



Port of Warrnambool

Safer Boating and Harbour Facility

Study

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EXECUTIVE SUMMARY

Background

Water Technology, in association with Meinhardt, has been engaged by the Warrnambool City Council (WCC) to undertake an investigation of safer boating and harbour facilities in the Port of Warrnambool.

The establishment and maintenance of a working Port at Warrnambool has a long and problematic history due largely to the highly energetic wave climate and large sediment transport processes affecting the coast. The various extensions and modifications to the Port structures over the last approximately 150 years have had a profound impact on Lady Bay, with the shoreline prograding by over 300 metres and sedimentation dramatically reducing depths in the Port.

The major function of the Port of Warrnambool today is to provide safe havens and services to the commercial fishing industry, and recreational fishing and boating interests. The potential of the Port of Warrnambool is however currently limited principally by exposure to wave action that causes hazardous conditions at the boat ramp and forces vessels in the Port, including the Coast Guard and commercial fishing fleet to remain on swing moorings. Limited drafts due to ongoing sedimentation of the Port also currently limit the ability to launch and retrieve vessels from the boat ramp and for access to the landings on the breakwater.

The primary objective of the project is to identify options to provide safer boating and harbour facilities at the Port of Warrnambool, to maximise the significant tourism and commercial potential of the Harbour.

Wave Climate

The wave climate offshore of the Port of Warrnambool is highly energetic. In order to provide rigour and validation to the analysis of the wave climate in this study, a submersible wave recording instrument was deployed within the Port for a period of approximately 3 weeks. Significant wave heights in the Port were relatively small over the instrument deployment period at generally less than 0.2m.

Analysis of the frequency spectrum from the measurements in the Port however revealed that significant amounts of energy was present at frequencies beyond that which can be attributed to wind generated gravity waves (i.e. periods greater than ~20 seconds). These long waves have periods of between 40 to 130s. The primary source of the long waves measured in the Port is identified as likely to be associated with bounded long waves that propagate with shoaling wave groups past the end of the breakwater.

The evidence of significant long wave activity in the Port is particularly important as wave motions at these frequencies frequently produce surging motions on boat ramps and can cause problems for moored vessels in enclosed harbours. Mitigation of long wave activity from harbours is generally problematic and frequently cannot be practically eliminated.

The long term wave climate in the vicinity of the Port has been analysed using a numerical short wave model of the study area that has been validated to the wave measurements recovered from the instrument deployment in the Port. The wave model has been validated to the wave measurements recovered from the instrument deployment in the Port. The level of agreement between the modelled and observed wave conditions within the Port is considered to provide confidence that the wave model is capable of providing a valid tool for testing and refining options to improve the wave climate within the Port.

The validated wave model has been employed to hindcast the wave climate in the study area over a continuous 10 year period (2000 – 2010) to enable estimates of the annual exceedance probability (AEP) of extreme wave height and direction conditions to be estimated.

Coastal Processes

Lady Bay is part of the broader Warrnambool embayment excavated by an ancestral Merri River. The embayment has been progressively filled over the Quaternary by a series of shallow marine and dune formations. Overtime these formations were gradually lithified by the precipitation of the calcium carbonate to form calcarenite. These calcarenite formations now dominate the coastal morphology of Warrnambool and the erosion of these formations by wave action contributes the overwhelming majority of the beach sediments observed in Lady Bay.

The sediments of the Lady Bay beaches and that which is contributing to the siltation of the Port is calcareous sand. A unique feature of the sediments of Lady Bay is the marked change in grain size and colour of the beach sediment between the western and eastern extent of Lady Bay.

The variations in sediment characteristics within Lady Bay indicate that there are potentially different sediment sources within Lady Bay and/or the sediment is being sorted within Lady Bay.

A conceptual model of the main sources and pathways of the sediment transport in Lady Bay includes the following main components:

- The supply of sand around the southern edge of the existing breakwater is clearly visible in the bathymetric LiDAR survey of Lady Bay. This sand is spilling past the end of the breakwater and out onto the floor of Lady Bay.
- The sand transported past the edge of the breakwater is being drifted onshore by low diffracted swell waves. The sand drifting onshore onto Lady Bay beach is very fine grained. It is possible that the sediments are being winnowed by wave action such that only the finest material can be mobilised and transported onshore by the low swell wave energy generally observed in the western portion of Lady Bay.
- On the eastern section of Lady Bay, sediment supply from a different calcarenite formation is contributing light brown calcareous sediments to the shoreline. The greater exposure to wave energy is enabling coarser material to be mobilised on these beaches.
- A secondary sediment transport process associated with gradients in wave setup along Lady Bay is identified as causing an anti clockwise circulation within the western end of Lady Bay that is transporting fine grained sediment westward and into the Port.

Comparisons of recent repeat hydrographic surveys of the Port have been undertaken to quantify the observed volumes of sediment and pattern of accretion within the Port. The analysis of the volume differences between these surveys provided the following observations:

- There appears to be onshore drifting of sediment resulting in accretion of sediment on the seaward edge of the dredge pocket.
- Significant sediment accretion on the shoreward end of the dredge pocket within the Port was also observed. This sediment is considered to be transported by longshore transport mechanisms and being deposited in the lee of the breakwater in the form of a shore parallel bar. The total volume of sediment accreted in the offshore bar was approximately 2,500m³/yr.

The comparisons of the repeat bathymetric surveys presented above are considered to demonstrate that longshore drifting of sediment is causing a significant portion of the sedimentation in the Port.

A mechanism for the longshore drifting of sediment into the Port is identified by consideration of the gradient in the residual water levels generated by wave radiation stresses within Lady Bay. Within the surf zone of Lady Bay, radiation stresses at the shoreline result in an increase in water levels adjacent to the shoreline. Due to the presence of the main breakwater and sheltering of the western

section of Lady Bay from waves, the magnitude of the wave setup reduces towards the Port. The gradient in the wave setup along the shoreline of Lady Bay generates a westward longshore current towards the Port. Under prevailing, moderate south west swell wave conditions, the longshore current, in combination with wave action, transports fine sediments into the lee of the breakwater.

An estimate of the magnitude of the longshore sediment transport potential due to the combination of wave action and the longshore currents has been undertaken using the longshore sediment transport model. The total annual longshore transport potential is predicted as approximately 3,500m³/yr. The magnitude of this longshore transport is considered in good agreement with the rate of accretion within the Port due to longshore transport observed via the comparison of the repeat bathymetric surveys which was approximately 2,500m³/yr.

Stakeholder Consultation

In order to inform the consideration of options to provide safer boating and harbour facilities at the Port of Warrnambool, consultation with various stakeholders of the Port of Warrnambool was undertaken as part of this project. To facilitate the stakeholder consultation, the reference group were invited to participate in a questionnaire that was distributed during the course of the project.

The questionnaire was designed to assist in identifying the critical constraints on the use of the Port in the short term as well as identifying medium to long term opportunities for the Port as identified by the stakeholders.

The following summarises the main themes emanating from the responses received from the questionnaire:

- Improving wave conditions and reducing siltation and draft constraints in the Port were identified as highest priority for achieving Council's vision for the Port
- Providing additional lane capacity and alleviating draft constraints due to siltation were identified as highest priority for enabling full utilisation of the boat ramp.
- The majority of the respondents saw demand for at least 50 fixed berths at the Port of Warrnambool in the short term. Long waiting lists for berths at Port Fairy and the significant growth of Warrnambool and in recreational fishing in the region were cited as reasons why a minimum of 50 berths would be met by existing latent demand for fixed berths at Warrnambool.
- In the long term, the respondents see the potential for a wide variety of facilities and services to be provided as part of a significantly expanded Port of Warrnambool. Responses included suggestions for both marine and land based infrastructure, commercial facilities (although this was not universal), marine safety, access, environmental, and tourism opportunities.
- There was considered to be general sentiment amongst respondents that expansion of the Port of Warrnambool could be achieved through appropriate investment in planning, infrastructure, and management. Concerns for the future upgrade of the Port of Warrnambool included environmental impacts, traffic and amenity constraints.

Planning Provisions

The local planning scheme zones and overlays that are applicable to the Port of Warrnambool and surrounding study area have been reviewed. The Port and immediate foreshore area are not currently zoned. The foreshore (north of Breakwater Road) is zoned Public Park and Recreation Zone. Breakwater Road is zoned Road Zone – Category 2.

The following planning overlays are applicable to the Port of Warrnambool and immediate surrounds:

- The Heritage Overlay (HO19) has been applied to the Port of Warrnambool including the viaduct and breakwater road.

- Environmental Significance Overlay 1 (ESO 1) has been applied to the Port of Warrnambool and adjoining land along the Warrnambool coastline. The ESO identifies land of environmental value and seeks to protect these values from adverse impacts.
- The Significant Landscape Overlay 1 (SLO1) has been applied to part of the study area as part of a significant landscape and to conserve and enhance the character of the significant landscape.

Options Assessment

The options assessment for the Port has required consideration of formal engineering design guidelines, particularly related to wave condition criteria for boat ramps and small craft harbours, the consideration of the priorities and preferences identified by the reference group from the questionnaire responses and the relevant planning scheme controls and overlays. The options assessment also required consideration of the sediment transport processes in the study area to ensure that sedimentation of the Port could be managed and that the options did not adversely impact the shoreline of Lady Bay.

Two primary concepts have been assessed and developed for the Port. The two concepts are referred to as follows:

- Option 1 – Spur Breakwater
- Option 2 – Detached Breakwater

The principle component of both options is an additional breakwater structure. Option 1 is a spur breakwater attached to and orientated normal to the existing breakwater. Option 2 is a detached breakwater located within the lee of the existing breakwater..

Each option has been tested and refined in the wave model to determine the wave climate characteristics and sediment transport impacts of the option. Concept layouts and overview of the key design components, construction considerations and options and costs have also been developed for each option.

A dredge basin would be constructed to 3.3m LAT for both options. The total volume of capital dredging for both options, including the development of sediment traps, is in the order of 35,000m³. Appropriate disposal options for the dredge spoil are considered a significant constraint.

Both options include the construction of a shore normal groyne to the north of the Port. The groyne has been located to reduce the longshore transport component of the sedimentation in the Port

The spur breakwater option provides the opportunity to establish fixed berth capacity at the port with access via the existing breakwater. A preliminary layout has been developed that would provide capacity for approximately 50 fixed berths.

The detached breakwater option provides the opportunity to establish approximately 10 fixed berths with access via the existing breakwater. Capacity to safely moor approximately 26 additional vessels can be provided by establishing a piled mooring field in the lee of the breakwater. Access to these vessels would require a tender, launched from the main breakwater or shoreline.

To alleviate constraints on the use of the boat ramp and safety concerns raised by the stakeholder consultation, an upgraded boat ramp facility has been proposed for both options incorporating a third lane to ease congestion during peak periods. A separate queue and launch/retrieval lanes and wider turning radius are provided to improve the efficiency in which boats can be launched and retrieved from the ramp. Pedestrian access to a new jetty and floating pontoon, including fish cleaning facility are also included in this concept. Approximately 100 boat trailer parking bays would need to be established to cater for a three lane ramp during peak periods.

The area between the boat ramp and existing breakwater and adjacent to the new lower landing could be upgraded for both options to provide additional temporary mooring capacity as it provides

good access to the car park for loading and unloading passengers and/or supplies. Alternatively, sewerage pump out and refuelling capability could be provided at this location.

Estimates of the construction, design and supervision costs for each option have been developed. Implementation of Option 1 - Spur Breakwater is estimated to cost approximately \$6.2M. Implementation of Option 2 – Detached Breakwater is estimated to cost approximately \$5.9M.

State Marine Precinct Expansion Option

The primary objective of this study has been to identify and assess options that provide safer boating and harbour facilities for the Port of Warrnambool. However, the Port of Warrnambool has been recommended as a location to provide a State Marine Precinct level of service (WCC, 2011).

A conceptual layout for incorporating the safer boating and harbour options developed in this study into an enclosed harbour option to provide State Marine Precinct levels of service at the Port of Warrnambool has been proposed.

More significant investigations are required to determine the feasibility of establishing a significantly expanded harbour at the Port of Warrnambool given the range of engineering, planning and environmental constraints identified in this study.

Conclusions and Recommendations

The following main conclusions and recommendations are provided from the investigation of safer boating and harbour facilities study for the Port of Warrnambool:

- The exposure of the boat ramp and swing mooring to wave action was consistently identified by the Port stakeholders as an immediate constraint to providing safer boating and harbour facilities. Analysis of the frequency spectrum of the wave measurements in the Port revealed however that a significant component of the wave energy in the Port is associated with long waves. Mitigation of waves at these frequencies is often not practically achievable.

Both options developed in this study will significantly reduce the amount of wave action and surging motions at the boat ramp. Neither option will however completely eliminate surging motions on the boat ramp. Expectations of 'mill pond' conditions at the boat ramp under all conditions in the Port of Warrnambool is unlikely to be practically achievable, even with a fully enclosed harbour, due to the amount of long wave energy generated within Lady Bay. Improved education and awareness of the mechanism generating surging motions at the boat ramp is recommended to enable users of the boat ramp to properly prepare for and assess the risks of launching and retrieving vessels from the boat ramp.

- Sedimentation and resulting impact on drafts within the Port was also identified as a high priority for providing safer boating and harbour facilities. Sedimentation of the Port and study area more generally is an ongoing, long term process that will require active management to enable the Port to function effectively in the future. The development of a shore normal groyne and creation of sediment traps as part of the capital works dredge basin construction for either option will assist in limiting the impact of sedimentation on the Port function.

A commitment and corresponding funding to undertake regular maintenance dredging in the Port of Warrnambool will be required in association with the implementation of either option developed in this study. An appropriate, long term option for the disposal of capital and ongoing maintenance dredge spoil needs to be identified to enable the options developed in this study to be implemented.

- It is considered that the environmental impacts of the harbour options are largely limited to disturbance of the seabed associated with dredging and spoil disposal and the accretion of

sediment north of the groyne resulting in additional seaward advancement of the Lady Bay shoreline in the vicinity of the groyne. Mitigation measures have however been identified to appropriately manage these potential impacts.

- Options to increase the number of dedicated boat trailer parking bays to approximately 100 are required to be identified as part of the traffic and parking planning for the implementation of either of the options developed in this study.
- The study has included consideration of options and their construction methods that would endeavour to retain the cultural heritage values of the existing breakwater. The method proposed for the construction of the spur breakwater option provides a breakwater option that would have a similar form, colour and texture to the existing breakwater. The detached breakwater option provides an alternative option that would be considered to have less direct impact on the heritage values of the existing breakwater as it would be separated from existing breakwater and can be constructed with a lower crest elevation.
- The options developed in this study should be exhibited for public comment to provide an opportunity to gauge the public's acceptance of the options developed and assist to identify and refine the preferred option.
- More significant investigations are required to determine the feasibility of establishing a State Marine Precinct scale harbour at the Port of Warrnambool given the range of engineering, planning and environmental constraints that have been identified in this study.

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1. INTRODUCTION

Water Technology, in association with Meinhardt, has been engaged by the Warrnambool City Council (WCC) to undertake an investigation of safer boating and harbour facilities in the Port of Warrnambool, including consideration of potential coastal process and environment impacts on the Lady Bay foreshore.

1.1 Background

Warrnambool was the centre of the prosperous Western Districts farming region in the mid 1800's. Following the construction of jetties in Lady Bay in the 1850's. The Port of Warrnambool provided a major regional hub for the movement of goods and people.

The establishment and maintenance of a working Port at Warrnambool has a long and problematic history due largely to the highly energetic wave climate and large sediment transport processes affecting the coast. Since the earliest jetty was built in 1850, there have been numerous extensions and redesigns of the breakwater, viaduct and causeway. These changes were instituted in an attempt to improve the wave climate and berthing conditions and limit the impact of sedimentation on the Port operations. The various extensions and modifications to the Port structures over the last approximately 150 years have had a profound impact on Lady Bay, with the western shoreline prograding by over 300 metres and sedimentation dramatically reducing depths in the Port.

The major function of the Port of Warrnambool today is to provide a safe haven and services to the commercial fishing industry and recreational fishing and boating interests. The Port of Warrnambool precinct is utilised by a wide range of commercial, recreational and community groups. The Port has the second largest allocation and quota for Southern Rock Lobster in Victoria and the commercial fishing industry is estimated to directly employ approximately 20 people and contributes approximately \$18M to the local economy (WCC, 2010). There are currently 14 swing moorings at the Port.

Warrnambool is one of the fastest growing regional cities in Victoria with tourism providing a major contributor to economic activity and employment. The Port of Warrnambool is a major tourist drawcard and improvements to the Port infrastructure and functionality have been identified as providing significant opportunity to increase the tourism and economic potential of the Port and of Warrnambool more generally.

The potential of the Port of Warrnambool is however currently limited principally by exposure to wave action that causes hazardous conditions at the boat ramp and forces vessels in the Port, including the Coast Guard and commercial fishing fleet to remain on swing moorings. Limited drafts due to ongoing sedimentation of the Port also currently limit the ability to launch and retrieve vessels from the boat ramp and for access to the landings on the breakwater.

1.2 Scope of Works

The primary objective of the project, as outlined in the project brief issued by WCC, is to identify options to provide safer boating and harbour facilities at the Port of Warrnambool, to maximise the significant tourism and commercial potential of the Harbour. The options are required to have minimal impact on the Lady Bay foreshore and environment nor compromise the heritage status of the existing breakwater. The additional objectives of the study also include the following:

- Provision of recommendations on the feasibility of various harbour improvement options
- Estimated costings to enable feasibility and cost-benefit trade-offs to be evaluated
- Stakeholder engagement to ensure ample opportunity for input and comment

To achieve the above objectives of the study, the following scope of works has been undertaken:

- Collection of wave data and analysis of the wave climate within the Port by numerical modelling techniques
- Review and modelling analysis of the sediment transport processes and magnitudes in the study area
- Consultation with Port stakeholders including the preparation and review of responses to a questionnaire distributed to the Project Reference Group.
- Development and detailed analysis of two options for improving wave conditions and mitigating sedimentation impacts in the Port
- Evaluation of the two options against relevant design criteria and constraints
- Review of regulatory and approval requirements and development of an implementation schedule

2. WAVE CLIMATE

The wave climate offshore of the Port of Warrnambool is highly energetic. Wave action in the Port is currently a critical constraint limiting the utility of the Port infrastructure such as the boat ramp and the low level landing. The action of waves also drives the sediment transport processes in Lady Bay. Detailed analysis of the wave climate (including extreme events) and wave transformation processes in the vicinity of the Port has therefore been undertaken to support the development and analysis of options for improving the wave climate in the Port.

2.1 Wave Instrumentation

In order to provide rigour and validation to the analysis of the wave climate in this study, an RBR TWR-2050P submersible tide and wave recorder was deployed within the Port between 16 September to 4 October 2011. The instrument was located at the position within the Port identified in Figure 2-1. The instrument sampled tidal water levels every 15 minutes and the wave spectra were burst sampled at 4Hz for 1024 samples every 15 minutes. The frequency range for the wave spectra was 2 – 130s.

The measured data recorded by the instrument is displayed in Figure 2-2 in terms of water levels (relative to mean sea level) and significant wave height and spectral peak period, where wave periods greater than 20 seconds have been truncated from the frequency spectrum. Figure 2-2 is considered to show the following information:

- Meteorologically driven processes have a significant influence on sea level variability when compared to the variability associated with astronomical tidal water level variations
- Significant wave heights in the Port were relatively small over the instrument deployment period at generally less than 0.2m
- Wave periods (<20s) showed relatively minor variation and varied between approximately 11 and 15 seconds.

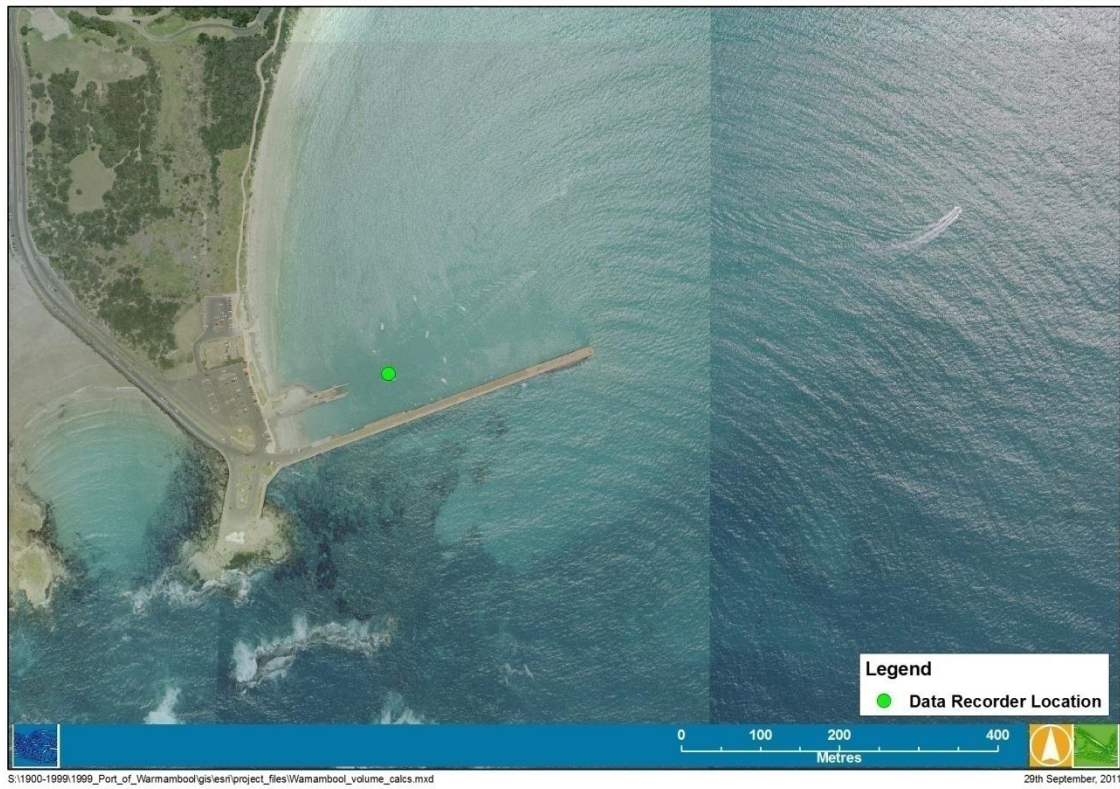


Figure 2-1 Wave Recording Instrument Deployment Location

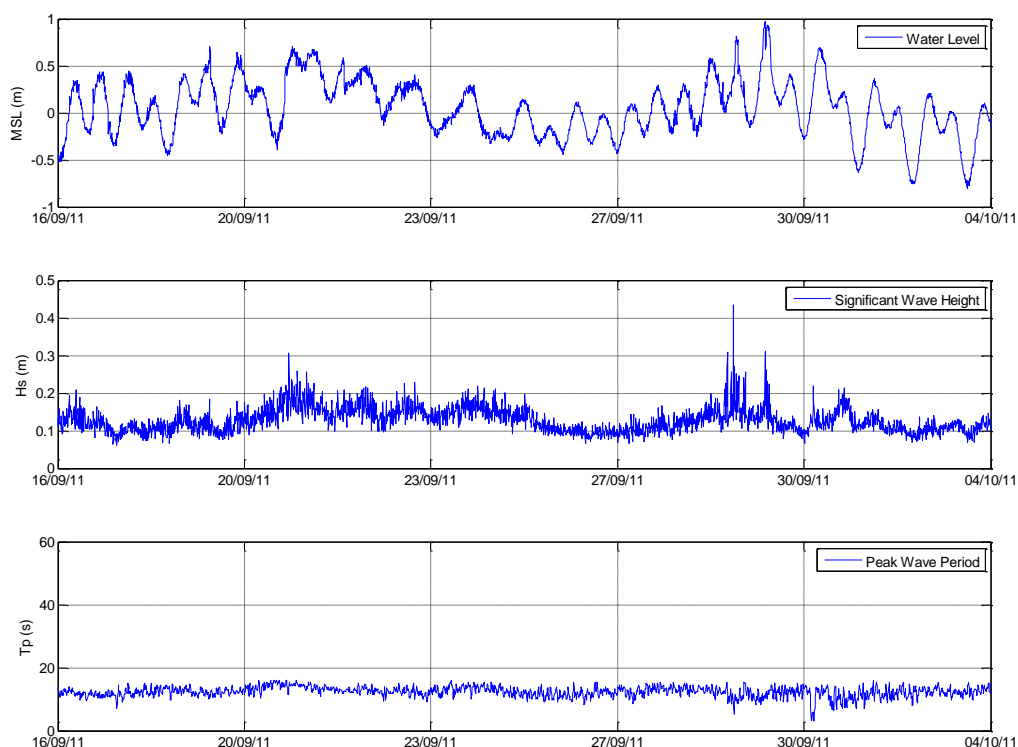


Figure 2-2 Observed Water Level and Wave Conditions in the Port of Warrnambool

2.2 Long Waves

Analysis of the frequency spectrum from the measurements in the Port also revealed significant amounts of energy was present at frequencies beyond that which can be attributed to wind generated gravity waves (i.e. periods greater than ~ 20 seconds). These long waves have periods of between 40 to 130s. The frequency spectrum in the Port is displayed in Figure 2-3 and shows the significant component of long wave energy in the wave spectra. The indication of significant long wave activity in the Port is particularly important as wave motions at these frequencies frequently produce surging motions on boat ramps and can cause problems for moored vessels in enclosed harbours. Mitigation of long wave activity from harbours is generally problematic and frequently cannot be practically eliminated.

The generation and dynamics of long waves in coastal zones is relatively complicated and requires an understanding of wave theory however, long waves are essentially related to the shoaling and/or breaking of wave groups in shallow water.

The possible source of the long waves measured in the Port is identified as associated with bound long waves that propagate with shoaling wave groups in the vicinity of the breakwater. As the wave groups pass the end of the breakwater, the bound long waves propagate into the sheltered zone behind the breakwater. Anecdotal observations describing surging behaviour along the inside edge of the breakwater following the passage of large groups of waves past the end of the breakwater is considered to provide some corroboration of this long wave source.

An additional source of long waves in the Port is possibly also associated with wave breaking in the surf zone to the east of the Port along the Lady Bay shoreline. Wave breaking in the surf zone may

be releasing bounded long waves that are reflecting off the shoreline and into the Port or travelling as edge waves around the shoreline of Lady Bay and into the Port.

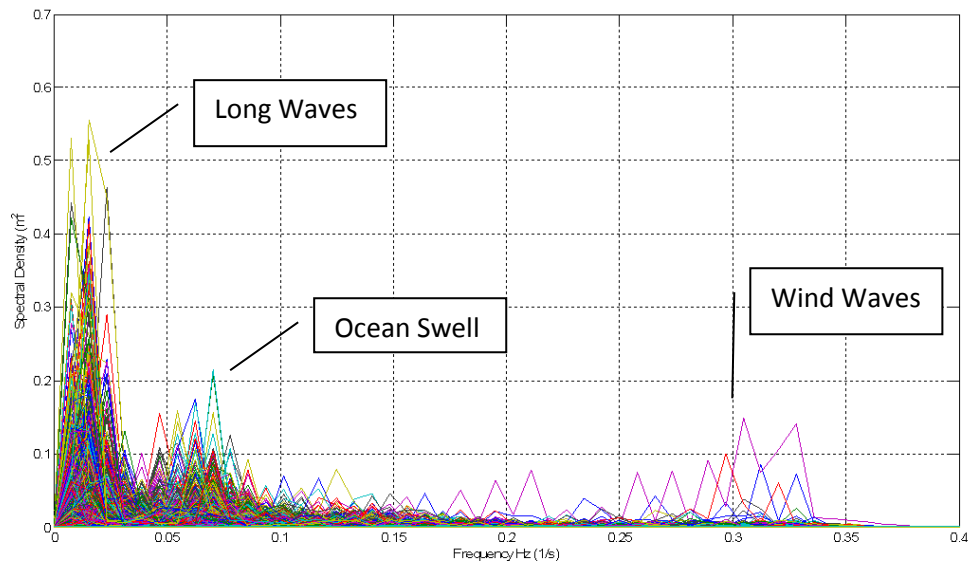


Figure 2-3 Observed Wave Spectra in the Port of Warrnambool

2.3 Spectral Wave Model Calibration

The long term wave climate in the vicinity of the Port has been analysed using a numerical short wave model of the study area that has been validated to the wave measurements recovered from the instrument deployment in the Port. The MIKE 21 spectral wave model has been utilised for the analysis. The model resolves physical short wave phenomena of interest in this study including refraction, diffraction, shoaling and wave breaking.

The development of the wave model requires the study area to be schematised as an unstructured triangular mesh of water depths. The resolution of the mesh is increased in areas of particular interest such as around the Port. Figure 2-4 displays the local wave model domain schematisation.

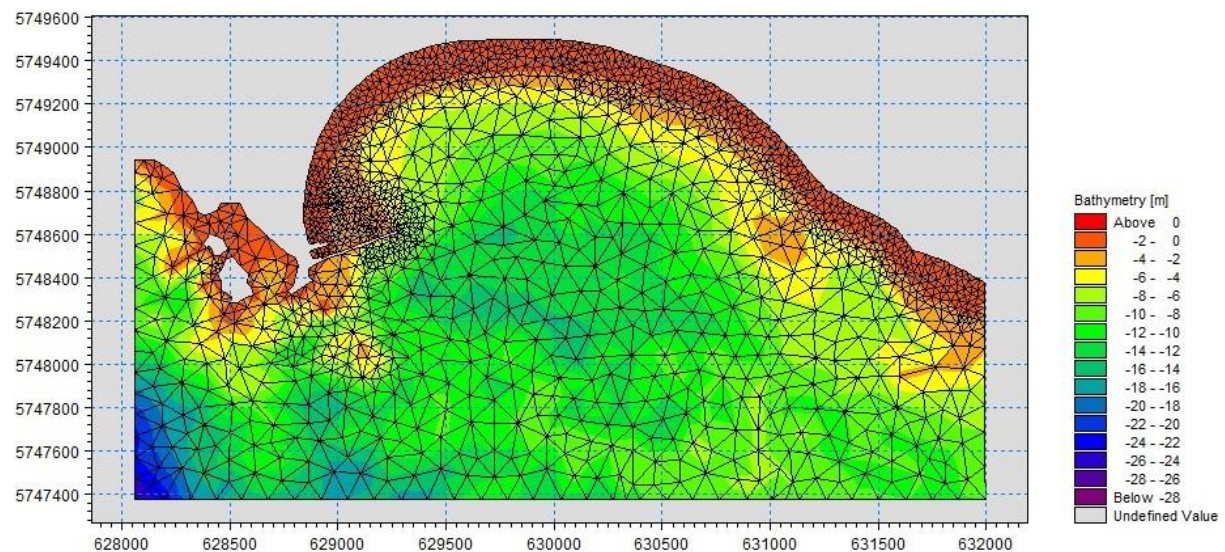


Figure 2-4 Local Spectral Wave Model Geometry

The essentially unlimited fetch over which waves may be generated and influence the Port of Warrnambool and surrounding coastline is such that developing wave boundary conditions to support the local wave climate analysis is relatively complicated. The technique adopted required the extraction of 10 years of deep water wave reanalysis data from the global WAVEWATCH III wave model. The WAVEWATCH III model is operated by US National Oceanic and Atmospheric Administration (NOAA) and provides key spectral wave and wind parameters at approximately 100km resolution at six hourly intervals. The wave and wind reanalysis data extracted from the WAVEWATCH III model was then simulated in a regional spectral wave model of Bass Strait operated by Water Technology. This model has been extensively validated to wave rider buoy observations at Cape Sorell, Lakes Entrance and Point Nepean. The wave outputs from the regional model were then used to drive the boundary conditions of the local wave model of the study area displayed in Figure 2-4.

Figure 2-5 displays an example of the local spectral wave model results under typical south west swell conditions in the vicinity of the Port of Warrnambool.

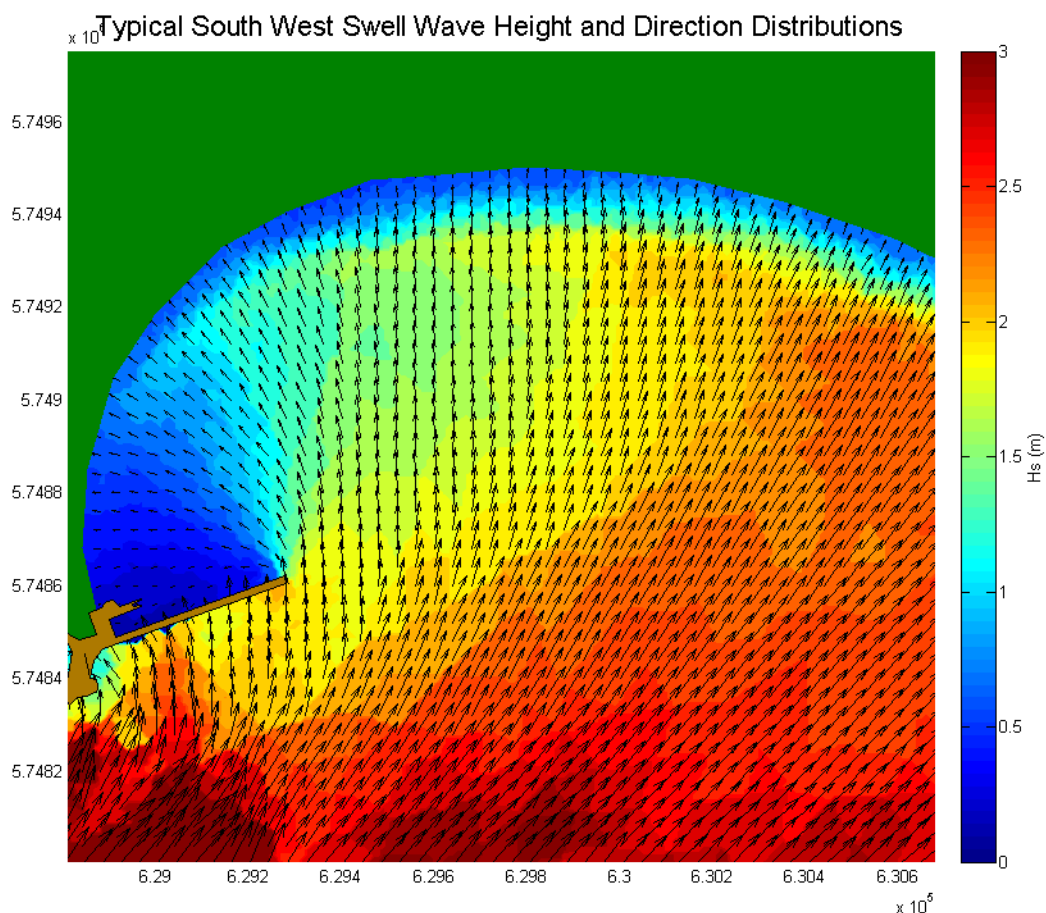


Figure 2-5 Example Spectral Wave Model Results Under Prevailing South West Swell Conditions

The local wave model has been validated to the wave measurements recovered from the instrument deployment in the Port. A comparison of the modelled and observed significant wave heights and peak periods (<20s) in the Port are displayed in Figure 2-6. Figure 2-6 also displays the significant wave heights offshore of Warrnambool and shows the extent of the wave transformation observed from offshore to behind the breakwater within the Port of Warrnambool. The level of agreement between the modelled and observed wave conditions within the Port displayed in Figure

2-6 is considered to provide confidence that the spectral wave model is capable of providing a valid tool for testing and refining options to improve wave conditions within the Port.

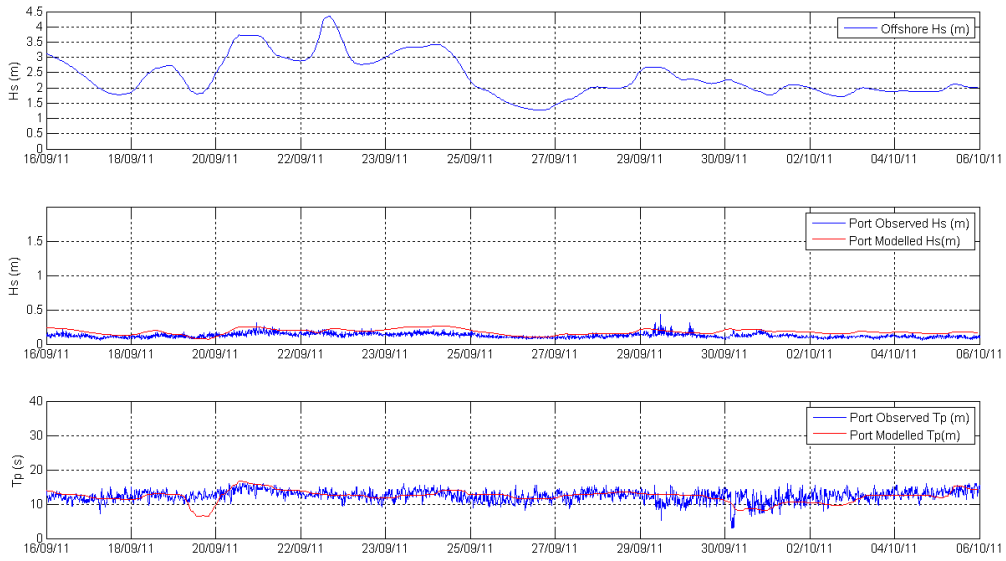


Figure 2-6 Comparison of Modelled and Observed Conditions in the Port of Warrnambool

2.4 Design Wave Climate Analysis

The validated local spectral wave model has been employed to hindcast the wave climate in the study area over a continuous 10 year period (2000 – 2010) with the wave boundary and wind fields derived from the WAVEWATCH III global reanalysis outputs. Figure 2-7 displays summary wave rose plots of the 10 year hindcast results showing the directional distribution and percentage occurrence of significant wave heights and peak periods offshore of the Port of Warrnambool in approximately 30m depth.

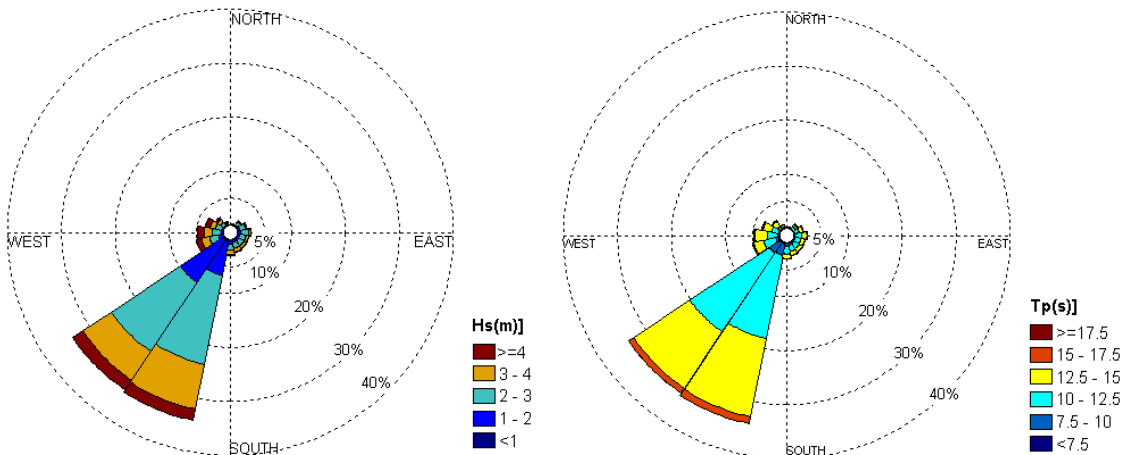


Figure 2-7 10 Year Offshore Wave Climate Hindcast Results

Estimates of the annual exceedance probability (AEP) of extreme wave height and direction conditions have been estimated from the long term wave climate hindcast. These extreme wave height conditions have been estimated for both south west and south east quarter wave directions. The analysis has been undertaken by fitting an appropriate statistical distribution to the record of annual maximum significant wave heights derived from the longterm wave climate hindcast. The tail of this distribution was then analysed to estimate the exceedance probability of large wave heights. The fit of the statistical distribution to the annual maximum wave height series from the south west and south east quarter is displayed in Figure 2-8. Table 2-1 summarises the key significant wave height annual exceedance probabilities developed from this analysis.

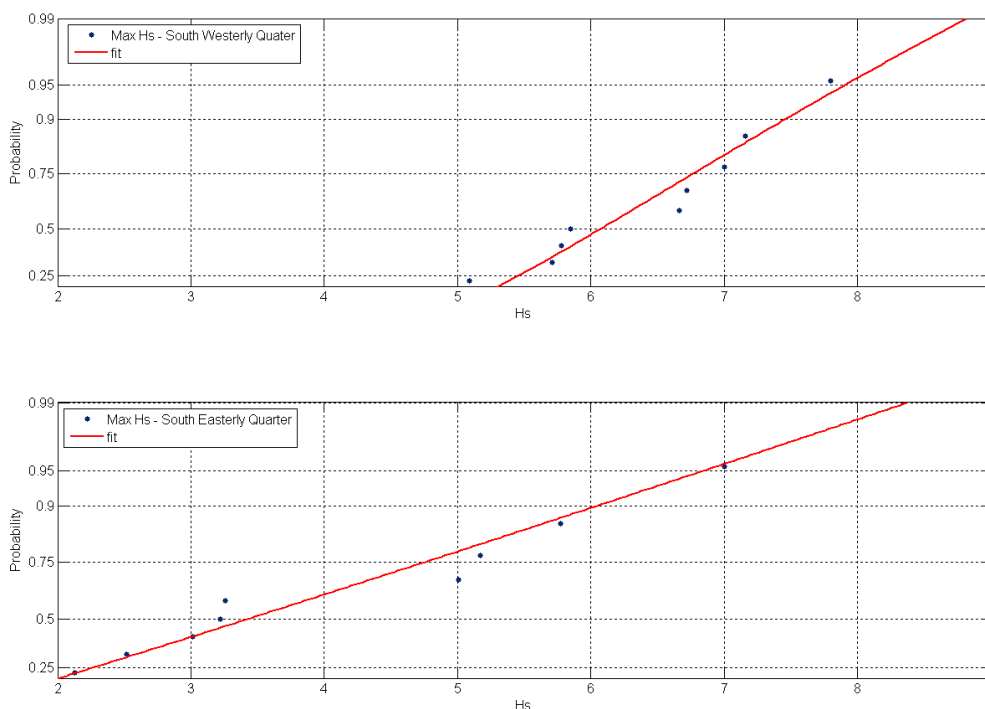


Figure 2-8 Analysis of the Distribution of Extreme Wave Heights at Warrnambool

Table 2-1 Summary of Design Wave Height Estimates for Warrnambool

| Design Wave Direction | Design Wave Heights | | |
|-----------------------|---------------------|----------------|-----------------|
| | 1 Yr (63.2% AEP) | 50 Yr (2% AEP) | 100 Yr (1% AEP) |
| SW | 5.7 | 8.4 | 8.9 |
| SE | 2.8 | 7.7 | 8.3 |

3. COASTAL PROCESSES

Since the construction of the initial Thornton Jetty in the 1850's, the sediment transport processes in Lady Bay have confounded and frustrated efforts to establish and maintain a harbour at Warrnambool. A significant body of previous investigations and studies into the sediment transport processes in Lady Bay therefore exists. Over this time, the steady development of a more sophisticated understanding of the sediment transport processes operating in Lady Bay has evolved.

This evolution has been facilitated primarily by continuing advancements in data collection and surveying techniques and in numerical modelling tools for integrating the physical processes of waves, hydrodynamics and sediment transport in coastal environments.

The following sections provide an overview of the understanding of the sediment transport processes developed from previous investigations as well as some additional interpretation and analysis undertaken as part of this study.

3.1 Geomorphology

Lady Bay is part of the broader Warrnambool embayment excavated by an ancestral Merri River. The embayment has been progressively filled over the Quaternary (2.6M years ago to present) by a series of shallow marine and dune formations (Gill, 1984). These formations are comprised primarily of biogenic (calcium carbonate) material originating from molluscs, algae and foraminifera that were drifted onto ancient shorelines within the Warrnambool embayment during successive interglacial periods in the Quaternary. Overtime these formations were gradually lithified by the precipitation of the calcium carbonate to form calcarenite. These calcarenite formations now dominate the coastal morphology of Warrnambool and the erosion of these formations by wave action contributes the overwhelming majority of the beach sediments observed in Lady Bay. The calcarenite formations vary subtly in their grain size characteristics and composition revealing differences in the origin of coastal sediments within the study area.

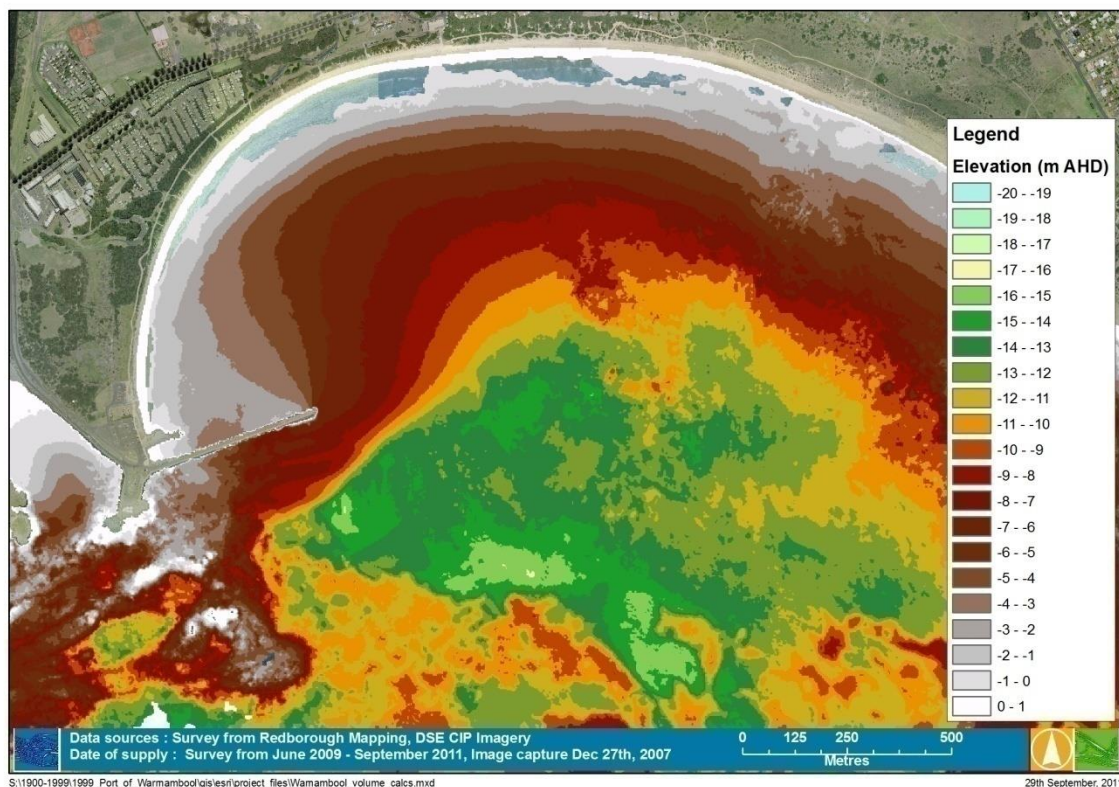


Figure 3-1 Bathymetry Overview

3.2 Sediment Characteristics

The sediments of the Lady Bay beaches and that which is contributing to the siltation of the Port is calcareous sand. Chemical analysis of the sands of the Warrnambool district yielded calcium carbonate fractions as high as 86% (Gill, 1984). The calcareous sand of Lady Bay is derived primarily from the erosion of calcarenite formations by wave action to the west and east of Lady Bay. A minor component of calcareous material is possibly being supplied to Lady Bay by the contemporary production of biogenic material from offshore.

A unique feature of the sediments of Lady Bay is the marked change in grain size and colour of the beach sediment between the western and eastern extent of Lady Bay.

The sediment in the western portion of Lady Bay and that which is contributing to the siltation of the Port is light grey in colour and fine to very fine grained with a median diameter (D_{50}) of less than 0.2mm (CES, 1999).

Towards the eastern section of Lady Bay the beach sediment gradually transitions to a light brown colour and grain size increases noticeably to a fine to medium grain size with a median diameter (D_{50}) of approximately of 0.5mm (CES, 1999).

The variations in sediment characteristics within Lady Bay indicate that there are potentially different sediment sources within Lady Bay and/or the sediment is being sorted by wave action within Lady Bay.

The source of the light grey sand has been previously identified by Gill (1984) as a local source of calcareous sediment derived from the erosion of the calcarenite reefs to the south west of the Port. These reefs are an extension of the calcarenite formations of Thunder Point and Merri and Middle Islands. This sediment source is likely to be complimented by calcareous sediments drifted from further offshore.

To the west of Lady Bay in the vicinity of the entrance to the Hopkins River, erosion of another calcarenite formation has supplied sediments to the beaches. This formation is referred to as Dennington Aeolianate (Gill, 1984) which is a wind blown dune formation that has been lithified. The iron has been oxidised in these sediments imparting a brownish colour to these sediments.

Close inspection of the light grey sediment samples taken from the vicinity of the Port show that a minor fraction of this sediment is comprised of fine grained light brown particles. This suggests there is some westward longshore transport of sediments along Lady Bay. The mechanism that drives this westward sediment transport in Lady Bay is discussed in the following sections.

3.3 Sediment Transport

The process in which sediment is being transported within Lady Bay has been the subject of considerable previous analysis. A summary of the previously identified components of the sediment transport within Lady Bay is presented including some additional analysis undertaken for this project with the benefit of improved survey and numerical modelling.

A conceptual model of the main sources and pathways of the sediment transport in Lady Bay is displayed in Figure 3-2 and discussed below:

- The supply of sand around the southern edge of the breakwater is clearly visible in the bathymetric LiDAR survey of Lady Bay. This sand is spilling past the end of the breakwater and out onto the floor of Lady Bay. The reflection of waves off the southern face of the breakwater has scoured the sediments in front of the breakwater creating localised wave patterns in these sediments. This sand is the light grey sand identified by Gill (1984) and originates from the erosion of the calcarenite reefs to the immediate southwest of the Port and/or onshore drifting of calcareous sediment from offshore.

- The sand transported past the edge of the breakwater is being drifted onshore by low diffracted swell waves. The sand drifting onshore onto Lady Bay beach is very fine grained. It is possible that the sediments are being winnowed by wave action such that only the finest material can be mobilised and transported onshore by the low swell wave energy generally observed in the western portion of Lady Bay. This process has been responsible for the majority of the shoreline accretion observed in Lady Bay over the last approximately 150 years.
- On the eastern section of Lady Bay, sediment supply from a different calcarenite formation is contributing light brown calcareous sediments to the shoreline. The greater exposure to wave energy is enabling coarser material to be mobilised on these beaches. This sediment is primarily being transported away from Lady Bay to the east, however, seasonal variations in wave and wind directions to the east and south east have transported some of this sediment westward towards the Port.
- A secondary sediment transport process associated with gradients in wave setup along Lady Bay is identified as causing an anti clockwise circulation within the western end of Lady Bay that is transporting fine grained sediment westward and into the Port. This process is discussed in more detail in the following sections.

The fact that such a vast quantity of sand has accreted behind the breakwater and that only very minor downdrift erosion has occurred historically on the eastern section of Lady Bay, strongly indicates that there is an abundant supply of sediment to this coast and that this sediment is being supplied by onshore sediment transport processes as well as longshore processes.

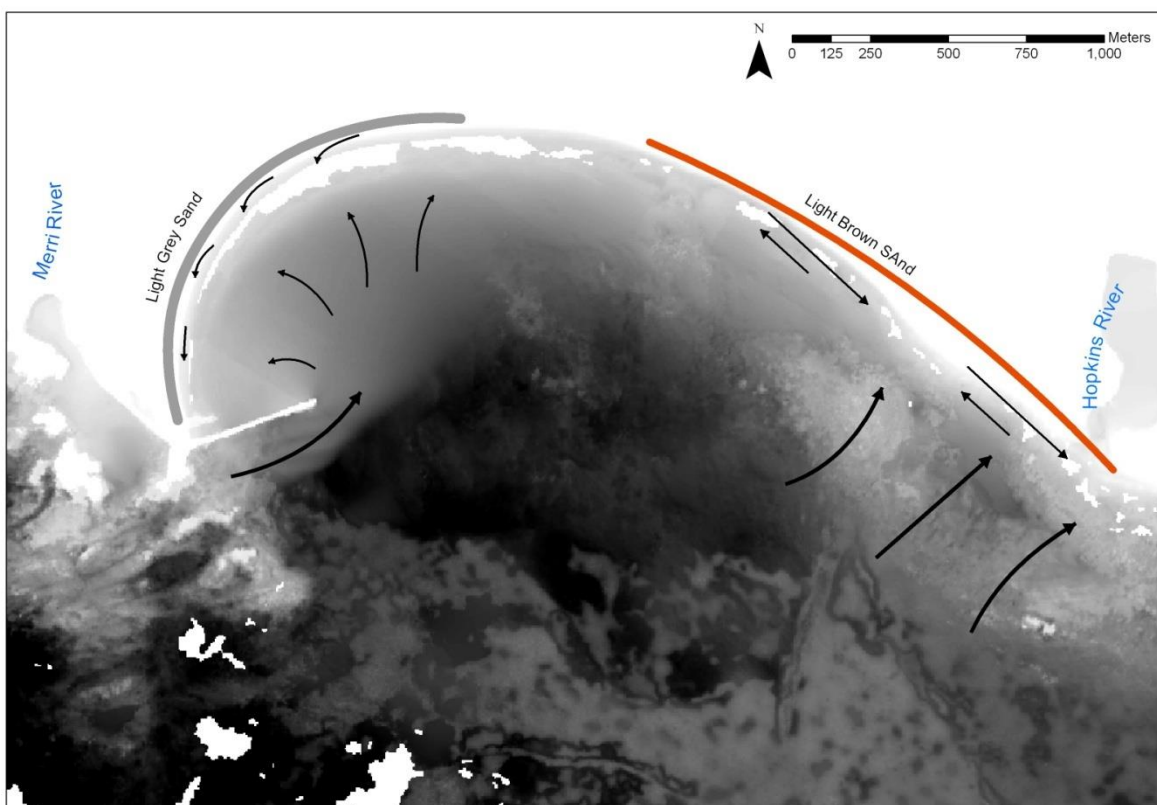


Figure 3-2 Conceptual Model of Sediment Transport Sources and Pathways in Lady Bay

3.3.1 Sediment Transport Analysis

Analysis of the magnitude of the sediment transport processes in the vicinity of the Port has been undertaken by the following two methods:

- Comparisons of repeat hydrographic surveys of the Port
- Numerical modelling analysis of sediment transport potentials due to wave and current action

Comparisons of recent repeat hydrographic surveys of the Port have been undertaken to quantify the observed volumes of sediment and pattern of accretion within the Port.

A detailed hydrographic survey of the Port is available immediately post the dredging of 15,000m³ of sediment from the Port in November 2009. Repeat hydrographic surveys have then been taken in October 2010 and September 2011. The approximate 12 and 24 month repeat surveys have been compared to the immediate post dredge 2009 survey to display the differences in bed elevations at these two time intervals.

Figure 3-3 displays the difference in bed elevations after 12 months post dredging of the Port. Figure 3-4 displays the difference in bed elevations after 24 months post dredging of the Port. From the comparisons displayed in Figure 3-3 and Figure 3-4, and subsequent analysis of the volume differences between these surveys, the following observations are provided:

- The comparisons of the surveys and patterns of sediment accretion are considered to reveal that both onshore and longshore sediment transport processes are likely to be contributing to siltation of the Port
- There appears to be onshore drifting of sediment resulting in accretion of sediment on the seaward edge of the dredge pocket. Analysis of the sediment volume differences on the seaward side of the dredge pocket found that approximately 2,000m³ of sediment accreted along the seaward edge of the dredge pocket over the first 12 months following dredging. However, only relatively minor additional accretion was observed in the subsequent 12 months via this sediment transport mechanism.
- Significant sediment accretion on the shoreward end of the dredge pocket within the Port is observed. This sediment is considered to be transported by longshore transport mechanisms and being deposited in the lee of the breakwater in the form of a shore parallel bar. The formation of the shore parallel bar also suggests that the longshore transport process is occurring in the presence of cross shore transport from the beach. The total volume of sediment accreted in the offshore bar was approximately 2,500m³/yr in both surveys.

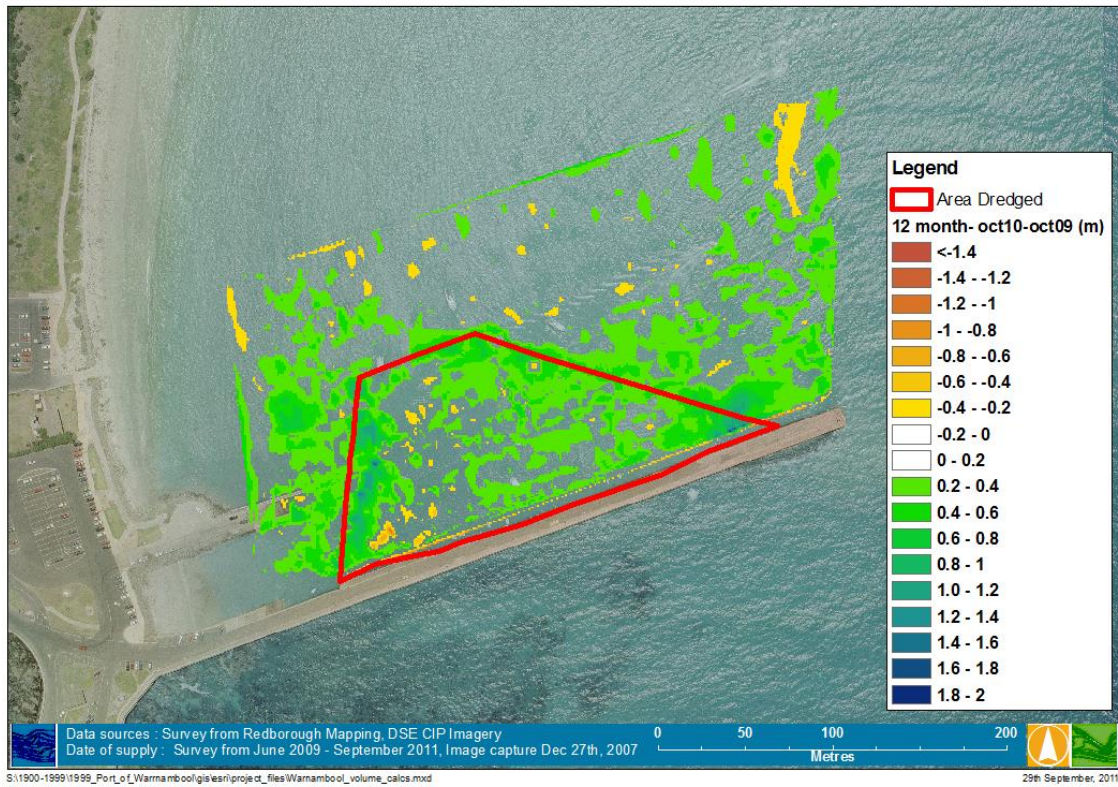


Figure 3-3 ~12 Month Post Dredge Survey Comparison

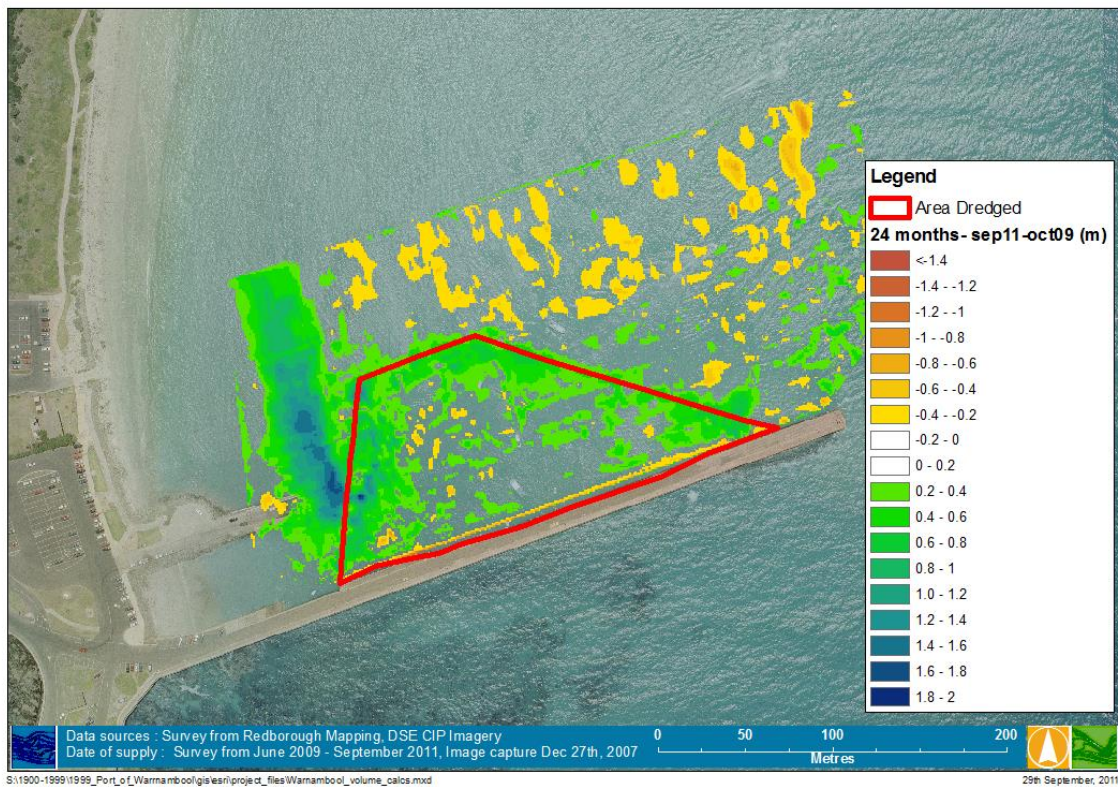


Figure 3-4 ~24 Month Post Dredge Survey Comparison

The comparisons of the repeat bathymetric surveys presented above are considered to demonstrate that longshore drifting of sediment is causing a significant portion of the siltation in the Port. The longshore transport of sediment is however not considered to be caused by obliquely incident waves generating longshore currents as is conventionally observed on open coasts. For this longshore transport process to cause westward transport into the Port, waves would be required to approach the shoreline at angles north of approximately east. The spectral wave modelling undertaken in this study indicates that under prevailing southwest swell conditions, diffracted waves around the end of the main breakwater are arriving at directions very close to normal along the shoreline of Lady Bay. Minimal longshore drifting of sediment would therefore be expected under these conditions.

A mechanism for the longshore drifting of sediment into the Port is however identified by consideration of the gradient in the residual water levels generated by wave action within Lady Bay. As relatively large and long period waves propagate over the shallow depths of Lady Bay, radiation stresses are generated within the water column which induce variations in mean water levels and currents within Lady Bay.

The influence of wave radiation stresses on mean water levels and currents in Lady Bay has been simulated by forcing a two dimensional hydrodynamic model of Lady Bay with wave radiation stresses extracted from the spectral wave model. Figure 3-5 displays the residual water level and mean current results from the hydrodynamic model which has been forced by wave radiation stresses from the spectral wave model under representative 3.0m, 14s south west swell conditions.

From the results presented in Figure 3-5, the following observations of the impact of wave radiation stresses on water levels and currents in Lady Bay is provided:

- Within the surf zone of Lady Bay, radiation stresses at the shoreline results in an increase in water levels adjacent to the shoreline. This is commonly referred to as wave setup.
- Due to the presence of the main breakwater and sheltering of the western section of Lady Bay from waves, the magnitude of the wave setup reduces towards the Port. The gradient in the wave setup along the shoreline of Lady Bay generates a south westward longshore current towards the Port. This current has been identified previously (CES, 1999) but was incorrectly attributed to tidal currents.
- Residual water levels past the end of the breakwater are also set down relative to water levels in the lee of the breakwater and this generates a slow return flow that completes the circulation back into Lady Bay. It is noted that this process is also most likely responsible for the generation of long waves in the Port discussed in Section 2.2. The variation in radiation stresses associated with the passage of wave groups causes periodic differences in mean water levels in Lady Bay, resulting in low frequency oscillations (long waves) in the lee of the breakwater.

Under prevailing, moderate south west swell wave conditions, the magnitude of the longshore current generated by gradients in the wave setup along Lady Bay is relatively minor at approximately 0.05 – 0.1m/s. However, due to the very small particle size of the sediments in the western section of Lady Bay, any sediment that is mobilised from the bed by wave action can then be slowly worked westward by this prevailing current.

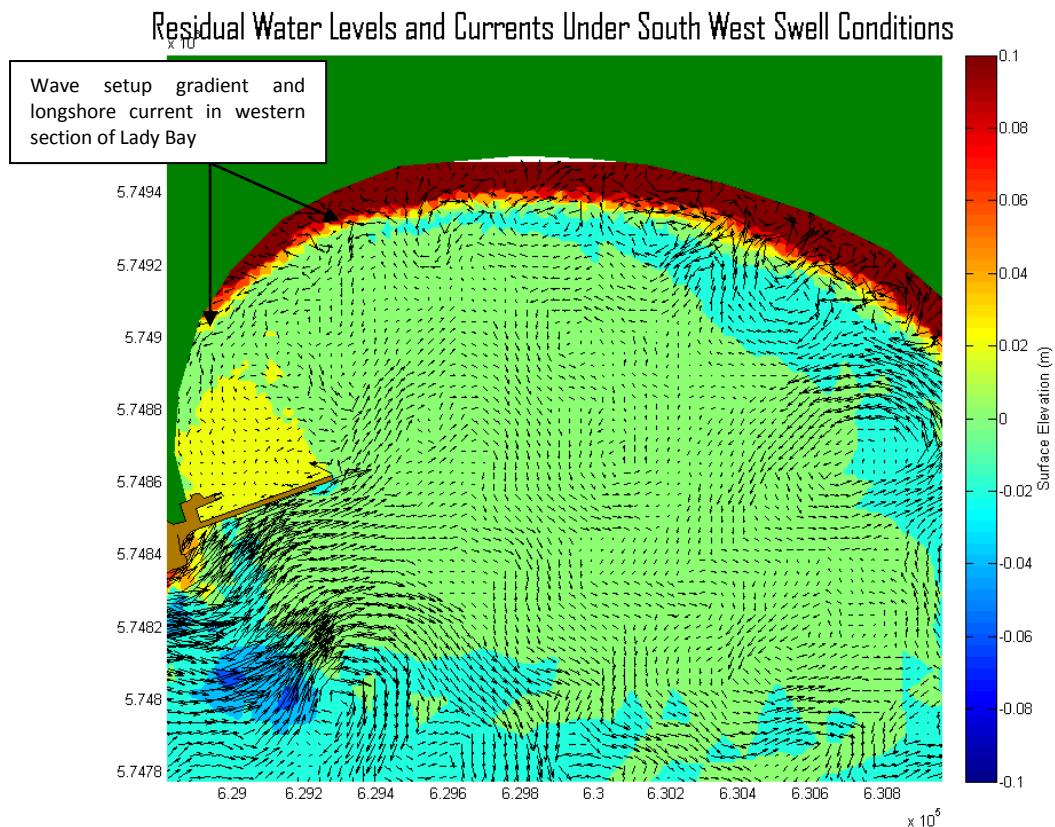


Figure 3-5 Wave Driven Residual Water Levels and Currents Under Prevailing South West Swell Conditions

An estimate of the magnitude of the longshore sediment transport potential due to the combination of wave action and the longshore currents has been undertaken using the longshore sediment transport model LITPACK. The LITPACK model provides a deterministic description of the alongshore littoral drift by solving the longshore and cross-shore distribution of the longshore current and wave set-up. The LITPACK model has been configured from a cross shore profile extracted from the LiDAR bathymetric data at a location approximately 300m north of the existing breakwater.

As input into the longshore transport model, a representative year of wave, water level and current conditions was hindcast by coupling the spectral wave model to a hydrodynamic model of Lady Bay. The 12 month timeseries of wave and hydrodynamic conditions were simulated in the LITPACK model to provide an estimate of the longshore sediment transport potentials across the profile. Figure 3-6 displays the predicted accumulated longshore transport rates as a function of time. From Figure 3-6, the following observations as to the predicted accumulated longshore transport in the vicinity of the Port are provided:

- The longshore transport potentials are almost entirely southward (i.e. -ve values), towards the Port in this region of Lady Bay. This is considered due to the prevailing longshore current generated by the gradient in the wave setup in Lady Bay described previously. This indicates that once sediment is transported into the lee of the breakwater it cannot be remobilised and transported away from the Port.
- The total annual longshore transport potential is predicted as approximately 3,500m³/yr. The magnitude of this longshore transport is considered in good agreement with the rate of

accretion within the Port due to longshore transport observed via the comparison of the repeat bathymetric surveys which was approximately 2,500m³/yr.

- The rate of longshore transport is greatest during the autumn months when the largest south westerly swell waves are generally observed on this coast and when the strongest longshore currents are generated.

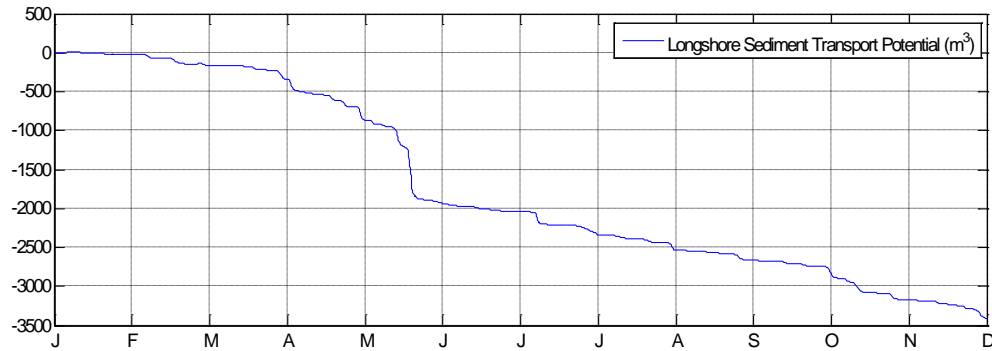


Figure 3-6 Rate of Predicted Longshore Transport Potentials North of the Port

-ve values indicate transport towards the Port

4. STAKEHOLDER CONSULTATION

In order to inform the consideration of options to provide safer boating and harbour facilities at the Port of Warrnambool, consultation with various stakeholders of the Port of Warrnambool was undertaken as part of this project. The objectives of the stakeholder consultation were twofold:

- Identify and record the immediate constraints and priorities for providing safer boating and harbour facilities
- Identify the long term options and views as to the range and scale of facilities that should be considered in any future expansion of the Port of Warrnambool

To facilitate the stakeholder consultation, the members of the reference group were invited to participate in a questionnaire that was distributed to the reference group during the course of the project.

The stakeholder consultation by means of a questionnaire provided an opportunity for each member of the reference group to provide a formal response as part of the consideration and development of options for improving the Port.

The questionnaire was designed to assist in identifying the critical constraints on the use of the Port in the short term as well as identifying medium to long term opportunities for the Port as identified by the stakeholders. The questionnaire responses provided by the reference group provided important criteria for developing and evaluating the effectiveness of options to improve the Ports facilities and provide safe launching and retrieval of vessels in the Port.

The following summarises the responses to each of the questions put to the reference group in the questionnaire. The complete questionnaire responses from each of the reference group members are provided in Appendix A.

1. *Council's vision for the Port of Warrnambool is to provide safe, effective and sustainable Port operation and to deliver development that enhances the economic growth of Warrnambool.*

*Question: Which of the following actions is highest priority in achieving this vision?
(Please rank all 4 - 1 being the most immediate priority)*

Table 4-1 Summary of Question 1 Responses

| Action | Priority | | | |
|---|----------|-------|-----|-----|
| | 1 | 2 | 3 | 4 |
| Provide fixed berth capacity in the Port | ✓✓ | | ✓✓✓ | ✓✓✓ |
| Reduce siltation and draft constraints | ✓✓✓✓ | ✓✓✓ | ✓ | |
| Provide the ability to safely launch and retrieve vessels in all conditions | ✓✓ | ✓✓✓✓✓ | ✓ | ✓ |
| Improve land based services | ✓ | | ✓✓ | ✓✓✓ |

From the summary of the responses provided in Table 4-1, it can be seen that ‘reducing siltation and draft constraints’ was identified as highest priority for achieving the Council’s vision for the Port. ‘Providing the ability to safely launch and retrieve vessels’ was also considered high priority. The priority for ‘Providing fixed berth capacity in the Port’ was split between some stakeholders who see this as highest priority and others who consider it a less immediate priority.

2. *It is reported that boat users bypass Warrnambool for Portland and Port Fairy due to the inability to safely launch and retrieve vessels under all conditions. One way to improve this situation would be to change the wave conditions at the boat ramp to allow vessels to be safely launched and retrieved under all weather conditions.*

Which of the following additional factors do you consider are also high priority to enable full utilisation of the boat ramp?

(Please rank all 7 - 1 being the most immediate priority)

Table 4-2 Summary of Question 2 Responses

| Action | Priority | | | | | | |
|------------------------------------|----------|----|---------|---------|----------|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Existing lanes too narrow | | ✓✓ | ✓ | ✓ | | ✓✓ | ✓✓ |
| Grade of ramp too flat | ✓ | | ✓ | ✓ | | ✓ | ✓✓ |
| Additional lane capacity required | ✓✓✓✓ | ✓✓ | ✓ | | ✓ | | |
| Draft constraints due to siltation | ✓✓✓✓ | ✓ | ✓✓ ✓ | ✓ | | | |
| Temporary mooring capacity | | ✓ | ✓ | ✓✓ ✓ | ✓✓ | | |
| Limited car-trailer parking | | | | ✓✓ | ✓✓ ✓✓ | | ✓ |
| Other | ✓ | | | | | ✓✓ | ✓ |

From the summary of the responses provided in Table 4-2, it can be seen that in addition to improving wave conditions at the boat ramp, providing additional lane capacity and alleviating draft constraints due to siltation were identified as highest priority for enabling full utilisation of the boat ramp.

The respondents provided a number of additional issues with the use of the boat ramp. These related primarily to the associated land based components of the boat ramp infrastructure and included the following:

- Safety concerns associated with tourists walking out along the boat ramp whilst boats are being launched and retrieved. Suggested another landing or pier is constructed with cleaning tables located away from the boat ramp to separate tourists/pedestrians from boat ramp activity.

- While not identified as highest priority, a number of additional responses to this question from respondents highlighted the requirement for a floating pontoon type structure to provide temporary mooring capacity and easier access to boats already launched.
3. *Existing tenants in the Port include commercial fishing boats, charter boats and the coast guard. There are currently 14 swing moorings at the Port. Works could be undertaken to create a limited number of fixed berths through an initial, staged expansion of the Port.*

What minimum number of fixed berths should be created in an initial stage?

Table 4-3 Summary of Question 3 Responses

| Number of Fixed Berths | Number of Respondents |
|------------------------|-----------------------|
| 10 | |
| 20 | ✓✓ |
| 50 | ✓✓✓✓✓ |
| 100 | ✓ |

From the summary of the responses provided in Table 4-3, it can be seen that the majority of the respondents saw demand for at least 50 fixed berths at the Port of Warrnambool in the short term.

A number of respondents indicated that they saw immediate need for the coast guard and professional fishing fleet to have access to fixed berths. Long waiting lists for berths at Port Fairy and the significant growth of Warrnambool and in recreational fishing in the region were cited as reasons why a minimum of 50 berths would be met by existing latent demand for fixed berths at Warrnambool.

A number of respondents also indicated they saw the potential for in excess of 100 recreational berths in the long term at Warrnambool.

4. *The Western Coastal Boards Boating Coastal Action Plan (2010) has recommended the Port of Warrnambool as a location to provide a State Marine Precinct level of service in the long term.*

Question: In your own words, describe the type and mix of services and facilities that would you like to see incorporated into a significantly expanded Port of Warrnambool in the long term.

Table 4-4 Summary of Comments Provided for Question 4 of Survey

| No. | Summary of Comments Provided |
|-----|---|
| 1 | Anything that makes Boating and the launching and retrieval of vessels safer and easier |
| 2 | An upgrade of Viaduct Road |
| 3 | A slipway and hard stand for commercial and private vessels |

| | |
|----|--|
| 4 | Fuel availability at all times |
| 5 | Penned moorings |
| 6 | Toilet facilities with 24 hour access (Currently there is none after dark) |
| 7 | Additional commercial and food and drink premises. |
| 8 | Signage |
| 9 | Safe access must be given to the amateur fisherman |
| 10 | Marine Radio Station and aerials |
| 11 | Provision of safe waters protected from wave and surge action. |
| 12 | Port manager/ control facility with emergency and security management infrastructure. |
| 13 | Heavy lift appliance(s) – for removal of engines, commercial fishing catches and other items. |
| 14 | Capability to berth Navy patrol boats – national importance. |
| 15 | Fixed berths |
| 16 | Freshwater wash down at boat ramps and fixed berths |
| 17 | Replenishment facilities including fuel and water. |
| 18 | Environmental containment facilities for oil spills etc |
| 19 | Waste management facilities – greywater, sewage, refuse. |
| 20 | Public transport to and from Warrnambool shopping and restaurant precincts. |
| 21 | Toilets and showers in proximity of beach, proposed family boating area and boat ramp areas. |
| 22 | Covered picnic facilities in proximity to proposed family boating area. |
| 23 | Improvements for those wanting to safely fish from shore e.g. safe access onto any proposed breakwaters/ seawalls |
| 24 | Facilities could be considered through a masterplan process which consider environmental, economic and social impacts. |
| 25 | Vastly improved lighting facilities at ramp for night time use |
| 26 | Enabling land based anglers better access to fishing Lady Bay |
| 27 | Better access to beach areas in front of Harbour Pavillion and facilities for horse trainers and beachgoers |
| 28 | Marine centre/tourist attraction/interpretive centre |
| 29 | No commercial shopping as the area becomes congested as it is during peak holiday time. |

From the summary of the responses provided in Table 4-4, it can be seen that a wide variety of facilities and services have been suggested. Responses included suggestions for both marine and land based infrastructure, commercial facilities (although this was not universal), safety, access, environmental, and tourism opportunities. It is evident from the responses received that the Port of Warrnambool currently serves a wide variety of user groups / different interests.

5. *A broad range of commercial, recreational and community stakeholders currently utilise the Port of Warrnambool precinct. Significant expansion of the Port has the potential to impact upon various stakeholders use and enjoyment of the Port and surrounding environment.*

Question: In your own words, what do you see as the main concerns for any upgrade of the Port of Warrnambool?

Table 4-5 Summary of Comments Provided for Question 5 of Survey

| No. | Summary of Concerns Raised |
|-----|--|
| 1 | Traffic control systems (Signs) in place for designated parking areas are insufficient |
| 2 | Consideration should be given to opening up the area currently not used between the Lady Bay Hotel complex and the Harbour Pavilion. This large area could be utilised for vehicle / trailer parking as well as tourist parking. |
| 3 | No loss of any enjoyment of any of the beach areas in Warrnambool. |
| 4 | Any commercial development should possibly be restricted to the northern aspect of the Pavilion area |
| 5 | In constructing a Marina the infrastructure for dredging should be incorporated in any structure. |
| 6 | Impact on the environment, heritage values, aesthetics and beaches is very important and achieving minimal impact in these areas will enhance attraction for recreational users. |
| 7 | Restrictions imposed as a result of modifications to the Port, or interruption to port activities during upgrades. |
| 8 | A register of stakeholder requirements should be established to determine dependencies and constraints. |
| 9 | Continuing management of kelp washed up on foreshore. |
| 10 | Navigational safety within the Port and in approaches under all conditions e.g. poor visibility. |
| 11 | Competition for resources in relation to other Council initiatives. |
| 12 | Placement of spoils from any dredging required |
| 13 | Attracting events to the Port and surrounds e.g. national and state competitions such as: kite surfing, surf life saving, waveski surfing, surfing etc |
| 14 | Expanded harbour and more vessels may result in increased risk of marine pests spreading from other ports |
| 15 | Expanded Port with new facilities will create more usage so carparking will be an issue. |
| 16 | Quality of viaduct road will be a major factor |
| 17 | Significant expansion of the port carries little negative effects that cannot be easily eliminated with careful planning |

There was considered to be general sentiment amongst respondents that expansion of the Port of Warrnambool could be achieved through appropriate investment in planning, infrastructure, and

management. Concerns for the future upgrade of the Port of Warrnambool included environmental impacts and traffic, amenity constraints.

5. PLANNING PROVISIONS

The local planning scheme zones and overlays that are applicable to the Port of Warrnambool and surrounding study area have been reviewed in the following sections. The planning scheme sets out policies and provisions for the use, development and protection of land in the study area and subsequently informs the consideration of options to provide safer boating and harbour facilities at the Port of Warrnambool. The local planning controls also contain a list of the information requirements which would need to be provided through a planning permit and/or planning scheme amendment process as part of the implementation phase of any Port improvement options.

5.1 Zones

The relevant planning zones in the vicinity of the study area are displayed in Figure 5-1 and summarised below:

- The foreshore (north of Breakwater Road) is zoned Public Park and Recreation Zone.
- The foreshore (south of Breakwater Road) is not zoned, but is shown in the Planning Scheme.
- Breakwater Road is zoned Road Zone – Category 2.
- The coastline is not zoned, but is shown in the Planning Scheme.
- The marine environment and marine infrastructure are not zoned (with the exception of Breakwater Road), but are shown in the Planning Scheme.

In summary, it is evident that the Port and immediate foreshore area are not currently zoned.

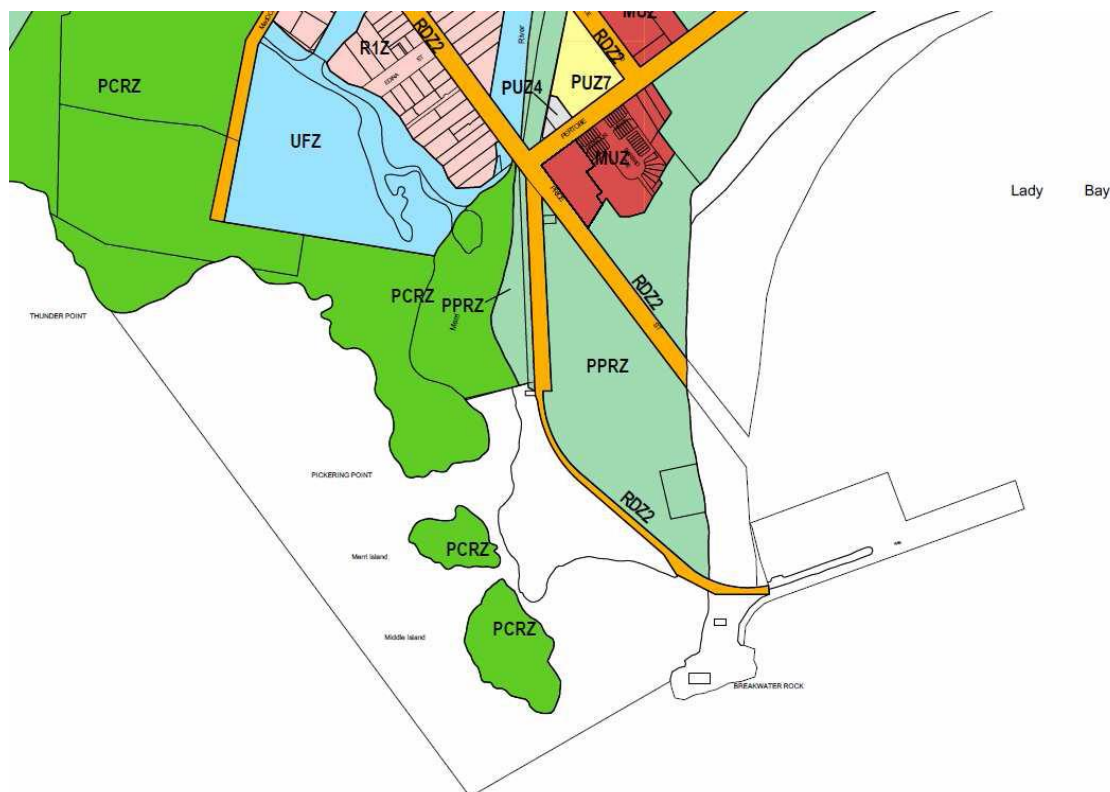


Figure 5-1 Planning Zones

5.2 Overlays

The following planning overlays are applicable to the Port of Warrnambool and immediate surrounds:

Clause 43.01: Heritage Overlay – Schedule 19 - Warrnambool Breakwater, *Viaduct and Harbour, Breakwater Road, Warrnambool*

The Heritage Overlay (HO19) has been applied to the Port of Warrnambool. The Heritage Overlay seeks to conserve places of heritage significance, and ensure that development does not compromise the significance of heritage places. The Schedule to the Heritage Overlay identifies the subject land as included on the Victorian Heritage Register (Ref No. H2124). The subject land (or parts thereof) are of local and State significance.

Clause 42.01: *Environmental Significance Overlay (ESO1 – Coastal Environs)*

Environmental Significance Overlay 1 (ESO 1) has been applied to the Port of Warrnambool and adjoining land along the Warrnambool coastline. The ESO identifies land of environmental value and seeks to protect these values from adverse impacts. An extract from the Statement of Significance from ESO1 is provided overleaf:

“The Breakwater Harbour/Lady Bay area is Warrnambool’s main beach and foreshore reserve and is identified in the Victorian Coastal Strategy as a tourism node. It is important that the environmental qualities of the coast are maintained through the protection of the indigenous coastal vegetation (described in 21.09 of the MSS) and the maintenance of the coastal dune system which can be significantly affected by erosion, pest plants and animals and the impact of settlement. Coastal areas especially in the west have been identified as high potential recharge areas. Potential impacts of development on the water table must be considered.”

Of relevance to this project, the ESO (amongst many considerations) establishes the following policy statement:

“Development should not significantly alter the morphology of watercourses, estuaries, lagoons, coastal outlets, offshore bars and the like. Interference with the natural processes of deposition and erosion should only occur where there is an overriding public need.”

The ESO contains a list of information requirements which must be provided through a planning permit process. The ESO would also be considered as part of any Planning Scheme Amendment process. The ESO also triggers the consideration of any relevant strategy or policy prepared by the Victorian Coastal Council and the relevant Coastal Management Board including the Victorian Coastal Strategy and any relevant Coastal Action Plan.

Clause 42.03: *Significant Landscape Overlay – Schedule 1 (SLO1 – Coastal Hinterland Landscape Area).*

The Significant Landscape Overlay 1 (SLO1) has been applied to part of the study area as part of a significant landscape and to conserve and enhance the character of the significant landscape. The Statement of Significance is as follows:

“Warrnambool is the largest coastal city in Victoria, and is bordered by scenic coasts. The proximity of the Hopkins and Merri rivers to the coast also gives the rivers, their estuaries and the coasts important landscape qualities. Coastal and coastal hinterland views are of significance to residents, visitors and the tourist industry.”

The SLO contains a list of information requirements which must be provided through a planning permit process. The SLO would also be considered as part of any Planning Scheme Amendment process.

6. DESIGN CRITERIA AND CONSIDERATIONS FOR PORT OPTIONS ASSESSMENT

The options assessment for the Port has required consideration of the following key design criteria and constraints:

- Formal engineering design guidelines, particularly related to wave condition criteria for boat ramps and small craft harbours
- Consideration of the priorities and preferences identified by the reference group from the questionnaire responses
- Relevant planning scheme controls and overlays.
- Consideration of the sediment transport processes in the study area to ensure that siltation of the Port could be managed and that the options did not adversely impact the shoreline of Lady Bay.

The critical design criteria and constraints that were adopted to inform and evaluate the options assessment for the Port are discussed in more detail below:

Wave Climate Criteria

The Australian Standard Guidelines for Design of Marinas (AS3962) provides only the following limited direction on appropriate wave conditions for the design of boat ramps:

- Sheltered from waves larger than 0.2m
- Aligned into the dominant waves from swell

Options were therefore considered that limited annual wave height exceedance to below 0.2m significant at the boat ramp. As discussed previously in Section 2.2, the presence of significant long wave activity in the Port will limit the ability to mitigate surge motions at the boat ramp. These waves propagate at frequencies which cannot be practically mitigated, even if a fully enclosed harbour were to be constructed at Warrnambool. The surging motions generated by long waves are likely to remain the most critical constraint limiting the functionality and safety of the boat ramp. However, reducing the diffracted short wave energy at the boat ramp to below 0.2m under all but the most extreme conditions will mitigate the magnitude of the surge motions on the boat ramp and significantly improve safety and the ability to launch and retrieve vessels under all conditions.

The Australian Standard Guidelines for Design of Marinas (AS3962) provides specifications of wave climate conditions for small craft harbours. The specifications provide a range of wave height criteria for various recurrence intervals, incident wave directions and wave periods for vessel berths to achieve either 'moderate', 'good' or 'excellent' wave climate conditions.

The relevant wave height criteria, assuming oblique incident wave conditions, for the consideration of potential mooring areas as part of the options assessment are displayed in Table 6-1.

Table 6-1 Oblique Wave Height Criteria for Vessel Berths

| Wave Climate | Significant Wave Height (m) | |
|--------------|-----------------------------|-------------|
| | 1 year ARI | 50 year ARI |
| Moderate | <0.375m | <0.5m |
| Good | <0.3m | <0.4m |
| Excellent | <0.23m | <0.3m |

Sediment Transport Processes

Sedimentation of the Port and study area more generally is an ongoing, long term process that will require active management to enable the Port to function in the future. The sediment transport processes occurring in the vicinity of the Port are problematic for the following reasons:

- The longshore transport is driven by longshore currents associated with gradients in wave setup along Lady Bay which cannot be directly mitigated.
- A portion of the sediment transport in the Port appears to occur through onshore migration which is difficult to mitigate.
- The sediment is particularly fine grained such that it can be mobilised and transported by relatively minor wave and current action

The complete elimination of sediment transport and sedimentation impacts in the Port is considered unlikely to be achievable, even with a fully enclosed harbour. However, the impacts of sedimentation can be mitigated and managed. A critical design objective for the options assessment has therefore been to incorporate features into the options that will mitigate the rate of sedimentation of the Port and prevent the sedimentation from impacting the Ports function between maintenance dredging campaigns.

The assessment of options for the Port must also be able to demonstrate that the options will not significantly impact the morphology of the coastline and offshore areas as per the policy statement contained with the Environmental Significance Overlay.

Boat Ramp

The stakeholder consultation identified a number of constraints associated with the existing boat ramp facility. To improve the utility of the existing boat ramp facility, the options assessment has included an upgraded boat ramp facility concept.

Mooring Capacity

A constraint on the consideration of options to improve the wave conditions at the boat ramp was that the options could not impact the total number of swing moorings in the Port without offsetting any loss by creation of additional swing mooring capacity and/or development of fixed berth capacity within the Port. The stakeholder consultation also identified that there was likely to be existing demand for at least 50 berths at the Port. The consideration of options for the Port therefore required that options provided the opportunity to develop the capacity for approximately 50 moorings in the Port. The preference was for these mooring to be fixed berths however improved swing mooring and/or piled mooring options were also considered.

Low Landing Project

The Council is currently (2011) upgrading the lower landing at the breakwater. The project includes the construction of a new timber landing from the old breakwater boat ramp, connecting to the existing lower landing. The lower landing contains a turning node to allow vehicles to turn on the lower landing. The total project cost estimate is \$650,000 (WCC, 2010). The options considered in this study have been developed to ensure the investment in the Port infrastructure associated with the Lower Landing Project can be incorporated into the safer boating and harbour facilities study options.

Breakwater Heritage Status

The breakwater was gazetted on the Victorian Heritage Register in 2009 due to its historical significance as one of the most important maritime engineering projects in Victoria in the late nineteenth century. While gazetting of the breakwater does not necessarily preclude the adaptive reuse and/or new development on or adjacent to the breakwater, it does require that options are considered that retain the cultural heritage significance of the registered place and its setting. The

extent to which options may impact upon the heritage values of the breakwater have required consideration in terms of the location and construction methods and materials proposed.

State Marine Precinct Designation

The Port of Warrnambool has been recommended as a location to provide a State Marine Precinct level of service (WCC, 2011). This designation implies that significant expansion of the Port facilities is envisaged in the long term if found to be feasible. The scope and objectives of this project have not specifically requested the consideration of options to develop State Marine Precinct levels of infrastructure and services at the Port of Warrnambool. However, consideration of these long term objectives have informed the consideration of options to provide safer boating and harbour facilities in the medium term, to ensure the options considered in this study would compliment and/or could be incorporated into a significantly expanded Port facility if found to be feasible in the long term.

7. OPTIONS ASSESSMENT

Based on the design criteria outlined in Section 6, two primary concepts have been assessed and developed for the Port. The two concepts that have been considered are referred to as follows:

- Option 1 – Spur Breakwater
- Option 2 – Detached Breakwater

Each option has been tested and refined in the spectral wave model to determine the wave climate characteristics and sediment transport impacts. A concept layout and overview of the key design components, construction considerations and options and costs are also provided for each option.

7.1 Options Overview

The principle component of both options is an additional breakwater structure. The size and period of the waves requiring attenuation in the Port are such that only full depth breakwater options can be considered for the Port of Warrnambool.

Option 1 is a spur breakwater attached to and orientated normal to the existing breakwater. The spur breakwater would significantly reduce the amount of diffracted wave energy at the boat ramp and create a semi enclosed basin in its lee which would provide the opportunity to provide fixed berth capacity within the Port.

Option 2 is a detached breakwater located within the lee of the existing breakwater. The detached breakwater would also significantly reduce the amount of diffracted wave energy at the boat ramp and create conditions in its lee that would provide the opportunity to establish a piled mooring field that could accommodate a significantly greater number of vessels than can be presently accommodated by swing moorings.

Both options include the construction of a shore normal groyne to the north of the Port. The groyne has been located to reduce the longshore transport component of the sedimentation in the Port area.

The following analysis of the breakwater options has been undertaken:

- Section 7.2 summarises the wave modelling analysis undertaken to optimise the breakwater configurations and assess wave climate conditions at the boat ramp.
- Section 7.3 summarises the analysis of the sediment transport impacts of the breakwater options and the optimisation of the groyne location and length.
- Section 7.4 summarises key design components and construction considerations of each option.

- Section 7.5 summarises of order construction cost estimates for the main elements of each option.
- Section 7.6 summarises the key processes and investigations likely to be required to implement either option.

7.2 Wave Climate Conditions Analysis

The wave conditions in the Port have been tested in the spectral wave model to optimise the breakwater configurations to provide the best possible wave climate under design wave conditions. The wave conditions within the Port have been assessed under both south west and south east design wave directions for the 1, 50 and 100 year ARI design wave heights. Consideration of local wind generated waves within Lady Bay has also informed the design of the breakwater alignments.

7.2.1 Option 1 – Spur Breakwater

The length and location of the spur breakwater along the existing breakwater has been designed with the following considerations:

- Placement of the spur breakwater within the lee of the existing breakwater significantly reduces the incident design wave heights at this structure and will significantly reduce the cost and complexity of constructing the spur breakwater.
- The further seaward the spur breakwater is placed along the existing breakwater, the greater the amount of diffracted wave energy that is able to impact the boat ramp and low level landing in its lee. In addition, if the spur breakwater is located at the seaward end of the existing breakwater, it will cause a wave shadow zone along the western section of Lady Bay and significant increase the rate of sedimentation along the shoreline and is to be avoided.

A number of iterations, trialling different spur breakwater lengths and locations along the existing breakwater, were tested in the spectral wave model until an optimal arrangement was identified.

Figure 7-1 displays the comparison of significant wave heights under existing conditions and the final Option 1 spur breakwater configuration for 1 year ARI design south west wave conditions.

Figure 7-2 displays the comparison of significant wave heights under existing conditions and the final Option 1 spur breakwater configuration for 1 year ARI design south east wave conditions.

From Figure 7-1 and Figure 7-2 it can be seen that spur breakwater significantly reduces wave heights within the lee of the breakwater including at the boat ramp and the low level landing. The reduction in wave heights is greatest for the south east wave conditions. The predicted wave heights in the lee of the spur breakwater are considered to meet good to excellent wave climate conditions for berthed vessels. The area in the lee of the spur breakwater would still be exposed to local wind waves generated within Lady Bay from the north to north east and this exposure has been mitigated by incorporating a north westward hook on the end of the spur breakwater. The available fetches from these directions are however not significant enough to enable wind waves to be generated under design wind speed scenarios that would exceed 'good' berthed wave climate conditions.

It is also noted from Figure 7-1 and Figure 7-2 that the spur breakwater has only very minor impact on wave heights and directions outside the immediate Port area along the Lady Bay shoreline and this is considered to limit the impact of the option on sediment transport processes along the Lady Bay shoreline.

Table 7-1 displays a summary of the predicted design wave heights at a location immediately seaward of the end of the boat ramp for both design wave directions and relevant recurrence interval wave heights. As can be seen from Table 7-1, significant wave heights are predicted to be

reduced by approximately 75% and are less than the 0.2m wave height criteria for boat ramps under all design wave conditions.

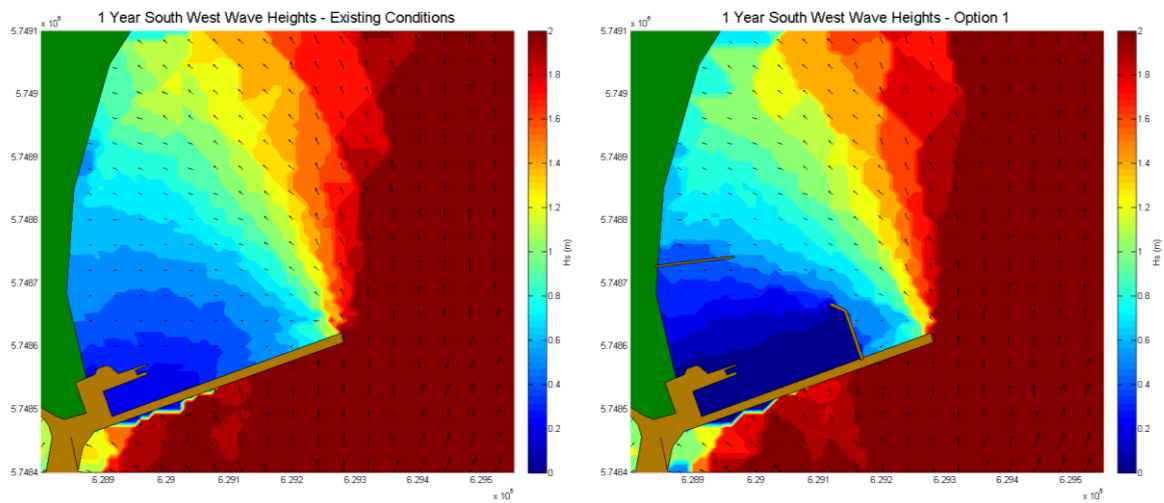


Figure 7-1 Option 1 – 1 Year South West Design Wave Conditions

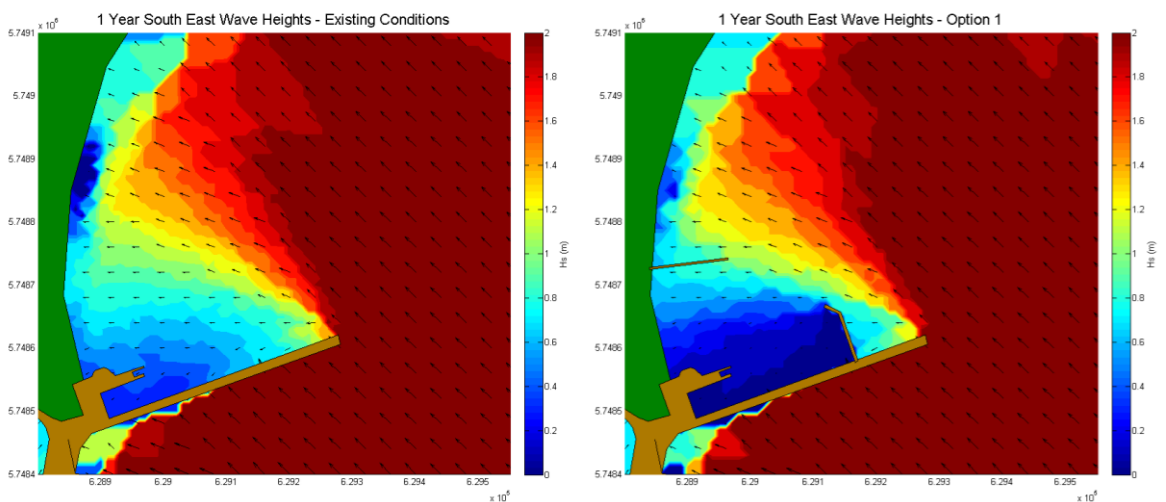


Figure 7-2 Option 1 – 1 Year South East Design Wave Conditions

Table 7-1 Comparison of Design Wave Heights at Boat Ramp for Option 1

| ARI | SW | | SE | |
|-------|----------|----------|----------|----------|
| | Existing | Option 1 | Existing | Option 1 |
| 1yr | 0.37 | 0.08 | 0.59 | 0.13 |
| 50yr | 0.40 | 0.09 | 0.78 | 0.19 |
| 100yr | 0.40 | 0.09 | 0.79 | 0.19 |

7.2.2 Option 2 – Detached Breakwater

The detached breakwater configuration has been tested in the spectral wave model to optimise its location and orientation to provide the best possible wave climate at the boat ramp and for moored vessels under design wave conditions. Achieving appropriate attenuation of wave energy at the boat ramp with the detached breakwater options was relatively difficult to achieve in practice and the length and orientation of the breakwater required several iterations in the model to achieve acceptable results.

The distance between the detached breakwater and the existing breakwater has been reduced to the minimum of 30m required for safe navigation through this entrance. This relatively small distance still however enables wave energy to propagate through this gap and into the lee of the detached breakwater, slightly increasing wave heights in the breakwaters lee compared to the spur breakwater option.

Figure 7-3 displays the comparison of significant wave heights under existing conditions and the final Option 1 detached breakwater configuration for 1 year ARI design south west wave conditions.

Figure 7-4 displays the comparison of significant wave heights under existing conditions and the final Option 1 detached breakwater configuration for 1 year ARI design south east wave conditions.

From Figure 7-3 and Figure 7-4 it can be seen that the detached breakwater will significantly reduce wave heights within the lee of the breakwater including at the boat ramp and low level landing. The reduction in wave heights is greatest in the immediate lee of the breakwater. The predicted wave heights in the lee of the spur breakwater are considered to meet moderate to good wave climate conditions for berthed vessels. The detached breakwater option also provides good protection to the boat ramp and mooring areas in its lee to locally generated wind waves from the north east.

Similarly to Option 1, it is noted that the detached breakwater has only very minor impact on wave heights and directions outside the immediate Port area along the Lady Bay shoreline and this is considered to limit the impact of the option on sediment transport processes along the Lady Bay shoreline.

Table 7-1 displays a summary of the predicted design wave heights at a location immediately seaward of the end of the boat ramp for both design wave directions and relevant recurrence interval wave heights. As can be seen from Table 7-1, significant wave heights are predicted to be reduced by approximately 50% or greater and are close to the 0.2m wave height criteria for the boat ramp under 1 year ARI wave conditions.

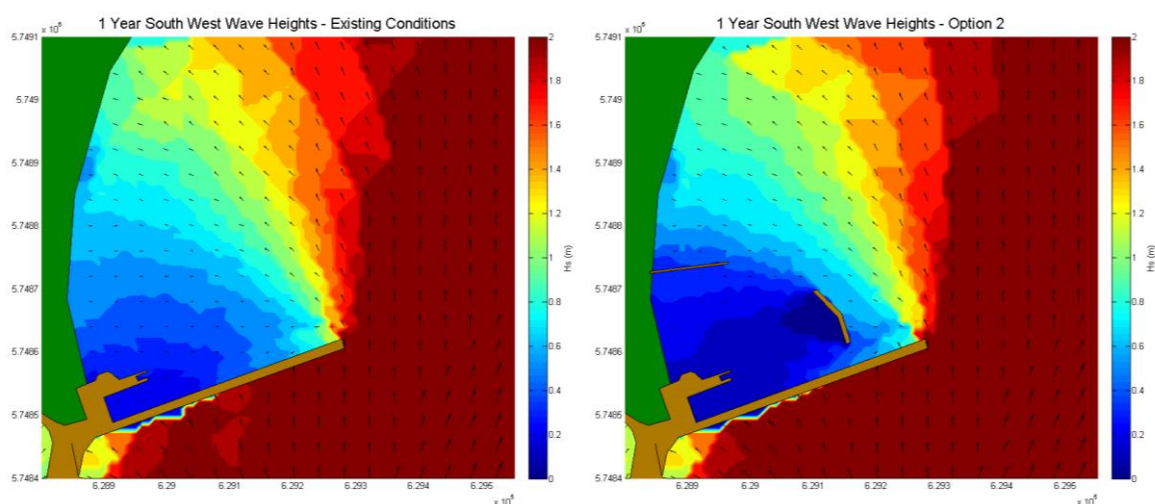


Figure 7-3 Option 2 – 1 Year South West Design Wave Conditions

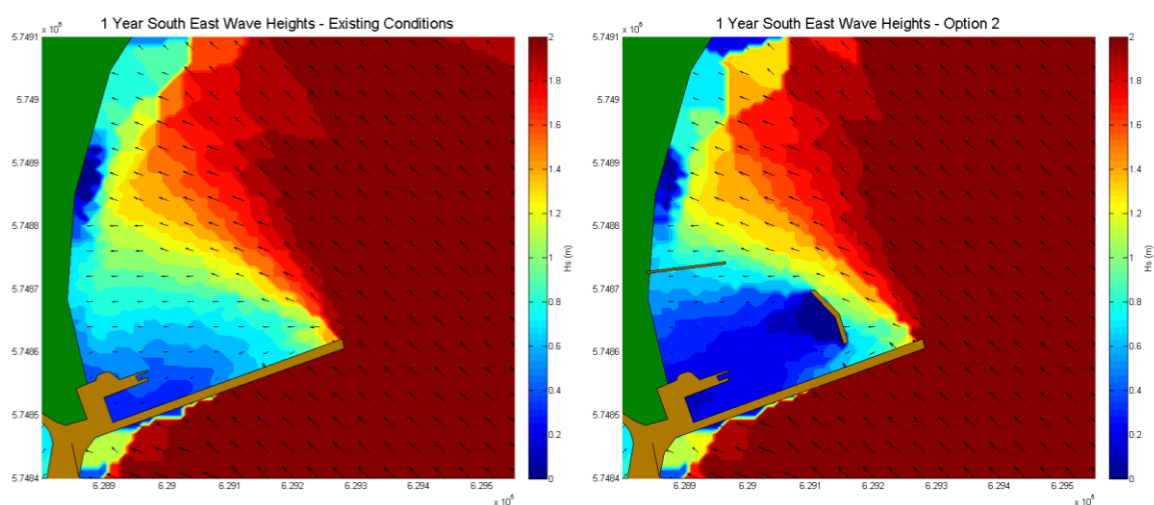


Figure 7-4 Option 2 – 1 Year South East Design Wave Conditions

Table 7-2 Comparison of Design Wave Heights at Boat Ramp for Option 1

| | SW | | SE | |
|-------|----------|----------|----------|----------|
| | Existing | Option 2 | Existing | Option 2 |
| 1yr | 0.37 | 0.16 | 0.59 | 0.24 |
| 50yr | 0.40 | 0.17 | 0.78 | 0.33 |
| 100yr | 0.40 | 0.17 | 0.79 | 0.33 |

7.3 Sediment Transport Impact

To mitigate the rate of sedimentation of the Port, a shore normal groyne located approximately 200m north of the main breakwater, has been incorporated into both options. The purpose of the groyne is to mitigate the longshore migration of sediment into the Port. The groyne will achieve this principally by deflecting the longshore current, generated by the gradient in wave setup along Lady Bay, offshore at the location of the groyne. This will prevent the current from transporting sediment into the Port and will result in sediment slowly accumulating on the northern side of the groyne.

The potential impact of the breakwater options, including groyne, on sediment transport processes in the study area has been tested in the spectral wave model and hydrodynamic model to identify changes to the distribution of wave heights and directions and residual currents in the study area associated with the construction of the breakwater options and groyne. The location and length of the groyne was optimised as part of this modelling process.

The extent of the wave shadow zone and any changes to wave directions associated with the breakwater options has been assessed with the spectral wave model under representative 3.0m, 14s south west swell conditions. The spectral wave model results under existing conditions have been compared to the results predicted with the two breakwater options to enable the differences to be directly observed.

Figure 7-5 displays the difference in significant wave heights and comparison of the peak wave direction vectors within the study area for Option 1 relative to existing conditions. From Figure 7-5 it can be seen that the extent of the wave shadow zone is confined to the immediate vicinity of the Port. No significant changes to peak wave directions are expected outside of the immediate vicinity of the Port along the Lady Bay shoreline. The localised impact of Option 1 on waves in Lady Bay is considered to indicate that there will be minimal impact on wave driven sediment transport processes and currents outside the immediate Port area with this option.

Figure 7-6 displays the difference in significant wave heights and comparison of the peak wave direction vectors within the study area for Option 2 relative to existing conditions. From Figure 7-6 it can be seen that the extent of the wave shadow zone is also confined to the immediate vicinity of the Port. No significant changes to peak wave directions are also expected outside of the immediate vicinity of the Port along the Lady Bay shoreline. The localised impact of Option 2 on waves in Lady Bay is considered to indicate that there will be minimal impact on wave driven sediment transport processes and currents outside the immediate Port area with this option.

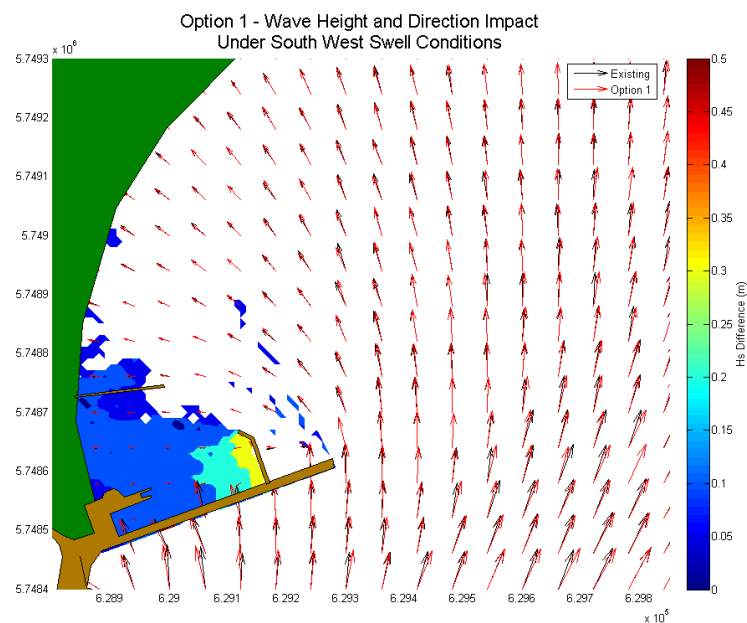


Figure 7-5 Option 1 – Wave Height and Direction Impact under South West Swell Conditions

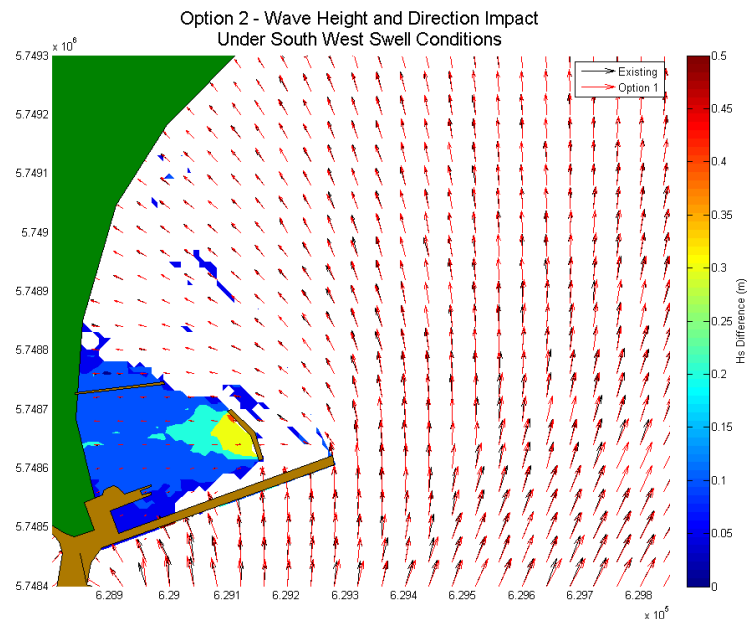


Figure 7-6 Option 2 – Wave Height and Direction Impact under South West Swell Conditions

The impact of the groyne on the longshore current speeds and directions under typical south west swell conditions has been analysed in the hydrodynamic model and are displayed in Figure 7-7 for Option 1 and Figure 7-8 for Option 2. Figure 7-7 and Figure 7-8 show that for both options, the groyne will deflect the longshore current seaward and sediment carried by this current will be deposited adjacent to the groyne and along the shoreline north of the groyne. The rate of accretion of sediment north of the groyne is likely to be in the order of 2,000 – 4,000 m³/yr based on the longshore transport potentials determined in Section 3. Overtime, the accretion of sediment on the northern side of the groyne would be expected to increase the rate at which the shoreline is prograding seaward compared to existing conditions.

The slow onshore drifting of sand by wave action into the Port is still expected to continue with both options. The magnitude of this transport is however relatively small and the attenuation of wave action by the breakwaters should reduce the rates of onshore sediment drifting by wave action further. Additional mitigation of the sediment transport impacts in the Port have been incorporated into the concept layout options for the Port by the inclusion of sediment traps as part of the dredge basin.

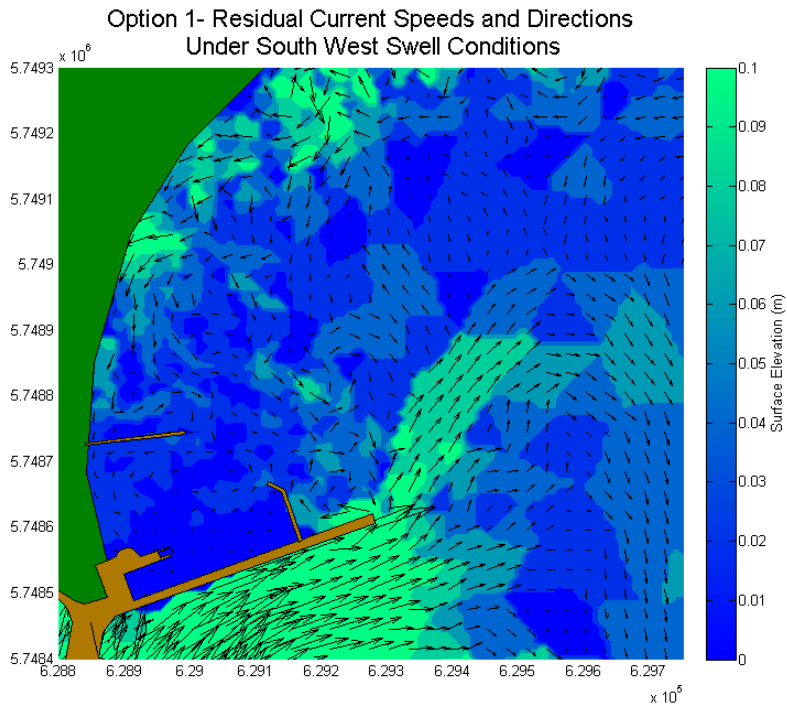


Figure 7-7 Option 1 – Residual Current Speeds and Direction under South West Swell Conditions

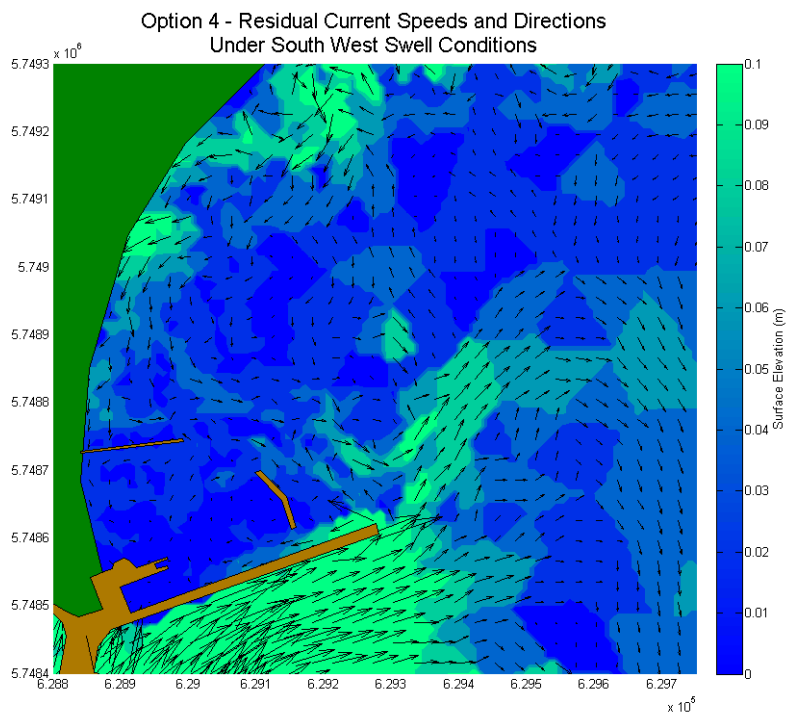


Figure 7-8 Option 2 – Residual Current Speeds and Direction under South West Swell Conditions

7.4 Key Design Elements

The schematic breakwater and groyne options assessed in the previous sections have been further developed into conceptual layout options for the Port of Warrnambool. The conceptual layouts are displayed for Option 1 and Option 2 in Figure 7-9 and Figure 7-10 respectively.

The following sections summarise the key design components of the two breakwater options for the Port of Warrnambool.

7.4.1 Breakwater

Spur Breakwater

The spur breakwater is approximately 110m in total length, with the final 30m oriented to the north west to provide additional protection from wind waves generated within Lady Bay from the north through to north east.

There are multiple options for the construction of the spur breakwater. These options have different trade offs in terms of cost, aesthetics and functionality. Given the gazetted heritage status of the existing breakwater, it is considered more likely that options that provide a spur breakwater with a similar form, colour and texture to the existing breakwater would more readily achieve approval. This constraint is likely to rule out a traditional rubble mound type breakwater option. A rubble mound breakwater is however likely to be the cheapest construction method.

It would therefore be proposed to construct the spur breakwater from pre cast concrete units that would be lowered over piles and filled with rubble to secure the units to the seabed. The top of the units could be capped with concrete. The spur breakwater would be required to be a non-overtopping structure as vessel berths and floating walkways would be located in its immediate lee. This is likely to require a crest elevation of approximately greater than 4.0m AHD. Some toe protection in the form of rock armour stones may be required to be laid on the seaward side of the spur breakwater to mitigate scour associated with wave reflections off the vertical walls of the spur breakwater

Detached Breakwater

The detached breakwater is proposed to be approximately 110m in total length. The detached breakwater may be constructed as a typical rubble mound breakwater or alternatively, it would be possible to construct the breakwater from large geotextile containers filled with dredge spoil and anchored to the seabed. The geotextile construction option would require approximately 7,000 – 10,000m³ of dredge spoil to fill the geotextile containers to create a breakwater crest height of approximately 3.5m AHD.

7.4.2 Dredge Basin

A dredge basin would be constructed to 3.3m Lowest Astronomical Tide for both Option 1 & 2 to enable keel boats up to approximately 25m in length to access the Port at all stages of the tide. An approach channel with a minimum width of 30m would also be established and maintained for both options. To limit the impact of ongoing sedimentation in the vicinity of the Port, sediment traps would be dredged to the north of the basin to capture drifting sediment before it can impact drafts within the basin and approach channels. The total volume of capital dredging required to establish the dredge basin and sediment traps for Option 1 has been calculated as approximately 35,000m³. The total volume of capital works dredging required to establish the dredge basin and sediment traps for Option 2 has been calculated as approximately 30,000m³

Disposal options for the dredge spoil are considered a significant constraint. It is proposed to utilise some relatively minor amounts of the total dredge spoil volume as material to fill the geotextile groynes and the detached breakwater and for reclamation adjacent to the low landing. However,

disposal of the majority of the dredge spoil will be required. The following options have been considered for disposal of the dredge spoil:

- The dredge spoil could be pumped onto the beach on the northern side of the proposed groyne. However, given the volume of dredge spoil this would result in a significant widening of the beach and would increase the rate at which sediment may begin to bypass the end of the groyne and contribute to siltation of the Port. This option is therefore not recommended.
- The dredge spoil could be disposed of to land, either immediately adjacent to the Port or trucked to another location. However, because the sediment is predominately calcium carbonate it may not necessarily be appropriate for all land based fill applications.
- The dredge spoil could be pumped along the seabed to the eastern section of Lady Bay where the sediment would be slowly drifted onshore and to the east, away from the western end of Lady Bay and the Port.

7.4.3 Groyne

The groyne is required to be approximately 150m long (measured from the top of the active beach), to mitigate the longshore current and associated sediment transport. The groyne will extend to a mean depth of approximately 2.5m and will need to extend to a height of approximately 1.5m AHD.

It is proposed to construct the groyne from geotextile tubes that are hydraulically filled with dredge spoil from the excavation of the dredge basin. The filling of the geotextile tubes to create the groyne will require approximately 1,500 – 2,000m³ of sediment.

7.4.4 Mooring Capacity

Option 1 – Spur Breakwater

The spur breakwater option provides the opportunity to establish fixed berth capacity at the Port with access via gangways from the existing breakwater. A preliminary layout has been developed that would provide capacity for approximately 50 fixed berths within the lee of the spur breakwater.

Two floating pontoon walkways accessed via gangways from the existing breakwater would provide approximately 36 fixed berths for vessels up to approximately 13m, including a 28m wide interior fairway.

Space for a further 12-15 fixed berths for vessels up to and exceeding approximately 15m can be provided along the edge of the existing breakwater. It is anticipated that these berths would be provided preferentially to the Coast Guard and commercial fishing fleet.

Option 2 – Detached Breakwater

The detached breakwater option provides the opportunity to establish a small number of fixed berths at the Port with access via the existing breakwater. A preliminary layout incorporating approximately 10 fixed berths has been developed. It is anticipated that these berths would be provided preferentially to the Coast Guard and commercial fishing fleet. Capacity to safely moor approximately 26 additional vessels is provided by establishing a piled mooring field in the lee of the detached breakwater to provide for and aft mooring. Access to these vessels would require a tender, launched from the main breakwater or shoreline.

7.4.5 Boat Ramp

To alleviate constraints on the use of the boat ramp and safety concerns raised by the stakeholder consultation, an upgraded boat ramp facility has been proposed for both options incorporating the following:

- Increasing the widths of the boat ramp lanes as per AS 3962 guidelines and incorporating a third lane to ease congestion during peak periods.
- Providing separate queue and launch/retrieval lanes including a wider turning radius as per AS3962 guidelines to improve the efficiency in which boats can be launched and retrieved from the ramp.
- Provide separated pedestrian access to a new jetty and floating pontoon including fish cleaning facilities

There are presently 44 designated boat trailer parking bays adjacent to the boat ramp. Guidelines for a regional boat ramp suggest approximately 30-40 boat trailer parking bays are provided per boat ramp lane to cater for peak periods. This would indicate approximately 100 designated boat trailer parking bays are likely to be required if the boat ramp facility was upgraded to three lanes and wave and draft constraints were mitigated. Within the current parking area there is unlikely to be sufficient space to cater for this number of boat trailer parking bays. However, additional boat trailer parking space may be able to be developed on land adjacent to the existing parking area.

7.4.6 Reclamation and Temporary Berths

The area between the boat ramp and existing breakwater and adjacent to the new lower landing could be upgraded to provide additional temporary mooring capacity as it provides good access to the car park for loading and unloading passengers and/or supplies. Alternatively, sewerage pump out and refuelling capability could be provided at this location.

It is proposed to reclaim the most shoreward 30 metres of this area as the underlying reef is expected to prevent this area from being dredged to the total depths required.

The widths between the boat ramp and the existing breakwater are sufficient to enable access by vessels up to approximately 15m in length. However, dredging of this area is likely to require the foundations of the boat ramp to be sheet piled to prevent undermining

7.5 Cost Estimates

Of order construction costs for each of the main elements of the Option 1 – Spur Breakwater concept has been prepared and is displayed in Table 7-3. The total construction costs, including contingencies, are estimated at approximately \$5.3M for Option 1.

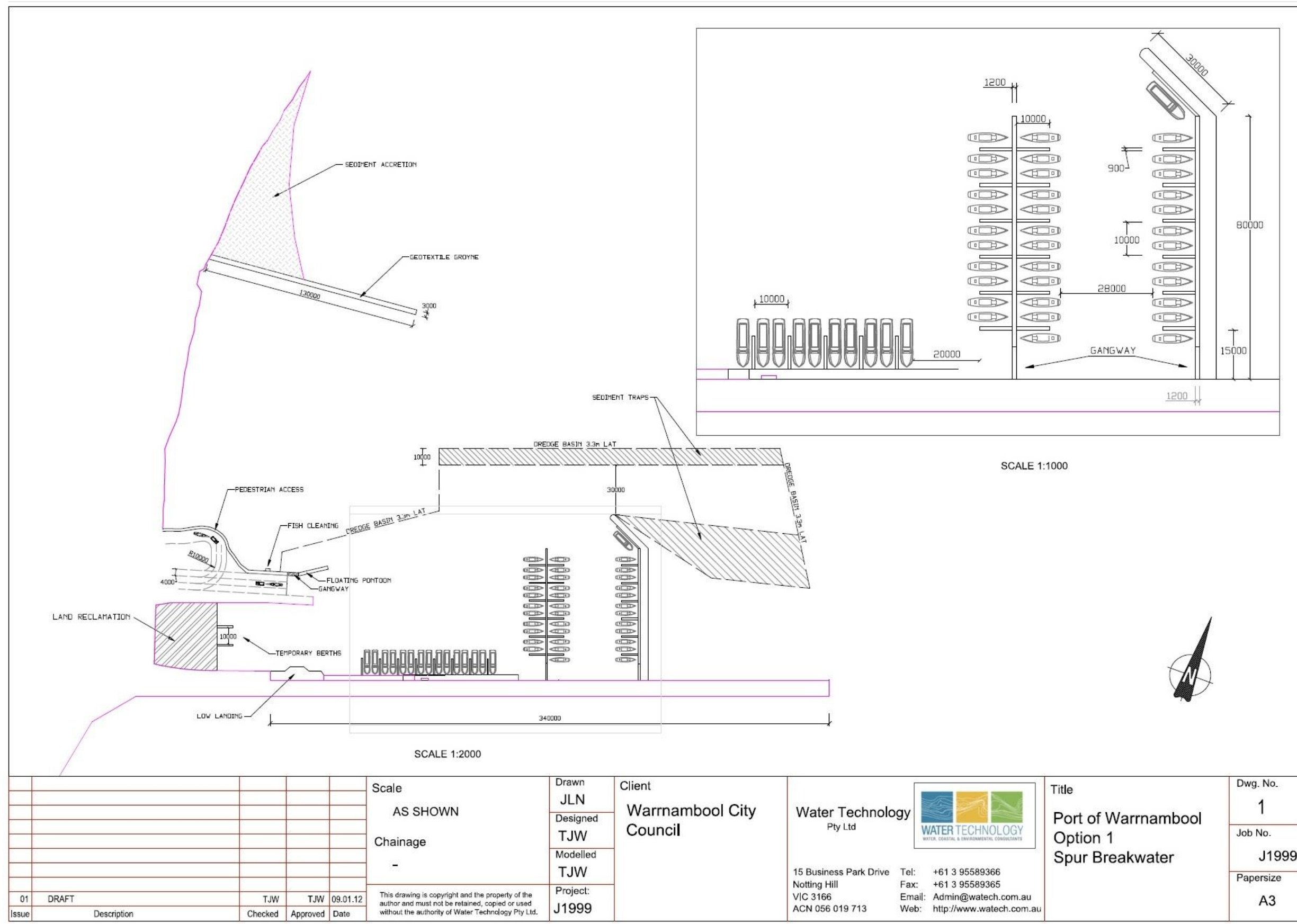
Of order construction costs for each of the main elements of the Option 2 – Detached Breakwater concept has been prepared and is displayed in Table 7-4. The total construction costs, including contingencies, are estimated at approximately \$4.3M for Option 2.

Table 7-3 Option 1 – Spur Breakwater Indicative Implementation Costs

| Option 1 Element | Cost (\$) | Notes |
|--|--------------------|--|
| Spur Breakwater | \$1,100,000 | 110m @ \$10,000/m |
| Dredge Basin | \$1,050,000 | ~35,000m ³ @ \$30m ³ |
| Groyne | \$500,000 | 150m length, ~2,000m ³ dredge spoil |
| Boat Ramp Upgrade | \$750,000 | Reclamation, shore protection, surface treatment, jetty and floating pontoon |
| Berths/Moorings | \$1,000,000 | ~50 @ \$20,000/berth |
| Reclamation and Temporary Berths | \$300,000 | ~2,500m ³ reclamation, sheet piling |
| Total Construction Cost (+ 20% Contingency) | \$5,600,000 | |
| Detailed Design Costs | \$225,000 | @ 4% of construction costs |
| Construction Management and Supervision | \$390,000 | @ 7% of construction costs |
| Total Implementation Cost | \$6,200,000 | |

Table 7-4 Option 2 – Detached Breakwater Indicative Implementation Costs

| Option 2 Element | Construction Cost (\$) | Notes |
|--|------------------------|---|
| Detached Breakwater | \$1,600,000 | 110m @ \$15,000/m |
| Dredge Basin | \$900,000 | ~30,000m ³ @ \$30m ³ |
| Groyne | \$500,000 | 150m length, ~2,000m ³ dredge spoil, 15 * 20m geotextiles @ \$7,500/each |
| Boat Ramp Upgrade | \$750,000 | Reclamation, shore protection, surface treatment, jetty and floating pontoon |
| Berths/Moorings | \$350,000 | ~10 @ \$20,000/berth, 50 piles @ \$3,000 |
| Reclamation and Temporary Berths | \$300,000 | ~2,500m ³ reclamation, sheet piling |
| Total Construction Costs(+ 20% Contingency) | \$5,300,000 | |
| Detailed Design Costs | \$212,000 | @ 4% of construction costs |
| Construction Management and Supervision | \$370,000 | @ 7% of construction costs |
| Total Implementation Cost | \$5,900,000 | |



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| | | | | | Scale | AS SHOWN | Drawn | JLN | Client | Warrnambool City Council | Water Technology Pty Ltd |  15 Business Park Drive Notting Hill VIC 3166 ACN 056 019 713 | Tel: +61 3 95589366 Fax: +61 3 95589365 Email: Admin@watech.com.au Web: http://www.watech.com.au | Title | Port of Warrnambool Option 1 Spur Breakwater | Dwg. No. | 1 |
| | | | | | Chainage | - | Designed | TJW | | | | | | Job No. | J1999 | | |
| | | | | | Modelled | TJW | Project: | J1999 | | | | | | Papersize | A3 | | |
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| Issue | Description | Checked | Approved | Date | | | | | | | | | | | | | |

Figure 7-9 Option 1 – Spur Breakwater Conceptual Layout

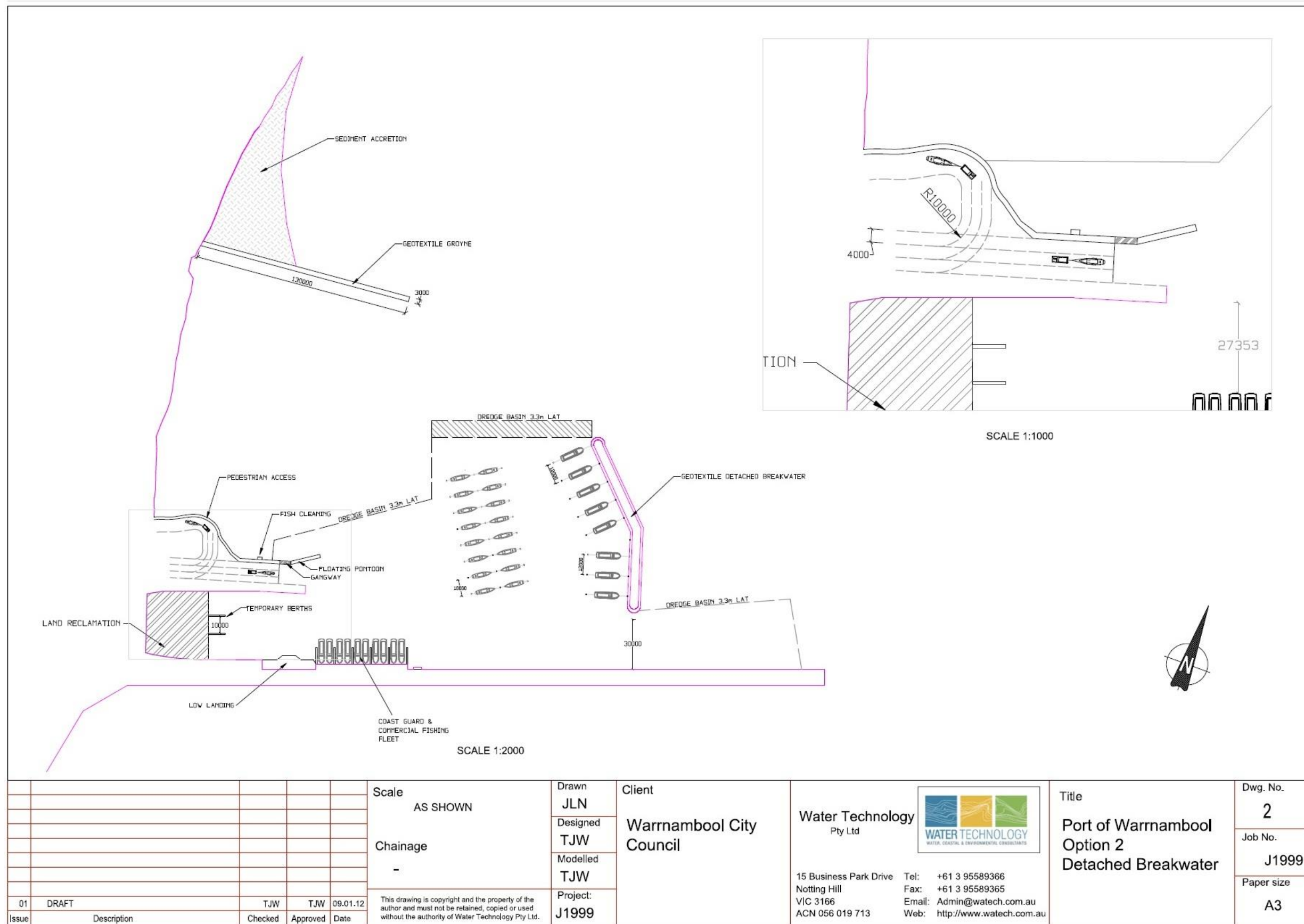


Figure 7-10 Option 2 – Detached Breakwater Conceptual Layout

7.6 Potential Environmental Impacts

The potential environmental impacts associated with the two options investigated for the Port of Warrnambool are considered to generally relate to the following:

- Disturbance of the seabed associated with dredging and spoil disposal
- Accretion of sediment north of the groyne and advancement of Lady Bay shoreline seaward

These potential impacts are discussed in more detail below.

Dredging and Spoil Disposal

The capital works dredging will disturb the seabed and associated benthic flora and fauna existing within the dredge basin. It is however noted that the seabed in much of the area proposed to be dredged represents an already disturbed environment due to previous maintenance dredging of the Port.

The process of dredging tends to cause fine sediments to be entrained into the water column which can create turbid plumes around the dredge area. These turbid plumes can reduce the penetration of light through the water column and the settling of the fine sediments in the plumes can smother benthic flora and fauna in the vicinity of the dredge area. The sediments to be dredged are however comprised of clean, fine sand and dredging of these sediments would not be expected to generate large or prolonged turbid sediment plumes and the sediment particles would be expected to settle out relatively quickly around the immediate vicinity of the dredging works.

If offshore disposal of the dredge spoil from the Port was found to be the only viable long term option for the dredge spoil from the Port, then the disposal of dredge spoil via this method could potentially have some impacts on the receiving environment. Investigations would be required to identify a location where the disposal of dredge spoil could be undertaken without significant environmental impact. It is noted that historical spoil grounds do exist in the vicinity of the Port associated with the historical sea disposal of dredge spoil.

Sediment Accretion

Vast quantities of sand have accreted in the western section of Lady Bay and Port following the construction of the breakwater and closure of the viaduct. This has resulted in the advancement of the shoreline in the western section of Lady Bay by over 300 metres over the last approximately 150 years. The process of sediment accretion is still continuing today (albeit at a slower rate), as evidenced by the ongoing seaward advancement of the western Lady Bay shoreline and the decline in depths and requirements for maintenance dredging of the Port.

In order to provide for a functional Port and limit the amount and frequency of maintenance dredging, a groyne is proposed to be constructed to the immediate north of the Port to reduce the volume of sand being transported into the Port. Therefore, sand that would have otherwise ended up within the Port would be deposited close to the existing shoreline on the northern side of the groyne. Overtime, the additional accretion of sand on the northern side of the groyne is likely to result in the shoreline advancing seaward at a slightly faster rate than this shoreline would have otherwise advanced.

As the shoreline slowly advances, pioneering vegetation will begin to colonise the back beach areas and they will ultimately be converted into the vegetated dune system that presently covers much of the area between the Viaduct Road and the shoreline.

An option to reduce the additional rate of shoreline advance associated with the groyne construction would be to periodically dredge sand from the shoreline immediately north of the groyne, as part of maintenance dredging of the Port, to remove this sediment from the system and reduce the rate at which the shoreline advances.

7.7 Implementation

Implementation of either option would be anticipated to take a minimum of 3 years and require the following additional investigations and approval processes to be undertaken:

7.7.1 Public Consultation

The options developed in this study should be exhibited for public comment. Feedback from the public would provide an opportunity to gauge the public's acceptance of the options developed in this study for the Port of Warrnambool and assist to identify and refine the preferred option.

7.7.2 Detailed Engineering Design

Additional technical investigations and detailed design will be required to support regulatory approval applications, refine costings and enable construction works to be tendered. The following detailed engineering investigations are likely to be required:

- Geotechnical Investigations – Geotechnical investigations will be required to confirm sediment depths within the proposed dredge basin, assess foundation requirements of the existing and proposed breakwaters, reclamation, boat ramp and piling
- Coastal/Maritime Engineering – Detailed engineering design of the breakwater, dredge basin, boat ramp and vessel berths will be required.
- Traffic and Parking – An improved traffic and parking plan will be required to cater for increased traffic volumes and parking requirements associated with either option.

7.7.3 Approvals

Based on the review of planning provisions, the study area is recognised as of landscape, environmental, and heritage importance. The following approval processes would therefore be likely to apply to either of the two options developed in this study:

Planning and Environment Act 1987

It is likely that a planning permit may be triggered under the provisions of the Public Park and Recreation Zone, Heritage Overlay, Environmental Significance Overlay, and Significant Landscape Overlay (all of which apply to parts of the site). A detailed planning report, plans, and associated technical reports would be required to support a planning application.

In the event that larger scale development and expansion of the Port was envisaged, including more comprehensive onshore development, Council would need to undertake an amendment to the Planning Scheme. This would provide an opportunity to include all of the subject land within a site specific zone (ie: Special Use Zone) to allow an appropriate range of potential future uses as part of the long term development of the Port of Warrnambool.

Heritage Act 1995

The subject land is included on the Victorian Heritage Register. A permit will be required from Heritage Victoria to alter a heritage place. The application will be required to be prepared by a qualified Heritage Architect and supported by detailed plans.

Environmental Effects Act 1978

The Environmental Effects Act 1978 (the EEA Act) provides that where proposed works may have a significant effect on the environment, either a proponent or a decision-maker may refer these works (or project) to the Minister for Planning for advice as to whether an Environment Effects Statement (EES) is required. Information regarding the project would

need to be submitted to the Minister for Planning in requesting advice as to whether an EES was required. The Ministerial response may impart conditions which need to be adhered to in order to avoid EES approval. Draft Concept Plans and technical studies should be provided to the Minister for consideration.

Environment Protection and Biodiversity Conservation Act 1999

The Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act) provides for the protection of the environment, especially matters of national environmental significance (NES). Under the EPBC Act, a person must not take an action that has, will have, or is likely to have a significant impact on any of the matters of NES without approval from the Australian Government Environment Minister or the Minister's delegate. The purpose of a referral is to obtain a decision on whether the proposed action will need formal assessment and approval under the EPBC Act. Advice should be sort as to the ecological values of the subject land and whether referral is required under the EPBC Act. Referral should only be submitted to the Federal Environment Minister if agreement to a Draft Concept Plan has been obtained (Council resolution).

Coastal Management Act 1995

Proposals to use or develop coastal Crown land must gain written consent under the Coastal Management Act 1995 (the CMA) from the Department of Sustainability and Environment (DSE). The consent process applies to all coastal Crown land, regardless of status in a planning scheme and ensures that the Crown has the opportunity to represent the broader public interest in matters affecting the coast and seabed. CMA consent can only be granted based on detailed plans that would normally form part of a planning permit application. We would suggest however that 'In principle consent' based on Draft Concept Plans be obtained in advance to determine any issues, up front. A section 40 (Coastal Management Act 1995) consent for a dredging application would also need to be submitted as part of the Coastal Management Act consent.

7.8 State Marine Precinct Expansion Option

The primary objective of this study has been to identify and assess options that provide safer boating and harbour facilities for the Port of Warrnambool. However, the Port of Warrnambool has been recommended as a location to provide a State Marine Precinct level of service (WCC, 2011).

A State Marine Precinct incorporates facilities of national, state, regional and local significance and includes the following criteria:

- A State level of significance that provides a key boating and tourist destination.
- A high level of investment as a key boating activity centre.
- An exceptional level of service that caters for a wide range of boating activity and skill levels.
- Provides a safe harbour and controlled water space.
- Services a wide catchment area at major population centres.
- Provides all tide access.
- Provides public access to the facility and coastal environment and servicing facilities.
- Commercial shipping activities may be present.

This recommendation was based largely on the fact that Warrnambool is the largest coastal city in the Western coastal region and has a significant regional population as well as existing breakwater and boat ramp infrastructure.

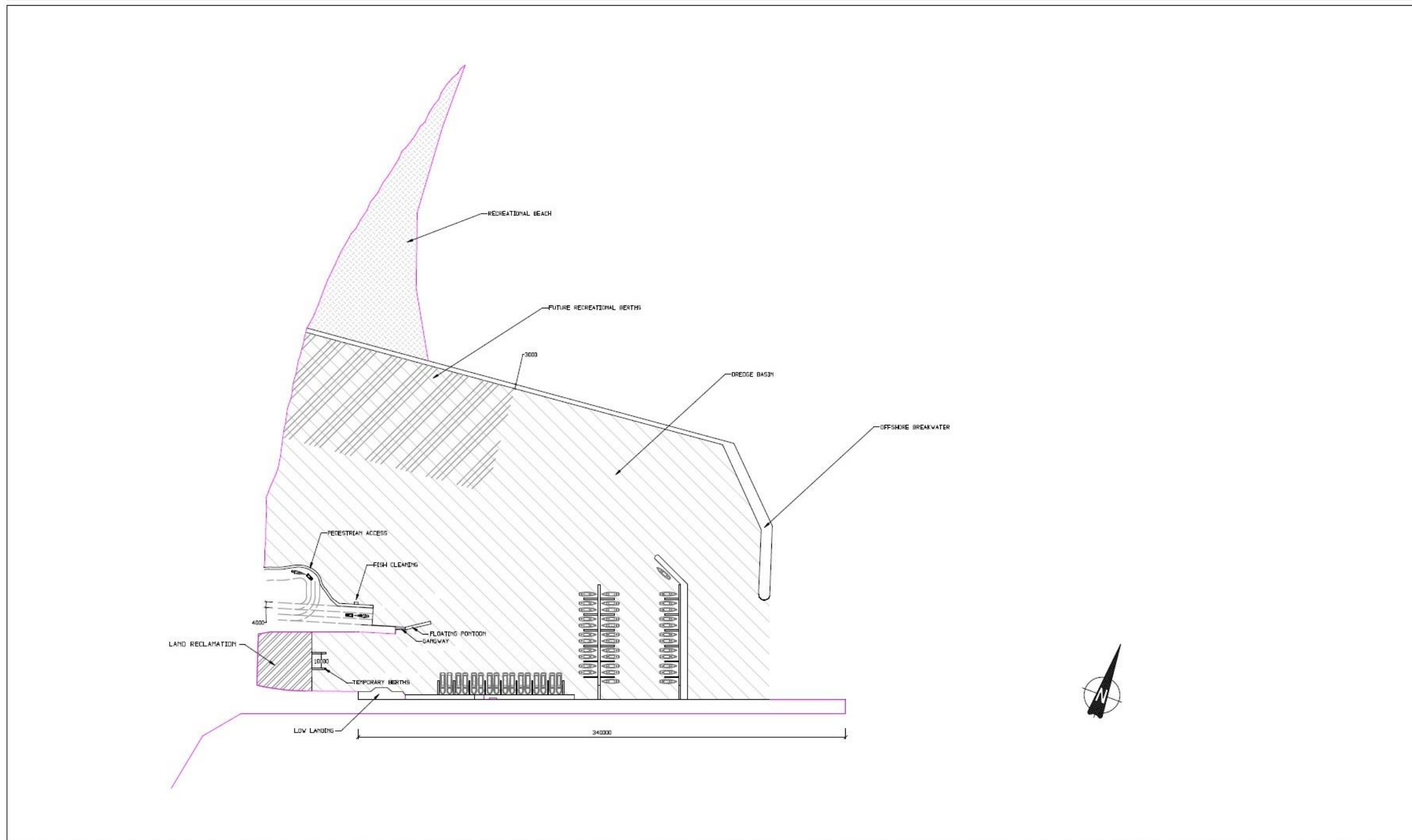
However, from a coastal engineering perspective, there are considered to be a number of constraints on the ability of the Port of Warrnambool to provide State Marine Precinct levels of service. These constraints require more detailed investigation to establish the feasibility of establishing a State Marine Precinct at the Port of Warrnambool over the long term. These constraints are considered to include the following:

- There is significant long wave activity in Lady Bay generated by the interaction of the high energy wave climate and relatively shallow depths. The creation of a fully enclosed harbour at the Port of Warrnambool will not necessarily mitigate long wave impacts and wave and current conditions at the boat ramp and for berthed vessels in an enclosed harbour at the Port of Warrnambool may never achieve conditions that would be considered commensurate with a State Marine Precinct.
- Any significant expansion of the Port of Warrnambool is likely to modify the incident wave conditions along the Lady Bay shoreline which will result in changes to the sediment transport processes. This is likely to result in long term changes to the alignment of the Lady Bay shoreline which would require extensive investigations and ongoing management.
- The lack of natural deep water will require capital dredging and ongoing maintenance dredging to maintain depths within the harbour and approaches. Options for the disposal of significant volumes of capital works dredge spoil and ongoing maintenance dredging would need to be identified early in the planning of any major expansion of the Port of Warrnambool.

Subsequent investigations may be able to identify appropriate engineering solutions to overcome or mitigate the above constraints.

As part of future feasibility assessments of harbour layouts for any major expansion of the Port of Warrnambool, it is proposed that consideration is given to the harbour concept provided in Figure 7-11. The southern entrance layout provided in Figure 7-11 is considered to have the following advantages:

- The harbour layout concept would enable the spur breakwater and to a slightly lesser degree, the detached breakwater option, to be incorporated into an enclosed harbour.
- The southern entrance provided in this concept is unlikely to experience sedimentation impacts to the same degree as alternative north facing entrances over the long term.
- The southern entrance is considered to provide safer navigation of the entrance under large sea conditions than a north facing entrance.



| | | | | | | | | | | |
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| | | | | | Chainage - | Designed TJW | | | | Job No. J1999 |
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Figure 7-11 State Marine Precinct Expansion Concept

8. CONCLUSIONS & RECOMMENDATIONS

An assessment of options to provide safer boating and harbour facilities at the Port of Warrnambool has been undertaken. The assessment has included the collection and analysis of wave data in the Port to enable options to improve the wave climate to be tested within a validated numerical wave model of the study area. A comprehensive review of the sediment transport processes and magnitudes has been undertaken to assist in identifying options for mitigating the impacts of sedimentation on the Port. In order to inform the consideration and development of options for the Port, stakeholders have been consulted to assist in identifying the critical constraints and priorities for providing safer boating and harbour facilities at the Port of Warrnambool.

Two options for providing safer boating and harbour facilities have been developed to a concept stage including testing and refinement of the options with wave and hydrodynamic models of the study area. Of order construction costs and approval requirements for these options have been documented.

The following main conclusions and recommendations are provided from the safer boating and harbour facilities option assessment for the Port of Warrnambool.

Wave Climate

The exposure of the boat ramp and swing mooring to wave action was consistently identified by the Port stakeholders as an immediate constraint to providing safer boating and harbour facilities.

Analysis of the frequency spectrum of the wave measurements in the Port revealed however that a significant component of the wave energy in the Port is associated with long waves. Mitigation of waves at these frequencies is often not practically achievable.

The swell and wind wave components of the wave energy in the Port can however be mitigated to improve wave conditions at the boat ramp and provide improved mooring capacity and functionality within the Port. Long wave energy is likely to be less problematic for moored vessels and the wave climate under both options would be appropriate to enable fixed berth capacity to be developed within the Port.

Both options developed in this study will significantly reduce the amount of wave action and surging motions at the boat ramp. Neither option will however completely eliminate surging motions on the boat ramp due to the amount of long wave energy generated within Lady Bay. Expectations of 'mill pond' conditions at the boat ramp under all conditions in the Port of Warrnambool is unlikely to be practically achievable, even with a fully enclosed harbour. Improved education and awareness of the mechanism generating surging motions at the boat ramp is recommended to enable users of the boat ramp to properly prepare for and assess the risks of launching and retrieving vessels from the boat ramp.

Sedimentation and Sediment Transport Processes

Sedimentation and resulting impact on drafts within the Port was also identified as a high priority for providing safer boating and harbour facilities.

Sedimentation of the Port and study area more generally is an ongoing, long term process that will require active management to enable the Port to function effectively in the future. The complete elimination of sediment transport and sedimentation impacts in the Port is considered unlikely to be achievable, even with a fully enclosed harbour, however these impacts can be mitigated and managed.

The development of a shore normal groyne to the north of the Port will deflect a longshore current generated by gradients in wave setup along Lady Bay. In combination with wave action, this current

transports fine sediments into the lee of the main breakwater. The groyne will cause these sediments to accrete on the northern side of the groyne instead of within the Port.

The development of sediment traps as part of the capital works dredge basin construction will assist in limiting the impact of onshore drifting of sediment into the Port.

A commitment and corresponding funding to undertake regular maintenance dredging in the Port of Warrnambool will be required in association with the implementation of either option developed in this study.

An appropriate, long term option for the disposal of capital and ongoing maintenance dredge spoil needs to be identified to enable the options developed in this study to be implemented.

Boat Ramp

Functionality and safety constraints on the use of the boat ramp were identified by the Port stakeholders. To alleviate these constraints, both options incorporate an upgraded boat ramp concept including the addition of a third lane and widening of the existing lanes. Separate queue and launch/retrieval lanes, including a wider turning cycle radius are proposed to improve the efficiency and ease with which boats can be launched and retrieved from the ramp. Separated pedestrian access to a new jetty and floating pontoon are provided in the concept plan to improve safety of pedestrians.

Options to increase the number of dedicated boat trailer parking bays to approximately 100 will be required as part of the traffic and parking planning for the implementation of either of these options.

Mooring Capacity

The consideration of options to improve wave conditions at the boat ramp could not impact the total number of swing moorings in the port without offsetting any loss by creation of additional swing mooring capacity and/or alternative mooring capacity. Port stakeholders also identified existing demand for at least 50 berths or moorings within the Port.

Option 1 – Spur breakwater provides the opportunity to establish approximately 50 fixed berths at the Port for a range of vessels sizes up to and including 15m. These berths would be accessed from the existing breakwater.

Option 2 – Detached breakwater provides the opportunity to establish approximately 10 fixed berths at the Port with access via the existing breakwater. Capacity to safely moor an additional 26 vessels is provided by establishing a piled mooring field in the lee of the detached breakwater to provide for and aft mooring. Access to these vessels would require a tender, launched from the main breakwater or shoreline.

Breakwater Heritage Status

The study has included consideration of options and their construction methods that would endeavour to retain the cultural heritage values of the existing breakwater.

The method proposed for the construction of the spur breakwater option provides a breakwater option that would have a similar form, colour and texture to the existing breakwater.

The detached breakwater option provides an alternative option that would be considered to have less direct impact on the heritage values of the existing breakwater as it would be separated from existing breakwater and can be constructed with a lower crest elevation.

Potential Environmental Impacts

It is considered that the environmental impacts of the harbour options are largely limited to disturbance of the seabed associated with dredging and spoil disposal and the accretion of sediment

north of the groyne resulting in additional seaward advancement of the Lady Bay shoreline in the vicinity of the groyne. Mitigation measures have however been identified to appropriately manage these potential impacts.

Implementation

The options developed in this study should be exhibited for public comment to gauge the public's acceptance of the options developed and assist to identify and refine the preferred option. Additional technical investigations and detailed design will be required to support regulatory approval applications, refine costings and enable construction works to be tendered.

A minimum of three years for implementation of either option would be anticipated.

State Marine Precinct Expansion

A conceptual layout for incorporating the safer boating and harbour options developed in this study into an enclosed harbour option to provide State Marine Precinct levels of service at the Port of Warrnambool has been proposed.

More investigations are required to determine the feasibility of establishing a significantly expanded harbour at the Port of Warrnambool given the range of engineering, planning and environmental constraints that currently exist.

9. REFERENCES

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APPENDIX A REFERENCE GROUP QUESTIONNAIRE RESPONSES