

Woy Woy Peninsula Climate Change Adaptation Study

Final Report

R05

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Executive Summary

The Woy Woy Peninsula is located within the Brisbane Water catchment, within the Central Coast Local Government Area (LGA). Previous studies of Brisbane Water (*Brisbane Water Foreshore Flood Study* (Cardno Lawson Treloar, 2013) and the *Floodplain Risk Management Study and Plan* (Cardno, 2015)) have shown that the low lying portions of the Woy Woy Peninsula will face difficulty with maintaining normal urban residential area functions under climate change projections for sea level rise.

The suburbs of Woy Woy, Blackwall, Booker Bay and Ettalong are low lying and susceptible to the effects of climate change and the existing threat from flooding in and around Brisbane Water Estuary. **Figure A** illustrates the study locations within the peninsula.

Raising existing ground levels and associated infrastructure was identified in Cardno, 2015 as a potential solution provided there are no long-term detrimental effects as a result of maladaptation. Raising land on a large scale regional basis is not practical given the multiple landholders and existing development. However, by developing a regional adaptation concept masterplan, incremental filling could be achieved, albeit over the longer term on individual or multiple sites through development and urban renewal.

The purpose of this climate change adaptation study is to inform the processes to realise a final adaptation landform. This study defines the conceptual landform designs and drainage masterplan, as well as outlining possible adaptation pathways and significant issues likely to arise during the process of landform raising.

Study Objectives

The primary aim of the study is to undertake a case study that will assist planning for future development in the Woy Woy peninsula and other low lying areas in and around the Brisbane Water Foreshore to adapt to future changes such as climate risks.

This climate change adaptation study focuses on the technical analysis of potential landforms and associated measures to provide flood protection against existing and future flood risk to the year 2100, associated with both catchment and ocean flooding (both tidal and storm induced).

The key objectives are:

- Developing a concept landform and drainage study for four areas of inundation located along the foreshore of Woy Woy Peninsula identified in the Brisbane Water Foreshore Floodplain Risk Management Plan (Cardno, 2015) as vulnerable areas that require adaptation plans to address existing and future tidal and storm surge events.
- Developing adaptation pathways that would assist the implementation of a future landform and drainage master plan that would address priority adaptation Subset Actions identified in the Coastal Councils Climate Change Adaptation Plan (2010) commissioned by Hunter and Central Coast Regional Environmental Strategy (HCCREMS). Specifically, actions A4, A5, B6 and B8 shown in *Table ES1 Infrastructure and Assets* (HCCREMS, 2010).
- Undertaking this project in line with the NSW Government's initiatives for adapting to climate change and best practice adaptation planning and implementation.

Study Approach

The following approach was adopted for this study:

- Site inspections of the study areas by the project team on 30 January 2020.

- Compile and review of all previous reports, studies, and available data.
- Define the existing flood risk from tides, ocean storms and local catchment runoff.
- Apply guidance from Council's Climate Change Policy (2019) to determine future flood risk from sea level rise up to 2100.
- Provide a conceptual design for landform adaptation and drainage masterplanning to reduce future flood risk within the study area due to rising sea levels.
- Identify potential issues associated with incremental lots raising to achieve the final adaptation landform.
- Define adaptation pathways based on thresholds for maintaining liveability within the study locations and trigger points for those thresholds associated with sea level rise projections.
- Provide guidance on adaptive planning measures for Council.

Flood Risk

The four study areas can be impacted by flood risk from Brisbane Water flooding as a result of ocean storms, local catchment flooding as a result of local rainfall and tidal inundation during high tides. All of these flood risks would increase as a result of sea level rise. Sea level rise for this study is based on the RCP8.5 projections, consistent with the Brisbane Water Foreshore Floodplain Risk Management Plan (Cardno, 2015).

Table A outlines the sea level rise projections as the apply to a range of ocean storm events and tidal events. Ettalong, with it's closer proximity to the ocean, is subject to the highest end of the range and Woy Woy being furthest inland has the lower limit applied.

Table A. Brisbane Water Estuary Level for Representative Tidal and Ocean Events

Year	Sea Level Rise (m)	Tidal 1%PoE[1] (mAHD)	Ocean Storm 1% AEP[2] (mAHD)
2015	0	0.68 – 0.93	1.58 – 1.78
2030	0.1	0.78 – 1.03	1.68 – 1.88
2050	0.2	0.88 – 1.03	1.78 – 1.98
2070	0.4	1.08 – 1.33	1.98 – 2.18
2100	0.7	1.38 – 1.63	2.28 – 2.48

1 Probability of Exceedance. The 1% PoE is defined as the level which is exceeded, on a time basis, for 1% of time recorded in the estuary water level gauge.

2 Annual Exceedance Probability. The 1% AEP is defined at the estuary level produced by an ocean storm surge event which has a 1% chance of occurring at least once in the next 12 months.

Investigation into the existing flood risk for the study locations and the flood levels with respect to the existing ground level provided a reasonable technical objective for landform adaptation: protection of private and public land for existing ocean storm in the 1% AEP event and for the 1% PoE tidal events considering sea level rise up to 2100.

Landform Outcomes

The adaptation landform design was developed iteratively to achieve an outcome where:

- Flood risk for the 1% PoE tidal level (for sea level rise top 2100) and the 1% AEP ocean storm (existing conditions) are eliminated.

- Flood risk from local catchment runoff is significantly reduced.
- Fill levels for private properties are minimised, generally around 0.5 m, with a maximum of approximately 1.5 m in isolated instances.

To achieve these outcomes, the adaptation landforms made use of existing open spaces and laneways which could be converted into drainage paths, as well as the introduction of new drainage easements. This allows the stormwater drainage network to run a shorter distance (i.e. not all the way to the foreshore), requiring less rise from the outlet and less fill for the surrounding land. The easements and open space drainage paths will eventually become tidal due to sea level rise and could take on multiple forms, such as culverts, open channels, riparian areas, or combination of these.

Further refinement of the landform and drainage masterplan will be required to eliminate isolated instances where flood depths have increased on private property.

Adaptation Pathways

Following development of the landforms and identification of issues associated with progressing the adaptation strategy from concept to realisation, a series of adaptation pathways were generated following the guidance outlined in the Decision Support for Coastal Adaptation: The Handbook (HCCREMS, 2012). The pathways include a conceptual breakdown of the options and actions associated with realising the proposed landforms over the next century.

Six adaptation pathways were produced for the project (refer to **Figure B**). These are listed in order of most preferrable (Pathway A) to least (Pathway F). Pathway A requires relatively quick action to be taken this decade to avoid losing liveability of some properties in the Woy Woy study location. Pathway B represents the scenario where initial actions are delayed and an accelerated workplan is required; however, the risk of losing liveability is increased. The other pathways (Pathways C through F) involve planned retreat of some of the lowest-lying and at risk properties. The workplan for Pathway A is summarised in **Table B**.

It should be emphasised that the retreat actions identified in the adaptation pathways only refers to the loss of liveability for the most vulnerable portions of the study areas, and not a signal for the entire study area to begin retreating.

The adaptation pathways assessed in this study only reflect the consequences to the year 2100. A revised climate change adaptation study would need to be completed prior to this end date to ensure the liveability, with respect to sea level rise, of the Woy Woy Peninsula into next century.

Economic Analysis

An economic assessment was undertaken by comparing the costs and benefits of two scenarios: the Base Case (or do minimum) and the concept masterplan scenarios. It is important that these scenarios or alternatives were clearly defined to ensure a robust analysis.

A benefit-cost ratio (BCR) was determined by comparing the concept masterplan scenarios against the base case, for each study location. A BCR greater than 1 result in an economic outcome that exceeds the cost of implementing the works, a BCR between zero and one produces less economic benefits than the cost of implementing the works but still has an economic benefit, and a BCR less than zero has a negative economic outcome. For Woy Woy, the concept masterplan had a BCR of 0.8. For Blackwall, Ettalong and Booker Bay, the estimated BCR was 0.4, 0.7 and 0.2, respectively. However, the incorporation of unquantified benefits may change this outcome (e.g. recreational value, environmental value, public infrastructure).

The higher BCR for Woy Woy reflected the fact that this area is subject to tidal and ocean storm inundation in the relatively immediate future.

The economic analysis for all locations assumed that works would start immediately. The lower short term risk at Blackwall, Ettalong and Booker Bay, would suggest that initiating landform works could commence at a later date (as per the adaptation pathways presented). The delay in works, and therefore delay in expenditure, would likely improve the outcome of the economic analysis for these locations.

Recommendations

Significant work is required to ensure that Adaptation Pathway A can be fulfilled. In additional to the workplan (**Table B**), the following actions should be undertaken:

- Distribution of the information contained in this study to all relevant Council staff and Councillors.
- Further refinement of the concept masterplan provided in this study into a detailed masterplan, such as:
    - Detailed design of the landform and drainage system to ensure no increases in flood risk for any private properties;
    - More detailed investigations into interim scenarios, impacts and triggers and the framework for Council to enable adaptation pathways for all properties and residents;
    - Prepare standardised schematic drawings for individual lots (e.g. fill containment, drainage);
    - Constructability methodology reporting;
    - Review of the Development Control Plan (DCP) and Local Environment Plan (LEP) for permissible development, height restrictions and consolidations of allotments for potential larger scale development;
    - The environmental impacts and impacts on Aboriginal and non-Aboriginal heritage to be considered; and
    - Other non-flooding planning impacts, such as solar access for homes.
- Include this climate change adaption strategy as a mitigation option in the Woy Woy Floodplain Risk Management Study and Plan. This may assist in application for funding from the NSW Floodplain Management Program for components of the landform that address existing flood risk, such as raising of public assets and easements.
- Community engagement for the proposed landform and individual flood management works to be undertaken as part of the detailed masterplan preparation.
- Facilitate knowledge sharing by establishing a working group with other coastal councils which are considering landform raising as an adaptation to sea level rise.
- Dissemination of this report through the public domain to initiate discussion and provide a road map with the wider community.
- Create a road map based on the following principles acknowledged in Council's Climate Change Policy:
    - Principle 5: Council implement a proactive approach and ensure continuity to better anticipate and adapt to complex challenges posed by the changing climate.
    - Principle 6: Council implement a Place-based approach to enhance Council and community capacity for climate resilience that is context specific, knowledge based and collaborative.
    - Commitment D4: Council develop place based Climate Change Action Plans in partnership with the community that establishes regional targets for mitigation and prioritises local adaptation planning.

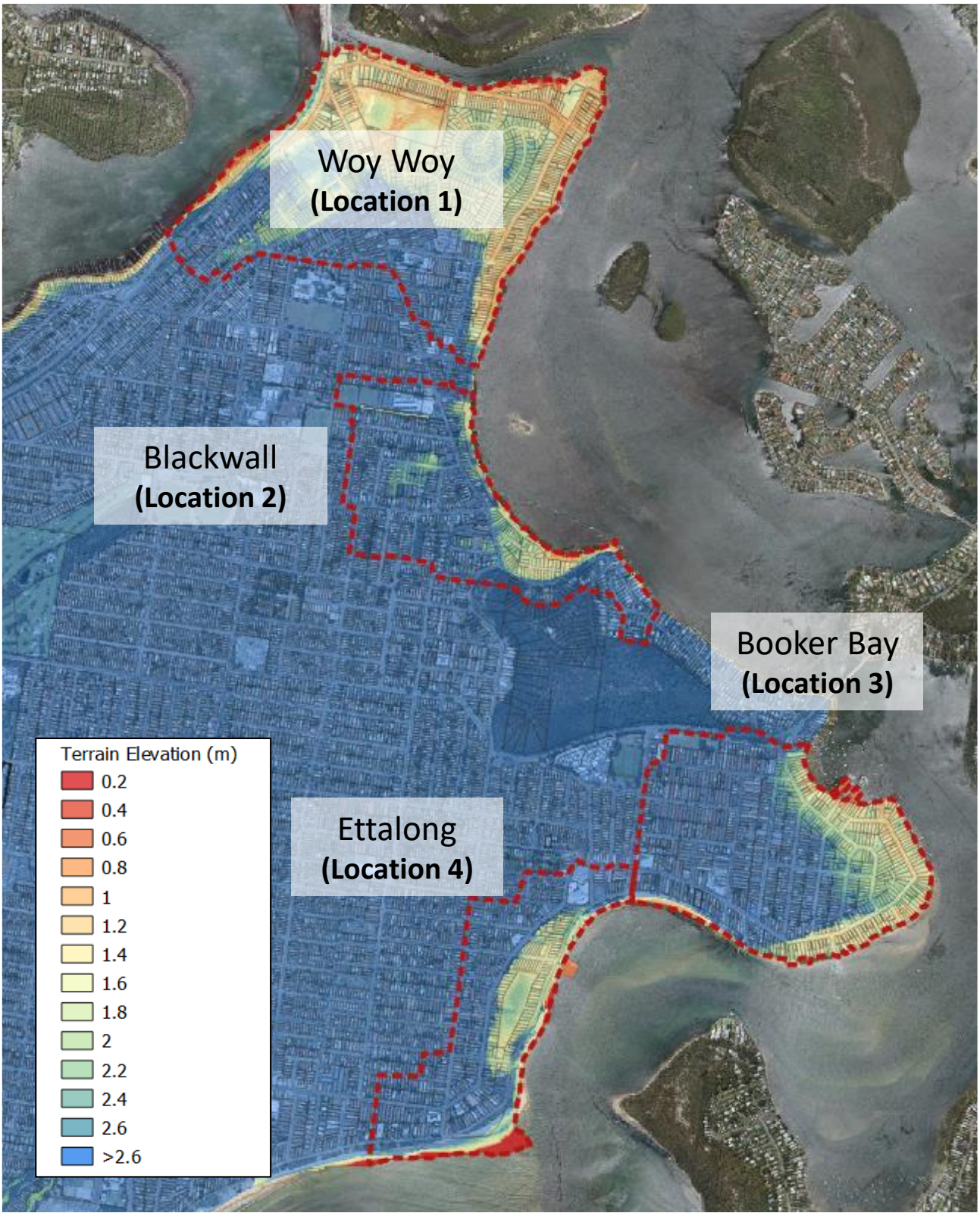

Figure A. Study Areas Overview

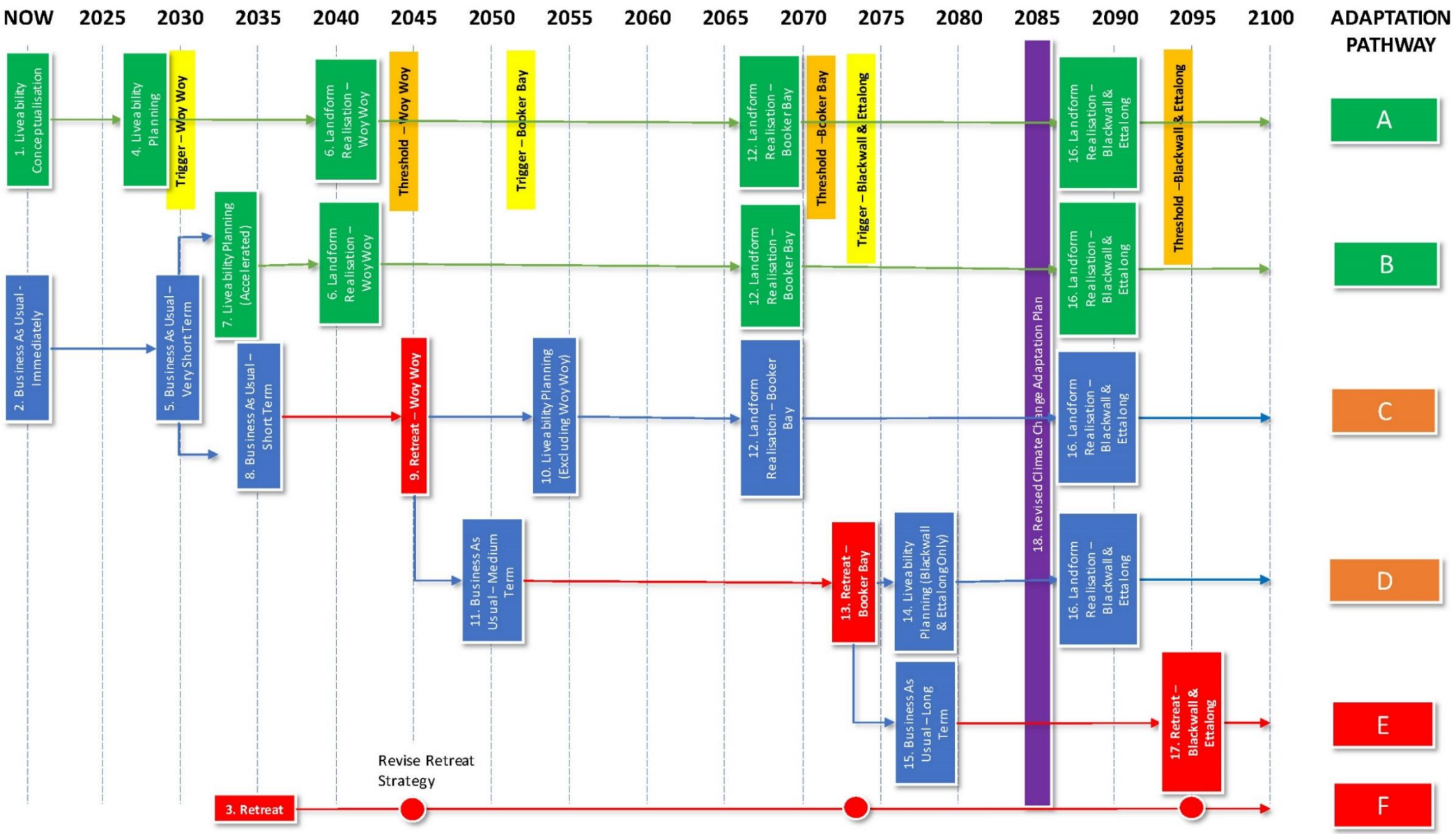

Figure B. Preliminary Adaptation Pathways

Table B. Workplan - Adaptation Pathway A

Begin Actions	Option	Actions
Now	Liveability Conceptualisation	• Complete Woy Woy Climate Change Adaptation Case Study • Report Recommendations and Include in Draft Woy Woy FRMSP • Exhibit and Adopt Woy Woy FRMSP • Develop Masterplan and Public Domain Plan • Adopt Sea Level Rise Policy • Adopt Floodplain Risk Management Policy • LEP & DCP Review • Develop Drainage Master Plan - Constructability • Disseminate in Public Domain Results of this Study • Collaborate with Other Coastal Councils to Create a Working Group
2030	Liveability Planning	• Adopt Climate Change Adaptation Plan • Revised Adaptation Pathways • Community Engagement - Triggers and Threshold • Community Education - Adaptation Plan Process • Prepare Climate Adaptation Plan - Place Based • Adopt Masterplan and Public Domain Plan • LEP & DCP Revised to Include Climate Actions • Private Seawalls and Levees Guidelines • Establish Easements • Monitor Sea Level Rise
2040	Landform Realisation - Woy Woy	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform - Roads • Monitor Sea Level Rise
2070	Landform Realisation – Booker Bay	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise
2085		Undertake Revised Climate Change Adaptation Study
2090	Landform Realisation – Blackwall and Ettalong	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise

Glossary

Annual exceedance probability (AEP)	The chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (i.e. a 1 in 20 chance) of a peak discharge of 500 m^3/s (or larger) occurring in any one year. (See also average recurrence interval).
Australian Height Datum (AHD)	National survey datum corresponding approximately to mean sea level.
Average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood as big as (or larger than) the selected event. For example, floods with a discharge as great as (or greater than) the 20 year ARI design flood will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. (See also annual exceedance probability).
Climate Change	A change of climate over an extended period, typically decades or longer, which is caused by human activity or natural climate variability that have direct and indirect impact on the environment, community and Council business. The adopted Representative Concentration Pathway (RCP) for this study is RCP8.5. The reflects a business as usual scenario where the effort to curb greenhouse gas emissions is low. Central Coast Council's Climate Change Policy was adopted in 2018.
Catchment	The catchment, at a particular point, is the area of land that drains to that point.
Design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year ARI or 1% AEP flood).
Development	Is defined in Part 4 of the AP&A Act as: - Infill Development: development of vacant blocks of land that are generally surrounded by developed properties. - New Development: development of a completely different nature to that associated with the former land use. - Redevelopment: Rebuilding in an area with similar development.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
Flood	Relatively high river or creek flows, which overtop the natural or artificial banks, and inundate floodplains and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood Awareness	Awareness is an appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response ad evacuation procedures.

Flood Education	Education that seeks to provide information to raise awareness of the flood problem to enable individuals to understand how to manage themselves and their property in a flood event.
Flood level	The height or elevation of floodwaters relative to a datum (typically the Australian Height Datum). Also referred to as "stage".
Floodplain	Area of land which is subject to floods up to and including the probable maximum flood.
Floodplain risk management plan	A document outlining a range of actions aimed at improving floodplain management. The plan is the principal means of managing the risks associated with the use of the floodplain. A floodplain risk management plan needs to be developed in accordance with the principles and guidelines contained in the NSW Floodplain Development Manual. The plan usually contains both written and diagrammatic information describing how particular areas of the floodplain are to be used and managed to achieve defined objectives.
Flood planning levels (FPLs)	Flood planning levels selected for planning purposes are derived from a combination of the adopted flood level plus free board, as determined in floodplain management studies and incorporated in floodplain risk management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also consider the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plans. The concept of FPLs supersedes the "standard flood event". As FPLs do not necessarily extend to the limits of flood prone land, floodplain risk management plans may apply to flood prone land beyond that defined by the FPLs.
Flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).
High High Water Spring Solstices	Rarer high tides occurring approximately twice a year, during the June and December solstices ("king tides")
Hydraulic	The term given to the study of water flow in rivers, estuaries and coastal systems, in particular the evaluation of flow parameters such as water level and velocity.
Hydrograph	A graph showing how a river or creek's discharge changes with time.
Hydrologic	Pertaining to rainfall-runoff processes in catchments.
Hydrology	The term given to the study of the rainfall-runoff process in catchments, in particular, the evaluation of peak flows and flow volumes. .

Masterplan	A highly detailed Plan prepared by Council to provide guidance for potential development of a particular area including development concepts. This climate change adaptation study provides elements of a conceptual masterplan. The detailed masterplan refers to the next phase of design for the landform including further refinement of the proposed surface and drainage network. It is also used to develop specific development controls that consider constructability, adaptive pathways and staging of development.
Mean High Water Springs	"Every day" tidal inundation caused by high tides. The MHWS tide is the average of all high water observations at the time of spring tide over a period time (generally 19 years)
Peak flood level, flow or velocity	The maximum flood level, flow or velocity that occurs during a flood event.
Probable maximum flood (PMF)	An extreme flood deemed to be the maximum flood that could conceivably occur.
Probability	A statistical measure of the likely frequency or occurrence of flooding.
Public Domain Plan	A very highly detailed Plan prepared by Council to establish design direction and general criteria to apply to the design of the public open space network. Generally, this works towards the implementation of the public facilities recommended in a Masterplan.
Runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.
Storm Surge	A rise and onshore surge of seawater as the result primarily of the winds of a storm, and secondarily of the surface pressure drop near the storm centre.
Topography	The shape of the surface features of land.
Velocity	The speed at which the floodwaters are moving. A flood velocity predicted by a 2D computer flood model is quoted as the depth averaged velocity, i.e. the average velocity throughout the depth of the water column. A flood velocity predicted by a 1D or quasi-2D computer flood model is quoted as the depth and width averaged velocity, i.e. the average velocity across the whole river or creek section.

Acronyms

1D	One Dimensional
2D	Two Dimensional
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARF	Areal Reduction Factor
AR&R	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
BVSC	Bega Valley Shire Council
DCP	Development Control Plan
DEM	Digital Elevation Model
DPE	Department of Planning and Environment
ECL	East Coast Low
IFD	Intensity Frequency Duration
FPL	Flood Planning Level
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
FPRMSP	Floodplain Risk Management Study & Plan
ha	hectare
HAT	Highest Astronomical Tide
HCCREMS	Hunter and Central Coast Regional Environmental Management Strategy
HHWSS	High High Water Spring Solstices
km	kilometres
km^2	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging
m	metre
m^2	Square metres
m^3	Cubic metres
mAHD	metres to Australian Height Datum
mm	millimetres
m/s	metres per second

MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MHWN	Mean High Water Neap
MLWN	Mean Low Water Neap
MSL	Mean Sea Level
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW)
PMF	Probable Maximum Flood
SES	State Emergency Service (NSW)

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Maps

Description	Woy Woy CBD	Blackwall	Booker Bay	Ettalong
Site Inspection Photos	G150	G151		
Brisbane Water 1% Probability of Exceedance	G160			
Brisbane Water 1% AEP Flood Extents	G161			
Brisbane Water HHWSS Flood Extents	G162			
Woy Woy Flood Study 1% AEP Flood Depth	G163			
Design Landform	G220	G221	G222	G223
Landform Fill Depths	G320	G321	G322	G323
Existing Flood Depths – 1% AEP	G420	G422	G424	G426
Existing Flood Depths – 20% AEP	G421	G423	G425	G427
Sensitivity Analysis – 2030 Sea Level Rise	G430			
Sensitivity Analysis – 2070 Sea Level Rise	G431			
Sensitivity Analysis – 2100 Sea Level Rise	G432			
Sensitivity Analysis – Increase Losses 20%	G433			
Sensitivity Analysis – Decrease Losses 20%	G434			
Sensitivity Analysis – Increase Culvert Blockage 50%	G435			
Flood Depth – Business as Usual Scenario	G449			
Design Landform Flood Depths – 1% AEP	G450	G452	G454	G456
Design Landform Flood Depths – 20% AEP	G451	G453	G455	G457
Design Landform Flood Depth, Interim Scenario – 1% AEP	G460	No interim scenario assessed		
Design Landform Flood Depth Impact – 1% AEP	G470	G472	G474	G476
Design Landform Flood Depth Impact – 20% AEP	G471	G473	G475	G477
Potential Staging of Works	G551	G552	G553	G554

1 Introduction

1.1 Background

The Woy Woy Peninsula is located within the Brisbane Water catchment, within the Central Coast Local Government Area (LGA). Previous studies of Brisbane Water (*Brisbane Water Foreshore Flood Study* (Cardno Lawson Treloar, 2013) and the *Floodplain Risk Management Study and Plan* (Cardno, 2015)) have shown that the low lying portions of the Woy Woy Peninsula will face difficulty with maintaining normal urban residential area functions under climate change projections for sea level rise.

Raising existing ground levels and associated infrastructure was identified in Cardno, 2015 as a potential solution provided there are no long-term detrimental effects as a result of maladaptation. Raising land on a large scale regional basis is not practical given the multiple landholders and existing development. However, by developing a regional adaptation concept masterplan, incremental filling could be achieved, albeit over the longer term on individual or multiple sites through development and urban renewal.

The suburbs of Woy Woy, Blackwall, Booker Bay and Ettalong, located in the Woy Woy Peninsula, are representative of a number of suburbs that are low lying and susceptible to the effects of climate change and the existing threat from flooding in and around Brisbane Water Estuary. By undertaking a regional adaptation concept masterplan for these locations, adaption pathways can be developed such as development controls, drainage easements and other mitigation measures which could be implemented over time in consultation with the community. The purpose of this climate change adaptation study is to inform these processes.

A local study of catchment flooding for the Woy Woy Peninsula (DHI, 2010) shows that the suburbs of Woy Woy, Blackwall, Booker Bay and Ettalong are also affected by overland flows. The local catchment flood behaviour is currently being reviewed as part of a coupled groundwater-surface water analysis in the *Woy Woy Floodplain Risk Management Study and Plan* (FRMSP) by DHI.

This study will look to achieve a conceptual landform masterplan that addresses sea level rise risk and an improvement to local drainage.

1.2 Study Objectives

The primary aim of the study is to undertake a case study that will assist planning for future development in the Woy Woy peninsula and other low lying areas in and around the Brisbane Water Foreshore to adapt to future changes such as climate risks.

This climate change adaptation study focuses on the technical analysis of potential landforms and associated measures to provide flood protection against existing and future flood risk to the year 2100, associated with both catchment and ocean flooding (both tidal and storm induced).

The key objectives are:

- Developing a concept landform and drainage study for four areas of inundation located along the foreshore of Woy Woy Peninsula identified in the Brisbane Water Foreshore Floodplain Risk Management Plan (2015) as vulnerable areas that require adaptation plans to address existing and future tidal and storm surge events.
- Developing adaptation pathways that would assist the implementation of a future landform and drainage master plan that would address priority adaptation Subset Actions identified in the Coastal Councils Climate Change Adaptation Plan (2010) commissioned by Hunter and Central Coast Regional

Environmental Strategy (HCCREMS). Specifically, actions A4, A5, B6 and B8 shown in *Table ES1 Infrastructure and Assets* (HCCREMS, 2010).

- Undertaking this project in line with the NSW Government's initiatives for adapting to climate change and best practice adaptation planning and implementation.

2 Study Area

The study areas are within the Woy Woy Peninsula and are sub-catchments of Brisbane Water, which connects to Broken Bay. The peninsula is bounded by Brisbane Water to the north and east, Broken Bay to the south and Brisbane Water National Park to the west. The study area can be subdivided in three catchment areas: Woy Woy Bay Drainage Catchment, Woy Woy Peninsula East Drainage Catchment and Kahibah Creek Drainage Catchment.

This study will focus on four areas along the Brisbane Water foreshore: Woy Woy, Blackwall, Booker Bay and Ettalong. Woy Woy is situated in the Woy Woy Bay Drainage Catchment areas, whereas the other three precincts are located within the Woy Woy Peninsula East Drainage Catchment.

The study locations are characterised by a predominantly flat terrain, with elevations ranging from 0 to 2 metres above the sea level for the most part of the area. Land-use in the catchments is primarily residential, with the presence of commercial spaces. Grassed areas, such as parks and sports fields are also present in the area and vegetation of a larger size can be found in the Blackwall Mountain Reserve.

The terrain in the area is characterised by sand dune ridge system that, at times, contains a high water table. The status of the water table has a significant impact on soil infiltration capacity and is further aggravated in some areas by the presence of soils with low hydraulic conductivity.

The suburbs of Woy Woy, Blackwall, Ettalong and Booker Bay are affected by ocean flooding from the Brisbane Water estuary, both tidal and storm induced. These locations have also been identified as vulnerable to storm surge and increasing risk due to the consequences of climate change. In particular, Woy Woy is at most risk of flooding from Brisbane Water with relatively lower ground levels and greater areas of inundation now and into the future. Blackwall, Ettalong and Booker Bay are generally elevated slightly higher and do not begin to be affected by tides until the latter part of this century.

The Woy Woy peninsula has also historically experienced low-level catchment flooding, particularly during long-duration rainfall events. The flooding issues in the region can be attributed to the poor drainage capacity of the area, caused by the flat terrain, deficient infrastructure, lack of well-defined flow paths and ground conditions that restrict infiltration.

A significant portion of the study area is not serviced by pipe drainage systems or kerb and gutter infrastructure, as well as natural watercourses and well-defined flow paths. As a result, ponding can occur in unrelieved sags within the street network or private property when pit capacities are exceeded.

A general view of the study areas within the Woy Woy Peninsula is provided by **Figure 2-1**. The existing stormwater drainage system in each of the study areas is shown on **Figure 2-2**.

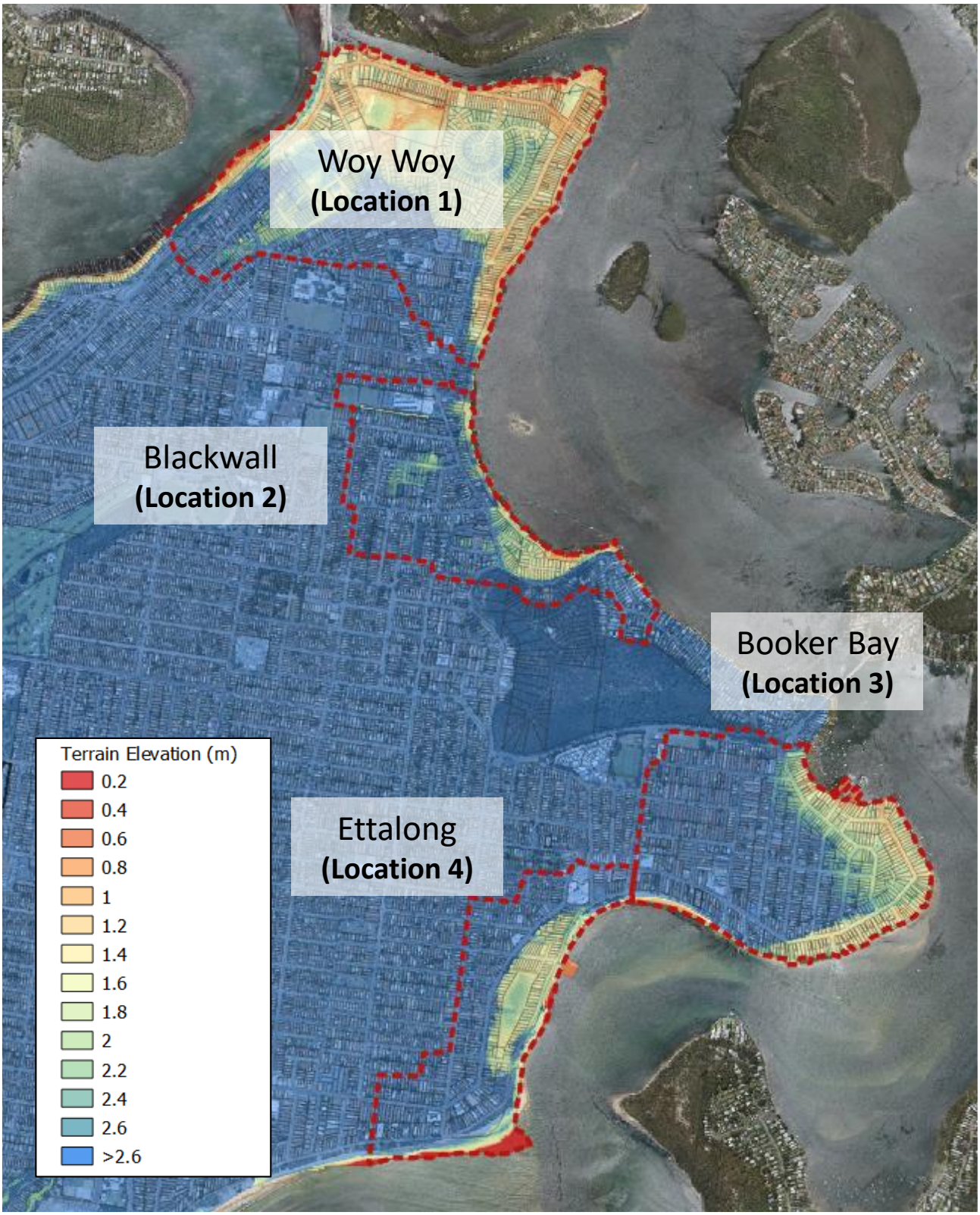

Figure 2-1 Study Areas Overview

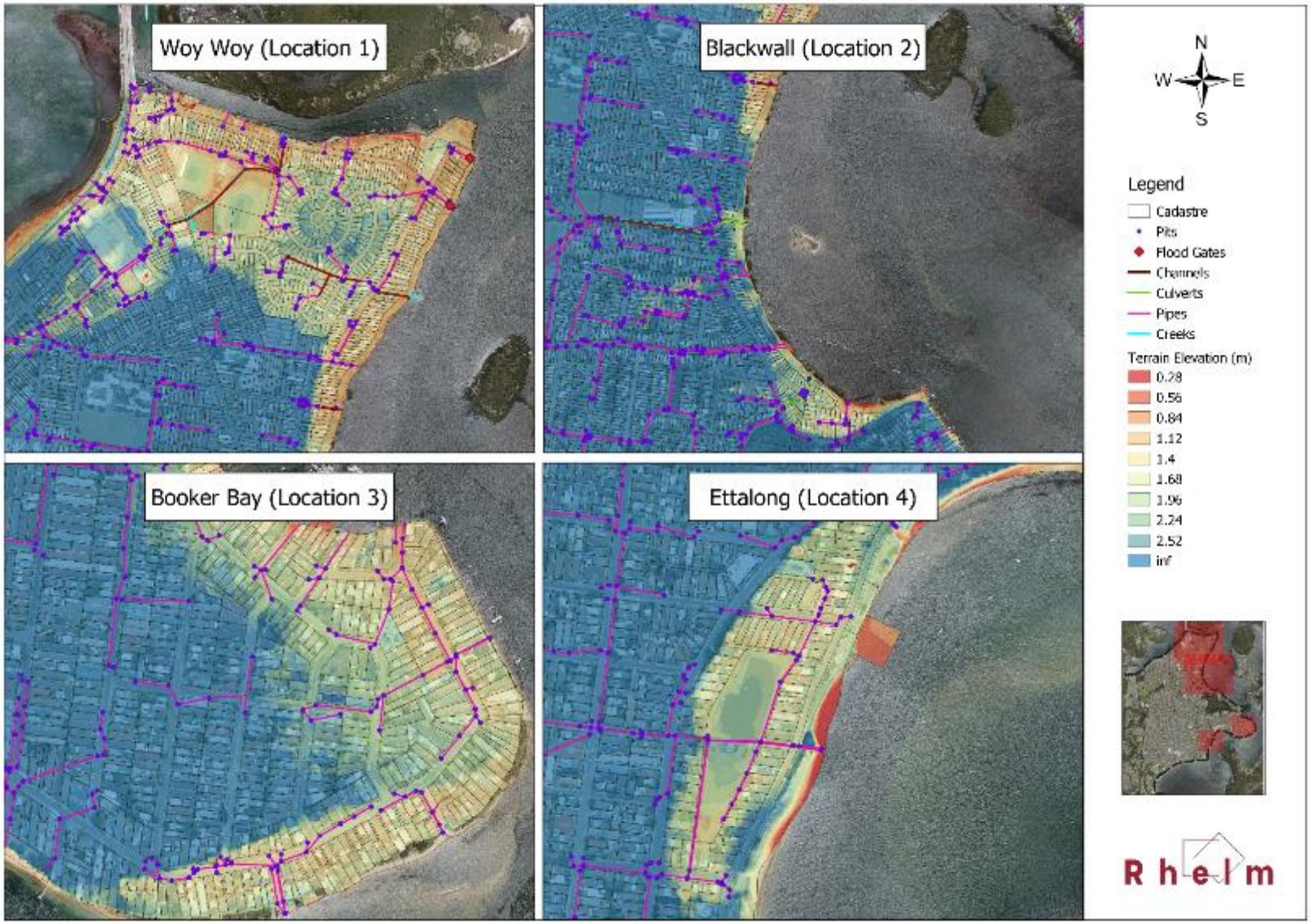

Figure 2-2 Existing Stormwater Drainge System Study Area

3 Existing Data

3.1 Site Inspections

Site inspections of the study areas were undertaken on 30 January 2020 by Rhelm Staff (Emma Maratea, Joel Fraleigh and Julia Sa) and Council's Project Manager (Robert Baker). The inspections were undertaken to review the results of the 2010 flood study and to appraise existing development, foreshore usage, topography and property access.

3.2 Existing Reports and Data

A range of existing reports and data were reviewed as part of this study. All reports and data included in the review are summarised in **Table 3-1**. The key documents are discussed in **Sections 3.2.1** to **3.2.8**.

Table 3-1 Data Collation

Data Type	Description	Date	Author	Key Reference for Current Study
Flood Modelling Results	Brisbane Water FRMS Flood extents – Existing scenario (5y, 20y, 100y, 200y, PMF) and sea level rise scenarios (0.4m and 0.9m – 2y, 5y, 10y, 20y, 50y, 100y, 200y, 500y, PMF)	2015	Cardno	Yes
Flood Modelling Results	Brisbane Water FRMS Flood and Flood Function Hazard (5y, 20y, 100y, 200y, PMF).	2015	Cardno	Yes
Flood Modelling Results	Brisbane Water FS Catchment Flood Modelling Results at Reporting Locations	2014	Cardno	Yes
Flood Modelling Results	Woy Woy Peninsula flood mapping - Existing and Future conditions (2y, 10y, 20y, 50y, 100y, 200y, PMF) and Sensitivity Analysis Results.	2010	DHI	Yes
Flood Models	Woy Woy Flood Study Mike SHE and MOUSE Models	2010	DHI	Yes
Flood Report	Woy Woy Peninsula FRMSP (DHI, 2020) – Stage 1, Stage 2, Stage 3 and Stage 4 Reports	2019/2020	DHI	Yes
Flood Report	Data compilation report for the Brisbane Water Flood Study	1991	PWD	No
Flood Report	Report outlining the data collected for the February 1992 flood event.	1992	MHL	No
Flood Report	Brisbane Water FRMS and FRMP	2015	Cardno	Yes
GIS	Council GIS: Vegetation, Cadastre, Roads, Council Reserves, National Parks, Coastal Open Space System, Creeks, Crown Land, Drainage channels, Headwalls, Pipes, Pits, Culverts, Catchments, Gross Pollutant Traps, Flood Gates, Rain Gauges, Sewer, Water Supply Structures, WL Recorders, Waterways / Ocean.	Various	Central Coast Council	Yes

Data Type	Description	Date	Author	Key Reference for Current Study
GIS	Aerials December 2015	2015	Unknown	Yes
Survey	Brisbane Water Floor Level Survey	2015	Cardno	Yes
Survey	Council Lidar	2013	Central Coast Council	Yes
Woy Woy Oval Proposed Upgrade Plans	Woy Woy Oval Grandstand Preliminary Forecourt Contour Plan (CGRAMW, 2014); Proposed Woy Woy Oval Upgrade Geotechnical Investigation Report (JK Geotechnics, 2014); Woy Woy Oval & Grandstand Project Drawings (SDA Structures, 2014); Woy Woy Oval Playing Field Relocation Works Drawings and New Woy Woy Oval Grandstand and Forecourt Works Drawings (Conrad Gargeit, 2015); Rugby Field Construction Drawing (Conrad Gargeit, 2014) and Proposed Playing Field Drainage Drawing (YSCO Geomatics, 2015)	2014/2015	CGRAMW; JK Geotechnics; SDA Structures; Conrad Gargeit; YSCO Geomatics	No

3.2.1 Brisbane Water Flood Study (2013)

The Brisbane Water Foreshore Flood Study (Cardno Lawson Treloar) was completed in 2013. Prior to this study being undertaken, numerous floodplain management studies for the tributaries of Brisbane Water had been completed utilising a 1% AEP flood level in Brisbane Water of 1.95 mAHD. This level was based on the observed levels in Brisbane Water during the 1974 ocean storm event.

The 2013 Flood Study provided more reliable estimates of the 1% AEP flood level throughout Brisbane Water. The study investigated a range of natural mechanisms that impact water level, as well as the effects of man-made structures. The flood study also assessed the locally generated waves across the waterway.

The key results of the Flood Study (2013) in the vicinity of the study areas are summarised in **Table 3-2**.

Table 3-2 Water Levels for Tidal and Ocean Storm Results (Cardno, 2013)

Study Area	HHWSS[1]	MHWS[1]	1% AEP[2]	5% AEP[2]	20% AEP[2]
	mAHD				
Woy Woy and Blackwall	0.61	0.37	1.58	1.43	1.29
Booker Bay	0.74	0.47	1.58	1.45	1.35
Ettalong	0.80	0.52	1.78	1.63	1.51

[1] The HHWSS (High High Water Springs Solstices) and MHWS (Mean High Water Spring) levels were extracted from table B2 from the Brisbane Water Flood Study (2013)

[2] The 1% AEP, 5% AEP and 20% AEP water levels were extracted from table 6.3 from the Brisbane Water FRMS (2015)

Table 3-3 Water Levels with 1% Probability of Exceedance (PoE) in the Woy Woy Peninsula (Cardno, 2013)

Study Area	1% PoE[1]
Woy Woy	0.68[2]
Ettalong Creek	0.93[2]

[1] Probability of Exceedance: the level that one can be 99% confident will not be exceeded during any estuary flood event.
[2] The 1% PoE values were obtained from Table 6.3 from the Brisbane Water Flood Study (2013).

The hazard associated with the ocean flooding along the Brisbane Water Foreshore was also calculated in the Flood Study (Cardno, 2013). In this study, the hazard was calculated based only on the hydrodynamic characteristics of the flood. The Brisbane Water FRMS (Cardno, 2015) provides a detailed analysis of the true hazard in the study area, taking into consideration other important factors, such as warning time available, rate of rise of floodwaters, potential evacuation issues, among others. The conclusion of this analysis was that, given the characteristics of the flood and the study area, the provisional hazard presented in the Flood Study was an adequate estimate of the real hazard in the region and should be considered equivalent to the true flood hazard. It is noted that provisional high hazard is primarily driven by the depth of flooding not the flow velocity.

The flood hazard maps prepared in the Flood Study (Cardno, 2013) show that, in 1% AEP flood event, the properties within the Woy Woy Peninsula are generally located outside the high hazard flood extent. In the PMF event, some of the properties situated closer to the ocean are partially subjected to high hazard flooding. However, most of the flood affected areas in the region experience low flood hazard for this flood event.

3.2.2 Brisbane Water Floodplain Risk Management Study and Plan (2015)

The Brisbane Water FRMS (Cardno, 2015) provides a summary of the potential impacts caused by coastal flooding for the locations within the Brisbane Water Foreshore, considering existing and future flood behaviour. The impacts relative to the suburbs in the Woy Woy Peninsula are listed in **Table 3-4**.

Table 3-4 Brisbane Water flooding - potential impacts in the Woy Woy Peninsula (Cardno 2015)

Location	Description of Flooding Issues	Predominantly Affected Land Uses	Number of Properties Affected*		
			1% AEP Existing	1% AEP 0.4m SLR	1% AEP 0.9m SLR
Woy Woy and Blackwall (MA14)	• Residential and commercial properties are affected by flooding even in more frequent flood events such as the 20% and 5% AEP. • Existing high tides in this area can cause inundation, especially with joint occurrence of storm conditions. • Flooding likely to affect evacuation. • Flood island issues. • Longer term asset deterioration may occur.	• Residential • Commercial • Special Uses /Infrastructure • Open Space	704	884	1034
Booker Bay (MA13)	• Some water-front residential properties in this location are likely to be subject to over-ground flooding in more frequent events such as the 20% and 5% AEP. • Existing high tides in this area can cause foreshore inundation, especially high tides with joint occurrence of storm conditions. In these instances, roads and some residential properties are affected.	• Residential	207	275	353

Location	Description of Flooding Issues	Predominantly Affected Land Uses	Number of Properties Affected*		
			1% AEP Existing	1% AEP 0.4m SLR	1% AEP 0.9m SLR
Ettalong (MA12)	• Residential properties are generally not affected by flooding in more frequent events. • In the existing 1% AEP event, the foredune protects properties from direct inundation, however, properties are inundated instead due to surcharge of the stormwater system whereby elevated waters in Brisbane Water "back up" the stormwater system. • High tides do not generally result in foreshore inundation within Ettalong.	• Open Space • Residential	10**	112	119

*These numbers indicate all properties that intersect with the flood extent for each respective event, whether flooding overtops floor levels or not. Numbers include all properties (residential, commercial, industrial, open space etc.).

**A substantial increase in affected properties occurs if indirect flooding (via surcharge of the stormwater system) is considered (86 properties instead of 10)

The Brisbane Water Floodplain Risk Management Study and Plan (FRMSP) looked at options to manage the flood risks that results from coastal processes, such as significant coastal wave events and storm surge associated with low pressure systems off the East Coast of Australia. In addition to considering the flood risks presented in the Brisbane Water Flood Study (Cardno, 2013), the FRMSP also undertook additional assessments of flooding risk under projected sea level rise scenarios. These assessments looked at the impacts of sea level rise on flooding from ocean storm events and also the impact on more regular (but less severe) tidal inundation. The study looked at sea level rise of 0.4 m and 0.9 m.

The detailed assessment of the impacts associated with increased tidal inundation as a result of sea level rise was beyond the scope of the FRMSP. However, management Action PM9 of the FRMSP recommended the development of Climate Change Adaptation Plans.

Given that new developments may have an asset life of 50+ years any present-day planning approvals could have longer term implications to occupiers of flood prone land. Action PM9 highlights the importance of beginning the process of planning for the potential impacts of sea level rise.

As part of the Brisbane Water Flood Risk Management Study (Cardno, 2015), a series of measures were proposed to address current and future flood risk. Specific flood mitigation options were proposed for each management area, as well as more general measures for all the flood affected regions in the Brisbane Water foreshore. These measures were then prioritised using a multi-criteria matrix assessment, that took into consideration economic, social, environmental and planning and governance factors.

A summary of the options proposed for Woy Woy, Blackwall, Booker Bay and Ettalong is provided in **Appendix B**, as well as maps showing the locations where the proposed interventions would take place.

3.2.3 Independent Report on Sea Level Rise (2015)

An independent report on projected sea level rise in Brisbane Water was prepared for the former Gosford City Council by Doug Lord of Coastal Environment Pty Ltd and by Dr David Wainwright from Whitehead and Associates in 2015.

The independent report recommended RCP8.5 as a suitable and defensible basis for sea level rise projection at the present time. The report also indicates that recent research on global emissions from recent years indicates that we are tracking on top of the RCP8.5 projection. Within the high emissions scenario (RCP 8.5), there are three possible trajectories (low, medium, high) which encapsulate the range of the modelling. In March 2015 Gosford City Council resolved to adopt sea level rise planning levels based on projections for the Representative Concentration Pathway Scenario RCP 8.5, utilising the medium sea level rise projection. This projection has been provided from 2015 mean sea level. The adopted sea level rise predictions are summarised in **Table 3-5**.

Table 3-5 Projected Sea Level Rise RCP8.5

Year	Sea Level Rise (m)
2015	0
2030	0.1
2050	0.2
2070	0.4
2100	0.7

3.2.4 Woy Woy Peninsula Flood Study (2010)

A flood study was undertaken in 2010 for the Woy Woy Peninsula to assess the risk associated with catchment flooding.

Hydrologic and hydraulic modelling was completed to assess flood behaviour within the catchment. Since the ground water behaviour is an important element for the flood behaviour in this catchment, the MIKE SHE modelling system was adopted, as it is capable of simulating the interaction between surface water and groundwater. In the model, the hydrological analysis is performed according to the rainfall-on-grid methodology. This means rainfall is applied directly to the 2D terrain, and the flow is routed automatically by the hydraulic model.

The model was calibrated using the 1988 storm event as reference, considering records of flood depths obtained from community consultation and Council maps indicating areas historically prone to flooding.

Flood behaviour was modelled for a series of Annual Exceedance Probabilities (AEP); 0.5% AEP, 1%, 5%, 10%, 50%, and Probable Maximum Flood (PMF).

3.2.5 Central Coast Council Climate Change Policy (2019)

The Central Coast Council Climate Change Policy (The Policy) sets out Council's position relating to climate change with a view to maximising the economic, social and environmental wellbeing of Council and guides the planning and development of the Central Coast Region's resilience to climate change.

Of specific relevance to this climate change adaptation study are the following strategic principals and commitments made in The Policy:

- Principle 2: Council implement a holistic approach to anticipate and adapt to climate change actions that comprise the time scales such as now and the future as well as the impacts of the complex interactions and interdependencies between the human and the environment systems.
- Principle 3: Council implement an evidence based decision making to respond, to adapt and build resilience to Climate Change.
- Principle 5: Council implement a proactive approach and ensure continuity to better anticipate and adapt to complex challenges posed by the changing climate.
- Principle 6: Council implement a Place-based approach to enhance Council and community capacity for climate resilience that is context specific, knowledge based and collaborative.
- Commitment D4: Council develop place based Climate Change Action Plans in partnership with the community that establishes regional targets for mitigation and prioritises local adaptation planning (e.g. sea level rise, coastal hazards, disaster management).
- Commitment D7: Incorporate climate change risks in strategic and infrastructure planning for the region to maximise local liveability through informed land use planning, development of planning controls and guidelines that facilitates regional urban growth, transport connectivity and utility services.

3.2.6 Davistown and Empire Bay Climate Change Adaptation Study (2019)

The Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2019) analysed potential landforms and associated measures to allow the suburbs of Davistown and Empire Bay to adapt to the impacts of sea level rise (both tidal and storm surge events). The study area is located in the Brisbane Water foreshore and, like the Woy Woy Peninsula, is affected by ocean flooding (both tidal and storm induced) as well as catchment flooding. The scope of the study included presenting several landform options and evaluating their performance during flooding events and their practical feasibility.

The initial step in the landform development process was the identification of a minimum ground level, that would guarantee appropriate flood protection for the properties in the study area. Based on the analysis of the flooding behaviour in the catchment, it was determined that a minimum level of 1.5 mAHD would provide reasonable protection for existing and future risks.

Taking this minimum elevation into consideration, several options for filling of low-lying areas of Davistown and Empire Bay were investigated. The final landform designs were refined in consultation with internal Council stakeholders.

For both Davistown and Empire Bay, the proposed landforms were modelled for local catchment rainfall with the 1% and 20% AEP events. The results from the flood modelling demonstrated that the selected landform improves the existing drainage conditions within the study areas.

Additionally, an economic assessment was undertaken on the proposed landforms. The results of this analysis demonstrated that the presented plan was economically viable for Davistown. For Empire Bay, the calculated Benefit Cost Ratio (BCR) suggested that the plan would be marginally unviable. However, according to the study, there are a number of unquantified benefits that may change this outcome.

Another important part of this study was the development of a phased implementation strategy to gradually achieve the proposed landform. The presented implementation plan took into consideration the practical

aspects of filling private land, the timings and staging of the plan, and also the determination of seal level triggers.

3.2.7 Woy Woy Groundwater Modelling Integrated Water Management and Case Study Everglades Catchment (Ongoing)

In this ongoing project, Central Coast Council has requested integrated water modelling services (both groundwater and surface water) for the Woy Woy Peninsula and the Everglades Catchment. The aim is to assess integrated water management options to minimise peak stormwater runoff. There is a need for a holistic water management assessment for the peninsula, in particular for the Everglades Catchment where conceptual mitigation strategies need to be developed to assess flood reduction options. Furthermore, an integrated approach is required to enable Council to make informed decisions in the future.

DHI's approach, coupling MIKE SHE to MIKE URBAN includes the entire water balance of the study area and provide a sophisticated framework to assess different mitigation strategies.

This flood model developed for this study are being utilised in the Woy Woy Peninsula FRMS to assess design catchment flood conditions utilising Australian Rainfall and Runoff 2019 (ARR2019) (**Section 3.2.8**).

The flood models developed as part of the case study were not available at the time of this climate change adaptation study.

3.2.8 Woy Woy Peninsula Floodplain Risk Management Study and Plan (Ongoing)

This FRMSP is currently in preparation. The design flood modelling for the FRMSP was completed utilising the model developed as part of the Integrated Water Management Study (**Section 3.2.7**). These results vary somewhat to the flood mapping presented in the 2010 Flood Study (**Section 3.2.4**) and will take precedence for comparison against the existing conditions design flood event flooding used in this climate change adaptation study.

4 Current and Future Risk

The four study areas in the Woy Woy Peninsula (Woy Woy, Broken Bay, Booker Bay and Ettalong) can be impacted by flood risk from Brisbane Water flooding as a result of ocean storms, local catchment flooding as a result of local rainfall and tidal inundation during high tides. All of these flood risks would increase as a result of sea level rise.

The flood risks in the study areas have been discussed briefly below with regards to existing risks (based on existing studies) and the likely increase in those risks as a result of sea level rise, based on the RCP8.5 projections (**Section 3.2.3**).

4.1 Brisbane Water Flooding

Major historical coastal flood events for the Brisbane Water foreshore floodplain include the severe ocean storm of 1974 and the more recent, but less severe, event in 2007.

There are significant low-lying areas within the Woy Woy Peninsula making these areas susceptible to flooding from Brisbane Water even in more frequent events. Existing high tides in this area can cause foreshore inundation, especially with joint occurrence of local rainfall.

The Brisbane Water Flood Study (2013) considered the flooding that results from coastal processes, such as significant coastal wave events and storm surge associated with low pressure systems off the East Coast of Australia. Analysis undertaken in the Brisbane Water Flood Study (2013) identified that sea level rise would result in an almost equivalent increase in water levels at the Woy Woy Peninsula. The flood levels for existing (shown as 2015) conditions and under sea level rise scenarios is shown in **Table 4-1, Table 4-2** and **Table 4-3**. The 1% PoE and the 1% AEP levels for the existing conditions and Sea Level Rise scenarios are shown in **Appendix A**.

Based on the results from the Brisbane Water Flood Study (2013), the suburbs of Woy Woy and Booker Bay are more significantly affected by ocean floods. In these locations there is considerable number of properties and roads affected by the 20% AEP flood. The same is not true for Blackwall and Ettalong study areas, where only rarer events have a major impact. In Ettalong, in particular, only the PMF flood covers a significant portion of the study area.

Table 4-1 Brisbane Water Flood Levels for Woy Woy and Blackwall – Existing and Future Flood Behaviour (Cardno, 2015)

Year	Sea Level Rise (m)	1%PoE (mAHD)	1% AEP (mAHD)	5% AEP (mAHD)	20% AEP (mAHD)
2015	0	0.68	1.58	1.43	1.29
2030	0.1	0.78	1.68	1.53	1.39
2050	0.2	0.88	1.78	1.63	1.49
2070	0.4	1.08	1.98	1.83	1.69
2100	0.7	1.38	2.28	2.13	1.99

Table 4-2 Brisbane Water Flood Levels for Booker Bay – Existing and Future Flood Behaviour (Cardno, 2015)

Year	Sea Level Rise (m)	1%PoE (mAHD)	1% AEP (mAHD)	5% AEP (mAHD)	20% AEP (mAHD)
2015	0	0.68	1.58	1.45	1.35
2030	0.1	0.78	1.68	1.55	1.45
2050	0.2	0.88	1.78	1.65	1.55
2070	0.4	1.08	1.98	1.85	1.75
2100	0.7	1.38	2.28	2.15	2.05

Table 4-3 Brisbane Water Flood Levels for Ettalong – Existing and Future Flood Behaviour (Cardno, 2015)

Year	Sea Level Rise (m)	1%PoE (mAHD)	1% AEP (mAHD)	5% AEP (mAHD)	20% AEP (mAHD)
2015	0	0.93	1.78	1.63	1.51
2030	0.1	1.03	1.88	1.73	1.61
2050	0.2	1.13	1.98	1.83	1.71
2070	0.4	1.33	2.18	2.03	1.91
2100	0.7	1.63	2.48	2.33	2.21

4.2 Local Catchment Flooding

The results of Woy Woy Peninsula Flood Study (DHI, 2010) demonstrated that flood depths in the 1% AEP event are mostly lower than 0.4 m in the four study areas, with the exception of Ettalong, where flood depths around 0.7 m have been identified. The higher flood depths are mostly found in the areas with lower elevation and with a higher groundwater table. The Flood Study (DHI, 2010) concluded that the accumulation of rainfall runoff is mostly caused by the inefficiency of the existing stormwater drainage system and the limited infiltration capacity of the soil, due to the high level of the groundwater table.

In Woy Woy, the flood depths for the 1% AEP event and the 10% AEP event are relatively similar, with a depth difference below 0.05 m for most of the study area. For these two events, the most significant flood depths (higher than 0.2 m) were identified in the north-west of the study area, between Railway Street and Chambers place, around the drainage channels (in the Oval and behind the properties in Norma Crescent) and in the intersection between Brick Wharf Road and North Burge Road.

Potential impacts to flood behaviour in the catchments due to climate change were analysed for sea level rises of 0.55m and 0.91m. According to the Flood Study (DHI, 2010), the model showed moderate sensitivity to Sea Level Rise, with an average increase in flood depths of 50 mm for the lower rise scenario and of 90 mm for the higher rise scenario.

The sensitivity of the model to the level of blockage of the stormwater network was also assessed in the Flood Study (DHI, 2010). According to the study, some areas in the Peninsula are highly sensitive to this parameter, showing an increase of up to 1.75 m in flood depths in the full blockage scenario, compared to the no blockage scenario.

The Flood Study (DHI, 2010) results are currently being updated as part of the Woy Woy FRMSP (DHI, ongoing).

4.3 Tidal Inundation

The Brisbane Water Foreshore Flood Study (Cardno, 2013) explored the effects of 0.3 m of projected sea level rise (SLR) on tidal signal change throughout Brisbane Water (the DECCW benchmarks of 0.4m and 0.9m had not yet been published at that time).

The *Sea Level Rise and the Estuarine Intertidal Zone discussion paper* was included as an Appendix to the *Brisbane Water Estuary Management Study* undertaken by Cardno (2010a). The paper focused on the environmental implications of sea level rise (such as the impacts on intertidal vegetation).

A discussion paper was also included in the *Brisbane Water Foreshore Floodplain Risk Management Study* (Cardno, 2015) to identify the impacts of projected sea level rise on tidal inundation. The Delft3D hydrodynamic model, typically used to estimate flood behaviour in estuaries, was used to investigate the tidal response to climate change and entrance morphology. The model setup used for the *Brisbane Water Foreshore Flood Study* (Cardno, 2013) was employed for these tasks.

The tidal events selected for mapping represent:

- High High Water Spring Solstices (HHWSS) – Rarer high tides occurring approximately twice a year, during the June and December solstices ("king tides"); and
- Mean High Water Springs (MHWS) – "Every day" tidal inundation caused by high tides. The MHWS tide is the average of all high water observations at the time of spring tide over a period of time (generally 19 years).

The results presented in the discussion paper are summarised in **Table 4-4**, which shows the comparison between the tidal planes for the present sea level scenario and the 0.40 m SLR scenario for the study areas in the Woy Woy Peninsula . The key consideration for this current study is that the modelling indicated that a 0.4 m rise in sea levels relates to approximately 0.4 m rise in estuarine levels at the study area locations.

Table 4-4 Tidal Plane Comparison (SLR 0.4m – Present Sea Level) Cases (Cardno, 2015)

Location	MHWS (m)	MLWS (m)	HHWSS (m)
Woy Woy And Blackwall	0.40	0.33	0.42
Booker Bay	0.40	0.33	0.42
Ettalong	0.40	0.33	0.41

The sea level rise projections outlined in **Section 3.2.3** were applied to the results of the discussion paper and are summarised in **Table 4-5**. The risk areas associated with the HHWSS levels are presented in **Appendix A – Figure B4**.

The areas that are shown as inundated in this map would be potentially affected by tidal inundation several times a year and, therefore, demand special attention. In general, the 0.2 m sea level rise, which corresponds to the predicted sea level for 2050, does not significantly modify the tidal inundation extent for the study areas within the Woy Woy Peninsula. In Woy Woy and Booker Bay the tidal inundation is significant in the 2070 sea level scenario (0.4 m SLR), with some properties and streets being affected. The same is not observed in Blackwall and Ettalong, where the tidal inundations extents are limited for this scenario. In the 2100 (0.7 m SLR) scenario tidal inundation covers a considerable portion of Woy Woy, Booker Bay and Ettalong, with a

significant number of properties and roads affected. It should be noted that the impacts of tidal inundation in Blackwall are low for all future water levels up to 2100.

Table 4-5 Sea Level Rise Impacts on Tidal Levels

Year	Sea Level Rise (m)	MHWS (mAHD)			HHWSS (mAHD)		
		Woy Woy And Blackwall	Booker Bay	Ettalong	Woy Woy And Blackwall	Booker Bay	Ettalong
2015	0	0.37	0.47	0.52	0.61	0.74	0.80
2030	0.1	0.47	0.57	0.62	0.71	0.84	0.90
2050	0.2	0.57	0.67	0.72	0.81	0.94	1
2070	0.4	0.77	0.87	0.92	1.01	1.14	1.2
2100	0.7	1.07	1.17	1.22	1.31	1.44	1.5

5 Climate Change Adaptation

5.1 Approach

Adapting to climate change and rising sea levels is a complex problem, with no single technical solution, and involving multiple interests and stakeholders. A *Decision Support Framework and Guide (The Handbook)* has been developed to assist the HCCREMS coastal councils more effectively approach and determine adaptation responses and pathways for vulnerable coastal areas. *The Handbook* discusses 10 main stages in the decision-making process. Although the process is presented as a series of numbered stages, it is recognised that, decision-making will often jump backwards and forwards between stages. The stages are summarised in **Figure 5-1**.

The stages focused on in this current study are:

- **Stage 4 Assess hazards and risks:** this has been done in previous studies and forms the basis on the adaptation plan. The hazards and risks are summarised in **Section 4**.
- **Stage 5 Identify options and pathways:** various options are being developed for discussion with stakeholders and identification of a preferred approach. The preferred approach may involve several structural components (e.g. landform design and levees) as well as strategic planning to support its implementation. Options and pathways for addressing sea level rise are further detailed in **Sections 5.2** and **5.3**.
- **Stage 6 Establish Triggers:** As part of the strategic planning to be included in the adaptation plan, a series of triggers will be identified to assist future decision making and implementation. These are further discussed in **Section 8**.

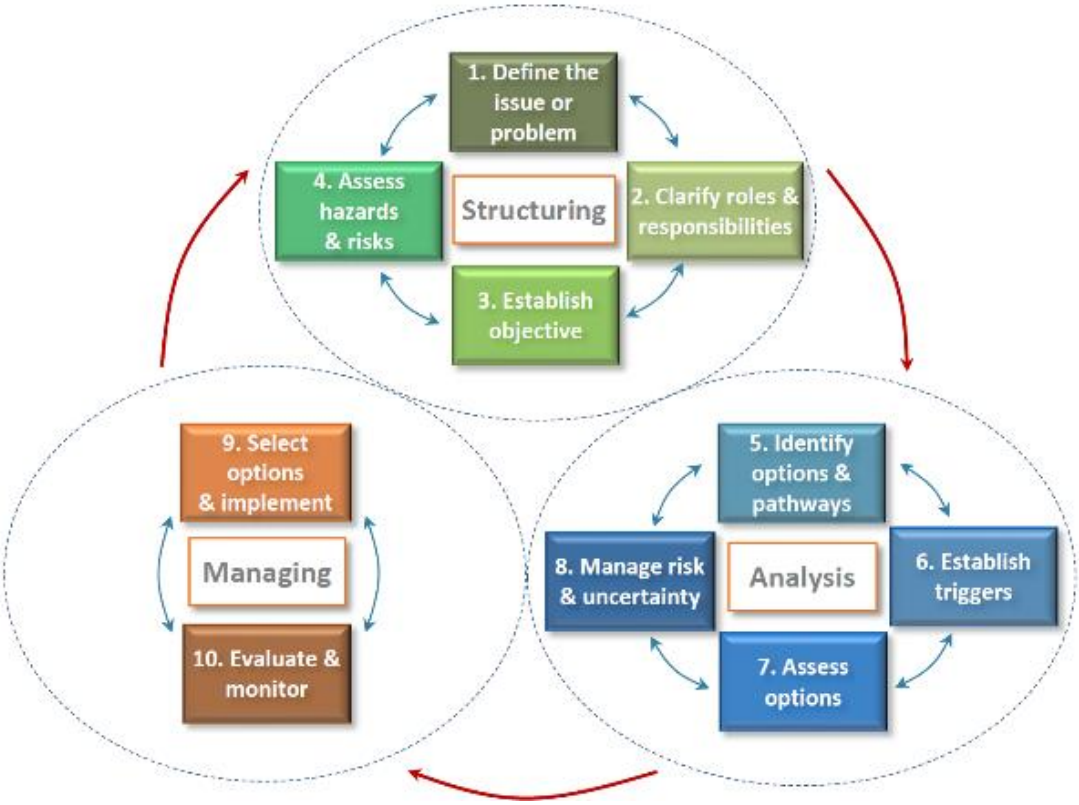

Figure 5-1 Stages in the adaptation decision making process (HCCREMS, 2012)

5.2 Conceptualisation

5.2.1 Do Nothing (Planned Retreat)

If no steps towards climate change adaptation are adopted in the coming decades, then current sea level rise predictions would suggest that portions of the Woy Woy Peninsula will become increasing impacted by tides, with large urban areas inundated by 'king tides' (HHWSS) by 2100.

Planned retreat is a coastal hazards management approach that aims to allow the natural coastal processes (e.g. inundation and erosion) to carry on without resisting against them with counteracting engineering structures. As the inundation areas and / or erosion escarpment moves landward the existing development, infrastructure and property boundaries will be required to retreat along with it.

Planned retreat has not been considered in detail in this study as the objective of the study was to identify a landform and drainage design for consideration as part of the climate change adaptation planning.

5.2.2 Filling / Landform Raising

The Gosford DCP 2013 requires all floor levels of residential buildings to be above the Flood Planning Level (FPL). To assist in achieving this level, filling of individual properties is permitted by the Brisbane Water FRMP (Cardno, 2015) where it does not impact on active flow areas in the stream networks feeding Brisbane Water. Filling operations must include adequate provision for drainage of surface water, erosion and siltation control, and be so placed and graded as to prevent the shedding of surface water direct to adjoining properties.

According to the DCP, the flood planning level for the Woy Woy Peninsula varies slightly depending on location but is approximately 2.4 to 2.6 mAHD. There is currently very little direction on what level of fill is acceptable and how filling of properties can be undertaken to minimise the long-term impacts on local drainage.

Taking this into consideration, several options for filling of low lying areas of Woy Woy, Blackwall, Booker Bay and Ettalong have been investigated.

The initial step in investigating fill options was to identify an appropriate level of protection. Based on the information presented in **Section 4**, it was determined that a minimum level of 1.6 to 1.8 mAHD provides reasonable protection for existing and future flood risk, namely because for Brisbane Water in the vicinity of the Woy Woy Peninsula:

- The existing 1% AEP flood level is approximately 1.6 to 1.8 mAHD, depending on the location;
- The 1% Probability of Exceedance Level (PoE) in 2100 (+0.7m SLR) is approximately 1.4 to 1.6 mAHD, depending on the location; and
- This provides protection from king tides (HHWSS) beyond 2100 (refer **Table 4-5**).

Floor levels would usually be constructed higher than the ground level, affording a greater level of protection than the fill levels proposed. This would provide additional property protection to water levels exceeding 1.6 to 1.8 mAHD such as ocean storm events in the future (i.e. under sea level rise conditions).

Generally, the development of the landform options considered the following primary objectives :

- Protect the community from ocean and tidal flooding, which will be aggravated from climate change effects.
- Improve the drainage conditions in the study areas, relative to what would be expected in the 2100 sea level rise scenario. If this is not possible then maintain existing conditions (i.e. do not negatively impact local drainage).

- Consider feasibility of the proposed option, by minimising required land fill depths and by considering other practical implementation aspects at a conceptual level.

The underlying soils across the Woy Woy Peninsula generally have high permeability because of the predominant presence of sand layers. Any filling completed as part of land raising would need to be controlled as to not significantly reduce the capacity of the soil to infiltrate surface water. It is expected that DCP amendments would be necessary to achieve this.

5.2.2.1 Standard Fill Depth

One approach to property filling is to allow the same amount of fill on all properties. This would ensure no properties are required to fill more than others and filling only impacts adjoining properties by equal height above existing ground levels. However, this would also in its ultimate fill condition (i.e. all properties, public space and roads filled) maintain the existing topography and, by extension, existing low points and drainage issues would remain unimproved. In some cases, given the low-lying nature of the Woy Woy peninsula, this approach may unintentionally cause additional drainage problems inside or adjacent to the study areas.

This approach would apply a fill depth based on the ground level of the most at risk location and look to raise this to the minimum level of protection (ranging from 1.6 to 1.8 mAHD depending on location). Under this approach, for example, the approximate fill depth across the Woy Woy CBD study location would be in the range of 0.8 m.

5.2.2.2 Landform Raising

There is an opportunity as part of climate change adaptation to improve local drainage and impacts associated with catchment flooding. To achieve these improvements in drainage, any proposed filling would aim to provide suitable landform slope and drainage conveyance. This could be achieved by ensuring a minimum slope of 0.3% and designing the roadways to convey flows that exceed the local drainage network capacity.

Any filling or landform raising would need to incorporate a *minimum level of protection* (i.e. 1.6 – 1.8 mAHD, as discussed above). This would effectively become the lowest level of the future landform. This would be situated along foreshore edges, and in some locations along drainage channels.

5.2.3 Drainage Easements

Drainage easements could provide a method of improvement for local catchment flow conveyance, improving open space and connectivity, while also reducing the depth of fill required to achieve an appropriate landform.

Opportunities for drainage easements were identified during site inspections, and included existing overland flow and channel drainage easements, laneways and public open space.

5.2.4 Private Flood Barriers

To achieve an ultimate landform design, roads cannot be filled until all adjoining properties have also been filled to allow for access and avoid drainage issues (i.e. if the street is higher than the property, the property will not be able to drain to the street). Depending on Council's approach to policy and planning around property filling, it is likely that in the short term, at least, properties will be filled as Development Applications are lodged for property redevelopment and therefore the staging will be subject to progressive urban renewal.

Although there will likely be trigger points with regards to sea level rise that may expediate property owners need or desire to fill, the reality is that impacts associated with king tides and ocean storm events are likely to increase to a level that causes access issues and property damage before the final landform is achieved.

An interim measure may be required if property filling does not progress sufficiently in time to provide adequate protection from sea level rise. The use of private flood barriers has been investigated for this purpose. The extent of these barriers ultimately adopted will depend largely on the degree of landform raising achieved when roadways or properties become inundated with unacceptable frequency.

5.3 Concept Landscape – Landuse Masterplans

5.3.1 Preliminary Schematics

Based on the outcomes of the data review and site inspections a series of initial landscape schematics were prepared to provide a framework in developing or optimising existing or future land use in these low-lying areas. These schematics have identified high flood risk areas under existing and climate change scenarios (from both catchment and ocean storms, as well as tidal inundation), as well as constraints and opportunities to be considered in the development of a conceptual landform masterplan (e.g. public open space for drainage easements or foreshore barriers, land use zones allowing a change in development type, low grades, key access roads). Green Grid objectives were considered as part of these schematics as opportunities, notably the effective use of and access to public open spaces.

5.3.2 Stakeholder Workshop

The initial landform schematics were presented to stakeholders in a workshop environment at Central Coast Council (Wednesday, 4 March 2020). The following key issues for consideration were raised at the workshop by stakeholders:

- Numerous heritage buildings in Woy Woy, different adaptation approaches may be required for each.
    - Aboriginal burial sites are prevalent in Ettalong and Booker Bay.
- Existing planning controls / land use zones allow for higher density development than the exists. Although there hasn't been much push from developer for multistorey dwellings (e.g. like the apartments located on the eastern Woy Woy foreshore).
- Poor drainage and flooding are issue along the Victoria Road flow path.
- Traffic is a key issue for the peninsula.
- Filling for climate change adaptation will result in the loss of trees and vegetation.
- Potential areas for extension of the 'green grid' principals: Station St, Charlton St, George St, and surrounding sports fields.
- Green grid areas are currently planned for Chambers Place and Oval Avenue. This needs to be included in the adaptation landform.

5.3.3 Concept Landform Designs

The concept landform designs have been prepared as an outcome of the stakeholder workshop, based on the preliminary schematics. The landform surface was initially coarsely prepared using the 12d ground modelling software to allow for greater understanding of design issues such as grades, fill depths, and road corridor requirements. The initial landforms were run through a 'first pass' flood model to check the adequacy of proposed drainage easements and identify other drainage infrastructure (i.e. pipes and culverts) requiring capacity upgrades.

The landforms were further refined by Allen Price & Scarratts (APS) in Civil3D, applying typical road cross-section templates and appropriate grading techniques. It is this final surface which can be brought forward and developed into a masterplan for the study locations. Ideally, it can be utilised to inform fill levels for private property redevelopment and guide design of public spaces including roadways and drainage easements.

The impacts of the concept landform designs on local flooding and drainage have been assessed using TUFLOW (refer **Section 6** for details of flood modelling).

Maps showing the concept landform surfaces are in **Appendix C**. Discussion on the development of the concept landforms in provided in **Sections 5.3.3.1** to **5.3.3.4**.

5.3.3.1 Woy Woy CBD

Much of the Woy Woy CBD study area, especially along the foreshore, is located below the proposed Brisbane Water minimum protection level of 1.6 mAHD. This includes both residential properties, roads and open space.

There are opportunities for utilising existing open space to reduce requirements for fill. As sea levels rise, these areas will eventually become inundated but would also provide flow paths for runoff to discharge into Brisbane Water. These areas include:

- the perimeter of the recreational open space east of the Woy Woy Football Club (Austin Butler Oval);
- access to the eastern foreshore adjacent to North Burge Road;
- open space at the corner of North Burge Road and Brick Wharf Road;
- the existing drainage channel located between Pattie Place and Camellia Circle; and
- multiple laneways along Camellia Circle and east of Daffodil Drive.

With respect to landform design, ground levels at these locations remain as existing or be lowere d in order to create drainage pathways whilst the adjacent properties can be raised, thereby allowing runoff to collect along these pathways and drain to Brisbane Water. **Figure 5-2** displays these locations.



Figure 5-2 Woy Woy - Existing Opportunities to Reduce Landform Fill

Utilising these locations as low points and drainage locations across the study area allows adjacent roads and residential properties to require less fill depth.

From here, roadways are graded until they intersect with the existing landform. Minimum road gradients are initially set at 0.5%; however, where this results in unnecessarily long regrading of road, a flatter gradient of 0.3% is used. Although this does not meet typically adopted Austroads or Council road grading requirements, it is seen as an improvement to the existing situation where roadways are much flatter and contain multiple sag points.

Development pressure for the open space at the corner of North Burge Road and Brick Wharf Road may result in this area needing to be filled in the near future. If this occurs, an allowance should be made for a channel or other drainage feature to remain in the reserve for the future adaptation landform.

The above strategy results in an idealised situation where road and property drainage are improved. Unfortunately, fill depths exceed reasonable levels along Robin Crescent, North Burge Road, Brick Wharf Road, Blackwall Road and east of Paton Street.

In the case of excessive design fill depths east of Paton Street, the properties requiring this degree of fill are already above the adopted minimum protection level of 1.6 mAHD. This would cause an unreasonable imposition to property owners to only achieve improved drainage for the immediate vicinity.

To create a more equitable landform, a new drainage channel is introduced between Blackwall Road and Charlton Street. This requires the acquisition of existing land currently being used as minor roadways and carparking. The result would be that the proposed landform for surrounding properties and roadways could be reduced and the imposition of fill lessened. Furthermore, the area west of Charlton Street previously requiring fill in excess of 2 m can remain in its existing condition, albeit without any drainage improvement. This strategy can create a synergy with Council's proposed Green Grid strategy by providing a link with the open space surrounding Austin Butler Oval.

The final form of these channels between Blackwall Road and Charlton Street may be revised, subject to development pressure in the area. That is, although the drainage here is represented by an open channel in this study, the final form could be any structure which could convey the surface runoff such as culverts or concrete channels.

An additional opportunity to enhance and collaborate with the proposed Green Grid strategy is presented along Oval Avenue and Chambers Place where a channel (with associated pedestrian pathways) can be extended to reduce proposed fill depths along Blackwall Road. **Figure 5-3** shows the locations for both proposed channels.



Figure 5-3 Woy Woy – Potential Additional Channels and Green Grid Synergy

To reduce fill requirements in the eastern portion of the Woy Woy CBD, a strategy of introducing well placed drainage easements between North Burge Road and the eastern foreshore has been used. Given these proposed drainage easements are in high value residential properties, it is envisaged these would be located along boundaries to reduce land take requirements. To further reduce proposed fill levels, the existing drainage channel at the rear of properties on Pattie Place has been extended. The proposed easements are shown in **Figure 5-4**.



Figure 5-4 Woy Woy – Potential Additional Drainage Easements

The two easements proposed along North Burge Road serve two purposes:

- they are placed at a high point in the proposed preliminary schematic landform roadway, maximising fill reduction in the road and surrounding properties; and
- they further reduce proposed fill levels west along Robin Crescent and the existing laneway to Daffodil Drive.

The extension of the easement at Pattie Place recreates (and formalises) the existing situation where a low point / drainage pathway is currently roughly aligned along property rear boundaries. The final form of this easement can be in the form of a retaining wall on either side which surrounding properties can fill to when developing. Alternatively, an inverted box culvert section can be used to both convey flows in the easement and provide a minimum fill level for the surrounding properties to achieve the final landform.

The fill depth at Brick Wharf Road remains, as it is expected the cost of a land take for an easement to lower this would likely exceed the cost of fill requirements.

For all of the proposed easement and channels, the final form of these are open to Council and community wishes during progression of the detailed masterplan. They include any of the following:

- open grassed or concrete lined channel;
- adjacent footpaths or open space;
- drainage channels with coverings to allow runoff to enter;
- culverts; or
- green grid solutions, combining two or more of the above forms and providing access to existing open spaces.

In the case of all the existing and proposed easements at the downstream outlet to Brisbane Water, manually controlled flood gates should be installed to protect the community from storm surges and extreme tides.

The resulting landform and subsequent fill depths are shown in **Maps G220** and **G320 (Appendix C)**, respectively.

In its current state, the landform described above does not make allowance for protection of heritage items. It is anticipated that where these cannot feasibly be physically raised above the minimum level for protection from Brisbane Water flood levels or catchment runoff a number of strategies could be implemented such as minor flood walls, pumped drainage, raising of floor levels, or a combination of these. Site specific measures will be further assessed as the adaptation strategy progresses.

5.3.3.2 Blackwall

The Blackwall study area represents a relatively small area of residential properties and two roads (Plane Street and Oak Street) located below the adopted 1.6 mAHD Brisbane Water minimum protection level.

The strategy adopted for landform design is to utilise existing drainage easements and convert an existing footpath / laneway to become submerged and act as channel. This will allow the road to be raised above the minimum protection level and the surrounding residential properties to direct runoff to the roadways.

Refer **Figure 5-5** for a schematic of the proposed Blackwall landform.



Figure 5-5 Blackwall – Drainage and Landform Strategy

Initial investigations and testing indicated that applying consistent grading within private properties down to the roadways would result in a landform strategy requiring potentially excessive and unfair fill depths in private properties up to approximately 1 m in lots where existing ground elevations already exceed 1.6 mAHD. To resolve this, an alternative approach was taken to establish a minimum level of fill for the residential lots in this area of 1.6 mAHD and provide a nominal fall from the rear of each lot towards its frontage on either Plane or Oak Street. This would require a different road drainage approach to a traditional kerb and gutter system for Plane and Oak Streets in order for adjacent properties to drain to the road reserve. A swale system will provide such drainage outcome but will become periodically inundated during high tides and Brisbane Water flood events.

The resulting landform and fill depths for Blackwall are shown in **Maps G221** and **G321 (Appendix C)**, respectively.

5.3.3.3 Booker Bay

Booker Bay is a relatively flat study area. It is located on a wide peninsula with no significant external catchment inflows aside from the northern-most extent. The land use in this area is primarily residential.

The initial approach here is to raise the foreshore properties to the minimum protection level of 1.6 mAHD then apply road grading at a minimum of 0.3% inland until intersection with the existing landform. This approach left some areas with significant amounts of fill, notably along Booker Bay Road. Further landform level reduction was achieved by the introduction of drainage easements between the foreshore and Booker

Bay Road. However, to achieve a minimum gradient along the roadways in the study area, fill was still required for private properties which are currently well above the minimum protection level of 1.6 mAHD.

The solution introduced to both allow for raising of properties at risk from Brisbane Water flooding and achieve a workable drainage strategy was to include the following elements:

- Maintain the proposed easements between the foreshore and Booker Bay Road;
- Shorter roads between Booker Bay Road and the foreshore (e.g. Karu Avenue, Guyra Street, Munal Avenue, and Petit Street) and graded flat but have roadside swales which discharge catchment runoff to Brisbane Water and under future sea level rise conditions will become permanently inundated;
- Introduce two 'tiers' of landform raising:
    - Tier 1 between the foreshore and Booker Bay Road, where levels vary from 1.6 to 1.8 mAHD
    - Tier 2 between Booker Bay Road and Bogan Road where levels vary from 1.8 to 2.0 mAHD
- Bogan Road remains in its existing condition except for minor regrading between Webb Road and Davis Street to create a low point draining to Karu Avenue; and
- Properties west of Bogan Road do not fill.

Although the eastern extent of Bogan Road will be a localised low point in the study area, the introduction of open channel easements leading directly to the foreshore approximately 4 m wide will allow for the area to be drained without additional blockage risks associated with culverts. Property values are relatively high in this study area and easements would be considered preferable over complete property purchases. The same is true for those proposed easements from Booker Bay Road down to the foreshore.

The roadside swales proposed along the shortened streets between Booker Bay Road and the foreshore will have a maximum elevation of 1.6 mAHD and will become frequently inundated by rising tides. Properties which utilise these streets for access will require driveways which allow these swales to remain operable.

Figure 5-6 depicts the landform strategy adopted in Booker Bay.



Figure 5-6 Booker Bay – Drainage and Landform Strategy

Refer to **Maps G222** and **G322 (Appendix C)** for the proposed landform and required fill depths.

5.3.3.4 Ettalong

The Ettalong study area has significant upstream catchments producing runoff into the central open space / netball courts. This reflects the likely pre-development scenario where this may have been a wetland located behind sand dunes on the foreshore.

The approach to landform design here is similar to the Woy Woy CBD open space utilisation (i.e. at Austin Butler Oval). That is, to allow the central open space and area around the periphery the existing netball courts to become inundated in the future sea level rise scenario and allow the surrounding residential properties and roadways to drain into this 'basin'. The 'basin' would be drained by culverts crossing The Esplanade as the existing scenario does, however with an upgraded capacity.

Grading the surrounding roadways at minimum gradients results in fill requirements for some properties which are currently higher than the minimum level of protection for this area (1.8 mAHD). These are primarily found north of Bangalow Street. The adopted modified approach is to raise properties bordering the open space and netball courts to the minimum level of protection while then requiring the properties north of Bangalow Street to raise to a level marginally higher than this to allow for positive drainage to the south at Tenalga Avenue.

Some of these properties north of Bangalow Street cannot drain to The Esplanade as the existing road levels here are higher than the proposed landform and lowering the roadway would reduce existing protection from storm surge events and wave action. This is also an issue with the existing landform as there appears to be an informal interallotment drainage path flowing in a southerly direction. It is proposed to introduce a more formal pit and pipe interallotment drainage system as well as regrade the trunk stormwater line which outlets to Brisbane Water to reduce the inundation of the outlet under sea level rise conditions. **Figure 5-7** outlines the landform and drainage strategy adopted in Ettalong.



Figure 5-7 Ettalong – Drainage and Landform Strategy

Refer to **Maps G223** and **G323 (Appendix C)** for the proposed landform and required fill depths.

6 Catchment Flood Modelling

Hydrologic/hydraulic modelling was undertaken for the four study areas (Woy Woy, Blackwall, Booker Bay and Ettalong) to understand the potential impacts that the proposed landform options would have on the existing and future flood behaviour.

The modelling aims to provide an understanding of the performance of the landform options and the overall effect they have on local flooding.

The Woy Woy FRMSP (DHI, 2020) also establishes a hydraulic catchment flooding model utilising the MIKE SHE software which is able to integrate the groundwater domain with the surface water domain. The TUFLOW 2D hydrodynamic model was selected for estimating flood behaviour in the adaptation study areas because it more accurately reflects the movement of water across the ground surface. This is able to better determine the impacts of the landforms on flood behaviour when comparing to the existing scenario. Allowance has been made in the form of higher loss values to account for the sandy soils in the area (refer **Section 6.1.2**). The TUFLOW model is also inherently faster at completing model runs, and with the iterative nature of design for this landform it was concluded that this would provide for enhanced refinement of surface modelling.

The existing and future flood behaviour in the study areas was evaluated for the flood events shown in **Table 6-1**.

Table 6-1 Flood Modelling Scenarios

Scenario	Flood Event	Reference Section in this report
Existing Conditions	1%, 10% and 20% AEP	**Section 6.2.1**
Sensitivity Analysis	1% AEP	**Section 6.2.2**
Business as Usual	1%, 10% and 20% AEP	**Section 6.2.3**
Landform Options	1%, 10% and 20% AEP	**Section 6.2.4**
Interim Landform Scenarios	1% AEP	**Section 6.2.5**

6.1 Hydrology

For Woy Woy and Booker Bay a hydrologic/hydraulic model was set up in TUFLOW, and the rainfall on grid methodology was used to generate all flows coming into the study area as the catchment is not significantly larger than the landform study area. This approach was considered suitable for these two study areas.

For the Blackwall and Ettalong areas, including the full catchment in the 2D model would not be practical, as it is significantly larger than the landform study area. Therefore, a combined hydrological approach was adopted, using XP-RAFTS and TUFLOW. The flows generated in the areas upstream of the study area were obtained using an XP-RAFTS model and the resulting hydrographs were applied as upstream boundary conditions in the TUFLOW model. The local flows were generated using a rainfall on grid approach, similar to the methodology for Woy Woy and Booker Bay.

Hydrological model parameters for the XP-RAFTS model are consistent with the following descriptions of parameters for the TUFLOW rainfall on grid model and Australian Rainfall and Runoff 2019 (ARR 2019). The only difference is in the application of losses to the effective impervious areas, indirectly connected areas and pervious areas as these can be split into subcatchments in XP-RAFTS and not in TUFLOW using rainfall on grid.

6.1.1 Rainfall

The rainfall applied to the model and the parameters adopted in RAFTS are based on ARR 2019 and sourced from both the Bureau of Meteorology and ARR Data Hub websites.

Table 6-2 shows the IFD tables adopted for Woy Woy and Blackwall and **Table 6-3** the values adopted for Booker Bay and Ettalong.

Table 6-2 IFD Table Adopted for Woy Woy and Blackwall (Source: Bureau of Meteorology)

Duration	Duration in min	50%	20%	10%	5%	2%	1%
10 min	10	13.7	19.4	23.7	28.1	34.5	39.8
15 min	15	17.1	24.3	29.7	35.3	43.3	50
30 min	30	23.6	33.6	41	48.8	59.9	69.1
45 min	45	27.7	39.4	48.1	57.2	70.2	80.9
1 hour	60	30.8	43.8	53.5	63.5	77.9	89.7
1.5 hour	90	35.7	50.6	61.6	73	89.4	103
3 hours	180	46	64.5	78.2	92.5	113	130
4.5 hour	270	53.9	75	90.6	107	130	150
6 hour	360	60.5	83.9	101	119	145	167
9 hour	540	71.8	99	119	141	171	196
12 hour	720	81.2	112	135	159	193	221
18 hour	1080	96.7	134	161	190	231	264
24 hour	1440	109	152	183	217	262	299
36 hour	2160	128	180	219	259	313	356
48 hour	2880	143	202	246	292	352	399
72 hour	4320	163	232	284	337	405	457

Table 6-3 IFD Table Adopted for Booker Bay and Ettalong (Source: Bureau of Meteorology)

Duration	Duration in min	50%	20%	10%	5%	2%	1%
10 min	10	13.8	19.5	23.6	28	34.3	39.4
15 min	15	17.2	24.4	29.7	35.2	43.1	49.6
30 min	30	23.7	33.6	40.9	48.5	59.4	68.3
45 min	45	27.8	39.4	47.9	56.8	69.4	79.8
1 hour	60	31	43.8	53.2	63	76.9	88.3
1.5 hour	90	35.9	50.4	61.2	72.4	88.1	101
3 hour	180	46.2	64.2	77.6	91.4	111	127
4.5 hour	270	54	74.6	89.8	106	128	147
6 hour	360	60.6	83.4	100	118	143	164
9 hour	540	71.6	98.3	118	139	169	193
12 hour	720	80.8	111	133	157	191	218
18 hour	1080	95.9	132	159	188	228	260

Duration	Duration in min	50%	20%	10%	5%	2%	1%
24 hour	1440	108	150	181	214	259	295
36 hour	2160	127	178	216	256	309	351
48 hour	2880	141	199	242	288	346	392
72 hour	4320	160	228	279	331	397	448

6.1.2 Losses

For the rainfall on grid approach, an initial/continuing loss model was adopted. This involves an initial infiltration of rainfall depth and subsequently a rate of infiltration that must be exceeded before runoff can occur in each 2D grid cell.

The BoM Data Hub identifies the initial and continuing loss parameters of the study areas as 48 mm and 2.4 mm/h, respectively. The values were derived for pervious rural areas. Therefore, these values should be adapted when used in the analysis of urban environments to account for the existence of impervious surfaces. The recommended continuing loss value for impervious areas, according to the ARR 2019 is 0 mm/h and, for initial losses, values between 1 to 2 mm are recommended. However, given the localised factors, it may be more appropriate to adopt alternative loss values.

The Woy Woy peninsula has predominantly sandy soils with high infiltration values in areas where groundwater elevations are relatively deep. Furthermore, the Woy Woy FRMSP (DHI, 2020) has provided preliminary results using a coupled groundwater/surface water model. These high infiltration values are not necessarily represented by the regionalised guidance values derived from the BoM Data Hub. Given that the Woy Woy FRMSP model has been calibrated, and provides a more accurate assessment of the groundwater interaction which is particularly important in Woy Woy, the DHI work was used as the basis for deriving approximate initial and continuing losses suitable for testing of the existing and proposed landforms. This is consistent with the Floodplain Risk Management Guide - Incorporating 2016 Australian Rainfall and Runoff in Studies (OEH, 2019), which identifies that calibrated losses are more appropriate to use than regionalised parameters.

Model testing was undertaken to determine a suitably representative loss value that more closely aligned the results of the Tuflow modelling with the groundwater/ surface water model from DHI. The testing of the XP-RAFTS and TUFLOW modelling converged on the loss values outlined in **Table 6-4** and adopted for this study. These values provide results which are a reasonable match to the preliminary results from the Woy Woy FRMSP. Refer to **Maps G420** to **G427** for comparison of model results to the Woy Woy FRMSP preliminary results.

Table 6-4 Adopted Loss Values

Type of Surface	Initial Loss (mm)	Continuing Loss (mm/hr)
Pervious	100	5
Impervious	1	0

Losses in urban areas are generally modelled as a combination of both the pervious and impervious adopted loss values. **Table 6-5** summarises the values adopted for the initial and continuing loss parameters for each land-use zone in the study areas. This table also shows the total impervious area (TIA) and effective impervious

area (EIA) percentages considered for each land-use zone. The adopted EIA is lower than the value normally recommended by ARR2019 (usually 50% to 70% of the TIA). This reflects the abundance of indirectly connected impervious surfaces in the study areas (such as sheds and footpaths) where runoff flows onto pervious surfaces before it can reach the drainage network. This is important in the Woy Woy study area, where there is greater potential for infiltration from these indirectly connected areas. The initial and continuing loss parameters have been calculated as a weighted average of the values for pervious and impervious surfaces.

Table 6-5 Adopted Loss Values Based on Land-Use

Land-use zone	Total Impervious Area (TIA)	Effective Impervious Area (EIA)	Continuous Loss (CL)	Initial Loss (IL)
Roads	95%	95%	0.25	5.95[1]
General Residential (Medium Density)	80%	30%	3.5	70.30
Low Density Residential	60%	20%	4	80.20
Local Centre	90%	90%	0.5	10.90
Public/Private Recreation	15%	9%	4.55	91.09
Infrastructure (Railway)	50%	50%	2.5	50.50

6.1.3 XP-RAFTS Model

The XP-RAFTS model was established to determine external inflows into the TUFLOW hydraulic model. It assumes the same aforementioned loss values and land-use based catchment imperviousness.

Figure 6-1 shows the delineation between the modelled XP-RAFTS subcatchments and the adopted TUFLOW 2D model domains.

[1]Covers the entire road reserve, including footpaths and nature strips or verges.

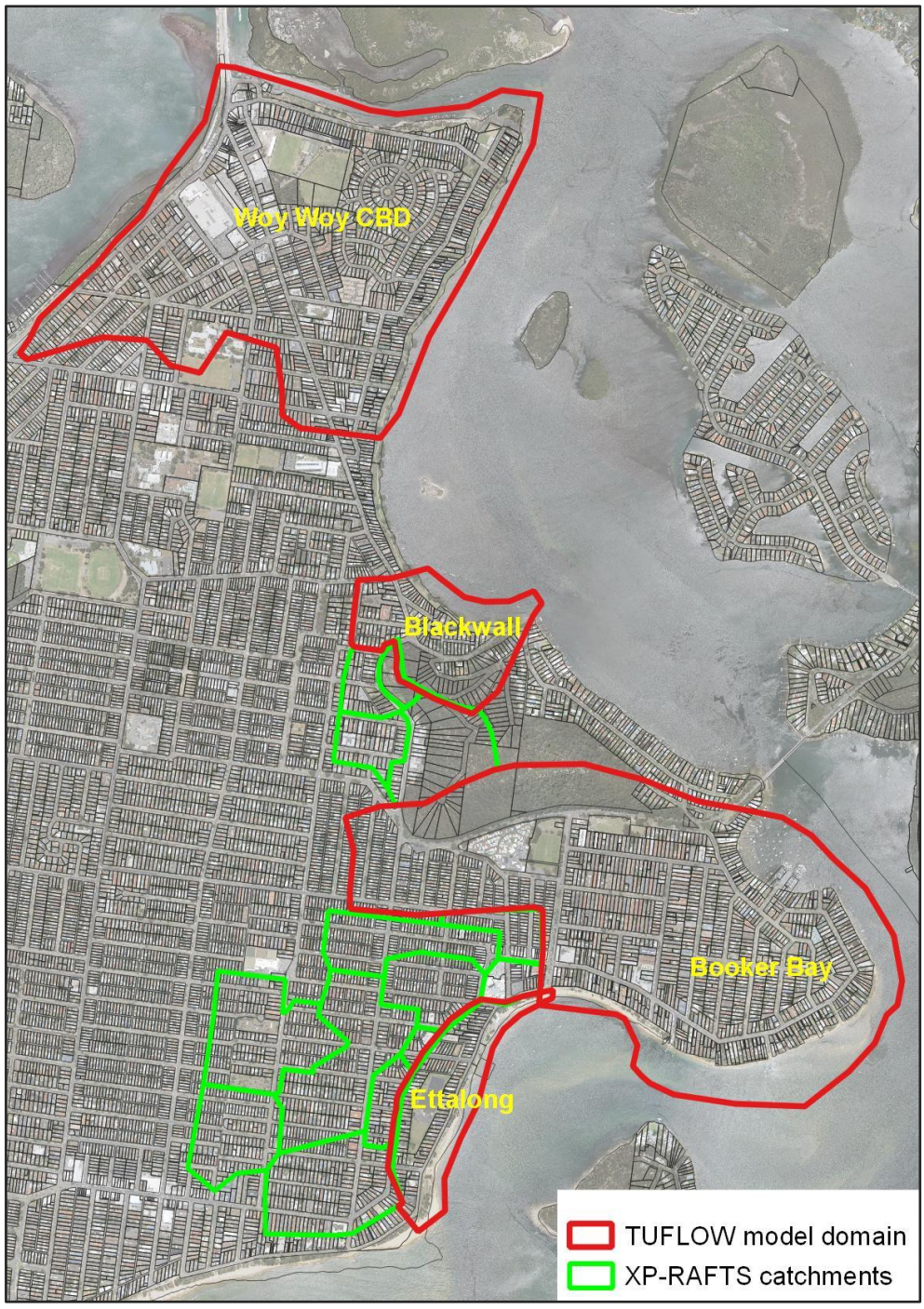

Figure 6-1 XP-RAFTS Catchemnts and TUFLOW Model Domain

Subcatchment extents and slopes were calculated based on 2013 LiDAR data for the Woy Woy peninsula, provided by Council.

6.2 Hydraulics

6.2.1 Existing Conditions

A 1D/2D model was developed for the existing conditions of each study area using TUFLOW. The assumptions and parameters considered in this model were, when possible, based on the current modelling being undertaken by DHI.

Sections **6.2.1.1** to **6.2.1.4** provide a summary of the parameters considered on the model. The comparison between the obtained results and the preliminary outcomes of the Woy Woy FRMSP is discussed in **Section 6.2.1.5**.

It should be noted that no modelling of groundwater or its interaction with surface water was undertaken. As described in **Section 6.1.2**, appropriate loss values were selected based on preliminary results of provided by DHI.

6.2.1.1 Digital Elevation Model

The digital elevation model (DEM) was constructed using primarily the 2013 LiDAR data (refer **Section 3**).

One of the important components in the development of hydraulic models is to ensure that key hydraulic controls and features are defined appropriately within the DEM. For this reason, the existing terrain elevations were modified to represent the open channels in the centre and eastern foreshore of Woy Woy. This was done by including GIS layers which ensure the bottom of the channels are maintained at the minimum elevations and not artificially increased based on the model grid size selected. For the purposes of this study, it was considered that the 2013 LiDAR adequately represents all other key features.

TUFLOW model grid sizes were selected to provide an appropriate representation of flood behaviour in the study areas, without demanding excessive model run times. Considering the size of the study areas, general characteristic of the features affecting flood behaviour, and the number of model runs required to comply with ARR2019 (i.e. 10 temporal patterns per event duration and multiple event durations), a grid size of 5 m was adopted for initial model runs to select critical storm durations and temporal patterns as well as for sensitivity testing. Final design event modelling runs for the existing conditions, final and interim landform scenarios were undertaken utilising a 2 m grid size.

6.2.1.2 Roughness

The roughness values considered in the model were selected according to the land use zones present within the study areas, which were defined as part of the 2014 Gosford Local Environment Plan.

The proposed landform options primarily retain the existing land uses. As such, the existing and future roughness values are consistent.

Table 6-6 summarises the roughness values adopted for the land-use zones present in the four study areas. This differs from the Woy Woy FRMSP (DHI, 2020) which utilises point cloud data to identify surface types and subsequent Manning's n roughness values.

Table 6-6 Adopted Surface Roughness Values

Land-Use Zone	Adopted Roughness
Roads	0.020
General Residential (Medium density)	0.100
Low Residential	0.100
Local Centre	0.025
Public/Private Recreation	0.040
Infrastructure (Railway)	0.040

6.2.1.3 Boundary Conditions

The downstream boundary conditions for the four study areas were defined in accordance with the results of the Brisbane Water Flood Study (2013). For the existing conditions scenario, a constant ocean level equivalent to the 1% Probably of Exceedance (1% PoE) was adopted for the 1% and 20% AEP flood events.

As summarised in Table 4-1, Table 4-2 and **Table 4-3** (**Section 4.1**), the 1% PoE levels for the four study areas are:

- Woy Woy, Blackwall and Booker Bay: 0.68 mAHD
- Ettalong: 0.93 mAHD

6.2.1.4 Drainage Infrastructure

The existing drainage network (pits, pipes, and culverts) in the study areas was represented in the model as a 1D network integrated within the 2D environment.

GIS data with the characteristics of the drainage network has been provided by DHI. This data has been developed based on the information provided by the Council and has been adapted to address data gaps. In general, the drainage network used as input for the TUFLOW model is equivalent to the one provided by DHI, with minor adaptations required.

The exception is the open channel in the centre of Woy Woy. Instead of using a 1D element to represent this structure, the DEM utilises the 2013 LiDAR data to define this channel geometry with GIS layers used to ensure the minimum channel invert is maintained irrespective of the 2D grid resolution adopted. This approach was also used for other two smaller open channels in the Woy Woy eastern foreshore.

6.2.1.5 Blockage

Similar to the Woy Woy FRMSP (DHI, 2020), a risk-based approach to design event blockage has been adopted. This is in accordance with the most recent guidance from ARR2019.

Blockage has only been applied to the culvert and bridge openings, which is consistent with the approach used in the DHI modelling. **Table 6-7**, reproduced from the Woy Woy FRMSP (DHI, 2020), shows the blockage strategy values adopted in the 1% AEP. The four study areas in this study are considered to have Low debris potential. Adopted blockage values for other design events use the AEP adjusted blockage process outlined in ARR2019.

Table 6-7 1% AEP Adopted Blockage (DHI, 2020)

Clear Opening Width (m)	Debris Potential at Structure		
	High	Medium	Low
W < 1.5m	100%	50%	25%
1.5m < W < 4.5m	20%	10%	0%
W > 4.5m	10%	0%	05

6.2.1.6 Selection of Critical Storm

The initial 5 m grid model was run for a range of storm events, based on the results of the Woy Woy Flood Study (DHI, 2010), from 30 minutes to 48 hours. The coarse grid model allowed for relatively faster run times and results were used as basis for the selection of a single representative storm event for each storm frequency and study location.

Table 6-8 outlines the critical durations utilised for each study area when processing the coarse grid model results. Each event frequency (1%, 10% and 20% AEP) was modelled for the same event durations.

Table 6-8 Critical Durations

Location	Critical Durations Across Study Area – Coarse Grid
Woy Woy	30 minute, 2 hour, 3 hour, 12 hour, 24 hour, 48 hour
Blackwall	30 minute, 1 hour, 2 hour, 9 hour, 24 hour, 48 hour
Booker Bay	30 minute, 2 hour, 6 hour, 12 hour, 24 hour, 48 hour
Ettalong	30 minute, 2 hour, 6 hour, 12 hour, 24 hour, 48 hour

All 10 temporal patterns for the critical durations were modelled in the coarse grid with the standard ARR2019 approach to determine median temporal pattern results and maximum duration results for each grid cell were processed.

To reduce the unrealistic modelling run time required to produce results in strict accordance with ARR2019 methodologies for a 2 m grid DEM, the 'most representative' storm event was selected based on:

- The temporal pattern for each duration which matches closest to the median raster results, and
- The critical storm which is the maximum raster result across the majority of the study area and does not underrepresent modelled peak flood behaviour in areas critical to the landform design.

Table 6-9 identifies the selected storm duration and temporal pattern for each AEP modelled in the study locations.

Table 6-9 Critical Storm Selection

Location	AEP Event	Modelled Duration and Temporal Pattern – Fine Grid
Woy Woy	1%	12 hour, Temporal Pattern 08
	10%	24 hour, Temporal Pattern 02
	20%	24 hour, Temporal Pattern 08
Blackwall	1%	1 hour, Temporal Pattern 08
	10%	1 hour, Temporal Pattern 10
	20%	1 hour, Temporal Pattern 06
Booker Bay	1%	12 hour, Temporal Pattern 08
	10%	24 hour, Temporal Pattern 02
	20%	24 hour, Temporal Pattern 06
Ettalong	1%	2 hour, Temporal Pattern 06
	10%	6 hour, Temporal Pattern 08
	20%	24 hour, Temporal Pattern 04

Modelling of the above listed storms will provide an approximation of design flood behaviour appropriate for this study. The final landform, interim landform scenarios both utilise the same design storm events in their respective modelling.

6.2.1.7 Existing Model Results

The results for the existing scenario model for the 1% AEP and 20% AEP are provided in **Maps G420** to **G427 (Appendix D)**.

The results were compared against the Woy Woy FRMSP (DHI, 2020) report preliminary results to provide validation of the models developed for this study. The focus of the comparison was on the flood extents and flowpaths/ponding areas identified, rather than comparing peak levels. This is because the focus of this assessment is on the strategic level assessment on the landform design, and on assessing the potential influence that this might have on the existing flowpaths and how these flowpaths might be improved. As this study is focused on the concept masterplan, and not specifically intended to replace or supersede design flood behaviour modelled in the Woy Woy FRMSP (DHI, 2020), this type of comparison was appropriate. Where peak flood levels are required for planning or development purposes the DHI study, which incorporates a comprehensive integration of groundwater and surface water, should be adopted.

As shown by **Maps G420** to **G427 (Appendix D)**, the flooding results for the existing scenario exhibit a similar pattern of flooding, when compared to the outcomes of the Woy Woy FRMSP (DHI, 2020). Differences in the extent of flooding can be attributed to:

- The difference in grid resolution – 10 m vs. 2 m for the FRMSP and this study, respectively; and
- The modelling approach, with the FRMSP utilising a coupled groundwater and surface water model while this study adopts a surface water only model.

Generally, the results obtained for the existing scenario modelling show a flood behaviour that is consistent with the Woy Woy FRMSP (DHI, 2020) results, identifying the same significant issues due to flooding. It can be concluded that, for the strategic purposes of this study, the results obtained for the existing scenario adequately represent the flooding behaviour in the study areas. Although in most cases the TUFLOW modelled results show a greater flood depth and extent compared to the DHI modelling, this is a slightly conservative approach to assessment of the design landforms.

6.2.2 Sensitivity Analysis

To understand the effects of certain modelling parameters on the flood behaviour within the four study areas, a sensitivity analysis was undertaken.

The following parameters have been varied to quantify their impacts on the existing conditions flood behaviour and acquire an overall understanding of the range of accuracy for the flood model results:

- Downstream Boundary;
- Losses; and
- Blockage.

As this analysis assesses the relative impact of the aforementioned parameters, only one event frequency (1% AEP), one event duration, and one temporal pattern (refer **Table 6-9**) has been modelled in the coarse 5 m grid.

6.2.2.1 Downstream Boundary

The effect of Sea Level Rise (SLR) on the flood modelling has been assessed using three scenarios: 2030, 2070 and 2100 SLR, or 0.1 m, 0.4 m, and 0.7 m increase in the downstream boundary condition, respectively.

Refer to **Map G430** to **G432 (Appendix D)**, which show the impact this variable has on flooding in the rest of the catchment.

As expected, the impact of increasing the boundary condition has a similar or less degree of impact upstream into the catchment on the peak flood depth. For example, in the Woy Woy CBD study area, peak levels increased approximately 50 mm, 200 mm and 400 mm for the 2030, 2070 and 2100 SLR scenarios, respectively.

The areas most susceptible to changes in the downstream boundary condition are Woy Woy and Ettalong as their natural topography allows for lower ground elevations to extend further inland. Whereas, Blackwall and Booker Bay slope up from their respective foreshores.

This sensitivity analysis also provides an understanding of the impacts of progressive sea level rise. The 2100 SLR scenario is also representative of the 'Business as Usual' scenario further explored in **Section 6.2.3**.

6.2.2.2 Losses

To better understand the impact of the adopted loss values on the flood modelling results, the loss values, both initial and continuing, were adjusted by +20% and -20%.

Refer to **Maps G433** and **G434 (Appendix D)**, which shows the impact losses has on flooding in the rest of the catchment.

Results show the greatest impact in those area of the study which are subject to greater degree of ponding across the model topography. The study areas of Woy Woy and Ettalong show the greatest impact on peak flood depths relative to the adopted losses, with a maximum increase of 100 mm when losses are decreased and a maximum decrease of 100 mm when losses are increased.

It can be concluded that the study areas are not significantly sensitive to losses.

6.2.2.3 Blockage

The ARR2019 risk based blockage approach results in a maximum blockage for culverts within the study area of 25%. To understand the potential impacts of higher blockage, this value was set to 50% for all culverts.

Refer to **Map G435 (Appendix D)**, which shows the impact that a higher level of blockage has on flooding in the rest of the catchment.

Given the lack of culverts across the study area, the effect of increasing blockage is minimal with a maximum increase of approximately 50 mm in isolated areas and between 10 to 50 mm in some widespread areas of Woy Woy.

6.2.3 Business as Usual Scenario

The Business as Usual scenario assesses the performance of the existing terrain in relation to catchment flooding, at future periods of time under the influence of climate change. This provides a relevant base case against which to compare the performance of the proposed concept masterplan landform.

In this scenario, the parameters adopted for the hydrologic/hydraulic model were mostly identical from the ones used in the existing conditions model. The only parameter that has been altered was the model downstream boundary conditions, which has been adapted to account for predicted sea level rise.

The ocean levels adopted for this scenario were equivalent to the 1% PoE level predicted for 2100, which considers a sea level rise of 0.7m. The adopted values, which are also summarised in Table 4-1, Table 4-2 and **Table 4-3**, are:

- Woy Woy, Blackwall and Booker Bay: 1.38 mAHD
- Ettalong: 1.63 mAHD

It is important to compare the flooding results for the modified landforms with the future flooding characteristics, as opposed to the existing conditions. The outcomes of this comparison will allow identification of the locations where increases in flood level were effectively caused by the alterations in the landform, and where flooding conditions would be naturally aggravated by the effects of climate change.

Therefore, the 'Business as Usual' scenario was used as a base case to evaluate the impact of the landform options in the flooding characteristics in the study areas. It is expected that this approach will result in the optimisation of the landforms and minimisation of fill depths.

In this study, the potential effects of climate change on the rainfall volumes has not been addressed, with sea level being the only variable altered from the existing to the future flooding scenarios. There is no specific guidance in ARR2019 on how climate change will affect rainfall volumes and patterns.

The results for the 'Business as Usual' scenario are also provided in **Map G449 (Appendix D)**. As expected, the flood depths observed in this scenario are generally higher and flood extents greater compared to the existing scenario in the four study areas, particularly in the areas near the foreshore.

6.2.4 Adaptation Landforms

6.2.4.1 DEM Modification

The TUFLOW hydraulic model was updated to represent the concept landform options (**Section 5.3**). For this purpose, the DEM used as input in the model was modified to represent each of the proposed landform options.

When required, the drainage network was adapted in accordance with the landform drainage concept. These modifications comprised the inclusion of pits, pipes, and culverts, as well as the increase of pipe capacities where necessary to alleviate flooding in both the proposed landform and existing conditions.

The other parameters considered in this scenario (rainfall, losses, roughness and boundary conditions) were equivalent to the ones adopted in the 'Business as Usual' scenario.

Hydraulic modelling was undertaken for each of the proposed landform options, considering the 20%, 10% and 1% AEP flood events.

6.2.4.2 Landform Modelling Results

To reduce the number of model runs required to evaluate the landform design for each study area, a single event duration for each event frequency was selected as the 'most representative' of the peak flood depths across the study areas. The events selected are outlined in **Table 6-9**.

Modelling of each design landform produced the following general results within the proposed landforms:

- 20% AEP:
    - Catchment flood extents contained within road reserves and easements for all study locations and in many cases restricted to gutter flows only allowing the passage of vehicles;
    - Safe passage of larger vehicles through flood waters along all roadways (i.e. hazard category H2 or less) for all study locations; and
    - Reduction of flood levels compared to 'Business as Usual' scenario for all residential properties. However, there are some minor exceptions in Woy Woy where flood depths increase marginally (less than 0.05 m) along Melba Road. This is likely attributed to the loss in flood storage downstream and a higher water level along the stormwater pipe network at

Victoria Road and Charlton Street. This could potentially be alleviated by further increasing the drainage capacity of this system.

- 10% AEP:
  - Catchment flood extents contained within road reserves and easements for all study locations, with the exception of the rear of properties in Pattie Place, Woy Woy where there is a minor overtopping of the proposed channel through here;
  - Safe passage of larger vehicles through flood waters along roadways (i.e. hazard category H2 or less) for all study locations; and
  - Reduction of flood levels compared to 'Business as Usual' scenario for all residential properties.
- 1% AEP:
  - Flood extents contained within road reserves and easements for almost all study locations, and exceptions being:
    - Rear of properties at Pattie Place, Woy Woy (maximum depth of 300 mm at rear of lots),
    - Plane Street, Blackwall there are four properties with minor flood depth (maximum depth of approximately 200 mm),
    - Approximately seven properties at the eastern extent of Flathead Road (maximum depth of approximately 200 mm), and
    - Properties surrounding the netball courts and open space in the centre of Ettalong (maximum depth of approximately 250 mm).
  - Safe passage of larger vehicles through flood waters along roadways (i.e. hazard category H2 or less) for all study locations with the exception of very small pockets represented by one or two grid cells; and
  - Reduction of flood levels compared to 'Business as Usual' scenario for all residential properties, with the exception of:
    - The rear of some properties on Pattie Place where flood depths increase marginally (approximately 200 to 300 mm). Further investigation may be required for a drainage solution in this location.
    - Some properties on the margin of the 'Business as Usual' flood extents where loss of storage in the floodplain causes flooding where there originally was no flooding (occurs across all study locations). Minor site drainage solutions or interallotment drainage systems could provide a solution to these issues.

Refer to **Maps G450** to **G457 (Appendix D)** for results of the 1% and 20% peak flood depths. Although there are still a relatively small number of private properties subject to flood waters in the 1% AEP event it is still viewed as an overall improvement to flood risk in the study areas. Additionally, to remove this catchment flooding from the proposed landform, an unreasonable degree of fill would be required. The landform solution represents a fair balance between improvements to the drainage systems and fill requirements for individual property owners.

Some isolated properties experience deeper flooding compared to the existing scenario (although generally in larger magnitude events). Although it is ideal to reduce flooding for all properties, the purpose of this landform conceptualisation design is to demonstrate that the adaptation strategy is possible to achieve and provide a

guide for further concept design. This may include measures such as wider easements, larger culverts or bridges or greater fill depths.

For all locations, protection of all private property and roadways from tidal events to 2100 and ocean storms up to the 1% AEP Brisbane Water flood event is achieved.

6.2.5 Interim Landform Scenario

An interim scenario for the Woy Woy CBD location was modelled to gain a better appreciation of the potential flood issues which could arise from a situation where some properties have been progressively raised before others, creating a significant change in overland flow patterns.

This includes analysis of the Woy Woy area only, which assumes:

- Sea Level Rise in 2070 (i.e. 1% PoE of 1.08 mAHD);
- Realisation of the landform for the commercial area of the Woy Woy CBD, as it is most likely this area will undergo redevelopment at a faster rate compared to residential areas;
- Realisation of the landform area located below the adopted 2070 1% PoE level, as it is assumed that all private properties and adjacent roadways would undergo filling once they begin to be inundated multiple times per year, and
- Raised landform for properties which have been identified as being likely to undergo redevelopment relatively sooner as they currently are older stock houses.

Results of the interim scenario modelling are shown in **Map G460**, highlighting the 1% AEP design flood depths for the Woy Woy CBD location.

Potential flooding issues are created where an increase in flood depths is modelled for properties which are adjacent to those which have raised ground levels. Additionally, some trapped low points are produced when raised properties closer to the foreshore (all of which have been raised because their original ground levels are below the adopted downstream boundary) block the flow of runoff down to Brisbane Water. These flooding issues can be at least partially alleviated with the introduction of temporary inter-allotment drainage in the form of piped drainage or swales to direct runoff away from those properties negatively impacted during this hypothetical interim scenario.

DCP modifications to allow for the progressive fill of private properties, with appropriate material as to not significantly lose infiltration capacity of the soil, in the study locations are further recommended in **Section 9**.

7 Economic Analysis

An economic assessment has been undertaken on the proposed landform and drainage plan for the Woy Woy Peninsula climate change adaptation study to understand the overall economic viability of implementing it. The full details of this assessment are provided in **Appendix F**. This assessment has been conducted over a period to 2100, and results would change if this timeframe were to be significantly extended.

An economic assessment is undertaken by comparing one alternative against another. It is important that these scenarios or alternatives are clearly defined to ensure a robust analysis. Two scenarios have been adopted for this assessment:

1. **Base Case** – this represents the 'Do-Minimum' scenario and represents the base case against which the concept masterplan options are considered.
2. **Concept Masterplan Scenario** – this scenario incorporates the concept masterplan (landform and drainage plan).

A summary of the undiscounted costs is provided in **Table 7-1**. These are provided to give an indication of overall costs associated with the concept masterplan. They indicate that both the total cost and the average cost per property associated with the Woy Woy concept masterplan are significantly higher than the costs for the other study areas. This difference could be attributed to amount of roadworks required and also to the larger proportion of low-lying properties, which demand a higher average fill depth. For the other three study areas the overall average cost per property is roughly the same and, therefore, proportional to the number of properties included in the concept masterplan.

While it is useful to review the overall costs involved, these costs will be spread over the period 2025 to 2100. The present value of these cost estimates (i.e. discounted costs) is provided in **Table 7-2**. Given the relatively long timespan of the proposed concept masterplan, the present value costs are significantly less than the undiscounted costs.

Table 7-1 Undiscounted Costs

Location	Roads	Property Filling	Parks	Total	No of Properties	Avg Cost per property
Woy Woy	$40.9 M	$7.6 M	$1.1 M	$49.6 M	580	$85,517
Blackwall	$1.8 M	$0.2 M	$0.0 M	$2.0 M	32	$62,500
Booker Bay	$12.2 M	$1.6 M	$0.0 M	$13.8 M	209	$66,029
Ettalong	$6 M	$1 M	$0 M	$6.9 M	101	$68,317

Table 7-2 Present Value Costs of Concept Masterplan Scenarios

Location	Costs	No of Properties	Avg Cost per property
Woy Woy CBD	$6.7 M	580	$11,000
Blackwall	$0.1 M	32	$3,000
Booker Bay	$2.4 M	209	$11,000
Ettalong	$0.4 M	101	$4,000

A summary of the benefits is provided in **Table 7-3**. The values represent the benefit of these things not occurring (i.e. property retreat not happening, not losing roads and parks). Property retreat is an inevitable outcome of doing nothing or continuing on with business as usual. The negative benefits of property damages occur because in the base case scenario properties are lost and these are no longer subject to flood damages, whereas in the concept masterplan scenario more properties are subject to flood damages.

Table 7-3 Summary of Benefits (present values)

Location	Property Retreat	Property Damages	Road Loss	Park Loss	Total	No of Properties	Avg Benefit per property
Woy Woy CBD	$4.22 M	$0.11 M	$0.93 M	$0.37 M	$5.64 M	580	$10,000
Blackwall	$0.05 M	-$0.02 M	$0.00 M	$0.00 M	$0.04 M	32	$1,000
Booker Bay	$0.51 M	-$0.09 M	$0.14 M	$0.00 M	$0.56 M	209	$3,000
Ettalong	$0.26 M	-$0.03 M	$0.01 M	$0.00 M	$0.23 M	101	$2,000

The economic assessment was undertaken by comparing the concept masterplan scenarios against the base case, for all study locations. These results are summarised in **Table 7-4.** Table 7-4A benefit-cost ratio (BCR) has been determined by comparing the concept masterplan scenarios against the base case, for each study location. A BCR greater than 1 result in an economic outcome that exceeds the cost of implementing the works, a BCR between zero and one produces less economic benefits than the cost of implementing the works but still has an economic benefit, and a BCR less than zero has a negative economic outcome. For Woy Woy, the concept masterplan has a BCR of 0.8. For Blackwall, Ettalong and Booker Bay, the estimated BCR was 0.4, 0.7 and 0.2, respectively. However, the incorporation of unquantified benefits may change this outcome (e.g. recreational value, environmental value, public infrastructure).

In addition to the base assumption of a discount rate of 7%, discount rates of 4% and 10% have also been tested. Net present value (NPV) is calculated as the value, in today's dollars using the aforementioned discount rates, of the benefits realised by the concept masterplan less the costs incurred to implement it. In some instances, a negative NPV is a result of the benefits being realised further in the future (and being significantly discounted) while the costs are incurred before this (and discounted less).

Table 7-4 Summary of Economic Results[2]

Discount Rate	Woy Woy CBD - NPV	Woy Woy CBD - BCR	Blackwall - NPV	Blackwall - BCR	Booker Bay - NPV	Booker Bay - BCR	Ettalong - NPV	Ettalong - BCR
7%	$-1.02 M	0.8	$-0.07 M	0.4	$-1.82 M	0.2	$-0.12 M	0.7
4%	$8.39 M	1.7	$-0.03 M	0.9	$-0.9 M	0.8	$0.3 M	1.3
10%	$-2.29 M	0.5	$-0.04 M	0.1	$-1.44 M	0.1	$-0.1 M	0.3

The highest BCR value and marginally economically unviable concept masterplan option is attributed to the Woy Woy location. This reflects the reality that this area is subject to tidal and ocean storm inundation in the relatively immediate future. The other three study locations are not significantly affected until the latter half of this century and their BCR values incur a cost well before the benefits are experienced when sea level rise begins to inundate the existing property and road ground levels. If, for example, the economic analysis for Blackwall, Booker Bay and Ettalong were undertaken starting in 2050 the resulting BCR values would significantly increase and the options may prove to be more economically viable.

[2] BCR – Benefit Cost Ratio, NPV – Net Present Value

8 Strategic Phased Action Plan

Realisation of the proposed landforms for the low-lying areas of the Woy Woy Peninsula relies on timely, and in some cases urgent, raising of private properties coupled with modification to public lands (i.e. roadways). In this respect, the completion of the project is the joint responsibility of Council and community members affected by sea level rise.

Once the outcomes of this study are progressed to a detailed masterplan that is adopted by Council, it is proposed that the DCP be amended to require all development applications within the study area to include fill to the required landform level. The strategy adopted for filling of land by private property owners as a requirement for Development Applications has the following advantages:

- The bulk of the costs of filling land is shouldered by those who are most at risk of flooding by rising sea level;
- Those who have the greatest flood risk also stand to gain the most by raising the landform;
- Most of the community already located above the projected sea level rise only pay for the landform adaptation indirectly (e.g. through Council rates); and
- The incentive for private property owners is immediately tangible, as the frequency of inundation of their land is reduced;
- Generally, the highest value land is located closer to the foreshore where land owners are assumed to have a higher amount of available capital to implement filling of their land.

However, there are some disadvantages to this strategy:

- The rate of incoming Development Applications can be slow and not necessarily concentrated in areas where immediate raising is required;
- To raise a section of roadway all adjacent properties (at least those which direct stormwater and sewer to the roadway) must also be raised, and if only one property remains at its original ground level it will not be able to be serviced without inefficient service designs; and
- Those properties bordering the foreshore will be required, if they do not raise their land, to at minimum provide a private seawall to protect adjacent and inland areas.
- Interim scenarios where only a portion of properties are raised may produce significant negative flood impacts on properties not raised in the study area.

Despite these disadvantages to the strategy, this is viewed as the most feasible and cost-effective method to proceed with raising the landform. The alternatives (e.g. planned retreat, raising of floor levels only, unavailable or unaffordable increases in insurance, reduction of services to the community) are strategies deemed unacceptable by Council and/or the community.

To better inform the process of the landform being realised, issues have been explored at the level of individual elements (e.g. roads, properties) undergoing raising as well as the adaptation pathways possible to undertake the high level planning which will enable the landform raising.

8.1 Staging and Potential Flood Impact Issues

The approach to staging of raising land to create the final landform is based on the projected sea level up to 2100, with the lowest lying areas being the first to require raising. This applies to both private and public land.

Maps displaying preliminary staging are shown in **Appendix E**, on **Maps G551 to G554**.

The preliminary staging boundaries were delineated based on existing LiDAR where low points in roadways and private properties exist below the defined projected future sea levels. In additional to this, where a public roadway begins to be inundated, the adjacent properties discharging to the public stormwater drainage system will also be required to be filled to enable the raising of the road. If all adjacent properties are not raised, those which remain at their existing levels will be subject to potentially increased design flood levels due to loss of storage within the floodplain. In addition, new services requiring gravity to run the system (i.e. stormwater and sewer services) will not be accessible. This is illustrated below in **Figure 8-1**.

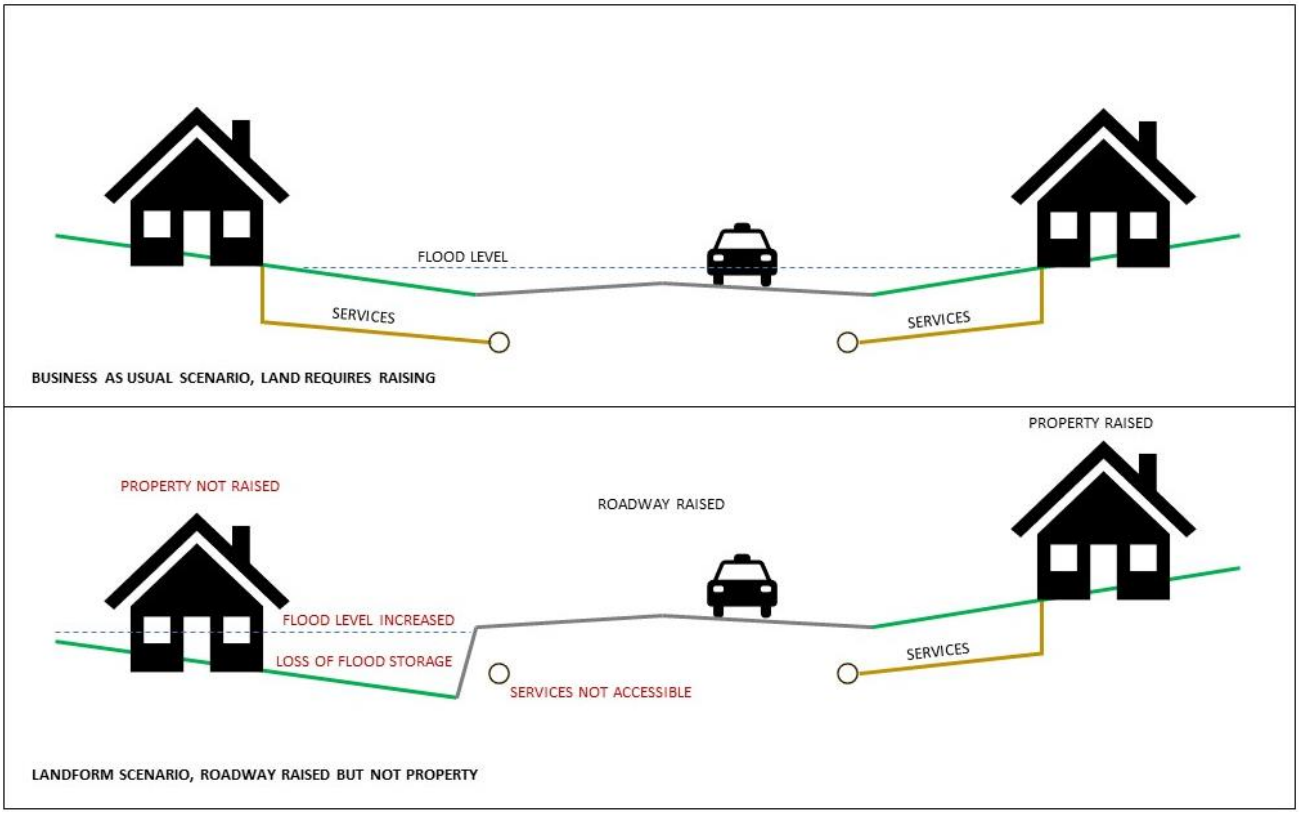

Figure 8-1 Impact of Raising Roads and Not Adjacent Properties

It is not necessarily the case that the proposed landform will be raised in accordance with the preliminary staging maps. Rather they represent the minimum areas required to be raised due to sea level rise alone. Some properties within the proposed landform extents may raise when the opportunity presents itself, such as when the lot undergoes redevelopment.

The acceptable frequency of inundation, and therefore the requirement to raise roadways, will be dictated by the community and Council. For example, residential roadways being inundated by the HHWSS, or approximately twice per year, may not pose much of an inconvenience to those requiring flood free access to their homes. If this progresses to residential roadways being inundated by the MHWS, or daily high tides, it is likely that those needing to use the roadway to access their homes would find this an unacceptable frequency of flooding. This can also be affected by other factors outside of strictly sea level rise, such as:

- Rainfall. An area not inundated by HHWSS or MHWS may become inundated during a very frequent event such as the 50% AEP or 2 EY.
- Emergency Routes. A roadway which is utilised as an emergency access (or evacuation) route would not have a low acceptable frequency of inundation. Furthermore, in a very rare event such as the

PMF, the roadway would need to be flood free given the flood risk associated with unusable emergency routes.

Given the scope and breadth of this study, the scenario will likely occur where a roadway will need to be raised due to an unacceptable frequency of flooding or the flood risk associated with the loss of use of the roadway is too great, but also not all private properties draining to the road will have been raised. In this case, the following options may be available to both the property owner and/or Council, in order of preference:

1. Incentivising fill through Council assistance, subject to financial capacity.
2. Construction of a private levee or seawall (location dependent) with design guidance from Council.
3. Raise dwelling floor level and driveway access only.
4. Voluntary purchase of private land by Council, and:
    a. Fill and resell land, or
    b. Back zone to open space or other flood compatible land use.

Options 2 and 3 would essentially buy time for the property owner to fill their land as flood levels slowly increase and once again their property and dwelling become inundated. It would also come with the risk of a lowered level of service for the property owner. These options would require pumping of flood waters during a tidal or rainfall event into the stormwater system. The property's sewer service would require either conversion to a septic system or a pumped system into the public network.

Option 1 would be the most preferred option, as it eliminates the need for voluntary purchase and continues to make the area viable for residential land use into the future. The cost and sustainability of this incentivisation will need to be carefully considered. Funding could be sought from state or federal agencies for cases studies to examine the full effects of filling.

8.1.1 Local Decision Process

As sea levels rise, there are many potential outcomes and scenarios for raising of private properties public areas such as roadways and open spaces. This will depend on multiple factors, mentioned previously in this report, affecting the ability and need for raising the landform such as:

- Acceptability of flooding frequency;
- Rate of redevelopment;
- Financial capacity of property owners;
- Financial capacity of Council;
- Location of essential services; and
- Location of evacuation routes.

The priority for realising the future landform roadways will be for evacuation routes and routes to, from, or containing essential services (e.g. sewer/stormwater/water trunk lines, pumping stations, electrical grid substations, etc). Ideally, these roadways would be raised following the filling of all adjacent properties. However, as this is dependent on the rate of redevelopment, it is very likely that a situation would arise where the frequency of inundation alone will not provide enough impetus for a property owner to fill their land to the landform level. For instance, they may not have the available funds to redevelop or find that the frequency of flooding on their property and adjacent roadway is more acceptable relevant tot eh rest of the community.

Figure 8-2 gives a general flow chart to guide Council with their decision making and inform the community of other possible outcomes. It is also displayed in the context of the adaptation decision making process (refer **Figure 5-1**).

There are multiple pathways for ending up with the final landform, and allowance is made for property owners to have a decision on how and when their land is raised. The inclusion of temporary or interim measures (private levees, partial raising, raising floor levels) accepts that not everyone has the ability to raise their land when road raising is required and provides a process for reassessing risks and hazards while potentially establishing new objectives as the effectiveness of those temporary measures are evaluated and monitored. Further into the future it is expected that the barriers to fully raising the entire landform will be removed.

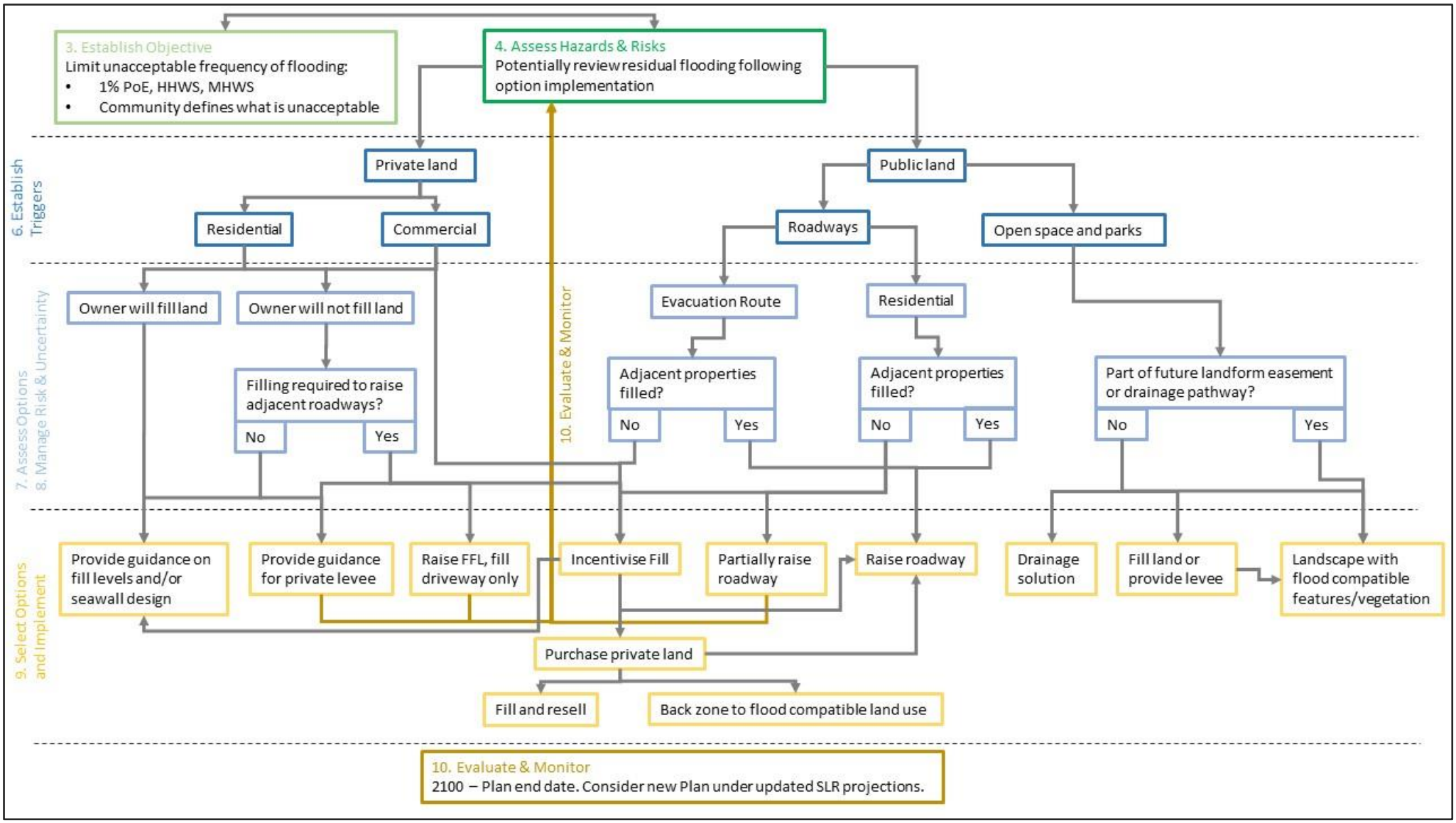

Figure 8-2 Local Action Flow Chart

8.1.2 Example Scenarios

As an example of how the adaptation pathway and action flow chart operate, two example scenarios have been devised to test the robustness of the proposed systems. These are considered to be some of the more difficult scenarios expected when adapting to sea level rise by raising landforms in the Woy Woy peninsula. These examples of specific properties should not be taken to mean that these are significantly more at risk than other properties, rather that they provide a clear example of the issues likely to be faced by many property openers in the study areas.

8.1.2.1 Residential Properties Unable to Fill

This scenario represents one of the most likely scenarios across the study locations where residential properties are unable to raise their land prior to adjacent roads needing to be raised. The aim here is for Council to provide every opportunity for the landowner to adapt to rising sea levels without assistance.

Location: Booker Bay Road, south of Guyra Street

Scenario: Mean High Water Springs (i.e. daily tides) have reached 1.0 mAHD along the low point of Booker Bay Road. Guyra Street has already been raised, as have all of the properties along this section of Booker Bay Road, save for the example site in question. The community has deemed this level of very frequent flooding unacceptable as those attempting to enter their driveways or parking their vehicles on the street are incurring damage from the salt water. Additionally, during rainfall events the road becomes unusable and residents living around this low point are unable to access by vehicle or are stuck in their homes for significant lengths of time. Council proposes to now raise Booker Bay Road in this area as the adjacent landform easements have also been established. The owner of the existing site is elderly and cannot afford to redevelop and raise their land.

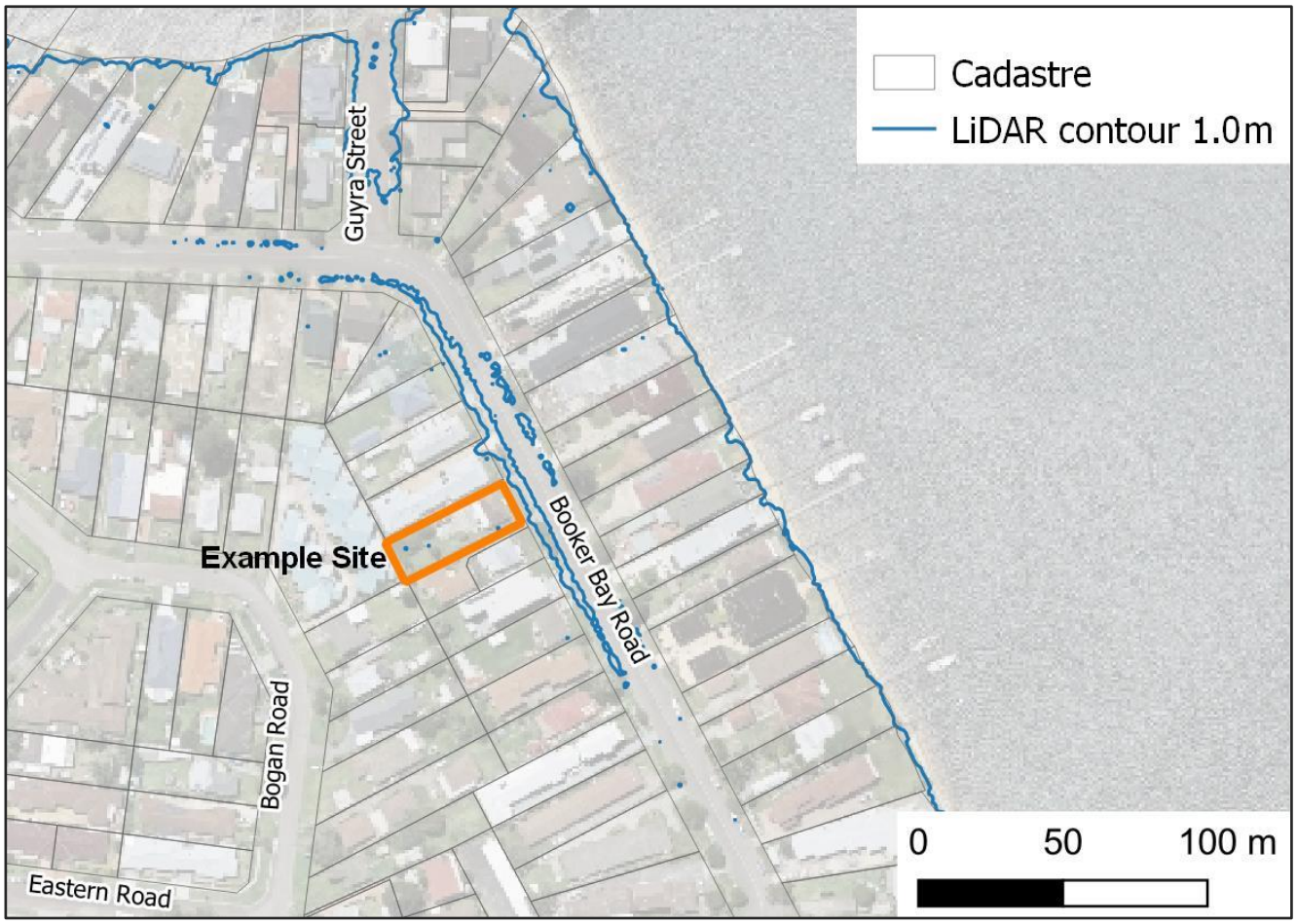

Figure 8-3 Example Residential Site in Booker Bay

Solution: To accommodate the road raising, Council may pursue one or many of the following options, in order of preference, in consultation with the landowner.

1. Council offers the existing site owner an incentivisation to redevelop their land. This could be in the form of relaxed development restrictions, reduced fees, financial assistance, etc. The owner agrees, redevelops the land and the road can be raised. (Adaptation Pathway 'A')
2. The owner still cannot afford to redevelop even with the incentivisation. Council proposes different options to maintain the liveability of the property (albeit, at a reduced level of service) and also raise the roadway. These include: guidance on a private bund or levee within the property so that runoff along the roadway (and rising tides) does not spill into the property, guidance on a pumped stormwater system and septic tank solution to maintain services, state government funded assistance with raising of floor levels. The property owner is able to implement some of these temporary measures and they are viable until sea levels rise further. At this point the owner is able to redevelop and raise the land. (Adaptation Pathway 'B')
3. Similar to the previous option, but the owner is unable to redevelop after further sea level rise and the temporary measure are no longer viable (e.g. ingress of groundwater caused by a higher sea level can no longer be pumped out). Council then offers a voluntary purchase

of the property at market value. The owner accepts this, then Council is able to fill the property and sell it again. (Adaptation Pathway 'E').

4. Council offers a voluntary purchase of the property at market value originally, when MHWS is at 1.0 mAHD. The owner accepts this, Council fills the land and then resells. (Adaptation Pathway 'F')

8.1.2.2 Heritage Property in Woy Woy CBD

There are two recognised heritage buildings in the Woy Woy CBD area which are subject to inundation during future sea level rise. These are the Woy Woy Library and the Woy Woy Hotel.

This scenario considers the Woy Woy Library, although many of the same measures can be put into place for the Woy Woy Hotel.

Location: Woy Woy Library, corner of Blackwall Road and Oval Avenue

Scenario: HHWSS (i.e. king tides) have reached 1.0 mAHD and within the Woy Woy CBD roadways are becoming inundated in very frequent rainfall events. Commercial properties within the CBD have already redeveloped and filled, however the roadways are still at the existing levels. The community has found it to be unacceptable that during even minor rainfall events they cannot access areas of the Woy Woy CBD and Council has decided to raise roadways. The Woy Woy Library is heritage listed and the building cannot be demolished and rebuilt on raised ground.

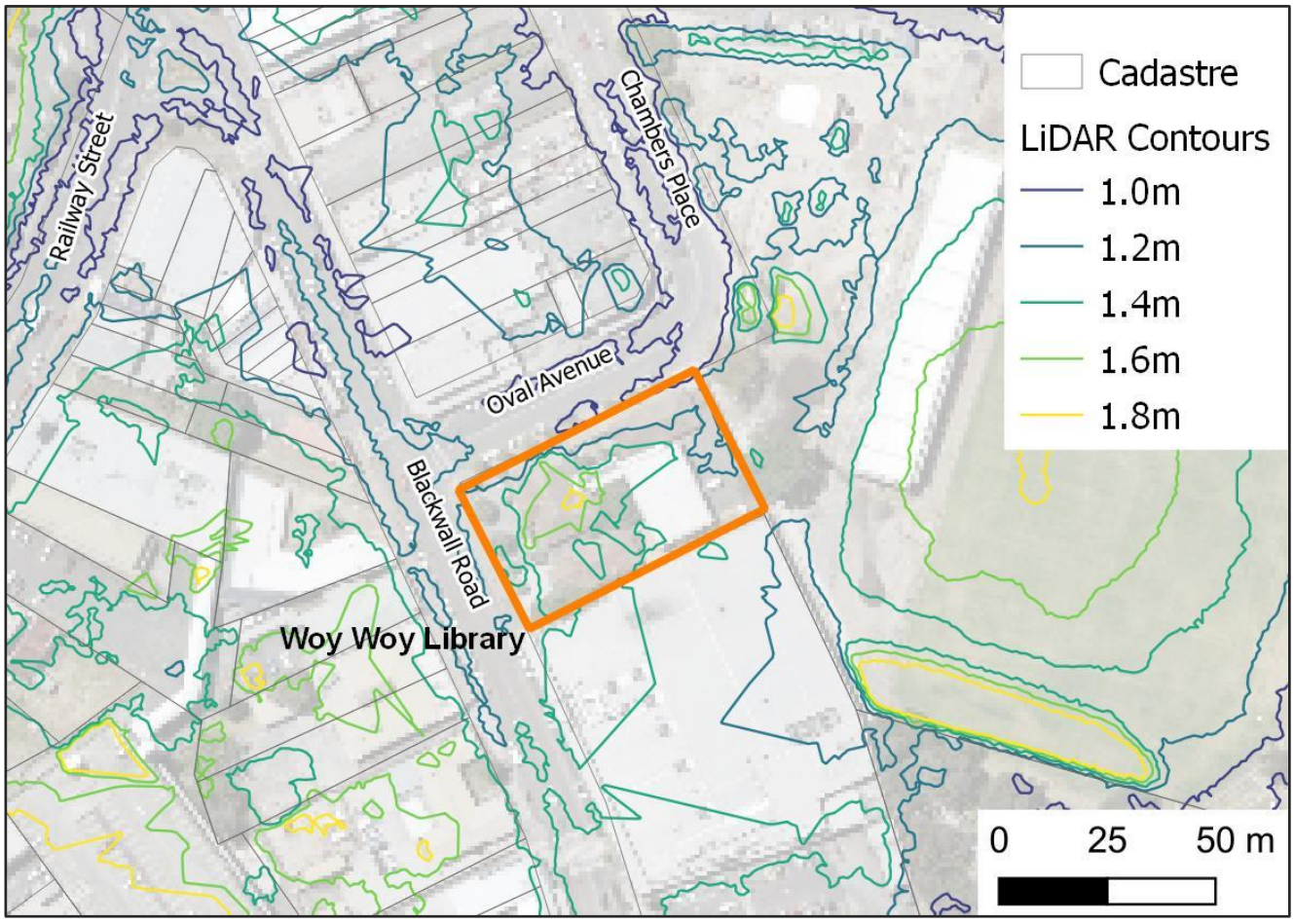

Figure 8-4 Example Woy Woy Library Heritage Site

Solution: The adjacent roads must be raised, and the heritage property owner has elected in the short term to protect the building from rising sea levels by constructing a flood wall (private levee guidance provided by Council) surrounding the site to the height of the final landform while a permanent solution is ascertained. During rainfall events, a pumped drainage system will allow the area behind the flood wall to drain to the public stormwater system. As sea levels rise, the site continues to be able to be protected by the flood wall until either a technical solution is determined to raise the entire building or, more likely, the ground level around the building can be raised, while internally the floor level is raised or a flood barrier is constructed at entry ways and the floor level remains below sea level. (Adaptation Pathway 'C')

This solution would require continuous evaluation and monitoring if floor levels were to remain below predicted sea level elevations.

This solution outlined in this scenario (temporary protection with private levees and pumped drainage) may also be applicable to other properties which are less easily able to redevelop and raised ground levels such as residential apartment blocks and some commercial properties.

8.2 Adaptation Pathway Analysis

The process of defining adaptation pathways was guided by the steps outlined in the Decision Support for Coastal Adaptation: The Handbook (HCCREMS, 2012). The establishment of adaptation pathways enables the selection of potential triggers and thresholds where action needs to be taken, particularly planning actions by Council, for the landform at each study location to be realised with liveability maintained for all properties. It also indicates the consequences for inaction or continuing on with business as usual.

The adaptation pathways, options within those pathways and the thresholds and triggers associated with them are provided in this study as a preliminary assessment and present approximate timelines for implementation and decision making for Council. The detailed masterplan and Public Domain Plan will provide further assessment and fine tuning of these adaptation pathways. Extensive community engagement should inform this process.

8.2.1 Identification of Options

Each adaptation pathway is based on the selection of options by Council over time. The options outlined for these adaptation pathways refer to inaction / business as usual, planning actions and public works required to be undertaken by Council to enable each pathway.

The options are listed in **Table 8-1**. A full list of required works and a workplan timeline for each pathway is shown in **Appendix G**.

Table 8-1 Adaptation Options

Option	Description
Liveability Conceptualisation	Involves preparation of short-term studies, planning documentation and policies, as well as reviews of existing planning documentation. Preparation of this Study and the Woy Woy FRMSP are included in this option. Issues dealing with constructability of the detailed drainage masterplan would need to be considered here.
Liveability Planning	Further planning measures including adoption of policies, plans, and guidelines to enable Council and the community to begin raising the landform. This is inclusive of the detailed landform masterplan, Public Domain Plan, and DCP/LEP amendments.
Liveability Planning (Accelerated)	Includes all of the aspect of the Liveability Conceptualisation and Planning; however, the process is less linear and therefore can be completed faster if needed.
Landform Realisation	All of the actions required to physically raise the landform once planning and policy guidance has been put in place. This applies to public and private property.
Business As Usual	Utilising all of the current planning and policies to best mitigate the effects of sea level rise.
Retreat	Acknowledgement that full realisation of the proposed landform is no longer possible, and the full extent of the study locations cannot remain liveable. Includes planning and policy measures to enable controlled retreat of the area.

All of the above options include significant community engagement and education to make the public aware of and be involved in how the adaptation processes can be best enacted taking into consideration the needs of all of those affected.

8.2.2 Thresholds and Triggers

The Decision Support for Coastal Adaptation: The Handbook (HCCREMS, 2012) provides specific definitions for both thresholds and triggers in the context of adaptation pathways:

- *A threshold is a point or minimum level at which a possibly irreversible change, response or specified effect would happen or cease to happen. In the case of decision-making for coastal adaptation, an objective, as defined in Stage 3, can be achieved / met until a particular threshold is reached. The threshold therefore defines a point at which a risk has reached an unacceptable level and the objective for an area can no longer be achieved without intervention and implementation of adaptation options.*
- *A trigger is an incident or occurrence that initiates other events. In the case of decision-making, a trigger is used to indicate when a management response is required and/or an option should be implemented.*

For this study, thresholds have been adopted as the degree of sea level rise within each study location where private properties begin to lose their liveability. This may be because properties have become inundated, or access to these properties has become inundated. It is acknowledged that as sea levels rise and some properties become inviable, not all properties in the study location become unviable. The aim of the selected thresholds (and subsequent adaptation pathways) is to achieve liveability for all properties in the study area.

Important to adopting a threshold level, it is necessary to define the degree and frequency of flooding it represents. For the purposes of this study, the adopted threshold is defined as the 1% PoE (refer **Section 4** for

existing and future sea level rise levels). In this sense, the adopted threshold will a reflection of a physical threshold (sea level rise), economic thresholds (frequency to disruption of business, usability of assets), and social thresholds (public appetite for risk, community outrage, people and properties at risk). Through community consultation, this threshold should be refined depending on the public's acceptability of flooding frequency in their properties and roadways as well as Council's ability to maintain public areas.

Table 8-2 outlines the thresholds adopted for each study location.

Table 8-2 Adopted Thresholds

Study Location	1% PoE Level (mAHD)	Description
Woy Woy	0.85	Roads in the Woy Woy CBD begin to become inundated, namely, the intersection of Oval Avenue and The Boulevard. The Woy Woy Wharf will also be inaccessible.
Blackwall	1.10	Properties become inundated.
Booker Bay	1.30	Booker Bay Road becomes inundated, blocking access to private properties.
Ettalong	1.30	Properties become inundated.

The trigger points for each of these events require analysis of the timeline between when the threshold is reach and when a response is required to avoid losing liveability of the area. Again, in accordance with guidance in the Decision Support for Coastal Adaptation: The Handbook (HCCREMS, 2012), there a number of allowances which need to be made between the timing of the trigger point and when the threshold is reached. These include:

- Monitoring period. Sea level rise should be continuously monitored following the point where a trigger is reached. This will enable decision making to be informed by the rate of sea level rise and determine if the threshold is on track to be met. The suggested monitoring period for this study is five years. Although in the case of Woy Woy, which is currently subject to rising sea levels (evidenced by tidal flooding at the intersection of Brick Wharf Road and North Burge Road) this monitoring period can be waived in order to allow for the responses to be undertaken in the very short term. Existing sea level data can be analysed to determine definitively if this particular threshold is on track to be met.
- Response Time. A nominal allowance for policy and planning guidance to be implemented and mitigation works to be undertaken. In the case of Woy Woy, an allowance has been made for five years. It is anticipated that lessons learnt from this experience can reduce the response time for those study locations affected by sea level rise later in the century. An allowance of three years has been made for the study locations of Blackwall, Booker Bay and Ettalong.
- Safety Buffer. This is an allowance for variation in the rate of rise of sea levels. For the later half of the century a safety buffer of 100 mm was adopted to allow for the estimated rate of sea level rise being greater at that time and as climate science becomes more refined this rate could possibly increase. For Woy Woy, the safety buffer was reduced to 50 mm to account for the relative imminence of the threshold and any increase in the rate of sea level rise would be less severe.

Figure 8-5 outlines the projected sea level rise against the adopted thresholds and defines the adopted triggers shown in **Table 8-3**.

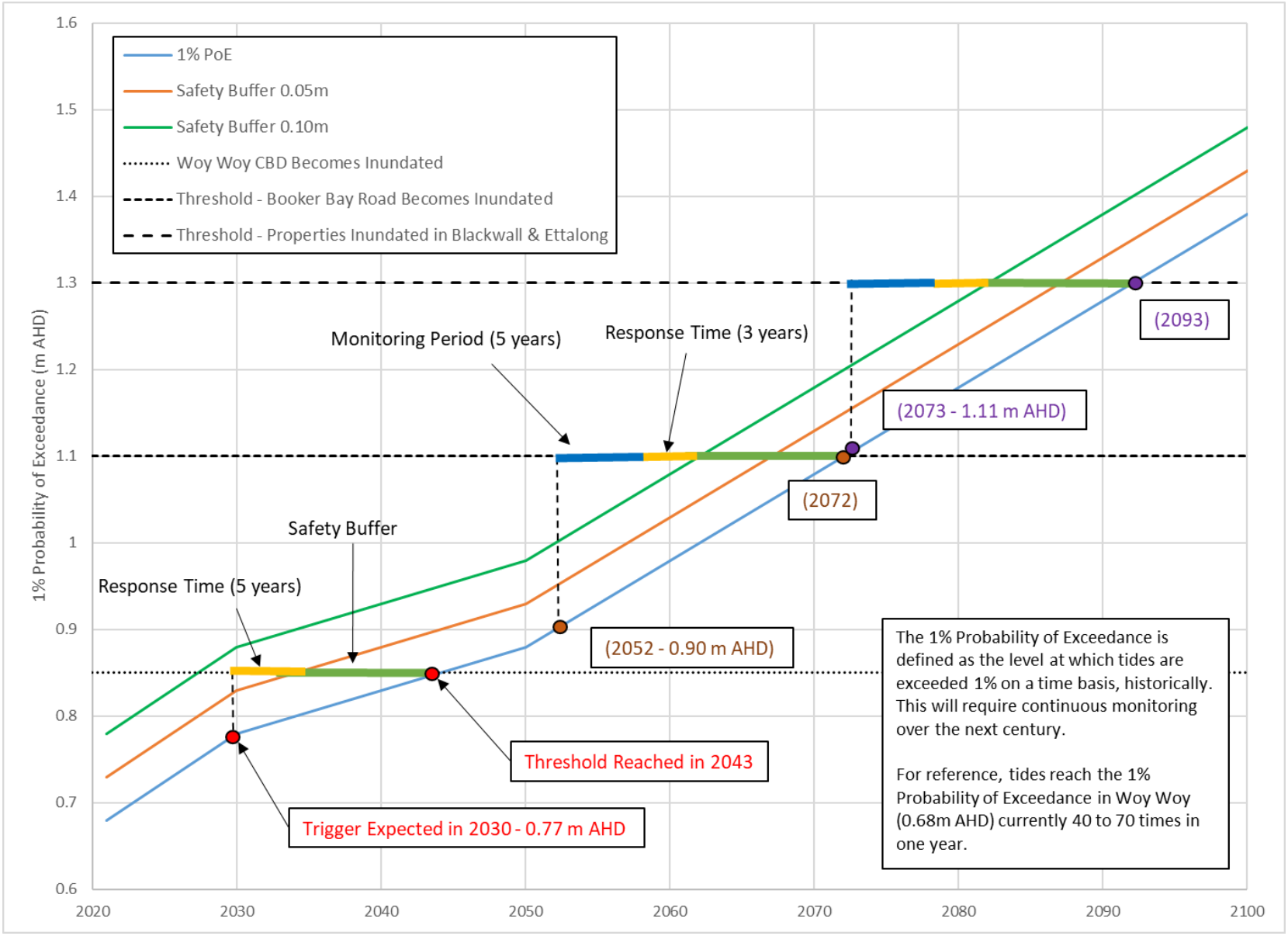

Figure 8-5 Thresholds and Triggers

Table 8-3 Adopted Triggers

Study Location	1% PoE Level (mAHD)
Woy Woy	0.77
Blackwall	0.90
Booker Bay	1.11
Ettalong	1.11

8.2.3 Adopted Adaptation Pathways

With the thresholds and triggers identified, a framework for the adaptation timelines can be made. Reponses will be required when triggers are reached and, more importantly, timeframes for prerequisite actions are known in order to enable those responses.

With each study location having a separate threshold and trigger, it is not absolutely necessary to have options apply to all locations at the same point in time (although this may be advantageous from a planning and policy direction). For example, if the 'Business As Usual' option is maintained and areas of Woy Woy lose their viability, the Liveability Conceptualisation and Liveability Planning options can still be undertaken for the remaining locations. Conversely, if it is imperative to undertake the Liveability Planning (Accelerated) option as soon as possible in order to maintain the viability of Woy Woy, this option can be undertaken in the context of Woy Woy alone. Proceeding this way may also provide an opportunity to learn lessons from its implementation and the remaining locations may be adapted more effectively at a later time.

Figure 8-6 illustrates the possible adaptation pathways for this study.

The most preferrable pathway is **Adaptation Pathway A** where *Liveability Conceptualisation* proceeds immediately and *Liveability Planning* soon after so that by the time the trigger for Woy Woy is reached all of the necessary policies, planning and guidelines will be in place to enable a response to sea level rise and (while also allowing for the appropriate safety buffer) the landform can begin to be realised when the thresholds is reached.

Adaptation Pathway B allows for a brief period where *Business As Usual* can proceed in this decade before the trigger for Woy Woy is reached. Some actions for the landform adaptation can still be undertaken within the *Business As Usual* option (e.g. completion of this study and the Woy Woy FRMSP, reviewing the LEP and DCP, installation of flood gates, etc.) as current planning will still allow this. The *Liveability Planning (Accelerated)* option will then have to fast track the remaining actions for the landform to begin to be realised before any liveability is lost.

Adaptation Pathways C, D and E represent scenarios where liveability is progressively lost across the study locations when the Business As Usual options is selected.

Adaptation Pathway F represents the scenario in which the option of Retreat for all locations occurs. In this scenario, policy and planning will still be needed to effectively manage retreat form the coastal areas, with revisions to the strategy happening as each location is subject to this.

It should be stressed that **Adaptation Pathway F** is highly unlikely as it is expected that through stakeholder and community consultation, managed retreat would be unpalatable. In accordance with the Decision Support for Coastal Adaptation: The Handbook (HCCREMS, 2012), this option is required to be explored and remain open as a fallback option.

Reiterating that the scope of this climate change adaptation study only extends to addressing flood risk up to 2100, all adaptation pathways will allow for another climate change adaptation study beyond this limit to begin in approximately 2085.

Appendix G includes workplans for all of the preliminary adaptation pathways.

Appendix H provides examples of two pathways (Adaptation Pathways B and D) and the decisions taken as each pathway progresses.

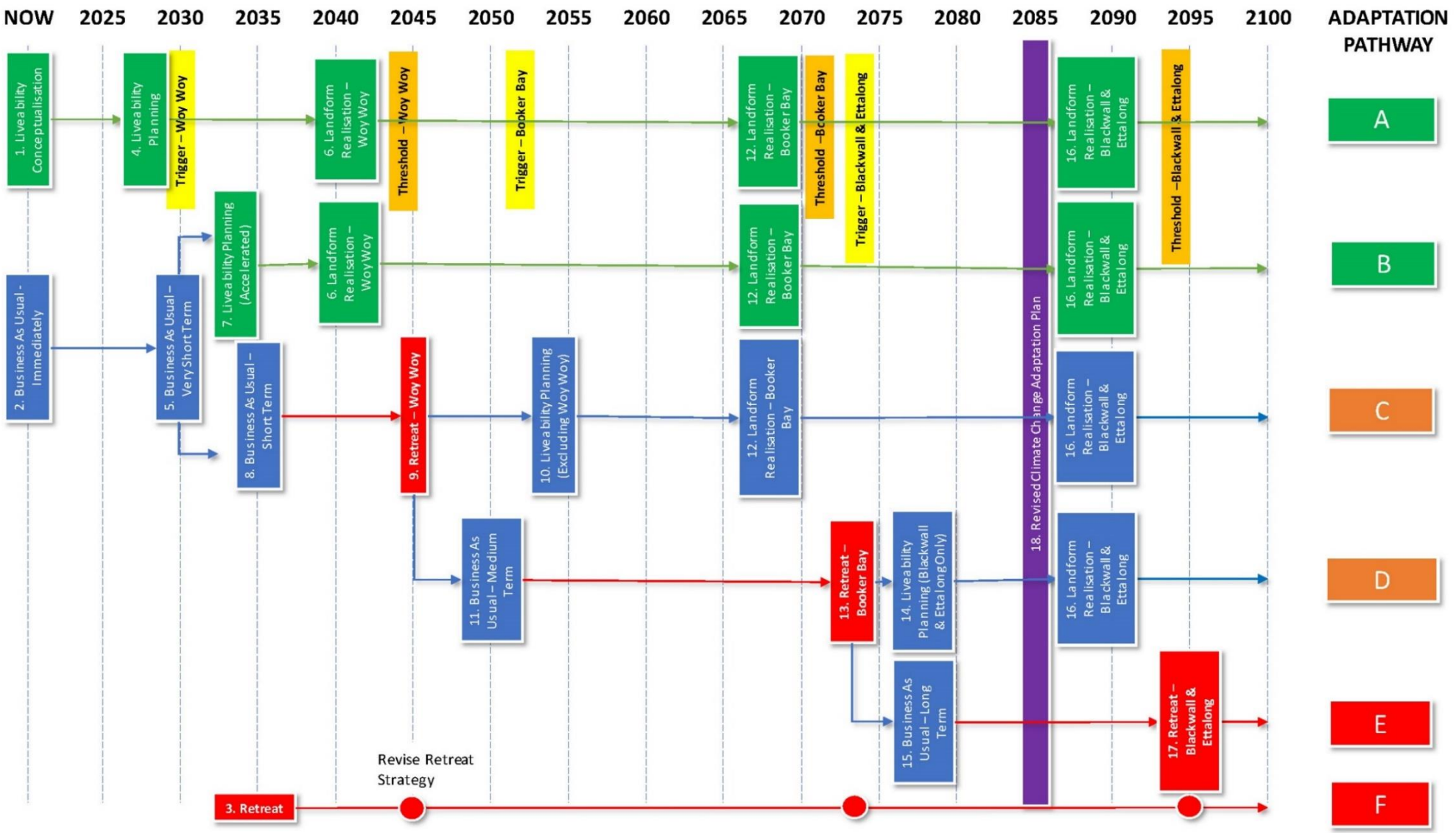

Figure 8-6 Preliminary Adaptation Pathways

8.2.4 Stakeholder Workshop

The adaptation pathway analysis, as part of the larger draft report, was presented to stakeholders in an online workshop on 15 June 2021. The purpose of this workshop was to present the climate change adaptation study and its outcomes to attendees and gather feedback.

A total of 51 people were invited to attend which represented all levels Council staff (planning, flooding, civil works, etc.), Department of Planning, Industry and Environment staff, and Rhelm staff involved in the project. Approximately 10-15 people attended the workshop.

The following issues were raised for consideration by stakeholders:

- Timing is important for funding to be acquired for public works.
- Filling of properties can still happen before trigger levels occur.
- Raising of the roadways can impact private properties. Therefore, the private properties should be raised first.
- Filling materials should be of a similar sandy material, but his will need to be strictly monitored to be sure the permeability of the soil is not affected.
- Groundwater may also become an issue during filling as the groundwater regime in this area may change with the added load of soil on one property compared to an adjacent one.
- Community engagement needs to be part of the process. A similar study in Davistown and Empire Bay was supported from the community perspective. Feedback from the community in Davistown is that they were impressed at Council being proactive.
- Sale of public land within the study locations could be an opportunity to include this study's outcomes ahead of time.
- Department of Planning, Industry and Environment - land raising may not be limited to just this location. There may be some potential that legislation be created if this is happening on a wider scale which would allow for purchasing or similar.
- It may be that the Hunter and Mid Coast groups of councils could undertake some advocacy around the required planning mechanisms.

9 Adaptive Measures Guidance

9.1 Approach

It is proposed that the landform be implemented through the following approach:

- Preparation of a detailed masterplan, including the constructability of the landform and drainage elements, that develops a detailed design of the proposed landform and also provides property filling design guidelines and other specifications.
- Update of *Gosford Council DCP 2013* (or the Draft Central Coast DCP) to require filling of properties in accordance with this climate change adaptation plan. This would be enforced as part of any significant development application within the study area. This would incrementally raise private property to the final landform levels, allowing Council to then raise roads and other infrastructure.
- Council to look for opportunities to raise the roads identified in **Section 6.2.5**. This would likely be done as part of road maintenance programs. However, there may also be opportunities to raise key access roads through the state government floodplain risk management process to improve existing emergency response access during Brisbane Water flood events.
- Implementation of selected aspects of the landform to be assessed for their ability to manage existing flood risk in the Woy Woy FRMSP (currently being prepared by Council).
- Raising of infrastructure, including roads as completion of adjoining property filling allows.

9.2 Policy and Planning Framework

On 12 May 2016, a proclamation to merge the former Gosford City and Wyong Shire Councils and form the Central Coast Council was announced by the Department of Premier and Cabinet. At the same time, the State Government issued Guidance for Merged Councils on Planning Functions. These guidelines recommended Council analyse the differences in the current planning controls, including existing and deemed Environmental Planning Instruments (EPIs) and Development Control Plans (DCPs).

Council has been preparing a draft Central Coast Local Environmental Plan (CCLEP) and draft Central Coast Development Control Plan (CCDCP) in response to these guidelines. However, at the time this study was undertaken the Gosford DCP (2013) and Gosford LEP (2014) was still in force for Woy Woy.

9.2.1 Gosford Council Development Control Plan 2013

Filling of properties (with Council approval) within the Brisbane Water floodplain (i.e. inclusive of the entire current study area locations) is permitted by the DCP, in so far as it is allowable as part of the Brisbane Water FRMP (2015). However, the FRMP does not permit filling within local catchment floodways or flood storage areas.

The proposed landform would require filling within local catchment floodways and flood storage areas. The DCP would need to be updated to reflect this.

The DCP states that filling of individual sites in isolation, without consideration of the cumulative effects is not permitted. The consideration of the cumulative effects is considered to the modelling and analysis undertaken within this document.

9.2.2 Gosford Local Environmental Plan 2014

The residential land within the study area is primarily zoned 'R2 – Low Density Residential' and 'R1 – General Residential'. In the locations where significant fill depths are required to achieve the proposed landform, Council may consider rezoning 'R2 – Low Density Residential' lots to 'R1 – General Residential' to allow for

higher density development (such as multi dwelling housing) to provide better financial returns on development (i.e. the cost of filling and associated works per m^2 will be higher than for those properties with less fill depth). This primarily located in the Blackwall study area location.

Any rezoning would need to consider a range of planning aspects outside of the scope of this study.

9.2.3 Central Coast Council Climate Change Policy (2019)

The Central Coast Council Climate Change Policy (2019) supports the adaptation plan proposed in this document for Woy Woy.

The Climate Change Adaptation Strategy aims to specifically address Principals 3 and 5 and Commitment D4 of the Central Coast Council Climate Change Policy (2019) (**Section 3.2.5**).

This Climate Change Adaptation Study has involved hydraulic modelling of local catchment flows of the existing and proposed landform under existing and sea level rise conditions to assist in evidence based decision making to respond, to adapt and build resilience to climate change (Principal 3 of the Climate Change Policy). Evidence based decision making is also achieved through the undertaking of a cost benefit analysis. This analysis looked at the staging of costs associated with implementing the proposed landform design (e.g. filling, drainage and roads) and compared this against the economic cost of 'doing nothing' (e.g. flood damages and loss of land value).

The next step in implementing the outcomes of this study is the preparation of a detailed masterplan that will be used to develop specific development controls that consider constructability, adaptive pathways and staging of development. It is critical that these controls are developed before critical sea level rise triggers are reached to ensure that the controls are implemented as development occurs to achieve a proactive approach and to ensure continuity to better anticipate and adapt to complex challenges posed by the changing climate (Principal 5 of the Climate Change Policy).

9.2.4 Floodplain Risk Management Program

The floodplain management program is implemented by State Government in collaboration with local councils to assist in the implementation of measures to reduce the impacts of flooding and flood liability on communities. This program serves as an important mechanism which allows climate change, and by extension Council's Climate Change Policy, to be considered within operational planning.

There may be opportunities to implement aspects of the landform and drainage plan under this program to manage existing flood risk, while also contributing to planning for the management of future risk. This may include:

- Proposed easements and drainage channels in Woy Woy and Booker Bay; and
- Raising of selected roads for evacuation purposes.

The benefits of these works in managing existing flood risk will be assessed further in the Woy Woy FRMSP (currently being undertaken by Council).

It is also noted that the outcomes of this climate change adaptation study seek to address the following recommendations of the Brisbane Water FRMP (2015):

- PM9 – Develop Climate Change Adaptation Plan: this is the key purpose of this study.
- PM11 – Overland Flows Studies: The analysis undertaken as part of this landform design assessed the impacts of filling in the floodplain on local flood behaviour.

10 Recommendations

The outcomes of this adaptation plan will be used to inform a series of planning decisions by Council. The key recommendations to assist in this process are to undertake the following:

- Distribution of the information contained in this study to all relevant Council staff and Councillors.
- Review the outcomes of this study and prepare concept and detailed masterplan and Public Domain Plans that will inform a future local precinct development control. Plan and develop adaptive pathways that considers constructability with respect to incremental phasing and implementation of a future landform. These Plans would need to consider:
    - Sensitivity of the drainage system and the flood protection to downstream boundary conditions and changes in rainfall;
    - More detailed investigations into interim scenarios, impacts and triggers and the framework for Council to enable adaptive pathways for all properties and residents;
    - Prepare standardised schematic drawings for individual lots (e.g. fill containment, drainage);
    - Constructability methodology reporting;
    - Review of the Development Control Plan (DCP) and Local Environment Plan (LEP) for permissible development, height restrictions and consolidations of allotments for potential larger scale development;
    - The impacts on Aboriginal heritage; and
    - Other non-flooding planning impacts, such as solar access for homes.
- Investigate options for internal and external funding for the detailed masterplan and Public Domain Plan.
- Include specific works in FRMSP to assess the existing flood risk management benefits of proposed easements in Woy Woy.
- Include the recommended landform in the *Woy Woy FRMSP* (currently being prepared) to assess its ability to address existing and future flood risk. This may assist in application for funding from the NSW Floodplain Management Program for components of the landform, such as raising of public assets and easements.
- The flood modelling undertaken as part of this study does not take into account the interaction with groundwater. The intention of modelling is to determine the effectiveness of the proposed landform at reducing flooding in the study area. Flood Planning Levels and Flood Planning Areas should be determined from the *Woy Woy FRMSP* (currently being prepared) which takes into account the underlying groundwater conditions in the Woy Woy Peninsula.
- Review rezoning opportunities with Council planners to consider planning aspects not considered in this study.
- Community engagement for the proposed landform and individual flood management works to be undertaken as part of the detailed masterplan preparation.
- Community engagement for the proposed landform and associated works to showcase Council's innovative and proactive approach to climate change adaptation.
- To facilitate knowledge sharing, establish a working group with other coastal councils which are considering landform raising as an adaptation to sea level rise.

- Prioritise adaptation works and planning measures for the Woy Woy CBD. This area is subject to greater risk of inundation from ocean storm events and tides compared to the other three study locations.
- Dissemination of this report through the public domain to initiate discussion and provide a road map with the wider community.
- Create a road map based on the following principles acknowledged in Council's Climate Change Policy:
    - Principle 5: Council implement a proactive approach and ensure continuity to better anticipate and adapt to complex challenges posed by the changing climate.
    - Principle 6: Council implement a Place-based approach to enhance Council and community capacity for climate resilience that is context specific, knowledge based and collaborative.
    - Commitment D4: Council develop place based Climate Change Action Plans in partnership with the community that establishes regional targets for mitigation and prioritises local adaptation planning.

The outcomes of this study should also be used to develop climate change adaptation studies for other at-risk locations.

11 Conclusions

This climate change adaptation study identified that incremental filling to reduce existing and future flood risk may be feasible within four low-lying areas of the Woy Woy Peninsula. Filling of private and public land in this way achieves a flood compatible landform where the cost is shared by those who gain the most benefit (the landowners) and public funding. This provides some equity across the LGA with regards to community costs associated with climate change adaptation.

The Woy Woy CBD should be considered as priority for progressive realisation of the final landform. It is currently subject to tidal inundation while Blackwall, Booker Bay and Ettalong only being to be significantly inundated by tidal events in the latter half of this century. This is also reflected in the economic analysis and a higher benefit-cost ratio in the Woy Woy CBD where a greater value of land (private and public) benefits from the landform raising almost immediately. Although no locations produce a benefit-cost ratio above 1.0.

The uncertainty and unreliability associated with determining future climate change scenarios means planning and management options need to be adaptive and adjustable. However, the available data and sea level rise projections would indicate that adaptation needs to start as soon as possible to ensure communities achieve adaptation goals before sea level rise trigger levels are reached. Within the context of this adaptation study and the study area, this mean providing the community with private property filling criteria so that all future development can incorporate this. This is likely to be most effectively achieved by incorporating these criteria within Council's DCP. This is a high priority outcome of this study.

12 References

Cardno Lawson Treloar, 2013. Brisbane Water Foreshore Flood Study

Cardno, 2015. Brisbane Water Foreshore Floodplain Risk Management Study

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DHI, 2010. Woy Woy Peninsula Flood Study

DHI, 2020. Stage 5 Woy Woy Floodplain Risk Management Study & Plan

HCCREMS, 2012. Decision Support for Coastal Adaptation: The Handbook. Hunter Councils NSW

Office of Environment and Heritage (OEH), 2019. Floodplain Risk Management Guide - Incorporating 2016 Australian Rainfall and Runoff in Studies

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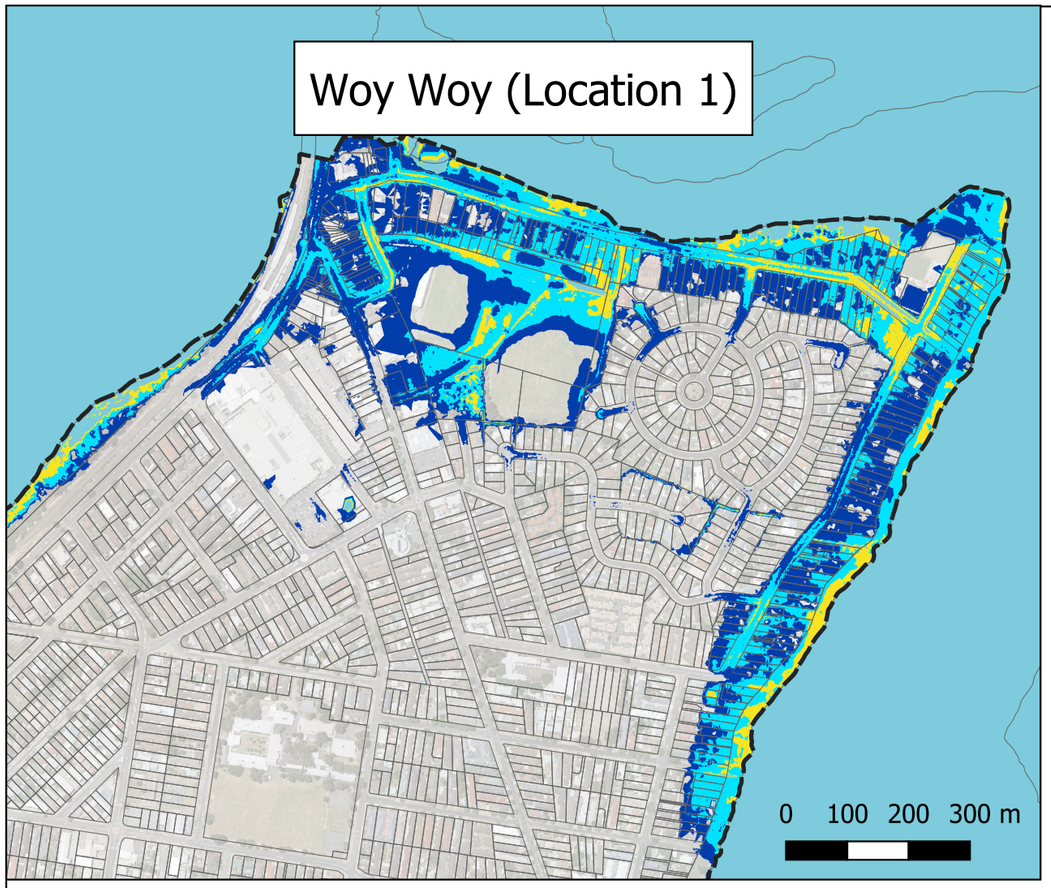
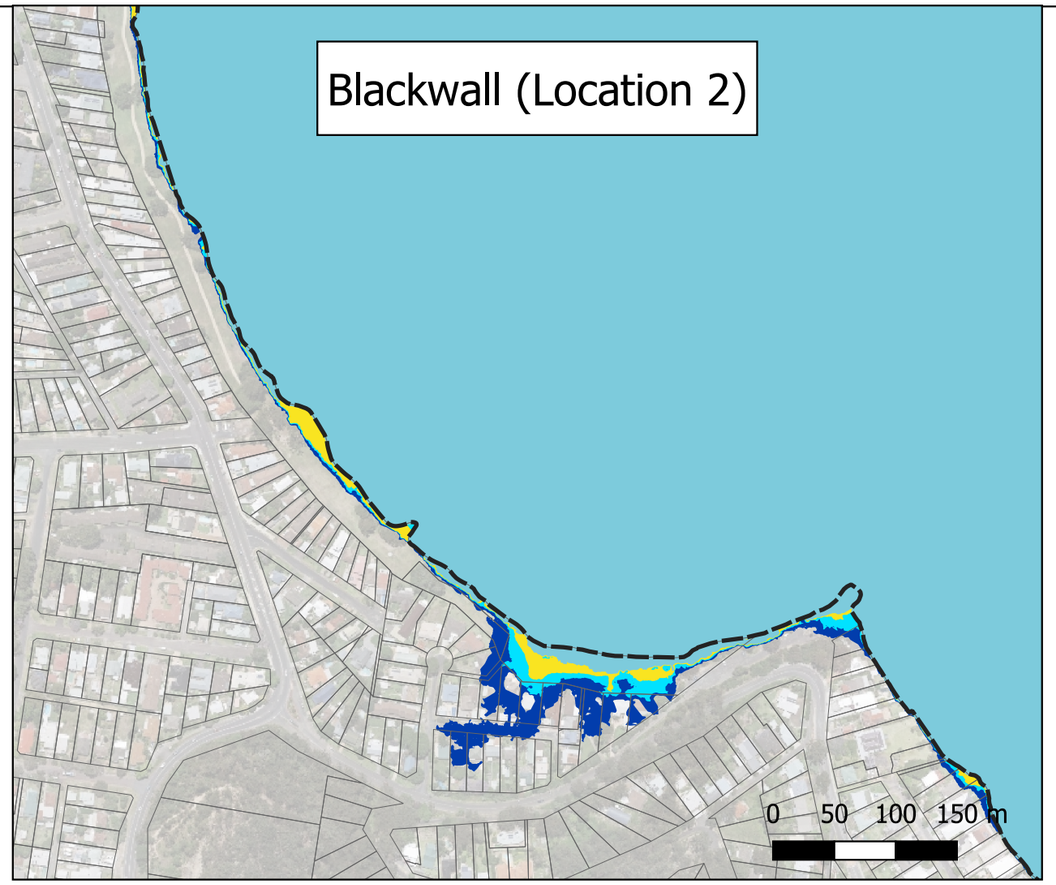
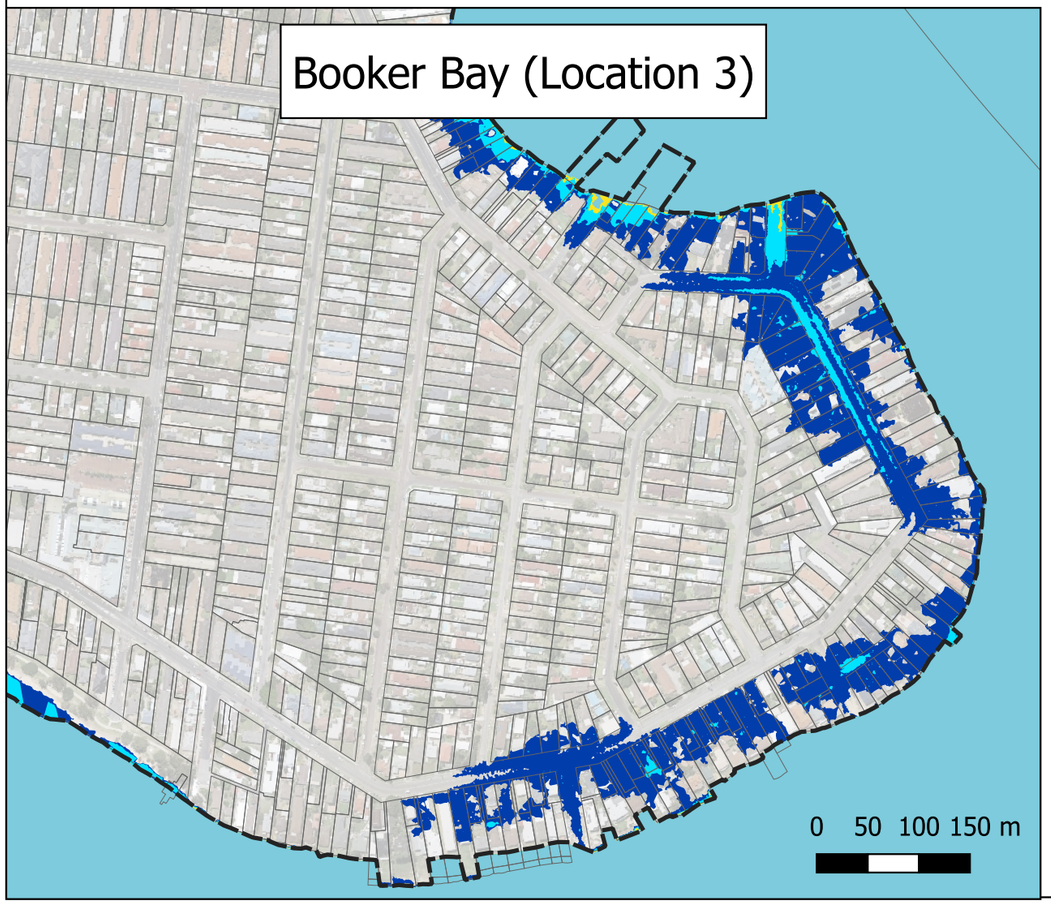
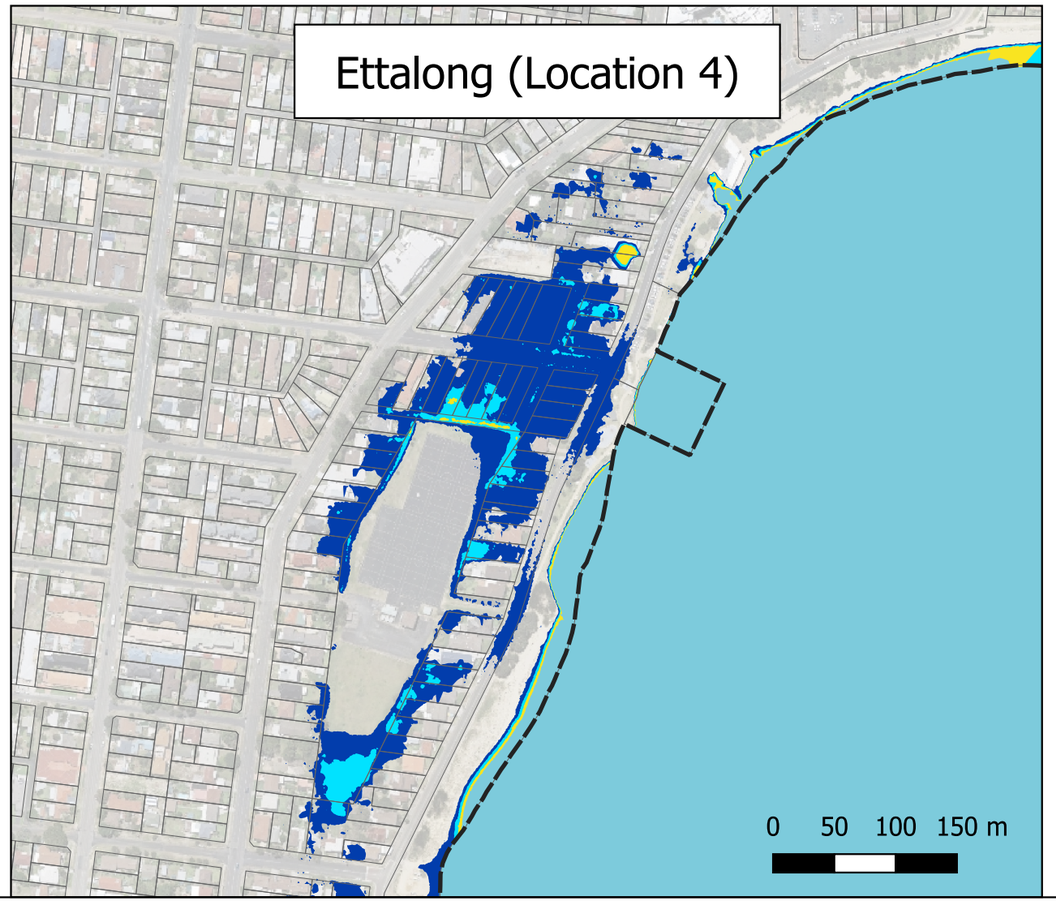
APPENDIX A

Flood and Tidal Inundation Extents









N
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Map G160

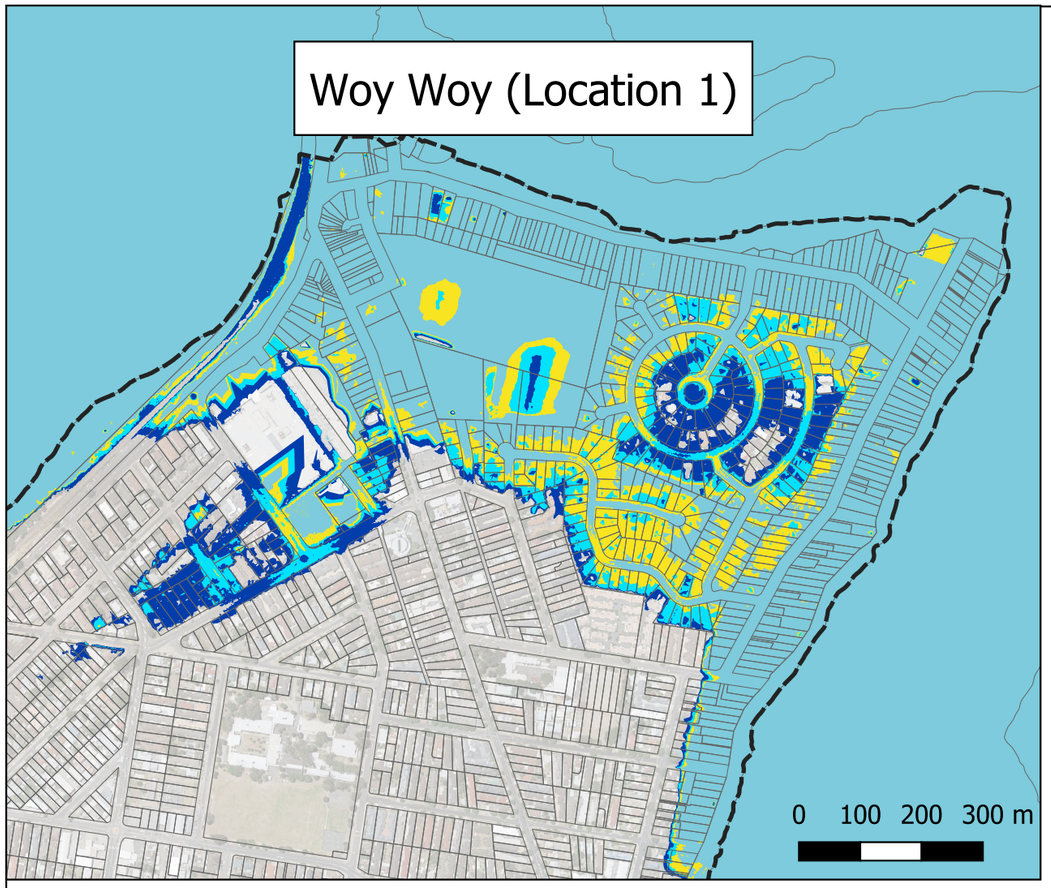
1% Probability of Excedence (PoE) Flood Extents

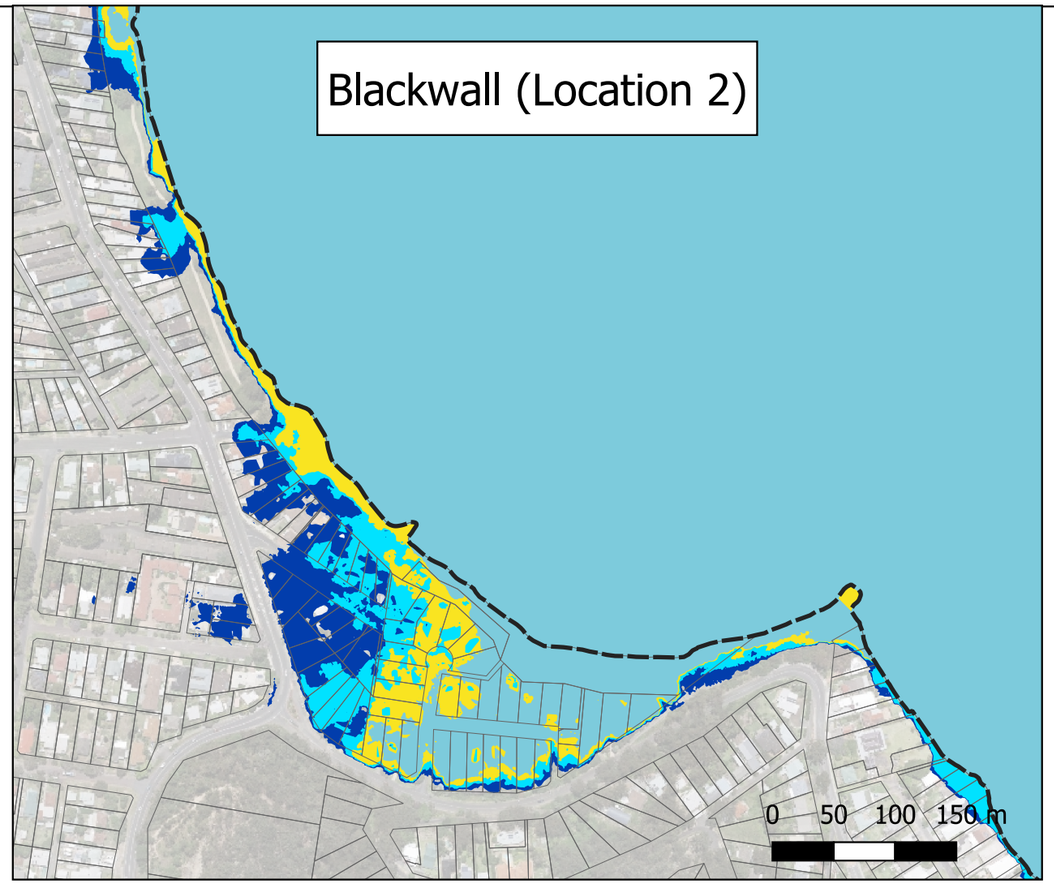
Legend

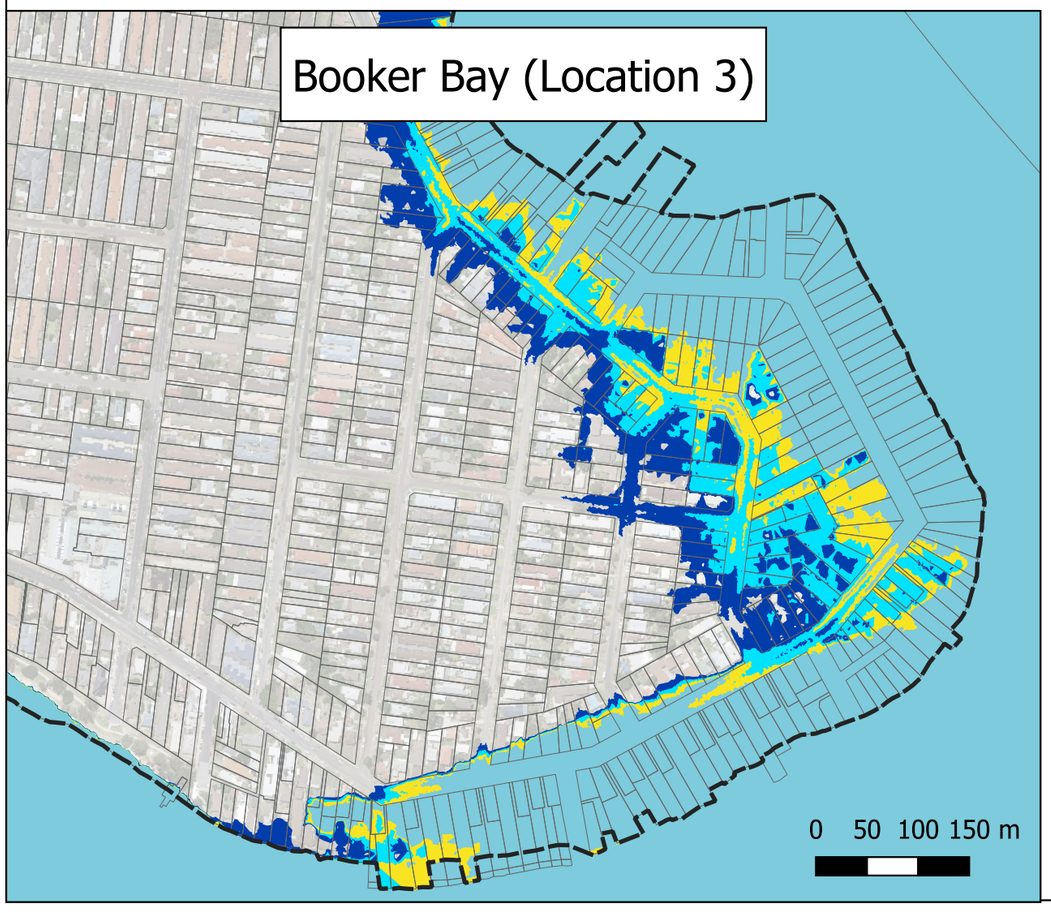
- Cadastre
- 2015 Flood Extents
- 2050 Flood Extents (+0.2 SLR)
- 2070 Flood Extents (+0.4 SLR)
- 2100 Flood Extents (+0.7 SLR)

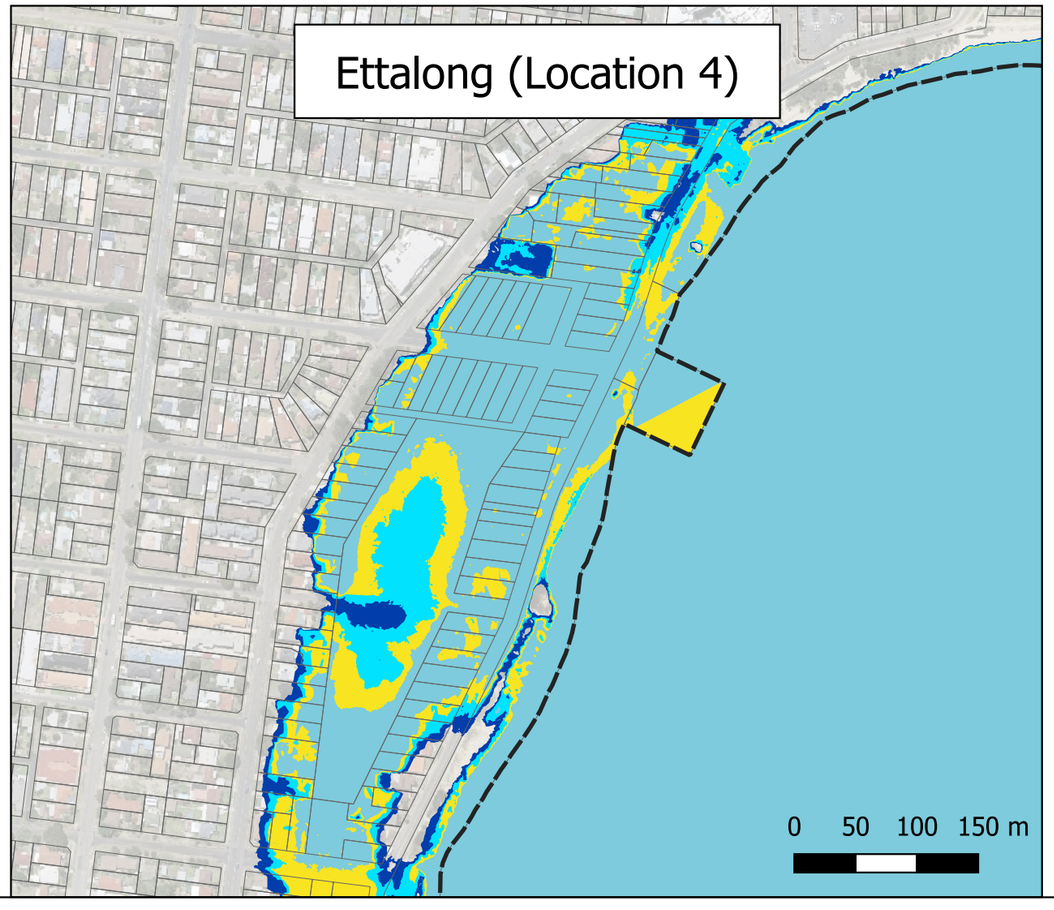
Date : 29 April 2021
Revision : A
Created by : JS
Coordinate System : MGA 56

Rhelm









N
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Map G161

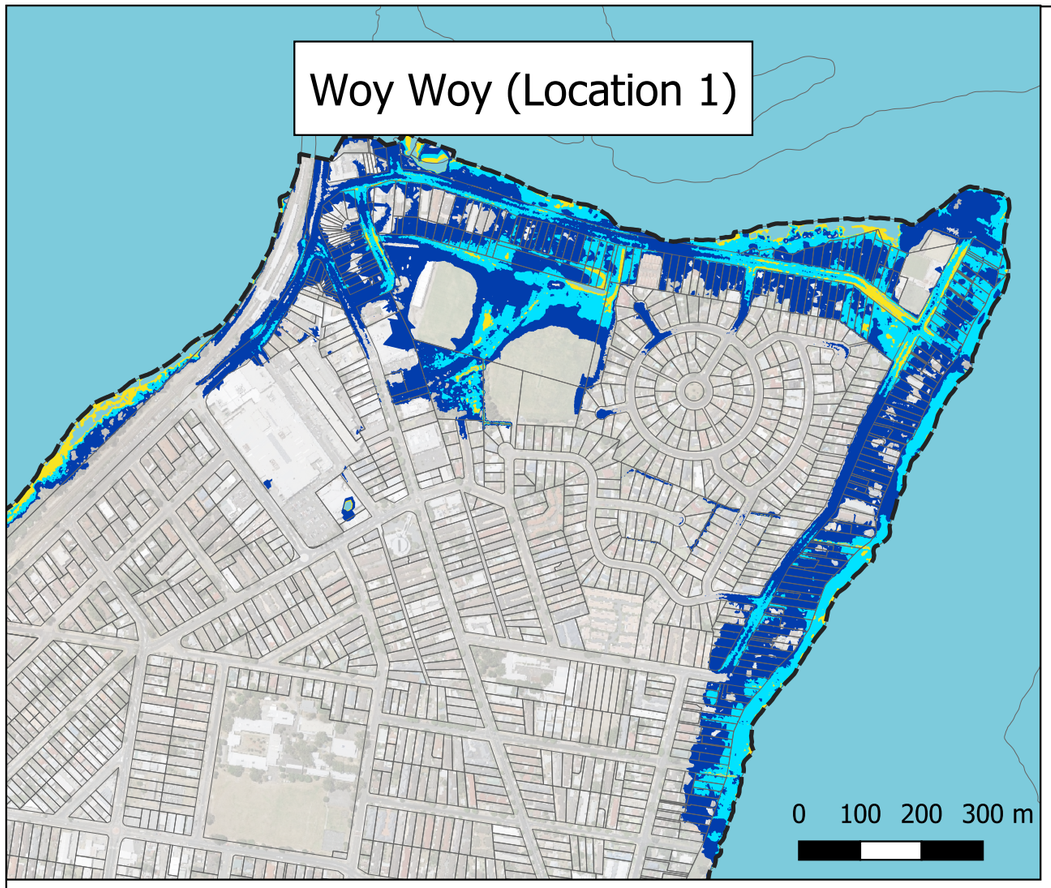
1% AEP Flood Extents

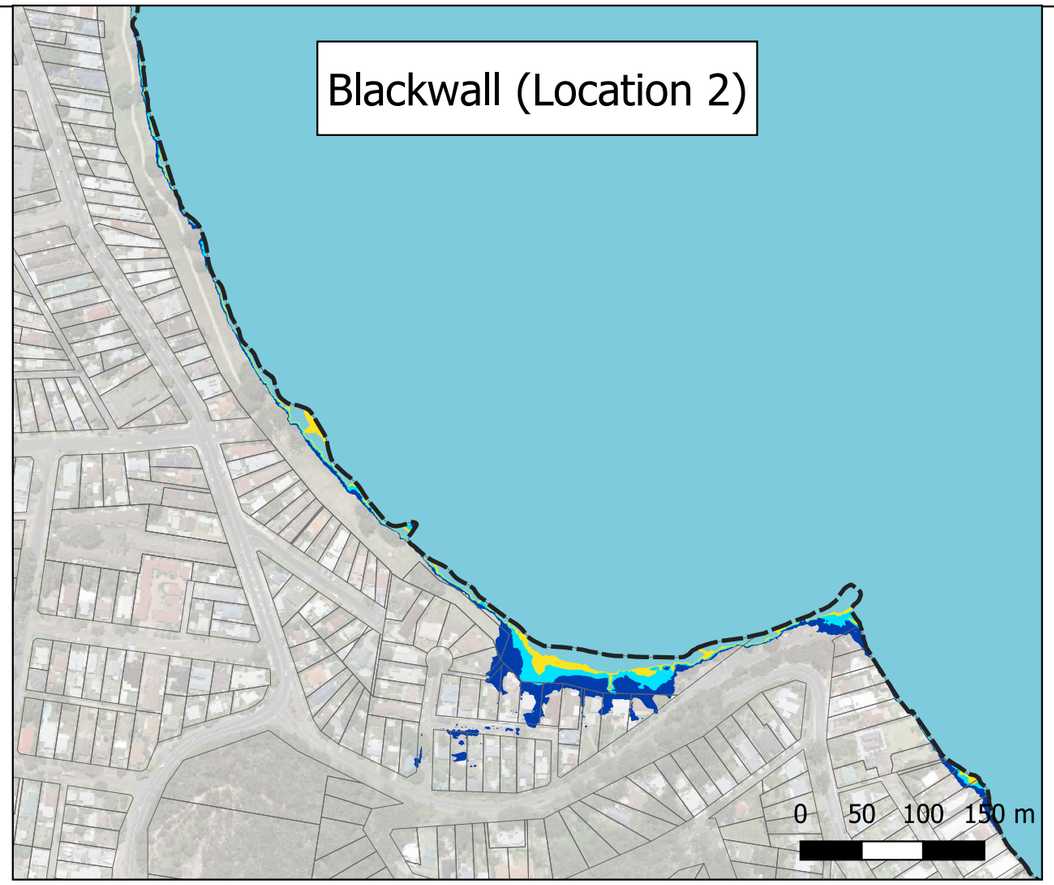
Legend

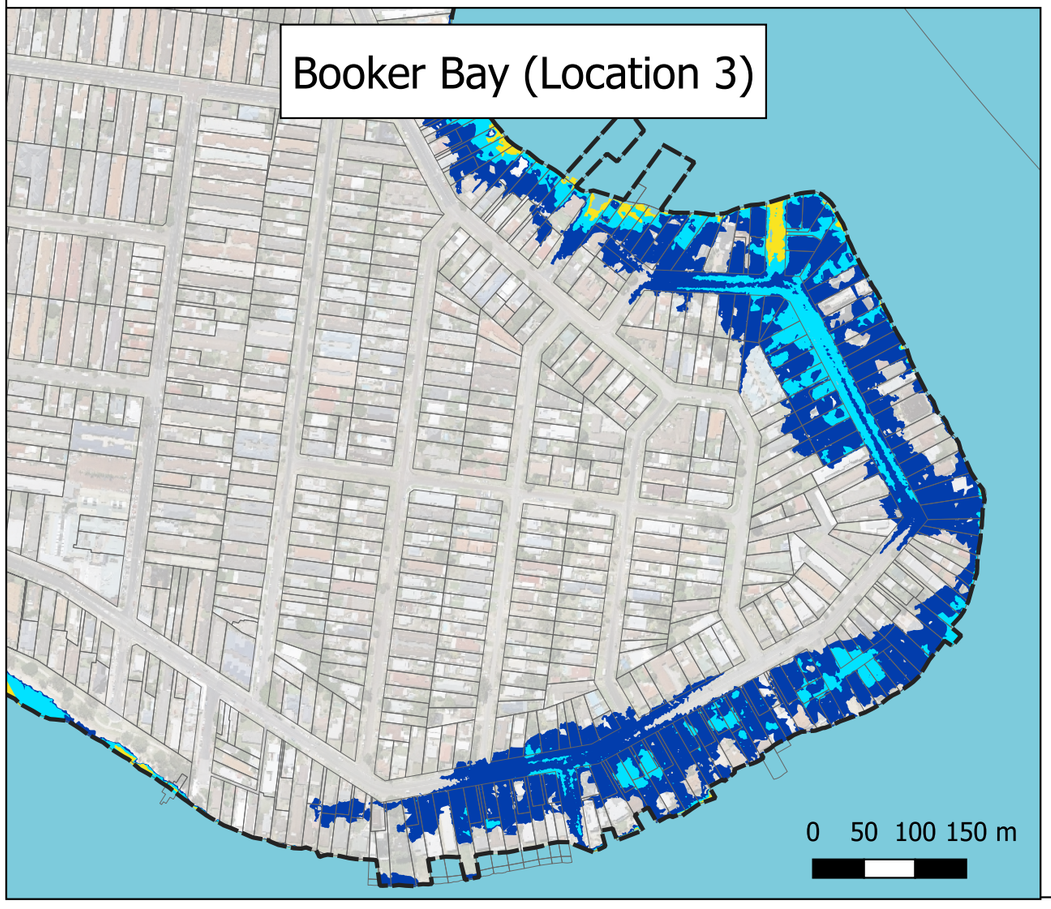
- Cadastre
- 2015 Flood Extents
- 2050 Flood Extents (+0.2 SLR)
- 2070 Flood Extents (+0.4 SLR)
- 2100 Flood Extents (+0.7 SLR)

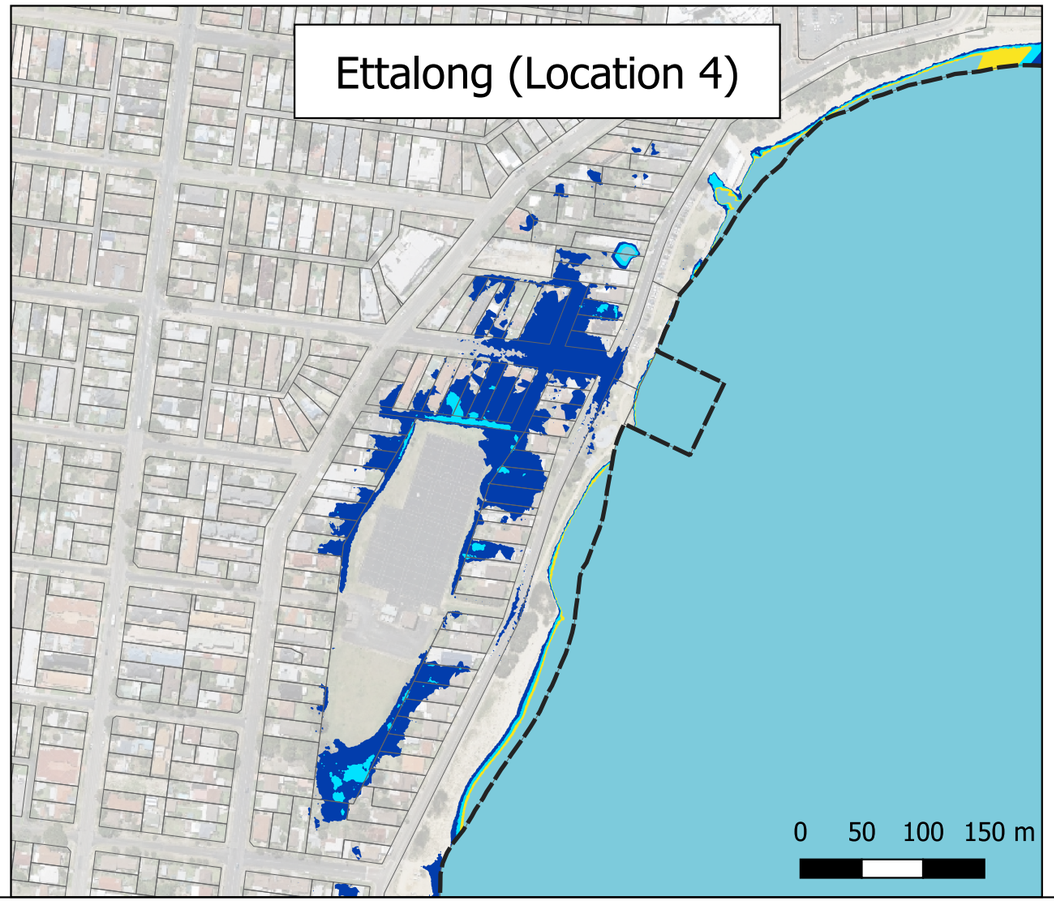
Date : 29 April 2021
Revision : A
Created by : JS
Coordinate System : MGA 56

Rhelm









N
W E
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Map G162

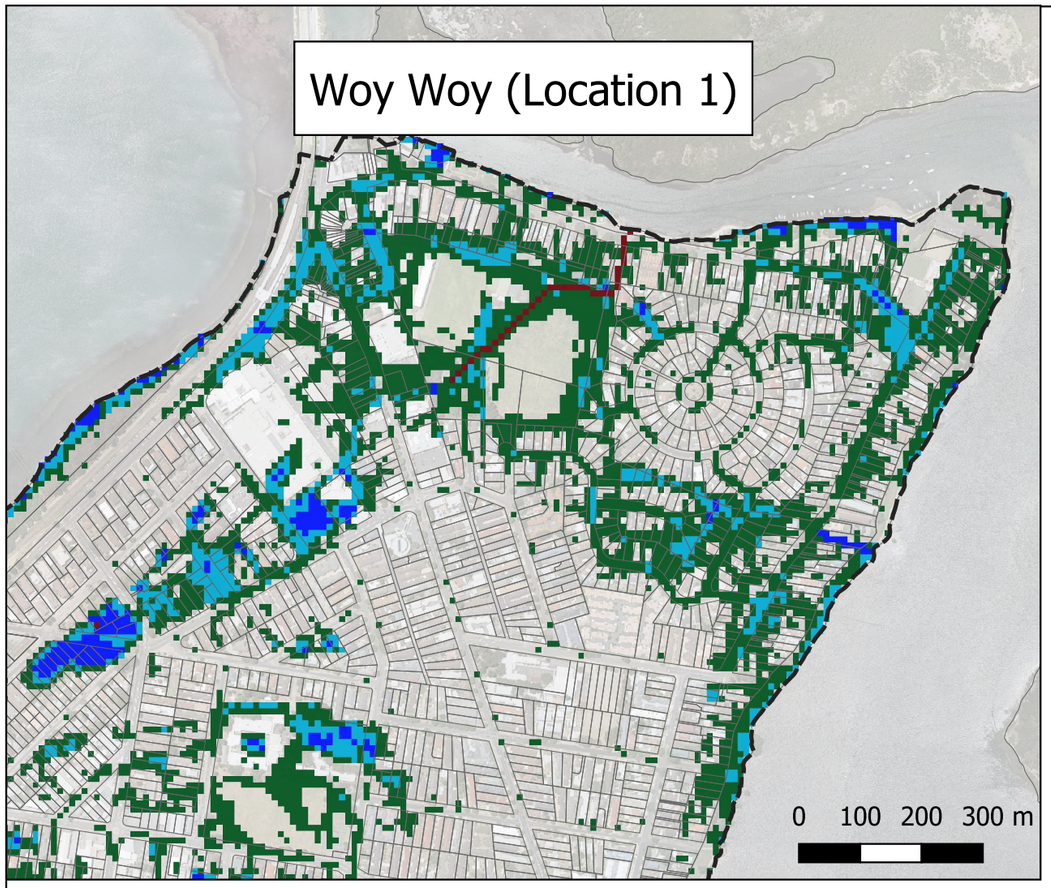
HHWSS Flood Extents

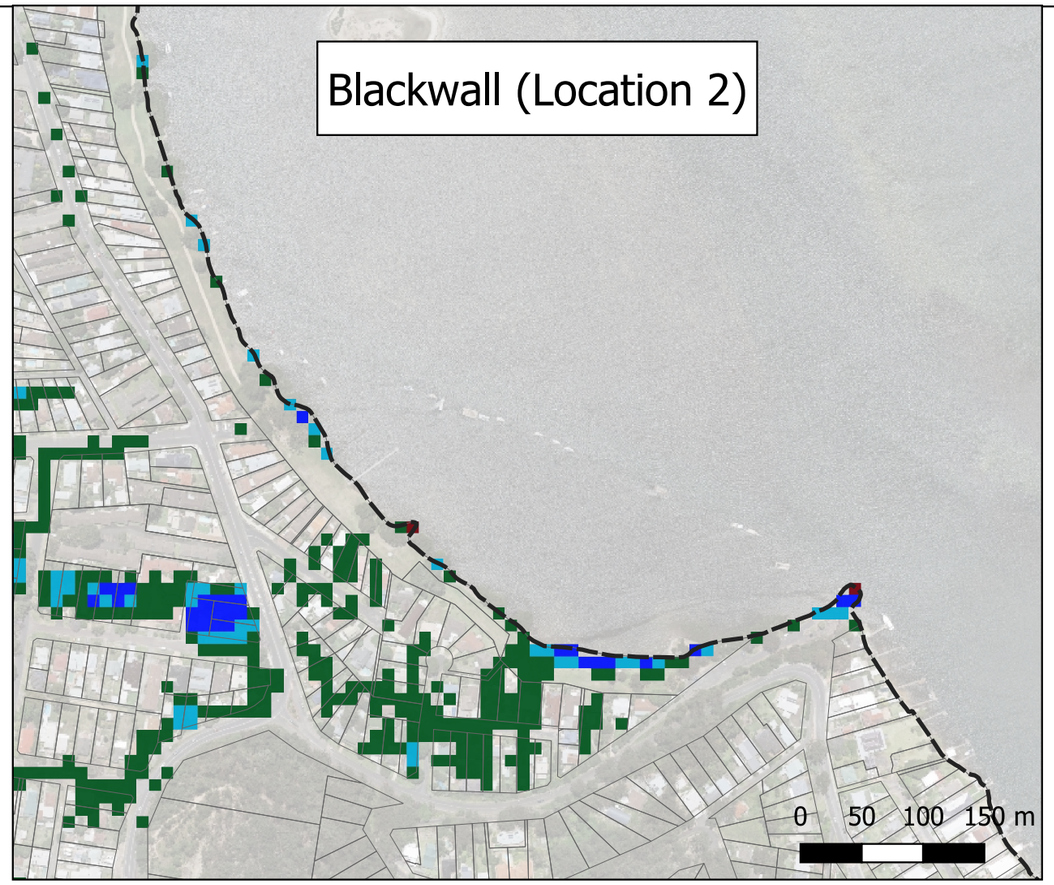
Legend

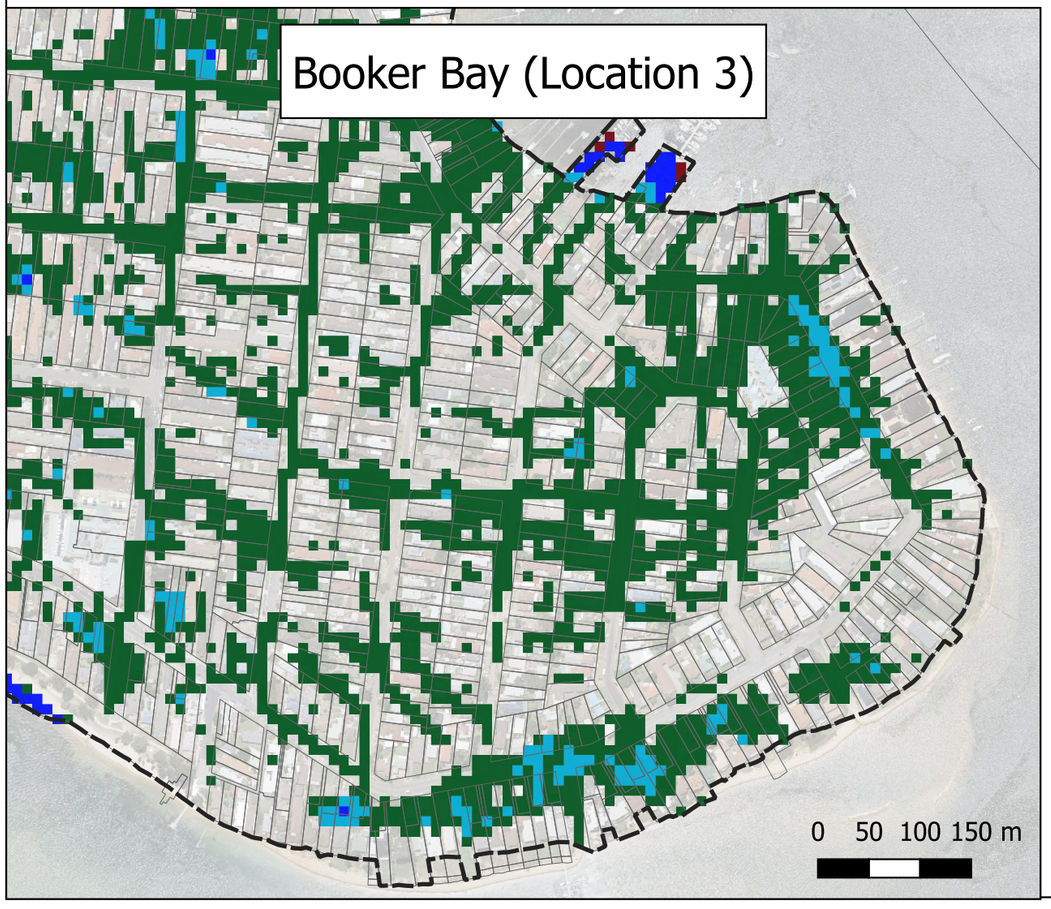
- Cadastre
- 2015 Flood Extents
- 2050 Flood Extents (+0.2 SLR)
- 2070 Flood Extents (+0.4 SLR)
- 2100 Flood Extents (+0.7 SLR)

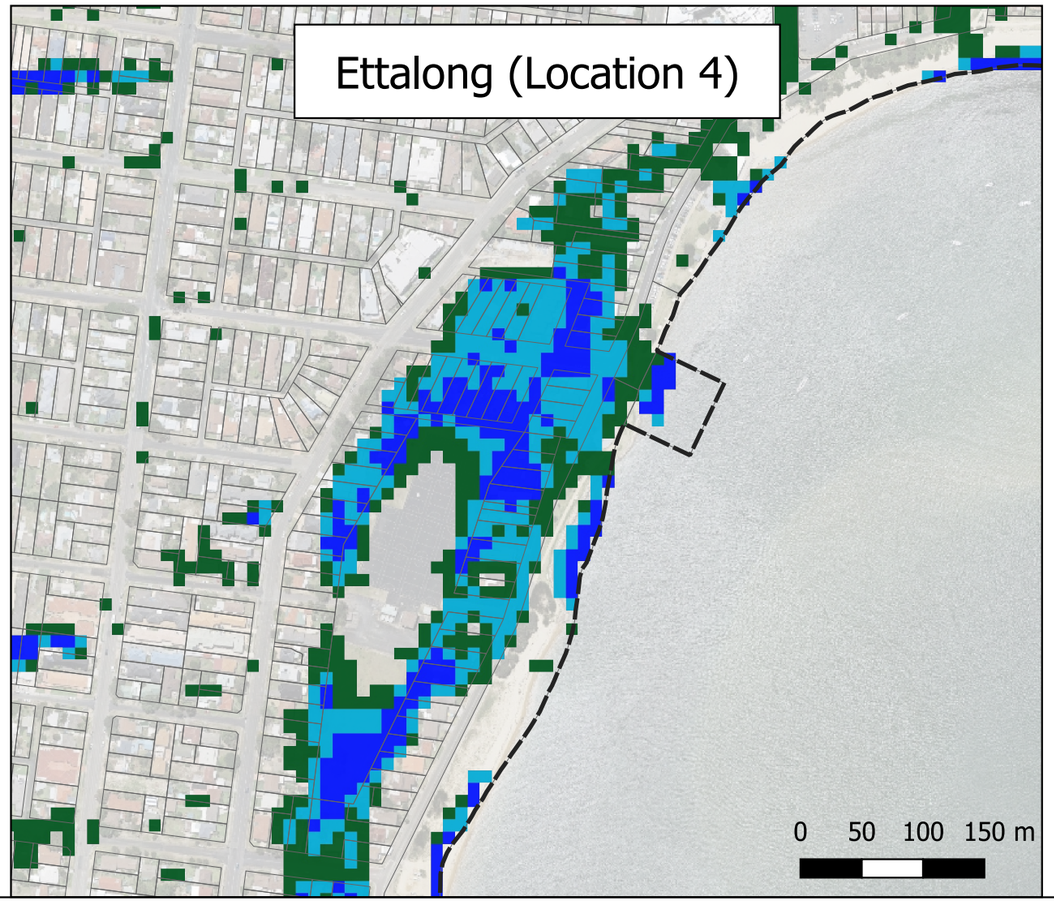
Date : 29 April 2021
Revision : A
Created by : JS
Coordinate System : MGA 56

Rhelm









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Map G163

1% AEP
Flood Study (DHI, 2010)

Legend

- Cadastre

1% AEP Flood Depth (m) - Flood Study(DHI,2010)

- <0.01
- 0.01-0.2
- 0.2-0.4
- 0.4-0.8
- 0.8-1.6
- > 1.6

Date : 29 April 2021
Revision : A
Created by : JS
Coordinate System : MGA 56

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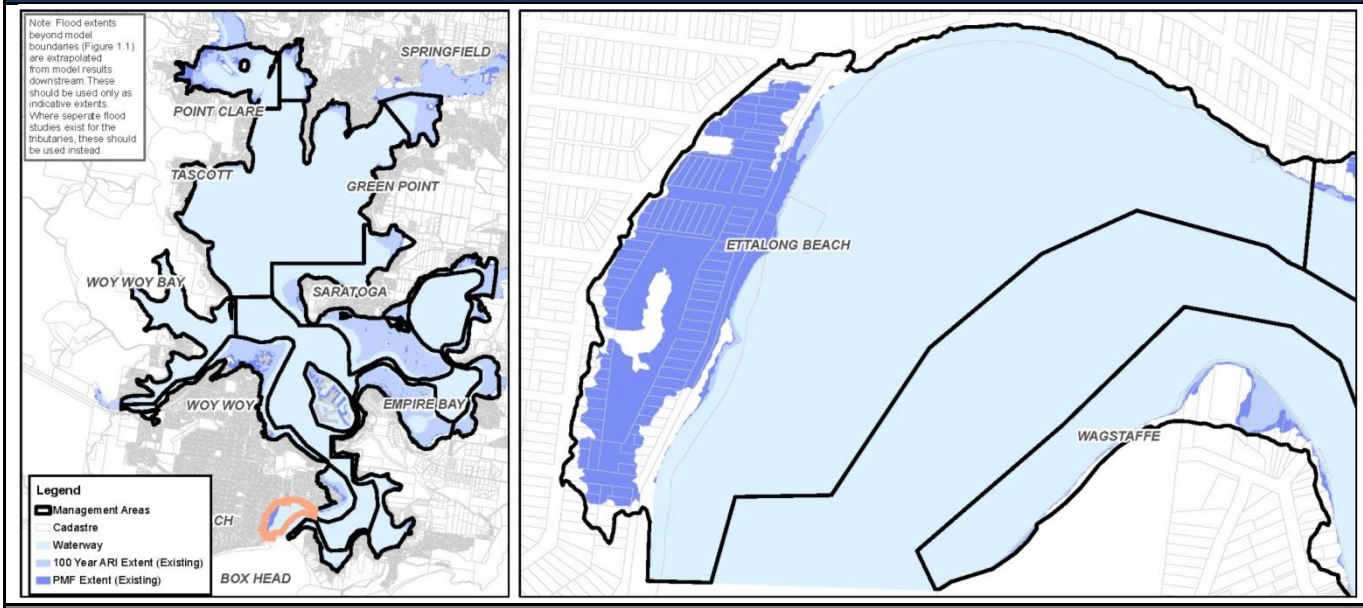
APPENDIX B

Brisbane Water Flood Mitigation Options (from Cardno, 2015)

Management Area 12 – Ettalong



Management Area Details

Land Use

This management area consists primarily of residential and open space and some commercial land uses.

Flooding Mechanisms

Existing Scenario (no SLR):	**Future Scenario (0.9m SLR):**
High tides do not affect many areas within Ettalong. Residential properties are generally not affected in higher probability ARIs events. In the existing 100 year ARI event, the majority of affected properties are inundated due to surcharge of the stormwater system.	High tides are unlikely to affect properties or roads. Residential properties and some roads are likely to be impacted in higher probability ARI events.

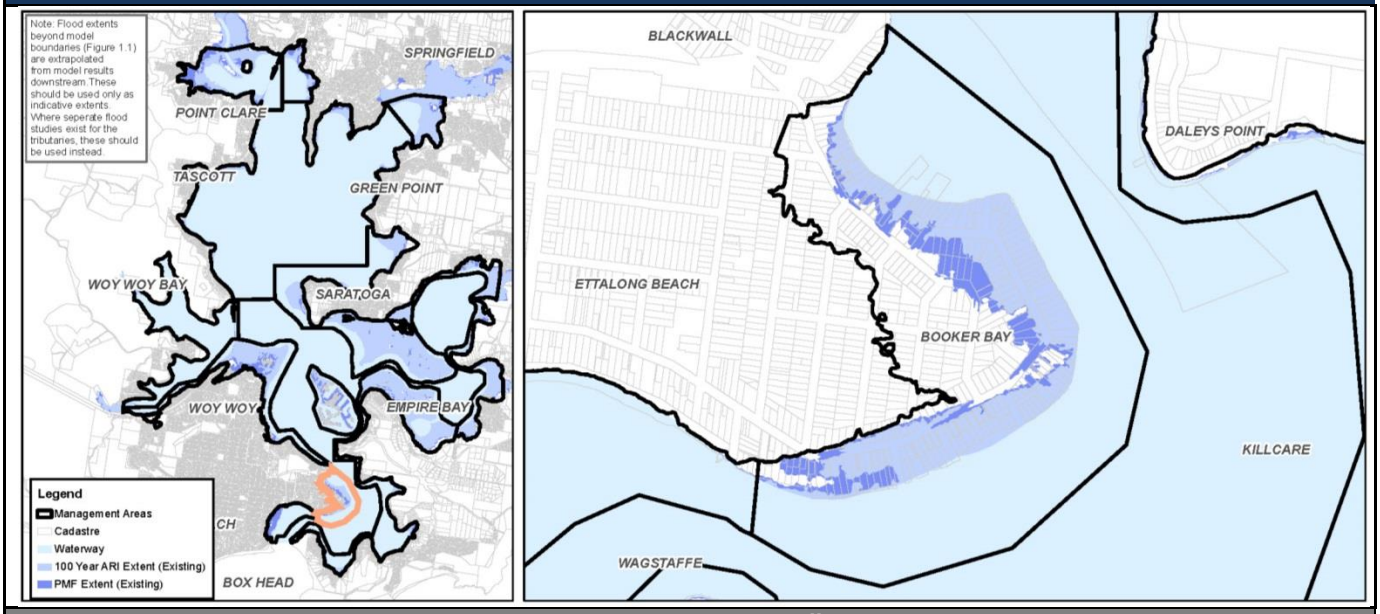
Recommended Actions – Management Area-Specific

No management area-specific actions recommended.

Recommended Actions – Floodplain-Wide	Implementation
EM7: **Review evacuation centre locations** to ensure that evacuation centres that lie within the floodplain are not utilised during flood emergencies. The evacuation centres nearest to MA12 that are not within the floodplain are the Ettalong War Memorial Club and Umina Bowling Club.	**Immediate**
EM4: **Review flood warning systems** on a periodic basis and update as necessary. This could include a provision for demountable road sign flood warnings on roads in nearby areas.	**Immediate**
EM8: Develop and review detours and alternative routes to be used during times of coastal flooding to **enhance road evacuation**. Roads subject to coastal flooding in MA12 include The Esplanade.	**Immediate**
EM3: **Review the Gosford Local Flood Emergency Sub-Plan** (Gosford LEMC, 2013) with regards to the updated Brisbane Water Floodplain Risk Management Study results. This will allow community emergency services to be better prepared to assist the community during storm surge flood events.	**Immediate**
PM7: **Review and amend planning instruments and development controls** across the floodplain to ensure consistency with ocean flooding. Review every five years.	**Staged**
PM5: **Continue to monitor sea levels** in Brisbane Water. A water level gauge is located at Ettalong, and the results of water level analyses from this and other gauges would need to be communicated to residents in this management area.	**Immediate**
PM10: **Evaluate utilities infrastructure** and partner with private utilities managers to better understand the coastal flood and sea level rise risks to assets. Formulate a plan of management over the long term for integration into Council's planning objectives. A range of utilities exist in MA12, including electricity, telecommunications, water and sewer.	**Staged**

PM3: Investigate the potential for implementation of a **land swap program** for properties that meet specified criteria (e.g. inundated by sea level rise and flooding in regular events) with land that Council owns in non flood-prone areas.	**Staged**
PM8: Develop a series of **management-area specific development controls**, customised to suit each locality.	**Staged**
PM4: Conduct a program of strategic, **balanced and socially sensitive education** to advise the local community and prospective property purchasers about the risk and effects of coastal flooding. This could include the provision of additional information regarding s149 Certificates.	**Staged**
PM9: **Develop sea level rise management strategies**, particularly with regard to tidal inundation. This management action should be considered as the basis of the proposed *Climate Change Adaptation Plan* for this management area.	**Staged**
EM1: Conduct targeted **flood education programs** for flood-affected residents, with an emphasis on access and evacuation during storm surge flood events.	**Staged**
PM2: **Implement a voluntary house raising program** for identified dwellings that meet specified criteria. A detailed floor survey would be required prior to the final selection of any properties for voluntary house raising.	**Staged**
FM4: **Install flood gates/valves on stormwater pipe** outlets as required.	**Staged**

Management Area 13 – Booker Bay



Management Area Details

Land Use

This management area consists primarily of residential land uses, and includes many waterfront properties.

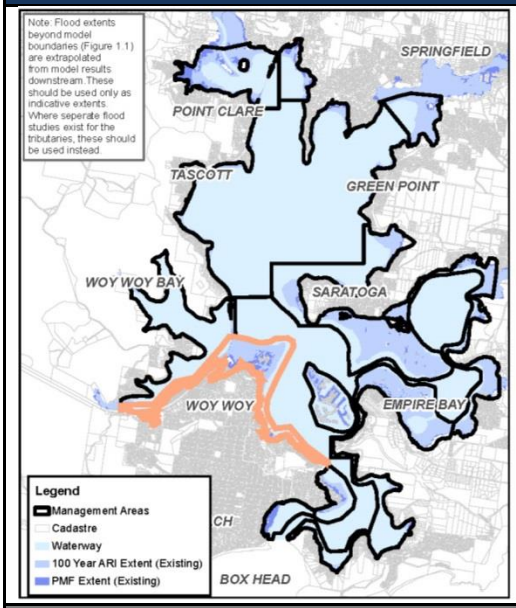
Flooding Mechanisms

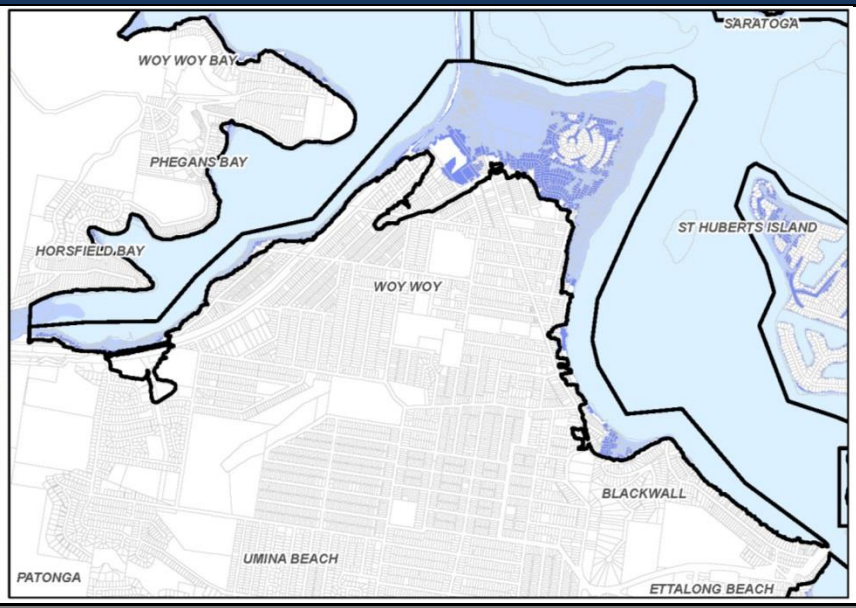
Existing Scenario (no SLR):	**Future Scenario (0.9m SLR):**
Existing high tides in this area can cause inundation, especially high tides with joint occurrence of storm conditions. In these instances, roads and some residential properties are affected.	High tides in this area are likely to cause inundation of properties and roads. Further inundation of properties and roads, is likely to occur in higher probability ARI events.

Recommended Actions – Management Area-Specific	
13_PM11a: Undertake detailed investigation of the **impacts of structural floodplain risk management options on overland flows** in Booker Bay.	**Immediate**
13_FM3: Modify the existing foreshore in areas most affected by wave run-up to **incorporate wave energy dissipating designs**. This will assist in the protection of individual properties not already identified as flood affected (as they lie outside the 100 year ARI extent, but may be impacted by wave run-up depending on swell and wind conditions). On-the-ground surveys will be required to ascertain the exact locations where dissipation designs will be appropriate within associated environmental constraints.	**Staged**
Recommended Actions – Floodplain-Wide	**Implementation**
EM7: **Review evacuation centre locations** to ensure that evacuation centres that lie within the floodplain are not utilised during flood emergencies. The evacuation centres nearest to MA13 that are not within the floodplain are the Ettalong War Memorial Club and Umina Bowling Club.	**Immediate**
EM4: **Review flood warning systems** on a periodic basis and update as necessary. This could include a provision for demountable road sign flood warnings on roads in nearby areas.	**Immediate**
EM8: Develop and review detours and alternative routes to be used during times of coastal flooding to **enhance road evacuation**. Roads subject to coastal flooding in MA13 include Booker Bay Road..	**Immediate**
EM3: **Review the Gosford Local Flood Emergency Sub-Plan** (Gosford LEMC, 2013) with regards to the updated Brisbane Water Floodplain Risk Management Study results. This will allow community emergency services to be better prepared to assist the community during storm surge flood events.	**Immediate**
PM7: **Review and amend planning instruments and development controls** across the floodplain to ensure consistency with ocean flooding. Review every five years.	**Staged**

PM5: **Continue to monitor sea levels** in Brisbane Water. There are no water level gauges in MA13, however the results of water level analyses would still need to be communicated to residents in this management area. The nearest gauge is at Ettalong.	**Immediate**
PM10: **Evaluate utilities infrastructure** and partner with private utilities managers to better understand the coastal flood and sea level rise risks to assets. Formulate a plan of management over the long term for integration into Council's planning objectives. A range of utilities exist in MA13, including electricity, telecommunications, water and sewer.	**Staged**
PM3: Investigate the potential for implementation of a **land swap program** for properties that meet specified criteria (e.g. inundated by sea level rise and flooding in regular events) with land that Council owns in non flood-prone areas.	**Staged**
PM8: Develop a series of **management-area specific development controls**, customised to suit each locality.	**Staged**
PM4: Conduct a program of strategic, **balanced and socially sensitive education** to advise the local community and prospective property purchasers about the risk and effects of coastal flooding. This could include the provision of additional information regarding s149 Certificates.	**Staged**
PM9: **Develop sea level rise management strategies**, particularly with regard to tidal inundation. This management action should be considered as the basis of the proposed *Climate Change Adaptation Plan* for this management area.	**Staged**
EM1: Conduct targeted **flood education programs** for flood-affected residents, with an emphasis on access and evacuation during storm surge flood events.	**Staged**
PM2: **Implement a voluntary house raising program** for identified dwellings that meet specified criteria. Some properties have been identified in this management area as being eligible for voluntary house raising. A detailed floor survey would be required prior to the final selection of properties.	**Staged**
FM4: **Install flood gates/valves on stormwater pipe outlets** as required.	**Staged**

Management Area 14 – Woy Woy and Blackwall





Management Area Details

Land Use

This management area consists primarily of residential land uses, commercial land uses, open space and infrastructure (including the Central Coast railway line).

Flooding Mechanisms

Existing Scenario (no SLR):	**Future Scenario (0.9m SLR):**
Existing high tides in this area can cause inundation, especially with joint occurrence of storm conditions. Some residential and commercial properties are affected even in higher probability ARIs events.	Roads and a large number of residential properties are likely to be affected by high tides. Further inundation is likely in higher probability ARI events. High flood depths are more common due to very flat terrain.

Recommended Actions – Management Area-Specific	
14_EM2: Install and maintain "Road Floods" signs at Blackwall Road, Brick Wharf Road and North Burge Road, Woy Woy. Flood signage along roads that are liable to flood allow residents to be aware of whether it is dangerous to traverse a particular section of road during a flood event.	**Immediate**
14_PM6: **Relocate Woy Woy Police Station** to a location outside of the floodplain. This facility is likely to be subject to coastal flooding in events greater than the 20 year ARI (existing case). Relocating this infrastructure to a location outside the floodplain would provide access to and from the station so that more reliable assistance could be provided to those in need of police assistance during a flood event.	**Staged**
Recommended Actions – Floodplain-Wide	**Implementation**
EM7: **Review evacuation centre locations** to ensure that evacuation centres that lie within the floodplain are not utilised during flood emergencies. The evacuation centre nearest to MA14 that is not within the floodplain is the Woy Woy Peninsula Community Centre.	**Immediate**
EM4: **Review flood warning systems** on a periodic basis and update as necessary. This could include a provision for demountable road sign flood warnings on roads such as Woy Woy Road.	**Immediate**
EM8: Develop and review detours and alternative routes to be used during times of coastal flooding to **enhance road evacuation**. Roads subject to coastal flooding in MA14 include Woy Woy Road, Blackwall Road, Brick Wharf Road, North Burge Road and Brisbane Water Drive.	**Immediate**
EM3: **Review the Gosford Local Flood Emergency Sub-Plan** (Gosford LEMC, 2013) with regards to the updated Brisbane Water Floodplain Risk Management Study results. This will allow community emergency services to be better prepared to assist the community during storm surge flood events.	**Immediate**
PM7: **Review and amend planning instruments and development controls** across the floodplain to ensure consistency with ocean flooding. Review every five years.	**Staged**

PM5: **Continue to monitor sea levels** in Brisbane Water. There are no water level gauges in MA14, however the results of water level analyses would still need to be communicated to residents in this management area. The nearest gauge is at Koolewong.	**Immediate**
PM10: **Evaluate utilities infrastructure** and partner with private utilities managers to better understand the coastal flood and sea level rise risks to assets. Formulate a plan of management over the long term for integration into Council's planning objectives. A range of utilities exist in MA14, including electricity, telecommunications, water and sewer.	**Staged**
PM3: Investigate the potential for implementation of a **land swap program** for properties that meet specified criteria (e.g. inundated by sea level rise and flooding in regular events) with land that Council owns in non flood-prone areas.	**Staged**
PM8: Develop a series of **management-area specific development controls**, customised to suit each locality.	**Staged**
PM4: Conduct a program of strategic, **balanced and socially sensitive education** to advise the local community and prospective property purchasers about the risk and effects of coastal flooding. This could include the provision of additional information regarding s149 Certificates.	**Staged**
PM9: **Develop sea level rise management strategies**, particularly with regard to tidal inundation. This management action should be considered as the basis of the proposed *Climate Change Adaptation Plan* for this management area.	**Staged**
EM1: Conduct targeted **flood education programs** for flood-affected residents, with an emphasis on access and evacuation during storm surge flood events.	**Staged**
PM2: **Implement a voluntary house raising program** for identified dwellings that meet specified criteria. Some properties have been identified in this management area as being eligible for voluntary house raising. A detailed floor survey would be required prior to the final selection of properties.	**Staged**
FM4: **Install flood gates/valves on stormwater pipe outlets** as required.	**Staged**

Table 10.14: Management Area 12 (Ettalong) Options (No Preferred)

Option ID	Management Strategy	Action Timeline	Estimated Cost	Annual Cost	Tidal/Flood Event Addressed										Properties Protected (Existing PMF)	Properties Protected (PMF+0.9m SLR)	Cost : Benefit Ratio (Existing)	Responsibility	Key Issues / Comments	Option to be investigated further in CCAP (PM9)
					Tidal			Foreshore Flood												
					MHWS	+SLR (0.4m)	+SLR (0.9m)	5 yr ARI (20%)	100 yr ARI (1%)	PMF	100 yr ARI (0.4m SLR)	5 yr ARI (0.9m SLR)	100 yr ARI (0.9m SLR)	PMF (0.9m SLR)						
					0.50m AHD	0.90m AHD	1.40m AHD	1.51m AHD	1.78m AHD	2.08m AHD	1.97m AHD	2.41m AHD	2.66m AHD	2.94m AHD						
12_FM1a	Undertake a review/updated investigation of the impacts of structural floodplain risk management options on overland flows in Pretty Beach and Wagstaffe.	Immediate	$30,000	$0	✓	✓	✓	✓	✓		✓	✓	✓		0	0	N/A	GCC/ State	Roads, if raised, may act as a weir and increase flooding associated with catchment runoff on the upstream side of the road. Potential future increase in road height to account for SLR should be considered in the initial design. It is noted that 1m of fill has been assumed across all locations to provide an indication of a "worst-case" scenario, however actual fill levels are likely to be much lower depending on gradients and flood levels.	Y
12_FM1b	Raise only The Esplanade, Bangalow Street and Beach Street above the 100 year ARI +0.9 m level.	Staged	$5,200,000	$100,000	✓	✓	✓	✓	✓		✓	✓	✓		0	0	N/A	GCC/ State	Roads, if raised, may act as a weir and increase flooding associated with catchment runoff on the upstream side of the road. Potential future increase in road height to account for SLR should be considered in the initial design. It is noted that 1m of fill has been assumed across all locations to provide an indication of a "worst-case" scenario, however actual fill levels are likely to be much lower depending on gradients and flood levels.	Y
12_FM5	Undertake a program of seawall maintenance and raising along the foreshore.	Staged	$260,000	$2,600	✓	✓	✓								Unkn.	Unkn.	N/A	Private	Further investigation into seawall condition would be necessary. The cost associated with this option is for the entire length of sea wall proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP. It is noted that upgrades to the Ettalong foreshore have already been undertaken including the installation of rock revetment to the 100 year ARI level.	Y
12_FM6a	Construct a levee (0.9km) around Ettalong to above the PMF level.	Staged	$3,200,000	$63,000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	110	0.02	GCC/ State	Susceptible to breaches. Drainage and stormwater retention required behind levee. May impact on catchment flooding. Community perception of safety behind levee may lead to increased risk if breach occurs. The future increase in levee height to account for SLR needs to be considered in the initial design. The cost associated with this option is for the entire length of levee proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP.	Y
12_FM6b	Construct a levee (0.9km) around Ettalong to above the 5 year ARI level.	Staged	$1,500,000	$31,000	✓	✓	✓	✓				✓			10	91	0.03	GCC/ State	Susceptible to breaches and overtopping. Drainage and stormwater retention required behind levee. May impact on catchment flooding. Community perception of safety behind levee may lead to increased risk if breach occurs. The future increase in levee height to account for SLR needs to be considered in the initial design. The cost associated with this option is for the entire length of levee proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP.	Y
12_FM9	Raise areas within Ettalong at risk of coastal flooding.	Trigger	$36,000,000	$0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100	110	N/A	State/ Private	Without masterplanning, consultation and effective staging, this option is unlikely to be feasible on a regional scale.	Y
12_PM11a	Undertake detailed investigation of the impacts of structural floodplain risk management options on overland flows in Ettalong.	Immediate	$100,000	$0											0	0	N/A	GCC/ State	Large structural options have the potential to impact on overland flows. Investigations are needed to fully understand these impacts.	Y
12_PM11b	Undertake a review/updated investigation of the impacts of structural floodplain risk management options on overland flows in Ettalong.	Immediate	$30,000	$0											0	0	N/A	GCC/ State	Large structural options have the potential to impact on overland flows. Investigations are needed to fully understand these impacts.	Y

Legend

No Preferred Options

✓ Water level addressed by option

✓ Stage / trigger level response

Action Timeline: **Immediate** - Short term, minimal further investigations required

Staged - Short/medium term, further investigations required

Trigger - Longer term, sea level rise trigger level to initiate management respons

Unkn. Unknown

Residential properties are generally not affected in smaller ARI flood events, however some open space areas are affected. A large low-lying area extends from Lemon Grove Park out to surrounding residential properties and some roads. Although not directly connected to floodwaters in existing ARI events, this area may be affected by surcharges of the stormwater system, particularly in the existing 100 Year ARI event. The number of affected properties is expected to increase with projected sea level rise.

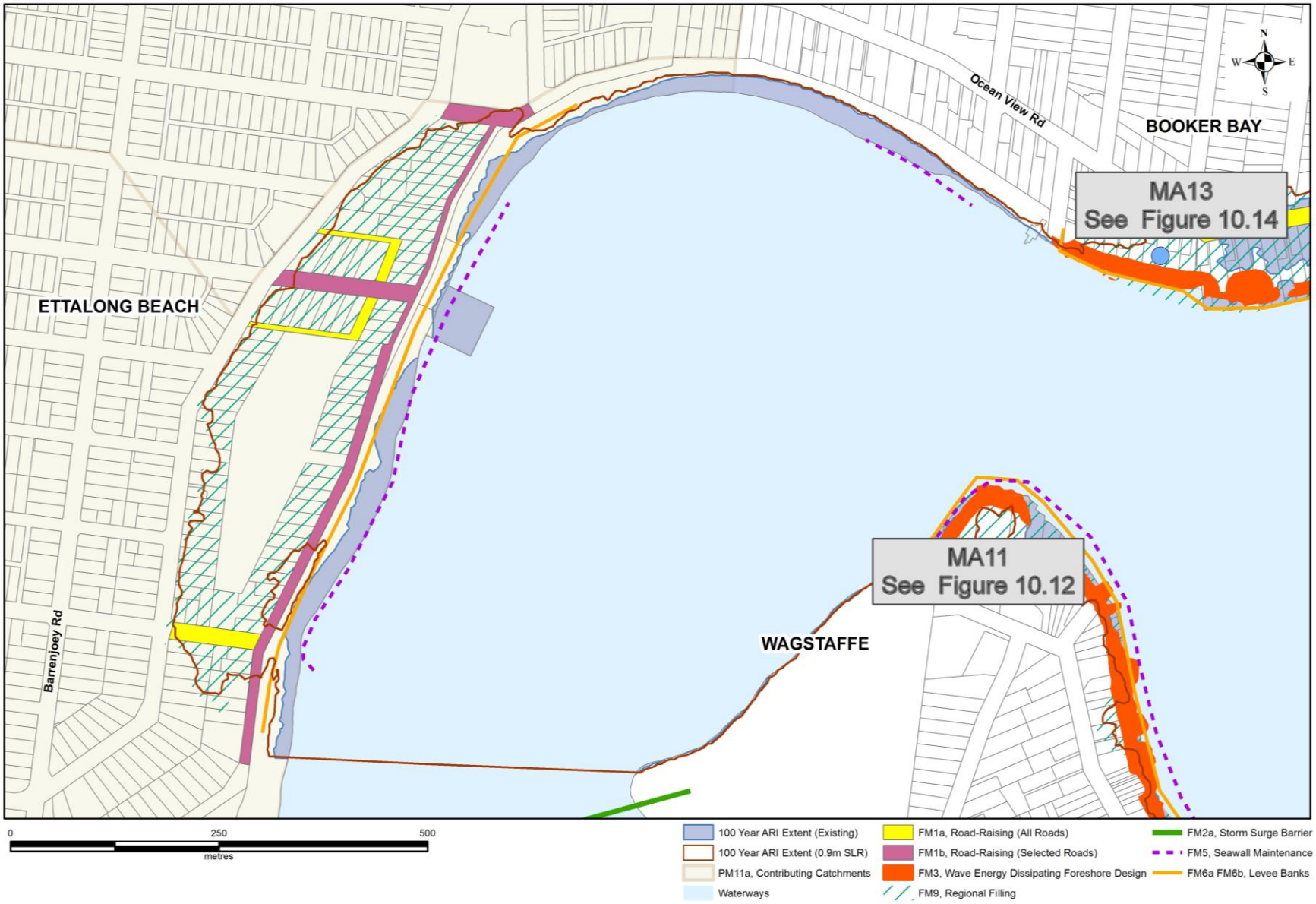


Figure 10.13 Management Area 12 (Ettalong)

Table 10.15: Management Area 13 (Booker Bay) Options (Including Preferred)

Option ID	Management Strategy	Action Timeline	Estimated Cost	Annual Cost	Tidal/Flood Event Addressed										Properties Protected (Existing PMF)	Properties Protected (PMF+0.9m SLR)	Cost : Benefit Ratio (Existing)	Responsibility	Key Issues / Comments	Option to be investigated further in CCAP (PM9)
					Tidal			Foreshore Flood												
					MHWS	+SLR (0.4m)	+SLR (0.9m)	5 yr ARI (20%)	100 yr ARI (1%)	PMF	100 yr ARI (0.4m SLR)	5 yr ARI (0.9m SLR)	100 yr ARI (0.9m SLR)	PMF (0.9m SLR)						
					0.50m AHD	0.90m AHD	1.40m AHD	1.35m AHD	1.58m AHD	1.87m AHD	1.99m AHD	2.25m AHD	2.48m AHD	2.77m AHD						
13_FM1a	Raise all flood-affected roads in Booker Bay to above the 100 year ARI +0.9 m level.	Staged	$8,900,000	$180,000	✓	✓	✓	✓	✓		✓	✓	✓		0	0	N/A	GCC/ State	Roads, if raised, may act as a weir and increase flooding associated with catchment runoff on the upstream side of the road. Potential future increase in road height to account for SLR should be considered in the initial design. It is noted that 1m of fill has been assumed across all locations to provide an indication of a "worst-case" scenario, however actual fill levels are likely to be much lower depending on gradients and flood levels.	Y
13_FM1b	Raise only portions of Bogan Road and Booker Bay Road above the 100 year ARI +0.9 m level.	Staged	$4,600,000	$92,000	✓	✓	✓	✓	✓		✓	✓	✓		0	0	N/A	GCC/ State	Roads, if raised, may act as a weir and increase flooding associated with catchment runoff on the upstream side of the road. Potential future increase in road height to account for SLR should be considered in the initial design. It is noted that 1m of fill has been assumed across all locations to provide an indication of a "worst-case" scenario, however actual fill levels are likely to be much lower depending on gradients and flood levels.	Y
13_FM3	Modify the existing foreshore at Booker Bay in areas most affected by wave runup to incorporate wave energy dissipating designs.	Staged	$720,000	$22,000	Likely to assist in reducing wave run-up-inundation only.										56	0	N/A	GCC/ State/Private	Would only assist in reducing wave run-up in excess of flood events. Wave run-up reduction could be incorporated incrementally over time through development controls on private property.	N
13_FM5	Undertake a program of seawall maintenance and raising along the foreshore.	Staged	$970,000	$9,700	✓	✓	✓								Unkn.	Unkn.	N/A	Private	Further investigation into seawall condition would be necessary. The cost associated with this option is for the entire length of sea wall proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP.	Y
13_FM6a	Construct a levee (1.9km) around Booker Bay to above the PMF level.	Staged	$6,700,000	$130,000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	224	360	0.06	GCC/ State	Susceptible to breaches. Drainage and stormwater retention required behind levee. May impact on catchment flooding. Community perception of safety behind levee may lead to increased risk if breach occurs. The future increase in levee height to account for SLR needs to be considered in the initial design. It is noted that waterfront land is primarily private land and so traditional levees are unlikely to be well-accepted by the community. Alternative barrier-type structures may instead be incrementally incorporated as properties are redeveloped over time. The cost associated with this option is for the entire length of levee proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP.	Y
13_FM6b	Construct a levee (1.9km) around Booker Bay to above the 5 year ARI level.	Staged	$3,200,000	$65,000	✓	✓	✓	✓				✓			30	237	0.03	GCC/ State	Susceptible to breaches and overtopping. Drainage and stormwater retention required behind levee. May impact on catchment flooding. Community perception of safety behind levee may lead to increased risk if breach occurs. The future increase in levee height to account for SLR needs to be considered in the initial design. It is noted that waterfront land is primarily private land and so traditional levees are unlikely to be well-accepted by the community. Alternative barrier-type structures may instead be incrementally incorporated as properties are redeveloped over time. The cost associated with this option is for the entire length of levee proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP.	Y
13_FM9	Raise land areas within Booker Bay at risk of coastal flooding.	Trigger	$120,000,000	$0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	224	360	N/A	State/ Private	Without masterplanning, consultation and effective staging, this option is unlikely to be feasible on a regional scale. As properties are redeveloped along Booker Bay Road, DCP controls could include filling opportunities for waterfront properties including wave run-up if appropriate.	Y
13_PM11a	Undertake detailed investigation of the impacts of structural floodplain risk management options on overland flows in Booker Bay.	Immediate	$100,000	$0											0	0	N/A	GCC/ State	Large structural options have the potential to impact on overland flows. Investigations are needed to fully understand these impacts.	Y
13_PM11b	Undertake a review/updated investigation of the impacts of structural floodplain risk management options on overland flows in Booker Bay.	Immediate	$30,000	$0											0	0	N/A	GCC/ State	Large structural options have the potential to impact on overland flows. Investigations are needed to fully understand these impacts.	Y
13_EM5	Implement a pumping station near residences along Booker Bay Road.	Staged	$120,000	$12,000					✓*						6	0	N/A	GCC/ Private	Very small number of properties protected.	N

Legend

	FRMS / FRMP Preferred Options
✓	Water level addressed by option
✓	Stage / trigger level response
✓*	Assessment was only undertaken for the 100 year ARI event

Action Timeline: **Immediate** - Short term, minimal further investigations required
Staged - Short/medium term, further investigations required
Trigger - Longer term, sea level rise trigger level to initiate management respons
Unkn. Unknown

Existing high tides in this area can cause inundation, especially high high tides with joint occurrence of storm conditions. In these instances, roads and some residential properties are affected. Projected sea level rise is anticipated to increase the number of affected properties.

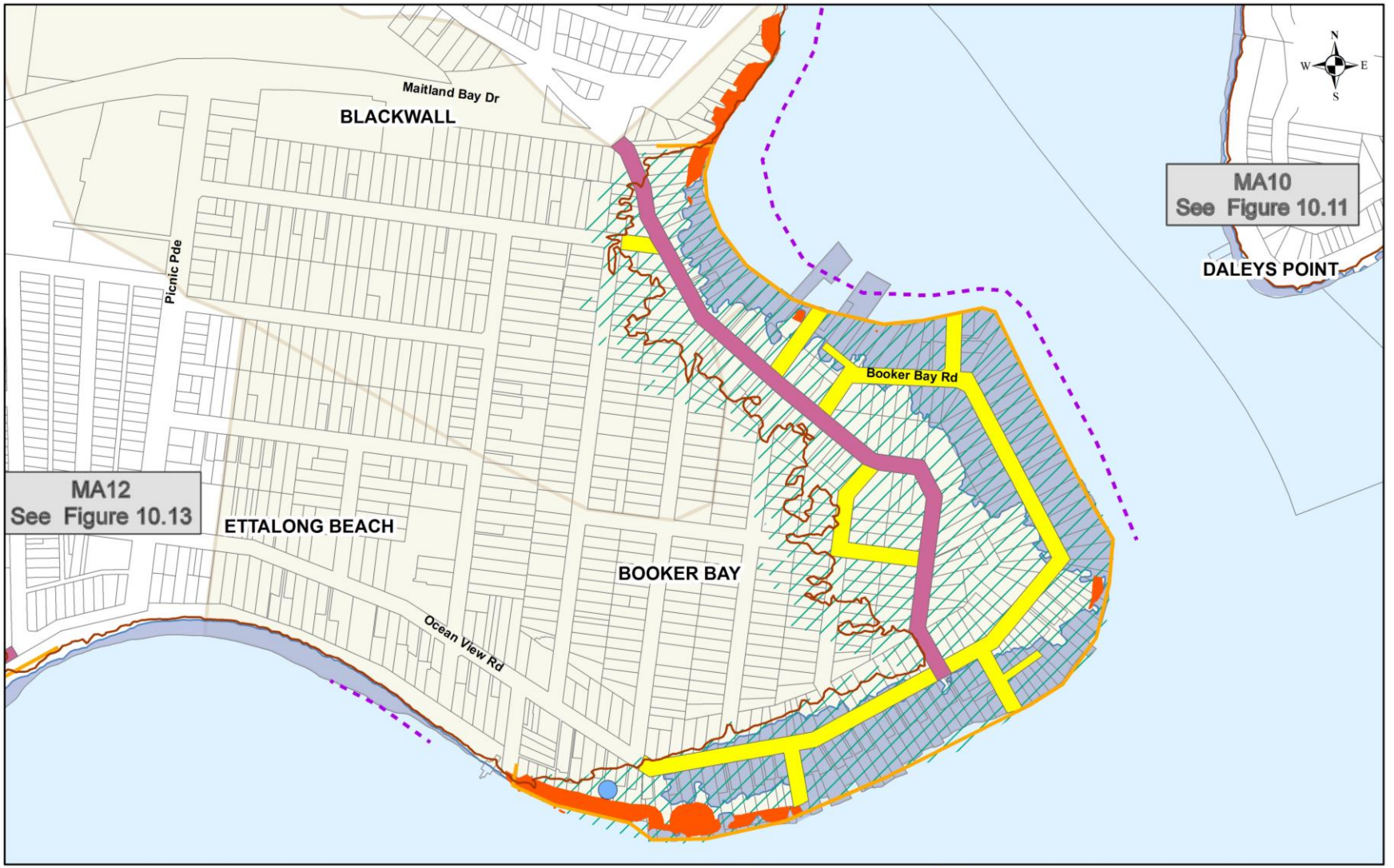


Figure 10.14 Management Area 13 (Booker Bay)

Table 10.16: Management Area 14 (Woy Woy and Blackwall) Options (Including Preferred)

Option ID	Management Strategy	Action Timeline	Estimated Cost	Annual Cost	Tidal/Flood Event Addressed											Properties Protected (Existing PMF)	Properties Protected (PMF+ 0.9m SLR)	Cost : Benefit Ratio (Existing)	Responsibility	Key Issues / Comments	Option to be investigated further in CCAP (PM9)
					Tidal			Foreshore Flood													
					MHWS	+SLR (0.4m)	+SLR (0.9m)	5 yr ARI (20%)	100 yr ARI (1%)	PMF	100 yr ARI (0.4m SLR)	5 yr ARI (0.9m SLR)	100 yr ARI (0.9m SLR)	PMF (0.9m SLR)							
					0.37m AHD	0.77m AHD	1.27m AHD	1.29m AHD	1.58m AHD	1.92m AHD	2.00m AHD	2.22m AHD	2.51m AHD	2.86m AHD							
14_FM1a	Raise all flood-affected roads in Woy Woy to above the 100 year ARI +0.9 m level.	Staged	$32,000,000	$630,000	✓	✓	✓	✓	✓		✓	✓	✓		0	0	N/A	GCC/ State	Roads, if raised, may act as a weir and increase flooding associated with catchment runoff on the upstream side of the road. Potential future increase in road height to account for SLR should be considered in the initial design. It is noted that 1m of fill has been assumed across all locations to provide an indication of a "worst-case" scenario, however actual fill levels are likely to be much lower depending on gradients and flood levels.	Y
14_FM1b	Raise only Woy Woy Road, Blackwall Road, The Boulevarde, Brick Wharf Road, Railway Street, North Burge Road, Park Road, Norma Crescent, Sonter Avenue and Brisbane Water Drive/Railway Street above the 100 year ARI +0.9 m level.	Staged	$23,000,000	$450,000	✓	✓	✓	✓	✓		✓	✓	✓		0	0	N/A	GCC/ State	Roads, if raised, may act as a weir and increase flooding associated with catchment runoff on the upstream side of the road. Potential future increase in road height to account for SLR should be considered in the initial design. It is noted that 1m of fill has been assumed across all locations to provide an indication of a "worst-case" scenario, however actual fill levels are likely to be much lower depending on gradients and flood levels.	Y
14_FM3	Modify the existing foreshore at Woy Woy and Blackwall in areas most affected by wave runup to incorporate wave energy dissipating designs.	Staged	$2,200,000	$65,000	Likely to assist in reducing wave run-up-inundation only.										127	0	N/A	GCC/ State/Private	Would only assist in reducing wave run-up in excess of flood events.	N
14_FM5	Undertake a program of seawall maintenance and raising along the Woy Woy foreshore.	Staged	$2,100,000	$21,000	✓	✓	✓								Unkn.	Unkn.	N/A	Private	Further investigation into seawall condition would be necessary. The cost associated with this option is for the entire length of sea wall proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP.	Y
14_FM6a	Construct a levee (8.2km) around Woy Woy to above the PMF level.	Staged	$29,000,000	$570,000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	196	745	0.01	GCC/ State	Susceptible to breaches. Drainage and stormwater retention required behind levee. May impact on catchment flooding. Community perception of safety behind levee may lead to increased risk if breach occurs. The future increase in levee height to account for SLR needs to be considered in the initial design. The cost associated with this option is for the entire length of levee proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP.	Y
14_FM6b	Construct a levee (8.2km) around Woy Woy to above the 5 year ARI level.	Staged	$14,000,000	$280,000	✓	✓	✓	✓				✓			797	1059	0.16	GCC/ State	Susceptible to breaches and overtopping. Drainage and stormwater retention required behind levee. May impact on catchment flooding. Community perception of safety behind levee may lead to increased risk if breach occurs. The future increase in levee height to account for SLR needs to be considered in the initial design. The cost associated with this option is for the entire length of levee proposed. This cost could be shared by private developers through the implementation of development controls associated with filling and protection from SLR. This can be investigated as part of CCAP.	Y
14_FM9	Raise land areas within Woy Woy at risk of coastal flooding.	Trigger	$340,000,000	$0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	196	745	0.00	State/ Private	Without masterplanning, consultation and effective staging, this option is unlikely to be feasible on a regional scale.	Y
14_PM6	Relocate Woy Woy Police Station out of the floodplain.	Staged	$4,300,000	$0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0	0	N/A	State	This station is inundated in the existing 100 year ARI flood event.	N
14_PM11b	Undertake a review/updated investigation of the impacts of structural floodplain risk management options on overland flows in Woy Woy and Blackwall.	Immediate	$30,000	$0											0	0	N/A	GCC/ State	Large structural options have the potential to impact on overland flows. Investigations are needed to fully understand these impacts.	Y
14_EM2	Install and maintain "Road Floods" signs at Blackwall Road, Brick Wharf Road and North Burge Road, Woy Woy.	Immediate	$3,600	$540	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	0	0	N/A	GCC/ State	Nearby residents may feel that their property will be devalued because flood markers indicate the presence of flood risk.	N
14_EM6	Upgrade Woy Woy Road to facilitate more effective evacuation from, and emergency services access to, the Woy Woy area.	Trigger	$52,000,000	$520,000	✓	✓	✓	✓	✓		✓	✓	✓		0	0	N/A	GCC/ State	Large economic cost.	N

Legend

FRMS / FRMP Preferred Options

✓ Water level addressed by option

✓ Stage / trigger level response

Action Timeline: **Immediate** - Short term, minimal further investigations required
Staged - Short/medium term, further investigations required
Trigger - Longer term, sea level rise trigger level to initiate management response
Unkn. Unknown

Existing high tides in this area can cause inundation, especially with joint occurrence of storm conditions. Some residential and commercial properties are affected even in higher probability ARIs events. For the existing 100 Year ARI event, Woy Woy and Blackwall have one of the largest numbers of inundated properties of all management areas. This number is likely to increase with projected sea level rise scenarios. Infrastructure is also affected (including some roads and critical infrastructure) and with proejcted sea level rise, railway infrastructure may also be affected. However, Woy Woy has been named a "town centre" under the DoP's Central Coast Regional Strategy (DoP, 2008) and is expected to provide future housing development and continue to provide retail, health, professional and transport services to surrounding residential areas into the future.

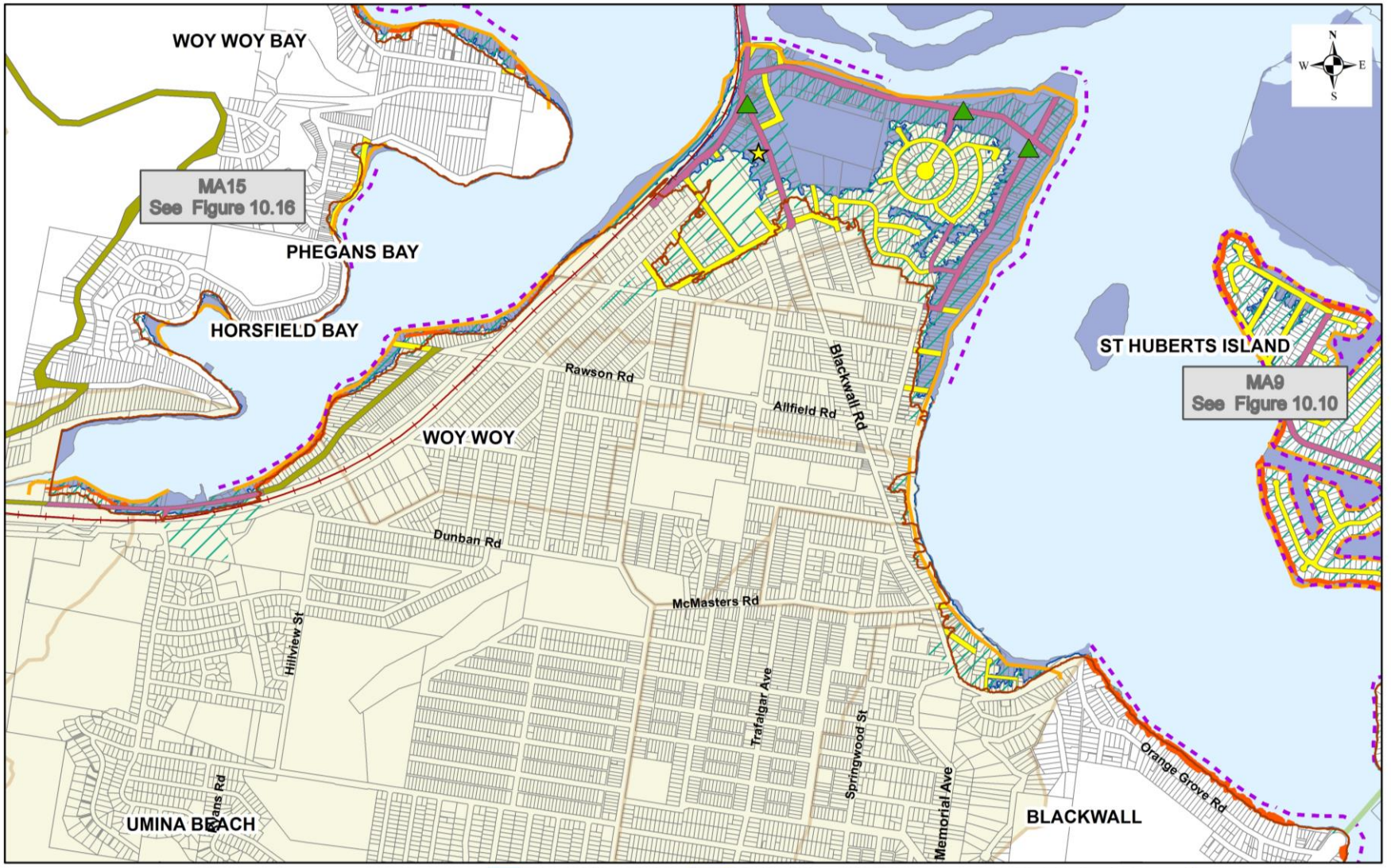


Figure 10.15 Management Area 14 (Woy Woy & Blackwall)

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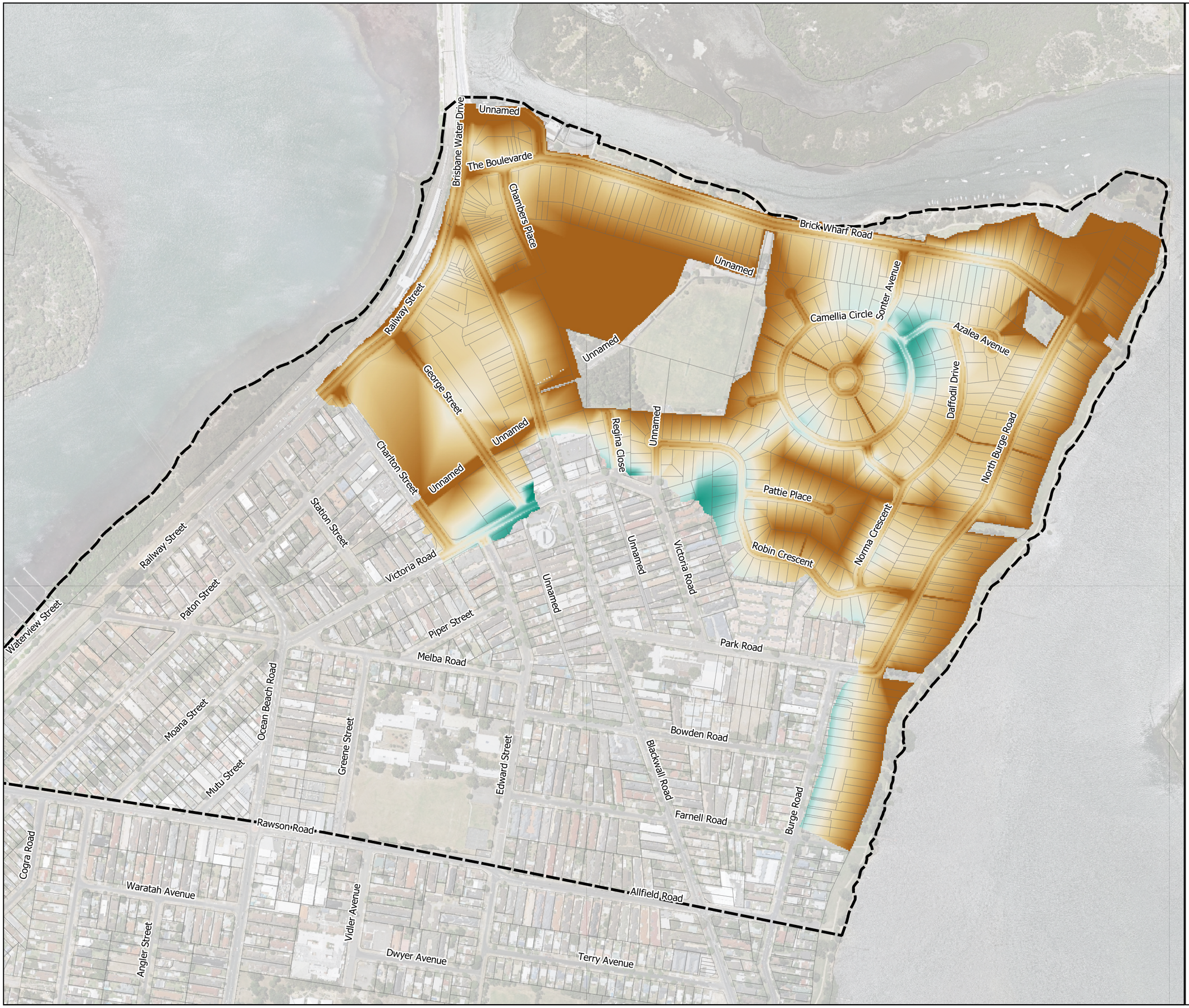
APPENDIX C

Proposed Adaptation Landforms



N

W E

S

Map G220

Design Landform

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area

Design Terrain (m)

- 1.6
- 1.8
- 2
- 2.2
- 2.4
- 2.6
- 2.8
- 3
- 3.2
- 3.4

0 100 200 300 m

Scale : 1:5500@A3
Date : 29 April 2020
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N
W E
S

Map G221

Design Landform

Blackwall (Location 2)

Legend

- Cadastre
- Study Area

Design Terrain (m)

- 1.6
- 1.8
- 2
- 2.2
- 2.4
- 2.6
- 2.8
- 3
- 3.2
- 3.4

0 25 50 75 m

Scale : 1:1500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : GDA 94/MGA 56

Rhelm



N
W E
S

Map G222

Design Landform

Booker Bay (Location 3)

Legend

- Cadastre
- Study Area

Design Terrain (m)

- 1.6
- 1.8
- 2
- 2.2
- 2.4
- 2.6
- 2.8
- 3
- 3.2
- 3.4

0 50 100 150 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N
W E
S

Map G223

Design Landform

Ettalong (Location 4)

Legend

- Cadastre
- Study Area

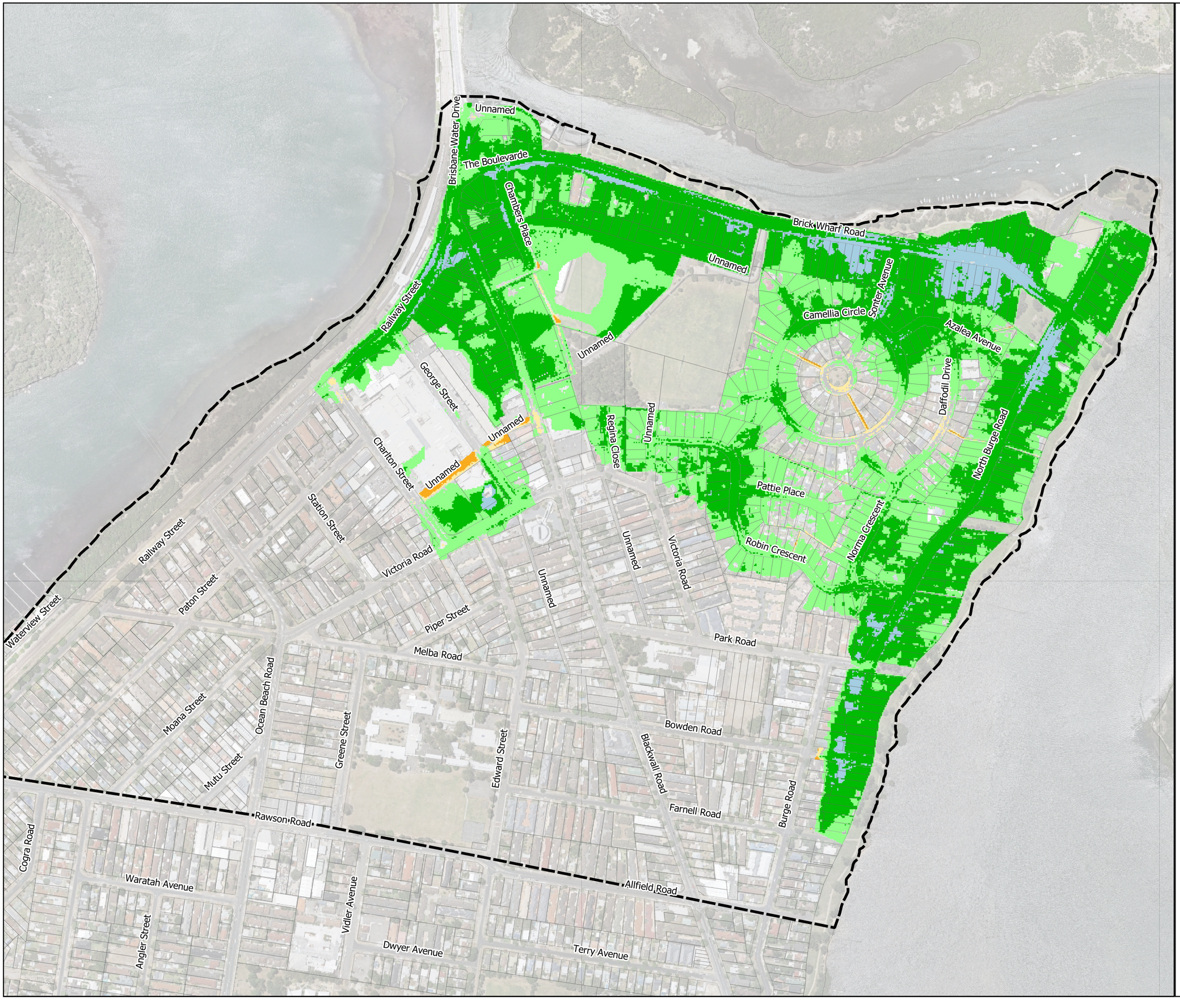
Design Terrain (m)

- 1.6
- 1.8
- 2
- 2.2
- 2.4
- 2.6
- 2.8
- 3
- 3.2
- 3.4

0 25 50 75 m

Scale : 1:2500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : GDA 94/MGA 56

Rhelm



N

W E

S

Map G320

Fill Depth

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area

Fill Depth (m)

- <= -0.5
- -0.5 - -0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5

0 100 200 300 m

Scale : 1:5500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N
W E
S

Map G321

Fill Depth

Blackwall (Location 2)

Legend

- Cadastre
- Study Area

Fill Depth (m)

- <= -0.5
- -0.5 - -0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5

0 25 50 75 m

Scale : 1:15000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N

W E

S

Map G322

Fill Depth

Booker Bay (Location 3)

Legend

- Cadastre
- Study Area

Cut/Fill (m)

Fill Depth (m)

- <= -0.5
- -0.5 - -0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5

0 50 100 150 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N
W E
S

Map G323

Fill Depth

Ettalong (Location 4)

Legend

- Cadastre
- Study Area

Fill Depth (m)

- <= -0.5
- -0.5 - -0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 1.5

0 25 50 75 m

Scale : 1:2500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm

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APPENDIX D

Flood Modelling Results



N

W E

S

Map G420

Existing Flood Depths

1% AEP, 12 hour, TP08

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area
- Flood Extents from FRMS (DHI,2020)

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 100 200 300 m

Scale : 1:5500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N

W E

S

Map G421

Existing Flood Depths

20% AEP, 24 hour, TP08

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area
- Flood Extents from FRMS (DHI,2020)

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 100 200 300 m

Scale : 1:5500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N
W E
S

Map G422

Existing Flood Depths

1% AEP, 1 hour, TP08

Blackwall (Location 2)

Legend

- Cadastre
- Study Area
- Flood Extents from FRMS (DHI,2020)

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 25 50 75 m

Scale : 1:15000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : GDA 94/MGA 56

Rhelm



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Map G423

Existing Flood Depths

20% AEP, 1 hour, TP06

Blackwall (Location 2)

Legend

- Cadastre
- Study Area
- Flood Extents from FRMS (DHI,2020)

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 25 50 75 m

Scale : 1:15000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : GDA 94/MGA 56

Rhelm



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Map G424

Existing Flood Depths

1% AEP, 12 hour, TP08

Booker Bay (Location 3)

Legend

- Cadastre
- Study Area
- Flood Extents from FRMS (DHI,2020)

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 50 100 150 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G425

Existing Flood Depths

20% AEP, 24 hour, TP06

Booker Bay (Location 3)

Legend

- Cadastre
- Study Area
- Flood Extents from FRMS (DHI,2020)

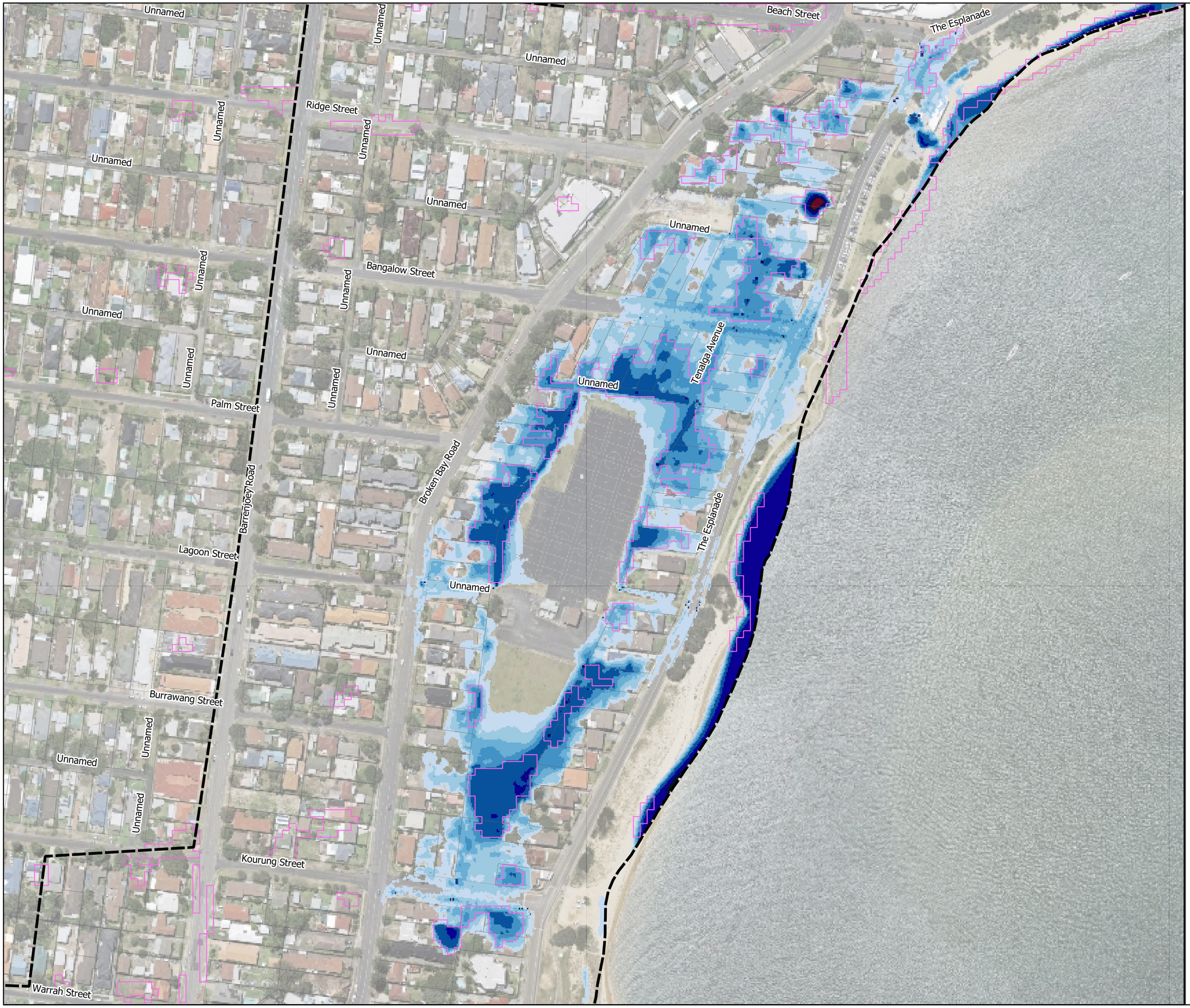
Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 50 100 150 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G426

Existing Flood Depths

1% AEP, 2 hour, TP06

Ettalong (Location 4)

Legend

- Cadastre
- Study Area
- Flood Extents from FRMS (DHI,2020)

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 25 50 75 m

Scale : 1:2500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G427

Existing Flood Depths

20% AEP, 24 hour, TP04

Ettalong (Location 4)

Legend

- Cadastre
- Study Area
- Flood Extents from FRMS (DHI,2020)

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 25 50 75 m

Scale : 1:2500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm

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Map G430

Sensitivity Analysis

Flood Depth Impact

2030 Sea Level Rise

1% AEP

Legend

Model Extents

Cadastre

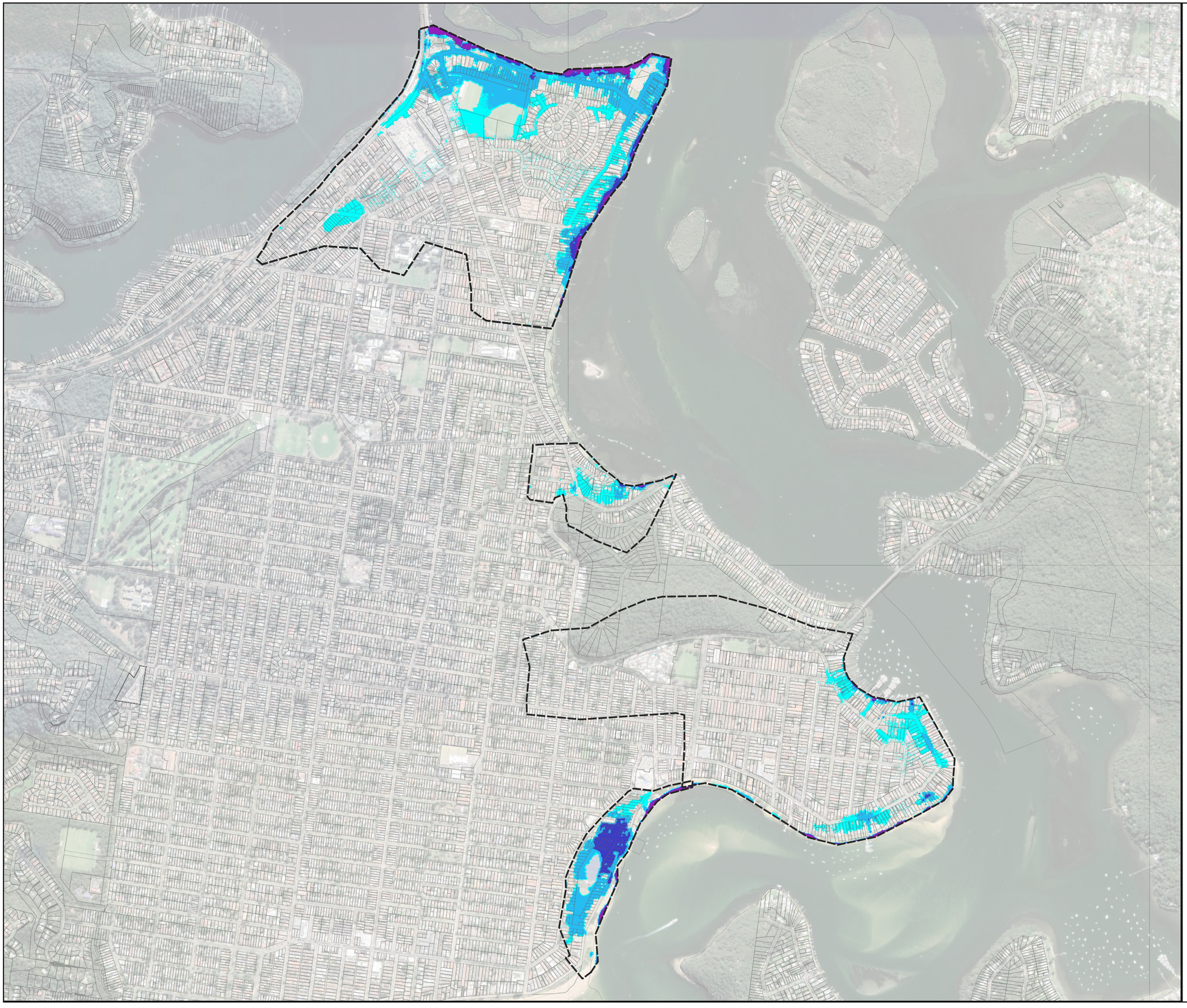
Depth Difference (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 0.25 0.5 0.75 km

Scale : 1:16000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G431

Sensitivity Analysis

Flood Depth Impact

2070 Sea Level Rise

1% AEP

Legend

- Model Extents
- Cadastre

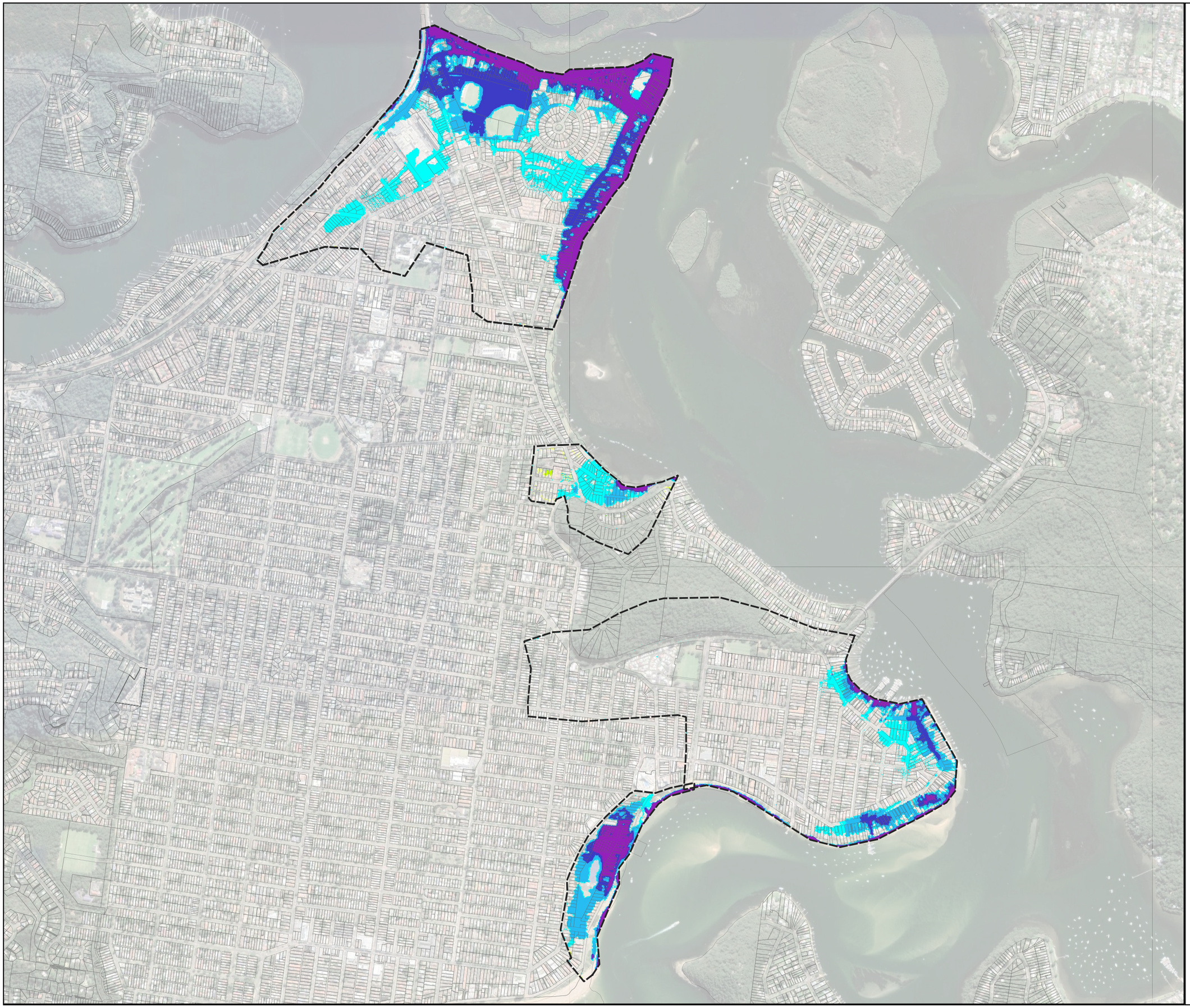
Depth Difference (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 0.25 0.5 0.75 km

Scale : 1:16000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G432

Sensitivity Analysis

Flood Depth Impact

2100 Sea Level Rise

1% AEP

Legend

- Model Extents
- Cadastre

Depth Difference (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 0.25 0.5 0.75 km

Scale : 1:16000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm

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W E

S

Map G433

Sensitivity Analysis

Flood Depth Impact

Increase Losses 20%

1% AEP

Legend

Model Extents

Cadastre

Depth Difference (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 0.25 0.5 0.75 km

Scale : 1:16000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm

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Map G434

Sensitivity Analysis

Flood Depth Impact

Decrease Losses 20%

1% AEP

Legend

Model Extents

Cadastre

Depth Difference (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 0.25 0.5 0.75 km

Scale : 1:16000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm

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W E
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Map G435

Sensitivity Analysis

Flood Depth Impact

Increase Culvert Blockage 50%

1% AEP

Legend

- Model Extents
- Cadastre

Depth Difference (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 0.25 0.5 0.75 km

Scale : 1:16000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm

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S

Map G449

Flood Depth

Business As Usual Scenario

1% AEP

Legend

- Model Extents
- Cadastre

Peak Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 0.25 0.5 0.75 km

Scale : 1:16000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G450

Design Landform

Flood Depths

1% AEP, 12 hour, TP08

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 100 200 300 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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W E

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Map G451

Design Landform

Flood Depths

20% AEP, 24 hour, TP08

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 100 200 300 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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W E
S

Map G452

Design Landform

Flood Depths

1% AEP, 1 hour, TP08

Blackwall (Location 2)

Legend

- Cadastre
- Study Area

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 25 50 75 m

Scale : 1:15000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N
W E
S

Map G453

Design Landform

Flood Depths

20% AEP, 1 hour, TP06

Blackwall (Location 2)

Legend

- Cadastre
- Study Area

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 25 50 75 m

Scale : 1:15000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N
W E
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Map G454

Design Landform

Flood Depths

1% AEP, 12 hour, TP08

Booker Bay (Location 3)

Legend

- Cadastre
- Study Area

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 50 100 150 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G455

Design Landform

Flood Depths

20% AEP, 24 hour, TP06

Booker Bay (Location 3)

Legend

- Cadastre
- Study Area

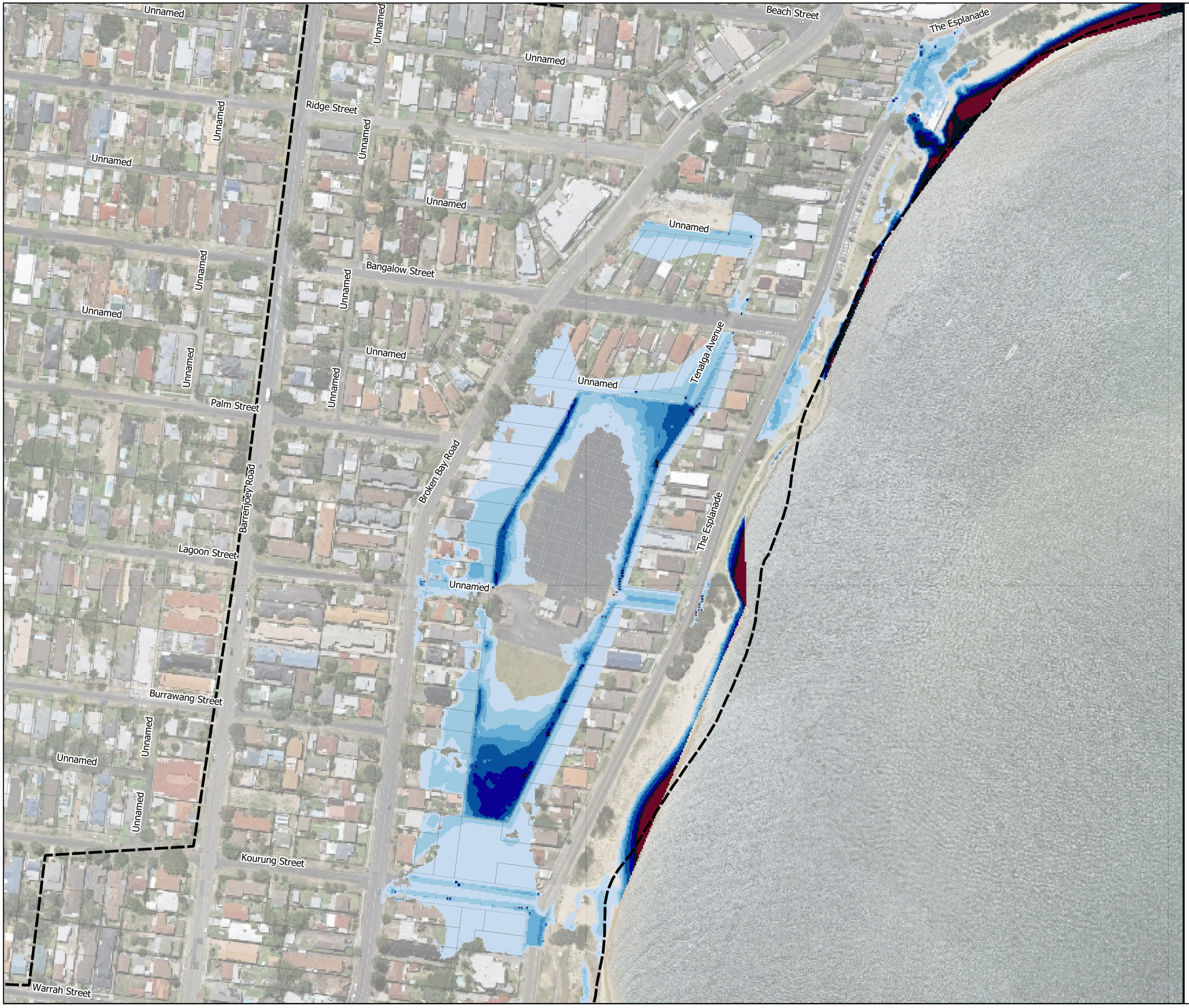
Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 50 100 150 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G456

Design Landform

Flood Depths

1% AEP, 2 hour, TP06

Ettalong (Location 4)

Legend

- Cadastre
- Study Area

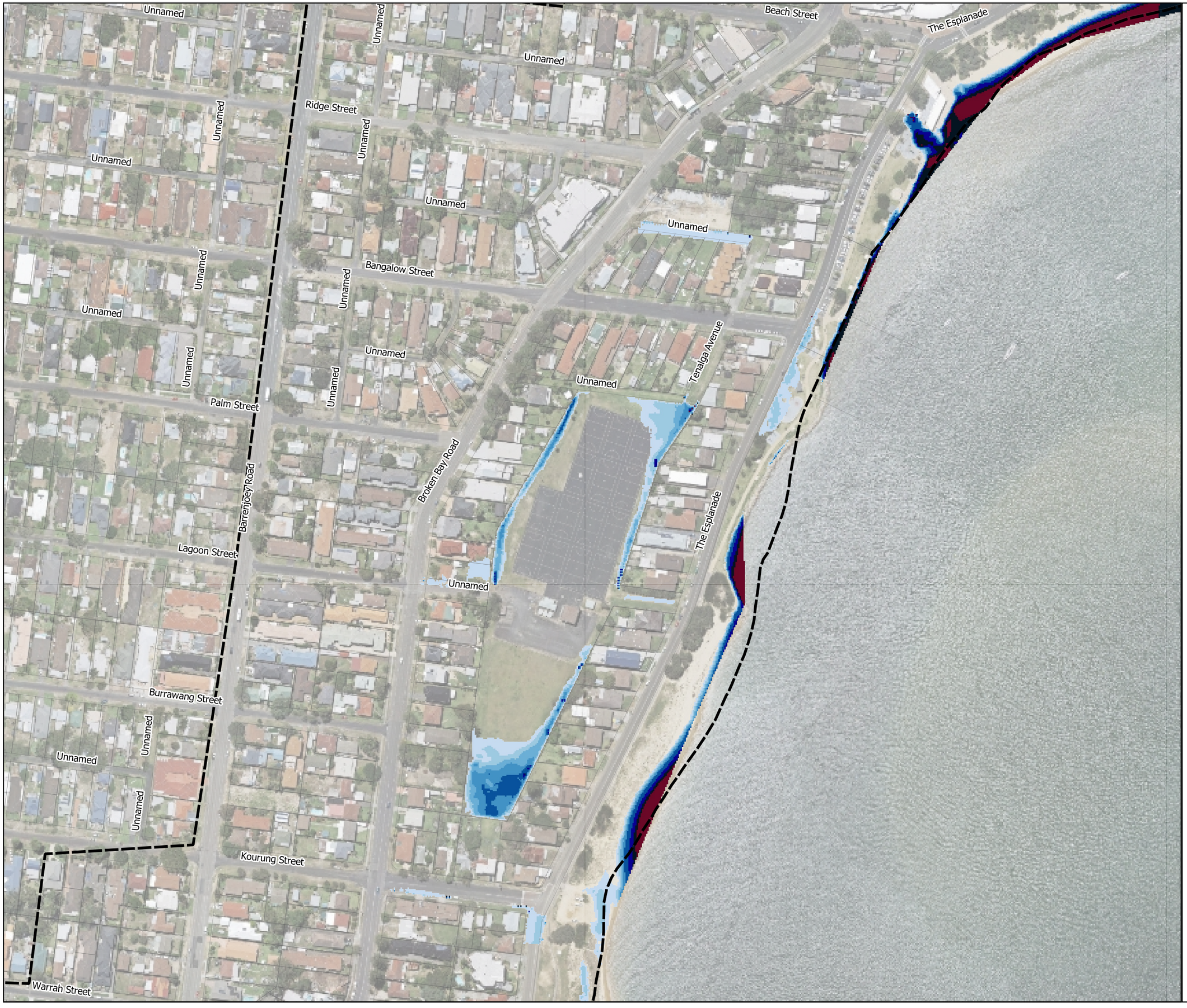
Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 25 50 75 m

Scale : 1:2500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G457

Design Landform

Flood Depths

20% AEP, 24 hour, TP04

Ettalong (Location 4)

Legend

- Cadastre
- Study Area

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 25 50 75 m

Scale : 1:2500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G460

Interim Landform

Flood Depths

1% AEP, 12 hour, TP08

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area
- Properties identified as likely to redevelop within the next 50 years
- Areas identified for raising in Stage 1 and Stage 2 of the masterplan implementation strategy

Flood Depth (m)

- 0.10 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.2
- > 1.2

0 100 200 300 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G470

Design Landform

Flood Depth Impact

1% AEP, 12 hour, TP08

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area

Depth Difference (m)
(Design Less
Business as Usual Scenario)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 100 200 300 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G471

Design Landform

Flood Depth Impact

20% AEP, 24 hour, TP08

Woy Woy (Location 1)

Legend

- Cadastre
- Study Area

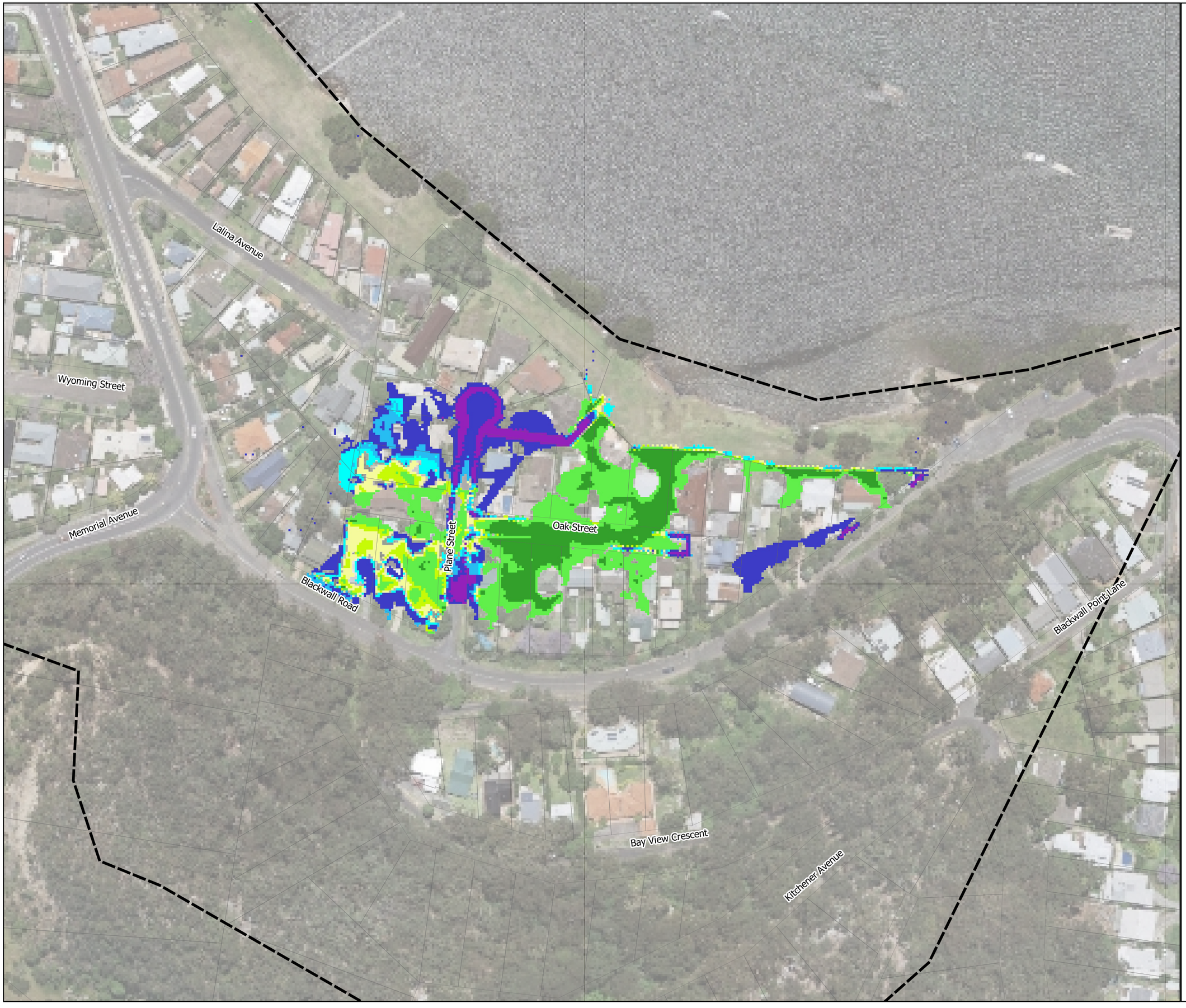
Depth Difference (m)
(Design Less
Business as Usual Scenario)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 100 200 300 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G472

Design Landform

Flood Depth Impact

1% AEP, 1 hour, TP08

Blackwall (Location 2)

Legend

- Cadastre
- Study Area

Depth Difference (m)
(Design Less
Business as Usual Scenario)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 25 50 75 m

Scale : 1:15000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N
W E
S

Map G473

Design Landform

Flood Depth Impact

20% AEP, 1 hour, TP06

Blackwall (Location 2)

Legend

Cadastre

Study Area

Depth Difference (m)
(Design Less
Business as Usual Scenario)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 25 50 75 m

Scale : 1:15000@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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W E

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Map G474

Design Landform

Flood Depth Impact

1% AEP, 12 hour, TP08

Booker Bay (Location 3)

Legend

- Cadastre
- Study Area

Depth Difference (m)
(Design Less
Business as Usual Scenario)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 50 100 150 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N

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Map G475

Design Landform

Flood Depth Impact

20% AEP, 24 hour, TP06

Booker Bay (Location 3)

Legend

Cadastre

Study Area

Depth Difference (m)
(Design Less
Business as Usual Scenario)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 50 100 150 m

Scale : 1:3500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



N

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Map G476

Design Landform

Flood Depth Impact

1% AEP, 2 hour, TP06

Ettalong (Location 4)

Legend

- Cadastre
- Study Area

Depth Difference (m)
(Design Less
Business as Usual Scenario)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 25 50 75 m

Scale : 1:2500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

Rhelm



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Map G477

Design Landform

Flood Depth Impact

20% AEP, 24 hour, TP04

Ettalong (Location 4)

Legend

- Cadastre
- Study Area

Depth Difference (m)
(Design Less
Business as Usual Scenario)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2

0 25 50 75 m

Scale : 1:2500@A3
Date : 29 April 2021
Revision : B
Created by : JS
Coordinate System : MGA 56

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APPENDIX E

Preliminary Staging of Works

Protection of hertiage properties in the CBD with lot scale levee and pumped drainage or raised floor levels as part of Stage 1. Wil require survey to confirm ground levels and FFL.

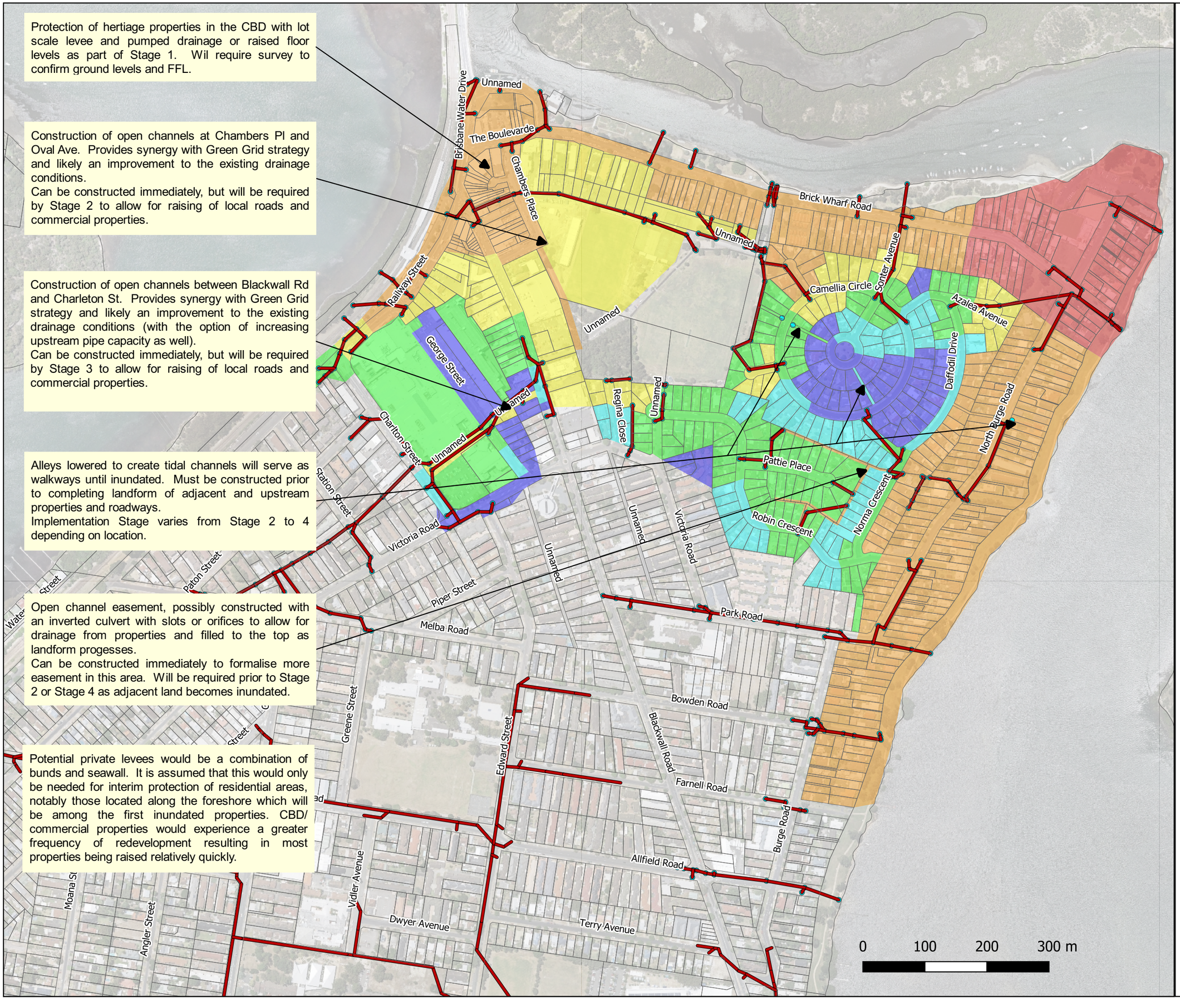
Construction of open channels at Chambers Pl and Oval Ave. Provides synergy with Green Grid strategy and likely an improvement to the existing drainage conditions.
Can be constructed immediately, but will be required by Stage 2 to allow for raising of local roads and commercial properties.

Construction of open channels between Blackwall Rd and Charleton St. Provides synergy with Green Grid strategy and likely an improvement to the existing drainage conditions (with the option of increasing upstream pipe capacity as well).
Can be constructed immediately, but will be required by Stage 3 to allow for raising of local roads and commercial properties.

Alleys lowered to create tidal channels will serve as walkways until inundated. Must be constructed prior to completing landform of adjacent and upstream properties and roadways.
Implementation Stage varies from Stage 2 to 4 depending on location.

Open channel easement, possibly constructed with an inverted culvert with slots or orifices to allow for drainage from properties and filled to the top as landform progesses.
Can be constructed immediately to formalise more easement in this area. Will be required prior to Stage 2 or Stage 4 as adjacent land becomes inundated.

Potential private levees would be a combination of bunds and seawall. It is assumed that this would only be needed for interim protection of residential areas, notably those located along the foreshore which will be among the first inundated properties. CBD/ commercial properties would experience a greater frequency of redevelopment resulting in most properties being raised relatively quickly.



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Map G551

Potential Staging Woy Woy (Location 1)

Legend

- Cadastre
- Pits
- Pipes/Culverts

Staging

- Stage 1, Up to 0.8 m AHD
- Stage 2, Up to 1.0 m AHD
- Stage 3, Up to 1.2 m AHD
- Stage 4, Up to 1.4 m AHD
- Stage 5, Up to 1.6 m AHD
- Stage 6, Over 1.6 m AHD

Scale : 1:5500@A3
Date : 12 April 2021
Revision : B
Created by : JRF
Coordinate System : GDA 94/MGA 56

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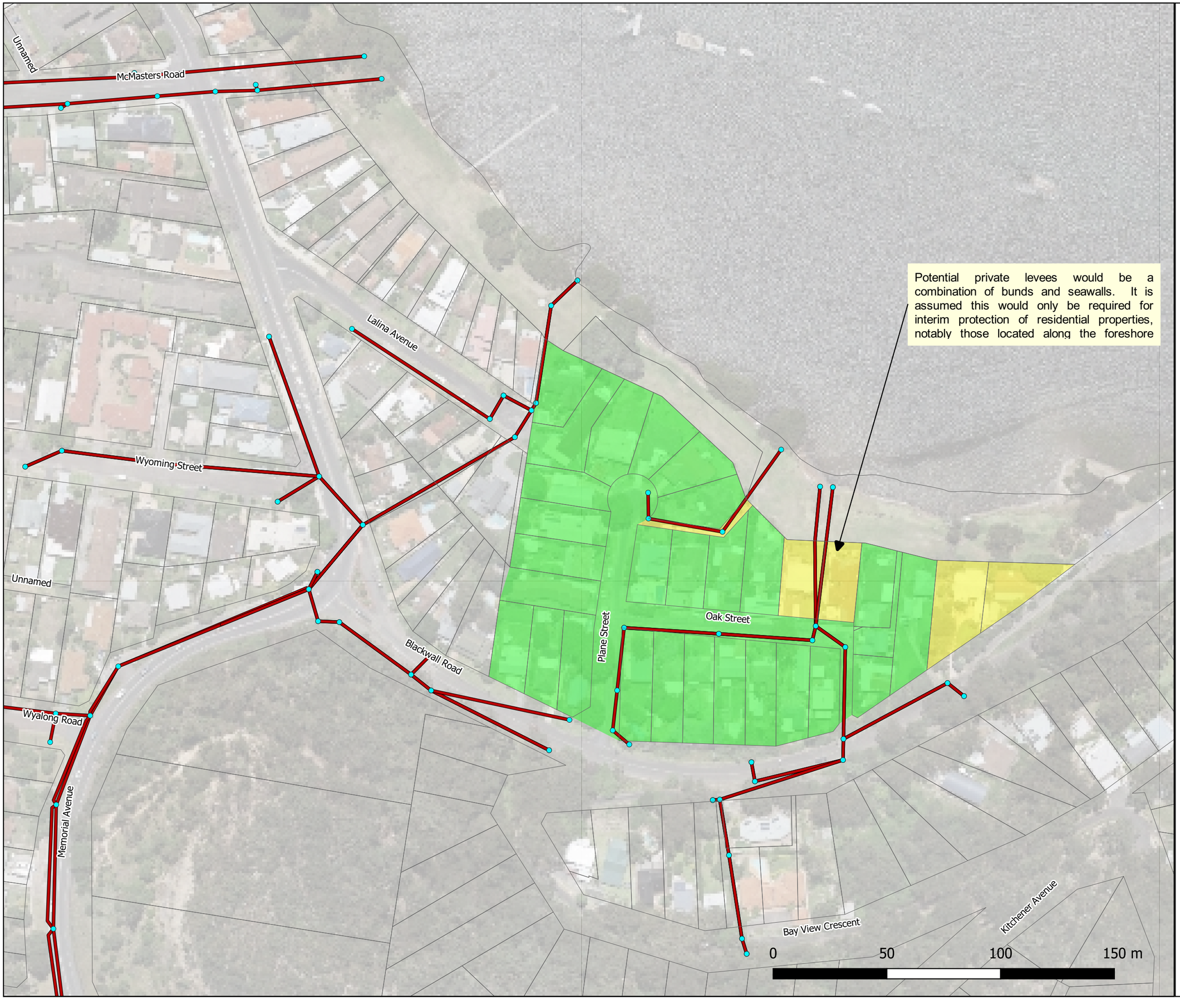

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Map G552

Proposed Staging Blackwall (Location 2)

Legend

- Cadastre
- Pits
- Pipes/Culverts

Staging

- Stage 1, Up to 0.8 m AHD
- Stage 2, Up to 1.0 m AHD
- Stage 3, Up to 1.2 m AHD
- Stage 4, Up to 1.4 m AHD
- Stage 5, Up to 1.6 m AHD
- Stage 6, Over 1.6 m AHD

Scale : 1:1500@A3
Date : 12 April 2021
Revision : B
Created by : JRF
Coordinate System : GDA 94/MGA 56

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Map G553

Proposed Staging Booker Bay (Location 3)

Construction of easements to be undertaken as soon as practical to allow drainage of Bogan Road as surrounding land raising progresses.

Flathead Road
Flounder Road
Bream Road
Whiting Road
Schnapper Road
Murray Street
Webb Road
Eastern Road
Davis Street
Karu Avenue
Bilba Avenue
Guyra Street
Bogan Road
Telopea Street
Munal Avenue
Ocean View Road
Ferny Road
Booker Bay Road
Petitt Street

0 50 100 150 m

Legend

- Cadastre
- Pits
- Pipes/Culverts

Staging

- Stage 1, Up to 0.8 m AHD
- Stage 2, Up to 1.0 m AHD
- Stage 3, Up to 1.2 m AHD
- Stage 4, Up to 1.4 m AHD
- Stage 5, Up to 1.6 m AHD
- Stage 6, Over 1.6 m AHD

Scale : 1:3000@A3
Date : 12 April 2021
Revision : B
Created by : JRF
Coordinate System : GDA 94/MGA 56

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Map G554

Proposed Staging Ettalong (Location 4)

Formalised interallottment drainage can be constructed immediately and progressively have cover levels raised over time.

The Esplanade can be constructed at any time for additional protection from coastal flooding. The Stages noted along the roadway represent the water level at which the road becomes inundated.

Increasing drainage capacity at outlet can occur immediately, without detriment to the existing flood behaviour.

0 50 100 150 m

Legend

- Cadastre
- Pits
- Pipes/Culverts

Staging

- Stage 1, Up to 0.8 m AHD
- Stage 2, Up to 1.0 m AHD
- Stage 3, Up to 1.2 m AHD
- Stage 4, Up to 1.4 m AHD
- Stage 5, Up to 1.6 m AHD
- Stage 6, Over 1.6 m AHD

Scale : 1:3000@A3
Date : 12 April 2021
Revision : B
Created by : JRF
Coordinate System : GDA 94/MGA 56

Rhelm

engineering | environmental | economics | engagement

APPENDIX F

Economic Analysis Technical Note

WOY WOY PENINSULA CLIMATE CHANGE ADAPTATION STUDY

Economic Assessment Technical Note

Reference: J1304 **Date : 4 May 2021 Rev: 0**

1 Introduction

Woy Woy, Blackwall, Booker Bay and Ettalong are low lying suburbs on the Woy Woy Peninsula. A climate change adaptation study has been undertaken for these suburbs, as described in the draft *Woy Woy Peninsula Adaptation Study* (Rhelm, 2021). This adaptation study describes the development of a draft landform and drainage masterplan for the suburbs of Woy Woy, Blackwall, Booker Bay and Ettalong, to manage the impacts of sea level rise and local drainage.

This Technical Note describes the economic assessment that has been undertaken on the proposed masterplan for each of the four study areas to understand the overall economic viability of implementing the proposed masterplan. This Technical Note forms an appendix of the climate change adaptation study (2019).

2 Key Assumptions

2.1 Economic Parameters

The following are the key parameters adopted for the economic assessment:

- Discount Rate of 7%;
- Economic Assessment Period from 2021 to 2100, aligning with the overall timeframe for implementation of the masterplan;
- All values are expressed in 2021 dollars unless otherwise noted; and
- Given the relatively long assessment period, no residual value has been assumed.

2.2 Brisbane Water Flooding

Only impacts from inundation as a result of Brisbane Water flooding have currently been considered in the economic analysis.

Local catchment flooding will be generally improved in the overall masterplan, following the implementation of all roads and associated drainage. This will occur towards the latter part of the overall economic assessment period, and the benefits are unlikely to be as significant (in dollar terms) as those considered in this assessment. Therefore, these have conservatively not been considered.

2.3 Sea Level Rise

The rate of sea level rise was assumed as per previous work and reporting, as discussed in Rhelm (2021). The key relevant levels are provided in **Table 2-1, Table 2-2 and Table 2-3**, which show Brisbane Water flood levels for Woy Woy and Blackwall, Booker Bay and Ettalong, respectively. The 2015 levels are sourced from the Brisbane Water Flood Study (Cardno, 2010). The rate of sea level rise has been adopted from an independent report on projected sea level rise in Brisbane Water prepared by Doug Lord of Coastal Environment Pty Ltd and by Dr David Wainwright from Whitehead and Associates in 2015.

For simplicity, it has been assumed that there has been no sea level rise between 2015 and 2021, which represents the start of the economic assessment.

Table 2-1. Sea Level Rise and Brisbane Water levels Assumed – Woy Woy and Blackwall

Year	Sea Level Rise (m)	1% POE	MHWS (m AHD)	PMF (m AHD)	0.5% AEP (m AHD)	1% AEP (m AHD)	2% AEP (m AHD)	5% AEP (m AHD)	10% AEP (m AHD)	20% AEP (m AHD)
2015	0	0.68	0.37	1.92	1.65	1.58	1.51	1.43	1.36	1.29
2021	0	0.68	0.37	1.92	1.65	1.58	1.51	1.43	1.36	1.29
2030	0.1	0.78	0.47	2.02	1.75	1.68	1.61	1.53	1.46	1.39
2050	0.2	0.88	0.57	2.12	1.85	1.78	1.71	1.63	1.56	1.49
2070	0.4	1.08	0.77	2.32	2.05	1.98	1.91	1.83	1.76	1.69
2100	0.7	1.38	1.07	2.62	2.35	2.28	2.21	2.13	2.06	1.99

Table 2-2. Sea Level Rise and Brisbane Water levels Assumed – Booker Bay

Year	Sea Level Rise (m)	1% POE	MHWS (m AHD)	PMF (m AHD)	0.5% AEP (m AHD)	1% AEP (m AHD)	2% AEP (m AHD)	5% AEP (m AHD)	10% AEP (m AHD)	20% AEP (m AHD)
2015		0.68	0.47	1.87	1.65	1.58	1.52	1.45	1.4	1.35
2021	0	0.68	0.47	1.87	1.65	1.58	1.52	1.45	1.4	1.35
2030	0.1	0.78	0.57	1.97	1.75	1.68	1.62	1.55	1.5	1.45
2050	0.2	0.88	0.67	2.07	1.85	1.78	1.72	1.65	1.6	1.55
2070	0.4	1.08	0.87	2.27	2.05	1.98	1.92	1.85	1.8	1.75
2100	0.7	1.38	1.17	2.57	2.35	2.28	2.22	2.15	2.1	2.05

Table 2-3. Sea Level Rise and Brisbane Water levels Assumed – Ettalong

Year	Sea Level Rise (m)	1% POE	MHWS (m AHD)	PMF (m AHD)	0.5% AEP (m AHD)	1% AEP (m AHD)	2% AEP (m AHD)	5% AEP (m AHD)	10% AEP (m AHD)	20% AEP (m AHD)
2015	0	0.93	0.52	2.08	1.85	1.78	1.7	1.63	1.56	1.51
2020	0	0.93	0.52	2.08	1.85	1.78	1.7	1.63	1.56	1.51
2030	0.1	1.03	0.62	2.18	1.95	1.88	1.8	1.73	1.66	1.61
2050	0.2	1.13	0.72	2.28	2.05	1.98	1.9	1.83	1.76	1.71
2070	0.4	1.33	0.92	2.48	2.25	2.18	2.1	2.03	1.96	1.91
2100	0.7	1.63	1.22	2.78	2.55	2.48	2.4	2.33	2.26	2.21

3 Scenarios

An economic assessment is undertaken by comparing one alternative against another. It is important that these scenarios or alternatives are clearly defined to ensure a robust analysis. Two scenarios have been adopted for this assessment:

1. Base Case – this represents the 'Do-Minimum' scenario, and represents the base case against which the masterplan options are considered;
2. Masterplan Scenario – this scenario incorporates the masterplan as defined in Rhelm (2021).

3.1 Base Case

The base case represents the 'Do-Minimum' scenario moving forward for the four study areas. The basic premise under this scenario is that while redevelopment will occur (through renewal and redevelopment of properties), little will be done to specifically address climate change. Over time, with increasing sea level rise, it will be necessary to retreat from the area. It is noted that this is not necessarily reflective of Council policies, but rather as a baseline for the economic assessment.

3.1.1 Retreat

Under the base case, it is assumed that there would be minimal action to minimize the impacts of sea level rise, and that eventually properties would be forced to retreat (or abandoned) due to increase d tidal inundation and more frequent storm surge inundation.

The point at which this occurs is difficult to estimate and will be dependent on what the community is willing to accept in terms of roads and properties being inundated. In the absence of detailed studies on this issue for the study areas, a trigger level based on the 1% Probability of Exceedance (1% PoE) has been adopted.

While roads may become inundated in some situations more frequently than properties, the 1% PoE inundation of individual properties was adopted as the trigger at which point a retreat would be undertaken. The 1% PoE represents the tidal level that would be experienced for a total duration of around 3.6 days on average per year. Given that this would only occur during the high tide periods, this has the potential to occur over numerous tides and periods over a year and therefore was considered as a reasonable trigger for the economic analysis.

The 1% PoE over time was compared against the average ground level over a cadastral lot, based on the available LIDAR information for the area. The LiDAR data was extracted through GIS to determine the average ground level. It is noted that there would be lower ground levels on a property, and therefore this represents approximately 50% of the property that might be inundated by the 1% PoE.

The rate of properties abandoned, or rate of retreat is shown in **Figure 3-1**, as a percentage of the overall properties within the masterplan study areas. The total number of properties in each study area is provided in **Table 3-1**.

Table 3-1. Total of properties within the Masterplan study areas

Study Area	Total number of properties included in the Masterplan
Woy Woy	580
Blackwall	32
Booker Bay	209
Ettalong	101

The analysis suggests that the potential retreat would be more pronounced in the latter half of the century, with a larger proportion of properties in Woy Woy given that it is lower lying than the other study areas on average. By 2100, roughly 39% of properties would have retreated in Woy Woy, 19% in Blackwall, 30% in Booker Bay and 29% in Ettalong.

The rate of retreat in Blackwall, Booker Bay and Ettalong is slower than Woy Woy, with most properties not requiring retreat until 2080 or later.

It is possible that the proportions would be larger than this, particularly for Woy Woy, as the surrounding roads and services would become increasingly difficult to maintain. Further, as surrounding properties are abandoned, the remaining properties may become less viable. However, for the economic assessment this provided a reasonable basis for the evaluation.

Figure 3-2 shows the histogram of average ground levels for the properties in the four study areas. This shows the generally higher ground levels in Booker Bay, Blackwall and Ettalong on average, resulting in less retreat across the entire masterplan area compared with Woy Woy.

A further consideration would be the influence of coastal events. For example, a 20% AEP event that occurs at a higher level would have more significant impacts on the community and may result in a greater acceleration of retreat. However, this has been conservatively ignored for this assessment.

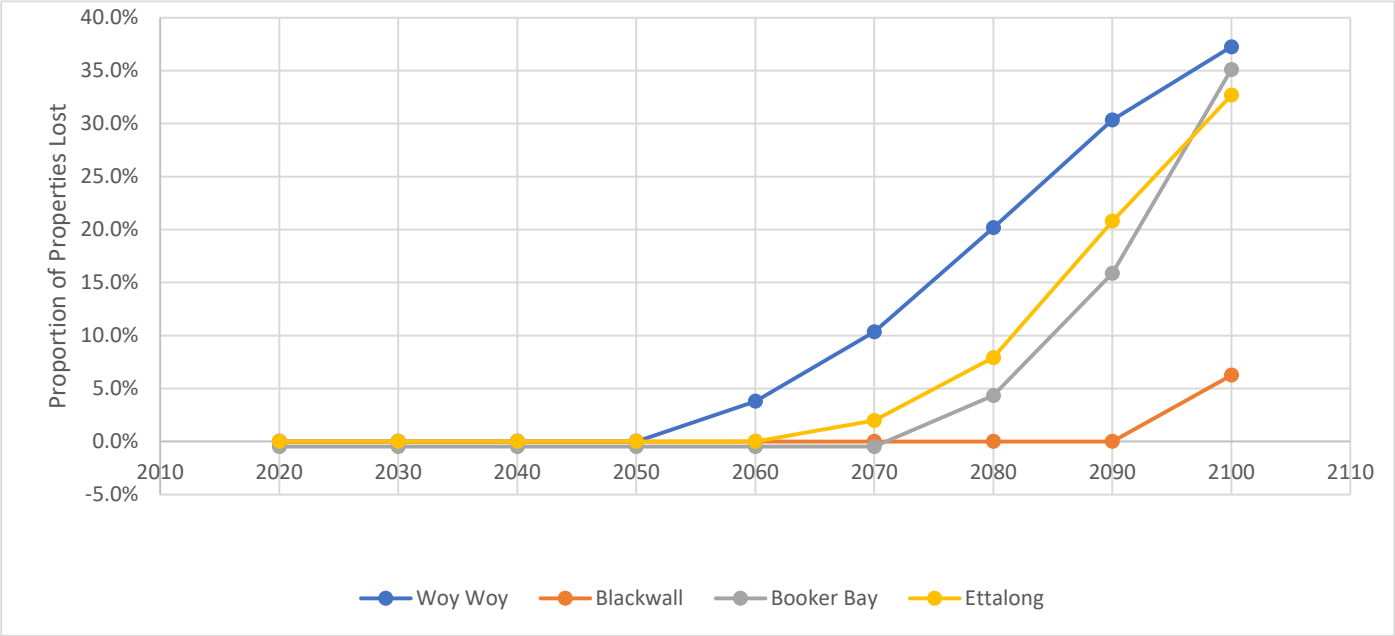

Figure 3-1. Rate of Retreat

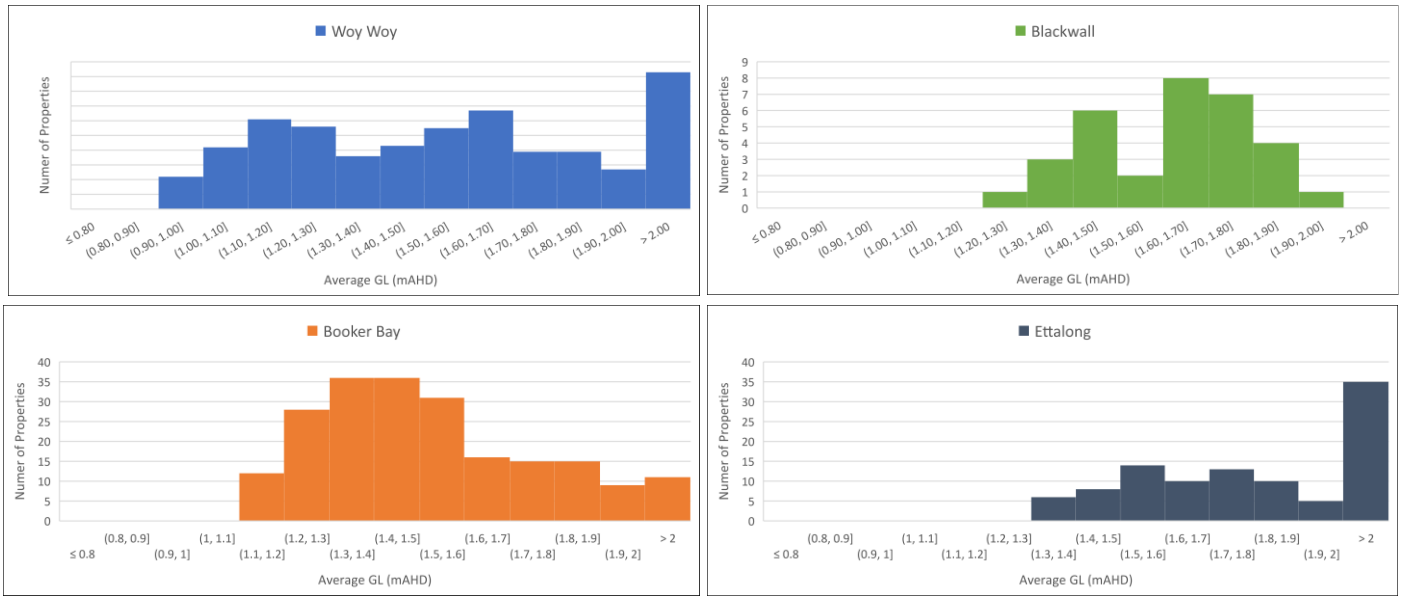

Figure 3-2. Histogram of Ground Levels

3.1.2 Redevelopment

The rate of retreat identified above occurs more significantly after 2070 to 2090. Given that this is relatively far in the future, it is likely that redevelopment would still occur in the interim time under the base case. Therefore, redevelopment has been included in the base case to reflect the natural renewal and redevelopment.

Based on Council's current policies regarding filling to achieve flood planning levels, it is assumed that Council would permit filling on properties, not for the entire property boundary but only primarily for the building footprint. The following was assumed:

- A typical floor area of a house is roughly 220m^2, NSW state-wide average floor areas[1] for new residential dwelling. It should be noted that there is a number of properties in Woy Woy, mostly commercial, with smaller lot sizes for which would be unreasonable to consider a floor area of 220m^2. Therefore, for these properties the floor area was considered to be the minimum between 220 m^2 and 80% of the total lot area.
- It was assumed that most new housing stock would be two-storey, resulting in a building footprint of 110m^2.
- As a part of a redevelopment of a property, a total of 220 m^2 of filling was assumed, allowing for batter slopes, garages and other features etc.
- A fill level corresponding to the Brisbane Water 1% AEP level for the existing climate condition was assumed. Therefore, for Woy Woy, Blackwall and Booker Bay the adopted fill level was equal to 1.58 mAHD, for Ettalong the assumed level was 1.78 mAHD. It is assumed that the remainder for the flood planning level is achieved through raising of the property floor level.
- A floor level of 1% AEP plus a 0.5 metre freeboard plus a 0.3 metre climate change increase was assumed. This is generally in accordance with Council's existing policies, although it is noted that the climate change allowance varies depending on when the structure is approved. For simplicity, a constant 0.3 metres was adopted.

The rate of development is dependent on a number of factors, including the wider economy, age of the structure and residential market conditions. The interim masterplan from Rhelm (2021) identified a number of properties that were most likely to redevelop due to their age by 2050. These properties, which are shown on **Map G600**, have been assumed to redevelop by 2050.

In addition, properties that are likely to be impacted by the 1% PoE by 2050 were considered to redevelop in the 2025 – 2050 period. This assumes that they would redevelop in an attempt to mitigate the impacts of sea level rise prior to any abandonment. However, as identified in Section 3.1.1, there are only a limited number of these properties in Woy Woy, and no properties in Booker Bay, Ettalong and Blackwall. A summary of the time periods and the redevelopment are provided in **Table 3-2**.

Table 3-2. Summary of Key assumptions - Redevelopment

Time Period	Base Case	Masterplan
2025 – 2050	Properties identified in G600, as well as anywhere the 1% PoE would inundate by 2050, are assumed to redevelop. Fill only within building footprint.	Properties identified in G600, as well as anywhere the 1% PoE would be inundated by 2050, are assumed to redevelop. Fill properties to proposed masterplan level. Fill portion of roads impacted by the 1% PoE by 2050.
2050 – 2100	All remaining properties are assumed to redevelop.	All remaining properties and roads are raised and redeveloped as per G220 and G223.

[1] ABS - 8752.0 - Building Activity, Australia, Dec 2018

3.2 Masterplan Scenario

Under the masterplan scenario, properties and roads are progressively raised to the proposed masterplan ground levels as identified in Woy Woy Peninsula Climate Change Adaptation Study and summarised in Maps G220 to G223. Further details on the masterplan are provided in the study.

Associated with the filling and redevelopment of properties, the new properties would have floor levels to comply with Council's development controls. The maximum floor level based on the following was adopted for the analysis:

- Flood planning level of 1%AEP plus 0.5 metre freeboard plus 0.3 metre climate change increase, as per the base case; or
- A level 0.3 metres above ground level, given that the masterplan ground levels exceed the FPL in some locations to achieve the overall surface.

It is assumed that the refinement of the masterplan, together with associated implementation of policies etc., would occur between 2021 and 2025. Therefore, the development of the masterplan would occur after 2025.

A summary of the proposed redevelopment timeframes is provided in **Table 3-2**.

4 Cost Estimates

High level concept cost estimates were prepared for the masterplan for the four study areas. These cost estimates were prepared by Allan Price and Scarratts based on the available conceptual design. Detailed cost estimate breakdowns are provided in **Attachment A**. A summary is provided in **Table 4-1** to **Table 4-4**.

4.1 Public Infrastructure

Table 4-1 to **Table 4-4** provide an estimate of the capital costs associated with the roads for the masterplan scenarios.

The rate and progress of the development of the roads is uncertain and will be dependent on when properties are filled and raised, as well as Council's available funding. In the absence of a detailed schedule, it has been assumed that the costs are equally spread over the periods of time shown in **Table 4-1** to **Table 4-4**.

It should be noted that these time periods are not equivalent to the preliminary staging shown on **Maps G551** to **G554** from Rhelm (2021). The preliminary staging is reflective of when properties and roads are likely to be inundated based on flooding from both Brisbane Water and local catchment flooding and provides guidance on which properties need to be filled prior to road raising.

Table 4-1. Woy Woy Masterplan Cost Estimates - Public Infrastructure Components

Time Periods of Masterplan Implementation	Cost Estimate	Start Year	End Year
Time Period 1	$2,083,089	2025	2030
Time Period 2	$8,594,428	2030	2050
Time Period 3	$30,191,599	2050	2100
Total	**$40,869,116**		

Table 4-2. Blackwall Masterplan Cost Estimates - Public Infrastructure Components

Time Periods of Masterplan Implementation	Cost Estimate	Start Year	End Year
Time Period 3	$1,824,095	2050	2100
Total	**$1,824,095**		

Table 4-3. Booker Bay Masterplan Cost Estimates - Public Infrastructure Components

Time Periods of Masterplan Implementation	Cost Estimate	Start Year	End Year
Time Period 1	$995,893	2025	2030
Time Period 2	$3,865,843	2030	2050
Time Period 3	$7,347,834	2050	2100
Total	**$12,209,569**		

Table 4-4. Ettalong Masterplan Cost Estimates - Public Infrastructure Components

Time Periods of Masterplan Implementation	Cost Estimate	Start Year	End Year
Time Period 3	$6,235,078	2050	2100
Total	**$6,235,078**		

4.2 Property Filling

The development of properties under both the base case and the masterplan scenarios results in filling on the properties. Under the base case, only a portion of the property is filled to achieve the flood planning level, while under the masterplan the full property is assumed to be filled to the proposed masterplan level.

Two key periods were considered as identified in **Table 3-2.** It was assumed that the rate of redevelopment was constant over these periods.

The incremental cost of the masterplan is the cost to fill to the masterplan level, less the cost of any fill that might be undertaken under the base case scenario. The amount of fill estimated for the masterplan was based on the average depth of fill for the cadastral lot and multiplied by the area of the cadastral lot.

The cost of fill is difficult to estimate on an individual property basis. Dependent on the magnitude of the works being undertaken, then there may be some economies of scale if a number of properties are developed. For the purposes of this analysis, a flat rate of $\$40/m^3$ has been assumed as the cost of fill. An additional cost of $\$10/m^2$ was included to account for the cost of topsoil and coverage. This expense was applied only to the external area, i.e. it excluded the building footprint.

It should be noted that the commercial centre located at 52 Railway Street, which is shown on **Figure 4-1** was excluded from the property filling estimation. Given the large size of this property, the volume of fill calculated using the considered assumptions would not be reasonable. Since the minimum floor level at this property (2. 5 mAHD) is considerably higher than the 1%PoE elevation for the 2100 scenario (1.38m AHD), it would be possible to integrate this building to the surrounding masterplan landform just by raising the roads around the site. Therefore, modifying the centre of the building would not be necessary.



Figure 4-1. Commercial Centre (52 Railway Street)

A summary of the incremental cost of filling under the masterplan is shown in **Figure 4-2**.

It is noted that no cost has been estimated for the redevelopment of the building itself. It is assumed that this would be redeveloped under both the base case and the masterplan scenario, and therefore there is no change in incremental cost.

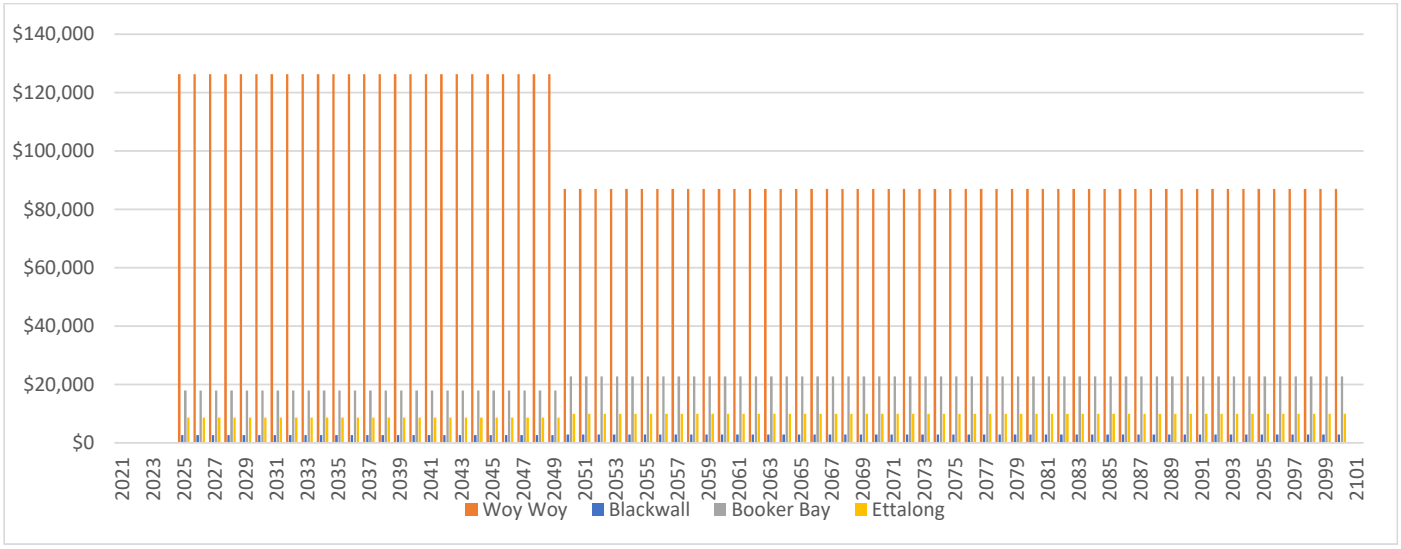

Figure 4-2. Incremental Cost of Filling - Masterplan Scenarios

4.3 Parks

As a part of the masterplan, there is a total of three existing parks (both foreshore and recreational areas) that would be raised. These areas are all located in the Woy Woy study area. An approximate $40/m^3 was assumed as

the cost of fill, together with an allowance of $15/m^2 for topsoil, grassing and landscaping works. This is an approximate value, as it would be highly dependent on the format of the park and the facilities. However, the overall costs for the parks are relatively minor compared with the overall masterplan.

Staging of the works in the parks was assumed to occur either between 2025 – 2050 or 2050 – 2100, based on when the park would be inundated by the 1% PoE. Costs for the works were evenly spread across these periods, given the uncertainty of when the work would occur.

4.4 Maintenance

For the purposes of this assessment, the level of maintenance was assumed to be consistent across both the base case and the masterplan scenario. The amount of public infrastructure and private infrastructure is similar, and therefore unlikely to be a significant variance in the overall annual maintenance.

A key issue would be the maintenance of services (such as water, sewer and drainage) with sea level rise. There are likely to become increasingly challenging maintenance requirements on these services moving forward. This has not been quantified for this assessment as it is likely to be a lower order of magnitude compared to other benefits in the assessment but remains a consideration for Council in maintaining their assets.

4.5 Summary of Costs

A summary of the undiscounted costs is provided in **Table 4-5**. These are provided to give an indication of overall costs associated with the masterplan. They indicate that both the total cost and the average cost per property associated with the Woy Woy masterplan are significantly higher than the costs for the other study areas. This difference could be attributed to the amount of roadworks required and also to the larger proportion of low-lying properties, which demand a higher average fill depth. For the other three study areas the overall average cost per property is roughly the same and, therefore, proportional to the number of properties included in the masterplan.

While it is useful to review the overall costs involved, these costs will be spread over the period 2025 to 2100. The present value of these cost estimates is provided in **Table 4-6**. Given the relatively long timespan of the proposed masterplan, the present value costs are significantly less than the undiscounted costs.

Table 4-5. Undiscounted Costs

Locations of Masterplan	Roads	Property Filling	Parks	Total	No of Properties	Avg Cost per property
Woy Woy	$40.9 M	$7.6 M	$1.1 M	$49.6 M	580	$85,517
Blackwall	$1.8 M	$0.2 M	$0.0 M	$2.0 M	32	$62,500
Booker Bay	$12.2 M	$1.6 M	$0.0 M	$13.8 M	209	$66,029
Ettalong	$6 M	$1 M	$0 M	$6.9 M	101	$68,317

Table 4-6. Present Value Costs of Masterplan Scenarios

Study Area	Costs	No of Properties	Avg Cost per property
Woy Woy	$6.7 M	580	$11,000
Blackwall	$0.1 M	32	$3,000
Booker Bay	$2.4 M	209	$11,000
Ettalong	$0.4 M	101	$4,000

5 Benefits

5.1 Retreat and Loss of Properties

As identified in **Section 3.1.1**, it is assumed in the base case that retreat from individual properties would be triggered by the 1% PoE exceeding the average property ground level. This effectively results in the loss of both the building and land asset.

Typical property prices were estimated for the four Study Areas as shown in **Table 5-1**. These were estimated based on data from realestate.com.au and cross checked against information from propertyvalue.com.au. Rather than adopting separate values for each study area, given the similarities between the four suburbs an overall average was adopted, as identified in **Table 5-1**.

It was assumed that this loss of value would occur in the year when the 1% PoE reaches the average ground level of the property. In reality, it is likely that values of the properties would start to decline earlier than this, as it becomes evident that sea level rise will impact on the suburb. However, from an economic viewpoint it is conservative to assume that the loss in value occurs in the final year (i.e. year of abandonment).

There are a number of different lot sizes throughout the study area. To account for this, an estimate of the value of land per square metre was made. This was estimated based on the average value of property as shown in **Table 5-1,** and divided by a property area of 770.5 m^2, which is the average lot area from the properties within the study area**.**

This value of property estimate was also applied to commercial properties within the study area as a coarse approximation of the commercial property value.

For lots with apartment buildings there was no information available for the number of apartment blocks within each affected lot. Therefore, no additional value was considered for the loss of apartment blocks within a single lot. Conservatively, it is assumed that these have the same value as a detached dwelling.

The commercial centre located at 52 Railway street was not considered as being lost. As explained in **Section 4.2**, since the building has an elevated floor level it would be possible to guarantee its usability by modifying the roads around it, with no need fill the site.

The time series of the loss of property value for Woy Woy and or the other three study areas is shown in **Figure 5-1** and **Figure 5-2**, respectively.

Table 5-1. Property Values[2]

Study Location	Property Value
Woy Woy	$735,500
Blackwall	$895,000
Booker Bay	$1,100,000
Ettalong	$850,000
Adopted Average	**$895,125**

[2] Based on realestate.com.au suburb profile data (www.realestate.com.au/neighbourhoods/woy-woy-2256-nsw), (www.realestate.com.au/neighbourhoods/blackwall-2256-nsw), (www.realestate.com.au/neighbourhoods/ettalong-beach-2257-nsw), and (www.realestate.com.au/neighbourhoods/booker-bay-2257-nsw) accessed on 30 April 2021. Data cross checked against propertyvalue.com.au (www.propertyvalue.com.au/map/woy%20woy-nsw-2256/buy).

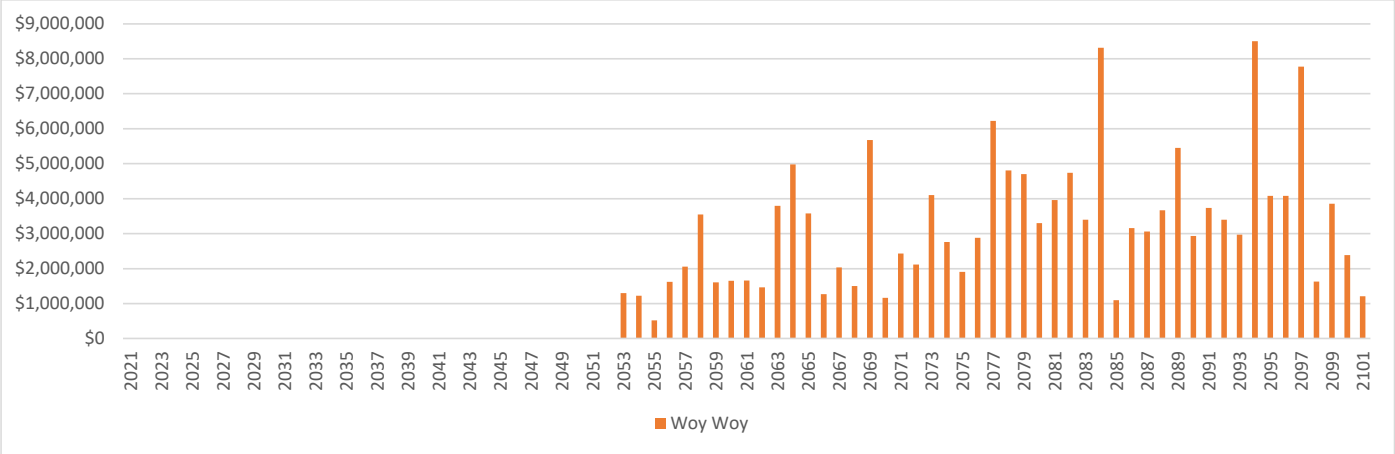

Figure 5-1. Retreat and Loss of Property Value – Woy Woy

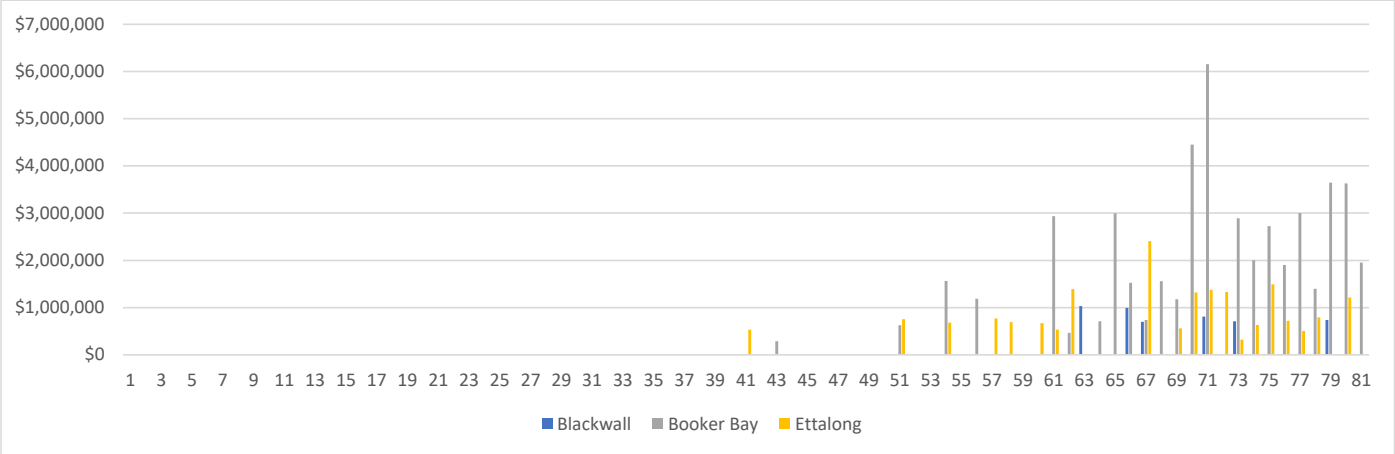

Figure 5-2. Retreat and Loss of Property Value – Booker Bay, Blackwall and Ettalong

5.2 Flood Damages

Flood damage is experienced on a property when flood waters inundate the property, resulting in overground flooding and potential overfloor flooding. This results in an economic impact, with repairs, damages to buildings and loss of building contents.

5.2.1 Flood Damage Curves

Flood damage curves are typically used to estimate the level of damage (in dollar terms) that is likely to be experienced at different depths of inundation. The Department of Planning, Industry and Environment have a guideline prepared that provides a methodology for estimating flood damages for residential structures (DECC, 2007). This guideline was adopted to establish a residential flood damage curve for the Woy Woy Peninsula. Key assumptions in the derivation of these curves in accordance with the guideline:

- Changes in average weekly earnings from 2001 to 2021 – 2.02
- Building floor area – 220m^2
- Building Damage Repair Factor – 0.9 (assuming a reasonable duration of inundation)
- Level of flood awareness – Low

- The high set (Queenslander style) development was assumed not to be present in the study area, and therefore only slab on ground and two storey were adopted.

In addition, there are a number of commercial properties in the study areas. ANUFLOOD estimate of commercial damages (for low value commercial) was adopted.

A summary of the damage curves is provided in **Figure 5-3**. The damage curves typically have a portion of external damages that trigger when overground flooding of a property occurs. For the analysed areas, there are large numbers of properties with relatively shallow overground flooding. It was conservatively assumed that no external damages occurred when depths of overground flooding were less than 0.2 metres.

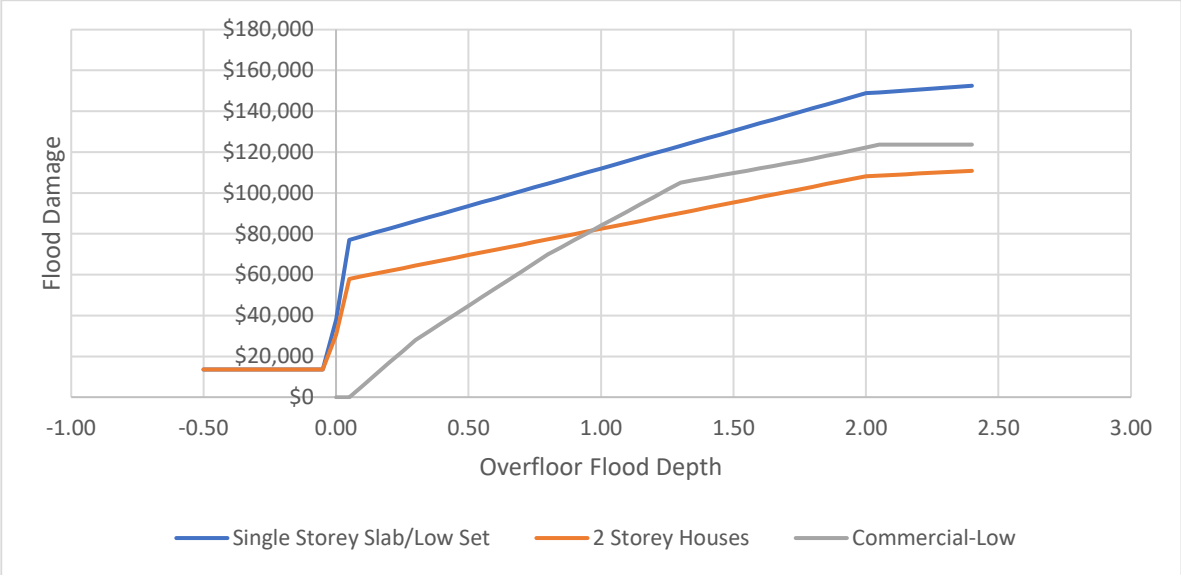

Figure 5-3. Flood Damage Curves

5.2.2 Flood Damages

Using the flood damage curves derived above, flood damages were calculated for each study area. Key inputs to this assessment:

- Floor Level Survey – based on information that was collected as a part of the *Woy Woy Floodplain Risk Management Study* (DHI, 2020). This data provides information on the floor level, as well as other property characteristics (such as two storey or one storey).
- Flood levels for Brisbane Water, as identified in **Table 2-1**.

Aligning with the information available and the key staging in the masterplan, the damages assessment was undertaken for four snapshots in time (2020, 2030, 2050 and 2100).

Under the base case, as identified in **Section 3.1.1**, retreat has been assumed for properties when the 1% PoE reaches the average property ground level. While this results in an impact on the loss of property value, the removal of that property results in a subsequent reduction in the number of properties exposed to flood damages. To account for this, these properties were removed from the damage analysis based on the period when their retreat would occur.

A summary of the damages and the overfloor flooding is provided in **Attachment B**. A summary of the damages is provided in **Figure 5-4** for the 2021 base case.

Annual Average Damages (AAD) is the typical method that is adopted in economics to annualise damage costs such as those in flooding based on their probabilities. This allows for the conversion of the different flood event damages into a singular annual average that represents (based on the overall probabilities of events) the most likely damage that is likely to be experienced in any given year. This process is described in detail in the Floodplain Development Manual (2005). It was assumed that there would be no damage in events more frequent than the 20% AEP.

The traditional approach is to calculate this AAD, and then assume that it remains constant for the economic assessment period. However, climate change results in a complication of this assumption, as the damage that is experienced in different flood events is likely to change, and therefore the AAD is no longer stationary.

In recognition of these changes, the AAD was calculated at four snapshots in time as noted above (2020, 2030, 2050 and 2100). It was then assumed that the AAD changed linearly between these snapshots, which effectively assumes a linear change in climate change and other time variant factors (such as the property retreat). These are summarised in **Figure 5-5** and **Figure 5-6**.

An interesting outcome of the analysis is the reduction of AAD in Woy Woy in the Base Case Scenario. This is a result of a relatively large number of properties that have other study areas, as only a small number of properties are abandoned in this study area.

As the base case assumes that redevelopment will still occur, and that properties will build to the flood planning level, there are minimal differences in flood damages between the two scenarios up to 2050, from this year onwards the difference becomes more significant.

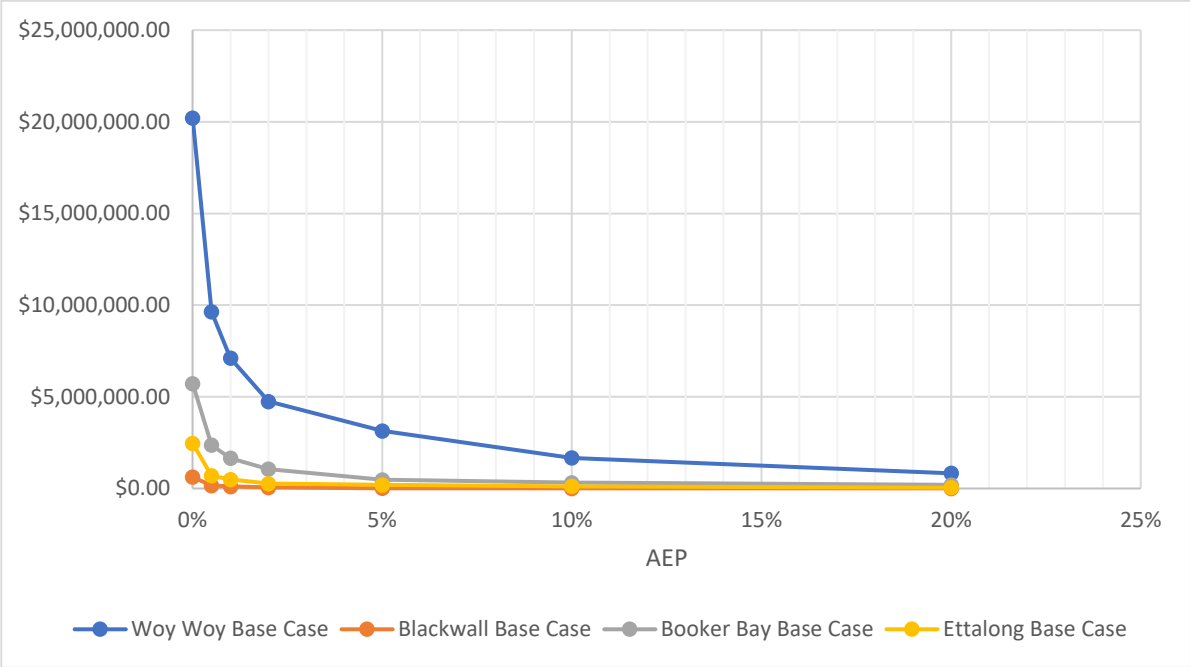

Figure 5-4. Flood Damages - Base Case – 2021

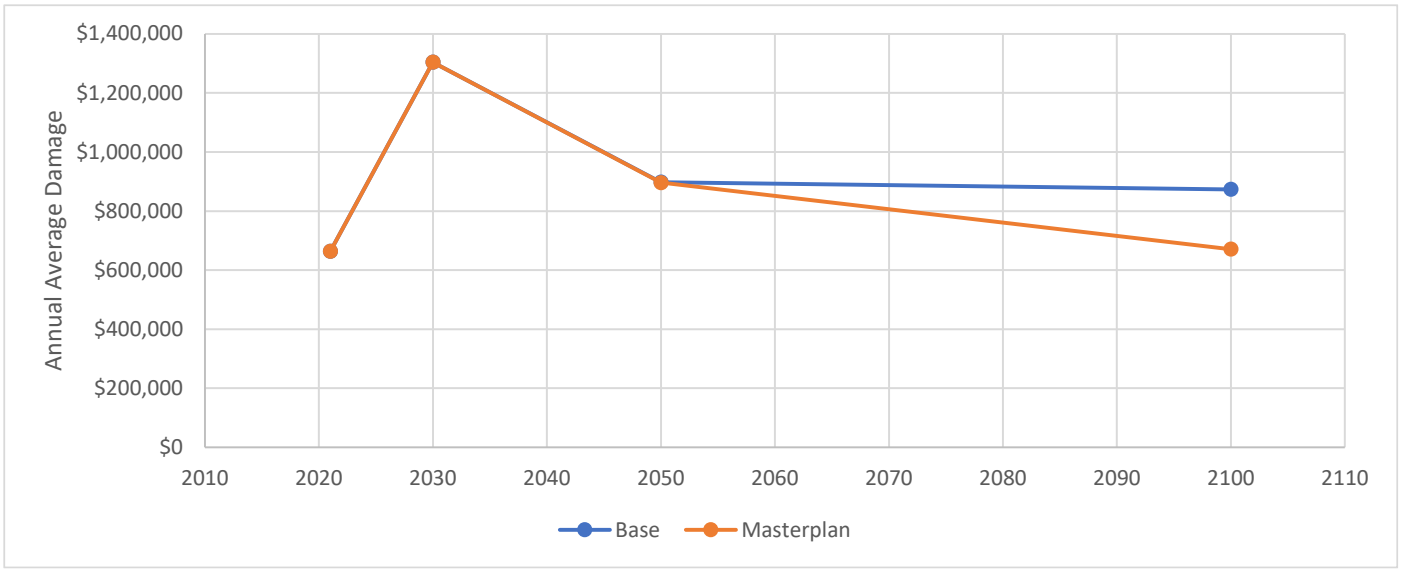

Figure 5-5.Woy Woy Annual Average Damage

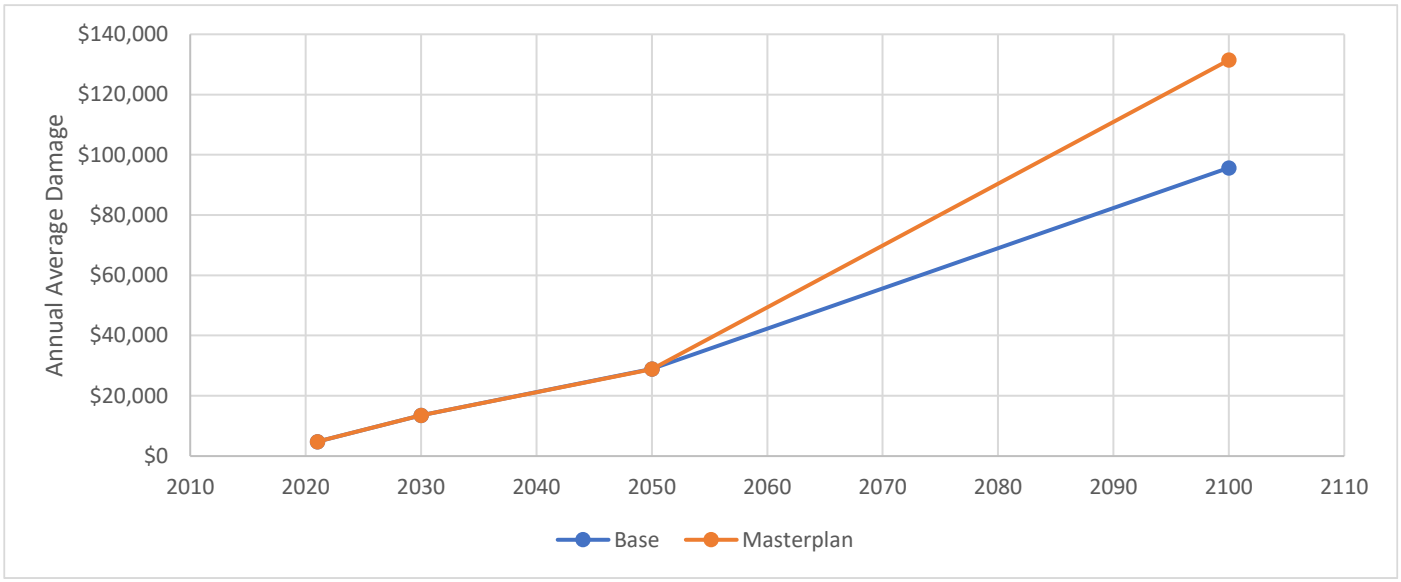

Figure 5-6. Blackwall Annual Average Damage

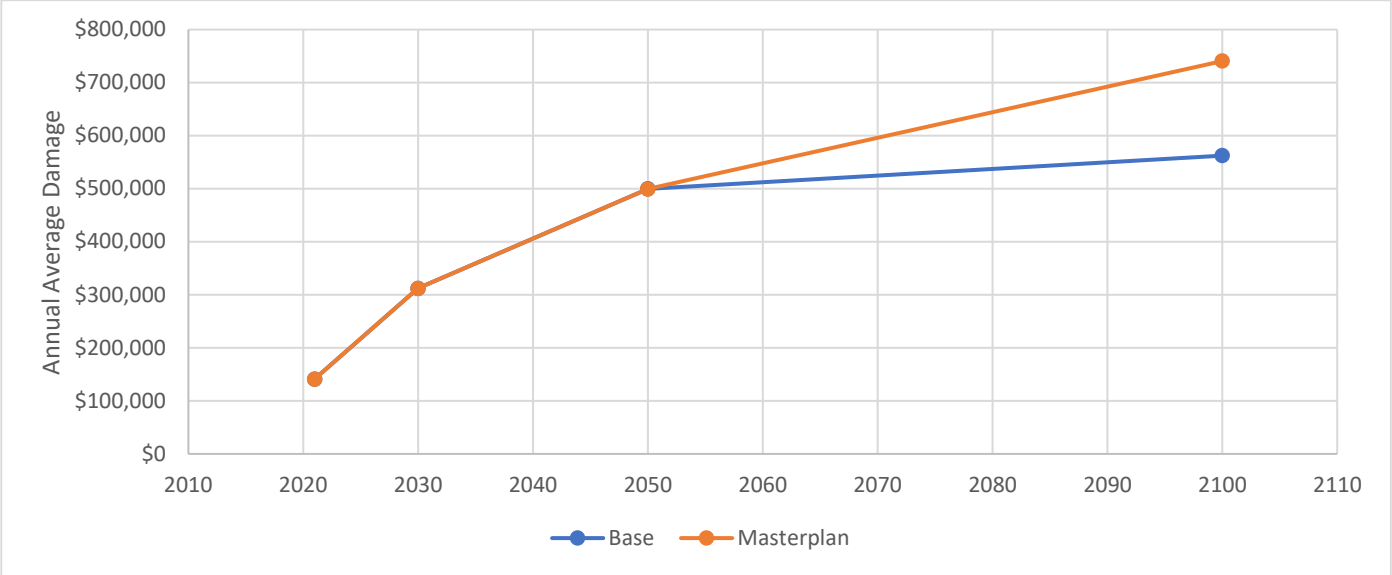

Figure 5-7. Booker Bay Annual Average Damage

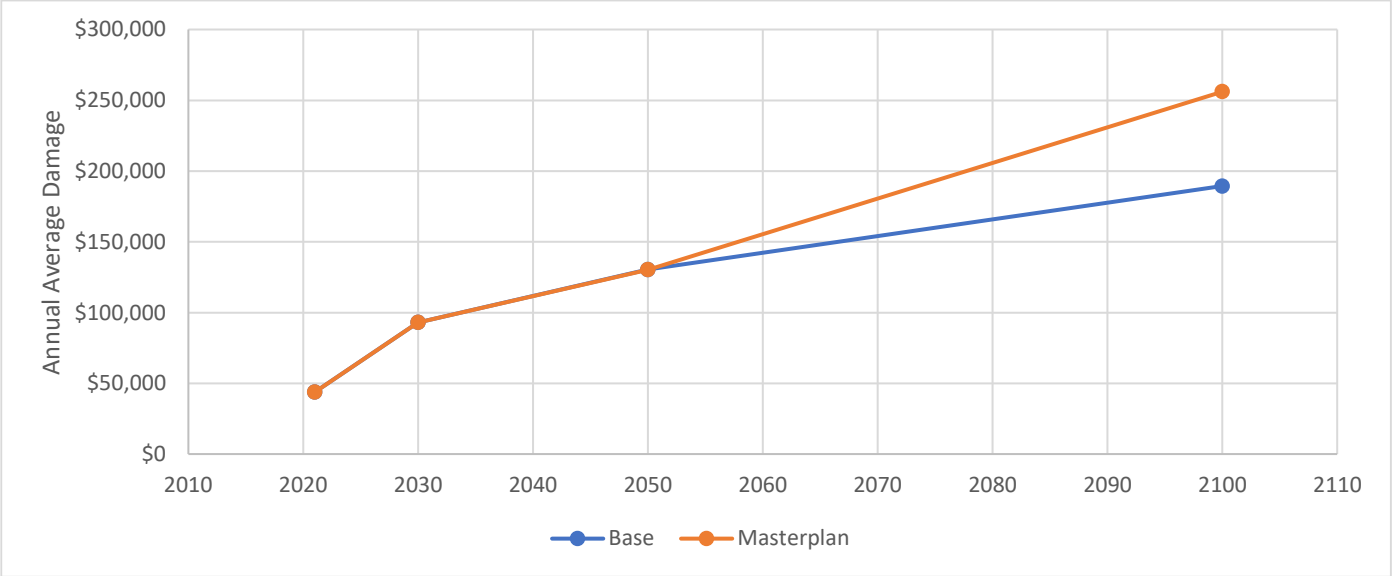

Figure 5-8. Ettalong Annual Average Damage

5.3 Loss of Public Infrastructure

The retreat under the base case will progressively result in the loss of key public infrastructure, including parks, roads, nature reserves and utilities and services. Of these, the following was included in the economic analysis:

- Roads and associated smaller services – these are the road areas plus services (such as power, telecommunications) provided alongside the road. It does not include major services such as pumping stations and sub-stations;
- Parks, both passive foreshore parks and recreational parks in the study areas.

At this stage, other services, such as pumping stations, sub-stations have conservatively not been included in the analysis.

5.3.1 Roads

With increasing sea levels, the existing roads will progressively become less usable and eventually need to be abandoned unless raising of the roads, along the lines of the masterplan, is undertaken.

Using LiDAR data, representative minimum, maximum and average levels along the various roads in the study area were extracted. Using this information, it was assumed that the road would be progressively abandoned once the 1% PoE reached the minimum ground level on the road[3]. It was assumed that there would be a linear loss of value between that point in time and when the 1% PoE reached the average ground level, when the entire road would be abandoned. The assumption on this basis is that once half of the road has been inundated by the 1% PoE, it is unlikely to be functional. This is particularly because a number of roads are undulating in the study area, and therefore there would be multiple points cut off along the road. Further, the minimum, average and maximum levels include road crest and gutter levels along a road, so may result in partial widths of the road being closed.

This is likely to be a relatively conservative assumption, given that the road base and services associated with the road would become progressively more difficult to maintain with rising sea levels.

The cost estimates provided in **Attachment A** were used as a basis to estimate the asset value of the roads. **Table 5-2** shows the items that were included in order to estimate the asset values. Based on a representative selection of the roads within the study area under the masterplan, a typical value of approximately $2,097 per metre was adopted.

A key consideration is understanding the point in its service life when the road would be abandoned. It is difficult to know when this would occur. For simplicity, it was assumed that on average the roads would be roughly 50% through their service life when they are abandoned.

Table 5-2. Cost Items included in Asset Value Estimate

Cost Component	Included (Y/N)	Comment
Establishment & Preliminaries	N	
Site Works	N	This generally includes the fill for the masterplan roads. Have excluded to be conservative.
Road works	Y	
Stormwater Drainage	Y	
Concrete Works	Y	
Signage and Road furniture	N	It was assumed that these would either be partially recoverable, or towards the end of their service life.
Testing and WAE	N	Assumed that this did not contribute to the asset value at the mid point of service life
Soil & Water management	N	Assumed that this did not contribute to the asset value at the mid point of service life
Service Conduit Installation	Y	
Miscellaneous	N	Assumed that this did not contribute to the asset value at the mid point of service life

[3] The earliest year when this would occur was adopted as 2025

5.3.2 Parks

Under the base case, the recreational (passive and active) parks in the study area would be progressively abandoned as they are inundated. The parks themselves have an economic value, which is combined by the value they provide to the community through recreational activities, visual amenity and general existence values.

Understanding this value would typically require detailed willingness to pay studies and surveys, or usage surveys on the parks. These types of studies have not been undertaken for the study area. In the absence of detailed studies, relevant literature reviewed.

Pascoe et al (2017) provides non-market values for a number of coastal areas, but does not include estimates for parkland. While there are some similar studies on parkland values, most require some estimate of the usage of the parkland. Given the lack of information on park usage, conservatively only the non-use value was considered based on Pascoe et al (2017).

A summary of the average non-use values from Pascoe et al (2017) are provided in **Table 5-3**. For the purposes of this study, it was conservatively assumed that the non-use value of the parks would be approximately $\$120/m^2$, which is on the lowest end of these values.

A review of the average cadastral lot and property values as identified in **Section 5.1**, suggests that the average property value is around $\$1,130/m^2$. Therefore, a value of $\$120/m^2$ would appear to be in the appropriate order of magnitude, and likely a conservative estimate.

The above only includes the non-use values of these assets. This is likely to represent a conservative estimate of the value, as it does not include the usage values. Usage values are likely to be more significant for the formal recreation parks, such as the tennis club and oval.

Table 5-3. Values for Different Areas (based on Pascoe, 2017)

	Value ($/square metre)
Sandy Beach	$263
Rocky Shoreline	$125
Dunes	$184
Scrubland	$149

For the parks, a minimum and maximum elevation were extracted for the base case. It was assumed that there would be a linear loss in value from the point at which the minimum elevation was inundation in the 1% PoE until the maximum elevation is reached. This assumes that the remaining areas of the park that are not inundated in a particular point of time are still operational and functional.

5.4 Unquantified Benefits

There are a number of unquantified benefits in this analysis. These generally have been excluded to be conservative, or where monetary values are more difficult to estimate. A summary of some of these includes:

- Loss of Public Infrastructure – no allowance was provided for the loss of public infrastructure assets beyond road and parks were included.
- Environmental values – no inclusion of environmental values was provided (other than through some non-use values for the parks).
- Recreational value – under the base case, the existing foreshore parks would be lost as retreat is undertaken. These parks would have a recreational value associated with them and have an overall value. This has not been included in the assessment.

The unquantified benefits are discussed in more detail in the Adaptation Study (Rhelm, 2021).

5.5 Summary of Benefits

A summary of the benefits described above are summarised in **Table 5-4**.

Table 5-4. Summary of Benefits (present values)

Study Areas	Property Retreat	Property Damages	Road Loss	Park Loss	Total	No of Properties	Avg Benefit per property
Woy Woy	$4.22 M	$0.11 M	$0.93 M	$0.37 M	$5.64 M	580	$10,000
Blackwall	$0.05 M	-$0.02 M	$0.00 M	$0.00 M	$0.04 M	32	$1,000
Booker Bay	$0.51 M	-$0.09 M	$0.14 M	$0.00 M	$0.56 M	209	$3,000
Ettalong	$0.26 M	-$0.03 M	$0.01 M	$0.00 M	$0.23 M	101	$2,000

6 Economic Results

The economic assessment was undertaken by comparing the masterplan scenarios against the base case, for all four study areas. These results are summarised in **Table 6-1**. In addition to the base assumption of a discount rate of 7%, 4% and 10% have also been tested.

For all the study areas, the masterplan has a BCR lower than 1, with the present value of cost exceeding the benefits. This suggests that the masterplan is economically unviable for these areas study area based on the assumptions in this report.

It should be noted that this analysis considered conservative assumptions that could be reviewed for the final version of this report.

Some examples of considerations with potential to change the analysis outcome are outlined below:

- Inclusion of usage values in the park loss evaluation.
- Review of the assumptions surrounding commercial property values.
- Alteration of some property values to account for multiple units within a single lot.
- Simulate starting the implementation of the masterplan in a period further into the future.

Table 6-1. Summary of Economic Results[4]

	Woy Woy		Blackwall		Booker Bay		Ettalong	
	NPV	BCR	NPV	BCR	NPV	BCR	NPV	BCR
7%	$-1.02 M	0.8	$-0.07 M	0.4	$-1.82 M	0.2	$-0.12 M	0.7
4%	$8.39 M	1.7	$-0.03 M	0.9	$-0.9 M	0.8	$0.3 M	1.3
10%	$-2.29M	0.5	$-0.04 M	0.1	$-1.44 M	0.1	$-0.1 M	0.3

[4] BCR – Benefit Cost Ratio, NPV – Net Present Value

7 Conclusions

An economic assessment has been undertaken on the draft masterplan prepared for the Woy Woy Peninsula as a part of the Rhelm (2021) *Woy Woy Peninsula Climate Change Adaptation Study*. This assessment has compared a Base Case or 'Do-Minimum' scenario against masterplan scenarios for Woy Woy, Blackwall, Booker Bay and Ettalong.

For all the study areas, the masterplan has a BCR lower than 1, with the present value of cost exceeding the benefits. This suggests that the masterplan is economically unviable for these study areas based on the assumptions in this report.

The highest BCR value and only marginally economically viable masterplan option is attributed to the Woy Woy location. This reflects the reality that this area is subject to tidal and ocean storm inundation in the relatively immediate future. The other three study locations are not significantly affected until the latter half of this century and their BCR values incur a costs well before the benefits are experienced when sea level rise begins to inundate the existing property and road ground levels. If, for example, the economic analysis for Blackwall, Booker Bay and Ettalong were undertaken starting in 2050 the resulting BCR values would significantly increase and the options may prove to be more economically viable.

8 References

Cardno (2015a) Brisbane Water Foreshore Floodplain Risk Management Study

Cardno Lawson Treloar (2010) Brisbane Water Foreshore Flood Study

Department of Environment and Climate Change (2007) *Floodplain Risk Management Guideline - Residential Flood Damages*, Revision 1, October.

NSW Government (2005). *Floodplain Development Manual.*

Pascoe, S., Doshi, A., Kovac M. & Austin, A. (2017). *What's my beach worth? Economic values of NSW coastal Assets*. NSW Coastal Conference: November 2017. Port Stephens, NSW.

Rhelm (2021). *Draft Woy Woy Peninsula Climate Change Adaptation Study*, May 2021.

ATTACHMENT 1 – COST ESTIMATES

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

The Boulevarde

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.3	ha	100,000	33,600
2.2	Import, place and compact select fill	621	m^3	40	24,853
2.3	Trim and compact verge areas and swales	2184	m^2	5	10,920
2.4	Topsoil and turf verge areas and swales	1932	m^2	10	19,320
2.5	Street trees	22	each	500	11,200.00
				Subtotal	**99,892.80**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1344	m^2	5	6,720
3.3	Subbase DGB20 (280mm thick)	1344	m^2	25	33,600
3.4	Base Course DGB20 (120mm thick)	1176	m^2	15	17,640
3.5	Prime Seal	1176	m^2	8	9,408
3.6	Asphalt AC10 (min 30mm thick)	1176	m^2	25	29,400
				Subtotal	**96,768**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	67	m	300	20,100
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	336	m	35	11,760
4.5	Pit (900x900)	2	each	2,500	5,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	2	Item	3,000	6,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**42,860**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	336	m	70	23,520

5.3	Footpath - 1.5m wide	168	m	150	25,200
				Subtotal	**48,720**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	168	m	15	2,520
				Subtotal	**2,520**

7	**TESTING & WAE**				
7.1	Density testing	168	m	20	3,360
7.2	Road & drainage works as executed	168	Item	15	2,520
				Subtotal	**5,880**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	168	m	20	3,360
				Subtotal	**3,360**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	168	m	20	3,360
9.2	Install new water conduit crossings	112	m	15	1,680
				Subtotal	**5,040**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**372,181**
				Contingency (30%)	**111,654**
				Total (excl GST)	**483,835**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	2	Lots	8,000	16,000
11.2	Underground telecommunications	2	Lots	1,000	2,000
11.3	Water reticulation	2	Lots	3,000	6,000
11.3	Re-connections allowance	2	Lots	10,000	20,000
				Subtotal	**44,000**
				Sub-total (excl GST)	**44,000**
				Contingency (30%)	**13,200**
				Total (excl GST)	**57,200**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	2	Lots	2,500	5,000
12.2	Geotechnical/pavement design	2	Lots	150	300
12.3	Electrical and street lighting design	2	Lots	250	500
12.4	Telecommunications design	2	Lots	80	160
				Subtotal	**5,960**
				Sub-total (excl GST)	**5,960**
				Contingency (20%)	**1,192**
				Total (excl GST)	**7,152**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	2	Lots	100	200
13.2	Telecommunications authority	2	Lots	600	1,200
13.3	Council	2	Lots	300	600
13.4	Water authority	2	Lots	80	160
				Subtotal	**2,160**
				Sub-total (excl GST)	**2,160**
				Contingency (20%)	**432**
				Total (excl GST)	**2,592**
				Grand Total including contingency (excl GST)	**550,779**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Brisbane Water Drive

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	1.1	ha	100,000	110,200
2.2	Import, place and compact select fill	6562	m^3	40	262,468
2.3	Trim and compact verge areas and swales	5510	m^2	5	27,550
2.4	Topsoil and turf verge areas and swales	4684	m^2	10	46,835
2.5	Street trees	73	each	500	36,733.33
				Subtotal	**483,786.33**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	6061	m^2	5	30,305
3.3	Subbase DGB20 (280mm thick)	6061	m^2	25	151,525
3.4	Base Course DGB20 (120mm thick)	5510	m^2	15	82,650
3.5	Prime Seal	5510	m^2	8	44,080
3.6	Asphalt AC10 (min 30mm thick)	5510	m^2	25	137,750
				Subtotal	**446,310**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	733	m	300	219,900
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	1102	m	35	38,570
4.5	Pit (900x900)	34	each	2,500	85,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	3	Item	3,000	9,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**352,470**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	1102	m	70	77,140
5.3	Footpath - 1.5m wide	551	m	150	82,650
				Subtotal	**159,790**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	551	m	15	8,265
				Subtotal	**8,265**

7	**TESTING & WAE**				
7.1	Density testing	551	m	20	11,020
7.2	Road & drainage works as executed	551	Item	15	8,265
				Subtotal	**19,285**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	551	m	20	11,020
				Subtotal	**11,020**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	551	m	20	11,020
9.2	Install new water conduit crossings	367	m	15	5,510
				Subtotal	**16,530**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**1,607,456**
				Contingency (30%)	**482,237**
				Total (excl GST)	**2,089,693**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	31	Lots	8,000	248,000
11.2	Underground telecommunications	31	Lots	1,000	31,000
11.3	Water reticulation	31	Lots	3,000	93,000
11.3	Re-connections allowance	31	Lots	10,000	310,000
				Subtotal	**682,000**
				Sub-total (excl GST)	**682,000**
				Contingency (30%)	**204,600**
				Total (excl GST)	**886,600**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	31	Lots	2,500	77,500
12.2	Geotechnical/pavement design	31	Lots	150	4,650
12.3	Electrical and street lighting design	31	Lots	250	7,750
12.4	Telecommunications design	31	Lots	80	2,480
				Subtotal	**92,380**
				Sub-total (excl GST)	**92,380**
				Contingency (20%)	**18,476**
				Total (excl GST)	**110,856**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	31	Lots	100	3,100
13.2	Telecommunications authority	31	Lots	600	18,600
13.3	Council	31	Lots	300	9,300
13.4	Water authority	31	Lots	80	2,480
				Subtotal	**33,480**
				Sub-total (excl GST)	**33,480**
				Contingency (20%)	**6,696**
				Total (excl GST)	**40,176**
				Grand Total including contingency (excl GST)	**3,127,325**

Allen Price & Scarratts
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NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Brick Wharf Road

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	2.1	ha	100,000	214,200
2.2	Import, place and compact select fill	13291	m^3	40	531,628
2.3	Trim and compact verge areas and swales	10710	m^2	5	53,550
2.4	Topsoil and turf verge areas and swales	9104	m^2	10	91,035
2.5	Street trees	143	each	500	71,400.00
				Subtotal	**961,813.00**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	11781	m^2	5	58,905
3.3	Subbase DGB20 (280mm thick)	11781	m^2	25	294,525
3.4	Base Course DGB20 (120mm thick)	10710	m^2	15	160,650
3.5	Prime Seal	10710	m^2	8	85,680
3.6	Asphalt AC10 (min 30mm thick)	10710	m^2	25	267,750
				Subtotal	**867,510**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	1030	m	300	309,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	2142	m	35	74,970
4.5	Pit (900x900)	32	each	2,500	80,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	6	Item	3,000	18,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**481,970**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	2142	m	50	107,100

5.2	Kerb - Upright Kerb & Gutter	2142	m	70	149,940
5.3	Footpath - 1.5m wide	1071	m	150	160,650
				Subtotal	**417,690**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	1071	m	15	16,065
				Subtotal	**16,065**

7	**TESTING & WAE**				
7.1	Density testing	1071	m	20	21,420
7.2	Road & drainage works as executed	1071	Item	15	16,065
				Subtotal	**37,485**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	1071	m	20	21,420
				Subtotal	**21,420**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	1071	m	20	21,420
9.2	Install new water conduit crossings	714	m	15	10,710
				Subtotal	**32,130**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**2,946,083**
				Contingency (30%)	**883,825**
				Total (excl GST)	**3,829,908**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	90	Lots	8,000	720,000
11.2	Underground telecommunications	90	Lots	1,000	90,000
11.3	Water reticulation	90	Lots	3,000	270,000
11.3	Re-connections allowance	90	Lots	10,000	900,000
				Subtotal	**1,980,000**
				Sub-total (excl GST)	**1,980,000**
				Contingency (30%)	**594,000**
				Total (excl GST)	**2,574,000**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	90	Lots	2,500	225,000
12.2	Geotechnical/pavement design	90	Lots	150	13,500
12.3	Electrical and street lighting design	90	Lots	250	22,500
12.4	Telecommunications design	90	Lots	80	7,200
				Subtotal	**268,200**
				Sub-total (excl GST)	**268,200**
				Contingency (20%)	**53,640**
				Total (excl GST)	**321,840**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	90	Lots	100	9,000
13.2	Telecommunications authority	90	Lots	600	54,000
13.3	Council	90	Lots	300	27,000
13.4	Water authority	90	Lots	80	7,200
				Subtotal	**97,200**
				Sub-total (excl GST)	**97,200**
				Contingency (20%)	**19,440**
				Total (excl GST)	**116,640**
				Grand Total including contingency (excl GST)	**6,842,388**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Chamber Place

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.3	ha	100,000	33,800
2.2	Import, place and compact select fill	1490	m^3	40	59,612
2.3	Trim and compact verge areas and swales	1690	m^2	5	8,450
2.4	Topsoil and turf verge areas and swales	1437	m^2	10	14,365
2.5	Street trees	23	each	500	11,266.67
				Subtotal	**127,493.67**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1859	m^2	5	9,295
3.3	Subbase DGB20 (280mm thick)	1859	m^2	25	46,475
3.4	Base Course DGB20 (120mm thick)	1690	m^2	15	25,350
3.5	Prime Seal	1690	m^2	8	13,520
3.6	Asphalt AC10 (min 30mm thick)	1690	m^2	25	42,250
				Subtotal	**136,890**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	35	m	300	10,500
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	338	m	35	11,830
4.5	Pit (900x900)	3	each	2,500	7,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**29,830**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	338	m	70	23,660
5.3	Footpath - 1.5m wide	169	m	150	25,350
				Subtotal	**49,010**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	169	m	15	2,535
				Subtotal	**2,535**

7	**TESTING & WAE**				
7.1	Density testing	169	m	20	3,380
7.2	Road & drainage works as executed	169	Item	15	2,535
				Subtotal	**5,915**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	169	m	20	3,380
				Subtotal	**3,380**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	169	m	20	3,380
9.2	Install new water conduit crossings	113	m	15	1,690
				Subtotal	**5,070**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**470,124**
				Contingency (30%)	**141,037**
				Total (excl GST)	**611,161**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	14	Lots	8,000	112,000
11.2	Underground telecommunications	14	Lots	1,000	14,000
11.3	Water reticulation	14	Lots	3,000	42,000
11.3	Re-connections allowance	14	Lots	10,000	140,000
				Subtotal	**308,000**
				Sub-total (excl GST)	**308,000**
				Contingency (30%)	**92,400**
				Total (excl GST)	**400,400**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	14	Lots	2,500	35,000
12.2	Geotechnical/pavement design	14	Lots	150	2,100
12.3	Electrical and street lighting design	14	Lots	250	3,500
12.4	Telecommunications design	14	Lots	80	1,120
				Subtotal	**41,720**
				Sub-total (excl GST)	**41,720**
				Contingency (20%)	**8,344**
				Total (excl GST)	**50,064**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	14	Lots	100	1,400
13.2	Telecommunications authority	14	Lots	600	8,400
13.3	Council	14	Lots	300	4,200
13.4	Water authority	14	Lots	80	1,120
				Subtotal	**15,120**
				Sub-total (excl GST)	**15,120**
				Contingency (20%)	**3,024**
				Total (excl GST)	**18,144**
				Grand Total including contingency (excl GST)	**1,079,769**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Black Wall Drive

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.7	ha	100,000	74,600
2.2	Import, place and compact select fill	1880	m^3	40	75,204
2.3	Trim and compact verge areas and swales	3730	m^2	5	18,650
2.4	Topsoil and turf verge areas and swales	3171	m^2	10	31,705
2.5	Street trees	50	each	500	24,866.67
				Subtotal	**225,025.67**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	4103	m^2	5	20,515
3.3	Subbase DGB20 (280mm thick)	4103	m^2	25	102,575
3.4	Base Course DGB20 (120mm thick)	3730	m^2	15	55,950
3.5	Prime Seal	3730	m^2	8	29,840
3.6	Asphalt AC10 (min 30mm thick)	3730	m^2	25	93,250
				Subtotal	**302,130**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	317	m	300	95,100
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	746	m	35	26,110
4.5	Pit (900x900)	11	each	2,500	27,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	RCBC Headwall	1	Item	5,000	5,000
4.12	2.1 x 0.750 RCBC	48	m	5,000	240,000
				Subtotal	**396,710**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	746	m	70	52,220
5.3	Footpath - 1.5m wide	373	m	150	55,950
				Subtotal	**108,170**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	373	m	15	5,595
				Subtotal	**5,595**

7	**TESTING & WAE**				
7.1	Density testing	373	m	20	7,460
7.2	Road & drainage works as executed	373	Item	15	5,595
				Subtotal	**13,055**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	373	m	20	7,460
				Subtotal	**7,460**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	373	m	20	7,460
9.2	Install new water conduit crossings	249	m	15	3,730
				Subtotal	**11,190**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**1,179,336**
				Contingency (30%)	**353,801**
				Total (excl GST)	**1,533,136**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	31	Lots	8,000	248,000
11.2	Underground telecommunications	31	Lots	1,000	31,000
11.3	Water reticulation	31	Lots	3,000	93,000
11.3	Re-connections allowance	31	Lots	10,000	310,000
				Subtotal	**682,000**
				Sub-total (excl GST)	**682,000**
				Contingency (30%)	**204,600**
				Total (excl GST)	**886,600**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	31	Lots	2,500	77,500
12.2	Geotechnical/pavement design	31	Lots	150	4,650
12.3	Electrical and street lighting design	31	Lots	250	7,750
12.4	Telecommunications design	31	Lots	80	2,480
				Subtotal	**92,380**
				Sub-total (excl GST)	**92,380**
				Contingency (20%)	**18,476**
				Total (excl GST)	**110,856**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	31	Lots	100	3,100
13.2	Telecommunications authority	31	Lots	600	18,600
13.3	Council	31	Lots	300	9,300
13.4	Water authority	31	Lots	80	2,480
				Subtotal	**33,480**
				Sub-total (excl GST)	**33,480**
				Contingency (20%)	**6,696**
				Total (excl GST)	**40,176**
				Grand Total including contingency (excl GST)	**2,570,768**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Charlton Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.3	ha	100,000	27,200
2.2	Import, place and compact select fill	0	m^3	40	-
2.3	Trim and compact verge areas and swales	1360	m^2	5	6,800
2.4	Topsoil and turf verge areas and swales	1156	m^2	10	11,560
2.5	Street trees	18	each	500	9,066.67
				Subtotal	**54,626.67**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1496	m^2	5	7,480
3.3	Subbase DGB20 (280mm thick)	1496	m^2	25	37,400
3.4	Base Course DGB20 (120mm thick)	1360	m^2	15	20,400
3.5	Prime Seal	1360	m^2	8	10,880
3.6	Asphalt AC10 (min 30mm thick)	1360	m^2	25	34,000
				Subtotal	**110,160**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	118	m	300	35,400
4.3	DN900 RRJ Class 3	281	m	550	154,550
4.4	DN100mm subsoil drainage	272	m	35	9,520
4.5	Pit (900x900)	8	each	2,500	20,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**219,470**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	272	m	70	19,040
5.3	Footpath - 1.5m wide	136	m	150	20,400
				Subtotal	**39,440**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	136	m	15	2,040
				Subtotal	**2,040**

7	**TESTING & WAE**				
7.1	Density testing	136	m	20	2,720
7.2	Road & drainage works as executed	136	Item	15	2,040
				Subtotal	**4,760**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	136	m	20	2,720
				Subtotal	**2,720**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	136	m	20	2,720
9.2	Install new water conduit crossings	91	m	15	1,360
				Subtotal	**4,080**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**547,297**
				Contingency (30%)	**164,189**
				Total (excl GST)	**711,486**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	6	Lots	8,000	48,000
11.2	Underground telecommunications	6	Lots	1,000	6,000
11.3	Water reticulation	6	Lots	3,000	18,000
11.3	Re-connections allowance	6	Lots	10,000	60,000
				Subtotal	**132,000**
				Sub-total (excl GST)	**132,000**
				Contingency (30%)	**39,600**
				Total (excl GST)	**171,600**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	6	Lots	2,500	15,000
12.2	Geotechnical/pavement design	6	Lots	150	900
12.3	Electrical and street lighting design	6	Lots	250	1,500
12.4	Telecommunications design	6	Lots	80	480
				Subtotal	**17,880**
				Sub-total (excl GST)	**17,880**
				Contingency (20%)	**3,576**
				Total (excl GST)	**21,456**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	6	Lots	100	600
13.2	Telecommunications authority	6	Lots	600	3,600
13.3	Council	6	Lots	300	1,800
13.4	Water authority	6	Lots	80	480
				Subtotal	**6,480**
				Sub-total (excl GST)	**6,480**
				Contingency (20%)	**1,296**
				Total (excl GST)	**7,776**
				Grand Total including contingency (excl GST)	**912,318**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

George Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.7	ha	100,000	70,200
2.2	Import, place and compact select fill	0	m^3	40	-
2.3	Trim and compact verge areas and swales	3510	m^2	5	17,550
2.4	Topsoil and turf verge areas and swales	2984	m^2	10	29,835
2.5	Street trees	47	each	500	23,400.00
				Subtotal	**140,985.00**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	3861	m^2	5	19,305
3.3	Subbase DGB20 (280mm thick)	3861	m^2	25	96,525
3.4	Base Course DGB20 (120mm thick)	3510	m^2	15	52,650
3.5	Prime Seal	3510	m^2	8	28,080
3.6	Asphalt AC10 (min 30mm thick)	3510	m^2	25	87,750
				Subtotal	**284,310**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	0	m	300	-
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	702	m	35	24,570
4.5	Pit (900x900)	0	each	2,500	-
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	RCBC Headwall	2	Item	5,000	10,000
4.12	2.1 x 0.750 RCBC	31	m	5,000	152,500
				Subtotal	**187,070**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	702	m	70	49,140
5.3	Footpath - 1.5m wide	351	m	150	52,650
				Subtotal	**101,790**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	351	m	15	5,265
				Subtotal	**5,265**

7	**TESTING & WAE**				
7.1	Density testing	351	m	20	7,020
7.2	Road & drainage works as executed	351	Item	15	5,265
				Subtotal	**12,285**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	351	m	20	7,020
				Subtotal	**7,020**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	351	m	20	7,020
9.2	Install new water conduit crossings	234	m	15	3,510
				Subtotal	**10,530**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**859,255**
				Contingency (30%)	**257,777**
				Total (excl GST)	**1,117,032**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	9	Lots	8,000	72,000
11.2	Underground telecommunications	9	Lots	1,000	9,000
11.3	Water reticulation	9	Lots	3,000	27,000
11.3	Re-connections allowance	9	Lots	10,000	90,000
				Subtotal	**198,000**
				Sub-total (excl GST)	**198,000**
				Contingency (30%)	**59,400**
				Total (excl GST)	**257,400**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	9	Lots	2,500	22,500
12.2	Geotechnical/pavement design	9	Lots	150	1,350
12.3	Electrical and street lighting design	9	Lots	250	2,250
12.4	Telecommunications design	9	Lots	80	720
				Subtotal	**26,820**
				Sub-total (excl GST)	**26,820**
				Contingency (20%)	**5,364**
				Total (excl GST)	**32,184**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	9	Lots	100	900
13.2	Telecommunications authority	9	Lots	600	5,400
13.3	Council	9	Lots	300	2,700
13.4	Water authority	9	Lots	80	720
				Subtotal	**9,720**
				Sub-total (excl GST)	**9,720**
				Contingency (20%)	**1,944**
				Total (excl GST)	**11,664**
				Grand Total including contingency (excl GST)	**1,418,280**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Victoria Road

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.4	ha	100,000	35,600
2.2	Import, place and compact select fill	281	m^3	40	11,224
2.3	Trim and compact verge areas and swales	1780	m^2	5	8,900
2.4	Topsoil and turf verge areas and swales	1513	m^2	10	15,130
2.5	Street trees	24	each	500	11,866.67
				Subtotal	**82,720.67**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1958	m^2	5	9,790
3.3	Subbase DGB20 (280mm thick)	1958	m^2	25	48,950
3.4	Base Course DGB20 (120mm thick)	1780	m^2	15	26,700
3.5	Prime Seal	1780	m^2	8	14,240
3.6	Asphalt AC10 (min 30mm thick)	1780	m^2	25	44,500
				Subtotal	**144,180**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	110	m	300	33,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	356	m	35	12,460
4.5	Pit (900x900)	5	each	2,500	12,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**57,960**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	356	m	70	24,920
5.3	Footpath - 1.5m wide	178	m	150	26,700
				Subtotal	**51,620**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	178	m	15	2,670
				Subtotal	**2,670**

7	**TESTING & WAE**				
7.1	Density testing	178	m	20	3,560
7.2	Road & drainage works as executed	178	Item	15	2,670
				Subtotal	**6,230**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	178	m	20	3,560
				Subtotal	**3,560**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	178	m	20	3,560
9.2	Install new water conduit crossings	119	m	15	1,780
				Subtotal	**5,340**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**464,281**
				Contingency (30%)	**139,284**
				Total (excl GST)	**603,565**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	6	Lots	8,000	48,000
11.2	Underground telecommunications	6	Lots	1,000	6,000
11.3	Water reticulation	6	Lots	3,000	18,000
11.3	Re-connections allowance	6	Lots	10,000	60,000
				Subtotal	**132,000**
				Sub-total (excl GST)	**132,000**
				Contingency (30%)	**39,600**
				Total (excl GST)	**171,600**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	6	Lots	2,500	15,000
12.2	Geotechnical/pavement design	6	Lots	150	900
12.3	Electrical and street lighting design	6	Lots	250	1,500
12.4	Telecommunications design	6	Lots	80	480
				Subtotal	**17,880**
				Sub-total (excl GST)	**17,880**
				Contingency (20%)	**3,576**
				Total (excl GST)	**21,456**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	6	Lots	100	600
13.2	Telecommunications authority	6	Lots	600	3,600
13.3	Council	6	Lots	300	1,800
13.4	Water authority	6	Lots	80	480
				Subtotal	**6,480**
				Sub-total (excl GST)	**6,480**
				Contingency (20%)	**1,296**
				Total (excl GST)	**7,776**
				Grand Total including contingency (excl GST)	**804,397**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Regina Close

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	13,800
2.2	Import, place and compact select fill	347	m^3	40	13,883
2.3	Trim and compact verge areas and swales	736	m^2	5	3,680
2.4	Topsoil and turf verge areas and swales	598	m^2	10	5,980
2.5	Street trees	12	each	500	6,133.33
				Subtotal	**43,476.53**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	736	m^2	5	3,680
3.3	Subbase DGB20 (280mm thick)	736	m^2	25	18,400
3.4	Base Course DGB20 (120mm thick)	644	m^2	15	9,660
3.5	Prime Seal	644	m^2	8	5,152
3.6	Asphalt AC10 (min 30mm thick)	644	m^2	25	16,100
				Subtotal	**52,992**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	40	m	300	12,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	184	m	35	6,440
4.5	Pit (900x900)	2	each	2,500	5,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**26,440**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	184	m	70	12,880
5.3	Footpath - 1.5m wide	92	m	150	13,800
				Subtotal	**26,680**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	92	m	15	1,380
				Subtotal	**1,380**

7	**TESTING & WAE**				
7.1	Density testing	92	m	20	1,840
7.2	Road & drainage works as executed	92	Item	15	1,380
				Subtotal	**3,220**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	92	m	20	1,840
				Subtotal	**1,840**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	92	m	20	1,840
9.2	Install new water conduit crossings	61	m	15	920
				Subtotal	**2,760**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**268,789**
				Contingency (30%)	**80,637**
				Total (excl GST)	**349,425**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	7	Lots	8,000	56,000
11.2	Underground telecommunications	7	Lots	1,000	7,000
11.3	Water reticulation	7	Lots	3,000	21,000
11.3	Re-connections allowance	7	Lots	10,000	70,000
				Subtotal	**154,000**
				Sub-total (excl GST)	**154,000**
				Contingency (30%)	**46,200**
				Total (excl GST)	**200,200**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	7	Lots	2,500	17,500
12.2	Geotechnical/pavement design	7	Lots	150	1,050
12.3	Electrical and street lighting design	7	Lots	250	1,750
12.4	Telecommunications design	7	Lots	80	560
				Subtotal	**20,860**
				Sub-total (excl GST)	**20,860**
				Contingency (20%)	**4,172**
				Total (excl GST)	**25,032**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	7	Lots	100	700
13.2	Telecommunications authority	7	Lots	600	4,200
13.3	Council	7	Lots	300	2,100
13.4	Water authority	7	Lots	80	560
				Subtotal	**7,560**
				Sub-total (excl GST)	**7,560**
				Contingency (20%)	**1,512**
				Total (excl GST)	**9,072**
				Grand Total including contingency (excl GST)	**583,729**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Robin Crescent

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.9	ha	100,000	93,450
2.2	Import, place and compact select fill	1006	m^3	40	40,231
2.3	Trim and compact verge areas and swales	4984	m^2	5	24,920
2.4	Topsoil and turf verge areas and swales	4050	m^2	10	40,495
2.5	Street trees	83	each	500	41,533.33
				Subtotal	**240,629.13**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	4984	m^2	5	24,920
3.3	Subbase DGB20 (280mm thick)	4984	m^2	25	124,600
3.4	Base Course DGB20 (120mm thick)	4361	m^2	15	65,415
3.5	Prime Seal	4361	m^2	8	34,888
3.6	Asphalt AC10 (min 30mm thick)	4361	m^2	25	109,025
				Subtotal	**358,848**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	240	m	300	72,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	1246	m	35	43,610
4.5	Pit (900x900)	9	each	2,500	22,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	5	Item	3,000	15,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**153,110**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	1246	m	70	87,220
5.3	Footpath - 1.5m wide	623	m	150	93,450
				Subtotal	**180,670**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	623	m	15	9,345
				Subtotal	**9,345**

7	**TESTING & WAE**				
7.1	Density testing	623	m	20	12,460
7.2	Road & drainage works as executed	623	Item	15	9,345
				Subtotal	**21,805**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	623	m	20	12,460
				Subtotal	**12,460**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	623	m	20	12,460
9.2	Install new water conduit crossings	415	m	15	6,230
				Subtotal	**18,690**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**1,105,557**
				Contingency (30%)	**331,667**
				Total (excl GST)	**1,437,224**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	75	Lots	8,000	600,000
11.2	Underground telecommunications	75	Lots	1,000	75,000
11.3	Water reticulation	75	Lots	3,000	225,000
11.3	Re-connections allowance	75	Lots	10,000	750,000
				Subtotal	**1,650,000**
				Sub-total (excl GST)	**1,650,000**
				Contingency (30%)	**495,000**
				Total (excl GST)	**2,145,000**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	75	Lots	2,500	187,500
12.2	Geotechnical/pavement design	75	Lots	150	11,250
12.3	Electrical and street lighting design	75	Lots	250	18,750
12.4	Telecommunications design	75	Lots	80	6,000
				Subtotal	**223,500**
				Sub-total (excl GST)	**223,500**
				Contingency (20%)	**44,700**
				Total (excl GST)	**268,200**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	75	Lots	100	7,500
13.2	Telecommunications authority	75	Lots	600	45,000
13.3	Council	75	Lots	300	22,500
13.4	Water authority	75	Lots	80	6,000
				Subtotal	**81,000**
				Sub-total (excl GST)	**81,000**
				Contingency (20%)	**16,200**
				Total (excl GST)	**97,200**
				Grand Total including contingency (excl GST)	**3,947,624**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Iris Place

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	7,200
2.2	Import, place and compact select fill	0	m^3	40	-
2.3	Trim and compact verge areas and swales	384	m^2	5	1,920
2.4	Topsoil and turf verge areas and swales	312	m^2	10	3,120
2.5	Street trees	6	each	500	3,200.00
				Subtotal	**15,440.00**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	384	m^2	5	1,920
3.3	Subbase DGB20 (280mm thick)	384	m^2	25	9,600
3.4	Base Course DGB20 (120mm thick)	336	m^2	15	5,040
3.5	Prime Seal	336	m^2	8	2,688
3.6	Asphalt AC10 (min 30mm thick)	336	m^2	25	8,400
				Subtotal	**27,648**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	95	m	300	28,500
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	96	m	35	3,360
4.5	Pit (900x900)	3	each	2,500	7,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**39,360**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	96	m	70	6,720
5.3	Footpath - 1.5m wide	48	m	150	7,200
				Subtotal	**13,920**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	48	m	15	720
				Subtotal	**720**

7	**TESTING & WAE**				
7.1	Density testing	48	m	20	960
7.2	Road & drainage works as executed	48	Item	15	720
				Subtotal	**1,680**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	48	m	20	960
				Subtotal	**960**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	48	m	20	960
9.2	Install new water conduit crossings	32	m	15	480
				Subtotal	**1,440**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**211,168**
				Contingency (30%)	**63,350**
				Total (excl GST)	**274,518**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	8	Lots	8,000	64,000
11.2	Underground telecommunications	8	Lots	1,000	8,000
11.3	Water reticulation	8	Lots	3,000	24,000
11.3	Re-connections allowance	8	Lots	10,000	80,000
				Subtotal	**176,000**
				Sub-total (excl GST)	**176,000**
				Contingency (30%)	**52,800**
				Total (excl GST)	**228,800**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	8	Lots	2,500	20,000
12.2	Geotechnical/pavement design	8	Lots	150	1,200
12.3	Electrical and street lighting design	8	Lots	250	2,000
12.4	Telecommunications design	8	Lots	80	640
				Subtotal	**23,840**
				Sub-total (excl GST)	**23,840**
				Contingency (20%)	**4,768**
				Total (excl GST)	**28,608**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	8	Lots	100	800
13.2	Telecommunications authority	8	Lots	600	4,800
13.3	Council	8	Lots	300	2,400
13.4	Water authority	8	Lots	80	640
				Subtotal	**8,640**
				Sub-total (excl GST)	**8,640**
				Contingency (20%)	**1,728**
				Total (excl GST)	**10,368**
				Grand Total including contingency (excl GST)	**542,294**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Camellia Circle

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	1.0	ha	100,000	98,700
2.2	Import, place and compact select fill	1112	m^3	40	44,497
2.3	Trim and compact verge areas and swales	5264	m^2	5	26,320
2.4	Topsoil and turf verge areas and swales	4277	m^2	10	42,770
2.5	Street trees	88	each	500	43,866.67
				Subtotal	**256,153.47**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	5264	m^2	5	26,320
3.3	Subbase DGB20 (280mm thick)	5264	m^2	25	131,600
3.4	Base Course DGB20 (120mm thick)	4606	m^2	15	69,090
3.5	Prime Seal	4606	m^2	8	36,848
3.6	Asphalt AC10 (min 30mm thick)	4606	m^2	25	115,150
				Subtotal	**379,008**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	110	m	300	33,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	1316	m	35	46,060
4.5	Pit (900x900)	13	each	2,500	32,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	2	Item	3,000	6,000
4.10	DN900mm Headwall	0	Item	3,500	-
				Subtotal	**117,560**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	1316	m	70	92,120

5.3	Footpath - 1.5m wide	658	m	150	98,700
				Subtotal	**190,820**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	658	m	15	9,870
				Subtotal	**9,870**

7	**TESTING & WAE**				
7.1	Density testing	658	m	20	13,160
7.2	Road & drainage works as executed	658	Item	15	9,870
				Subtotal	**23,030**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	658	m	20	13,160
				Subtotal	**13,160**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	658	m	20	13,160
9.2	Install new water conduit crossings	439	m	15	6,580
				Subtotal	**19,740**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**1,119,341**
				Contingency (30%)	**335,802**
				Total (excl GST)	**1,455,144**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	67	Lots	8,000	536,000
11.2	Underground telecommunications	67	Lots	1,000	67,000
11.3	Water reticulation	67	Lots	3,000	201,000
11.3	Re-connections allowance	67	Lots	10,000	670,000
				Subtotal	**1,474,000**
				Sub-total (excl GST)	**1,474,000**
				Contingency (30%)	**442,200**
				Total (excl GST)	**1,916,200**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	67	Lots	2,500	167,500
12.2	Geotechnical/pavement design	67	Lots	150	10,050
12.3	Electrical and street lighting design	67	Lots	250	16,750
12.4	Telecommunications design	67	Lots	80	5,360
				Subtotal	**199,660**
				Sub-total (excl GST)	**199,660**
				Contingency (20%)	**39,932**
				Total (excl GST)	**239,592**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	67	Lots	100	6,700
13.2	Telecommunications authority	67	Lots	600	40,200
13.3	Council	67	Lots	300	20,100
13.4	Water authority	67	Lots	80	5,360
				Subtotal	**72,360**
				Sub-total (excl GST)	**72,360**
				Contingency (20%)	**14,472**
				Total (excl GST)	**86,832**
				Grand Total including contingency (excl GST)	**3,697,768**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Pattie Place

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.2	ha	100,000	21,300
2.2	Import, place and compact select fill	28	m^3	40	1,103
2.3	Trim and compact verge areas and swales	1136	m^2	5	5,680
2.4	Topsoil and turf verge areas and swales	923	m^2	10	9,230
2.5	Street trees	19	each	500	9,466.67
				Subtotal	**46,779.87**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1136	m^2	5	5,680
3.3	Subbase DGB20 (280mm thick)	1136	m^2	25	28,400
3.4	Base Course DGB20 (120mm thick)	994	m^2	15	14,910
3.5	Prime Seal	994	m^2	8	7,952
3.6	Asphalt AC10 (min 30mm thick)	994	m^2	25	24,850
				Subtotal	**81,792**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	140	m	300	42,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	284	m	35	9,940
4.5	Pit (900x900)	7	each	2,500	17,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**72,440**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	284	m	70	19,880
5.3	Footpath - 1.5m wide	142	m	150	21,300
				Subtotal	**41,180**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	142	m	15	2,130
				Subtotal	**2,130**

7	**TESTING & WAE**				
7.1	Density testing	142	m	20	2,840
7.2	Road & drainage works as executed	142	Item	15	2,130
				Subtotal	**4,970**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	142	m	20	2,840
				Subtotal	**2,840**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	142	m	20	2,840
9.2	Install new water conduit crossings	95	m	15	1,420
				Subtotal	**4,260**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**366,392**
				Contingency (30%)	**109,918**
				Total (excl GST)	**476,309**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	17	Lots	8,000	136,000
11.2	Underground telecommunications	17	Lots	1,000	17,000
11.3	Water reticulation	17	Lots	3,000	51,000
11.3	Re-connections allowance	17	Lots	10,000	170,000
				Subtotal	**374,000**
				Sub-total (excl GST)	**374,000**
				Contingency (30%)	**112,200**
				Total (excl GST)	**486,200**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	17	Lots	2,500	42,500
12.2	Geotechnical/pavement design	17	Lots	150	2,550
12.3	Electrical and street lighting design	17	Lots	250	4,250
12.4	Telecommunications design	17	Lots	80	1,360
				Subtotal	**50,660**
				Sub-total (excl GST)	**50,660**
				Contingency (20%)	**10,132**
				Total (excl GST)	**60,792**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	17	Lots	100	1,700
13.2	Telecommunications authority	17	Lots	600	10,200
13.3	Council	17	Lots	300	5,100
13.4	Water authority	17	Lots	80	1,360
				Subtotal	**18,360**
				Sub-total (excl GST)	**18,360**
				Contingency (20%)	**3,672**
				Total (excl GST)	**22,032**
				Grand Total including contingency (excl GST)	**1,045,333**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Primrose Place

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	8,550
2.2	Import, place and compact select fill	78	m^3	40	3,137
2.3	Trim and compact verge areas and swales	456	m^2	5	2,280
2.4	Topsoil and turf verge areas and swales	371	m^2	10	3,705
2.5	Street trees	8	each	500	3,800.00
				Subtotal	**21,472.20**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	456	m^2	5	2,280
3.3	Subbase DGB20 (280mm thick)	456	m^2	25	11,400
3.4	Base Course DGB20 (120mm thick)	399	m^2	15	5,985
3.5	Prime Seal	399	m^2	8	3,192
3.6	Asphalt AC10 (min 30mm thick)	399	m^2	25	9,975
				Subtotal	**32,832**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	120	m	300	36,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	114	m	35	3,990
4.5	Pit (900x900)	1	each	2,500	2,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**42,490**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	114	m	70	7,980
5.3	Footpath - 1.5m wide	57	m	150	8,550
				Subtotal	**16,530**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	57	m	15	855
				Subtotal	**855**

7	**TESTING & WAE**				
7.1	Density testing	57	m	20	1,140
7.2	Road & drainage works as executed	57	Item	15	855
				Subtotal	**1,995**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	57	m	20	1,140
				Subtotal	**1,140**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	57	m	20	1,140
9.2	Install new water conduit crossings	38	m	15	570
				Subtotal	**1,710**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**229,024**
				Contingency (30%)	**68,707**
				Total (excl GST)	**297,731**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	7	Lots	8,000	56,000
11.2	Underground telecommunications	7	Lots	1,000	7,000
11.3	Water reticulation	7	Lots	3,000	21,000
11.3	Re-connections allowance	7	Lots	10,000	70,000
				Subtotal	**154,000**
				Sub-total (excl GST)	**154,000**
				Contingency (30%)	**46,200**
				Total (excl GST)	**200,200**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	7	Lots	2,500	17,500
12.2	Geotechnical/pavement design	7	Lots	150	1,050
12.3	Electrical and street lighting design	7	Lots	250	1,750
12.4	Telecommunications design	7	Lots	80	560
				Subtotal	**20,860**
				Sub-total (excl GST)	**20,860**
				Contingency (20%)	**4,172**
				Total (excl GST)	**25,032**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	7	Lots	100	700
13.2	Telecommunications authority	7	Lots	600	4,200
13.3	Council	7	Lots	300	2,100
13.4	Water authority	7	Lots	80	560
				Subtotal	**7,560**
				Sub-total (excl GST)	**7,560**
				Contingency (20%)	**1,512**
				Total (excl GST)	**9,072**
				Grand Total including contingency (excl GST)	**532,035**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Sonter Avenue

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.5	ha	100,000	53,400
2.2	Import, place and compact select fill	568	m^3	40	22,738
2.3	Trim and compact verge areas and swales	2848	m^2	5	14,240
2.4	Topsoil and turf verge areas and swales	2314	m^2	10	23,140
2.5	Street trees	47	each	500	23,733.33
				Subtotal	**137,250.93**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	2848	m^2	5	14,240
3.3	Subbase DGB20 (280mm thick)	2848	m^2	25	71,200
3.4	Base Course DGB20 (120mm thick)	2492	m^2	15	37,380
3.5	Prime Seal	2492	m^2	8	19,936
3.6	Asphalt AC10 (min 30mm thick)	2492	m^2	25	62,300
				Subtotal	**205,056**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	210	m	300	63,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	712	m	35	24,920
4.5	Pit (900x900)	4	each	2,500	10,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**100,920**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	712	m	50	35,600

5.2	Kerb - Upright Kerb & Gutter	712	m	70	49,840
5.3	Footpath - 1.5m wide	356	m	150	53,400
				Subtotal	**138,840**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	356	m	15	5,340
				Subtotal	**5,340**

7	**TESTING & WAE**				
7.1	Density testing	356	m	20	7,120
7.2	Road & drainage works as executed	356	Item	15	5,340
				Subtotal	**12,460**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	356	m	20	7,120
				Subtotal	**7,120**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	356	m	20	7,120
9.2	Install new water conduit crossings	237	m	15	3,560
				Subtotal	**10,680**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**727,667**
				Contingency (30%)	**218,300**
				Total (excl GST)	**945,967**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	21	Lots	8,000	168,000
11.2	Underground telecommunications	21	Lots	1,000	21,000
11.3	Water reticulation	21	Lots	3,000	63,000
11.3	Re-connections allowance	21	Lots	10,000	210,000
				Subtotal	**462,000**
				Sub-total (excl GST)	**462,000**
				Contingency (30%)	**138,600**
				Total (excl GST)	**600,600**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	21	Lots	2,500	52,500
12.2	Geotechnical/pavement design	21	Lots	150	3,150
12.3	Electrical and street lighting design	21	Lots	250	5,250
12.4	Telecommunications design	21	Lots	80	1,680
				Subtotal	**62,580**
				Sub-total (excl GST)	**62,580**
				Contingency (20%)	**12,516**
				Total (excl GST)	**75,096**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	21	Lots	100	2,100
13.2	Telecommunications authority	21	Lots	600	12,600
13.3	Council	21	Lots	300	6,300
13.4	Water authority	21	Lots	80	1,680
				Subtotal	**22,680**
				Sub-total (excl GST)	**22,680**
				Contingency (20%)	**4,536**
				Total (excl GST)	**27,216**
				Grand Total including contingency (excl GST)	**1,648,879**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Azalea Avenue

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	13,350
2.2	Import, place and compact select fill	232	m^3	40	9,284
2.3	Trim and compact verge areas and swales	712	m^2	5	3,560
2.4	Topsoil and turf verge areas and swales	579	m^2	10	5,785
2.5	Street trees	12	each	500	5,933.33
				Subtotal	**37,912.73**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	712	m^2	5	3,560
3.3	Subbase DGB20 (280mm thick)	712	m^2	25	17,800
3.4	Base Course DGB20 (120mm thick)	623	m^2	15	9,345
3.5	Prime Seal	623	m^2	8	4,984
3.6	Asphalt AC10 (min 30mm thick)	623	m^2	25	15,575
				Subtotal	**51,264**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	65	m	300	19,500
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	178	m	35	6,230
4.5	Pit (900x900)	3	each	2,500	7,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**33,230**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	178	m	70	12,460
5.3	Footpath - 1.5m wide	89	m	150	13,350
				Subtotal	**25,810**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	89	m	15	1,335
				Subtotal	**1,335**

7	**TESTING & WAE**				
7.1	Density testing	89	m	20	1,780
7.2	Road & drainage works as executed	89	Item	15	1,335
				Subtotal	**3,115**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	89	m	20	1,780
				Subtotal	**1,780**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	89	m	20	1,780
9.2	Install new water conduit crossings	59	m	15	890
				Subtotal	**2,670**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**267,117**
				Contingency (30%)	**80,135**
				Total (excl GST)	**347,252**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	10	Lots	8,000	80,000
11.2	Underground telecommunications	10	Lots	1,000	10,000
11.3	Water reticulation	10	Lots	3,000	30,000
11.3	Re-connections allowance	10	Lots	10,000	100,000
				Subtotal	**220,000**
				Sub-total (excl GST)	**220,000**
				Contingency (30%)	**66,000**
				Total (excl GST)	**286,000**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	10	Lots	2,500	25,000
12.2	Geotechnical/pavement design	10	Lots	150	1,500
12.3	Electrical and street lighting design	10	Lots	250	2,500
12.4	Telecommunications design	10	Lots	80	800
				Subtotal	**29,800**
				Sub-total (excl GST)	**29,800**
				Contingency (20%)	**5,960**
				Total (excl GST)	**35,760**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	10	Lots	100	1,000
13.2	Telecommunications authority	10	Lots	600	6,000
13.3	Council	10	Lots	300	3,000
13.4	Water authority	10	Lots	80	800
				Subtotal	**10,800**
				Sub-total (excl GST)	**10,800**
				Contingency (20%)	**2,160**
				Total (excl GST)	**12,960**
				Grand Total including contingency (excl GST)	**681,972**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Daffodil Drive

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.9	ha	100,000	86,400
2.2	Import, place and compact select fill	0	m^3	40	-
2.3	Trim and compact verge areas and swales	4608	m^2	5	23,040
2.4	Topsoil and turf verge areas and swales	3744	m^2	10	37,440
2.5	Street trees	77	each	500	38,400.00
				Subtotal	**185,280.00**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	4608	m^2	5	23,040
3.3	Subbase DGB20 (280mm thick)	4608	m^2	25	115,200
3.4	Base Course DGB20 (120mm thick)	4032	m^2	15	60,480
3.5	Prime Seal	4032	m^2	8	32,256
3.6	Asphalt AC10 (min 30mm thick)	4032	m^2	25	100,800
				Subtotal	**331,776**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	110	m	300	33,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	1152	m	35	40,320
4.5	Pit (900x900)	3	each	2,500	7,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**80,820**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	1152	m	70	80,640
5.3	Footpath - 1.5m wide	576	m	150	86,400
				Subtotal	**167,040**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	576	m	15	8,640
				Subtotal	**8,640**

7	**TESTING & WAE**				
7.1	Density testing	576	m	20	11,520
7.2	Road & drainage works as executed	576	Item	15	8,640
				Subtotal	**20,160**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	576	m	20	11,520
				Subtotal	**11,520**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	576	m	20	11,520
9.2	Install new water conduit crossings	384	m	15	5,760
				Subtotal	**17,280**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**932,516**
				Contingency (30%)	**279,755**
				Total (excl GST)	**1,212,271**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	41	Lots	8,000	328,000
11.2	Underground telecommunications	41	Lots	1,000	41,000
11.3	Water reticulation	41	Lots	3,000	123,000
11.3	Re-connections allowance	41	Lots	10,000	410,000
				Subtotal	**902,000**
				Sub-total (excl GST)	**902,000**
				Contingency (30%)	**270,600**
				Total (excl GST)	**1,172,600**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	41	Lots	2,500	102,500
12.2	Geotechnical/pavement design	41	Lots	150	6,150
12.3	Electrical and street lighting design	41	Lots	250	10,250
12.4	Telecommunications design	41	Lots	80	3,280
				Subtotal	**122,180**
				Sub-total (excl GST)	**122,180**
				Contingency (20%)	**24,436**
				Total (excl GST)	**146,616**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	41	Lots	100	4,100
13.2	Telecommunications authority	41	Lots	600	24,600
13.3	Council	41	Lots	300	12,300
13.4	Water authority	41	Lots	80	3,280
				Subtotal	**44,280**
				Sub-total (excl GST)	**44,280**
				Contingency (20%)	**8,856**
				Total (excl GST)	**53,136**
				Grand Total including contingency (excl GST)	**2,584,623**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

North Burge Road

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	1.7	ha	100,000	167,000
2.2	Import, place and compact select fill	7071	m^3	40	282,820
2.3	Trim and compact verge areas and swales	8350	m^2	5	41,750
2.4	Topsoil and turf verge areas and swales	7098	m^2	10	70,975
2.5	Street trees	111	each	500	55,666.67
				Subtotal	**618,211.67**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	9185	m^2	5	45,925
3.3	Subbase DGB20 (280mm thick)	9185	m^2	25	229,625
3.4	Base Course DGB20 (120mm thick)	8350	m^2	15	125,250
3.5	Prime Seal	8350	m^2	8	66,800
3.6	Asphalt AC10 (min 30mm thick)	8350	m^2	25	208,750
				Subtotal	**676,350**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	608	m	300	182,400
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	1670	m	35	58,450
4.5	Pit (900x900)	28	each	2,500	70,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	3	Item	3,000	9,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	RCBC Headwall	2	Item	5,000	10,000
4.12	1.2 x 0.6 RCBC	77	m	1,500	115,500
				Subtotal	**445,350**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	1670	m	70	116,900
5.3	Footpath - 1.5m wide	835	m	150	125,250
				Subtotal	**242,150**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	835	m	15	12,525
				Subtotal	**12,525**

7	**TESTING & WAE**				
7.1	Density testing	835	m	20	16,700
7.2	Road & drainage works as executed	835	Item	15	12,525
				Subtotal	**29,225**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	835	m	20	16,700
				Subtotal	**16,700**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	835	m	20	16,700
9.2	Install new water conduit crossings	557	m	15	8,350
				Subtotal	**25,050**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**2,175,562**
				Contingency (30%)	**652,669**
				Total (excl GST)	**2,828,230**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	129	Lots	8,000	1,032,000
11.2	Underground telecommunications	129	Lots	1,000	129,000
11.3	Water reticulation	129	Lots	3,000	387,000
11.3	Re-connections allowance	129	Lots	10,000	1,290,000
				Subtotal	**2,838,000**
				Sub-total (excl GST)	**2,838,000**
				Contingency (30%)	**851,400**
				Total (excl GST)	**3,689,400**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	129	Lots	2,500	322,500
12.2	Geotechnical/pavement design	129	Lots	150	19,350
12.3	Electrical and street lighting design	129	Lots	250	32,250
12.4	Telecommunications design	129	Lots	80	10,320
				Subtotal	**384,420**
				Sub-total (excl GST)	**384,420**
				Contingency (20%)	**76,884**
				Total (excl GST)	**461,304**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	129	Lots	100	12,900
13.2	Telecommunications authority	129	Lots	600	77,400
13.3	Council	129	Lots	300	38,700
13.4	Water authority	129	Lots	80	10,320
				Subtotal	**139,320**
				Sub-total (excl GST)	**139,320**
				Contingency (20%)	**27,864**
				Total (excl GST)	**167,184**
				Grand Total including contingency (excl GST)	**7,146,118**

Allen Price & Scarratts
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NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Norma Crescent

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.3	ha	100,000	27,750
2.2	Import, place and compact select fill	503	m^3	40	20,126
2.3	Trim and compact verge areas and swales	1480	m^2	5	7,400
2.4	Topsoil and turf verge areas and swales	1203	m^2	10	12,025
2.5	Street trees	25	each	500	12,333.33
				Subtotal	**79,634.33**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1480	m^2	5	7,400
3.3	Subbase DGB20 (280mm thick)	1480	m^2	25	37,000
3.4	Base Course DGB20 (120mm thick)	1295	m^2	15	19,425
3.5	Prime Seal	1295	m^2	8	10,360
3.6	Asphalt AC10 (min 30mm thick)	1295	m^2	25	32,375
				Subtotal	**106,560**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	63	m	300	18,900
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	370	m	35	12,950
4.5	Pit (900x900)	3	each	2,500	7,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	RCBC Headwall	1	Item	5,000	5,000
4.12	1.2 x 0.6 RCBC	22	m	1,500	33,300
				Subtotal	**80,650**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	370	m	70	25,900
5.3	Footpath - 1.5m wide	185	m	150	27,750
				Subtotal	**53,650**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	185	m	15	2,775
				Subtotal	**2,775**

7	**TESTING & WAE**				
7.1	Density testing	185	m	20	3,700
7.2	Road & drainage works as executed	185	Item	15	2,775
				Subtotal	**6,475**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	185	m	20	3,700
				Subtotal	**3,700**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	185	m	20	3,700
9.2	Install new water conduit crossings	123	m	15	1,850
				Subtotal	**5,550**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**448,994**
				Contingency (30%)	**134,698**
				Total (excl GST)	**583,693**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	17	Lots	8,000	136,000
11.2	Underground telecommunications	17	Lots	1,000	17,000
11.3	Water reticulation	17	Lots	3,000	51,000
11.3	Re-connections allowance	17	Lots	10,000	170,000
				Subtotal	**374,000**
				Sub-total (excl GST)	**374,000**
				Contingency (30%)	**112,200**
				Total (excl GST)	**486,200**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	17	Lots	2,500	42,500
12.2	Geotechnical/pavement design	17	Lots	150	2,550
12.3	Electrical and street lighting design	17	Lots	250	4,250
12.4	Telecommunications design	17	Lots	80	1,360
				Subtotal	**50,660**
				Sub-total (excl GST)	**50,660**
				Contingency (20%)	**10,132**
				Total (excl GST)	**60,792**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	17	Lots	100	1,700
13.2	Telecommunications authority	17	Lots	600	10,200
13.3	Council	17	Lots	300	5,100
13.4	Water authority	17	Lots	80	1,360
				Subtotal	**18,360**
				Sub-total (excl GST)	**18,360**
				Contingency (20%)	**3,672**
				Total (excl GST)	**22,032**
				Grand Total including contingency (excl GST)	**1,152,717**

Allen Price & Scarratts
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NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Plane Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	11,960
2.2	Import, place and compact select fill	0	m^3	40	-
2.3	Trim and compact verge areas and swales	644	m^2	5	3,220
2.4	Topsoil and turf verge areas and swales	506	m^2	10	5,060
2.5	Street trees	12	each	500	6,133.33
				Subtotal	**26,373.33**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	644	m^2	5	3,220
3.3	Subbase DGB20 (280mm thick)	644	m^2	25	16,100
3.4	Base Course DGB20 (120mm thick)	552	m^2	15	8,280
3.5	Prime Seal	552	m^2	8	4,416
3.6	Asphalt AC10 (min 30mm thick)	552	m^2	25	13,800
				Subtotal	**45,816**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	85	m	300	25,500
4.3	DN1050 RRJ Class 3	15	m	650	9,750
4.4	DN100mm subsoil drainage	184	m	35	6,440
4.5	Pit (900x900)	8	each	2,500	20,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN10500mm Headwall	1	Item	4,000	4,000
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**65,690**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	184	m	50	9,200
5.2	Kerb - Upright Kerb & Gutter	0	m	70	-
5.3	Footpath - 1.5m wide	92	m	150	13,800
				Subtotal	**23,000**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	92	m	15	1,380
				Subtotal	**1,380**

7	**TESTING & WAE**				
7.1	Density testing	92	m	20	1,840
7.2	Road & drainage works as executed	92	Item	15	1,380
				Subtotal	**3,220**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	92	m	20	1,840
				Subtotal	**1,840**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	92	m	20	1,840
9.2	Install new water conduit crossings	61	m	15	920
				Subtotal	**2,760**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**218,389**
				Contingency (30%)	**65,517**
				Total (excl GST)	**283,906**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	15	Lots	8,000	120,000
11.2	Underground telecommunications	15	Lots	1,000	15,000
11.3	Water reticulation	15	Lots	3,000	45,000
11.3	Re-connections allowance	15	Lots	10,000	150,000
				Subtotal	**330,000**
				Sub-total (excl GST)	**330,000**
				Contingency (30%)	**99,000**
				Total (excl GST)	**429,000**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	15	Lots	2,500	37,500
12.2	Geotechnical/pavement design	15	Lots	150	2,250
12.3	Electrical and street lighting design	15	Lots	250	3,750
12.4	Telecommunications design	15	Lots	80	1,200
				Subtotal	**44,700**
				Sub-total (excl GST)	**44,700**
				Contingency (20%)	**8,940**
				Total (excl GST)	**53,640**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	15	Lots	100	1,500
13.2	Telecommunications authority	15	Lots	600	9,000
13.3	Council	15	Lots	300	4,500
13.4	Water authority	15	Lots	80	1,200
				Subtotal	**16,200**
				Sub-total (excl GST)	**16,200**
				Contingency (20%)	**3,240**
				Total (excl GST)	**19,440**
				Grand Total including contingency (excl GST)	**785,986**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Oak Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	12,000
2.2	Import, place and compact select fill	153	m^3	40	6,120
2.3	Trim and compact verge areas and swales	600	m^2	5	3,000
2.4	Topsoil and turf verge areas and swales	450	m^2	10	4,500
2.5	Street trees	13	each	500	6,666.67
				Subtotal	**32,286.67**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	700	m^2	5	3,500
3.3	Subbase DGB20 (280mm thick)	700	m^2	25	17,500
3.4	Base Course DGB20 (120mm thick)	600	m^2	15	9,000
3.5	Prime Seal	600	m^2	8	4,800
3.6	Asphalt AC10 (min 30mm thick)	600	m^2	25	15,000
				Subtotal	**49,800**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	275	m	300	82,500
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	200	m	35	7,000
4.5	Pit (900x900)	5	each	2,500	12,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	2	Item	3,000	6,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**108,000**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	200	m	50	10,000
5.2	Kerb - Upright Kerb & Gutter	0	m	70	-
5.3	Footpath - 1.5m wide	100	m	150	15,000
				Subtotal	**25,000**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	100	m	15	1,500
				Subtotal	**1,500**

7	**TESTING & WAE**				
7.1	Density testing	100	m	20	2,000
7.2	Road & drainage works as executed	100	Item	15	1,500
				Subtotal	**3,500**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	100	m	20	2,000
				Subtotal	**2,000**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	100	m	20	2,000
9.2	Install new water conduit crossings	67	m	15	1,000
				Subtotal	**3,000**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**335,087**
				Contingency (30%)	**100,526**
				Total (excl GST)	**435,613**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	18	Lots	8,000	144,000
11.2	Underground telecommunications	18	Lots	1,000	18,000
11.3	Water reticulation	18	Lots	3,000	54,000
11.3	Re-connections allowance	18	Lots	10,000	180,000
				Subtotal	**396,000**
				Sub-total (excl GST)	**396,000**
				Contingency (30%)	**118,800**
				Total (excl GST)	**514,800**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	18	Lots	2,500	45,000
12.2	Geotechnical/pavement design	18	Lots	150	2,700
12.3	Electrical and street lighting design	18	Lots	250	4,500
12.4	Telecommunications design	18	Lots	80	1,440
				Subtotal	**53,640**
				Sub-total (excl GST)	**53,640**
				Contingency (20%)	**10,728**
				Total (excl GST)	**64,368**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	18	Lots	100	1,800
13.2	Telecommunications authority	18	Lots	600	10,800
13.3	Council	18	Lots	300	5,400
13.4	Water authority	18	Lots	80	1,440
				Subtotal	**19,440**
				Sub-total (excl GST)	**19,440**
				Contingency (20%)	**3,888**
				Total (excl GST)	**23,328**
				Grand Total including contingency (excl GST)	**1,038,109**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Booker Bay Road

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	2.4	ha	100,000	239,408
2.2	Import, place and compact select fill	4752	m^3	40	190,064
2.3	Trim and compact verge areas and swales	10726	m^2	5	53,629
2.4	Topsoil and turf verge areas and swales	8801	m^2	10	88,014
2.5	Street trees	171	each	500	85,533.33
				Subtotal	**656,648.05**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	14498	m^2	5	72,490
3.3	Subbase DGB20 (280mm thick)	14498	m^2	25	362,448
3.4	Base Course DGB20 (120mm thick)	13215	m^2	15	198,224
3.5	Prime Seal	13215	m^2	8	105,719
3.6	Asphalt AC10 (min 30mm thick)	13215	m^2	25	330,373
				Subtotal	**1,069,252**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	1180	m	300	354,000
4.3	DN1050 RRJ Class 3	10	m	650	6,500
4.4	DN100mm subsoil drainage	2566	m	35	89,810
4.5	Pit (900x900)	50	each	2,500	125,000
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	6	Item	3,000	18,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	RCBC Headwall	4	Item	5,000	20,000
4.12	3.6 x 0.6 RCBC	65	m	7,000	455,000
				Subtotal	**1,068,310**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	2566	m	70	179,620
5.3	Footpath - 1.5m wide	1283	m	150	192,450
				Subtotal	**372,070**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	1283	m	15	19,245
				Subtotal	**19,245**

7	**TESTING & WAE**				
7.1	Density testing	1283	m	20	25,660
7.2	Road & drainage works as executed	1283	Item	15	19,245
				Subtotal	**44,905**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	1283	m	20	25,660
				Subtotal	**25,660**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	1283	m	20	25,660
9.2	Install new water conduit crossings	855	m	15	12,830
				Subtotal	**38,490**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**2,336,270**
				Contingency (30%)	**700,881**
				Total (excl GST)	**3,037,151**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	198	Lots	8,000	1,584,000
11.2	Underground telecommunications	198	Lots	1,000	198,000
11.3	Water reticulation	198	Lots	3,000	594,000
11.3	Re-connections allowance	198	Lots	10,000	1,980,000
				Subtotal	**4,356,000**
				Sub-total (excl GST)	**4,356,000**
				Contingency (30%)	**1,306,800**
				Total (excl GST)	**5,662,800**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	198	Lots	2,500	495,000
12.2	Geotechnical/pavement design	198	Lots	150	29,700
12.3	Electrical and street lighting design	198	Lots	250	49,500
12.4	Telecommunications design	198	Lots	80	15,840
				Subtotal	**590,040**
				Sub-total (excl GST)	**590,040**
				Contingency (20%)	**118,008**
				Total (excl GST)	**708,048**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	198	Lots	100	19,800
13.2	Telecommunications authority	198	Lots	600	118,800
13.3	Council	198	Lots	300	59,400
13.4	Water authority	198	Lots	80	15,840
				Subtotal	**213,840**
				Sub-total (excl GST)	**213,840**
				Contingency (20%)	**42,768**
				Total (excl GST)	**256,608**
				Grand Total including contingency (excl GST)	**9,664,607**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Karu Avenue

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.2	ha	100,000	20,153
2.2	Import, place and compact select fill	98	m^3	40	3,907
2.3	Trim and compact verge areas and swales	903	m^2	5	4,514
2.4	Topsoil and turf verge areas and swales	741	m^2	10	7,409
2.5	Street trees	14	each	500	7,200.00
				Subtotal	**43,182.72**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1220	m^2	5	6,102
3.3	Subbase DGB20 (280mm thick)	1220	m^2	25	30,510
3.4	Base Course DGB20 (120mm thick)	1112	m^2	15	16,686
3.5	Prime Seal	1112	m^2	8	8,899
3.6	Asphalt AC10 (min 30mm thick)	1112	m^2	25	27,810
				Subtotal	**90,007**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	35	m	300	10,500
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	216	m	35	7,560
4.5	Pit (900x900)	0	each	2,500	-
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	3m wide roadside drainage channels. Assume tapering retaining walls inc structural certification	174	m	2,000	348,000
				Subtotal	**369,060**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	216	m	50	10,800
5.2	Kerb - Upright Kerb & Gutter	0	m	70	-
5.3	Footpath - 1.5m wide	108	m	150	16,200
				Subtotal	**27,000**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	108	m	15	1,620
				Subtotal	**1,620**

7	**TESTING & WAE**				
7.1	Density testing	108	m	20	2,160
7.2	Road & drainage works as executed	108	Item	15	1,620
				Subtotal	**3,780**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	108	m	20	2,160
				Subtotal	**2,160**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	108	m	20	2,160
9.2	Install new water conduit crossings	72	m	15	1,080
				Subtotal	**3,240**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**280,990**
				Contingency (30%)	**84,297**
				Total (excl GST)	**365,287**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	4	Lots	8,000	32,000
11.2	Underground telecommunications	4	Lots	1,000	4,000
11.3	Water reticulation	4	Lots	3,000	12,000
11.3	Re-connections allowance	4	Lots	10,000	40,000
				Subtotal	**88,000**
				Sub-total (excl GST)	**88,000**
				Contingency (30%)	**26,400**
				Total (excl GST)	**114,400**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	4	Lots	2,500	10,000
12.2	Geotechnical/pavement design	4	Lots	150	600
12.3	Electrical and street lighting design	4	Lots	250	1,000
12.4	Telecommunications design	4	Lots	80	320
				Subtotal	**11,920**
				Sub-total (excl GST)	**11,920**
				Contingency (20%)	**2,384**
				Total (excl GST)	**14,304**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	4	Lots	100	400
13.2	Telecommunications authority	4	Lots	600	2,400
13.3	Council	4	Lots	300	1,200
13.4	Water authority	4	Lots	80	320
				Subtotal	**4,320**
				Sub-total (excl GST)	**4,320**
				Contingency (20%)	**864**
				Total (excl GST)	**5,184**
				Grand Total including contingency (excl GST)	**499,175**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Davis Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	5,971
2.2	Import, place and compact select fill	0	m^3	40	-
2.3	Trim and compact verge areas and swales	268	m^2	5	1,338
2.4	Topsoil and turf verge areas and swales	220	m^2	10	2,195
2.5	Street trees	4	each	500	2,133.33
				Subtotal	**11,637.33**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	362	m^2	5	1,808
3.3	Subbase DGB20 (280mm thick)	362	m^2	25	9,040
3.4	Base Course DGB20 (120mm thick)	330	m^2	15	4,944
3.5	Prime Seal	330	m^2	8	2,637
3.6	Asphalt AC10 (min 30mm thick)	330	m^2	25	8,240
				Subtotal	**26,669**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	170	m	300	51,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	64	m	35	2,240
4.5	Pit (900x900)	7	each	2,500	17,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	5	Item	3,000	15,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**85,740**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	64	m	70	4,480
5.3	Footpath - 1.5m wide	32	m	150	4,800
				Subtotal	**9,280**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	32	m	15	480
				Subtotal	**480**

7	**TESTING & WAE**				
7.1	Density testing	32	m	20	640
7.2	Road & drainage works as executed	32	Item	15	480
				Subtotal	**1,120**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	32	m	20	640
				Subtotal	**640**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	32	m	20	640
9.2	Install new water conduit crossings	21	m	15	320
				Subtotal	**960**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**160,786**
				Contingency (30%)	**48,236**
				Total (excl GST)	**209,022**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	0	Lots	8,000	-
11.2	Underground telecommunications	0	Lots	1,000	-
11.3	Water reticulation	0	Lots	3,000	-
11.3	Re-connections allowance	0	Lots	10,000	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (30%)	**-**
				Total (excl GST)	**-**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	0	Lots	2,500	-
12.2	Geotechnical/pavement design	0	Lots	150	-
12.3	Electrical and street lighting design	0	Lots	250	-
12.4	Telecommunications design	0	Lots	80	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (20%)	**-**
				Total (excl GST)	**-**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	0	Lots	100	-
13.2	Telecommunications authority	0	Lots	600	-
13.3	Council	0	Lots	300	-
13.4	Water authority	0	Lots	80	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (20%)	**-**
				Total (excl GST)	**-**
				Grand Total including contingency (excl GST)	**209,022**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Petit Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	13,995
2.2	Import, place and compact select fill	3	m^3	40	113
2.3	Trim and compact verge areas and swales	627	m^2	5	3,135
2.4	Topsoil and turf verge areas and swales	515	m^2	10	5,145
2.5	Street trees	10	each	500	5,000.00
				Subtotal	**27,388.00**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	848	m^2	5	4,238
3.3	Subbase DGB20 (280mm thick)	848	m^2	25	21,188
3.4	Base Course DGB20 (120mm thick)	773	m^2	15	11,588
3.5	Prime Seal	773	m^2	8	6,180
3.6	Asphalt AC10 (min 30mm thick)	773	m^2	25	19,313
				Subtotal	**62,505**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	10	m	300	3,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	150	m	35	5,250
4.5	Pit (900x900)	1	each	2,500	2,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	3m wide roadside drainage channels. Assume tapering retaining walls inc structural certification	110	m	2,000	220,000
				Subtotal	**233,750**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	150	m	50	7,500
5.2	Kerb - Upright Kerb & Gutter	0	m	70	-
5.3	Footpath - 1.5m wide	75	m	150	11,250
				Subtotal	**18,750**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	75	m	15	1,125
				Subtotal	**1,125**

7	**TESTING & WAE**				
7.1	Density testing	75	m	20	1,500
7.2	Road & drainage works as executed	75	Item	15	1,125
				Subtotal	**2,625**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	75	m	20	1,500
				Subtotal	**1,500**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	75	m	20	1,500
9.2	Install new water conduit crossings	50	m	15	750
				Subtotal	**2,250**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**226,143**
				Contingency (30%)	**67,843**
				Total (excl GST)	**293,986**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	3	Lots	8,000	24,000
11.2	Underground telecommunications	3	Lots	1,000	3,000
11.3	Water reticulation	3	Lots	3,000	9,000
11.3	Re-connections allowance	3	Lots	10,000	30,000
				Subtotal	**66,000**
				Sub-total (excl GST)	**66,000**
				Contingency (30%)	**19,800**
				Total (excl GST)	**85,800**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	3	Lots	2,500	7,500
12.2	Geotechnical/pavement design	3	Lots	150	450
12.3	Electrical and street lighting design	3	Lots	250	750
12.4	Telecommunications design	3	Lots	80	240
				Subtotal	**8,940**
				Sub-total (excl GST)	**8,940**
				Contingency (20%)	**1,788**
				Total (excl GST)	**10,728**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	3	Lots	100	300
13.2	Telecommunications authority	3	Lots	600	1,800
13.3	Council	3	Lots	300	900
13.4	Water authority	3	Lots	80	240
				Subtotal	**3,240**
				Sub-total (excl GST)	**3,240**
				Contingency (20%)	**648**
				Total (excl GST)	**3,888**
				Grand Total including contingency (excl GST)	**394,402**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Bogan Road

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.0	ha	100,000	3,919
2.2	Import, place and compact select fill	0	m^3	40	-
2.3	Trim and compact verge areas and swales	176	m^2	5	878
2.4	Topsoil and turf verge areas and swales	144	m^2	10	1,441
2.5	Street trees	3	each	500	1,400.00
				Subtotal	**7,637.00**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	237	m^2	5	1,187
3.3	Subbase DGB20 (280mm thick)	237	m^2	25	5,933
3.4	Base Course DGB20 (120mm thick)	216	m^2	15	3,245
3.5	Prime Seal	216	m^2	8	1,730
3.6	Asphalt AC10 (min 30mm thick)	216	m^2	25	5,408
				Subtotal	**17,501**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	0	m	300	-
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	42	m	35	1,470
4.5	Pit (900x900)	0	each	2,500	-
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	7	Item	3,000	21,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**22,470**
5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-

5.2	Kerb - Upright Kerb & Gutter	42	m	70	2,940
5.3	Footpath - 1.5m wide	21	m	150	3,150
				Subtotal	**6,090**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	21	m	15	315
				Subtotal	**315**

7	**TESTING & WAE**				
7.1	Density testing	21	m	20	420
7.2	Road & drainage works as executed	21	Item	15	315
				Subtotal	**735**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	21	m	20	420
				Subtotal	**420**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	21	m	20	420
9.2	Install new water conduit crossings	14	m	15	210
				Subtotal	**630**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**143,328**
				Contingency (30%)	**42,999**
				Total (excl GST)	**186,327**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	0	Lots	8,000	-
11.2	Underground telecommunications	0	Lots	1,000	-
11.3	Water reticulation	0	Lots	3,000	-
11.3	Re-connections allowance	0	Lots	10,000	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (30%)	**-**
				Total (excl GST)	**-**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	0	Lots	2,500	-
12.2	Geotechnical/pavement design	0	Lots	150	-
12.3	Electrical and street lighting design	0	Lots	250	-
12.4	Telecommunications design	0	Lots	80	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (20%)	**-**
				Total (excl GST)	**-**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	0	Lots	100	-
13.2	Telecommunications authority	0	Lots	600	-
13.3	Council	0	Lots	300	-
13.4	Water authority	0	Lots	80	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (20%)	**-**
				Total (excl GST)	**-**
				Grand Total including contingency (excl GST)	**186,327**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Mareela Avenue

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.1	ha	100,000	13,249
2.2	Import, place and compact select fill	95	m^3	40	3,782
2.3	Trim and compact verge areas and swales	594	m^2	5	2,968
2.4	Topsoil and turf verge areas and swales	487	m^2	10	4,871
2.5	Street trees	9	each	500	4,733.33
				Subtotal	**29,601.97**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	802	m^2	5	4,012
3.3	Subbase DGB20 (280mm thick)	802	m^2	25	20,058
3.4	Base Course DGB20 (120mm thick)	731	m^2	15	10,970
3.5	Prime Seal	731	m^2	8	5,850
3.6	Asphalt AC10 (min 30mm thick)	731	m^2	25	18,283
				Subtotal	**59,171**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	15	m	300	4,500
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	142	m	35	4,970
4.5	Pit (900x900)	1	each	2,500	2,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	3m wide roadside drainage channels. Assume tapering retaining walls inc structural certification	110	m	2,000	220,000
				Subtotal	**234,970**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	142	m	50	7,100
5.2	Kerb - Upright Kerb & Gutter	0	m	70	-
5.3	Footpath - 1.5m wide	71	m	150	10,650
				Subtotal	**17,750**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	71	m	15	1,065
				Subtotal	**1,065**

7	**TESTING & WAE**				
7.1	Density testing	71	m	20	1,420
7.2	Road & drainage works as executed	71	Item	15	1,065
				Subtotal	**2,485**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	71	m	20	1,420
				Subtotal	**1,420**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	71	m	20	1,420
9.2	Install new water conduit crossings	47	m	15	710
				Subtotal	**2,130**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**223,623**
				Contingency (30%)	**67,087**
				Total (excl GST)	**290,710**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	14	Lots	8,000	112,000
11.2	Underground telecommunications	14	Lots	1,000	14,000
11.3	Water reticulation	14	Lots	3,000	42,000
11.3	Re-connections allowance	14	Lots	10,000	140,000
				Subtotal	**308,000**
				Sub-total (excl GST)	**308,000**
				Contingency (30%)	**92,400**
				Total (excl GST)	**400,400**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	14	Lots	2,500	35,000
12.2	Geotechnical/pavement design	14	Lots	150	2,100
12.3	Electrical and street lighting design	14	Lots	250	3,500
12.4	Telecommunications design	14	Lots	80	1,120
				Subtotal	**41,720**
				Sub-total (excl GST)	**41,720**
				Contingency (20%)	**8,344**
				Total (excl GST)	**50,064**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	14	Lots	100	1,400
13.2	Telecommunications authority	14	Lots	600	8,400
13.3	Council	14	Lots	300	4,200
13.4	Water authority	14	Lots	80	1,120
				Subtotal	**15,120**
				Sub-total (excl GST)	**15,120**
				Contingency (20%)	**3,024**
				Total (excl GST)	**18,144**
				Grand Total including contingency (excl GST)	**759,318**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Guyra Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.2	ha	100,000	15,674
2.2	Import, place and compact select fill	335	m^3	40	13,399
2.3	Trim and compact verge areas and swales	702	m^2	5	3,511
2.4	Topsoil and turf verge areas and swales	576	m^2	10	5,762
2.5	Street trees	11	each	500	5,600.00
				Subtotal	**43,946.56**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	949	m^2	5	4,746
3.3	Subbase DGB20 (280mm thick)	949	m^2	25	23,730
3.4	Base Course DGB20 (120mm thick)	865	m^2	15	12,978
3.5	Prime Seal	865	m^2	8	6,922
3.6	Asphalt AC10 (min 30mm thick)	865	m^2	25	21,630
				Subtotal	**70,006**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	5	m	300	1,500
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	168	m	35	5,880
4.5	Pit (900x900)	1	each	2,500	2,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	1	Item	3,000	3,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	3m wide roadside drainage channels. Assume tapering retaining walls inc structural certification	130	m	2,000	260,000
				Subtotal	**272,880**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	168	m	50	8,400
5.2	Kerb - Upright Kerb & Gutter	0	m	70	-
5.3	Footpath - 1.5m wide	84	m	150	12,600
				Subtotal	**21,000**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	84	m	15	1,260
				Subtotal	**1,260**

7	**TESTING & WAE**				
7.1	Density testing	84	m	20	1,680
7.2	Road & drainage works as executed	84	Item	15	1,260
				Subtotal	**2,940**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	84	m	20	1,680
				Subtotal	**1,680**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	84	m	20	1,680
9.2	Install new water conduit crossings	56	m	15	840
				Subtotal	**2,520**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**253,352**
				Contingency (30%)	**76,006**
				Total (excl GST)	**329,358**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	5	Lots	8,000	40,000
11.2	Underground telecommunications	5	Lots	1,000	5,000
11.3	Water reticulation	5	Lots	3,000	15,000
11.3	Re-connections allowance	5	Lots	10,000	50,000
				Subtotal	**110,000**
				Sub-total (excl GST)	**110,000**
				Contingency (30%)	**33,000**
				Total (excl GST)	**143,000**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	5	Lots	2,500	12,500
12.2	Geotechnical/pavement design	5	Lots	150	750
12.3	Electrical and street lighting design	5	Lots	250	1,250
12.4	Telecommunications design	5	Lots	80	400
				Subtotal	**14,900**
				Sub-total (excl GST)	**14,900**
				Contingency (20%)	**2,980**
				Total (excl GST)	**17,880**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	5	Lots	100	500
13.2	Telecommunications authority	5	Lots	600	3,000
13.3	Council	5	Lots	300	1,500
13.4	Water authority	5	Lots	80	400
				Subtotal	**5,400**
				Sub-total (excl GST)	**5,400**
				Contingency (20%)	**1,080**
				Total (excl GST)	**6,480**
				Grand Total including contingency (excl GST)	**496,718**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

The Esplanade

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.8	ha	100,000	84,960
2.2	Import, place and compact select fill	0	m^3	40	-
2.3	Trim and compact verge areas and swales	1239	m^2	5	6,195
2.4	Topsoil and turf verge areas and swales	177	m^2	10	1,770
2.5	Street trees	94	each	500	47,200.00
				Subtotal	**140,125.00**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	7965	m^2	5	39,825
3.3	Subbase DGB20 (280mm thick)	7965	m^2	25	199,125
3.4	Base Course DGB20 (120mm thick)	7257	m^2	15	108,855
3.5	Prime Seal	7257	m^2	8	58,056
3.6	Asphalt AC10 (min 30mm thick)	7257	m^2	25	181,425
				Subtotal	**587,286**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	165	m	300	49,500
4.3	DN825 RRJ Class 3	52	m	450	23,400
4.4	DN900 RRJ Class 3	101	m	550	55,550
4.5	DN1500 RRJ Class 3	53	m	1,000	53,000
4.6	DN100mm subsoil drainage	1416	m	35	49,560
4.7	Pit (900x900)	9	each	2,500	22,500
4.8	Pit (1200x1200)	2	each	4,000	8,000
4.9	Pit (1500x1500)	5	each	5,000	25,000
4.10	DN450mm Headwall	0	Item	1,500	-
4.11	DN600mm Headwall	1	Item	3,000	3,000
4.12	RCBC Headwall	1	Item	5,000	5,000
4.13	2.4 x 0.9 RCBC	185	m	6,000	1,110,000
				Subtotal	**1,404,510**

5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	708	m	50	35,400
5.2	Kerb - Upright Kerb & Gutter	708	m	70	49,560
5.3	Footpath - 1.5m wide	708	m	150	106,200
				Subtotal	**191,160**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	708	m	15	10,620
				Subtotal	**10,620**

7	**TESTING & WAE**				
7.1	Density testing	708	m	20	14,160
7.2	Road & drainage works as executed	708	Item	15	10,620
				Subtotal	**24,780**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	708	m	20	14,160
				Subtotal	**14,160**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	708	m	20	14,160
9.2	Install new water conduit crossings	472	m	15	7,080
				Subtotal	**21,240**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**1,104,371**
				Contingency (30%)	**331,311**
				Total (excl GST)	**1,435,682**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	79	Lots	8,000	632,000
11.2	Underground telecommunications	79	Lots	1,000	79,000
11.3	Water reticulation	79	Lots	3,000	237,000
11.3	Re-connections allowance	79	Lots	10,000	790,000
				Subtotal	**1,738,000**
				Sub-total (excl GST)	**1,738,000**
				Contingency (30%)	**521,400**
				Total (excl GST)	**2,259,400**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	79	Lots	2,500	197,500
12.2	Geotechnical/pavement design	79	Lots	150	11,850
12.3	Electrical and street lighting design	79	Lots	250	19,750
12.4	Telecommunications design	79	Lots	80	6,320
				Subtotal	**235,420**
				Sub-total (excl GST)	**235,420**
				Contingency (20%)	**47,084**
				Total (excl GST)	**282,504**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	79	Lots	100	7,900
13.2	Telecommunications authority	79	Lots	600	47,400
13.3	Council	79	Lots	300	23,700
13.4	Water authority	79	Lots	80	6,320
				Subtotal	**85,320**
				Sub-total (excl GST)	**85,320**
				Contingency (20%)	**17,064**
				Total (excl GST)	**102,384**
				Grand Total including contingency (excl GST)	**4,079,970**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Bangalow Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.3	ha	100,000	30,600
2.2	Import, place and compact select fill	767	m^3	40	30,671
2.3	Trim and compact verge areas and swales	597	m^2	5	2,984
2.4	Topsoil and turf verge areas and swales	367	m^2	10	3,672
2.5	Street trees	20	each	500	10,200.00
				Subtotal	**78,126.74**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	2616	m^2	5	13,082
3.3	Subbase DGB20 (280mm thick)	2616	m^2	25	65,408
3.4	Base Course DGB20 (120mm thick)	2463	m^2	15	36,950
3.5	Prime Seal	2463	m^2	8	19,706
3.6	Asphalt AC10 (min 30mm thick)	2463	m^2	25	61,583
				Subtotal	**196,727**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	215	m	300	64,500
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	306	m	35	10,710
4.5	Pit (900x900)	7	each	2,500	17,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	0	Item	3,000	-
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**92,710**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	306	m	70	21,420
5.3	Footpath - 1.5m wide	153	m	150	22,950
				Subtotal	**44,370**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	153	m	15	2,295
				Subtotal	**2,295**

7	**TESTING & WAE**				
7.1	Density testing	153	m	20	3,060
7.2	Road & drainage works as executed	153	Item	15	2,295
				Subtotal	**5,355**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	153	m	20	3,060
				Subtotal	**3,060**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	153	m	20	3,060
9.2	Install new water conduit crossings	102	m	15	1,530
				Subtotal	**4,590**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**444,524**
				Contingency (30%)	**133,357**
				Total (excl GST)	**577,881**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	17	Lots	8,000	136,000
11.2	Underground telecommunications	17	Lots	1,000	17,000
11.3	Water reticulation	17	Lots	3,000	51,000
11.3	Re-connections allowance	17	Lots	10,000	170,000
				Subtotal	**374,000**
				Sub-total (excl GST)	**374,000**
				Contingency (30%)	**112,200**
				Total (excl GST)	**486,200**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	17	Lots	2,500	42,500
12.2	Geotechnical/pavement design	17	Lots	150	2,550
12.3	Electrical and street lighting design	17	Lots	250	4,250
12.4	Telecommunications design	17	Lots	80	1,360
				Subtotal	**50,660**
				Sub-total (excl GST)	**50,660**
				Contingency (20%)	**10,132**
				Total (excl GST)	**60,792**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	17	Lots	100	1,700
13.2	Telecommunications authority	17	Lots	600	10,200
13.3	Council	17	Lots	300	5,100
13.4	Water authority	17	Lots	80	1,360
				Subtotal	**18,360**
				Sub-total (excl GST)	**18,360**
				Contingency (20%)	**3,672**
				Total (excl GST)	**22,032**
				Grand Total including contingency (excl GST)	**1,146,905**

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NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Unnamed Road

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.2	ha	100,000	16,640
2.2	Import, place and compact select fill	22	m^3	40	883
2.3	Trim and compact verge areas and swales	269	m^2	5	1,344
2.4	Topsoil and turf verge areas and swales	77	m^2	10	768
2.5	Street trees	17	each	500	8,533.33
				Subtotal	**28,167.89**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1523	m^2	5	7,616
3.3	Subbase DGB20 (280mm thick)	1523	m^2	25	38,080
3.4	Base Course DGB20 (120mm thick)	1395	m^2	15	20,928
3.5	Prime Seal	1395	m^2	8	11,162
3.6	Asphalt AC10 (min 30mm thick)	1395	m^2	25	34,880
				Subtotal	**112,666**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	124	m	300	37,200
4.3	DN750 RRJ Class 3	61	m	400	24,400
4.4	DN900 RRJ Class 3	0	m	550	-
4.5	DN100mm subsoil drainage	256	m	35	8,960
4.6	Pit (900x900)	8	each	2,500	20,000
4.7	Pit (1200x1200)	2	each	4,000	8,000
4.8	Pit (1500x1500)	0	each	5,000	-
4.9	DN450mm Headwall	0	Item	1,500	-
4.10	DN600mm Headwall	0	Item	3,000	-
4.11	DN900mm Headwall	0	Item	3,500	-
4.12	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**98,560**

5	**CONCRETE WORKS**				
5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	256	m	70	17,920
5.3	Footpath - 1.5m wide	128	m	150	19,200
				Subtotal	**37,120**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	128	m	15	1,920
				Subtotal	**1,920**

7	**TESTING & WAE**				
7.1	Density testing	128	m	20	2,560
7.2	Road & drainage works as executed	128	Item	15	1,920
				Subtotal	**4,480**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	128	m	20	2,560
				Subtotal	**2,560**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	128	m	20	2,560
9.2	Install new water conduit crossings	85	m	15	1,280
				Subtotal	**3,840**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**300,753**
				Contingency (30%)	**90,226**
				Total (excl GST)	**390,980**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	0	Lots	8,000	-
11.2	Underground telecommunications	0	Lots	1,000	-
11.3	Water reticulation	0	Lots	3,000	-
11.3	Re-connections allowance	0	Lots	10,000	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (30%)	**-**
				Total (excl GST)	**-**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	0	Lots	2,500	-
12.2	Geotechnical/pavement design	0	Lots	150	-
12.3	Electrical and street lighting design	0	Lots	250	-
12.4	Telecommunications design	0	Lots	80	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (20%)	**-**
				Total (excl GST)	**-**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	0	Lots	100	-
13.2	Telecommunications authority	0	Lots	600	-
13.3	Council	0	Lots	300	-
13.4	Water authority	0	Lots	80	-
				Subtotal	**-**
				Sub-total (excl GST)	**-**
				Contingency (20%)	**-**
				Total (excl GST)	**-**
				Grand Total including contingency (excl GST)	**390,980**

Allen Price & Scarratts
Land & Development Consultants
NOWRA AND KIAMA - NSW

ESTIMATED QUANTITIES

Kourung Street

Road

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT excl GST
1	**ESTABLISHMENT AND PRELIMINARIES**				
1.1	Establishment	1	Item	20,000	20,000
1.2	Set out works	1	Item	10,000	10,000
1.3	Services location	1	Item	5,000	5,000
1.4	Traffic & Pedestrian Management Plan	1	Item	30,000	30,000
1.5	Stabilised site access and wash bay	1	Each	15,000	15,000
				Subtotal	**80,000**
2	**SITE WORKS**				
2.1	Demolition (allowance)	0.2	ha	100,000	19,800
2.2	Import, place and compact select fill	120	m^3	40	4,782
2.3	Trim and compact verge areas and swales	653	m^2	5	3,267
2.4	Topsoil and turf verge areas and swales	505	m^2	10	5,049
2.5	Street trees	13	each	500	6,600.00
				Subtotal	**39,498.48**
3	**ROADWORKS**				
3.1	**Road Pavement (8.5m wide)**				
3.2	Trim and Compact Subgrade	1426	m^2	5	7,128
3.3	Subbase DGB20 (280mm thick)	1426	m^2	25	35,640
3.4	Base Course DGB20 (120mm thick)	1327	m^2	15	19,899
3.5	Prime Seal	1327	m^2	8	10,613
3.6	Asphalt AC10 (min 30mm thick)	1327	m^2	25	33,165
				Subtotal	**106,445**
4	**STORMWATER DRAINAGE**				
4.1	DN450 RRJ Class 3	0	m	250	-
4.2	DN600 RRJ Class 3	150	m	300	45,000
4.3	DN900 RRJ Class 3	0	m	550	-
4.4	DN100mm subsoil drainage	198	m	35	6,930
4.5	Pit (900x900)	7	each	2,500	17,500
4.6	Pit (1200x1200)	0	each	4,000	-
4.7	Pit (1500x1500)	0	each	5,000	-
4.8	DN450mm Headwall	0	Item	1,500	-
4.9	DN600mm Headwall	2	Item	3,000	6,000
4.10	DN900mm Headwall	0	Item	3,500	-
4.11	1.3 x 0.3 RCBC	0	m	900	-
				Subtotal	**75,430**
5	**CONCRETE WORKS**				

5.1	Kerb - Edge strip	0	m	50	-
5.2	Kerb - Upright Kerb & Gutter	198	m	70	13,860
5.3	Footpath - 1.5m wide	99	m	150	14,850
				Subtotal	**28,710**
6	**SIGNAGE & ROAD FURNITURE**				
6.1	Signage and linemarking	99	m	15	1,485
				Subtotal	**1,485**

7	**TESTING & WAE**				
7.1	Density testing	99	m	20	1,980
7.2	Road & drainage works as executed	99	Item	15	1,485
				Subtotal	**3,465**
8	**SOIL AND WATER MANAGEMENT**				
8.1	Soil and water management	99	m	20	1,980
				Subtotal	**1,980**
9	**SERVICE CONDUIT INSTALLATION**				
9.1	Install new elec and comms road crossings	99	m	20	1,980
9.2	Install new water conduit crossings	66	m	15	990
				Subtotal	**2,970**
10	**MISCELLANEOUS**				
10.1	Road ends transition allowance	2	Each	10,000	20,000
10.2	Clean-up and disestablish	1	Item	10,000	10,000
				Subtotal	**30,000**
				Sub-total (excl GST)	**294,553**
				Contingency (30%)	**88,366**
				Total (excl GST)	**382,919**

Reticulated services

11	**Reticulated services**				
11.1	Underground electricity and street lighting	7	Lots	8,000	56,000
11.2	Underground telecommunications	7	Lots	1,000	7,000
11.3	Water reticulation	7	Lots	3,000	21,000
11.3	Re-connections allowance	7	Lots	10,000	70,000
				Subtotal	**154,000**
				Sub-total (excl GST)	**154,000**
				Contingency (30%)	**46,200**
				Total (excl GST)	**200,200**

Consultancy services

12	**Consultancy services**				
12.1	Survey, design and construction management	7	Lots	2,500	17,500
12.2	Geotechnical/pavement design	7	Lots	150	1,050
12.3	Electrical and street lighting design	7	Lots	250	1,750
12.4	Telecommunications design	7	Lots	80	560
				Subtotal	**20,860**
				Sub-total (excl GST)	**20,860**
				Contingency (20%)	**4,172**
				Total (excl GST)	**25,032**

Authority design and inspection fees

13	**Authority design and inspection fees**				
13.1	Electricity authority	7	Lots	100	700
13.2	Telecommunications authority	7	Lots	600	4,200
13.3	Council	7	Lots	300	2,100
13.4	Water authority	7	Lots	80	560
				Subtotal	**7,560**
				Sub-total (excl GST)	**7,560**
				Contingency (20%)	**1,512**
				Total (excl GST)	**9,072**
				Grand Total including contingency (excl GST)	**617,223**

ATTACHMENT 2 – FLOOD DAMAGE SUMMARY

Woy Woy

Base Case														
	PMF		0.5% AEP		1% AEP		2% AEP		5%AEP		10% AEP		20% AEP		AAD
	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	
2021	$20,203,948.77	215	$9,632,512.17	136	$7,108,935.15	101	$4,745,679.82	71	$3,139,652.53	47	$1,663,721.21	26	$831,231.93	15	$663,365.44
2030	$24,903,157.56	241	$13,421,176.48	167	$10,942,690.19	144	$8,204,743.07	114	$5,690,507.82	77	$3,733,112.78	54	$2,103,713.54	35	$1,303,683.67
2050	$14,319,322.09	135	$6,891,110.30	82	$5,777,776.00	70	$4,650,757.75	58	$3,539,696.21	47	$2,475,006.71	30	$1,820,295.78	19	$897,768.79
2100	$22,063,921.80	303	$3,742,851.94	0	$3,486,122.02	0	$3,242,904.21	0	$2,945,637.99	0	$2,580,811.26	0	$1,986,278.83	0	$873,391.16
Masterplan															
	PMF		0.5% AEP		1% AEP		2% AEP		5%AEP		10% AEP		20% AEP		AAD
	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	
2021	$20,203,948.77	215	$9,632,512.17	136	$7,108,935.15	101	$4,745,679.82	71	$3,139,652.53	47	$1,663,721.21	26	$831,231.93	15	$663,365.44
2030	$24,903,157.56	241	$13,421,176.48	167	$10,942,690.19	144	$8,204,743.07	114	$5,690,507.82	77	$3,733,112.78	54	$2,103,713.54	35	$1,303,683.67
2050	$13,670,741.25	135	$6,891,110.30	82	$5,777,776.00	70	$4,650,757.75	58	$3,539,696.21	47	$2,475,006.71	30	$1,820,295.78	19	$896,150.58
2100	$32,290,330.43	477	$4,756,259.50	0	$3,999,581.85	0	$3,459,097.82	0	$2,729,444.37	0	$1,783,597.31	0	$1,121,504.37	0	$670,749.16

Blackwall

Base Case														
	PMF		0.5% AEP		1% AEP		2% AEP		5%AEP		10% AEP		20% AEP		AAD
	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	
2021	$625,110.39	8	$159,923.42	1	$105,602.63	1	$54,048.40	0	$13,512.10	0	$0.00	0	$0.00	0	$4,771.94
2030	$1,050,795.63	11	$228,670.41	2	$211,477.65	1	$146,411.32	1	$54,048.40	0	$40,536.30	0	$0.00	0	$13,480.41
2050	$1,209,376.64	12	$339,390.83	3	$253,472.82	2	$174,622.00	1	$119,387.12	1	$78,578.43	1	$40,536.30	0	$28,882.27
2100	$1,793,250.36	24	$337,802.52	0	$337,802.52	0	$337,802.52	0	$324,290.42	0	$283,754.12	0	$229,705.71	0	$95,645.37
Masterplan															
	PMF		0.5% AEP		1% AEP		2% AEP		5%AEP		10% AEP		20% AEP		AAD
	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	
2021	$625,110.39	8	$159,923.42	1	$105,602.63	1	$54,048.40	0	$13,512.10	0	$0.00	0	$0.00	0	$4,771.94
2030	$1,050,795.63	11	$228,670.41	2	$211,477.65	1	$146,411.32	1	$54,048.40	0	$40,536.30	0	$0.00	0	$13,480.41
2050	$1,195,864.54	12	$339,390.83	3	$253,472.82	2	$174,622.00	1	$119,387.12	1	$78,578.43	1	$40,536.30	0	$28,848.55
2100	$2,266,355.25	30	$418,875.13	0	$418,875.13	0	$418,875.13	0	$405,363.03	0	$378,338.82	0	$337,802.52	0	$131,416.34

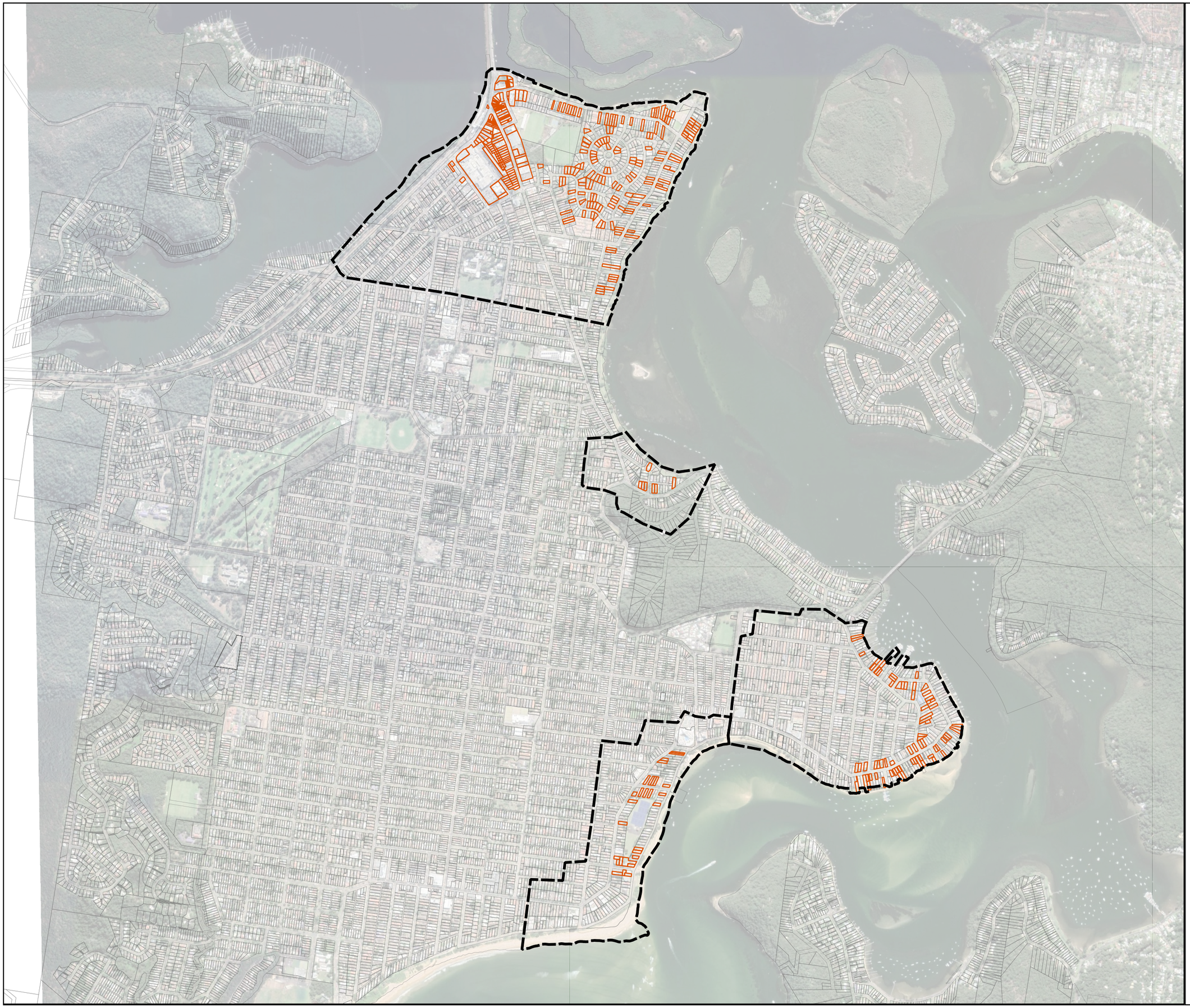
Booker Bay

Base Case															
	PMF		0.5% AEP		1% AEP		2% AEP		5%AEP		10% AEP		20% AEP		AAD
	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	
2021	$5,718,828.59	73	$2,365,415.63	30	$1,651,163.27	22	$1,055,198.83	13	$471,566.62	6	$312,867.89	4	$195,807.34	3	$141,060.65
2030	$7,510,134.37	87	$3,888,252.10	48	$2,862,116.26	34	$2,039,978.91	25	$1,304,289.31	15	$868,931.12	12	$471,566.62	6	$312,079.79
2050	$6,683,232.24	70	$3,554,720.31	41	$3,006,027.42	35	$2,423,736.12	30	$1,800,368.50	24	$1,416,490.34	19	$1,080,318.44	14	$499,765.62
2100	$11,185,211.54	157	$1,932,230.42	0	$1,864,669.92	0	$1,824,133.62	0	$1,648,476.30	0	$1,553,891.60	0	$1,459,306.89	0	$562,368.59
Masterplan															
	PMF		0.5% AEP		1% AEP		2% AEP		5%AEP		10% AEP		20% AEP		AAD
	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	
2021	$5,718,828.59	73	$2,365,415.63	30	$1,651,163.27	22	$1,055,198.83	13	$471,566.62	6	$312,867.89	4	$195,807.34	3	$141,060.65
2030	$7,510,134.37	87	$3,888,252.10	48	$2,862,116.26	34	$2,039,978.91	25	$1,304,289.31	15	$868,931.12	12	$471,566.62	6	$312,079.79
2050	$6,602,159.63	70	$3,554,720.31	41	$3,006,027.42	35	$2,423,736.12	30	$1,800,368.50	24	$1,416,490.34	19	$1,080,318.44	14	$499,563.35
2100	$13,953,465.30	198	$2,621,347.57	0	$2,553,787.06	0	$2,499,738.66	0	$2,337,593.45	0	$2,094,375.63	0	$1,864,669.92	0	$740,571.60

Ettalong

Base Case															
	PMF		0.5% AEP		1% AEP		2% AEP		5%AEP		10% AEP		20% AEP		AAD
	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	
2021	$2,462,862.76	34	$693,597.76	7	$486,484.41	5	$266,090.17	3	$192,294.28	2	$116,956.52	2	$44,195.22	1	$43,882.35
2030	$3,325,925.35	45	$1,288,166.13	17	$842,525.60	8	$515,050.49	5	$389,323.24	3	$192,294.28	2	$159,034.70	2	$93,154.47
2050	$2,841,455.08	34	$1,512,185.50	20	$1,094,135.97	14	$706,658.10	9	$514,281.53	6	$335,274.84	4	$239,065.97	3	$130,512.05
2100	$4,221,406.87	60	$702,629.24	0	$689,117.14	0	$621,556.64	0	$567,508.24	0	$540,484.03	0	$472,923.53	0	$189,462.89
Masterplan															
	PMF		0.5% AEP		1% AEP		2% AEP		5%AEP		10% AEP		20% AEP		AAD
	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	Damages	Overfloor Flooding	
2021	$2,462,862.76	34	$693,597.76	7	$486,484.41	5	$266,090.17	3	$192,294.28	2	$116,956.52	2	$44,195.22	1	$43,882.35
2030	$3,325,925.35	45	$1,288,166.13	17	$842,525.60	8	$515,050.49	5	$389,323.24	3	$192,294.28	2	$159,034.70	2	$93,154.47
2050	$2,773,894.57	34	$1,512,185.50	20	$1,094,135.97	14	$706,658.10	9	$514,281.53	6	$335,274.84	4	$239,065.97	3	$130,343.48
2100	$5,433,109.50	77	$1,067,455.97	0	$999,895.46	0	$891,798.66	0	$824,238.15	0	$729,653.45	0	$621,556.64	0	$256,227.60

ATTACHMENT 3 – ASSUMED PROPERTIES REDEVELOPED BY 2050 (MAP G600)



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W E

S

Map G600

Properties Identified as Likely to Redvelop within the Next 50 Years

Legend

- Study Area
- Cadastre
- Identified Properties

0 0.25 0.5 0.75 km

Scale : 1:18000@A3
Date : 29 April 2021
Revision : A
Created by : JS
Coordinate System : MGA 56

Rhelm

engineering | environmental | economics | engagement

APPENDIX G

Adaptation Pathway Workplans

Work Plan – Adaptation Pathway A

Begin Actions	Option	Actions
Now	Liveability Conceptualisation	• Complete Woy Woy Climate Change Adaptation Case Study • Report Recommendations and Include in Draft Woy Woy FRMSP • Exhibit and Adopt Woy Woy FRMSP • Develop Masterplan and Public Domain Plan • Adopt Sea Level Rise Policy • Adopt Floodplain Risk Management Policy • LEP & DCP Review
2030	Liveability Planning	• Adopt Climate Change Adaptation Plan • Revised Adaptation Pathways • Community Engagement - Triggers and Threshold • Community Education - Adaptation Plan Process • Develop Drainage Master Plan -Constructability • Prepare Climate Adaptation Plan - Place Based • Adopt Masterplan and Public Domain Plan • LEP & DCP Revised to Include Climate Actions • Private Seawalls and Levees Guidelines • Establish Easements • Monitor Sea Level Rise
2040	Landform Realisation - Woy Woy	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform - Roads • Monitor Sea Level Rise
2070	Landform Realisation – Booker Bay	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise
2085		Undertake Revised Climate Change Adaptation Study
2090	Landform Realisation – Blackwall and Ettalong	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise

Work Plan – Adaptation Pathway B

Begin Actions	Option	Actions
Now	Business As Usual - Immediately	• Maintain Flood Planning Level for Storm Surge • Raise Landform - Roads with No Impact on Future Planning • Forward Capital Works Planning • Complete Woy Woy Climate Change Adaptation Case Study • Report recommendations and include in Draft Woy Woy FRMSP • Exhibit and Adopt Woy Woy FRMSP • Adopt Sea Level Rise Policy • Adopt Floodplain Risk Management Policy • LEP & DCP Reviewed
2030	Business As Usual – Very Short Term	• Adopt and Implement Woy Woy FRMSP • Adopt Climate Change Adaptation Plan • Forward Capital Works Planning • Develop Masterplan and Public Domain Plan • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise, Proposed Adaptation Plan • Guidance for Private Pumped Drainage Systems
2035	Liveability Planning (Accelerated)	• Community Engagement - Triggers and Threshold • Community Education - Adaptation Plan Process • Develop Drainage Master Plan -Constructability • Prepare Climate Adaptation Plan - Place Based • Adopt Masterplan and Public Domain Plan • LEP & DCP Revised to Include Climate Actions • Private Seawalls and Levees Guidelines • Establish Easements • Monitor Sea Level Rise
2040	Landform Realisation - Woy Woy	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform - Roads • Monitor Sea Level Rise
2070	Landform Realisation – Booker Bay	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise
2085		Undertake Revised Climate Change Adaptation Study
2090	Landform Realisation – Blackwall and Ettalong	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise

Work Plan – Adaptation Pathway C

Begin Actions	Option	Actions
Now	Business As Usual - Immediately	• Maintain Flood Planning Level for Storm Surge • Raise Landform - Roads with No Impact on Future Planning • Forward Capital Works Planning • Complete Woy Woy Climate Change Adaptation Case Study • Report recommendations and include in Draft Woy Woy FRMSP • Exhibit and Adopt Woy Woy FRMSP • Adopt Sea Level Rise Policy • Adopt Floodplain Risk Management Policy • LEP & DCP Reviewed
2030	Business As Usual – Very Short Term	• Adopt and Implement Woy Woy FRMSP • Adopt Climate Change Adaptation Plan • Forward Capital Works Planning • Develop Masterplan and Public Domain Plan • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise, Proposed Adaptation Plan • Guidance for Private Pumped Drainage Systems
2035	Business As Usual –Short Term	• Adopt Strategic Action Plan for Climate Change Adaptation • Forward Capital Works Planning • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise • Retreat Planning
2045	Retreat – Woy Woy	• Prepare and Adopt Retreat Policy • Community Education - Retreat Process • Evacuation Strategy • Reclassify Public Land • Forward Capital Works Planning • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas
2055	Liveability Planning (Excluding Woy Woy)	• Community Engagement - Triggers and Threshold • Community Education - Adaptation Plan Process • Develop Drainage Master Plan -Constructability • Prepare Climate Adaptation Plan - Place Based • Adopt Masterplan and Public Domain Plan • LEP & DCP Revised to Include Climate Actions • Private Seawalls and Levees Guidelines • Establish Easements • Monitor Sea Level Rise
2070	Landform Realisation – Booker Bay	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise
2085		Undertake Revised Climate Change Adaptation Study
2090	Landform Realisation – Blackwall and Ettalong	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise

Work Plan – Adaptation Pathway D

Begin Actions	Option	Actions
Now	Business As Usual - Immediately	• Maintain Flood Planning Level for Storm Surge • Raise Landform - Roads with No Impact on Future Planning • Forward Capital Works Planning • Complete Woy Woy Climate Change Adaptation Case Study • Report recommendations and include in Draft Woy Woy FRMSP • Exhibit and Adopt Woy Woy FRMSP • Adopt Sea Level Rise Policy • Adopt Floodplain Risk Management Policy • LEP & DCP Reviewed
2030	Business As Usual – Very Short Term	• Adopt and Implement Woy Woy FRMSP • Adopt Climate Change Adaptation Plan • Forward Capital Works Planning • Develop Masterplan and Public Domain Plan • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise, Proposed Adaptation Plan • Guidance for Private Pumped Drainage Systems
2035	Business As Usual –Short Term	• Adopt Strategic Action Plan for Climate Change Adaptation • Forward Capital Works Planning • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise • Retreat Planning
2045	Retreat – Woy Woy	• Prepare and Adopt Retreat Policy • Community Education - Retreat Process • Evacuation Strategy • Reclassify Public Land • Forward Capital Works Planning • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas
2050	Business As Usual – Medium Term	• Forward Capital Works Planning • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise
2075	Retreat – Booker Bay	• Revise and Adopt Retreat Policy • Community Education - Retreat Process • Evacuation Strategy • Reclassify Public Land • Forward Capital Works Planning • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas
2080	Liveability Planning (Blackwall & Ettalong only)	• Community Engagement - Triggers and Threshold • Community Education - Adaptation Plan Process • Develop Drainage Master Plan -Constructability • Prepare Climate Adaptation Plan - Place Based • Adopt Masterplan and Public Domain Plan • LEP & DCP Revised to Include Climate Actions • Private Seawalls and Levees Guidelines • Establish Easements • Monitor Sea Level Rise
2085		Undertake Revised Climate Change Adaptation Study
2090	Landform Realisation – Blackwall and Ettalong	• Community Education - Filling Process • Property Filling Guidelines • Temporary Private Levees/Seawalls • Raise Landform - Private Land • Raise Landform - Public Land • Raise Landform – Roads • Monitor Sea Level Rise

Work Plan – Adaptation Pathway E

Begin Actions	Option	Actions
Now	Business As Usual - Immediately	• Maintain Flood Planning Level for Storm Surge • Raise Landform - Roads with No Impact on Future Planning • Forward Capital Works Planning • Complete Woy Woy Climate Change Adaptation Case Study • Report recommendations and include in Draft Woy Woy FRMSP • Exhibit and Adopt Woy Woy FRMSP • Adopt Sea Level Rise Policy • Adopt Floodplain Risk Management Policy • LEP & DCP Reviewed
2030	Business As Usual – Very Short Term	• Adopt and Implement Woy Woy FRMSP • Adopt Climate Change Adaptation Plan • Forward Capital Works Planning • Develop Masterplan and Public Domain Plan • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise, Proposed Adaptation Plan • Guidance for Private Pumped Drainage Systems
2035	Business As Usual –Short Term	• Adopt Strategic Action Plan for Climate Change Adaptation • Forward Capital Works Planning • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise • Retreat Planning
2045	Retreat – Woy Woy	• Prepare and Adopt Retreat Policy • Community Education - Retreat Process • Evacuation Strategy • Reclassify Public Land • Forward Capital Works Planning • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas
2050	Business As Usual – Medium Term	• Forward Capital Works Planning • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise
2075	Retreat – Booker Bay	• Revise and Adopt Retreat Policy • Community Education - Retreat Process • Evacuation Strategy • Reclassify Public Land • Forward Capital Works Planning • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas
2080	Business As Usual – Long Term	• Forward Capital Works Planning • Lift Existing Dwellings • Raise Landform - Roads • Install Flood Gates / One-way Valves • Community Education - Future Sea Level Rise
2085		Undertake Revised Climate Change Adaptation Study
2095	Retreat – Blackwall & Ettalong	• Revise and Adopt Retreat Policy • Community Education - Retreat Process • Evacuation Strategy • Reclassify Public Land • Forward Capital Works Planning • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas

Work Plan – Adaptation Pathway F

Begin Actions	Option	Actions
2035	Retreat Planning	• Prepare and Adopt Retreat Policy • Community Education - Retreat Process • Evacuation Strategy • Forward Capital Works Planning
2045	Retreat Woy Woy	• Reclassify Public Land • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas
2075	Retreat – Booker Bay	• Revise and Adopt Retreat Policy • Community Education - Retreat Process • Reclassify Public Land • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas
2085		Undertake Revised Climate Change Adaptation Study
2095	Retreat – Blackwall & Ettalong	• Revise and Adopt Retreat Policy • Community Education - Retreat Process • Reclassify Public Land • Relocate Community Infrastructure • Re-zoning Coastal Areas • Decommission Public Assets • Closing of Public Recreational Areas

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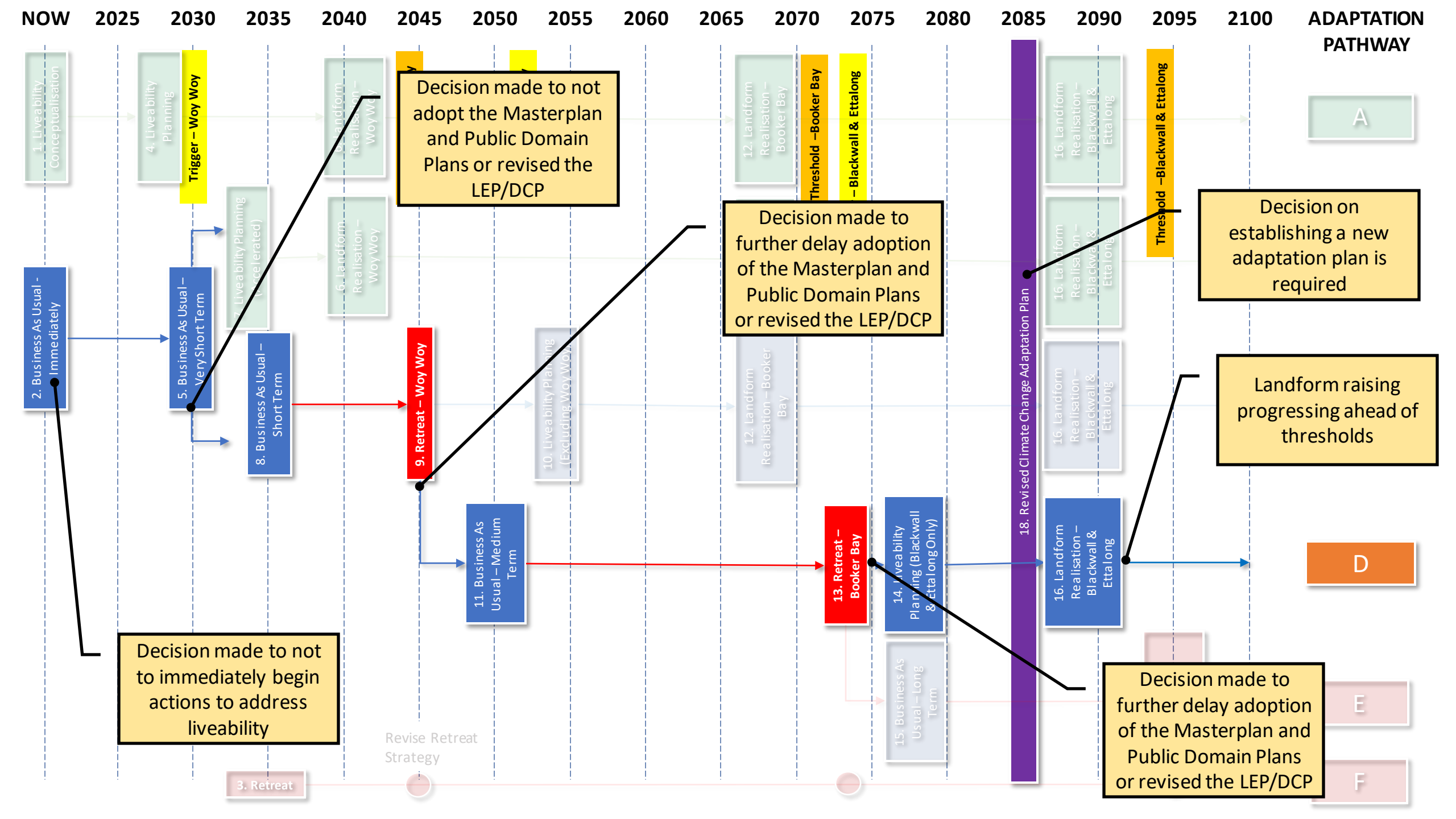
APPENDIX H

Adaptation Pathway Decision Examples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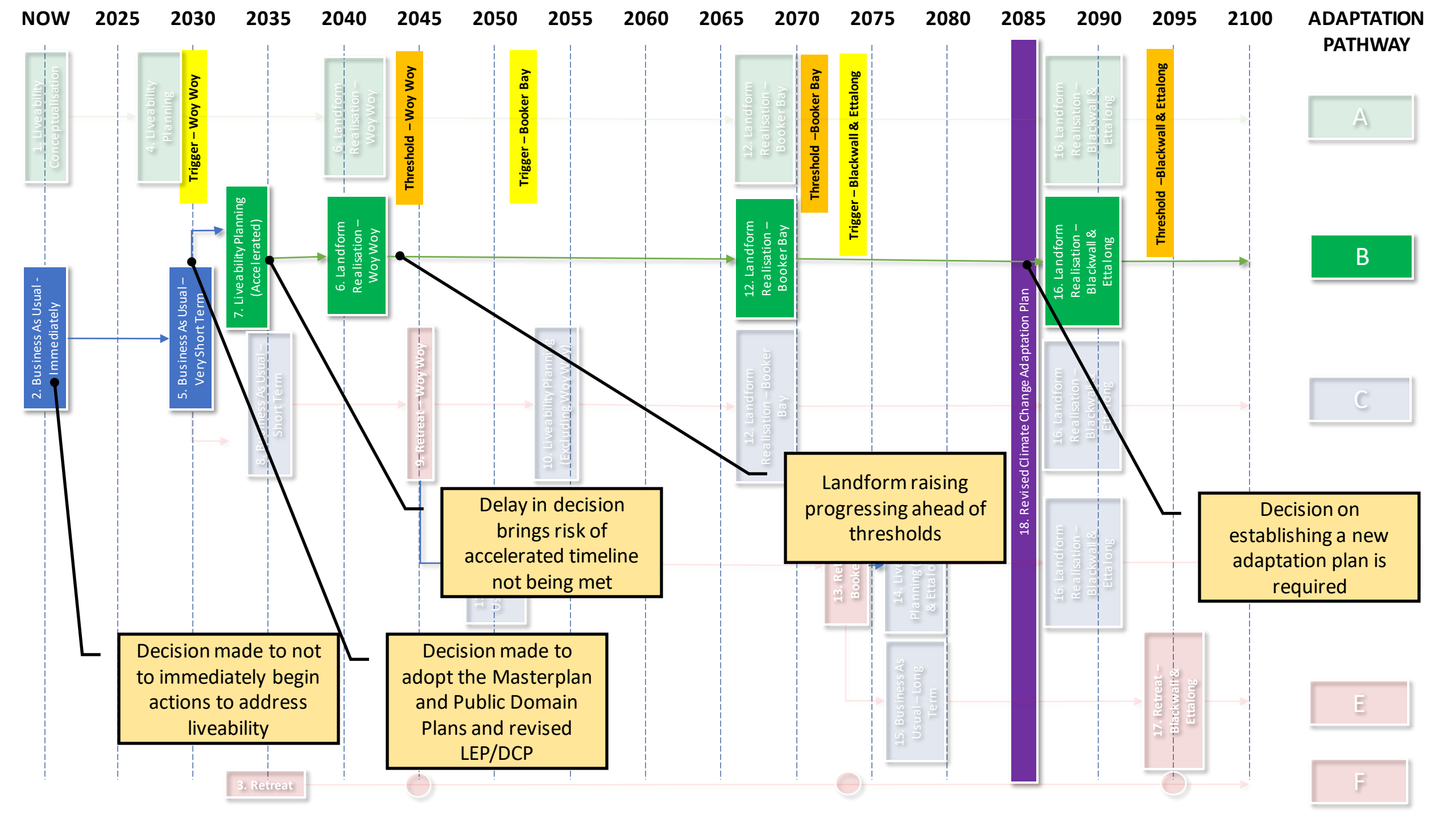
ADAPTATION PATHWAY
1. Liveability Conceptualisation
4. Liveability Planning
Trigger – Woy Woy
Landform Realisation – Woy Woy
7. Liveability Planning (Accelerated)
6. Landform Realisation – Woy Woy
Decision made to not adopt the Masterplan and Public Domain Plans or revised the LEP/DCP
12. Landform Realisation – Booker Bay
Threshold –Booker Bay
– Blackwall & Ettalong
16. Landform Realisation – Blackwall & Ettalong
Threshold –Blackwall & Ettalong
A
Decision on establishing a new adaptation plan is required
2. Business As Usual - Immediately
5. Business As Usual – Very Short Term
8. Business As Usual – Short Term
9. Retreat – Woy Woy
10. Liveability Planning (Excluding Woy Woy)
Decision made to further delay adoption of the Masterplan and Public Domain Plans or revised the LEP/DCP
12. Landform Realisation – Booker Bay
16. Landform Realisation – Blackwall & Ettalong
Landform raising progressing ahead of thresholds
18. Revised Climate Change Adaptation Plan
11. Business As Usual – Medium Term
13. Retreat – Booker Bay
14. Liveability Planning (Blackwall & Ettalong Only)
16. Landform Realisation – Blackwall & Ettalong
D
Decision made to not to immediately begin actions to address liveability
15. Business As Usual – Long Term
Revise Retreat Strategy
Decision made to further delay adoption of the Masterplan and Public Domain Plans or revised the LEP/DCP
E
3. Retreat
F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ADAPTATION PATHWAY
A
B
C
E
F
1. Liveability Conceptualisation
4. Liveability Planning
Trigger – Woy Woy
6. Landform Realisation – Woy Woy
Threshold – Woy Woy
Trigger – Booker Bay
12. Landform Realisation – Booker Bay
Threshold –Booker Bay
Trigger – Blackwall & Ettalong
16. Landform Realisation – Blackwall & Ettalong
Threshold –Blackwall & Ettalong
2. Business As Usual - Immediately
5. Business As Usual – Very Short Term
7. Liveability Planning (Accelerated)
6. Landform Realisation – Woy Woy
12. Landform Realisation – Booker Bay
16. Landform Realisation – Blackwall & Ettalong
8. Business As Usual – Short Term
9. Retreat – Woy Woy
10. Liveability Planning (Excluding Woy Woy)
12. Landform Realisation – Booker Bay
16. Landform Realisation – Blackwall & Ettalong
13. Retreat – Booker Bay
14. Liveability Planning – Blackwall & Ettalong
15. Business As Usual – Long Term
16. Landform Realisation – Blackwall & Ettalong
17. Retreat – Blackwall & Ettalong
18. Revised Climate Change Adaptation Plan
3. Retreat
Decision made to not to immediately begin actions to address liveability
Decision made to adopt the Masterplan and Public Domain Plans and revised LEP/DCP
Delay in decision brings risk of accelerated timeline not being met
Landform raising progressing ahead of thresholds
Decision on establishing a new adaptation plan is required

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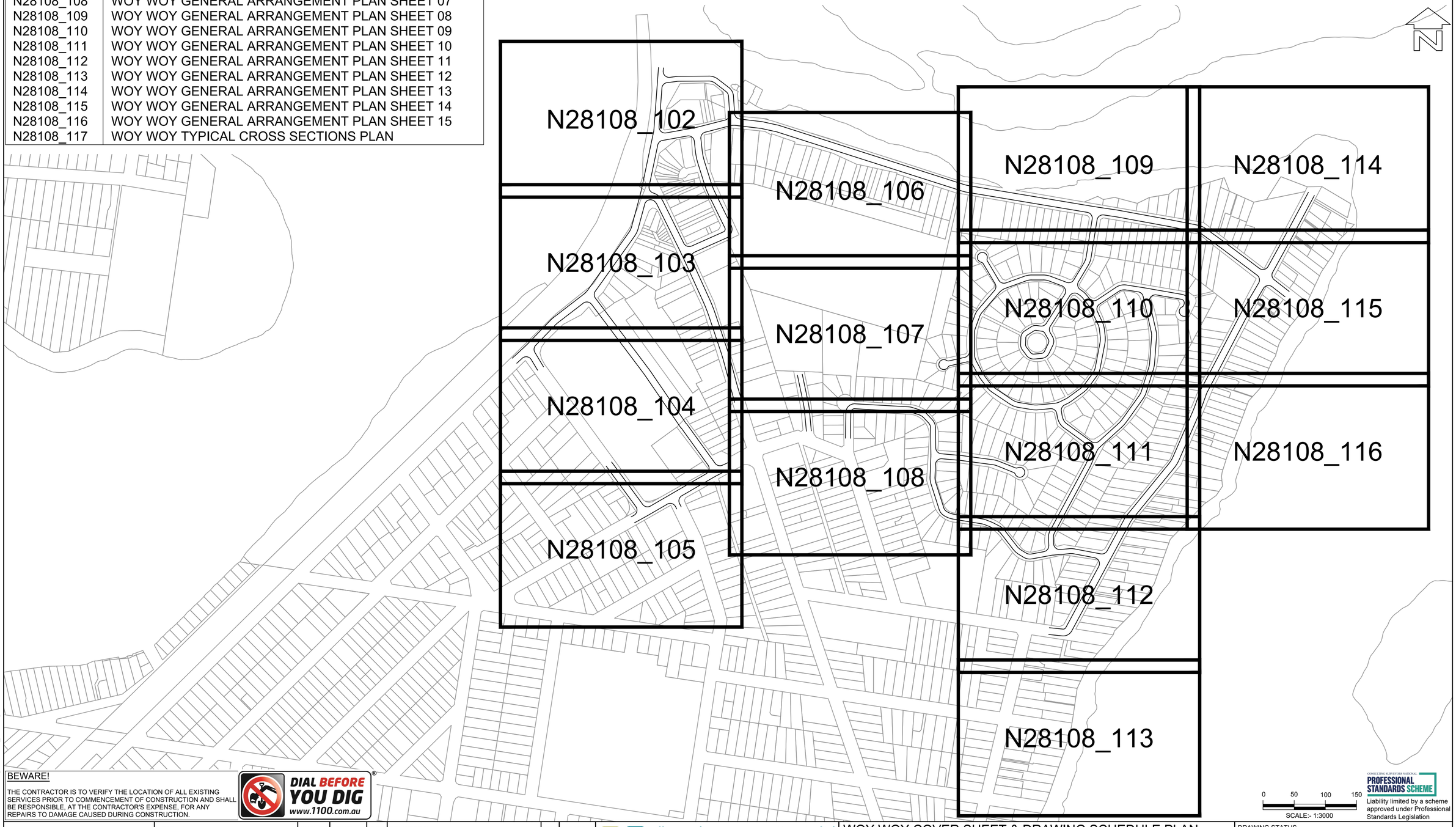
APPENDIX I

Adaptation Landform Concept Civil Design

WOY WOY CLIMATE CHANGE ADAPTATION LANDFORM DESIGN

DRAWING SCHEDULE

N28108_101	WOY WOY COVER SHEET & DRAWING SCHEDULE PLAN
N28108_102	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 01
N28108_103	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 02
N28108_104	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 03
N28108_105	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 04
N28108_106	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 05
N28108_107	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 06
N28108_108	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 07
N28108_109	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 08
N28108_110	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 09
N28108_111	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 10
N28108_112	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 11
N28108_113	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 12
N28108_114	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 13
N28108_115	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 14
N28108_116	WOY WOY GENERAL ARRANGEMENT PLAN SHEET 15
N28108_117	WOY WOY TYPICAL CROSS SECTIONS PLAN



BEWARE!

THE CONTRACTOR IS TO VERIFY THE LOCATION OF ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF CONSTRUCTION AND SHALL BE RESPONSIBLE, AT THE CONTRACTOR'S EXPENSE, FOR ANY REPAIRS TO DAMAGE CAUSED DURING CONSTRUCTION.

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SCALE:- 1:3000

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RATIO: 1:3000 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

		REV	DESCRIPTION	BY	DATE
SURVEY	RHELM	=			
DESIGN	CJG				
DRAWN	CJG				
CHECK'D	RHM				

allen price & scarratts pty ltd
land and development consultants
Nowra Branch: 75 Plunkett Street, Nowra NSW 2541
Kiama Branch: 1/28 Bong Bong Street, Kiama NSW 2533
phone:(02) 4421 6544
consultants@allenprice.com.au www.allenprice.com.au

WOY WOY COVER SHEET & DRAWING SCHEDULE PLAN
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE
ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_101
SHEET 1 OF 17
REVISION: P0

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BRICK WHARF ROAD
BRISBANE WATER DRIVE
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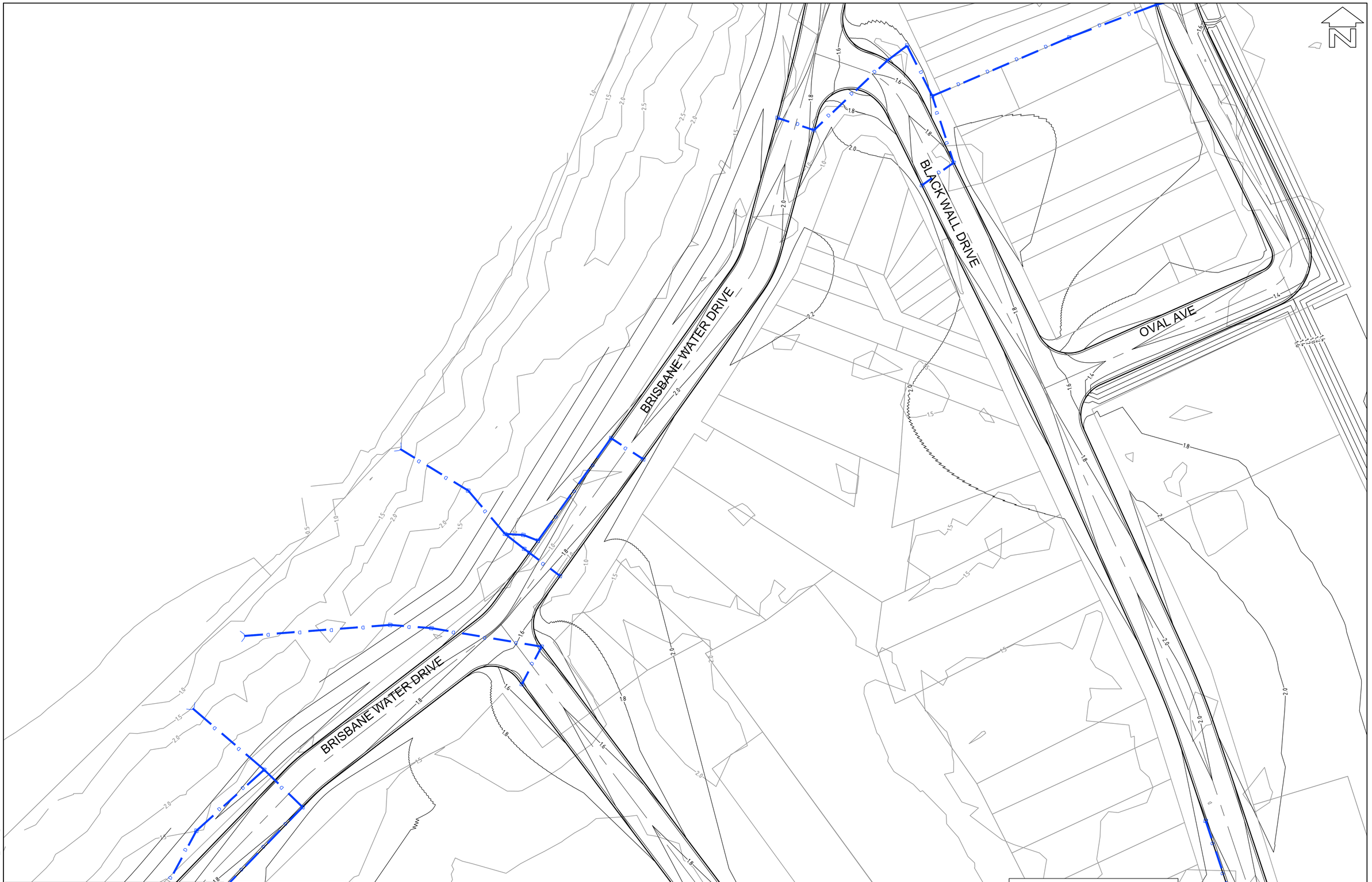

LAYOUT PLAN
SCALE 1:500

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LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
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land and development consultants
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consultants@allenprice.com.au www.allenprice.com.au

WOY WOY GENERAL ARRANGEMENT PLAN SHEET 02
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
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DRAWING NUMBER: N28108_103
SHEET 3 OF 17
REVISION: P0

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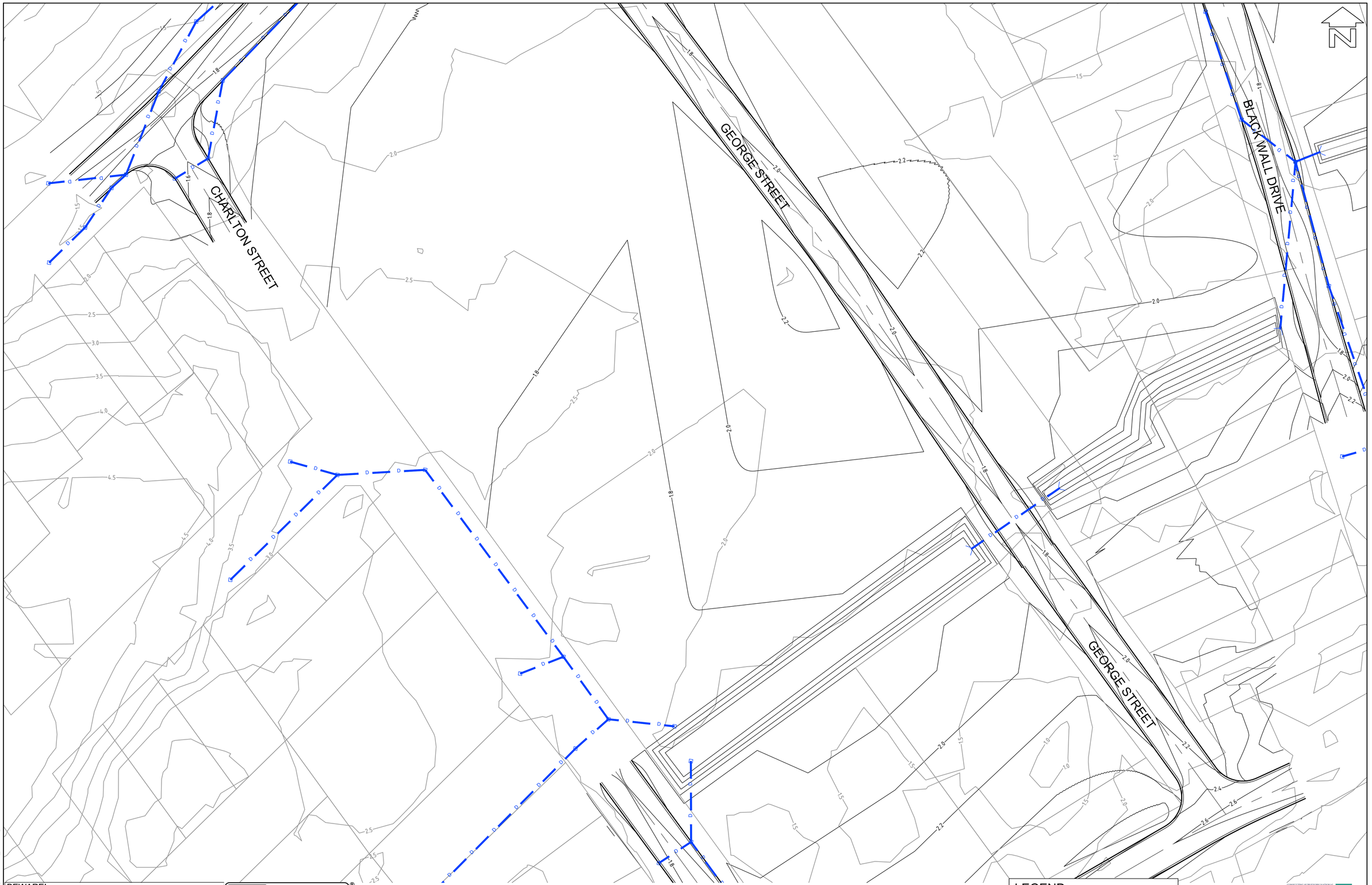

LAYOUT PLAN
SCALE 1:500

BEWARE!

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LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

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SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 03
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
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DRAWING NUMBER: N28108_104
SHEET 4 OF 17
REVISION: P0

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LAYOUT PLAN
SCALE 1:500

LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO:	DATUM:						
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		CHECK'D	RHM				
	DATE OF PLAN: OCTOBER 2020						

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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 04
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

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REVISION P0

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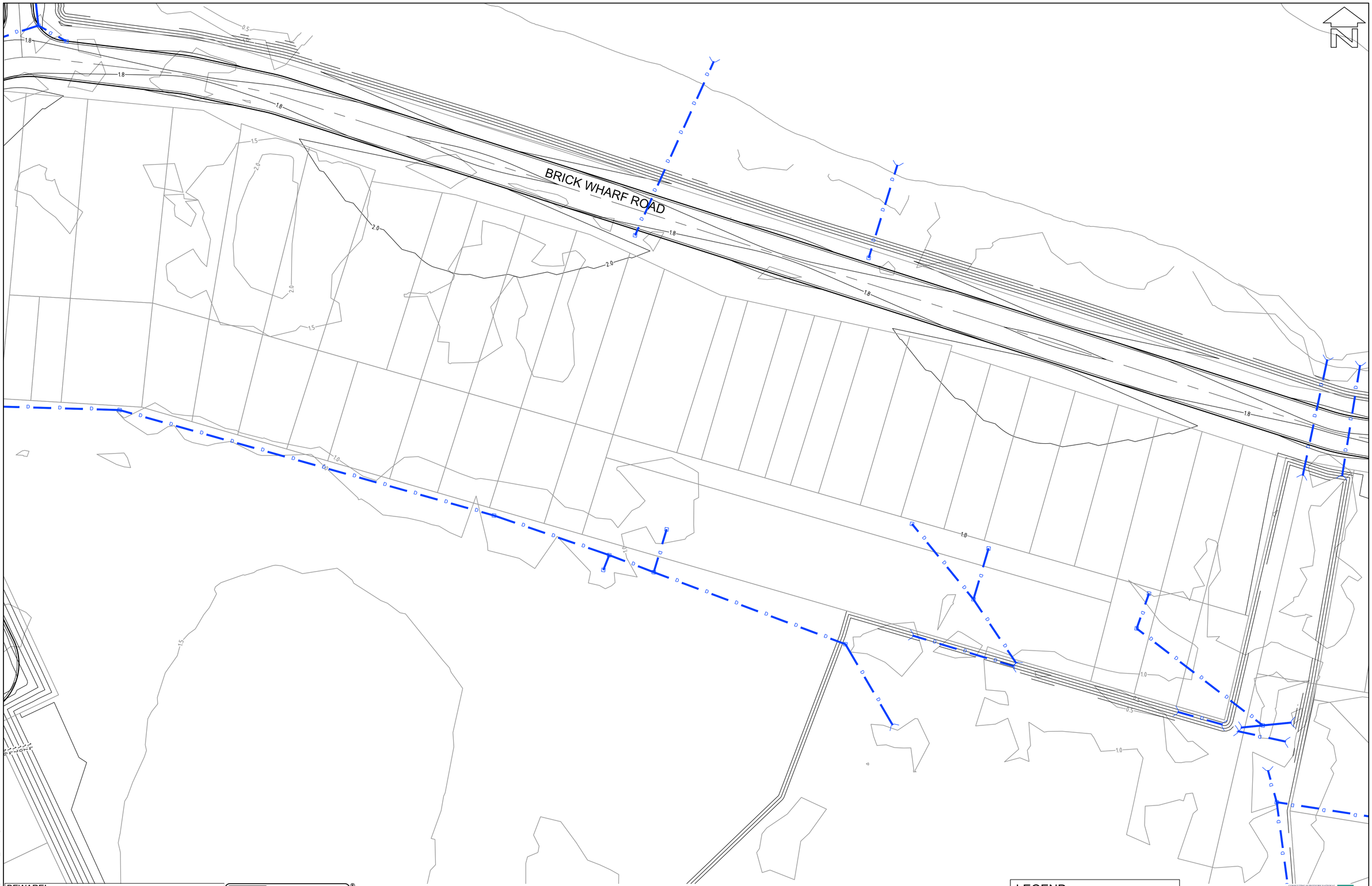

LAYOUT PLAN
SCALE 1:500

BEWARE!

THE CONTRACTOR IS TO VERIFY THE LOCATION OF ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF CONSTRUCTION AND SHALL BE RESPONSIBLE, AT THE CONTRACTOR'S EXPENSE, FOR ANY REPAIRS TO DAMAGE CAUSED DURING CONSTRUCTION.

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LEGEND:

- 1.5 DESIGN SURFACE CONTOURS
- 1.5 EXISTING SURFACE CONTOURS
- D STORMWATER DRAINAGE LINES

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SCALE:- 1:500

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		CHECK'D	RHM				
	DATE OF PLAN: OCTOBER 2020						

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land and development consultants
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Kiama Branch: 1/28 Bong Bong Street, Kiama NSW 2533
phone:(02) 4421 6544
consultants@allenprice.com.au www.allenprice.com.au

WOY WOY GENERAL ARRANGEMENT PLAN SHEET 05
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

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REVISION: P0

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LAYOUT PLAN
SCALE 1:500

BEWARE!

THE CONTRACTOR IS TO VERIFY THE LOCATION OF ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF CONSTRUCTION AND SHALL BE RESPONSIBLE, AT THE CONTRACTOR'S EXPENSE, FOR ANY REPAIRS TO DAMAGE CAUSED DURING CONSTRUCTION.

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LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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Kiama Branch: 1/28 Bong Bong Street, Kiama NSW 2533
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consultants@allenprice.com.au www.allenprice.com.au

WOY WOY GENERAL ARRANGEMENT PLAN SHEET 06
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_107
SHEET 7 OF 17
REVISION: P0

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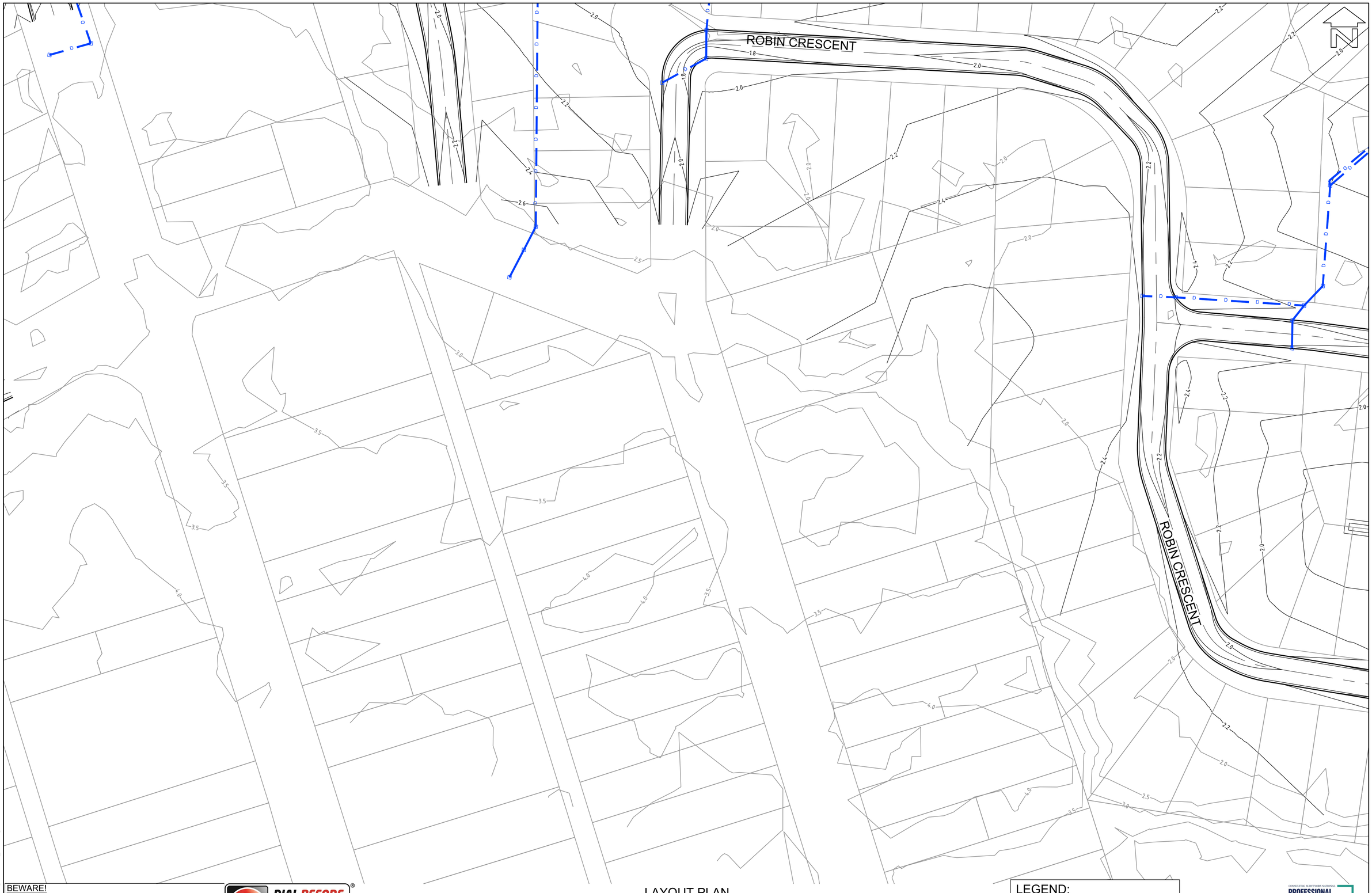

BEWARE!

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LAYOUT PLAN
SCALE 1:500

LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
	DESIGN	CJG
	DRAWN	CJG
	CHECK'D	RHM

REV	DESCRIPTION	BY	DATE
=			

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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 07
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_108
SHEET 8 OF 17
REVISION: P0

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BRICK WHARF ROAD

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LAYOUT PLAN
SCALE 1:500

LEGEND:

- 1.5 DESIGN SURFACE CONTOURS
- 1.5 EXISTING SURFACE CONTOURS
- D STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)	DATUM: AUSTRALIAN HEIGHT DATUM ORIGIN: SSM RL DATE OF PLAN: OCTOBER 2020	SURVEY	RHELM	REV	DESCRIPTION	BY	DATE
		DESIGN	CJG	=			
		DRAWN	CJG				
		CHECK'D	RHM				

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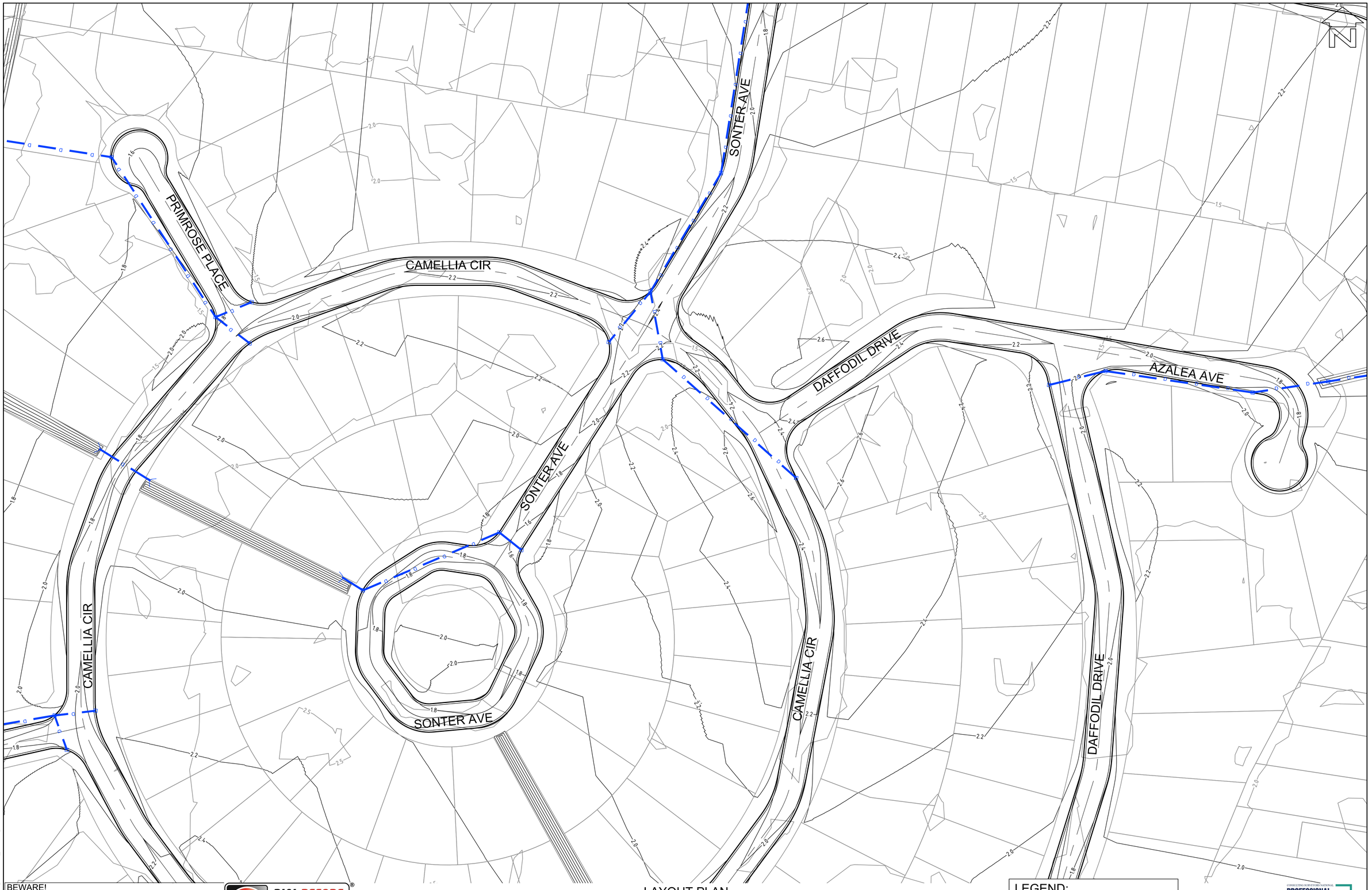
WOY WOY GENERAL ARRANGEMENT PLAN SHEET 08
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_109
SHEET: 9 OF 17
REVISION: P0



LAYOUT PLAN
SCALE 1:500

LEGEND:
- 1.5 DESIGN SURFACE CONTOURS
- 1.5 EXISTING SURFACE CONTOURS
- D STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 09
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_110
SHEET 10 OF 17
REVISION: P0

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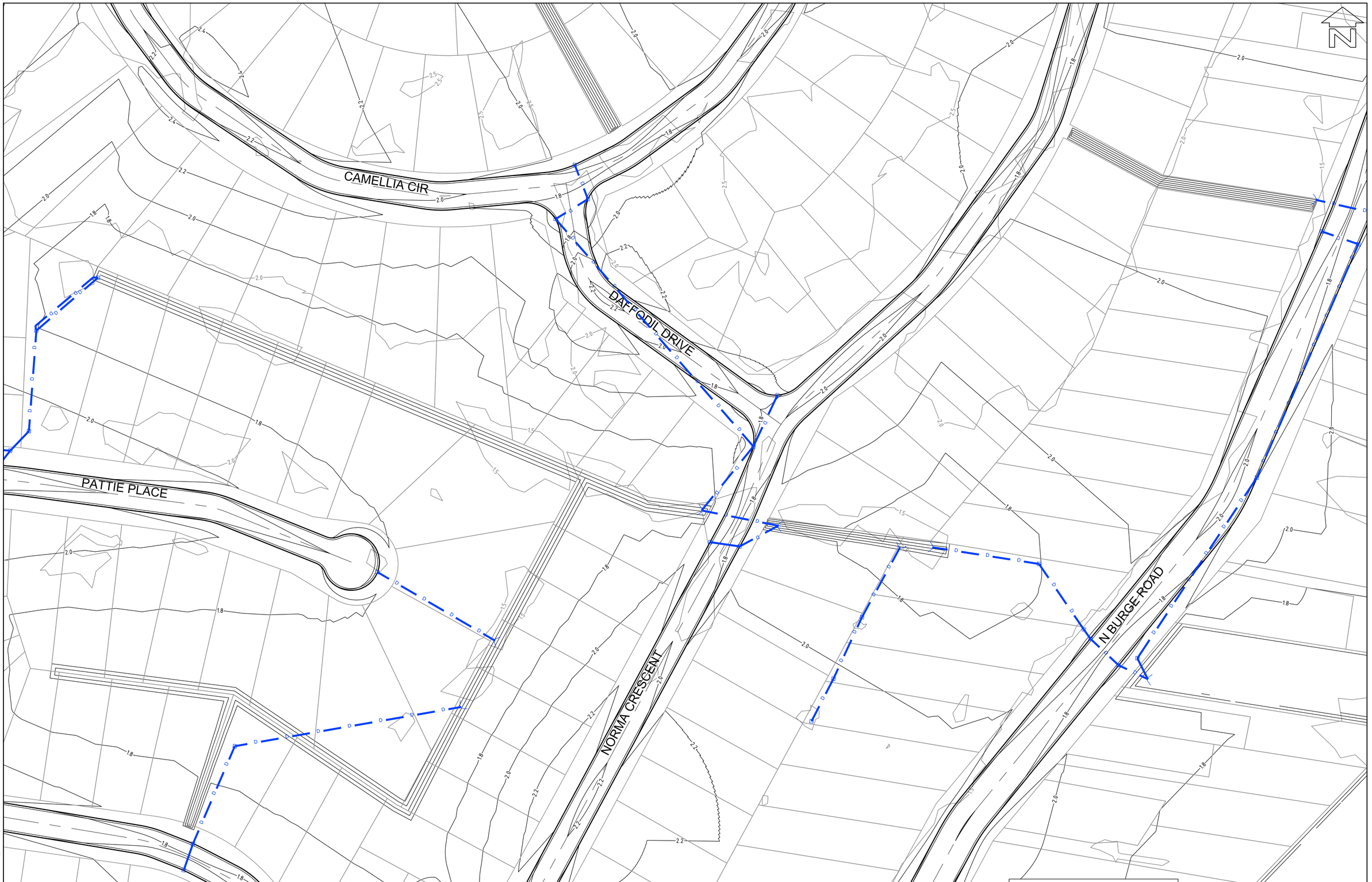

LAYOUT PLAN
SCALE 1:500

BEWARE!

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LEGEND:

- 1.5 DESIGN SURFACE CONTOURS
- 1.5 EXISTING SURFACE CONTOURS
- D STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO:	DATUM:							
1:500 (AT A1 ORIGINAL)	AUSTRALIAN HEIGHT DATUM	SURVEY	RHELM	REV	DESCRIPTION	BY	DATE
	ORIGIN: SSM RL	DESIGN	CJG	=			
		DRAWN	CJG				
		CHECK'D	RHM				
	DATE OF PLAN: OCTOBER 2020						

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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 10
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_111
SHEET 11 OF 17
REVISION: P0

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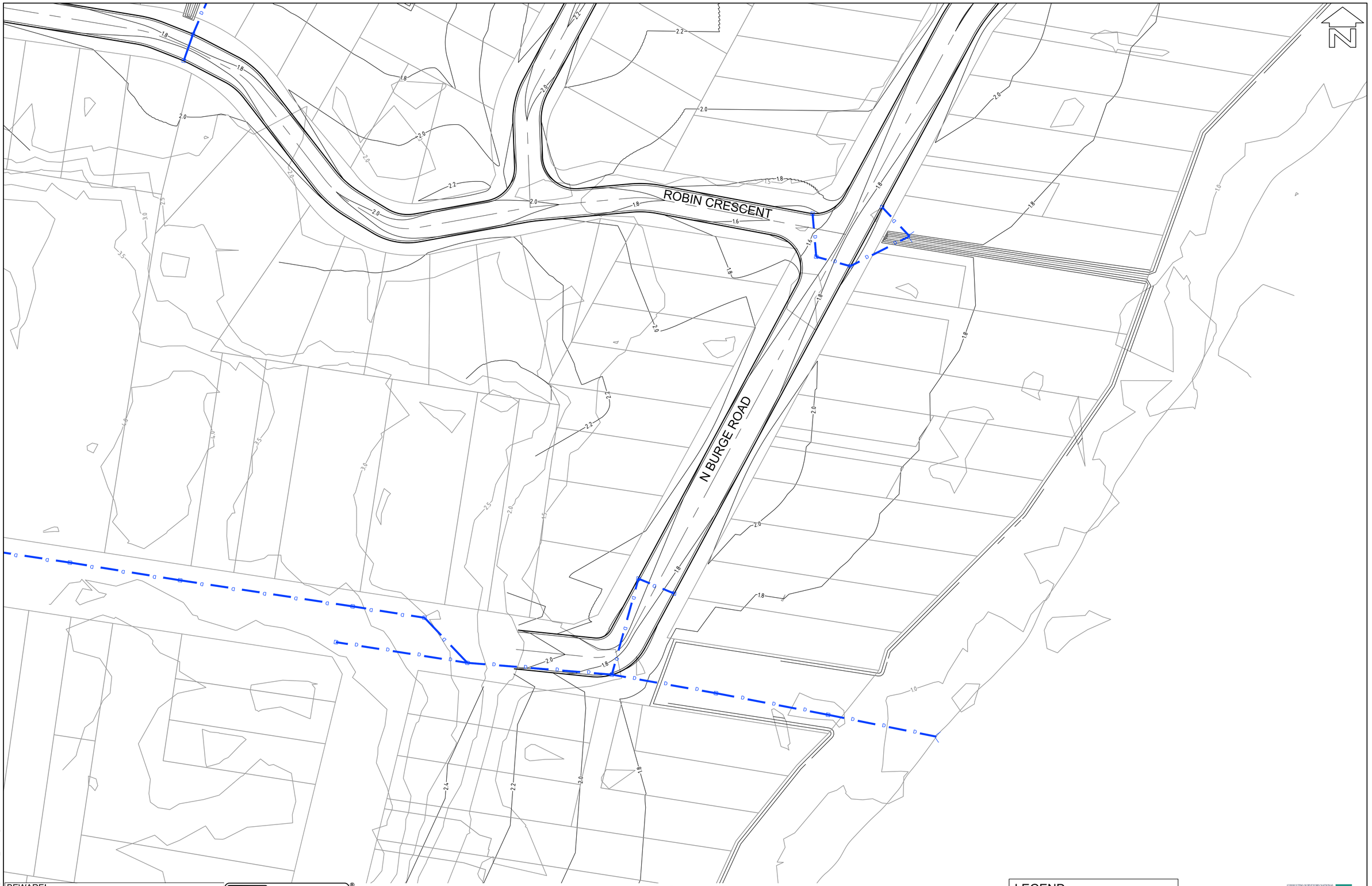

LAYOUT PLAN
SCALE 1:500

BEWARE!

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LEGEND:

- 1.5 DESIGN SURFACE CONTOURS
- 1.5 EXISTING SURFACE CONTOURS
- D STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 11
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_112
SHEET 12 OF 17
REVISION: P0

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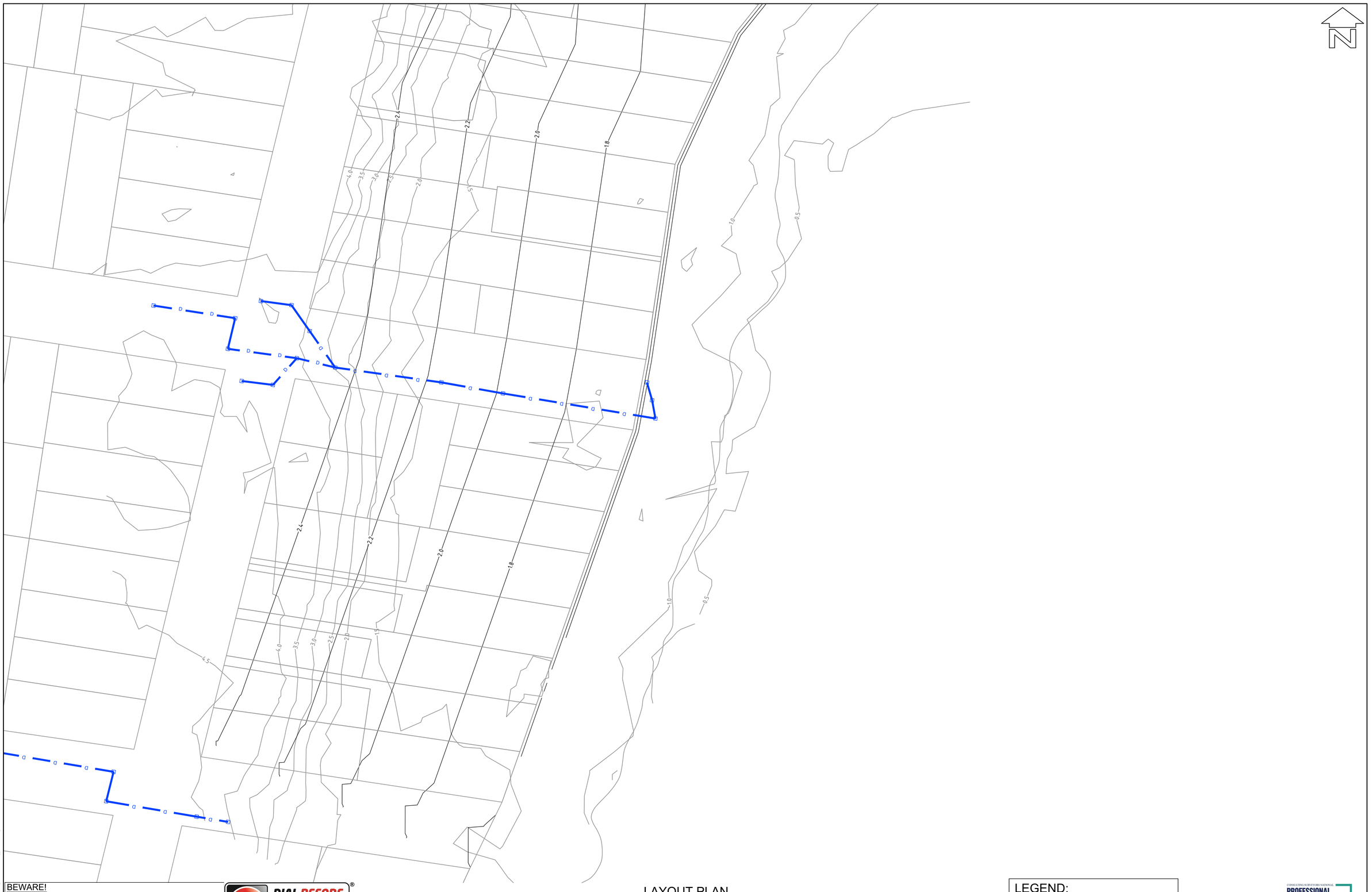

LAYOUT PLAN
SCALE 1:500

BEWARE!

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LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 12
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_113
SHEET 13 OF 17
REVISION: P0

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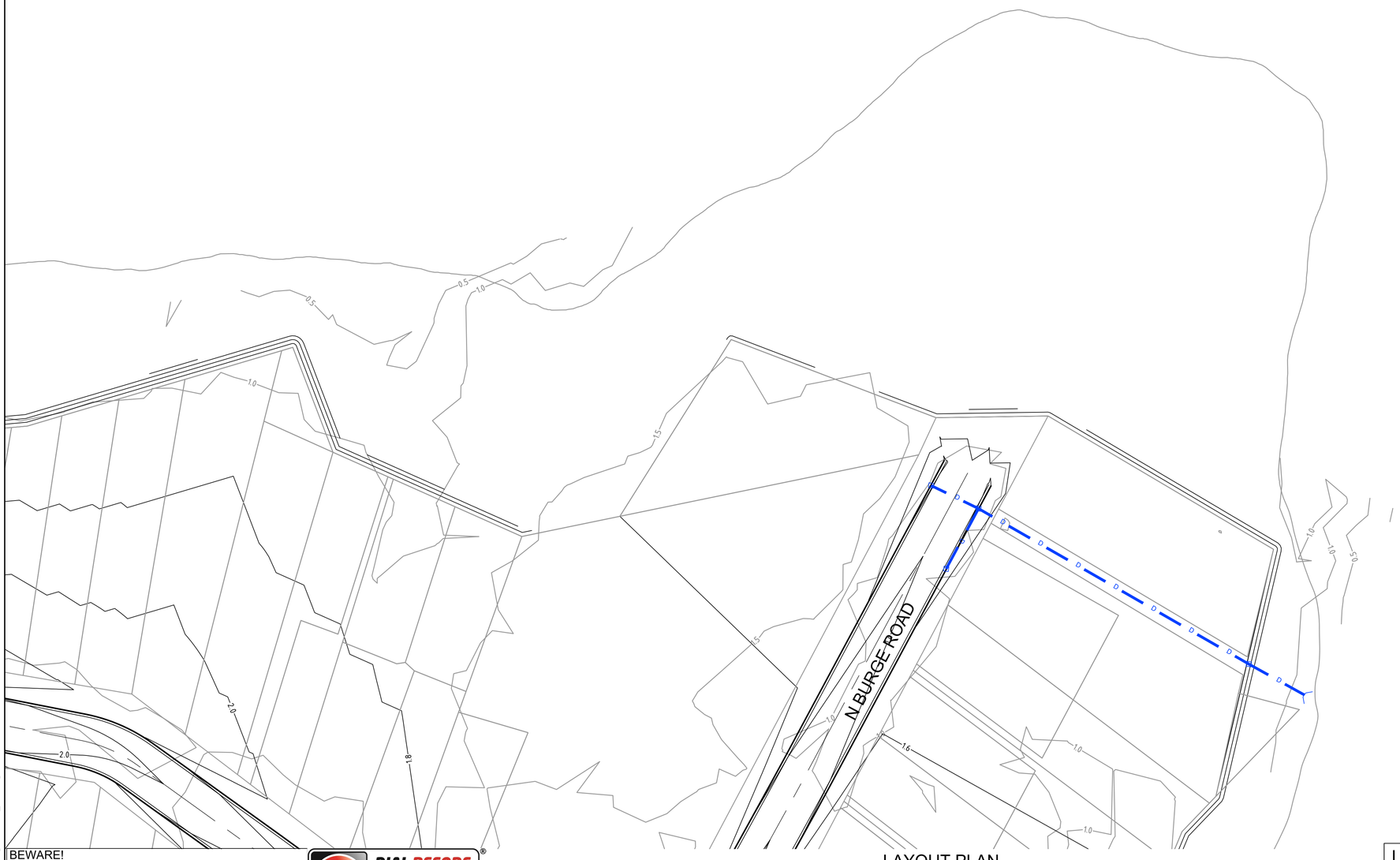

LAYOUT PLAN
SCALE 1:500

LEGEND:
- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

SCALE:- 1:500

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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
	DESIGN	CJG
	DRAWN	CJG
	CHECK'D	RHM

REV	DESCRIPTION	BY	DATE
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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 13
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_114
SHEET 14 OF 17
REVISION: P0

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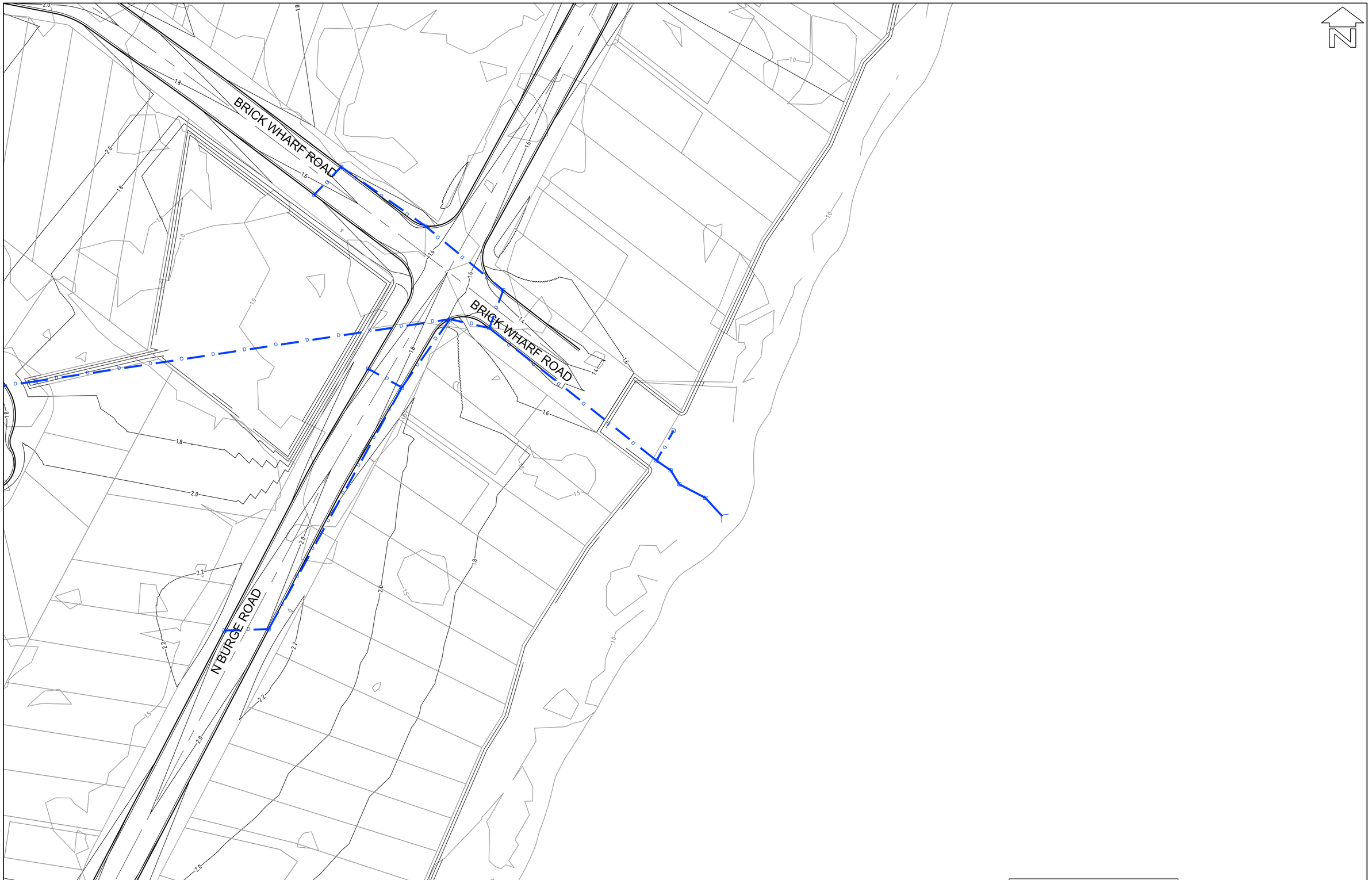

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LAYOUT PLAN
SCALE 1:500

LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 14
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_115
SHEET 15 OF 17
REVISION: P0

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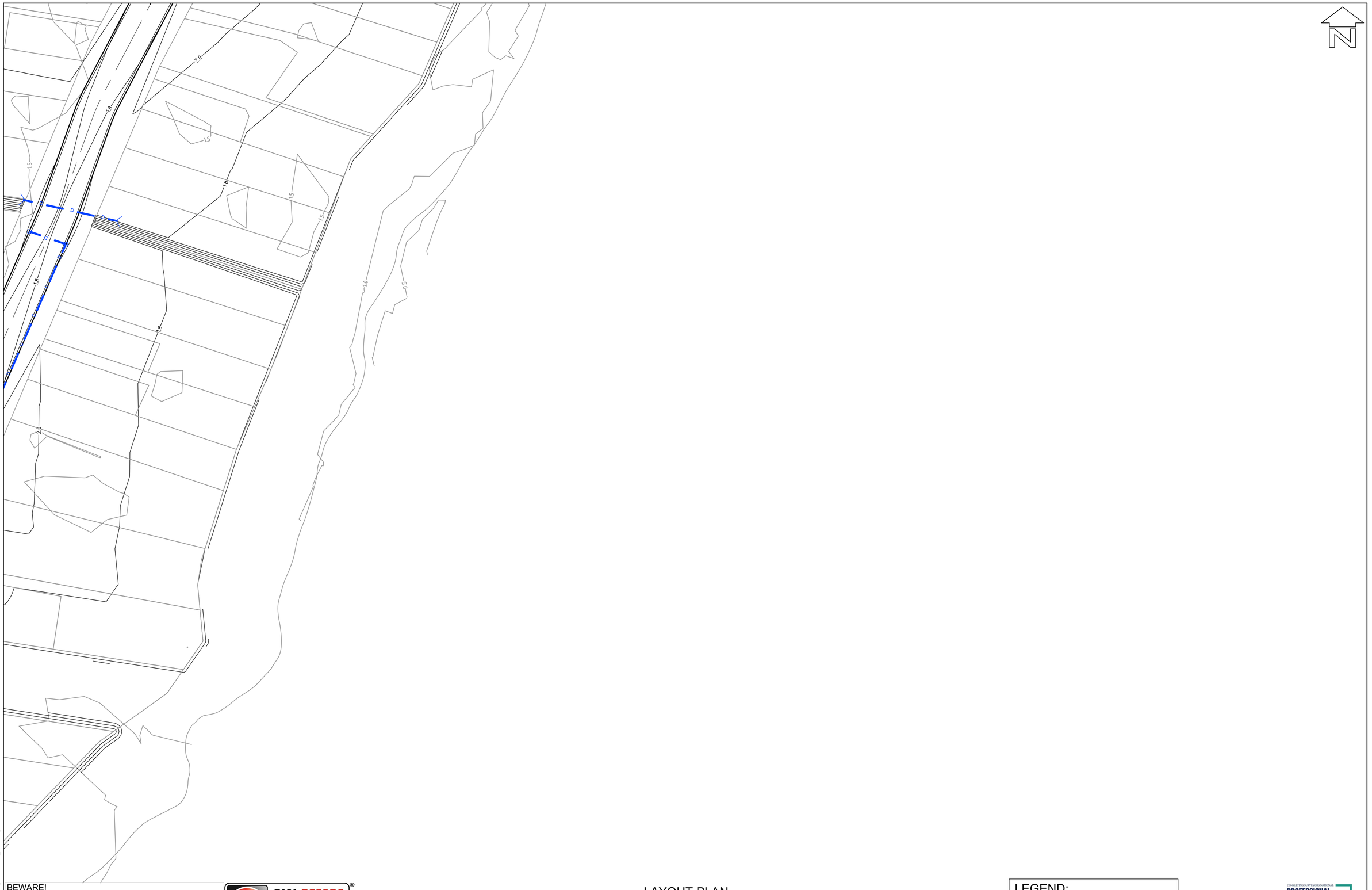

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LAYOUT PLAN
SCALE 1:500

LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

		REV	DESCRIPTION	BY	DATE
SURVEY	RHELM	=			
DESIGN	CJG				
DRAWN	CJG				
CHECK'D	RHM				

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WOY WOY GENERAL ARRANGEMENT PLAN SHEET 15
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE
ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_116
SHEET 16 OF 17
REVISION: P0

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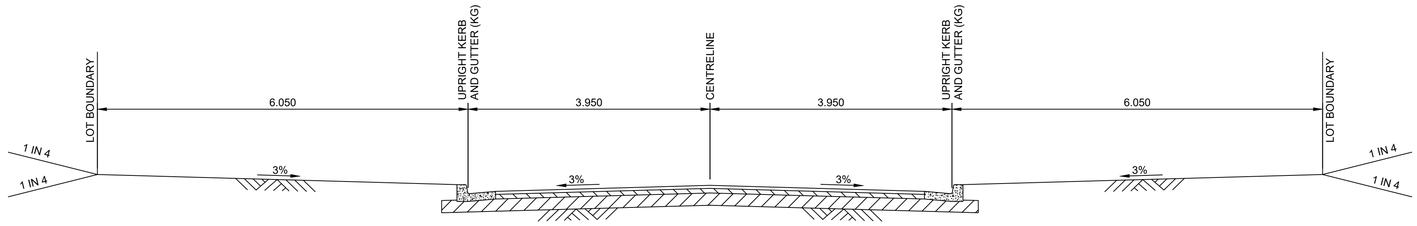
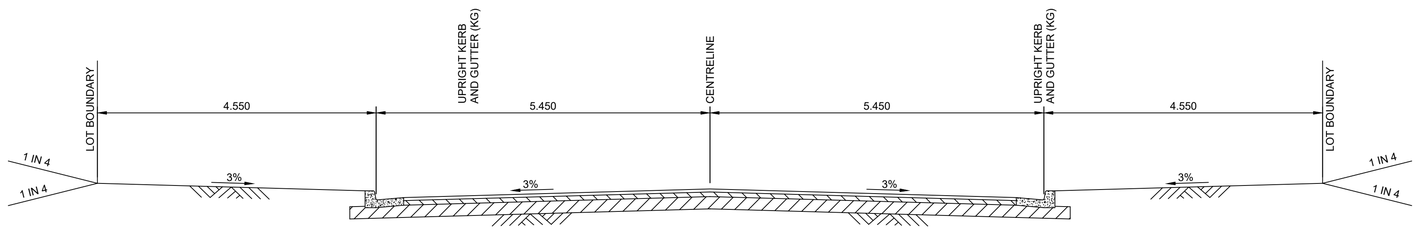


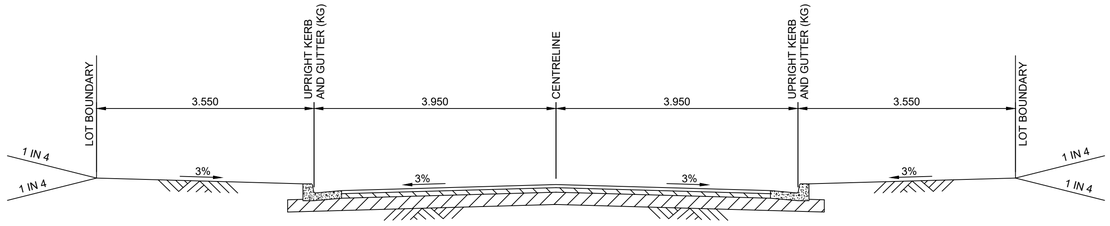
TYPICAL 7m ROAD IN 20m ROAD RESERVE CROSS SECTION

SCALE 1:50



TYPICAL 10m ROAD IN 20m ROAD RESERVE CROSS SECTION

SCALE 1:50



TYPICAL 7m ROAD IN 15m ROAD RESERVE CROSS SECTION

SCALE 1:50

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0 0.5 1.0 1.5 2.0 2.5

SCALE:- 1:50

PROFESSIONAL STANDARDS SCHEME

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RATIO: 1:50 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM

ORIGIN: SSM RL

DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
	DESIGN	CJG
	DRAWN	CJG
	CHECK'D	RHM

REV	DESCRIPTION	BY	DATE
=			

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WOY WOY TYPICAL CROSS SECTIONS PLAN
WOY WOY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT WOY WOY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_117

SHEET 17 OF 17

REVISION: P0

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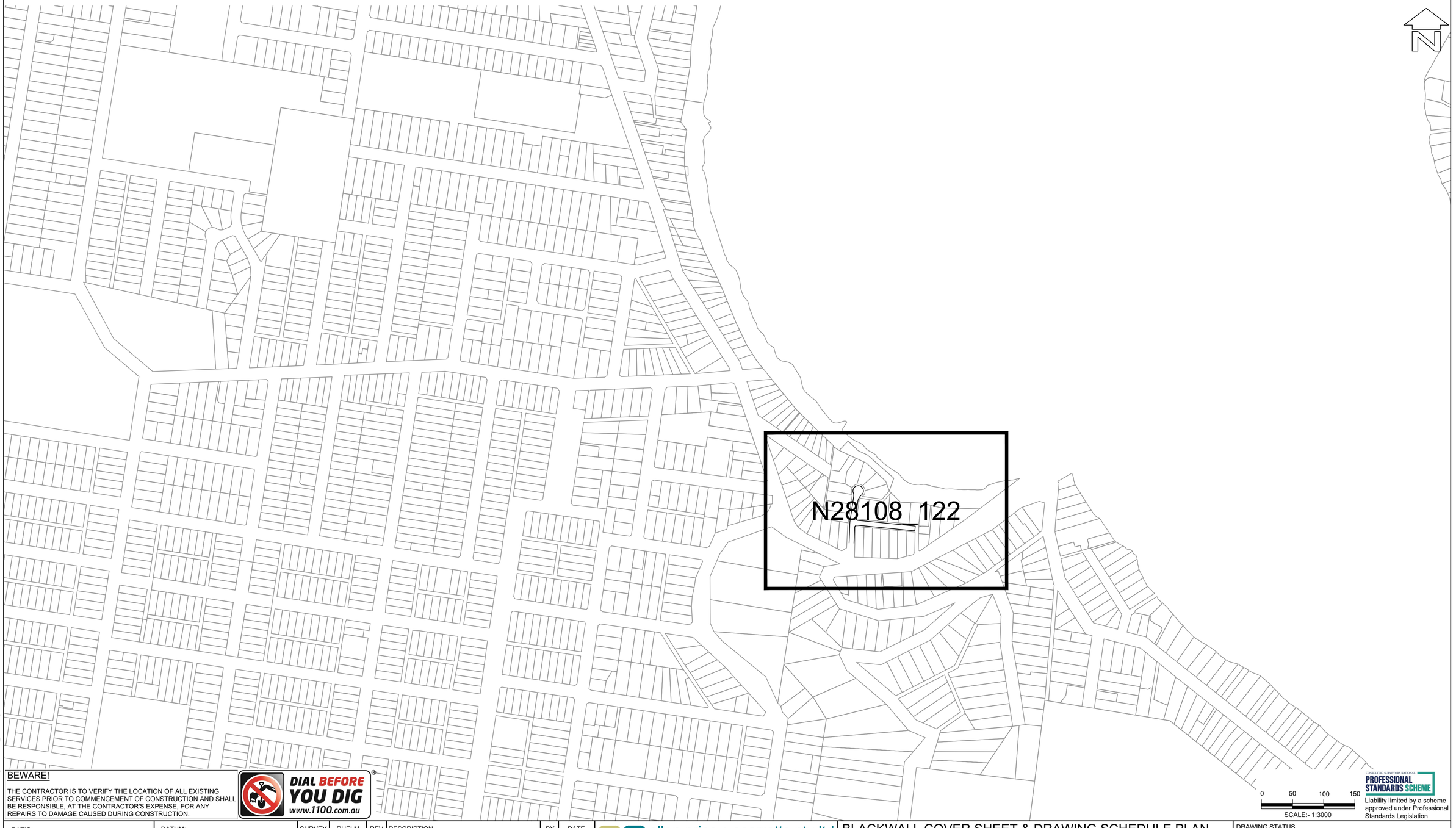
BLACK WALL CLIMATE CHANGE ADAPTATION LANDFORM DESIGN

DRAWING SCHEDULE

N28108_121	BLACKWALL COVER SHEET & DRAWING SCHEDULE PLAN
N28108_122	BLACKWALL GENERAL ARRANGEMENT PLAN SHEET 01
N28108_123	BLACKWALL TYPICAL CROSS SECTIONS PLAN



BEWARE!

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PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO: 1:3000 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	REV	DESCRIPTION	BY	DATE
DESIGN	CJG	=			
DRAWN	CJG				
CHECK'D	RHM				

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phone:(02) 4421 6544
consultants@allenprice.com.au www.allenprice.com.au

BLACKWALL COVER SHEET & DRAWING SCHEDULE PLAN
BLACKWALL CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE
ADAPTATION OPTIONS AT BLACKWALL, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_121
SHEET 1 OF 3
REVISION: P0

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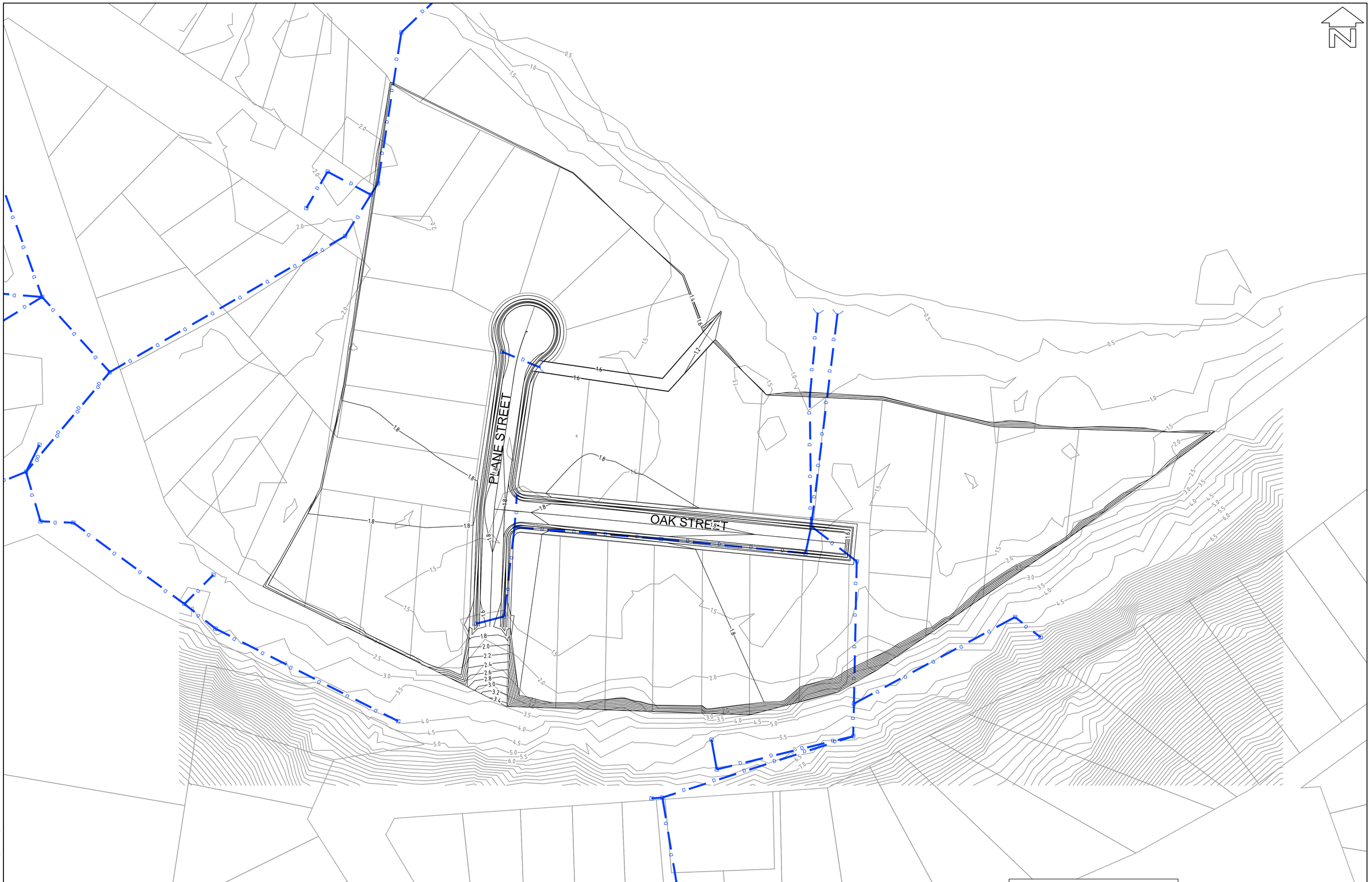

LAYOUT PLAN
SCALE 1:500

BEWARE!

THE CONTRACTOR IS TO VERIFY THE LOCATION OF ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF CONSTRUCTION AND SHALL BE RESPONSIBLE, AT THE CONTRACTOR'S EXPENSE, FOR ANY REPAIRS TO DAMAGE CAUSED DURING CONSTRUCTION.

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LEGEND:

- 1.5 DESIGN SURFACE CONTOURS
- 1.5 EXISTING SURFACE CONTOURS
- STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO:	DATUM:						
1:500 (AT A1 ORIGINAL)	AUSTRALIAN HEIGHT DATUM	SURVEY	RHELM	REV	DESCRIPTION	BY	DATE
	ORIGIN: SSM RL	DESIGN	CJG	=			
		DRAWN	CJG				
		CHECK'D	RHM				
	DATE OF PLAN: OCTOBER 2020						

allen price & scarratts pty ltd
land and development consultants
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Kiama Branch: 1/28 Bong Bong Street, Kiama NSW 2533
phone:(02) 4421 6544
consultants@allenprice.com.au www.allenprice.com.au

BLACKWALL GENERAL ARRANGEMENT PLAN SHEET 01
BLACKWALL CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BLACKWALL, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER	SHEET	REVISION
N28108_122	2 OF 3	P0

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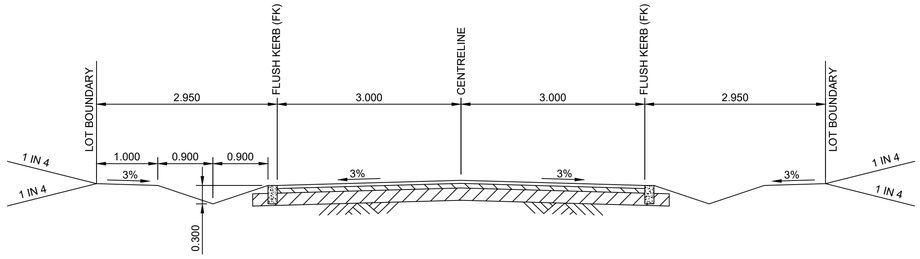

TYPICAL 6m ROAD IN 11.9m ROAD RESERVE CROSS SECTION

SCALE 1:50

BEWARE!

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0 0.5 1.0 1.5 2.0 2.5
SCALE:- 1:50

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO: 1:50 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

	SURVEY	RHELM
	DESIGN	CJG
	DRAWN	CJG
	CHECK'D	RHM

REV	DESCRIPTION	BY	DATE
=			

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BLACKWALL TYPICAL CROSS SECTIONS PLAN
BLACKWALL CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BLACKWALL, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_123
SHEET 3 OF 3
REVISION: P0

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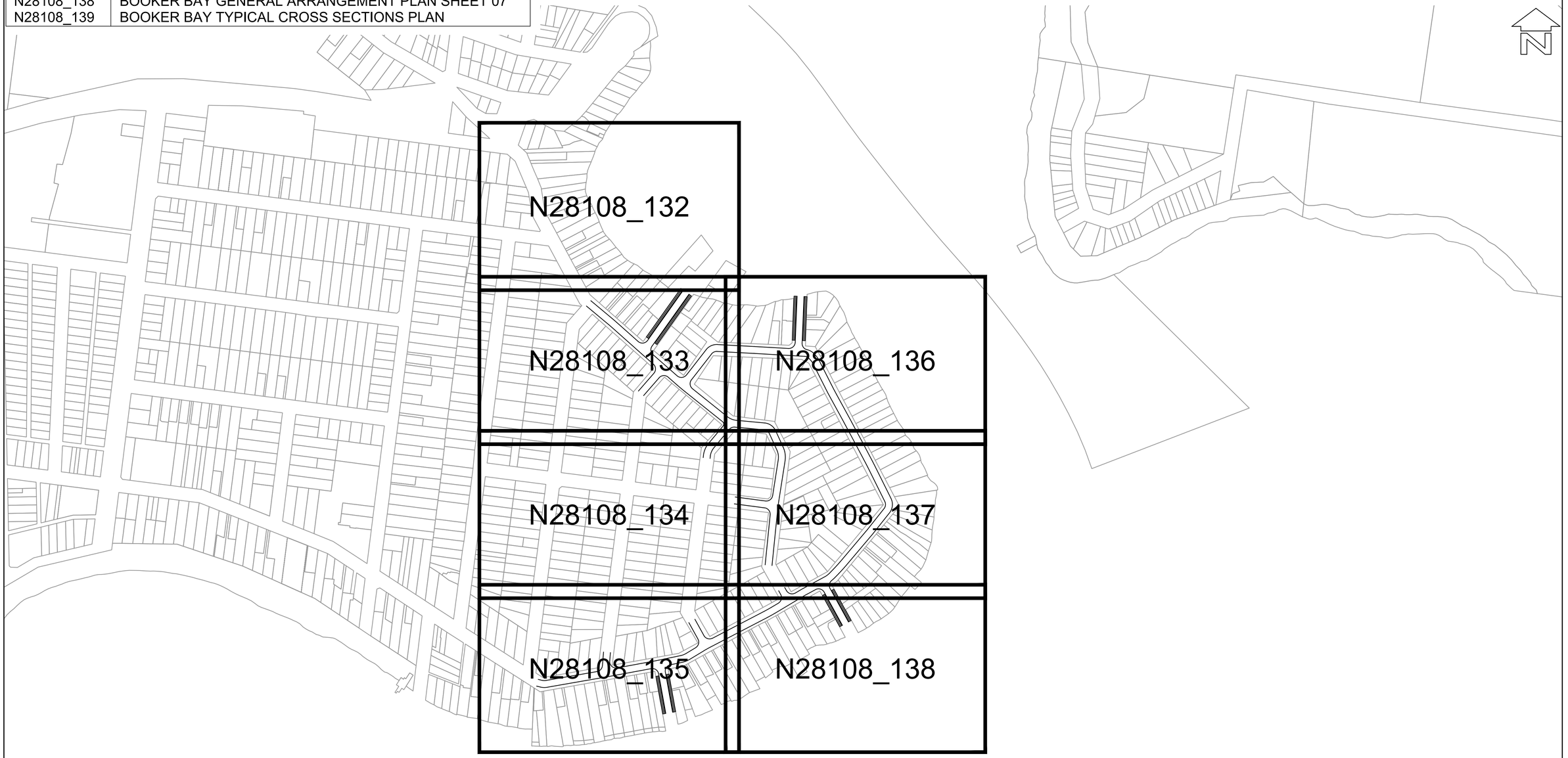
BOOKER BAY CLIMATE CHANGE ADAPTATION LANDFORM DESIGN

DRAWING SCHEDULE

N28108_131	BOOKER BAY COVER SHEET & DRAWING SCHEDULE PLAN
N28108_132	BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 01
N28108_133	BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 02
N28108_134	BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 03
N28108_135	BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 04
N28108_136	BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 05
N28108_137	BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 06
N28108_138	BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 07
N28108_139	BOOKER BAY TYPICAL CROSS SECTIONS PLAN



BEWARE!

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0 50 100 150
SCALE:- 1:3000

PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:3000 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

		REV	DESCRIPTION	BY	DATE
SURVEY	RHELM	=			
DESIGN	CJG				
DRAWN	CJG				
CHECK'D	RHM				

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BOOKER BAY COVER SHEET & DRAWING SCHEDULE PLAN
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE
ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_131
SHEET 1 OF 9
REVISION: P0

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LAYOUT PLAN
SCALE 1:500

LEGEND:
- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
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BEWARE!

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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	REV	DESCRIPTION	BY	DATE
DESIGN	CJG	=			
DRAWN	CJG				
CHECK'D	RHM				

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BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 01
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_132
SHEET 2 OF 9
REVISION: P0

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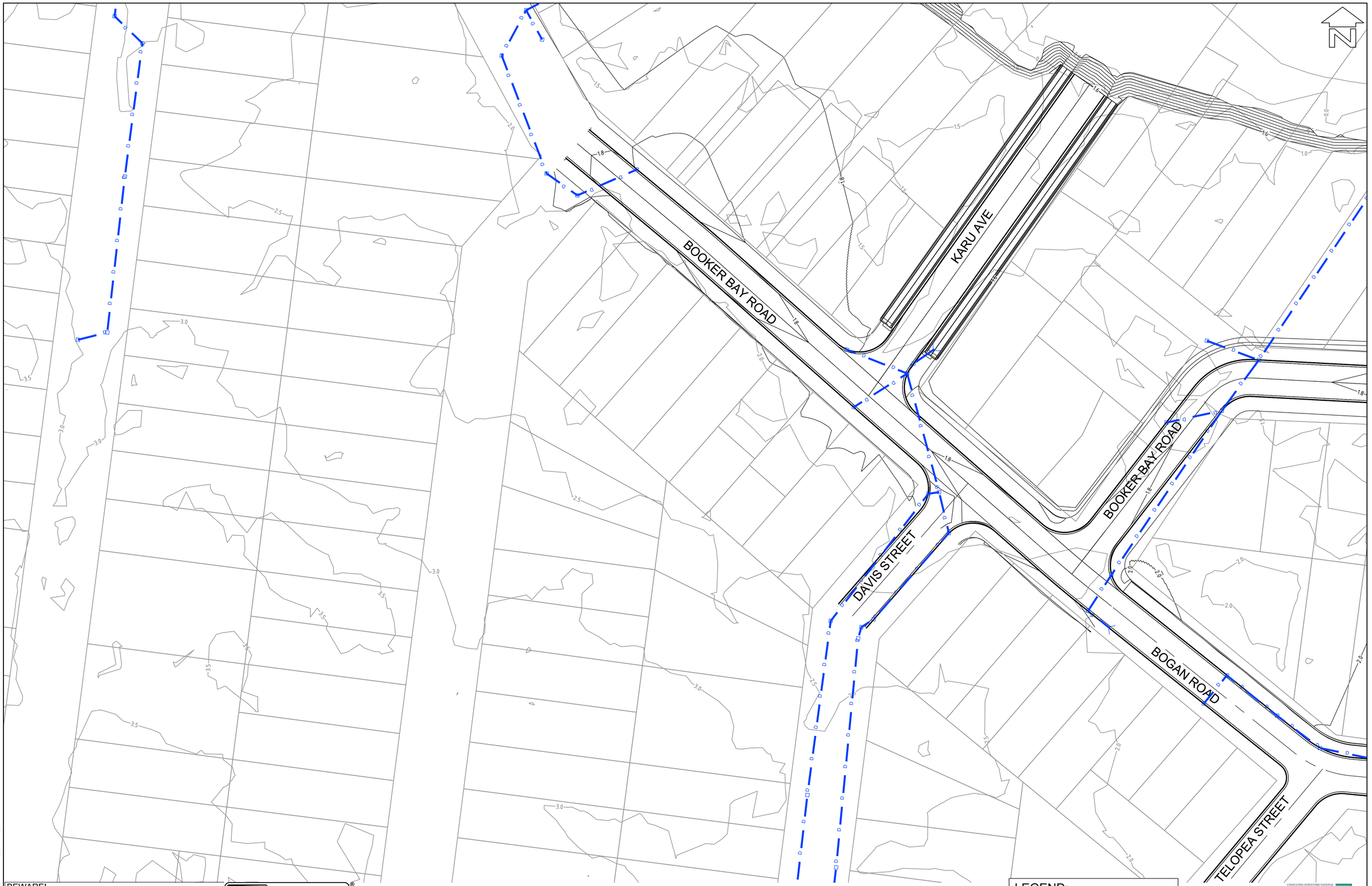

LAYOUT PLAN
SCALE 1:500

LEGEND:
- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

SCALE:- 1:500

BEWARE!

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PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 02
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_133
SHEET 3 OF 9
REVISION: P0

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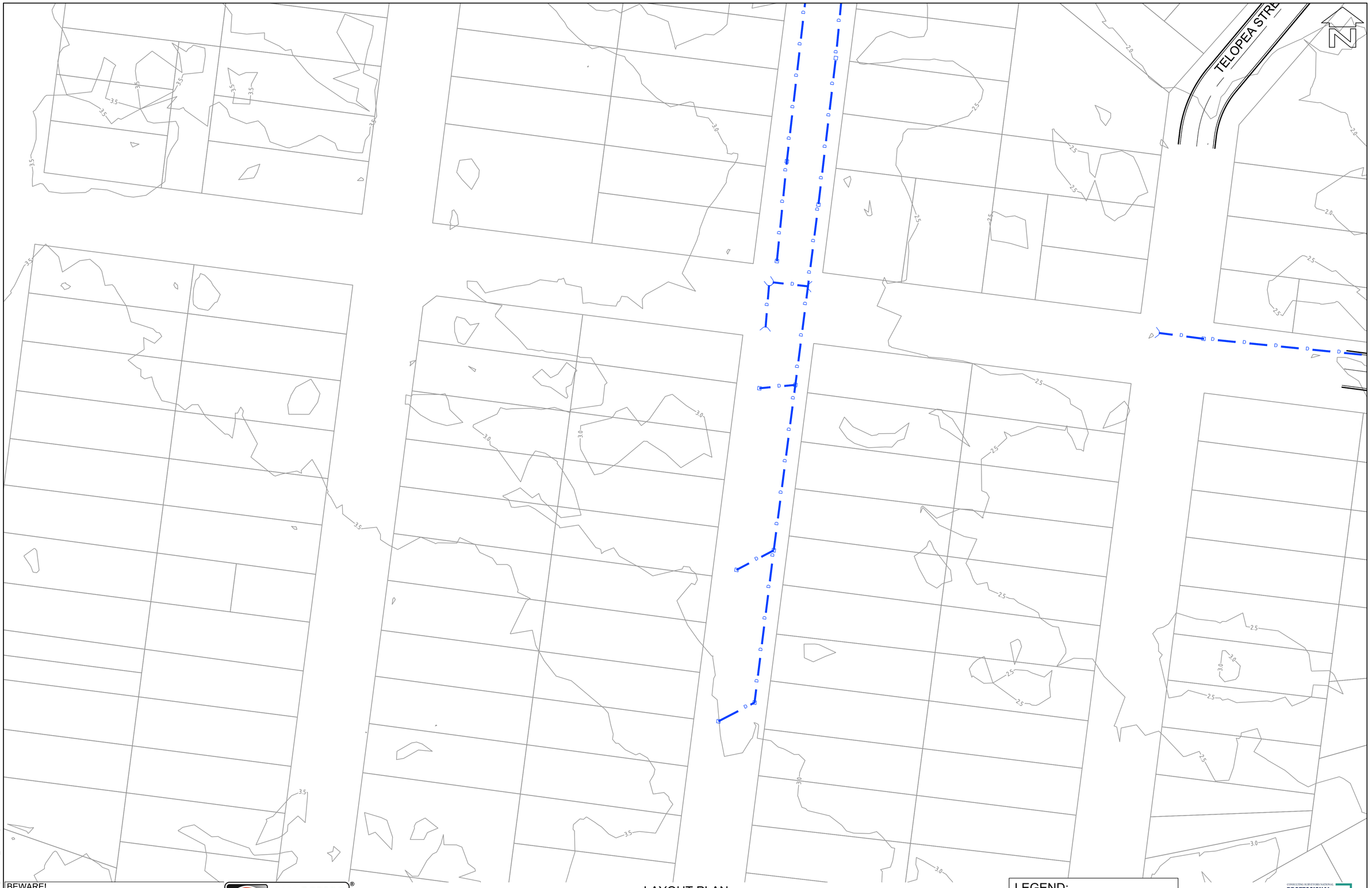

LAYOUT PLAN
SCALE 1:500

LEGEND:

1.5	DESIGN SURFACE CONTOURS
1.5	EXISTING SURFACE CONTOURS
D	STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

BEWARE!

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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 03
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_134
SHEET: 4 OF 9
REVISION: P0

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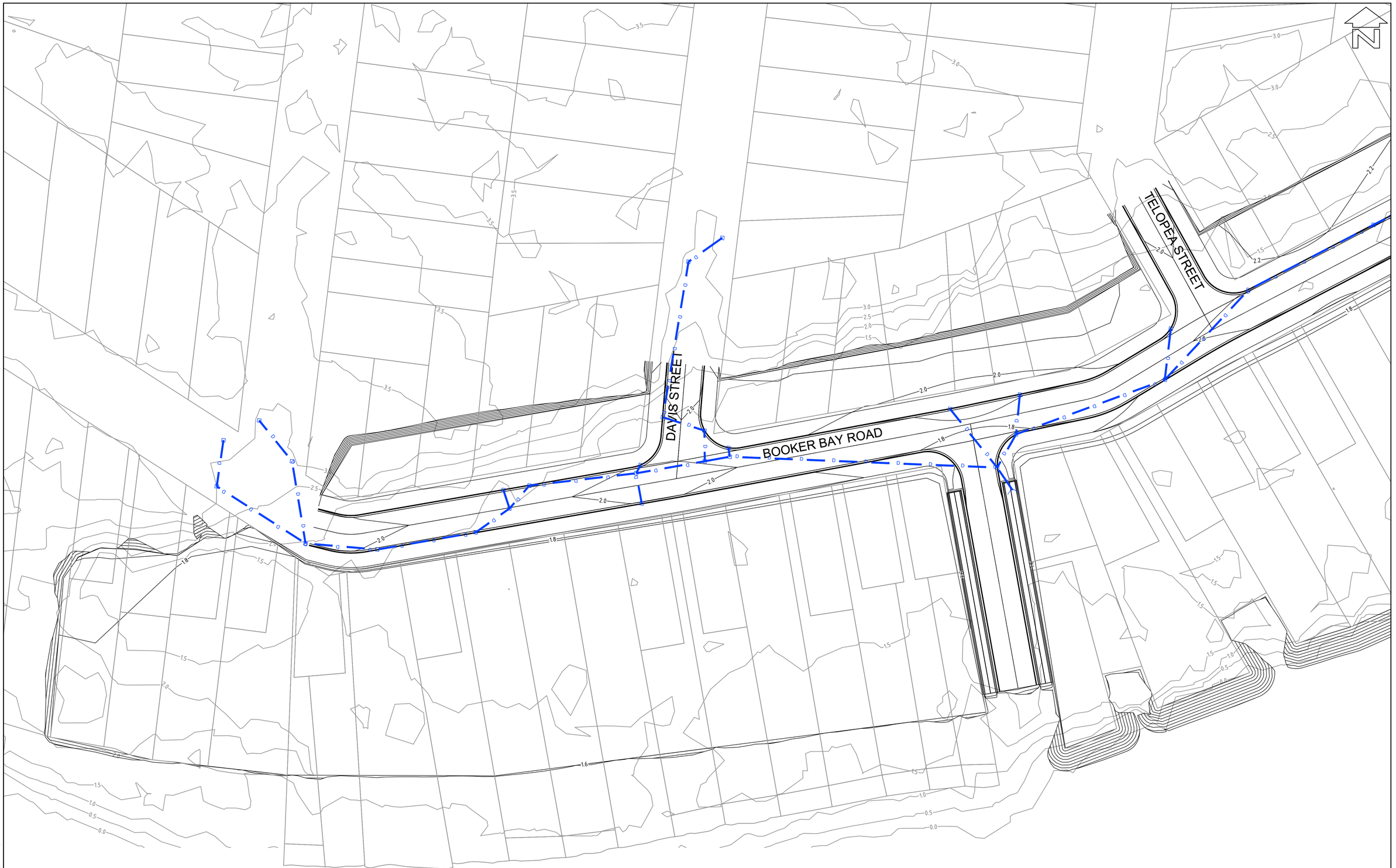

BEWARE!

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LAYOUT PLAN
SCALE 1:500

LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
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RATIO:	DATUM:						
1:500 (AT A1 ORIGINAL)	AUSTRALIAN HEIGHT DATUM	SURVEY	RHELM	REV	DESCRIPTION	BY	DATE
	ORIGIN: SSM RL	DESIGN	CJG	=			
		DRAWN	CJG				
		CHECK'D	RHM				
	DATE OF PLAN: OCTOBER 2020						

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BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 04
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_135
SHEET 5 OF 9
REVISION: P0

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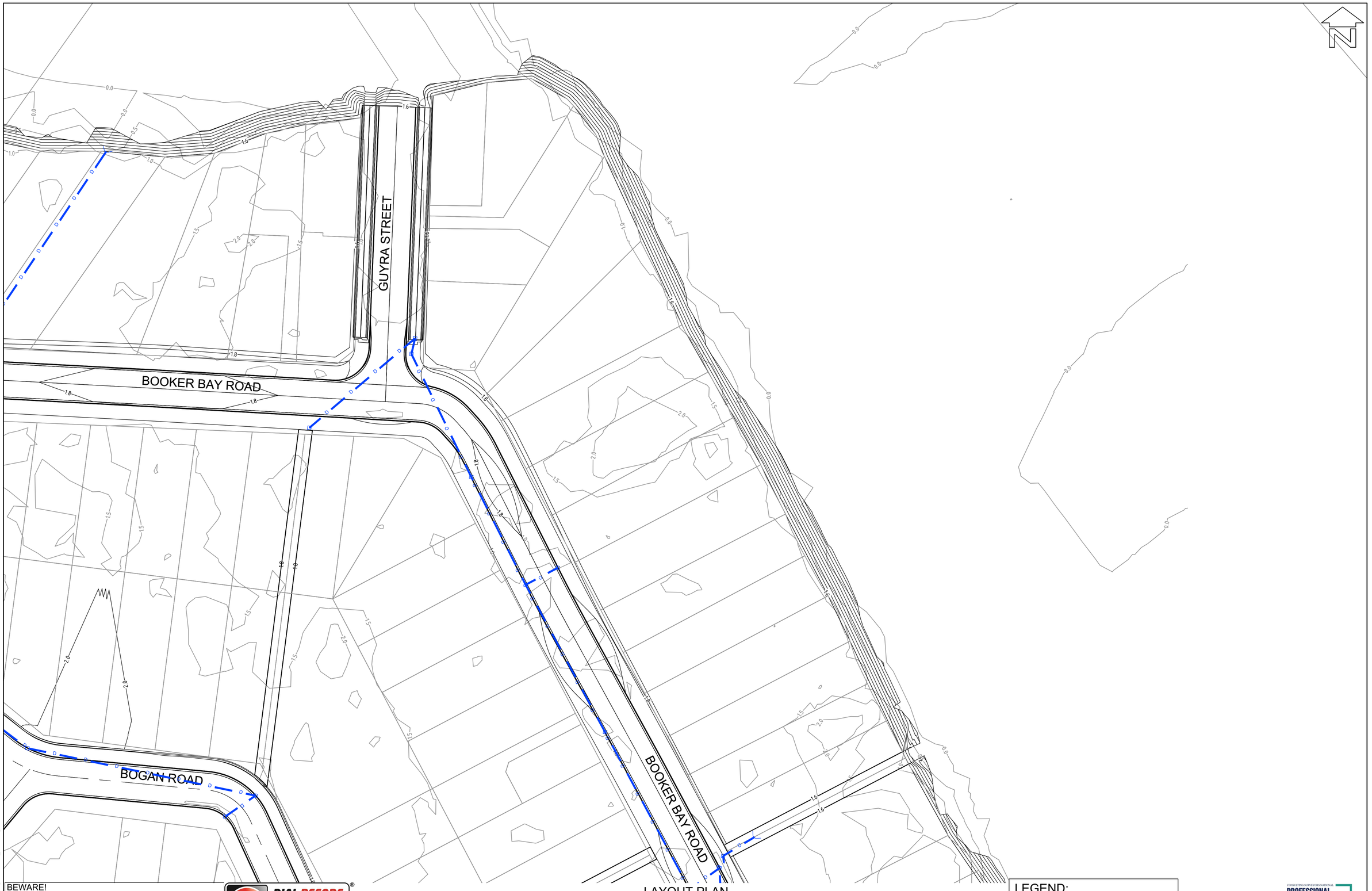

LAYOUT PLAN
SCALE 1:500

BEWARE!

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LEGEND:

- 1.5 DESIGN SURFACE CONTOURS
- 1.5 EXISTING SURFACE CONTOURS
- D STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 05
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_136
SHEET 6 OF 9
REVISION: P0

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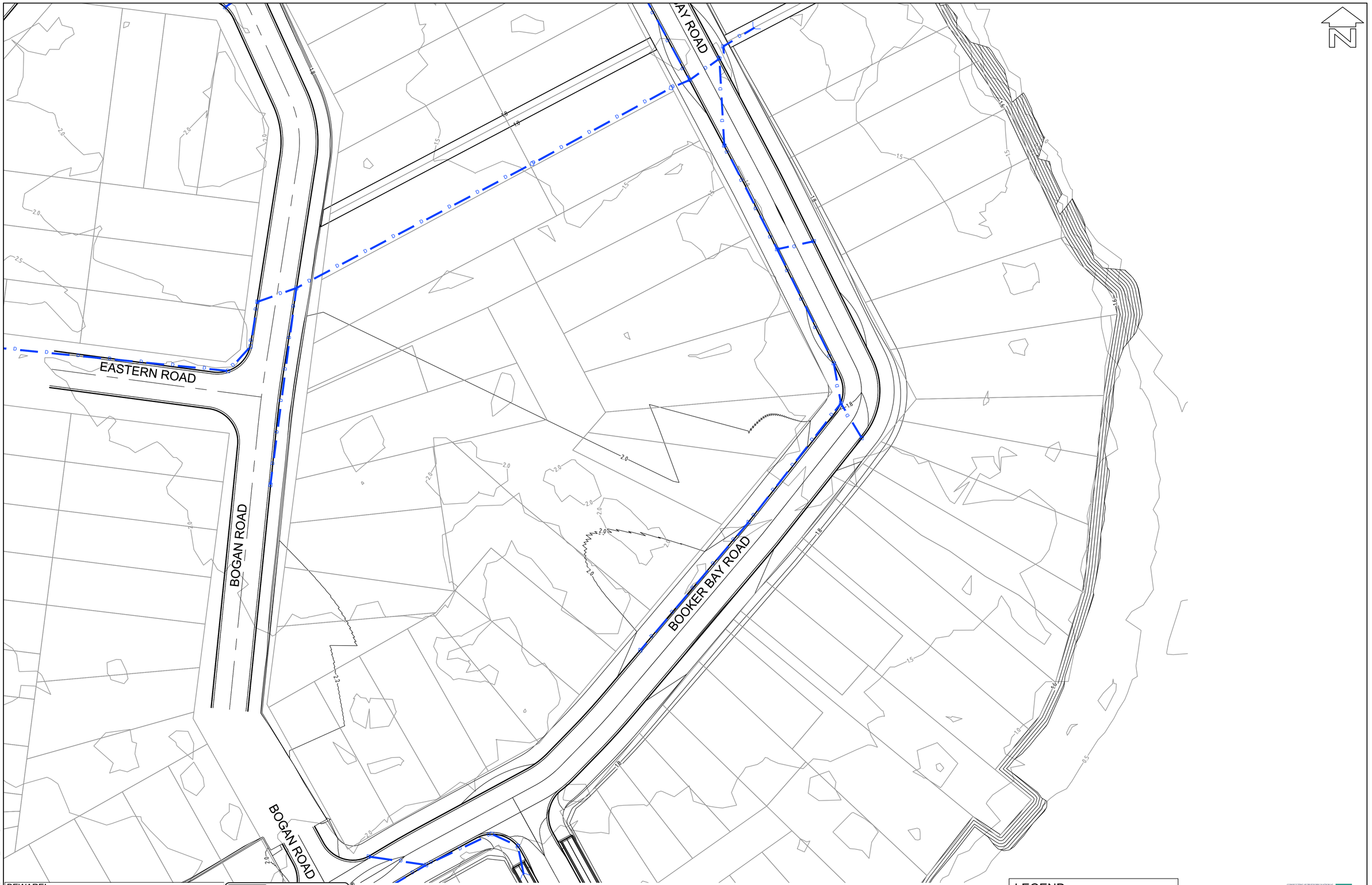

LAYOUT PLAN
SCALE 1:500

BEWARE!

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LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 06
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_137
SHEET 7 OF 9
REVISION: P0

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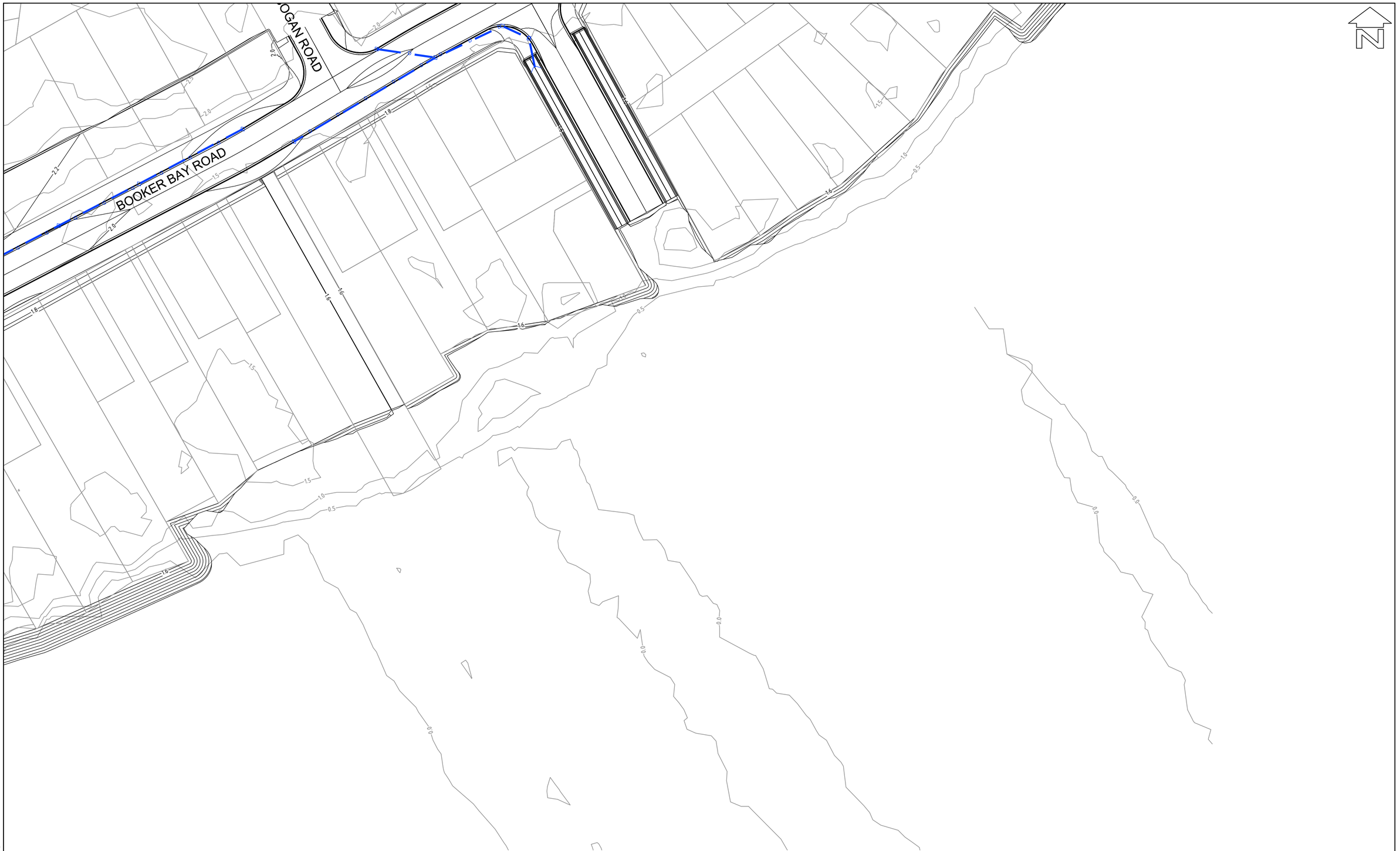

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LAYOUT PLAN
SCALE 1:500

LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

		REV	DESCRIPTION	BY	DATE
SURVEY	RHELM	=			
DESIGN	CJG				
DRAWN	CJG				
CHECK'D	RHM				

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BOOKER BAY GENERAL ARRANGEMENT PLAN SHEET 07
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE
ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_138
SHEET 8 OF 9
REVISION: P0

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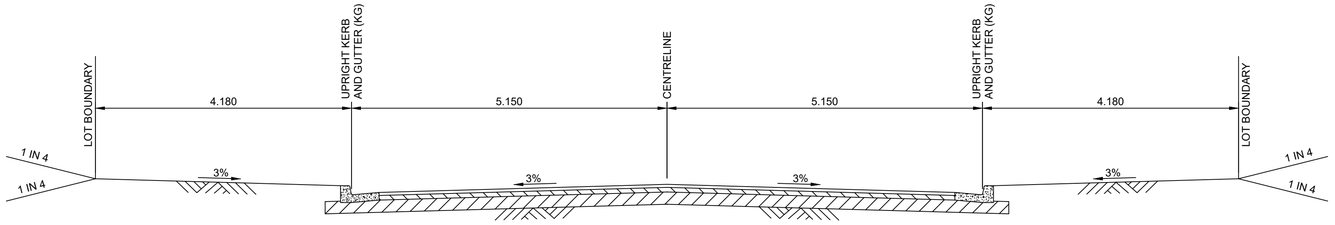

TYPICAL 10.3m ROAD IN 18.66m ROAD RESERVE CROSS SECTION

SCALE 1:50

BEWARE!

THE CONTRACTOR IS TO VERIFY THE LOCATION OF ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF CONSTRUCTION AND SHALL BE RESPONSIBLE, AT THE CONTRACTOR'S EXPENSE, FOR ANY REPAIRS TO DAMAGE CAUSED DURING CONSTRUCTION.

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0 0.5 1.0 1.5 2.0 2.5

SCALE:- 1:50

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME

Liability limited by a scheme approved under Professional Standards Legislation

RATIO:	DATUM:	SURVEY	RHELM	REV	DESCRIPTION	BY	DATE
1:50 (AT A1 ORIGINAL)	AUSTRALIAN HEIGHT DATUM	DESIGN	CJG	=			
	ORIGIN: SSM RL	DRAWN	CJG				
		CHECK'D	RHM				
	DATE OF PLAN: OCTOBER 2020						

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BOOKER BAY TYPICAL CROSS SECTIONS PLAN
BOOKER BAY CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT BOOKER BAY, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_139

SHEET 9 OF 9

REVISION: P0

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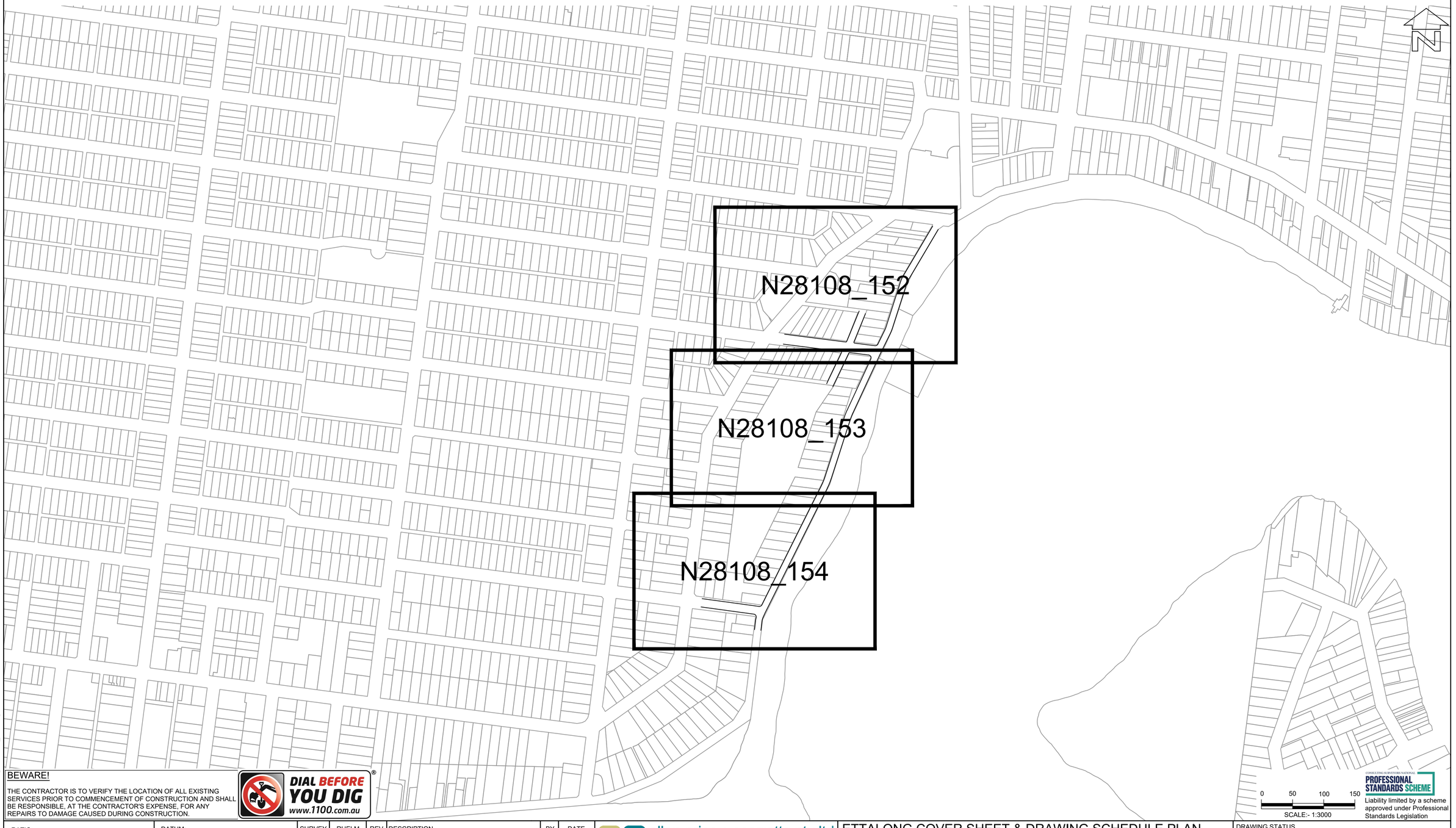
ETTALONG CLIMATE CHANGE ADAPTATION LANDFORM DESIGN

DRAWING SCHEDULE

N28108_151	ETTALONG COVER SHEET & DRAWING SCHEDULE PLAN
N28108_152	ETTALONG GENERAL ARRANGEMENT PLAN SHEET 01
N28108_153	ETTALONG GENERAL ARRANGEMENT PLAN SHEET 02
N28108_154	ETTALONG GENERAL ARRANGEMENT PLAN SHEET 03
N28108_155	ETTALONG TYPICAL CROSS SECTIONS PLAN



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PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO:	DATUM:	SURVEY	RHELM	REV	DESCRIPTION	BY	DATE
1:3000 (AT A1 ORIGINAL)	AUSTRALIAN HEIGHT DATUM	DESIGN	CJG	=			
	ORIGIN: SSM RL	DRAWN	CJG				
		CHECK'D	RHM				
	DATE OF PLAN: OCTOBER 2020						

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phone:(02) 4421 6544
consultants@allenprice.com.au www.allenprice.com.au

ETTALONG COVER SHEET & DRAWING SCHEDULE PLAN
ETTALONG CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE
ADAPTATION OPTIONS AT ETTALONG, NSW
FOR RHELM PTY LTD

DRAWING STATUS
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER	SHEET	REVISION
N28108_151	1 OF 5	P0

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LAYOUT PLAN
SCALE 1:500

BEWARE!

THE CONTRACTOR IS TO VERIFY THE LOCATION OF ALL EXISTING SERVICES PRIOR TO COMMENCEMENT OF CONSTRUCTION AND SHALL BE RESPONSIBLE, AT THE CONTRACTOR'S EXPENSE, FOR ANY REPAIRS TO DAMAGE CAUSED DURING CONSTRUCTION.

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LEGEND:

- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME
Liability limited by a scheme approved under Professional Standards Legislation

RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

allen price & scarratts pty ltd
land and development consultants
Nowra Branch: 75 Plunkett Street, Nowra NSW 2541
Kiama Branch: 1/28 Bong Bong Street, Kiama NSW 2533
phone:(02) 4421 6544
consultants@allenprice.com.au www.allenprice.com.au

ETTALONG GENERAL ARRANGEMENT PLAN SHEET 01
ETTALONG CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT ETTALONG, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_152
SHEET 2 OF 5
REVISION: P0

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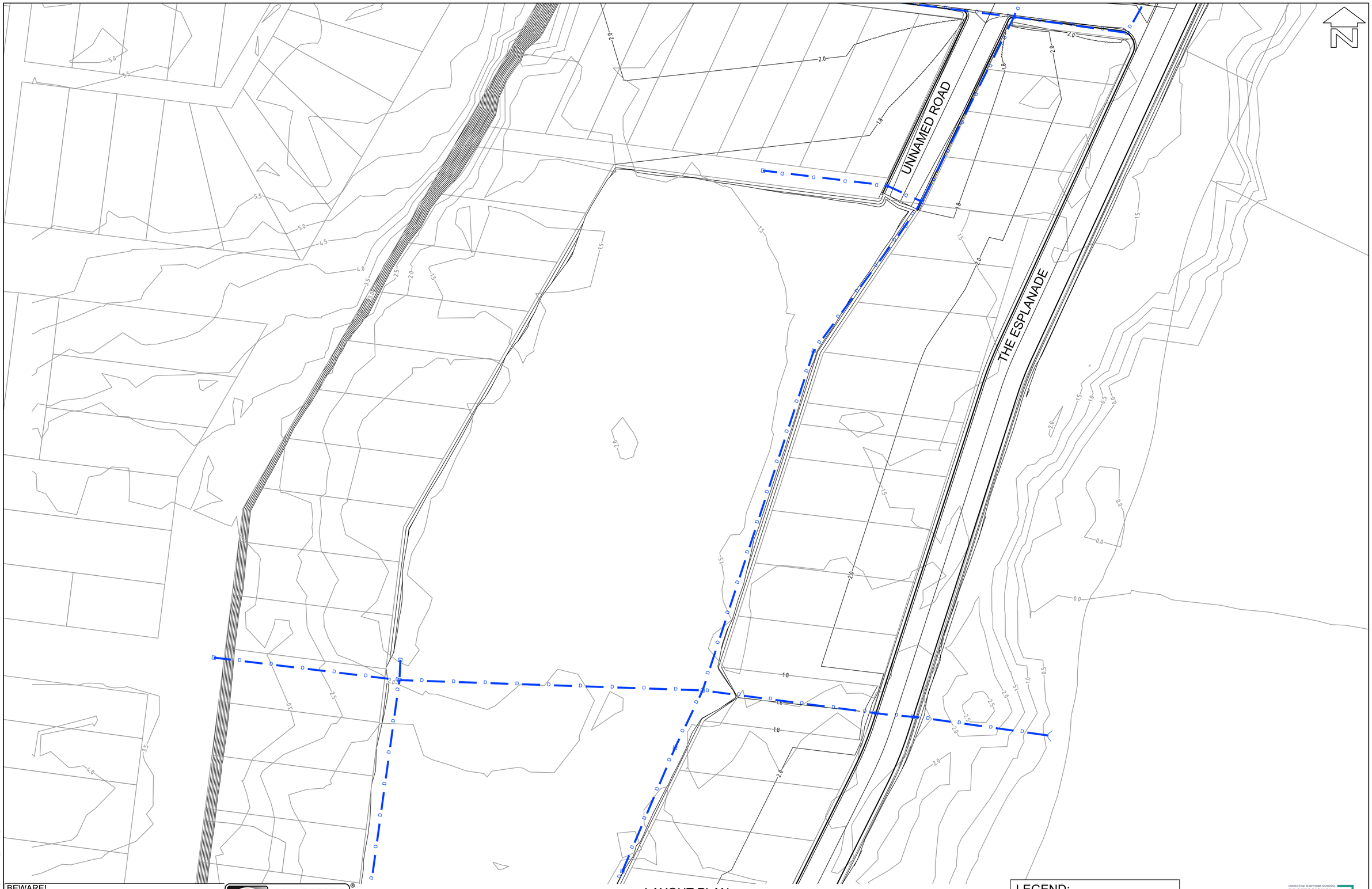

LAYOUT PLAN
SCALE 1:500

LEGEND:
- 1.5 DESIGN SURFACE CONTOURS
- 1.5 EXISTING SURFACE CONTOURS
- D STORMWATER DRAINAGE LINES

0 5 10 15 20 25
SCALE:- 1:500

PROFESSIONAL STANDARDS SCHEME
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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL
DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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ETTALONG GENERAL ARRANGEMENT PLAN SHEET 02
ETTALONG CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT ETTALONG, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
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DRAWING NUMBER: N28108_153
SHEET 3 OF 5
REVISION: P0

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LAYOUT PLAN
SCALE 1:500

LEGEND:
- 1.5 — DESIGN SURFACE CONTOURS
- 1.5 — EXISTING SURFACE CONTOURS
- D — STORMWATER DRAINAGE LINES

SCALE:- 1:500

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RATIO: 1:500 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM
ORIGIN: SSM RL

DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
=			

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ETTALONG GENERAL ARRANGEMENT PLAN SHEET 03
ETTALONG CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT ETTALONG, NSW
FOR RHELM PTY LTD

DRAWING STATUS: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DRAWING NUMBER: N28108_154
SHEET 4 OF 5
REVISION: P0

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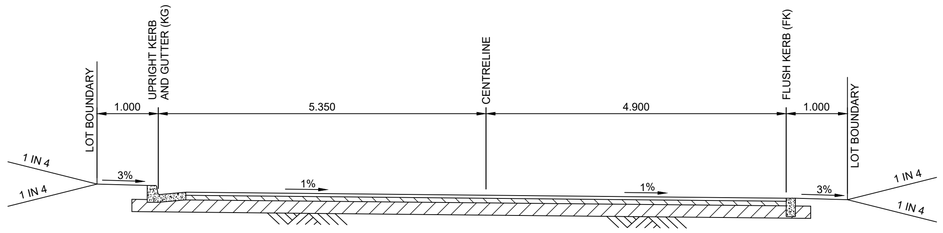
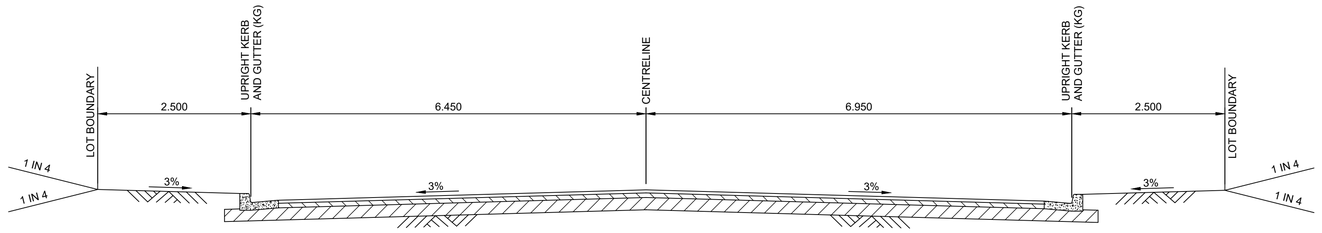


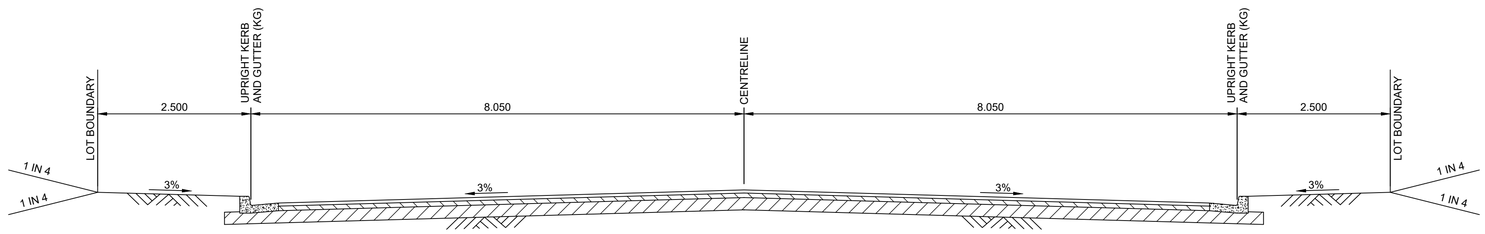
TYPICAL THE ESPLANADE ROAD CROSS SECTION

SCALE 1:50



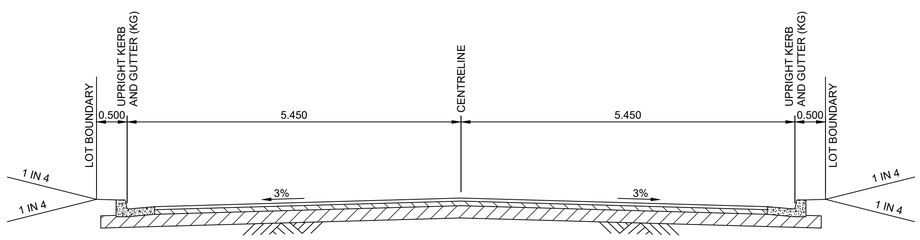
TYPICAL KOURUNG STREET ROAD CROSS SECTION

SCALE 1:50



TYPICAL BANGALOW STREET ROAD CROSS SECTION

SCALE 1:50



TYPICAL UNNAMED ROAD CROSS SECTION

SCALE 1:50

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0 0.5 1.0 1.5 2.0 2.5

SCALE:- 1:50

CONSULTING SURVEYORS NATIONAL PROFESSIONAL STANDARDS SCHEME

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RATIO: 1:50 (AT A1 ORIGINAL)

DATUM: AUSTRALIAN HEIGHT DATUM

ORIGIN: SSM RL

DATE OF PLAN: OCTOBER 2020

SURVEY	RHELM	
DESIGN	CJG	
DRAWN	CJG	
CHECK'D	RHM	

REV	DESCRIPTION	BY	DATE
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ETTALONG TYPICAL CROSS SECTIONS PLAN
ETTALONG CLIMATE CHANGE ADAPTATION
LANDFORM DESIGN IN SUPPORT OF CLIMATE CHANGE ADAPTATION OPTIONS AT ETTALONG, NSW
FOR RHELM PTY LTD

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DRAWING NUMBER: N28108_155

SHEET 5 OF 5

REVISION: P0

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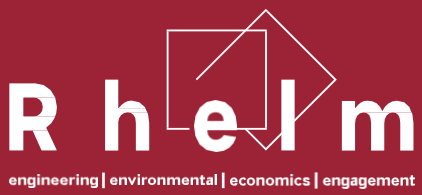

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