COMPARISON OF HARD AND SOFT ENGINEERING TECHNIQUES FOR EROSION CONTROL OF HISTORIC RUBBISH TIP SITES ON THE OPEN COASTLINE IN PORT FAIRY.

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1. ABSTRACT

Since January 2011, the primary dune system along the Port Fairy East Beach coastline has eroded 5 to 10 metres during storm surges and king tides. This has caused the exposure of hazardous waste materials at two historic rubbish tip sites in the dunes, increasing the risk to public health and the environment. Differing approaches of hard engineering (rock breakwater and vegetation) and soft engineering (sand trap fencing and vegetation) to control erosion at the two sites, has illustrated varying degrees of cost and technical effectiveness in managing risks and coastal processes evident on this section of coastline.

The aim of this paper is to describe the effectiveness of using sand trap fencing as an erosion control measure on the open coastline at an historic tip site, in comparison to the construction of a rock breakwater structure on the beach to dissipate wave energy at a tip site further eastward. The methodology used will be a combination of data collection and analysis through beach monitoring undertaken by the local community along the East Beach coastline at Port Fairy, as well relevant literature which examine the issue of coastal erosion along the coastline at Port Fairy. Through the data collection and literature, the findings will provide and details of why the sand trap fencing has been successful at its current location and how its design and alignment could inform and assist other coastal land managers wishing to re-establish a dune profile within an open coast environment.

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- Ms. Ebony Perrin, Environmental Services Team Leader, Moyne Shire Council VIC
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3. CONTEXT

Port Fairy is a small coastal town on the south west coast of Victoria located 293km south west from Melbourne, with a permanent population of 3,340. This 'grows' to 10,000 over the peak holiday season and to 40,000 during the Port Fairy folk festival held over the Victorian Labour day weekend (Early March).

It contains many natural features which shape the town and its surrounds, namely the Port Fairy bay, Southern Ocean, Moyne River and Griffiths Island. The town's main industries are tourism and fishing, with agriculture and the service industry are contributors to the town's economy.

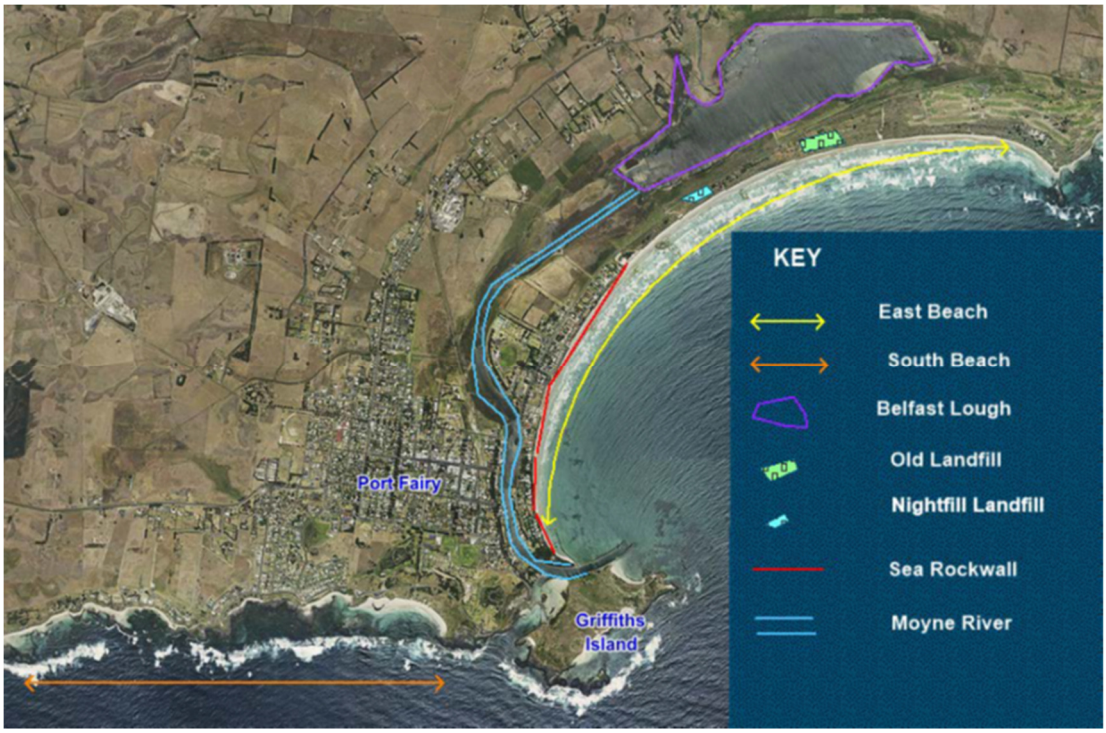

Figure 1- Aerial photo showing approximate location of key features as described through this research paper. Moyne Shire (2017)

In terms of geology, East Beach consists not only of a simple Holocene coastal barrier, but also low Late Pleistocene dune calcarenite ridges, overlapped by grassy Holocene dunes along the seaward margin. The Belfast Lough is also a depression in the Moyne River valley that was formed in late Pleistocene times rather than a former marine embayment. The primary landform is a sandy coast at the subject area and landfill sites.

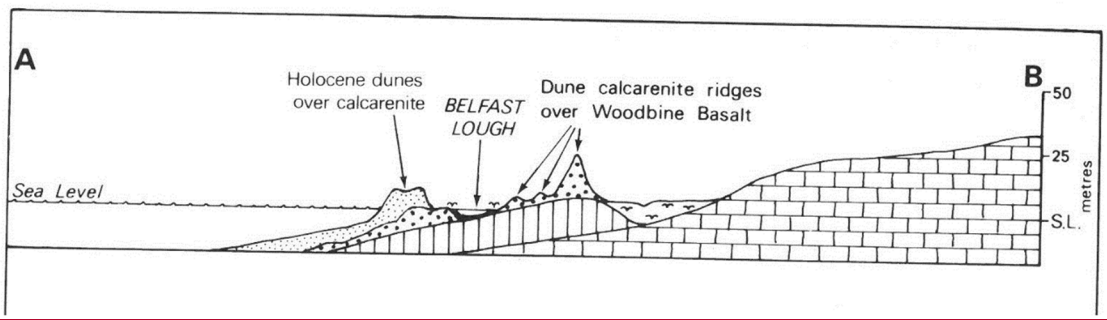

Figure 2- Cross-section of the coastal region between Port Fairy and Warrnambool. Located on Figure 3 (Bird 1993 and Gill 1967)

Port Fairy and district was originally home to the Peek whurrong tribe and was originally covered by damp sand and herb rich woodlands species such as manna gums, swamp gums, she oaks and blackwoods. With the introduction of white settlers to the district, these woodlands were cleared for pasture and grazing and only a few remnant pockets of indigenous vegetation remain in the district.

Wind erosion of poorly vegetated dunes initially caused substantial losses of sand from the Port Fairy beach and the dune systems occurred in the early 1900's when cattle grazing led to loss of protective vegetation cover and extensive dune instability. Figure 3 shows marram grass being planted to prevent further sand loss due to wind. Further the construction of training walls in 1870 along the Moyne River out to sea to enable the Port of Port Fairy to function has irreversibly altered the longshore transport of sand along the coast from west to east. This is highlighted in the aerial photo in Figure 4.

Increased frequency and intensity of storms also causes substantial loss of sand from Port Fairy beaches**.** Waves moving sand from offshore sand banks onto the beach form sandy coastlines such as those at Port Fairy. These waves are usually from the south east and occur over the summer and early Autumn months. The action of waves also transports sand back offshore from the beach and dunes. During storms, higher waves move sand from the beach to offshore sand banks. This occurs more frequently during the winter months when winds are generally from the south/south west direction. During calmer periods wave action helps to deposit sand build up back onto the beach. This cross-shore sand movement is a slow process of sand transport back to the beach over many months or several years; and beach recovery following storm erosion is slow.

Figure 3- Marram grass planting along East Beach during the 1800's. WBM Pty Ltd. (2007)

Since 2007, there has been progressive erosion of the foredune without the dune re-establishing itself. **Coastal Engineering Solutions (2006)**

Historically erosion trends at East Beach can be summarised as follows:

- Prior to settlement of Port Fairy, sand was supplied at the southern end of East Beach, and transported along the beach at a relatively uniform rate (long-shore sand drift);
- The Moyne River training walls restricted the supply of sand to East Beach causing permanent erosion of the beach and dune, including loss of fore-dune;
- A rock seawall was constructed to protect infrastructure built on the dunes;
- A comparison between 1870 and 2007 maps indicated limited shoreline recession in the north-eastern section of the East Beach towards the golf course, but significant recession of up to 40 metres along East Beach further to the southwest; and
- Documentation shows loss of sand in the 1910's and again in the 1950's.

Figure 4- Aerial photo of Griffiths Island showing Southwest Passage and former Griffiths and Rabbit Islands. Moyne Shire Council (2017)

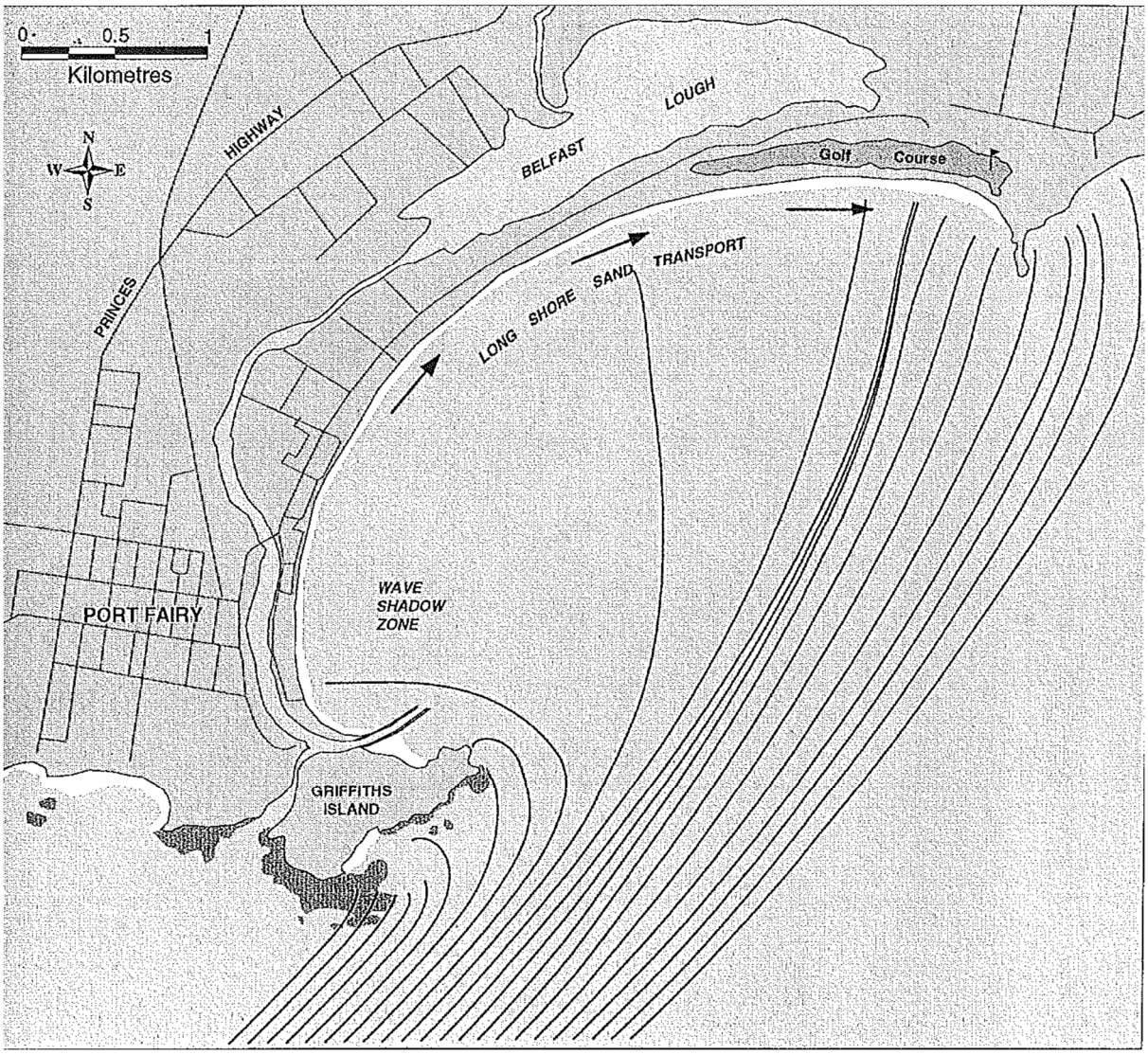

Figure 5- Wave refraction patterns- South west waves WBM Oceanics Australia (1996)

The above figure shows how sand is transported along East Beach when waves come from the south west. Note the 'wave shadow' zone in front of the most utilised section of East Beach and that sand is normally deposited further along to the north east of East Beach away from the town.

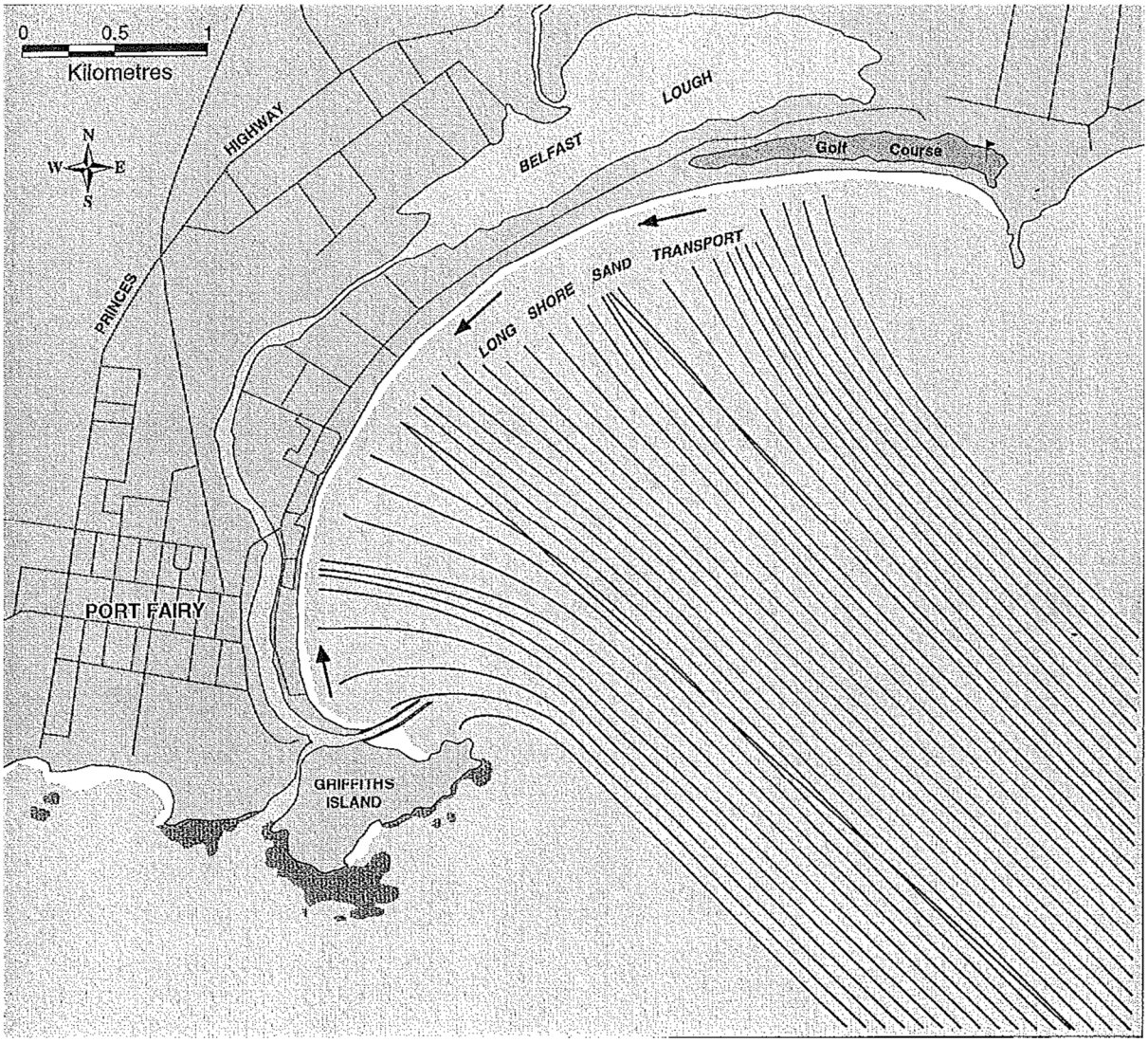

Figure 6- Wave refraction pattern South East waves. WBM Oceanics Australia (1996)

The above diagram demonstrates far more sand deposition occurring on East Beach when waves from the south east are prevalent. There is generally a more uniform deposition of sand as well not only in front of the dunes north east of the town but along the main section of East Beach where there is more activity occurring.

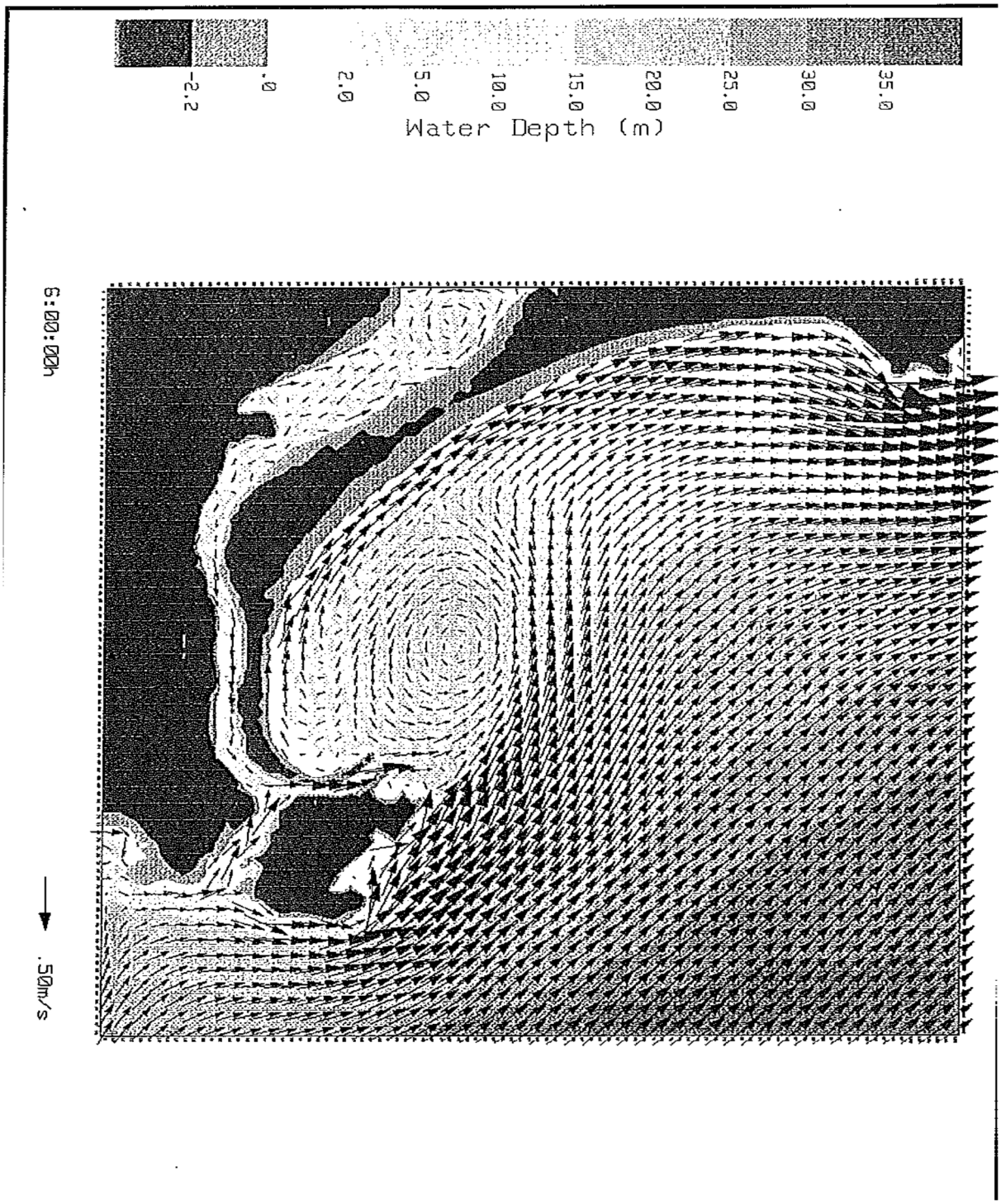

Figure 7- Wind induced longshore sand transport at 35 knots (65km/per hour) South west wind.

WBM Oceanics Australia (1996) show that gale force south westerly winds, which occur in winter, are likely to remove sand from East Beach at its most popular locations and push it to the east. Note also the presence of an eddy in the protected part of Port Fairy in its south-eastern section.

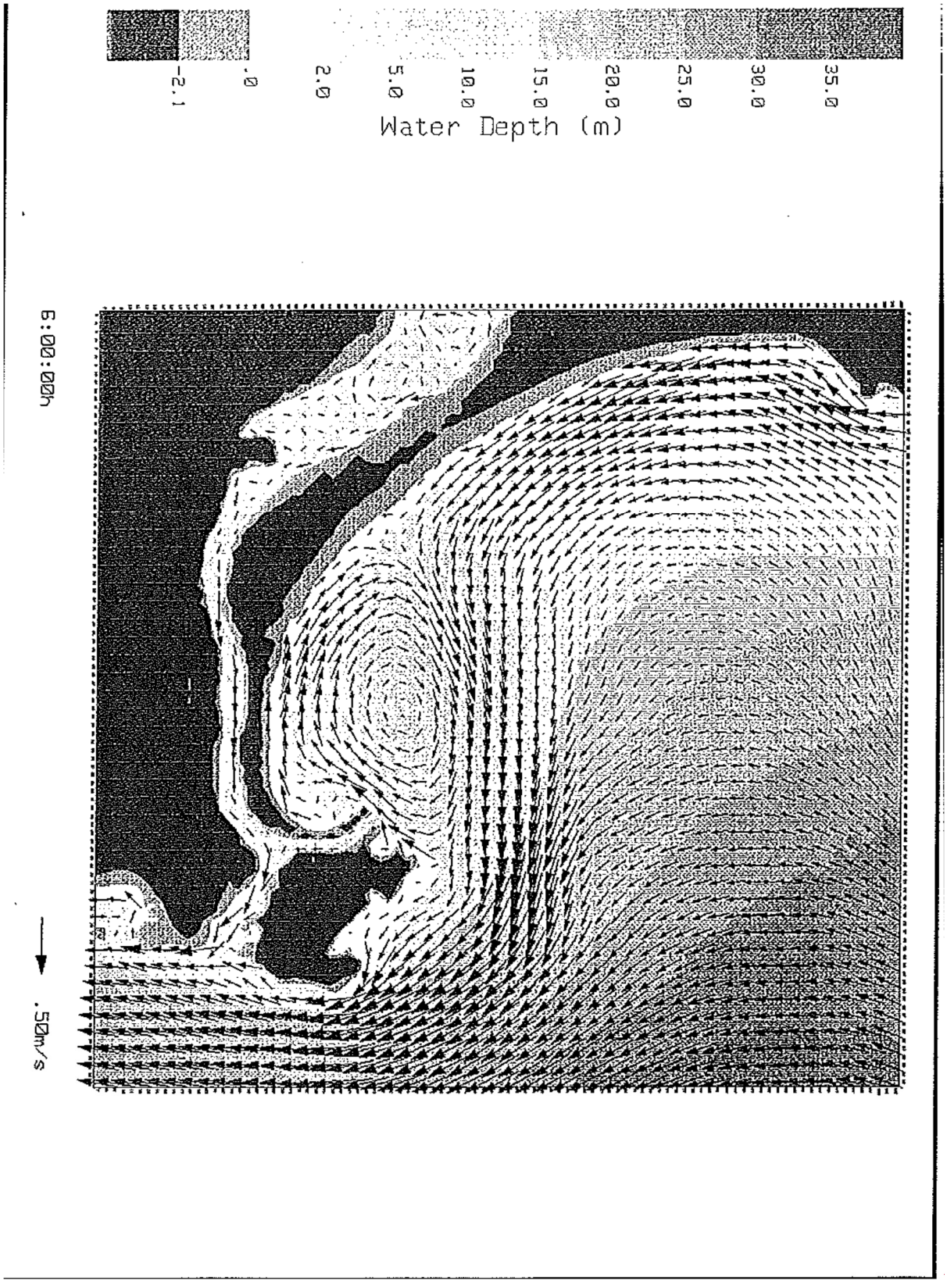

Figure 8- Wind induced longshore sand transport at 35 knots (65km/per hour) South east wind. WBM Oceanics Australia (1996)

This diagram on page 13 shows longshore sand transportation in gale force south easterly wind conditions. Sand transport is far more uniform across East Beach in these types of conditions.

Land use and boundaries

The introduction of sheep and cattle for grazing from the mid-1800s resulted in significant degradation and subsequent vegetation change along beach and dune systems in this region. Major modifications to the coastline have taken place because of the construction of the training walls at the entrance to the Moyne River at Port Fairy. Armouring of the coastline commenced in the early 1960s and has been progressively upgraded and extended. Several coastal protection structures exist in and around Port Fairy.

The foredune is in public land although much of this has eroded at the terminal end of an historic rock revetment. The back-dune is a combination of public and private land and provides the resilience to a potential breach of the dune barrier during storms. Hence, failure of both the foredune and the back-dune barrier has potentially significant consequences for both private and public land and assets.

It is understood that the local Shire Council has previously operated a 'sand dune mine' from the back-dune (i.e. it is protected by the foredune and not directly exposed to the force of coastal processes) for unknown purposes that are presumably for civil construction in the local area (e.g. road base and cement etc.). It is unknown when or what quantities of sand have been mined from the back-dune. It is understood that the Council has decommissioned the sand mine and that the land where the sand mine was located is now in private ownership.

The landforms most susceptible to coastal hazards in this area are the dune-backed systems at Port Fairy. High wave energy dominates the coastline of Victoria. Climate change is predicted to increase the impacts of coastal hazards on public and private property, including essential public infrastructure, where some areas are expected to be extensively inundated on a permanent or semi-permanent basis by 2100. The realignment of the sandy open beach coastline is projected to affect ecosystem services such as tourism and recreation, which is the mainstay for many coastal towns.

Recent storm surge events associated with southerly low-pressure weather patterns have caused high water levels and swell waves which in turn have caused shoreline erosion at many locations along the west coast of Victoria, including at Port Fairy. The period 2009 to 2011

is likely to have had high storm activity because the El Nino / La Nina weather patterns. Storms have occurred at other times and seasons on the open coast of Victoria.

Coastal protection

At Port Fairy, beach and dune erosion threatens public land and private land and assets. A sloping revetment constructed of randomly placed angular rocks to an approximately uniform slope and crest height is protecting 730 metres of Crown land foreshore and public assets (two toilet blocks, Surf Life Saving Club, a boat ramp, carparks, and picnic areas, grassed open space), as well as two kilometres of private assets (principally coastal residential properties) from coastal storms. The revetment has been constructed to protect the sandy dune escarpment from erosion by waves, tides and currents.

Figure 9- Photo of rock revetment looking to the south west. This section of the revetment was repaired and upgraded in 2012 BMT WBM (2007)

The revetment extends along the shoreline in front of the residential properties. The revetment has been damaged during recent storms and likely limited preventative maintenance at the eastern or terminal end. The damage is some rock displacement and outflanking by waves and subsequent erosion behind the wall causing collapse of a short section of wall. It is difficult to conclude that a single storm event has caused the damage, as some of the displaced rock is scattered along the beach and partly or completely buried, and therefore it is plausible that failure is caused by numerous/ongoing wave attack and storm events rather than a single event.

Beyond the rock revetment to the northeast is a naturally formed beach-dune barrier separating the Bass Strait ocean from the Moyne River floodplain. The dune barrier is approximately 6 to 10 metres in height, with peaks up to 15 metres height, and approximately 50 to 60 metres in width. The dune is comprised of vegetated mounds of sand varying in uniformity and morphology. The foredune toe line is approximately uniform and follows the beach contour, except for the terminal end of the revetment where the dune has eroded more severely.

The beach-dune barrier is a natural form of coastal defence that protects the Port Fairy community against storm damage and subsequent inundation hazards. If the dune barrier was eroded to the point of failure and breach the Port Fairy community and infrastructure could be at risk of coastal inundation hazards during severe storm events. Hence, the importance of dune management and integrity at Port Fairy is significant and discussed.

Rock revetment and breakwaters will have a large footprint on beach aesthetics and access. Any extension is highly likely to cause terminal scour erosion, similar to the existing revetment terminal scour erosion over time (i.e. months to years). Extending the revetment will transfer the terminal scour erosion further down drift to the northeast. Transferring erosion further towards the northeast may contribute to undermining of the Night Soil tip site (400 to 500 meters to the northeast) on DELWP managed land, which should be avoided if practicable.

Figure 10- Photo showing end of wall effects at southern end of old Council landfill site

4. LITERATURE REVIEW

A considerable number of reports and studies have been commissioned by various levels of government since 1986. They are listed below and a brief comment is made on each relevant to the topic where available. They have also been referenced where relevant in the paper.

Gill. E (1986) **Geological Notebooks Western Victoria** (Melbourne VIC) provides detail and eyewitness account of the geology of the region which is useful in understanding the geological processes that have shaped East Beach at Port Fairy

Cecil. M K (1986) **Beach Erosion at Eastern Beach, Port Fairy (Unpublished report)** was commissioned at the request of the former Borough of Port Fairy because of the increasing erosion of East Beach at the time. Using monitoring posts at four (4) different locations along East Beach, the author found that the cause of erosion was not primarily due to the closing of the South West passage blocking the longshore transport of sand but due to prevalent winds at the time the beach monitoring was undertaken.

Bird. E (1993) **The Coast of Victoria**, (Melbourne University VIC) provides a concise description of the geological and geomorphological processes that created not only East Beach but also the Belfast lough and broader Moyne River valley.

WBM Oceanics Australia (1996) **Draft Coastal Study of East Beach Port Fairy**, (Melbourne VIC) identifies several contributors to the loss of sand at East Beach, namely the introduction of training walls to the Moyne River, wind/swell patterns and direction, the location of Griffiths Island blocking the longshore sand transportation and the impacts of climate change. Options considered to address these issues are considered from a short, medium and long-term perspective mainly centred around beach renourishment, offshore breakwaters, terminal protection or planned retreat.

van de Graaff. R (2008) **Assessment of erosion trends from an interpretation of an exposed organic soil layer which is part of the primary dune ridge acing Port fairy bay, (**Mitcham VIC) found that the dune erosion and landward advance of the shore from East Beach towards the nearby Belfast lough environment was a natural and unstoppable process that would not be able to support a substantial residential development at the one proposed.

UNSW Water Research Laboratories (2008) **Expert Witness Statement by James Carley regarding**

Coastal Processes and Hazards for Proposed Subdivision at 228 Griffiths Street Port Fairy, (Manly Vale NSW) was prepared this report on behalf of the Department of Sustainability and Environment regarding a residential subdivision proposed on the primary dune immediately north east of the DELWP nightsoil site. The statement reviewed reports prepared by Coastal Engineering Solutions regarding the proposal and identified the dune system at this location having recessed over the period 2003-2008, particularly at its southern end where it intersects with the end of the rock revetment protecting residential properties on East Beach. It attributed the dune recession to increased storm events, recent sea level rise, end of rock revetment effects accelerating the dune erosion, loss of littoral drift of sand up the beach due to possible lowering of the beach at its southern end and beach rotation due to a short term or long-term change in wave climate.

BMT WBM (2007) **Port Fairy East Beach Coastal Erosion and Engineering Feasibility Study**, (Brisbane QLD) highlighted the poor condition East Beach was in at the time due to the construction of the Moyne River training walls diverting the longshore transport of sand away from East Beach and the closing of the South Wes passage. The report also states in the absence of remedial coastal management action the beach and dune will remain in poor condition and its amenity will be further downgraded. It further states that the natural accretion of sand on the beach is unlikely and recommends beach improvement programs (through dredging of sand from Griffiths Island and investigating offshore options and rock revetment upgrades with associated management and maintenance programs be adopted for East Beach.

Aurecon (2010) **Peer review of East Beach Coastal Erosion and Engineering Feasibility Study**, Maroochydore (QLD) undertook a risk assessment of the issues identified in the original study and relating to the topic of this paper. It stated that beach restoration and ongoing renourishment were key components of a more detailed strategy to address coastal erosion issues at East Beach which also included rock revetment repairs and upgrades and beach monitoring.

UNSW Water Research Laboratories (2012) **Future Coasts Port Fairy Coastal Hazard Assessment**, (Manly Vale NSW) findings relevant to this paper were that East Beach was eroding at 0.1 to 0.3 m/year over the past 150 years due not only to the construction of the Moyne River training walls but also the prevalent wind/wave climate and platform of Port Fairy and that the opening of the south west passage was unlikely to restore a full sand

supply to East Beach sufficient to prevent or reverse the recession that has occurred for the past 150 years.

Coastal Engineering Solutions (CES) (2013) **Port Fairy Sand Sourcing Study (**Fish Creek VIC) looked at different locations where sand could be sourced from to assist in beach re-nourishment at East Beach. It found the most efficient way to do this would to be source sand in 6 to 10 metres of water from Port Fairy bay and pump around 100,000m3 of sand back onto East Beach near the surf club to allow winds and swells to transport it along the beach. It also highlighted the possibility that more re-nourishment may need to occur at higher risk locations along East Beach to the north east.

CES (2014) also undertook a **Review of WEDS (Wave Energy Dissipation Structure) and Wattle and Wire Fencing plus concept designs for WED upgrade and Seawall for MSC**. The review found that the trial use of the wattle and wire fencing at DELWP's landfill site had functioned in a similar manner to the WEDS but at a smaller scale and at a location which is not exposed to storm waves or long-term erosion compared to the WEDS site. It also highlighted the significantly smaller cost of the fencing compared to the WEDS and that it is only seen as short-term solution towards managing the site. Regarding the WEDS site, the review put forward options regarding extending and widening the WEDS for a 50-year life span (taking into account climate change) and adding wattle wire and fencing to each end to address potential scouring of the dune face. It also highlighted a risk of failure of the WEDS performing due to potential overtopping during storm events over the next 25 years regardless of global warming.

Moyne Shire Council's (2017) **Draft Port Fairy Coastal Climate Change Adaptation Plan**, Port Fairy VIC identifies both landfill sites at being high or extreme risk to coastal hazards and recommends $2 million be committed towards an ongoing beach re-nourishment program. It also recommends long term management options paper be prepared to investigate costs for the long-term management of both sites.

5. COMPARISON OF MITIGATION IMPACTS AT BOTH SITES

Severe storm events in 2011 and 2014 eroded up to 10 metres of the primary dune at East Beach north east of the Port Fairy township. These storms exposed two old landfill sites, one a former night soil site (located on crown land directly managed) by DELWP and the other a former council landfill site (located on council freehold land).

When material was first exposed at the DELWP landfill site in 2011, a number of short term management options were considered to address and minimise any risks to public health and safety. The options were:

Short-term Option 1 –

- Regular management to remove exposed waste. Clean-up waste at weekly frequency or after storm events
- Machine skims and removes visible waste from the site

1. Long reach excavator working from top of dune. May not reach / remove all waste.
2. Crane to drop a machine and skip onto the beach.
3. Construct a steel or aluminium ramp from the top of dune to the beach to enable machine access. Ramp removed at the end of each clean-up and stored at the top of the dune.
4. Cut a track from the top of the dune to the beach and build a sand ramp to enable machine access onto the beach. Erosion may be accelerated. At the end of each clean-up, the sand ramp would need to be rebuilt possible including some toe protection with rock or geotextile bags

- Waste removed offsite
- Details and costs need to be confirmed
- Some manual clean still required

Short-term Option 2 – Protective seawall to minimise exposure of waste

- Construct a seawall parallel to the dune to minimise exposure of the dune to erosion by waves and storms
- Minimise waste entering the beach

1. Buried seawall toe protection, ideally covered with sand
2. Low seawall protection, above the toe

3. High seawall protection

4. Rock protection 10 metres seaward off the toe of the dune

5. Build, remove and rebuild seawall as required when erosion is observed, which would involve stockpiling the rock

6. Compare rock or geotextile materials

- Length of seawall at night soil site ~350 metres
- Would require detailed design, terminal erosion scour

Some initial and regular management to remove exposed waste is likely to be required depending on seawall design, dune stability and storm events.

Medium to long-term options

- Presently insufficient information or data to give clear advice on long-term options
- Limited long-term options, would require detailed design investigations:

Set-back: staged option based on modelling and monitoring, excavate and rehabilitate dune at the 1 in 100 or 1 in 200 ARI erosion line to create a set-back toe line

- Permanent seawall, up to 5 km
- Renourishment (importing sand, beach scraping, and/or dredging)
- Offshore reefs
- 'Do nothing' to compare against other options' benefits and costs

DELWP site

Because of storm events in 2011, the dune crest at the site was measured to be receding inland at an average rate of 1m per year since January 1996.

As a result, the following mitigation works were undertaken in 2014-

- Installation of two (2) rows of sand trap fencing for 205 metres along the beach in front of the site. The rows are separated 1.5 metres apart from each other with the row.
- Re-profiling of the dune face and installation of Geotech fabric and matting along with plantings of native vegetation to stabilize the dune face.

Total cost of works was $60,000.

Figure 11- View of active dune erosion to the south west of the DELWP landfill site in November 2011 after storm damage

Council site

After severe storms in 2015, Moyne Shire Council undertook the following works regarding their landfill site-

- Between May-June, construction of a 235 metre rock wall (known also as 'WEDS' Wave Energy Dissipation Structure) along the beach about 4 metres in front of the landfill site.
- In November, the installation of 25 metres of sand-trap fencing at each end of the WEDS. These works did not occur until
- Re-profiling of the dune face and installation of Geotech fabric and matting along with plantings of native vegetation to stabilize the dune face

Total costs of the works were $171,000.

Figure 12- Council landfill site looking to north east exposed due to dune erosion after 2015 storm event with WEDS in foreground

Effectiveness of mitigation techniques at both sites

At the DELWP nightsoil site, reshaping of the dune crest and dune face, together with the geo tech matting and sand fence at the Night Soil site, have eliminated dune crest recession that has been a major concern in recent years. Further, both rows of sand trap fencing have been completely submerged by sand with vegetation now establishing there and therefore creating a tertiary dune in front of the primary dune. It is estimated that since these works took place that 1,000 to 2,000 cubic metres of sand has been trapped and maintained on the beach. This is likely to be due to aeolian (wind driven) processes and the mitigation works undertaken at the site.

Figure 13- Photo taken 17 October of DELWP nightsoil site looking to the north east showing sand accretion and vegetation over

At the Council landfill site, the dunes behind the WEDS have stabilised considerably due to the works undertaken. However, it is noted at both ends of the WEDS where sand trap fencing has been installed that 'end of wall' impacts or scouring have occurred. This is likely to be due to the location and alignment of the sand trap fencing as well as the more exposed location of this site to the elements, particularly tides, swells and winds. The works were also impacted heavily by severe storm events over 5-6 months in 2015 with increased king tides and storm surges.

Figure 14- Photo of the old Council landfill site looking to the north east. Note the smaller amount of sand on the beach compared to the DELWP landfill site

6. COMMUNITY AT CENTRE – BEACH MONITORING AND MEASUREMENTS

Beach Monitoring and measurements

To understand the condition of the beach, the performance of coastal protection structures, and the risks to the landfill sites at Port Fairy, it is essential to conduct beach monitoring measurements on horizontal and vertical sand erosion and accretion, frequently over many years to decades. Both of these methods provide important information and data to inform decision making of options and management of risks

The volunteer Port Fairy Coastal Group (PFCG) has been monitoring East Beach monthly since January 2013. Concerned about erosion of beaches and dunes around Port Fairy and wanting to be a part of the solution, the PFCG facilitates community participation in coastal management decisions. PFCG's beach monitoring team uses a survey level each month to accurately measure beach profiles at fourteen posts located at intervals along four kilometres of East Beach in Port Fairy. Post 1 is at the southern end of East Beach and Post 12 is at the northern end of East Beach.

Information acquired from the PFCG monitoring of East Beach includes:

- Several areas along East Beach show differing seasonal responses with sand return taking several months. Annual sand loss tends to occur almost simultaneously over the whole of the beach.
- Areas of East Beach between the rock seawall and the DELWP 'Nightsoil Landfill' site (Post 4) have excellent sand build up.
- The area in front of the 'Old Landfill' (Posts 7.5 – 8.5) that is now protected by the Wave Energy Dissipation Structure (WEDS) continues to demonstrate the capacity for active sea erosion. As indicated at Post 8 in Figure 11, the WEDS appears to be preventing high-energy waves from reaching the dune toe.
- Evidence of sand height movement is first detected at a point 30m seaward from the reference Post. Data from this area is most likely to yield information on the influence of various weather and tidal factors.

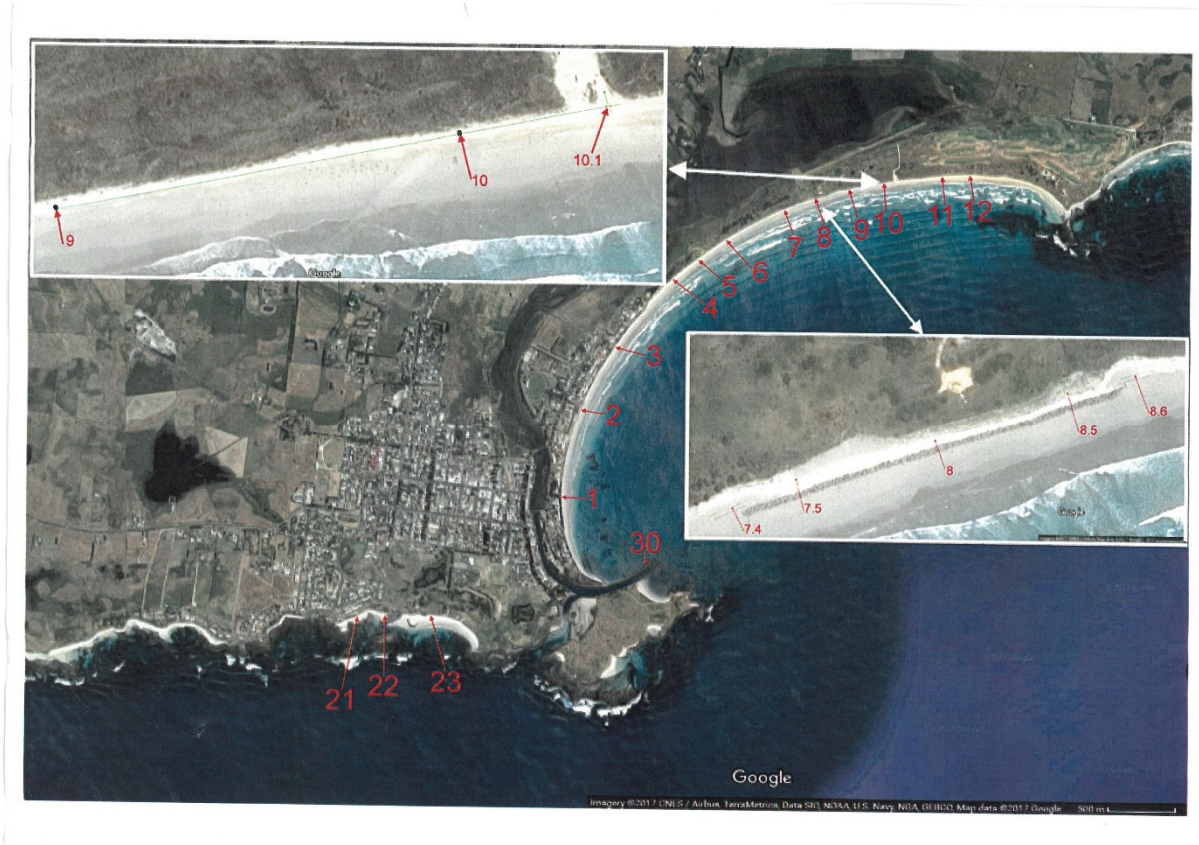

Figure 15- Location of beach monitoring sites in Port Fairy

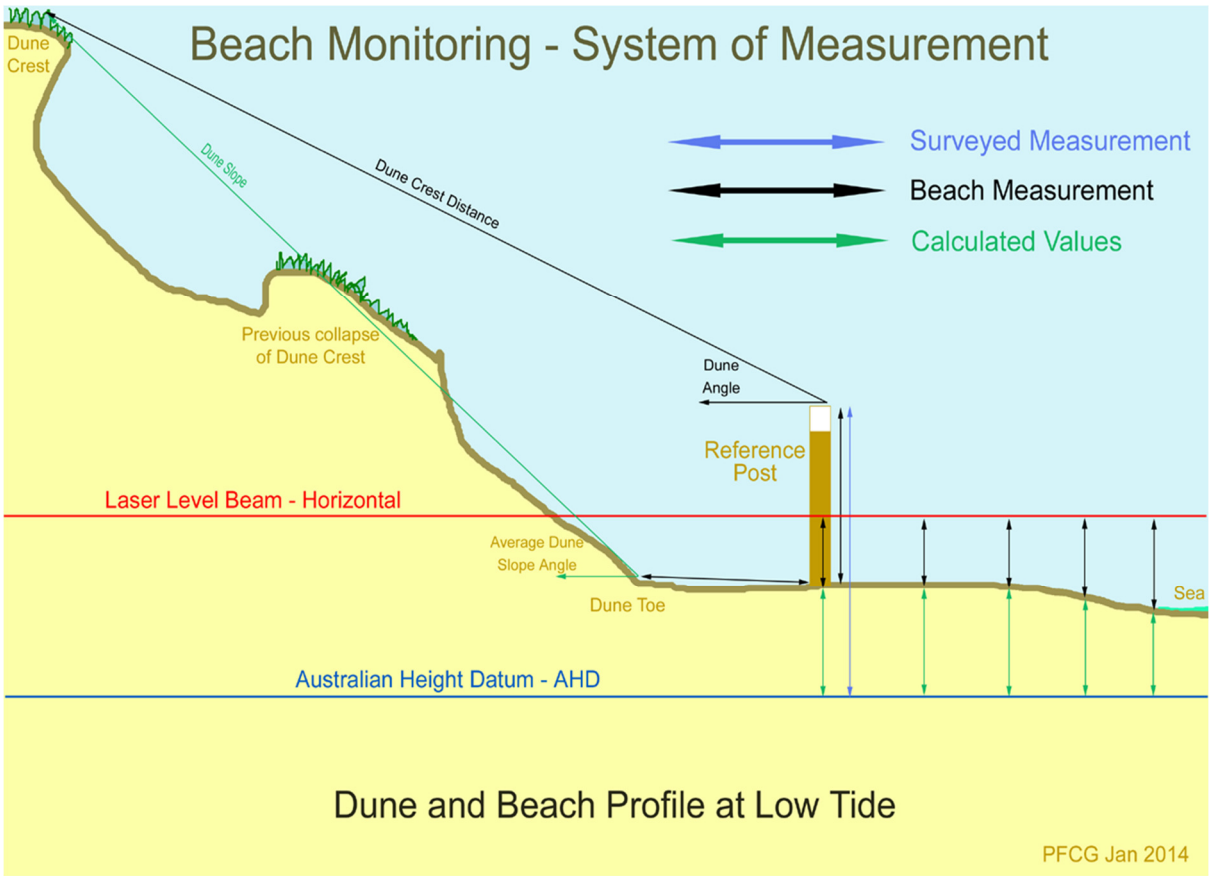

Figure 16- Diagram showing methods used for beach monitoring by Port Fairy Coastal Group

7. ANALYSIS

A combination of mitigation measures were used at both sites to address the issue of waste falling onto the beach and causing a public health and safety risk to the users along this section of East Beach as well as marine pollution into Port Fairy bay.

The use of 'soft engineering' techniques at the DELWP nightsoil site, combined with wind driven (aeolian) sand transportation has stabilised the dune system along this section of East Beach. The sand trap fencing has acted as an anchor point for the sand to be trapped and then stabilise itself in front of not only the landfill site but for a considerable distance along the beach to the south west and north east. It can also be pointed out that in this section of beach there are no rock revetments or other hard engineering structures which would divert the transport of sand away from the beach or cause 'end of wall' scouring effects on the dune system.

The WEDS at the Council landfill site has effectively directed wave and swell action away from the dune face which has been re-profiled and profilgated with vegetation. However, it is evident that 'end of wall' effects have occurred at each end of the WEDS despite the installation of sand trap fencing. It may be that the fencing was not designed and located appropriately given the more exposed location of this site compared to the other and that works occurred over period of severe storm activity in 2015. It also not evident that the fencing has provided an anchor point for sand to be trapped and establish itself to create a fore dune to protect the primary dune as has happened at the DELWP landfill site.

From a literature review perspective, all the papers and reports referred to state that the main cause of the lack of sand deposition on East Beach is due to the construction of the training walls along the Moyne River out to Port Fairy bay. Recent information and commentary also attribute this to the changed wave/wind climate in the Port Fairy bay due to construction of rock revetments etc protecting public and private land. It could also be stated that due to the shallowness of the bay platform ,the sand accumulates offshore rather than accreting back onto the beach, hence why offshore beach renourishment has been identified as an option to assist in depositing sand on the beach and reversing the erosion process. Some also attribute the loss of sand to the proliferation of hard structures on East Beach, such as sections of the rock revetment, that are currently not up to standard refracting sand off the beach back into Port Fairy bay and that sand

being lost for considerable period. This is also likely to explain the end of wall effects evident at the old Council landfill site caused by the construction of the WEDS.

The location of both sites is also likely to impact on the effectiveness of mitigation techniques undertaken. The location of the DELWP site is more sheltered from the open ocean environment than the old Council landfill site as can be seen in the maps and photos referred to in this paper. However, the impact of the WEDS as a hard structure located in open coastal environment has contributed to scouring of the dune system at each end of the WEDS. There is no evidence of scouring on either side of the DELWP landfill site due to the mitigation works undertaken only consisting of soft engineering techniques.

8. THE FUTURE

It is unlikely in the short term that DELWP will change the mitigation techniques used to managed its site. Some have suggested extending the sand trap fencing to the north east to assist in stabilising the primary dune and foredune that has been created. However, the author believes that digging up the sand that has established itself as a foredune recently may disrupt the natural processes that have contributed to the sand replenishment and impact its effectiveness in the long term.

For the Council landfill site, there have been calls in the community to remove and relocate all the waste at this site. Cost estimates for this type of work are up to $50 million due to the nature of material to be removed, transportation costs, landfill costs and the cost of rehabilitating the site effectively. State government is petitioned consistently by Council to fund the works from fees earned through the State Landfill levy.

For now, consultants have been engaged to prepare an options paper for the long-term management of both sites. Costs of total removal and rehabilitation of both sites are starting to become prohibitive and outside of the scope of local and state governments.

At Port Fairy, the recommendations on the future are below.

A monitoring program should be designed for the Port Fairy sand dune barrier, with a focus on risk management of a potential breach of the dune barrier at the narrower sections of the dune (sites include the old sand mine and the old tips, as well as other yet to be identified sites). I am currently developing a conceptual design for the monitoring program, that will need to be implemented by a consultant/contractor.

There has been some discussion through the community about the construction of a five-kilometre-long seawall to protect the dune barrier. The costs of such as seawall will depend on the design, materials and construction. Based on recent estimates, the cost of a five-kilometre seawall at an exposed ocean site such as Port Fairy is in the order of $10 million to $25 million (this is based on cost of $2000/lineal metre to $5000/lineal metre).

Construction of short seawalls and/or toe protection structures is not recommended at an exposed ocean site because of the potential flow-on erosion impacts to adjacent beaches and land resulting in an increased risk of a breach of the dune barrier.

To increase the resilience of the dune barrier, dune management and restoration works should be undertaken at the old sand mine site (located at end of town rock revetment) and the old tip sites and other yet to be identified sites. Land tenure is an issue as some of these sites are largely or wholly in private ownership and hence Council will be the responsible authority to lead negotiations with land owners.

Other options that should be investigated to manage dune erosion and terminal scour, such as: beach scraping, dune management and reshaping, filling in the historic sand mines with suitable quality sand, and revegetation. These options would increase the resilience of the sand dune barrier to coastal storms.

Any substantive volume of sand or rubbish removed from the tip sites decreases the sediment reserve and the resilience of the dune barrier to breach during a storm event(s). Any substantive volume of sand or rubbish removed from the tip should be replaced with an equivalent volume of suitable grade beach sand. Appropriate dune rehabilitation should be conducted. A staged approach (possibly over years) should be considered to ensure that the site clean-up is conducted at an acceptable risk level of dune breach.

On a final note and something to think about: Buy-back of some private land is possibly a cheaper option than protection; In the mid-1970s the NSW State government has previously conducted buy-back of 17 highly vulnerable coastal private properties following large storm events to restore dune systems and prevent associated loss of amenity and impact on tourism and other commercial activities.