Executive Summary

The Sandy Point / Conroy Park Foreshore Erosion and Drainage Management Study aims to identify a preferred solution for the management of the shoreline between The Anchorage Marina and Bagnalls Beach in Corlette, on the southern side of Port Stephens.

Detailed investigations of coastal and drainage processes were completed. The resulting reports are appended. The foreshores were first subdivided and settled in the 1940's and 1950's. At that time, sand was plentiful along the foreshore.

Unfortunately, the whole of lower Port Stephens (east of Corlette Point) is changing as a large sand feature known as a "Flood Tide Delta" moves slowly in to the Port. The foreshore in our study area was not stable and has been subject to erosion and attack by waves ever since it was settled.

The first protective structures were built in the late 1950's/early 1960's. Ongoing erosion has gradually moved from east to west and the need to protect the foreshores has extended in the same direction.

During the past two decades, erosion has become particularly notable at Conroy Park. This pattern is consistent with other information that shows sand moves from east to west along the foreshore. The clearest evidence of this is the more recent widening of the beach next to "The Anchorage" at Corlette Point.

Areas that previously had a sandy beach are now exposed to direct attack by waves and overtopping during storms, such as the "Super Storm" of April 2015. The piecemeal foreshore protection that has been constructed in front of individual properties does not provide a suitable level of protection from waves to all residential properties in the area. Various stormwater outlets cross the foreshore and any foreshore plan needs to consider those outlets.

Following our review of background information and a detailed engineering site inspection, the study foreshore was divided into six different "Precincts" which are shown on Figure E.1.

These precincts have been used to develop and assess different management options. "Chainages" are used to identify the extent of these precincts and are measured in distance east from the Anchorage Marina eastern breakwater (Figure E.1). Briefly, the precincts are:

Precinct 1: (Between approximately 0m and 250m east of The Anchorage). Comprising the western end of Corlette Beach. This area has been accreting since construction of The Anchorage. A significant stormwater outlet crosses the beach near the eastern end.

Precinct 2: (Between approximately 250m and 520m east of The Anchorage). Comprising the Eastern end of Corlette Beach, transitioning from Precinct 1 to an actively eroding section of beach fronting Conroy Park. In the past few years, geotextile sand bags have been used to protect the eastern end of this precinct.

Precinct 3: (Between approximately 520m and 710m east of The Anchorage). Comprising a north-north westerly facing length of foreshore protected by a tipped rock revetment which is too steep and failing extensively. This reach stretches from the eastern end of Conroy Park through to the westernmost groyne (Groyne A), at the tip of Sandy Point, fronting properties between #70 and #48 Sandy Point Road.

Precinct 4: (Between approximately 710m and 810m east of The Anchorage). Comprising a north to north easterly facing length of foreshore revetment between the westernmost groyne, at the tip of Sandy Point (Groyne A), through to the next groyne east (Groyne B). Again there is significant revetment failure, particularly through loss of armour from the crest of the revetment. This precinct comprises the foreshore between #46 and #38 Sandy Point Road.

Precinct 5: (Between approximately 810m and 950m east of The Anchorage). Comprising a variable but heavily protected section of foreshore stretching between Groyne B and Groyne D. This section is the most "at-risk" length of foreshore within the study area. Swell waves tend to approach perpendicularly to the foreshore, maximising runup and overtopping during severe storm events. A significant stormwater outlet runs through the centre of Groyne D. This precinct comprises the foreshore between #36 and #20 Sandy Point Road.

Precinct 6: (Between approximately 950m and 1150m east of The Anchorage). Comprising the foreshore between Groyne D and the easternmost residence on Sandy Point Road (i.e. between addresses #18 and #2). This shoreline section is presently more sheltered than areas to the west, and is afforded some protection by Groyne D, which is acting to both reduce wave heights and also trap sand on its eastern side, creating a sandy beach buffer. Even so, there is photographic and field evidence of past damage to structures and overtopping along this length of foreshore, particularly at boat ramps which are "weak points" along the foreshore.

To support subsequent conceptual design activities detailed survey, including hydrographic and unmanned aerial vehicle (UAV or 'drone') surveys were undertaken. A summary of that data is provided in Appendix C.

Early contact was made with the local community through a questionnaire (online and print), followed by targeted interviews with interested parties that either lived along the foreshore or had a particular or long standing interest in the study foreshores.

Key issues identified by consultation included:

- There has been long term recognition of erosion problems along the study foreshores;
- There was a perception that the problems have worsened over time;
- Management options involving sand nourishment and rock revetments are most preferred by the community;
- While the broader response to questionnaires did not highlight the provision/retention of public access as being an important aim for management, the issues of public safety, variability and scouring of the pathway around Sandy Point are evident;
- The community sees a need for active intervention in the foreshore which goes beyond the piecemeal and reactive approach of the past and there was concern that the present effort was "just another study" that would not result in any meaningful action;
- Boat ramps are seen as a problem by many foreshore residents as they present weak points for wave runup during storms. However, some residents see the boat ramps as an asset which adds value to individual properties. Management of this issue will require further consultation with affected owners; and
- Poor drainage across the foreshore is seen as a problem which appears to be getting worse with time.

ITEM 3 - ATTACHMENT 1 SANDY POINT/CONROY PARK FORESHOER EROSION AND DRAINAGE MANAGEMENT PLAN.

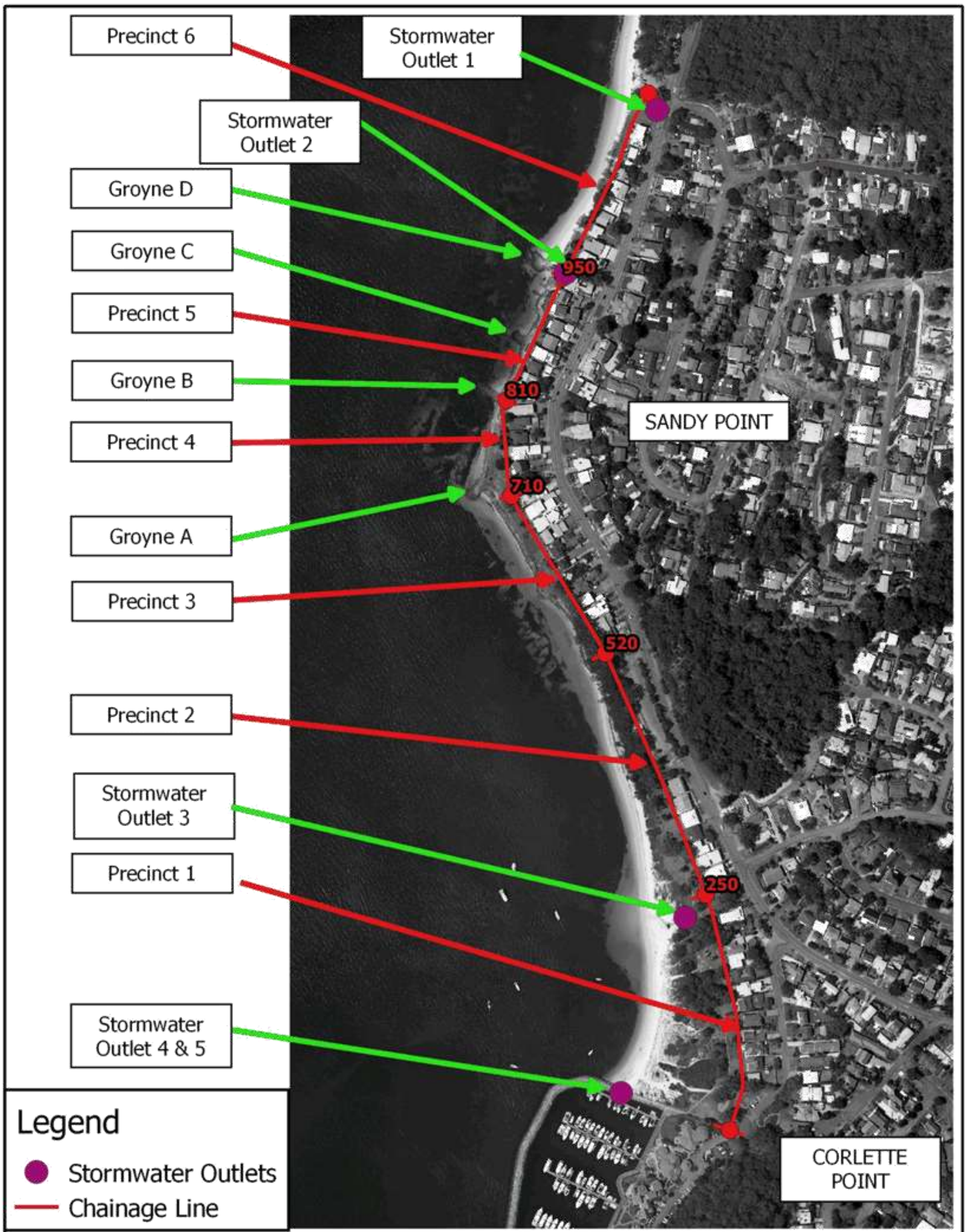

Figure E1 Study Area Precincts, Groyne and Stormwater Outlet Locations

Sandy Point - Conroy Park Foreshore Erosion and Drainage Management Plan

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Whitehead & Associates Environmental Consultants

0 100 200 300 m (Approx Scale)

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Approved	DW

Utilising the findings of the background studies and community opinions, a long list of potential management options was developed for the site. Subsequently, a "Multi-criteria" analysis approach was adopted to short list the most preferable options.

This process resulted in the development of three comprehensive "schemes" for the entire foreshore, with each scheme comprising options for each precinct that were compatible with each other. These schemes are presented in Table E.1.

At the exhibition stage, the three schemes were presented to the community to seek feedback. To facilitate further consultation with the community, conceptual design cross sections and plans have been drafted, and cost estimates have been prepared. The cost estimates include an allowance for contingencies (20%) and inflation to bring the estimates forward to the beginning of 2016. Those estimates are also presented in Table E.1.

At the exhibition stage a community brochure was prepared to succinctly present the three schemes and summarise the project findings thus far. In addition, images illustrating the visual impact of all three schemes for two of the key precincts have been prepared. These were chosen in consultation with Council as follows:

- Precinct 5: On the eastern side of Sandy Point, this precinct is presently the most exposed to severe wave overtopping and scour;
- Precinct 2: Conroy Park, which has been subject to significant erosion over the past two decades.

Cost estimates for the conceptual designs have been prepared. Details are provided in Appendix H, but a summary is provided in Table E2. The base estimate values have been adjusted upwards for a contingency amount of 20% and for inflation to place the estimates at the end of 2015. The methods used to estimate quantities are based on conceptual cross sections and modifications at detailed design stage, and changes to the economic situation prior to construction means that these estimates must be considered as preliminary, but reasonably indicative. The cost for additional investigation, detailed design and environmental impact assessment activities has not been included in these estimates, and would typically be somewhere around 10% of the capital cost.

The final chapter of this document was completed once community feedback from the exhibition had been reviewed and comprises a plan with recommended options and guidance for subsequent detailed design and implementation. Importantly, it is not necessary that all precincts would be treated at the same time and some areas will be prioritised over others in the order of execution of any works to optimise available funding and local concerns. Furthermore, it is likely that the management plan, when finalized and fully implemented, will comprise a mixture of elements from the different schemes outlined.

Table E1 Shortlisted Management Options for 6 Foreshore Precincts

Precinct	Scheme 1 Treatments	Scheme 2 Treatments	Scheme 3 Treatments
1	Relocate sand to Precincts 2 and 3.	Retain sand and install twin gross pollutant traps to existing stormwater line.	Retain sand and construct groyne to convey stormwater line across beach. Install twin gross pollutant traps to existing stormwater line.
2	Use Precinct 1 sand to nourish and construct groyne at western end of Conroy Park	Nourish with sand imported from elsewhere.	Nourish with sand imported from elsewhere.
3	Relocate Fence. Remove stairs and ramps. Batter slope back and reconstruct revetment to engineered standard. Nourished using sand from Precinct 1.	Relocate Fence. Remove stairs and ramps. Batter slope back and reconstruct revetment to engineered standard. Repair, bolster and extend Groyne A. Nourishment from imported sand.	Relocate fence. Remove stairs and ramps. Batter slope back and reconstruct revetment to engineered standard. Repair, bolster and extend Groyne 'A'. Enhance existing "headlands" to form pocket beaches and nourish.
4	Rebuild and bolster foreshore revetment (mainly along existing alignment but will require some reclamation).	Rebuild and bolster foreshore revetment (will require some reclamation). Extend and reconstruct Groyne B.	Rebuild and bolster foreshore revetment (will require some reclamation). Extend and reconstruct Groyne B. Nourish beach between Groynes A and B.
5	Remove boat ramps, Reconstruct wall, reclaiming where necessary to provide for 2.4m path landward and allowance for raised crest elevation to accommodate sea level rise.	Provide for "mega" nourishment of beach profile offshore, to the east of and in the vicinity of Precinct 5. Aims to replicate historical beach conditions. Extend Groynes B and C to anchor beaches.	Remove boat ramps, Reconstruct wall true to present alignment and provide a robust, suspended walkway around the front of the new revetment.
6	Remove boat ramps, reconstruct path and replace with a low revetment with adequate space for future crest heightening as required. Reconstructed revetment along existing alignment. Retain eastern stormwater line as is.	Extend Groyne D and nourish to the south to provide a future source of sand for east to west transport around Sandy Point. Ongoing nourishment would be required. Remove boat ramps and rebuild back beach. Install two pollution traps upstream of Groyne D, Formalise eastern stormwater crossing	Remove boat ramps, reconstruct path and replace with a low revetment with allowance for a wave deflector wall to be installed in future. Formalise stormwater crossing with shallow dish drain and infiltration trench.

Table E2 Preliminary Cost Estimates.
(Annualised Maintenance Cost in Brackets)

Location	Scheme 1	Scheme 2	Scheme 3
Precinct 1	$0.085M ($8,500)	$0.38M ($11,000)	$1.3M ($6,300)
Precinct 2	$0.51M ($500)	$0.26M ($21,000)	$0.26M ($21,000)
Precinct 3	$1.1M ($1,100)	$1.65M ($9,000)	$2.7M ($10,000)
Precinct 4	$0.43M ($430)	$0.91M ($1,000)	$0.94M ($4,300)
Precinct 5	1.3M ($1300)	$2.23M ($9,500)	$1.53M ($1,500)
Precinct 6	0.81M ($850)	$0.85M ($31,000)	$0.82M ($800)

Following exhibition, consultation and reconsideration of the options presented, the strategies summarised in Table E3 are recommended for management of the foreshores within the study area. These typically involve a mixture of elements from the schemes presented to the community.

Nourishment in front of Conroy Park is prioritised first due to the benefit in protecting the park and relatively low costs. Priorities 2 and 3, dealing with Precincts 5 and 3 respectively, are considered critical with regards to public safety and the protection of property.

Table E3 Selected Strategies, Prioritisation and Costs[1]

Priority	Works	Design Timing	Detailed Design Costs	Construction Timing	Construction Costs	Maintenance Cost (/annum)
1	Precinct 1 & 2 (Nourishment)	Early 2016	$15,000	Mid 2016	$0.06M	$10,000
Description: Move sand from Precinct 1 (around 15,000m^3) and place in front of Precincts 2 (and 3). Restores beach width fronting Conroy Park and allows proper operation of Outlets 4 and 5 (adjacent to The Anchorage)						
2	Precinct 5	2016	$60,000	2017-2018[2]	$1.65M	$1,500
Description: Construct robust revetment with some realignment to enable construction of a shared pathway. Install twin gross pollutant traps to Outlet 2. Determine foreshore access requirements in consultation with community.						
3	Precinct 3 (Make Safe)	2016	$5,000	2016	$0.06M	$5,000
Description: Construct pathway and fence to divert pedestrians from the unsafe foreshore. Monitoring and maintenance required until full option is adopted (see below).						
4	Precinct 4	2019	$50,000	2020 or later	$0.43M	$1,000
Description: Demolish foreshore protection and reconstruct revetment. Some reclamation required at eastern end (adjacent to Precinct 5). Consolidate foreshore accesses in consultation with community.						
5	Precinct 1 (Stormwater)	2019	$30,000	2020 (or later)	$1.35M	$1,500
Description: Construct Twin Gross Pollutant Traps and carry stormwater line across Corlette Beach, but minimise the scale of the groyne wherever possible.						
6	Precinct 3 (Revetment)	2019	$100,000	2020 (or later)	$1.00M	$1,000
Description: Demolish existing structures, batter back foreshore and construct new revetment. Note that path and fencing will have been constructed as part of Priority 3.						
7	Precinct 6[3]	As Required	$50,000	As Required	$0.83M	$1,000
Description: Demolish existing structures and construct continuous revetment with appropriate pedestrian crossings. Construct dish drain and infiltration trench to outlet 1. Note that the dish drain is relatively cheap and could be constructed as a separable piece of work.						

[1] Costs are approximate and based on the detailed estimates provided for the three schemes exhibited. Costs exclude GST but include a contingency of 20%. Costs relevant to late 2015/early 2016 and an allowance for inflation needs to be applied to future costs.
[2] Subject to identification of suitable funding source.
[3] Note that preliminary works to remove existing weak points (boat ramps, foreshore crossings) from this precinct could be undertaken initially, possibly in conjunction with the Precinct 5 construction. Refer to text.

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1 Introduction

The foreshores of Sandy Point and Conroy Park, along the southern shoreline of Port Stephens at Corlette, have experienced erosion for a number of years. Furthermore, the ground immediately landward of the foreshore is low and flat, meaning that effectively draining stormwater from this area is a challenge.

Port Stephens Council (PSC) engaged Whitehead & Associates (W&A), in consultation with Coastal Environment Pty. Ltd. (CE) to investigate both of these issues and to formulate a management plan which addresses them. This document describes the work completed and issues considered in developing an appropriate plan. The report concludes with a detailed description of the management strategy ultimately recommended to PSC.

The location of the study area along the southern foreshore of Eastern Port Stephens is shown in Figure 1. The site is around 3km west of Nelson Bay and some 40km and 150km north of Newcastle and Sydney respectively.

A more detailed view of the foreshore in question is presented in Figure 2. The foreshore of interest to the present study extends from “The Anchorage” Marina at Corlette Headland eastwards along Corlette Beach and around Sandy Point for a distance of nearly 1200m. Immediately to the east of The Anchorage, a small park, Corlette Point Park exists behind a stretch of Corlette Beach which is presently accreting, owing to the construction of the eastern breakwater of The Anchorage in the early 1990’s. That breakwater interrupted the natural (east to west) longshore transport along Conroy Beach, causing sand to accumulate on the eastern side of the breakwater and subsequent widening of the beach in this location. Two separate stormwater lines exist near the eastern breakwater. One drains the residential tourist accommodation associated with the marina and runs up the spine of the breakwater, discharging through an outlet located on the eastern face of the breakwater. The other drains a small residential sub catchment to the south of the western end of the study area. Both outlets are presently subject to inundation and burial by the build-up of sand against the breakwater.

From The Anchorage, the beach extends eastwards for some 450m in front of 21 residential properties and then Conroy Park. Along this length, the beach gradually narrows, transitioning from an accreting beach to an eroding beach with distance.

Erosion is most pronounced at the eastern end of Conroy Park, a location where a geotextile sand bag revetment was constructed in May 2013. That revetment is presently showing signs of significant deterioration, with undermining of the toe and tearing of the fabric acting as an anchor for the toe back into the main bulk of the placed geobag containers. The wall has also been “out flanked” by erosion at its western end and erosion continues to impact the beach to the west, in front of Conroy Park.

Midway along Corlette Beach, a significant stormwater drainage path crosses the foreshore. Discharge from this outlet washes sand from the beach and deposits it in a nearshore fan which can be readily identified on aerial photography, and in the field. Localised erosion around this stormwater discharge is present but presently disconnected from the erosion occurring across the front of Conroy Park.

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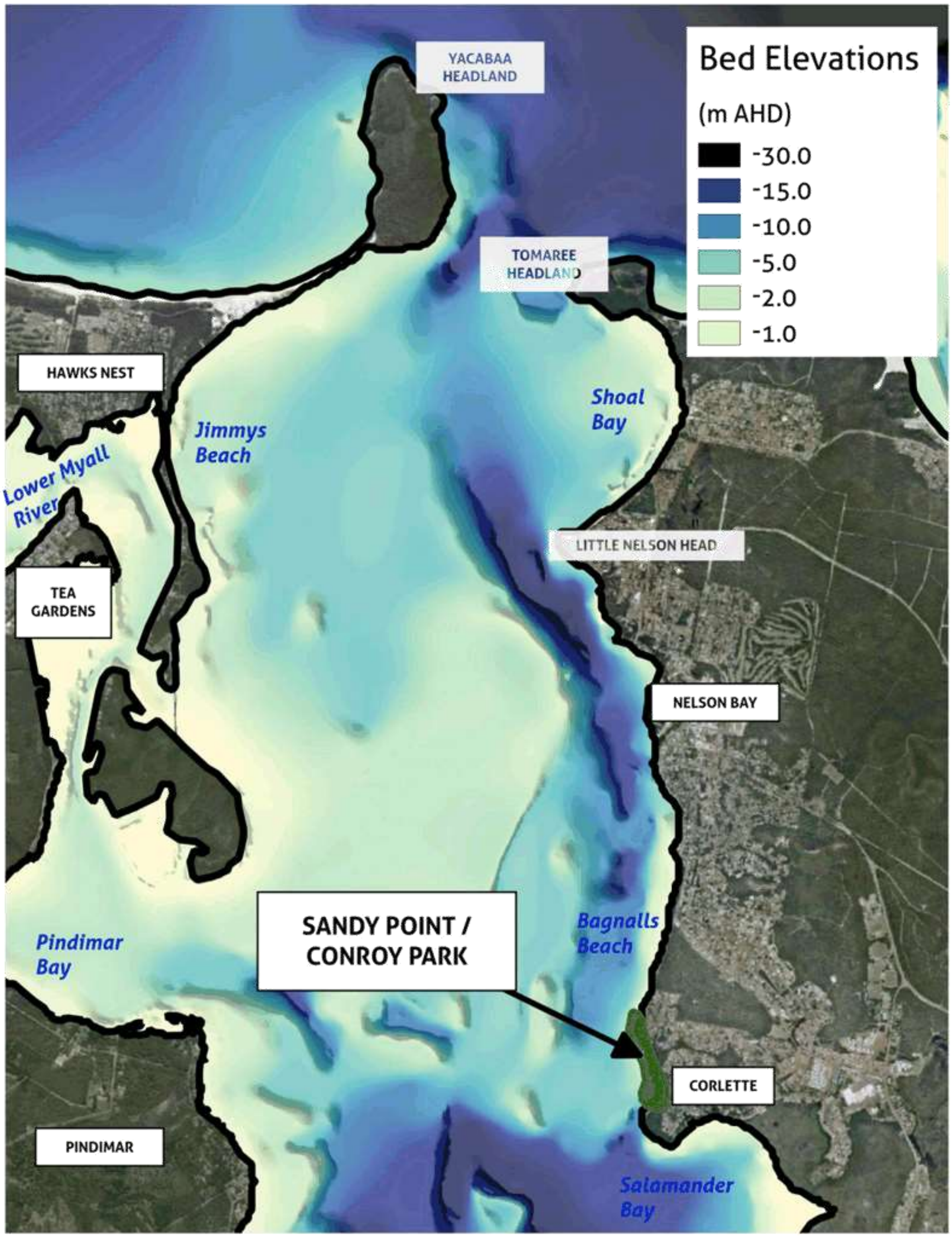

Figure 1: Location of Study Area within Port Stephens

Sandy Point / Conroy Park Foreshore Erosion and Drainage Management Plan

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Environmental Consultants

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Approved	DJW

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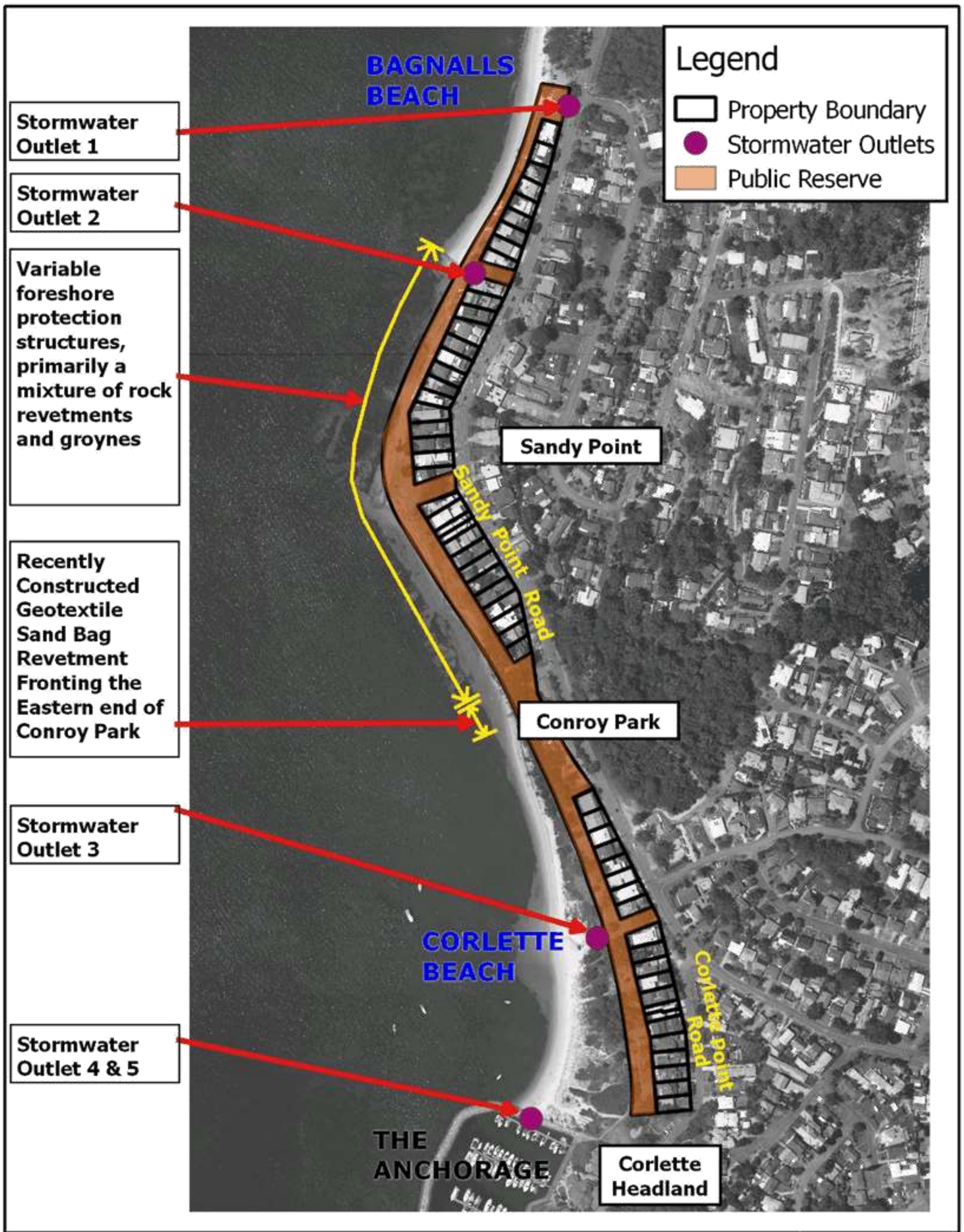

Figure 2 Site Features

Sandy Point - Conroy Park Foreshore Erosion and Drainage Management Plan

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To the east of Conroy Park, the foreshore is characterised by a mixture of rock revetments in varying states of repair, crossed by some pathways and access stairs. This continues around the front of 13 properties along Sandy Point Road until it meets the northern most point of the foreshore (i.e. the present "apex" of Sandy Point) which is marked by the western most groyne of a series that have been constructed to protect the foreshore to the east of this point. The foreshore alignment changes here from a more north-westerly facing alignment to more north-easterly, and the buffer of public land between the foreshore and residential property boundaries rapidly narrows, over a distance of around 100m, eventually becoming extremely narrow.

The north easterly facing section of foreshore fronts properties that are most at threat from the impact of waves. The beach here is very narrow, and property owners have constructed a variety of protective structures, with varying degrees of effectiveness, in front of their properties. While somewhat effective, it is clear that none of these structures have been engineered to acceptable coastal engineering standards. The property by property approach is non-cohesive and, in some areas the nature of the construction has the potential to adversely impact on adjacent properties. Boat ramps along this length of foreshore present a particular weakness against wave uprush and overtopping and subsequent flooding of the backshore area during stormy conditions. A number of shore normal groyne type structures have been built in this area, with the most significant being the easternmost groyne. There are approximately 15 residential properties fronting the foreshore between the western and easternmost groynes, with the easternmost 10 of these properties having the most severe exposure to swell waves that are refracted towards this shoreline after propagating through the entrance of Port Stephens.

The easternmost groyne also provides protection for a stormwater pipe which runs up the spine of the groyne and is visible at low tide levels, protruding from the tip of the structure. This stormwater line drains the main eastern sub catchment (broadly, to the east of Conroy Park) of concern to the present study. From Figure 2, it is clear that sand has more recently accumulated on the updrift (eastern) side of the easternmost groyne. On this side of the groyne, properties presently have a wider sandy beach which acts to protect those properties from storm waves and runup. Properties in this area have adapted to these conditions by constructing protective structures that are much smaller in scale. The difference between the scale of structures to the east and west of the easternmost groyne is notable. The northern boundary of our study area is marked by a stormwater line which crosses the beach opposite the intersection of Pantowara Road with Sandy Point Road, adjacent to the western car park of Bagnalls Beach Reserve.

2 Background Information

2.1 Existing State of the Study Foreshores

A full description of the study foreshores is provided in Chapter 2 of Appendix A. Within that appendix, the foreshore was divided into 6 separate precincts which are presented here as Figure 3. These precincts have been used to develop and assess different management options. "Chainages" are used to identify the extent of these precincts and are measured in distance east from the Anchorage Marina eastern breakwater (Figure 3). Briefly, they are characterised as:

Precinct 1: (Between approximately 0m and 250m east of The Anchorage). Comprising the western end of Corlette Beach. This area has been accreting since construction of The Anchorage. A significant stormwater outlet crosses the beach at the eastern end of this precinct.

Precinct 2: (Between approximately 250m and 520m east of The Anchorage). Comprising the Eastern end of Corlette Beach, transitioning from Precinct 1 to an actively eroding section of beach fronting Conroy Park. In the past few years, geotextile sand bags have been used to protect the eastern end of this precinct.

Precinct 3: (Between approximately 520m and 710m east of The Anchorage). Comprising a north-north westerly facing length of foreshore protected by a tipped rock revetment which is too steep and failing extensively. This reach stretches from the eastern end of Conroy Park through to the westernmost groyne (Groyne A), at the tip of Sandy Point, fronting properties between #70 and #48 Sandy Point Road.

Precinct 4: (Between approximately 710m and 810m east of The Anchorage). Comprising a north to north easterly facing length of foreshore revetment between the westernmost groyne, at the tip of Sandy Point (Groyne A), through to the next groyne east (Groyne B). Again there is significant failure, particularly through loss of armour from the crest of the revetment. This precinct comprises the foreshore between #46 and #38 Sandy Point Road.

Precinct 5: (Between approximately 810m and 950m east of The Anchorage). Comprising a variable but heavily protected section of foreshore stretching between Groyne B to Groyne D. This section is the most "at-risk" length of foreshore within the study area. Swell waves tend to approach perpendicularly to the foreshore, maximising runup and overtopping during severe storm events. A significant stormwater outlet runs through the centre of Groyne D. This precinct comprises the foreshore between #36 and #20 Sandy Point Road.

Precinct 6: (Between approximately 950m and 1150m east of The Anchorage). Comprising the foreshore between Groyne D and the easternmost residence on Sandy Point Road (i.e. between addresses #18 and #2). This shoreline section is presently more sheltered than areas to the west, and is afforded some protection by Groyne D, which is acting to both reduce wave heights and trap sand on its eastern side, creating a sandy beach buffer. Even so, there is photographic and field evidence of past damage to structures and overtopping along this length of foreshore, particularly at boat ramps which are "weak points" along the foreshore.

The detailed information presented in Appendices A and B are summarised here for each precinct.

ITEM 3 - ATTACHMENT 1 SANDY POINT/CONROY PARK FORESHOER EROSION AND DRAINAGE MANAGEMENT PLAN.

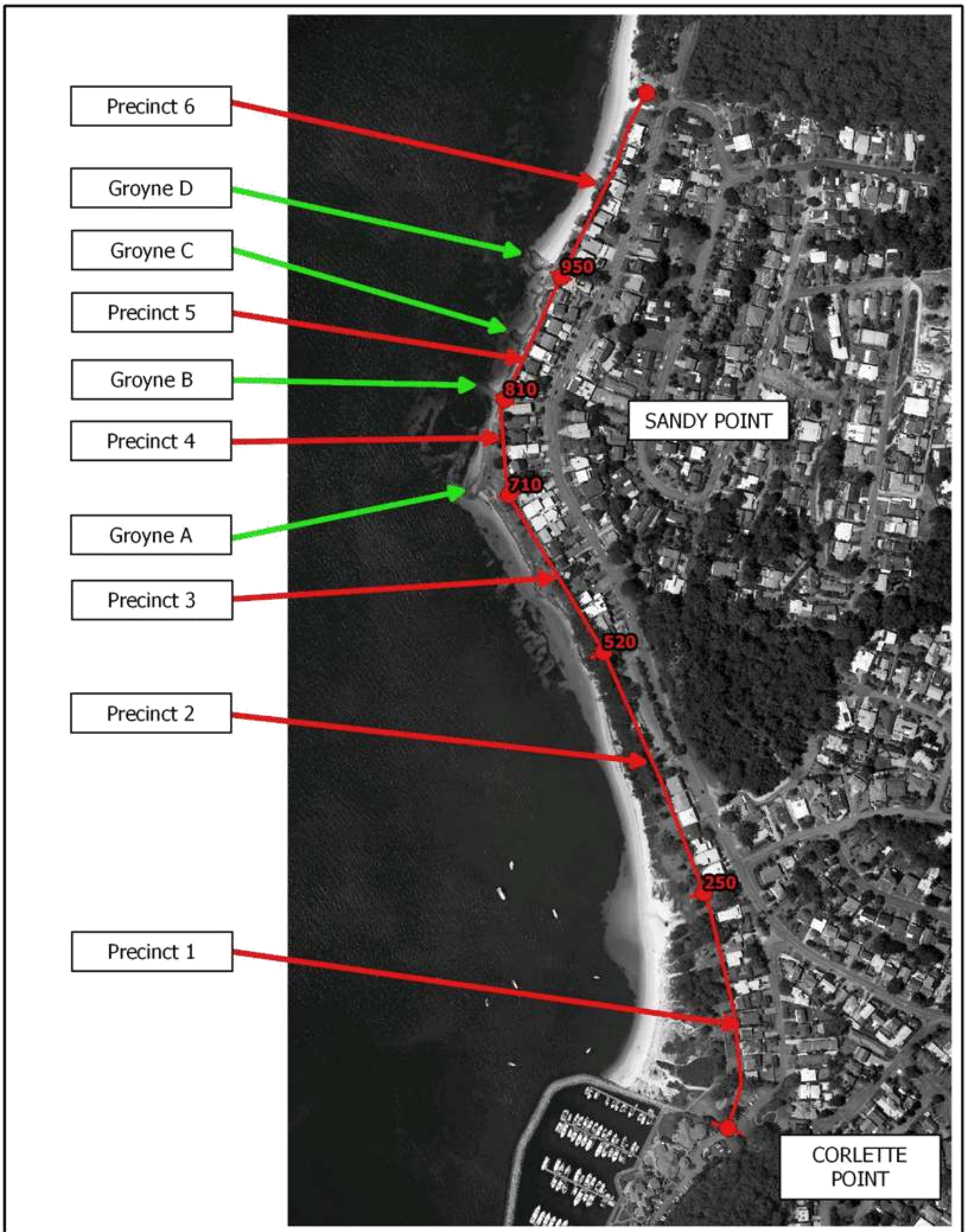

Figure 3 Study Area Precincts

Sandy Point - Conroy Park Foreshore Erosion and Drainage Management Plan

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Whitehead & Associates
Environmental Consultants

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(Approx Scale)

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Approved	DW

2.2 Summary of Coastal Processes

2.2.1 Precinct 1

Precinct 1 has seen a substantial accumulation of sand over the last 20 years at rate of around 1,750m^3/year (35,000m^3 total). The construction of "The Anchorage" breakwater in the early 1990s has temporarily blocked the westerly movement of sand and the beach has widened by approximately 60m adjacent to the breakwater. Prior to construction of "The Anchorage" sand would have continued moving westward being transported over the leading edge of the flood tide delta by waves and flood tides and deposited into the deeper estuarine basin of Port Stephens.

The build-up of sand has affected the growth of vegetation in Precinct 1 reducing the area available for seagrass with the shoreward edge of the seagrass retreating over time. However, there has been a commensurate increase in the area occupied by sand dunes and their associated vegetation. Two stormwater outlets adjacent to the Anchorage have been buried by the accumulated sand.

Precinct 1 includes a large stormwater outlet across the middle of Corlette Beach. During high stormwater flows, sand is eroded from the beach face and deposited in the nearshore zone potentially smothering any seagrass that may be growing there.

2.2.2 Precinct 2

Erosion in Precinct 2 is progressing from east to west at the present time, with the most obviously eroding area immediately west of the geotextile sand bag revetment fronting Conroy Park. This erosion has progressively affected the whole of the Sandy Point foreshore from Bagnalls Beach to the west. The erosion is caused by refracted swell waves entering Port Stephens which approach Corlette from the north east. Severe undermining has resulted in the collapse of a number of trees immediately behind the beach along Conroy Park.

At its western end Precinct 2 also contains an inflexion about which the pattern of shoreline evolution changes from receding to accreting. While most of Precinct 2 is eroding, the areas west of the inflexion point, and all of Precinct 1, are presently accumulating sand.

2.2.3 Precinct 3

Precinct 3 extends from the eastern end of Conroy Park through to "Groyne A" at the tip of Sandy Point. Historically, a lobe of sand has existed off the tip of Sandy Point. This has gradually eroded as sand has moved from east to west through the study area over the last 60 years, primarily under the action of swell waves. In the absence of a source of sand from the east of Sandy Point (i.e. from Bagnalls Beach) this sand has not replenished.

Swell waves in Precinct 3 approach the shoreline at a very oblique angle and the resulting erosion has stripped the beach of sand, leaving only a very narrow beach at most tide levels, and the foreshore exposed to wave attack. The overly steep foreshore revetment with a lack of a structural toe and small armour sizes is particularly susceptible to slumping. Storm waves may overtop the foreshore in Precinct 3 on occasion although, as the development is set well back, overtopping is less of an issue than for precincts 4 through 6 (to the east).

2.2.4 Precinct 4

Precinct 4 comprises the foreshore between Groynes A and B. At the western end of the precinct (Groyne A), a small fillet of sand has formed on the eastern side of the groyne due to the dominant east to west littoral transport along this foreshore. Community reports indicate that the location of this fillet may shift to the eastern end, following periods of significant north westerly wind waves, which can also overtop the foreshore protection. In the absence of an ongoing sand supply from the east, there is no significant natural replenishment in this precinct and therefore no wide beach to provide protection from swell waves. When the volume of sand leaving a precinct to the west exceeds the volume entering from the east, the foreshore recedes and the beach is removed. Wave overtopping has caused scouring/slumping of the land surface immediately behind the revetment and also caused the revetment to slump in some sections.

2.2.5 Precinct 5

Precinct 5 includes the foreshore between Groynes B and D. This stretch of foreshore, facing the north east, is presently the most exposed to refracted swell waves and a hydrographic survey undertaken for this study indicates that this may partially be caused by ledges and drop overs in the bathymetry offshore of the precinct. Similar to Precinct 4, a small fillet of sand has built up on the eastern side of Groyne B, under the influence of the dominant east to west littoral transport.

Again, the lack of sand entering the precinct from the east means that no substantial beach is retained here. Groynes B and C are undersized and the foreshore here is particularly exposed to waves. This causes regular overtopping and has resulted in scouring of the land behind the revetment and weakening/failure of sections of the protection works. Smaller, local wind generated waves from the North East and North West are of comparatively minor concern, the major risk being high water levels and ocean swells during storms.

2.2.6 Precinct 6

The western end of Bagnalls Beach is relatively sheltered from swell waves. Groyne D, which is more substantial, has trapped a larger fillet of sand to retain some beach at the western end of Precinct 6, providing some protection, particularly between #10 and #20 Sandy Point Road at the present time. Between #2 and #10 Sandy Point Road, the beach is narrower but, the shoreline is less exposed to these refracted, oblique waves.

Overall, the following combination of factors makes properties within Precinct 6 less exposed to inundation from wave overtopping than Precinct 5:

- presence of a beach;
- more favourable alignment to incoming waves; and
- less focussing of refracted swell energy at this location.

However, the foreshore structures in Precinct 6 are too low to provide the required level of protection from present and future wave inundation. Furthermore, several boat ramps provide points of weakness through which overtopping and inundation of the foreshore can readily occur.

The fillet of sand which has formed to the east of Groyne D has caused a minor reduction in the seagrass area fronting Precinct 6 during recent decades, although the sand here at present is substantially less extensive than it was during the 1950s and 1960s.

2.3 Summary of Drainage Processes

2.3.1 Precinct 1

Within Precinct 1, there are three stormwater outlets (Figure 2) as follows:

- Outlet 5: A pipeline conveyed through the centre of the eastern breakwater of The Anchorage, draining the small catchment comprising the marina resort itself. This outlet presently discharges from the side of the breakwater and, when inspected as part of this study, was partly buried by beach sand limiting performance;

- Outlet 4: A pipeline which drains a small 1.66ha urban catchment comprising the area, generally, to the north of Judith Street and west of the intersection of Corlette Point Rd. and Sandy Pt Road. This pipeline discharges across the beach adjacent to the Anchorage Breakwater to approximately the same location as Outlet 5. At the time of inspection, this outlet was completely buried in beach sand; and
- Outlet 3: The major stormwater crossing of Corlette Beach, which drains areas to the east of Sandy Point Road and west of Conroy Park, including The Peninsula, Corrie Parade and intersecting streets.

Overall, drainage within the residential streets is under designed, in the sense that a 1 in 5 year recurrence interval storm event results in widespread surcharging of the minor stormwater system (pits and pipes). It is estimated that outlets 4 and 5 do not contribute significant pollutants, litter or suspended sediment to the Port, when compared with Outlet 3, which contributes around 10 times more than the other two outlets combined. Management of stormwater in Precinct 1 should focus on Outlet 3, although the intermittent burial of Outlets 4 and 5 by beach sand is not appropriate and may impact overall flood behaviour during storms.

The main concern with Outlet 3 is that it now discharges across a substantial width of beach. Every time a significant storm occurs, sand that has accumulated on the beach seaward of the outlet is scoured from the beach face and spread within the nearshore zone. While this is not of significant concern to the movement of sand and overall foreshore erosion, the large sand delta which has been formed may have otherwise been colonised by seagrasses.

2.3.2 Precinct 5

Within Precinct 5 the second major stormwater outlet (Outlet 2, shown on Figure 2), which discharges through Groyne D is presently fulfilling that role relatively efficiently. Similarly to the western stormwater catchments, the minor stormwater systems draining to Outlet 2 suffer from significant surcharge during a 1 in 5 year recurrence interval storm.

In conjunction with Outlet 1, at the eastern end of the study area, and at the end of Pantowora Street, Outlet 2 is responsible for draining the residential area to the east of Conroy Park, west of Bagnalls Beach and, broadly, to the north of Mulubinda Parade.

In comparison to the main stormwater crossing of Corlette Beach (Precinct 1), this discharge point does not result in the scouring of sand by flowing across a beach. Instead, it discharges directly into Port Stephens from the end of groyne D at around the low tide level. Some sand bypassing of the groyne does occur under waves and currents, but there is no evidence that the outlet has been subject to burial or blockage by sand.

Again, it is estimated that this outlet supplies a similar amount of flow, suspended sediment and pollutants to the coast as Outlet 3 (Precinct 1). When compared to Outlet 5, at the end of Pantowora St., this outlet discharges around an order of magnitude more pollution (and flow) to the coast.

2.3.3 Precinct 6

Outlet 1 crosses the foreshore at the eastern end of the study area, at the end of Pantowora St. While this outlet sits in a low point along Sandy Point Road, it actually plays a secondary role to Outlet 1 in draining the catchment. In effect, Outlet 1 acts as an overflow or relief during very large events. In terms of capturing sediments, pollutants and litter, it is more sensible to target

Outlet 2 for management options, although there are ways in which Outlet 1 could be improved to make the maintenance task here less onerous. Regular maintenance is crucial to ensure efficient operation of this outlet during the largest storm events.

3 Consultation

3.1 Community Questionnaire

3.1.1 Survey Methodology

As a part of this project W&A prepared a questionnaire for PSC for distribution to the Corlette community, seeking local knowledge, historic imagery and also to hear the opinions and concerns of the local residents. Questionnaires were mailed to the residents located on the shoreline and an online survey was made available to the general public. A total of 66 responses were received. The data from these surveys is summarised in the sections below. Examples of the online and mailed surveys are presented in Appendix D.

3.1.2 Respondents

The questionnaire asked if the respondent was an owner-occupier, absentee owner, tenant or a community member from nearby. Of the 64 valid responses, 42 were owner/occupiers, and 15 were non-resident community members.

The survey found that 22 of the respondents had lived in the area between 10-20 years and 17 had lived in the region for more than 20 years. This was followed by 12 residents living in the area for 2-5 years, 8 residents living there for 5-10 years and finally 5 residents had lived there for less than 2 years. Of 63 responses the majority indicated that they use the foreshore and reserves for passive recreation (52) and active recreation (54).

3.1.3 Responses - Changes to the Foreshore

62 respondents reported observed changes to the Sandy Point/Conroy Park shoreline. Shoreline erosion was the most common change observed (55) with respondents voicing particular concern over the loss of land at the eastern end of Corlette Beach. 26 respondents also noted a loss in trees or loss in tree stability due to erosion and storms. 21 respondents reported large sediment build up at the west end of Corlette at The Anchorage and an associated loss of seagrass.

A reduction in small and large fish species was raised as being related to the loss of seagrass. 19 respondents also noted changes in the foreshore region due to the stormwater pipes and outlets. Related issues included were scouring of the beach and sand build up adjacent to The Anchorage, the resulting blocked stormwater pipe and flooding, and odour. 7 residents also noted that the existing seawalls no longer provide suitable protection against large tides, waves and storms. 3 residents also noted that rocks from seawalls had fallen over the years.

52 respondents believe that the changes have become more pronounced in recent years whilst 7 respondents believe they have not.

Many different reasons were provided for the cause of erosion and loss of trees on the shoreline. 5 people believe erosion was caused by The Anchorage and its breakwaters, 8 people believe it is caused by the groynes around Sandy Point, 21 people believe it is caused by natural processes such as storms, winds, tides and waves, 12 people believe that erosion was caused by increased urban development and the associated stormwater run-off and the pipe outlet flows and 3 people believed the erosion has been caused by sea level rise and more intense storms associated with climate change.

13 respondents believe The Anchorage break wall constructed at the western end of Corlette Beach is the reason for sediment build up and reduction of seagrass. A number of alternative reasons were identified by a minority of respondents including (i) natural weather processes; (ii)

groynes; and (iii) increased stormwater flows. Issues with stormwater outlets were associated with (i) the actions of Council, (ii) natural causes (weather); (iii) insufficient structures; and (iv) increased runoff

3.1.4 Management Options

The ranked issues needing to be addressed by the management plan (in order of decreasing importance) were;

1. Foreshore Erosion
2. Stormwater Drainage & Flooding;
3. Loss of Public Access; and
4. Ocean Inundation

The ranked management options, with most favoured first, were:

1. Sand Nourishment; (closely followed by)
2. Rock Revetments;
3. Low Native Vegetation;
4. Increasing Public Access to the Water;
5. Increasing Public Access to the Reserve;
6. More Shade; and
7. Improved Public Safety

Conversely, when asked to identify the management options that they specifically did not want, the following ranking, with least favoured first, were

1. More Public Access; (equal with);
2. Better Access to the water;
3. Rock Revetments;
4. More Shade;
5. Improved Public Safety;
6. Native Vegetation; and
7. Sand Nourishment.

3.1.5 Other

The open comments left the by the respondents varied in nature however reinforce the nature of sections 3.1.2 through to 3.1.4. Many residents left comments placing emphasis on improving public access, safety and defining public and private land better. Residents also placed emphasis on protecting the land from erosion, improving the stormwater outlets and preventing blockage.

3.2 Community Interviews

3.2.1 Purpose of Consultation

Following on from the assessment of the questionnaire results (Section 3.1), interviews were undertaken directly with those residents and community representatives who indicate that they would like to discuss the project face to face. This opportunity was limited to residents directly adjacent to the Sandy Point shoreline or who Council indicate as having a close association with that shoreline.

Previous detailed studies have been undertaken with a view to addressing the issues around the Port Stephens shoreline generally and at Sandy Point in particular. There exists a community perception of the need for active intervention to occur at Sandy Point. Community perceptions are that responses to requests for protection to date have been reactionary, addressing problems after they occur or where public safety may be compromised. Often no Council action is forthcoming. Many longer term residents and some more recent purchasers have undertaken their own works to address the issues of wave inundation, recession and provision of beach access over many years. In the main, these works have been undertaken outside the property boundaries and, at least in part, on the foreshore reserve. Where they have been funded by the residents, there is frequently a sense of “ownership” which includes seawalls, boat ramps and access stairs to the beach. Council has also undertaken significant works over many years to address the issues at various locations within the study area, including the tipping of rock for erosion protection, the construction of rock groynes and the installation of stormwater drainage. In general no evidence of design or formal approvals is available for either private or Council works.

The face to face community consultation has been undertaken by W&A and Coastal Environment for this project. The consultants recognise that the Sandy Point foreshore has a long history of perceived issues and erosion problems. In consulting with the community the objective was specifically to focus on the study area with emphasis on the maintenance of public access along the shoreline, the protection of the existing foreshore (private) development, protection of the foreshore reserves and vegetation thereon, particularly Conroy Park, improving stormwater drainage and the maintenance and potential enhancement of the beach amenity. The purpose of the consultations was to commence a two way dialogue, providing the residents an opportunity to clearly elaborate on the issues they see, the likely causes and their preferred solutions. It also allowed the consultants to discuss the likely feasible options and to obtain additional information relating to the foreshore changes over a long time period. The face to face consultation was undertaken near the commencement of the consultation process, with the intention that contact would continue as the viable management options were developed and evaluated.

The interviews provided an individual opportunity to discuss approaches to management and protection of the area and the viability of undertaking such improvements including advantages, disadvantages, difficulties and costs. In preparing background material for this, we have considered the previous studies, their findings and recommendations. Where practical we have updated those results with more recent information that may be available. The objective was not to revisit the previous studies but to assess the viability of undertaking the management options proposed including practicality, cost and environmental impacts.

One on one interviews were conducted over an extended period of time during June-July 2015 with those residents identified. Interviews were undertaken with residents at their homes on 17th June, 20th June, 23rd June and 16th July 2015. The interviews were undertaken by David

Wainwright (W&A) and Doug Lord (Coastal Environment). An average of 45minutes was allowed for each interview. Where residents were unavailable to interview, phone interviews were undertaken, if required, at the convenience of the residents.

The period of the interviews followed closely after the ANZAC day "super storm" and a following period of elevated ocean levels and high swells which affected the Central Coast, Newcastle and Port Stephens. Those storms had focussed resident interest on the protection issues and provided the opportunity for recent insights into the potential severity and impact of the storms. Residents also provided photo images and video taken during and following those events.

A total of 17 interview requests were followed up, several of which included more than one resident associated with a particular property or strata. One resident could not be contacted and one indicated that he was satisfied with the current protection of his property and did not wish to proceed further with an interview. Three residents were overseas at the time of the interviews and so opted for telephone consultation or later follow up, while another was unavailable and also opted for a telephone discussion. A total of 11 separate face to face interviews were undertaken several of which included more than one party.

The level of response to the initial questionnaire and additional information provided together with the high proportion of responders seeking a further personal consultation, are indicative of the keen local interest in the health and management of the foreshores in the study area. The information acquired during the interviews remains confidential and, given the relatively small size of the sample (compared with the total population of the Corlette area); no statistical analysis of these results was intended or undertaken. The purpose of both the questionnaire and subsequent interviews was to facilitate an understanding by the Council and the consultants of the community issues and preferred solutions.

3.2.1.1 Key Issues from "One on One" Consultation

Recent storms, resulted in overtopping of the existing seawalls, damage to the alongshore access paths and further erosion and loss of trees in Conroy Park in the period immediately prior to the consultation. These storms were foremost in the thinking of residents during the interviews and featured prominently in our discussions.

There was a perception reflected in comments from residents that Council was merely repeating studies that had already been undertaken. Several residents drew attention to the development of the estuary and foreshore management plans and the consultation associated with those which promised improvements to the foreshore but delivered very little in the study area. The purpose of the existing study was clearly explained, the constraints on the area being studied and the limits of what may or may not be achieved were outlined. In particular, the current study was explained to be the next step in addressing the local recommendations already made in the estuary and foreshore management plans. It forms an essential part of the approval and implementation process which Council must address to implement the actions identified in those plans.

There was general agreement amongst all interviewed that the issues relating to the foreshore erosion have worsened over the years. In that regard we were provided with historical photos of the area that confirmed both the increase in the protection works along the central areas of the study area, east of Conroy Park, and the general loss of sandy beach seaward of those protection works. However they also confirmed the existence of protection measures back to the 1960s indicating the problems have existed since the earliest development along the strip and confirming that, at least in part, the present day hazards are exacerbated by the original subdivision and development being too close to the active coastal zone. This problem has been magnified through approval of more development over many years and a recent trend to redevelopment and intensification of that development on foreshore properties.

There was strong support from residents along the foreshore and broader groups within the catchment interviewed as to the importance of Conroy Park as a community resource and access point to the sandy beach west to The Anchorage. There was concern that the increasing protection works along the park, while addressing erosion would result in the loss of the beach and access to the foreshore. There was strong support for the maintenance of tree cover in the reserve both as an important source of shade and also as a stabilising and sheltering buffer from winds and coastal processes. One resident argued the importance of the Coral trees which provide summer shade but permit winter sun into the reserve. Unfortunately, over the course of the consultation period several trees considered a safety hazard were removed from the seaward edge of the reserve. Future management of the reserve and appropriate landscaping and access are a high priority.

A small number of those interviewed identify the loss of sand around Sandy Point with the completion of the Anchorage in the early 1990s and brought our attention to a submission of the Corlette Concerned Citizens Association to the Commission of Inquiry during the approval of that development. They argued that the marina construction has blocked the west to east movement of sand from the marina area along Corlette Beach to Sandy Point under westerly winds. While this effect may operate to a small degree during certain weather conditions, the predominant sand movement along this shoreline is from east to west under swell waves and tidal currents; any impact from blocking the local winds is likely to be minimal, localised and short lived. The erosion problems existed at Sandy Point prior to the marina construction and the beach accretion adjacent to the marina is as predicted in the studies undertaken prior to marina construction.

It was widely recognised amongst the community that a condition of the original approval was the removal of sand accreting on the western side of the marina walls and the placement of that sand at Council's direction for beach nourishment along the beaches on the southern foreshore of Port Stephens. This condition was also intended to limit the losses of sand from the active beach system as, if the beach is allowed to accrete too far, the sand would begin to move around the harbour and over the flood tide delta face into deep water off Corlette Head. A second intent was to prevent the stormwater outfalls adjacent to that wall from being buried and therefore not performing appropriately during storm events.

There was strong support generally for the maintenance and improvement of alongshore public access from Bagnalls Beach to The Anchorage, seaward of existing development. A couple of residents expressed concern with privacy and security arising from such access and this is particularly exacerbated along the eastern end of the study are where the distance between the seaward property boundaries and the existing revetment crest is minimal. There was less support for a cycleway through this narrow access. Within that area there were concerns at the variations in the existing access path including levels, materials, widths and scour. Many of the residents assume responsibility for either constructing the path or maintaining it after storms and there is some degree of "ownership" of the reserve area associated with this. There is a clear recognition that the pathway needs to be improved and be constructed consistently and in accordance with current standards.

Of more concern are the issues relating to the constructed boat launching ramps and access stairs across the walls to the beach area along the foreshores east of Conroy Park to Bagnalls Beach.

The boat ramps and pedestrian accessways (stairs, ramps etc.) are constructed within the public reserve and, in some locations, they have been present for many decades without challenge. This situation has fostered a strong sense of ownership and entitlement for these structures amongst the foreshore residents.

There is broad recognition that pedestrian access to the water needs to be rationalised and probably reduced in number. However this will need to be carefully negotiated with the residents during the implementation phase. Of more concern is the existence of the numerous boat ramps across the walls and servicing individual properties. Only one resident indicated that there was approval for their ramp and, in fact, had paid a permissive occupancy fee at some time in the past. The opinions of residents on these are firmly divided with some property owners expressing a strong desire to retain their ramps which they both use and see as an important attribute to their property value. Others, who generally do not have a ramp, recognise that these are a primary weakness in the foreshore defence, exacerbating wave overtopping during storms.

The existence of boat ramps on adjacent properties increases the extent and frequency of inundation of adjacent properties. It is clear to us that an effective management strategy which has the primary purpose of protecting foreshore development from wave inundation is not compatible with the retention of these boat ramps. Maintaining a low point in any protection works with a smooth ramp that increases wave runup levels will compromise the overall effectiveness of foreshore protection works. This matter will require close consultation with individual property owners as the management options are further developed.

Similarly, there is some sense of ownership of the seawalls constructed along the foreshores east of Conroy Park. Residents have funded and constructed many of these walls and several are satisfied that their works are adequate. Detailed negotiation will be required before these sections of protection can be dismantled, removed or replaced. Where the reserve is wider (immediately east and west of Conroy Park, again many residents have taken a lead role in managing the reserve including gardening and maintaining lawns and this must be recognised in adopting any changes or in formalising future maintenance by Council.

Stormwater drainage was generally identified as an issue with recent experience of water pooling along Sandy Point Road during storms. It was acknowledged that this appeared to be worsening and some residents expressed concern that this would be exacerbated by sea level rise. One resident indicated problems with vehicles driving through the ponded water and generating waves across their property which for the first time posed a risk of inundation of the ground floor from the roadway. This problem is not uncommon during flood events.

3.2.2 Issues beyond the Study Scope

A range of issues were raised by the residents both through the questionnaires and subsequent interviews which are beyond the scope of this study. However, they are listed here for future reference and information. No assessment has been undertaken of these issues and no opinion is offered here as to their veracity. The order of listing does not imply any priority or level of community support.

3.2.2.1 Issues outside the Study Area

The following issues have been raised during consultation. They relate specifically to locations which are outside the scope of the present study but which may affect future management and risks, raise concerns, or be impacted by management measures within the study area.

- Issues relating to the cost; who will pay and timing of implementation of a management strategy were raised by residents;
- Erosion of sediment from the developed areas behind the beaches and increased concentration of stormwater flows to existing outlets;
- The potential impact of movement of the tidal channel and shoals on the foreshores of the study area;
- Increasing depths at the toe of the rock walls and ongoing loss of the sandy beaches;
- Dredging currently undertaken in the Myall River entrance and the potential impact on the sediment movement along the southern foreshore of Port Stephens;
- A small number of those interviewed raised potential changes in management strategy limiting alongshore access at The Anchorage. These include use of the boardwalk for dining and the construction of a concrete function area blocking access to the western rock shelf when functions are in progress.

3.2.2.2 General issues raised

The following issues have been raised during consultation. They relate to more general issues of relevance to the study area and the broader Port Stephens area

- Perception that Council has been slow to address maintenance issues raised following storm damage;
- General reduction in fish stocks through the area;
- Sediment and litter load from stormwater outlets increasing and affecting sea grasses;
- Perceptions of higher and more frequent average water levels and wave heights within the Port and adjacent to Sandy Point;
- Future inundation hazards resulting from climate change and storms;
- Increasing and decreasing areas of seagrass.

4 Summary of Issues, Opportunities and Constraints

4.1 Introduction

This chapter clarifies the underlying problems to be addressed by the Foreshore Erosion and Drainage and Management Plan for the Sandy Point / Conroy Park Area, summarising the key findings of Chapters 2 and 3. As per previous sections of this report the "issues, opportunities and constraints" have been organised on a precinct by precinct basis, summarised in the following sections. These are also presented on Figure 4 (Precincts 1, 2 & 3) and Figure 5 (Precincts 4, 5 & 6).

4.2 Precinct 1

The key issues within Precinct 1 are the ongoing accumulation of sand adjacent to The Anchorage Breakwater, and the presence of stormwater outlets.

The shoreline adjacent to The Anchorage has accreted (widened) by approximately 60m since the early 1990's. At the present time, the accretion is such that two stormwater outlets adjacent to the Breakwater have been buried by sand, rendering them ineffective. The wide beach in this location is viewed as positive for The Anchorage from a tourist perspective. However, the sand that has accumulated here (around 35,000m^3 total within Precinct 1) could also be used beneficially to address erosion within other areas to the east.

The stormwater outlet at around Chainage 250m mobilises a lot of sand from the beach during storm events. That sand is scoured from the beach and deposited in the nearshore zone from which it is gradually reworked onto the shoreline. The deposition of this lobe of sand in the nearshore zone prevents seagrasses from establishing.

There is an opportunity to extend and formalise this stormwater outlet by construction of a groyne through which the stormwater line could pass. This approach has proven effective at Groyne D, at the boundary between Precincts 5 and 6. That stormwater line drains a similar catchment (size and amount of development) to the line draining across Corlette Beach in Precinct 1 and historical aerial photographs show that there is no loss of seagrass at the end of that groyne. A constraint associated with the construction of this groyne relates to the acceptability of such a structure to the community and State Government agencies, and whether it is considered more acceptable than the present, unconstrained discharge across the beach which requires continuous maintenance. Furthermore, as a groyne may present a barrier to pedestrian movement along the beach, it may be desirable to make provisions for access past or over a groyne in this location. Variations on the concept of a groyne as put forward could be considered.

4.3 Precinct 2

The key issue within Precinct 2 is erosion. Erosion is most severe near the eastern end of Conroy Park, but this is becoming more pronounced along the entire length of the foreshore fronting Conroy Park. The shoreline will continue to recede without intervention due to coastal processes in the area and a rising sea level. The geobag walls placed by council recently are unlikely to provide a long term solution to the foreshore recession. To maximise the potential of the park in this area while maintaining the sandy beach amenity, there is an opportunity to nourish the beach, using sand sourced locally, from adjacent to The Anchorage or, alternatively, won by dredging from the leading edge of the flood tide delta (to the north of Corlette Head).

ITEM 3 - ATTACHMENT 1 SANDY POINT/CONROY PARK FORESHOER EROSION AND DRAINAGE MANAGEMENT PLAN.

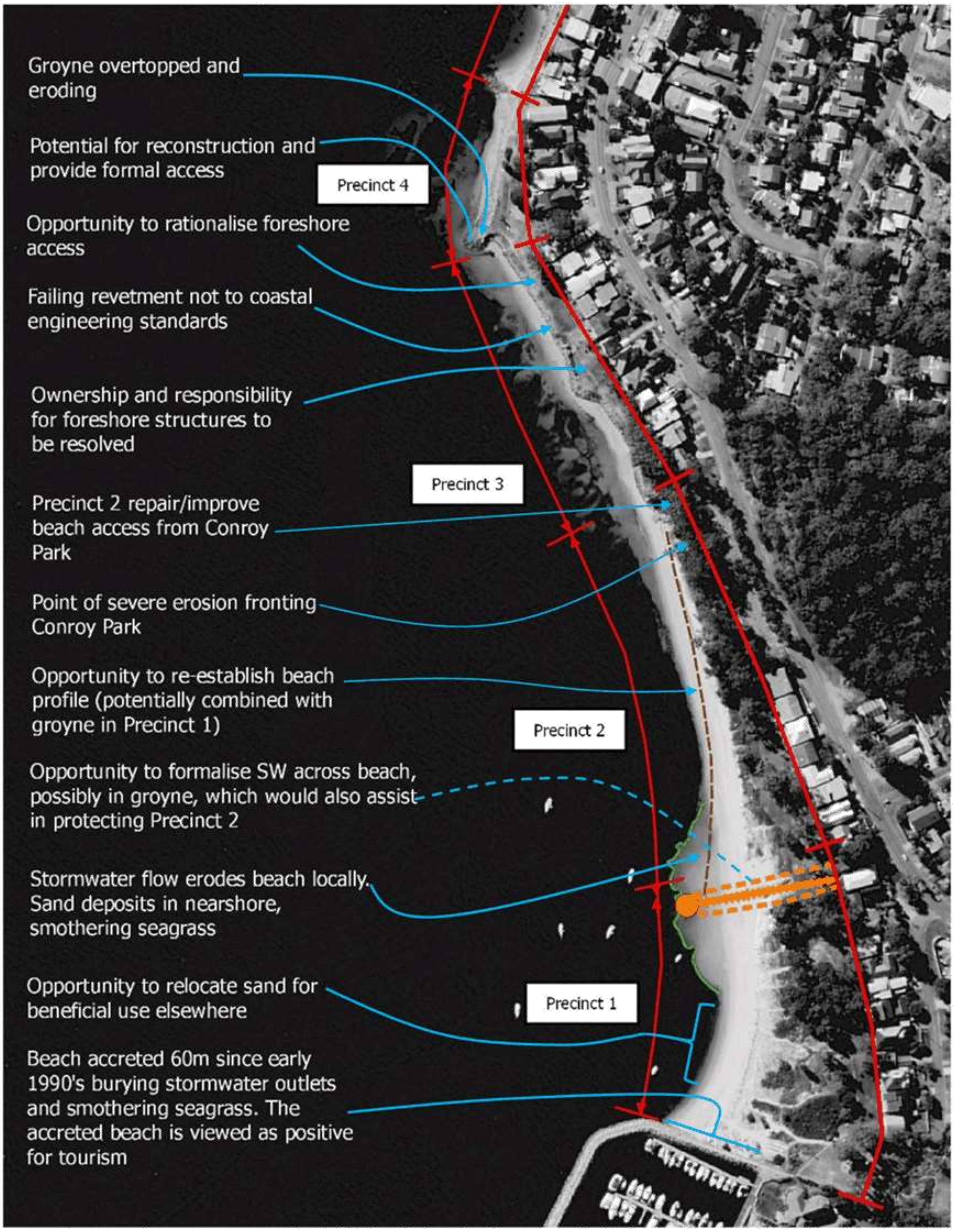

Figure 4: Issues, Opportunities and Constraints: Western Precincts	
Sandy Point - Conroy Park Foreshore Erosion and Drainage Management Plan	
Whitehead & Associates Environmental Consultants	Revision: A; Drawn: BC; Approved: DW

As the shoreline will continue to recede, linear seawall protection without nourishment will result in progressive loss of the sandy beach and, if the seawall is inadequately designed, eventual loss of that protection as well. Provision of a groyne at the main stormwater outlet in Precinct 1 would act to anchor the beach, causing the beach to accrete on the eastern side of the groyne, in the same manner as has occurred at The Anchorage. The length of that groyne would control the amount of protection provided. There are opportunities to restore and improve access from Conroy Park to the foreshore to enhance access for water based recreation activities in this area, as originally suggested in the Port Stephens foreshore management plan. Extended and/or improved linear protection may be considered for Conroy Park; however, continued access to the preferably sandy foreshore should be an aim for this area.

4.4 Precinct 3

The key issue with Precinct 3 is the ongoing failure of the foreshore protection works. 'Slumps' and 'sinkholes' are present along the crest, and these present a significant safety issue for the public and result in deterioration and increased risk to the public reserve which exists along the foreshore. Ownership of this foreshore should be clarified with the public to set clear responsibilities for the maintenance and upkeep of the reserve and protection works.

There is an opportunity to reconstruct this revetment to a more acceptable coastal engineering standard. Much of the armour stone is good quality/size and may be re-used. That material of lesser quality/size could be used in a filter layer for the revetment. As the reserve has a significant width between the foreshore and the private property boundaries, there is opportunity to batter back the foreshore slope to a more stable, and safer angle (no steeper than 1V:1.5H) which would enable construction of a more effective and robust revetment.

The ability to retain a broad, sandy beach in this location is constrained by the angle of approach of refracted ocean swell and tidal currents, which tend to transport any sand placed here towards the west. With minimal sand being transported around the tip of Sandy Point (i.e. Groyne "A"), there will continue to be an absence of sandy beach in this area, without intervention (e.g. groyne construction and nourishment).To retain a beach here, a groyne would need to be constructed near the border between Precinct's 2 and 3 and an appropriate source of nourishment sand identified and secured.

Several foreshore access structures have been built down the face of this revetment. Most of them are unsafe and none comply with current standards for public access ways, raising liability concerns. There is an opportunity to remove unsafe foreshore crossings and to rationalise public foreshore access down the face of the revetment. Due to the height and steepness of this section of foreshore, a final design may need to incorporate a safety railing and accord with relevant standards. Such accessways would be a community rather than private asset.

4.5 Precinct 4

Issues with Precinct 4 are similar to those at Precinct 3, although this precinct is more exposed to refracted swell overtopping and the width of the public reserve is narrower, with that width decreasing with distance east from Precinct 3.

Groyne A is in poor condition, actively eroding and slumping with undersized armour. There is an opportunity to redesign and reconstruct this groyne to a better standard. Lengthening of this groyne will help to shelter the foreshore within Precinct 4 and there is an opportunity to provide pedestrian access out to the end of this structure, with more general community access to the foreshore provided through the easement between #50 and #48 Sandy Point Road.

ITEM 3 - ATTACHMENT 1 SANDY POINT/CONROY PARK FORESHOER EROSION AND DRAINAGE MANAGEMENT PLAN.

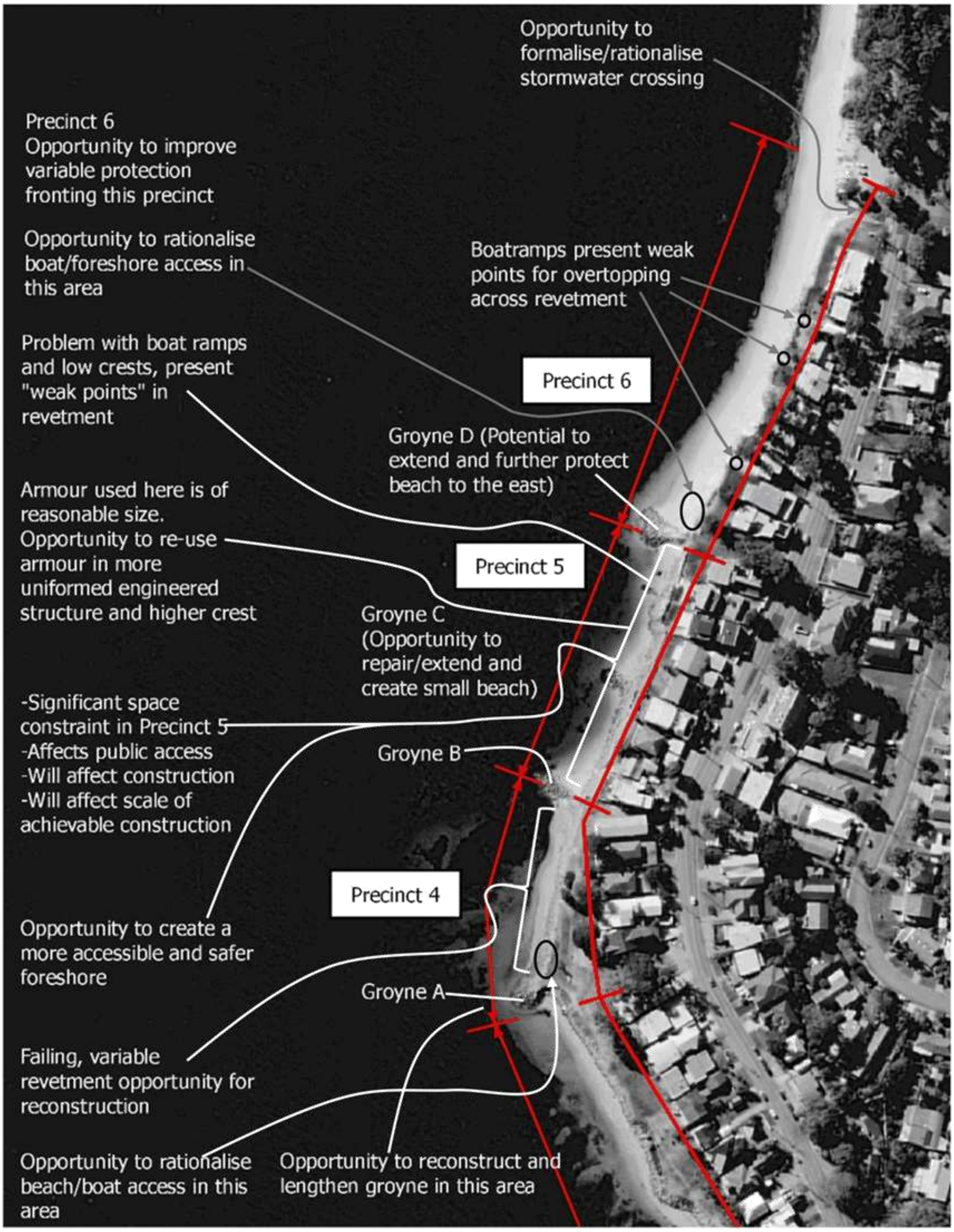

Figure 5: Issues, Opportunities and Constraints: Eastern Precinct

Sandy Point - Conroy Park Foreshore Erosion and Drainage Management Plan

Whitehead & Associates Environmental Consultants

0 50 100 150 m (Approx Scale)

Revision	A
Drawn	BC
Approved	DW

The armour stone comprising the revetment here is undersized for the prevailing storm waves and generally unsuitable for primary armour in this more exposed location. The revetment is subject to overtopping during severe storms, but the residual width of the foreshore reserve is enough to prevent significant damage to properties behind the foreshore.

Again, there are safety issues associated with overtopping and pedestrian access. At the western end of Precinct 4, the width of the foreshore reserve provides some space where access to the foreshore for launching boats could be provided. This is likely to become an issue within Precinct 5, where existing boat ramps provide gaps in the overall revetment structure, through which overtopping and flooding of the backyards of properties is known to occur.

4.6 Precinct 5

Precinct 5 is the most highly constrained section within the study area. The distance between the foreshore and private properties is next to non-existent, and along this section, it will prove difficult. Issues include:

- Providing public access under all weather conditions;
- Undertaking construction works;
- Need to widen or flatten the foreshore revetment;
- Need to provide more width; it is possible that the foreshore would need to extend further into Port Stephens, to accommodate the revetment and public access requirements. The degree of public access to be provided here needs to be considered carefully from a safety perspective. In addition, some residents expressed concerns about theft from their yards from time to time. The three groynes in this precinct (Particularly Groynes, B & C) could be bolstered, although their ability to retain fillets of sand is uncertain, as the focussing of wave energy in this area would tend to encourage offshore transport of sand during storms. A permanent sandy beach at all tide conditions may not be practically achievable within this precinct. Frequent, artificial sand nourishment may be essential.
- The precinct is more exposed than any other within the study area. Overall, the armour stone used here is substantial and much is likely to be reusable in a properly engineered structure. Such a structure would require a higher crest and, if achievable, a flatter slope to dissipate wave energy and reduce the overtopping threat during storms as sea levels rise. There is an opportunity to remove weak spots in this revetment by reconstructing to a standard and consistent design, and by removing all boat ramps, which encourage runup and flooding of the backshore area. This is a particular problem here as residential backyards exist immediately behind the foreshore and wave overwash is known to impact against houses within this precinct.
- The practicalities of construction in this location need to be considered at the conceptual design stage.

4.7 Precinct 6

At the present time, Precinct 6 is less exposed to refracted ocean swell and overtopping than Precinct 5. Even so, it still experiences overtopping during periods of large ocean swell, although the damage caused by this overtopping is presently less severe than in Precinct 5. This is partly due to the ways in which waves are focussed, and partly because Groyne D has caused a sandy beach to form along much of the length of this foreshore. Even so, given that the eastern basin of Port Stephens including the flood tide delta is continually changing, the degree of exposure may increase in future. Therefore, design of the foreshore works must take that into account.

Again, boat ramps in this area present a point of weakness along this foreshore. Swell waves easily run up these structures and allow water to impact on buildings behind the foreshore. This increases the risk to residents, the public and neighbouring properties. In addition to the issues with wave overtopping, boat ramps also create an impediment to members of the public walking along the foreshore reserve. There is an opportunity to remove these weak points and to rationalise access to the foreshore adjacent to Groyne 'D', in the vicinity of the public easement between the foreshore and Sandy Point Road (between residences #20 and #18). At the present time, the stormwater outlet at the eastern end of Precinct 6 discharges from Sandy Point Road, across a channel scoured through the Sandy Beach. Our analysis indicates that this outlet acts primarily as a secondary "relief" outlet for the stormwater catchment which discharges the majority of its flow through Groyne D. There is an opportunity to reconsider how this stormwater might be handled, either by formalising the crossing, or discharging through a groyne, similar to Groyne D, which could carry a pipe across the beach into the waters of Port Stephens. Such a groyne could create some issues with public access to the foreshore and would need further, careful consideration.

5 Identification, Assessment and Shortlisting of Management Schemes

5.1 Methodology

A long list of feasible options was determined for the six precincts and these were assessed using a multi criteria assessment method. The criteria against which the options were assessed for each precinct were:

- **Public Access**: Referring to either an existing level of use by the public for recreation, and whether this is presently difficult, threatened or could be improved or impeded;
- **Public Safety**: Referring to whether a particular option could either improve or negatively affect safety of the public when using the foreshore;
- **Recreation / Boating**: Referring to whether options are likely to improve or detract from recreational amenity of the foreshore;
- **Foreshore Protection From Erosion**: Referring to whether the particular option would significantly improve protection of the foreshore from erosion;
- **Foreshore Protection From Overtopping**: Referring to whether the particular option would significantly improve protection of the foreshore from overtopping;
- **Impact on Coastal Processes**: Referring to whether the option would have a positive or negative impact on broader coastal processes in adjacent precincts;
- **Seagrasses / Ecology**: Referring to whether the option would tend to enhance or detract from nearshore seagrass habitat;
- **Provision of a Sandy Beach**: Referring to whether the option tends to enhance the provision of a sandy beach, which is seen by many in the community as desirable;
- **Enhancement of Dune / Native Vegetation**: Referring to whether the option would tend to create opportunities to create or enhance coastal dunes & vegetation;
- **Management of Stormwater**: Referring to whether the option would tend to improve the handling of stormwater issues, including water quality, the amount of sand scoured from the beach and ease of maintenance;
- **Aesthetics**: Referring to whether the option would tend to improve or detract from the general appearance of the foreshore and associated beaches;
- **Residential Security**: Referring to whether the option would tend to adversely impact the privacy of residents and/or affect the potential for burglary / theft;
- **Adaptability**: Referring to whether the option incorporates the ability to adapt to changing conditions, such as the movement of the flood tide delta affecting wave focussing along the foreshore, or a rise in mean sea level; and
- **Ease of Construction**: Referring to whether the option involves difficult, in-water construction or whether there is limited foreshore access, which would increase the risk of unforeseen costs during construction.

A total of six individuals, including three members of the study team, and three Council staff members were provided with lists of these 14 criteria and asked to grade the importance of those issues for each of the six precincts using the following scale:

- A – Critically Important;
- B - Very Important;
- C – Important;
- D - A Bit Important; and
- E - Not Important / Irrelevant.

Values of A through E were converted to values of 4 through 0 respectively for subsequent calculation. All individuals that took part had been either involved in consultation activities as part of the project, or had experience in management of foreshores and drainage within the study area.

The long list of feasible options are summarised in the following sections. Again, three engineers from W&A and CE were asked to score how well the options performed against each of the 14 criteria. In this instance the following scale was adopted:

- +2 – Addresses issue well;
- +1 – Somewhat addresses issue;
- 0 – Irrelevant / has neutral impact;
- -1 – Has somewhat negative impact; and
- -2 – Makes the situation significantly worse

For each issue/option combination, the average issue importance and option performance scores were multiplied together, considering the responses of all participants. These were then totalled to give an overall score for each of the options. The overall score is representative of the level of benefit that would result from that option. For each precinct the options were subsequently ranked.

The outcomes of the multi-criteria analysis are presented in Appendix E. However, this analysis has some weaknesses, for example:

- Different individuals will interpret the scoring/ranking criteria differently;
- Anomalies will arise from the way individuals interpret (or misinterpret) the different issue/option combinations. However, revisiting and discussing every individual score undermines a key advantage of the method: that individuals are able to exercise their own subjective judgement and preferences relating to the different options, based on a variety of personal experiences; and
- The analysis does not incorporate the compatibility of options between precincts.

For these reasons, the process of selecting final options and formulating the final schemes also involves a degree of oversight. The results were also considered in a high level, qualitative manner to ensure that clearly infeasible options are not short-listed. Any surprising deviation from the expected rankings would be reassessed. In this case, the most highly ranked options coincided with those which were qualitatively considered to be most feasible

Detail on the ranking of each option in the multi criteria analysis, and further consideration of limitations are discussed in Appendix E. Considering all aspects, three final short-listed "schemes", comprising compatible treatments in adjacent precincts are presented in Section 5.2.

5.2 Shortlisted Foreshore/Drainage Management Schemes

Table 1 Summary of Shortlisted Options

Precinct	Scheme 1 Treatments	Scheme 2 Treatments	Scheme 3 Treatments
1	Relocate sand to Precincts 2 and 3.	Retain sand and install twin gross pollutant traps to existing stormwater line.	Retain sand and construct groyne to convey stormwater line across beach. Install twin gross pollutant traps to existing stormwater line.
2	Use Precinct 1 sand to nourish and construct groyne at western end of Conroy Park	Nourish with sand imported from elsewhere.	Nourish with sand imported from elsewhere.
3	Relocate Fence. Remove stairs and ramps. Batter slope back and reconstruct revetment to engineered standard. Nourished using sand from Precinct 1.	Relocate Fence. Remove stairs and ramps. Batter slope back and reconstruct revetment to engineered standard. Repair, bolster and extend Groyne A. Nourishment from imported sand.	Relocate fence. Remove stairs and ramps. Batter slope back and reconstruct revetment to engineered standard. Repair, bolster and extend Groyne 'A'. Enhance existing "headlands" to form pocket beaches and nourish.
4	Rebuild and bolster foreshore revetment (mainly along existing alignment but will require some reclamation).	Rebuild and bolster foreshore revetment (will require some reclamation). Extend and reconstruct Groyne B.	Rebuild and bolster foreshore revetment (will require some reclamation). Extend and reconstruct Groyne B. Nourish beach between Groynes A and B.
5	Remove Boat Ramps, Reconstruct wall, reclaiming where necessary to provide for 2.4m path landward and allowance for crest elevation to accommodate sea level rise.	Provide for "mega" nourishment of beach profile offshore, to the south of and in the vicinity of Precinct 5. Aims to replicate historical beach conditions. Extend Groynes B and C to anchor beaches.	Remove Boat Ramps, Reconstruct wall true to present alignment and provide a robust, suspended walkway around the front of the new revetment.
6	Remove Boat Ramps, reconstruct path and replace with a low revetment with adequate space for future crest heightening as required. Reconstructed revetment along existing alignment. Retain eastern stormwater line as is.	Extend Groyne D and nourish to the south to provide a future source of sand for east to west transport around Sandy Point. Ongoing nourishment would be required. Remove boat ramps and rebuild back beach. Install two pollution traps upstream of Groyne D, Formalise eastern stormwater crossing with shallow dish drain and infiltration trench	Remove Boat Ramps, reconstruct path and replace with a low revetment with allowance for a wave deflector wall to be installed in future. Formalise eastern stormwater crossing with shallow dish drain and infiltration trench.

6 Potential Management Schemes: Detailed Assessment

6.1 Design Parameters

6.1.1 Design Life and Design Standards

A design life of 25 years has been specified by Council. Commonly, shore protection works will need intermittent maintenance to remain serviceable. Examples of this may include periodic renourishment of beaches or topping up of rock revetments following damage by storms. An acceptable maintenance regime needs to be considered as part of the design calculations.

To consider the acceptable risk of damage and/or overtopping of structures, the appropriate level of maintenance, issues associated with access, and the purpose of the structures need to be considered. As a key example, any proposed foreshore rock revetment structure in Precinct 5 would need to minimise overtopping to prevent flooding of the area behind the revetment and to minimise danger to any pedestrians utilising the foreshore reserve. Furthermore, protection of properties behind the foreshore from the impact of waves is important. Overtopping is primarily controlled by setting an appropriate combination of revetment slope and revetment crest elevation.

Similarly, any work in Precinct 2 to create a recreational beach would need primarily to consider the longshore transport rate that arises from changed alignment of the beach and the expected longevity of any nourishment and consequent average time interval between renourishment campaigns. This is affected by the grain size characteristics of any sand used in renourishment (i.e. the "borrow" sand), the final expected planform arrangement of the nourished beach and whether or not structural protection in the form of artificial headlands or groynes are provided to help retain the sand. The performance and maintenance requirements are dependent on the weather. Topping up of nourishment in particular may be required immediately following storm events. These can occur immediately after the nourishment is placed or perhaps not for months or years following initial placement. Renourishment requirements are estimated from average anticipated losses over time, but remain entirely dependent on the conditions that actually occur.

An important consideration in making a decision about appropriate design conditions is the encounter probability. Encounter probability can be calculated using the following equation:

$$P_e = 1 - e^{\frac{-N}{ARI}}$$

$N = \text{Design Life (25 years)}$

$ARI = \text{Recurrance Interval of Event Being Considered (years)}$

$P_e = \text{Probability that the event being considered will occur during the design life}$

The present Australian Standard for Maritime Structures (Standards Australia, 2005) recommends appropriate recurrence intervals for design waves. While the standard explicitly excludes breakwaters, rock armoured walls and groynes, it does provide some context of use. Examining the structures actually covered by the standard indicates that its focus is structures that tend to fail in a more sudden manner rather than "flexible" rock armoured structures which are typically designed to accommodate some level of damage (under the assumption that this will be promptly followed by maintenance). The amount of damage that is considered reasonable during a design event is an important input when sizing armour for flexible rock armoured structures. A more frequent design event could be considered in that context.

Nevertheless, the Australian standard (AS 4997) provides recommendations for structures with a 25 year design life as reproduced in Table 2.

Table 2 Wave Height Recurrence Intervals Recommended by AS4997 (2015)

Function	Average Recurrence Interval For Design Wave Height (yrs.)	Equivalent Encounter Probability (25yr Life)
Structures Presenting a Low Degree of Hazard to Life or Property	50	0.39
Normal Structures	200	0.12
High Property Value or High Risk to People	500	0.05

From Table 2, a decision relating to the consequences of failure needs to be made. Considering the scope of the standard, it is clear that there exist structures with far greater consequences of failure (e.g. community critical infrastructure, high rise apartments adjacent to the shoreline) and it seems unlikely that the structures in the study area would fit into this category. However, the exposure in some areas does pose a significant hazard to life and property. Some structures in the design schemes considered here would fall into the "Normal" category, whereas some would fit into the "Low Degree of Hazard" category.

In the case of a flexible rock revetment structure, it is expected that the design wave height could cause significant, but repairable damage (up to 20%) to the revetment, meaning that up to 20% of the primary armour stones may move from their placement position during the design storm event.

6.1.2 Water Levels

The design "still" water levels have been determined based on research presented in Section 6.3 of Appendix A. A conservative, but reasonable assumption is that the design water level (including a suitably rare "Storm Surge" component) can be combined with an offshore wave of the same recurrence interval. The still water level is primarily of importance in the calculation of overtopping flow rates and volumes. Therefore, in accordance with guidance from the Eurotop Manual (Pullen et al., 2007), a recurrence interval of 50 years is appropriate. Bearing this in mind, the still water level adopted for design of rock armour has been set as follows:

- 1.40m AHD (Table 12 of Appendix A, 50yr ARI water level within Fort Denison);
- + 0.35m (Sea Level Rise, derived from PSC benchmarks, considering a structure life to 2040); and
- +0.13m (Wind Setup).

This gives a design still water level of ~1.9m AHD. We note that this differs from the design still water levels presented by WMA Water (2010), with the differences arising from:

- A lower, up to date, 50yr ARI water level estimate provided during this study by Manly Hydraulics Laboratory, when compared to that utilised during the floodplain management process (1.40m c.f. 1.47m). That earlier analysis was undertaken nearly 20 years ago;
- No allowance for elevation of water levels due to catchment flooding.

The second point is considered reasonable given the dynamics of flow between the western and eastern basin of Port Stephens, which is constrained at Soldiers Point and tend to make water levels in the eastern basin more closely match those of the ocean (including some super elevation due to the tide). In addition, given that this water level is primarily being used for an overtopping calculation, it is important to note that the design swell wave is dependent on a wind approaching from the south east sector and following the swell on its way from offshore to the entrance to Port Stephens. The wind is more or less an offshore wind when considering the southern shoreline of the Port, which tends to cause a set-down of water levels on the southern side of the Port. In this way the inclusion of a positive wind set-up could be viewed as conservative. However, we consider it reasonable to incorporate this degree of conservatism at this conceptual design stage, given our reliance on a numerical wave model that, as yet, has only been validated on the basis of performance across Precinct 5 during the April 2014 storm.

An allowance for wave setup is not required, as the overtopping calculations are based on still water levels which, by definition, do not include wave setup (i.e. when the water is "still" waves are not acting). The overtopping calculations incorporate an intrinsic allowance for wave set up.

6.1.3 Shoreline Wave Conditions

The design waves derived from numerical modelling (Appendix A) were extracted at locations at least 100m offshore of the study site and in depths of at least 7m, offshore of the immediate shoreline around the study site. Those locations are reproduced here in Figure 6.

In order to develop conditions at the immediate shoreline, it is necessary to consider the wave transformation processes that will alter the waves as they traverse the surf zone before they impact upon the foreshore.

To traverse the surf zone, we have utilised relationships put forward by Goda (2000, as recommended in CIRIA, 2007), which account for both the breaking of larger waves, and shoaling as the waves approach the foreshore across the surf zone. Conservatively, the analysis has not considered the effects of refraction across the surf zone, and in calculating armour size, the waves have been assumed to approach the shoreline from a shore normal direction. While this is likely to be reasonable for most precincts, it likely causes a significant difference for swell waves approaching Precinct 3 and the eastern end of Precinct 2. Some relaxation of conditions may be considered in Precinct 3 in particular, although this should be justified at the detailed design stage. The governing design waves are refracted swell waves. Details of the adopted "offshore" wave conditions (from the model) and the calculation used to bring those waves to the immediate foreshore are presented in Appendix F.

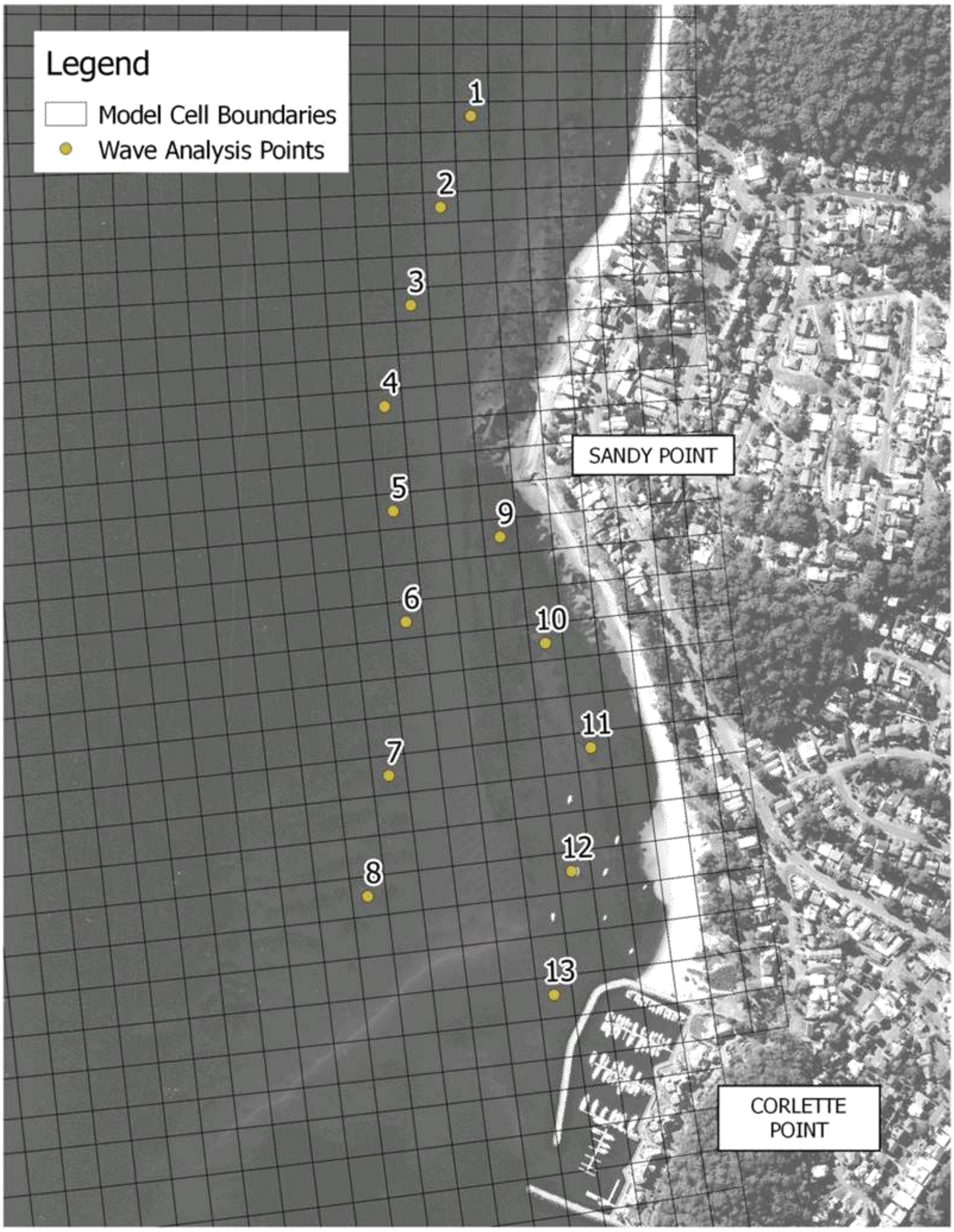

Figure 6 Model Grid near Corlette with Analysis Points

Sandy Point - Conroy Park Foreshore Erosion and Drainage Management Plan

Whitehead & Associates
Environmental Consultants

Revision	A
Drawn	DW
Approved	DW

6.1.4 Overtopping

Overtopping is of key concern, particularly with respect to damage to buildings behind the foreshore (water impact and inundation) and the possible danger to pedestrians that may venture out along the access path behind the beach or into the foreshore reserve during a significant storm. Accepted professional guidance for limits to overtopping are provided in the Eurotop Manual (Pullen et al., 2007). That manual also indicates (Table 3.1 of Pullen et al, 2007) that, for a design life of between 20 and 30 years, protection against a 50 year average recurrence interval event is acceptable. Commensurate with Table 2, such an event would have around a 40% chance of occurring over a 25 year design life.

Values of average overtopping discharge and maximum individual overtopping "event" values of relevance to the study are presented in Table 3.

Table 3 Tolerable Discharge Limits (Pullen et al., 2007)

Description	Mean Discharge (litres/second/metre of seawall)	Maximum Volume of an Individual Overtopping Event (litres/metre)
"Aware" Pedestrian[4]	0.1	20-50
Building Structure Elements	1	-

6.1.5 Toe Scour Conditions

Toe scour is of particular importance to the overall stability of foreshore structures. Historically, studies in the UK have indicated that close to 50% of seawall failures are at least partly attributable to the failure of the toe (CIRIA, 2007). However, the toe can be particularly difficult and costly to construct, which means that design is often finely balanced between construction cost and toe level.

Historical practice along the open coast of NSW has been to adopt a scour level of -1.0m AHD on a sandy beach. -2.0m AHD is adopted for vertical seawalls, to account for the additional scour that can be expected due to the reflective nature of those structures (Nielsen et al., 1992). This was based on available field data for open coast NSW beaches.

Broad guidance in CIRIA, 2007 indicates that scour is of the order of the maximum, incident unbroken wave, when the structure is vertical and highly reflective. That document also indicates that scour depth is related to the magnitude of reflection and is therefore proportional to the "reflection coefficient". For our design purposes, the reflection coefficient has been calculated using the expression:

$$C_r = (0.64 \times {\xi_m}^2)/(8.85 + {\xi_m}^2)$$

This assumes that a two layered armour stone structure is proposed. ξ_m is the surf-similarity parameter relating to the mean wave period, as recommended by CIRIA (2007).

[4] The manual describes this as "*Aware pedestrian, clear view of the sea, not easily upset or frightened, able to tolerate getting wet, wider walkway.*" In reality, the foreshore reserve will be accessible to the public. However, we doubt that the reserve would be attractive to normal, rational members of the general public during extreme storm condition. Individuals that are most likely to venture out would be generally aware residents securing items in their front yards, etc.

6.1.6 Rock Armour, Availability and Sizing

Two local quarries were approached to provide details of available rock armour, including density and the testing of parameters relevant for application in a marine environment. Details of parameters of interest to the selection of armour stone were as detailed in Table 4.

Table 4 Rock Size and Density Options

Quarry	Product	Density (kg/m^3)
Boral (Seaham)	400-700mm, Ryolitic Tuff	2560
Boral (Seaham)	700-1200mm, , Ryolitic Tuff	2560
Hunter Quarries (Karuah)	Hornblende, Latite Tuff[5]	2600

Laboratory and Petrographic analyses of stone from both sources was obtained and examined. Either source is considered to be of suitable quality, although the overall grading of the mix and shape of rock sizes would need to be negotiated at a later stage.

6.1.7 Groyne Geometry

The purpose of a groyne is to exert control over the alignment of the shoreline. The following general design principles are summarised from a text by van Rijn (2005) and relate to the use of low groynes to stabilise an existing sandy beach area:

- The crest level near the dune toe should be just below the local beach level;
- The crest level near the tip of the groyne should be slightly higher than the mean low water line and about 1m above the local sea bed to block longshore transport under moderate waves. Within our designs, the crest elevation of groynes has been assumed to slope downwards with distance offshore.
- Overtopping and wash over of sand during storm conditions is acceptable;
- Crest width should be no smaller than 3m to allow the passage of construction equipment;
- Spacing between groynes in a field is around 2 to 4 times the length, with closer spacing where the beach has an oblique angle of wave attack, depending on the length of beach to be stabilised;
- The groynes tend to extend into the surf zone; out to around the mean low water springs tide mark.
- Artificial beaches tend to have generally longer and higher terminal groynes.
- The key areas for considering groynes within this study are Precincts 4, 5 and 6, where 4 groynes already exist, and groynes which feature as part of schemes 1 and 3 near the interface of Precincts 1 and 2.

For the existing groynes, the intention is primarily to bolster and bring existing Groynes A, B and D up to a more engineered standard where possible. A small amount of lengthening could be

[5] Hunter Quarries have advised that they can provide armour stone sizes as required, having previously supplied stone for the breakwaters of the Hunter River. Confirmation of this would be required at detailed design, along with acceptance of the colours available. The material presently quarried from Karuah appears to be darker than the pink rhyodacite that has been previously placed along the study foreshore.

considered to provide some additional stability to the shoreline on the downdrift (western) side by blocking storm waves which may otherwise impact on foreshore properties.

The impact of any groyne extension, or the construction of a long groyne on the stability of the foreshore can be assessed using concept summarised in Hsu et al. (2010). In summary, this method requires the identification of three different aspects:

- The dominant direction of swell wave approach;
- A fixed "updrift" point where wave approach, around which "diffraction" can be considered to occur; and
- A downdrift point where the alignment of the beach is either fixed or in equilibrium.

Utilising this information and a parabolic equation to describe the planform shape of the Bay, the equilibrium alignment of the shoreline can be assessed. Where this method has been applied, the calculations were undertaken using GIS software and the resulting equilibrium shoreline is presented as part of the scheme details provided in Section 6.2.

Further indication of the likely effect of groynes is obtained by assessing the pre-existing geomorphology of the shoreline. At this location, there is a ready illustration of the potential impact in the historical behaviour of the beach following construction of The Anchorage. The eastern breakwater of The Anchorage is effectively a large groyne. Following construction, this breakwater has arrested sand moving along the shoreline from east to west, retaining and stabilising the beach for some 250m to the east. Other examples include short groynes around the eastern side of Sandy Point.

6.1.8 Nourishment Sand

A number of sources for nourishment sand were considered from the area south of Port Stephen's. General compatibility in terms of colour and grain composition is not considered to be an issue, given that the beaches fronting the foreshore will have a similar marine quartzose sand origin as the surface sands present in the majority of sand quarries in the area.

Generally, coarser sands are considered somewhat desirable, although care is required, as significantly coarser may cause a steepening of the beach profile. Placement of sand as part of beach nourishment can incorporate a degree of "overfill", which aims to account for the loss of sand from a nourishment project where the borrow sand is finer than the sand which occurs natively in the area being nourished.

The method is empirical, and involves calculation of the phi sorting ratio and phi mean difference between "borrow" and "native" sands:

$$\text{Phi Sorting Ratio} = \frac{\left\{\frac{(\phi_{84}-\phi_{16})}{4} + \frac{(\phi_{95}-\phi_5)}{6}\right\}_b}{\left\{\frac{(\phi_{84}-\phi_{16})}{4} + \frac{(\phi_{95}-\phi_5)}{6}\right\}_n}$$

$$\text{Phi Mean Difference} = \frac{\left\{\left[\frac{\phi_{16}+\phi_{50}+\phi_{84}}{3}\right]_b - \left[\frac{\phi_{16}+\phi_{50}+\phi_{84}}{3}\right]_n\right\}}{\left\{\frac{(\phi_{84}-\phi_{16})}{4} + \frac{(\phi_{95}-\phi_5)}{6}\right\}_n}$$

Where:

$\varphi_s = \log_2 d_s$

$d_s ='\ s'$percentile exceedance grain size in mm

b, s subscripts refer to 'borrow' and 'native'sand grins respectively

These values are then used with a chart to determine the necessary overfill factor (CERC, 1984). For borrow materials, the particle size distribution published by quarries from around the Port Stephens area, and from sediment sampling undertaken from the leading edge of the flood tide delta (north of Corlette Head) were considered. The sand from the flood tide delta was more compatible with the beach sand (similar size distribution) whereas data from local quarries indicated that the sand was notably coarser. In both cases, an overfill factor of less than 2% was determined from (CERC, 1984).

While the charts from the Shore Protection Manual have been used, some researchers advise that those methods are not very accurate for sands below 0.3mm in size (Van Rijn, 2005). Beach sands from the study area have a mean grain size of around 0.3mm. More sophisticated and/or supplementary methods are presently recommended in the present revision of the United States' Coastal Engineering Manual (US Army Corps of Engineers, 2014). In particular, that manual recommends that nourishment design be based on equilibrium beach profile concepts and an assessment of storm erosion and wave driven longshore transport losses. It is questionable whether the coastal equilibrium beach profile is valid for the study area, given its location well inside the estuary, relative sheltering from highly modified oceanic swell, strong longshore variation and lack of a consistent supply of sediment from the east (Pilkey et al., 1993). Furthermore, the subject shoreline is influenced by dynamics across the flood tide delta of Port Stephens and future behaviour is likely to differ from that of the past.

In designing the nourishment profiles, slopes greater than 1 in 20 have been avoided. In some instances, slightly steeper slopes have been adopted to minimise the coverage of existing seagrass beds. The extent of the profile has been controlled by other concerns, informed by estimates of longshore transport and considerations such as the plan form geometric equilibrium discussed in Section 6.1.7.

Given these concerns, it is important to recognise that beach nourishment design is imprecise. While longevity of 5 or 10 years may be designed for, one significant storm may result in significant removal of the nourished sand. This raises understandable concerns in the community and it is therefore desirable to aim to design for a longer time period if possible.

A management strategy which includes beach nourishment should also include an allowance for regular monitoring, both seasonally and following any significant storm. Monitoring is particularly important to inform and adjust the nourishment requirements as ongoing maintenance is called for in future.

In the case of the subject foreshore, the required volumes of sand have been determined using these considerations, available aerial photography, the digital elevation model developed as part of this study and the results of plan form analyses as required.

6.1.9 Stormwater Drainage Considerations

Outfall 1: Precinct 6

Outfall 1 serves as a relief/surcharge point within the eastern most catchment which drains the area east of Conroy Park. The outlet relieves some of the localised flooding along Sandy Point Road during large storm events. Its removal is not a sensible option.

The main issue with Outfall 1 is backing up of sand into the overflow channel from wave action and tidal surges during large storms events, which blocks off the overland flow path. It is therefore critical that Council regularly clean-out and maintain this overflow channel. Another issue is that, being a surcharge pit, it and the pipe system it serves are always charged (full of stormwater). Therefore, the pit regularly surcharges stormwater into the beach reserve adding to localised erosion problems.

Based on stormwater modelling (Appendix B), the combined 5 Year and 100 year recurrence flows from this outfall only represent 20 percent of the total flow from the overall catchment (Tables 1 & 2). Considering this, and also due to existing pipe invert levels, it would be impractical to retro-fit a gross pollution trap (GPT) to reduce gross pollutants.

Outfall 2: Precinct 5/6

Outfall 2 is one of the major outfalls in the study area, discharging through a pipeline within an existing groyne. It presently works effectively and remains unblocked. Stormwater modelling indicates that the outlet is undersized for the 5 year storm event, with surcharging predicted from pits upstream in Sandy Point Road. Even though it is undersized, it would be impractical and costly at this stage to try and augment the existing piped drainage system.

Outfall 2 carries a considerable amount of suspended sediment and pollutants from the upstream urban areas and the installation of a GPT to address this could be considered.

Outfall 3: Precinct 1

Outfall 3 is the second major outfall, presently discharging across the centre of Corlette Beach. During significant flow events the discharge causes significant erosion and scour of sand from the beach face. Stormwater modelling indicates that the outlet is under-sized for the 5 Year storm event with surcharging and localised flooding evident through the stormwater network upstream of Sandy Point Road.

Like Outfall 2, Outfall 3 carries a considerable amount of suspended sediment and pollutants from the upstream urban areas and the installation of a GPT to address this could be considered.

Outfalls 4 & 5: Precinct 1

Outfalls 4 and 5 have the smallest catchments and contribute the smallest amount of suspended sediment and gross pollutants to the waterway when compared with the other catchments. Outfall 4 was completely buried and Outfall 5 was partially blocked at the time of inspection.

While these outlets are minor, the underperformance of the stormwater system makes it unacceptable that they remain blocked. If the broader management options adopted for the foreshore do not involve the relocation of sand from next to the Anchorage to the foreshores further to the east, regular and vigilant maintenance of these outlets would be required to ensure that they remain clear of sand.

6.1.10 Summary of Design Parameters

For each of the precincts, appropriate design parameters have been calculated and these are tabulated in Appendix F. Those design parameters and the summary considerations provided in Sections 6.1.1 through Sections 6.1.9 have been used to derive the layout, extents, dimensions, armour sizes and costs presented in the remainder of Section 6.

6.2 Presentation of Scheme Design and Costing Details

The important aspects of the different schemes are outlined in tables, followed by figures for Scheme 1 (6.2.1), Scheme 2 (Section 6.2.2) and Scheme 3 (Section 6.2.3). In addition to these descriptions and the associated figures, an artist's impression of each option for Precincts 2 and 5 are presented in Appendix G.

6.2.1 Scheme 1

Table 5 Scheme 1 Details

Scheme 1		
Precinct and Details	**Figures**	**Notes**
Precinct 1: Plan	Figure 7	In this option, sand is moved from the western end of Corlette Beach, to the eastern end (Precincts 2 and 3). The desired beach width was based on conditions from 1992, and it is estimated that around 20,000 to 25,000m^3 of sand would need to be moved to return Precincts 2 and 3 to their 1992 state.
Precinct 1: Profiles	Figure 8 Figure 9	A substantial amount of sand will need to be removed from the delta that has formed in front of the major stormwater crossing of Corlette Beach. This sand will need to be tested for contaminants although, based on its location, is likely to be fairly clean. For costing purposes, it has been assumed that the works would be undertaken by two scrapers assisted by two bulldozers to facilitate loading and spreading of the sand once transported. The designed cut profile aims to create a bench at -1.0m AHD across the beach sloping up at 1 in 10 to meet the existing surface. This leaves the beach with a similar volume to that present during the late 1990's. Over time, the beach will reform, with sand from the bench reworked onshore to form a more natural beach profile. The approach adopted has aimed to acquire the amount of sand needed to nourish precincts 2 and 3 while minimising the loss of existing dune vegetation adjacent to The Anchorage.

Scheme 1		
Precinct and Details	**Figures**	**Notes**
Precinct 2: Plan	Figure 10	Sand has been added to renourish this beach, as per the description provided for Precinct 1. In addition, a groyne is provided at the western end of Conroy Park which aims to hold the beach in place. The groyne is curved to facilitate holding the beach in place. However, even with this groyne, Conroy Park will still tend towards erosion, and periodic renourishment will be required if a sandy beach is to be maintained in this location. Erosion of sand would, however, be less pronounced than in the past. Nourishment activities would normally occur every 5-10 years or more frequently depending on weather conditions.
Precinct 2: Profiles	Figure 11	Sand is to be placed at a slope of no greater than 1 in 10. The aim of this placement activity is to recreate the situation present when the beach was last full of sand, around the middle of the 1990's. This would increase beach width at mid-tide from zero at the present time, to around 30-35 metres when fully nourished.
Precinct 3: Plan	Figure 12	Similarly to Precinct 2, sand nourishment is occurring here to recreate conditions similar to those around the middle of the 1990's. The amount of nourishment in Precincts 2 and 3 is the same for all three schemes. However, the option also includes reconstruction of the foreshore revetment to a proper engineered standard. This means that construction will occur carefully and will not involve the direct dumping of rock onto the eroding face.

Scheme 1		
Precinct and Details	**Figures**	**Notes**
Precinct 3: Profiles	Figure 13 Figure 14	Considering the amount of useful, reasonably sized armour stone on the face of the existing revetment, it has been assumed that cost savings equate to not needing to obtain secondary armour. However, there is effort and cost associated with breaking up and stockpiling existing materials for recycling in the new structure. Once stripped of existing rock armour and debris, the existing slope will be battered back and the slope prepared for construction of the new revetment. Any suitable sand excavated from the embankment can be reused in front of the wall as nourishment material once the revetment has been reconstructed. The revetment face has primary armour stone of 450kg (~700mm diameter) placed at a slope of 1 in 1.5. The revetment toe sits at -1.7m AHD the crest will be set at either 2.65m AHD or at least 1 stone above the reserve ground level. Due to the relative steepness and height of the revetment in this location, a fence is proposed to separate pedestrians from the revetment.
Precinct 4: Plan	Figure 15	For Precinct 4, revetment reconstruction is proposed along the same alignment as exists presently, although some reclamation may be required towards the eastern end.
Precinct 4: Profiles	Figure 16	The revetment proposed has a very similar design to Precinct 3, although the ground elevations in Precinct 4 are generally lower than for Precinct 3. Furthermore, the revetment is now on the eastern side of Sandy Point, meaning that it is more exposed to oceanic swell waves. For this reason, the proposed revetment is at a flatter slope of 1V:2H. Based on the potential for overtopping, the footpath in this precinct needs to be maintained at a level of 2.35m AHD to provide a final barrier against any waves that do manage to run up the front face of the structure and flow between the topmost rows of armour stone.

Scheme 1

Precinct and Details	Figures	Notes
Precinct 5: Plan	Figure 17	This revetment has an identical design to that in Precinct 4. However, there are significant construction issues with access to this length of foreshore. This markedly increases the cost of demolition and reconstruction efforts. The plan alignment of the revetment adopted for this option involves some reclamation, up to 10m seaward if the worst affected properties, which are particularly vulnerable at this point in time. By adopting this alignment, we achieve a more consistent, smoother planform without any sharp transitions that might concentrate wave energy and runup. All boat ramps will be demolished. The presence of solid concrete structures throughout Precinct 5 will prove difficult to reuse within the new structure, and it is assumed that half of the materials resulting from demolition of the existing structures will need to be disposed to landfill. A significant cost saving could be made if the demolition materials (bricks, mass concrete etc.) could be reused. In costing, we have assumed that materials amounting to half of the secondary armour will be able to be recycled in the new structure, resulting in some cost saving.
Precinct 5: Profiles	Figure 18	The revetment design is essentially the same as for Precinct 4. However existing ground levels here are typically 2.3m AHD or below. For this reason, there will need to be an allowance for cross drainage, or ground filling in areas where the finished path level is higher than the yards of the adjacent residential properties. The way in which this drainage is provided will be a subject of detailed design.
Precinct 6: Plan	Figure 19	In Precinct 6, the existing foreshore protection is low key compared to Precinct 5. However, the area is still overtopped by ocean swell, a process which is particularly exacerbated by the presence of boat ramps which present a weak point in the existing foreshore protection. The existing beach, which has accreted to the east of Groyne D, provides added protection to the foreshore properties. This beach should be maintained. Scheme 1 proposes that the present, ad-hoc arrangement of foreshore protection works be replaced by a properly engineered structure along the present alignment. The existing stormwater crossing (~ Chainage 1150) is to be retained as is.

Scheme 1		
Precinct and Details	**Figures**	**Notes**
Precinct 6: Profiles	Figure 20 Figure 21	The revetment design is similar to that of Precincts 4 and 5, although it incorporates a self-launching toe at -1.0m AHD to minimise the amount of excavation required in the beach which sits relatively high at present. This toe is designed to slump as/if any scour holes develop during a severe storm, thus extending scour protection down to around -2.0m AHD. The footpath is again set at a level of 2.35m AHD and the structure is designed to allow an additional row of armour stone to be added at some time in the future, if required. This may be required as sea levels rise, or if the beach which presently fronts this structure erodes, reducing the amount of protection afforded. In costing, similarly to Precinct 5, we have assumed that materials amounting to half of the secondary armour will be able to be recycled in the new structure, resulting in some materials cost saving. Around half of the demolished structure would require disposal to landfill, with significant savings possible if this building rubble (masonry blocks, bricks, concrete) can be recycled for use elsewhere.

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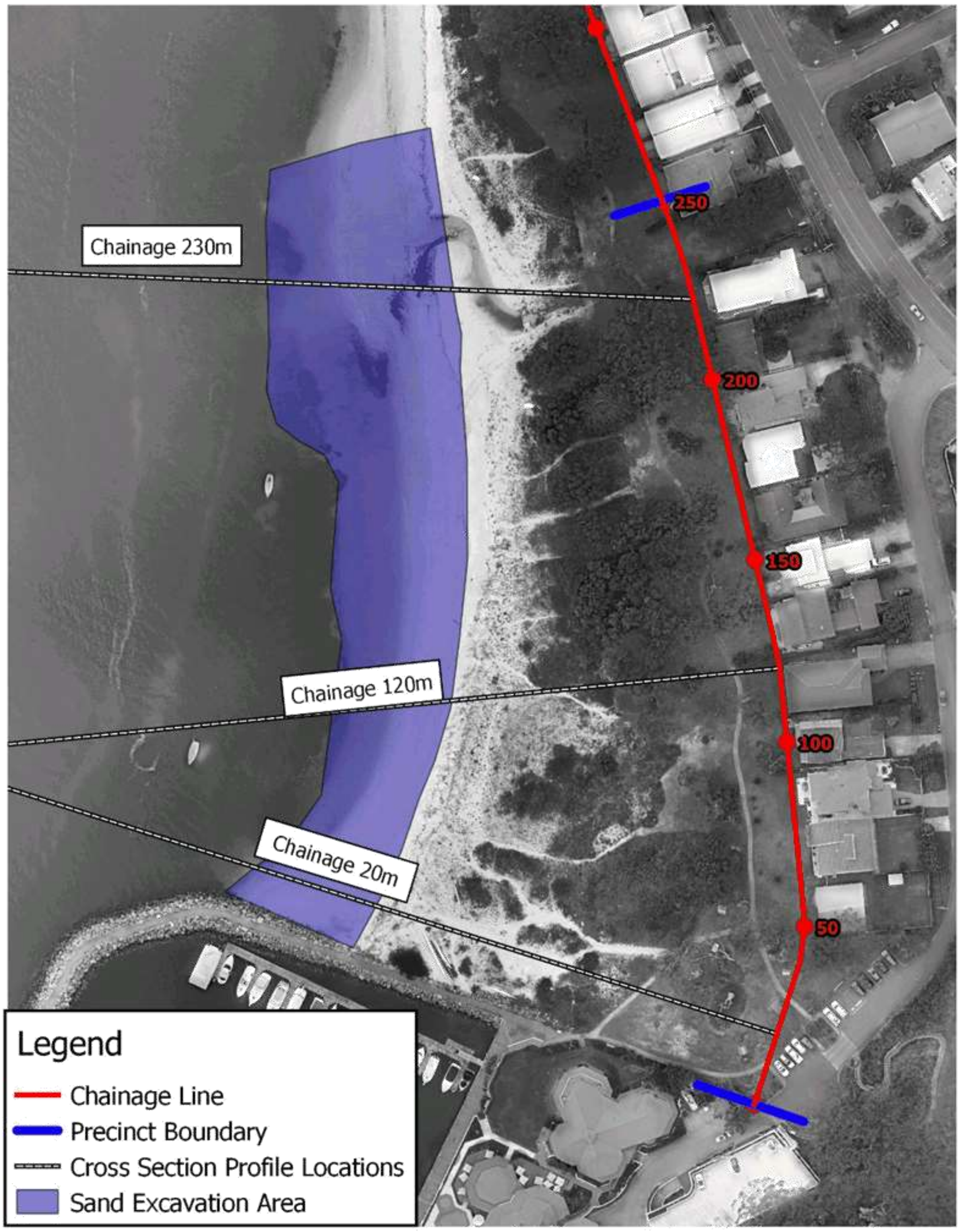

Figure 7 Scheme 1, Precinct 1: Plan

Sandy Point/Conroy Park Foreshore Erosion and Drainage Management Plan

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0 20 40 60 80 m (Approx Scale)

Revision	A
Drawn	BC
Approved	DW

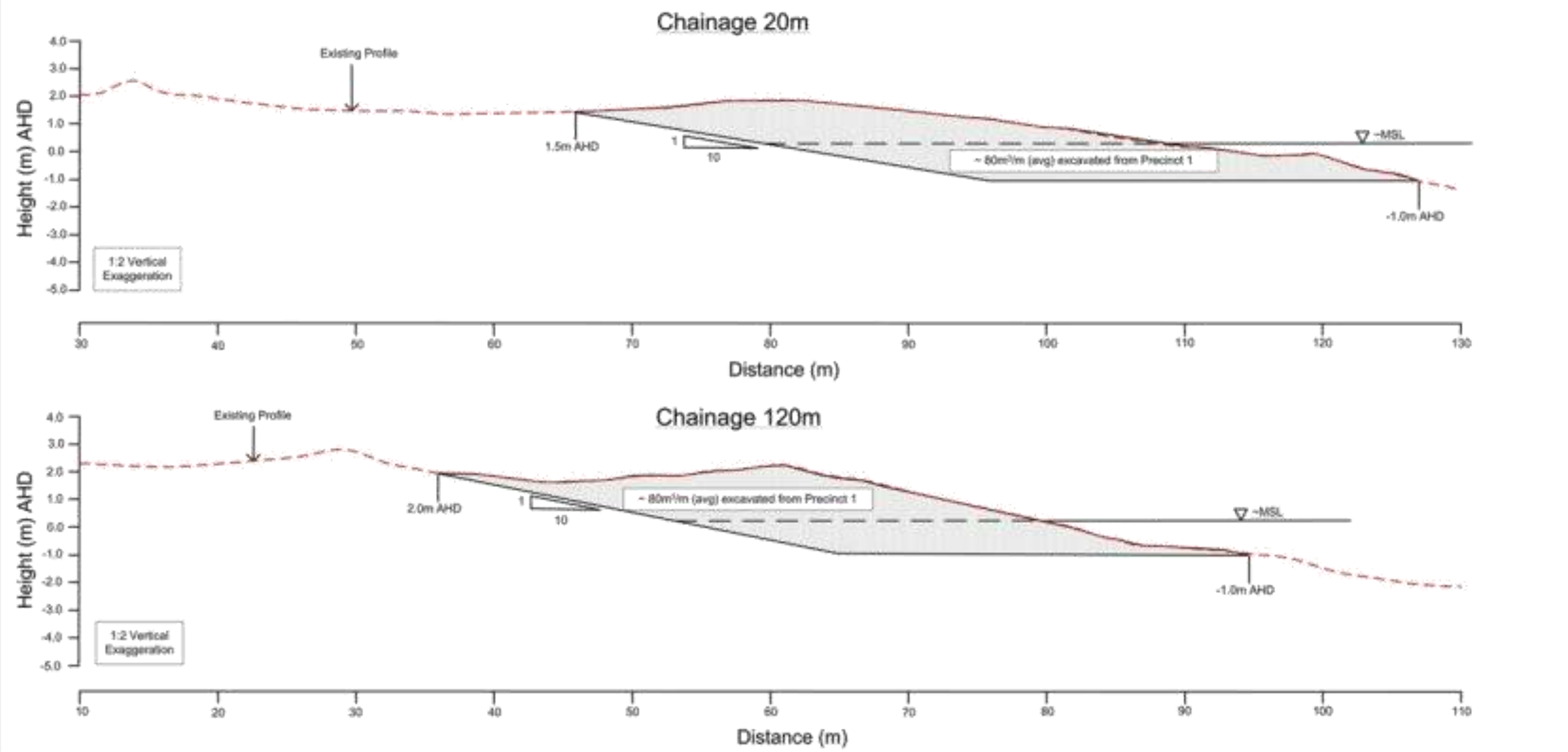

Figure 8 Scheme 1, Precinct 1: Profiles - Chainages 20 and 120m

Sandy Point/Conroy Park Foreshore Erosion and Management Plan

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Cross sections are conceptual, for costing and visualisation purposes only, and are not for construction. Distances along the cross sections are measured in an offshore direction from the main chainage line, which is shown on the corresponding plan.

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1:2 Vertical Exaggeration

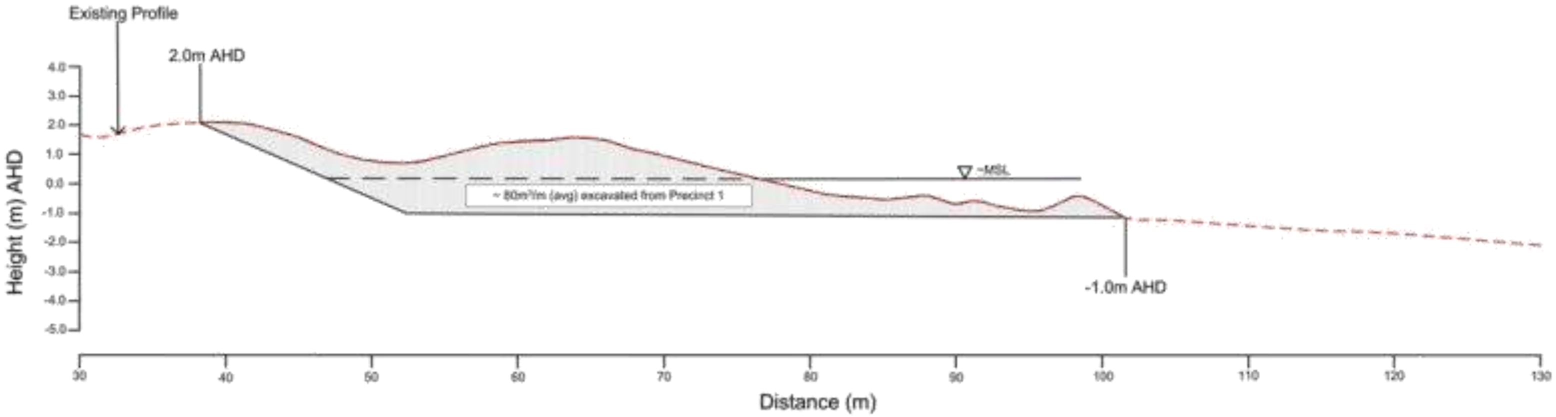

Figure 9 Scheme 1, Precinct 1: Profiles - Chainage 230m

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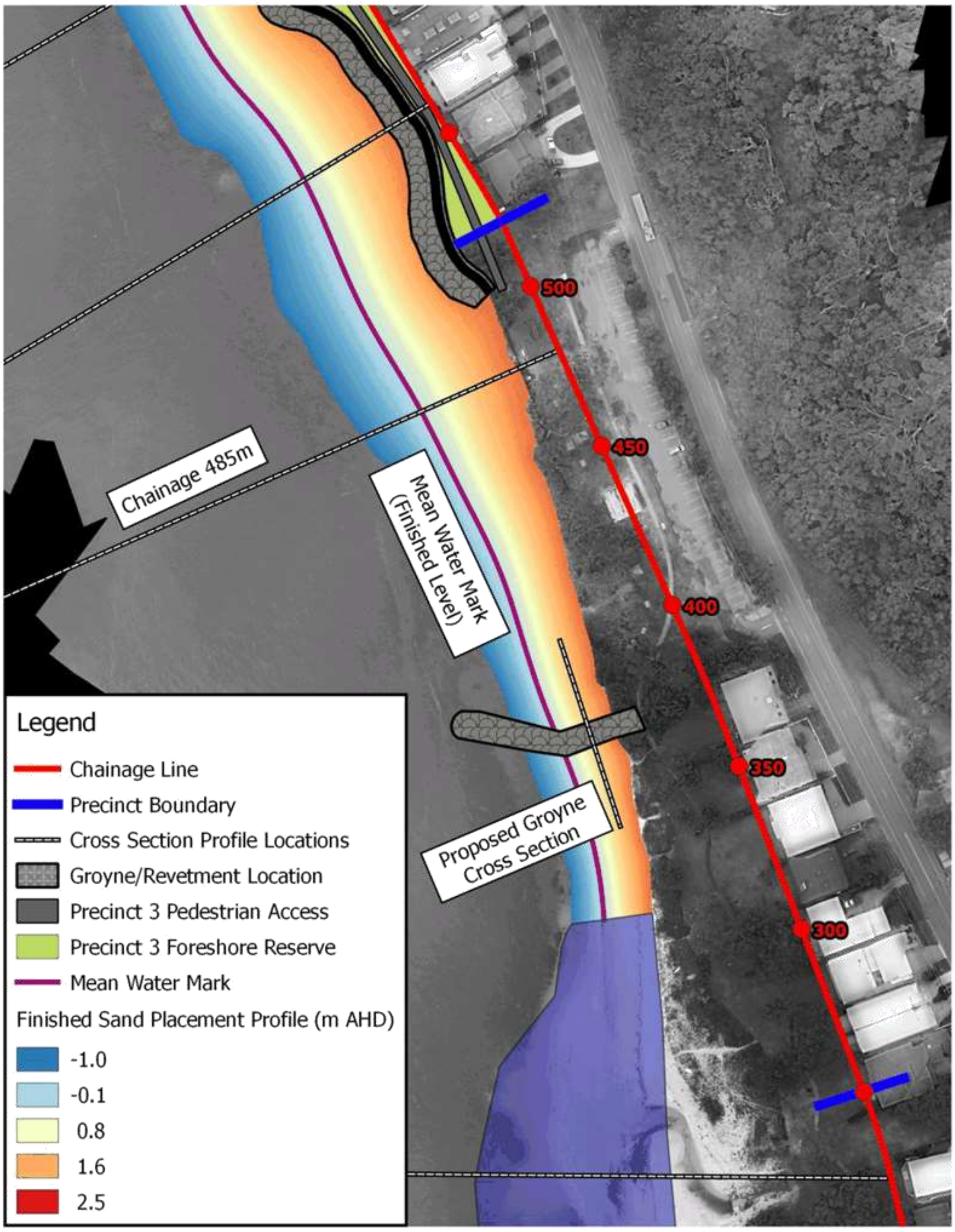

Figure 10 Scheme 1, Precinct 2: Plan

Sandy Point/Conroy Park Foreshore Erosion and Drainage Management Plan

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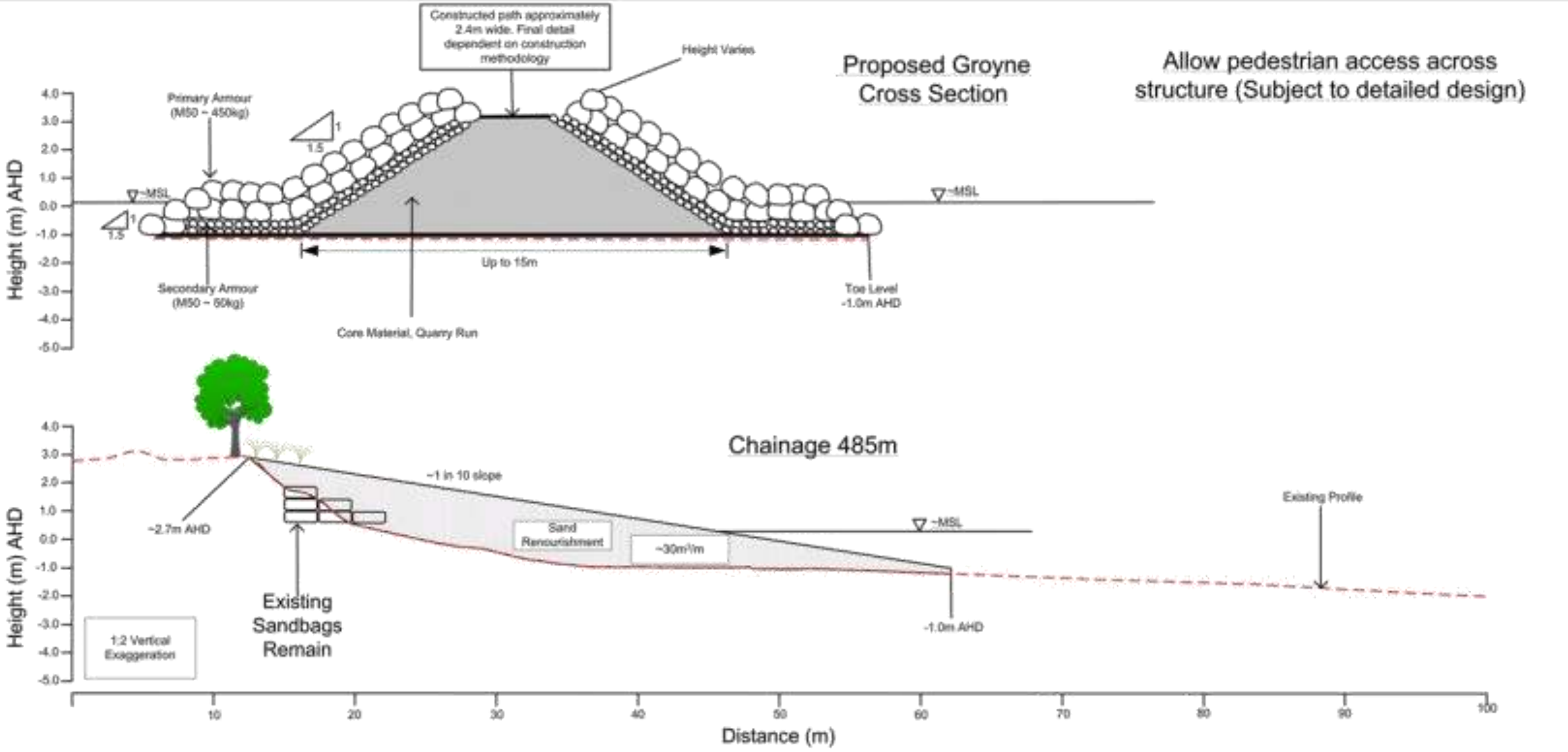

Figure 11 Scheme 1, Precinct 2: Profiles – Chainage 485m and Groyne		
Sandy Point/Conroy Park Foreshore Erosion and Management Plan		
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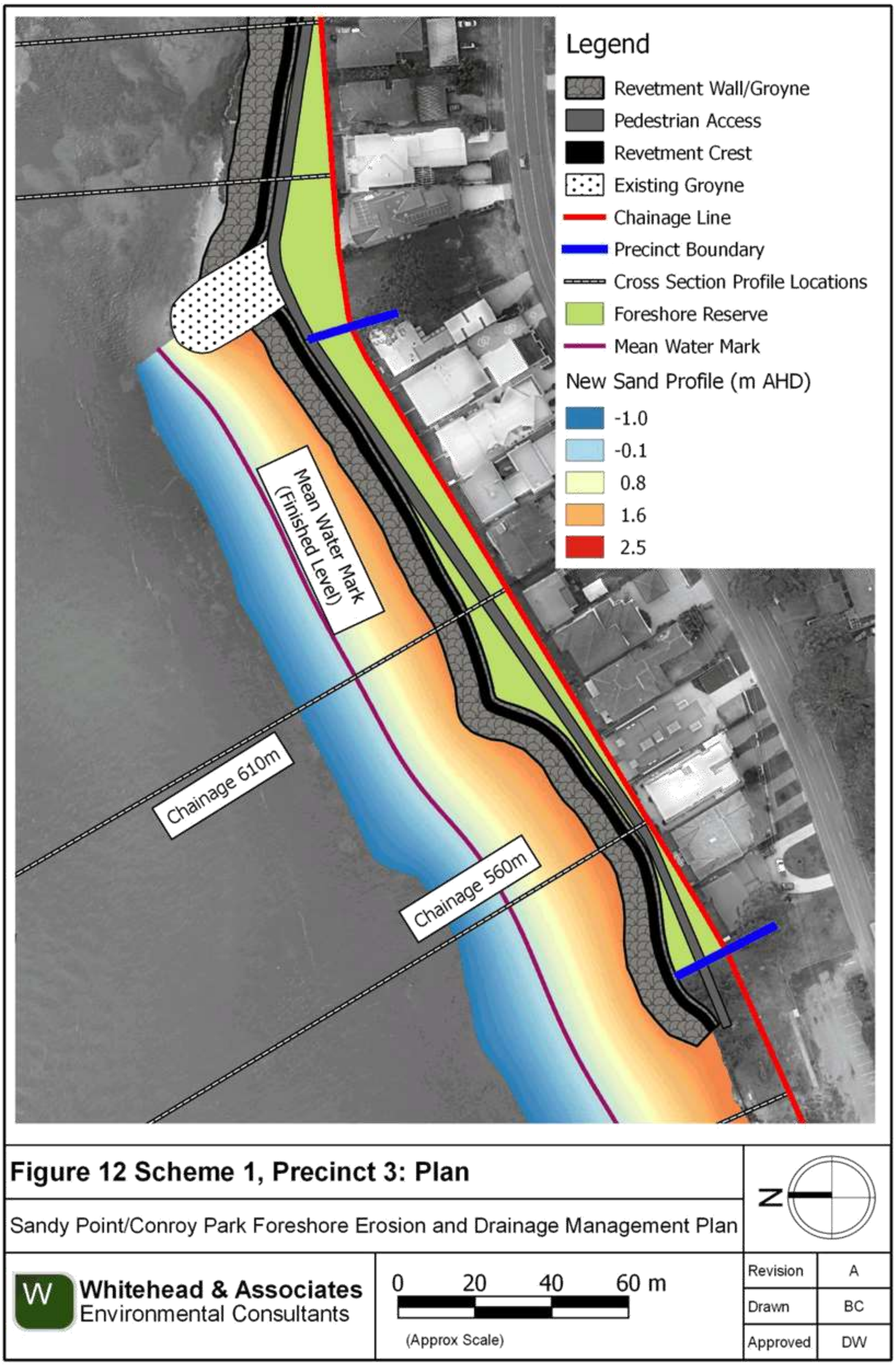

Figure 12 Scheme 1, Precinct 3: Plan

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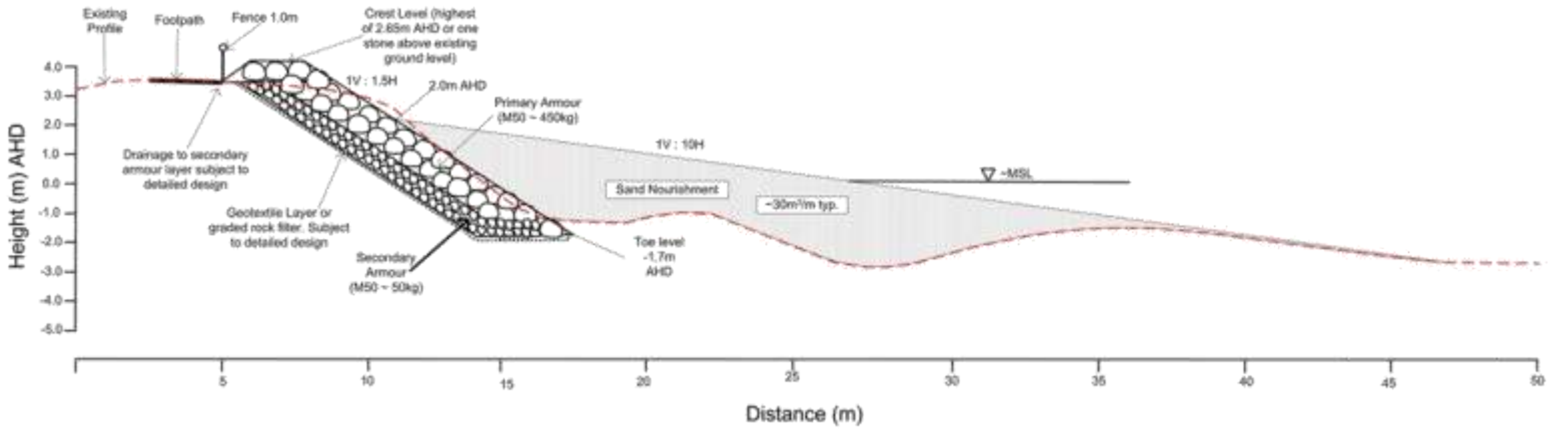

Figure 13 Scheme 1, Precinct 3: Profiles - Chainage 560		
Sandy Point/Conroy Park Foreshore Erosion and Management Plan		
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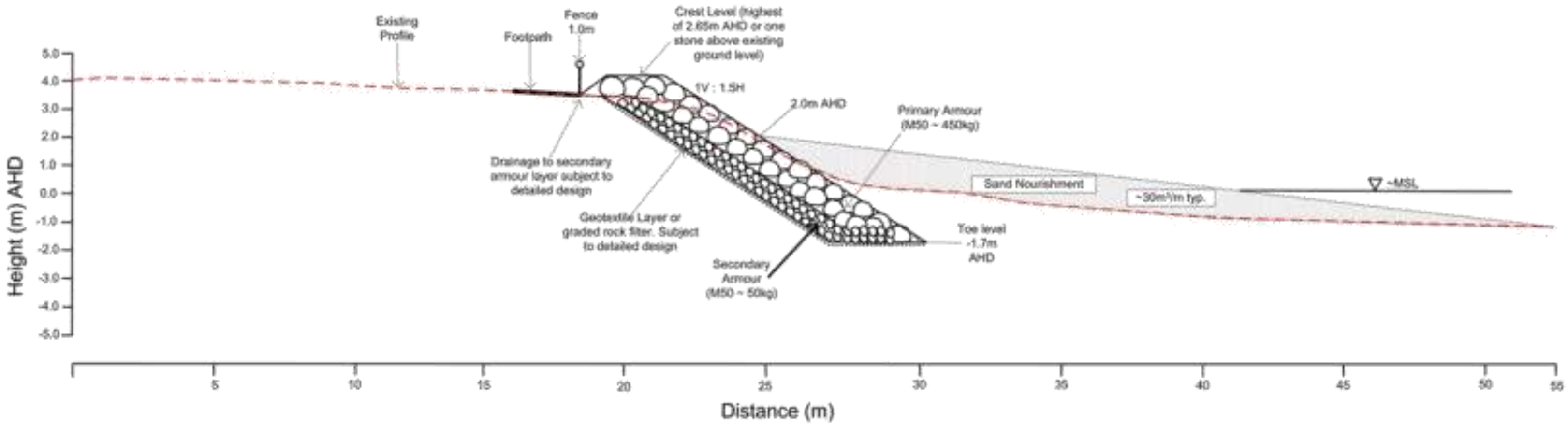

Figure 14 Scheme 1, Precinct 3: Profiles - Chainage 610m

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Drawn	BC
Approved	DW

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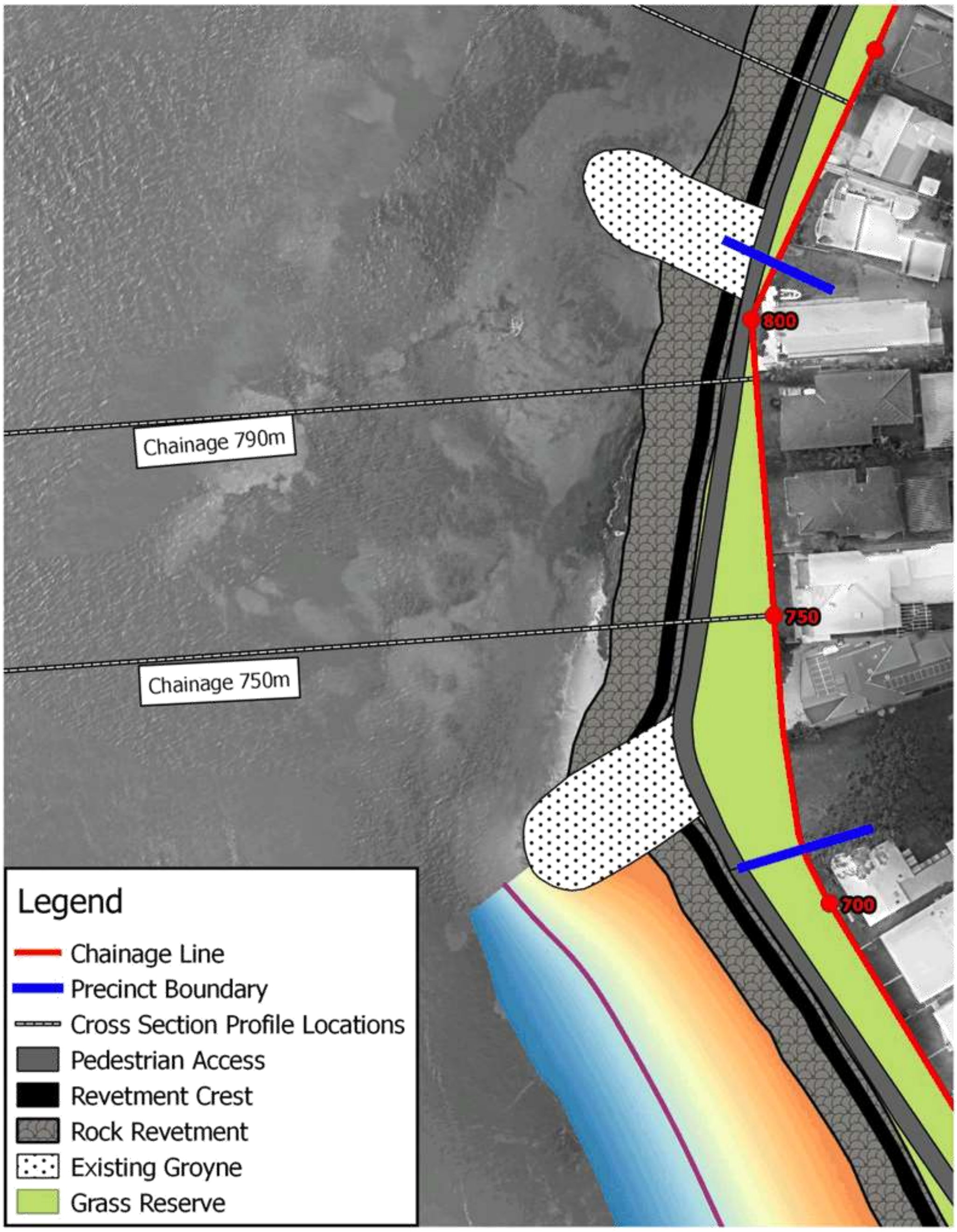

Figure 15 Scheme 1, Precinct 4: Plan

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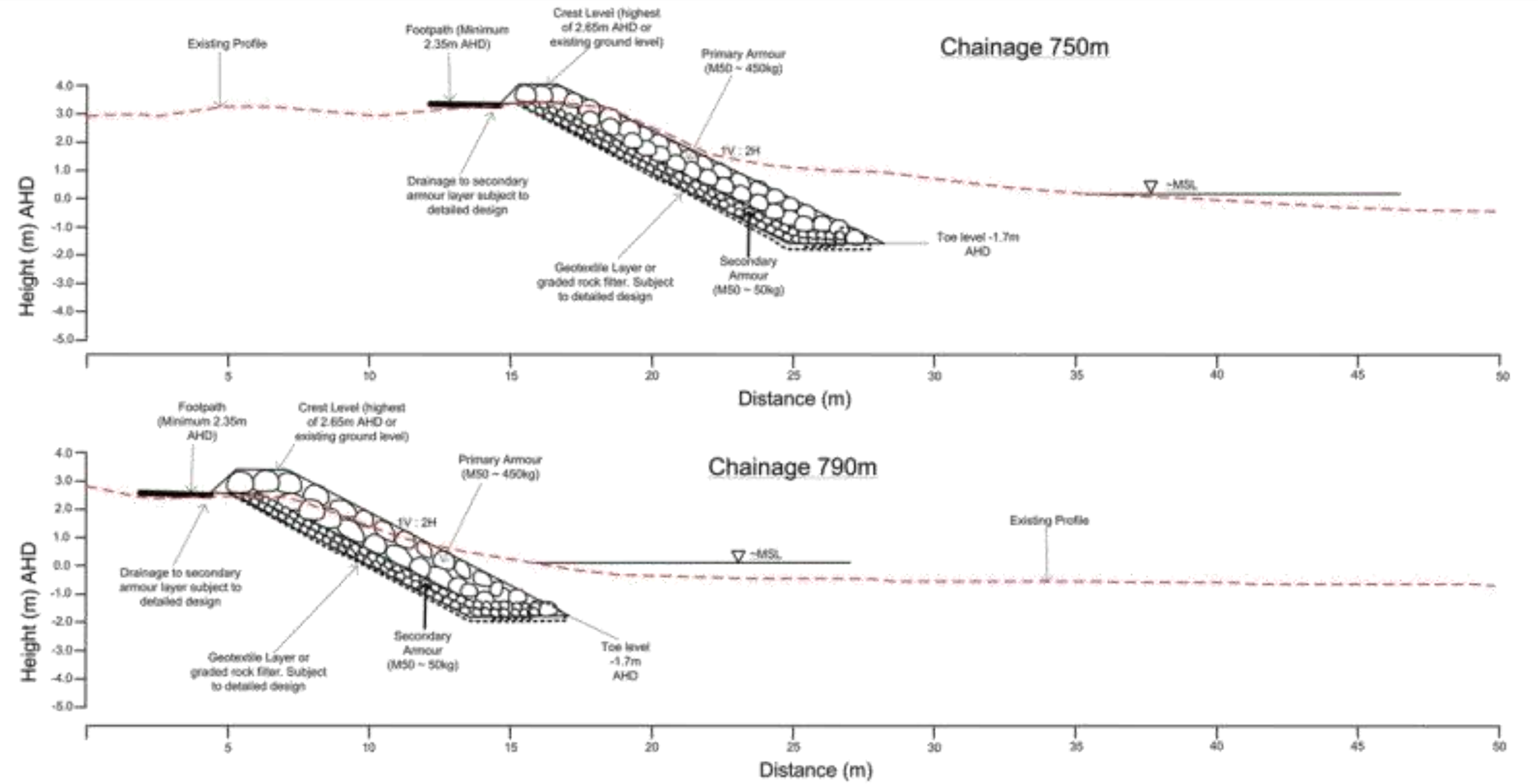

Figure 16 Scheme 1, Precinct 4: Profiles - Chainages 750 and 790m

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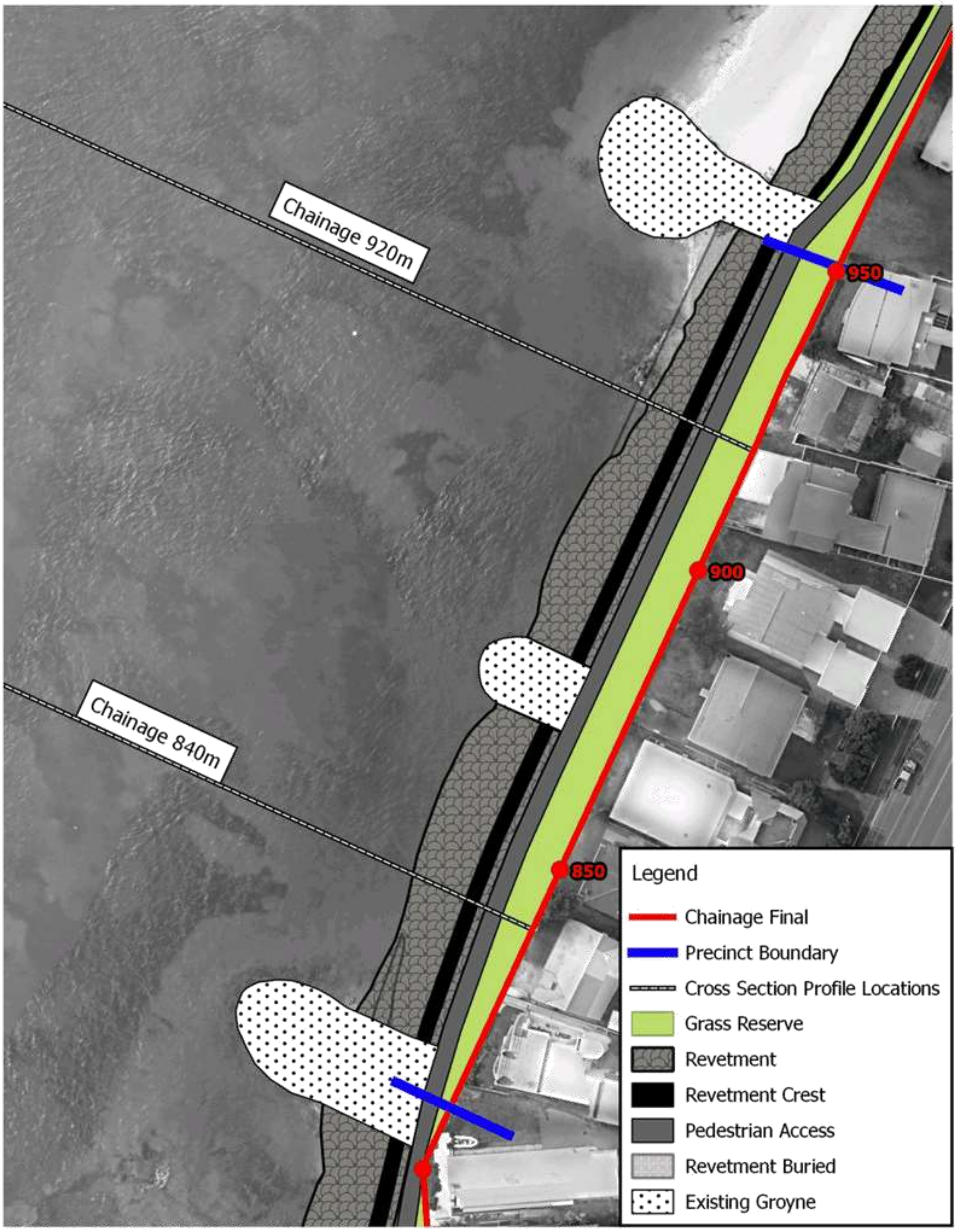

Figure 17 Scheme 1, Precinct 5: Plan

Sandy Point/Conroy Park Foreshore Erosion and Drainage Management Plan

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0 10 20 30 40 50 m
(Approx Scale)

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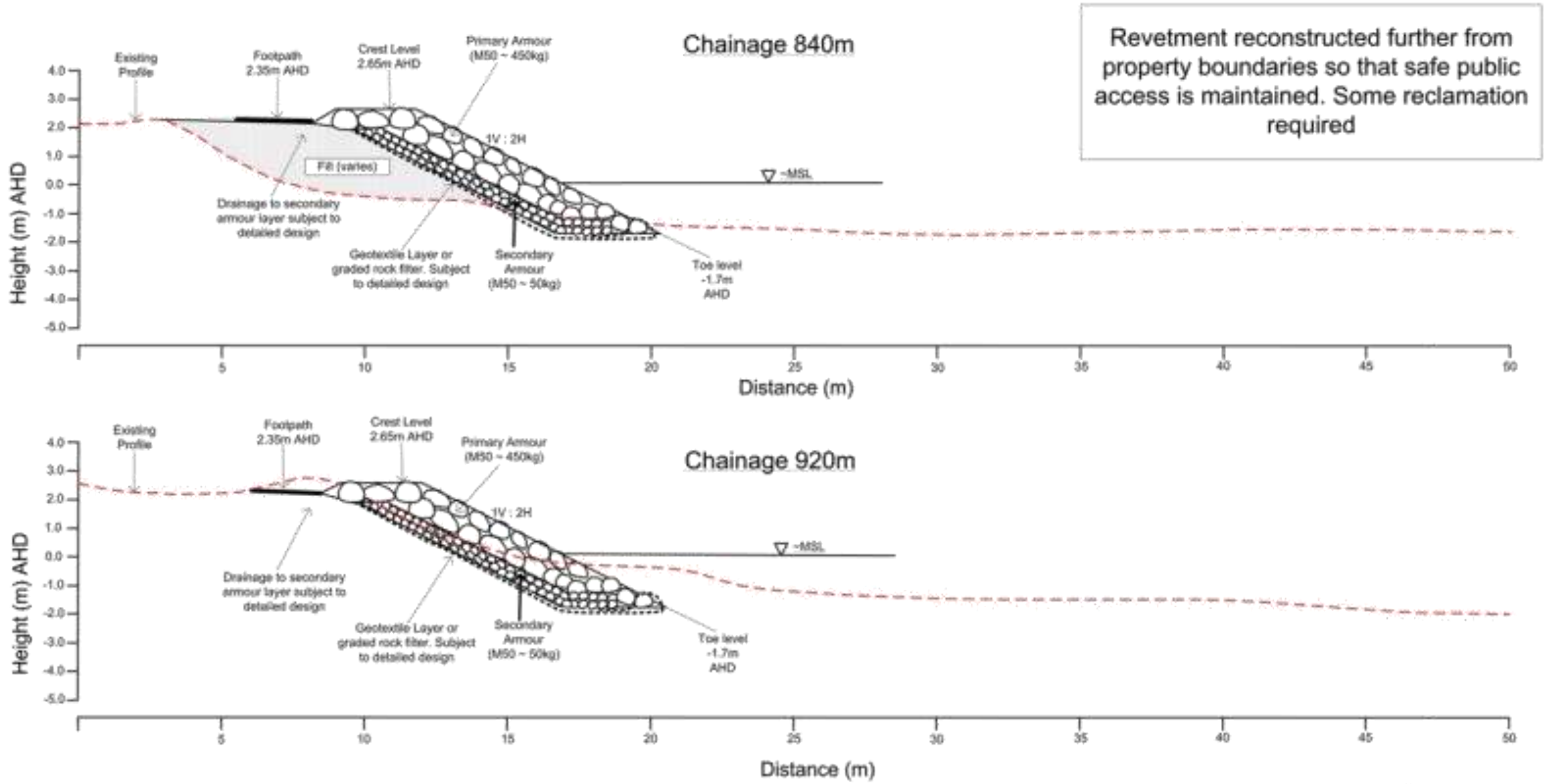

Figure 18 Scheme 1, Precinct 5: Profiles - Chainages 840 and 920m

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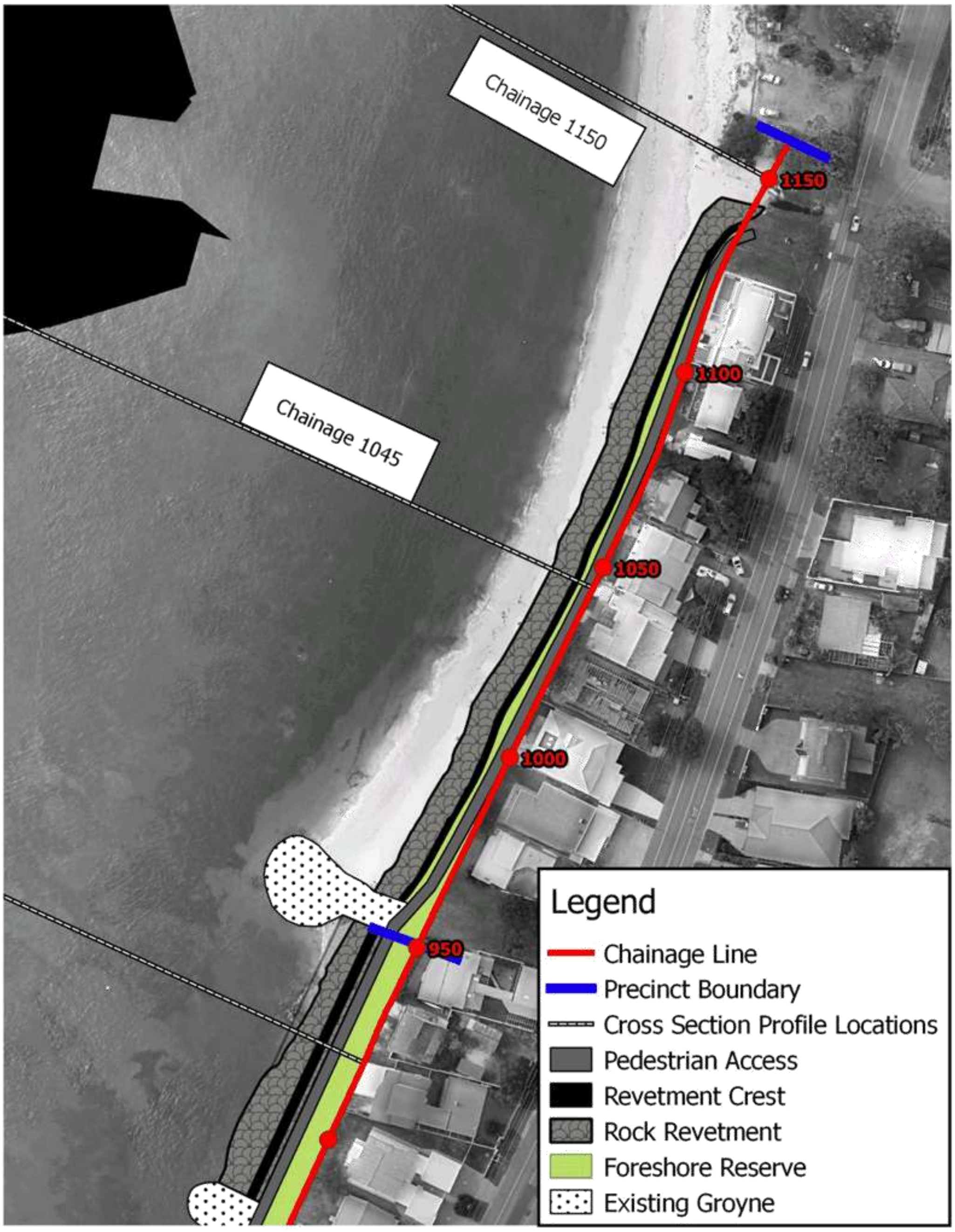

Figure 19 Scheme 1, Precinct 6: Plan

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0 20 40 60 80 m (Approx Scale)

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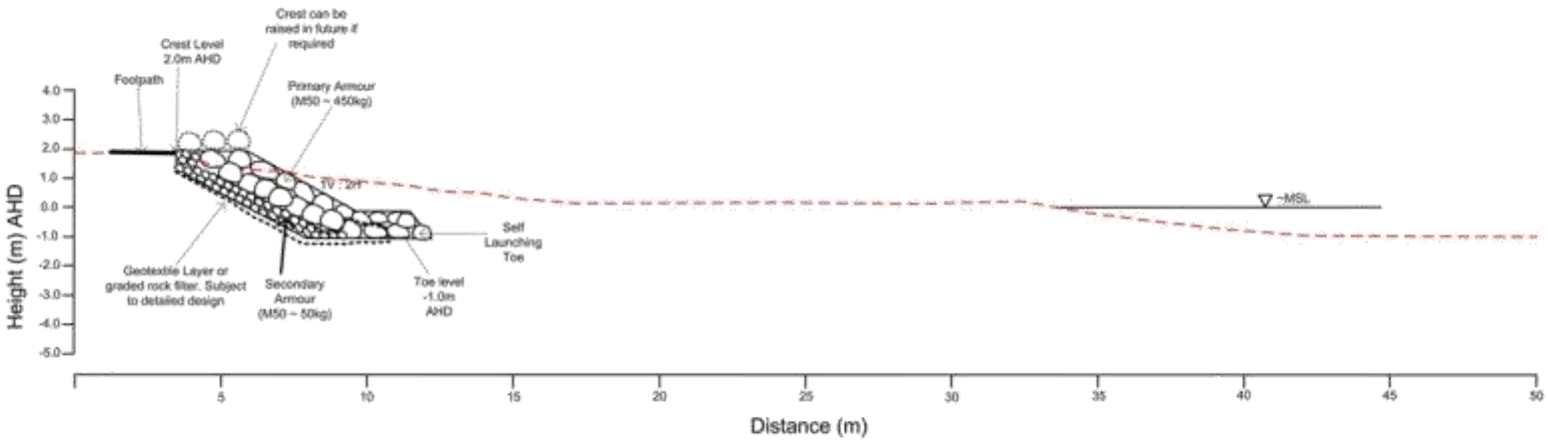

Figure 20 Scheme 1, Precinct 6: Profile – Chainage 1045m

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Scheme 1, Precinct 6, Chainage 1150m,
Drainage Cross Section

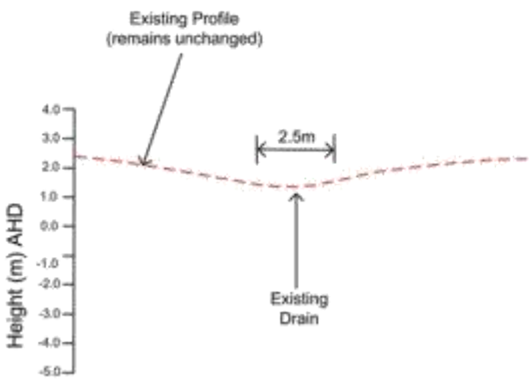

Figure 21 Scheme 1, Precinct 6: Profile 1150m

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Approved	DW

6.2.2 Scheme 2

Table 6 Scheme 2 Presentation

Scheme 2		
Precinct and Details	**Figures**	**Notes**
Precinct 1: Plan	Figure 22	Minimal plan changes are proposed for Precinct 1 in Scheme 2. Twin Gross Pollutant Traps would be installed shoreward of the stormwater outlet across Corlette Beach.
Precinct 1: Profiles	Figure 23 Figure 24	There will be no change from the existing situation
Precinct 2: Plan	Figure 25	The beach would be nourished with imported sand, Dredging from the leading edge of the Port Stephens flood tide delta dropover the most economical source, pending permission from state government agencies. The proposed nourishment would increase beach width at mid-tide from zero at the present time, to around 30-35 metres when fully nourished. Nourishment activities would normally occur every 5-10 years or more frequently depending on weather conditions.
Precinct 2: Profiles	Figure 26	Nourished Beach Profiles are identical to those proposed as part of Scheme 1.
Precinct 3: Plan	Figure 27	Similarly to Scheme 1, the revetment is reconstructed and the beach nourished although this time nourished sand would be imported and not taken from the accumulated sand adjacent to “The Anchorage”. The amount of nourishment in Precincts 2 and 3 is the same for all three schemes. In addition to these changes, Groyne ‘A’ would be bolstered, extended and reconfigured to a “fishtail” to encourage the retention of a wider beach adjacent to the foreshore.
Precinct 3: Profiles	Figure 28 Figure 29	It is envisaged that the existing structure at Groyne A will reduce the need to import fill to create the core of the structure by 50%. Otherwise construction and cross section of the groyne is similar to that proposed in Precinct 2 (Scheme 1), with the exception that the side slopes would be at 1V:2H. The flatter slopes are required to accommodate a higher exposure to wave energy in this location.

Scheme 2

Precinct and Details	Figures	Notes
Precinct 4: Plan	Figure 30	Similarly to Scheme 1, the revetment is reconstructed with some reclamation. In addition to these changes, groyne 'B' would be bolstered, extended and reconfigured to encourage the retention of a wider beach adjacent to the foreshore.
Precinct 4: Profiles	Figure 31	It is envisaged that the existing structure at groyne B will reduce the need to import fill to create the core of the structure by 50%. Otherwise construction and cross section of the groyne is similar to that proposed for Groyne 'A' (Precinct 3)
Precinct 5: Plan	Figure 32	This option illustrates what would be required to maintain a stable beach in front of Precinct 5. Groyne C is extended (along with Groynes B from Precinct 4 and Groyne D from Precinct 6) to the approximate extent required to provide for a stable beach in each compartment, without the need for a continual infeed of sediment from the east. Periodic nourishment may still be required.
Precinct 5: Profiles	Figure 33	As the beach is currently protected from wave impact and erosion, the revetment is only demolished and reconstructed down to an elevation of 0.5m and reconstructed with the same primary and secondary armour as Scheme 1, providing a clear delineation between the back of the beach and the foreshore reserve. All boat ramps would be demolished and filled in. The groyne cross sections are similar to that for Groyne A; however groynes C and D, as proposed, are longer. The beach is nourished with around 12,500 cubic metres of sand.
Precinct 6: Plan	Figure 34	The existing structures are demolished with non-reusable materials disposed to landfill. Re-useable rock is used to provide delineation between the beach and the foreshore reserve. The beach is nourished offshore to provide an ongoing source of beach sand for longshore transport. Two Gross pollutant traps are proposed upstream of Groyne D and the eastern stormwater crossing is to be formalised by filling and construction of a dish drain with an infiltration trench.

Scheme 2		
Precinct and Details	**Figures**	**Notes**
Precinct 6: Profiles	Figure 35 Figure 36	20,000 cubic metres of sand nourishment is proposed. This will initially bolster the beach fronting Precinct 6 providing protection from storms. However, this will need to be monitored as no enhanced structural protection is proposed. The sandy beach will form the primary defence of this shoreline against the impact of storms. It is expected that sand will progressively move around the coast past precincts 5, 4, 3 and 2 providing "seed" nourishment for the whole study area coastline over coming decades. 20,000 m^3 of sand approximates 10-12 years of the average sand movement rate along Corlette Beach over the past two decades. However, stormier conditions may result in more rapid erosion of Precinct 6 and the sand buffer needs to be maintained.

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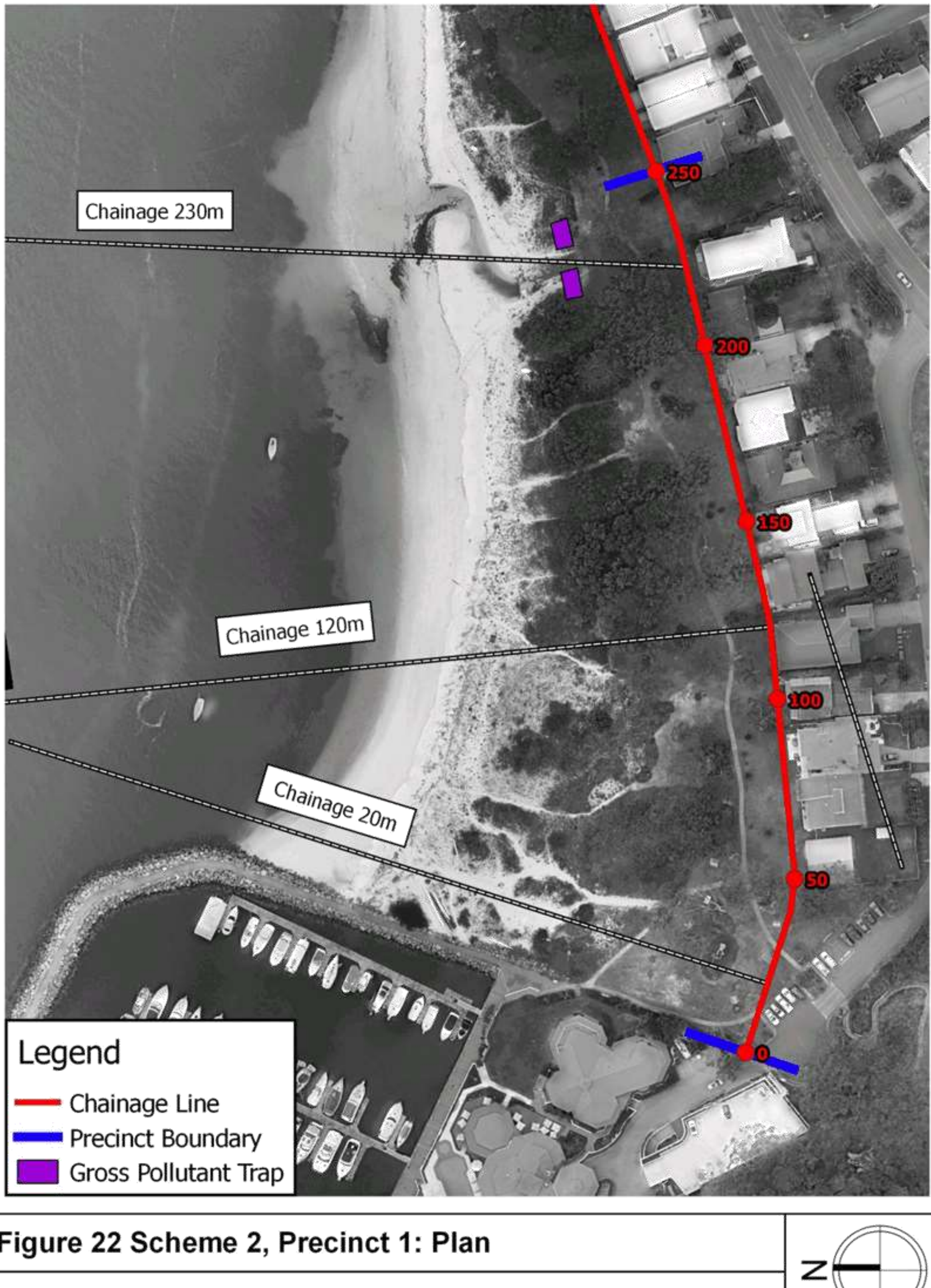

Figure 22 Scheme 2, Precinct 1: Plan

Sandy Point/Conroy Park Foreshore Erosion and Drainage Management Plan

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