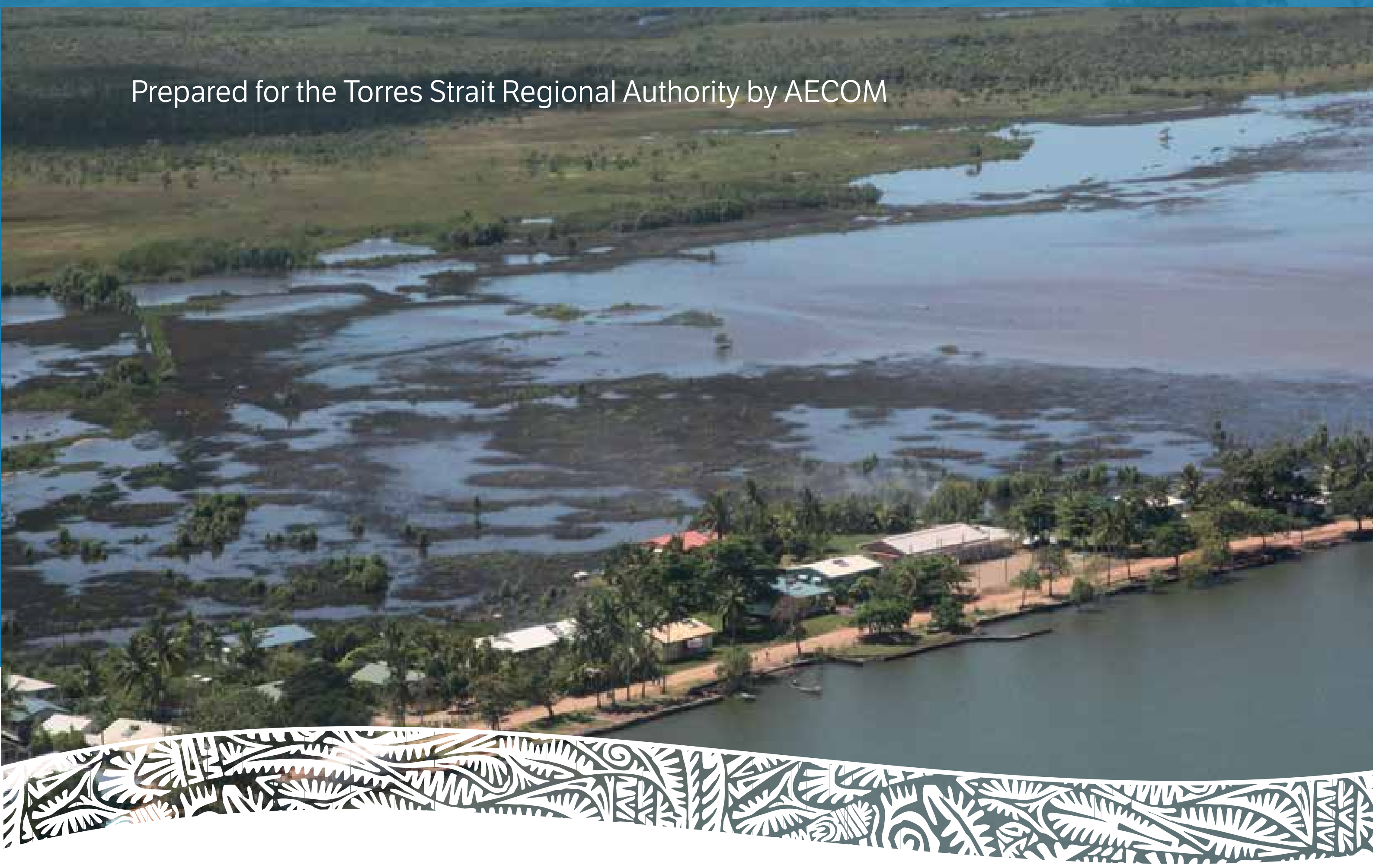
INUNDATION MANAGEMENT ON SAIBAI, BOIGU AND IAMA ISLANDS

Drainage and Seawalls

September 2012



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Seawalls and Drainage

Prepared for

Torres Strait Regional Authority

Prepared by

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Executive Summary

The communities of Saibai, Boigu and Iama are all experiencing regular inundation during king tides. This problem fundamentally arises from a lack of suitable elevated land. This study has examined the issues facing the communities and suggested solutions to improve the immunity of the communities against inundation.

At all three communities a concrete wave return wall has been recommended to exclude tides and waves from inundating the land. These structures are efficient and resistant to wave action, but need to be founded behind stable foreshore works. To this end a range of seawall replacement or upgrades have been nominated.

Inundation by high tides also impacts the communities indirectly through wetlands at the rear of the communities. To obtain similar immunity from wetland inundation engineered bund walls are also recommended at communities where they are not present.

The suggested works are:

Saibai

- Replace the existing seawall with either a Seabee or rock seawall that incorporates a wave return wall with a crest height at 3.1m AHD. These works are estimated to cost approximately $11,000,000 or $11,300,000, depending on whether Seabee or rock armour is selected.
- Provide protection against inundation from the wetlands at the rear of the community by upgrading drainage and constructing a bun wall with a crest at 2.5mAHD. These works will cost approximately $7,900,000
- Construct a 1m high reinforced concrete wave return wall around the Cemetery to improve inundation immunity at a cost of approximately $590,000.

Boigu

- Repair the existing seawall, including a rebuild in the area between the jetty and boat ramp, and incorporate a wave return wall with a crest elevation at 3.5m AHD (along the frontage of the community and at the cemetery). These works are estimated to cost approximately $1,900,000.
- Reconstruct the bund wall in areas where the internal batter is slumping. Lift crest of the bund wall to RL2.9m AHD.

Iama

- Depending on TSIRC landuse planning, repair/upgrade the seawall at the northern spit incorporating a wave return wall with a crest at 3.6m AHD, and construct a bund wall with a crest elevation at 2.8m around the rear of the community at an estimated approximate cost of $930,000. Included in this estimate is allowance to repair seawalls at the southern end of the Iama community and near the water treatment plant.

The scale of proposed works is more significant at Saibai due to the poor condition of the existing seawall and the geographic reality of the high ground on which the community is located being spread along the foreshore.

Note that the works have a degree of integration and economies of scale will be achieved if the complete scope of works is included in a single contract. If staging does occur then the best approach would be to separate on an island by island basis.

1.0 Introduction

The islands of Saibai, Boigu and Iama in the Torres Strait all suffer from inundation during extreme tide events. The Torres Strait Regional Authority (TSRA) commissioned AECOM to investigate possible solutions to the issues of coastal inundation of the communities on these islands. This investigation included an inspection of the communities, a review of previous studies and the development of costed solutions for consideration of possible future funding.

These communities are all exposed to flooding threats from both the sea and from wetlands areas located behind the communities. As such consideration has been given to both foreshore works and to works at the rear of the communities.

The site inspection attended by AECOM, TSRA and members of the Torres Strait Island Regional Council (TSIRC) was undertaken on the 2nd and 3rd of November 2011. The extensive observations of this site inspection, supported by previous studies are presented in Chapter 2. This review has included an assessment of existing infrastructure and an assessment of the scale and nature of issues impacting the communities.

This report will assess the need for a range of seawall and earthen bund works (and associated drainage) which have been developed to primarily reduce the risk of tidal inundation and secondly to provide additional foreshore stabilisation.

2.0 Site Inspection and Overview of Issues

The notes in this chapter were written following a site inspection to the Torres Strait islands of Saibai, Boigu and Iama over the 2nd and 3rd November 2011. They are intended to assist in the explanation of existing processes occurring on these islands and to develop a background for possible design solutions.

2.1 Saibai

The island, located 3km off the coast of Papua New Guinea (PNG) is very low and flat, with extensive areas of mangroves and wetlands. The community, located on the northwest coast of the island occupies a narrow strip of comparatively higher ground between the sea and wetlands (refer Figure 1)

Figure 1 Overview of Saibai Community (looking west)

Geologically the island is located on a coral reef platform; however, active coral growth has long been suppressed by the impact of fluvial discharges from the nearby rivers in PNG, including the Fly River some 60km to the east. Much, if not most, of sediments that make up the island are derived from the fluvial sources rather than from coral.

The community is impacted by coastal erosion and marine derived inundation (flooding during very high tides). To combat this, significant though usually poorly designed seawall and drainage works have been constructed. A discussion of the issues and possible solutions is given below. For reference in the photos, tide levels during the most recent site visit were approximately +2.1m Lowest Astronomical Tide (LAT), some 0.4m above the Mean Sea Level (MSL - that is at 1.7m LAT).

2.1.1 Coastal Erosion

The natural coastline in the area would have consisted of a mangrove forest backed by a sandy beach that was pushed up by the limited wave energy that passed through the mangrove forests during high tides. Examples of this beach form can be found west of the sewage treatment plant (refer Figure 2).

Figure 2 Natural beach and mangrove foreshore (cemetery on left with mangrove forest on right)

Previous clearing of mangroves in front of the community has allowed a significant increase in wave energy to reach the foreshore of the island and this in turn has led to significant coastal erosion issues. To combat these issues a seawall has been built along the entire foreshore of the community. It is noted that even if the mangrove forest were re-established in front of the community the restoration of a sandy foreshore would take a long time under natural conditions.

Unlike islands further south the beach material on this island did not appear to be carbonations (coral) in origin, rather the beaches contained sediments of terrestrial origin (often dark) that most likely have come from material washed down rivers in PNG and deposited in this part of the Torres Strait.

2.1.2 Seawalls

The seawall along the entire length of the community is not properly engineered and is typically in a poor state of repair. Issues noted included foundation undermining, piping behind the wall, and collapse of the seawall.

2.1.2.1 Foundation undermining

Along large lengths of the structures there is clear evidence of the toe of the existing seawalls being undermined by erosion of the foreshore (refer Figure 3). Any replacement structures will need to have toes properly designed to account for the coastal erosion. Any seawall with a brittle design that is vulnerable to rapid failure (e.g. Seabee or masonry structures) needs to be founded well below likely scour limits and preferably on the underlying coral platform.

Figure 3 Example of toe undermining

2.1.2.2 Piping

Piping failure is caused by water finding a flow path through the fill behind the wall and in the process washing the fill out, creating a "pipe" for the water to use. Piping failure results from lack of filter materials behind the wall, poor drainage (no alternate flow path) and undermining of the seawall toe.

Piping failure was wide spread along the wall and is contributing to wall failures and seawater intrusion issues (refer Figure 4). There have been many ad-hoc attempts to repair piping issues by placing fill, rubbish, and bags of cement into the holes (refer Figure 5 and Figure 6).

Figure 4 Example piping failure

Figure 5 Bags of cement used to repair piping issues.

Figure 6 Rubbish used to fill piping failure holes.

2.1.2.3 Complete Failure of Seawall

At a number of locations along the structure the seawall has completely failed or is well on its way. Some striking examples are presented in the following Figures.

Figure 7 Failure (collapsed landward) due to piping and toe undermining

Figure 8 Failure (old wall collapsed seaward) due to toe undermining

Figure 9 Localised failure (foreground) probably due to overtopping and piping more distant front face failure due to undermining of toe

Figure 10 Section of wall with large cracks, ready to collapse seaward during high wave/water level event.

2.1.3 Inundation (Flooding)

A major issues for the community is the regular inundation during the king tides in January and February. The tides at the Island have a large range with Highest Astronomical Tide (HAT) at approximately +4m LAT (2.3m above MSL). Peak water levels during the NW monsoon are often above forecast tide levels due to surges driven by weather conditions. The occupied land on the island in the community can be as low as 1.4m above MSL (0.9m below HAT) and once the sea breaches the seawall extensive flooding results. The tidal inundation issues are exacerbated by the high rainfall during the NW monsoon that occurs from approximately mid December to mid April.

Some of the land behind the seawall is inundated so frequently that mangroves can grow on the landward side of the seawall in a number of locations (refer Figure 11). These areas will be inundated during normal tidal movements.

Figure 11 Mangroves growing on landward side of seawall.

There have been some more significant inundation events over the years however as an indication of the problem observations made by Angus Gordon in February 2007 are presented in the series of comparative images from the site in Figure 12 to Figure 17. During this event the tide rose up to 3.9m LAT (2.2m above MSL).

Many locals commented on inundation coming in from both sides (refer Figure 18). That is the community was flooded from both the sea and the wetlands. Angus Gordon during his visit made comment on the apparent mechanisms in play with this inundation. In summary Angus noted that the inundation from the wetland was not a problem initially but that the level in the wetland built up during the spring tides, and flooded land towards the end of the spring tide cycle. He concluded the high roughness in the system impeded marine infilling and that it took a number of high tide levels to "pump up" the wetlands. He also noted that the peak in wetland water levels occurred some hours after peak tide levels. This indicates that the peak water levels in the wetland are below those of the ocean. At this stage no recorded data exists to confirm this theory nor is there any data on how exposed the community is to flooding from the wetlands.

To reduce the risk of flooding in the community inflows into the wetlands during spring tides should be kept to a minimum, while outflows should be maximised. This could be achieved by the use of substantial one way valves in key locations.

Figure 12 Above the box culverts looking west 2nd November 2011

Figure 13 Looking west over the box culverts 16th February 2007

Figure 14 View towards jetty 2nd November 2011

Figure 15 View towards jetty 16th February 2007

Figure 16 Sewage treatment plant 2nd November 2011

Figure 17 Sewage treatment plant 16th February 2007

Figure 18 Saibai - Between the sea and the extensive wetland that are connected to the sea through the mangroves and channels (looking south)

2.2 Boigu

Boigu Island, located approximately 3km off the PNG coast, is very similar to Saibai Island located some 30km east south east. Both Islands are very low and flat and consist primarily of mangrove forests and wetlands. The community, located on the north coast of the island, occupies comparatively high ground but unlike Saibai is a relatively compact community protected in large part from wetland flooding by the airport runway that forms its southern boundary (refer Figure 19)

Figure 19 Overview of Boigu community (looking south)

Geologically the island is located on a coral reef platform; however, active coral growth has long been suppressed by the impact of fluvial discharges from the nearby rivers in PNG, including the Fly River some 60km to the east. Much, if not most, of sediments that make up the island are derived from the fluvial sources rather than from coral.

For this community the inundation issues are similar to Saibai, though the reduced length and good repair of the seawall make the coastal defence issues a much less significant aspect. A discussion of the issues and possible solutions is given below. For reference in the photos tide levels during the most recent site visit were approximately +3.0m Lowest Astronomical Tide (LAT), some 0.6m above the Mean Sea Level (MSL- that is at 2.5m LAT).

2.2.1 Seawalls

The seawalls protecting the foreshore of Boigu were generally in good repair and relatively well engineered, using geotextile, filter layers and suitably sized armour units. The seawalls were a mixture of conventional rock armour (refer Figure 20) and pattern placed Seabee units (refer Figure 21).

There are a few issues that need to be addressed to ensure the continued good performance of the seawall. Beyond that there are some areas of concern that may be addressed when resources are available.

Figure 20 Rock armour seawall built over a relic block work wall

Figure 21 Seabee seawall in good order (note mangrove growing out of wall)

2.2.1.1 Urgent Maintenance Issues

Most of the wall is in good order but some maintenance is required to keep the seawall functioning correctly.

Mangroves

There are a number of mangroves growing through the Seabee seawalls (refer Figure 21). This vegetation needs to be removed to prevent the trees becoming large and the root system compromising the wall integrity. Poisoning or savage cut back is preferred to pulling the plants out as this may cause damage. The problem also exists in the rock seawalls but here the risks of damage are less significant.

Junctions

A number of junctions in the wall are in poor repair (refer Figure 22) and should be replaced/repaired as needed. It may be prudent to replace some junctions with a set of concrete stairs to allow easy access down the face.

Figure 22 Junction in Seabee seawall

Seabee seawall settlement

A section of the Seabee seawall has experienced excessive settlement (refer Figure 23) and the fill behind the capping beam has been washed through the armour below (refer Figure 24). On closer inspection it was apparent that bedding layers have been undersized and washed away and that a geotextile filter was absent (refer Figure 25and & Figure 26). Areas with excessive differential settlement (>100mm between armour units) require partial dismantlement and replacement from the top down, including:

- Installation of geotextile filter layer achieving at least 0.5m overlap with surrounding material
- Reinstate 0.3m thick bedding layer using rock in the range 65 to 165mm
- Reinstate the Seabee face
- Reinstate capping and end beams

Figure 23 Seabee settlement

Figure 24 Crest of wall with gap behind the capping beam

Figure 25 Beneath armour; note Seabee settled onto sand (l) & Figure 26 capping beam undermined (r)

2.2.1.2 Areas of concern

Inadequate seawall height between boat ramp and jetty

It is not clear why but the section of seawall between the boat ramp and the jetty is too low to provide protection for even moderate high tides. It would appear that the seawall is losing material from behind through wash back and that this is then allowing the waves to wash over and lower the crest armour even further (refer Figure 27and Figure 28). This issue is leading to a slow loss of land elevation behind the seawall.

In this area land needs to be raised and the seawall also needs to be raised to protect it. The land should be raised to a level of at least Highest Astronomical Tide (HAT) which is 2.4m above MSL (4.9m above LAT). Based on the tide wetting lines in the lowest areas the land needs to be raised by up to 1.2m to achieve this level.

If the land cannot be raised then armouring of the crest of the seawall with large rock that will remain in place under overtopping waves will be required to stabilise the seawall and backing land.

Figure 27 At a gap in the inadequate seawall looking east towards jetty

Figure 28 Inadequate seawall looking west towards boat ramp (note mangrove trees behind seawall)

Toe stability of Seabee seawall

It is understood from design drawings for this seawall that the toe of the Seabee seawall was buried approximately 0.5m into the existing sandy bed and may not be founded into the coral platform. The design called up the use of rock protection on the toe though it is not clear if this was constructed. If there are doubts about the use of the armour on the toe during construction it would be prudent to armour up the toe of the structure to prevent the seawall being undermined. This can best be achieved by placing significant rock armour units on the toe of the structure. Some lengths of the Seabee seawall have an armoured toe (refer Figure 29).

Figure 29 Armoured toe for Seabee seawall.

2.2.2 Inundation (Flooding)

A major issues for the community is the regular inundation during the king tides in January and February. The tides at the Island have a large range with Highest Astronomical Tide (HAT) at approximately +4.9m LAT (2.4m above MSL). Peak water levels during the NW monsoon are often above forecast tide levels due to surges driven by weather conditions. The occupied land on the island in the community can be as low as 2.3m above MSL (0.1m below HAT). This means that the inundation events are limited to the most extreme tides or surge events, but the flat nature of the land means the flooding can be wide spread.

Drainage infrastructure was seen as an issue; allowing tidal water through the seawall and reducing the immunity of the community (refer Figure 30). The community is protected to the south from inundation through the mangroves and wetlands by the airport runway and a system of bund walls (refer Figure 31). Discussions with the school headmaster indicated there was a considerable amount of standing water within the community area, especially during larger tidal events. It appears that ocean water is back flowing past the tide flaps and inundating the lower lying areas of the community. This indicates that the flaps installed on the 2/1200 x 450 RCBC are not entirely effective. It is therefore recommended that the council inspect and replace the valves in the bund as required. This should preferably occur prior to the next king tide event.

Interrogation of the bund wall design indicates the crest has been constructed to a constant level, approximately +4.4m LAT (1.9m above MSL). Comments received from the Boigu community members indicate the bund wall has previously been overtopped during higher tidal events. Therefore, the feasibility of raising the bund wall crest will be considered so that it provides a comparable level of immunity to the seawall structure. Furthermore, on inspection of the bund wall, it was noted there is some slumping of the batter on the community side of the wall. This is thought to have arisen during periods of protracted high tide events and the lack of geotextile protection of the wall. The proposed upgrade solution will be similar in nature to what is provided on the outer batter of the bund wall.

Figure 30 Drains through seawall have lost gates and allow back flooding.

Figure 31 Bund wall at the eastern end of the community.

2.3 Iama

Iama Island is located centrally in the Torres Strait and consists of a rock outcrop with fringing reef. The fringing reef has supplied sand sediments that have collected on reef platform on the northern side of the rocky outcrop. This sand build up is where the community of Iama is constructed (refer Figure 32). The island is fortunate in that it can source good rock locally, making construction of foreshore works more economical than in other parts of the Torres Strait.

Figure 32 Iama community foreshore, looking south, with the eroded northern beach in the foreground.

The community had some specific areas of concern. These were the seawall protecting the road at the southern end of the south beach, the drainage channel in the centre of the south beach, the security and flooding of the spit of sand to the north of the IBIS store and the sheltered boat ramp in the mangroves, near the airport.

For reference in the photos tide levels during the most recent site visit were approximately +2.3m Lowest Astronomical Tide (LAT), some 0.3m above the Mean Sea Level (MSL - that is at 2.0m LAT).

2.3.1 Coastal Processes

Because much of the foreshore is sandy and a significant area of concern is the undermining of structures by erosion a quick overview of the coastal processes is useful. The island beaches are fed by a supply of sand from the fringing coral reef. The strong season wave climate has led to the build up of sand on the northern side of the island. Net sand movements are to the north and sand from the island ultimately works its way along the beach and is transported off the reef to the north.

Construction of the boat ramp and dredged channel has interrupted the natural sand transport mechanism. Sand is still being brought onto the southern beach from the reef top; however, movement of sand between the spit and the southern beach no longer takes place. Rather sediments are washed into the dredge channel and are trapped. This interruption to natural flow of sand has led to the north beach on the spit being starved of sand. Looking into the future this erosion is expected to continue.

Overlaying the net northerly drift of sand during the NW monsoon the waves will drive southerly movement of sand that will cause a fluctuation in the beach orientation, fattening the southern end of the beaches and eroding the northern ends.

2.3.2 Southern Beach

The main beach does not appear to be suffering any ongoing erosion issues. The construction of the boat ramp acts as a groyne on the northern end of the beach and is helping to maintain a healthy beach width at this end of the beach (refer Figure 33).

Figure 33 Southern Beach (looking south)

2.3.2.1 Southern seawall

Near the southern end of the beach a seawall has been constructed to protect a road that extends out onto the edge of the beach at that location (refer Figure 34). The seawall is required because the road has been constructed too close to the active beach profile and not because of any ongoing coastal erosion issue in the area. Examination of cadastral lines indicates that this road is a recent construction. The seawall has not been designed by an engineer and has been constructed at a very steep slope. Despite this fact the seawall was constructed using a geotextile filter and the blocks were carefully laid resulting in a functional seawall.

It was stated that the wall has not been properly founded and may be vulnerable to undermining during severe beach scour at the southern end of the beach. Because the seawall is too steep and the toe is not properly founded the seawall is vulnerable, and sections of the structure have collapsed or slumped (refer Figure 35).

The seawall needs additional armour to flatten the slope of the front face to a more stable 1 in 1.5. The additional armour placed on the front face should extend at least 1m below the current beach level or to the reef platform, whichever is encountered first to stabilise the toe of the structure.

An offshore breakwater was constructed as a first attempt to protect the road (refer Figure 36). This structure serves no purpose now, and should be dismantled.

Figure 34 Road protected by seawall

Figure 35 Slumped section of the seawall

Figure 36 Ineffective offshore breakwater

2.3.2.2 Erosion at Southern end of South Beach

Beyond the southern seawall the beach has evidence of more severe erosion than typical with tree roots exposed (refer Figure 37). This erosion may have been exacerbated by the construction of the southern seawall. It is anticipated that during the NW monsoon this beach will recover, however, the erosion experienced will probably return annually with the seasonal movement of sand.

This section of beach is naturally anchored by rock at both ends, with a headland to the south and a substantial rock feature that defines the southern end of the seawall. These features combined with the fact the sand supplies to this section of beach have not been interrupted, indicate that the erosion experienced will not significantly worsen.

If the community is concerned about the erosion then the use of vandal resistant geotextile bags filled with local sand supplies would be an appropriate defence solution. Should this work be undertaken it would be best if it were timed to be completed just before the NW monsoon commences. This would allow the work to be constructed on the eroded face and ensure that the structure was typically buried.

Figure 37 Erosion scarp at southern end of South beach (note native terrestrial rock in foreground)

2.3.2.3 Drain

A lined drain discharges onto the rear of the southern beach. It was noted the drain near the beach was filled with sand and that the beach berm in front of the drain was higher than the drain (refer Figure 38). There was concern that the elevated beach levels prevented storm water from getting away.

The beach berm serves a vital role in keeping tidal and storm water out of the community and needs to be preserved to protect against inundation. The berm in front of the drain was slightly lower than in other areas of the beach (refer Figure 39). Care should be taken to ensure that the berm here is restored to a level consistent with the rest of the beach to provide appropriate immunity.

A culvert with a one way valve was discussed. This would require a culvert be dug into the beach and discharge onto the reef flats beyond the beach. It is felt at this stage that the need to construct of a culvert discharge requires monitoring. As a first step it is recommended that the drain be cleaned out to the lining. Where the drain discharges onto the beach a hollow should be dug out to allow water to pond and drain into the sand. The end of the drain and the hollow should be cleaned out regularly, with a clean out at the start of the NW monsoon being a minimum requirement.

If water levels behind the beach berm are an issue a channel can be dug through the beach berm to allow water to escape. Once water levels have dropped sufficiently the beach berm should be reinstated from material washed down the beach.

Figure 38 Lined channel discharges onto beach

Figure 39 Lowered beach berm at entrance where drain discharges

2.3.3 Boat Ramp & Desalination Plant

A wave return wall is to be constructed around the desalination plant area. This structure has been designed to exclude wave action and has a design crest height of 4.2m MSL (6.2m LAT). No works were proposed for the seawall in front of the wave return wall, though during the site inspection some concerns were identified.

2.3.3.1 Seawall

Generally the seawall around the desalination plant is in good repair (refer Figure 40). On the northern side however the quality of the construction is diminished (refer Figure 41), with a very steep wall transforming into a low poorly formed seawall heading towards the northern beach. This section of seawall is generally inadequate for a structure protecting high value assets.

For this length of seawall it is recommended that the seawall be topped up with suitable rock armour laid at a slope of 1 in 1.5 (similar to the units near the boat ramp).

At the northern end of this section of seawall there is a particularly poor section of seawall that appears to be located at the site of an old boat ramp (refer Figure 42). The section of seawall does not appear to contain a filter layer or geotextile layer to confine the sediments. Here the armour needs to be dismantled and rebuilt using a filter layer and suitable armour at a slope of 1 in 1.5.

Figure 40 Seawall protecting desalination plant with offshore breakwater in background (looking north)

Figure 41 Northern part of seawall protecting Desalination Plant (looking north), very steep in foreground.

Figure 42 Northern part of seawall protecting Desalination Plant with low section in foreground (looking south)

2.3.3.2 Safe landing

During a meeting with local council personnel the issue of safe landing at or near the boat ramp during the NW monsoon was raised. It was claimed that the offshore breakwater (refer Figure 40) is not proving sufficient protection and that as a result people are sailing around the spit and using the high tide boat ramp in the mangroves (refer Photo 42). It was noted that doing this at night was a safety issue.

On face value the breakwater seems ideally placed for NW waves approaching the boat ramp, however, the fact that people are making use of the less than ideal high tide boat ramp indicates that wave climate at the main ramp is an issue that needs to be considered.

During the meeting it was suggested that the community needs to raise the issue with the Department of Transport and Main Roads. This department includes Maritime Safety Queensland and are responsible for boat ramps such as this.

Figure 43 High tide boat ramp in mangroves sheltered from NW waves (note tide was 0.3m above MSL in photo)

2.3.4 Northern Beach (The Spit)

2.3.4.1 Northern Seawall

As discussed above the northern beach is suffering from a loss of sand supply and as a result is eroded. A seawall has been constructed to protect the spit and over the years this has been "reinforced" with concrete. The beach erosion has resulted in some undermining of the seawall (refer Figure 42). The seawall construction deteriorates towards the north of the structure (refer Figure 45).

The seawall is functioning to stabilise the foreshore spit at the moment, but concerns have been raised about its integrity and longevity.

Figure 44 Northern beach seawall undermined by beach erosion.

Figure 45 Northern end of seawall (note rubbish piled up to reinforce seawall crest)

2.3.4.2 Inundation

A major issue for the spit is the regular inundation during the king tides in January and February. During these events significant overtopping of the seawall occurs and the area experiences inundation more than other parts of the community. Locally people have attempted to stabilise the areas behind the seawall with block walls and sand bags (refer Figure 46)

The tides at the Island have a large range with Highest Astronomical Tide (HAT) at approximately +4.5m LAT (2.5m above MSL). Peak water levels during the NW monsoon are often above forecast tide levels due to surges driven by weather conditions. The occupied land as low as 2.4m above MSL (0.1m below HAT).

Inundation from the rear of the spit is also an issue with land on the eastern side of the spit lower than the land facing the sea. There are however no waves on the rear side. Some local attempts have been made to keep high water out by the construction of low earth bunds (refer Figure 47), masonry walls and sand bags.

Figure 46 Sand bagging to stabilise areas behind seawall

Figure 47 Earth bund to exclude sea water eastern side of the spit

2.3.4.3 Alternate approaches

The approach to be adopted here and thus the amount of money to be spent, is dependent on the long term management approach for the land on the northern spit. It is understood that at the southern end of the spit there are 4 formalised blocks of land, while the remainder of the spit is community land occupied on an informal basis. It is also understood that there is a long term plan to relocate the people and buildings from the spit to higher land elsewhere in the community.

If habitation of the area is to continue, the seawall needs to be reinforced/repaired and a wave return wall constructed to exclude the high tide waves that occur. This work would require additional toe armour to be placed along the length of the seawall to stabilise the structure from undermining and the repair of the crest of the structure. A wave return wall, with special toe detailing to protect against scour of material in front of the wall would occupy the first metre or so of land behind the armour and will require the relocation/removal of structures built close to the foreshore (refer Figure 44and Figure 48) and some mature trees. On the eastern side of the spit the construction of an earth embankment with a crest height approximately 0.5m lower than the wall can exclude inundation from that direction

If the area is to be abandoned as inhabited land then the recommendation is to do nothing, except for to protect the 4 blocks at the southern end of the beach. The seawall as it stands will stabilise the foreshore in its current location for the near to medium term.

Figure 48 Structure near seawall crest.

2.3.5 Alternate (High Tide) Boat Ramp

Concern was expressed that the alternate high tide boat ramp located in the mangroves near the airport is an area that is exposing the community to inundation risk by providing an easy flow path into the community (refer Figure 43 and Figure 49). The existing foreshore defences in this area consist of a low wall facing into the mangroves and a more recent and higher wall along property boundaries across the road (refer Figure 50). The boat ramp is providing a gap in lower structure and leads to flooding of the road and the need to sandbag the gaps in the higher wall more frequently than might otherwise be the case. If the boat ramp crest were raised to the same level as the adjacent wave wall structure it would improve the flood immunity of the road and reduce the need to sand bag driveways. This is an issue that council is aware of.

Related to the boat ramp is the vulnerability of the second and more substantial wall (painted yellow and white) because of the gaps left in the wall for vehicular access. These gaps are blocked with sand bags when the risk of flooding is high. A more permanent solution might be attractive to council. This could either be a ramped driveway that rises to a level equivalent with the wall of the provision of light weight gates that can be dropped in place.

Figure 49 Low Foreshore at alternate boat ramp.

Figure 50 Double line of defence, low wall facing mangroves and higher yellow/white wall protecting houses (l).

3.0 Coastal Considerations

3.1 Island Morphology

3.1.1 Low Muddy Island – Saibai and Boigu

Saibai and Boigu are both low muddy islands. These islands are located on reef platforms that have long since had coral growth suppressed by the high sediment loads originating from nearby rivers in PNG. This is reflected in the nature of the sediments on island. The island foreshores are dominated by mangrove forests that typically surround central areas dominated by wetlands. This typical island formation is apparent in the satellite images presented in **Error! Reference source not found.** and Figure 52.

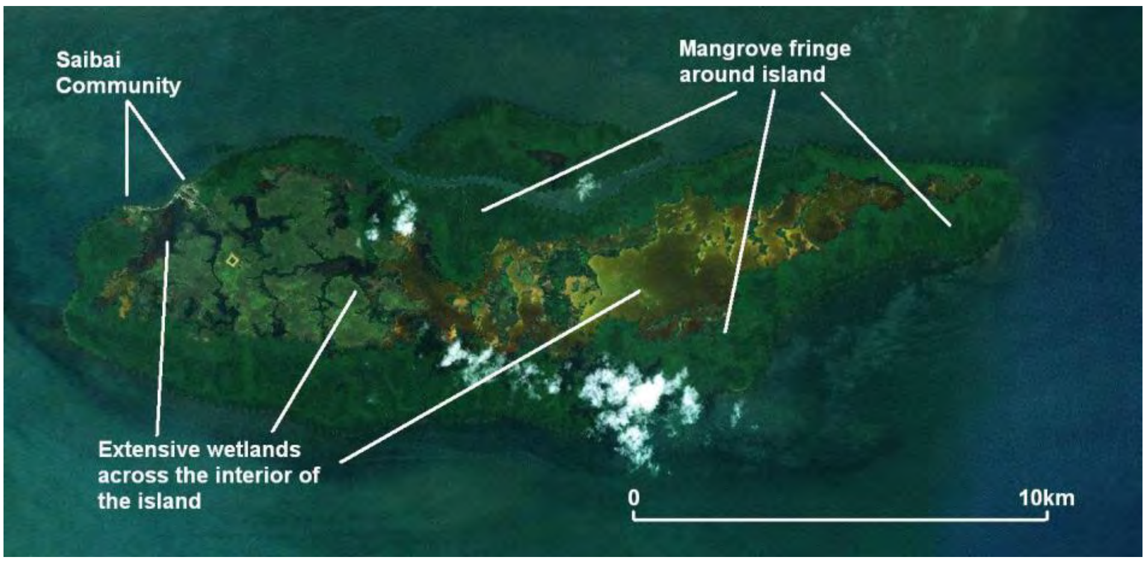

Figure 51 Saibai Island Satellite Image

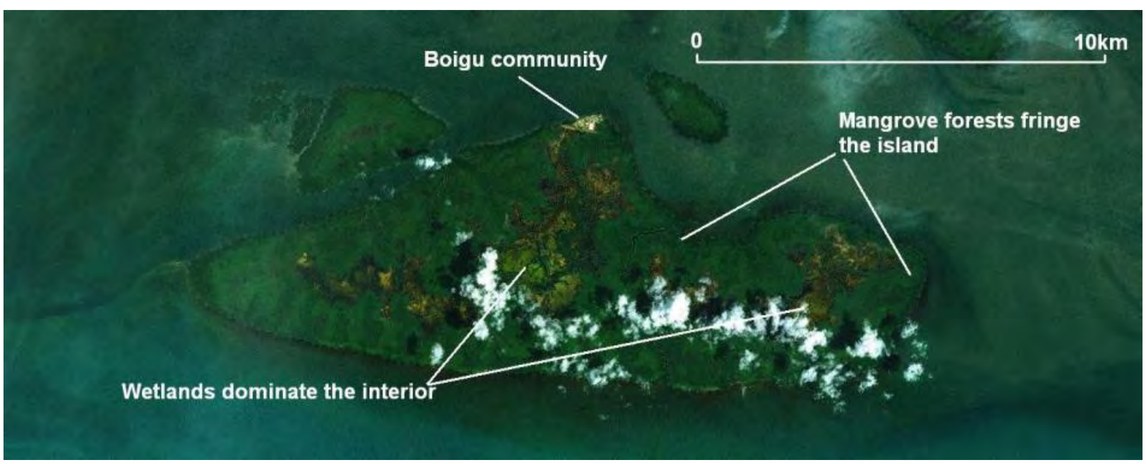

Figure 52 Boigu Island Satellite Image

The habitable land on these islands is limited. Most of the apparent island is in fact below the level of Highest Astronomical Tide (HAT), being mangroves forests or wetlands. The communities are both located on sediment build up that has accumulated on the NW side of islands. As is typical in the Torres Strait the sediment accumulates in an area most sheltered from the predominant SE winds. This build up of sediments has occurred in the lee of mangroves forests. The mangroves protect the beach from a significant portion of the wave activity but allow sufficient wave energy through at high tide to push up a sandy berm formation. This mechanism of formation unfortunately has left the island with only low lying land, with the land levels at or slightly below the extreme water levels that impact the islands.

The inactivity of the coral on the reefs around these islands has resulted in different coastal dynamic, when compared with many of the other islands in the Torres Strait. Sediments on the islands appear to come from terrestrial sources (PNG). This can be seen in the natural beaches that have dark rounded sediments, unlike the angular light sediments that originate from coral breakdown.

3.1.2 Continental Island – Iama

Iama is a continental island. That is, the island is formed by a rock outcrop that is not volcanic in origin. A fringing coral reef platform has developed that surrounds the entire island. This coral reef is providing a sandy sediment supply that has led to the development of low lying flat land on the north-west side of the island. Although high ground is available on the island the community, for convenience, is primarily located on this low flat sandy area, as seen in Figure 53. Extensive areas of mangroves also exist on the island, where sediment build-up is less deep.

As seen on other Torres Strait islands the sand sediment created by the coral is transported around the island under wave action. For the community the primary source of sediment appears to be from the south coast of the island, where the lack of mangroves allows sediments to move freely. The sandy part of the island has been formed by marine forces (tides, currents and waves) and as such this land is typically only one or two meters above HAT. The lack of mangroves has allowed larger waves to reach the shore and this has allowed the land to be pushed up higher than on the muddy islands. Mangrove forests are present on the island in the more sheltered locations where sediments have built up.

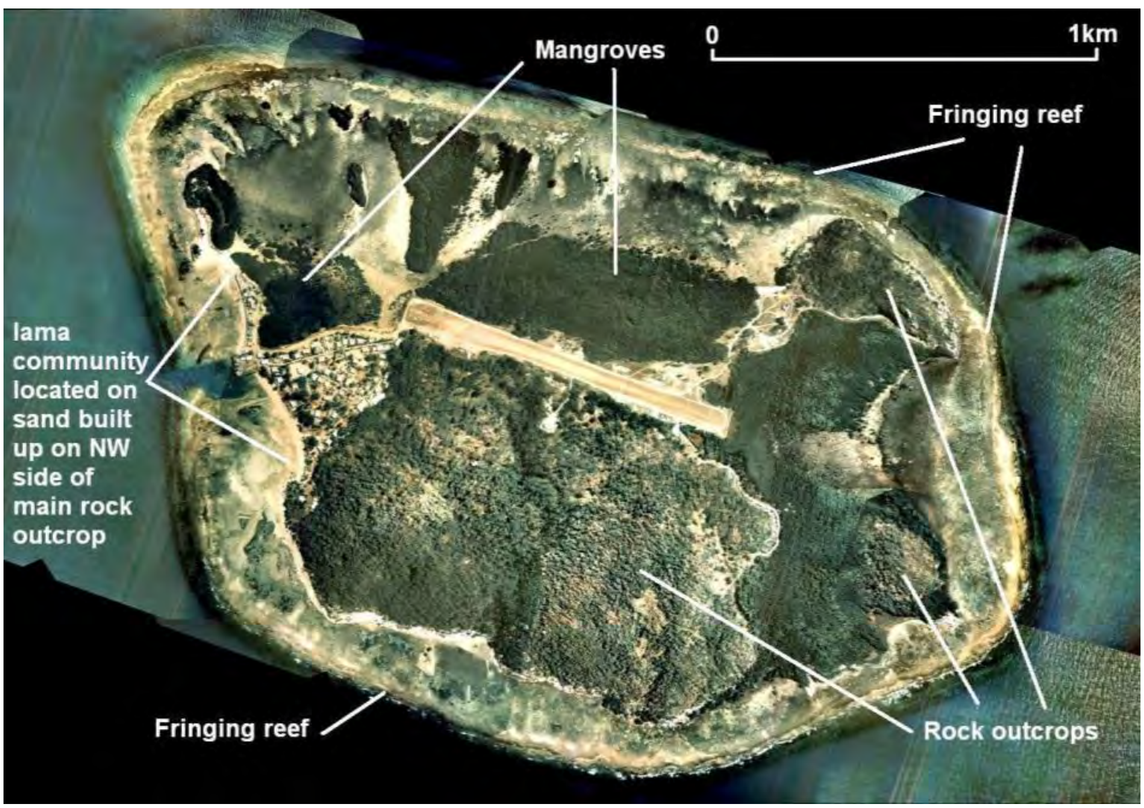

Figure 53 Iama Aerial Photography

3.1.3 Bathymetry and Foreshore Levels

The coral reef platforms are significant features for the coastal processes on all three islands. The level of the reef is an important factor in limiting wave heights that reach the islands. Reef levels are typically observed to have an upper level approximately equivalent to the mean sea level. This level represents the approximate limit of coral survivability, with water coverage 50% of the time.

The low lying land that the communities are located on were all formed from marine actions and thus lie at or slightly above high tidal levels. The community of Saibai is particularly low, with land typically falling away from the foreshore towards the wetlands beyond.

As an indication of the severity of the inundation problem for each of the communities the elevation of the lowest habitation is a useful guide. For all three communities this level is below the Highest Astronomical Tide (HAT). Typical reef levels, foreshore land levels and the level of lowest habitation are presented in Table 1.

Table 1 Reef and Land Levels

	Saibai ***(m above MSL)***	***Boigu*** ***(m above MSL)***	***Iama*** ***(m above MSL)***
Typical reef level	-0.1	-1.0	-0.3
Typical foreshore level	1.9	1.9	3.0
Lowest habitation level	1.4	2.3	2.4

Note that the foreshore and reef levels are taken in the vicinity of the boat ramp in each community. Lowest habitation levels were taken from the study done by Bruce Harper.

3.2 Coastal erosion

Coastal erosion is an issue for all three communities, though the nature of the problem is different on Iama when compared with Saibai and Boigu. On all three communities erosion seawalls have been constructed to combat coastal erosion. A cautionary note when considering coastal erosion issues is that most commentary on coastal erosion is based on the recollections of people who have lived on the island for considerable time. This data is normally considered unreliable as it can be compromised by current agendas. In many situations inundation or normal coastal fluctuations can be described incorrectly as erosion.

3.2.1 Saibai and Boigu Erosion Issues

On Saibai and Boigu the mangroves play a significant role in foreshore stability. It is likely that the foreshore of both communities were protected by mangroves in past, allowing sediments to build up in these locations. Today both communities are exposed to the sea with only occasional mangrove trees to be found. It is likely that the removal of mangroves at some time in the past has allowed a significant increase in energy to reach the foreshore and this in turn has led to erosion. At both communities the existing foreshores are protected by seawalls with very little sandy material in front of the seawalls.

The only solution to stabilise these foreshores in the short to medium turn is to maintain seawalls on the foreshore. In the longer term it may be possible to stabilise the foreshore by re-establishing mangrove forests, however, this may not be supported by the community and will require long time frames to be achieved.

3.2.2 Iama Erosion Issues

Based on the coastal features it is apparent that the primary sediment source for the beaches in front of the Iama Community is from the south coast of the island. Sand movements around the island will have a seasonal bias. During the SE winds sand moves towards the west and north, maintaining a regular sand supply into the beach in front of the community. During the NW winds sand on the beach is exposed to the waves and will redistribute along the coast.

Interference with the natural movements of the sand can upset the delicate balance of the sand budget in various parts of the island. It is clear that the construction of the boat ramp and dredge channel have interrupted the natural movement of sand on the beach. The southern beach does not appear to be adversely impacted. The northern beach on the other hand has been starved of sand supply from the south while sand losses to the north or south into the dredge channel continuing. This has led to the northern beach eroding over the last decade or so.

3.3 Metocean

Metocean refers to the weather (Met) and sea (ocean) conditions. Thus it includes winds, waves, currents, temperatures, rainfall and tides.

3.3.1 Winds

There are two prevailing wind seasons in the Torres Strait. They are the dominant south easterly winds that blow for 9 months of the year from March to December, and the equally strong but less persistent north westerly winds that blow for 3 months from December to March. The summer period is also called the NW monsoon as it is associated with the heaviest rain falls. Associated with these winds are also local seas and currents.

3.3.2 Tides

Tides at the islands are defined as diurnal; that is they have one very dominant high and low tide each day. The astronomical tidal ranges are large at 4m or more. The tidal plans are presented in Table 2.

Table 2 Tidal Planes (Hydrographic Service - RAN)

Tidal Plane	*Saibai Tides (m above MSL)*	*Boigu Tides (m above MSL)*	*Iama Tides (m above MSL)*
HAT	2.3	2.4	2.5
MHHW	1.1	1.6	1.2
MLHW	0.7	0.5	0.0
MSL	0.0	0.0	0.0
MHLW	-0.7	-0.6	-0.1
MLLW	-1.1	-1.7	-1.3
ISLW	-1.8	-2.1	-1.8
LAT	-1.7	-2.5	-2.0

Note: Datum levels in the Torres Strait are considered to be unreliable. There is some doubt over the exact levels of tidal planes nominated in this table.

Significant tidal anomalies can occur in the Torres Strait. One cause of these is the strong wind fields that force water into the strait. Data from tide gauges in the area (ref Duce etal 2010) indicates an annual season variation (on Booby Island) of approximately 0.5m is typical, with the summer NW winds producing the higher water levels. Another site on Goods Island indicates that sea level anomalies of up to 1.1m have been measured, though again the large variations were in summer, while typical maximum monthly variations were less than 0.4m. Because of the cyclical nature of these anomalies it is anticipated that at significant portion of this anomaly is represented in the nominated Highest Astronomical Tide (HAT).

Highest tides occur around full moons during December, January and February, coinciding with the NW monsoon. Thus high tides occur during the time of year when elevated sea levels also occur. This combination will occasionally cause extra high water levels, even above HAT, without any major weather systems (cyclones) to push up a storm surge.

3.3.3 Climate Change

The primary area of concern relating to climate for the design of the proposed structure is sea level rise. For a design horizon of 2070 the suggested sea level rise allowance in “Queensland Coastal Plan” is 0.5m. Note that if a longer design life were being considered the nominated sea level by 2100 is 0.8m.

Other potential impacts relating increased storminess, reduction or increase in coral productions or changes to seasonal patterns will have little to no impact on design.

3.4 Inundation

During the king tides water simply washes over the foreshore and floods sections of all three communities on a regular basis. Observations of inundation at all three islands comprise verbal descriptions from untrained sources. Some photos of inundation events and occasionally observations and measurements by a trained professional. This lack of reliable data makes quantifying the problem difficult and determination of the optimal solution problematic.

Primarily the inundation issues at all three islands are related to high storm tide levels. Waves on top of these high ocean levels will worsen the situation. Even without detailed measurements a simple comparison of HAT levels with foreshore and habitation levels (Table 1 and Table 2) indicates that all three communities are vulnerable and that the issues at Saibai and to a lesser extent Boigu are dire.

At all three of the communities water can encroach from two sides. On Iama the water levels in the relatively small mangrove forests behind the community will be very similar to those facing the ocean, though without waves. At Saibai, observations by Angus Gordon indicate that water levels in the wetlands respond slowly to tidal forcing, with water levels pumping up over a number of days of king tides. Thus in this community the wetlands can flood the community from behind even after flooding from the sea has abated. At Boigu it is not clear what the situation is but it is more likely to be similar to Iama due to the location of the community on a peninsular.

3.5 Design or Extreme Events

3.5.1 Design Life

A design life of 50 years has been adopted for the design of the seawall options, with a design end of life at 2070. This is consistent with a normal commercial structure as set out AS 4997-2005 “Guidelines for the design of maritime structures” and is equivalent to the design life that would be adopted for a residential structure in the “Queensland Coastal Plan” (ref DERM 2011).

3.5.2 Design Waves and Water Levels

As the function of the proposed structures offers a low degree of hazard to life or property a design event with a 0.5% AEP (Annual Exceedance Probability) or 200 year ARI (Average Recurrence Interval) has been adopted. This is consistent with the defined design events in both AS 4997-2005 and the Queensland Coastal Plan.

3.5.2.1 Water levels

Considering the tides, and weather related anomalies design still water levels for the three study sites have been determined. Design water levels are derived from the Bruce Harper study into water levels in the Torres Strait.

Table 3 Design Event Water Levels

	Saibai ***(m above MSL)***	***Boigu*** ***(m above MSL)***	***Iama*** ***(m above MSL)***
200 yr ARI WL today	2.3	2.7	2.6
200 yr ARI WL in 2070	2.8	3.2	3.1

3.5.2.2 Wave Heights

No site specific wave data is available. However, due to the extensive reef flats that surround the islands even moderate wave events will result in waves breaking on the reef edge and over the reef flat. That is to say the waves reaching the shore are depth limited.

Studies of wave climates over flat reef tops revealed that the maximum sustainable wave height is 0.55 times the depth of water. For a design water depth of 3.1m the largest design wave that can reach the island is 1.7m. When this limiting wave height is considered the relevant design wave heights in the depth limited wave spectrum are set out in Table 4

It is assumed that these waves will be short crested (choppy) with wave periods of less than 5 seconds.

All three sites being considered have a north westerly aspect. That is to say that during the period of elevated water levels they also are exposed to the NW winds and associated waves. Thus it is appropriate to use the high water levels in concurrence with a moderate wave climate.

Table 4 Design Waves 200yr ARI Event

	Saibai* *(m)	***Boigu* *(m)***	***Iama* *(m)***
Depth 200 yr ARI in 2070 to MSL	2.9	4.2	3.6
$H_{2\%}$	1.6	2.2	1.9
$H_{10\%}$	1.5	2.1	1.8
H_s	1.2	1.8	1.6

Note: $H_{2\%}$ = height exceeded by the 2% largest waves

$H_{1/10}$ = average height of largest 10% of waves

H_s = significant wave height or average height of largest third of waves

The wave height reaching the revetment defines the size of armour required for a stable revetment and is a key factor in estimating the amount of overtopping that occurs.

4.0 Options and Solutions – Marine

4.1 Saibai Solutions

4.1.1 Replace seawall including wave return wall

The entire length of the seawall should be demolished and replaced with a new rock or Seabee seawall structure to secure the coast in its current location and provide a reliable frontage for the proposed wave return wall. The existing seawall material can be used as a filter layer beneath and behind the new seawall structure. It is noted some lengths of the existing seawall are still functional and intact, particularly on the eastern end of the community. However, the poor design of the existing structure (inadequate toe and lack of filter layer) combined with the eroding foreshore means that damage and failure will most likely impact even these areas in the future. It may be possible to stage the works giving lower priority to the intact sections, though the construction of the wave return wall would also be impacted by such a decision.

A wave return wall tied into the crest of the seawall structure should be constructed along the entire length of the community. The crest of the wave return wall should be at a uniform level along its entire length to ensure equal immunity for the entire community. This element of the design would act to reduce the vulnerability of wave ingress and inundation from the sea. Because the land of the island is so low a wave return wall will need to have a crest at approximately 3.1m above MSL (4.8m LAT) to provide a reasonable level of immunity to tidal inundation and overtopping waves, and typically will be 1.2m above existing ground levels (a significant water exclusion structure).

4.1.2 Cemetery Wave Wall

At the cemetery construct a wave return wall immediately seaward of the established trees. This can be a community driven effort, with a small excavator, steel reinforcement, concrete and possibly besser blocks required to complete the task. This structure is intended to exclude marine inundation and should be founded suitably deep to ensure beach fluctuations do not undermine it.

Do no remove existing mangrove forests as they play a vital role in maintaining and protecting unarmoured coastlines. Reinstating areas of lost mangrove is a community program that could be undertaken in areas with suitable conditions (sediments at the correct levels). The loss of sediments over the past decades will make the re-establishment of the removed mangroves difficult to achieve, and the beneficial effects of the mangrove forest on foreshore stability will take considerable time to be realised.

4.2 Boigu Solutions

4.2.1 Targeted Seawall Maintenance/Upgrade

Undertake maintenance of the seawalls as describe previously, including management of mangroves and repairs to the Seabee seawalls.

Undertake repairs/rebuild the section of seawall between the boat ramp and the jetty. Preferably this work would be undertaken with some back filling to raise the land level in this location.

Check toe armour extent on the Seabee seawall and where lacking add rock armour to the toe.

4.2.2 Wave return Wall

A wave return wall tied into the crest of the seawall structure should be constructed along the entire length of the community. The crest of the wave return wall should be at a uniform level along its entire length to ensure a consistent flood immunity level for the entire community. This structure would act to reduce the vulnerability of wave ingress and inundation from the sea and should tie into the existing bund system protecting the rear of the community. The wave return wall will need to have a crest at approximately 3.1m above MSL (5.6m LAT) to provide a reasonable level of immunity to tidal inundation and overtopping waves, this will typically will be 1.2m above existing ground levels (a significant water exclusion structure). If the area between the boat ramp and the jetty is not raised by infilling then the wave return should follow a roughly horizontal contour and be located back towards the road.

4.2.3 Rectify Erosion Issues and Increase Bund Height

Rectify the erosion issues associated with the internal face of the bund wall. Undertake investigations to confirm the adequacy of existing crest levels on the bund wall. A similar level of immunity should be provided to the crest level of the seawall. A wave return wall will not be required along the bund.

4.2.4 Drainage Infrastructure Maintenance

Council to check performance of existing tide flap valves and undertake maintenance or replacement works as required. The timing of this works should preferably be prior to the next king tide events.

4.3 Iama Solutions

4.3.1 Reinforce southern seawall

The seawall at the southern end of the main beach is excessively steep and additional material is required to flatten the slope of the structure. A slope of 1 in 1.5 with the armour units of a similar size to those already in use would be of assistance. Toe armour should be buried into the beach to provide additional protection for the toe. Some sections of the wall have collapsed and in these locations additional top up armour would be appropriate.

The area at the southern extremity of the beach was eroded during the site visit. If the community is concerned about the erosion or the mature trees in this area a low seawall may be appropriate. Use of vandal resistant geotextile bags or rock armour would be a suitable protection in this location.

4.3.2 Maintain beach discharge

Excavate the lined drain on the main beach and establish a sink hole at the end to receive runoff. At the start of the wet season (December) clean out the hole to remove built up sand, litter and leaf matter to allow free drainage. Care should be taken to ensure that the beach berm height is not reduced in front of the drain to maintain immunity to tidal inundation. If a significant flood event does occur and excess water needs to be drained quickly then cut a narrow channel through the berm to facilitate the breakout of the flow. Any sand won from this work should be distributed along the beach berm to help build up immunity of the beach to high tide and surge events.

4.3.3 Repair Seawall near Ibis

The seawall immediately to the north of the desalination plant is inadequate. This seawall requires some rebuilding/upgrade to be considered acceptable.

Concerns over the performance of the breakwater in creating suitable mooring conditions at the jetty and boat ramp should be taken up with the Department of Transport and Main Roads.

4.3.4 Northern Spit

For the northern Spit there are two options for consideration:

- Do nothing and abandon the area most exposed to inundation. The seawall will continue to stabilise the coast for the near to medium term future but will degrade over time, particularly due to undermining of the structure. The low crest of the seawall will not inhibit inundation from high tides and storm surge; or

- Establish a wave return wall along the crest of the existing seawall and undertake repairs/upgrade of the seawall to protect the toe of the structure. The crest of the wave return wall should be at a uniform level along its entire length to ensure flood equal immunity for the entire community. This structure would act to reduce the vulnerability of wave ingress and inundation from the sea and should tie into the proposed seawall to be built around the facility near the boat ramp. The wave return wall will need to have a crest at approximately 3.7m above MSL (5.7m LAT) to provide a reasonable level of immunity to tidal inundation and overtopping waves, typically this will be 0.7m above existing ground levels (a significant water exclusion structure).The construction of the wave return wall would require a number of buildings to be fully or partially removed. The eastern or rear side of the spit would require the construction of an earth bund with a crest level of approximately 3.0m above MSL (5.0m LAT) to provide a similar level of protection from rear inundation (no waves).

A more permanent solution to the blocking of the gaps in the existing low concrete wall constructed along the northern side of the community should be considered. This could include light weight gates or the construction of low flat berms at the driveway entrance to properties. This would alleviate the need to sand bag every year.

4.3.5 High Tide Boat Ramp

The level of the crest of the alternate or high tide boat ramp should be raised to improve the immunity of the road to flooding. Because of the more substantial secondary wall these works are low priority and can be undertaken at the Council's leisure.

5.0 Marine Design

This chapter covers the design of new seawall or wave return wall elements. Marine works that are classified as repair are assumed to be undertaken with similar materials used in the existing structures. It is, however, assumed that repairs to rock walls will be undertaken using suitable sized rock armour and as such rock armour sizes have been provided for all three islands.

Design water levels and wave climates are described Chapter 3.5.

To combat inundation wave return walls and bund heights for consistent immunity have been assessed.

5.1 Armour Type

It is envisaged that a new seawall be built on Saibai while at Boigu and Iama there is the possibility of repairing or upgrading existing rock armour seawalls. Design solutions for both a rock armour revetment and a Seabee armour revetment have been considered at Boigu and Saibai. At Iama, because the ready availability of rock and the nature of existing structures, only rock armour breakwaters have been considered.

5.1.1 Conventional Rock Armour

Normally a conventional double layer rock armour sea wall is the most economical and robust solution and thus is usually preferred for coastal protection where suitable sized rock is available. For Saibai and Boigu Islands rock would need to come from off the island. A quarry exists on Horn and Badu Islands and rock armour can be produced on demand.

An economically attractive alternative to sourcing rock off the island is the mining of the reef material such as the armour often found in use near the dredged channel, as seen in Figure 54. This option has not been actively examined here on the grounds of environmental and community concern, however the design could be easily altered to suit this material if required.

Rock armour is durable and well designed seawalls built of large rock are robust, which means that even if conditions exceed design the seawall though damaged will remain functional in some form. This is an important feature in a location with little metocean data and considering possible impacts of climate change into the more distant future.

Figure 54 Rock armour seawall on Iama Island (note the native rock in foreground and the coral rock beyond)

Rock armour units were sized using Hudson Formula and checked using the Van der Meers Formulae and a revetment slope of 1:1.5 (ref. CIRIA 2007). In the design allowance has been made for minor damage to the seawall. Assuming that reasonable rock can be sourced the adopted rock armour density is 2.6t/m^3. The adopted sizes are presented in the Table 5.

Table 5 Design Rock Armour

	Saibai	***Boigu***	***Iama***
M_{50} (kg)	180	530	450
D_{n50} (m)	0.41	0.59	0.56
Nominal Layer Thickness (m)	0.8	1.2	1.1

Based on the armour sizing in Table 5 the associated recommended grading limits for the rock armour (ref CIRIA 2007) are presented in Table 6.

Table 6 Recommended Armour Grades

	Saibai	***Boigu***	***Iama***
Extreme Lower Limit – $M_{<5\%}$ (kg)	80	220	190
Nominal Lower Limit – $M_{<10\%}$ (kg)	110	340	280
Nominal Upper Limit – $M_{<70\%}$ (kg)	230	670	380
Extreme Upper Limit – $M_{<97\%}$ (kg)	340	1000	850

Note in practical terms the nominal upper and lower limits are visual limits that should be used during construction as the target range for armour sizes.

A geotextile filter layer shall be laid under the rock to prevent movement of sand through the seawall armour. This geotextile material shall be a needle punched non-woven fabric Class E (per NSW RTA Guideline). A suitable material that meets specifications is Elcomax 1200R with a drop height of up to 1m for the armour. To ensure complete coverage a minimum overlap of 0.5m at sheet edges is required. After the revetment is constructed the beach is reinstated over the structure. Drawings presenting recommended rock armour solutions are included in Appendix A.

5.1.2 Pattern Placed Concrete Seabee Units.

Pattern placed armour behaves as a mattress, with the units held in place by the units surrounding them. This allows significant savings in volume/mass of armour required over rock to achieve an equivalent level of protection. Concrete armour units such as Seabees also offer a neat visually pleasing solution. Because of the relatively light units involved and reduced volumes of material required seawalls of this type are an attractive option in remote locations such as the Torres Strait Islands. Figure 21 presents a view of the Seabee seawall constructed on Boigu Island. These were installed on the northern foreshore in the late 1990s and have successfully withstood climatic conditions since. One of their main reasons why Seabee walls were adopted at Boigu was the opportunity for local labour to assist in the construction process, hence reducing the cost of the project. The Seabee units were cast on site and Boigu locals were employed by the Principal Contractor to pour and place them (under supervision).

Seabee armour units rely on interlocking to hold them in place, and a single unit offers little resistance to wave attack. If a seawall of this type is damaged the seawall can quickly unravel, resulting in a catastrophic failure of the structure. Because of this failure mechanism seawalls constructed of relatively light interlocking units such as Seabees are said to have a brittle failure mechanism. During construction care is required to ensure that this interlocking between units is achieved.

To help ensure that the seawall remains intact strong edges are required. The toe of the seawall needs to be well founded, which means it will need to be cut into the reef platform. The crest and ends require suitable fixing with concrete beams. Other issues with this type of sea wall include high wave run-up and high reflectivity. This heightened wave action on the face discourages sand build up on the seawall.

The thickness of armour layer required should vary with the size of the incident waves. However on a practical scale an armour layer thickness needs to be sufficient to ensure that differential settlement, such as those observed in Figure 23, do not lead to failure of the revetment. The existing Seabee units in use on Boigu have dimensions of 0.3m wide by 0.29m long. Based on the observations of armour layer integrity the minimum length for units of this size would appear to be approximately 0.3m.

Estimation of the required armour layer thickness using standard tables from the University of NSW Seabees Design Manual (ref. UNSW 1997) indicate that a depth of Seabee armour of 0.3m will be suitable for all the wave climates being considered. Thus the nominated Seabee amour for all three island seawalls at a slope of 1:1.5 with an armour porosity of 35% the nominated design is a single layer of 0.3m long by 0.3m wide units weighing 27kg each. This armour is laid over 0.3m thick layer of 60 to 160mm secondary rock armour. Beneath the secondary armour a light geotextile layer is required to ensure that the sub soil profile remains stable. For this a suitable material would be Elcomax 360R. Sections representing the Seabee seawall design solution are presented in Appendix A.

5.1.3 Foreshore Seawalls

Due to practical considerations of the structure height no attempt has been made to define the overtopping limit in relation to the wave climate for Saibai or Boigu. For these islands the wall crest levels were determined as the Design 200yr ARI in 2070 plus a free board of 0.3m. This will effectively put the crest of the wave wall 0.8m above the present day 200yr ARI still water level. For Iama the design crest levels have been defined by considering overtopping criteria based on present day wave and water level climate. The design seawall crest levels are presented in Table 7.

Table 7 Wave return wall heights

	Saibai	*Boigu*	*Iama*
2070 Design 200 Yr ARI SWL (m MSL)	2.8	3.2	3.1
Wave Wall Crest Elevation (m MSL)	3.1	3.5	3.7
Nominal Ground Level (m MSL)	1.9	1.9	3.0
Nominal Wall Height (m)	1.2	1.6	0.7

5.1.4 Wave Return Walls

Wave return walls are simple reinforced concrete walls that are designed to resist the forces of water and in particular waves on the foreshore.

The impact an excessively high wall would have on foreshore amenity at Boigu is an important consideration. To this end a maximum nominal wave wall height of 1.2m has been adopted. Although this reduces the immunity offered by the wall it is considered an appropriate compromise, with the adopted wave wall crest heights for the three communities presented in Table 8. In areas where the foreshore ground levels are below nominated the ground should be raised.

Table 8 Adopted wave return wall crest height

	Saibai	*Boigu*	*Iama*
Adopted Wave Wall Crest Elevation (m MSL)	3.1	3.1	3.7

The wave return wall should be tied into the crest of the seawall to minimise erosion and to improve the aesthetic appeal of the structure. Appropriate wave return walls are shown in the sections found in the appendices.

5.1.5 Saibai Cemetery

The Saibai cemetery experiences inundation from the sea and the wetlands. Native mangrove forest on the sea side of the site is still intact and offering protection from seas. Because of this sheltering the natural beach conditions are still present and the foreshore does not appear to have experiencing sustained coastal erosion in front of the community. As such the solution proposed for this location does not include a seawall. Rather a wave wall similar to those proposed for the other parts of the island is considered the best solution.

No ground levels were available for the cemetery, however based on the relative level of the ground to the surrounding mangroves forests it would appear that the grounds levels are lower than for the main community.

As such it will not be possible to achieve the same level of immunity for the cemetery as will be targeted for the community. Rather the height of the wave return wall was selected to be appropriate for the nature of the structure. The wave return wall should have a maximum height of 1.0m above existing ground levels.

The wave return wall should be located as close to the cemetery as possible to minimise the risk that the structure will be undermined by erosion. This would result in the wall being located behind the stand of trees that define the crest of the beach. It is also recommended that riprap be used to provide toe scour protection.

To provide complete coverage a low wall needs to extend around the entire cemetery with a crest height slightly below though similar to the wave return wall. Ideally the wall could be a continuation of the wave return wall with the crest height defined by the ground levels plus 1 m. If this structure is done well the wall could appear to be a fence around the cemetery.

As seen in Figure 2 there is some evidence that minor erosion on the upper beach, with tree roots exposed. To combat this minor erosion the use small rock armour along the crest of the beach is recommended. This is intended to be a flexible minor armouring solution that can stabilise the upper beach against small wave attack and currents.

5.1.6 Bunds Facing Wetlands

To ensure consistent immunity for the communities they need to be adequately protected from inundation from wetlands as well the sea. The water in the wetlands is typically lower than on the sea side and are not accompanied by waves. As such the use of earth bunds built up to levels appropriate to the inundation risk are required.

The crest height of earth bunds can be raised at a future date and as such it is recommended that bunds be constructed to a level that will provide protection for today's conditions. The recommend bund heights are the design 200 year ARI water today plus a small free board of 0.2m.

Table 9 Recommended Earth Bund Crest Elevations

	Saibai	***Boigu***	***Iama***
Today's Design 200 Yr ARI SWL (m MSL)	2.3	2.7	2.6
Recommended Earth Bund Elevation (m MSL)	2.5	2.9	2.8

As noted previously the water levels in the wetlands on Saibai are significantly altered from the offshore water levels. The bund height at Saibai may be lowered if appropriate measurements and design assessments have been undertaken.

All bunds should be finished with appropriate cover to stabilise the material against erosion.

6.0 Drainage Design (Culverts and Bunds)

6.1 General

Currently the Saibai community experiences inundation from both seaward and landward directions. While construction of a formal seawall and wave return wall will reduce the likelihood of the community suffering from seaward inundation, it will not stop waters inundating the community from the wetlands. Therefore, the proposed scheme will need to adopt a two-fold approach whereby adequate immunity is provided by the seawall structure and an additional measure to prevent landward inundation.

Investigations undertaken in this project have identified the following feasible options to address landward inundation:

- Construction of a bund wall at the rear of the community;
- Construction of new serviced allotments with a greater immunity to landward and seaward inundation. Once complete, the community residents could be relocated to the new allotments.

Further details of each scheme appear below.

6.2 Construct bund at rear of community

One possible option to prevent inundation of the community from the wetland area towards its rear is to construct an earthen bund wall with a crest level similar to that of the proposed wave return wall.

As part of the scheme, runoff from the community area must be considered to ensure that ponding does not exacerbate the inundation problem. The proposed approach is similar to that constructed at Boigu, whereby urban runoff is controlled in overland flow channels which discharge through the bund wall via a set of culverts (complete with tidal flaps). The main difference between Boigu and Saibai communities is that the developed area on Boigu is quite compact while Saibai is linear. So drainage can outfall, multiple outlets through the bund wall will be required. This approach will minimise the length of each drainage path and the requirement for excessively deep excavations. An additional advantage of this approach is that it minimises the size of the contributing catchment for each outfall, which will provide better drainage immunity for the community.

Initial investigations were undertaken to determine the approximate areas that would need to be drained and the likely locations for drainage outfalls. Existing outlets were used where ever possible, however new outlets through the proposed seawall will need to be constructed. Some community consultation will be required so that agreement is reached regarding the location of these.

It is anticipated that the drainage outlet works will include construction of an overland flow drain and culvert outlet with backflow protection valving and will be a similar arrangement to the main Saibai ocean outlet. A concept plan of the proposed drainage network is attached in Appendix A. Similar to Boigu, drainage will need to be concrete lined.

From initial investigations, it is not possible to construct drainage to cater for a 100-year ARI event. During a 100-year ARI event, it will be likely the community will be subject to severe storm surges which may breach the main seawall defences. As a result, any drainage infrastructure will be ineffective.

Therefore, the drainage design should be based on a more frequent recurrence interval, with specific immunity level depending on the downstream tidal level. The main objective of the drainage system would be to provide a flow path for stormwater runoff so the community area drains much faster than what currently occurs.

Further investigations are required to confirm the scheme details and to determine opportunities and constraints.

6.3 Build up higher land

A possible solution to the inundation issue at Saibai is to create an area of raised land in wetlands located south west of the runway and to the south east of the main community centre. The finished level of the fill would be similar to levels within the existing Saibai community area. Community members currently residing to the west of the main tidal drain could be relocated to this area. This option would deliver the following advantages:

- Reduces the length of the inhabited coastline to be protected and therefore reduces the cost of the foreshore protection works;

- Reduces the length and necessity of the bund wall required to the rear of the community (depending on the finished levels adopted for the fill); and
- Results in better drainage immunity within the community area.

This option would involve dredging material from offshore or other wetlands areas and placing as fill material in the new community area. Land improvements and dwelling construction will also be required prior to relocating community residents.

Despite the advantages this solution would incur significant costs and have lengthy approvals and consultation processes. As such they have not been actively pursued here other than to flag it is a solution. If this option were to be seriously pursued in the short to medium term it may impact on the decision of what foreshore works are undertaken on Saibai.

7.0 Opinion on Probable Construction Costs (OPCC)

7.1 Basis

An opinion of probable construction costs (OPCC) was prepared to determine the financial implications of the proposed options. The tender schedules used as part of the original Boigu Seabee wall construction was used as a basis for the cost estimates and were modified to suit the works proposed at all three communities. This approach provides some surety that major project elements have not been disregarded. A considerable amount of investigation went into the preparation of the original schedule and accordingly it documents in some detail the actual steps the construction contractor will need to take in order to complete the works.

The OPCC includes the following items:

- Establishment and dis-establishment;
- Setting out the works;
- Clearing and grubbing;
- Earthworks for the seawall. Most notably this includes imported material that will be used to achieve the desired slope;
- Supply and installation of geotextile, rock layers or Seabee wall units (depending on the option);
- Supply and installation of a wave return wall ;
- Compliance assessment testing; and
- As constructed records.

Costs calculated from the OPCC are summarised in the section below.

7.2 Results

Reference should be made to the OPCCs attached to this report as Appendix C. Separate schedules have been created for each community and the different options discussed for the works at Saibai. A summary of the OPCC appears in the following table:

Table 10 Summary of OPCC

Schedule	OPCC Sub-Total	Contingency (25%)	Total
Saibai Seawall Upgrade (Seabee Wall)	$8,824,595	$2,206,149	$11,030,744
Saibai Seawall Upgrade (Rock Wall)	$9,021,270	$2,255,318	$11,276,588
Saibai Seawall Upgrade (Cemetery)	$470,469	$117,617	$588,086
Saibai Drainage Upgrade	$6,311,614	$1,577,903	$7,889,517
Boigu Seawall Upgrade	$1,536,499	$384,125	$1,920,623
Boigu Bund Wall Upgrade	$713,750	$178,438	$892,188
Iama Seawall Upgrade	$742,110	$185,527	$927,637

On review of the OPCC, it is clear the majority of the cost is contained in only a few items, including supply and installation of rock, concrete and fill material. Given the associated quantities have not been calculated with a great degree of accuracy (based on typical sections) and are of considerable size, small inaccuracies in either quantities or construction rates will have a significant bearing on the total cost. The following section provides an explanation of the allowances and assumptions made which attempt to mitigate the risk of inaccuracies.

It should be noted there has not been any substantial seawall works in the Torres Strait in quite some time, and therefore the rates developed as part of this study are approximate only. Should this project proceed past feasibility stage, there may be some merit in advice from a reputable construction contractor with respect to construction methodologies and rates. This would deliver more certainty that the assigned budget is adequate.

7.3 Explanation of Critical Assumptions

7.3.1 Site Establishment

Based on experience with previous construction works conducted in the Torres Strait, the cost for site establishment can be generally estimated at 15% of the project costs, not including project management.

7.3.2 Supply and Installation of Rock

Rock in the Torres Strait represents a significant construction cost specifically because it cannot be won locally in the outer islands and transport costs to import acceptable materials to site are expensive. For example, an average rate of approximately $1000/m^3 for gravel screenings was received as part of the recently tendered Poruma Sewerage Scheme project. Discussions with the Horn Island Quarry indicate rates for screenings and rock armour are comparable, while the supply of rock filter material is cheaper. Therefore a rate of $1,000/m^3 has been included for the supply and installation of armour rock while a rate of $800/m^3 has been adopted for rock filter material.

At Iama, the rate for the supply and installation of rock has been reduced because it is available locally and therefore there is no need to include the expensive transportation costs. As a result, a rate of $500/m^3 has been adopted, which represents half the cost to import the rock from Horn.

7.3.3 Supply and Installation of Reinforced Concrete Wave Return and Unreinforced Seabee Walls

A unit rate of $2,500 has been adopted for all reinforced concrete installation works. This is based on the recently tendered Regional Asset Replacement Project where there was a substantial amount of concrete works required.

A unit rate of $1,750 has been adopted for unreinforced concrete works including supply and installation of the Seabee precast units. This is considered appropriate given there will not be the need to supply and fix the steelwork.

7.3.4 Supply and Installation of General Fill Material

A unit rate of $580/m3 has been adopted to import general fill material. This is based on the rate received as part of the recently tendered Poruma Sewerage Scheme project. General fill material will need to be imported from the Horn Island Quarry.

7.3.5 Reconstruction of Seawalls at Iama and Boigu

From the site inspection, the following walls require reconstruction:

- Boigu, between the jetty and the barge ramp. It was noted that crest levels in this area were relatively low and would need to be raised in order to achieve a consistent immunity level. As a result, allowance has been made to import general fill material and rock armour to facilitate a full reconstruction of the wall (to 2m height). In practice, it may be possible to reuse some of the existing armour on site, and this will deliver a saving to the overall project. Given the difficulties estimating how much material would be available, the approach taken to determine probable costs can be considered conservative.
- The southern beach at Iama. TSIRC staff has undertaken some works on the existing rock wall in an effort to flatten its slope. However, it would appear that works were not undertaken to construct a suitable toe founded on the stable coral layer. The costs included against this scope item are based on supply and installation of armour rock to construct a toe only (estimated at approximately 1.5m deep) and 75m long.
- The northern spit at Iama. Similar to the treatment identified at Iama's southern beach, this OPCC has been developed assuming that seawall works will consist of reconstructing the toe of the wall only (i.e. 1.5m deep and 175m long). An allowance has also been made for a small bund wall (0.5m high, 1m wide, 200m long and 1:3 side slopes) constructed using imported fill material at the rear of the spit. There may be an opportunity to source fill material locally and this will also deliver savings to the project.

7.3.6 Extent of Works at Boigu and Saibai Cemeteries

The OPCC includes an allowance to construct a wave return wall along the coastline only. During the visit to Saibai, the local residents advised the rear of the cemetery was inundated during prolonged periods of high tide. The extent of the inundation was not clear.

Construction of a rear bund wall would protect against inundation, however brings with it additional complexities where drainage issues would also need to be addressed. In the first instance it is proposed to install the wave return wall to see if this increases amenity to an acceptable level. Should inundation from the rear still be viewed as unacceptable, then a small bund wall or masonry block wall could be constructed along with drainage swales and culverts. No allowance has been made for this in the OPCC.

7.3.7 Location of Seawall Crest at Saibai

During the visit to Saibai, it was clear the local residents were concerned over the impact of coastal processes and that continual erosion of the coastline had resulted in loss of available land. With this in mind, it is proposed to construct the crest of the seawall in a similar location to the existing wall, minimising the encroachment of the new seawall and wave return wall structure towards the community.

This arrangement will enable the majority of the existing wall to remain in place. For the Seabee wall option, consideration was given to demolishing the wall completely and reusing materials in the filter layer. While this option would deliver cost savings, there was concern that inappropriately sized filter material would detrimentally affect the overall stability of the wall. Accordingly, a decision was taken whereby it was preferred to import materials for the rock filter material rather than the commensurate amount of general fill material.

The need to import fill material could also be significantly reduced by reconsidering the positioning of the seawall crest. Further encroachment of the seawall crest towards the community would yield some financial benefit where the earthworks trend towards a cut to fill operation (i.e. reduced need to cover the costs associated with importing fill)

8.0 Project Approval Requirements

8.1 General

A project of this magnitude will require a number of approvals prior to commencement of works on site. The following key project stakeholders will need to be consulted with over the course of the project:

- The community and Prescribed Body Corporate;
- TSIRC;
- DERM; and
- Fisheries Queensland.

Further discussions appear below.

8.2 Community Approval Requirements

8.2.1 Native Title

At least part of the proposed works in all three communities will be located within the Deed of Grant In Trust (DOGIT) area. Generally the DOGIT covers most of the community including houses, Council offices, shops and some roads and infrastructure. Native title rights are held by the Saibai People as determined by a consent determination on 12 February 1999. Native title rights are managed by the Saibai Mura Buway (Torres Strait Islanders) Registered Native Title Body Corporate (the PBC).

There are a number of approaches that can be used to obtain native title consent. Both of these approaches have been utilised in recent MIP projects and are considered to be applicable to the proposed infrastructure types included in this project. Further consultation will be required with the PBC and the TSRA native title office to confirm the preferred approach is acceptable:

- Indigenous Land Use Agreement (ILUA); or
- 24KA Notice.

The latter is by far the simplest and fastest way to obtain consent, however the TSRA native title office has a clear preference for an ILUA.

8.2.2 Cultural Heritage

The Aboriginal Cultural Heritage Act 2003 (QLD) establishes a cultural heritage duty of care for addressing cultural heritage issues. Substantial penalties support the duty of care.

The legislation provides that cultural heritage matters are deemed to have been adequately addressed where a person is acting in accordance with an ILUA. In these circumstances, once an ILUA has been entered into for the project area, it will not be necessary to address cultural heritage matters a second time under Queensland cultural heritage legislation.

Cultural heritage assessment and management generally involves a cultural heritage survey of the area by the traditional owners; management of arrangements for any identified cultural heritage within the project area, and provisional arrangements for managing cultural heritage finds during construction.

The cultural heritage survey may be undertaken with the PBC to assist, determine and resolve design issues. It is understood under the cultural heritage legislation representatives from the PBC can undertake the cultural heritage survey.

Additional cultural heritage inspections and discussions will also be required with the traditional owners if it is decided to adopt a 24KA process. Similar measures have been incorporated within the MIP process and it is thought that these are directly applicable to the nature of the infrastructure to be constructed in this project.

8.3 Statutory Agency Approval Requirements

8.3.1 The IDAS Process

The Integrated Development Assessment System (IDAS) applies to all development applications in Queensland and provides a framework for project stakeholders to be involved in the approval process. Under IDAS, government departments and agencies are defined into three separate categories depending on the impact the development will have on their interests. Details of each role are presented below:

- Assessment Manager: This is the party that collates responses from referral agencies, assesses the application and issues the development approval;
- Referral Agency: Depending on the type and location of the proposed development, an application may need to be referred to another Queensland State Government Department for their assessment:
    - Concurrence Agency: Where a development is considered to have significant impact on a referral agency's interests, the referral agency can direct the assessment manager to approve or reject the application; and
    - Advice Agency: Where a development has a lesser impact on a referral agency's interests, the referral agency can only provide advice. The assessment manager can, acting on this advice, impose restrictions or request modifications to the application. An advice agency cannot direct the assessment manager to decide the application a particular way or impose conditions.

Experience in past infrastructure projects within the Torres Strait was used to determine the range of approvals required for this project. The role referral agencies take will depend on the nature of the application. Details appear below:

- Assessment Manager: Cairns Regional Council (CRC);
- Concurrence Agencies:
    - Department of Environment and Resource Management (DERM); and
    - Queensland Fisheries (within DEEDI).

Once an application is lodged under IDAS, the assessment manager must follow a specific review and approval process. A flowchart explaining the major steps and their timing is attached to this report as Appendix B. The flowchart explains how referral agencies are involved and the additional time requirements they add to the approvals process. Each of the agencies was approached to clarify the issues that would be referred to them for consideration. More detailed discussions appear in the sections below.

8.3.2 TSIRC

TSIRC will be a key stakeholder in the overall project and will take on multiple roles during delivery. Not only will they be the Principal to the design and construction contracts, they will also be responsible for delivering and shaping the preferred solution and will act as the assessment manager to procure the necessary statutory permits.

Close consultation will be required with key TSIRC engineering staff to ensure successful project outcomes.

8.3.3 DERM

Due to the nature of the project, works will be conducted within tidal lands outside the DOGIT area. Tidal land falls within the jurisdiction of DERM, who will need to issue a prescribed tidal works approval in order for construction to proceed. Typically background information including environmental reports and certified construction drawings are required by DERM prior to approval. DERM is bound by the Integrated Development Assessment System (IDAS) and therefore has statutory timeframes by which an approval must be provided. Further details of these are included in **Section 9.3.**

Evidence of resource entitlement will be required and this is available as a general authority for works within DOGIT lands.

8.3.4 Fisheries Queensland

The proposed works may require removal of marine plants. Inspections will be required during the design period to confirm any impacts. Fisheries Queensland is responsible for provision of permits for this activity. Background information including drawings and environmental reports will need to be submitted with the application in order for an approval to be provided.

9.0 Project Delivery Approach

9.1 Preconstruction Approach

Based on the investigations undertaken as part of this project, it is recommended that the seawall upgrade works are delivered under a traditional engineering format whereby detailed design drawings are prepared prior to going to the open market to procure a construction contractor. Preconstruction could be broken down into a number of distinct stages similar to the approach taken by MIP when delivering infrastructure projects within the region. This ensures a suitable scheme is prepared and provides opportunities for the infrastructure owners to provide input in a timely nature.

Stages would include:

- Planning and Design Stage where a report is prepared to document a preliminary design. The preliminary design would include key concepts and information to provide some surety to TSIRC that the design is fit for purpose; and
- Documentation stage whereby detailed design drawings and documents are prepared ready for tender. The Design Report is used as a background for the design drawings.

9.2 Construction Approach

Based on discussions with TSRA, it would appear unlikely that sufficient funding will be available to construct all upgrades within a single construction contract. The next preferred approach would be to undertake the complete scope of works in each community in a single contract. There are numerous financial advantages associated with this approach, with economies of scale delivering more favourable construction rates and site establishment costs. Based on the condition of the infrastructure at each of the three communities, it is clear the seawall upgrades at Saibai are the highest priority and the upgrades at Iama the lowest priority.

Should insufficient funding be available, then the following approaches require consideration:

- Breaking up the works on the Saibai seawall into separate packages. While this process will result in infrastructure being delivered at Saibai it will not deliver the project objectives until the seawall and bund wall are completed. Parts of the community will still be inundated until this has occurred; or
- Prioritise projects where key outcomes can be achieved within the available budget. This may result in the works at Boigu and Iama being undertaken first.

9.3 Anticipated Project Program

An anticipated project program has been developed (Appendix D), taking into account critical timeframes associated with the following:

- Survey investigations as required;
- Preliminary and detailed design works;
- Environmental permits;
- Native title approvals (based on 24KA approach);
- Procurement of construction contractor;
- Construction (assuming sufficient funding is available to commence on Saibai first); and
- Defects Liability period.

Based on discussions with the TSRA, it is understood they are pursuing funding under the Regional Development Australia Fund. To be eligible for funding, construction must commence within six months of signing of the funding agreement. Approved projects will be released mid to late May and funding agreements must be signed within eight weeks.

The program has been arranged around this requirement and indicates, if a project management consultancy was awarded at the end of February, all planning, design and approvals could be undertaken to facilitate commencement of construction at the end of September, approximately one month prior to the deadline (based on a conservative assumption whereby the funding agreement is signed the same day that funding is announced).

Nonetheless, TSRA need to consider strategies to commence investigation works with a view to commissioning a project manager as soon as possible.

10.0 Summary and Recommendations

In response to serious inundation issues at Saibai, Boigu and Iama AECOM has been commissioned to develop and cost infrastructure solutions. Out of this study a program of works has been suggested that will improve the immunity of the three communities to flooding from marine inundation, and stabilise areas of foreshore erosion. In summary the proposed works are:

Saibai

- Replace the existing seawall with either a Seabee or rock seawall that incorporates a wave return wall with a crest height at 3.1m AHD. These works are estimated to cost approximately $11,000,000 or $11,300,000, depending on whether Seabee or rock armour is selected.
- Provide protection against inundation from the wetlands at the rear of the community by upgrading drainage and constructing a bun wall with a crest at 2.5mAHD. These works will cost approximately $7,900,000
- Construct a 1m high reinforced concrete wave return wall around the Cemetery to improve inundation immunity at a cost of approximately $590,000.

Boigu

- Repair the existing seawall, including a rebuild in the area between the jetty and boat ramp, and incorporate a wave return wall with a crest elevation at 3.5m AHD (along the frontage of the community and at the cemetery). These works are estimated to cost approximately $1,900,000.
- Reconstruct the bund wall in areas where the internal batter is slumping. Lift crest of the bund wall to RL2.9m AHD.

Iama

- Depending on TSIRC landuse planning, repair/upgrade the seawall at the northern spit incorporating a wave return wall with a crest at 3.6m AHD, and construct a bund wall with a crest elevation at 2.8m around the rear of the community at an estimated approximate cost of $930,000. Included in this estimate is allowance to repair seawalls at the southern end of the Iama community and near the water treatment plant.

While it is recommended that all these works be undertaken in a single contract, it is realised that because of the infrastructure costs (Saibai ~$20M, Boigu ~ $2M and Iama ~$1), funding may be difficult to procure. As a result, the works may need to staged over a number of funding cycles. Should this be the case, then the next best option is to undertake works on an island by island basis. This will deliver project savings, particular around site establishment.

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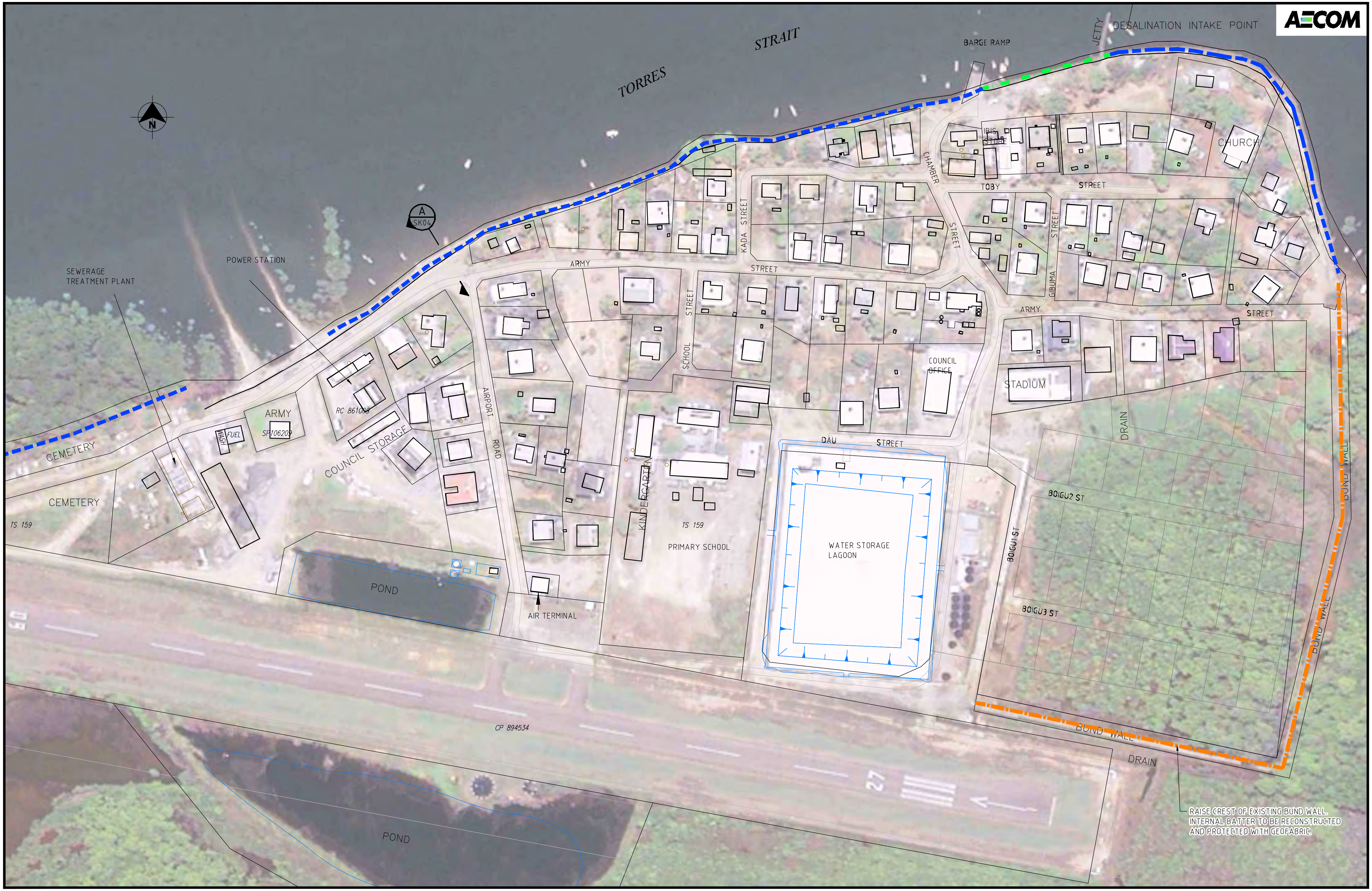
Appendix A

Seawall Option Sketches for Saibai, Boigu and Iama



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PROJECT No. 60237674

DATE 09.01.12 ISSUE 1

SCALE A 0 10 20 30 40 50m 1:2000 (A3) 1:1000 (A1)

LEGEND

- PROPOSED WAVE RETURN WALL TO BE CONSTRUCTED BEHIND THE CONCRETE CAPPING ON THE EXISTING SEABEE WALL.
- RAISE CREST OF EXISTING ROCK SEAWALL. CONSTRUCT NEW WAVE RETURN WALL.
- EXISTING BUND WALL

TORRES STRAIT REGIONAL AUTHORITY
BOIGU SEAWALL AND BUNDING OPTIONS
GENERAL ARRANGEMENT PLAN
60237674-01-GA01

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PROJECT No. 60237674

DATE 09.01.12

ISSUE 1

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TORRES STRAIT REGIONAL AUTHORITY
IAMA SEAWALL AND BUNDING OPTIONS
GENERAL ARRANGEMENT
60237674-02-GA01

PROJECT No. 60237674

DATE 09.01.12 ISSUE 1

SCALE A 0 10 20 30 40 50m 1:2000 (A3) 1:1000 (A1)

LEGEND

- PROPOSED ROCK OR SEABEE SEAWALL WITH CONCRETE WAVE RETURN WALL.
- PROPOSED BUND WALL AND DRAINAGE CHANNEL
- PROPOSED CULVERT OUTLET WITH NON-RETURN VALVE/FLAP.

TORRES STRAIT REGIONAL AUTHORITY
SAIBAI SEAWALL AND BUNDING OPTIONS
GENERAL ARRANGMENT SHEET 1 OF 3
60237674-03-GA01

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PROJECT No. 60237674

DATE 09.01.12

ISSUE 1

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LEGEND

- PROPOSED ROCK OR SEABEE SEAWALL WITH CONCRETE WAVE RETURN WALL
- PROPOSED BUND WALL AND DRAINAGE CHANNEL
- PROPOSED CULVERT OUTLET WITH NON-RETURN VALVE/FLAP

TORRES STRAIT REGIONAL AUTHORITY
SAIBAI SEAWALL AND BUNDING OPTIONS
GENERAL ARRANGEMENT SHEET 2 OF 3
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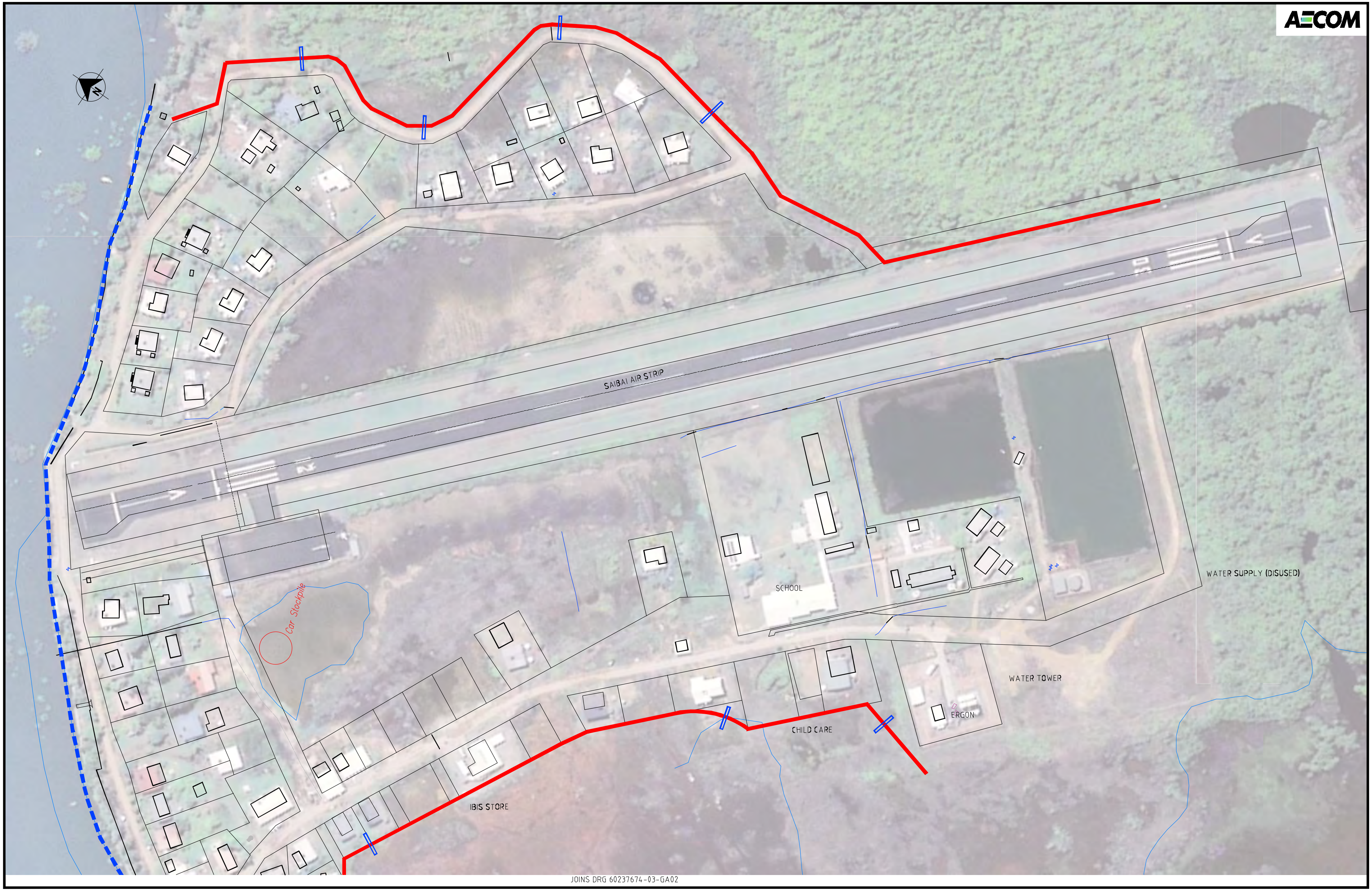

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PROJECT No. 60237674

DATE 09.01.12 ISSUE 1

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LEGEND

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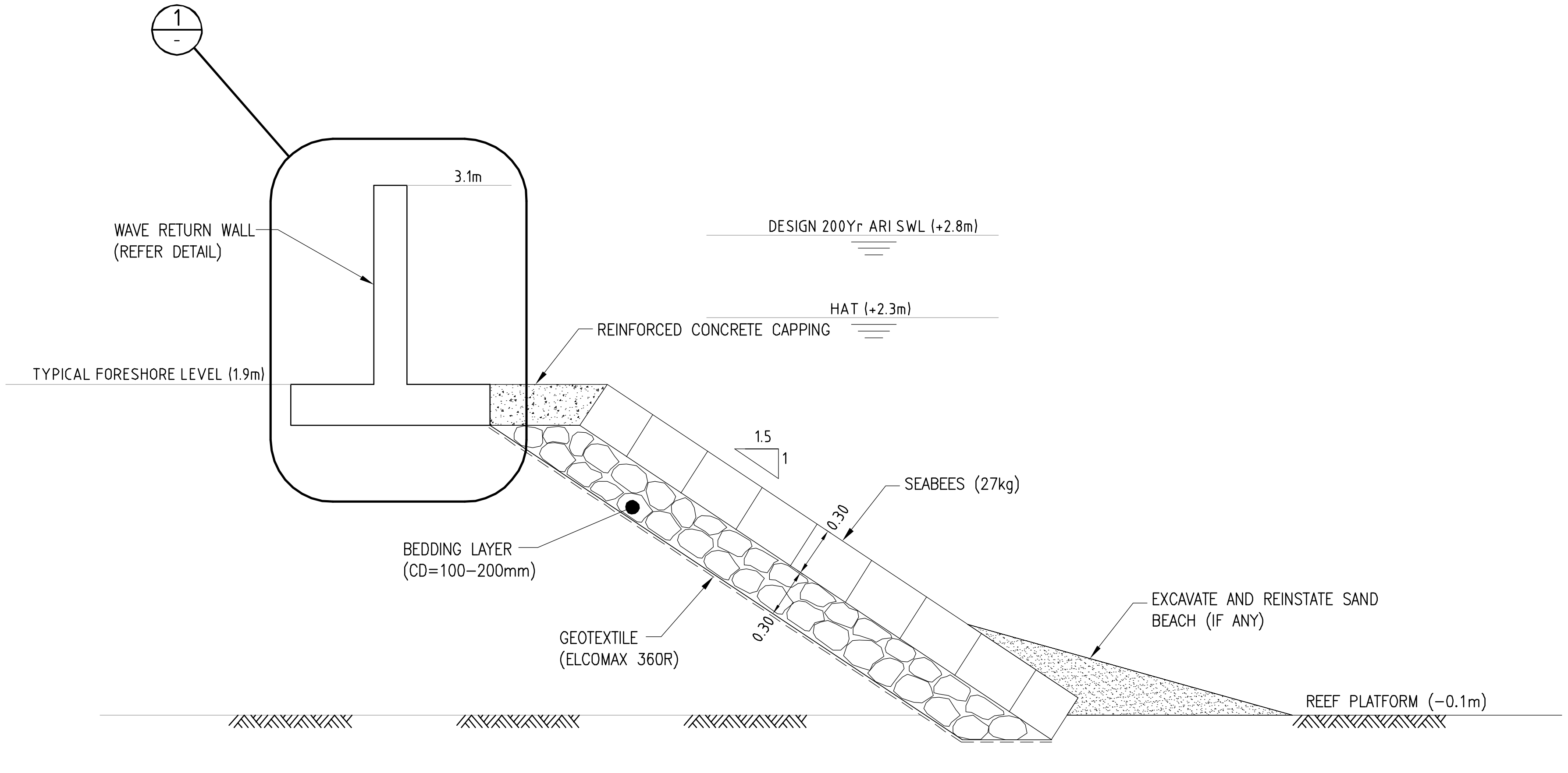
- PROPOSED BUND WALL AND DRAINAGE CHANNEL
- PROPOSED CULVERT OUTLET WITH NON-RETURN VALVE/FLAP

TORRES STRAIT REGIONAL AUTHORITY
SAIBAI SEAWALL AND BUNDING OPTIONS
GENERAL ARRANGEMENT PLAN SHEET 3 OF 3
60237674-03-GA03



SECTION A
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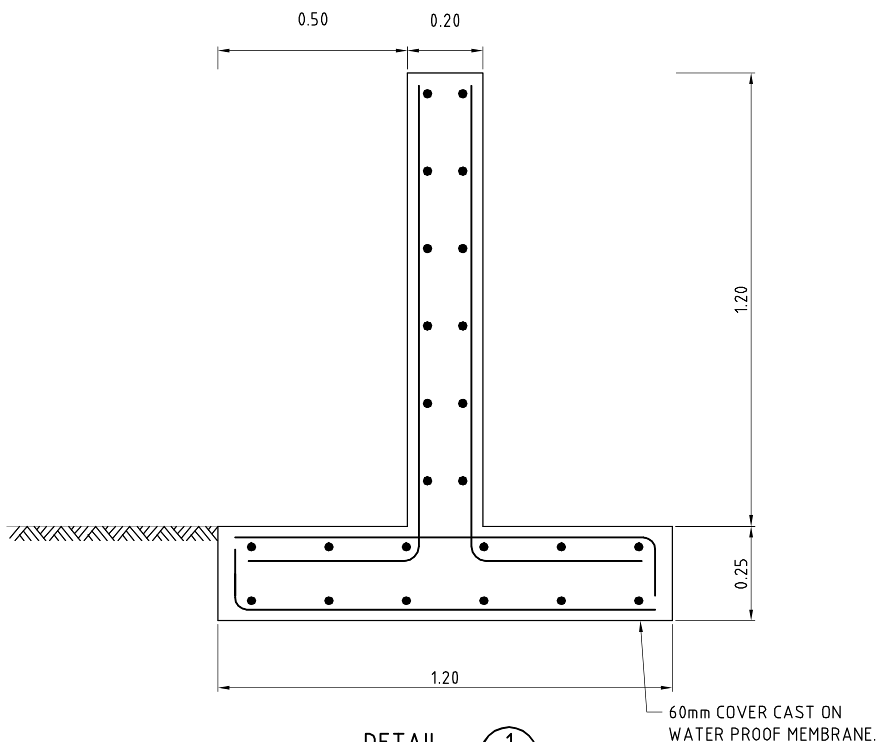


DETAIL 1
SCALE J

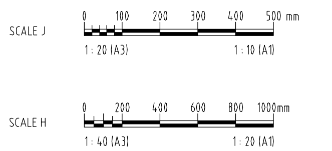
WAVE RETURN WALL HEIGHTS ARE NOT SUFFICIENT TO PREVENT WAVE OVERTOPPING IN EXTREME EVENTS AND THE WALL HEIGHTS HAVE BEEN RESTRICTED TO ENSURE THE AMENITY OF THE AREA IS NOT EXCESSIVELY COMPROMISED.

NOTE:
- DATUM = MEAN SEA LEVEL (MSL) IS 1.7m ABOVE LAT.
- MSL APPROXIMATELY EQUATES TO AHD.
- DESIGN 200yr ARI SWL INCLUDES 0.5m SEA LEVEL RISE ALLOWANCE.

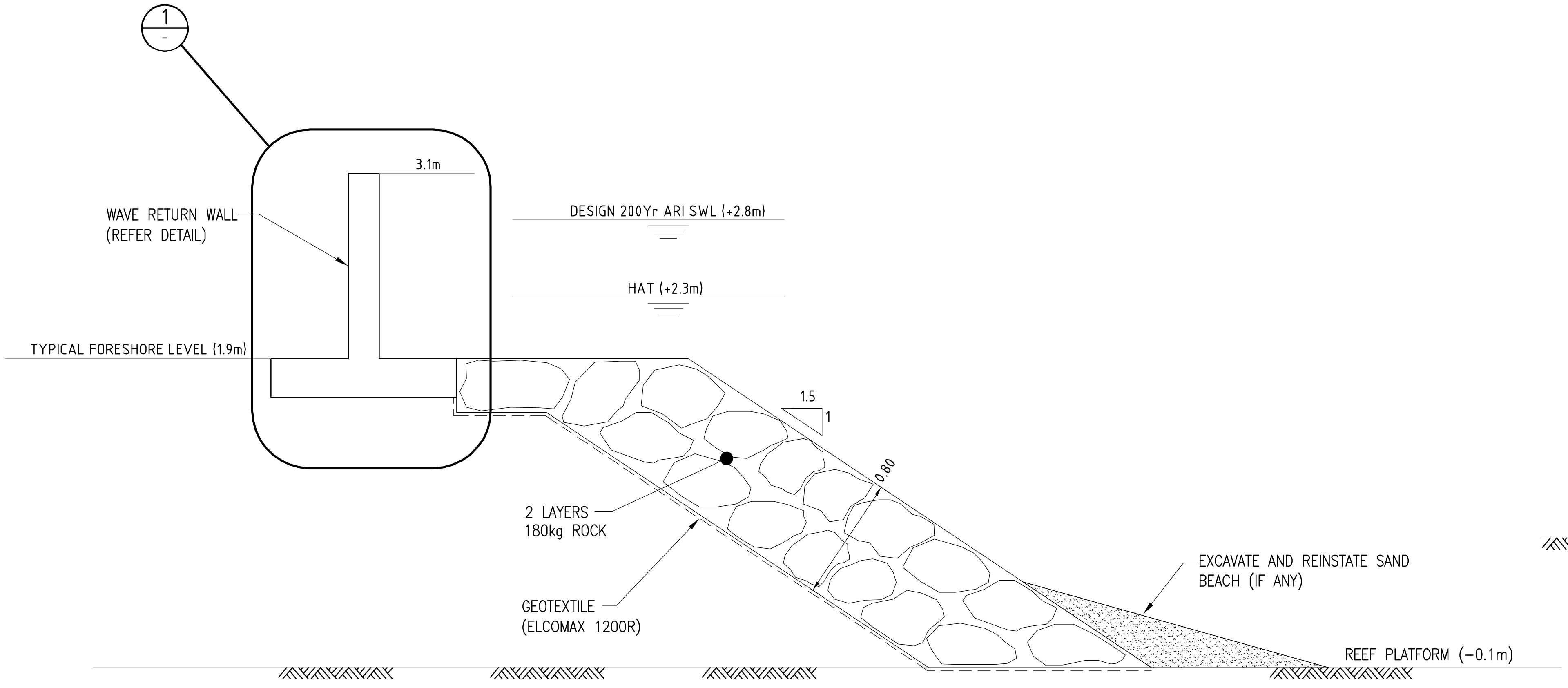
Last modified: 23 Jan 12 - 11:18
Cad ref: J:\60237674\5. CADD\5.3 Working\Sketches\60237674-SK-01.dwg

PROJECT No. 60237674

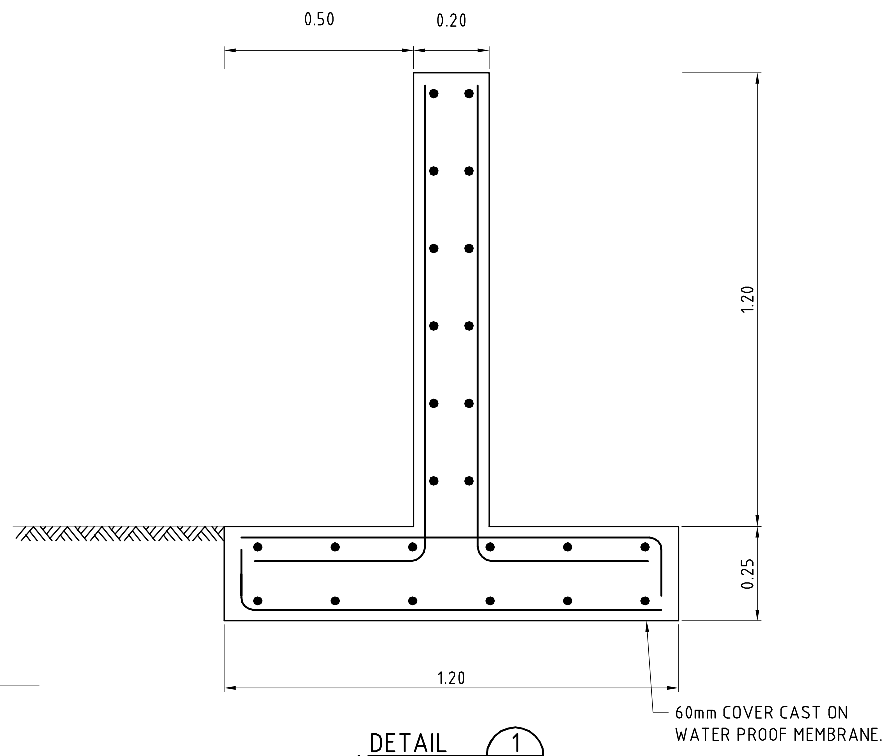
DATE 09.01.12
ISSUE 1



TORRES STRAIT REGIONAL AUTHORITY
SAIBAI SEAWALLS
SEABEE SOLUTION
60237674-SK-01



SECTION A
SCALE H



DETAIL 1
SCALE J

WAVE RETURN WALL HEIGHTS ARE NOT SUFFICIENT TO PREVENT WAVE OVERTOPPING IN EXTREME EVENTS AND THE WALL HEIGHTS HAVE BEEN RESTRICTED TO ENSURE THE AMENITY OF THE AREA IS NOT EXCESSIVELY COMPROMISED.

NOTE:

- DATUM = MEAN SEA LEVEL (MSL) IS 1.7m ABOVE LAT.
- MSL APPROXIMATELY EQUATES TO AHD.
- DESIGN 200yr ARI SWL INCLUDES 0.5m SEA LEVEL RISE ALLOWANCE.

Last modified: 23 Jan 12 - 08:21
Cad ref: J:\60237674\5. CADD\5.3 Working\Sketches\60237674-SK-02.dwg

PROJECT No. 60237674

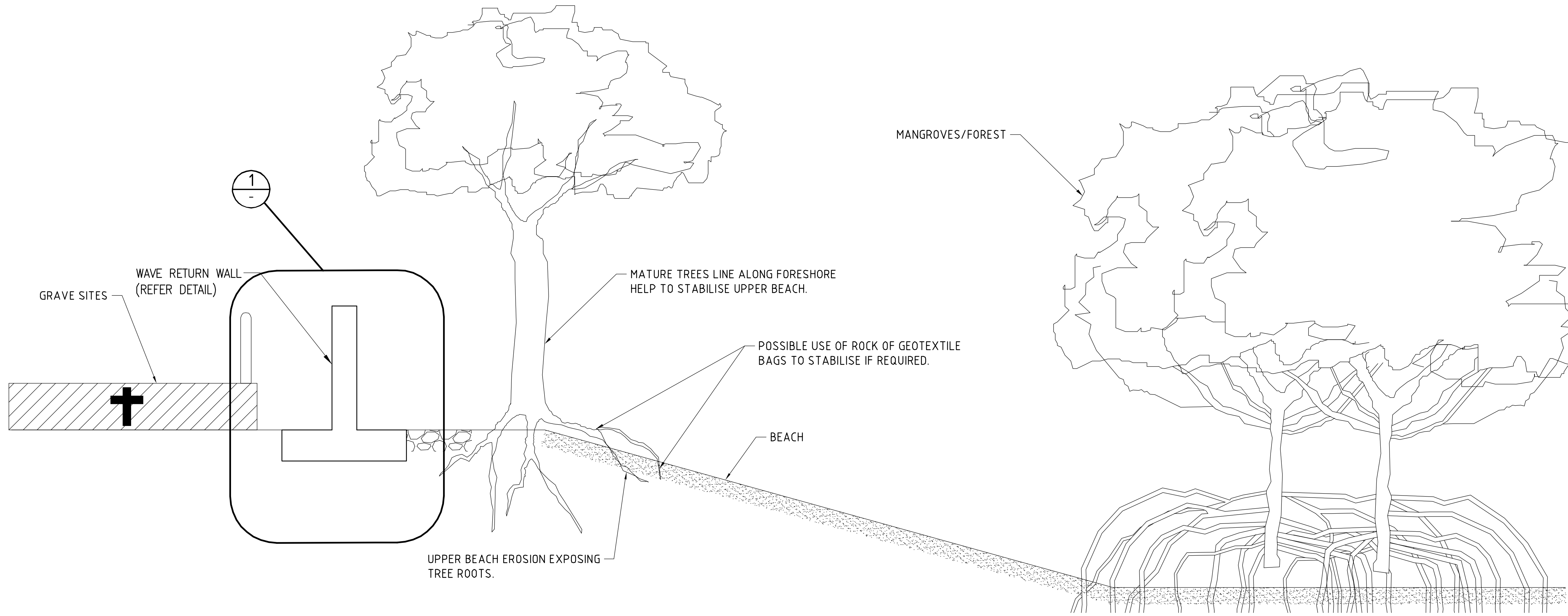
DATE 09.01.12 ISSUE 1

SCALE J 0 100 200 300 400 500 mm 1 : 20 (A3) 1 : 10 (A1)

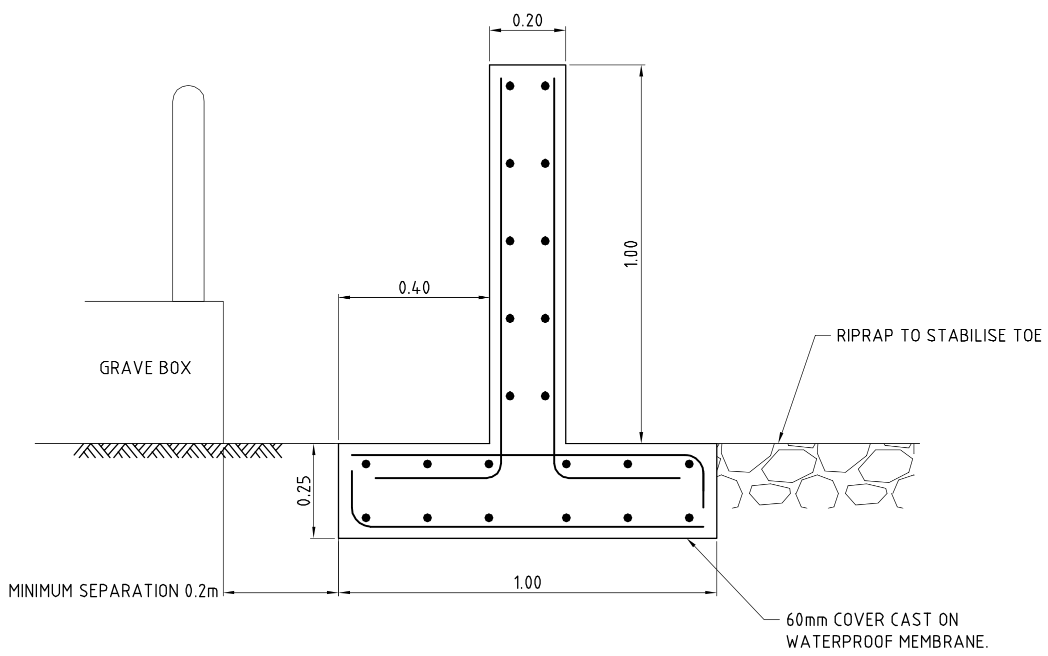
SCALE H 0 200 400 600 800 1000mm 1 : 40 (A3) 1 : 20 (A1)

TORRES STRAIT SEA WALL
SAIBAI SEAWALLS
ROCK ARMOUR SOLUTION
60237674-SK-02

AECOM



SECTION A
SCALE H



DETAIL 1
SCALE J

WAVE RETURN WALL HEIGHTS ARE NOT SUFFICIENT TO PREVENT WAVE OVERTOPPING IN EXTREME EVENTS AND THE WALL HEIGHTS HAVE BEEN RESTRICTED TO ENSURE THE AMENITY OF THE AREA IS NOT EXCESSIVELY COMPROMISED.

NOTE:

- LEVELS AT SITE NOT KNOWN.

Last modified: 23 Jan 12 - 08:49
Cad ref: J:\60237674\5. CADD\5.3 Working\Sketches\60237674-SK-03.dwg

PROJECT No. 60237674

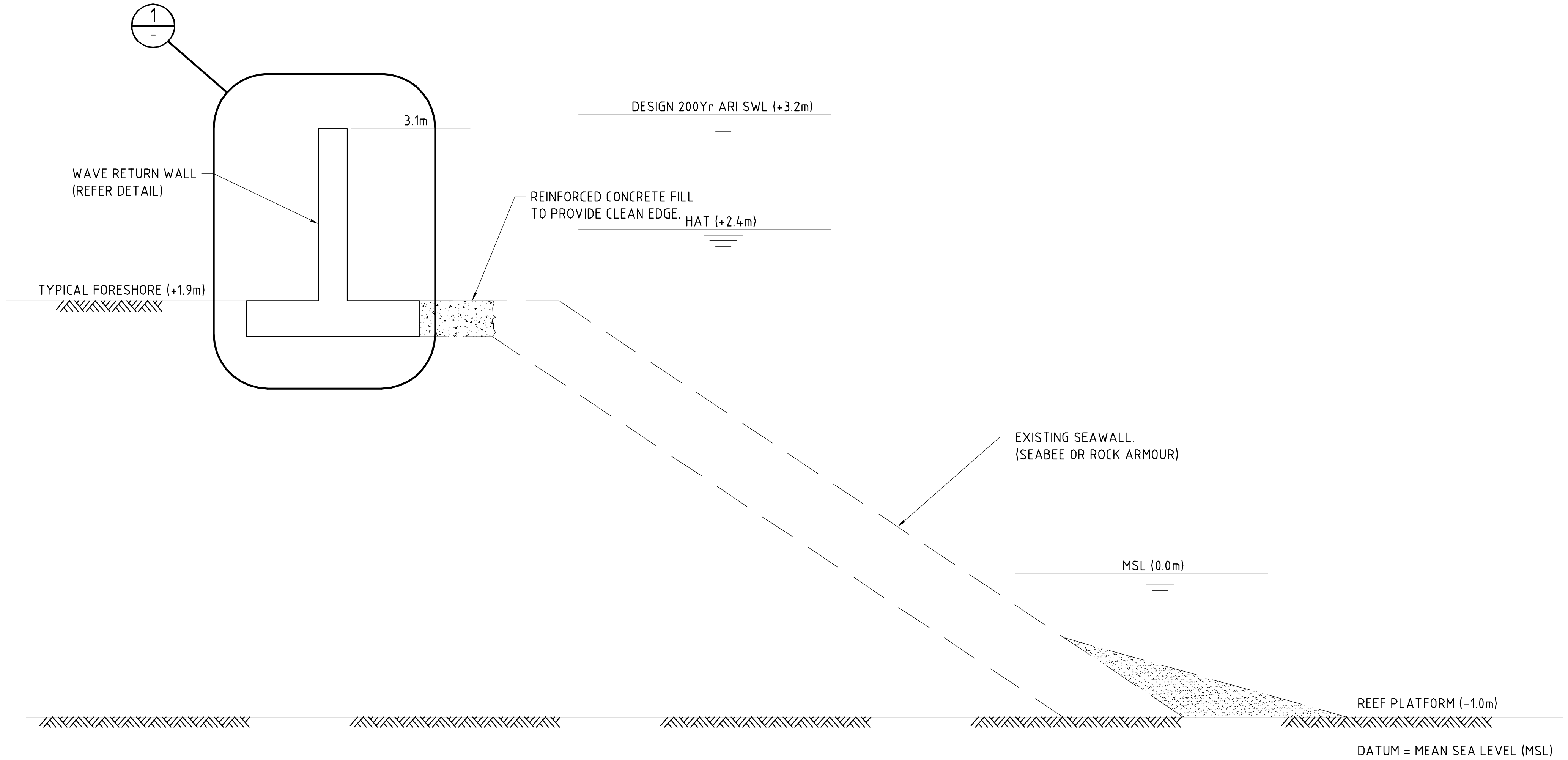
DATE	ISSUE
09.01.12	1

SCALE J 0 100 200 300 400 500 mm 1 : 20 (A3) 1 : 10 (A1)

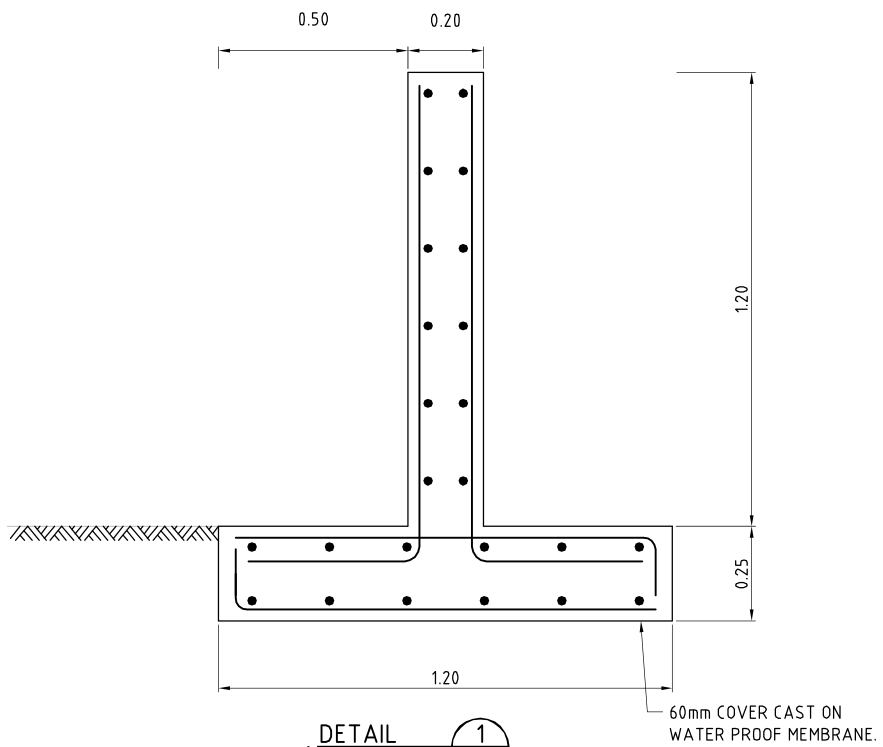
SCALE H 0 200 400 600 800 1000mm 1 : 40 (A3) 1 : 20 (A1)

TORRES STRAIT REGIONAL AUTHORITY
SAIBAI
CEMETERY WAVE RETURN WALL
60237674-SK-03

AECOM



SECTION A
SCALE H



DETAIL 1
SCALE J

WAVE RETURN WALL HEIGHTS ARE NOT SUFFICIENT TO PREVENT WAVE OVERTOPPING IN EXTREME EVENTS AND THE WALL HEIGHTS HAVE BEEN RESTRICTED TO ENSURE THE AMENITY OF THE AREA IS NOT EXCESSIVELY COMPROMISED.

NOTE:

- DATUM = MEAN SEA LEVEL (MSL) IS 2.5m ABOVE LAT.
- MSL APPROXIMATELY EQUATES TO AHD.
- DESIGN 200yr ARI SWL INCLUDES 0.5m SEA LEVEL RISE ALLOWANCE.

Last modified: 23 Jan 12 - 08:49
Cad ref: J:\60237674\5. CADD\5.3 Working\Sketches\60237674-SK-04.dwg

PROJECT No. 60237674

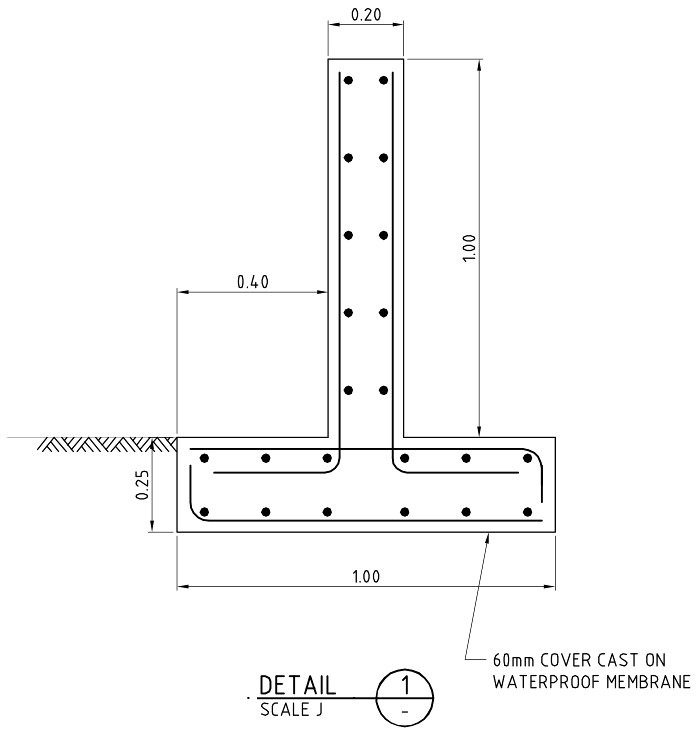
DATE 09.01.12
ISSUE 1

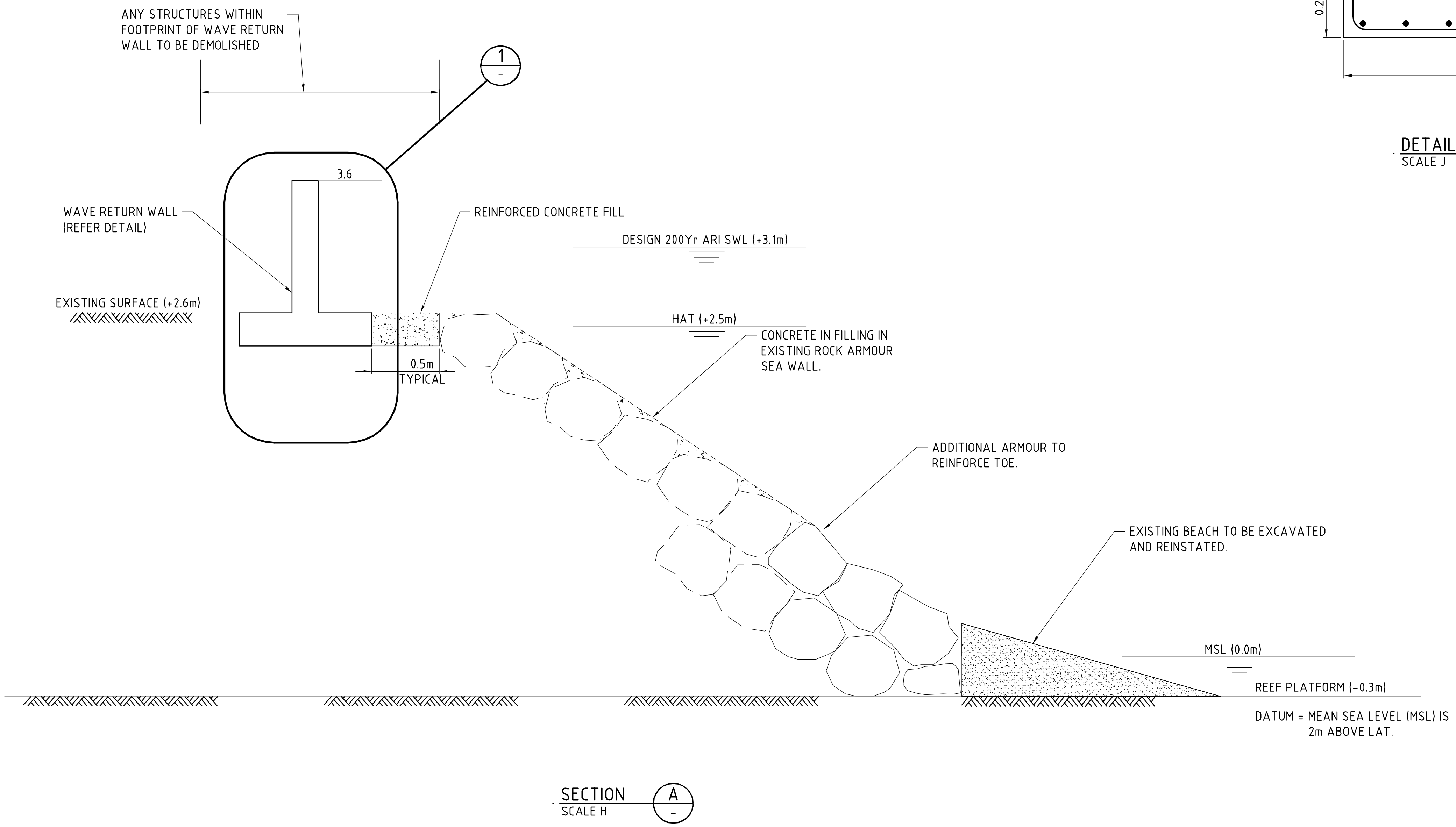
SCALE J: 0 100 200 300 400 500 mm — 1 : 20 (A3) 1 : 10 (A1)

SCALE H: 0 200 400 600 800 1000mm — 1 : 40 (A3) 1 : 20 (A1)

TORRES STRAIT REGIONAL AUTHORITY
BOIGU SEAWALLS
WAVE RETURN WALL ON EXISTING STRUCTURE
60237674-SK-04

AECOM





WAVE RETURN WALL HEIGHTS ARE NOT SUFFICIENT TO PREVENT WAVE OVERTOPPING IN EXTREME EVENTS AND THE WALL HEIGHTS HAVE BEEN RESTRICTED TO ENSURE THE AMENITY OF THE AREA IS NOT EXCESSIVELY COMPROMISED.

NOTE:

- DATUM = MEAN SEA LEVEL (MSL) IS 2.0m ABOVE LAT.
- MSL APPROXIMATELY EQUATES TO AHD.
- DESIGN 200yr ARI SWL INCLUDES 0.5m SEA LEVEL RISE ALLOWANCE.
- ADDITIONAL ARMOUR WON FROM LOCAL QUARRY.

Last modified: 23 Jan 12 - 08:49
Cad ref: J:\60237674\5. CADD\5.3 Working\Sketches\60237674-SK-05.dwg

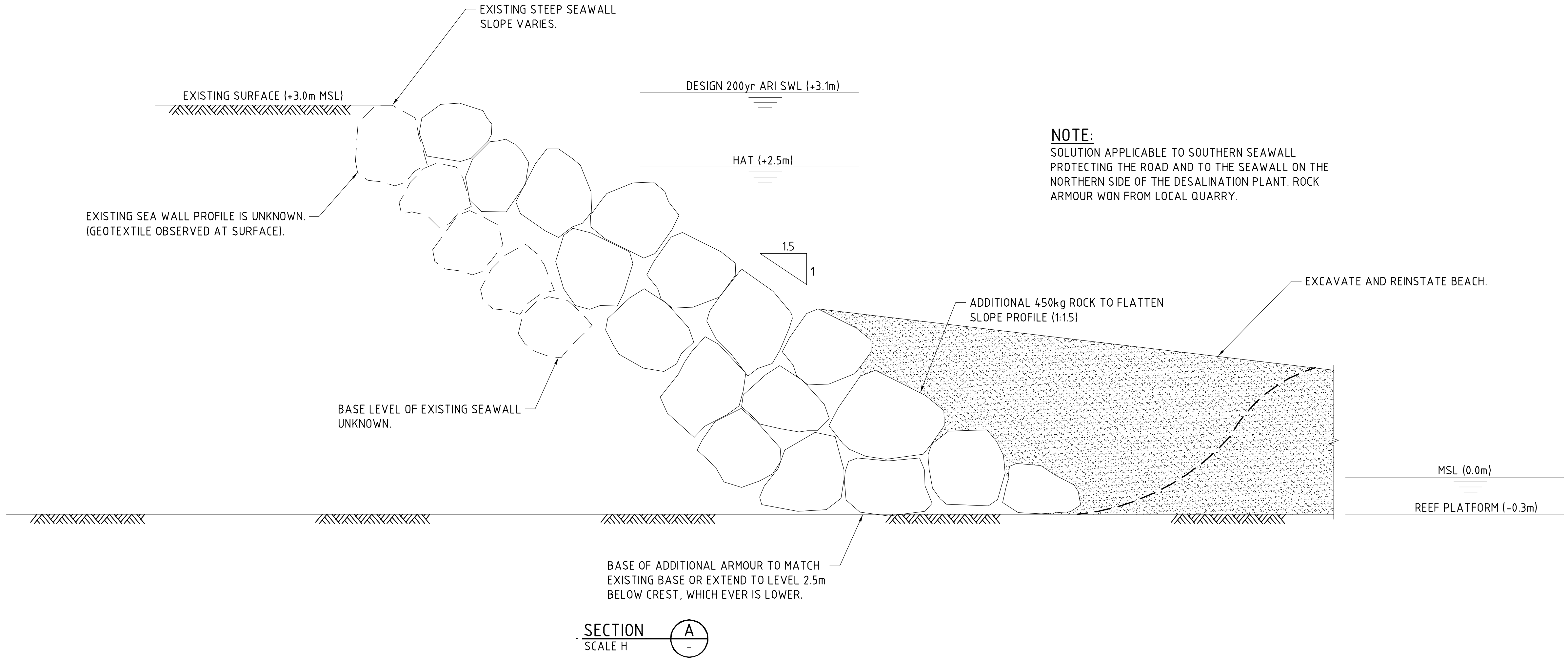
PROJECT No. 60237674

DATE 09.01.12 ISSUE 1

SCALE J 0 100 200 300 400 500 mm 1 : 20 (A3) 1 : 10 (A1)

SCALE H 0 200 400 600 800 1000mm 1 : 40 (A3) 1 : 20 (A1)

TORRES STRAIT REGIONAL AUTHORITY
IAMA SEAWALLS
NORTHERN SEAWALL (THE SPIT) UPGRADE OPTION
60237674-SK-05



AECOM

NOTE:

SOLUTION APPLICABLE TO SOUTHERN SEAWALL PROTECTING THE ROAD AND TO THE SEAWALL ON THE NORTHERN SIDE OF THE DESALINATION PLANT. ROCK ARMOUR WON FROM LOCAL QUARRY.

NOTE:

- DATUM = MEAN SEA LEVEL (MSL) IS 2.0m ABOVE LAT.
- MSL APPROXIMATELY EQUATES TO AHD.
- DESIGN 200yr ARI SWL INCLUDES 0.5m SEA LEVEL RISE ALLOWANCE.

Last modified: 23 Jan 12 - 08:49
Cad ref: J:\60237674\5. CADD\5.3 Working\Sketches\60237674-SK-06.dwg

PROJECT No. 60237674

DATE	ISSUE
09.01.12	1

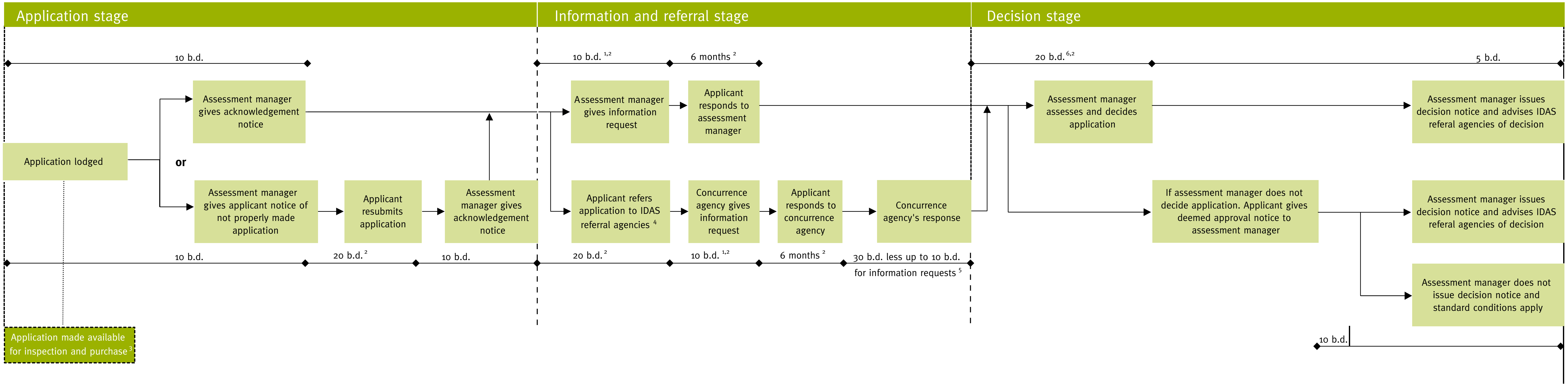
SCALE H 0 200 400 600 800 1000mm
1 : 40 (A3) 1 : 20 (A1)

TORRES STRAIT REGIONAL AUTHORITY
IAMA SEAWALLS
STEEP SEA WALL REPROFILE
60237674-SK-06

Appendix B

Approvals Process Flowchart

For application involving: code assessment only, information request, IDAS referral agencies



Note: b.d. = business days

1. This timeframe may be extended by a further 10 b.d. by the assessment manager or referral agency.
2. This timeframe may be further extended by agreement between the applicant and the assessment manager.
3. The application and any supporting material must be kept available for inspection and purchase from the time the assessement manager recieves the application until the end of any appeal period or the application is withdrawn or lapses.
4. The applicant must also provide the assessment manager written notice of when the application was referred.
5. This timeframe may be extended by up to a further 20 b.d. by the referral agency and may be further extended with written agreement from the applicant.
6. This timeframe may be extended by a further 20 b.d. by the assessment manager.

Qplan

Appendix C

Opinion of Probable Construction Costs

AECOM

Opinion of Probable Construction Costs (OPCC)
IAMA SEAWALL

Item	Description		Unit	Quantity	Rate	Amount
1	**SITE ESTABLISHMENT / DISESTABLISHMENT**		LS	-	-	$93,000
2	**SETTING OUT OF THE WORKS**		LS	-	-	$10,000
3	**SURFACE PREPARATION**					
(a)	Clearing and Grubbing		LS	-	-	$25,000
4	**RECONSTRUCT EXISTING WALL - SOUTHERN BEACH**					
(a)	Rock Armour		m^3	90	500	$45,000
(b)	Excavation and reinstatement at toe.	(provisional)	m^3	150	100	$15,000
5	**RECONSTRUCT EXISTING WALL - NORTHERN SPIT**					
(a)	Rock Armour		m^3	210	500	$105,000
(b)	Excavation and reinstatement at toe.	(provisional)	m^3	350	100	$35,000
5	**REINFORCED CONCRETE WAVE RETURN WALL**					
(a)	Northern Spit		m^3	43.95	2500	$109,875
6	**BUND WALL TO REAR OF SPIT**					
(a)	Stripping of Topsoil (150mm deep)	(provisional)	m^3	120	25	$3,000
(b)	Preparation of Subgrade		m^2	800	15	$12,000
(c)	Geofabric		m^2	1416.23	20	$28,325
(d)	Imported Fill		m^3	250	580	$145,000
6	**COMPLIANCE ASSESSMENT TESTING**	(provisional) (if ordered)	PS	-	-	$25,000
7	**MISCELLANEOUS WORKS**	(provisional) (if ordered)	PS	-	-	$10,000
8	**AS-CONSTRUCTED DRAWINGS**		LS	-	-	$50,000
9	**PROJECT MANAGEMENT COSTS (5%)**		LS	-	-	$30,910

SUBTOTAL	**(Excl. GST)**	$742,110
CONTINGENCY	**(25%)**	$185,527
		$927,637
GST	**(10%)**	$92,764
TOTAL	**(Incl. GST)**	$1,020,401

Please note that AECOM has no control over the cost of labour, materials, equipment or services furnished by others, neither has it control over contractors methods for determining prices, competitive bidding or market conditions. The opinion of probable construction cost produced by AECOM will therefore be provided on the basis of its best judgement as an experienced and qualified engineering consultant, familiar with the construction industry. We can therefore not guarantee that any tenders or actual construction costs will not vary from any opinion of probable construction cost provided by AECOM.

AECOM

Opinion of Probable Construction Costs (OPCC)
BOIGU SEAWALL WORKS

Item	*Description*		*Unit*	*Quantity*	*Rate*	*Amount*
1	**SITE ESTABLISHMENT / DISESTABLISHMENT**		LS	-	-	$192,000
2	**SETTING OUT OF THE WORKS**		LS	-	-	$30,000
3	**SURFACE PREPARATION**					
(a)	Clearing and Grubbing		LS	-	-	$25,000
4	**RECONSTRUCT EXISTING SEAWALL - JETTY TO BOAT RAMP**					
(a)	Geofabric Underlay		m^2	450	20	$9,000
(b)	Rock Armour		m^3	216	1000	$216,000
(c)	Filling to raise height at crest of seawall	(provisional)	m^3	100	580	$58,000
5	**REINFORCED CONCRETE WAVE RETURN WALL**					
(a)	Community area		m^3	228.24	2500	$570,600
(b)	Cemetary		m	155	1125	$174,375
(b)	Allowance for Extension of Cemetary		m	100	1125	$112,500
6	**COMPLIANCE ASSESSMENT TESTING**	(provisional) (if ordered)	PS	-	-	$25,000
7	**MISCELLANEOUS WORKS**	(provisional) (if ordered)	PS	-	-	$10,000
8	**AS-CONSTRUCTED DRAWINGS**		LS	-	-	$50,000
9	**PROJECT MANAGEMENT COSTS (5%)**		LS	-	-	$64,024

SUBTOTAL	**(Excl. GST)**	$1,536,499
CONTINGENCY	**(25%)**	$384,125
		$1,920,623
GST	**(10%)**	$192,062
TOTAL	**(Incl. GST)**	$2,112,686

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AECOM

Opinion of Probable Construction Costs (OPCC)
ROCK WALL OPTION w/ WAVE RETURN WALL

Item	*Description*		*Unit*	*Quantity*	*Rate*	*Amount*
1	**SITE ESTABLISHMENT / DISESTABLISHMENT**		LS	-	-	$1,128,000
2	**SETTING OUT OF THE WORKS**		LS	-	-	$35,000
3	**SURFACE PREPARATION**					
(a)	Demolition of Existing Wall		LS	-	-	$100,000
(b)	Clearing and Grubbing		LS	-	-	$25,000
4	**EARTHWORKS**					
(a)	Imported Fill		m^3	2648	580	$1,535,550
5	**GEO FABRIC UNDERLAY**		m^2	8825	20	$176,500
6	**ROCK ARMOUR**		m^3	4236	1000	$4,236,000
7	**CONCRETE WAVE RETURN WALL**		m^3	529.74	2500	$1,324,350
8	**COMPLIANCE ASSESSMENT TESTING**	(provisional) (if ordered)	PS	-	-	$25,000
9	**MISCELLANEOUS WORKS**	(provisional) (if ordered)	PS	-	-	$10,000
10	**AS-CONSTRUCTED DRAWINGS**		LS	-	-	$50,000
11	**PROJECT MANAGEMENT COSTS (5%)**		LS	-	-	$375,870

SUBTOTAL	**(Excl. GST)**	$9,021,270
CONTINGENCY	**(25%)**	$2,255,318
		$11,276,588
GST	**(10%)**	$1,127,659
TOTAL	**(Incl. GST)**	$12,404,246

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Opinion of Probable Construction Costs (OPCC)
SAIBAI DRAINAGE AND BUND WALL

Item	*Description*		*Unit*	*Quantity*	*Rate*	*Amount*
1	**SITE ESTABLISHMENT / DISESTABLISHMENT**		LS	-	-	$781,000
2	**SETTING OUT OF THE WORKS**		LS	-	-	$30,000
3	**CLEARING AND GRUBBING**		LS	-	-	
4	**STRIPPING OF TOPSOIL (150mm)**		m^3	5515.2	25	$137,880
5	**ALLOWANCE FOR SUBGRADE WORKS**		LS			$300,000
6	**EARTHWORKS**					
(a)	Cut to Fill		m^3	7354	50	$367,680
(b)	Imported Fill		m^3	1838	580	$1,066,272
(c)	Removal of Unsuitable Material	*(Provisional Quantity)*	m^3	2000	50	$100,000
7	**GEO FABRIC FOR BUND WALL**		m^2	30640	20	$612,800
8	**CONCRETE LINING OF DRAINS**		m	1000	2250	$2,250,000
9	**ALLOWANCE FOR DRAINAGE STRUCTURES**		LS	-	-	$300,000
10	**COMPLIANCE ASSESSMENT TESTING**	(provisional) (if ordered)	PS	-	-	$10,000
11	**MISCELLANEOUS WORKS**	(provisional) (if ordered)	PS	-	-	$10,000
12	**AS-CONSTRUCTED DRAWINGS**		LS	-	-	$25,000
13	**PROJECT MANAGEMENT COSTS (5%)**		LS	-	-	$260,482

SUBTOTAL	**(Excl. GST)**	$6,251,114
CONTINGENCY	**(25%)**	$1,562,778
		$7,813,892
GST	**(10%)**	$781,389
TOTAL	**(Incl. GST)**	$8,595,281

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AECOM

Opinion of Probable Construction Costs (OPCC)
SEABEE WALL OPTION w/ WAVE RETURN WALL

Item	*Description*		*Unit*	*Quantity*	*Rate*	*Amount*
1	**SITE ESTABLISHMENT / DISESTABLISHMENT**		LS	-	-	$1,103,000
2	**SETTING OUT OF THE WORKS**		LS	-	-	$35,000
3	**SURFACE PREPARATION**					
(a)	Demolition of Existing Wall		LS	-	-	$100,000
(b)	Clearing and Grubbing		LS	-	-	$25,000
4	**EARTHWORKS**					
(a)	Imported Fill		m3	2648	580	$1,535,550
5	**GEO FABRIC UNDERLAY**		m^2	8825	10	$88,250
6	**ROCK BEDDING**					
(a)	Rock bedding		m^3	1750	800	$1,400,000
7	**CONCRETE HEXAGONAL PROTECTION UNITS (300mm)**					
(a)	Construction	(provisional)	No.	88250	26	$2,294,500
8	**REINFORCED CONCRETE CAPPING (TOP)**		m^3	176.5	2500	$441,250
9	**REINFORCED CONCRETE CAPPING (ENDS)**		m^3	10	2500	$25,000
10	**REINFORCED CONCRETE WAVE RETURN WALL**		m^3	529.74	2500	$1,324,350
12	**COMPLIANCE ASSESSMENT TESTING**	(provisional) (if ordered)	PS	-	-	$25,000
13	**MISCELLANEOUS WORKS**	(provisional) (if ordered)	PS	-	-	$10,000
14	**AS-CONSTRUCTED DRAWINGS**		LS	-	-	$50,000
15	**PROJECT MANAGEMENT COSTS (5%)**		LS	-	-	$367,695

SUBTOTAL	**(Excl. GST)**	$8,824,595
CONTINGENCY	**(25%)**	$2,206,149
		$11,030,744
GST	**(10%)**	$1,103,074
TOTAL	**(Incl. GST)**	$12,133,818

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AECOM

Opinion of Probable Construction Costs (OPCC)
WAVE RETURN WALL AT SAIBAI CEMETARY

Item	*Description*		*Unit*	*Quantity*	*Rate*	*Amount*
1	**SITE ESTABLISHMENT / DISESTABLISHMENT**		LS	-	-	$59,000
2	**SETTING OUT OF THE WORKS**		LS	-	-	$20,000
3	**SURFACE PREPARATION**					
(a)	Clearing and Grubbing		LS	-	-	$25,000
4	**REINFORCED CONCRETE WAVE RETURN WALL**					
(a)	Protection to Existing Cemetary		m	155	1125	$174,375
(b)	Allowance for Extension of Cemetary		m	100	1125	$112,500
5	**COMPLIANCE ASSESSMENT TESTING**	(provisional) (if ordered)	PS	-	-	$25,000
6	**MISCELLANEOUS WORKS**	(provisional) (if ordered)	PS	-	-	$10,000
7	**AS-CONSTRUCTED DRAWINGS**		LS	-	-	$25,000
8	**PROJECT MANAGEMENT COSTS (5%)**		LS	-	-	$19,594

SUBTOTAL	**(Excl. GST)**	$470,469
CONTINGENCY	**(25%)**	$117,617
		$588,086
GST	**(10%)**	$58,809
TOTAL	**(Incl. GST)**	$646,895

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AECOM

Opinion of Probable Construction Costs (OPCC)
BOIGU BUND WORKS

Item	*Description*		*Unit*	*Quantity*	*Rate*	*Amount*
1	**SITE ESTABLISHMENT / DISESTABLISHMENT**		LS	-	-	$89,000
2	**SETTING OUT OF THE WORKS**		LS	-	-	$15,000
3	**SURFACE PREPARATION**					
(a)	Clearing and Grubbing		LS	-	-	$20,000
4	**EARTHWORKS**					
(a)	Geofabric Underlay		m^2	2000	20	$40,000
(c)	Filling to raise height and rectify erosion issues	(provisional)	m^3	750	580	$435,000
5	**COMPLIANCE ASSESSMENT TESTING**	(provisional) (if ordered)	PS	-	-	$25,000
6	**MISCELLANEOUS WORKS**	(provisional) (if ordered)	PS	-	-	$10,000
7	**AS-CONSTRUCTED DRAWINGS**		LS	-	-	$50,000
8	**PROJECT MANAGEMENT COSTS (5%)**		LS	-	-	$29,750

SUBTOTAL	**(Excl. GST)**	$713,750
CONTINGENCY	**(25%)**	$178,438
		$892,188
GST	**(10%)**	$89,219
TOTAL	**(Incl. GST)**	$981,406

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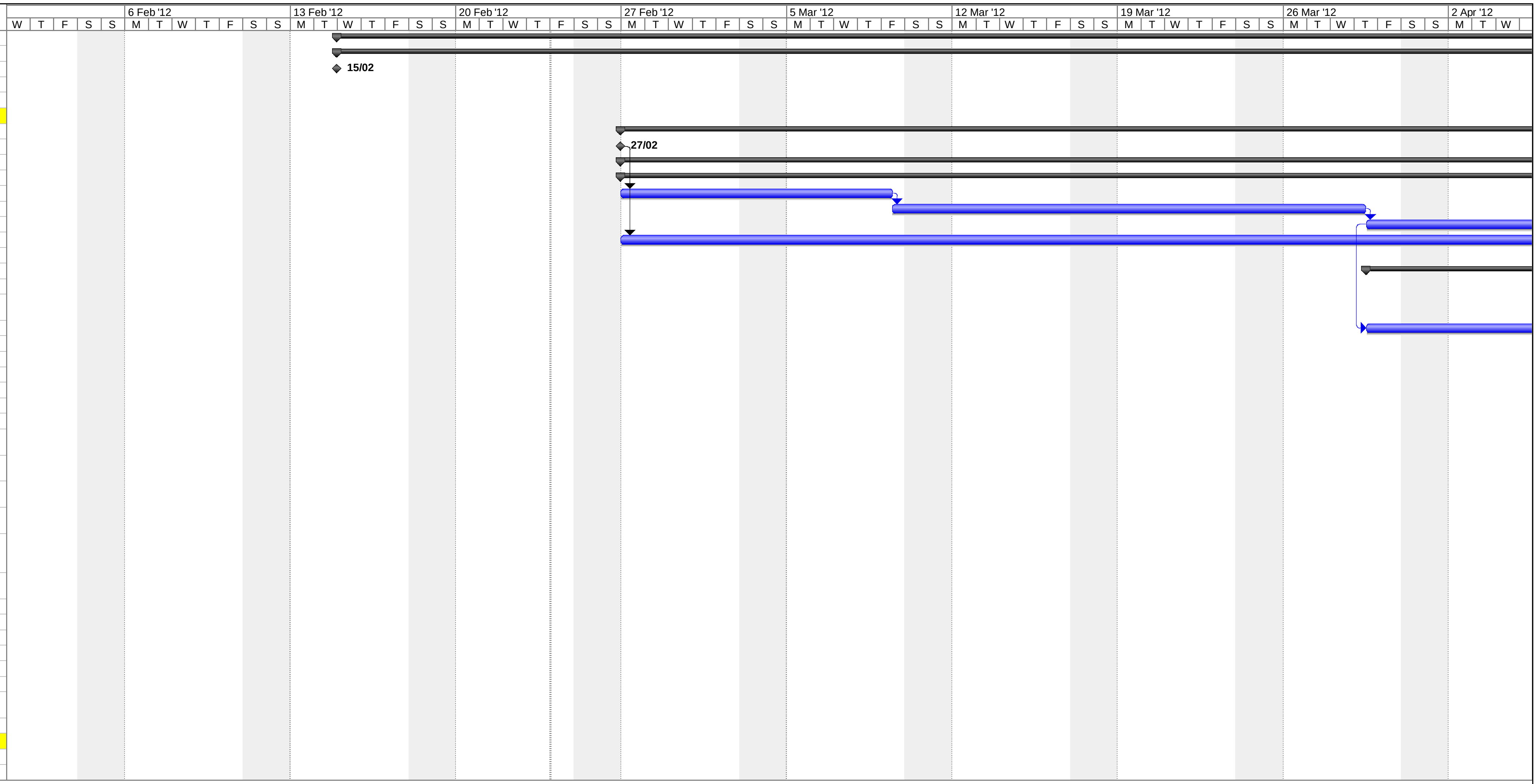
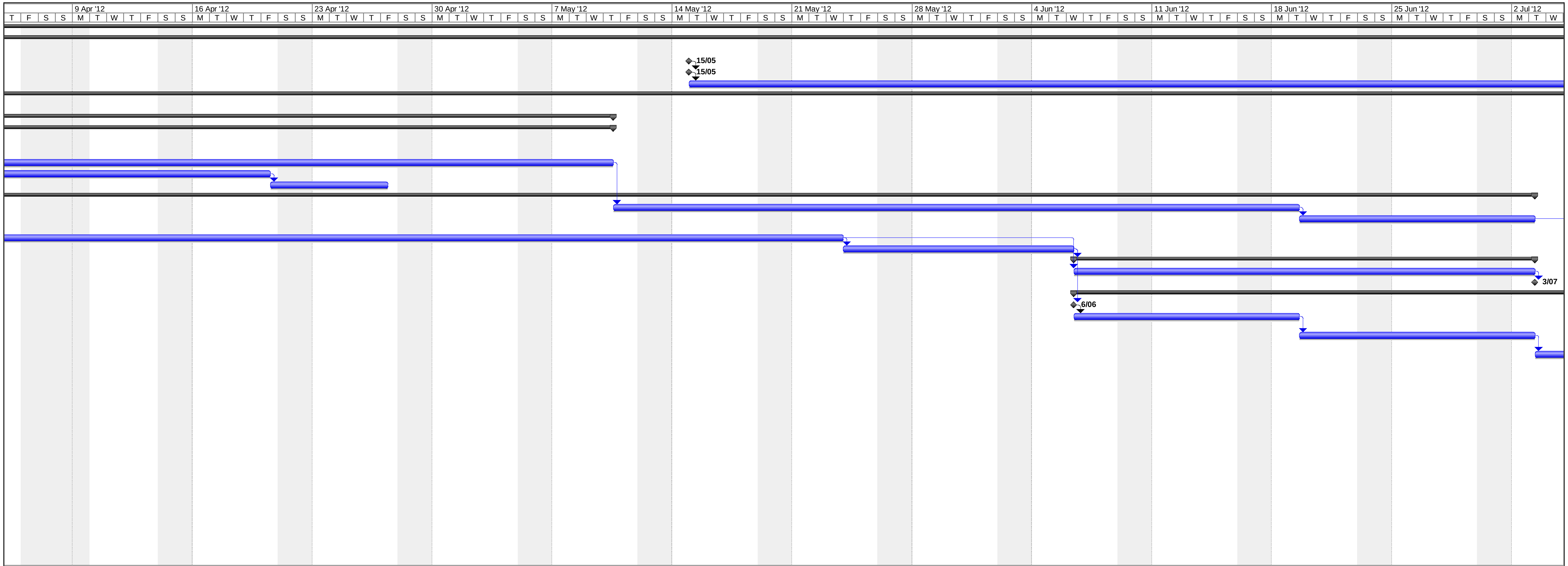
Appendix D

Project Program

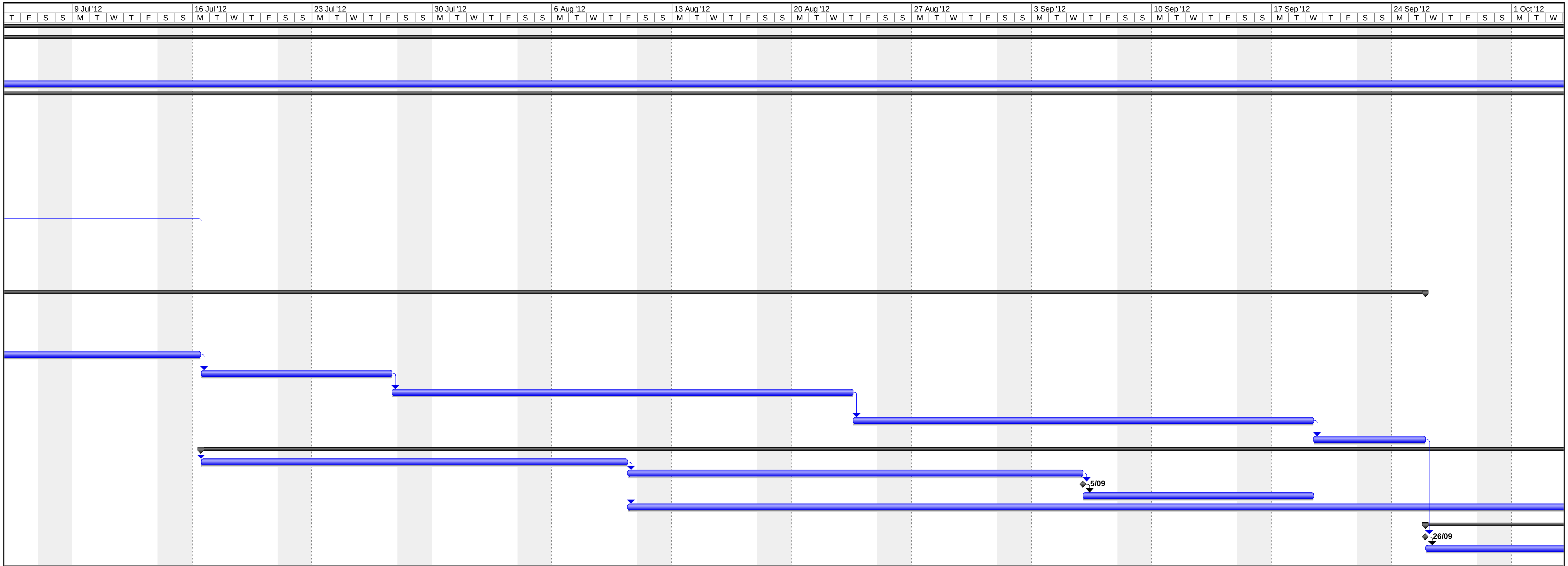
ID	Indicators	Task Name	Duration	Start	Finish	Predecessors
1		**Project Program - Torres Strait Seawalls**	**46.53 days**	**Wed 15/02/12**	**Tue 18/02/14**	
2		**Funding Proposal**	**96.13 days**	**Wed 15/02/12**	**Wed 31/10/12**	
3		Round 2 Funding Proposal Due	0 days	Wed 15/02/12	Wed 15/02/12	
4		Successful Projects Announced	0 days	Tue 15/05/12	Tue 15/05/12	
5		Funding Agreement Signed	0 wks	Tue 15/05/12	Tue 15/05/12	4
6		Construction Commencement Date	26 wks	Tue 15/05/12	Wed 31/10/12	5
7		**Project Management Commission**	**538 days**	**Mon 27/02/12**	**Tue 18/02/14**	
8		Project Award	0 days	Mon 27/02/12	Mon 27/02/12	
9		**Planning and Design Stage**	**55 days**	**Mon 27/02/12**	**Thu 10/05/12**	
10		**Survey Investigations**	**55 days**	**Mon 27/02/12**	**Thu 10/05/12**	
11		Tender Brief	2 wks	Mon 27/02/12	Fri 9/03/12	8
12		Commission Surveyor	3 wks	Fri 9/03/12	Thu 29/03/12	11
13		Survey Period	6 wks	Thu 29/03/12	Thu 10/05/12	12
14		Design Report	8 wks	Mon 27/02/12	Fri 20/04/12	8
15		Client Review Period	1 wk	Fri 20/04/12	Fri 27/04/12	14
16		**Documentation Stage**	**70 days**	**Thu 29/03/12**	**Tue 3/07/12**	
17		Detailed Design Drawings	6 wks	Thu 10/05/12	Tue 19/06/12	13
18		Specification and Tender Documents	2 wks	Tue 19/06/12	Tue 3/07/12	17
19		Environmental Investigation	8 wks	Thu 29/03/12	Wed 23/05/12	13SS
20		Client Review	2 wks	Thu 24/05/12	Wed 6/06/12	19
21		**Native Title Approval**	**20 days**	**Wed 6/06/12**	**Tue 3/07/12**	**20**
22		24KA	4 wks	Wed 6/06/12	Tue 3/07/12	19FS+5 days
23		Native Title Approval	0 days	Tue 3/07/12	Tue 3/07/12	22
24		**Environmental Approvals**	**85 days**	**Wed 6/06/12**	**Wed 26/09/12**	
25		Lodge Application	0 days	Wed 6/06/12	Wed 6/06/12	20
26		Assessment Manager Approval Notice	2 wks	Wed 6/06/12	Tue 19/06/12	25
27		Referral to Concurrence Agencies	2 wks	Tue 19/06/12	Tue 3/07/12	26
28		Concurrence Agency Assessment of Submission	2 wks	Tue 3/07/12	Mon 16/07/12	27
29		Response to Information Request	2 wks	Mon 16/07/12	Fri 27/07/12	28
30		Concurrence Agency Assessment	4 wks	Fri 27/07/12	Thu 23/08/12	29
31		Assessment Manager Decides Application	4 wks	Thu 23/08/12	Wed 19/09/12	30
32		Issue of DA	1 wk	Wed 19/09/12	Wed 26/09/12	31
33		**Procurement**	**85 days**	**Mon 16/07/12**	**Mon 5/11/12**	
34		Tender Period	4 wks	Mon 16/07/12	Fri 10/08/12	18FS+2 wks
35		Tender Assessment	4 wks	Fri 10/08/12	Wed 5/09/12	34
36		Issue Tender Evaluation Report	0 days	Wed 5/09/12	Wed 5/09/12	35
37		Client Review Period	2 wks	Thu 6/09/12	Wed 19/09/12	36
38		Tender Period Validity Period expires	65 days	Fri 10/08/12	Mon 5/11/12	34
39		**Construction**	**100 days**	**Wed 26/09/12**	**Mon 18/02/13**	
40		Award Construction Contract	0 days	Wed 26/09/12	Wed 26/09/12	32
41		Construction Contract Duration	20 wks	Wed 26/09/12	Mon 18/02/13	40
42		Defects Liability	278 days	Mon 18/02/13	Tue 18/02/14	41



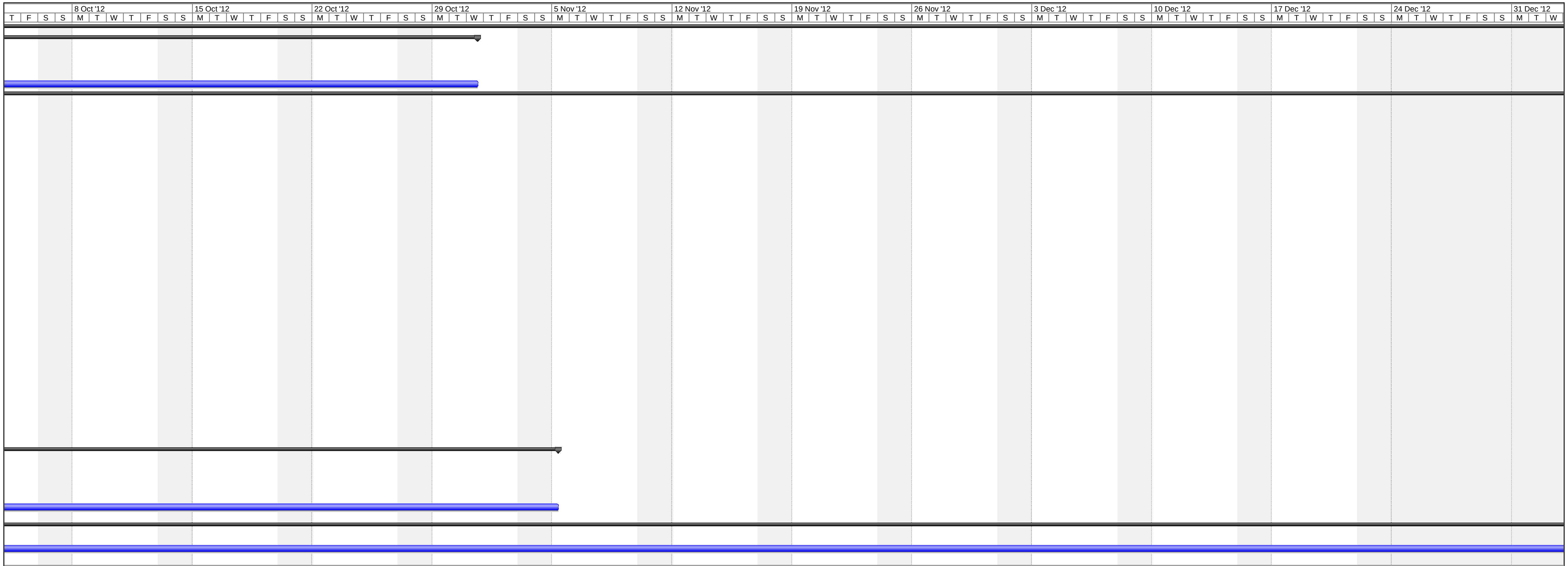
Project: Program Date: Fri 24/02/12	Task		Split		Progress		Milestone	◆	Summary		Project Summary		External Tasks		External Milestone ◆	Deadline ⇩



Project: Program Date: Fri 24/02/12	Task		Split		Progress		Milestone		Summary		Project Summary	External Tasks	External Milestone	Deadline



Project: Program Date: Fri 24/02/12	Task		Split		Progress		Milestone		Summary		Project Summary		External Tasks		External Milestone		Deadline		



Project: Program Date: Fri 24/02/12	Task	Split	Progress	Milestone	Summary	Project Summary	External Tasks	External Milestone	Deadline