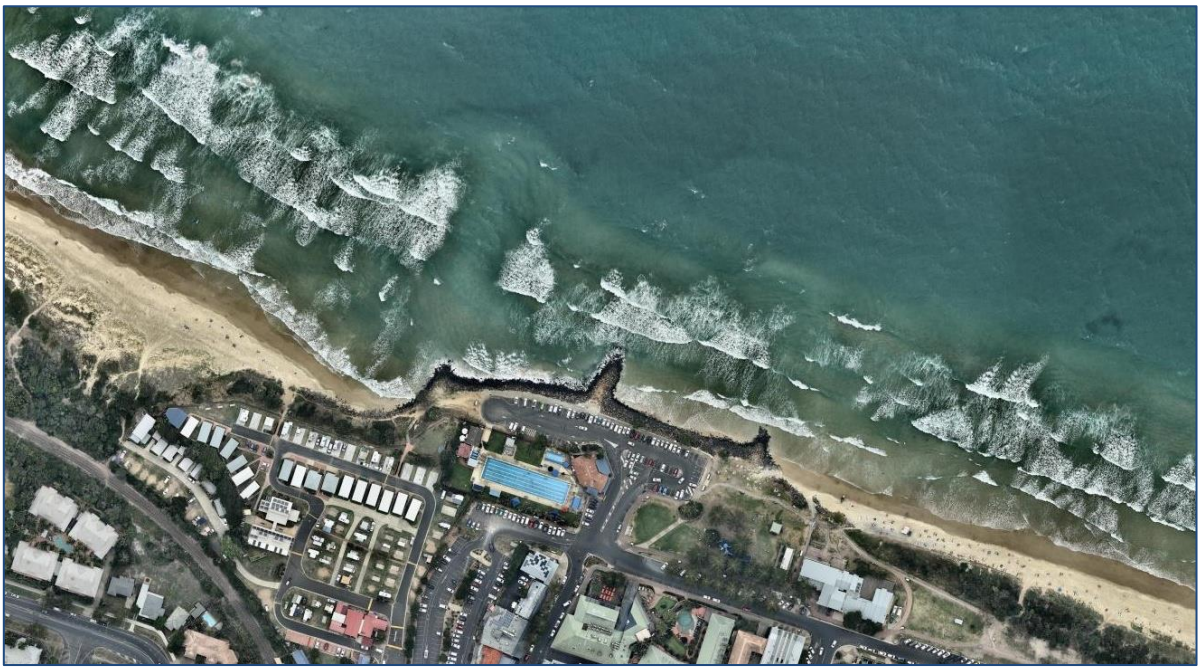

Byron Shire Council

Design Investigation for the Modification of the Jonson Street Protection Works

Consultancy Scope of Work

17 May 2019

Disclaimer

Title page photo: Byron Bay aerial photograph from March 2019

This Scope of Work for the JSPW Modification Project has been amended from the original Bluecoast proposal P194010 submitted on 17 May 2019 to accurately detail the scope of work for public distribution.

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1 INTRODUCTION

1.1 General

In response to the Byron Shire Council's (Council's) *Request for Tender 2018-0029 – Design Investigation for the Modification of the Jonson Street Protection Works* (the project brief), Bluecoast Consulting Engineers Pty Ltd (Bluecoast) is pleased to submit this proposal. Our proposal includes all submission requirements as set out in Council's Project Brief.

1.2 Why us?

Bluecoast specialise in coastal engineering, including coastal management and climate change resilience. We are recognised for our innovative approach to employing cutting edge technology and research in addressing the needs of our clients. Our staff have carried out a broad range of coastal engineering projects, often complex in nature, and have provided solutions that benefit from our 'out-of-the-box' thinking. Our expertise covers the full range of project requirements from prefeasibility and conceptual assessment, through to detailed design, tendering, design and construct project teams and construction supervision. The JSPW upgrade project is a complex coastal engineering project and the concept and detailed phase will require a consultant who has proven experience in resolving the challenges a project of this nature presents. Complex coastal engineering is what we do, and we do it to the highest standard.

We have an extensive track record in coastal projects in NSW and work with Department of Planning, Industry and Environment and Council collaboratively to develop future-proof coastal solutions and understand the policy framework and Coastal Management Plan. To assemble the optimal mix of expertise, insight and experience required for the JSPW upgrade, Bluecoast has picked a team of industry-leading and like-minded experts complementing our own skills. We have work closely with these complementary team members in the past and have a good working relationship. Being an independent small business, we are in a position to selectively 'cherry-pick' the best team for the job ensuring best value-for-money with minimal overheads.

Bluecoast is collaborating with the following experts for the JSPW upgrade:

Tonkin & Taylor – We have an excellent relationship with T&T staff and have appointed Tom Shand as a Technical Reviewer for this study. Tom has undertaken assessments across NSW and Australia These include, Assessment of the NSW Extreme Coastal Wave Climate, the results of which are still used frequently today and Review of the Effects of Seawalls on NSW Beaches for Department of Planning, Industry and Environment, including the Jonson Street seawall. We also propose to draw on T&Ts resources and experience for the detailed design phase of the JSPW upgrade. T&T's multi-disciplinary team of engineering, scientists and planners offer a comprehensive range of services related to the enhancement and protection of the coastal edge.

Space Studio – We have teamed with the local architects at Space Studio who were engaged on the Byron Bay Master Plan team as architects and local consultants. Their role was to advise on architectural matters such as sub-tropical design, materials and building form, local character and the built environment. They have also provided advice on local community matters and understand the need for a bespoke solution reflecting the informal nature of Byron Bay and the broader Shire.

Space Studio are on our team to ensure seamless incorporation of the wealth of work completed for the Masterplan and will be included in the MCA process.

Rhelm – Our former colleagues at Rhelm are specialist consultants in engagement and economics in coastal management projects. They will draw on their NSW experience to complement the project team in the planning, environmental, economic and engagement tasks as well as the MCA assessment. Bluecoast and Rhelm each have a detailed understanding of the NSW policy context and Coastal Management Plan which will ensure the relevant policy and planning guidelines are adhered to.

Andrew Short – We invited Andrew to lead our geomorphological assessment in this study. He is unrivalled in his wealth of knowledge of coastal processes in Australia. Andrew will ensure all the opportunities and impacts of our proposed concept designs are identified. He will provide a key input to our multiple-lines of evidence approach, alongside the numerical modelling and data collection undertaken ,and bring a high-level view in interpreting this information.

Sikko Krol – Bluecoast has included Sikko Krol in our design team. Sikko is a respected maritime construction expert in Australia. Most recently Sikko was appointed to provide advice during the design development of the Palm Beach Shoreline Project. Sikko and our coastal engineers have a good professional relationship and a wealth of understanding of the local construction industry, and of the available plant and material transport considerations required for the JSPW. As such, this will ensure buildability of the concept designs, identify any opportunities and constructions risks early in the project as well as an accurate construction cost and anticipated maintenance cost for each of the three detailed concept design options.

To round up our team we have also included senior ecologists, quantity surveyors, landscaping architects, a science communicator and a 3D designer.

2 PROJECT APPRECIATION

Based on our review of the project brief and associated reference material, we consider the follow elements will be important to the success of this assessment:

- **Getting the science right:** Finding the right solution from a coastal processes and climate change perspective will be challenging. The solution must be supported and justified by robust evidence that clearly illustrates the comparative impacts between distinct and well selected options. The solution should align with the visions of the draft CZMP and CMP which will be developed concurrently.

  The existing JSPW acts as a headland control influencing the alignment of updrift beaches as well as downdrift beaches. The alignment of the modification options will be a key consideration when developing options and needs to consider embayment wide processes as well as the finer scale hydrodynamics and sediment transport around the existing and proposed structures. The structure footprint will also be a factor regarding amenity. The formation of mini-rips (public safety concerns) and end effects are also considerations. Risks associated with wave overtopping need to be accurately quantified and managed. The impacts, positive and negative, on surfing amenity at popular and nearby surf spot, including The Wreck, will need to be considered.

  We would carefully develop and refine the design solution using a 'multiple lines of evidence' approach incorporating coastal observations from monitoring data, numerical modelling, physical modelling and a quantified conceptual model of sand movement. This approach provides confidence in the options assessment against the performance outcomes against relevant project objectives. This approach allows cross-checking and validation between the various investigations. We have included leading experts such as Andrew Short in our team to maximise the value of this approach.

  For example, we have carefully selected SWASH and XBEACH as appropriate numerical modelling tools that are well suited to the key questions around alignment. These detailed models are able to resolve the small scale differences between alignment options as well as cover embayment wide considerations. The application of these models will be enhanced by the targeted field data collection we have included.

  Bluecoast are experts at developing the right solution for complex coastal problems. This is demonstrated by our work on the Palm Beach Shoreline Project and the Beresford Coastal Protection Scheme, undertaken by us while with our former employer.

- **Getting the story right:** The design solution needs to be bespoke and reflect the informal nature of Byron Bay and the broader Shire. Traditionally an important meeting place for the Arakwal people of the Bundjalung Nation, Cavanbah, or Byron Bay is much loved for its natural beauty. The benign subtropical climate encourages outdoor living and the foreshore area is a focal point for outdoor activities and gatherings. The list of users is eclectic and extensive and includes whale watchers, runners, dog walkers, drummers, ocean swimmers, yoga practitioners, surf lifesavers, buskers, surfers, surf and ocean observers, beachgoers, snorkelers and people looking for somewhere to relax and hang out. A design solution for this area needs to be based on this existing use pattern and the desire to enhance and protect the area without resorting to a standard urban solution.

Structure alignment, terracing and softening characteristics, provision of beach effective access, including compliant disable access, recreational, beach and surf amenity, visual amenity and usage and value of existing assets (e.g. pool and car park) are important considerations.

A strong connection to the Byron Masterplan will benefit the design development and evaluation processes. Space Studios are a local architect firm that was heavily involved in the award-winning community engagement process undertaken for the Masterplan.
The Byron community is vocal and strongly resistant to proposals that threaten the informal feel of the town. The community is keen to give input and feedback on proposals, and is generous with its time and expertise in doing so, but it is imperative that expressed opinions shape the result to avoid 'consultation fatigue'. Our team will benefit from having local residents with children and a business based in the town who use and observe the foreshore area on a regular basis. Passive knowledge of the town as well as professional knowledge will enable us to rapidly obtain effective insight on user groups and use patterns. We have included community engagement experts Rhelm in our team which will bridge the gap between stakeholders and the engineering team effectively.

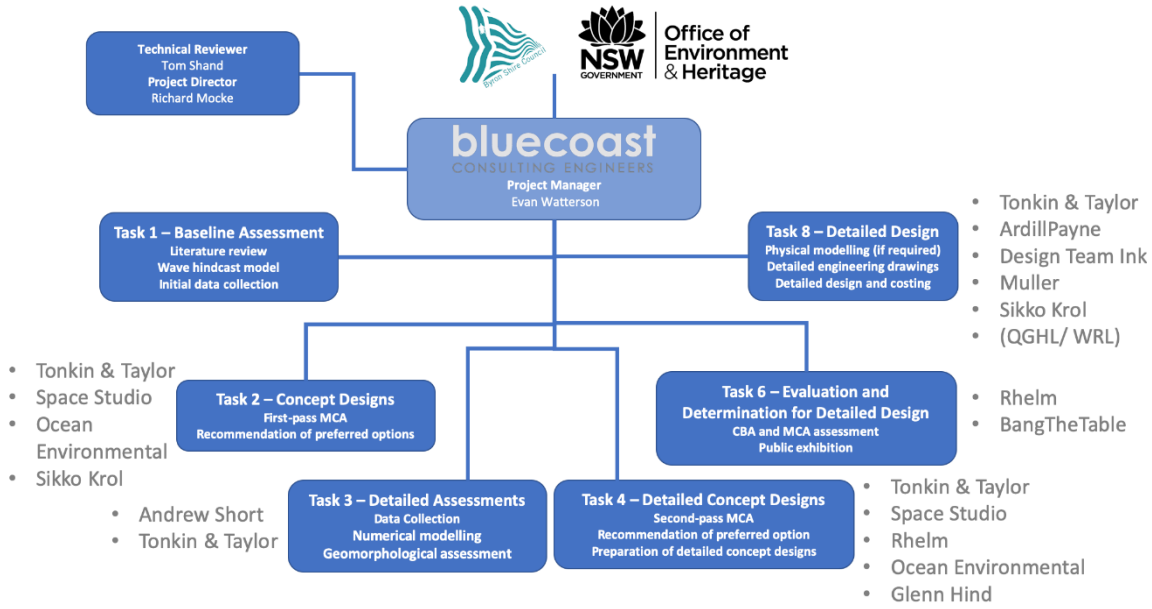
- **Getting the engineering right:** The design solution needs to be well engineered and buildable. Stable rock sizing, appropriate toe level based on scour level, crest levels and details, ground conditions, beach access and adaptability are all key consideration for the JSPW modification works. A practical understanding of the engineering design will be required during the design development stage and critical to ensure that a wealth of experience is harnessed to finalise the detailed design.

  The Bluecoast team of Richard Mocke, Evan Watterson, James Lewis and Heiko Lr has a wealth of experience in the design of coastal structures along the NSW, QLD and WA coastlines. To further enhance our coastal engineering and marine structures capabilities we have teamed with New Zealand based firm Tonkin and Taylor who will support Bluecoast's coastal engineers with technical input and review so that Council can be sure our engineering solution will be of the required quality. Tonkin and Taylor's, Tom Shand has worked extensively in NSW in his former role at WRL. Our expertise also covers the full range of project requirements from prefeasibility and conceptual assessments, through to detailed design (including design optimisation with physical modelling), tendering and construction supervision.

3 METHODOLOGY

3.1 Approach

Bluecoast has developed a suitable approach to meet the requirements set-out in the project brief which is detailed in the following sections. Our work breakdown structure and input from our sub-consultants for the JSPW upgrade is shown in the below graph.



3.2 Phase 1 – Baseline assessment (including Task 1)

In response to the scope of works outlined in the project brief, we have allowed for the following tasks as part of Phase 1.

Project kick-off meeting (including site visit)

We propose to meet with Council and Department of Planning, Industry and Environment project managers on site to kick off the consultancy. Two of our key project staff will attend, including our project director and/or project manager. The purpose of the meeting will be to discuss and arrive at a firm understanding of the project objectives, review our proposal and confirm the approach and delivery milestones as well as receive from Council any hard or soft copies of background information (e.g. reports, drawings and/or data). For this and all other scoped meetings, we will offer our suggestions regarding the meeting's agenda items as well as produce draft meeting minutes within two-days of the meeting.

We will undertake a walkover inspection during this visit paying attention to the existing structure, exposed bedrock, drainage lines, any areas of settlement in the foreshore. Our team is already familiar with this iconic area of Byron Bay but will also use the time we spend on site over the course of the project to get a first-hand feel for how the area is used. For example, beach, car park and open space usage, local surf breaks and how people tend to move through the area. Structural details, such as rock type and size, slope and dimension of the seawall will be gathered using the drone survey and condition assessment tasks.

Based on previous experience working with Department of Planning, Industry and Environment on coastal projects, Bluecoast firmly believe that the positive involvement of Council and Department of Planning, Industry and Environment's experts will be critical to successful outcomes of the project. We see this initial meeting as the first step towards an open and collaborative project approach.

Project plan and communications

Within two weeks of the project's kick-off meeting, we will provide a draft project plan that includes:

- The work breakdown structure, based on a revised version provided in this proposal,
- Delivery schedule showing each of the agreed project milestones, based on a revised version provided in this proposal..
- Structure and format for report and data deliverables. This will include a draft front cover and table of contents (showing report structure) following the requirements set-out in Section 5 of the project brief and in Council's style guide.
- Bluecoast's Quality Assurance Plan for the project.

The project plan will be updated following Council/Department of Planning, Industry and Environment comments on the draft. The project plan will be referred to in fortnightly project updates that will be provided by email to the Council project manager to advise on the progress of the project.

Task 1 – Literature review and baseline assessment

We will undertake a comprehensive desktop review of all relevant documents and data. Having worked on previous projects in the Byron region our team already have a level of familiarity with the relevant information and data, including those provided with the project brief. We will further update and re-familiarise ourselves with all relevant reports focusing on the history, values and uses, risks and opportunities relating to the JSPW under projected climate change impacts into the future out to the 2100 planning horizon. Our literature review will include the original *Byron Bay – Hastings Point Erosion Study* completed by the then Public Works Department (PWD) as NSW's first comprehensive costal investigation and management study.

The *Byron Bay Town Centre Masterplan* has been developed through an extensive, robust and award-winning community consultation process. It will be important that the design team and design process is informed by the local voices, idea and values captured in this document. Our understanding of this important local context will be enhanced through a close collaboration with our study partner Space Studios, who are based in Byron Bay and acted in a key community engagement role for the Masterplan project team and are still connected to the Byron Masterplan Guidance Group.

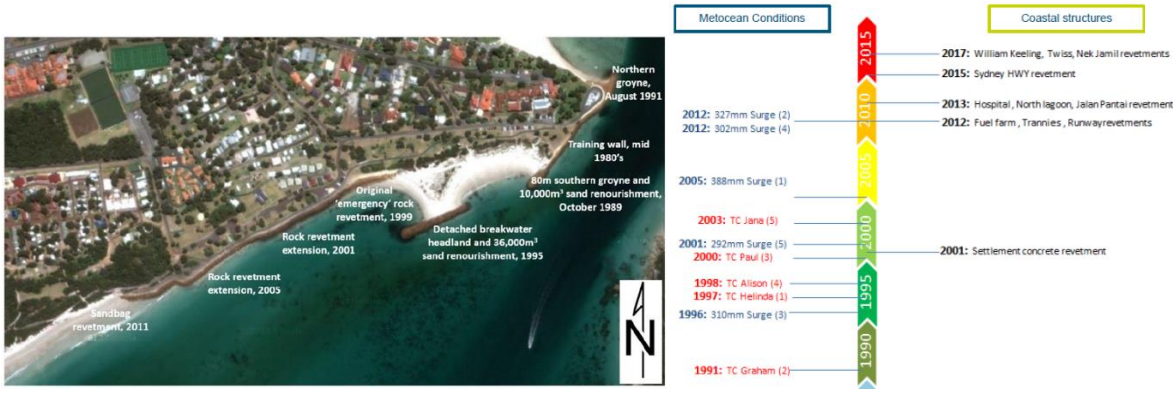
1a History, design characteristics and structures condition

Our baseline assessment for this element will comprise:

- Development of a historical timeline for the JPSW.
- Completion of a drone survey to provide a detailed 3D model of the structure in its current state.
- Coastal engineering condition assessment to document the structural features and current condition of the JPSW.

Given the history of JSPW it will be important develop a timeline which will be referred to throughout this project. WorleyParsons's 2014 report provides a historical overview of the various subsections of the JSPW. Using this information and other sources, we will compile a timeline including details of construction and maintenance works, storms events and key investigations. This will be summarised

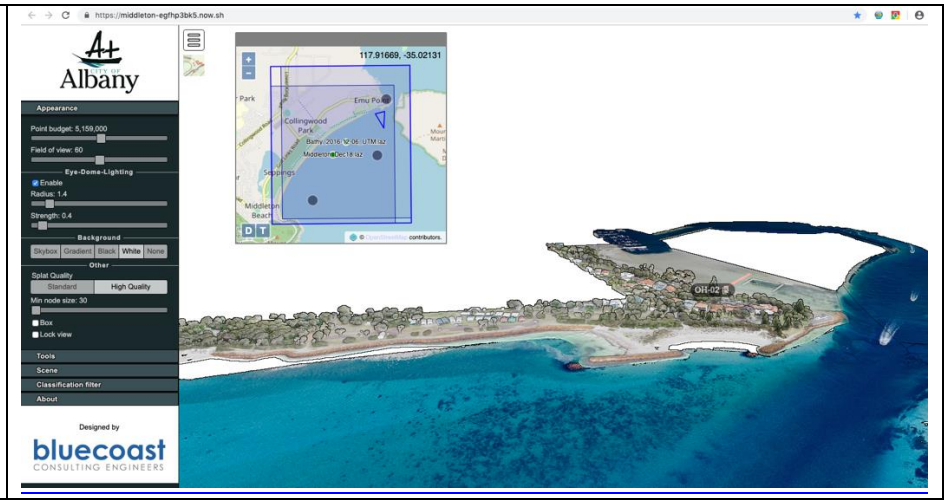
and presented visually on maps, in an easy to understand timeline (example provided below) and in a table where more detail is required.



Coastal structures are often built progressive as unintended consequences of the initial structure affects neighbour areas. Visual histories, like the map (Emu Point, WA) and timeline (Cocos Keeling Islands) shown here can be a simple but effective way to illustrate the progressive construction.

Bluecoast will undertake an unmanned aerial system (UAS or drone) survey to obtain a 3D topographic model of the JPSW and coastline 500m either side of the structure. The survey would be undertaken using Bluecoast's DJI Phantom 4 Pro drone and Trimble R8 RTK GNSS to provide survey grade results for the area at the selected validation site. Bluecoast is fully CASA accredited and has developed robust safety procedures which will be provided for review and approval prior to any field data. Enough ground control points (typically 10 or more) would be surveyed using the RTK to enable accurate geo-referencing of the data into real world coordinates and datum (AHD). In addition to this, we will compare the data to nearby permanent survey markers, available from government agencies, for quality control. Flights will be timed to coincide with low tide and mild wave conditions to maximise survey coverage.

Following the data collection, the drone data will be used to generate a georeferenced, orthomosaic image (.tif) and an elevation data point cloud of the site (. las and .xyz). The ortho-mosaic is anticipated to have a resolution of 3cm/pixel based on a flying height of 80m and the resulting point cloud with a point density of approximately 80points/m^3. An additional lower altitude flight will be made to produce a 1.2cm/pixel point cloud of the JPSW structure. The data is expected to have a nominal XYZ accuracy of ±7cm. The drone survey data will be combined with Councils existing survey and used to inform concept design, coastal processes and modelling and structural condition assessment. An interactive version of the 3D model will be hosted online for use by Council and Department of Planning, Industry and Environment accessible using web-browser (e.g. Google Chrome). We will also capture high resolution aerial imagery and video of the survey area taken from the same orientation to enable qualitative tracking of sediment and stakeholder engagement activities.

https://middleton-egfhp3bk5.now.sh/	

Example of one of Bluecoast's recent drone surveys showing rock revetment at Emu Point (WA), access full interactive model here: https://middleton-egfhp3bk5.now.sh/.

Our experienced coastal engineers we will undertake coastal engineering condition assessment of the Jonson Street Protection Works structure from east of the Byron Bay Surf Life Saving Club (in east or sediment updrift direction) to the First Sun Caravan Park (in the west of sediment downdrift direction). Prior to the inspections, we will provide Council and Department of Planning, Industry and Environment with the inspection methodology. This will follow a standardised asset condition assessment for coastal engineering structures including defects categories, condition assessment rating scale, inspection process, repair and maintenance rating scale and functional scale rating. Relevant structural information (material types, nature and extent of damage, etc) will be gathered for each section the works. For example, following the methods outlined in CIRIA C683 The Rock Manual (2007), rock grading (size based) will be determined for each representative section of the rock revetment. The primary armour and underlay rock would be assessed for their suitability for re-use in the modification design. Geotextile containers sizes and numbers will be documented for the section in-front of the surf club. Visual inspections will include assessment of visible attributes against standard indicators. A scoring system from very poor to very good (1-5) is proposed. Any observed defects will also be logged. This allows repeatable assessments that can be applied across a range of assets. This will be logged in the field using a smart device-based platform developed by Bluecoast called CoastMap.

A chainage system would be developed for the JSPW and the results of the condition assessment would be captured on a plan with corresponding photos and comments.

Data from the drone and existing survey will be used to define accurate levels, slope and dimensions to complement the visual inspection methods. Our condition assessment results will be compared to the details contained in Worley Parsons 2014 report.

Items 1b to 1h – Constraints and opportunities analysis

To access and describe criteria 1b to 1h listed in the project brief, as they relate to the JSPW, we will undertake a constraints and opportunities analysis. Based on a desktop review of existing information, GIS-mapping and site visit observations and in close collaboration with our local project partner, Space Studios, the analysis will inform the development of concept design options. Where applicable, the results will be mapped and presented spatially.

1b Land ownership and management arrangements at and adjacent to the site

As part of a GIS-based constraints and opportunities analysis we will overly Council's existing land ownership mapping layers to determine land ownership across the JSPW and adjacent areas. For each land tenure identified we will determine if there is a current management arrangement in place and review each of the associated plans of management. This will be documented using an up-to-date and project/site specific land tenure map together with a concise summary of land management arrangements relevant to the JSPW that highlights any implication for the proposed JSPW modifications. This will be undertaken for land south of the JPSW, seabed areas north of JSPW and adjacent land either side of the structure.

Our review will be undertaken in collaboration with the Council and Department of Planning, Industry and Environment and include, but not be limited to:

- Much of JSPW is contained within Byron Coast Reserve Trust an area of land classified as 'Council Managed Crown Reserve' and is managed by the Byron Coast Reserve Trust with the Crown as the landowner. Byron Bay Shire manages the trust. There is no plan of management in place, but the *Crown Land Management Act 2016* is applicable.
- Cape Byron Marine Park which covers all areas below mean high tide. The *Cape Byron Marine Park Zoning Plan* and the *Cape Byron Marine Park Operational Plan* (Marine Park Authority, 2010) will be reviewed.
- Aboriginal land management arrangements will also be reviewed, including the Arakwal People Native Title Claim, Indigenous Land Use Arrangements (ILUA1 and ILUA2), the Heads of Agreement and Memorandum of Understanding between Byron Shire Council and the Arakwal people
- Council's draft CZMP and CMP Scoping Study will be reviewed including Vision Statement/s to ensure the coastal management intention are incorporated into the design of the proposed JPSW modifications.

The Council's draft CZMP (2018) provides a recent review of land ownership and management arrangements for the broader area (source: Byron Shire Council).

1c Economic values

As noted in the project brief, Council intend to undertake a Cost Benefits Analysis (CBA) for the JSPW modifications as a separate parallel project. Our review and baseline assessment of economic values associated with the JSPW and adjacent land uses will focus on informing the multi-criteria assessment (MCA). In collaboration with our economic experts, Rhelm, economic factors will be reviewed including assets potentially protected/impacts, indirect costs such as loss of carpark revenue (for re-alignment options), indirect cost of disruption to the community during construction works, or indirect costs associated with changes to the recreational space. We will:

- Review relevant previous studies including the *Byron Coastline Values Study* (2000) and WRL (2016) *Coastal Hazard Management Study for the Byron Bay Embayment* which included an overview of assets affected by the coastal hazards defined in WBM BMT 2013 report, including property, structures and significant infrastructure. Information relevant to the JSPW area will be reviewed and incorporated.
- Private and public assets will be mapped and incorporated into coastal asset database for the area adjacent to JSPW. The GIS database will include available asset attributes such as: asset class, ownership, construction date, useful life, planned renew, cost/replacement value and condition information. Attributes for the JSPW asset itself will include the detailed information. To inform the first-pass MCA assets potential impacted will be identified using the most recent coastal hazard overlays mapped by WBM BMT 2013.
- If supplied by Council, we will review and summarise the carpark revenue, swimming pool and First Sun Caravan Park.

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- Literature on the economic value of tourism to the region and town centre will be summarised.
- Relevant outcomes of the *Byron Bay Town Centre Masterplan's* economic development strategy, and sub-strategy 01 (a centre for local opportunity) and sub-strategy 02 (a diverse lifestyle centre) will be considered.

1d Community and cultural values and uses

In collaboration with Space Studios, we will review the overwhelming community feedback from the Masterplan process on the community's values for this area. We understand that one of the strong messages for this area was the desire to retain the unique and informal feel to the foreshore area of Byron Bay town centre (i.e. does not have a 'formula' for foreshore reserves like other areas like the Gold Coast and Noosa). We will summarise constraints and opportunities associated with:

- Community use of assets like the Memorial Pool, car park, surf club and the foreshore reserve as a meeting and hang-out place.
- Cultural values and use of the area for public art, events and impromptu performances.
- Visual amenity and aesthetics of the area as captured in the Byron Masterplan and the desire for a natural and softened appeal. Constraints on levels to avoid a reduction in views and the trade-off this places on public safety.
- Amenity value for beach and surfing recreational activities as well as how people move through the area.
- Other priorities outlined in the Masterplan including Indigenous values and tourism.

Bluecoast plan on taking a hands-on approach to the project and will spend significant time on site to gather data. During this time, we hope to develop our own appreciation of the community and cultural values of the area. This was our approach adopted for a recent project on Cocos (Keeling) Islands, where time on-site talking to locals gave valuable insight to the communities and cultural values of these unique islands.

1e Environmental values associated with JSPW and adjacent site

A review of the environmental values (marine and terrestrial) of the JSPW site would be undertaken and summary of environmental values documented. The review of environmental values is considered to require the following information:

Mapping of vegetation, seagrass, wetlands, marine protected area and other habitat and sensitivity environmental receptors would be presented to illustrate project constraints. Our desktop review will be undertaken by Katie Smythe, who has previously (2012) undertaken field surveys and reported on marine impacts related to the Byron Bay Erosion Works. It will cover:

- Marine Habitats - Background data relating to marine habitats in the study area would be reviewed. This may include information regarding the Byron Bay Marine Park.
- Aquatic Vegetation – including mangroves, seagrass and macroalgae in NSW is protected and cannot be disturbed or harmed without a permit from NSW DPI (Fisheries). NSW DPI has mapped aquatic vegetation in all NSW estuaries, however, these maps typically do not extend into coastal/oceanic areas. The estuarine vegetation map for the local area would be reviewed and any usable data included.

- Waterway and Fish Habitat Classification (NSW DPI) - The Fisheries NSW Policy and Guidelines for Fish Habitat Conservation and Management (NSW DPI 2013) would be referred to and classification of the local marine habitats made in accordance with Table 1 and 2 of the Policy. This is expected to be required by NSW DPI who will assume that all works are undertaken in accordance with the Policy. Noting this, in accordance with the Policy, DPI would typically expect a site inspection to be undertaken.
- Previous Field Survey Results – A review of the field survey results in the WorleyParsons (2012) Marine Habitat Survey and Impact Assessment for the Byron Bay Erosion Works would be made and summarised in the background review.
- Marine Protected Areas – the Byron Protected areas, which are set aside for conservation under the National Parks and Wildlife Act 1974, are managed by the National Parks and Wildlife Service (NPWS). An important component of the State's reserve system are marine protected areas.
- Matters of National Environmental Significance
- SEPP 14 Wetlands and Nationally Important Wetlands
- Land Identified as Critical Habitat – Any land declared as Critical Habitat located within the study area as listed under the Fisheries Management Act 1994, former Threatened Species Conservation Act 1995 (repealed by the Biodiversity Conservation Act 2016) and EPBC Act 1999 would be made. This would include marine and terrestrial land.
- Areas of Outstanding Biodiversity Value (AOBV) – AOBVs in the study area as declared under Biodiversity Conservation Act 2016 would be identified. This would include marine and terrestrial land.
- Threatened and Protected Marine Fauna
- Existing Terrestrial Environment and Values including terrestrial habitats based on background data and any relevant information which can be provided by Council.

<u>1f Coastal processes and hazards in the Byron Bay embayment</u>

Existing coastal processes and hazard studies in the Byron Bay embayment will be reviewed. The most relevant and up-to-date mapping related to coastal erosion, shoreline recession, wave overtopping and coastal inundation, both for present-day and for climate change futures, will be extracted and mapped as part of the constraint and opportunities analysis. Byron Shire *Coastline Hazard Assessment Update* (WBM BMT 2013) provides the latest coastline hazard assessment and includes 'best estimate', 'minimum' and 'maximum' hazard lines for two erosion scenarios (i.e. retention of all coastal protection structures or JSPW only). This report also provides sediment budgets for the embayment along with storm bite extents, metocean regime (wave climate and design wave heights, water levels etc.), and wave overtopping rates of shoreline recession estimates relevant to JSPW.

While our focus will be on the JPSW, the coastal processes assessment must consider the entire sediment compartment of the Byron Bay embayment. Alongside the incorporation of the 2013 hazard study, a comprehensive review of previous studies would be undertaken. In addition to the reports listed in the project brief, some highlighted previous study including:

- Byron Bay - Hastings Erosion Study (Gordon et. al., 1978)
- Scoping study for the Feasibility to Access the Cape Byron Sand Lobe for Sand Extraction for Beach Nourishment (PBP, 2006)

- Byron Bay Erosion Protection Structures – Risk Assessment (Worley Parson, 2013)
- Design of Interim Beach Access Stabilisation Works – Belongil, Byron Bay (WRL, 2013)

It will be important to recognise the synergies with the Coastal Management Program (CMP), as well as integrate any relevant outcomes from the CMP if the two projects progress in parallel. This will ensure a consistent approach to coastal management, embayment wide. Council are currently undertaking a scoping study for the CMP and when available we would review this report.

The NSW Government categorises Belongil Beach as one of 15 coastal erosion 'hot spots' and significant previous work has been completed on coastal processes and hazards. The potential long-term impacts of a modification to the JSPW needs to be viewed in context with the overall management of the coast. Key concerns relevant to JSPW were:

- Alignment of the coastal protection works within the Byron Bay embayment to avoid the possibility of creating an artificial headland situation. The need for an overall alignment for any protection works was put forward to ensure the coastline is managed in a coordinated and consistent way.
- Structure footprint and possible impact of structures or parts of structures (i.e. toe apron) placed directly on the beach and reduced amenity.
- Modular design of beach access and the development of safety management plans to reduce potential public safety when the beach and structure crest are deemed unsafe.
- Avoiding the creation of mini-rips embayment as these can present public safety concerns for swimmer and surfers and have beach process directly inshore of the rip.
- Environmental and social factors as well as long term maintenance issues and plans.

In order to include the most up-to-date observations in the assessment of coastal processes and hazards, we have also allowed for an analysis of contemporary coastal monitoring data including but not limited to photogrammetry, aerial photography (sourced from Nearmaps), bathymetric data (e.g. recent LADS data collected by Department of Planning, Industry and Environment), tidal gauge data and Byron Bay Waverider buoy. A detailed geomorphological assessment is further described in Task 3.

IPCC's AR5 and the relevant Global Climate Models will be used to supplement the available information on climate change and sea level rise. We appreciate the uncertainties around the local sea level rise predictions and will include these in our analysis to determine each asset's vulnerability.

<u>1g Current and future risks including public safety, projected climate change impacts,</u>

The baseline constraints and opportunities analysis will consider:

- Assets potentially impacted will be identified using the most recent coastal hazard overlays mapped by WBM BMT 2013. This will provide an overview and baseline understanding of the level of risks to coastal assets.
- The NSW Coastal Panel have previous raised public safety in relation to beach access over rock revetments in the Byron Bay embayment. Public safety risks associated with pedestrians on rock revetments, access via stairs and access via ramps will be considered.

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- The risk to public safety from overtopping during large waves events with high water levels under will increase from its current level into the and future due to projected sea level rise. The baseline assessment will include a review of previous estimates or overtopping rates at JSPW, such as those presented in Worley Parsons 2014 and WBM BMT 2013.
- A review of aerial photograph indicates mini rips can be associated with the JSPW, these can have implications for swimmer and surfer safety.

1h Opportunities associated with the modification of the JSPW

By reviewing each of the individual criteria, along with the Masterplan, opportunities will be identified and documented to inform options development. This will be guided by the six project objectives Specific examples include:

- Opportunities to improve beach and surf amenity, public access, foreshore space as well as public safety.
- Opportunities to mitigate the JSPW impacts on coastal processes as well as reduce the level of risk from current and future coastal hazards.
- Drone and other survey data along with conditions assessment results will be used to inform an upfront assessment of the potential to reuse the existing rock in the structure.

1h Geotechnical conditions

We would request Council's assistance to obtain any existing reports and data on previous geotechnical investigations undertaken in the vicinity of JSPW. Knowledge of ground conditions are important to reduce design risks for coastal structure. Key requirements including the depth of erodible material at the structure toe, slope stability and foundations for the structure and/or pilling. We would review broad scale geology as well as all existing information provided by Council, to summarise available information, identify any potential underlying geotechnical problems and identify gaps in the geotechnical information required for design.

1i Wave hindcast

A spectral wave model (SWAN by Deltares) will be employed to transform offshore global wave model data (Wavewatch III) to generate a ~40-year hindcast of local nearshore wave conditions. While the design wave conditions at the JSPW are likely to be depth-limited (i.e. the maximum wave heights are limited by the water depth in front of the structures) a high-resolution wave hindcast will improve the understanding of the local wave and hydrodynamic processes. This will be essential to not only infer the interaction of the current and proposed structures with the nearshore wave and hydrodynamic processes but also to provide an understanding of long-term wave statistics and variety of characteristic conditions. This understanding will ensure that the proposed concept options can be optimised to minimise any potential negative amenity impacts (e.g. beach width, surfing quality) at an early stage of this project (i.e. prior to detailed modelling of concept options).

Validation of the nearshore wave hindcast will be undertaken using the Byron Bay Wave Buoy data, any existing nearshore wave measurements, as well as the proposed wave measurements as part of this project (see Task 3).

3.3 Phase 2 – Concept designs

Task 2 – Identify concept designs

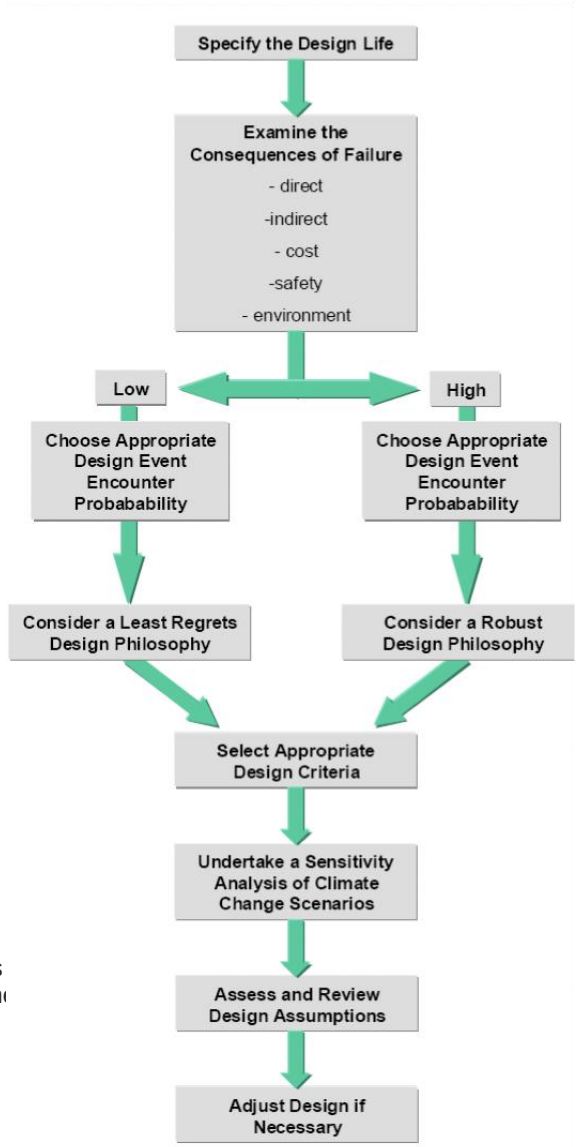
The objective of this task will be to determine a set of suitable preliminary concept design options that meet the six project objectives and provide a range of viable design solutions to the proposed JSPW modifications. In response to the project brief our approach is outlined below

1. Liaise with Council during the develop a preliminary Basis of Design

As is our standard practice, we propose to complete a preliminary Basis of Design (BOD) in the form of a concise technical note or memorandum. The document would outline key features and assumptions that underpin the design development for the modification to JSPW, including the design standards, design life, planning horizons, design parameters based on site conditions, maintenance requirements, extents of the structure and the like. We would liaise with Council and Department of Planning, Industry and Environment during the development of preliminary Basis of Design and incorporate design guidance. A draft will be presented to Council for review and liaison and acceptance prior to commencement of design development and documentation. We have allowed receiving one set of Council comments on the draft BOD, following which the technical note would be finalised.

The preliminary BOD would be based on baseline information obtained from our Task 1 review and will build information contained in the project brief and design proposal, incorporating baseline physical assumptions. It would provide an agreed platform between Bluecoast and Council for the initial stage of the design development but would be further refined as the project progresses with the final Basis of Design proposed to be completed as part of Task 5. Key design parameters in the preliminary BOD, such as local water depth at the structure toe, design water conditions at the structure, scour depth, ground conditions, wave run-up level, etc. would also be based on existing information and subject to refinement in Tasks 3, 4 and 5.

In assessing design standard Bluecoast proposes to follow the coastal hazard risk assessment recommended by The National Committee of Coastal and Ocean Engineering of Engineers Australia (shown to the right). Given the uncertainties of factors affecting coastal engineering, particularly regarding the impact of climate change, the approach that we would adopt is one of combined risk and sensitivity analysis. The steps in the procedure are outlined in the following sections.



<u>Specify the design life or planning horizon</u>
The design life of the JSPW would be governed by the requirements of Council and other stakeholders. It is assumed the required service life includes the provision of future maintenance. The design would need to recognise that

maintenance would be required for sections of the structure into the future.

Examine the consequences of failure
The impact of possible "failure" of the JSPW as a result of a large storm could have both direct and indirect consequences and would be assessed in terms of primary risk outcomes as issues of cost, safety, environment, downdrift erosion impacts and damage to public/private infrastructure. An appropriate damage coefficient for the JSPW would be determined through an extensive literature review.

Select the design event encounter probability
This quantifies the acceptable risk of "failure" of the facility for the duration of the chosen design life or planning horizon and would be based on the assessed consequences of failure. Worley Parson (2014) assessed the existing rock armour to be unstable for wave conditions above 1-year ARI with a “no damage” criteria using Hudson’s Equation. This risk profile is clearly not acceptable. A 50-year ARI event is often used for land accessible seawalls where maintenance is relatively. Bluecoast would utilise the CIRIA Rock Manual 2007, BS 6349-1:2000 (Maritime Structures, Part 1 Code of practice for general criteria, BSI 07-2000) and AS 4997-2005 (Guidelines for the design of maritime structures) to advice Council on the selection of the most appropriate design event. However, it is envisaged that the selection of the design event would be discussed and agreed with Council.

As discussed above the key design parameters for the preliminary BOD would be based on existing information. Sensitivity analysis to these parameters would be examined to assess the sensitivity of the design at this initial concept design development stage including uncertainty related to climate change projections.

2. Investigate various concept design options

Bluecoast will investigate potential concept options by considering each of the criteria listed in the project brief.
A review of the previously proposed design options will be undertaken in-light of contemporary best practice and cost-effective coastal protection works. Given the site constraints and opportunities identified in Task 1, a technical and literature review of a long-list of feasible options will be considered including different material types, seawall and revetments, groynes, submerged reefs, artificial headlands, sand by-passing, nourishment, dune rehabilitation and retreat. Each will be summarised in relation to the six project objectives and justification provided where options are considered unfeasible or marginally feasible. Bluecoast operates on the building with nature approach and has considerable experience in applying this philosophy to identifying suitable coastal management/protection solutions. Where hard engineering structures are required consideration of incorporating appropriate environmentally friendly elements will be discussed. Adaptive design measures to accommodate future climate change and sea level rise will be assessed. For example, if the works were to remain on the current alignment and future shoreline recession due to sea level rise resulted in reduced natural bypassing of sand, a future adaptation could be the introduction of a small-scale sand by-passing operation.

The inclusion of options that re-align the JSPW landward will be considered as will options to remove or reduce in length the existing groynes. As discussed above, the alignment of other structures proposed within the Byron Bay embayment has raised concerns around creation of a headland effect and unintended effects on beaches, particularly those downdrift. The existing JSPW is seaward of the natural alignment of the embayment and future sea level rise and shoreline recession will increase the protruding distance. In addition to coastal processes, the alignment issue will need to

be assessed in the context of the landward assets (car park, pool etc), foreshore usage, beach amenity, movement of pedestrians, improved public safety, climate change risks and other criteria.

By reducing the headland effect, the removal of the groynes would be expected to have a beneficial effect on coastal processes. The current arrangement of the groynes appears to have some influence on the nearshore hydrodynamics and rip formation. Nearby surf breaks may be impacted if these groynes are removed and would need to be considered in combination with coastal processes, public access and beach amenity. Selecting the optimal alignment and groyne/no groyne configuration, and confidently assessing the impact on coastal processes, both local and embayment wide, will require the numerical detailed modelling that is proposed in Task 3.

The alongshore length will be considered from a cost and benefit perspective. Extension or upgrading the structure to provide additional protection to the surf club will be a key consideration in the alongshore extent.

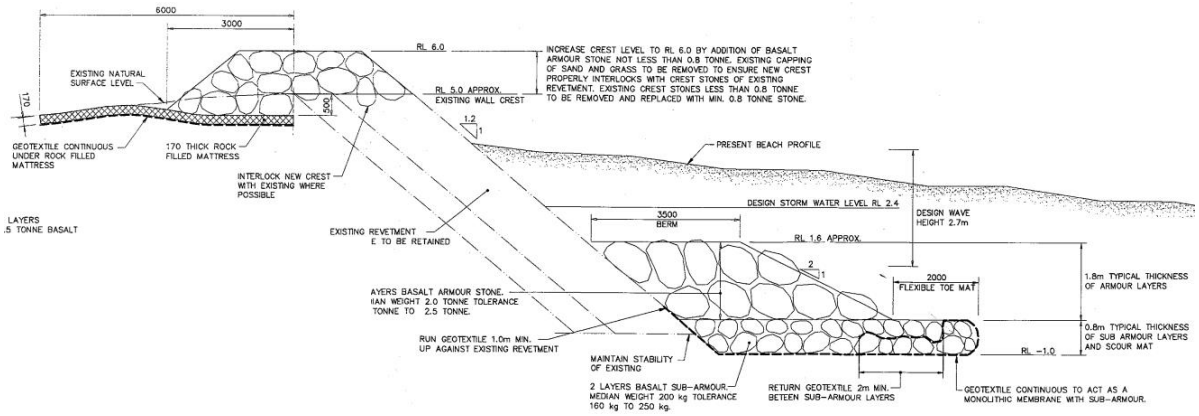
Overtopping performance in large return interval wave events will be considered during design development. The design development will be informed using the empirical approaches to calculate overtopping outlined in EurOtop 2nd Edition (2018). The performance of options regarding stability, failure modes and damage will also be considered for these extreme events.

The concept design phase would also have regard to:

- Improving public access, safety, and amenity across the whole JSPW precinct. With consideration of two beach accesses either side of the car park and disable access arrangements on at least one access.
- Construction costs will be considered based on the costs of previous projects, material availability and selection.
- Maintenance and whole of asset costs based on the expected longevity of the design options over a 50-year planning horizon and beyond. Access requirements for equipment to undertake maintenance on the structure will be considered.
- Inclusion of a shower, viewing platform, natural features, terracing and informal seating associated with the western access
- Byron Masterplan

3. Identify and document a suite of preliminary options

We have allowed for up to five distinct options to be developed for the modification of the JSPW. It is anticipated that one of these design options would comprise a berm type rock revetment seawall, which we have applied successfully for other projects to provide significant savings in the capital cost of the works. The creation of a berm at the toe of the seawall (which would only be exposed during extreme events) allows waves to break on the structures at an earlier stage, which in turn reduces the wave runup and overtopping experienced at the structure and enables a reduced rock size to be applied on the sloped face of the seawall than would have otherwise been required without a berm. An example typical cross-section of a berm type seawall is shown below.



For each selected concept we will produce high quality sketches of the concept layouts. Our layouts will include a plan showing the extent and nature of the works, typical cross sections and conflict points for further consideration. These layouts will be sent to Council, with a brief accompanying technical note, for consideration. Following a round of discussions/deliberations with Council and Department of Planning, Industry and Environment, the proposed layouts will be refined. The layout will not include design drawings or a technical specification. Drawings would be in A3 format provided in CAD and pdf files.

Based on the concept design layouts, material take-off quantities would be calculated. Quantities will be presented in the documentation and used to determine order of magnitude costs.

4. Planning and approvals pathways

For each of the concept designs our study partner Realm will consider the required planning matters and approvals. Bluecoast staff have experience with obtaining state, federal and commonwealth approvals and permits for beach nourishment and coastal structures projects and would work with Rhelm to identify any opportunities and limitations associated with these for each of the designs.

To do this we will include a review of existing local, state and federal approval conditions and limitations. A flow chart which clearly identifies the required development applications, processes and timeframes to gain approval for the proposed works will be developed. Consideration will be given to the relative cost and risk associated with the approvals process for each option. Any gaps in supporting documentation required for the development applications will be identified and documented.

5. First pass Multi-Criteria Assessment (MCA)

We propose to undertake the following approach to the first-pass MCA:

a. In collaboration with Council and Department of Planning, Industry and Environment formulate a range of suitable performance measures, or Key Performance Indicators (KPIs), associated with each of the project objectives. Each KPI should be formulated to offer a true assessment of the design options performance in achieving the project objectives. Consideration should also be given to KPIs that can be assessed using results of the design investigations (e.g. predictive modelling results) and monitored post-project implementation. While multiple KPI may be required for each project objective, careful consideration by the project team would reduce unnecessary overlap. A table would be developed showing the draft KPI's assigned to against each project objective (see example below). These KPIs can

be used throughout the remaining design development and evaluation stages to objectively assess performance outcomes.

Key Result Area (KRAs)	Performance Criteria	KPI		
		KPI	Priority	Targets Additional information on the KPI's target is provided in the table notes below.
Coastal Protection	The scheme must provide improved coastal protection for Palm Beach.	Sustained (i.e. long-term) increase in beach volume to act as a buffer against storm erosion. .	High	Overall sustained increase in beach volume of at least **300,000m^3** above pre-project levels. (see Table Note 1)
		No unacceptable downdrift impacts.	High	Downdrift shoreline adjustment within the range of natural shoreline variability in historical record. (See Table Note 2)
Amenity (Recreational and Tourist)	The scheme should enhance the overall amenity of Palm Beach.	Maintain or improve beach amenity.	Medium	Useable beach width maintained or increased compared to pre-project levels. (See Table Note 3)
		Increase in rideable waves in the area of the SCS. No negative impact on surfing conditions in the lee of the SCS.	Medium	SCS to produce rideable waves on a regular basis. No reduction in the number of rideable waves in the lee of the SCS. (See Table Note 4)
Capital Costs	Ability of the design to be constructed to a budget with an acceptable risk profile.	Cost (including contingency) for the construction of the SCS.	High	Target Outturn Cost (TOC) is within project budget (less than $17M). (See Table Note 5)

Example KPI table for the Palm Beach Shoreline Project developed by Bluecoast staff. Here KPI are associated with Key Result Areas, however, for JSPW project this could be project objective.

b. We will then outline the approach for the first pass MCA, including the methodology for attributes, scores and weights in a concise technical note for Council's consideration. In addition to the project objectives and KPI, the MCA approach would consider the positive and negative aspects of each concept option having regard to the project criteria discussed in dot-point 2 above. Our engagement and economics experts would provide input into the approach to the first pass MCA to ensure that it is set up in a consistent manner with a Cost Benefit Analysis (CBA). Rhelm would assess the positives and negatives of each preliminary concept design with regards to:

    - Environmental considerations;
    - Planning and approvals (see Task 2.4); and
    - Economics.

    The MCA will be structured to provide a robust and defensible basis for the selection of the most suitable design options. Equally, this assessment will provide the basis for excluding any options that will not hold water with stakeholders. The MCA incorporates consideration of projects interdependencies including costs, geotechnical considerations, public safety, alignment, crest height, structure length and material type. This would be done using constraint mapping, where possible. Prior to the workshop, we would liaise with Council to make any adjustments to the first-pass MCA methodology.

c. A workshop for the first-pass MCA will be arranged with Council and key stakeholders in which attributes, scores and weights will be deliberated. Bluecoast and Rhelm will work collaboratively to prepare materials (e.g. presentation, surveys or other handouts) as well as determine the most suitable workshop agenda. This is envisaged to include:

    - discuss and confirm criteria and the proposed MCA methodology including weighting of key themes

- discuss pros and cons of each concept design under each MCA criteria
- complete the MCA scoring of all criteria for each concept design.

Emma, Rhelm's engagement lead, would facilitate the workshop.

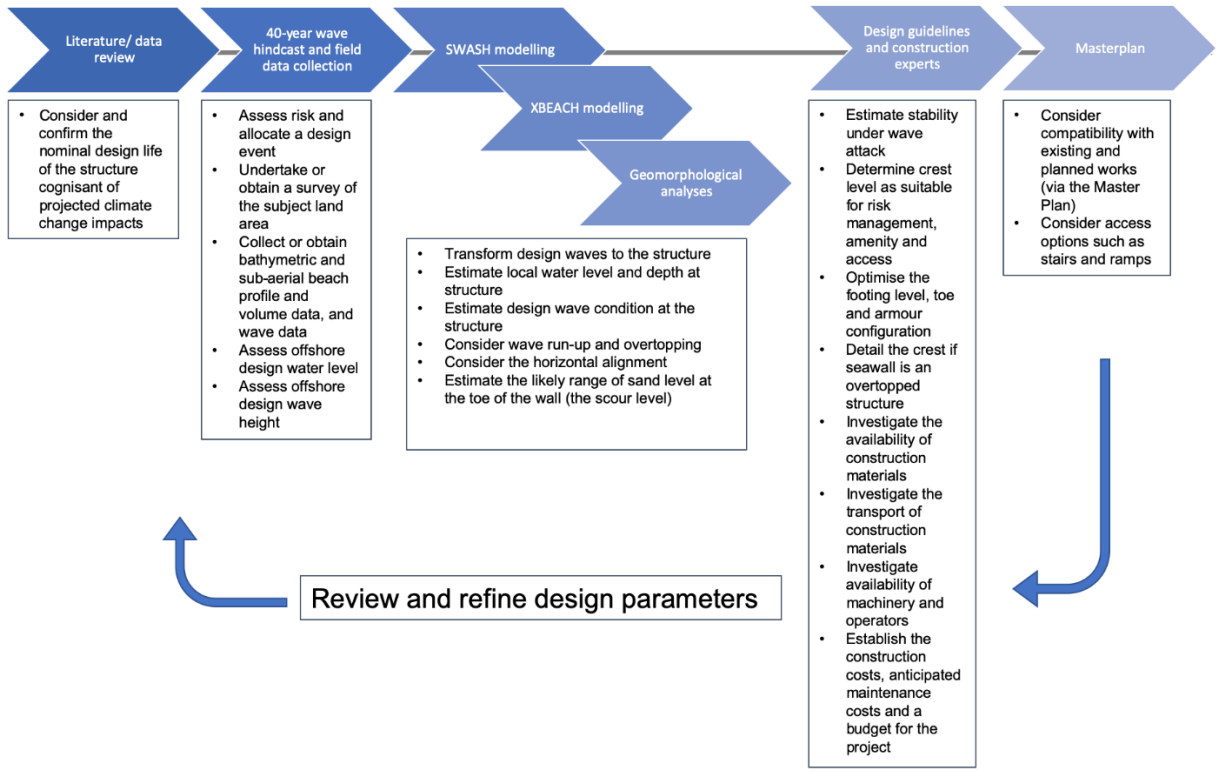
Prepare a draft JSPW Investigation Report

A clear and concise report will be prepared following the requirements laid out in the project brief. High quality figures (maps, plots and other visualisation) will be used wherever possible. The report will:

- Describe the work completed in Task 1
- Describe the modification options assessment process completed to this point, including the first pass MCA. The report will clearly identify and justify all recommendations in relation to concept design options to be further considered, including those that should be modelled during Task 3.

Task 3 – Modelling and geomorphological assessment

Bluecoast has developed a multiple-lines of evidence approach that fulfils the requirements outlined in the project brief and is effective in reducing project uncertainties in design criteria and structure performance. Our proposed workflow for completing the design steps that inform the detailed concept design is presented in the below schematic and described in detail in the following sections.



1. Task 3 inception meeting

This Scope of Work for the JSPW Modification Project has been amended from the original Bluecoast proposal P194010 submitted on 17 May 2019 to accurately detail the scope of work for public distribution.

The Bluecoast project team, including our key coastal engineers and geomorphologist Andrew Short, will attend a meeting (via telephone or in person) with Council staff and Department of Planning, Industry and Environment staff to discuss and confirm the concept design scenarios to be included in the coastal processes modelling, and to discuss and confirm the intended approach to modelling and proposed input parameters.

2. Local data collection

Bluecoast are strong believers in using measured/observational data to enhance coastal processes understanding and increase confidence in numerical modelling tools used in parallel. Our engineers are experts in field data collection and we have access to the latest monitoring technology. As such, we have included an effective monitoring approach to collect data of key physical parameters that are required for the design of the JSPW. We have included the data collection as part of Task 3, however, we suggest some of these tasks be moved into Phase 1 to ensure this data is available early in the project timeline, this suggestion could be discussed at the project inception meeting.

The key objectives of the monitoring deployments are to collect coastal metocean data which will:

- improve the understanding of the metocean conditions contributing to coastal change;
- confirm design assumptions and design criteria adopted in previous studies;
- support the verification/calibration of numerical models; and
- support the design of concept design options.

The data will also benefit concurrent (e.g. coastal hazard definition) and future studies that rely on the effects of local metocean conditions. The monitoring tasks are described in the following sections.

Bluecoast recognises the importance of implementing safe work practices, especially when conducting works in the field. Through working with large clients for complex metocean monitoring projects we have developed all the required health and safety procedures and policies required for this project. We have consistently exceeded the health and safety requirements specified by the clients for the large data collection projects we have recently been involved in. Bluecoast will attain all necessary permits and approvals including a ‘notice to mariner’ prior to undertaking any monitoring deployments. A project specific Safe Work Method Statement would be prepared and provided to Council for review.

Bluecoast believes a robust data management and data processing routine is imperative in ensuring the accuracy and reliability of the final data set and maximising the data life cycle. In order to ensure the reliability and integrity of the data collected throughout the project, Bluecoast will make use of previously developed in-house data management procedures (i.e. Data Management Plan) and data Quality Assurance (QA) processing tools which maximise high quality data return at reduced labour intensity. Our engineers have developed a number of QA procedures which are applied to all data collection works we undertake. A key component of these procedures involves the detailed screening of all acquired raw data.

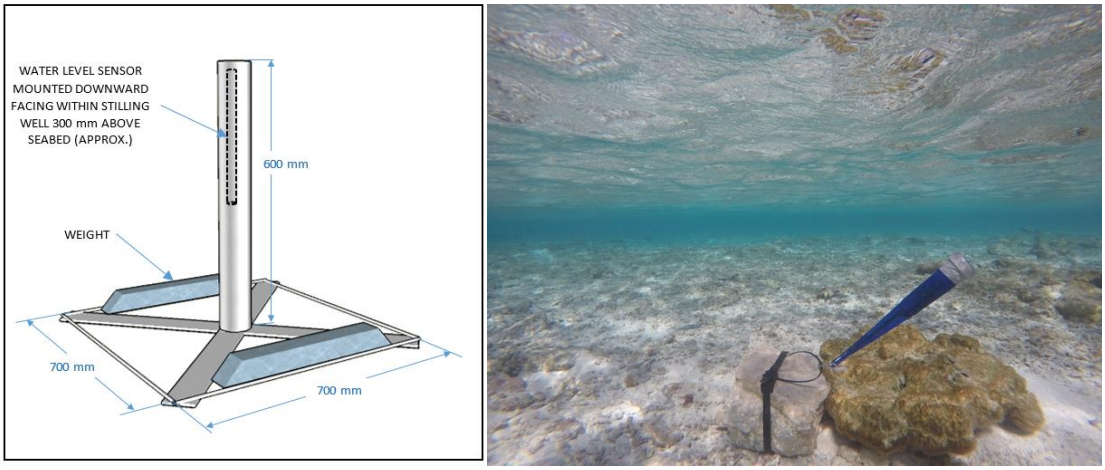
3. Nearshore waves and currents

A RBR Virtuoso high-frequency pressure sensor will be deployed for two months in combination with a Marotte HS current meter on the seabed to measure non-directional waves, water level and near-bed currents in the immediate nearshore area off the JSPW (in approximately 5-10m water depth). This is a cost-effective way of collecting the minimum required data to gain the necessary confidence

in nearshore process understanding and modelling. We have used this monitoring setup multiple times where project budgets are tight and deployments need to be kept simple with minimal footprint.

The monitoring data will benefit the study by providing:

- An understanding of wave transformation from offshore areas;
- Hydrodynamic processes in the nearshore area; and
- Validation data for numerical models.

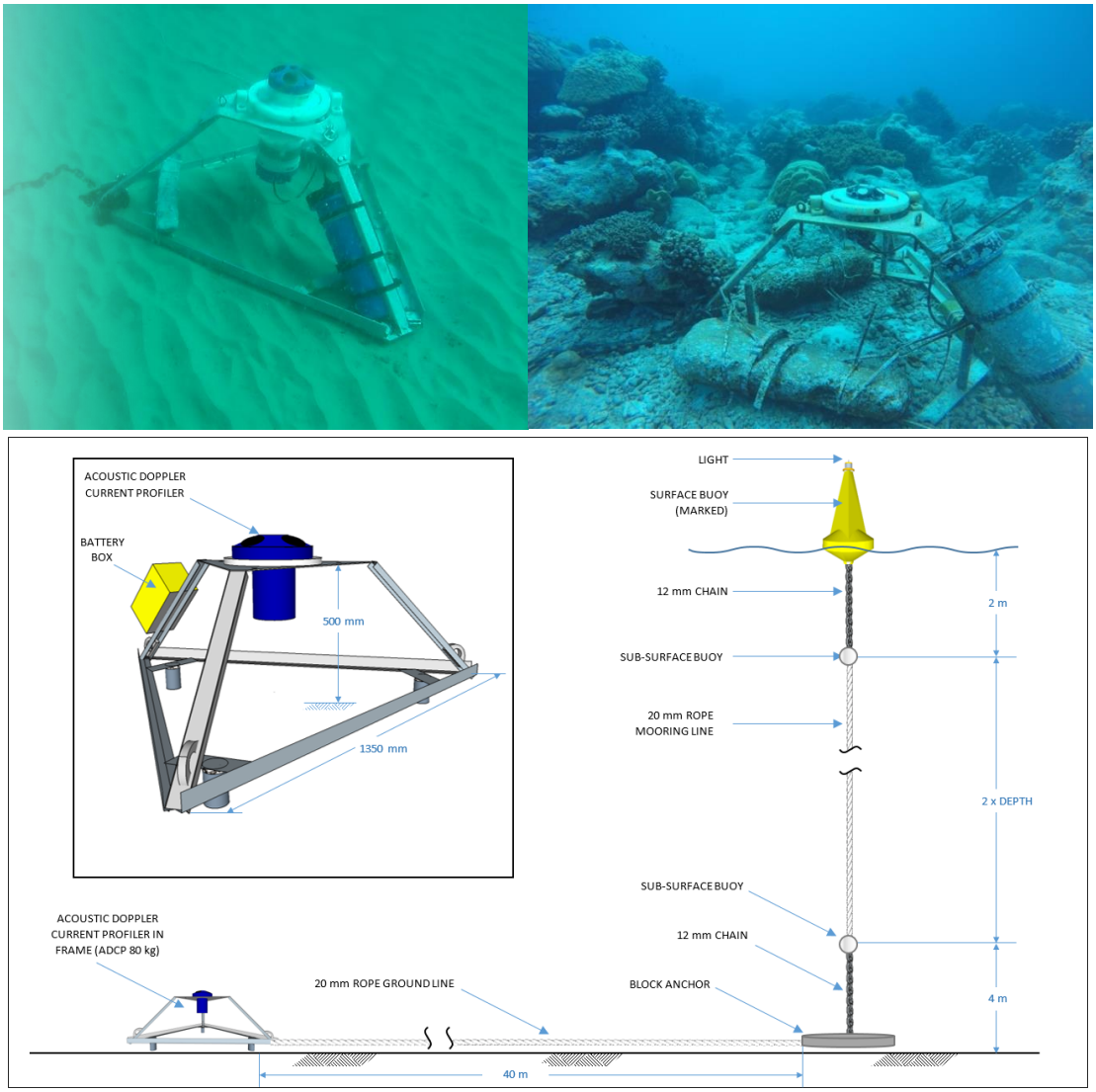


Examples of mooring configuration for the seabed mounted pressure sensor (left) and deployment of a Marotte HS current meter (right).

4. Measurement of directional waves and currents

Bluecoast will deploy an Acoustic Doppler Current Profiler (ADCP) in the nearshore location instead of the pressure sensor and current meter for a two month period. We have access to industry-leading equipment that is able to measure wave heights, periods and directions as well as directional current speeds at a number of vertical bins throughout the water column (and water level). The additional parameters collected with this instrument would further improve the coastal process understanding in the study area as well as provide excellent data to undertake a detailed validation of the numerical models. The exact location of this monitoring instrument would be strategically determined through the use of preliminary numerical models and current coastal process understanding. For example, this could be where uncertainties in processes are evident or key processes such as rip currents, wave focussing areas are identified that could have implications for the design of the proposed structures.

We have developed innovative deployment techniques that allow us to deploy our equipment on the seabed without the use of divers while not compromising data quality. This not only significantly reduces the safety risk associated with commercial diving, but also considerably reduces deployment cost. An example of our diver-less and low-profile 'L-shape' mooring system is provided in the below sketch. The durability and low-profile of our mooring and frame configuration, ensured that two ADCP devices remained intact and unmoved from their shallow water moorings offshore of Mackay Harbour during the passage of TC Debbie allowing for 100% data capture during the cyclone event (this data became even more valuable given the Mackay WRB came adrift in this cyclone).



Examples of previous Bluecoast ADCP deployments and diver-less 'L-shape' mooring system developed by our engineers

5. Water level at structure toe

A low-profile RBR Solo high-frequency pressure sensor will be deployed to measure water level variations in front of the existing rock revetment at the Jonson Street car park (at approximately mean sea level) for a two month period. This real-world laboratory experiment will provide accurate, measured water level and wave induced setup which form important design parameters for the proposed structures. This low-profile pressure sensor can be anchored to the seabed or fixed to the toe of the existing structure (see example below). Having confidence in the design water levels prior to finalising the concept designs or commencing any physical modelling will significantly reduce costs associated with design alterations and additional test experiments.

The monitoring data will benefit the study by providing:

- An understanding of wave-driven water level variations;
- Critical information about design parameters (e.g. wave height, water level, wave run-up, overtopping); and
- Validation data for numerical models.

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Example of previous deployment of RBR pressure sensor measuring water level and waves atop a coral reef flat in Cocos (Keeling) Islands

Nearshore bathymetry and beach profiles

6. RTK-GPS and drone survey

Bluecoast proposes a beach transect survey regime be undertaken for the period of the concept design stage. A simple RTK-GPS (Trimble R8 RTK GNSS) survey will be performed at regular intervals (50m) tangential to the shore and vegetation lines at (as a minimum) approximately 1km either side of the JSPW (i.e. Clarkes Beach to Belongil). To ensure seasonal variability is captured the same transect lines will be repeated at four months intervals and capped to three surveys commencement of Phase 3 (i.e. 3 x survey dates). If a significant (forecasted) erosion event, these surveys can be undertaken either side of the erosion event and used for a before/after event analysis. Should this prove successful, it is recommended that a full-time Council staff member be trained in this undertaking and repeat the process on a regular basis to create a larger data set for the future.

An additional drone survey would also be captured using the approach outlined in Task 1. The repeat data would provide an opportunity to access change between drone surveys.

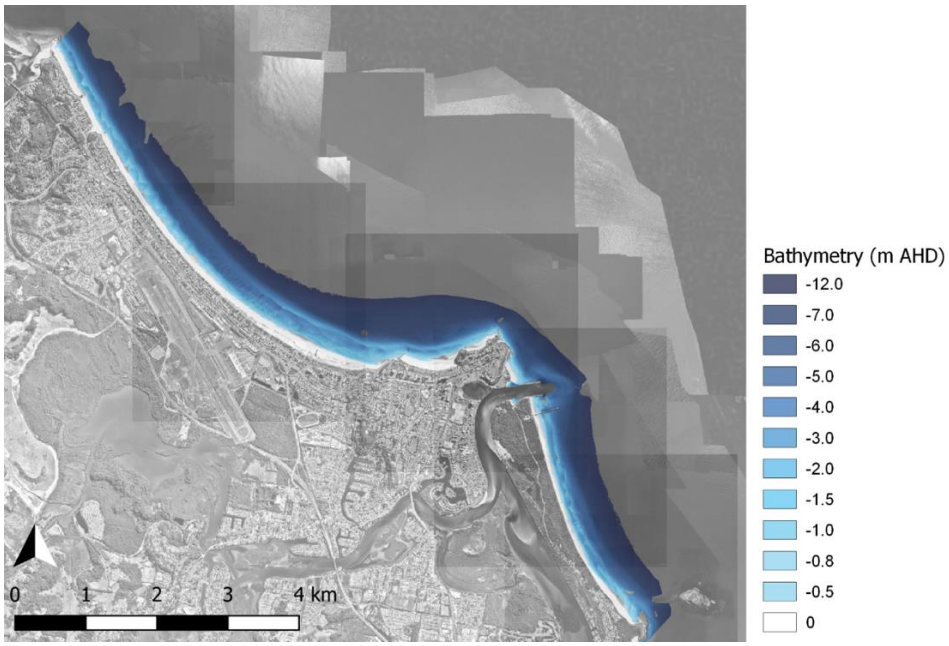
7. Satellite-derived bathymetry (SDB)

With the improvement of spatial coverage, spatial resolution and temporal resolution of satellite data over the last decade, the use of such data for environmental and coastal engineering purposes has become very attractive. Our remote sensing specialist partner has developed algorithms that allow converting satellite imagery into accurate nearshore bathymetry up to approximately 20m water depth. Our engineers are at the forefront of applying this technology in the coastal engineering and management space, see (LDepartment of Planning, Industry and Environmentr et al., 2018 and LDepartment of Planning, Industry and Environmentr et al., 2019). This includes the completion of detailed validation studies in northern NSW and south-east Queensland that highlighted typical vertical errors are around 0.3m. The nearshore area at Byron Bay is particularly suitable for the acquisition of SDB due to the shallow coastal profiles, predominantly sand bottom and clear water.

The key advantages of using this remote sensing data are its cost-effectiveness, readily available 10-years historic database, up to weekly 2x2m resolution images available suitable for high-resolution bathymetry conversion. Furthermore, the 2x2m gridded data is capable of accurately describing nearshore morphological features (e.g. sand bars) in both cross-shore and along-shore directions (i.e. no interpolation between survey transects).

Bluecoast has included the cost for purchasing one 2x2m resolution bathymetry data sets for the study area (up to 25m^2). The image capture date for this dataset will be informed by the earlier tasks of this study and, for example, could be selected based on specific known morphology conditions (i.e. low-energy or storm profile, or bar morphology for good/bad surfing conditions). The SDB dataset will provide a recent high-resolution bathymetry for the project area in addition to the existing LADS data. Having at least two such datasets will provide the opportunity to assess morphological change over time for the whole project area, this is further described below.

In comparison to other airborne bathymetry survey techniques such as LiDAR no significant draw backs exist using SDB for most applications. Both LiDAR and SDB require visible light reflectance from the seafloor to estimate water depth. Essentially, if the seafloor is not visible in aerial imagery then no bathymetry data can be derived. For the majority of the time in shallow sandy environments along the east coast of Australia the water clarity is sufficient for SDB.



Example of 2m resolution satellite derived bathymetry for the Tweed Sand Bypass study area for July 2017.

The bathymetry and topography monitoring data will benefit the study by providing:

- Design beach profile elevations;
- Excellent data for geomorphologic assessment (see following tasks);
- Recent data for input to numerical models; and
- Validation data for numerical models (morphology).

8. Long-term coastal processes

Bluecoast will determine a detailed understanding of the long-term morphological conditions of the nearshore and sub-aerial areas within the Byron Bay embayment. This will be achieved by undertaking the following tasks:

<u>8a Geomorphological assessment</u>

A detailed analysis of nearshore bathymetry and topography as well as shoreline position will be undertaken based on the existing information and data as well as monitoring data collected by Bluecoast for this study and geomorphological tools, including (but not limited to):

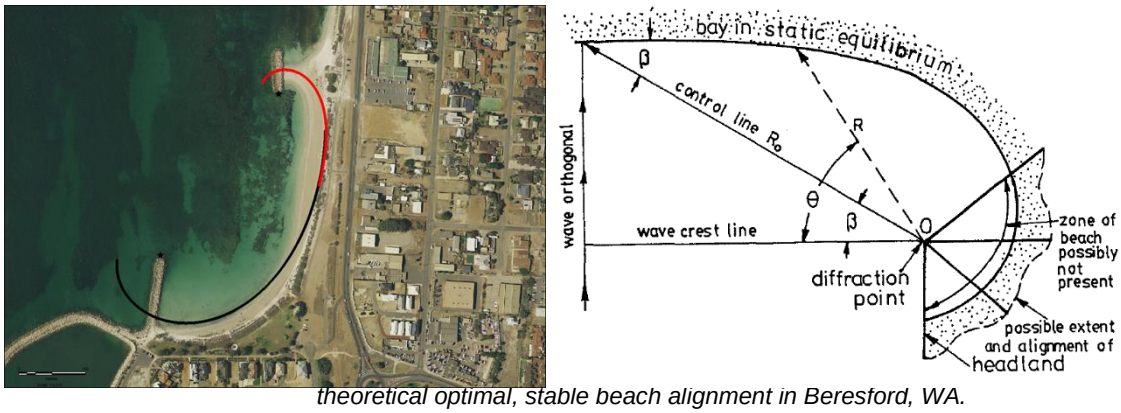
- Photogrammetry dating from 1947
- Lidar and LADS data
- Subtidal bathymetric survey data (existing)
- Bluecoast satellite derived bathymetry (one date, see example below)
- Bluecoast topographic survey data (drone + beach profiles)
- Coastal imaging (Coastalwatch Main Beach camera)
- Aerial imagery (e.g. Nearmap)
- Other existing data or previous/concurrent studies (e.g. BMT WBM, 2013)
- Crenulate Bay empirical geomorphological tool (Hsu et al., 1989)

Our engineers are experts in the analysis of spatial data to infer sediment processes using GIS and Matlab software. Having completed numerous similar analyses, for example, along the Tweed Sand Bypassing study area, other Gold Coast Beaches, NSW embayment's and river entrances and within Queensland port areas, we have an in-depth knowledge of interpreting long term coastal sediment processes as well as event based coastal response along the east coast of Australia. We will undertake volumetric change analyses as well as profile comparisons between survey dates and describe the key morphological features and their evolution over time. This will include presentation of annotated spatial difference maps as well as beach profile plots and statistical descriptors. Bringing a well-respected geomorphologist, Andrew Short, on our project team will maximise the value this analysis.

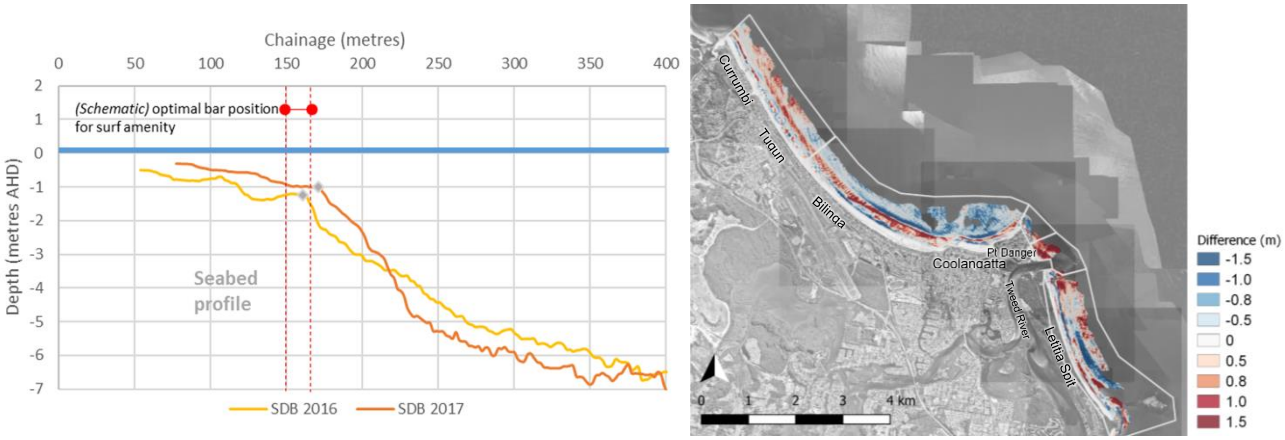
In addition, we will apply an empirical geomorphological tool 'Crenulate Bay' by Hsu et al. (1989) which our engineers have applied on similar previous studies to estimate the stable crenulate bay shape based on the existing environment. Crenulate Bays represent the balancing of the natural processes of wave action and sediment load on the shoreline. The empirical approach requires the diffraction point and the dominant wave direction to be known, once these are known it is possible to determine the equilibrium crenulate bay shape for suitable existing beaches. As such, this approach can be used to determine the optimum layout for existing and future structures, helping to achieve the optimum beach shape with minimal sediment loss.

The geomorphologic analysis will benefit the study by providing:

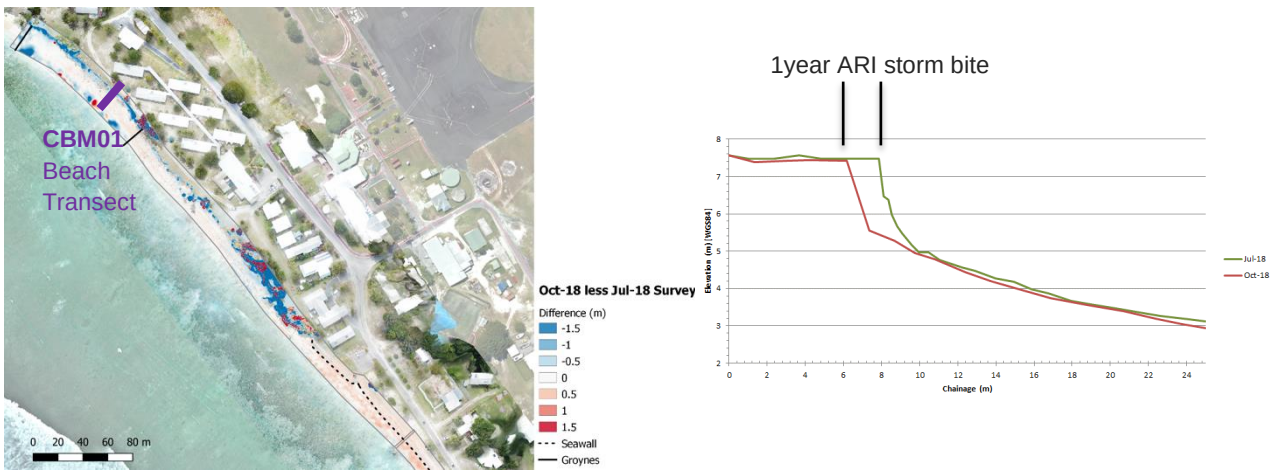
- High-level processes understanding of Byron Bay compartment;
- Long-term and event-based sediment transport and transport volumes;
- Seasonal effects on morphological conditions;
- Critical information of design parameters; and
- Informing numerical modelling investigations.



theoretical optimal, stable beach alignment in Beresford, WA.

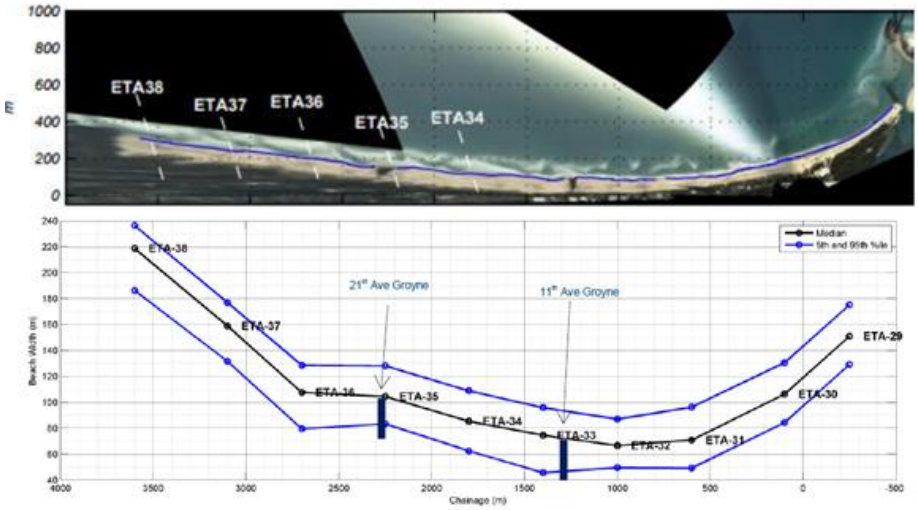


Examples of long-term bathymetric change analyses between two satellite derived bathymetry 'survey' dates at the Tweed Sand Bypassing study area.



This Scope of Work for the JSPW Modification Project has been amended from the original Bluecoast proposal P194010 submitted on 17 May 2019 to accurately detail the scope of work for public distribution.

Examples of topography change analyses between two drone survey dates before and after an extreme erosion event at Cocos (Keeling) Island.

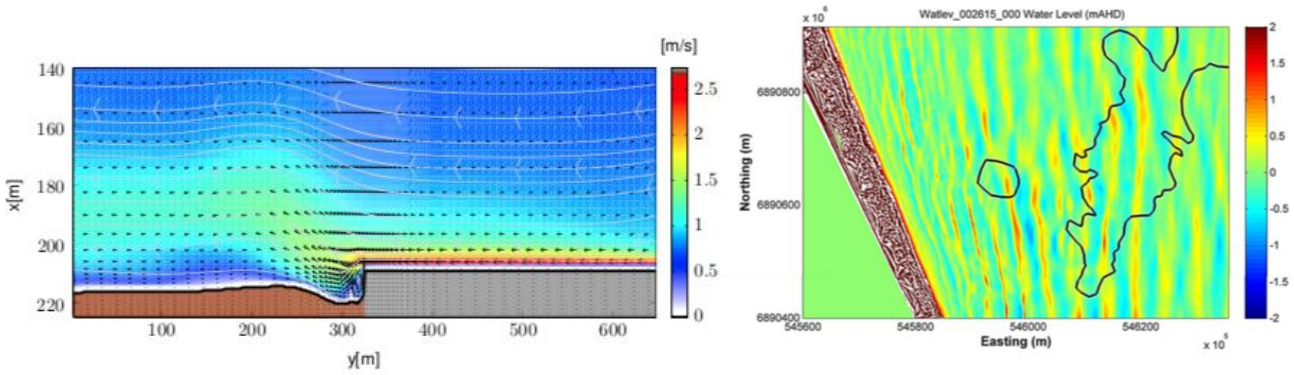


Example of previous analysis of coastal imaging beach width statistics along Palm Beach for the period from 2004 to 2017.

8b SWASH modelling of typical conditions

Based on the metocean data review and ~40-year wave hindcast undertaken as part Task 1, three representative periods associated with low-energy, medium-energy and high-energy metocean conditions will be simulated using a phase-resolving hydrodynamic and wave model (i.e. individual waves are being resolved). This will be undertaken using the state-of-the-art numerical model SWASH developed by Deltares for a model domain stretching from The Pass to Belongil Beach. SWASH is a nonlinear shallow water wave and hydrodynamic model which accounts for wave-breaking, non-linear wave transformation (e.g. wave focussing over nearshore reefs), interaction with structures and can accurately estimate wave-induced water level setup. A detailed calibration and validation exercise will be undertaken using the measured nearshore currents and wave data (see above) and wave setup measurements at the structure's toe (see above). This will ensure the model results can be trusted and significantly reduce uncertainties in the predictions, hence reducing the project risk.

This model is the best tool for assessing the baseline conditions and impacts of the selected concept designs on the nearshore wave and hydrodynamic processes at JSPW. This high-resolution model (proposed 2m by 2m spatial resolution near the structures) will be able to predict any downdrift or updrift impacts caused by the structures under current and future climatic conditions (e.g. sea level rise, increased storminess). An example of simulating the downdrift impacts of the seawall on a sandy beach using SWASH is provided in the figure below.



Example of simulated currents at the downdrift interface between a seawall and sandy beach (left) and wave transformation over nearshore reef (right) using SWASH.

The numerical simulation results will be assessed and interpreted by our expert coastal engineers and geomorphologists in direct comparison with the results of the desktop analysis of bathymetry data and the identified morphological processes and our team's existing understanding of the nearshore coastal processes in Byron Bay. The potential impact on the identified morphological processes by the JSPW upgrade will be discussed for each of the assessed concept design options.

The SWASH wave and flow modelling will benefit the study by providing:

- Typical and event-based nearshore hydrodynamics and wave transformation;
- Impact of JSPW upgrade options on nearshore hydrodynamics and wave transformation;
- Critical information of design parameters (e.g. water level, wave setup, wave runup, overtopping); and
- Informing overall coastal processes understanding.

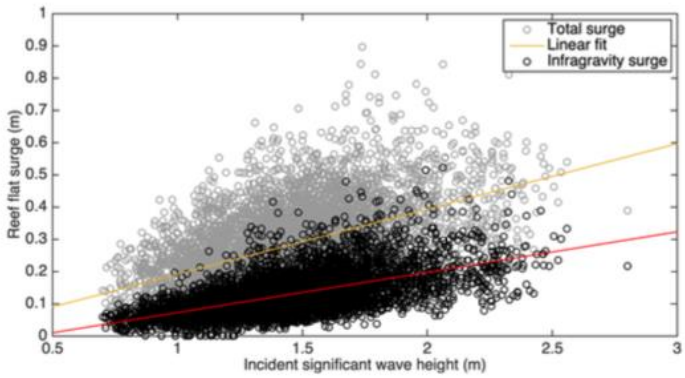
9. Storm-event modelling

9a Design waves and overtopping during storm conditions

The high-resolution, calibrated SWASH model described above will be used to estimate design wave conditions and overtopping volumes during storm conditions for the baseline and selected concept design options for the JSPW. While the design wave height will be depth-limited, any increases in water level will significantly alter this wave height. A selection of annual recurrence interval (ARI) events (e.g. 1, 5, 10, 50, 100 year ARI) will be simulated to assess the design wave height, water level and the structure's performance in limiting overtopping during these events and during future sea level rise scenarios.

The offshore boundary wave and water level conditions for the SWASH model will be derived from the 40-year wave hindcast and measured water level data. Joint occurrence and cumulative effects of wave conditions and water level would be considered in the selection of the model boundary conditions. Bluecoast has developed state-of-the-art joint occurrence analysis tools using Matlab software which would be used to produce data summary tables demonstrating calculated occurrence probabilities of different metocean parameters for a series of values/magnitudes (e.g. wave height, water level, wave-setup, etc). Joint occurrence frequencies will be estimated from the long-term hindcast data and nearby water level measurements (e.g. Tweed Heads) as well as the short-term measurements undertaken as part of this study. These will then be compared to previously adopted design water levels and similar studies in the area (e.g. Shand, 2012) and a justification of the final design water levels will be provided.

Wave-setup and run-up will be accurately simulated by the calibrated SWASH model and these values will be extracted for each of the selected ARI events. The relationship between incident wave conditions and increases in water level at the structure's toe will be assessed in light of previously adopted values and studies (e.g. Dally et al., 1984) as well the water level measurements undertaken as part of this study. A recent study undertaken by Bluecoast's engineers has assessed measured water level setup in the nearshore on Cocos (Keeling) Islands, see example below.



Example of nearshore wave setup assessment undertaken by Bluecoast's engineers based on measured data in 2019.

Simulated overtopping volumes will be compared against the tolerable thresholds published in EuroTop (2018). SWASH has been widely used to estimate overtopping volumes for a variety of coastal protection structures and is considered industry-leading software for this type of numerical modelling tools (not CFD models, which are significantly more computational demanding). Simulating wave overtopping at the concept design stage will provide valuable information for the design considerations of the JSPW upgrade and reduce the need for additional design modification steps later on and during physical modelling (if at all required).

Sensitivity tests of the design wave and overtopping estimates to varying design water levels and morphology in front of the structure (e.g. scour during storm conditions) will be undertaken and discussed.

The SWASH wave and flow modelling for storm events will benefit the study by providing:

- Event-based/extreme nearshore hydrodynamics and wave transformation;
- Impact/performance of JSPW upgrade options on nearshore hydrodynamics and wave transformation;
- Critical information of design parameters (e.g. wave conditions, water level, wave setup, wave runup, overtopping); and
- Structure adaptation design requirements for future climate scenarios.

<u>9b Morphology response during storm conditions</u>

In order to understand short term shoreline stability due to energetic storm events a process-based sediment transport model needs to be incorporated. Bluecoast proposes to use XBEACH to gauge shoreline stability due to energetic storm events. XBEACH is a process based model that is frequently used by our engineers, other engineering companies and researchers to determine nearshore morphological changes. Similar to SWASH, return flow, wave asymmetry, wave rollers and long waves are examples of processes that are included in XBEACH. The key difference

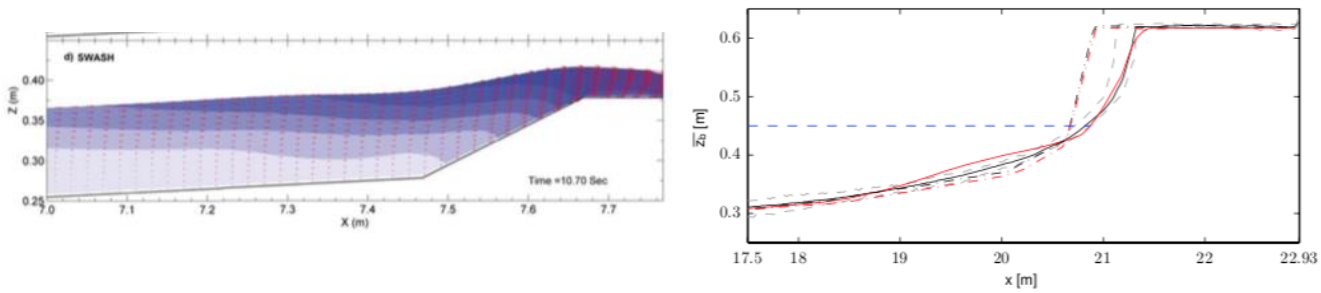
between SWASH and XBEACH being that the latter is able to predict morphology changes including shoreline position and, in particular, sub-aqueous and sub-aerial profile erosion. Because of the inclusion of long waves (infra gravity waves) XBEACH is specifically suitable for models in the nearshore zone, where phase-averaged models such as DHI's MIKE 21 SW/ST or Delft3D are often used for larger domains and deeper areas. XBEACH was initially designed to determine the coastal erosion during storms (Roelvink et al., 2009) and (Roelvink et al., 2015).

Shoreline response to the selected ARI offshore wave and water level conditions (as determined in previous task) will be simulated using a 2D non-hydrostatic XBEACH model for the baseline and selected concept design options. This will predict morphology changes in front of the structures (including scour at the structure's toe) as well as in unprotected updrift and downdrift areas (i.e. from The Pass to Belongil Beach) and sediment bypassing at the JSPW. It is proposed that the XBEACH model be calibrated to the measured nearshore wave and currents as well as water levels at the structure's toe to ensure wave setup during these events is correctly resolved.

XBEACH cross-shore sediment transport predictions would be calibrated to any measured storm bites (or the amount of beach erosion caused by storms) captured in the topographic measurements undertaken as part of this study. Simulated storm bites for each of the ARI events will be tabulated for the baseline and selected concept design options.

The XBEACH morphology modelling for storm events will benefit the study by providing:

- Event-based/extreme nearshore morphology;
- Impact/performance of JSPW upgrade options on nearshore morphology; and
- Critical information of design parameters (e.g. design profile, scour depth, toe configuration).



Examples of SWASH overtopping (left) and XBEACH morphology (right) simulation results during storm conditions.

10. Amenity assessment

To understand the impact of the JSPW upgrade on the surrounding surf breaks and swimming areas (i.e. between Main Beach and The Wreck), a baseline characterisation of the existing wave mechanics will be undertaken first considering effects of bathymetry, incident wave conditions (height, period, direction) and water levels. This approach will then be reproduced for post-JSPW upgrade conditions (i.e. structures, alignment and inferred/modelled bathymetry) to evaluate relative changes in incident and reflected wave energy and wave breaking positions and potential effects on the wave quality and swimmer's safety.

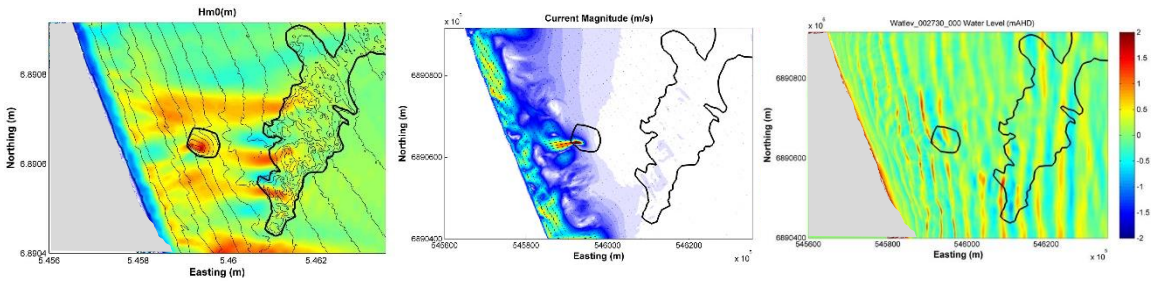
Surf specific metocean conditions will be derived from the ~40-year wave hindcast and known 'good surfing' conditions (to be determined in consultation with the local surfing community or social media

research). The high-resolution and calibrated SWASH model will be used which simulates individual non-linear waves as they propagate over the nearshore bathymetry and break, forcing wave-driven currents which may in turn interact with the incoming wave field. Wave breaking patterns and wave-driven current simulations will allow defining general wave breaking footprints, wave sections as well as key features of the surf break circulation. A comparative analysis and presentation of the results will be undertaken to demonstrate the modelling results for the current conditions and selected concept designs.

Furthermore, the results will be assessed with a focus on identifying any changes in the location and magnitude of rip currents that could pose a safety risk for swimmers.

The amenity assessment will benefit the study by providing:

- Baseline surfing and swim amenity conditions;
- Impact/performance of JSPW upgrade options on surfing and swim amenity; and
- Critical information of design parameters (e.g. alignment, slopes and access).



Example of surf amenity assessment for a multi-purpose reef at Palm Beach using SWASH.

11. Conceptual coastal processes model

The findings from the literature and data review (Task 1), geomorphological assessment as well as analysis of the numerical modelling results will be used to form and reiterate coastal process understanding at the project site for the production of a conceptual coastal process model, as seen in below figure. Any inconsistencies in the results of the various investigations would be assessed using expert judgement and described accordingly.

The conceptual model will include the key coastal processes and key morphological features (e.g. nearshore reefs, wrecks, etc). This will be presented clearly as annotated overlays and maps for various metocean scenarios and/or JSPW concept options. Again, our well-respected geomorphologist Andrew Short will bring a wealth of local knowledge and process understanding to this exercise, maximising the value of the above investigations.

The conceptual coastal processes model will benefit the study by providing:

- Summary of relevant coastal processes and key features;
- Combining multiple-lines of evidence;
- Clear presentation of inferred impact of JSPW upgrade options on local coastal processes; and
- Enhancement of overall coastal processes understanding.

12. Task 3 Deliverables

The methodology and results of the modelling and geomorphological assessments will be described and issued to Council in the draft report (Issue #2). This will include the predicted impacts to coastal processes associated with each concept option in form of a clear discussion and visualised on a map (i.e. modified conceptual coastal processes model). Our engineers appreciate the inherent uncertainties associated with modelling and assessing coastal processes, in particular, sediment transport and the potential impact on the design/performance of the JSPW upgrade. This will be discussed critically.

Following receipt of comments from Council (Hold Point #2) we will finalise the draft report (Issue #2).

Task 4 – Evaluation of concept design and key stakeholder engagement

The key objective of this task is to provide a comprehensive and transparent evaluation of the concept designs for the modification of the JSPW. This will be completed using a second-pass multicriteria assessment as the guiding framework. A significant body of work will have been completed in Tasks 1 to 3 and this will be incorporated into the evaluation processes.

13. Co-design the second-pass MCA methodology with Council

We will work in close collaboration with Council to co-design the second-pass MCA methodology. We proposed to meet with Council's project team at the outset of this phase to review the positives and negatives of the first-pass MCA, discuss possible refinements to the projects draft KPIs, assess any gaps in the assessment criteria and discuss the strategy, stakeholders and methodology for the next pass.

Following this initial meeting, we will undertake further work to comprehensively assess each option against the themes outlined in the project brief as outlined below. This work will be completed by our second pass MCA project team, including Rhelm (Engagement, Environment and Economics), Space Studio (local engagement and linkage with Byron Masterplan) and Katie Sythmie (Ecology).

This work will be summarised and used by Council and Bluecoast to complete the design of the workshops in a collaborative approach.

a. Community/cultural values

Traditionally an important meeting place for the Arakwal people of the Bundjalung Nation, Cavanbah, or Byron Bay is much loved for its natural beauty. The subtropical climate encourages locals and visitors to spend time outdoors and the foreshore area near JSWP is a focal point for outdoor activities and gatherings. The list of users is eclectic and extensive and includes whale watchers, runners, dog walkers, drummers, ocean swimmers, yoga practitioners, surf lifesavers, buskers, surfers, surf and ocean observers, beachgoers, snorkelers and people looking for somewhere to relax and hang out. A design solution for this area needs to be based on this existing use pattern and the desire to enhance and protect the area without resorting to a standard urban solution. A bespoke design reflecting the informal nature of Byron Bay and the broader Shire is likely to gain greater community support.

Space Studio were involved in the development of the Byron Masterplan and provided a strong linkage between advice on local community matters. The Masterplan project was structured as a 'ground up', and Space Studio were involved in extensive community consultation both online and face to face. The data gathered from the workshops, information sessions and user group meetings will be referenced to assist in the evaluation criteria for the assessment of modification options for JSPW.

Values such as community use of assets (Memorial Pool) adjacent the JSPW, priorities of the Byron Masterplan which include sensitive integration of the foreshore and works with recreation, nature and pedestrian movement, Indigenous values, tourism, and surfing amenity will be considered.

Figure 6.11 - Short Term Plan: Main Beach Precinct

b. Public recreational amenity and public safety

Each of the concept design options assessed against recreational amenity and public safety criteria such as pedestrian safety around rock walls (slippage), alongshore access, safe swimming areas and beach amenity. Byron Masterplan seeks to create a seamless connection between Apex Park, Peace Park, Denning Park and Foreshore Park. The movement of people through the foreshore area will be an important consideration as with the potential for any linkages with the potential upgrade of the Surf Lifesaving Club. The modification options should seek to strengthen Main Beach's role as Byron Bay's most popular asset.

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Any works should be aiming to minimise negative impact on surfing amenity and the detailed modelling completed as part of Task 3 will assist in evaluating any positive or negative impacts on surf amenity and inform key decisions of the structure's alignment.

c. Visual amenity and aspect

Based on visual amenity and aspect recommendation and from Space Studio, we will develop visualisation of each of the concept design options for assessment. These will assist in the comparative assessment of visual impact of the works on the area, including the view from land adjacent the JSPW towards the sea, the ranges to the west, and Cape Byron to the east. We will also work collaboratively with Space Studio to consider each option against the priorities in the Byron Masterplan.

d. Economic factors

Economic factors will be assessed for each concept design option including construction costs, maintenance costs, and indirect costs such as loss of carpark revenue (for re-alignment options), indirect cost due to the disruption to the community during construction works, or indirect costs associated with changes to the recreational space.

e. Ecological impacts of marine and terrestrial habitats

Ecological impacts on marine and terrestrial habitats will be assessed and compared for each concept design option. Factors considered will include loss or gain of intertidal areas, loss or gain of vegetation, potential pests associated with rocks (rats and/or snakes) and degradation of materials into the marine environment.

f. Coastal process, beach profile and planform and surf amenity

The comparative assessment for each of the concept designs will be based on the results of the modelling and geomorphological assessment completed as part of Task 3. The modelling approach we have adopted will allow KPIs to be quantitatively assessed and compared across options including predicted impacts to shoreline alignment, beach profile, sediment transport as well as surf quality. For the purpose of the second-pass MCA we will present the results in a clear and concise summary, including any key limitations and uncertainties, and seek feedback and assist in the evaluation.

f. Climate change and sea level rise

Future climate change scenarios will be modelled for each concept design as part of Task 3. This modelling and associated analysis as part of the geomorphological assessment will be used to compare the sensitivity and/or resilience of each concept design option. This assessment will have regard to climate change impacts including sea level rise, storm intensity increases and changes to wave climate (including direction). Options with the ability to adapt to withstand predicted future physical forces will be considered favourably.

14. Second-pass MCA workshop

The second-pass MCA will be a critical step in the projects progressing and the positive involvement of the Council and stakeholders will be critical to successful outcomes for the modifications of the JSPW. With Rhelm's assistance, Bluecoast will plan and facilitate each workshop so that all participants have a clear understanding of the agenda and MCA process. The workshop will aim to be focused and engaging with the aim of obtaining feedback that will inform the assessment of the concept designs.

The workshop is anticipated to include engagement with Councillors, Council staff and State agency representatives and other key stakeholders. Bluecoast will undertake the second-pass MCA in a workshop style setting to evaluate and score the concept designs against the endorsed criteria and the project objectives. The workshop attendees are to be confirmed in liaison with Council. The MCA workshop will be facilitated to provide an opportunity for stakeholders to;

- discuss and confirm criteria and the proposed MCA methodology including weighting of key themes
- discuss pros and cons of each concept design under each MCA criteria
- complete the MCA scoring of all criteria for each concept design.

15. Update draft report (issue #3)

A clear and concise report will be drafted following the requirements laid out in the project brief. High quality figures (maps, plots and other visualisation) will be used wherever possible. The report issue #3 will:

a. Provide a comprehensive discussion on the assessment methodology (including stakeholder engagement),

b. Provide a comprehensive analysis of the results of the second-pass MCA including description of key assumptions, key uncertainties, key limitations, and other matters requiring clarification

c. A full justified technical recommendation of the preferred concept designs that best fulfil the project objectives will be provided. This option will be suitable for progression to detailed concept designs in the next phase of the project.

16. Finalise report (issue #3)

Following receipt of a single set of consolidated comments from Council and Council's technical reviewer we will update the draft report for issue.

17. Strategic Planning Councillor Workshop

In collaboration with Council's project team we will present the findings of the Draft Report (Issue #3) to Byron Shire Councillor's at a Strategic Planning Councillor Workshop. Our project lead will engage in discussion to assist Councillors in their deliberations on the recommended concept designs.

18. Strategic Planning Councillor Workshop

Following feedback and direction received from Council on the outcomes of the project to this point, and in accordance with any consolidated feedback from the Strategic Planning Councillor Workshop, we will finalise and reissue the draft report

3.4 Phase 3 – Detailed concept designs

Task 5 – Prepare detailed concept designs

Bluecoast's coastal engineers will incorporate the findings from Phase 1 and Phase 2 to update the basis of design for the optimisation of the three endorsed JSPW modification options. The detailed concept designs will incorporate the design steps outlined in the Project brief and are informed by the investigations undertaken in Phase 1 and Phase 2 (see flow chart in Task 3). Further, we have included architects with an invaluable understanding of the Masterplan as well as construction experts that will bring value to developing the construction methodology and costs. Our project team has been involved in all stages of the design of coastal protection options and construction of coastal protection structures and identified the following key opportunities in the JSPW upgrade:

- **Byron Bay Masterplan integration**

  Considerable community engagement and planning of the JSPW area has been undertaken as part of the development of the Masterplan. To ensure the findings from the Masterplan are effectively incorporated into the detailed concept design developments, we have included the Masterplan architects, Space Studio, in our design team. The architects will not only bring their knowledge of the already completed investigations and planned works in the surrounding area to this team but also provide design input in optimising the detailed concept designs in alignment with the Masterplan. Space Studio was engaged on the Masterplan team as architect and local consultant. Their role was to advise on architectural matters such as sub-tropical design, materials and building form, local character and the built environment as well as providing advice on local community matters.

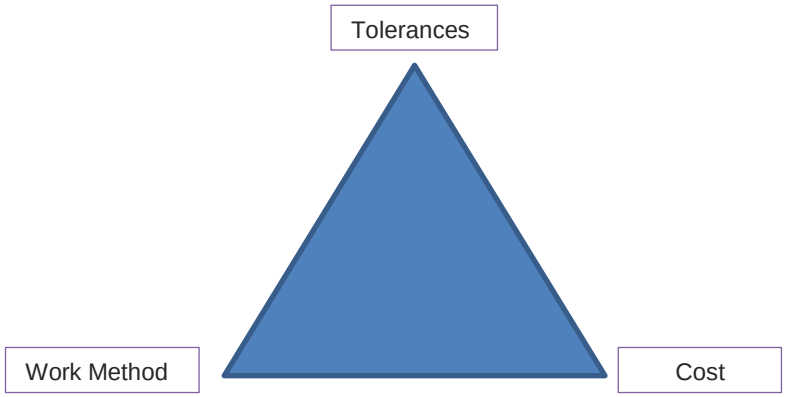
- **Understanding of risk management and adaptation options**

  Bluecoast and Tonkin & Taylor coastal engineers appreciate that, other than building hard engineering structures to withstand the most extreme climatic conditions, there are opportunities in incorporating risk management and adaptation options. This may provide considerable benefits in increasing amenity while reducing cost and structure footprint as well as potential downdrift impacts. Bluecoast are believers in the working with nature principle through innovative design solutions and detailed understanding of coastal processes, their interaction with coastal protection structures and associated risks. We will apply our broad knowledge of such risk management and structure adaptation options to find the right balance of level of protection, sustainability and cost-effectiveness. Our engineers have significant experience in 'soft-engineering' approaches due to their involvement in the design of coastal protection options in remote locations with limited material availability and small island developing countries with limited budgets.

- **Early construction expert involvement**

  Early involvement of construction experts or contractors is now used in the industry during the appraisal and design stage with the benefit of more cost certainty, sustainability and buildability. Other key benefits of such early involvement are in the mobilisation of both design and construction skills at a key development stage in the project, with the anticipated result of an inherently safer and lower risk project. The below figure shows the balancing of three key construction considerations that need to be addressed in the design of coastal protection structures. As such, Bluecoast have included Sikko Krol to our design team who is

a respected maritime construction expert in Australia. Most recently, Sikko has been appointed to provide advice during the design development of the Palm Beach Shoreline Project. Sikko and our coastal engineers have a good understanding of the local construction industry, available plant and material transport considerations required for the JSPW. As such, this will ensure an accurate construction cost and anticipated maintenance cost for each of the three detailed concept design options can be established at this stage.



Construction criteria of the coastal engineering structures

- **Quarry investigations**

  Bluecoast has an in-depth knowledge of the quarries in northern NSW and south-east Queensland. Our engineers have recently undertaken visits to most of the quarries in this region to find suitable construction materials and adequate volume of larger rock for the Palm Beach Shoreline Project. For these, we have detailed quarry reports stating yield and inspection test results. In addition, we have access to a detailed quarry review for this region undertaken by the City of Gold Coast for the Kirra groyne upgrade. We will use our existing knowledge of the quarries in this area and experience from similar projects to effectively provide the information required for the detailed concept design of the JSPW upgrade options.

- **Artists impressions and visualisations**

  Previous coastal design projects, that included significant stakeholder consultation undertaken by Bluecoast engineers, proved the effectiveness of producing artist impressions and visualisations for concept design options. As such, we have included 3D designer Glenn Hind in our team and allowed for two impressions for each concept design option. An example from previous concept designs is provided below.

Task 5 Deliverables

As the main deliverable from this task we will update the Draft Report (Issue #4) to describe in clear terms the design specifications, design rationale, and design limitations for each detailed concept design.

The issue of the Draft Report will include a full suite of drawings for each detailed concept design including cross section, plan and elevation views.

Following receipt of Council's technical review comments (Hold Point #6) we will finalise the Draft Report (Issue #4) within two weeks.

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3.5 Phase 4 – Evaluation and determination for detailed design

Task 6 – Evaluate detailed concept design and engage with the broader community

Phase 4 and Task 6 will determine the recommended detailed concept design that best satisfies the project objectives. The selected detailed concept design will be progressed to Phase 5, which will include assessment of the requirement for physical modelling.

Assess and consider the results of the completed Cost Benefit Analysis (CBA)
As noted in project brief the CBA will be undertaken as a separate parallel project. Our economist, Rhys Thomson, would consider the outcomes of the CBA and provide a summary report with regard to considerations for the CBA and design process (see Task 6.3 below for reporting). Through his earlier involvement in assessing the economic factors and broader review of the first and second pass MCA process, Rhys will already be embedded in the project and well placed to assess and consider the results of the CBA.

1. Assess and consider the results of the second-pass MCA

We will consider and assess the outcomes of the second-pass MCA in-light of the CBA results and the development and costing undertaken in the detailed concept design task (Task 5).

2. Update the draft report (issue #5)

A clear and concise report will be drafted following the requirements laid out in the project brief. High quality figures (maps, plots and other visualisation) will be used wherever possible. Our economist, Rhys Thomson, would provide input to the draft report with regards a. and b. below to: The report issue #4 will:

a. Summarise the CBA process and outcomes.

b. Undertake a technical comparison between the CBA results and the second pass MCA results to describe possible reasoning for any differences in the rankings of design options, the key differences in the two assessments, etc. The technical analysis would include discussion outlining the Consultant's opinions and insights on the outcomes of the CBA and MCA, including on the top ranked options correlation with the project objectives.

c. Identify one, or a maximum of two, detailed concept designs that are recommended to Council for progression towards 'detailed design and costing' with accompanying justification.

5. Update the draft report (issue #5)

Following feedback received after Hold Point #7, (Task 6.4), we will update and finalise draft report issue #5.

6. Council's report to a formal meeting of Council

Bluecoast will provide support, if required, in preparing or responding to endorsement by Council.

7. Public exhibition

Our engagement specialist, Emma Maratea, would develop an engagement strategy for the public exhibition period in accordance with the objectives of the NSW Coastal Management Manual and the IAP2 framework. The engagement strategy will identify the consultation context, scope, stakeholders, purpose and goals, engagement methods and evaluation strategies. Emma would work closely with Council and Department of Planning, Industry and Environment to ensure that the objectives and goals of the consultation are identified, scoped and evaluated.

From our initial appraisal of the project, the community and the likely issues and questions to be raised by the community, we have allowed for undertaking the following engagement tasks during the public exhibition period:

- Providing Council with project information for website content (assumed to be hosted on Council's website), this would include project details, content and key images and maps. It is assumed that Council will provide an opportunity on the webpage for the community to submit comments and feedback.
- An information brochure will be prepared by Rhelm and Bluecoast for Council to review and distribute to the community via mail. This would include project details, information on how to make a submission, and direct the recipient to the website and drop in information session.
- Rhelm would prepare for and facilitate two drop-in information sessions. It is expected that these sessions would be undertaken on the same day or concurrent days. The format of the sessions would be discussed with Council. These sessions would be attended by one Rhelm staff and at least one Bluecoast staff as well as Council's project manager.

8. Task 6.8 Compile and Respond to Public Exhibition Submissions

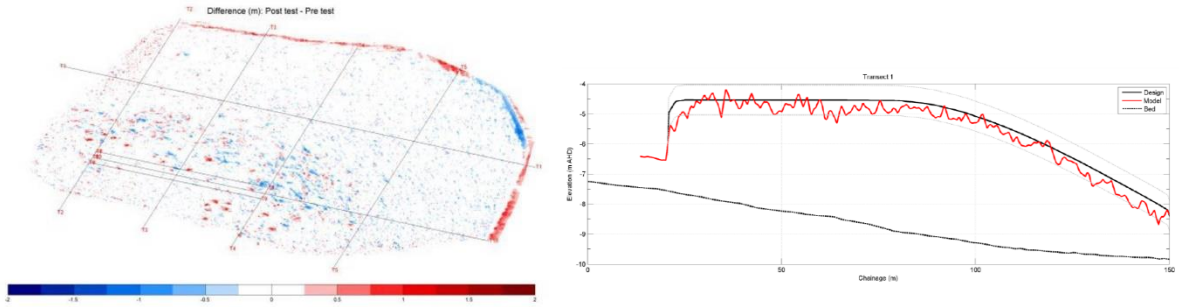
Bluecoast and Rhelm would consider the submissions, community feedback and agency comments received and compile the submissions into a report (or spreadsheet) and would gather responses from the project team and Council. If individual responses need to be sent to the community, these will be drafted with input from Bluecoast and provided to Council for review.

We have allowed for an update to the Draft Report to describe the public exhibition activities and summarise the key issues raised. Responses to key themes will be provided, whereever relevant.

3.6 Phase 5 – Physical modelling requirement

Task 7 – Physical modelling requirement

Bluecoast has extensive experience in the use of physical models to confirm design parameters and undertaking coastal processes assessments. Our engineers have previously developed physical modelling methodologies, test programs and undertaken detailed measurements, analysis and interpretation of the measured parameters. We have an in-depth understanding of the advantages and limitations that come with physical model tests. Most recently, we have undertaken a multiple-lines of evidence approach in the design of the Palm Beach submerged control structure using coastal monitoring, numerical models and physical models. In addition, we have an excellent professional relationship with two physical modelling laboratories in Australia suitable for the JSPW upgrade design, i.e. Water Research Laboratory in Manly, NSW and the Queensland Government Hydraulics Laboratory in Deagon, QLD. However, being an independent engineering consultant firm, we are in a position to liberally advice Council whether this additional investigation will be required.



Example of damage assessment in physical modelling undertaken at QGHL for the Palm Beach Shoreline Project.

We have designed our approach to develop the detailed concept design options for the JSPW upgrade to reduce the need for physical modelling. Our multiple-lines of evidence approach significantly reduces uncertainties in design parameters and structure performance. Furthermore, we will identify any similarities of the developed concept designs and design criteria with previous physical modelling undertaken in Australia. Where appropriate, we will present findings and lessons learnt from these investigations to Council. In principal, we recommend undertaking a small number of physical modelling tests to confirm the adopted stability criteria and overtopping performance. Nevertheless, following the completion of the investigations outlined in our proposal Bluecoast will be in a position to advice Council in how much value the physical modelling will add to the study.

Our design team will provide a clear case (in writing) to Council justifying our recommendation, approach and constraints and opportunities (e.g. reduction in rock sizing or structure height/ footprint), and whether to go ahead with physical modelling or not.

4 CAPABILITIES AND EXPERIENCE

4.1 Statement of capability

Bluecoast specialise in coastal engineering, including coastal monitoring, numerical modelling and engineering design. We are a newly established firm, bringing together a team of industry-leading experts with a wealth of expertise in coastal management and climate change resilience. We have a passion for solving complex coastal problems from idea to implementation.

The digital era is rapidly altering the coastal engineering industry. We are proud to be a business empowered by the latest technology and research. We apply this knowledge and technology to provide innovative and adaptive solutions customised for each client's specific needs.

4.2 Project team

Our team is composed of a well-balanced mix of highly skilled professionals with extensive experience in assessing coastal hazards, associated climate change impacts, design of coastal protection schemes and engagement of all relevant stakeholders. Our project management team will provide efficient, quality and open communication directly to the Byron Shire Council. Our team structure and key staff members are presented below. Full CVs for key personnel are provided in **Appendix A**.

NAME / ROLE	EXPERTISE
RICHARD MOCKE Project Director / Technical Review 	Richard is a Chartered Civil Engineer with a Master's degree in Coastal/Maritime Engineering and over 25 years of experience in a range of civil engineering development and infrastructure projects across five continents, undertaking numerous technical design and design/construction management, project and contract management roles and overseeing a range of projects from concept development, managing on-site investigations, detailed design and through to final site construction and implementation. Richard is a leading expert in port engineering and planning. He has acted as project director, project manager or lead engineer on numerous port development projects. Many of these projects involved multi-disciplinary teams. Richard's core expertise includes marine/shipping facilities, channel design, dredging, breakwater design and SHIP navigation studies. Many of the projects Richard has worked on have included the removal, treatment, transportation and placement on-land and at sea of large quantities of excavated and dredged material. Richard has published over 20 peer reviewed papers, many of them covering design of shipping channels, port design and breakwaters, including mass armoured breakwaters like the Port of Mackay structures. He has personally scoped and managed over nine major projects involving channel design and ship simulation. Richard will act as Project Director and Technical Reviewer for this study.

NAME / ROLE	EXPERTISE
EVAN WATTERSON Project Manager / Principal Coastal Engineer *Time committed to project: 40%* 	Evan is a Principal Coastal Engineer and Director of Bluecoast Engineering Consultants. He has over 15 years of experience in coastal engineering investigations and design. He previously worked within specialised coastal and marine teams at Royal HaskoningDHV, SMEC, WorleyParsons and Cardno Lawson Treloar. He graduated from University of New South Wales with a first-class honours degree in Environmental Engineering in 2005. Evan also has a Science degree majoring in Physical Oceanography. Evan specialises in the investigations and design of complex coastal projects. Having worked on a range of projects in the consulting industry Evan has developed a sound understanding of dynamic coastal environments and has an extensive skill set. Evan has demonstrated leadership and acted as a project director, project manager and/or technical lead on projects involving monitoring, coastal engineering design, numerical modelling, physical modelling and community engagement. For example, Evan is currently completing his role as senior project engineer and project manager for the design team on the Palm Beach Shoreline Project. The first phase of this project, beach nourishment, was implemented in 2017 and the second phase, an artificial rock reef, is currently being constructed. The design investigations for this project involved a multiple lines of evidence approach. Phases included field data collection, design development and material selection, extensive physical and numerical modelling, a quantified conceptual sand movement model, constructability assessment, detailed design and documentation, an early tenderer involvement (ETI) tendering process and finally certification services for the construction of the reef. For this project, Evan would act as Project Manager and Principal Coastal Engineer with a role to ensure deliverables meet Councils expectations. Evan will be involved in much of the technical aspects of the work along with the other technical experts.
JAMES LEWIS Coastal Engineer *Time committed to project: 30%* 	James is a Coastal/Metocean Engineer with ten years of experience in coastal, and metocean engineering. James has an in-depth knowledge of metocean deployment, data analysis and numerical modelling of coastal and estuarine environments. James has worked on major coastal infrastructure projects such as the Seaway SmartRelease, Palm Beach Protection Strategy and the Hastings Container Port Project. James has been responsible for all facets of the feasibility, scoping and concept design of Albany Artificial Surfing Reef Project, a surfing specific submerged structure from leading extensive field monitoring and data collection campaigns, state-of-the-art numerical modelling and data analysis as well as project management and extensive stakeholder consultation. James was technical lead on the City of Gold Coast's Surf Management Plan and more recently has undertaken a surf quality and amenity

NAME / ROLE	EXPERTISE
	assessment of Duranbah Beach as it relates to the Tweed Sand Bypass Project for NSW Crown Lands.
HEIKO LDEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENTR Coastal Engineer *Time committed to project: 50%* 	Heiko is a coastal engineer specialising in metocean studies, coastal processes and coastal risk assessments. He previously worked within specialised coastal and marine teams at Royal HaskoningDHV, MetOcean Solutions (NZ) and the University of Southampton (UK). Having worked on a range of innovative coastal industry projects, Heiko has developed a hollistic understanding of dynamic coastal environments and has an extensive skill set ranging from problem definition to engineering design. He is also an expert in modelling of hydrodynamic, wave and sediment transport processes ranging from ocean scale to CFD modelling tools using numerous licensed and open source software. He has completed several numerical modelling courses including SWASH/XBEACH, Delft3D FM, MIKE 21, WaveWatch III and TELEMAC. Heiko was a key member of the design team for the Palm Beach Shoreline Project since commencement of the concept design phase (2015). He undertook detailed coastal processes assessments, engineering design tasks as well as developing the physical model approach and program as well as supervision during testing at QGHL. Heiko has also led a wide range of coastal hazard (including a recent review of the Lake Cakora Hazard study, Clarence Valley), numerical modelling and data collection projects. He has developed numerous innovative tools for coastal and metocean studies including probabilistic hazard models, tropical cyclone risk models and user-interactive predictive tools as well as 2D/3D GIS products for asset management and decision support.
SIKKO KROLL Maritime Construction *Time committed to project: 10%* 	Sikko is an industry professional having worked on a range of large scale maritime infrastructural projects around the world. He has extensive experience in the management of dredging and dredging related projects, and has worked with specialised equipment under the most extreme conditions all over the world. Since completion of his Civil Engineering degree in The Netherlands in 1992, he has managed a variety of marine projects all over the world. In his extensive international dredging career, he has been climbing the ranks from trainee superintendent to Project Manager on many differing projects ranging in value from less than $1M to more than $100M. Sikko' operational experience ranges from shore protection works to tunnel immersion operations; from general dredging operations to specialist underwater protection and foundation works. Besides his extensive hands-on project experience, Sikko has been crucial in the overall management and development of individual business units and the training and coaching of project managers and their teams. Sikko has been instrumental in the development of the operations

NAME / ROLE	EXPERTISE
	manual for Maritime Constructions. He has successfully managed the newly created company MC Dredging & Port Development and has created new business opportunities, both nationally as well as on the international markets. In April 2014, he started his own consultancy business “Dredge Advice”, providing assistance for dredging and related marine construction projects with respect to tendering, contract- and project management and general business development. A comprehensive overview of Sikko’s career is attached.
CHLOE WARREN **Communications** *Time committed to project: 10%* 	Chloe is a science, technology and medical communications expert. Chloe will assist the team in communicating scientific and engineering aspects of the project to the wider community and stakeholders. A summarised version of her CV is provided below. JOURNALISM - Works commissioned/ published by: ABC, The Guardian, Huffington Post, The Conversation, SBS, Junkee, Royal Society of Biology, Lateral Magazine, Positive News (UK), Ensia (US). COPY-WRITING - Clients include: Nature Publishing, CSIRO, Australian Institute of Tropical Health and Medicine, STEM Matters, Engage Media (Bite Magazine, Vet Practise), BRITA, Hunter Medical Research Institute. EDUCATION - Editing of professional development resources for early childhood educators (Little Scientists) - Presentation of school-holiday science shows (Newcastle Museum, Museum Express) - Design and delivery of primary school biology program (The Junction Public School) - Provision of an interactive, educational and fun science party experience for children aged 5-10 years (Founder, Science with Chloe) - Editing of resources for after-schools science clubs (UON SMART program).
EMMA MARATEA Engagement Specialist / Environmental Engineer *Time committed to project 20%*	Emma is an experienced coastal and catchment engineer with 15 years’ experience undertaking related assessment. She is both experienced in the technical aspects of these studies as well as the relevant local and state government context, guidelines and best practice. Emma is also a qualified engagement practitioner specialising in the development and implementation of engagement strategies to support coastal and catchment management. As an environmental engineer and a consultation specialist, Emma brings her scientific and critical thinking to her approach to consultation, to create effective and meaningful engagement processes that ensure community views, and those of stakeholders, are captured and understood. Emma is able to craft communication collateral that simply and concisely explains technical information to support understanding and ensure community feedback into complex project is informed.

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NAME / ROLE	EXPERTISE
	Emma is accredited and experienced in delivering engagement strategies in accordance with the IAP2 framework. Emma would be responsible for preparing the engagement strategy and undertaking engagement activities during the scoping study.
RHYS THOMSON Environmental Economist / Hydraulic Engineer *Time committed to project: 5%* 	Rhys is a senior economist, who has worked across economics in both infrastructure, environment and in the flood specialist space. He is currently working with Office of Environment and Heritage in developing economic guidance in the assessment of floodplain management options. Beyond this, Rhys has strong experience in the external development and appraisal of business cases for local, state and federal government. In addition to this economic experience, Rhys is a leading specialist in the water resources sector. He is a leader in the industry and has published in numerous national and international conference. He has also authored various guideline documents, including key guideline documents for Department of Public Works and Highways in the Philippines and the Department of Roads in Indonesia. Working with standard cost benefit analysis and more qualitative methodologies (e.g. multi - criteria assessment, adjusted CBAs, preliminary economic appraisals) Rhys has aided client decision making through comparison of options and project economic and financial feasibility. Rhys Thomson will act as technical expert for the project providing input to the Preliminary Business Case.
PROFESSOR ANDREW SHORT OAM Marine Scientist / technical review *Time committed to project: 5%* 	Professor Andrew Short OAM Andrew Short is a surfer and marine scientist specializing in coastal processes and beach dynamics. He has degrees from the University of Sydney, University of Hawaii and Louisiana State University and has worked on the coasts of North and South America, including north Alaska and Hawaii, Europe, New Zealand and the entire Australian coast. He is presently Honorary Professor in the School of Geosciences at the University of Sydney; Adjunct Professor in the Griffith (University) Centre for Coastal Management; Senior Coastal Scientist (part-time) with CoastalCOMS.com; Deputy Chair of National Surfing Reserves (Australia); and on the Executive Committee of World Surfing Reserves. He also runs his own consultancy called Coastal Studies and serves on the NSW Coastal Expert Group and the Eurobodalla Coastal

NAME / ROLE	EXPERTISE
	Management Advisory Committee. He has written 12 books and over 200 scientific publications. He lives on 17 acres at Moruya Heads and more importantly he has recently switched to stand-up paddle boarding and enjoys the long rides at the Moruya River mouth and other usually empty breaks around the area. His extensive contribution to both coastal science and beach safety was recognised on Australia Day 2010 with an Order of Australia Medal. Andrew has investigated all 10,685 mainland beaches (including Tasmania) plus another 1500 on 30 major islands. This information is contained in a database and has been written up in eight books, one for each state and territory.
RICHARD REINEN-HAMILL Principal Coastal Engineer / technical review *Time committed to project: 10%*	Richard is Tonkin+Taylor's Sector Director – Natural Hazard Resilience which comprises 20% of T+T's annual revenue. He is also New Zealand's leading Coastal Engineer. He has more than 28 years' international experience in coastal processes, coastal hazard assessment, including climate change effects, coastal management, and designing coastal and marine structures. He has undertaken and assisted in coastal hazard assessments and provided coastal hazard advice on regional, district and individual lot scales for many territorial local authorities and regional councils. This has included supporting DELWP with the development of the Victorian Coastal Hazard Guideline and the setting up, management and review of four Local Coastal Hazard Assessments in Victoria, including Port Fairy. He has directed coastal activities for many large high-profile projects in New Zealand – including Orewa Beach Foreshore Enhancement, the restoration of Wellington's Oriental Bay and Auckland's Onehunga Foreshore – as well as internationally. He continues to provide innovative, cost effective solutions for our clients and is increasingly called upon as an expert witness, presenting evidence at more than 30 Environment Court hearings and having prepared more than 200 technical reports. He has also written some 20 technical papers.
TOM SHAND Principal Coastal Engineer / technical review *Time committed to project: 15%*	Senior Engineer Dr Tom Shand is one of Australasia's leading coastal engineers, he leads a specialist team of engineers and scientists that consult on and research complex natural hazard and coastal processes. Tom and his team's expertise is called upon to develop sustainable solutions for communities, public and private sites dealing with climate change, sea-level rise, erosion and seismic vulnerability. Tom also specialises in developing innovative design solutions for coastal protection works, often using numerical and physical modelling to confirm and optimise designs and test new design approaches and effects. Tom and his team have been involved with many of the major coastal structures and beach nourishment schemes that have been developed around New Zealand, Australia and across the South Pacific. Prior to returning to Tonkin + Taylor, Tom was employed as a project engineer at the Water Research Laboratory. Here he undertook assessments across NSW and Australia such as Assessment of the

NAME / ROLE	EXPERTISE
	NSW Extreme Coastal Wave Climate, the results of which are still used frequently today and Review of the Effects of Seawalls on NSW Beaches for Department of Planning, Industry and Environment including the Jonson Street seawall. Tom also undertook physical model investigations for coastal projects across NSW, Victoria and WA.
GRANT PEARCE Principal Coastal Engineer / technical review *Time committed to project: 5%*	Grant is a coastal and marine engineer with 30 years' experience in port and coastal engineering covering all aspects from feasibility studies to detailed design and construction supervision. Prior to joining Tonkin + Taylor in 1991 Grant was employed by Ports of Auckland Ltd. As a result, Grant has gained specialist expertise in many aspects of coastal and marine engineering including port planning, wharf design and condition assessment, reclamations, marina and breakwater design, coastal protection, sedimentation and erosion. He has extensive experience in wharf and marine structure design, coastal engineering, heavy duty pavements, reclamation and breakwater design, and coastal protection works.
DR KATIE SMYTHE Environmental Scientist / Ecology expert *Time committed to project: 10%*	Dr Katie Smythe is a Marine Environmental Scientist based in Newcastle, NSW. Katie has a PhD in Marine Ecology and an Honours Degree in Marine Biodiversity and Conservation. Katie has over 15 years' experience in the project management, design and implementation of marine environmental research projects, with over 11 years in the consulting field. Her experience covers a wide variety of environmental sampling and survey methods including marine habitat surveys, vegetation mapping, riparian / coastal vegetation assessments, marine and freshwater macroinvertebrate sampling, marine water and sediment quality monitoring, ecotoxicology, bioaccumulation and seafood contamination studies, freshwater fish ecology, electrofishing, community and stakeholder consultation, project management, data analysis, reporting and delivery. Katie specialises in small coastal infrastructure project marine environmental assessments and also the design, implementation and project management of large multidisciplinary marine environmental monitoring projects. The majority of her consulting work has been undertaken to determine the potential environmental impacts of various

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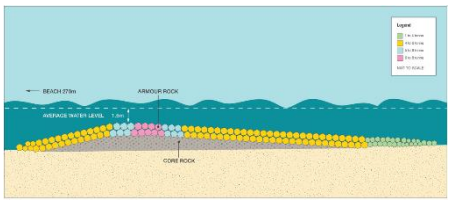
NAME / ROLE	EXPERTISE
	maritime and coastal infrastructure on marine and foreshore environments for licencing, planning and approvals purposes.
CAMERON BEARD Quantity surveying *Time committed to project: 10%* 	Areas of Expertise: Pre-construction tasks including preliminary and detailed elemental estimates, Builders & Traditional Bills of Quantities and funders pre-commencement risk assessment and reporting. Construction stage activities including progress claim reporting and variation assessment for funders and developers. Post-construction activities including tax depreciation schedules, sinking funds and building replacement costs.
SARAH ALDRIDGE Architect / Master-planning *Time committed to project: 10%* 	Since founding Space Studio in 2008, Sarah has worked within the Byron community to design and deliver buildings of a high quality that are very much 'of their place'. Her extensive design and project management experience gained from working across a broad range of project types in Europe and Japan has provided her with a high level of expertise in client liaison and an understanding of complex projects and the importance of community consultation. As Associate Professor of Architecture at Bond University Sarah has taught climate appropriate design, professional practice and design studio. Sarah's pro-bono work includes her roles as founding member of the Design Advisory Panel, providing pro-bono design advice to Northern Rivers communities, Chair of the NSW Country Division 2012-2016, representing all Australian Institute of Architects members across regional NSW.
JASON TRISLEY Architect / Master-planning *Time committed to project: 10%*	Jason has over twenty years' experience working on complex projects in Australia, Europe and Japan, ranging from single private and public buildings to multi-million dollar urban regeneration masterplanning projects. Jason is able to engage with every level of these projects and is equally comfortable with the small details and end-user requirements as with the overall strategic planning. Born and bred on the NSW north coast, Jason combines this global urban experience with his innate

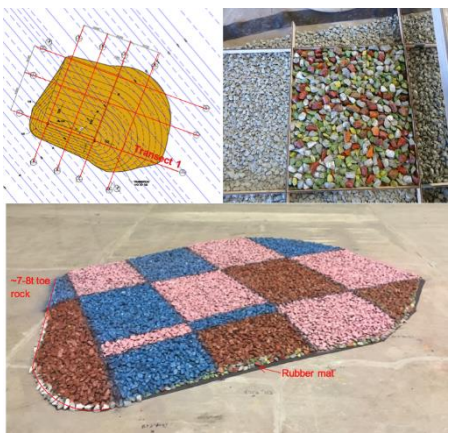
NAME / ROLE	EXPERTISE
	understanding of regional NSW communities on his projects at Space Studio. Jason's pro-bono work includes being a founding member of the Design Advisory Panel (Northern Rivers) and being an active member of the NSW Country Division of the Australian Institute of Architects, including being awards Jury Chair, creative director of the Byron seminar 'The Subtropical Project' and co-creative director of the conference 'From Soup to Nuts'.

4.3 Relevant experience

A selection of recent projects delivered by Bluecoast team members relevant to this study are provided below[1]. Additional projects are found on staff CVs or can be provided on request.

Palm Beach Shoreline Project
Contract Period: 2014 - ongoing
Client: City of Gold Coast





Bluecoast engineers form part of the design team for the delivery of the Palm Beach Shoreline Project Design Reference Report. This project encompasses the investigations and design of a submerged control structure (i.e. a nearshore artificial reef) and beach nourishment planned to enhance the Palm Beach foreshore. The submerged control structure is an innovative approach to increasing the longevity of beach nourishment and has a second objective of providing recreational amenity (particularly surfing).

The study included comprehensive numerical shoreline modelling, geophysical and geotechnical field investigations, metocean data collection, physical model testing undertaken at the Queensland Government Hydraulic Laboratory (QGHL) as well as at the Water Research Laboratory (WRL), coastal engineering design and constructability assessment via formal early contractor engagement.

Our principal engineer Evan is acting in the ongoing role as the project manager for the engineering team working closely with the City, engineering consultants, the contractor and City stakeholders during the construction phase of this project.

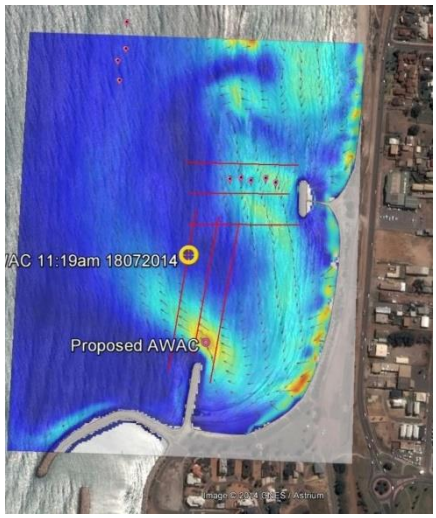
Project parallels:

- Numerical shoreline modelling
- Geophysical and geotechnical field investigations

[1] Some of these projects were delivered while at places of previous employment.

- Metocean data collection
- Coastal engineering design
- Surf amenity assessment
- Physical modelling (integrity + coastal processes)
- Basis of design
- Construction support

Beresford Foreshore Coastal Protection Enhancement Project
Contract Period: 2014 - 2016
Client: City of Greater Geraldton



Following severe coastal erosion and the threat of coastal infrastructure being damaged, Bluecoast engineers undertook an investigation to determine the cause of the coastal erosion and to determine measures for stabilising this section of coast.

The project involved the understanding of complex foreshore processes to allow long term coastal protection measures to be developed. The study included metocean data collection, detailed wave transformation modelling, sediment transport modelling, optimisation of design options, concept design, costings and detailed design. The project was recently successfully constructed.

An optimal design was found that intercepted the nearshore wave driven current, removing the mechanism for erosion in the beach compartment. The solution that was delivered allows for coastal stabilisation to be achieved whilst also providing a user-friendly recreational beach and foreshore area.

Members of the Bluecoast team were responsible for the coastal process's assessment and concept design development.

Project parallels:

- Detailed site observations
- Beach profile analysis
- Collection and analysis of detailed bathymetry
- Conceptual coastal processes model
- SWASH detailed wave transformation and hydrodynamic modelling
- Metocean data collection (waves, currents, water level)
- Multi-criteria analysis/ options testing
- Detailed design of large-scale coastal scheme including rock revetment, groynes and beach nourishment
- Construction methodology

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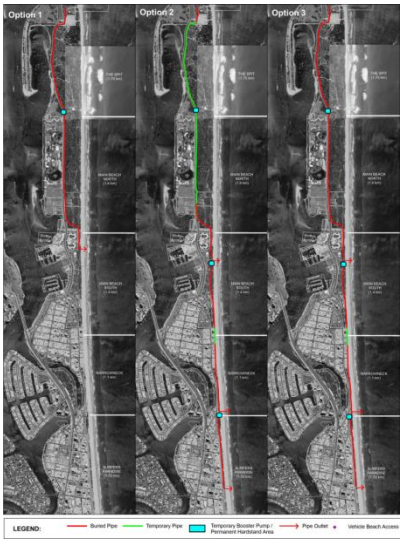
Surfers Paradise Sand Backpassing Project
Contract Period: 2015
Client: City of Gold Coast



Bluecoast engineers investigated options for the efficient transfer of sand from the Gold Coast Seaway Sand Bypassing System (GCSSBS) to the receding Northern Gold Coast Beaches. The investigation included:

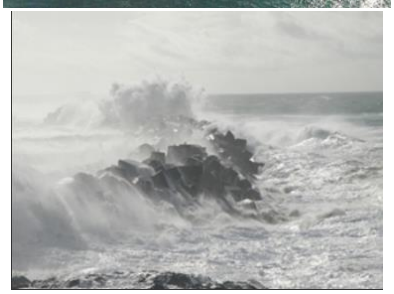
- Coastal processes understanding and development of a sand placement strategy.
- Backpassing system engineering concept design, option assessment and forward planning report.

Our engineers were responsible for the delivery of this project during previous employment including the coastal processes assessment, concept design development, MCA and CBA.

Project parallels:

- Comprehensive stakeholder engagement (GCCC, GCCM and GCWA etc.);
- Pipe and booster pump requirements;
- Pipeline alignment and discharge infrastructure;
- Operational procedures and practices;
- Design risk assessment;
- Approvals requirements;
- Cost estimations; and
- Project cost benefit analysis.

Coffs Harbour Eastern Breakwater Remediation Works
Contract Period: 2002
Value of Engagement:
Client: New South Wales Department of Primary Industries

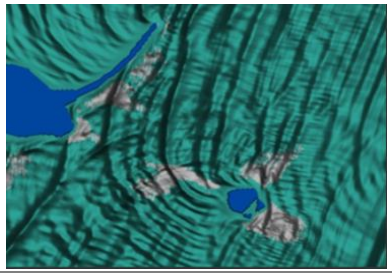


The Coffs Harbour Eastern Breakwater project involved the provision of remediation design for 100+ year old structure using concrete Hanbar armour units for the Department of Primary Industries - Lands. The Coffs Harbour Eastern breakwater is one of the most exposed breakwaters on NSW coast. This project involved:

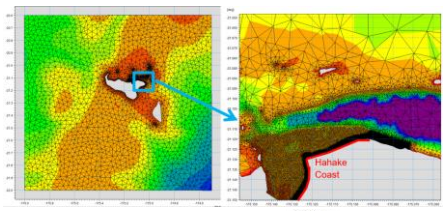
- Condition assessment (including geotechnical stability);
- Detailed numerical modelling of wave dynamics and armour stability;
- Physical model testing of design in association with WRL.
- Construction and cost optimisation.
- Detailed design and documentation for the works.

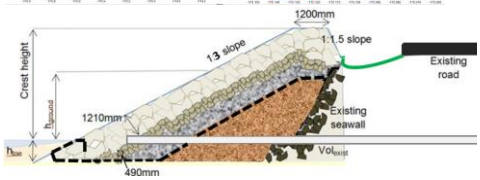
Detailed wave modelling was conducted using the BOUSS-2D model. This included East Coast Lows which produce waves in the order of 8 metres at the structure's toe. Modelling included detailed analysis of the potential for breaking waves, for wave

overtopping and wave reflections. Capital and maintenance costs were rationalised with the associated risk profile to present remedial works that were within the allocated project budget and still met projects objectives.



Hahake coastal protection
Contract Period: 2016-2017
Value of Engagement:
Client: Ministry of Infrastructure, Kingdom of Tonga





Bluecoast undertook the scoping, prioritisation, detailed design, procurement and construction of coastal defences along the Hahake (East) coast of Tongatapu, the largest and most populated island of the Kingdom of Tonga as part of the Asian Development Bank (ADB)-funded Climate Resilience Sector Project.

Extensive stakeholder engagement was undertaken with local communities, the government as well as the ADB and local contractors to determine the most appropriate method of coastal protection measures. Numerical modelling was undertaken to quantify design parameters to determine the most suitable method of coastal protection for at-risk sections of the coastline.

A locally sourced rubble mound seawall was designed to protect the most critical section of a coastal road used to access important emergency inner-island evacuation routes. Local contractors were engaged and trained in the sourcing of rock and build of a modern seawall. Bluecoast assisted in the tender selection process, contract administration and site supervision throughout the construction phase.

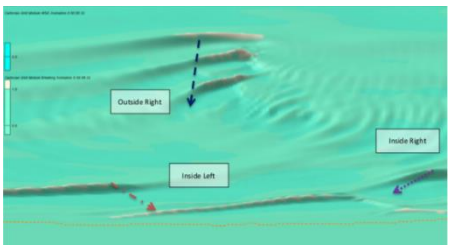
Cooktown Wave Modelling and Coastal Engineering Design Review
Contract Period: 2017
Client: Cook Shire Council

Bluecoast team members were part of a team that completed the design, specialist supervisory input and certification for the repair to the rock revetment at Webber Esplanade, Cooktown. The project culminates over a decade of design development, construction and certification issues, and has led the imminent approval of the works by EHP.

Bluecoast team members were involved in the review of a remedial coastal engineering design assessment, coastal wave penetration modelling and development of a detailed remedial

design.

Albany Artificial Surf Reef (WA)
Contract Period: 2015 - ongoing
Client: City of Albany



In order to assess the feasibility of constructing an artificial surf reef at Middleton Beach, the following works were undertaken by members of the Bluecoast team: stakeholder engagement; options assessment (including metocean investigation, numerical modelling, development of key design criteria, define approvals process); presentation of options and stakeholder workshop; engineering design (including refinement of design quantities and costs, constructability and materials availability, outline approvals requirements).

Bluecoast is providing ongoing support to the City guiding their project managers through funding application and approvals process.

Project Parallels:

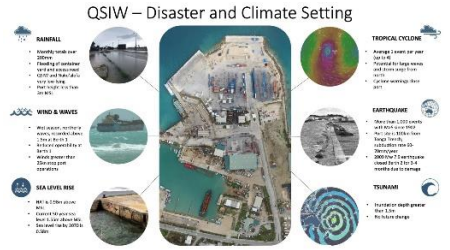
- Metocean investigations
- Detailed numerical modelling
- Coastal assessment
- Beach and surf amenity assessment
- Extensive stakeholder engagement lead by Bluecoast team
- Concept engineering from material justification (rock) to design drawings
- Construction methodology

Tanilba Bay Foreshore Protection
Contract Period: c.2010
Client: Port Stephens Council

Bluecoast personnel in previous employment provided engineering services associated with the design of foreshore protection works for Tanilba Bay for Port Stephens Council. The scope of works included site investigations, coastal processes assessment and conceptual model, geotechnical assessment, ASS management plan, digital wave modelling, consultation with community and major stakeholders, concept design, detailed design and documentation and construction inspections.

Tonga Climate Change Adaptation Project
Contract Period: 2017
Client: Ministry of Infrastructure, Kingdom of Tonga

Asian Development Bank funded project to future proof low lying areas with significant infrastructure in the South Pacific Island of Tonga. Members of the Bluecoast team were involved in the entire project implementation from coastal hazard definition, prioritisation of risk areas, development of coastal adaptation options through to construction support of the preferred option.



Project parallels:

- Climate change adaptation
- Coastal processes understanding
- Concept design of terminal seawall protection
- Detailed design of terminal seawall protection

Bluecoast were engaged to undertake a Disaster Risk Assessment (DRA) as well as a Climate Risk and Vulnerability Assessment (CRVA) for the project. These assessments aimed at providing a basis for integrating disaster risk into the design and implementation of the port upgrade project. They form part of the first phase of the feasibility study.

Bluecoast undertook metocean monitoring as well as topographic and bathymetric surveys to inform local metocean climate assessments. The data was also used to validate hindcast wave and current numerical models and assisted to calibrate a cyclone model. The work also involved stakeholder engagement with both government dignitaries as well as local port workers in order to inform the basis of the assessments.

Project parallels:

- Coastal processes assessment and data collection
- Detailed numerical modelling
- Stakeholder engagement
- Climate change resilience

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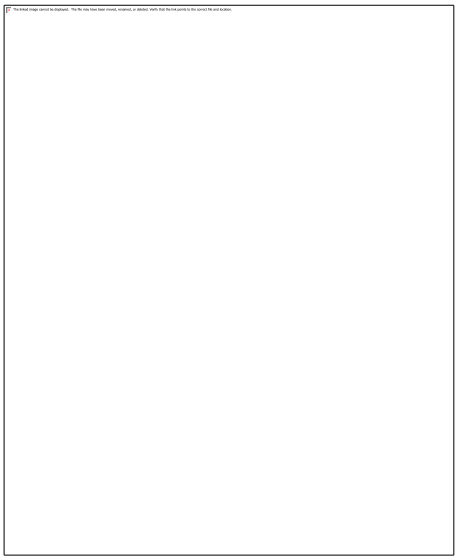
Cocos (Keeling) Islands Coastal Vulnerability Assessment
Contract Period: 2018 - 2019
Client: Western Australia Department of Planning, Lands and Heritage



The Department on behalf of Commonwealth Government of Australia engaged the Bluecoast team to undertake a Coastal Vulnerability Assessment (CVA) for the Cocos (Keeling) Island.

Bluecoast engineers are currently undertaking the following five key stages of the project:

1. Collate, analyse, and summaries relevant historic metocean data, survey data, and any other previous studies and data critical for appropriate model validation and effective data analysis.
2. A data collection program at CKI that gathers and analyses metocean and survey data.
3. Build a digital map-based coastal asset data base from existing GIS information as well as site inspections.
4. Identify, assess, and model relevant coastal processes and hazards at CKI using the outcomes of (1) and (2) for ambient conditions and over various scenarios.
5. Identify, assess, and map areas subject to inundation and/or erosion by coastal processes described in (3) over various scenarios (detailed in Schedule 2).
6. Identify, assess, and map the exposure, sensitivity, and adaptive capacity of key built, natural and community assets to coastal hazards using the outcomes of (3) and (4).

Stakeholder and community engagement was undertaken by our engineers to inform the assessment and confirm our approach including a review of current coastal management practices by Council. At present, the Bluecoast team is finalising the data collection campaign and building the numerical modelling tools for the CVA prior to mapping coastal hazards and asset (natural and built) vulnerability providing the basis for the development of adaptation options.

Project parallels:

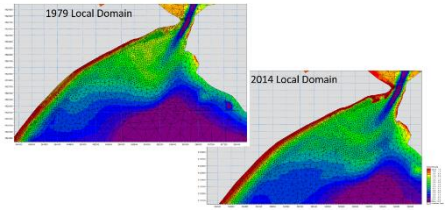
- Coastal processes assessment and data collection
- Detailed numerical modelling
- Review of existing coastal protection structures
- Stakeholder engagement

This Scope of Work for the JSPW Modification Project has been amended from the original Bluecoast proposal P194010 submitted on 17 May 2019 to accurately detail the scope of work for public distribution.

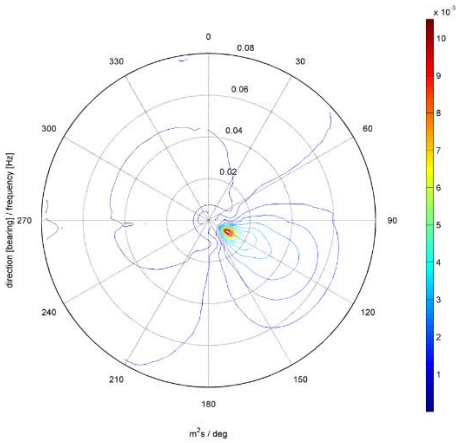
Emu Point and Middleton Beach CHRMAP
Contract Period: 2016 - 2019
Client: Western Australia Department of Planning, Lands and Heritage

This study included detailed coastal processes assessment including numerical modelling, a coastal vulnerability assessment and adaptation options assessment. The key tasks included:

- Review of a coastal monitoring data (bathymetric surveys, wave data, etc.) and previous coastal hazard studies.
- Numerical modelling of wave, hydrodynamic and sediment transport.
- Coastal hazard definition and mapping.
- Risk assessment and vulnerability assessment for coastal assets.
- Development of adaptation options.



In collaboration with local government, this coastal risk assessment led to a greater understanding of the coastal processes in the study area, the identification and definition of coastal hazard and hazard mapping as well as the completion of a detailed risk assessment for all coastal assets and the identification and evaluation of adaptation options.



Project parallels:

- Coastal processes assessment
- Detailed numerical modelling
- Stakeholder engagement
- Concept design and option assessment

Lake Cakora Entrance Coastal Hazard Review
Contract Period: 2018 - 2019
Client: Clarence Valley Council, NSW

The Bluecoast team undertook a review of the 2016 coastal hazard assessment for the coastline of Brooms Head and Lake Cakora ICOLL in NSW. The review involved undertaking a geotechnical and geophysical analysis and estimation of historic beach recession rates, sea level rise induced recession and short-term storm demand from photogrammetry data and subsequent mapping. Members of the Bluecoast team were also involved in the original development of the CZMP for this area including the hazard definition, estuary processes study, coastal management study as well as drafting of the CZMP in 2014.

Following the thorough review of existing information and filling of data gaps as well as direct liaison with the Office of Environment and Council this study was recently successfully completed by members of the Bluecoast team. We have received very positive feedback on all aspects of the project.

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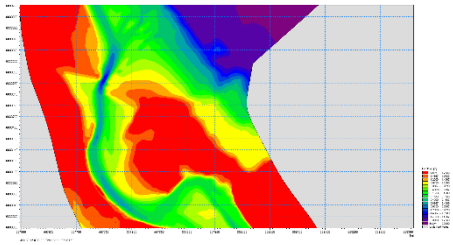
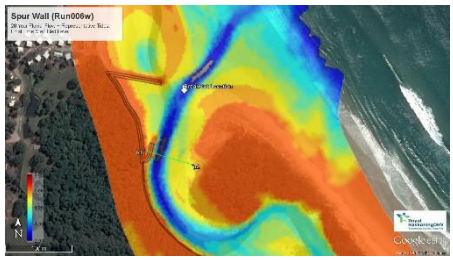
Project parallels:

- Coastal processes assessment
- Northern NSW location
- Working with Department of Planning, Industry and Environment and local council

Belongil Estuary Protection Works Investigations
Contract Period: 2015
Client: North Byron Beach Resort





The Bluecoast team has extensive experience working along the NSW far north coast as well as throughout south-east QLD and is familiar with the coastal processes and geomorphology of the Byron embayment. Bluecoast team members were part of a team that investigated the proposed protection works to protect North Byron Beach Resort (NBBR) against further loss of land due to coastal processes and channel scour at the Belongil Creek entrance in Byron Bay. Bluecoast team members undertook detailed numerical modelling of the existing channel and proposed protection works, in order to:

- Provide technical information required for the design of the protection works;
- Assess the likely effectiveness and impacts of the proposed protection works

The study showed that the protection works were able to protect NBBR lands against scour during short-term fluvial and ocean storm events and do not appear to increase erosion on adjacent lands.

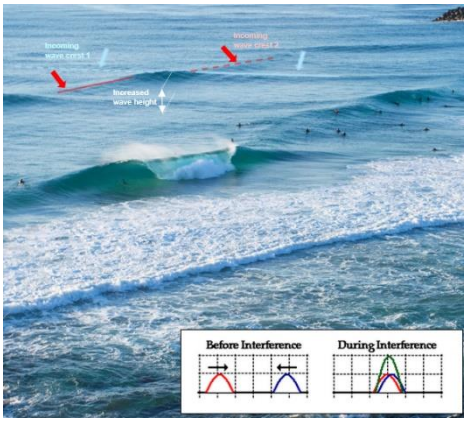
Project parallels:

- Metocean investigations
- Coastal processes assessment
- Detailed numerical modelling
- Byron embayment location
- Working with Department of Planning, Industry and Environment and local council

Duranbah Beach Surf Quality Investigation
Contract Period: 2018
Client: NSW Dept of Primary Industry (Lands)

Bluecoast was engaged to complete a technical investigation into surf amenity at Duranbah Beach as part of a DoI contract. Utilising available data including historic bathymetry, dredge and pump rates from the TSB and incorporating coastal monitoring imagery and videos as well as collected surf amenity information, the study objectives were met through six key tasks:

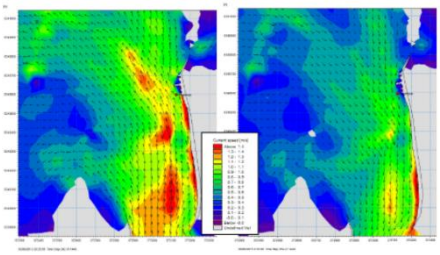
- Report the key coastal processes that impact surf quality and beach management issues at Duranbah Beach.
- Quantify and record the historical and current patterns of sand bank formation in both the nearshore and offshore zones that create the highest quality surf amenity at Duranbah Beach.
- Evaluate the impact of the Tweed River entrance bar and how this influences surf quality.
- Explore how previous sand placement strategies (pumping and dredging strategies) at Duranbah Beach associated with TSB operations have historically impacted surf quality at Duranbah Beach.
- Identify and map an idealised nearshore profile which seeks to maximise surfing amenity and can be used to provide a baseline against which changes in bathymetry due to sand delivery can be compared.
- Propose how sand placement strategies at Duranbah Beach could be managed with the aim of optimising surf quality.

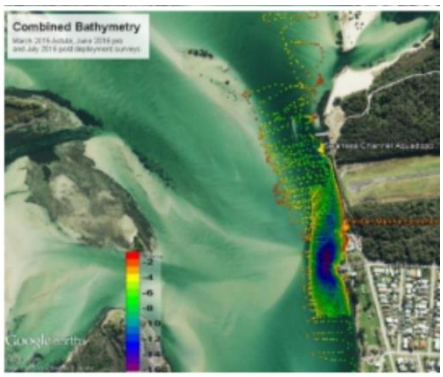


Project parallels:

- Beach and surf amenity assessment
- Coastal processes assessment
- Far north NSW location
- Working with Department of Planning, Industry and Environment and local council

Pelican Marina Foreshore Stabilisation
Contract Period: 2016
Client: NSW Dept of Primary Industry (Lands)





Bluecoast engineers were part of a team engaged by DPI-Lands to undertake investigations aimed at informing a holistic plan for the future management of a vulnerable area of the Swansea Channel. The work followed demolition works at the ex-Pelican Marina site, which had failed due to the migration of the Swansea Channel. This work included the temporary stabilisation of the foreshore in that area. Outcomes from the study informed the development of concept design options aimed at addressing the erosion problems along the Pelican foreshore.

The work included ongoing metoecan monitoring of waves, water levels and currents as well as bathymetric survey to inform the development of detailed hydrodynamic and sediment transport numerical models. The models were used to assess various design options.

- Metocean investigations
- Coastal processes assessment

This Scope of Work for the JSPW Modification Project has been amended from the original Bluecoast proposal P194010 submitted on 17 May 2019 to accurately detail the scope of work for public distribution.

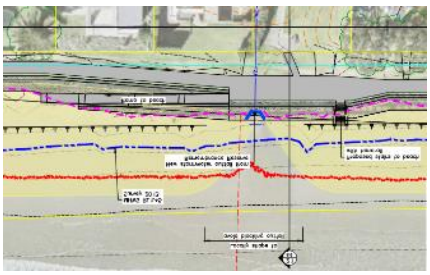
- Detailed numerical modelling
- Working with Department of Planning, Industry and Environment and local council

Further relevant projects that were completed by the Bluecoast team include:

- St Georges Foreshore Coastal Protection and Enhancement Project (WA)
- Whiting Beach Erosion Processes Study (NSW)
- Old Bar Coastal Hazard Study
- Blueys and Boomerang Beach Coastal Hazard Study
- Tweed Sand Transfer Information System coastal processes studies.

Relevant experience of our key sub-consultants is provided below

Orewa Beach Seawall Design and Consenting
Contract Period: 2018-2019
Client: Auckland Council
Sub-consultant: Tonkin + Taylor



Orewa Beach has had a long history of storm induced erosion and human development and modification that has impacted the beach and reduces access and amenity. Council developed a long term strategy to reduce erosion to prevent loss of access along the reserve and to improve access to the beach. Tonkin + Taylor were engaged as the lead consultant to develop a coastal protection solution that improves safe access from an esplanade reserve to the beach that combines all mobility access (stairs and ramp) with a robust seawall to provide 50+ years of service on one of Auckland City's most significant beaches. This included strong liaison and collaboration with a wide range of experts from landscape, urban design, recreational access and ecologists to develop the preferred solution.

Project Parallels

- Developed design that integrates erosion protection with public access and amenity on a high profile beach.
- Strong collaboration with client and experts from landscape, urban design, recreation, arborist and ecologists

Onehunga Foreshore Reserve (Taumanu)
Contract Period: 2016-2019
Client: Auckland Council
Sub-consultant: Tonkin + Taylor

Tonkin + Taylor led the development and design of this multi award winning project which comprised the restoration and reclamation of the Onehunga foreshore to create the Taumanu

Reserve - a 6.8 ha recreational park formed on reclaimed land in the Manukau Harbour, Auckland, New Zealand.
The reserve's central features include:

- 1.4 km of restored coastline
- Three new sandy beaches
- Six gravel/shell beaches
- A pedestrian and cycle bridge over a state highway to connect Onehunga Bay Reserve to the foreshore
- A series of rocky headlands
- A new boat ramp
- A pedestrian and cycle path
- Park amenities - including a toilet, park furniture and the upgrade of Orpheus Drive carpark.

As lead consultants for the project, T+T's objectives were to:

- Restore the environmental character of Onehunga Bay and to enhance the integrity and function of its landscapes, coastal processes, habitats and intrinsic biodiversity values
- Restore and enhance the public access to the coastal edge and coastal waters and to provide a wide range of new recreational opportunities for the whole community
- Acknowledge the cultural connections and heritage values of tangata whenua (the indigenous people of New Zealand)
- Restore the connectivity of the site to the Onehunga community and enhance the important public access corridors and connections.

These objectives were selected to maximise environmental improvements delivered by the restoration and manifested in all aspects of the project's delivery.

Project Parallels

- maximise environmental improvements
- restoration

Byron Bay Erosion Protection Works - Marine Ecology & Habitat Assessment
Contract Period: 2012
Client: Byron Shire Council
Sub-consultant: Ocean Environmental

In 2012 Katie (under the employment of WorleyParsons Pty Ltd) undertook a qualitative marine habitat survey (of intertidal and coastal habitat) and ecological impact assessment for the Jonson Street Protection Works and an area extending to the end of the then existing Belongil Beach Protection Works for Byron Shire Council. This work was undertaken to inform a risk assessment of these various erosion protection structures and to investigate potential re-design options for the Jonson Street works (these

works were also undertaken by WorleyParsons Pty Ltd). The study involved fieldwork to describe the intertidal marine and coastal habitats in the vicinity of the existing and proposed works.

The study aimed to identify:

- Direct impacts on ecological processes, habitats, communities and species (for example impacts on the intertidal zone such as modification and fragmentation of habitat)
- Indirect impacts on ecological processes, habitats, communities and species (for example end wall effects and subsequent increased erosion of vegetation in hind dune).

Byron Bay Town Centre Master Plan
Contract Period: 2014-2016
Client: Byron Shire Council
Sub-consultant: Space Studio

This masterplan was conceived as a flexible framework built up from community input, rather than the traditional 'top down' rigid masterplan. The project team, led by McGregor Coxall, identified six strategies that formed the basis for the framework: Access and movement, public domain, natural environment, culture, economic development, built form and aesthetics.

The team identified 12 precincts within the masterplan area for which short and long term priorities were presented, based on the place strategies developed during the process.
Space Studio were engaged to provide architectural and community engagement services. The project took 16 months to complete and was adopted by Byron Shire Council in 2016.

RH Dougherty Award for Excellence in Communication, NSW Local Government Awards Communities award of excellence, Australian Institute of Landscape Architects