Cowan Creek Estuarine Planning Levels Study

Stage 1 and 2 Report

Contact Information

Rhelm Pty Ltd
ABN: 55 616 964 517
Level 1, 50 Yeo Street
Neutral Bay NSW 2089
Australia

Contact:
Emma Maratea
emma.maratea@rhelm.com.au

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Executive Summary

Cowan Creek is a tributary of the Hawkesbury River, located in its downstream reaches, where the river flows to the sea. Foreshore areas of Cowan Creek are subject to periodic inundation by coastal and estuarine processes (coastal/estuarine inundation is one aspect of coastal hazard).

Cowan Creek is located within Ku-ring-gai Chase National Park and includes Cottage Point as the main populated settlement. The local government boundary between the Northern Beaches local government area (LGA) and the Hornsby Shire local government area sets an administrative border along the length of Cowan Creek.

This estuarine planning levels study seeks to define the estuarine inundation risk on foreshore properties (primarily residential properties) within the Northern Beaches LGA both under existing and future sea level conditions.

Coastal Inundation and Development

Coastal inundation (and subsequent impacts on property and infrastructure within this zone) can be caused by large waves and elevated water levels associated with a range of coastal and oceanographic responses to severe storms. Within this report this is referred to as 'Estuarine Inundation Risk' (estuaries form part of the overall coastal zone). The nature and extent of the inundation is dependent on the interactions between the ocean and the land. Thus, an understanding of the interactions of the ocean and the land is essential to identify the likely extent of coastal inundation.

In order to ensure development is compatible with the effects of coastal inundation, it is necessary to apply appropriate development controls to proposed developments and considered in infrastructure planning. Appropriate planning levels for the purposes of design and construction of buildings and other features are estimated from the best available information on water levels associated with either or both catchment flooding and coastal inundation (both types of flooding/inundation can occur on some properties).

The planning levels are generally set to seek to minimise the potential for inundation and damage during rare and extreme inundation events. In this report the levels associated with Estuarine Inundation Risk are referred to as Estuarine Planning Levels (EPLs). Flood Planning Levels (FPLs) are those associated with catchment flooding, which may be associated with flooding from the Hawkesbury-Nepean River system or from local overland flows. These FPLs are beyond the scope of this assessment. In the study area estuarine inundation is considered the predominant form of flooding. There will be interaction with catchment flooding and there may be local circumstances where a property has both an EPL and an FPL notification on its Section 10.7 planning certificate.

This EPL Study has been prepared in the following stages, which are both presented within this report:

- Stage 1 Coastal Modelling: coastal and estuarine modelling to define the foreshore inundation risk; and
- Stage 2 Property Data: application of the modelling outcomes at a property scale (i.e. defining the EPLs for each at risk property).

Coastal Inundation Processes Overview

To calculate appropriate EPLs it is necessary to understand the oceanographic and coastal processes impacting the foreshore. The following coastal processes have been considered in the determination of EPLs for Cowan Creek:

- Regional Processes (ocean scale of hundreds of kilometres);
- Local Processes (within Hawkesbury River and Cowan Creek – scale of a few kilometres); and
- Site Specific Processes (scales of tens of metres).

The following data and model inputs have been utilised in this study to complete numerical modelling required to define coastal inundation extent and levels in the study area:

- Cowan Creek Water Levels; and
- Coastal Storm Winds.

Note that Cowan Creek is sufficiently protected from ocean swells and only local wind waves generated over Cowan Creek have been considered in this study.

Coastal Inundation Numerical Modelling

The estuarine modelling has been undertaken with two separate model systems to account for the varying processes that contribute to the calculation of EPLs. The two model systems are:

1. Delft3D hydrodynamic model to model local wind setup that occurs within Cowan Creek; and
2. SWAN wave model, which adopts the same grid as the Delft3D model, to model local sea waves generated within Cowan Creek from wind forcing.

Estuarine Planning Levels

Results for over 1900 output locations at 30m spacing were derived, however only 74 locations from Cottage Point and the d'Albora Marina at Akuna Bay, are presented in this report as these generally relate directly to the location of private property. EPLs have been calculated for each of these output locations along the foreshore at Cottage Point and Akuna Bay based on the outcomes of the estuarine modelling. Specifically, this includes:

- Identifying the 100 Year ARI ocean tidal level and incorporating sea level rise;
- Calculating the wind setup and wave heights (sea and swell) based on the model results;
- Calculating wave run-up and overtopping, which requires:
    - Defining the typical foreshore types around the Cowan Creek study area;
    - Calculation of the reduction in overtopping wave heights as a result of distance from the foreshore; and
- Applying a freeboard to allow for any uncertainties primarily associated with the water level and wave calculations.

The components of the EPLs are shown diagrammatically in **Figure E1-1**.

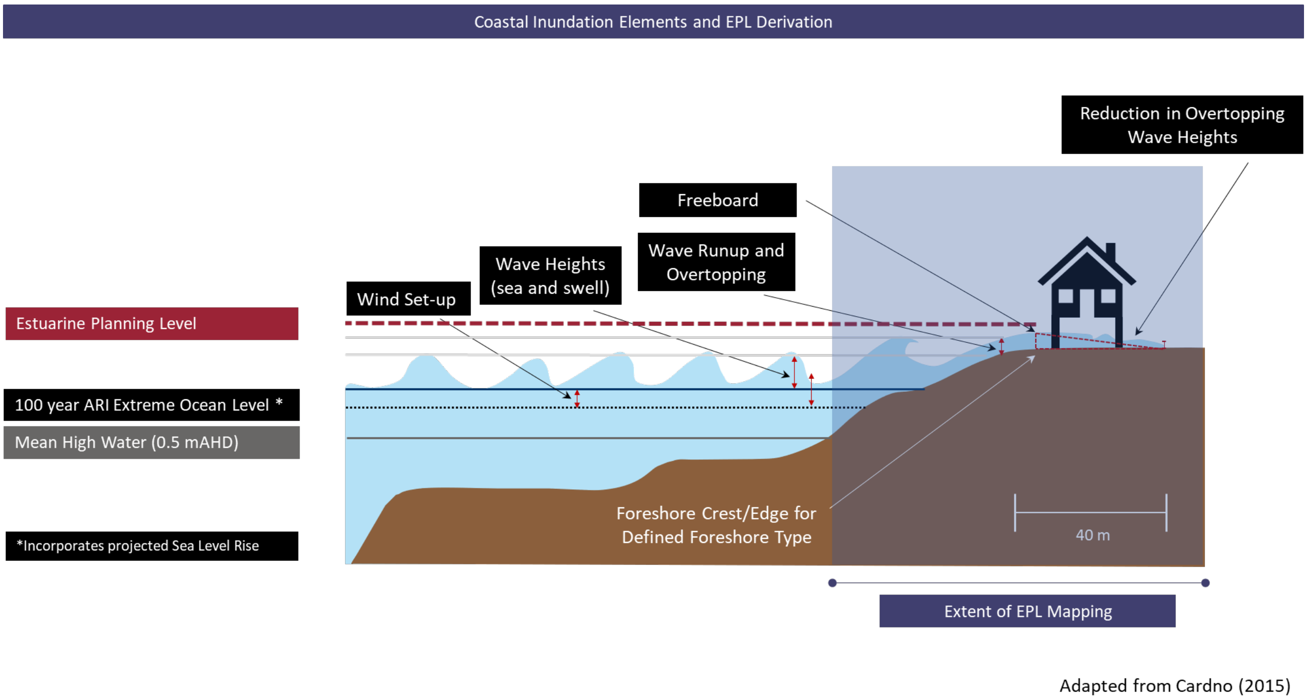

Figure E1-1 Estuarine Planning Level Components

This report provides the identification of 61 allotments in Cowan Creek, specifically at Cottage Point and Akuna Bay, that would potentially have estuarine inundation risk planning controls applied to development proposed on these allotments. Further, this report identifies EPLs for each of these allotments.

Council is currently reviewing its planning process with regards to the application of EPLs within the study area and notification of estuarine inundation risk on property planning certificates. The results of this study should be used to update planning certificates for properties that have an estuarine inundation risk within Cowan Creek.

It is anticipated that community engagement will be an important aspect of future stages of this project.

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Glossary*

Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average recurrence interval (ARI)	The average time between which a threshold is reached or exceeded (e.g. large wave height or high water level) of a given value. Also known as Return Period.
Benchmarks	A standard by which something can be measured or judged. For example, predicted amounts of sea level rise to incorporate into planning considerations.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Climate change	A process that occurs naturally in response to long-term variables, but often used to describe a change of climate that is directly attributable to human activity that alters the global atmosphere, increasing change beyond natural variability and trends.
Crest level	The level in metres Australian Height Datum (mAHD) of the top of a particular foreshore type.
Coast	A strip of land of variable width that extends from the shoreline inland to the first significant landform that is not influenced by coastal processes (such as waves, tides and associated currents).
Coastal inundation	Coastal inundation occurs when a combination of marine and atmospheric processes raises the water level at the coast above normal elevations, causing land that is usually ‘dry’ to become inundated by sea water. Alternatively, the elevated water level may result in wave run-up and overtopping of natural or built shoreline structures (e.g. dunes, seawalls). In the case of an estuary, coastal inundation may be caused by a combination of processes including high tides, storm surge and wave run-up onto the foreshore.
Coastal processes	Coastal processes are the set of mechanisms that operate at the land-water interface. These processes incorporate sediment transport and are governed by factors such as tide, wave and wind energy.
Coastal Zone	The coastal zone, as defined by the Coastal Management Act 2016, means the area of land comprised of the following coastal management areas: (a) the coastal wetlands and littoral rainforests area, (b) the coastal vulnerability area, (c) the coastal environment area, (d) the coastal use area.

Design storm event	A significant event to be considered in the planning process.
Development	As defined in the Environmental Planning and Assessment Act 1979 (EP&A Act). New development refers to development of a completely different nature to that associated with the former land use, e.g. the urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. Infill development refers to the development of vacant blocks of land that are generally surrounded by already developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development Redevelopment refers to rebuilding in an area, e.g., as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.
Estuarine Planning Level	The combinations of elevated estuarine water levels (derived from significant historical sea or ocean events or sea/ocean levels of specific ARIs) and freeboards selected for estuarine inundation risk management purposes.
Estuary	The CM Act defines an estuary as any part of a river, lake, lagoon, or coastal creek whose level is periodically or intermittently affected by coastal tides, up to the highest astronomical tide.
Extreme Ocean Water Level	The highest elevation reached by the sea/ocean as recorded by a tide gauge during a given period (after MHL, 2018).
Extreme Storm Event	Storm for which characteristics (wave height, period, water level etc.) were derived by statistical 'extreme value' analysis. Typically, these are storms with average recurrence intervals (ARI) ranging from one to 100 years.
Foreshore	The part of the shore, lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the ordinary low water mark, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall; or the beach face, the portion of the shore extending from the low water line up to the limit of wave uprush at high tide. The CM Act defines the foreshore as 'the area of land between highest astronomical tide and the lowest astronomical tide'.
Foreshore Crest/Edge	Generally, the landward limit of the foreshore. In some cases, it may be located higher than the upper limit of wave wash at high tide.
Foreshore type	The nature of the foreshore at any given location, e.g. retaining wall, sandy beach, rocky foreshore.

Flood	A general and temporary condition of partial or complete inundation of normally dry land areas, including inundation as a result of sea/ocean storms and other coastal processes or catchment flows.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into three types, existing, future and continuing risks as described below: ▪ Existing flood risk is the risk a community is exposed to as a result of its location on the floodplain. ▪ Future flood risk is the risk a community may be exposed to as a result of new development on the floodplain. ▪ Residual flood risk is the risk a community is exposed to after floodplain risk management measures have been implemented.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the EPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level. As a component of the EPL, a freeboard is added to the local (still) water level.
Geographical information system (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High Tide	The maximum height reached by a rising tide. The high water is due to the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions.
Highest astronomical tide (HAT)	The highest level which can be predicted to occur under average meteorological conditions and any combination of astronomical conditions. In Australia HAT is calculated as the highest level from tide predictions over the tidal datum epoch (TDE), this is currently set to 1992 to 2011. The HAT and the Lowest Astronomical Tide (LAT) levels will not be reached every year. LAT and HAT are not the extreme water levels which can be reached, as storm surges may cause considerably higher and lower levels to occur.
Mean high water mark	The line of the medium high tide between the highest tide each lunar month (the springs) and the lowest tide each lunar month (the neap) averaged over out over the year. In NSW, the methods for determining the position of the MHWM are outlined in the *Crown Directions to Surveyors - No. 6 Water as a Boundary.*
Mean High Water Springs (MHWS)	The MHWS is the highest level which spring tides reach on the average over a period of time (usually several years).
Mean Low Water Springs (MLWS)	The MLWS is the lowest level which spring tides reach on the average over a time period (usually several years).

Mean Sea Level (MSL)	MSL is a measure of the average height of the sea or ocean's surface such as the halfway point between the mean high tide and the mean low tide. At present, mean sea level is approximately equivalent to 0mAHD (reported as 0.03 mAHD in MHL, 2019).
Probability	A statistical measure of the expected frequency or occurrence of flooding.
Risk	The chance of something happening that will have an impact on objectives, usually measured in terms of a combination of the consequences of an event and their likelihood.
Sea	Tasman Sea (interchangeably also referred to as Ocean in this report).
Sea level rise (SLR)	A rise in the level of the sea surface that has occurred or is projected to occur in the future, as measured from a point in time. The rise can be reported as a global mean or as measured at a specific point or estimated for a specific part of the sea or ocean.
Storm surge	The increase in coastal water level caused by the effects of storms. Storm surge consists of two components – the increase in water level caused by the reduction in barometric pressure and the increase in water level caused by the action of wind blowing over the sea surface (wind set-up).
Storm tide	An abnormally high water level that occurs when a storm surge combines with a high astronomical tide. The storm tide must be accurately predicted to determine the extent of coastal inundation.
Tidal inundation	The inundation of land by tidal action under average meteorological conditions and the incursion of sea water onto low lying land that is not normally inundated, during a high sea level event such as a king tide or due to longer-term sea level rise. For these planning controls, it is defined as the land that is inundated up to the level of Highest Astronomical Tide (HAT).
Wave run-up	The vertical distance above mean water level reached by the uprush of water from waves across a beach or up a structure.
Wave set-up	The rise in the water level above the still water level when a wave reaches the coast. It can be very important during storm events as it results in further increases in water level above the tide and surge levels.
Wind waves	Waves resulting from the action of the wind on the surface of the water.

*Many of the glossary terms here are derived or adapted from the *Coastal Management Glossary* (OEH, 2018).

Acronyms and Abbreviations

1D	One-Dimensional
2D	Two- Dimensional
3D	Three-Dimensional
AHD	Australian Height Datum
AEP	Annual Exceedance Probability
AIDR	Australian Institute for Disaster Resilience
ARI	Average Recurrence Interval
AR	Assessment Report (IPCC)
ARR	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
CD	Chart Datum
CM Act	Coastal Management Act, 2016
CM SEPP	State Environmental Planning Policy (Coastal Management) 2018
DCP	Development Control Plan
DECC	Department of Environment and Climate Change (now largely DPIE)
DECCW	Department of Environment, Climate Change & Water (now largely DPIE)
DEM	Digital Elevation Model
DLWC	Department of Land and Water Conservation (now largely DPIE)
DoI (Water)	Department of Industry (Water) (formerly DPI Water) (now DPIE)
DPE	Department of Planning and Environment (now DPIE)
DPIE	Department of Planning, Industry and Environment
DPI Water	Department of Primary Industries – Water (Now DPIE)
ECL	East Coast Low
ENSO	El Niño-Southern Oscillation
EPL	Estuarine Planning Level
FFL	Finished Floor Level
FPL	Flood Planning Level
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
Ha	Hectares

Hs	Significant Wave Height
Hm0	Significant Wave Height
IFD	Intensity-Frequency-Duration
IPCC	Intergovernmental Panel on Climate Change
ISEPP	State Environmental Planning Policy (Infrastructure) 2007
km^2	Square kilometres
LAT	Lowest Astronomical Tide
LEP	Local Environment Plan
LGA	Local Government Area
LiDAR	Light Detention and Ranging
m^2	Square metres
m^3	Cubic metres
m/s	Metres per second
m^3/s	Cubic metres per second
mAHD	metres to Australian Height Datum
mm	Millimetres
m/s	Metres per second
NSW	New South Wales
OEH	Office of Environment and Heritage (now DPIE)
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
$R_{2\%}$	Two percent wave run up level. This is the run-up level, vertically measured with respect to the still water level, which is exceeded by two per cent of the incoming waves.
RCP	Representative Concentration Pathway
SES	State Emergency Service
SWL	Still Water Level
TN	True North
Tp	Wave period

1 Introduction

Cowan Creek is a tributary of the Hawkesbury River, located in its downstream reaches, where the river flows to the sea (see **Figure 1-1**). Foreshore areas of Cowan Creek are subject to periodic inundation by coastal and estuarine processes. Coastal/estuarine inundation is one aspect of coastal hazard (*Coastal Management Act 2016*).

In order to ensure development is compatible with the effects of coastal inundation, it is necessary to ensure appropriate development controls are applied to proposed developments where consent is required under Part 4 of the *Environmental Planning and Assessment Act 1979* or where information is relevant to infrastructure planning (such as under the provisions of *State Environmental Planning Policy (Infrastructure) 2007*). Appropriate planning levels for the purposes of design and construction of buildings and other features are estimated from the best available information on water levels associated with either or both catchment flooding and coastal inundation (both types of flooding/inundation can occur on some properties). The planning levels are generally set to seek to minimise the potential for inundation and damage during rare and extreme inundation events.

Rhelm, with the assistance of Baird Australia, was engaged by Northern Beaches Council (Council) to determine appropriate planning levels for the foreshore areas of Cowan Creek based on a range of oceanic and estuarine processes (including ocean tide, wind set up and wave height, wave runup, a freeboard and allowance for sea level rise).

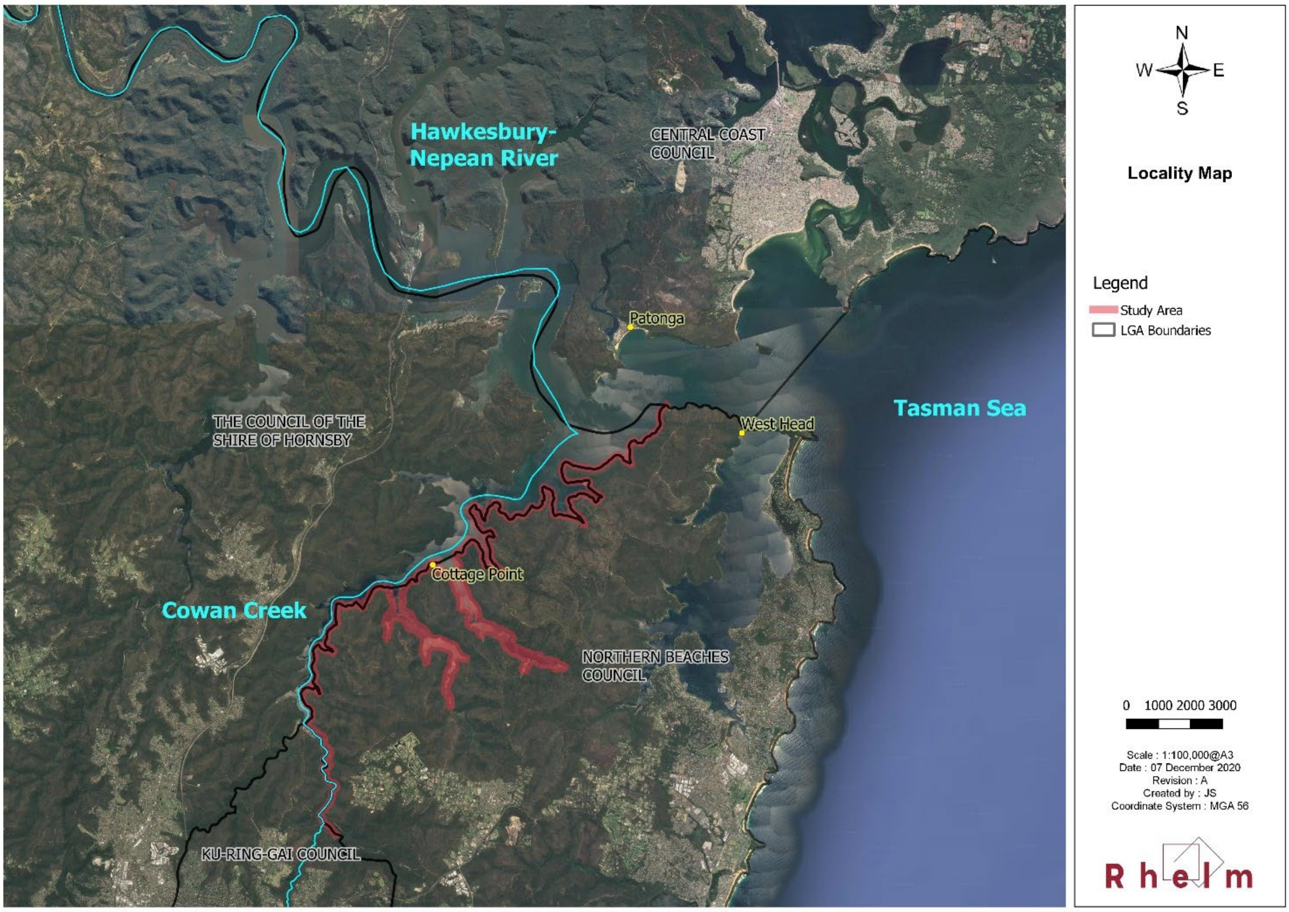

Figure 1-1 Locality Map

1.1 Study Context

Inundation of the coastal zone (and subsequent impacts on the urban development within this zone) can be caused by large waves and elevated water levels associated with a range of coastal and oceanographic process responses to severe storms. Within this report this is referred to as 'Estuarine Inundation Risk'. The nature and extent of the inundation is dependent on the interactions between the ocean and the land. Thus, an understanding of the interactions of the ocean and the land is essential to identify the extent of coastal inundation.

Estuarine Planning Levels (EPLs) are currently applied as a method for managing risk to property along the foreshore of Pittwater (in the north of the Northern Beaches LGA). EPLs are applied under the provisions of the *Pittwater Local Environmental Plan 2014*. More specifically, Council's approach to managing this risk is set out in the *Estuarine Risk Management Policy for Development in Pittwater*, within the *Pittwater 21 Development Control Plan*.

At the time of preparation of this study Northern Beaches Council still had separate Local Environmental Plans (LEPs) and Development Control Plans (DCPs) operating for the three former LGA regions (Manly, Warringah and Pittwater). The study area includes part of both the former Pittwater and Warringah LGAs, with the boundary between the former LGAs generally being Coal and Candle Creek in this area.

Coastal hazard is managed at the highest level through the *State Environmental Planning Policy (Coastal Management) 2018*. However, the coastal vulnerability provisions for the Northern Beaches LGA are not yet operational as vulnerability mapping was not in place for Cowan Creek at the time of the completion of this study.

Cowan Creek was not included in the previous EPL study for the Pittwater LGA, *Pittwater Estuary Mapping of Sea Level Rise* (Cardno, 2015), as it was located outside the former Pittwater LGA boundary at the time. Cottage Point is the main population settlement associated with Cowan Creek and this suburb is located in the former Warringah LGA.

Coastal hazard is managed through Clause 6.5 of the *Warringah LEP 2011*, however, this clause only applies to the Coastal Hazard Map (Sheet CHZ_009) and Cowan Creek is not included on this map. Specific development controls relating to coastal hazard are contained within the *Warringah DCP 2011* (Section E9).

The EPLs derived from this study will inform the new planning controls currently being developed by Council for the amalgamated Northern Beaches LGA. This may be done in a similar manner to the existing *Pittwater LEP 2014* and *Pittwater 21 DCP*.

1.2 Study Approach

This EPL Study has been prepared in the following stages, which are both presented within this report:

- Stage 1 Coastal Modelling: coastal and estuarine modelling to define the foreshore risk; and
- Stage 2 Property Data: application of the modelling outcomes at a property scale (i.e. defining the EPLs for each at risk property).

The coastal modelling for Stage 1 has adopted methods to generate coastal flood parameters that are consistent with the *Pittwater Estuary Mapping of Sea Level Rise* (Cardno, 2015) which provided the flood data to inform coastal planning. This included the analysis of the impact of sea level rise values of 0.4m and 0.9m on estuarine inundation.

2 Study Area

The study area includes the foreshore areas of Cowan Creek that lie within the Northern Beaches LGA. Cowan Creek is located within Ku-ring-gai Chase National Park and includes Cottage Point as the main populated settlement. Land uses are predominantly national park, public recreation, and residential and commercial within the suburb of Cottage Point. The study area is shown in **Figure 2-1**.

The local government boundary between the Northern Beaches local government area and the Hornsby Shire local government area sets an administrative border along the length of Cowan Creek. The whole of Cowan Creek has been considered for this study, however reporting only relates to the Northern Beaches portion of the foreshore.

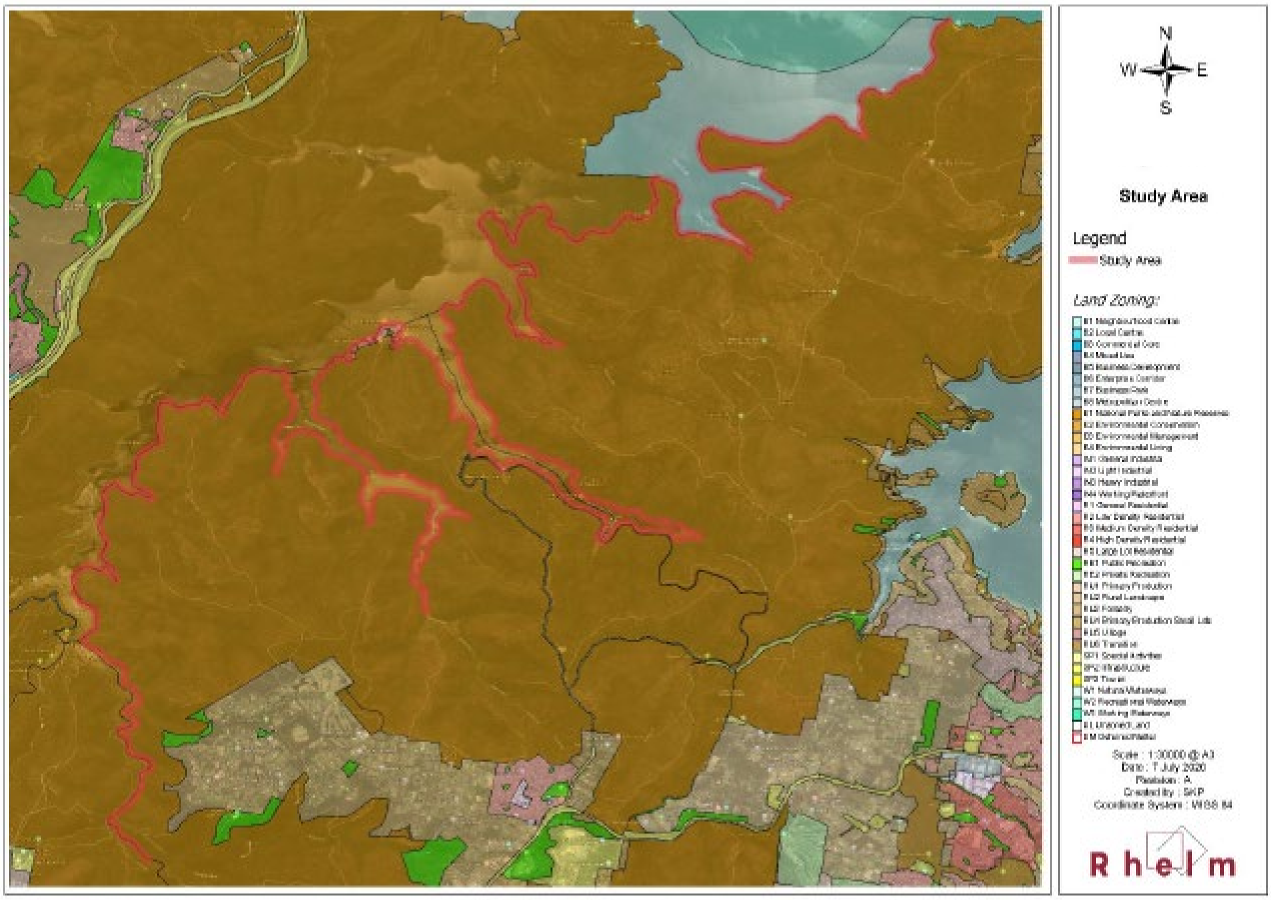

Figure 2-1 Study Area

2.1 Coastal Processes Summary

Cowan Creek is a tributary of the Hawkesbury River, which is a drowned river valley estuary. The Hawkesbury River is tidally dominated in its lower reaches, where Cowan Creek is located (see **Figure 2-1**). Diurnal tides with a range of 0.3-1.6 mLAT (-0.6 - +0.7 mAHD) flow through Cowan Creek with minimal friction loss or transformation of the tide characteristics compared to the open ocean due to the relatively deep channels and uninhibited waters.

The most significant weather systems which can lead to coastal inundation of the Northern Beaches Council areas of Cowan Creek are associated with East Coastal Low (ECL) storms that generate strong winds offshore and along the coastal fringe. These events result in elevated coastal water levels, and strong winds within Cowan Creek to produce wind waves.

Elevated coastal water levels during the passage of a severe storm are the result of barometric effects and wind setup. The combined effect of barometric setup and wind setup is referred to as storm surge. Barometric setup occurs due to the intense low-pressure systems that generate large storms. This reduction in air pressure over the water surface results in a local rise of the water level. Wind setup is a result of the wind inducing wind shear stresses on the water, which in turn generate currents. When these currents are impeded by the coast, a resulting increase in the water level occurs.

As Cowan Creek is very protected from the prevailing southerly and south-easterly swell waves that occur in the Sydney Region, limited swell waves propagate into the creek. Locally generated wind waves are the predominant wave type in Cowan Creek and can be particularly significant for coastal inundation when wave or wave runup impact on coastal structures, for example seawalls. Waves can overtop these structures which can result in significant inundation of adjoining properties. However, the configuration of Cowan Creek and small distances over water the wind can act on, the “fetch”, result in relatively small waves produced by even the strongest winds.

The coastal modelling completed in this study to define coastal flood levels within Cowan Creek have focused on spatially quantifying the following processes that result in coastal inundation of foreshore areas:

- Wind and water level setup from winds acting over Cowan Creek from all possible directions; and
- Local wind waves generated over Cowan Creek from all possible directions.

3 Discussion of Coastal Processes

To calculate appropriate EPLs it is necessary to understand the oceanographic and coastal processes impacting the foreshore. The following coastal processes have been considered in the determination of EPLs for Cowan Creek:

- Regional Processes (ocean scale of hundreds of kilometres);
- Local Processes (within Hawkesbury River and Cowan Creek – scale of a few kilometres); and
- Site Specific Processes (scales of tens of metres).

These processes are consistent with those adopted for the Pittwater EPL Study (Cardno, 2015) and North and Middle Harbour EPL Study (Rhelm, 2022), and are outlined schematically in **Figure 3-1** and described in more detail in the following sections.

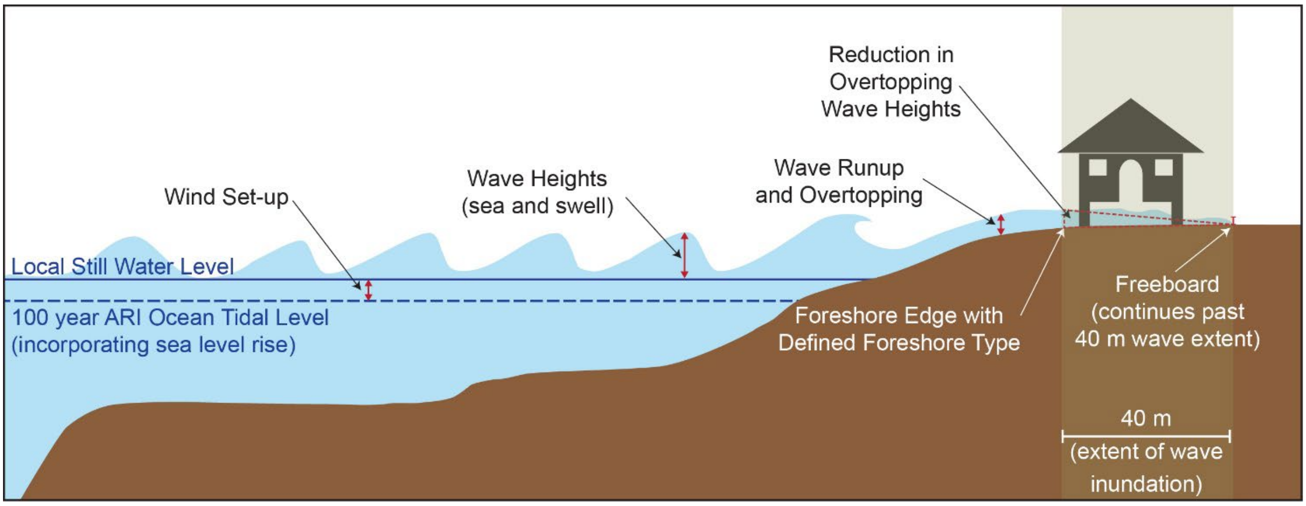

Figure 3-1 Coastal Processes Affecting Estuarine Planning Levels

3.1 Regional Processes

Regional oceanographic processes relate to those ocean processes that are influenced by energy inputs causing sea level fluctuations over the larger scales of the NSW coastal waters and essentially affect coastal waters between Wollongong and Newcastle simultaneously (i.e. hundreds of kilometres of coastline). Coastal water levels in the study area region can be influenced by the following oceanographic processes:

- Astronomic Tides;
- Meteorological / Oceanographic Processes:
    - Storm Surge from wind setup and barometric setup;
    - Ocean Waves;
    - Coastal Trapped Waves;
    - El Niño-Southern Oscillation (ENSO);
    - Meteorological Oscillations;
- Climate Change and Sea Level Rise; and
- Tectonic Processes.

Tectonic processes are not considered in this assessment as they play a very minor role (and hence low risk) in the study area.

At times, these individual factors interact in complex ways to elevate water levels significantly above normal tidal levels. Storms, principally East Coast Lows, with low central atmospheric pressure (barometric setup), strong onshore winds (resulting in wind setup) and large waves superimposed on spring (or king) tides, are the most common cause of elevated water levels (NSW Government, 1990). This is shown diagrammatically in **Figure 3-2**.

Taylor *et al* (2017) and Aldridge *et al* (2018) were able to replicate the extreme wave and water level probability distributions along the NSW coastline with a stochastic East Coast Low model. Those studies concluded along the NSW coast hazard models for the erosion and coastal inundation needed to include astronomical tide, storm surge and ocean waves.

For the Sydney Region, those processes can all be defined from analysis of measured data. The combined probability of water levels from Astronomic Tides and Meteorological / Oceanographic Processes can be well defined from the long-term Fort Denison tide gauge data set (Watson and Lord, 2008). The deep water probability of ocean wave conditions can be defined from the long-term measured wave data along the NSW coast (Shand *et al*, 2011). **Sections 4.1** and **4.2** present the regional scale water level and wave conditions adopted for this study.

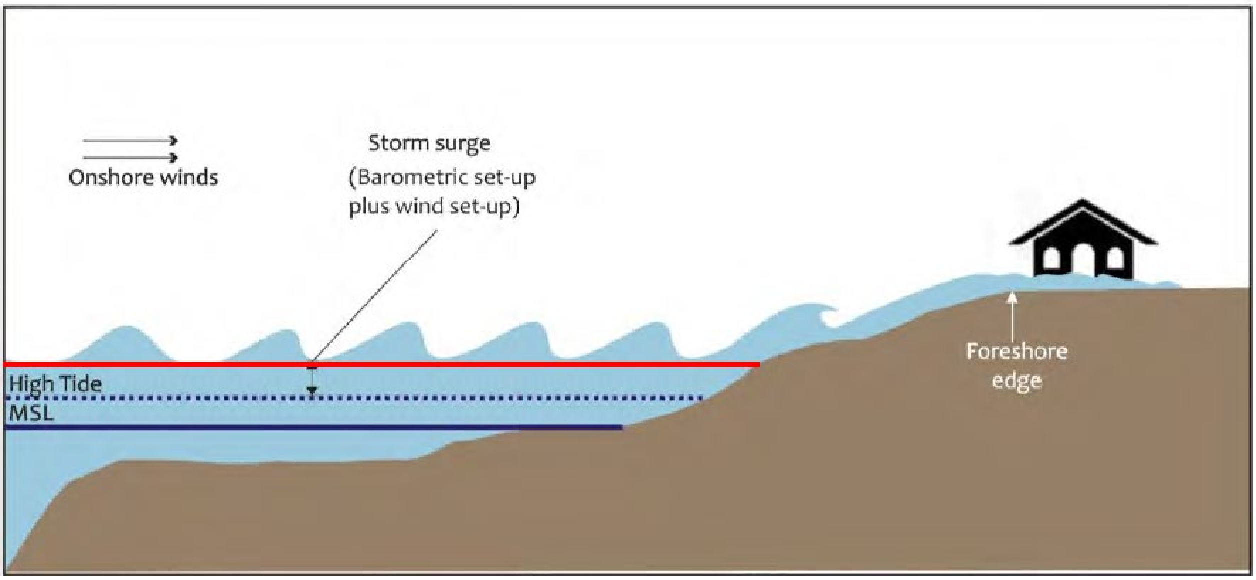

Figure 3-2 Regional Coastal Processes (Source: Cardno, 2015)

Determining a regional elevated water level for planning purposes depends on the probability of that level occurring and the risk associated with it. Planning benchmarks are generally determined on the basis of an annual exceedance probability (AEP) or average recurrence interval (ARI), which relates to the probability of a particular water level occurring or being exceeded. Department of Planning (2007) advises that for flood prone land unless there are exceptional circumstances, councils should adopt the 100 Year Average Recurrence Interval (ARI) flood levels for planning of residential development. This relates to the water level associated with a storm event that has the probability of occurring approximately once every hundred years.

It is important to note that at the time of preparation of this study, the planning circular of 2007 (Department of Planning, 2007) was under review and the Draft Flood Prone Land Package was exhibited for this purpose in mid-2020 (Department of Planning, Industry and Environment, 2020).

3.1.1 Sea Level Rise

Sea level rise will have an impact on coastal inundation levels in the future. It is noted that estuarine inundation is an existing risk as well as a future risk. Sea level rise analysis was therefore undertaken to understand how that risk may increase in the future.

The impact of two sea level rise scenarios has been assessed in this study. In the absence of a Council policy defining specific sea level rise values for this purpose, sea level rise of 0.4m and 0.9m have been selected for analysis to ensure consistency with many of Council's previous flood studies, the Pittwater EPL Study (Cardno, 2015) and the North and Middle Harbour EPL Study (Rhelm, 2022).

The selection of these values is supported by current science. In its fifth assessment report (2013), the IPCC (reported in Church et al, 2013) developed a range of future sea level rise projections associated with different greenhouse gas emission scenarios (representative concentration pathways (RCPs)). These indicate that 0.4m sea level rise is almost certain by 2100 and 0.9m is likely (**Table 3-1**). The application of these levels in this study is discussed in **Section 6.2**. More recent analyses prepared in advance of the sixth assessment report for the IPCC affirm these projections (Oppenheimer et al, 2019).

Table 3-1 Likely Global Sea Level Rise by 2100 (Church et al, 2013)

Scenario	***Likely* global mean sea level rise range by 2100 (relative to 1986-2005)**
Significantly Reduced Emissions (RCP 2.6)	0.24–0.61 m
Highest Emissions (RCP 8.5)	0.54–1.06 m

3.2 Local Processes

Local processes within the context of this study relate to the processes that cause variations in 'elevated local water levels' within Cowan Creek (see **Figure 2-1**). Water levels within the study area will be influenced by local variations as a result of both wind strength and direction and waves.

3.2.1 Local Wind Setup

The same wind that adds to the regional storm surge in the form of wind setup will also cause further variation in the water level through wind setup developed over Cowan Creek. This wind setup, however, is much smaller than the regional storm surge discussed in **Section 3.1** and is limited by the distance of water (fetch) over which the wind blows. As Cowan Creek is relatively narrow, the fetch is small and therefore only a small local wind setup is generated i.e. the highest wind setup is 0.05m at Akuna Bay.

3.2.2 Wave Height

Ocean storms can contribute to elevated water levels along the coastline and inside Hawkesbury River. In the Sydney region the most severe ocean storm waves come from the southeast to south sector. The ocean storm waves propagate from the deeper ocean into the shallow water of Hawkesbury River and the waves undergo changes caused by diffraction, refraction, shoaling, bed friction and wave breaking. As Cowan Creek is located a significant distance from the open ocean (the confluence of Cowan Creek and the Hawkesbury River is approximately 8 km upstream of West Head and Cottage Point is approximately 13 km upstream of West Head), these processes lead to a substantial reduction in swell wave occurrence; hence as influence on local water level is minimal, swell waves have not been analysed in this study.

Local wind generated waves can contribute to the elevated water levels during coastal storms. The highest local wind generated waves will occur during storms that have south to easterly winds that 'push' water onto the coast. In this way the two processes (regional and local) are correlated and the likelihood the highest ocean water levels and highest local wind-generated waves occurring together (joint occurrence) will be very rare on the westward-facing shorelines of the study area. As the foreshore of Cowan Creek within the Northern Beaches LGA has large proportions of west-oriented coastline, this means that the co-incident occurrence of highest ocean water levels and the largest wind-generated waves have a very small likelihood.

Numerical wave modelling of the local wind waves is presented in **Section 5**. Wave heights will vary depending on the location along the Council foreshore areas, however wave heights are typically very small in the study area (0.26m to 0.56m).

3.3 Site Specific Processes

Site specific processes within the context of this study relate to the processes at the foreshore. The physical factors that will impact the elevated water level will be the nature of the foreshore (e.g. retaining wall or sandy beach, referred to in this report as "foreshore type") and the height of the foreshore.

As a wave reaches the foreshore an 'uprush' of water onto the foreshore will occur, this is called wave run-up. The height of wave run-up is affected by the nature of the foreshore. Should wave run-up be large, wave overtopping may occur, which results in the temporary inundation of the foreshore area. The inland extent of the wave inundation is assumed to be 40m from the foreshore crest. With the inclusion of a freeboard allowance (see **Section 6.4**) this is an appropriate distance to assess the impacts of waves on coastal inundation and has been verified from site observations by this study's coastal engineers following severe storms along the NSW coastline.

Wave run-up mechanisms in this study have been quantified in a manner consistent with the Pittwater EPL Study (Cardno, 2015) and North and Middle Harbour EPL Study (Rhelm, 2022), described in **Figure 3-3**. Wave run-up for shoreline types in the study area is presented in **Section 6.3**.

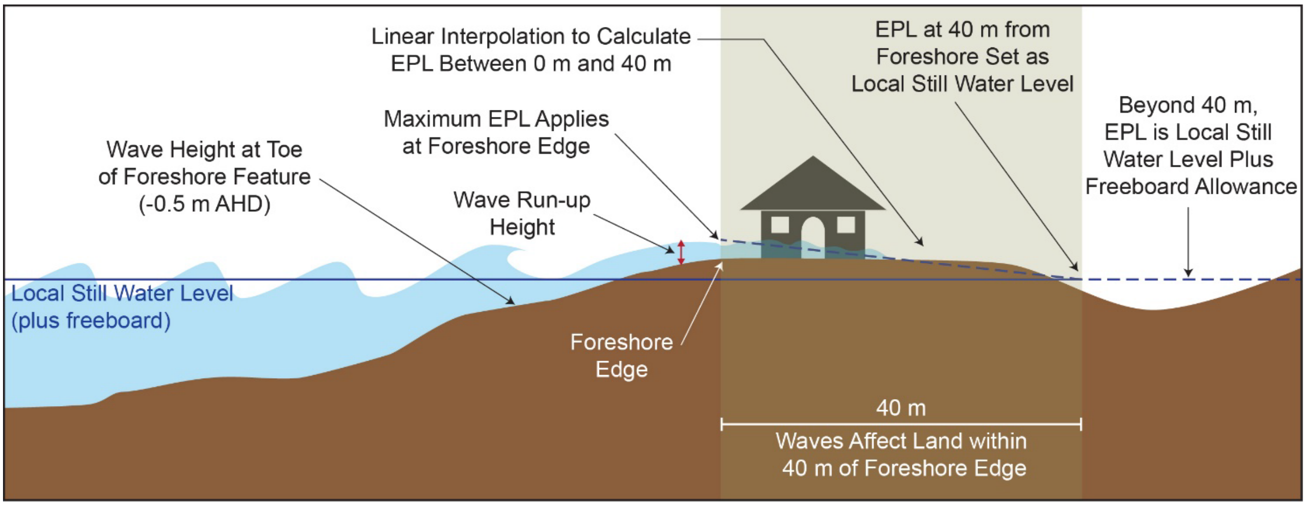

Figure 3-3 Site Specific Coastal Processes

4 Data Compilation and Review

The following sections summarise the data and model inputs that have been utilised in this study to complete modelling required to define estuarine planning levels in the study area.

4.1 Cowan Creek Water Levels

Water levels were obtained from Patonga tide gauge, which provided data in close proximity to Cowan Creek, and from Sydney Harbour (Fort Denison) tide gauge, which provides a long, reliable dataset. Present day extreme design still water levels at Fort Denison based on a statistical analysis of measured historical records are provided in **Table 4-1** which are aligned with the outputs from the Fort Denison Sea Level Rise Vulnerability Study (Watson and Lord, 2008). The extremes analysis is based on water level data measured continuously at Fort Denison for over 100 years. The data reflects the astronomical tide levels as well as anomalies or variations from the predicted tide from storm surge and freshwater flows (assumed very minimal). Similarly, the data inherently incorporates climate change and other seasonal-induced sea level rise over this timeframe. **Table 4-1** presents the extreme water levels for Fort Denison from Watson and Lord (2008).

Table 4-1 Extreme water levels at Fort Denison, Sydney (Watson and Lord, 2008)

Average Recurrence Interval (ARI) (years)	Present Day Extreme Still Water Level	
	m CD*	m AHD
1	2.2	1.2
10	2.3	1.3
50	2.3	1.4
100	2.4	1.4
200	2.4	1.5

* CD = Chart Datum which approximates to LAT and is about 0.93m below AHD.

To determine the difference in water level between Patonga (estuary entrance to Cowan Creek) and Fort Denison, Extreme Value Analysis was performed for concurrent data for both sites. Patonga was observed to have higher water levels than Fort Denison, as shown in **Table 4-2.** A report by Manly Hydraulics Laboratory analysed numerous tidal gauges along the NSW coastline using several methods; the 100 Year ARI water level determined is presented in **Table 6-1** showing a difference of 0.01m between the two gauges (MHL, 2018).

Previous Northern Beaches EPL studies (Cardno, 2015 and Rhelm, 2022) have applied a 100 Year ARI of 1.4 mAHD and 1.44 mAHD respectively. To provide consistency across the Council area, the Watson and Lord (2008) Fort Denison 100 Year ARI value of 1.44mAHD was selected; then a +0.01m correction was applied to account for the variability in water level identified by MHL (2018).

Table 4-2 Comparison of Patonga and Fort Denison tide gauge 100 Year ARI: Various sources

Data Reference	Present Day Extreme Still Water Level (m AHD)	
	Patonga	Fort Denison
Current Study (Concurrent Data)	1.45	1.42
Manly Hydraulics Laboratory (MHL, 2018)	1.43	1.42
Watson and Lord (2008)	-	1.44

4.2 Coastal Storm Winds

A range of wind data sets have been analysed to define extreme winds which can generate enhanced storm surge and local sea waves in the study area. The key data sets reviewed in this study were:

- Long-term measured wind speeds at Sydney Airport which spanning 68 years (1948-2016);
- 23 years of wind measurements from at Fort Denison (1990-2019); and
- A synthetic ECL wind dataset which is a 1,000 year independently derived Monte Carlo model (Taylor et al, 2017).

The directional extreme wind data from Sydney Airport has been adopted to define 100-year ARI sustained (10-minute average) winds for 8 directional sectors as defined in **Table 4-3**. The strongest storm winds occur from a southerly direction, which results in minimal exposure for the majority of the Cowan Creek coastline that is predominantly west to north-west facing. Due to the steep ridges that surround Cowan Creek, the wind speeds specified in **Table 4-3** are likely to be conservative for sustained winds acting over the surface of Cowan Creek.

Table 4-3 Extreme wind speeds (10min average, 10 m elevation) based on long-term Sydney Airport data (1948-2016)

Direction	100-year ARI wind speed (m/s)
Omni-Directional	28.2
North	15.4
Northeast	16.3
East	17.8
Southeast	20.4
South	27.5
Southwest	22.7
West	22.3
Northwest	20.8

4.3 Extreme Coastal Waves

Cowan Creek is sufficiently protected from ocean swells and only local wind waves generated over Cowan Creek have been considered in this study.

5 Estuarine Modelling

The estuarine modelling has been undertaken with two separate model systems to account for the following processes that contribute to the calculation of EPL's. The two model systems are:

- Delft3D hydrodynamic model to model local wind setup that occurs within Cowan Creek; and
- SWAN wave model, which adopts the same grid as the Delft3D model, to model local sea waves generated within Cowan Creek from wind forcing.

The extent of these models is shown in **Figure 5-1.**

The EPLs derived from the results from these two models are presented in **Appendix B**. Results for over 1900 output locations at 30m spacing were derived, however, only 48 locations from Cottage Point have been presented in this report, in addition to 26 locations at the d'Albora Marina in Akuna Bay, with locations shown in **Figure 5-2** and **Figure 5-3**.

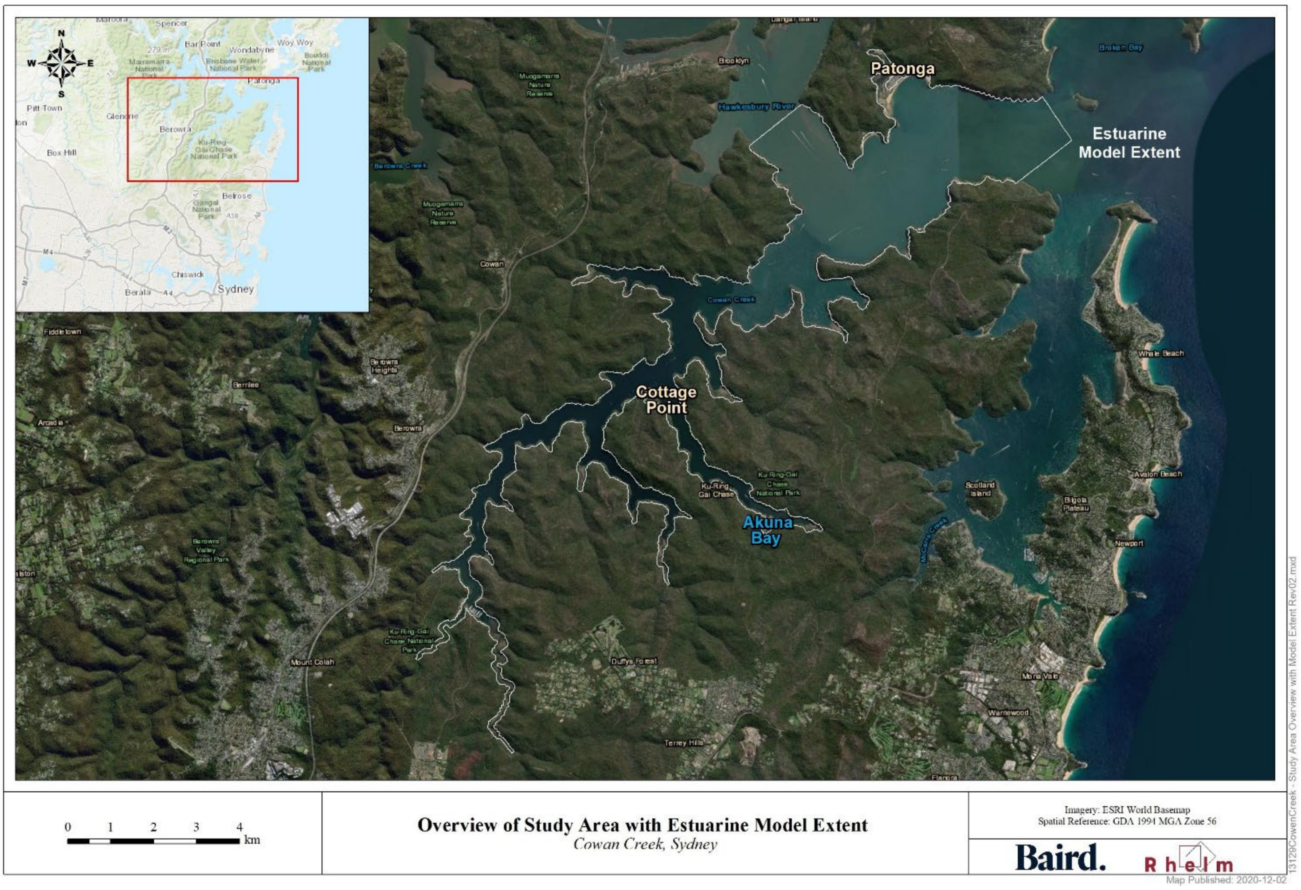

Figure 5-1 Plan view of Delft3D and SWAN model Extents

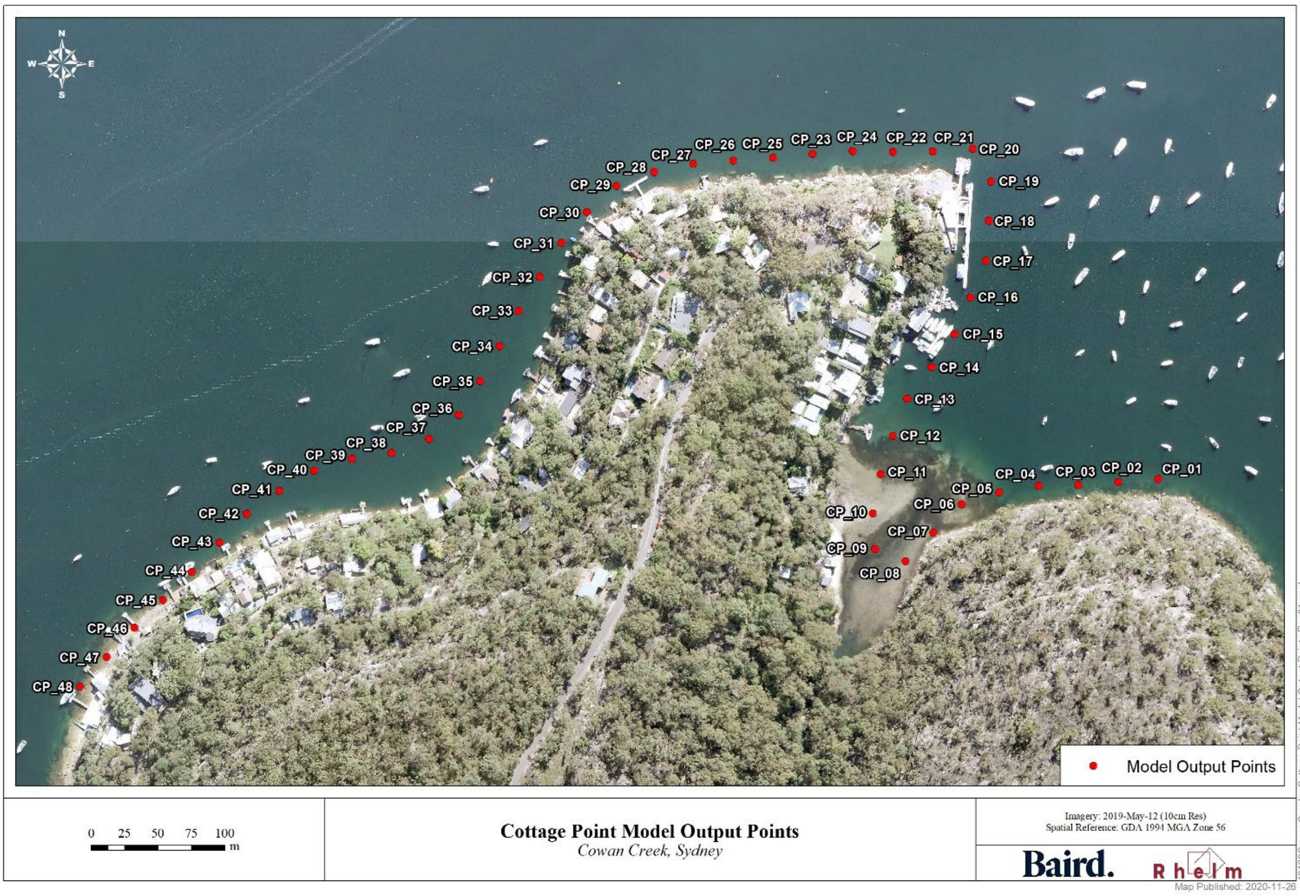

Figure 5-2 Plan view of EPL calculation points – Cottage Point

Figure 5-3 Plan view of EPL calculation points – Akuna Bay

5.1 Delft3D Model

The Patonga and Fort Denison water level datasets provide a good basis to define extreme ocean water levels for return periods of 200-years ARI and greater. However, additional wind setup can occur within embayments, which could potentially elevate water levels compared to the local Patonga dataset.

Modelling of wind setup along the foreshore has been undertaken using a Delft3D hydrodynamic model covering the whole of Cowan Creek, and part of the Hawkesbury River to Patonga to quantify the variation in extreme water levels between Patonga and the study area. High model resolution of 35m grid cells enable detailed results for properties along the Cowan Creek foreshore areas.

The Delft3D model was applied with the 100 Year ARI water level (1.45 mAHD) and wind forcing to model wind setup for the eight directional sector winds defined in **Table 4-3.** The wind setup was calculated as the maximum difference between the maximum modelled water level and the boundary tide level for each of the calculation points. The largest wind setup from all direction scenarios were adopted as the 100-year ARI wind setup at a particular output location.

5.2 SWAN Wave Model

Local sea waves were calculated in a consistent manner using a SWAN wave model which adopted the same model grids and wind conditions as the Delft3D model scenarios described in the previous section, with an additional nested grid of 10m resolution around Cottage Point. The SWAN wave model adopted a fixed 100-year ARI water level (1.45 mAHD) for each model simulation and local sea waves defined by significant wave height (Hm0), wave period (Tp) and wave direction were computed for each output location. The 100 Year ARI north-west wind wave modelling results are shown in **Appendix A**.

6 Calculation of Estuarine Planning Levels

6.1 Estuarine Planning Level Components

EPLs have been calculated for each of the 74 output locations (**Section 5**) based on the outcomes of the estuarine modelling. Specifically, this includes:

- Identifying the 100 Year ARI ocean tidal level and incorporating sea level rise;
- Calculating the wind setup and wave heights (sea and swell) based on the model results described in **Section 5.2**;
- Calculating wave run-up and overtopping, which requires:
    - Defining the typical foreshore types around the Cowan Creek study area;
    - Calculation of the reduction in overtopping wave heights as a result of distance from the foreshore; and
- Applying a freeboard to allow for any uncertainties primarily associated with the water level and wave calculations.

The components of the EPLs are shown diagrammatically in **Figure 6-1**.

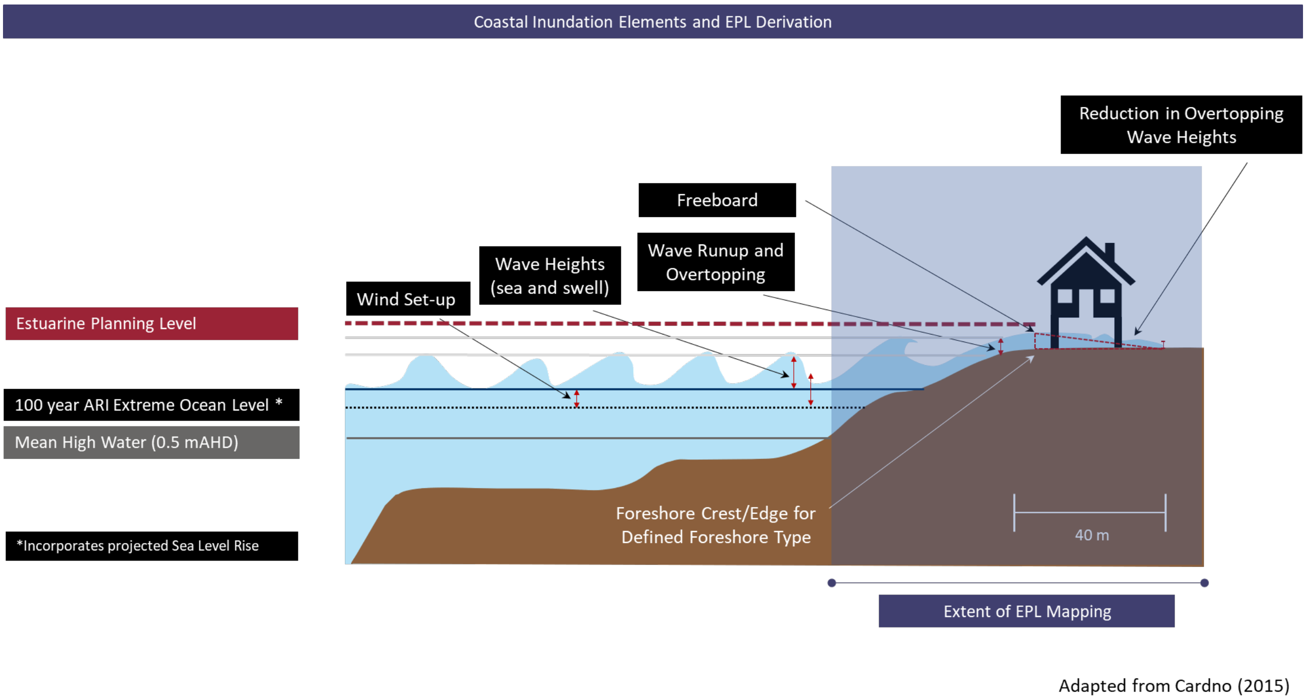

Figure 6-1 Estuarine Planning Level Components

6.2 Tidal Event Mapping and Sea Level Rise

It was considered appropriate to adopt the 100 Year ARI ocean water level event as the design event for planning purposes within the Cowan Creek coastal zone. As outlined in **Section 4.1**, extremal analysis of the Fort Denison tide gauge data reported in Watson and Lord (2008) has been applied. The extreme water levels provided from this gauge provide a historical record of the combined effects of the processes described above. The 100 Year ARI level at Fort Denison was determined to be 1.44 mAHD (to two decimal places).

To provide an estimation of the projected impact of sea level rise on these tidal events, predicted sea level rise of 0.4m and 0.9m have been applied (see **Section 3.1.1**, as per Cardno (2015) and Rhelm (2022)).

Table 6-1 provides the levels that were used with what is referred to here as the 'present-day levels', which are actually based on the analysis of recorded tidal levels for the period 1914 – 2006 (Watson and Lord, 2008). In reality, Watson and Lord (2008) note that sea level rise has been observed at a rate of 3.1 mm/year and so using this trend as a coarse guide then the actual present-day reference point (at 2020 when the calculations for this study were conducted) is potentially up to 0.04 m higher (i.e. 3.1 mm/yr times 13 years that have elapsed since the calculations based on actual data were completed). Given the small nature of the variance, the present-day values have been retained as those reported by Watson and Lord (2008), which is consistent with that adopted for Pittwater (Cardno, 2015). It is important to note that the ocean water level projections in **Table 6-1** for 2050 and 2100 are adjusted from the reference point of 1990 which has been the common basis for sea level rise projections by the Intergovernmental Panel for Climate Change (Gregory and Church, 2001; Church et al, 2013).

Table 6-1 Present Day, 2050 and 2100 Ocean Levels

	Present Day Level	**2050**	**2100**
Predicted Sea Level Rise	0 m	0.4 m	0.9 m
100 Year ARI Ocean Water Level*	1.45 mAHD	1.85 mAHD	2.35 mAHD

*Does not include wind set up or wave run up.

Sea level rise has been incorporated into the determination of EPLs by calculating EPLs for 0.4m and 0.9m of sea level rise (in addition to the existing sea level). The shoreline wave height has also been updated where appropriate for the sea level rise predictions.

6.3 Wave Height and Wind Set-up

When selecting a design event upon which to calculate local wave heights, the likelihood of those waves occurring at the same time as the 100 Year ARI ocean water level needs to be considered.

Since many of the shoreline areas in the study area experience the largest local sea waves and wind setup as a result of winds from a southeast to southwest direction, the maximum 100-year ARI ocean water level was adopted to be concurrent with the 100-year ARI wind setup, local sea and ocean swell waves modelled in the scenarios presented in **Section 5**.

The wind setup and local sea waves were calculated at 1934 output locations along the Council foreshore areas of Cowan Creek; presented in this report and provided to Council are results for Cottage Point, the only developed location in the study area, as well as the marina at Akuna Bay.

6.3.1 Wave Run-up and Overtopping

The height of wave run-up and the depth of overtopping are dependent on the foreshore type and the height of the foreshore edge (crest level). The inland extent of the wave inundation is assumed to be 40 m from the foreshore crest based on the study team's observations from severe storms in the Sydney region. Therefore, the EPL applied to a development depends on the distance of the development from the foreshore edge.

6.3.2 Foreshore Types

The nature of the foreshore (foreshore type) is critical in the calculation of wave run-up and overtopping. The Pittwater EPL Study (see Cardno, 2015) adopted the following foreshore types:

- Type 1 – 1 in 10 natural slope (representing grassed and sandy gently sloping foreshores);
- Type 2 – 1 in 5 rocky shoreline (representing natural rocky foreshore or sloped rip rap);

- Type 3 – Vertical sea wall (e.g. block work or other retaining walls); and
- Type 4 – Mangroves.

The shoreline types are also appropriate for Cowan Creek and each foreshore type has been applied to determine wave run-up to the maximum vertical level (or 'crest') of shoreline structures and the toe level of structures based on information for the study area. This study has adopted the following assumptions for structure levels that are consistent with Cardno (2015) and Rhelm (2022) for the wave overtopping calculations:

- Structure crest levels up to 3.5 m AHD have been adopted. In Cowan Creek at Cottage Point several seawalls have high crest elevations; and
- Toe level of the shoreline seaward of the structure of -0.5 mAHD. This level was adopted to calculate breaking wave heights (where applicable) but is not a sensitive parameter in the context of the wave conditions in Cowen Creek.

For these foreshore type categories, with the exception of mangroves, calculations were undertaken for five foreshore crest levels, being:

- 1.5 mAHD;
- 2.0 mAHD;
- 2.5 mAHD;
- 3.0 mAHD; and
- 3.5 mAHD.

The wave overtopping of the shore were calculated using methods described in USACE (2002) and CERC (1984). The methods and equations are briefly summarised below.

Firstly, wave run-up is computed for a scenario without overtopping to determine the maximum elevation of run-up for each shoreline type. This was calculated using the equations of De Waal and van der Meer (1992). The runup level equation is presented in equation 6.1:

$$\frac{R_{2\%}}{H_s} = 1.6\,\xi_{op}\ where\ 0.5 < \xi_{op} < 2, or\ 3.2\ where\ \xi_{op} > 2 \tag{6.1}$$

$$Level = SWL + R_{2\%} \tag{6.2}$$

ξ_{op} is the surf similarity parameter based on deepwater wave height and wavelength and includes the structure slopes that were specified at the start of this Section. The 2% wave run-up level is adjusted based on shoreline type using the following reduction factors:

- Smooth concrete or block waves: 1.0 (no reduction);
- Grassy or vegetated bank: 0.9; and
- Rocky shoreline: 0.6.

Following calculation of the unobstructed maximum run-up level, wave run-up and overtopping is calculated using van der Meer and Janssen (1995):

$$K_{TO} = C\left(1 - \frac{R_c}{R_{2\%}}\right)\ where\ C = 0.51 \tag{6.3}$$

For vertical walls, Equation 6.3 is modified and the shoreline wave height replaces the $R_{2\%}$term. The wave height transmitted over the wall and flood level is then calculated as follows:

$$H_{TO} = K_{TO} \times H_s \tag{6.4}$$

$$Level = Crest\ Level\ +\ H_{TO} \qquad (6.5)$$

If the still water level is above the structure crest, the following equation from Public Works (1990) is adopted:

$$Level = SWL\ +\ \frac{H_s}{2} \qquad (6.6)$$

6.3.3 Inland Extent of Wave Overtopping

Where a block slopes steeply back from the shoreline edge structure, the EPL may affect only a small part of the block. However, where a block is relatively flat, wave run-up may penetrate some distance inland, but is attenuated by percolation and friction. This landward reduction of wave inundation cannot be estimated with great confidence and has been based on observational experience. As Cowan Creek, in particular Cottage Point properties, has steep slopes rising from the shoreline, wave run-up is not expected to contribute to inundation a significant distance from the shoreline.

It is assumed that wave run-up diminishes to zero at a point 40m inland from the edge structure. This means that at the foreshore, the EPL is set to the "maximum EPL" and at 40m from the foreshore the EPL is set at the local (still) water level. A linear interpolation has been used to calculate the EPL for areas between 0m and 40m from the foreshore, as shown in **Figure 6-2**.

The freeboard allowance accommodates the potential that some shallow, low velocity wave inundation may extend further than 40 m from the foreshore edge.

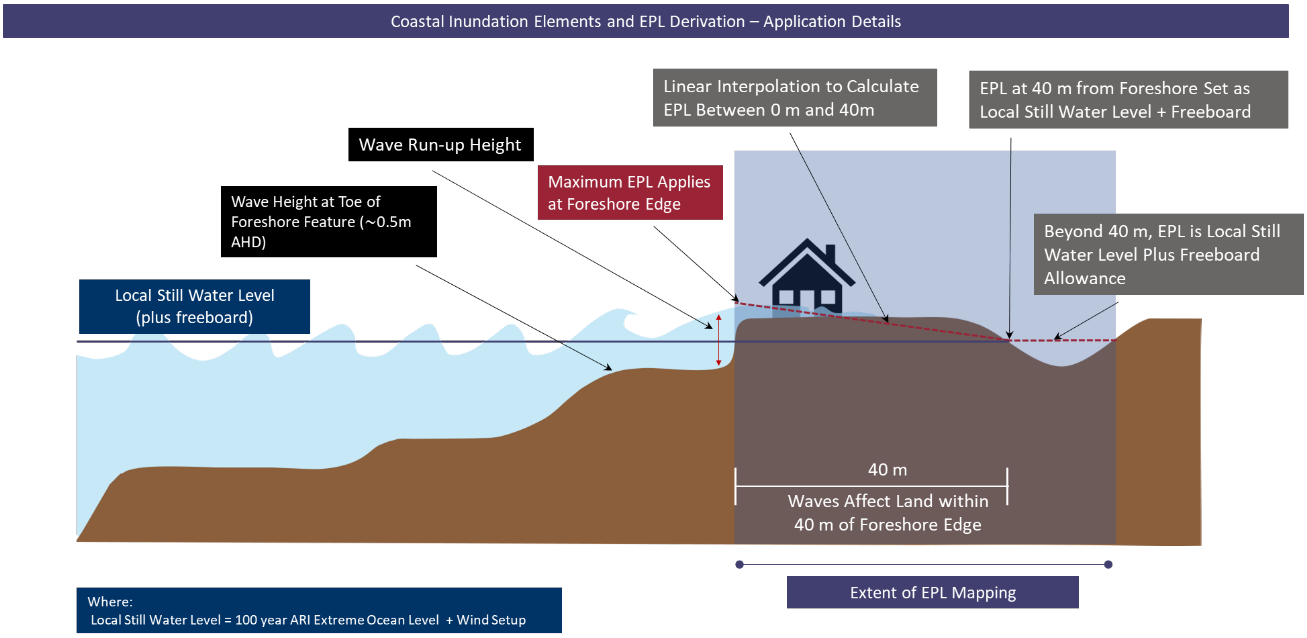

Figure 6-2 Calculation of Landward Reduction in Wave Inundation

Reduction factors have been calculated for each of the Foreshore Zones (**Section 6.3.2**). The reduction factors vary for each of the localities due to the fact that the Design Still Water Levels and Wave Height calculations vary between each locality.

Reduction factors have been calculated:

- At 5 metre increments with regards to distance from the foreshore edge (up to a maximum distance of 40 metres);
- For the foreshore type and height combination that produces the greatest amount of wave run-up (i.e. the highest EPL for that location); and

- For the 0.4m and 0.9m sea level rise scenarios (the existing or present day sea level rise scenario is not used for planning purposes and as such no reduction factors are required).

This results in a total of 16 reduction factors (8 for each sea level rise scenario) for each property within the 'existing' (or present day) sea level EPL database.

6.4 Freeboard

The estimation of all the components that make up the EPL at each selected location includes some uncertainty, and the degree of uncertainty varies with each water level component. It is greatest for wave run-up; and wave run-up is normally the largest water level component, other than astronomical tide.

It is common practice to take some precaution over this uncertainty. This is generally achieved through the application of a freeboard.

Prior to explicit incorporation of provision for sea level rise in planning levels, a freeboard of 0.5 m was commonly been adopted in NSW, incorporating a 0.3 m freeboard with an additional 0.2 m to account for potential sea level rise (much less than the current predicted sea level rise).

A freeboard of 0.3m is considered appropriate for the definition of the EPL. This accounts for 0.05m uncertainty in wind setup, 0.15m (i.e. 10% variance on 1.5m) uncertainty on maximum wave height, with the remaining 0.1m allowing for uncertainty in wave overtopping and runup.

It should be noted that the freeboard has not been included in the provisions of estuarine risk inundation extents to identify affected properties. However, those properties identified as being affected by estuarine risk inundation would have a freeboard included in their EPL.

The identification of "at risk" properties is discussed in more detail in **Section 7.1**.

6.5 Summary of Calculated EPLs

A summary of the significant EPL parameters from the 48 output points at Cottage Point are presented in **Table 6-2.** The full suite of EPLs from Cottage Point and Akuna Bay (48 and 26 output points respectively) are presented in **Appendix B** (also provided to Council in digital format).

Table 6-2 Summary of Significant EPL Parameters for Present Day, 2050 and 2100 Ocean Levels at Cottage Point, Cowan Creek

Parameter	Location Name	Easting (MGA z56)	Northing (MGA z56)	Current	2050	2100
Maximum local wind setup	91% of locations	-	-	0.03 m	0.03 m	0.03 m
Maximum Wave Height – Sea Dominated	CP-04	334165	6279203	0.61 m	0.61 m	0.61 m
Maximum EPL – Type 1 3.5 m AHD Crest (1 in 10 natural slope)	CP-03, CP-04	334165 334165	6279243 6279203	2.21 mAHD	2.61 mAHD	3.11 mAHD
Maximum EPL – Type 2 3.5 m AHD Crest (1 in 5 rocky slope)	CP-01 – CP-05	334184 – 334186	6279177 – 6279299	2.22 mAHD	2.62 mAHD	3.12 mAHD

Parameter	Location Name	Easting (MGA z56)	Northing (MGA z56)	Current	2050	2100
Maximum EPL – Type 3 3.5 m AHD Crest (Vertical sea wall)	CP-03 CP-04	334165 334165	6279243 6279203	2.38 mAHD	2.78 mAHD	3.28 mAHD
Maximum EPL – Type 4 (Mangrove)	91% of locations	-	-	1.78 mAHD	2.18 mAHD	2.68 mAHD

7 Properties Affected by Estuarine Planning Levels

7.1 Identifying Affected Properties

Those properties affected by EPLs have been identified spatially using an 'EPL extent' generated as an area using the EPL calculations described in this report and LiDAR survey for the study area.

Properties have been identified as being affected if they are:

- Entirely or partially within the still water level map extent; and / or
- Entirely or partially within 'Worst Case' 'Maximum' EPL Extent within 40m of the foreshore - this is the highest wave run-up and overtopping level possible at that location. The foreshore type that produces the highest level of wave run up and over topping has been used for this purpose, rather the existing foreshore type.

Sea level rise of 0.9m has been used to identify the at-risk properties (**Section 3.1.1** and **6.2**).

It should be noted that no reduction factor has been applied to the overtopping height. For the purposes of identifying the 40m setback, it has been assumed that the foreshore crest/edge is located at the 0.5mAHD contour (which is approximately the mean high water (MHW) tide level of 0.56 mAHD, as measured at Patonga tide gauge for the period 1992-2010 (MHL, 2012).

No freeboard has been applied for the purposes of mapping the EPL extent. However, a freeboard of 0.3m will be applied for all planning levels issued to properties (as discussed in **Section 6.4**).

The estuarine inundation risk properties for Cottage Point are shown on **Figure 7-1**, 60 land parcels in total. The estuarine inundation risk extent mapping for the affected Cottage Point residential properties are shown on **Figure 7-2**. The extent shown is for the 0.9m sea level rise scenario. **Figure 7-3** shows the estuarine inundation risk properties and inundation risk extent for Akuna Bay, 1 land parcel in total. To be conservative the EPL results for AB_26 have been applied to the single affected lot/DP at Akuna Bay in the EPL database.

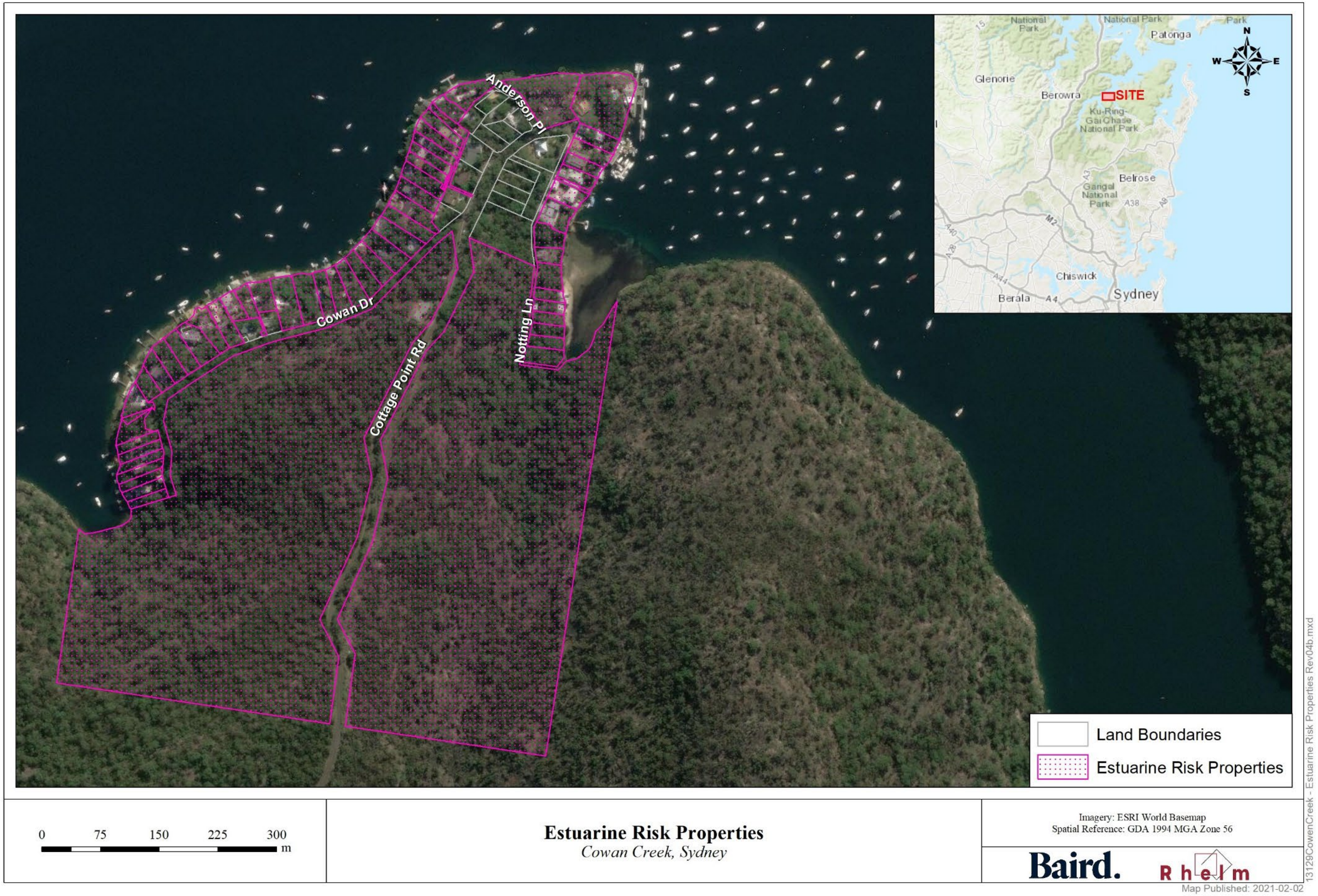

Figure 7-1 Estuarine Inundation Risk Properties at Cottage Point, Cowan Creek

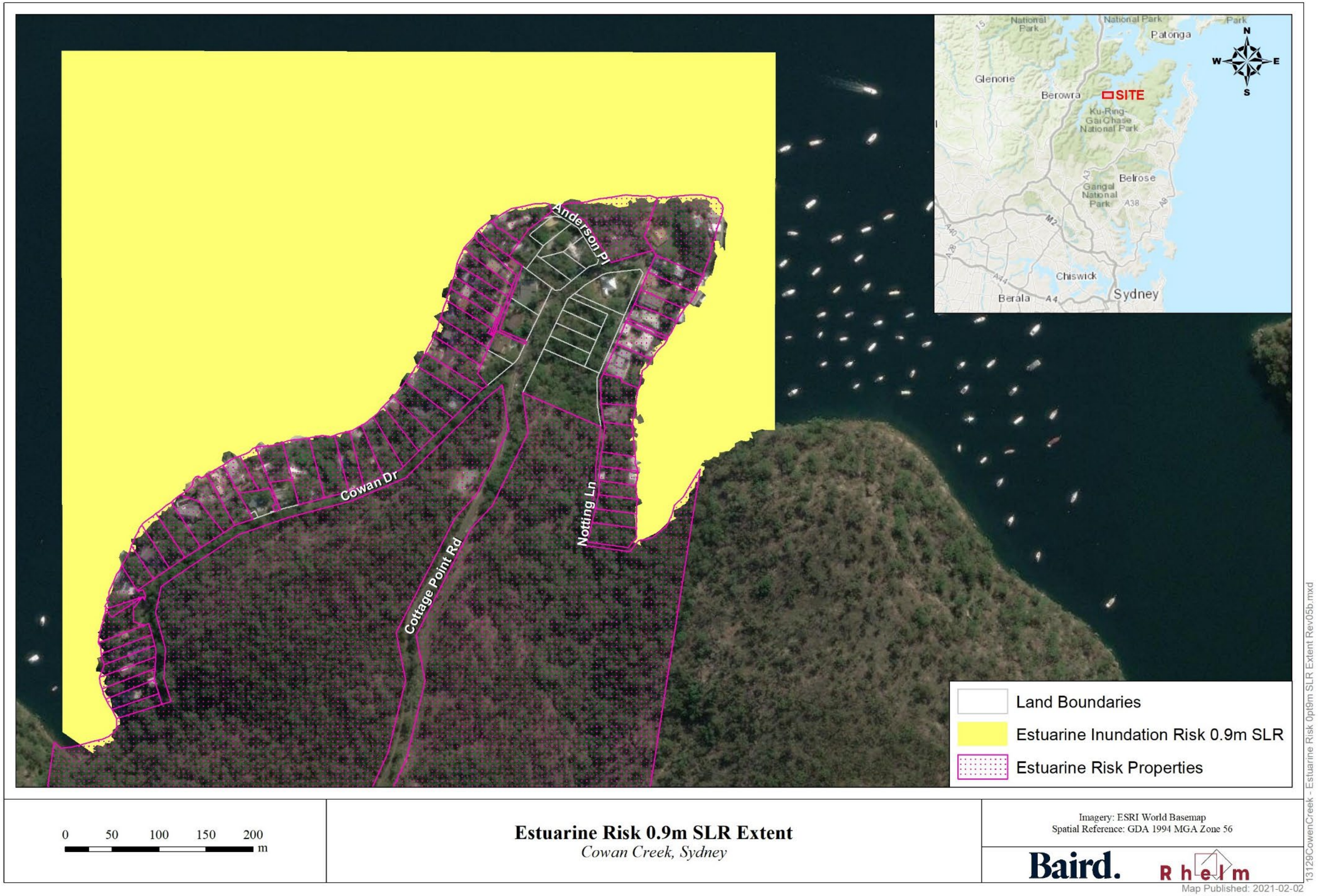

Figure 7-2 Estuarine Inundation Risk Extent at Cottage Point, Cowan Creek

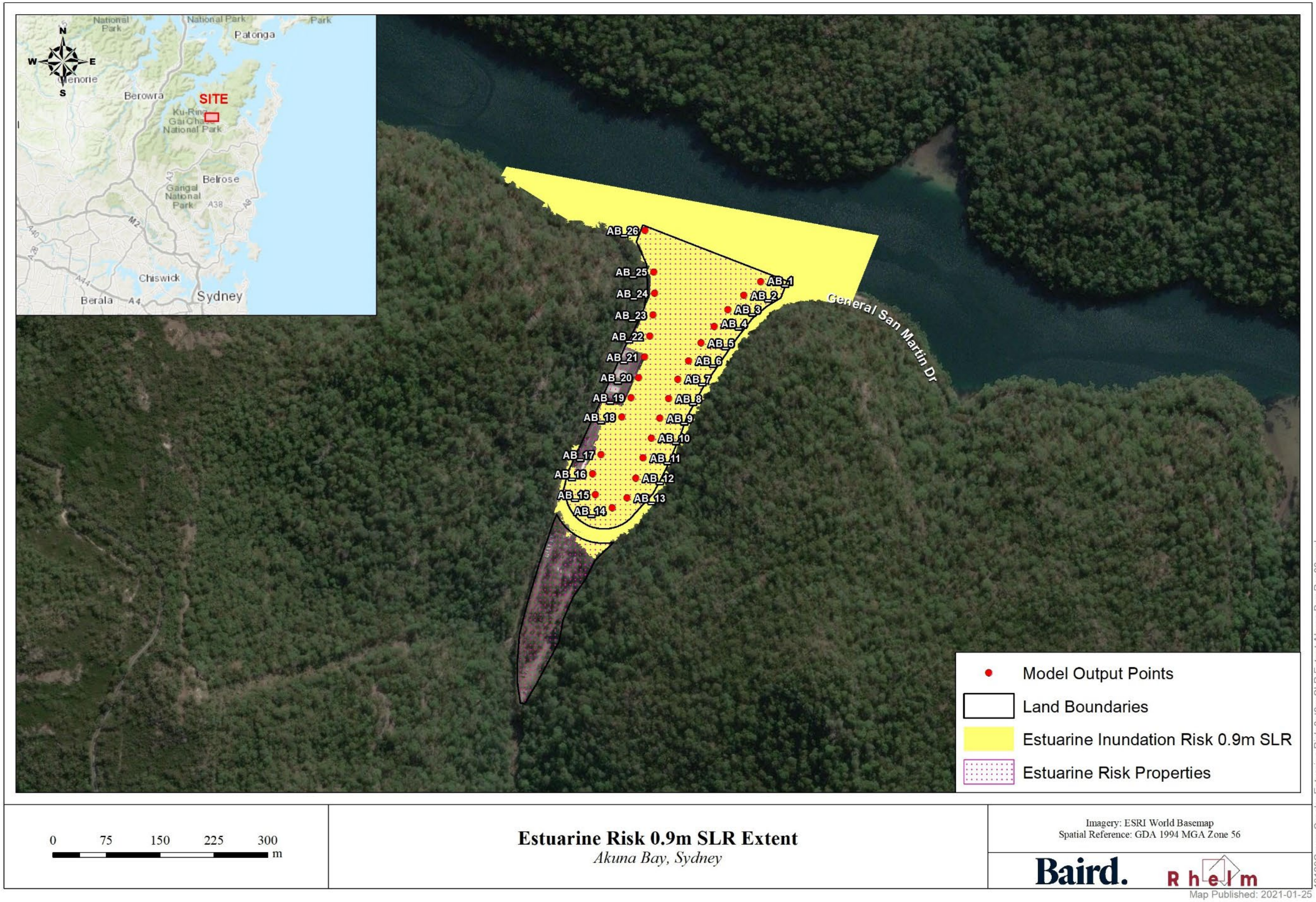

Figure 7-3 Estuarine Inundation Risk Properties and Inundation Risk Extent at Akuna Bay, Cowan Creek

7.2 Partially Affected Properties and Foreshore Reserves

Due to the relatively steep topography around the foreshore in the study area, there are a large number of land parcels (properties) where the estuarine inundation risk mapping only impacts the portion of the property at the water interface and the existing dwelling is located outside of the risk extent. Whilst there would be no estuarine inundation risk associated with the dwelling, the notification would still be present on the property's Section 10.7 planning certificate. This would ensure that any development or works proposed on the affected portion of the property (e.g. boatsheds, jetties or other structures) would consider the impacts of estuarine inundation risk.

Several private properties are fronted by foreshore reserves or have domestic waterfront tenancy arrangements over Crown Land parcels. Where the estuarine inundation risk mapping is contained within these foreshore land parcels, no notification will be present for the adjacent private property. Where the estuarine inundation risk mapping includes even a small area of the private property, the relevant planning certificate notation would be present.

7.3 Application of Estuarine Planning Levels

The EPL for any proposed development on properties within 40m of the foreshore edge is calculated for the proposed foreshore type (or existing if to remain the same after the development) and the distance of the development from the foreshore edge. The resulting EPL will account for the 'local water level', wave run-up and overtopping and the reduction in the wave height as a result of distance from the foreshore, plus a freeboard of 0.3m, as described in **Sections 6.3** and **6.4**.

The EPL for any proposed development on properties beyond 40m of the foreshore edge will be equal to the 'local water level' at the property location, plus a freeboard of 0.3m.

If the proposed development lies outside the EPL extent, then no EPL or estuarine hazard mitigation measures would be applied to the development.

7.4 Piered Properties over Water

No site inspection was undertaken for this study, however based on aerial imagery it appears several properties or ancillary structures in Cottage Point may be piered over water. This will impact the coastal processes at these locations and associated risk to estuarine inundation. In order to improve the estimation of the EPL it is recommended that floor survey of the properties identified in **Appendix C** be undertaken by Council. If any properties are confirmed to be piered over-water it may be reasonable to add an additional freeboard to these properties.

7.5 Estuarine Inundation Risk Related Development Controls

As discussed in **Section 1.1**, EPLs are currently applied as a method for managing risk along the foreshore of Pittwater (in the north of the Northern Beaches LGA) and similarly will be applied to all coastal and estuarine inundation risk areas within the Northern Beaches LGA, including within the Cowan Creek study area, in future planning controls.

The EPLs derived from this study will inform the new planning controls currently being developed by Council for the amalgamated Northern Beaches LGA. This may be done in a similar manner to the existing *Pittwater LEP 2014* and *Pittwater 21 DCP*. The application of planning controls is discussed further in Rhelm (2020).

8 Recommendations

This report provides the identification of land parcels in Cowan Creek, specifically at Cottage Point and Akuna Bay, that would potentially have estuarine inundation risk planning controls applied to development proposed within these land parcels. Further, this report identifies EPLs for each of these land parcels.

Council is currently reviewing its planning process with regards to the application of EPLs within the study area and notification of estuarine inundation risk on property planning certificates. The results of this study should be used to update planning certificates for properties that have an estuarine inundation risk within Cowan Creek (**Figure 7-1**, **Figure 7-3** and model results in **Appendix B**).

It is anticipated that community engagement will be an important aspect of future stages of this project.

9 Assumptions and Qualifications

The following assumptions and qualifications apply to this study:

- Storm climatology which processes storm surge and waves has been analysed as a stationary data record based on the available historical data sets for water levels and waves referenced in this report;
- A toe level of -0.5 m AHD was adopted for all shoreline and structure types. The toe level drives the wave run up and overtopping calculations. As such, where the toe level may be deeper than -0.5 m AHD, the EPL's may be non-conservative. Similarly, if a scoured toe level seaward of the edge treatment is higher than -0.5 m AHD, the EPLs may be more conservative;
- The EPLs have been calculated for a select number of edge treatments that comprise the majority of the shoreline area in Cowan Creek. If a particular property has an edge treatment that significantly differs from the edge treatments considered in this study, a site-specific assessment by a coastal engineer may be required;
- The hydrodynamic model has not been calibrated or validated with any site specific data, however, appropriate model coefficients are adopted based on similar models that have had site specific calibration; and
- No changes to future storm climatology (such as those potentially associated with climate change) have been considered.

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Appendix A

Local Wave Results

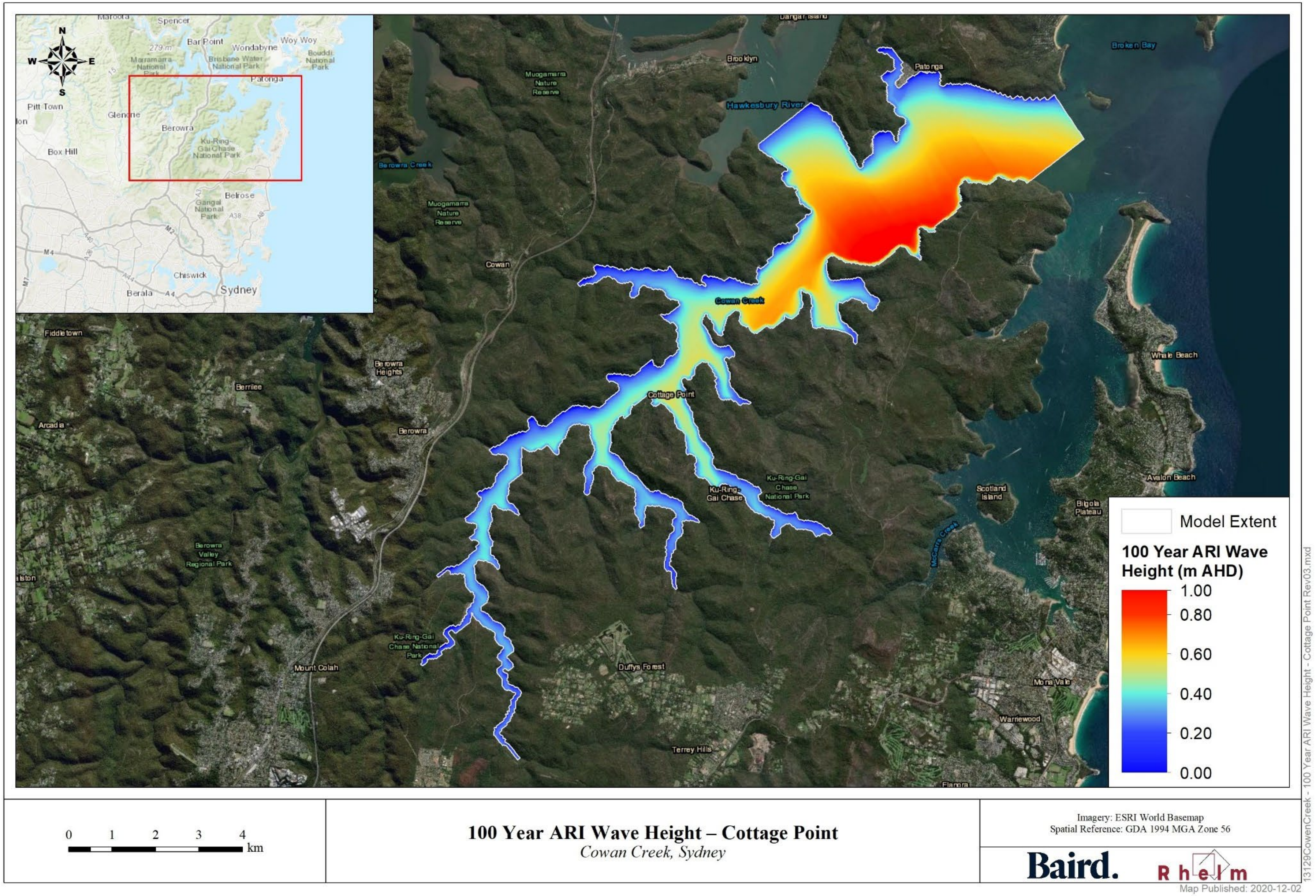

Figure A-1 North-West 100 Year ARI Wind Wave Height at Cottage Point and Cowan Creek

Appendix B

Model Results for Cottage Point and Akuna Bay

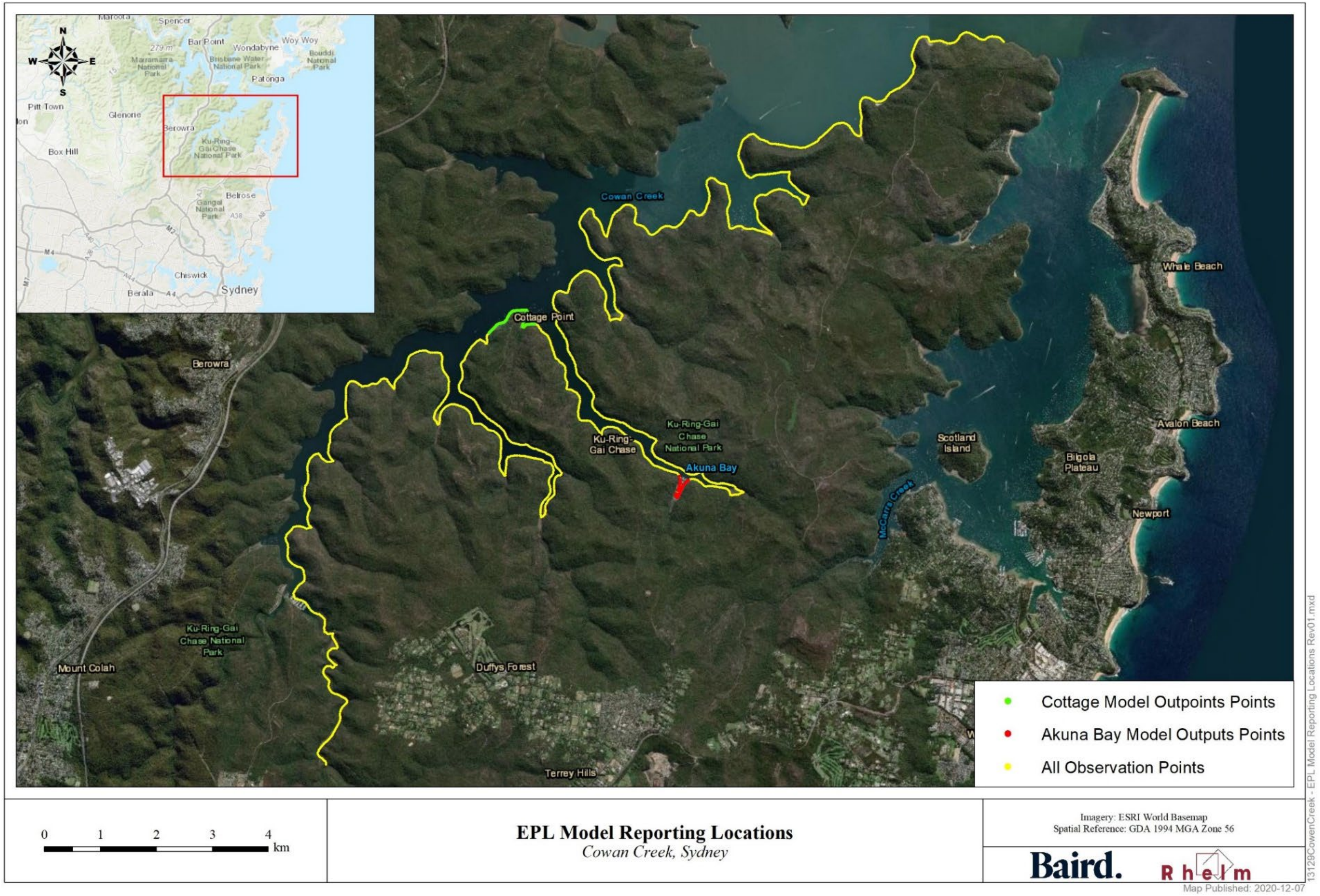

Figure B-1 Model Output Points

Foreshore Types:
1. Grassed or Sandy Slope (1 in 10 slope)
2. Rocky Shoreline (1 in 5 slope)
3. Sea Wall
4. Mangroves

100-year ARI Storm Tide at Patonga is **1.45** mAHD (excluding Sea Level Rise)
EPLs for all sea wall heights less than 1.5m will be the equivalent.

Mean Sea Level Rise Allowances taken from Council Policy **0.00** m to the year 2010
Freeboard of **0.3** m included in EPLs

Foreshore Location				100yrARI					Estuarine Planning Level (m)																	REDUCTION FACTORS NOT CALCULATED FOR 2010 LEVELS AS THE 0m SLR LEVELS ARE NOT BEING USED FOR PLANNING PURPOSES							
				Wave						Foreshore Type ##																							
										1					2					3					4								
										Crest Level (mAHD)																							
Location ID	Location	X MGAz56	Y MGAz56	Hs (m)	Tp (sec)	Local Wind Setup* (m)	Local (Still) Water Level (mAHD) 2010	Local (Still) Water Level with 0.3m Freeboard (mAHD) 2010	Max EPL of all Foreshore Types and Crest Levels (mAHD)	1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	N/A	5m	10m	15m	20m	25m	30m	35m	40m
CP_01	Cottage Point	333834	6278821	0.56	2.40	0.03	1.48	1.78	2.33	2.07	2.18	2.18	2.18	2.18	2.07	2.20	2.20	2.20	2.20	2.07	2.32	2.33	2.33	2.33	1.78								
CP_02	Cottage Point	333794	6278832	0.55	2.40	0.03	1.48	1.78	2.33	2.06	2.17	2.17	2.17	2.17	2.06	2.20	2.20	2.20	2.20	2.07	2.31	2.33	2.33	2.33	1.78								
CP_03	Cottage Point	333774	6278816	0.54	2.40	0.03	1.48	1.78	2.32	2.06	2.17	2.17	2.17	2.17	2.06	2.20	2.20	2.20	2.20	2.06	2.31	2.32	2.32	2.32	1.78								
CP_04	Cottage Point	333734	6278827	0.52	2.40	0.03	1.48	1.78	2.30	2.05	2.15	2.15	2.15	2.15	2.05	2.19	2.19	2.19	2.19	2.06	2.30	2.30	2.30	2.30	1.78								
CP_05	Cottage Point	333715	6278811	0.50	2.40	0.03	1.48	1.78	2.28	2.04	2.14	2.14	2.14	2.14	2.04	2.19	2.19	2.19	2.19	2.05	2.28	2.28	2.28	2.28	1.78								
CP_06	Cottage Point	333695	6278796	0.48	2.40	0.03	1.48	1.78	2.26	2.03	2.13	2.13	2.13	2.13	2.03	2.18	2.18	2.18	2.18	2.04	2.26	2.26	2.26	2.26	1.78								
CP_07	Cottage Point	333675	6278781	0.47	2.40	0.03	1.48	1.78	2.25	2.03	2.12	2.12	2.12	2.12	2.03	2.17	2.17	2.17	2.17	2.03	2.25	2.25	2.25	2.25	1.78								
CP_08	Cottage Point	333656	6278766	0.45	2.40	0.03	1.48	1.78	2.24	2.02	2.11	2.11	2.11	2.11	2.02	2.17	2.17	2.17	2.17	2.02	2.24	2.24	2.24	2.24	1.78								
CP_09	Cottage Point	333636	6278750	0.44	2.40	0.03	1.48	1.78	2.22	2.01	2.10	2.10	2.10	2.10	2.01	2.16	2.16	2.16	2.16	2.02	2.22	2.22	2.22	2.22	1.78								
CP_10	Cottage Point	333636	6278791	0.43	2.40	0.03	1.48	1.78	2.21	2.01	2.09	2.09	2.09	2.09	2.01	2.16	2.16	2.16	2.16	2.01	2.21	2.21	2.21	2.21	1.78								
CP_11	Cottage Point	333635	6278832	0.42	2.40	0.03	1.48	1.78	2.21	2.01	2.09	2.09	2.09	2.09	2.01	2.15	2.15	2.15	2.15	2.01	2.21	2.21	2.21	2.21	1.78								
CP_12	Cottage Point	333655	6278847	0.42	2.40	0.03	1.48	1.78	2.20	2.00	2.08	2.08	2.08	2.08	2.00	2.15	2.15	2.15	2.15	2.00	2.20	2.20	2.20	2.20	1.78								
CP_13	Cottage Point	333674	6278862	0.43	1.87	0.03	1.48	1.78	2.21	2.00	2.09	2.09	2.09	2.09	2.00	2.07	2.07	2.07	2.07	2.01	2.21	2.21	2.21	2.21	1.78								
CP_14	Cottage Point	333674	6278903	0.46	1.87	0.03	1.48	1.78	2.24	2.02	2.11	2.11	2.11	2.11	2.02	2.08	2.08	2.08	2.08	2.02	2.24	2.24	2.24	2.24	1.78								
CP_15	Cottage Point	333713	6278933	0.49	1.87	0.03	1.48	1.78	2.27	2.03	2.13	2.13	2.13	2.13	2.03	2.09	2.09	2.09	2.09	2.04	2.27	2.27	2.27	2.27	1.78								
CP_16	Cottage Point	333712	6278974	0.52	1.87	0.03	1.48	1.78	2.30	2.05	2.15	2.15	2.15	2.15	2.05	2.10	2.10	2.10	2.10	2.05	2.30	2.30	2.30	2.30	1.78								
CP_17	Cottage Point	333732	6278989	0.54	1.87	0.03	1.48	1.78	2.32	2.06	2.17	2.17	2.17	2.17	2.06	2.11	2.11	2.11	2.11	2.06	2.31	2.32	2.32	2.32	1.78								
CP_18	Cottage Point	333712	6279014	0.56	2.11	0.03	1.48	1.78	2.33	2.06	2.18	2.18	2.18	2.18	2.06	2.15	2.15	2.15	2.15	2.07	2.32	2.33	2.33	2.33	1.78								
CP_19	Cottage Point	333711	6279055	0.58	2.11	0.02	1.47	1.77	2.35	2.07	2.19	2.19	2.19	2.19	2.07	2.16	2.16	2.16	2.16	2.08	2.33	2.35	2.35	2.35	1.77								
CP_20	Cottage Point	333691	6279080	0.59	2.40	0.03	1.48	1.78	2.36	2.08	2.20	2.20	2.20	2.20	2.08	2.22	2.22	2.22	2.22	2.09	2.33	2.36	2.36	2.36	1.78								
CP_21	Cottage Point	333671	6279065	0.56	1.87	0.02	1.47	1.77	2.34	2.06	2.18	2.18	2.18	2.18	2.06	2.11	2.11	2.11	2.11	2.07	2.32	2.34	2.34	2.34	1.77								
CP_22	Cottage Point	333632	6279075	0.53	1.87	0.03	1.48	1.78	2.31	2.05	2.16	2.16	2.16	2.16	2.05	2.10	2.10	2.10	2.10	2.06	2.30	2.31	2.31	2.31	1.78								
CP_23	Cottage Point	333612	6279060	0.50	2.11	0.03	1.48	1.78	2.28	2.04	2.14	2.14	2.14	2.14	2.04	2.14	2.14	2.14	2.14	2.04	2.28	2.28	2.28	2.28	1.78								
CP_24	Cottage Point	333572	6279070	0.50	2.11	0.03	1.48	1.78	2.28	2.04	2.14	2.14	2.14	2.14	2.04	2.14	2.14	2.14	2.14	2.04	2.28	2.28	2.28	2.28	1.78								
CP_25	Cottage Point	333552	6279055	0.49	2.11	0.03	1.48	1.78	2.27	2.04	2.13	2.13	2.13	2.13	2.04	2.13	2.13	2.13	2.13	2.04	2.27	2.27	2.27	2.27	1.78								
CP_26	Cottage Point	333513	6279065	0.50	2.40	0.03	1.48	1.78	2.27	2.04	2.13	2.13	2.13	2.13	2.04	2.18	2.18	2.18	2.18	2.04	2.27	2.27	2.27	2.27	1.78								
CP_27	Cottage Point	333493	6279050	0.52	2.40	0.03	1.48	1.78	2.30	2.05	2.15	2.15	2.15	2.15	2.05	2.19	2.19	2.19	2.19	2.06	2.30	2.30	2.30	2.30	1.78								
CP_28	Cottage Point	333453	6279060	0.55	2.40	0.03	1.48	1.78	2.33	2.07	2.18	2.18	2.18	2.18	2.07	2.21	2.21	2.21	2.21	2.07	2.32	2.33	2.33	2.33	1.78								
CP_29	Cottage Point	333434	6279045	0.56	2.40	0.03	1.48	1.78	2.34	2.07	2.18	2.18	2.18	2.18	2.07	2.21	2.21	2.21	2.21	2.08	2.32	2.34	2.34	2.34	1.78								
CP_30	Cottage Point	333414	6279029	0.56	2.40	0.03	1.48	1.78	2.34	2.07	2.18	2.18	2.18	2.18	2.07	2.21	2.21	2.21	2.21	2.08	2.32	2.34	2.34	2.34	1.78								
CP_31	Cottage Point	333394	6279014	0.56	2.40	0.03	1.48	1.78	2.34	2.07	2.18	2.18	2.18	2.18	2.07	2.21	2.21	2.21	2.21	2.08	2.32	2.34	2.34	2.34	1.78								
CP_32	Cottage Point	333395	6278973	0.56	2.40	0.03	1.48	1.78	2.34	2.07	2.18	2.18	2.18	2.18	2.07	2.21	2.21	2.21	2.21	2.07	2.32	2.34	2.34	2.34	1.78								
CP_33	Cottage Point	333375	6278958	0.55	2.40	0.03	1.48	1.78	2.33	2.07	2.18	2.18	2.18	2.18	2.07	2.21	2.21	2.21	2.21	2.07	2.32	2.33	2.33	2.33	1.78								
CP_34	Cottage Point	333356	6278902	0.54	2.40	0.03	1.48	1.78	2.32	2.06	2.17	2.17	2.17	2.17	2.06	2.20	2.20	2.20	2.20	2.07	2.31	2.32	2.32	2.32	1.78								
CP_35	Cottage Point	333337	6278887	0.53	2.11	0.03	1.48	1.78	2.31	2.05	2.16	2.16	2.16	2.16	2.05	2.15	2.15	2.15	2.15	2.06	2.30	2.31	2.31	2.31	1.78								
CP_36	Cottage Point	333317	6278872	0.51	2.11	0.03	1.48	1.78	2.29	2.04	2.15	2.15	2.15	2.15	2.04	2.14	2.14	2.14	2.14	2.05	2.29	2.29	2.29	2.29	1.78								
CP_37	Cottage Point	333298	6278856	0.49	2.11	0.03	1.48	1.78	2.27	2.04	2.13	2.13	2.13	2.13	2.04	2.13	2.13	2.13	2.13	2.04	2.27	2.27	2.27	2.27	1.78								
CP_38	Cottage Point	333278	6278841	0.49	2.11	0.03	1.48	1.78	2.27	2.04	2.13	2.13	2.13	2.13	2.04	2.13	2.13	2.13	2.13	2.04	2.27	2.27	2.27	2.27	1.78								
CP_39	Cottage Point	333238	6278851	0.52	2.40	0.03	1.48	1.78	2.30	2.05	2.15	2.15	2.15	2.15	2.05	2.19	2.19	2.19	2.19	2.05	2.30	2.30	2.30	2.30	1.78								
CP_40	Cottage Point	333199	6278821	0.54	2.40	0.03	1.48	1.78	2.31	2.06	2.16	2.16	2.16	2.16	2.06	2.20	2.20	2.20	2.20	2.06	2.31	2.31	2.31	2.31	1.78								
CP_41	Cottage Point	333179	6278805	0.54	2.40	0.03	1.48	1.78	2.32	2.06	2.17	2.17	2.17	2.17	2.06	2.20	2.20	2.20	2.20	2.06	2.31	2.32	2.32	2.32	1.78								
CP_42	Cottage Point	333160	6278790	0.54	2.40	0.03	1.48	1.78	2.32	2.06	2.17	2.17	2.17	2.17	2.06	2.20	2.20	2.20	2.20	2.06	2.31	2.32	2.32	2.32	1.78								
CP_43	Cottage Point	333140	6278775	0.53	2.40	0.03	1.48	1.78	2.31	2.06	2.16	2.16	2.16	2.16	2.06	2.20	2.20	2.20	2.20	2.06	2.31	2.31	2.31	2.31	1.78								
CP_44	Cottage Point	333121	6278760	0.53	2.40	0.03	1.48	1.78	2.31	2.06	2.16	2.16	2.16	2.16	2.06	2.20	2.20	2.20	2.20	2.06	2.30	2.31	2.31	2.31	1.78								
CP_45	Cottage Point	333081	6278729	0.53	2.40	0.03	1.48	1.78	2.30	2.05	2.16	2.16	2.16	2.16	2.05	2.20	2.20	2.20	2.20	2.06	2.30	2.30	2.30	2.30	1.78								
CP_46	Cottage Point	333082	6278689	0.52	2.40	0.03	1.48	1.78	2.30	2.05	2.16	2.16	2.16	2.16	2.05	2.19	2.19	2.19	2.19	2.06	2.30	2.30	2.30	2.30	1.78								
CP_47	Cottage Point	333062	6278673	0.52	2.40	0.03	1.48	1.78	2.30	2.05	2.15	2.15	2.15	2.15	2.05	2.19	2.19	2.19	2.19	2.05	2.30	2.30	2.30	2.30	1.78								
CP_48	Cottage Point	333043	6278658	0.50	2.40	0.03	1.48	1.78	2.28	2.04	2.14	2.14	2.14	2.14	2.04	2.19	2.19	2.19	2.19	2.05	2.28	2.28	2.28	2.28	1.78								
AB_1	Akuna Bay	336595	6276023	0.36	1.65	0.04	1.49	1.79	2.15	1.98	2.05	2.05	2.05	2.05	1.98	2.03	2.03	2.03	2.03	1.98	2.15	2.15	2.15	2.15	1.79								
AB_2	Akuna Bay	336575	6276008	0.35	1.65	0.04	1.49	1.79	2.14	1.97	2.05	2.05	2.05	2.05	1.97	2.03	2.03	2.03	2.03	1.98	2.14	2.14	2.14	2.14	1.79								
AB_3	Akuna Bay	336555	6275994	0.35	1.65	0.04	1.49	1.79	2.14	1.97	2.04	2.04	2.04	2.04	1.97	2.02	2.02	2.02	2.02	1.97	2.14	2.14	2.14	2.14	1.79								
AB_4	Akuna Bay	336516	6275964	0.34	1.65	0.04	1.49	1.79	2.14	1.97	2.04	2.04	2.04	2.04	1.97	2.02	2.02	2.02	2.02	1.97	2.14	2.14	2.14	2.14	1.79								
AB_5	Akuna Bay	336496	6275949	0.34	1.65	0.04	1.49	1.79	2.13	1.97	2.04	2.04	2.04	2.04	1.97	2.02	2.02	2.02	2.02	1.97	2.13	2.13	2.13	2.13	1.79								
AB_6	Akuna Bay	336476	6275934	0.33	1.65	0.04	1.49	1.79	2.12	1.96	2.03	2.03	2.03	2.03	1.96	2.02	2.02	2.02	2.02	1.96	2.12	2.12	2.12	2.12	1.79								
AB_7	Akuna Bay	336476	6275893	0.33	1.65	0.04	1.49	1.79	2.12	1.96	2.03	2.03	2.03	2.03	1.96	2.02	2.02	2.02	2.02	1.97	2.12	2.12	2.12	2.12	1.79								
AB_8	Akuna Bay	336456	6275878	0.32	1.45	0.04	1.49	1.79	2.12	1.96	2.03	2.03	2.03	2.03	1.96	1.99	1.99	1.99	1.99	1.96	2.12	2.12	2.12	2.12	1.79								
AB_9	Akuna Bay	336456	6275838	0.31	1.45	0.05	1.50	1.80	2.11	1.96	2.02	2.02	2.02	2.02	1.96	1.99	1.99	1.99	1.99	1.96	2.11	2.11	2.11	2.11	1.80								
AB_10	Akuna Bay	336436	6275823	0.30	1.45	0.05	1.50	1.80	2.09	1.95	2.01	2.01	2.01	2.01	1.95	1.99	1.99	1.99	1.99	1.95	2.09	2.09	2.09	2.09	1.80								
AB_11	Akuna Bay	336436	6275782	0.28	1.65	0.05	1.50	1.80	2.07	1.94	2.00	2.00	2.00	2.00	1.94	2.00	2.00	2.00	2.00	1.94	2.07	2.07	2.07	2.07	1.80								

Foreshore Types:
1. Grassed or Sandy Slope (1 in 10 slope)
2. Rocky Shoreline (1 in 5 slope)
3. Sea Wall
4. Mangroves

100-year ARI Storm Tide at Patonga is **1.45** mAHD (excluding Sea Level Rise)
EPLs for all sea wall heights less than 1.5m will be the equivalent.

Mean Sea Level Rise Allowances taken from Council Policy **0.00** m to the year 2010
Freeboard of **0.3** m included in EPLs

Foreshore Location				100yrARI					Estuarine Planning Level (m)																	REDUCTION FACTORS NOT CALCULATED FOR 2010 LEVELS AS THE 0m SLR LEVELS ARE NOT BEING USED FOR PLANNING PURPOSES							
Location ID	Location	X MGAz56	Y MGAz56	Wave		Local Wind Setup* (m)	Local (Still) Water Level (mAHD)	Local (Still) Water Level with 0.3m Freeboard (mAHD)	Max EPL of all Foreshore Types and Crest Levels (mAHD)	Foreshore Type ##																5m	10m	15m	20m	25m	30m	35m	40m
										1					2					3					4								
										Crest Level (mAHD)																							
				Hs (m)	Tp (sec)		2010	2010		1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	N/A								
AB_12	Akuna Bay	336416	6275767	0.28	1.65	0.05	1.50	1.80	2.08	1.94	2.00	2.00	2.00	2.00	1.94	2.01	2.01	2.01	2.01	1.94	2.08	2.08	2.08	2.08	1.80								
AB_13	Akuna Bay	336415	6275726	0.28	1.65	0.05	1.50	1.80	2.07	1.94	2.00	2.00	2.00	2.00	1.94	2.01	2.01	2.01	2.01	1.94	2.07	2.07	2.07	2.07	1.80								
AB_14	Akuna Bay	336376	6275737	0.27	1.65	0.05	1.50	1.80	2.07	1.94	1.99	1.99	1.99	1.99	1.94	2.00	2.00	2.00	2.00	1.94	2.07	2.07	2.07	2.07	1.80								
AB_15	Akuna Bay	336356	6275722	0.26	1.65	0.05	1.50	1.80	2.06	1.93	1.98	1.98	1.98	1.98	1.93	2.00	2.00	2.00	2.00	1.93	2.06	2.06	2.06	2.06	1.80								
AB_16	Akuna Bay	336357	6275763	0.26	1.28	0.05	1.50	1.80	2.05	1.93	1.98	1.98	1.98	1.98	1.93	1.95	1.95	1.95	1.95	1.93	2.05	2.05	2.05	2.05	1.80								
AB_17	Akuna Bay	336357	6275804	0.28	1.45	0.04	1.49	1.79	2.07	1.94	1.99	1.99	1.99	1.99	1.94	1.98	1.98	1.98	1.98	1.94	2.07	2.07	2.07	2.07	1.79								
AB_18	Akuna Bay	336377	6275819	0.29	1.45	0.04	1.49	1.79	2.09	1.95	2.01	2.01	2.01	2.01	1.95	1.98	1.98	1.98	1.98	1.95	2.09	2.09	2.09	2.09	1.79								
AB_19	Akuna Bay	336396	6275834	0.31	1.45	0.05	1.50	1.80	2.11	1.95	2.02	2.02	2.02	2.02	1.95	1.99	1.99	1.99	1.99	1.96	2.11	2.11	2.11	2.11	1.80								
AB_20	Akuna Bay	336397	6275875	0.32	1.65	0.04	1.49	1.79	2.12	1.96	2.03	2.03	2.03	2.03	1.96	2.02	2.02	2.02	2.02	1.96	2.12	2.12	2.12	2.12	1.79								
AB_21	Akuna Bay	336417	6275890	0.33	1.65	0.04	1.49	1.79	2.13	1.97	2.03	2.03	2.03	2.03	1.97	2.02	2.02	2.02	2.02	1.97	2.13	2.13	2.13	2.13	1.79								
AB_22	Akuna Bay	336417	6275930	0.34	1.65	0.04	1.49	1.79	2.13	1.97	2.04	2.04	2.04	2.04	1.97	2.02	2.02	2.02	2.02	1.97	2.13	2.13	2.13	2.13	1.79								
AB_23	Akuna Bay	336437	6275945	0.35	1.65	0.04	1.49	1.79	2.14	1.97	2.04	2.04	2.04	2.04	1.97	2.03	2.03	2.03	2.03	1.97	2.14	2.14	2.14	2.14	1.79								
AB_24	Akuna Bay	336437	6275986	0.36	1.65	0.04	1.49	1.79	2.15	1.98	2.05	2.05	2.05	2.05	1.98	2.03	2.03	2.03	2.03	1.98	2.15	2.15	2.15	2.15	1.79								
AB_25	Akuna Bay	336437	6276027	0.37	1.65	0.04	1.49	1.79	2.16	1.98	2.06	2.06	2.06	2.06	1.98	2.03	2.03	2.03	2.03	1.98	2.16	2.16	2.16	2.16	1.79								
AB_26	Akuna Bay	336437	6276068	0.38	1.87	0.04	1.49	1.79	2.17	1.99	2.06	2.06	2.06	2.06	1.99	2.06	2.06	2.06	2.06	1.99	2.17	2.17	2.17	2.17	1.79								

100yr ARI Planning Levels - 2050 Planning Period - 0.4m Sea Level Rise

Foreshore Types:

1. Grassed or Sandy Slope (1 in 10 slope)
2. Rocky Shoreline (1 in 5 slope)
3. Sea Wall
4. Mangroves

100-year ARI Storm Tide at Patonga is **1.45** mAHD (excluding Sea Level Rise)

EPLs for all sea wall heights less than 1.5m will be the equivalent.

Mean Sea Level Rise Allowances taken from Council Policy **0.40** m to the year 2010

Freeboard of **0.3** m included in EPLs

Foreshore Location				100yrARI					Estuarine Planning Level (m)																	Reduction Factor							
				Wave			Local (Still) Water Level (mAHD)	Local (Still) Water Level with 0.3m Freeboard (mAHD)	Max EPL of all Foreshore Types and Crest Levels (mAHD)	Foreshore Type ##																							
										1					2					3					4								
										Crest Level (mAHD)																							
Location ID	Location	X MGAz56	Y MGAz56	Hs (m)	Tp (sec)	Local Wind Setup* (m)	2050	2050		1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	N/A	5m	10m	15m	20m	25m	30m	35m	40m
CP_01	Cottage Point	333834	6278821	0.56	2.40	0.03	1.88	2.18	2.73	2.45	2.50	2.58	2.58	2.58	2.45	2.50	2.60	2.60	2.60	2.45	2.52	2.73	2.73	2.73	2.18	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_02	Cottage Point	333794	6278832	0.55	2.40	0.03	1.88	2.18	2.73	2.45	2.49	2.57	2.57	2.57	2.45	2.50	2.60	2.60	2.60	2.45	2.52	2.73	2.73	2.73	2.18	0.07	0.14	0.21	0.28	0.34	0.41	0.48	0.55
CP_03	Cottage Point	333774	6278816	0.54	2.40	0.03	1.88	2.18	2.72	2.45	2.49	2.57	2.57	2.57	2.45	2.50	2.60	2.60	2.60	2.45	2.51	2.72	2.72	2.72	2.18	0.07	0.14	0.20	0.27	0.34	0.41	0.47	0.54
CP_04	Cottage Point	333734	6278827	0.52	2.40	0.03	1.88	2.18	2.70	2.44	2.48	2.55	2.55	2.55	2.44	2.49	2.59	2.59	2.59	2.44	2.50	2.70	2.70	2.70	2.18	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.52
CP_05	Cottage Point	333715	6278811	0.50	2.40	0.03	1.88	2.18	2.68	2.43	2.47	2.54	2.54	2.54	2.43	2.48	2.59	2.59	2.59	2.43	2.49	2.68	2.68	2.68	2.18	0.06	0.13	0.19	0.25	0.31	0.38	0.44	0.50
CP_06	Cottage Point	333695	6278796	0.48	2.40	0.03	1.88	2.18	2.66	2.42	2.46	2.53	2.53	2.53	2.42	2.47	2.58	2.58	2.58	2.42	2.48	2.66	2.66	2.66	2.18	0.06	0.12	0.18	0.24	0.30	0.36	0.42	0.48
CP_07	Cottage Point	333675	6278781	0.47	2.40	0.03	1.88	2.18	2.65	2.41	2.45	2.52	2.52	2.52	2.41	2.47	2.57	2.57	2.57	2.41	2.48	2.65	2.65	2.65	2.18	0.06	0.12	0.18	0.23	0.29	0.35	0.41	0.47
CP_08	Cottage Point	333656	6278766	0.45	2.40	0.03	1.88	2.18	2.64	2.41	2.45	2.51	2.51	2.51	2.41	2.46	2.57	2.57	2.57	2.41	2.47	2.64	2.64	2.64	2.18	0.06	0.11	0.17	0.23	0.28	0.34	0.40	0.45
CP_09	Cottage Point	333636	6278750	0.44	2.40	0.03	1.88	2.18	2.62	2.40	2.44	2.50	2.50	2.50	2.40	2.45	2.56	2.56	2.56	2.40	2.46	2.62	2.62	2.62	2.18	0.06	0.11	0.17	0.22	0.28	0.33	0.39	0.44
CP_10	Cottage Point	333636	6278791	0.43	2.40	0.03	1.88	2.18	2.61	2.40	2.44	2.49	2.49	2.49	2.40	2.45	2.56	2.56	2.56	2.40	2.46	2.61	2.61	2.61	2.18	0.05	0.11	0.16	0.22	0.27	0.32	0.38	0.43
CP_11	Cottage Point	333635	6278832	0.42	2.40	0.03	1.88	2.18	2.61	2.39	2.43	2.49	2.49	2.49	2.39	2.45	2.55	2.55	2.55	2.39	2.46	2.61	2.61	2.61	2.18	0.05	0.11	0.16	0.21	0.27	0.32	0.37	0.42
CP_12	Cottage Point	333655	6278847	0.42	2.40	0.03	1.88	2.18	2.60	2.39	2.43	2.48	2.48	2.48	2.39	2.44	2.55	2.55	2.55	2.39	2.45	2.60	2.60	2.60	2.18	0.05	0.11	0.16	0.21	0.26	0.32	0.37	0.42
CP_13	Cottage Point	333674	6278862	0.43	1.87	0.03	1.88	2.18	2.61	2.39	2.43	2.49	2.49	2.49	2.39	2.43	2.47	2.47	2.47	2.39	2.46	2.61	2.61	2.61	2.18	0.05	0.11	0.16	0.22	0.27	0.32	0.38	0.43
CP_14	Cottage Point	333674	6278903	0.46	1.87	0.03	1.88	2.18	2.64	2.41	2.45	2.51	2.51	2.51	2.41	2.44	2.48	2.48	2.48	2.41	2.47	2.64	2.64	2.64	2.18	0.06	0.12	0.17	0.23	0.29	0.35	0.40	0.46
CP_15	Cottage Point	333713	6278933	0.49	1.87	0.03	1.88	2.18	2.67	2.42	2.46	2.53	2.53	2.53	2.42	2.45	2.49	2.49	2.49	2.42	2.49	2.67	2.67	2.67	2.18	0.06	0.12	0.18	0.25	0.31	0.37	0.43	0.49
CP_16	Cottage Point	333712	6278974	0.52	1.87	0.03	1.88	2.18	2.70	2.44	2.48	2.55	2.55	2.55	2.44	2.46	2.50	2.50	2.50	2.44	2.50	2.70	2.70	2.70	2.18	0.06	0.13	0.19	0.26	0.32	0.39	0.45	0.52
CP_17	Cottage Point	333732	6278989	0.54	1.87	0.03	1.88	2.18	2.72	2.45	2.49	2.57	2.57	2.57	2.45	2.47	2.51	2.51	2.51	2.45	2.51	2.72	2.72	2.72	2.18	0.07	0.14	0.20	0.27	0.34	0.41	0.47	0.54
CP_18	Cottage Point	333712	6279014	0.56	2.11	0.03	1.88	2.18	2.73	2.45	2.49	2.58	2.58	2.58	2.45	2.49	2.55	2.55	2.55	2.45	2.52	2.73	2.73	2.73	2.18	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_19	Cottage Point	333711	6279055	0.58	2.11	0.02	1.87	2.17	2.75	2.46	2.51	2.59	2.59	2.59	2.46	2.50	2.56	2.56	2.56	2.46	2.53	2.75	2.75	2.75	2.17	0.07	0.14	0.22	0.29	0.36	0.43	0.50	0.58
CP_20	Cottage Point	333691	6279080	0.59	2.40	0.03	1.88	2.18	2.76	2.47	2.51	2.60	2.60	2.60	2.47	2.52	2.62	2.62	2.62	2.47	2.54	2.76	2.76	2.76	2.18	0.07	0.15	0.22	0.29	0.37	0.44	0.52	0.59
CP_21	Cottage Point	333671	6279065	0.56	1.87	0.02	1.87	2.17	2.74	2.45	2.50	2.58	2.58	2.58	2.45	2.48	2.51	2.51	2.51	2.45	2.52	2.74	2.74	2.74	2.17	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_22	Cottage Point	333632	6279075	0.53	1.87	0.03	1.88	2.18	2.71	2.44	2.48	2.56	2.56	2.56	2.44	2.47	2.50	2.50	2.50	2.44	2.51	2.71	2.71	2.71	2.18	0.07	0.13	0.20	0.27	0.33	0.40	0.46	0.53
CP_23	Cottage Point	333612	6279060	0.50	2.11	0.03	1.88	2.18	2.68	2.43	2.47	2.54	2.54	2.54	2.43	2.47	2.54	2.54	2.54	2.43	2.49	2.68	2.68	2.68	2.18	0.06	0.13	0.19	0.25	0.32	0.38	0.44	0.50
CP_24	Cottage Point	333572	6279070	0.50	2.11	0.03	1.88	2.18	2.68	2.43	2.47	2.54	2.54	2.54	2.43	2.47	2.54	2.54	2.54	2.43	2.49	2.68	2.68	2.68	2.18	0.06	0.12	0.19	0.25	0.31	0.37	0.44	0.50
CP_25	Cottage Point	333552	6279055	0.49	2.11	0.03	1.88	2.18	2.67	2.42	2.46	2.53	2.53	2.53	2.42	2.46	2.53	2.53	2.53	2.42	2.49	2.67	2.67	2.67	2.18	0.06	0.12	0.19	0.25	0.31	0.37	0.43	0.49
CP_26	Cottage Point	333513	6279065	0.50	2.40	0.03	1.88	2.18	2.67	2.42	2.47	2.53	2.53	2.53	2.42	2.48	2.58	2.58	2.58	2.42	2.49	2.67	2.67	2.67	2.18	0.06	0.12	0.19	0.25	0.31	0.37	0.43	0.50
CP_27	Cottage Point	333493	6279050	0.52	2.40	0.03	1.88	2.18	2.70	2.44	2.48	2.55	2.55	2.55	2.44	2.49	2.59	2.59	2.59	2.44	2.50	2.70	2.70	2.70	2.18	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.52
CP_28	Cottage Point	333453	6279060	0.55	2.40	0.03	1.88	2.18	2.73	2.45	2.50	2.58	2.58	2.58	2.45	2.50	2.61	2.61	2.61	2.45	2.52	2.73	2.73	2.73	2.18	0.07	0.14	0.21	0.28	0.35	0.42	0.48	0.55
CP_29	Cottage Point	333434	6279045	0.56	2.40	0.03	1.88	2.18	2.74	2.46	2.50	2.58	2.58	2.58	2.46	2.51	2.61	2.61	2.61	2.46	2.52	2.74	2.74	2.74	2.18	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_30	Cottage Point	333414	6279029	0.56	2.40	0.03	1.88	2.18	2.74	2.46	2.50	2.58	2.58	2.58	2.46	2.51	2.61	2.61	2.61	2.46	2.52	2.74	2.74	2.74	2.18	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_31	Cottage Point	333394	6279014	0.56	2.40	0.03	1.88	2.18	2.74	2.46	2.50	2.58	2.58	2.58	2.46	2.51	2.61	2.61	2.61	2.46	2.52	2.74	2.74	2.74	2.18	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_32	Cottage Point	333395	6278973	0.56	2.40	0.03	1.88	2.18	2.74	2.46	2.50	2.58	2.58	2.58	2.46	2.50	2.61	2.61	2.61	2.46	2.52	2.74	2.74	2.74	2.18	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_33	Cottage Point	333375	6278958	0.55	2.40	0.03	1.88	2.18	2.73	2.45	2.50	2.58	2.58	2.58	2.45	2.50	2.61	2.61	2.61	2.45	2.52	2.73	2.73	2.73	2.18	0.07	0.14	0.21	0.28	0.35	0.42	0.48	0.55
CP_34	Cottage Point	333356	6278902	0.54	2.40	0.03	1.88	2.18	2.72	2.45	2.49	2.57	2.57	2.57	2.45	2.50	2.60	2.60	2.60	2.45	2.52	2.72	2.72	2.72	2.18	0.07	0.14	0.20	0.27	0.34	0.41	0.48	0.54
CP_35	Cottage Point	333337	6278887	0.53	2.11	0.03	1.88	2.18	2.71	2.44	2.48	2.56	2.56	2.56	2.44	2.48	2.55	2.55	2.55	2.44	2.51	2.71	2.71	2.71	2.18	0.07	0.13	0.20	0.26	0.33	0.40	0.46	0.53
CP_36	Cottage Point	333317	6278872	0.51	2.11	0.03	1.88	2.18	2.69	2.43	2.47	2.55	2.55	2.55	2.43	2.47	2.54	2.54	2.54	2.43	2.50	2.69	2.69	2.69	2.18	0.06	0.13	0.19	0.25	0.32	0.38	0.45	0.51
CP_37	Cottage Point	333298	6278856	0.49	2.11	0.03	1.88	2.18	2.67	2.43	2.47	2.53	2.53	2.53	2.43	2.47	2.53	2.53	2.53	2.43	2.49	2.67	2.67	2.67	2.18	0.06	0.12	0.18	0.25	0.31	0.37	0.43	0.49
CP_38	Cottage Point	333278	6278841	0.49	2.11	0.03	1.88	2.18	2.67	2.42	2.47	2.53	2.53	2.53	2.42	2.47	2.53	2.53	2.53	2.42	2.49	2.67	2.67	2.67	2.18	0.06	0.12	0.18	0.25	0.31	0.37	0.43	0.49
CP_39	Cottage Point	333238	6278851	0.52	2.40	0.03	1.88	2.18	2.70	2.44	2.48	2.55	2.55	2.55	2.44	2.49	2.59	2.59	2.59	2.44	2.50	2.70	2.70	2.70	2.18	0.06	0.13	0.19	0.26	0.32	0.39	0.45	0.52
CP_40	Cottage Point	333199	6278821	0.54	2.40	0.03	1.88	2.18	2.71	2.45	2.49	2.56	2.56	2.56	2.45	2.49	2.60	2.60	2.60	2.45	2.51	2.71	2.71	2.71	2.18	0.07	0.13	0.20	0.27	0.33	0.40	0.47	0.54
CP_41	Cottage Point	333179	6278805	0.54	2.40	0.03	1.88	2.18	2.72	2.45	2.49	2.57	2.57	2.57	2.45	2.50	2.60	2.60	2.60	2.45	2.51	2.72	2.72	2.72	2.18	0.07	0.13	0.20	0.27	0.34	0.40	0.47	0.54
CP_42	Cottage Point	333160	6278790	0.54	2.40	0.03	1.88	2.18	2.72	2.45	2.49	2.57	2.57	2.57	2.45	2.50	2.60	2.60	2.60	2.45	2.51	2.72	2.72	2.72	2.18	0.07	0.13	0.20	0.27	0.34	0.40	0.47	0.54
CP_43	Cottage Point	333140	6278775	0.53	2.40	0.03	1.88	2.18	2.71	2.45	2.49	2.56	2.56	2.56	2.45	2.49	2.60	2.60	2.60	2.45	2.51	2.71	2.71	2.71	2.18	0.07	0.13	0.20	0.27	0.33	0.40	0.47	0.53
CP_44	Cottage Point	333121	6278760	0.53	2.40	0.03	1.88	2.18	2.71	2.44	2.48	2.56	2.56	2.56	2.44	2.49	2.60	2.60	2.60	2.44	2.51	2.71	2.71	2.71	2.18	0.07	0.13	0.20	0.26	0.33	0.40	0.46	0.53
CP_45	Cottage Point	333081	6278729	0.53	2.40	0.03	1.88	2.18	2.70	2.44	2.48	2.56	2.56	2.56	2.44	2.49	2.60	2.60	2.60	2.44	2.51	2.70	2.70	2.70	2.18	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.53
CP_46	Cottage Point	333082	6278689	0.52	2.40	0.03	1.88	2.18	2.70	2.44	2.48	2.56	2.56	2.56	2.44	2.49	2.59	2.59	2.59	2.44	2.50	2.70	2.70	2.70	2.18	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.52
CP_47	Cottage Point	333062	6278673	0.52	2.40	0.03	1.88	2.18	2.70	2.44	2.48	2.55	2.55	2.55	2.44	2.49	2.59	2.59	2.59	2.44	2.50	2.70	2.70	2.70	2.18	0.06	0.13	0.19	0.26	0.32	0.39	0.45	0.52
CP_48	Cottage Point	333043	6278658	0.50	2.40	0.03	1.88	2.18	2.68	2.43	2.47	2.54	2.54	2.54	2.43	2.48	2.59	2.59	2.59	2.43	2.49	2.68	2.68	2.68	2.18	0.06	0.13	0.19	0.25	0.31	0.38	0.44	0.50
AB_1	Akuna Bay	336595	6276023	0.36	1.65	0.04	1.89	2.29	2.65	2.47	2.50	2.55	2.55	2.55	2.47	2.50	2.53	2.53	2.53	2.47	2.53	2.65	2.65	2.65	2.29	0.04	0.09	0.13	0.18	0.22	0.27	0.31	0.36
AB_2	Akuna Bay	336575	6276008	0.35	1.65	0.04	1.89	2.29	2.64	2.47	2.50	2.55	2.55	2.55	2.47	2.50	2.53	2.53	2.53	2.47	2.52	2.64	2.64	2.64	2.29	0.04	0.09	0.13	0.18	0.22	0.26	0.31	0.35
AB_3	Akuna Bay	336555	6275994	0.35	1.65	0.04	1.89	2.29	2.64	2.47	2.50	2.54	2.54	2.54	2.47	2.50	2.52	2.52	2.52	2.47	2.52	2.64	2.64	2.64	2.29	0.04	0.09	0.13	0.17	0.22	0.26	0.31	0.35
AB_4	Akuna Bay	336516	6275964	0.34	1.65	0.04	1.89	2.29	2.64	2.46	2.50	2.54	2.54	2.54	2.46	2.49	2.52	2.52	2.52	2.46	2.52	2.64	2.64	2.64	2.29	0.04	0.09	0.13	0.17	0.22	0.26	0.30	0.34
AB_5	Akuna Bay	336496	6275949	0.34	1.65	0.04	1.89	2.29	2.63	2.46	2.50	2.54	2.54	2.54	2.46	2.49	2.52	2.52	2.52	2.46	2.52	2.63	2.63	2.63	2.29	0.04	0.08	0.13	0.17	0.21	0.25	0.29	0.34
AB_6	Akuna Bay	336476	6275934	0.33	1.65	0.04	1.89	2.29	2.62	2.46	2.49	2.53	2.53	2.53	2.46	2.49	2.52	2.52	2.52	2.46	2.51	2.62	2.62	2.62	2.29	0.04	0.08	0.12	0.16	0.20	0.24	0.29	0.33
AB_7	Akuna Bay	336476	6275893	0.33	1.65	0.04	1.89	2.29	2.62	2.46	2.49	2.53	2.53	2.53	2.46	2.49	2.52	2.52	2.52	2.46	2.51	2.62	2.62	2.62	2.29	0.04	0.08	0.12	0.16	0.21	0.25	0.29	0.33
AB_8	Akuna Bay	336456	6275878	0.32	1.45	0.04	1.89	2.29	2.62	2.46	2.49	2.53	2.53	2.53	2.46	2.48	2.49	2.49	2.49	2.46	2.51	2.62	2.62	2.62	2.29	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32
AB_9	Akuna Bay	336456	6275838	0.31	1.45	0.05	1.90	2.30	2.61	2.45	2.48	2.52	2.52	2.52	2.45	2.47	2.49	2.49	2.49	2.45	2.51	2.61	2.61	2.61	2.30	0.04	0.08	0.12	0.16	0.19	0.23	0.27	0.31

100yr ARI Planning Levels - 2050 Planning Period - 0.4m Sea Level Rise

Foreshore Types:

1. Grassed or Sandy Slope (1 in 10 slope)
2. Rocky Shoreline (1 in 5 slope)
3. Sea Wall
4. Mangroves

100-year ARI Storm Tide at Patonga is **1.45** mAHD (excluding Sea Level Rise)

EPLs for all sea wall heights less than 1.5m will be the equivalent.

Mean Sea Level Rise Allowances taken from Council Policy **0.40** m to the year 2010

Freeboard of **0.3** m included in EPLs

Foreshore Location				100yrARI					Estuarine Planning Level (m)																	Reduction Factor							
Location ID	Location	X MGAz56	Y MGAz56	Wave		Local Wind Setup* (m)	Local (Still) Water Level (mAHD)	Local (Still) Water Level with 0.3m Freeboard (mAHD)	Max EPL of all Foreshore Types and Crest Levels (mAHD)	Foreshore Type ##																5m	10m	15m	20m	25m	30m	35m	40m
				Hs (m)	Tp (sec)					1					2					3					4								
										Crest Level (mAHD)																							
							2050	2050		1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	N/A								
AB_10	Akuna Bay	336436	6275823	0.30	1.45	0.05	1.90	2.30	2.59	2.44	2.48	2.51	2.51	2.51	2.44	2.47	2.49	2.49	2.49	2.44	2.50	2.59	2.59	2.59	2.30	0.04	0.07	0.11	0.15	0.19	0.22	0.26	0.30
AB_11	Akuna Bay	336436	6275782	0.28	1.65	0.05	1.90	2.30	2.57	2.44	2.47	2.50	2.50	2.50	2.44	2.47	2.50	2.50	2.50	2.44	2.49	2.57	2.57	2.57	2.30	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28
AB_12	Akuna Bay	336416	6275767	0.28	1.65	0.05	1.90	2.30	2.58	2.44	2.47	2.50	2.50	2.50	2.44	2.47	2.51	2.51	2.51	2.44	2.49	2.58	2.58	2.58	2.30	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28
AB_13	Akuna Bay	336415	6275726	0.28	1.65	0.05	1.90	2.30	2.57	2.44	2.47	2.50	2.50	2.50	2.44	2.47	2.51	2.51	2.51	2.44	2.49	2.57	2.57	2.57	2.30	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28
AB_14	Akuna Bay	336376	6275737	0.27	1.65	0.05	1.90	2.30	2.57	2.43	2.47	2.49	2.49	2.49	2.43	2.47	2.50	2.50	2.50	2.43	2.49	2.57	2.57	2.57	2.30	0.03	0.07	0.10	0.14	0.17	0.20	0.24	0.27
AB_15	Akuna Bay	336356	6275722	0.26	1.65	0.05	1.90	2.30	2.56	2.43	2.46	2.48	2.48	2.48	2.43	2.46	2.50	2.50	2.50	2.43	2.48	2.56	2.56	2.56	2.30	0.03	0.06	0.10	0.13	0.16	0.19	0.23	0.26
AB_16	Akuna Bay	336357	6275763	0.26	1.28	0.05	1.90	2.30	2.55	2.42	2.46	2.48	2.48	2.48	2.42	2.44	2.45	2.45	2.45	2.42	2.48	2.55	2.55	2.55	2.30	0.03	0.06	0.10	0.13	0.16	0.19	0.22	0.26
AB_17	Akuna Bay	336357	6275804	0.28	1.45	0.04	1.89	2.29	2.57	2.43	2.47	2.49	2.49	2.49	2.43	2.46	2.48	2.48	2.48	2.43	2.49	2.57	2.57	2.57	2.29	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28
AB_18	Akuna Bay	336377	6275819	0.29	1.45	0.04	1.89	2.29	2.59	2.44	2.48	2.51	2.51	2.51	2.44	2.47	2.48	2.48	2.48	2.44	2.50	2.59	2.59	2.59	2.29	0.04	0.07	0.11	0.15	0.18	0.22	0.26	0.29
AB_19	Akuna Bay	336396	6275834	0.31	1.45	0.05	1.90	2.30	2.61	2.45	2.48	2.52	2.52	2.52	2.45	2.47	2.49	2.49	2.49	2.45	2.51	2.61	2.61	2.61	2.30	0.04	0.08	0.12	0.16	0.19	0.23	0.27	0.31
AB_20	Akuna Bay	336397	6275875	0.32	1.65	0.04	1.89	2.29	2.62	2.46	2.49	2.53	2.53	2.53	2.46	2.49	2.52	2.52	2.52	2.46	2.51	2.62	2.62	2.62	2.29	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32
AB_21	Akuna Bay	336417	6275890	0.33	1.65	0.04	1.89	2.29	2.63	2.46	2.50	2.53	2.53	2.53	2.46	2.49	2.52	2.52	2.52	2.46	2.52	2.63	2.63	2.63	2.29	0.04	0.08	0.13	0.17	0.21	0.25	0.29	0.33
AB_22	Akuna Bay	336417	6275930	0.34	1.65	0.04	1.89	2.29	2.63	2.46	2.50	2.54	2.54	2.54	2.46	2.49	2.52	2.52	2.52	2.46	2.52	2.63	2.63	2.63	2.29	0.04	0.09	0.13	0.17	0.21	0.26	0.30	0.34
AB_23	Akuna Bay	336437	6275945	0.35	1.65	0.04	1.89	2.29	2.64	2.47	2.50	2.54	2.54	2.54	2.47	2.50	2.53	2.53	2.53	2.47	2.52	2.64	2.64	2.64	2.29	0.04	0.09	0.13	0.17	0.22	0.26	0.30	0.35
AB_24	Akuna Bay	336437	6275986	0.36	1.65	0.04	1.89	2.29	2.65	2.47	2.51	2.55	2.55	2.55	2.47	2.50	2.53	2.53	2.53	2.47	2.53	2.65	2.65	2.65	2.29	0.04	0.09	0.13	0.18	0.22	0.27	0.31	0.36
AB_25	Akuna Bay	336437	6276027	0.37	1.65	0.04	1.89	2.29	2.66	2.47	2.51	2.56	2.56	2.56	2.47	2.50	2.53	2.53	2.53	2.47	2.53	2.66	2.66	2.66	2.29	0.05	0.09	0.14	0.18	0.23	0.28	0.32	0.37
AB_26	Akuna Bay	336437	6276068	0.38	1.87	0.04	1.89	2.29	2.67	2.48	2.51	2.56	2.56	2.56	2.48	2.52	2.56	2.56	2.56	2.48	2.54	2.67	2.67	2.67	2.29	0.05	0.09	0.14	0.19	0.24	0.28	0.33	0.38

100yr ARI Planning Levels - 2100 Planning Period - 0.9m SLR

Foreshore Types:

1. Grassed or Sandy Slope (1 in 10 slope)
2. Rocky Shoreline (1 in 5 slope)
3. Sea Wall
4. Mangroves

100-year ARI Storm Tide at Patonga is **1.45** mAHD (excluding Sea Level Rise)

EPLs for all sea wall heights less than 1.5m will be the equivalent.

Mean Sea Level Rise Allowances taken from Council Policy **0.90** m to the year 2010

Freeboard of **0.3** m included in EPLs

Foreshore Location				100yrARI					Estuarine Planning Level (m)																	Reduction Factor							
Location ID	Location	X MGAz56	Y MGAz56	Wave		Local Wind Setup* (m)	Local (Still) Water Level (mAHD)	Local (Still) Water Level with 0.3m Freeboard (mAHD)	Max EPL of all Foreshore Types and Crest Levels (mAHD)	Foreshore Type ## 1					2					3					4	5m	10m	15m	20m	25m	30m	35m	40m
				Hs (m)	Tp (sec)					Crest Level (mAHD)																							
							2100	2100		1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	N/A								
CP_01	Cottage Point	333834	6278821	0.56	2.40	0.03	2.38	2.68	3.23	2.95	2.95	3.00	3.08	3.08	2.95	2.95	3.00	3.10	3.10	2.95	2.95	3.02	3.23	3.23	2.68	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_02	Cottage Point	333794	6278832	0.55	2.40	0.03	2.38	2.68	3.23	2.95	2.95	2.99	3.07	3.07	2.95	2.95	3.00	3.10	3.10	2.95	2.95	3.02	3.23	3.23	2.68	0.07	0.14	0.21	0.28	0.34	0.41	0.48	0.55
CP_03	Cottage Point	333774	6278816	0.54	2.40	0.03	2.38	2.68	3.22	2.95	2.95	2.99	3.07	3.07	2.95	2.95	3.00	3.10	3.10	2.95	2.95	3.01	3.22	3.22	2.68	0.07	0.14	0.20	0.27	0.34	0.41	0.47	0.54
CP_04	Cottage Point	333734	6278827	0.52	2.40	0.03	2.38	2.68	3.20	2.94	2.94	2.98	3.05	3.05	2.94	2.94	2.99	3.09	3.09	2.94	2.94	3.00	3.20	3.20	2.68	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.52
CP_05	Cottage Point	333715	6278811	0.50	2.40	0.03	2.38	2.68	3.18	2.93	2.93	2.97	3.04	3.04	2.93	2.93	2.98	3.09	3.09	2.93	2.93	2.99	3.18	3.18	2.68	0.06	0.13	0.19	0.25	0.31	0.38	0.44	0.50
CP_06	Cottage Point	333695	6278796	0.48	2.40	0.03	2.38	2.68	3.16	2.92	2.92	2.96	3.03	3.03	2.92	2.92	2.97	3.08	3.08	2.92	2.92	2.98	3.16	3.16	2.68	0.06	0.12	0.18	0.24	0.30	0.36	0.42	0.48
CP_07	Cottage Point	333675	6278781	0.47	2.40	0.03	2.38	2.68	3.15	2.91	2.91	2.95	3.02	3.02	2.91	2.91	2.97	3.07	3.07	2.91	2.91	2.98	3.15	3.15	2.68	0.06	0.12	0.18	0.23	0.29	0.35	0.41	0.47
CP_08	Cottage Point	333656	6278766	0.45	2.40	0.03	2.38	2.68	3.14	2.91	2.91	2.95	3.01	3.01	2.91	2.91	2.96	3.07	3.07	2.91	2.91	2.97	3.14	3.14	2.68	0.06	0.11	0.17	0.23	0.28	0.34	0.40	0.45
CP_09	Cottage Point	333636	6278750	0.44	2.40	0.03	2.38	2.68	3.12	2.90	2.90	2.94	3.00	3.00	2.90	2.90	2.95	3.06	3.06	2.90	2.90	2.96	3.12	3.12	2.68	0.06	0.11	0.17	0.22	0.28	0.33	0.39	0.44
CP_10	Cottage Point	333636	6278791	0.43	2.40	0.03	2.38	2.68	3.11	2.90	2.90	2.94	2.99	2.99	2.90	2.90	2.95	3.06	3.06	2.90	2.90	2.96	3.11	3.11	2.68	0.05	0.11	0.16	0.22	0.27	0.32	0.38	0.43
CP_11	Cottage Point	333635	6278832	0.42	2.40	0.03	2.38	2.68	3.11	2.89	2.89	2.93	2.99	2.99	2.89	2.89	2.95	3.05	3.05	2.89	2.89	2.96	3.11	3.11	2.68	0.05	0.11	0.16	0.21	0.27	0.32	0.37	0.42
CP_12	Cottage Point	333655	6278847	0.42	2.40	0.03	2.38	2.68	3.10	2.89	2.89	2.93	2.98	2.98	2.89	2.89	2.94	3.05	3.05	2.89	2.89	2.95	3.10	3.10	2.68	0.05	0.11	0.16	0.21	0.26	0.32	0.37	0.42
CP_13	Cottage Point	333674	6278862	0.43	1.87	0.03	2.38	2.68	3.11	2.89	2.89	2.93	2.99	2.99	2.89	2.89	2.93	2.97	2.97	2.89	2.89	2.96	3.11	3.11	2.68	0.05	0.11	0.16	0.22	0.27	0.32	0.38	0.43
CP_14	Cottage Point	333674	6278903	0.46	1.87	0.03	2.38	2.68	3.14	2.91	2.91	2.95	3.01	3.01	2.91	2.91	2.94	2.98	2.98	2.91	2.91	2.97	3.14	3.14	2.68	0.06	0.12	0.17	0.23	0.29	0.35	0.40	0.46
CP_15	Cottage Point	333713	6278933	0.49	1.87	0.03	2.38	2.68	3.17	2.92	2.92	2.96	3.03	3.03	2.92	2.92	2.95	2.99	2.99	2.92	2.92	2.99	3.17	3.17	2.68	0.06	0.12	0.18	0.25	0.31	0.37	0.43	0.49
CP_16	Cottage Point	333712	6278974	0.52	1.87	0.03	2.38	2.68	3.20	2.94	2.94	2.98	3.05	3.05	2.94	2.94	2.96	3.00	3.00	2.94	2.94	3.00	3.20	3.20	2.68	0.06	0.13	0.19	0.26	0.32	0.39	0.45	0.52
CP_17	Cottage Point	333732	6278989	0.54	1.87	0.03	2.38	2.68	3.22	2.95	2.95	2.99	3.07	3.07	2.95	2.95	2.97	3.01	3.01	2.95	2.95	3.01	3.22	3.22	2.68	0.07	0.14	0.20	0.27	0.34	0.41	0.47	0.54
CP_18	Cottage Point	333712	6279014	0.56	2.11	0.03	2.38	2.68	3.23	2.95	2.95	2.99	3.08	3.08	2.95	2.95	2.99	3.05	3.05	2.95	2.95	3.02	3.23	3.23	2.68	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_19	Cottage Point	333711	6279055	0.58	2.11	0.02	2.37	2.67	3.25	2.96	2.96	3.01	3.09	3.09	2.96	2.96	3.00	3.06	3.06	2.96	2.96	3.03	3.25	3.25	2.67	0.07	0.14	0.22	0.29	0.36	0.43	0.50	0.58
CP_20	Cottage Point	333691	6279080	0.59	2.40	0.03	2.38	2.68	3.26	2.97	2.97	3.01	3.10	3.10	2.97	2.97	3.02	3.12	3.12	2.97	2.97	3.04	3.26	3.26	2.68	0.07	0.15	0.22	0.29	0.37	0.44	0.52	0.59
CP_21	Cottage Point	333671	6279065	0.56	1.87	0.02	2.37	2.67	3.24	2.95	2.95	3.00	3.08	3.08	2.95	2.95	2.98	3.01	3.01	2.95	2.95	3.02	3.24	3.24	2.67	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_22	Cottage Point	333632	6279075	0.53	1.87	0.03	2.38	2.68	3.21	2.94	2.94	2.98	3.06	3.06	2.94	2.94	2.97	3.00	3.00	2.94	2.94	3.01	3.21	3.21	2.68	0.07	0.13	0.20	0.27	0.33	0.40	0.46	0.53
CP_23	Cottage Point	333612	6279060	0.50	2.11	0.03	2.38	2.68	3.18	2.93	2.93	2.97	3.04	3.04	2.93	2.93	2.97	3.04	3.04	2.93	2.93	2.99	3.18	3.18	2.68	0.06	0.13	0.19	0.25	0.32	0.38	0.44	0.50
CP_24	Cottage Point	333572	6279070	0.50	2.11	0.03	2.38	2.68	3.18	2.93	2.93	2.97	3.04	3.04	2.93	2.93	2.97	3.04	3.04	2.93	2.93	2.99	3.18	3.18	2.68	0.06	0.12	0.19	0.25	0.31	0.37	0.44	0.50
CP_25	Cottage Point	333552	6279055	0.49	2.11	0.03	2.38	2.68	3.17	2.92	2.92	2.96	3.03	3.03	2.92	2.92	2.96	3.03	3.03	2.92	2.92	2.99	3.17	3.17	2.68	0.06	0.12	0.19	0.25	0.31	0.37	0.43	0.49
CP_26	Cottage Point	333513	6279065	0.50	2.40	0.03	2.38	2.68	3.17	2.92	2.92	2.97	3.03	3.03	2.92	2.92	2.98	3.08	3.08	2.92	2.92	2.99	3.17	3.17	2.68	0.06	0.12	0.19	0.25	0.31	0.37	0.43	0.50
CP_27	Cottage Point	333493	6279050	0.52	2.40	0.03	2.38	2.68	3.20	2.94	2.94	2.98	3.05	3.05	2.94	2.94	2.99	3.09	3.09	2.94	2.94	3.00	3.20	3.20	2.68	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.52
CP_28	Cottage Point	333453	6279060	0.55	2.40	0.03	2.38	2.68	3.23	2.95	2.95	3.00	3.08	3.08	2.95	2.95	3.00	3.11	3.11	2.95	2.95	3.02	3.23	3.23	2.68	0.07	0.14	0.21	0.28	0.35	0.42	0.48	0.55
CP_29	Cottage Point	333434	6279045	0.56	2.40	0.03	2.38	2.68	3.24	2.96	2.96	3.00	3.08	3.08	2.96	2.96	3.01	3.11	3.11	2.96	2.96	3.02	3.24	3.24	2.68	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_30	Cottage Point	333414	6279029	0.56	2.40	0.03	2.38	2.68	3.24	2.96	2.96	3.00	3.08	3.08	2.96	2.96	3.01	3.11	3.11	2.96	2.96	3.02	3.24	3.24	2.68	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_31	Cottage Point	333394	6279014	0.56	2.40	0.03	2.38	2.68	3.24	2.96	2.96	3.00	3.08	3.08	2.96	2.96	3.01	3.11	3.11	2.96	2.96	3.02	3.24	3.24	2.68	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_32	Cottage Point	333395	6278973	0.56	2.40	0.03	2.38	2.68	3.24	2.96	2.96	3.00	3.08	3.08	2.96	2.96	3.00	3.11	3.11	2.96	2.96	3.02	3.24	3.24	2.68	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
CP_33	Cottage Point	333375	6278958	0.55	2.40	0.03	2.38	2.68	3.23	2.95	2.95	3.00	3.08	3.08	2.95	2.95	3.00	3.11	3.11	2.95	2.95	3.02	3.23	3.23	2.68	0.07	0.14	0.21	0.28	0.35	0.42	0.48	0.55
CP_34	Cottage Point	333356	6278902	0.54	2.40	0.03	2.38	2.68	3.22	2.95	2.95	2.99	3.07	3.07	2.95	2.95	3.00	3.10	3.10	2.95	2.95	3.02	3.22	3.22	2.68	0.07	0.14	0.20	0.27	0.34	0.41	0.48	0.54
CP_35	Cottage Point	333337	6278887	0.53	2.11	0.03	2.38	2.68	3.21	2.94	2.94	2.98	3.06	3.06	2.94	2.94	2.98	3.05	3.05	2.94	2.94	3.01	3.21	3.21	2.68	0.07	0.13	0.20	0.26	0.33	0.40	0.46	0.53
CP_36	Cottage Point	333317	6278872	0.51	2.11	0.03	2.38	2.68	3.19	2.93	2.93	2.97	3.05	3.05	2.93	2.93	2.97	3.04	3.04	2.93	2.93	3.00	3.19	3.19	2.68	0.06	0.13	0.19	0.25	0.32	0.38	0.45	0.51
CP_37	Cottage Point	333298	6278856	0.49	2.11	0.03	2.38	2.68	3.17	2.93	2.93	2.97	3.03	3.03	2.93	2.93	2.97	3.03	3.03	2.93	2.93	2.99	3.17	3.17	2.68	0.06	0.12	0.18	0.25	0.31	0.37	0.43	0.49
CP_38	Cottage Point	333278	6278841	0.49	2.11	0.03	2.38	2.68	3.17	2.92	2.92	2.97	3.03	3.03	2.92	2.92	2.97	3.03	3.03	2.92	2.92	2.99	3.17	3.17	2.68	0.06	0.12	0.18	0.25	0.31	0.37	0.43	0.49
CP_39	Cottage Point	333238	6278851	0.52	2.40	0.03	2.38	2.68	3.20	2.94	2.94	2.98	3.05	3.05	2.94	2.94	2.99	3.09	3.09	2.94	2.94	3.00	3.20	3.20	2.68	0.06	0.13	0.19	0.26	0.32	0.39	0.45	0.52
CP_40	Cottage Point	333199	6278821	0.54	2.40	0.03	2.38	2.68	3.21	2.95	2.95	2.99	3.06	3.06	2.95	2.95	2.99	3.10	3.10	2.95	2.95	3.01	3.21	3.21	2.68	0.07	0.13	0.20	0.27	0.33	0.40	0.47	0.54
CP_41	Cottage Point	333179	6278805	0.54	2.40	0.03	2.38	2.68	3.22	2.95	2.95	2.99	3.07	3.07	2.95	2.95	3.00	3.10	3.10	2.95	2.95	3.01	3.22	3.22	2.68	0.07	0.13	0.20	0.27	0.34	0.40	0.47	0.54
CP_42	Cottage Point	333160	6278790	0.54	2.40	0.03	2.38	2.68	3.22	2.95	2.95	2.99	3.07	3.07	2.95	2.95	3.00	3.10	3.10	2.95	2.95	3.01	3.22	3.22	2.68	0.07	0.13	0.20	0.27	0.34	0.40	0.47	0.54
CP_43	Cottage Point	333140	6278775	0.53	2.40	0.03	2.38	2.68	3.21	2.95	2.95	2.99	3.06	3.06	2.95	2.95	2.99	3.10	3.10	2.95	2.95	3.01	3.21	3.21	2.68	0.07	0.13	0.20	0.27	0.33	0.40	0.47	0.53
CP_44	Cottage Point	333121	6278760	0.53	2.40	0.03	2.38	2.68	3.21	2.94	2.94	2.98	3.06	3.06	2.94	2.94	2.99	3.10	3.10	2.94	2.94	3.01	3.21	3.21	2.68	0.07	0.13	0.20	0.26	0.33	0.40	0.46	0.53
CP_45	Cottage Point	333081	6278729	0.53	2.40	0.03	2.38	2.68	3.20	2.94	2.94	2.98	3.06	3.06	2.94	2.94	2.99	3.10	3.10	2.94	2.94	3.01	3.20	3.20	2.68	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.53
CP_46	Cottage Point	333082	6278689	0.52	2.40	0.03	2.38	2.68	3.20	2.94	2.94	2.98	3.06	3.06	2.94	2.94	2.99	3.09	3.09	2.94	2.94	3.00	3.20	3.20	2.68	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.52
CP_47	Cottage Point	333062	6278673	0.52	2.40	0.03	2.38	2.68	3.20	2.94	2.94	2.98	3.05	3.05	2.94	2.94	2.99	3.09	3.09	2.94	2.94	3.00	3.20	3.20	2.68	0.06	0.13	0.19	0.26	0.32	0.39	0.45	0.52
CP_48	Cottage Point	333043	6278658	0.50	2.40	0.03	2.38	2.68	3.18	2.93	2.93	2.97	3.04	3.04	2.93	2.93	2.98	3.09	3.09	2.93	2.93	2.99	3.18	3.18	2.68	0.06	0.13	0.19	0.25	0.31	0.38	0.44	0.50
AB_1	Akuna Bay	336595	6276023	0.36	1.65	0.04	2.39	2.69	3.05	2.87	2.87	2.90	2.95	2.95	2.87	2.87	2.90	2.93	2.93	2.87	2.87	2.93	3.05	3.05	2.69	0.04	0.09	0.13	0.18	0.22	0.27	0.31	0.36
AB_2	Akuna Bay	336575	6276008	0.35	1.65	0.04	2.39	2.69	3.04	2.87	2.87	2.90	2.95	2.95	2.87	2.87	2.90	2.93	2.93	2.87	2.87	2.92	3.04	3.04	2.69	0.04	0.09	0.13	0.18	0.22	0.26	0.31	0.35
AB_3	Akuna Bay	336555	6275994	0.35	1.65	0.04	2.39	2.69	3.04	2.87	2.87	2.90	2.94	2.94	2.87	2.87	2.90	2.92	2.92	2.87	2.87	2.92	3.04	3.04	2.69	0.04	0.09	0.13	0.17	0.22	0.26	0.31	0.35
AB_4	Akuna Bay	336516	6275964	0.34	1.65	0.04	2.39	2.69	3.04	2.86	2.86	2.90	2.94	2.94	2.86	2.86	2.89	2.92	2.92	2.86	2.86	2.92	3.04	3.04	2.69	0.04	0.09	0.13	0.17	0.22	0.26	0.30	0.34
AB_5	Akuna Bay	336496	6275949	0.34	1.65	0.04	2.39	2.69	3.03	2.86	2.86	2.90	2.94	2.94	2.86	2.86	2.89	2.92	2.92	2.86	2.86	2.92	3.03	3.03	2.69	0.04	0.08	0.13	0.17	0.21	0.25	0.29	0.34
AB_6	Akuna Bay	336476	6275934	0.33	1.65	0.04	2.39	2.69	3.02	2.86	2.86	2.89	2.93	2.93	2.86	2.86	2.89	2.92	2.92	2.86	2.86	2.91	3.02	3.02	2.69	0.04	0.08	0.12	0.16	0.20	0.24	0.29	0.33
AB_7	Akuna Bay	336476	6275893	0.33	1.65	0.04	2.39	2.69	3.02	2.86	2.86	2.89	2.93	2.93	2.86	2.86	2.89	2.92	2.92	2.86	2.86	2.91	3.02	3.02	2.69	0.04	0.08	0.12	0.16	0.21	0.25	0.29	0.33
AB_8	Akuna Bay	336456	6275878	0.32	1.45	0.04	2.39	2.69	3.02	2.86	2.86	2.89	2.93	2.93	2.86	2.86	2.88	2.89	2.89	2.86	2.86	2.91	3.02	3.02	2.69	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32
AB_9	Akuna Bay	336456	6275838	0.31	1.45	0.05	2.40	2.70	3.01	2.85	2.85	2.88	2.92	2.92	2.85	2.85	2.87	2.89	2.89	2.85	2.85	2.91	3.01	3.01	2.70	0.04	0.08	0.12	0.16	0.19	0.23	0.27	0.31

100yr ARI Planning Levels - 2100 Planning Period - 0.9m SLR

Foreshore Types:

1. Grassed or Sandy Slope (1 in 10 slope)
2. Rocky Shoreline (1 in 5 slope)
3. Sea Wall
4. Mangroves

100-year ARI Storm Tide at Patonga is **1.45** mAHD (excluding Sea Level Rise)

EPLs for all sea wall heights less than 1.5m will be the equivalent.

Mean Sea Level Rise Allowances taken from Council Policy **0.90** m to the year 2010

Freeboard of **0.3** m included in EPLs

Foreshore Location				100yrARI					Estuarine Planning Level (m)																	Reduction Factor							
Location ID	Location	X MGAz56	Y MGAz56	Wave Hs (m)	Wave Tp (sec)	Local Wind Setup* (m)	Local (Still) Water Level (mAHD) 2100	Local (Still) Water Level with 0.3m Freeboard (mAHD) 2100	Max EPL of all Foreshore Types and Crest Levels (mAHD)	Foreshore Type ## 1					Foreshore Type ## 2					Foreshore Type ## 3					Foreshore Type ## 4	5m	10m	15m	20m	25m	30m	35m	40m
										Crest Level (mAHD) 1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	1.5	2	2.5	3	3.5	N/A								
AB_10	Akuna Bay	336436	6275823	0.30	1.45	0.05	2.40	2.70	2.99	2.84	2.84	2.88	2.91	2.91	2.84	2.84	2.87	2.89	2.89	2.84	2.84	2.90	2.99	2.99	2.70	0.04	0.07	0.11	0.15	0.19	0.22	0.26	0.30
AB_11	Akuna Bay	336436	6275782	0.28	1.65	0.05	2.40	2.70	2.97	2.84	2.84	2.87	2.90	2.90	2.84	2.84	2.87	2.90	2.90	2.84	2.84	2.89	2.97	2.97	2.70	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28
AB_12	Akuna Bay	336416	6275767	0.28	1.65	0.05	2.40	2.70	2.98	2.84	2.84	2.87	2.90	2.90	2.84	2.84	2.87	2.91	2.91	2.84	2.84	2.89	2.98	2.98	2.70	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28
AB_13	Akuna Bay	336415	6275726	0.28	1.65	0.05	2.40	2.70	2.97	2.84	2.84	2.87	2.90	2.90	2.84	2.84	2.87	2.91	2.91	2.84	2.84	2.89	2.97	2.97	2.70	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28
AB_14	Akuna Bay	336376	6275737	0.27	1.65	0.05	2.40	2.70	2.97	2.83	2.83	2.87	2.89	2.89	2.83	2.83	2.87	2.90	2.90	2.83	2.83	2.89	2.97	2.97	2.70	0.03	0.07	0.10	0.14	0.17	0.20	0.24	0.27
AB_15	Akuna Bay	336356	6275722	0.26	1.65	0.05	2.40	2.70	2.96	2.83	2.83	2.86	2.88	2.88	2.83	2.83	2.86	2.90	2.90	2.83	2.83	2.88	2.96	2.96	2.70	0.03	0.06	0.10	0.13	0.16	0.19	0.23	0.26
AB_16	Akuna Bay	336357	6275763	0.26	1.28	0.05	2.40	2.70	2.95	2.82	2.82	2.86	2.88	2.88	2.82	2.82	2.84	2.85	2.85	2.82	2.82	2.88	2.95	2.95	2.70	0.03	0.06	0.10	0.13	0.16	0.19	0.22	0.26
AB_17	Akuna Bay	336357	6275804	0.28	1.45	0.04	2.39	2.69	2.97	2.83	2.83	2.87	2.89	2.89	2.83	2.83	2.86	2.88	2.88	2.83	2.83	2.89	2.97	2.97	2.69	0.03	0.07	0.10	0.14	0.17	0.21	0.24	0.28
AB_18	Akuna Bay	336377	6275819	0.29	1.45	0.04	2.39	2.69	2.99	2.84	2.84	2.88	2.91	2.91	2.84	2.84	2.87	2.88	2.88	2.84	2.84	2.90	2.99	2.99	2.69	0.04	0.07	0.11	0.15	0.18	0.22	0.26	0.29
AB_19	Akuna Bay	336396	6275834	0.31	1.45	0.05	2.40	2.70	3.01	2.85	2.85	2.88	2.92	2.92	2.85	2.85	2.87	2.89	2.89	2.85	2.85	2.91	3.01	3.01	2.70	0.04	0.08	0.12	0.16	0.19	0.23	0.27	0.31
AB_20	Akuna Bay	336397	6275875	0.32	1.65	0.04	2.39	2.69	3.02	2.86	2.86	2.89	2.93	2.93	2.86	2.86	2.89	2.92	2.92	2.86	2.86	2.91	3.02	3.02	2.69	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32
AB_21	Akuna Bay	336417	6275890	0.33	1.65	0.04	2.39	2.69	3.03	2.86	2.86	2.90	2.93	2.93	2.86	2.86	2.89	2.92	2.92	2.86	2.86	2.92	3.03	3.03	2.69	0.04	0.08	0.13	0.17	0.21	0.25	0.29	0.33
AB_22	Akuna Bay	336417	6275930	0.34	1.65	0.04	2.39	2.69	3.03	2.86	2.86	2.90	2.94	2.94	2.86	2.86	2.89	2.92	2.92	2.86	2.86	2.92	3.03	3.03	2.69	0.04	0.09	0.13	0.17	0.21	0.26	0.30	0.34
AB_23	Akuna Bay	336437	6275945	0.35	1.65	0.04	2.39	2.69	3.04	2.87	2.87	2.90	2.94	2.94	2.87	2.87	2.90	2.93	2.93	2.87	2.87	2.92	3.04	3.04	2.69	0.04	0.09	0.13	0.17	0.22	0.26	0.30	0.35
AB_24	Akuna Bay	336437	6275986	0.36	1.65	0.04	2.39	2.69	3.05	2.87	2.87	2.91	2.95	2.95	2.87	2.87	2.90	2.93	2.93	2.87	2.87	2.93	3.05	3.05	2.69	0.04	0.09	0.13	0.18	0.22	0.27	0.31	0.36
AB_25	Akuna Bay	336437	6276027	0.37	1.65	0.04	2.39	2.69	3.06	2.87	2.87	2.91	2.96	2.96	2.87	2.87	2.90	2.93	2.93	2.87	2.87	2.93	3.06	3.06	2.69	0.05	0.09	0.14	0.18	0.23	0.28	0.32	0.37
AB_26	Akuna Bay	336437	6276068	0.38	1.87	0.04	2.39	2.69	3.07	2.88	2.88	2.91	2.96	2.96	2.88	2.88	2.92	2.96	2.96	2.88	2.88	2.94	3.07	3.07	2.69	0.05	0.09	0.14	0.19	0.24	0.28	0.33	0.38

Appendix C

Properties that may Require Floor Survey

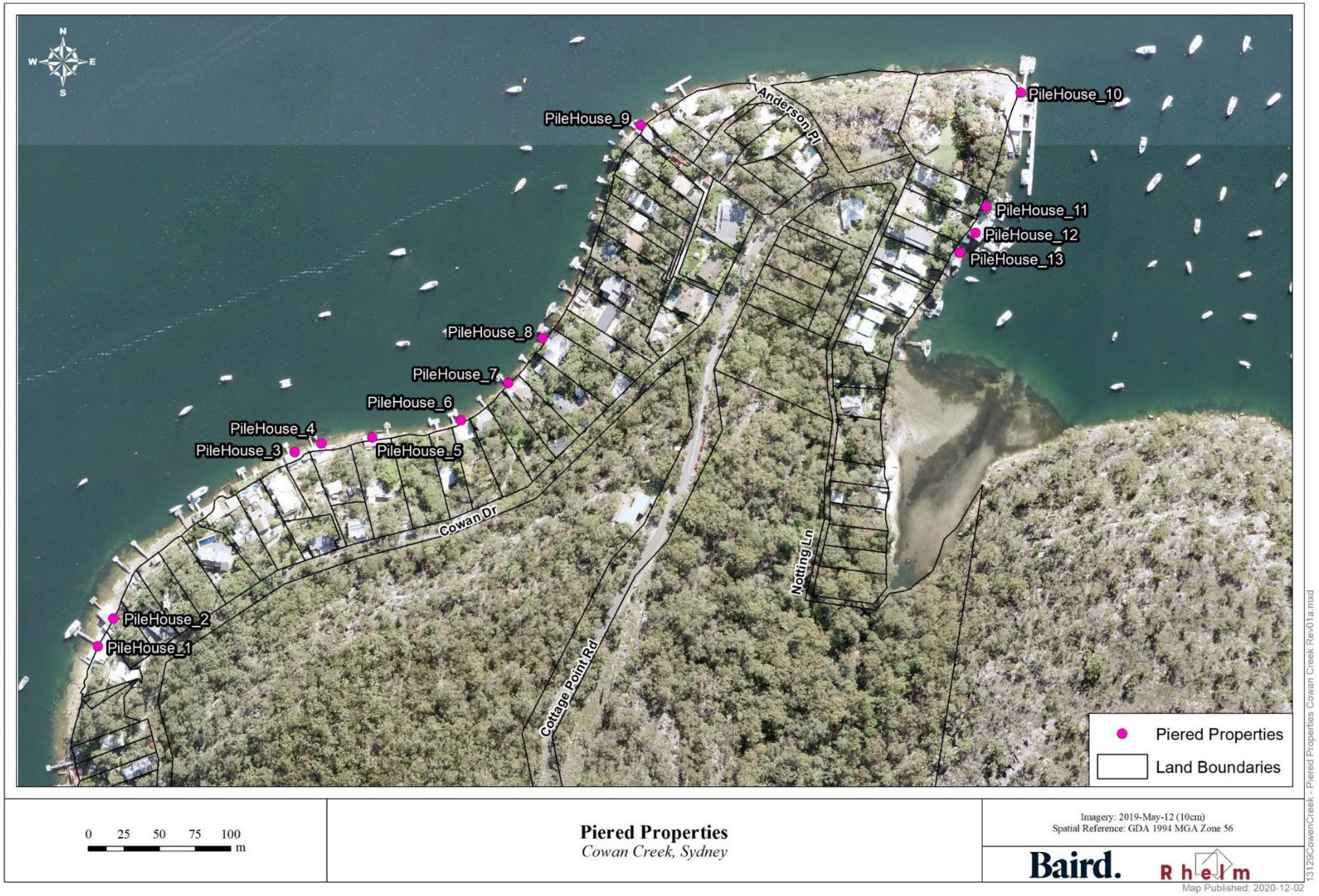

Figure C-1 Properties that may require floor survey

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Table C-3 – Location of Identified Piered Properties, Cowan Creek (MGA z56)

Easting (m)	Northing (m)	Name
333056	6278648	PileHouse_1
333067	6278667	PileHouse_2
333194	6278784	PileHouse_3
333213	6278791	PileHouse_4
333249	6278795	PileHouse_5
333311	6278807	PileHouse_6
333344	6278833	PileHouse_7
333368	6278865	PileHouse_8
333437	6279014	PileHouse_9
333704	6279037	PileHouse_10
333680	6278957	PileHouse_11
333672	6278939	PileHouse_12
333661	6278925	PileHouse_13

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Rhelm Pty Ltd

ABN 55 616 964 517

ACN 616 964 517

Head Office

Level 1, 50 Yeo Street

Neutral Bay NSW 2089

contact@rhelm.com.au

+61 2 9098 6998

www.rhelm.com.au