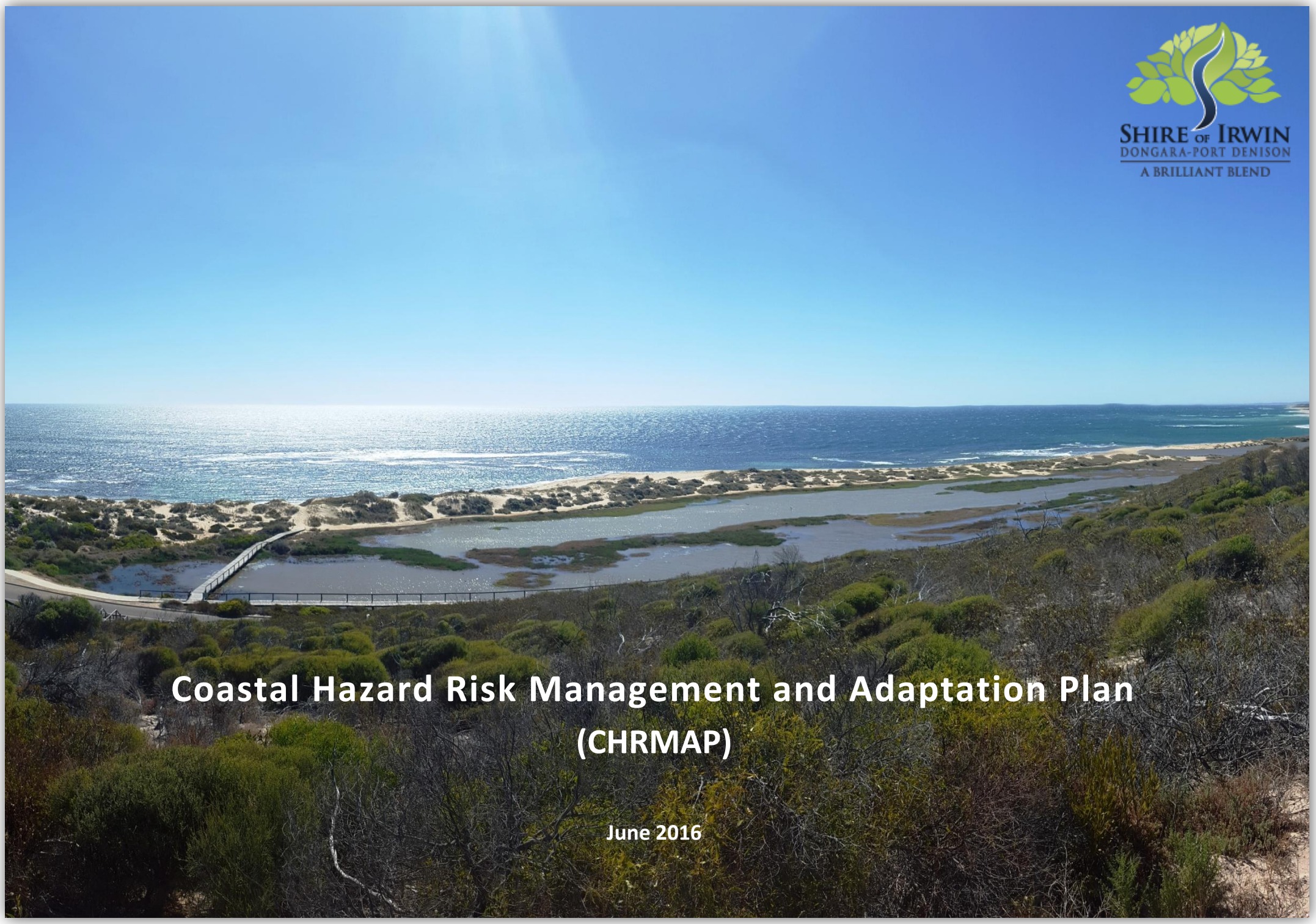
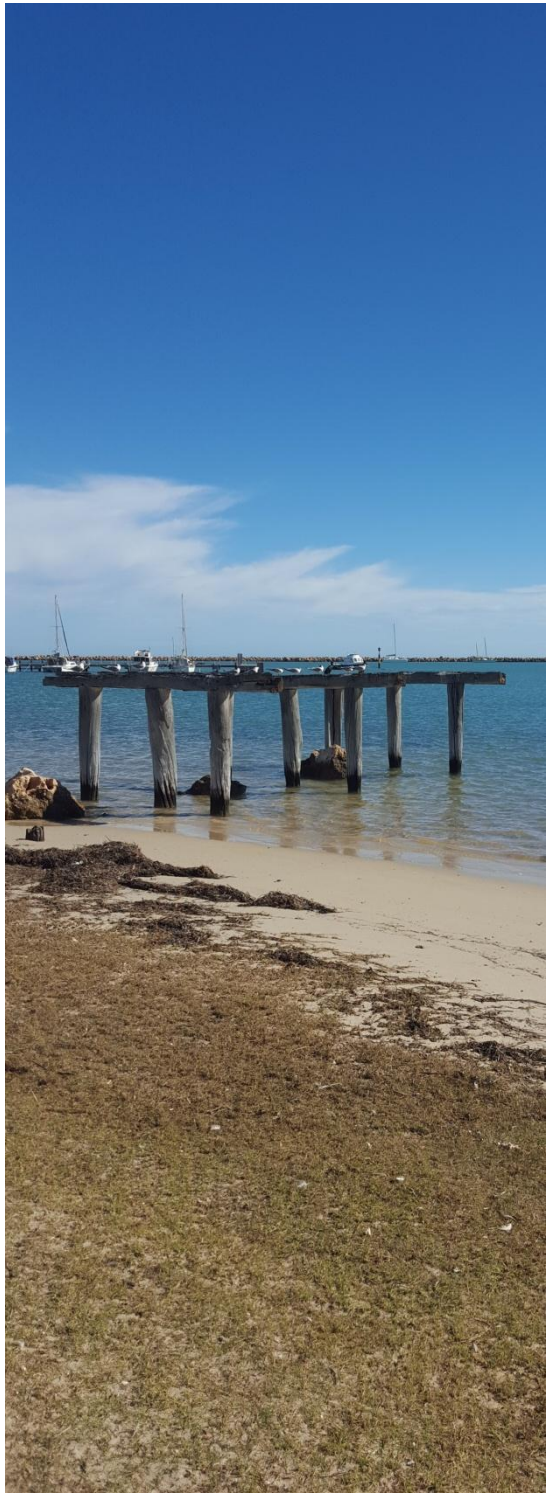


SHIRE OF IRWIN
DONGARA-PORT DENISON
A BRILLIANT BLEND

Coastal Hazard Risk Management and Adaptation Plan (CHRMAP)

June 2016



SUMMARY

The purpose of the Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) is to provide strategic guidance on coordinated, integrated and sustainable management and adaptation for land use and development in the coastal zone. Specifically this CHRMAP:

- provides information on the effects of coastal hazards;
- presents a decision-making framework to assess the associated risks;
- highlights coastal hazard areas in terms of vulnerability and risk; and
- suggests possible adaptation options.

The objectives of the CHRMAP are to:

- increase knowledge of coastal features, processes and hazards in the Shire;
- increase stakeholders and community in planning and decision-making processes
- identify coastal hazards;
- identify coastal hazard risk areas (both natural and man-made) impacted by coastal hazards and their functions;
- determine likelihood and consequence of impacts from coastal hazards on assets and assign a level of risk; and
- identify relevant management/Coastal adaptation actions and how these can be incorporated into short and long term planning.

After identifying coastal hazard risk areas, modelling was carried out for various inundation and erosion scenarios. This is the first time the Irwin coast has been modelled in this way. The modelling results are limited by the availability of accurate data. This means that there are likely to be inherent inaccuracies with the modelling results, which cannot be taken as a true representation of what may happen during inundation and erosion events. However, the results can be used as indicators and preliminary findings for further detailed studies.

Following a risk analysis and evaluation of the inundation and erosion scenarios for each coastal hazard risk area, the CHRMAP recommends the following coastal adaptation actions:

PORT DENISON, GRANNY'S BEACH AND SURF BEACH

The Shire of Irwin will:

a. investigate potential inundation impacts and ascertain the need and viability for improving the inundation resilience of public infrastructure in this area (e.g. public buildings on the Foreshore, the sea wall between Granny's Beach and Surf Beach);
b. investigate retrofitting urban drainage systems to accommodate fluvial flooding;
c. investigate the need for coastal protection structures to protect/defend areas from erosion;
d. continue to implement the Shire's Green Infrastructure Strategy and the Local Planning Policy for Water Sensitive Urban Design; and
e. continue to monitor coastal processes.

Following consideration of further investigative studies, in the Port Denison, Granny's Beach and Surf Beach area, planning scheme modifications may be required, which identify:

a. the future relocation of public infrastructure; and
b. minimum floor levels in accordance with potential flood levels (e.g. there are 3 vacant freehold lots on the Foreshore).

SOUTH BEACH (NORTH)

The Shire of Irwin will:

a. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area;
b. ensure that all approved buildings are relocatable;
c. monitor and allow natural processes to occur, and ensure the public are kept informed;
d. plan for the movement of public infrastructure around the south beach car park, when inundation and erosion threats materialise.

SOUTH BEACH (SOUTH)

The Shire of Irwin will:

a. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area;
b. ensure that all approved buildings within the caravan park are relocatable;
c. monitor and allow natural processes to occur, and ensure the public are kept informed; and
d. plan for the movement of public and private infrastructure when threats materialise.

SEASPRAY AND IRWIN RIVERMOUTH AREA

The Shire of Irwin will:

a. continue to educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area;
b. carry out flood modelling of the Irwin River, including an analysis of combined river flooding and coastal impacts; and
c. monitor and allow natural processes to occur, and ensure the public are kept informed;
d. plan for the movement of public infrastructure when threats materialise.

SEVEN MILE BEACH

The Shire of Irwin will:

a. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area;
b. monitor and allow natural processes to occur, and ensure the public are kept informed; and
c. plan for the movement of public infrastructure when threats materialise.

FRESHWATER POINT

The Shire of Irwin will:

a. ensure that all approved buildings are relocatable;
b. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area;
c. monitor and allow natural processes to occur, and ensure the public are kept informed; and
d. plan for the movement of public infrastructure when threats materialise.

CLIFF HEAD NORTH

The Shire of Irwin will:

a. ensure that all approved buildings are relocatable;
b. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area;
c. monitor and allow natural processes to occur, and ensure the public are kept informed; and
d. plan for the movement of public infrastructure when threats materialise.

CLIFF HEAD SOUTH

The Shire of Irwin will:

a. ensure that all approved buildings are relocatable;
b. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area;
c. monitor and allow natural processes to occur, and ensure the public are kept informed; and
d. plan for the movement of public infrastructure when threats materialise.

IMPLEMENTATION PLAN

Priority	Action	Timeframe	Responsibility
High	In the Port Denison, Granny's Beach and Surf Beach area: a. investigate potential inundation impacts and ascertain the need and viability for improving the inundation resilience of public infrastructure in this area (e.g. the sea wall between Granny's Beach and Surf Beach); b. investigate retrofitting urban drainage systems to accommodate fluvial flooding; c. investigate the need for coastal protection structures to protect/defend areas from erosion.	July 2021	Shire of Irwin / Department of Planning / Department of Transport
High	Carry out flood modelling of the Irwin River, including an analysis of combined river flooding and coastal impacts	July 2021	Shire of Irwin
Medium	In all coastal areas where new buildings are proposed, ensure all buildings are relocatable.	As need arises	Shire of Irwin
Medium	In urban areas - continue to implement the Shire's Green Infrastructure Strategy and the Local Planning Policy for Water Sensitive Urban Design.	Ongoing	Shire of Irwin
Medium	Modifications to Planning Scheme	As need arises	Shire of Irwin / WAPC
Medium	In all areas, educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area.	Ongoing	Shire of Irwin
Medium	In all areas monitor and allow natural processes to occur, and ensure the public are kept informed.	Ongoing	Shire of Irwin / NACC
Low	Plan for the future relocation of the airfield by 2070, or sooner if threats materialise.	2031 (or sooner, if required)	Shire of Irwin / WAPC

CONTENTS PAGE

Introduction 7
Context 9
Coastal Hazard Risk Identification 10
Community Workshop 10
Modelling of Risk Areas for Inundation and Coastal Erosion Scenarios 11
Coastal Hazard Risk Adaptation Planning 13
Port Denison, Granny's Beach and Surf Beach 16
South Beach North 18
South Beach South 20
Seaspray and Irwin River Mouth 22
Seven Mile Beach 24
Freshwater Point 26
Cliff Head North 28
Cliff Head South 30
Implementation Plan 32
Monitoring and Review 33
Consultation and Education 34

Appendix 35
Appendix One – Inundation and Erosion Maps for Hazard Areas 35
Appendix Two – Risk Analysis and Evaluation Process and Results 98



INTRODUCTION

This Coastal Hazard Risk Management Plan (CHRMAP) has been developed in accordance with the requirements of the Western Australian Planning Commission's (WAPC) State Planning Policy 2.6 – State Coastal Planning Policy (SPP2.6) and associated guidelines. As a minimum CHRMAP should include the following elements:

1. establish the context;
2. coastal hazard risk identification/vulnerability assessment;
3. coastal hazard risk analysis;
4. coastal hazard risk evaluation;
5. coastal hazard risk adaptation planning; and
6. monitor and review.

Throughout the development of the CHRMAP it was important to communicate, consult and involve key stakeholders and the wider community to provide, share and obtain information. This is particularly important because of the inherent diversity of community and stakeholder views. The diagram below shows CHRMAP's process.

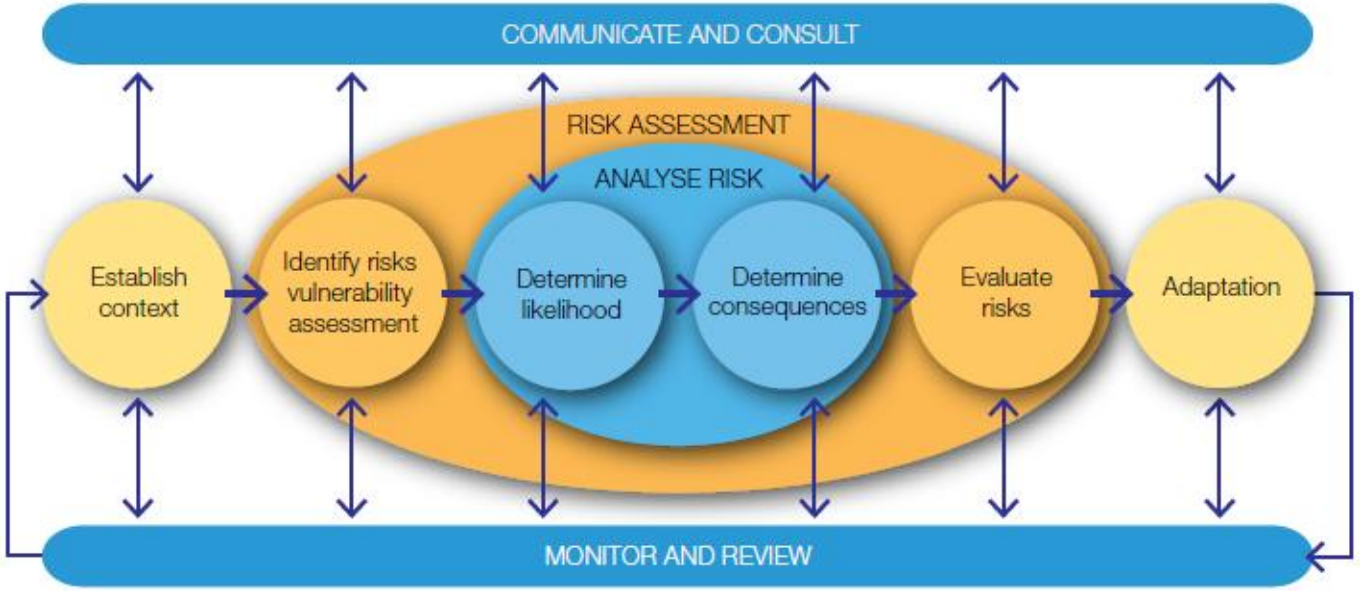


Figure 1: The CHRMAP Process

The CHRMAP has been prepared for the Shire of Irwin's entire coastline. Figure 2 shows the study area.

The project was developed by partnership working between Curtin University's Department of Engineering, the Northern Agricultural Catchments Council (NACC) and the Shire of Irwin. The key stakeholders include the Shire's community, the Department of Planning and Department of Transport.

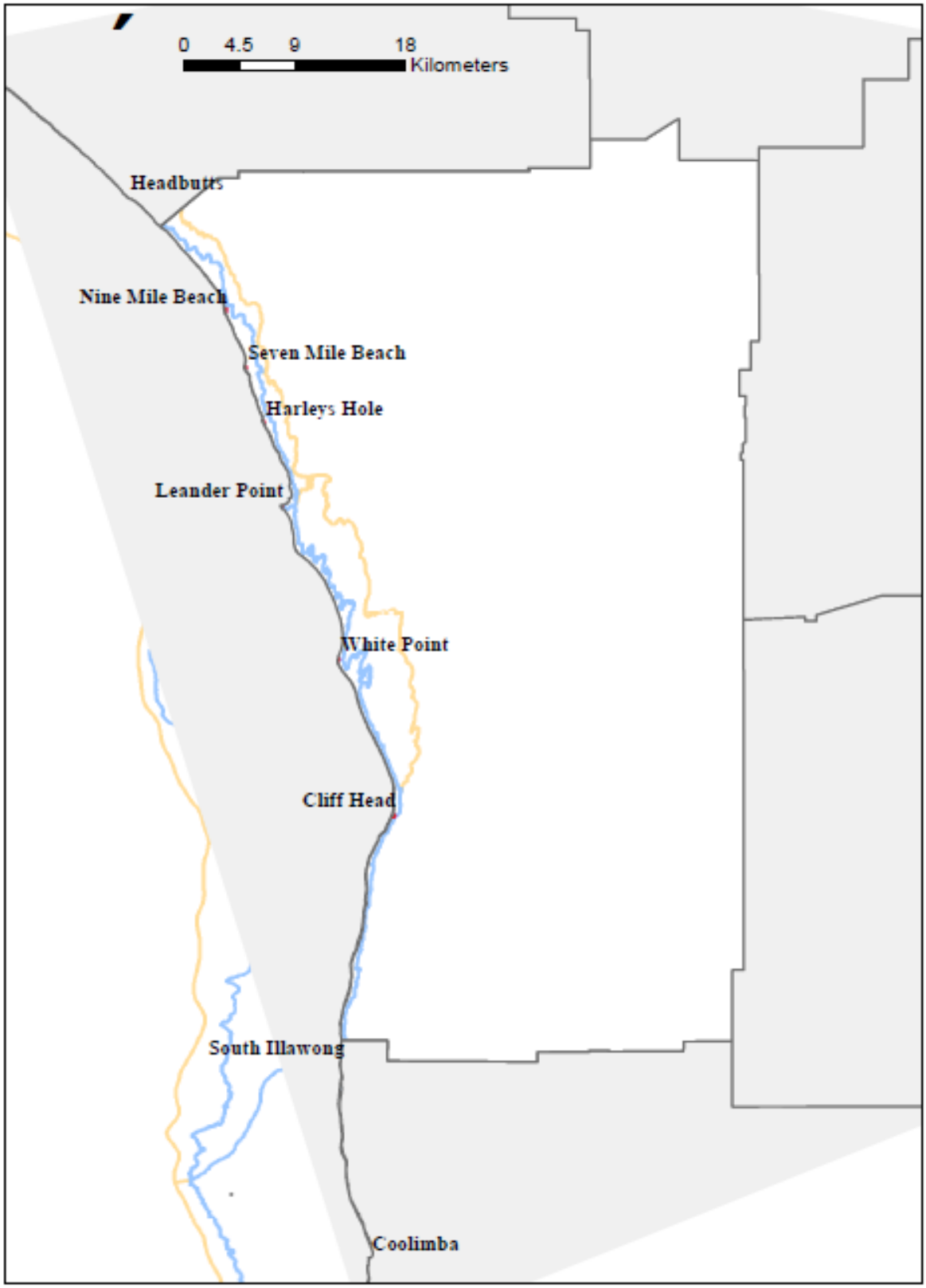


Figure 2: Delineation of the Study Area (source: Coastal Sediment Cells for the Mid-West Coast)



Context

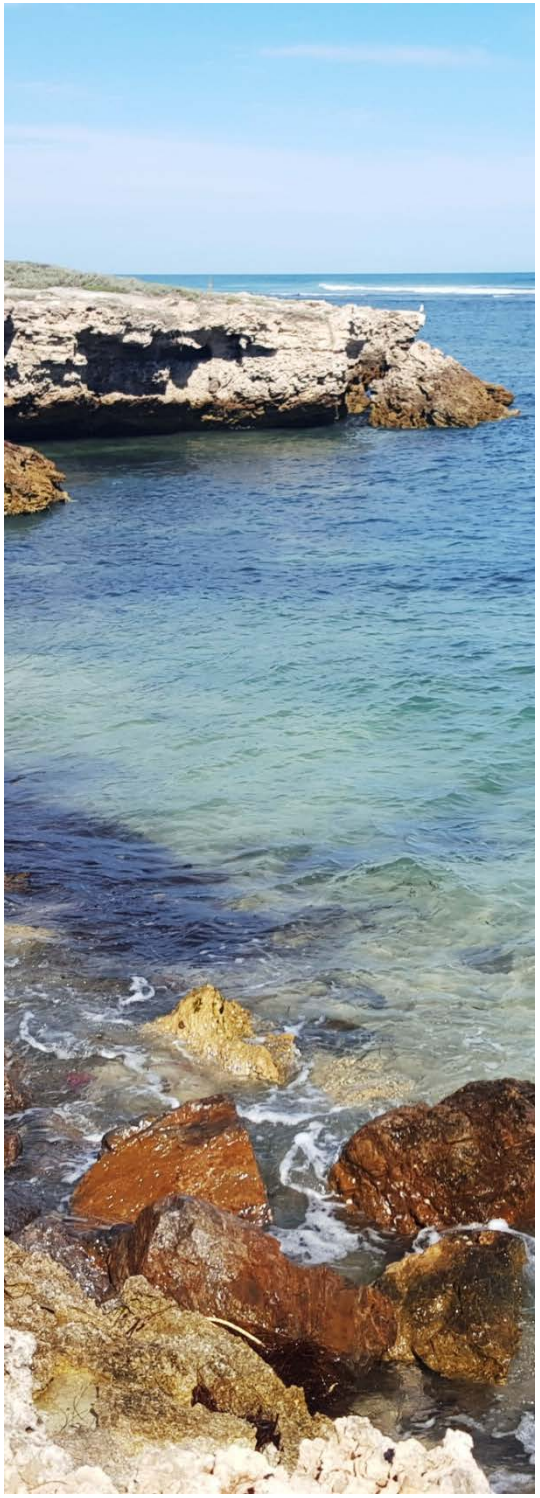
The purpose of the CHRMAP is to provide strategic guidance on coordinated, integrated and sustainable management and adaptation for land use and development in the coastal zone. Specifically this CHRMAP:

- provides information on the effects of coastal hazards;
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The objectives of the CHRMAP are to:

- increase knowledge of coastal features, processes and hazards in the Shire;
- include stakeholders and community in planning and decision-making process;
- identify coastal hazards;
- identify coastal hazard risk areas (both natural and man-made) impacted by coastal hazards and their functions;
- determine likelihood and consequence of impacts from coastal hazards on assets and assign a level of risk; and
- identify relevant management/Coastal adaptation actions and how these can be incorporated into short and long term planning.

To begin the project, Curtin University carried out a literature review aimed at collecting and reviewing all available information. The literature review was conducted under several sub topics including state government policy and CHRMAP guidelines, CHRMAP studies conducted nationally and internationally, information on the study area, literature on data availability and literature on modelling methods. The literature review was made publicly available on the Shire's website during the course of the project, and is still available on request.



Coastal Hazard Risk Identification

Community Workshop

An initial community workshop was held in April 2015, when the project was presented to the community, a summary of the workshop outcomes is presented within the table below. The State Government's Department of Planning explained the policy background of SPP 2.6, and its requirements for this CHRMAP. Curtin explained that their role was to identify and carry out modelling for coastal hazard risks and NACC explained the CHRMAP risk analysis and evaluation methodology.

At the initial community workshop and drawing from their literature review, Curtin identified the risks that coastal communities face as a result of sea level increases, warming ocean temperatures, and other coastal processes. Curtin also identified that for the purposes of this CHRMAP, the coastal hazards that we are exclusively concerned with are:

- coastal erosion; and
- coastal inundation.

Also at the initial community workshop, NACC highlighted known coastal hazard risk areas along the Shire's coastline (these were identified during field visits conducted by the Shire). Based on the Shire's knowledge, the following hazard risk areas were identified to be modelled for inundation and erosion and included:

- Port Denison, Granny's Beach and Surf Beach;
- South Beach North;
- South Beach South;
- Seaspray Beach and Irwin Rivermouth;
- Seven Mile Beach;
- Freshwater Point;
- Cliff Head North; and
- Cliff Head South.

Community Workshop Summary Notes

On 23 April 2015, the Shire of Irwin and the Northern Agricultural Catchments Council (NACC) hosted a Coastal Adaptation Information Forum in Port Denison. This forum brought together members of the community and representatives from the Department of Planning (DoP), Curtin University, NACC and the Shire to discuss the Shire's new coastal planning project – the Coastal Hazard Risk Management and Adaptation Plan (CHRMAP). The Shire is leading the project with partners from the DoP, Curtin and NACC. Around twenty community members and stakeholders attended the workshop and witnessed three presentations before taking part in a question and answer session and informal discussion. The workshop discussed topics such as coastal assets, hazards, processes, coastal data, planning, protection infrastructure, communication, and partnerships.

At the end of the presentations, the question and answer session discussed:

- the importance of the type of sand used for replenishing projects;
- the impact of a trench dug in the early 80s on a sandbar, which was located between the river mouth and Nun's Pool;
- the limestone which is immediately below the sandbar at the river mouth, which may explain why the sandbar builds-up regularly;
- the development of the Port Denison Harbour has impacted on coastal erosion along Granny's and Surf beaches;
- the variability of sea level rise across different world regions, which is due to different currents and weather patterns;
- tidal impacts which have been seen upriver beyond the bridge as recently as March 2015; and
- the DoP clarified that modelling of the river can only be incorporated into the coastal CHRMAP if it is primarily driven by coastal processes.

Following the workshop, the Shire requested that South Beach North and South Beach South be modelled, as this area is greatly valued by the community.

Modelling of Risk Areas for Coastal Inundation and Coastal Erosion Scenarios

The modelling methodology incorporated several steps including: field visits, a literature review, data collection and numerical modelling. It followed the requirements of SPP 2.6 and was reviewed and considered satisfactory by the Department of Planning and the Department of Transport.

Modelling was carried out for various inundation and erosion scenarios. This is the first time the Irwin coast has been modelled in this way. The modelling results are limited by the availability of accurate data. ***This means that there are likely to be inherent inaccuracies with the modelling results, which cannot be taken as a true representation of what may happen during inundation and erosion events.*** However, the results can be used as indicators and preliminary findings for further detailed studies.

The first step of the methodology was to conduct bathymetry and topography modelling (contour plotting) to find the extent of the study area, then:

1. **Coastal Inundation** was assessed by using a dynamic (wave driven) inundation model. The available water levels, wave and wind data were used for the dynamic modelling. Water levels include astronomical tide, storm surge, wave set-up and wave run-up; and
2. **Coastal Erosion** was assessed by using a dynamic (wave driven) model. The available water levels, wave and wind data were used for dynamic modelling.

In basic terms, inundation and erosion modelling was carried out for each coastal hazard risk area based on the following 4 scenarios for a planning timeframe of 96 years:

Scenario	Year	Sea Level Rise	Average Recurring Interval for Extreme Storm Events**		
1	Present* (2014)	0 metre	1 year	100 year	500 year
2	2070	0.5 metre			
3	2110	0.9 metre			
4	2110	1.5 metre			

*As the most recent data available was from 2014, this year was considered as the present condition.
**This is a way of expressing the likelihood of occurrence of a storm event e.g. a 100 year storm event is likely to happen, on average, once in a 100 years or 1% chance of happening in any one year.

The modelling results include a series of inundation and erosion vulnerability maps contained within the Curtin's final modelling report – Modelling of Coastal Inundation and Erosion Process at the Shire of Irwin Coastal Region. This report contains the full modelling methodology and is available on the website or on request at the Shire Offices. The key inundation and erosion maps are located in Appendix 1.



Coastal Hazard Risk Analysis and Evaluation

After identifying the coastal hazard risks, and producing the inundation and erosion maps for each identified risk area, NACC facilitated two risk analysis and evaluation workshops with Shire Councillors and Officers. Appendix 2 of this CHRMAP contains the summary report which details the outcomes from the workshops.

For each of the four modelling scenarios, inundation and erosion maps produced for each hazard risk area were analysed by Shire Councillors and Officers using a methodology recommended by the WAPC, as set out in SPP2.6.

In basic terms, the inundation and erosion maps were analysed by a group of people with local knowledge of the coastline. ***This analysis investigated the likelihood and consequence of the modelling results. In doing so, inherent inaccuracies within the inundation and erosion maps have been tempered with some rational thought.***

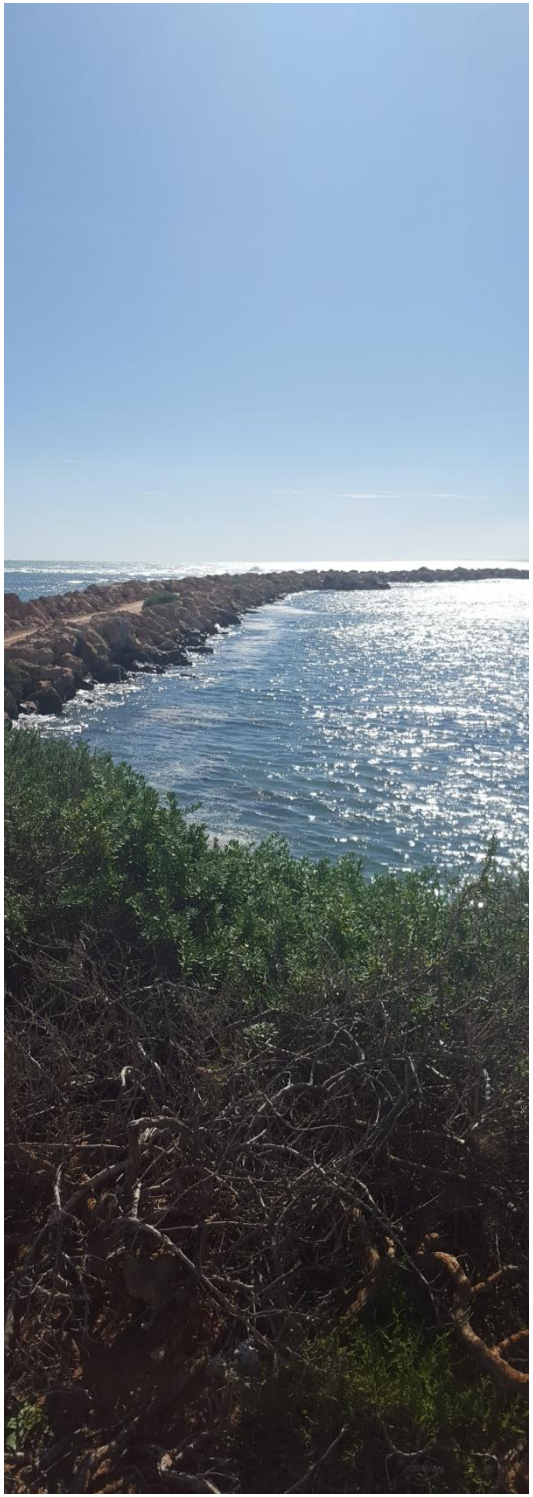
Limitations of the Inundation and Erosion Maps include:

- **The entire coastline was taken to be sandy beach, as there was no geotechnical data available,**
- **The sea wall in front of the Big 4 Caravan Park was not considered, as there was no survey data available, and**
- **Other coastline data used in the study was over 20 years old**

After analysing the likelihood and consequence of the inundation and erosion maps for each hazard risk area, the risk levels for each scenario were averaged for each site. This then provided the following Risk Priority Levels for each site. The risk analysis and evaluation results for each hazard risk area are set out in the tables below.

Risk Analysis and Evaluation of the Coastal Inundation Maps			
Risk Hazard Area	**Likelihood**	**Consequence**	**Risk Priority Level**
Port Denison, Granny's Beach and Surf Beach	Likely	Moderate	High
South Beach North	Possible	Minor	Medium
South Beach South	Almost Certain	Minor	High
Seaspray	Almost certain	Minor	High
Seven Mile Beach	Unlikely	Insignificant	Low
Freshwater Point	Unlikely	Minor	Low
Cliff Head North	Rare	Insignificant	Low
Cliff Head South	Possible	Insignificant	Low

Risk analysis and evaluation of the coastal erosion maps			
Risk Hazard Area	**Likelihood**	**Consequence**	**Risk Priority Level**
Port Denison, Granny's Beach and Surf Beach	Possible	Catastrophic	Extreme
South Beach North	Possible	Major	Extreme
South Beach South	Unlikely	Major	High
Seaspray	Almost certain	Major	Extreme
Seven Mile Beach	Possible	Minor	Medium
Freshwater Point	Likely	Moderate	High
Cliff Head North	Possible	Moderate	High
Cliff Head South	Possible	Moderate	High



Coastal Hazard Risk Adaptation Planning

After carrying out the risk analysis and evaluation of the inundation and erosion maps, Shire Officers followed the WAPC's CHRMAP Guidelines to carry out an assessment of coastal hazard risk adaptation options. To do this, the Risk Priority Levels for inundation and erosion in each area were reviewed to determine a broad adaptation option category based on the hierarchy in Figure 3.



Figure 3: Risk Management and Adaptation Hierarchy (source: WAPC's CHRMAP Guidelines)

This process enabled coastal adaptation actions to be made for each hazard risk area. The rest of this section sets out the rationale and recommendations for each area.

PORT DENISON, GRANNY'S BEACH AND SURF BEACH

This area is comprised of fairly significant levels of public infrastructure, a caravan site, beaches and adjacent residential and commercial properties. When reviewing the modelling results for this area it was important to consider that there was no accurate height data for the sea wall located between Granny's Beach and Surf Beach. Another important factor is that the sea wall around the Port Denison Marina protects the Foreshore (hence there is no erosion mapping for this area in Curtin's modelling report). The area has experienced significant levels of erosion between Granny's Beach and Surf Beach and minor levels of erosion on the foreshore within the marina. With regard to the modelling maps, the table below shows that the Risk Priority Level for inundation is high and for erosion it is extreme. Most of the areas likely to be significantly affected by coastal inundation and erosion over the next 94 years are likely to be public land. That said, given the inherent uncertainties with climate change, coastal processes, the modelling results and the wider impacts of storm events (e.g. inundation of urban drainage systems), there is an obvious need for further studies and ongoing monitoring.



Coastal Hazard	Risk Priority Level	Action Required	Tolerance level	Broad Adaptation Option Category	Coastal adaptation actions
Inundation	High	Immediate to short-term action required to reduce risk to acceptable levels.	Tolerable	Accommodate	1. In the Port Denison, Granny's Beach and Surf Beach area: a. investigate potential inundation impacts and ascertain the need and viability for improving the inundation resilience of public infrastructure in this area (e.g. the sea wall between Granny's Beach and Surf Beach); b. investigate retrofitting urban drainage systems to accommodate fluvial flooding; c. investigate the need for coastal protection structures to protect/defend areas from erosion; d. continue to implement the Shire's Green Infrastructure Strategy and the Local Planning Policy for Water Sensitive Urban Design; and e. continue to monitor coastal processes. 2. Following consideration of further investigative studies, in the Port Denison, Granny's Beach and Surf Beach area, planning scheme modifications may be required, which identify: a. the future relocation of public infrastructure; and b. minimum finished floor levels in accordance with potential flood levels (e.g. there are 3 vacant freehold lots on the Foreshore).
Erosion	Extreme	Immediate action required to reduce risk to acceptable levels.	Unacceptable - Intolerable	Protect	

SOUTH BEACH NORTH

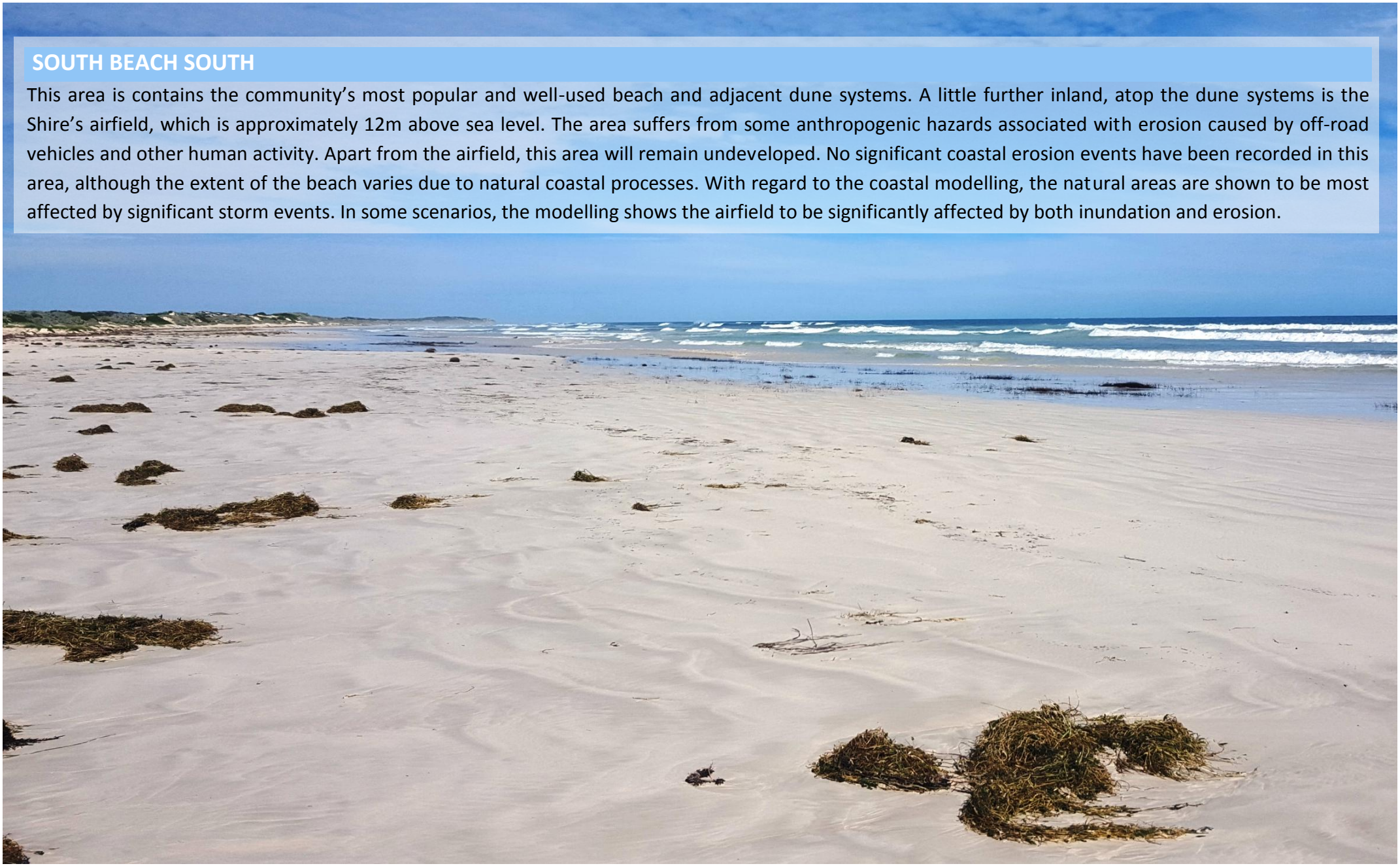
This area includes the beach and adjacent dunes and scrubland, a caravan park, a public road, a cafe and the Surf Lifesaving Club's shed. All of the land is public land. Development within the caravan site is expected to be controlled by an emerging Local Development Plan, which will take the requirements of SPP 2.6 into consideration (e.g. requirements for buildings to be relocated). The South Beach reserve is managed by the Shire of Irwin, and there is no expected need for further development. No significant coastal erosion events have been recorded in this area, although the car park and public road are experiencing inundation annually. The modelling shows that the caravan park will be unaffected by coastal inundation over the 96 years, but may be affected by erosion in the 2110 scenarios, which consider the potential impact of 0.9m and 1.5m sea level rises. The buildings near the public car park may be affected by inundation and erosion over the next 50 years.



Coastal Hazard	Risk Priority Level	Action Required	Tolerance	Broad Adaptation Option Category	Coastal adaptation actions
Inundation	Medium	Short to medium term action to reduce risk to acceptable levels, or accept risk.	Tolerable - Acceptable	Retreat	3. In South Beach (north), the Shire will: a. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area; b. ensure that all approved buildings are relocatable; c. monitor and allow natural processes to occur, and ensure the public are kept informed; and d. plan for the movement of public infrastructure around the south beach car park, when inundation and erosion threats materialise.
Erosion	Extreme	Immediate action required to eliminate or reduce risk to acceptable levels.	Unacceptable - Intolerable	Retreat	

SOUTH BEACH SOUTH

This area is contains the community's most popular and well-used beach and adjacent dune systems. A little further inland, atop the dune systems is the Shire's airfield, which is approximately 12m above sea level. The area suffers from some anthropogenic hazards associated with erosion caused by off-road vehicles and other human activity. Apart from the airfield, this area will remain undeveloped. No significant coastal erosion events have been recorded in this area, although the extent of the beach varies due to natural coastal processes. With regard to the coastal modelling, the natural areas are shown to be most affected by significant storm events. In some scenarios, the modelling shows the airfield to be significantly affected by both inundation and erosion.



Coastal Hazard	Risk Priority Level	Action Required	Tolerance	Broad Adaptation Option Category	Coastal adaptation actions
Inundation	High	Immediate to short-term action required to eliminate or reduce risk to acceptable levels	Tolerable	Retreat	4. In South Beach (south), the Shire will: a. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area; b. monitor and allow natural processes to occur and ensure the public are kept informed; and c. plan for the future relocation of the airfield by 2070, or sooner if threats materialise.
Erosion	Low	Immediate to short-term action required to eliminate or reduce risk to acceptable levels	Tolerable	Retreat	

SEASPRAY BEACH AND IRWIN RIVERMOUTH

This area is comprised of beaches and adjacent dune systems, a rivermouth, a coastal wetland system, public roads, boardwalks, a car park and public toilet and a caravan park. Most of this area is public land, with the exception of a freehold lot containing buildings associated with the caravan park. Erosion issues at the Seaspray Beach have unearthed infrastructure placed during the days of the crayfish factory. The modelling indicates that the most significant impacts for the Seaspray Beach area are likely to occur in the 2110 scenarios, where the 0.9m and 1.5m rises in sea levels were considered. The Irwin Rivermouth area is likely to be much more sensitive to significant inundation and erosion events across the 94 year period.



Coastal Hazard	Risk Priority Level	Action Required	Tolerance	Broad Adaptation Option Category	Coastal adaptation actions
Inundation	High	Immediate to short-term action required to eliminate or reduce risk to acceptable levels	Tolerable	Retreat	5. In the Seaspray Beach area: a. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area; b. ensure that all approved buildings within the caravan park are relocatable; c. monitor and allow natural processes to occur, and ensure the public are kept informed; and d. plan for the movement of public and private infrastructure when threats materialise. 6. In the Irwin Rivermouth area: a. Continue to educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area; b. carry out flood modelling of the Irwin River, including an analysis of combined river flooding and coastal impacts; c. monitor and allow natural processes to occur, and ensure the public are kept informed; and d. plan for the movement of public infrastructure when threats materialise.
Erosion	Extreme	Immediate action required to eliminate or reduce risk to acceptable levels.	Unacceptable - Intolerable	Retreat	

SEVEN MILE BEACH

Seven Mile Beach is comprised of beaches and associated dunes systems, a public car park and public road. The car park is used for overnight camping and recreational fishing. In October 2103, the car park was eroded leaving 1.5m drop to the beach. The dune heading south has undergone extensive erosion through the winter months. The area suffers from some anthropogenic hazards associated with erosion caused by off-road vehicles, uncontrolled pedestrian activity, stock and feral animal grazing and bushfire hazards. The modelling shows the natural areas may be affected in most scenarios. The car park and public road are shown to be affected by erosion in the 2070 (0.5m sea level rise) and 2110 (0.9m and 1.5m sea level rise) scenarios.



Coastal Hazard	Risk Priority Level	Action Required	Tolerance	Broad Adaptation Option Category	Coastal adaptation actions
Inundation	Low	Accept risk.	Tolerable - Acceptable	Retreat	7. In the Seven Mile Beach area: a. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area; b. monitor and allow natural processes to occur, and ensure the public are kept informed; and c. plan for the movement of public infrastructure when threats materialise.
Erosion	Medium	Short to medium term action to reduce risk to acceptable levels, or accept risk.	Acceptable	Retreat	

FRESHWATER POINT

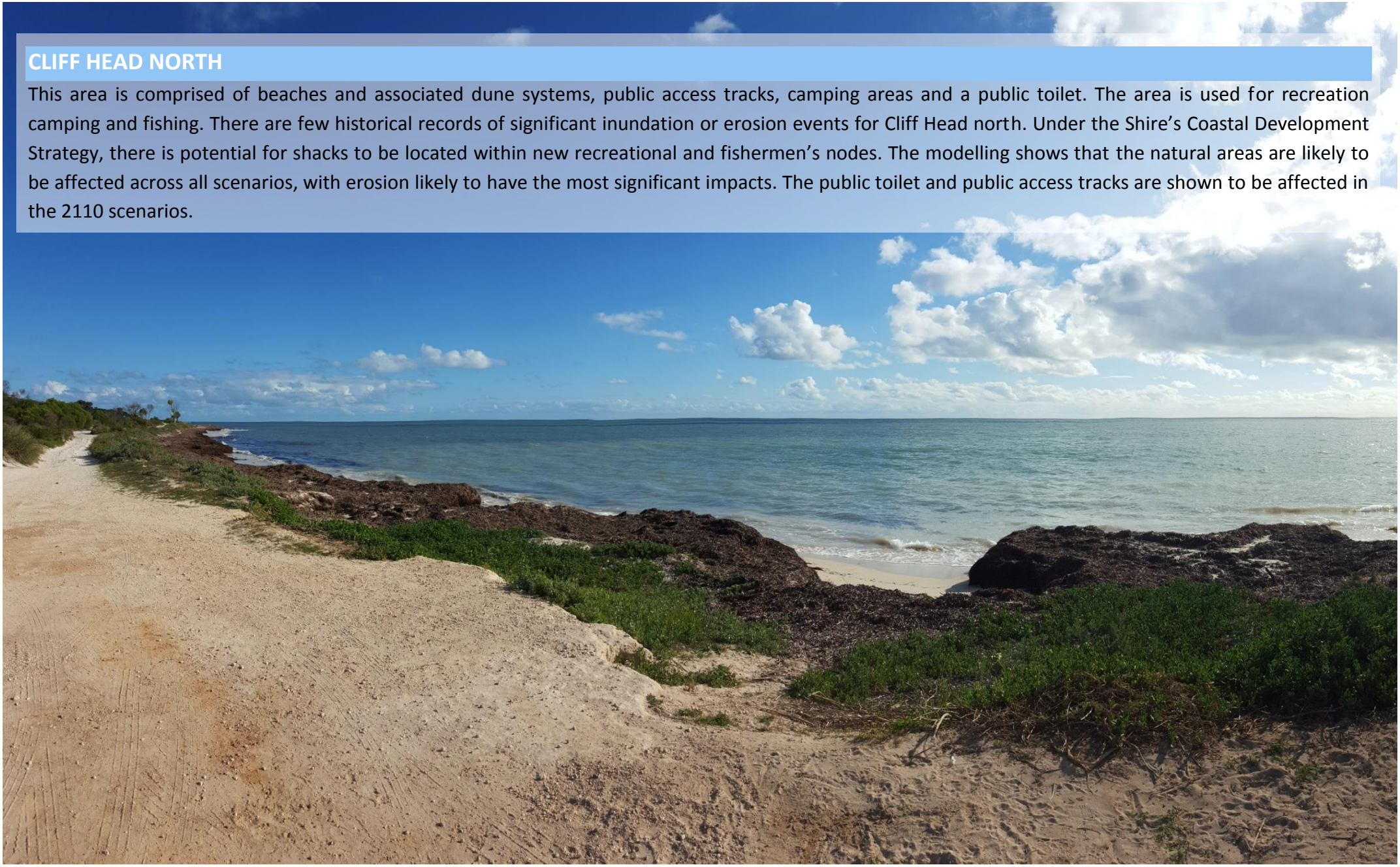
This area is comprised of limestone shoulder that protects a small bay, beaches and adjoining scrubland, a public access track and parking area, public toilet and a number of shacks and other structures associated with the fishing industry. A number of shacks and structure have been recently removed due to the shrinking coastline in this location. The area is used by overnight campers and fishermen. Under the Shire's Coastal Development Strategy, there is potential for shacks to be located within new recreational and fishermen's nodes. As the modelling methodology did not discern between rock types, the inundation and erosion maps may not be particularly reliable in the way they show the limestone shoulder to be affected. The modelling shows the natural areas will be affected in most scenarios and that the private and public infrastructure would be most threatened by the erosion scenarios.



Coastal Hazard	Risk Priority Level	Action Required	Tolerance	Broad Adaptation Option Category	Coastal adaptation actions
Inundation	Low	Accept risk	Acceptable	Retreat	8. In the Freshwater Point Area: a. ensure that all approved buildings are relocatable; b. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area; c. monitor and allow natural processes to occur, and ensure the public are kept informed; and d. plan for the movement of public infrastructure when threats materialise.
Erosion	High	Immediate to short-term action required to eliminate or reduce risk to acceptable levels	Tolerable	Retreat	

CLIFF HEAD NORTH

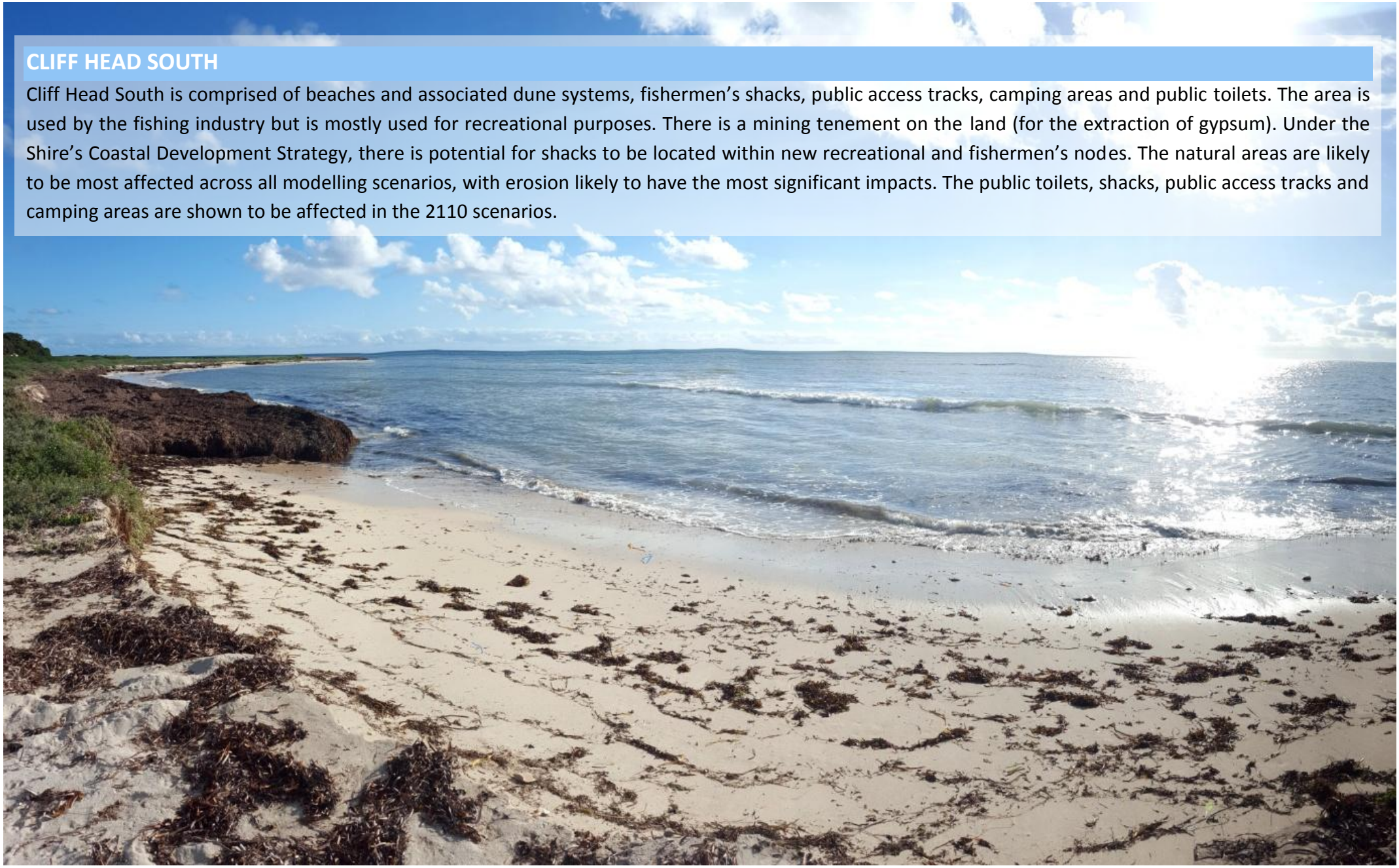
This area is comprised of beaches and associated dune systems, public access tracks, camping areas and a public toilet. The area is used for recreation camping and fishing. There are few historical records of significant inundation or erosion events for Cliff Head north. Under the Shire's Coastal Development Strategy, there is potential for shacks to be located within new recreational and fishermen's nodes. The modelling shows that the natural areas are likely to be affected across all scenarios, with erosion likely to have the most significant impacts. The public toilet and public access tracks are shown to be affected in the 2110 scenarios.



Coastal Hazard	Risk Priority Level	Action Required	Tolerance	Broad Adaptation Option Category	Coastal adaptation actions
Inundation	Low	Accept risk.	Acceptable	Retreat	9. In the Cliff Head North area: a. ensure that all approved buildings are relocatable; b. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area; c. monitor and allow natural processes to occur, and ensure the public are kept informed; and d. plan for the movement of public infrastructure when threats materialise.
Erosion	High	Immediate to short-term action required to eliminate or reduce risk to acceptable levels.	Tolerable	Retreat	

CLIFF HEAD SOUTH

Cliff Head South is comprised of beaches and associated dune systems, fishermen's shacks, public access tracks, camping areas and public toilets. The area is used by the fishing industry but is mostly used for recreational purposes. There is a mining tenement on the land (for the extraction of gypsum). Under the Shire's Coastal Development Strategy, there is potential for shacks to be located within new recreational and fishermen's nodes. The natural areas are likely to be most affected across all modelling scenarios, with erosion likely to have the most significant impacts. The public toilets, shacks, public access tracks and camping areas are shown to be affected in the 2110 scenarios.



Coastal Hazard	Priority	Action Required	Tolerance	Broad Adaptation Option Category	Coastal adaptation actions
Inundation	Low	Accept risk.	Acceptable	Retreat	10. In the Cliff Head South area: a. ensure that all approved buildings are relocatable; b. educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area; c. monitor and allow natural processes to occur, and ensure the public are kept informed; and d. plan for the movement of public infrastructure when threats materialise.
Erosion	High	Immediate to short-term action required to eliminate or reduce risk to acceptable levels.	Tolerable	Retreat	

IMPLEMENTATION PLAN

Priority	Action	Timeframe	Responsibility
High	In the Port Denison, Granny's Beach and Surf Beach area: a. investigate potential inundation impacts and ascertain the need and viability for improving the inundation resilience of public infrastructure in this area (e.g. the sea wall between Granny's Beach and Surf Beach); b. investigate retrofitting urban drainage systems to accommodate fluvial flooding; c. investigate the need for coastal protection structures to protect/defend areas from erosion.	July 2021	Shire of Irwin / Department of Planning / Department of Transport
High	Carry out flood modelling of the Irwin River, including an analysis of combined river flooding and coastal impacts	July 2021	Shire of Irwin
Medium	In all coastal areas where new buildings are proposed, ensure all buildings are relocatable.	As need arises	Shire of Irwin
Medium	In urban areas - continue to implement the Shire's Green Infrastructure Strategy and the Local Planning Policy for Water Sensitive Urban Design.	Ongoing	Shire of Irwin
Medium	Modifications to Planning Scheme	As need arises	Shire of Irwin / WAPC
Medium	In all areas, educate the public about the area's natural communities and sensitive habitats and encourage public appreciation and environmentally sound recreational enjoyment of the area.	Ongoing	Shire of Irwin
Medium	In all areas monitor and allow natural processes to occur, and ensure the public are kept informed.	Ongoing	Shire of Irwin / NACC
Low	Plan for the future relocation of the airfield by 2070, or sooner if threats materialise.	2031 (or sooner, if required)	Shire of Irwin / WAPC



MONITORING AND REVIEW

The CHRMAP will be monitored by:

- providing Council with annual reports on the coastal adaptation actions, at the next opportunity, outstanding actions incorporated into the Shire's Community Strategic Plan and Corporate Business Plan;
- recording the impacts of significant inundation and erosion events;
- continuing photographic monitoring of the coastline through NACC's photomon app;
- continuing to manage public access areas through Council by-laws and policies.

The CHRMAP will be reviewed every five years and updated as required, and will inform the Shire's Local Planning Strategy and Local Planning Scheme.

This CHRMAP does not include the Knobby Head or Little Mexico coastal nodes. A future review should carry out a risk assessment and evaluation process for the inundation and erosion maps for these areas.



CONSULTATION AND EDUCATION

The Shire of Irwin developed the CHRMAP in partnership with Curtin University, NACC, and in close consultation with the Department of Planning and the Department of Transport. A Steering Committee incorporating individuals from the partnership and consultees met bi-monthly to ensure the CHRMAP project stayed on course and met the requirements of SPP 2.6. A community workshop was held in April 2015 to present the CHRMAP project, identify coastal hazard risks and receive community feedback. NACC facilitated two risk analysis and evaluation workshops with Shire Councillors and Officers to analyse the modelling results.

The draft CHRMAP was reviewed by the Steering Committee, prior to being workshopped with the community and publicly advertised. The draft was also referred to a number of state government agencies for comment.

Appendix One – Inundation and Erosion Maps for Hazard Areas

(source: Curtin University)

These maps will demonstrate the modelling results for Inundation, and then Erosion for each study area. These are the initial modelling results, identified study areas will be subject to further modelling research.

The Average Recurring Interval (ARI) is way of expressing the likelihood of occurrence of a storm event e.g. a 100 year storm event is likely to happen, on average, once in a 100 years or 1% chance of happening in any one year.

Limitations of the Inundation and Erosion Maps include:

- **The entire coastline was taken to be sandy beach, as there was no geotechnical data available,**
- **The sea wall in front of the Big 4 Caravan Park was not considered, as there was no survey data available, and**
- **Other coastline data used in the study was over 20 years old**

The modelling result scenarios are as follows;

Scenario	Sea Level Rise (SLR)	Year
1	0.0 metre	Current
2	0.5 metre	2070
3	0.9 metre	2110
4	1.5 metre	2110



Integrated inundation map of Port Denison at present (0.0m SLR)



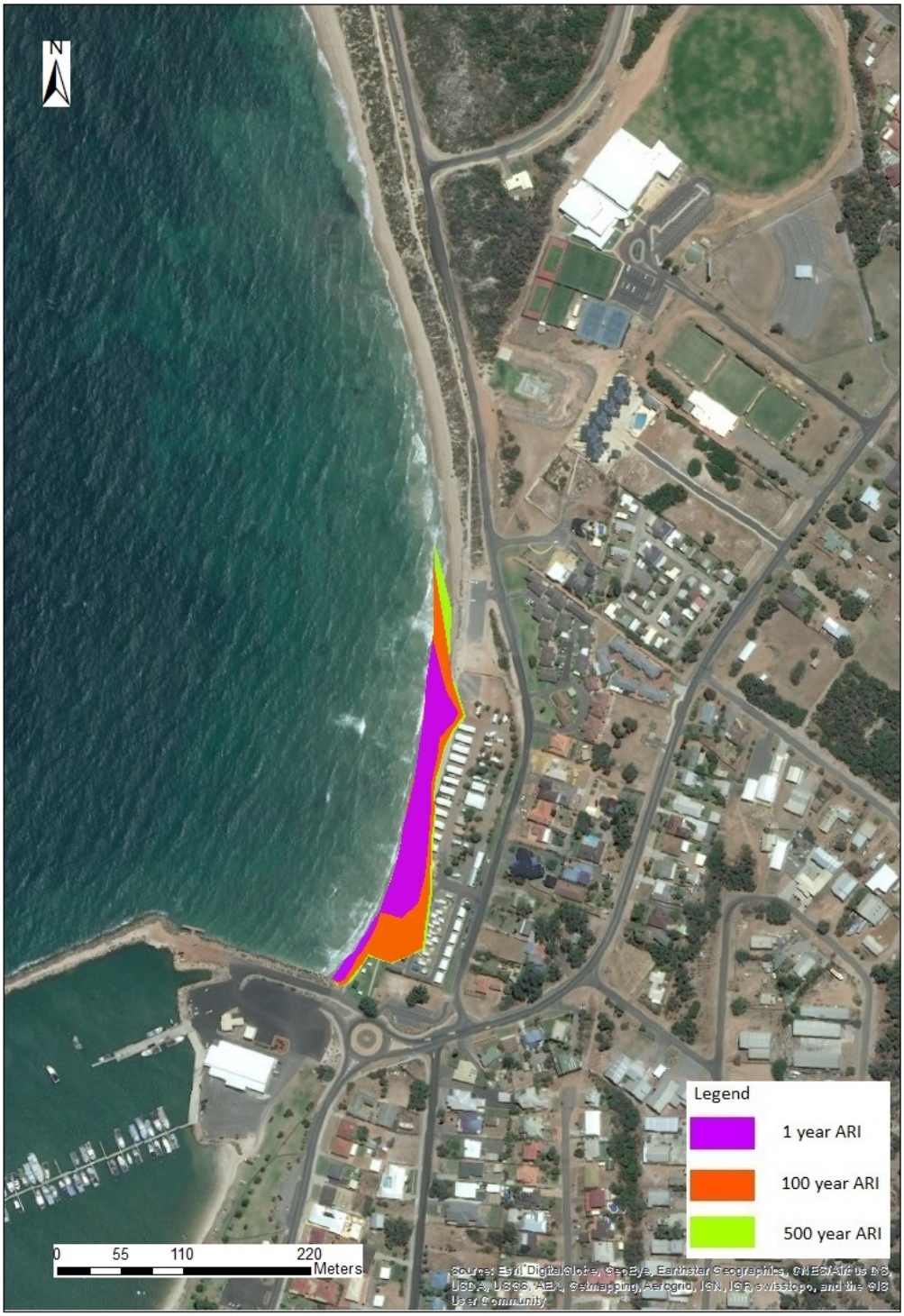
Integrated inundation map of Port Denison in 2070 (0.5m SLR)



Integrated inundation map of Port Denison in 2110 (0.9m SLR)



Integrated inundation map of Port Denison in 2110 (1.5m SLR)



Integrated erosion map of Granny's Beach /Surf Beach at present (0.0m SLR)



Integrated erosion map of Granny's Beach /Surf Beach in 2110 (0.5m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Granny's Beach /Surf Beach in 2110 (0.9m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Granny's Beach/Surf Beach in 2110 (1.5m SLR) + (Shore line movement + allowance for uncertainty)



Integrated inundation map of South Beach (North) at present (0.0 m SLR)



Integrated inundation map of South Beach (North) in 2070 (0.5 m SLR)



Inundation map of South Beach (North) in 2110 (0.9 m SLR)



: Inundation map of South Beach (North) in 2110 (1.5m SLR)



Integrated erosion map of South Beach (North) at present (0m SLR)



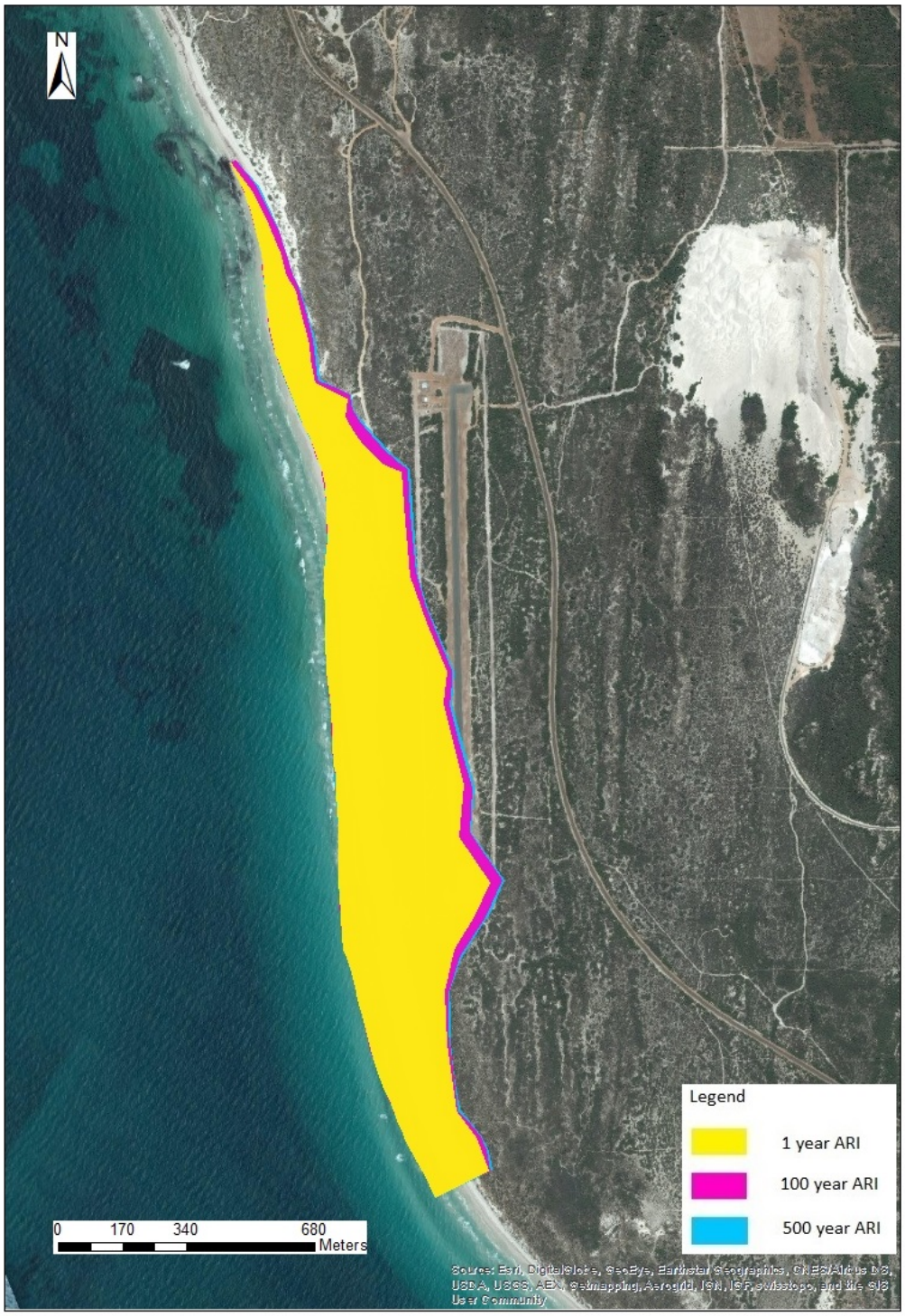
Integrated erosion map of South Beach (North) in 2070 (0.5m SLR) + (Shore line movement + allowance for uncertainty)



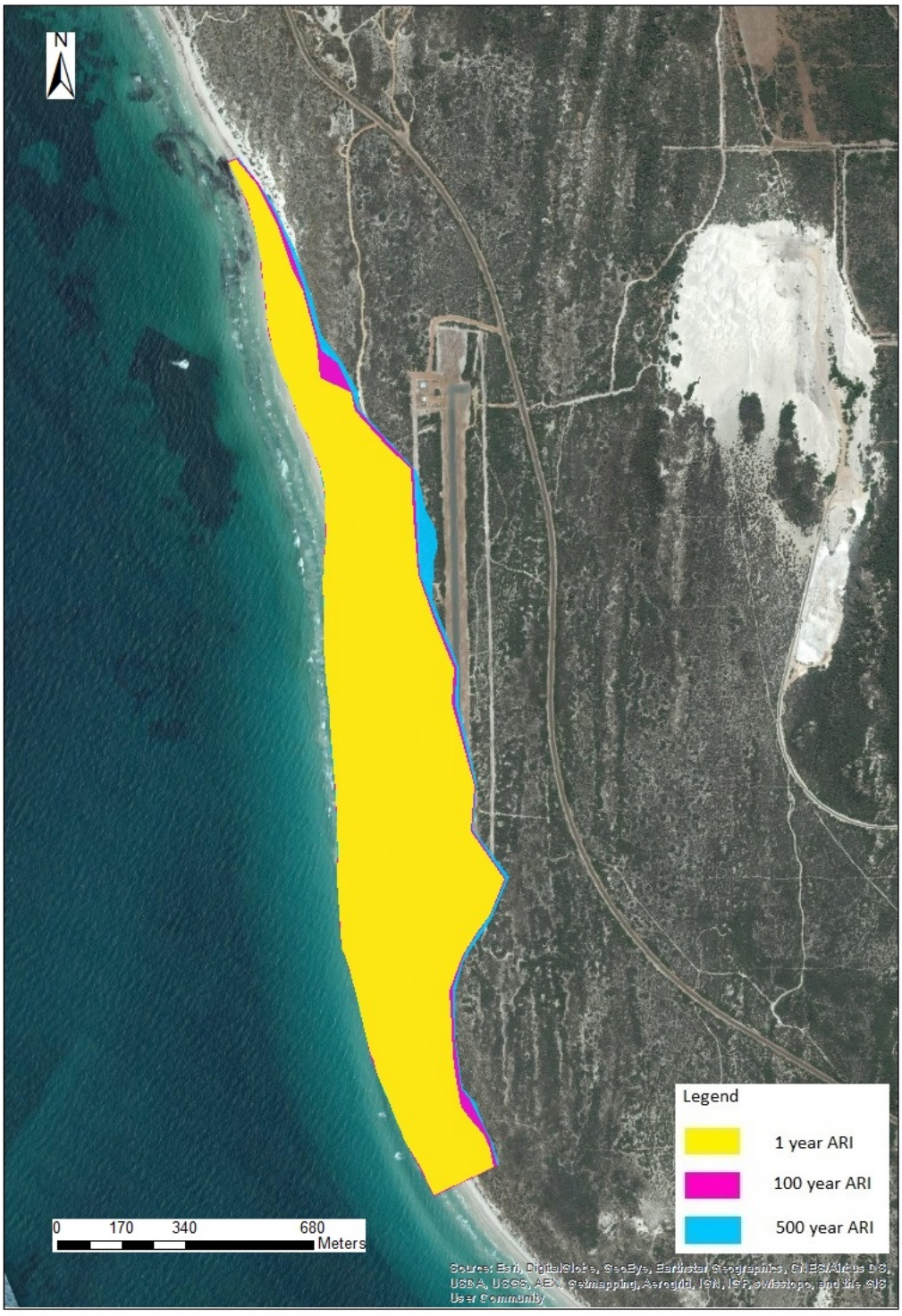
Integrated erosion map of South Beach (North) in 2110 (0.9m SLR) + (Shore line movement + allowance for uncertainty)



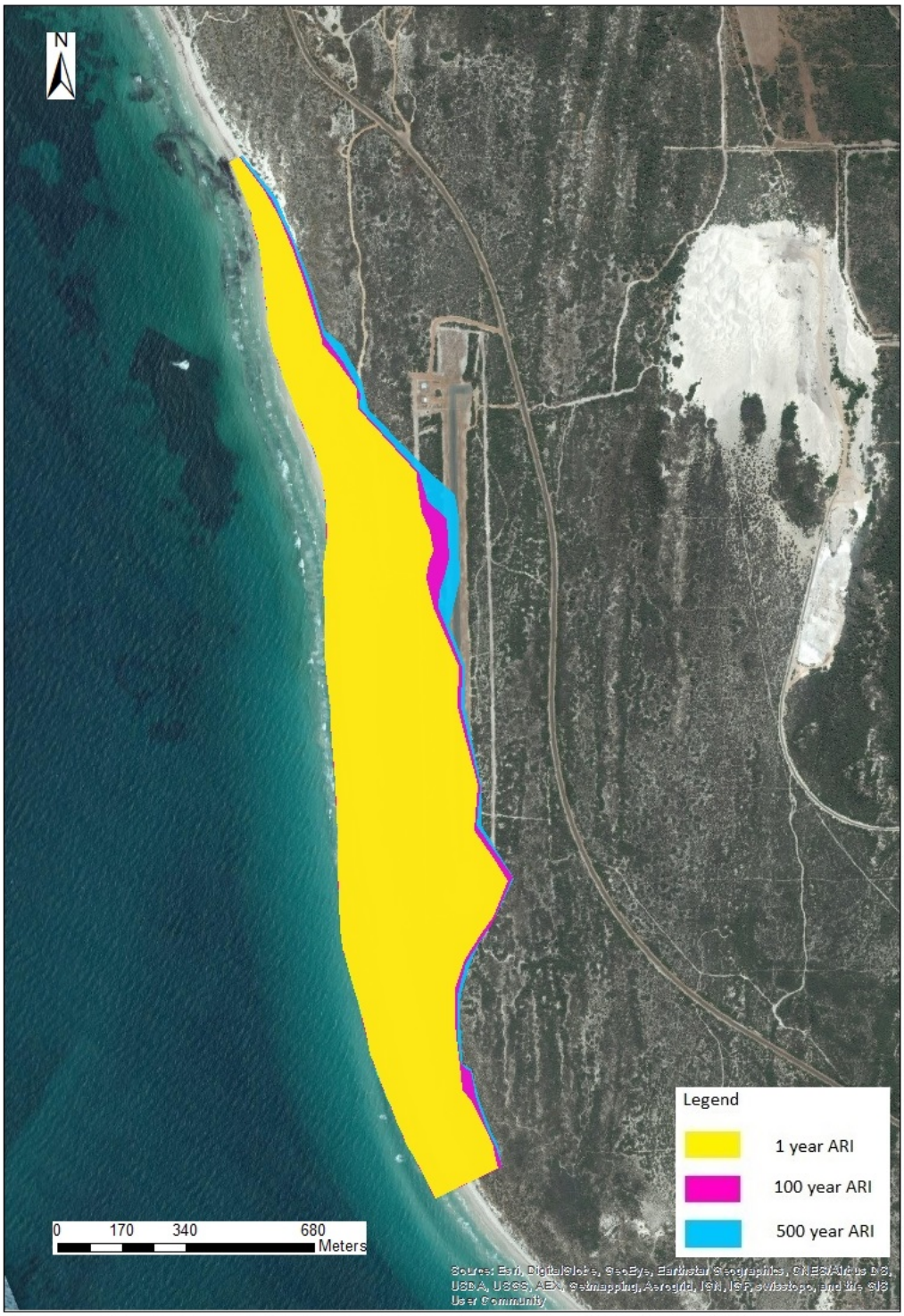
Integration erosion map of South Beach (North) -500 in 2110 (1.5m SLR) + (Shore line movement + allowance for uncertainty)



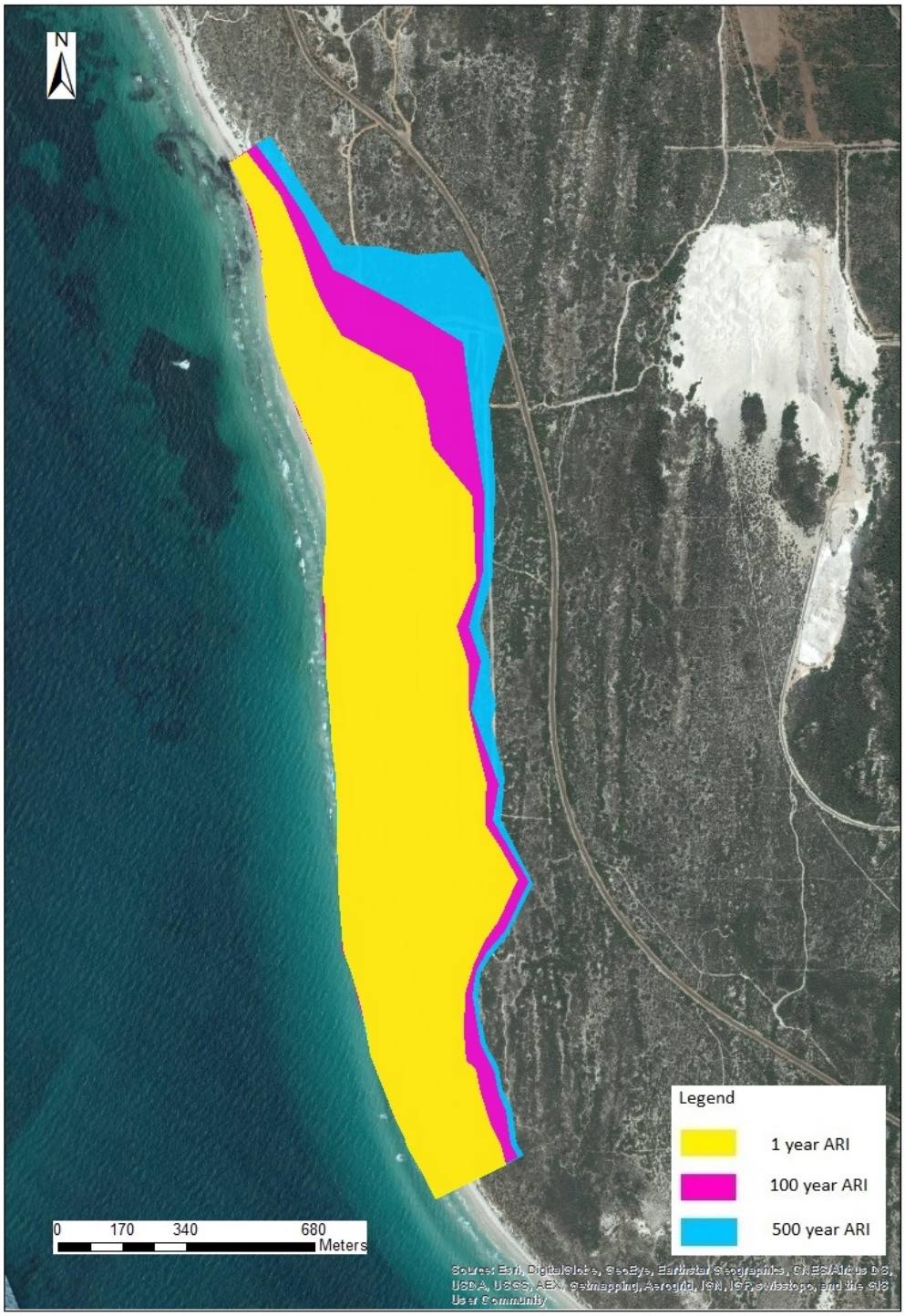
Integrated inundation map of South Beach at present (0.0 m SLR)



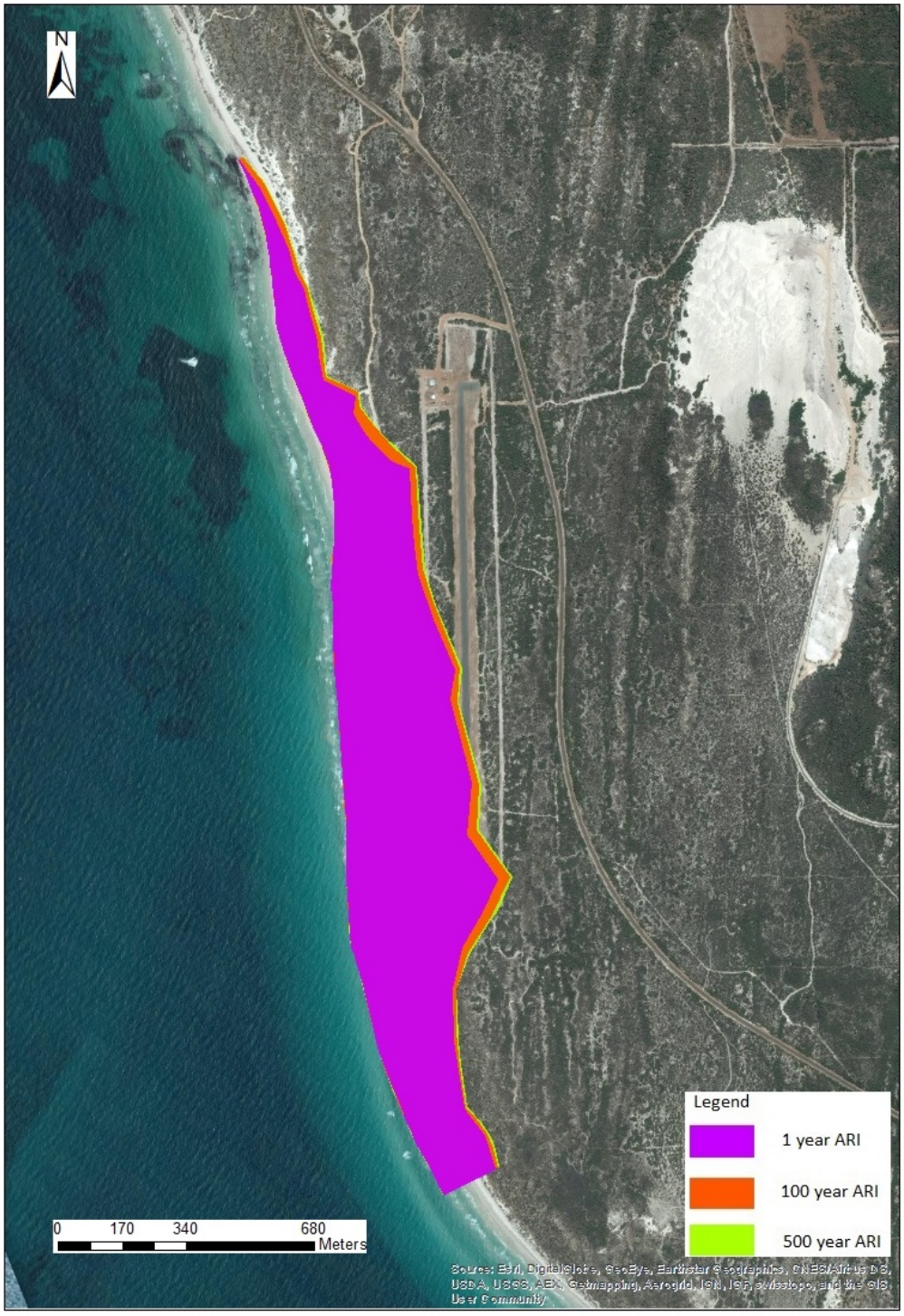
Integrated inundation map of South Beach in 2070 (0.5 m SLR)



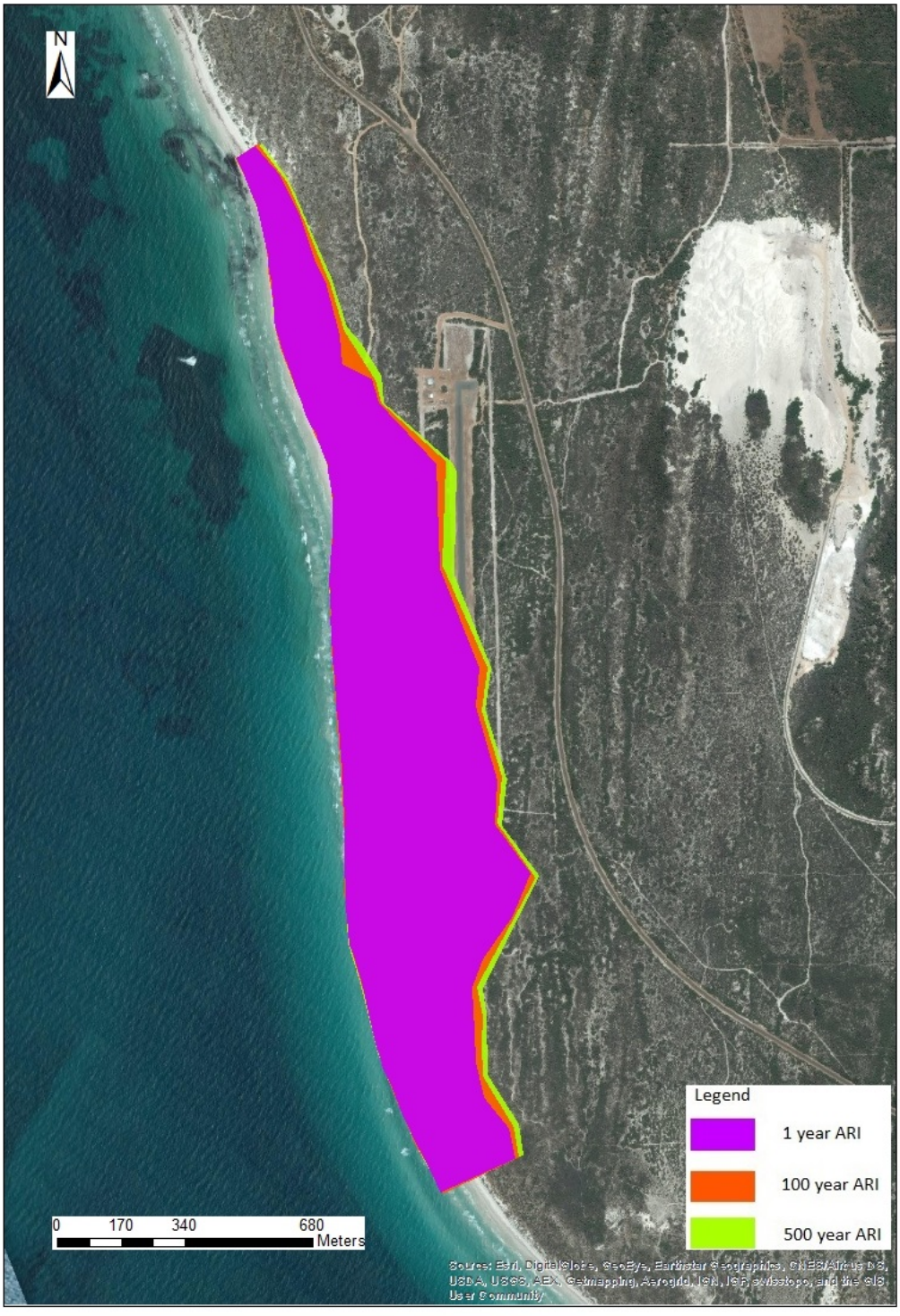
Inundation map of South Beach in 2110 (0.9 m SLR)



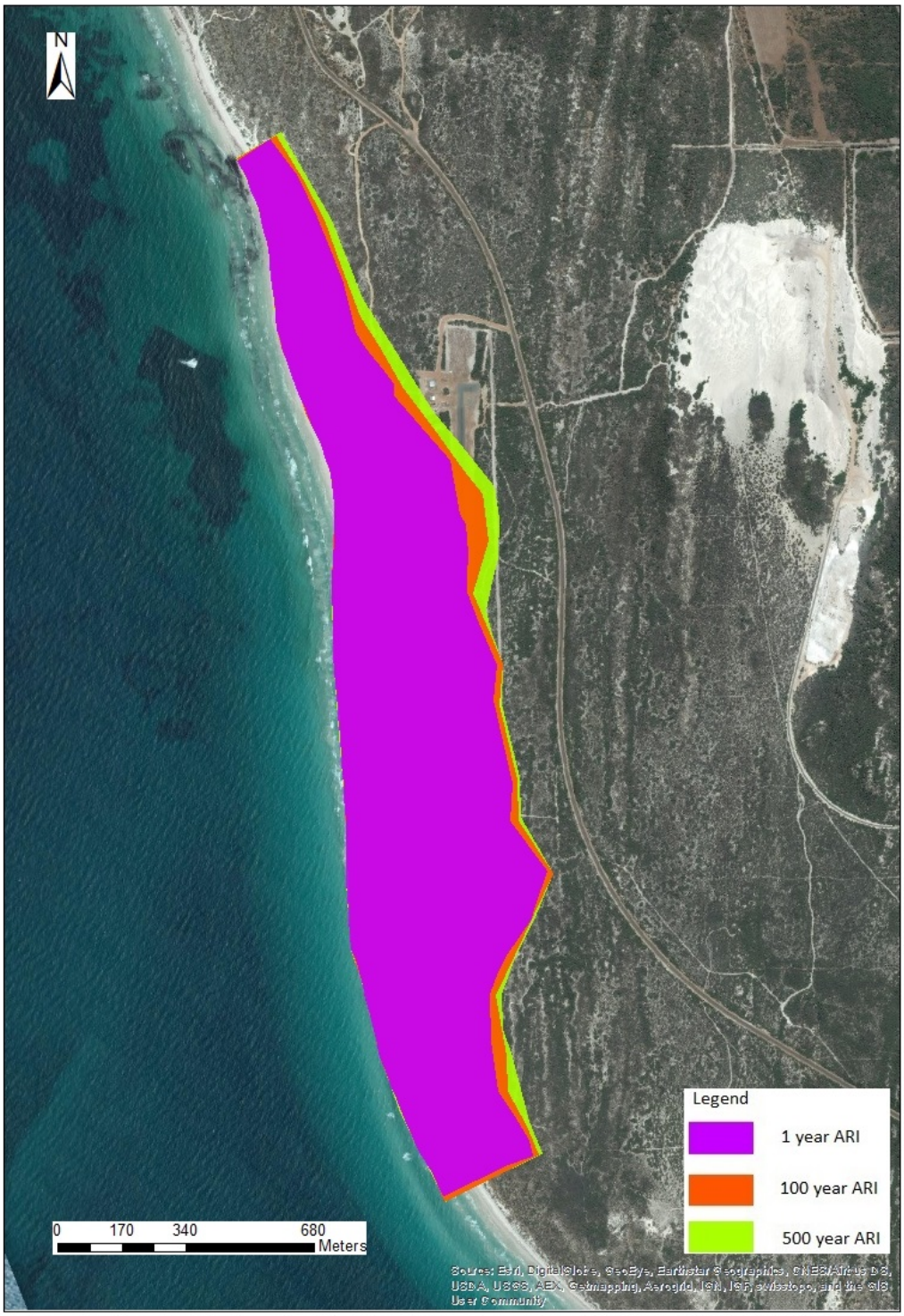
Inundation map of South Beach in 2110 (1.5m SLR)



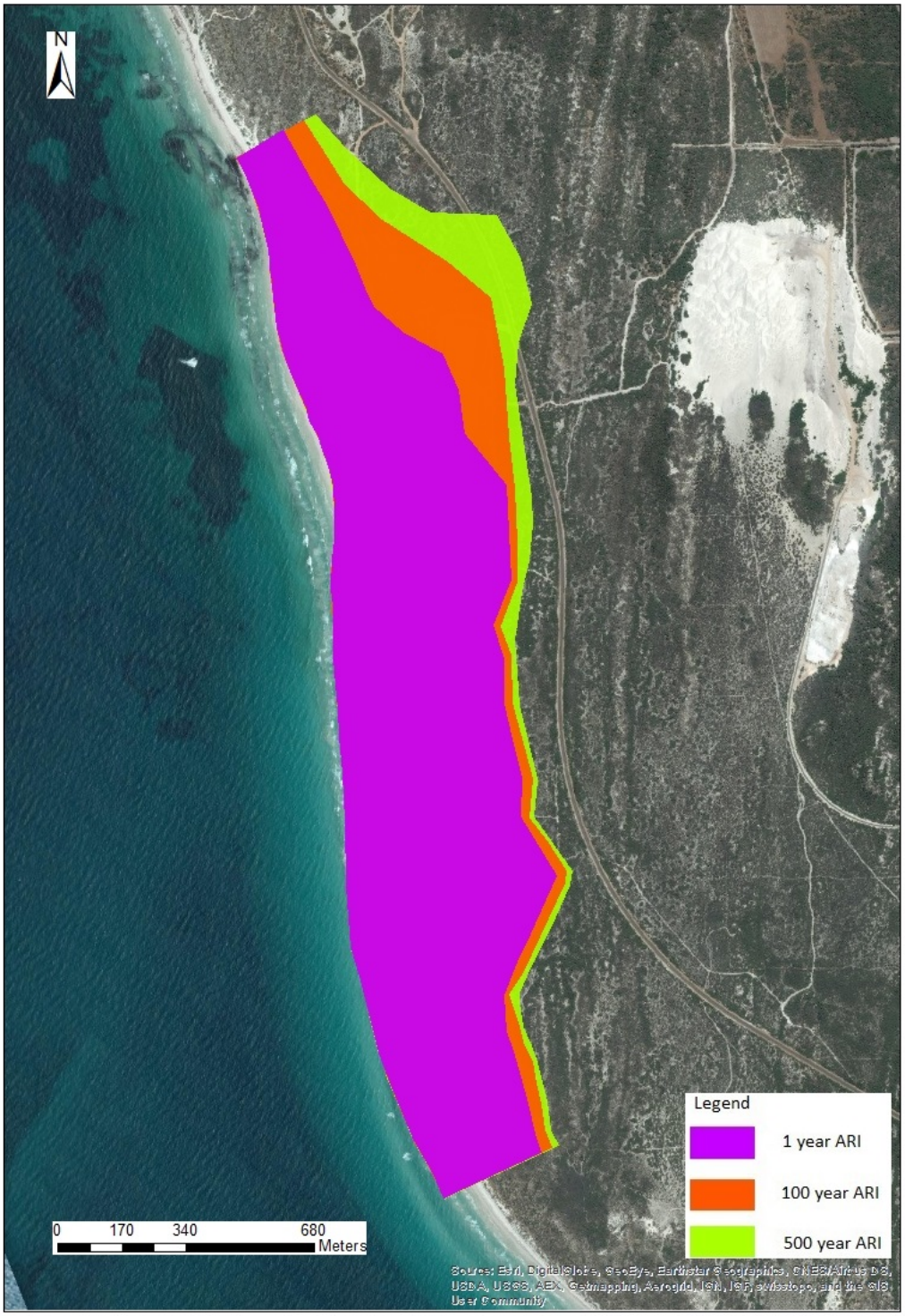
Integrated erosion map of South Beach at present (0m SLR)



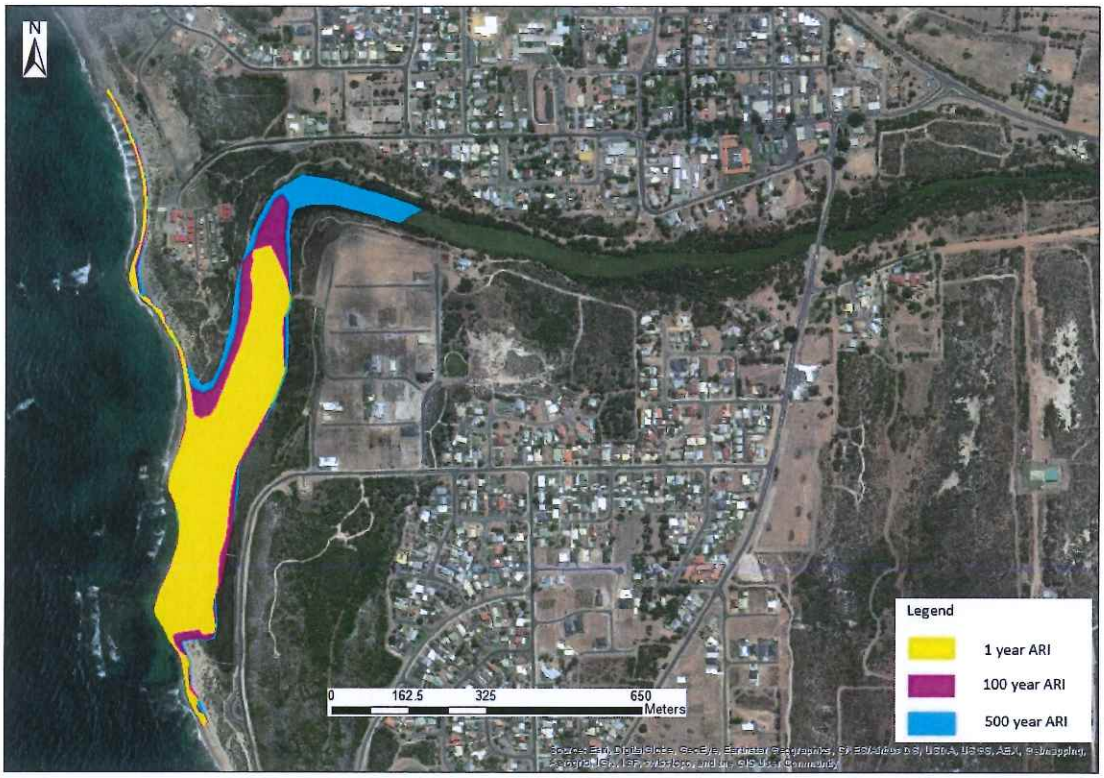
Integrated erosion map of South Beach in 2070 (0.5m SLR) + (Shore line movement + allowance for uncertainty)



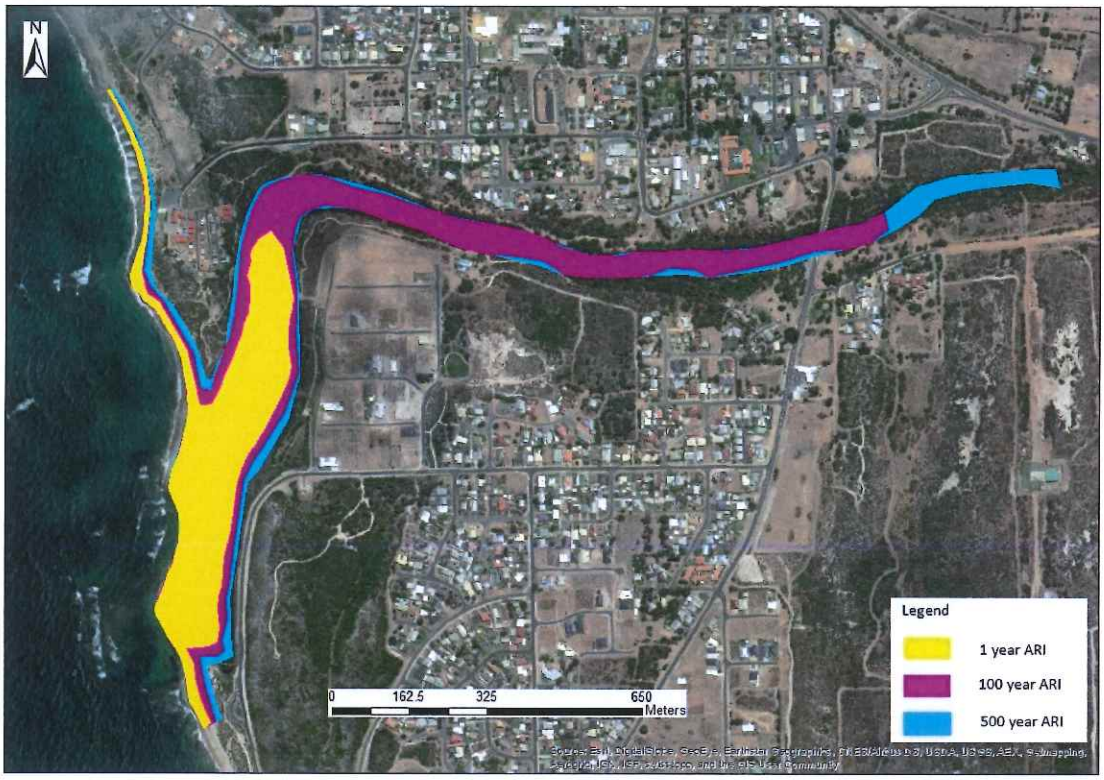
Integrated erosion map of South Beach in 2110 (0.9m SLR) + (Shore line movement + allowance for uncertainty)



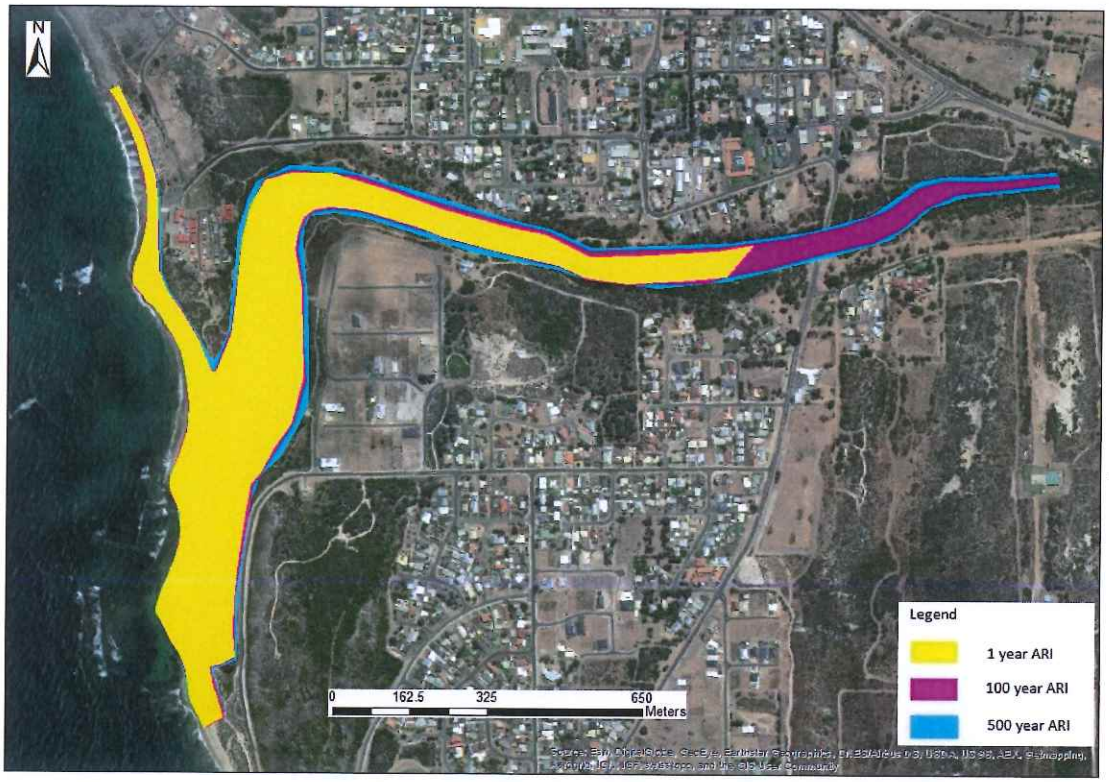
Integration erosion map of South Beach -500 in 2110 (1.5m SLR) + (Shore line movement + allowance for uncertainty)



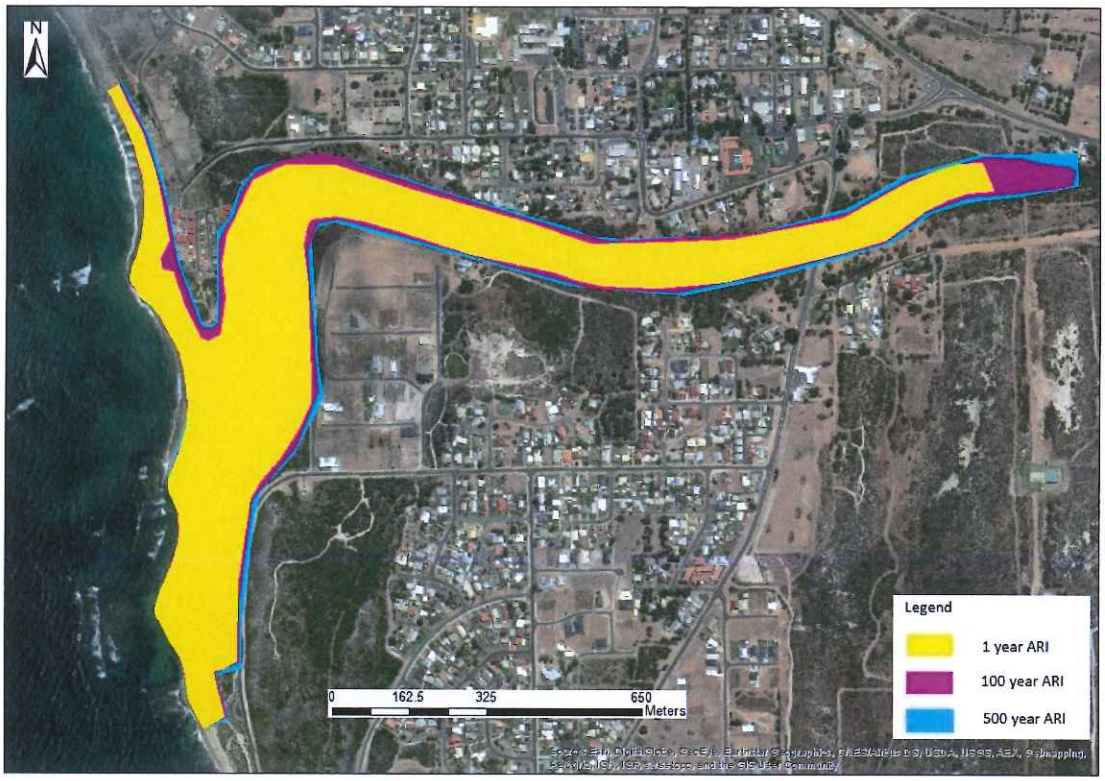
Integrated Inundation map of Seaspray Beach at Present (0 m SLR)



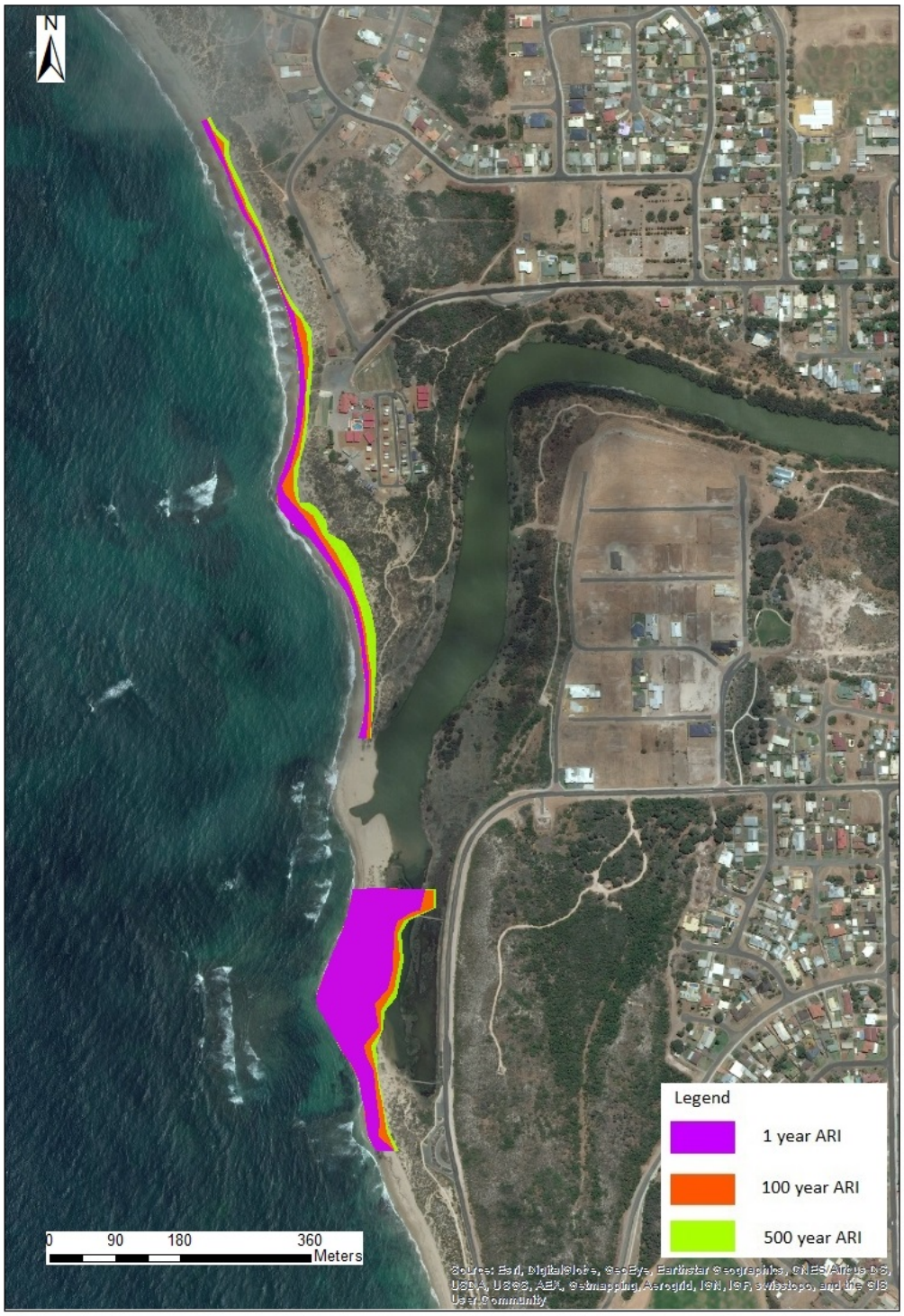
Integrated Inundation map of Seaspray Beach in 2070 (0.5m SLR)



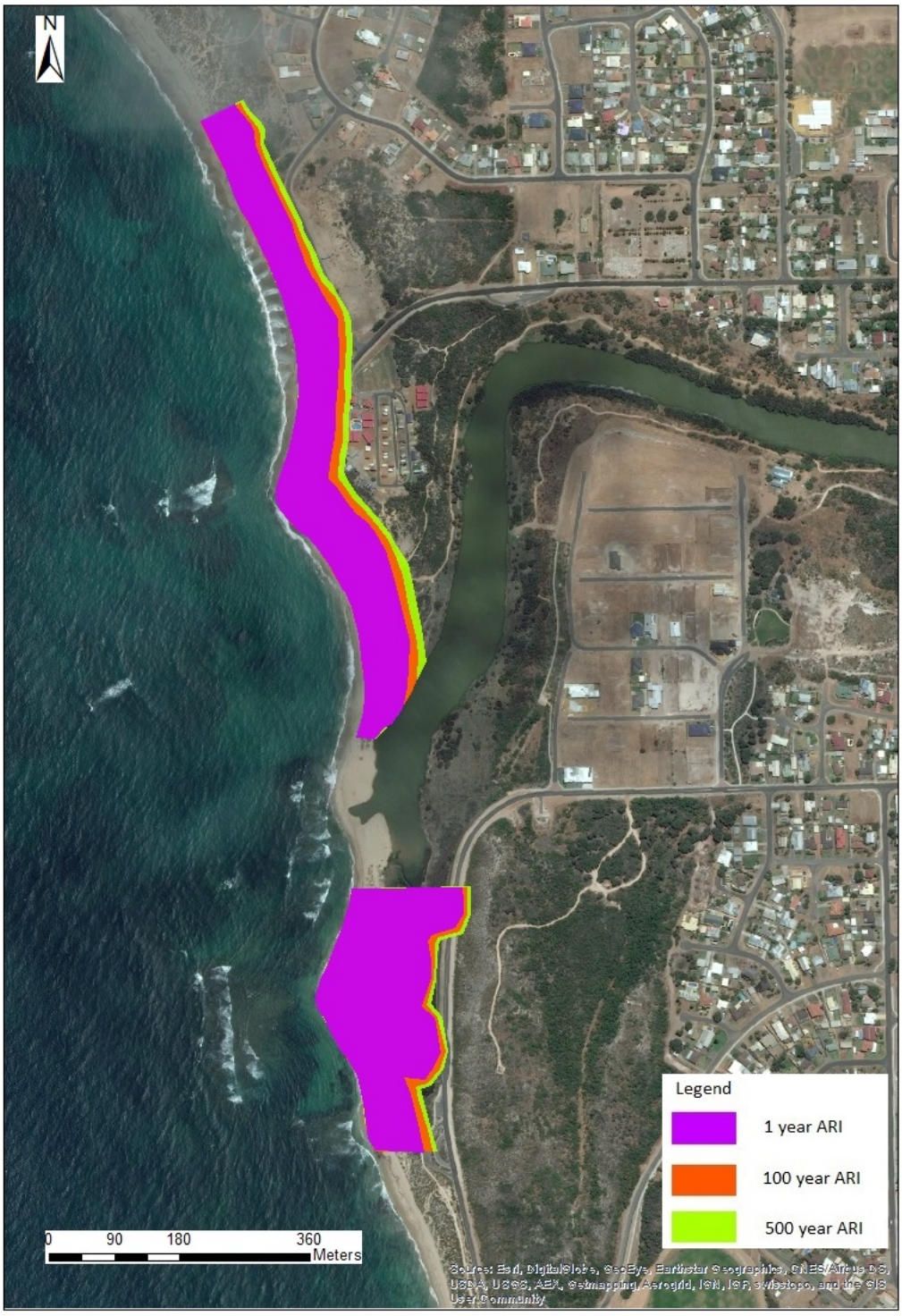
Inundation map of Seaspray Beach in 2110 (0.9m SLR)



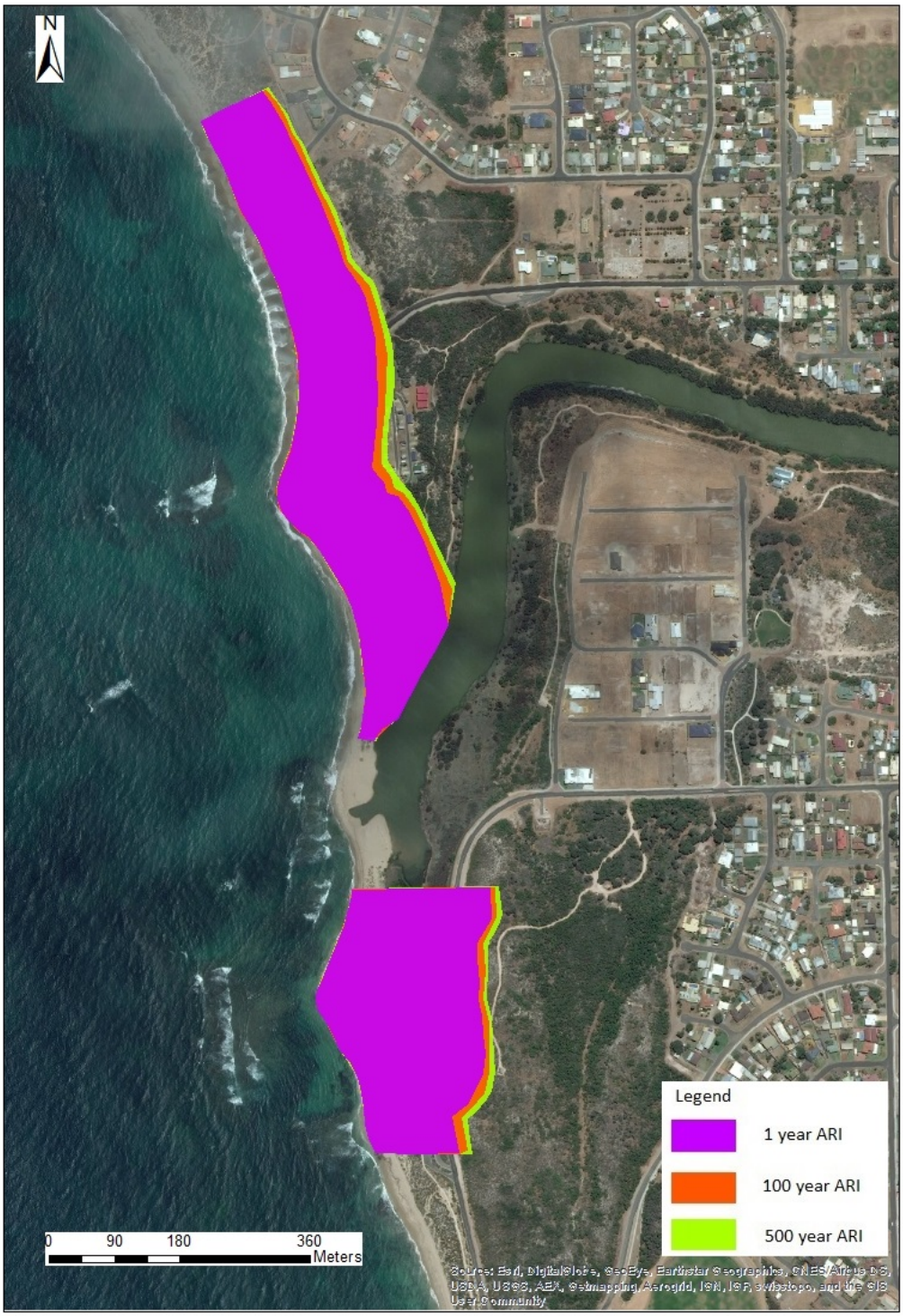
Inundation map of Seaspray Beach in 2110 (1.5 m SLR)



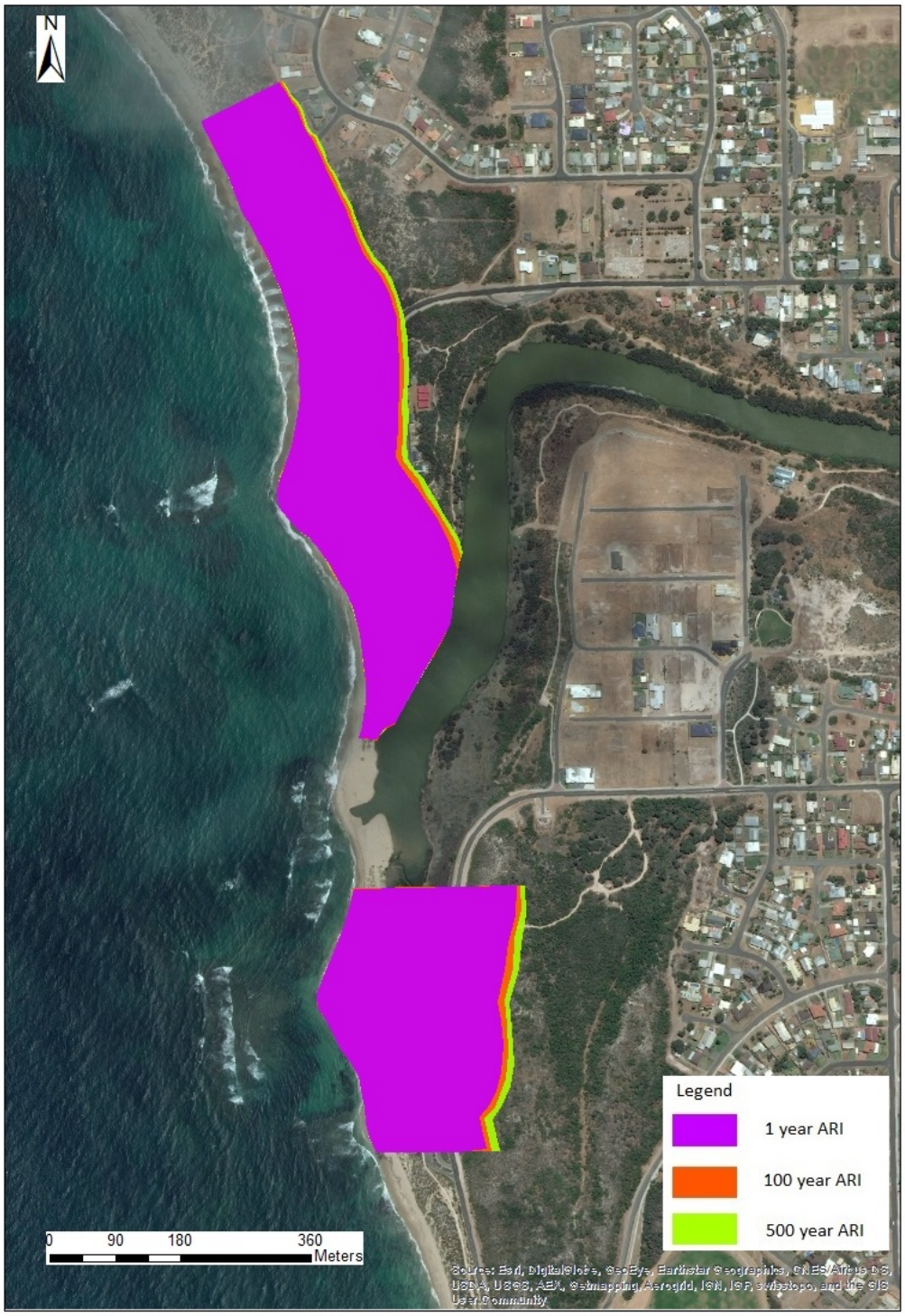
Integrated erosion map of Seaspray Beach at present (0.0m SLR)



Integrated erosion map of Seaspray Beach in 2070 (0.5m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Seaspray Beach in 2110(0.9m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Seaspray Beach in 2110(1.5m SLR) + (Shore line movement + allowance for uncertainty)



Integrated inundation map of Seven Mile Beach at Present (0.0 m SLR)



Integrated inundation map of Seven Mile Beach in 2070 (0.5 m SLR)



Integrated inundation map of Seven Mile Beach in 2110 (0.9 m SLR)



Integrated inundation map of Seven Mile Beach in 2110 (1.5 m SLR)



Integrated erosion map of Seven Mile Beach at present (0.0m SLR)



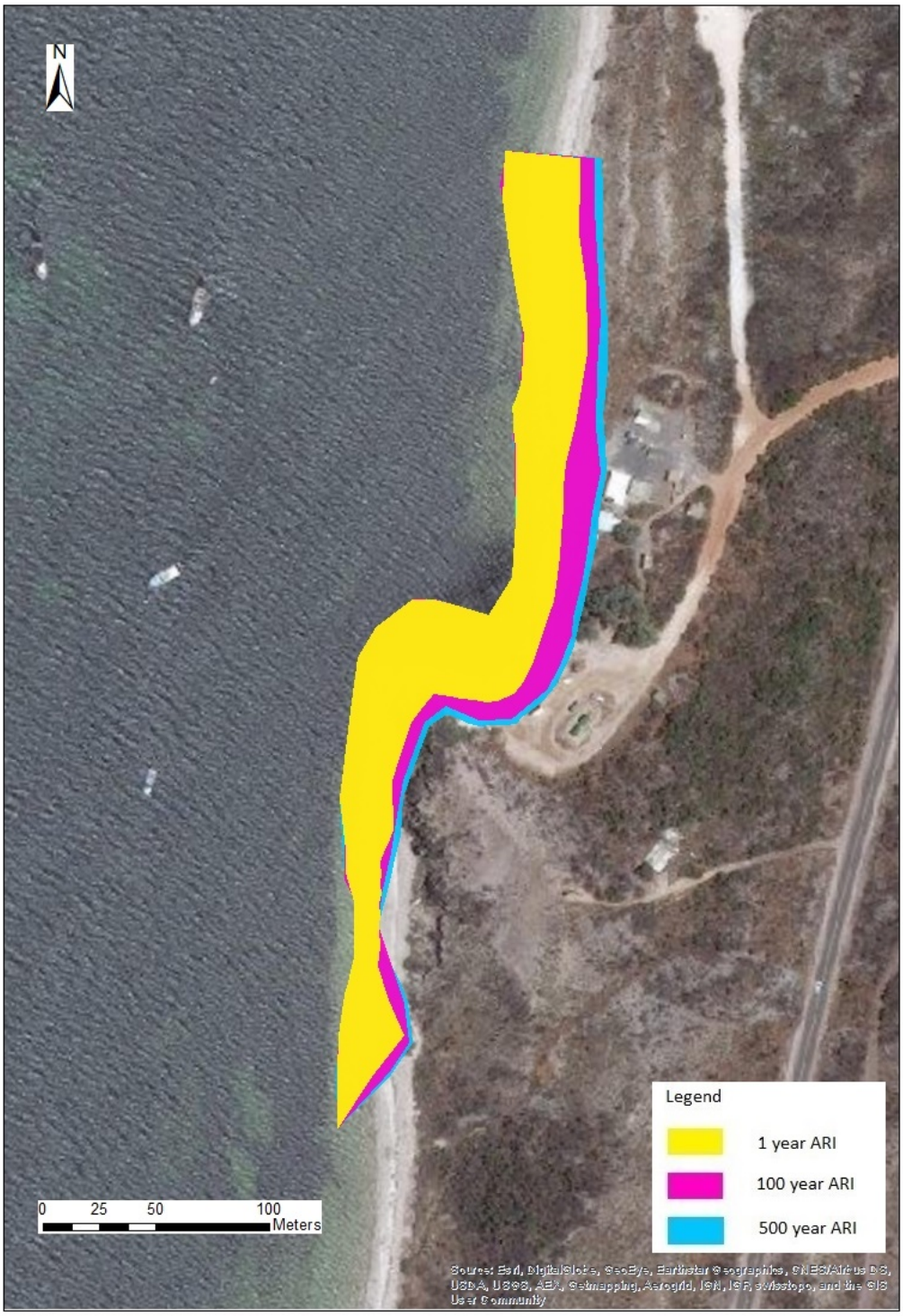
Integrated erosion map of Seven Mile Beach in 2070 (0.5m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Seven Mile Beach in 2110(0.9m SLR) + (Shore line movement + allowance for uncertainty)



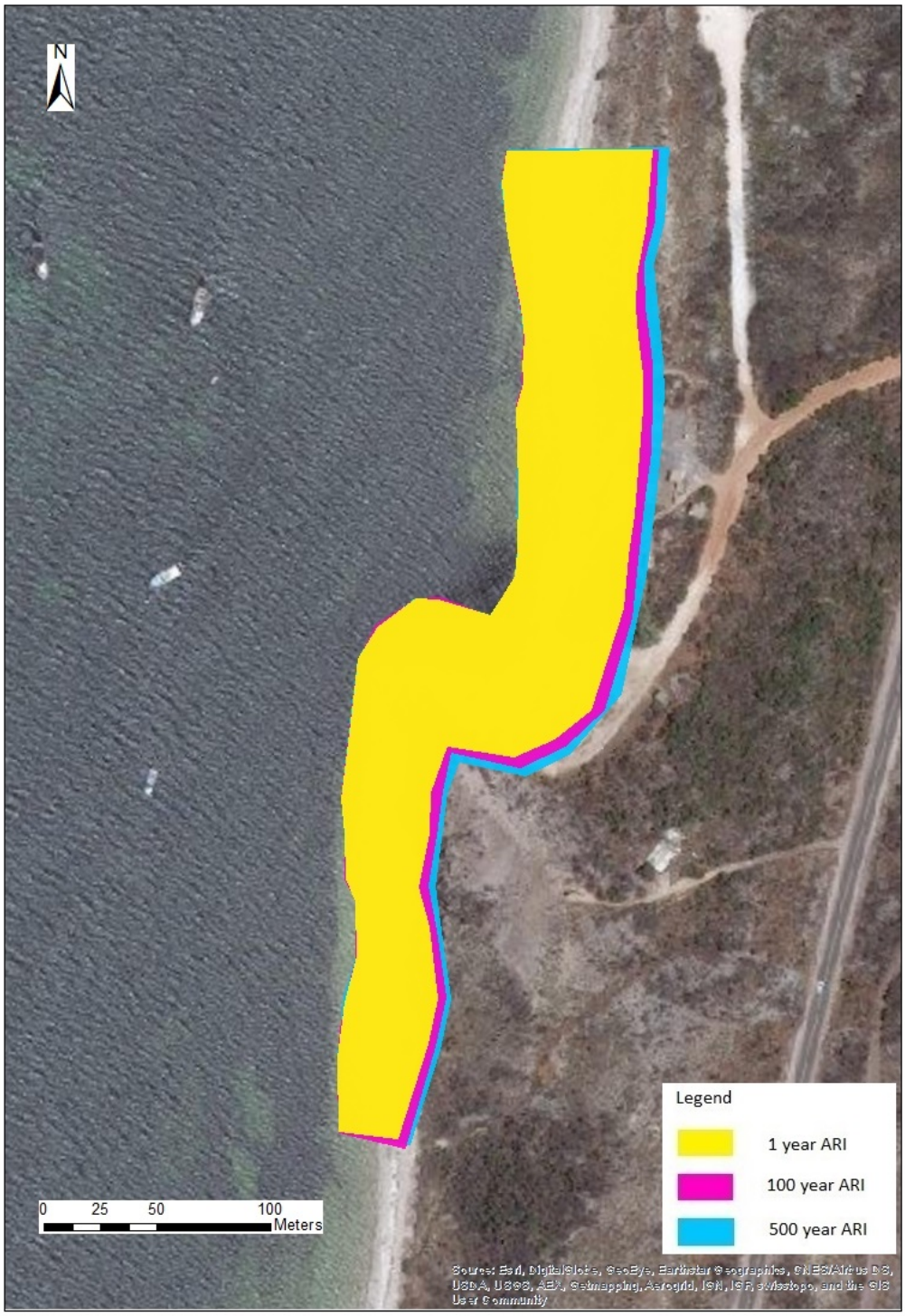
Integrated erosion map of Seven Mile Beach in 2110(1.5m SLR) + (Shore line movement + allowance for uncertainty)



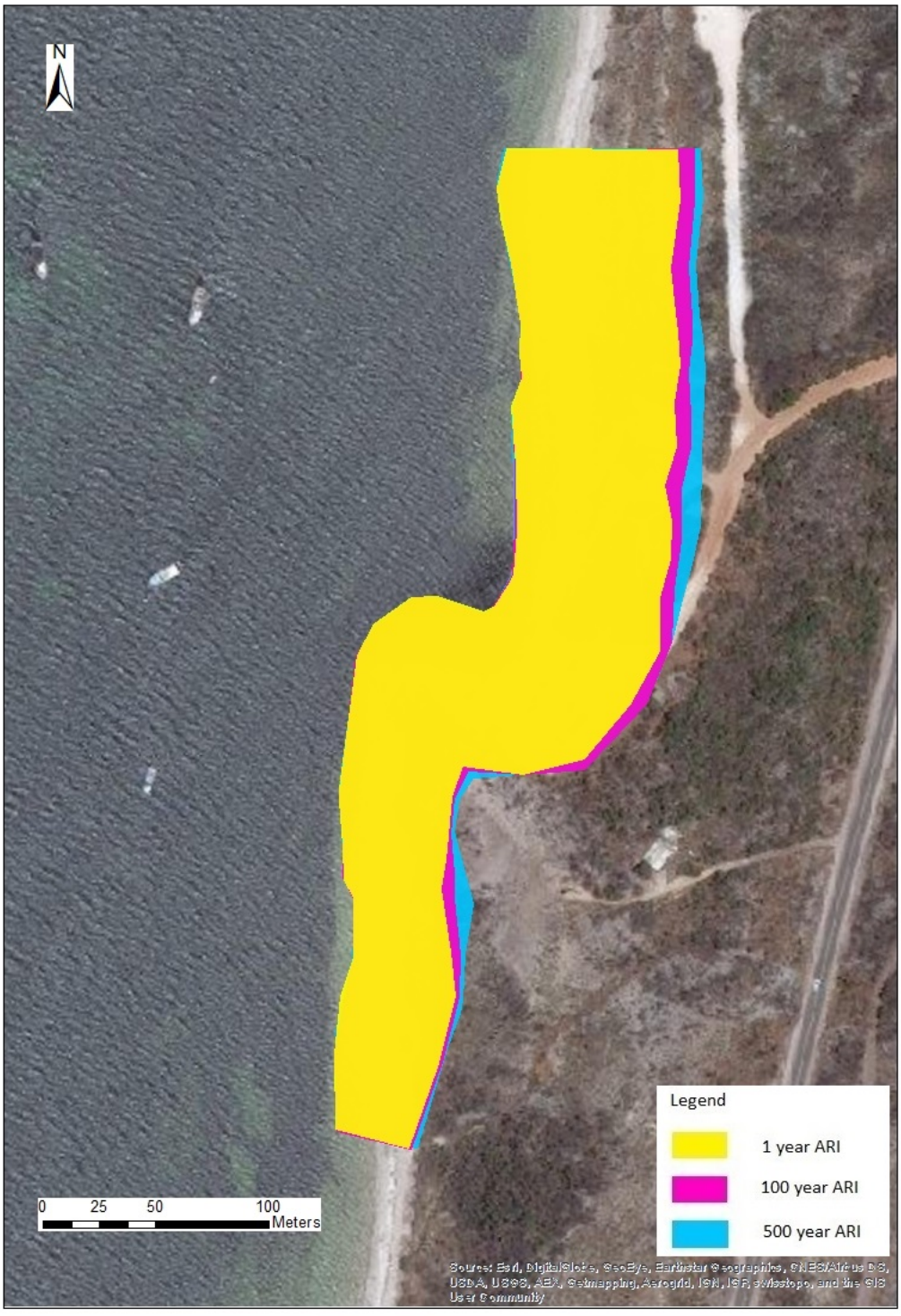
Integrated inundation map of Freshwater Point at present (0.0 m SLR)



Integrated inundation map of Freshwater Point in 2070(0.5 m SLR)



Integrated inundation map of Freshwater Point in 2110(0.9 m SLR)



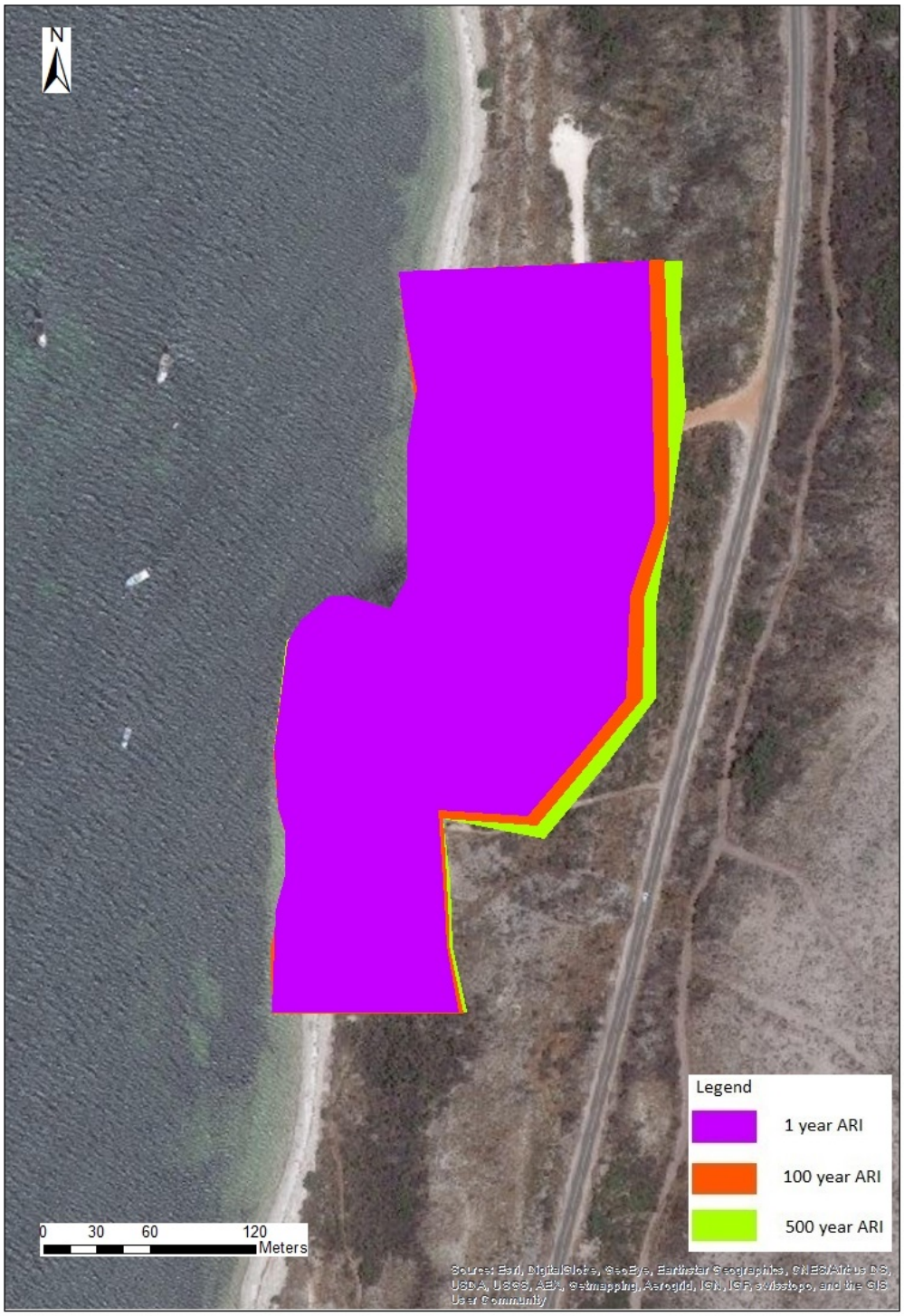
Integrated inundation map of Freshwater Point in 2110(1.5 m SLR)



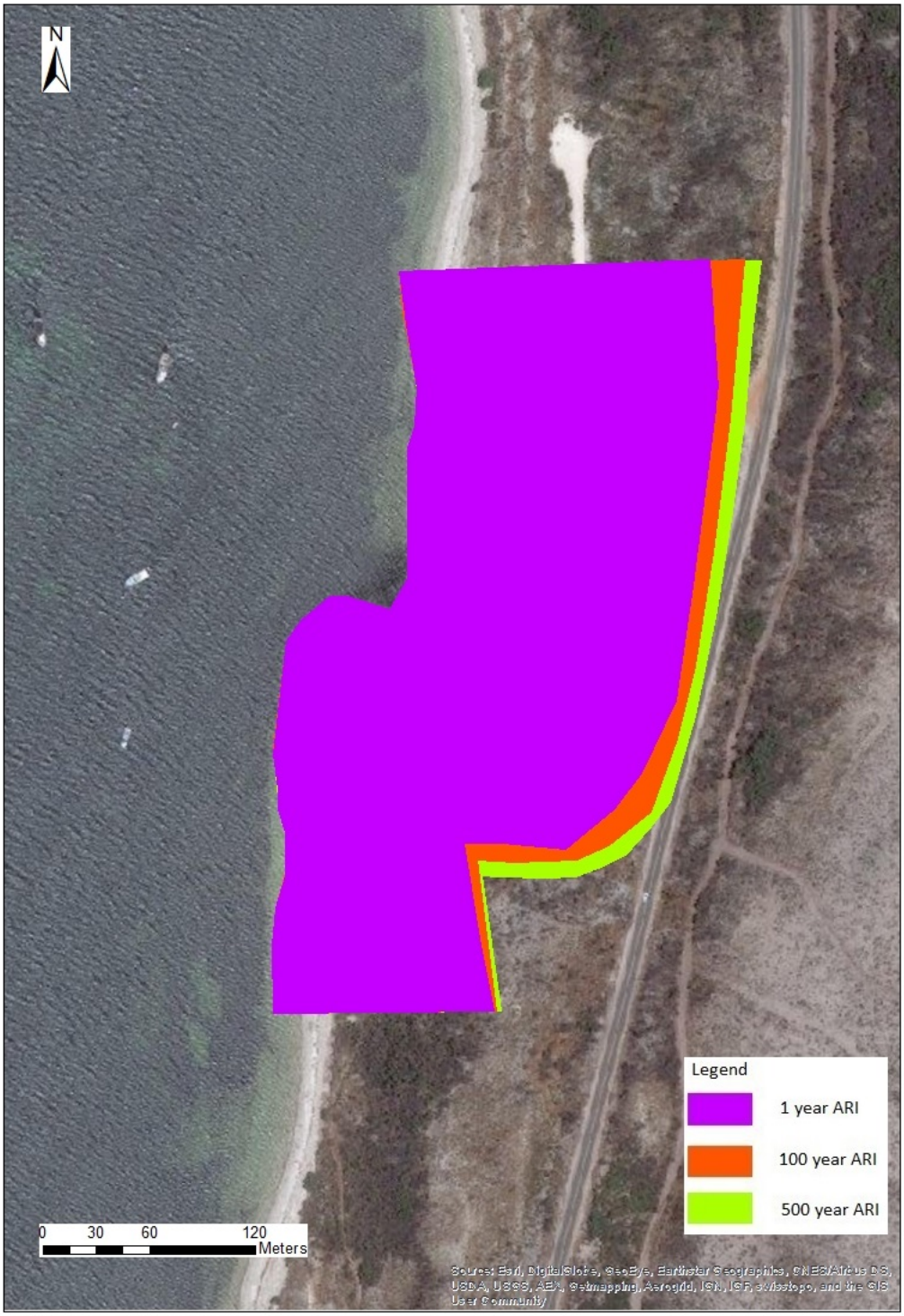
Integrated erosion map of Freshwater Point at present (0.0m SLR)



Integrated erosion map of Freshwater Point in 2070 (0.5m SLR) + (Shore line movement + allowance for uncertainty)



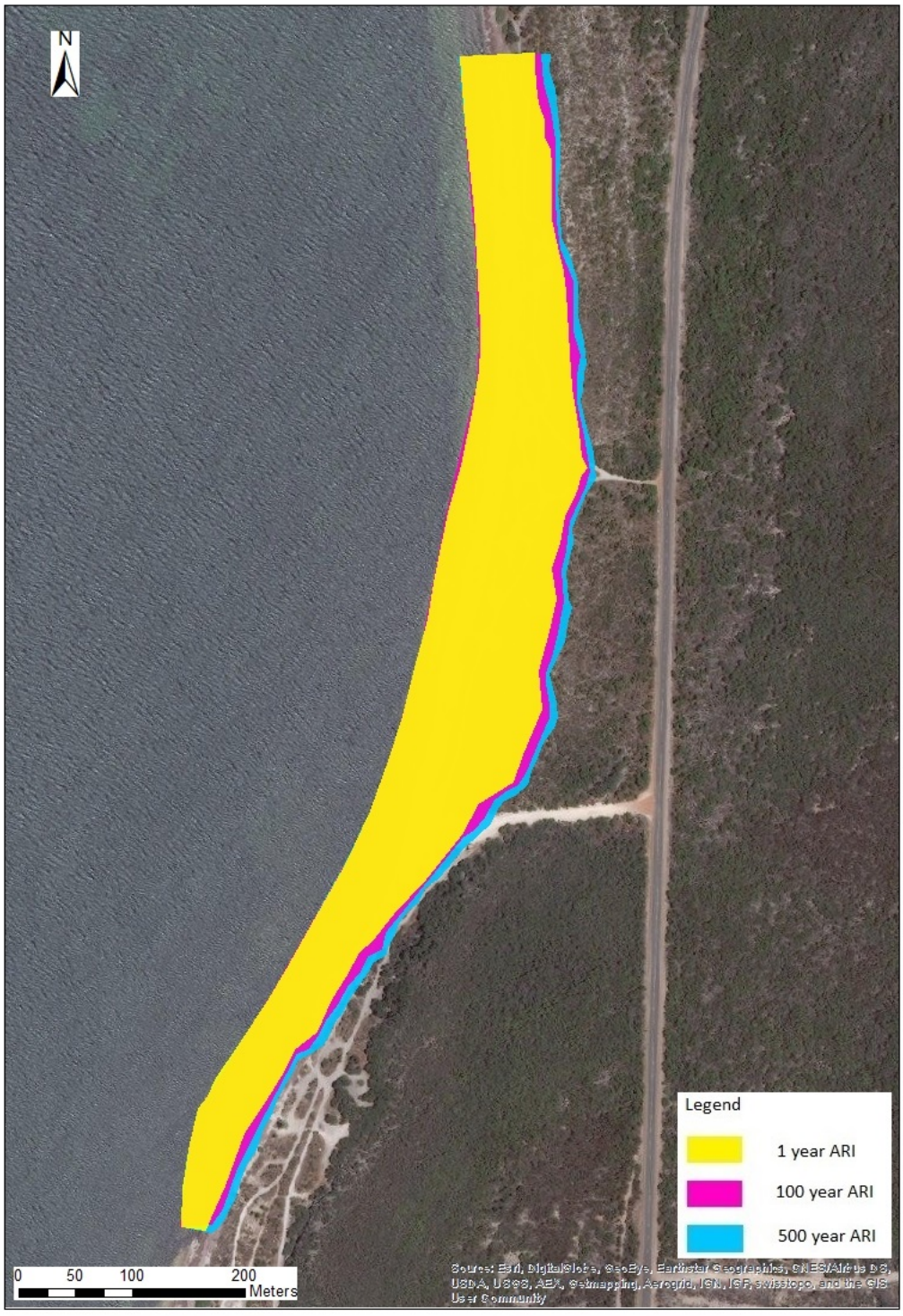
Integrated erosion map of Freshwater Point in 2110(0.9m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Freshwater Point in 2110(1.5m SLR) + (Shore line movement + allowance for uncertainty)



Integrated inundation map of Cliff Head at present (0.0m SLR)



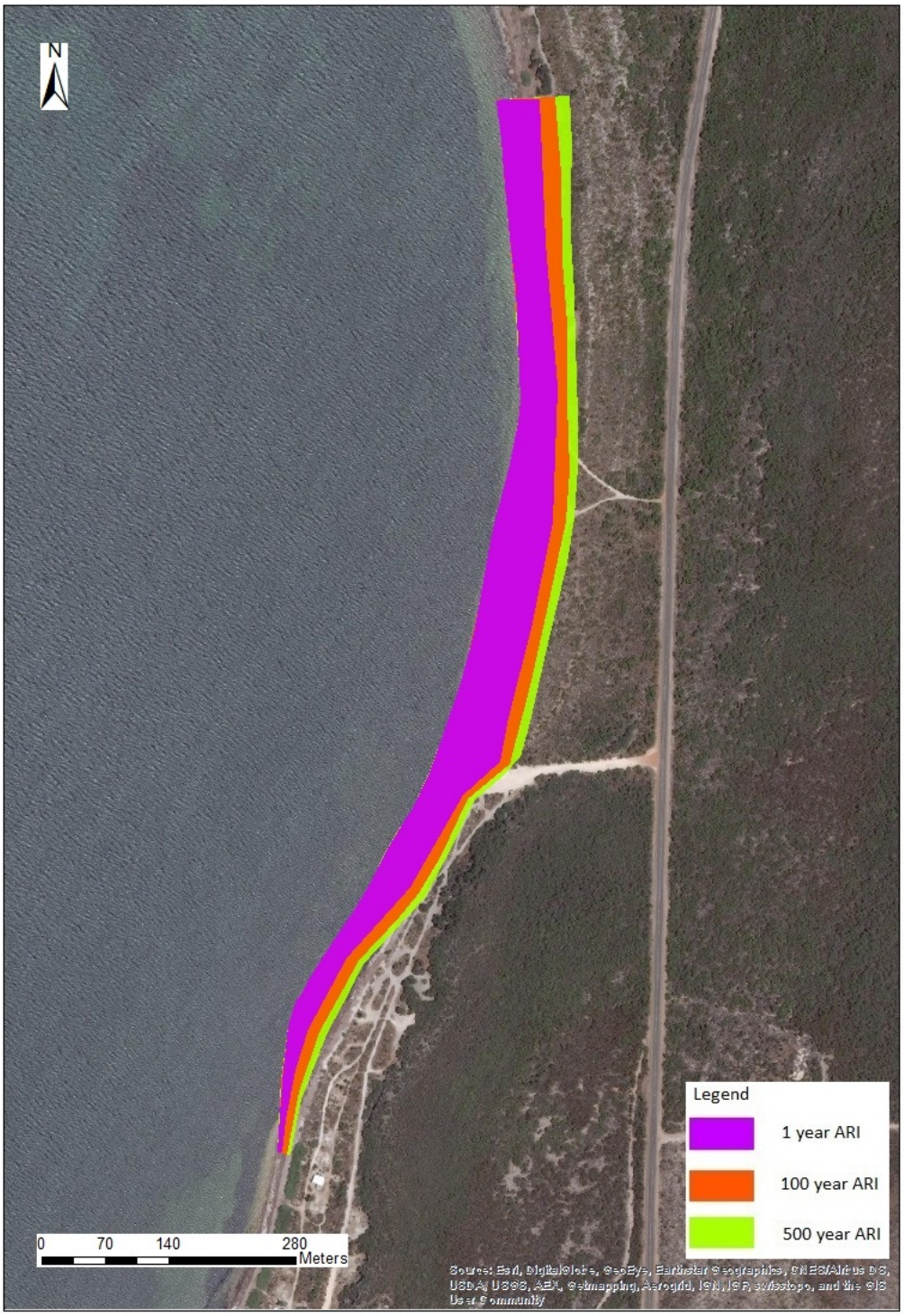
Integrated inundation map of Cliff Head in 2070 (0.5m SLR)



Inundation map of Cliff Head in 2110(0.9m SLR)



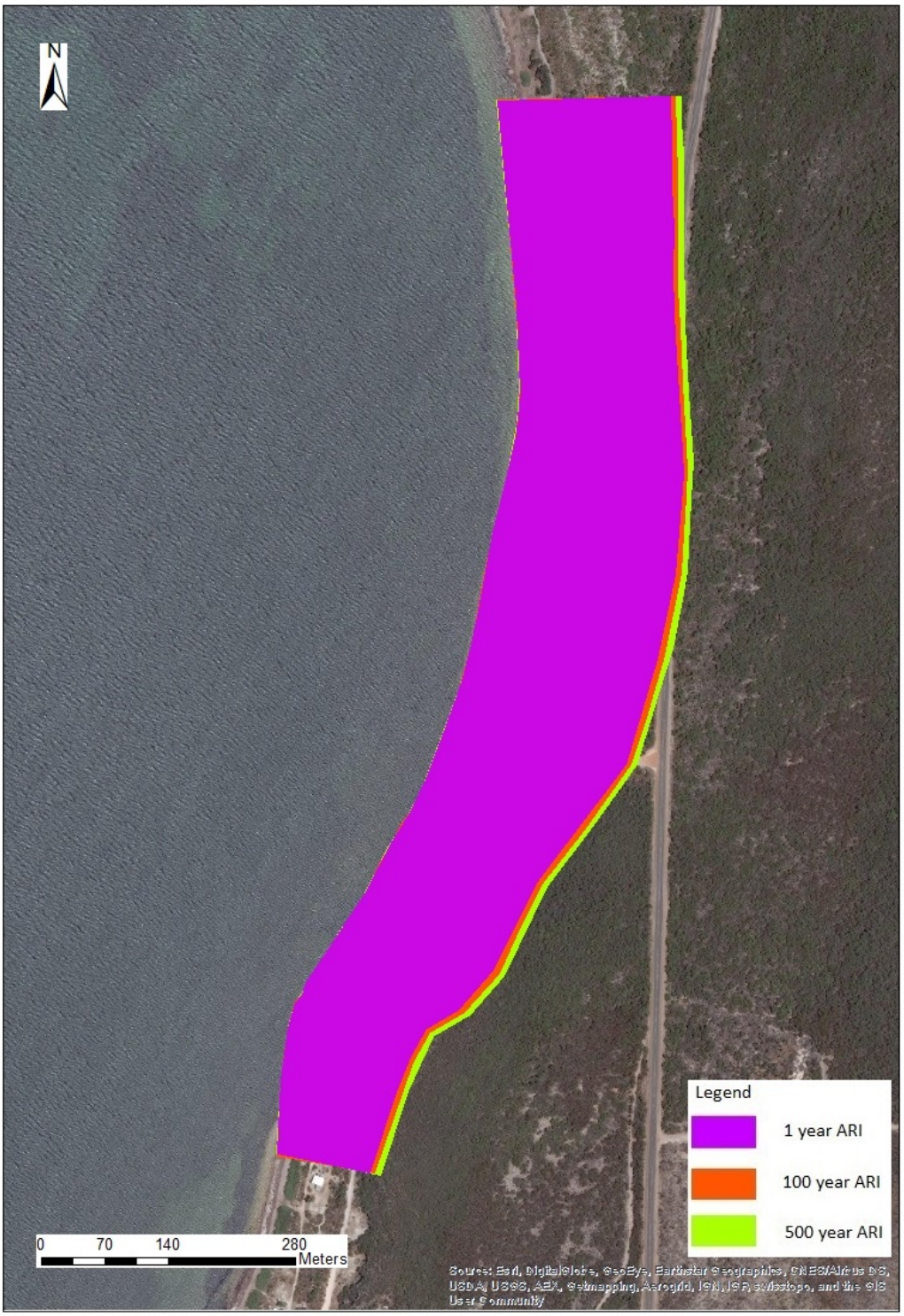
Inundation map of Cliff Head in 2110(1.5m SLR)



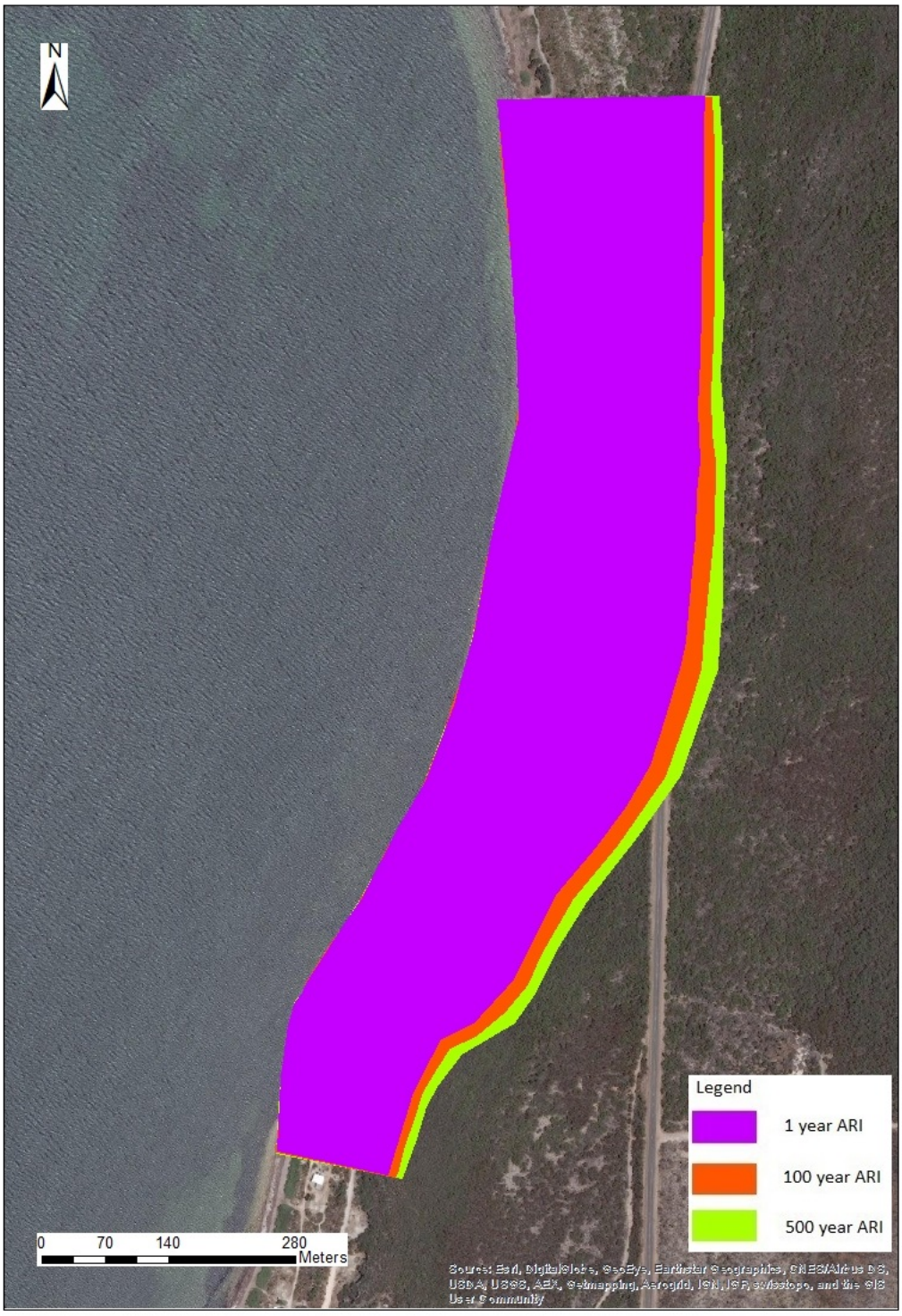
Integrated erosion map of Cliff Head at present (0.0m SLR)



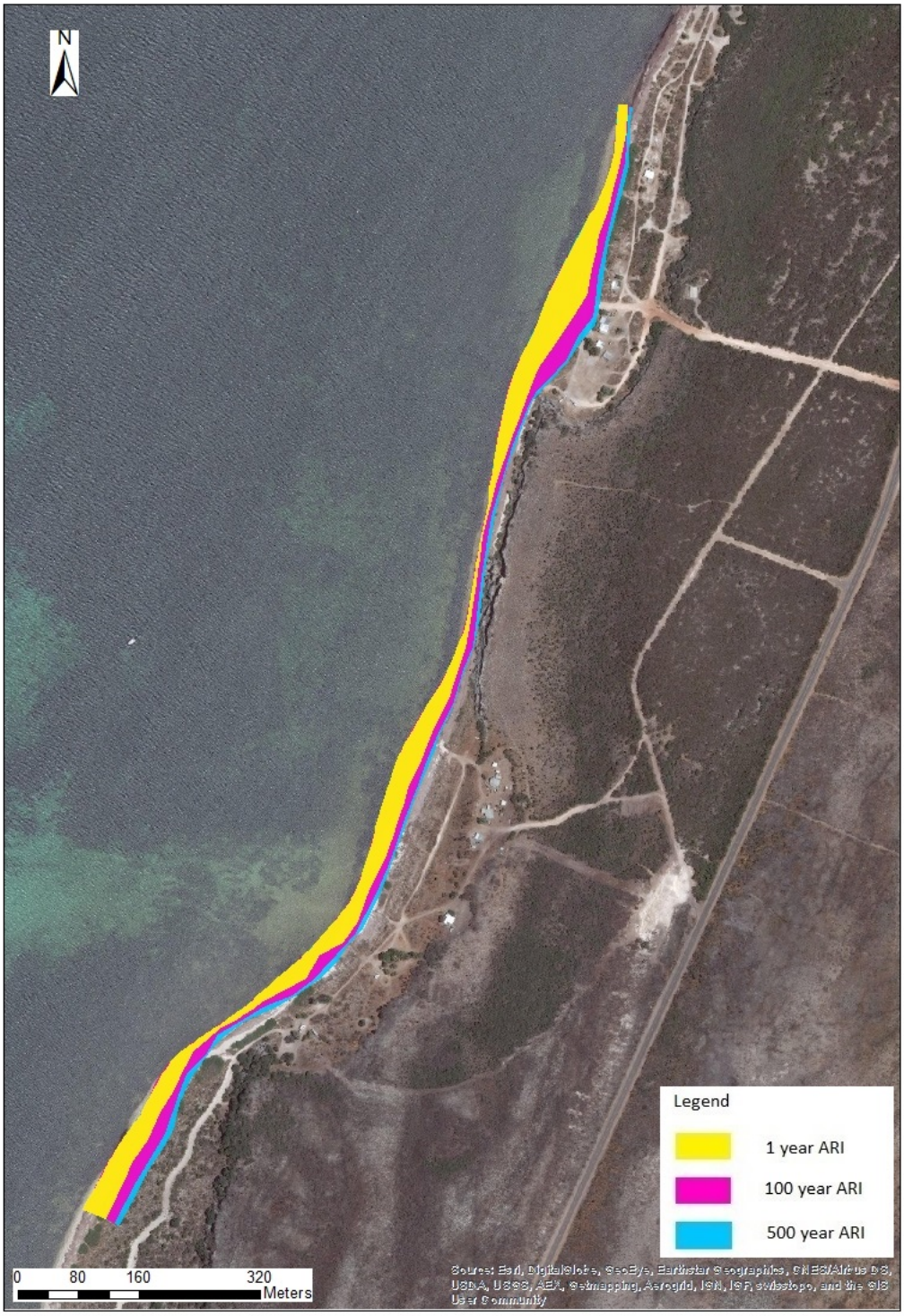
Integrated erosion map of Cliff Head in 2070 (0.5m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Cliff Head in 2110(0.9m SLR) + (Shore line movement + allowance for uncertainty)



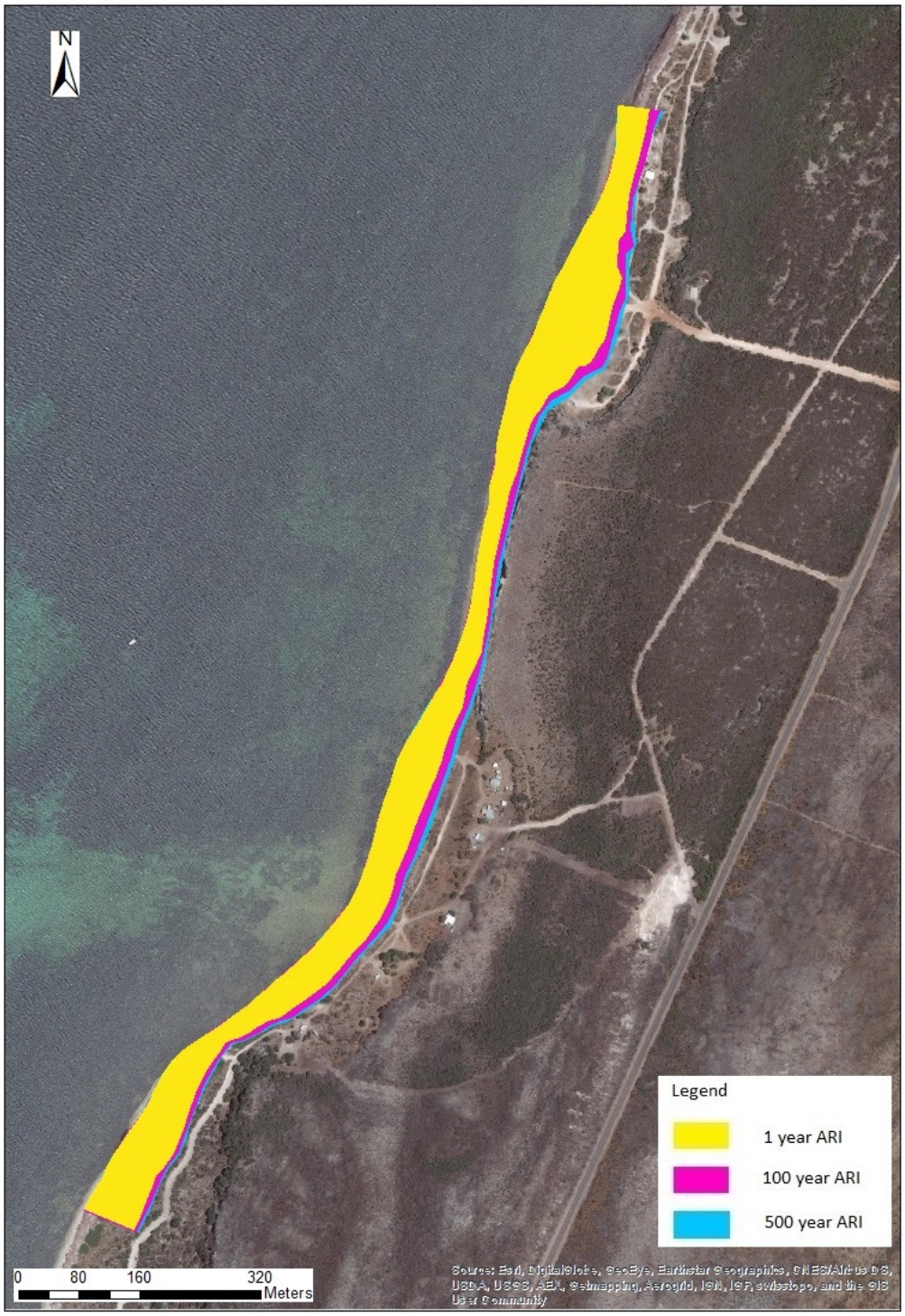
Integrated erosion map of Cliff Head in 2110(1.5m SLR) + (Shore line movement + allowance for uncertainty)



Inundation map of Cliff Head South at present (0.0m SLR)



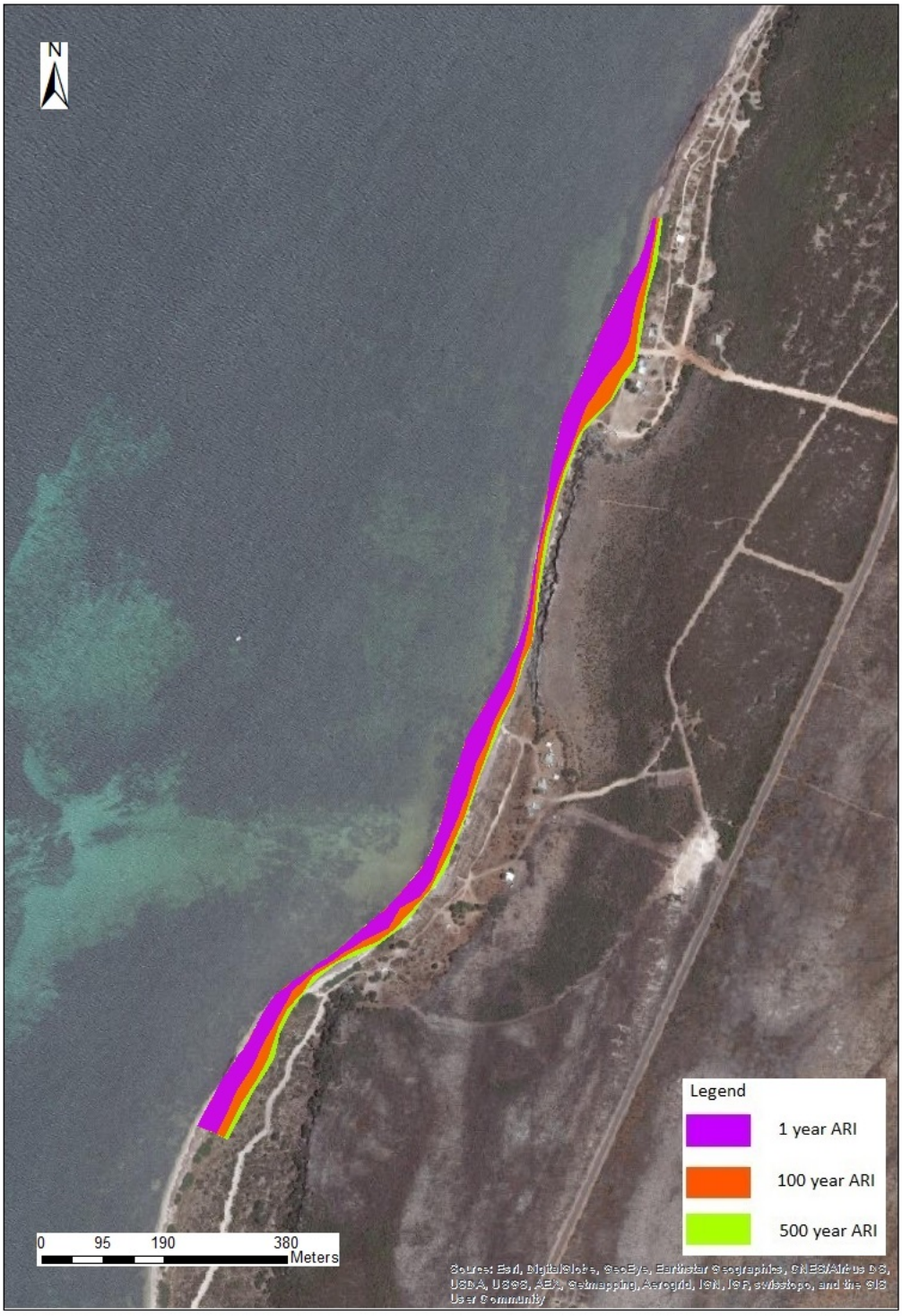
: Inundation map of Cliff Head South in 2070 (0.5m SLR)



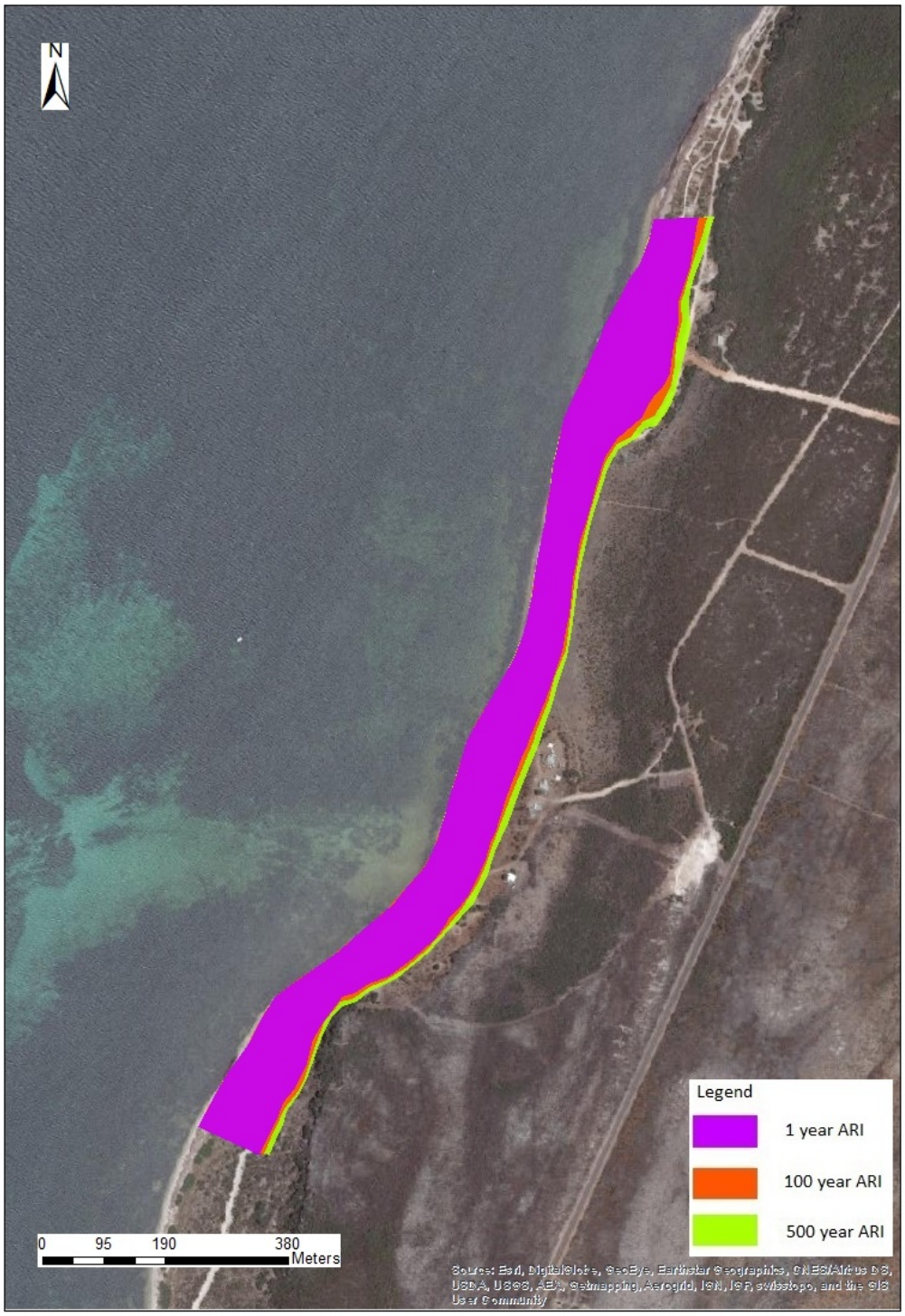
Inundation map of Cliff Head South in 2110 (0.9m SLR)



Integrated inundation map of Cliff Head South in 2110 (1.5m SLR)



Integrated erosion map of Cliff Head South at present (0.0m SLR)



Integrated erosion map of Cliff Head South in 2070(0.5m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Cliff Head South in 2110(0.9m SLR) + (Shore line movement + allowance for uncertainty)



Integrated erosion map of Cliff Head South in 2110(1.5m SLR) + (Shore line movement + allowance for uncertainty)

Appendix Two - Risk Analysis and Evaluation Process and Results

INTRODUCTION

After identifying the coastal hazards, and producing the inundation and erosion maps for each identified priority area, NACC facilitated two risk analysis and evaluation workshops with Shire Councillors and Officers. The workshops were held on 27 March 2016 and 07 April 2016. Following the workshops, Shire Officers evaluated the risks and determined coastal adaptation actions for the various coastal hazard areas.

Risk Analysis and Evaluation Process

The risk and evaluation process was derived from the WAPC'S CHRMAP Guidelines and incorporated a robust methodology for dealing with outcomes that are uncertain or have limited data, or for impacts with uncertain timeframes. This methodology is particularly applicable to coastal hazards impacts and the impacts of predicted sea level rise, where there is considerable uncertainty regarding when and if impacts will manifest. Uncertainties associated with future climate change presents huge challenges to local government and the wider community, who need to consider and manage future risks. Decisions made today are likely to have ramifications for up to 100 years or more (depending on the development), so consideration of an extended timeframe is essential, even though risks may not manifest for several decades.

In Western Australia, State Planning Policy 2.6 provides the framework for undertaking risk management and adaptation planning for coastal hazards such as beach erosion, long term recession and coastal inundation. It is a step-by-step process of identifying coastal assets; identifying potential risk to coastal assets caused by changing coastal processes, such as winds, waves, sea levels, currents, storms; and developing strategies for mitigating and adapting to the identified risks.

With the context of the CHRMAP established and the hazards and risks identified, the risk analysis and evaluation process was used to analyse the inundation and erosion maps in terms of the likelihood and the consequences of the identified risks, to determine the overall risk priority level for each hazard risk area.

Likelihood

Likelihood is the chance of erosion and storm surge inundation occurring or how often they might impact on the existing and future assets and their values. Likelihood was assessed for each scenario over the planning timeframe. Two main components to likelihood were considered: frequency of the risk and probability of risk event(s) occurring over a given duration. The likelihood scale in Figure 1 below was used to determine a rating for each coastal hazard area.

Designation	Rating	Frequency	Annual Expenditure
A	Almost Certain	Could occur several times per year	High possibility event will occur as there is history or periodic occurrence – Probability > 50%
B	Likely	May occur once per year	As likely as not – 50/50 chance
C	Possible	May occur once in 10 years	Less likely than not but still acceptable
D	Unlikely	May occur once in 10 to 25 years	Low possibility event will occur, however, there is history of infrequent and isolated occurrence – probability low but noticeably greater than zero
E	Rare	Unlikely during next 25 years	Highly unlikely event will occur, except in extreme circumstances that have not been historically recorded – probability very small, close to 0

Figure 1: Likelihood Scale (source: WAPC's CHRMAP Guidelines)

Consequence

Consequence is the impact of erosion and storm surge inundation occurring to the existing and future assets and their values and what is meant by each level for a range of exposure/receptor categories. Consequences are not limited to possible damage to assets, but also for its exposure/receptor categories such as social, economic and environment. These issues are captured in a consequence scale, which generally includes the identification of the scale and range of impacts and the tolerability. The consequences were assessed for each scenario. This consequence scale in Figure 2 below was used to determine a rating for each coastal hazard area. The financial impact column has been adapted from the Shire's own risk framework.

Designation	Rating	Social	Economic	Environment
1	Catastrophic	Loss of life and serious injury. Large long-term or permanent loss of services, employment wellbeing, finances or culture (e.g. >75% of community affected), international loss, no suitable alternative sites exist.	More than $1,000,000	Permanent loss of flora and fauna (no chance of recovery) with national impact.
2	Major	Serious injury. Medium-term disruption to services, employment well being, finances or culture (e.g. 50% of community affected), national loss, very limited suitable alternative sites exist.	$100,001 - $1,000,000	Long-term loss of flora and fauna (limited chance of recovery) with regional impact.
3	Moderate	Minor injury. Major short-term or minor long-term disruptions to services, employment wellbeing, finances or culture (e.g. <25% of community affected), regional loss, limited suitable alternative sites exist.	$20,001 - $100,000	Medium-term loss of flora and fauna (recovery likely) with regional impact.
4	Minor	Small to medium disruption to services, employment wellbeing, finances or culture (e.g. <10% of community affected), local loss, many suitable alternative sites exist.	$5,001 - $20,000	Short-term loss of flora and fauna (strong recovery) with local impact.
5	Insignificant	Minimal short-term inconveniences to services, employment wellbeing, finances or culture (e.g. <5% of community affected), neighbourhood loss, many suitable alternative sites exist.	Less than $5,000	Negligible to no loss flora and fauna (strong recovery) with local impact.

Figure 2: Consequence Scale (source: WAPC's CHRMAP Guidelines, Shire of Irwin Consequence Scale)

Evaluation

Evaluation of the risk analysis is about prioritising risk management and adaptation. It is an important part of the process as it may not be possible or necessary to treat every risk. Also, the cost of implementing management and adaptation measures may outweigh the benefits gained. In prioritising management and adaptation actions, comparison of the results of the risk analysis is undertaken to determine the acceptability/tolerability, unacceptability/intolerability of the risks based on the outcomes of the risk assessment. The risk priority matrix in Figure 3 below was used to determine the risk priority level for each coastal hazard area.

Consequence	Risk Level				
1 Catastrophic	High	Extreme	Extreme	Extreme	Extreme
2 Major	High	High	Extreme	Extreme	Extreme
3 Moderate	Medium	Medium	High	High	Extreme
4 Minor	Low	Low	Medium	High	High
5 Insignificant	Low	Low	Low	Medium	High
	E Rare	D Unlikely	C Possible	B Likely	A Almost Certain
	Likelihood				

Figure 3: Risk Priority Matrix (source: WAPC's CHRMAP Guidelines)

Inundation Risk Analysis and Evaluation Results

Table 1: Inundation Likelihood Results					
Location	**Present**	**2070**	**2110 M**	**2110 H**	**Overall**
Port Denison	Unlikely	Unlikely	Possible	Possible	Possible
Granny's Beach and Surf Beach	Likely	Likely	Almost certain	Almost certain	Likely
South Beach North	Almost certain	Almost certain	Almost certain	Almost certain	Almost Certain
South Beach South	Rare	Rare	Rare	Unlikely	Rare
Seaspray	Possible	Almost certain	Almost certain	Almost certain	Almost certain
Seven Mile Beach	Rare	Unlikely	Unlikely	Possible	Unlikely
Freshwater Point	Likely	Almost Certain	Almost Certain	Almost Certain	Almost certain
Cliff Head North	Rare	Unlikely	Possible	Likely	Possible
Cliff Head South	Rare	Unlikely	Possible	Possible	Unlikely

Table 2: Inundation Consequence Results					
Location	**Present**	**2070**	**2110 M**	**2110 H**	**Overall**
Port Denison	Insignificant	Minor	Minor	Moderate	Minor
Granny's Beach and Surf Beach	Insignificant	Minor	Moderate	Major	Moderate
South Beach North	Insignificant	Insignificant	Minor	Minor	Minor
South Beach South	Insignificant	Insignificant	Insignificant	Minor	Insignificant
Seaspray	Insignificant	Insignificant	Minor	Minor	Minor
Seven Mile Beach	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Freshwater Point	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Cliff Head North	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Cliff Head South	Insignificant	Insignificant	Minor	Minor	Minor

Table 3: Inundation Risk Priority Level Results			
Location	**Likelihood**	**Consequence**	**Priority**
Port Denison, Granny's Beach and Surf Beach	Likely	Moderate	High
South Beach North	Possible	Minor	Medium
South Beach South	Almost Certain	Minor	High
Seaspray	Almost certain	Minor	High
Seven Mile Beach	Unlikely	Insignificant	Low
Freshwater Point	Unlikely	Minor	Low
Cliff Head North	Rare	Insignificant	Low
Cliff Head South	Possible	Insignificant	Low

Erosion Risk Analysis and Evaluation Results

Erosion Likelihood Results					
Location	**Present**	**2070**	**2110 M**	**2110 H**	**Overall**
Granny's Beach and Surf Beach	Likely	Possible	Possible	Possible	Possible
South Beach North	Unlikely	Possible	Possible	Possible	Possible
South Beach South	Rare	Unlikely	Unlikely	Possible	Unlikely
Seaspray	Likely	Likely	Almost certain	Almost certain	Almost certain
Seven Mile Beach	Unlikely	Possible	Likely	Likely	Possible
Freshwater Point	Almost Certain	Likely	Likely	Likely	Likely
Cliff Head North	Rare	Possible	Likely	Likely	Possible
Cliff Head South	Unlikely	Unlikely	Possible	Possible	Possible

Erosion Consequence Results					
Location	**Present**	**2070**	**2110 M**	**2110 H**	**Overall**
Granny's Beach and Surf Beach	Major	Catastrophic	Catastrophic	Catastrophic	Catastrophic
South Beach North	Insignificant	Major	Catastrophic	Catastrophic	Major
South Beach South	Insignificant	Insignificant	Minor	Minor	Minor
Seaspray	Minor	Major	Major	Major	Major
Seven Mile Beach	Insignificant	Minor	Minor	Minor	Minor
Freshwater Point	Minor	Moderate	Moderate	Major	Moderate
Cliff Head North	Minor	Moderate	Major	Major	Moderate
Cliff Head South	Insignificant	Moderate	Major	Major	Moderate

Erosion Risk Priority Level Results			
Location	**Likelihood**	**Consequence**	**Priority**
Port Denison, Granny's Beach and Surf Beach	Possible	Catastrophic	Extreme
South Beach North	Possible	Major	Extreme
South Beach South	Unlikely	Minor	Low
Seaspray	Almost certain	Major	Extreme
Seven Mile Beach	Possible	Minor	Medium
Freshwater Point	Likely	Moderate	High
Cliff Head North	Possible	Moderate	High
Cliff Head South	Possible	Moderate	High