St Kilda Marina

Environmental & Coastal Hazard Assessment

City of Port Phillip

07 February 2018

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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Client Project Manager	Steven McKellar
Water Technology Project Manager	Joanna Garcia-Webb
Water Technology Project Director	Christine Lauchlan-Arrowsmith
Authors	OMN, RJD, JGW, JK, CD
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15 Business Park Drive
Notting Hill VIC 3168

Telephone	(03) 8526 0800
Fax	(03) 9558 9365
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Steven McKellar
Senior Project Manager Climate Adaptation and Sustainability
City of Port Phillip
99a Carlisle Street, St Kilda
Via email Steven.Mckellar@portphillip.vic.gov.au

Dear Steven

Environmental & Coastal Hazard Assessment

We are pleased to present our report for the environmental and coastal hazard assessments in relation to the St Kilda Marina.

Yours sincerely

Joanna Garcia-Webb
Assistant Group Manager – Coastal | Senior Coastal Engineer

joanna.garcia-webb@watertech.com.au

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1 INTRODUCTION

The St Kilda Marina, one of Melbourne's largest facilities, has been managed by Australian Marinas (Australasia) since 1969. The current 50-year lease is due to expire in April 2019. Located adjacent to the St Kilda and Elwood foreshore areas (refer Figure 1-1 for locality), the City of Port Phillip (CoPP) is the Crown Land Manager. The expiry of the head lease in 2019 presents an opportunity for CoPP to embark on an integrated planning process to review the long-term use of the site. This process will aim to produce a tender document for a new lease or leases that will maximise the social, economic and environmental benefits of St Kilda Marina to the municipality and the Victorian Government. It will consider community and key stakeholder needs and desires through progressive urban design and environmentally sustainable practice.

Water Technology was engaged by CoPP to undertake an environmental and coastal hazard assessment to define the extent of existing coastal hazards, and potential future coastal hazards associated with climate change at the site of the St Kilda Marina. This project supports the planning process by considering the opportunities and constraints in the context of existing marine and land ecosystems, inclusive of flora, fauna, and water quality, whilst also considering coastal hazard vulnerability and the exposure to climate change impacts such as sea level rise, storm surge and coastal erosion.

FIGURE 1-1 MARINA LOCATION AND STUDY AREA TOPOGRAPHY

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1.1 Site Details

The study area extends to the north of the marina to Brookes Jetty, and to the south to Point Ormond, bounded to the east by Marine Parade. It includes MO Moran Reserve and the public open space adjacent to Elwood Canal. Figure 1-1 provides the locality plan and extent of the study area. The key features of the site are shown in Figure A-1 in Appendix B. The ocean side of the marina is protected by a rock seawall along its entire length; the seawall extends to the southern limit of the study area.

The marina has the following facilities:

- 7 floating finger jetties providing wet berths for both boats and jet skis; 5 land-backed floating jetties for long-term moorings, short term tie-up, and access to the works area.
- Boat trailer and car parking facilities
- Dry boat storage: partially covered stacks as well as hard stand area
- Public access boat ramp; 2 private boat ramps providing marina access to the boats stored in the hard stand areas
- Boat services including fuel dock, sales, detailing, anti-fouling, maintenance, marine trimming, and timber work
- Two restaurants

1.2 Assessment Approach

To capture the environmental significance of the marina and its surrounding context, the overall study approach is as follows:

- Hydrographic Survey
- Environmental Assessment, addressed separately by:
  - Marine Ecosystems
  - Terrestrial Ecology
  - Water Quality
  - Environmental Management of the Marina
- Coastal Hazard Vulnerability Assessment
- Expansion Impact Analysis and Advice

2 TOPOGRAPHY AND BATHYMETRY

The site consists of dry areas above typical tidal water levels, as well as areas that are below sea level. Bathymetric survey of the site undertaken by Farren Group (Drawing STK38, 20/12/2017; full survey drawing presented in Appendix B) as well as Vicmap Elevation Coastal topographic data from DELWP (Department of Land, Water and Planning) is shown in Figure 1-1. Combining these two datasets allows for a 3D representation of the land and underwater topography.

The harbour ranges from a depth of -2.5 to -2.0m AHD and appears to have been dredged regularly to maintain access and acceptable draft for boating activities. Outside the Marina the southern end of St Kilda beach slopes at an approximate 1 in 70 grade towards the Marina dredge channel, where a clear change in bathymetry is visible due to dredging activities. The northern side of the Marina displays a gradual offshore slope of approximately 1 in 30, steeper than St Kilda beach.

The Marina assets have a level ranging from water level to 3.4m AHD, with different assets located at different levels. The floating jetties at the time of the survey are the lowest lying part of the site at approximately water level, however as these are floating can therefore move up with higher water levels. The carpark area is typically at 2.2 – 2.9m AHD and other hardstand areas on the ocean side of the site of the site at 2.5 – 1.5m AHD, grading down away from the ocean. The highest part of the site is in the southern carpark. The seawall that protects the site on the northern side has a varying crest level of approximately 2.5m AHD.

To the south of the marina, the foreshore reserves is consistently above 2 m AHD. The crest of the seawall is approximately 1.5 – 2 m AHD.

3 MARINE ECOSYSTEMS

3.1 Description & Condition of Marine Habitats

The study area contains four general habitats: sandy seabed and rocky reef/boulders outside the marina; and, soft sand/silt seabed and artificial hard substrates (piles, pontoons, walls) inside the marina.

Documentation of marine habitat conditions used towed underwater video outside the marina and underwater photography, video, visual inspection and sediment jet-probing by scientist divers inside the marina. Video, photographic and written records were analysed by qualified marine biologists to compile a list of marine species within each habitat type, as well as a description of the condition, state and value of marine habitats.

The field assessment took place on 23 December 2017. Heavy rain over preceding days meant water clarity was reduced. Underwater visibility for the survey was fair. The survey provides a snapshot of the habitats in the area and identifies the key species present at the time of the survey.

3.1.1 St Kilda Marina Habitats

The area inside the marina has no appreciable currents or waves. The seabed within the marina is mostly soft sediment of variable depth over harder clay. The soft sediments have a high proportion of fine silt due to the quiescent conditions. Waters within the marina had very low clarity at the time of the survey and were perhaps murkier than normal due to recent rain. The key species associated with soft sediments within the marina are infauna (a range of small worms, crustaceans and molluscs), microphytobenthos (benthic microalgae), drifting filamentous red algae (Griffithsia sp.), the introduced Mediterranean Fan Worm (Sabella spallanzanii) and North Pacific Seastar (Asterias amurensis) and gobies (burrow dwelling fish). A smooth stingray (Bathytoshia brevicaudata) was sighted during the survey – these very large rays are commonly sighted around boat ramps, where they scavenge discarded fish.

The artificial hard substrates within the marina provide habitat for a different range of species. The concrete piles support a profuse growth of sponges, ascidians and seaweed, as do the floating pontoons. Seaweeds grow most profusely on the floating pontoons – these make ideal habitat for seaweeds as they remain at a constant shallow depth providing the algae with plenty of sunlight in the otherwise low-clarity marina waters. Sea lettuce (Ulva) was particularly abundant at the time of the survey. The introduced Wakame kelp Undaria pinnatifida had clearly been abundant in spring but had mostly died back to its reproductive sporophylls by the time of this survey. Filamentous red algae including Griffithsia were also abundant. Mussels grow abundantly on the sides and undersides of the pontoons, out of reach of their main predator - seastars. The introduced Mediterranean Fan Worm was also very common on the floating pontoons. The concrete walls around the marina have a less dense cover of marine growth comprising mostly the green algae Ulva (sea lettuce) and ascidians (sea squirts).

The species found within St Kilda Marina are typical of quiescent, artificial environments in northern Port Phillip Bay. Some of the most common biota are introduced species – most introduced marine species originate from ports and harbours in other parts of the world and are best adapted to these environments.

Marinas tend to accumulate fine sediment over time due to the low current speeds and lack of flushing. Sediment becomes muddy and is generally anaerobic a short distance below the surface – St Kilda Marina is no exception.

Images of the habitats and species within the marina are provided in Appendix C, together with a list of species identified.

3.1.2 Adjacent Habitats

Aerial imagery of the surrounding area indicates seabed habitats are predominantly unvegetated sandy seabed and sandbars with small areas of patchy seagrass and hard seabed (reef, boulder) nearshore. Figure 3-1 shows an aerial image of the area overlaid with the bathymetric survey and habitat classifications from towed underwater video. Maximum depths in the area are around 5-6 m. The seabed slopes gently from the beach, meaning most seabed is less than 4-5 m deep. Areas of rocky reef and boulder are shallow – less than 2-3 m depth, and areas of seagrass are mostly less than 4 m deep. The aerial image shows large areas of bare sand (light coloured seabed), patchy seagrass (dark blotches) and rocky seabed (dark areas nearer to shore south of the marina and around Pt Ormond.

Bare sand provides habitat for a range of burrowing infauna (beyond the scope of this assessment). Unattached green seaweed Codium fragile fragile or 'broccoli weed' was the only conspicuous biota over bare sand. Sandy seabed contains a variable proportion of shell.

There are small patches of sandy seabed which provide habitat for the subtidal seagrass Heterozostera nigricaulis (showing up as darker blotches in aerial imagery). The patchy growth habitat of seagrass is typical of this species in areas of Port Phillip Bay exposed to some wave action and sand movement. There is a patch of seagrass immediately north of the marina entrance which also has heavy growth of the introduced 'Slippery red seaweed' Grateloupia turuturu. This area has accumulated a large amount of debris (leaf litter, rubbish) due to its protection from waves by the breakwater around the marina.

The boulders and rocky reef provide habitat for a range of seaweeds, sessile invertebrates and fish. A key seaweed on reefs in the area is the common kelp Ecklonia radiata, which is not particularly common in northern Port Phillip Bay. Ecklonia is also seen on reefs in the Elwood area. The introduced Wakame kelp Undaria pinnatifida was also common on boulders and reef in the area. The introduced green seaweed Codium fragile fragile was the most common seaweed, with Ulva (sea lettuce), Dictyota sp. (brown algae), filamentous red algae and coralline encrusting red algae also common in the area.

Sessile invertebrates included the sea-squirt Pyura dalbyi, various sponges including the golf-ball sponge Tethya australis and the Blue Mussel Mytilus spp. Coscinasterias muricata (native eleven arm seastar) was the most common mobile invertebrate, with a few Asterias amurensis (North Pacific seastar) also sighted.

Fish included Diodon nichtemerus (Globe or Puffer Fish), Tetractenos glaber (Smooth Toad Fish) and Girella zebra (Zebra fish).

The species present in the area adjacent to (outside) the St Kilda Marina were typical of such habitats in northern Port Phillip Bay, comprising mostly native and endemic species, with a proportion of introduced species widely distributed in Port Phillip Bay.

Images of key species in the habitats outside the marina are provided in Appendix C, together with a list of species identified.

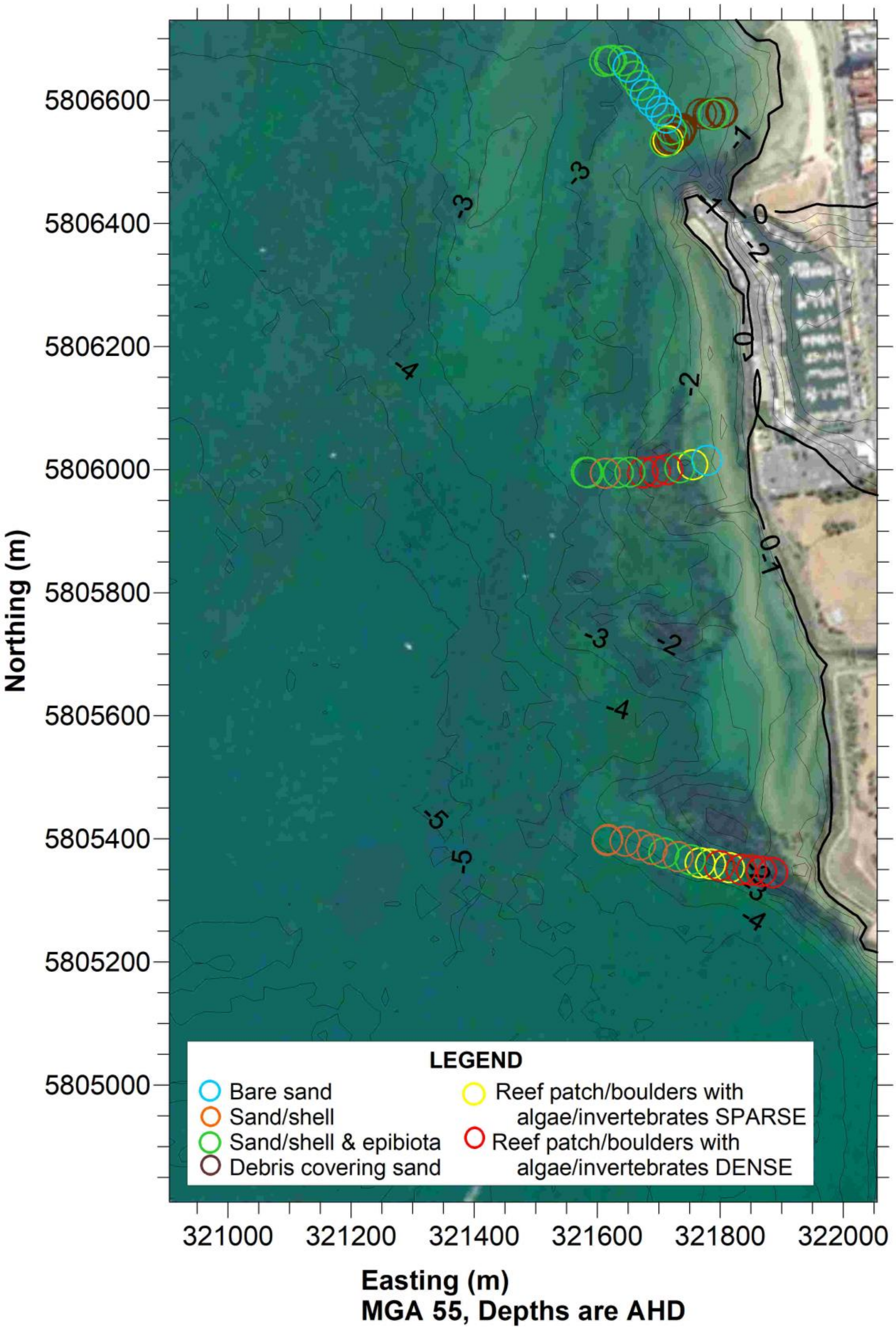

FIGURE 3-1 MAP SHOWING BATHYMETRIC CONTOURS, AERIAL IMAGERY AND HABITAT TYPES

3.2 Sediment Depths Within St Kilda Marina

The depth of sediments within St Kilda Marina was assessed in several locations using a diver operated jet-probe. Sediments depths ranged from 0.1 m or less to 0.9 m deep. Sediments were underlain by stiff clay. Thin sediments occurred in areas nearer the entrance of the marina and deeper sediments occurred in areas further within the marina.

Figure C-4 in Appendix C illustrates the distribution of sediment depths within the marina.

3.3 State & Value of Marine Habitats

Northern Port Phillip Bay is a highly modified environment due to long-term development of ports, harbours and urban areas. The area around St Kilda receives large amounts of local urban stormwater run-off, as well as nearfield exposure to flows from the Yarra River catchment. Water quality in the area is typically lower than areas with a less urbanised catchment, particularly after heavy rainfall. The coastline is largely modified by seawalls and regular beach renourishment.

A long history of international vessel traffic means Port Phillip Bay has a particularly large number of introduced marine species. It has a much larger number of native or endemic species.

The condition and value of habitats around St Kilda Marina are comparable to other areas in northern Port Phillip Bay in terms of the range and abundance of marine species. The habitats are in good condition relative to the level of disturbance from a large modern city. Effective and proactive management of water quality, recreational fishing and vessel hygiene by appropriate authorities will maintain or improve the condition of the local environment.

The range of species and habitats present have significant local environmental and social value – the area's aesthetics, environmental health and value to the community would be reduced were the range of species and habitats present in the area lower.

4 TERRESTRIAL ECOLOGY

4.1 Flora and Fauna Desktop Review

A desktop review of flora and fauna within the project area was undertaken primarily by referencing the DELWP NatureKit website. NatureKit (DELWP, 2017) is a biodiversity decision support tool for Victoria, from which flora and fauna data and sighting records can be searched.

A summary of the desktop results are as follows:

- DELWP's Ecological Vegetation Class (EVC) mapping of Pre-1750 and 2005 cover and type suggests that much of the project area is likely to have been filled and therefore does not contain native vegetation. It is likely that all native vegetation within the project area has been planted or naturally recruited post European settlement. The lack of large remnant trees is possibly confirming this inference.
- The predicted Pre-1750 EVC mapping suggest Coast Banksia Woodland/Coastal Dune Scrub Mosaic to be adjacent to or just within the study area.
- The 2005 EVC mapping suggests there is no remnant vegetation within the study area, with only a small patch of Coast Banksia Woodland/Coastal Dune Scrub Mosaic present to the east of Point Ormond.
- Strategic Biodiversity Values (SBV) mapping was reviewed for the study area. The SBV combines information on important areas for threatened flora and fauna, levels of depletion, connectivity, vegetation types and condition to provide a view of relative biodiversity importance. The mapping showed the SBV highest around Point Ormond (81), moderate to the south of the main carpark (46) and relatively low across the remainder of the study area (26-27).
- There was one vegetation survey registered on the Victorian Biodiversity Atlas. This survey was undertaken on the edge of the Elster Canal in 1992. 26 species were recorded, with no species listed on Victoria's advisory list of rare or threatened plants.
- Two fauna survey locations are registered on the Victorian Biodiversity Atlas, one within the marina and another on Elster Canal. No species recorded are on the current Advisory List of Threatened Fauna in Victoria.

4.2 Vegetation Zones and Conservation Values

The study area has been divided into 24 Vegetation Zones to facilitate description and to provide advice as to the conservation value of each area.

Conservation value has been classified under the following four categories:

- Category 1, High Conservation Value Native - These areas contain many mature woody indigenous trees and shrubs that would take decades to replace. These areas have high habitat values in what is otherwise a relatively bare landscape.
- Category 2, Moderate Conservation Value Native - These areas contain at least some mature native trees but are often dominated by shorter lived shrubs and grasses. These zones are less mature than the High Conservation Value Native areas and could be replaced in a much shorter period of time. Coast Saltbush dominated zones have been placed in this category due to their stability and habitat values, despite the expectation that this hardy shrub could be re-established relatively quickly.
- Category 3, Low Conservation Value Native - These areas are often well planted garden beds with a variety of low growing shrubs and grasses. These zones contain mostly young plantings and can be established relatively quickly.

- Category 4, Ornamental Value Non-Indigenous Native or Exotic – These trees have been planted for their ornamental value and include species such as Canary Island Palm, Norfolk Pine, Moreton Bay Fig and Norfolk Island Hibiscus.

These categories have been created for the purpose of this assessment and do not specifically relate to Victoria’s native vegetation legislation. However, it is likely that if a large number of trees, or area, of Category 1 or 2 vegetation were proposed for removal, referral to DELWP may be required.

The vegetation zones have been mapped and colour coded by conservation value (Figure 4-1). This figure shows the highest conservation value coloured red, moderate value amber and low value green. Ornamental trees have been shown in yellow. It should be noted that Zone 11 covers the main carpark, boat ramp and Riva Restaurant areas and trees are only scattered to patchy within this large zone.

The highest value native Vegetation Zones (12 and 14) comprise a high diversity of tree, shrub and ground species. These two patches of vegetation contain relatively old/mature trees (including Coastal Banksia, Manna Gum, Swamp Gum and Drooping She-oak) and shrubs (including Coast Tea-tree, Boobialla and Coastal Wattle) and the areas show signs of ongoing active management including weed control and revegetation. At the time of assessment, it was evident that these patches provide important habitats as many species of birds were observed and heard within these areas.

FIGURE 4-1 VEGETATION ZONES BY CONSERVATION VALUE

FIGURE 4-2 VEGETATION ZONES 12 AND 14

4.3 Flora and Fauna Recommendations

Should the marina be redeveloped in the future, the following summarises the recommendations regarding terrestrial flora and fauna:

- Vegetation Zones 12 and 14 hold the highest native vegetation value and conservation significance. These areas should be protected if possible in any redevelopment. Any disturbance to these areas, if permitted by Council and DELWP, is likely to require offsetting despite not being true remnant vegetation.
- Avoidance of disturbing Moderate Value Native vegetation is recommended where possible. Significant amount of work and expense has gone in to establishing these areas and they provide important vegetation links along the Bay. Any redevelopment should aim to maintain or enhance longitudinal continuity of native vegetation along the Bay.
- Any redevelopment is likely to modify sections of rock seawall. Coast Saltbush has been planted and has colonised the areas immediately above the seawalls. This hardy shrub is perfectly suited to these areas and tolerates salt wind and occasional inundation, waterlogging and dryness. It is recommended that this attractive shrub be incorporated at the top of any future rockwork for aesthetics, stability and habitat value.
- Protection of high value vegetation and the maintenance/enhancement of native vegetation connectivity and overall cover is the most effective method of providing fauna habitat.
- No fauna field surveys have been undertaken as part of this study. Targeted field fauna surveys should be undertaken within and adjacent to any proposed development area while at the concept design stage.

4.4 Potential Impacts of Sea-level Rise on Existing Vegetation

Coast Saltbush (*Atriplex cinerea*) is a coastal saltmarsh species that has high salt tolerance. However, most other woody vegetation within the study area will not tolerate salt water inundation. The impact of sea-level rise on existing vegetation depends upon the level of inundation and potential elevation of saline groundwater.

5 WATER QUALITY ANALYSIS

Background information pertaining to water quality within the St Kilda Marina and surrounding waters is provided in Appendix D. The dominant source of pollutants into the Bay is from stormwater. Stormwater draining directly to Port Phillip Bay can cause water quality concerns in a number of various scenarios. There are three sources of stormwater within the study area:

- Two smaller catchments managed by CoPP that discharge directly to the Bay via outlets immediately north and south of the Marina.
- Two larger catchments managed by Melbourne Water also discharge directly to the bay, these being the Shakespeare Grove Main Drain and the Elwood Canal/Elster Creek.
- Rainfall falling directly within the site is likely to be discharged directly to the marina via local drainage or overland flow paths.

Stormwater from the local marina catchment is further investigated in Table 5-1 and Figure 5-1 below. The analysis for the full study area is presented in Table D-7 in Appendix D. Of key importance is the recommendation of the generation of a site-specific Stormwater Management Strategy and water quality monitoring program.

FIGURE 5-1 INDICATIVE LOCATION OF RAINGARDENS IN THE VICINITY OF THE MARINA

TABLE 5-1 STORMWATER CHARACTERISATION WITHIN THE MARINA

	Marina Catchment Outfall
Catchment serviced	Areas within the Marina that don't discharge to the Council pipe network. These may be limited to the hard stand areas, docks and other low-lying areas.
Estimated catchment size	~0.120 km^2
Catchment characteristics	Where run-off is present directly to the marina, the surface is generally concreted, gravel or part of the dock infrastructure. Further development of the marina may increase the catchment area.
Water quality treatment infrastructure	It is unlikely that any water from this area is treated.
Water quality data	Not currently available to Water Technology
Water quality considerations	▪ Threats to water quality in this area are likely to be similar across all types of events, with any pollutants in the areas washed directly into the Marina. ▪ It is assumed that any refuelling locations or washdown areas are managed through the operation of the Marina and processes are in place to manage spills.
Opportunities to improve the water quality of the water reaching the bay	▪ Hard surface areas could be converted into permeable surfaces and encouraged to infiltrate, subject to soil tests. ▪ The hardstand area provides opportunities for rainwater harvesting which may be able to provide a sustainable source of fresh water whilst minimising pollutant run-off. ▪ Other WSUD features within the site could be considered, particularly if the site is undergoing upgrades (e.g. tree pit raingardens, examples provided in Figure 5-1) where possible ▪ Collection and disposal of oils and grease generated in the hardstand and launching areas as well as signage to educate the users of the site. ▪ Other potential sources of pollutants may be pumps (with location and operation potentially causing re-suspension of sediment), the boats (rusting features for example), sanitation stations and the boat storage areas (oils, fuels and greases)
Suggested Water Quality Investigations	▪ A site Stormwater Management Strategy would identify any opportunities to improve the water quality in the marina directly as well as minimise the risk of issues following rainfall events or spills. ▪ A water quality monitoring program is recommended at the present and future facilities to understand any pollutant contribution from the marina.

6 ENVIRONMENTAL MANAGEMENT OF THE MARINA

As part of the investigation, Water Technology assessed the general environmental management practices of the marina. This was undertaken from an observational perspective, based on visits to the site. Specific marina management documentation and communication to boat owners was not provided. General observations and recommendations are provided in Table 6-1.

TABLE 6-1 ENVIRONMENTAL MANAGEMENT OBSERVATIONS AND RECOMMENDATIONS

Item	Observation	Recommendation
Recycling	▪ Only 2 small bins for recycling glass were observed ▪ No provision for wide-scale recycling across the facility	Install recycling station(s) across the marina. This includes public and private areas, with clear signage to their location
Oil Spill Kits	▪ Fuel spill kit located at fuel dock ▪ No oil spill kits provided along jetties	Install at least one oil spill kit along each jetty for boat owners' and management use in case of oil spill. Provide site signage as to the location of this equipment
Hazardous Waste Storage / Disposal	Hazardous waste not stored as per the guidelines. This includes disposed oil and old batteries. Evidence of corrosive material disposal was observed at a stormwater drain location.	Facility upgraded appropriately so hazardous waste storage meets legislative requirements.
Stormwater Run-off / Water Quality	As per Section 5 above	Recommend the generation of a site-specific stormwater management strategy and water quality monitoring program
Educational signage	No educational signage regarding environmental impacts / rules observed	As part of the Environmental Management Plan, include a section regarding marina users' education and signage
Works Area	No bunding and collection of hazardous material was observed	All works areas, such as marine trimming, anti-fouling, boat detailing etc to be undertaken within bunded areas. Waste collected from this area must be disposed of appropriately.

A summary of the relevant legislation, regulation and policies that may be utilised to generate an Environmental Management Plan for the St Kilda Marina is provided in Appendix E. Recommendations for inclusions in the environmental plan are listed below. Additional headings / topics should be added, as per the legislation:

- Generation of Environmental Rules as part of the overall Marina Rules document
- Clear list of roles and responsibilities of marina staff and marina users, as they relate to the Environmental Management Plan
- Education and training of staff and contractors to ensure they are familiar with the requirements of environmental management. Contractors should be made aware of their responsibilities for environmental management, possibly through a site induction process.
- Communication and education of marina users, for example information provided on websites, signage, and licensee newsletters.
- Timeframe for audits, review, and updates of the Environmental Management Plan
- In addition to the above, general sections can include:
  - Management of Marine Pests
  - Water Quality Monitoring Plan
  - Waste & Wastewater Management, including sewage, bilge water and solid waste
  - Refuelling Requirements
  - Hazardous Materials
  - Maintenance Activities and Associated Rules, e.g. boat wash down, painting
  - Emergency & Incident Management (many emergencies directly linked to environmental impacts)

7 COASTAL HAZARD RISK ASSESSMENT

7.1 Oceanographic Conditions

To provide context to the coastal hazard vulnerability assessment, the relevant oceanographic conditions of the site are presented in Appendix F. In particular:

- Section F-1-3 describes the water levels, which inform the Coastal Inundation Hazard Assessment.
- Section F-1-5 provides input into the Short-Term Erosion and Long-Term Coastal Recession Assessments

7.2 Geomorphology & Coastal Processes

To provide context to the coastal hazard vulnerability assessment and the potential risks posed by sea level rise to the St Kilda Marina, a geological history of the formation of Port Phillip Bay (see Appendix G), and the underlying geomorphology, and coastal processes in the vicinity of St Kilda have been reviewed. The coastal processes are driven by the oceanographic conditions which are outlined Section G-2.

In particular, Section G-2 provides input into the Short-Term Erosion and Long-Term Coastal Recession Assessments.

7.3 Seawall Condition

Structural failure of rock-armoured seawalls can be caused by any of three fundamental mechanisms - or indeed by any combination of these, namely:

- Erosion of the armour layer - instigated when the rocks on the front face of the wall are not able to withstand the forces applied by waves as they wash against the slope. The rocks are effectively swept off the structure by the waves.
- Undermining - occurs when wave action causes scouring of erodible material at the toe of the armoured slope, causing it to be undermined and to then collapse (even though it may consist of large rocks that would otherwise not have been moved by waves).
- Wave overtopping - caused by waves that wash up over the top of the armoured slope and scour the material immediately behind the wall. The top of the wall is then no longer supported by underlying material and it collapses into the scoured area behind it - lowering the top of the seawall further, allowing greater overtopping, greater scour and rapid progression to structural failure.

All three of these failure mechanisms have occurred (or are in the process of occurring) at the St Kilda Marina seawalls and are further discussed below.

7.3.1 Northern Seawall

The northern seawall protects the northern side of the marina, as shown in Figure 7-4. This seawall appears to be in relatively good condition. The rocks are well interlocked, there is no evidence of significant scour or overtopping. The vegetation behind the seawall is in good health. An image of the seawall taken in December 2017 is shown in Figure 7-1.

FIGURE 7-1 NORTHERN SEAWALL

7.3.2 Western Seawall and Groyne

The Western Seawall and Groyne is of varying structural standard, being typical of a “riprap” structure. It generally comprises rocks of a wide range of sizes simply tipped onto the foreshore slope, with no apparent geotextile layer and no apparent placement to form graded layers. There also appears to be other materials mixed into the rock such as concrete debris. This means that the seawall is prone to damage by erosion of the armour layer, and this is evident at the site. The rocks are not well interlocked and appear to be unstable. An example of the typical seawall is shown in Figure 7-2. There is not a clear crest to the structure, and, in some places, this has slumped considerably.

It appears many of the smaller rocks have been washed out of the armour matrix and strewn across the nearshore area in front of the seawall.

It is not evident from the site inspection the depth of the toe rock, so the likelihood of scour is unclear. At the time of inspection, a layer of sand was evident covering the toe of the seawall. There is also evidence of an erosion scarp at the rear (landward) of the seawall, especially in the southern section, indicating that wave overtopping of the seawall has occurred during storm events in the recent past. Whilst this has caused some erosion and damage to grassed and landscaped areas, as well as along the crest of the seawall, there has been only minor structural damage attributable to this process.

Overall, this seawall is considered to be in poor condition. The seawall is currently directly protecting a large portion of the St Kilda Marina site from erosion and inundation. The seawall is in its present state under existing wave and water level conditions, and is likely to get worse, especially with sea level rise and overtopping issues, into the near future.

FIGURE 7-2 WESTERN SEAWALL: SEAWARD OF HARDSTAND AREA (LEFT) AND AT THE MARINE ENTRANCE (RIGHT)

7.3.3 Southern Seawall

The southern seawall is similar in condition to the western seawall. There is no clear crest or rock placement present. In most area, the seawall would be classified as 'failed'. Water Technology recommends the investigation into repairs in the immediate term.

FIGURE 7-3 SOUTHERN SEAWALL: IMMEDIATELY SOUTH OF ELWOOD CANAL (LEFT) AND AT POINT ORMOND (RIGHT)

FIGURE 7-4 SEAWALL LOCATIONS

7.4 Risk Assessment Approach

Risk Management is the term applied to a logical and systematic method of establishing the context, identifying, analysing, evaluating, treating, monitoring and communicating the risks associated with any activity, function or process in a way that will enable organisations to minimise losses and maximise opportunities (Standards Australia, 2004). Risk is identified as the product of the likelihood and consequence of an event impacting on an asset or objective.

Risk profiles have been developed by assigning scores to the consequence of each relevant coastal hazard and the likelihood of this coastal hazard impacting the site over a range of relevant timeframes this century. The risk profile is determined by applying the scores to a risk matrix such as the one shown in Table H-12, Appendix H. The risk profile assists with the identification and analysis of priority risks for subsequent decision making and planning.

- Table H-13 within Appendix H displays a description and semi-quantitative score that has been assigned to the range of coastal hazard likelihoods.
- Table H-14 within Appendix H displays a description and semi-quantitative score that has been assigned to the range of coastal hazard consequences.
- Table H-15 and Table H-12 display the resulting risk profile and risk matrix definitions respectively.
- **Topography used utilised is 2007 Vicmap data; Water Technology understands CoPP is in the process of collecting up to date topographical data. Risk ratings may be adjusted as a result.**

7.5 Coastal Inundation Hazard

The likelihood and consequence of the coastal inundation hazards impacting the St Kilda Marina has been assessed based on the review of the storm tide levels and existing topography. Risk ratings for the coastal inundation hazard are provided in Table 7-1.

The key justifications for the risk ratings assigned for this hazard are provided below:

- At present, the site is not significantly inundated by Mean High High Water (MHHW). Even in 2100, MHHW does not cause inundation at the site (refer Figure F-6 in Appendix F).
- At present, 1% AEP storm tide levels at the site are predicted to inundate the marina access road and low-lying hardstand areas. These hardstand areas often contain moored boats; the access road parked cars. This event would also have an impact on some of the low-lying commercial areas around the marina.
- The 2040 1% AEP storm tide levels do not show a significant increase in flood level, with the major storage shed and carpark not overtopped. More inundation of the low-lying hardstand areas is visible.
- The 2100 1% AEP storm tide levels show major inundation of the boat sheds, car park and hardstand area. At this level it is also likely the floating pontoons would be reaching their level limit, due to the crest level of the supporting piles. Widespread and severe inundation is likely if a 1% AEP event occurred in 2100.

TABLE 7-1 COASTAL INUNDATION RISK ASSSESMENT RESULTS

Coastal Hazard	Specific Impact	Timeline	Likelihood	Consequence	Risk Rank
Coastal Inundation	Inundation of the site or its access by elevated storm tide and additional elevated water levels associated with wave action on the coastline.	Existing	Possible	Minor	**Medium**
		2040	Likely	Moderate	**Medium**
		2100	Likely	Major	**High**

7.6 Long-Term Coastal Recession

The likelihood and consequence of long term coastal recession hazards at the site has been assessed based on the review of the coastal and oceanographic processes expected to impact the property this century. The key justifications for the risk ratings assigned for this hazard in Table 7-2 are provided below:

- The marina is completely protected by a seawall. Long-term erosion is unlikely to be a major issue as long as the seawall remains in place.
- The northern seawall protecting the marina reserve appears to be of adequate design and construction standard for present day conditions. Facing north, it is unlikely to experience large wave events.
- The western and southern seawalls and groyne are in poor condition. However, in its current state long-term erosion is unlikely, however maintenance of the seawall is required to prevent deterioration to the point where erosion becomes an issue.
- If the seawall continues to further deteriorate, it is likely that by 2100 it will not be providing any protection for the site. With the higher sea levels in 2100, high tides with any wave action could cause a long-term erosion risk; there may regular events that erode the site. Minor mitigation measures undertaken to improve the seawall should reduce this risk.

TABLE 7-2 LONG TERM COASTAL RECESSION RISK ASSESSMENT RESULTS

Coastal Hazard	Specific Impact	Timeline	Likelihood	Consequence	Risk Rank
Coastal Recession	Long term coastal recession. A sustained and progressive erosive recession of the high tide water mark on the coastline that impinges upon the site or its access and may expose the site to more frequent and significant coastal inundation.	Existing	Unlikely	Minor	**Low**
		2040	Possible	Minor	**Medium**
		2100	Possible	Moderate	**Medium**

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7.7 Short-Term Erosion

The likelihood and consequence of short term erosion hazards impacting the site has been based on the review of the coastal and oceanographic processes expected in the study area this century. The key justifications for the risk ratings assigned for this hazard are provided below.

- The majority of the study area is protected by a seawall. An appropriately designed seawall can typically reduce the likelihood of any short-term erosion.
- The northern seawall protecting the marina reserve appears to be of adequate design and construction standard under present-day conditions. Facing north, it is unlikely to experience large wave events, and is therefore unlikely to be at risk from short-term erosion.
- The western and southern seawalls and groyne are in poor condition. In their current state, it appears vulnerable to a number of failure mechanisms, and a large storm event is likely to exacerbate this. Maintenance of the seawall would reduce deterioration and drastically reduce the likelihood of short-term erosion.
- If the seawalls continue to deteriorate, it is likely that by 2100 it will not be providing any protection for the site. With the higher sea levels in 2100, storms would pose a definite short-term erosion risk and there may regular events that erode the site. Upgrading the seawall should reduce this risk.

The risk assessment has been undertaken twice: the first assuming the seawalls are maintained or upgraded to an appropriate standard (Table 7-3), and the second assuming present conditions (Table 7-4).

TABLE 7-3 SHORT TERM COASTAL EROSION RISK ASSESSMENT – WITH SEAWALL MAINTENANCE

Coastal Hazard	Specific Impact	Timeline	Likelihood	Consequence	Risk Rank
Coastal Erosion	Short term beach erosion. Dynamic, short term recession or breach of the seawall by wave action and elevated water levels that impacts the site and may expose the site to potentially more significant coastal inundation.	Existing	Unlikely	Minor	**Low**
		2040	Unlikely	Moderate	**Medium**
		2100	Unlikely	Moderate	**Medium**

TABLE 7-4 SHORT TERM COASTAL EROSION RISK ASSESSMENT – NO SEAWALL MAINTENANCE

Coastal Hazard	Specific Impact	Timeline	Likelihood	Consequence	Risk Rank
Coastal Erosion	Short term beach erosion. Dynamic, short term recession or breach of the seawall by wave action and elevated water levels that impacts the site and may expose the site to potentially more significant coastal inundation.	Existing	Likely	Moderate	**Medium**
		2040	Likely	Major	**High**
		2100	Likely	Major	**High**

7.8 Existing Coastal Hazards & Adaptation Recommendations

Following the coastal hazard vulnerability assessment, several preliminary recommendations have been formulated to respond to the coastal management issues raised at St Kilda Marina. These recommendations suggest a general seawall maintenance regime be undertaken, along with a planned accommodation of sea level rise and future storm tide events through raising of primary assets. Key recommendations are provided below:

- Undertake a program of re-building the western and southern seawalls. This entails re-use of any existing rock that suit the new specification and raising the crest level to meet future overtopping requirements. There will be a need to import extra rocks from a local quarry to supplement the rocks required. This seawall should be designed by a suitably qualified coastal engineer. Rock specifications will need to be determined as part of a Detailed Engineering Design phase. An indicative seawall replacement cost is $3,500 / linear metre (ex-GST), depending on rock availability and source.
- Undertake a detailed assessment of inundation impacts at the site. No Finished Floor Level survey or identification of primary assets was available for this study at this time. However, it is expected that some assets are currently below 1% AEP storm tide inundation levels and are likely to be inundated in future sea level rise scenarios.
- Develop an inundation mitigation and adaptation strategy. This may entail accommodating existing assets to have floor levels above storm tide levels or relocating assets from vulnerable areas to higher ground once certain triggers such as specified increases in sea level have occurred.

8 CONCLUSIONS & RECOMMENDATIONS

8.1 General

8.1.1 Marine Ecosystems

- The condition and value of habitats around St Kilda Marina are comparable to other areas in northern Port Phillip Bay in terms of the range and abundance of marine species. The habitats are in good condition relative to the level of disturbance from a large modern city. Effective and proactive management of water quality, recreational fishing and vessel hygiene by appropriate authorities will maintain or improve the condition of the local environment.
- The range of species and habitats present have significant local environmental and social value – the area's aesthetics, environmental health and value to the community would be reduced were the range of species and habitats present in the area lower.

8.1.2 Water Quality Analysis / Environmental Management

A site-specific stormwater management strategy and water quality monitoring program should be developed. As the facility was constructed some 50-years ago, it does not incorporate allowances for present-day environmental requirements. There may be a need to upgrade some of the infrastructure / systems in order to meet legislative requirements.

A comprehensive Environmental Management Plan is recommended for the marina. Suggested topics to be included are provided in Section 6.

8.1.3 Coastal Hazard Vulnerability Assessment

- Undertake a program of re-building the western and southern seawall. This entails re-use of any existing rock that suit the new specification and raising the crest level to meet future overtopping requirements. There will be a need to import extra rocks from a local quarry to supplement the rocks required. This seawall should be designed by a suitably qualified coastal engineer. Rock specifications will need to be determined as part of a Detailed Engineering Design phase. An indicative seawall replacement cost is $3,500 / linear metre (ex-GST), depending on rock availability and source.
- Undertake a detailed assessment of inundation impacts at the site. No Finished Floor Level survey or identification of primary assets was available for this study at this time. However, it is expected that some assets are currently below 1% AEP storm tide inundation levels and are likely to be inundated in future sea level rise scenarios.
- Develop a coastal inundation and adaptation mitigation strategy. This may entail accommodating existing assets to have floor levels above storm tide levels or relocating assets from vulnerable areas to higher ground.

8.2 Marina Expansion Assessment Considerations

8.2.1 Marine Ecosystems

The following recommendations relate to the dredging and spoil disposal, construction of retaining walls and breakwaters involved with expanding the marina. A Coastal Management Act 1995 consent must be obtained and must address the issues outlined in the EPA Victoria Guidelines for Dredging 2001 (publication 691). The project would need to be referred to the Minister responsible for the Environmental Effects Act 1978 to decide whether an Environmental Effects Statement (EES) is required, and an EES is likely to be required. A likely project scope for a 'marine environmental assessment' would include:

- Assessment of Dredging:
  - Sediment characterisation (minimum 3 sediment cores at dredging site and 3 at disposal site) – analysis for particle size, organic content, contamination
  - Assessment of sediments for pest species – infauna and epifauna
  - Assessment of sediment contamination using National Assessment Guidelines for Dredging
  - Assessment of vulnerability of disposal site and surrounds to turbid plumes – benthic macrophytes
  - Identification of spoil disposal options including beneficial uses, optimal timing (vulnerable biota), minimisation of seabed and water quality impacts
- EES Referral:
  - Assessment of dredging project for potential 'significant effect on the environment'
  - Water quality impacts, including flushing of the marina
  - Flora and fauna impacts (including EPBC/FFG listed species)
  - Habitat impacts
- EES:
  - Detailed assessment of issues with potential 'significant effects on the environment', e.g.:
    - Water quality
    - Flora and fauna (including EPBC/FFG listed species)
    - Habitats
- Implement an Environmental Improvement Plan for the dredging and construction program:
  - Before/After monitoring of vulnerable flora and fauna and habitats, marine pests
  - Before/During/After monitoring of water quality

8.2.2 Terrestrial Ecology

- Vegetation Zones 12 and 14 hold the highest native vegetation value and conservation significance. These areas should be protected if possible in any redevelopment. Any disturbance to these areas, if permitted by council and DELWP, is likely to require offsetting despite not being true remnant vegetation.
- Avoidance of disturbing Moderate Value Native vegetation is recommended where possible. Significant amount of work and expense has gone in to establishing these areas and they provide important vegetation links along the Bay. Any redevelopment should aim to maintain or enhance longitudinal continuity of native vegetation along the Bay.

- Any redevelopment is likely to modify sections of rock seawall. Coast Saltbush has been planted and has colonised the areas immediately above the seawalls. This hardy shrub is perfectly suited to these areas and tolerates salt wind and occasional inundation, waterlogging and dryness. It is recommended that this attractive shrub be incorporated at the top of any future rockwork for aesthetics, stability and habitat value.
- Protection of high value vegetation and the maintenance/enhancement of native vegetation connectivity and overall cover is the most effective method of providing fauna habitat.
- No fauna field surveys have been undertaken as part of this study. Targeted field fauna surveys should be undertaken within and adjacent to any proposed development area while at the concept design stage

8.2.3 Coastal Processes

- Following the coastal hazard vulnerability assessment, marina expansion has been considered in terms of its impact on coastal processes. Key to the marina's impact on coastal processes is the impact on beaches either side of the study.
- Sediment is thought to move in a predominantly northerly direction along the existing marina, where it is either captured by the small groyne at the north western end of the marina or moves past the groyne into the access channel to the marina and St Kilda Beach. Any expansion of the marina into Port Phillip Bay would have to consider this coastal process. St Kilda Beach is typically protected from storm events and is not under erosion threat in the present day. It has been heavily artificially impacted by beach nourishment. Therefore, it is likely that any expansion to the marina will be able to negate any effects to St Kilda Beach if an appropriate sediment management plan is undertaken, likely incorporating dredging excess sand that collects at the marina and the marina entrance to St Kilda Beach.
- The beach to the south of the marina is reinforced by seawall, and any expansion will be unlikely to affect this area.
- Marina expansion would also need to take into account maintenance of its access channel if any expansion was undertaken, with the current alignment highly desirable due to the low sediment transport rates and therefore low need for maintenance in the channel.

9 REFERENCES

ANZECC (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Vol. 1, The Guidelines. Australian and New Zealand Environment and Conservation Council

Bird, E.C.F., (1993). *The Coast of Victoria – the shaping of scenery*, Melbourne University Press

Bird, E. (2011). *Changes on the Coastline of Port Phillip Bay*. Prepared for the Department of Sustainability and Environment, Victoria.

Cardno (2015). *Preliminary Assessment of Beach Renourishment Priorities 2015 – 2017*, report prepared for Department of Environment, Land, Water and Planning, Victoria.

Department of Planning and Community Development (DPCD), 2012. *Practice Note 53: Managing coastal hazards and the coastal impacts of climate change*, State Government of Victoria.

DELWP (2017). *NatureKit*, [ONLINE] Available at:
(http://maps.biodiversity.vic.gov.au/viewer/?viewer=NatureKit [Accessed February 7, 2018]

EPA 2002 Long Term Trends in Nutrient Status and Clarity, 1984-1999. Victorian Environmental Protection Agency

EPA 2010, Baywide Water Quality Monitoring Program, Victorian Environmental Protection Agency

EPA 2017, *Beach Monitoring Data*, [ONLINE] Available at:
http://yarraandbay.vic.gov.au/weeklywatersamples?type=beach&site=99650 , [Accessed February 7, 2018]

NHMRC (2008). *Guidelines for Managing Risks in Recreational Water*, National Health and Medical Research Council

Hunter, J., (2014). *Derivation of Revised Victorian Sea-Level Planning Allowances Using the Projections of the Fifth Assessment Report of the IPCC*, Research conducted for the Victorian Coastal Council.

Victorian Coastal Council (VCC, 2014). *The Victorian Coastal Strategy*.

APPENDIX A
SITE MAP

FIGURE A-1 SITE MAP

APPENDIX B
HYDROGRAPHIC SURVEY

N

AHD DRAWING

NOT FOR

NAVIGATION

NOTES:

COORDINATES BASED ON: MGA94. ZONE 55

HEIGHT DATUM BASED ON: AHD

CONTOUR INTERVAL: 0.5M

0 30 60 90 120 150 m

SCALE 1:1500

COORDINATES: MGA 94	SURVEY: PB 20 DEC 2017
HEIGHT DATUM: AHD	CALC.: PB 11 JAN 2018
CAD REF.:	DRAWN: PB 12 JAN 2018
FLD/LVL BOOK:	CHECKED:

Farren Group
Creating New Boundaries
74 Maribyrnong Street Footscray 3011
Phone 9689 1000 Mob 0409 432 241
hydro@farrengroup.com.au
LAND SURVEYING - TOWN PLANNING - HYDROGRAPHIC MAPPING

ST KILDA MARINA CURRENT SITUATION HYDROGRAPHIC SURVEY

DRAWING No. STK38

SHEET 1

REVISION 0

APPENDIX C
MARINE ECOSYSTEM SUPPORTING DATA

C-1 Images of Key Species

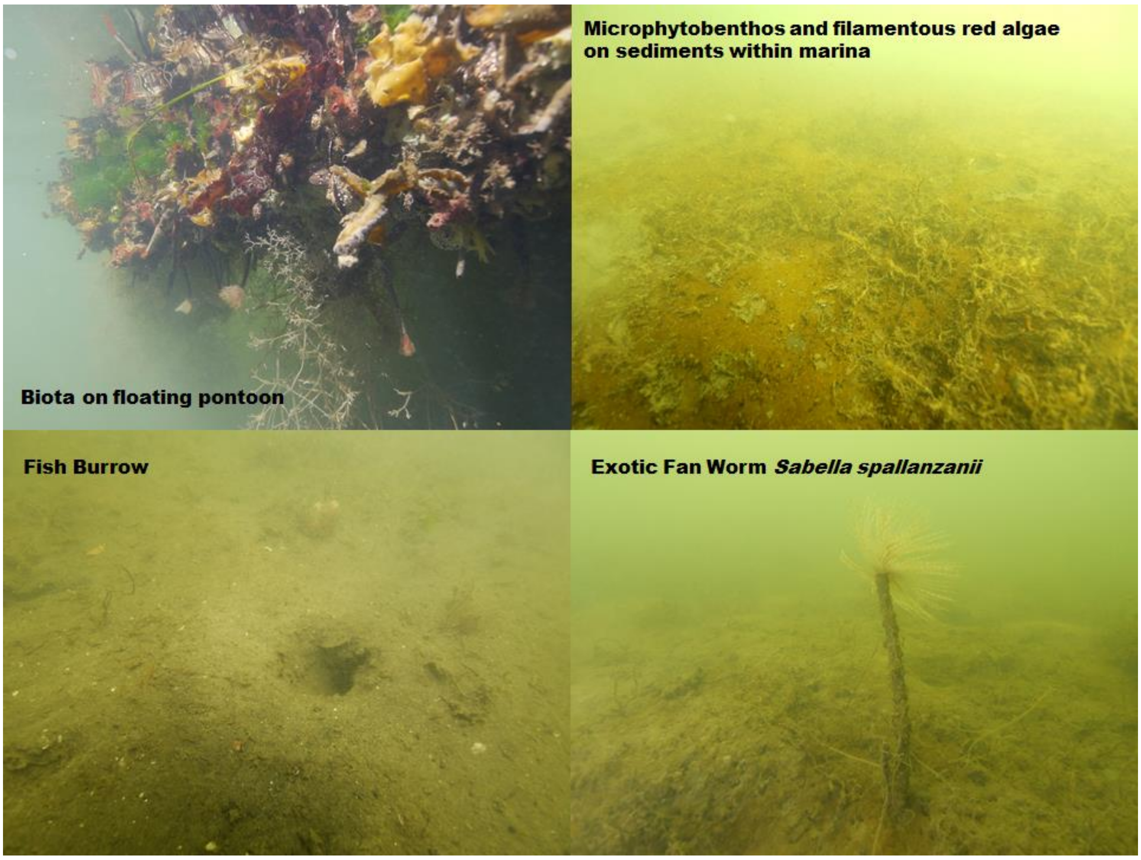

FIGURE C-2 IMAGES COLLECTED BY DIVER WITHIN ST KILDA MARINA

FIGURE C-3 IMAGES FROM TOWED VIDEO OUTSIDE ST KILDA MARINA

C-2 Observed Marine Species

TABLE C-1 SPECIES LIST FOR HABITATS INSIDE MARINA

Phylum/Class	Genus/Species (Common Name)
Sand/silt seabed inside marina	
Rhodophyta (Red Algae)	*Griffithsia* sp. (Filamentous red algae)
Phaeophyta (Brown Algae)	Microphytobenthos (benthic microalgae)
Chlorophyta (Green Algae)	*Ulva* sp. (Sea Lettuce)
Porifera (Sponges)	Various species
Cnidaria (Anemones)	Aliciidae sp. (undescribed species)
Annelida (Worms)	*Sabella spallanzanii* (Mediterranean Fan Worm)*
Echinodermata (Sea Stars)	*Asterias amurensis* (Northern Pacific Sea Star)*
Tunicata (Sea Squirts)	*Pyura dalbyi* (Yellow Mouthed Ascidian)
Osteichthys (Bony Fishes)	*Nesogobius* sp. (Sand Goby)
Chondrichtys (Cartilagenous Fishes)	*Bathytoshia brevicaudata* (Smooth Stingray)
Piles, pontoons and walls inside marina	
Rhodophyta (Red Algae)	*Griffithsia* sp. (Filamentous red algae)
	Grateloupia turu (Slippery red seaweed)*
Phaeophyta (Brown Algae)	*Dictyota* spp.
	Undaria pinnatifida (Wakame)*
Chlorophyta (Green Algae)	*Ulva* spp. (Sea Lettuce)
	Cladophora sp.
Porifera (Sponges)	Various species
Annelida (Worms)	*Sabella spallanzanii (*Mediterranean Fan Worm)
	Serpulidae spp. (Tube worms)
Mollusca	*Mytilus* sp. (Blue Mussel)
Bryozoa (Lace Corals)	*Bugula dentata*
Tunicata (Sea Squirts)	*Botrylloides* spp.
	Herdmania grandis (Red Mouthed Ascidian)
	Pyura stolonifera (Cunjevoi)
	Ciona intestinalis (Introduced)

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TABLE C-2 SPECIES LIST FOR HABITATS OUTSIDE MARINA

Phylum/Class	Genus/Species (Common Name)
Sand/shell seabed outside marina	
Rhodophyta (Red Algae)	Filamentous red algae
	Grateloupia turu (Slippery red seaweed)
Phaeophyta (Brown Algae)	Microphytobenthos (benthic microalgae)
Chlorophyta (Green Algae)	*Codium fragile* (broccoli weed)
Poacea (Seagrass)	*Heterozostera nigricaulis* (seagrass)
Uncertain	Tube worm/tube dwelling shrimp
Tunicata (Sea Squirts)	*Pyura dalbyi* (yellow mouthed ascidian)
Rocky reef and boulders outside marina	
Rhodophyta (Red Algae)	Encrusting coralline red algae
	Filamentous red algae
	Grateloupia turu-turu (introduced)
Phaeophyta (Brown Algae)	*Ecklonia radiata* (Common Kelp)
	Undaria pinnatifida (Wakame)*
	Sargassum sp.
Chlorophyta (Green Algae)	*Ulva* sp. (sea lettuce)
	Codium fragile fragile (broccoli weed)*
	Caulerpa remotifolia (saw-toothed caulerpa)
Poacea (Seagrass)	*Heterozostera nigricaulis* (Sea Grass)
Porifera (Sponges)	*Tethya australis* (golf ball sponge)
Annelida (Worms)	*Galeolaria* sp.
Crustacea	Mysidacea (mysid shrimp)
Mollusca	*Mytilus* sp. (Blue Mussel)
Echinodermata (Sea Stars and Urchins)	*Coscinasterias muricata* (11 arm sea star)
	Asterias amurensis (North-Pacific Seastar)*
Tunicata (Sea Squirts)	*Pyura dalbyi* (yellow mouthed ascidian)
Osteichthys (Bony Fishes)	*Diodon nichtemerus* (Globe Fish)
	Tetractenos glaber (Smooth Toad Fish)
	Girella zebra (Zebra fish)

C-3 Sediment Depth Within St Kilda Marina

FIGURE C-4 SEDIMENT DEPTHS WITHIN ST KILDA MARINA

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APPENDIX D
WATER QUALITY BACKGROUND DATA

D-1 Available Data Sources

A number of available data sources and assessment criteria have been used to collate information and provide a context for background water quality concentrations in the proximity of the Marina. Key data sources are presented in Table D-3 below; assessment criteria established by standard guidelines are presented in Table D-4.

TABLE D-3 DATA SOURCES

Data Source	Comments
Bay Wide Water Quality Monitoring Program, Milestone Report No.7 December (2010), EPA Victoria.	Significant sampling program undertaken to understand the impacts of dredging. The sampling occurred across three years. Hobson Bay monitoring locations are used as these are the closest to the study site. In the study, Shewhard Control Limits are calculated as the maximum concentration of a parameter due to natural variability i.e. the maximum expected peak values. The Exponentially Weighted Moving Average (EWMA) is used as a comparison level for average concentrations.
http://yarraandbay.vic.gov.au/ enterococci monitoring results, accessed online for St Kilda and Elwood Stations. Regular data from December 2013 to January 2018.	Study site located between the two Monitoring Locations. Median and maximum values calculated by Water Technology.
Port Phillip Bay Water Quality: Long - Term Trends In Nutrient Status And Clarity, 1984—1999	Long term monitoring of Nutrient Concentrations across Port Phillip Bay.

TABLE D-4 RELEVANT ASSESSMENT CRITERIA

Assessment Criteria	Comments
Department of the Environment, 2008 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2008). The above Guidelines contain numerous assessment criteria for different contexts. Key criteria used within this report are: ▪ Trigger levels for toxicants at 95% Protection of Marine Species; ▪ Default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems; and, ▪ Physio-chemical stressor guidelines for the protection of aquaculture species.	▪ Where available, either the trigger levels for toxicants at 95% Protection of Marine Species, or Default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems have been used. ▪ Where not available, physio-chemical stressor guidelines for the protection of aquaculture species has also been considered.
National Health and Medical Research Council, 2008. Guidelines for Managing Risks in Recreational Water.	▪ Used to derive EPA trigger levels for Enterococci for the beach monitoring program. Greater than 500 enterococci/100mL is the limit that indicates a significant risk of high levels of illness transmission. ▪ Also contains drinking water guideline values for some toxicants and advises safe levels for swimming at 10x greater due to limited ingestion of water whilst swimming. Some toxicants also include aesthetic guideline values.
Victoria State Environment Protection Policy, Waters of Victoria 1988.	A number of the guidelines referred to in this document have been updated, where available updated guideline values have been chosen.

D-2 Nutrient Records

Nutrients such as nitrogen and phosphorus are key for plant and animal development. However, aquatic plants and subsequently environmental water quality are highly impacted by excessive levels of nutrients in the water. Table D-5 presents the data compiled for nutrient records over time, as applicable to the study area. The recorded data shows that the concentration of nutrients have been above the assessment criteria for most parameters for the majority of the time. Stormwater discharges from the urban catchments are likely to be a significant source of nutrients reaching the Bay.

TABLE D-5 NUTRIENT RECORDS

Analytes	Ammonia as N	Nitrate as N	Nitrite + Nitrate as N	Total Kjeldahl Nitrogen as N	Total Nitrogen as N	Total Phosphorus as P	Reactive Phosphorus as P
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Limit of Reaction	0.01	0.01	0.01	0.1	0.1	0.01	0.01
Assessment Criteria	0.015*	na	0.005*	na	0.12*	0.025*	0.01*
EPA 2002	0.0052	na	0.0004	na	0.1695	0.0728	na
EPA 2010 EWMA Hobsons Bay	0.01945	na	0.03953	na	0.26622	0.10532	na
EPA 2010 control limits Hobsons Bay	na	na	0.2575	na	0.38282	0.13551	na

* ANZECC 2000, Default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

EPA 2002 Long Term Trends in Nutrient Status and Clarity, 1984-1999. Median value for Port Phillip Bay.

EPA 2010, Baywide Water Quality Monitoring Program

na not available N/A Not Analysed

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D-3 Bacterial records

A range of bacterial organisms are often used to assess the microbial conditions in water. Enterococci is considered the most suitable indicator of faecal pollution present at high levels in sewerage and doesn't grow in water. It also can survive longer then Escherichia coli (E.coli) within the Marine Environment. Similarly, E.coli is present in high concentrations in both human and animal faeces and generally doesn't grow in water.

Table D-6 presents total suspended solids and bacterial records compiled from the literature. Closer inspection of the Enterococci recorded data (not shown here) revealed that the frequency of higher levels increased from 2015; it might be hypothesised that the drought during the previous years might have contributed for such increase. Total suspended solids are below the regional records.

TABLE D-6 TOTAL SUSPENDED SOLIDS AND BACTERIAL RECORD

Analytes	Chlorophyll a	Suspended Solids (SS)	Escherichia coli (Colilert)	Total Coliforms (Colilert)	Enterococci
Units	mg/m³	mg/L	orgs/ 100mL	orgs/ 100mL	orgs/ 100mL
Limit of Reaction	1	5	1	1	1
Assessment Criteria	1*	10^	#14/200/400	na	**200/ 500
Regional recorded values	3.9/ 2.2	4.0/8.0	na	na	46.5/7700 41/6900
Regional recorded values source	EPA 2010	EPA 2002	na	na	EPA 2018

* ANZECC 2000, Default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

^ANZECC 2000, Guidelines for the protection of aquaculture species

**NHMRC 2008, Guidelines for Managing Risks in Recreational Water and EPA trigger level

Victorian SEPP 42 day geom. Mean: <14 (Aquaculture zones)/ 42 day geom. Mean: <200 (all other zones/42 day 80 percentile: <400

EPA 2002 Long Term Trends in Nutrient Status and Clarity, 1984-1999. Median / 80th Percentile at Hobsons Bay

EPA 2018, Monitoring data from St Kilda Median/Maximum Elwood Median/ Max

na not available N/A Not Analysed

D-4 Stormwater Within the Study Area

As discussed in Section 5, the full version of Table 5-1 is presented below. This includes analysis of all the stormwater catchments in the study area. Figure D-5 presents the catchment areas.

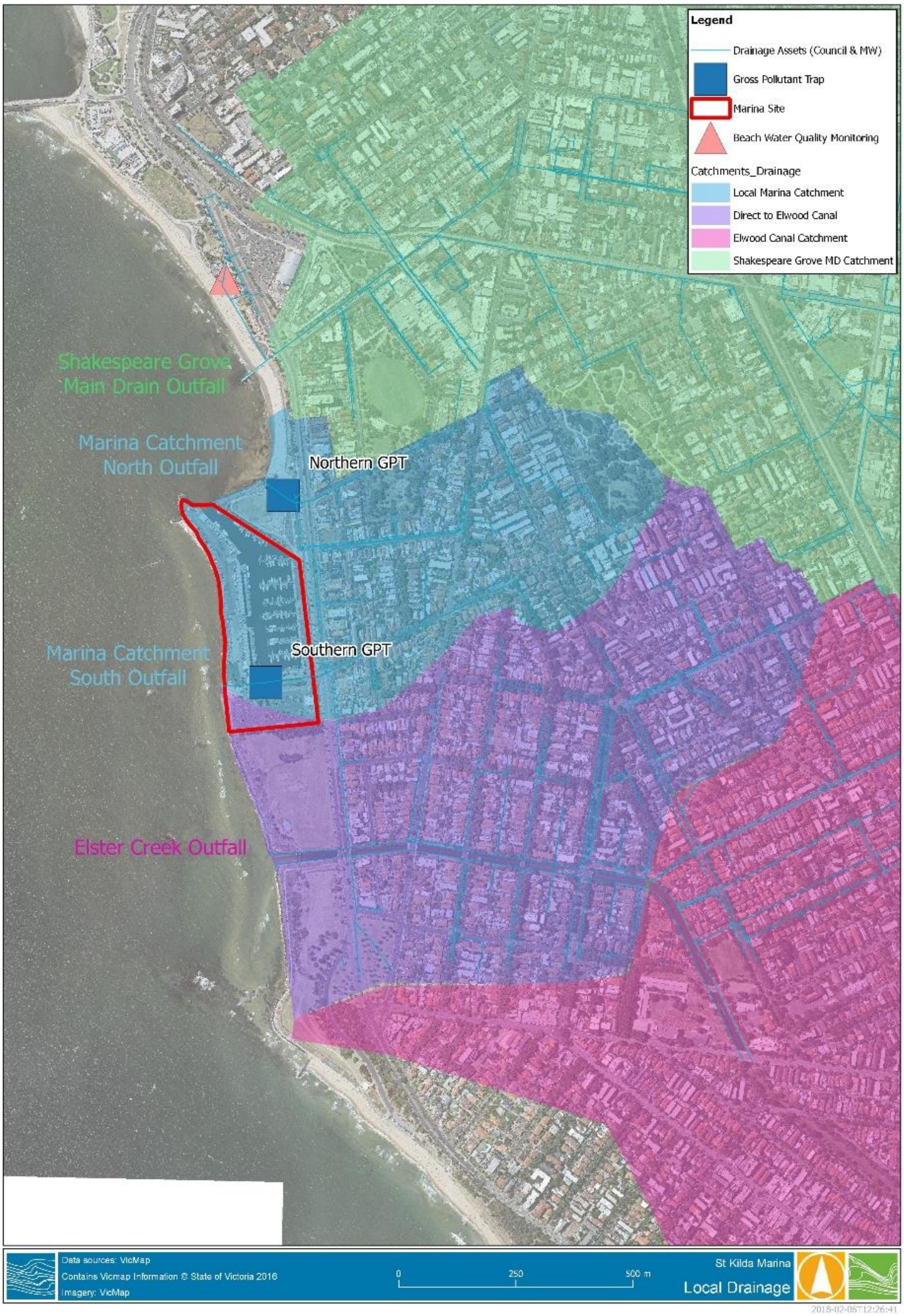

FIGURE D-5 STUDY AREA AND LOCAL DRAINAGE

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TABLE D-7 STORMWATER CHARACTERISATION WITHIN THE STUDY AREA

	Northern and southern marina outfalls	Shakespeare Grove Drain Outfall	Elwood Canal/Elster Creek Drain Outfall	Marina Catchment Outfall
Catchment serviced	Comprised of two small catchments, mainly residential, with some open green space within the catchment as well as along the foreshore. Council assets only.	Large catchment to the north of the study site. Council assets leading to Melbourne Water main drain.	Large catchment to the south of the study site. Council assets leading to Melbourne Water main drain.	Areas within the Marina that don't discharge to the Council pipe network. These may be limited to the boat loading areas, docks and other low-lying areas.
Estimated catchment size	Northern 0.72 km^2 (including the marina) Southern 0.89 km^2	8.44 km^2	40.00 km^2	~0.120 km^2
Catchment characteristics	▪ Highly built up ▪ Mainly residential. ▪ Estimated percentage imperviousness of 75%. Not likely to undergo further increases in hard surface unless parks are lost to development.	▪ Highly built up ▪ Mainly residential. ▪ Estimated percentage imperviousness of 60-70%. Some potential for further infill development is likely to increase this number slightly. Open green space within the catchment is a potential future source of hard surface if redeveloped, although this is acknowledged to be unlikely.	▪ Highly built up ▪ Mainly residential. ▪ Estimated percentage imperviousness of 60-70%. Some potential for further infill development is likely to increase this number slightly. Open green space within the catchment is a potential future source of hard surface if redeveloped, although this is acknowledged to be unlikely.	Where runoff is present directly to the Marina, the surface is generally concreted, gravel or part of the dock infrastructure. Further development of the Marina may increase the catchment area.
Water quality treatment infrastructure	▪ Council Gross Pollutant Trap upstream of each outlet in foreshore reserve. ▪ Raingardens upstream of the outfall in the northern outfall catchment within the foreshore reserve. Removal of nutrients from the runoff generated from the roads and carparks in the vicinity of the marina. ▪ Inspection of recent imagery from the area do not suggest the presence of any regional wetland within any of the local catchments	▪ A brief inspection of the wetland database map in the Victorian Wetland Inventory Edit Tool does not suggest the presence of any regional wetland within any of the catchment. ▪ During this assessment, Water Technology has insufficient information and resources to identify Water Sensitive Urban Design (WSUD) systems within this catchment.	▪ While previous studies indicate the presence of some wetlands, a brief inspection the wetland database map in the Victorian Wetland Inventory Edit Tool does not suggest the presence of any regional wetland within any of the catchment. ▪ During this assessment Water Technology has insufficient information and resources to identify WSUD systems within this catchment.	It is unlikely that any water from this area is treated.
Water quality data	▪ Not currently available to Water Technology	▪ Not currently available to Water Technology	▪ Melbourne Water undertook long-term sampling at Elster Creek at Cochrane Street, Elwood. The results can be sought with Melbourne Water in the next stages of work.	Not currently available to Water Technology
Water quality considerations	▪ More frequent events would wash catchment born pollutants through the drainage network and to the outlets. The GPTs in place would be effective in removing large floating debris but would have little impact on other pollutants such as Nitrogen and Phosphorous. ▪ The raingardens in the northern catchment will allow for the removal of some nutrient loads. ▪ Larger storm events where flooding is present will also carry pollutants through the catchment. There is also potential for sewer spills in these large events. There are no known ERSs (Emergency Relief Structure) in the catchment.	▪ More frequent events would wash catchment born pollutants through the drainage network and to the outlets. Any existing water quality treatment devices are assumed to be targeted at reducing gross pollutants and organic pollutants. ▪ Larger storm events where flooding is present will also carry pollutants through the catchment. There is also potential for sewer spills in these large events. It is not known if any Melbourne Water or South East Water ERSs are located in the catchment. Sewers may also surcharge in other areas in larger events, causing pollution in the bay.	▪ More frequent events would wash catchment born pollutants through the drainage network and to the outlets. Any existing water quality treatment devices are assumed to be targeted at reducing gross pollutants and organic pollutants. ▪ Larger storm events where flooding is present will also carry pollutants through the catchment. There is also potential for sewer spills in these large events. It is not known if any Melbourne Water or South East Water ERSs are located in the catchment. Sewers may also surcharge in other areas in larger events, causing pollution in the bay.	▪ Threats to water quality in this area are likely to be similar across all types of events, with any pollutants in the areas washed directly into the Marina. ▪ It is assumed that any refuelling locations or washdown areas are managed through the operation of the Marina and processes are in place to manage spills.

	Northern and southern marina outfalls	Shakespeare Grove Drain Outfall	Elwood Canal/Elster Creek Drain Outfall	Marina Catchment Outfall
Opportunities to improve the water quality of the water reaching the bay	Large areas of open space near the outlets, particularly the northern outlet, provide an opportunity to incorporate a treatment train. Bioretention systems, buffer strips and small wetlands could be possible in this area subject to further investigation, particularly around ground water levels.	There may be opportunities to explore if the local vegetation around the shore can be upgraded (e.g. buffer gardens) to help reducing the nutrient loads reaching the bay. Other open spaces throughout the catchment would be likely locations to incorporate WSUD principles.	▪ There may be opportunities to explore if the local vegetation around the shore can be upgraded (e.g. buffer gardens) to help reducing the nutrient loads reaching the bay. Other open spaces throughout the catchment would be likely locations to incorporate WSUD principles. ▪ Significant flooding throughout the catchment is the topic of various investigations and research at the moment. Water quality improvement opportunities are likely to be looked at with any flood mitigation design.	▪ Hard surface areas could be converted into permeable surfaces and encouraged to infiltrate subject to soil tests. ▪ The dock area provides opportunities for rainwater harvesting which may be able to provide a sustainable source of fresh water whilst minimising pollutant runoff. ▪ Other WSUD features within the site could be considered, particularly if the site is undergoing upgrades (e.g. tree pit raingardens) where possible ▪ Collection and disposable of oils and grease generated in the boat parking and launching areas as well as signage to educate the users of the site. ▪ Other potential sources of pollutants may be pumps (with location and operation potentially causing re-suspension of sediment), the boats (rusting features for example), sanitation stations and the boat storage areas (oils, fuels and greases)
Suggested Water Quality Investigations	Given the size of the catchments and the localities of the outfalls to the Marina, these catchments provide the most realistic options to improve local water quality. Basic MUSIC modelling and a Stormwater Management Strategy is recommended to investigate the potential of a treatment train near the outlets in the foreshore reserve.	With the outlet located to the north of the Marina, the impact to users is likely to be less than in the local catchments, although the larger catchment sizes will provide considerably more runoff. A water quality investigation into the entire catchment would determine the effectiveness of the WSUD elements in place and suggest any further works that could be completed to improve the catchment to Best Practice.	▪ A wholesale review of the entire catchment would provide a base line expected water quality treatment within the catchment with today's infrastructure. This could then be used to determine upgrade works or new assets to be built within the catchment. ▪ Given the locality of the outfall with regards to the Marina and the opening, the impacts directly from Elwood Canal may be reduced, although the very large catchment has capacity to significantly impact large areas of the surrounding Bay	▪ A site Stormwater Management Strategy would identify any opportunities to improve the water quality in the Marina directly as well as minimise the risk of issues following rainfall events or spills. ▪ A water quality monitoring program is recommended at the current and future facilities to understand any pollutant contribution from the marina.

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APPENDIX E
ENVIRONMENTAL MANAGEMENT OF THE MARINA BACKGROUND DATA

E-1 Statutory Framework

Table E-8 presents relevant legislation, regulation and policies that may be used to generate an Environmental Management Plan for the St Kilda Marina

TABLE E-8 RELEVANT LEGISLATION, REGULATION AND POLICIES

	Document Title
Acts – Commonwealth	▪ Native Title Act 1993 ▪ Environment Protection and Biodiversity Conservation Act 1999 ▪ Biosecurity (Consequential Amendments and Transitional Provisions) Act 2015 ▪ Pollution of Water by Oils and Noxious Substances Act 1986
Acts – State	▪ Coastal Management Act 1995 ▪ Crown Land (Reserves) Act 1978 ▪ Dangerous Goods Act 1985 ▪ Environment Protection Act 1970 ▪ Fisheries Act 1995 ▪ Flora and Fauna Guarantee Act 1988 ▪ Marine Act 1988 ▪ Port Services Act 1995 ▪ Planning and Environment Act 1987 ▪ Quarantine Act 1908 ▪ Land Act 1958 ▪ Wildlife Act 1975
Regulations	▪ Dangerous Goods (Storage and Handling) Regulations 2012 ▪ Pollution of Waters by Oil and Noxious Substances Regulations 2012 ▪ Environment Protection (Ships' Ballast Water) Regulations 2017 ▪ Environment Protection (Industrial Waste Resource) Regulations 2009 ▪ Port Services (Designated Ports) Regulations 2015 ▪ Environment Protection (Industrial Waste Resource) Regulations 2009 ▪ Environment Protection (Prescribed Waste) Regulations 1998 ▪ Dangerous Goods (Storage and Handling) Regulations 2000 ▪ State Environment Protection Policy (Air Quality Management) ▪ State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) 1989 N-1 ▪ State Environment Protection Policy (Waters of Victoria) 2003 ▪ State Environment Protection Policy (Waters of Victoria) Schedule F6 (Table 2) 1997 ▪ State Environment Protection Policy (Prevention and Management of Contamination of Land)

	Document Title
Guidelines	▪ AS1940 - 2004: Storage and handling of flammable combustible Liquids ▪ AS2508: Safe Storage and Handling Information Cards for Hazardous ▪ Materials ▪ AS/NZA ISO 14001: 2016 Environmental management systems requirements with guidance for use ▪ AS/NZS 5667.9-1998 Water Quality Sampling – Guidance on sampling from marine waters ▪ AS4997-2005 Guidelines for the Design of Maritime Structures ▪ ANZECC Best Practice Guidelines for Waste Reception Facilities at Ports, ▪ Marinas and Boat Harbours in Australia and New Zealand ▪ EPA (Victoria) 1992, Noise Control Guidelines. Publication 1254/2008 ▪ Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance ▪ (ANZECC 2000) ▪ Cleaner Marina's: EPA guidelines for protecting Victoria's marinas (1998) ▪ Aquatic Pests: Treat 'em mean – keep your boat clean (DELWP) ▪ EPA Publication 275: Construction Techniques for Sediment Pollution Control ▪ (May 1991) ▪ EPA Publication 981: Reducing Stormwater Pollution from Construction Sites ▪ (May 2005) ▪ EPA Publication IWRG600 Waste Categorisation, Dec 2010 ▪ EPA publication 347.1 Bunding guidelines Oct 2015 ▪ EPA Victoria Publication 624, Guidelines for Protecting Victoria's Marinas, 1998 ▪ ANZECC Best Practice Guidelines for Waste Reception Facilities at Ports, ▪ Marinas and Boat Harbours in Australia and New Zealand

APPENDIX F
OCEANOGRAPHIC CONDITIONS

F-1 Water Levels

When considering potential coastal hazards on any foreshore, it is necessary to understand the following ocean levels that can occur from time to time:

- *Astronomical Tide* - this is the "normal" rising and falling of the oceans in response to the gravitational influences of the moon, sun and other astronomical bodies. These effects are predictable and consequently the astronomical tide levels can be forecast with confidence.
- *Storm Tide* - this is the combined action of the astronomical tide and any storm surge that also happens to be prevailing at the time. Surge is the rise above normal water level as a consequence of surface wind stress and atmospheric pressure fluctuations induced by synoptic events, such as severe storms or cyclones.
- *Climate change* - this is the combined effect of environmental changes as a consequence of future climate scenarios. One of these possible effects is an increase in ocean water levels.

F-1-1 Mean Sea Level

Table F-9 provides a summary of relevant sea level rise scenarios for planning. Estimates of sea level rise by Hunter (2014), incorporating the IPCC 2014 A1F1 climate change scenario, predict an increase in the mean sea level of 0.8 m by 2100. This scenario is considered to meet the minimum sea level rise scenario for planning as per the Victorian Coastal Strategy (VCC, 2014). This level is also assumed for Port Philip Bay by Melbourne Water's (2017), *Planning for Sea Level Rise* document.

Practice Note 53 from the Department of Planning and Community Development (DPCD, 2012) also notes the following amendment to the State Planning Policy Framework:

"*In planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100-year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill)*".

TABLE F-9 SEA LEVEL RISE SCENARIOS (MELBOURNE WATER, 2017)

	Scenario and Year	
	2040 High	2100 High
Global Mean Sea Level Rise (m)	0.2	0.8

F-1-2 Astronomical Tide

Astronomical tide refers to the rise and fall of the sea surface due to gravitational attraction between Earth, Moon and Sun. Water level variations in coastal areas due to the astronomical tide can be reliably predicted provided a reasonable length of continuous water level observations is available.

Tidal plane information from Williamstown was adopted as listed in the Victorian Tide Tables (VRCA, 2018). The Mean Higher High Water (MHHW) and the Highest Astronomical Tide (HAT) have been combined with the applied sea level rise scenarios for the 2040 and 2100 shown in Table F-9, and are listed in Table F-10, rounded to 1 decimal place.

TABLE F-10 ESTIMATE OF HIGH WATER LEVELS FOR DIFFERENT SEA LEVEL RISE SCENARIOS

m AHD	Existing	2040 High	2100 High
Mean Sea Level Rise	-	0.2	0.8
MHHW	0.4	0.6	1.2
HAT	0.5	0.7	1.3

The predicted extent of the MHHW tidal planes under existing, 2040 and 2100 sea level scenarios on the topographical elevation data are shown in Figure F-6 below. The changes in MHHW extent are confined to the bottom of boat ramps and the front beach. This suggests the increased level of tidal fluctuations are not likely to have a major impact on inundation at the site.

F-1-3 Storm Tides

The term storm tide refers to coastal water levels produced by the combination of astronomical and meteorological ocean water level forcing. The meteorological component of the storm tide is commonly referred to as storm surge, and collectively describes the variation in coastal water levels in response to atmospheric pressure fluctuations and wind setup.

Melbourne Water refers to 100-year flood levels (1% AEP), which it requires to be used for planning in the Port Phillip and Western Port regions (Melbourne Water, 2017). These flood levels are based on the Intergovernmental Panel on Climate Change (IPCC) Scenario 2, with consideration for the uncertainty associated with sea level rise predictions, and some small allowance for wave action (Melbourne Water, 2017). The difference between the levels provided for 2040, 2100 and present-day conditions are consistent with the projected sea level rise scenarios provided in Table F-9. A single water level is provided in the Melbourne Water document to cover the whole of Port Phillip Bay (Melbourne Water, 2017).

The existing and predicted 2040 and 2100, 1% AEP flood levels as provided by Melbourne Water are shown in bold in Table F-11.

TABLE F-11 1% AEP STORM TIDE LEVELS INCORPORATING MEAN SEA LEVEL RISE SCENARIOS

m AHD	Existing	2040 High	2100 High
1% AEP	**1.6**	**1.8**	**2.4**

The potential extents of inundation from the predicted 1% AEP storm tides are displayed in Figure F-7 below. The cross-section profiles shown in Figure F-8 also help to illustrate the typical topography of the study area in relation to storm tide levels. The figures are annotated to show particular features. These figures suggest the following

- For present day and 2040 levels, St Kilda Beach is not expected to be inundation. By 2100, the foreshore reserve may be inundated. Depending on flood pathways, the road has the potential to also be impacted.
- Within the marina, hardstand areas may be inundated in the present day. The level of inundation will increase by 2100.
- The car park is predicted to remain dry until 2100, when the western foreshore / portion of the car park may become inundated.
- South of the marina, the seawall and foreshore reserve west of the public pathway may become inundated by 2100

FIGURE F-6 PREDICTED MHHW EXTENT AT ST KILDA MARINA FOR VARIOUS SEA LEVEL RISE SCENARIOS (USING 2009 LIDAR AND 2017 BATHYMETRY SURVEY)

FIGURE F-7 1% AEP STORM TIDE LEVELS AND CROSS SECTION LOCATION

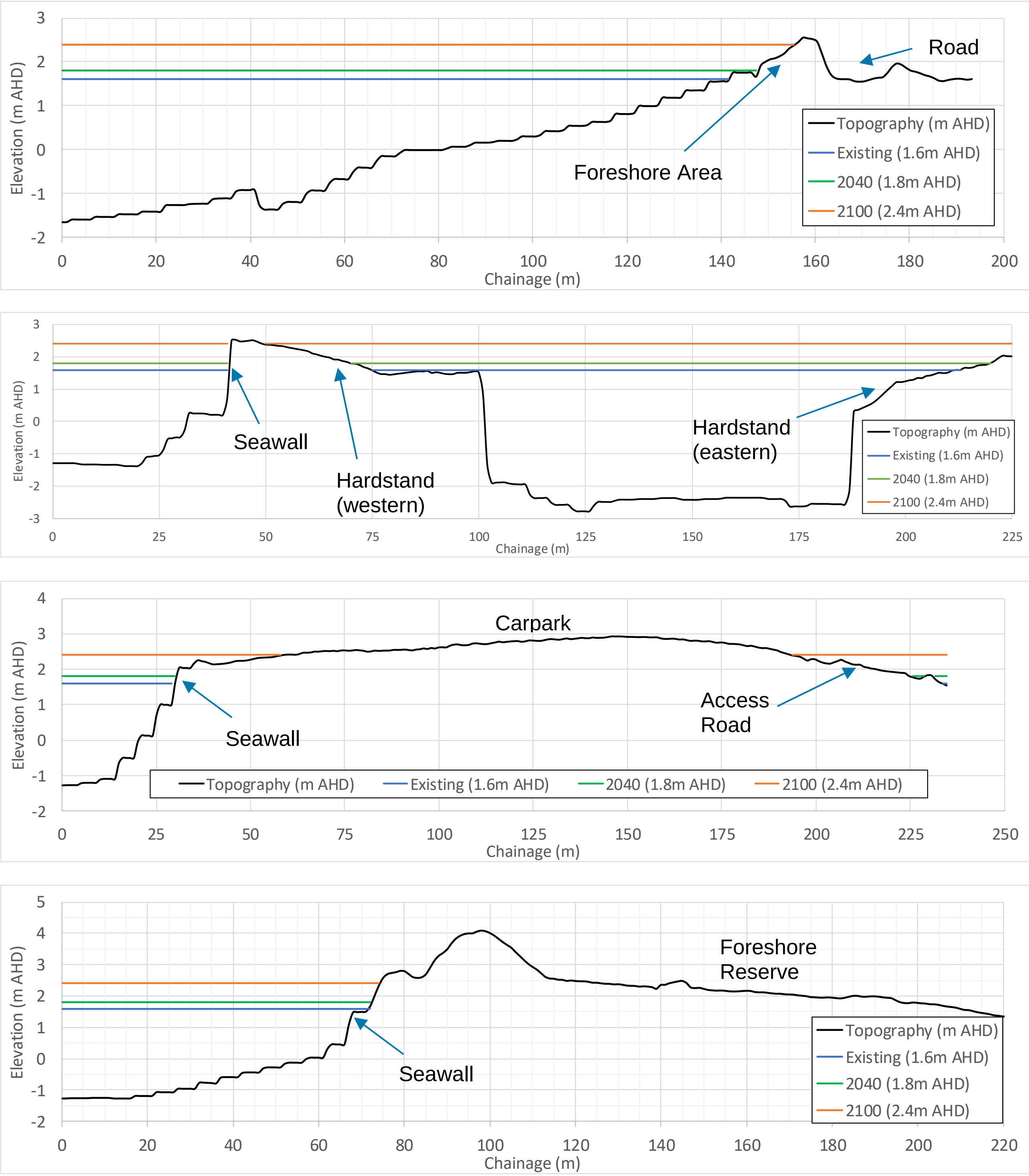

FIGURE F-8 CROSS SECTION PROFILES 1 TO 4 (TOP TO BOTTOM) – PROFILE AND 1% AEP STORM TIDE LEVELS

F-1-4 Wind Climate

The wind climate around the study area is measured by the Bureau of Meteorology (BoM) at South Channel Island (086344), located 17km west of the site. The wind climate representing the full available 40-year dataset is shown in Figure F-9 (top). The wind climate is dominated by winds from the north and, to a lesser extent, the south through west. Wind speeds are generally below 10m/s with strongest winds from the north. Summer and winter conditions across the dataset are provided in Figure F-9 (bottom left and right respectively). During summer, southerly conditions dominate, with approximately 50% of winds from the southeast through southwest. During winter, this is reversed, and the northerly and westerly wind directions are dominant, with over 60% of winds are from the west through northeast, with close to 20% from the north alone. During spring and autumn, the wind conditions transition between these dominant positions.

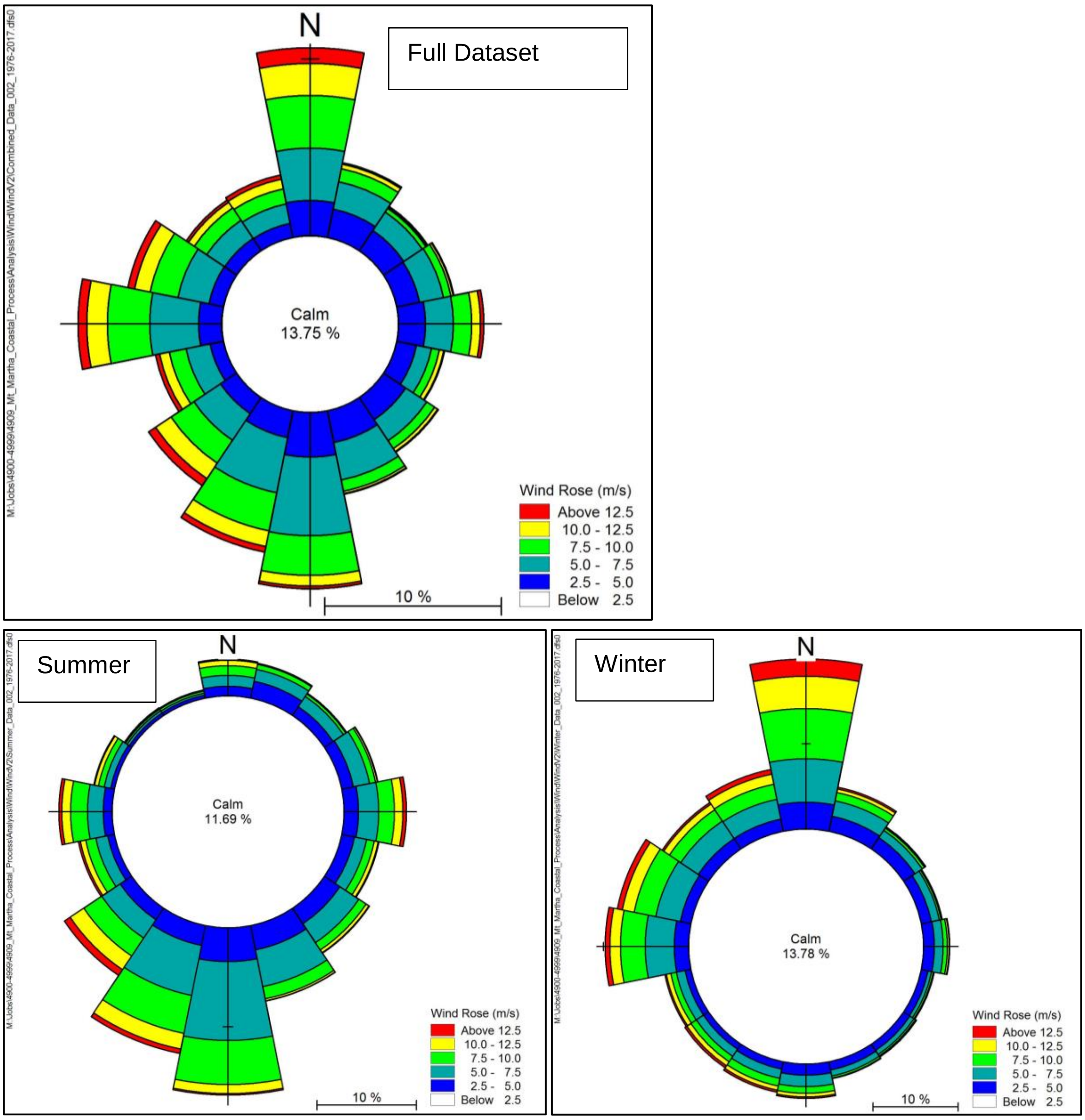

FIGURE F-9 SOUTH CHANNEL ISLAND (1976 – 2016) WIND ROSE, ANNUAL (TOP), SUMMER (BOTTOM LEFT) AND WINTER (BOTTOM RIGHT)

F-1-5 Waves

The coastline shoreward of the St Kilda Marina is exposed to locally generated wind-waves from within Port Phillip Bay. Strong wind-wave conditions from the west are generally accompanied by storm surge events.

The action of waves, both in terms of their erosive capacity and their contribution to coastal water levels, are potentially significant to the coastal hazard risks on the shoreline at the Marina. To enable estimation of the contribution of wave action in the nearshore zone to local coastal water levels, an estimate of design wave conditions on the coastline in the vicinity of the project area has been undertaken. Wave setup and the height and extent of wave run-up contribute to the total water level as shown in Figure F-10.

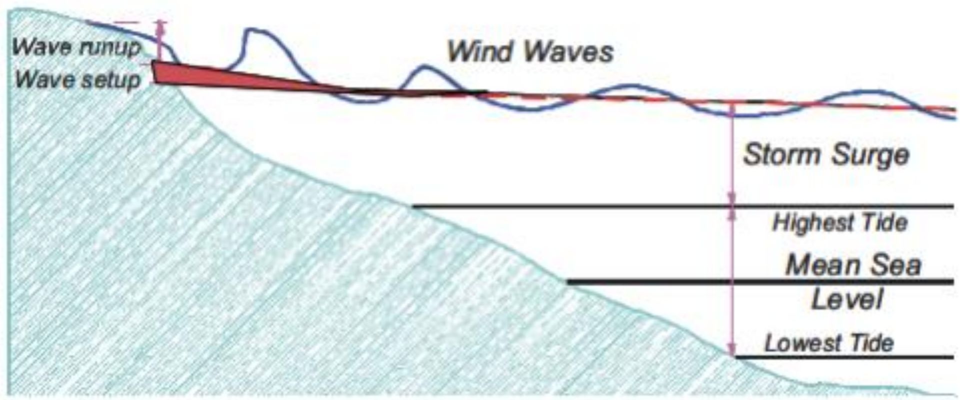

FIGURE F-10 WAVE SET-UP AND RUN-UP (CSIRO 2009)

The design wave height was calculated using a previously developed numerical spectral wave model of Port Phillip Bay. Design wind speeds for Port Phillip Bay were calculated using Standards Australia Design Wind Load Code (AS 1170.2-2002). The longest fetch for waves at St Kilda are from the southwest, extending 50 km across the Bay to the southern end of Port Phillip. 1% AEP wind speeds from the south-southwest and southwest are in the order of 26 m/s.

Using a spectral wave model, the highest significant wave height was determined to be from the southwest and in the order of 0.9 m when combined with the 2100 1% AEP storm tide level of 2.4 m AHD for Port Phillip Bay shown in Table F-11 above. The shoreward flux of water resulting from breaking waves of this height has been estimated as potentially resulting in an additional hydrostatic pressure increase (wave set-up) at the immediate shoreline of approximately 0.4 m above the mean water level.

An estimate of maximum run up for the depth limited breaking wave height, considering a 4.5 second wave and beach slope of approximately 0.1, provides an estimated maximum wave run-up elevation of 0.9 m (CEM, 2000). The beach slope used is at the back of the beach above where the waves will meet the protective structures.

The theoretical maximum total **wave** component of coastal water levels at the site is therefore estimated as approximately 1.3 m (i.e. 0.4 m wave setup + 0.9 m wave run up) above the mean water level.

The existing seawall reduces the direct wave action acting on the site, however overtopping and failure is a possibility at the site, as discussed in Section 7.3.

APPENDIX G
GEOMORPHOLOGY & COASTAL PROCESSES

G-1 Geomorphology of Port Phillip Bay

G-1-1 Pliocene Period

During the late Miocene (5.3 - 11.6 m.a.) through to the early Pliocene (3.6 - 5.3 m.a.), the embayment of the Port Phillip region was much larger, and bound by the elevated ranges visible away from the present day shoreline, i.e. the You Yangs and the Dandenong, Otway and Mornington Peninsula ranges (Figure G-11 left).

River sediments eroded from the elevated ranges to the east of Edithvale were deposited in the shallow waters, creating the Black Rock/Beaumaris sandstone and Red Bluff material which now forms the elevated cliffed outcrops Beaumaris and Sandringham, and bounds the northern end of the sandy beach which extends south past Edithvale to Frankston.

G-1-2 Pleistocene Period

Through the Pleistocene Period (2.5 m.a. - 11,000 years ago) there was significant global climatic fluctuation, during which several glacial phases (colder temperatures, increase in glacial and polar ice growth) and interglacial phases (warming of temperatures, melting of ice) occurred.

During the glacial phases the area was dry, and vegetation was sparse due to the water locked in the polar and glacial regions. Sands deposited on the bed during the interglacial periods were blown by the dominant north-westerly winds across the now dry coastal plain of Port Phillip region to form sand ridges across the south-eastern area. The coastal dune running along the shores of Aspendale south to Frankston are evidence of this Aeolian formation, enhanced by drying and wetting through the Pleistocene.

Within the last glacial period of the Pleistocene, sea levels fell to as much as 120 m below the present day levels and the rivers of the Port Phillip region formed a large river across the coastal plain, cutting a gorge through the dune ridges across the south, forming the present day “Rip” at the entrance to Port Phillip Bay (Figure G-11 right). The watercourses which flowed into the south eastern region, inland to the east of Edithvale, were separated from this large river by the wind-blown dunes forming a swampy area of river deposits.

G-1-3 Holocene Period

During the Holocene (the most recent geological epoch, beginning around 11,000 years ago), sea levels rose and flooded the Port Phillip region, creating a shoreline close the present-day configuration of Port Phillip Bay.

Around 4,000 years ago, during the mid-Holocene, there was an increase in temperature and sea levels rose around 1-2 m above present-day levels, creating shore platforms around Port Phillip Bay before falling back to present day levels.

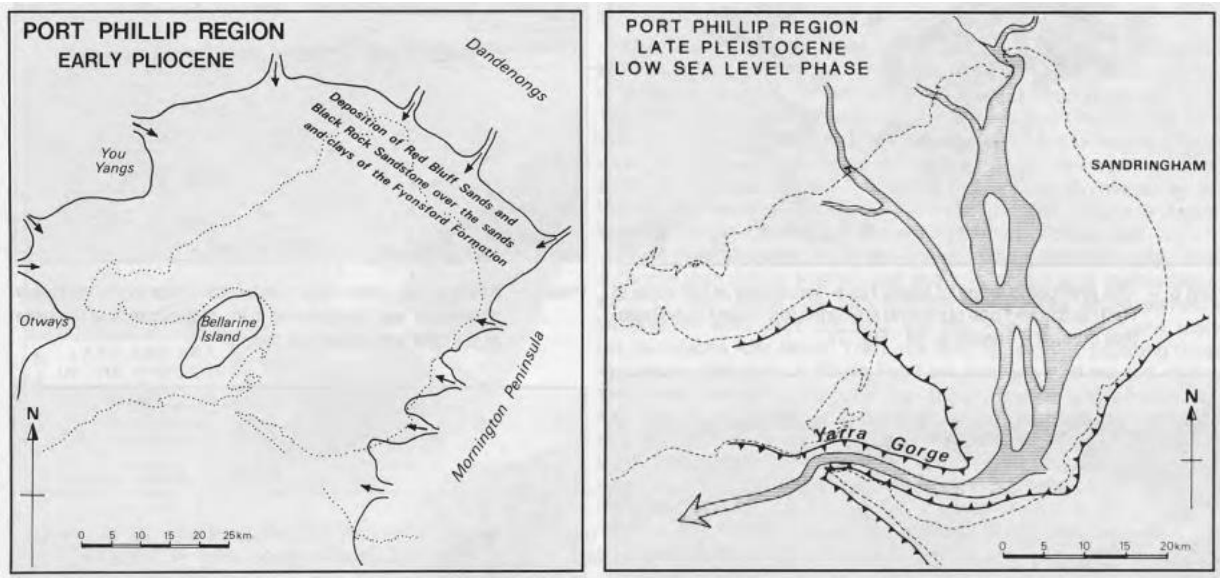

FIGURE G-11PORT PHILLIP REGION DURING THE EARLY PLIOCENE (LEFT) AND LATE PLEISTOCENE (RIGHT). (BIRD, 1993)

G-2 Coastal Processes

The underlying coastal processes comprise of a combination of artificial and natural influence. To assess the coastal processes occurring at St Kilda Marina and the impact any redevelopment may have, the coastal compartment around the site must be considered.

The main driver of coastal processes in the St Kilda area is the wave climate, which is fetch limited, and generated by local winds blowing across Port Phillip Bay (as discussed in Section F-1-5). The site (and most of Port Phillip) is protected from swell waves generated in the Southern Ocean by the narrow entrance to Port Phillip Bay, and The Great Sands between the entrance and a line between Rosebud and Indented Head. The longest fetch at St Kilda is to the southwest, but there is also a significant fetch south, resulting in higher waves at the study site when the wind blows from these directions.

G-2-1 St Kilda Beach

North of St Kilda Marina exists the sandy St Kilda beach, which fronts extensive commercial infrastructure and amenities. The beach is typically wide and sandy, however can be washed away during large storms, and is replenished via artificial nourishment, with renourishment occurring in 1981 and 1984 (Bird, 2011). According to the *Preliminary Assessment of Beach Renourishment Priorities 2015 – 2017* (Cardno, 2015) this beach was not recommended as a priority for nourishment in the 2015 to 2017 time period, with no recent erosion, and the beach width only showing seasonal variation. This beach is considered to generally be contained to its own sediment compartment, with minimal transport to the north around a large groyne at the southern end of St Kilda Harbour, and minimal sediment transport to the south around St Kilda Marina. The structures at either end contain the existing sand and a large storm is required to move the sand out of the compartment. However, this also means that if sand is removed from the compartment, it is not naturally replenished and requires sand nourishment from artificial sources.

St Kilda beach is typically protected from winter storm events, with the typical storm events dominated by winds coming from the west to north quadrant. The location of the beach within Port Phillip Bay means winds from this quadrant have a maximum fetch of approximately 5km to Williamstown, and therefore do not have the necessary distance to build substantial erosion producing waves.

St Kilda beach is more heavily affected by summer wave conditions, which typically produce waves from the south and south-westerly quadrant. These waves have the whole of Port Phillip Bay as a fetch and are therefore able to generate a larger wave height at St Kilda Beach. However, summer winds typically tend to be lighter than winter conditions. The beach is also sheltered from direct southerly swells by St Kilda Marina, further reducing the likelihood of storm waves reaching the beach.

To remove sand from St Kilda beach, a large south-easterly storm would be required, which are relatively rare in Port Phillip Bay. The storm would need to be strong enough to strip sand from the beach offshore.

Apart from major storm events and subsequent renourishment, sediment is also naturally transported on St Kilda beach on a seasonal basis. Cardno (2015) noted minor seasonal variation, and this variation would be expected to be to typically move sand towards the northern groyne in summer and back towards the southern end of the beach in winter, as per the wind and associated swell conditions discussed in Section F-1-4.

At the southern end of the beach, 200m north of St Kilda Marina, a stormwater drain that used to form the start of the now-demolished Brookes Jetty extends offshore of the beach. This drain appears to form a minor blockage to sand bypassing, with sand able to slowly build up on either side before leaking around. The low longshore sediment transport rates and artificial nourishment of the area suggest this is unlikely to cause major issues.

The lack of fetch to the north and west also suggests that sediment transport rates are extremely low to the south, and therefore unlikely to fill the entrance channel to St Kilda Marina.

It is likely that with climate change into the future, St Kilda beach will need more regular nourishment, as higher water levels on a more regular basis during storms allow for enhanced erosion on the beach. St Kilda could also be affected by changes in storminess and direction of storms.

G-2-2 St Kilda Marina

The Port Phillip side of St Kilda Marina is effectively subjected to similar coastal process conditions as St Kilda beach in terms of waves. However, a rock seawall revetment extends along the entire length of St Kilda Marina. This results in wave reflection from the wall, that enhances the rate of erosion of any sediment seaward of the seawall.

The seawall provides a barrier to any cross-shore erosion processes. An assessment of the quality of the seawall, and what might be required to upgrade the seawall has been made in Section 7.3. Any major failure of the seawall during a storm, such as overtopping, collapse or scour could have an impact on the immediate foreshore behind the seawall. The condition of the seawall is discussed in Section 7.3.

Whilst there is often some sediment immediately adjacent to the seawall and offshore of the seawall, this is likely to be transported in a typically northerly direction due to the extensive southerly wave fetch to the marina site.

At the northern end of the marina site also exists a 30m groyne, which does sometimes appear to capture a small beach on the southern side, further suggesting the presence of net northerly longshore transport. The purpose of this groyne is not immediately clear. As it captures some sediment it may be aimed at reducing the maintenance dredging requirements of the marina entrance as this capture means less sediment leaks around the headland.

The marina entrance is regularly dredged to allow for safe boat passage. The dredged sand is pumped to the north of the Brookes Jetty stormwater drain on St Kilda Beach. The source of the sediment that fills the marina entrance is thought to be due to sediment leaking around the headland from the south rather than due to sediment travelling from St Kilda Beach.

Inside the marina there is unlikely to be any significant wave action or sediment movement. The entrance faces north-west, and has a very limited wave fetch, and is therefore not involved in any active coastal processes.

South of the marina site is seawall protected foreshore, where similar coastal processes to the marina site are displayed, for approximately 250m before reaching Elwood Canal entrance. Elwood Canal is the downstream end of Elster Creek, which has an approximate 40km^2 catchment area, flowing from Bentleigh through Gardenvale and Brighton to Elwood. The concrete lined canal has a seawall either side at its mouth and is not expected to vary in its outlet location. Further south of Elwood canal is another 400m stretch of rock seawall fronted foreshore, before rounding Point Ormond and reaching a groyne at the northern end of Elwood Beach.

APPENDIX H
COASTAL HAZARD RISK ASSESSMENT SUPPORTING INFORMATION

H-1 Regulatory Framework

The coastal hazard risk assessment has been undertaken in accordance with the following regulatory framework and advisory documentation and information:

- *Planning for Sea Level Rise Guidelines (Melbourne Water, 2017)*
- *The Victorian Coastal Strategy (VCC, 2014)*
- *Derivation of Revised Victorian Sea-Level Planning Allowances Using the Projections of the Fifth Assessment Report of the IPCC (Hunter, 2014)*
- *The Effect of Climate Change on Extreme Sea Levels along Victoria's Coast (CSIRO, 2009)*
- *How to consider sea level rise along the Victorian Coast (DSE, 2008)*
- *The Victorian Coastal Hazards Guide (DSE, 2012)*
- *Practice Note 53: Managing Coastal hazards and the Coastal Impacts of Climate Change (DPCD, 2012)*
- *Guidelines for Coastal Management Authorities: Assessing Development in Relation to Sea Level Rise (DSE, 2012)*
- *Planning for Sea Level Rise: Assessing Development in Areas Prone to Tidal Inundation from Sea Level Rise in the Port Phillip and Western Port Region (Melbourne Water, 2012)*
- *State Planning Policy Framework, Amendment VC94 Clause 13.01*

H-2 Coastal Hazard Risk Assessment Definitions

TABLE H-12 RISK ASSESSMENT MATRIX

Likelihood	Consequence				
	1 – Insignificant	2 – Minor	3 – Moderate	4 – Major	5 – Extreme
5 – Almost Certain	**Medium**	**Medium**	**High**	**Extreme**	**Extreme**
4 – Likely	**Medium**	**Medium**	**Medium**	**High**	**Extreme**
3 – Possible	**Low**	**Medium**	**Medium**	**Medium**	**High**
2 – Unlikely	**Low**	**Low**	**Medium**	**Medium**	**Medium**
1 – Rare	**Low**	**Low**	**Low**	**Medium**	**Medium**

TABLE H-13 LIKELIHOOD RANKING

Likelihood Level	Description	Annual Exceedance Probability
1 – Rare	Risk will occur in exceptional circumstances.	1:10,000
2 – Unlikely	Risk not likely to occur within the period.	1:1,000
3 – Possible	Risk may occur within the period.	1:100
4 – Likely	Risk likely to occur within the period.	1:10
5 – Almost Certain	Risk will occur within the period.	1:1

TABLE H-14 CONSEQUENCE RANKING

Consequence Level	Description
1 – Insignificant	Minimal impact in a localised area within existing natural variability.
2 – Minor	Low impact in a localised area with minimal impact to the site or its function. Flood depths <0.3m.
3 – Moderate	Medium impact in a broad area with minor, local consequences to the site or its function. Flood depths 0.3 – 0.6m.
4 – Major	High impact in a broad area resulting in significant consequence to the site or its function. Flood depths 0.6 – 1.2m.
5 – Extreme	Very high impact with broad and significant consequences to the site and its function. Flood depths > 1.2m.

TABLE H-15 RISK PROFILE DEFINITION

Risk Profile	Definition
Low	Tolerable risk. A level of risk that is low and manageable without intervention.
Medium	A level to frisk that may require intervention to mitigate.
High	A level of risk requiring significant intervention to mitigate.

Melbourne

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365

Brisbane

Level 3, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460
Fax (07) 3846 5144

Adelaide

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000
Fax (08) 8357 8988

Perth

Ground Floor
430 Roberts Road
Subiaco WA 6008
Telephone 0438 347 968

Geelong

PO Box 436
Geelong VIC 3220
Telephone 0458 015 664

Gippsland

154 Macleod Street
Bairnsdale VIC 3875
Telephone (03) 5152 5833

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Wimmera

PO Box 584
Stawell VIC 3380
Telephone 0438 510 240

www.watertech.com.au

info@watertech.com.au