



Eastern Great Ocean Road Cliff Hazards: Brief Assessment

April 2023, Jak McCarroll
Victorian Coastal Monitoring Program, DEECA

Acknowledgment

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We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.



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Jak McCarroll, Victorian Coastal Monitoring Program, DEECA (April 2023)

1. Introduction

Cliffs are an erosive coastal feature which present a potential hazard. Coastal cliff falls (also described as ‘cliff collapses’ or ‘landslips’), are a form of natural hazard that can present a significant risk if members of the public regularly access areas at the base or crest of the cliff.

All cliff types (hard and soft) may present a hazard, and should be addressed within a comprehensive cliff hazard assessment. The focus in this report is on soft cliffs, as they are likely to emerge as high risk areas. Soft rock cliffs are highly erodible, and are therefore more vulnerable to periodic cliff fall events. The process of progressive cliff falls leading to the cliff line gradually moving landward is described as ‘cliff recession’, measured in metres per year. Geology (hard/soft) is the primary driver of recession rates. Shoreline erosion is a secondary control, as the base of the cliff is exposed to greater wave action. Sea level rise (SLR) will accelerate shoreline recession and cliff line recession in some parts of the coast. Terrestrial processes, such as rainfall, drainage, soil erosion and groundwater infiltration, are also causal factors in cliff falls.

Cliffs (hard and soft) are widely distributed across Victoria (Fig. 1, top row), with large extents of rocky coastline in East Gippsland, central Victoria (Wilsons Promontory to Mornington Peninsula) and the southwest (Surf Coast to Cape Bridgewater). Soft rock cliffs are concentrated across several regions (Fig. 1, bottom row), including the high-elevation (>30 m), soft cliffs along the eastern Great Ocean Road (GOR), covering a 25-km stretch from Aireys Inlet to Torquay. Frequent cliff collapses occur in some sections of this region. Previous reports (listed in Section 4) have identified cliff falls coinciding with high-public usage as a significant risk in some areas.

A broad examination of cliff hazards and risk is currently underway in Victoria, prompted by recent incidents, including a fatality due to cliff collapse at Jarosite Headland near Bells Beach. A statewide examination will include:

- Mapping of all cliff types (hard/soft, low/high elevation) along the Victorian coast.
- Determination of land managers of all cliffed areas.
- An audit of actions related to cliffs in general.
- Risk assessment based on likelihood and consequence of cliff falls in all areas (to public safety, and to other values / uses).

Within this context, this brief report identifies regions of soft rock cliffs across Victoria (Section 2). Focussed analysis is applied to the soft rock cliffs across the eastern section of the Great Ocean Road, including identification of land managers (Section 3), review of geotechnical assessments (Section 4), and cliff monitoring practices (section 5). Recommendations are then made as to how this approach could be expanded statewide, including all cliff types (Section 6).

2. Statewide and regional distribution of cliffs and rates of shoreline erosion

A brief assessment of Victorian cliff locations, focussing on soft rock cliffs, was made using the Australia-wide ‘Smartline’ dataset, which includes a broad classification of coastal geomorphology. The definitions used here are “Hard rock cliffs, >5 m” and “Soft rock cliffs, >5 m”. Broad regions of soft cliffs were identified, including:

- Great Ocean Road (West), from east of the Twelve Apostles to west of Peterborough.
- Great Ocean Road (East), in particular from Torquay to Aireys Inlet.
- Port Phillip Bay, to the northeast around Bayside, and southeast from Mt Martha to Mt Eliza.
- Isolated areas including Cape Bridgewater, Portland, west of Cape Otway, Skenes Creek, Waratah Bay and East Gippsland

The three major regions of interest are overlaid with rates of shoreline erosion (Fig. 1, bottom row), over the time period 1988 – 2019, using data from Digital Earth Australia (DEA) Coastlines. As noted, geology (hard/soft) is a primary control on cliff recession, while shoreline recession is a secondary control. Other processes also influence cliff recession (e.g., rainfall, soil erosion). This approach (i.e., soft cliffs coinciding with high underlying shoreline erosion) can be used as a preliminary indicator of areas of interest that can be targeted for more detailed analysis. Preferably, a first-pass assessment should include cliff recession rates and geotechnical indicators; however, these metrics are not currently accessible as statewide datasets. Additionally, Smartline and Digital Earth Australia are national datasets, and more detailed satellite-based or regional datasets would be preferable, though are not available.

A cursory examination of the Great Ocean Road (West) and Port Phillip Bay (East) regions determined that areas of soft cliffs and high erosion are coincident in limited areas (e.g., Bayside in PPB). In order to assess risk across these regions, additional analysis should be applied to review geology, cliff heights, recession rates, accessibility and visitation.

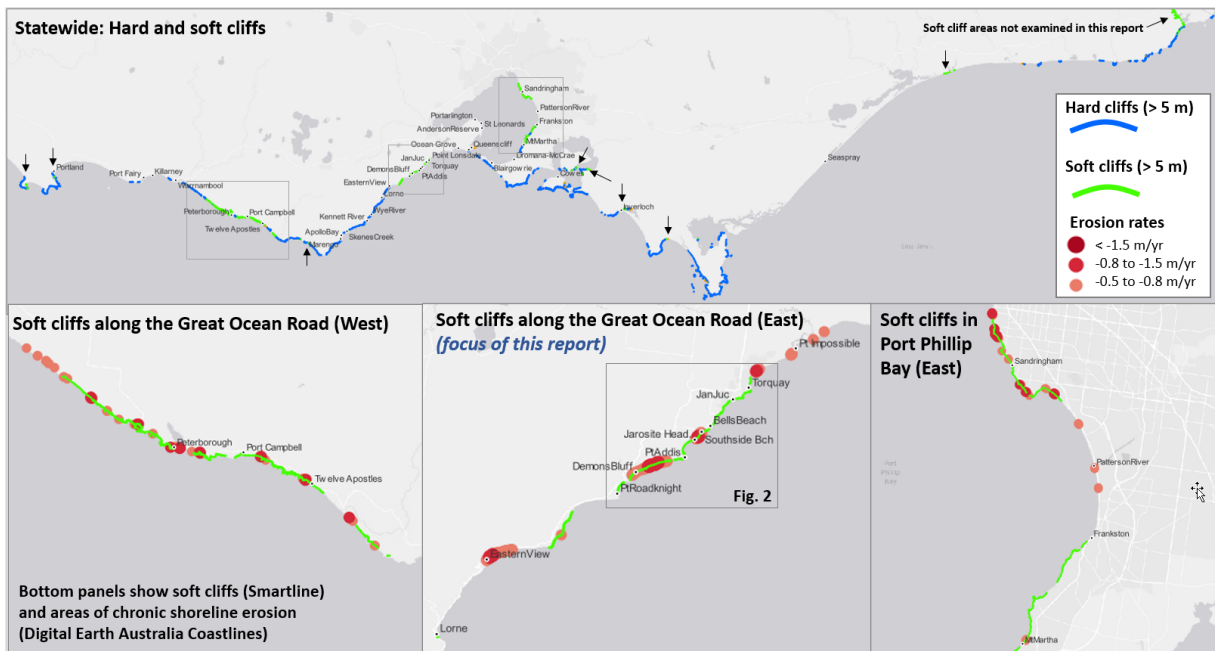


Figure 1. Statewide distribution of soft cliffs (source: Smartline), and regional overlays of soft cliff locations with areas of high underlying shoreline erosion, over the period 1988 - 2019 (source: Digital Earth Australia Coastlines).

The coastline of the Great Ocean Road (East) zone, from Point Roadknight to Torquay (Fig. 2) is mostly comprised of soft rock cliffs. Extensive geotechnical and geomorphological consultant reports (see Section 4) and academic papers (e.g., Birch, 2003; Bezore et al., 2019) describe the geology of this area in detail. The geology of the cliffs is highly-weathered sedimentary rock, which has broken down to a soft clay in some areas, easily broken apart by hand. The softest geological unit, the Demons Bluff Formation, extends from Anglesea northeast to Jarosite Headland (geological map in Appendix A), and has been noted as an area susceptible to cliff falls (e.g., AECOM, 2016; GHD, 2020).

Two areas of high erosion coincident with soft rock are apparent from Figure 2:

- Demons Bluff, Anglesea (beach permanently closed in this area due to risk associated with cliff falls).
- Southside Beach to Jarosite Headland (the region associated with the fatality on Jan 1, 2022).

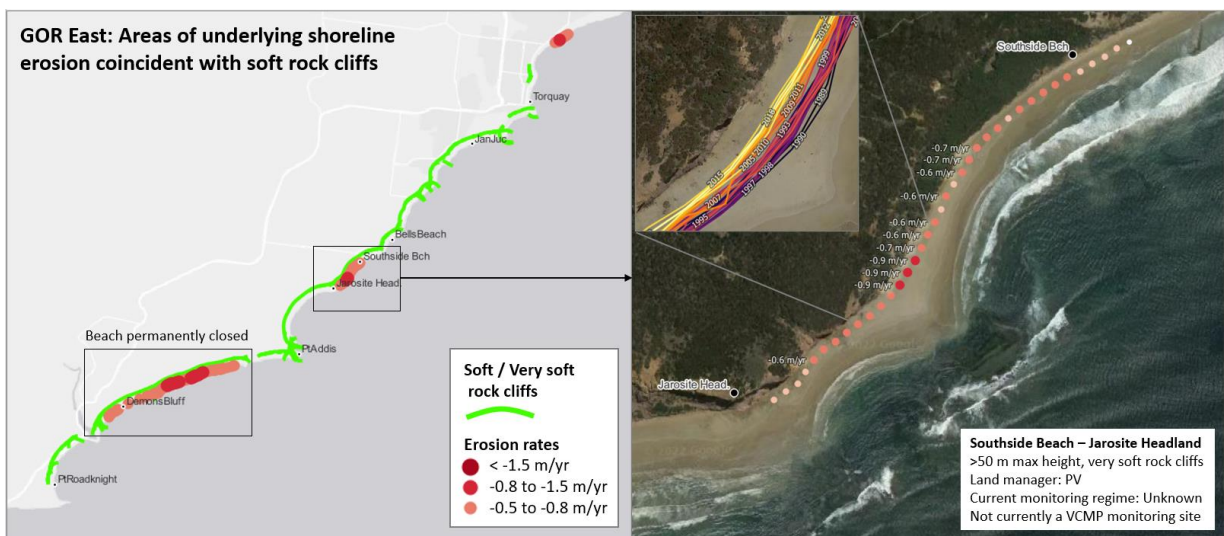


Figure 2. Great Ocean Road (East) overlay of shoreline erosion with soft rock cliffs (left); with an inset of shoreline erosion around Southside Beach (right).

3. Great Ocean Road (East): Soft cliff locations and land managers

The key land managers for the eastern section of the GOR, from Point Impossible to Aireys Inlet are summarised in Table 1, with more detailed information in Table 2 and Figures 3-4. Broadly, GORCAPA are responsible for the southern and northern sections of this region (Figs. 3,4), while the central sections are currently managed by PV and SCSC. Further effort is required to determine the elements in the Coastal Marine Manager Plans (CMMP) for each land manager, that are relevant to cliff hazard management and risk.

Table 1. Land Managers for the Eastern Great Ocean Road Region

Land manager	Contact	Locations / Sites
Great Ocean Road Coast and Parks Authority (GORCAPA)	Oliver Nickson	* Pt Impossible, Torquay, Jan Juc (northeast) * Anglesea, Demons Bluff (west) to Aireys Inlet
Surf Coast Shire Council (SCSC)	Gabrielle O'Shea	* Bells Beach
Parks Victoria (PV)	(none)	* Southside - Point Addis * Anglesea, Demons Bluff (east)

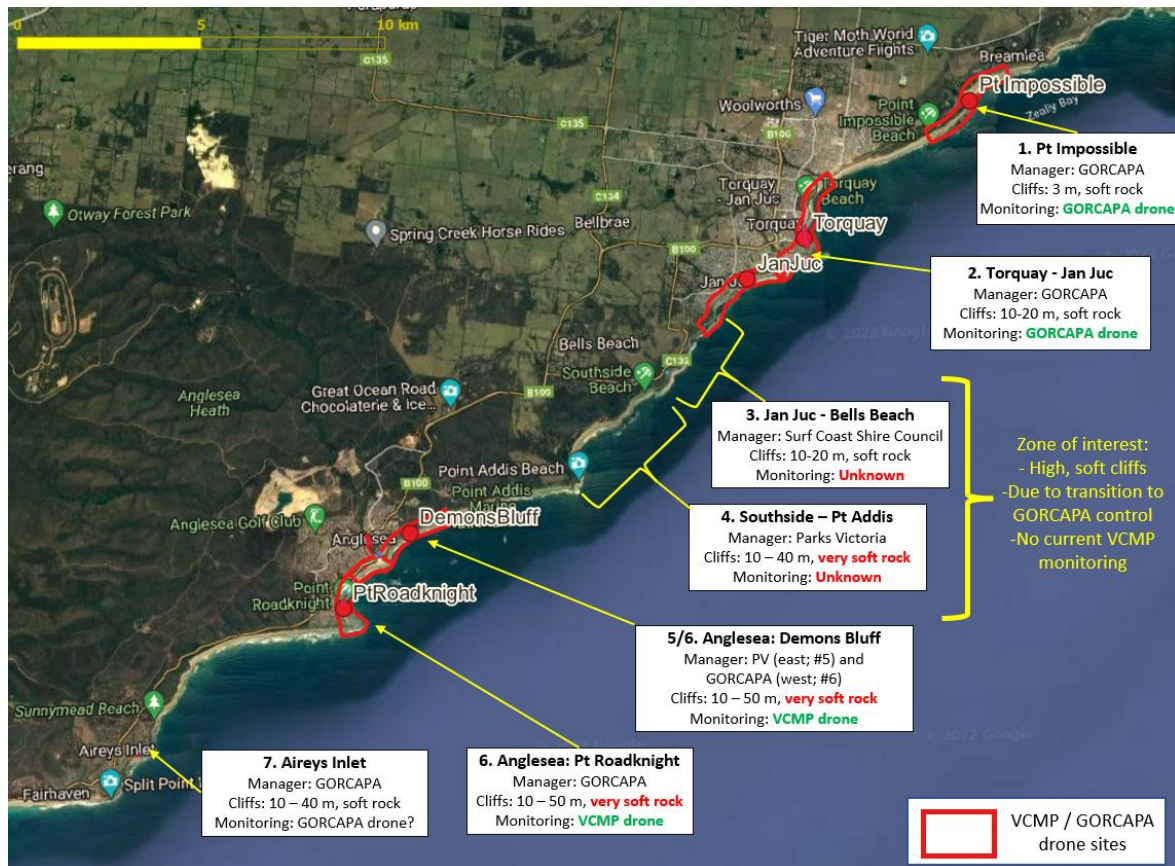


Figure 3. Great Ocean Road (East) soft cliff sites, with information on relevant land managers and monitoring. (Site numbers match Table 2).

Table 2. Great Ocean Road (East) Management Areas, includes information provided by GORCAPA

Location	Land Manager	Cliff Type	Max height	General Comments	Cliff Hazard Management	Monitoring
1. Point Impossible	GORCAPA	Soft	<3m	<ul style="list-style-type: none"> * Risk currently considered low. * To be reviewed by GORCAPA following recent events. 	<ul style="list-style-type: none"> * Warning signs. 	Drone survey (GORCAPA, 1-2 / year, since 2020).
2. Torquay-Jan Juc	GORCAPA	Soft	>20m	<ul style="list-style-type: none"> * High Usage Areas. * People often seen sitting under cliffs as they provide shade during the heat of the day. * Following an injury in the early 2000s from falling debris on the beach, the main Bird Rock Access track was closed. 	<ul style="list-style-type: none"> * Warning signs. * Geotech Risk assessment at regular intervals (frequency TBC). * Asset management – closure of stairs, additional fencing, warning signs and infrastructure improvement including replacement. 	Drone survey (GORCAPA, 1-2 / year, since 2020).
3. Jan Juc - Bells Beach	Surf Coast Shire Council	Soft	>30m	<ul style="list-style-type: none"> * Usage is lower than Torquay to Jan Juc. 	<ul style="list-style-type: none"> * High level of hazard management around Bells Beach related to hosting of surf events. * (see text for further details). 	<ul style="list-style-type: none"> * PV may conduct monitoring (unknown). * Plans are underway to make this a VCMP site.
4. South Side – Point Addis	Parks Victoria	Very soft	>50m	<ul style="list-style-type: none"> * Usage Lower than Torquay and Jan Juc. * Change in cliff type occurs past Southside, with large mass failures of loose soil cliffs. * Increased frequency of failure. * Large debris fields seen in aerial imagery. 	<ul style="list-style-type: none"> * Risk assessments have been conducted by PV (frequency/schedule TBC). 	<ul style="list-style-type: none"> * PV may conduct monitoring (unknown). * Recommend this be made a VCMP monitoring site.
5. Demons Bluff (eastern section)	Parks Victoria	Very soft	>50m	<ul style="list-style-type: none"> * Significant erosion rates (Fig. 2). * Relatively high failure frequency and large failure size. 		<ul style="list-style-type: none"> * PV may conduct monitoring (unknown). * Recommend extend VCMP survey coverage eastward into PV section of Demons Bluff.
6. Demons Bluff (western section)	GORCAPA	Very soft	>40m	<ul style="list-style-type: none"> * Significant erosion rates (Fig. 2). * Relatively high failure frequency and large failure size. 	<ul style="list-style-type: none"> * Beach permanently closed. * Warning signs * Geotech Risk assessment at regular intervals (frequency TBC) 	VCMP drone surveys, 6-8 weekly since 2018.
7. Anglesea to Point Roadknight	GORCAPA	Very soft	>50m	<ul style="list-style-type: none"> * Moderate failure frequency and medium failure size (sufficient to require active monitoring). * Usage = Substantial 	<ul style="list-style-type: none"> * Warning signs * Geotech Risk assessment at regular intervals (frequency TBC) * Infrastructure management (additional fencing, warning signs etc.) 	VCMP drone surveys, 6-8 weekly since 2018.
8. Aireys Inlet	GORCAPA	Soft	40m	<ul style="list-style-type: none"> * Rock is harder here (relative to Anglesea) * Usage = Substantial 	<ul style="list-style-type: none"> * Warning signs. * Geotech Risk assessment at regular intervals (frequency TBC). * Infrastructure above cliffs has been relocated back from the cliffs (2020) and additional fencing and warning signs installed. 	GORCAPA may have conducted drone surveys (need to confirm).

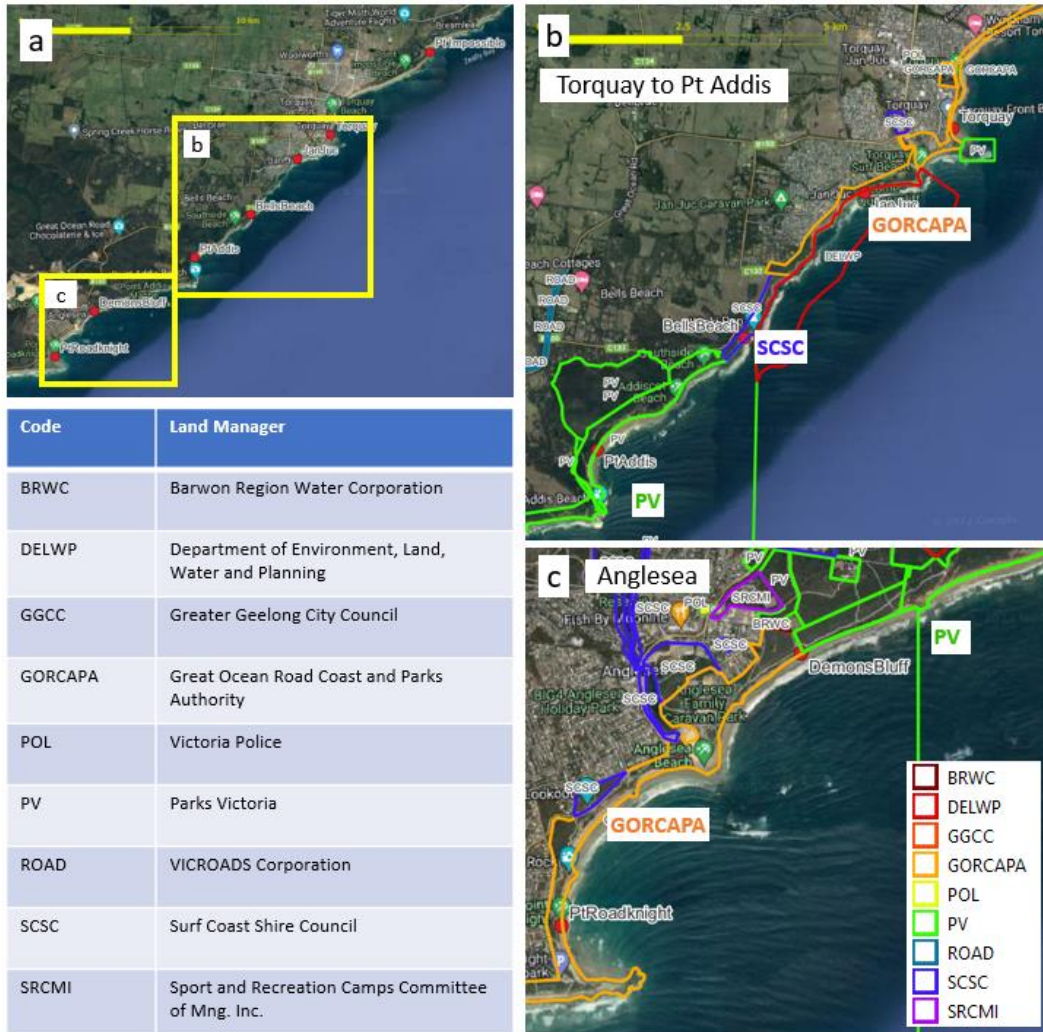


Figure 4. Great Ocean Road (East) detailed map of land management zone boundaries (source: DEECA internal).

Summary points on land managers and current hazard management strategy:

- All land managers are known to have conducted extensive geotechnical risk assessments (Section 4), some of which are highly detailed.
- Warning signage, fencing and similar measures are used at all sites (Figs. 3,4, Table 2), though this report does not assess the degree/suitability of these measures.
- The degree of active management, such as regular site visits, and updates to hazard management practices in response to changing conditions, is not thoroughly assessed in this report.
- Anglesea, Demons Bluff (both PV and GORCAPA sections) has previously been identified as an extreme risk area and has been closed permanently to public access.
- It is understood that the land managers' preferred approach at all other sites in Table 2 (excepting Demons Bluff) is to use warning signs, fencing and other safety measures, while maintaining some degree of public access. This should be confirmed with regard to specific sites.

4. Geotechnical assessments

Extensive historical geotechnical assessments have been conducted at many sites along the eastern GOR. Reports that have been sourced from GORCAPA and SCSC are listed in Table 3. Many of these reports contain detailed evaluations of risk levels for particular sites. Additional assessments are likely to exist, but have not been sourced, in particular for PV managed sites.

A major assessment was conducted by GORCAPA for east GOR in 2020 (Torquay to Aireys Inlet, only including GORCAPA managed sites), the primary findings of this report include recommendations to:

- Close Alice Rd Lookout, Aireys Inlet (this was the only ‘unacceptable risk’ level in the report).
- Plan retreat of Sparrow Beach Surf Coast Walk due to likely erosion in future.
- Monitor hot spot erosion and expand drone coverage at multiple locations around Anglesea.
- Procure advanced drone data analysis and people counting drone methods.
- Standardise signage, and add signs (e.g., to stay on cliff top path).
- Conduct the next major geotechnical risk review in 10 years (2030), with more frequent site inspections (several per year, at some sites).

GORCAPA also obtained a major review for the Lorne to Apollo Bay region in 2021 (outside the primary region of interest in this report). No ‘unacceptable risks’ were identified in that report.

For and the Bells Beach site (SCSC), the most recent major risk assessment obtained are from 2006-07. While annual checks are known to occur, follow-up with SCSC is required to determine if a more recent major review has been undertaken.

For Southside – Jarosite Headland – Pt Addis (PV) only a single report has been obtained (2016). Follow up is required to obtain a more thorough record.

Table 3: Great Ocean Road (East) Geotechnical Reports, by Land Manager

Prepared for	Report Title	Date	Prepared by	Area / locations
GORCAPA (prev. GORCC)	Anglesea Yacht Club Foreshore Stability (brief assessment)	2006	CES	Anglesea - Pt Roadknight
	Surf Coast Walk - Geotechnical Risk Assessment	2011	PB	Jan Juc, Bells Beach to Aireys Inlet
	Report on Coastal Stability, Study and Risk Assessment, Coastal Reserves between Torquay and Aireys Inlet	2012	GHD	Torquay to Aireys Inlet
	Sunnymead Stairway, Landslide Risk Assessment	2012	GHD	Aireys Inlet
	Cliff Top Asset User Risk Assessments, Coastal Reserves in Jan Juc and Aireys Inlet	2013	GHD	Aireys Inlet, Jan Juc
	Anglesea East Cliff Stability Review, Cliff Recession Study	2015	GHD	Anglesea - Demons Bluff
	Lorne Quarry Redevelopment	2019	ARUP	Lorne
	Torquay to Aireys Inlet Coastal Cliff Stability Review	2020	GHD	Torquay, Jan Juc, Anglesea, Aireys Inlet
	GHD - Additional Risk Areas	2020	GHD	Anglesea Lorne, Cumberland Rv, Wye Rv, Kennett Rv, Skenes Crk, Apollo Bay
Lorne to Apollo Bay, Geotechnical Risk Assessment	2021	GOLDER		
PV	Anglesea Geotechnical Risk Assessment and Operational Management Plan, Great Otway National Park	2016	AECOM	Anglesea (Demons Bluff), Jarosite, Southside
SCSC	Landslide Risk Assessment, Bells Beach Surfing Recreation Reserve - Stage 1	2006	Coffey	Bells Beach
	Landslide Risk Assessment, Bells Beach Surfing Recreation Reserve - Stage 2	2007	Coffey	Bells Beach
	Letter RE: Bells Beach - Review of Slope Hazards and Erosion	2009	Coffey	Bells Beach
	Letter RE: Bells Beach - Storm Erosion July 2011	2011	Coffey	Bells Beach
DEECA (and earlier entities)	Coastal Stability Study, Jan Juc, Victoria	2002	Douglas Part.	Jan Juc
	Aquatic Safety Signage Audit, Bells Beach Surfing Reserve	2002	SLSV	Bells Beach
	Coastal Stability Study, Bells Beach to Painkalac Creek, Surf Coast, Victoria	2005	Douglas Part.	Bells - Southside - Pt Addis - Anglesea - Aireys Inlet

5. Coastal Monitoring

A summary of current coastal monitoring practices along the eastern GOR are provided in Table 4. GORCAPA and the VCMP are presently in a data sharing arrangement. The advantage of obtaining and sharing data through the VCMP is that survey outputs can be maintained on centralised portals, including PropellerAero and CoastKit (Figs. 5-6), with a range of data analysis tools and outputs available to partners and other data users across government. For example, sites surveyed by the GORCAPA survey team (e.g., Torquay to Jan Juc) are processed and hosted through the VCMP data portals (Figs. 5-6).

Survey data are not currently available to the VCMP for Bells Beach (SCSC) and Southside to Point Addis (PV). Further discussion is required to determine if any historical monitoring data exists that can be shared with the VCMP and DEECA.

It is recommended that Bells to Pt Addis be added as regular VCMP drone monitoring sites, through data sharing partnerships between DEECA, SLSC and PV (as per the current arrangement with GORCAPA).

Efforts are currently underway to begin surveying this region (Bells to Pt Addis). An initial survey is being planned to be undertaken by GORCAPA (likely in March 2022). Surf Coast Shire (through Gabrielle O’Shea) has expressed interest in being involved with VCMP monitoring. Further discussion with PV is required to determine if a data sharing arrangement is possible.

Table 4: Cliff Monitoring for Great Ocean Road (East) Sites

Monitoring site	Land manager	Current surveyor	Data now available through VCMP	Current monitoring	Recommended change
1. Point Impossible	GORCAPA	GORCAPA	YES	1-2 surveys / year	(none)
2. Torquay-Jan Juc	GORCAPA	GORCAPA	YES	1-2 surveys / year	Increase survey frequency to 6 surveys / year.
3. Jan Juc - Bells Beach	SCSC	(none / unknown)	NO	(unknown)	Add Bells Beach as VCMP site. Partner and data share with SCSC.
4. South Side – Pt Addis	PV	(PV?)	NO	(unknown)	Add Southside to Point Addis as VCMP site. Partner and data share with PV.
5. Demons Bluff (eastern section)	PV	(PV?)	NO	(unknown)	Determine if data available through PV. Extend VCMP survey coverage eastward.
6. Demons Bluff (western section)	GORCAPA	VCMP	YES	6 surveys / year	(none)
7. Anglesea: Pt Roadknight	GORCAPA	VCMP	YES	6 surveys / year	(none)
8. Aireys Inlet	GORCAPA	(GORCAPA?)	NO	(unknown)	Determine if data available through GORCAPA. Potentially add as new VCMP site.



Figure 5. Example analysis from the PropellerAero data processing and hosting portal.

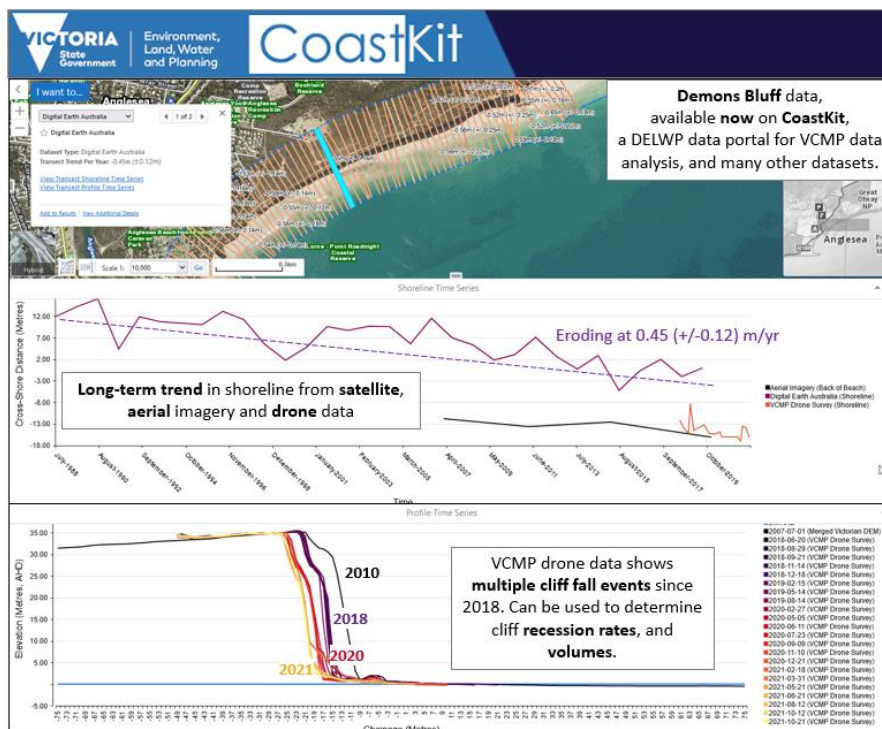


Figure 6. Example analysis from the CoastKit data portal.

6. Summary and Recommendations

This section includes a plan for conducting a rapid statewide cliff risk assessment (Section 6.1) and brief summary of the major outputs and recommendations of this report (Section 6.2).

6.1 Approach for statewide cliffs risk assessment

Step 1: Define list of potential sites

Based on the approach of this report to focus initially on soft cliffs as likely hazard areas, the statewide list of **soft cliff sites** includes (Fig. 1):

- Primary regions
 - Great Ocean Road (East) – Point Impossible to Aireys Inlet (focus of this report)
 - Great Ocean Road (West) – From east of the Twelve Apostles to west of Peterborough
 - Port Phillip Bay – northeast (Bayside) and southeast (Mt Martha to Mt Eliza)
- Secondary or isolated regions
 - Cape Bridgewater
 - Portland (harbour and foreshore area)
 - Skenes Creek
 - Lorne
 - Western Port (south side of French Island, Tenby Point, Coronet Bay)
 - Inverloch
 - Waratah Bay
 - Lake Tyers region
 - Mallacoota region

Note that a statewide cliff hazard assessment should address **both hard and soft cliffs**.

For each of the above sites, a first-pass assessment of historical shoreline erosion rates should be undertaken. This is not directly equivalent to cliff recession rates (which are unavailable), but is a useful indicator to determine initial areas of high-interest (e.g., Fig. 1-bottom row; Fig. 2).

The above list uses only the Smartline dataset which is nationwide and may not capture important local details. Other data sources should be checked (including geotechnical reports), and any omitted areas of cliffs or known landslip hazards should be included. For example, Kennett River is known as an area of significant risk which was not identified through the first-pass method shown in Figure 1.

Step 2: Land manager and site information

The relevant land managers can be internally sourced within DEECA (Julie Gale; Crown Land Administration Support, Land Governance; Land Management Policy Division), as per Figure 4.

Land managers may be contacted to obtain information on cliff sites, including:

- Technical information: Cliff height, geology (hard/soft). Cliff recession rates and cliff landslip/collapse history. Shoreline erosion trends, rainfall and other relevant data relating to cliff recession.
- Geotechnical risk assessment (and related) reports:
 - Frequency of major reviews of geotechnical risk.
 - Frequency of minor updates and site visits.
 - Include probabilistic estimates of risk, where available.
- Monitoring: History, methods and planned schedule.

- Public usage and access to the site.
- Coastal values and uses, including: public usage levels and access, cultural and heritage, environmental, social, and public safety.
- Site management: Warning signage, beach closures, fencing.
 - Include details on active site management, e.g., frequency of updates, responsiveness to changing conditions.

Summary land manager information should be converted into spatial data layers, e.g., geotechnical report dates and coverage areas, cliff monitoring dates and coverage areas.

Step 3: Assess site specific hazards

For the areas targeted through Steps 1 and 2, detailed site assessments can be prepared, which should include:

- Land manager details.
- Tabulated site information (as per bullet points in Step 2).
- Site map (example in Fig. 7).

Level of risk should be obtained from existing geotechnical risk assessments. If sites are identified that do not have existing risk assessments, these can be highlighted as areas of interest for further investigation. Geotechnical data and recession rates can be used to determine likelihood of cliff falls. Level of risk needs to be determined using the DEECA risk based framework. Once technical information becomes available, it may be necessary to conduct risk workshops with relevant teams.

An example map that includes hazard data (cliff height, rock type, shoreline erosion rates), access and usage data is provided as an example in Fig. 7, Southside - Pt Addis section.

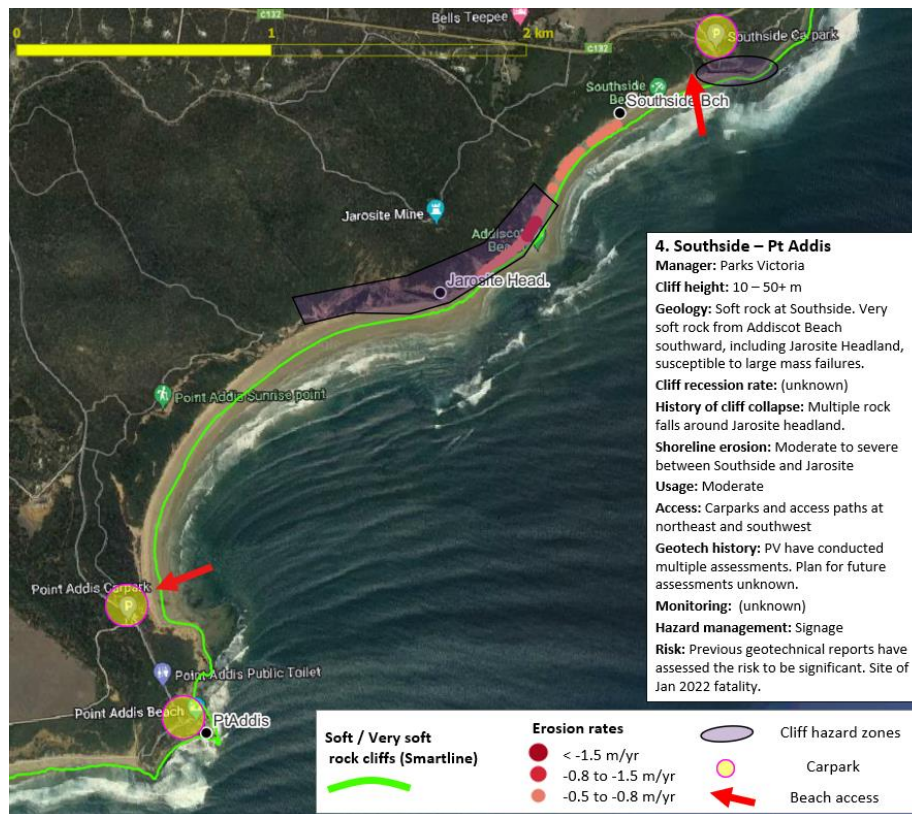


Figure 7. Combined physical processes and management/access/usage assessment for a single site.

6.2 Summary findings and recommendations

This report provided a first-pass examination of soft cliff hazards across Victoria, with a focus on the eastern Great Ocean Road region, from Aireys Inlet to Point Impossible. The summary findings and recommendations include:

- At a statewide level, three major regions of soft cliffs were identified (Great Ocean Road [West], Great Ocean Road [East], and Port Phillip Bay [NE and SE]). Several isolated soft cliff areas were also identified [Section 2; Section 6.1].
- For the primary area of interest (Great Ocean Road - East), the focus is on the region from Anglesea to Torquay. The highest, softest cliffs, most prone to mass failures, occur in the Demons Bluff formation (Appendix A), extending from Anglesea to Jarosite Headland. Within that region, two zones were identified as being coincident with high rates of shoreline erosion, which will exacerbate cliff recession rates:
 - Demons Bluff, Anglesea (beach permanently closed in this area due to risk associated with cliff falls).
 - Southside Beach to Jarosite Headland (the region associated with the fatality on Jan 1, 2022).
- Land managers in the Great Ocean Road (East) region include [Section 3]:
 - GORCAPA (southwest - Aireys Inlet to western Demons Bluff; northeast – Jan Juc to Point Impossible)
 - PV (eastern Demons Bluff to Southside)
 - SCSC (Bells Beach to southwestern Jan Juc)
- All land managers have undertaken geotechnical risk assessments [Section 4] and employ signage across cliff sites. The degree of active management, such as regular site visits, and updates to hazard management practices in response to changing conditions, is not thoroughly assessed in this report, and should be the subject of subsequent assessments.
- Regarding site monitoring [Section 5]:
 - GORCAPA conducts drone surveys at all its sites, and has entered into a data sharing arrangement with the VCMP.
 - SCSC (Bells) has expressed interest in conducting surveys and entering a data sharing arrangement.
 - It is uncertain if PV has existing monitoring data that may be available, and discussion is required on future monitoring arrangements.
 - The Point Addis to Bells Beach extent stands out as an area for which no monitoring data is currently available, and efforts are already underway to begin survey this area.
 - Additional surveying sites should include:
 - Point Addis to Southside (data sharing arrangement to be arranged with PV).
 - Bells Beach (data sharing arrangement currently being discussed with SCSC).
- As a next-step, a method for rapidly assessing cliff hazard statewide was outlined, including a process for identifying and contacting land managers [Section 6.1].

REFERENCES

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APPENDIX A: Geological Map

A geology map (Fig. A1; GHD, 2012) indicates that a transition from the ‘soft’ Torquay Group to the ‘very soft’ Demons Bluff Formation occurs at the mid-point of Southside Beach.

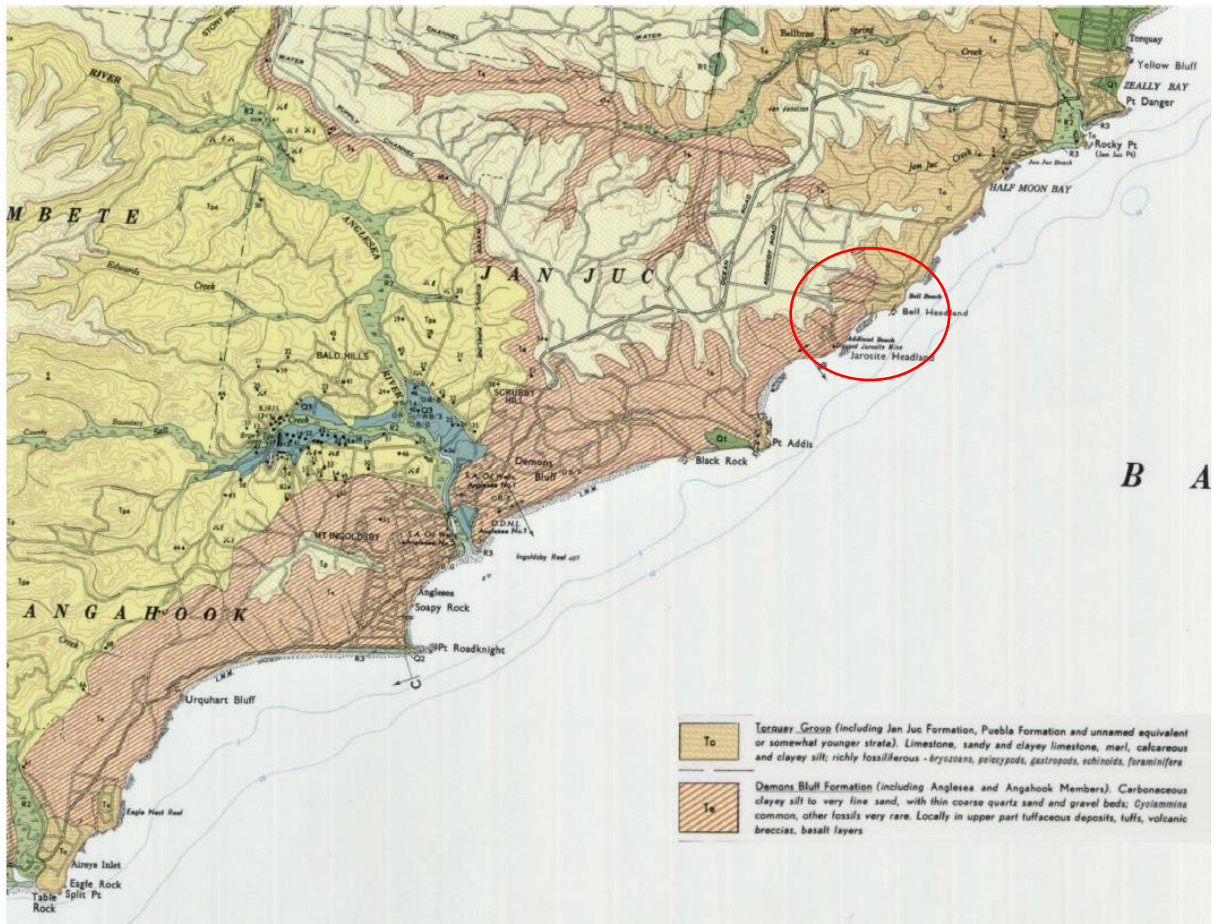


Figure A1: Geology map of eastern Great Ocean Road region. Source: GHD (Report on Coastal Stability, Study and Risk Assessment, Coastal Reserves between Torquay and Aireys Inlet; 2012), prepared for GORCAPA (GORCC).