Profiling - Why monitor the beach?

- Develop an understanding of sand movement.
- Provide a bench mark of sand movement to detect new events and assess the influence of any implemented protection strategies.
- Provide coastal managers and government authorities with the latest information about the coastal process.

Port Fairy Coastal Group Inc.

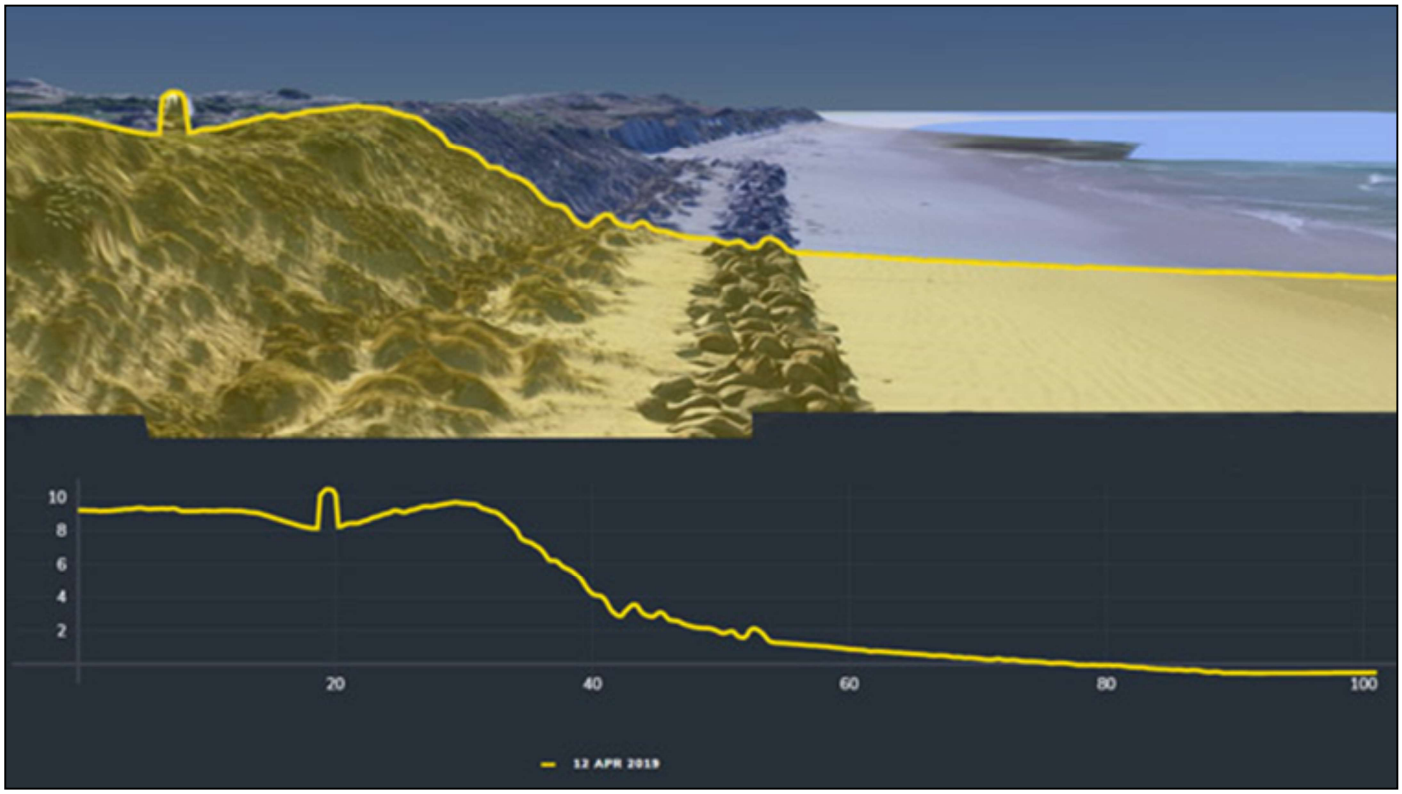
Profiling is a specific group of beach height measurements that can be used to estimate sand volumes on a beach

Coastal Engineers have general knowledge and understanding of beach and coastal processes but to optimize the response of coastal managers to storm surges, climate change and sea level rise, we need a specific understanding of the systems at work around our local coast.

Formal documentation of our beach system provides a reference against which we can compare results after physical prevention strategies are implemented to confirm a positive result with minimal adverse side effects.

Coastal managers must have relevant data in order to make the best decisions about coastal protection strategies and formulate a cost effective response to environmental issues related to climate change.

If you already measure the sand height at a single point near the dune face, consider extending your monitoring to include the beach profile down to the water's edge.



A beach profile is a cross sectional view of the beach to show how the height of the sand changes as you move over the beach. Vertical heights are measured relative to the Australian Height Datum

Above is a transverse profile which can show more information about beach sand movement than a longitudinal profile. The highest range of sand height seems to be near the low tide area of the foreshore and at Port Fairy's East Beach, achieving height measurements at least 30m from the reference post is a high priority.

In contrast, sand height range at the Backshore is less, so a longitudinal profile at the Backshore may not show much at all.

A longitudinal profile would run parallel to the rock wall above, either at the front or the back or in both places. Longitudinal profiles can indicate if water has passed through the wall causing erosion gullies in the sand. The horizontal measurement interval should not be larger than 5m and preferably less if you need to detect water channels.

The results from RPA mapping in Propeller Aero are excellent for sourcing data on water channels in longitudinal profiles as the horizontal resolution of the height measurements are by pixel. This means you can easily extract height measurements at 1m increments or less but remember that the smaller the increment, the longer it will take to transfer the readings to a spreadsheet chart.

This photograph taken in 2013 on East Beach shows the dune toe has been under continual attack by wave energy which is undermining the dune face allowing the dune face to slump and causing dune recession inland. This is a serious and destructive situation. Appropriate monitoring should be regularly measuring the distance of the dune toe behind the reference post.

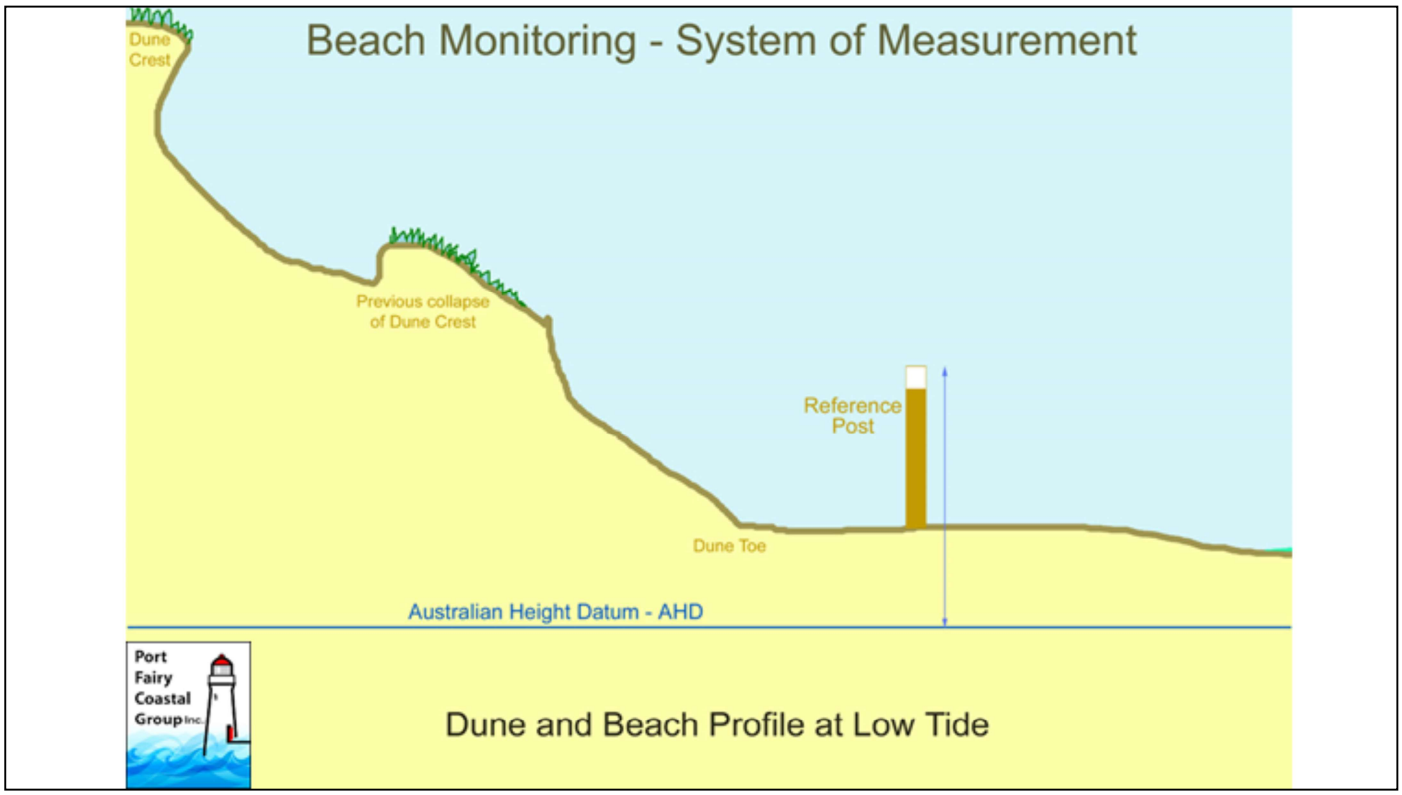
See the PFCGnotes1118.pdf file.

Reliable profiling requires an accurate reference point whether its using a builder's laser level or the ground Control Points (Aero Point targets) and a Remotely Piloted Aircraft.

Port Fairy's reference posts are placed deep into the sand and are capable of surviving the worst of storm events. Once the post is installed, it is surveyed by engineers with enhanced GPS/GNSS technology to establish not only its position on a map (Eastings and Northings) but its height relative to the Australian Height Datum. This is a vital measurement for determining a beach profile and is different for each post.

The post height above the datum is critical information for accurate beach monitoring.

The more remote sections of East Beach are also part of the Victorian Coastal Monitoring Program using a Remotely Piloted Aircraft (RPA) to conduct aerial mapping. Those parts of the beach monitored by RPA use ten automated electronic targets (Ground Control Points) that provide similar accuracy of position and height to a Surveyor's GPS/GNSS system. These can be seen along the beach on days when RPA mapping is being conducted.



To fully understand beach profiling, we need to define what we will measure and where the measurements will be made.

The diagram above represents a typical cross section of a sand dune and beach that is already subject to water erosion which is undermining the dune toe allowing the dune face to slump onto the beach leaving the dune crest with insufficient support and it eventually shears off, continuing the slumping process and recession of the dune crest inland.

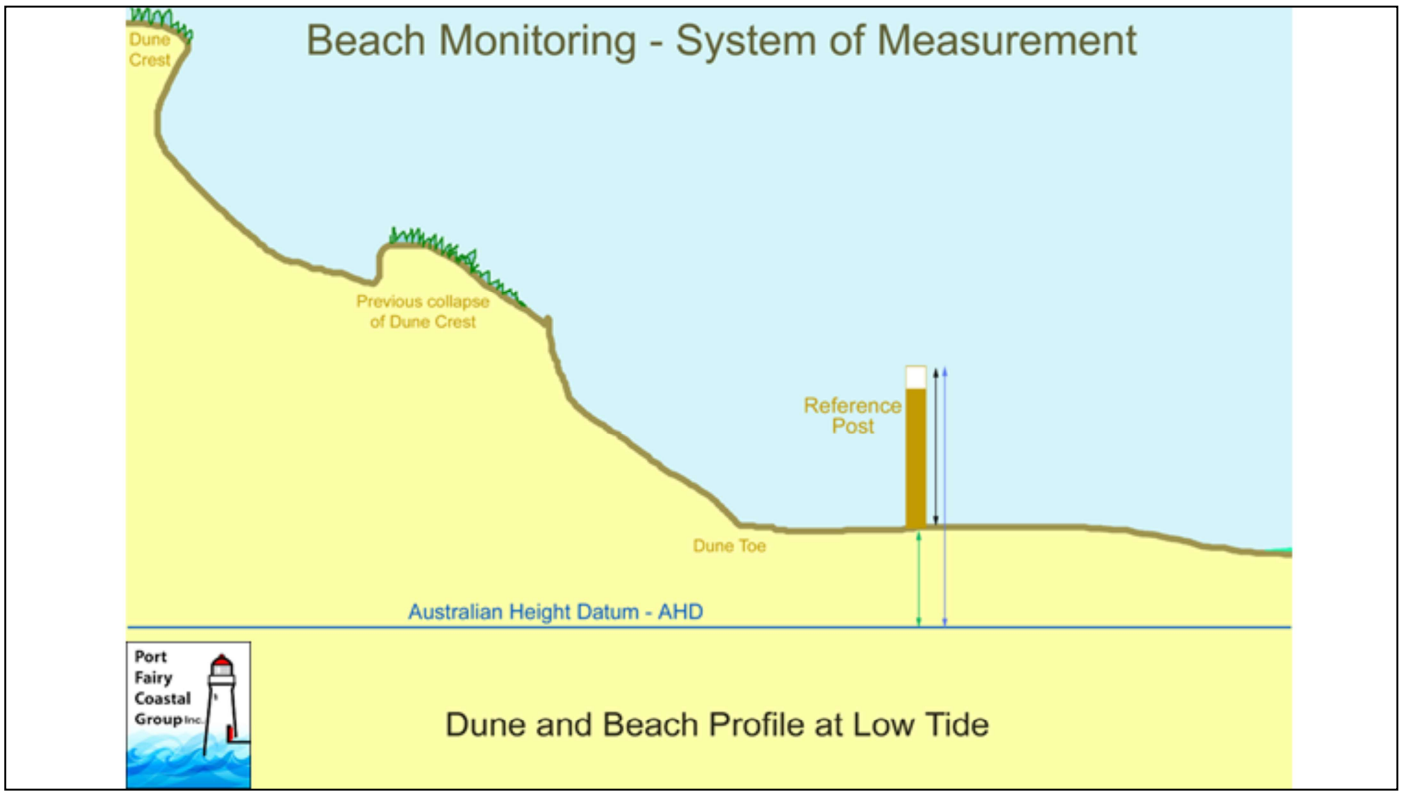
Australian Geoscience has established a reference level known as the Australian Height Datum which is accessible by surveyors around Australia.

Using a datum that is common around the coast enables the comparison of sand heights anywhere along the beach

Surveyors determine the height of each reference post above the datum using enhanced GPS/GNSS devices.

Recent advances in Geoscience provide a datum that is independent of tectonic plate movement on the earths surface however, height data from Propeller Aero is relative to the Australian Height Datum. All the fixed reference points in the Victorian Coastal Monitoring Program use the AHD.

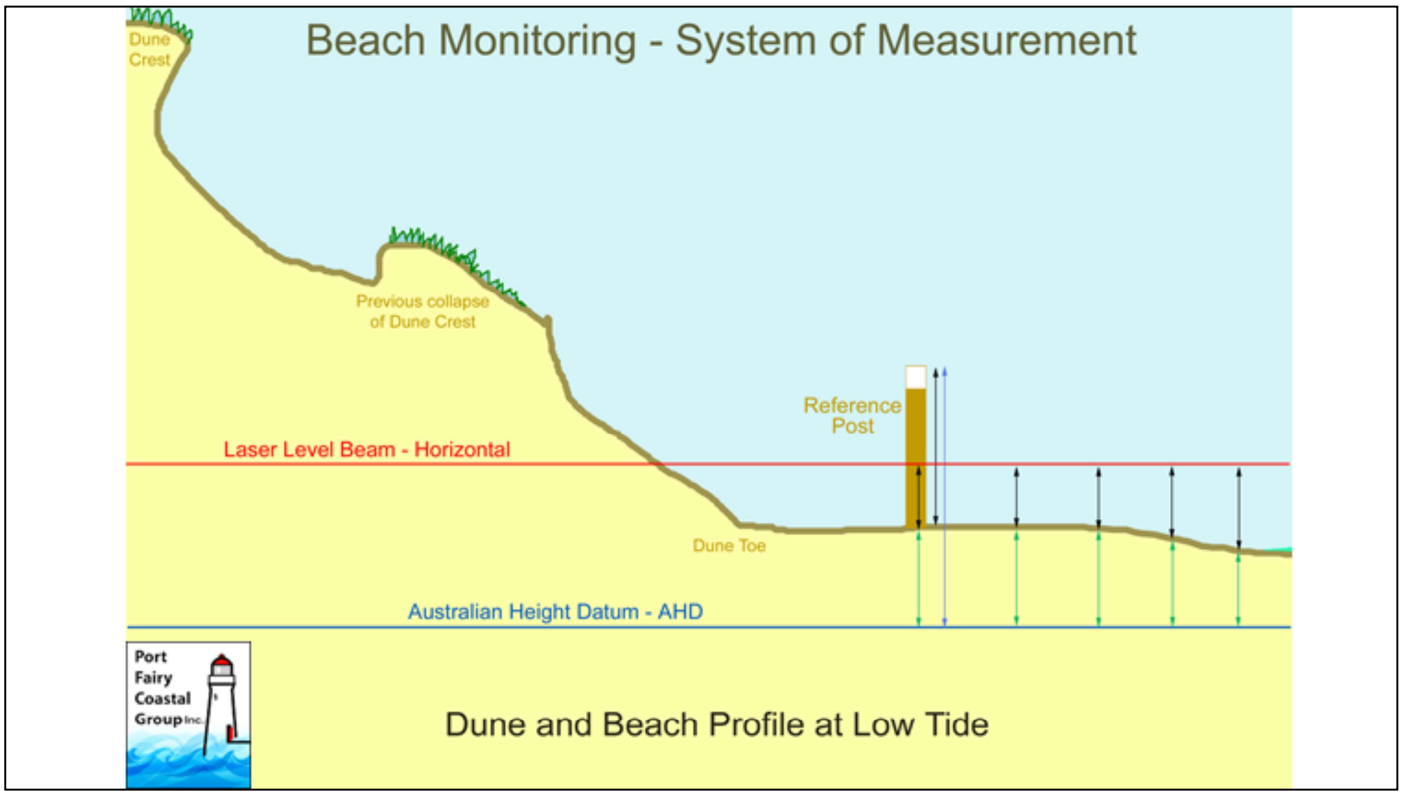
Movement in the height of the tectonic plate as well as sea level rise will determine the degree of land inundation.



If the post height above the datum is known and the length of post above the sand measured, the sand height above the datum can be calculated. This sand height can then be compared to other parts along the beach.

All beach height measurements by the Port Fairy Coastal Group are referenced to the Australian Height Datum.

Lower parts of the beach are then identifiable as potential areas of greater erosion.



Unlike the dune toe measurements, sand height measurements for beach profile determination involve more readings and the use of a builders laser level to provide a height reference **above** the sand and parallel to the Australian Height Datum.

Alternatively we can derive profile heights directly from Propeller Aero.

Height measurements from the sand to the laser reference can then be used to calculate the height of the sand surface above the datum.

A cross section profile of the beach can then be charted for a visual comparison of the current sand height with previous measurements.

The various measurements from the system diagram above are used in the following formula:

Sand Height above AHD **=** Laser beam Height at Post **plus** Post Height above AHD **minus** Post Length above Sand **minus** Laser beam Height above Sand

This formula is used in the Universal Spreadsheet to calculate sand height.

The **TPSystem** Tab in the spreadsheet shows how it is derived.

The beach monitoring team of volunteers initially conducted measurements at 12 posts along 4.5 kilometres of beach approximately once per month. Members from the Port Fairy Surf Lifesaving Club also assist by transporting measuring equipment in their support vehicle.

A beach monitoring team consists of only three people because of the vehicle seating capacity.

The PFSLSC registered driver also scribes the measurements onto the data collection sheet while the other two PFCG members make up the monitoring team who operate the laser level to measure sand height and photograph beach condition around each measuring post.

Recently, several PFCG members have also qualified to drive the surf club vehicle which has added more flexibility to the monitoring team.

On the day of our first monitoring, several members joined the team on foot to witness the process.

An experienced team could complete an East Beach monitoring in under two hours.

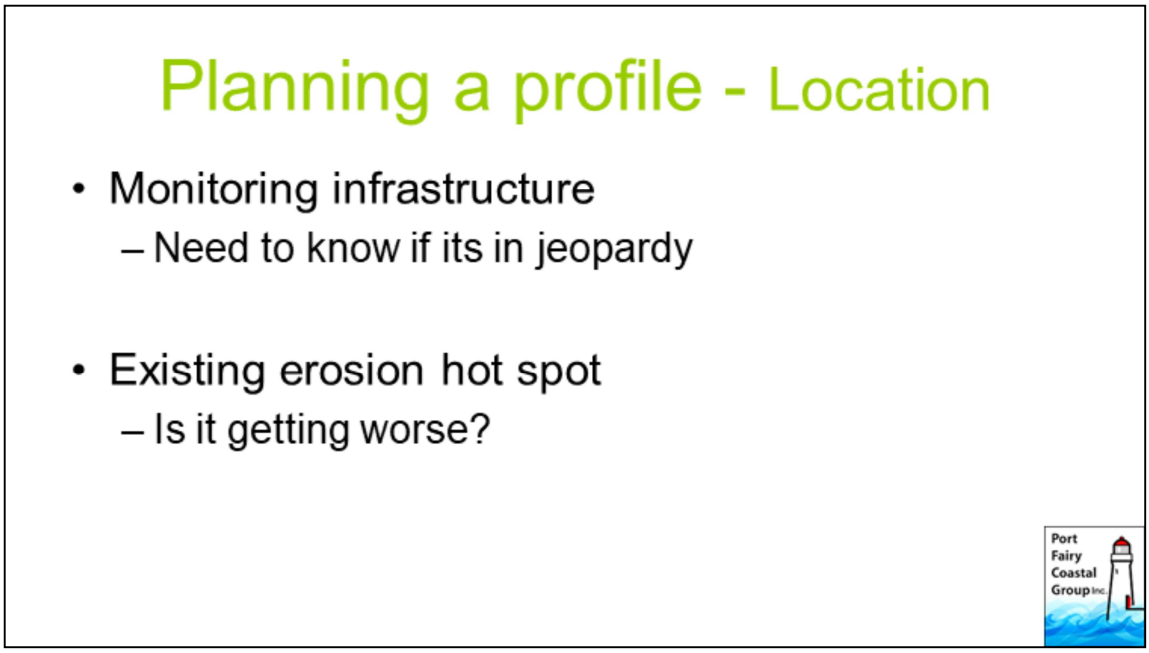
Remotely Piloted Aircraft surveys were introduced in March 2018 so laser monitoring now only monitors seven of the East Beach posts including posts 6 and 9 for consistency with the ongoing sand cycle phase change study. See the PFCGnotes1118.pdf file.

Profile measurements conducted by the year 6 students under the guidance of the Port Fairy Coastal Group provide advanced warning of any changes in sand conditions and give the students unique work experience.

After a year of beach monitoring, students from the Port Fairy Consolidated School apply their own solution to the problem of measuring a beam height of 230 cm near the water's edge.

Also visible in this image is the measuring rope and reel. The rope has distance labels attached every 5 metres.

The beam height in some areas can range from the beach surface to over 4m above the beach. Such a large range requires additional monitoring equipment. However, with the introduction of the Victorian Coastal Monitoring Program using remotely piloted aircraft, long steep areas like the Gully can now be easily profiled by extracting the heights from Propeller Aero.



As a general rule, select the part of the beach that is showing the largest erosion and plan a Transverse Profile (Approximately perpendicular to the dune and down to the waters edge) of 30 to 60 metres in length.

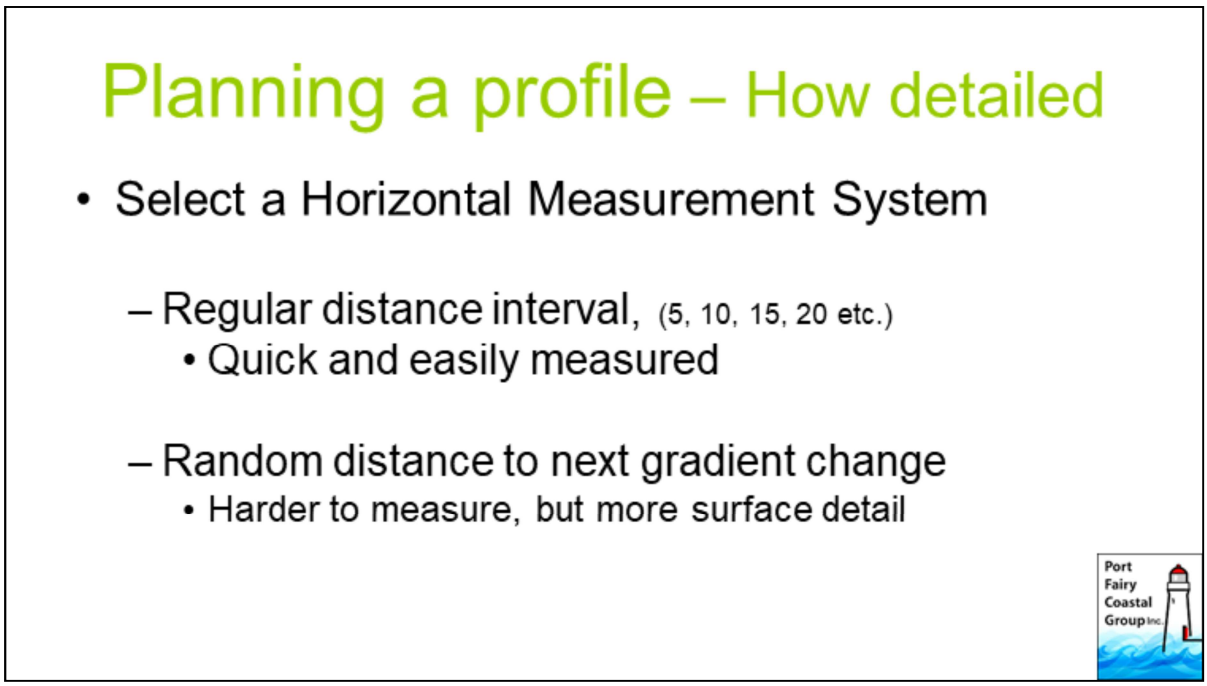
When there is significant infrastructure behind the dune crest nearby, make profiling in front of that infrastructure a priority. It may also be valuable to set up a Longitudinal profile for up to 60m along the shore line.

The requirement for a longitudinal profile can be judged by inspecting the beach for transverse water channels and judging if wave damage is inconsistent along the dune face. If the area is already monitored under the VCMP, then a longitudinal profile using a reference post and laser is not necessary.

You can chart any type of profile without a reference post or laser level if the area is part of the VCMP and you have access to propeller aero.

The performance of Wattle and Wire sand fences is best monitored under the VCMP where propeller Aero allows the profile to be altered and use what ever resolution is needed.

If the need for profile monitoring happens to be in a no-fly part of the beach then a surveyed reference post and a laser level will be necessary.



There are two main options for locating the horizontal distance of the point where the vertical height to the laser beam is measured:

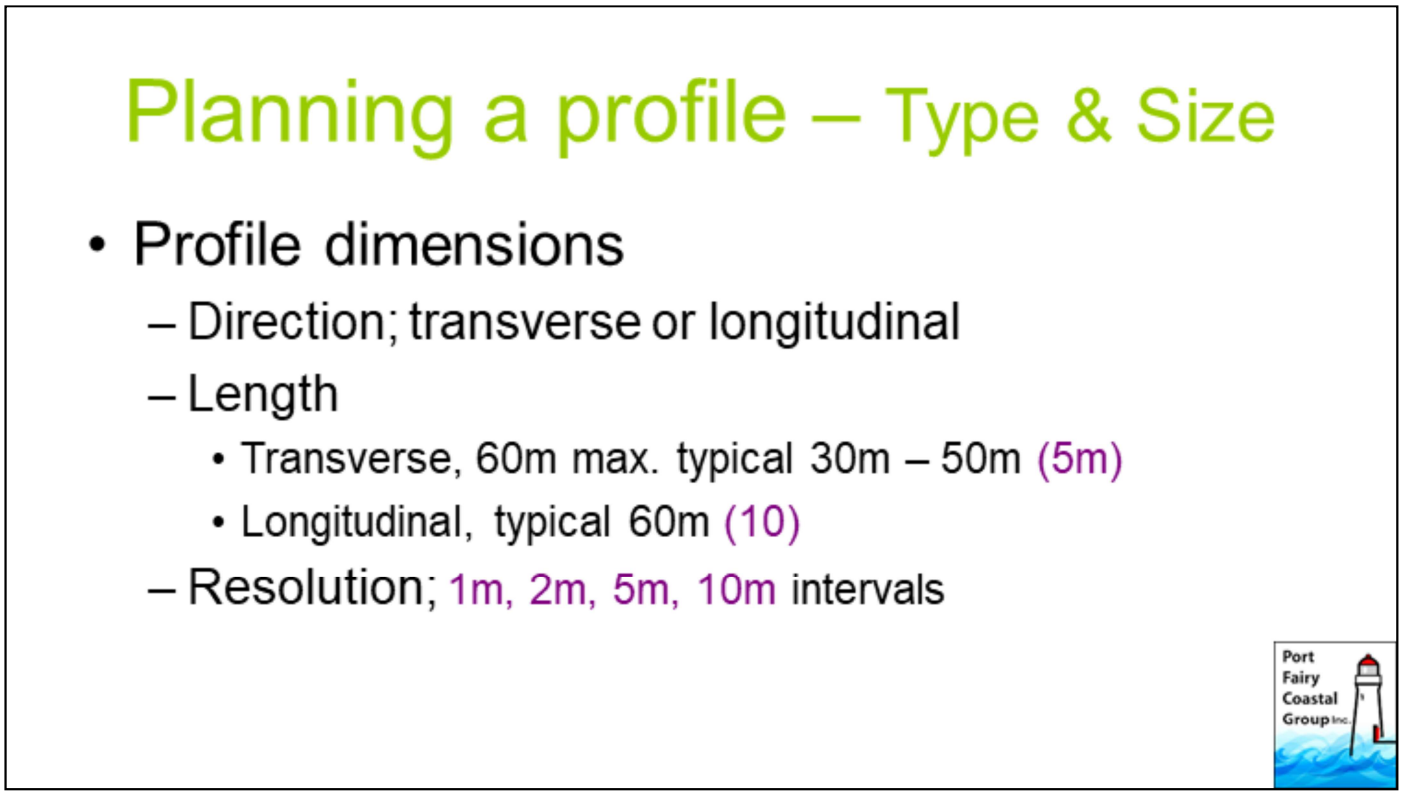
1. Measure a regular distance interval of (say) 5 metres with a calibrated rope and at each distance interval measure the laser beam height above the sand. Using this method is the fastest because the distance values are already located and printed on the data collection sheet. Data entry is also quicker as the distance values are already set in the profile spreadsheet so there is half as much data to enter for each measurement.

2. Measure the distance from the reference point to the first significant gradient change feature and then take a height measurement to the laser beam. Record on the data sheet both the **height** and **distance**. Then measure the distance from that feature to the next gradient change and record the height and distance measurements. Note that if the gradient change feature is a Berm (abrupt step in the sand height from wave erosion) the next distance increment might be as short as 10cm. Continue this process until the whole profile has been measured.

This method will more accurately represent the surface detail of the beach but as an estimate, the 'random distance method' could triple your work load on the beach and it doubles your work load at data entry.

All of the profile measurements at Port Fairy use the fixed distance method, even when deriving profiles from Propeller Aero although the capability exists to choose any size increment and take as many readings as you need.

The Port Fairy Coastal Group uses the regular distance method because the loss in volume accuracy is minor but the time saving allows a full East Beach monitoring to be completed in under two hours while the tide is lowest at most parts of the beach.



What ever direction you choose for a profile, the profile line will at some point pass through the reference post or reference point.

If the area is part of the Victorian Coastal Monitoring Program and no laser profiling is conducted, the reference point only has to be identifiable in the Propeller Aero 3D image.

You can also mark the point in Propeller Aero and then share the point with all of the subsequent mapping dates.

Special structures like a sand fence or a rock wall are usually the appropriate location to use a longitudinal profile but for most beach systems, a transverse profile is the most useful.

The maximum length of a transverse profile is usually limited by the distance from the reference point to the low tide water's edge so a distance of between 25 and 50m is common and the Port Fairy Coastal Group find that a measurement interval of 5m is a good compromise, providing enough measurements to give sufficient accuracy without being a burden on the measuring team and taking too long to do.

When using the regular distance method, smoothing and curve fitting in spreadsheet charts masks surface detail like Berms but the net volume result is still a good approximation of the amount of sand on the beach in that area.

Volume calculations help you understand if sand is being lost from or accreted to the beach in that area by wind or water but the volume calculation is less sensitive to sand height variations if the sand is just moving between the

Foreshore and the Backshore.

Data Collection Sheet - Contents

- Design the Data Collection Sheet
  - Date and team members
  - Profile or reference point name
  - Reference post length
  - Distance markers
  - Check boxes for all tasks

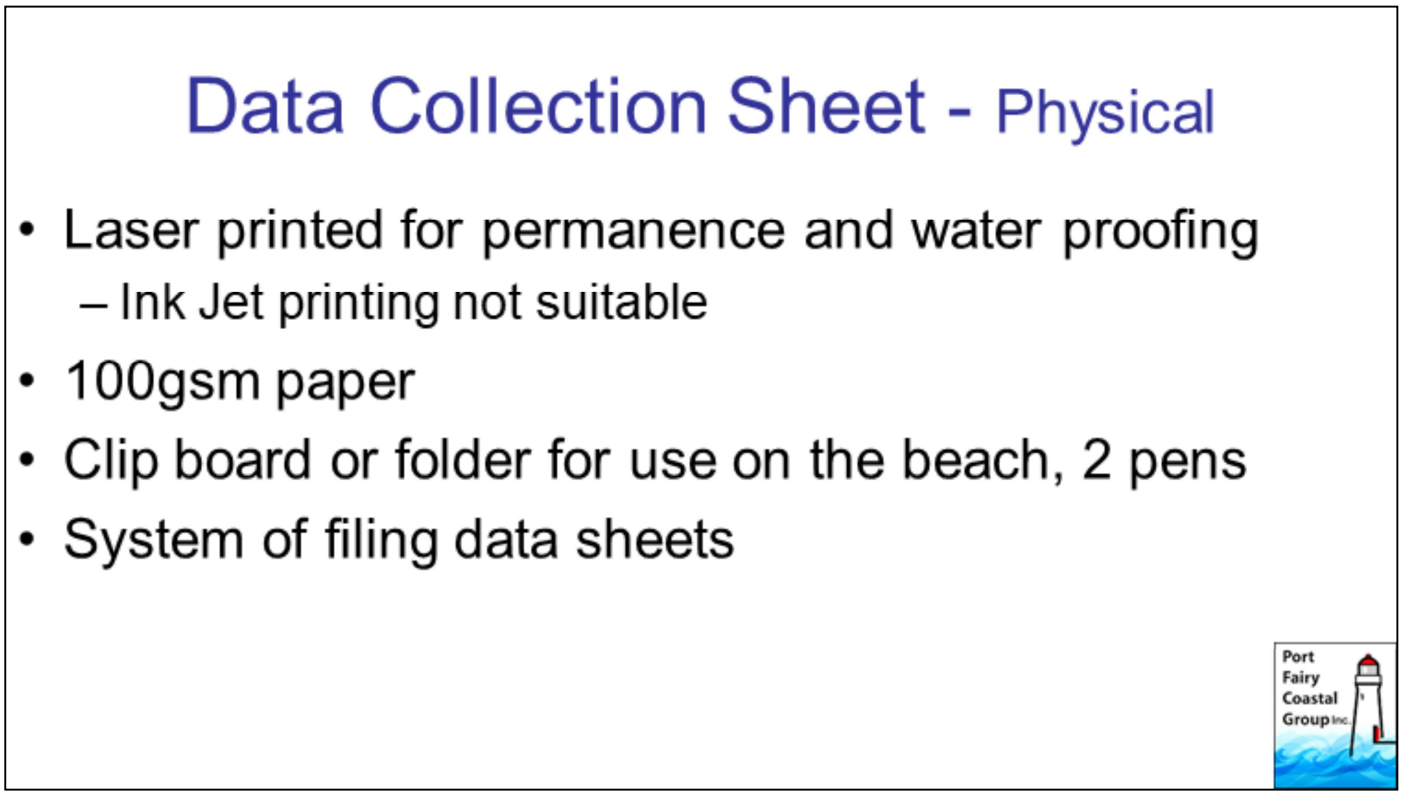
Once you have determined what to measure on the beach, you can then design the Data Collection Sheet to ensure that all measurements and other jobs will be carried out.

Another important function of the data sheet is to preserve the measurements so they will be available for analysis in the distant future. We cannot rely on personal computing systems to remain backward compatible for ever, so our hard won spreadsheet charts may not be readable in 30 years.

Could you read an 8” or 51/4” or maybe a 31/2” floppy disk? What about a Flash card from an early digital camera?

Does your lap top have a CD/DVD drive?

Please preserve your data collection sheets.



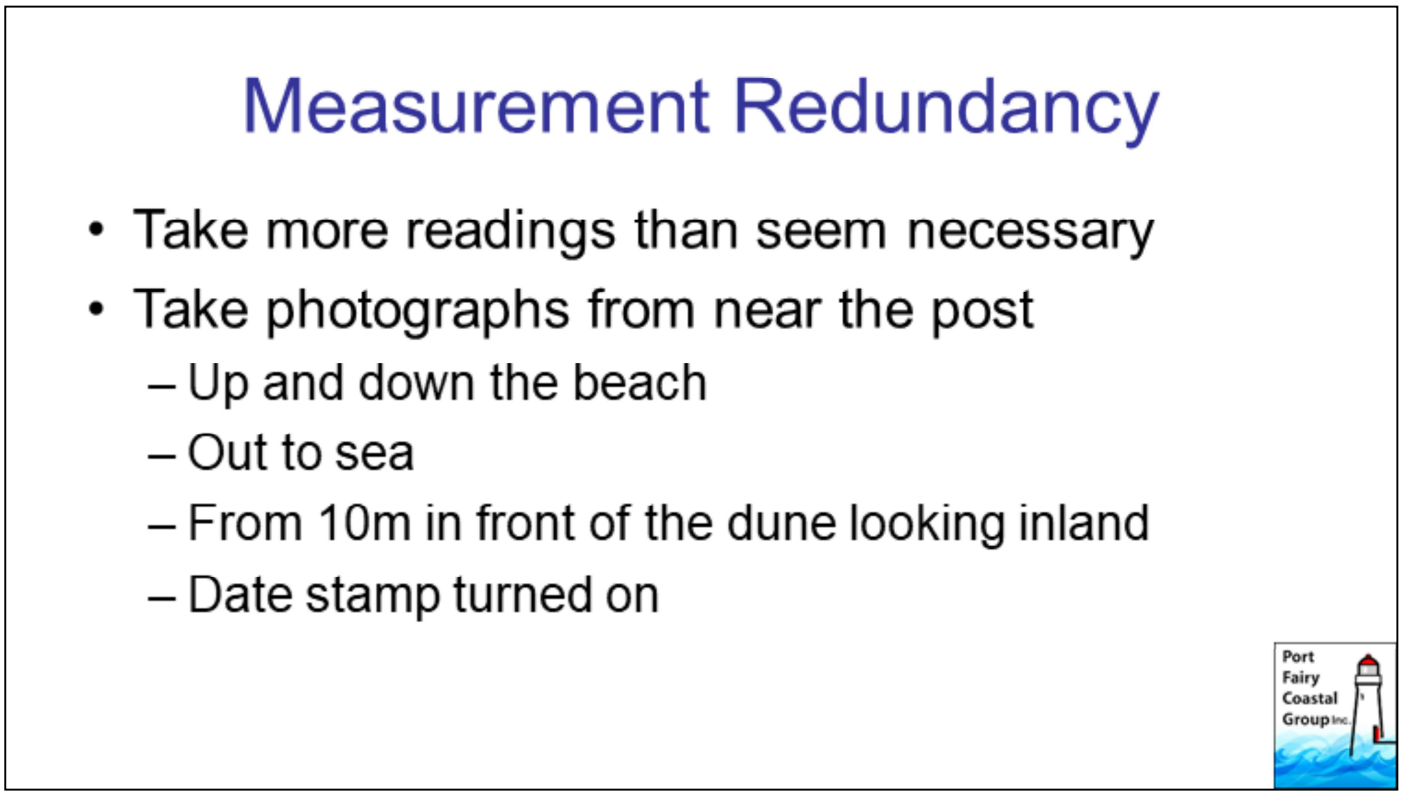
The most reliable form of data collection is to write down the height readings on a sheet of paper. The advantage of a hard copy is portability because the people taking the measurements are probably not the people doing the data entry and circulating the results.

Profiling with a laser level is almost independent of the weather so working in the wind and rain is quite common when the priority is to access as much of the beach as possible during low tide.

The most important physical characteristic is to be waterproof which means laser printed rather than ink jet printed. A heavier grade of paper is also advisable to help the sheet stay intact when wet.

A clip board or folder is necessary to control the data sheet and provide some protection for it.

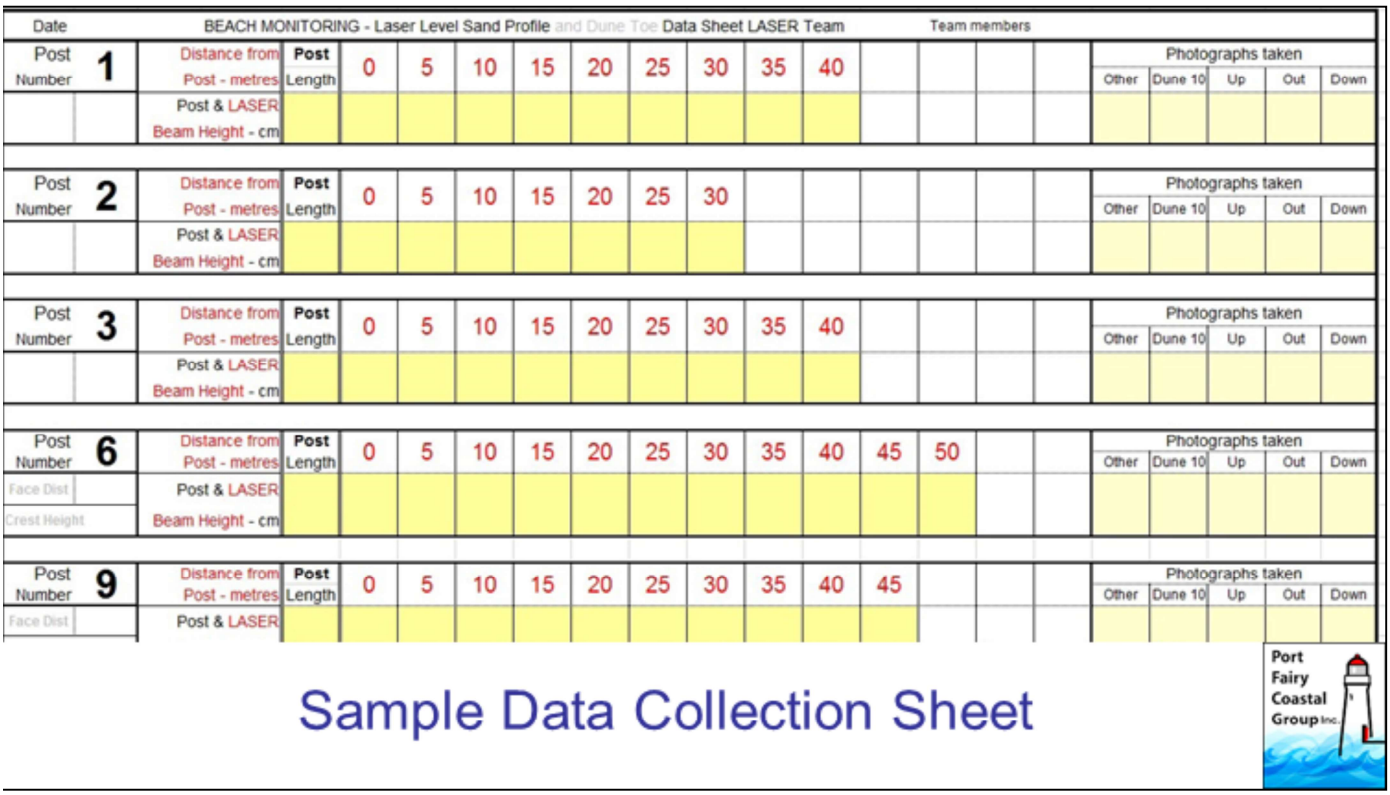
When the data has been entered, presumably into a spreadsheet for storage and analysis, the data sheet should be filed in such a manner that it will be accessible and readable for many years to come. We are all aware of the pace of technology developments and this is likely make much of our electronic records unreadable in 30 years time so the only sure way for researcher's to access our coastal data may be from the hard copies of the data sheets.



When the Port Fairy Coastal Group commenced profiling in 2013, we would rarely take more than four readings if the beach slope was linear. As our experience increased, it was realized that not only was estimating linear slope a subjective measure, it also did not provide redundancy to confirm if adjacent readings were correct. When there is redundancy in the readings, an incorrect value on the data sheet such as a “7” mistaken for a “1” or an extra digit added or left off can be easily identified as an erroneous reading rather than a sink hole or a large mound of sand.

Measuring a profile every 5m between the post and the shallow water ensures sufficient redundancy to provide confidence in the profile result.

It can be very helpful to refer to photographs taken during measurements when entering and analysing profile data however, be sure and have the date stamp function active and that the date and time are set correctly. The Port Fairy Coastal Group have a dedicated waterproof digital camera and one of the set tasks during beach monitoring is to take photographs from known fixed positions and have the tasked jobs checked off from the data sheet.



Date	BEACH MONITORING - Laser Level Sand Profile and Dune Toe Data Sheet LASER Team													Team members					
Post Number 1	Distance from Post - metres	Post Length	0	5	10	15	20	25	30	35	40					Photographs taken			
	Post & LASER Beam Height - cm															Other	Dune 10	Up	Out	Down
Post Number 2	Distance from Post - metres	Post Length	0	5	10	15	20	25	30							Photographs taken			
	Post & LASER Beam Height - cm															Other	Dune 10	Up	Out	Down
Post Number 3	Distance from Post - metres	Post Length	0	5	10	15	20	25	30	35	40					Photographs taken			
	Post & LASER Beam Height - cm															Other	Dune 10	Up	Out	Down
Post Number 6	Distance from Post - metres	Post Length	0	5	10	15	20	25	30	35	40	45	50			Photographs taken			
Face Dist	Post & LASER															Other	Dune 10	Up	Out	Down
Crest Height	Beam Height - cm																			
Post Number 9	Distance from Post - metres	Post Length	0	5	10	15	20	25	30	35	40	45				Photographs taken			
Face Dist	Post & LASER															Other	Dune 10	Up	Out	Down

Sample Data Collection Sheet

Port Fairy Coastal Group Inc.

Part of one of several data collection sheets used at Port Fairy when profiling with a builder's laser level.

The beam height at distance zero refers to the height of the beam at the reference post.

The brief for the monitoring team is to collect heights in all of the shaded boxes. In some wind and tide conditions, wave height will prevent the last two or three readings from being measured.

There are two blank data sheets (as Tabs) in the Universal Spreadsheet used as examples of Left to Right, Right to Left and Centre zero profiles.

Drawing a profile – Universal Spreadsheet

- Easy to add new data; no advanced XL knowledge
- View any results from up to ten different dates
- Compare recent results with past readings
- Charts and data easily embedded in reports

The Port Fairy Coastal Group have always used a spreadsheet as the means to store and display data collected from beach monitoring. As more data was collected, charts became cluttered with readings to the point where the chart became unreadable and another solution was needed.

Provision was then made to be able to select any monitoring date from the entire history of monitoring with up to ten readings displayed simultaneously. Other enhancements allowed new data to be entered without advanced spreadsheet knowledge; just enter the data into the Sand Table as it appears on the data collection sheet and then select the Chart option and the date you need to display.

In addition to displaying profiles, basic statistics of Minimum, Average and Maximum values can be displayed on the chart between any of the available dates. This feature can be useful in several ways. If taken over the whole range of monitored dates, it shows the range of heights that occurred during monitoring. If the last date for statistics is set to the second last date, it will be obvious if the latest measurement falls outside of any of the existing values.

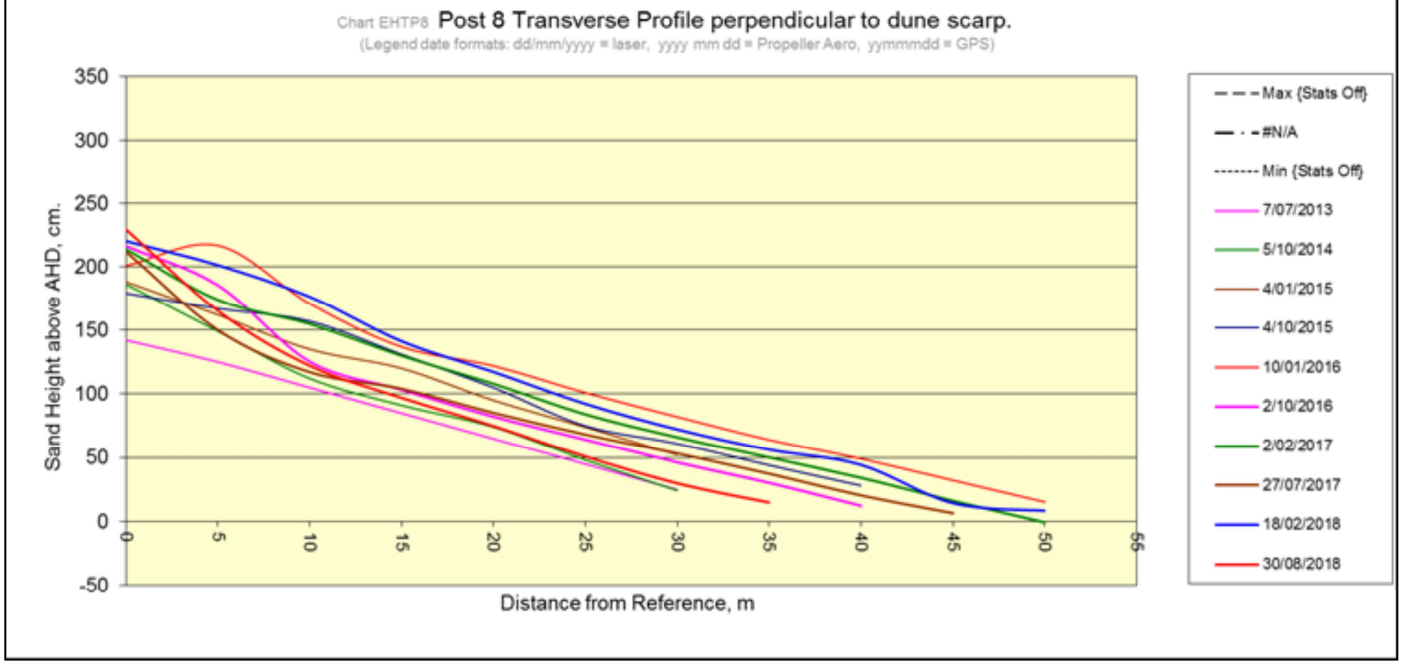
Alternatively the date range can be set to a time before beach works were carried out and then compared to a range of dates after the works have been completed. On the next page we look at the beach profiles before and after the Wave Energy Dissipation structure was installed.

Charts and data tables are compatible with most word processors so illustrating reports with appropriate data is easy. The chart layout, colours and line thickness have been selected for best clarity and minimum toner usage when printing charts.

Compare the profile charts in Propeller Aero which use a black background and similar

pale colours that make it difficult to discriminate more than three chart ranges in a profile.

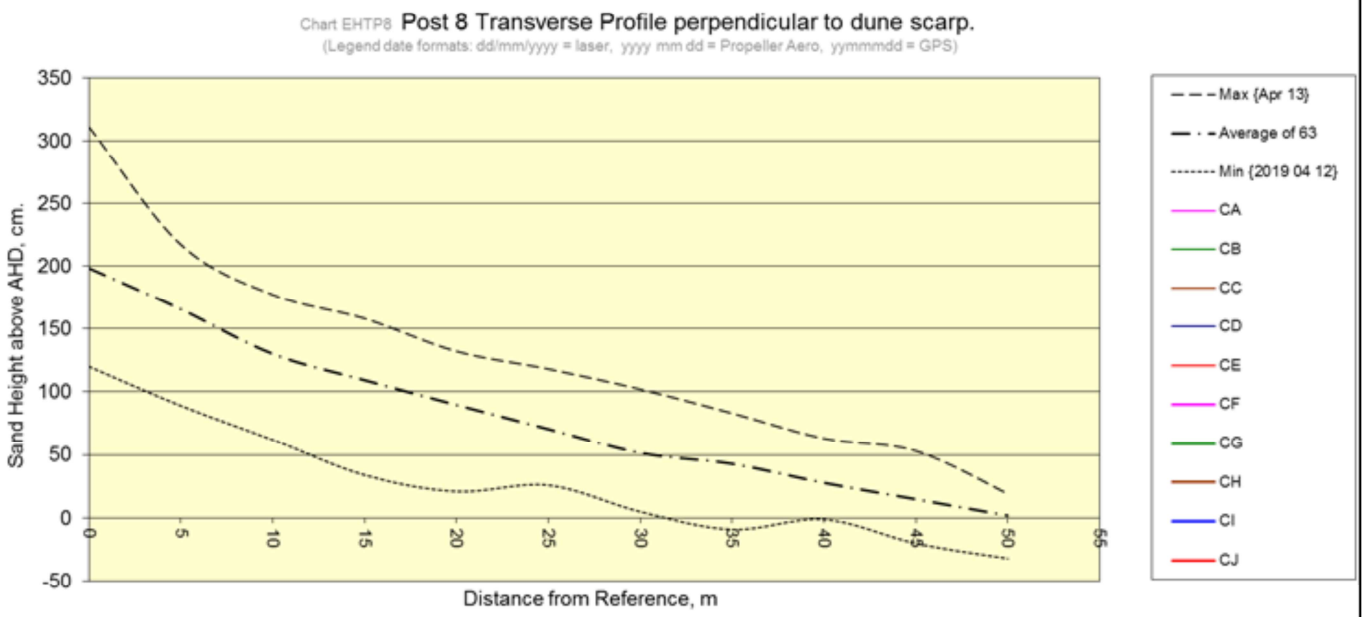
Profile Samples – Jul 13 to Apr 19



Its not possible to make a useful display of all the profile measurements by just adding them to the chart; you reach a point where it is impossible to follow each profile and the importance of some variation can be lost. However, we need to have historical data available for comparison when its needed but out of the way at other times even though it may still be counted in the statistics.

By limiting the number of simultaneously displayed profiles to ten but making all of the profiles user selectable, any comparison can be easily displayed while keeping the chart concise and uncluttered.

Profile Range – Apr 13 to Apr 19



Part of the solution is to use basic statistical methods to determines the maximum and minimum height values that occurred at each distance point. When these values are drawn on the chart, we have an envelope of just two lines that enclose all of the profiles in the sample. We can also plot the average height value at each distance which ends up running somewhere close to the middle between the Max and Min lines. The average line is a useful guide when you plot a new profile and you know immediately if your beach is currently above or below average.

The chart Legend not only shows the identity of the three statistical values but also incorporates the range of dates used to calculate the statistics and the number of samples used in the Average calculation.

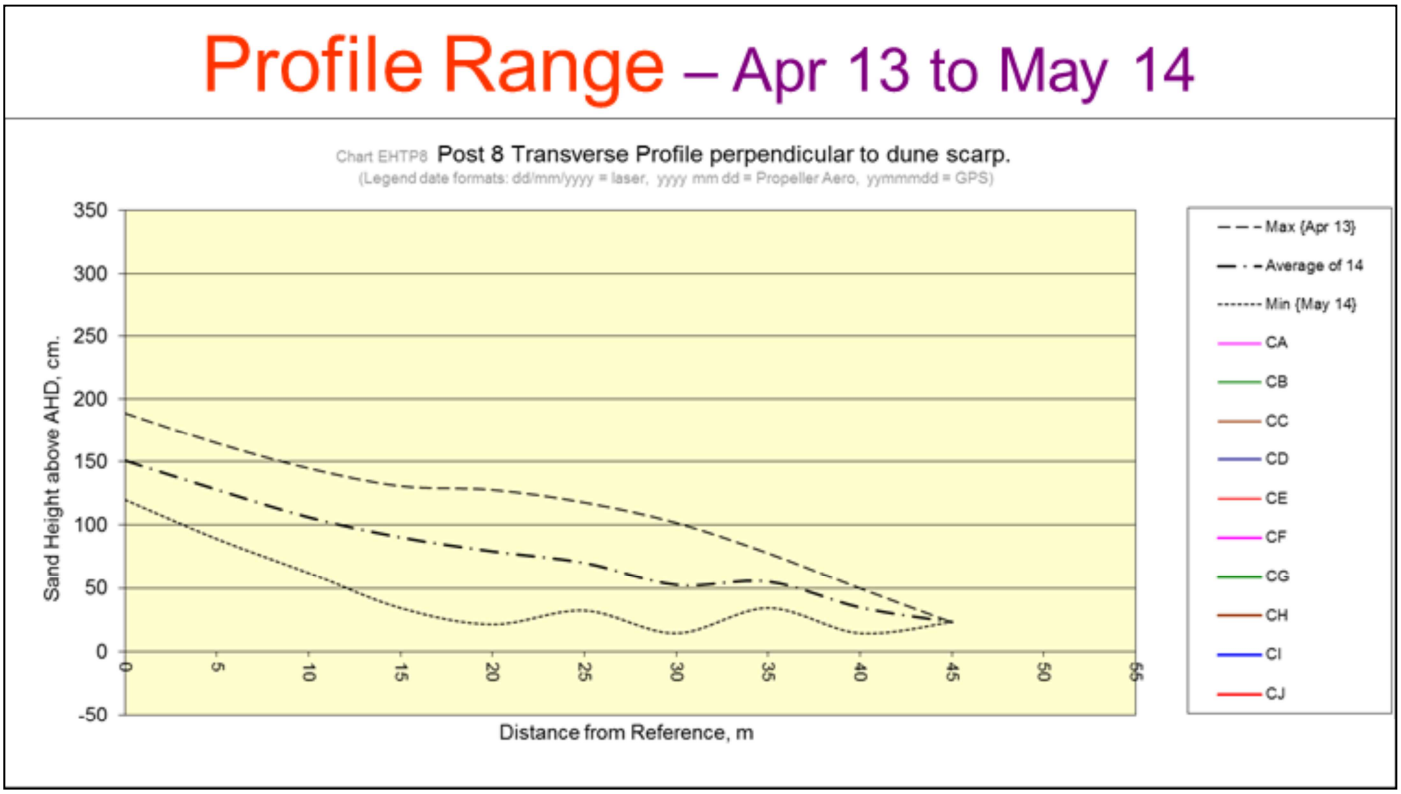
In the above example, - - -Max {Apr 13} means the dashed line represents the Maximum values and that the starting date for statistical calculations was April 2013. It does not mean the Maximum occurred in April 2013.

Similarly the Legend …….Min {2019 04 12} means the dotted line represents the Minimum values and that the last date for statistical calculations was the measurement taken on 12th April 2019. It does not mean that the minimum occurred on that date.

The Legend for the average height shown as alternate dots and dashes also specifies how many samples (profiles) make up the average calculation.

The date format tells us the profile information was derived from Propeller Aero on that date. See the date format legend in the second line of the chart title. This date format legend also applies to the ten options to draw individual profiles.

Profile Range – Apr 13 to May 14

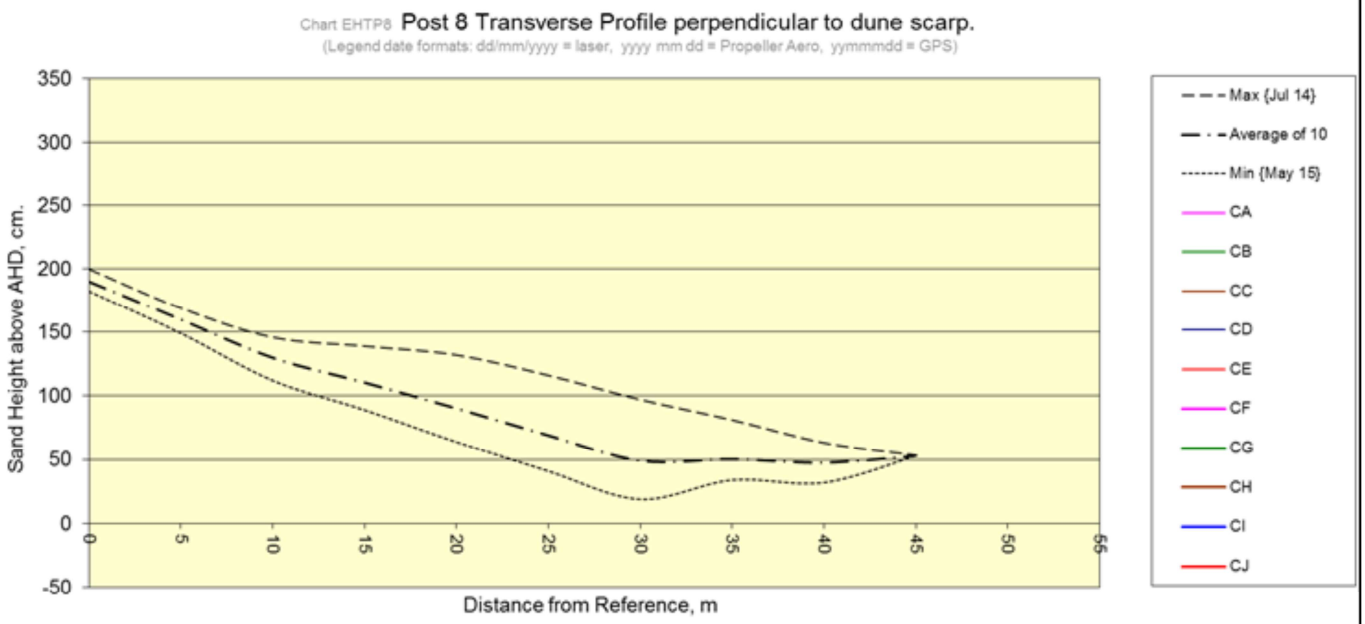


Now that we understand the Max, Min and Average lines, we can set specific ranges of dates and study the effects of any changes in the profiles before and after modifications on the beach.

For the fourteen readings up to May 2014, there was no protection in front of the closed tip site monitored by Post 8.

The Wave Energy Dissipation structure (WEDs) was installed between May and June 2014 and physically sits between the 5 and 8 metre distance from the reference post 8. Compare the profile envelope at this distance with the envelope on the next page.

Profile Range – Jul 14 to May 15



Our discussion on the previous page was prior to the installation of the WEDs rock wall. This chart shows the envelope of profiles in the year following the installation of the WEDs rock wall.

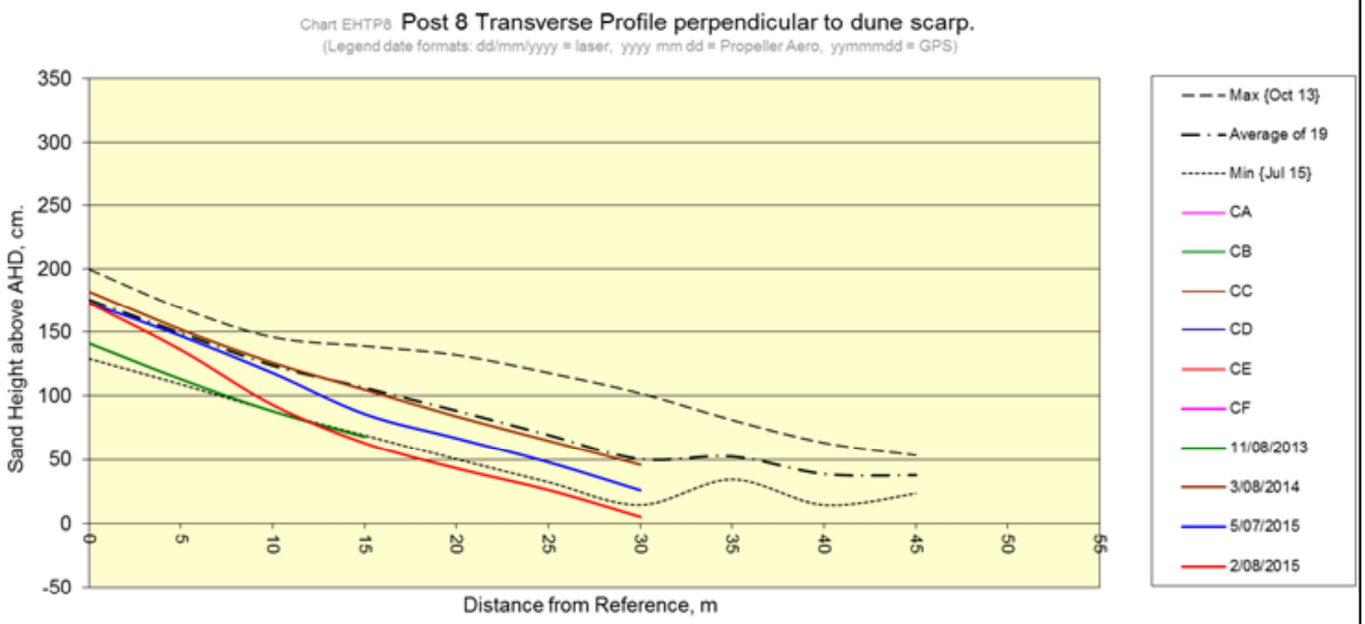
Compare the envelope of profiles above in the distance 5 to 8m from the reference post. Note the reduced range of heights measured behind the WEDs compared to the range of heights in front of the wall.

On page 18 there is an explanation of the Legend for the statistics lines.

The reason the date function had to be jumbled up with the chart legend was to ensure that when a profile chart was copied from the spreadsheet to a report, information about the statistics date range stayed with the chart.

The same reason for the three date formats being different is to preserve the source of the data, albeit a little clunky but a necessary work around the limitations of the software.

Previous low limit exceeded – Aug 15



One of the important features developed in earlier spreadsheets was a visual alert to a new low or high value. By setting the statistics date range to be one reading behind the current reading, allows the current profile to plot outside the envelope if its value is greater or less than the previous maximum or minimum at that distance.

We see that beyond about 12m from the post, we have new record low heights all the way to 30m.

However, readings at the post and immediately behind the WEDs show sand loss has been reduced. The blue line (from the month before) shows sand loss started earlier but had not yet reached the previous minimum.

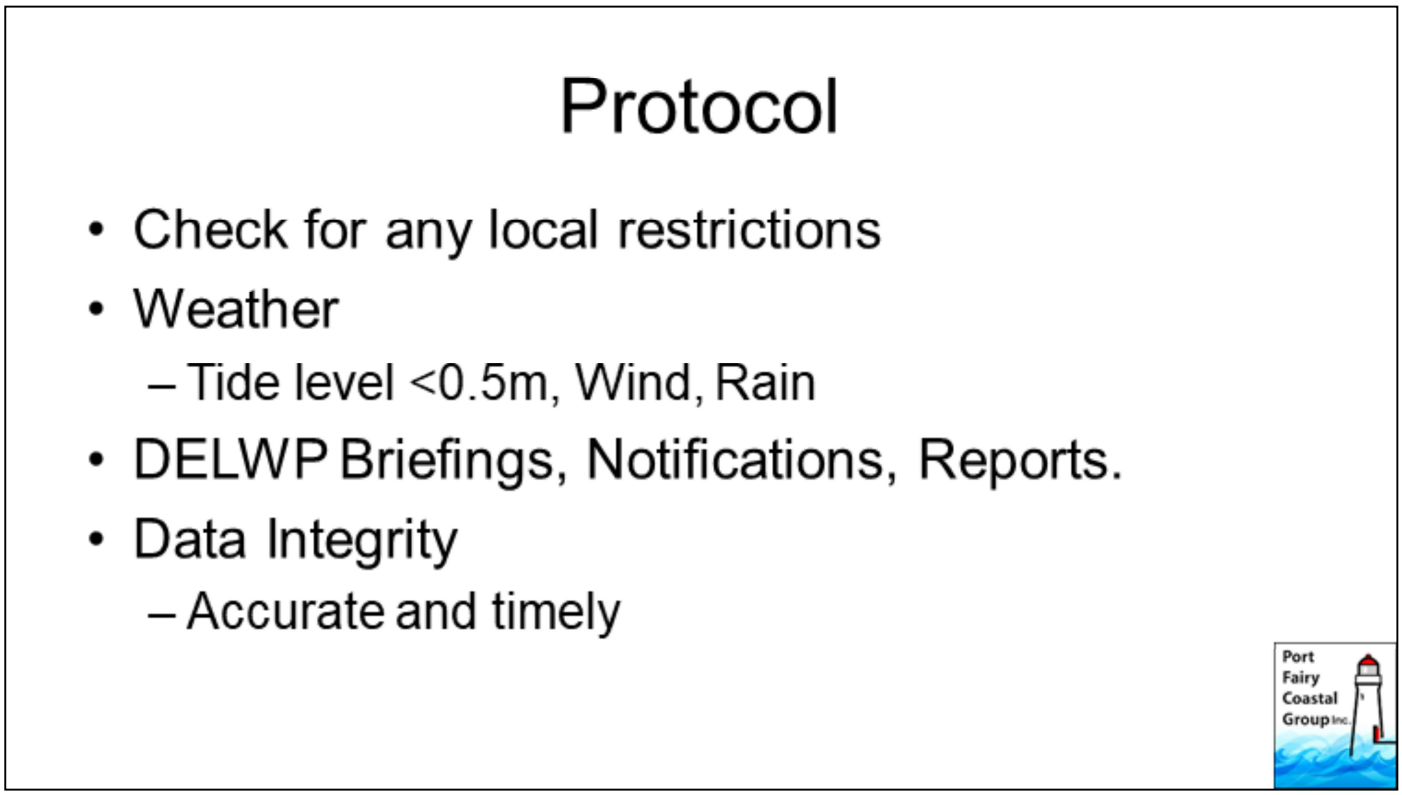
The brown line shows average sand height values maintained across the beach a year earlier in 2014.

The green line shows low sand levels near the post in 2013 prior to the installation of the WEDs.

If the statistics date range was the same as all of the readings, the last reading would plot on top of the statistics line even if it was a new high or low value. You would not be alerted to the new record value.

In the Universal Spreadsheet when selecting the last date to calculate statistics, an option called **2nd Last** is available. This automatically tracks new data entries and keeps the last date for statistics one reading behind the last reading. New data exceeding previous limits will always be flagged. If you don't need to alter the statistics date, "**2nd Last**" is the 'set and forget' option.

If you need to remove the statistics lines for clarity, just select the blank option at the top of the start date list.



Although we are granted certain privileges like driving authorized vehicles on the beach and flying remotely piloted mapping aircraft over the beach, we still share the space with people, native birds and animals and we have a responsibility to share the beach with others while we are collecting measurements.

Several sections of Port Fairy's East Beach are the favourite nesting ground for the endangered Hooded Plover. During nesting season these parts of the beach are off limits to the monitoring team and vehicles. If the nesting areas are clear of the launch areas, RPA mapping is still possible.

The PFCG aim to monitor only when a low tide is below or around the 0.5m level; above this height, it is unlikely that the 30m distance would be reached at the more exposed sections of the beach. While wind and rain make less than ideal monitoring conditions for laser profiling, bad weather generally prevents RPA operations.

Collecting data about the beach, whether from profiles or other measurements is just the first of many steps in the process of coastal management; big budget expenditures will be made relating to climate adaption so you as a data collector must ensure the integrity of your data. Nothing less than scientifically vigorous methods are acceptable. The reputation of Citizen Science groups as reliable contributors is important.

www.portfairy.town/PFCG/vmcf

- PFCG Presentation notes
- PFCG Universal spreadsheet
- PFCG Data Sheet files
- PFCG Basic Beach Monitoring Notes
- Link to Defend Port Fairy video
- ABC documentary on RPA coastal monitoring
- Link to Deakin Propeller Aero support

Complete Notes and Slides from the Beach Profiling presentation at the Victorian Marine and Coastal Forum, Melbourne June 2019

A universal spreadsheet developed after 6 years of beach profiling at Port Fairy that accepts data from laser or GPS/GNSS measurements or from Propeller Aero to draw beach profiles and basic statistical comparisons.

Sample Data Collection sheets used at Port Fairy.

Basic Beach Monitoring notes compiled from various presentations given over the years. Some of this material is also present in the VMCF presentation.

A link to the Defend Port Fairy Video on Utube, produced by PHP Productions.

A link to a mini documentary by ABC journalist Sarah Abbott about RPA Mapping along Victoria's Southern Coast. Has integrated sub titles of all audio commentary.

A Link to resource material prepared by Deakin University to assist with using Propeller Aero.