

Assessment of Erosion Mitigation Options

Amity Point SEMP

Redland City Council

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29 November 2016

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Dear Tim

Amity Point Shoreline Erosion Management Plan Interim Report – Assessment of Erosion Mitigation Options

The attached progress report regarding the assessment of erosion mitigation options for Amity Point has been prepared following completion of Stage 3 of the Study. It offers a discussion of a range of potential options considered for the Shoreline Erosion Management Plan, followed by an assessment of each option.

The outcomes of this Stage 3 assessment should be regarded as emerging mitigation strategies only. They are to be further refined and developed in subsequent Stages 4 and 5 of the study where all strategies will again be assessed and modified if appropriate before being endorsed or recommended.

Should you have any queries regarding any aspect of the report, please contact the undersigned.

Yours sincerely

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1 INTRODUCTION

Water Technology has been commissioned by Redland City Council to prepare a *Shoreline Erosion Management Plan* (SEMP) for Amity Point on North Stradbroke Island.

The Project Brief sets out the Terms of Reference (TOR) for the SEMP and specifically nominates the following staged approach:

- Stage 1 - Project Initiation
- Stage 2 - Shoreline Erosion Management Processes Study
- Stage 3 - Management Options
- Stage 4 - Detailed Design
- Stage 5 - Project Delivery

Upon completion of Stage 3, the TOR requires a report to be submitted which identifies the preferred erosion management option.

This document has been prepared by Water Technology to fulfil that requirement for a Stage 3 report regarding the Assessment of Erosion Mitigation Options.



2 SHORELINE EROSION MANAGEMENT OPTIONS

2.1 Guiding Principles

When preparing the SEMP several 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 erosion risks. Defend strategies may include maintaining the existing use or 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 the 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 impact areas through relocation or abandonment. This approach involves removing vulnerable uses from the identified coastal hazard zone 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 are:

- 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 and better prepare.



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 restrict land owners from defending their own land (e.g. collaboratively with adjoining landowners) or to *accommodate* the impact of coastal hazards.

2.2 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

2.2.1 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 exiting 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 process¹. 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...*”² 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 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 so as 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 so as 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.

¹ The *Acquisition of Land Act 1967*.

² 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.

2.2.2 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 natural processes that are 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 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, 2016, pers. comm., 06 Jan 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 strategy applied by the local community 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 in order 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.

Such adhoc 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 are 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 a number of 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.

2.3 Assessment of Shoreline Erosion Management Options

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.

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.

2.3.1 Southern Precinct - Camping Ground Foreshore

Due to the different type and orientation of the shoreline at the southern-most end of this foreshore (at the end of Basin Drive), there is scope to further refine the partitioning within this precinct. As shown on Figure 2-1 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.



FIGURE 2-1 SOUTHERN PRECINCT – CAMPING GROUND FORESHORE

2.3.1.1 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;
- result in continued loss and damage to long-established foreshore trees;
- potentially lead to adverse implications to the camping ground, including loss of available land.

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

Further south where there is a rock-armoured seawall, the implications of a Do Nothing strategy is likely to be less severe, and is a possibly acceptable strategy. The existing 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 that 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 and Mines as a Reserve for community or public purpose.

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 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 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 so as 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

The eastward migration of Rainbow Channel represents a 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 a number of 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 such dredges currently based in Australia. Leaving aside the issue of cost, the works would have to be undertaken within the Moreton Bay Marine Park and have significant environmental impacts on areas designated as *Conservation Park Zone* and *Habitat Protection Zone* within the Park. There would also be 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 will not remain permanent.



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

2.3.1.2 Structural Management Options

FLOW SLIDE BARRIER

Whilst flow slides are known to occur fairly regularly on the submerged slopes of Rainbow Channel further north within the Central Precinct (Beinssen et. al., 2014 and Beinssen & Neil, 2015), an analysis of recent and historical bathymetric surveys suggests that they are likely to be less frequent on the channel sides of the Southern Precinct. 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, they may still happen - with the signature of one that occurred in late-2004 (near the southern-most groyne) still being evident in mid-2016. However, 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 directly threaten the sandy foreshore of the Southern Precinct. Rainbow Channel has an eastward migration of around 2.0 to 2.8 metres per year. This means that flow slides are unlikely to represent a significant threat at present, with this scenario extending for a period of around 25 to 30 years.

If a flow slide barrier was to be adopted along the Southern Precinct at some point in the future, it would require the placement of very large volumes of rock directly onto the submerged channel bank, as well as in 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 Precinct.

There seems little merit in considering a flow slide barrier as the primary means of mitigating foreshore erosion of the Southern Precinct, which is primarily a result of storm wave action.

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 initially be 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 on many foreshores around the world.



GROYNES

There are already two long groynes and one short groyne constructed on the foreshore of the Southern Precinct. These were initially constructed to capture sand being moved southward by the naturally prevailing littoral drift. However, 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 Precinct and thereby intercepting any littoral sand supply along the northern shores of North Stradbroke Island.

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

GROYNES WITH BEACH NOURISHMENT

Since there are already three groynes on the foreshore of the Southern Precinct, 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.

2.3.2 Central Precinct - Flow Slide Barrier

The Central Precinct consists of the existing rock wall frontage extending northwards from the boat ramp at Claytons Road to near the northern end of Millers Lane (refer to Figure 2-2). 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 Precinct is primarily as 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 Precinct, it is necessary to consider the ability of each option to prevent, impede or accommodate future flow slides.



FIGURE 2-2 CENTRAL PRECINCT – ROCK WALL FRONTAGE

2.3.2.1 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. A do-nothing strategy of preventing any such future reinstatement of the barrier's function could result in an on-going deterioration of that 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 shoreline recession along the Central Precinct.

AVOID DEVELOPMENT

This is not relevant since the Central Precinct is already developed.

PLANNED RETREAT

This option of erosion management has previously been recommended (BMT WBM, 2013) but has been met with considerable opposition by the local community of Amity Point which views this option as a harsh and ill-considered response. The extent of opposition indicates just how such a 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 likely that it would be challenged in the courts by foreshore property owners, either collectively or individually.



Apart from the social dislocation of the Amity Point community, the acquisition costs associated with a planned retreat strategy will be considerable. 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 32 separate land parcels of mixed tenure along the foreshore of the Central Precinct. 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 - \$2million. So acquisition costs will be 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 so as to mitigate any adverse implications to public safety. However, the existing flow slide barrier consists of a 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 associated large 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 any effective flow slide barrier.

BEACH NOURISHMENT

Given the proximity of Rainbow Channel to the foreshore, in conjunction with the 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 or economically feasible. It would not inhibit flow slides nor prevent the eastward migration of Rainbow Channel.

BEACH RE-PROFILING

This option is not relevant as there is no existing beach along the Central Precinct.

CHANNEL RELOCATION

The discussion in Section 2.3.1.1 regarding the viability of this option for mitigating the erosion threat along the Southern Precinct is relevant to the Central Precinct as well. A management strategy of redirecting Rainbow Channel to alleviate the erosion threat along the Central Precinct is not environmentally nor financially feasible.

2.3.2.2 Structural Management Options

FLOW SLIDE BARRIER

As noted previously in this report, the primary threat to the foreshores of the Central Precinct are flow slides (which are also often referred to as *retrogressive breach failures*). 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.

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; or
- 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 shoreline of the Central Precinct. Despite the fact that 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 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 Precinct 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 that the depth of the rock placement in the northern part of the Central Precinct is likely to be such as to block the development of the flow slides that frequently occur immediately alongside. This is perhaps best illustrated by reference to Figure 2-3.

The flow slide event depicted in that 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 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.

However, this barrier function would only be maintained provided that the current practice of recharging the upper reserves of rock in the structure occurs whenever there is local undermining of the barrier. A focus of work to be undertaken in future Stages 4 and 5 of the SEMP will be the determination of the vulnerability of the existing flow slide barrier to future flow slide events. A geophysical survey currently underway to determine the extent of the rock buried in the Amity Point foreshore will significantly assist in that determination.



FIGURE 2-3 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 Precinct provides 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 Precinct (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 Precinct – 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 prevent nor inhibit flow slides. A strategy combining both of these options is also not viable.

2.3.3 Northern Precinct - Amity Beach

The Northern Precinct consists of the sandy Amity Beach foreshore extending from the northern-most end of the Central Precinct's flow slide barrier, to the prograding sand bar feature at the western end of Flinders Beach (refer to Figure 2-4). The erosion processes along Amity Beach are due primarily to the changing sediment transport regime driven by the wave climate, in conjunction with the shifting and complex bathymetry of South Passage immediately offshore.



FIGURE 2-4 NORTHERN PRECINCT – AMITY BEACH

2.3.3.1 Non-structural Management Options

DO NOTHING

A “do-nothing” strategy is primarily 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.

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.

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. 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 *Sustainable Planning Act 2009*.

There is currently a 145-metre-wide erosion prone area designated by the Department of Environment and Heritage Protection along Amity Beach³. 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.

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 Precinct.

BEACH NOURISHMENT

The foreshore of the Northern Precinct 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 Precinct. This would require enormously 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 Precinct.

BEACH RE-PROFILING

The erosion threat along the Northern Precinct 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 Precinct 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.

³ "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.



CHANNEL RELOCATION

The discussion in Section 2.3.1.1 regarding the viability of this option for mitigating the erosion threat along the Southern Precinct is relevant to the Northern Precinct 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.

2.3.3.2 Structural Management Options

FLOW SLIDE BARRIER

The only section of the Northern Precinct vulnerable to flow slide events is at its western-most end, where the flow slide barrier of the Central Precinct terminates (refer Figure 2-4). 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 Precinct.

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 local 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 Precinct is to be protected from the fluctuations induced by frequent flow slides, then a rock barrier comparable in scale to that along the Central Precinct would need to be buried within this section of foreshore as well. This would entail significant construction works, at very significant cost. 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 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 very large cost of the structure means that it is not a viable strategy for the Northern Precinct.

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.



3 ASSESSMENT METHODOLOGY

3.1 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 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 indigenous and non-indigenous members of the Amity Point 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.

3.2 Assessment Criteria

Within each of the above categories, a number of assessment criteria have been assigned. These are presented in Figure 3-1.

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 3-1. 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).



		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 3-1 ASSESSMENT CRITERIA AND WEIGHTING

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 and/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 departments; 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.



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. 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. However, should an erosion mitigation strategy score a zero (ie. *unacceptable*) against any of the criteria whatsoever, then that strategy is deemed unacceptable.

The preferred erosion mitigation option then emerges as that having the highest overall weighted score.

3.3 Preferred Erosion Mitigation Options

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

- For the Southern Precinct : Figure 3-2 : Beach Nourishment with a Seawall
- For the Central Precinct : Figure 3-3 : Flow Slide Barrier
- For the Northern Precinct : Figure 3-4 : Maintain the Status Quo

Each of these preferred strategies will be investigated in greater detail during Stages 4 and 5 of the SEMP study.



SOUTHERN REACH - CAMPING GROUND				Non-structural (soft) options							Structural (hard) options		
	category weighting	Assessment Criteria	criteria weighting	Maintain Status Quo / Do Nothing	Avoid Development / Re-purpose	Planned Retreat	Beach Nourishment	Beach Re-profiling	Channel Relocation	Seawall Barrier	Nourishment & seawalls	Groynes	Groynes & Nourishment
environmental	1	Maintaining coastal processes	0.40	2		4	4	2	2	2	4	2	3
		Maintenance of Marine Values	0.30	3	n/a	4	4	2	1	2	4	2	3
		Maintenance of Terrestrial Values	0.30	2		2	2	2	3	4	4	2	3
social	1	Maintenance of Social Values	0.75	3		2	4	2	3	3	4	2	3
		Visual amenity	0.10	2	n/a	2	4	3	4	2	4	2	2
		Foreshore access and amenity	0.15	2		2	4	3	4	2	4	2	2
economic	1	Planning & design costs	0.10	5		2	3	4	2	3	3	3	3
		Initial implementation cost (direct & indirect)	0.67	3	n/a	2	3	4	0	2	3	2	2
		Ongoing financial cost (direct & indirect)	0.23	4		2	3	4	3	4	3	3	2
legislative	1	Compliance with State Coastal Policy	0.50	3		4	5	2	1	2	5	2	2
		Compliance with other legislation/policies	0.20	3	n/a	3	3	2	0	3	3	3	3
		Complexity of approval (inc. costs)	0.30	5		2	4	3	0	2	4	2	3
		WEIGHTED SCORE		12.1	10.6	14.7	10.6	0	10.1	15.3	8.5	10.4	

FIGURE 3-2 ASSESSMENT FOR THE SOUTHERN REACH – CAMPING GROUND



CENTRAL REACH - FLOW SLIDE BARRIER													
		Assessment Criteria	category weighting criteria weighting Do Nothing Avoid Development / Re-purpose Planned Retreat (& remove rocks) Beach Nourishment Beach Re-profiling Channel Relocation Flow Slide Barrier Nourishment & barrier Groynes Groynes & Nourishment										
environmental	1	Maintaining coastal processes	0.40	3		4	4		2	3	4		4
		Maintenance of Marine Values	0.30	2	n/a	2	4	n/a	1	4	4	n/a	4
		Maintenance of Terrestrial Values	0.30	1		3	4		3	4	4		4
social	1	Maintenance of Social Values	0.75	0		1	4		3	5	4		4
		Visual amenity	0.10	0	n/a	1	4	n/a	4	2	3	n/a	4
		Foreshore access and amenity	0.15	0		1	4		4	2	3		4
economic	1	Planning & design costs	0.10	5		1	1		2	3	1		1
		Initial implementation cost (direct & indirect)	0.67	4	n/a	1	0	n/a	0	3	0	n/a	0
		Ongoing financial cost (direct & indirect)	0.23	0		3	0		3	4	0		0
legislative	1	Compliance with State Coastal Policy	0.50	3		3	3		1	3	3		3
		Compliance with other legislation/policies	0.20	2	n/a	3	1	n/a	0	3	1	n/a	1
		Complexity of approval (inc. costs)	0.30	3		1	1		0	3	1		1
		WEIGHTED SCORE		0		8.0	0		0	14.1	0		0

FIGURE 3-3 ASSESSMENT FOR THE CENTRAL REACH – FLOW SLIDE BARRIER



NORTHERN REACH - AMITY BEACH														
		category weighting	Assessment Criteria	criteria weighting	Maintain Status Quo / Do Nothing	Avoid Development / Re-purpose	Planned Retreat	Beach Nourishment	Beach Re-profiling	Channel Relocation	Seawall Barrier	Nourishment & barrier	Groynes	Groynes & Nourishment
environmental	1	Maintaining coastal processes	0.40	5		5	5	2	1	1	5	2	4	
		Maintenance of Marine Values	0.30	5	n/a	5	5	2	0.5	2	4	3	4	
		Maintenance of Terrestrial Values	0.30	5		5	5	2	1.5	4	5	2	3	
social	1	Maintenance of Social Values	0.75	3		1	5	2	1.5	2	3	3	3	
		Visual amenity	0.10	4	n/a	4	5	3	2	2	3	2	3	
		Foreshore access and amenity	0.15	4		4	5	3	2	2	3	2	3	
economic	1	Planning & design costs	0.10	5		2	2	4	1	2	2	3	2	
		Initial implementation cost (direct & indirect)	0.67	5	n/a	2	0	4	0	1	0	2	0	
		Ongoing financial cost (direct & indirect)	0.23	5		3	0	4	1.5	3	0	3	0	
legislative	1	Compliance with State Coastal Policy	0.50	5		4	5	2	0.5	2	4	2	4	
		Compliance with other legislation/policies	0.20	5	n/a	4	4	2	0	3	4	3	4	
		Complexity of approval (inc. costs)	0.30	5		1	2	3	0	2	3	2	3	
		WEIGHTED SCORE		18.3		12.1	0		0	8.0	0	9.6	0	

FIGURE 3-4 ASSESSMENT FOR THE NORTHERN REACH – AMITY BEACH



4 REFERENCES

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