Assessment and Decision Frameworks for Seawall Structures

2013

Project Summary Report

SYDNEY COASTAL COUNCILS GROUP

Coastal Adaptation Decision Pathways Project **(CAP)**

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The Sydney Coastal Councils Group (SCCG) is a voluntary Regional Organisation of Councils representing fifteen coastal and estuarine Councils in the Sydney region. The Group promotes cooperation and coordination between Members to achieve the sustainable management of the urban coastal environment.

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Cover image Coastal seawall. Provided by Douglas Lord

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Glossary

Adaptation	Action taken to avoid actual or anticipated impacts from climate change, or to attain potential benefits arising from climate change [IPCC, 2007a].
Adaptive Capacity	The emergent property of a system to adjust its characteristics or behaviour to better cope with existing climate variability or future climate conditions. Adaptive capacity also refers to the set of resources available for adaptation, and the ability of a system to deploy resources effectively in pursuit of adaption (UNDP 2005).
CBD	Central business district.
Climate	Average weather (or, more specifically, the mean and variability of variables such as temperature, precipitation and winds) over a time period ranging from months to thousands of years to millions of years.
Climate Change	A statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
Flexible Adaptation Pathway (FAP)	An adaptation plan which identifies a range of potential adaptation options which may be implemented depending on when or if certain climate thresholds are reached. The Flexible Adaptation Pathway is dynamic and can incorporate new science as it emerges and supports iterative decisions in context of long-term view of change.
Interconnected water infrastructure	Stormwater, wastewater and water supply infrastructure, where management is shared between agencies or different tiers of government, or where there is physical interconnectedness or shared financial or asset management due to overlapping governance.
Low regrets	An adaptation option which is highly likely to increase resilience to climate change, no matter what the extent of climate change that occurs, and if it does not increase resilience, results in very little loss of resources or capital.
Maladaptation	Any changes in natural or human systems that inadvertently increase vulnerability to climate variables; an adaptation that does not succeed in reducing vulnerability but increases it instead.
No regrets	An adaptation option which increases resilience to climate change no matter what the extent of climate change that occurs.
Real options	Real options are adaptation options which include flexibility over time to avoid inefficient maladaptation. Real options are 'fitted with' flexibility to adapt to future changes, rather than be fitted for the projected change.
Risk appetite	The level of risk that an individual or organisation is willing to accept and tolerate before they require action to take place to mitigate the risk.
Scenarios	Scientifically based projection of one plausible future climate and likely biophysical impacts for a region based on knowledge of human impact on climate.
SLR	Sea Level Rise.
Threshold	Point expressed in terms of a climate variable beyond which risks become unacceptable.
Trigger point	Point (expressed either in terms of climate parameters or as a point in time) at which action must occur to avoid unacceptable impacts.
Vulnerability	The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.
Water infrastructure managers	Persons who has a responsibility for the design or ongoing maintenance and performance of water infrastructure assets such as but not limited to pumping stations, pipes, channels.
Weather	Atmospheric conditions at a particular time, such as hours or days, as defined by variables such as temperature, precipitation and winds.

Assessment and Decision Frameworks for Seawall Structures

The Sydney Coastal Council's "Assessment and Decision Frameworks for Seawall Structures" will assist Local and State Governments evaluate the robustness and condition of existing seawalls of unknown construction and quality; including identifying/ quantifying what exists, defining likely future changes to design conditions, and outlining possible options for further upgrades.

1. EXECUTIVE SUMMARY

The purpose of the report is to address the issues relating to the adequacy of minor seawalls along the coast where no detailed design information or certification is available and to provide guidance to Local Government in assessing and managing these structures at present and for a changing climate.

Seawalls and protection structures are found at many locations around the 30,000 kilometres of the Australian coast. For many of these protection structures construction details are unknown and the capacity of the structures to withstand existing (or future) storm and inundation events is not well understood. Seawall and asset owners and managers (usually Local Government) may be faced with determining development applications in areas protected by structures of unknown quality and origin (some approved and some not). Frequently there is conflict between the coastal managers and the community who have varying impressions of their effectiveness.

This project discusses;

- available methods to determine the construction and condition of existing structures (including remote and innovative techniques as applicable)
- the key design parameters for small seawalls
- the way these may change into the future with changing climate
- the primary failure modes for various types of walls
- opportunities for upgrading existing structure as appropriate
- key triggers for initiating upgrading/replacement/removal, and
- the inclusion of these structures and ongoing condition and performance monitoring within Local Government asset management registers.

The Report includes templates for assessing the suitability, monitoring, and maintenance of existing walls, and in determining investment strategies for coastal defences. Importantly the project heightens Local Government awareness of the difficulty posed by these structures and the need to identify and record key components of these structures as part of asset management.

2. INTRODUCTION AND AIMS

This Assessment and Decision Framework for Existing Seawalls project aims to assist Local and State Governments' coastal managers to understand, from a practical perspective, the issues relating to small seawalls that are not certified.

The intent is to raise awareness of the potential issues arising from the existence of these structures and, where appropriate, to alert the coastal manager to potential signs of failure that might require detailed and expert professional assessment.

The guidelines in this report do not replace the need for that expert advice, but will assist the coastal manager to identify the issues and risks requiring professional assistance, and to ask the appropriate questions in the subsequent briefing process.

2.1 Objectives:

- to canvass the issues arising from the existence and performance of these structures
- to provide guidance to assist in evaluating the robustness and condition of minor existing seawalls for coastal climate change protection, particularly where no design details or drawings are available
- to discuss the difficulties in managing such structures, including responsibility, maintenance and impacts
- to raise awareness of the potential for these structures to fail and discuss the various failure modes
- to outline possible options for future upgrades or retention of these structures as climate changes
- to identify and encourage ongoing condition and performance monitoring
- to provide practical guidance to assist Local Government in the inclusion of these structures in their asset management planning; and
- to illustrate these issues through selected case studies and economic modelling.

3. METHODS

The objective of the study is to identify information relating to the evaluation of the effectiveness of existing revetments constructed to protect properties where no design details are available.

This project has used literature searches and professional experience to identify the types of structures, likely failure modes, and shortcomings for adapting to future climate change.

It has used field studies to assess methods for gathering additional data and the need for recording of information on these structures into a Council's asset management system.

Two case studies were used to investigate approaches to evaluating the condition and suitability of existing un-certified seawalls for current and future projected climate conditions.

To support the overall assessment the following sub-consultancies have been prepared:

1. Literature Review of existing seawall type, remote sensing techniques, options for upgrading, and certification requirements (WRL; Appendix A)

2. Geotechnical report providing guidance on seawall stability and assessment, including a proforma checklists and assessment sheets for use by local government staffs. (Worley Parsons; Appendix B)

3. Economic aspects of the appraisal of the effectiveness of seawalls assuming that a seawall already exists

   The report has two components:

   i. A discussion of the economic appraisal of options for the future management of the wall and adjacent lands, including sensitivity/scenario testing of critical parameters for seawall assessment and evaluation (Griffith University in conjunction with Bond University; Appendix C), and

   ii. A spreadsheet to allow modelling of the economic parameters and Net Present Value over various time horizons

4. Site Field Data Collection to investigate methods available to assess the nature and extent of existing (often buried and not readily inspected) protection structures. (WRL; Appendix D)

5. Field assessment to identify the effectiveness or otherwise of existing structures based on available site inspections, records, and other evaluation processes identified. Trials undertaken at two Sydney Metropolitan areas:

   a. Bilgola Beach (exposed ocean beach, two revetment types) and

   b. Clontarf Beach (harbour beach, three revetment types)

   (WRL, jointly with Coastal Environment Pty Ltd and Pittwater and Manly Councils; Appendices E & F)

6. Gold Coast A line seawall Gold Coast City Council has required construction since the early 1970s of seawalls, to a common alignment and design, by individual property owners as they wish to upgrade their properties. Questions have been raised about the design standards of some early sections of the wall, and its integrity as some sections of the wall are discontinuous, leading to concerns as to the ability of the wall the withstand future increases in sea level rise and wave attack. (Griffith University; Appendix G)

A key feature of the project methodology was the establishment of a Technical Reference Group (TRG) to provide feedback on the various aspects of the project. This reference group included leading practicing engineers and government coastal managers from most jurisdictions. It comprised relevant and appropriately experienced personnel from local government, state government, and professional associations around Australia.

4. OUTPUTS

4.1 Literature Review (Appendix A)

The Literature Review provided a useful background on a range of Climate Change-related issues, and a more thorough appraisal of new methods that might be useful to assess the condition of existing (buried or otherwise difficult to assess) seawalls. This information informed the field-data collection studies.

4.2 Geotechnical Aspects of Seawall Stability (Appendix B)

The Geotechnical Aspects deals succinctly, in a clear style, with the key seawalls and modes of failure. Walls described include:

- Bulkhead Walls
- Anchored Bulkhead Walls
- Free-Standing Bulkhead Walls
- Rigid Near-Vertical Concrete and Blockwork Gravity Structures
- Rigid Sloping Revetments
- Semi-Rigid Sloping Pattern-Placed Unit revetments
- Flexible Near-Vertical Mass Gravity Structures
- Flexible Sloping Rock Rubble Revetments
- Flexible Sloping Sandbag Revetments
- Flexible Sloping Rock Mattress Revetments
- Environmentally Friendly Seawalls

Figure 1 Illustration for Anchored Bulkhead Walls

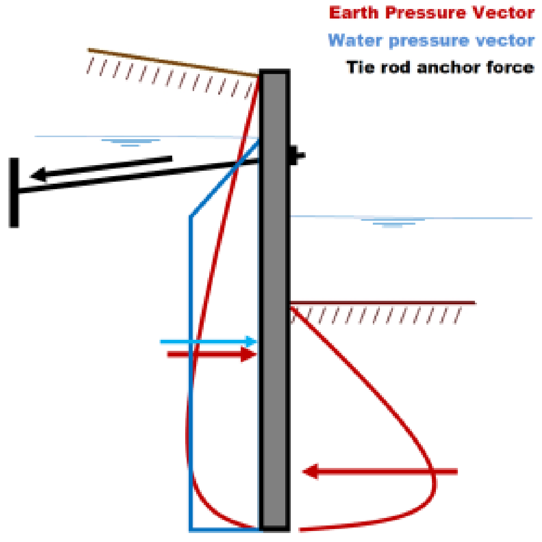


Figure 2 Earth pressure and hydrostatic loading schema for an anchored bulkhead

The Report also discusses Geotechnical Failure Modes, including:

- Bulkhead Seawalls
  - Rotational slip failure
  - Overwash Scour
  - Anchor Pull-out
- Rigid Gravity Seawalls
  - Rotational slip failure
  - Backfill wash-out
  - Toe Bearing Failure
  - Sliding and Overturning
- Blockwork Gravity Walls
- Flexible Mass Gravity Seawalls and Sandbag Revetments
- Rigid Sloping Revetments
  - Push-out and Subsidence
  - Toe Erosion
  - Differential Settlements and Global Stability
- Flexible Sloping Revetments
  - Back scour failure due to overtopping.
  - Toe Erosion
  - Washout of Fine Material
  - Subsidence of Blocks into Fine Material Seabed

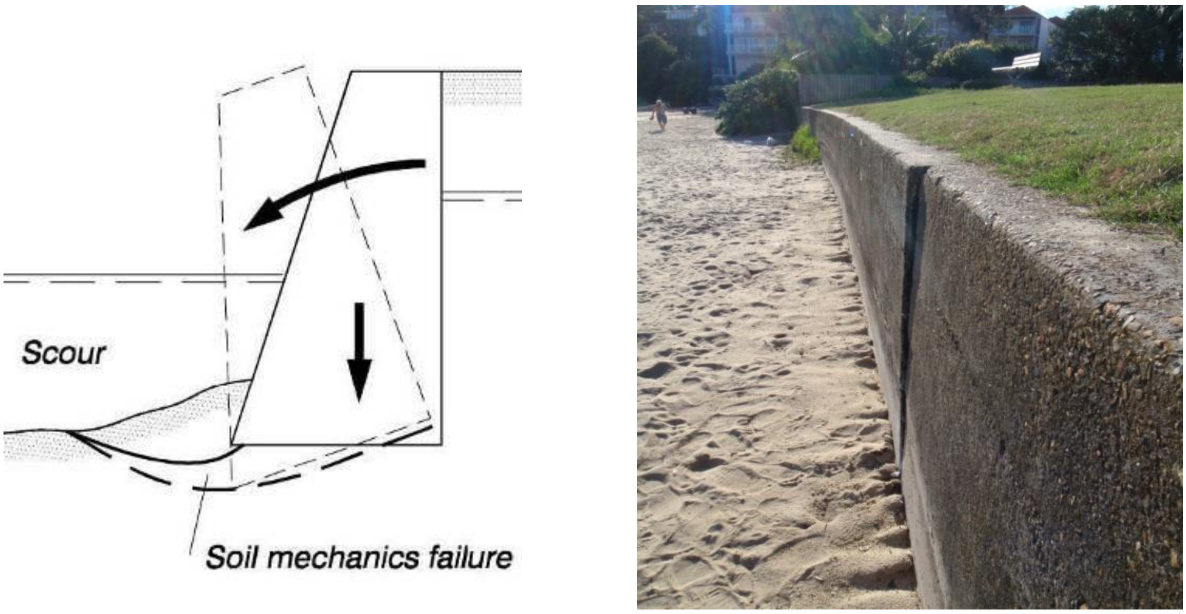


Figure 3 Toe bearing failure schema and illustration showing incipient failure

Preparation of a Pro-Forma Evaluation Form.

The proforma assessment approach is useful although requires some development in consultation with key stakeholders to ensure it is effective in promoting and integrating seawalls into asset management and the Integrated Reporting Framework (NSW). The process needs to incorporate an historical record as a static assessment, in many cases, will not reveal a potential failure.

The inclusion of these seawall into the formal asset management systems of Councils will require proper evaluation to be included in Community and Financial plans as part of the Integrated Reporting Process (NSW), ensuring appropriate planning and management.

4.3 Economic aspects of the appraisal of the effectiveness of seawalls (Appendix C)

Economic appraisal

The economic appraisal, based on a welfare economics approach, attempts to capture a full range of values to assist asset managers (and the community) make decisions about management of seawalls. We understand that economic appraisal (as applied in the case study) cannot answer these questions fully or appropriately. For the most part the seawall replacement questions will primarily be engineering and strategic planning or social questions, which economics cannot answer alone.

The same goes for many coastal management decisions, particularly in response to unpredictable influences like storm severity and frequency. What economics (non-market valuation, at least) can do reasonably well is translate preferences into a common unit.

The number or result is not important, in and of itself, but the process forces people to prioritise their desired outcomes. In recognising the limitations of the method, it can assist people to understand the dimensions of the problem space without pretending to provide THE solution.

It is easy for theory to get ahead of practice when it comes to decision-making, the reality that we are facing right at the moment is that:

- Most councils don’t fully understand benefit cost analysis, and their technical capacity to do something else is extremely limited
- They are subject to a planning framework which dictates that BCA, or something similar, must be applied (including rules of discounting that affect all long-term planning decisions)
- They are unfamiliar with alternative appraisal tools like MCA, which they perceive as subject to bias and interest groups (MCA is the subject of the SCCG CAP Project “*Prioritising Coastal Adaptation Development Options for Local Government*”)
- They don’t have the resources and time for more intensive, deliberative processes that are probably the best alternatives

The evaluation methods demonstrated the sensitivity of decision-making to particular parameters to help understand some of the potential financial consequences.

A spreadsheet

The spreadsheet, in Excel, provides a vehicle to gain insight into decisions about seawalls. The model is not exhaustive, or robust, to any/all situations and we do not intend to release it for general use. The author demonstrated the potential usefulness (with limitations) of such an approach, but considerable effort is required to develop it for non-professionals to use it confidently. Peer review has revealed anomalies in the output in particular situations, and shows the need for professional judgement to interpret the results.

The spreadsheet provides a cost-benefit framework, examining the costs and benefits associated with adaptation options in response to climate change projections, in locations where there is an existing coastal protection structure, and where this structure will not be suitable over the planning assessment period. **It is not intended to be a standalone decision-making tool, and does not constitute professional advice**, but is developed to demonstrate how different assumptions about key variables may influence the selection of appropriate adaptation options. In conjunction with the other components of this report, it can also suggest appropriate further investigations necessary to provide more certainty to the appraisal of these options in a formal context.

The spreadsheet allows both physical (environmental) factors, and soft factors (e.g. Management criteria) to be included.

The impacts of climate change on coastal regions will differ both in terms of magnitude and timing, and cannot be predicted with a high degree of local certainty. There will also be site-specific differences that cannot be incorporated into this generic model.

This model is based on the assumption that the primary source of damage to coastal land in the study area is from a seaward direction, through the influences of shoreline recession, erosion and inundation from marine sources. There may be instances where the primary sources of inundation are from a landward direction, either via surface or groundwater. Whilst these may be exacerbated by coastal protection structures, they are considered to be issues for consideration in flood management rather than coastal asset management and planning.

Table 1 Environmental Factors

Site descriptors	Unit of measurement	Symbol	Value
Shoreline length	metres	L	500
Shoreline recession rate, 2012-2050	m/year	r1	0.35
Shoreline recession rate, 2050-2100	m/year	r2	0.39
Beach width	m	W	70
Critical width	m	Wc	20
Storm occurance delay	years in future	SD	10
Storm bite	m3/m	SB	250
Available sand in beach system	m3/m	AS	150

Management Interventions

Broadly speaking, there are two classes of responses to the projected shoreline recession and storm impacts exceeding the design parameters of existing seawalls. The first class is the enhancement of the protective structures through either retrofitting or replacement, and the second is the removal of the assets currently protected by the seawall and the seawall itself. The enhancement of the protective structures could take two different forms, one being the use of hard structures such as the seawall, the other being the use of sand in the form of beach nourishment. Nourishment is a form of protection, or a means of delaying an inevitable retreat decision.

For the purpose of this appendix, it is assumed that:

- there is an appropriate and abundant source of sand for beach nourishment
- there are no political or legal obstacles to the use of this sand
- the cost of accessing and placing this sand is constant throughout the planning period.

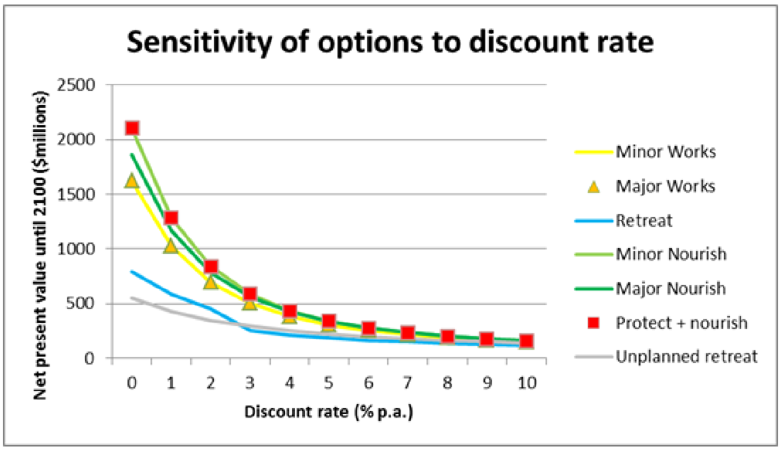
Given these assumptions, the economic viability of long term nourishment is a key determinant of its utility as a protection measure. Clearly, these assumptions will not be valid for all situations or locations and may need to be revisited in further applications of this model approach.

Table 2 Management decision components

Site descriptors	Unit of measurement	Symbol	Value
Remaining design life	Years of effective protection	DLE	**50**
Delay until Protection/Retreat decision	years	TL	**30**
Delay until nourishment application	years	TN	**20**
Planning period for retreat	Years between delayed decision and implementation	PP	**50**
Assessment period	Years over which assessment is undertaken	AP	**88**

The substantial influence of discount rates is to reduce the relative contribution of future costs and benefits on the NPV of each option. It can be seen that the relative contribution of future values to present value calculations decreases substantially at high discount rates and long time periods.

There is also a difference between the ‘hard protection’ options and those that account for beach amenity. Those options which involve nourishment have the highest NPV for all discount rates, as they preserve the value of the protected land and retain the recreational value of the beach.



One of the key issues for an economic appraisal is the way standard discount rates rapidly reduce the value of the asset to zero, making an assessment of its future value in community terms difficult

Figure 4 Impact of discount rate variables on the outcomes

It can be seen that there is a large difference in the NPV of options at low discount rates. Those options which involve retreat are much lower than the protective options. The costs associated with retreat are substantial, whether it is a planned or unplanned process. Low discount rates mean that when these options are undertaken a long time in the future they still have significant impacts on the relative attractiveness of the options.

There is also a difference between the 'hard protection' options and those that account for beach amenity. Those options which involve nourishment have the highest NPV for all discount rates, as they preserve the value of the protected land and retain the recreational value of the beach.

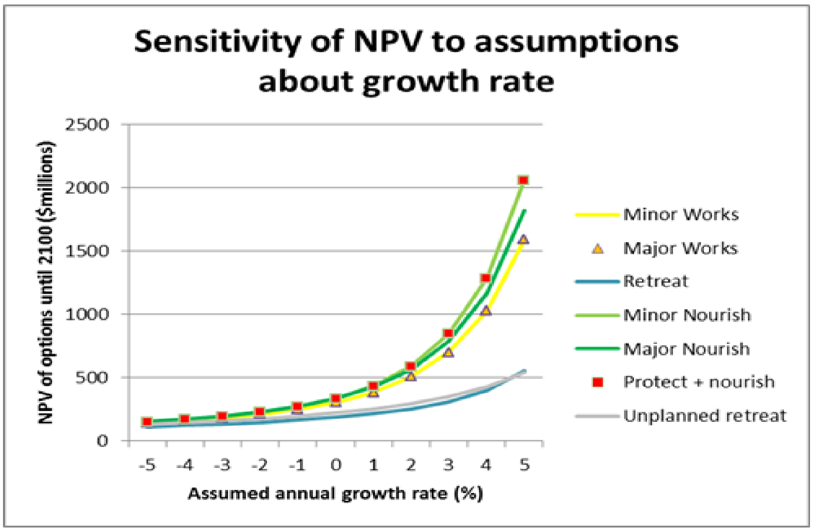


Figure 5

The other side of economic appraisal is the way the property values, protected by the sea wall, can drive the final assessment. Delays in making a decision about a seawall can result in rapidly increasing property prices, favouring the retention of the seawall in financial terms.

Figure 5 Impact of growth rate on evaluation

Given the assumptions about the protected values and the high level of benefits associated with these assets, these figures overwhelm any consideration of storm impacts or costs associated with management interventions, with the exception of those also linked to property values (i.e. costs associated with retreat options. Figure 5 displays the extent of this sensitivity, and demonstrates that the assumptions of an ever-increasing coastal property market are drivers of the decision outcomes. When negative growth rates are considered, the difference between the management options is greatly reduced, to the extent that the retreat options merit further consideration.

It can be seen from the sensitivity analysis that the favourability of each option is impacted differently by the variation in key parameters. Key among these is a parameter over which the manager has no control, the timing of storm impacts. The sensitivity analyses presented here, though simple and based on a number of assumptions that require further testing, demonstrate that there is an obvious risk to effective management posed by the occurrence of a storm before a management decision has been made, or at a time that precludes strategic options such as efficient planned retreat.

It can also be seen that the high level of benefits assumed through protection of property drives the NPV of all options. This fails to consider the fact that these protective benefits may not actually exist, as the existing structure may not adequately protect the adjacent assets in any meaningful way. In the absence of complete knowledge of the protection provided by the seawall structure, this model essentially considers only the protection buffer provided by the existing beach width. Ideally, the protective benefits should be weighted by some measure of the effective protection provided by the structure. This would greatly influence the outcomes, to the extent that further discussion about the implications of these analyses is probably not warranted.

4.4 Site Field Data Collection (Appendix D)

The Bilgola Beach case study explored the use of an air lance, and ground penetrating radar (GPR) to assess the location and condition of existing seawalls that are below ground.

Both methods proved useful although the GPR, like any remote sensing technique requires experience to interpret the output with any confidence.

There is potential for other methods, such as ultraseismic, to be applicable for some kinds of masonry walls.

Figure 6 Collecting GPS and GPR data

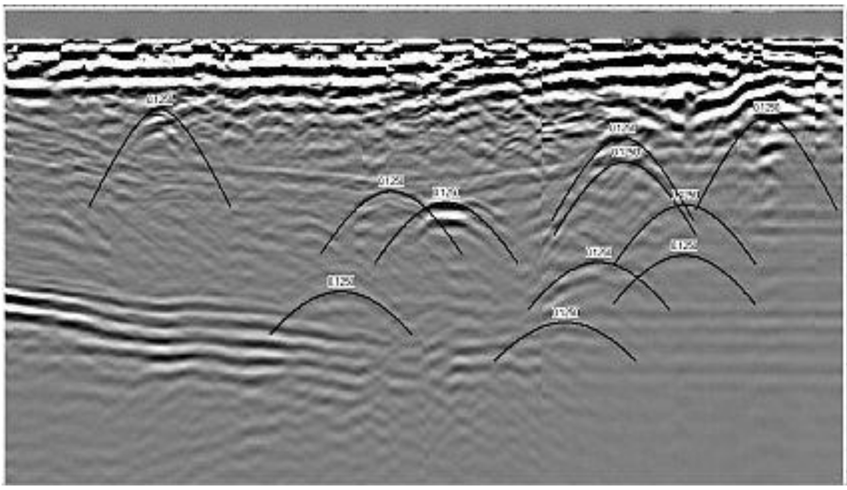


Figure 7 Ground penetrating radar image, showing possible location of boulders.

Figure 8 Using air lance

4.5 Field assessment

Sections of the project (particularly Bilgola Beach, Clontarf Beach and the Gold coast) deal with structures constructed by local residents (some on Crown Land) at their expense and protecting their properties. The economic appraisal and engineering assessment uses typical data based on these locations but is not site specific.

The assessments undertaken were purely a technical exercise in establishing and demonstrating methodologies for seawall assessment, and that while it considered the engineering, economic, wider environmental and community values, and planning contexts associated with managing seawalls, the level of detail or assessment and the assumptions required, are not suitable for planning or decision-making purposes at specific locations. The Report identifies this constraint clearly.

Bilgola Beach (exposed ocean beach, two revetment types) (Appendix E)

The seawalls were assessed with regards to their suitability to withstand the occurrence of the adopted design storm event i.e. the 100 year ARI event for present day conditions and for the 2050 and 2100 planning horizons, including SLR projections. The following coastal processes were considered in assessing the likelihood of the seawall to fail:

- Erosion of sand in front of the seawall during storm events;
- Wave impacts due to elevated water levels and large wave conditions; and
- Wave overtopping of the seawall due to elevated water levels and storm wave conditions.

All existing seawalls were assessed from available historical data and by investigation. These data were compared to modelled data for beach scour to assess potential for failure. The example results below are for the seawall in front of the Surf Club (south end of beach).

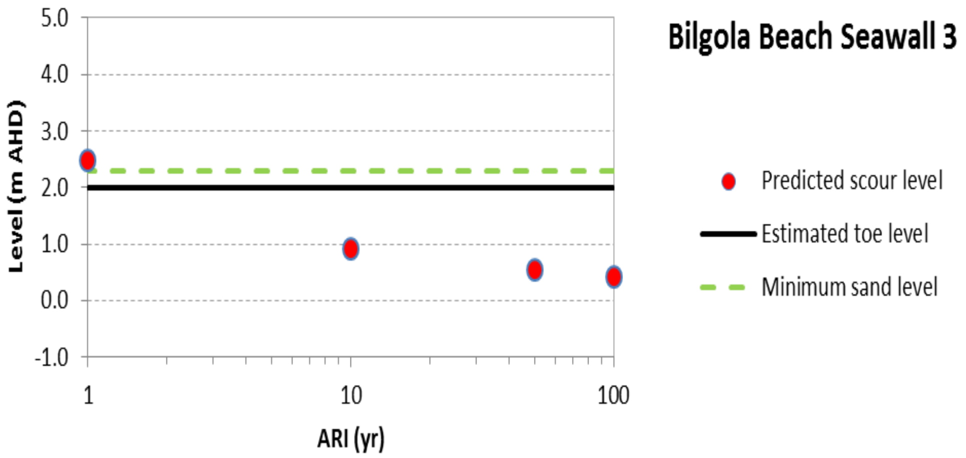


Figure 9 Data compared to modelled beach scour

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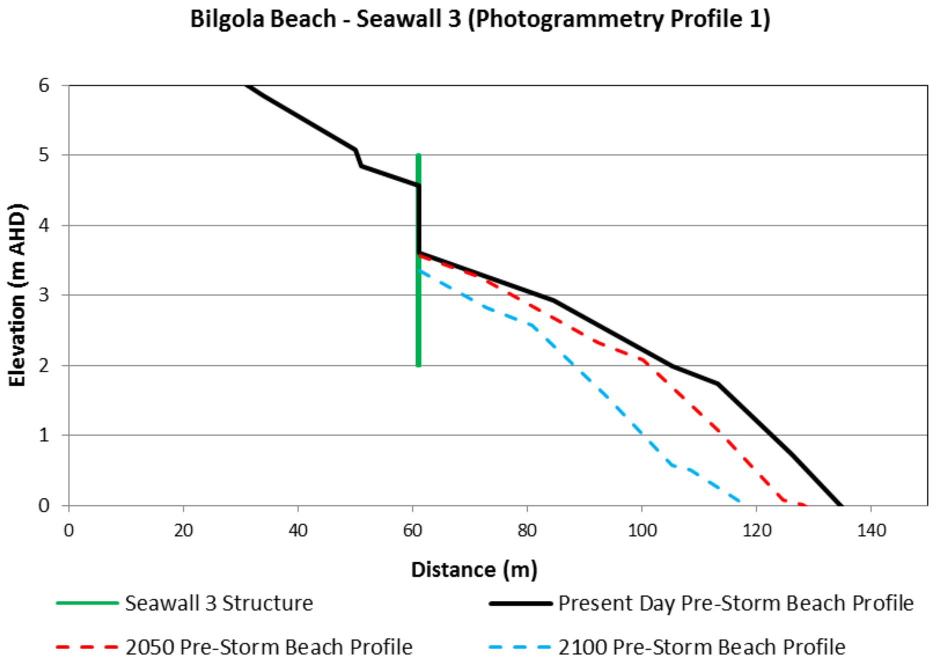

Figure 10 Results compared to modelled sea level rise

WRL undertook a detailed assessment for each of the four seawalls at Bilgola Beach to assess their suitability to withstand the occurrence of 1, 10, 50 and 100 year ARI events for present day conditions and for the 2050 and 2100 planning horizons, including sea level rise projections. The likelihood of failure of the seawalls was assessed for undermining, structure instability (for rock seawalls only) and erosion of the backfill (wave overtopping) though excluded geotechnical considerations. Each of the four structures was found to be at risk of failure by one of the assessed modes by the 2100 planning horizon, based on the assumptions used for the study.

Clontarf Beach (harbour beach, three revetment types) (Appendix F)

WRL undertook a detailed assessment for each of the three seawalls at Clontarf with regards to their suitability to withstand the occurrence of 1, 10, 50 and 100 year ARI events for present day conditions and for the 2050 and 2100 planning horizons, including sea level rise projections. The likelihood of failure of the seawalls was assessed for undermining, structure instability (qualitative only) and erosion of the backfill (wave overtopping) though excluded geotechnical considerations. Each of the three structures was found to be at risk of failure by one of the assessed modes under present day design conditions. A summary detailing if structural failure is likely to occur is presented in Table C.20 for each seawall within each planning period and for each storm event considered.

To consider the likely time to failure for each of the seawalls at Clontarf it is helpful to consider the probability of encountering one of the modelled storm events (1, 10, 50 and 100 year ARI). The "encounter probability" is the chance of a given ARI event occurring during the service life a seawall.

Tabulated values for this probability are presented in Table C.21. Ignoring the variable length of service already provided by each of the seawalls (i.e. commencing calculations from 2012), it can be seen that the probability of encountering 1 and 10 year ARI events by 2050 and 2100 is near certain. However, the probability of encountering a 100 year ARI storm event by 2050 is 32% and by 2100, 59%. While this analysis has its limitations, it is useful for considering the planning horizon over which failure may be likely.

Table 3 Summary of Seawall Assessment for Present Day, 2050 and 2100 Planning Horizons

Planning Horizon	ARI	Structural Failure					
		Seawall 1		Seawall 2		Seawall 3	
		Scour	OT	Scour	OT	Scour	OT
Present Day	1	no	no	no	no	no	no
	10	no	no	no	yes	no	no
	50	no	yes	no	yes	yes	no
	100	no	yes	no	yes	yes	no
2050	1	yes	yes	no	yes	yes	no
	10	yes	yes	yes	yes	yes	yes
	50	yes	yes	yes	yes	yes	yes
	100	yes	yes	yes	yes	yes	yes
2100	1	yes	yes	yes	yes	yes	yes
	10	yes	yes	yes	yes	yes	yes
	50	yes	yes	yes	yes	yes	yes
	100	yes	yes	yes	yes	yes	yes

Note that this technique assumes that the consequences of each respective ARI storm are stationary. As noted earlier, this is not the case under sea level rise projections and the consequences (and hence risk) for a given ARI storm will increase with time.

Considering the mechanism by which structural failure is first likely to occur and the likely time to failure (to within a planning horizon) for each of the seawalls at Clontarf, a summary presenting the most likely outcomes is presented in Table C.22. This indicates that wave overtopping is the most likely failure mechanism for Seawalls 1 and 2. Structural instability due to toe undermining is the predicted failure mechanism for Seawall 3. The time to failure for each of the seawalls is expected to be within the Present Day to 2050 planning horizons.

Table 4 Encounter Probability for ARI Event and Service Life

ARI		Encounter Probability (%) for ARI Event (years)			
		1	**10**	**50**	**100**
AEP		**63.21%**	**9.52%**	**1.98%**	**1.00%**
Service Life (Years)	**Calender Year**				
1	2013	63.21%	9.52%	1.98%	1.00%
2	2014	86.47%	18.13%	3.92%	1.98%
5	2017	99.33%	39.35%	9.52%	4.88%
10	2022	100.00%	63.21%	18.13%	9.52%
20	2032	100.00%	86.47%	32.97%	18.13%
38	**2050**	**100.00%**	**97.76%**	**53.23%**	**31.61%**
50	2062	100.00%	99.33%	63.21%	39.35%
88	**2100**	**100.00%**	**99.98%**	**82.80%**	**58.52%**
100	2112	100.00%	100.00%	86.47%	63.21%

Gold Coast A-Line seawall (Appendix G)

The Gold Coast A-Line case study provides insight into the long-term management issues where high property values are the main driver in decision-making. The Council 'designed' the "A-Line" seawall in terms of required standards of construction and alignment (at the time), but did not build it in one project. The objective was a continuous revetment to a suitable design standard, to be funded and maintained by the property owners (private land) or Council (public land).

After a period of forty years the wall is approximately 50% complete with significant gaps remaining. In addition, design standards have changed with present sea level rise predictions currently well above those generally incorporated in the design in 1970, raising the potential requirement for upgrading of the existing structures. The seawall now consists of many, discontinuous, small walls leaving the unprotected beach sections potentially exposed to severe erosion. The original assumption that property values drive high levels of redevelopment in short times, leading to a completed seawall achieved by ongoing infill, has proven flawed.

The Gold Coast City Council (GCCC) is now looking at ways to drive the remaining infill as part of the need to defend properties against the potential for increased wave attack. Beach nourishment to maintain an erosion buffer, seaward of the A-Line, is also a critical component of the current strategy. These responses are still under active development and discussion in Council. The Synthesis Report evaluates and compares the GCCC approach to other approaches and comments on the effectiveness of each approach.

5. CONCLUSIONS

The existence of coastal protection structures without certification poses a particular difficulty for Local Government. Where structures are located on Crown Land or public land within care and control of Council, but not built by the Council, issues of ownership and responsibility for ongoing maintenance is not always clear. Frequently, such structures are often not formally recognised and are not included within the Local Government asset management system.

Where structures are located either partially or wholly on private property then the question of ownership and responsibility for future maintenance needs to be determined. In some jurisdictions, Council may have the power, and some would argue the responsibility, to ensure that such structures are removed where they have not gone through the formal approval process. Residents constructed these structures in response to some real, or perceived, threat from coastal processes, which may return during similar or future weather conditions. In some local instances, they are simply old works, constructed prior to the need for formal approvals.

The possibility exists that these structures may be ineffective, ultimately resulting in damage to assets they are supposed to protect. By their nature, seawalls resist the landward incursion of coastal processes during severe events. However, this may result in the transfer of storm impacts to adjacent land (seaward or further along the coast) with loss of public amenity and environment or, possibly, damage to adjacent property.

As climate changes, more intense and increasingly frequent coastal impacts will subject these structures to stresses beyond their design capability. In particular, any rise in sea level over time will result in:

- an increase in the frequency of exposure of such structures
- increased scour at the base of the structures, allowing larger wave impacts
- increased wave run-up levels and overtopping volumes above those which are currently observed.

The risk of failure of such structures will increase.

Requests to Councils to approve new or expanded development, relying on the level of protection provided by such structures, highlights the dilemma. Local residents, who may have been responsible for the installation of the protection works or who have purchased the property in the belief that the structure is providing protection, may genuinely believe that the structures are appropriate to the level of risk to their property. Where Council is the owner or manager of the structure, then there may be an expectation that the design, and future maintenance/upgrading, may be undertaken by Council as and when required.

Before Council can approve any works it usually requests a certification (from an appropriately qualified engineer) that the structure is “fit for purpose”. This requires consideration of:

- the appropriate design conditions at the time,
- the structure and condition of the seawall, the remaining design life of the structure and
- the changes that are likely to occur to present design criteria over that design life.

Where the key components of the seawall cannot be determined then an engineer is unlikely to issue a certification or, at best, to condition that certificate.

In most cases, an existing seawall provides some measure of protection, albeit not at levels considered necessary now. Removal of the wall will increase the exposure to the property to the risks from storms. Council is not in a position to approve works on the property without adequate protection or, in many cases, the approval of a new seawall because of consequent off-site impacts.

6. RECOMMENDATIONS

It is recommended that:

1. Councils review the protection structures currently existing along their foreshores and address the legal implications relating to ownership, responsibility and liability arising from each structure

2. Councils identify all structures on public land and incorporate assessment and management of these structures into their current asset management systems

3. Councils review their asset management processes specifically in relation to protection structures of all types determining their future role and how they are proposed to be managed

4. For minor structures, Councils implement relevant and ongoing monitoring regimes to collate data and to gain a better understanding of their current performance and likely future performance in providing the requisite level of protection.

5. Where Council identifies liability issues arising from the location and/or condition of these structures, Council enter into discussions with local residents regarding these issues and potential outcomes. This should be undertaken within the framework of developing and implementing an overall coastal strategy for the beach compartment.

7. WHAT NEXT?

Preparation of technical papers for coastal management experts and managers.

Continued refinement of the pro-forma assessment sheets with Local Government staffs.

Workshops/field trips with Local Government staffs to improve proficiency of staff and improve quality of reporting for asset management

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