McEwens Beach Seawall

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Abstract

McEwens Beach is exposed to wave erosion and threatened by shoreline recession, particularly during cyclone and storm events. Residents now live only a few meters from the beach erosion scarp, surrounded by an extensive floodplain. The Mackay City Council conducted feasibility studies, modeling studies and design studies for erosion protection measures and undertook community consultation. This process led to the development of Council's coastal erosion policy.

1. INTORDUCTION AND PROJECT HISTORY

McEwens Beach is an isolated coastal suburb, located approximately 10km South of Mackay City. The Mackay City Council is leading agent for the design construction and maintenance of a seawall. In March 2006, a 25m dune buffer was available behind a steep beach erosion scarp (Figure 1).

Figure 1: McEwens Beach erosion scarp

In 1989, Cyclone Aivu reached the Queensland Coast near Townsville. The cyclone waves caused erosion and a berm retreat of approximately 3.0m at McEwens Beach. Initial complaints from the resident were received and regular recording of the erosion scarp position was initiated through the Council's surveying services. In mid 1990s property owners along McEwens beach sought assistance from the Council to protect the shoreline. In 1997 Cyclone Justin induced a berm retreat of approximately 5.0m.

In the early 2000s, the IPA development approval process kicked off. In January 2001, the Queensland Environmental Protection Agency (EPA) agreed to undertake a Coastal Erosion Study. In September 2002 the Coastal Erosion Study was completed, recommending a 30,000m^3 sand-nourishment; or alternatively the construction of a seawall built and maintained by the Council.

In December 2002, Ullman and Nolan carried out a Sand Source evaluation in Sandringham Bay. The investigation concluded that no substantial sand source was readily available. In May 2003, Mackay City Council and the residents met and discussed a range of shore protection option. Residents gave a strong support to the construction of the seawall.

In July 2003 a Council briefing was held to discuss the alternative seawall proposal. In September 2003, the Council requested the EPA support for the seawall option. The EPA requested a design and justification documentation for the seawall. In May 2004, the EPA detailed the development application process, particularly regarding design documentation. A meeting with the residents was held in August 2004. At the same period, EPA advised that they would consider an application for the seawall.

In January 2005 Connell Wagner prepared a Draft Design Report for the seawall, including provisional quantities and cost estimates. In April 2005, Ullman and Nolan undertook a geotechnical investigation and a limited acid sulphate soil report.

In July 2005 a legal opinion was requested by the Mackay City Council from King and Company on cost recovery options. In September 2005 the seawall contribution and cost recovery policy TS02 was formally adopted by the Mackay City Council.

In March 2006 Connell Wagner prepared a design report, including cross-shore erosion estimates and a brief Shoreline Erosion Management Plan, to justify the proposed Seawall Alignment. The residents had another meeting with the council in July 2006 to confirm their commitment for cost recovery.

In September 2006, Ullman and Nolan provided an Acid Sulphate Soil Investigation report following additional soil testing. Connell Wagner prepared an Acid Sulfate Soil Management Plan in November 2006. Connell Wagner provided a final design report including sediment transport study, detailed drawings for development approval as well as quantities and cost estimates. The Development Approval was lodged by Council on 13 November 2006 and awarded on 22 March 2007.

2. DESIGN CRITERIA

2.1 Geotechnical considerations

A detailed site soil investigation, including beach morphology, geotechnical drilling and acid sulphate soil investigation demonstrated that:

- A surface 2 to 3m thick medium sand (Standard Penetration Test - SPT 5-10) overlying;
- An intermediate soft to firm dark grey sandy clay (SPT 5) overlying;
- A stiff to hard residual clayey sand basal layer at depth 6m to 7m (SPT > 50);
- A safety factor of 2.2 has been calculated for the seawall section; and
- The intermediate layer could require Acid Sulphate Soil Treatment (ASST).

Acid Sulfate Soil investigation, testing and recommendations were detailed in the “McEwens Beach Seawall Acid Sulphate Management Plan” (Connell Wagner 2006). Overall a total of 8 boreholes were explored during the project for the preliminary soil investigations, foundation stability analysis and Acid Sulphate Soil screening.

2.2 Development level

Tidal planes are assumed to be similar to Hay Point, this being the closest reference port. Table 1 details the envisaged tidal planes.

Table 1: Tidal plane summary (Port of Hay Point)

Tidal Plane	Water Level, metres above LAT
Highest Astronomical Tide (HAT)	7.14
Mean Sea Level (MSL)	3.34
Australian Height Datum (AHD)	3.34
Lowest Astronomical Tide (LAT)	0

Source: Queensland Transport Tide Tables, 2006

Storm Tide: On average, cyclonic winds develop over Mackay fetch about once a year. Storm surge combines cyclone wind set-up and barometric set-up. Storm tide is the sum of the storm surge plus astronomical tide. McEwens Beach storm tide level is supposed to be similar to Mackay storm surge tide level. Recommended storm tide levels were 0.3m above HAT for a 50-year ARI event and 0.7m above HAT for a 100-year ARI event, according to the Commonwealth Department of Environment and Heritage (DEH, Harper, 1999).

Climate Change: Allowances for sea level rise of 0.30m and 0.50m were adopted for the 50-year and 100-year Planning horizons respectively.

Wave Set-up: Wave setup is due to the wave radiation stress on the seabed when waves shoal and break in the surf-zone. During cyclones a 0.5m allowance for wave set-up is suggested by DEH for Mackay. The extreme total water levels used for the McEwens Beach seawall design are 4.9m above MSL for a 50-year ARI event and 5.5m above MSL for a 100-year ARI event. These estimated levels represent peak water level.

The maximum total water level is close to the top of the dune at the peak of the 50-year ARI design storm. In this condition, it is anticipated that waves would break and overtop the dune top, and that coastal flooding would occur. The purpose of the proposed wall is to provide erosion protection, rather than coastal flooding protection.

2.3 Waves

The EPA's Mackay Coast Study (2004) evaluated the wave climate offshore Mackay during cyclones using wave rider buoy analysis, tide gauge analyses, cyclone, storm surge and wave numerical models. Table 2 details the recommended offshore wave climate:

Table 2: Offshore wave parameters (Mackay Area)

Event	Mackay Coast Study, recommendation 2004	
ARI, year	Wave Significant Height, m	Peak Period, s
50	4.9	12 to 14
100	5.2	12 to 14

Considering a Rayleigh distribution of waves, the largest offshore waves are approximately 10.0m height for a 50-year return event. Because Sandringham Bay is relatively shallow the water depth limits the wave size at McEwens Beach.

A SWAN numerical wave model was used to estimate nearshore wave generation and transformation. Waves were generated for the 50 and 100 year ARI wind speeds (respectively 34.7m/s and 37.3m/s) and for various wind directions.

The wave significant height H_s and the wave peak period T_p estimated by SWAN were respectively 1.9m and 4.2s for a 50-year ARI event, and 2.0m and 4.2s for a 100-year ARI event.

2.4 Quantity and cost estimate

It was found that the cost of Acid Sulphate Soil Treatment (ASST) and revetment material could cost each approximately a third of the total cost. ASST presents a significant cost risk, since the quantity of material to treat would be determined as the seawall construction progresses.

3. SEAWALL DEVELOPMENT LINE JUSTIFICATION

3.1 Erosion record

Mackay City Council records the erosion scarp offset from the property boundaries approximately twice a year since October 1988. The erosion is relatively uniform since 1988, and averaged 2.5m/year. Cyclones action influences the erosion rate. Table 3 summarises the measurements of erosion and some estimates of cyclonic erosion.

Table 3 Erosion during Cyclone

Erosion Event	Peak Storm Level (m, AHD)	Significant Wave Height (m)	Storm Bite (m)
Cyclone Aivu	3.6	1.4	3 to 4
Cyclone Justin	3.9	1.6	4 to 5
50 year ARI Cyclone	4.4	1.9	N/A
100 year ARI Cyclone	5.0	2.0	Approx. 30m

3.2 Sediment Transport Model

It was proposed to use the berm position survey lines to calibrate the Kriebel and Dean (1993) model, a relatively sophisticated parametric “storm bite model”. The model aimed to mimic the recorded beach erosion behaviour using existing erosion data to provide a justified basis for interpolation. Table 4 indicates the modelled berm retreats.

Table 4 Cyclone erosion (cross-shore transport)

	Potential Berm Retreat m
Yearly erosion event	0.7
Cyclone Aivu 1989	3.3
Cyclone Justin 1997	5.1
50 ARI wave event	11.7
100 ARI wave event	18.3

It appears that the development line should be at least 11.7m to provide some immunity to coastal erosion during a 50-year event that may occur prior or during construction. Using a safety coefficient of 1.4 for storm bite estimation as per EPA's standard erosion prone area calculation method provides a 17m buffer. This safety coefficient is in effect similar to the collapse of the quasi-vertical erosion scarp. A 15m development line was therefore recommended and confirmed by the EPA.

4. SEAWALL GENERAL ARRANGEMENT

The seawall is designed for minimal damage under a 50-year ARI cyclone event and revetment stability is verified for the 100-year ARI cyclone event.

The seawall is to be built 15m in front of properties and is to be buried in the dune at the northern end to mitigate the "end effects". The crest level is to suit the dune height of approximately 5.5m above AHD. The toe will be buried at -1.0m AHD with a Dutch toe to mitigate any important scouring. The southern end of the seawall is maintained by nourishment.

The seawall is 150m long and is made of two successive armour layers, two-rock thickness primary armour and two-rock thickness secondary armour. A geotextile will be used as a filter layer. Various wave load cases derived from the wave modelling were investigated to desktop-design the rock revetment. The recommended armour rock median mass is 1,300kg for the primary armour layer. Figure 3 shows a typical cross-section of the seawall.

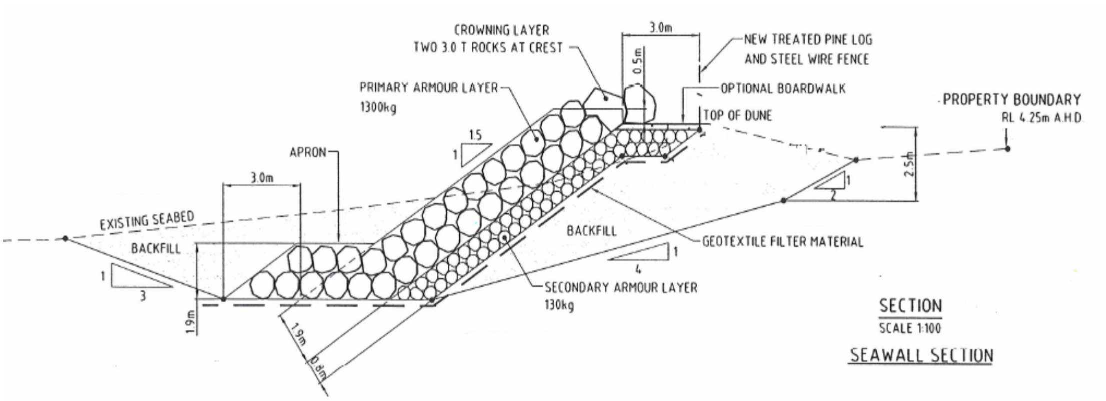

Figure 3 Seawall section

It was proposed to manage end-effects using partial yearly beach-nourishment with imported quarry sand and/or to extend the wall if these nourishments are not successful.

4.1 Drainage and Flooding

The estimated overtopping rate during the peak of the 50-year ARI and 100-year ARI events, using the Owens formula are respectively $0.3m^3/s/m$ and $1.6m^3/s/m$. Such overtopping rates are very substantial and too large to be accommodated through standard drainage works. The dune top would be damaged by such high flows. The seawall crest has been reinforced with 3.0T rocks and underlying armour to mitigate scouring at the crest. The extra permeability of this area alleviates run-up velocities.

Proposed drainage infrastructure will mitigate the effects of overtopping on the seawall, but will not protect properties from the consequences and damage due to run-up, overtopping and flooding. Flooding of the properties behind the seawall could be expected during extreme events.

5. MACKAY CITY COUNCIL SEAWALL POLICY

The Seawall Contribution and Cost Recovery Policy TS02 provide details and conditions under which Mackay City Council could act as a lead agent for the design, construction, and maintenance of seawall. Council's seawalls are only used to protect essential public infrastructures (roads, etc…). Essentially the conditions for Private infrastructure and housing are as follow:

- 75% of property owners support the design and construction of the seawall;
- The Council and EPA consider that the seawall is the most appropriate and effective solution;
- The engineering design of the seawall is practical to build and maintain; and
- A special rate is charged to the owners to recover costs.

6. TAKE HOME MESSAGES

Key aspects of this project were:

- Mackay City Council may act as a lead agent, on behalf of property owners, to facilitate engineering, permitting, construction and maintenance for coastal management purposes – Policy TS02 detail cost recover arrangements
- Political pressure may be necessary to obtain a Development Approval, however it is more effective when investigation and development studies are completed
- Mackay City council recovery costs with property owners through a "special rate", when 75% of the property owners are committed to the seawall and the seawall engineering standard is acceptable to Council and EPA
- Development approval was awarded 10 years after cyclone Justin
- 7 years of consultation with Owners and EPA was required to obtain a Development Application and to complete the recovery cost process
- 2 years were necessary to complete engineering and design process
- Detailed design is necessary to provide a reliable cost estimate
- Acid Sulfate Soil and revetment costs are instrumental to provide realistic cost estimates

7. REFERENCES

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