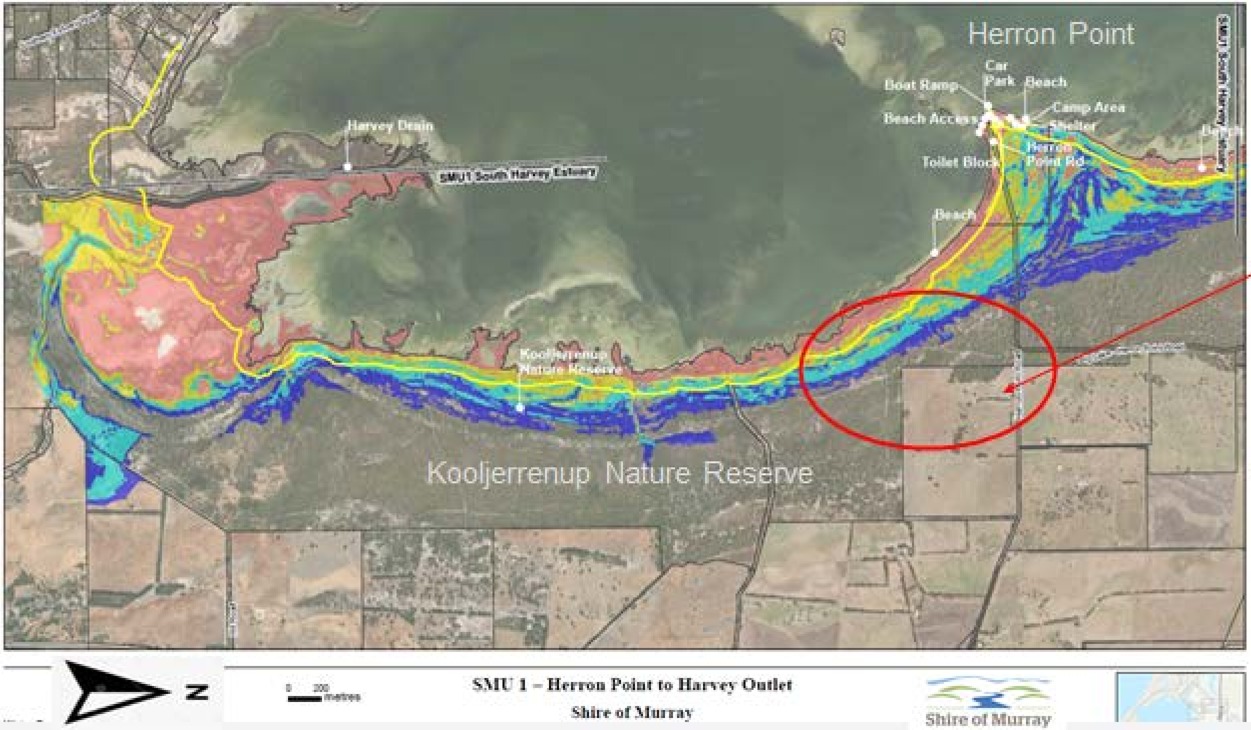
Score	Cost
1	Most Expensive
2	
3	
4	
5	Least Expensive

costs to include private costs as well

Structure of Discussion

- Overview of the issue
- Options identified to mitigate the issue
- Scoring of the options
    - Discussion amongst the group

Erosion / Inundation Nature Reserve



- Loss of width
- Potential for retreat into the landside area in future ?

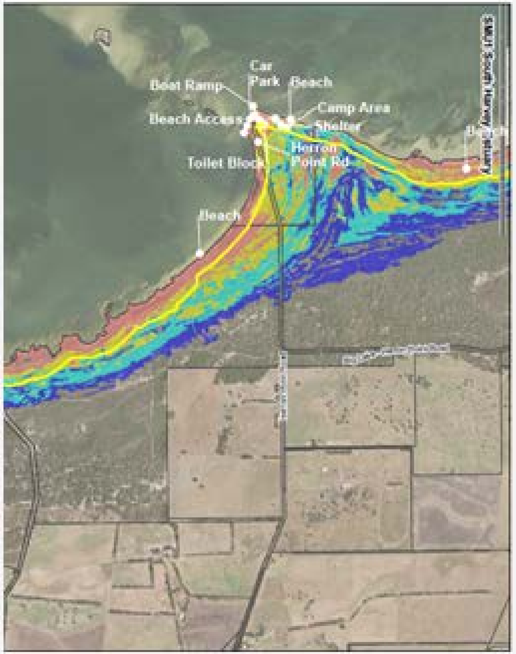
Inundation – 2120, ARI500yr

Water Depth (m)

- 1.6 - 2
- 1.1 - 1.5
- 0.6 - 1
- 0 - 0.5
- 2120 Coastal Processes Line

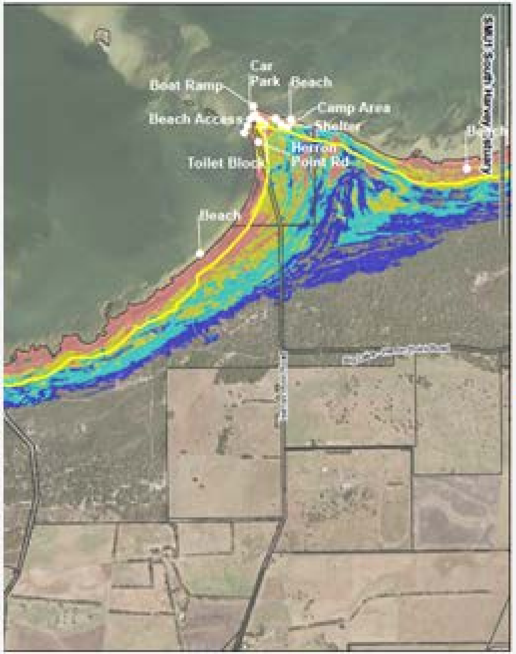
Erosion / Inundation Nature Reserve

- Overview of the issue
  - Erosion potential. Future coastal processes allowance of 150m - 200m inland
  - With sea level rise and extreme events the inundation area extends ~500m inland
  - Loss of Habitat for water birds / shore birds
  - Modification of coastal saltmarsh area
- Options identified to mitigate the issue
  1. Do nothing (annual monitoring)
  2. Managed Retreat
  3. Protect

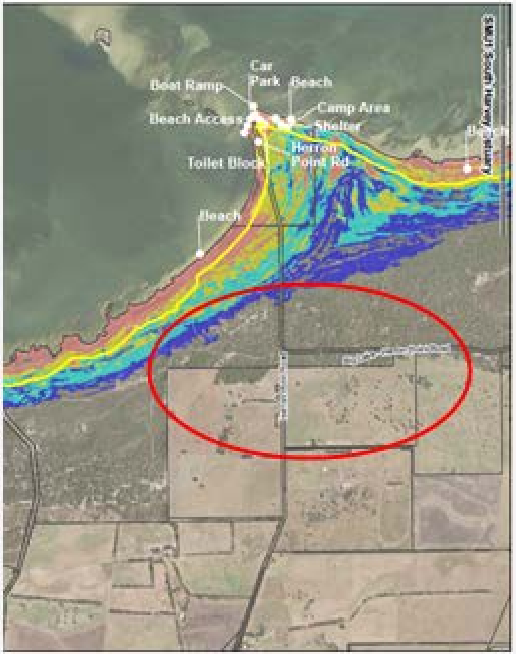


Nature Based Solutions
to protect shoreline areas

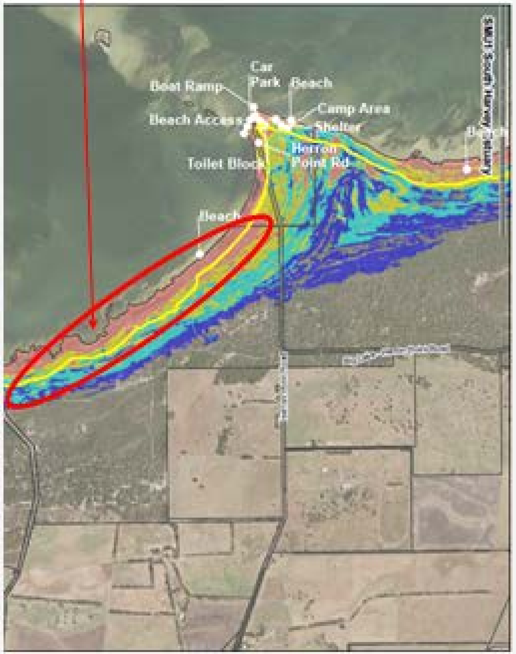
Erosion / Inundation Nature Reserve



Do Nothing / Monitor



Managed Retreat



Protect

MCA Scoring

	Technical				
Option	Feasibility	Effectiveness	Climate Change Adaptation	Construction & Maintenance	Technical Score
1. Managed Retreat - do nothing	2	-2	2	2	4
2. Managed Retreat - purchase Farm Areas Landward for future expansion	0	1	1	-1	1
3. Protection - nature based approaches	-1	2	1	-1	1

challenges in acquisition of land

establishment of vegetation - challenges over the timeframes

nature based - oyster reefs/ submerged reefs etc

MCA Scoring

	Social		
Option	Community	Public Amenity	**Social Score**
1. Managed Retreat - do nothing	-2	-1	**-4**
2. Managed Retreat - purchase Farm	1	1	**4**
3. Protection - nature based approaches	2	1	**6**

issues with landowners

MCA Scoring

	Environment		
Option	**Natural Environment**	**Visual Amenity**	**Environmental Score**
1. Managed Retreat - do nothing	-2	-1	-6
2. Managed Retreat - purchase Farm Areas Landward for future expansion	1	1	**4**
3. Protection - nature based approaches	2	1	6

MCA Scoring

Option	Cost Score
1. Managed Retreat - do nothing	5
2. Managed Retreat - purchase Farm Areas Landward for future expansion	2
3. Protection - nature based approaches	3

only buying enough to provide buffer

Option Weighting	Technical 50%	Social 25%	Environment 25%	Total Performance Score	Cost Score
1. Managed Retreat - do nothing	4	-6	-6	-1	5
2. Managed Retreat - purchase Farm Areas Landward for future expansion	1	4	4	2.5	2
3. Protection - nature based approaches	1	6	6	3.5	3

Option Weighting	Technical 33%	Social 33%	Environment 33%	Total Performance Score	Cost Score
1. Managed Retreat - do nothing	4	-6	-6	-2.64	5
2. Managed Retreat - purchase Farm Areas Landward for future expansion	1	4	4	2.97	2
3. Protection - nature based approaches	1	6	6	4.29	3

legal - built into feasibility and constructability

Inundation of Properties

- Overview of the issue
  - Under projected sea level rise there is increased risk of inundation for properties in low lying areas
  - Areas of Interest - Murray Delta Islands, North / South Yunderup, Furnissdale
  - 2000 properties are within the 2120 coastal inundation hazard extent under a projected sea level rise of 0.9m in 100 years

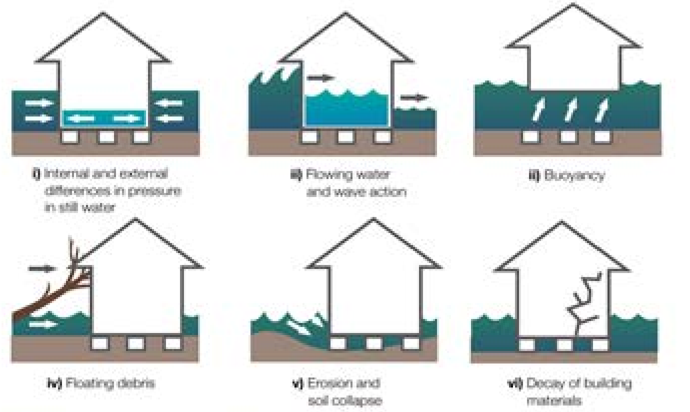


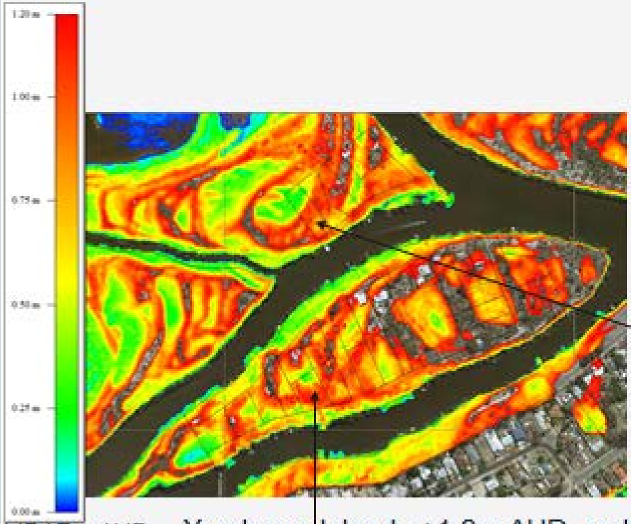
Figure 1 Floods can result in structural damage of buildings in one of several ways.

Structural Damage to Buildings in Floods - NCCARF

Inundation of Properties

Overview – Water Level

- General Tide Range +0.3m AHD (0.9mCD)
- Winter Storms +0.8m AHD (1.4mCD)
- Largest Measured +1.0mAHD (1.6mCD)



LiDAR mAHD

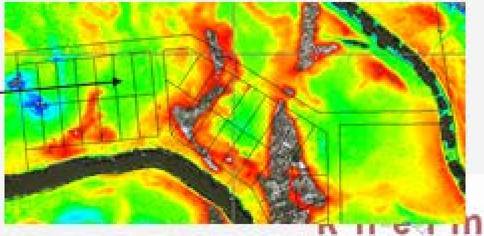
Land Elevation – Murray Delta Islands

Ballee Island +1.2m AHD

Yunderup Island +1.2m AHD and above

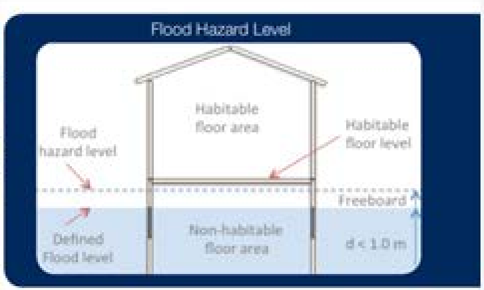
NW Cooleenup Island +0.3m AHD

Mid /Lower Cooleenup Is +1.2m AHD and above



Inundation Properties

- Options identified
  1. Housing Design - Raise Floor Level
  2. Housing Design - Use Fill to raise development pad
  3. Temporary Flood Barrier
  4. Permanent Flood Barrier
  5. Storm Surge Barrier at Dawesville Cut
  6. Voluntary Acquisition / Managed Retreat



Op1 Raise Floor Level

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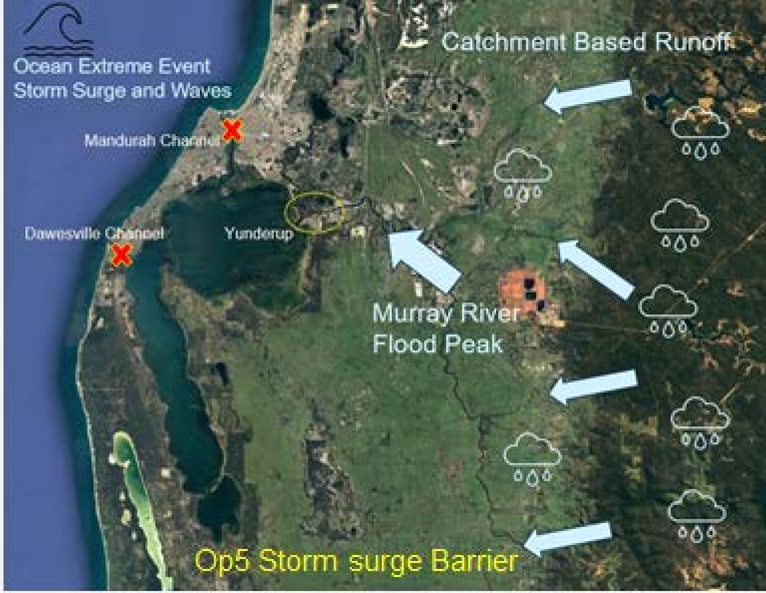
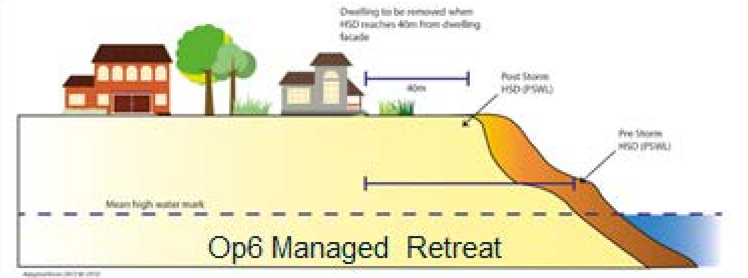
Inundation Properties





MCA Scoring

	Technical				
Option	Feasibility	Effectiveness	Climate Change Adaptation	Construction & Maintenance	Technical Score
1. Planning Based Approaches for Housing Design - Raise Floor Levels and improve foundation design to withstand flood conditions (as redev.)	2	1	1	2	6
2. Planning Based Approached for Housing Design. Fill Properties to Design Level (as redev.)	1	1	-1	1	2
3. Temporary Flood Barriers at the edge of the 3 Islands that can be erected to protect from inundation ahead of the event	-2	-1	1	-2	-4
4. Permanent Flood Barriers at the edge of the 3 Islands that can be built and maintained at a level above the design flood	1	1	1	-1	2
5. Build Flood Barrier at the Dawesville Cut	-2	2	1	-2	-1
6. Managed Retreat. Islands returned to Nature	-1	2	2	-1	2

consider not having slab on ground

could be for a property only

property level protection?

flood barrage needs to consider the wider area (not just shire)

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MCA Scoring

	Social		
Option	Community	Public Amenity	Social Score
1. Planning Based Approaches for Housing Design - Raise Floor Levels and improve foundation design to withstand flood conditions (as redev.)	2	0	4
2. Planning Based Approached for Housing Design . Fill Properties to Design Level (as redev.)	2	1	6
3. Temporary Flood Barriers at the edge of the 3 Islands that can be erected to protect from inundation ahead of the event	1	0	2
4. Permanent Flood Barriers at the edge of the 3 Islands that can be built and maintained at a level above the design flood	1	-1	0
5. Build Flood Barrier at the Dawesville Cut	2	0	4
6. Managed Retreat. Islands returned to Nature	-2	1	-2

with fill - opportunity to est. vegetation

can have natural features in the permanent barrier

barriers can be at property or island edge

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MCA Scoring

	Environment		
Option	Natural Environment	Visual Amenity	Environmental Score
1. Planning Based Approaches for Housing Design - Raise Floor Levels and improve foundation design to withstand flood conditions (as redev.)	0	0	0
2. Planning Based Approached for Housing Design . Fill Properties to Design Level (as redev.)	-1	-1	-4
3. Temporary Flood Barriers at the edge of the 3 Islands that can be erected to protect from inundation ahead of the event	0	0	0
4. Permanent Flood Barriers at the edge of the 3 Islands that can be built and maintained at a level above the design flood	-1	0	-2
5. Build Flood Barrier at the Dawesville Cut	0	-1	-2
6. Managed Retreat. Islands returned to Nature	2	1	6

barrage potential benefits for SLR for enviro

MCA Scoring

Option	Cost Score
1. Planning Based Approaches for Housing Design - Raise Floor Levels and improve foundation design to withstand flood conditions (as redev.)	5
2. Planning Based Approached for Housing Design . Fill Properties to Design Level (as redev.)	5
3. Temporary Flood Barriers at the edge of the 3 Islands that can be erected to protect from inundation ahead of the event	3
4. Permanent Flood Barriers at the edge of the 3 Islands that can be built and maintained at a level above the design flood	2
5. Build Flood Barrier at the Dawesville Cut	1
6. Managed Retreat. Islands returned to Nature	2

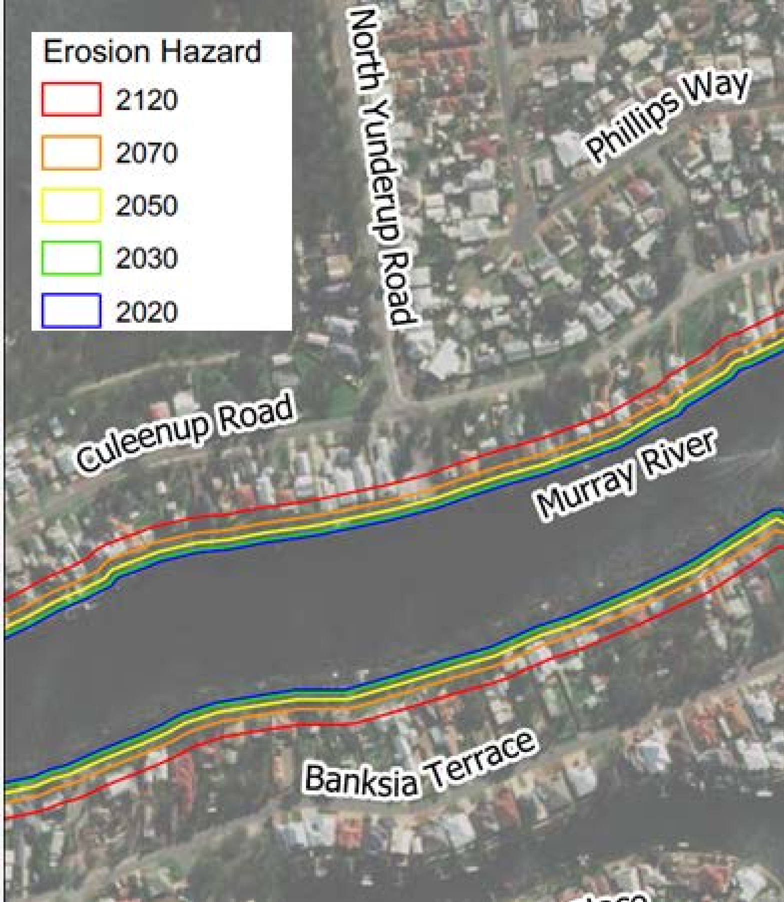
private based costs

Option	Technical	Social	Environment	Total Performance	Cost Score
Weighting	33%	33%	33%		
1. Planning Based Approaches for Housing Design - Raise Floor Levels and improve foundation design to withstand flood conditions (as redev.)	6	4	0	3.3	5
2. Planning Based Approached for Housing Design . Fill Properties to Design Level (as redev.)	2	6	-4	1.32	5
3. Temporary Flood Barriers at the edge of the 3 Islands that can be erected to protect from inundation ahead of the event	-4	2	0	-0.66	3
4. Permanent Flood Barriers at the edge of the 3 Islands that can be built and maintained at a level above the design flood	2	0	-2	0	2
5. Build Flood Barrier at the Dawesville Cut	-1	4	-2	0.33	1
6. Managed Retreat. Islands returned to Nature	2	-2	6	1.98	2

Erosion of Riverbanks

- Overview of the issue
  - Erosion of Murray and Serpentine Shorelines
  - Threat to property and assets landward
  - Affects North / South Yunderup, Murray Delta Islands, Furnissdale
- Options identified to mitigate issue
  1. Do nothing (annual monitoring)
  2. Managed Retreat
  3. Protection – Hard engineered walls
  4. Protection through Nature Based Solutions
  5. Reduce Vessel Speed (*** Implement)

vessel type rather than just speed



MCA Scoring

	Technical				
Option	Feasibility	Effectiveness	Climate Change Adaptation	Construction & Maintenance	**Technical Score**
Do Nothing	2	-2	2	2	**4**
Hard Engineering Solutions	1	2	-1	-1	**1**
Soft Edge Treatments	1	1	1	1	**4**
Managed Retreat	-1	2	2	-1	**4**

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MCA Scoring

	Social		
Option	Community	Public Amenity	Social Score
Do Nothing	-2	-2	**-8**
Hard Engineering Solutions	0	1	**2**
Soft Edge Treatments	1	2	**6**
Managed Retreat	-2	1	**-2**

potential for properties with no public land - hard engineering may be better

managed retreat - empty blocks over time an issue (visual etc)

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MCA Scoring

	Environment		
Option	Natural Environment	Visual Amenity	**Environmental Score**
Do Nothing	-1	-1	**-4**
Hard Engineering Solutions	-1	-1	**-4**
Soft Edge Treatments	1	2	**6**
Managed Retreat	2	1	**6**

MCA Scoring

Option	Cost Score
Do Nothing	5
Hard Engineering Solutions	2
Soft Edge Treatments	3
Managed Retreat	1

hard engineering could be more expensive

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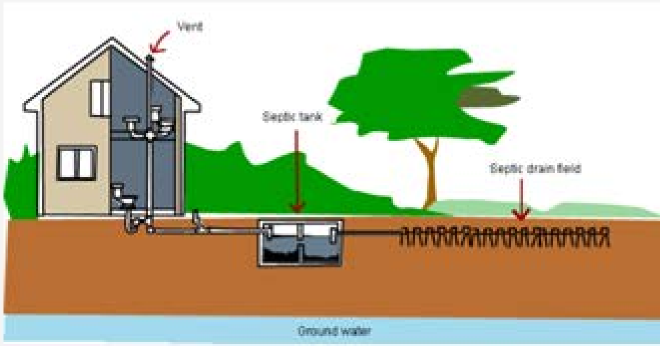
Option	Technical	Social	Environment	Total Performance Score	Cost Score
Weighting	33%	33%	33%		
Do Nothing	4	-8	-4	-2.64	5
Hard Engineering Solutions	1	2	-4	-0.33	2
Soft Edge Treatments	4	6	6	5.28	3
Managed Retreat	2	-2	6	1.98	1

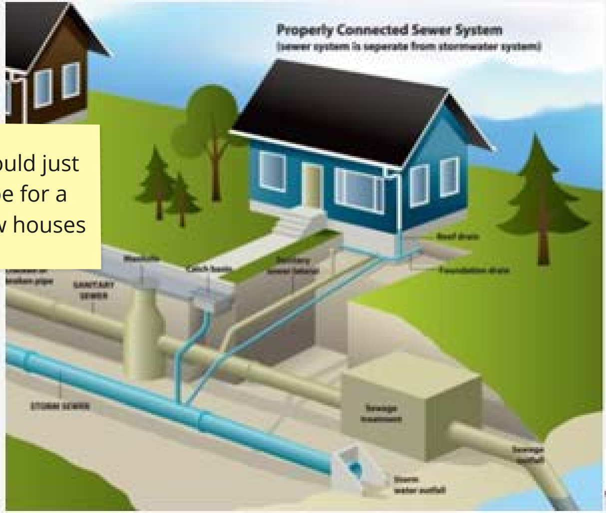
Septic Systems

- Overview of the issue
  - The septic systems on Murray Delta Islands pose a risk to River Water Quality in Future under sea level rise scenarios
  - An extreme inundation event could flood the septic and release faecal material into the Murray
- Options identified to mitigate the issue
  1. Upgrade all systems on each island to one centralised unit (ATU) above hazard level
  2. Connect to mains (WaterCorp)
  3. Managed Retreat of all houses

note that there are other places as well



Could just be for a few houses



MCA Scoring

	Technical				
Option	Feasibility	Effectiveness	Climate Change Adaptation	Construction & Maintenance	**Technical Score**
1. Managed Retreat - all properties	-1	2	2	-1	2
2. Upgrade Island septic to be on one central system located and maintained above the flodd level	1	1	2	-1	3
3. Connect the Islands to Main Sewage (WaterCorp). This would require pipe network and pumps under the river onto the islands.	-1	2	1	-2	0

several sub-options could be possible

MCA Scoring

	Social		
Option	Community	Public Amenity	Social Score
1. Managed Retreat - all properties	-2	1	-2
2. Upgrade Island septic to be on one central system located and maintained above the flodd level	2	1	6
3. Connect the Islands to Main Sewage (WaterCorp). This would require pipe network and pumps under the river onto the islands.	2	1	6

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MCA Scoring

	Environment		
Option	Natural Environment	Visual Amenity	**Environmental Score**
1. Managed Retreat - all properties	2	2	**8**
2. Upgrade Island septic to be on one central system located and maintained above the flodd level	1	1	4
3. Connect the Islands to Main Sewage (WaterCorp). This would require pipe network and pumps under the river onto the islands.	2	1	6

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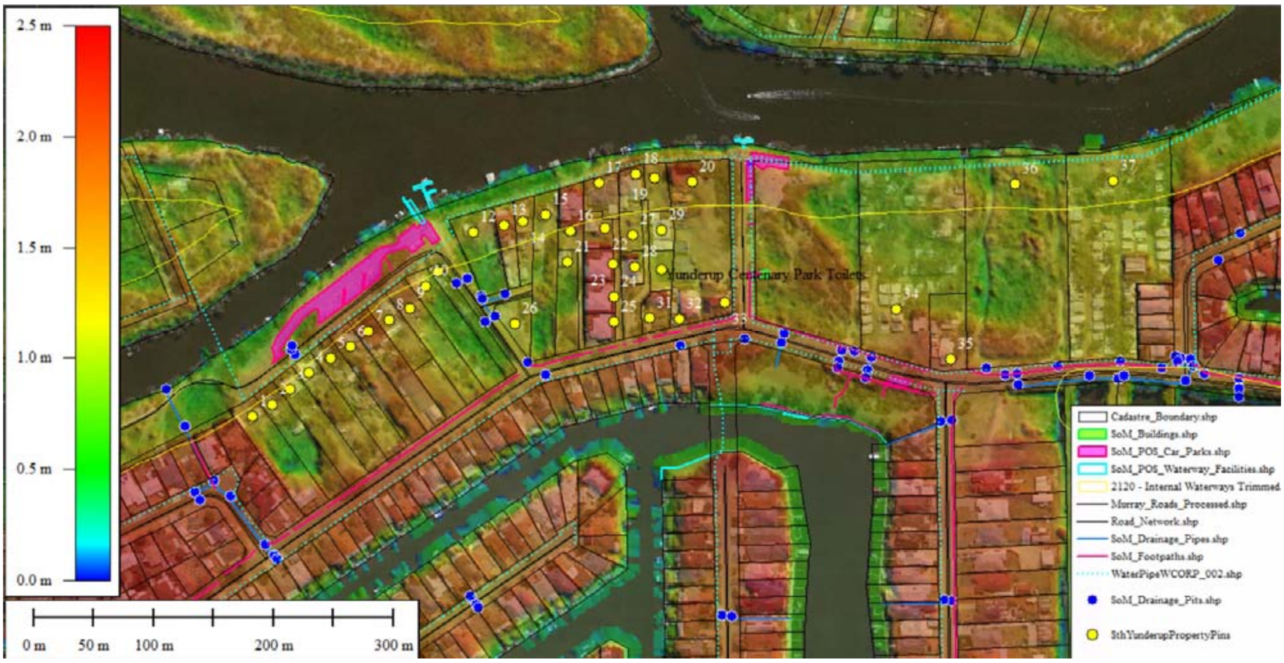
Appendix H

Hazard Impact Regions

H.1 Hazard Region Calculated for Inundation and Erosion

South Yunderup




0 m
50 m
100 m
150 m
200 m
250 m


50 m
150 m
250 m
350 m

Depth of Overfloor Inundation Calculated for South Yunderup Properties

ASSUMPTIONS

ARI Considered: 1yr, 2yr, 5yr, 10yr, 20yr, 50yr, 100yr, 500yr

Planning Periods and Sea Level Rise

Planning Periods	2020	2030	2050	2070	2120
Sea Level Rise (m)	0	0.1	0.2	0.4	0.9
Assumed Freeboard of Houses			0.3	m	

Elevation Calculated from LiDAr Data

Depth of Overfloor Inundation (m) for each property. Calculated for 8 ARI inundation levels across the 5 Respective Planning Periods

Location	Property Pin	East	North	House=H Undeveloped = U	Elevation (mAHD)	Floor Level with Freeboard Allowance	2020 (Present Day) No SLR								2030 (+0.1m SLR)								2050 (+0.2m SLR)								2070 (+0.4m SLR)								2120 (+0.9m SLR)							
						Return Period	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr
						Peak Inundation Level (m AHD)	0.60	0.78	0.87	0.91	0.96	1.04	1.09	1.44	0.70	0.88	0.97	1.01	1.06	1.14	1.19	1.54	0.80	0.98	1.07	1.11	1.16	1.24	1.29	1.64	1.00	1.18	1.27	1.31	1.36	1.44	1.49	1.84	1.50	1.68	1.77	1.81	1.86	1.94	1.99	2.34
South Yunderup Properties	1	384989.6	6394044	H	1.56	1.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.08	0.13	0.48
	2	385005.6	6394055	H	1.34	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	0.21	-	0.05	0.14	0.18	0.23	0.31	0.36	0.71
	3	385020.7	6394068	H	1.31	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.23	-	0.07	0.16	0.20	0.25	0.33	0.38	0.73
	4	385036.1	6394082	H	1.28	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.26	-	0.10	0.19	0.23	0.28	0.36	0.41	0.76
	5	385054	6394094	H	1.56	1.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.13	0.48
	6	385070.5	6394104	H	1.57	1.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	0.12	0.47
	7	385085.9	6394117	H	1.95	2.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09
	8	385103.2	6394127	H	1.54	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	0.02	0.10	0.15	0.50
	9	385120.8	6394137	H	1.61	1.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.08	0.43
	10	385133.2	6394156	H	1.19	1.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	0.15	-	-	-	-	-	-	-	0.35	0.01	0.19	0.28	0.32	0.37	0.45	0.50	0.85
	11	385143.2	6394168	H	1.04	1.34	-	-	-	-	-	-	-	0.10	-	-	-	-	-	-	-	0.20	-	-	-	-	-	-	-	0.30	-	-	-	-	0.02	0.10	0.15	0.50	0.16	0.34	0.43	0.47	0.52	0.60	0.65	1.00
	12	385172.9	6394202	H	1.28	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.26	-	0.10	0.19	0.23	0.28	0.36	0.41	0.76
	13	385198.7	6394208	H	1.85	2.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19
	14	385214	6394211	H	1.53	1.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	0.03	0.11	0.16	0.51
	15	385233.1	6394217	H	1.41	1.71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	-	-	0.06	0.10	0.15	0.23	0.28	0.63
	16	385253.9	6394203	H	1.32	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.22	-	0.06	0.15	0.19	0.24	0.32	0.37	0.72
	17	385277.9	6394244	H	1.84	2.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20
	18	385308.2	6394252	H	1.89	2.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15
	19	385324.3	6394249	H	1.54	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.10	0.15	0.50
	20	385355.8	6394245	H	1.71	2.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33
	21	385251.2	6394177	H	1.21	1.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-	-	0.34	-	0.18	0.27	0.31	0.36	0.44	0.49	0.84
	22	385282.8	6394205	H	1.62	1.92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.08	0.43
	23	385289.4	6394175	H	1.88	2.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16
	24	385290.1	6394147	H	2.01	2.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
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	26	385208	6394124	H	1.12	1.42	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.22	-	-	-	-	-	0.02	0.07	0.42	0.08	0.26	0.35	0.39	0.44	0.52	0.57	0.92
	27	385306	6394200	H	1.40	1.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	-	0.07	0.11	0.16	0.24	0.29	0.64
	28	385307.9	6394172	H	1.83	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21
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	30	385330.1	6394170	H	1.18	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.17	-	-	-	-	-	-	0.02	0.37	0.02	0.21	0.30	0.34	0.39	0.47	0.52	0.87
	31	385320	6394129	H	1.51	1.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	-	0.05	0.13	0.18	0.53
	32	385344.5	6394128	H	1.91	2.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13
	33	385382.7	6394142	H	1.88	2.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16
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	35	385570.6	6394094	H	1.99	2.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05
	36	385624	6394243	H	1.25	1.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-	-	0.29	-	0.13	0.22	0.26	0.31	0.39	0.44	0.79
	37	385705.9	6394246	H	1.13	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.01	0.06	0.41	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
	38	386268	6394385	H	1.47	1.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	-	-	-	0.04	0.09	0.17	0.22	0.57
	39	386292	6394355	H	1.86	2.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18
	40	386311	6394388	H	1.09	1.39	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	0.15	-	-	-	-	-	-	-	0.25	-	-	-	-	-	0.05	0.10	0.45	0.11	0.29	0.38	0.42	0.47	0.55	0.60	0.95
	41	386331	6394387	H	1.36	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	-	0.02	0.11	0.15	0.20	0.28	0.33	0.68
	42	386350	6394386	H	1.82	2.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22
	43	386369	6394385	H	1.55	1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.09	0.14	0.49
	44	386391	6394404	H	1.42	1.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	0.05	0.09	0.14	0.22	0.27	0.62
	45	386391.5	6394374	H	1.53	1.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	0.03	0.11	0.16	0.51
	46	386431.7	6394398	H	1.68	1.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.36
	47	386470.6	6394444	H	1.58	1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.11	0.46
	48	386488.9	6394416	H	1.39	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	-	-	0.08	0.12	0.17	0.25	0.30	0.65
	49	386512.7	6394435	H	1.33	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.21	-	0.05	0.14	0.18	0.23	0.31	0.36	0.71
	50	386530	6394449	H	1.60	1.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.09	0.44
	51	386548.7	6394461	H	1.54	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	0.02	0.10	0.15	0.50
	52	386570.6	6394457	H	1.83	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21
	53	386595.2	6394465	H	1.90	2.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15
	54	386617.2	6394462	H	1.34	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	0.20	-	0.04	0.13	0.17	0.22	0.30	0.35	0.70
	55	386661.2	6394438	H	1.94	2.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10
	56	386685.8	6394462	H	1.61	1.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.08	0.43
	57	386704.2	6394470	H	2.03	2.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
	58	386725	6394474	H	1.76	2.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.28
	59	386742.3	6394491	H	1.90	2.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
	60	386748.9	6394523	H	1.65	1.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.39
	61	386768.2	6394531	H	2.05	2.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	62	386786.3	6394539	H	1.65	1.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.39
	63	386804.9	6394546	H	1.68	1.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.36
	64	386823.4	6394552	H	1.60	1.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.09	0.44
	65	386843	6394562	H	2.03	2.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
	66	386859	6394569	H	1.68	1.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.36
	67	386877	6394576	H	2.03	2.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
	68	386892.2	6394582	H	2.03	2.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
	69	386901.5	6394585	H	2.16	2.46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	70	386915.9	6394590	H	1.64	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.05	0.40
	71	386936	6394594	H	2.25	2.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	386950	6394614	H	1.42	1.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	0.05	0.09	0.14	0.22	0.27	0.62
	73	386968.4	6394564	H	1.83	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21
	74	386173	6394370	H	2.50	2.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	75	386209	6394380	H	2.15	2.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	76	386227	6394391	H	1.95	2.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09
	77	386245.6	6394392	H	1.79	2.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26
	78	386254.1	6394392	H	1.85	2.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19
	79	387592.1	6394685	H	2.12	2.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	80	387609	6394685	H	2.50	2.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	81	387630	6394681	H	2.15	2.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	82	387658	6394689	H	1.99	2.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05
	83	387677	6394691	H	2.00	2.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
	84	387696	6394691	H	2.00	2.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
	85	387718	6394685	H	2.31	2.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	86	387741	6394678	H	2.34	2.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	87	387761	6394676	H	2.39	2.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	88	387777	6394689	H	1.73	2.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.31
	89	387797.3	6394695	H	1.94	2.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10
	90	387820	6394687	H	2.13	2.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	91	387836.9	6394682	H	1.96	2.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08
	92	387869.5	6394675	H	2.23	2.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	93	387888.4	6394693	H	2.45	2.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	94	387906	6394700	H	2.43	2.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	95	387926.9	6394706	H	2.30	2.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	96	387944.8	6394710	H	2.13	2.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	97	387966.1	6394712	H	2.06	2.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	98	387998.6	6394743	H	1.97	2.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07
	99	388016.2	6394749	H	2.02	2.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
	100	388035.3	6394754	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	101	388051.4	6394760	H	2.29	2.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	102	387823.6	6394616	H	2.01	2.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
	103	387847.6	6394528	H	1.80	2.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24
	104	387926.7	6394609	H	1.93	2.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11
	105	387989.7	6394576	H	1.91	2.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
	106	387993.6	6394504	H	1.56	1.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.13	0.48
	107	387951.8	6394393	H	1.61	1.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.08	0.43
	108	387905.6	6394359	H	1.78	2.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26

	109	387816	6394225	H	1.82	2.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22
	110	388158.7	6394559	H	1.69	1.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.35
	111	388129	6394486	H	1.59	1.89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.10	0.45
	112	388119.1	6394411	H	2.03	2.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
	113	388063.8	6394345	H	1.61	1.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.08	0.43
	114	388026	6394267	H	1.84	2.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20
	115	387960	6394221	H	1.63	1.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.06	0.41
	116	387894	6394126	H	1.78	2.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26
	117	386152.5	6394242	H	1.27	1.57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	0.27	-	0.11	0.20	0.24	0.29	0.37	0.42	0.77
	118	386173.6	6394247	H	1.77	2.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27
	119	386192.7	6394155	H	1.02	1.32	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.22	-	-	-	-	-	-	-	0.32	-	-	-	-	0.04	0.12	0.17	0.52	0.18	0.36	0.45	0.49	0.54	0.62	0.67	1.02
	120	386225.3	6394162	H	1.15	1.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-	-	-	-	-	-	-	0.20	-	-	-	-	-	-	0.05	0.40	0.05	0.24	0.33	0.37	0.42	0.50	0.55	0.90
	121	386252.4	6394274	H	1.47	1.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	-	-	0.00	0.04	0.09	0.18	0.23	0.58
	122	386274	6394099	H	1.05	1.35	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	-	0.29	-	-	-	-	0.01	0.09	0.14	0.49	0.15	0.33	0.42	0.46	0.51	0.59	0.64	0.99
	123	386301.1	6394290	H	1.53	1.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	0.03	0.11	0.16	0.51
	124	386337.3	6394023	H	1.65	1.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.39
	125	386357.1	6393992	H	1.76	2.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.28

Calculated Erosion Areas for South Yunderup RiverFront Properties

ASSUMPTIONS

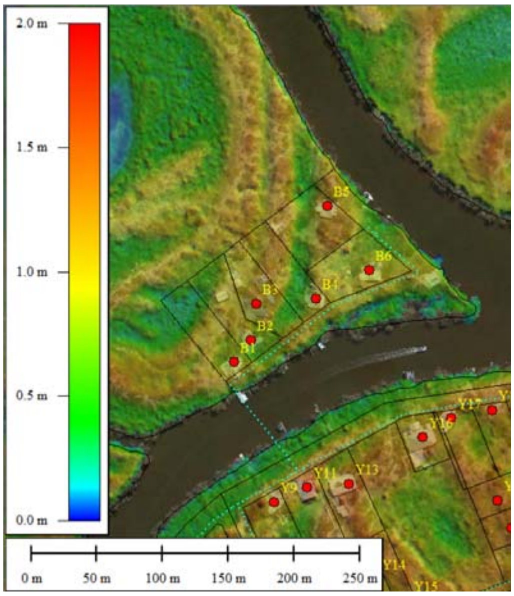
Estimate of the lot area

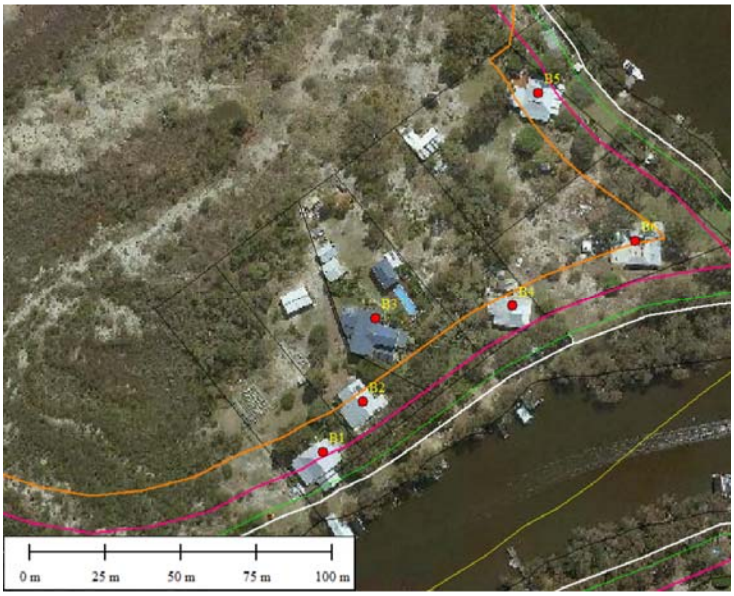
Erosion areas do not consider erosion of house a total loss of area (approach adopted at the Islands)

Elevation Calculated from LiDAr Data			Area of the Lot Which is lost to Erosion (m2)					% of the Total Lot Which is lost to Erosion				
Location	Property Pin	Lot Size (m2)	2120	2130	2150	2170	2120	2120	2130	2150	2170	2120
South Yunderup Riverfront Properties	1	2627	0	0	0	0	160	0%	0%	0%	0%	6%
	2	2198	0	0	0	0	160	0%	0%	0%	0%	7%
	3	2225	0	0	0	0	155	0%	0%	0%	0%	7%
	4	2249	0	0	0	0	145	0%	0%	0%	0%	6%
	5	2300	0	0	0	0	165	0%	0%	0%	0%	7%
	6	2225	0	0	0	0	160	0%	0%	0%	0%	7%
	7	2326	0	0	0	0	155	0%	0%	0%	0%	7%
	8	1351	0	0	0	0	155	0%	0%	0%	0%	11%
	9	2376	0	0	0	0	155	0%	0%	0%	0%	7%
	10	2359	0	0	0	0	166	0%	0%	0%	0%	7%
	11	1191	0	0	0	0	72	0%	0%	0%	0%	6%
	12	2096	0	0	230	630	1230	0%	0%	11%	30%	59%
	13	1007	0	0	60	260	580	0%	0%	6%	26%	58%
	14	1005	0	0	60	260	580	0%	0%	6%	26%	58%
	15	2943	0	0	44	314	772	0%	0%	1%	11%	26%
	16	1599	0	0	40	270	780	0%	0%	3%	17%	49%
	17	973	0	0	112	337	973	0%	0%	12%	35%	100%
	18	786	0	0	160	390	786	0%	0%	20%	50%	100%
	19	793	0	0	80	370	793	0%	0%	10%	47%	100%
	20	6759	0	0	370	1024	2061	0%	0%	5%	15%	30%
	21											
	22											
	23											
	24											
	25											
	26											
	27											
	28											
	29											
	30											
	31											
	32											
	33											
	34	13270	0	295	1060	2117	3800	0%	2%	8%	16%	29%
	35											
	36	15273	0	295	1060	2117	3800	0%	2%	7%	14%	25%
	37	13724	0	295	1060	2117	3800	0%	2%	8%	15%	28%
	38	1869	0	0	0	150	390	0%	0%	0%	8%	21%
	39	1763	0	0	0	140	370	0%	0%	0%	8%	21%
	40	1656	0	0	0	120	340	0%	0%	0%	7%	21%
	41	1550	0	0	0	110	335	0%	0%	0%	7%	22%
	42	1495	0	0	0	105	360	0%	0%	0%	7%	24%
	43	1495	0	0	0	105	340	0%	0%	0%	7%	23%
	44	748	0	0	0	110	340	0%	0%	0%	15%	45%
	45											
	46	3018	0	0	0	140	600	0%	0%	0%	5%	20%
	47	1549	0	0	0	69	300	0%	0%	0%	4%	19%
	48	1567	0	0	0	70	310	0%	0%	0%	4%	20%
	49	1585	0	0	0	75	290	0%	0%	0%	5%	18%
	50	1524	0	0	0	70	300	0%	0%	0%	5%	20%
	51	1386	0	0	0	75	305	0%	0%	0%	5%	22%
	52	1248	0	0	0	54	300	0%	0%	0%	4%	24%
	53	1532	0	0	0	30	300	0%	0%	0%	2%	20%
	54	1651	0	0	0	0	300	0%	0%	0%	0%	18%
	55	3389	0	0	0	70	310	0%	0%	0%	2%	9%
	56	1616	0	0	0	20	240	0%	0%	0%	1%	15%
	57	1616	0	0	0	65	240	0%	0%	0%	4%	15%
	58	1617	0	0	0	70	240	0%	0%	0%	4%	15%
	59	1617	0	0	0	145	375	0%	0%	0%	9%	23%
	60	1617	0	0	0	145	375	0%	0%	0%	9%	23%
	61	1617	0	0	0	145	375	0%	0%	0%	9%	23%
	62	1617	0	0	0	145	375	0%	0%	0%	9%	23%

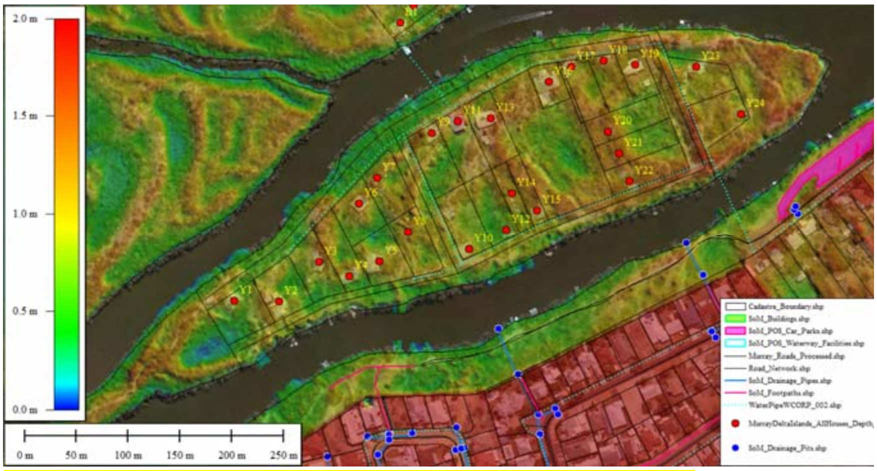
63	1617	0	0	0	145	375	0%	0%	0%	9%	23%
64	1617	0	0	0	145	375	0%	0%	0%	9%	23%
65	1617	0	0	0	145	375	0%	0%	0%	9%	23%
66	1617	0	0	0	145	375	0%	0%	0%	9%	23%
67	1617	0	0	0	145	375	0%	0%	0%	9%	23%
68	808	0	0	0	55	90	0%	0%	0%	7%	11%
69	808	0	0	0	55	90	0%	0%	0%	7%	11%
70	1681	0	0	0	90	315	0%	0%	0%	5%	19%
71	1732	0	0	0	90	315	0%	0%	0%	5%	18%
72	933	0	0	0	80	320	0%	0%	0%	9%	34%
73											
74	5763	0	0	0	0	225	0%	0%	0%	0%	4%
75	2263	0	0	0	101	315	0%	0%	0%	4%	14%
76	1828	0	0	0	180	470	0%	0%	0%	10%	26%
77	1013	0	0	0	75	190	0%	0%	0%	7%	19%
78	1013	0	0	0	75	190	0%	0%	0%	7%	19%

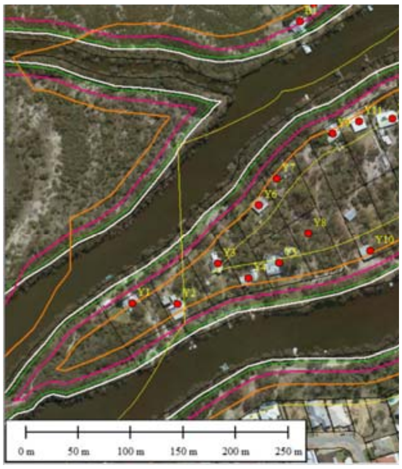
Ballee Island



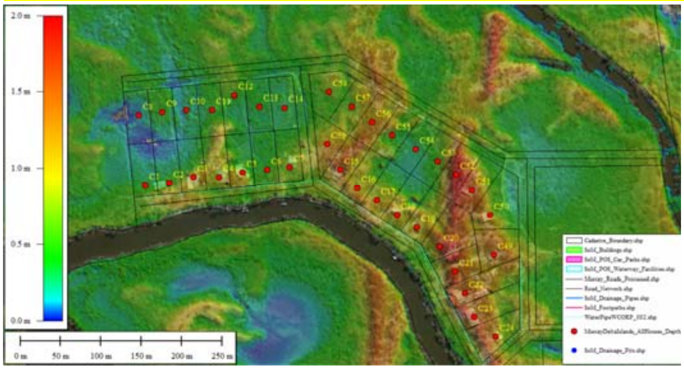


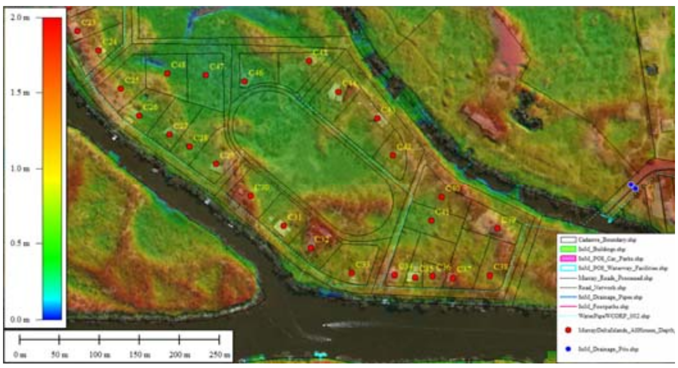
Yunderup Island





Coolenup Island





Depth of Overfloor Inundation Calculated for the Murray Delta Island Properties

ASSUMPTIONS

ARI Considered: 1yr, 2yr, 5yr, 10yr, 20yr, 50yr, 100yr, 500yr

Planning Periods and Sea Level Rise

Planning Periods	2020	2030	2050	2070	2120
Sea Level Rise (m)	0	0.1	0.2	0.4	0.9
Assumed Freeboard of Houses			0.3	m	

Elevation Calculated from LiDAr Data

Depth of Overfloor Inundation (m) for each property. Calculated for 8 ARI inundation levels across the 5 Respective Planning Periods

ISLAND	Property Pin	East	North	House=H Undeveloped = U	Elevation (mAHD)	Floor Level with Freeboard Allowance	2020 (Present Day) No SLR								2030 (+0.1m SLR)							
						Return Period	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr
						Peak Inundation Level (m AHD)	0.60	0.78	0.87	0.91	0.96	1.04	1.09	1.44	0.70	0.88	0.97	1.01	1.06	1.14	1.19	1.54
Ballee Island	B1	384640.7	6394288	H	0.88	1.18	-	-	-	-	-	-	-	0.26	-	-	-	-	-	-	0.01	0.36
	B2	384654	6394305	H	0.71	1.01	-	-	-	-	-	0.03	0.08	0.43	-	-	-	0.00	0.05	0.13	0.18	0.53
	B3	384657.9	6394333	H	1.19	1.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05
	B4	384703.3	6394337	H	1.02	1.32	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.22
	B5	384711.9	6394410	H	1.11	1.41	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.13
	B6	384744	6394360	H	0.88	1.18	-	-	-	-	-	-	-	0.26	-	-	-	-	-	-	0.01	0.36
Yunderup Island	Y1	384480.8	6394011	H	0.95	1.25	-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	-	0.29
	Y2	384524.2	6394010	H	1.01	1.31	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	0.23
	Y3	384562.8	6394049	H	1.16	1.46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08
	Y4	384591.7	6394035	H	0.96	1.26	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	-	0.28
	Y5	384620.6	6394050	H	1.11	1.41	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.13
	Y6	384601.3	6394107	H	1.26	1.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y7	384618.7	6394133	H	1.34	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y8	*384649*	*6394079*	*U*	*1.22*	*1.52*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
	Y9	384671.7	6394178	H	1.09	1.39	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	0.15
	Y10	384707.4	6394062	H	1.01	1.31	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	0.23
	Y11	384696.8	6394189	H	1.38	1.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y12	384743	6394081	H	0.72	1.02	-	-	-	-	-	0.02	0.07	0.42	-	-	-	-	0.04	0.12	0.17	0.52
	Y13	384728.6	6394192	H	1.41	1.71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y14	384748.5	6394118	H	1.14	1.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10
	Y15	384773.3	6394101	H	1.16	1.46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08
	Y16	384784.5	6394229	H	1.28	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y17	384806.3	6394244	H	1.22	1.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
	Y18	384837.6	6394250	H	1.28	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y19	384867.6	6394246	H	1.14	1.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10
	Y20	*384841*	*6394179*	*U*	*1.48*	*1.78*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y21	*384852*	*6394158*	*U*	*1.42*	*1.72*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y22	384862.4	6394130	H	1.37	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Y23	384926.3	6394244	H	1.04	1.34	-	-	-	-	-	-	-	0.10	-	-	-	-	-	-	-	0.20
	Y24	384970	6394197	H	1.13	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11
Cooleenup Island	*C1*	*384687*	*6394864*	*U*	*0.33*	*0.63*	-	0.15	0.24	0.28	0.33	0.41	0.46	0.81	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
	C2	384716.6	6394867	H	0.89	1.19	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-	0.00	0.35
	C3	384746.5	6394875	H	1.08	1.38	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.16
	C4	384778.3	6394875	H	0.88	1.18	-	-	-	-	-	-	-	0.26	-	-	-	-	-	-	0.01	0.36
	C5	384807.2	6394881	H	0.79	1.09	-	-	-	-	-	-	-	0.35	-	-	-	-	-	0.05	0.10	0.45
	C6	*384838*	*6394885*	*U*	*0.43*	*0.73*	-	0.05	0.14	0.18	0.23	0.31	0.36	0.71	-	0.15	0.24	0.28	0.33	0.41	0.46	0.81
	C7	384866	6394888	H	0.67	0.97	-	-	-	-	-	0.07	0.12	0.47	-	-	-	0.04	0.09	0.17	0.22	0.57
	C8	*384679*	*6394954*	*U*	*0.12*	*0.42*	0.18	0.36	0.45	0.49	0.54	0.62	0.67	1.02	0.28	0.46	0.55	0.59	0.64	0.72	0.77	1.12
	C9	*384708*	*6394958*	*U*	*0.39*	*0.69*	-	0.09	0.18	0.22	0.27	0.35	0.40	0.75	0.01	0.19	0.28	0.32	0.37	0.45	0.50	0.85
	C10	*384738*	*6394961*	*U*	*0.40*	*0.70*	-	0.08	0.17	0.21	0.26	0.34	0.39	0.74	0.00	0.18	0.27	0.31	0.36	0.44	0.49	0.84
	C11	*384770*	*6394961*	*U*	*0.40*	*0.70*	-	0.08	0.17	0.21	0.26	0.34	0.39	0.74	-	0.18	0.27	0.31	0.36	0.44	0.49	0.84
	C12	*384798*	*6394979*	*U*	*0.51*	*0.81*	-	-	0.06	0.10	0.15	0.23	0.28	0.63	-	0.07	0.16	0.20	0.25	0.33	0.38	0.73
	C13	*384828*	*6394965*	*U*	*0.36*	*0.66*	-	0.13	0.22	0.26	0.31	0.39	0.44	0.79	0.04	0.23	0.32	0.36	0.41	0.49	0.54	0.89
	C14	*384859*	*6394964*	*U*	*0.30*	*0.60*	0.01	0.19	0.28	0.32	0.37	0.45	0.50	0.85	0.11	0.29	0.38	0.42	0.47	0.55	0.60	0.95
	C15	384928.7	6394885	H	1.27	1.57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C16	384949.9	6394862	H	0.95	1.25	-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	-	0.29
	C17	384974	6394846	H	1.03	1.33	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.22
	C18	384999.1	6394827	H	1.10	1.40	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	-	0.15
	C19	385023.2	6394811	H	1.18	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06
	C20	385052.1	6394786	U	1.64	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C21	385070.4	6394755	U	1.66	1.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C22	385082.9	6394728	H	1.47	1.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C23	385094.5	6394697	H	1.39	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C24	385120.5	6394672	H	1.27	1.57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C25	385148.5	6394623	U	1.02	1.32	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.22
	C26	385171.6	6394589	H	0.58	0.88	-	-	-	0.03	0.08	0.16	0.21	0.56	-	-	0.09	0.13	0.18	0.26	0.31	0.66
	C27	385209.2	6394565	H	0.63	0.93	-	-	-	-	0.03	0.11	0.16	0.51	-	-	0.04	0.08	0.13	0.21	0.26	0.61
	C28	*385235*	*6394549*	*U*	*0.61*	*0.91*	-	-	-	-	0.05	0.13	0.18	0.53	-	-	0.06	0.10	0.15	0.23	0.28	0.63
	C29	385267.5	6394527	H	0.76	1.06	-	-	-	-	-	-	0.04	0.39	-	-	-	-	0.01	0.09	0.14	0.49
	C30	385310.9	6394484	H	1.32	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C31	385352.3	6394446	H	0.95	1.25	-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	-	0.29
	C32	385386.1	6394418	H	1.53	1.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C33	385437.2	6394385	H	1.11	1.41	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.13
	C34	385491.1	6394383	H	1.42	1.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C35	385516.3	6394380	H	0.85	1.15	-	-	-	-	-	-	-	0.29	-	-	-	-	-	-	0.04	0.39
	C36	*385539*	*6394382*	*U*	*1.13*	*1.43*	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11
	C37	*385564*	*6394379*	*U*	*1.61*	*1.91*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C38	385609.7	6394382	H	1.13	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11
	C39	385619.6	6394442	H	1.57	1.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C40	385549.7	6394483	U	1.15	1.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09
	C41	*385537*	*6394453*	*U*	*0.68*	*0.98*	-	-	-	-	-	0.06	0.11	0.46	-	-	-	0.03	0.08	0.16	0.21	0.56
	C42	*385489*	*6394537*	*U*	*0.92*	*1.22*	-	-	-	-	-	-	-	0.22	-	-	-	-	-	-	-	0.32
	C43	385469.1	6394585	H	1.15	1.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09
	C44	385420.2	6394618	H	0.85	1.15	-	-	-	-	-	-	-	0.29	-	-	-	-	-	-	0.04	0.39
	C45	385384.3	6394659	H	0.81	1.11	-	-	-	-	-	-	-	0.33	-	-	-	-	-	0.03	0.08	0.43
	C46	*385303*	*6394632*	*U*	*0.32*	*0.62*	-	0.17	0.26	0.30	0.35	0.43	0.48	0.83	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93
	C47	385254.4	6394640	H	0.34	0.64	-	0.14	0.23	0.27	0.32	0.40	0.45	0.80	0.06	0.24	0.33	0.37	0.42	0.50	0.55	0.90
	C48	385206.9	6394642	H	0.41	0.71	-	0.07	0.16	0.20	0.25	0.33	0.38	0.73	-	0.17	0.26	0.30	0.35	0.43	0.48	0.83
	C49	385118.5	6394776	H	1.39	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C50	385113.7	6394827	H	1.13	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.12
	C51	*385092*	*6394859*	*U*	*1.61*	*1.91*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C52	*385072*	*6394878*	*U*	*2.35*	*2.65*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C53	*385049*	*6394895*	*U*	*0.48*	*0.78*	-	-	0.09	0.13	0.18	0.26	0.31	0.66	-	0.10	0.19	0.23	0.28	0.36	0.41	0.76
	C54	*385022*	*6394911*	*U*	*0.27*	*0.57*	0.03	0.21	0.30	0.34	0.39	0.47	0.52	0.87	0.13	0.31	0.40	0.44	0.49	0.57	0.62	0.97
	C55	*384993*	*6394928*	*U*	*0.38*	*0.68*	-	0.10	0.19	0.23	0.28	0.36	0.41	0.76	0.02	0.20	0.29	0.33	0.38	0.46	0.51	0.86
	C56	*384968*	*6394946*	*U*	*1.22*	*1.52*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
	C57	*384943*	*6394965*	*U*	*0.63*	*0.93*	-	-	-	-	0.03	0.11	0.16	0.51	-	-	0.04	0.08	0.13	0.21	0.26	0.61
	C58	*384914*	*6394983*	*U*	*0.65*	*0.95*	-	-	-	-	0.01	0.09	0.14	0.49	-	-	0.02	0.06	0.11	0.19	0.24	0.59
	C59	384912.3	6394918	H	1.23	1.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
	Mill Cott	384090.3	6395002	H	0.85	1.15	-	-	-	-	-	-	-	0.29	-	-	-	-	-	-	0.04	0.39
	Mill	384121.2	6395021	U	0.50	0.80	-	-	0.07	0.11	0.16	0.24	0.29	0.64	-	0.08	0.17	0.21	0.26	0.34	0.39	0.74

Property Pin	2050 (+0.2m SLR)								2070 (+0.4m SLR)								2120 (+0.9m SLR)							
Return Period	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr
Peak Inundation Level (m AHD)	0.80	0.98	1.07	1.11	1.16	1.24	1.29	1.64	1.00	1.18	1.27	1.31	1.36	1.44	1.49	1.84	1.50	1.68	1.77	1.81	1.86	1.94	1.99	2.34
B1	-	-	-	-	-	0.06	0.11	0.46	-	-	0.09	0.13	0.18	0.26	0.31	0.66	0.32	0.50	0.59	0.63	0.68	0.76	0.81	1.16
B2	-	-	0.06	0.10	0.15	0.23	0.28	0.63	-	0.17	0.26	0.30	0.35	0.43	0.48	0.83	0.49	0.67	0.76	0.80	0.85	0.93	0.98	1.33
B3	-	-	-	-	-	-	-	0.15	-	-	-	-	-	-	0.00	0.35	0.01	0.19	0.28	0.32	0.37	0.45	0.50	0.85
B4	-	-	-	-	-	-	-	0.32	-	-	-	-	0.04	0.12	0.17	0.52	0.18	0.36	0.45	0.49	0.54	0.62	0.67	1.02
B5	-	-	-	-	-	-	-	0.23	-	-	-	-	-	0.03	0.08	0.43	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93
B6	-	-	-	-	-	0.06	0.11	0.46	-	-	0.09	0.13	0.18	0.26	0.31	0.66	0.32	0.50	0.59	0.63	0.68	0.76	0.81	1.16
Y1	-	-	-	-	-	-	0.04	0.39	-	-	0.02	0.06	0.11	0.19	0.24	0.59	0.25	0.43	0.52	0.56	0.61	0.69	0.74	1.09
Y2	-	-	-	-	-	-	-	0.33	-	-	-	-	0.05	0.13	0.18	0.53	0.19	0.37	0.46	0.50	0.55	0.63	0.68	1.03
Y3	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	0.03	0.38	0.04	0.22	0.31	0.35	0.40	0.48	0.53	0.88
Y4	-	-	-	-	-	-	0.03	0.38	-	-	0.01	0.05	0.10	0.18	0.23	0.58	0.24	0.42	0.51	0.55	0.60	0.68	0.73	1.08
Y5	-	-	-	-	-	-	-	0.23	-	-	-	-	-	0.03	0.08	0.43	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93
Y6	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.28	-	0.12	0.21	0.25	0.30	0.38	0.43	0.78
Y7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20	-	0.04	0.13	0.17	0.22	0.30	0.35	0.70
Y8	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.32	-	0.16	0.25	0.29	0.34	0.42	0.47	0.82
Y9	-	-	-	-	-	-	-	0.25	-	-	-	-	-	0.05	0.10	0.45	0.11	0.29	0.38	0.42	0.47	0.55	0.60	0.95
Y10	-	-	-	-	-	-	-	0.33	-	-	-	-	0.05	0.13	0.18	0.53	0.19	0.37	0.46	0.50	0.55	0.63	0.68	1.03
Y11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16	-	-	0.09	0.13	0.18	0.26	0.31	0.66
Y12	-	-	0.05	0.09	0.14	0.22	0.27	0.62	-	0.16	0.25	0.29	0.34	0.42	0.47	0.82	0.48	0.66	0.75	0.79	0.84	0.92	0.97	1.32
Y13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	-	-	0.06	0.10	0.15	0.23	0.28	0.63
Y14	-	-	-	-	-	-	-	0.20	-	-	-	-	-	-	0.05	0.40	0.06	0.24	0.33	0.37	0.42	0.50	0.55	0.90
Y15	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	0.03	0.38	0.04	0.22	0.31	0.35	0.40	0.48	0.53	0.88
Y16	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.26	-	0.10	0.19	0.23	0.28	0.36	0.41	0.76
Y17	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.32	-	0.16	0.25	0.29	0.34	0.42	0.47	0.82
Y18	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.26	-	0.10	0.19	0.23	0.28	0.36	0.41	0.76
Y19	-	-	-	-	-	-	-	0.20	-	-	-	-	-	-	0.05	0.40	0.06	0.24	0.33	0.37	0.42	0.50	0.55	0.90
Y20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	0.03	0.08	0.16	0.21	0.56
Y21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	0.05	0.09	0.14	0.22	0.27	0.62
Y22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	-	0.01	0.10	0.14	0.19	0.27	0.32	0.67
Y23	-	-	-	-	-	-	-	0.30	-	-	-	-	0.02	0.10	0.15	0.50	0.16	0.34	0.43	0.47	0.52	0.60	0.65	1.00
Y24	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.01	0.06	0.41	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
C1	0.17	0.35	0.44	0.48	0.53	0.61	0.66	1.01	0.37	0.55	0.64	0.68	0.73	0.81	0.86	1.21	0.87	1.05	1.14	1.18	1.23	1.31	1.36	1.71
C2	-	-	-	-	-	0.05	0.10	0.45	-	-	0.08	0.12	0.17	0.25	0.30	0.65	0.31	0.49	0.58	0.62	0.67	0.75	0.80	1.15
C3	-	-	-	-	-	-	-	0.26	-	-	-	-	-	0.06	0.11	0.46	0.12	0.30	0.39	0.43	0.48	0.56	0.61	0.96
C4	-	-	-	-	-	0.06	0.11	0.46	-	-	0.09	0.13	0.18	0.26	0.31	0.66	0.32	0.50	0.59	0.63	0.68	0.76	0.81	1.16
C5	-	-	-	0.02	0.07	0.15	0.20	0.55	-	0.09	0.18	0.22	0.27	0.35	0.40	0.75	0.41	0.59	0.68	0.72	0.77	0.85	0.90	1.25
C6	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91	0.27	0.45	0.54	0.58	0.63	0.71	0.76	1.11	0.77	0.95	1.04	1.08	1.13	1.21	1.26	1.61
C7	-	0.01	0.10	0.14	0.19	0.27	0.32	0.67	0.03	0.21	0.30	0.34	0.39	0.47	0.52	0.87	0.53	0.71	0.80	0.84	0.89	0.97	1.02	1.37
C8	0.38	0.56	0.65	0.69	0.74	0.82	0.87	1.22	0.58	0.76	0.85	0.89	0.94	1.02	1.07	1.42	1.08	1.26	1.35	1.39	1.44	1.52	1.57	1.92
C9	0.11	0.29	0.38	0.42	0.47	0.55	0.60	0.95	0.31	0.49	0.58	0.62	0.67	0.75	0.80	1.15	0.81	0.99	1.08	1.12	1.17	1.25	1.30	1.65
C10	0.10	0.28	0.37	0.41	0.46	0.54	0.59	0.94	0.30	0.48	0.57	0.61	0.66	0.74	0.79	1.14	0.80	0.98	1.07	1.11	1.16	1.24	1.29	1.64
C11	0.10	0.28	0.37	0.41	0.46	0.54	0.59	0.94	0.30	0.48	0.57	0.61	0.66	0.74	0.79	1.14	0.80	0.98	1.07	1.11	1.16	1.24	1.29	1.64
C12	-	0.17	0.26	0.30	0.35	0.43	0.48	0.83	0.19	0.37	0.46	0.50	0.55	0.63	0.68	1.03	0.69	0.87	0.96	1.00	1.05	1.13	1.18	1.53
C13	0.15	0.33	0.42	0.46	0.51	0.59	0.64	0.99	0.35	0.53	0.62	0.66	0.71	0.79	0.84	1.19	0.85	1.03	1.12	1.16	1.21	1.29	1.34	1.69
C14	0.21	0.39	0.48	0.52	0.57	0.65	0.70	1.05	0.41	0.59	0.68	0.72	0.77	0.85	0.90	1.25	0.91	1.09	1.18	1.22	1.27	1.35	1.40	1.75
C15	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	0.27	-	0.11	0.20	0.24	0.29	0.37	0.42	0.77
C16	-	-	-	-	-	-	0.04	0.39	-	-	0.02	0.06	0.11	0.19	0.24	0.59	0.25	0.43	0.52	0.56	0.61	0.69	0.74	1.09
C17	-	-	-	-	-	-	-	0.32	-	-	-	-	0.03	0.12	0.17	0.52	0.18	0.36	0.45	0.49	0.54	0.62	0.67	1.02
C18	-	-	-	-	-	-	-	0.25	-	-	-	-	-	0.04	0.10	0.45	0.11	0.29	0.38	0.42	0.47	0.55	0.60	0.95
C19	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	0.01	0.36	0.02	0.20	0.29	0.33	0.38	0.46	0.51	0.86
C20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.40
C21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.38
C22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	-	-	0.00	0.04	0.09	0.18	0.23	0.58
C23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	-	-	0.08	0.12	0.17	0.25	0.30	0.65
C24	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	0.27	-	0.11	0.20	0.24	0.29	0.37	0.42	0.77
C25	-	-	-	-	-	-	-	0.32	-	-	-	-	0.04	0.12	0.17	0.52	0.18	0.36	0.45	0.49	0.54	0.62	0.67	1.02
C26	-	0.10	0.19	0.23	0.28	0.36	0.41	0.76	0.12	0.30	0.39	0.43	0.48	0.56	0.61	0.96	0.62	0.80	0.89	0.93	0.98	1.06	1.11	1.46
C27	-	0.05	0.14	0.18	0.23	0.31	0.36	0.71	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91	0.57	0.75	0.84	0.88	0.93	1.01	1.06	1.41
C28	-	0.07	0.16	0.20	0.25	0.33	0.38	0.73	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93	0.59	0.77	0.86	0.90	0.95	1.03	1.08	1.43
C29	-	-	0.02	0.06	0.11	0.19	0.24	0.59	-	0.13	0.22	0.26	0.31	0.39	0.44	0.79	0.45	0.63	0.72	0.76	0.81	0.89	0.94	1.29
C30	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.22	-	0.06	0.15	0.19	0.24	0.32	0.37	0.72
C31	-	-	-	-	-	-	0.04	0.39	-	-	0.02	0.06	0.11	0.19	0.24	0.59	0.25	0.43	0.52	0.56	0.61	0.69	0.74	1.09
C32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	0.03	0.11	0.16	0.51
C33	-	-	-	-	-	-	-	0.23	-	-	-	-	-	0.03	0.08	0.43	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93
C34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	0.05	0.09	0.14	0.22	0.27	0.62
C35	-	-	-	-	0.01	0.09	0.14	0.49	-	0.03	0.12	0.16	0.21	0.29	0.34	0.69	0.35	0.53	0.62	0.66	0.71	0.79	0.84	1.19
C36	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.01	0.06	0.41	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
C37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.08	0.43
C38	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.01	0.06	0.41	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
C39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	0.12	0.47
C40	-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	0.04	0.39	0.05	0.23	0.32	0.36	0.41	0.49	0.54	0.89
C41	-	-	0.09	0.13	0.18	0.26	0.31	0.66	0.02	0.20	0.29	0.33	0.38	0.46	0.51	0.86	0.52	0.70	0.79	0.83	0.88	0.96	1.01	1.36
C42	-	-	-	-	-	0.02	0.07	0.42	-	-	0.05	0.09	0.14	0.22	0.27	0.62	0.28	0.46	0.55	0.59	0.64	0.72	0.77	1.12
C43	-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	0.04	0.39	0.05	0.23	0.32	0.36	0.41	0.49	0.54	0.89
C44	-	-	-	-	0.01	0.09	0.14	0.49	-	0.03	0.12	0.16	0.21	0.29	0.34	0.69	0.35	0.53	0.62	0.66	0.71	0.79	0.84	1.19
C45	-	-	-	0.00	0.05	0.13	0.18	0.53	-	0.07	0.16	0.20	0.25	0.33	0.38	0.73	0.39	0.57	0.66	0.70	0.75	0.83	0.88	1.23
C46	0.19	0.37	0.46	0.50	0.55	0.63	0.68	1.03	0.39	0.57	0.66	0.70	0.75	0.83	0.88	1.23	0.89	1.07	1.16	1.20	1.25	1.33	1.38	1.73
C47	0.16	0.34	0.43	0.47	0.52	0.60	0.65	1.00	0.36	0.54	0.63	0.67	0.72	0.80	0.85	1.20	0.86	1.04	1.13	1.17	1.22	1.30	1.35	1.70
C48	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93	0.29	0.47	0.56	0.60	0.65	0.73	0.78	1.13	0.79	0.97	1.06	1.10	1.15	1.23	1.28	1.63
C49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	-	-	0.08	0.12	0.17	0.25	0.30	0.65
C50	-	-	-	-	-	-	-	0.22	-	-	-	-	-	0.01	0.07	0.42	0.08	0.26	0.35	0.39	0.44	0.52	0.57	0.92
C51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.08	0.43
C52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C53	0.02	0.20	0.29	0.33	0.38	0.46	0.51	0.86	0.22	0.40	0.49	0.53	0.58	0.66	0.71	1.06	0.72	0.90	0.99	1.03	1.08	1.16	1.21	1.56
C54	0.23	0.41	0.50	0.54	0.59	0.67	0.72	1.07	0.43	0.61	0.70	0.74	0.79	0.87	0.92	1.27	0.93	1.11	1.20	1.24	1.29	1.37	1.42	1.77
C55	0.12	0.30	0.39	0.43	0.48	0.56	0.61	0.96	0.32	0.50	0.59	0.63	0.68	0.76	0.81	1.16	0.82	1.00	1.09	1.13	1.18	1.26	1.31	1.66
C56	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.32	-	0.16	0.25	0.29	0.34	0.42	0.47	0.82
C57	-	0.05	0.14	0.18	0.23	0.31	0.36	0.71	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91	0.57	0.75	0.84	0.88	0.93	1.01	1.06	1.41
C58	-	0.03	0.12	0.16	0.21	0.29	0.34	0.69	0.05	0.23	0.32	0.36	0.41	0.49	0.54	0.89	0.55	0.73	0.82	0.86	0.91	0.99	1.04	1.39
C59	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.32	-	0.16	0.25	0.29	0.34	0.42	0.47	0.82
Mill Cott	-	-	-	-	0.01	0.09	0.14	0.49	-	0.03	0.12	0.16	0.21	0.29	0.34	0.69	0.35	0.53	0.62	0.66	0.71	0.79	0.84	1.19
Mill	-	0.18	0.27	0.31	0.36	0.44	0.49	0.84	0.20	0.38	0.47	0.51	0.56	0.64	0.69	1.04	0.70	0.88	0.97	1.01	1.06	1.14	1.19	1.54

Calculated Erosion Areas for Murray Delta Islands

ASSUMPTIONS

Estimate of the lot area / % lost to erosion over 5 planning periods

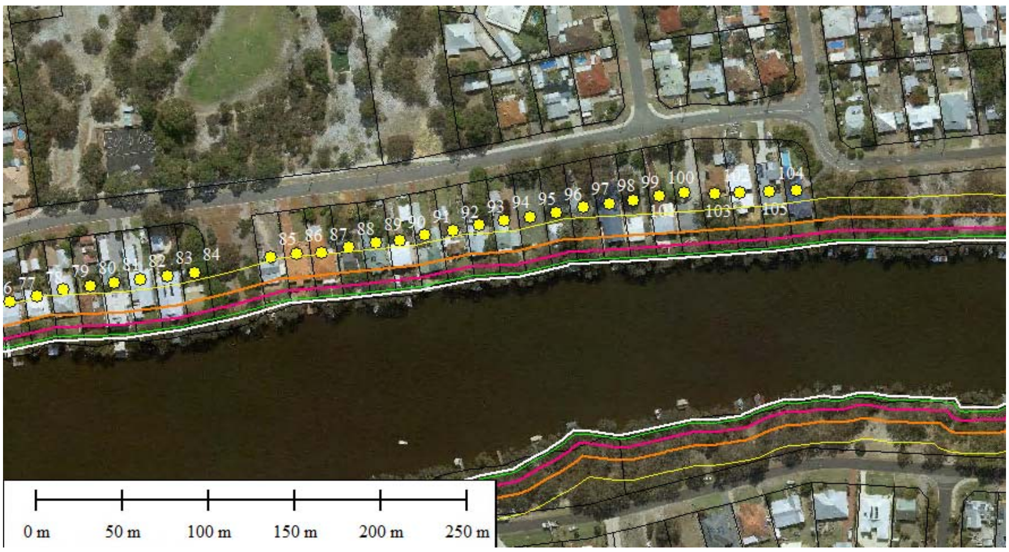
Once the Erosion Setback line hits the house assume all is lost. Shows as **100%**

Elevation Calculated from LiDAr Data

Location	Property Pin	East	North	House=H Undeveloped = U	Elevation (mAHD)	Lot Size (m2)	Area of the Lot Which is lost to Erosion					% of the Total Lot Which is lost to Erosion				
							2120	2130	2150	2170	2120	2120	2130	2150	2170	2120
Murray Delta Islands	B1	384640.7	6394288	H	1.52	2022	0	0	100	2022	2022	0%	0%	5%	100%	100%
	B2	384654	6394305	H	1.56	2022	0	0	120	2022	2022	0%	0%	6%	100%	100%
	B3	384657.9	6394333	H	1.77	2023	0	0	100	370	2023	0%	0%	5%	18%	100%
	B4	384703.3	6394337	H	1.58	2022	0	0	50	2022	2022	0%	0%	2%	100%	100%
	B5	384711.9	6394410	H	1.54	2564	0	0	50	2564	2564	0%	0%	2%	100%	100%
	B6	384744	6394360	H	1.63	2319	0	0	70	2319	2319	0%	0%	3%	100%	100%
	Y1	384480.8	6394011	H	1.55	2240	0	0	0	2240	2240	0%	0%	0%	100%	100%
	Y2	384524.2	6394010	H	2.10	2104	0	0	0	2104	2104	0%	0%	0%	100%	100%
	Y3	384562.8	6394049	H	2.09	2035	0	0	0	600	2035	0%	0%	0%	29%	100%
	Y4	384591.7	6394035	H	2.18	1967	0	0	0	211	1967	0%	0%	0%	11%	100%
	Y5	384620.6	6394050	H	1.75	2084	0	0	0	266	2084	0%	0%	0%	13%	100%
	Y6	384601.3	6394107	H	1.55	1966	0	0	0	467	1966	0%	0%	0%	24%	100%
	Y7	384618.7	6394133	H	2.13	2003	0	0	0	300	2003	0%	0%	0%	15%	100%
	Y8	384649	6394079	U	1.96	1962	0	0	0	158	770	0%	0%	0%	8%	39%
	Y9	384671.7	6394178	H	1.90	2102	0	0	0	128	2102	0%	0%	0%	6%	100%
	Y10	384707.4	6394062	H	2.20	2109	0	0	0	132	2109	0%	0%	0%	6%	100%
	Y11	384696.8	6394189	H	1.94	2058	0	0	0	135	2058	0%	0%	0%	7%	100%
	Y12	384743	6394081	H	1.82	2075	0	0	0	145	2075	0%	0%	0%	7%	100%
	Y13	384728.6	6394192	H	1.88	2089	0	0	0	100	2089	0%	0%	0%	5%	100%
	Y14	384748.5	6394118	H	1.25	1063	0	0	0	68	1063	0%	0%	0%	6%	100%
	Y15	384773.3	6394101	H	1.30	1063	0	0	0	68	1063	0%	0%	0%	6%	100%
	Y16	384784.5	6394229	H	1.43	1200	0	0	0	222	1200	0%	0%	0%	19%	100%
	Y17	384806.3	6394244	H	2.10	1595	0	0	0	70	1595	0%	0%	0%	4%	100%
	Y18	384837.6	6394250	H	1.99	1446	0	0	0	70	1446	0%	0%	0%	5%	100%
	Y19	384867.6	6394246	H	1.26	1283	0	0	0	70	1283	0%	0%	0%	5%	100%
	Y20	384841	6394179	U	1.68	2050	0	0	0	0	0	0%	0%	0%	0%	0%
	Y21	384852	6394158	U	1.87	2050	0	0	0	0	0	0%	0%	0%	0%	0%
	Y22	384862.4	6394130	H	1.29	2063	0	0	0	171	2063	0%	0%	0%	8%	100%
	Y23	384926.3	6394244	H	0.99	2022	0	0	0	64	2022	0%	0%	0%	3%	100%
	Y24	384970	6394197	H	1.00	2022	0	0	0	2022	2022	0%	0%	0%	100%	100%
	C1	384687	6394864	U	1.01	2022	0	0	0	0	2022	0%	0%	0%	0%	100%
	C2	384716.6	6394867	H	2.42	2022	0	0	0	35	2022	0%	0%	0%	2%	100%
	C3	384746.5	6394875	H	1.82	2022	0	0	0	70	2022	0%	0%	0%	3%	100%
	C4	384778.3	6394875	H	1.45	2022	0	0	0	70	2022	0%	0%	0%	3%	100%
	C5	384807.2	6394881	H	2.04	2022	0	0	0	235	2022	0%	0%	0%	12%	100%
	C6	384838	6394885	U	2.19	2022	0	0	0	333	951	0%	0%	0%	16%	47%
	C7	384866	6394888	H	1.57	2022	0	0	0	408	2022	0%	0%	0%	20%	100%
	C8	384679	6394954	U	1.48	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C9	384708	6394958	U	1.36	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C10	384738	6394961	U	1.61	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C11	384770	6394961	U	1.55	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C12	384798	6394979	U	1.43	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C13	384828	6394965	U	1.10	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C14	384859	6394964	U	1.29	2022	0	0	0	0	0	0%	0%	5%	0%	0%
	C15	384928.7	6394885	H	1.77	2022	0	0	100	345	2022	0%	0%	2%	17%	100%
	C16	384949.9	6394862	H	1.93	2022	0	0	50	350	1000	0%	0%	1%	17%	49%
	C17	384974	6394846	H	2.14	2022	0	0	20	360	1000	0%	0%	0%	18%	49%
	C18	384999.1	6394827	H	1.77	2022	0	0	0	350	2022	0%	0%	0%	17%	100%
	C19	385023.2	6394811	H	1.83	2022	0	0	0	175	2022	0%	0%	0%	9%	100%
	C20	385052.1	6394786	U	2.02	3143	0	0	0	82	825	0%	0%	0%	3%	26%
	C21	385070.4	6394755	U	2.32	2019	0	0	0	250	2019	0%	0%	0%	12%	100%
	C22	385082.9	6394728	H	2.15	2730	0	0	0	254	2730	0%	0%	0%	9%	100%
	C23	385094.5	6394697	H	1.95	2481	0	0	0	2481	2481	0%	0%	2%	100%	100%
	C24	385120.5	6394672	H	2.03	2306	0	0	55	990	2306	0%	0%	5%	43%	100%
	C25	385148.5	6394623	U	1.67	2611	0	75	107	620	1460	0%	3%	4%	24%	56%
	C26	385171.6	6394589	H	2.24	2200	0	0	110	600	2200	0%	0%	5%	27%	100%
	C27	385209.2	6394565	H	2.01	2407	0	0	120	590	2407	0%	0%	5%	25%	100%
	C28	385235	6394549	U	2.23	2369	0	0	130	580	1115	0%	0%	5%	24%	47%
	C29	385267.5	6394527	H	2.14	2295	0	0	130	2295	2295	0%	0%	0%	100%	100%
	C30	385310.9	6394484	H	1.71	2320	0	0	0	380	2320	0%	0%	0%	16%	100%
	C31	385352.3	6394446	H	1.81	2320	0	0	0	330	2320	0%	0%	0%	14%	100%
	C32	385386.1	6394418	H	2.09	2320	0	0	10	420	2320	0%	0%	2%	18%	100%
	C33	385437.2	6394385	H	2.25	2670	0	0	40	2670	2670	0%	0%	0%	100%	100%
	C34	385491.1	6394383	H	2.30	1760	0	0	0	1760	1760	0%	0%	0%	100%	100%
	C35	385516.3	6394380	H	2.37	2291	0	0	2	2291	2291	0%	0%	0%	100%	100%
	C36	385539	6394382	U	2.23	825	0	0	10	825	825	0%	0%	2%	100%	100%
	C37	385564	6394379	U	2.29	2810	0	0	20	2810	2810	0%	0%	1%	100%	100%
	C38	385609.7	6394382	H	1.90	2132	0	0	25	460	1120	0%	0%	3%	22%	53%
	C39	385619.6	6394442	H	2.09	2364	0	0	55	880	2364	0%	0%	0%	37%	100%
	C40	385549.7	6394483	U	2.23	2509	0	0	5	780	2260	0%	0%	0%	31%	90%
	C41	385537	6394453	U	1.63	2406	0	0	0	0	170	0%	0%	0%	0%	7%
	C42	385489	6394537	U	1.52	1615	0	0	0	70	920	0%	0%	0%	4%	57%
	C43	385469.1	6394585	H	1.67	3422	0	0	0	3422	3422	0%	0%	0%	100%	100%
	C44	385420.2	6394618	H	2.06	2368	0	0	0	340	2368	0%	0%	0%	14%	100%
	C45	385384.3	6394659	H	2.14	2200	0	0	0	210	210	0%	0%	0%	10%	10%
	C46	385303	6394632	U	2.21	1990	0	0	0	0	0	0%	0%	0%	0%	0%
	C47	385254.4	6394640	H	2.14	3080	0	0	0	0	0	0%	0%	0%	0%	0%
	C48	385206.9	6394642	H	2.28	2721	0	0	0	0	0	0%	0%	0%	0%	0%
	C49	385118.5	6394776	H	2.50	2384	0	0	0	0	0	0%	0%	0%	0%	0%
	C50	385113.7	6394827	H	2.33	3291	0	0	0	0	0	0%	0%	0%	0%	0%
	C51	385092	6394859	U	2.49	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C52	385072	6394878	U	2.32	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C53	385049	6394895	U	2.45	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C54	385022	6394911	U	2.47	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C55	384993	6394928	U	2.37	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C56	384968	6394946	U	2.40	2022	0	0	0	0	0	0%	0%	0%	0%	0%
	C57	384943	6394965	U	2.31	2044	0	0	0	0	0	0%	0%	0%	0%	0%
	C58	384914	6394983	U	2.01	2336	0	0	0	0	0	0%	0%	0%	0%	0%
	C59	384912.3	6394918	H	2.18	1835	0	0	0	15	270	0%	0%	0%	1%	15%
	Mill Cott	384090.3	6395002	H	2.13											
	Mill	384121.2	6395021	U	2.26											

North Yunderup


ucture.shp [88 Features]
0 m
50 m
100 m
150 m
200 m
250 m


0 m
50 m
100 m
150 m
200 m
250 m

Depth of Overfloor Inundation Calculated for North Yunderup Properties

ASSUMPTIONS
ARI Considered: 1yr, 2yr, 5yr, 10yr, 20yr, 50yr, 100yr, 500yr
Planning Periods and Sea Level Rise

Planning Periods	2020	2030	2050	2070	2120
Sea Level Rise (m)	0	0.1	0.2	0.4	0.9
Assumed Freeboard of Houses			0.3	m	

Elevation Calculated from LiDAr Data

Depth of Overfloor Inundation (m) for each property. Calculated for 8 ARI inundation levels across the 5 Respective Planning Periods

Location	Property Pin	East	North	House=H Undeveloped = U	Elevation (mAHD)	Floor Level with Freeboard Allowance	2020 (Present Day) No SLR								2030 (+0.1m SLR)							
						Return Period	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr
						Peak Inundation Level (m AHD)	0.60	0.78	0.87	0.91	0.96	1.04	1.09	1.44	0.70	0.88	0.97	1.01	1.06	1.14	1.19	1.54
North Yunderup Properties	1	385819.3	6394469	H	1.52	1.82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	385835.2	6394464	H	1.56	1.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	385854.1	6394454	H	1.77	2.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	385870.7	6394455	H	1.58	1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	385883.7	6394474	H	1.54	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	385899	6394480	H	1.63	1.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	385917.6	6394464	H	1.55	1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8	385933.3	6394469	H	2.10	2.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9	385949.3	6394470	H	2.09	2.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	385964.3	6394469	H	2.18	2.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11	385977.6	6394482	H	1.75	2.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	12	385996.4	6394464	H	1.55	1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13	386010.1	6394479	H	2.13	2.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14	*386028*	*6394471*	H	*1.96*	2.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15	386041.8	6394481	H	1.90	2.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16	386056.9	6394481	H	2.20	2.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17	386072.1	6394482	H	1.94	2.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	18	386088.6	6394482	H	1.82	2.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	19	386103.6	6394487	H	1.88	2.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	20	386117.2	6394492	H	1.25	1.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	21	386136.7	6394493	H	1.30	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	22	386150.2	6394507	H	1.43	1.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	23	386163	6394526	H	2.10	2.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24	386177.8	6394537	H	1.99	2.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	25	386193.7	6394546	H	1.26	1.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	26	*386216*	*6394547*	H	*1.68*	1.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	27	*386239*	*6394549*	H	*1.87*	2.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	28	386255.4	6394549	H	1.29	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29	386271.6	6394552	H	0.99	1.29	-	-	-	-	-	-	-	0.15	-	-	-	-	-	-	-	0.25
	30	386288.1	6394555	H	1.00	1.30	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-	-	0.24
	31	*386303*	*6394560*	H	*1.01*	1.31	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-	-	0.24
	32	386319	6394564	H	2.42	2.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	33	386334.1	6394570	H	1.82	2.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	34	386346.5	6394575	H	1.45	1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	35	386363	6394581	H	2.04	2.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	36	*386375*	*6394585*	H	*2.19*	2.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	37	386389.4	6394592	H	1.57	1.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	38	*386404*	*6394601*	H	*1.48*	1.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	39	*386415*	*6394607*	H	*1.36*	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	40	*386431*	*6394613*	H	*1.61*	1.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	41	*386444*	*6394622*	H	*1.55*	1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	42	*386459*	*6394634*	H	*1.43*	1.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	43	*386483*	*6394643*	H	*1.10*	1.40	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	-	0.14
	44	*386507*	*6394648*	H	*1.29*	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	45	386523	6394651	H	1.77	2.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	46	386536.8	6394653	H	1.93	2.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	47	386553.5	6394655	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	386569.3	6394659	H	1.77	2.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	49	386584.5	6394662	H	1.83	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	50	386599.4	6394664	H	2.02	2.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	51	386613.8	6394666	H	2.32	2.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	52	386627.4	6394670	H	2.15	2.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	53	386644.3	6394673	H	1.95	2.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	54	386660	6394677	H	2.03	2.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	55	386693.7	6394687	H	1.67	1.97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	56	386711.3	6394689	H	2.24	2.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	57	386724.9	6394694	H	2.01	2.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	58	*386739*	*6394697*	H	*2.23*	2.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	59	386754.8	6394701	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	60	386769.2	6394703	H	1.71	2.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	61	386784.7	6394708	H	1.81	2.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	62	386798.3	6394711	H	2.09	2.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	63	386813.7	6394717	H	2.25	2.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	64	386828	6394724	H	2.30	2.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	65	386846.3	6394738	H	2.37	2.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	66	*386870*	*6394754*	H	*2.23*	2.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	67	*386885*	*6394764*	H	*2.29*	2.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	68	386898.2	6394772	H	1.90	2.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	69	386913.2	6394782	H	2.09	2.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	70	386926.4	6394790	H	2.23	2.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	71	*386940*	*6394796*	H	*1.63*	1.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	*386954*	*6394801*	H	*1.52*	1.82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	73	386969.1	6394806	H	1.67	1.97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	74	386984	6394811	H	2.06	2.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	75	387000.4	6394815	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	76	*387015*	*6394819*	H	*2.21*	2.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	77	387029.9	6394822	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	78	387045.3	6394825	H	2.28	2.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	79	387060.5	6394829	H	2.50	2.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	80	387076	6394831	H	2.33	2.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	81	*387090*	*6394832*	H	*2.49*	2.79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	82	*387105*	*6394835*	H	*2.32*	2.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	83	*387121*	*6394837*	H	*2.45*	2.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	84	*387137*	*6394839*	H	*2.47*	2.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	85	*387181*	*6394848*	H	*2.37*	2.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	86	*387196*	*6394850*	H	*2.40*	2.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	87	*387210*	*6394851*	H	*2.31*	2.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	88	*387226*	*6394854*	H	*2.01*	2.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	89	387241.7	6394856	H	2.18	2.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	90	387255.6	6394857	H	2.13	2.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	91	387270.3	6394861	H	2.26	2.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	92	387286.5	6394864	H	2.23	2.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	93	387301.3	6394867	H	2.21	2.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	94	387315.8	6394869	H	2.26	2.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	95	387331.4	6394872	H	2.12	2.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	96	387346	6394874	H	2.04	2.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	97	387361.7	6394877	H	1.29	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	98	387376.9	6394879	H	1.96	2.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	99	387390.9	6394881	H	1.60	1.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	100	387406	6394884	H	1.84	2.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	101	387420.6	6394886	H	1.91	2.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	102	387438.3	6394885	H	2.36	2.66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	103	387452.5	6394886	H	2.12	2.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	104	387469.9	6394887	H	2.50	2.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	105	387485.2	6394887	H	2.50	2.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	106	385835	6394564	H	1.11	1.41	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.13
	107	385863.9	6394551	H	2.00	2.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	108	385884.2	6394551	H	1.63	1.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Property Pin	2050 (+0.2m SLR)								2070 (+0.4m SLR)								2120 (+0.9m SLR)							
Return Period	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr
Peak Inundation Level (m AHD)	0.80	0.98	1.07	1.11	1.16	1.24	1.29	1.64	1.00	1.18	1.27	1.31	1.36	1.44	1.49	1.84	1.50	1.68	1.77	1.81	1.86	1.94	1.99	2.34
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	0.04	0.12	0.17	0.52
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.08	0.13	0.48
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.11	0.46
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.10	0.15	0.50
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.06	0.41
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.09	0.14	0.49
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.09	0.14	0.49
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.23
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16
20	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-	-	0.29	-	0.13	0.22	0.26	0.31	0.39	0.44	0.79
21	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	-	0.24	-	0.08	0.17	0.21	0.26	0.34	0.39	0.74
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-	-	0.04	0.08	0.13	0.21	0.26	0.61
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05
25	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.28	-	0.12	0.21	0.25	0.30	0.38	0.43	0.78
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.36
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17
28	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	0.25	-	0.09	0.18	0.22	0.27	0.35	0.40	0.75
29	-	-	-	-	-	-	-	0.35	-	-	-	0.02	0.07	0.15	0.20	0.55	0.21	0.39	0.48	0.52	0.57	0.65	0.70	1.05
30	-	-	-	-	-	-	-	0.34	-	-	-	0.01	0.06	0.14	0.19	0.54	0.20	0.38	0.47	0.51	0.56	0.64	0.69	1.04
31	-	-	-	-	-	-	-	0.34	-	-	-	0.01	0.05	0.14	0.19	0.54	0.20	0.38	0.47	0.51	0.56	0.64	0.69	1.04
32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22
34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-	-	0.02	0.06	0.11	0.19	0.24	0.59
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	0.12	0.47
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	0.03	0.08	0.16	0.21	0.56
39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	-	0.02	0.11	0.15	0.20	0.28	0.33	0.68
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.09	0.44
41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.09	0.14	0.49
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-	-	0.04	0.08	0.13	0.21	0.26	0.61
43	-	-	-	-	-	-	-	0.24	-	-	-	-	-	0.04	0.09	0.44	0.10	0.28	0.37	0.41	0.46	0.54	0.59	0.94
44	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	0.25	-	0.09	0.18	0.22	0.27	0.35	0.40	0.75
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27
46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11
47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.28
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09
54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.37
56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33
61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.23
62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.06	0.41
72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	0.04	0.12	0.17	0.52
73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.37
74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
97	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	0.25	-	0.09	0.18	0.22	0.27	0.35	0.40	0.75
98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08
99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.09	0.44
100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20
101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
106	-	-	-	-	-	-	-	0.23	-	-	-	-	-	0.03	0.08	0.43	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93
107	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
108	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.06	0.41

109	385903.6	6394546	H	1.85	2.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19
110	385919.8	6394608	H	1.21	1.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	0.33	-	0.17	0.26	0.30	0.35	0.43	0.48	0.83
111	385923	6394548	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
112	385939.5	6394549	H	1.82	2.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22
113	385958.8	6394550	H	1.91	2.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13
114	385978.6	6394552	H	1.79	2.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25
115	385995.5	6394553	H	2.04	2.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
116	386012.9	6394572	H	2.19	2.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
117	386028.2	6394600	H	1.42	1.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	0.05	0.09	0.14	0.22	0.27	0.62
118	386052.6	6394591	H	1.83	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22
119	386080.3	6394554	H	1.70	2.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34
120	386098.5	6394567	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121	386118	6394576	H	1.37	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	-	0.01	0.10	0.14	0.19	0.27	0.32	0.67
122	386133.6	6394613	H	2.05	2.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
123	386152	6394620	H	2.01	2.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
124	386172.7	6394624	H	1.75	2.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29
125	386198.3	6394621	H	1.66	1.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.38
126	386216.6	6394633	H	1.83	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21
127	386238.9	6394608	H	1.87	2.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17
128	386256.7	6394626	H	1.18	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	0.01	0.36	0.02	0.20	0.29	0.33	0.38	0.46	0.51	0.86
129	386279.6	6394628	H	1.49	1.79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	0.02	0.07	0.15	0.20	0.55
130	386298.2	6394648	H	1.86	2.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18
131	386319.7	6394637	H	1.61	1.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.08	0.43
132	386348.1	6394640	H	2.20	2.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
133	386366.7	6394651	H	2.03	2.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01
134	386382	6394660	H	1.78	2.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26
135	386401.3	6394674	H	2.07	2.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
136	386418.1	6394682	H	1.92	2.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12
137	386437	6394688	H	1.39	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	-	-	0.08	0.12	0.17	0.25	0.30	0.65
138	386471.3	6394698	H	1.96	2.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08
139	386493.3	6394709	H	1.69	1.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.35
140	386514.8	6394705	H	2.05	2.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
141	386531.2	6394713	H	2.29	2.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
142	386553.7	6394722	H	1.60	1.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.09	0.44
143	386572.7	6394729	H	1.52	1.82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	0.04	0.12	0.17	0.52
144	386598.8	6394739	H	1.39	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	-	-	0.08	0.12	0.17	0.25	0.30	0.65
145	386629.2	6394756	H	1.80	2.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25
146	386600	6394783	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
147	386615.3	6394810	H	2.09	2.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
148	386613.5	6394831	H	1.79	2.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25
149	386613.2	6394850	H	1.80	2.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24
150	386655.5	6394842	H	1.57	1.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	0.12	0.47
151	386659.1	6394821	H	1.95	2.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09
152	386662.7	6394800	H	2.16	2.46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
153	386661.8	6394767	H	1.69	1.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.35
154	386695.2	6394748	H	2.21	2.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
155	386725	6394757	H	1.89	2.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15
156	388056.7	6395015	H	2.25	2.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
157	388072.5	6395021	H	1.90	2.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
158	388099.6	6395022	H	1.82	2.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22
159	388115.8	6395025	H	2.06	2.36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
160	388134.7	6395031	H	1.45	1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-	-	0.02	0.06	0.11	0.19	0.24	0.59
161	388154.1	6395035	H	1.67	1.97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.37
162	388175.8	6395041	H	1.57	1.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	0.12	0.47
163	388199.2	6395050	H	1.71	2.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33
164	388218.2	6395061	H	1.90	2.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
165	388236.2	6395075	H	1.66	1.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.38
166	388251.3	6395086	H	1.70	2.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34
167	388268.1	6395099	H	1.82	2.12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.23
168	388283.2	6395111	H	1.65	1.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.40
169	388300	6395122	H	2.00	2.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
170	388317.4	6395135	H	1.69	1.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.35
171	388335.5	6395155	H	1.94	2.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11
172	388351.1	6395172	H	2.01	2.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
173	388051.6	6395055	H	2.09	2.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
174	388072.9	6395060	H	2.11	2.41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
175	388103	6395068	H	2.12	2.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
176	388128.5	6395074	H	2.17	2.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
177	388155.1	6395081	H	2.17	2.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
178	388183.4	6395093	H	2.19	2.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
179	388208.1	6395112	H	2.15	2.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
180	388229.1	6395130	H	2.14	2.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
181	388259.3	6395152	H	2.42	2.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Calculated Erosion Areas for North Yunderup RiverFront Properties

ASSUMPTIONS

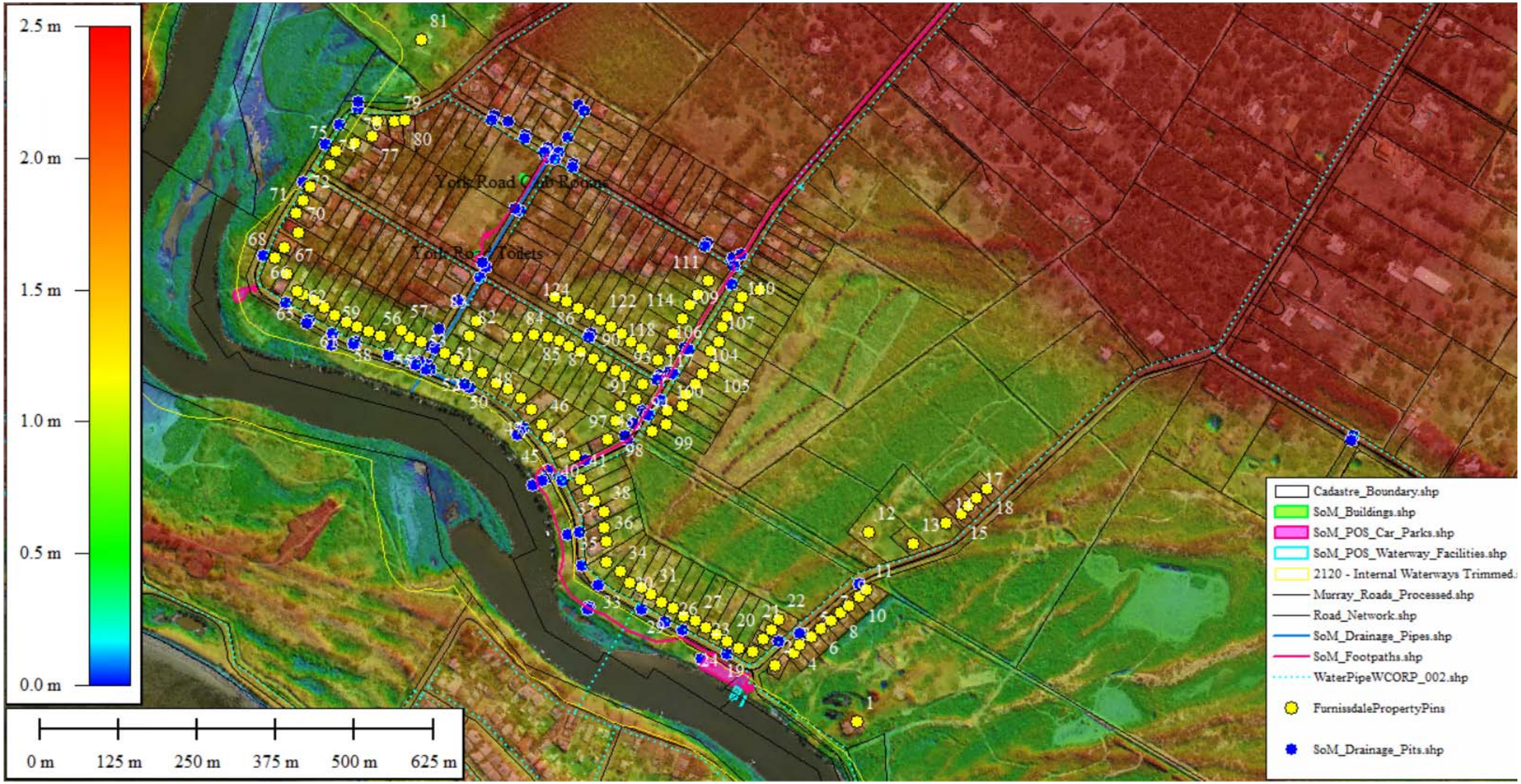
Estimate of the lot area / % lost to erosion over 5 planning periods

Erosion areas do not consider erosion of house a total loss of area (approach adopted at the Islands)

Elevation Calculated from LiDAr Data

Location	Property Pin	East	North	House=H Undeveloped = U	Elevation (mAHD)	Lot Size (m2)	Area of the Lot Which is lost to Erosion 2120	2130	2150	2170	2120	% of the Total Lot Which is lost to Erosion 2120	2130	2150	2170	2120
North Yunderup Riverfront Properties	1	385819.3	6394469	H	1.52	1368	40	80	160	285	1075	3%	6%	12%	21%	79%
	2	385835.2	6394464	H	1.56	1406	40	80	160	285	970	3%	6%	11%	20%	69%
	3	385854.1	6394454	H	1.77	1319	40	80	160	285	700	3%	6%	12%	22%	53%
	4	385870.7	6394455	H	1.58	1151	40	80	160	285	450	3%	7%	14%	25%	39%
	5	385883.7	6394474	H	1.54	1104	40	80	160	285	420	4%	7%	14%	26%	38%
	6	385899	6394480	H	1.63	1100	40	80	160	285	420	4%	7%	15%	26%	38%
	7	385917.6	6394464	H	1.55	1184	40	80	160	285	420	3%	7%	14%	24%	35%
	8	385933.3	6394469	H	2.10	1091	20	40	140	285	420	2%	4%	13%	26%	38%
	9	385949.3	6394470	H	2.09	1143	20	40	140	285	420	2%	3%	12%	25%	37%
	10	385964.3	6394469	H	2.18	981	20	40	140	285	420	2%	4%	14%	29%	43%
	11	385977.6	6394482	H	1.75	1099	20	40	140	285	420	2%	4%	13%	26%	38%
	12	385996.4	6394464	H	1.55	1151	20	40	140	285	420	2%	3%	12%	25%	36%
	13	386010.1	6394479	H	2.13	1174	20	40	140	285	420	2%	3%	12%	24%	36%
	14	*386028*	*6394471*	H	*1.96*	1094	20	40	140	285	420	2%	4%	13%	26%	38%
	15	386041.8	6394481	H	1.90	1158	20	40	140	285	420	2%	3%	12%	25%	36%
	16	386056.9	6394481	H	2.20	1123	20	40	140	285	420	2%	4%	12%	25%	37%
	17	386072.1	6394482	H	1.94	1125	20	40	140	285	420	2%	4%	12%	25%	37%
	18	386088.6	6394482	H	1.82	1113	20	40	140	285	420	2%	4%	13%	26%	38%
	19	386103.6	6394487	H	1.88	1097	20	40	140	285	420	2%	4%	13%	26%	38%
	20	386117.2	6394492	H	1.25	1058	20	40	140	285	420	2%	4%	13%	27%	40%
	21	386136.7	6394493	H	1.30	1160	20	40	140	285	420	2%	3%	12%	25%	36%
	22	386150.2	6394507	H	1.43	1101	20	40	140	285	420	2%	4%	13%	26%	38%
	23	386163	6394526	H	2.10	1137	20	40	140	285	420	2%	4%	12%	25%	37%
	24	386177.8	6394537	H	1.99	1139	0	0	140	285	420	0%	0%	12%	25%	37%
	25	386193.7	6394546	H	1.26	1153	0	0	160	340	380	0%	0%	14%	29%	33%
	26	*386216*	*6394547*	H	*1.68*	1822	0	0	120	220	730	0%	0%	7%	12%	40%
	27	*386239*	*6394549*	H	*1.87*	1073	0	0	140	220	400	0%	0%	13%	21%	37%
	28	386255.4	6394549	H	1.29	1008	20	40	150	220	410	2%	4%	15%	22%	41%
	29	386271.6	6394552	H	0.99	1005	20	40	160	220	410	2%	4%	16%	22%	41%
	30	386288.1	6394555	H	1.00	1003	20	40	120	220	410	2%	4%	12%	22%	41%
	31	*386303*	*6394560*	H	*1.01*	1006	0	0	110	220	410	0%	0%	11%	22%	41%
	32	386319	6394564	H	2.42	1046	20	40	115	220	410	2%	4%	11%	21%	39%
	33	386334.1	6394570	H	1.82	1078	0	0	120	220	410	0%	0%	12%	20%	38%
	34	386346.5	6394575	H	1.45	1102	0	0	125	220	410	0%	0%	13%	20%	37%
	35	386363	6394581	H	2.04	1037	20	40	140	220	410	2%	4%	8%	21%	40%
	36	*386375*	*6394585*	H	*2.19*	888	20	40	80	220	410	2%	5%	9%	25%	46%
	37	386389.4	6394592	H	1.57	984	20	40	80	220	410	2%	4%	8%	22%	42%
	38	*386404*	*6394601*	H	*1.48*	979	20	40	80	220	410	2%	4%	13%	22%	42%
	39	*386415*	*6394607*	H	*1.36*	970	0	0	130	220	410	0%	0%	13%	23%	42%
	40	*386431*	*6394613*	H	*1.61*	969	0	0	125	220	410	0%	0%	12%	23%	42%
	41	*386444*	*6394622*	H	*1.55*	1550	0	0	120	220	410	0%	0%	7%	14%	26%
	42	*386459*	*6394634*	H	*1.43*	951	0	0	110	200	410	0%	0%	19%	21%	43%
	43	*386483*	*6394643*	H	*1.10*	1040	0	0	180	380	710	0%	0%	6%	37%	68%
	44	*386507*	*6394648*	H	*1.29*	1070	0	0	60	180	410	0%	0%	5%	17%	38%
	45	386523	6394651	H	1.77	1038	0	0	55	180	410	0%	0%	6%	17%	39%
	46	386536.8	6394653	H	1.93	1898	0	0	60	180	410	0%	0%	3%	9%	22%
	47	386553.5	6394655	H	2.14	1014	0	0	55	180	410	0%	0%	6%	18%	40%
	48	386569.3	6394659	H	1.77	1049	0	0	60	180	410	0%	0%	6%	17%	39%
	49	386584.5	6394662	H	1.83	1056	0	0	60	180	410	0%	0%	1%	17%	39%
	50	386599.4	6394664	H	2.02	1007	0	0	6	180	410	0%	0%	5%	18%	41%
	51	386613.8	6394666	H	2.32	1037	0	0	55	180	410	0%	0%	6%	17%	40%
	52	386627.4	6394670	H	2.15	1037	0	0	60	180	410	0%	0%	6%	17%	40%
	53	386644.3	6394673	H	1.95	1016	0	0	60	180	410	0%	0%	6%	18%	40%
	54	386660	6394677	H	2.03	893	0	0	60	180	410	0%	0%	2%	20%	46%
	55	386693.7	6394687	H	1.67	898	0	0	20	280	450	0%	0%	9%	31%	50%
	56	386711.3	6394689	H	2.24	921	0	0	80	280	450	0%	0%	12%	30%	49%
	57	386724.9	6394694	H	2.01	996	0	0	110	280	450	0%	0%	15%	28%	45%
	58	*386739*	*6394697*	H	*2.23*	919	0	0	150	280	450	0%	0%	16%	30%	49%
	59	386754.8	6394701	H	2.14	994	50	100	150	280	450	5%	10%	17%	28%	45%
	60	386769.2	6394703	H	1.71	964	50	100	165	280	450	5%	10%	17%	29%	47%
	61	386784.7	6394708	H	1.81	964	50	100	160	280	450	5%	10%	15%	29%	47%
	62	386798.3	6394711	H	2.09	935	50	100	140	280	450	5%	11%	16%	30%	48%
	63	386813.7	6394717	H	2.25	941	50	100	145	280	450	5%	11%	9%	30%	48%
	64	386828	6394724	H	2.30	916	20	40	80	280	450	2%	4%	29%	31%	49%
	65	386846.3	6394738	H	2.37	1963	25	50	265	605	450	1%	3%	8%	31%	23%
	66	*386870*	*6394754*	H	*2.23*	1066	40	80	150	280	450	4%	8%	15%	26%	42%
	67	*386885*	*6394764*	H	*2.29*	1086	40	80	160	280	450	4%	7%	15%	26%	41%
	68	386898.2	6394772	H	1.90	1033	40	80	160	280	450	4%	8%	15%	27%	44%
	69	386913.2	6394782	H	2.09	979	40	80	160	280	450	4%	8%	16%	29%	46%
	70	386926.4	6394790	H	2.23	1050	40	80	160	280	460	4%	8%	15%	27%	44%
	71	*386940*	*6394796*	H	*1.63*	1011	40	80	160	280	460	4%	8%	16%	28%	45%
	72	*386954*	*6394801*	H	*1.52*	898	40	80	160	280	460	4%	9%	18%	31%	51%
	73	386969.1	6394806	H	1.67	924	40	80	160	280	460	4%	9%	18%	30%	50%
	74	386984	6394811	H	2.06	915	30	60	170	280	460	3%	7%	19%	31%	50%
	75	387000.4	6394815	H	2.14	893	30	60	170	280	460	3%	7%	19%	31%	52%
	76	*387015*	*6394819*	H	*2.21*	926	30	60	170	280	460	3%	6%	18%	30%	50%
	77	387029.9	6394822	H	2.14	1007	30	60	170	270	460	3%	6%	17%	27%	46%
	78	387045.3	6394825	H	2.28	991	30	60	170	270	460	3%	6%	17%	27%	46%
	79	387060.5	6394829	H	2.50	957	30	60	170	270	460	3%	6%	18%	28%	48%
	80	387076	6394831	H	2.33	938	30	60	170	270	460	3%	6%	19%	29%	49%
	81	*387090*	*6394832*	H	*2.49*	961	35	70	180	270	460	4%	7%	19%	28%	48%
	82	*387105*	*6394835*	H	*2.32*	1014	35	70	180	270	460	3%	7%	17%	27%	45%
	83	*387121*	*6394837*	H	*2.45*	1000	25	50	175	270	460	3%	5%	17%	27%	46%
	84	*387137*	*6394839*	H	*2.47*	972	25	50	170	270	460	3%	5%	18%	28%	47%
	85	*387181*	*6394848*	H	*2.37*	847	5	10	175	270	460	1%	1%	17%	32%	54%
	86	*387196*	*6394850*	H	*2.40*	878	10	20	140	270	460	1%	2%	16%	31%	52%
	87	*387210*	*6394851*	H	*2.31*	891	10	20	140	270	460	1%	2%	16%	30%	52%
	88	*387226*	*6394854*	H	*2.01*	861	10	20	140	270	460	1%	2%	16%	31%	53%
	89	387241.7	6394856	H	2.18	879	10	20	140	270	460	1%	2%	16%	31%	52%
	90	387255.6	6394857	H	2.13	871	10	20	140	270	460	1%	2%	16%	31%	53%
	91	387270.3	6394861	H	2.26	883	10	20	140	270	460	1%	2%	16%	31%	52%
	92	387286.5	6394864	H	2.23	854	10	20	140	270	460	1%	2%	16%	32%	54%
	93	387301.3	6394867	H	2.21	899	10	20	140	270	460	1%	2%	16%	30%	51%
	94	387315.8	6394869	H	2.26	871	10	20	140	240	460	1%	2%	14%	28%	53%
	95	387331.4	6394872	H	2.12	941	10	20	120	240	460	1%	2%	13%	26%	49%
	96	387346	6394874	H	2.04	898	10	20	120	240	460	1%	2%	13%	27%	51%
	97	387361.7	6394877	H	1.29	1001	10	20	120	240	460	1%	2%	12%	24%	46%
	98	387376.9	6394879	H	1.96	1007	10	20	120	240	460	1%	2%	12%	24%	46%
	99	387390.9	6394881	H	1.60	906	10	20	120	240	460	1%	2%	13%	26%	51%
	100	387406	6394884	H	1.84	967	10	20	120	240	460	1%	2%	12%	25%	48%
	101	387420.6	6394886	H	1.91	1121	10	20	120	240	460	1%	2%	11%	21%	41%
	102	387438.3	6394885	H	2.36	1015	10	20	120	220	460	1%	2%	12%	22%	45%
	103	387452.5	6394886	H	2.12	1030	10	20	120	220	460	1%	2%	12%	21%	45%
	104	387469.9	6394887	H	2.50	1084	10	20	120	220	460	1%	2%	11%	20%	42%
	105	387485.2	6394887	H	2.50	960	10	20	120	220	460	1%	2%	0%	23%	48%

Furnissdale



Depth of Overfloor Inundation Calculated for Furnissdale Properties

ASSUMPTIONS
ARI Considered: 1yr, 2yr, 5yr, 10yr, 20yr, 50yr, 100yr, 500yr
Planning Periods and Sea Level Rise

Planning Periods	2020	2030	2050	2070	2120
Sea Level Rise (m)	0	0.1	0.2	0.4	0.9
Assumed Freeboard of Houses			0.3	m	
Elevation Calculated from LiDAr Data					

Depth of Overfloor Inundation (m) for each property. Calculated for 8 ARI inundation levels across the 5 Respective Planning Periods

Location	Property Pin	East	North	House=H Undeveloped = U	Elevation (mAHD)	Floor Level with Freeboard Allowance	2020 (Present Day) No SLR								2030 (+0.1m SLR)								2050 (+0.2m SLR)								2070 (+0.4m SLR)								2120 (+0.9m SLR)							
						Return Period	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	20yr	50yr	100yr	500yr
						Peak Inundation Level (m AHD)	0.60	0.78	0.87	0.91	0.96	1.04	1.09	1.44	0.70	0.88	0.97	1.01	1.06	1.14	1.19	1.54	0.80	0.98	1.07	1.11	1.16	1.24	1.29	1.64	1.00	1.18	1.27	1.31	1.36	1.44	1.49	1.84	1.50	1.68	1.77	1.81	1.86	1.94	1.99	2.34
Furnissdale Properties	1	384215	6396161	H	1.89	2.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15
	2	384085	6396251	H	1.87	2.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17
	3	384113.4	6396271	H	1.74	2.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30
	4	384124.1	6396284	H	1.62	1.92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.07	0.42
	5	384141	6396296	H	1.63	1.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.06	0.41
	6	384156.4	6396309	H	1.67	1.97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.37
	7	384172.8	6396323	H	1.58	1.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.12	0.47
	8	384187.5	6396337	H	1.77	2.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27
	9	384201.4	6396348	H	1.44	1.74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-	-	0.03	0.07	0.12	0.20	0.25	0.60
	10	384217.3	6396362	H	1.55	1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.09	0.14	0.49
	11	384229.8	6396372	H	1.51	1.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	-	0.05	0.13	0.18	0.53
	12	384232.3	6396466	H	1.54	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	0.02	0.11	0.16	0.51
	13	384303.4	6396447	H	1.60	1.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.09	0.44
	14	*384355*	*6396481*	H	*1.73*	2.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.31
	15	384379.3	6396496	H	1.83	2.13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21
	16	384390.3	6396509	H	1.90	2.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
	17	384404.2	6396522	H	2.05	2.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	18	384419.6	6396536	H	1.95	2.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09
	19	384049.3	6396274	H	1.26	1.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.28	-	0.12	0.21	0.25	0.30	0.38	0.43	0.78
	20	384065.3	6396293	H	1.64	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.40
	21	384078.5	6396309	H	1.62	1.92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.07	0.42
	22	384089.1	6396326	H	1.44	1.74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-	-	0.03	0.08	0.13	0.21	0.26	0.61
	23	384027.5	6396279	H	1.24	1.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	0.10	-	-	-	-	-	-	-	0.30	-	0.14	0.23	0.27	0.32	0.40	0.45	0.80
	24	384008.1	6396290	H	0.96	1.26	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	-	0.28	-	-	-	-	-	-	0.03	0.38	-	-	0.01	0.05	0.10	0.18	0.23	0.58	0.24	0.42	0.51	0.55	0.60	0.68	0.73	1.08
	25	383992.3	6396301	H	1.37	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	-	0.01	0.10	0.14	0.19	0.27	0.32	0.67
	26	*383974*	*6396312*	H	*1.42*	1.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	0.05	0.09	0.14	0.22	0.27	0.62
	27	*383959*	*6396323*	H	*1.29*	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	0.25	-	0.09	0.18	0.22	0.27	0.35	0.40	0.75
	28	383940.3	6396331	H	1.14	1.44	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	0.10	-	-	-	-	-	-	-	0.20	-	-	-	-	-	0.00	0.05	0.40	0.06	0.24	0.33	0.37	0.42	0.50	0.55	0.90
	29	383922.3	6396343	H	1.13	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.01	0.06	0.41	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
	30	383904.7	6396353	H	1.08	1.38	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.17	-	-	-	-	-	-	-	0.27	-	-	-	-	-	0.06	0.12	0.47	0.13	0.31	0.40	0.44	0.49	0.57	0.62	0.97
	31	*383888*	*6396365*	H	*1.32*	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.22	-	0.06	0.15	0.19	0.24	0.32	0.37	0.72
	32	383872.8	6396378	H	1.36	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	-	0.02	0.11	0.15	0.20	0.28	0.33	0.68
	33	383853.9	6396385	H	1.22	1.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.32	-	0.16	0.25	0.29	0.34	0.42	0.47	0.82
	34	383840	6396403	H	1.12	1.42	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.22	-	-	-	-	-	0.02	0.07	0.42	0.08	0.26	0.35	0.39	0.44	0.52	0.57	0.92
	35	383816.5	6396417	H	1.01	1.31	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	0.23	-	-	-	-	-	-	-	0.33	-	-	-	-	0.05	0.13	0.18	0.53	0.19	0.37	0.46	0.50	0.55	0.63	0.68	1.03
	36	*383817*	*6396451*	H	*1.55*	1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.09	0.14	0.49
	37	383813.6	6396473	H	1.09	1.39	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	0.15	-	-	-	-	-	-	-	0.25	-	-	-	-	-	0.05	0.10	0.45	0.11	0.29	0.38	0.42	0.47	0.55	0.60	0.95
	38	*383813*	*6396499*	H	*1.63*	1.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.07	0.42
	39	*383799*	*6396517*	H	*1.49*	1.79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	0.02	0.07	0.16	0.21	0.56
	40	*383787*	*6396535*	H	*1.63*	1.93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.06	0.41
	41	*383777*	*6396552*	H	*1.31*	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.23	-	0.07	0.16	0.20	0.25	0.33	0.38	0.73
	42	*383766*	*6396591*	H	*1.16*	1.46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	0.03	0.38	0.04	0.22	0.31	0.35	0.40	0.48	0.53	0.88
	43	*383818*	*6396617*	H	*1.86*	2.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18
	44	*383747*	*6396610*	H	*1.46*	1.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	0.01	0.05	0.10	0.18	0.23	0.58
	45	383724.3	6396621	H	2.09	2.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	46	383715.8	6396641	H	1.35	1.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19	-	0.03	0.12	0.16	0.21	0.29	0.34	0.69
	47	383699	6396664	H	1.74	2.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30
	48	383681.7	6396684	H	1.18	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	0.01	0.36	0.02	0.20	0.29	0.33	0.38	0.46	0.51	0.86
	49	383661.9	6396698	H	1.35	1.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19	-	0.03	0.12	0.16	0.21	0.29	0.34	0.69
	50	383642.2	6396708	H	1.33	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.22	-	0.06	0.15	0.19	0.24	0.32	0.37	0.72
	51	383619.8	6396724	H	1.16	1.46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	0.03	0.38	0.04	0.22	0.31	0.35	0.40	0.48	0.53	0.88
	52	383597.5	6396736	H	1.11	1.41	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	0.23	-	-	-	-	-	0.03	0.08	0.43	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93
	53	383576.8	6396744	H	1.11	1.41	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	0.23	-	-	-	-	-	0.03	0.08	0.43	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93
	54	383561	6396755	H	0.99	1.29	-	-	-	-	-	-	-	0.15	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-	0.00	0.35	-	-	-	0.02	0.07	0.15	0.20	0.55	0.21	0.39	0.48	0.52	0.57	0.65	0.70	1.05
	55	383523.3	6396774	H	0.92	1.22	-	-	-	-	-	-	-	0.22	-	-	-	-	-	-	-	0.32	-	-	-	-	-	0.02	0.07	0.42	-	-	0.05	0.09	0.14	0.22	0.27	0.62	0.28	0.46	0.55	0.59	0.64	0.72	0.77	1.12
	56	383505	6396781	H	0.84	1.14	-	-	-	-	-	-	-	0.30	-	-	-	-	-	-	0.05	0.40	-	-	-	-	0.02	0.10	0.15	0.50	-	0.04	0.13	0.17	0.22	0.30	0.35	0.70	0.36	0.54	0.63	0.67	0.72	0.80	0.85	1.20
	57	383492.1	6396794	H	1.05	1.35	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	-	0.29	-	-	-	-	0.01	0.09	0.14	0.49	0.15	0.33	0.42	0.46	0.51	0.59	0.64	0.99
	58	*383459*	*6396783*	H	*1.00*	1.30	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-	-	0.24	-	-	-	-	-	-	-	0.34	-	-	-	0.01	0.06	0.14	0.19	0.54	0.20	0.38	0.47	0.51	0.56	0.64	0.69	1.04
	59	383441	6396790	H	1.08	1.38	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	0.26	-	-	-	-	-	0.06	0.11	0.46	0.12	0.30	0.39	0.43	0.48	0.56	0.61	0.96
	60	383420.8	6396798	H	0.98	1.28	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	0.26	-	-	-	-	-	-	0.01	0.36	-	-	-	0.03	0.08	0.16	0.21	0.56	0.22	0.40	0.49	0.53	0.58	0.66	0.71	1.06
	61	383404.3	6396806	H	1.02	1.32	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.22	-	-	-	-	-	-	-	0.32	-	-	-	-	0.04	0.12	0.17	0.52	0.18	0.36	0.45	0.49	0.54	0.62	0.67	1.02
	62	383386.9	6396818	H	1.15	1.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-	-	0.19	-	-	-	-	-	-	0.04	0.39	0.05	0.23	0.32	0.36	0.41	0.49	0.54	0.89
	63	383369.7	6396830	H	1.44	1.74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-	-	0.03	0.07	0.12	0.20	0.25	0.60
	64	383354.3	6396841	H	1.25	1.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-	-	0.29	-	0.13	0.22	0.26	0.31	0.39	0.44	0.79
	65	383337.1	6396851	H	1.08	1.38	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	0.26	-	-	-	-	-	0.06	0.11	0.46	0.12	0.30	0.39	0.43	0.48	0.56	0.61	0.96
	66	*383327*	*6396857*	H	*1.17*	1.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	0.17	-	-	-	-	-	-	0.02	0.37	0.03	0.21	0.30	0.34	0.39	0.47	0.52	0.87
	67	*383310*	*6396883*	H	*1.44*	1.74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-	-	0.03	0.07	0.12	0.20	0.25	0.60
	68	383290.9	6396909	H	1.25	1.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-	-	0.29	-	0.13	0.22	0.26	0.31	0.39	0.44	0.79
	69	383307.1	6396926	H	1.94	2.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10
	70	383329.8	6396951	H	1.99	2.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05
	71	*383325*	*6396981*	H	*1.52*	1.82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	0.04	0.12	0.17	0.52
	72	*383337*	*6397002*	H	*1.43*	1.73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-	-	0.04	0.08	0.13	0.21	0.26	0.61
	73	383346.7	6397025	H	1.98	2.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06
	74	383378.9	6397060	H	1.55	1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.09	0.14	0.49
	75	383388	6397081	H	1.75	2.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29
	76	*383418*	*6397095*	H	*1.52*	1.82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	0.04	0.12	0.17	0.52
	77	383444.9	6397107	H	1.33	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.21	-	0.05	0.14	0.18	0.23	0.31	0.36	0.71
	78	383452.4	6397131	H	1.31	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.23	-	0.07	0.16	0.20	0.25	0.33	0.38	0.73
	79	383481	6397130	H	1.94	2.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10
	80	383498.6	6397133	H	2.21	2.51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	81	*383524*	*6397263*	H	*0.87*	1.17	-	-	-	-	-	-	-	0.27	-	-	-	-	-	-	0.02	0.37	-	-	-	-	-	0.07	0.12	0.47	-	0.01	0.10	0.14	0.19	0.27	0.32	0.67	0.33	0.51	0.60	0.64	0.69	0.77	0.82	1.17
	82	*383599*	*6396784*	H	*1.12*	1.42	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	0.23	-	-	-	-	-	0.02	0.08	0.43	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93
	83	*383611*	*6396807*	H	*1.20*	1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-	-	0.34	-	0.18	0.27	0.31	0.36	0.44	0.49	0.84
	84	*383676*	*6396782*	H	*1.40*	1.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	-	0.07	0.11	0.16	0.24	0.29	0.64
	85	*383701*	*6396786*	H	*1.20*	1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-	-	0.34	0.00	0.18	0.27	0.31	0.36	0.44	0.49	0.84
	86	*383724*	*6396782*	H	*1.13*	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.01	0.06	0.41	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
	87	*383744*	*6396776*	H	*1.32*	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.23	-	0.07	0.16	0.20	0.25	0.33	0.38	0.73
	88	*383758*	*6396766*	H	*1.18*	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	0.01	0.36	0.02	0.20	0.29	0.33	0.38	0.46	0.51	0.86
	89	383776.6	6396758	H	1.23	1.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.31	-	0.15	0.24	0.28	0.33	0.41	0.46	0.81
	90	383796.1	6396747	H	1.34	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	0.20	-	0.04	0.13	0.17	0.22	0.30	0.35	0.70
	91	383810.4	6396734	H	1.13	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.22	-	-	-	-	-	0.01	0.07	0.42	0.08	0.26	0.35	0.39	0.44	0.52	0.57	0.92
	92	383832.3	6396729	H	1.50	1.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-	-	0.01	0.06	0.14	0.19	0.54
	93	383847.2	6396719	H	1.26	1.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.28	-	0.12	0.21	0.25	0.30	0.38	0.43	0.78
	94	383875.3	6396705	H	1.26	1.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.28	-	0.12	0.21	0.25	0.30	0.38	0.43	0.78
	95	383863.3	6396682	H	1.14	1.44	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.00	0.06	0.41	0.06	0.25	0.34	0.38	0.43	0.51	0.56	0.91
	96	383839.1	6396670	H	1.17	1.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	0.17	-	-	-	-	-	-	0.02	0.37	0.03	0.21	0.30	0.34	0.39	0.47	0.52	0.87
	97	383831.3	6396646	H	1.14	1.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-	-	-	-	-	-	-	0.20	-	-	-	-	-	-	0.05	0.40	0.06	0.24	0.33	0.37	0.42	0.50	0.55	0.90
	98	383890.3	6396630	H	1.07	1.37	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	0.17	-	-	-	-	-	-	-	0.27	-	-	-	-	-	0.07	0.12	0.47	0.13	0.31	0.40	0.44	0.49	0.57	0.62	0.97
	99	383912.3	6396640	H	1.20	1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-	-	0.34	0.00	0.18	0.27	0.31	0.36	0.44	0.49	0.84
	100	383912.6	6396663	H	1.32	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.22	-	0.06	0.15	0.19	0.24	0.32	0.37	0.72
	101	383936.8	6396671	H	1.54	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	0.02	0.10	0.15	0.50
	102	383943.8	6396689	H	1.13	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.01	0.06	0.41	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
	103	383958.8	6396705	H	1.68	1.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.36
	104	383968.4	6396721	H	1.46	1.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	0.01	0.05	0.10	0.18	0.23	0.58
	105	383988.2	6396734	H	1.17	1.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	0.17	-	-	-	-	-	-	0.02	0.37	0.03	0.21	0.30	0.34	0.39	0.47	0.52	0.87
	106	383982.7	6396760	H	1.18	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	0.01	0.36	0.02	0.20	0.29	0.33	0.38	0.46	0.51	0.86
	107	383994.7	6396775	H	1.22	1.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	0.32	-	0.16	0.25	0.29	0.34	0.42	0.47	0.82
	108	384001.4	6396798	H	1.11	1.41	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	0.23	-	-	-	-	-	0.03	0.08	0.43	0.09	0.27	0.36	0.40	0.45	0.53	0.58	0.93

	109	384007.6	6396814	H	1.48	1.78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-	0.03	0.08	0.16	0.21	0.56
	110	384026	6396830	H	1.35	1.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.19	-	0.03	0.12	0.16	0.21	0.29	0.34	0.69
	111	384032.8	6396847	H	1.32	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	-	0.22	-	0.06	0.15	0.19	0.24	0.32	0.37	0.72
	112	384059.4	6396857	H	1.13	1.43	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.01	0.06	0.41	0.07	0.25	0.34	0.38	0.43	0.51	0.56	0.91
	113	383977.8	6396872	H	1.54	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.10	0.15	0.50
	114	383962.4	6396851	H	1.14	1.44	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.21	-	-	-	-	-	0.00	0.06	0.41	0.06	0.25	0.34	0.38	0.43	0.51	0.56	0.91
	115	383948.9	6396833	H	1.08	1.38	-	-	-	-	-	-	-	0.06	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	0.26	-	-	-	-	-	0.06	0.11	0.46	0.12	0.30	0.39	0.43	0.48	0.56	0.61	0.96
	116	383937.9	6396811	H	0.96	1.26	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	-	0.28	-	-	-	-	-	-	0.03	0.38	-	-	0.01	0.05	0.10	0.18	0.23	0.58	0.24	0.42	0.51	0.55	0.60	0.68	0.73	1.08
	117	383922.8	6396788	H	1.60	1.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	0.09	0.44
	118	383918.8	6396761	H	2.07	2.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	119	383898.3	6396744	H	1.26	1.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	0.28	-	0.12	0.21	0.25	0.30	0.38	0.43	0.78
	120	383872.2	6396762	H	1.23	1.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.31	-	0.15	0.24	0.28	0.33	0.41	0.46	0.81
	121	383856.8	6396774	H	1.30	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	-	0.24	-	0.08	0.17	0.21	0.26	0.34	0.39	0.74
	122	383841.1	6396788	H	1.36	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	-	0.02	0.11	0.15	0.20	0.28	0.33	0.68
	123	383824.2	6396799	H	1.38	1.68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16	-	-	0.09	0.13	0.18	0.26	0.31	0.66
	124	383808.4	6396809	H	1.23	1.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	0.31	-	0.15	0.24	0.28	0.33	0.41	0.46	0.81
	125	383790.1	6396818	H	1.61	1.91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03	0.08	0.43
	126	383772.2	6396828	H	1.39	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	-	-	0.08	0.12	0.17	0.25	0.30	0.65
	127	383754.2	6396838	H	1.37	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	-	0.01	0.10	0.14	0.19	0.27	0.32	0.67
	128	383734.8	6396846	H	1.68	1.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.36

Appendix I

Economic Report (Rhelm)

I.1 Economic Analysis - Technical Report

Shire of Murray: Coastal Hazard Risk Management and Adaptation Planning

Economic Assessment

Prepared for: **Baird**

February 2022

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Executive Summary

Overview

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

Objectives & Methodology

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

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

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

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

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

Assessment Scenarios

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

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

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

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

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

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

Base Case Economic Impacts

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

Table i. Base Case Impacts

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

Cost Benefit Analysis

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

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

Table ii. Summary of Economic Results

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

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

Table iii. Distributional Analysis

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

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

Table of Contents

Figures

Tables

Acronyms

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

1 Introduction

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

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

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

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

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

Figure 1-1. Locality

Figure 1-2. Key Areas of Investigation

Figure 1-3. Kooljerrenup Nature Reserve

2 Economic Assessment

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

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

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

2.1 Assumptions

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

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

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

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

2.2 Scenarios

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

2.2.1 The Base Case

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

2.2.2 Mitigation Options

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

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

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

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

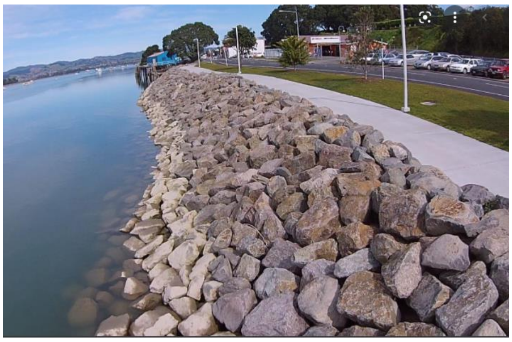


Figure 2-1. Example of "Hard" Engineering Solution (left)[3] and Nature Based Solution (right)[4]

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

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

3 Base Case

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

3.1 Erosion

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

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

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

3.1.1 Private Land

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

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

The analysis estimated:

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

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

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

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

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

3.1.2 Private Houses

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

The following was assumed for the building values:

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

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

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

3.1.3 Public Assets

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

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

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

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

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

3.1.4 Kooljerrenup Nature Reserve

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

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

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

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

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

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

Figure 3-1 Kooljerrenup Nature Reserve forecast erosion

3.2 Flood Inundation and Damages

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

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

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

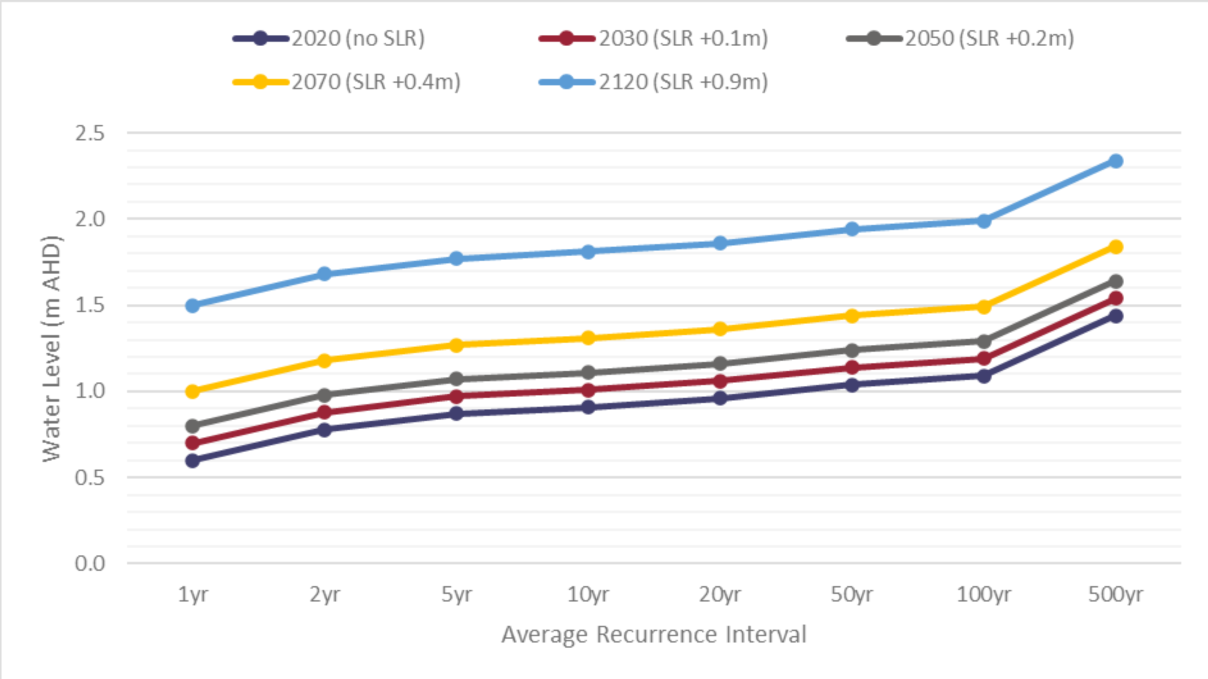

Figure 3-2 Water levels (m AHD) for each ARI in each modelled year (SLR scenario)

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

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

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

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

Table 3-3 Flood damage estimation tool: user inputs

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

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

External damages were only incorporated when overfloor flooding occurred.

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

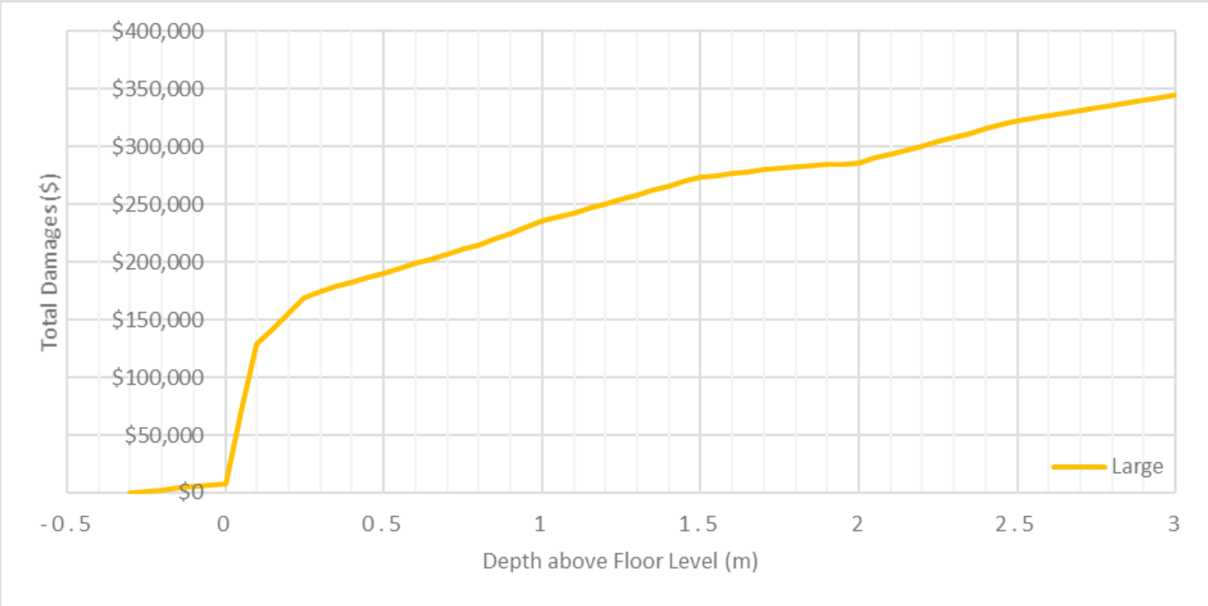

Figure 3-3 Residential damage curve adopted for the analysis

3.3 Other Considerations

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

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

[5] ABS Series ID - A85002148L

4 Mitigation Options

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

4.1 Option Performance

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

Table 4-1 Mitigation Option Protection Levels

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

4.2 Mitigation Option Costs

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

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

Table 4-2. Summary of Mitigation Option Costs

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

5 Economic Results

5.1 Benefit Summary

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

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

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

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

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

5.2 Cost Benefit Analysis

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

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

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

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

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

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

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

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

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

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

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

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

5.3 Distributional Analysis

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

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

Table 5-3. Distributional Analysis

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

5.4 Sensitivity Analysis

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

Table 5-4. Sensitivity Analysis - BCR

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

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