WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Final Report

Amity Point Shoreline Erosion Management Plan

Redland City Council

March 2019



Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
V01	Draft Report	Christine Lauchlan Arrowsmith	Steve Clark	13Dec16
V02	Final Report	Christine Lauchlan Arrowsmith	Christine Lauchlan Arrowsmith	18Dec17
V03	Final Report	Paul O'Brien	Christine Lauchlan Arrowsmith	01May18
V04	Final Report	Christine Lauchlan Arrowsmith	Christine Lauchlan Arrowsmith	13June18
V05	Final Report	Paul O'Brien	Christine Lauchlan Arrowsmith	14Sep18
V06	Final Report	Astrid Stuer	Paul O'Brien	26Feb19
V07	Final Report	Astrid Stuer	Paul O'Brien	20Mar19

Project Details

Project Name	Amity Point Shoreline Erosion Management Plan
Client	Redland City Council
Client Project Manager	Rod Powell
Water Technology Project Manager	Paul O'Brien
Water Technology Project Director	Steve Clark
Authors	Paul O'Brien
Document Number	4193-01_R03v07

COPYRIGHT

Water Technology Pty Ltd has produced this document in accordance with instructions from Redland City Council for their use only. The concepts and information contained in this document are the copyright of Water Technology Pty Ltd. Use or copying of this document in whole or in part without written permission of Water Technology Pty Ltd constitutes an infringement of copyright. Water Technology Pty Ltd does not warrant this document is definitive nor free from error and does not accept liability for any loss caused, or arising from, reliance upon the information provided herein.

Level 3, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460
Fax (07) 3846 5144
ACN 093 377 283
ABN 60 093 377 283

Certified System Quality ISO 9001 SAI GLOBAL
Certified System Environment ISO 14001 SAI GLOBAL
Certified System Health & Safety AS 4801 SAI GLOBAL

20 March 2019

Rod Powell
Marine Projects
Redland City Council
Cnr. Middle and Bloomfield Streets
Cleveland QLD 4163

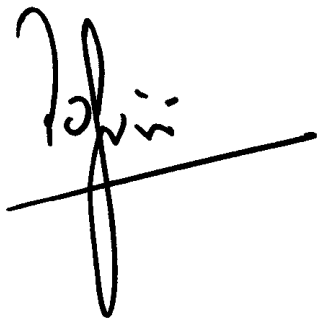
Dear Rod,

Amity Point Shoreline Erosion Management Plan

Attached please find our Final Report of the Shoreline Erosion Management Plan (SEMP) for Amity Point.

We would like to take this opportunity to once again sincerely thank the Amity Point community, the SEMP Reference Group and Council's project team for the invaluable assistance provided in developing the SEMP.

Yours sincerely,



Paul O'Brien
Senior Principal Engineer
Amity Point SEMP Study Manager
RPEQ No. 5638

p.obrien@watertech.com.au

WATER TECHNOLOGY

EXECUTIVE SUMMARY

Located on the north-west corner of North Stradbroke Island, the township of Amity Point enjoys a rich diversity of seascapes and landscapes - providing extensive recreational and lifestyle opportunities that are considerably enhanced by local cultural, heritage and environmental values.

The historical development of Amity Point has focused on the shoreline - as residents and visitors seek to enjoy the unique character of this coastal precinct. However, the dynamic nature of the coastal environment means that some local foreshores are experiencing erosion which is threatening these values, as well as endangering essential infrastructure.

The *Amity Point Shoreline Erosion Management Plan* will provide a framework for the sustainable use, development and management of this vulnerable foreshore.

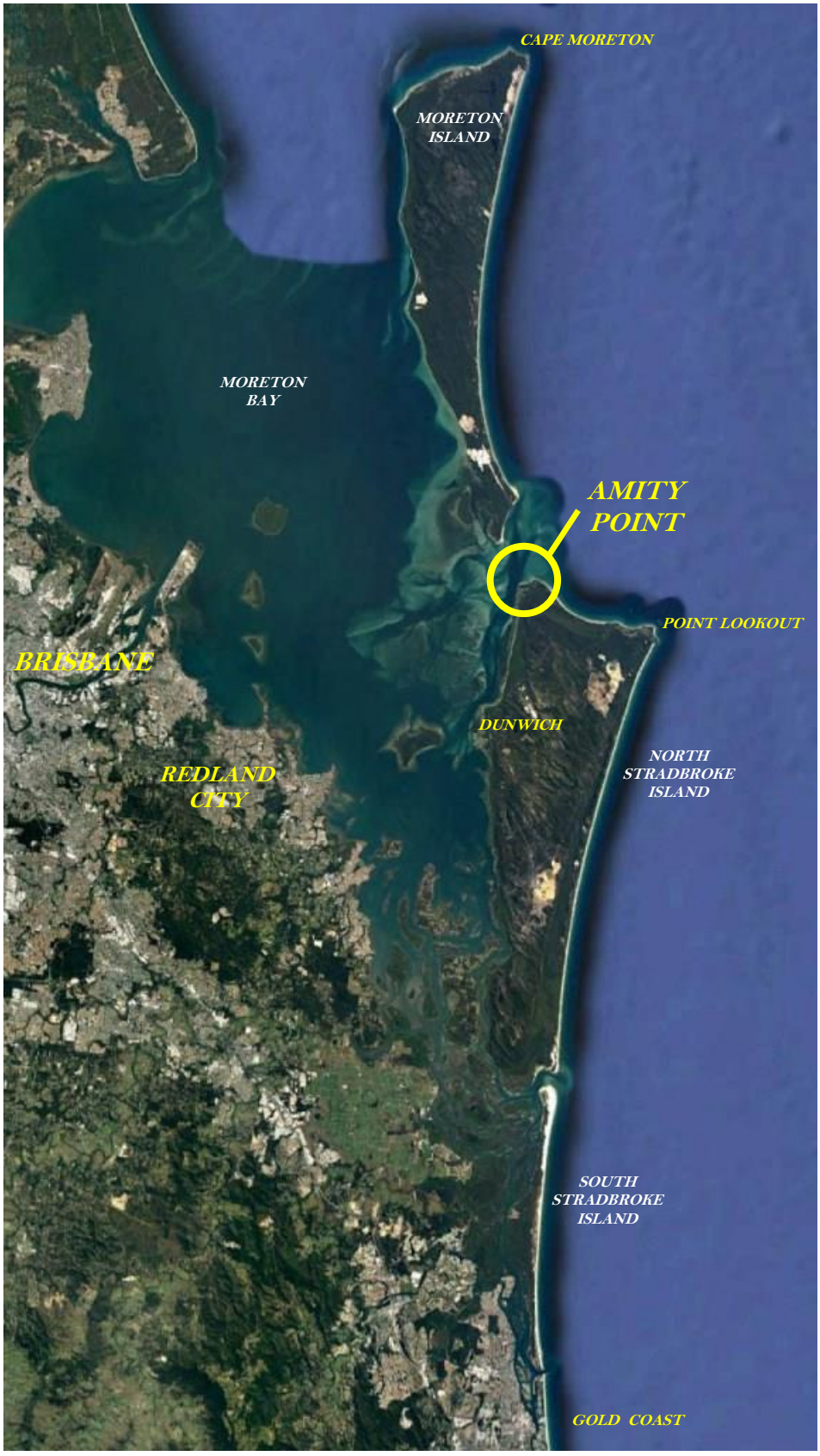
Objectives of the Shoreline Erosion Management Plan

A Shoreline Erosion Management Plan (SEMP) is a non-statutory planning document that sets out an agreed framework and management strategy for responding to existing erosion problems and possible future erosion threats.

This is achieved by considering the physical coastal processes in conjunction with the environmental, cultural, social and economic values of the shoreline. The Amity Point SEMP will determine management goals agreed to by governments and the community. It will:

- Enable land owners to proactively plan for erosion management in vulnerable foreshore areas in a way that is consistent with community aspirations and the policies of the Commonwealth and State Governments, Redland City Council and the Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC).
- Investigate and address the underlying causes of shoreline erosion and its likely future progression.
- Determine cost effective and sustainable erosion management strategies that maintain natural coastal processes and resources; and consider community needs in both the short- and long-term.
- Assist in defining the roles and responsibility of property owners, local government and traditional owners in relation to foreshore management.

It is important to appreciate that the SEMP has a planning horizon of 20 years, and as such is a medium-term management plan. Consequently, the recommended management strategies need to be adaptive and flexible according to the level of risk, and tailored to fit within the “pathways” approach to adaptation needs defined in Council’s *Draft Coastal Adaptation Strategy*. Recommended options will be the most appropriate at this point in time, but may not be the optimum beyond the planning period for the SEMP.

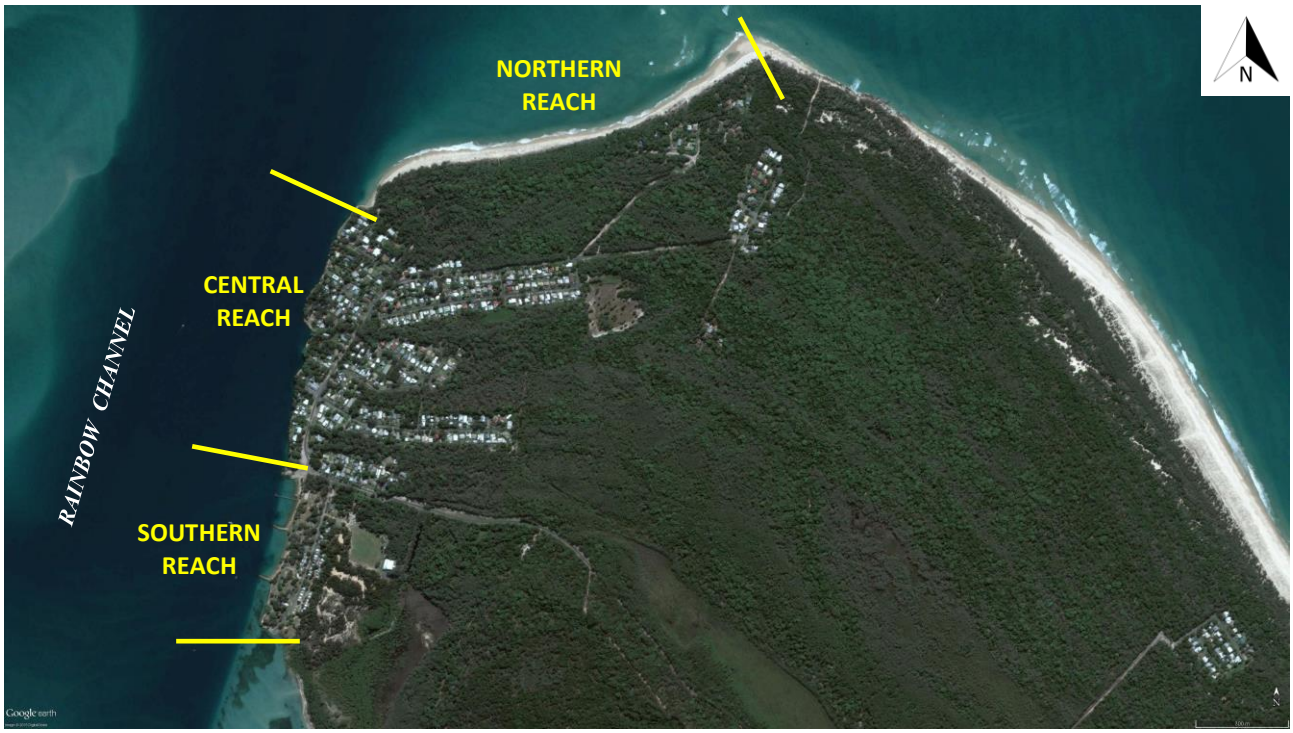

CAPE MORETON
MORETON ISLAND
MORETON BAY
AMITY POINT
POINT LOOKOUT
BRISBANE
DUNWICH
NORTH STRADBROKE ISLAND
REDLAND CITY
SOUTH STRADBROKE ISLAND
GOLD COAST

Erosion Threats to the Amity Point Foreshore

When considering appropriate erosion management options along the Amity Point shoreline it is evident that the shoreline can be considered in three coastal precincts, namely

- Southern Reach: the foreshore frontage of the camping ground and boat ramp;
- Central Reach: along the alignment of the rock armoured foreshore; and
- Northern Reach: the sandy foreshore of Amity Beach.

The locations of these coastal precincts are shown below. This partitioning lends itself to the development of viable erosion management strategies that integrate well over the entire Amity Point shoreline.



Southern Reach – Camping Ground Foreshore

Coastal Erosion

Numerical modelling of shoreline response indicates that in the event of storms having ARIs of 50 year, 100 year and 200 year; the corresponding shoreline recessions on the sand beaches would be approximately 15 metres, 18 metres and 21 metres respectively.

Such shoreline erosion would cause damage to trees and planted vegetation along the foreshore, but would not damage any significant infrastructure associated with the camping ground. An exception to this is likely damage to the unpaved car-park behind the swimming enclosure alongside the boat ramp; as well as a sealed roadway that runs close to the beach near the southern-most groyne.

It is expected that future climate change will exacerbate foreshore erosion along the Southern Reach.

Flow Slides

The potential threat posed by retrogressive flow slides to the Southern Reach is expected to increase in coming years. This is because the submerged eastern side slope of Rainbow Channel is slowly migrating towards the foreshore, gradually becoming steeper as it does so. This steepening sand slope will likely experience increased occurrences of flow slides.

Despite understanding where retrogressive flow slides can occur on this submerged channel slope, it is not possible to determine to what size or extent they reach once triggered. At present, internationally available technical literature pertaining to retrogressive flow slides in this type of coastal environment offers no definitive method to determine where a specific event may terminate. Consequently, until a better understanding of such events is developed, it would be prudent when considering the possible landward extent of flow slide effects to base predictions on the extents of past events. The largest event captured on aerial photography occurred alongside the southern-most groyne of the Southern Reach. That event progressed to the toe of the beach at this location.

Consequently, it is conceivable that a future event could do the same. Furthermore, since the eastern side slope of the Rainbow Channel is slowly migrating towards the foreshore, flow slides may extend into the camping ground sometime within the 20 year planning horizon for this SEMP.

Central Reach – Rock Armoured Foreshore

Coastal Erosion

The foreshore of the Central Reach is armoured with rock. The considerable size, thickness, location and depth of the rock armouring (evident from the results of geophysical investigations) are adequate to structurally mitigate present-day and likely future wave-induced coastal erosion.

Flow Slides

The primary threat of shoreline recession along the Central Reach is the gradual eastern migration of Rainbow Channel, in conjunction with occurrences of retrogressive flow slides on the underwater side slopes of the channel.

In response to the historical threat of such events, foreshore property owners have been progressively placing rock armour on affected sections of their bay frontage. As part of technical work undertaken for this SEMP, a Concept Design for a flow slide barrier has been prepared. A structural audit of the rock placements along the Central Reach has also been undertaken so as to compare the existing rock placements with the structural concept of a flow slide barrier. That audit was informed by the results of geophysical investigations and a bathymetric survey of Rainbow Channel. The Concept Design for a flow slide barrier and the outcomes of the structural audit are reported in this SEMP.

An important finding of the geophysical investigations is that the existing rock placements along the foreshore of the Central Reach are consistent with the Concept Design for a flow slide barrier, confirming that it is indeed appropriate to consider the existing rock placements as being a flow slide barrier.

At present, the only location along the flow slide barrier where there is currently evidence that a flow slide might undermine and damage the barrier is on the foreshore opposite Old School House Park. This vulnerability is likely to change since the sandy side slopes of Rainbow Channel are slowly migrating towards Amity Point and are slowly becoming steeper - increasing the risk of flow slide occurrences and their potential impacts on the flow slide barrier.

Northern Reach – Amity Beach

Coastal Erosion

Erosion processes along Amity Beach are primarily due to the changing sediment transport regime driven by the local wave climate, in conjunction with the shifting and complex bathymetry of the South Passage Bar immediately offshore**.** It is expected that future climate change will exacerbate foreshore erosion.

The complexity of the nearshore bathymetry (including the dynamic sand spit and offshore sand banks), in conjunction with the complexity of the natural littoral transport processes, means that it is extremely difficult to predict future beach changes at a specific location – such as on the private property frontages of Amity Beach. A greater understanding of these local processes needs to be acquired.

Flow Slides

The only section of the Northern Reach vulnerable to flow slide events is at its western-most end, where the flow slide barrier of the Central Reach terminates. Due to the orientation of Rainbow Channel (in conjunction with the prevailing littoral processes of sand supply to this location) this area is particularly prone to flow slide events. This situation is likely to continue; and flow slides might in fact increase in frequency here as Rainbow Channel migrates eastward and comes up against the existing flow slide barrier of the Central Reach.

Recommended Shoreline Erosion Mitigation Strategies

Southern Reach – Camping Ground Foreshore

> *The recommended erosion mitigation strategy along the Southern Reach is to undertake beach nourishment within each of the three existing beach compartments; and to construct cut-off seawalls behind each beach where an appropriate structure does not already exist.*

The strategy for mitigating future erosion threats along the Southern Reach is shown summarised in the figure on the following page 10. It entails:

- Construction of approximately 165 metres of seawalls to be buried at the rear of the northern and southern beach compartments. This consists of approximately 55 metres along the northern compartment and 110 metres on the southern compartment. The characteristics of these two seawalls are to be determined by detailed coastal engineering design. It is likely that a rock armour sourcing study will need to be undertaken as part of the design stage.
- Placement of approximately 5,000 cubic metres of sand (of appropriate grading and size) within the existing three beach compartments. This consists of approximately 800 cubic metres along the northern compartment, approximately 1,700 cubic metres on the central compartment, and approximately 2,500 cubic metres on the southern compartment. The characteristics of the sand nourishment works are to be determined by detailed coastal engineering design. It is likely that a sand sourcing study will need to be undertaken as part of the design stage.
- Undertaking a structural audit of the existing rock-armoured seawall to the south of the three beach compartments to confirm its future effectiveness as a foreshore defence structure.
- Monitoring the performance of the beach nourishment by annual surveys of the foreshore profile.
- Undertake future beach renourishment campaigns to reinstate beach widths should sand losses result from severe storms and/or future climate change.

- Since Rainbow Channel is migrating gradually towards Amity Point increasing the risk of flow slides adversely affecting the foreshore, it is also recommended that an annual bathymetric survey of Rainbow Channel be undertaken to provide a better understanding of how this potential risk is developing. This will determine the likelihood, the timescales and extent that the foreshores of the Southern Reach are becoming more vulnerable to future damage by flow slide events because of changing bathymetry in the migrating channel. This will allow for the planning of appropriate future strategies to mitigate the emerging threat.
- For the purposes of developing cost estimates, it is assumed that local sources of sand for beach nourishment and armour rocks for seawall construction are available on North Stradbroke Island. The table below provides a summary of the estimated costs to implement the recommended strategy. The estimate excludes any costs associated with establishing a local sand source.

Activity	Cost	Annual Cost
Project Design and Approvals		
Site survey	$5,000	
Sand sourcing study	$15,000	
Structural audit of existing seawall	$7,500	
Design of seawalls & beach nourishment	$30,000	
Obtain appropriate approvals	$17,500	
Construction Works		
Construct approx. 165m of buried rock seawall	$112,500	
Procure and place 5,000m^3 of sand	$87,500	
Allowance for annual renourishment		$5,000
Project Monitoring		
Annual survey of beach (additional to survey of Rainbow Channel)		$5,000
Annual bathymetric survey of Rainbow Channel side slopes	*refer costs for Central Reach*	
Totals	**$275,000**	**$10,000**



Recommended erosion mitigation strategy for the Southern Reach

Central Reach – Rock Flow Slide Barrier

> *The recommended erosion mitigation strategy for the Central Reach is to support and enhance the effectiveness of the current erosion management practice of repairing damage to the existing flow slide barrier whenever necessary following flow slide events - by placing additional rock armouring.*

The threat of shoreline recession along the Central Reach is due the gradual eastern migration of Rainbow Channel, in conjunction with occurrences of retrogressive flow slides on the underwater side slopes of the channel. In recent times, the existing rock structure has been effective in preventing the development of retrogressive flow slides to damaging proportions. A related outcome of terminating flow slides in the submerged side slopes of Rainbow Channel is that in recent years maintaining and repairing the structure has also maintained the existing foreshore alignment - despite the eastward migration of the channel.

It is important to the continuing function of this coastal defence structure that it be repaired following any damage caused by retrogressive flow slides. This includes repairs and improvements to its northern-most end (at the confluence of the Central and Northern Reaches) whenever such events cause damage in this area.

Geophysical surveys of the buried rock along the foreshore of the Central Reach confirm that these rock placements conform to the requirements and characteristics of the structural concept of a flow slide barrier.

The recommended erosion mitigation strategy for the Central Reach basically entails:

- Adopting a flow slide barrier as the necessary coastal protection works required to manage the erosion threat along the Central Reach of Amity Point.
- Recognising that the existing rock placements along this shoreline are consistent with conceptual structural requirements for a flow slide barrier and to therefore seek formal approval of the existing barrier as substantially completed tidal works.
- Monitoring the continued structural adequacy of the existing flow slide barrier, through regular bathymetric surveys to identify emerging vulnerabilities to potential flow slides - and to inform structural reinforcement and repair needs.
- Formalising a maintenance regime of periodic “topping up” of rocks to maintain the effectiveness of the structure in mitigating the threat of flow slides. Where this is within the footprint of the approved structure it can be considered as maintenance works required to preserve the integrity and function of the flow slide barrier.

Structural audit of the flow slide barrier

A structural audit of the existing flow slide barrier has been undertaken as a component of the SEMP. The audit necessitated geophysical investigations comprising overwater and land-based geophysics techniques to identify the extent of rock and other materials buried in the foreshore as a result of the community’s historical response to the threat of retrogressive flow slide events.

The geophysical data has been used in conjunction with surveyed bathymetry of Rainbow Channel, along with the known mechanisms of retrogressive flow slide events, to determine the effectiveness of the existing rock barrier. Important findings of the structural audit are:

- The existing rock placements along the foreshore of the Central Reach are consistent with the Concept Design for a flow slide barrier, confirming that it is appropriate to consider the existing rock placements as being a flow slide barrier.

- There are many locations where flow slides could be initiated on the sandy eastern bank of Rainbow Channel in front of the flow slide barrier.
- Such locations are deep, typically at or below RL-10m AHD.
- The only location along the entire barrier where there is currently evidence that a flow slide might undermine and damage the barrier is on the foreshore opposite Old School House Park. There is merit in adopting a proactive strategy of reinforcing the flow slide barrier at this location - by placing approximately 45cu.m./m of rock either directly into the front upper slopes of the armoured foreshore above RL-5m AHD, or onto the seabed offshore at the RL-5m AHD depth contour approximately. Both of these options are consistent with maintaining conceptual requirements for a flow slide barrier.

These findings are based on bathymetric features identified in the survey completed in December 2015. Due to the dynamic nature of the side slopes of Rainbow Channel, it is possible that the vulnerability of the flow slide barrier could have changed since that time.

Approval for both the flow slide barrier and for its repair following damage

In the past, repairs to the flow slide barrier by foreshore property owners have been viewed as being unapproved (or unlawful) works in the context of Queensland's *Coastal Protection and Management Act 1995*. This is because it had not been approved as prescribed tidal work under the *Sustainable Planning Act 2009* (SPA).

To date, considerations for its approval have been based on the notion that this rock-armoured structure is a seawall. A seawall is a conventional response to conventional erosion processes – such as those caused by wave action and/or a deficit in the supply of littoral sand. Where such structures had formal approval under the SPA, repairs were authorised to be undertaken to reinstate their primary function whenever they were damaged.

The rock structure along the foreshore of the Central Reach currently does not have the status of approved tidal works. A requirement for the implementation of the recommended erosion mitigation strategy is that this physical barrier to retrogressive flow slides be formally approved under the *Planning Act 2016* (formerly SPA), thereby enabling its function to be maintained in the event of damage. This will require an application for prescribed tidal works relating to the flow slide barrier. The findings of this SEMP can be used to provide technical support for that application. It is expected that the conceptual design for the flow slide will need to be further refined by a subsequent detailed engineering design phase to also provide support to the approval application process.

However, Section 166 of the *Planning Act 2016* allows tidal works to be undertaken without a development approval in an emergency. Circumstances that constitute an emergency are provided in the *Planning Act 2016 Section 166* and include events that endanger the life or health of people; or that threaten the structural safety of buildings. Large retrogressive flow slides on the foreshores of Amity Point are likely to be considered as such an emergency.

An exemption for prior approval of repair works to the flow slide barrier applies - provided those repairs are in accordance with a *Safety Management Plan* and having formal endorsement by a Registered Professional Engineer of Queensland that the completed works are in a safe condition. However, as soon as "reasonably practicable after starting the emergency works", a development application is to be made. Should that development application be refused, then the emergency repair works must be removed.

Having a *Safety Management Plan* in place does not invalidate the fundamental need for development approval of the flow slide barrier. Nevertheless, a *Safety Management Plan* for emergency repairs to the existing flow slide barrier has been prepared as a component of this SEMP.

The challenge to the process of formal application and approval is that the flow slide barrier forms the bayside frontage of several private properties as well as public land. There are in total 34 land parcels having the flow slide barrier along their frontage. This includes four freehold parcels alongside Old Schoolhouse Park, each having a narrow reserve in front (varying between 2m and 6m width), but still with at least part of the buried structure within their boundaries.

Monitoring future effectiveness of the flow slide barrier

Given that Rainbow Channel is migrating towards Amity Point, it is recommended that a structural audit of the flow slide barrier be undertaken at least annually - using information from an annual bathymetric survey of the vulnerable side slopes of Rainbow Channel. This will determine whether (as a consequence of changing bathymetry in Rainbow Channel) sections of the existing structure are becoming more vulnerable to future damage. This will allow for the planning of structural reinforcement and/or repair campaigns to the flow slide barrier.

The annual bathymetric survey should comprise a full hydrographic survey of the channel bank using both multibeam and single beam sounders. The physical extent of the survey is to be no less than that covered by the survey undertaken in December 2015 (Port of Brisbane, 2015). Included in the deliverables of each annual survey is to be a comparison with previous surveys to clearly indicate the extent of changes to the local bathymetry of Rainbow Channel. Comparisons with earlier transect surveys is also to be undertaken - comparable in scope and detail to those undertaken for this SEMP.

Availability of suitable rock armour for repairs to the flow slide barrier

In the past, rock for repairs to the flow slide barrier along the Central Reach has been available from two quarry sources on North Stradbroke Island. However, since the 2011 native title consent determination there is ongoing dialogue with the relevant stakeholders, and it will be necessary to establish administrative and financial structures to facilitate the supply of rock armour for Council projects and by Council to third parties.

A critical aspect determining the effectiveness of repairs to the flow slide barrier is having rocks placed to recharge the upper slopes as soon as possible after each damaging event. Apart from having the appropriate approvals in place to undertake necessary repairs, this will require:

- Having a stockpile of suitable rock armour ready for the emergency repairs. This stockpile could be located at a location close to Amity Point;
- Having contracts and/or arrangements in place for the appropriate loading, carriage and placement of rocks into damaged areas of the barrier as soon as possible following an event. This could be through commercial arrangements with private earthmoving contractors based on North Stradbroke Island;
- Having contracts and/or arrangements in place for access and the initiation of repair works to damaged areas of the flow slide barrier where landowners immediately affected by the threat are not residing at Amity Point and/or may not be readily contacted;
- Having contracts and/or agreements in place for the payment of repairs to damaged areas of the flow slide barrier.

To secure a long-term, sustainable and economic source of rock for repairs, it is recommended that a *Rock Armour Supply Study* be commissioned by Council to investigate and determine the procedures necessary to facilitate the appropriate sourcing and placement of rocks into an approved flow slide barrier along the Central Reach.

Payment for repairs to the flow slide barrier

To date, the cost of constructing and intermittently repairing the flow slide barrier along the Central Reach has been met by the local foreshore property owners. It is recommended that Council engage with other

stakeholders (and obtain assistance and advice on legal issues as required) to determine an appropriate funding arrangement for future maintenance works to the rock-armoured flow slide barrier.

Access for facilitating repairs to the flow slide barrier

The availability of access for trucks carrying rocks to the foreshore along the alignment of the flow slide barrier is varied. In many cases the residential home on private properties is of a size or location that prevents vehicular access from the street-side entrance through to the foreshore. In such cases the only available access route for construction plant and equipment to effect repairs to a damaged section of the flow slide barrier is via a nearby property without that impediment, then along the foreshore. In the past, this has entailed removing fences; traversing lawns and gardens; and removing and/or pruning established trees of neighbouring properties.

There appears to be an informal agreement amongst the present owners of foreshore properties that such access ought to be available, but any damage caused by this traffic is to be rectified at no cost to the affected property owners.

The ability to repair damaged sections of the flow slide barrier as soon as possible after each event in many cases relies on the goodwill of neighbouring residents. Whilst this informal arrangement is reputedly effective at present, there is no surety that it will remain so in future. There is merit in having present foreshore property owners investigate and implement a more formal agreement for such access that will be binding on existing and future owners of their property. It is beyond the scope of this SEMP to determine the need, and the planning and legislative frameworks, for any such agreements.

Cost Estimate

It is beyond the scope of this SEMP to determine the procedures, scheduling and the costs associated with resolution of issues relating to:

- Obtaining development approval for the flow slide barrier;
- Securing an on-going cost-effective and sustainable source of rocks for any future repairs;
- Payment provisions for repairs; and
- The securing of formal agreements for access by construction equipment for repairs.

The estimated costs associated with implementation of the recommended erosion mitigation strategy along the Central Reach are summarised in the table below.

Activity	Initial Cost	Annual Cost
Structural Audit		
Annual bathymetric survey of Rainbow Channel side slopes		$17,500
Annual structural audit of flow slide barrier		$7,500
Totals	*nil*	**$25,000**

Northern Reach – Amity Beach

The recommended erosion mitigation strategy along the Northern Reach is to maintain the existing strategy of non-intervention, but to monitor future shoreline behaviour.

The erosion threat to private landholdings with frontages on Amity Beach is caused primarily by erosion "hot-spots" that migrate along the shoreline. The extent, location and severity of such hot-spots is influenced by the extent of the changing sand spit that forms at the eastern end of the beach, in conjunction with the severity of future storm events.

Given the relationship between the erosion threat and the processes shaping the sand spit, there is considerable merit in further investigations to better understand the local coastal processes on Amity Beach and to therefore better predict emerging threats. Such investigations would require the establishment and operation of a Monitoring Survey Program.

Rather than just surveying along transects, recent developments in surveying technology now make it cost effective to obtain a full three-dimensional (3-d) representation of beaches utilising unmanned aerial vehicles (UAVs). This allows for more accurate calculations of changes in beach volumes over time. Repeated 3-d acquisition allows for accurate determinations of where, and how much, sand is being lost from the beach profile and where sand is accreting.

It is recommended that the following monitoring aspects be included in the strategy for mitigating the erosion threat on the Northern Reach:

- Monitoring Survey Program: Stage 1
  - The foreshore from 500 metres east of the sand spit (i.e. along the adjacent Flinders Beach) to a location at the northern end of the flow slide barrier of the Central Reach be captured by 3-d survey. This should be undertaken during a low spring tide to maximise the coverage of nearshore areas. It is to include the entire sand spit at the eastern end of Amity Beach.
  - Initially this 3-d survey should be undertaken at least twice yearly for three years, with extra surveys undertaken as soon as possible after major erosion events on Amity Beach.
- Coastal Processes Assessment
  - Upon completion of Stage 1 of the Monitoring Survey Program in three years' time, a *Coastal Processes Assessment* should be undertaken by suitably qualified coastal engineers/scientists to determine the erosion processes affecting Amity Beach. This would utilise the results of the Monitoring Survey Program to that time, in conjunction with analysis of aerial photographs, and reference to offshore waves measured by Queensland's Department of Environment and Science's directional Waverider station in deep water off Cape Moreton.
  - The requirements for further surveys under the Monitoring Survey Program would be determined by the Coastal Processes Assessment. However, this subsequent Stage 2 of the Monitoring Survey Program is likely to entail at least annual 3-d surveys.
  - The necessity for any erosion mitigation strategy for the Northern Reach would be addressed by the Coastal Processes Assessment.

The estimated costs associated with implementation of the recommended erosion mitigation strategy along the Northern Reach are summarised in the table below.

Activity	Initial Cost	Annual Cost
Monitoring Survey Program		
Stage 1 : Initial year of survey (2No.), including establishing controls	$15,000	
Stage 1 : twice yearly thereafter for two years		$10,000
Stage 2 : assumed annually after initial 3 years		$5,000
Coastal Processes Assessment – in three years' time		
Analysis of aerial photographs	$7,500	
Analysis of wave records	$7,500	
Coastal Engineering Assessment & reporting	$20,000	
Totals	**$50,000**	**$10,000 then $5,000**

GLOSSARY AND DEFINITIONS

accretion	The accumulation of beach sediment on a shoreline, having been deposited by natural processes.
AEP	Annual Exceedance Probability: The measure of the likelihood (expressed as a probability) of an event equalling or exceeding a given magnitude in any given year.
AHD	Australian Height Datum (AHD) is the geodetic datum for altitude measurement in Australia. The level of 0.0metres AHD approximately corresponds to mean sea level.
ARI	Average Recurrence Interval (ARI) is a statistical estimate of the average period in years between the occurrences of an event of a particular size. For example, a 100 year ARI event will occur on average once every 100 years. Such an event would have a 1% AEP (probability of occurring in any particular year)
angle of repose	The steepest angle at which a sloping surface formed of loose unconfined material is naturally stable.
astronomical tide	Water level variations due to the combined effects of the Earth's rotation, the Moon's orbit around the Earth and the Earth's orbit around the Sun. It excludes and oceanographic or meteorological influences.
bathymetry	The term bathymetry originally referred to the ocean's depth relative to sea level, although it has come to mean "submarine topography," or the depths and shapes of underwater terrain.
coastal processes	The physical processes that act to shape the coast and the landforms that make up the coast.
dilation	The observed tendency of a compacted granular soil (such as sand) to expand in volume as it is sheared.
exceedance probability	The probability of an extreme event occurring at least once during a prescribed period of assessment is given by the exceedance probability. The probability of a 1 in 100 year event (1% AEP) occurring during the first 25 years is 22%, during the first 50 years the probability is 39% and over a 100 year asset life the probability is 63%.
geophysical survey	A geophysical survey detects and maps subsurface features.

HAT	Highest Astronomical Tide: the highest water level that can occur due to the effects of the astronomical tide in isolation from meteorological effects.
hydrographic survey	A hydrographic survey maps the features of the sea bottom.
intertidal	The area of a shoreline that is above water at low tide and under water at high tide (in other words, the area between the low & high tide levels).
littoral	Relating to (or situated on) the shore of the sea.
littoral drift	The natural geographical process that consists of the transportation of sediments along a coast.
longshore	In the direction along the shoreline (i.e. parallel to the coast).
MSL	Mean Sea Level (MSL) is the long-term average level of the sea surface.
neap tides	Neap tides occur when the gravitational influences of the sun and moon are not aligned, resulting in high and low tides that are not as extreme as those during spring tides.
significant wave height	Due to the random nature and size of waves, the term “significant wave height” is used by engineers and scientists to quantify wave heights in a sea state. It represents the average of all the third highest waves that occur over a particular timeframe.
spring tide	In a lunar month, the highest tides occur at the time of the new moon and the full moon (when the gravitational forces of sun and moon are in alignment). These are called “spring” tides and they occur approximately every 14 days.
storm surge	The meteorological component of the coastal water level variations associated with atmospheric pressure fluctuations and wind setup.
storm tide	Coastal water level produced by the combination of astronomical and meteorological (storm surge) ocean water level forcing.
subaerial	On the earth’s surface, not underwater or underground.
subaqueous	Situated under water.

CONTENTS

EXECUTIVE SUMMARY 4
Objectives of the Shoreline Erosion Management Plan 4
Erosion Threats to the Amity Point Foreshore 6
Southern Reach – Camping Ground Foreshore 6
Central Reach – Rock Armoured Foreshore 7
Northern Reach – Amity Beach 8
Recommended Shoreline Erosion Mitigation Strategies 8
Southern Reach – Camping Ground Foreshore 8
Central Reach – Rock Flow Slide Barrier 11
Northern Reach – Amity Beach 15

GLOSSARY AND DEFINITIONS 17

1. INTRODUCTION 24
1.1 Background 24
1.2 Regional and Local Setting 25
1.3 The Erosion Problem 25
1.4 Objectives of this Shoreline Erosion Management Plan 27
1.5 Structure of this Shoreline Erosion Management Plan 29

2. COASTAL VALUES 30
2.1 Indigenous Cultural Heritage Values 30
2.2 Post-European Heritage Values 32
2.3 The Marine Environment 33
2.4 The Terrestrial Environment 35
2.5 The Social Environment 38

3. PHYSICAL PROCESSES ANALYSIS 39
3.1 Local Bathymetry 39
3.2 Local Coastal Processes 41
3.2.1 Ocean Water Levels 43
3.2.2 Ocean Currents 46
3.2.3 Wave Climate 46
3.2.4 Sediment Supply and Transport Mechanisms 47
3.3 Retrogressive Flow Slides 48
3.4 Future Climate Change 52
3.5 Coastal Reaches of Amity Point 52
3.5.1 Southern Reach - Camping Ground Foreshore 53
3.5.2 Central Reach - Flow Slide Barrier 54
3.5.3 Northern Reach - Amity Beach 54

4. RISK ASSESSMENT 56
4.1 Erosion Threat 56
4.1.1 Coastal Erosion 56
4.1.2 Retrogressive Flow Slides 59
4.2 Concept Design of a Flow Slide Barrier 60
4.3 Structural Audit of the Flow Slide Barrier Along the Central Reach 62
4.3.1 Performance of the Existing Flow Slide Barrier 62
4.3.2 Summary of the Structural Audit 68
4.4 Erosion Threat at the Southern Reach - Camping Ground Foreshore 69
4.4.1 Coastal Erosion 69
4.4.2 Retrogressive Flow Slides 71
4.5 Erosion Threat at the Central Reach - Flow Slide Barrier 74
4.5.1 Coastal Erosion 74
4.5.2 Retrogressive Flow Slides 74
4.6 Erosion Threat at the Northern Reach - Amity Beach 74
4.6.1 Coastal Erosion 74
4.6.2 Retrogressive Flow Slides 75

5. SHORELINE EROSION MANAGEMENT OPTIONS 77
5.1 Guiding Principles 77
5.2 Generic Erosion Management Options 78
5.2.1 Non-structural Erosion Management Options 78
5.2.2 Structural Erosion Management Options 80

6. ASSESSMENT OF SHORELINE MANAGEMENT OPTIONS 84
6.1 Southern Reach - Camping Ground Foreshore 84
6.1.1 Non-structural Management Options 84
6.1.2 Structural Management Options 86
6.2 Central Reach - Flow Slide Barrier 88
6.2.1 Non-structural Management Options 88
6.2.2 Structural Management Options 89
6.2.3 Further Research and Investigation 92
6.3 Northern Reach - Amity Beach 93
6.3.1 Non-structural Management Options 93
6.3.2 Structural Management Options 94
6.4 Assessment Methodology 95
6.4.1 Values to Guide the Assessment 95
6.4.2 Assessment Criteria 96
6.4.3 Assessment Outcomes 101

7. STAKEHOLDER CONSULTATION AND ENGAGEMENT 102
7.1 Methodology 102
7.2 Community Response 103

8. PLANNING AND LEGISLATION REVIEW 104
8.1 Background 104
8.2 Coastal Protection and Management Act 1995 104
8.3 Planning Act 2016 105
8.3.1 State Planning Policy (SPP) 2017 107
8.3.2 State Development Assessment Provisions 108
8.3.3 SEQ Regional Plan 108
8.4 Coastal Management Plan 109
8.5 Other Legislation and Approvals 110
8.5.1 Commonwealth Legislation 110
8.5.2 State Legislation and Instruments 113
8.5.3 Other Considerations 120
8.6 Local Government 121
8.6.1 Redlands Planning Scheme 121
8.6.2 Other Local Government Instruments and Strategies 121

9. RECOMMENDED SHORELINE EROSION MANAGEMENT 123
9.1 Southern Reach - Camping Ground Foreshore 123
9.1.1 Recommended Strategy 123
9.1.2 Cost Estimate 125
9.1.3 Implementation Schedule 127
9.2 Central Reach - Flow Slide Barrier 127
9.2.1 Recommended Strategy 127
9.2.2 Cost Estimate 130
9.3 Northern Reach - Amity Beach 131
9.3.1 Recommended Strategy 131
9.3.2 Cost Estimate 132

10. REFERENCES 133

APPENDICES

Appendix A Comparison of Historical Transect Surveys
Appendix B Analysis of Rainbow Channel Migration
Appendix C Summary Report - Amity Point SEMP Open House
Appendix D Coastal Hazard Plans
Appendix E EPBC Act Protected Matters Report
Appendix F Potential Interaction of Flow Slides with the Existing Flow Slide Barrier Along the Central Reach
Appendix G Safety Management Plan – Flow Slide Barrier
Appendix H Concept Design for a Flow Slide Barrier

LIST OF FIGURES

Figure 1-1	Regional Setting	26
Figure 1-2	Historical Changes to Tidal Channels and Shorelines	27
Figure 1-3	Present-day Passage Between Moreton and North Stradbroke Islands	28
Figure 2-1	The Regional Setting within Quandamooka Country	31
Figure 2-2	Marine Park Zoning	33
Figure 2-3	Fish Habitat	34
Figure 2-4	Wetland and Marine Habitat	34
Figure 2-5	Terrestrial Vegetation	37
Figure 2-6	Koala Habitat	37
Figure 2-7	Land Zoning, Community and Emergency Facilities	38
Figure 3-1	Location of Historical Survey Transects on Amity Point Foreshore	40
Figure 3-2	Sand Waves on the Seabed in Rainbow Channel off Amity Point	42
Figure 3-3	Components of a Storm Tide Event	44
Figure 3-4	Historical Changes to the Shoreline at Amity Point	49
Figure 3-5	A Retrogressive Flow Slide Underway at Amity Point	50
Figure 3-6	Coastal Reaches of Amity Point Study Area	53
Figure 3-7	Southern Reach – Camping Ground Foreshore	54
Figure 3-8	Central Reach – Rock Wall Frontage	55
Figure 3-9	Northern Reach – Amity Beach	55
Figure 4-1	Erosion Prone Area Map	58
Figure 4-2	Concept Design for a Flow Slide Barrier	61
Figure 4-3	Slope Analysis of Rainbow Channel, Highlighting Areas at Risk of Flow Slides	64
Figure 4-4	Potential Locations For Initiation of Retrogressive Flow Slides	65
Figure 4-5	Example of Interaction of Flow Slide with Barrier – Chainage 1300m	66
Figure 4-6	Flow Slide Emerging on the Foreshore at Old School House Park, January 2011	67
Figure 4-7	Options to Reinforce the Flow Slide Barrier Opposite Old School House Park	68
Figure 4-8	Predicted Beach Response Along the Southern Reach for Various Storm Events	71
Figure 4-9	Extent of Coastal Erosion Threat Along the Southern Reach	72
Figure 4-10	Evidence of Past Flow Slide Events Opposite the Southern Reach	73
Figure 4-11	Erosion Processes on the Northern Reach – Amity Beach	75
Figure 6-1	Existing Flow Slide Barrier Inhibiting Development of Flow Slides	91
Figure 6-2	Assessment Criteria and Weighting	97
Figure 6-3	Assessment for the Southern Reach – Camping Ground	98
Figure 6-4	Assessment for the Central Reach – Flow Slide Barrier	99
Figure 6-5	Assessment for the Northern Reach – Amity Beach	100
Figure 8-1	Queensland's Planning Framework	106
Figure 8-2	Areas of Native Title Determination at Amity Point - *Exclusive Use*	112
Figure 8-3	Areas of Native Title Determination at Amity Point - *Non-Exclusive Use*	112
Figure 8-4	Designated Zones of the Marine Park at Amity Point	115
Figure 8-5	Designated Minjerribah Recreational Area	116
Figure 8-6	Fish Habitat Areas	117
Figure 8-7	Remnant Vegetation	119
Figure 8-8	Wetland and Marine Regional Ecosystems	119

Figure 8-9 Koala Habitat Categories 120
Figure 8-10 Redlands Planning Scheme Map – North Stradbroke Island, Amity Point Inset 122
Figure 9-1 Recommended Erosion Mitigation Strategy – Southern Reach 124

LIST OF TABLES

Table 3-1 Migration Rates of Rainbow Channel 41
Table 3-2 Tidal Planes at Amity Point 43
Table 3-3 Storm Tide Levels at Amity Point 46
Table 3-4 Annual Average Wave Height & Direction Occurences 47
Table 8-1 Objectives of Marine Park Zones within the SEMP Area 115
Table 9-1 Characteristics of Recommended Strategy for Southern Reach 123
Table 9-2 Cost Estimate for Recommended Mitigation Strategy – Southern Reach 126
Table 9-3 Southern Reach – Implementation Schedule 127
Table 9-4 Land Tenure Along the Alignment of the Existing Flow Slide Barrier 129
Table 9-5 Cost Estimate for Recommended Mitigation Strategy – Central Reach 131
Table 9-6 Cost Estimate for Recommended Mitigation Strategy – Northern Reach 132

1. INTRODUCTION

Located on the north-west corner of North Stradbroke Island, the township of Amity Point enjoys a rich diversity of seascapes and landscapes - providing extensive recreational and lifestyle opportunities that are considerably enhanced by local cultural, heritage and environmental values.

The historical development of Amity Point has focused on the shoreline - as residents and visitors seek to enjoy the unique character of this coastal precinct. However, the dynamic nature of the coastal environment means that some local foreshores are experiencing erosion which is threatening these values, as well as endangering essential infrastructure.

1.1 Background

As part of the early development of the *Amity Point Shoreline Erosion Management Plan*, Redland City Council previously commissioned a Shoreline Erosion Study (BMT WBM, 2013). At that time, it was envisaged the study would be one of several sources of information that would contribute to the development and adoption by Council of an implementation plan for future shoreline management.

That 2013 Shoreline Erosion Study investigated local coastal processes; assessed local social, environmental, cultural and economic values; appraised coastal risks and hazards; identified viable erosion management options; and then recommended mitigation strategies for various coastal reaches of Amity Point. The erosion mitigation strategies recommended by the Draft Report of the Shoreline Erosion Study were:

> ***Amity Township***
>
> *Firstly, the design and construction of a full rock revetment at an estimated cost of $15M with the expectation that this will need to be extended in the future as Rainbow Channel continues to realign.*
>
> *Secondly, planned retreat where the danger zone related to unforeseen slumping of the foreshore into Rainbow Channel is assessed by a Geotechnical Consultant and affected buildings and infrastructure is moved out of the nominated danger zone……*
>
> *…… Of these it is recommended that the planned retreat strategy be implemented as it has the highest likelihood of success, lower cost and will leave the foreshore in a natural state.*
>
> ***Amity Caravan Park***
>
> *After assessment of the management options, it is recommended that the beach nourishment option be implemented at this beach. The beach nourishment will provide added protection to the assets and minimise the need for other structural protection measures in the future. It will retain natural processes and provide an improvement to the beach amenity……..*
>
> ***Flinders Beach***
>
> *The recommended shoreline erosion management strategy for the communities of Geera Street and Providence Street is to "do nothing" at this time and monitor the location of the shoreline.*

The recommendation of the 2013 Draft Report for planned retreat along the frontage of Amity Township met with considerable opposition from the local community. Council has subsequently ensured that extensive consultations with key stakeholders has been an integral component of later phases of developing the SEMP.

To assist in guiding the SEMP process, Council established the Amity Point SEMP Reference Group. The Group is chaired by the Divisional Councillor and has members drawn from affected property owners; the Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC), the local residential community; community groups across North Stradbroke Island and Council staff. The primary purpose of the reference group is to:

- Work with Redland City Council officers to contribute their expertise and knowledge to shoreline erosion planning for Amity Point; and
- Provide valuable local input to enable the delivery of a SEMP and Draft Implementation Plan that meets the current and long term needs of the community.

The Project Brief for this Amity Point SEMP has been prepared with the assistance of the SEMP Reference Group. The intent of the *Amity Point Shoreline Erosion Management Plan* (Amity Point SEMP) is to provide a framework for the sustainable use, development and management of this vulnerable foreshore.

1.2 Regional and Local Setting

Being approximately 275 km^2 in area, North Stradbroke Island is the second-largest sand island in the world. Along with Moreton and South Stradbroke Islands, it forms the eastern edge of Moreton Bay. North Stradbroke Island's regional setting is illustrated on Figure 1-1.

The island is located some 38kms from Brisbane's CBD; and is serviced by car and passenger ferries from Toondah Harbour at Cleveland in Redland City. This proximity to a major capital city means that tourism is a significant and growing industry on the island. There are three main settlements on North Stradbroke Island – Dunwich, from which the mainland ferries operate; Amity Point on the north-western tip of the island; and Point Lookout on the north-eastern tip.

North Stradbroke Island has three quite distinctive coastlines. The east to south-east facing ocean coast experiences persistent south-easterly swell and is distinguished by its 33km long Main Beach, having Point Lookout at its northern-most end. The northern shoreline of North Stradbroke Island experiences somewhat lower swell energy on its beaches, but it is nevertheless exposed to north-east fetches across which large waves from storms/cyclones can arrive. The western shores of the island front onto the calmer waters of Moreton Bay. As well as experiencing a mild wave climate, these western beaches are typically fronted by intertidal sand flats and tidal channels.

Being situated on the north-western tip of North Stradbroke Island, the foreshores of Amity Point are located within the dynamic region at the junction of ocean and bayside shorelines.

1.3 The Erosion Problem

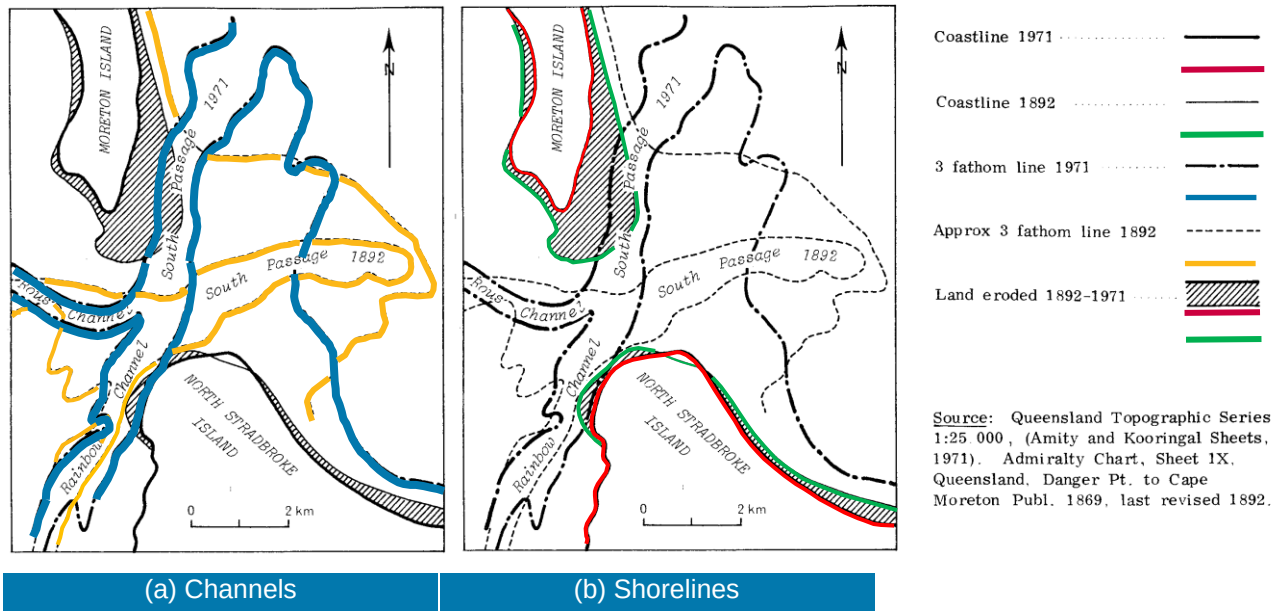
A significant exchange of tidal waters occurs between Moreton Bay and the open ocean through the passage separating Moreton Island and North Stradbroke Island. This 3.5km wide passage consists of ever-changing sand banks and shoals as the complex flow regime shapes the seabed bathymetry and the adjacent shorelines of Moreton and North Stradbroke Islands.

The location, orientation and size of the various channels that meander through this dynamic setting vary considerably. Historically there have been two significant channels on the Moreton Bay side of the passage which carry most of the tidal flows eastward to the ocean. Rainbow Channel and Rous Channel join to the north of Amity Point to form the South Passage Channel on the ocean-side of the strait between the two islands.

Historical records and surveys document significant changes to these channels. Figure 1-2 shows historic variations to the main channels (on the left-hand side of that figure) and changes to shorelines (on the right-hand side). Figure 1-2 has been produced by modifying a figure from an earlier report (Eberhardt, 1978).



FIGURE 1-1 REGIONAL SETTING



(a) Channels (b) Shorelines

FIGURE 1-2 HISTORICAL CHANGES TO TIDAL CHANNELS AND SHORELINES

Figure 1-3 illustrates the current condition of the channels between Moreton and North Stradbroke Islands. The orientation of the South Passage Channel has changed significantly since it was first surveyed in 1892. In those earlier times, it was oriented almost east/west - with Rous Channel being the main navigable route for vessels entering Moreton Bay. Since then, the orientation of the South Passage Channel has become more north/south; and Rainbow Channel is now the more dominant of the two main channels inside of the Bay.

Since the scenario recorded in 1892, Rainbow Channel has slowly migrated eastward towards the north-west tip of North Stradbroke Island where Amity Point is located.

This eastward migration of Rainbow Channel - in conjunction with the changing bathymetry as many tidal channels meander and large sand shoals shift – has resulted in the north-west tip of North Stradbroke Island at Amity Point experiencing an erosion threat which has persisted for many decades.

1.4 Objectives of this Shoreline Erosion Management Plan

A Shoreline Erosion Management Plan (SEMP) is a non-statutory planning document that sets out an agreed framework and management strategy for responding to existing erosion problems and possible future erosion threats. This is achieved by considering the physical coastal processes in conjunction with the environmental, cultural, social and economic values of the shoreline. The Amity Point SEMP will determine management goals agreed to by governments and the community. It will:

- Enable land owners to proactively plan for erosion management in vulnerable foreshore areas in a way that is consistent with community aspirations and the policies of the Commonwealth and State Governments, Redland City Council and the Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC);
- Investigate and address the underlying causes of shoreline erosion and its likely future progression;
- Determine cost effective and sustainable erosion management strategies that maintain natural coastal processes and resources; and consider community needs in both the short- and long-term.
- Assist in defining the roles and responsibility of property owners, local government and traditional owners in relation to foreshore management.

However, it is important to appreciate that the SEMP has a planning horizon of 20 years[1], and as such is a medium-term management plan. Consequently, the recommended management strategies need to be adaptive and flexible according to the level of risk, and be tailored to fit within the "pathways" approach to adaptation needs defined in Council's *Draft Coastal Adaptation Strategy*. Recommended options will be the most appropriate at this point in time, but may not be the optimum beyond the planning period for the SEMP.



FIGURE 1-3 PRESENT-DAY PASSAGE BETWEEN MORETON AND NORTH STRADBROKE ISLANDS

[1] "*Project Brief – Amity Point Shoreline Erosion Management Plan*". Redland City Council, document number Q-1740-15/16-PRP. October 2015

1.5 Structure of this Shoreline Erosion Management Plan

The Shoreline Erosion Management Plan for Amity Point has been structured as follows:

- This Section 1, which consists of an introduction and provides some background to the need and development of the Plan.
- Section 2 provides an assessment of the coastal environmental and social values of Amity Point which might be compromised by on-going erosion.
- Then in Section 3 the natural physical processes that shape the project shoreline are discussed.
- This is followed in Section 4 by a discussion of the risks that these various natural processes represent to local coastal values and infrastructure. It includes a structural audit of the existing rock-armoured foreshore.
- Section 5 then offers several potential strategies that could mitigate these risks.
- Section 6 provides an assessment of the various management strategies - leading to the establishment of a preferred erosion management strategy.
- Section 7 provides background as to the stakeholder consultation and engagement undertaken in the development of the preferred mitigation strategies.
- An outline of the commonwealth, state and local government planning and legislative framework affecting the implementation of the Plan is offered in Section 8.
- Following consideration of all aspects investigated and discussed in preceding sections of the report, Section 9 then presents the preferred shoreline erosion management plan for locations along the shoreline of Amity Point.
- Appendices to support the technical content of the Plan are included.

2. COASTAL VALUES

2.1 Indigenous Cultural Heritage Values

Amity Point (originally known as Pulan Pulan) is the traditional home of the Nunukul people, a clan of the Quandamooka Peoples. The location of Pulan Pulan within Quandamooka Country is shown in Figure 2-1.

Prior to contact with Europeans, the Quandamooka people maintained significant trade and ceremonial networks, sophisticated systems of territorial and political affiliation, complex language patterns and intricate but flexible social relationships (Whalley, 1987). For over 50,000 years, the Quandamooka people have maintained a strong connection to land, water, sea, air, flora, fauna and other natural resources.

This deep and intrinsic connection is expressed by Robert Anderson, Gheebelum, Ngugi, Mulgumpin - a Ngugi Elder of Mulgumpin in Quandamooka Country.

> *"The vision of my country, the way I view or see my country, the way I talk or sing up my country, the way I talk of the stories of my country and talk about my Elders and Ancestors, this is my cultural heritage. The way I call their names as I walk the sacred places of my country and the way I remember their brave deeds on my land is my cultural heritage. My spiritual connection with the land is my cultural heritage. All these things are a part of my cultural heritage.*
>
> *To walk my country, to gather the shell fish from the ocean beaches and the bay side beaches, is part of my cultural heritage. To see the changing nature of the flora with the seasons, to gather the wild flowers and to eat the berries and fruits of my country, reminds me of my mother and her connection to this my cultural heritage. To observe the birds, their migratory flight patterns, and nesting habitats, to understand how their presence fertilises, pollinates and regenerates the plant growth; how they herald the arrival of the deep-sea mullet, the whales and other sea inhabitants, for seasonal sustenance. This is the cultural heritage of my country.*
>
> *To be with my family and community people walking the country together, making that strong spiritual connection with the land is my cultural heritage. To continue to walk the bora ground and practice my cultural rights and responsibilities, as well as acknowledge the importance of this continuation on my country, is my cultural heritage.*
>
> *If we do not have access to our land, we are denied the right to maintain our practices that protect, preserve and nurture our land and our cultural heritage." (Peacock, 2001).*

A native title consent determination was made in 2011 recognising the Quandamooka People's cultural heritage, and as native title holders of areas of national park, reserve, unallocated state land and other leases on and surrounding North Stradbroke Island (National Native Title Tribunal, 2011).

The determination finalised two claims lodged in 1995 and 1999 by the Quandamooka people. The Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC) is the Prescribed Body Corporate that manages the native title rights on behalf of the native title holders. The determination covers exclusive rights to about 2,264 hectares of land and non-exclusive rights to about 22,639 hectares of onshore areas and about 29,505 hectares of offshore areas.

The rights protected by the determination include the right to live and be present in the areas; conduct ceremonies; to maintain places of importance and areas of significance; and to take, use, share and exchange traditional natural resources and seawater for any non-commercial purpose.

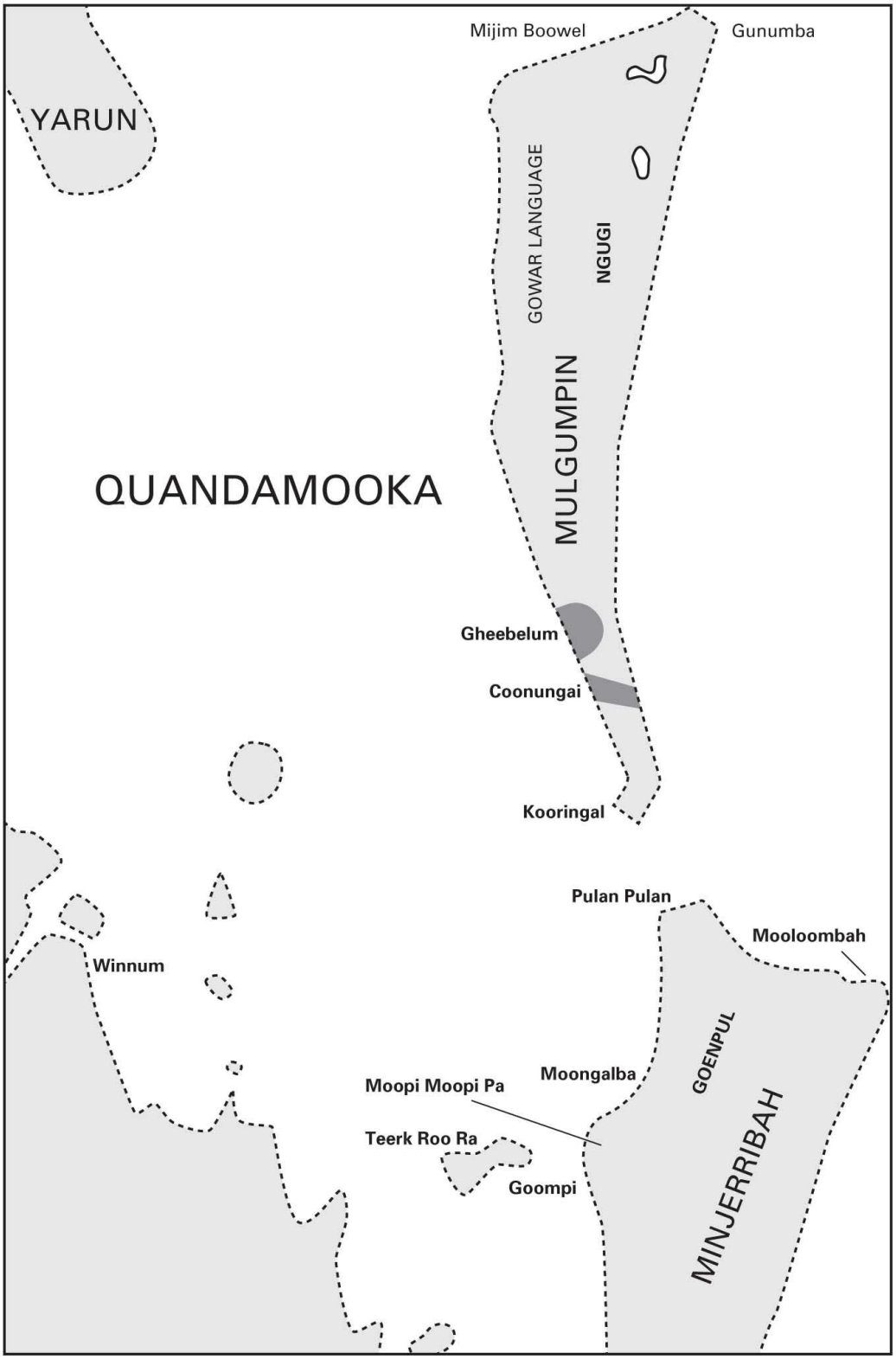


FIGURE 2-1 THE REGIONAL SETTING WITHIN QUANDAMOOKA COUNTRY[2]

[2] Figure 2-1 has been reproduced from Peacock, 2001. Copyright is acknowledged.

2.2 Post-European Heritage Values

The North Stradbroke Island Historical Museum was founded at Dunwich in 1987 to curate the history of North Stradbroke Island. The substantial collection of documents, images and records within the Museum attest to the significant cultural and historical values of North Stradbroke Island - both prior to, and following European contact with the Quandamooka people. Most of the information presented in this Section 2.2 of the SEMP has been obtained from sources within that much-valued collection.

In 1770 Captain James Cook made the first documented European sighting of North Stradbroke Island whilst sailing northward in *HMS Endeavour*. However, a landing was not made on the island at that time. The first significant contact between Europeans and the local Aboriginal people is thought to have occurred in 1803, when Matthew Flinders and his crew of *HMS Investigator* landed in search of fresh water whilst undertaking Flinder's renowned circumnavigation of Australia. Contact between Europeans and the Aboriginal peoples of North Stradbroke Island was first officially recorded in April 1823 when three timber-getters were shipwrecked in Moreton Bay. Shortly thereafter, Pulan Pulan was renamed Amity - after the Surveyor General, John Oxley's ship of the same name.

In 1825 a pilot station was established at Amity Point to guide ships through the hazardous South Passage between Moreton and Stradbroke Islands to the newly established Moreton Bay penal settlement. This was the first European settlement on Stradbroke Island. In those days, Stradbroke Island was just the one single landmass - whereas today it consists of North and South Stradbroke Islands, with their separation occurring at Jumpinpin during a cyclone in 1896.

In March 1847 whilst navigating South Passage the ship *SS Sovereign* sank, and many lives were lost. A group of Moreton Island and Stradbroke Island Aboriginal men nevertheless rescued ten passengers and were rewarded at that time for their efforts by the State Government. A plaque commemorating this rescue was unveiled in 2002 on the Amity Point foreshore at Cabarita Park (just to the north of the existing boat ramp).

As a result of that shipwreck, an alternative pilot station was opened at the northern end of Moreton Island; and the North Passage became the main navigable entry into Moreton Bay rather than South Passage. The pilot station at Amity was therefore closed in the 1840s, and its original site has since been lost to coastal erosion.

Other historic sites at Amity Point lost to coastal erosion include a racecourse, the original jetty, and a kiosk located next to the jetty (built by Hayles Cruises in 1935 as the landing place for launch operations to the island) and the original site of the explorer and noted local historian Thomas Welsby's cottage. Timbers from Welsby's cottage were reputedly used to re-build the kiosk as "Cabarita" in 1947. Cabarita has since been relocated several times over the years to avoid the threat of foreshore erosion. It is now privately owned and located on Ballow Street, approximately 80 metres landward of the rock-armoured foreshore.

A fishing community became established at Amity Point in the 1880s. The size and permanence of the community has fluctuated since that time. A school operated at Amity Point from 1919 to 1920, then from 1937 to 1938 and again from 1951 until 1961 (when it was last closed due to low enrolment numbers). Amity Point's Old Schoolhouse Park is the site of the last school and is located on the immediate foreshore. The school building was relocated to Dunwich State School in 1965.

The Amity Point Public Hall is located on Ballow Street some 200 metres inland of the rock-armoured foreshore. It was built in 1950 by the Amity Point Progress Association by relocating a former ward of the Dunwich Benevolent Asylum. The hall was used for social activities such as dances and community meetings, and was also the site of a provisional school from 1951 until 1954. The hall remains a significant centre for the local community to this day; and the Amity Point Progress Association remains very active.

When considering appropriate erosion management strategies at Amity Point, it is necessary to consider the valuable and much esteemed role that Amity Point has played in the historical development of the wider Moreton Bay region.

2.3 The Marine Environment

The waters off Amity Point lie within the Moreton Bay Marine Park; and have been mapped as an area of conservation significance under the Moreton Bay Marine Park Management Plan. The location is shown in Figure 2-2 as being a *Conservation park zone*. Such designated zones are deemed areas of high conservation value for habitat and wildlife, nevertheless they allow for limited recreational and commercial uses such as fishing and crabbing.

Rainbow Channel is aligned alongside the Amity Point shoreline. The seabed drops steeply from shore to approximately 20 metres depth of water at the channel bed. Whilst the channel itself is not designated an important fish habitat area, the Myora-Amity Banks on the western side of the channel; and the shoreline to the immediate south of the Amity Point SEMP area are each declared a Fish Habitat Area[3] (refer Figure 2-3).



FIGURE 2-2 MARINE PARK ZONING

Declared Fish Habitat Areas are areas of high-value fish habitat which are safeguarded from physical disturbance associated with coastal development. They are declared under Queensland's *Fisheries Act 1994*. Fish Habitat Areas are a key element of the State government's strategy for sustaining fish stocks and fisheries. More broadly, they are recognised as part of Australia's *Nationally Representative System of Marine Protected Areas*, and fit within the *International Union for the Conservation of Nature's* (IUCN's) "Protected Area Management Category VI - Protected area with sustainable use of natural resources".

[3] "*Myora-Amity Banks Fish Habitat Area Outer Boundary*". Plan number FHA-017.
Originally prepared in 1999 by Queensland Department of Primary Industries. Published online at:
https://www.npsr.qld.gov.au/managing/pdf/myora.pdf

Seagrass meadows have been identified and mapped off Amity Point (refer to Figure 2-4) and these occur near the shoreline along the southern part of the SEMP area. Benthic assemblages occur in these areas.

Whilst the foreshores of Amity Point themselves do not fall within a declared Fish Habitat Area, their very close proximity to such areas means that any erosion mitigation strategies implemented under this SEMP must be carefully considered so as not to adversely affect these important marine areas.

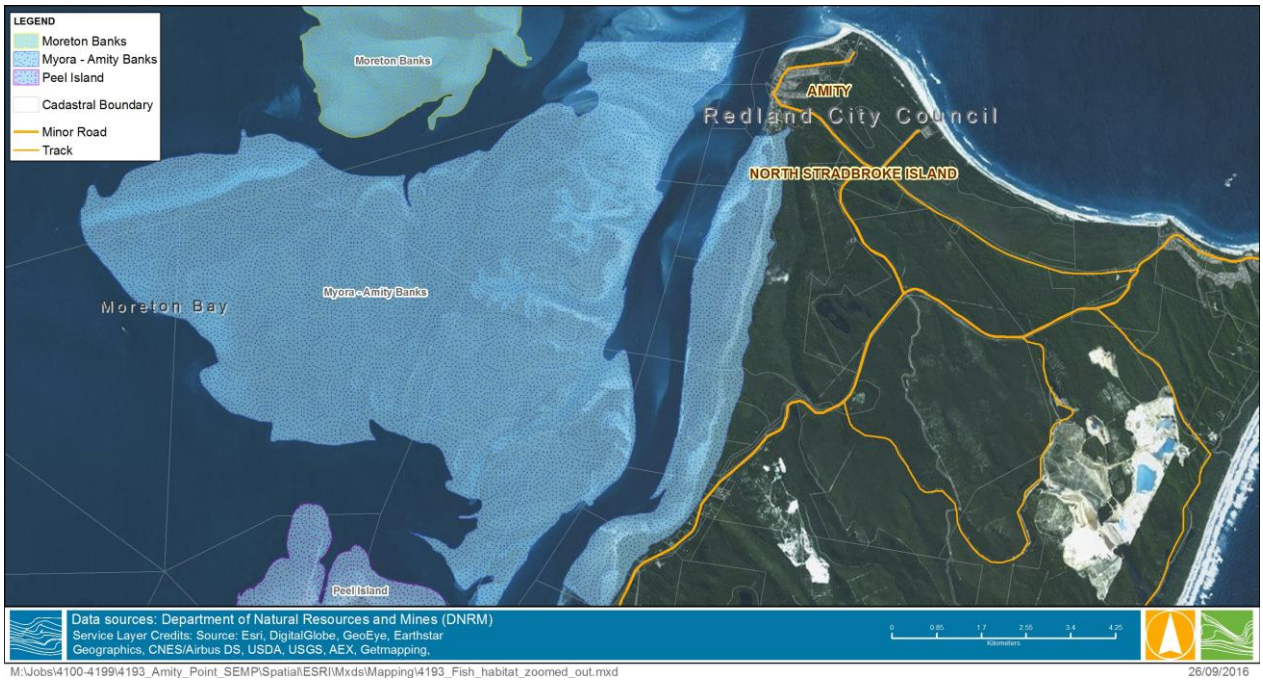


FIGURE 2-3 FISH HABITAT

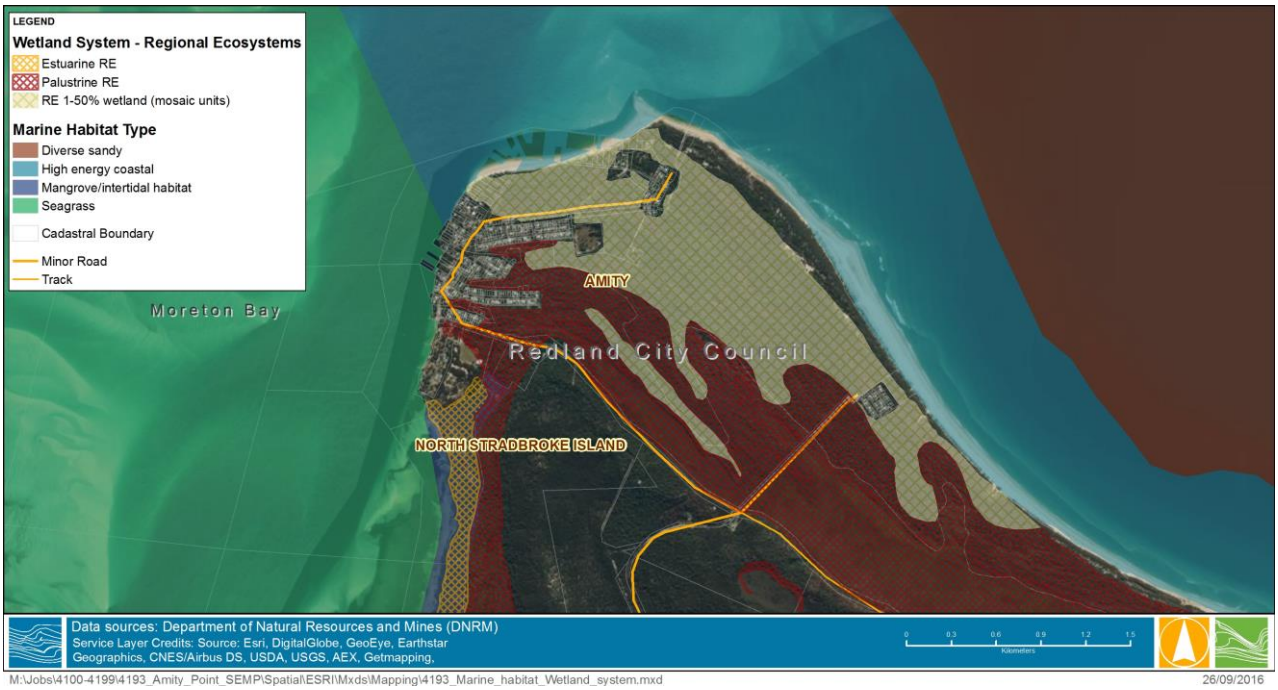


FIGURE 2-4 WETLAND AND MARINE HABITAT

On the foreshore of Amity Point, the rock-armoured subaqueous slope of Rainbow Channel hosts a diverse assemblage of marine life, including corals (Tibbets and Townsend, 2010; Tibbets, pers. comm.[4]; Townsend, pers. comm.[5]; Burns, pers. comm.[6]). This results in the wall being much utilised for recreational diving, spear fishing, recreational line fishing and indigenous fishing.

The hard rock surfaces along this foreshore provide "*algal turf substrates and excellent cover for fishes, which may well have contributed to the high diversity and abundance of grazers at (this) site*" (Tibbetts and Townsend, 2010).

Any erosion mitigation strategies implemented under this SEMP must seek to preserve the unique marine environment of the Amity Point foreshore and to not adversely affect these important marine values.

2.4 The Terrestrial Environment

Vegetation communities throughout Queensland are characterised and mapped by a procedure known as *Regional Ecosystems*. A Regional Ecosystem is a specific vegetation community occurring in conjunction with a particular combination of geology, soil type and landform within a specific bioregion of Queensland.

Many people would have a colloquial name for the vegetation type on their properties (such as open scrub, or coastal vine thicket) and know the land type (e.g. floodplains or rocky slopes). A Regional Ecosystem basically defines a grouping of land types and vegetation. Defining Regional Ecosystems assists in classifying biodiversity, ecological processes and vegetation communities on a landscape scale. They are used to provide a consistent approach to planning, vegetation management and legislation across Queensland.

Each Regional Ecosystem (RE) is classified by a three-part code (e.g. 12.2.5). The first number of the RE classification is the bioregion, the second part signifies the geology, soil and landform, while the third part refers to the vegetation. The grouping of these three factors produces a Regional Ecosystem.

As noted above, the first part of the RE classification is the bioregion. Queensland has been divided into thirteen different bioregions which are based on broad landscape patterns that indicate major differences in climate, geology, animals and plants across Queensland. South-East Queensland (of which Amity Point is a part) is designated as bioregion number 12.

The second number of a RE is the land zone. Twelve land zones have been defined in Queensland. Land zones represent considerable differences in geology, landforms and soil types. Land zones largely match broad geological types, and can therefore be identified using geological maps. The area of Amity Point covered by the SEMP is typically either:

- Land zone 1 – which is land that is subject to tidal inundations (e.g. mangroves, beaches, tidal flats) or
- Land zone 2 - such as coastal dunes, coastal lakes and swamps that do not get inundated by seawater.

The third number of a RE describes the vegetation type. A Regional Ecosystem describes vegetation by its structure (e.g., grassy woodland, open forest or wet heathland), the dominant plants in the canopy, and associated plants in the understorey. Scientific names are used since common plant names vary from one locale to another; and can sometimes be unreliable.

---

[4] Telephone discussions with Dr. Ian Tibbetts (Associate Professor, School of Biological Sciences Faculty of Science, University of Queensland) with P.L. O'Brien of Water Technology Pty Ltd. 04th February 2016.

[5] Telephone discussions with Dr. Kathy Townsend (Lecturer/ Education Officer, Moreton Bay Research Station, University of Queensland) with P.L. O'Brien of Water Technology Pty Ltd. 04th February 2016.

[6] Interview with Darren Burns (Land and Sea Management Coordinator, Quandamooka Yoolooburrabee Aboriginal Corporation) with P.L. O'Brien of Water Technology Pty Ltd. 26th February 2016.

Amity Point township is closely surrounded by high-value remnant terrestrial ecosystems of state significance (refer to Figure 2-5). Regional ecosystems around the township include:

- 12.1.3 - Mangrove shrubland to low closed forest on marine clay plains and estuaries;
- 12.2.5 - Corymbia intermedia +/- Lophostemon confertus +/- Banksia spp. +/- Callitris columellaris open forest on beach ridges - usually in the southern half of the bioregion;
- 12.2.6 - Eucalyptus racemosa subsp. racemosa open forest on dunes and sand plains. Usually deeply leached soils;
- 12.2.7 - Melaleuca quinquenervia or rarely M. dealbata open forest on sand plains;
- 12.2.14 - Foredune complex;
- 12.2.16 - Sand blows largely devoid of vegetation;
- 12.2.18 - Abutilon albescens +/- Wollastonia biflora low shrubland. Restricted to coral, shingle and sand cays.

As illustrated in Figure 2-5, the area directly surrounding the residential area is designated Essential Habitat under the *Vegetation Management Act 1999*. The Essential Habitat protects three vulnerable frog species, the Wallum Rocketfrog (*Litoria freycineti*), the Wallum Froglet (*Crinia tinnula*) and the Wallum Sedgefrog (*Litoria olongburensis*). The species occur in freshwater swamps, sedgelands, lakes and creeks; heathlands; wallum (Banksia aemula shrubland/woodland) or Melaleuca open forest; and adjacent Eucalyptus racemosa forest.

Significant palustrine (e.g. vegetated swamps in dune swales) and estuarine (e.g. mangroves, salt flats and estuaries) wetland ecosystems surround Amity Point township (again refer to Figure 2-5). Segments of these wetlands and shoreline areas surrounding Amity Point are part of the Moreton Bay Ramsar Site and are protected as wetlands of international importance for migratory shorebirds.

Koalas occur on North Stradbroke Island, which is included in the South-East Queensland Koala Protection Area. Amity Point is surrounded by a large contiguous area of medium value bushland habitat for koalas (refer to Figure 2-6). The koala populations of Queensland, New South Wales and the Australian Capital Territory are listed as *Vulnerable* under national environment law. Consequently, erosion of their bushland habitat along the Amity Point foreshore represents a significant threat to these important koala communities.



FIGURE 2-5 TERRESTRIAL VEGETATION



FIGURE 2-6 KOALA HABITAT

2.5 The Social Environment

Amity Point is a residential area comprising mainly low density residential development, with some area reserved for commercial, community, recreation and open space land uses (refer to Figure 2-7). The area surrounding the township is mainly reserved for conservation.

At the time of the 2011 census, Amity Point had a population of 348, including 6 persons who identified themselves as being Aboriginal and Torres Strait Islander people. The population is ageing with a median age of 53 years, compared to a Queensland state average of 36 (Australian Bureau of Statistics, 2011).

A general store in Ballow Street provides fuel, food and postal services. Other commercial activity includes a cafe, community club, and holiday accommodation including cottage-style accommodation and a camping ground. The largest industries of employment are hospitality, cleaning / pest control / gardening services, accommodation, fishing and grocery stores (Australian Bureau of Statistics, 2011).

Community facilities in Amity Point include a community hall, library, auxiliary fire station, recreation reserve and several foreshore parks and reserves. The Amity Point boat ramp, beach and jetty provide access for residents and visitors to the waters of Moreton Bay for boating, fishing and bathing.



FIGURE 2-7 LAND ZONING, COMMUNITY AND EMERGENCY FACILITIES

3. PHYSICAL PROCESSES ANALYSIS

3.1 Local Bathymetry

The natural processes shaping the foreshores of Amity Point are considerably influenced by the changing morphology of Rainbow Channel. To better appreciate the extent of changes to Rainbow Channel near Amity Point, in November 1970 Queensland's Beach Protection Authority (BPA) initiated a monitoring program consisting of surveyed profiles on several transects across Rainbow Channel and the Amity Point foreshore.

Transect surveys were undertaken intermittently by the BPA until that Authority was disbanded - at which point Redland City Council took on responsibility for the survey monitoring program. Intermittent transect surveys have continued over the years, with the latest being commissioned by Council in December 2015 to inform the preparation of this SEMP (Port of Brisbane, 2015). That most-recent survey was not just a transect survey, but was a multibeam sonar survey that captured the entire seabed bathymetry for approximately 200 metres offshore and along approximately 1.93kms of foreshore. The extent of the survey is shown on Figure 3-1.

Council subsequently commissioned the Hydrographic Survey Section of the Port of Brisbane Pty Ltd (PBPL) to undertake a comparison of all surveys undertaken since November 1970 - across a total of nine foreshore/channel transects. The historical cross sections produced by PBPL for each of these transects are included in Appendix A. The location of the nine transects used in the analysis are also shown on Figure 3-1.

These surveys offer the opportunity to determine the rate that the submerged eastern bank of Rainbow Channel has been migrating towards the Amity Point foreshore.

Appendix B presents plots of the distance that the RL 0.0m AHD, RL-4.0m AHD and RL-8.0m AHD contours on the eastern submerged bank of Rainbow Channel are offshore of the Amity Point shoreline. Deeper contour lines were not considered since there are quite large mobile sand waves moving across the seabed of Rainbow Channel that could lead to erroneous conclusions. Since the crest levels of the sand waves are typically below RL-9.0m AHD, the decision was made to only consider the channel side-slopes above that level when determining channel migration rates. The nearshore sand wave features are shown in Figure 3-2.

The results of an analysis of changes to the position of contours along the eastern side slopes of Rainbow Channel are presented in Table 3-1. This analysis indicates that:

- The eastern submerged slope of Rainbow Channel is indeed migrating towards Amity Point.
- The migrating rate on average has been around 1.8 metres/year along the entire length of the surveyed Channel, with rates being slightly higher at the southern end of the study foreshore.
- The rate has been reasonably constant over the years of 1970 to 2015, with no periods of notable quickening or slowing down.
- Since about 2002, as well as migrating eastward the northern part of the surveyed Channel has been steepening.

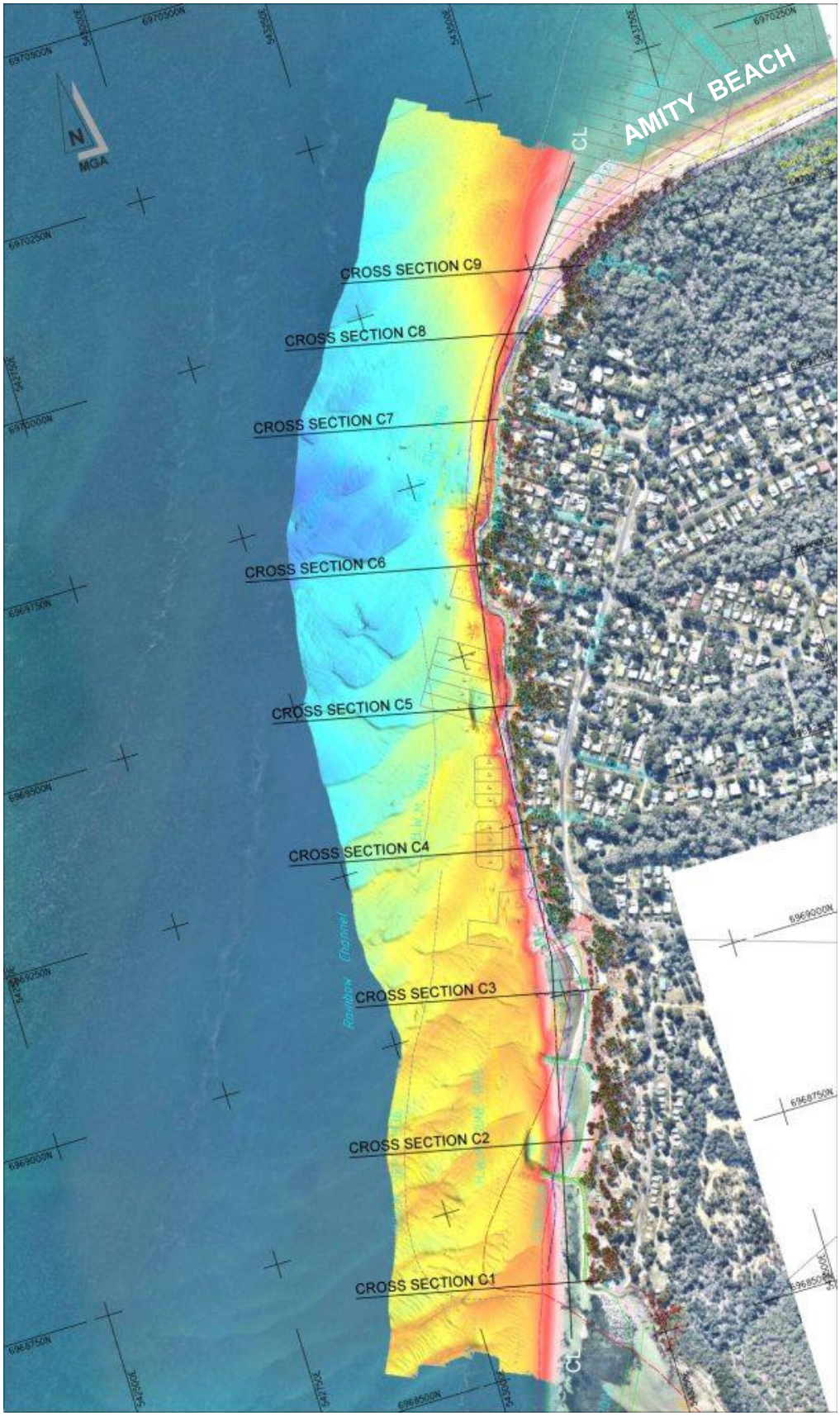


FIGURE 3-1 LOCATION OF HISTORICAL SURVEY TRANSECTS ON AMITY POINT FORESHORE

4193-01_R03v07

TABLE 3-1 MIGRATION RATES OF RAINBOW CHANNEL

		Offset Distance									
Cross Section	Contour	1970	1982	1983	1984	1987	1997	2002	2015	Avg change (m/year)	Avg change (m/year)
1	0m	132	110		99	87	78	78	54	2.3	
	-4m	148	138		129	122	98	92	71	2.1	**2.3**
	-8m	165	170		157	148	114	112	92	2.4	
2	0m	106	91	84	84	69	44	36	27	2.6	
	-4m	129	111	106	102	96	65	71	59	2.2	**2.8**
	-8m	148	130	124	115	102	94	78	72	3.6	
3	0m	88	83	81	81	70	75	75	72	0.8	
	-4m	100	99	97	95	85	88	93	87	0.9	**0.9**
	-8m	116	129	121	127	113	110	118	98	0.8	
4	0m	37	17		17	10	15	13	16	0.6	
	-4m	42	40		27	23	22	23	21	1.3	**1.1**
	-8m	61	56		43	40	40	41	36	1.4	
5	0m	46	30		30	25	17	18	14	0.7	
	-4m	63	46		38	29	26	27	21	1.5	**1.3**
	-8m	91	54		47	39	35	35	31	1.7	
6	0m	44	28		12		17	16	18	1.8	
	-4m	53	45		23		25	24	21	2.4	**2.0**
	-8m	62	66		52		41	39	29	1.7	
7	0m	53	37		33		24	3	6	1.6	
	-4m	72	54		47		35	19	11	1.9	**2.1**
	-8m	93	80		64		48	45	17	2.6	
8	0m		57		46		41	46	20	1.7	
	-4m		82		70		62	52	27	2.6	**2.2**
	-8m		113		107		78	67	42	2.3	
9	0m						100	103	75	0.8	
	-4m						124	116	88	1.9	**1.8**
	-8m						153	134	112	2.7	
									Avg: 0m	1.4	
									Avg: -4m	1.9	**1.8**
									Avg: -8m	2.1	

Tidal flows in Rainbow Channel are strongest on the ebb tide (i.e. on the falling/outgoing tide). It is likely to be these ebb tide currents that are generating the formation and slow movement of sand waves on the seabed of Rainbow Channel. The extent to which these sand wave features are changing can only be determined by comparisons with future bathymetric surveys.

The depth of water immediately offshore of the Amity Point foreshore (and in particular at the bottom of the rock-armoured foreshore slope) is determined to a large extent by the location of the sand waves. As these seabed features slowly move, the locations where their crests and troughs intersect the rock-armoured wall also move along the wall. This means that the passage of the deeper troughs along the structure results in localised deepening at the toe of the wall as they pass.

This localised deepening (and possible steepening) of the channel side slopes needs to be considered when assessing processes that might threaten the integrity of the rock-armoured structure.

3.2 Local Coastal Processes

The term “coastal processes” refers to the complex interaction of ocean water levels, currents and waves that drive the transport of coastal sediments and consequently shape shorelines. Some discussion of each of these individual influences at Amity Point is offered in the following sections.

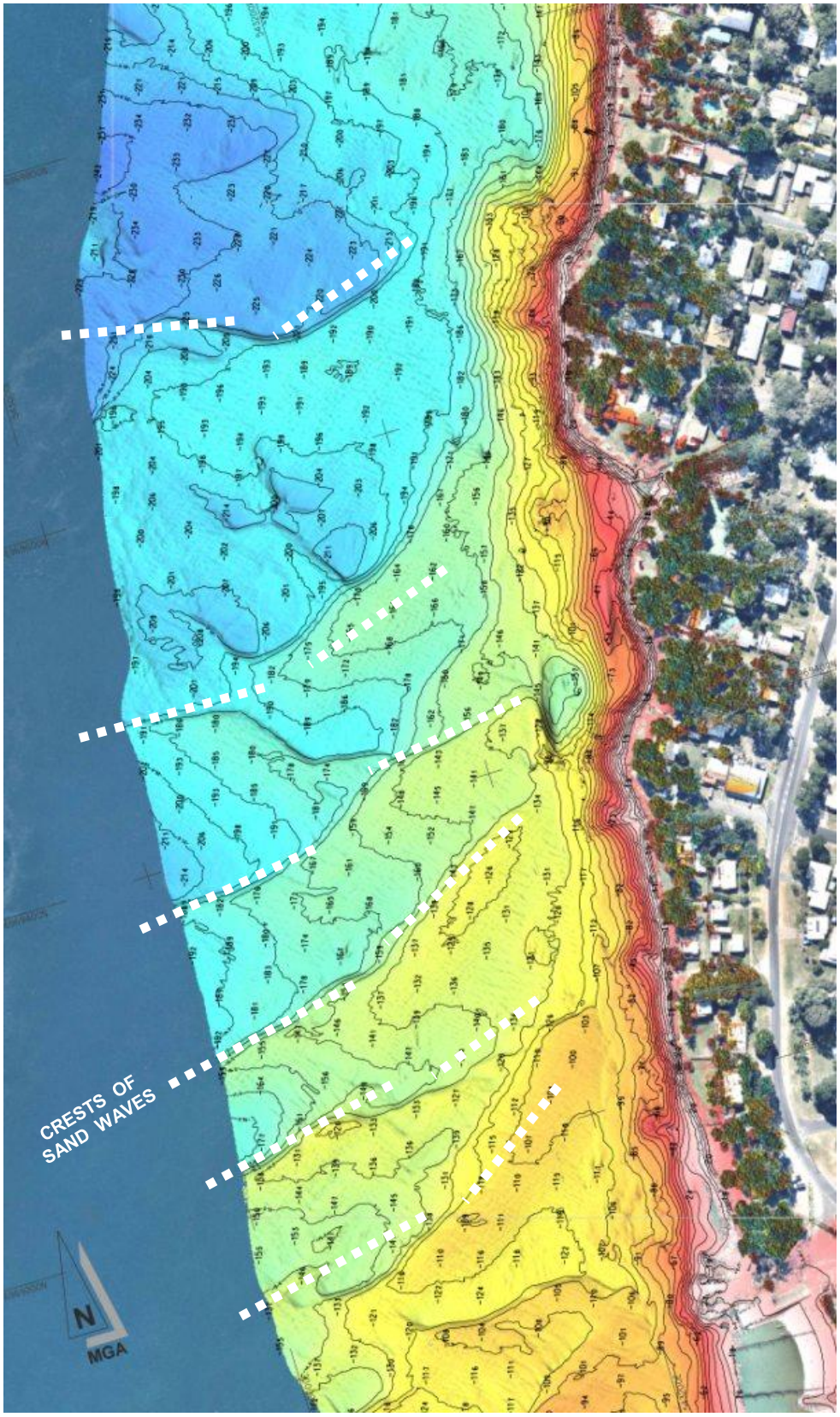


FIGURE 3-2 SAND WAVES ON THE SEABED IN RAINBOW CHANNEL OFF AMITY POINT

3.2.1 Ocean Water Levels

When considering the processes that shape shorelines it is necessary to consider the ocean water levels that prevail from time to time. This appreciation not only relates to the day-to-day tidal influences, but also to the storm surges which occur as a result of extreme weather conditions. The expected impacts of climate change on sea levels also need to be considered.

As ocean waves propagate shoreward into shallower water, they begin to "feel" the seabed. The decreasing depths cause the waves to change direction so as to become aligned to the seabed contours and to also shoal up in height until such time as they may break - dissipating their energy as they do so. Just how much wave energy reaches the shoreline is therefore determined largely by the depth of water over the seabed approaches. Ocean water levels and the seabed bathymetry are important aspects in this process of wave energy transmission.

Consequently, it is necessary to have a thorough understanding of the following ocean levels on local foreshores:

- *Astronomical Tides* - this is the "normal" rising and falling of the oceans in response to the gravitational influences of the moon, sun and other astronomical bodies. These effects are predictable and consequently the astronomical tide levels can be forecast with confidence.
- *Storm Tides* - this is the combined action of the astronomical tide and any storm surge that also happens to be prevailing at the time. Surge is the rise above normal water level as a consequence of surface wind stress and atmospheric pressure fluctuations induced by severe synoptic events (such as tropical cyclones).

Astronomical tides

The tidal rising and falling of the oceans is in response to the gravitational influences of the moon, sun and other astronomical bodies. Whilst being complex, these effects are nevertheless predictable, and consequently past and future astronomical tide levels can be forecast with confidence at many coastal locations. Tidal planes have been published for Amity Point (Department of Transport and Main Roads, 2018) and these are summarised in Table 3-2.

TABLE 3-2 TIDAL PLANES AT AMITY POINT

Tidal Plane	to AHD	to Chart Datum
Highest Astronomical Tide (HAT)	1.22 metres	2.24 metres
Mean High Water Springs (MHWS)	0.76 metres	1.78 metres
Mean High Water Neaps (MHWN)	0.44 metres	1.46 metres
Mean Sea Level (MSL)	0.07 metres	1.09 metres
Mean Low Water Neaps (MLWN)	-0.40 metres	0.62 metres
Mean Low Water Springs (MLWS)	-0.72 metres	0.30 metres
Lowest Astronomical Tide (LAT)	-1.02 metres	0.00 metres

In a lunar month, the highest tides occur at the time of the new moon and the full moon (when the gravitational forces of sun and moon are in alignment). These are called "*spring*" tides and they occur approximately every 14 days. Conversely "*neap*" tides occur when the gravitational influences of the sun and moon are not aligned, resulting in high and low tides that are not as extreme as those during spring tides.

As can be seen in Table 3-2, the maximum possible astronomical tidal range at Amity Point is 2.24 metres, with an average range during spring tides of 1.48 metres and 0.84 metres during neap tides.

Spring tides tend to be higher than normal around the time of the Christmas / New Year period (i.e. December - February); and in mid-year (i.e. around May - July). The various occurrences of particularly high spring tides are often referred to in lay terms as "*king tides*" - in popular terminology meaning any high tide well above average height.

The widespread notion is that king tides are the very high tides which occur around Christmas or in the New Year. However, equally high tides occur in the winter months, but these are typically at night and therefore are not as apparent as those during the summer holiday period - which generally occur during daylight hours.

Since tidal predictions are computed based on astronomical influences only, they inherently discount any meteorological effects that can also influence ocean water levels from time to time. When meteorological conditions vary from the average, they can cause a difference between the predicted tide and the actual tide. This occurs within the Moreton Bay region to varying degrees. The deviations from predicted astronomical tidal heights are primarily caused by strong or prolonged winds, and/or by uncharacteristically high or low barometric pressures.

Differences between the predicted and actual times of low and high water are primarily caused by wind. A strong wind blowing directly onshore will "pile up" the water and cause tides to be higher than predicted, while winds blowing off the land can have the reverse effect. Clearly the occurrence of storm surges associated with severe storms can significantly influence ocean water levels.

Storm tides

The level to which ocean water can rise on a foreshore during the passage of an extreme storm event or a cyclone is typically a result of several different effects. The combination of these various effects is known as *storm tide*. Figure 3-3 illustrates the primary water level components of a storm tide event. A brief discussion of each of these various components is offered below.

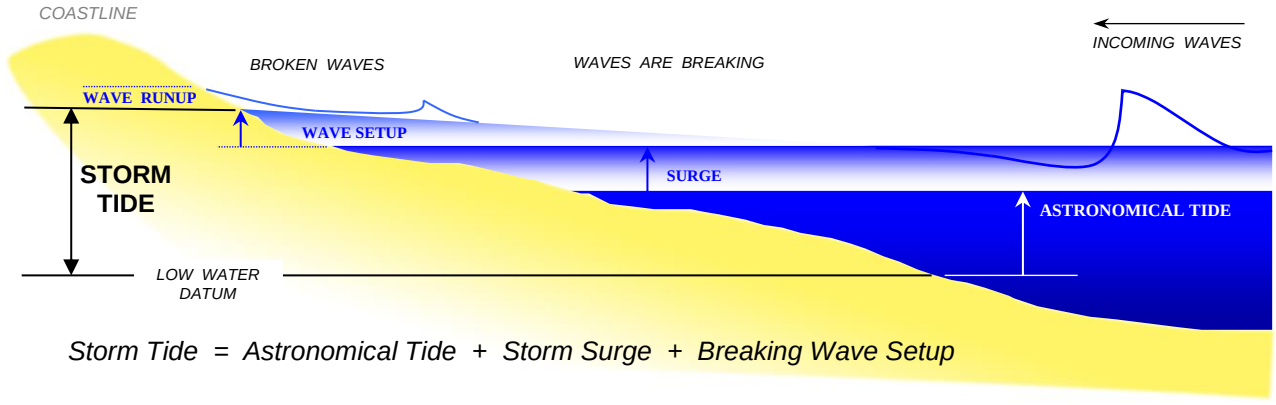


FIGURE 3-3 COMPONENTS OF A STORM TIDE EVENT

- Astronomical Tide

As discussed earlier, the astronomical tide is the normal day-to-day rising and falling of ocean waters in response to the gravitational influences of the sun and the moon. The astronomical tide can be predicted with considerable accuracy. Astronomical tide is an important component of the overall storm tide because if the peak of the storm were to coincide with a high spring tide for instance, severe flooding of low lying coastal areas can occur and the upper sections of coastal structures can be subjected to severe wave action.

- Storm Surge

This increase in the ocean water level is caused by the severe atmospheric pressure gradients and the high wind shear induced on the surface of the ocean by a severe storm or tropical cyclone. The magnitude of the surge is dependent upon several factors such as the intensity of the storm, its overall physical size, the speed at which it moves, and if associated with a cyclone - the direction of its approach to the coast, as well as the specific bathymetry of the coastal regions affected.

To predict the height of storm surges, these various influences and their complex interaction are typically replicated by numerical modelling techniques using computers.

- Breaking Wave Setup

The strong winds associated with severe storms generate waves which themselves can be quite severe. As these waves propagate into shallower coastal waters, they begin to shoal and will break as they encounter the nearshore region. The dissipation of wave energy during the wave breaking process induces a localised increase in the ocean water level shoreward of the breaking point which is called *breaking wave setup*.

Through the continued action of many breaking waves, the setup experienced on a foreshore during a severe wave event can be sustained for a significant timeframe and needs to be considered as an important component of the overall storm tide on a foreshore.

- Wave Runup

Wave runup is the vertical height above the local water level up to which incoming waves will rush when they encounter the land/sea interface. The level to which waves will run up a structure (or a natural foreshore) depends significantly on the nature, slope and extent of the land boundary, as well as the characteristics of the incident waves. For example, the wave runup on a gently sloping beach is quite different to that of say a near-vertical concrete seawall.

Since this component is very dependent upon the local foreshore type, it is not normally incorporated into the determination of the storm tide height. Nevertheless, it needs to be considered separately during the assessment of the storm tide vulnerability of Amity Point foreshores.

Storm Tide Levels at Amity Point

A storm tide study has previously been undertaken for Redland City (Cardno Lawson & Treloar, 2009 and Cardno, 2011). That study also addressed the effect of future climate change on sea level rise and tropical cyclone occurrences.

The storm tides reported by that regional study have been used in the preparation of this SEMP and are summarised in Table 3-3 for the present-day climate scenario. These levels are without the effects of wave runup, since this component varies along the length of the Amity Point foreshore.

The duration of the storm tide is also a critical consideration when determining effects on sandy shorelines in Moreton Bay. The surge component of the storm tide typically builds quickly to a peak over several hours, then drops away over a similar or even shorter timeframe as storm/cyclone influences pass.

TABLE 3-3 STORM TIDE LEVELS AT AMITY POINT

Average Recurrence Interval[7]	RL to AHD without Breaking Wave Setup	RL to AHD with Breaking Wave Setup
50 years[8]	1.77 metres	1.89 metres
100 years	1.79 metres	1.95 metres
200 years	1.81 metres	2.01 metres
500 years	1.83 metres	2.08 metres
1,000 years	1.85 metres	2.34 metres

3.2.2 Ocean Currents

Several investigations and modelling studies have been undertaken in recent years regarding the ocean current regime near Amity Point (WBM, 1998 and BMT WBM, 2013). Numerical modelling of the local ocean current regime in Rainbow Channel using the TUFLOW FV proprietary software was undertaken as part of the 2013 study. That modelling exercise investigated tidal currents in Rainbow Channel off Amity Point for a typical spring tide in Moreton Bay. The modelling identified peak ebb (i.e. outgoing/falling) tide velocities of around 1.8m/sec, and somewhat lower peak flood (i.e. incoming/rising) tide velocities of approximately 1.4m/sec. These velocities are above the threshold that causes local sand to be entrained in the flow and to be moved along the seabed by tidal currents. Consequently, tidal flows are shaping the seabed bathymetry of Rainbow Channel near Amity Point.

During the flood tide phase the strongest currents off Amity Point occur on the western edge of Rainbow Channel (i.e. on the opposite side of the Channel to the township). These flood tide currents carry sand southward along this part of the Channel, sculpting the complex bathymetry of Amity Bank, Pelican Bank and the shoals around Welsby Light. During ebb tides, the strongest currents are on the eastern edge of Rainbow Channel against the Amity Point foreshore. These currents sweep any sand that is deposited into the Channel (by the prevailing westward littoral drift to Amity Point) northwards towards South Passage Bar.

3.2.3 Wave Climate

The wave climate on the bayside foreshores of Amity Point is dominated by waves that are generated by winds blowing across the fetches within Moreton Bay, with negligible open ocean swell penetrating to these foreshores. The length and depth of the fetches are limited by the many shoals and islands within the Bay, resulting in a mild to moderate wave energy climate at Amity Point.

The sandy foreshore of Amity Beach (refer to Figure 1-3 and Figure 3-1 for its location) is more exposed to swell wave energy. Nevertheless, the significant shoals of South Passage Bar still afford some protection by causing large waves in the sea state to break offshore before reaching that shoreline.

Numerical modelling of the local wave climate on the bayside foreshores of Amity Point has previously been undertaken using the SWAN proprietary modelling software (BMT WBM, 2013). Wind data recorded by the

[7] Average Recurrence Interval (ARI) is a statistical estimate of the average period in years between the occurrences of an event of a particular size. For example, a 100 year ARI event will occur on average once every 100 years. Such an event would have a 1% probability of occurring in any particular year.

[8] For ARI of around 50 years and less, the maximum local storm tide level may not necessarily be associated with cyclones. Other more frequent meteorological or synoptic events may combine with high spring tides to result in potentially greater levels than that listed here for 50 year ARI.

Bureau of Meteorology weather station at the Cape Moreton Lighthouse during the period of 1996 to 2010 was used as input to that SWAN wave model. The wave model generated wave height/direction recurrence frequencies for an offshore location in approximately 16 metres depth of water in Rainbow Channel, to the north-west of Amity Point. The results reported by that earlier numerical modelling work (BMT WBM, 2013) are reproduced in Table 3-4 below. The wave heights reported are the *significant wave heights*[9].

TABLE 3-4 ANNUAL AVERAGE WAVE HEIGHT & DIRECTION OCCURENCES

Wave Direction (degrees from north)											
H_s (metres)	**0°**	**30°**	**60°**	**90°**	**120°**	**150°**	**180°**	**210°**	**240°**	**270°**	**Total**
0.1 – 0.3	1.9%	8.8%	24.0%	5.1%			9.5%	10.7%	6.9%	2.8%	69.8%
0.3 – 0.5	0.5%	2.5%	2.1%				1.7%	4.9%	0.3%	0.2%	12.2%
0.5 – 0.7	0.0%	0.1%	0.1%				0.2%	0.6%	0.0%	0.0%	1.1%
>0.7		0.0%	0.0%				0.0%	0.0%			0.0%
Total	**2.4%**	**11.4%**	**26.2%**	**5.1%**	**0.0%**	**0.0%**	**11.4%**	**16.2%**	**7.3%**	**3.0%**	**83.2%**

Note : Calms (with Hs < 0.1 metres) = 16.8%

It is evident from the summary provided in Table 3-4 that the wave climate on the bayside foreshores of Amity Point is mild.

It is pertinent to note that the wave occurrences from the north-east and south-east quadrants (i.e. from 0° to 180°) in Table 3-4 represent waves occurring offshore in the Channel that would not propagate onto the foreshores of Amity Point. Therefore, for only around 26.5% of the time are there waves greater than 0.1 metres occurring on the bayside foreshores of Amity Point.

Rarely does the significant wave height exceed 0.5 metres during these times. The largest of such waves occur from the south-west sector (i.e. 180° to 270°). These occur for less than 1% of the time and are typically due to discrete storm events having strong south-westerly winds.

3.2.4 Sediment Supply and Transport Mechanisms

Waves and tidal currents are the primary processes driving the supply and transport of littoral sand at Amity Point. There is a net supply of littoral sand from the east along the northern coast of North Stradbroke Island towards the Amity Point area.

The eastern and northern shores of North Stradbroke Island experience quite strong wave energy. The prevailing south-easterly waves in the open ocean create a northerly littoral drift along the island's ocean-side Main Beach. Sand is transported along Main Beach towards Point Lookout primarily by longshore wave processes. In the vicinity of Point Lookout, it accumulates in offshore shoals from where waves and currents disperse it towards Moreton Island and the northern shores of North Stradbroke Island. Some of the sand is moved directly along the island's northern shoreline through Deadman's, Cylinder, Home and Flinders Beaches.

Waves arriving from the north-east quadrant (i.e. from north around to east) are the main cause of this transport along the northern shoreline, although there is also a contribution by south-easterly waves refracting around

[9] Due to the random nature and size of waves, the term *"significant wave height"* is used by engineers and scientists to quantify wave heights in a sea state. It represents the average of all the third highest waves that occur over a particular timeframe. It is typically written as H_s. It is important to appreciate that in deep offshore waters the largest individual wave in the sea state may be around twice the significant wave height.

Point Lookout. Sand arriving at the north-west corner of North Stradbroke Island in the general vicinity of Amity Point then comes under the additional influence of the tidal flows between Moreton and North Stradbroke Islands.

Whilst these regional sediment transport processes have remained somewhat regular, there have been significant changes to the natural sand transport regime on the local foreshores of Amity Point since the township was first founded. Historical photographs, surveys and written records indicate that the bay-side foreshore of Amity Point once consisted of a wide sandy beach with a well-established vegetated dune system. As discussed in Section 3.1, local shorelines and the bathymetry of the main tidal channels between Moreton and North Stradbroke Islands have been changing quite considerably.

In earlier times, the westward supply of littoral sand to the north-west corner of North Stradbroke Island would have continued around onto the western-facing sandy beach fronting Amity Point township – being transported by ocean waves refracting and diffracting around Amity Point itself. However, the gradual migration of Rainbow Channel towards Amity Point and its increasing dominance as the main tidal channel, has seen this once sandy foreshore become eroded. Channel migration is accompanied by retrogressive flow slides in the submerged channel side slopes (refer subsequent discussions in Section 3.3), and indeed such events are likely to be a contributing process to this migration of the channel.

As well as causing erosion of the foreshore, the increasing proximity of Rainbow Channel to Amity Point has intercepted the sand that once supplied the bay-side foreshore south of Amity Point. Sand is instead deposited directly into Rainbow Channel (from where the dominant ebb tide carries it northward towards South Passage Bar and Moreton Island), or is carried directly northward across South Passage Bar by ebb tide flows passing through the passage.

In response to the diminishing longshore supply of sand, groynes were constructed on the bay-side foreshores around 1955 (Eberhardt, 1978) to retain sand on the foreshore for longer periods. Additional rock-armoured groynes were constructed and upgraded several times in recent years, with a total of ten groynes having been constructed by the 1970's. There are still three of these in place on the foreshore frontage of the camping ground. These three groynes contain beach compartments that provide an erosion buffer to the local foreshore, as well as offering an enhanced beach amenity much-used by residents and visitors.

A consequence of the complex interaction of waves and currents that are shaping the local littoral sand transport regime has been the loss of foreshore land at Amity Point. This has included land subdivided based on the shoreline position that existed in 1886. Figure 3-4 has been reproduced directly from Eberhardt (1978)[10] and shows the historical changes to the shoreline at Amity Point between the years of 1886 and 1976. Up to 300 metres foreshore recession occurred in that period.

3.3 Retrogressive Flow Slides

Retrogressive flow slides (also known as *retrogressive breach failures*) are natural events which occur in sandy deposits of many river, estuarine and coastal locations around the world. They can have a significant influence on the stability of river banks, as well as estuarine and coastal foreshores.

They have also been responsible for levee collapses along the lower reaches of the Mississippi River that have resulted in adverse flooding and damage to essential infrastructure. In the Netherlands, retrogressive flow slides have been recognised for many years as being a threat to the vital flood and sea defences along that country's coastline and riverbanks.

[10] Eberhardt (1978) quotes the original source of the drawing as the Beach Protection Authority's map number SC881.

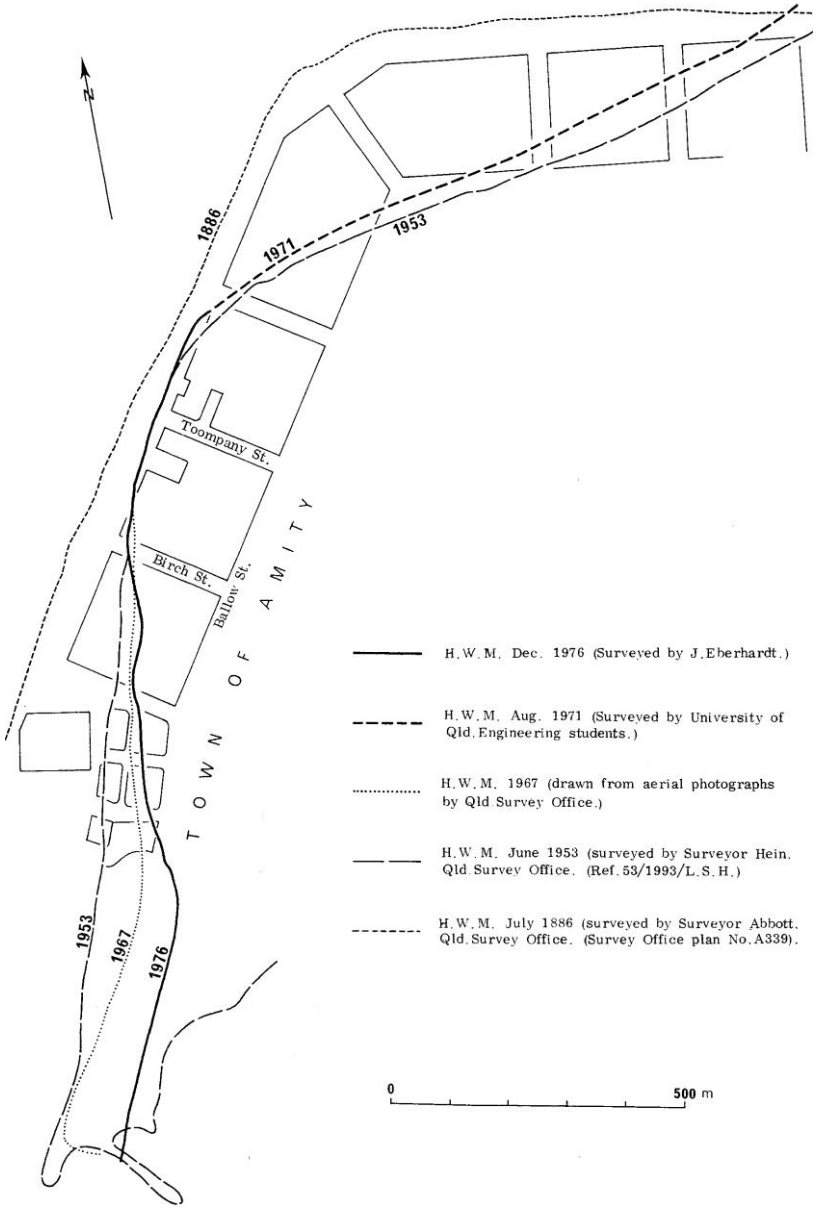


FIGURE 3-4 HISTORICAL CHANGES TO THE SHORELINE AT AMITY POINT

Due to their potentially catastrophic consequences, considerable research effort has been applied to understand retrogressive flow slides. Consequently, there is a significant body of technical literature available that describes the geomorphological mechanisms associated with retrogressive flow slide failures, as well as measures for either preventing their initiation or inhibiting their development to destructive scales.

Figure 3-5 shows images of a retrogressive flow slide underway at Amity Point[11].

[11] Images in Figure 3-5 are reproduced from *Beinssen et al, 2014*. Copyright is acknowledged.

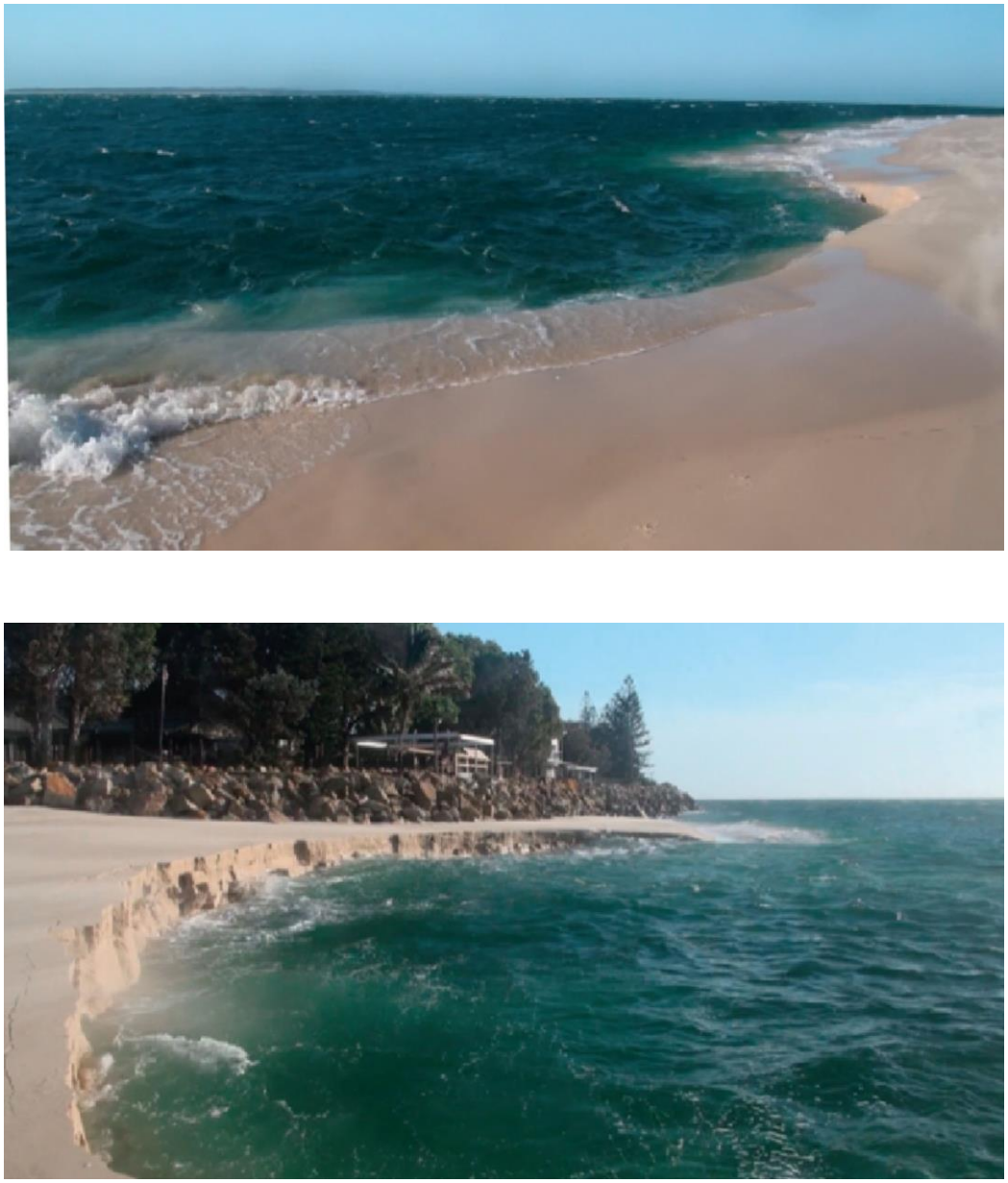


FIGURE 3-5 A RETROGRESSIVE FLOW SLIDE UNDERWAY AT AMITY POINT

The processes associated with a retrogressive flow slide can be summarised as follows:

- They occur on densely packed subaqueous sand slopes, such as those that exist along the underwater edge of tidal channels and river banks. At Amity Point they occur just offshore, on the submerged side slopes of Rainbow Channel.
- A triggering mechanism develops a localised scour somewhere on the submerged slope, which can then progress to a shear failure should the disturbed area exceed the stable angle of repose for the sand.
- The sand grains remaining on the sheared face of the slope are unsupported, and will consequently move apart - increasing the void ratio (this is called *dilation*) which temporarily decreases pore pressures within the face of the slope. The lower pore pressures (compared to the surrounding hydrostatic water pressures) cause individual sand grains near the face to be “sucked” together for a short time. This enables the sand body to resist further collapse and for a near-vertical face to develop.

- The lower pore pressures at the near-vertical sand face are quickly dissipated - by the surrounding water infiltrating the voids. The unconfined grains at the face then detach and fall from the wall, generating a density current of entrained sand which carries the falling sand away into deeper water. The process continues on the newly exposed sand grains in the near-vertical face, increasing the momentum of the event.
- The density currents carry the removed sand away from the failure zone and beyond the immediate toe of the near-vertical face, allowing it to remain steep and high. This dispersion of sand away from the base of the breach can be further assisted by tidal currents flowing in the channel itself.
- In other words, the mechanism of flow slide development is driven by short-lived density currents that entrain sand off the near-vertical wall of a shoreward moving failure plane, causing sand grains to continually cascade off this advancing face. This process is classed as *retrogressive breaching failure*.
- As the advancing sand wall grows in height, wedges of sand can also collapse off the vertical face - breaking up as they fall and then mix with water, thereby enhancing the density current. Dilation in the sand face immediately behind the collapsing wedge temporarily stabilises the wall until retrogressive breaching restarts.
- Retrogression continues, creating a deep bowl-shaped scour feature in the submerged side slope of the tidal channel or river bank (as seen in Figure 3-5). Typically, as the event grows, this then becomes more of an amphitheatre-shaped characteristic with a narrower throat at its deeper offshore end.
- The base of the retrogressing sand wall propagates into the sand slope slightly upwards on an approximate angle of 1 vertical **:** 15 horizontal.
- The event ceases when the density current can no longer entrain sand from the retrogressing near-vertical face. This occurs either because there is no longer any sand available within the profile of the submerged slope to sustain the process; or the volume of sand being removed from the breaching face becomes so great as to "choke" the flow of entrained sand out of the bowl-shaped feature.
- Whilst they proceed entirely underwater, such events typically cannot be seen. It is only when they emerge above the waterline onto exposed beaches or sand banks that they can be detected by eye.

The occurrence of a retrogressive flow slide has three pre-condition requirements. These being:

- Requirement 1: The sand in the slope must be dense and fine- to medium-grained, typically with an average grain size between approximately 0.15mm and 0.25mm.
- Requirement 2: The sand slope must be steeper than 1 vertical to 3 horizontal (i.e. 18.4° above the horizontal) over a minimum vertical height of 5 metres.
- Requirement 3: A "triggering" mechanism is needed to initiate the event by disturbing the sand slope in such a way as to create a localised over-steepening of the slope - which can then develop into a retrogressive flow slide.

The mechanisms that can trigger a retrogressive flow slide are not particularly well understood at present. Technical investigations and studies suggest that it can be because of almost any local change in internal stresses within the susceptible sand slope. Silvis and de Groot (1995) postulate that it could be

> *"…….**a** sudden, local change in water pressure due to waves from a passing ship or a wind wave, an increase in outflowing groundwater during an extreme low tide, a quickly changing soil pressure due to a local shear failure or due to dredging activities, vibrations by pile driving, and so on."*

3.4 Future Climate Change

Climate change as a consequence of enhanced Greenhouse gas emissions will cause environmental changes to ocean temperatures, rainfall, sea levels, wind speeds and storm systems. If climate changes develop as predicted, the foreshores of Amity Point will be subjected to potentially greater storm and cyclone energy, higher waves, stronger winds and increased water levels.

To assist local government, business, industry and communities in understanding the risks and to better prepare for the impacts of climate change, the State Government has developed regional climate change projections for 13 Queensland regions. A *Climate Change in Queensland* map application[12] and regional climate change impact summaries[13] are based on the CSIRO and Bureau of Meteorology's Climate Change in Australia data.

These future climate projections use both low- and high-emissions futures modelling. The high emissions future (RCP 8.5) assumes "business as usual" or no future curbing of greenhouse gas emissions. A lower emissions future (RCP 4.5) assumes a reduction in greenhouse gas emissions achieved by application of some mitigation strategies and technologies. The regional climate change impact summaries show climate change projections for the years 2030 and 2070 at a state-wide level and for the 13 Queensland regions - including South-East Queensland.

The projected sea level rise currently adopted for planning purposes in Queensland is 0.8 metres by the year 2100.

In addition to sea level rise, there is opinion that the intensity of tropical cyclones may increase - although it is also acknowledged that there is a possibility of the overall number of cyclones affecting coastal regions decreasing. However, estimating any changes to the intensity and occurrence of cyclones is particularly problematic since their formation and subsequent track are dependent upon the complex interaction of several natural phenomena (such as the El Nino - Southern Oscillation) which themselves are not yet well understood.

Of significant uncertainty is the effect of future climate change on the complex tidal hydrodynamics and shifting bathymetry of the passage between Moreton and North Stradbroke Islands.

In summary, it is expected that future climate change will exacerbate foreshore erosion and increase the risk of coastal hazards associated with the changing morphology of Rainbow Channel. Given the present uncertainties associated with the extent and nature of future climate change, when developing and assessing appropriate erosion mitigation strategies there is considerable merit in applying strategies that are flexible and can be tailored to suit impacts as they gradually evolve.

3.5 Coastal Reaches of Amity Point

When considering appropriate erosion management options along the Amity Point shoreline it is evident that the shoreline can be considered in three coastal precincts, namely

- Southern Reach: the foreshore frontage of the camping ground and boat ramp;
- Central Reach: along the alignment of the rock armoured foreshore; and
- Northern Reach: the sandy foreshore of Amity Beach.

[12] Available at : http://qgsp.maps.arcgis.com/apps/MapJournal/index.html?appid=1f3c05235c6a44dcb1a6faebad4683fc

[13] At : https://www.qld.gov.au/environment/climate/projections/

This separation into coastal reaches does not imply that the coastal processes within each are in any way compartmentalised. They are by no means isolated or discrete sections of shoreline, since the processes affecting each can have an influence on the others. However, this partitioning lends itself to the development of viable erosion management strategies that integrate well over the entire Amity Point coastal reach.

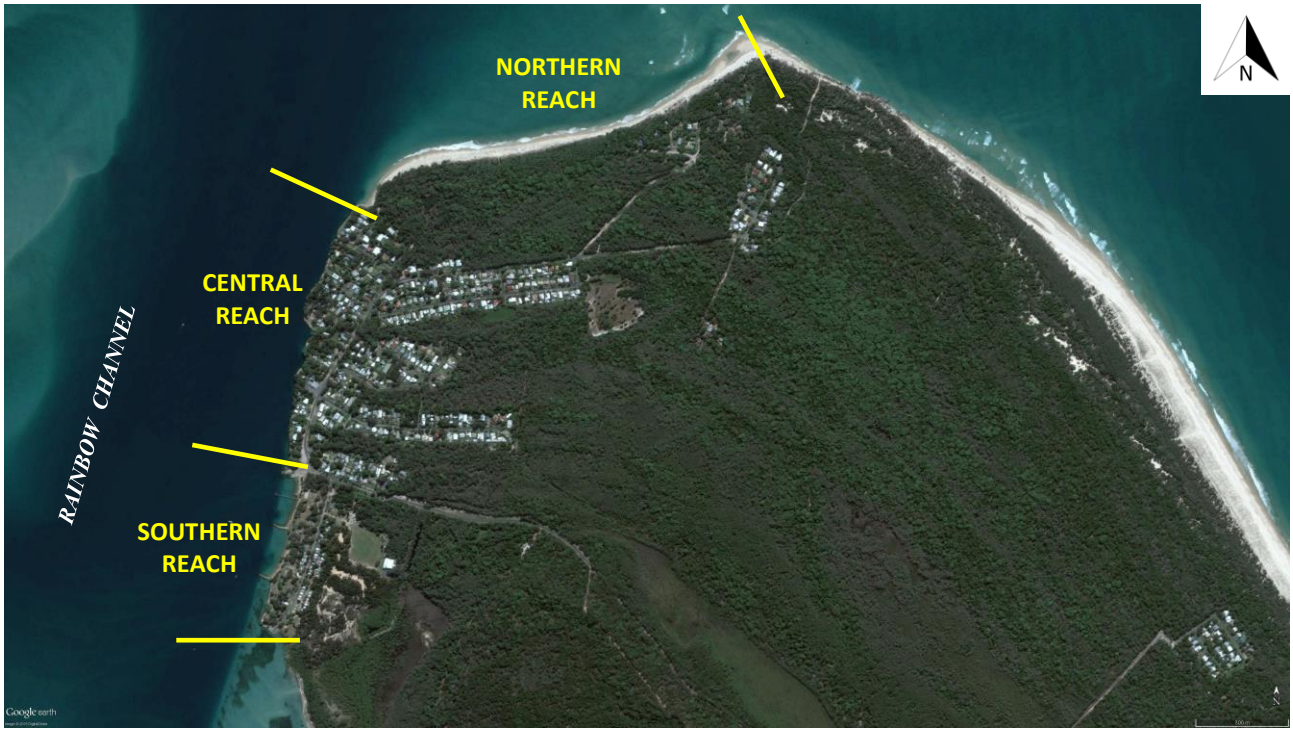


FIGURE 3-6 COASTAL REACHES OF AMITY POINT STUDY AREA

3.5.1 Southern Reach - Camping Ground Foreshore

As shown on Figure 3-7 the southern precinct consists of an approximately 355 metre long beach frontage to the camping ground; and a 215 metre long rock-armoured seawall bordering the southern part of the reserve. The natural sand transport regime has resulted in beach fillets forming against the northern side of the groynes, and beaches being eroded on the southern sides of groynes. The reduced beach buffer to the south of each groyne has necessitated the construction of rock-armoured seawalls to mitigate further erosion in these areas.

The flat intertidal zone between the camping ground and Rainbow Channel consists of fine-grained sediments in front of a steeper sloped beach of coarser grained sand perched at the landward edge of this zone. The intertidal area is around RL-0.5m AHD, and the sand beach slopes at approximately 1-in-8 up to the level of the camping ground at approximately RL+3.0m to RL+3.5m AHD.

The foreshore has the very distinct morphological characteristics of a tide-dominated beach, with the beach sub-type defined as *Beach and Sand Flats* (ie . B+SF) under the Australian Beach Systems classification (Short, 2006). The B+SF classification is assigned specifically to the camping ground foreshore by Short (2000).



FIGURE 3-7 SOUTHERN REACH – CAMPING GROUND FORESHORE

In response to the diminishing longshore supply of sand, groynes were constructed on the bay-side foreshores of Amity Point around 1955 (Eberhardt, 1978) to retain sand on the foreshore for longer periods. Additional rock-armoured groynes have been constructed and upgraded several times in recent years, with a total of ten groynes having been constructed by the 1970's. There are still three on the foreshore frontage of the camping ground. As can be seen in Figure 3-7, these groynes create three beach compartments.

3.5.2 Central Reach - Flow Slide Barrier

The Central Reach consists of the existing rock wall frontage extending approximately 955 metres northwards from the boat ramp at Claytons Road, to near the northern end of Millers Lane (refer to Figure 3-8). As discussed in Section 3.3, this rock structure is a flow slide barrier that has been progressively reinforced by local property owners over many years.

The erosion threat along this Central Reach is due to the natural processes causing Rainbow Channel to slowly migrate eastward, in conjunction with occurrences of retrogressive flow slides.

3.5.3 Northern Reach - Amity Beach

The Northern Reach consists of the sandy Amity Beach foreshore extending from the northern-most end of the Central Reach's flow slide barrier, to the sand bar feature at the western end of Flinders Beach (refer to Figure 3-9).

As will be discussed in the later Section 4.6, this sand spit plays a significant role in the erosion and accretion processes affecting Amity Beach.



FIGURE 3-8 CENTRAL REACH – ROCK WALL FRONTAGE

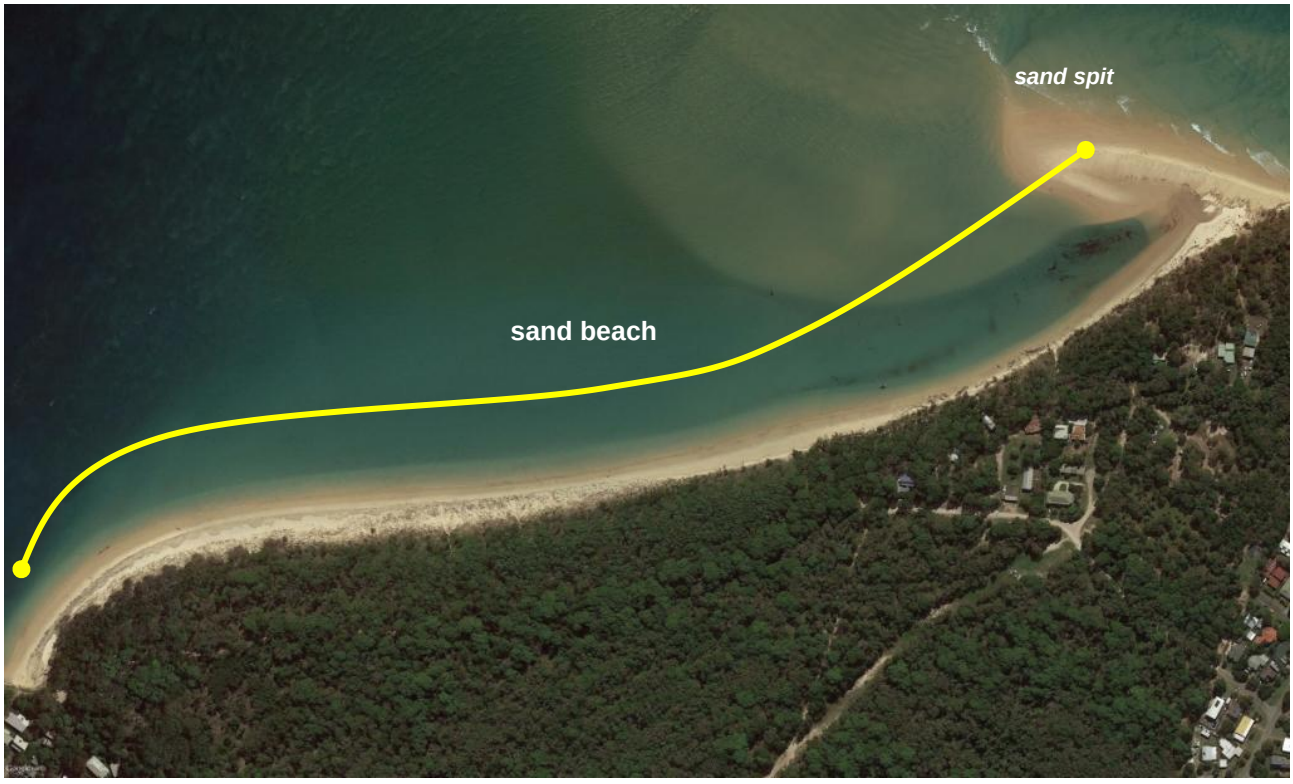


FIGURE 3-9 NORTHERN REACH – AMITY BEACH

4. RISK ASSESSMENT

4.1 Erosion Threat

The threat of shoreline erosion along the foreshores of Amity Point varies depending upon location. However, it is typically a consequence of the following:

- Coastal Erosion
  - Short-term episodic erosion on sandy foreshores caused by the strong waves and elevated ocean water levels that occur during severe storm events; and/or
  - Long-term on-going erosion to sandy foreshores as a consequence of an imbalance in the littoral transport regime.
- Retrogressive Flow Slides
  - Retrogressive flow slides events occurring on the underwater eastern side slopes of Rainbow Channel, with the threat exacerbated by the slow eastward migration of the Channel towards Amity Point.

4.1.1 Coastal Erosion

In the past, coastal development has occurred throughout Queensland within areas vulnerable to erosion. Such development often constitutes significant private and public investment. However coastal protection works for the built environment are costly, and can have adverse implications to coastal resources and their values. Consequently, the concept of having undeveloped erosion buffers along the coastline is an intrinsic part of the coastal management policy of the Queensland State Government, and indeed has been since the state's Beach Protection Authority was established in 1968.

In July 2015, the then Department of Environment and Heritage Protection (now gazetted as the Department of Environment and Science) declared new erosion prone areas for the Queensland coastline. The new erosion prone areas re-introduce climate change factors (including a sea level rise factor of 0.8 metres) in new ways; and updates the position of the state's shoreline.

Erosion Prone Areas are widths of the Queensland coast considered as being vulnerable to inundation and coastal erosion. The determination of an erosion prone area width at any particular location is based on considerations of:

- Short-term erosion - caused by extreme storm/cyclone events;
- Long-term erosion - where gradual on-going shoreline recession is occurring, typically this is due to a deficit of natural sediment supply, or gradual changes to nearshore bathymetry;
- Dune scarp collapse - where slumping of a beach erosion scarp occurs following storm erosion events;
- Added risk of erosion due to future climate change influences – due to permanent inundation of land by tidal water and/or the morphological response of the coast to a rise in sea levels; and
- An allowance for a 40% safety factor.

Statutory erosion prone areas have been declared by the Department of Environment and Science (DES) under section 70 of the *Coastal Protection and Management Act 1995* (Coastal Act). Such declarations are made by referencing erosion prone area plans prepared for all local government areas throughout Queensland. These plans are used for development assessment purposes, and to inform the preparation of planning instruments such as planning schemes and regional plans under the *Planning Act 2016*.

The objective of designated erosion prone areas is to set aside undeveloped buffer zones, thereby implementing a philosophy that biophysical coastal processes should be accommodated rather than prevented. The most basic form of accommodation is to avoid locating development and vital infrastructure within dynamic coastal areas affected by the natural processes of shoreline erosion and accretion.

An adequate buffer zone allows for the maintenance of coastal ecosystems (including within littoral and sublittoral zones), visual amenity, public access and the impacts of natural processes - without the high cost and potentially adverse effects of property protection works.

The statutory erosion prone area plan of relevance to Amity Point is *REC3A Map 3*[14]. A copy of that plan and its related definitions and clarifications is included as Figure 4-1. The definition of the Erosion Prone Area as it applies to coastal land throughout Queensland is provided on all erosion prone area plans, as well as on *REC3A Map 3*, and is stated as follows:

1. *Erosion prone areas are deemed to exist over all tidal water to the extent of Queensland Coastal Waters and on all land adjacent to tidal water.*
2. *Erosion prone areas include areas subject to inundation by the highest astronomical tides (HAT) by the year 2100 or at risk from sea erosion.*
3. *On land adjacent to tidal water the landward boundary of the erosion prone area shall be defined by whichever of the following methods gives the greater erosion prone area width:*
    a. *a line measured 40 metres landward of the plan position of the present day HAT level except where approved revetments exist in which case the line is measured 10 metres landward of the upper seaward edge of the revetment, irrespective of the presence of outcropping bedrock;*
    b. *a line located by the linear distance shown on Table 1 and measured, unless specified otherwise, inland from:*
        i. *the seaward toe of the frontal dune (the seaward toe of the frontal dune is normally approximated by the seaward limit of terrestrial vegetation or, where this cannot be determined, the level of present day HAT); or*
        ii. *a straight line drawn across the mouth of a waterway between the alignment of the seaward toe of the frontal dune on either side of the mouth*
    c. *the plan position of the level of HAT plus 0.8 m vertical elevation.*

<u>Except</u>:

i. *where the linear distance specified in 3b is less than 40 metres, in which case section 3a. does not apply and the erosion prone area width will be the greater of 3b and 3c; or*

ii. *where outcropping bedrock is present and no approved revetments exist, in which case the line is defined as being coincident with the most seaward bedrock outcrop at the plan position of present day HAT plus 0.8m; or*

iii. *in approved canals in which case the line of present day HAT applies, irrespective of the presence of approved revetments or outcropping bedrock.*

4. *Erosion prone areas defined in accordance with the above are deemed to exist throughout all the local government areas, irrespective of whether the entire local government area is depicted on erosion prone area plans for the area.*

As shown on Figure 4-1, the designated width of the erosion prone area throughout the Amity Point SEMP study area is 145 metres.

[14] *Erosion Prone Area Redland City Local Government Area - REC3A*. Date of erosion prone declaration, 8th July 2015. Available online: https://www.ehp.qld.gov.au/coastal/development/assessment/pdf/redland-erosion-prone-area-plan.pdf.

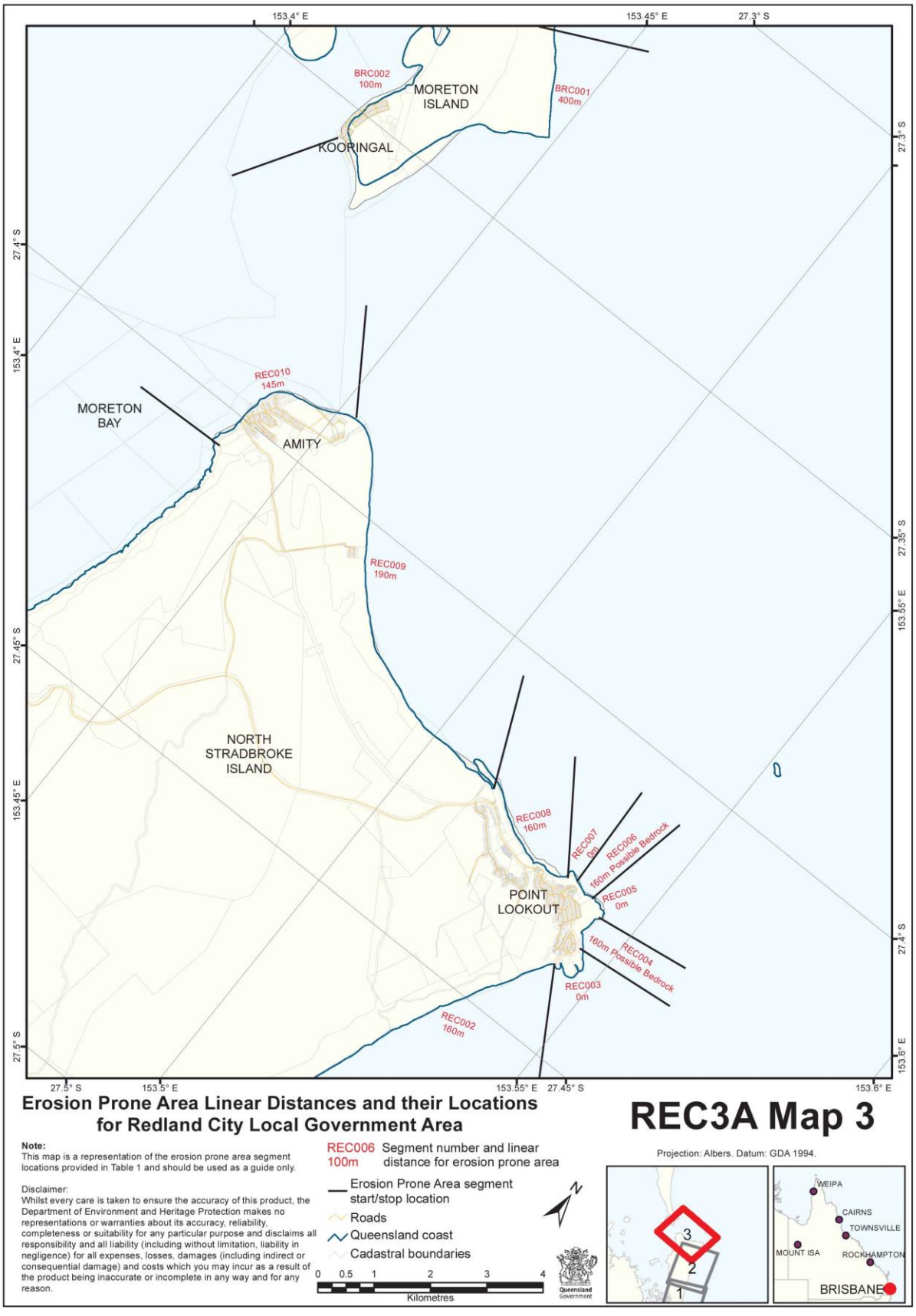


FIGURE 4-1 EROSION PRONE AREA MAP

4193-01_R03v07

4.1.2 Retrogressive Flow Slides

It is apparent from the historical record that retrogressive flow slides have been occurring along the eastern edge of Rainbow Channel for over one hundred years, and probably longer. Renowned local historian Thomas Welsby wrote in 1913 (Thomson, 1967) of his recollections prior to that time of many "large slips" occurring at Amity Point which swept away "tons of sand". His observations dating back to the late 1800's indicate the occurrence of retrogressive flow slides and their adverse impacts on local foreshores and sand shoals at that time.

Since then there have been numerous such events, many of which can be recalled by long-term residents[15] and are recorded in photographs dating back to the 1940's. Residents of Amity Point have historically (and still today) refer to retrogressive flow slides as "sink holes". There is wide-spread understanding in the local community that such events occur regularly at Amity Point and that they represent a threat - not only to foreshore properties, but potentially to the township itself.

The response of the local community to the threat of retrogressive flow slides have been varied over the years. These have included sea defences constructed of timber piles salvaged from an abandoned WW2 anti-submarine netting project, large ti-tree mats, and cement stabilisation (G. Litherland 2015 pers. comm.). Prior to the opening of a quarry on North Stradbroke Island in the 1970's, fill comprising large tree trunks, old car bodies and other such materials (including the *Bandicoot*, a decommissioned steam launch previously used as a dredge tender) were placed as emergency works by the community at locations of retrogressive flow slides.

Large rocks became available from the island's quarry around the mid-1970's. As a consequence, foreshore property owners have more recently used this material to armour their properties. Typically, this entails the placement of large volumes of rock into any areas of foreshore adversely affected by retrogressive flow slides. When a retrogressive flow slide undermines previously placed armour, those rocks slump or collapse into the eroded shoreline. Residents would then place additional rocks to "top-up" the slumped armour. This would generally occur as soon as possible after each event.

In effect this is progressively building a rock barrier to retrogressive flow slides, since each local undermining occurrence results in deeper foundations and a recharging of the reserves of rock higher in the structure by residents.

Investigations regarding the phenomenon of retrogressive flow slides at Amity Point have previously been undertaken (Beinssen, et. al., 2014 and Beinssen & Neil, 2015). They have included almost daily field monitoring of the at-risk beach and Rainbow Channel slope immediately to the north of the existing flow slide barrier for a period of 26 months. Sand on the side slopes of Rainbow Channel in this area typically have an average grain size (i.e. D_{50} value) of around 0.22mm, which meets the pre-condition requirement for a retrogressive flow slide – namely an average grain size between approximately 0.15mm and 0.25mm

Monitoring was carried out from July 2012 to August 2014. In that period, 52 retrogressive flow slides were recorded. This averages approximately one every fortnight. A summary of other findings are as follows:

- On no occasion was the approach of a subaqueous retrogressive flow slide evident on the surface of the water. Such events only became visible when they reached the beach.

[15] G.&L. Litherland, 16/12/2015 pers. comm.; D. & E. Cilento 15/01/2016 pers. comm.; C. & M. McIllwain, 15/12/2015 pers. comm.; J. & L. Walker 12/01/2016 pers. comm.; K. Norris 10/01/2016 pers. comm.; I. Panebianco 15/01/2016 pers. comm.; B. Hoare 13/06/2016 pers. comm.; G. Nankervis 13/06/2016 pers. comm.

- The morphology of each event was amphitheatre-shaped as it progressed up the beach slope. Whilst sand grains could be seen cascading down the near-vertical face below the waterline, occasionally wedges of sand above the waterline sheared off the top of the wall and sank vertically down its face.
- The speed of the retrogressing near-vertical sand face in all cases was approximately 0.8 metres / minute. However, this rate reduced as the event reached the upper beach area and began to diminish.
- The height of the subaqueous sand wall was measured on six occasions to be around 6m to 7m.
- Following each retrogressive flow slide event, the longshore littoral supply of sand from the north-west (supplied from Amity Beach) filled the bowl-shaped erosion feature within one day to several weeks – depending upon the size of the retrogressive flow slide.
- Of the 52 events recorded, 48 were identified as having encroached onto the flow slide barrier - but none caused significant structural damage.

Whilst there has been intermittent damage to the flow slide barrier by deep retrogressive flow slides that have required placement of additional armour rocks to reinstate its alignment and effectiveness, this flow slide barrier has prevented any significant or on-going shoreline recession for more than 40 years. This is apparent from the historical foreshore surveys that have been undertaken since 1970 (refer discussions in Section 3.1).

However, such protection is not necessarily ensured in future years. Retrogressive flow slides are initiated on the submerged eastern slopes of Rainbow Channel immediately offshore of the flow slide barrier. Since these slopes are gradually steepening as the Channel slowly migrates eastward, there is the potential risk of flow slides being initiated at lower levels on the changing channel slopes; and possibly undermining the existing flow slide barrier.

As discussed in Section 3.3, a pre-condition for the initiation of a flow slide on the submerged sand side slopes of Rainbow Channel is that the gradient of the slope needs to be steeper than 1 vertical **:** 3 horizontal over a vertical height of 5 metres. As Rainbow Channel slowly migrates eastward, it encounters the mostly buried rock barrier that has been built progressively in response to historical flow slides on the channel's submerged bank. This submerged sandy bank is tending to become steeper, increasing the possibility of retrogressive flow slides being triggered.

This presents a potential threat to the ability of the buried rock barrier along the Central Reach frontage to prevent any development of future flow slides to destructive scales. To investigate this risk, a Concept Design for a flow slide barrier has been developed as part of technical investigations for this SEMP, and a structural audit of the existing flow slide barrier along the Central Reach has been undertaken to compare it with the Concept Design.

4.2 Concept Design of a Flow Slide Barrier

As discussed in the preceding Section 3.3, there is a significant body of technical literature available that describes the geomorphological mechanisms associated with retrogressive flow slide failures, as well as measures for either preventing their initiation or inhibiting their development to destructive scales.

As part of technical work undertaken for this SEMP, a Concept Design for a flow slide barrier has been developed. The Concept Design has been completed by drawing on the various findings of international research into retrogressive flow slide processes. It has also been informed by the many observed interactions between flow slides that have occurred along the Coastal Reach of Amity Point and the rock armour placements along that foreshore.

The Concept Design for a flow slide barrier is shown on Figure 4-2 and is included as Appendix H.

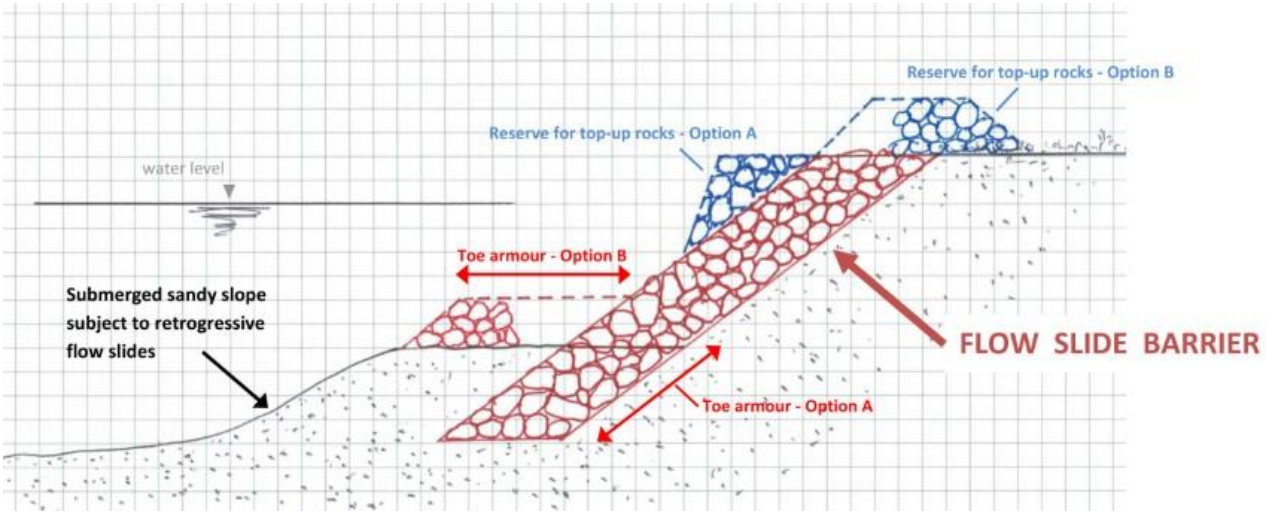


FIGURE 4-2 CONCEPT DESIGN FOR A FLOW SLIDE BARRIER

The structural concept includes the following important features:

- All armour rocks used in the flow slide barrier are to have a nominal weight that will withstand the largest tide/flood currents washing against and along the structure. In those parts of the structure exposed to wave action, rock characteristics must also accommodate large storm tides and severe storm wave action - comparable to the design standards for rock-armoured seawalls in Queensland. This will include the determination of minimum and maximum weights of individual rocks to ensure tight interlocking of all rocks within the armour matrix.
- The thickness of the flow slide barrier is to be such as to prevent the unrestricted growth of any flow slide that develops on the adjacent seabed slope. The minimum thickness is to be at least ten times (x10) the dimension of the smallest allowable rock armour size.
- The gradient of all exposed rock slopes are to be no steeper than 1 horizontal to 1.33 vertical.
- Two options are shown in Figure 4-2 as acceptable arrangements for the placement of rocks in the lower toe area of the Flow Slide Barrier. The intent is to ensure that there are adequate rocks in this toe area to provide protection for the maximum expected scour level of adjacent seabed/channel features. In the case of Option A, this is achieved by armouring down to at least the expected level of seabed scour/lowering. In the case of Option B, this is achieved by having an adequate volume of rock to self-armour the slope below in the event of undercutting of this reserve of rocks as the seabed level drops.
- Two options are also shown in Figure 4-2 as acceptable arrangements for the placement of rocks in the upper area of the flow slide barrier that provide a reserve of top-up rocks. Such reserves are to mitigate any slumping or structural damage to lower regions of the barrier that may be initiated by a flow slide. The intent is to ensure that there is a sufficient volume of top-up rocks to reinstate the form and function of the flow slide barrier during and following any such slumping/damage.

4.3 Structural Audit of the Flow Slide Barrier Along the Central Reach

To determine the extent of rock buried within the foreshore along the Central Reach of Amity Point, extensive geophysical investigations were commissioned by Council to map the extent of the buried rock in the foreshore.

The geophysical investigations (Golder & Associates, 2016 & 2017) utilised the combined findings of land-based survey methods of Multi-Channel Analysis of Surface Waves (MASW), Electromagnetic (EM), and Ground Penetrating Radar (GPR), as well as the overwater survey techniques of Sub-Bottom Profiling (SBP) and Side Scan Sonar (SSS). A summary of the findings of these investigations is presented as cross sections in Appendix F.

As discussed in the preceding Section 4.1.2, foreshore property owners along the Central Reach have for many years used rocks to armour the foreshores of their properties. This involves the placement of large volumes of rock into any areas of foreshore adversely affected by flow slides. When a flow slide undermines previously placed armour, those rocks slump or collapse into the eroded shoreline. Residents would then place additional rocks to "top-up" the slumped armour. Basically this has been progressively building a barrier to flow slides, since local undermining occurrences result in deeper foundations and a recharging of the reserves of rock higher in the structure.

The results of the geophysical investigations indicate that the rocks that have been progressively placed along the foreshore of the Central Reach in response to flow slides collectively take a structural form consistent with the Concept Design for a flow slide barrier shown in Figure 4-2. This confirms that it is indeed appropriate to consider the existing rock placements along the Central Reach as being a flow slide barrier.

4.3.1 Performance of the Existing Flow Slide Barrier

The results of the geophysical investigations can also be used in conjunction with the surveyed bathymetry of the side slopes of Rainbow Channel, and the known mechanisms of retrogressive flow slide events, to determine the current effectiveness of the existing flow slide barrier.

The threat of shoreline recession along the Central Reach is due to the eastward migration of Rainbow Channel - in conjunction with the occurrences of retrogressive flow slides on the underwater side slopes of the channel. Whilst there is considerable uncertainty regarding when and how flow slide events might be triggered, it is nevertheless possible to determine where along Rainbow Channel they could form.

A pre-condition for the initiation of retrogressive flow slides in Rainbow Channel is that the sand slope must be steeper than 1 vertical to 3 horizontal (i.e. steeper than 18.4° above the horizontal) over a minimum height of 5 metres (refer to more detailed discussions in Section 3.3). An analysis of digital bathymetric survey files of Rainbow Channel (Port of Brisbane, 2015) indicates that there are several such vulnerable locations along the bay-side frontage of the Central Reach.

Should a retrogressive flow slide develop on the submerged sandy slopes at one of these locations, the event would progress until it encounters the buried rocks of the existing flow slide barrier, at which point it would terminate.

As a retrogressive flow slide erodes into the subaerial sand slope, the floor of the evolving feature is not horizontal, but is on an upward angle of around 1 vertical to 15 horizontal (i.e. approximately 3.8° above the horizontal). Should this failure plane encounter the buried rock of the flow slide barrier, the flow slide will terminate.

Alternatively, should it pass below the rocks buried within the sand slope, it will either partially or completely undermine the barrier. In either of these two scenarios, rocks will collapse down the near-vertical retrogressing

sand face. Depending on the scale of undermining and the amount of rock in the barrier above it, this will either terminate the flow slide, or it will continue into the sand slope emerging on the surface behind the barrier.

There are therefore three levels of risk associated with a retrogressive flow slide initiated on the underwater side slopes of Rainbow Channel:

- No damage to the structure – where the developing retrogressive flow slide encounters the buried rock of the flow slide barrier and stops;
- Damage to the structure – where the base of the flow slide barrier is undermined and rocks collapse down the near-vertical sand face, causing the retrogressive flow slide to terminate;
- Failure of the structure – where the extent of undermining is such that the collapsing rocks are unable to disrupt the density current driving the retreating sand face and it continues into the sand slope emerging on the surface behind the barrier.

A critical consideration in determining the risk of such events to the Central Reach is ascertaining whether the retrogressing sand wall of a flow slide will encounter buried rocks.

To determine the extent of rock buried within the foreshore, extensive geophysical investigations were commissioned by Council to map the extent of the buried rock in the foreshore. The geophysical investigations (Golder & Associates, 2016 & 2017) utilised the combined findings of land-based survey methods of Multi-Channel Analysis of Surface Waves (MASW), Electromagnetic (EM), and Ground Penetrating Radar (GPR), as well as the overwater survey techniques of Sub-Bottom Profiling (SBP) and Side Scan Sonar (SSS).

The results of the geophysical investigations can be used in conjunction with the surveyed bathymetry of the side slopes of Rainbow Channel, and the known mechanisms of retrogressive flow slide events, to determine the current effectiveness of the existing flow slide barrier.

The bathymetric survey of Rainbow Channel (Port of Brisbane, 2015) has been investigated to identify locations where the channel side slopes are steeper than 1:3 over a 5 metre height - since such locations represent a location where a flow slide could start. These locations are shown highlighted in red and orange on Figure 4-3. It is important to appreciate that the bathymetry of Rainbow Channel is very dynamic, and the survey data used for this assessment was captured in December 2015 – so the vulnerable areas shown on Figure 4-3 may have changed since that time.

The potential locations for the initiation of flow slides is shown mapped in Figure 4-4 as a continuous red line along the surveyed channel slopes. Should a flow slide event occur in front of the flow slide barrier, it would start at a location somewhere along that line and would progress with the base of the retrogressing sand wall propagating into the sand slope slightly upwards on an approximate angle of 1 vertical : 15 horizontal.

The geophysical survey has identified the extent of buried rock within the sand slope (i.e. the extent of the flow slide barrier). It is therefore possible to identify where and how a developing flow slide would interact with the barrier. This can be done at cross sections along the entire length of the flow slide barrier frontage of the Central Reach. By way of example, reference is made to Figure 4-5, which shows a cross-section at a location on the foreshore defined as Chainage 1300m (which is at the end of Birch Street). Figure 4-4 shows the location of the various cross sections discussed.

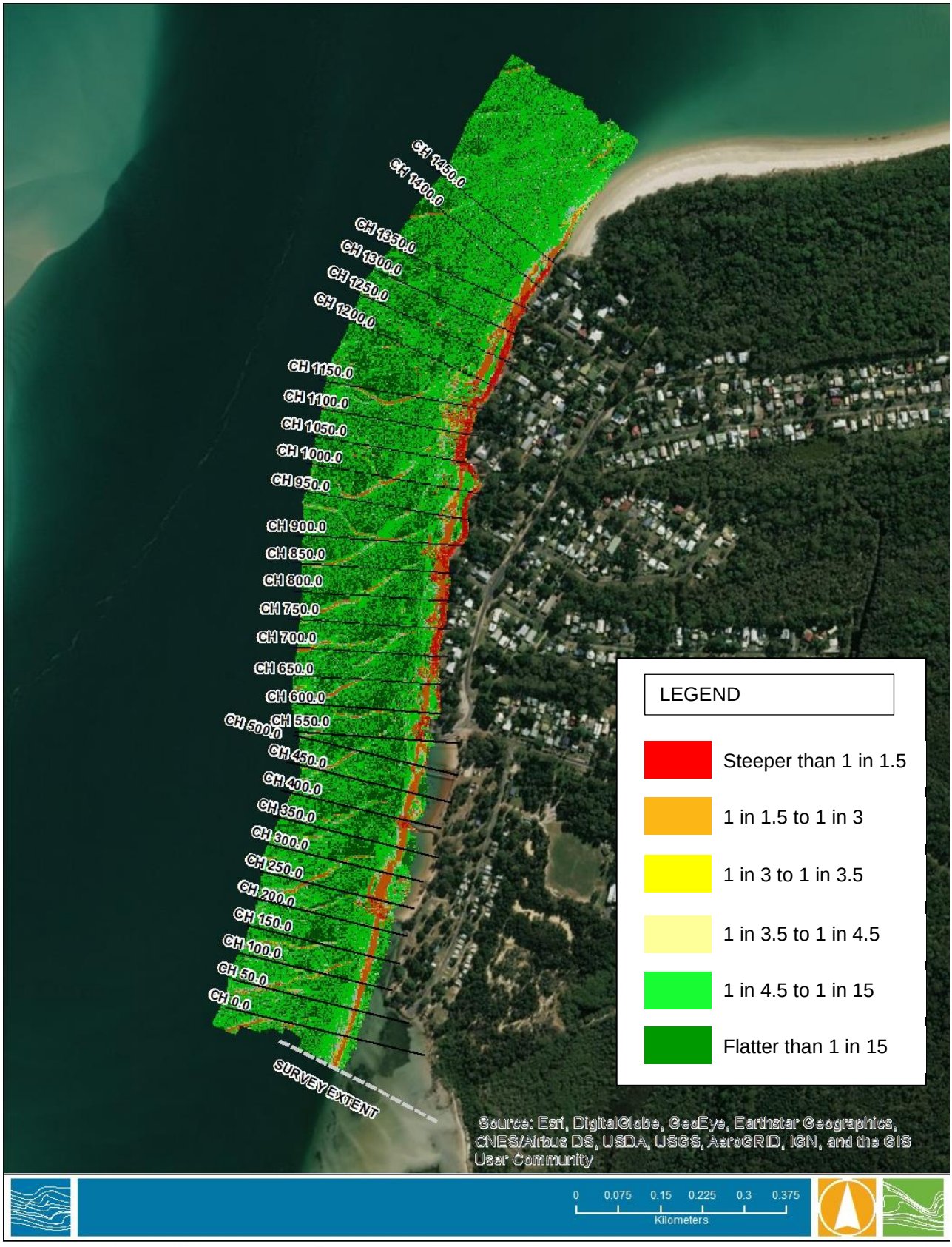


FIGURE 4-3 SLOPE ANALYSIS OF RAINBOW CHANNEL, HIGHLIGHTING AREAS AT RISK OF FLOW SLIDES

4193-01_R03v07

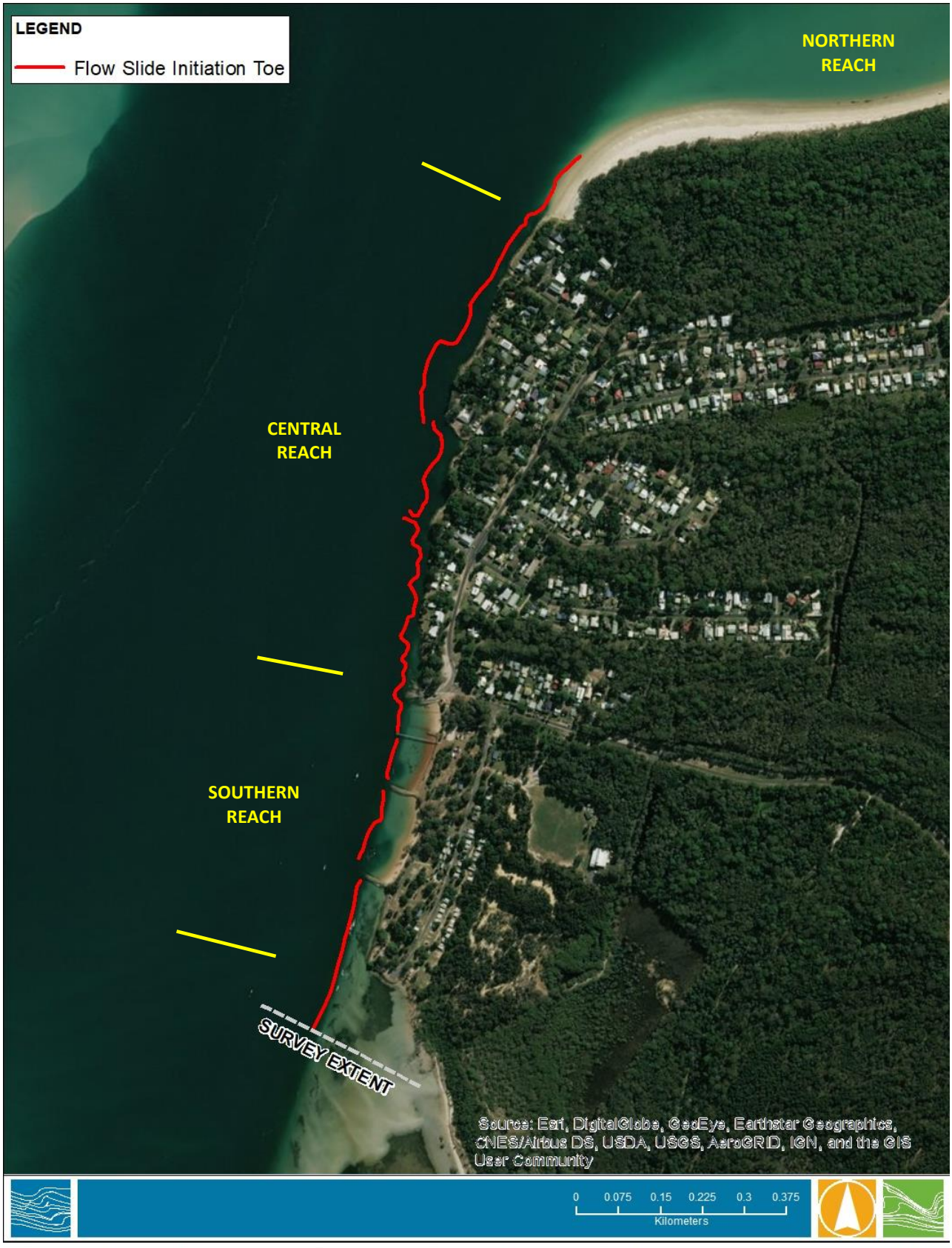


FIGURE 4-4 POTENTIAL LOCATIONS FOR INITIATION OF RETROGRESSIVE FLOW SLIDES

4193-01_R03v07

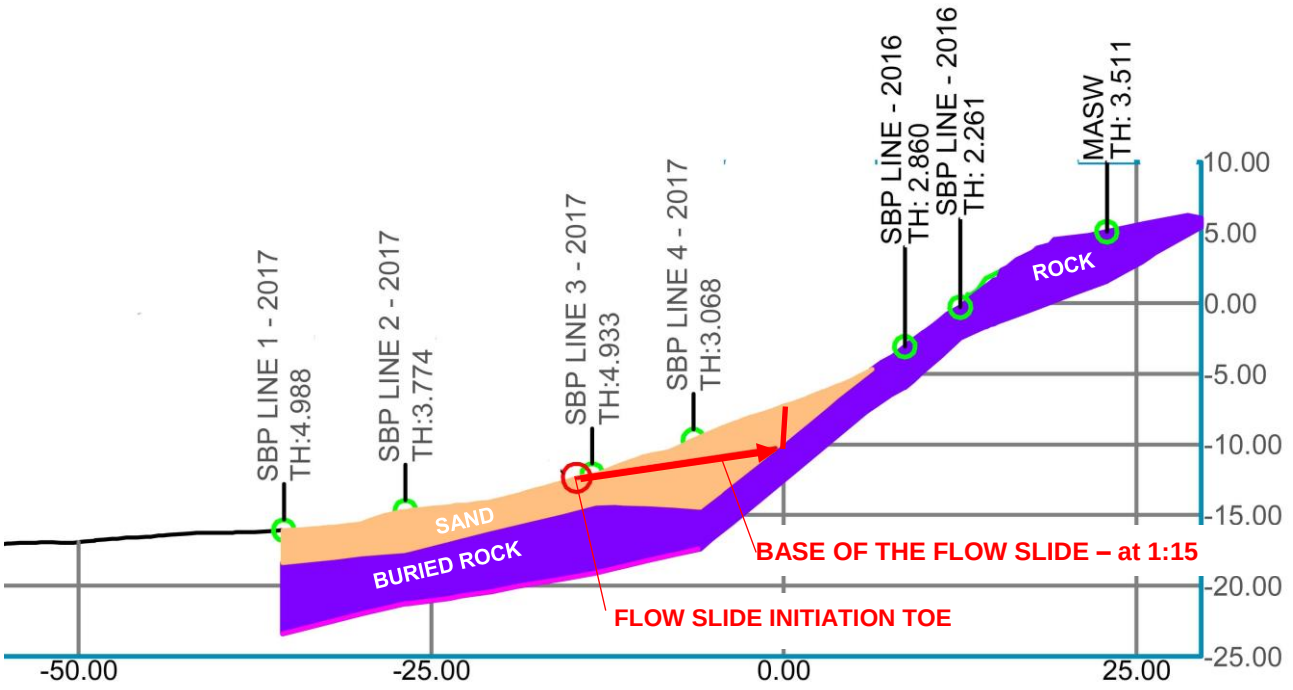


FIGURE 4-5 EXAMPLE OF INTERACTION OF FLOW SLIDE WITH BARRIER – CHAINAGE 1300M

For the location at Chainage 1300, the critical gradient of 1vert : 3horiz on the submerged sand slope of the Rainbow Channel is seen in Figure 4-5 as at approximately RL-12.5m AHD. If a flow slide is triggered in Rainbow Channel near Chainage 1300, it would be at this level on the submerged sand slope. It would erode into the sandy slope as it developed, but would encounter the buried rock of the flow slide barrier at around RL-10m AHD (refer Figure 4-5 above). Once the flow slide reaches the rock, the event ceases. This is because the density current driving the flow slide can no longer entrain sand from the retrogressing near-vertical face. This is because there is no longer any sand available within the profile of the submerged slope to sustain the process – only rocks.

Such an event is very likely to go unnoticed because it happens in deep water, and it does not reach the surface, and it has no adverse effects on the buried rock structure. That might not be the case if the advancing near-vertical wall of the shoreward moving failure plane didn't encounter rock (because such rock did not extend down deep enough). In which case the rock structure would be undermined, collapsing into the flow slide.

An analysis of where flow slides could be initiated on the submerged eastern bank of Rainbow Channel, and how they might then interact with the buried flow slide barrier along the Central Reach, has been undertaken. The results are summarised in Appendix F, which shows the cross-sections (at 50m intervals) extracted from the geophysical survey[16] overlain with the locations and development path of potentially triggered flow slide events.

It is pertinent to note that the thickness of rock forming the flow slide barrier along the frontage of Old School House Park (at approximate location of Chainage 1000 in Appendix F) is quite sparse at the location where a flow slide might encounter buried rock. A flow slide event occurred opposite Old School House Park on 18th January 2011. As shown in Figure 4-6, it undermined the flow slide barrier at this location - causing the structure to collapse, and the flow slide itself emerged on the foreshore.

[16] Digital file of Golders Associates Drawing No. 1650770-004-F-001_005, dated August 2017.



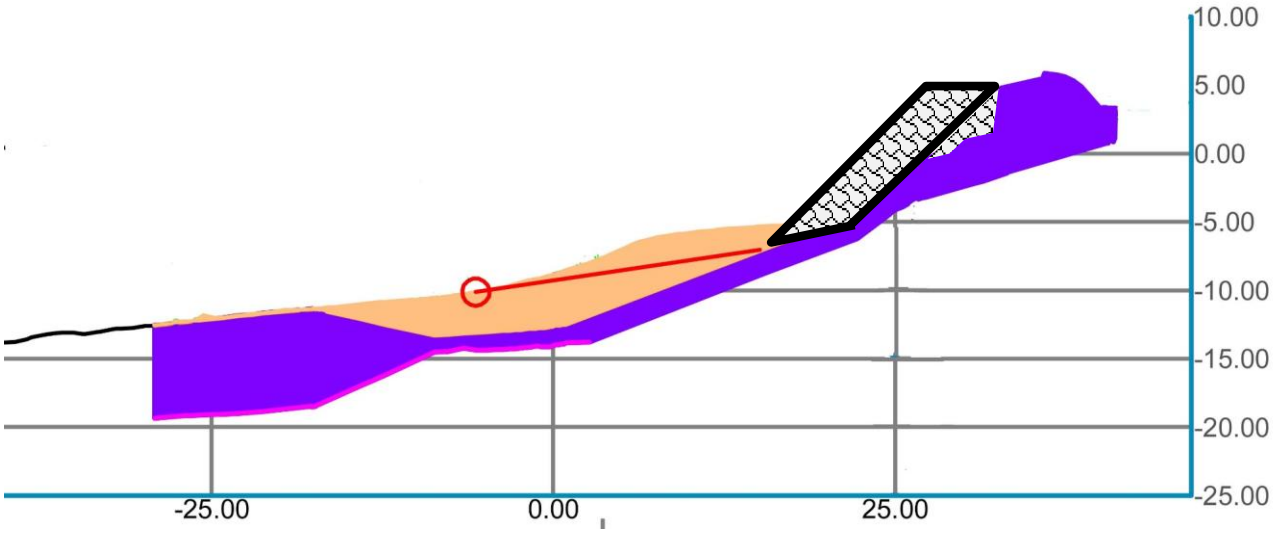
FIGURE 4-6 FLOW SLIDE EMERGING ON THE FORESHORE AT OLD SCHOOL HOUSE PARK, JANUARY 2011

A large volume of rock was subsequently placed into the foreshore immediately after this event ceased - as has been the community's response to such events in the past. Coastal processes have since partially filled the flow slide "hole" in the seabed immediately offshore with sand. It is evident from the results of the recent geophysical survey that the rocks that were armouring the upper part of the foreshore opposite Old School House Park at that time collapsed down into the deep bowl of the flow slide as it was occurring, and were spread thinly across the floor of the flow slide. The subsequent placement of rock in the foreshore has resulted in a substantial reserve of rock in the upper foreshore above approximately RL-5m AHD.

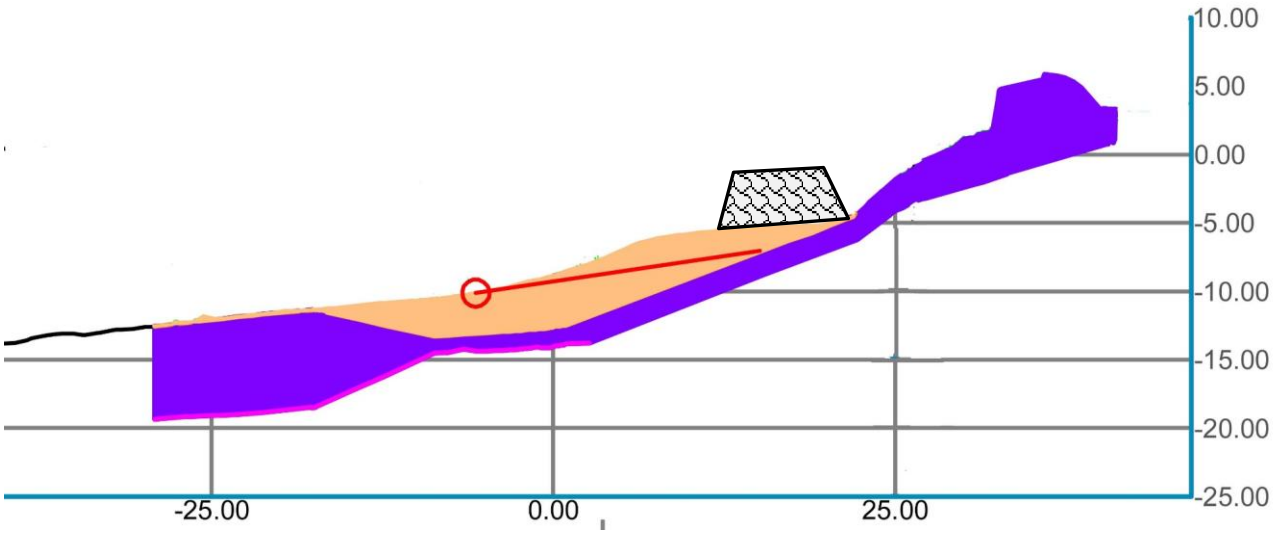
Should another flow slide event occur at this location, then the thin layer of rock it will encounter between depths of RL-5m AHD and RL-10m AHD may not be sufficient to stop the flow slide immediately. It is possible (indeed somewhat likely) that it will undermine some of the rock dispersed deeply after the January 2011 event, causing these rocks to slump down into the developing flow slide. Given the significant volume of new rock placed in the upper foreshore above approximately RL-5m AHD, it is very likely that these rocks collapsing into the advancing flow slide will disrupt the density current driving the advancement of the near-vertical retrograding sand face, thereby halting the event.

Nevertheless, some visible slumping of the rock armour of the existing flow slide barrier opposite Old School House Park could occur. This would require topping-up of rock following such an event to reinstate the function of the flow slide barrier at this location.

Alternatively, as a more proactive management approach, the reserves of rock currently in the flow slide barrier fronting Old School House Park could be augmented by the placement of approximately 45cu.m./m of rock in anticipation of another retrogressive flow slide event occurring. The additional rock could either be placed directly into the front upper slopes of the armoured foreshore above RL-5m AHD as shown on Figure 4-7(a), or onto the seabed offshore between RL-5m AHD and RL-10m AHD, as shown on Figure 4-7(b). Both options are consistent with the Concept Design for a flow slide barrier – as presented in Figure 4-2.



(a) Concept showing placement against existing front slope (above. RL-5m AHD). Not to scale.



(b) Concept showing placement on seabed (above RL-5m AHD). Not to scale.

FIGURE 4-7 OPTIONS TO REINFORCE THE FLOW SLIDE BARRIER OPPOSITE OLD SCHOOL HOUSE PARK

4.3.2 Summary of the Structural Audit

Important findings of this structural audit of the flow slide barrier are:

- The existing rock placements along the foreshore of the Central Reach are consistent with the Concept Design for a flow slide barrier, confirming that it is appropriate to consider the existing rock placements as being a flow slide barrier.
- There are many locations where flow slides could be initiated on the sandy eastern bank of Rainbow Channel in front of the flow slide barrier.

- Such locations are deep, typically at or below RL-10m AHD.
- The only location along the entire barrier where there is evidence that a flow slide might undermine and damage the barrier is on the foreshore opposite Old School House Park. There is merit in adopting a proactive strategy of reinforcing the flow slide barrier at this location - by placing approximately 45cu.m./m of rock either directly into the front upper slopes of the armoured foreshore above RL-5m AHD, or onto the seabed offshore at the RL-5m AHD depth contour approximately. Both of these options are consistent with the structural requirements and physical characteristics of a conceptual flow slide barrier.
- These findings are based on bathymetric features identified in the survey completed in December 2015. Due to the dynamic nature of the side slopes of Rainbow Channel, it is possible that the vulnerability of the flow slide barrier could have changed since that survey. As will be discussed in the following sections of this report, a recommendation of this SEMP is to undertake regular bathymetric surveys and to subsequently undertake a check on whether there are implications to how retrogressive flow slides might affect the buried flow slide barrier.

4.4 Erosion Threat at the Southern Reach - Camping Ground Foreshore

4.4.1 Coastal Erosion

In earlier times, the natural transport of littoral sand from Flinders Beach to the Amity Point area would have continued around onto the western-facing sand beaches fronting Amity Point township – being transported by ocean waves refracting and diffracting around Amity Point itself. However, the gradual eastward migration of Rainbow Channel towards the north-west corner of North Stradbroke Island (and its increasing dominance as the main tidal channel), has seen this once sandy foreshore become eroded.

The increasing proximity of Rainbow Channel to Amity Point has intercepted littoral sand that once supplied the bay-side foreshores of the Southern Reach. Sand carried by the prevailing coastal processes towards the north-west point of North Stradbroke Island is instead now deposited directly into Rainbow Channel - from where the dominant ebb tide carries it northward towards South Passage Channel and Moreton Island. It can also be carried directly northward across South Passage Bar by ebb tide flows passing through the passage.

In response to the diminishing longshore supply of sand to the Southern Reach, groynes were constructed on the bay-side foreshores around 1955 (Eberhardt, 1978). The likely intent of that work being to retain sand on the foreshore for longer periods. Approximately ten rock-armoured groynes were constructed by the 1970's, some along the Southern Reach and some along the Central Reach. Of those there are only three still left, all of them being on the foreshore of the Southern Reach.

As shown previously on Figure 3-7, the three groynes have created three beach compartments along the foreshore of the Southern Reach. The prevailing coastal processes along this coastal precinct are such that the naturally preferred plan orientation of the beaches between the existing groynes is for them to face north-west towards a bearing of approximately 312°. Consequently, sand has built up against the northern side of each groyne so as to form a triangular-shaped fillet at the southern end of each beach compartment. However, the northern part of the beach compartment has eroded so it too can achieve the preferred plan alignment of approximately 312°. But this results in localised erosion of the foreshore – which has been addressed by construction of a riprap armoured seawall in some locations, and geotextile sand containers in others.

The three beach compartments are relatively "closed" beach systems - in that they have very little natural supply of sand by the prevailing coastal processes. However, despite the effectiveness of the three groynes, they do lose sand from time to time as a consequence of storms. This steady loss of sand from the beaches and its association with shoreline recession has resulted in at least one sand re-nourishment campaign being undertaken in recent years.

Retrogressive flow slides occasionally occur at the western edge of the intertidal flats, since this is also the top of the subaqueous side slopes of Rainbow Channel. The morphological signatures of these events tend to remain observable for quite long periods. For example, a large eroded amphitheatre-shaped feature left by a retrogressive flow slide which occurred sometime prior to October 2004 (near the southern-most groyne) is still evident on aerial photographs some 12 years later.

These scour features are long-lived because there is no longer a supply of littoral sand from a sandy shoreline to the north to fill them. As discussed, the combined effect of the eastern migration of Rainbow Channel in conjunction with armouring of that adjacent shoreline by a flow slide barrier, has removed the longshore sediment supply which once naturally nourished the foreshores of the Southern Reach.

These seabed scour features act as a "sink" for any sand that is moved offshore from the nearby beaches by the cross-shore sand transport processes that typically occur during severe storm events. This slow filling of past retrogressive flow slide scour features represents a slow on-going loss of sand from the beach fillets between the groynes. As a result, the beaches have been diminishing and storm erosion can now encroach further into the camping ground. However not all of the Southern Reach is at the same risk of storm erosion. The foreshore south of the southern-most groyne is armoured by a rock seawall which has been successfully performing the task of mitigating shoreline recession. It is uncertain at this point whether it will continue to serve that purpose for a changing future climate.

Likewise, there is a rock-armoured seawall at the rear of the beach in the centre beach compartment. The toe level and underlayer arrangements of this structure are unknown, so it is not possible to determine whether it would be undermined by severe storms or would be an effective long-term erosion mitigation structure.

Technical work undertaken for this SEMP included application of the SBEACH proprietary mathematical model to predict the response of the beach profiles along the Southern Reach to several different storm scenarios. The fundamental approach to this beach response modelling has been to:

- Utilise wave information for the deeper waters in Rainbow Channel offshore of the Southern Reach - using the maximum average wave conditions presented previously in Table 3-4. No attempt was made to assign average recurrence intervals to wave parameters;
- Utilise storm tide levels for extreme events which have previously been determined by extensive numerical modelling of storm tides in the Moreton Bay and Redland City regions (refer to discussions in Section 3.2.1 and levels reported in Table 3-3); then
- Apply the above extreme wave / storm tide conditions in conjunction with the most recent beach transect surveys as input to the SBEACH model to determine the eroded post-storm profile. The profiles representative of the beaches of the Southern Reach are Transects C2 and C3 (refer Figure 3-1 and Appendix A for their locations).

Figure 4-8 illustrates a typical outcome of the SBEACH modelling, namely the pre-storm profile and post-storm profiles for the beach at Transect C2 for the selected range of storm scenarios.

It indicates that in the event of storms having ARIs of 50 year, 100 year and 200 year; the corresponding shoreline recessions on the sand beaches would be approximately 15 metres, 18 metres and 21 metres respectively. Figure 4-9 shows the extent of such recession along the sand beaches of the Southern Reach.

Such shoreline erosion would cause damage to trees and planted vegetation along the foreshore, but would not damage any significant infrastructure associated with the camping ground. An exception to this is the likely damage to the unpaved car-park behind the swimming enclosure alongside the boat ramp; as well as a sealed roadway that runs close to the beach near the southern-most groyne.

The SBEACH model was also run for an arrangement where there are existing rock seawalls along the immediate foreshore. This was done to investigate the possible performance of the rock seawall beyond the

southern-most groyne, as well as that within the central of the three beach compartments. The results indicate that these two seawalls need to be founded at around RL+0.1m AHD so as not to be undermined by severe storms of approximately 100 year ARI. However, it is not known whether this is the case.

A structural audit of the walls would be required to ascertain toe/foundation levels. The audit would need to incorporate excavation of sections of armour along their length to identify primary armour, underlayer and foundation arrangements - with subsequent rebuilding of the examined sections. The need for any upgrading works for the existing seawalls could then be determined.

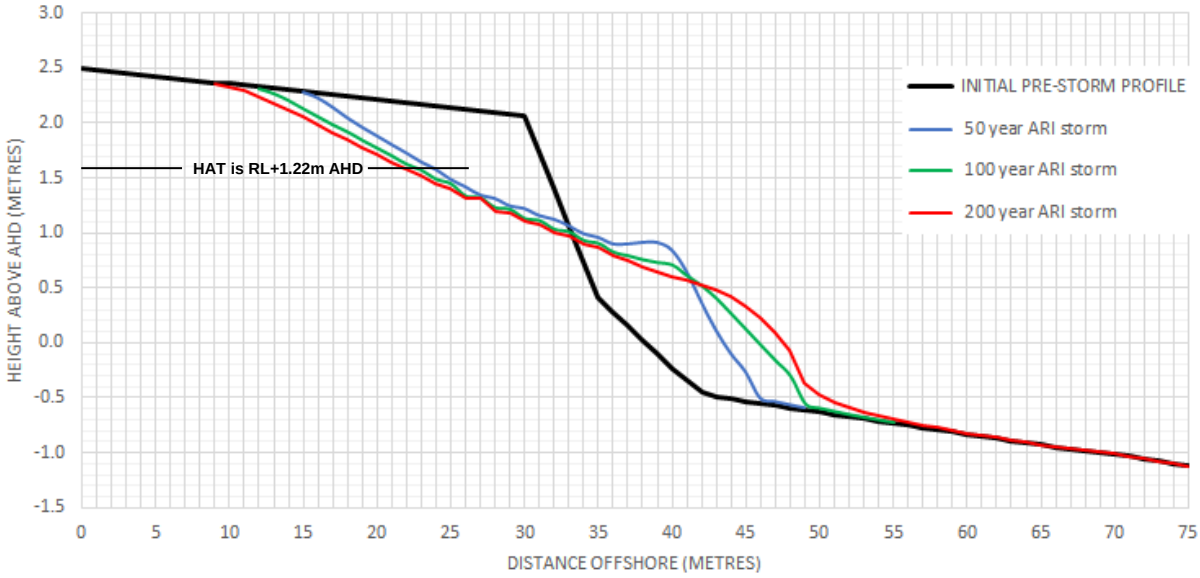


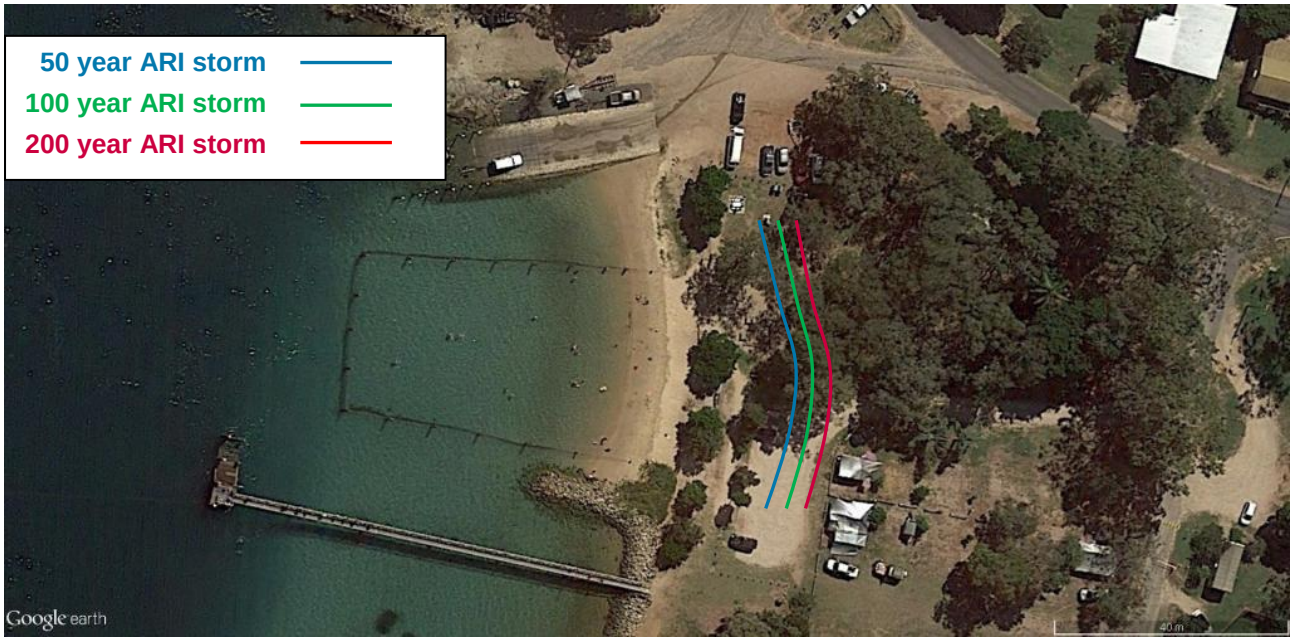
FIGURE 4-8 PREDICTED BEACH RESPONSE ALONG THE SOUTHERN REACH FOR VARIOUS STORM EVENTS

4.4.2 Retrogressive Flow Slides

Figure 4-4 shows locations along the submerged eastern bank of Rainbow Channel where flow slide events could be triggered. Reference to that figure shows that they can occur in the channel opposite the Southern Reach. Indeed, there are anecdotal reports[17] of such events occurring regularly in the past. Aerial photographs show the signature of past events in the morphology of the intertidal flat opposite the camping ground. These can be seen in the images of Figure 4-10.

The deep areas created in the nearshore area of the Southern Reach by retrogressive flow slides tend to remain for quite some time. This is because there is not significant longshore sand transport in this area to fill these depressions with sand (refer to Section 3.2.4 for a more detailed discussion of coastal processes). The morphological signature of an event evident in the aerial image of Figure 4-10 dated 17th June 2009 is still evident in the image dated 18th August 2014. Indeed, it still is evident in the 2015 bathymetric survey and the most recent aerial photographs (mid-2017).

[17] G.&L. Litherland, 16/12/2015 pers. comm.; D. & E. Cilento 15/01/2016 pers. comm.; C. & M. McIllwain, 15/12/2015 pers. comm.; J. & L. Walker 12/01/2016 pers. comm.; K. Norris 10/01/2016 pers. comm.; I. Panebianco 15/01/2016 pers. comm.; B. Hoare 13/06/2016 pers. comm.; G. Nankervis 13/06/2016 pers. comm.



(a) Recession Lines on northern-most beach compartment – Southern Reach



(b) Recession Lines on southern-most beach compartment – Southern Reach

FIGURE 4-9 EXTENT OF COASTAL EROSION THREAT ALONG THE SOUTHERN REACH



(a) Google Earth Image dated 17 June 2009



(b) Google Earth Image dated 18 August 2014

FIGURE 4-10 EVIDENCE OF PAST FLOW SLIDE EVENTS OPPOSITE THE SOUTHERN REACH

The potential threat posed by retrogressive flow slides to the Southern Reach is expected to increase in coming years. This is because the submerged eastern side slope of Rainbow Channel is slowly migrating towards the foreshore, gradually becoming steeper as it does so. This steepening sand slope will likely experience increased occurrences of flow slides.

Despite understanding where retrogressive flow slides can occur on this submerged channel slope, it is not possible to determine to what size or extent they reach once triggered. As noted previously (refer discussions in Section 3.3), a flow slide event will stop when the density current which drives the event is unable to continue to transport sand away from the retrogressing sand face; and it builds up at the base of the sand face - leading to the breakdown of the density current.

At this stage, internationally available technical literature pertaining to retrogressive flow slides in this type of coastal environment offers no definitive method to determine where a specific event may terminate. Consequently, until a better understanding of such events is developed, it would be prudent when considering the possible landward extent of flow slide effects to base predictions on the extents of past events. The largest event captured on aerial photography is that shown alongside the southern-most groyne of the Southern Reach. That event progressed to the toe of the beach at this location.

Consequently, it is conceivable that a future event could do the same, and given that the eastern side slope of the Rainbow Channel is slowly migrating towards the foreshore, may even extend into the camping ground sometime within the 20 year planning horizon for this SEMP.

4.5 Erosion Threat at the Central Reach - Flow Slide Barrier

4.5.1 Coastal Erosion

The foreshore of the Central Reach is armoured with rock. The considerable size, thickness, location and depth of the rock armouring evident from the results of the geophysical investigations are adequate to structurally mitigate wave-induced coastal erosion. The primary erosion hazard is due to retrogressive flow slides.

4.5.2 Retrogressive Flow Slides

The threat of shoreline recession along the Central Reach is due to the eastward migration of Rainbow Channel in conjunction with occurrences of retrogressive flow slides on the underwater side slopes of the Channel .

In response to the historical threat of such events, a rock flow slide barrier has been progressively built by the local community. As part of the technical work undertaken for this SEMP, a structural audit of the flow slide barrier has been undertaken. That audit was informed by the results of the geophysical investigations (Golder & Associates, 2016 & 2017), in conjunction with a bathymetric survey of Rainbow Channel (Port of Brisbane, 2015). The outcomes of the structural audit are reported previously in Section 4.3 of this SEMP.

The only location along the flow slide barrier where there is currently evidence that a flow slide might undermine and damage the barrier is on the foreshore opposite Old School House Park.

4.6 Erosion Threat at the Northern Reach - Amity Beach

4.6.1 Coastal Erosion

Erosion processes along Amity Beach are primarily due to the changing sediment transport regime driven by the local wave climate, in conjunction with the shifting and complex bathymetry of the South Passage Bar immediately offshore. As discussed in Section 3.2.4, sand is transported towards Amity Beach from the east.

Longshore sand transport sweeps sand westward along nearby Flinders Beach, where it accumulates in the sand spit at the eastern end of Amity Beach. The spit increases in length, width and height until such time as storm waves from the north-east sector sweep sand off the spit onto and along Amity Beach.

This delivery of sand from the spit onto the beach during predominantly north-easterly sea conditions can occur over quite short timeframes. It can result in almost complete removal of the spit - with a corresponding and considerable increase to the width of sand on the beach.

As the sand spit then begins to redevelop, it creates a "wave shadow" on the eastern end of Amity Beach. This is perhaps best explained by reference to Figure 4-11 below. Due to the diminished wave energy in the lee of the growing spit, there is no longshore transport of sand westward to the downdrift part of the beach. However just beyond the influence of the wave shadow, the arriving wave energy can sweep sand alongshore towards Amity Point. But since there is no longshore supply of sand out of the wave shadow to compensate for this westward moving sand, the shoreline will erode at this location. Such erosion "hotspots" therefore tend to migrate along Amity Beach in response to the changing characteristics of the sand spit.

The complexity of the nearshore bathymetry (including the dynamic sand spit and offshore sand banks), in conjunction with the complexity of the natural littoral transport processes, means that it is extremely difficult to predict future beach changes at a specific location – such as on the private property frontages of Amity Beach. A greater understanding of these local processes needs to be acquired.

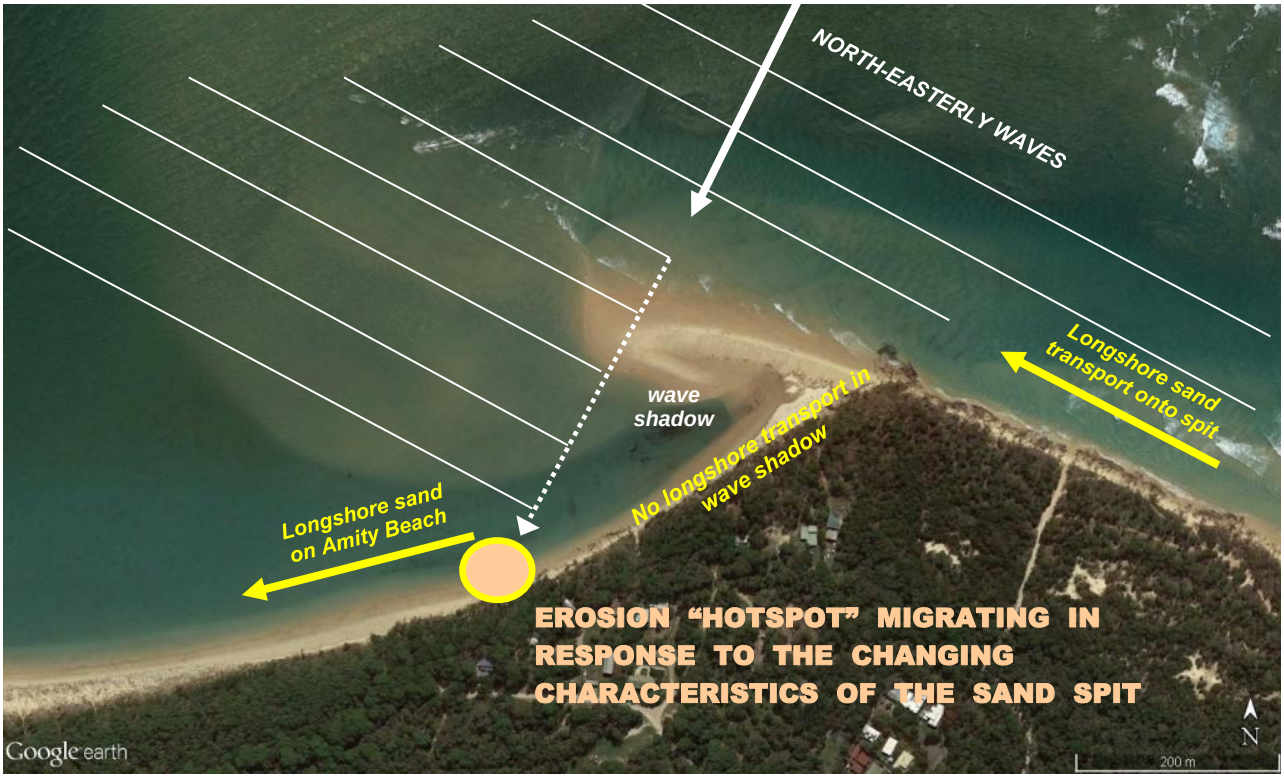


FIGURE 4-11 EROSION PROCESSES ON THE NORTHERN REACH – AMITY BEACH

4.6.2 Retrogressive Flow Slides

The only section of the Northern Reach vulnerable to flow slide events is at its western-most end, where the flow slide barrier of the Central Reach terminates (refer Figure 3-9). Indeed, due to the orientation of Rainbow

Channel (in conjunction with the prevailing littoral processes of sand supply to this location) this area is particularly prone to flow slide events. This situation is likely to continue; and flow slides might in fact increase in frequency here as Rainbow Channel migrates eastward and comes up against the existing flow slide barrier of the Central Reach. It is pertinent to note however that due to the longshore supply of sand from the east, the foreshore and nearshore bathymetry at this location are soon reinstated following flow slide events.

5. SHORELINE EROSION MANAGEMENT OPTIONS

5.1 Guiding Principles

When preparing this SEMP, a number of strategies and generic solutions have been considered for mitigating the erosion threat on local foreshores. Specific mitigation options have been developed for each of the coastal reaches covered by the SEMP based on the following management approaches:

- ***DEFEND***: Protect sectors of the coastal hazard area with either hard or assimilating coastal engineering structures to reduce or remove storm tide inundation or the erosion risks. Defend strategies may include maintaining the existing use or even intensifying development on the land. Coastal protection may combine long-term strategies for defence and maintenance including regenerative and structural options such as beach nourishment, dune construction, seawalls and storm tide barriers.
- ***ACCOMMODATE***: Maintain the current level of use within coastal hazard areas and raise the tolerance to periodic storm tide inundation or erosion events by means of innovative designs for buildings and infrastructure. This entails undertaking actions that will reduce the impacts from coastal hazards to an acceptable level. Actions can generally be broken into two categories:
  - Works that will allow current use to continue; or
  - Physical works and legislative amendments that provide for more appropriate future use of the land that can tolerate a higher level of risk (i.e. changing the zoning of the land from residential to open space), or operational works to raise the height of developable land above the height of potential sea level rise.

  In the context of this SEMP, *Accommodate* has been classified as supplementing or enhancing the effectiveness of existing erosion management practices and strategies.
- ***RETREAT***: Entails implementing actions to withdraw from the coastal hazard impacts through relocation or abandonment. This approach involves removing vulnerable uses from the identified coastal hazard and this can be achieved by relocating the community (i.e. land swap arrangement) or abandoning the area (e.g. buy back mechanism or rezoning of land to a more suitable use).
- ***RE-PURPOSE*****:** Focuses on long term planning as a mechanism to reassess existing land uses. This approach evaluates the vulnerability of land impacted by coastal hazards to determine if the land is suitable to be reused for an alternative purpose. The decision to repurpose an identified hazard area could be a result of managing community expectations of an already popular destination. Key elements that need to be considered when determining an area for repurpose is:
  - The vulnerability to coastal hazards
  - Current level of development and population
  - Possibility to achieve desired outcomes through land use criteria
  - Projected population growth and presence of critical infrastructure and services
- ***MAINTAIN STATUS QUO***: Allows for the continuation of the existing use in an area but prevents any further intensification of those uses. The decision to maintain the status quo demonstrates a clear intention that intensification of development will not occur in identified areas, but without creating a community expectation that a particular action (defend, retreat, accommodate) will be undertaken at a future date. If supported by public education on the risks associated with coastal hazards, it enables the community to understand, better prepare and be proactive .

This approach may be appropriate where there is a low level of infrastructure or assets and further intensification is unlikely to occur. Or, in locations where other management choices, such as defend or retreat, are not cost effective or technically feasible. It does not prohibit land owners from defending their own land (e.g. collaboratively with adjoining landowners) or to *accommodate* the impact of coastal hazards.

5.2 Generic Erosion Management Options

Applying the above management principles to the consideration of all shoreline erosion management options identifies two fundamental strategic approaches, namely:

- Non-structural (or "soft") measures; and
- Structural (or "hard") measures.

Given the variability of local coastal processes, foreshore uses, and the physical nature of existing foreshores types along the Amity Point shoreline, it is likely that the optimum management strategy will include a combination of non-structural and structural solutions

5.2.1 Non-structural Erosion Management Options

These erosion management options allow the shoreline to adapt naturally to the prevailing coastal processes. This restores and/or preserves the natural character, response and values of the coastal system – but could be at the expense of existing land and infrastructure assets.

Non-structural solutions would typically include:

DO NOTHING

A "do nothing" strategy of coastal management can be appropriate where foreshore land is undeveloped, or assets and property are of only limited value. It allows local coastal processes to take their natural course while accepting the resulting losses.

It is well suited to situations where available erosion buffers are sufficient to accommodate long-term and short-term erosion over the nominated planning period. However, on foreshores where existing development and infrastructure is threatened by erosion, the high social and financial costs associated with their loss are generally unacceptable.

Indeed, it is the threat of such loss along the shores of Amity Point that has necessitated significant intervention in recent years - by way of Council's beach nourishment alongside the boat ramp, emergency foreshore stabilisation works at the camping ground, and local foreshore property owners armouring their properties following flow slide events.

AVOIDING DEVELOPMENT

Along sections of foreshore that remain substantially undeveloped, a key objective would be to prevent an erosion problem from occurring by allowing the natural coastal processes of erosion and accretion to occur unimpeded. This would also preserve the natural ecosystem, amenity and character of the foreshore.

The implementation of such a strategy requires appropriate planning controls to prevent future development and infrastructure occurring in these areas. However, such instruments are already in place on the foreshores of Amity Point – either through local or state planning schemes.

PLANNED RETREAT

Removing the erosion threat by relocating existing development away from vulnerable areas of coastal precincts can require the acquisition of privately owned properties. In Queensland, land can be acquired either by agreement between the relevant government entity and the private owner, or through a compulsory

acquisition process[18]. The acquisition legislation allows local governments as well as state agencies to acquire land for specific purposes - including the "*management, protection or control of the seashore*…"[19] which also includes implementing works to achieve that purpose. Acquisitions must be compensated at the market value of the property at the time of the acquisition.

Although a planned retreat strategy involving land acquisition may be technically feasible, there are a number of practical considerations which affect the viability of such a management option at Amity Point. These include:

- Budgetary constraints regarding compensation at market value for many expensive foreshore properties;
- Implications to the disruption of a long-established and close-knit community which has previously regarded this option as a harsh and ill-considered response;
- Since only the amount of land required to fulfil the stated purpose of the acquisition can be resumed, where the risk is uncertain acquisitions are likely to be subjected to legal challenge;
- The implied determination that the existing flow slide barrier is inadequate (and hence will likely fail or be substantially damaged) necessitates its physical removal so as to mitigate any adverse implications to public safety.

A strategy of Planned Retreat was recommended previously for Amity Point (BMT WBM, 2013) and was met with significant opposition by the local community. Should such a strategy be progressed as a foreshore management option, it is likely that it would be challenged in the courts.

BEACH NOURISHMENT

A strategy of beach nourishment entails the placement of sand directly onto a foreshore - either by using conventional earthmoving techniques or by pumping - so as to restore an adequate erosion buffer on the foreshore. The advantages of beach nourishment as an erosion management strategy are that it has no adverse impacts on adjacent foreshores, and it restores and maintains the beach amenity.

It is generally regarded as being the most desirable solution to erosion problems on foreshores where a suitable and economic source of sand is available.

A frequent community criticism of beach nourishment projects is that it does not provide a permanent solution to persistent long-term erosion problems since it requires an on-going commitment to further renourishment. Nevertheless, most other forms of direct intervention (even those of a "hard" structural nature) also require maintenance and a commitment to future costs. When all impacts and costs are taken into account, the requirement for future nourishment campaigns often does not detract from the cost/benefit advantage of a beach nourishment strategy.

However, the ability to immediately replace sand lost in a storm to provide continual protection by an adequate buffer is often a challenging issue under this strategy. This is particularly the case given that there can be several storms or cyclones in any one season; and means that sand may need to be placed on the beach more than once in any storm season to be completely effective.

Sand used for nourishment should be sourced from outside of the active beach system to exclude any possibility that the benefit to the nourished foreshore is achieved at the expense of beach erosion elsewhere. This places a constraint on prompt restoration of buffers depleted by storm events if such sources are not readily to hand.

[18] The *Acquisition of Land Act 1967*.
[19] Ibid, Schedule 1, Part 2. *Purposes relating to the environment*.

The requirements for an effective beach nourishment strategy are determined by the local sediment transport regime. The objectives of such a strategy are to establish and maintain adequate erosion buffers. Local cross-shore sand transport processes dictate the overall volume of sand required in the buffer to accommodate a particular storm ARI. On the other hand, longshore transport processes determine the average rate at which sand needs to be added periodically to the buffers so that they are maintained in the long-term.

BEACH RE-PROFILING

The concept of beach re-profiling (or "beach scraping") entails moving sand from lower levels of the cross-shore beach profile (typically from tidal flats immediately in front of a beach) up onto the beach slope or into the dune system.

In essence it is simply redistributing sand that is already within the active beach profile and as such does not provide a net long-term benefit unless it is undertaken frequently.

Beach re-profiling can be beneficial in reinstating or reshaping the dune following a storm event, thereby assisting and accelerating natural processes that would otherwise rebuild the eroded dune system over much longer timeframes. However, since significant re-profiling lowers the seabed in front of the beach, it allows slightly increased wave energy to reach shore, offsetting to some degree the benefits achieved by reinforcing the beach face and/or dune.

CHANNEL RELOCATION

In some cases, foreshore erosion can be attributed in varying degrees to the dynamic nature of tidal channels. The sandbanks and shoals of these local coastal systems can affect tidal currents and/or wave patterns which can have an adverse effect on nearby sandy shorelines. In some of those instances the problem can be alleviated somewhat by the planned relocation of the main channel flow. Given that the changing morphology of Rainbow Channel represents a significant threat to Amity Point foreshores, such an option must be considered.

5.2.2 Structural Erosion Management Options

These erosion management options entail engineering works which either form a physical barrier to maintain the existing shoreline position, or alter the nearshore wave climate that is contributing to the erosion problem.

FLOW SLIDE BARRIER

In the Netherlands, flow slides on the extensive levee systems that protect vast areas of the country have been extensively researched and numerous mitigation measures proposed, implemented and monitored (Silvis and de Groot; 1995). Initially the focus of mitigation measures was on engineering works that prevented the flow slides from occurring. In the early part of the nineteenth century, a strategy was adopted of constructing groynes underwater to protect submerged sandy slopes from slide failures by directing the flow of water away from the slope. This proved to be unsuccessful in preventing many flow slide failures.

Over time the approach adopted in the Netherlands has evolved so as to include armouring of the at-risk slope itself - through the placement of layers of rubble/rock. This is not only an attempt to prevent flow slides from being initiated on submerged sand slopes, but also to prevent their propagation to damaging proportions if they do occur. It is widely acknowledged that the presence of hard material/layers (such as rock) interrupts the processes causing the near-vertical sand face of a flow slide from progressing (Mastbergen; pers. comm.[20]).

[20] Email from D.R. Mastbergen (Senior Adviseur/Onderzoeker, Department of Marine and Coastal Systems, Deltares) regarding "*retrogressive breach failures – mitigation works*" to P.L. O'Brien of Water Technology Pty Ltd. 06 January 2016.

This blockage of potential flow slide failures by rock overburden was also identified as a mitigation measure in early studies undertaken by the U.S. Army Corps of Engineers (Banks, et. al.; 1965 and Torrey, et. al.; 1988) on flow slide failures in levees of the Mississippi River.

An option to mitigate the threat that the flow slides (or, as they are also called, retrogressive breach failures) which occur along the eastern edge of Rainbow Channel is to provide a physical barrier. Indeed, this has been the intent of ad-hoc works undertaken by the local community in response to flow slide events along the Central Reach foreshore ever since the threat of flow slides first emerged at Amity Point many years ago.

SEAWALLS

Rock armouring is commonly used to provide a physical barrier to continuing shoreline recession along sandy foreshores. Properly designed and constructed seawalls can be effective in protecting foreshore assets by stopping any further recession. However, on sandy foreshores seawalls significantly interfere with natural beach processes by separating the active beach from sand reserves stored in beach ridges and dunes. In other words, seawalls can protect property behind the wall, but they do not prevent in any way the erosion processes continuing on the beach in front of them. In fact, they very often exacerbate and accelerate the erosion.

Typically, the effect of seawall construction on actively eroding shores is for the level of the beach in front of the structure to steadily lower - until the beach reaches a new equilibrium profile.

This lowering is primarily caused by wave action washing against the wall causing a high degree of turbulence in front of the structure - which scours the beach material. Wave energy reflected from the seawall also contributes to these scour and beach lowering processes. In many cases this lowering continues until the level of the beach is below prevailing tide levels, in which case the ocean simply washes against the face of the seawall and there is no beach for part (or possibly for all) of the tide cycle. The amenity of the beach and foreshore is therefore significantly degraded in order for the seawall to protect the area behind it.

This lowering of the sand level in front of seawalls can also present problems for the overall stability of the structure. Unless appropriate foundation and toe arrangements are constructed, the seawall can fail by undermining. Even if only damaged, it is extremely difficult and very expensive to repair existing seawalls that have been damaged by undermining. Indeed, frequently the most cost-effective solution is to demolish the structure and rebuild it with deeper and more robust foundations.

Another typically adverse impact of seawalls is that the original erosion problem that they were meant to solve is simply relocated further along the shore. Natural beach processes can no longer access the sand reserves in the upper part of the active beach that are behind the seawall. Consequently, this sand cannot be moved downdrift by longshore sand transport processes to replenish the sand that these same processes are moving along the shoreline beyond the end of the seawall.

The deficit in sand supply to these downdrift sections initiates greater erosion there, ultimately requiring extension of the seawall along the entire downdrift shoreline to protect it.

Seawalls have an effect on the visual amenity of a shoreline, and this can be quite adverse if the wall is high - or if it becomes so as a consequence of natural beach lowering in front of it. Such walls also inhibit easy public access across the foreshore onto the beach. Typically access stairways or ramps need to be provided on seawalls to ensure the safety of beach access by pedestrians.

Appropriately designed and constructed seawalls are relatively expensive and they do not always compare favourably with the cost of other alternatives. However, many seawalls constructed in Queensland have been built of rock during or immediately following severe sea conditions and significant cyclone erosion events.

Under such circumstances appropriate design and construction of these walls may not have been implemented. Consequently, most of the seawalls constructed in this manner require significant maintenance to prevent structural failure and the subsequent re-establishment of the original erosion problem.

Despite their disadvantages, rock seawalls are probably the most commonly used method in Queensland for protecting foreshore assets against the threat of erosion. This can probably be attributed to their versatility. They are relatively easy to construct using conventional earthmoving plant and equipment; and this is often accomplished by simply dumping rock on a prepared slope rather than applying more appropriate construction practises to create a robust structure that can accommodate the adverse effects of severe storm/cyclone waves.

Such ad-hoc methods can be used to not only protect long sections of foreshore, but also individual private properties. The substantial and solid appearance of rock walls can provide owners of foreshore assets with a sense of security - which can be misguided given the often-inadequate design and construction of these structures. Their subsequent failure or damage can not only lead to the re-establishment of the original erosion problem, but the scattering of removed rocks can adversely affect foreshore use and visual amenity.

SEAWALLS WITH BEACH NOURISHMENT

To mitigate some of the disadvantages of seawalls, beach nourishment can also be undertaken to create a beach amenity in front of the structure. This sand placement also provides a reservoir of sand to feed the downdrift foreshore which would otherwise be starved of sand by the wall.

The seawall structure still serves as the primary defence against erosion, particularly during severe storm events, so must be designed and constructed accordingly. The amount of sand initially placed as beach nourishment will depend on the extent of the amenity to be provided.

Nevertheless, regular sand placement by way of renourishment campaigns would be required to maintain the beach amenity, as well as prevent migration of the initial erosion problem along the downdrift shore. This intermittent renourishment would need to at least match the average net longshore sand transport rate.

GROYNES

The longshore transport of sand on an eroding shoreline can be impeded by constructing groynes across the active beach. A groyne functions as a physical barrier by intercepting sand moving along the shore. Sand is gradually trapped against the updrift side of the structure, resulting in a wider beach on this “supply-side” of the structure. However, the downdrift beach is deprived of the sand trapped by the groyne and therefore it erodes.

This process of updrift entrapment and downdrift erosion continues until such time as sand has accumulated on the updrift side of the groyne to the extent that it starts to feed around its seaward end. Sand supply is then reinstated to the downdrift foreshore. However, this then simply maintains the shoreline on its eroded alignment.

Groynes cannot prevent the significant cross-shore erosion that typically occurs during severe storms. Nevertheless, they have an indirect effect in that by having trapped sand on their updrift side, they have created a wider beach and an enhanced erosion buffer on that section of foreshore. However, on the depleted downdrift side, the foreshore is more susceptible to cyclone erosion due to the depleted beach/buffer width. Consequently, the construction of a groyne does not in itself resolve the erosion problem, but merely transfers it further along the beach.

The same effect of impeding the longshore transport of sand by a groyne can also be achieved by a structure built offshore of the beach, but not connected to it. Such structures a called *offshore breakwaters* and function by casting a “wave shadow” onto the shoreline in its lee.

The reduced wave energy landward of the offshore breakwater means that the ability of the waves to keep moving sand along the shoreline is reduced. Consequently, the supply of sand from the updrift shoreline is greater than that at which it can be moved out of the wave shadow. Sand therefore accumulates in the lee of the structure. However, as is the case with a conventional groyne, the shoreline downdrift of the wave shadow is deprived of sand and therefore erodes.

GROYNES WITH BEACH NOURISHMENT

The downdrift erosion caused by groynes can be compensated to a large extent by incorporating beach nourishment into the strategy. This is achieved by placing sand against the updrift side of the groyne immediately after it is constructed so that it is "filled". Any additional sand moved against this side of the structure by natural processes can therefore be carried around the end of the groyne to supply the downdrift shoreline.

The length of updrift shoreline that benefits from such groyne and beach nourishment is somewhat limited. Therefore, if long sections of shoreline require protection then several groynes can be built at intervals along the shoreline. This is typically called a *groyne field*.

The length and spacing of such groynes depend to a large degree on the local longshore sand transport regime; and in particular, the naturally preferred stable orientation of the beach. Their length and spacing are also somewhat dependent upon each other. Under any given longshore transport regime, it is possible to achieve a similar degree of protection by using short closely spaced groynes, or longer more widely spaced structures. Such issues can only be resolved by further detailed study and design.

Nevertheless, such intervention will have a significant impact on the visual amenity of foreshores. Structures such as groynes that cross the shore can also have an adverse impact on beach use since walking along the beach will entail crossing over the groynes. This experience is also potentially marred by the different beach levels on the updrift and downdrift sides. It is for these reasons that a management strategy that entails a groyne field rarely has appeal.

6. ASSESSMENT OF SHORELINE MANAGEMENT OPTIONS

As discussed previously in Section 3.5, when considering appropriate erosion management options along the Amity Point shoreline it is evident that the shoreline can be considered in three coastal precincts, namely

- Southern Reach: the foreshore frontage of the camping ground and boat ramp;
- Central Reach: along the alignment of the rock flow slide barrier; and
- Northern Reach: the sandy foreshore of Amity Beach.

The three coastal reaches are shown on the preceding Figure 3-6. This separation into coastal reaches does not imply that the coastal processes within each are in any way compartmentalised. They are by no means isolated or discrete sections of shoreline, since the processes affecting each can have an influence on the others. However, this partitioning lends itself to the development of viable erosion management strategies that integrate well over the entire Amity Point coastal reach.

An assessment of potential management strategies for each of these three coastal precincts is presented in the following sections.

6.1 Southern Reach - Camping Ground Foreshore

Due to the different type and orientation of the shoreline at the southern-most end of this foreshore (towards the end of Basin Drive), there is scope to further refine the partitioning within this precinct. As shown previously on Figure 3-7, the southern reach consists of an approximately 355 metre long beach frontage to the camping ground; and a 215 metre long rock-armoured seawall bordering the southern part of the reserve.

As noted in Section 4.1.2, the primary threat to the foreshores of the Southern Reach is storm-induced erosion. This will be exacerbated by future climate change.

6.1.1 Non-structural Management Options

DO NOTHING

Intermittent beach erosion due to storms, in conjunction with the on-going long-term erosion trend at this location means that the existing sandy beach frontage will continue to be eroded. This will:

- Detract from the local beach amenity;
- Detract from the visual amenity of the foreshore;
- Potentially lead to damage/collapse of the existing rock groynes, and sections of seawall at the back of the beach;
- Continued loss and damage to long-established foreshore trees;
- Adverse implications to the camping ground, including loss of available land.

These outcomes are considered unacceptable, as evidenced by recent works undertaken by Council to armour the eroded upper beach with sand-filed geotextile bags.

Further south where there is a rock-armoured seawall, the implications of a Do Nothing strategy is possibly an acceptable strategy. The structure has performed its intended role of mitigating any erosion of this section of foreshore without any obvious signs of structural damage to date. It is possible that this may change in future

years should the long-term deficit in longshore sand supply to this area result in a lowering of the seabed at the toe of the seawall - leading to its undermining.

The potential vulnerability of the seawall to undermining depends upon the depth that the toe of the armoured slope is buried below the seabed surface. A structural audit of the seawall at this location (which includes intrusive testing to excavate to the toe level) would provide greater certainty to a Do Nothing strategy along this southern section.

AVOID DEVELOPMENT

This option is not applicable. The foreshore has already been developed, but is designated by the Department of Natural Resources, Mines and Energy (DNRME) formerly Department of Natural Resources and Mines, as a Reserve for community or public purpose. In November 2011, this area was declared under the *Recreational Areas Management Act 2006* as being part of the *Minjerribah Recreational Area*. Straddie Camping now administers the area under a new management framework operated by Indigenous Business Australia in conjunction with the Quandamooka People. Regulations apply under the Act to the entire Minjerribah Recreational Area to ensure that the island's foreshores, dune systems, bushland and freshwater systems are appropriately cared for to maintain their visual amenity, and to protect the island's unique natural and Aboriginal cultural heritage.

PLANNED RETREAT

The scale of the erosion along this reach is such that infrastructure associated with the camping ground is not significantly threatened. Given the high socio-economic values associated with the camping ground, there is no merit in relocation (either partially or wholly) of this approximately 6-hectare facility to another foreshore location.

BEACH NOURISHMENT

Under a beach nourishment strategy, the width and height of the beach slope fronting the camping ground would be increased. Apart from increasing the resilience to erosion, the benefit to the area is that the overall amenity of this much-valued foreshore would be enhanced for residents and visitors.

Sand brought in for placement on the foreshore should have the same (or slightly larger) grain size as that on the existing beach. It should also be of uniform grading - this being a physical characteristic of naturally occurring beach sand.

The prevailing coastal processes along the southern reach of Amity Point are such that the naturally preferred plan orientation of beaches between the existing groynes is for them to face north-west towards a bearing of approximately 312°. This means that sand placed along the foreshore will be moved southward against each groyne so as to adopt this natural plan alignment. As a consequence, sand builds up against each groyne to form a triangular-shaped fillet on the southern end of the beach compartment. However, the northern part of the beach compartment will gradually become depleted of sand, thereby negating any benefit of beach nourishment at those particular locations. This will require either further local renourishment, or another form of protection (such as a seawall) in these northern pockets of each beach compartment.

BEACH RE-PROFILING

The intertidal flats immediately in front of the beaches at this location consist of fine-grained sediments that are quite different in characteristics to the sand forming the beach itself. Any redistribution by scraping of this material onto the beach slopes would degrade the beach amenity and (due to being fine-grained) would provide minimal protection as a beach buffer.

CHANNEL RELOCATION

As discussed in the preceding Sections 3 and 4, the eastward migration of Rainbow Channel represents a significant threat to the Amity Point area. Perhaps the most obvious options to mitigate this threat is to either relocate this channel by dredging, or to undertake such dredging as might be required to prevent further migration. There are several very significant impediments to such a management approach.

The physical scale of the required dredging works would be enormous. A special large dredge would need to be commissioned from overseas at considerable cost, as there are no dredges currently based in Australia that could undertake such major works. Leaving aside the issue of cost, the works would have to be undertaken within the Moreton Bay Marine Park and would have significant environmental impacts on areas designated as *Conservation Park Zone* and *Habitat Protection Zone* within the Park.

There would also be major changes to the hydrodynamics of Moreton Bay - since Rainbow Channel plays an important role in the tidal exchange of water between the ocean and the Bay through South Passage. Any dredged changes to the complex bathymetry of South Passage are unlikely to remain permanent.

Given these various implications of cost and adverse environmental impacts, a management strategy of redirecting Rainbow Channel to alleviate the erosion threat to Amity Point is not feasible.

6.1.2 Structural Management Options

FLOW SLIDE BARRIER

Whilst flow slides are known to occur regularly on the submerged slopes of Rainbow Channel further north within the Central Reach (Beinssen et. al., 2014 and Beinssen & Neil, 2015), an analysis of recent and historical bathymetric surveys suggests that they have been less frequent on the channel sides of the Southern Reach. This is because the channel side slopes are not as steep or as high as they are further north, meaning they are less susceptible to flow slide events. Nevertheless as discussed in Section 4.4.2, they may still happen.

Because of the shallower depth of Rainbow Channel along this precinct, in conjunction with its distance offshore, any flow slides that do develop are unlikely to significantly threaten the sandy foreshore of the Southern Reach at present.

As discussed in Section 3.1, Rainbow Channel is nevertheless migrating eastward towards the Southern Reach foreshore at an average rate of between 0.9metres/year and 2.8metres/year. As well as the edge of Rainbow Channel moving closer to the shore, the side slopes are becoming steeper – thereby increasing the risk of retrogressive flow slides developing.

If a flow slide barrier was to be adopted along the Southern Reach at some point in the future, it would require the placement of very large volumes of rock directly onto the submerged channel bank, possibly also as a thick layer along the seaward edge of the intertidal flats. This would be an undertaking to replicate the construction of the flow slide barrier constructed intermittently by foreshore property owners along the Central Reach.

There seems little merit in considering a flow slide barrier as the primary means of mitigating the threat of foreshore erosion along the Southern Reach at present, since this is mainly due to storm wave action. Nevertheless, there is considerable merit in regularly monitoring changes to the submerged side slopes of Rainbow Channel by way of regular bathymetric surveys to identify the emerging risks of flow slides to the Southern Reach.

SEAWALLS

There are already rock-armoured seawalls protecting sections of foreshore along this precinct. These have been constructed for short lengths - along the foreshore immediately south of the jetty, as well as along the southern-most end of the foreshore. Both have proven to be effective means of mitigating the local erosion

threat. However, a natural consequence of seawall construction on these two foreshores is that in each case the beach immediately in front of them has been degraded.

SEAWALLS WITH BEACH NOURISHMENT

This option would entail utilising the benefits of both a beach nourishment strategy along with that of seawalls.

In this case, sand would be placed on the foreshores between each groyne so as to create a stable triangular-shaped fillet against the groyne at the southern end of each beach compartment. However, any sand placed on the northern part of each beach compartment would tend to be moved southwards towards the groyne due to the prevailing coastal processes on this precinct.

This natural gradual migration of placed sand would manifest itself as erosion in the northern pockets of each beach compartment. For this mitigation option, a seawall would be built on the alignment of the acceptable limit of shoreline recession. This section of seawall could be initially covered over with sand to create a larger beach amenity. But as stated, the placed sand would gradually migrate southwards towards the next groyne where it would contribute to the sand fillet that accumulates there.

A strategy of intermittent “back-passing” campaigns could be implemented, whereby sand could be collected from within the accumulating reserves at each groyne; and placed back on the northern section. This could be readily undertaken using small earth-moving equipment such as a front-end loader and trucks operating over a period of 1 to 2 days. Back-passing is a common means of erosion mitigation and amenity improvement on many foreshores around the world.

GROYNES

There are already two long groynes and one short groyne constructed on the foreshore of the Southern Reach. These were initially constructed to capture sand being moved southward by the naturally prevailing littoral drift. However, as discussed in Section 3.5.1, there is no longer any significant longshore supply of sand to this foreshore due to Rainbow Channel having migrated against the rock wall of the Central Reach and thereby intercepting any littoral sand supply.

Neither enhancing the characteristics of the existing groynes nor the construction of additional groynes will be effective in mitigating foreshore erosion of the Southern Reach.

GROYNES WITH BEACH NOURISHMENT

Since there are already three groynes on the foreshore of the Southern Reach, this option entails placing sand into the beach compartments between the groynes by way of a beach nourishment campaign. However, (as discussed for the *Beach Nourishment* option) the naturally preferred orientation of any sand beach is such that over time the northern end of each compartment will become depleted of sand.

This could be mitigated if the triangular-shaped fillet of sand that forms against each groyne was large enough to cover the full length of shoreline within each beach compartment. But for this to occur the groynes would need to be much longer than they are at the moment. However, it is not possible to lengthen the groynes as their offshore ends are already close to the edge of Rainbow Channel. Any extension would intrude into the deep waters of the Channel, and this is not technically feasible.

Another option involving groynes and beach nourishment is to construct additional groynes between those that are existing - so as to create more (but shorter) beach compartments. However, the quantity of rock required to construct the additional groynes would be much greater than that for the *Seawalls with Beach Nourishment* option, and also have a more adverse impact on visual amenity and foreshore use.

6.2 Central Reach - Flow Slide Barrier

The Central Reach consists of the existing rock armoured frontage extending northwards from the boat ramp at Claytons Road to near the northern end of Millers Lane (refer to earlier Figure 3-8). The rock structure is a flow slide barrier that has been progressively reinforced by local property owners over many years. The erosion threat along this Central Reach is primarily a consequence of discrete flow slides (or retrogressive breach failures) in conjunction with the processes causing Rainbow Channel to slowly migrate eastward.

When assessing the viability of strategies to mitigate the threat of shoreline recession along the Central Reach, it is necessary to consider the ability of each option to prevent, impede or accommodate future flow slides.

6.2.1 Non-structural Management Options

DO NOTHING

A do-nothing strategy on this precinct would result in future flow slide events that occur on the submerged edges of Rainbow Channel potentially damaging the existing flow slide barrier. This would compromise the barrier's effectiveness in impeding the development of each event to damaging proportions. In the past, whenever the barrier has been damaged by a flow slide, the response of the local community has been to reinstate the barrier's effectiveness by recharging the reserves of rock armour in the upper regions of the barrier's profile (refer discussions in Section 4.5).

A do-nothing strategy of preventing any such future reinstatement of the barrier's purpose could result in an on-going deterioration of its function. This would increase the threat of shoreline recession, not mitigate it. A do-nothing strategy is therefore not a viable option to manage the threat of flow slides and the associated shoreline recession along the Central Reach.

AVOID DEVELOPMENT

This is not relevant since the Central Reach is already developed. There is nevertheless merit in maintaining a planning strategy of not allowing any future development on existing land parcels to be any further seaward than at present.

PLANNED RETREAT

Council currently has a policy of planned retreat at Amity Point, which is reflected in the zoning for the area. This policy has been in place for some time and has been adopted in response to the historic loss of significant areas of foreshore land and infrastructure.

The urban residential area of Amity Point (west of Ballow Street) is zoned as sub-area UR3 (*Redlands Planning Scheme* - Version 7.1). In this sub-area, all future buildings and structures are to be demountable and capable of removal. Furthermore, structures or infrastructure associated with other development or use must not extend any further seaward than existing development and uses on the site. This forms part of a strategic plan of retreat adopted by Council, whereby the line of foreshore development will retreat as shoreline erosion continues, rather than allow future development within the erosion prone area.

The strategy of planned retreat was recommended by the Draft Shoreline Erosion Study (BMT WBM, 2013) which met with considerable opposition by the local community of Amity Point. The extent of that opposition indicates that a retreat strategy is viewed as a significant disruption of a long-established and close-knit community. Should such a strategy be progressed as a foreshore management option, it is evident from stakeholder engagement activities undertaken for this SEMP, that it would be challenged in the courts by Amity Point residents - either collectively or individually.

Apart from the social dislocation of the Amity Point community, the acquisition costs associated with a planned retreat strategy would be considerable. Council has previously determined[21] that such a strategy "*is likely to be an expensive option and unlikely to be either technically or financially feasible without State or Federal Government support*".

A requirement of any acquisitions under the *The Acquisition of Land Act (1967)* is that it must be compensated at the market value of the properties. There are 34 separate land parcels of mixed tenure along the foreshore of the Central Reach. Many of these properties have quite substantial homes built on them. Recent property sales along this foreshore have been in the range of $1 million to $2million - so acquisition costs would be very high.

The implied determination that the existing flow slide barrier is ineffectual (and hence will likely fail or be substantially damaged) necessitates its physical removal to mitigate any adverse implications to public safety. As noted in Section 4.5, the existing flow slide barrier consists of a very considerable volume of rock. The removal of that material, even progressively should future flow slides damage the structure, represents a significant engineering and earthmoving exercise with large associated costs.

It is pertinent to note that a planned retreat strategy (in conjunction with removal of the existing rock flow slide barrier) may necessitate further planned retreat campaigns at Amity Point. This is because the interrupted eastward migration of Rainbow Channel and potentially damaging flow slides will instead be unchecked by an effective flow slide barrier.

BEACH NOURISHMENT

Given the proximity of the very wide and deep Rainbow Channel to the foreshore, in conjunction with the significant tidal flows that the channel carries, means that any strategy that relies on placing a sufficient volume of sand to create a natural sandy foreshore as a buffer to erosion is not technically feasible. It would not inhibit flow slides nor prevent the eastward migration of Rainbow Channel.

BEACH RE-PROFILING

This option is not relevant since there is no existing beach along the Central Reach.

CHANNEL RELOCATION

The discussion in Section 6.1.1 regarding the viability of this option for mitigating the erosion threat along the Southern Reach is relevant to the Central Reach as well. A management strategy of redirecting Rainbow Channel to alleviate the erosion threat along the Central Reach is not environmentally nor financially feasible.

6.2.2 Structural Management Options

FLOW SLIDE BARRIER

As noted previously in this report, the primary threat to the foreshores of the Central Reach are retrogressive flow slides. Such phenomena have been extensively researched overseas – particularly in The Netherlands where they represent a significant threat to vital flood and sea defences along that country's coastline and riverbanks. Consequently, there is a significant body of technical literature available that describes the morphological mechanisms associated with flow slide failures, as well as measures for either preventing their initiation or inhibiting their development to destructive scales.

[21] Document 9240G-Amity-Erosion-question-sheet-A4.pdf, titled "Shoreline Erosion Amity Point, North Stradbroke Island – Questions & Answers". https://yoursay.redland.qld.gov.au/10540/documents/21042. Accessed 30th November 2017.

The mechanism of flow slide development is driven by short-lived density currents that entrain sand off the near-vertical wall of the shoreward moving failure plane, causing sand grains to cascade off the advancing failure face. Measures to prevent flow slides from being triggered on submarine sand slopes can be difficult and costly to implement, often with only limited effectiveness. Therefore, a significant focus of overseas research has been directed to identifying submarine sand slopes that are susceptible to flow slides; and to then devise the means to prevent them from developing into large scale failures.

For strategies that seek to prevent further development of an initiated flow slide, the primary objective is to disrupt or completely dissipate the density currents which entrain sand on the near-vertical failure plane. Blocking of flow slide development occurs when:

- The advancing near-vertical sand wall encounters non-erodible material within the sand body. In which case, there is no longer sand available to sustain the momentum of the density currents driving the growth of the flow slide event;
- Non-erodible layers present in the sand slope above the point of flow slide initiation become undermined and collapse in sufficient quantity down into the bowl-shaped failure area - thereby diffusing the density currents and armouring the near-vertical advancing sand wall.

As noted in Appendix F, the geophysical survey results indicate that there is a very large volume of rock (and other non-erodible material) placed by foreshore property owners into the shoreline of the Central Reach in recent decades. Even though Rainbow Channel has been migrating eastward towards Amity Point, resulting in deeper and steeper seabed slopes in front of the foreshore (with resulting greater vulnerability of the foreshore to flow slides), there have been fewer large failure events in recent years. This is very likely due to the blocking effect of the rock barrier that has been progressively reinforced by foreshore property owners.

In the past, whenever a flow slide event occurring on the submerged sand slopes of Rainbow Channel undermines any rocks placed previously, the buried rock mass slumps or collapses into the active flow slide region bringing the processes to an end. This typically manifests itself as a settling or dislodgement of rocks at the top of the slope. The response of local property owners is to then (and as soon as possible after the event) place additional rocks in the upper part of the collapsed rock slope. Consequently, the flow slide barrier made of rock has been progressively built along the foreshore of the Central Reach over many years. Each undermining event caused by deep flow slides locates the foundations of the barrier deeper; whilst the reserve of rocks higher in the structure (to accommodate any future slumping) is recharged by local property owners.

It is apparent from the structural audit of the flow slide barrier (refer outcomes in 4.3) that the depth of rock placement in the northern part of the Central Reach is such as to block the development of the flow slides that frequently occur immediately alongside. This is perhaps best illustrated by reference to Figure 6-1.

The flow slide event depicted in the figure has developed and penetrated into the unprotected sand foreshore to the north, but the existing rock barrier that has been progressively built on the frontage of the adjacent private property has prevented the flow slide developing into the land behind and on top of it. It is evident that the existing flow slide barrier is effective in limiting the development of the frequent flow slides that occur on the submerged side slopes of Rainbow Channel from developing into destructive events.

The flow slide barrier would only continue to be an effective means of mitigating the effects of flow slides if a process is formalised that enables recharging the upper sections of the structure with rock whenever it is locally undermined by a flow slide event.



FIGURE 6-1 EXISTING FLOW SLIDE BARRIER INHIBITING DEVELOPMENT OF FLOW SLIDES

SEAWALLS

The existing rock flow slide barrier at Amity Point has at times been referred to as a "seawall". This is not strictly correct, as a seawall is typically a foreshore protection structure having the intended purpose of providing defence against adverse erosion by waves. A seawall is a conventional response to conventional erosion processes. The rock within and along the foreshore of the Central Reach does provide protection against severe wave action. However, its' primary function is not to protect the foreshore from waves, but rather to prevent flow slides on the side slopes of Rainbow Channel from developing to destructive proportions.

Consequently, a seawall along the foreshore of the Central Reach (as opposed to a flow slide barrier) is not a relevant strategy.

SEAWALLS WITH BEACH NOURISHMENT

The depth of water in Rainbow Channel immediately in front of the existing flow slide barrier prohibits any strategy relying on beach nourishment to prevent or inhibit the cause of the erosion threat on the Central Reach – namely flow slides.

GROYNES

The construction of groynes (either submerged or otherwise) along this foreshore will neither prevent nor inhibit flow slides.

GROYNES WITH BEACH NOURISHMENT

As discussed above, neither the construction of groynes (either submerged or otherwise) or beach nourishment along this foreshore will not prevent nor inhibit flow slides. A strategy combining both options is also not viable.

6.2.3 Further Research and Investigation

The underlying causes of shoreline erosion and its likely future progression require further investigations. To address this an assessment of groundwater flows and their potential, or actual contribution to shoreline erosion events and risks will be undertaken.

Council and the University of Queensland (UQ) are looking to invest in a future body of work examining possible trigger mechanisms and recovery processes associated with retrogressive slope failures. Studies are proposed to be carried out in the 2019/20 financial year. Through field investigations and modelling, UQ would investigate and understand the natural processes occurring at Amity Point which are contributing to the flow slide events, with the prospect of developing the capability of predicting such events and the processes and timescales involved in recovery.

Investigations to understand the local subsurface hydrological conditions including groundwater investigations needs to be carried out during the development of the SEMP Implementation Plan. Findings from further research and investigations carried out at Amity Point would be used to update, review and inform the current and proposed future management options.

6.3 Northern Reach - Amity Beach

As discussed in Section 4.6, the primary threat of shoreline recession to property fronting Amity Beach is the erosion that occurs because of the migrating erosion hot-spots induced by the changing morphology of the eastern sand spit. The complexity of the nearshore bathymetry (including the dynamic sand spit and offshore sand banks), in conjunction with the complexity of the natural littoral transport processes, means that it is extremely difficult at present to predict future beach changes at a specific location – such as on the private property frontages of Amity Beach.

6.3.1 Non-structural Management Options

DO NOTHING

A "do-nothing" strategy is somewhat aligned to one of maintaining the status quo. There have been no significant interventions undertaken to address the natural cycles of erosion and accretion of this foreshore. However, some local property owners in Old Ballow Street have undertaken vegetation planting and dune enhancement activities (such as using cut vegetation as barriers to mitigate wind-blown sand losses). These measures assist in stabilising a sand dune at the rear of sections along this beach, which in turn adds to the resilience of the foreshore to accommodate storm-induced erosion.

A strategy of maintaining the status quo on this coastal precinct entails letting natural coastal processes continue to shape this foreshore; and accepting that sections will erode from time to time. However, it is pertinent to note that this north-west corner of North Stradbroke Island has experienced considerable erosion in the past. The most adverse erosion phase occurred when the dynamic South Passage had quite a different morphological and bathymetric regime than at present.

The shifting bathymetry of South Passage, in conjunction with any variability in the natural supply of littoral sediments from Flinders Beach, means that the local foreshore will always experience the vagaries of natural long-term erosion and accretion processes that shape Amity Beach. At the moment, there are no significant erosion threats to private infrastructure, but that could change. Future monitoring of the behaviour of Amity Beach would assist considerably in better understanding beach performance and identifying any emerging erosion threats.

AVOID DEVELOPMENT

Statutory erosion prone areas are declared under section 70 of the *Coastal Protection and Management Act 1995* (Coastal Act) by reference to specific erosion prone area plans produced by the Department of Environment and Heritage Protection (recently gazetted as the Department of Environment and Science). The plans are used for development assessment purposes, and to inform the preparation of planning instruments, such as planning schemes and regional plans under the *Planning Act 2016.*

There is currently a 145-metre-wide erosion prone area designated along Amity Beach[22]. The Coastal Protection (Erosion Prone Areas) overlay of Council's *City Plan* incorporates this buffer. Development for a dwelling house, dual occupancy or community residence on affected land is code assessable, to ensure that this area is not inappropriately developed.

[22] "*Erosion Prone Area Linear Distances and their Locations for Redland City Local Government Area*". REC3A Map 3 Segment Number 010. https://www.ehp.qld.gov.au/coastal/development/assessment/pdf/redland-erosion-prone-area-plan.pdf. Accessed September 2016.

PLANNED RETREAT

At the moment, the extent of foreshore erosion processes is such that there is no merit in considering relocation of private or public infrastructure along the Northern Reach.

BEACH NOURISHMENT

The foreshore of the Northern Reach is subjected to quite significant erosion and accretion processes. The scale of local natural short-term and long-term sand transport processes are considerable. Any sand placement undertaken by beach nourishment campaigns would be ineffectual unless they encompassed the entire length of this Northern Reach. This would require extremely large sand volumes. Consequently, the very high cost of beach nourishment, along with its transient benefits, means that it is not a viable strategy for the Northern Reach.

BEACH RE-PROFILING

As discussed in Section 4.6, the erosion threat along the Northern Reach is heightened at migrating erosion "hot-spots". These are related primarily to the changing morphology of the sand spit that occurs at the eastern end of this coastal reach. When circumstances result in an erosion hot-spot moving onto the foreshores of local properties, beach profiling could provide some short-term benefit to foreshore properties that experience significant erosion during severe storms.

Reinstating sand reserves in local sand dunes improves their natural resilience and effectiveness to act as erosion buffers. However due to the large scale of natural coastal processes shaping this shoreline, such dune reinforcement would be short-lived – as the sand would soon be dispersed throughout the active beach system of the Northern Reach and beyond.

Nevertheless, beach scraping could provide an effective means of reinforcing natural dune buffers in anticipation of an erosion hot-spot migrating onto local properties. This would require monitoring of natural beach processes so as to better understand and predict localised erosion threats on Amity Beach.

CHANNEL RELOCATION

The discussion in Section 6.1.1 regarding the viability of this option for mitigating the erosion threat along the Southern Reach is relevant to the Northern Reach as well. A management strategy of redirecting the Rous and Rainbow Channels to mitigate the erosion threat along Amity Beach is not environmentally nor financially feasible.

6.3.2 Structural Management Options

FLOW SLIDE BARRIER

The only section of the Northern Reach vulnerable to flow slide events is at its western-most end, where the flow slide barrier of the Central Reach terminates (refer Figure 3-9). Indeed, due to the orientation of Rainbow Channel (in conjunction with the prevailing littoral processes of sand supply to this location) this area is particularly prone to flow slide events. This situation is likely to continue; and flow slides might in fact increase in frequency here as Rainbow Channel migrates eastward and comes up against the existing flow slide barrier of the Central Reach.

It is pertinent to note however that due to the longshore supply of sand from the east, the foreshore and nearshore bathymetry at this location are soon reinstated following flow slide events.

Provided the existing flow slide barrier to the immediate south is maintained so as to continue its function of inhibiting development of destructive failures, then it will tend to restrict the scale of any flow slide events that might occur on the sandy foreshore of Amity Beach immediately alongside it.

If the beach at the western-most end of the Northern Reach is to be immediately protected from the fluctuations induced by frequent flow slides, then a rock barrier comparable in scale to that along the Central Reach would need to be buried within this section of foreshore as well. This would entail significant construction works (at very significant cost) if such a structure was to be built in one construction campaign.

Furthermore, given the large scale of those works it is likely that the construction activity would require considerable vegetation clearing. This could result in a greater impact on local terrestrial values (including local koala communities) than flow slides - at least until appropriate revegetation following completion of the barrier's construction matures. Elsewhere along Amity Beach there is no need for a flow slide barrier, as there is no threat posed by such events.

SEAWALLS

As noted elsewhere, Amity Beach is subjected to quite significant erosion and accretion processes. The scale of local natural short-term and long-term sand transport processes are very considerable. A seawall to protect the foreshore would need to be a large robust structure buried at the back of the existing beach alignment. As most of this foreshore is State Land and zoned as *Conservation* by Redland City Council, approval for such major protection works would not be forthcoming. The Queensland Government maintains a policy of not protecting unallocated state land with seawalls.

Local residents could elect to build a buried seawall completely within their property and immediately alongside their seaward boundaries. However, such works would prove to be largely ineffective should the foreshore of Amity Beach recede during a major storm event, unless it was properly designed and constructed so as to also protect sections of side boundaries. Leaving aside the issue of unlikely approval for a seawall to protect State Land, the enormous cost of the structure means that it is not a viable strategy for the Northern Reach.

SEAWALLS WITH BEACH NOURISHMENT

This option is not viable for the reasons given above for each of the seawall and beach nourishment options.

GROYNES

As noted elsewhere, Amity Beach is subjected to quite significant erosion and accretion processes. The scale of local natural short-term and long-term sand transport processes are very considerable. The construction of groynes alone would not offer any long-term benefits to this foreshore.

GROYNES WITH BEACH NOURISHMENT

This option is not viable for the reasons given above for each of the groyne and beach nourishment options.

6.4 Assessment Methodology

6.4.1 Values to Guide the Assessment

In order to assess all of the various erosion management strategies that could be applied to each of the three coastal reaches, a methodology has been applied which rates their impacts and implications against environmental, social, economic and legislative principles and values. Each of these four important criteria are considered of equal value in the assessment of the erosion management options.

- *Environmental Values*: This consideration relates to the importance of biological diversity and ecological integrity of the local coastal environment of Amity Point. It considers the abundance, diversity, physical distribution and the productivity of terrestrial and marine flora and fauna - at both species and ecosystem levels. The maintenance of these values can be achieved by appropriate avoidance or management of adverse impacts.

- *Social Values*: The concept of social values has a very broad definition, but in the context of the Amity Point SEMP it encompasses the sense of community; connectedness; along with the personal and community health and wellbeing felt by all residents. This includes the indigenous and non-indigenous members of the Amity Point community and the wider North Stradbroke Island community.
- *Economic Considerations*: Implementation of erosion mitigation strategies will invariably involve financial implications. These will include the direct costs of initial expenditure; subsequent maintenance and/or upgrading costs; as well as any offsets by the indirect financial benefits that may flow through to the local community by the implementation of a particular strategy.
- *Legislative Considerations:* To ensure that erosion mitigation strategies are consistent with planning and legislative requirements of Commonwealth, State and Local governments it is necessary to have appropriate regard for the full range of legislation that controls activities in the coastal zone. The extent to which such strategies comply with such requirements varies and is an important consideration when selecting the preferred option.

6.4.2 Assessment Criteria

Within each of the above categories, several assessment criteria have been assigned. These are presented in Figure 6-2. A further refinement is made to this rating methodology by giving each of the assessment criteria within a particular category a weighting. The weighting reflects the relative importance of each to the others.

This application of a weighting methodology is perhaps best explained by reference to Figure 6-2. For example, the *Social* category has three assessment criteria namely: maintaining social values; visual amenity; and foreshore access and amenity.

A weighting of 75%, 10% and 15% has been applied to those criteria respectively. This is in recognition that maintaining social values (that for instance include a strong and robust connectedness with the Amity Point community, along with a shared sense of place and belonging) rates far more importantly than providing an erosion mitigation strategy that is visually appealing (visual amenity) or provides for ready access and use of the immediate foreshore (foreshore access and amenity).

The various weightings were determined by consideration of the feasibility and technical merits of each option; along with regard to issues identified as being important to all stakeholders. This later aspect was achieved by way of the following:

- Discussions with members of the Project Reference Group, both collectively and individually;
- One-on-one meetings or telephone interviews with occupants and owners of foreshore homes;
- One-on-one meetings with residents of Amity Point who responded to offers of engagement;
- Feedback captured during discussions with (and in written responses offered by) attendees at the project's Open House community engagement event at Amity Point Community Hall in April 2016;
- Meetings and discussions with relevant Redland City Council officers; and
- Meetings and discussions with relevant State Government agencies.
- The assessment methodology, weightings and outcomes of the MCA were endorsed at an *Amity Point SEMP Community Reference Group Workshop* held at Cleveland on 01st September 2016.

	category weighting	Assessment Criteria	criteria weighting
environmental	*1*	Maintaining coastal processes	*0.40*
		Maintenance of Marine Values	*0.30*
		Maintenance of Terrestrial Values	*0.30*
social	*1*	Maintenance of Social Values	*0.75*
		Visual amenity	*0.10*
		Foreshore access and amenity	*0.15*
economic	*1*	Planning & design costs	*0.10*
		Initial implementation cost (direct & indirect)	*0.67*
		Ongoing financial cost (direct & indirect)	*0.23*
legislative	*1*	Compliance with State Coastal Policy	*0.50*
		Compliance with other legislation/policies	*0.20*
		Complexity of approval (inc. costs)	*0.30*

FIGURE 6-2 ASSESSMENT CRITERIA AND WEIGHTING

In order to rate the various erosion mitigation, for each a score is intuitively assigned to each of the assessment criteria using a numerical scale as follows:

- 0 = unacceptable
- 1 = very poor
- 2 = poor
- 3 = neutral
- 4 = good
- 5 = very good

That is, the higher the score, the more appropriate or desirable is the option's outcome. Should an erosion mitigation strategy score a zero (i.e. *unacceptable*) against any of the criteria whatsoever, that strategy is deemed unacceptable.

An overall weighted score for each mitigation option is obtained by multiplying the individual scores by their assigned criteria weighting; and then adding them all together for that option. The preferred erosion mitigation option then emerges as that having the highest overall weighted score.

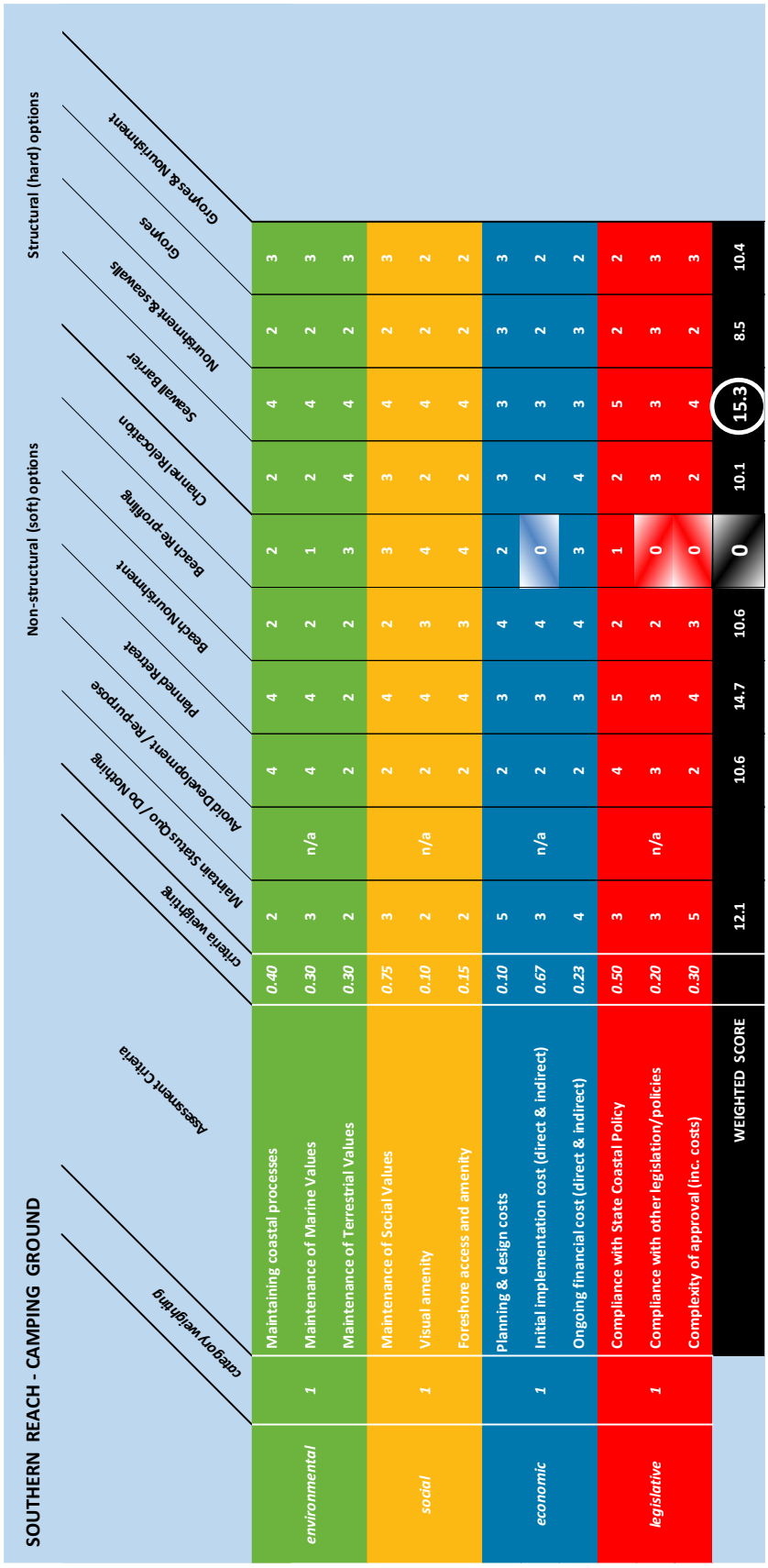


FIGURE 6-3 ASSESSMENT FOR THE SOUTHERN REACH – CAMPING GROUND

4193-01_R03v07

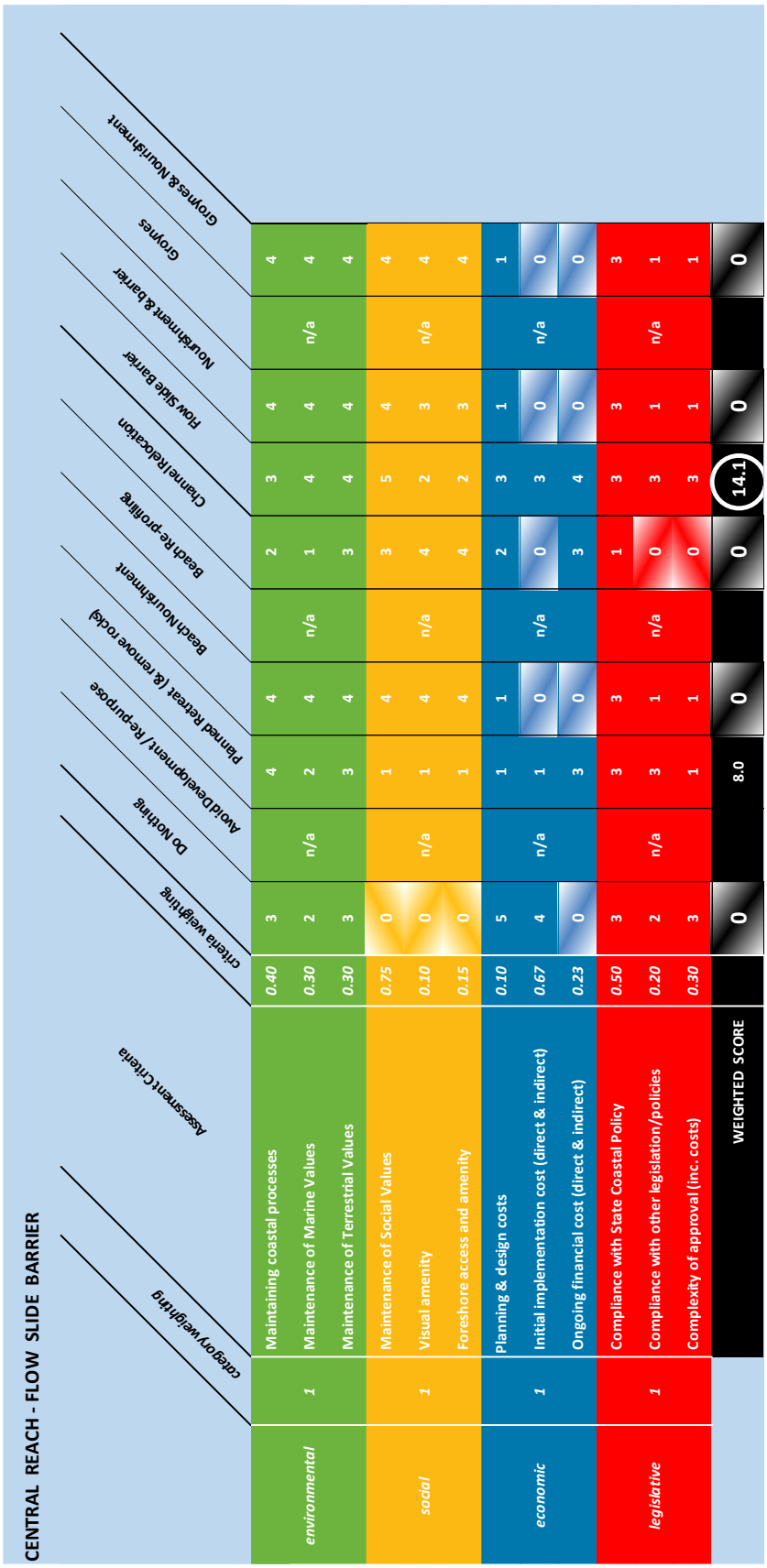


FIGURE 6-4 ASSESSMENT FOR THE CENTRAL REACH – FLOW SLIDE BARRIER

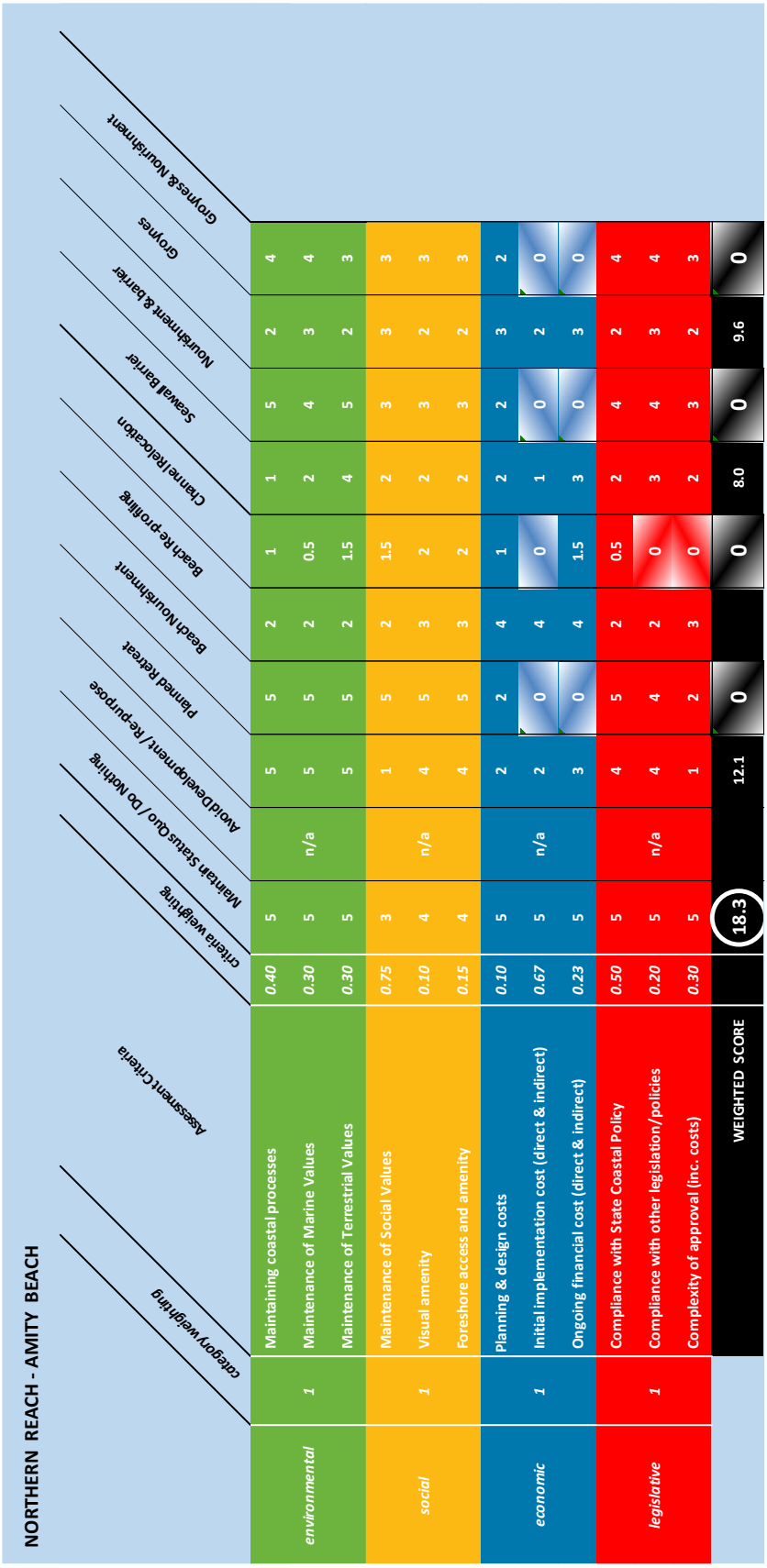


FIGURE 6-5 ASSESSMENT FOR THE NORTHERN REACH – AMITY BEACH

6.4.3 Assessment Outcomes

The outcome of this assessment methodology is the emergence of the following preferred erosion management strategies:

- For the Southern Reach: Figure 6-3 : Beach nourishment with a seawall
- For the Central Reach: Figure 6-4 : Flow Slide Barrier
- For the Northern Reach: Figure 6-5 : Maintain the existing strategy of non-intervention, but monitor future shoreline behavior.

Each of these preferred strategies are discussed in more detail in Section 9 of this report.

7. STAKEHOLDER CONSULTATION AND ENGAGEMENT

7.1 Methodology

Extensive consultation with stakeholders formed an important component in the development of the Amity Point Shoreline Erosion Management Plan.

Consultation with the local Amity Point community was identified by Redland City Council as a critical component in the determination of an appropriate SEMP and was written into the Terms of Reference for the study. To assist in this consultation process, and to contribute expertise and local knowledge to shoreline erosion planning for Amity Point, Council facilitated the establishment of the *Amity Point SEMP Community Reference Group* (Reference Group). The Reference Group consists of local community members and groups who expressed an interest in the SEMP process and nominated to become a member.

It includes members drawn from foreshore property owners, the local residential community, the wider North Stradbroke Island community, the Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC), various community groups and Council officers. Its role is defined in the specific Terms of Reference as follows:

> *"Members of this reference group will:*
>
> - *Be briefed on Council and State policy requirements for coastal protection and management, and the three-stage consultation and engagement process during the completion of the SEMP, including preparation of a Draft Implementation Plan;*
> - *Contribute advice, information and insight on shoreline erosion and practical management options based on personal and professional knowledge and experience of local conditions and community economic, cultural, historical and environmental considerations;*
> - *Independently review and comment on existing technical data, and any further shoreline erosion research, as it becomes available;*
> - *Share information and reports on the progress and direction of the SEMP action planning process to relevant community networks. "*

Several formal meetings of the Reference Group and the SEMP Study Team were convened during the study which assisted in the development of the SEMP. However, members also contributed individually throughout the study.

The SEMP Study Team also engaged with the local Amity Point community by way of:

- One-on-one meetings with occupants and owners of foreshore homes, either at Amity Point or on the mainland (for non-resident property owners);
- Telephone interviews with non-resident property owners;
- One-on-one meetings at Amity Point with residents and other interested people who responded to offers of engagement, often meeting several times with individuals;
- Discussions with (and in written responses offered by) attendees at the project's Open House community engagement event at Amity Point Community Hall in April 2016.

Redland City Council commissioned the preparation of the Amity Point Shoreline Erosion Management Plan and as such provided essential input and guidance to the SEMP Study Team. This was facilitated by many formal and informal meetings, discussions and an internal Council workshop.

During the preparation of the SEMP, various state government departments and agencies were consulted and kept informed of emerging outcomes as the SEMP was developed. On 12th December 2017 the Queensland State Government gazetted some new Departmental name changes. The key agencies that were consulted during the preparation of this SEMP are listed below under their previous Departmental names, with reference made to the new Departmental names:

- Queensland Department of Environment and Heritage Protection (now Department of Environment and Science)
- Queensland Department of National Parks, Recreation, Sport and Racing (now abolished, with relevant responsibilities with the Department of Environment and Science)
- Queensland Department of Science, Information Technology and Innovation (now abolished, with relevant responsibilities with the Department of Environment and Science)
- Queensland Department of Agriculture and Fisheries (this Departmental name is retained)
- Queensland Department of Natural Resources and Mines (now Department of Natural Resources, Mines and Energy)

7.2 Community Response

It was very evident that there is considerable interest in the development of the Amity Point Shoreline Erosion Management Plan. This includes members of the Amity Point community who are not part of the SEMP Reference Group, as well as people from elsewhere on North Stradbroke Island.

There is significant enthusiasm in the Amity Point community with regard to being involved in strategic planning projects within their township - which reaffirms the value and importance of engaging with the community during the development of this Shoreline Erosion Management Plan.

Appendix C provides a summary of the Open House engagement that took place on Saturday 23 April, 2016 at the Amity Point Community Hall. It captures the issues of most concern to the local community, namely:

- There is a considerable erosion threat, and that this is not only to the existing foreshore, but to the wider environs of Amity Point.
- The erosion threat is a consequence of complex and dynamic natural processes.
- There is a need to protect existing private and public assets.
- There is a need to provide an enduring solution to the erosion threat.
- The cost of any mitigation strategy should be shared equitably by those who benefit.

8. PLANNING AND LEGISLATION REVIEW

8.1 Background

The *Amity Point Shoreline Erosion Management Plan* sits within the context of Commonwealth and State legislation and Redland City Council's local planning policies. This section provides a summary of the key legislative and planning requirements that may impact how coastal erosion is managed in the study area, and how the recommendations of the SEMP are affected by those requirements.

The basis and control of management of Queensland's coast is governed by the *Coastal Protection and Management Act 1995* (Coastal Act) and the *Planning Act 2016*. Under these Acts, the Coastal Management Plan (CMP), the Coastal Protection State Planning Regulatory Provision (Coastal SPRP), the State Planning Policy (SPP) and the State Development Assessment Provisions (SDAP) are the primary statutory planning instruments for development planning and assessment.

Legislation and policies considered in this SEMP require consideration of issues including, but not limited to:

- The use of coastal structures for property protection,
- Protection of species listed under State and Commonwealth legislation and conservation of their habitat,
- Management of shoreline erosion in a manner that is not detrimental to the adjacent Moreton Bay Marine Park, and
- The maintenance of local biodiversity.

These legislative and policy considerations are described in more detail in the following sections.

8.2 Coastal Protection and Management Act 1995

The *Queensland Coastal Protection and Management Act 1995* (Coastal Act) governs the way coastal land is managed in Queensland. The main objects of this Act are to:

- Provide for the protection, conservation, rehabilitation and management of the coastal zone, including its resources and biological diversity; and
- Have regard to the goal, core objectives and guiding principles of the National Strategy for Ecologically Sustainable Development in the use of the coastal zone; and
- Ensure decisions about land use and development safeguard life and property from the threat of coastal hazards; and
- Encourage the enhancement of knowledge of coastal resources and the effect of human activities on the coastal zone.

The primary means of achieving these management objectives under the Coastal Act is through regulation of developments and allocations, and the preparation of management plans.

The coastal zone includes Queensland's coastal waters (to 3 nautical miles from the coast); as well as land and waters landward of coastal waters to a limit of 5 km from the coast, or to 10 m AHD elevation, whichever is further inland. The entire study area of the Amity Point SEMP is within the coastal zone.

A coastal management district (CMD) has been declared under the *Coastal Act* over lots which are likely to be subject to inundation by tidal water or increased coastal erosion under future climate change. The CMD defines an area in which the Department of State Development, Manufacturing, Infrastructure, and Planning (DSDMIP) has assessment manager or referral agency powers and responsibilities to assess certain development

applications. The Department of Environment and Science (DES) is a technical advice agency to DSDMIP for development proposals in coastal management districts.

Coastal Management Districts are shown on development assessment maps held by DSDMIP, as well as on coastal hazard maps prepared by DES. The coastal hazard maps of relevance to Amity Point are included in Appendix D of this SEMP. The CMD at Amity Point incorporates many landholdings within the township, including all lots with coastal frontage.

Erosion prone areas are also declared over land vulnerable to short-term and long-term coastal erosion and tidal inundation. Such declarations are made under Part 4, section 70 of the *Coastal Act* by reference to erosion prone area plans that have previously been prepared by EHP (now DES). A 145-metre-wide erosion prone area has been declared over the entire Amity Point coastline under the *Coastal Act*. The statutory erosion prone area plan of relevance to the Amity Point SEMP is *REC3A Map 3*[23], which is also included in Appendix D.

The Queensland Government currently manages the coastal zone using the Coastal Management Plan (CMP) and the State Planning Policy (SPP). The Coastal Management Plan (prepared under the *Coastal Act* and commenced in 18 March 2014) provides non-regulatory policy guidance to coastal land managers (primarily local government) for the management of the coastal zone and works that are not assessable development under the *Planning Act 2016*.

The State Planning Policy (SPP) provides State interests with policies to be considered by land managers particularly when preparing planning schemes. State interests include the coastal environment, biodiversity and natural hazards (i.e. coastal erosion). In addition, the SPP also provides development assessment criteria. The policy applies to a range of interests relevant to the SEMP, including coastal protection, water quality, native vegetation clearing, Queensland heritage, wetlands and environmentally relevant activities.

8.3 Planning Act 2016

In July 2017, Queensland began operating under new planning legislation – the *Planning Act 2016*, which replaced the *Sustainable Planning Act 2009* (SPA). Development within the coastal zone is regulated under the *Planning Act 2016*. The Act provides a framework to integrate planning and development assessment so that development and its effects are managed in a way that is ecologically sustainable.

The *Planning Act 2016* mandates a state-wide, applicant-driven development assessment system, by which local governments (and state agencies in some circumstances) assess and make decisions on the various land-use and development proposals.

The *Planning Act 2016* provides for the crafting of documents that guide strategic planning and development throughout Queensland. The foremost document is the planning scheme, which is created by local government taking into account the aspirations of their communities and the state's interests. Each scheme specifies the levels of assessment for all defined land uses, and the assessment requirements for each. The local planning scheme identifies what development and land-use proposals require an approval from council and what proposals do not need an approval.

The *Planning Regulation 2017* supports the principal legislation by outlining the mechanics for the operation of the Planning Act. It deals with practical matters such as: how development is categorised, who will assess a development application, and the state interest matters for development. In most cases, local government is the assessment manager. However, where the state identifies that it has a particular interest through the

[23] *Erosion Prone Area Redland City Local Government Area - REC3A*. Date of erosion prone declaration, 8th July 2015. Available online: https://www.ehp.qld.gov.au/coastal/development/assessment/pdf/redland-erosion-prone-area-plan.pdf.

Planning Regulation, the state assesses those aspects of the development through the State Assessment and Referral Agency (SARA).

There are two statutory state planning instruments. These being:

- State Planning Policy (SPP) This instrument sets out the state planning matters considered as crucial to responsible land-use planning and development across the state. Councils must consider the state interests that apply to their local government areas when making, amending and implementing their planning schemes.
- Regional Plans. A regional plan focuses on the growth and development of a specific part of Queensland. Regional planning matters are identified in collaboration with local governments, key industry groups and the wider community. Where a regional plan exists, the local government must consider it when making or amending its planning scheme. The *South-East Queensland Regional Plan 2017* (DILGP, 2017) includes the local government area of Redland City Council, including Amity Point.

A summary of the Queensland planning framework is shown in Figure 8-1 (reproduced from Figure 28 of DILGP, 2017).

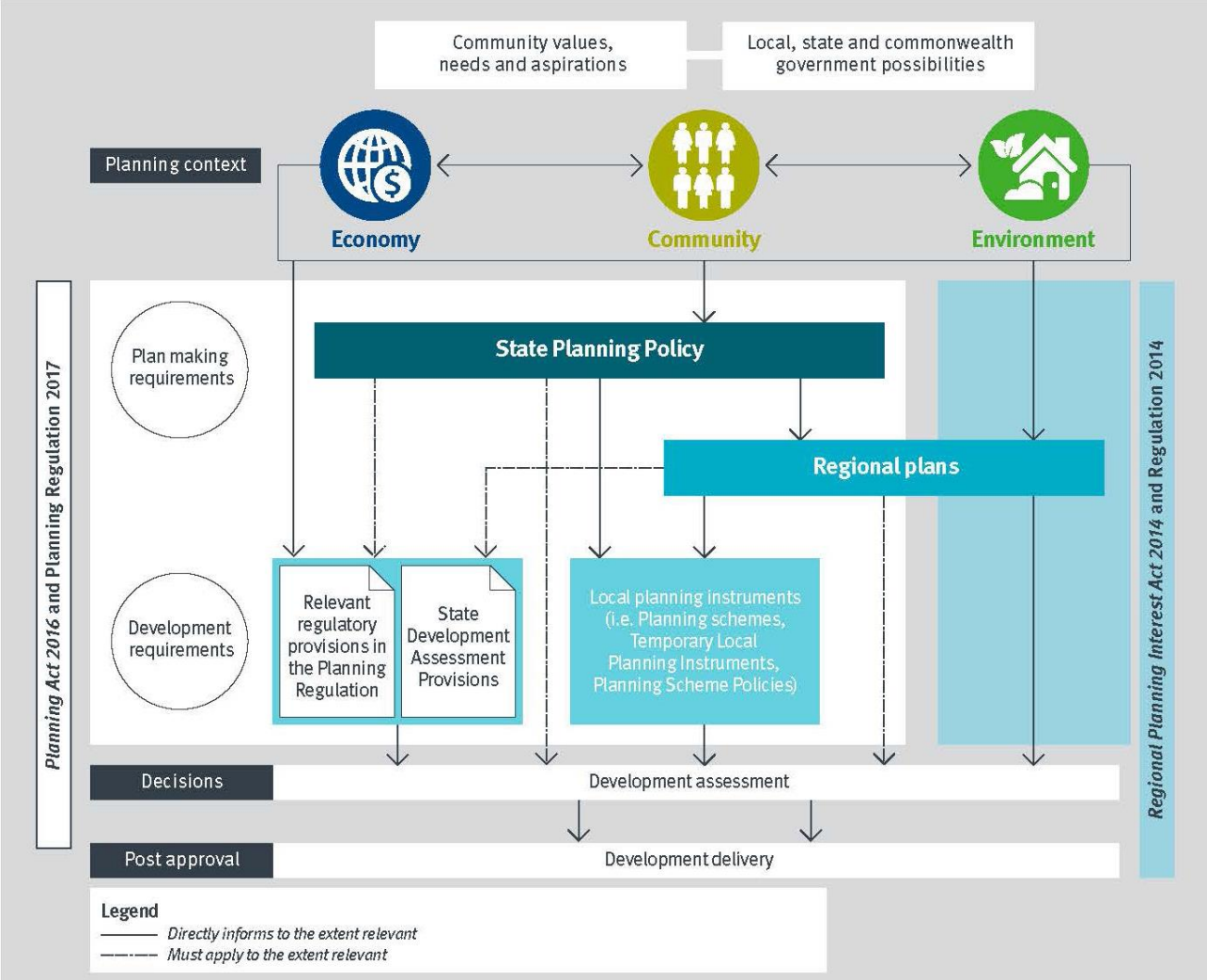


FIGURE 8-1 QUEENSLAND'S PLANNING FRAMEWORK

4193-01_R03v07

8.3.1 State Planning Policy (SPP) 2017

A new State Planning Policy (SPP) was introduced in July 2017 to replace a number of former state planning policies and instruments. The SPP is a statutory instrument which defines the Queensland Government's policies about matters of state interest in land use planning and development.

The SPP includes 17 state interests that must be considered in every planning scheme across Queensland. Each of the 17 state interests in the SPP is supported by guidelines which help councils to implement the SPP provisions. State interests are arranged under five broad themes. Those relating to the Amity Point SEMP include:

Environment and heritage

- *Biodiversity*
  - *Matters of environmental significance are valued and protected, and the health and resilience of biodiversity is maintained or enhanced to support ecological integrity*
- Coastal environment
  - *The coastal environment is protected and enhanced, while supporting opportunities for coastal-dependent development, compatible urban form, and maintaining appropriate public use of and access to (and along) state coastal land.*
- Cultural heritage
  - *The cultural heritage significance of heritage places and heritage areas, including places of Aboriginal and Torres Strait Islander cultural heritage, is conserved for the benefit of the community and future generations.*
- Water quality
  - *The environmental values and quality of Queensland waters are protected and enhanced.*

Safety and resilience to hazards

- Natural hazards, risk and resilience
  - *The risks associated with natural hazards, including the projected impacts of climate change, are avoided or mitigated to protect people and property and enhance the community's resilience to natural hazards.*

Liveable communities and housing

- Liveable communities
  - *Liveable, well-designed and serviced communities are delivered to support wellbeing and enhance quality of life.*

The Department of State Development, Manufacturing, Infrastructure, and Planning (DSDMIP) provides mapping that spatially represents matters of state interest in the planning system. This is provided by way of two GIS (Geographic Information Systems) platforms: the *State Planning Policy Interactive Mapping System* (SPP IMS), which is a standalone mapping system, and the *Development Assessment Mapping System* (DAMS), which incorporates mapping used for a number of different functions in development assessment.

Both the SPP IMS and DAMS are updated as required to reflect the latest information and any relevant government policy and legislative changes.

8.3.2 State Development Assessment Provisions

Development applications concerning certain matters of interest to the state are referred to the State Assessment and Referral Agency (SARA). In assessing applications, the state refers to both the SPP and the State Development Assessment Provisions (SDAP). The SDAP is a statutory instrument prescribed by the Planning Regulation 2017, which sets out the matters of interest to the State government when assessing a development application as either an assessment manager or a referral agency for a development application. The state uses SDAP to deliver a coordinated, whole-of-government approach to the state's assessment of development applications.

State Code 8: Coastal development and tidal works of the SDAP provides a state code for development in the coastal management district or for tidal works. The criteria outlined in State Code 8 will need to be followed in a development application for coastal erosion protection works, as such works will be located within the coastal management district. The assessment criteria in relation to erosion prone areas generally emphasise avoiding new development and intensification, avoiding disruption to existing coastal processes and adopting "soft" solutions to coastal protection in preference to "hard" erosion control structures. Relevant performance outcomes (assessment criteria) include:

- Natural processes and the protective function of landforms and vegetation are maintained in coastal hazard areas.
- Erosion prone areas in a coastal management district are maintained as development free buffers, or where permanent buildings or structures exist, coastal erosion risks are avoided or mitigated.
- Development avoids or minimises adverse impacts on coastal resources and their values, to the maximum extent reasonable.
- Coastal protection work is undertaken only as a last resort where erosion presents an imminent threat to public safety or permanent structures.
- Development avoids adverse impacts on matters of state environmental significance, or where this is not reasonably possible, impacts are minimised and an environmental offset is provided for any significant residual impacts to matters of state environmental significance that are prescribed environmental matters.

Coastal protection work is only to be undertaken to protect permanent structures which cannot reasonably be relocated or abandoned from imminent adverse coastal erosion impacts. Coastal protection work should involve beach nourishment as a first priority. The construction of an erosion control structure should only be considered if it is the only feasible option for protecting permanent structures from coastal erosion and those structures cannot be abandoned or relocated. Coastal protection work to protect private structures should be located on private land where possible and should not increase the coastal hazard risk for adjacent areas.

8.3.3 SEQ Regional Plan

Statutory regional planning in South East Queensland (SEQ) has been accompanied by regulatory provisions since October 2004. The *South-East Queensland Regional Plan 2017* (also referred to as *ShapingSEQ*) sets out the strategic directions, principles and policies to manage regional growth and change in the most sustainable way – to protect and improve the quality of life in South-East Queensland.

As noted above, the State Planning Policy (SPP) sets out the Queensland Government's interests in planning and development for Queensland. *ShapingSEQ* refines these state interests to provide the planning and decision-making framework for how the SPP will be applied cross the twelve local government areas in South-East Queensland (SEQ) to achieve desired planning outcomes.

Under the Planning Act 2016, the SPP prevails where there is any inconsistency with a regional plan. *ShapingSEQ's* strategies and sub-regional directions are consistent with the SPP. The SPP and *ShapingSEQ*

perform complementary roles - where *ShapingSEQ* provides the basis for prioritising, qualifying or resolving the state interests in SEQ. As such, *ShapingSEQ* advances the SPP in response to the region's projected growth, community expectations, values, opportunities and constraints.

The Plan is perhaps best defined as follows[24] :

> *ShapingSEQ sits within Queensland's planning framework and informs:*
>
> - *the making and amending of local government planning schemes*
> - *infrastructure planning, prioritisation and funding decisions made by state and local government, and other infrastructure agencies*
> - *other plans and programs, including non-statutory processes, that may influence change and growth management in SEQ, including natural resource management*
> - *the assessment of certain development applications made under the Planning Act 2016*
> - *the assessment of certain types of resource activities or regulated activities as defined under the Regional Planning Interests Act 2014.*
>
> *ShapingSEQ advances a range of state interests defined in the State Planning Policy (SPP) by providing a spatial context, defining key outcomes, and establishing planning strategies and directions to achieve these outcomes in response to SEQ's unique values, drivers, expectations, projections and constraints.*
>
> *The Planning Regulation 2017 contains SEQ regulatory provisions to ensure that particular forms of development in SEQ are consistent with ShapingSEQ policy.*

Regulation plays a critical role in ensuring *ShapingSEQ* policy is delivered through development assessment. In the recently superseded South-East Queensland Regional Plan 2009-2031, regulation was delivered through the state planning instrument known as State Planning Regulatory Provisions (SPRP). With the adoption of the Planning Act 2016 on 3 July 2017, SPRPs were repealed and their regulatory provisions transitioned into the Planning Regulation 2017. The Planning Regulation 2017 now contains the regulatory provisions for *ShapingSEQ*.

8.4 Coastal Management Plan

The Coastal Management Plan (CMP) seeks to manage all coastal land and coastal resources within the coastal zone as defined by the *Coastal Act*. It applies to all management planning, activities, decisions and works that are not assessable development under the SP Act, including the development of a SEMP.

The guiding principle for the management of coastal landforms and processes is to preserve the long-term stability of dunes and other natural coastal landforms; and to allow physical coastal process including erosion, accretion and the movement of sediment to occur without interruption. However, the plan acknowledges that erosion can threaten communities and infrastructure. In this case, the CMP specifically calls for a shoreline erosion management plan (SEMP) to deliver a science-based solution to the erosion problem that considers social, environmental and economic issues.

Other matters on which the CMP provides policy guidance include:

- Conserving matters of state environmental significance (MSES),
- Maintaining and enhancing the connection of Aboriginal People and Torres Strait Islanders to coastal and marine resources,

[24] Refer to https://dilgpprd.blob.core.windows.net/general/shapingseq.pdf, accessed 18th December 2017.

- Maintaining and enhancing public access and use of the coast,
- Ensuring continuous improvement in management outcomes through planning, monitoring, reporting and review, and
- Sharing knowledge of coastal resources and management with the community and engaging the community in decision making processes.

8.5 Other Legislation and Approvals

8.5.1 Commonwealth Legislation

EPBC Act

The *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) is the Federal Government's key piece of environmental legislation. It is designed to protect matters of national environmental significance (MNES). Within the study area of Amity Point, MNES in the SEMP study area include:

- Moreton Bay Wetlands (wetlands of international importance under the Ramsar Treaty)
- Listed threatened species
- Migratory species

The fifty listed threatened species and the seventy-two listed migratory species protected by the *EPBC Act* within the study area are listed in Appendix E. Approval from the Minister responsible for the *EPBC Act*[25] is required to take any action (e.g. project, development, activity) that is likely to result in a significant impact on a MNES.

Native Title Act 1993

The *Native Title Act 1993* provides for the recognition and protection of native title in Australia. It is a recognition by Australian law that indigenous people have rights and interests to their land that derive from their traditional laws and customs. Native title determinations are undertaken in the Federal Court, upon application by a native title claimant.

The Quandamooka People filed applications in 1995 and 1999 for recognition of native title rights interest over land and waters on and surrounding North Stradbroke Island, and some islands in Moreton Bay. A consent determination on both submissions was made in July 2011 and recognised the Quandamooka People's native title rights and interest to 54,408 hectares of land and waters, including areas of national parks, reserves, unallocated State land and other leases. The determinations recognise the Quandamooka people's rights amongst others to:

- live and be present on the determination areas;
- conduct traditional ceremonies;
- take, use, share and exchange traditional natural resources;
- conduct burial rites, teach about the physical and spiritual attributes of the area; and
- maintain places of importance and areas of significance.

The area includes exclusive native title rights to 2,264 hectares of land; and non-exclusive native title rights to 22,639 hectares of land and 29,505 hectares of offshore areas

[25] Currently administered by the Commonwealth Department for the Environment and Energy.

The exercise of native title rights in the exclusive-use areas is subject to the traditional laws and customs practised by the Quandamooka people. The Quandamooka people therefore have exclusive rights to possess, occupy, use and enjoy the area to the exclusion of all others. Such exclusive use areas are also subject to all other Australian laws including underlying land tenure and related building, planning and environmental regulations and the local laws that cover North Stradbroke Island. Only some of those rights are recognised in non-exclusive native title areas.

Figure 8-2 below shows the areas[26] near Amity Point on which consent determinations for Exclusive Use native title have been made. This includes land within the Northern Reach of the SEMP study area, including part of the ocean frontage along Amity Beach.

Figure 8-3 shows the areas[27] near Amity Point on which consent determinations for Non-exclusive Use native title have been made. This includes land within the Southern Reach, including the ocean frontage of the camping ground (although this is not shown in its entirety on Figure 8-3).

The Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC) is the Registered Prescribed Body Corporate (PBC) under the *Native Title Act 1993* which manages the native title rights and interests of the Quandamooka People. Indigenous Land Use Agreements (ILUA) have been negotiated with the State of Queensland and Redland City Council to govern the management and use of land and waters within the native title claim areas.

The *Native Title Act 1993* sets out procedures for dealing with "future acts", which are proposals to use land or change administration or legislative arrangements in a way that affects native title rights and interests. Examples include grazing, horticulture, water diversion and mining licences and construction of public infrastructure. The procedures for future acts depend on the nature of the act, and generally require more consultation and negotiation for acts that have higher impact on native title rights and interests.

[26] Extract from Federal Court Order No. QUD6024/1999, dated 04th July 2011. Prepared in the Queensland District Registry, Federal Court Of Australia, Harry Gibbs Commonwealth Law Courts Building, Level 6, 119 North Quay, BRISBANE QLD 4000, Telephone 07 3248 1100.

[27] Extract from Federal Court Order No. QUD6010/1998, dated 04th July 2011. Prepared in the Queensland District Registry, Federal Court Of Australia, Harry Gibbs Commonwealth Law Courts Building, Level 6, 119 North Quay, BRISBANE QLD 4000, Telephone 07 3248 1100.

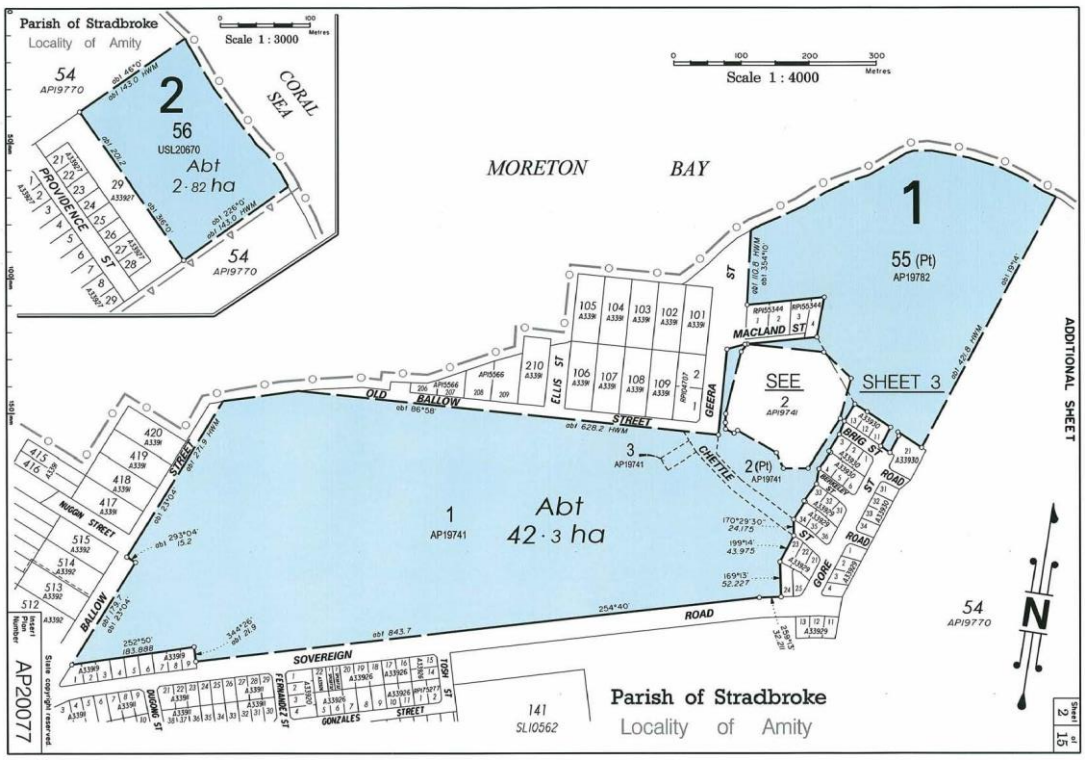


FIGURE 8-2 AREAS OF NATIVE TITLE DETERMINATION AT AMITY POINT - *EXCLUSIVE USE*

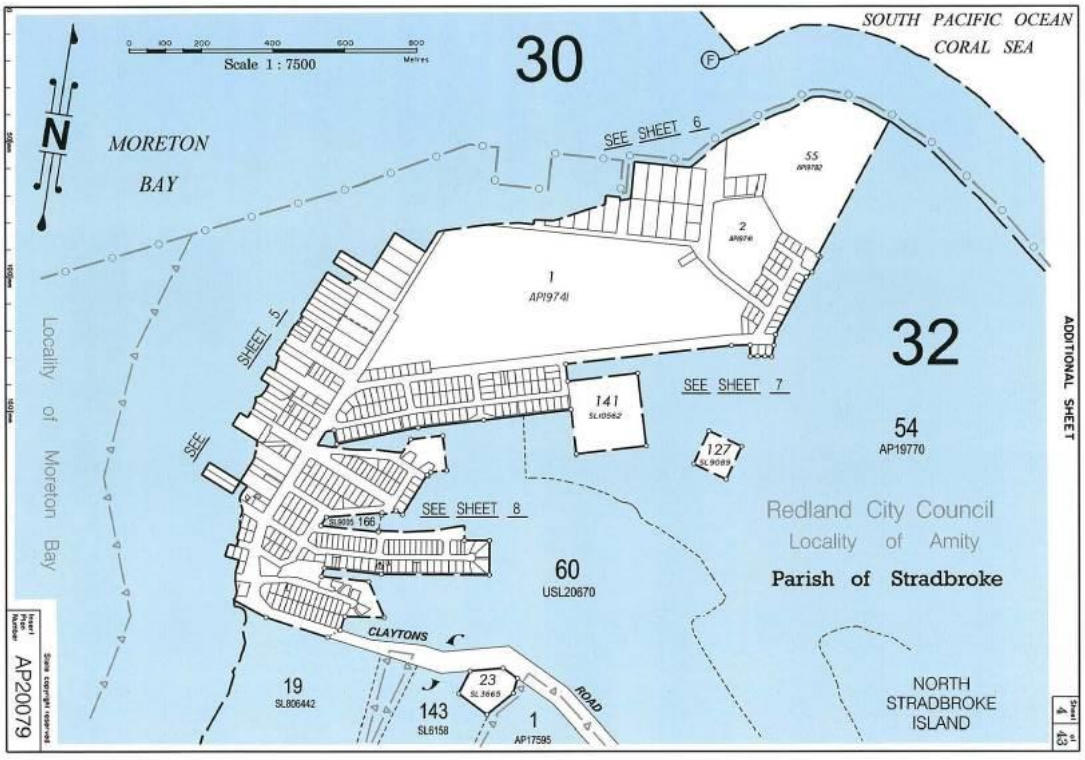


FIGURE 8-3 AREAS OF NATIVE TITLE DETERMINATION AT AMITY POINT - *NON-EXCLUSIVE USE*

4193-01_R03v07

8.5.2 State Legislation and Instruments

Matters of State Environmental Significance

Matters of State Environmental Significance (MSES) are a component of the state's biodiversity interests that are defined under the State Planning Policy. MSES includes certain environmental values that are protected under Queensland legislation, including the:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992*.
- Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the *Marine Parks Act 2004.*
- Areas within declared fish habitat areas that are management A areas or management B areas under the *Fisheries Regulation 2008.*
- Threatened wildlife under the *Nature Conservation Act 1992* and special least concern animal under the Nature Conservation (Wildlife) Regulation 2006.
- Regulated vegetation under the *Vegetation Management Act 1999* that is:
  - Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;
  - Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;
  - Category R areas on the regulated vegetation management map;
  - Areas of essential habitat on the essential habitat map for wildlife prescribed as 'endangered wildlife' or 'vulnerable wildlife' under the *Nature Conservation Act 1992;*
  - Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse map;
  - Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map.
- High preservation areas of wild river areas under the *Wild Rivers Act 2005*.
- Wetlands in a wetland protection area or wetlands of high ecological significance shown on the Map of Referable Wetlands under the *Environmental Protection Regulation 2008*.
- Wetlands and watercourses in high ecological value waters as defined in the *Environmental Protection (Water) Policy 2009, Schedule 2.*
- Legally secured offset areas.

MSES mapping represents the definition for MSES under the SPP. The mapping generates individual layers using information from data including, but not limited to:

- marine parks
- fish habitat areas
- regulated vegetation mapping
- Queensland wetland mapping
- protected areas
- legally secured offsets included in the 'offsets register'.

The State Government's MSES mapping product[28] is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirement of other Acts or regulations.

Nature Conservation Act 1992

The *Nature Conservation Act 1992* (the NC Act) relates to the protection of native flora and fauna and the declaration of protected areas. There are no protected areas designated under the Nature Conservation (Protected Areas) Regulation 1994 within the SEMP area.

The removal or destruction of native flora or fauna is unlawful unless it is authorised by a permit. If vegetation clearing is necessary for the purposes of implementing coastal protection works (including clearing to gain foreshore access) an appropriate permit under the NC Act must first be obtained. However, this does not apply to flora protected under the provisions of other Acts (e.g. marine plants).

Any clearing of koala habitat trees must be in accord with the *Nature Conservation (Koala) Conservation Plan 2006*.

Environmental Protection Act 1994

The *Environmental Protection Act 1994* (the EP Act) and the *Environmental Protection Regulation 2008* provide the main framework for controlling environmental harm and pollution resulting from development.

The EP Act establishes an environmental duty requiring entities to not cause adverse environmental effects unless all reasonable and practicable measures are undertaken to avert or lessen such harm. In the context of this SEMP, Redland City Council is under an obligation to not undertake any activities that cause, or are likely to cause, environmental harm unless it takes reasonable and practicable measures to prevent or minimise harm. Environmental protection policies (EPPs) are also prepared under the EP Act to protect Queensland's environment. The objective of an EPP is to protect the environmental values and quality objectives for several attributes of the environment - including water, noise, air and waste management.

Environmental values and water quality objectives within the *Environmental Protection (Water) Policy 2009* are defined in the specific plan titled *Moreton Bay environmental values and water quality objectives*[29].

Marine Parks Act 2004

The *Marine Parks Act 2004* (MP Act) establishes a framework for protecting the marine environment through the declaration of state marine parks. The Moreton Bay Marine Park has been declared by the MP Act as being over tidal waters and over tidal land up to the level of Highest Astronomical Tide. As noted in Section 3.2.1 of this SEMP, the level of Highest Astronomical Tide at Amity Point is RL+1.22m AHD.

The Moreton Bay Marine Park is managed under the *Marine Parks (Moreton Bay) Zoning Plan 2008*. The SEMP proposes works within a conservation zone of the Marine Park. While such works are not prohibited by the *Marine Parks (Moreton Bay) Zoning Plan 2008,* they will nevertheless require a marine park permit. Permits are obtained for such works from the Department of Environment and Science. The various zones near Amity Point are shown on Figure 8-4. Details regarding their objectives are provided in Table 8-1.

---

[28] Refer online at https://www.ehp.qld.gov.au/maps-imagery-data/online/

[29] Environmental Protection (Water) Policy 2009. *South-east Queensland Map Series Plan No. WQ1441*, dated July 2010. Available online at : https://www.ehp.qld.gov.au/water/policy/pdf/plans/moreton-bay-ev-plan-2010.pdf.

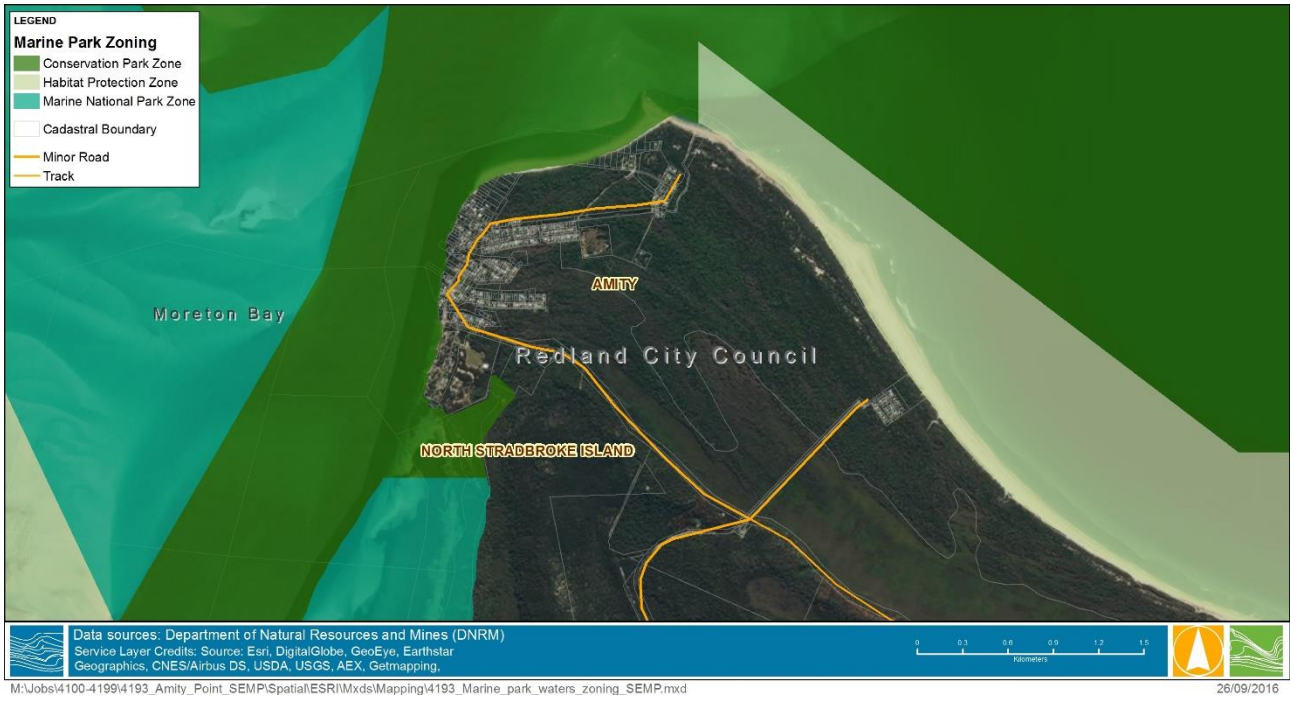


FIGURE 8-4 DESIGNATED ZONES OF THE MARINE PARK AT AMITY POINT

TABLE 8-1 OBJECTIVES OF MARINE PARK ZONES WITHIN THE SEMP AREA

Zone	Areas	Objectives
Conservation park (green)	Amity Point foreshore and Rainbow Channel	■ To provide for the conservation of the areas of the marine park within the zone ■ To provide opportunities for reasonable use and enjoyment, including, for example, limited extractive uses, of the areas.
Habitat protection (yellow)	Flinders Beach	■ To provide for the conservation of the areas of the marine park within the zone through the protection and management of sensitive habitats that are generally free from potentially damaging activities. ■ To provide opportunities for reasonable use of the areas.
Marine national park (aqua)	South of the foreshores of Amity Point Township	■ To provide for the protection of the natural integrity and values of the areas of the marine park that are generally dree of extractive activities. ■ To provide opportunities for particular activities, including, for example, the presentation of the values of the marine park, to be undertaken in relatively undisturbed areas within the zone.

Any application for works within the marine park must include other options that have been considered and the reasons they are not preferred. The assessment of shoreline erosion management options undertaken for this SEMP provides such rationale and can be used to support permit applications for the SEMP's recommended works within the Moreton Bay Marine Park.

Sections 43 and 44 of the *Marine Parks Regulation 2017* provide for the permittee to authorise another person to conduct an activity that is authorised under the permission, provided the permit has a condition to this effect. This would allow a marine park permit to be issued to Council for works within the marine park at Amity Point and for Council to authorise landowners to carry out the works when necessary.

As noted above, the boundary of the marine park is generally HAT with freehold land excluded. Works to protect private structures should be within the freehold land where possible. While the extension of works from freehold land (e.g. the toe of a seawall) into the marine park can be considered, reclamation extending into the marine park is not supported.

Recreational Areas Management Act 2006

Queensland has seven recreational areas established under the *Recreational Areas Management Act 2006,* including parts of North Stradbroke Island. In declared recreation areas, nature-based recreation is encouraged but is carefully planned and managed to protect these places for conservation. The Act outlines best practice whilst in a Recreation Area, as well as the penalties that apply for non-compliance.

In November 2011, those areas which had previously been managed under the Act by Redland City Council were declared the *Minjerribah Recreational Area*. Straddie Camping now manages these areas under a new management framework operated by Indigenous Business Australia in conjunction with the Quandamooka People. The Recreational Areas Management regulations apply to the Minjerribah Recreational Area to ensure that the island's foreshores, dune systems, bushland and freshwater systems are appropriately cared for to maintain their visual amenity, and to protect the island's unique natural and Aboriginal cultural heritage.

Those parts of the Minjerribah Recreational Area within the Amity Point SEMP area are shown in Figure 8-5. They include the Amity Point Camping Ground (south of the existing boat ramp), and the foreshore of Amity Beach down to Low Water Mark.

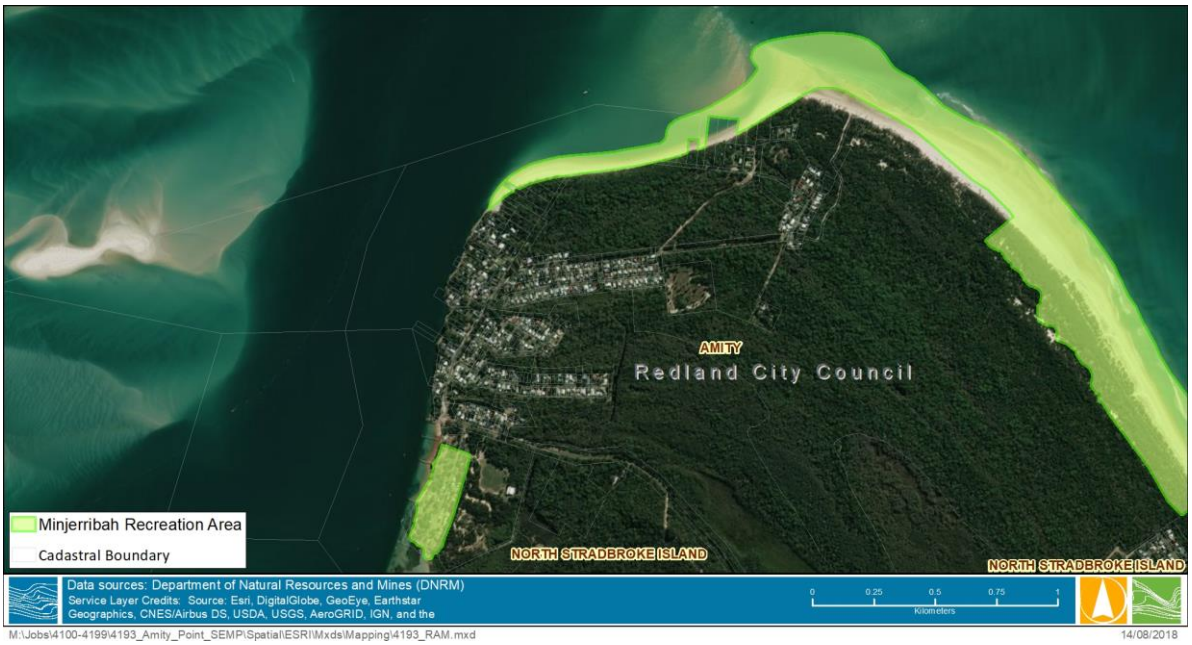


FIGURE 8-5 DESIGNATED MINJERRIBAH RECREATIONAL AREA

Fisheries Act 1994

The *Fisheries Act 1994* sets out Queensland's Department of Agriculture and Fisheries responsibilities for the economically viable, socially acceptable and ecologically sustainable development of Queensland's fisheries resources. A fish habitat area (FHA) is declared over the Myora-Amity Banks area - covering coastal waters offshore (adjacent to Rainbow Channel) and to the south of Amity Point. These areas are shown in Figure 8-6. Seagrass beds occur in these areas.



FIGURE 8-6 FISH HABITAT AREAS

All marine plants are protected under Queensland law through provisions of the *Fisheries Act 1994*. Approval is required under the *Planning Act 2016* for removal of marine plants and works in a declared fish habitat area.

The area of Amity Point prone to coastal erosion is not directly adjacent to the FHA or mapped seagrass areas. However marine plants may grow locally and will need to be assessed where works recommended under this SEMP occur.

Forestry Act 1959

Under the provisions of the *Forestry Act 1959,* the Department of Agriculture and Fisheries sells quarry material from land where such material has been reserved to the State - including in State forests, timber reserves, forest entitlement areas and State plantation forests. Sales permits are issued by the Department to enable local authorities, government agencies and private sector quarry operators to utilise State-owned quarry material.

Because the definition of 'mineral' in the *Mineral Resources Act 1989* excludes most materials used for construction purposes, quarry sites are mostly assessed, approved and administered by local government authorities. The *Planning Regulations 2017 - Schedule 10 (Environmentally relevant activities)* states that dredging or extracting more than 10,000 tonnes of material a year from the North Stradbroke Island Region is Prohibited Development.

Native Title (Queensland) Act 1993

The *Native Title (Queensland) Act 1993* is a state act which ensures that Queensland law is consistent with the Commonwealth *Native Title Act 1993* and validates pre-existing rights of the state. Certain past acts of the state, such as freehold grants, some leasehold grants, and public works are validated, such that they extinguish native title in relation to the land or waters concerned. Other rights such as existing ownership of natural resources, water and fishing access rights and public access to and enjoyment of beaches and other public places are confirmed by the act. Native title determinations and ILUAs made under the commonwealth's *Native Title Act 1993* are valid under this state Act.

Aboriginal Cultural Heritage Act 2003

In proclaiming the *Aboriginal Cultural Heritage Act 2003*, the state government provided statutory protection to all of Queensland's Aboriginal cultural heritage, irrespective of whether or not that heritage is known to land users.

To achieve this outcome, a formal statutory "duty of care" by which anyone carrying out any activity on any land (including freehold) anywhere in Queensland is required by law to take all reasonable and practicable measures to ensure their activity does not harm Aboriginal cultural heritage. Aboriginal cultural heritage values should not be confused with native title. As with non-Aboriginal heritage values, Aboriginal cultural heritage can exist on an area regardless of the nature of land tenure. The existence of Aboriginal cultural heritage in an area does not mean that native title exists over that area.

Compliance with the *Aboriginal Cultural Heritage Act 2003* should be determined at the planning stage of any coastal protection works. Guidelines relating to the duty of care required under the Act have been published by the Department of Aboriginal and Torres Strait Islander Partnerships[30].

Land Act 1994

The *Land Act 1994* regulates the management of non-freehold land for the benefit of the people of Queensland. The Act invokes principles of sustainable resource use and development, consideration of land capability, allowing sustainable development in the context of the State's planning framework, ensuring land is allocated to people or bodies who will facilitate the most appropriate use for the benefit of the people of Queensland, retention of land for community purposes, and protection of environmentally and culturally valuable and sensitive areas and features.

In coastal areas, this means that any development of land other than private freehold land must demonstrate a clear public benefit, or demonstrate resource allocation.

Vegetation Management Act 1999

The *Vegetation Management Act 1999* prohibits clearing of regional ecosystems (i.e. native vegetation communities) unless it is for a relevant purpose. Clearing may be exempt from the approval process where listed under Schedule 24 of the SP Regulation.

Mapping of regional ecosystems and remnant vegetation for Amity Point shown in Figure 8-7 and Figure 8-8. This shows that almost all the freehold land at Amity Point is either cleared or is non-remnant vegetation. Land further inland and along the Northern Reach behind Amity Beach is marked as essential habitat for protected species. This restricts clearing of vegetation in this area under any development approval.

[30] Aboriginal Cultural Heritage Act 2003. Duty of Care Guidelines. Gazetted date: 16 April 2004. Prepared by the Department of Aboriginal and Torres Strait Islander Partnerships. Available online at: https://www.datsip.qld.gov.au/resources/datsima/people-communities/cultural-heritage/duty-of-care-guidelines.pdf



FIGURE 8-7 REMNANT VEGETATION

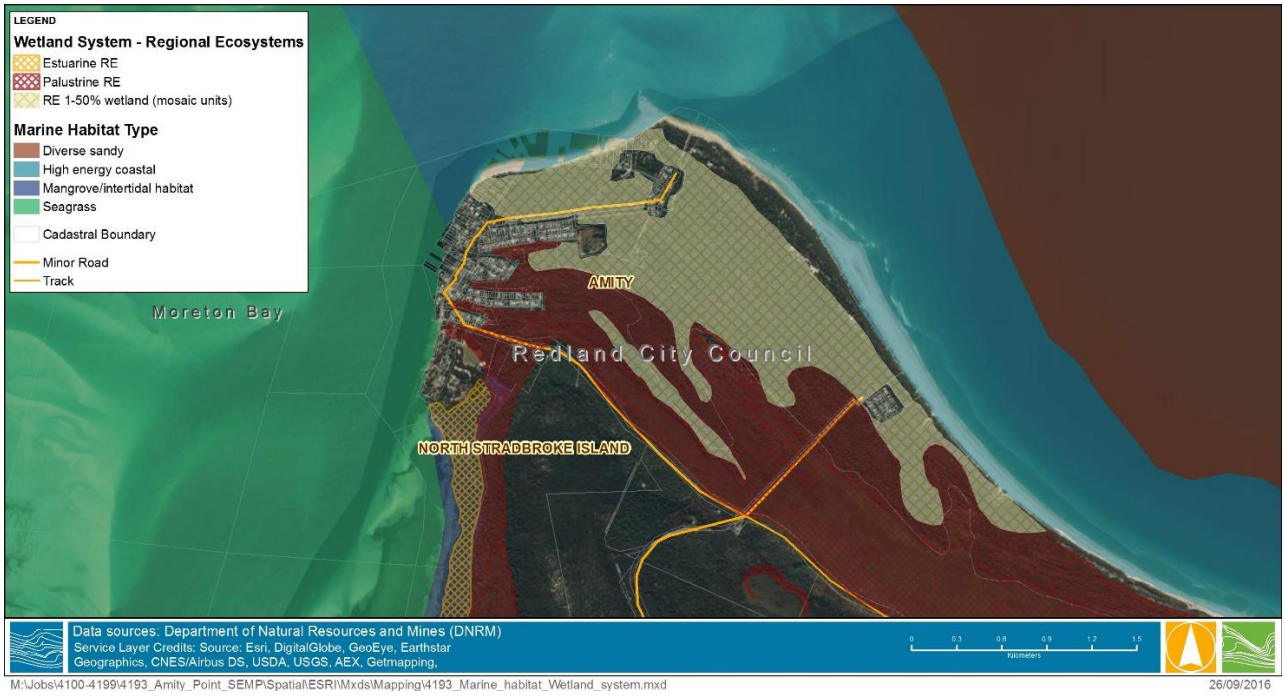


FIGURE 8-8 WETLAND AND MARINE REGIONAL ECOSYSTEMS

Queensland Heritage Act 1992

The object of the *Queensland Heritage Act 1992* is to provide for the conservation of Queensland's cultural heritage for the benefit of the community and future generations. This is achieved in part by the establishment of a register of places and areas of State cultural heritage significance called the Queensland Heritage Register. Any development that will occur in (or in association with) a heritage place listed on the Register by

the Queensland Heritage Council requires assessment. However, no State heritage places have been identified with the SEMP study area.

State Planning Policy 2/10 Koala Conservation in South-East Queensland

State Planning Policy 2/10 (SPP 2/10): Koala Conservation in South-East Queensland aims to ensure that Koala habitat conservation is taken into account during planning processes in South-East Queensland. Where the recommendations of this SEMP have consequences for the existing koala habitat in the Amity Point area, the requirements of SPP 2/10 need to be taken into account in the SEMP.

As shown in Figure 8-9, much of the SEMP area is mapped as having koala habitat values. It is therefore important to avoid disturbing areas marked as having bushland or rehabilitation value for koalas. This may apply in terms of erosion mitigation strategies that require clearing of these areas for activities such as accessing or installing erosion protection development works.



FIGURE 8-9 KOALA HABITAT CATEGORIES

8.5.3 Other Considerations

Consultation with the following agencies may be required regarding the legislation detailed previously:

- Department of Environment and Science (DES) for matters concerning foreshore protection works, conservation values, tidal quarry material allocations, management under the QCP; marine parks and NC Act permits;
- Department of Natural Resources, Mines and Energy (DNRME) for matters concerning the allocation and use of State Land, vegetation management, Indigenous cultural issues and land title;
- Department of Agriculture and Fisheries (DAF) for matters concerning fisheries resources, marine plants, FHAs, and quarry operations.

8.6 Local Government

The Amity Point SEMP lies within the local government jurisdiction of Redland City Council. Under *the Local Government Act 2009* (LG Act) this jurisdiction extends offshore to the high tide mark. However, Council also has jurisdiction for development assessment over its local tidal area. The LG Act permits local governments to acquire jurisdiction from the State Government over the foreshore between the low water and high water lines for special purposes such as foreshore protection works.

Redland City Council controls land use and activities under the local planning scheme (under the SP Act) and Local Laws (LG Act).

8.6.1 Redlands Planning Scheme

The current *Redlands Planning Scheme* (Version 7.1) came into effect on the 17th June 2016. It is the primary local planning instrument governing all planning and development with the Redland City Council area.

Codes, zones and overlays are used to achieve the outcomes identified in the Planning Scheme. The relevant Planning Scheme map for North Stradbroke Island is shown in Figure 8-10.

The urban residential area of Amity Point (which includes locations along the alignment of the existing flow slide barrier in the Central Reach and west of Ballow Street) has been zoned as sub-area UR3. Within this area, future buildings and structures are to be demountable and capable of being removed. All buildings, structures or infrastructure associated with the use or other development should not extend any further seaward than existing uses and development of the site.

8.6.2 Other Local Government Instruments and Strategies

When determining appropriate erosion mitigation strategies for this SEMP, other relevant planning instruments have been considered. These have included:

Redlands 2030 Community Plan. The Redlands 2030 Community Plan sets out Council's long term vision and outlines eight vision outcomes for Redland City.

Corporate Plan 2015 – 2020. The Corporate Plan guides how Council will direct planning and resources to deliver outcomes consistent with the *Redlands 2030 Community Plan*. It informs annual operational planning and budget, and provides a road map against which Council's performance will be measured. Amongst other outcomes it aims to ensure the City's community is ready for (and adapting to) changing coastlines, storm tides and severe weather; and that the City's residents and visitors can easily access local foreshores and use recreational foreshore infrastructure for boating and non-boating activities.

North Stradbroke Island Economic Transition Strategy, 2016. In May 2016, the Queensland Parliament passed legislation that will substantially cease sand mining on the island by 2019. The strategy sets out the Queensland Government's plan for transitioning the island to become an eco-tourism hub. The strategy was released on 01st September 2016 following stakeholder and community consultation.

Confronting Our Climate Future. 2010. A strategy to the year 2030 for Redland City to reduce greenhouse gas emissions, respond to climate change, and achieve energy transition. It includes mitigation and adaptation strategies regarding coastal erosion and storm tide / sea level inundation.

Biodiversity Strategy, 2008 – 2012. The biodiversity strategy highlights the extent and quality of the local biodiversity and threatening processes. It outlines key actions to address long-term protection and enhancement.

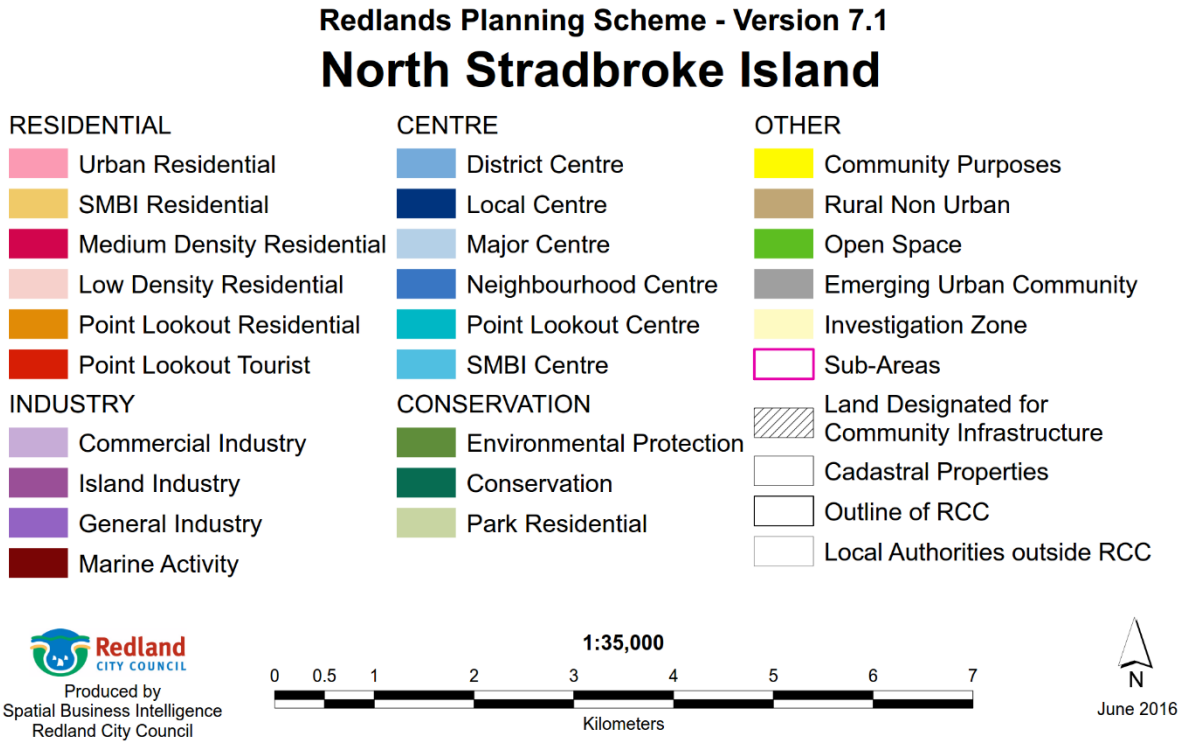


FIGURE 8-10 REDLANDS PLANNING SCHEME MAP – NORTH STRADBROKE ISLAND, AMITY POINT INSET

4193-01_R03v07

9. RECOMMENDED SHORELINE EROSION MANAGEMENT

9.1 Southern Reach - Camping Ground Foreshore

9.1.1 Recommended Strategy

The recommended erosion mitigation strategy along the Southern Reach is to undertake beach nourishment within each of the three existing beach compartments; and to construct cut-off seawalls behind each beach where an appropriate structure does not already exist.

Under a beach nourishment strategy, the width and height of the beach slope fronting the camping ground will be increased. Apart from increasing the resilience to erosion, the benefit to the area is that the overall amenity of this much-valued foreshore would be enhanced for residents and visitors.

The volume of sand required to create an adequate erosion buffer along this foreshore is primarily determined by the length of the existing groynes which can contain the naturally preferred characteristics of each triangular-shaped sand fillet. There is no scope to increase the length of the existing groynes (and therefore the volume/length of retained beach) since each groyne already extends out to near the edge of Rainbow Channel.

Sand brought in for placement on the foreshore should have the same grain size (or slightly larger) as that currently on the beach. It must also be of uniform grading - this being a physical characteristic of naturally occurring beach sand.

The prevailing coastal processes along the southern precinct of Amity Point are such that the naturally preferred plan orientation of beaches between the existing groynes is for them to face north-west towards a bearing of approximately 312°. This means that additional sand placed along the foreshore will be moved southward against each groyne to adopt this natural plan alignment. As a consequence, sand builds up against each groyne so as to form a triangular-shaped fillet on the southern end of each beach compartment. However, the northern part of the beach compartment will gradually become depleted of sand, thereby negating any benefit of beach nourishment at those particular locations. This will require a seawall in the northern pockets of each beach compartment to mitigate further erosion at those places.

The beach nourishment and required seawalls will need to be designed by appropriately qualified coastal engineers as part of the implication of this strategy. Nevertheless, approximate requirements are presented in Table 9-1. The recommended erosion mitigation strategy is summarised in Figure 9-1.

TABLE 9-1 CHARACTERISTICS OF RECOMMENDED STRATEGY FOR SOUTHERN REACH

Location	Approximate sand volume	Approximate seawall length
Northern-most of the three beach compartments	800 m^3	55 metres
Central of the three beach compartments	1,700 m^3	n/a
Southern-most of the three beach compartments	2,500 m^3	110 metres
Totals	**5,000 m^3**	**165 metres**



FIGURE 9-1 RECOMMENDED EROSION MITIGATION STRATEGY – SOUTHERN REACH

4193-01_R03v07

The strategy for mitigating future erosion threats along the Southern Reach is as follows:

- Construction of approximately 165 metres of seawalls to be buried at the rear of the northern and southern beach compartments. This consists of approximately 55 metres along the northern compartment and 110 metres on the southern compartment. The characteristics of these two seawalls are to be determined by detailed coastal engineering design. It is likely that a rock armour sourcing study will need to be undertaken as part of the design stage.
- Placement of approximately 5,000 cubic metres of sand (of appropriate grading and size) within the existing three beach compartments. This consists of approximately 800 cubic metres along the northern compartment, approximately 1,700 cubic metres on the central compartment, and approximately 2,500 cubic metres on the southern compartment. The characteristics of the sand nourishment works are to be determined by detailed coastal engineering design. It is likely that a sand sourcing study will need to be undertaken as part of the design stage.
- Undertake a structural audit of the existing rock-armoured seawall to the south of the three beach compartments to confirm its future effectiveness as a foreshore defence structure.
- Monitor the performance of the beach nourishment by annual surveys of the foreshore profile.
- Undertake future beach renourishment campaigns to reinstate beach widths should sand losses result from severe storms and/or future climate change.
- Since Rainbow Channel is migrating gradually towards Amity Point increasing the risk of flow slides adversely affecting the foreshore, it is also recommended that an annual bathymetric survey of Rainbow Channel be undertaken to provide a better understanding of how this potential risk is developing. This will determine the likelihood, the timescales and extent that the foreshores of the Southern Reach are becoming more vulnerable to future damage by flow slide events because of changing bathymetry in the migrating channel. This will allow for the planning of appropriate future strategies to mitigate the emerging threat.

9.1.2 Cost Estimate

Seawalls

Whilst the structural form of the seawalls needs to be determined by detailed coastal engineering design during the implementation phase of this SEMP, experience suggests it is likely that the most cost effective outcome will be rock-armoured structures rather than sand-filled geotextile bags or pre-cast concrete units. That being the case, it is estimated that approximately 475 cubic metres (around 850 tonnes) of rock will be required to construct the seawalls.

The strategy for mitigating the erosion threat on the Central Reach also involves a requirement for rock armour. Therefore, for the purposes of preparing cost estimates for seawall construction on the Southern Reach, it is assumed that the necessary procedures would be implemented for rocks to be commercially available from the same local source rather than be imported from the mainland to construct the seawalls.

Sand for beach nourishment

A previous beach nourishment exercise was undertaken on the foreshore frontage of the camping ground. Sand was supplied from a commercial source at Ningi near Bribie Island. Whilst that may have been an appropriate source at that time, other viable sources may now be available.

For example, meetings with the Department of Agriculture and Fisheries and the Department of Natural Resources Mines and Energy (pers. comm. 13th January, 2016) indicate that Redland City Council acts as Trustee for an approximately 4-hectare sand reserve on Fisherman's Track. Whilst this is reputedly undeveloped at present, it may be a viable source of sand for the approximately 5,000 cubic metres needed for beach nourishment on the Southern Reach.

Alternatively, a viable source for beach nourishment purposes might be sand dredged by the Port of Brisbane which is currently stockpiled within the Port's Fisherman Island precinct. That sand could be loaded onto an appropriate barge, transhipped to Amity Point then offloaded directly onto the foreshore for subsequent placement into the existing beach compartments along the Southern Reach.

It is recommended that a Sand Sourcing Study be commissioned by Redland City Council as part of the detailed design phase of the SEMP's implementation to determine an appropriate sand source for beach nourishment.

Estimated Cost of Implementation

For the purposes of developing cost estimates, it is assumed that local sources of sand for beach nourishment and armour rocks for seawall construction are available on North Stradbroke Island. Table 9-2 below provides a summary of the estimated costs to implement the recommended strategy for mitigating the erosion threat along the Southern Reach. The estimate excludes any costs associated with establishing the local sand source and any upgrading of Fisherman's Track required for construction access.

TABLE 9-2 COST ESTIMATE FOR RECOMMENDED MITIGATION STRATEGY – SOUTHERN REACH

Activity	Cost	Annual Cost
Project Design and Approvals		
Site survey	$5,000	
Sand sourcing study	$15,000	
Structural audit of existing seawall	$7,500	
Design of seawalls & beach nourishment	$30,000	
Obtain appropriate approvals	$17,500	
Construction Works		
Construct approx. 165m of buried rock seawall	$112,500	
Procure and place 5,000m^3 of sand	$87,500	
Allowance for annual renourishment		$5,000
Project Monitoring		
Annual survey of beach (additional to survey of Rainbow Channel)		$5,000
Annual bathymetric survey of Rainbow Channel side slopes	*refer costs for Central Reach*	
Totals	**$275,000**	**$10,000**

9.1.3 Implementation Schedule

The various tasks associated with the implementation of the recommended strategy are shown in Table 9-3.

TABLE 9-3 SOUTHERN REACH – IMPLEMENTATION SCHEDULE

Activity	Month						
	1	2	3	4	5	6	7
Project Design and Approvals							
Site survey	■						
Sand sourcing study	■						
Structural audit of existing seawall	■						
Design of seawalls & beach nourishment	■	■					
Obtain appropriate approvals			■	■			
Construction Works							
Tender for Works					■		
Construct approx. 165m of buried rock seawall						■	
Procure and place 5,000m^3 of sand							■

9.2 Central Reach - Flow Slide Barrier

9.2.1 Recommended Strategy

As discussed in earlier sections of this SEMP, in recent times the existing flow slide barrier has been effective in preventing the development of retrogressive flow slides to damaging proportions. A related outcome of terminating flow slides in the submerged side slopes of Rainbow Channel is that the structure has also maintained the existing foreshore alignment despite the eastward migration of the channel.

Therefore, it is important to the continuing function of this coastal defence structure that it be repaired following any damage caused by retrogressive flow slides. This includes repairs and improvements to the northern-most end of the flow slide barrier (at the confluence of the Central and Northern Reaches) whenever such events cause damage in this area.

The recommended erosion mitigation strategy for the Central Reach is to support and enhance the effectiveness of the current erosion management practice of repairing damage to the existing flow slide barrier and reinstating the foreshore whenever necessary following flow slide events - by placing additional rock armouring.

This basically entails:

- Adopting a flow slide barrier as the necessary coastal protection works required to manage the erosion threat along the Central Reach of Amity Point.
- Recognising that the existing rock placements along this shoreline are consistent with conceptual structural requirements for a flow slide barrier and to seek formal approval of the existing barrier as substantially completed tidal works.

- Monitoring the continued structural adequacy of the flow slide barrier, through regular bathymetric surveys to identify emerging vulnerabilities to potential flow slides - and to inform structural reinforcement and repair needs.
- Formalising a maintenance regime of periodic "topping up" of rocks to maintain the effectiveness of the structure in mitigating the threat of flow slides. Where this is within the footprint of the approved structure it can be considered as maintenance works required to preserve the integrity and function of the flow slide barrier.

The only location along the entire barrier where there is currently evidence that a flow slide might undermine and damage the barrier is on the foreshore frontage of Old School House Park. There is merit in adopting a proactive strategy of reinforcing the flow slide barrier at this location - by placing approximately 45cu.m./m of rock either directly into the front upper slopes of the armoured foreshore above RL-5m AHD, or onto the seabed offshore at around the RL-5m AHD depth contour. Both of these options are consistent with maintaining conceptual requirements for a flow slide barrier.

Approval for both the Flow Slide Barrier and for its repair following damage

In the past, repairs to the flow slide barrier by foreshore property owners have been viewed as being unapproved (or unlawful) works in the context of Queensland's *Coastal Protection and Management Act 1995*. This is because it had not been approved as prescribed tidal work[31] under the *Sustainable Planning Act 2009* (SPA).

To date, considerations for its approval have been based on the notion that this rock-armoured structure is a seawall. A seawall is a conventional response to conventional erosion processes – such as those caused by wave action and/or a deficit in the supply of littoral sand. Where such structures had formal approval under the SPA, repairs were authorised to be undertaken to reinstate their primary function whenever they were damaged.

The rock structure along the foreshore of the Central Reach currently does not have the status of approved tidal works. A requirement for the implementation of the recommended erosion mitigation strategy is that this physical barrier to retrogressive flow slides be formally approved under the *Planning Act 2016* (formerly SPA), thereby enabling its function to be maintained in the event of damage. This will require an application for prescribed tidal works relating to the flow slide barrier. The findings of this SEMP can be used to provide technical support for that application. It is expected that the conceptual design for the flow slide will need to be further refined by a subsequent detailed engineering design phase to also provide support to the approval application process.

Nevertheless, Section 166 of the *Planning Act 2016* allows tidal works to be undertaken without a development approval in an emergency[32]. Circumstances that constitute an emergency are provided in Section 166 of the *Planning Act 2016* , and include events that endanger the life or health of people; and that threaten the structural safety of buildings. Large retrogressive flow slides on the foreshores of Amity Point are likely to be considered as such an emergency.

An exemption for prior approval of repair works to the flow slide barrier applies provided those repairs are in accordance with a Safety Management Plan, and having formal endorsement by a Registered Professional Engineer of Queensland that the completed works are in a safe condition. However, as soon as "reasonably

[31] Prescribed tidal work is defined in s.14 and 15 of the *Coastal Protection and Management Regulation 2003.*

[32] *Necessary operational work that is tidal works - Guideline (version 3)*. Document issued by Queensland Department of Environment and Science regarding the processes and requirements for emergency tidal works under s.166 of the *Planning Act 2016.* Publication number ESR/2016/2045, version 3, dated 03 July 2017.

practicable after starting the emergency works", a development application is to be made. Should that development application be refused, then the emergency repair works must be removed.

So simply having a Safety Management Plan in place does not invalidate the fundamental need for development approval of the flow slide barrier. Nevertheless, a Safety Management Plan for emergency repairs to the existing flow slide barrier has been prepared as a component of this SEMP. That document is included as Appendix G.

The challenge to the process of formal application and approval is that the flow slide barrier forms the bayside frontage of several private properties as well as public land. There are in total 34 land parcels having the flow slide barrier along their frontage. This includes four freehold parcels alongside Old Schoolhouse Park, each having a narrow reserve in front (varying between 2m and 6m width), but still with at least part of the buried structure within their boundaries.

The allocation of foreshore lengths to the various land tenures along the Central Reach is presented below in Table 9-4.

TABLE 9-4 LAND TENURE ALONG THE ALIGNMENT OF THE EXISTING FLOW SLIDE BARRIER

Tenure	No. of land parcels	Foreshore Length	Foreshore Length (%)
Freehold	23	526 metres	55.8%
State Land	5	141 metres	15.0%
Reserve	2	168 metres	17.8%
end of public roads	4	107 metres	11.4%
Totals	34	942 metres	100%

Monitoring future effectiveness of the flow slide barrier

Given that Rainbow Channel is migrating towards Amity Point, it is recommended that a structural audit of the flow slide barrier be undertaken at least annually - using information from an annual bathymetric survey of the vulnerable side slopes of Rainbow Channel. This will determine whether (as a consequence of changing bathymetry in Rainbow Channel) sections of the existing structure are becoming more vulnerable to future damage. This will allow for the planning of structural reinforcement and/or repair campaigns to the flow slide barrier.

The annual bathymetric survey should comprise a full hydrographic survey of the channel bank using both multibeam and single beam sounders. The physical extent of the survey is to be no less than that covered by the survey undertaken in December 2015 (Port of Brisbane, 2015). Included in the deliverables of each annual survey is to be a comparison with previous surveys to clearly indicate the extent of changes to the local bathymetry of Rainbow Channel. Comparisons with earlier transect surveys is also to be undertaken - comparable in scope and detail to those in Appendix A.

Availability of suitable rock armour for repairs to the flow slide barrier

In the past, rock for repairs to the flow slide barrier along the Central Reach has been available from two quarry sources on North Stradbroke Island. However, since the 2011 native title consent determination there is ongoing dialogue with the relevant stakeholders; and it will be necessary to establish administrative and financial structures to facilitate the supply of rock armour for Council projects and by Council to third parties..

A critical aspect determining the effectiveness of repairs to the flow slide barrier is having rocks placed to recharge the upper slopes as soon as possible after each damaging event. Apart from having the appropriate approvals in place to undertake necessary repairs, this will require:

- Ensure availability and access to a suitable source of rock, with the intent being to create a stockpile of rock ready for emergency repairs. This stockpile could be located at a location near Amity Point;
- Having contracts and/or arrangements in place for the appropriate loading, carriage and placement of rocks into damaged areas of the barrier as soon as possible following an event. This could be through commercial arrangements with private earthmoving contractors based on North Stradbroke Island;
- Having contracts and/or arrangements in place for access and the initiation of repair works to damaged areas of the flow slide barrier where landowners immediately affected by the threat are not residing at Amity Point and/or may not be readily contacted;
- Having contracts and/or agreements in place for the payment of repairs to damaged areas of the flow slide barrier.

To secure a long-term, sustainable and economic source of rock for repairs, it is recommended that a *Rock Armour Supply Study* be commissioned by Council to investigate and determine the procedures necessary to facilitate the appropriate sourcing and placement of rocks into an approved flow slide barrier along the Central Reach.

Payment for repairs to the flow slide barrier

To date, the cost of constructing and intermittently repairing the flow slide barrier along the Central Reach has been met by the local foreshore property owners. It is recommended that Council engage with other stakeholders (and obtain assistance and advice on legal issues as required) to determine an appropriate funding arrangement for future maintenance works to the rock-armoured flow slide barrier.

Access for facilitating repairs to the flow slide barrier

The availability of access for trucks carrying rocks to the foreshore along the alignment of the flow slide barrier is varied. In many cases the residential home on private properties is of a size or location that prevents vehicular access from the street-side entrance through to the foreshore. In such cases the only available access route for construction plant and equipment to effect repairs to a damaged section of the flow slide barrier is via a nearby property without that impediment, then along the foreshore. In the past, this has entailed removing fences; traversing lawns and gardens; and removing and/or pruning established trees of neighbouring properties.

There appears to be an informal agreement amongst the present owners of foreshore properties that such access ought to be available, but any damage caused by this traffic is to be rectified at no cost to the affected property owners.

The ability to repair damaged sections of the flow slide barrier as soon as possible after each event in many cases relies on the goodwill of neighbouring residents. Whilst this informal arrangement is reputedly effective at present, there is no surety that it will remain so in future. There is merit in having present foreshore property owners investigate and implement a more formal agreement for such access that will be binding on existing and future owners of their property. It is beyond the scope of this SEMP to determine the need, and the planning and legislative frameworks, for any such agreements.

9.2.2 Cost Estimate

The estimates presented in this SEMP do not include costs associated with:

- Obtaining development approval for the flow slide barrier;
- Securing an on-going cost-effective and sustainable source of rocks for any future repairs;
- Payment provisions for repairs; and

- The securing of formal agreements for access by construction equipment for repairs.

The estimated costs associated with implementation of the recommended erosion mitigation strategy along the Central Reach are summarised below in Table 9-5.

TABLE 9-5 COST ESTIMATE FOR RECOMMENDED MITIGATION STRATEGY – CENTRAL REACH

Activity	Initial Cost	Annual Cost
Annual bathymetric survey of Rainbow Channel side slopes		$17,500
Annual structural audit of flow slide barrier		$7,500
Totals	*nil*	**$25,000**

9.3 Northern Reach - Amity Beach

9.3.1 Recommended Strategy

The recommended erosion mitigation strategy along the Northern Reach is to maintain the existing strategy of non-intervention along Amity Beach, but to monitor future shoreline behaviour.

As discussed in Section 4.6, the erosion threat to private landholdings with frontages on Amity Beach is caused primarily by erosion "hot-spots" that migrate along the shoreline. The extent, location and severity of such hot-spots is influenced by the extent of the changing sand spit that forms at the eastern end of the beach, in conjunction with the severity of future storm events.

Given the relationship between the erosion threat and the processes shaping the sand spit, there is considerable merit in further investigations to better understand the local coastal processes on Amity Beach and predict emerging threats. Such investigations would require the establishment and operation of a Monitoring Survey Program.

Rather than just surveying along transects, recent developments in surveying technology now make it cost effective to obtain a full three-dimensional (3-d) representation of beaches utilising unmanned aerial vehicles (UAVs). This allows for more accurate calculations of changes in beach volumes over time. Repeated 3-d acquisition allows for accurate determinations of where, and how much, sand is being lost from the beach profile and where sand is accreting. It is recommended that the following monitoring aspects be included in the strategy for mitigating the erosion threat on the Northern Reach:

- Monitoring Survey Program: Stage 1
  - The foreshore from 500 metres east of the sand spit (i.e. along the adjacent Flinders Beach) to a location at the northern end of the flow slide barrier of the Central Reach be captured by 3-d survey. This should be undertaken during a low spring tide to maximise the coverage of nearshore areas. It is to include the entire sand spit at the eastern end of Amity Beach.
  - Initially this 3-d survey should be undertaken at least twice yearly for three years, with extra surveys undertaken as soon as possible after major erosion events on Amity Beach.
- Coastal Processes Assessment
  - Upon completion of Stage 1 of the Monitoring Survey Program in three years' time, a *Coastal Processes Assessment* should be undertaken by suitably qualified coastal engineers/scientists to determine the erosion processes affecting Amity Beach. This would utilise the results of the Monitoring Survey Program to that time, in conjunction with analysis of aerial photographs, and

reference to offshore waves measured by DES's directional Waverider station in deep water off Cape Moreton.

- The requirements for further surveys under the Monitoring Survey Program would be determined by the Coastal Processes Assessment. However, this subsequent Stage 2 of the Monitoring Survey Program is likely to entail at least annual 3-d surveys.
- The necessity for any erosion mitigation strategy for the Northern Reach would be addressed by the Coastal Processes Assessment.

9.3.2 Cost Estimate

The estimated costs associated with implementation of the recommended erosion mitigation strategy along the Northern Reach are summarised below in Table 9-6.

TABLE 9-6 COST ESTIMATE FOR RECOMMENDED MITIGATION STRATEGY – NORTHERN REACH

Activity	Initial Cost	Annual Cost
Monitoring Survey Program		
Stage 1: Initial year of survey (2No.), including establishing controls	$15,000	
Stage 1: twice yearly thereafter for two years		$10,000
Stage 2: assumed annually after initial 3 years		$5,000
Coastal Processes Assessment – in three years' time		
Analysis of aerial photographs	$7,500	
Analysis of wave records	$7,500	
Coastal Engineering Assessment & reporting	$20,000	
Totals	**$50,000**	**$10,000 then $5,000**

10. REFERENCES

Australian Bureau of Statistics, 2011. "*Amity Point (L) QuickStats*", viewed 20 September 2016, <http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/UCL322004?opendocument&navpos=220>

Banks, D.C. and Strohm, W.E. 1965. "*Methods of Preventing Flow Slides"* Potamology Investigations Report No. 12-16,. U.S. Army Corps of Engineers' Waterways Experiment Station, Vicksburg, Mississippi. Dated October 1965.

Beinssen, K., Neil D.T. and Mastbergen D.R. 2014. "*Field observations of retrogressive breach failures at two tidal inlets in Queensland, Australia".* Journal *Australian Geomechanics*. Vol. 49 No. 3, Sept 2014. pp55-63.

Beinssen, K., and Neil D.T. 2015. "*Retrogressive Breach Failure Events at Amity Point, Australia and their Interaction with Built Defences".* Proceedings of the 25th International Ocean and Polar Engineering Conference. Hawaii, USA; June 21-26, 2015. Copyright the International Society of Offshore and Polar Engineers (ISOPE). pp 1325-1339. ISBN 978-1-880653-89-0; ISSN 1098-6189.

BMT WBM, 2013. "*Amity Point Shoreline Erosion Management Plan – Draft Report"*. Subsequently termed "Shoreline Erosion Study". Report prepared for Redland City Council. Document No.R.B18390.001.01 Revision No.1, dated 31 May 2013.

Cardno, 2011. "*Storm Tide Hazard Study. Summary Report"*. Report prepared for Redland City Council. Document No. J11023/R1, dated June 2011.

Cardno Lawson & Treloar, 2009. "*Storm Tide Hazard Study. Redland Shire and Logan City Councils"*. Report prepared for (then) Redland Shire Council and Logan City Council. Document No. LJ8824/R2504/V2, dated 22 January 2009.

Department of Infrastructure, Local Government and Planning, 2017. *"ShapingSEQ –South-East Queensland Regional Plan"*. Prepared by Department of Infrastructure, Local Government and Planning. August 2017. Published online at: https://dilgpprd.blob.core.windows.net/general/shapingseq.pdf.

Department of Transport and Main Roads, 2018. "*Queensland Tide Tables – Standard Port Tide Times 2019*". Prepared by Maritime Safety Queensland, Department of Transport and Main Roads. Published online at: https://www.msq.qld.gov.au/Tides/Tide-Tables.

Eberhardt, J.M. 1978. "*Erosion at Amity Point – An Example of Shoreline Erosion in a Tidal Inlet".* Paper Department of Geology, University of Queensland. 8(2) pp82-88. October 1978.

Golder & Associates, 2016. "*Geophysics Investigation – Rock Armoured Revetment, Amity Point"*. Report prepared for Redland City Council. Document No. 1650770-003-Rev2, dated 12th December 2016.

Golder & Associates, 2017. "Additional *Geophysics Investigation – Rock Armour Revetment, Amity Point"*. Report prepared for Redland City Council. Document No. 1650770-006-R-Rev1, dated 05th September 2017.

National Native Title Tribunal, 2011. "*Quandamooka People's native title determinations*". Published at: http://www.nntt.gov.au/Information%20Publications/Determination%20brochure%20%20-%20Quandamooka%20People's%204%20July%202011.pdf. Viewed online 25th November 2016.

Peacock, E.C. 2001. "*History Life and times of Robert Anderson, Gheebelum, Ngugi, Mulgumpin".* Published September 2001 by Uniikup Productions. ISBN 0-9579026-0-3.

4193-01_R03v07.docx
g.docx

Port of Brisbane, 2015. "*High Resolution Multibeam/Laser Survey of Part of the Rainbow Channel, Amity Point – Job 30399"*. Report prepared for Redland City Council. Undated.

Short, A.D. 2000. "*Beaches of the Queensland Coast: Cooktown to Coolangatta*." 0-9586504-1-1. Reprinted 2005. Sydney University Press, Sydney.

Short, A.D. 2006. "*Australian Beach Systems – Nature and Distribution"*. Journal of Coastal Research. Vol22, No.1. pp 11-27. January 2006.

Silvis, F. and de Groot M.B. 1995. "*Flow Slides in the Netherlands : experience and engineering practise*." Can. Geotech. J. Vol. 32, 1995. pp1086-1092.

Thomson, A.K. (Ed.) 1967. "*The Collected Works of Thomas Welsby ".* Jacaranda Press Pty Ltd., Brisbane.

Tibbetts, I.R. and Townsend, K.A. 2010. "*The abundance, biomass and size of macrograzers on reefs in Moreton Bay, Queensland"* Memoirs of the Queensland Museum. Volume 54, Part3. pp373-384. published by Queensland Museum, dated 30th December 2010. ISSN 0079-8835.

Torrey, V.H. III; Dunbar, J.B.; Peterson, R.W. 1988. "*Retrogressive Failures in Sand Deposits of the Mississippi River*." Report No.1 Field Investigations, Laboratory Studies and Analysis of the Hypothesized Failure Mechanism. U.S. Army Corps of Engineers' Waterways Experiment Station, Vicksburg, Mississippi. Report No. AD-A198 760 dated June 1988.

WBM, 1998. "*Brisbane River & Moreton Bay Wastewater Management Study. Task HD Phase 2 – Field Data Collection"*. Report prepared for Brisbane City Council. Dated November 1998.

Whalley, P. 1987. "*An introduction to the Aboriginal social history of Moreton Bay, South-east Queensland, from 1799- 1830".* Thesis (B.A.(Hons.)) - University of Queensland, St. Lucia , Qld., 1987.

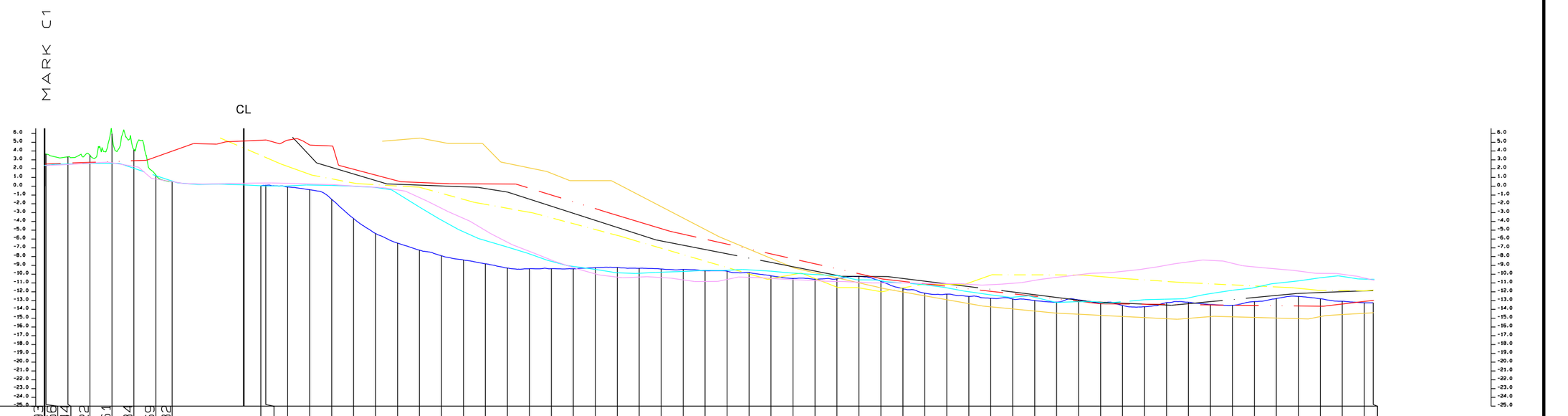
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX A
COMPARISON OF HISTORICAL TRANSECT SURVEYS



Cross Section C1
Scale(H) 1 : 1000
Scale(V) 1 : 500

CL Coordinates
E = 543138.573
N = 6968606.005



OFFSET	SURVEY - BATHY	SURVEY - LASER
-45.34		3.693
-45.00		3.656
-40.00		3.344
-35.00		3.522
-30.00		5.961
-25.00		4.134
-20.00		1.269
-16.31		0.532
-15.00		
-10.00		
-5.00		
0.00	0.035	
3.87	0.099	
5.00	-0.086	
10.00	-0.397	
15.00	-1.482	
20.00	-3.680	
25.00	-5.380	
30.00	-6.466	
35.00	-7.270	
40.00	-7.900	
45.00	-8.382	
50.00	-8.814	
55.00	-9.305	
60.00	-9.380	
65.00	-9.372	
70.00	-9.385	
75.00	-9.268	
80.00	-9.237	
85.00	-9.334	
90.00	-9.411	
95.00	-9.461	
100.00	-9.603	
105.00	-9.665	
110.00	-9.808	
115.00	-10.175	
120.00	-10.484	
125.00	-10.576	
130.00	-10.520	
135.00	-10.236	
140.00	-10.811	
145.00	-11.636	
150.00	-12.163	
155.00	-12.257	
160.00	-12.527	
165.00	-12.744	
170.00	-12.817	
175.00	-12.994	
180.00	-13.179	
185.00	-12.923	
190.00	-13.251	
195.00	-13.561	
200.00	-13.692	
205.00	-13.239	
210.00	-13.191	
215.00	-13.447	
220.00	-13.529	
225.00	-13.117	
230.00	-12.768	
235.00	-12.523	
240.00	-12.785	
245.00	-13.081	
250.00	-13.245	
255.00	-13.231	
257.06		

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m Typical Coverage: 100%
Horizontal Tolerance (95%): ±0.5m Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED DATE

AMITY POINT
NORTH STRADBROKE ISLAND (SHEET 1 of 9)
HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey except to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

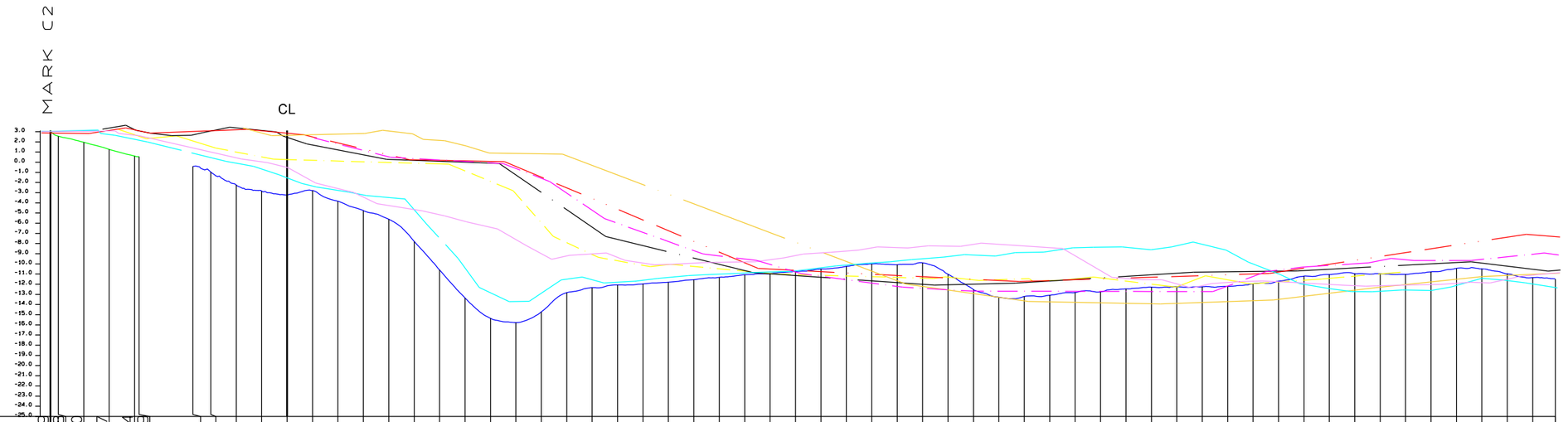
PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 1
Proj. File: AmityPoint.LWF

Cross Section C2
Scale(H) 1 : 1000
Scale(V) 1 : 500

CL Coordinates
E = 543186.206
N = 6968800.393



OFFSET	SURVEY - BATHY	SURVEY - LASER
-46.57		3.115
-45.00		2.556
-40.00		1.960
-35.00		1.257
-30.00		0.604
-29.13		0.549
-25.00	-0.399	
-20.00	-0.973	
-18.53	-2.246	
-15.00	-2.833	
-10.00	-3.221	
-5.00	-2.780	
0.00	-3.844	
5.00	-4.762	
10.00	-5.609	
15.00	-7.799	
20.00	-10.595	
25.00	-13.354	
30.00	-15.358	
35.00	-15.776	
40.00	-14.719	
45.00	-12.826	
50.00	-12.336	
55.00	-12.075	
60.00	-11.969	
65.00	-11.801	
70.00	-11.551	
75.00	-11.330	
80.00	-11.071	
85.00	-10.955	
90.00	-10.744	
95.00	-10.506	
100.00	-10.245	
105.00	-10.007	
110.00	-10.077	
115.00	-9.896	
120.00	-11.020	
125.00	-12.521	
130.00	-13.275	
135.00	-13.200	
140.00	-13.078	
145.00	-12.811	
150.00	-12.748	
155.00	-12.461	
160.00	-12.284	
165.00	-12.245	
170.00	-12.248	
175.00	-12.210	
180.00	-11.948	
185.00	-11.706	
190.00	-11.200	
195.00	-11.042	
200.00	-10.961	
205.00	-10.955	
210.00	-11.026	
215.00	-10.785	
220.00	-10.439	
225.00	-10.488	
230.00	-10.981	
235.00	-11.350	
240.00	-11.512	
245.00		
249.46		

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m
Horizontal Tolerance (95%): ±0.5m
Typical Coverage: 100%
Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED DATE

AMITY POINT
NORTH STRADBROKE ISLAND (SHEET 2 of 9)
HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey **except** to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

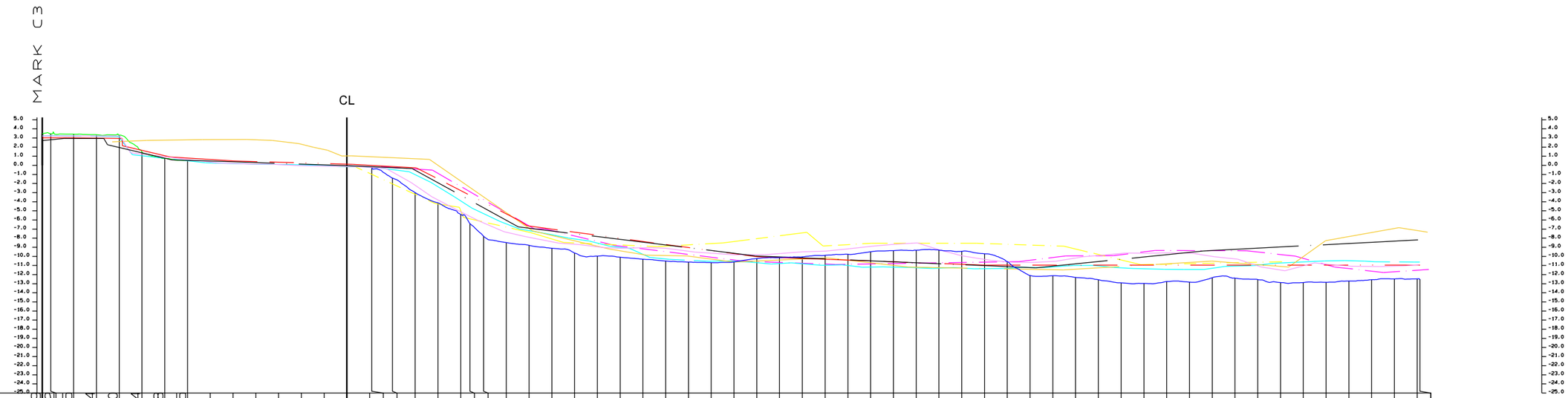
PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 2
Proj. File: AmityPoint.LWF

Cross Section C3
Scale(H) 1 : 1000
Scale(V) 1 : 500

CL Coordinates
E = 543236.574
N = 6969005.941



OFFSET	SURVEY - BATHY	SURVEY - LASER
-66.90		3.479
-65.00		3.472
-60.00		3.415
-55.00		3.354
-50.00		3.320
-45.00		1.494
-40.00		0.748
-35.00		0.535
-30.00		
-25.00		
-20.00		
-15.00		
-10.00		
-5.00		
0.00		
5.00	-0.293	
5.45	-1.394	
10.00	-3.001	
15.00	-4.119	
20.00	-5.386	
25.00	-6.403	
27.01	-7.772	
30.00	-8.482	
35.00	-8.787	
40.00	-9.109	
45.00	-9.626	
50.00	-9.967	
55.00	-10.081	
60.00	-10.304	
65.00	-10.502	
70.00	-10.622	
75.00	-10.685	
80.00	-10.609	
85.00	-10.237	
90.00	-10.127	
95.00	-10.054	
100.00	-9.887	
105.00	-9.771	
110.00	-9.485	
115.00	-9.374	
120.00	-9.326	
125.00	-9.309	
130.00	-9.436	
135.00	-9.715	
140.00	-10.568	
145.00	-12.101	
150.00	-12.130	
155.00	-12.311	
160.00	-12.565	
165.00	-12.909	
170.00	-12.975	
175.00	-12.766	
180.00	-12.822	
185.00	-12.342	
190.00	-12.385	
195.00	-12.542	
200.00	-12.875	
205.00	-12.872	
210.00	-12.840	
215.00	-12.703	
220.00	-12.567	
225.00	-12.473	
230.00	-12.465	
235.00	-12.515	
235.62		

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m
Horizontal Tolerance (95%): ±0.5m
Typical Coverage: 100%
Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED DATE

AMITY POINT
NORTH STRADBROKE ISLAND (SHEET 3 of 9)
HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey except to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

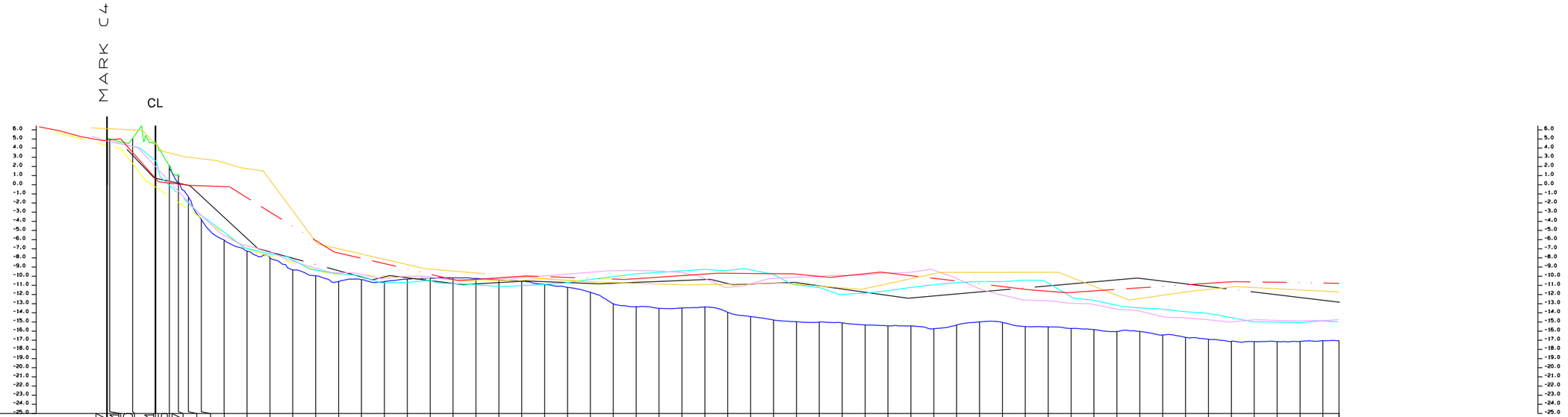
PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 3
Proj. File: AmityPoint.LWF

Cross Section C4
Scale(H) 1 : 1000
Scale(V) 1 : 500

CL Coordinates
E = 543258.848
N = 6969212.967



OFFSET	SURVEY - LASER	SURVEY - BATHY
-10.61	5.067	
-10.00	5.021	
-5.00	5.090	
0.00	4.571	
3.02	2.095	1.716
5.00	1.067	0.241
7.21		-1.337
10.00		-3.787
15.00		-6.030
20.00		-7.253
25.00		-7.998
30.00		-9.307
35.00		-9.946
40.00		-10.567
45.00		-10.369
50.00		-10.579
55.00		-10.322
60.00		-10.216
65.00		-10.175
70.00		-10.243
75.00		-10.414
80.00		-10.557
85.00		-10.894
90.00		-11.211
95.00		-11.757
100.00		-13.000
105.00		-13.321
110.00		-13.507
115.00		-13.472
120.00		-13.364
125.00		-13.937
130.00		-14.404
135.00		-14.782
140.00		-14.961
145.00		-15.008
150.00		-15.091
155.00		-15.321
160.00		-15.424
165.00		-15.427
170.00		-15.743
175.00		-15.330
180.00		-14.991
185.00		-15.058
190.00		-15.498
195.00		-15.539
200.00		-15.702
205.00		-15.837
210.00		-16.041
215.00		-16.039
220.00		-16.421
225.00		-16.677
230.00		-16.897
235.00		-17.108
240.00		-17.145
245.00		-17.154
250.00		-17.128
255.00		-17.052
258.52		-17.069

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m Typical Coverage: 100%
Horizontal Tolerance (95%): ±0.5m Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED DATE

AMITY POINT
NORTH STRADBROKE ISLAND (SHEET 4 of 9)
HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015

GDA

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey **except** to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

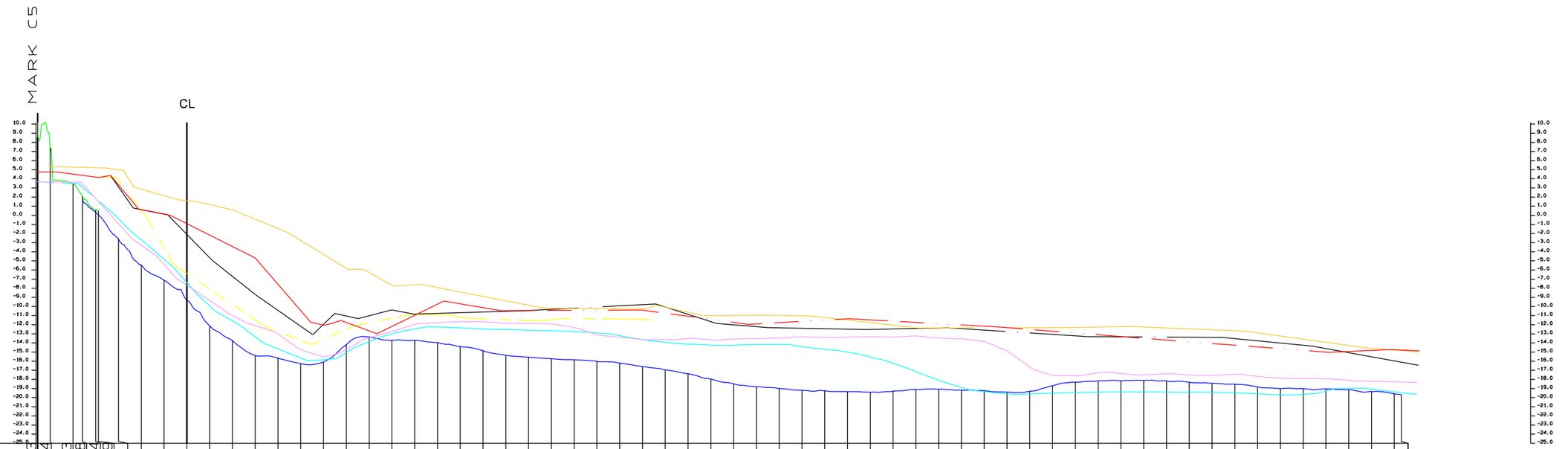
PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 4
Proj. File: AmityPoint.LWF

Cross Section C5
Scale(H) 1 : 1000
Scale(V) 1 : 500

CL Coordinates
E = 543272.511
N = 6969417.998



OFFSET	SURVEY - BATHY	SURVEY - LASER
-32.73		8.563
-30.00		7.404
-25.00		3.453
-22.90	1.491	2.078
-20.00	0.324	0.604
-19.42	0.040	0.519
-15.00	-2.608	
-10.00	-5.449	
-5.00	-7.109	
0.00	-9.295	
5.00	-12.128	
10.00	-13.746	
15.00	-15.379	
20.00	-15.669	
25.00	-16.268	
30.00	-16.087	
35.00	-14.172	
40.00	-13.341	
45.00	-13.707	
50.00	-13.704	
55.00	-13.961	
60.00	-14.381	
65.00	-14.835	
70.00	-15.365	
75.00	-15.569	
80.00	-15.730	
85.00	-15.842	
90.00	-16.019	
95.00	-16.211	
100.00	-16.600	
105.00	-16.947	
110.00	-17.375	
115.00	-17.958	
120.00	-18.475	
125.00	-18.803	
130.00	-18.986	
135.00	-19.188	
140.00	-19.247	
145.00	-19.338	
150.00	-19.406	
155.00	-19.286	
160.00	-19.112	
165.00	-19.079	
170.00	-19.184	
175.00	-19.231	
180.00	-19.393	
185.00	-19.294	
190.00	-18.685	
195.00	-18.310	
200.00	-18.163	
205.00	-18.161	
210.00	-18.102	
215.00	-18.164	
220.00	-18.311	
225.00	-18.426	
230.00	-18.528	
235.00	-18.813	
240.00	-19.011	
245.00	-19.007	
250.00	-19.037	
255.00	-19.127	
260.00	-19.322	
265.00	-19.576	
266.55	-19.658	

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m Typical Coverage: 100%
Horizontal Tolerance (95%): ±0.5m Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED DATE

AMITY POINT
NORTH STRADBROKE ISLAND (SHEET 5 of 9)
HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015

GDA

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey except to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

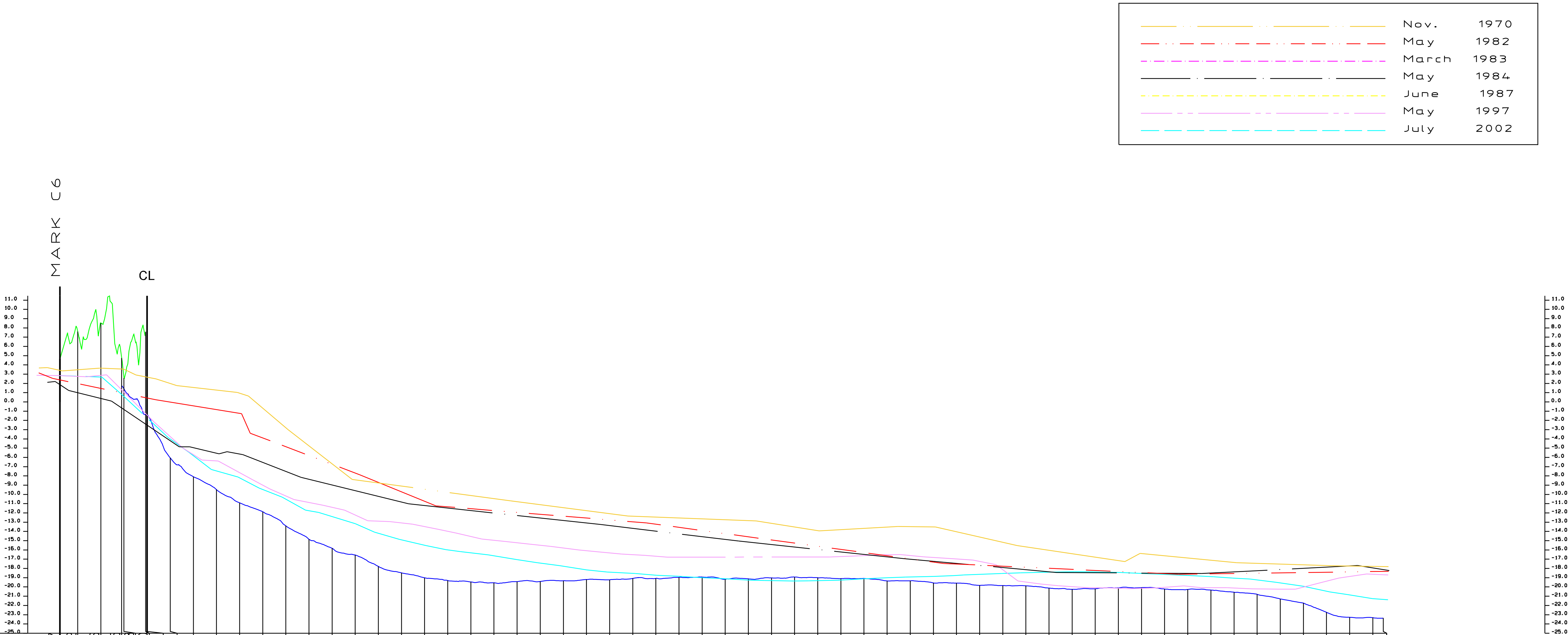
PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 5
Proj. File: AmityPoint.LWF

Cross Section C6
Scale (H) 1 : 1000
Scale (V) 1 : 500

CL Coordinates
E = 543307.437
N = 6969617.882



OFFSET	SURVEY - LASER	SURVEY - BATHY
-18.85	4.647	
-15.00	7.602	
-10.00	8.526	
-5.50	4.755	1.641
-5.00	2.598	1.419
-0.32	7.590	-1.415
0.00		-1.407
5.00		-6.050
10.00		-8.086
15.00		-9.475
20.00		-10.911
25.00		-11.871
30.00		-13.389
35.00		-14.846
40.00		-15.815
45.00		-16.549
50.00		-17.781
55.00		-18.479
60.00		-19.016
65.00		-19.299
70.00		-19.452
75.00		-19.543
80.00		-19.423
85.00		-19.409
90.00		-19.330
95.00		-19.194
100.00		-19.226
105.00		-19.079
110.00		-19.073
115.00		-18.962
120.00		-18.926
125.00		-19.167
130.00		-19.130
135.00		-19.018
140.00		-18.937
145.00		-19.008
150.00		-19.097
155.00		-19.086
160.00		-19.353
165.00		-19.333
170.00		-19.561
175.00		-19.583
180.00		-19.837
185.00		-19.849
190.00		-19.875
195.00		-20.125
200.00		-20.253
205.00		-20.196
210.00		-20.094
215.00		-20.066
220.00		-20.223
225.00		-20.271
230.00		-20.338
235.00		-20.576
240.00		-20.797
245.00		-21.295
250.00		-21.744
255.00		-22.741
260.00		-23.282
265.00		-23.315
267.27		-23.356

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m Typical Coverage: 100%
Horizontal Tolerance (95%): ±0.5m Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED — DATE

AMITY POINT
NORTH STRADBROKE ISLAND (SHEET 6 of 9)
HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015 GDA

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey **except** to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

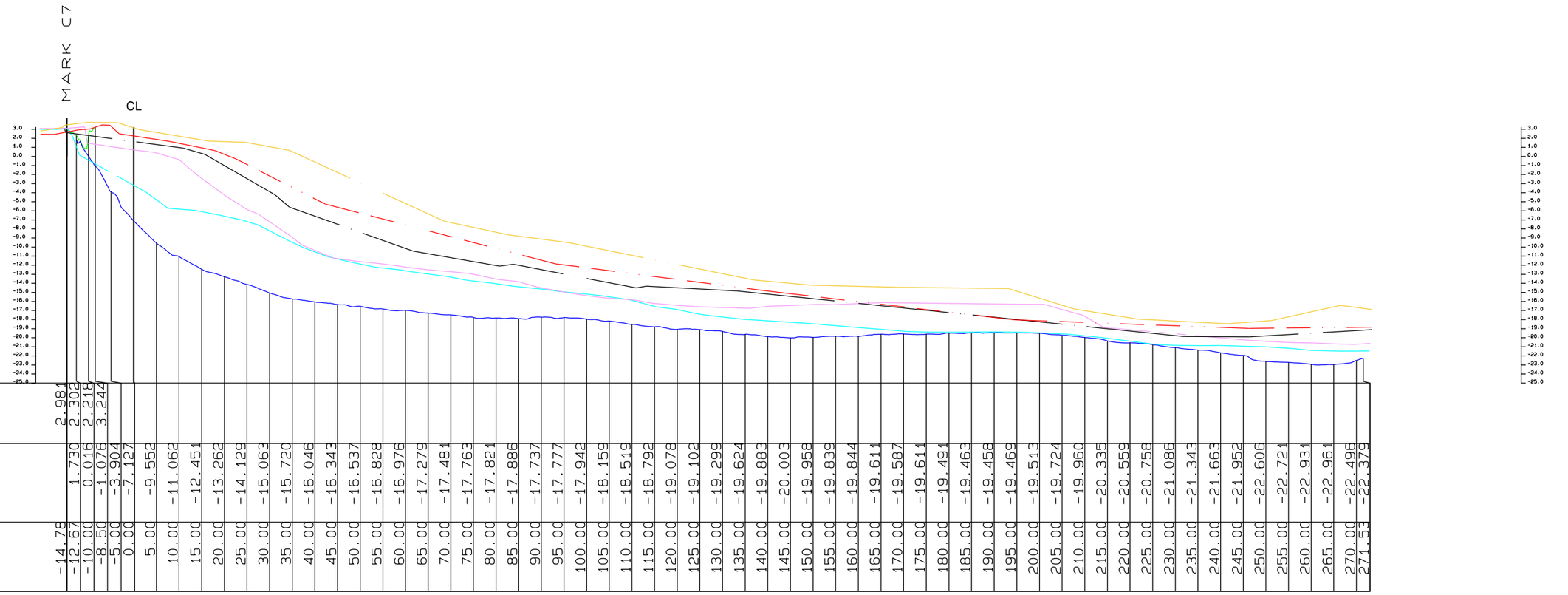
PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 6
Proj. File: AmityPoint.LWF

Cross Section C7
Scale(H) 1 : 1000
Scale(V) 1 : 500

CL Coordinates
E = 543382.167
N = 6969809.513



OFFSET	SURVEY - BATHY	SURVEY - LASER
-14.78	1.730	2.981
-12.67	0.016	2.302
-10.00	-1.076	2.218
-8.50	-3.904	3.244
-5.00	-7.127	
0.00	-9.552	
5.00	-11.062	
10.00	-12.451	
15.00	-13.262	
20.00	-14.129	
25.00	-15.063	
30.00	-15.720	
35.00	-16.046	
40.00	-16.343	
45.00	-16.537	
50.00	-16.828	
55.00	-16.976	
60.00	-17.279	
65.00	-17.481	
70.00	-17.763	
75.00	-17.821	
80.00	-17.886	
85.00	-17.737	
90.00	-17.777	
95.00	-17.942	
100.00	-18.159	
105.00	-18.519	
110.00	-18.792	
115.00	-19.078	
120.00	-19.102	
125.00	-19.299	
130.00	-19.624	
135.00	-19.883	
140.00	-20.003	
145.00	-19.958	
150.00	-19.839	
155.00	-19.844	
160.00	-19.611	
165.00	-19.587	
170.00	-19.611	
175.00	-19.491	
180.00	-19.463	
185.00	-19.458	
190.00	-19.469	
195.00	-19.513	
200.00	-19.724	
205.00	-19.960	
210.00	-20.335	
215.00	-20.559	
220.00	-20.758	
225.00	-21.086	
230.00	-21.343	
235.00	-21.663	
240.00	-21.952	
245.00	-22.606	
250.00	-22.721	
255.00	-22.931	
260.00	-22.961	
265.00	-22.496	
270.00	-22.379	
271.53		

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m Typical Coverage: 100%
Horizontal Tolerance (95%): ±0.5m Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED DATE

AMITY POINT
NORTH STRADBROKE ISLAND (SHEET 7 of 9)
HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015

GDA

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey **except** to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

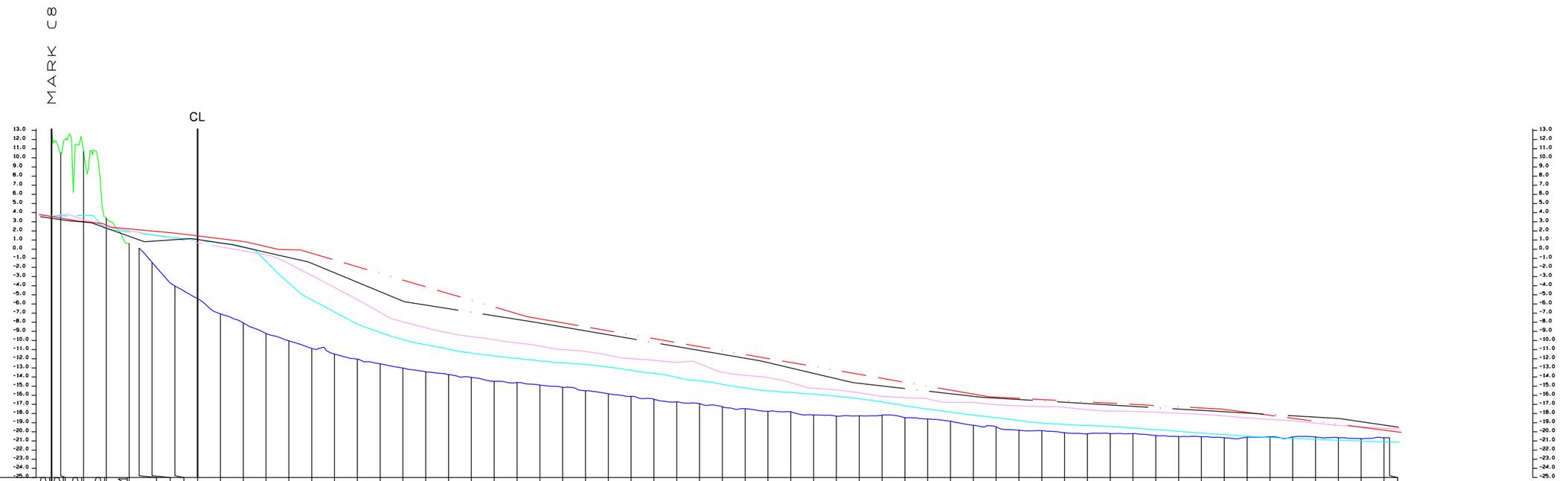
PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 7
Proj. File: AmityPoint.LWF

Cross Section C8
Scale(H) 1 : 1000
Scale(V) 1 : 500

CL Coordinates
E = 543443.799
N = 6969918.782



OFFSET	SURVEY - BATHY	SURVEY - LASER
-32.03		13.192
-30.00		10.552
-25.00		10.712
-20.00		3.382
-15.02		0.641
-15.00	0.125	
-12.83	-1.433	
-10.00	-4.020	
-5.00	-5.415	
0.00	-7.085	
5.00	-8.071	
10.00	-9.235	
15.00	-10.029	
20.00	-10.870	
25.00	-11.488	
30.00	-12.043	
35.00	-12.553	
40.00	-13.019	
45.00	-13.433	
50.00	-13.729	
55.00	-14.026	
60.00	-14.460	
65.00	-14.596	
70.00	-14.883	
75.00	-15.123	
80.00	-15.500	
85.00	-15.836	
90.00	-16.113	
95.00	-16.430	
100.00	-16.726	
105.00	-16.906	
110.00	-17.252	
115.00	-17.465	
120.00	-17.754	
125.00	-17.810	
130.00	-18.159	
135.00	-18.275	
140.00	-18.251	
145.00	-18.174	
150.00	-18.450	
155.00	-18.590	
160.00	-18.851	
165.00	-19.283	
170.00	-19.457	
175.00	-19.822	
180.00	-19.872	
185.00	-20.097	
190.00	-20.208	
195.00	-20.191	
200.00	-20.192	
205.00	-20.403	
210.00	-20.520	
215.00	-20.540	
220.00	-20.643	
225.00	-20.592	
230.00	-20.537	
235.00	-20.569	
240.00	-20.571	
245.00	-20.640	
250.00	-20.748	
255.00	-20.645	
260.00	-20.647	
261.25		

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m Typical Coverage: 100%
Horizontal Tolerance (95%): ±0.5m Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED DATE

AMITY POINT
NORTH STRADBROKE ISLAND (SHEET 8 of 9)
HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015

GDA

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey except to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

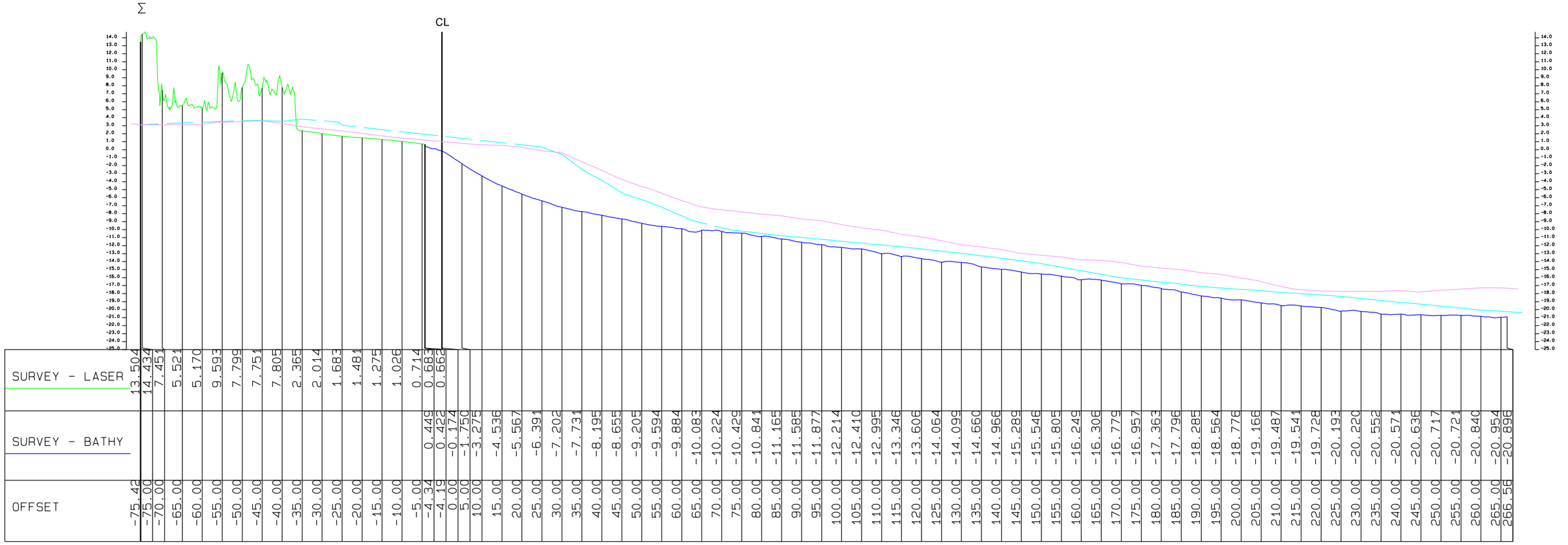
PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 8
Proj. File: AmityPoint.LWF

Cross Section C9
Scale(H) 1 : 1000
Scale(V) 1 : 500

CL Coordinates
E = 543504.219
N = 6969996.398



OFFSET	SURVEY - LASER	SURVEY - BATHY
-75.42	13.504	
-75.00	14.434	
-70.00	7.451	
-65.00	5.521	
-60.00	5.170	
-55.00	9.593	
-50.00	7.799	
-45.00	7.751	
-40.00	7.805	
-35.00	2.365	
-30.00	2.014	
-25.00	1.683	
-20.00	1.481	
-15.00	1.275	
-10.00	1.026	
-5.00	0.714	
-4.34	0.683	0.449
-4.19	0.662	0.422
0.00		-0.174
5.00		-1.750
10.00		-3.275
15.00		-4.536
20.00		-5.567
25.00		-6.391
30.00		-7.202
35.00		-7.731
40.00		-8.195
45.00		-8.655
50.00		-9.205
55.00		-9.594
60.00		-9.884
65.00		-10.083
70.00		-10.224
75.00		-10.429
80.00		-10.841
85.00		-11.165
90.00		-11.585
95.00		-11.877
100.00		-12.214
105.00		-12.410
110.00		-12.995
115.00		-13.346
120.00		-13.606
125.00		-14.064
130.00		-14.099
135.00		-14.660
140.00		-14.966
145.00		-15.289
150.00		-15.546
155.00		-15.805
160.00		-16.249
165.00		-16.306
170.00		-16.779
175.00		-16.957
180.00		-17.363
185.00		-17.796
190.00		-18.285
195.00		-18.564
200.00		-18.776
205.00		-19.166
210.00		-19.487
215.00		-19.541
220.00		-19.728
225.00		-20.193
230.00		-20.220
235.00		-20.552
240.00		-20.571
245.00		-20.636
250.00		-20.717
255.00		-20.721
260.00		-20.840
265.00		-20.954
266.56		-20.896

NOTES:
2015 Laser Survey Data may include Vegetation and/or Structures
Historical Linework supplied by Redland City Council
Historical Linework Converted from AMG and AHD to MGA and LAT Datums to match 2015 data.

Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m Typical Coverage: 100%
Horizontal Tolerance (95%): ±0.5m Survey Class: A

CLIENT: Redland City Council
PURPOSE OF SURVEY: Investigation
ROBERT SLATER — SURVEYED AND CHECKED
AARON WILLCOCK — SUPERVISING SURVEYOR (AHSCP LEVEL 1)
GILES STIMSON — APPROVED DATE

AMITY POINT

NORTH STRADBROKE ISLAND (SHEET 9 of 9)

HISTORICAL SECTIONS 16/12/2015 TO 22/12/2015

GDA

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:1000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

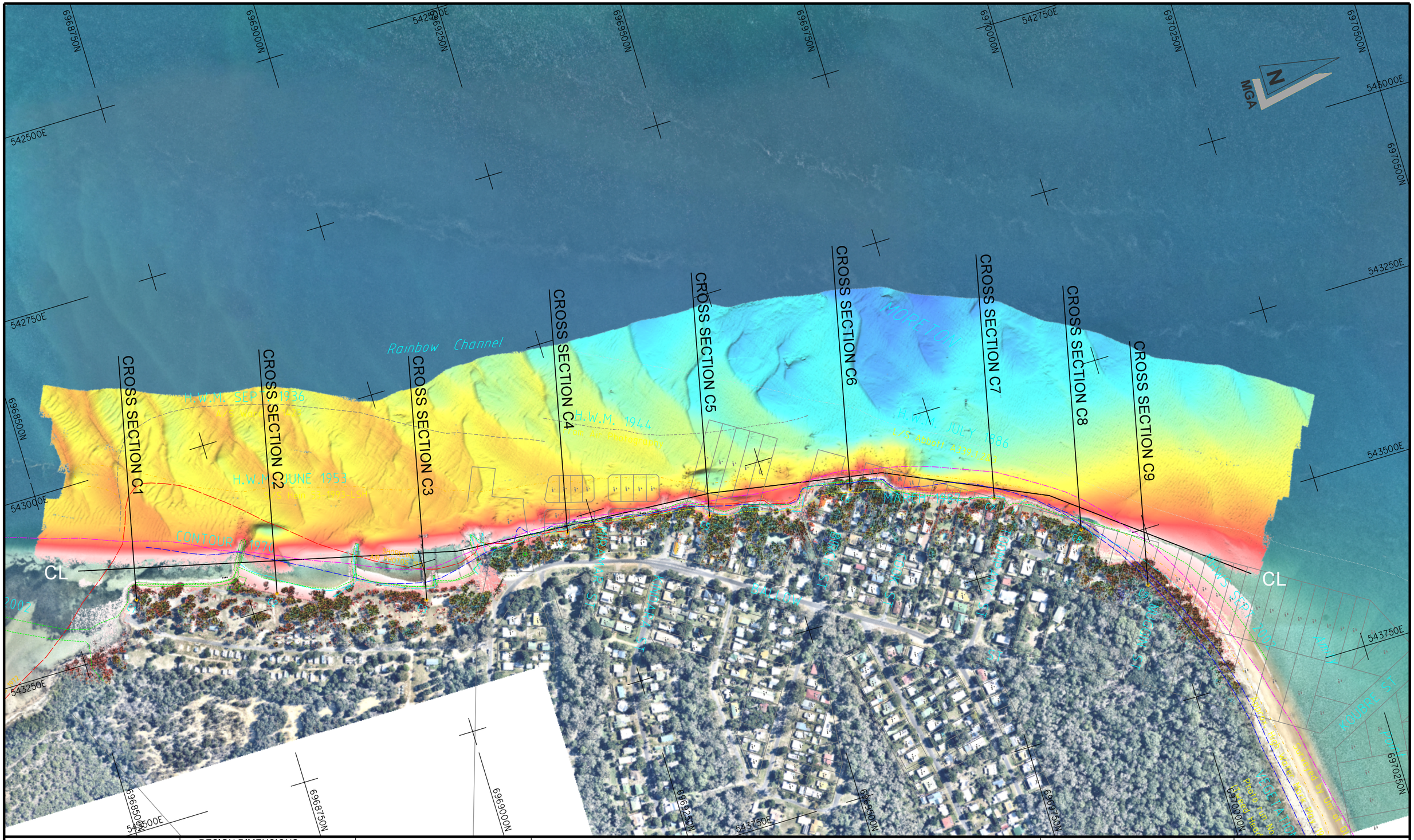
This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey **except** to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

PORT of BRISBANE
Here for the future

©PORT OF BRISBANE PTY LTD 2016

Dwg. No. 132670 - 9
Proj. File: AmityPoint.LWF



Surveyor: Robert Slater
Field Book: H17014
Vessel: Investigator
Data Type: MINIMUM DEPTHS
Data File: 18562004

VERTICAL MEASURMENTS
Equipment: Seabat 7125 SV2
Calibration: 19/11/2015
Tide Gauge: RTK Heights

DESIGN DIMENSIONS
Length: N/A Depth: N/A
Width: N/A Ins. Depth: N/A

HORIZONTAL POSITIONING
Equipment: POS MV
Mode: RTK GPS
Base Station: Smartnet iMax

SPECIFIED SYSTEM ACCURACY
Vertical Tolerance (95%): ±0.15m Typical Coverage: 100%
Horizontal Tolerance (95%): ±0.5m Survey Class: A

CLIENT: Redland City Council

PURPOSE OF SURVEY: Investigation

ROBERT SLATER
SURVEYED AND CHECKED

AARON WILLCOCK
SUPERVISING SURVEYOR (AHSCP LEVEL 1)

GILES STIMSON
APPROVED DATE

AMITY POINT
NORTH STRADBROKE ISLAND
HISTORICAL SECTION OVERVIEW

LEVEL DATUM: L.A.T. | AZIMUTH DATUM: GDA94 | SCALE 1:5000 (A3 sheet)

PORT OF BRISBANE PTY LTD 3 PORT CENTRAL AVENUE PORT OF BRISBANE QUEENSLAND 4178 Phone 07 32584888

Disclaimer:

This hydrographic survey is current at the date of publication shown and may not be accurate after this date. The period of its accuracy will depend upon weather conditions and natural rates of erosion or accretion in the survey area, as well as other causes.

Port of Brisbane Pty Ltd will in no circumstances be liable to any person that uses or relies upon the hydrographic survey **except** to the customer (as defined) when being used for the Purpose as defined. Port of Brisbane Pty Ltd expressly disclaims liability (including for negligence) to any other person for injury, loss or damage arising directly or indirectly out of any use of or reliance on this hydrographic survey.

PORT of BRISBANE
Here for the future

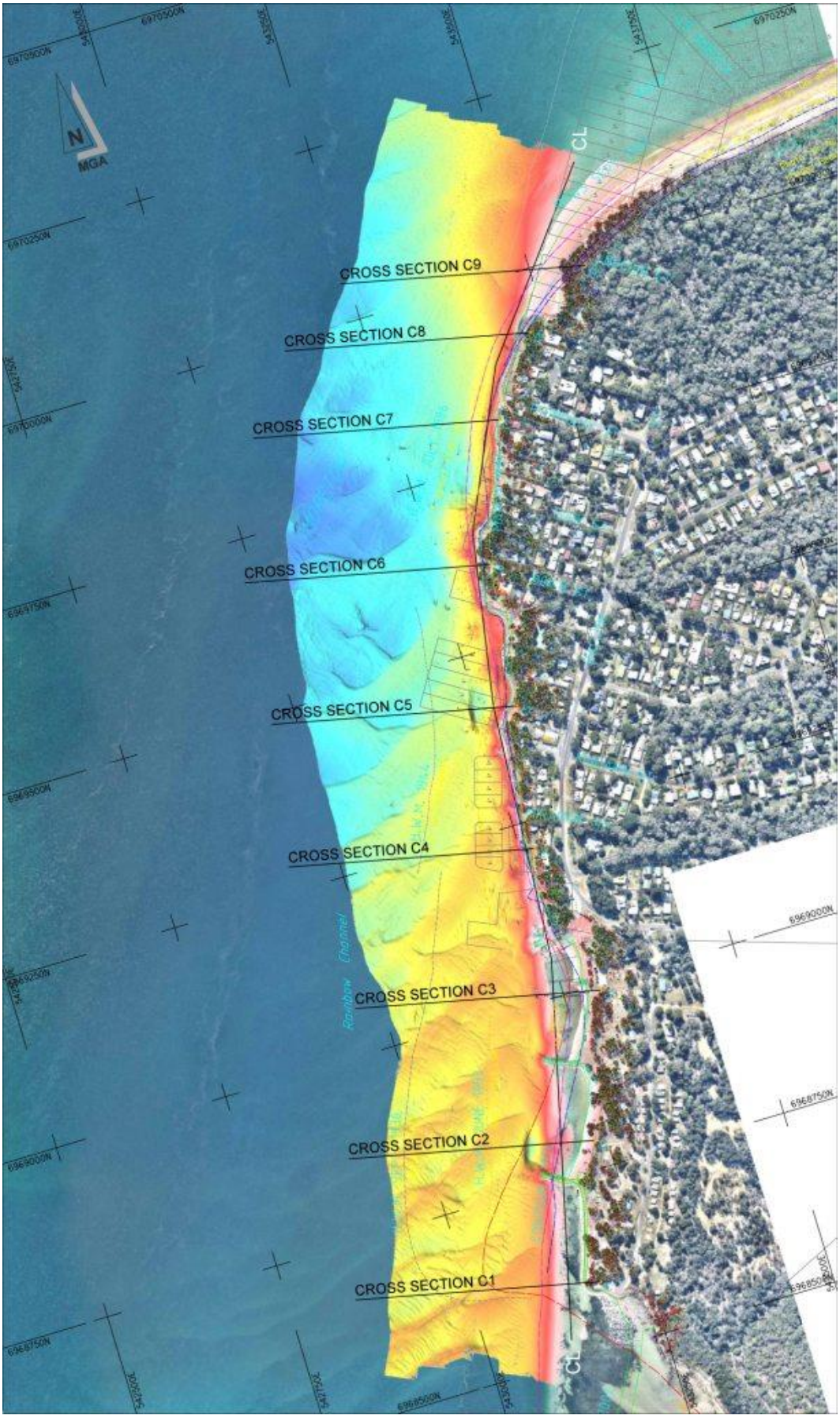
©PORT OF BRISBANE PTY LTD 2016

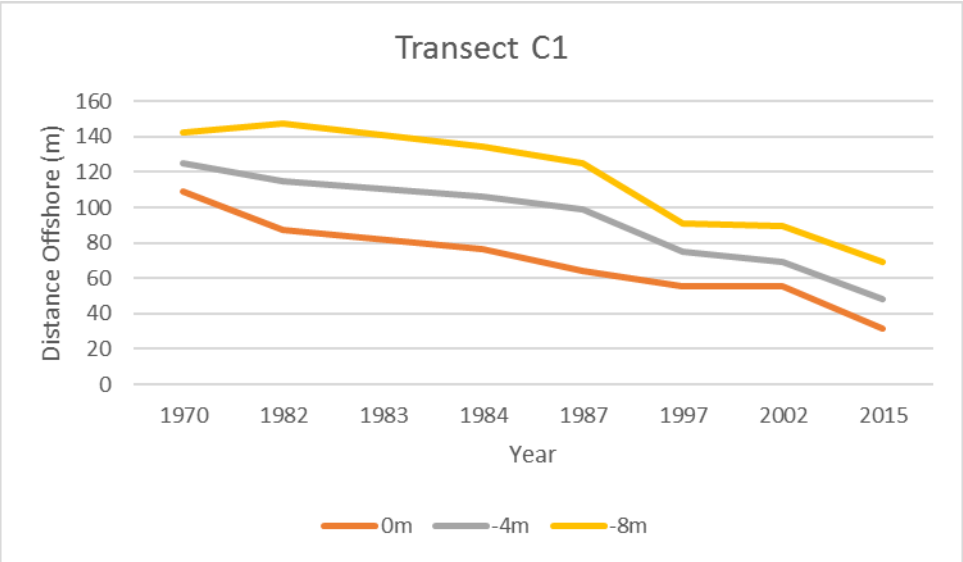
Dwg. No. 132670
Proj. File: AmityPoint.LWF

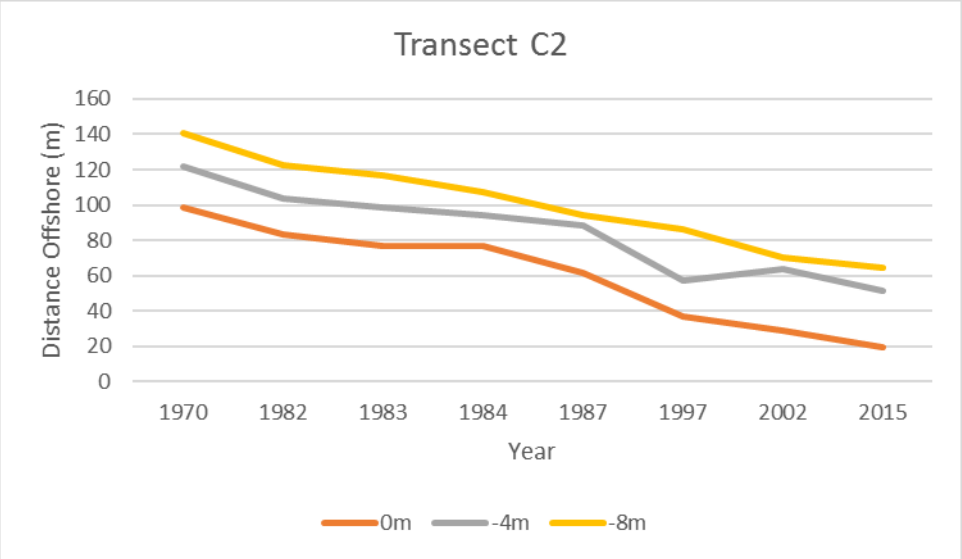
APPENDIX B
ANALYSIS OF RAINBOW CHANNEL MIGRATION

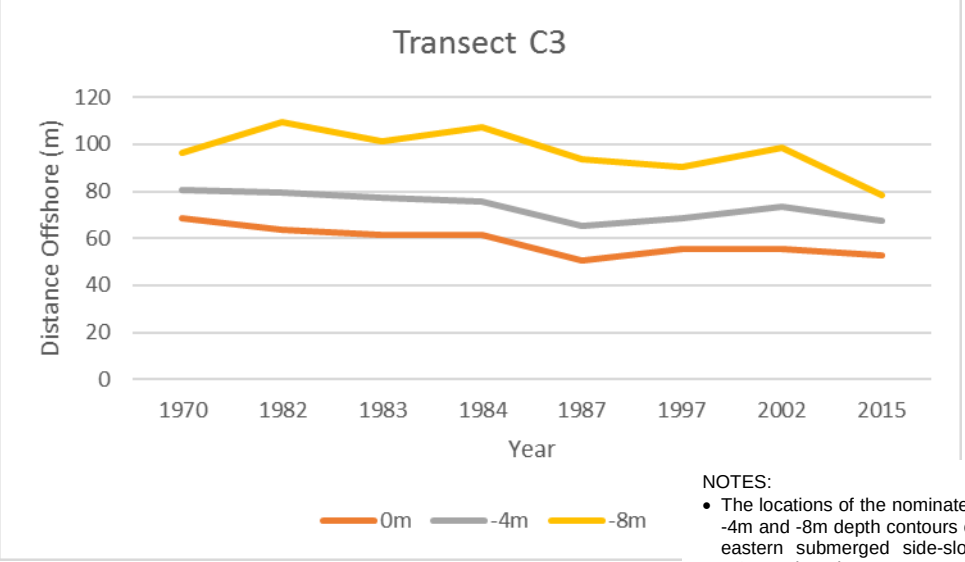
NOTES:

- The locations of the nominated 0m, -4m and -8m depth contours on the eastern submerged side-slope of RC are plotted.
- Distances offshore are measured from the position of HAT along the shoreline that was captured by survey in December 2015.


N
MGA
CL
CROSS SECTION C9
CROSS SECTION C8
CROSS SECTION C7
CROSS SECTION C6
CROSS SECTION C5
CROSS SECTION C4
CROSS SECTION C3
CROSS SECTION C2
CROSS SECTION C1
Rainbow Channel

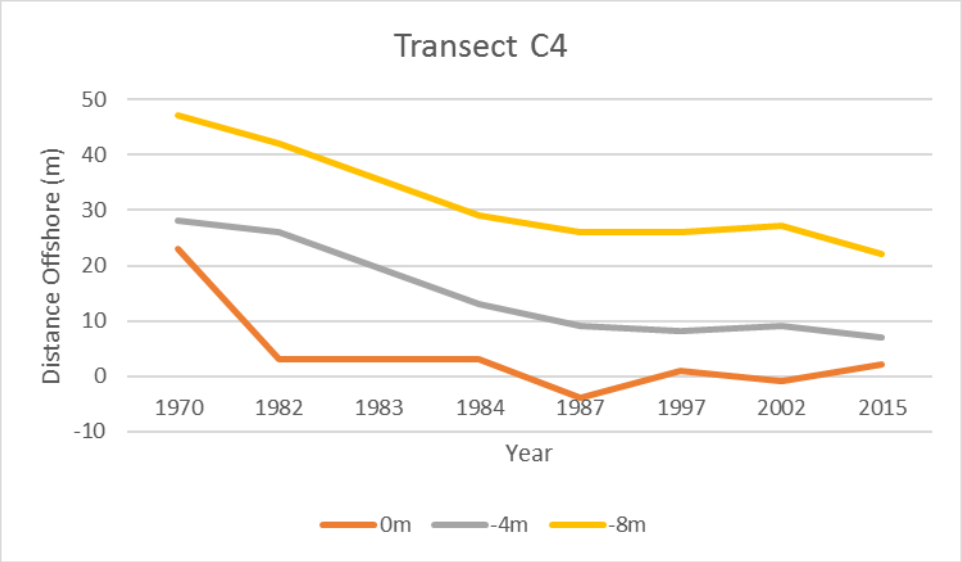


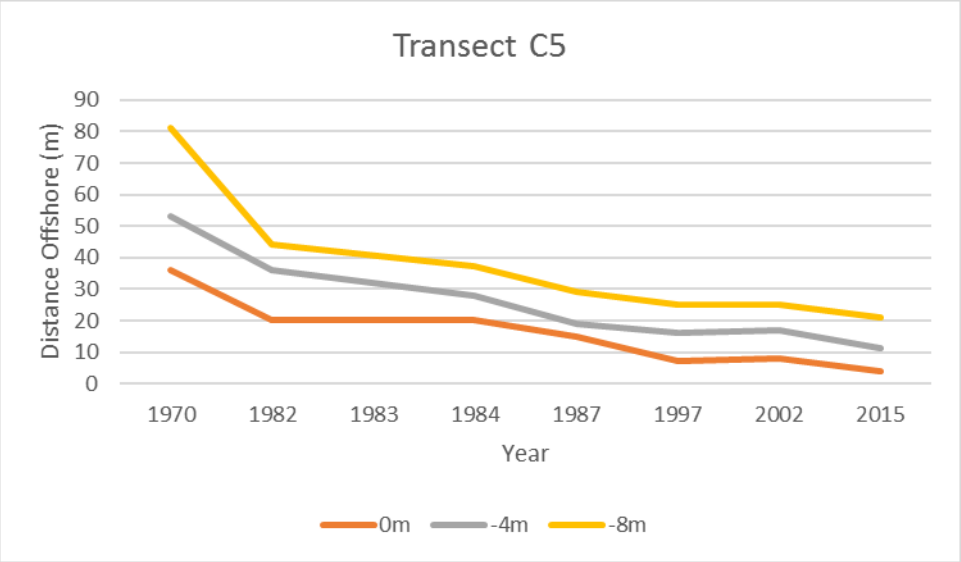


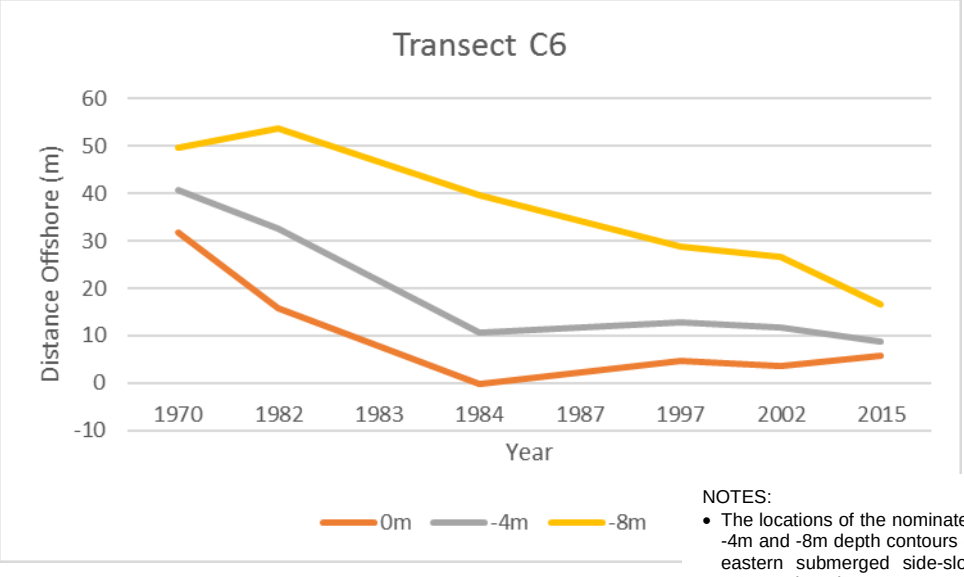


NOTES:

- The locations of the nominated 0m, -4m and -8m depth contours on the eastern submerged side-slope of RC are plotted.
- Distances offshore are measured from the position of HAT on the shoreline captured by survey in December 2015.

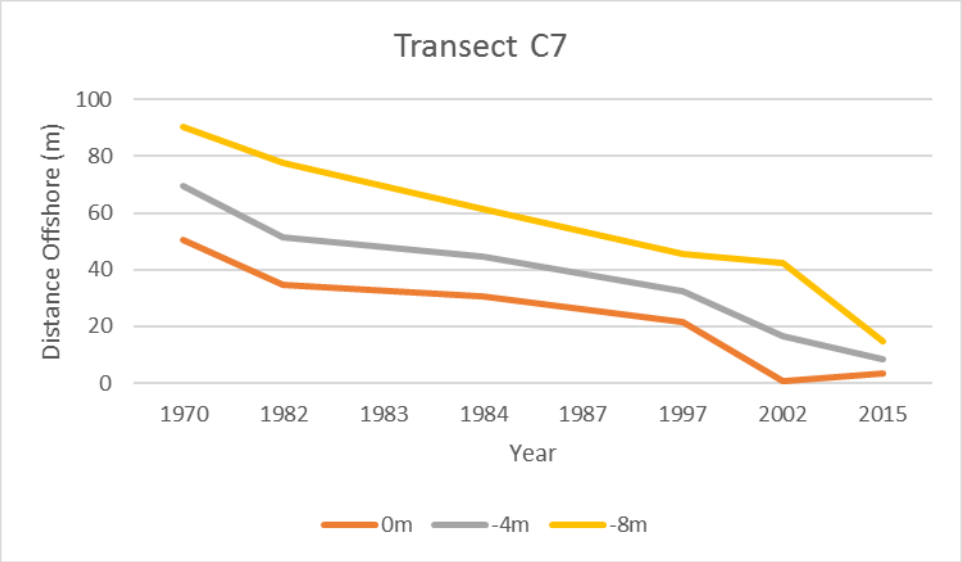


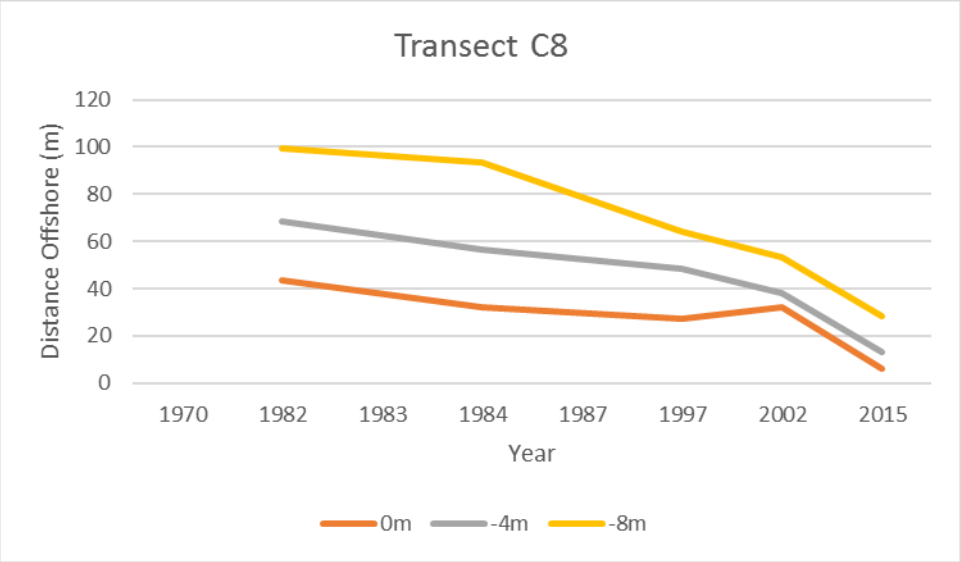


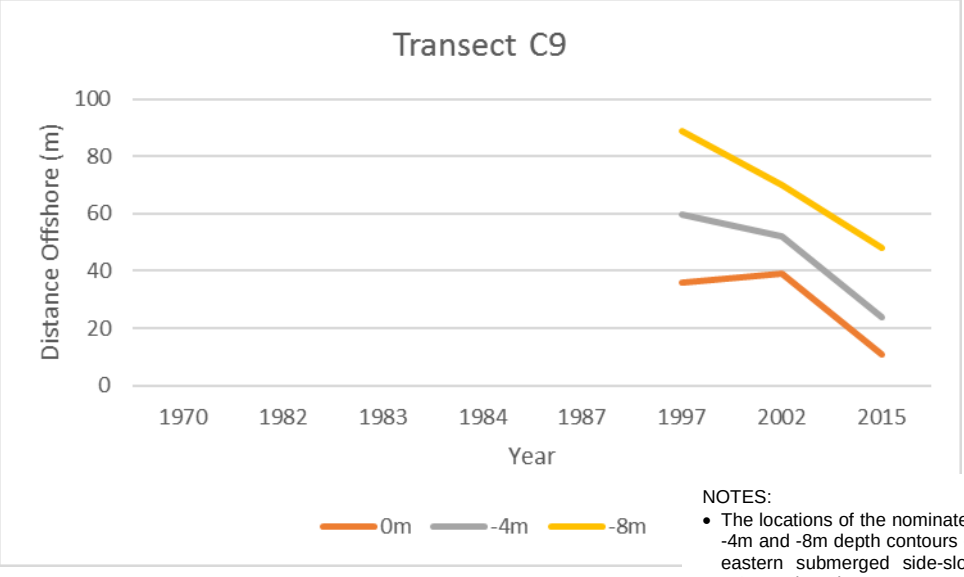


NOTES:

- The locations of the nominated 0m, -4m and -8m depth contours on the eastern submerged side-slope of RC are plotted.
- Distances offshore are measured from the position of HAT on the shoreline captured by survey in December 2015.







NOTES:

- The locations of the nominated 0m, -4m and -8m depth contours on the eastern submerged side-slope of RC are plotted.
- Distances offshore are measured from the position of HAT on the shoreline captured by survey in December 2015.

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX C
SUMMARY REPORT - AMITY POINT SEMP OPEN HOUSE



Summary Report – Amity Point SEMP Open House

Summary

Redland City Council's Community Engagement team in collaboration with Water Technology prepared an Open House event for the Amity Point Shoreline Erosion Management Plan. The Open House event took place on Saturday 23 April, 2016 at the Amity Point Community Hall. The aim of the Open House was to encourage the community to share their local knowledge of Amity Point and to learn/find out about the SEMP process and what it means for the township.

The Open House event was set up with a series of history and science rich display panels, and video presentations which illustrated:

- The aim of the projects and processes to produce a SEMP
- The history of Amity Point and experience with erosion
- Previous methods to manage and limit the extent of erosion
- Video footage of a 'Retrogressive Breach Failure' which is a commonly observed erosion feature at Amity Point
- A video presentation showing the changes that have occurred in the channel over a 26 year period, as captured by Google Earth
- Printed images of the recently completed hydrographic survey of a portion of the Amity Point foreshore and rock fill along Rainbow Channel.

The Open House also utilised a number of 'activities' which encouraged participants to consider the risks, values and possible management options in a holistic sense. The Open House was promoted through letterbox distribution of an invitation to all Amity point residents, posters which were put on display at key locations across North Stradbroke Island – ferry terminals, businesses, etc, and through direct contact with the Reference Group who leveraged their local networks to promote the event.

The community's response to the Open House was unanimously positive.

Key Open House Statistics

- Approximate number of attendees: ~100
- Approximate average attendee stay (duration): 45m-1hr
- Total number of engagement activity responses: Count (sign-in sheet), comments & post-its (Engagement activities)
- Event duration: 15 hours over 3 days
- Number of project team members present: 7

Background

The Open House event was initiated due to the progress of the Amity Point SEMP reaching a key milestone where it was necessary to engage the wider community on the project. Consultation with the community has been identified as a critical component of this project is complimented by the establishment of the Amity Point SEMP Community Reference Group (Reference Group). The Reference Group consists of local community members and groups who expressed an interest in the project and nominated to become a member.

The Event

Installation of the display panels for the open house event occurred on Thursday 21 April, allowing interested community members to drop-in prior to Saturday. The date for the open house was decided because of the high visitor numbers to North Stradbroke Island for holidays and long weekends, it was considered that with a high increase in population there was a likelihood that the event may experience additional interest from holiday renters or owners of holiday houses who do not live in the township permanently. The event was manned on Thursday, following installation (12pm-3pm), by a member of the Community Engagement Team and on Friday the event was left un-manned (9am – 3pm). The purpose of having an unmanned day during the consultation process was to encourage community members to visit the display and take note of the presented information in their own time without feeling 'pressured' into making comments.

Promotional material for the Open House was prepared and consisted of a letter to the Amity Point residents (Appendix 1) and posters (Appendix 2) were also created and installed at key locations across North Stradbroke Island – ferry terminals, notice boards and businesses – including Amity Point Community Club, the rangers office at the Camping ground, Seashells café, the library, Rufus King and the Little Ships Club at One Mile.

The Saturday Open House Event, from 9am – 3pm, was manned by members of the Council's Community Engagement Team and the SEMP Project team consisting of Council officers and Water Technology consultants. It was encouraging to see the number of local community members who visited the event on the day and were actively engaged and interested in the project. Furthermore, it is noted that the participants comprised many local community members who are not part of the SEMP Community Reference Group. This indicates that the role of the Reference Group to engage and disseminate information to the wider community has been successful and that the local community is interested in the Amity Point foreshore.

While it was anticipated that the local community's interest in foreshore management would be reflected in high levels of attendance, it was also noted that as a result of other community events taking place on the same day it was possible the number of attendees could have been higher. In total it is estimated that there was approximately one-hundred (100) community members who attended the Open House throughout the whole event.

An agreement has been made between Council's Community Engagement Team and the Dunwich Museum whereby panels from the open house event would be transferred to the Dunwich Museum for a static display. The panels to be displayed at the museum were to be identified by the

Museum's curators and will be held at the museum for an undisclosed period of time at which point will be returned to Council offices for storage, until needed again.

Display Panels

In total there were 11 full colour display panels installed throughout the Amity Point Community Hall outlining the SEMP process and history of Amity Point foreshore. The display panels were set out in the following order throughout the hall - refer to Appendix 3 for a copy of the display panels:

1. Welcome to the Open House
    a. What is it about?
    b. Aims of the Open House
2. What is a Shoreline Erosion Management Plan?
    a. How do you create a SEMP?
    b. Key Milestones
3. Story of Rainbow Channel
    a. Illustration of the realignment of South Passage
4. A snapshot of the European history of Amity Point
5. Why do flow side occur? *(pictorial of the observed erosion process)*
6. The story of the rock fill?
7. Why are we doing a SEMP?
8. Possible erosion mitigation strategy options
    a. Soft (or non-structural) solutions
    b. Hard (or structural) solutions
9. How does the SEMP fit in with other Council plans?
10. Hydrographic Survey – detailing the bathymetry of the rock fill and a portion of Rainbow channel
11. Hydrographic Survey– detailing the bathymetry of the rock fill and a portion of Rainbow channel

Activities

The activities at the Open House consisted of installing blank pieces of paper, essentially large post-it notes, with a leading question on the top of the page. The aim of this exercise is to encourage participants to consider the values and risks associated with the entire Amity Point foreshore. The benefit of this exercise is that requires participants to consider the holistic nature of management planning. The comments also reflect the breadth and depth of local knowledge and understanding about issues impacting on the foreshore.

What Changes have you seen?

- To date there has been too little help and so erosion continues
- The water table has lowered over last 10-15 years and does this affect hydrostatic pressure – and so impact on erosion?
- Middle sand bar has grown towards Amity Point by 300m+ - narrowing of main channel and increases to water flow rate (tide)

- There is a new channel forming to southern side of sand island parallel to top end of Rous Channel (about 5m)
- The deep water of channel is now much closer to the rock wall
- Oyster leases at Dialba Passage have increased in height, new sand levels by approximately 500mm.
- Middle Bank at 'Welsby Light' is much higher just below the low water mark.
- Draining of swamps at right angles to existing swamp. Water drains to Wallum Creek
- Need to protect $1M boat ramp that is used by tourist and commercial/professional fisherman
- The basin used to be a suitable for a large boat mooring area
- Very few changes in most areas as the rock fill seem to be holding along the Central Precinct

What mitigation area best suited to which precinct – why?

- Homes need to be protected
    - When will it start + who will pay?
- Channel diversion
    - Sink a big ship for divers, tourism, break flow current
    - NB: Beware of unintended consequences
- Look overseas → reefs, substitutes
    - Remember the load of coral put south side of the current jetty. This was to solve erosion but all the coral went out to sea on the first few high tides.
- Harness the channel energy → turbines to generate electricity to power our homes free of charge
- The owners on shoreline are responsible for paying for the rock which protects all of Amity. This does not seem fair.
- Attention to swamp outlet from Birch St to Tennis courts – erosion happening and backs up to swamp behind Gonzales St
- Fed up with "stop gap" measures
- Hard structural wall needed
- Need to stop four-wheel drive (4x4) traffic on the foreshore from Main beach to Amity Beach. Used to be signed (no longer) barrier. Traffic damages beach structure
- Central and southern precinct extend existing hard bottom in channel, maybe pylons at front of houses which could be backfilled
- The coast line in front of camping ground is vulnerable to erosion – will the rock wall be extended? Is there another solution?

Interactive mapping exercise

An interactive mapping exercise was undertaken at the event which was a printed map of Amity Point, separated into three precincts. The Northern Precinct consisted of Amity Beach and foreshore area; the Central Precinct was predominantly the rock fill section; and, the Southern Precinct being the boat ramp and beach south including the caravan park (refer to appendix 4). To engage the participants at the Open House event a separate map was printed which included a question – seeking the views of participants. In total there were seven (7) questions which sought to engage the participants at the Open House event, being:

1. What near-shore areas of Amity Point are important to local and regional marine biodiversity?
2. What changes have you seen and where?
3. What infrastructure such as roads, water, sewerage is important to the community?
4. Are there specific locations at Amity Point that are important to European heritage?
5. Are there any specific locations at Amity Point with important environmental values?
6. Are there specific locations at Amity Point that are important to Aboriginal heritage?
7. What are the implications of erosion threat to the community?

The outcome of this engagement activity was mixed with a number of comments attached to particular questions providing additional insight to the attributes and aspects of Amity Point which the community value. However, it is noted that some of the comments provided to particular maps did not match the question being asked. This indicates that the Open House project team should have placed a greater emphasis and guidance to ensure the participants was better informed and able to complete the activity.

Conclusion

The Amity Point SEMP Open House should be considered a successful engagement event based on the number of participants who attended, comments and general feedback received. The material from the open house, in particular the comments from the 'activities' will be used to help inform the development of the SEMP. These materials will also be attached as extrinsic material in the final SEMP document. The key lessons learnt from the event was the wider interest of the SEMP project from members of the Amity Point community who are not part of the SEMP Reference Group as well as members from the other townships at Point Lookout and Dunwich. The event also reaffirmed the enthusiasm of the Amity Point community in being involved in strategic planning projects within their township and importance of engaging the community during the development of a project.

APPENDIX 1 – Letter to Residents

12 April 2016

Dear Amity Point Resident

As you know, the Amity Point foreshore is constantly changing

Through talking to Amity Point and North Stradbroke Island residents and consultants, including specialised coastal engineers from Water Technology, Council has learnt a great deal about how, when and why these changes occur.

Council invites you to the Amity Point Shoreline Erosion Management Plan (SEMP) Open House, to:

- share this local knowledge, history and science (including a survey of the channel)
- find out if there is anything else relevant that you know, and
- find out what you and other members of the local community value most about Amity Point.

At the Open House you will be able to talk to the Amity Point SEMP project team, including a Council Planner, and Water Technology's consulting coastal engineer.

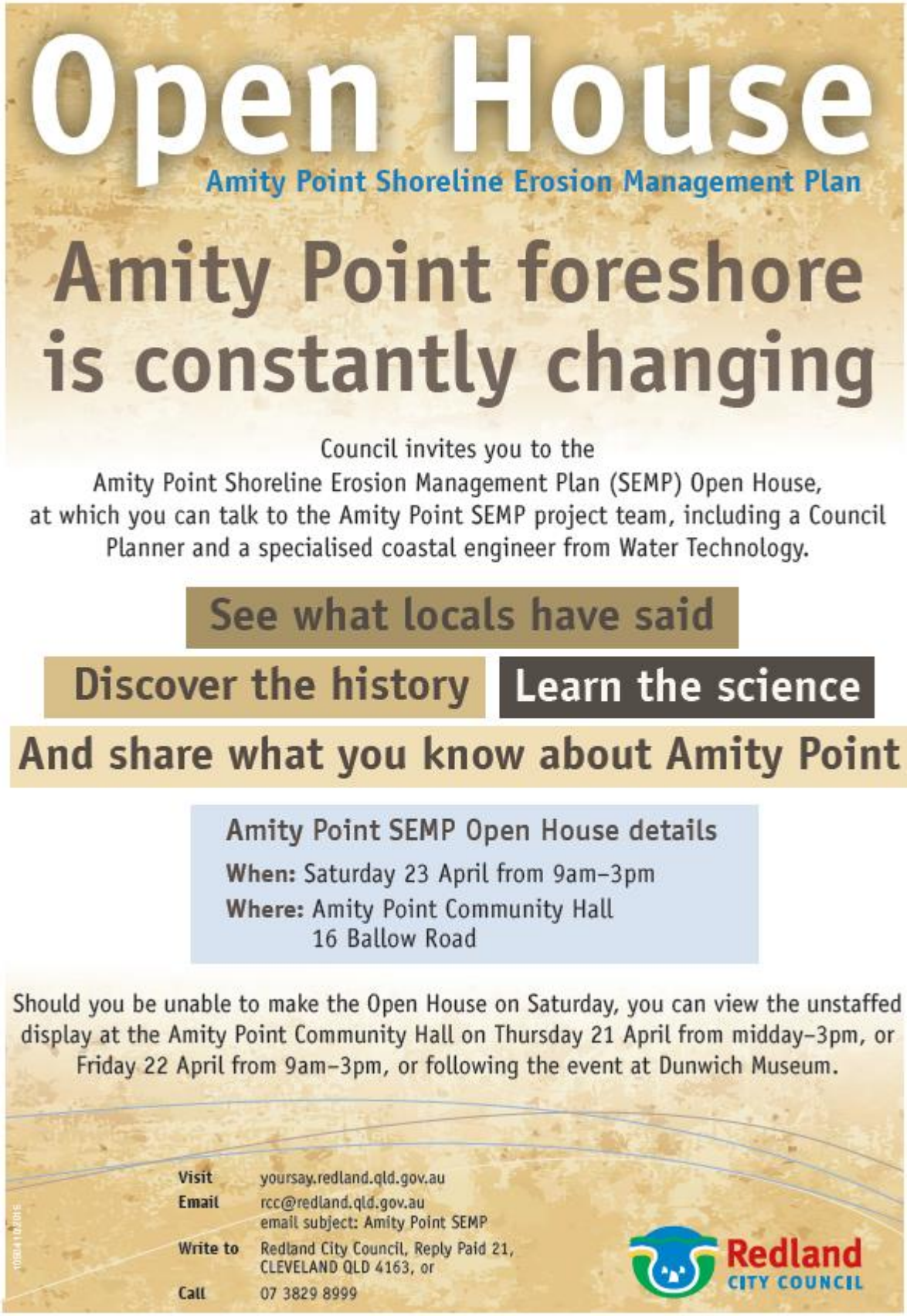
Amity Point SEMP Open House details
When: Saturday 23 April from 9am–3pm
Where: Amity Point Community Hall, 16 Ballow Road

Should you be unable to make the Open House on Saturday, you can view the unstaffed display at the Amity Point Community Hall on Thursday 21 April between 12pm–3pm, or Friday 22 April between 9am–3pm, or following the event at Dunwich Museum.

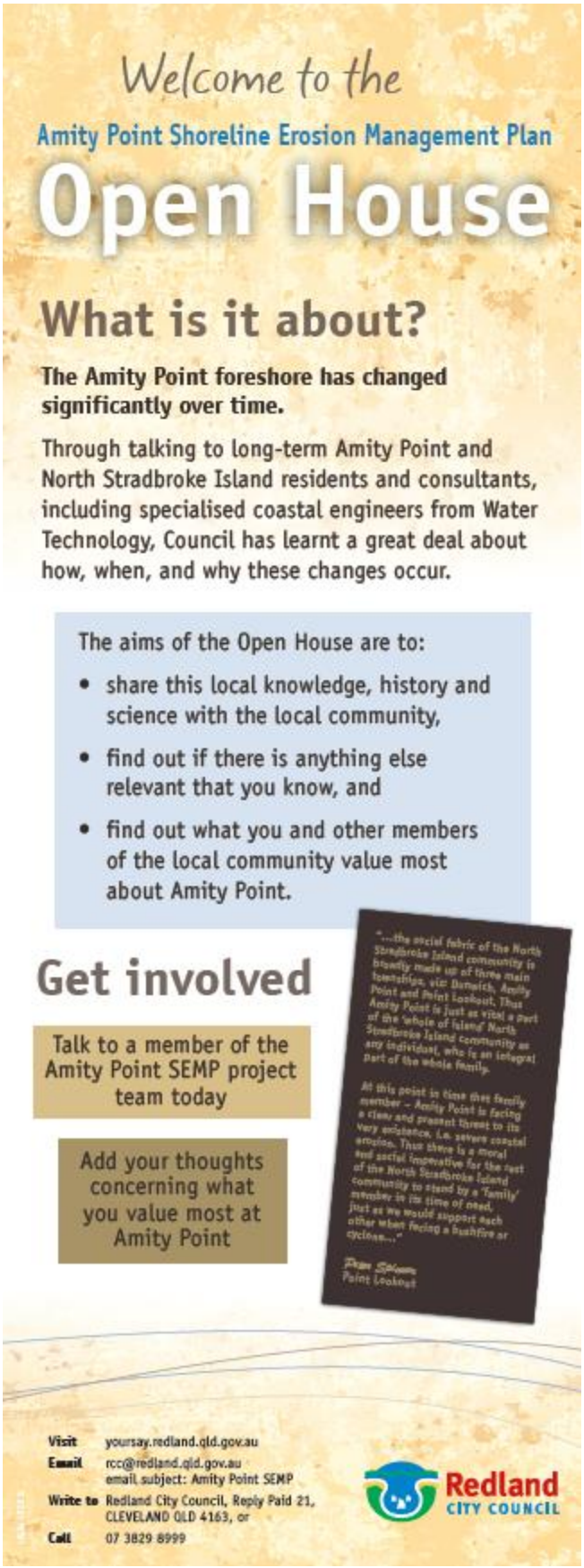
For further information, contact Bernard Houston at Redland City Council on 07 3829 8999, or email rcc@redland.qld.gov.au

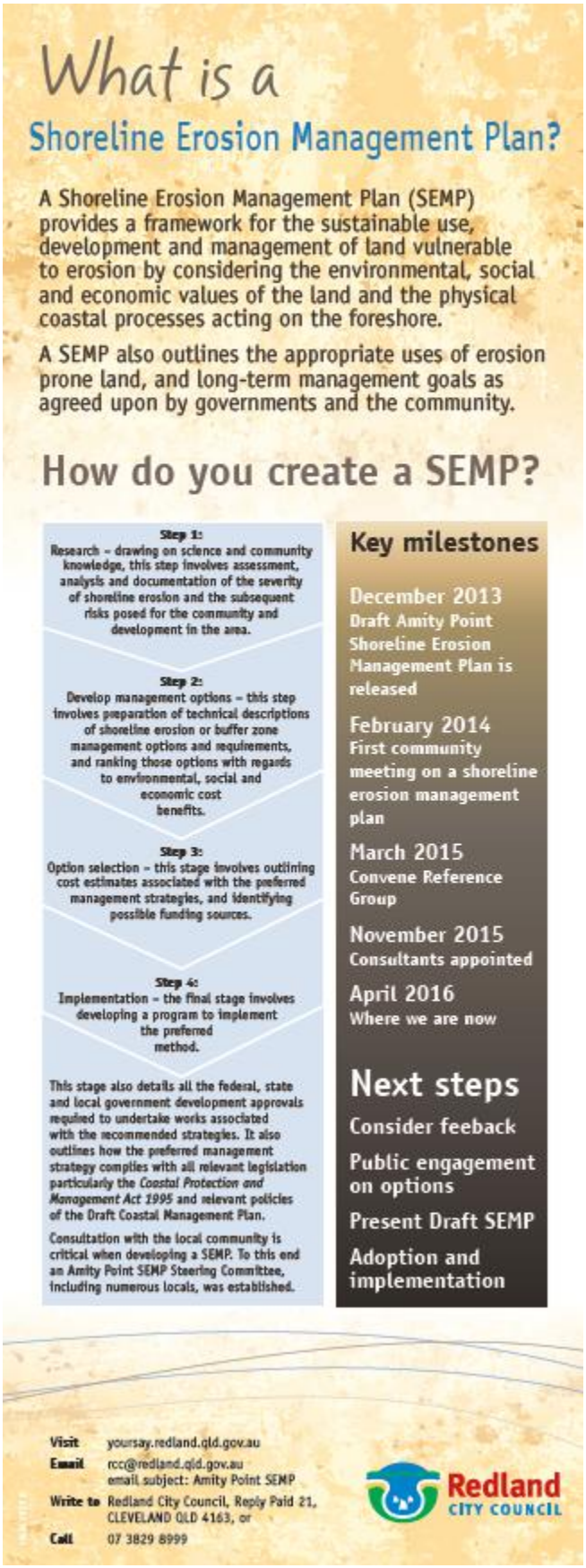
Amity Point SEMP Project Team

APPENDIX 2 - Poster



APPENDIX 3 – Display Panels





What is a Shoreline Erosion Management Plan?

A Shoreline Erosion Management Plan (SEMP) provides a framework for the sustainable use, development and management of land vulnerable to erosion by considering the environmental, social and economic values of the land and the physical coastal processes acting on the foreshore.

A SEMP also outlines the appropriate uses of erosion prone land, and long-term management goals as agreed upon by governments and the community.

How do you create a SEMP?

Step 1:
Research – drawing on science and community knowledge, this step involves assessment, analysis and documentation of the severity of shoreline erosion and the subsequent risks posed for the community and development in the area.

Step 2:
Develop management options – this step involves preparation of technical descriptions of shoreline erosion or buffer zone management options and requirements, and ranking those options with regards to environmental, social and economic cost benefits.

Step 3:
Option selection – this stage involves outlining cost estimates associated with the preferred management strategies, and identifying possible funding sources.

Step 4:
Implementation – the final stage involves developing a program to implement the preferred method.

This stage also details all the federal, state and local government development approvals required to undertake works associated with the recommended strategies. It also outlines how the preferred management strategy complies with all relevant legislation particularly the *Coastal Protection and Management Act 1995* and relevant policies of the Draft Coastal Management Plan.

Consultation with the local community is critical when developing a SEMP. To this end an Amity Point SEMP Steering Committee, including numerous locals, was established.

Key milestones

December 2013
Draft Amity Point Shoreline Erosion Management Plan is released

February 2014
First community meeting on a shoreline erosion management plan

March 2015
Convene Reference Group

November 2015
Consultants appointed

April 2016
Where we are now

Next steps

Consider feeback

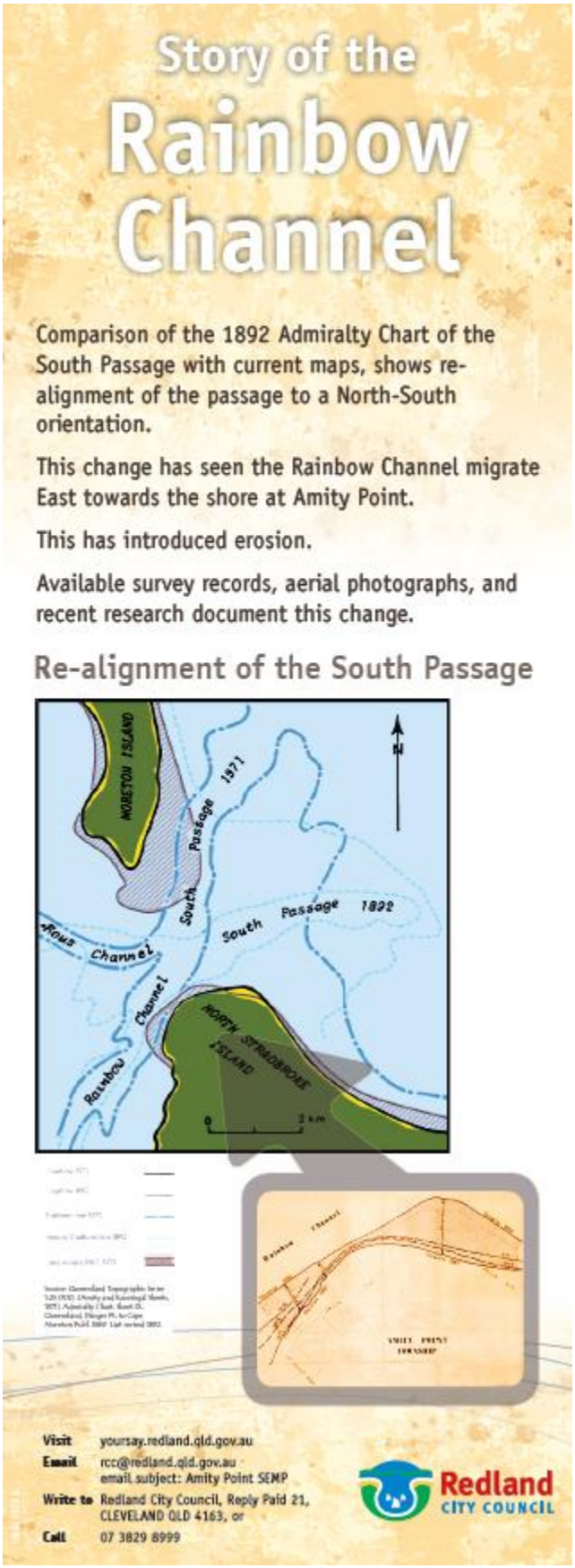
Public engagement on options

Present Draft SEMP

Adoption and implementation

Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au
email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21, CLEVELAND QLD 4163, or
Call 07 3829 8999

Redland CITY COUNCIL


Story of the
Rainbow Channel
Comparison of the 1892 Admiralty Chart of the South Passage with current maps, shows re-alignment of the passage to a North-South orientation.
This change has seen the Rainbow Channel migrate East towards the shore at Amity Point.
This has introduced erosion.
Available survey records, aerial photographs, and recent research document this change.
Re-alignment of the South Passage
MORETON ISLAND
South Passage 1971
South Passage 1892
Rainbow Channel
NORTH STRADBROKE ISLAND
N
0
3 km
Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au
email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21, CLEVELAND QLD 4163, or
Call 07 3829 8999
Redland CITY COUNCIL

A snapshot of the European history of Amity Point



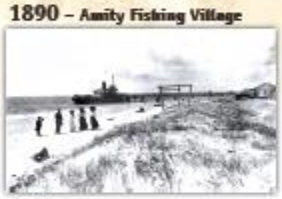
1823 – Pilot Station
Watercolour by Owen Stanley



1890 – Amity Fishing Village



1891 – Crouch's Fishing Amity



1910 – Amity Point Jetty



1920 – Amity Point Jetty



1926 – Amity Races



1938 – Wooley's Kiosk



1947 – Amity Tavern Washes In



1950 – Amity Boat Ramp

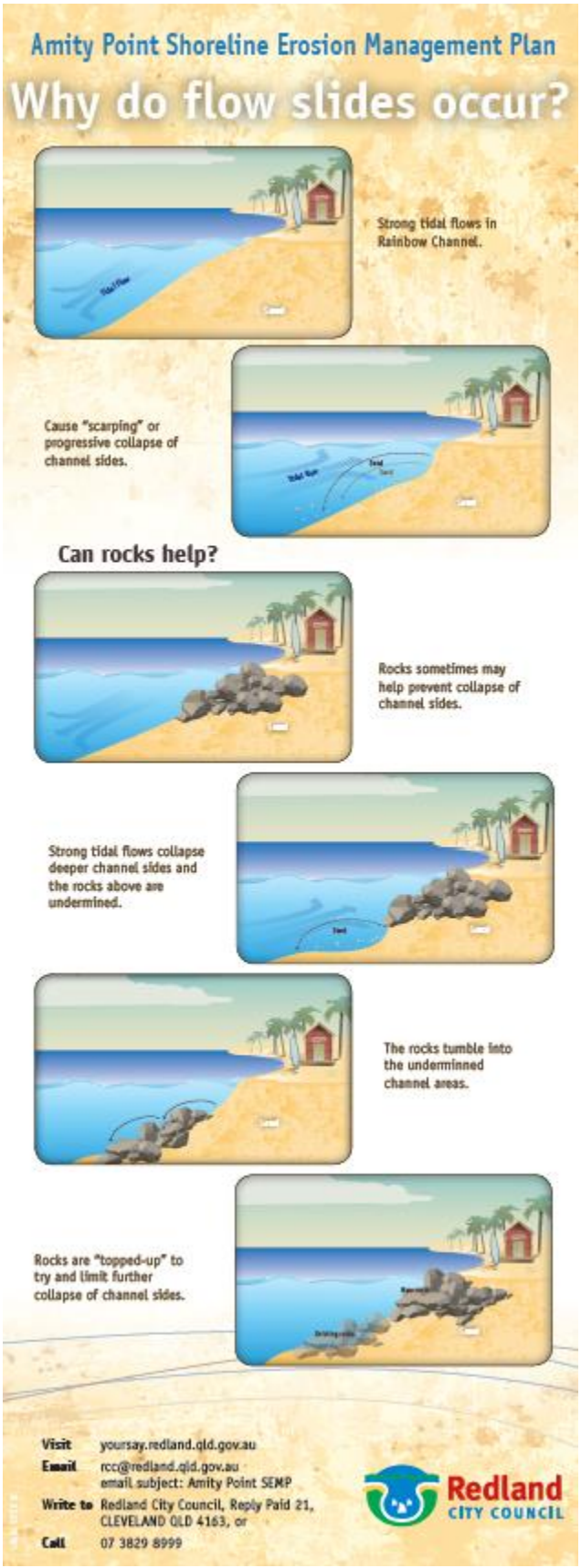
Thank you to the North Stradbroke Island Historical Museum for assistance in providing some of these photos.

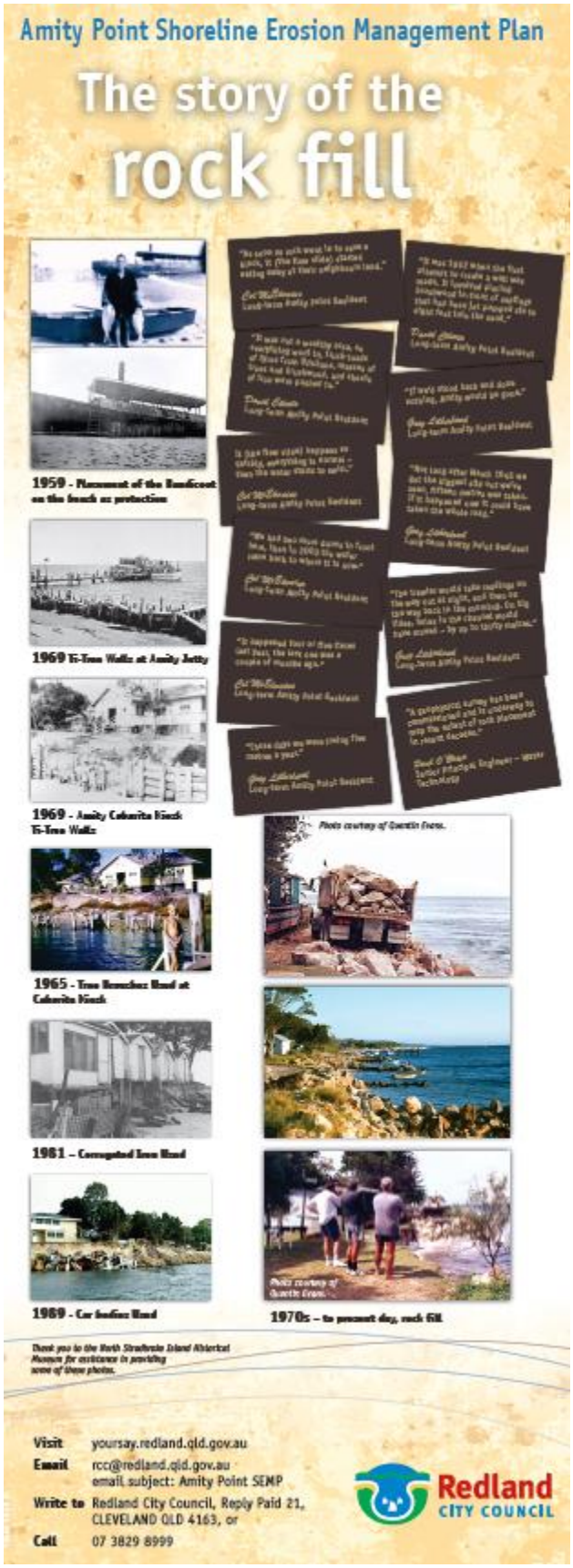


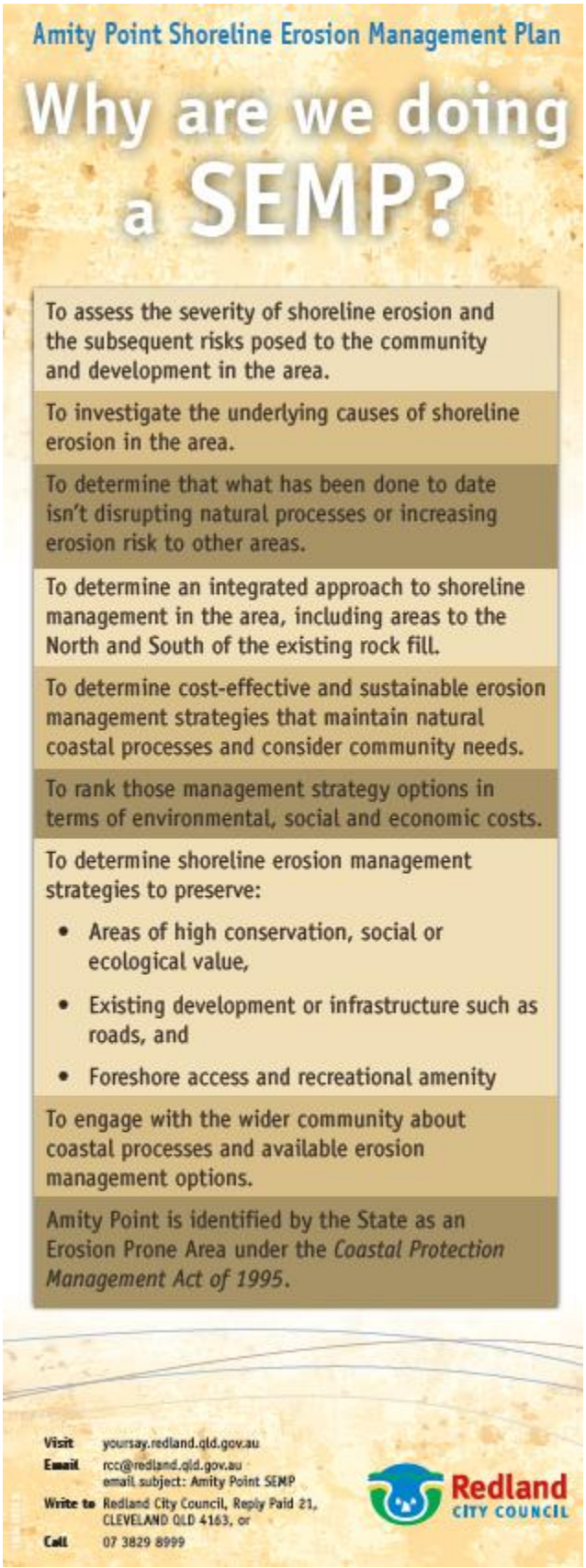
1993 – The 93 Flow Slide

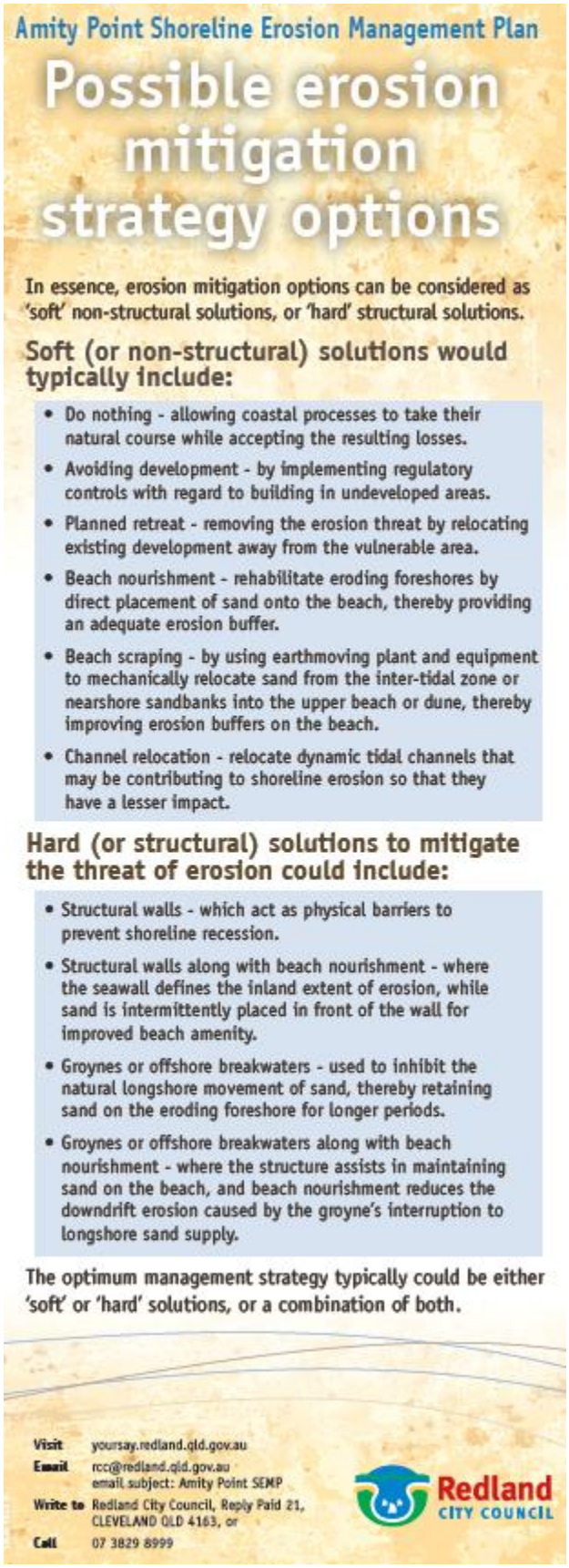
Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au
email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21, CLEVELAND QLD 4163, or
Call 07 3829 8999

Redland CITY COUNCIL


Amity Point Shoreline Erosion Management Plan
Why do flow slides occur?
Strong tidal flows in Rainbow Channel.
Cause "scarping" or progressive collapse of channel sides.
Can rocks help?
Rocks sometimes may help prevent collapse of channel sides.
Strong tidal flows collapse deeper channel sides and the rocks above are undermined.
The rocks tumble into the underminned channel areas.
Rocks are "topped-up" to try and limit further collapse of channel sides.
Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au
email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21, CLEVELAND QLD 4163, or
Call 07 3829 8999
Redland CITY COUNCIL


Amity Point Shoreline Erosion Management Plan
The story of the
rock fill
1959 - Placement of the Bandicoot on the beach as protection
1969 Ti-Tree Walks at Amity Jetty
1969 - Amity Cabarita Block Ti-Tree Walk
1965 - Tree Branches Used at Cabarita Block
1981 – Corrugated Iron Used
1989 - Car Bodies Used
Photo courtesy of Quentin Evans.
1970s – to present day, rock fill
Thank you to the North Stradbroke Island Historical Museum for assistance in providing some of these photos.
Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au
email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21, CLEVELAND QLD 4163, or
Call 07 3829 8999
Redland
CITY COUNCIL


Amity Point Shoreline Erosion Management Plan
Why are we doing a SEMP?
To assess the severity of shoreline erosion and the subsequent risks posed to the community and development in the area.
To investigate the underlying causes of shoreline erosion in the area.
To determine that what has been done to date isn't disrupting natural processes or increasing erosion risk to other areas.
To determine an integrated approach to shoreline management in the area, including areas to the North and South of the existing rock fill.
To determine cost-effective and sustainable erosion management strategies that maintain natural coastal processes and consider community needs.
To rank those management strategy options in terms of environmental, social and economic costs.
To determine shoreline erosion management strategies to preserve:
• Areas of high conservation, social or ecological value,
• Existing development or infrastructure such as roads, and
• Foreshore access and recreational amenity
To engage with the wider community about coastal processes and available erosion management options.
Amity Point is identified by the State as an Erosion Prone Area under the Coastal Protection Management Act of 1995.
Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au
email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21, CLEVELAND QLD 4163, or
Call 07 3829 8999
Redland CITY COUNCIL



Amity Point Shoreline Erosion Management Plan

Possible erosion mitigation strategy options

In essence, erosion mitigation options can be considered as 'soft' non-structural solutions, or 'hard' structural solutions.

Soft (or non-structural) solutions would typically include:

- Do nothing - allowing coastal processes to take their natural course while accepting the resulting losses.
- Avoiding development - by implementing regulatory controls with regard to building in undeveloped areas.
- Planned retreat - removing the erosion threat by relocating existing development away from the vulnerable area.
- Beach nourishment - rehabilitate eroding foreshores by direct placement of sand onto the beach, thereby providing an adequate erosion buffer.
- Beach scraping - by using earthmoving plant and equipment to mechanically relocate sand from the inter-tidal zone or nearshore sandbanks into the upper beach or dune, thereby improving erosion buffers on the beach.
- Channel relocation - relocate dynamic tidal channels that may be contributing to shoreline erosion so that they have a lesser impact.

Hard (or structural) solutions to mitigate the threat of erosion could include:

- Structural walls - which act as physical barriers to prevent shoreline recession.
- Structural walls along with beach nourishment - where the seawall defines the inland extent of erosion, while sand is intermittently placed in front of the wall for improved beach amenity.
- Groynes or offshore breakwaters - used to inhibit the natural longshore movement of sand, thereby retaining sand on the eroding foreshore for longer periods.
- Groynes or offshore breakwaters along with beach nourishment - where the structure assists in maintaining sand on the beach, and beach nourishment reduces the downdrift erosion caused by the groyne's interruption to longshore sand supply.

The optimum management strategy typically could be either 'soft' or 'hard' solutions, or a combination of both.

Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au
email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21, CLEVELAND QLD 4163, or
Call 07 3829 8999

Redland CITY COUNCIL

Amity Point Shoreline Erosion Management Plan

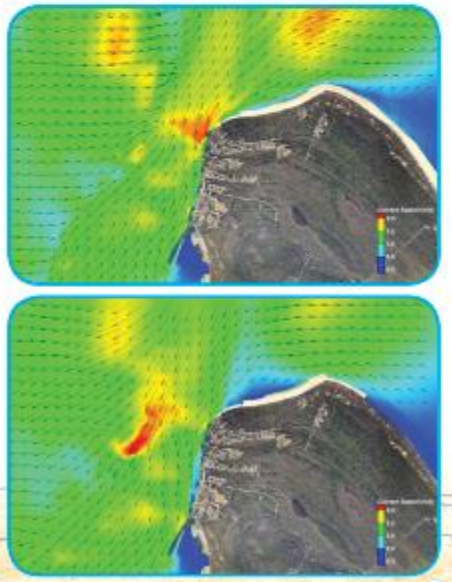
How does the SEMP fit in with other Council plans?

Management of coastal areas that are vulnerable to erosion is complex due to varying land tenure, high recreational and ecological values, competing interests in the land, and coastal processes. Long term planning for these areas must also consider the potential for coastal hazards, such as storm tide events and flooding, and the need for adaptation to climate change induced sea-level rise.

Also on display

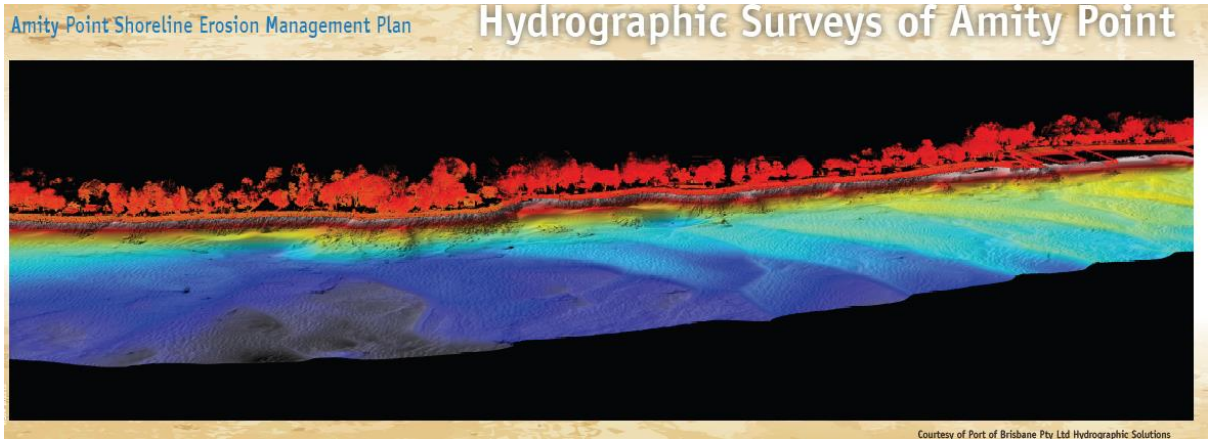
- Storm surge maps from City Plan
- Coastal erosion maps from City Plan
- City Plan zone map
- Explanations of zones and overlays panel from City Plan
- Explanation of tables of assessment from City Plan

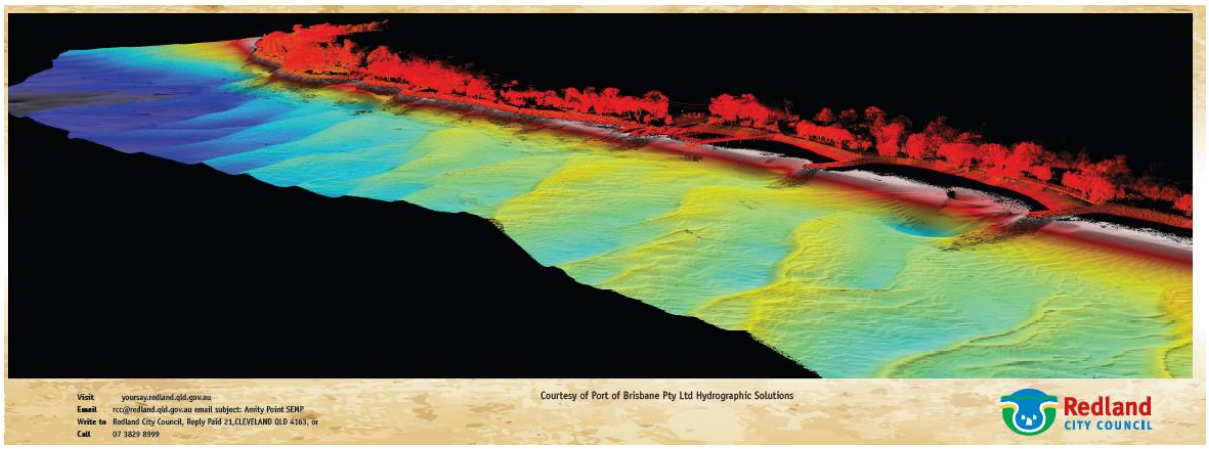
Amity Point Coastal processes



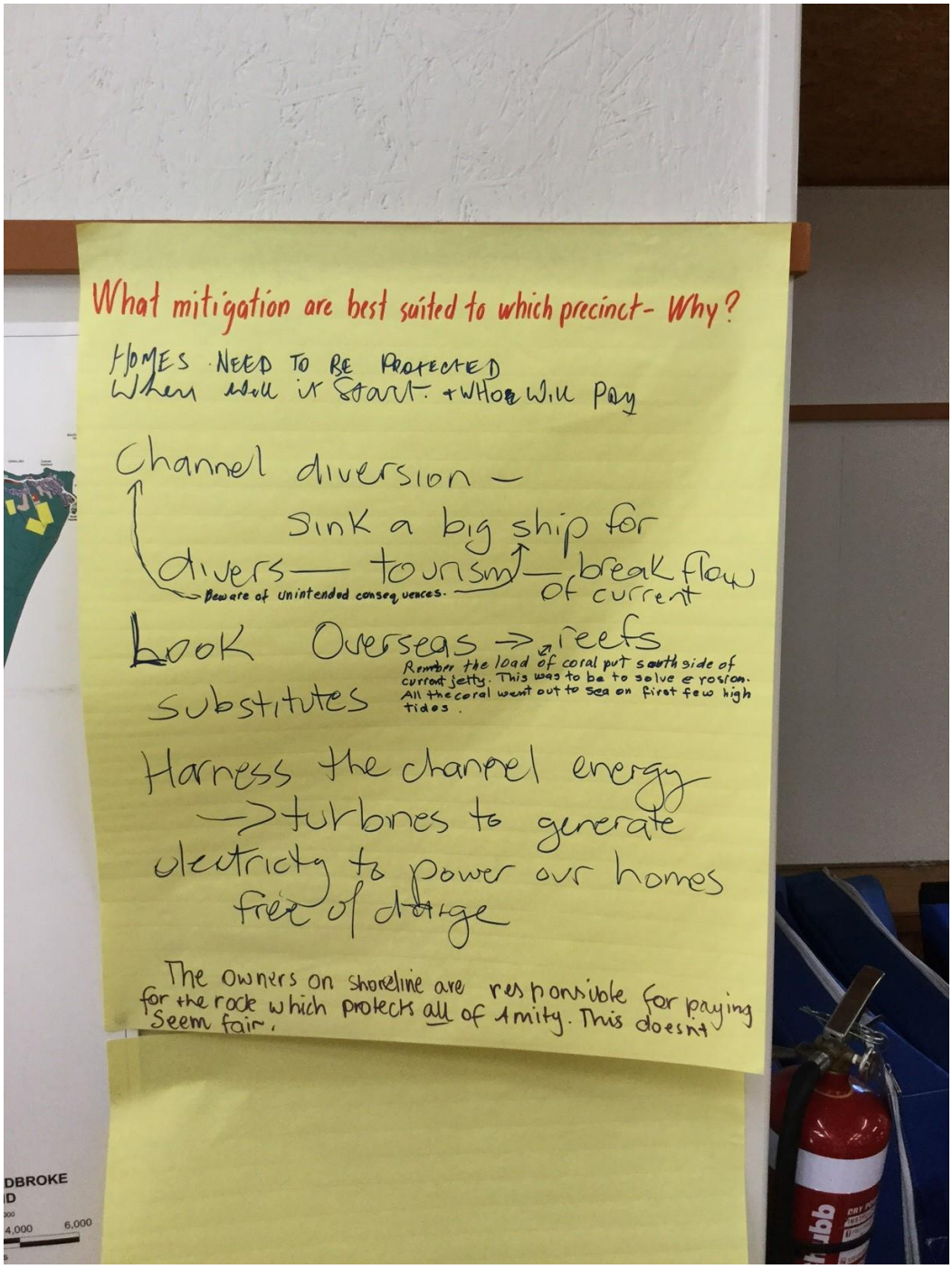
Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au
email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21, CLEVELAND QLD 4163, or
Call 07 3829 8999

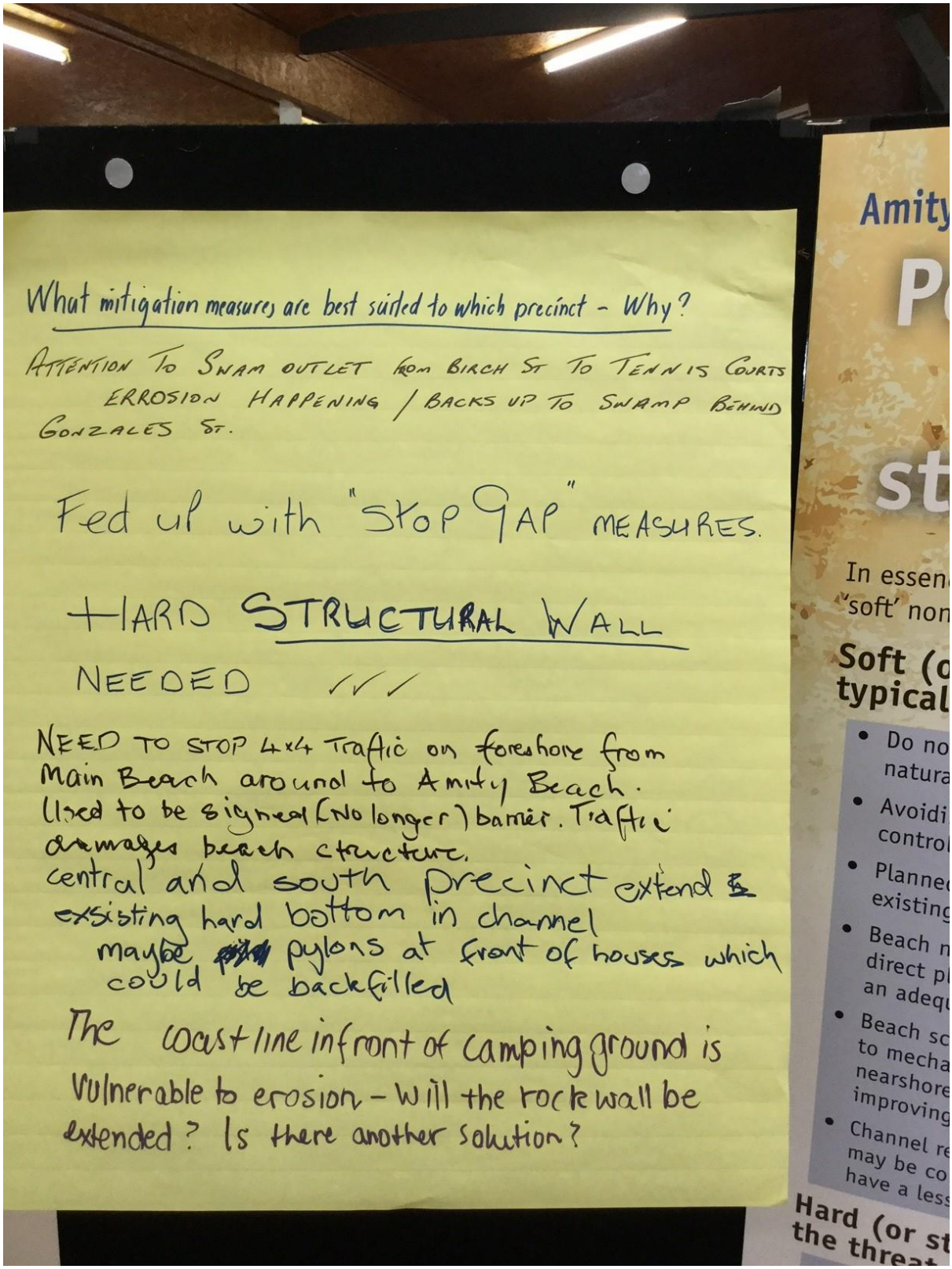
Redland CITY COUNCIL

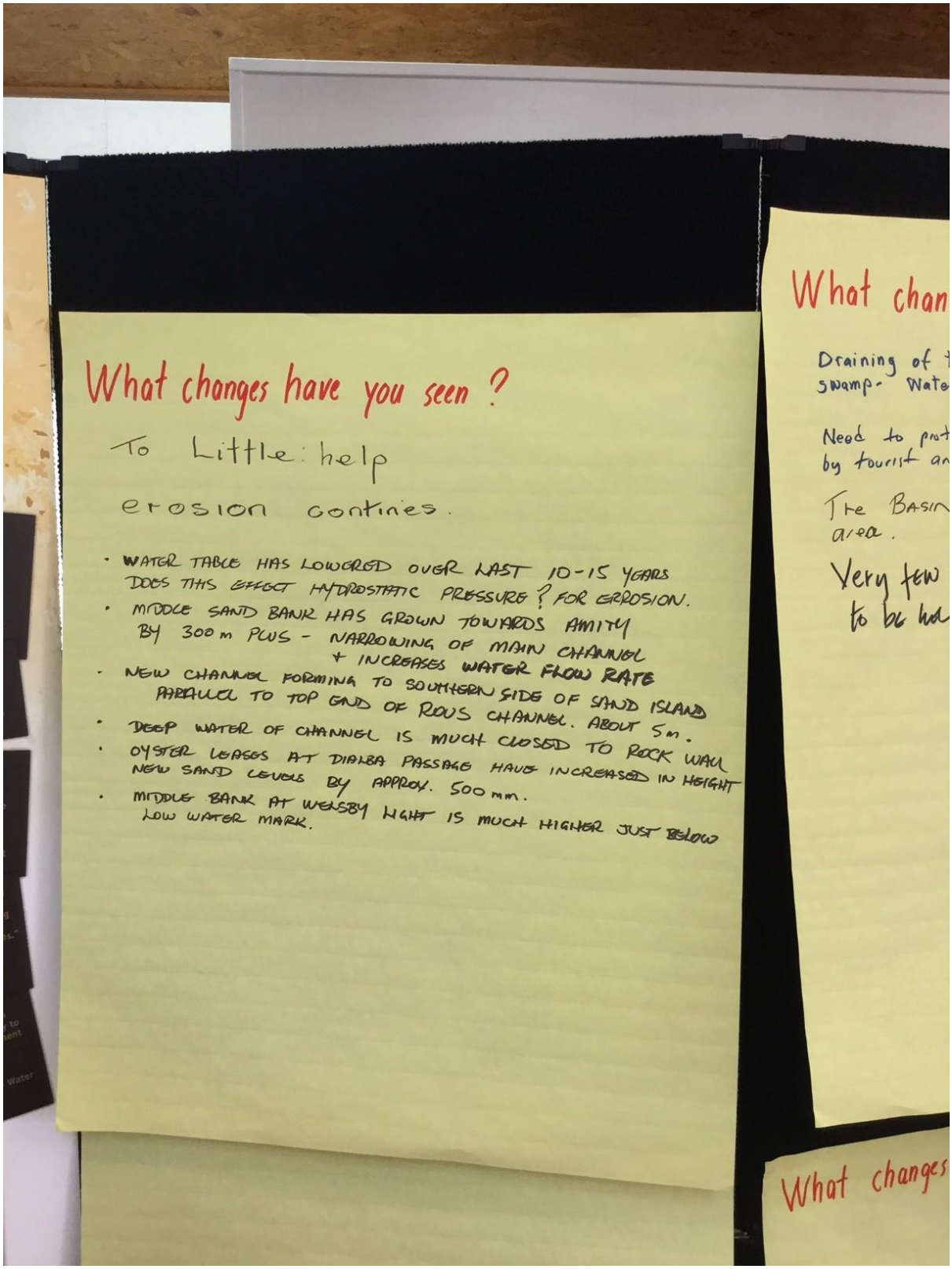

Amity Point Shoreline Erosion Management Plan
Hydrographic Surveys of Amity Point
Courtesy of Port of Brisbane Pty Ltd Hydrographic Solutions

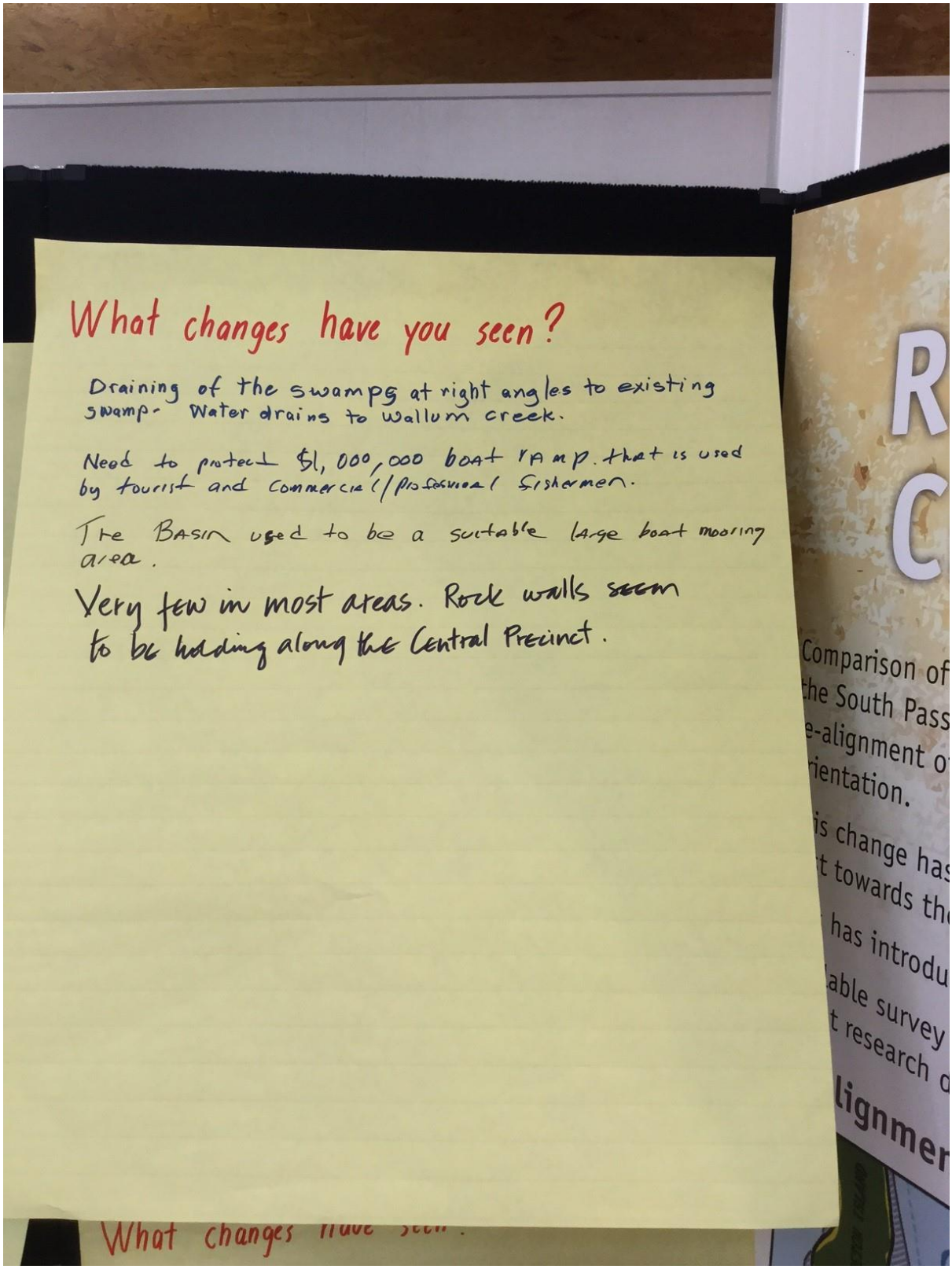

Visit yoursay.redland.qld.gov.au
Email rcc@redland.qld.gov.au email subject: Amity Point SEMP
Write to Redland City Council, Reply Paid 21,CLEVELAND QLD 4163, or
Call 07 3829 8999
Courtesy of Port of Brisbane Pty Ltd Hydrographic Solutions
Redland
CITY COUNCIL

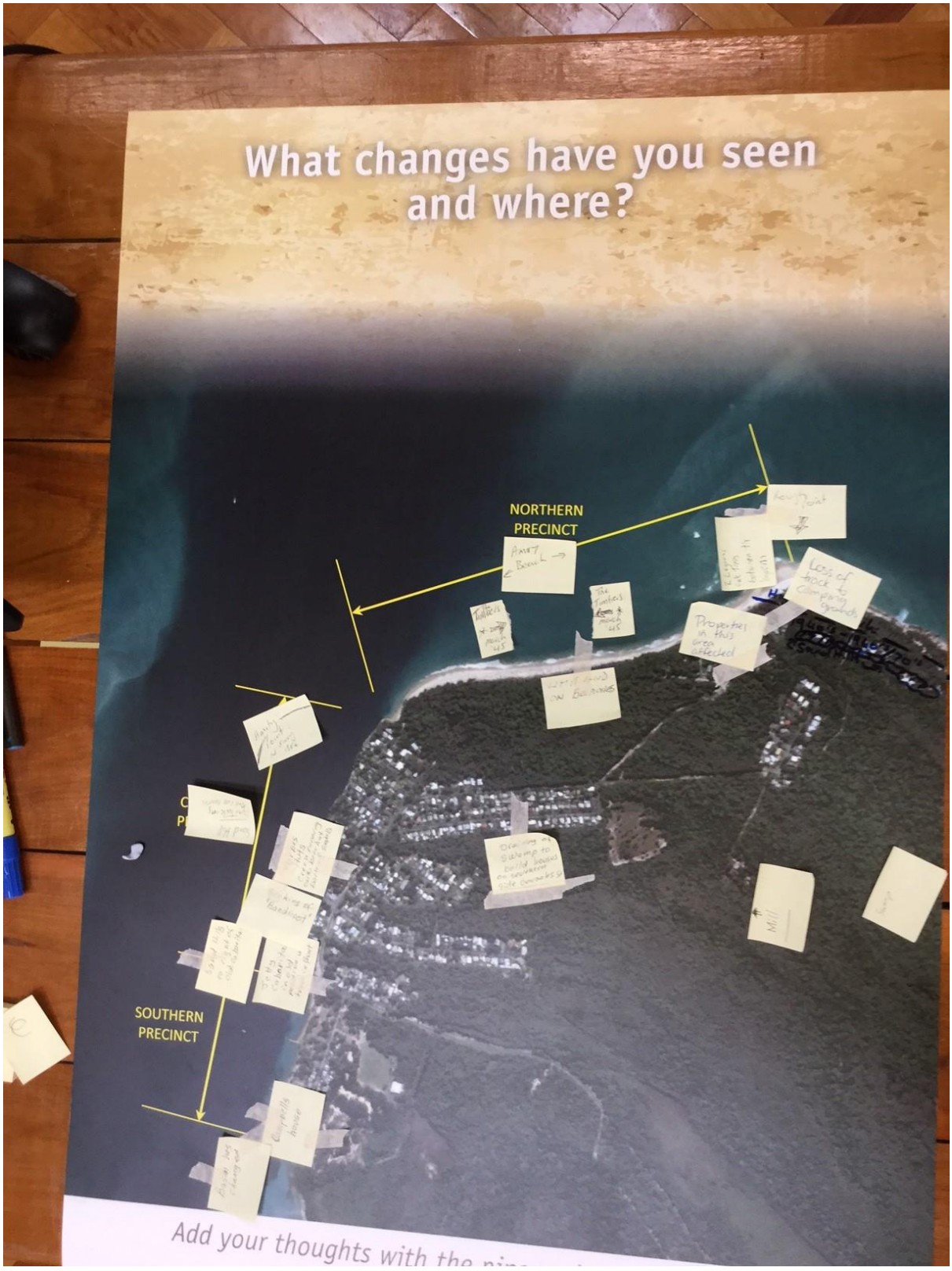
APPENDIX 4 - Open House Activities


What mitigation are best suited to which precinct- Why?
HOMES NEED TO BE PROTECTED
When will it start. + Who will Pay
Channel diversion —
Sink a big ship for
divers — tourism — break flow of current
Beware of unintended consequences.
Look Overseas → reefs
substitutes
Rember the load of coral put south side of current jetty. This was to be to solve erosion. All the coral went out to sea on first few high tides.
Harness the channel energy
→ turbines to generate
electricty to power our homes
free of charge
The owners on shoreline are responsible for paying for the rock which protects all of Amity. This doesn't seem fair.
DBROKE
D
4,000
6,000

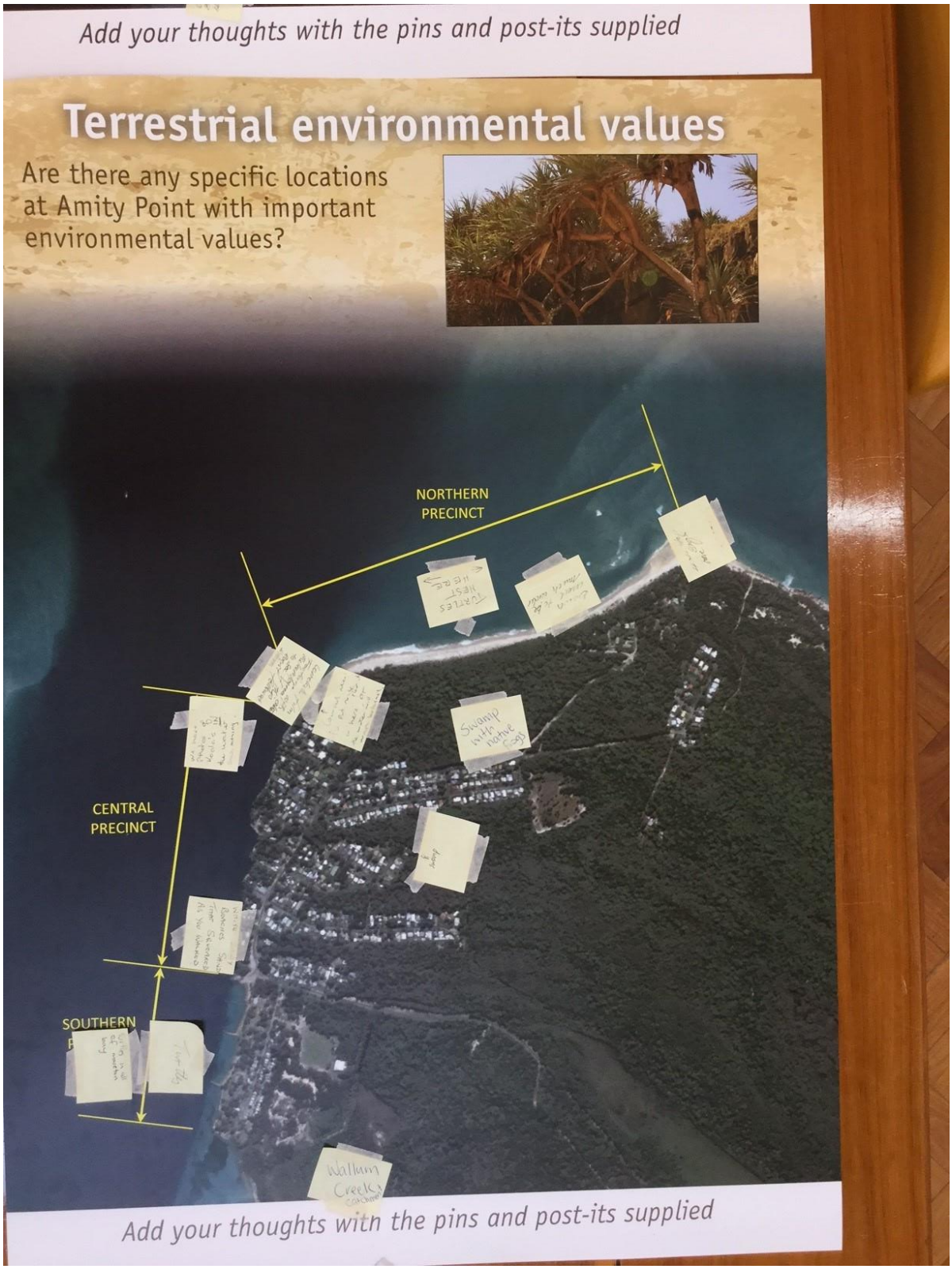

What mitigation measures are best suited to which precinct - Why?
ATTENTION TO SWAM OUTLET FROM BIRCH ST TO TENNIS COURTS ERROSION HAPPENING / BACKS UP TO SWAMP BEHIND GONZALES ST.
Fed up with "STOP GAP" MEASURES.
+HARD STRUCTURAL WALL NEEDED ✓✓✓
NEED TO STOP 4x4 Traffic on foreshore from Main Beach around to Amity Beach. Used to be signed (No longer) barrier. Traffic damages beach structure.
central and south precinct extend existing hard bottom in channel
maybe pylons at front of houses which could be backfilled
The coastline infront of camping ground is vulnerable to erosion - will the rock wall be extended? Is there another solution?
Amity
In essen
'soft' non
Soft (o
typical
Do no
natura
Avoidi
control
Planne
existing
Beach n
direct p
an adequ
Beach sc
to mecha
nearshore
improving
Channel re
may be co
have a less
Hard (or st
the threat

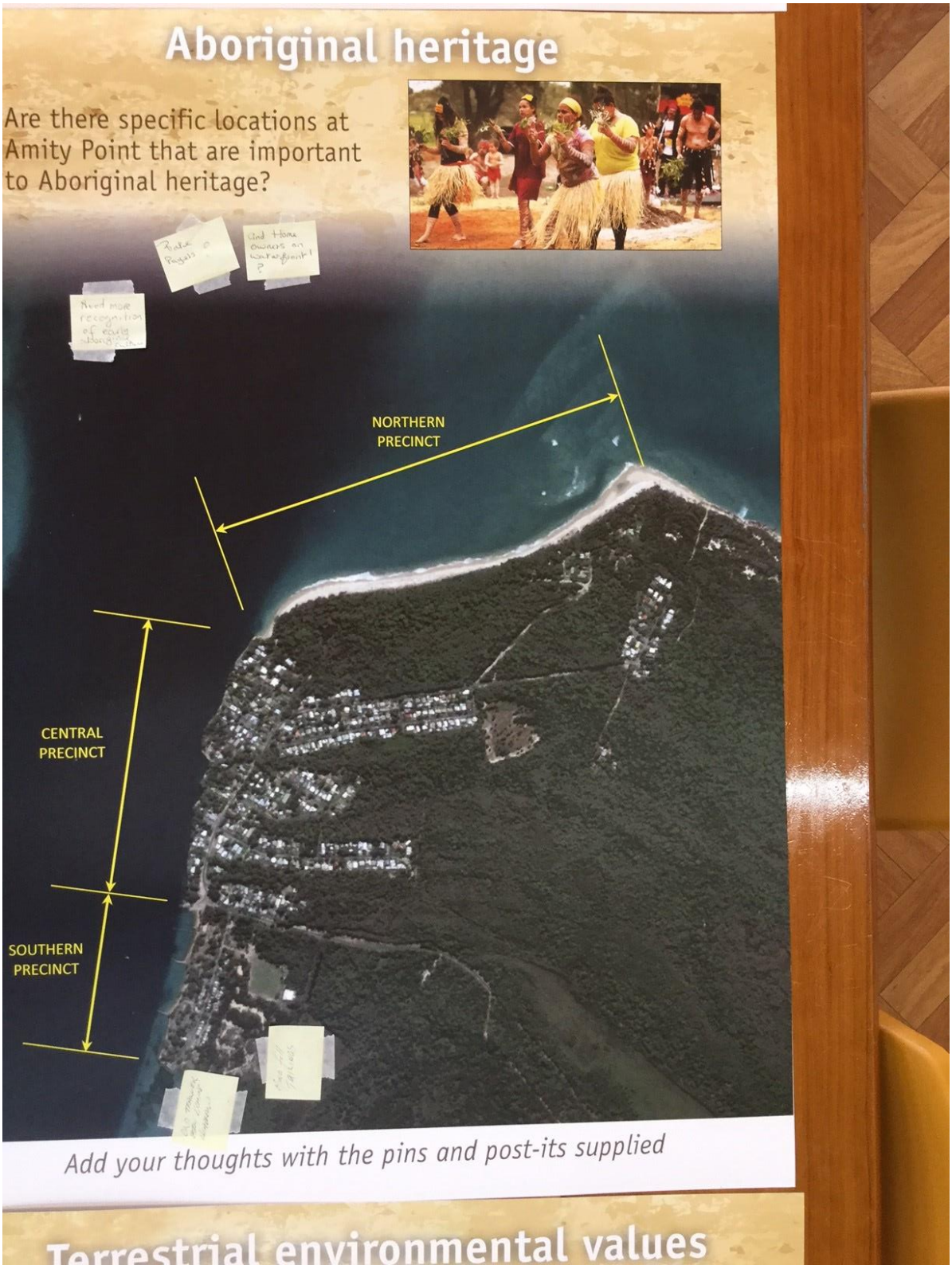

What changes have you seen ?
To Little: help
erosion contines.
• WATER TABLE HAS LOWERED OVER LAST 10-15 YEARS DOES THIS EFFECT HYDROSTATIC PRESSURE ? FOR ERROSION.
• MIDDLE SAND BANK HAS GROWN TOWARDS AMITY BY 300 m PLUS - NARROWING OF MAIN CHANNEL + INCREASES WATER FLOW RATE
• NEW CHANNEL FORMING TO SOUTHERN SIDE OF SAND ISLAND PARALLEL TO TOP END OF ROUS CHANNEL. ABOUT 5m.
• DEEP WATER OF CHANNEL IS MUCH CLOSED TO ROCK WALL
• OYSTER LEASES AT DIALBA PASSAGE HAVE INCREASED IN HEIGHT NEW SAND LEVELS BY APPROX. 500 mm.
• MIDDLE BANK AT WELSBY LIGHT IS MUCH HIGHER JUST BELOW LOW WATER MARK.
What chan
Draining of
swamp- Wate
Need to pro
by tourist a
The Basin
area.
Very few
to be ha
What changes


What changes have you seen?
Draining of the swamps at right angles to existing swamp- Water drains to Wallum creek.
Need to protect $1,000,000 boat ramp that is used by tourist and commercial/professional fishermen.
The Basin used to be a suitable large boat mooring area.
Very few in most areas. Rock walls seem to be holding along the Central Precinct.
What changes have seen?
Comparison of
the South Pass
e-alignment o
rientation.
is change has
t towards th
has introdu
able survey
t research
lignmer

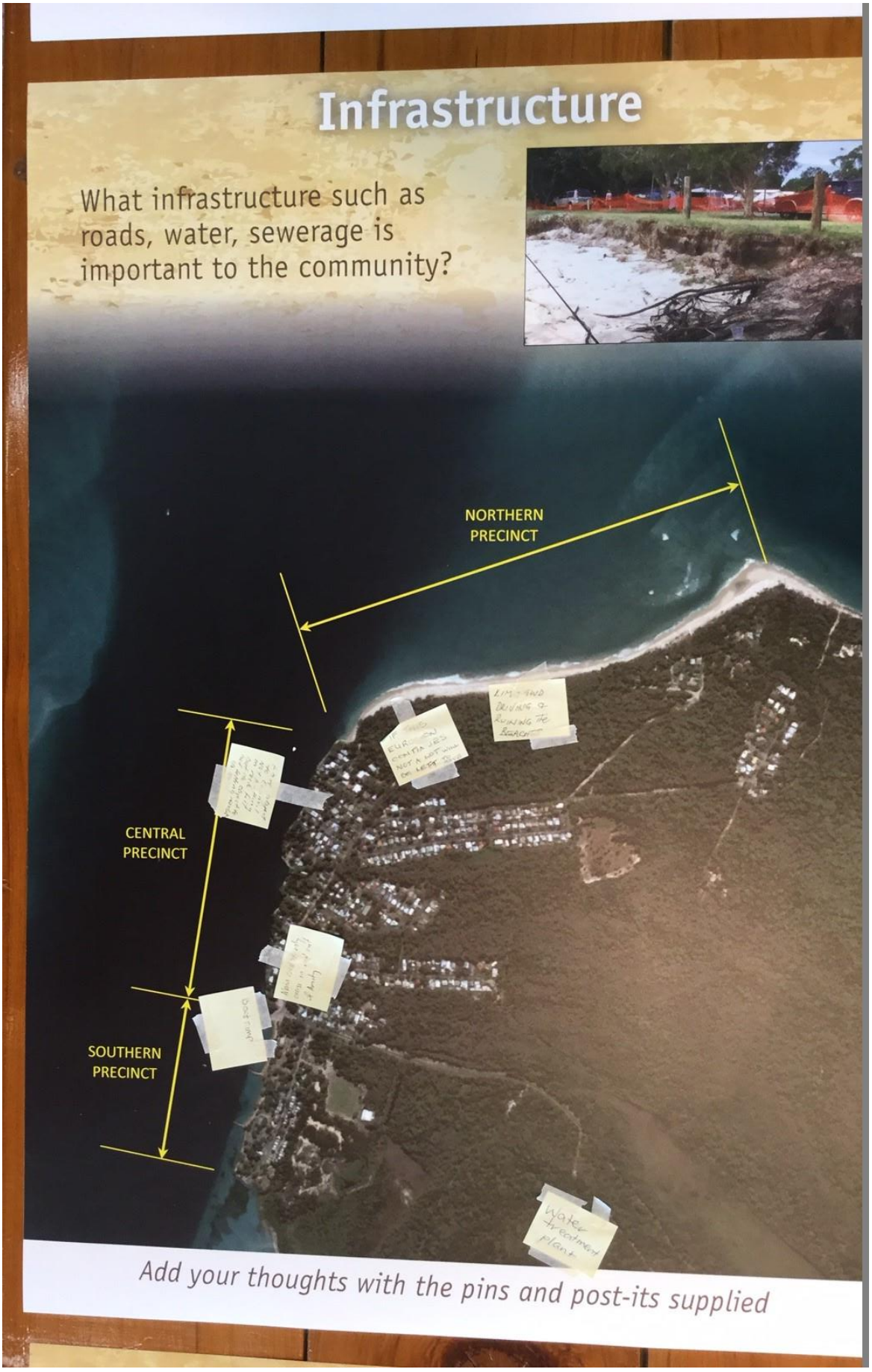

What changes have you seen and where?
NORTHERN PRECINCT
SOUTHERN PRECINCT
Add your thoughts with the


Social values
hat are the implications
erosion threat to
e community?
NORTHERN
PRECINCT
CENT
PRECI
SOUTHERN
PRECINCT
Add your thoughts with the pins and post-its supplied


Add your thoughts with the pins and post-its supplied
Terrestrial environmental values
Are there any specific locations at Amity Point with important environmental values?
NORTHERN PRECINCT
CENTRAL PRECINCT
SOUTHERN
Swamp with native
Add your thoughts with the pins and post-its supplied


Aboriginal heritage
Are there specific locations at Amity Point that are important to Aboriginal heritage?
NORTHERN PRECINCT
CENTRAL PRECINCT
SOUTHERN PRECINCT
Add your thoughts with the pins and post-its supplied
Terrestrial environmental values


Historical values
Are there specific locations at Amity Point that are important to European heritage?
NORTHERN PRECINCT
CENTRAL PRECINCT
SOUTHERN PRECINCT
Add your thoughts with the pins and post-its supplied


Infrastructure
What infrastructure such as roads, water, sewerage is important to the community?
NORTHERN PRECINCT
CENTRAL PRECINCT
SOUTHERN PRECINCT
Water treatment plant
Add your thoughts with the pins and post-its supplied


Marine values
What near-shore areas of Amity Point are important to local and regional marine biodiversity?
NORTHERN PRECINCT
CENTRAL PRECINCT
SOUTHERN PRECINCT
Sand banks
Mangrove habitat
Add your thoughts with the pins and post-its supplied

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX D
COASTAL HAZARD PLANS





Notes

1. The areas shown on this map are indicative of the extent of erosion and permanent inundation defined by erosion prone area plans declared under the *Coastal Protection and Management Act 1995*. Only the declared erosion prone area plans should be used for development assessment. To determine the actual position of the erosion prone area a registered surveyor or geotechnical consultant may be required if there is any doubt.

2. Erosion prone area plans for each local government area and a comprehensive description of their determination are available from the Department of Environment and Heritage Protection website at www.ehp.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of this product, the Department of Environment and Heritage Protection makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you may incur as a result of the product being inaccurate or incomplete in any way and for any reason. This map is intended to be printed on an A4 page.

© The State of Queensland 2016

Queensland Government

0 0.5 1
Kilometres
Scale at A4: 1:40,000

Coastal Hazard Areas Map
Erosion Prone Area

Version 6 - October 2016

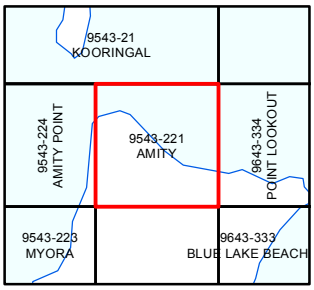
9543-221 AMITY

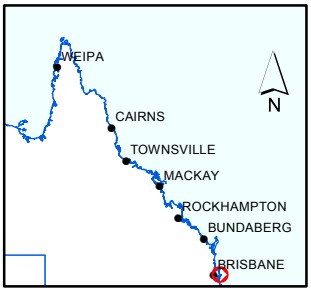
Indicative Erosion Prone Area footprint (including projected climate change impacts*)

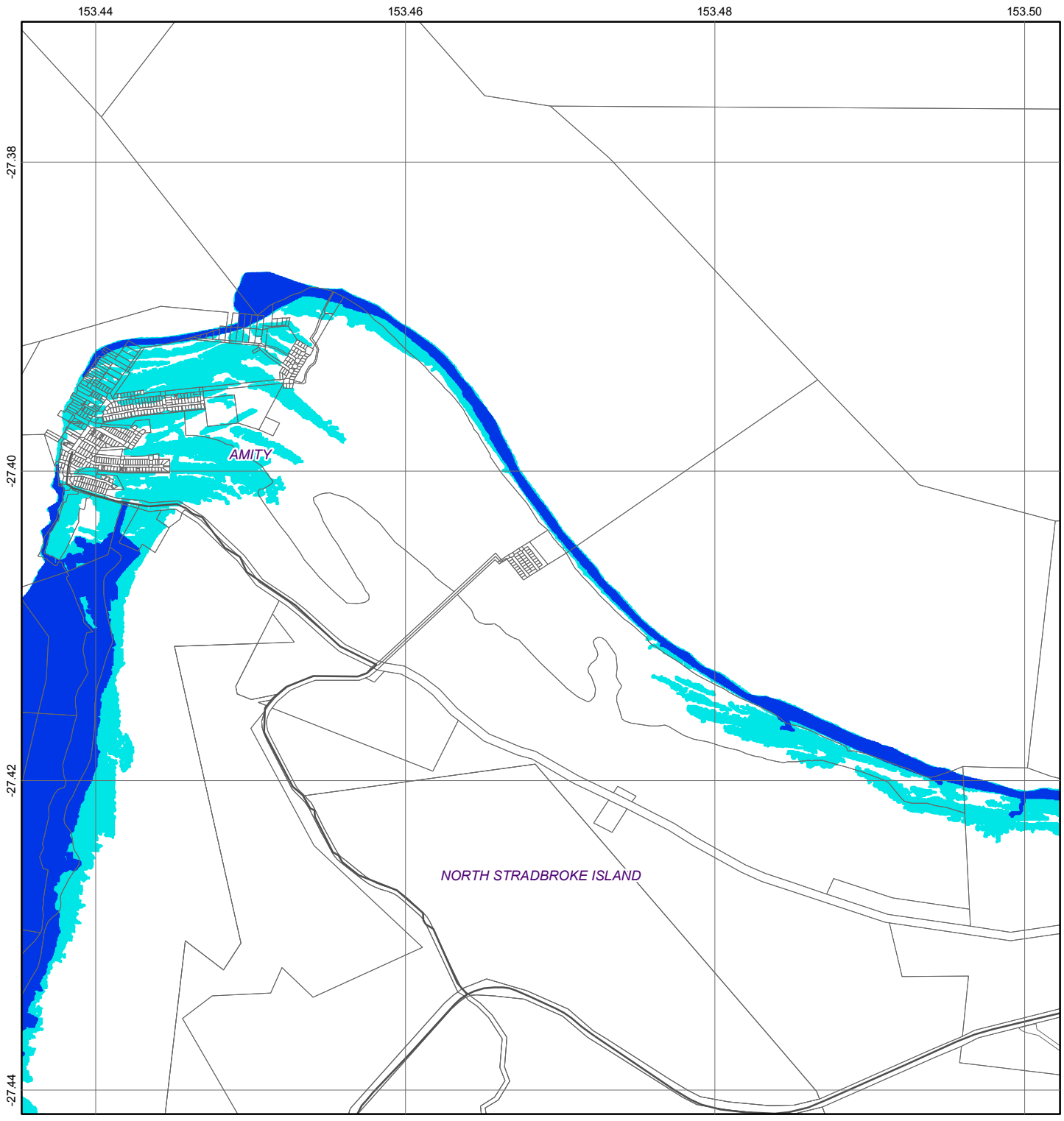
Erosion due to storm impact and long term trends of sediment loss and channel migration.

Erosion and permanent tidal inundation due to sea level rise.

*Sea level rise of 0.8m at 2100







Notes
1. A default storm tide inundation level of 1.5 m HAT in South East Queensland regional planning area and 2.0 m HAT for the remainder of Queensland is used where projected storm tide inundation levels have not been determined locally.
The default level uses a sea level rise factor of 0.8m to 2100.

2.The high hazard area may be also subject to permanent inundation by sea level rise - refer to the Erosion Prone Area map.

3. The map should be used as a guide only. Field surveys are recommended to verify feature boundaries.

Disclaimer
Whilst every care is taken to ensure the accuracy of this product, the Department of Environment and Heritage Protection makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you may incur as a result of the product being inaccurate or incomplete in any way and for any reason. This map is intended to be printed on an A4 page.

© The State of Queensland 2015

Queensland Government

0 0.5 1
Kilometres
Scale at A4: 1:40,000

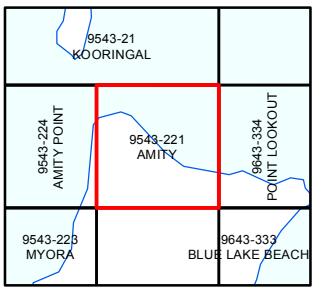
Coastal Hazard Areas Map
Storm Tide Inundation Areas

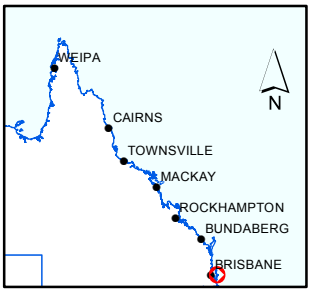
Version 4 - July 2015

9543-221 AMITY

Storm Tide Inundation Area (including projected climate change impacts to 2100)

- High hazard area (greater than 1.0 m water depth)
- Medium hazard area (less than 1.0 m water depth)
- Coastal hazard data not available in this area. Refer to notes 1 and 2 to determine.





Erosion Prone Area
Redland City Local Government Area

Erosion Prone Area Definition

1. Erosion prone areas are deemed to exist over all tidal water to the extent of Queensland Coastal Waters and on all land adjacent to tidal water.
2. Erosion prone areas include areas subject to inundation by the highest astronomical tides (HAT) by the year 2100 or at risk from sea erosion.
3. On land adjacent to tidal water the landward boundary of the erosion prone area shall be defined by whichever of the following methods gives the greater erosion prone area width:
   a. a line measured 40 metres landward of the plan position of the present day HAT level except where approved revetments exist in which case the line is measured 10 metres landward of the upper seaward edge of the revetment, irrespective of the presence of outcropping bedrock;
   b. a line located by the linear distance shown on Table 1 and measured, unless specified otherwise, inland from:
      i. the seaward toe of the frontal dune (the seaward toe of the frontal dune is normally approximated by the seaward limit of terrestrial vegetation or, where this cannot be determined, the level of present day HAT); or
      ii. a straight line drawn across the mouth of a waterway between the alignment of the seaward toe of the frontal dune on either side of the mouth
   c. the plan position of the level of HAT plus 0.8 m vertical elevation.

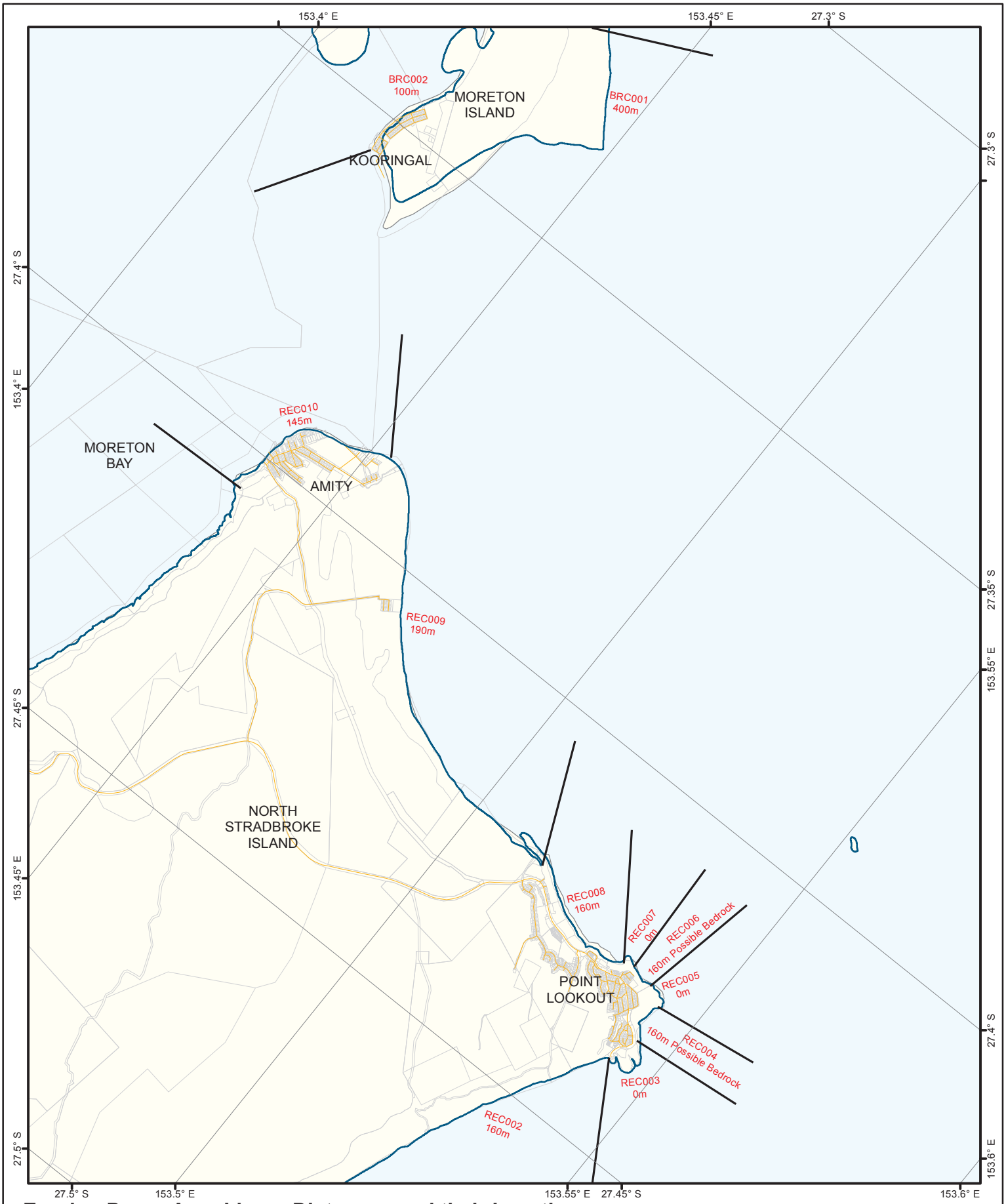
   Except:
   i. where the linear distance specified in 3b is less than 40 metres, in which case section 3a. does not apply and the erosion prone area width will be the greater of 3b and 3c; or
   ii. where outcropping bedrock is present and no approved revetments exist, in which case the line is defined as being coincident with the most seaward bedrock outcrop at the plan position of present day HAT plus 0.8m; or
   iii. in approved canals in which case the line of present day HAT applies, irrespective of the presence of approved revetments or outcropping bedrock.

4. Erosion prone areas defined in accordance with the above are deemed to exist throughout all the local government areas, irrespective of whether the entire local government area is depicted on erosion prone area plans for the area.

Notes to clarify the definition

1. The specific location along the coast to which each erosion prone area linear distance applies (a segment) is shown in Table 1.
2. A map indicating the approximate location along the coast of each linear distance segment is attached.
3. Each erosion prone area segment is located on the coastline between 2 points defined by latitude and longitude. A projection of each point to the nearest actual coastline and continuing inland perpendicular to the coast defines the erosion prone area segment.
4. “Present day HAT” in the definition is always taken to be the present day level of HAT for the coastline as defined in the Queensland Tide Tables for that year or as defined by empirical methodology at the site.
5. The extent of the erosion prone area where it is defined by “HAT plus 0.8m” is the HAT coastline at the year 2100 and includes sea level rise to that time. It is determined by the area of land inundated to the level HAT of the nearest adjacent open coast or river tide gauge plus 0.8m vertical elevation. Site based HAT is not to be used as present day attenuation of inland HAT level due to flow constraints may not persist to 2100 with coastline response to sea level rise. For further explanation see the Coastal Hazard Technical Guide.
6. Where noted on Table 1 (and the map) the specified linear distance applies except where a revetment has been constructed and maintained to the approved design in which case the landward boundary of the erosion prone area is at the upper seaward edge of the revetment (A-line).
7. The approximate erosion prone area footprint is shown on Coastal Hazard Area Maps available on the Department of Environment and Heritage Protection website at www.ehp.qld.gov.au. These footprints are indicative only and the definition in this plan prevails for any inconsistency between the two.
8. This erosion prone area plan may be updated from time to time and a new revision created. Please check with the Department of Environment and Heritage Protection or the local government that this copy is the current version prior to using the contained information in any way.

Date of Erosion Prone Area Declaration: 8 July 2015 **Date of Erosion Prone Area Amendment:**	**Plan No: REC3A**



Erosion Prone Area Linear Distances and their Locations for Redland City Local Government Area

REC3A Map 3

Note:
This map is a representation of the erosion prone area segment locations provided in Table 1 and should be used as a guide only.

Disclaimer:
Whilst every care is taken to ensure the accuracy of this product, the Department of Environment and Heritage Protection makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you may incur as a result of the product being inaccurate or incomplete in any way and for any reason.

REC006 100m — Segment number and linear distance for erosion prone area

— Erosion Prone Area segment start/stop location

Roads

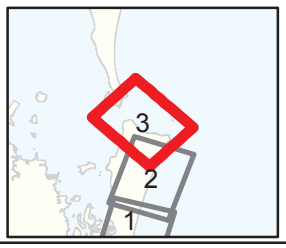
Queensland coast

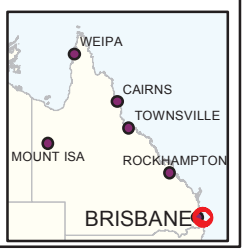
Cadastral boundaries

0 0.5 1 2 3 4
Kilometres

Queensland Government

Projection: Albers. Datum: GDA 1994.





WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX E
EPBC ACT PROTECTED MATTERS REPORT



Australian Government

Department of the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

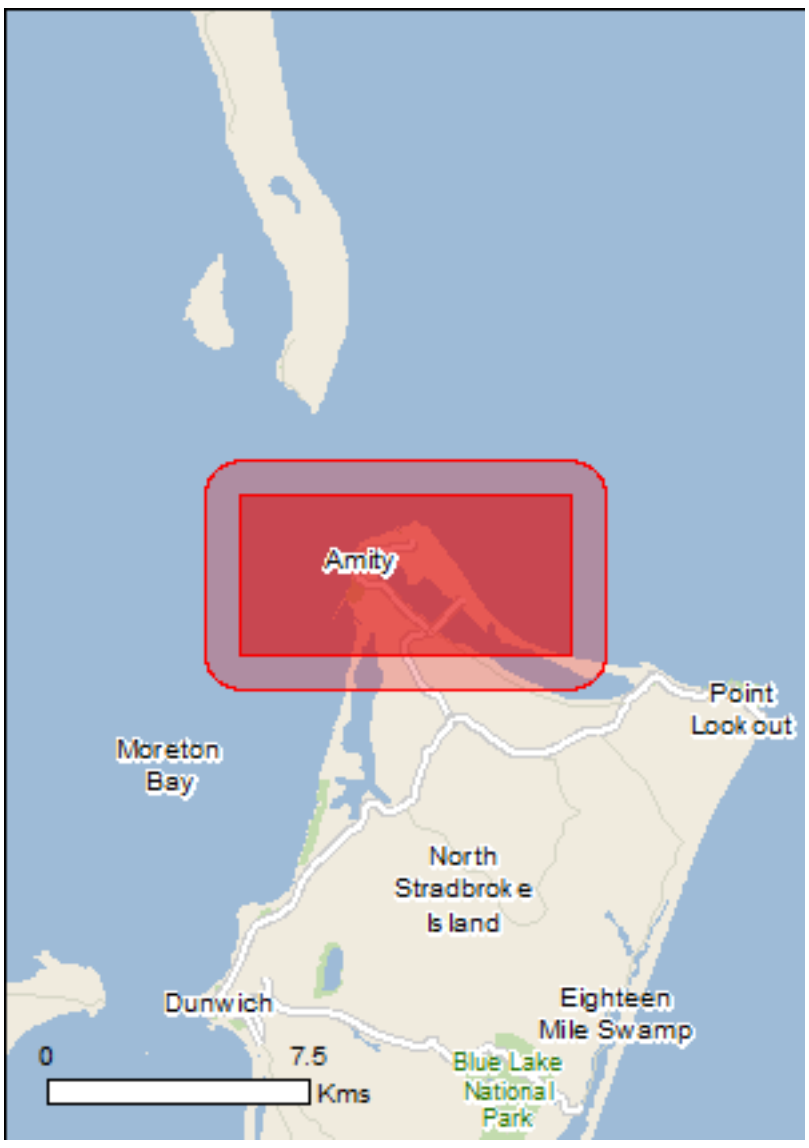
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 29/09/16 12:32:00

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

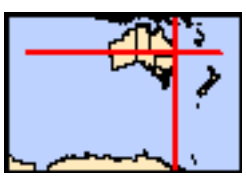
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	50
Listed Migratory Species:	72

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	103
Whales and Other Cetaceans:	14
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	22
Nationally Important Wetlands:	2
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar)	[Resource Information]
Name	Proximity
Moreton bay	Within Ramsar site

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Anthochaera phrygia		
Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour may occur within area
Botaurus poiciloptilus		
Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis gibsoni		
Gibson's Albatross [82270]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans (sensu lato)		
Wandering Albatross [1073]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus		
Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria		
White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Lathamus discolor		
Swift Parrot [744]	Critically Endangered	Species or species habitat may occur within area
Limosa lapponica baueri		
Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri		
Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli		
Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica		
Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Pterodroma neglecta neglecta		
Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta cauta		
Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi		
White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Fish		
Epinephelus daemelii		
Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat may occur within area
Frogs		
Litoria olongburensis		
Wallum Sedge Frog [1821]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Xeromys myoides		
Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Plants		
Arthraxon hispidus		
Hairy-joint Grass [9338]	Vulnerable	Species or species habitat may occur within area
Cryptocarya foetida		
Stinking Cryptocarya, Stinking Laurel [11976]	Vulnerable	Species or species habitat likely to occur within area
Macadamia integrifolia		
Macadamia Nut, Queensland Nut, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat may occur within area
Olearia hygrophila		
Swamp Daisy, Water Daisy [5631]	Endangered	Species or species habitat likely to occur within area
Phaius australis		
Lesser Swamp-orchid [5872]	Endangered	Species or species habitat known to occur within area
Phaius bernaysii		
Yellow Swamp-orchid [4918]	Endangered	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sharks		
Carcharias taurus (east coast population)		
Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat may occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans (sensu lato)		
Wandering Albatross [1073]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni		
Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli		
Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Puffinus carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat known to occur within area
Thalassarche cauta (sensu stricto)		
Shy Albatross, Tasmanian Shy Albatross [64697]	Vulnerable*	Species or species habitat may occur within area
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		

Name	Threatened	Type of Presence
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable	Breeding may occur

Name	Threatened	Type of Presence
[68442]		within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Migratory Terrestrial Species		
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat likely to occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba		
Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Species or species habitat known to occur within area
Charadrius bicinctus		
Double-banded Plover [895]		Species or species habitat known to occur

Name	Threatened	Type of Presence within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Pluvialis squatarola Grey Plover [865]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Xenus cinereus		
Terek Sandpiper [59300]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba		
Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris tenuirostris Great Knot [862]	Critically Endangered	Species or species habitat known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Species or species habitat known to occur within area
Himantopus himantopus Black-winged Stilt [870]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat may occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Species or species habitat known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Pluvialis squatarola Grey Plover [865]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross [64697]	Vulnerable*	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Species or species habitat known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish [66193]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys ocellatus Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
[Filicampus tigris](#) Tiger Pipefish [66217]		Species or species habitat may occur within area
[Halicampus grayi](#) Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
[Hippichthys cyanospilos](#) Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
[Hippichthys heptagonus](#) Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
[Hippichthys penicillus](#) Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
[Hippocampus kelloggi](#) Kellogg's Seahorse, Great Seahorse [66723]		Species or species habitat may occur within area
[Hippocampus kuda](#) Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
[Hippocampus planifrons](#) Flat-face Seahorse [66238]		Species or species habitat may occur within area
[Hippocampus trimaculatus](#) Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
[Hippocampus whitei](#) White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
[Lissocampus runa](#) Javelin Pipefish [66251]		Species or species habitat may occur within area
[Maroubra perserrata](#) Sawtooth Pipefish [66252]		Species or species habitat may occur within area
[Micrognathus andersonii](#) Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area
[Micrognathus brevirostris](#) thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
[Microphis manadensis](#) Manado Pipefish, Manado River Pipefish [66258]		Species or species habitat may occur within area
[Solegnathus dunckeri](#) Duncker's Pipehorse [66271]		Species or species habitat may occur within area
[Solegnathus hardwickii](#) Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
[Solegnathus spinosissimus](#) Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Laticauda laticaudata a sea krait [1093]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur

Name	Threatened	Type of Presence within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Naree Budjong Djara National Park	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		

Name	Status	Type of Presence
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Moreton Bay	QLD
North Stradbroke Island	QLD

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-27.382 153.409,-27.382 153.494,-27.418 153.494,-27.418 153.409,-27.382 153.409

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Parks and Wildlife Commission NT, Northern Territory Government
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

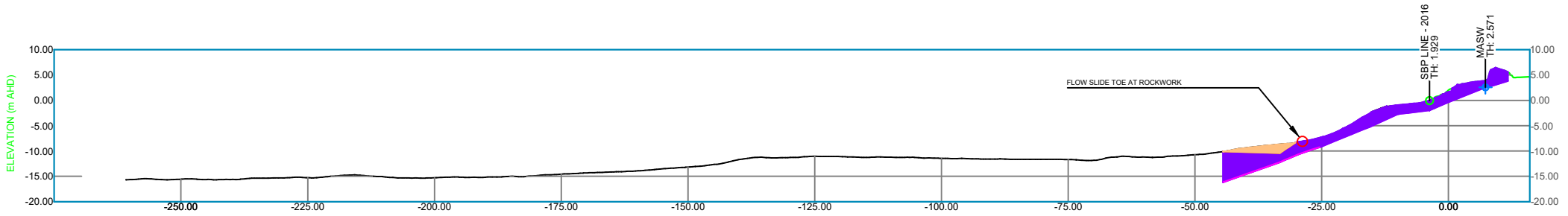
Please feel free to provide feedback via the Contact Us page.

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

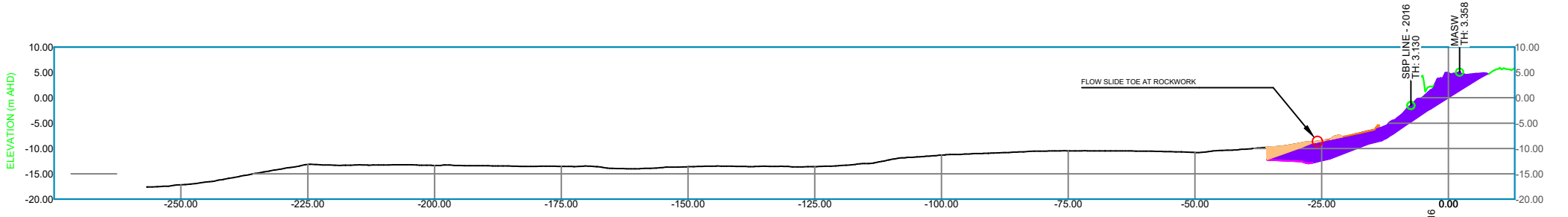
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX F
POTENTIAL INTERACTION OF FLOW SLIDES WITH THE EXISTING FLOW SLIDE BARRIER ALONG THE CENTRAL REACH

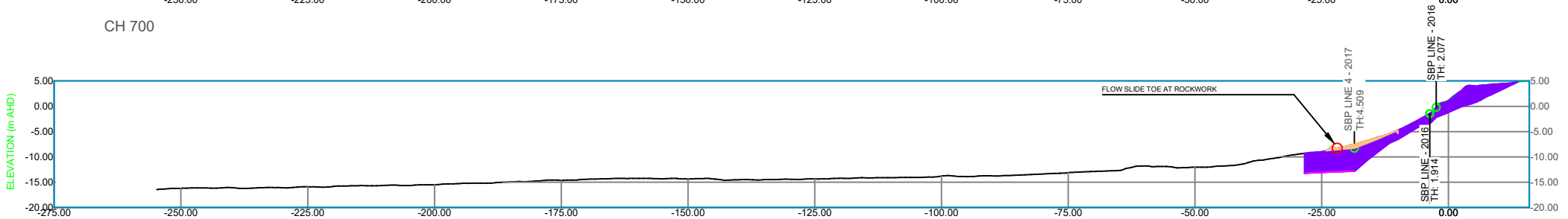




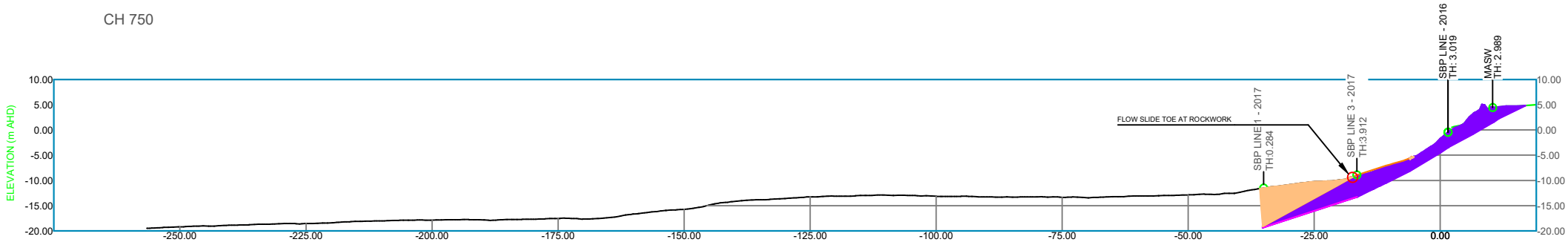
CH 650



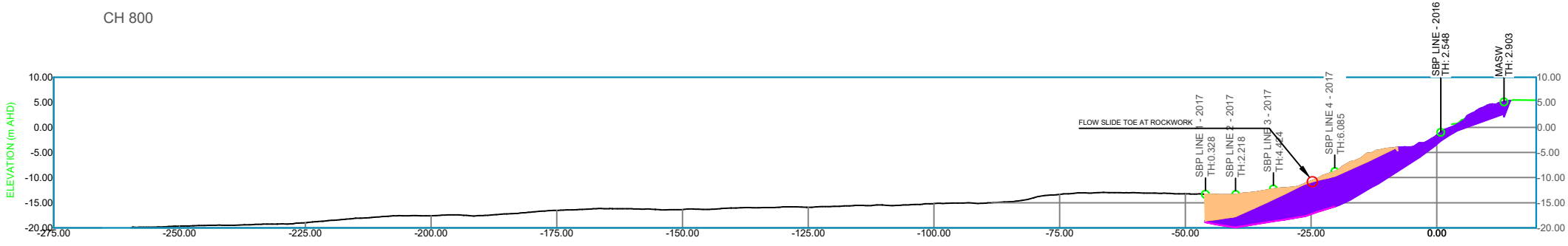
CH 700



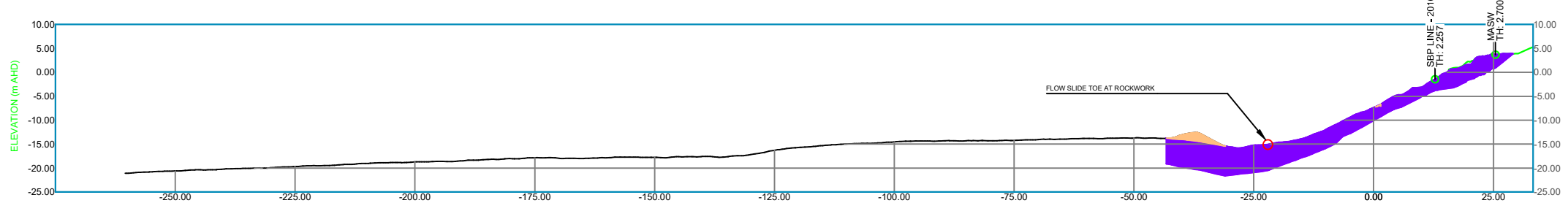
CH 750



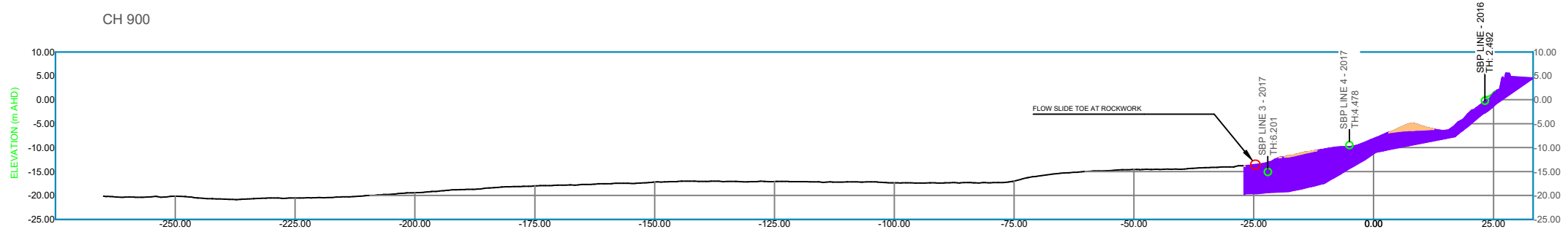
CH 800



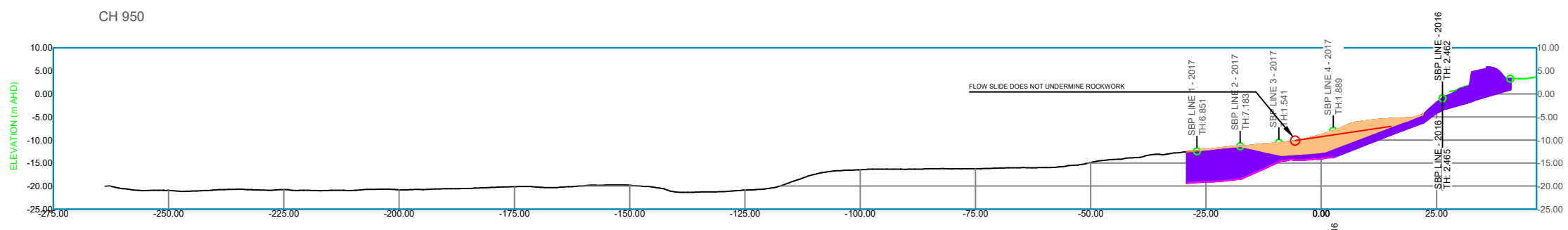
CH 850



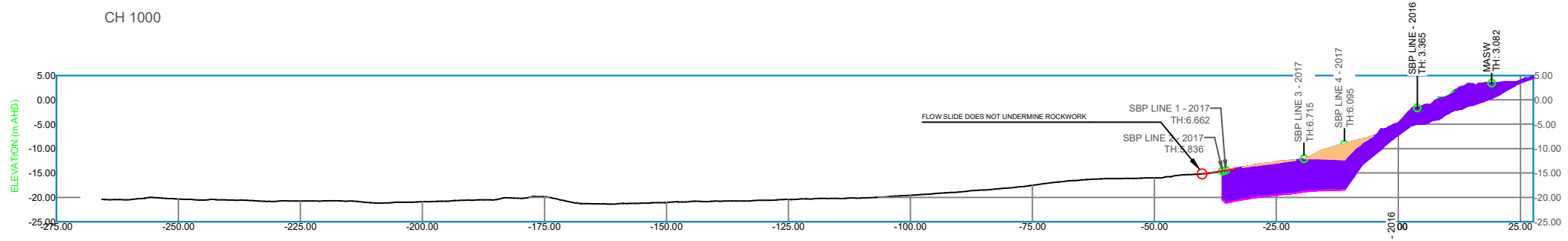
CH 900



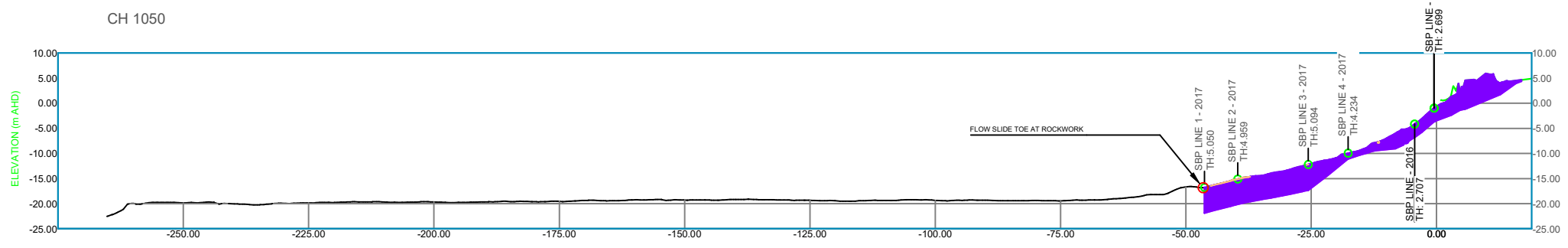
CH 950



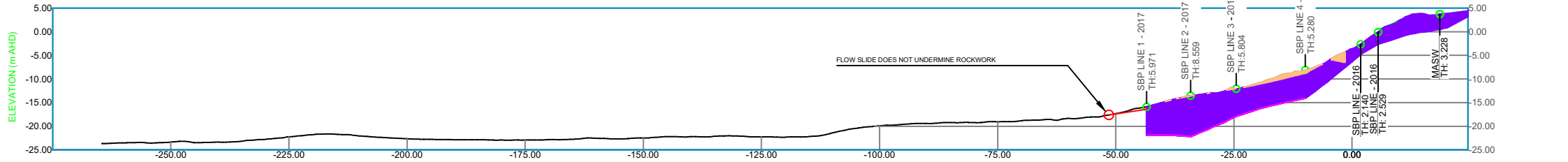
CH 1000



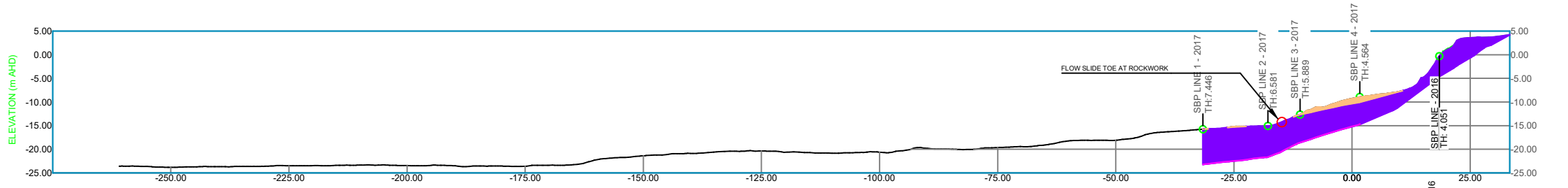
CH 1050



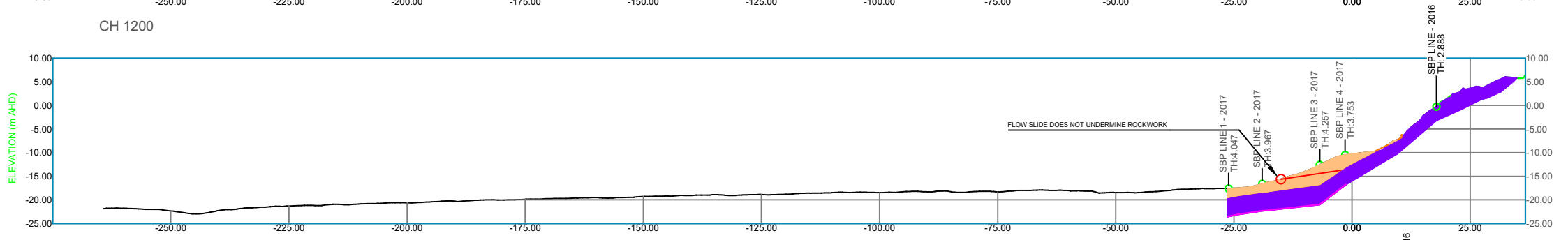
CH 1100



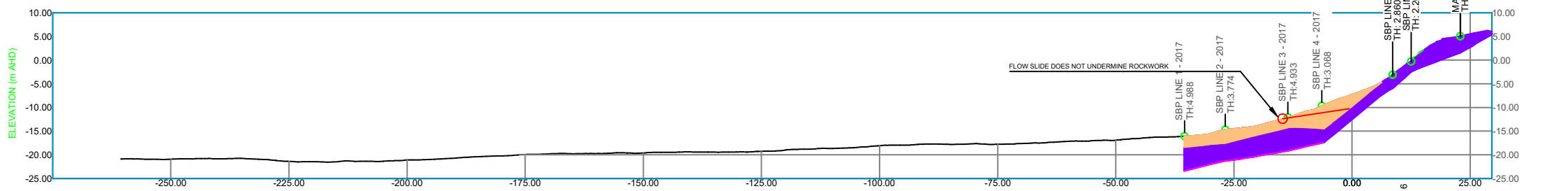
CH 1150



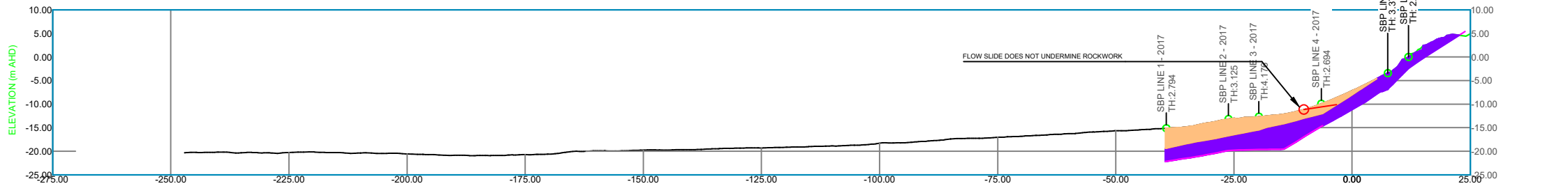
CH 1200



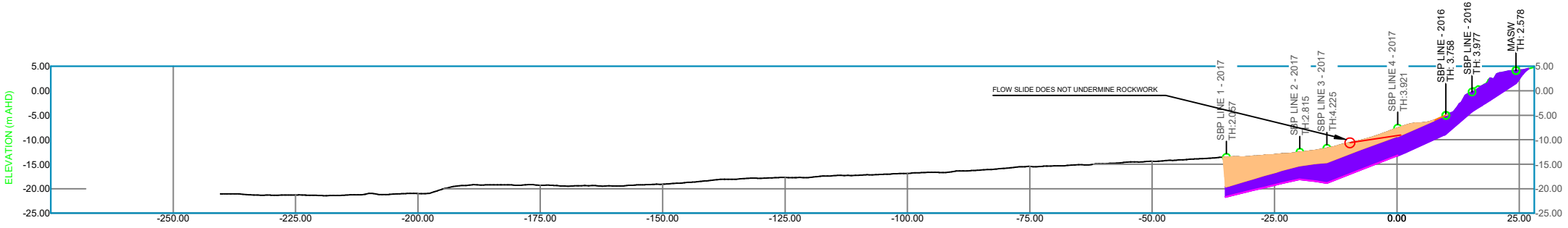
CH 1250



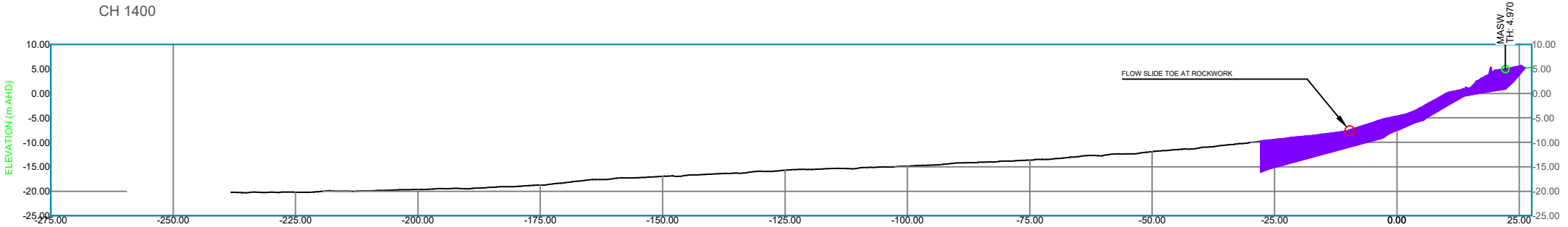
CH 1300



CH 1350



CH 1400



CH 1450

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX G
SAFETY MANAGEMENT PLAN – FLOW SLIDE BARRIER



WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Safety Management Plan

Amity Point Flow Slide Barrier

Redland City Council

February 2019



Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
v01	Report	Christine Lauchlan Arrowsmith	Steve Clark	12 December 2016
v02	Report	Christine Lauchlan Arrowsmith	Paul O'Brien	21 February 2017
v03	Report	Christine Lauchlan Arrowsmith	Paul O'Brien	15 December 2017
v04	Report	Paul O'Brien	Christine Lauchlan Arrowsmith	01 May 2018
v05	Report	Astrid Stuer	Paul O'Brien	26 February 2019

Project Details

Project Name	Amity Point Flow Slide Barrier
Client	Redland City Council
Client Project Manager	Rod Powell
Water Technology Project Manager	Paul O'Brien RPEQ No. 5638
Water Technology Project Director	Steve Clark
Authors	Paul O'Brien RPEQ No. 5638
Document Number	4193-01_R04v05.docx

COPYRIGHT

Water Technology Pty Ltd has produced this document in accordance with instructions from Redland City Council for their use only. The concepts and information contained in this document are the copyright of Water Technology Pty Ltd. Use or copying of this document in whole or in part without written permission of Water Technology Pty Ltd constitutes an infringement of copyright.

Water Technology Pty Ltd does not warrant this document is definitive nor free from error and does not accept liability for any loss caused, or arising from, reliance upon the information provided herein.

Level 3, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460
Fax (07) 3846 5144
ACN 093 377 283
ABN 60 093 377 283

Certified System Quality ISO 9001 SAI GLOBAL
Certified System Environment ISO 14001 SAI GLOBAL
Certified System Health & Safety AS 4801 SAI GLOBAL

22 February 2019

Rod Powell
Marine Projects
Redland City Council
cnr. Middle and Bloomfield Streets
CLEVELAND QLD 4163

Dear Rod

Safety Management Plan – Amity Point Flow Slide Barrier

Attached please find the Safety Management Plan with regard to undertaking future emergency works to the Flow Slide Barrier along the foreshore of Amity Point on North Stradbroke Island.

This Safety Management Plan has been prepared as part of the requirements of Section 166 of Queensland's *Planning Act 2016* for undertaking Emergency Tidal Works.

Yours sincerely



Paul O'Brien RPEQ No. 5638
Senior Principal Engineer

paul.obrien@watertech.com.au

WATER TECHNOLOGY PTY LTD

CONTENTS

1 INTRODUCTION 5

2 EMERGENCY EVENT RESPONSE 7

2.1 The Threat Requiring Emergency Works 7
2.2 The Historical Response to the Threat of Flow Slides 9

3 THE EMERGENCY TIDAL WORKS 12

3.1 Trigger Event 12
3.2 Rock Placement Requirements 15
3.3 Material Specification 15
3.4 Notification 15

LIST OF FIGURES

Figure 1-1 Regional Setting 6
Figure 2-1 A Retrogressive Flow Slide Underway at Amity Point 8
Figure 3-1 Emergency Tidal Works Trigger Event – Excessive Rock Slumping 13
Figure 3-2 Emergency Tidal Works Trigger Event – Excessive Rock Erosion 14

1 INTRODUCTION

Proactive management is an effective strategy to address coastal hazards, however given the nature of flow slide events occurring at Amity Point appropriate mechanisms to facilitate emergency works are also required. The role of this Safety Management Plan (Safety Management Plan) is to outline the emergency event, legislative requirements, triggers and the roles and responsibilities for undertaking emergency works.

The objectives of the Safety Management Plan are to:

- Outline a process to facilitate property owners to undertake emergency works along the Amity Point foreshore; and
- Provide advice on the legislative requirements

Section 166 of Queensland's *Planning Act 2016* allows tidal works to be constructed without a development approval in the event of an emergency. Nevertheless, whilst such works can be initiated quickly, there are provisions in Section 166 to ensure that proper precautions and due diligence are exercised when installing the emergency works to ensure that they are safe.

Section 166 states that development offence provisions of the *Planning Act 2016* do not apply if a person or entity who carries out the emergency work:

i. Has made and complies with a Safety Management Plan for the emergency works;

ii. Takes reasonable precautions and exercises proper diligence to ensure the works or a structure to which the works relate are in a safe condition, including by engaging a registered professional engineer to audit the works or structure;

iii. Gives a copy of the plan to the enforcement authority as soon as reasonably practicable after starting the works.

This Safety Management Plan has been prepared by Paul O'Brien (RPEQ No. 5638) in fulfillment of item (i) of the above requirements when undertaking any emergency works to the Flow Slide Barrier along the foreshore of Amity Point on North Stradbroke Island.

The location of Amity Point within the Moreton Bay regional setting is illustrated on Figure 1-1.



Figure 1-1 Regional Setting

2 EMERGENCY EVENT RESPONSE

2.1 The Threat Requiring Emergency Works

The threat of shoreline erosion along the foreshore of Amity Point relates to the occurrence of *retrogressive flow slides* in the underwater side slopes of Rainbow Channel.

Retrogressive flow slides (also known as *retrogressive breach failures*) are natural events which occur in sandy deposits of many river, estuarine and coastal locations around the world. They can have a significant influence on the stability of river banks, as well as estuarine and coastal foreshores.

They have also been responsible for levee collapses along the lower reaches of the Mississippi River that have resulted in adverse flooding and damage to essential infrastructure. In the Netherlands, retrogressive flow slides have been recognised for many years as being a threat to the vital flood and sea defences along that country's coastline and riverbanks.

Due to their potentially catastrophic consequences, considerable research effort has been applied to understand retrogressive flow slides. Consequently, there is a significant body of technical literature available that describes the geomorphological mechanisms associated with retrogressive flow slide failures, as well as measures for either preventing their initiation or inhibiting their development to destructive scales.

Figure 2-1 shows images of a retrogressive flow slide underway at Amity Point[1].

The processes associated with a retrogressive flow slide can be summarised as follows:

- They occur on densely packed subaqueous sand slopes, such as those that exist along the underwater edge of tidal channels and river banks. At Amity Point they occur just offshore on the submerged side slopes of Rainbow Channel.
- A triggering mechanism develops a localised scour somewhere on the submerged slope, which can then progress to a shear failure should the disturbed area exceed the stable angle of repose for the sand.
- The sand grains remaining on the sheared face of the slope are unsupported, and will consequently move apart - increasing the void ratio (this is called *dilation*) which temporarily decreases pore pressures within the face of the slope. The lower pore pressures (compared to the surrounding hydrostatic water pressures) cause individual sand grains near the face to be "sucked" together for a short time. This enables the sand body to resist further collapse and for a near-vertical face to develop.
- The lower pore pressures at the near-vertical sand face are quickly dissipated - by the surrounding water infiltrating the voids. The unconfined grains at the face then detach and fall from the wall, generating a density current of entrained sand which carries the falling sand away into deeper water. The process continues on the newly exposed sand grains in the near-vertical face - increasing the momentum of the event.
- The density currents carry the removed sand away from the failure zone and beyond the immediate toe of the near-vertical face, allowing it to remain steep and high. This dispersion of sand away from the base of the breach can be further assisted by tidal currents flowing in the channel itself.

[1] Images in Figure 2-1 are reproduced from Beinssen, K., Neil D.T. and Mastbergen D.R. 2014. "*Field observations of retrogressive breach failures at two tidal inlets in Queensland, Australia".* Journal *Australian Geomechanics*. Vol. 49 No. 3, Sept 2014. pp55-63.

- In other words, the mechanism of flow slide development is driven by short-lived density currents that entrain sand off the near-vertical wall of a shoreward moving failure plane, causing sand grains to continually cascade off this advancing face. This process is classed as retrogressive breaching failure.

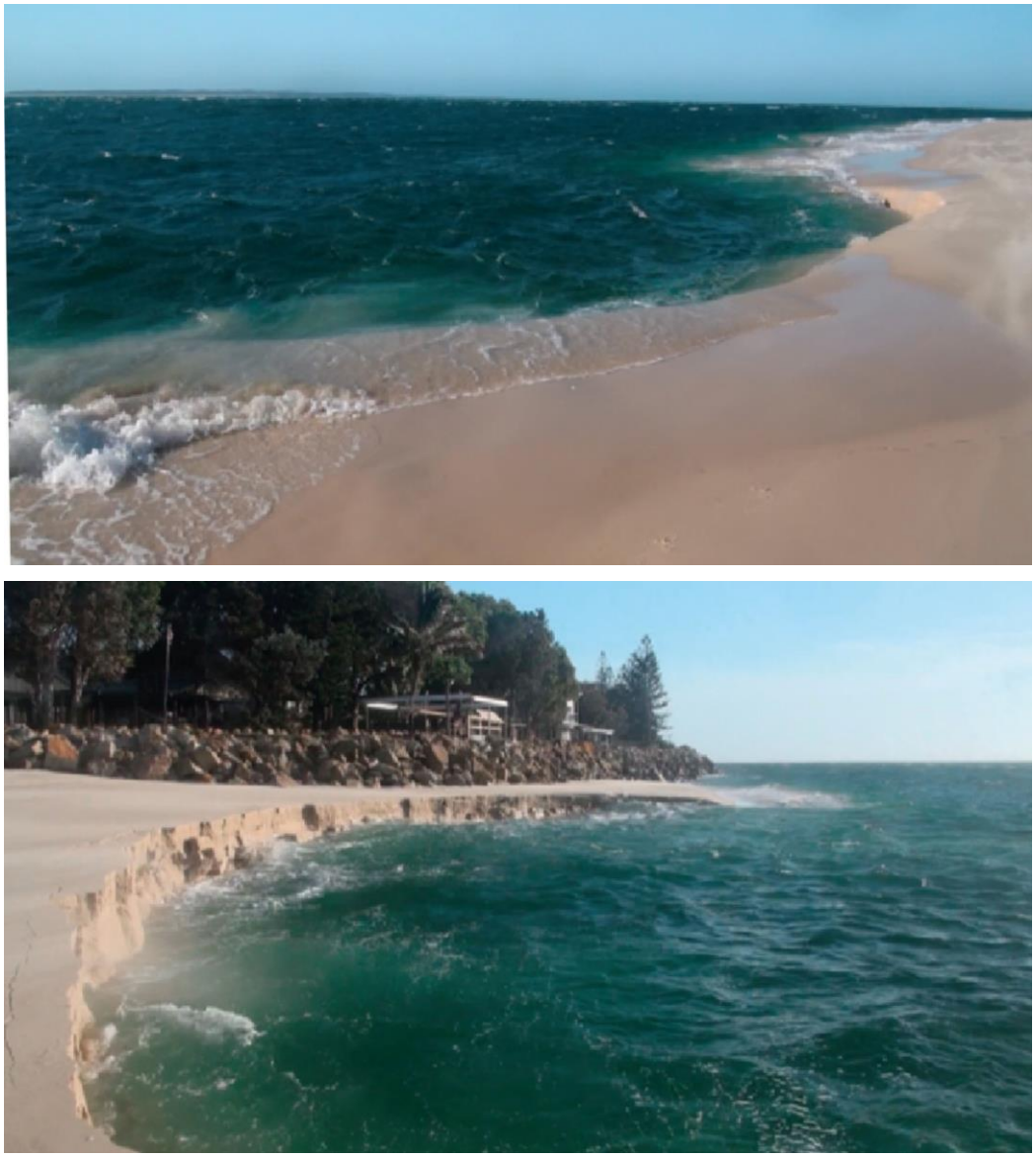


Figure 2-1 A Retrogressive Flow Slide Underway at Amity Point

- As the advancing sand wall grows in height, wedges of sand can also collapse off the vertical face - breaking up as they fall and mix with water, thereby enhancing the density current. Dilation in the sand face immediately behind the collapsing wedge temporarily stabilises the wall until retrogressive breaching restarts.
- Retrogression continues, creating a deep bowl-shaped scour feature in the submerged side slope of the tidal channel or river bank (as seen in Figure 2-1 above). Typically, as the event grows, this then becomes more of an amphitheatre-shaped characteristic with a narrower throat at its deeper offshore end.
- The base of the retrogressing sand wall propagates into the sand slope slightly upwards on an approximate angle of 1 vertical : 15 horizontal.

- The event ceases when the density current can no longer entrain sand from the retrogressing near-vertical face. This occurs either because there is no longer any sand available within the profile of the submerged slope to sustain the process; or the volume of sand being removed from the breaching face becomes so great as to "choke" the flow of entrained sand out of the bowl-shaped feature.
- Whilst they proceed entirely underwater, such events typically cannot be seen. It is only when they emerge above the waterline onto exposed beaches or sand banks that they can be detected by eye.

Investigations regarding the phenomenon of retrogressive flow slides at Amity Point have previously been undertaken[2]. They have included almost daily field monitoring for a period of 26 months of the at-risk beach and Rainbow Channel slope immediately to the north of the existing flow slide barrier.

Monitoring was carried out from July 2012 to August 2014. In that period, 52 retrogressive flow slides were recorded. This averages approximately one every fortnight. A summary of other findings are as follows:

- On no occasion was the approach of a subaqueous retrogressive flow slide evident on the surface of the water. Such events only became visible when they reached the beach.
- The morphology of each event was amphitheatre shaped as it progressed up the beach slope. Whilst sand grains could be seen cascading down the near-vertical face below the waterline, occasionally wedges of sand sheared off the top of the wall and sank vertically down its face.
- The speed of the retrogressing near-vertical sand face in all cases was approximately 0.8 metres / minute. However, this rate reduced as the event reached the upper beach area and began to diminish.
- The height of the subaqueous sand wall was measured on six occasions to be around 6m to 7m.
- Following each retrogressive flow slide event, the longshore littoral supply of sand from the north-west (from Amity Beach) filled the bowl-shaped erosion feature within one day to several weeks – depending upon the size of the retrogressive flow slide.
- Of the 52 events recorded, 48 were identified as having encroached onto the flow slide barrier - but none caused significant structural damage.

2.2 The Historical Response to the Threat of Flow Slides

It is apparent from the historical record that retrogressive flow slides have been occurring at Amity Point along the eastern edge of Rainbow Channel for over one hundred years, and probably longer.

Renowned local historian Thomas Welsby wrote in 1913 of his recollections[3] prior to that time of many "large slips" occurring at Amity Point which swept away "tons of sand". His observations dating back to the late 1800's indicate the occurrence of retrogressive flow slides and their adverse impacts on local foreshores and sand shoals at that time.

[2] Beinssen, K., and Neil D.T. 2015. "*Retrogressive Breach Failure Events at Amity Point, Australia and their Interaction with Built Defences".* Proceedings of the 25th International Ocean and Polar Engineering Conference. Hawaii, USA; June 21-26, 2015. Copyright the International Society of Offshore and Polar Engineers (ISOPE). pp 1325-1339. ISBN 978-1-880653-89-0; ISSN 1098-6189.

[3] Thomson, A.K. (Ed.) 1967. "*The Collected Works of Thomas Welsby ".* Jacaranda Press Pty Ltd., Brisbane.

Since then there have been numerous such events, many of which can be recalled by long-term residents[4] and are recorded in photographs dating back to the 1940's. Residents of Amity Point have historically (and still today) refer to retrogressive flow slides as "sink holes". There is wide-spread understanding in the local community that such events occur regularly at Amity Point and that they represent a threat - not only to foreshore properties, but potentially to the township itself.

The response of the local community to the threat of retrogressive flow slides have been varied over the years. These have included sea defences constructed of timber piles salvaged from an abandoned WW2 anti-submarine netting project, large ti-tree mats, and cement stabilisation (G. Litherland 2015 pers. comm.). Prior to the opening of a quarry on North Stradbroke Island in the 1970's, fill comprising large tree trunks, old car bodies and other such materials (including the *Bandicoot*, a decommissioned steam launch previously used as a dredge tender) were placed as emergency works by the community at locations of retrogressive flow slides.

Large rocks became available from the island's quarry around the mid-1970's. As a consequence, foreshore property owners have more recently used this material to armour their properties. Typically, this entails the placement of large volumes of rock into any areas of foreshore adversely affected by retrogressive flow slides. This occurs as soon as possible after each event. When a retrogressive flow slide undermines previously placed armour, those rocks slump or collapse into the eroded shoreline. Residents then place additional rocks to "top-up" the slumped armour. In effect this is progressively building a rock barrier to retrogressive flow slides, since each local undermining occurrence results in deeper foundations and a re-charging of the reserves of rock higher in the structure by residents.

Whilst there has been intermittent damage to the structure by deep retrogressive flow slides requiring placement of additional armour rocks to reinstate its alignment and effectiveness, this flow slide barrier has prevented any long-term recession of the shoreline alignment for more than 40 years. This is apparent from the historical foreshore surveys that have been undertaken since 1970.

As noted above, the mechanism of flow slide development is driven by short-lived density currents that entrain sand off the near-vertical wall of the shoreward moving failure plane, causing sand grains to cascade off the advancing failure face. Measures to prevent flow slides from being triggered on submarine sand slopes can be difficult and costly to implement, often with only limited effectiveness. Therefore, a significant focus of overseas research has been directed to identifying submarine sand slopes that are susceptible to flow slides; and to then devise the means to prevent them from developing into large scale failures.

For strategies that seek to prevent further development of an initiated flow slide, the primary objective is to disrupt or completely dissipate the density currents which entrain sand on the near-vertical failure plane. Blocking of flow slide development occurs when:

- The advancing near-vertical sand wall encounters non-erodible material within the sand body. In which case, there is no longer sand available to sustain the momentum of the density currents driving the growth of the flow slide event;
- Non-erodible layers present in the sand slope above the point of flow slide initiation become undermined and collapse in sufficient quantity down into the bowl-shaped failure area - thereby diffusing the density currents and armouring the near-vertical advancing sand wall.

There is a very large volume of rock (and other non-erodible material) placed by foreshore property owners over recent decades into the Amity Point foreshore. Even though Rainbow Channel has been migrating eastward towards Amity Point, resulting in deeper and steeper seabed slopes in front of the foreshore (with

[4] G. Litherland, 2015 pers. comm.; D. & E. Cilento 2015 pers. comm.; C. & M. McIllwain, 2015 pers. comm.; B. Hoare 2016 pers. comm.; J. & L. Walker 2016 pers. comm.; K. Norris 2016 pers. comm.; I. Panebianco 2016 pers. comm.

resulting greater vulnerability of the foreshore to flow slides), there have been fewer large failure events in recent years. This is very likely due to the blocking effect of the rock barrier that has been progressively reinforced by foreshore property owners.

In the past, whenever a flow slide event occurring on the submerged sand slopes of Rainbow Channel undermines any rocks placed previously, the buried rock mass slumps or collapses into the active flow slide region bringing the processes to an end. This typically manifests itself as a settling or dislodgement of rocks at the top of the slope. The response of local property owners is to then (and as soon as possible after the event) place additional rocks in the upper part of the collapsed rock slope.

Consequently, a flow slide barrier made of rock has been progressively built along the foreshore of the Central Reach over many years. Each undermining event caused by deep flow slides locates the foundations of the barrier deeper; whilst the reserve of rocks higher in the structure (to accommodate any future slumping) is recharged by local property owners.

The fundamental purpose of the flow slide barrier is to mitigate the development of flow slides to damaging proportions. This function will only be maintained if the current practice of recharging the upper reserves of rock in the structure occurs whenever there is local undermining of the barrier.

3 THE EMERGENCY TIDAL WORKS

The Emergency Tidal Works covered by this Safety Management Plan relate to the emergency placement of rocks to repair and reinstate the function of the existing flow slide barrier along the foreshores of Amity Point.

3.1 Trigger Event

Section 166 of the *Planning Act (2016)* defines emergency tidal works as being "…. *works, development or a use (an activity) carried out because an emergency endangers :*

i. a person's life or health; or

ii. a building's structural safety; or

iii. the operation or safety of infrastructure, other than a building; or

iv. *for tidal works – the structural safety of a structure for which there is a development permit for operational works that is tidal works*."

Given the physical characteristics of the existing flow slide barrier, in conjunction with the above definition of emergency tidal works, the trigger for implementation of this Safety Management Plan is when the flow slide barrier becomes damaged to the extent that people and houses adjacent to the structure are placed at significant risk.

Small movements and settlement of exposed rocks in the upper slope of the flow slide barrier can occur due to small retrogressive flow slides occurring near the buried toe of the barrier. This is acceptable from a structural integrity perspective. It is only when a deep retrogressive flow slide occurs which significantly undermines the barrier (causing significant slumping of the upper part of the barrier) is there a need to implement Emergency Tidal Works.

Such works should be triggered when:

- Excessive rock slumping : All visible rocks in the flow slide barrier above the prevailing tide level have slumped down below the waterline; or
- Excessive rock erosion : The extent of rock settlement during a single retrogressive flow slide event is such that the upper seaward-most corner of the barrier's front slope is eroded inland by 5 metres.

These two fundamental trigger actions are illustrated respectively in Figure 3-1 and Figure 3-2.



Figure 3-1 Emergency Tidal Works Trigger Event – Excessive Rock Slumping

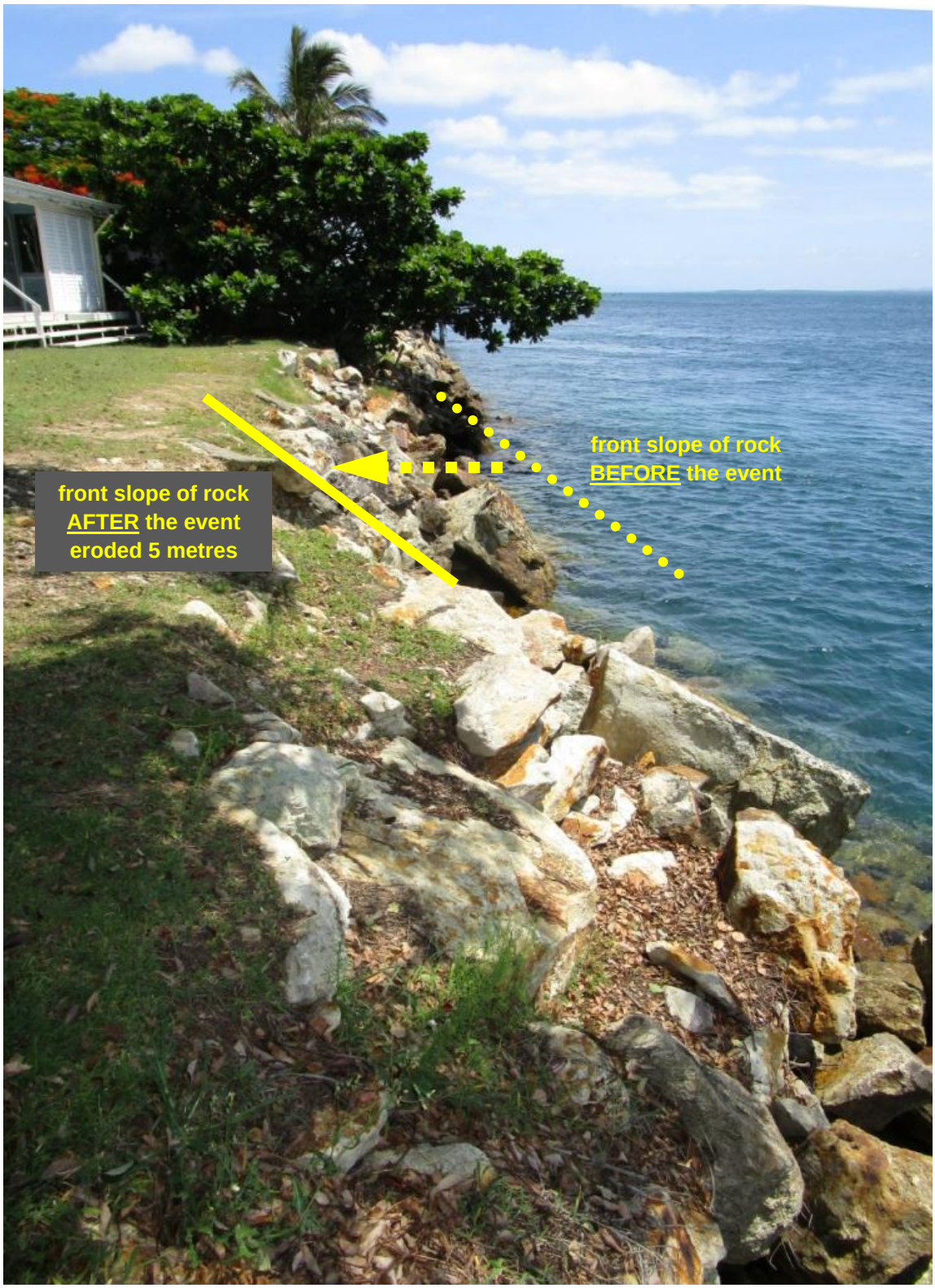


Figure 3-2 Emergency Tidal Works Trigger Event – Excessive Rock Erosion

3.2 Rock Placement Requirements

As part of obtaining development approval for the flow slide barrier, a Detailed Engineering Design will need to be undertaken. Repair works to that structure can then be done as approved works to reinstate the function of the flow slide barrier provided that they are in accordance with that Detailed Design.

However, if repair works to the existing flow slide barrier following a flow slide event are required prior to receiving development approval, then the works are to comply with the structural characteristics and requirements of the Concept Design prepared during the development of the Amity Point Shoreline Erosion Management Plan (SEMP). The Concept Design is shown overleaf on page 16.

In the event of damage to the flow slide barrier by a retrogressive flow slide, the effectiveness of structural repairs and the reinstatement of the barrier's primary function is significantly affected by the time between the occurrence of the damaging event and the commencement of the emergency tidal works.

It is important that repairs to the damaged flow slide barrier be initiated within only a few hours of the damaging event. Longer delays compromise the effectiveness of those repairs and the future effectiveness of the flow slide barrier in preventing the development of retrogressive flow slides to damaging proportions.

Repairs to the flow slide barrier can be effected by simply dumping rock armour (complying with the material specifications in Section 3.2) from conventional tip-trucks directly into the zone of the slumped/damaged barrier.

To ensure the safety of staff and equipment involved in the emergency work, it is essential that no dumping of rock occurs whilst a retrogressive flow slide is occurring. Rock placement should only be undertaken once the damaging flow slide event has ceased.

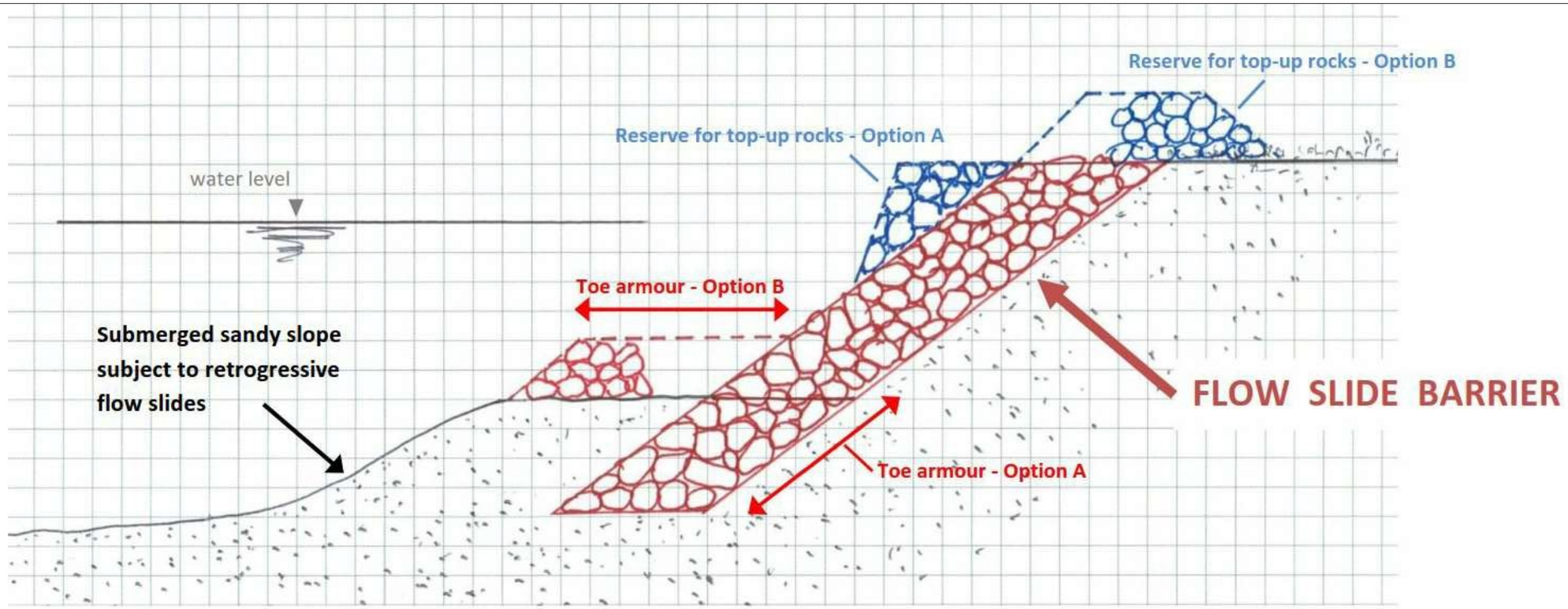
3.3 Material Specification

Rock material used to facilitate the emergency repairs to the damaged flow slide barrier shall be obtained from a stockpiled source maintained solely for that purpose. The material shall comply with the following specifications:

- All of the rocks used in the repair of the flow slide barrier are considered and referred to herein as "rock armour".
- All rock armour shall have a Specific Gravity of at least 2.60.
- Only rocks between the sizes of 50kg and 4tonnes shall be used for repair works on the flow slide barrier.
- All rock armour shall be well graded, clean, free from overburden, spoil, shale and organic matter.
- Individual rocks shall be slightly weathered to fresh; durable; sound; and suitable for use as armour in a marine environment.
- All rock armour must be free of any defects which would result in breakdown of individual stones in the foreshore environment of the works.
- Rocks displaying cleavage planes and weak seams shall not be used.

3.4 Notification

A requirement of Section 166 of the *Planning Act (2016)* is that a development approval is applied for as soon as "*reasonably practical*" after the Emergency Tidal Works are completed. It is also a requirement that the assessment manager for the application be given written notice of the emergency works and a copy of this Safety Management Plan.



NOTES :

1. All armour rocks used in the Flow Slide Barrier are to have a nominal weight designed to withstand tide/flood currents, storm tides and storm wave action– comparable to the design standards for rock-armoured seawalls in Queensland. This will include the determination of minimum and maximum weights of armour rocks to ensure tight interlocking of all rocks within the armour matrix.
2. The thickness of the Flow Slide Barrier is to be such as to prevent the unrestricted growth of any flow slide that develops on the adjacent seabed slope. The minimum thickness is to be at least ten times (x10) the dimension of the smallest allowable rock armour size.
3. The gradient of all exposed rock slopes are to be no steeper than 1 horizontal : 1.33 vertical.
4. Two options are shown as acceptable arrangements for the placement of rocks in the lower toe area of the Flow Slide Barrier. The intent is to ensure that there are adequate rocks in this toe area to provide protection for the maximum expected scour level of adjacent seabed/channel features. In the case of Option A, this is achieved by armouring down to at least the expected level of seabed scour/lowering. In the case of Option B, this is achieved by having an adequate volume of rock to self-armour the slope below in the event of undercutting of this reserve of rocks as the seabed level drops.
5. Two options are shown as acceptable arrangements for the placement of rocks in the upper area of the Flow Slide Barrier that provide a reserve of top-up rocks. Such reserves are to mitigate any slumping or structural damage to lower regions of the Barrier that may be initiated by a flow slide. The intent is to ensure that there is a sufficient volume of top-up rocks to reinstate the form and function of the Flow Slide Barrier following any such slumping/damage.

REVISIONS			
REV.	DESCRIPTION	DATE	INIT.
01	INITIAL RELEASE	21/02/2019	PLO

CLIENT:
Redland City Council

CONSULTANT:
Water Technology Pty Ltd
ABN: 60 093 377 283
Brisbane T +61 7 3105 1460

© Water Technology Pty Ltd

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

DRAWN	PLO	
CHECKED	ASX	
DESIGN	PLO	
CHECKED	AXS	
APPROVED	PLO	

AMITY POINT SEMP
CONCEPT DESIGN - FLOW SLIDE BARRIER

SHEET 1 of 1

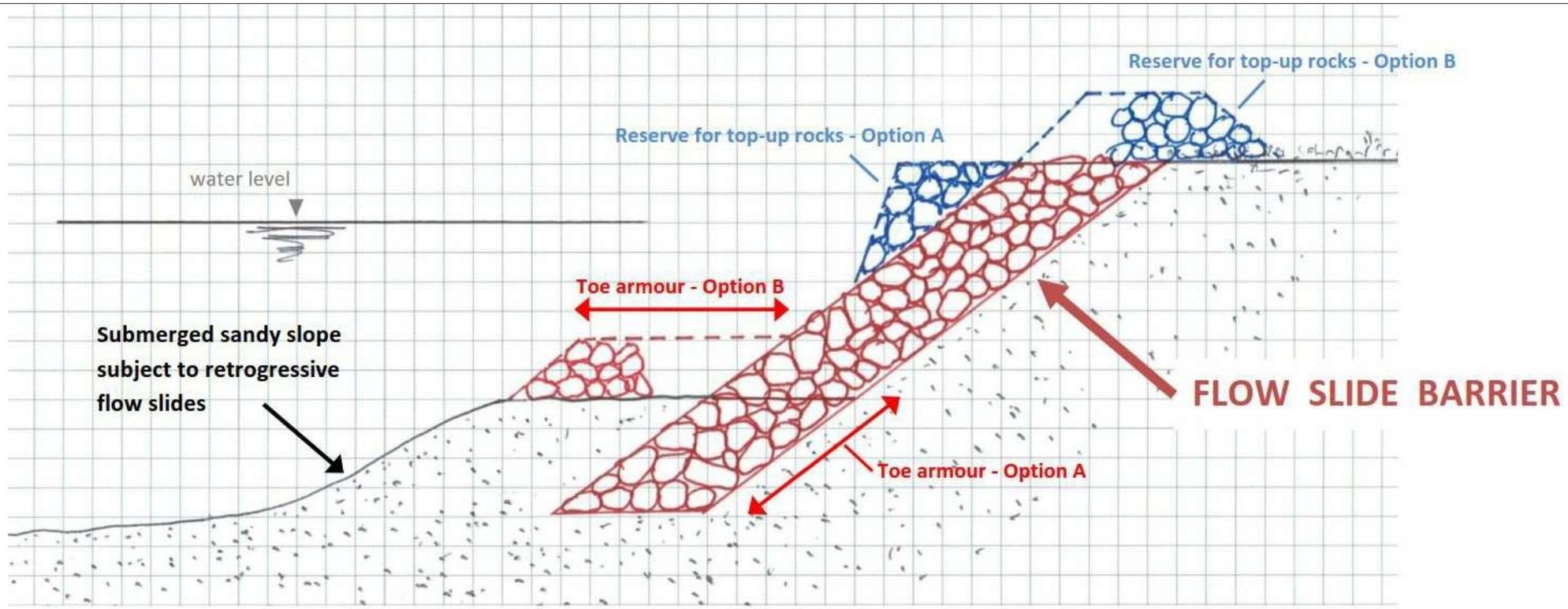
Drawing No. 4193-01-D01
Rev No. 01
JOB NO. 4193-01

SCALE: NTS
A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX H
CONCEPT DESIGN FOR A FLOW SLIDE BARRIER





NOTES :

1. All armour rocks used in the Flow Slide Barrier are to have a nominal weight designed to withstand tide/flood currents, storm tides and storm wave action– comparable to the design standards for rock-armoured seawalls in Queensland. This will include the determination of minimum and maximum weights of armour rocks to ensure tight interlocking of all rocks within the armour matrix.
2. The thickness of the Flow Slide Barrier is to be such as to prevent the unrestricted growth of any flow slide that develops on the adjacent seabed slope. The minimum thickness is to be at least ten times (x10) the dimension of the smallest allowable rock armour size.
3. The gradient of all exposed rock slopes are to be no steeper than 1 horizontal : 1.33 vertical.
4. Two options are shown as acceptable arrangements for the placement of rocks in the lower toe area of the Flow Slide Barrier. The intent is to ensure that there are adequate rocks in this toe area to provide protection for the maximum expected scour level of adjacent seabed/channel features. In the case of Option A, this is achieved by armouring down to at least the expected level of seabed scour/lowering. In the case of Option B, this is achieved by having an adequate volume of rock to self-armour the slope below in the event of undercutting of this reserve of rocks as the seabed level drops.
5. Two options are shown as acceptable arrangements for the placement of rocks in the upper area of the Flow Slide Barrier that provide a reserve of top-up rocks. Such reserves are to mitigate any slumping or structural damage to lower regions of the Barrier that may be initiated by a flow slide. The intent is to ensure that there is a sufficient volume of top-up rocks to reinstate the form and function of the Flow Slide Barrier following any such slumping/damage.

REVISIONS			
REV.	DESCRIPTION	DATE	INIT.
01	INITIAL RELEASE	21/02/2019	PLO

CLIENT:
Redland City Council

CONSULTANT:
Water Technology Pty Ltd
ABN: 60 093 377 283
Brisbane T +61 7 3105 1460

© Water Technology Pty Ltd

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

DRAWN	PLO	
CHECKED	ASX	
DESIGN	PLO	
CHECKED	AXS	
APPROVED	PLO	

AMITY POINT SEMP
CONCEPT DESIGN - FLOW SLIDE BARRIER

SHEET 1 of 1

Drawing No. 4193-01-D01
Rev No. 01
JOB NO. 4193-01

SCALE: NTS
A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Melbourne

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365

Brisbane

Level 3, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460
Fax (07) 3846 5144

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Perth

PO Box 362
Subiaco WA 6904
Telephone 0407 946 051

Geelong

PO Box 436
Geelong VIC 3220
Telephone 0458 015 664

Gippsland

154 Macleod Street
Bairnsdale VIC 3875
Telephone (03) 5152 5833

Wimmera

PO Box 584
Stawell VIC 3380
Telephone 0438 510 240

www.watertech.com.au

info@watertech.com.au

ocx