City of Fremantle & Town of Mosman Park

Coastal Adaptation Plan - Appendix G

Adaptation Options Compendium

September 2017

4. Summary of Adaptation Options

4.1 Interim Coastal Protection

The role of interim coastal protection measures is to reduce the risks associated with the coastal hazards of erosion and inundation to land and assets. There is a variety of options suitable to protect against these hazards involving either soft or hard engineering approaches. Some forms of coastal protection can provide protection against both hazards, but coastal protection works are generally designed to protect against either erosion or inundation and not both.

The development of interim protection measures can have implications for coastal processes and sediment transport at updrift and downdrift locations from the protection works. The development of interim protection measures therefore needs to consider scales larger than the area being protected as effects can be felt many kilometres away, particularly if there is a disruption to the pathways or quantities of longshore sediment transport.

The State Coastal Planning Policy (SPP 2.6) only permits the development of coastal protection works where all other options (Avoid, Planned or Managed Retreat and Accommodate) have been considered as part of a Coastal Hazard Risk Management Process.

Interim protection works are often expensive, require ongoing maintenance and therefore require ongoing funding to guarantee ongoing functionality of the protection over the design life.

The construction of interim protection measures alters how coastal processes act on the land/beach and can therefore affect the shape of the land. These changes to the shape of the land (e.g. erosion of a beach in front of a seawall) can have implications on usage of the land (e.g. loss of beach amenity). As a result, the associated effects of interim protection measures and the future desired land use need to be assessed when deciding on adaptation options as the implications of a particular interim protection measures itself may contradict the initial purpose of the coastal protection.

The following sections describe a variety of interim protection measures that that could be used along the Port, Leighton and Mosman Beaches. A background to how each protection functions, their general purpose and the main negatives associated with the style of protection are detailed.

4.1.1 Beach nourishment

Beach nourishment is the artificial addition of sand to a beach system. It increases the buffer against erosion and is used to maintain and/or advance the shoreline position in an area which has a sediment deficit or inadequate buffer zone. Beach nourishment is commonly carried out in response to long-term shoreline erosion trends and can be planned for whereas emergency works to cope with erosion from extreme storms is event based cannot be planned for.

Beach nourishment reduces the risk of storm tide inundation when combined with the creation and vegetative stabilisation of an elevated dune system. It is important to note that beach nourishment does not halt erosion, but simply provides sediment from an external source in the form of a natural beach, upon which wave and current forces will continue to act.

Beach nourishment is undertaken for the following purposes:

1. To control erosion and create a buffer for settlements and infrastructure (a wider beach system can reduce storm damage to coastal structures by dissipating energy across the surf zone, protecting settlements and infrastructure from extreme events); and

2. To broaden beaches for recreational purposes (beaches are valuable assets for tourism, recreation and economic drivers for coastal communities).

Beaches unable to naturally migrate landward will require additional sand volumes to counterbalance beach recession caused by sea level rise (refer Figure 4-1).

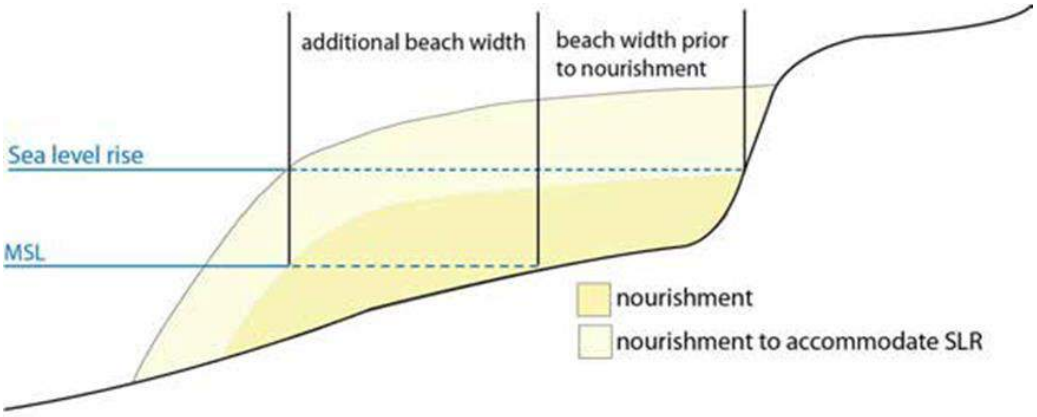

Figure 4-1 Diagram of typical beach nourishment cross-section (Linham et al 2010)

Beach nourishment can require large amounts of sand. For example, creating a 100m wide beach requires approximately 500m^3 per linear metre of coastline, depending on the beach slope and grain size. The identification of accessible and sustainable sand deposits is therefore critical to inform long-term strategies, especially in the light of the possible impacts of climate change.

Sand nourishment alone, without other forms of protection, will not prevent erosion and the nourishment material will be transported offshore or longshore over time. As such, beach nourishment should only be regarded as a short-term option feasible for short time scales of 1 to 5 years maximum depending on the wave climate and nourishment material used.

4.1.2 Artificial Reefs

Artificial reefs are submerged structures designed to reduce wave energy by causing waves to break or be disrupted at a suitable distance away from the shoreline in order to reduce the severity of erosive processes on the shoreline. This reduction in wave energy can also encourage sediment deposition in the lee of the structure. In some instances artificial reefs can be designed to enhance recreational amenity opportunities such as surfing and diving. However it is difficult to create an artificial reef that offers coastal protection and surfing amenity at the same time (due to different water depth requirements) an artificial surfing reef is not likely to be suitable to address coastal hazards along Port, Leighton and Mosman Beaches.

Artificial reefs can be effective as localised erosion control, however issues related with design and sea level rise exist because sea level rise will progressively impair the ability of the structure to reduce wave energy reaching the coast. Artificial reefs can also change beach alignment and erosion patterns.

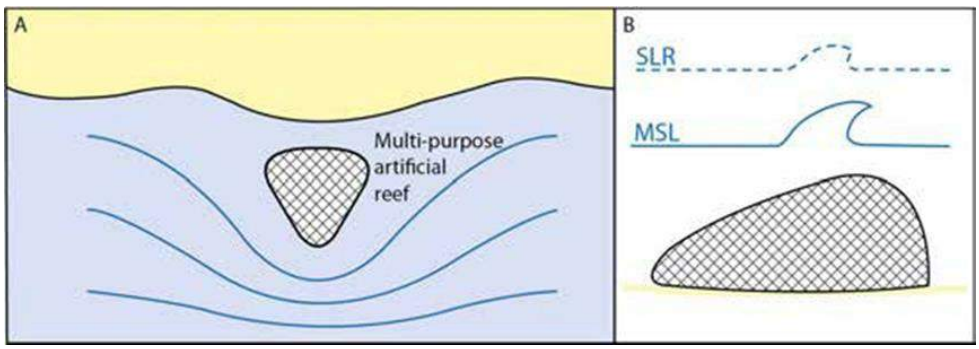

Figure 4-2 Typical diagram of a multi-purpose artificial reef (Linham et al 2010)

Sea level rise and changes in the wave climate can affect the efficiency and stability of artificial reefs, in the same way it can affect the efficiency of other emerged or submerged structures on wave energy reduction such as detached breakwaters. A rise in sea level or substantial changes in wave energy and direction can alter the reef's role in beach and shoreline stabilisation. Substantial changes in the wave climate can require expensive changes in the design of the structure (e.g. orientation). Artificial reefs can therefore be seen as a measure to control the shoreline position in the medium-term (5 to 20 years), but their efficiency as a long-term strategy to maintain the current shoreline configuration is limited.

4.1.3 Detached breakwaters

Detached breakwaters are erosion control structures. They are most frequently placed parallel to the coast to reduce wave energy and increase beach stability. Detached breakwaters can create salients (accretion of sand behind the structure) and stabilise the shoreline position against erosion.

They can be effective in defending the current shoreline position against erosion; however their effectiveness depends on the detailed design of the structure. Detached breakwaters can be used to reduce extreme and chronic storm erosion by reducing wave energy and sand movement and allowing for sand accumulation. They are not effective for protection against storm tide inundation.

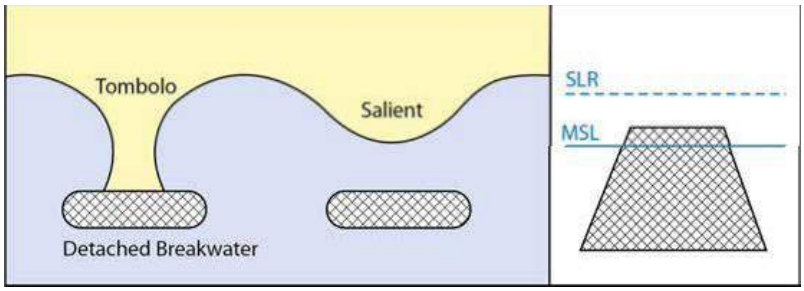

Figure 4-3 Typical detached breakwaters Note: MSL = mean sea level; SLR = sea level rise (Linham et al 2010)

Their purpose is to reduce wave energy transmission, long shore currents and therefore reduce cross-shore and longshore transport and, as a consequence, reduce erosion and increase the beach width. However by reducing the longshore transport of sand, offshore breakwaters may cause or significantly increase erosion in nearby unprotected down drift beaches.

Figure 4-4 Detached breakwater (bottom right) forming a tombolo in Geraldton, Western Australia, as part of a coastal protection and harbour configuration (Source: Google Earth Pro)

While breakwaters can be efficient in the short-term, a rise in sea level or substantial changes in wave energy and direction can alter their role in beach and shoreline stabilisation. The crest height of the structure can be submerged by rising sea levels, requiring further intervention to maintain functionality. Changes in the wave climate can require expensive changes to the design of the structure (e.g. orientation). Detached breakwaters can therefore be seen as a measure to control the shoreline position in the medium-term (5 to 20 years) but their efficacy as a long-term strategy to maintain the current shoreline configuration is questionable.

4.1.4 Groynes and artificial headlands

Groynes are structures built perpendicular to the shoreline that trap sand moving along the coast, causing sand build up on the downdrift side of the structure. A variant of a groyne is an artificial headland, which acts in the same manner but has a larger footprint. They can be effective in controlling coastal erosion, particularly due to a deficit in the supply of longshore sediment transport.

Groynes and artificial headlands can be effective in defending the current shoreline position against erosion. They are not effective for protection against storm tide inundation. As such, they should be combined with sand nourishment to mitigate the adverse effects on coastal processes. They can be used to reduce extreme storm erosion by reducing longshore sand movement.

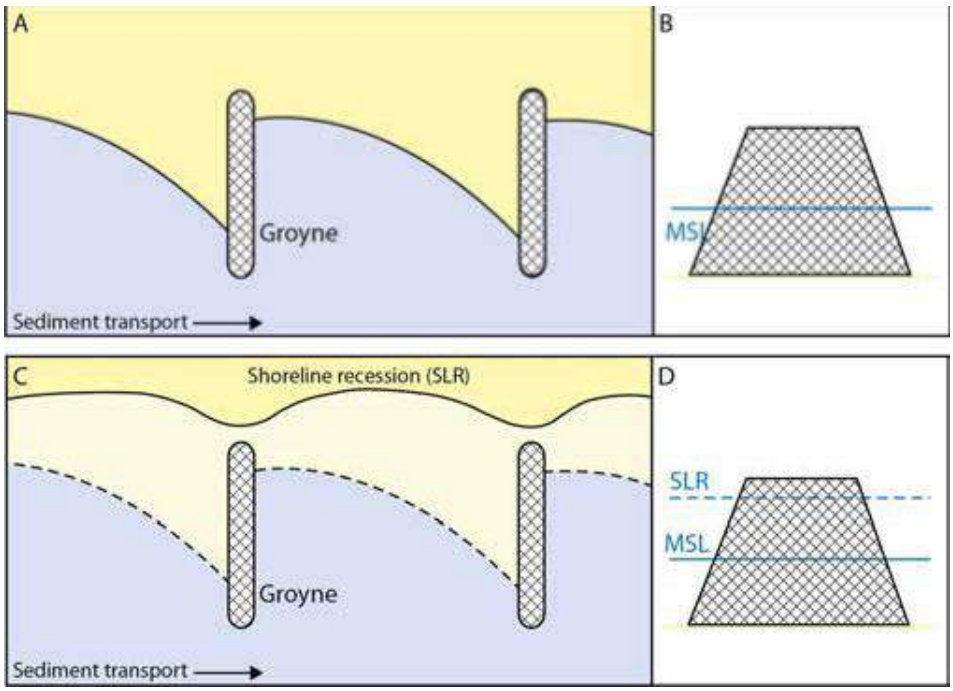

Figure 4-5 Groynes can be used to control longshore transport and facilitate beach accretion. Sea level rise can affect groynes functionality in the future (Linham et al 2010)

The primary negative impact includes coastal erosion on the lee side of the structure. In the case of a group of groynes (a groyne field), the above effect appears on the lee side of each structure within the system. Therefore it is recommended that sand nourishment is undertaken at the time of groyne construction to effectively "fill" the groyne and mitigate immediate adverse downdrift effects. The erosion is also observed in direct vicinity of the structures, particularly when waves approaching the shore are predominantly perpendicular.

Sea level rise and changes in the wave climate can affect the efficiency and stability of groynes. While groynes can be efficient in the medium-term (up to 50 years), a rise in sea level or substantial changes in wave energy and direction can alter their role in beach and shoreline stabilisation. These changes could require the implementation of adaptation measures to ensure that the groynes remain fit for purpose.

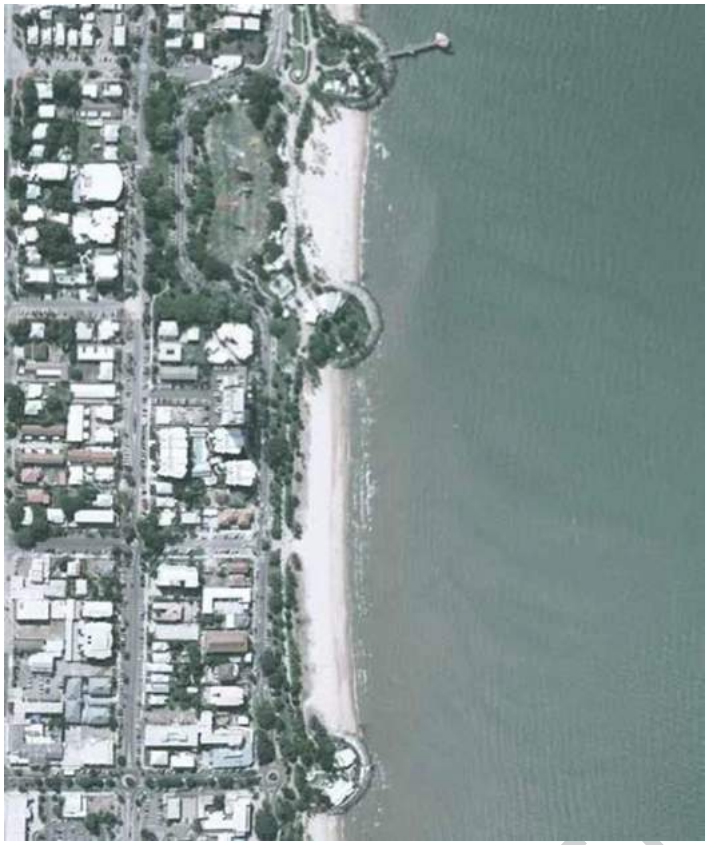

Figure 4-6 Artificial headlands along the Townsville esplanade

4.1.5 Sea dykes

A sea dyke or levee is an artificially constructed fill or wall commonly designed to regulate water levels and to avoid inundation from storm tides to low-lying land. It is usually earthen, covered with vegetation and parallel to the shoreline of low-lying coastlines. Sea dykes can be used to control extreme water levels associated with storm tides and in conjunction with sea level rise. They can also be used to defend low-lying areas from the risk of erosion provided that they are appropriately armoured on the seaward face.

Sea dykes require high levels of maintenance where extreme storms or rising sea levels challenge their efficiency and performance.

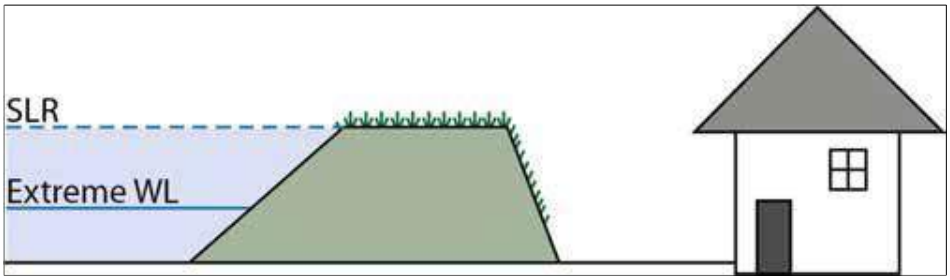

Figure 4-7 Typical sea dyke configuration Note: Extreme WL = extreme water level; SLR = sea level rise (Linham et al 2010)

Sea dykes can be used to protect human settlements from storm surge floods and sea level rise. However, sea level rise can threaten their efficiency and reshaping and upgrading may be required in the future if not adequately designed.

Sea dykes and levees can be an effective measure to reduce the risks of storm tides under sea level rise and could be designed with a 100 year or more design life, if adequate land and funding is available. However, raising sea dykes in response to sea level rise can cause the

area of land required for dyke construction to increase if slope gradients are maintained. The construction and maintenance costs are likely to increase into the future; caused by increases in water depth in front of the structure, which in turn causes increased wave heights and wave loadings on the structure. Therefore the design life needs to be considered with a long-term view in order to ensure the structure meets the needs and capabilities of future stakeholders.

4.1.6 Seawalls

Seawalls are structures separating land and water areas designed to prevent erosion of land and other damage due to wave action. Seawalls can be very large structures on the open coast as they are designed to resist the full force of waves and storm surges. Seawalls are effective in defending the current shoreline position against erosion. They are not effective for protection against storm tide inundation unless designed to be as they can be limited in height and may be porous. They should also be combined with sand nourishment to reduce beach loss in front of the wall due to wave reflection.

Seawalls are put in place to protect the land and associated land-based amenities behind them. While these structures are usually termed coastal protection structures, they effectively serve as land protection mechanisms as opposed to aiding in reducing coastal erosion. In many instances seawalls accelerate erosion on their seaward side, which ultimately results in a loss of the beach. In addition, these structures can be aesthetically unappealing and may hinder access to the beach.

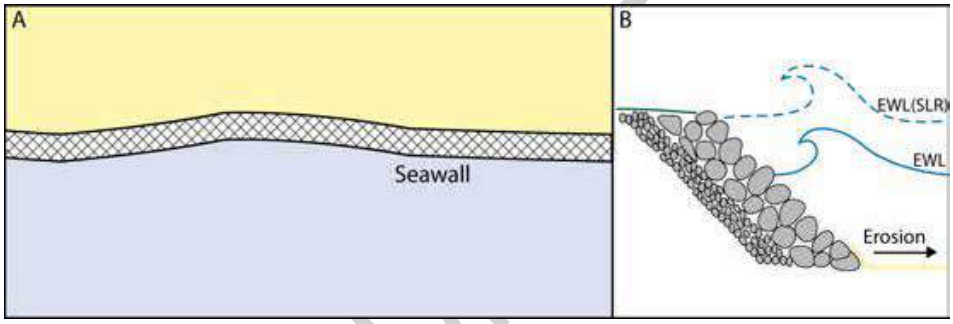

Figure 4-8 Typical seawall and the effect of sea level rise and erosion (Linham et al 2010)

Figure 4-9 Example of a seawall at Wells Park in the City of Kwinana.

It is desirable for seawalls to cover the full length of the sediment cell within which they are located in order to prevent down-coast effects. In some instances this is not practical or feasible,

in which case the potential for erosion to occur around the ends of the wall needs to be considered to ensure that the structure does not collapse adjacent to the unprotected coast, or accelerate erosion of the adjacent unprotected shoreline.

Seawalls do not typically require continuous maintenance, however, extreme storms can damage the structures and occasional maintenance can be required.

Seawalls on the open coast are typically designed with a 50 year design life, if adequate land and funding is available. However, it is important that the design life is considered with a long-term view in order to ensure the structure meets the needs and capabilities of future stakeholders. To address sea level rise, seawalls will either need to be designed and constructed to meet future requirements or planned for height increases to be undertaken periodically. However this will only be practical if the foundations of the wall have been built sufficiently robustly to allow the extra load. Otherwise the wall may need to be rebuilt or augmented.

4.2 Planning and Development Options

Planning adaptation responses are designed to reduce the risk of coastal hazards on human settlements by controlling development in high hazard risk areas and reducing the current urban footprint in high hazard risk areas. Planning responses ultimately contribute to strategic retreat pathways, however can also provide a framework for shorter term use and enjoyment of the coast prior to the realisation of coastal risks. Planning responses can also provide for intensification of coastal development, where community, economic and social values support the long-term (interim) protection of coastal developments.

Planning decisions made in short and medium term horizons should not pre-empt or restrict future planning decisions. This is supported by the WAPC's SPP 2.6 *State Coastal Planning Policy and Guidelines* which recommend that more favourable risk adaptation options will allow for a "wide range of potential future risk management options". For this reason, planning responses are most effective when considering the "avoid" and "planned or managed retreat" risk mitigation levels set out in the *Coastal Hazard Risk Management and Adaptation Planning Guidelines* (WAPC) and in Figure 2-4.

Relevant planning mechanisms in Western Australia include the *Environment Protection and Biodiversity Act 1999* (Commonwealth); the *Planning and Development Act 2005* (WA); *Planning and Development* (Local Planning *Schemes) Regulations Act 2015*; State Planning Policy 2.6 *State Coastal Planning Policy* and *State Coastal Planning Guidelines*; local planning schemes and local planning strategies; structure plans; local area plans; foreshore management plans and coastal management strategies. These are mechanisms that can deliver/implement planning responses, however do not operate as the discrete response themselves.

For future development, risks can be avoided by policy approaches that restrict vulnerable development in high-level coastal hazard risk areas. There is scope to accommodate risks through a range of planning policy mechanisms by providing warning to landowners, educating the community, government intervening to secure future vulnerable land, and reducing the consequences of impacts (e.g. development styles, construction techniques). Alternatively, there is an opportunity to accept the risk of development in vulnerable areas where the design life of the development aligns with the expected timeframe until a certain risk level is reached.

As comprehensive infrastructure and works are already in place in settlements within coastal hazard risk areas, it is much more difficult to manage existing development as there may be limited opportunity to avoid or accommodate the risk using planning responses alone. Risk management options, therefore, are mainly concerned with protecting the land or asset through

redevelopment, rezoning and land acquisition to utilise land and development in the most efficient way in providing protection from high coastal risk.

State Planning Policy 2.6 provides an effective planning tool in Western Australia, and provides development control and strategic planning guidance for new coastal development and land use. The limitations of SPP 2.6 in managing coastal risks in the long-term relate to the capacity of decision makers to understand and implement the policy, and the ability and precedence of the (non-statutory) policy to be varied in response to political outcomes. The focus of the SPP on new development and land use change limits its applicability to existing development within coastal risk areas.

The following planning options are described within this compendium. This information discusses the planning policy response to manage risks rather than the mechanisms in the Western Australia planning system that might be used to implement them. The mechanisms will be analysed and explored in the development of the adaptation plan:

- Coastal Development Control
  - Restriction of development in vulnerable areas
  - Coastal development setbacks
  - Temporary development
  - Managed redevelopment
  - Design standards to manage risk
- Strategic Planning
  - Rezoning land (density/land use)
  - Development incentives and split codings
  - Foreshore reserve expansion and retention
  - Intensification planning
- Retreat Strategies
  - Strategic withdrawal of utilities/infrastructure
  - Land acquisition (voluntary and compulsory, leaseback) and impermanent land tenure
  - Notifications on title

4.2.1 Coastal Development Control

Restriction of Development in Vulnerable areas

Prevention of further development within coastal areas at high risk, including primary and foredunes and low-lying coastal areas, is an effective policy tool to avoid future hazard issues with coastal development.

Restriction policy, using scheme provisions, special control areas, local or state planning policy, can be implemented by local and state government to avoid the need to provide longer-term interim protection for development in vulnerable locations.

The use of planning policy to restrict development on the basis of coastal vulnerability can be subject to challenge by developers and applicants, particularly where (interim) protection measures are seen to manage the risk in the current planning horizon. The use of statutory mechanisms (including scheme provisions and special control areas) can remove some level of discretion for such decisions.

Coastal development setbacks

Development setbacks establish fixed distances from a designated boundary (i.e. the high water mark, a hazard risk line, a defence line, or another specific line determined by the legislative framework) to the property line in which development is restricted, prohibited or regulated by specific design requirements to provide a safety buffer against extreme storms and future sea level rise.

Coastal development setbacks provide protection to properties and infrastructure against coastal flooding and erosion by ensuring that buildings are not located in an area susceptible to these hazards and that those structures which are susceptible are appropriately designed to mitigate against the risk. Coastal development setbacks can also be imposed to specify locations in which existing developments may not be rebuilt or improved following damage.

In general two types of setback can be implemented:

- Elevation setbacks to deal with flooding; and
- Lateral setbacks to deal with erosion.

Setback distances are determined either as:

- A fixed setback, which prohibits development for a fixed distance landward of a reference feature; or
- A floating setback, which uses dynamic, natural phenomenon to determine these distances case by case.

Building setbacks allow coastal processes, such as erosion, to continue naturally along strategic sections of the coast while ensuring that intensification of development in at-risk areas is restricted. Setback boundaries can be adopted on the basis of historical erosion rates, extreme water level rise predictions and sea level rise figures[i].

A limitation of development setbacks is their relevance only for a single planning horizon; land outside the defined setback will (in a future planning horizon) become land at risk. Therefore setbacks require ongoing regular review, alongside the use of other planning mechanisms to provide for retention of foreshore environments/retreat of development over subsequent planning horizons.

Temporary development

Where coastal areas are identified for retreat or interim protection (to delay retreat), their use and enjoyment by the community does not dissipate with that decision. Many vulnerable coastal areas (outside areas currently at risk) will be available for appropriate use and development for 50 and 100 years. There is opportunity to enjoy economic and social benefits of the vulnerable coast before the risks are realised, through appropriate temporary development.

Temporary development can include:

- Structures and development that have an asset design life that will expire prior to physical processes affecting their location; and
- Structures and development that are transportable, enabling their relocation as physical processes (and the coast) move toward their location.

With appropriate planning policy and design guidelines, temporary development can create distinct ‘pop up’ communities and facilities along the coast under the stipulation that these communities will be relocated in the future, as the coast moves further inland. This option is a temporary measure to maximise (temporary) land use opportunities along coastal locations with the ultimate aim of a planned retreat.

Temporary development can also assist in generating greater awareness of the temporary nature of our current beaches, in their current form/location. Design guidelines that require the physical built form to appear temporary can assist the community in understanding that coastal environments are dynamic and will change.

Modular architecture is an effective sustainable building technique that should be considered for development along the coast. Structures at a low cost or that can readily be repaired at low cost following likely impacts of coastal erosion are ideal for sites within the vulnerable area.

Temporary development policy can be very effective when planning for public recreational facilities in coastal areas, or private development on leased land. Challenges in land tenure for private development can arise where private investment prefers long-term or permanent land tenure.

Managed redevelopment

Conventional coastal development control policies have limited relevance to planning for existing freehold land located in vulnerable coastal areas. Existing policies in Western Australia tend not to be retrospectively applied to existing developed and zoned areas as decision makers are reluctant to remove existing development rights. The current policy framework and mechanisms do not facilitate adaptive planning and development in vulnerable coastal areas that can respond to changing conditions. Instead the current framework assumes an interim protection approach for the development and redevelopment of assets along the coast.

Planning policy that manages redevelopment of coastal processes can rely on the natural decommissioning and relocation of private assets at the end of their design life *prior* to coastal risks affecting the property and/or private asset through private redevelopment.

Alongside managed redevelopment policy, notifications can be placed on Certificate of Title that state that assets cannot be redeveloped beyond a certain date/risk level. This will enable freehold land to be developed now, but prevents redevelopment should the development exist within an identified coastal risk zone.

Design standards to manage risk

Increasing or changing asset design standards is one coastal adaptation option that can be used to withstand the impacts of coastal processes within coastal hazard zones. This measure should only be considered where avoiding risk or relocating an asset is not an option. This option is best implemented for new assets are considered at risk due to the pressing coastal risk line to ensure reduced cost in mitigating the impacts with initial design outcomes. Retrofitting of existing assets can be undertaken through redesign and renovations; however this would be at an increased cost to the proponent.

A design approach can inform developments sensitive to the unique natural coastal characteristics. When addressing both new and existing redevelopment, this option can be initiated through built form design controls that appropriately address the coastal impacts presented to a coastal asset. Design guidelines can include ways to 'live' with the effects of coastal inundation, including vertical building design, reducing or shifting the building footprint, locating the development on the least hazardous portion of the site, and using appropriate building materials. Guidelines can be updated according to changes in the risk line.

Figure 4-10 An example of retrospective design requirements: flood wall/gates and doors added to a dwelling to protect existing property from storm related flooding in United Kingdom

4.2.2 Strategic Planning

Our continued, long-term enjoyment of coastal environments and public beaches requires fundamental different approaches to planning of coastal settlements. Current practices, which result in intensive development adjacent to coastal foreshore due the market and amenity value of these locations, are not conducive to natural retreat of the coast, and therefore retention of the beach asset that creates the market and amenity value. Strategic planning measures therefore relate to changing settlement patterns, moving development away from the receding coastline, to retain public ownership of the beach and coast in the long-term.

Changes in land-use, for example from residential to recreational purposes, can be considered as part of a strategy to mitigate future development from exposure to risks from coastal erosion and storm tide inundation. Changes to land-use designation should be considered as a preventative mechanism to ensure that the distribution and intensity of future uses are compatible with identified risks in high coastal hazard and erosion prone areas.

Changes in land-use can be carried out to reduce the intensification within coastal hazard areas. Exposure of coastal settlements to coastal hazards can be reduced through a gradual land-use transition. Conversely, where social and economic values allow, changes in land use might intensify development in coastal areas to better justify the cost-benefit of coastal protection works.

Proposals for land-use change should be supported by a broad stakeholder consultation process. This could be a challenging process, particularly considering the loss of value of land that may be caused by land use planning changes.

There are several ways in which land use planning can mitigate the risks of high-level coastal hazard risks through local planning scheme mechanisms, primarily to encourage the provision of better land uses that are more naturally appropriate to the coastal hazards risk levels.

Rezoning land

Rezoning strategies enable planning decision makers to restrict and discourage development on residential, commercial and industrial areas along the coast, particularly in high-risk areas exposed to coastal hazards in the future. Rezoning forms a part of retreat strategies, effectively reducing and removing development potential in vulnerable locations to remove the need to protect private land from erosion over time.

Changes in land use – for example from intense commercial activities, to lower scale temporary activities – reduces the future cost of purchasing, compensating, and decommissioning private assets in vulnerable areas. Changing zones from intense residential and commercial zones to special use zones that restrict the nature of use and development can prepare private land and communities for eventual retreat.

On residential lots, rezoning to change density of development and redevelopment can ensure that intense, high-density areas are planned for outside vulnerable coastal locations. For example, increasing residential density in the Rockingham city centre, and lowering density on the immediate coast can enable the coastline to recede naturally over time, with fewer properties/dwellings at risk, and without impacting on the overall supply of dwellings in the area. The decline in value of coastal land (from the reduced density) is offset by the increase in value of higher density land elsewhere. Whilst restriction and down coding of coastal land may result in claims for compensation due to injurious effect on land values on the coast, these costs may be offset by the avoidance of interim protection measures and/or the social benefit of retaining public beaches which are otherwise lost where interim protection of private land is undertaken (through seawalls and other engineering structures).

As coastal locations are currently considered of high market value, a comprehensive change in community perceptions would be required regarding the risks of coastal hazards to land, land use and property to ensure community outrage over reducing density/perceived loss of land values is managed. Stakeholder and community engagement will be important to engage the community in decisions related to changing the structure of coastal settlements, to provide ongoing public benefit.

Development incentives

Development incentives provide a softer approach than rezoning to shift coastal development patterns. Opportunities to incentivise the ceding of private property at risk over time, through increased development potential elsewhere, can remove some of the angst felt by coastal landholders, and also alleviate compensation costs where land values are affected by rezoning policies.

Split coding (which tie increased development potential on a 'safe' lot to the ceding of a lot at risk) is an example of development incentives. These allow for more efficient land use along the coast as higher density development is encouraged outside of the hazard risk area, which could be used as public open space, community gardens or other public uses as the natural coastline continues to recede naturally. This option would make it appealing to developers and landowners who would likely benefit from the more flexible higher density coding.

The non-mandatory nature of developer incentives requires that private landholders choose to give up their coastal assets; in the context of the Port, Leighton and Mosman Beaches, many of these assets which are at risk are public infrastructure such as roads, paths, beach access points and the Fremantle Port. . Developer incentives alone may not adequately shift large private assets such as the Fremantle Port. Similarly, there is unlikely to be a development incentive that would encourage the shifting of public infrastructure assets. Developer incentives are most applicable to those land uses that are not coastal dependent such as residential and commercial properties. These development incentives may be more applicable to properties in the long-term as the risk increases.

Foreshore reserve expansion and retention

For some time, Western Australia has had a policy of public ownership and foreshore reserve along the coast and waterways. In line with this policy, the State Government has acquired land over time and requires ceding of land to provide public foreshores. This practice supports the principle that, in Western Australia, the coast and beaches are a public asset for community benefit.

Foreshore reserves along the Port, Leighton and Mosman Beaches are threatened by three key processes:

- Coastally dependent port assets;
- Erosion of the coast; and
- Road reserves

Where erosion extends beyond the foreshore reserve, or if no foreshore reserve exists, the ability to retain public beaches and foreshore reserves is entirely removed unless private land is relocated/acquired and land is reserved. The use of reserves also enable greater control of development in vulnerable areas, as private land use and development is subject to lease and approval, with no as of right development potential that exists in many zones.

In some areas of the study area, the existing foreshore reserve is insufficient to provide a beach and associated open space along the coast, particularly for Port Beach. Parts of the Port Beach area outside the foreshore reserve become impacted by erosion hazards in the short-term. .

Expanding the foreshore reserve to include all vulnerable land and some adjacent land, is the only planning response that enables retention of public beaches and coastal reserves in the long-term. Ensuring that the existing foreshore reserve is retained (i.e. not rezoned for private development) will avoid introduction of new development and assets within vulnerable areas, and therefore avoid the costs of acquisition/compensation/interim protection being borne by future communities.

Where expansion of the foreshore reserve impacts currently developed properties, existing land uses can continue to operate under non-conforming use rights; once those rights expire – or the land is purchased, the land on the coast shall form part of a foreshore reserve. A staged approach according to risk levels is appropriate in determining which lots should be rezoned and at what time. Reservation of public land will require compensation and/or purchase.

Intensification planning

Planning for intensification of coastal development may be a necessary planning strategy for development types that are dependent on coastal locations. This includes:

- Coastal dependent industrial development (e.g. access to import/export facilities and ocean outfalls); and
- Boating and marina facilities

Intensification of development may also be used in existing coastal settlements where social or economic values (e.g. value of private land, heritage values) provide justification for interim protection works. In such instances, intensifying development (and therefore the cost benefit of interim protection) can assist to offset the costs of interim protection measures over long (50+ years) planning horizons. In commercial/residential examples, increasing density and intensity can increase the number of users (e.g. residents) that benefit from the infrastructure, therefore reduce the cost per user (and share these costs through local area rates/special levies to fund the construction, maintenance and upgrading of the necessary temporary protection).

As population increases within a hazardous coastal zone, it is assumed that the intensification would support the ongoing protection of the land. Similar approaches have been undertaken in the Netherlands, where the high population density in vulnerable locations makes it viable to systematically protect in the long-term as the assets become too valuable to lose or to retreat. This is particularly relevant for state significant industrial development that is dependent on coastal access and infrastructure. The intensification option is effectively a high cost, high reward option. However, the extreme investment of costs in assets and services within a vulnerable zone means that there is a high cost associated with protection. Essentially, ever increasing seawalls would be required to protect the development from ever relocating. For this to be financially viable, it requires significant density and a critical mass of people/economic development potential to support the protection elements in the infinite term.

An issue emerges as, despite the proviso that protection will continue in the long-term, future climate change and evolving coastal processes are unknown. As such, future ways to protect the area, its land and assets, are also constantly changing. Despite the influx of communities and infrastructure through intensification making the land worthwhile to protect, as future climate change is unknown, it unsustainable to protect in the long-term and as a result, should only be considered as a long-term, but still an impermanent measure.

4.2.3 Retreat Strategies

Once a strategic decision to retreat has been made, additional responses are necessary to manage the infrastructure and financial impacts. Some preliminary responses may include the following options dependent on the primary issue/s relevant to the location:

- Strategic withdrawal of utilities/infrastructure
- Land acquisition (voluntary and compulsory, leaseback)
- Notifications on title

Strategic Withdrawal of Utilities/Infrastructure

Over time, strategic planning for utilities and infrastructure can identify ways to relocate and decommission infrastructure in areas at risk as assets become ready for renewal. With sufficient lead in, infrastructure providers are able to consider the level of maintenance, upgrade, and renewal that is appropriate in areas of coastal risk.

New infrastructure should be located outside areas of coastal risk, commensurate with asset lifetimes. Alternative servicing strategies for coastal developments, such as design and installation of infrastructure perpendicular to the coast, can enable staged decommissioning of infrastructure assets over time, as risks are realised.

For infrastructure that may already be located within an identified future retreat location, not allowing for any future upgrading or installation of new infrastructure. The installation of infrastructure is to be limited to outside the identified risk zone, and preferably perpendicular to the coast, as opposed to parallel, where possible. .

Land acquisition and impermanent land tenure

There may be potential for compensation claims to be made where private land will be affected by erosion and inundation.

Acquisition of land, through compulsory acquisition or market purchase can be explored for private land located within an identified area where a retreat strategy applies. Where land is acquired ahead of coastal risks being experienced, there is opportunity to lease these landholdings to provide income streams, and continue the use and enjoyment of coastal land.

In new coastal development areas, the release of private land should consider leasehold rather than freehold sale, to avoid future pressures and costs to protect private coastal land.

Notification on Title

In all instances, an effective and appropriate planning response is to place a notification on title on all affected landholdings, informing landholders of the status of the land being located within a vulnerable coastal area which has a retreat strategy applicable to it. This ensures all land holders and potential land purchases are aware of the risks, and assists to avoid an assumption that the land value will be retained in perpetuity through coastal protection works.