Garden Island Sands

Beach Access and Erosion Management plan

Report prepared for The Friends of Garden Island Creek

July 2023

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Important Information

This report was largely written by Kelsie Fractal, representing the Friends of Garden Island Creek as documentation of the outcomes of a Preparing Australian Communities Program grant. It is written with the support and guidance of Bill Cromer and Dr. Chris Sharples, however except for Section 4 (prepared by Bill Cromer) and the shoreline investigation summary in section 1 (prepared by Dr. Chris Sharples) all main text remains the views and opinion of the lead author unless stated otherwise. Appendices consist of reports that were written as standalone documents commissioned by the Friends of Garden Island Creek, during the grant period and information presented in each report is the work of their corresponding authors.

Cover image: Erosion at Garden Island Sands, 2022

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1. Summary

The Preparing Australian Communities Program – Local Stream (PACP), was part of a program funded by the Australian Government targeting locally led projects aimed at improving community resilience against natural hazards. The Friends of Garden Island Creek (FOGIC) community Landcare group received funding from this program in 2021 to undertake coastal erosion studies to identify the cause of local coastal erosion and provide guidance towards implementing a coastal protection strategy.

Through discussions with Huon Valley Council, Parks and Wildlife Services and several consultants, specific studies were identified to meet the aims of the project. These included geomorphic and geotechnical investigations to understand the local processes involved and inform the design of remedial works. A natural values assessment and cultural heritage assessment were undertaken to support future development applications that may be required.

Other elements of the project included a community engagement session which was held following the completion of studies to describe outcomes and discuss options. Following this the community were surveyed regarding their views on options for remedial works. Permanent survey benchmarks were installed, and equipment and educational support provided so that community members could engage in long term monitoring of the shoreline. Lastly a website was created to disseminate findings to other communities experiencing similar issues. This document contextualises and collates the findings of the FOGIC PACP project.

Main Findings

1.1 Short summary: "A Geomorphic Investigation of Shoreline Change at Garden Island Sands, Southern Tasmania" Chris Sharples, 5th July 2023

Analysis of 34 ortho-rectified air photos from 1948 to 2021 and one ground survey from 2022 shows that the beach and foredune at Garden Island Sands were stable or possibly slightly receding (at average rates of ~0.03m to ~0.05m per year) from at least 1948 until 2000. However, following an abrupt change of behaviour around 2000, the central to south-eastern two thirds of the beach and foredune switched to dominantly eroding and receding at an average rate of 0.35m per year over the period from 2000 to 2022. This is continuing with no signs of stopping or recovery. However, the north-western third of the beach is more wave-sheltered and has shown less erosion with some recovery at times. Since 2000, an average of about 7 metres width - and up to 12 metres width in places - has been removed from the central to south-eastern main part of the foredune, which is about a third to half of the original width of the dune as it was in 2000.

Analysis of the local and somewhat unusual geomorphic and sand-movement processes at this beach indicate sea-level rise as the only plausible driver of the observed change of behaviour at this beach. Only a small proportion of Tasmanian beaches are yet showing a clear physical response to global mean sea-level rise, making Garden Island Sands a somewhat unusual beach environment and an "Early Responder" to sea-level rise. Since the rate of global sea-level rise is currently increasing and is unlikely to stop for at least the next century or more, it is inferred that without intervention the observed rate of shoreline retreat in the central to south-eastern two thirds of Garden Island Sands beach will continue and possibly increase, resulting in eventual removal of the remaining foredune and increasingly frequent exposure of backing properties to storm wave erosion and flooding. The more wave-sheltered north-western third of the beach will probably also show some erosion and recession but at a slower rate over a longer timeframe.

A beach and foredune monitoring program commenced during 2022 to monitor continuing changes to the beach and foredune on 4 transects spaced along the beach.

1.2 Community Consultation

On the 28th January 2023 a community consultation was held with approximately 40 members of the community in attendance. Bill Cromer and Dr. Chris Sharples relayed the findings of their studies and community members were given the opportunity to ask questions. A discussion was facilitated to hear community concerns and workshop potential solutions for beach access and remedial/erosion control works.

There is a high level of frustration among residents due to the long-term nature of the issues and the lack of involvement of council and other governing bodies. The removal of the former boat ramp without community consultation has contributed to a legacy of mistrust of governing bodies and formal channels of approval. However, they are pleased with the outcomes of this project and the will of FOGIC to continue to seek a solution. Possible solutions including ramps and concrete steps for beach access, as well as sandbag and rock revetments for erosion mitigation were discussed. No clear direction was proposed at this stage. It was suggested that the focus should be on creating beach access in the short term, along with erosion protection measures for that access, which could be worked into a larger plan for the entire affected area of shoreline in the future. The need for long term planning and a cohesive strategy for the entire beach was a key point of discussion. There were mixed opinions over whether the original boat ramp should be replaced or whether pedestrian access is sufficient. There were some offers of support from members of the community in the form of labour, machinery and materials provided made that could support future works. A survey was sent out to all Garden Island Creek residents after the meeting to further gauge community attitudes on the issues (see section 3).

1.3 Potential Remedial Works

A wooden ramp and rock wall is proposed as a solution to beach access issues and as an erosion mitigation strategy (refer section 4 for design details). The access ramp is needed urgently to allow beach access by residents and visitors (as seen through community consultation) and a design is sort that incorporates the accessway, with a protecting rock wall to preserve it and prevent damage to the ramp from wave action and erosion. It is suggested that a rock wall of 30 m either side of the ramp is constructed as a test of the efficacy of the wall design before a further 220 m of wall is constructed to protect the remaining section of shoreline impacted by erosion. This two-stage process will allow beach access to be created promptly, while taking into the account the larger long-term issues of foreshore erosion. The design of this wall and accessway considers all the information generated through the PACP project and with initial consultation from the community. Further community consultation will be sought on a final design. Offers of in-kind support have been given from community members and other interested parties for the initial construction including an offer of machinery usage, labour, and reduced cost quarry materials from the local quarry owner. FOGIC is motivated to oversee the construction of these works, with the assistance of suitably qualified people and the approval of local council.

2. Background

2.1 Garden Island Sands

Garden Island Sands forms the seaside portion of the suburb of Garden Island Creek, located in the Huon Valley, between Randalls bay and Charlotte Cove (fig. 1). It incorporates an area of approximately 10.5 ha which includes 52 properties, 18 of which have beach frontage (fig. 2). Residential land use is a mixture of permanent residence and part time residence (second home or shack). Calm shallow waters with soft sandy sediments have led to the beach being recognised as a safe place for families, especially those with young children. The beach is also used for dog walking and kayaking by both locals and members of surrounding communities. There is approximately 500m of beach frontage with the creek opening to the ocean on the eastern side.

Figure 1. Location of Garden Island Sands

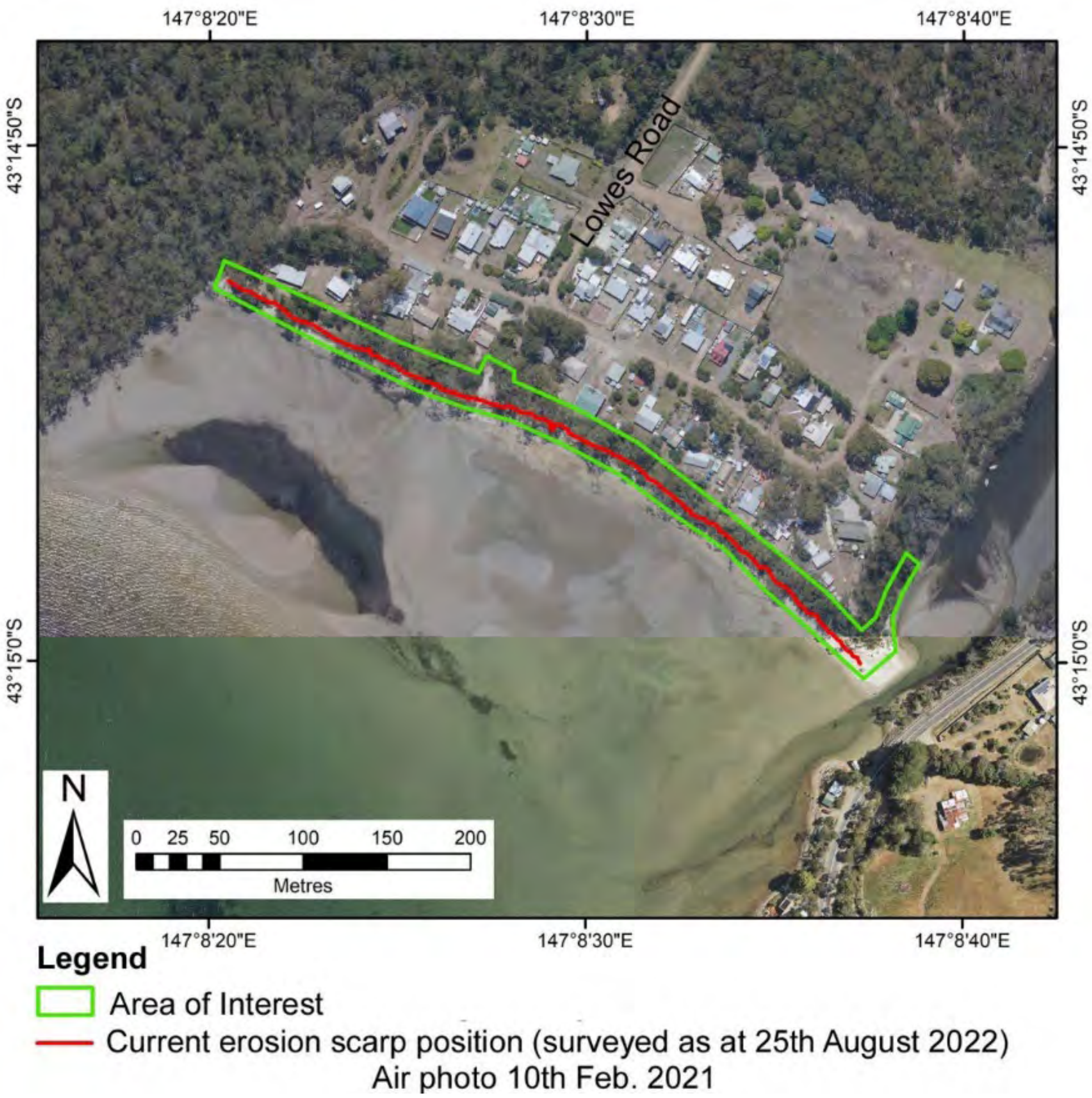


Figure 2. Shoreline study area of interest (green) and view of properties at Garden Island Sands.

2.2 History of investigations and issues related to beach access and erosion.

Residents of Garden Islands Sands have been concerned about beach erosion for more than 30 years. In the early 90s the Garden Island Sands Property Owners Association was formed with the aim of creating a management plan for erosion controls to be implemented. Plans were drawn up for a log wall to be constructed and these were submitted to the then Cygnet Council (now Huon Valley Council) but no further action was documented, and the group ceased to operate after three years.

In 2015, the Huon Valley Council and the Tasmanian Climate Change Office as part of the Tasmanian Coastal Adaptation Decision Pathways (or TCAP) project, commissioned a report on pathways for future adaptation to coastal erosion at Garden Island Creek (SGS Economics and Planning 2015). The report used modelling data to predict the risk to the community of flood inundation in in 2050 and 2100. The report suggested three options for adaptation including:

1. Let climate change take its course and retreat early
2. Protect existing development as long as practical while protecting natural values
3. Protect existing development and permit new development to the maximum possible extent for as long as possible (SGS Economics and Planning 2015, pg. 4)

The report suggested that doing nothing was unlikely to give the best result in terms of costs and benefits and that leaving the situation unmanaged exposed community to unacceptable risks to life and property while potentially several increasing demand on emergency services. The largest net worth was seen in pathway 2 (SGS Economics and Planning 2015). A community consultation took place (not many current long term residents remember it) where options were discussed, with the outcome being that the community wished for option 2, however no further action was taken on any pathway (pers. discussions with residents).

Several key recommendations were suggested regardless of the choice of pathway. These included:

- Vegetation management to protect the dune
- Emergency management planning regarding flood risk
- On ground studies to better understand dune susceptibility to erosion (as the erosion hazard mapping used was inconclusive)
- Monitoring of the beach condition to improve understanding of the processes involved in change to the shoreline.

None of these recommendations was enacted.

In mid 2020 the Huon Valley Council commissioned the removal of the concrete boat ramp at the end of Lowes Rd, Garden Island Sands (fig. 3). The boat ramp had become damaged (cracked) and was deemed unsafe. Residents were angry at the removal of the boat ramp as they considered that they had not been consulted on the decision, although Parks and Wildlife informed FOGIC that they did consult in 2018. After removal of the ramp, an approximate 1 m drop off was left onto unstable rubble (fig. 4). The boat ramp had once been the access point for most beach users and now only those that could navigate the drop could access the beach.

Residents contacted Huon Valley Council, Parks and Wildlife Services and Marine and Safety Tasmania (MAST) asking for the boat ramp to be replaced, however MAST would not intervene as they considered the boat ramp at Charlottes Cove to be sufficient for the needs of community and council would not get involved as they had no records of the construction of the original boat ramp and claimed it had been placed illegally. Local residents claim it was built by the former Cygnet Council, but no records of this are known.

Figure 3. Former concrete boat ramps, image taken while standing on the ramp.

Figure 4. Drop off left after the removal of the boat ramp in 2019.

A community action group was formed in late 2020 which presented a petition to parliament on November 9th 2020, regarding the status of erosion of Garden Island Sands and lack of safe beach access (Mendonca 2020). The response included statements that Crown is not responsible for naturally occurring erosion processes, private property is not immediately threatened, no public in infrastructure is threatened, and the removal of the boat ramp was necessary due to deterioration and that there is no council interest in providing recreation structure at Garden Island Creek due to proximity of similar structures in nearby locations (https://lcepetitions.parliament.tas.gov.au/lcepet/Home/DownloadResponse/f88263c8-2ffc-48a1-bf46-1dfb86c095f5).

The community action group became incorporated as the Friends of Garden Island Creek in early 2021 and began looking at ways to either continue to agitate government agencies to reconstruct the boat ramp or to apply for funding for a community led solution. Election promises of assistance were made to the community in 2021, however these did not come to fruition.

It was suggested by a consultant familiar with coastal zone management that the erosion problem that led to the failure of the original boat ramp could potentially be very serious and not only would it impact future structures but potentially result in flooding of residences. The group decided that both the shoreline erosion and beach access should be dealt with concurrently and a long-term plan established for management of the coastal erosion issue. The recommendation of the TCAP report that had not been followed through with, which suggested detailed on ground studies to understand the causes of shoreline change was seen as most obvious starting point. Julie Collins MP forwarded the details of the PACP grant to the group who successfully applied for funding in 2022.

2.3 Current state of shoreline erosion and beach access

- As of July 2023, there is no safe beach access at the carpark at the end of Lowes Rd. Shoreline erosion has smoothed the drop off that was left after the boat ramp was removed but it still cannot be navigated by many people, including elderly residents. Large rocks were placed to prevent vehicle access when the ramp was removed and the shoreline has since eroded back to this point. (fig. 5).
- The current state of shoreline erosion is continuously undermining the stability of large trees and many have fallen onto the beach over the last two decades (fig. 6).

- This is a large change from the gentle sloping beach with healthy native vegetation that there once was and reflects the switch from a formerly stable beach and foredune to a progressively eroding and receding shoreline since about 2000 (fig. 7).

Figure 5. Left: The drop down from road level to the beach at the site of the former boat ramp. Image from FOGIC 2021. Right: erosion has removed the shoreline back to the large rocks visible in the first image. Image from FOGIC 2023

Figure 6. Shoreline erosion has undermined large trees which have fallen, further destabilising the dune. Images from FOGIC 2022

Figure 7. Garden Island Sands, both photos taken in a similar location looking in the same direction. Photo A from FOGIC in 2022. Photo B. from an unknown source. Unkown, likley prior 2000.

2.4 Purpose and scope of this report

The initial PACP grant application listed the following key activities to be undertaken with funds provided:

a) assess the causes of erosion and flooding

b) present mitigation options to the community

c) develop a management plan

In addition, the project would:

a) train the community to monitor erosion

b) develop a framework to assist other communities experiencing similar erosion issues by providing information about the process, identifying suitable consultants, providing cost estimates, and guidance navigating council and crown processes.

c) build resilience in the local community through providing information that builds understanding of future mitigation options and their implementation, to protect properties and the beach.

The Friends of Garden Island Creek came in under budget in meeting these goals and through discussions with the funding body decided to extend the project to include further consultation to produce a design of a potential solution for both beach access and erosion mitigation (see section 4) as well as to take further steps towards the development approval process.

This purpose of this report is to put in context all information that was collected during the PACP project and to collate all reports generated. This document is intended to provide guidance to community, council and other interested parties as to appropriate direction for the future management of the Garden Island Sands shoreline.

The outcomes of a community consultation are recorded here as well as a preliminary design for a seawall that takes into account the results of geomorphic and geotechnical reports and the wishes of the community. This work will form the basis for a development application to be subsequently forwarded to Huon Valley Council for a proposed beach accessway and erosion mitigation test wall.

The reports from consultants (appendices 6.1 – 6.4) were written independently by their authors as stand-alone documents and have been compiled here (with permission) to present a complete picture of the outcomes of PACP grant funding. There is therefore some overlap in their introductory sections.

3. Outcomes of community consultation and survey

On the 28th January 2023 a community consultation session was held at Garden Island Sands next to the site of the former boat ramp. Approximately 40 community members attended. Dr Chris Sharples and William Cromer both presented the results of their studies. A session was then facilitated by Kelsie Fractal aimed at using the information presented from the consultants to discuss community concerns, ask questions of the consultants, and then workshop potential solutions that fit with the desires of the community and the information gathered through the consultation process.

Key points put forth by the community at the meeting included:

- Beach access is a high priority as many residents cannot access the beach
- Erosion has been ongoing for decades and it's frustrating that nothing has been done
- Some residents remember the TCAP consultation and are frustrated that nothing came of it

Ideas were discussed for solutions, highlighting the need for any structure such as the accessway to be incorporated into a larger design that would protect the shoreline from erosion. Ideas and key points discussed included:

- A 'sand ladder'/'board and chain walkway' for the accessway, a ramp (concrete or wooden) or a series of wide concrete steps.
- A local resident offered to donate recycled concrete slabs and provide machinery and labour to turn these into an accessway.
- Any design for the accessway should take account of the needs of elderly residents and parents with prams i.e., any steps should be shallow and wide and a handrail should be included in any design.
- Some residents felt strongly that the boat ramp should be replaced, others did not feel boat access was necessary. The ability to walk kayaks to the beach was desirable.
- Shoreline protection strategies discussed included sandbagging and sloping rock walls.
- Designs for shoreline protection need to be financially feasible.
- A local quarry owner offered to supply rock at discount prices to support shoreline protection works.

In the week following the consultation a survey was sent to all mailboxes in Garden Island Creek and was also made available on the Friends of Garden Island Creek Facebook page.

Twenty-two surveys were returned and all survey questions were answered. Results were as follows:

Q1. Are you a resident/landowner at:

- 66% - Garden Island Sands
- 44 % - Garden Island Creek
- 0 - Another area of the Huon Valley
- 0 - Not currently a resident/landowner in the above areas but interested in the issue
- 0 - Prefer not to say

Q2. Did you attend the community consultation and discussion about beach access and erosion held at the beach on the 28th of January?

- 44% - Yes
- 56% - No

Q3. How often do you visit the beach at Garden Island Sands?

- 41% - Daily
- 14 % - Once a month
- 18 % - Infrequently
- 5 % - Weekly
- 23 % - Frequently but seasonally

Q4. How long have you been visiting the beach at Garden Island Sands

- 43 % - Less than 5 years
- 18 % - 5 to 10 years
- 36 % - More than 10 years

Q5. Have you seen/experienced changes to the beach at Garden Island Sands?

- 5 % - Yes, minor change
- 86 % - Yes, major change
- 0 - No Change
- 9 % - I don't know

Q6. If visiting the beach at Garden Island Sands in the past 2 years have you found the beach difficult to access since the boat ramp was removed?

- 86 % - Yes
- 14 % - No

Q7. How important do you think it is to address beach access at Garden Island Sands

- 77 % - Very important – urgent action is needed.
- 18 % - Important – action is needed soon.
- 5% - Not important – no action required.

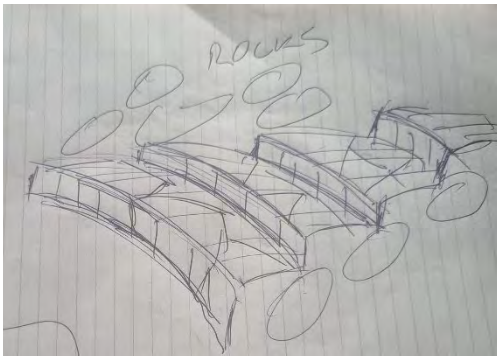
Q8. It has been suggested that safe beach access for people/prams/dogs may be easier to establish than boat access, how do you feel about that?

- 68 % - OK. Safe beach access for people is adequate.
- 32 % - Not OK. I feel the replacement of the boat ramp is very important.

Q9. Do you think either a 'sand ladder/board and chain walkway' seen at other local beaches, or a set of recycled concrete steps (for which the materials are currently available) are appropriate? (fig. 8)

- 32 % - I would be happy with either
- 18 % - I prefer the 'board and chain walkway'
- 36 % - I prefer the wide concrete steps

- 14 % - I have another idea



A) 'Board and chain walkway'. B) concrete steps, a quick sketch by Mick Kelly. Both of these ideas will have to go through engineering to see what's possible.

(Figure 8: images of accessways provided in the survey)

Comments provided alongside Q9.

- 'I've always found narrow steps difficult to walk on.'
- 'Replacement of boat ramp gives access for all.'
- 'Removal of boat ramp has made access very difficult.'
- 'In a perfect world access and a boat ramp ideal - but safe access easier.'
- 'The beach issues have gotten worse after boat ramp removal. It provided a buffer. Seawalls work overseas.'
- 'Boat ramp should be replaced.'
- 'Concrete will be undermined by erosion - action only needed to minimise erosion.'
- 'Being able to get Kayaks onto the beach is VIP to us, so a ramp of some description seems like a better option than steps. I imagine families with prams would prefer a ramp as well.'
- 'Access for horses. A ramp. Some councils have recycled plastic grate ramps. Both of the suggested options are susceptible to erosion.'

Q10. How important do you feel it is to take action regarding erosion of the beach at Garden Island Sands

- 86 % - Very important – urgent action is needed
- 18 % - Important – action is needed in the near future
- 0 – Not important – no action required
- 0 – I don't know

1 person answered both

Q 11. What do you think are the most important reasons for protecting the beach at Garden Island Sands from erosion? (please rank)

Percentage of first ranking given

- 39 % - Protect private property
- 25% - Protect the environment
- 32% - Ensure safe ongoing use of the beach by the community
- 0 - other

9 people ranked all options from 1-3

5 people selected all options as equally important

7 people ranked < 3 options

Comments provided alongside Q11.

- 'Clean out the dead wood and replace with wall similar to Gordon.'
- 'We frequented this beach when I had a toddler & children. It's such a shallow safe beach. Such a shame to see the trees & private property at risk.'
- 'Good meeting on the 28th thank you for organising and effort you've put in.'
- 'Mick Kelly's idea and donation - we should act now.'
- 'Severe erosion once boat ramp removed. I don't have a boat and don't even fish, but the boat ramp served a dual purpose.'
- 'The wide steps are a great idea but possibly a ramp next to them for prams, wheelchairs and Kayaks would we worth considering.'
- 'Once white gums are gone, erosion is likely to be exacerbated. Also the aesthetics of the beach will be diminished.'
- 'Tractor available if needed with front end loader.'

Q 12. I may like to be involved in the following moving forward

Number of respondents

- 13 people - Community meetings to discuss progress and options for beach access and erosion protection
- 6 people - A group that meets regularly to progress these specific projects (no experience necessary, no commitment required, just participation)
- 11 people - Working bees where I am able to be physically involved in sandbagging etc
- 7 people - Working bees where I can attend and have a less physical role
- 6 people - Joining the Friends of Garden Island Creek group or committee

Other Comments:

- 'Huon council and/or MAST should co-ordinate works. Contemplate an artificial reef to break waves.'
- 'The council should be urgently developing strategies relating to this site.'
- 'Can we ask council for a bin near the swing seat for rubbish.'

Conclusions from the community consultation and survey

The community feels strongly that urgent action is required to address beach access and erosion issues at Garden Island Sands. The survey suggests that the community feels that dealing with erosion is more important than the access issue, however the group at the consultation indicated the opposite. This may be because of a discussion about how fixing the access may be more achievable in the short term than implementing shoreline protection. Some residents have begun attempting to employ their own erosion control measures with small wooden walls or with cut vegetation, or to build temporary access structures with bricks and concrete blocks. This is further indicative of the frustration felt by residents, but these strategies are unlikely to be effective in the long term and this was discussed at the meeting, in hope of encouraging residents to stay interested in the legitimate community-shared process.

Many people indicated that they feel that the council/MAST/Parks and Wildlife should be taking the lead in fixing both access and erosion issues. However, they are happy for the work FOGIC is currently doing in progressing towards a solution.

Two ideas for an accessway were the preferred options discussed at the meeting – 'board and chain walkway' and concrete steps. The survey suggests respondents either prefer the concrete steps or are happy with either idea. Community was advised that further discussion with them would happen once suitably qualified people looked at the project to come up with a design.

The survey indicated that while protecting private property is important to over 1/3 of survey respondents, others in the community feel that protecting the environment and continuing to provide for safe use of the beach is also a high priority. This speaks to the fact that the current state of the beach effects more that just those residents who have private property to protect.

While 68% of people surveyed felt that installing safe beach access for people was adequate, the rest believe the replacement of the boat ramp should be a priority. At the consultation a discussion was had about FOGIC's dealings with MAST who advised that there would not be any interest from them in providing a new boat ramp due to proximity to existing ramps at Charlottes Cove. The extra cost of engineering a boat ramp versus pedestrian access was also discussed. Potentially those that indicated the need for the boat ramp in the survey were not part of those discussions, and further community consultation would need to be sought on this issue.

4. Proposed beach access and erosion control seawall

The shoreline erosion and geotechnical reports (Appendices 6.1 and 6.2) of consultant geologists Dr. Chris Sharples and Bill Cromer provide sufficient detail to design a coastal defence for the beach. Bill Cromer has designed coastal defences for several locations in the Derwent Estuary.

Of the various coastal defences available, a rockwall is regarded as appropriate for Garden Island Sands Beach, considering costs, available materials, and the need for a permanent, aesthetically agreeable structure. Preliminary designs of the wall have community support.

Figures 9, 10 and 11 show the proposed location of the rockwall. It will be built in two stages:

- Stage 1 will be a nominal 60 m length of wall, in two 30 m sections either side of the current beach access point off the end of Lowes Road. A new timber ramp and steps will be built at the access point, from where:
    - 30 m of wall will extend in a southeasterly direction along the beach, ending near the extended 16/18 Sunset Drive property boundaries, and protecting the start of that beach section most susceptible to landward erosion, and
    - 30 m of it will extend in a northwesterly direction (beach erosion decreases in this direction past this approximate point).
- Stage 2 is the extension of the Stage 1 rockwall: nominally 220 m will be added to the southeastern end of Stage 1, continuing the wall the remaining length of the eroding beach.

Figure 12 shows the current eroding access point to Garden Island Sands Beach off Lowes Road. Figure 13 is a schematic view of the proposed timber access ramp (and steps, not shown), and part of the Stage 1 rockwall. The boulders will be durable, high-strength rock (probably dolerite) with attractive, oxidised brown faces, each weighing a tonne or more, and individually selected from a local quarry to fit neatly together without mortar or other binding material. The base of the wall will be buried 0.7 m or so into the sand (based on advice from Dr. Chris Sharples) to withstand any beach lowering by wave action during storms.

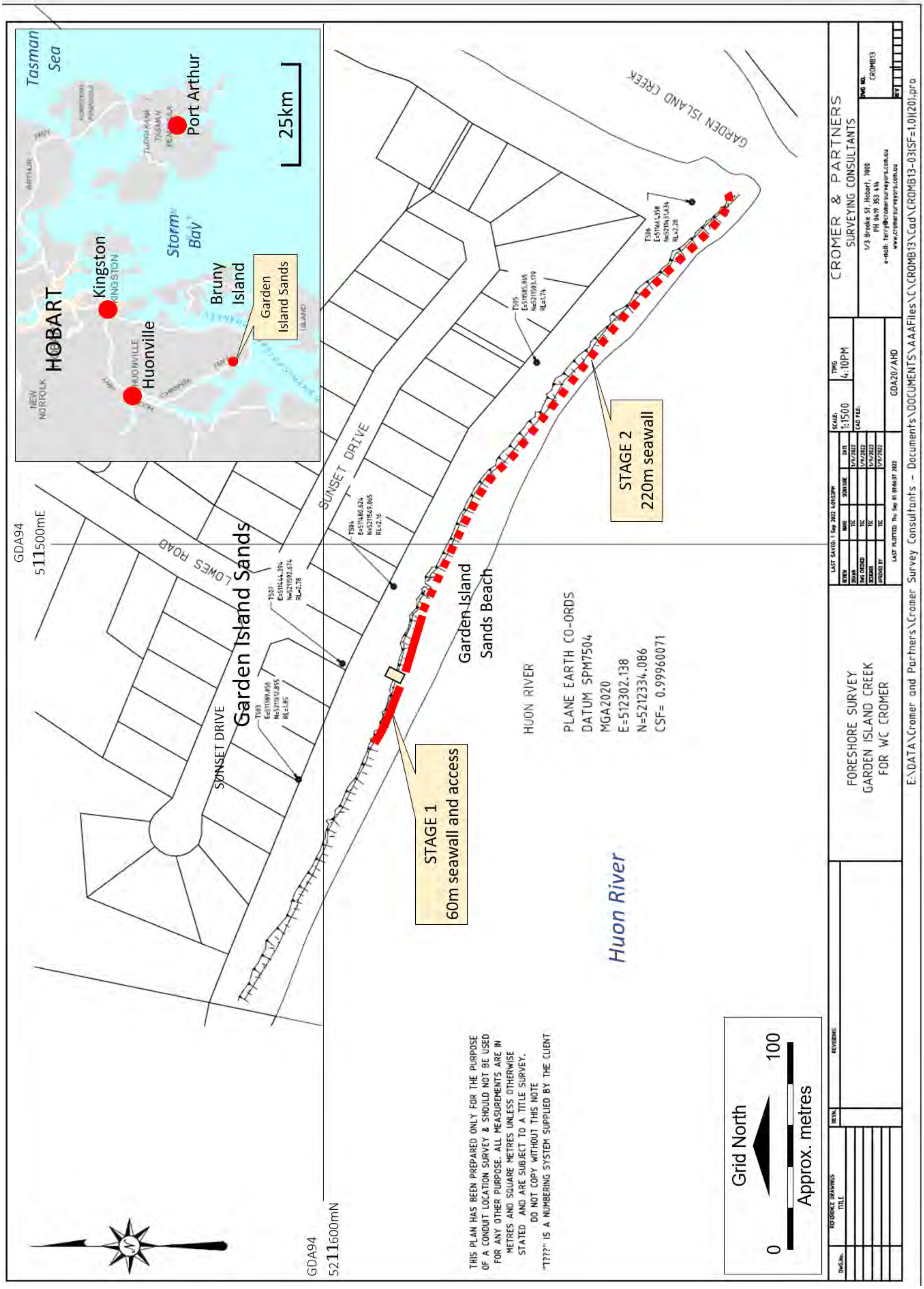


Figure 9. Proposed seawall at Garden Island Sands Beach, southern Tasmania.
Source of base map: Cromer & Partners Surveying Consultants

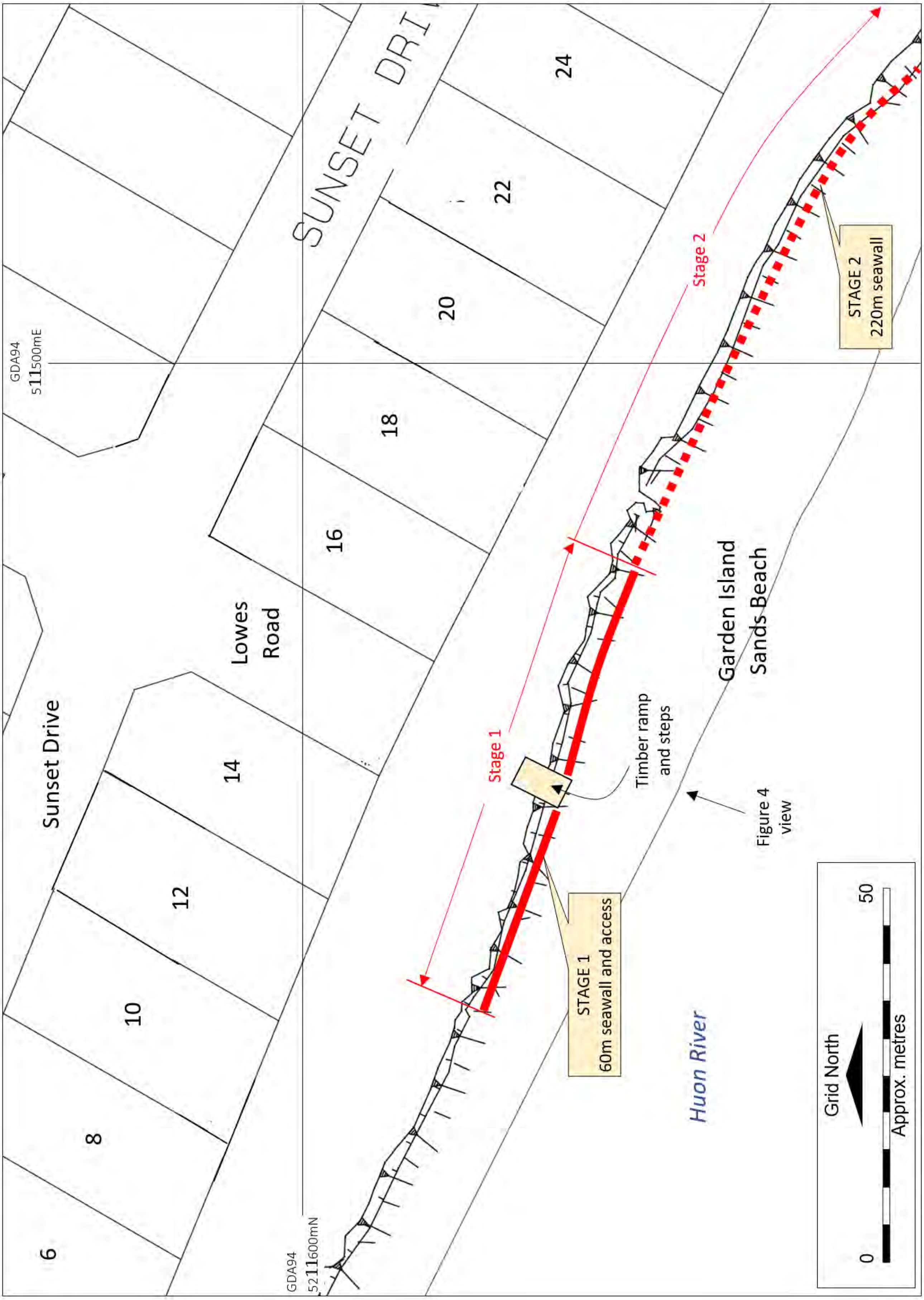


Figure 10. Detail of the proposed seawall at Garden Island Sands Beach, southern Tasmania.
Source of base map: Cromer & Partners Surveying Consultants

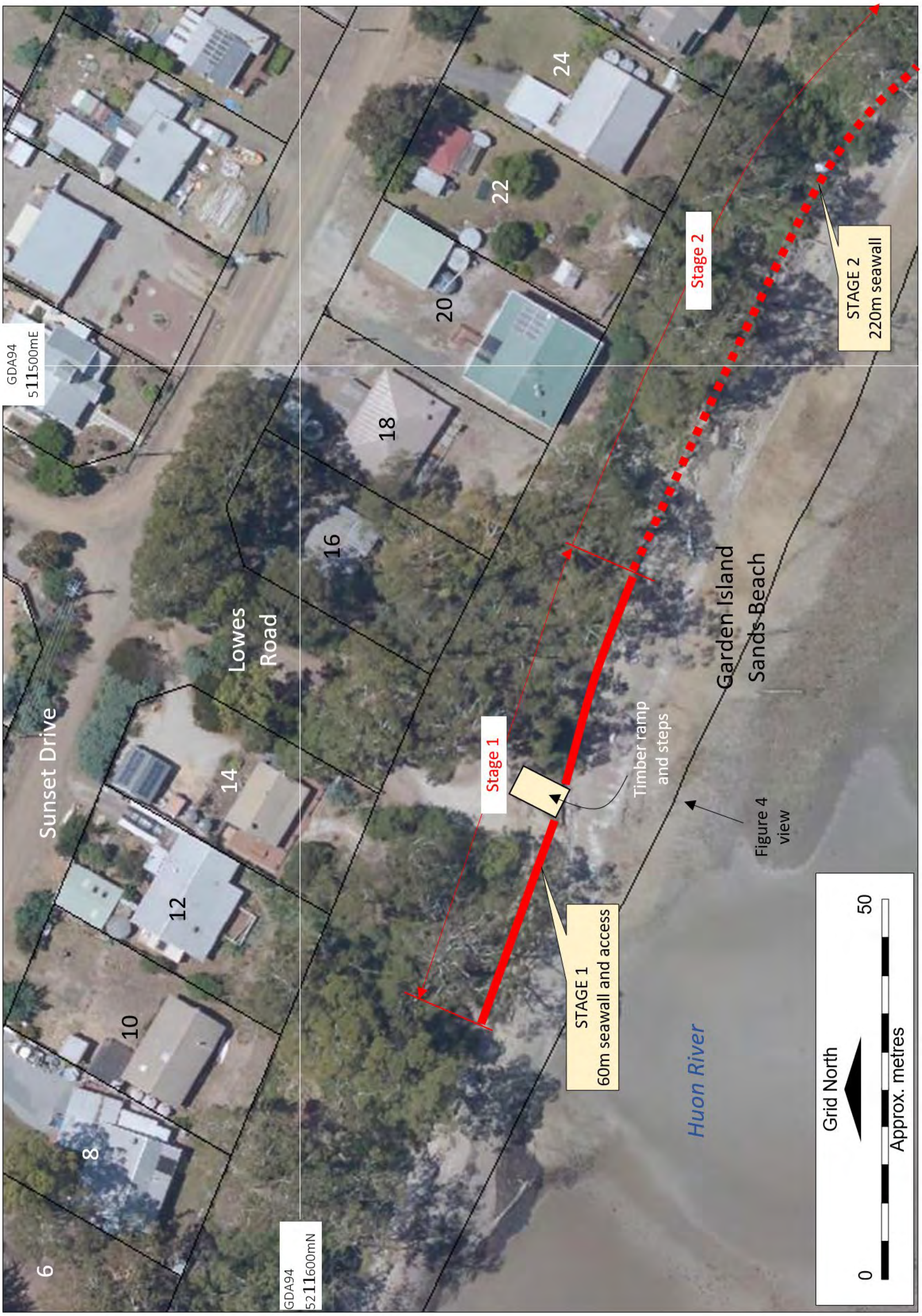


Figure 11. Aerial view of the proposed seawall at Garden Island Sands Beach, southern Tasmania.
Source of image: www.thelist.tas.gov.au

Figure 12. The current eroding access from Lowes Road onto Garden Island Sands Beach.

Figure 13. A schematic image of part of the proposed timber access and part of the Stage 1 seawall.

5. Conclusions and future planning

Information gathered during this consultation process showed that the state of shoreline erosion at Garden Island Sands is ongoing and that in some parts the process has already surpassed the highest crest of the dune and is now proceeding to erode the backslope of the dune (see Appendix 6.1). This suggests that the risk of storm flooding overtopping the dune and flooding into the back-dune area is increasing.

FOGIC feels that sufficient information has been generated through this grant to seek council development approval for the proposed accessway and 30 m of rockwall either side. Further refinement of the design is in process and expert opinion is being sought regarding development planning. It is hoped that the stage 1 proposal can be implemented soon. Stage 2 will need to costed (partly based on the implementation of Stage 1) and funding sought. FOGIC believe that promptly fixing the access issue as part of a larger management plan to deal with shoreline erosion will ease the general frustration felt by the community over the long-term nature and lack of action regarding both issues. As the area in question is on Crown land, FOGIC has been advised that the Huon Valley Council will need to make an agreement with Parks and Wildlife over the management of land needed for the beach accessway and erosion protection structure.

Advice on vegetation management and restoration/rehabilitation plantings has been provided by ECOtas (Appendix 6.3). FOGIC intends to incorporate this advice as well as the provided advice on weed management and the use of the cultural burning to return natural vegetation to a healthy state and further stabilise the foredune alongside the planned works. As a Landcare group FOGIC are well supported in these efforts with access to native plants and many willing volunteers.

There are currently numerous fallen trees and large stumps along the beach particularly on the eastern side between the creek and the proposed accessway. These obstruct access down the beach from mid to high tide. Currently, removal of fallen trees and stumps could enhance shoreline erosion. However, the creation of the rock wall would allow these obstructions to be removed returning a large proportion of the beach to its former state for use by residents and visitors. It is acknowledged that the proposed wall would also reduce the width of the beach, however not as severely as the fallen trees. The beach was once considered safe emergency refuge from bush fires which may cause the community to be cut off from accessing Channel

Highway for evacuation. With the large amounts of debris on the beach this option is less safe, however this community emergency refuge can be restored if the debris is removed.

FOGIC acknowledges that shoreline erosion is becoming an issue for many communities and many governing bodies. It was with this understanding that FOGIC members moved away from government agitation (petitions and letter writing) to engaged in a community led plan. It is their hope that local council and other agencies will be willing to work with them to see the plan to fruition for the benefit of all Garden Island Sands residents and visitors long into the future.

A suggested order or priority for future efforts is as follows:

- FOGIC should work with the Huon Valley Council to move through the development application process for suggested remedial work, this process may include:
    - Huon Valley Council making an agreement with Parks and Wildlife about the use of Crown land for this project
    - Consulting with a planner to ensure all data generated through PACP is used effectively, and identify any further data required to supplement this
    - Consult further with the community on the proposed design for access and remedial work.
    - Further develop the design and engineering needs of the project to support the development application
- Install the access ramp along with 30 m either side of erosion protection wall
    - Utilize offers of in-kind community and other support to reduce the costs of materials etc.
- Follow suggested guidelines from ECOtas for replanting and revegetation after the wall is installed
- FOGIC should continue the shoreline monitoring program using established methods and survey markers
- Being costing and further engineering consultation regarding the extension of the erosion protection wall to cover the rest of the erosion affected beach (approximately 220m)

References

Mendonca, K 2020, *Preservation of Garden Island Creek and Garden Island Sands from erosion and provision of safe beach access. Petition to the Parliament of Tasmania Legislative Council.*, <https://lcepetitions.parliament.tas.gov.au/lcepet/Home/PetitionDetails/35?title=Petition%20Details>.

SGS Economics and Planning 2015, *Garden Island Creek Coastal Adaptation Pathways, Final Report Prepared for Huon Valley Council and the Tasmanian Climate Change Office*, <https://recfit.tas.gov.au/tasmanian_coastal_adaptation_pathways_project

6. Appendices

Reports generated from this PACP project are attached in the following sections. As they were written as standalone documents but have been compiled here to provide a complete overview of the project, their formatting and page numbering will not align with this document.

6.1. A geomorphic investigation of shoreline change at Garden Island Sands, Southern Tasmania. Dr Chris Sharples

6.2 Coastal erosion at Garden Island Sands Beach southern Tasmania- Preliminary technical report January 2023. Bill Cromer (Engineering and groundwater geologists), William Cromer Pty Ltd.

6.3. Natural values assessment of LPI JYK07, Garden Island Sands, Tasmania, to inform the Garden Island Creek erosion and flood disaster reduction project. Mark Wapstra

(Appendices to this report can be obtained from FOGIC)

6.4. Aboriginal heritage assessment report, Garden Island Sands, February 2023. Dr. Silas Piotrowski and Stephen Stanton

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Coastal Geomorphology, Geodiversity and Landform Management

A Geomorphic Investigation of Shoreline Change at Garden Island Sands, Southern Tasmania

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7th February 2023

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Front Cover: Top: Aerial photographs of Garden Island Sands in 1948 (RHS) and 2015 (LHS); **Bottom:** Large mature tree on the foredune at Garden Island Sands, undermined by recent erosion (Photo date 3rd Aug. 2022).

CONTENTS

SUMMARY

Garden Island Sands is a large and nearly full sand-trapping embayment on the north shore of the lower Huon River estuary. Increasing erosion of the beach and its backing shore-parallel foredune - including the undermining and collapse of large mature trees growing on the foredune - has been a significant concern at Garden Island Sands Beach during recent years. This report was commissioned by the community group *Friends of Garden Island Creek Inc*. (FOGIC) to investigate the causes, magnitude, and rate of this erosion.

Analysis of 34 ortho-rectified (distortion-corrected) air photos plus a recent survey of Garden Island Sands provides a quantifiable history of shoreline, beach and dune behaviour from 1948 until 2022. For the purposes of this analysis the shoreline at Garden Island Sands Beach is defined as the seawards *in situ* vegetation line and currently mostly corresponds to a prominent erosion scarp along the seawards front of the foredune.

The air photo history demonstrates that a significant change in long-term shoreline behaviour along most of the beach commenced around the year 2000. Prior to 2000, the shoreline position had been mostly stable or only slowly receding since at least 1948, with some notable erosion and recovery cycles around this dominant shoreline behaviour. However, around the year 2000 there was a significant change to a more persistently and rapidly eroding shoreline recession trend which has continued to the present. Temporary sand bars largely filling the mouth of Garden Island Creek estuarine lagoon (at the south-east end of the main beach) have been recorded by air photos several times since 2001 but are absent from all earlier air photos since 1948. These are inferred to be composed of sand mobilised by the increased beach erosion since 2000 (see section 3.4.2).

These shoreline behaviour changes are identifiable from the air photo sequence data in retrospect but would probably not have become obvious to casual observers on the ground until sometime after 2000, when the impacts of the increased erosion started to “emerge” above the normal variability of prior beach erosion and accretion (recovery) cycles to which local observers would have been accustomed. Inspection of the air photo records suggests that the “time of emergence” for the changed beach behaviour probably occurred roughly around 2010 to 2015.

Several sub-ordinate shoreline behaviour patterns and changes are also evident from inspection of historical air photos and of the beach itself (see sections 3.2 and 3.4.2), with the most notable of these being a pattern of less erosion and recession along the north-western third (approximately) of the beach and foredune than elsewhere. This has been a long-term pattern along the beach since at least 1948 which continues at the present and is probably attributable to greater sheltering of that part of the beach from the dominant westerly to south-westerly locally generated wind–waves which are inferred to be the main agent of the observed erosion.

The observed change in the long-term behaviour of Garden Island Sands Beach implies a significant long-term change in some process or condition driving geomorphic processes at the beach. Sea level is the only major geomorphic process control known to have been changing in recent decades (by rising at both global and local scales) which provides a plausible mechanism of the observed beach and dune changes (see section 3.6.2). Some evidence is suggestive of possible wind (and thus wind-wave) speed and/or direction changes at Garden Island Sands since 2015 (see section 3.4.2), however no observational data on this is known to the writer, moreover it would not explain the significant changes in beach behaviour fifteen years earlier around 2000.

Sea-level rise provides a plausible explanation of the observed changes at Garden Island Sands beach because of two key effects of rising mean sea-level on sandy beaches, namely that it causes:

1. more frequent erosion to higher levels on the beach profile than before (even with no change in actual storm wave frequency and magnitude) because waves of any given size can run and erode further to landwards and higher on the shore profile than previously over the deepened water.

and because it allows:

2. the creation of more accommodation space for eroded sand by deepening water over depositional sandy bottoms including sand bars, which at Garden Island Sands is deduced to allow increasing amounts of eroded sand to be permanently sequestered in two “nested” sand sinks or traps within the overall sand trap that is Garden Island Sands. These nested sinks are in the estuarine lagoon, and a large sand bar offshore from the main beach).

These two factors mean that in a coastal environment such as Garden Island Sands, sea-level rise results in more erosion of the beach and dune than previously, and also that greater proportions of the eroded sand than previously are trapped in local sand sinks instead of being returned to rebuild the beach and dune before the next large erosion event occurs. These processes cause the shoreline (beach and dune) to begin to recede or to recede more rapidly as sea-level rise itself occurs at increased rates. In the case of Garden Island Sands, the increasing rate of global mean sea-level rise that was measured during the 1990s (see section 2.4.4) was evidently sufficient to tip the rate of (previously slow) shoreline recession into a significantly faster rate by around the year 2000. The air photo analysis shows that faster rate of shoreline recession has continued up to the present (alongside continuing increase in the rate of sea-level rise: see section 2.4.4).

No other plausible explanations of the change in shoreline behaviour at Garden Island Sands have been identified (see section 3.6.3). If this explanation of the observed changes is valid, the observed rapid recession can be expected to continue well into the future because it is driven by global mean sea-level rise which itself is continuing at an increasing rate (IPCC 2021).

Of particular concern from a coastal hazard perspective is that the air photo analysis shows that increased foredune scarp recession since 2000 has already removed variously 7 to 12 metres width of the dune front (the least from the north-western part of the beach, the most from the central to south-eastern parts of the beach). This amounts to the loss so far of one third to one half of the total original width of the foredune as it was during the year 2000. Moreover, the first set of profiles surveyed across the dune (see section 3.3) indicate that the erosion has already passed the highest crest of the original dune and is now progressing through the backslope (landwards side) of the original dune. This means the ground surface is getting lower as the erosion scarp recedes further to landwards, hence with each successive storm erosion event there is now an increasing risk that storm waves will finally be able to break through the remaining (lower) dune and allow storm waves to wash over into the residential areas behind causing flooding and other water damage.

From the perspective of coastal hazard management at Garden Island Sands, a high priority is therefore to reduce the risk of residential properties being damaged if the remaining (now lower) foredune barrier is breached by storm waves. There is arguably a need to address this priority before much more foredune erosion and recession has occurred. Sandbagging may be an achievable interim measure to manage this hazard while consideration is given to longer-term options.

1.0 INTRODUCTION

1.1 Purpose

This report was commissioned by the community group *Friends of Garden Island Creek Inc*. (FOGIC) to investigate the geomorphic (land forming) characteristics and processes of Garden Island Sands Beach in south-eastern Tasmania.

Significant and apparently increasing beach and foredune erosion has been of concern to local residents and landowners for some years. Of particular concern is that the erosion damaged a former boat ramp resulting in its removal, with the result that access to the beach and boating opportunities has become difficult for many local residents and visitors.

The primary purpose of this report has been to investigate the causes, magnitude, rate, and likely future impacts of this erosion. This information is needed to provide a basis for identifying and planning appropriate responses to the erosion.

It should be noted that the author of this report is a geologist and geomorphologist but is not an engineer. Hence no specific engineering designs for managing beach erosion are provided, however the information provided will enable the implications and consequences of the various options for managing the erosion to be assessed.

Note also that whereas this report is focussed on understanding the nature and causes of beach and shoreline erosion at Garden Island Sands Beach, other coastal hazards may also affect the beach and surrounding areas. These in particular include increasing groundwater levels, salty groundwater penetration and coastal (storm surge) and river flooding. These are briefly noted in Section 3.7; however, these issues were beyond the scope of this report and are not further discussed here.

1.2 Coastal Setting

Garden Island Sands is a small residential settlement at Garden Island Sands Beach (adjacent the outlet of Garden Island Creek) on the north shore of the lower Huon River estuary in south-eastern Tasmania. The estuary opens into D’Entrecasteaux Channel about 4.5 kilometres southeast of Garden Island Sands. The beach is accessed by Lowes Road, a short gravel road off the Channel Highway about 25 km south-east of Huonville and 42 km south of Hobart.

Garden Island Sands Beach is set within a very complex “ria” coast comprising drowned river valleys and estuaries which formed at periods of lower global sea-level during past glacial climatic phases and were subsequently drowned as sea-level rose under the warmer climatic conditions of the present interglacial phase (see also Section 2.4.4). The roughly WNW-ESE oriented beach is about 440 metres long and faces southwards onto the Southern Ocean via the southern end of D’Entrecasteaux Channel. Although this means the beach is exposed to swell waves driving directly up D’Entrecasteaux Channel from the Southern Ocean, the nearby Garden Island also provides the beach some sheltering from swells.

The Garden Island Sands Beach is a natural asset of considerable aesthetic and recreational value to the Garden Island Sands community.

1.3 Investigations undertaken

The information provided in this report is based on the following work by Chris Sharples:

1. A review of existing (published) geological and geomorphic mapping and other information pertaining to Garden Island Sands Beach.
2. A review (and field observations) of beach test pit results obtained by Bill Cromer (geologist) in a concurrent and related geological investigation for *Friends of Garden Island Creek Inc*. (Cromer 2023).
3. Field inspections of Garden Island Sands Beach and surrounding areas, including the use of a sea kayak to investigate shallow intertidal and subtidal sands offshore from the beach, as well as on the facing cobbly-sand spit on Garden Island and in the Garden Island Creek estuarine lagoon.
4. A time series of 34 air photos ranging in age from 1948 to 2021 were ortho-rectified and analysed together with a field-surveyed (GNSS) 2022 foredune scarp position. This information was used to determine the history of shore behaviour and change at Garden Island Sands Beach over the last 74 years. The air photos were also used to test for changes in offshore and estuarine shallow-water sand bars over the same period.
5. Together with surveyor Nick Bowden, back-dune survey marks were installed, and four high-resolution profiles were surveyed across the foredune and beach. These provide a basis for local volunteers to monitor future beach and shoreline changes from the 2022 baseline by repeating the profile surveys at regular intervals as part of the TASMARC beach monitoring project (www.tasmarc.info).

This work was undertaken concurrently with additional geological and hydrological investigations by Bill Cromer (environmental, engineering and groundwater geologist), which have informed this report and are cited where relevant.

1.4 Terminology and Acronyms used

The following technical terms and acronyms are used in this report and are briefly explained here to assist readers. This is not a comprehensive list of terminology relevant to coastal landforms, merely a list of potentially unfamiliar terms used in this report)

Accommodation space This term refers to the space available for sand (or other sediment) to settle out and accumulate in a marine environment. The vertical limits of sand accumulation on the seabed are determined by the “mobilisation depth” (or “closure depth”) to which waves, currents and tides can move sand (or other specified sediment). Below that critical depth – which varies from place to place and at different times depending on tides, wave, and current activity – sand may settle out and be stored indefinitely, however above that depth sand will be constantly or intermittently mobile until it reaches another location (e.g., deeper water or a beach) at which it can settle out. However, when a net rise in sea-level occurs, this creates additional accommodation space (i.e., water depth) for sand to accumulate below the “mobilisation depth”. When and where this occurs an enlarged or rejuvenated sand sink is created which may trap more sand than it previously had the capacity to hold.

Accretion Accumulation or deposition of sediment (e.g., sand accretion on a beach or dune).

Average Equivalent to “mean”. The sum of a collection of numbers divided by the count of numbers in the collection; commonly used to identify a central tendency in a dataset. See also “Median”.

BoM The Australian Bureau of Meteorology.

Change of Behaviour (COB) The time at which a long-term record of landform behaviour shows a major long-term change of behaviour occurring, for example a switch from dominantly depositional sand accretion to dominantly erosional sandy landform behaviour. However, note that the change to a new trend may take some years or decades to become obvious to casual observers because of short term variability (such as short-term erosion and deposition cycles) obscuring the new trend (see also "Time of Emergence" below).

DPIPWE The former Tasmanian Department of Primary Industries, Parks, Water & Environment, now the Tasmanian Department of Natural Resources and Environment (NRE)

Dynamic equilibrium A term to describe systems exhibiting cyclic or episodic change around a long-term net stable state. A beach undergoing cyclic erosion and recovery around a long-term stable position is an example of dynamic equilibrium.

ENSO El Nino Southern Oscillation; A major inter-annual Pacific – scale climatic cycle with affects sea-level variability, wave climate, and other climatic factors on Australian coasts.

Erosion The removal of material by natural processes such as wave attack. For example, beach or dune erosion.

Flood tide delta A body of sediment (e.g., sand) transported into a tidal inlet by flood tide currents and deposited there either temporarily or permanently.

Fluvial A geomorphic term pertaining to running water and river or stream landforms.

Foredune A shore-parallel dune ridge immediately behind and inland of the wave-washed beach face, comprising sand blown inland by onshore winds from the dry upper beach face, and captured amongst vegetation growing inland of normal storm wave run-up limits.

Incipient foredune A small "embryo" foredune beginning to accumulate in front of a larger, older foredune which has been scarped by wave erosion. The incipient foredune is the first stage in recovery of the eroded foredune, as sand begins to be captured by vegetation that is beginning to re-establish in front of the erosion scarp.

GMSL, GMSLR Global Mean Sea Level, Global Mean Sea Level Rise

GNSS Global Navigation Satellite System. A widely used high accuracy survey technology which was used in this project to survey profiles across the beach and foredune, and to map the current (2022) foredune scarp position along the whole beach length.

LIDAR is an acronym of "light detection and ranging" or "laser imaging, detection, and ranging". Lidar uses mostly airborne laser imaging techniques to map ground topography at high resolution.

LIST Land Information System Tasmania. A very wide range of mapped data on Tasmania is available on the LIST website at www.thelist.tas.gov.au

Littoral Pertaining to shores and shoreline zones.

Mean Equivalent to "average". The sum of a collection of numbers divided by the count of numbers in the collection; used to identify a central tendency in a dataset. See also "Median".

Median A description of central tendency in a collection of numbers which is often used for data with anomalous outlying values that may skew the central tendency as measured by a "mean" or "average". The median is the middle value in a collection of numbers.

NRE The Tasmanian Department of Natural Resources and Environment. Previously the Tasmanian Department of Primary Industries, Parks, Water & Environment (DPIPWE).

Progradation Progressive addition or accretion of sediment on a shoreline over years or decades, causing the shoreline to grow in a seawards direction (e.g., beach progradation).

Recession Progressive removal or erosion of sediment from a shoreline, causing the shoreline to recede in a landwards direction over years or decades. Recession is typically the cumulative result of multiple erosion events over a significant period of time.

Ria Complex coastal planform resulting from the drowning of deeply incised river landscapes during periods of higher relative sea-level, such as the present inter-glacial climatic phase.

Swell waves Waves generated by winds blowing across long oceanic fetches. These waves may propagate thousands of kilometres beyond the ocean regions in which they were generated.

TASMARC The TAsmanian Shoreline Monitoring and ARChiving project. A beach monitoring project which commenced in 2004 as a project of the Antarctic Climate and Ecosystems Co-operative Research Centre (ACE-CRC) at the University of Tasmania. The project is based on community "citizen science" groups surveying beach profiles at intervals, with the data being processed and made available for open public access at www.tasmarc.info .

Time of Emergence (ToE) The time at which a new natural process such as a new climatic trend or new landform behaviour trend becomes obvious to the casual observer above the noise of short-term natural variability which may have at first made the new trend hard to detect. The significance of the "Time of Emergence" concept in climate change studies was discussed by Hawkins and Sutton (2012)

Wind-waves Although swell waves (see above) are strictly speaking wind waves, the latter term is usually reserved for waves generated by local winds over local fetches of the order of kilometres.

1.5 Acknowledgements

I thank Peter Devine (Geodata Services, Tasmanian Department of Natural Resources and Environment for his assistance in obtaining scanned historical air photos from the large NRE air photo archive. I also thank Bill Cromer, Elliott Cromer, and Nick Bowden for their assistance with field work and surveys.

Kelsie Fractal and Angela Bird of the Friends of Garden Island Creek Inc. (FOGIC) community group organised the opportunity for the investigations in this report to be undertaken, and their assistance and enthusiasm for the project has been greatly appreciated.

2.0 GEOMORPHOLOGY – DESCRIPTION AND PROCESSES

2.1 Introduction

This report chapter describes the landforms of Garden Island Sands Beach and its environs, and the natural processes which shape and may modify those landforms. This descriptive information is based on existing information as referenced, together with field observations and inferences by the writer (Chris Sharples). This information provides the necessary basis for Chapter 3 which interprets the causes and implications of landform changes that have occurred at Garden Island Sands Beach within recent decades.

The term "Garden Island Sands" is taken here to refer to a related cluster of sandy landforms including a beach, foredune, and extensive estuarine, intertidal, and subtidal sand flats. These sandy landforms are located within a deep rocky embayment between Randall's Bay and Charlotte Cove in the Lower Huon River estuary and are partly protected from wave action by the large rocky Garden Island offshore (see air photos Figure 7 & Figure 8). Taken together these sand accumulations comprise a large sand-trapping coastal embayment from which it is likely that little sand is lost offshore or alongshore. However, at a smaller scale there is evidence of complex movements of sand within the Garden Island Sands landform system (see section 2.4.6) which – amongst other things – have in recent decades been depleting the beach and foredune of sand in response to increasing erosion and recession of the shoreline.

2.2 Geological setting

The best available geological mapping for the Garden Island Sands area is the 1:50,000 scale Kingborough and Dover geological map sheets (Farmer 1981; Farmer & Forsyth 1993) which are reproduced here as Figure 1 below.

Based on this mapping, Garden Island Sands Beach, and all surrounding areas within the scope of this report are underlain by dolerite bedrock of Jurassic age (see Figure 1). This dark bluish to dark-brown igneous rock type outcrops along sloping shorelines both west and east of the beach, and northwards along the eastern shore of Garden Island Creek estuarine lagoon (see Figure 2). Garden Island is also comprised of dolerite bedrock which outcrops along a large proportion of the islands shore. The rocky dolerite shores adjacent the beach and lagoon are moderately sloping hard rocky shorelines which are generally highly resistant to wave attack and erosion (although overlying soil horizons may at some time be expected to begin exhibiting erosion in response to wave attack at higher levels than previously in response to sea-level rise). Dolerite bedrock is assumed to underlie the beach at some depth greater than 2, but was not encountered in 6 test pits excavated by Cromer (2023) in sand and pebbly sand to depths of about 2 metres at intervals along the back of Garden Island Sands Beach.

Soft clay-rich Permian-age feldspathic sandstones outcrop about a kilometre west of Garden Island Sands where they form coastal cliffs and steep slopes adjacent Randall's Bay, but these are not encountered in the Garden Island Sands embayment. At Randall's Bay these cliffs are overlain by a thin veneer of unlithified gravels dominantly comprising rounded quartz pebbles of possibly Pleistocene-age and glacio-fluvial origin (see Figure 1). Similar veneers are not known to be exposed close to Garden Island Sands at present. However, excavations by Cromer (2023) at Garden Island Sands Beach showed that a layer of rounded quartz pebbles in a sandy and shelly matrix underlies geologically recent (Holocene-age) beach sands below about a metre depth (see Section 2.3.1 below). These may have been transported to the Garden Island Sands embayment by waves or other processes from deposits similar to those still exposed at Randall's Bay, during an earlier (but still geologically recent) phase of landscape development.

2.3 Landforms and Sediments

2.3.1 Beaches and Rocky Shorelines

Garden Island Sands Beach is located on the north shore of a partly sheltered coastal embayment behind and north-east of Garden Island (see Figure 1 & Figure 2). The beach is bounded to the northwest and southeast by moderately sloping hard rocky dolerite shores, which also extend northwards up the eastern side of the long narrow Garden Island Creek estuarine lagoon (see Figure 1 & Figure 2). The dolerite is inferred to underlie the whole beach at depths of greater than 2 metres, based on temporary beach excavations by Cromer (2023) which encountered only loose unconsolidated sand and pebbly sand to that depth.

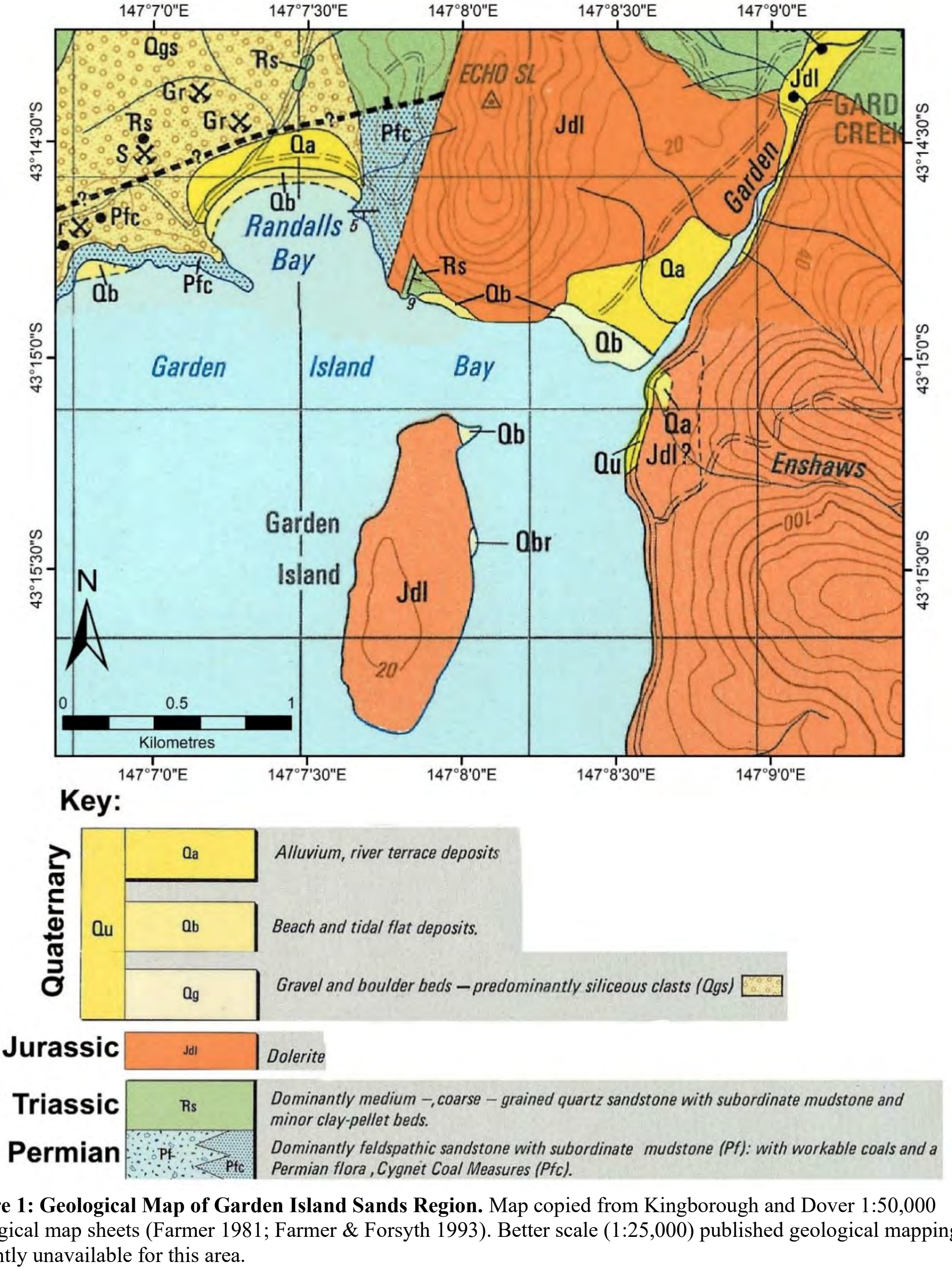


Figure 1: Geological Map of Garden Island Sands Region. Map copied from Kingborough and Dover 1:50,000 geological map sheets (Farmer 1981; Farmer & Forsyth 1993). Better scale (1:25,000) published geological mapping is currently unavailable for this area.

Garden Island Sands Beach is a 470 metres long, south- to south-southwest facing beach of fine-grained yellow-grey sand. Short (2006, p.141) has classified the beach as a steeper "reflective" upper beach (low-energy and wave-dominated) fronted by very broad (~400 metre wide) intertidal to sub-tidal sand flats. At the time of writing (2022), the beach above the low tide terrace is notably narrower (~3-4m) and wetter in its central to south-eastern areas (Figure 3) than it is near its wider (~8-9m) and drier north-west end (Figure 4). This pattern of a wider and drier

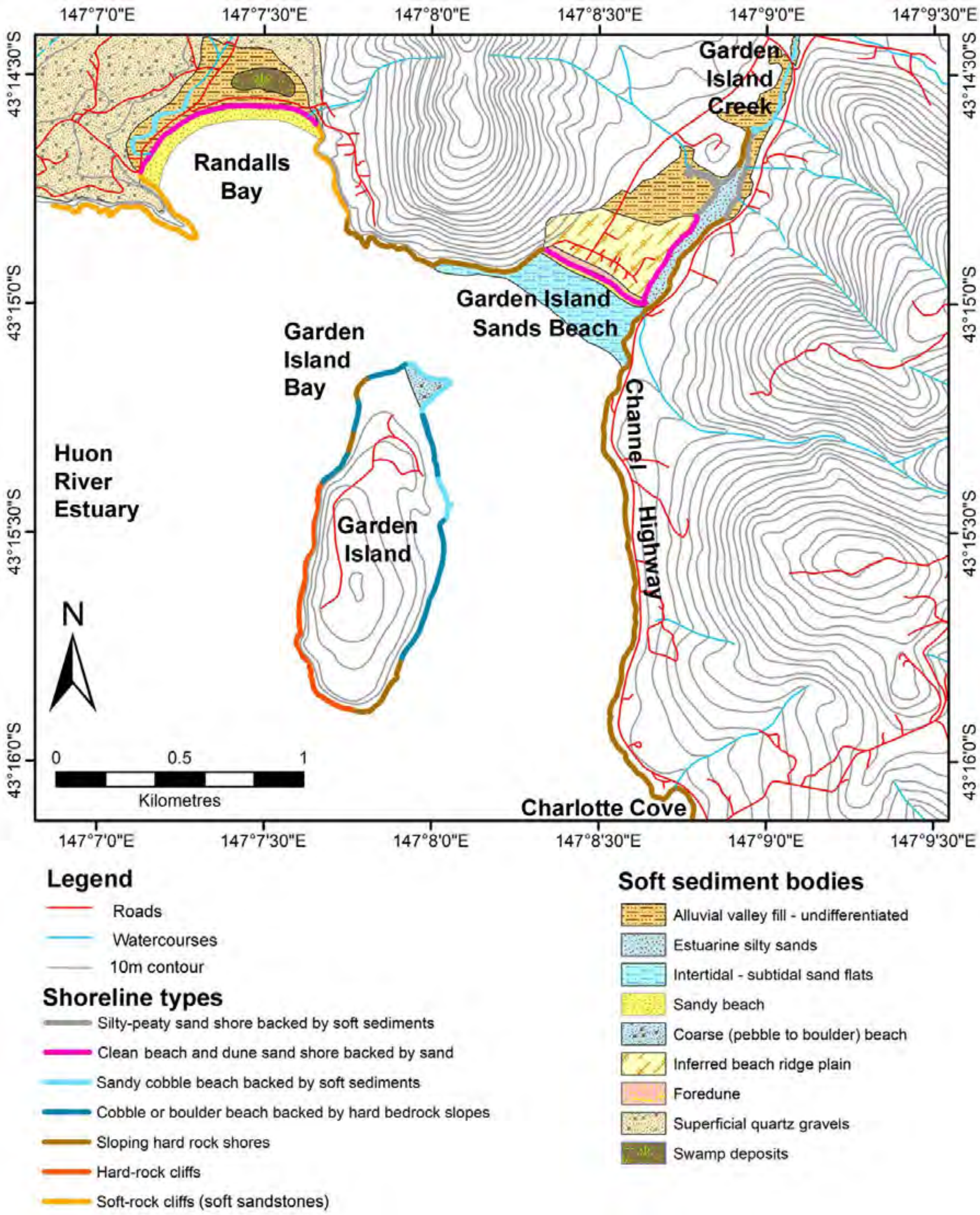


Figure 2: Shoreline types and onshore to shallow-water soft sediment bodies in the Garden Island Sands area. Shoreline types mapping is based on original field and air photo mapping by C. Sharples (including Sharples, Mount & Pedersen 2009, with map updates) and soft sediment bodies mapping is based on 1:50,000 mapping by the Geological Survey of Tasmania (Kingborough and Dover sheets, Farmer 1981; Farmer & Forsyth 1993). Co-ordinate system is geographical co-ordinates (WGS84 datum).

Figure 3: View eastward along the east end of Garden Island Sands Beach at close to low tide (3rd January 2022). This view shows a damp narrow upper sandy beach above the very broad flat wet sandy low tide terrace which here exhibits pebbles and shelly material. The cut woody debris artificially piled against the foredune on the left is covering a very fresh erosion scarp of recent origin (see also Figure 5).

Figure 4: View westwards along the west end of Garden Island Sands Beach at close to low tide (3rd January 2022). Compared to the eastern end of the beach (see Figure 3 above), this view clearly shows a much wider and drier upper beach above the broad flat wet low tide terrace to the left. Although an old erosion scarp is visible in the foredune at the right, it is becoming buried beneath the accreting incipient foredune at its foot, which has grown as sand has been returned to the beach following the last erosion event. This older and more recovered dune scarp contrasts with relatively fresh recent erosion scarping in the central to eastern part of the beach (see Figure 5).

beach towards its north-western end is seen in many (but not all) of the air photos from 1948 onwards and appears to have been a frequent (but not permanent) state of this beach since at least the earliest air photo in 1948. A good example is seen on the 18th Feb. 1967 air photo provided as Figure 13 elsewhere in this report. This pattern is inferred to be at least partly due to sheltering of the western end of the beach from the dominating westerly and south-westerly wind-waves (see section 2.4.2) by the rocky headland immediately west of the beach.

In contrast, inspection of the air photo time-series suggests that the central to south-eastern part of the beach is today persistently and notably narrower and lower (wetter) than it normally was prior to the last two decades (typically a dry upper beach 5 – 7 m wide in the 1960s and 1970s compared to about 3 – 4 m wide in the last few decades), with an average high tide today reaching almost to the foot of the foredune erosion scarp (see Figure 5). As demonstrated in section 3.4.2 below, the central to eastern part of the beach has undergone more erosion and shoreline recession since the year 2000 than the more sheltered western part has.

Six excavations to about two metres depth spaced along the back of the beach by Bill Cromer during 2022 (Cromer 2023, incl. Attachment 4) demonstrated that the beach comprises about a metre depth of unconsolidated light greyish-brown fine to medium grained and mostly shell-free sand, overlying at least a metre of unconsolidated grey or light grey fine to medium grained sand with trace silt, some shelly material and at least 10% well-rounded pebbles of quartzite, sandstone, siltstone and dolerite. This pebble material evidently relates to an early phase in the accumulation of sand in the Garden Island Sands embayment and could be derived from the same quartz-rich pebble beds that are exposed on the surface near Randall's Bay (see section 2.2).

A few discontinuous patches of quartz-pebbly material also occur on the present-day beach surface (see Figure 3), however given that the *in situ* pebble layer at the beach is buried beneath a metre of clean sand, it is possible that the surface patches are derived from artificial fill previously placed on the beach and foredune as protection against erosion.

The south-eastern extremity of the beach is a small sand spit protruding part-way across the mouth of the adjacent Garden Island Creek estuarine lagoon from its western side ('D' on Figure 15). Air photo inspection shows that this spit has been present persistently since at least 1948 although it has varied considerably in size from time to time (see Figure 29). It is inferred that the spit at times grows ("accretes") partly across the estuarine lagoon mouth from its west side, is trimmed by intermittent erosion events, tidal currents and flood discharges from the lagoon, but then recovers again from sand drifting south-east towards it along beach, particularly after beach erosion events. The persistence of this small spit at the south-eastern extremity of the beach is deduced to be an indicator of the predominance of a north-west to south-east littoral drift of sand along the beach (see also discussion of dominant wave directions in section 2.4.2).

Cuspate beach spit A small pointed or "cuspate" spit of mixed cobbles and sand has accumulated on the mostly rocky shore of Garden Island, directly south-west of and opposite from Garden Island Sands Beach (see Figure 1 and Figure 12). Field inspection during August 2022 revealed that the spit is comprised of mainly well-rounded dolerite and other cobbles, with fine sand patches at its tip and along the eastern side of spit. This is a distinctive feature whose shape and composition implies significant wave action from both the west and east sides of Garden Island (not necessarily at the same time), converging at the position of the spit (see also discussion in section 2.4.2 "Wave Climate" below).

2.3.2 Foredune

Nearly the full length of the beach is backed by a shore-parallel sand ridge which is a sandy foredune rising 1.0 to 1.5 m high above the back of the beach. The foredune is inferred to have grown by the accretion of sand blown landwards off the upper beach and captured by backshore vegetation after the backing sand plain had ceased to infill and prograde (see section 2.3.3 below). This probably occurred when the rate of sand delivery to the shore slowed after the end of the last post-glacial marine transgression circa 6000-7000 years ago (see section 2.4.4). No palaeosols (fossil soil horizons) were noted in the scarped dune face. Dating of the ages of beach ridges and foredunes is possible using optically stimulated luminescence (OSL) dating or other methods and could further illuminate the beach history described in Chapter 3.0 of this report, but was beyond the scope of this report.

Nick Bowden and Chris Sharples surveyed profiles across the foredune at four locations on 12th August 2022, and these are presented on Figure 17 (in section 3.3). The four profiles show a foredune ridge 10 to 20 metres wide (perpendicular to the shoreline) which slopes down to landwards from a high point at the crest of a seawards-facing erosion scarp immediately backing almost the full length of the beach (see Figure 5). The air photo analysis detailed in section 3.4.2 of this report shows that the present (2022) scarped front of the foredune is located variously 7 to 12 metres landwards of the position of the dune front in 2000[1]. This amounts to the loss so far of between one third to one half of the total width of the foredune since the year 2000.

The central to south-eastern two thirds of the beach mostly exhibited a fresh or "active" foredune erosion scarp with little slumping or incipient foredune accretion when inspected during 2022 (as shown in Figure 5). This part of the foredune has lost the greatest width since 2000. In contrast the foredune scarp along the north-western third of the beach was at the same dates looking less active

Figure 5: Landwards view of freshly eroded foredune scarp in the central area of the beach at close to low tide (3rd January 2022). This freshly eroded scarp is of similar size, character and freshness to that shown in Figure 3 (above) but has not been covered with cut branches. The woody debris scattered across the beach in this view mainly comprises mature trees formerly growing on the foredune, which have been undermined and toppled by storm wave erosion in recent times (precise storm dates unknown).

[1] The air photo analysis provided in section 3.4.2 shows that in some areas there was considerable short-term variability (erosion and recovery) in shoreline (dune-front) position between 1948 and 2000, but little long-term change. However, from 2000 onwards there has been significant progressive recession of most of the shoreline up to the present (2022). Consequently, the total shoreline recession distances from 2000 to 2022 are similar to the totals from 1948 to 2022 along much of the beach.

and more rounded, with significant sand accreting over the scarp in the form of an incipient foredune (see Figure 4). This part of the foredune has lost less width since 2000.

In recent years numerous mature trees formerly growing on the foredune have been undermined by wave erosion along the more recently eroded central to south-eastern parts of the foredune. These trees have collapsed onto the beach (see Figure 5 and front cover), where they have been partly cut up and piled against the erosion scarp in an effort to provide some protection (Figure 3).

2.3.3 Backshore sand plain

Clean fine-grained sand underlies a plain extending 250 to 350 metres inland (northwards) from Garden Island Sands Beach (see Figure 2). The sand is exposed in river erosion scarps for about 350 metres inland along the western shore of the Garden Island Creek estuarine lagoon. High resolution LIDAR Digital Terrain Modelling shows several broad, low, and roughly shore-parallel but curving ridges on the sandy backshore plain (see Figure 6). These do not appear to extend across the whole plain but may have been disturbed or destroyed in parts by artificial earthworks.

The location of the sand plain directly landwards of the beach and foredune, together with the presence of multiple semi-parallel sand ridges, are characteristic of the beach ridge plains that have formed behind many Australian beaches (e.g., see Oliver et al. 2017 for more details of a representative Tasmanian beach ridge and foredune system at Seven Mile Beach in south-eastern Tasmania). These landforms result from a continuation of onshore transport of sand after the last post-glacial marine transgression ceased about 6000 to 7000 years ago, causing average sea-level to stabilise at close to its present level (see section 2.4.4). With abundant sand available on the bed of the lower Huon estuary adjacent the Garden Island Sands embayment (see section 2.3.4, Figure 7, and Figure 8), wave action over several following millennia would have continued to push sand

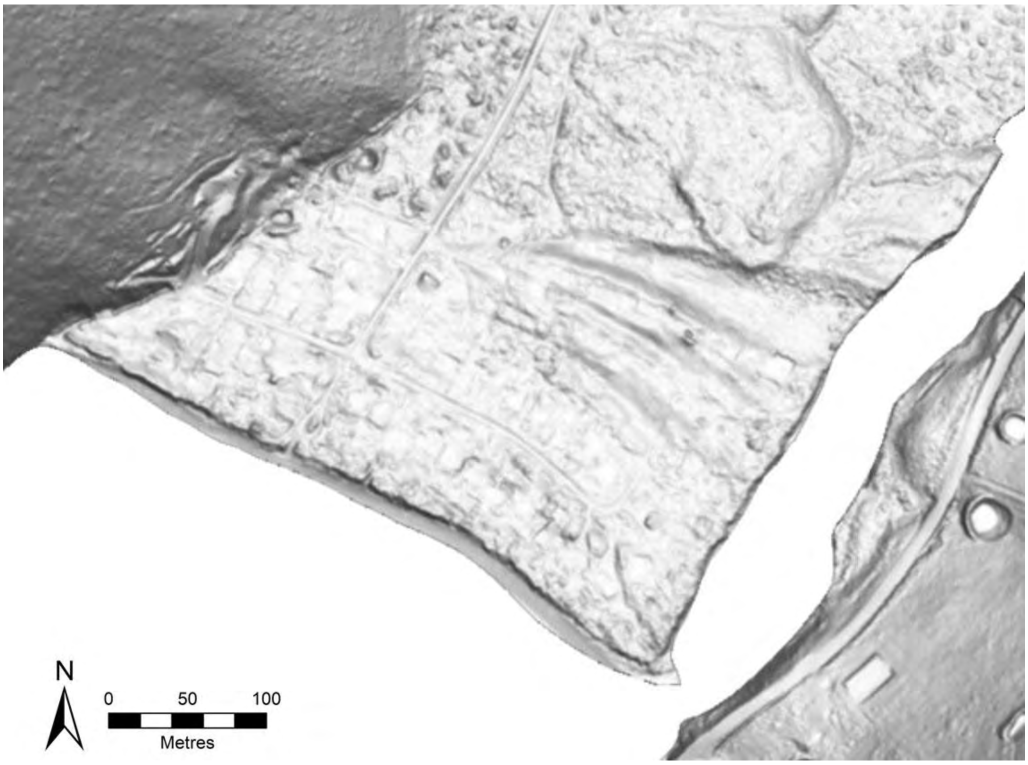


Figure 6: Onshore physiography of the Garden Island Sands Beach area. Hill-shaded LIDAR Digital Terrain Model sourced from the LIST website (www.thelist.tas.gov.au). Several low but distinct curvilinear and roughly shore-parallel ridges are visible on the broad backshore sandplain (compare Figure 2). These are interpreted as likely beach-ridges which originated as beach berms at various stages during the progradation (seawards accumulation) of the sand plain. Any former beach ridges immediately behind the beach have probably been artificially flattened in the course of roading and building construction in that area.

onshore resulting in continuing shoreline progradation (seawards growth) until an equilibrium was eventually reached between the available offshore sand and the wave energy available to move sand onshore (see also section 2.4.6 below regarding the history of sand accumulation at Garden Island Sands). The current foredune at Garden Island Sands probably then began to form - at a slower rate but essentially remaining in its current position - from the much-reduced rate of sand supply to the beach. Observed beach behaviour since 1948 (see section 3.4.2) suggests that eventually the sand supply was sufficiently reduced as to result in a reversal of sand accumulation and the beginning of a slow shoreline recession trend prior to 2000 as identified in the air photo record (see section 3.4.2).

A notable feature of the Garden Island Sands sandplain is that the relatively high-resolution LIDAR physiography of the plain (Figure 6) shows no indication (such as truncated beach ridges) that the Garden Creek estuary and its tidal mouth have ever been located anywhere other than hard up against the rocky shoreline beyond the eastern extremity of the sandplain and beach, where they are located at the present time (Figure 2 and Figure 6). This is an important observation because it suggests that the dominant sand transport direction in the nearshore zone close to the beach is a west to east sand movement driven by dominantly westerly to south-westerly wind-waves (see section 2.4.2) which has kept the creek estuary and its tidal mouth forced as far east as is possible.

The inferred outline of the development of the sandy plain described above is based on more detailed studies of other beach ridge plains elsewhere in Australia, with similar land forming processes inferred to apply to Garden Island Sands on the basis of similar landforms and coastal processes.

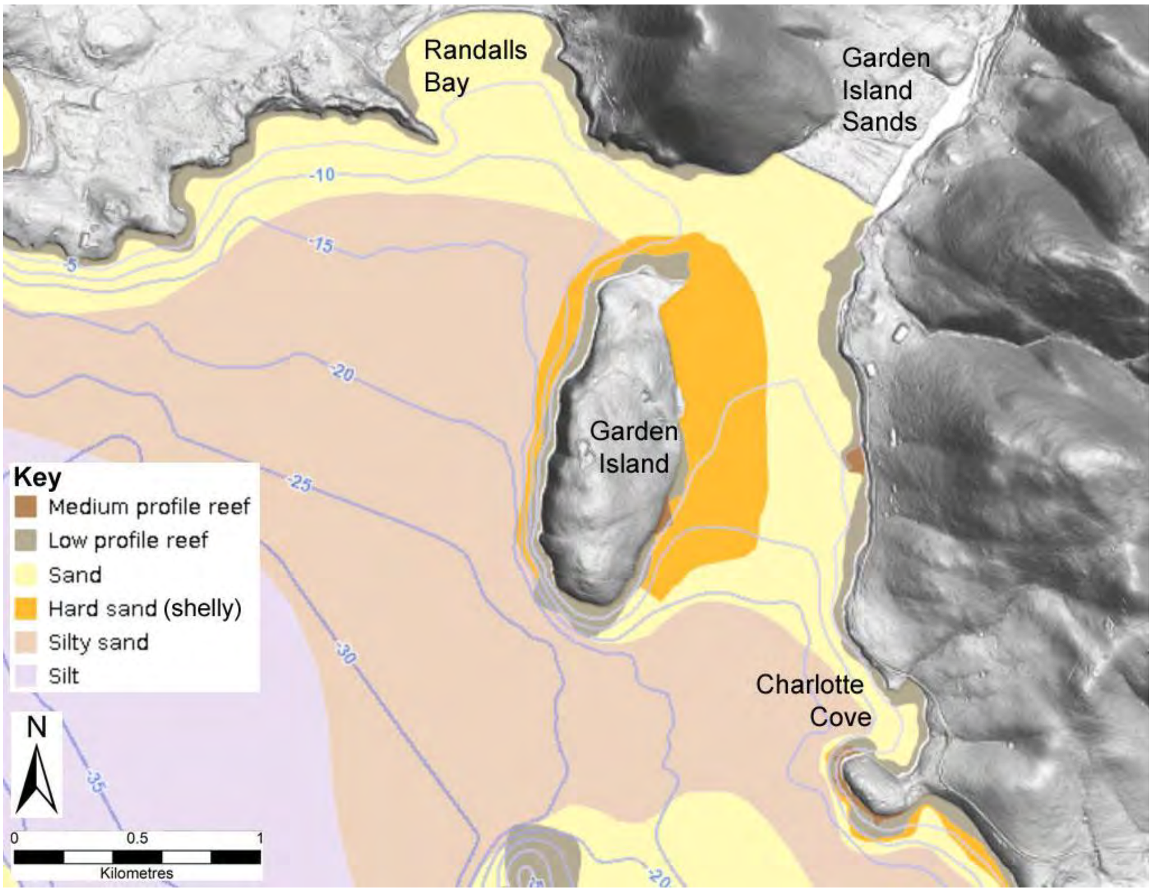


Figure 7: Bathymetry and marine bottom sediments of Garden Island Sands region, Lower Huon River estuary. Five-metre bathymetric contours (blue) and 1:25,000 scale marine sediment (habitat) mapping © Seamap Project, Tasmanian Aquaculture and Fisheries Institute (TAFI), University of Tasmania. Onshore physiography depicted using Lidar topography. Mapping copied from the LIST website (www.thelist.tas.gov.au).

2.3.4 Offshore intertidal to sub-tidal sands

Seabed substrate and habitat mapping by the Seamap project (Tasmanian Aquaculture and Fisheries Institute (TAFI), University of Tasmania) shows that most of the Huon Estuary seabed offshore from Garden Island Sands Beach and from Garden Island itself is mantled by unconsolidated sands, shelly sands, and silty sands (see Figure 7). The only exceptions to this are narrow subtidal rocky reefs close to rocky shorelines (Figure 7). These sandy bottom sediments extend to 30 metres depth southwest of Garden Island in the central part of the Huon estuary channel, and slope downwards into the channel at moderate gradients along most of the Randall's Bay to Charlotte Cove coast surrounding Garden Island Sands (see Figure 7).

Figure 8: Distribution of shallow sandy seabed in relation to Garden Island and Garden Island Sands Beach. This image is a vertical colour air photo dated 19th March 2012 which provides a particularly clear view of the shallow sandy seabed free of surface water reflections (compare Figure 7). This view demonstrates the "sand trap" nature of the area between Garden Island and the Garden Island Sands Beach embayment. Most of the very 'bright' sand close to the vegetated shoreline is submerged in very shallow water but may be partly or wholly exposed at low tide. Dark patches in the sandy seabed are mainly seagrass beds. Air photo © NRE.

Figure 9: Air photo of Garden Island Sands showing shallow sub-tidal sand bar features. Original photo dated 19th Decd. 2015 (top) and annotated version (bottom) showing ephemeral sandy flood-tide delta in estuarine lagoon and shore-parallel shallow offshore sand bar encroaching landwards over the margins of a large seagrass bed. Air photo © NRE

However bathymetric contouring (Figure 7), aerial photography (Figure 8) and the writers' personal observations (from kayaking) demonstrate that bottom gradients are much flatter and water depths to the sandy seabed are much shallower over much of the coastal embayment between Garden Island and Garden Island Sands Beach. In that area water depth is mostly less than 5 metres depth and is less than one metre (at mid-tide) for a distance of several hundred metres offshore from the beach. There is no apparent evidence of bedrock control producing the mostly shallow seabed seen in this area; instead, the most likely explanation is that the Garden Island Sands area is a large sand trap (or "sink") into which sandy sediments from further offshore have been driven and piled up by the dominant wave climate over a period of millennia as sea-levels rose to their present level circa 6000-7000 years ago after the last glacial climatic phase. It is inferred that the coastal planform and dominant wave directions have resulted in sand being pushed into this area over a period of millennia, but also mostly prevent sand from escaping this "sand trap" area (see further discussion of these processes in sections 2.4.2 *Wave climate* and 2.4.6 *Sand Transport and Budget*).

An important feature of the sand accumulation in the Garden Island Sands area is a prominent sand bar approximately 100 to 200 metres offshore and roughly parallel to Garden Island Sands Beach (see Figure 9). When observed on 14th Sept 2022, the bar was a very shallow discontinuous accumulation of clean fine-grained yellow-brown sand that was partly exposed above water level at mid-tide directly offshore from the Garden Island Creek mouth, and elsewhere was as shallow as only 0.2 m water depth. Low swell waves were breaking across the shallowest point of the bar. The full extent of the bar was not mapped; however, the water is deeper on both the beach and island sides, and seagrass beds on the beach side of the bar appear to be somewhat protected from wave action by the bar. It is likely the sand bar absorbs some of the energy of waves approaching the beach, albeit large storm waves would undoubtedly partly or wholly excavate the bar itself, resulting in increased wave attack on the beach and foredune.

It is evident that the pattern of tidal currents, wind- and swell-waves combine to determine the shape and position of this bar, which is a prominent topographic feature storing a large amount of sand within the Garden Island Sands embayment. It is assumed that the offshore sand bar is a permanent or semi-permanent feature of the embayment, albeit no clear evidence of the degree of short-term physical variability of the feature was identified from the air photo time series or any other source of information. Further discussion of the sand transport processes maintaining this feature are provided in section 2.4.6 below, and discussion of the possible role of this feature in the response of Garden Island sands to sea-level rise is provided in section 3.6.2.

2.3.5 Estuarine Lagoon

The following discussion is mainly focussed on landforms and sediments associated with the Garden Island Creek estuarine lagoon; river flow and discharges associated with this lagoon are briefly addressed in section 2.4.5 below.

The estuarine lagoon of Garden Island Creek is a tidal water body approximately 750 metres long by 50 to 90 metres wide, forming the lower reaches of Garden Island Creek which is sourced about 11 kilometres further north at Woodbridge Hill. Water depths in the lagoon have not been measured. Sloping dolerite bedrock shores are exposed along the lower 400 metres of the lagoons eastern shore (see Figure 2), preventing the river channel from moving any further east. The western shore of the lower lagoon exposes clean and readily erodible coastal sands (Figure 2) which however show no indication (in their surface forms – see Figure 6) of the estuarine channel and lagoon having previously been situated any further west than it is now. This supports the inference that the river and lagoon mouth has always been forced hard against the dolerite bedrock on its eastern side by a strong south-eastwards littoral drift of sand along the Garden Island Sands Beach (see also sections 2.3.3 and 2.4.6). The shores along the upstream half of the estuarine lagoon are dominantly fine silty and peaty sands (Figure 2), part of which are marginal to an artificially drained marshy area (see Figure 10).

Two large sediment bars are clearly evident within the lagoon in most air photos and are indicated at “A” and “B” on Figure 10. These were inspected by the writer using kayak access and comprise silty sands covered by shallow water and partly exposed at low tide. This suggests that they have little or no capacity to accommodate additional sediment, at least at present sea levels. The two silty sand bars are offset and separated from each other by a slightly meandering central channel which is indicative of the bars being characteristically fluvial (riverine) “point bar” landforms rather than dominantly tidal features (such as flood tide deltas). It is therefore likely that much of the fine silty sand of which the point bars are composed is derived from terrestrial catchment erosion rather than from marine sources.

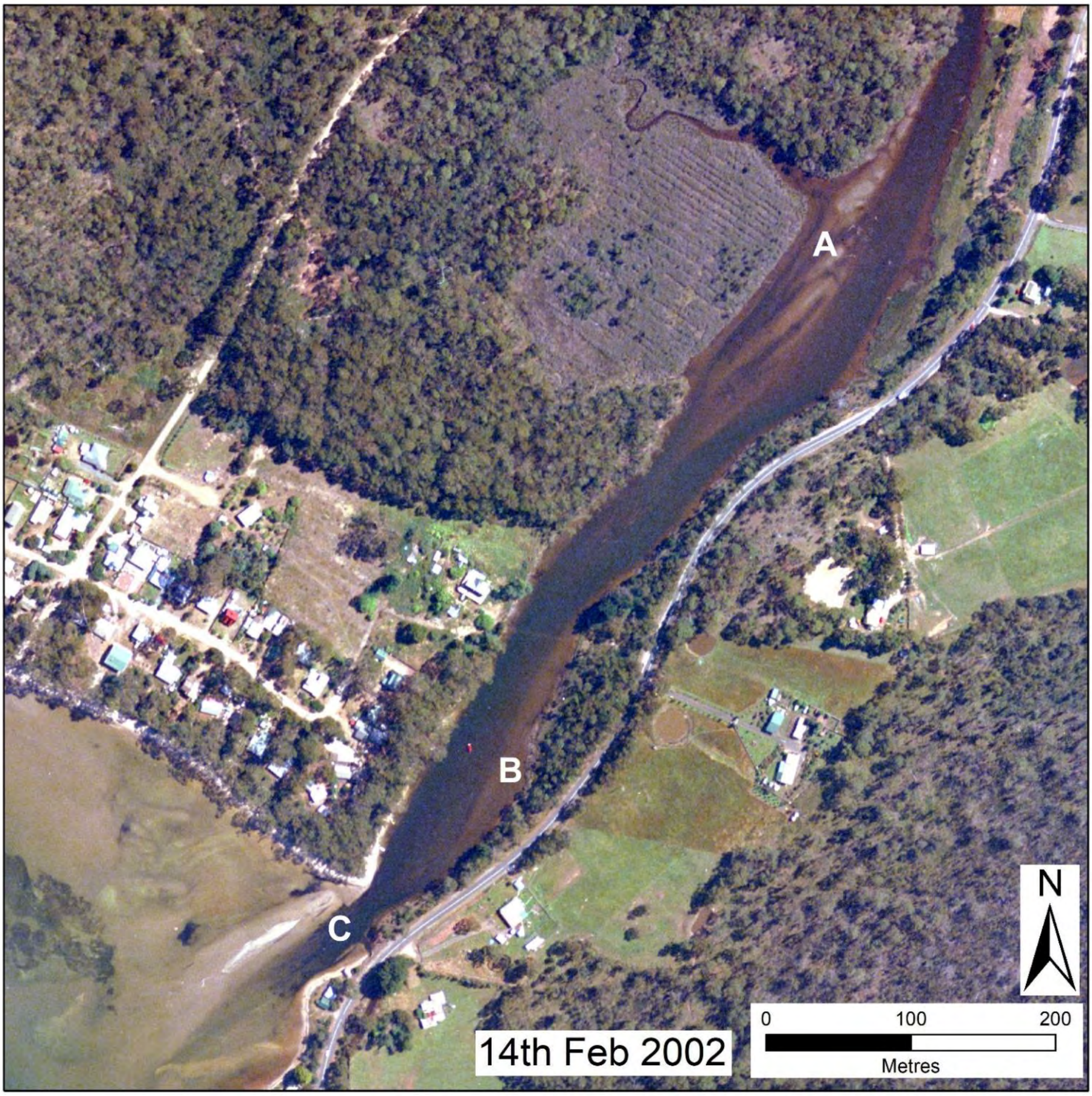


Figure 10: Air photo image of the Garden Island Creek estuarine lagoon, indicating persistent features. The two prominent fine silty-sand point bars (labelled here as A and B) have held roughly the same positions in the lagoon from the earliest (1948) till the latest (2021) air photos. In contrast, whereas the tidal lagoon mouth (C) was deep and open in all air photos from 1948 until 2001, subsequent air photos show intermittent blocking by a large sand bar (or "flood-tide delta") across the mouth of the lagoon (see also Figure 29 in section 3.4.2). Air photo film–frame 1354-45, dated 14th Feb. 2002, © NRE; see also details in Appendix 1.

Anecdotal information from local residents indicates that in historical times some shipping was able to regularly enter the estuarine lagoon and use jetty's there as sheltered anchorages, however this has not been possible for some (uncertain) time due to increasing silting of the estuarine lagoon. As has occurred in many Eastern Australian estuaries since early colonial times, it is likely that historical land clearance resulting in a phase of catchment erosion (Prosser & Winchester 1996) has in the past been responsible for supplying an increased silty-sand sediment load to the lagoon. Although there is little evidence of continuing transport of significant amounts of sandy or silty sediment down Garden Island Creek today, it is likely the point bars are largely composed of sediments derived from that earlier phase of anthropogenic catchment erosion, which have not yet been flushed out of the lagoon by tidal or river currents.

In contrast to the large fluvial point bars, sediments deposited into the estuarine lagoon by tidal currents appear to be less extensive and have likely been mainly restricted to the outlet area of the lagoon downstream of the main point bars. A small sand spit at the south-east end of Garden Sands Beach which is interpreted to be built of sands drifted south-eastwards along the beach has been observed to protrude varying distances across the mouth of the estuarine lagoon in all air photos from 1948 onwards (see "C" on Figure 10), however the tidal mouth of the lagoon was seen to be open in all air photos from 1948 until 2001.

However - as discussed and illustrated in section 3.4.2 including Figure 29 – several air photos from 2001 onwards have clearly shown a sandy flood-tide delta or sand bar intermittently but fully blocking the mouth of the lagoon. This feature is inferred to be indicative of larger and more frequent erosion events at Garden Island Sands after 2000 which have delivered more sand via littoral (alongshore) drift to the lagoon mouth than previously (see section 3.4.2). Flood tide (ingoing) tidal currents have moved and deposited this sand temporarily into the main tidal channel, however these features have not been permanent and are not seen in all photos after 2001 (see Figure 29). This indicates that river current discharges and/or tidal ebb currents have been capable of flushing all or most of the sand blockages out of the lagoon mouth.

The implication of the discussion and observations above is that there is currently only very limited (if any) space left in the Garden Island Creek estuarine lagoon to accommodate increasing amounts of eroded sand transported from the eroding beach and dune face and into the lagoon by tidal currents. However, ongoing global sea-level rise is (amongst other things) having the effect of increasing water depth in tidal lagoons, and this can be expected to have been creating more accommodation space at Garden Island Creek estuarine lagoon (at least in its lower reaches near the mouth) in which eroded sand can settle out and be permanently sequestered (Hennecke & Cowell 2000). This effect has probably been limited to date but can be expected to continue creating more accommodation space in the lagoon as sea-level continues to rise (see Section 2.4.4). The implications of this for coastal erosion at Garden Island Sands is discussed further in section 3.6.2.

2.4 Coastal Processes

2.4.1 Wind and aeolian processes

Wind may affect coastal processes in two important ways, namely by generating local wind waves (which may erode or otherwise transport sand) and by directly transporting sand from the dry upper beach to the foredune or further inland via aeolian (wind-blown) transport.

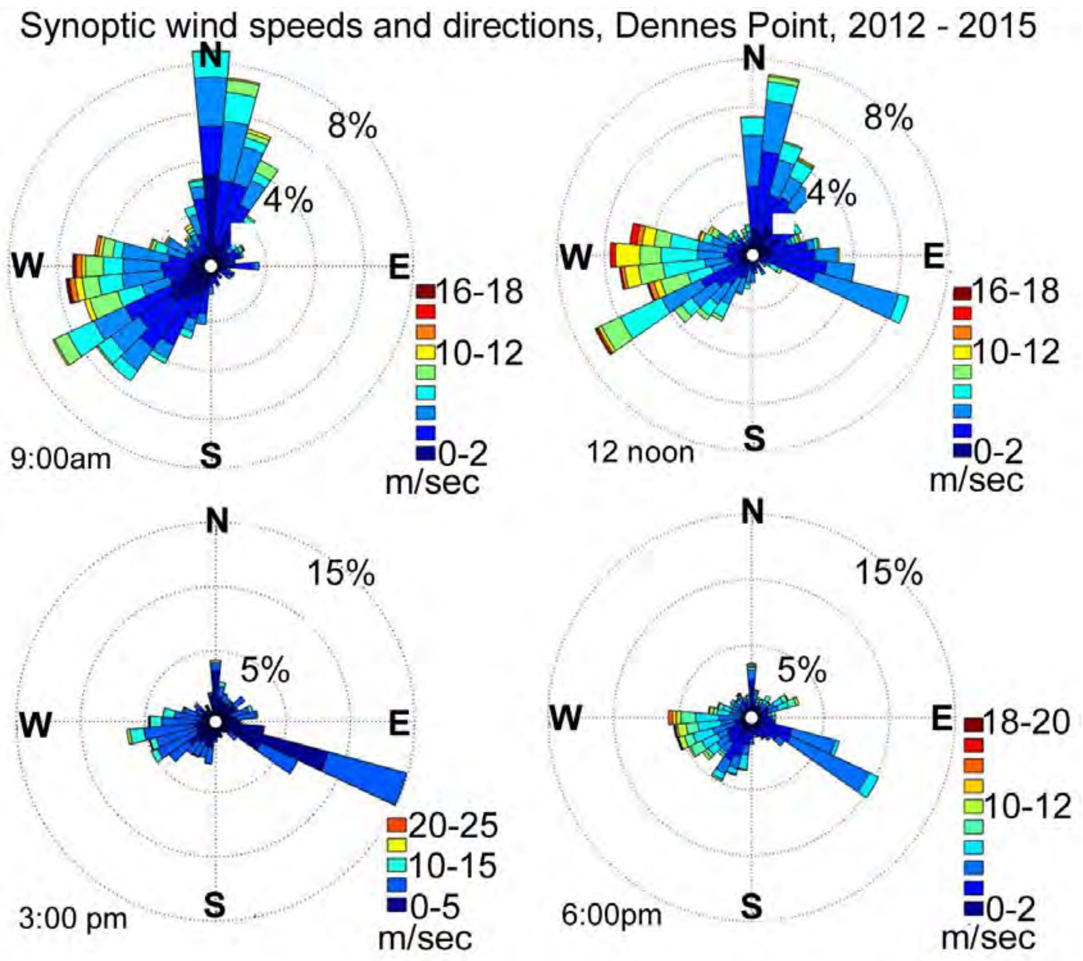
No long-term wind records are known to be publicly available for locations near Garden Island Sands. However, Garden Island Sands is centrally located between two regional coastal Bureau of Meteorology (BoM) weather stations at Dennes Point (north Bruny Island) and Cape Bruny (south Bruny Island). Wind records from these two stations are shown on Figure 11 below.

Both records show dominant westerly to south-westerly winds with a strong northerly wind component, suggesting these are characteristic wind patterns for the south-east Tasmanian coastal region and thus likely to be similar in the Garden Island Sands area. A notable south-easterly afternoon wind component in the Dennes Point record is not present at Cape Bruny and may be a local Dennes Point phenomenon, possibly afternoon sea breezes.

If northerly winds are significant at Garden Island Sands Beach (as they are at Dennes Point and Cape Bruny), they probably have little effect on the sandy landforms and beach processes because they will mostly be blowing from onshore to offshore. This means the winds have little capacity to mobilise sand from the foredune (as they blow onto the vegetated and thus protected side of the dune) or from the beach (which is sheltered from northerly winds by the foredune). Any waves generated by the offshore-directed winds will be of negligible size close to the shore, and further offshore will move away from the beach rather than towards it.

In contrast, westerly to south-westerly winds are likely to be the most important winds affecting Garden Island Sands, consistent with their importance in both the Dennes Point and Cape Bruny wind records, and the fact that regional westerly air flows are a dominant influence on Tasmania's weather generally (Grose et al. 2010). These winds may blow somewhat obliquely onshore at Garden Island Sands but are a key agent of foredune recovery from erosion since they can blow dry upper beach sand onto the foredune face where it can accumulate as a new incipient foredune and rebuild the dune face after erosion events (see Figure 4 above). In some locations strong onshore winds may also erode dunes, causing blow-outs and deflation hollows, however inspection of historic air photos indicates that this does not appear to have been a significant process at Garden Island Sands during the air photo period since 1948.

However, probably the most important role of wind in the Garden Island Sands coastal environment is its importance in driving locally generated wind waves. West-south-westerly winds in particular have a relatively long fetch across the Huon estuary to Garden Island Sands and thus are likely to produce some of the most energetic waves reaching Garden Island Sands beach. Locally wind-generated waves reaching Garden Island Sands may cause beach and foredune erosion when they are higher and more energetic (under stormy conditions) or may conversely push eroded sand back onto the beach from offshore sand bars and flats when they are lower and less energetic. In either case, westerly to south-westerly wind waves are likely the dominant driver of the prevalent north-west to south-east drift of sand along the nearshore (littoral) zone at Garden Island Sands Beach (see section 2.4.6). The following section 2.4.2 provides further discussion of the significance of locally generated wind waves at Garden Island Sands.



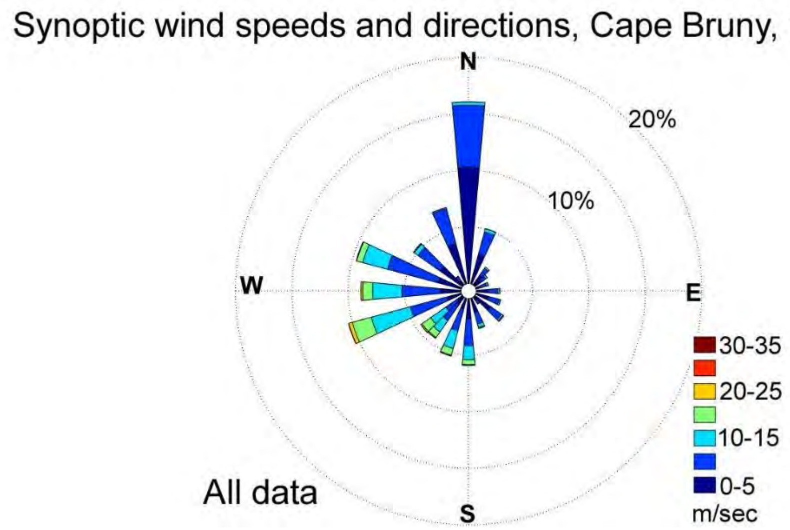


Figure 11: Wind data from the Dennes Point (top) and Cape Bruny (bottom) Bureau of Meteorology (BoM) weather stations. Garden Island Sands is centrally located between these two BoM south-east coastal weather stations in south-eastern Tasmania. Both records show dominant westerly to south-westerly winds with a strong northerly wind component, suggesting these are characteristic wind patterns for the south-east region and thus likely to be similar in the Garden Island Sands area. A notable south-easterly afternoon wind component in the Dennes Point record is not present at Cape Bruny and is evidently a local phenomenon, possibly afternoon sea breezes. Plots prepared from original BoM data by Chris Sharples.

2.4.2 Wave climate

Two dominant wave types reach Garden Island Sands Beach, namely oceanic swell waves and locally generated wind-waves. Wave conditions observed at Garden Island Sands by the writer on 14th Sept 2022 included both wave types and were probably typical for the locality. These comprised persistent low swell waves driven northwards directly up the channel on east side of Garden Island, breaking at about 0.2m height across the whole beach embayment on the shallow sand bar 150-200m offshore from the beach (see Figure 9). At the same time, intermittent south-westerly winds were intermittently generating south-westerly wind waves approaching the beach past the north end of Garden Island and breaking close to the beach at heights of up to roughly ~0.1 – 0.2m high. Figure 13 shows an example of both wave types arriving at the beach.

It is notable that a small cuspate sandy-cobble spit on the north end of Garden Island (see Figure 12 and notes in 2.3.1) is shaped by the differing wind-wave and swell-wave sets interacting as they come round the north side of the island, and as such marks the dividing point between sections of the island shore that are dominated by the two wave sets.

Storm wave activity – both from storm swells and locally-generated stormy wind-waves – is inferred to be the dominant cause of beach and dune erosion at Garden Island Sands (as is the case for most beaches). To the writer's knowledge no storm event records are available for Garden Island Sands. However, the dominant storm wave directions are inferred likely to be similar to the dominant fair-weather wave directions, albeit stormy locally generated wind-wave directions are likely to vary more than the longer storm swells whose directions are "trained" by their long run up D'Entrecasteaux channel. The following wave climate description for Garden Island Sands has been inferred from air photos, regional wind records (see section 2.4.1 above) and on-site observations (see also Figure 12 and Figure 13).

Swell waves

The whole length of Garden Island Sands Beach is directly exposed to swell waves that have propagated 30 km northwards directly up D'Entrecasteaux Channel from the Southern Ocean to arrive somewhat attenuated (weakened) and trained (straightened) at the beach via the channel on the eastern side of Garden Island (see Figure 12). In contrast, swells passing on the western side of Garden Island reach nearby Randall's Bay on a similarly direct pathway (Figure 12), but only refract very weakly around the north-western side of Garden Island to reach Garden Island Beach with minimal energy. Consequent, it is deduced that most swell waves (whether smaller fair weather swells or higher and more energetic storm swells) arrive at Garden Island Sands from almost the same direction (as shown on Figure 12 & Figure 13) after having penetrated northwards up the broad channel on the east side of Garden Island.

Wind waves

Wind waves may be occasionally generated by winds coming from any direction, however given the inferred dominantly westerly to south-westerly local winds in the lower Huon estuary region (see Section 2.4.1 above), the dominant locally generated wind waves reaching Garden Island Sands are expected to be mainly driven from westerly to south-westerly directions. See Figure 12. Although the more south-westerly fetches are relatively short, winds blowing from westerly to west-south-westerly directions may have fetches of up to 6 kilometres across the Lower Huon River estuary, potentially generating large energetic wind waves at the beach under storm wind conditions (see Figure 12).

As is evident from inspection of Figure 12 and Figure 13, the middle to eastern part of Garden Island Sands Beach is more exposed to these wind-wave directions, whereas the western end is comparatively sheltered from them by the curve of the rocky shore west of the beach. This exposure pattern corresponds well to the differing degrees of present-day erosion observed along

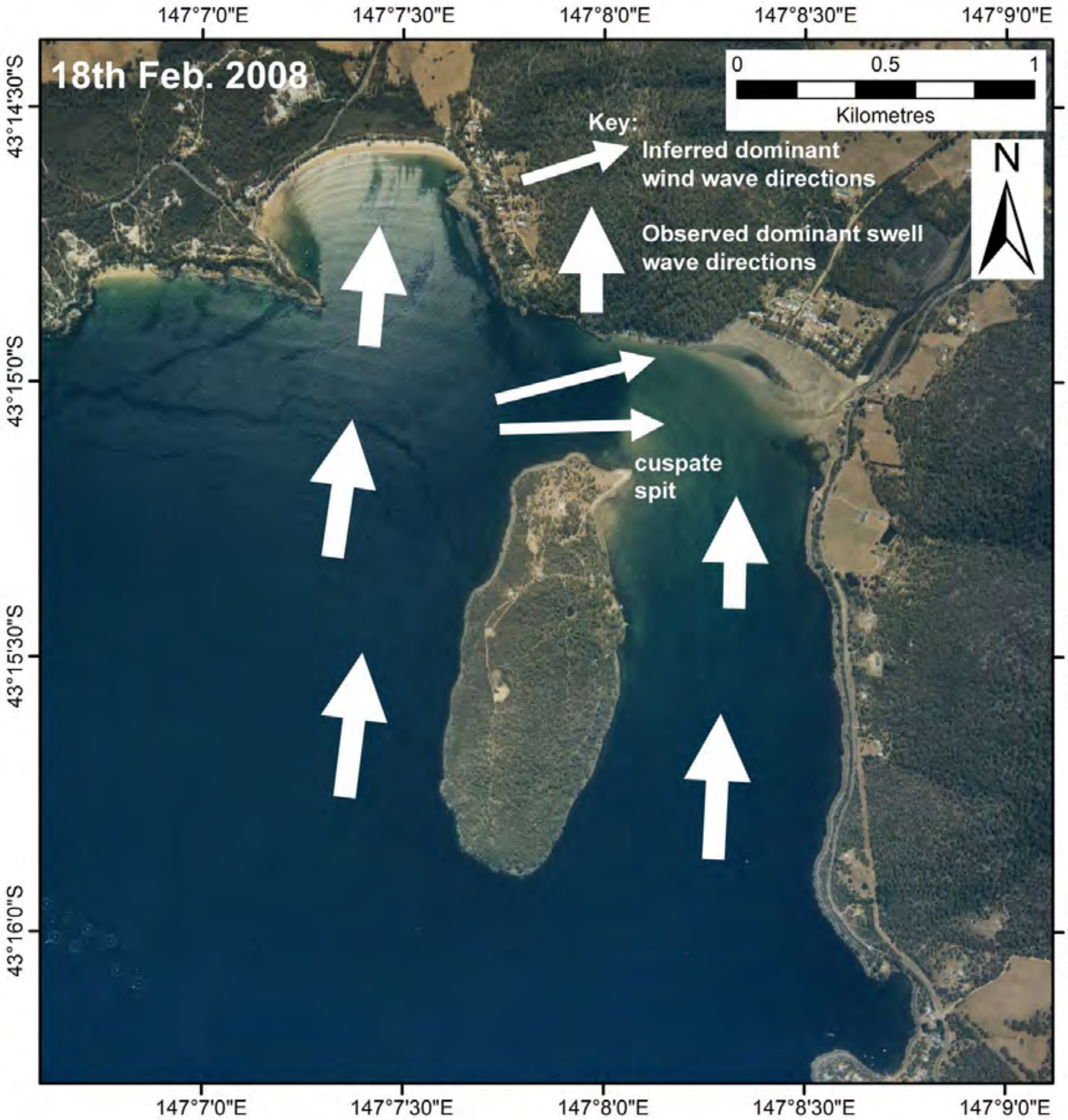


Figure 12: Diagrammatic representation of the dominant directions of swell and wind waves reaching Randall's Bay (LHS) and Garden Island Sands Beach (RHS). The observed swell wave direction indicated shows little variation in direction since it is trained and attenuated by a long refraction pathway up southern D'Entrecasteaux Channel. Whereas the whole beach is exposed to the dominant swell waves propagating northwards up the east side of Garden Island, the inferred dominant wind-wave directional range (westerly to south-westerly) results in the west end of the beach being most sheltered (by a rocky shoreline) from the dominant wind waves which impact most directly on the middle to eastern section of the beach. (air photo dated 18th Feb 2008, air photo film–frame 1430_222, © NRE; see also details in Appendix 1).

the beach (see Section 3.2) and to the degree of past shoreline recession along the beach (see Figure 18 and discussion in Section 3.4.3). This implies that locally generated westerly to south-westerly wind waves are probably the dominant agent of erosion and change on Garden Island Sands beach. That is, although the whole beach length is equally exposed to the most direct swell waves that reach Garden Island Sands, the pattern of shoreline erosion instead reflects the varying degree of wind-wave exposure along the beach, suggesting that the latter has typically had more control over the dominant historical and recent erosion pattern than do the swell waves. In part, this may be because swell waves lose a lot of their energy over the 30 km pathway from the southern Ocean to Garden Island sands via D'Entrecasteaux Channel, as well as losing further energy breaking on the shallow sand bar 100 to 200 metres off the beach (see section 2.3.4 and Figure 9). However, large swell storm waves have also often caused significant erosion on south-eastern Tasmanian beaches,

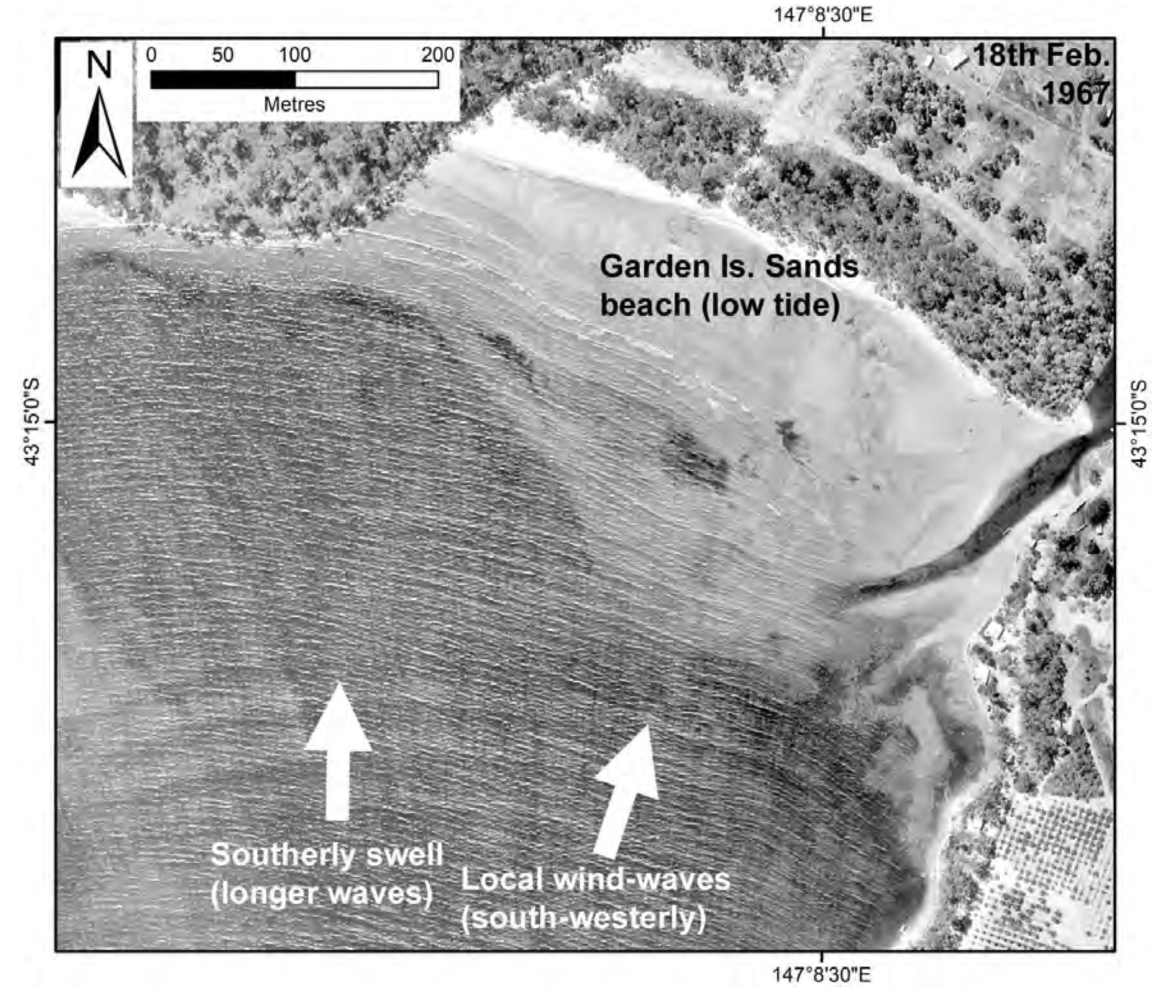


Figure 13: Air photo of Garden Island Sands Bay with both swell and wind-waves visible. This image highlights the longer-wavelength swell-waves which have propagated northwards up D'Entrecasteaux Channel and directly up the east side of Garden Island to the beach, as well as the shorter-wavelength locally-generated wind-waves which in this photo are seen propagating from a south-south-westerly direction reflecting the wind direction at the time this photo was taken (dated 18th Feb 1967, air photo film–frame 489-162, © NRE; see also details in Appendix 1). This photo also illustrates the greater wave-sheltering that has typically been found at the west end of Garden Island Sands Beach (see section 2.4.2 text). The wide expanse of dry upper beach sand accumulated at the west end of the beach is notable on this photo and implies that more sheltered conditions dominate that area than the wave patterns seen on this photo seem to suggest. Thus, it is likely that the dominant wind-wave direction is often more westerly than the south-westerly direction seen here. That would afford more shelter at the west end of the beach resulting in less erosion and more sand accumulation there, as is seen in this photo.

even after refracting and attenuating for significant distances up tidal embayments (as happened at Roches Beach in Frederick Henry Bay during July 2011, for example).

Nonetheless, as suggested above the locally generated westerly to south-westerly wind waves are deduced to dominantly drive the sandy coastal processes at Garden Island Sands. Not only do the dominantly westerly to south-westerly wind waves drive the important north-west to south-east littoral drift of sand along the beach (see section 2.4.6), but these waves are also the key agents of both erosion and recovery of the beach and foredune. Steep energetic stormy wind waves - often on elevated tidal levels because of stormy low-pressure systems – will readily erode the beach and foredune, carrying sand offshore in their energetic backwash. However lower, less energetic fair weather wind waves and swell waves may gradually drive sand back to the beach (as well as alongshore) after it has been eroded and dumped offshore by storm wave backwash.

2.4.3 Tidal Processes

The spring to neap tidal range at Garden Island Sands is approximately 1.3 to 0.3 metres (Short 2006, p. 141). This commonly results much of the central to eastern part of Garden Island Sands Beach exposing only a few (horizontal) metres of sand at high tide (see Figure 3 and section 2.3.1), yet allows exposure of lower beach sands over some tens of metres to seawards at low tide along the whole beach.

Tidal currents visibly move in and out of the mouth of the Garden Island Creek estuarine lagoon during each tidal cycle. No measurements of the tidal current flow rates or tidal prism (amount of water moved) are available, however visual inspection indicates that sand is moved by the tidal currents in the vicinity of the lagoon mouth. No attempts to measure tidal water movements within the lagoon are known to the writer, however the observation that large sediment bars inside the lagoon are geomorphically more akin to fluvial point bars than to tidal flood-tide deltas (see section 2.3.5) is suggestive that tidal currents are probably not very effective beyond a few tens of metres inside the lagoon mouth.

2.4.4 Sea-level variability

Global mean sea-level (GMSL) stood approximately 130 m below present levels during the Last Glacial Maximum (LGM) circa 20,000 years before the present (BP), but rose during the post-glacial marine transgression to reach approximately its present level by mid-Holocene time, circa 6000 - 7000 years BP (Lambeck & Chappell 2001; Lewis et al. 2013). After over 6000 years of relative stability, GMSL commenced a significant renewed rise from the 1800s (Woodworth 1999). The rate of this rise has increased over the Twentieth Century (Church & White 2006; Church & White 2011), albeit with some inter-decadal variability. Tide gauge and satellite altimetry data shows that by 2009, GMSL had risen 21 cm since 1880, and the average rate of global mean sea-level rise (GMSLR) over the whole Twentieth Century was 1.7 mm yr^{-1} (Church & White 2011). However, GMSL has continued to accelerate over the satellite altimetry era since 1993 (Watson et al. 2015), from 2.2 ± 0.3 mm yr^{-1} in 1993 to 3.3 ± 0.3 mm yr^{-1} in 2014 (Chen et al. 2017) and is continuing to increase.

A comparison between modern and historic (1840s) tide gauge records from Port Arthur have demonstrated that sea-level rise on the south-east Tasmanian coast over the last ~150 years has been comparable to the GMSL record (Hunter, Coleman & Pugh 2003). The nearest measured long-term (multi-decadal) sea level data to Garden Island Sands is from the Hobart port tide gauge record, located in the broad lower Derwent River estuary about 40 km north of Garden Island Sands. The net rate of mean sea-level rise indicated by a linear regression fit to the Hobart tide gauge record is 1.68 mm/yr^{-1} over the period 1962-2004 (original data processed by Dr John Hunter, oceanographer), which is comparable with the global-average rise of 2.0 ± 0.3 mm yr^{-1} over the 1966 – 2009 period (White et al. 2014).

Analysis of tide gauge data from around Australia (Figure 5 in Burgette et al. 2013) has shown that sea-level "noise" (i.e., variability related to seasonal, interannual and decadal processes, particularly the El Nino Southern Oscillation) is minimal in Tasmania compared to most northern and western Australian coasts. These data imply firstly, that local relative sea-level variability in the Hobart region of SE Tasmania (including Garden Island Sands) is dominantly attributable to global mean sea-level rise (GMSLR) rather than other more local causes, and secondly that Tasmanian shoreline behaviour is less influenced by regional sources of sea-level variability such as ENSO than are most other Australian shores where this source of coastal process noise is more likely to mask any sea-level rise signature in shoreline behaviour.

2.4.5 River discharge and flooding

The following brief note is focussed on river flows and discharge effects in Garden Island Creek; fluvial (riverine) sediments and landforms have been discussed in section 2.3.5 above.

Garden Island Creek is a freshwater river (or creek) with a catchment area of the order of about 35 square kilometres of mixed native forest and some cleared agricultural land. The river reaches the sea at Garden Island Sands where it has an estuarine lagoon which is described in Section 2.3.5 above. Average and flood stream flow and discharge data are not known to be available for Garden Island Creek (based on checking the NRE Tasmania Water Information Web Portal https://portal.wrt.tas.gov.au/Data on 3rd February 2023).

The observation that large sediment bars inside the Garden Island Creek estuarine lagoon are geomorphically more akin to fluvial point bars than to tidal flood-tide deltas (see section 2.3.5) is suggestive that river water discharges probably dominate over tidal currents in most of the lagoon except close to the tidal mouth (albeit no salinity measurements or other stream flow or water chemistry data is known to be available for the lagoon). This suggests that most sand brought into the lagoon mouth on flood-tide currents is likely to be rapidly flushed out again by the combined power of river and ebb tide currents. This suggestion is supported by the apparent failure of occasional sand bars deposited at the lagoon mouth after 2001 to persist at that location (see section 3.4.2, Figure 29). However, increasing accommodation space for sediment in the lagoon as a result of sea-level rise may allow small but increasing amounts of sand introduced into the lagoon from beach erosion to persist there despite the flushing action of fluvial discharge and ebb tidal currents (see section 3.6.2).

2.4.6 Sand transport and budget

Unconsolidated sand is a highly mobile sediment, and all sandy shores undergo some degree of sand movement - at least superficially - driven primarily by wind, waves, and tidal currents. These sand transport processes determine the form and scale of sandy shores, and the "sand budget" of a beach. This term refers to the net balance of sand gains and losses over time. Whereas many beaches are mostly stable, with either negligible or approximately equal gains and losses of sand, some beaches may undergo significant net gains or losses of sand over time. These conditions result in either gaining ("prograding") or losing ("receding") beaches.

Of particular interest from a coastal hazards perspective are locations at which changing conditions may result in a long-term switch from a stable beach to a losing (receding) beach. As described in Section 3.4.2 (below), an historic air photo time series shows that since circa 2000, Garden Island Sands Beach has undergone a change in its long-term behaviour, from being a stable or slightly receding beach to being a dominantly eroding and significantly receding beach. Understanding the reasons for such a change of long-term behaviour requires an understanding of the local sand transport and budget processes. This section summarises what is known or can be inferred of these for Garden Island Sands Beach, in order to provide a basis for the discussion of likely causes of the observed change provided in section 3.6 below.

The following discussion is a qualitative assessment of sand transport processes at and near Garden Island Sands Beach which the writer has deduced from interpretation of geomorphic features and processes (as described in sections 2.3 and 2.4 of this report), in the light of what is known about sand movement and budget processes elsewhere on the Tasmania coast. Although it is possible to measure coastal sand movement, accumulation, and erosion more quantitatively, this requires techniques which are generally expensive and time-consuming, and were beyond the scope of this project.

Overall Garden Island Sands embayment sand trap ("sink")

The Garden Island Sands embayment behind (north-east of) Garden Island is a large sand sink or sand-trapping coastal area separated from Randall's Bay to the west and Charlotte Cove to the south by long rocky shores (see Figure 2). Within the overall sand trap, sand circulates into and out of the Garden Creek estuarine lagoon and a large sand bar 100-200 metres off the beach, which are inferred to be a smaller nested "leaky" sand traps which intermittently both gain and lose sand from other parts of the embayment (see Figure 14 below).

The sand source for the Garden Island Sands embayment is inferred to be the sandy floor of the adjacent Huon estuary (see Figure 7). During each past low sea stand associated with the multiple repeated Pleistocene-age glacial climatic phases that have affected the Tasmanian landscape over the last 2.6 million years or so, glacial meltwater and outwash rivers (the proto-Huon) deposited sands eroded by glaciers from glaciated inland areas onto what were then coastal river plains but which are today "drowned" about 130 metres below present sea-level (Corbett 2019; Lambeck & Chappell 2001; Lewis et al. 2013). As the post-glacial global sea levels rose following the end of each glacial period, much of the sand now trapped in the embayment behind Garden Island is inferred to have been pushed landwards and into the embayment from the Huon estuary floor on the rapidly rising water levels by swell waves, locally generated wind waves and tidal currents (see Figure 12).

Sea level last stabilised at approximately its present level around 6000-7000 years ago (Lambeck & Chappell 2001; Lewis et al. 2013) after which the initially-abundant nearshore supply of sand into the sand-trapping embayment would have gradually reduced over several thousand years until an equilibrium was eventually reached between the available offshore sand and the wave energy available to move sand onshore. It is likely that there is today only a much-reduced sand exchange involving only small losses and gains between the sand trapping embayment and surrounding deeper sandy bottoms in the Huon estuary. The Garden Island Sands embayment is now nearly filled with sand, resulting in very shallow water depths over much of its area (see Figure 14). Despite this there is no evidence of significant sand losses from the embayment, with the coastal planform (shape) and dominant wave directions tending to push sand into but not out of the embayment[2] (see Figure 12, Figure 13), which is effectively a closed sediment compartment (Thom et al. 2018). With probably only very small sand gains and losses, the overall sand budget for the Garden Island Sands embayment is inferred to be balanced or nearly-balanced (stable).

Sand transport processes within Garden Island Sands embayment

The north-western quarter (approximately) of Garden Island Sands Beach appears to be relatively sheltered from both wind waves and swell waves by the combined sheltering effects of Garden Island, the rocky headland immediately west of the beach (see section 3.2 and 3.4.2) and an offshore sand bar (see Figure 9 in section 2.3.4). Consequently, the north-western quarter of the beach has historically shown – and currently continues to show - less evidence of erosion and shoreline recession than the rest of the beach (see sections 3.2 and 3.4.2) and is more frequently accreting rather than losing sand.

In contrast the longer central to south-eastern part of the beach is more strongly exposed to short steep westerly to south-westerly wind waves as well as to swell waves (see section 2.4.2). Multiple

[2] It is conceivable that river flood discharges and ebb tide currents emerging from the mouth of Garden Island Creek lagoon (within the embayment) could push some sand completely out of the overall embayment, however this would require considerable energy and appears unlikely or an infrequent occurrence at best, albeit this possibility has not been tested.

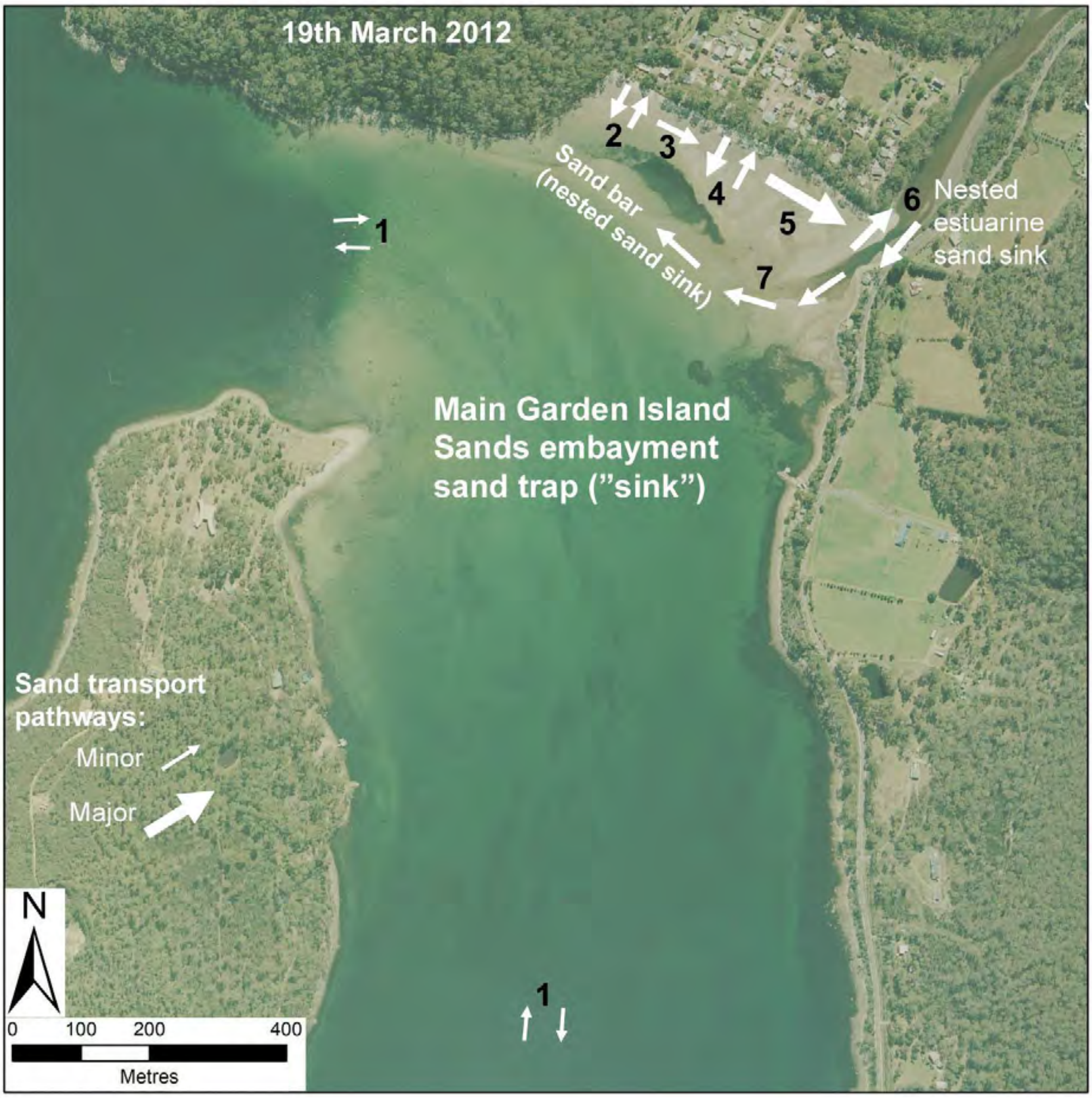


Figure 14: Deduced key sand transport pathways in the Garden Island sands embayment. Numbered arrows indicate key processes as follows: **1:** Minor (only) gains to or losses from whole embayment; **2:** Minor erosion and recovery of beach & dune sands at sheltered NW end of beach; **3:** Minor south-eastwards longshore drift of storm-eroded sand from sheltered NW end of beach; **4:** Strong erosion of exposed beach and dune in central to south-east part of beach, with some post-storm recovery (sand returned to beach), but: **5:** inferred major south-eastwards littoral drift of eroded sand during and after erosion events; **6;** drifted eroded sand builds spit at lagoon mouth, some is transported into lagoon by tidal currents but mostly then expelled back out of lagoon by tidal currents and river discharges; **7:** Sand expelled from estuarine lagoon eventually worked into large offshore sand bar by waves and tidal currents. Some of this sand is probably eventually but slowly returned to beach by wave action. Indicated sand bars have potential to be "rejuvenated" nested sand sinks in response to sea-level rise (see section 3.6.2). Aerial photo dated 19th March 2012, © NRE.

lines of evidence[3] indicate that these waves drive a dominantly north-west to south-east littoral current resulting in drift of sand south-eastwards along the beach. It can be reasonably inferred (in the absence of any physical observations) that whenever a (storm wave-driven) beach and foredune

[3] These include the inferred direction of littoral drift that should result from the dominant westerly wind-waves breaking and pushing sand along the beach (see section 2.4.2), the persistent location of the Garden Island Creek mouth which is and has historically been pushed hard up against the rocky shoreline on its eastern side (see section 2.3.3), and the historically persistent accretion of a small highly variable sand spit partway across the creek lagoon mouth at the south-eastern (downdrift) extremity of the beach (see "D" on Figure 15 in section 3.2, and also section 3.4.2).

erosion event occurs, the eroded sand will be dumped in the nearshore zone by storm wave backwash. Some of this sand will be returned to the beach by fair weather waves after the erosion (storm) event finishes, but a large proportion of the eroded sand will also be transported alongshore in a south-easterly direction by the nearshore littoral drift currents both during and after the storm.

Some of this sand accumulates in the small spit at the south-eastern extremity of the beach, and some of it can be assumed to be drawn from there into the mouth of the Garden Island Creek estuarine lagoon by flood-tide currents. Depending on how much space (depth of water) is available in the lagoon some of the transported sand may settle out permanently in the lagoon, or else the excess sand will subsequently be moved back out of the lagoon by ebb tide currents. Given the large amount of sand available in the Garden Island Sands embayment as a whole, it is probable that the estuarine lagoon has mostly been filled with as much sand as it can hold over most of the air photo period. This means that sand drawn into the lagoon by tidal currents has mostly been unable to settle into sufficiently deep accommodation space from which water currents cannot remove it and has instead been soon flushed back out of the lagoon mouth by ebb tide currents and/or by river discharge currents. It is likely that river flood discharges episodically flush more sediment out of the lagoon than usual, creating some additional accommodation space for more sand to be permanently sequestered in the lagoon, however it is also likely that the longer-term result (not taking into account the effects of progressive net rise in sea level) is that roughly equal amounts of sand are transported from the beach area into the lagoon, and then back out of the lagoon. See also estuarine lagoon discussion in section 2.3.5 above.

As noted above, sand flushed out of the lagoon by river discharge and tidal currents is unlikely to be entirely lost from the Garden Island Sands embayment but rather is likely to be circulated within the embayment by wave and tide-driven currents. It is likely that the notable sand bar located about 100 to 200 metres offshore and parallel to the Garden Island Sands Beach (see Figure 9 in section 2.3.4) is at least partly comprised of sand flushed out of the lagoon and then moved (along with other sands) by wave action. Some of this will probably be eventually returned to the beach face by wave action.

However, ongoing sea-level rise is deduced to be creating additional accommodation space for sand by deepening the water within both the estuarine lagoon of Garden Island Creek and over the large sand bar in the Garden Island embayment (Figure 9). This means that as sea-level continues to rise these two features are inferred to be increasingly functioning as “nested” sand sinks within the overall sand trap of the Garden Island Sands embayment and are likely to be significant factors on the increased shoreline erosion seen at Garden Island Sands since 2000. This likelihood is further discussed in section 3.6.2 below.

3.0 GARDEN ISLAND SANDS SHORELINE CHANGE HISTORY (1948 – 2022)

3.1 Introduction

Increasing foredune erosion causing the undermining and collapse of large mature trees has been a significant concern at Garden Island Sands for some years. It is unclear from anecdotal reports how long this has been noticeable, however interpretation of air photo data (described in section 3.4.2 below) suggests that a notable change of shoreline behaviour – namely a significant increase in the rate of shoreline erosion and retreat - began circa 2000. However, whilst the change of behaviour is easily detectable from air photo records (under appropriate analysis: section 3.4.2), it would probably not have become obvious to casual observers until sometime later, when the impacts of the increased erosion started to "emerge" above the normal variability of prior beach erosion and accretion (recovery) cycles to which local observers were accustomed. From inspection of the air photo records (see Figure 23 and Figure 26), the "time of emergence" (Hawkins & Sutton 2012) for the changed beach behaviour probably occurred roughly around 2010 to 2015.

The following subsections describe contemporary observations of the condition of the Garden Island Sands beach and foredune (section 3.2), profile surveys documenting the current physical conditions (Section 3.3), and an analysis of beach behaviour since 1948 based on all available historic air photos (section 3.4). Combined with available information relevant to geomorphic (landform) processes (sections 2.3 & 2.4), this data is used to better understand the nature and history (since 1948) of landform processes and changes at Garden Island Sands (as summarised in section 3.5). Section 3.6 explores the possible causes of the observed changes in long term behaviour.

3.2 Current (August 2022) beach and foredune condition

The state of the Garden Island Sands beach and foredune was systematically examined and photographed by Chris Sharples on 3rd August 2022. The condition of these landforms on that date is shown on Figure 15 (following) and is summarised as follows:

The north-western extremity of the upper beach for about 20 metres length was dry and about 8 metres wide above a flat wet low-tide terrace of sand. The beach ends against rocky shoreline dolerite outcrops, with a small stream emerging to flow across the extreme end of the beach. The backing foredune was a stable sandy ridge with no sign of recent erosion, rising a metre or so high behind the northwest part of the beach (see Figure 15 "stable sandy shore"). However, this dune (or ridge) is partly composed of gravel, which indicates artificial origin at least in part.

The north-western quarter (~100 m) of the upper beach was mostly dry over a width of ~8 – 10m above the wet low tide terrace (see also Figure 4) and was backed by a relatively old foredune erosion scarp which shows evidence of significant recovery, having been partly buried by an incipient foredune which has accreted following the last erosion event that affected this part of the beach (see Figure 15 including photo A).

The central to south-eastern three-quarters (~300m) of the upper beach was typically quite narrow (3 – 4 m wide) and wet above the wet low tide terrace of sand. The upper beach was entirely backed by a fresh vertical erosion scarp up to 1.5m high (see Figure 3, Figure 5, and see Figure 15 including photos B and C).

The south-eastern extremity of the beach (~20-30m long) was a small actively accreting sandspit dominated by marram grass (which is indicative of relatively recent sand accumulation) and protruding partway across the mouth of the Garden Island Creek estuarine lagoon (see Figure 15,

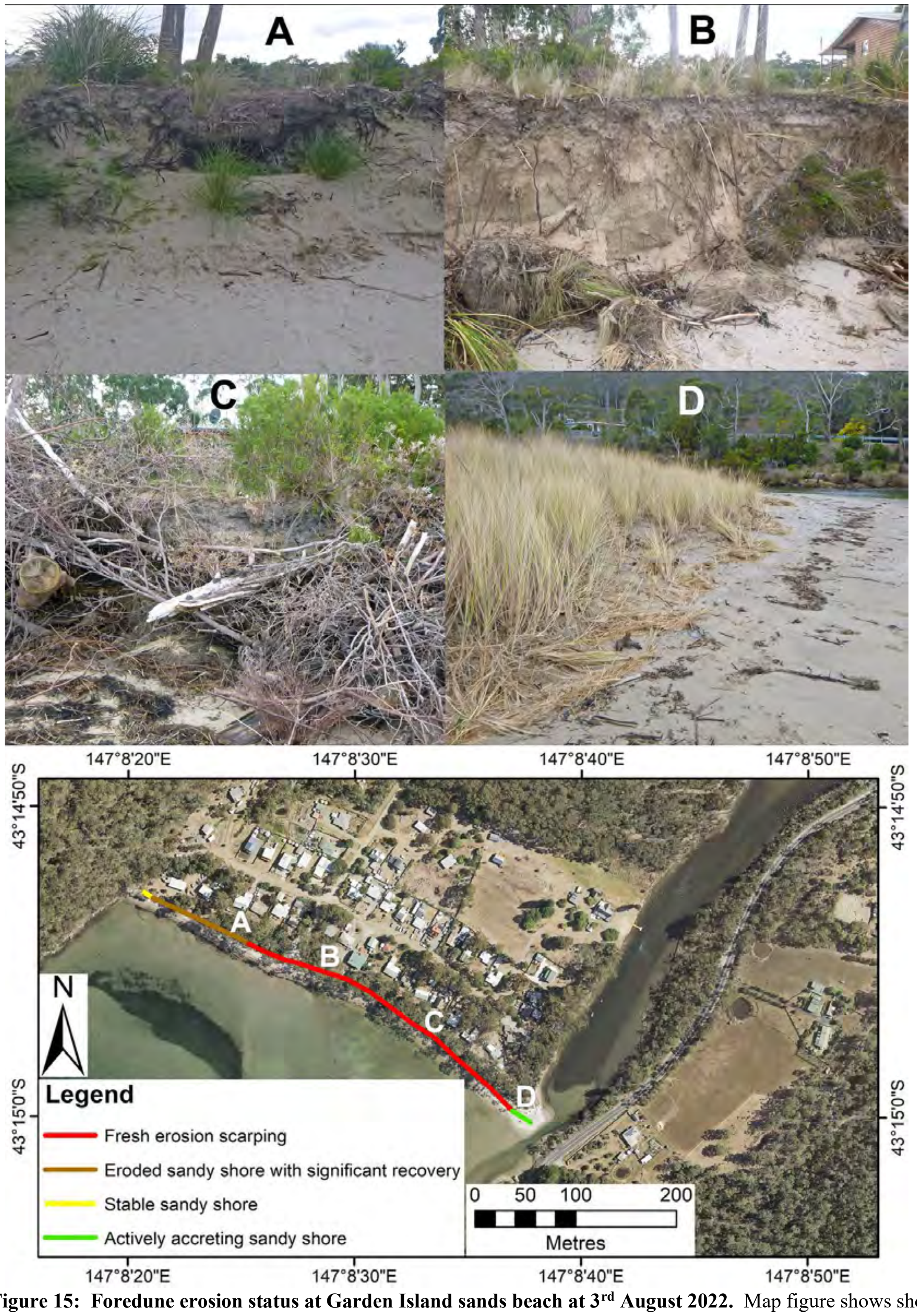


Figure 15: Foredune erosion status at Garden Island sands beach at 3rd August 2022. Map figure shows shore-parallel variation in foredune erosion status as mapped in the field by Chris Sharples. Background aerial photo is dated 19th December 2015. Labelled photos show four key examples of erosion status as follows: **A:** Old erosion scarp with significant wind-blown sand accretion in front (an "incipient foredune"), indicating little recent erosion and some beach and dune recovery along this part of the foredune face ("Eroded sandy shore with significant recovery". **B:** Fresh (active) vertical scarp face with vegetation-bound sand slab collapses at the base ("Fresh erosion scarping"). **C:** Fresh erosion scarp (as per B) with toppled and artificially cut vegetation piled in front as temporary protection ("Fresh erosion scarping" with artificial protection). **D:** Actively accreting (growing) sand spit at lagoon mouth with only minor signs of erosion ("Actively accreting sandy shore"). The short section of "stable sandy shore at the west end of the beach is a low section of foredune covered in artificial gravel fill with no current indications of erosion or accretion of sand.

including photo D). Some small erosion scarps were evident in parts, however sand accretion was the dominant landform condition here as at August 2022.

These conditions indicate that as of August 2022 the north-western quarter (approximately) of the beach and dune was being eroded less frequently or less energetically (or both) than the more actively eroding central to south-eastern three quarters of the beach and dune. The north-western extremity was essentially stable (partly due to artificial intervention), and the south-eastern extremity was actively accreting sand into a small spit protruding partway across the mouth of the Garden Island Creek estuarine lagoon. As discussed further in section 3.4.2, these current variations in geomorphic conditions along the beach strongly reflect variation in the historical behaviour of different parts of the beach since at least 1948.

3.3 Surveyed beach profiling (TASMARC)

The form and position of the Garden Island Sands beach and foredune as at 12th August 2022 has been precisely recorded by profile surveys at four transects spaced along the beach (see Figure 16 & Figure 17 below). Resurveys along the same survey transects at intervals in the future will enable precise measurement of any future landform changes to be made. It is intended that these surveys can be accurately carried out by volunteers (e.g., local residents) and the data be incorporated into the publicly available TASMARC database (www.tasmarc.info). Further documentation of these surveys is provided below and in Appendix 4 of this report, as well as in Cromer (2023, Attachment 3).

Four permanent TASMARC survey markers were established at Garden Island Sands Beach on the 12th of August 2022 by Chris Sharples and Nick Bowden. These consisted of screws on treated pine posts dug in on the back (landwards) slope of the foredune. Nick Bowden and Chris Sharples

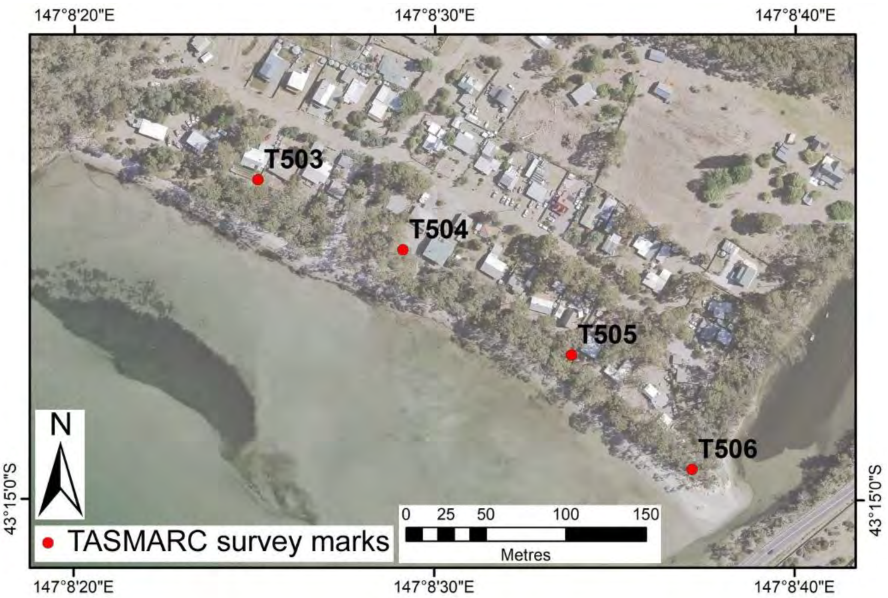


Figure 16: TASMARC survey mark positions at Garden Island Sands Beach. Each survey marker is a treated pine post embedded securely in the ground with a stainless-steel screw in the top of the post indicating the precise surveyed marker position. The survey transects extend seawards from the marks, normal (perpendicular) to the shoreline. Background image is the 19th of December 2015 air photo (© NRE). For larger version of this figure see Appendix 4.

[4] "TASMARC" is the TAsmanian Shoreline Monitoring and ARChiving project. This is a beach monitoring project which commenced in 2004 as a project of the Antarctic Climate and Ecosystems Co-operative Research Centre (ACE-CRC) at the University of Tasmania. The project is based on community "citizen science" groups surveying beach profiles at intervals, with the data being processed and made available for open public access at www.tasmarc.info.

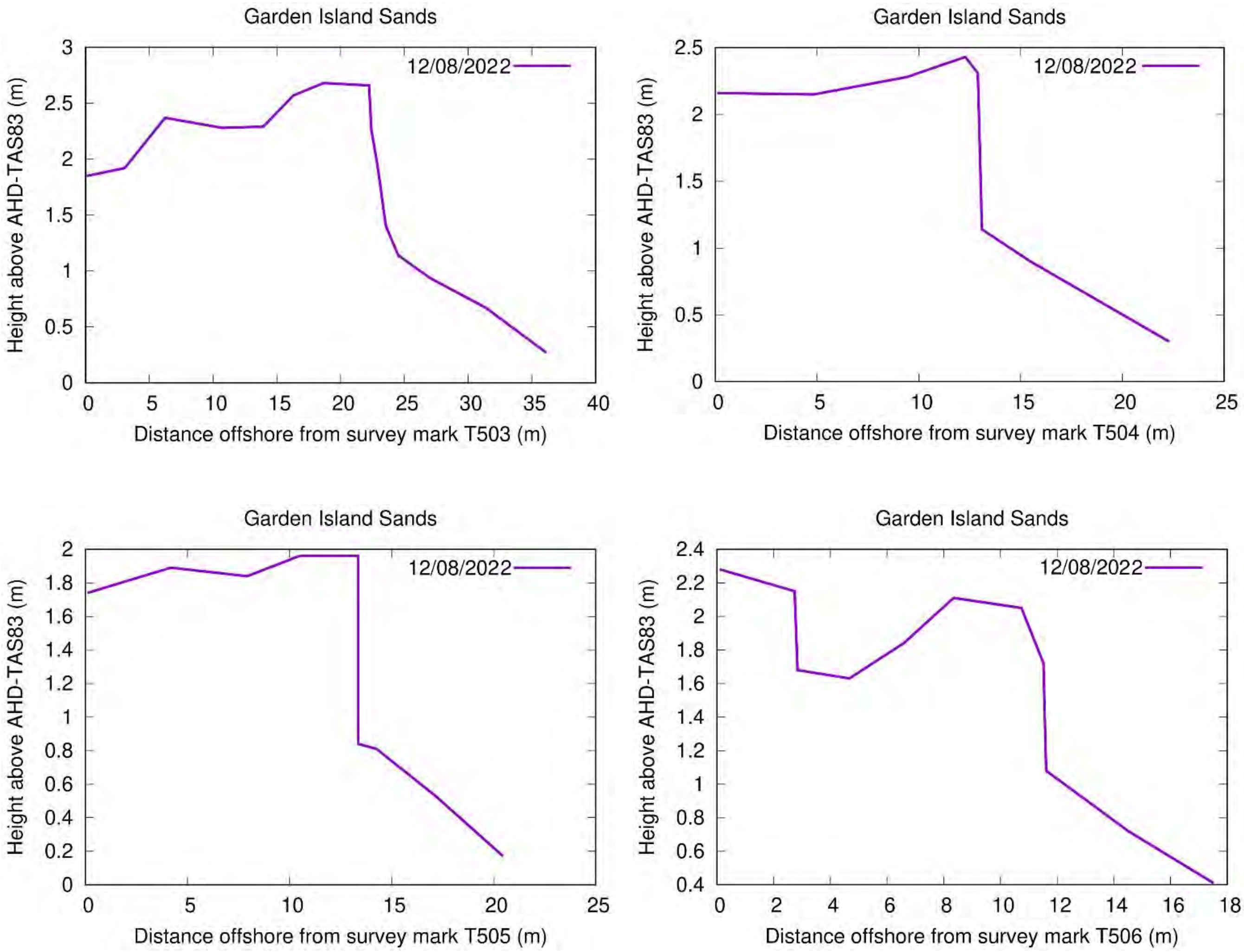


Figure 17: The first TASMARC profiles surveyed from the 4 survey markers at Garden Island Sands Beach, on 12th August 2022. Survey plots prepared by Nick Bowden; scales are in metres. Note that the vertical scale is exaggerated compared to the horizontal scale, which makes all landform features appear steeper and higher than they really are (albeit the vertical erosion faces are indeed as steep as they appear, but their height relative to the horizontal scale is exaggerated).

then surveyed profiles along transects running directly seawards from each mark using Total Station methods. The profiles run across the foredune and beach surface to the lowest seawards point accessed on the beach. The position of each survey mark was subsequently surveyed into the State Permanent Marker (SPM) network on 25th August 2022 by Elliott Cromer using professional GNSS survey methods. The surveyed position of each mark is estimated to have an error margin of ±50 millimetres relative to the metric Map Grid of Australia (Zone 55, GDA2020 datum). The locations of the survey markers are provided in Appendix 4 Table 5, and are indicated on Figure 16 above. The original survey data sheet for each survey marker and the initial profile surveyed along each transect on 12th August 2022 is also reproduced in Appendix 4.

The initial survey profiles are reproduced in Figure 17 above. These can be considered as baseline cross-sections ("profiles") of the beach and foredune against which all future surveys along the same transects from the same survey marks can be compared to detect changes. However, it is important to note that these profiles do not depict the beach and dune in any sort of "original" state, but rather show the state of the beach and dune during 2022 after about 2 decades of accelerated erosion (as determined from air photo analysis in section 3.4.2 below). For instance, the air photo analysis indicates that the foredune shown on the plots from survey marks T504 and T505 (Figure

17) has lost approximately half of its bulk and width since 2000 through accelerated erosion (see further below).

The profiles plotted on transects T503, T504 and T505 all depict recent near-vertical erosion scarps on the seawards face of the dune. The scarp at T503 is not quite vertical due to some slumping and incipient dune accretion in front of the scarp. This transect is located within the western part of the beach (near 'A' on Figure 15) which has both historically and currently been less prone to erosion than the central to eastern parts of the beach (see section 3.2). Comparison of the TASMARC plot (Figure 17) with digitised air photo shorelines (vegetation lines equivalent to the seawards front of the foredune) indicate that the foredune at T503 has lost about 8 metres of its width since 2001, with about 20 metres width remaining.

In contrast, the scarps at T504 and T505 are fresh, completely vertical and are located within the central to western part of the beach which has shown greater rates of erosion both historically and recently (see Sections 3.2 & 3.4.2, and Figure 15). Notably, all three profiles (T503, 504, 505) slope down to landwards from the crest of their erosion scarps. This implies that erosional recession of the foredune has already removed the entire front slope of the foredune and is now progressively eroding through the backslope of the foredune. Comparison of the TASMARC plots from T504 & T505 (Figure 17) with digitised air photo shorelines (vegetation lines equivalent to the seawards front of the foredune) indicate that the foredune fronts at T504 and T505 have lost 12 m and 10m of their width respectively since 2001, with about 10m and 13m respectively remaining.

The profile plotted on transect T506 has been surveyed across part of the small but highly variable grassy sand spit at the eastern extremity of the beach. This sandy feature at times partly grows across the mouth of the Garden Island Creek estuarine lagoon from its western side but may then be removed by creek and tidal discharges from the lagoon (see 'D' on Figure 15, and also Figure 29). Although the position of this spit has been slowly receding landwards along with the rest of the beach, it also has continued to exhibit larger and more rapid cycles of erosion and accretion than the rest of the beach (Figure 20 bottom plot). One result of this is that the overall dune surface still continues to rise inland, unlike the other three profiles noted above. This is probably because after erosion events this location receives large volumes of the sand eroded from the rest of the beach, which drifts dominantly eastwards towards the lagoon (as discussed in section 2.4.6) and can rapidly accumulate (accrete) at this location. The T506 plot shows both a current erosion scarp on its seawards (RH) side, and also an older scarp face about 10 metres inland from the current scarp. This is interpreted as the result of a large erosion event, which was then followed by the spit accreting rapidly with sand drifted east from the erosion of the main beach, but fast enough as to not first fully cover the prior scarp. In this interpretation the small current seawards scarp is the result of a later and probably lesser erosion event.

3.4 Air photo history

Air photo analysis has provided the most important and reliable information currently available on the behaviour of Garden Island Sands beach and foredune since 1948. The following subsections outline the methods used (section 3.4.1) and the results obtained (section 3.4.2).

3.4.1 Methods

This subsection briefly summarises the methods used to extract this information from the historic air photo record for the Garden Island Sands. Further description and explanation of the methods used is provided in Appendix 3. Appendix 1 lists details of all the air photos used for this project, and Appendix 2 lists the digitised shoreline position files (shapefiles) prepared using the ortho-rectified air photos.

Scanned copies (mostly at 2039 dpi) of all air photos covering Garden Island Sands Beach at scales of 1:45,000 or (mostly) better were obtained from the Department of Natural Resources and Environment Tasmania (NRE), which is the custodian of most historical air photos of Tasmania. Air photos from 39 dates were obtained, ranging from 1948 until 2021. Several of these were already ortho-rectified[5] by NRE, and one of these with good contrast and resolution (19th Dec. 2015, with 0.1m pixels) was selected as a reference image against which all other unrectified air photos were geo-registered[6] and ortho-rectified by Chris Sharples using Landscape Mapper™ software. This reference image was assigned a relative position error margin of 0.0 m by convention. Well-defined fixed features (e.g., distinctive coastal rock outcrops) on the reference photo were selected as ground control points (GCPs) to enable ortho-rectification of other photos in the time series relative to the reference photo. For each ortho-photo, position error margins were measured solely by one operator (Chris Sharples) as the mean (average) of the relative apparent displacement of at least 10 reference points (not the GCPs used in ortho-rectification) from their position on the reference photo. These photogrammetric error margins are arguably the main source of uncertainty for the shoreline position proxy and data source used, albeit more sophisticated uncertainty analyses are possible (Fletcher et al. 2011).

A shoreline behaviour history for Garden Island Sands Beach was compiled by using the seawards *in-situ* (living) vegetation line visible on the air photos as a standard shoreline position indicator or proxy (Boak & Turner 2005). The vegetation line is mostly a good indicator of eroded and receded shores (indicated on air photos by the vegetated top of a foredune erosion scarp) or of accretion and progradation of dunes and beaches (indicated by a lightly or heavily vegetated incipient dune front). Examples of both were mapped at various dates from the air photos used in this project. Some advantages of and limitations on the use of this shoreline proxy are described in Appendix 3

At each air photo date, a line representing this feature was manually digitised (as an ESRI shapefile) over the ortho-rectified air photo along the full approximately 500m length of Garden Island Sands Beach. Despite the presence of overhanging tree and shrub canopies as well as shadows obscuring parts of the vegetation line in most photos, sufficient sections of the identifiable vegetation line were visible in most photos as to allow most of the line to be reasonably interpolated between its visible sections[7].

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[5] Ortho-rectification is the process of removing certain inherent distortions from air photos so as to produce an accurate 2-dimension image of features on the ground surface in their correct positions and shapes relative to each other.

[6] Geo-registration assigns map co-ordinates to an ortho-rectified air photo so that it can be correctly positioned and oriented in mapping software.

[7] Some apparent anomalies resulting from using the vegetation line as a shoreline indicator were identified. For example, in some earlier photos, bare sand (possibly windblown?) behind the west end of the beach seems to extend some metres landwards behind the crest of the foredune in parts of the beach with no clear scarp, particularly at the western end of the beach. In this case the shoreline position (vegetation line) is not

The shoreline feature (vegetation line) was manually digitised as a line for each air photo date using a consistent process performed by only one operator (Chris Sharples). During the process of shoreline digitising, several air photos were rejected by reason of poor image quality (see Appendices 1 & 2), with the result that the final air photos used for shoreline behaviour analysis comprised photos from 34 dates ranging from 1948 to 2021.

In addition, the equivalent present-day shoreline feature (mostly the vegetated top edge of a fresh foredune erosion scarp) was surveyed in the field on 25th August 2022 by Elliott Cromer using high-accuracy survey methods, and this survey has been converted to a shapefile and added to the digital shorelines listed in Appendix 2. This most recent shoreline brings the total of digitised shoreline positions used for shoreline history analysis to 35 at dates ranging from 1948 to 2022.

Shoreline change over time was measured using the *Shoreline History* App developed by Dr Michael Lacey at the University of Tasmania. Shoreline change was measured as horizontal movement (landwards or seawards) of the digitised shoreline position over time along each of a series of 18 shore-normal digital transects spaced 25 m apart along the whole Garden Island Sands Beach shore (see Figure 19). See also Appendix 3 for further explanation and illustrations of the analysis method used.

Visual inspection of the shoreline history plots allowed grouping of transects with differing internally coherent histories in different parts of the beach (see Figure 19 and Figure 28). The median of the shoreline positions at each date across all transects in each group was then plotted to provide a final quantitative shoreline history summary for each coherently behaved group of transects. Figure 24 provides the final data plot for one of the two main sections defined for Garden Island Sands Beach in this fashion, with air photo position error bars derived as described above. From these plots, further analyses have been performing in some cases, including linear regression plots (or fits) to whole plots (Figure 24) or to sections of plots visually identified as representing long term changes in beach behaviour (e.g., see Figure 25). See also Appendix 3 for further explanations and examples of the data analysis methods used in this work.

Additional aspects of the history of beach changes at Garden Island Sands Beach have been analysed using the original shoreline plots (e.g., Figure 18 and Figure 27) and the original air photo imagery itself (e.g., Figure 29). These methods are described as needed in Section 3.4.2 following.

3.4.2 Air photo history results

As described in section 3.4.1 above, shoreline positions (defined as the *in-situ* seawards vegetation line) were plotted and digitised from each aerial photo used (listed in Appendices 1 & 2), together with an equivalent ground-surveyed 2022 shoreline. The resulting 35 shorelines dating from 1948 to 2022 are all shown plotted together on Figure 18 below. Eighteen 25m-spaced shore-normal transect lines were digitally generated across the full set of historic shorelines. These were used to measure and plot shoreline histories (movements or changes) along each transect as shown on Figure 19 and Figure 20 (see also section 3.4.1 above and Appendix 3 for further explanation of these data analysis methods).

Beach behaviour summary

Based on visual inspection of shoreline history plots along all transects, the beach was divided into 4 sections whose transect plots are grouped according to distinctive shoreline behaviour histories. These are shown as 4 separate inset shoreline history plots on Figure 19 and Figure 20. The same figures also show the earliest (15th Dec. 1948) and most recent (25th Aug. 2022) digitised

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the front of the dune as it is in most cases, however anomalies such as this were uncommon and probably do not significantly effect the interpretation of long term (multi-decadal) shoreline change trends.

shorelines, whose differences highlight some of the key historical differences between the 4 distinctive sections of the beach. The historical behaviour of each of the 4 distinctive sections based on visual inspection of the plots is briefly outlined below, and following sub-sections describe the data analysis used to define the historical shoreline behaviour more rigorously and quantitatively within the two main (longest) beach sections (transects 3-6 and 6–17).

Transects 1-2 ***Far north-western end of beach / dune:*** The beach shoreline (vegetation line) around transects 1 & 2 (see Figure 18 and Figure 20) showed highly variable behaviour between 1948 and 1966, with both apparent recession and then progradation (with incipient dune expansion) over a range of nearly 9 metres. The (dry) beach face itself was also quite variable in width over about the same period, ranging from about 15m wide on transect 1 in 1948 to 30 m wide on the same transect in 1967. However subsequent to 1966, the shoreline variability changed to a slow progressive trend of dominantly shoreline recession (see Figure 20). The net shoreline recession over the whole 1966 to 2022 period was up to 14 metres with little variability in the long-term rate of recession, and in particular no major change of behaviour around 2000 (as did more notably occur on transects 3 to 17: see below).

Transects 3–6 ***North-western part of beach:*** Like the area of transects 1 & 2, the shoreline position and beachface width in the adjacent area of transects 3 to 6 also shows notable variability (erosion then recovery) in the early period of the air photo record until circa 1965. However, in contrast to the north-western end of the beach, from 1965 until around 2000 the shoreline positions at transects 3 to 6 shows some notable short-term variability (cyclic shoreline erosion and recovery), which the plot indicates is a "dynamic equilibrium" around a stable to possibly slightly receding long-term (multi-decadal) shoreline position. Then a notable change of behaviour occurred circa 2000, following which the shoreline behaviour has been dominated by a significant erosion and net recession trend which is continuing at present (see Figure 19 top plot and Figure 23), albeit at a slower rate than the central to south-eastern part of the beach (see below). This section of the beach comprises much of the same beach and dune section whose present-day condition is classified as "Eroded sandy shore with significant recovery" on Figure 15 above.

Transects 6 – 17 ***Central to south-eastern main part of beach:*** This is the longest coherently-behaved section of the beach and foredune, and shows both the greatest amount of historical shoreline recession (see Figure 18) as well as the most freshly active current erosion (see Figure 15). The shoreline history plots for this long section of the beach (Figure 19 bottom plot and Figure 26) show some cyclic variability (erosion and recovery) around a long-term stable to possibly slightly receding shoreline position from at least 1948 until circa 2000. Then around 2000 there is a distinct change to a rapidly receding shoreline trend which has continued up to the present. This shoreline behaviour history is (after 1965) similar to that seen on the adjacent transects 3-6 (see above) but shows a more rapid rate of shoreline recession since 2000 than the latter, and fresher more active foredune erosion scarps at the present time (2022).

Transect 18 ***South-eastern extremity of beach:*** This transect crosses a small sandspit which is the extreme south-east end of the beach and protrudes partly across the mouth of the Garden Island Creek estuarine lagoon. For context, this transect has been plotted along with the adjacent transect 17 (Figure 20 bottom plot), with which it shares a similar behaviour history. Visual inspection of the shoreline history plot indicates highly variable short-term erosion and accretion (recovery) cycles throughout most of the air photo period, with a slight overall trend of shoreline recession over the whole period. At a more detailed level the plot is also suggestive of a dominantly stable ("dynamic equilibrium") average shoreline position from 1965 to 2000 followed by a minor net shoreline recession trend from circa 2000 until 2022. However, there is less confidence in this interpretation at this location due to the limited data available. Indeed, careful inspection of the plot suggests a significant net recession from 2000 to 2022 on transect 17 but not significantly on transect 18. The highly variable short-term behaviour of this part of the beach is consistent with it being a small sand spit at the mouth of the adjacent lagoon and thus likely to be regularly scoured

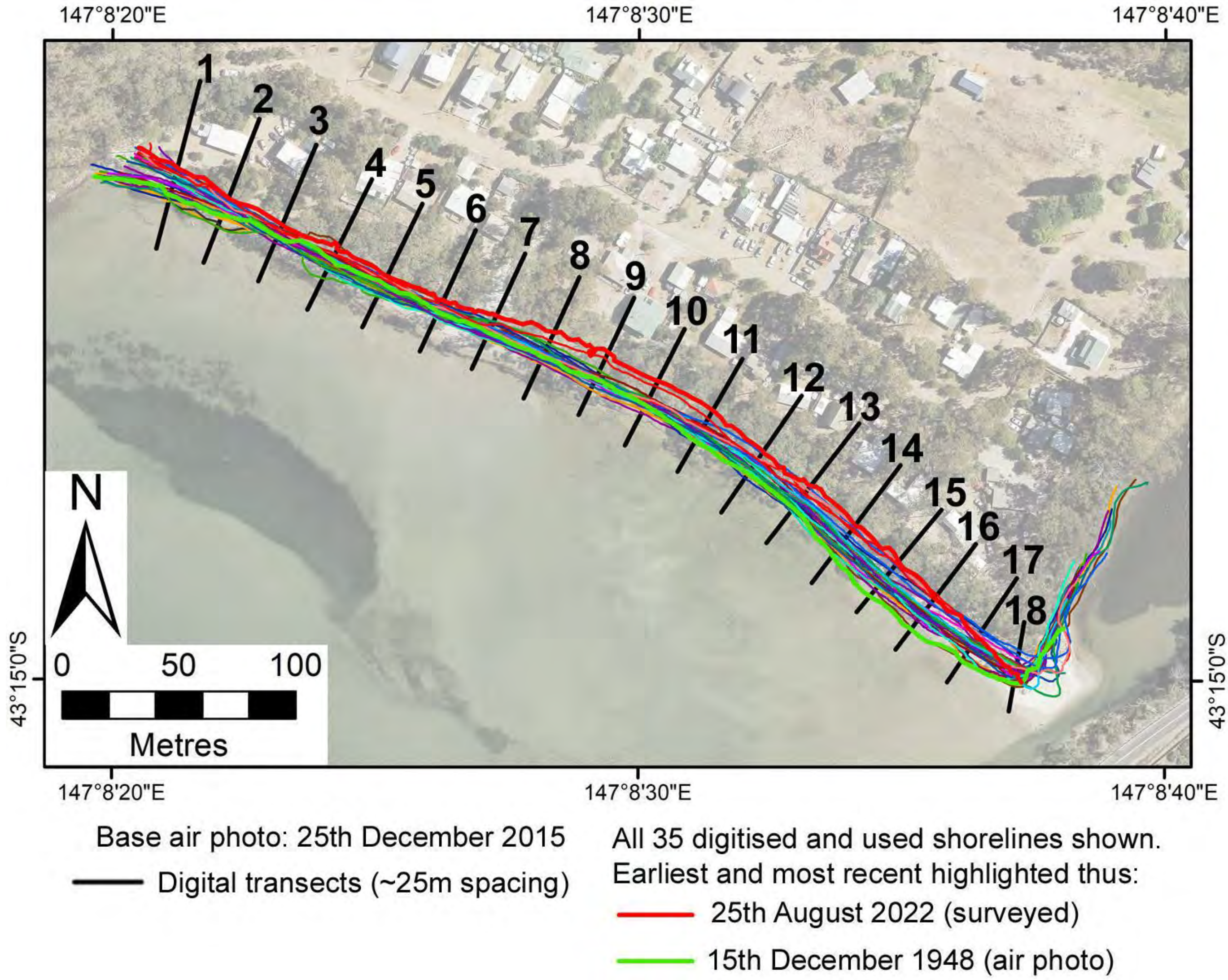

Figure 18: Air photo figure showing all 35 used and digitised shorelines plotted together. Digital transects (as used to construct shoreline history plots on Figure 19 and others) are shown for reference. This shows the variability of the mapped shoreline positions, from the earliest air photo date (15th Dec 1948: thick green shoreline) until the most recent equivalent surveyed shoreline (25th August 2022: thick red shoreline). Note that the wider shoreline variability zone (approximately the central to south-eastern 2/3rds of the beach) corresponds closely with a more active "fresh erosion scarp" zone indicated on Figure 15 above, whereas the narrower shoreline variability zone to its north-west corresponds to the less active "eroded sandy shore with significant recovery" on Figure 15. Background image is the 25th December 2015 air photo (© NRE).

and eroded by river discharges and tidal currents, but also receiving a large supply of eroded sand from the beach after erosion events that drifts south-eastwards along the beach and 'piles up' at the lagoon mouth (see section 2.4.6). The current condition of this part of the beach during 2022 was classed as "actively accreting" (see Figure 15), albeit some older and more recent erosion scarps were also visible on parts of the sand spit (see Figure 17, TASMARC profile T506).

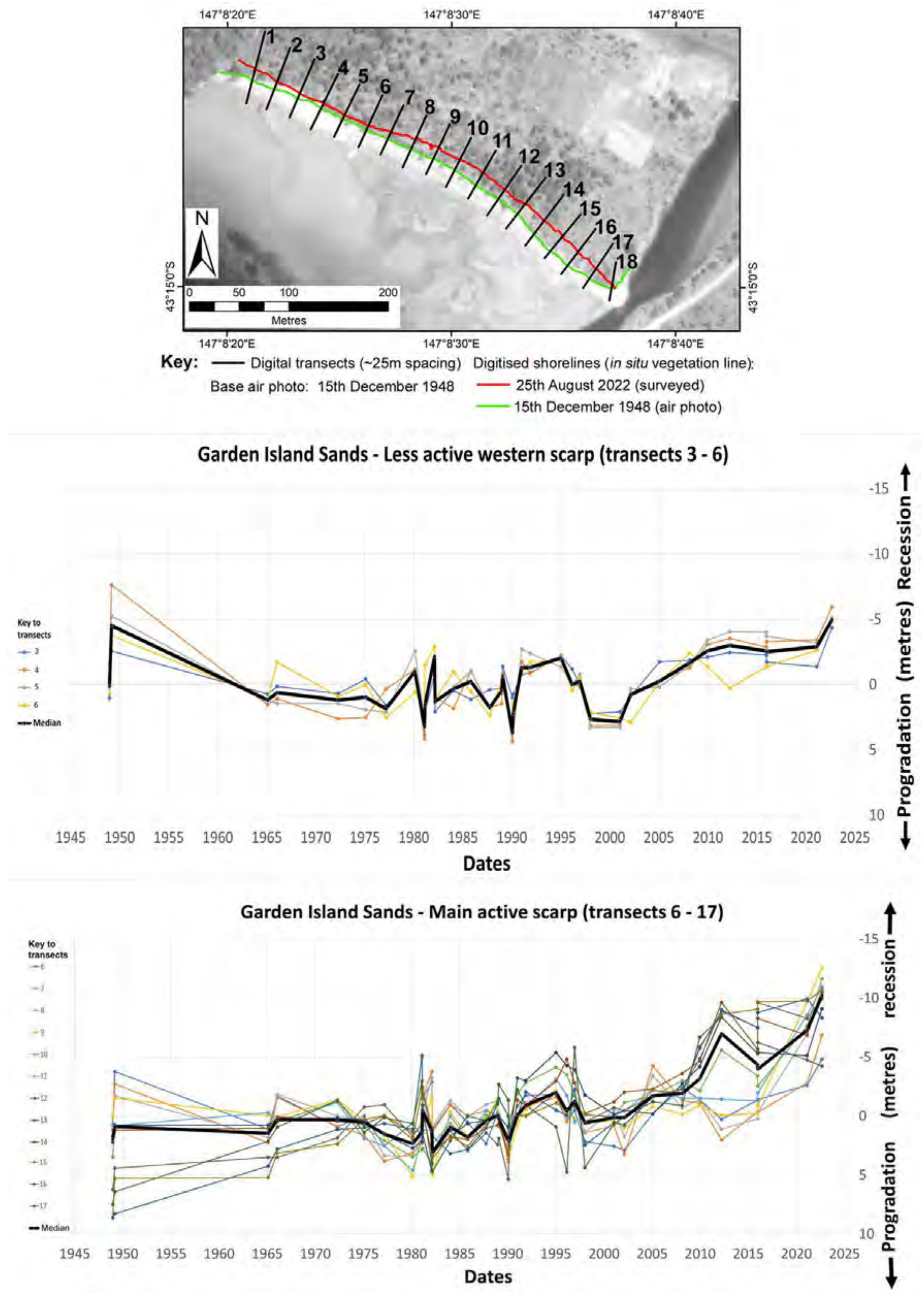

Figure 19: Shoreline history plots for Garden Island Sands Beach: Main transect groupings. These plots show the beach history (changes in shoreline position) along each transect, grouped into the main active beach section at transects 6-17 and the less active north-western section at transects 3-6). These sections correspond closely to the current variations in condition along the beach as shown on Figure 15 above. The shorter, different and at times more variable beach ends (transects 1 & 2, and 18) show more variable behaviour and are plotted separately in following Figure 20. The transect map at top shows the location of the transects along which these shoreline histories were plotted and maps the position of the earliest (green) and most recent (red) shoreline positions along the whole beach. See Appendix 3 for further explanation of how these plots are constructed.

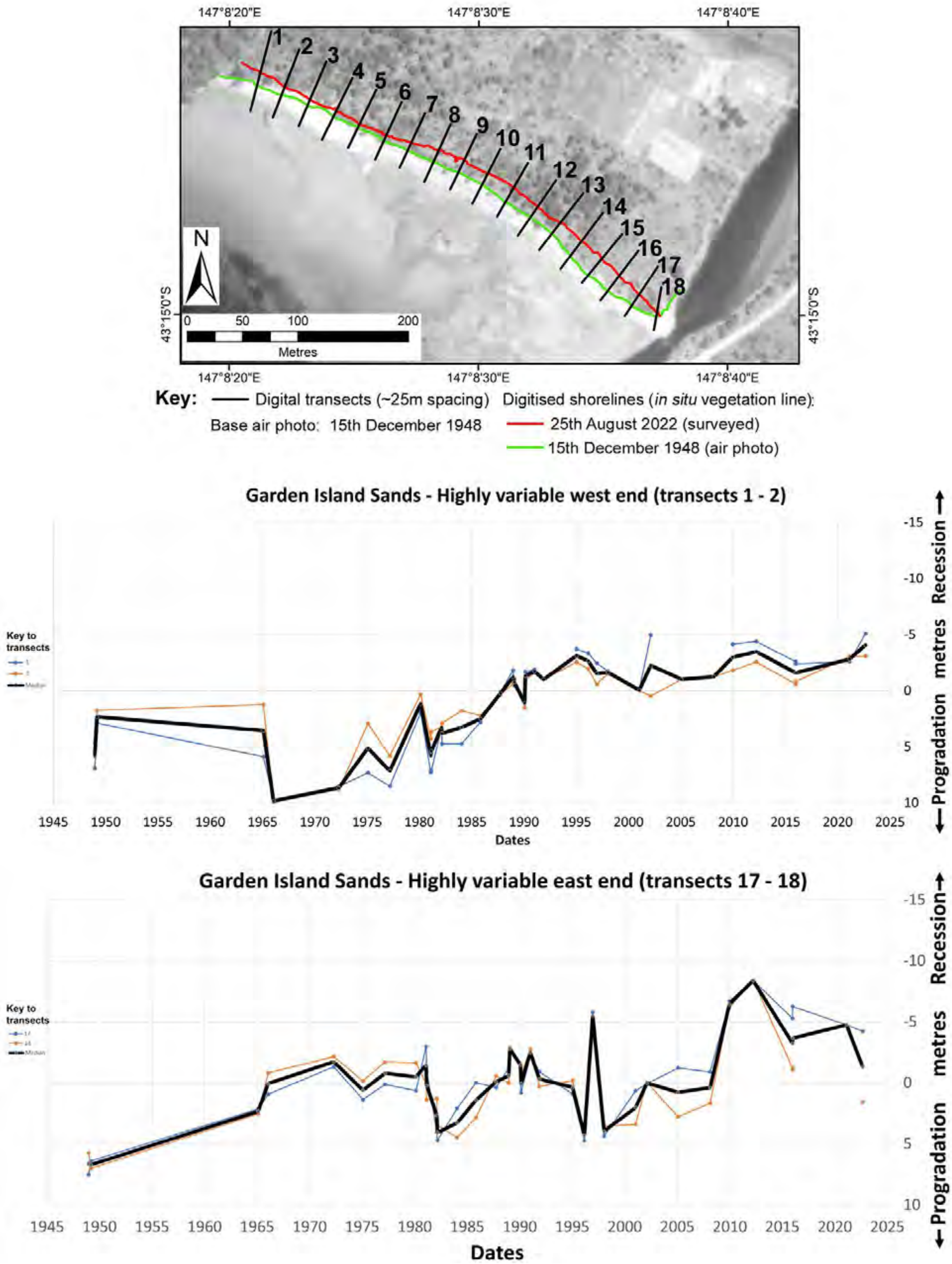

Figure 20: Shoreline history plots for Garden Island Sands Beach: Minor transect groupings of highly variable beach ends. Refer to preceding text descriptions for explanations of these plots. Transect map at top shows the location of the transects along which these shoreline histories were plotted and maps the position of the earliest (green) and most recent (red) shoreline positions along the whole beach. See Appendix 3 for further explanation of how these plots are constructed.

Statistical analysis: Main beach behaviour zones

The following discussion provides additional details supporting the identification of the main shore behaviour patterns described above, namely those identified on transects 3 to 6, and 6 to 17. The following plots and details use photogrammetric error margins and linear regression fits to assess the statistical significance and reliability of the main historical trends identified in the Garden Island Sands Beach data, as outlined above.

Transects 3-6 – *North-western part of beach:* *Early variability then dynamic equilibrium around a stable to slightly receding shoreline from 1965 to circa 2000, followed by a distinct change of behaviour to a moderate rate of progressive shoreline recession up to the present.*

Figure 21 to Figure 23 below show the same data for these transects as that provided in Figure 19 (top plot) above, but summarised by using only the median shoreline position across all the transects at each date rather than all the individual transect plots. Also shown here are the photogrammetric error margin bars at each air photo date (see section 3.4.1 and Appendix 1).

Figure 21 shows a single linear regression line fitted to the whole dataset. Whereas the linear fit suggests a slow overall net recession over the whole data period, the Pearson correlation co-efficient is quite low ($R^2 = 0.1136$) and evidently biased by some early (pre-1965) apparent outlying data points. Hence this fit appears unreliable.

However, visual inspection of the data is suggestive of a relatively stable long-term shoreline position from 1965 to 2000, with notable but short-term beach erosion and recovery cycles, followed by a distinct change to continuous shoreline recession trend after 2000. The statistical significance of this apparent change of behaviour was tested by applying separate ("piecewise") linear fits to the data before and after 2000, both unweighted (Figure 22) and weighted (Figure 23) according to the measured error margins at each photo date. Both methods yield a high Pearson correlation co-efficient on the post-2000 data indicating a statistically significant recession trend ($R^2 = 0.8001$ to 0.7862). Low correlation co-efficients ($R^2 = 0.0500$ unweighted and $R^2 = 0.0474$

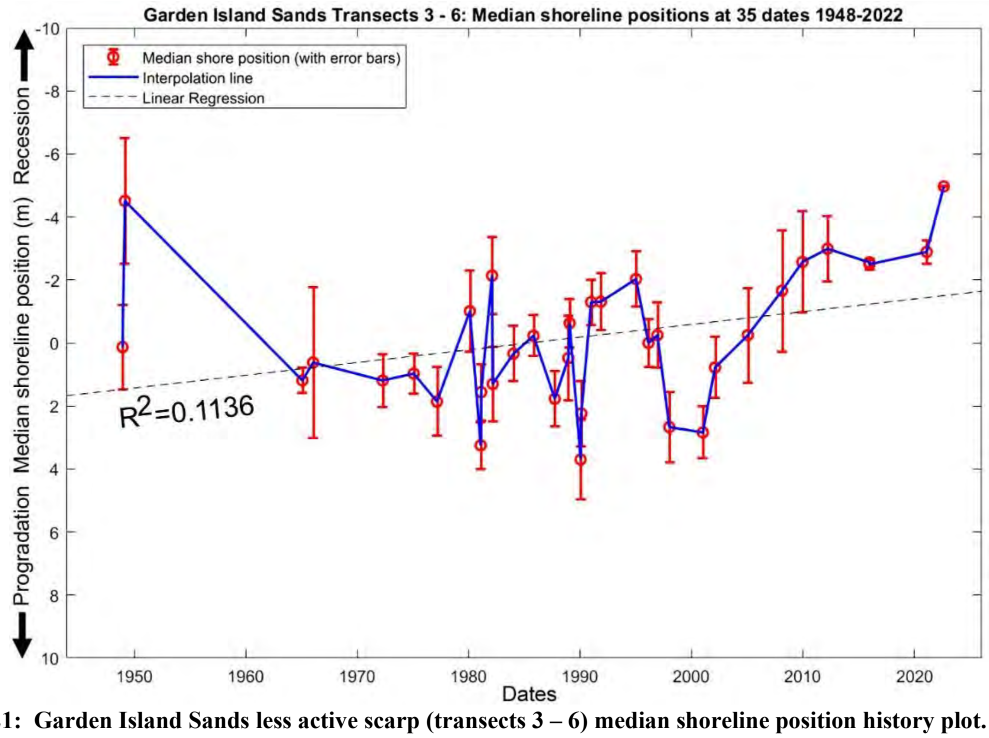

Figure 21: Garden Island Sands less active scarp (transects 3 – 6) median shoreline position history plot. Data error margins (see appendix Table 3) and unweighted linear fit to entire history plot shown. Overall, only a very weak trend towards recession is evident from the overall linear fit, and it is arguable that no long-term trend is present. Nonetheless following plots test for a plausible change of behaviour around 2000, as is seen in the main active area of this beach (see Figure 25 & Figure 26 below).

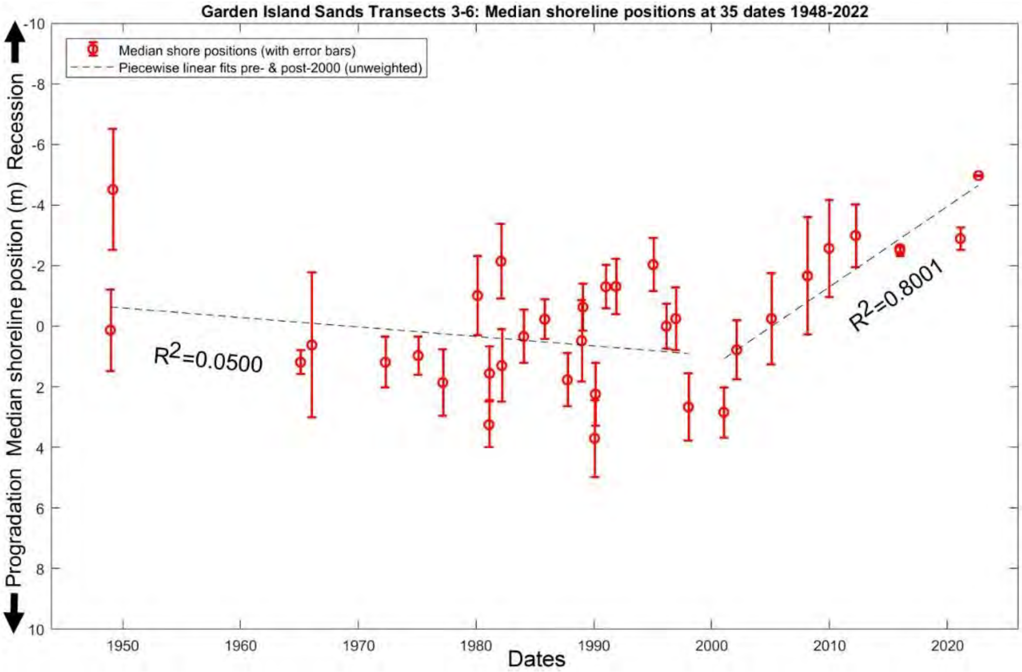

Figure 22: Garden Island Sands less active scarp (transects 3 – 6) median shoreline position history plot with piecewise linear fits. The piecewise fits around 2000 show no significant trend before 2000, but a strong trend towards shoreline recession after 2000, as is also seen in the more active part of this beach (see Figure 25 & Figure 26 below).

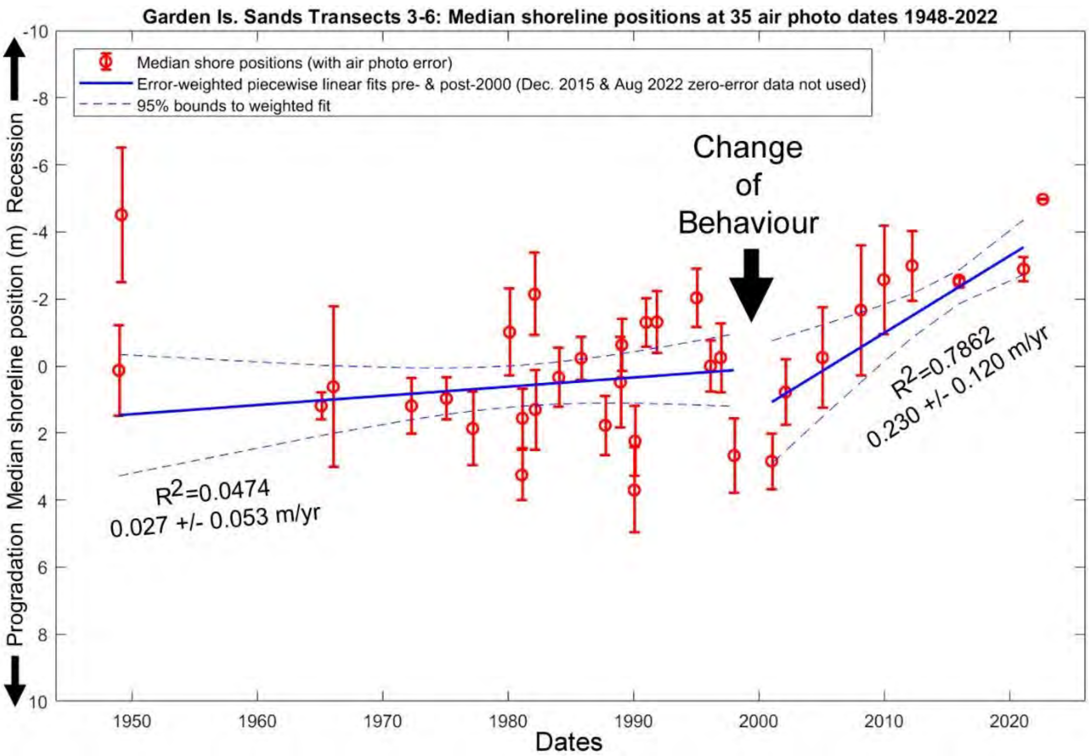

Figure 23: Garden Island Sands less active scarp (Transects 3 – 6) median shoreline position history plot with error-weighted piecewise linear fits. This is the same data shown in Figure 21 above, but with interpolation lines between data points omitted. This figure shows error-weighted linear fits before and after a visually determined apparent long-term change of behaviour around 2000. A clear Change of Behaviour around approximately 2000 is indicated, from a stable or slightly receding pre-2000 shoreline position to a strongly receding post-2000 shoreline position (with a high degree of confidence indicated by the R2 (Pearson) correlation co-efficient). However, whereas a Change of Behaviour is clearly indicated there has not yet been a "Time of Emergence" since the new post-2000 recession trend has not yet emerged above the pre-2000 noise (error margins). Also note that the R^2 (Pearson) correlation co-efficient for the strongly receding post-2000 section is less than that calculated for the unweighted version above (Figure 22) because two zero-error points in that section had to be disregarded to avoid biasing the error weighting.

error-weighted) for the pre-2000 linear fits are at least partly a result of several very outlying early data points, but visual inspection of these linear fits plausibly indicates a stable to slightly receding long term shoreline trend (with notable short-term erosion and recovery cycles) for the pre-2000 parts of these datasets.

In summary, the air photo data derived from photogrammetric analysis of shoreline changes along the north-western part (transects 3 to 6) of Garden Island Sands Beach plausibly supports the interpretation of a stable to slightly receding shoreline position (with short term erosion and recovery cycles) from at least 1965 until circa 2000, followed by a significant change of behaviour circa 2000 to a strong shoreline recession trend which has continued up to the present. This is a similar but slower post-2000 recession trend to that which has occurred in the central to south-eastern part of the beach (on transects 6 to 17; see below).

Transects 6-17 – *Central to south-eastern main part of beach:* *Stable to possibly slightly receding shoreline until circa 2000, then an abrupt change of behaviour to rapid progressive shoreline recession up to the present.*
Figure 24 to Figure 26 below show the same data for these transects as that provided in Figure 19 (bottom plot) above, but summarised by using only the median shoreline position across all the transects at each date rather than all the individual transect plots. Also shown here are the photogrammetric error margin bars at each air photo date (see section 3.4.1 and Appendix 1).

Figure 24 shows a single linear regression line fitted to the whole dataset. The Pearson correlation co-efficient of this linear fit ($R^2 = 0.5567$) is indicative of a significant net shoreline recession over the whole data set from 1948 to 2022. Moreover, the error margin range of data points at both the older and most recent ends of the data do not overlap, indicating that at least the apparent net recession between 1948 to 2022 is real.

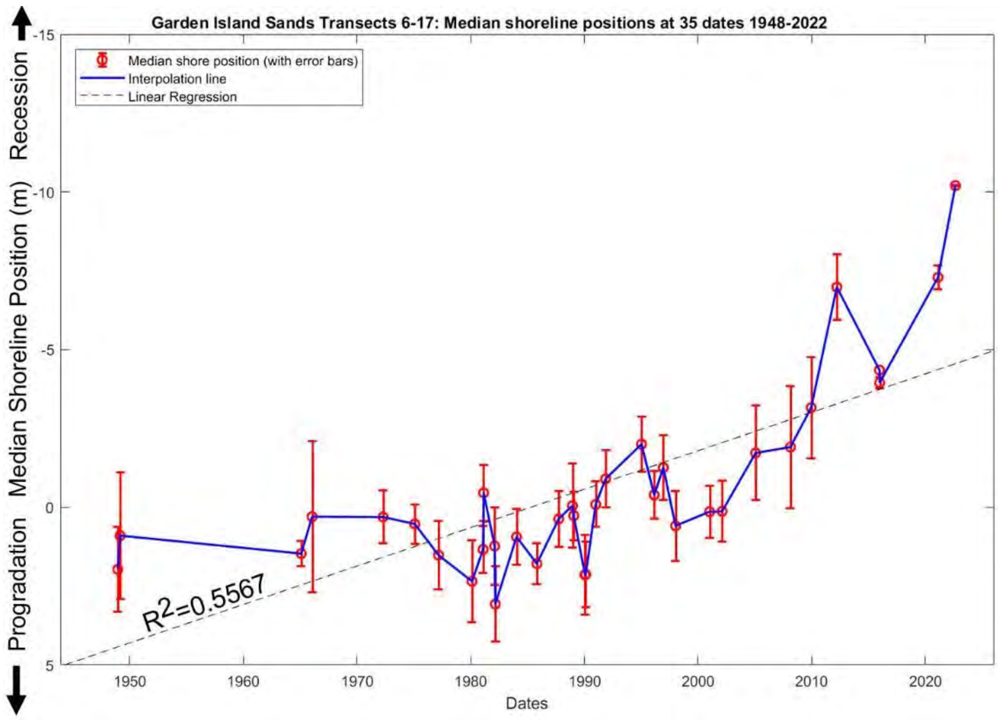

Figure 24: Garden Island Sands main active area (Transects 6 – 17) median shoreline position history plot. This is the same data as shown in Figure 19 (lower plot) above. Data error margins (see Appendix 1 Table 3) and unweighted linear fit to entire history plot shown. An apparent increase in the rate of shoreline retreat is evident around 2000. The significance of this is tested in the following Figure 25 and Figure 26 plots.

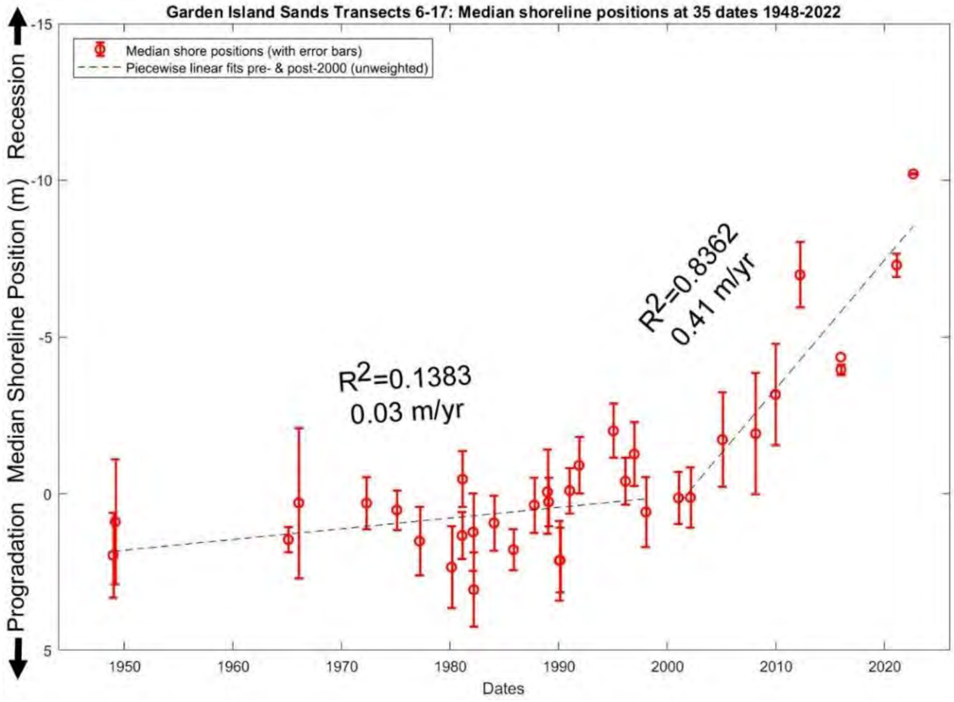

Figure 25: Garden Island Sands main active area (Transects 6 – 17) median shoreline position history plot with piecewise linear fits. This is the same data shown in Figure 24 above with interpolation lines between data points omitted. This figure shows unweighted piecewise linear fits before and after a visually determined apparent long-term change of behaviour around 2000. This yields a weaker pre-2000 linear fit, but the new post-2000 trend has a much better linear fit (R^2 correlation co-efficient) than does a single overall linear fit to the whole dataset. This supports the inference that a major and fairly abrupt change of behaviour occurred around 2000,

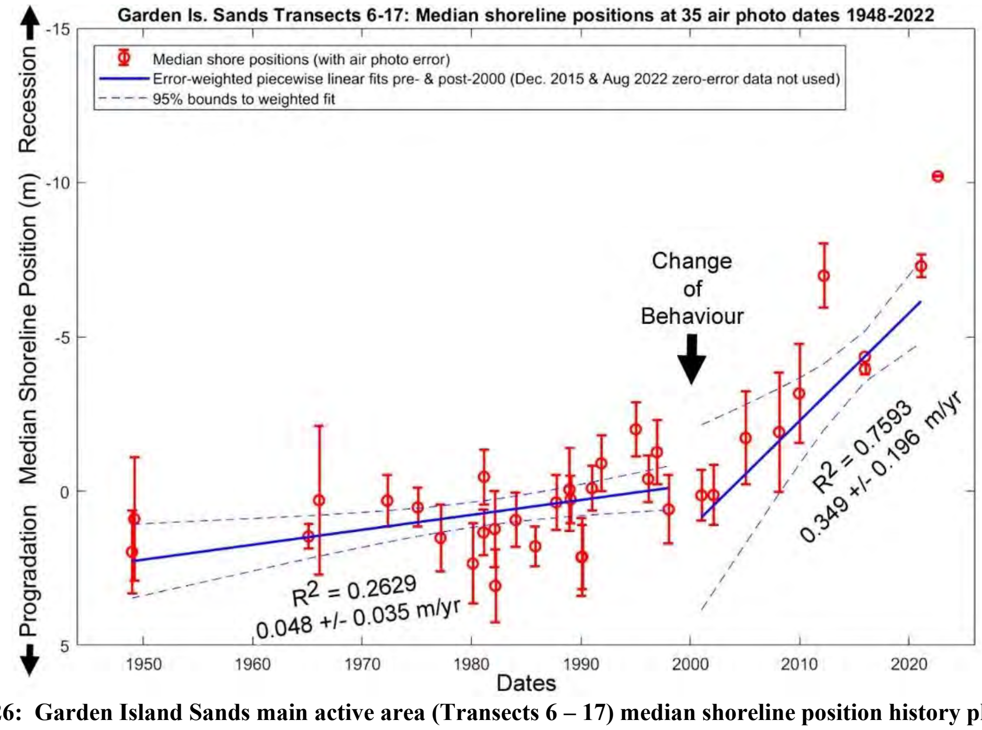

Figure 26: Garden Island Sands main active area (Transects 6 – 17) median shoreline position history plot with error-weighted piecewise linear fits. This is also the same data shown in Figure 24 above with interpolation lines between data points omitted. This figure shows error-weighted piecewise linear fits before and after a visually determined apparent long-term change of behaviour around 2000. This yields a stronger pre-2000 linear fit to a stable to slightly receding trend than the unweighted plot (above) and a slightly lower but still very strong post-2000 linear fit to a recession trend. Note that the R^2 co-efficient for post-2000 data is less than for the unweighted version (previous figure) because two zero-error points (the 19th Dec. 2015 reference image shoreline and the GNSS-surveyed 25th Aug. 2022 shoreline) plotted in that section had to be disregarded to avoid biasing the error weighting procedure.

However visual inspection of Figure 24 does show considerable overlap of the error margins between 1948 and 2000, and the data plot is suggestive of a different (roughly stable) data trend before 2000 compared to a strong recession trend after 2000. The statistical significance of this apparent change of behaviour was tested by applying separate ("piecewise") linear fits to the data before and after 2000, both unweighted (Figure 25) and weighted (Figure 26) according to the measured error margins at each photo date. Both methods yield a high Pearson correlation co-efficient on the post-2000 data indicating a strong recession trend (R^2 = 0.7593 to 0.8362). Correlation co-efficients of R^2 = 0.1383 (unweighted) and 0.2629 (error-weighted) for the pre-2000 data suggest a weaker but still significant stable to slightly receding pre-2000 shoreline behaviour trend with more short-term variability due to normal erosion and recovery beach cycles.

In summary, the air photo data derived from photogrammetric analysis of shoreline changes along the central to south-eastern parts (transects 6 to 17) of Garden Island Sands Beach supports the interpretation of a stable to slightly receding shoreline position (with short term erosion and recovery cycles) from at least 1948 until circa 2000, followed by significant change of behaviour circa 2000 to a strong shoreline recession trend which has continued up to the present. This is a similar but faster post-2000 recession trend to that which has occurred in the north-western part of the beach (on transects 3 to 6).

Summary of statistical analysis

Overall, both transect groups (3–6 and 6-17 as per plots) show a distinct Change of Behaviour around 2000, from a stable to slightly receding long-term pre-2000 shoreline position (with short-term erosion and recovery or accretion cycles) to a strongly and progressively receding post-2000 shoreline position; however, the rate of shoreline recession is much greater (~0.35 m/yr) on transects 6 to 17 than on transects 3 to 6 (~0.23 m/yr). This difference corresponds to the observed level of contemporary erosional activity in these respective sections today, with old erosion scarps showing accretional recovery at transects 3 to 6 while a fresh active erosion scarp shows no sign of foredune recovery at transects 6 to 17 (compare Figure 15 in section 3.2 to Figure 18 in section 3.4.2).

Spatial variability of recession within the main recession zone (transects 6 – 17).

Within the main recession zone described above (transects 6 to 17), visual inspection of the changing shoreline positions over the last two decades demonstrates an additional complexity in shoreline behaviour. This is that two noticeable episodes of more rapid beach and dune recession have occurred in two different parts of the zone at two different times. These are:

- During the period 2008 to 2012 a period of more rapid shoreline recession occurred in the area of transects 14 to 17 (south-east part) compared to the rest of the beach (see Figure 27 shoreline position changes and Figure 28 shoreline history plots below);

and:

- During the period 2015 to 2022 a phase of more rapid shoreline recession occurred in the area of transects 7 to 11 (central part) compared to the rest of the beach (see Figure 27 shoreline position changes and Figure 28 shoreline history plots below).

It is notable that the area of transects 14 to 17 which experienced the greatest recession in the period 2008 to 2012 is also where the greatest amount of historical recession over the whole air photo period (1948 to 2022) has occurred (see Figure 18). In contrast, the increased recession on transects 7 to 11 during 2015 to 2022 has been a more anomalous erosion period for that part of the beach (Figure 18), which otherwise had undergone relatively little shoreline recession from 1948 until 2015 (see shorelines on Figure 18 and top plot on Figure 27). However, this anomalous recent erosion phase has coincided with reduced erosion in the historically more receded area of transects 14-17, suggesting the possibility that a significant long-term switch in shoreline erosion spatial patterns has occurred at Garden Island Sands Beach since 2015.

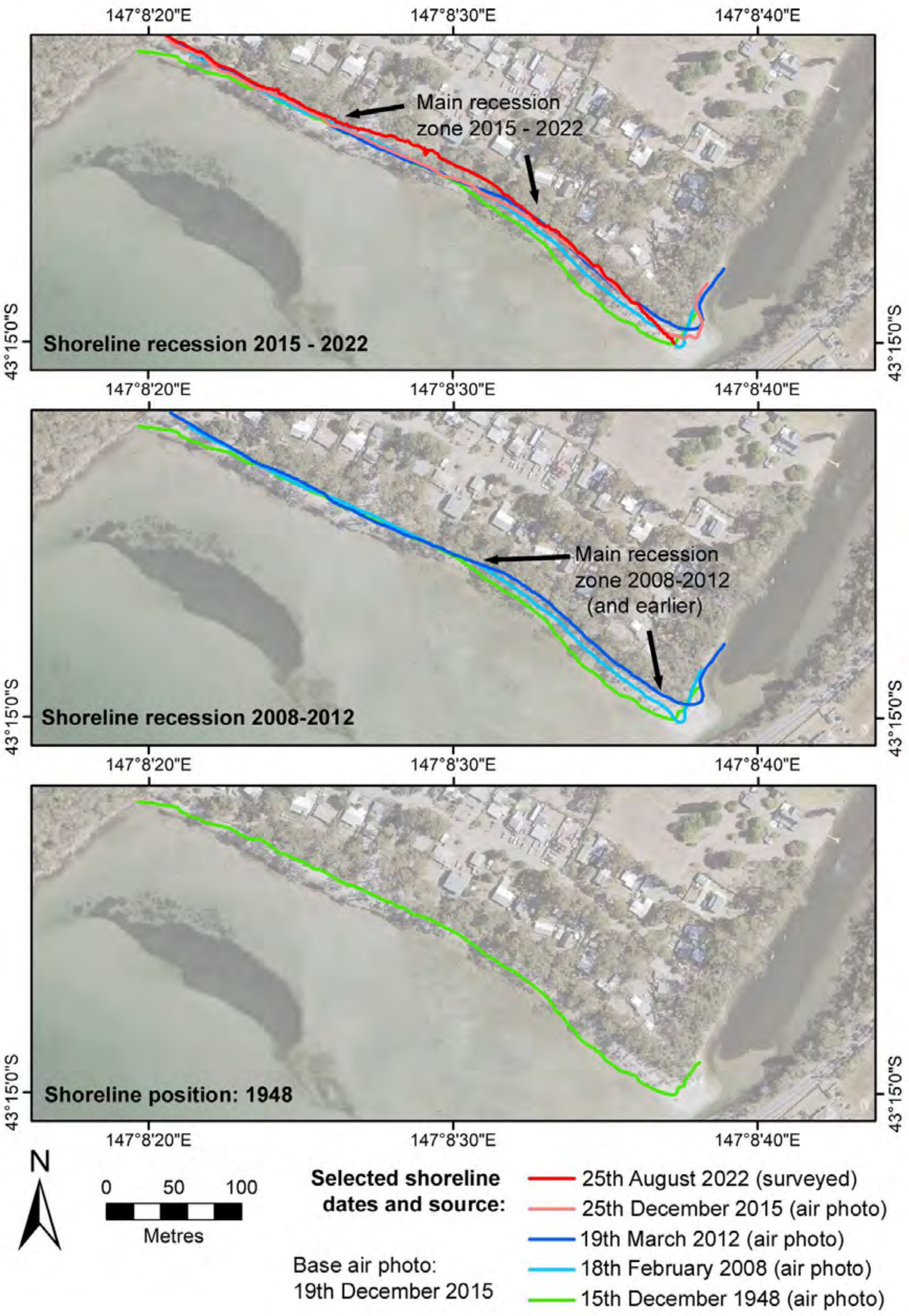

Figure 27: Air photo figure with digitised shorelines highlighting two areas of shoreline recession with differing histories. See also Figure 28 which displays the same histories as plots of shoreline movement along transects. The main recession zone in 2008-2012 is also where most of the recession since 1948 has happened (including during the July 2011 erosion event). In contrast shoreline positions in the 2015 – 2022 recession zone changed little from 1948 until 2015, then have receded dramatically during recent years (while recession in the 2008-2012 recession zone has been negligible).

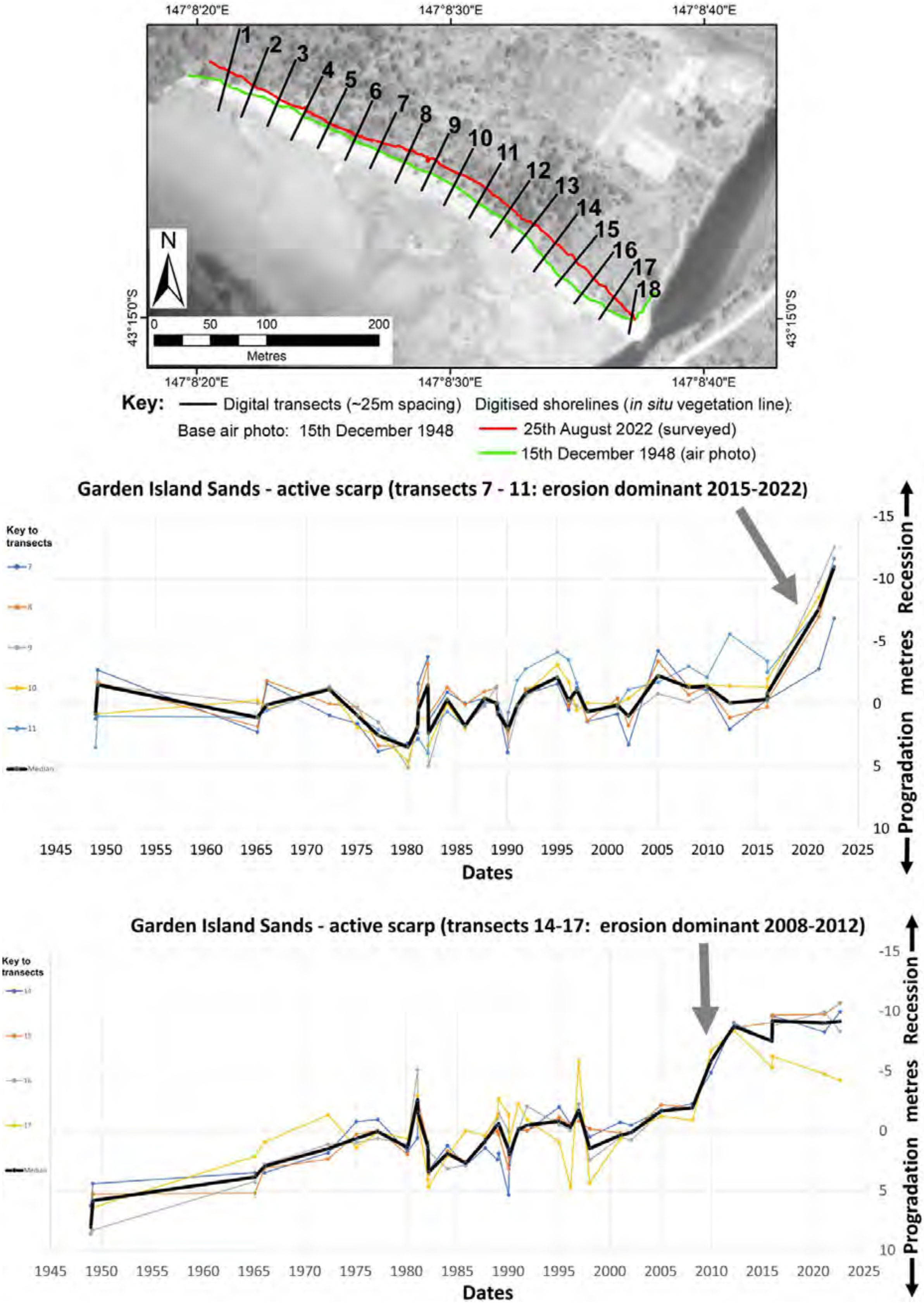

Figure 28: Shoreline history plots – Subsidiary groupings within main active section. These sub-sections show different timings for their most important recession phases: transects 14 – 17 is where most recession since 1948 occurred, including during 2008-2012 (compare Figure 27). Transects 7 – 11 didn't recede significantly until 2015-2022, then has receded dramatically since (also compare Figure 27).

Although it is arguably too soon to confirm that any long-term change in erosion patterns has occurred since 2015, the fact that some change in the spatial focus of erosion at Garden Island Sands Beach has occurred – whether it is merely a short-term variation or a new long-term trend - warrants notice and should be considered in planning any response to shoreline erosion at Garden Island Sands.

The cause of the observed variability in the spatial focus of erosion and recession at Garden Island Sands is not clear at present. However, the fact that the change manifests as a spatial shift in the focus of erosion along the beach is strongly suggestive that it is related to storm wave changes, given that wave direction changes are the most readily apparent and likely cause of any spatial variability of erosion along the beach. If this is the case, wind waves are more likely responsible than swell waves, given that the long swell wave refraction pathway of swells through D'Entrecasteaux Channel to Garden Island Sands means little directional variability in these waves is likely at Garden Island Sands (see section 2.4.2), albeit changes in local sand bars could at times result in differing amounts of swell wave energy reaching different parts of the shore.

As noted in section 2.4.2 above, the broad spatial distribution of erosion at Garden Island Sands suggests that locally generated westerly to south-westerly wind waves (rather than swell waves) are probably the main agent of shoreline erosion at the beach. Given that wind wave directions will vary rapidly with wind direction changes, a changing focus of wave erosion at the beach could be explained by a significant and perhaps long-term change in the dominant wind directions at Garden Island Sands. Thus, the north-westwards change in the focus of erosion along Garden Island Sands Beach observed between 2008-2012 and 2015-2022 (see Figure 27) could be explained by a shift of the inferred dominant westerly to south-westerly wind directions (see section 2.4.1) in a more southerly direction. This is a plausible possibility, however at the present time the writer is unaware of any analysis of Tasmanian wind records to test for such changes, and such an analysis was beyond the scope of the project reported on here. However, such analyses are likely to yield significantly improved understanding of Tasmanian beach erosion processes in future.

Shoreline and sand bar variability in Garden Island Creek estuarine lagoon

Visual inspection of the whole series of air photos from 1948 to 2021 (as listed in Appendix 1) was used to test for any significant changes to the Garden Island Creek estuarine lagoon over that 73-year period (Figure 29 following shows selected examples from the air photo time series).

Map Figure 2 (section 2.3.1) depicts the distribution of shorelines composed of hard rock (dolerite), clean sand and peaty silts around the downstream 1 kilometre of the Garden Island Creek estuarine lagoon (as mapped by Chris Sharples using kayak access during 2022). Erosion scarps are visible in the sandy and peaty-silt shoreline sediments at various locations around the lagoon, with some being relatively fresh and others partly rounded and vegetated inactive scarps. It is likely many of these erosion scarps result mainly from river discharge flood events, although coastal storm surges may also play a role. These estuarine erosion scarps have not been further investigated,

Air photo Figure 10 (in section 2.3.5 "Estuarine Lagoon" above) shows two large point-bar style silty-sand bars in the estuarine lagoon, which are labelled "A" and "B" on the figure. River bars of this type may migrate progressively downstream in meandering or slightly meandering rivers at varying rates depending on grainsize, river discharge and other factors. However, a brief visual comparison of all the air photos available for Garden Island Creek estuarine lagoon from1948 to 2021 (see selected example photos on Figure 29 following) did not identify any major changes on the size or location of these bars over that period.

In contrast, a notable change to sand bars at the lagoon mouth (labelled "C" on Figure 10) was identified over the air photo period. As noted in section 2.3.1, the extreme south-eastern end of Garden Island Sands beach is a small and highly variable sand spit which at times extends partway across the mouth of the Garden Island Creek Lagoon. However, a deep tidal channel generally remains at the mouth due to river discharges and tidal currents being sufficiently strong as to keep the mouth scoured open.

Inspection of all the available air photos showing the lagoon mouth (see Appendix 1) reveals no instance of a shallow or exposed sand bar extending fully across the lagoon mouth from 1948 until after 1998. That is 28 air photo dates across at least 50 years with no evidence of sand bars blocking the lagoon mouth. However, inspection of all subsequent air photos reveals 4 out of 10 available air photo dates from 9th January 2001 until 10th Feb 2021 which do show a shallow or exposed sand bar fully blocking the mouth of the estuarine lagoon. See example photos compiled at Figure 29 (below). A further (fifth) ephemeral sand bar was observed by the writer during early 2022 (see Table 1 below)

The blocking sand bars appear to be "flood-tide deltas" formed when excess sand is available immediately outside the estuarine lagoon (e.g., due to beach erosion), and so is transported into the lagoon by floodtide (ingoing) currents. However, it is evident from the air photo sequence that these blocking sand bars or 'flood-tide deltas" have only been intermittently present after 2001, which suggests that while they may occasionally form in the lagoon mouth (probably due to excess sand availability resulting from a beach erosion events), they still continue to be largely scoured out again and eventually removed, most probably by regular ebb-tide (out-going) currents and occasional river flood discharges. It is likely that the long narrow form of the lagoon contributes to a more concentrated flow of river discharges and outgoing tidal currents than would be the case in a broader lagoon with low-energy backwaters in which sand could more readily settle and remain. Hence the narrow form of the lagoon is likely to contribute to more rapid flushing of excess sand from the lagoon, including temporary build-ups of eroded sand in the mouth of the lagoon.

This evidence is suggestive of a long-term change in the sand budget at Garden Island Sands, with a change after 1998 (and possibly as late as 2001) to an increased supply of sand to the estuarine lagoon resulting in temporary sand bars blocking the lagoon mouth, albeit these continue to eventually be scoured away by tidal currents and/or river discharges. Given the air photo evidence (above) of significantly increased beach and foredune erosion at Garden Island Sands after 2000, this appears to be the most likely source of an increased supply of sand to the lagoon mouth via south-eastwards littoral drift along the eroded beachface.

Table 1: Air photo dates with or without sand bar fully across lagoon tidal entrance. Air photo dates refer to air photos listed in Appendix 1. Note that a small accretionary sand spit at the south-eastern extremity of the beach has extended partway across the lagoon mouth from the beach at all dates, but prior to 2001 this still left a deep tidal channel open at the mouth (see Figure 29). However, from 2001 onwards, there have been intermittent times when a shallow or exposed sand bar extended fully across the entrance (or very nearly so). Examples are shown on Figure 29; and this table identifies all air photos (and a recent fieldwork date) showing this sand bar.

Dates	Sand bar present fully across lagoon mouth?	Notes
15th Dec. 1948 to 9th Jan. 1998	No	Deep tidal channel at lagoon mouth open at all air photo dates.
9th Jan 2001	Yes	Shallow sand bar fully across mouth – first occurrence seen on air photos.
1st Feb. 2002 to 25th Jan 2005	No	Tidal channel entrance open at all air photo dates
18th Feb. 2008	Yes	Very small tidal channel visible at mouth.
15th Dec. 2009 to 19th Mar. 2012	No	
19th & 25th Dec. 2015	Yes	
10th Feb. 2021	Yes	
3rd Jan. 2022	Yes	Field observation – C. Sharples
14th Sept 2022	No	Field observation – C. Sharples (indicates sand bar flushed out sometime between 3rd Jan and 14th Sept 2022)

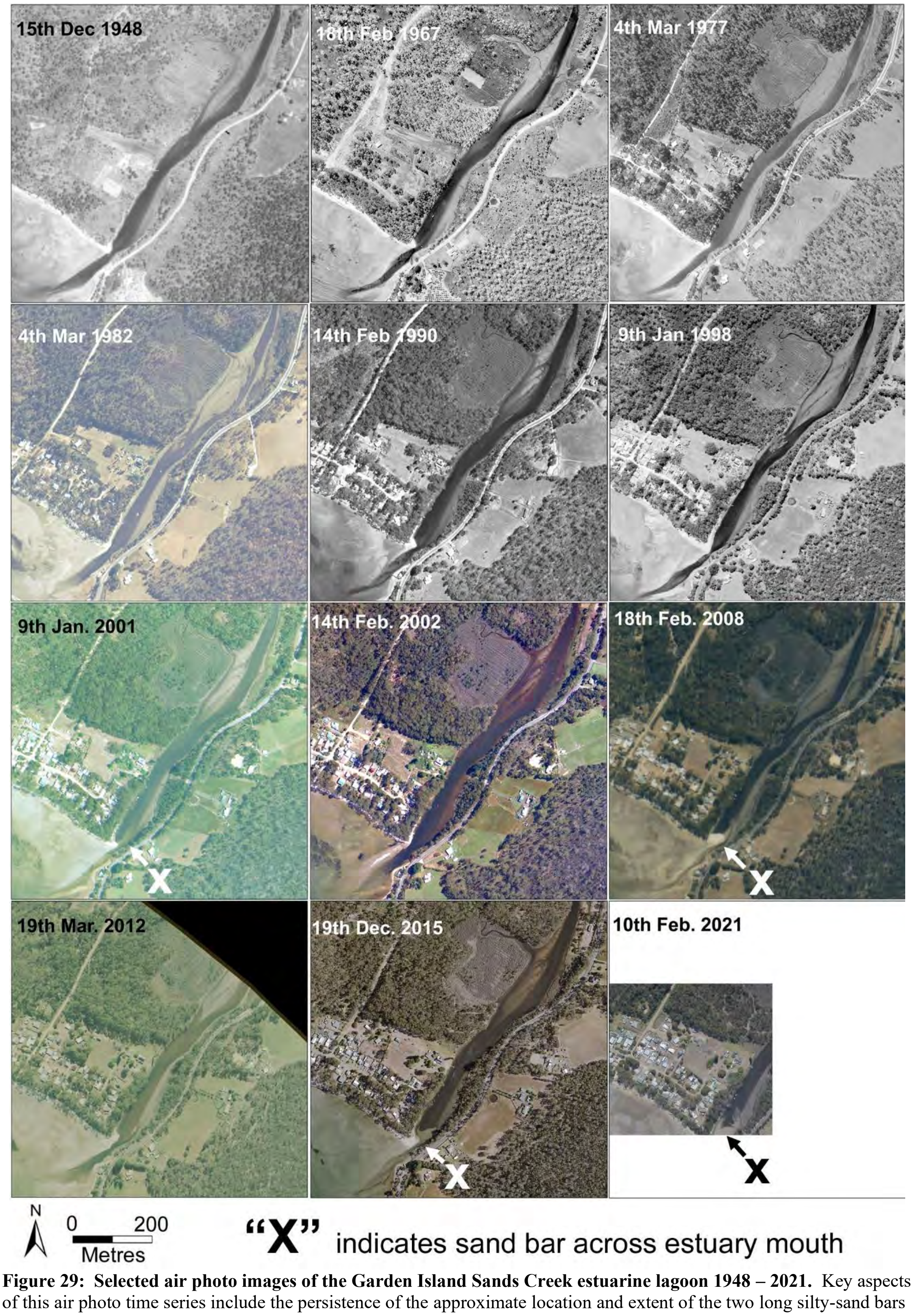

Figure 29: Selected air photo images of the Garden Island Sands Creek estuarine lagoon 1948 – 2021. Key aspects of this air photo time series include the persistence of the approximate location and extent of the two long silty-sand bars offset along opposite shores of the lagoon inside its mouth, and the persistence of the deep open tidal channel mouth of the lagoon at all air photo dates from 1948 until at least 1998. However, a significant change occurred after 1998, when the lagoon mouth has been intermittently but repeatedly filled by temporary sand bars (indicated by "X") which do not appear to be present at any air photo dates prior to 2001. Increased adjacent beach and foredune erosion from circa 2000 onwards appear to be the mostly likely source of such an increased sand supply to the lagoon.

3.5 Summary: Key elements of Garden Island Sands Beach shoreline behaviour history

Key elements of the shoreline behaviour history of Garden Island Sands Beach are summarised as follows. These findings are based on the more detailed analysis and discussions above in sections 3.2 (current shore conditions), 3.3 (TASMARC beach profiling) and 3.4.2 (air photo history), in the light of the descriptive geomorphic (landform) and processes information in section 2.0 above.

The air photo data demonstrates two distinct phases of significantly differing beach behaviour affecting most of Garden Island Sands Beach except the north-western and south-eastern extremities. These two phases have occurred along the length of beach covered by transects 3 to 17 (as shown on Figure 18) during the period since (and probably prior to) the earliest air photos (1948) up until the most recent shoreline position survey (2022). These phases are:

1. From at least 1948 until circa 2000 the beach and foredune maintained a stable or only slowly receding shoreline position, albeit with notable short-term erosion and recovery episodes super-imposed on this.
2. Following a notable change of behaviour around 2000, the beach and foredune have been progressively and relatively rapidly eroding and receding. This recession trend has continued to the present, with some variation in rates of recession along different parts of the beach (see below).

These two phases of beach behaviour are most clearly identified on the shoreline history plots on Figure 23 and Figure 26, but are also clearly seen in the shoreline history plots on Figure 19 (in section 3.4.2 above).

In contrast, the north-western extremity of the beach - mainly in the area of transects 1 and 2 (see Figure 18) - showed highly variable behaviour between 1948 and 1966, with both apparent recession and then progradation over a range of up to 9 metres seawards and landwards. After 1966 this end of the beach has dominantly shown a slow progressive recession trend over the whole period up to the present, but without the notable change of behaviour around 2000 that occurred along most of the beach (see shore history plot on Figure 20).

The south-eastern extremity of the beach – mainly in the area of Transect 18 (Figure 18) – also showed somewhat different behaviour to the rest of the beach over the whole air photo period from 1948 to 2022. The shoreline history plot (Figure 20) indicates highly variable short-term erosion and accretion (recovery) cycles throughout most of the air photo period, with a slight overall trend of shoreline recession over the whole period. This end of the beach is a small sand spit at the mouth of the adjacent Garden Island Creek estuarine lagoon which has been regularly scoured and eroded by river discharges and tidal currents but has also received large supplies of sand from the beach, especially following erosion events, which has drifted south-eastwards along the beach and ‘piled up’ at the lagoon mouth (see section 2.4.6).

In respect of the main receding section of the beach covered by transects 3 to 17 (see Figure 18), the dominant long-term change of behaviour around 2000 (from stable or slightly receding to more rapidly receding) has also shown some notable sub-ordinate variations in the rates and spatial pattern of shoreline recession, as follows:

1. During the whole period for which air photo and surveyed evidence of shoreline behaviour is available (1948 to present), the beach and foredune have exhibited a notably slower rate of recession with less shoreline change overall at transects 3 to 6 (roughly the north-west quarter of the beach), than it has at the more rapidly-receding transects 6 to 17 (the main central to south-east part of the beach). Compare Figure 23 and Figure 26. The beach at transects 3 – 6 is currently (2022) showing a wide dry sandy beach and some recovery

from old erosion scarps in the form of incipient foredune accretion. In contrast the main receding section (transects 6 – 17) is showing fresh erosion scarps, no sign of sand accretion and recovery, and a low narrow wet beachface. The inferred reason for the historically persistent lesser erosion and recession at transects 3 – 6 is that this section of the beach is more sheltered than transects 6 – 17 are by the rocky headland to its west. This headland shelters the north-western part of the beach from the westerly to south-westerly wind-waves that are probably responsible for most of the erosion along the beach (see section 2.4.2).

Within the less receded area (transects 3 – 6), the digitised air photo shorelines (vegetation lines equivalent to the seawards front of the foredune) demonstrate a net horizontal shoreline recession ranging between 7 and 9 metres from 2001 until 2022. Comparison of the TASMARC beach profile plots (Figure 17) with digitised air photo shorelines indicate that the foredune at T503 (near transect 4) has lost less than a third (8 metres) of its width since 2001, with about 20 metres width remaining.

In the more receded area (transects 6 – 17), the digitised air photo shorelines demonstrate a net horizontal shoreline recession ranging between 7 and 12 metres from 2001 until 2022. Comparison of the TASMARC plots from T504 & T505 (Figure 17) with digitised air photo shorelines indicate that the foredune at T504 (near transects 8 & 9) and T505 (near transect 13) has lost about half (12 m and 10m respectively) of its width since 2001, with about 10m and 13m respectively remaining.

2. Within the main zone of shoreline recession from 2000 onwards (transects 6 to 17), the main focus of erosion has shifted from the south-eastern half of the zone (transects 12-17) to the centre of the beach at transects 7-11 (see Figure 27). During 2008 to 2012, the shoreline receded about 5 to 7 metres in the area of transects 12 to 17, while the area from transects 7 to 11 showed negligible change. Then – conversely - during 2015 to 2022, the shoreline in the area of transects 7 to 11 receded about 8 to 11 metres while the shoreline from transects 12 to 17 showed very little change.

   It is noteworthy that the earlier (2008-2012) recession focus (transects 12-17) is also the area in which the greatest overall shoreline recession from 1948 to present has occurred. In contrast the later recession focus (transects 7 – 11) exhibited very little recession at all from 1948 until 2015 when this area became the main focus of erosion (see Figure 18 and Figure 27). This is suggestive that the change of the focus of erosion and recession within the main erosion zone could be a long-term change. Given that the main driver of erosion at Garden Island Sands is inferred to be locally generated wind-waves (see section 2.4.2), such a change could indicate a long-term change in dominant wind direction and/or extreme wind speeds, and thus the dominant storm wind-wave heights and directions. However, it is probably too soon to be confident that the change seen is long-term and not merely short-term variability superimposed on the longer-term erosion pattern that has held since at least 1948.

An additional notable change in beach behaviour at Garden Island Sands Beach has been the appearance of intermittent sand bars across the mouth of Garden Island Creek estuarine lagoon (see Figure 1, Figure 2 and Figure 29). These do not appear on any historical air photos from 1948 until 2001, but then from 2001 until 2021 they appear on four air photos. They are evidently short-lived intermittent features as they do not appear on other air photos during the same period (see Figure 29). Although it is not possible to be certain that similar features did not occur prior to 2001, the sampling of times provided by the air photo time series is suggestive that these features did appear at about the same time as the better-established change in beach behaviour to more rapid active shoreline erosion and recession (circa 2000). It is inferred these sand bars result from larger-than-previously erosion events causing more eroded sand to drift south-eastwards along the beach during and after erosion events, temporarily blocking the estuarine lagoon mouth until tidal and river discharge currents can flush them out again.

3.6 Causes of landform change at Garden Island Sands Beach

3.6.1 Introduction

The 74-year air photo and survey history of shoreline behaviour at Garden Island Sands Beach demonstrates a major long-term change in beach processes during that period, namely a change around 2000 from a long (at least 52 years 1948-2000) period of mostly stable or only slowly receding shoreline positions, to a long (22 years 2000-2022 and continuing) period of progressive and significantly more rapid erosional recession of the beach shoreline (section 3.4.2).

This major change from one long-term beach behaviour to another is indicative of a significant change in a major driver (cause) of shoreline behaviour over those 74 years, or perhaps of correlated changes in several related drivers. This report section identifies a range of conceivable causes of the observed change and evaluates their plausibility. In summary, an early shoreline response to Global Mean Sea-Level Rise (GMSLR) provides a plausible explanation of the observed changes involving a process driver (sea-level) known to be actively changing (rising) on Tasmanian coasts (see section 3.6.2). No other plausible changing driver likely to be effective at Garden Island Sands has been identified (see section 3.6.3).

3.6.2 A model for a response to sea-level rise at Garden Island Sands

Tide gauge and satellite altimetry data shows that Tasmanian coastal waters (including Garden Island Sands) have experienced a long-term average sea-level rise since the 1800's that is comparable to Global Mean Sea-Level Rise (GMSLR). This global rise averaged 21cm by 2009 (Church & White 2011) and is continuing at an increasing rate (see details in section 2.4.4 above). Although a vertical rise in sea-level of this magnitude may seem small, it can have significant effects on soft sandy coastal landforms in at least two ways, namely:

1. It causes waves of any given size to reach higher on the shore profile than they previously could over the deepened nearshore waters, resulting in more frequent beach and foredune wave erosion events at higher levels and further to landwards than previously (Zhang, Douglas & Leatherman 2004).

and:

2. Deepening water can create more shallow offshore accommodation space to 'sequester' (or trap) greater portions of the increasing amounts of sand excavated from the beach and foredune by the more frequent and larger erosion events (Hennecke & Cowell 2000).

Even a mean sea-level rise of only 21 centimetres on a gently sloping beach such as Garden Island Sands allows waves of any given size to run that much higher over the deepened nearshore waters, and so to reach some metres further landwards than the same waves could have run on the slightly lower mean sea-levels of the 1800's. Thus, more frequent, and larger erosion events may occur at the shoreline even with no significant change in the actual frequency and magnitude of storm waves arriving at Garden Island Sands Beach. This effect is the primary reason why global mean sea-level rise is expected to cause increasingly widespread coastal erosion and recession, as was originally shown by Bruun (1962).

Nonetheless, in many "closed" coastal compartments or embayments, no progressive shoreline recession in response to sea-level rise has yet been seen because the (increasing amount of) eroded sand is not permanently lost from the beach system but is merely dumped just offshore in shallow bars and then subsequently returned to the beach by fair weather swells quickly enough to rebuild the beach and dune before the next major erosion event occurs. However, in some “leaky” coastal compartments increasing proportions of the eroded sand may be quickly lost before it can be returned to rebuild the beach (e.g., Roches Beach in Frederick Henry Bay), or may be lost into a variety of local sand “sinks” or “traps” from which the sand cannot later be returned to the beach. These sorts of beaches with “losing” sand budgets are more prone to showing early net sand losses in response to increased erosion rates related to sea-level rise, and thus may show increased and progressive shoreline recession in response to sea-level rise (Sharples 2020; Sharples et al. 2020).

Garden Island Sands appears to be a good example of a “closed” sandy compartment which as a whole today receives only negligible sand gains and does not leak significant amounts of sand (see section 2.4.6). As noted above many closed compartments have stable sand budgets which quickly return eroded sand to the beach and so have not yet shown a recessional response to sea-level rise. However, Garden Island sands is somewhat unusual in that it has at least two “nested’ sand sinks within it that can be expected to permanently trap increasing amounts of eroded sand as sea-level rise increases the water depth over them and thus increases the available accommodation space. This is inferred to prevent a portion of the progressively increasing amount of eroded sand from being returned to rebuild the eroded beach and dune faces. These nested sinks comprise limited but increasing accommodation space for additional sand in the Garden Island Creek estuarine lagoon (see section 2.3.5), and the large sand bar area 100 to 200 metres offshore from the beach (see section 2.3.4).

Given these two key factors related to sea-level rise – increasing shoreline erosion and the potential for an increased capacity of local sand sinks to absorb greater amounts of the increasing eroded sand without returning it to the beach and foredune - the following model is proposed as a plausible explanation of the long-term change of behaviour observed at Garden Island Sands (see also explanatory Figure 30).

1. Prior to the year 2000, from at least 1948 most of Garden Island Sands beach was either maintaining a stable average position or else had a slowly receding average shoreline position, with notable cyclic beach erosion and recovery events super-imposed on these long-term trends. Sand eroded in major storm events was being returned to the beach fast enough to fully rebuild the beach and dune (or nearly so) before the next major erosion event occurred. Only small amounts of sand were being permanently lost into the nested sand sinks (see above), consistent with the relatively slow rate of sea-level rise over most of the Twentieth Century (see section 2.4.4).

2. However, by around 2000, higher wave erosion events were more frequently eroding the beach and foredune, resulting from and commensurate with the increasing rate of global mean sea-level rise by that time (see section 2.4.4). As a result, increased amounts of eroded sand were being moved offshore by storm wave backwash or were being drifted alongshore by the dominant south-eastwards littoral drift along the beach (see section 2.4.6). This increased amount of eroded sand was beginning to temporarily accumulate in sand bars across the mouth of the Garden Island Creek estuarine lagoon, that had not previously been recorded (see section 3.4.2). Although these bars were evidently subsequently scoured out by tidal currents and river discharges, an increasing proportion of the eroded sand is deduced to have begun to be permanently sequestered in the increased accommodation space resulting from sea-level rise within the lagoon (see section 2.3.5) and in the shallow sand bar between the beach and Garden Island itself (see section 2.3.4). As a result, less eroded sand was ultimately returned to rebuild the beach and foredune before the next major erosion event, so that there was no longer a full or nearly full recovery of the beach and dune between large erosion events. Instead, there was a significant increase in the rate of net shoreline recession at Garden Island Sands Beach (see Figure 19 & Figure 26). An increased rate of shoreline recession has persisted at Garden

Figure 30: Diagrammatic model of the inferred explanation for post-2000 shoreline changes at Garden Island Sands Beach. See also accompanying text explanation. The background air photo is dated 19th March 2012, © NRE.

Island Sands Beach from its onset about 2000 until the present (2022 – 2023) and is continuing.

3. Partial sheltering of the north-western area of the beach from westerly or south-westerly wind waves (see section 3.2) has resulted in a lesser rate and severity of shoreline recession in the area of transects 1 to 6 (see Figure 18). Much of this area (transects 3-6) has receded at an average rate of 0.23 metres per year since 2000 (see Figure 23). Most of the remainder of the beach (transects 6 to 17) has receded at a more rapid rate averaging 0.35 metres per year (see Figure 26) since 2000, resulting in removal of up to half of the 2000 foredune width in this area by 2022 (see section 3.3).

4. Within the most rapidly receding part of the beach shoreline (transects 6 to 17) there has been a change in the spatial focus of the maximum rate of erosion along the beach since 2015 (see details in section 3.4.2). However, it is too early to confidently speculate on whether this represents a long-term change of shoreline behaviour or is simply the result of shorter-term variability in the driving processes (e.g., storm wind-wave directions).

5. This model implies that the underlying driver of the changes of shoreline behaviour observed at Garden Island Sands since 2000 is long-term progressive sea-level rise. Since global mean sea-level rise is expected to continue for at least several centuries due to the thermal inertia of ocean waters (IPCC 2021)), shoreline recession at Garden Island Sands can also be expected to continue at a similar or possibly increasing rate until a natural limit is reached (such as a resilient rising bedrock slope) or erosion is artificially prevented by some means such as engineering works (see also Section 4.2).

Model testing The model proposed could be tested by taking sand cores from the sand bars in the lagoon and from the offshore sand bar (which are likely the main "nested" sand sinks with increased capacity due to SLR and are central to the model presented here). Dating of the sand in these cores (by available methods such as Optically Stimulated Luminescence or OSL) should show a rapid initial accumulation of sand circa 6000-7000 years BP (possibly over older Last Interglacial sands from circa 125,000 years ago), tapering off to a very slow sand accumulation after several thousand years until quite recently (see section 2.3.4), then a rapid increase in sand accumulation from around 2000 until the present. However, such work was beyond the scope of this project.

3.6.3 Can other factors explain the observed change of shoreline behaviour?

A range of other coastal process drivers have been identified as conceivable causes of the observed changes at Garden Island Beach. Upon examination none of these appear plausible as alternative explanations of the changes. These conceivable drivers of change are set out in Table 2 (following), along with comments on their plausibility as explanations. No other possible explanations have been identified; however, no guarantee is given that the table provided is exhaustive.

Table 2: Evaluation of alternative conceivable drivers of long-term shoreline behaviour changes at Garden Island Sands Beach.

Potential driver of change	Evaluation
Vertical Land Movement (VLM) is a common driver of increased coastal erosion in many parts of the world where coastal land is subsiding at rates of the order of several millimetres per year.	*Not supported.* Best current estimates of Tasmanian VLM are negligible rates of <1.0 mm per year (Riddell, King & Watson 2020), and there is no known evidence of increased local subsidence in the Garden Island region. VLM tends to be a long-term process, which does not explain the onset of significant erosional recession at Garden Island Sands around 2000.
Episodic or cyclic sea-level variability related to ENSO but not GMSLR. Known to affect beach erosion and accretion on eastern Australian coasts (Barnard et al. 2015).	*Not supported for Tasmania*. ENSO is a less important cause of sea-level variability on Tasmanian coasts compared to most Australian coasts (Burgette et al. 2013). However this is a cyclic phenomenon on inter-annual timescales which does not explain the observed one-time change of long-term shoreline behaviour at Garden Island Sands Beach circa 2000.

Increased wind speeds and/or changing wind directions resulting in increased wind-wave erosion at Garden Island Sands Beach.	*Not supported.* Increased wind speeds from the 1980s onwards attributable to climate change have been observed in western Tasmania coastal Bureau of Meteorology wind records (Kirkpatrick et al. 2017; Sharples et al. 2020), but have not been detected in south-eastern Tasmania wind records (Sharples 2020). A change in the spatial focus of erosion at Garden Island Sands Beach circa 2015 could possibly be attributable to wind changes (see section 3.4.2), but (1) is not supported by any wind measurements known to this writer, (2) is too recent to be confirmed as a long-term change, and (3) is too recent to explain the major change of beach behaviour from 2000 onwards.
Swell direction variability, which may trigger changes to focus of erosion and accretion of sand along a beach.	*Not supported*. Generally, an episodically variable process on inter-annual time scales, which does not explain the one-time circa 2000 change of long-term shoreline behaviour at Garden Island Sands Beach. Swell reaching Garden Island Sands Beach is attenuated and trained within southern D'Entrecasteaux Channel, resulting in little variability by the time it reaches Garden Island Sands Beach.
Increase in swell storm magnitudes and frequencies, which might trigger more erosion.	*Not supported.* No evidence of changes in Tasmanian region to date, to the writers' knowledge. Any such changes likely to be of negligible effect at Garden Island Sands Beach since swell reaching the beach is significantly attenuated by the time it has entered and refracted northwards up D'Entrecasteaux Channel.
Movement of large sand "waves" or "slugs" along the coastline causing alternating beach erosion and accretion cycles as they are driven past individual beaches and headlands.	*Not supported.* Mostly characteristic of some energetic swell-dominated coasts (e.g., northern NSW), unlikely to be a significant phenomenon at Garden Island Sands Beach and no evidence of any such features. Generally, a repeating and cyclic phenomenon which does not explain the one-time 2000 change of shoreline behaviour at Garden Island Sands Beach.
Artificial changes and structures.	*Not supported.* Only minor artificial structures are present at or near Garden Island Sands Beach (e.g., a small jetty south-east of the beach). None of the known coastal structures are likely to significantly obstruct sand movement or cause sand erosion, nor are any known to have a circa 2000 construction or removal date which might explain a circa 2000 change of shoreline behaviour.

3.7 Other hazard issues

This report focusses on understanding the nature and causes of shoreline erosion at Garden Island Sands Beach. However, it should be noted that several other coastal hazard issues may also be significant for the beach and adjacent settlement. These are briefly noted below, and it is recommended these be considered in any comprehensive coastal hazard planning for Garden Island Sands.

These hazards are:

1. *Coastal inundation* (flooding) resulting from storm surge conditions, noting that this will be progressively exacerbated by continuing sea-level rise. The LIST website (www.thelist.tas.gov.au) provides what is essentially a first pass or “bathtub inundation model” identifying coastal inundation hazard bands for all Tasmanian coasts. However the mapping is here referred to as “first pass” because more sophisticated “dynamic” flood modelling is needed to account for the effects of water velocities, tidal and river currents on actual time-varying flooding patterns.

2. *Groundwater intrusion* Higher and more saline coastal groundwaters are a consequence of sea-level rise which may have a range of effects including vegetation dieback, interference with septic systems and increased backshore flooding. Groundwater monitoring (using boreholes) may be a useful method of assessing the degree of groundwater hazard likely at paces such as Garden Island Sands.

3. *River flooding* resulting from high rainfall events in the Garden Island Creek catchment may also cause flooding of parts of the low-lying plain behind Garden Island Sands Beach. Such flooding may be exacerbated when it occurs simultaneously with a coastal storm surge or with an incoming (flood) tide causing the river flood discharge to back up in the estuarine lagoon.

4.0 FUTURE MANAGEMENT OF GARDEN ISLAND SANDS BEACH AND DUNE

4.1 Introduction

The key outcome of the data analysis and explanatory model provided in section 3.0 (above) is the recognition that Garden Island Sands Beach is an "Early Responder" to the renewed global mean sea-level rise that has now been in progress since the 1800s, and which has notably accelerated since the 1990s (see section 2.4.4). Bruun (1962) famously identified increased shoreline erosion and shoreline recession as a major physical response to be expected on soft erodible shorelines subject to sea-level rise. Although most sandy shorelines on the Tasmanian coast are not yet showing a physical response that can plausibly be attributed to global mean sea-level rise, a small number are doing so (Sharples 2020; Sharples et al. 2020).

Ongoing sea-level rise to higher levels than have been reached so far is expected to eventually cause increased erosion and recession of most Tasmanian beaches. However, at the present relatively early stage of renewed global sea-level rise only beaches whose "sand budget" makes them particularly sensitive to losing sand into sand sinks are yet showing a noticeable recessional response. Garden Island Sands Beach is one of these, as described in section 3.6 above.

The increased erosion and recession of Garden Island Sands Beach which has occurred since circa 2000 poses a number of hazards and concerns for both residents and other users of the beach. These include:

- Narrowing of the beach face along much of the central to south-eastern beach area has resulted in a lower and wetter beach face with less recreational amenity for users;
- Increasing difficulty accessing the beach for many people due to the continuing erosion and scarping of the foredune; and
- Increasing likelihood that storm erosion events will eventually remove enough of the foredune barrier to begin washing over and scouring out its low points, allowing storm waves to inundate and erode parts of the backshore area currently occupied by houses and roads.

A major concern for local residents and beach users is that the increased erosion during the last two decades damaged a boat ramp which was providing access to the beach. Removal of the damaged boat ramp has limited beach access for many including older people, and the replacement of some form of access that will not be subject to erosion damage is now considered a high priority by the local community.

4.2 Future geomorphic changes at Garden Island Sands Beach

Since global mean sea-level rise is expected to continue for at least several centuries due to the thermal inertia of ocean waters (IPCC 2021)), shoreline recession at Garden Island Sands can also be expected to continue at a similar or possibly increasing rate for at least decades into the future, unless it is deliberately prevented by some means such as engineering. On multi-decadal to century timescales, shoreline recession and flooding by rising sea levels at Garden Island Sands would ultimately be halted or drastically slowed by resilient dolerite bedrock rising behind the sandy and alluvial sediment infill at Garden Island Creek (about 600 metres north-east of the current shoreline: see Figure 1 & Figure 2). However, decisions about how to respond to the hazards to assets posed by ongoing shoreline recession will inevitably be needed well before that limiting factor is actually reached.

Within the next few decades, it can be anticipated that shoreline recession at Garden Island Sands Beach will proceed at similar rates to that observed from 2000 to 2022 (see section 3.4.2), perhaps with some acceleration. In keeping with past trends since 1948, recession rates are likely to be slower along the more sheltered beach section from transects 3 to 6, and more rapid along the main receding section from transects 6 to 17 (see Figure 18). Average rates of recession in these sections after circa 2000 were approximately 0.23 metres per year across transects 3 – 6 (Figure 23), and about 0.35 metres per year across transects 6 to 17 (Figure 26), with faster rates at some points. As has been the case during the last two decades (see 3.4.2) there may at times be some variation in the sections of the beach between transects 6 and 17 that have the greatest erosion and recession impacts (see Figure 27).

Of particular concern from a coastal hazard perspective is that the air photo analysis shows that increased foredune scarp recession since 2000 has already removed variously 7 to 12 metres width of the dune front (the least from the north-western part of the beach around transects 3 to 6, the most from the central to south-eastern parts of the beach between transects 6 to 17). This amounts to the loss so far of roughly between one third and one half of the total original width of the foredune as it was during the year 2000.

Moreover, the first set of TASMARC beach and dune profiles surveyed across the dune (see section 3.3) indicate that the shoreline erosion has already passed the highest crest of the original dune and is now progressing through the backslope (landwards side) of the original dune. This means the ground surface is getting lower as the erosion recedes further to landwards, hence with each successive storm erosion event there is now an increasing risk that storm waves will finally be able to break through the remaining (lower) dune and allow storm waves to wash over into the residential areas behind the breached dune barrier. This will cause flooding and other water damage including erosion and further scouring (erosion) of overwash gullies through the remaining dune barrier. It is likely that the rates and patterns of shoreline erosion would change considerably following such a breaching of the foredune barrier.

4.3 Priorities and options for future management

The writer is a geomorphologist and not an engineer, hence does not provide recommendations for the design and construction of protective coastal structures. The purpose of this final section is to highlight a number of options and priorities worthy of consideration from a geomorphic perspective.

The available responses to coastal erosion (and other) hazards are "traditionally" grouped as "Defend, Adapt or Retreat", where these terms refer to:

Defend: Harden or protect a shore to prevent hazards (e.g., storm waves) from damaging assets;
Adapt: Design assets to endure hazards (e.g., rising seas and storm waves) without damage; and:
Retreat: Move assets away from high hazard zones.

It may be difficult to determine which of these options is most appropriate because of lack of understanding of the hazards in question. For example, a common mistake it to attempt to protect assets using under-engineered protection works which are subsequently destroyed by following erosion events. There are no perfect solutions to eroding beaches – each potential solution has both benefits and costs. However, a useful approach to better understanding how a shoreline such as Garden Island Sands Beach is responding to drivers of change such as sea-level rise is to monitor the beach behaviour over time. See further below re monitoring.

A key community priority for Garden Island Sands in the near-term is to re-instate and retain access to the beach, for example by a ramp or steps over the foredune erosion scarp which is currently making access difficult for some beach users.

However, at the same time and for the same reason, as noted above another high priority is to reduce the risk of residential properties being damaged if the remaining (lower) foredune barrier is breached by storm waves. As noted above, this hazard is exacerbated by the fact that the original foredune (as it was around the year 2000) has been considerably cut back during the last two decades and is now potentially able to be breached by smaller storm waves than would have been needed two decades ago. There is arguably a need to address this priority alongside the need for beach access before much more foredune erosion and recession has occurred. Appropriate responses will be determined through consultation with relevant experts, however as a starting point it is worth noting that sandbagging may be an achievable interim measure to manage this hazard while consideration is given to longer-term options.

Monitoring
Ongoing monitoring of the beach and foredune at Garden Island Sands is a useful way of both measuring and documenting the continuing response of the shoreline to sea-level rise, and also of monitoring the effectiveness and durability of any engineering solutions that may be adopted. Three particularly useful monitoring options that are well suited to volunteer non-specialist community groups are noted here:

1. *Ground level beach photography*. Ground-level oblique photography at regular intervals using fixed viewpoints to enable extraction of beach change information from the photographs. A framework for this sort of monitoring is provided by the University of NSW CoastSnap app. (see www.coastsnap.com).

2. *Aerial photography*. Vertical beach photography using aircraft or drones is a powerful method of continuing to acquire the same sort of data as has been used by this report up to 2022. However, this data can be relatively expensive to acquire.

3. *Surveyed beach profile surveys*. Regular surveying of profiles over the beach and dune from fixed survey reference points, allowing sensitive detection of changes between surveys. The TASMARC project (see www.tasmarc.info) provides an existing framework for this type of beach monitoring which has been designed to be suitable for community volunteer groups to undertake, with the resulting data being publicly available from the project website. Four TASMARC survey marks have been established at Garden Island Sands and initial beach and dune profiles were surveyed by Nick Bowden (surveyor) and Chris Sharples on 12th August 2022. It is intended to provide surveying training for interested local volunteers to undertake ongoing monitoring of Garden Island Sands Beach by this method.

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APPENDIX 1: AIR PHOTOS ORTHO-RECTIFIED

Table 3: Original air photos and ortho-photos produced for Garden Island Sands. All ortho-photos listed in this table are geo-registered to the UTM Map Grid of Australia (MGA) co-ordinate system (Zone 55), based on the GDA94 datum.

Photo Date	**Original DPIPWE air photos (film-frame) / Ortho-photo file name**	**Final image resolution (original scan resolution if downsized) / pixel size (m) of final ortho-photo**	**Original photo scale**	**Mean measured feature position error (± metres) for ortho-photo** [No. of measured feature position reference points]	**Comments**
15th Dec 1948	171-143 (Run 11) / *GardenIslandSands_15thDec1948_MGA55*	2039 dpi / 0.7 m pixel size	1:15,840	1.35 m [8]	Ortho-rectified by Chris Sharples
2nd Mar 1949	182-2 (Run 11A) / *GardenIslandSands_2ndMar1949_MGA55*	2039 dpi / 0.7 m pixel size	1:15,840	2.0 m [10]	Ortho-rectified by Chris Sharples
4th Feb 1965	435-63 (Run 23) / *GardenIslandSands_4thFeb1965_MGA55*	2039 dpi / 0.2 m pixel size	1:15,840	0.4 m [12]	Ortho-rectified by Chris Sharples
21st Jan 1966	456-106 / *GardenIslandSands_21stJan1966_MGA55*	2039 dpi / 0.5 m pixel size	1:31,680	2.4 m [12]	Ortho-rectified by Chris Sharples.
18th Feb 1967	489-162 / *GardenIslandSands_18thFeb1967_MGA55*	2039 dpi / 0.22 m pixel size	1:15,840	1.0 m [9]	Ortho-rectified by Chris Sharples.
18th April 1972	601-52 / *GardenIslandSands_18thApr1972_MGA55*	1500 dpi (2039 dpi) / 0.36 m pixel size	1:15,840	0.84 m [11]	Ortho-rectified by Chris Sharples. Beach central.
31st Jan.1975	665-41 / *GardenIslandSands_31stJan1975_MGA55*	2039 dpi / 0.58 m pixel size	1:40,000	0.63 m [12]	Ortho-rectified by Chris Sharples.
4th Mar 1977	719-125 / *GardenIslandSands_4thMar1977_MGA55*	2039 dpi / 0.40 m pixel size	1:30,000	1.09 m [12]	Ortho-rectified by Chris Sharples.
6th Jan 1979	772-197 / *GardenIslandSands_6thJan1979_MGA55*	2039 dpi / 0.50 m pixel size	1:40,000	0.85 m [13]	Ortho-rectified by Chris Sharples.
14th Feb. 1980	817-126 / *GardenIslandSands_14thFeb1980_MGA55*	2039 dpi / 0.62 m pixel size	1:45,000	1.3 m [12]	Ortho-rectified by Chris Sharples.
3rd Feb 1981	867-167 / *GardenIslandSands_3rdFeb1981_MGA55*	2039 dpi / 0.22 m pixel size	1:15,000	0.75 m [13]	Ortho-rectified by Chris Sharples.
13th Feb 1981	870-121 / *GardenIslandSands_13thFeb1981_MGA55*	2039 dpi / 0.20 m pixel size	1:15,000	0.62 m [12]	Ortho-rectified by Chris Sharples.
20th Feb 1981	872-168 / *GardenIslandSands_20thFeb1981_MGA55*	2039 dpi / 0.42 m pixel size	1:32,000	0.89 m [12]	Ortho-rectified by Chris Sharples.
10th Feb 1982	904-189 / *GardenIslandSands_10thFeb1982_MGA55*	2039 dpi / 0.56 m pixel size	1:42,000	1.23 m [12]	Ortho-rectified by Chris Sharples.
4th Mar 1982	917-211 / *GardenIslandSands_4thMar1982_MGA55*	1500 dpi (2039 dpi) / 0.51m pixel size	1:30,000	1.19 m [12]	Ortho-rectified by Chris Sharples.

14th Jan 1984	978-199 / *GardenIslandSands_14thJan1984_MGA55*	1500 dpi (2039 dpi) / 0.38 m pixel size	1:20,000	0.88m [15]	Ortho-rectified by Chris Sharples.
29th Oct 1985	1042-221 / *GardenIslandSands_29thOct1985_MGA55*	2039 dpi / 0.2 m pixel size	1:15,000	0.65m [13]	Ortho-rectified by Chris Sharples. Same date & run frame 156 more marginal and not used.
30th Sept 1987	1092-136 / *GardenIslandSands_30thSept1987_MGA55*	2039 dpi / 0.56 m pixel size	1:42,000	0.88m [13]	Ortho-rectified by Chris Sharples.
15th Dec 1988	1124-60 / *GardenIslandSands_15thDec1988_MGA55*	1500 dpi (2039 dpi) / 0.75 m pixel size	1:42,000	1.34 [9]	Ortho-rectified by Chris Sharples. Colour, marginal position.
25th Jan 1989	1128-162 / *GardenIslandSands_25thJan1989_MGA55*	1500 dpi (2039 dpi) / 0.75 m pixel size	1:42,000	0.77 [13]	Ortho-rectified by Chris Sharples. Colour, fairly central
22nd Jan 1990	1148-65 / *GardenIslandSands_22ndJan1990_MGA55*	2039 dpi / 0.41 m pixel size	1:31,000	1.27m [10]	Ortho-rectified by Chris Sharples. Beach position is marginal, but good scale
14th Feb 1990	1150-186 / *GardenIslandSands_14thFeb1990_MGA55*	2039 dpi / 0.56 m pixel size	1:42,000	1.04 [16]	Ortho-rectified by Chris Sharples. Beach is more central than Jan 1990 image.
2nd Jan 1991	1162-121 / *GardenIslandSands_2ndJan1991_MGA55*	2039 dpi / 0.3 m pixel size	1:24,000	0.72 m [14]	Ortho-rectified by Chris Sharples
14th Nov 1991	1173-95 / *GardenIslandSands_14thNov1991_MGA55*	2039 dpi / 0.6 m pixel size	1:42,000	0.91 m [13]	Ortho-rectified by Chris Sharples. Fairly central
10th Jan 1995	1228-125 / *GardenIslandSands_10thJan1995_MGA55*	1500 dpi (2039 dpi) / 0.39 m pixel size	1:20,000	0.87 m [15]	Ortho-rectified by Chris Sharples.
23rd Feb 1996	1249-157 / *GardenIslandSands_23rdFeb1996_MGA55*	1500 dpi (2039 dpi) / 0.36 m pixel size	1:20,000	0.75 m [16]	Ortho-rectified by Chris Sharples.
13th Dec 1996	1256-30 / *GardenIslandSands_13thDec1996_MGA55*	1500 dpi (2039 dpi) / 0.42 m pixel size	1:24,000	1.03 m [16]	Ortho-rectified by Chris Sharples. 1256-29 similar but frame 30 has better view onto shoreline under trees.
9th Jan 1998	1285-12 / *GardenIslandSands_9thJan1998_MGA55*	2039 dpi / 0.4 m pixel size	1:24,000	1.11 m [14]	Ortho-rectified by Chris Sharples.
9th Jan 2001	1343-25 / *GardenIslandSands_9thJan 2001_MGA55*	1500 dpi (2039 dpi) / 0.4 m pixel size	1:24,000	0.83 m [17]	Ortho-rectified by Chris Sharples. Colour, good scale, good spread of GCP's. Used in preference to 21st Jan 2001 photo.
21st Jan 2001	1344-69		1:24,000	n/a	Not ortho-rectified or used. Marginal, can't get good GCPs for most of photo, very close in time to 1343-25 and same scale;
1st Feb 2002	1353-90 / *GardenIslandSands_1stFeb2002_MGA55*	1500 dpi (2039 dpi) / 0.4 m pixel size	1:20,000	1.4 m [17]	Ortho-rectified by Chris Sharples
14th Feb 2002	1354-45 / *GardenIslandSands_14thFeb2002_MGA55*	1500 dpi (2039 dpi) / 0.4 m pixel size	1:20,000	0.97 m [15]	Ortho-rectified by Chris Sharples
25th Jan 2005	1390_234_op.ecw / *GardenIslandSands_25thJan2005_MGA55*	2039 dpi / 0.5m pixel size	1:42,000	1.50 m [17]	Ortho-rectified by NRE Poor accuracy at Garden Island sands compared to other 4 NRE orthos.
18th Feb 2008	1430_222_op.ecw /	2039 dpi / 0.5m pixel size	1:24,000	1.93m [16]	Ortho-rectified by NRE. Poor accuracy compared to more

	GardenIslandSands_18thFeb2008_MGA55			Crap accuracy in parts (up to 4 m errors)	recent NRE orthos at Garden Island Sands.
15th Dec 2009	1440-237 / *GardenIslandSands_15thDec2009_MGA55*	1500 dpi (2039 dpi) / 0.8 m pixel size	1:42,000	1.61m [15] Crap accuracy in parts (up to 3.1m errors)	Ortho-rectified by Chris Sharples
19th Mar 2012	1469-220 / *GardenIslandSands_19thMar2012_MGA55*	1500 dpi (2039 dpi) / 0.56 m pixel size	1:24,000	1.04m [15]	Ortho-rectified by Chris Sharples.
19th Dec 2015	Eggs_and_Bacon_Bay_19_12_2015.ecw / *GardenIslandSands_19thDec2015_MGA55*	n/a / 0.1m pixel size	1:400	Reference photo: 0.0m error by definition	Extensive area digital ortho-rectified image by NRE
25th Dec 2015	FranklinExtract_25-12-2015.ecw / *GardenIslandSands_25thDec2015_MGA55*	n/a / 0.1m pixel size	1:400	0.17 m [12]	Extensive digital ortho-rectified image by NRE – cropped to Garden Island Sands
10th Feb 2021	GardenIslandSands_10cm_2021.ecw / *GardenIslandSands_10thFeb2021_MGA55*	n/a / 0.1m pixel size		0.37 m [6]	Whole local area digital ortho-rectified image by NRE
End (as of July 2022)					

APPENDIX 2: SHORELINES DIGITISED

Table 4: Digitised shoreline shapefiles produced for Garden Island Sands Beach (using ortho-photos listed separately in Appendix One Table 3). All shapefiles listed in this table are geo-registered to the UTM Map Grid of Australia (MGA) co-ordinate system (Zone 55), based on the GDA94 datum.

Date of air photo(s)	Shoreline shapefile	Shoreline digitised by	Comments
General comments all dates: Shoreline positions interpolated beneath overhanging tree and shrub canopies (common throughout beach history) when reasonable to do so; strong tree shadows and seagrass wrack in some air photos also needed to be carefully differentiated from *in situ* vegetation. Actual shoreline (*in situ* vegetation line) was easy to pick in some photos, difficult in others.			
15th Dec. 1948 (air photo 171-143)	GardenIslandSands_MGA55_19481215.shp	Chris Sharples (2022)	Limited photo contrast and detail. Little overhanging trees or shadows.
2nd Mar. 1949 (air photo 182-2)	GardenIslandSands_MGA55_19490302.shp	Chris Sharples (2022)	Limited photo contrast and detail. Little overhanging trees or shadows.
4th Feb 1965 (air photo 435-63)	GardenIslandSands_MGA55_19650204.shp	Chris Sharples (2022)	Lots of tree shading over beach, confusing in parts, but generally veg line (shoreline) is fairly distinct. Some beach scarping avoided.
21st Jan 1966 (air photo: 456-106)	GardenIslandSands_MGA55_19660121.shp	Chris Sharples (2022)	Some beach shadow (not too much); shoreline (veg line) fairly distinct along east half of beach, more difficult to pick along western half due to overhanging veg.
18th Feb 1967 (air photo: 489-162)	GardenIslandSands_MGA55_19670218.shp	Chris Sharples (2022)	Lots of shadows on beach, difficult to pick actual vegetation line in most areas. Visually anomalous plot – shoreline not used
18th April 1972 (air photo: 601-52)	GardenIslandSands_MGA55_19720418.shp	Chris Sharples (2022)	Lots of tree shadows on beach and prominent beach scarp. With these features accounted for, shoreline (veg. line/foredune scarp) is moderately clear along much of beach.
31st Jan.1975 (air photo: 665-41)	GardenIslandSands_MGA55_19750131.shp	Chris Sharples (2022)	Tree shadows on beach; parts of shoreline distinct but some difficult to pick. Beach scarp avoided.
4th Mar 1977 (air photo 719-125)	GardenIslandSands_MGA55_19770304.shp	Chris Sharples (2022)	Some tree shadows on beach, most of shoreline (veg. line) fairly distinct.
6th Jan 1979 (air photo: 772-197)	GardenIslandSands_MGA55_19790106.shp	Chris Sharples (2022)	Shadows from west prominent, not much shadow on main beach. However, shoreline difficult to pick along most of beach, and plot is anomalous. Shoreline not used.
14th Feb. 1980 (air photo: 817-126)	GardenIslandSands_MGA55_19800214.shp	Chris Sharples (2022)	Lots of beach shadows, shoreline (veg. line) position fairly clear in most areas
3rd Feb 1981 (air photo 867-167)	GardenIslandSands_MGA55_19810203.shp	Chris Sharples (2022)	Long tree shadows on beach, shoreline (veg. line) position fairly clear in most areas.
13th Feb 1981 (air photo 870-121)	GardenIslandSands_MGA55_19810213.shp	Chris Sharples (2022)	Short westerly tree shadows on beach. Shoreline difficult to pick on this photo. Visually anomalous plot – shoreline not used .
20th Feb 1981 (air photo 872-168)	GardenIslandSands_MGA55_19810220.shp	Chris Sharples (2022)	Seagrass wrack lines on beach, long tree shadows on beach. Shoreline clear in some areas, not others.
10th Feb 1982 (air photo 904-189)	GardenIslandSands_MGA55_19820210.shp	Chris Sharples (2022)	Seagrass wrack lines on beach, long tree shadows on beach. Shoreline clear in some areas, not others.

4th Mar 1982 (air photo 917-211)	GardenIslandSands_MGA55_19820304.shp	Chris Sharples (2022)	Shoreline position clear in most areas (prominent fresh erosion scarp) despite tree shadows and canopies.
14th Jan 1984 (air photo 978-199)	GardenIslandSands_MGA55_19840114.shp	Chris Sharples (2022)	Shoreline position fairly clear in most areas.
29th Oct 1985 (air photo 1042-221)	GardenIslandSands_MGA55_19851029.shp	Chris Sharples (2022)	Shoreline position fairly clear in most areas (prominent fresh erosion scarp).
30th Sept 1987 (air photo 1092-136)	GardenIslandSands_MGA55_19870930.shp	Chris Sharples (2022)	Shoreline detectable in parts, extrapolated in many places through tree canopies and shadows.
15th Dec 1988 (air photo: 1124-60)	GardenIslandSands_MGA55_19881215.shp	Chris Sharples (2022)	Shoreline position fairly clear in many areas, resolution a bit poor but OK.
25th Jan 1989 (air photo: 1128-162)	GardenIslandSands_MGA55_19890125.shp	Chris Sharples (2022)	No much shadow on beach, shoreline position reasonably clear.
22nd Jan 1990 (air photo: 1148-65)	GardenIslandSands_MGA55_19900122.shp	Chris Sharples (2022)	Shoreline position hard to pick in part, reasonably clear elsewhere.
14th Feb 1990 (air photo: 1150-186)	GardenIslandSands_MGA55_19900214.shp	Chris Sharples (2022)	Shoreline position reasonably clear in most areas. .
2nd Jan 1991 (air photo: 1162-121)	GardenIslandSands_MGA55_19910102.shp	Chris Sharples (2022)	Lots of shadow on the beach, however shoreline (veg. line) mostly fairly easy to map.
14th Nov 1991 (air photo: 1173-95)	GardenIslandSands_MGA55_19911114.shp	Chris Sharples (2022)	Coarse resolution, not much shadow on beach, but overhanging canopies obscure shoreline. Shoreline (veg. line) fairly clear along a large portion of beach.
10th Jan 1995 (air photo: 1228-125)	GardenIslandSands_MGA55_19950110.shp	Chris Sharples (2022)	Colour, shoreline (veg. line) distinct along much of beach. GOOD reliable shoreline
23rd Feb 1996 (air photo: 1249-157)	GardenIslandSands_MGA55_19960223.shp	Chris Sharples (2022)	Colour, Lots of shadow but shoreline (veg. line) distinct along much of beach. Large amounts of seagrass wrack on beach.
13th Dec 1996 (air photo 1256-30)	GardenIslandSands_MGA55_19961213.shp	Chris Sharples (2022)	Lots of shadow but shoreline (veg. line) distinct along much of beach.
9th Jan 1998 (air photo: 1285-12)	GardenIslandSands_MGA55_19980109.shp	Chris Sharples (2022)	Beach partly shadowed by trees; shoreline hard to pick in many areas fairly distinct in some parts.
9th Jan 2001 (air photo: 1343-25)	GardenIslandSands_MGA55_20010109.shp	Chris Sharples (2022)	Much of shoreline is fairly distinct, shadows on beach fairly easy to pick.
1st Feb. 2002 (air photo: 1353-90)	GardenIslandSands_MGA55_20020201.shp	Chris Sharples (2022)	Colour, fairly clear shoreline (veg. line). But poor error margin and anomalous plot – shoreline not used.
14th Feb. 2002 (air photo 1354-45)	GardenIslandSands_MGA55_20020214.shp	Chris Sharples (2022)	Colour. Good shoreline visibility in some areas, poor in a few.
25th Jan 2005 (air photo 1390_234_op.ecw)	GardenIslandSands_MGA55_20050125.shp	Chris Sharples (2022)	Poor quality photo, but shoreline distinct in most sections, interpolated elsewhere.
18th Feb 2008 (air photo 1430_222_op.ecw)	GardenIslandSands_MGA55_20080218.shp	Chris Sharples (2022)	Shoreline distinct in some sections, interpolated elsewhere.
15th Dec 2009 (air photo 1440-237)	GardenIslandSands_MGA55_20091215.shp	Chris Sharples (2022)	Shoreline mostly distinct, not much shadowing.
19th Mar 2012 (air photo: 1469-220)	GardenIslandSands_MGA55_20120319.shp	Chris Sharples (2022)	Most of shoreline visible with high confidence.
19th Dec. 2015 (air photo: Eggs_and_Bacon_Bay_19_12_2015.ecw)	GardenIslandSands_MGA55_20151219.shp	Chris Sharples (2022)	Reference air photo. Shoreline extrapolated between good visible sections – much obscured by tree canopies and shadows.

			East end accreting adjacent estuarine lagoon mouth.
25th Dec 2015 (air photo: FranklinExtract_25-12-2015.ecw)	GardenIslandSands_MGA55_20151225.shp	Chris Sharples (2022)	Much of shoreline visible but also much obscured by tree canopies and shadows. Considerable incipient foredune expansion obvious adjacent estuarine lagoon mouth.
10th Feb 2021 (air photo: GardenIslandSands_10cm_2021.ecw)	GardenIslandSands_MGA55_20210210.shp	Chris Sharples (2022)	Much of shoreline obscured by tree canopies and shadows, Extrapolated between visible sections.
25th Aug. 2022 (Field surveyed)	GardenIslandSands_MGA55_20220825.shp	Elliott Cromer & Chris Sharples 25th Aug. 2022	Scarp position (along scarp crest) captured with GNSS by Elliott Cromer (i.e., field-surveyed, not derived from aerial photography, but the feature mapped is the same feature that was digitised from ortho-photos in every other shapefile listed in this table). This is a very accurate shoreline position (error margin <10mm).

APPENDIX 3: EXTRACTION OF SHORELINE BEHAVIOUR INFORMATION AND HISTORIES FROM AIR PHOTO TIME SERIES

This appendix provides some additional information about the air photo shoreline history methods described briefly in section 3.4.1 and applied in section 3.4.2 of this report. The example figures used in this appendix are from Roches Beach (south-east Tasmania), however the same methods were used to analyse the Garden Island Sands Beach air photo information. These methods were developed by the writer and colleagues at the University of Tasmania, including Dr Michael Lacey (who wrote the *Shoreline History* Python script to measure shoreline positions along multiple shore-normal transects) and Dr Christopher Watson (assistance with *Matlab*™ scripting).

Repeated vertical aerial photography since 1948 has been a key source of shoreline behaviour data for this study. A time series comprising every available photo of adequate photogrammetric quality was used. All aerial photography used has been geo-referenced and ortho-rectified, mostly by the writer using *Landscape Mapper*™ software and ground control points identified on an existing reference ortho-photo. This and several other air photos were already available as ortho-photos previously prepared by NRE (details of all air photos used are provided in Appendix 1). Photogrammetric position error margins for each ortho-rectified air photo were quantified by measuring and taking the average of the apparent displacement of 10 or more well-defined fixed reference features visible on each air photo from their positions on the selected reference photo (identified in Appendix 1).

On each ortho-photo, the seawards vegetation limit (or line) was digitised as the shoreline position proxy (Boak & Turner 2005) for that date (see Figure 31 below). With a shoreline position digitised as a roughly shore-parallel line for each date, the landwards or seawards movement of the shoreline between consecutive air photo dates was interpolated along regular 25-metre-spaced shore-normal digital transects (Figure 32, LHS, note in this example 100m spaced transects used for Roches Beach). Each transect plot was normalised for comparison between transects by plotting shoreline positions along each transect relative to the median shoreline position on that transect (e.g., Figure 32, upper RHS). Groups of transects showing coherent behaviour over time were grouped into a single summary plot for each such shoreline section by plotting the medians of all transect shoreline positions at each air photo date (e.g., Figure 32, lower RHS; Figure 33).

The resulting shoreline history plots were analysed for long-term behaviour trends using a combination of visual inspection and linear regression analysis (to assess the numerical probability of apparent trends being real). Three simple types of long-term shoreline behaviour trend were identified in the data, namely linear shoreline position stability, progradation or recession trends. Some real and apparent variability around each linear trend was expected as a result of factors including short-term erosion and accretion cycles, erosion scarp slumping and air photo ortho-rectification errors.

Given the expected real shoreline position variability and the limited frequency of air photos, it was considered problematical to attempt to identify trends of greater complexity than linear (such as 2nd order polynomial trends). The measured air photo error margins were important to the analysis as 'reality checks' on identified shoreline behaviour trends and were used both for visual evaluation of apparent trends and also for numerical error-weighted linear trend analysis. For example, if a possible long-term linear recession or progradation trend exhibits less overall shoreline position change (landwards or seawards) than the scale of most of the air photo error margins, then it is not demonstrated to be a real trend. Conversely an apparent trend involving significantly greater shoreline position change than the air photo error margins is more likely to be a real trend.

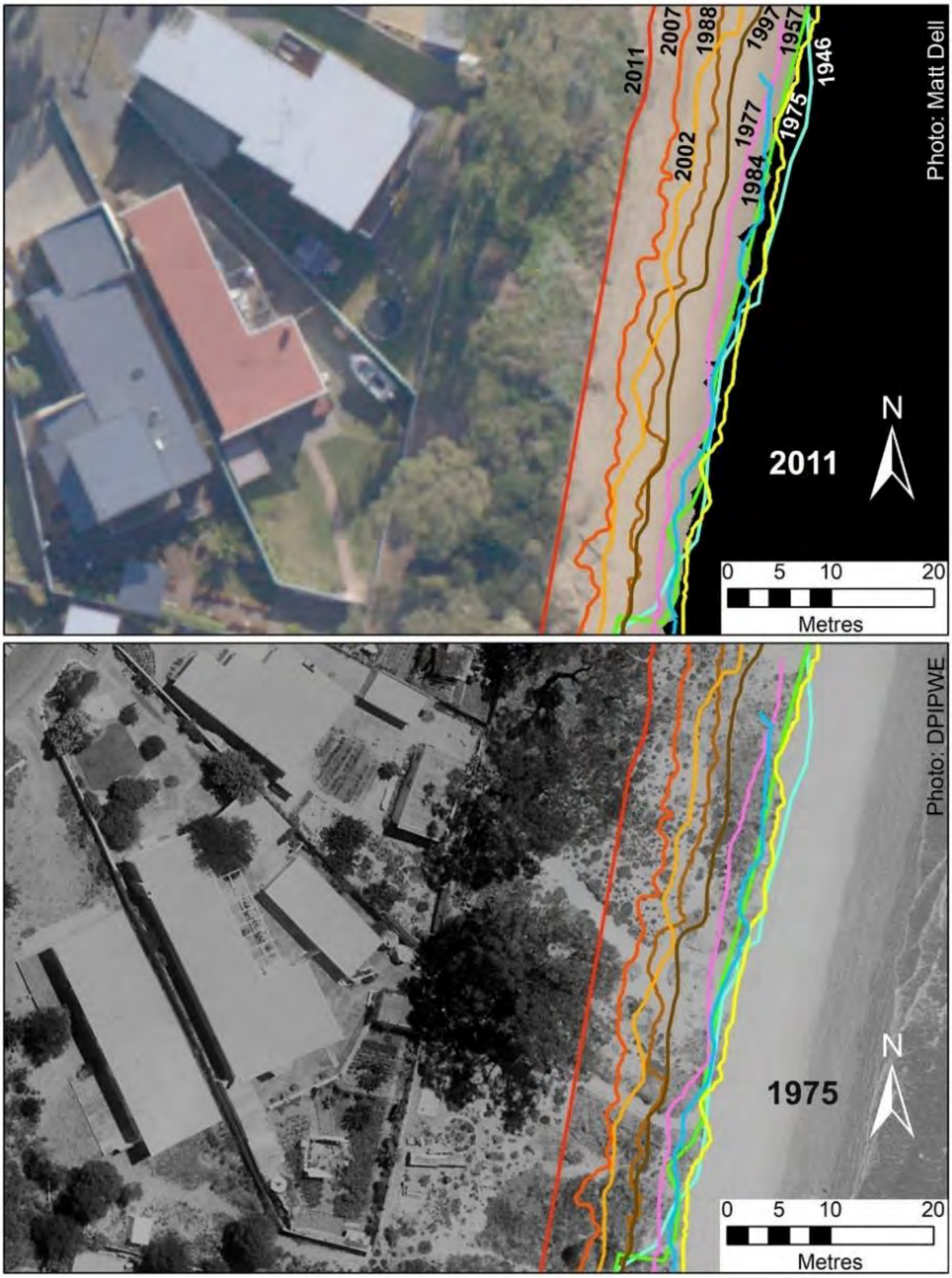


Figure 31: Example of a selected sequence of digitised shoreline positions at Roches Beach (Tasmania) from a time series of ortho-rectified air photos from 1946 to 2011, demonstrating how the vegetation line used as the shoreline proxy tracks shoreline change. The air photos used to digitise the 1975 and 2011 shorelines are shown to illustrate the shoreline position change between 1975 and 2011. Note that while the vegetation lines shown demonstrate an overall recession trend after 1984, they also demonstrate a shorter period of foredune accretion (shoreline progradation) within that period. More detail of shoreline position change is seen when all 30 air photo dates available for this section of shoreline are used (see Figure 33).

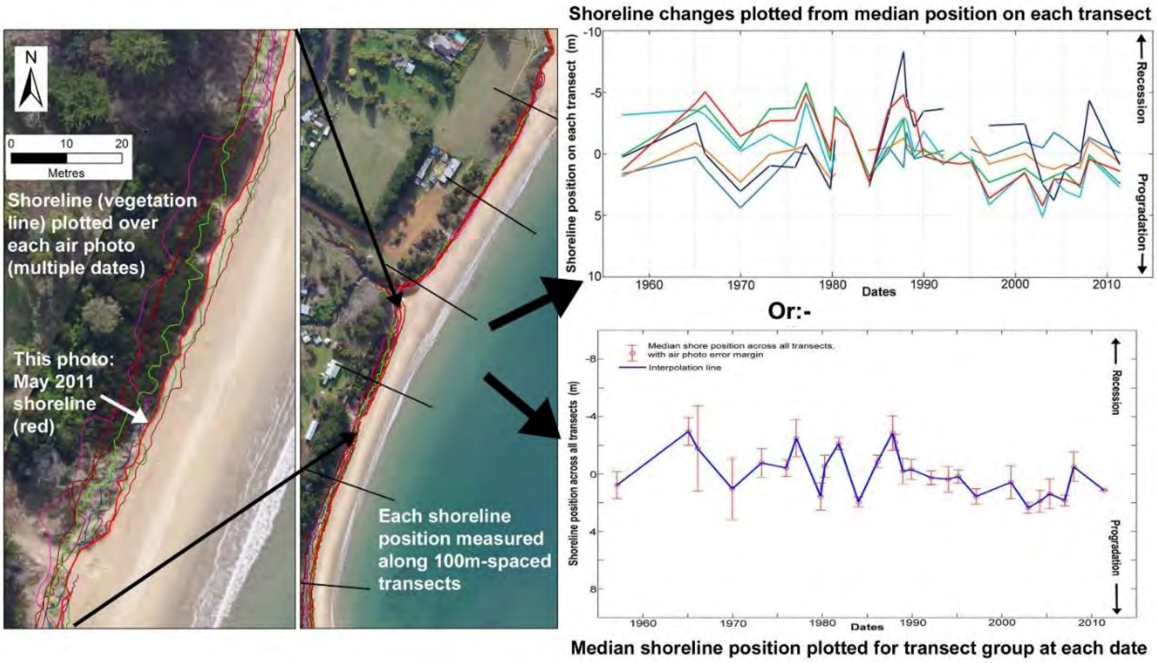


Figure 32: Figure illustrating the extraction of beach behaviour data from a time series of 27 aerial photo dates for Roches Beach North. This figure shows two ways of plotting the shoreline behaviour of Roches Beach N., which has undergone cyclic erosion and recovery events over a 50-year period with an essentially stable or slightly prograding underlying long-term trend. Shoreline position changes with time can be plotted along each transect within the beach section for individual comparison (top plot), or the median shoreline position at each date across all transects can be plotted to yield a summarised shoreline behaviour plot for the whole beach section (bottom plot).

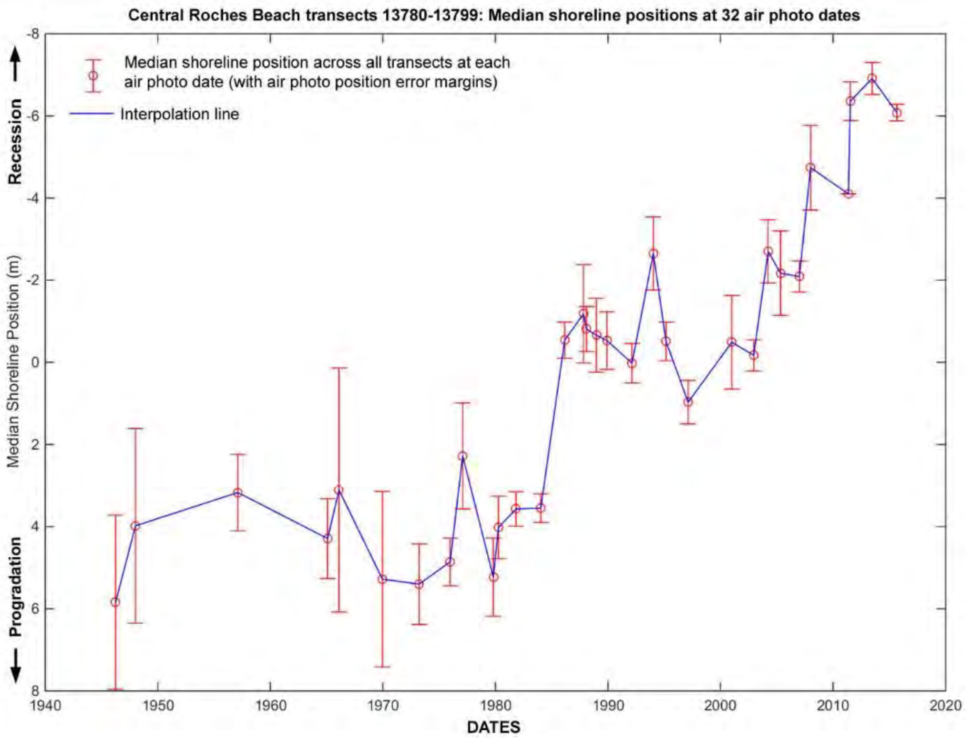


Figure 33: This summary plot of the median shoreline position at each of 32 air photo dates across 21 transects shows a marked long-term change of shoreline behaviour in the central (main) part of Roches Beach. The beach was essentially stable for over 30 years prior to 1985, with some erosion and accretion episodes around a roughly stable shoreline position. After 1985, the beach showed a markedly changed behaviour trend for 26 years to 2011, comprising a dominant recession trend much larger than the air photo error margins, with some partial recovery episodes but never full recovery to the pre-1985 shoreline position. This behaviour trend ceased after a large erosion event during 2011 because the local government began artificially replenishing the dune and beach face, so that subsequent beach behaviour can no longer be considered as a natural geomorphic response.

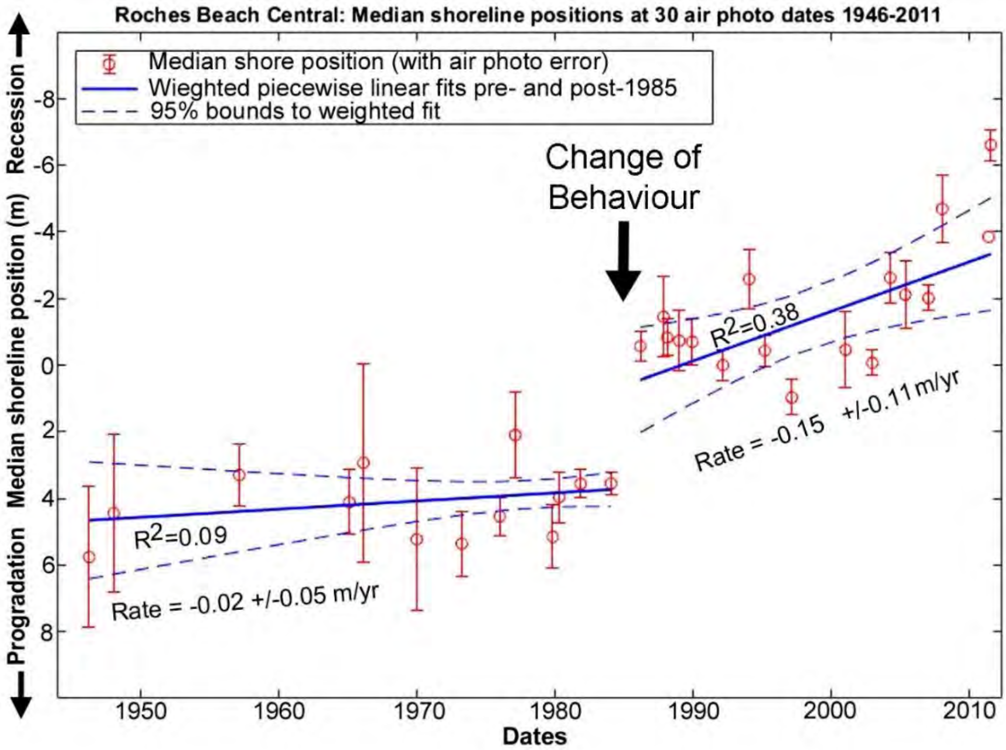


Figure 34: Shoreline history for Roches Beach central section (transects 13780 – 13801 except 13798). Median shoreline position across all used transects at each of 30 air photo dates (1946-2011), showing air photo position error bars at each date. Piecewise linear fits around 1985 shown weighted by error margin, with 95% bounds to weighted fit indicated.

At Roches Beach North, a single linear shoreline behaviour trend was identified over the whole air photo period (circa 65 years; see Figure 32 RHS). This demonstrates a stable or possibly slightly prograding long-term linear trend over the whole air photo period, with inter-annual variability of greater amplitude than the majority of error margins and thus inferred to be real shoreline position variability. The short-term variability at this site is most likely mainly a result of episodic beach erosion and recovery cycles.

By contrast, visual inspection of the shoreline behaviour plot for the main central part of Roches Beach at Figure 33 is strongly suggestive of a switch circa 1985 from a long – term (multi-decadal) stable trend to a long-term receding trend. In this case, piecewise linear regression (before and after 1985) was used to verify the statistical significance (Pearson correlation co-efficient) of the two trends, together with an error-weighted piecewise regression to further verify the validity of the apparent switch in shoreline behaviour (see Figure 34).

The use and limitations of vegetation line as shoreline proxy

Boak and Turner (2005) identified at least 16 types of shoreline features that could be mapped as proxies for the shoreline position. This study has used one of these, the seawards *in situ* vegetation line, for two main reasons, namely:

1. The vegetation line is generally a reliable indication of shoreline recession or progradation because under most circumstances it moves seawards in response to coastal accretion and progradation and landwards in response to erosion and recession. Hence, changes in the position of the vegetation line over time provide the type of shoreline behaviour history information this study has required, namely information on long-term shoreline trends of recession, stability or progradation.

2. The vegetation line is generally a high-contrast feature which can be readily mapped even on photos of relatively poor resolution and contrast, which is often the case for older air photos. Hence using this proxy allows the usable air photo time series to be extended to the earliest dates possible. This proxy may be mappable on older photos of poorer quality that may not support determination of some other shoreline proxies such as those based on specific contours or digital elevation models created from stereo air photos. The vegetation line may thus provide valid shoreline position data at more dates than some other methods can achieve.

The main limitation of using the vegetation line as a proxy for shoreline position change is that although it moves landwards in an effectively instantaneous manner during erosion events, there is generally a time lag before new vegetation establishes sufficiently to be visible on prograding shores (Boak & Turner 2005; Hanslow 2007). In addition, vegetation line position may be affected by other processes unrelated to sea-levels and wave erosion, including dune deflation and artificial disturbances (Hanslow 2007).

In regard to lag times in vegetation recovery and seawards growth, these are typically of the order of several months to several years. However, given that some of the time gaps between air photos used in this study are of a similar scale, and in addition that this study has been focussed on identifying long-term trends (10 years +) rather than analysing short-term (e.g., annual or inter-annual) variability in beach behaviour, the issue of vegetation growth lag times is unlikely to have significantly affected the main results obtained by this study.

Use of the vegetation line as a shoreline position proxy may also be subject to uncertainties such as operator error in digitising the position of the line. This particular uncertainty was minimised by only one operator digitising the shorelines used for this project using a consistent method. Beyond this, the use of a photogrammetric error margin (as described above) arguably captures the most important spatial uncertainty for the analyses undertaken, albeit more sophisticated uncertainty analyses can be applied (e.g., see Fletcher et al. 2011, p. 18).

APPENDIX 4: TASMARC SURVEY PROFILES

"TASMARC" is the TAsmanian Shoreline Monitoring and ARChiving project. This is a beach monitoring project which commenced in 2004 as a project of the Antarctic Climate and Ecosystems Co-operative Research Centre (ACE-CRC) at the University of Tasmania. The project is based on community "citizen science" groups surveying beach profiles at intervals, with the data being processed and made available for open public access at www.tasmarc.info. Section 3.3 of this report provides beach and dune profile plots surveyed across Garden Island Sands for this project, together with discussion of these. This appendix documents the survey data, which is expected to provide the starting point for monitoring the beach and dune condition into the future.

Four TASMARC survey markers were established at Garden Island Sands Beach on the 12th of August 2022 by Chris Sharples and Nick Bowden. These were located on the back (landwards) slope of the main foredune and their locations are shown on Figure 35 below, as well as in Cromer (2023, Attachment 3); the latter reference also provides photographic documentation of each survey marker. Nick Bowden and Chris Sharples then surveyed a profile along a transect running seawards (perpendicular or "normal" to the shoreline) from each marker. The profiles run across the foredune and beach surface to the lowest seawards point accessed on the beach. The data (survey measurement) records for these first and (at the time of writing) only surveyed profiles undertaken on 12th August are provided below in this appendix. The plots drawn from these surveys are provided in report, section 3.3 (Figure 17).

The position of each survey marker was subsequently surveyed to ±50 millimetres accuracy on 25th August 2022 by Elliott Cromer using the State Permanent Marker (SPM) network. These high-resolution survey marker positions are tabulated in Table 5 below and in Cromer (2023, Attachment 3).

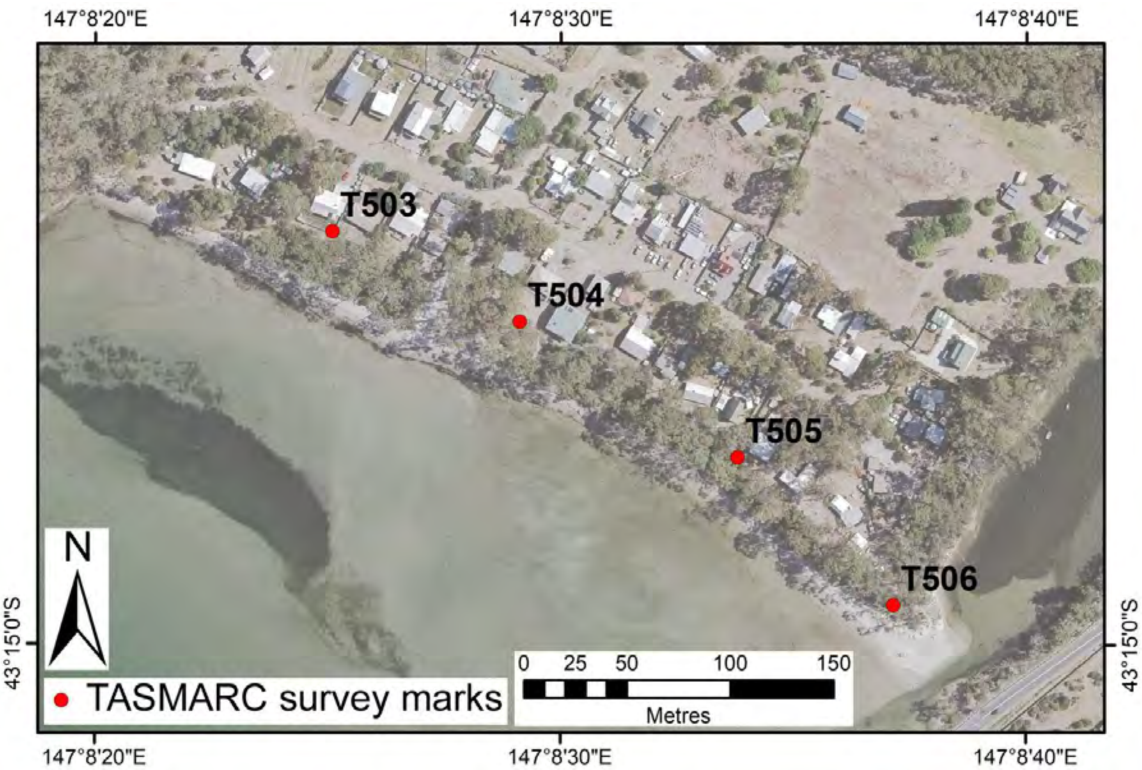


Figure 35: TASMARC survey mark positions at Garden Island Sands Beach. Each survey marker is a treated pine post embedded securely in the ground with a stainless-steel screw in the top of the post indicating the precise surveyed marker position. The survey transects extend seawards from the marks, normal (perpendicular) to the shoreline. Background image is the 19th of December 2015 air photo (© NRE).

Table 5: GNSS-surveyed co-ordinates of each TASMARC transect survey mark at Garden Island Sands. The survey marks are located at the landwards end of each transect, which runs seawards normal to the shoreline from each mark. The eastings and northings are metric co-ordinates of the Universal Transverse Mercator Map Grid of Australia Zone 55 (MGA55, GDA2020 datum).

Transect	Easting	Northing
T503	511389.856	5211612.855
T504	511480.624	5211569.065
T505	511585.965	5211503.179
T506	511661.358	5211431.634

Data Sheets for first transect profiles surveyed at Garden Island Sands Beach

The following four datasheets provide the survey data for the original TASMARC profiles surveyed on 12th August 2022 at Garden Island Sands Beach. These were measured normal (perpendicular) to the shoreline on each transect from the survey marker over the foredune and down the beach as far as practical on the day (i.e., to close to the water edge at the time surveyed).

Datasheet for 12th August 2022 survey based on Survey Marker T503
FORMAT VERSION 3.0
SITE NAME Garden Island Sands
SURVEY MARK T503
OBSERVERS Nick Bowden Chris Sharples
LATITUDE
LONGITUDE
EASTING 511389.856
NORTHING 5211612.855
HORIZONTAL DATUM GDA2020
UTM ZONE 55
VERTICAL DATUM AHD-TAS83
HEIGHT 2.77
START DATE/TIME 2022/08/12
END DATE/TIME 2022/08/12
TIME ZONE HOURS 10
TRUE BEARING TRANSECT DEGREES 200
SURVEY METHOD Total station
INSTRUMENT DESCRIPTION Topcon GTS-303
LEVEL MISCLOSURE MM
CREATION DATE 2022/11/13
#
IDENTITY PLATE T503
SURCOM ID
#
COLUMN 1 Horizontal distance from survey mark (m)
COLUMN 2 Vertical height above datum (m)
COLUMN 3 how-to-use flag (2 = use columns 1 and 2 (i.e. a levelling measurement),
1 = use column 1 only (i.e. a tape measurement or a comment)
0 = don't use data (i.e. erroneous data))
COLUMN 4 etc. any comments on this location (words separated by spaces;
if more than one word, all comment enclosed in quotes)
#
The perceived high water mark is indicated as follows:

#
<Start of line> <horizontal distance> <vertical height> 2 HWM
#
T503 is an stainless steel screw in the top of a square treated pine post
Coordinates of T503 determined by RTK GPS on 22/08/2022
#
SPM7504 adopted as coordinate and height origin
MGAE 512302.138 MGAN 5212334.085 AHD-TAS83 7.32
#
If/when it is necessary to establish a new mark, it is given a new ID.
It is always situated on an extension of the transect, at or landward
of the original SURVEY MARK. The horizontal distance in COLUMN 1 is,
however, always relative to the original SURVEY MARK.
#
0 2.77 2 T503
0.10 1.85 2
3.08 1.92 2
6.24 2.37 2
10.72 2.28 2
13.93 2.29 2
16.30 2.57 2
18.66 2.68 2
22.23 2.66 2
22.41 2.26 2
22.89 1.95 2
23.55 1.40 2
24.52 1.14 2
26.97 0.94 2
31.40 0.67 2
36.12 0.27 2

Datasheet for 12th August 2022 survey based on Survey Marker T504
FORMAT VERSION 3.0
SITE NAME Garden Island Sands
SURVEY MARK T504
OBSERVERS Nick Bowden Chris Sharples
LATITUDE
LONGITUDE
EASTING 511480.624
NORTHING 5211569.065
HORIZONTAL DATUM GDA2020
UTM ZONE 55
VERTICAL DATUM AHD-TAS83
HEIGHT 3.17
START DATE/TIME 2022/08/12
END DATE/TIME 2022/08/12
TIME ZONE HOURS 10
TRUE BEARING TRANSECT DEGREES 215
SURVEY METHOD Total station
INSTRUMENT DESCRIPTION Topcon GTS-303
LEVEL MISCLOSURE MM
CREATION DATE 2022/11/13
#
IDENTITY PLATE T504

SURCOM ID
#
COLUMN 1 Horizontal distance from survey mark (m)
COLUMN 2 Vertical height above datum (m)
COLUMN 3 how-to-use flag (2 = use columns 1 and 2 (i.e. a levelling measurement),
1 = use column 1 only (i.e. a tape measurement or a comment)
0 = don't use data (i.e. erroneous data))
COLUMN 4 etc. any comments on this location (words separated by spaces;
if more than one word, all comment enclosed in quotes)
#
The perceived high water mark is indicated as follows:
#
<Start of line> <horizontal distance> <vertical height> 2 HWM
#
T504 is an stainless steel screw in the top of a square treated pine post
Coordinates of T503 determined by RTK GPS on 22/08/2022
#
SPM7504 adopted as coordinate and height origin
MGAE 512302.138 MGAN 5212334.085 AHD-TAS83 7.32
#
If/when it is necessary to establish a new mark, it is given a new ID.
It is always situated on an extension of the transect, at or landward
of the original SURVEY MARK. The horizontal distance in COLUMN 1 is,
however, always relative to the original SURVEY MARK.
#
0 3.17 2 T504
0.10 2.16 2
4.85 2.15 2
9.41 2.28 2
12.28 2.43 2
12.90 2.31 2
13.10 1.14 2
15.48 0.90 2
22.30 0.30 2

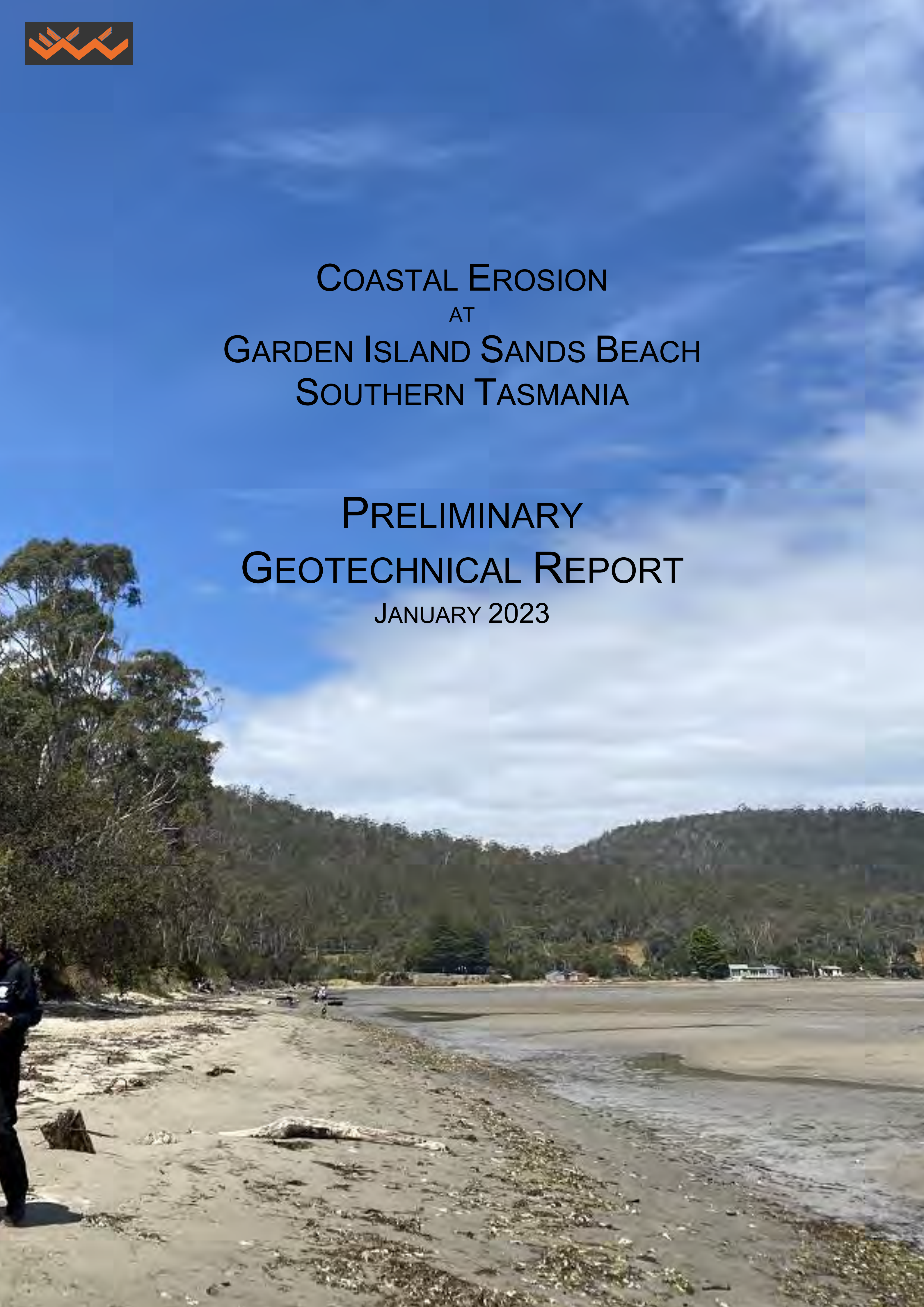
Datasheet for 12th August 2022 survey based on Survey Marker T505
FORMAT VERSION 3.0
SITE NAME Garden Island Sands
SURVEY MARK T505
OBSERVERS Nick Bowden Chris Sharples
LATITUDE
LONGITUDE
EASTING 511585.965
NORTHING 5211503.179
HORIZONTAL DATUM GDA2020
UTM ZONE 55
VERTICAL DATUM AHD-TAS83
HEIGHT 3.14
START DATE/TIME 2022/08/12
END DATE/TIME 2022/08/12
TIME ZONE HOURS 10
TRUE BEARING TRANSECT DEGREES 210
SURVEY METHOD Total station
INSTRUMENT DESCRIPTION Topcon GTS-303

```
# LEVEL MISCLOSURE MM
# CREATION DATE 2022/11/13
#
# IDENTITY PLATE T504
# SURCOM ID
#
# COLUMN 1 Horizontal distance from survey mark (m)
# COLUMN 2 Vertical height above datum (m)
# COLUMN 3 how-to-use flag (2 = use columns 1 and 2 (i.e. a levelling measurement),
#                   1 = use column 1 only (i.e. a tape measurement or a comment)
#                   0 = don't use data (i.e. erroneous data))
# COLUMN 4 etc. any comments on this location (words separated by spaces;
# if more than one word, all comment enclosed in quotes)
#
# The perceived high water mark is indicated as follows:
#
# <Start of line> <horizontal distance> <vertical height> 2 HWM
#
# T505 is an stainless steel screw in the top of a round treated pine fence post
# Coordinates of T503 determined by RTK GPS on 25/08/2022
#
# SPM7504 adopted as coordinate and height origin
# MGAE 512302.138 MGAN 5212334.085 AHD-TAS83 7.32
#
# If/when it is necessary to establish a new mark, it is given a new ID.
# It is always situated on an extension of the transect, at or landward
# of the original SURVEY MARK. The horizontal distance in COLUMN 1 is,
# however, always relative to the original SURVEY MARK.
#
0 3.14 2 T505
0.10 1.74 2
4.18 1.89 2
7.93 1.84 2
10.48 1.96 2
13.36 1.96 2
13.36 0.84 2
14.26 0.81 2
17.15 0.53 2
20.46 0.17 2
```

Datasheet for 12th August 2022 survey based on Survey Marker T506

```
# FORMAT VERSION 3.0
# SITE NAME Garden Island Sands
# SURVEY MARK T506
# OBSERVERS Nick Bowden Chris Sharples
# LATITUDE
# LONGITUDE
# EASTING 511661.358
# NORTHING 5211431.634
# HORIZONTAL DATUM GDA2020
# UTM ZONE 55
# VERTICAL DATUM AHD-TAS83
# HEIGHT 3.12
# START DATE/TIME 2022/08/12
```

```
# END DATE/TIME 2022/08/12
# TIME ZONE HOURS 10
# TRUE BEARING TRANSECT DEGREES 235
# SURVEY METHOD Total station
# INSTRUMENT DESCRIPTION Topcon GTS-303
# LEVEL MISCLOSURE MM
# CREATION DATE 2022/11/13
#
# IDENTITY PLATE T505
# SURCOM ID
#
# COLUMN 1 Horizontal distance from survey mark (m)
# COLUMN 2 Vertical height above datum (m)
# COLUMN 3 how-to-use flag (2 = use columns 1 and 2 (i.e. a levelling measurement),
#                       1 = use column 1 only (i.e. a tape measurement or a comment)
#                       0 = don't use data (i.e. erroneous data))
# COLUMN 4 etc. any comments on this location (words separated by spaces;
# if more than one word, all comment enclosed in quotes)
#
# The perceived high water mark is indicated as follows:
#
# <Start of line> <horizontal distance> <vertical height> 2 HWM
#
# T506 is an stainless steel screw in the top of a square treated pine post
# Coordinates of T505 determined by RTK GPS on 25/08/2022
#
# SPM7504 adopted as coordinate and height origin
# MGAE 512302.138 MGAN 5212334.085 AHD-TAS83 7.32
#
# If/when it is necessary to establish a new mark, it is given a new ID.
# It is always situated on an extension of the transect, at or landward
# of the original SURVEY MARK. The horizontal distance in COLUMN 1 is,
# however, always relative to the original SURVEY MARK.
#
0 3.12 2 T506
0.10 2.28 2
2.74 2.15 2
2.84 1.68 2
4.67 1.63 2
6.59 1.84 2
8.35 2.11 2
10.74 2.05 2
11.52 1.72 2
11.61 1.08 2
14.51 0.72 2
17.52 0.41 2
```



Coastal Erosion
at
Garden Island Sands Beach
Southern Tasmania

Preliminary Geotechnical Report
January 2023

Cover
View east-southeast along Garden Island Sands Beach
Image: Bill Cromer, 3 January 2022

Refer to this report as
Cromer, W. C. (2023). *Preliminary Geotechnical Report, Coastal Erosion at Garden Island Sands Beach, Southern Tasmania.* Unpublished report for Friends of Garden Island Creek (FOGIC) by William C. Cromer Pty. Ltd., 11 January 2023.

Important Notes

Report Purpose and Distribution

This document has been prepared by William C Cromer Pty Ltd (WCC) for use by stakeholders including but not limited to regulators, planners, surveyors, real estate agents, lawyers, developers, architects, engineers, contractors, builders, building surveyors and landowners involved with coastal erosion issues at Garden Island Sands. It is to be used only for the purposes of managing any existing or potential geotechnical (including erosion) issues relating to the foreshore.

This report contains new geotechnical information. To enhance the geotechnical database of Tasmania, it will be lodged with Mineral Resources Tasmania, and be publicly available.

Hard copies of this report must be in colour and in full. No responsibility is otherwise taken by WCC for its contents.

Limitations of this geotechnical report

Site investigations for geotechnical reports like this one usually but not always involve digging test holes and taking samples, at locations thought appropriate based on site conditions and general experience. The reports only apply to the tested part(s) of the site, and if not specifically stated otherwise, results should not be extrapolated to untested areas.

The main aim of the investigations is to reasonably determine the nature of and variability in subsurface conditions at the time of inspection. The number and location of test sites, and the number and types of tests done and samples collected, will vary from site to site. Subsurface conditions may change laterally and vertically between test sites, so discrepancies may occur between what is described in the reports, and what is exposed by subsequent excavations. No responsibility is therefore accepted for (a) any differences between what is reported, and actual site and soil conditions for parts of an investigation site not assessed at the time of inspection, and (b) subsequent activities on site by others, and/or climate variability (eg rainfall), which may alter subsurface conditions at the sites from those assessed at the time of inspection.

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Footings and foundations

In this report, foundations are (usually) natural materials into which man-made footings are placed to support man-made structures.

1 Introduction

1.1 Background

Garden Island Sands is a small community of about 50 houses bordering Garden Island Sands Beach in southern Tasmania (Figure 1).

Coastal erosion of the beach has concerned residents for some time, and its landward retreat may be accelerating (Plate 1). Beach amenity is being lost and property is increasingly threatened.

Figure 1. Location of Garden Island Sands

In a 2015 study funded by Huon Valley Council and the City of Hobart, consultants SGS reviewed the community costs and risks of coastal erosion associated with projected sea level rise[1]. Three general pathways were proposed to adapt to the risks:

1. Let climate change take its course and retreat early
2. Protect existing development as long as practical while protecting natural values
3. Protect existing development and support intensification as long as possible.

The pathways were reviewed by the Garden Island Creek community in May 2015. There was no community interest in pathway 1. Pathway 2 was considered the most practical.

[1] SGS (2015). *Garden Island Creek Coastal Adaptation Pathways.* Final Report by SGS Economics & Planning, prepared for Huon Valley Council and the Tasmanian Climate Change Office, July 2015.

Plate 1. View west-northwest along Garden Island Sands Beach in January 2022, showing active coastal erosion. Sharples (2023) has indicated the present scarp at the rear of the beach has retreated landwards 7 – 10m since 1948.

Subsequently, *Friends of Garden Island Creek* (FOGIC[2]) – a local group – was established to pursue Pathway 2. In January 2022, discussions between FOGIC, coastal geomorphologist Dr. Chris Sharples and engineering and groundwater geologist Bill Cromer resolved that effective remedial works to arrest the current rate of erosion might logically include, in order,

a) studies to understand the local processes involved, and to inform the design of any remedial works,

b) design of remedial works and obtaining regulatory approval, and

c) installation of the remedial works.

Sharples and Cromer were engaged by FOGIC[3] to address item a):

- Sharples has investigated and reported[4] on the recent geomorphic history and causes of coastal change at Garden Island Sands Beach, and

[2] Garden Island Creek is a small hamlet of 8 – 10 houses 1km north of Garden Island Sands. It is also the name of the creek which flows south past the hamlet and has its mouth and tidal estuary at the eastern end of Garden Island Sands beach.
[3] FOGIC has also commissioned other consultants to advise on flora/fauna/natural values, indigenous heritage, etc.
[4]Sharples (2023*). A Geomorphic Investigation of Shoreline Change at Garden Island Sands, Southern Tasmania*. Unpublished report by Chris Sharples (Coastal Geomorphology and Landform Management) for Friends of Garden Island Creek, January 2023.

- Cromer (this report) has conducted preliminary geotechnical investigations of shallow subsurface conditions at the base of the eroding beach scarp, to inform the design of possible future engineering works to alleviate the erosion.

1.2 Survey work and beach profile monitoring

Monitoring of surveyed beach profiles along Garden Island Sands Beach was considered a useful way of tracking erosional changes before and after any remedial works on the foreshore.

In August 2022, Nick Bowden and Dr Chris Sharples set up five markers along the beach as part of the TASMARC[5] network (Sharples, 2023). These were accurately surveyed on 12 August 2022 by Elliott Cromer (Attachment 3).

It is intended that after appropriate instruction, FOGIC and/or other community members will undertake continued beach profile monitoring using the markers.

1.3 Scope of and personnel for geotechnical investigations

1.3.1 Scope

The scope included:

- a preliminary site inspection and photography on 3 January 2022 with FOGIC and Dr. Chris Sharples,
- a desk-top review of relevant publicly-available information including topographic and geological maps, historical Google Earth satellite images, etc,
- geotechnical site investigations in the company of Dr. Sharples on 4 October 202; the work involved the digging, logging and photography of six excavator test pits, and
- desk-top review of field results and report compilation.

1.3.2 Personnel

The site investigations were conducted by engineering geologist Bill Cromer, aided by technical assistant Elliott Cromer. Dr. Chris Sharples attended the investigations.

[5] TASMARC = Tasmanian Shoreline Monitoring and Archiving Project. From the TASMARC website, TASMARC is an initiative started in 2004 by John Hunter, Chris Sharples, Richard Coleman and Werner Hanneke of the University of Tasmania. They were concerned about a lack of historical information about the Tasmanian shoreline and the way it is responding to storm events and sea-level rise. They identified a need for accurate measurements of shoreline positions and beach profiles with the data collected being securely archived for the future.
TASMARC relies on the work of volunteers who measure the profile of beaches from fixed survey marks using basic survey equipment (dumpy level, staff measuring tape). The measurements are usually made every 2 or 3 months depending on the availability of the volunteers.
The resultant data is stored in a database which can be accessed via the "Database" link on this web page. It includes the measurements recorded by the volunteers, profile plots and photographs. It will provide information about seasonal and long term changes in the shape and position of beaches. It will also provide information which can be used to verify beach measurements made by other methods.
Measurements were commenced in 2005 when 16 sites (ie beaches) were established. It has since been expanded to 30 sites with 20 of them being measured on a regular basis."
For further information about TASMARC contact: Nick Bowden nickbowden46@gmail.com

Auslocations checked the property for underground services on 3 October 2022, and the excavator was supplied by *Caydence Contracting* (operator Martin Lewis).

1.4 Locations of excavator test pits

Test pits were located at the erosion scarp at the rear of the beach. All except pit A were also aligned on or as close as practical to the beach profile line associated with each of the markers T503 – T507.

Test pit locations are shown in Attachments 2 and 4.

2 Results

2.1 Desk top study

Results of the desk-top study (Attachment 1) are:

- topographically the Garden Island settlement is almost flat, low-lying at less than 3m above sea level (ASL). The low-lying area extends inland for almost a kilometre bordering Garden Island Creek. More elevated ground exists to the west (up to 170mASL) and east (Maps 1.1 – 1.3 in Attachment 1).
- a search of Mineral Resources Tasmania files returned no relevant previous geological or related reports of Garden Island Sands – apart from published geological maps of the district[6],
- the bedrock of the area is Jurassic-age dolerite which has intruded older Permian- and Triassic-age sedimentary rocks. The sedimentary rocks are not exposed at Garden Island Sands, but dolerite is well-exposed at the western end of the beach, and on the eastern side of Garden Island Creek. The low lying areas of the settlement and beach are mapped as Holocene-age[7] alluvium and beach deposits.
- A set of historical satellite images from Google Earth for the period 2013 – 2022 are presented in Attachment 2.

2.2 Site investigations

2.2.1 Bedrock geology

Site inspection confirms the published geological mapping: Jurassic-age dolerite crops out at the western end of the beach, and was observed on foreshore exposures along the eastern side of the mouth of Garden Island Creek (Plates 2 and 3).

2.2.2 Holocene beach sediments

Tet pits A – F dug to depths of up to about 2m[8] below approximate high water mark all encountered only unconsolidated sand (Table 1 and Attachment 4). No dolerite bedrock was encountered to the depths investigated.

The pits were started in the beach escarpment, the upper levels of which probably included a capping of aeolian (windblown) sand. Below the veneer of aeolian sand, two types of materials are present:

- Layer 1 (in Table 1): light greyish brown SAND (SP): fine-medium grained, generally shell-free, up to about a metre or so thick, overlying
- Layer 2: grey, light grey SAND (SP): fine-medium grained, trace-some silt, shelly, with up to 10% well-graded, well-rounded, low-high sphericity gravel[9] (5 – 75mm) of quartzite, sandstone, siltstone and dolerite; at least 0.8 –1m thick.

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[6] The geological mapping is of 1:50,000 scale, on two maps: Farmer, N. (1981). Geological Atlas 1:50,000 Scale Series. *Kingborough*. Department of Mines Tasmania, and Farmer, N. and Forsyth, S. M. (1993). Geological Atlas 1:50,000 Scale Series. *Dover*. Department of Mines Tasmania.

[7] Holocene represents the last 11,700 years or so of geological time.

[8] Excavation depth was limited by the rapid collapse of the saturated sides of each pit.

Plate 2 (above). View southwest from the western end of Garden Island Sands Beach, across the Huon River to Garden Island. Fractured, relatively fresh and unweathered dolerite bedrock crops out in the bank (arrowed, at right), and is exposed on a narrow wave-cut platform at low tide (arrowed, centre). The staff at right is 2m long. (Photo: 3 January 2022).

Plate 3 (below). View east towards fractured, relatively fresh and unweathered dolerite bedrock i(arrowed) exposed on the eastern bank of Garden Island Creek at the eastern end of the beach. (Photo: 3 January 2022).

[9] The gravel may have originated from erosion of Quaternary gravels on terraces between Randalls Bay and Egg and Bacon Bay, to the west of Garden Island Sands Beach (*Pers. comm*. Dr. Chris Sharples).

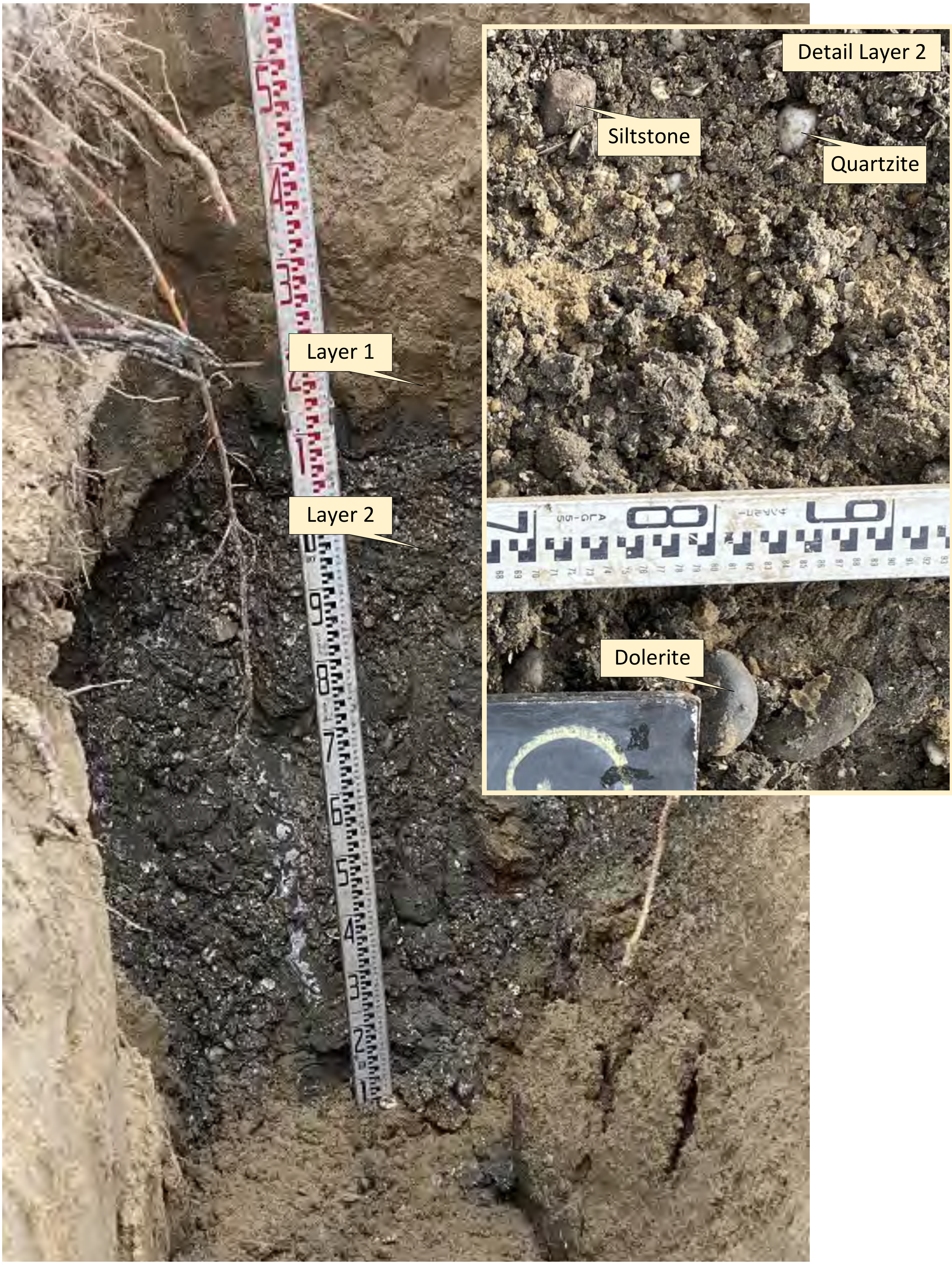


Plate 4 Layers 1 and 2 sand in test pit B. The detail shows types of gravel present in Layer 2. Layers 1 and2 materials are reasonably typical of materials in all six test pits, and by inference, beneath the full length of the beach. The large numbers on the scale are decimetres.

Table 1. Summary of test pits. See Attachment 4 for test pit photos.

Client FOGIC
Location Garden Island Sands Beach
Date dug 4-Oct-22

Test pit	A	B	C	D	E	F
Easting (GDA94)	511335	511370	511432	511474	511575	511651
Northing (GDA94)	5211611	5211587	5211568	5211554	5211490	5211422
Depth dug (m)[Note 1]	1.8	2.0	1.6	1.6	1.6	1.8
Water inflow (depths in m)	Inflow in all holes, from approx. mean sea level and below					
Standing water level (m)	Level rising during digging. Assumed to stabilise 0.5m below high water mark					

Note 1. Depth dug is below approx. high water mark

No.	**Layer**	**Details**	**USCS**	**Interp.**	Figures are approximate depths to top and bottom of layer, in metres					
1	**SAND**	Light yellowish brown, fine to medium grained; mostly shell-free; occasional artefacts (timber, concrete); loose; dry to moist, wet at base	SP	Holocene beach sand	0 to 1	0 to 0.9	0 to 1	0 to 1	0 to 0.8	0 to 1
2	**SAND**	grey, light grey (light yellowish brown in pit A), trace-some silt; fine-medium grained; shelly, with up to 10% well-graded, well-rounded, low-high sphericity gravel (5 – 75mm) of quartzite, sandstone, siltstone and dolerite; wet	SP	Quaternary near-shore sediments	1 to 1.8 Pit collapsing	0.9 to 2.0 Pit collapsing	1 to 1.6 Pit collapsing	1 to 1.6 Pit collapsing	0.8 to 1.8 Pit collapsing	1 to 1.8 Pit collapsing

Notes and abbreviations

USCS = Unified Soil Classification System
Grey cells indicate a missing layer or layers in a test pit
Easting and Northing coordinates from Google Earth and hand-held GPS. Datum is GDA94.
Excavability Equipment = 1.8t excavator; 0.45m GP bucket; 4 teeth; Operator: Martin Lewis
EAR = end as required; NR = no refusal; CR = close to refusal; R = refusal.
Samples D = disturbed sample; U50 = Undisturbed 50mm diameter drive tube sample
Weathering For rock only. F = fresh; SW = slightly weathered; MW = moderately weathered; HW = highly weathered;
EW = extremely weathered (ie soil properties; material can be remolded in the hand, with or without water)
Moisture D = dry; M = moist (M<=>PL = moisture less than, equal to or greater than Plastic Limit); W = wet.
Consistency *(silt and clay only)*
Fb = Friable (crumbles to powder when scraped with thumbnail)
S = Soft (Easily penetrated by fist; 25 - 50kPa)
F = Firm (Easily penetrated by thumb; 50 - 100kPa)
St = Stiff (Indented with thumb; penetrated with difficulty; 100 - 200kPa)
VSt = Very stiff (Easily indented with thumbnail; 200 - 400kPa)
H = Hard (Indented by thumbnail with difficulty; >400kPa)
Rel density *(sand and gravel only)*
VL = Very loose (ravelling)
L = Loose (easy shovelling)
MD = Medium dense (hard shovelling)
D = Dense (picking)
VD = Very dense (hard picking)

3 Conclusions

Based on the preliminary geotechnical investigations described here,

- unconsolidated beach sand extends the full length of Garden Island Sands Beach to depths of up to about 1.8m below high water mark
- except for the extreme western end of the beach (adjacent to dolerite outcrops), no hard bedrock will be encountered in excavations to at least this depth,
- the sands are saturated below about mean sea level, and excavations below this depth will collapse.

These findings will inform possible designs for coastal defences to arrest or at least substantially mitigate beach erosion in the short-long term,

4 Recommendations

In relation to the designs and possible installation of coastal defences at Garden Island Sands Beach,

1. engineering and geotechnical engineering advice should be obtained from persons appropriately experienced and qualified in coastal engineering, and
2. depending on design, follow-up geotechnical investigations should be done as required.

W. C. Cromer
Principal

11 January 2023

This report is and must remain accompanied by the following Attachments

Attachment 1. Published maps of the Garden Island Sands area (5 pages)
Attachment 2. Historical satellite imagery 2013 – 2022 (4 pages)
Attachment 3. TASMARC markers T503— T507 established August 2022 (8 pages)
Attachment 4. Site and test pit photos (17 pages)

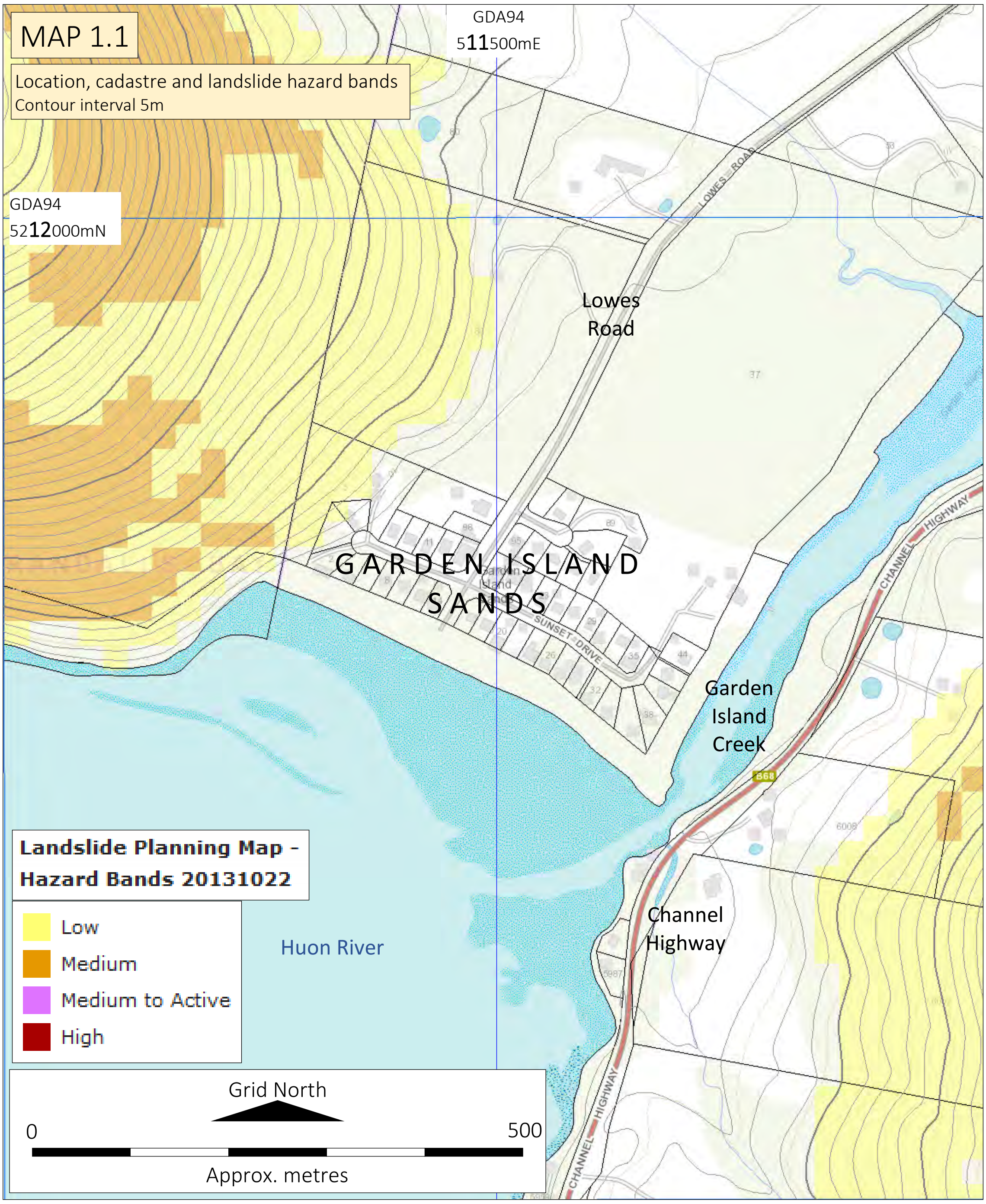
Attachment 1

(5 pages including this page)

PUBLISHED MAPS OF THE GARDEN ISLAND SANDS AREA

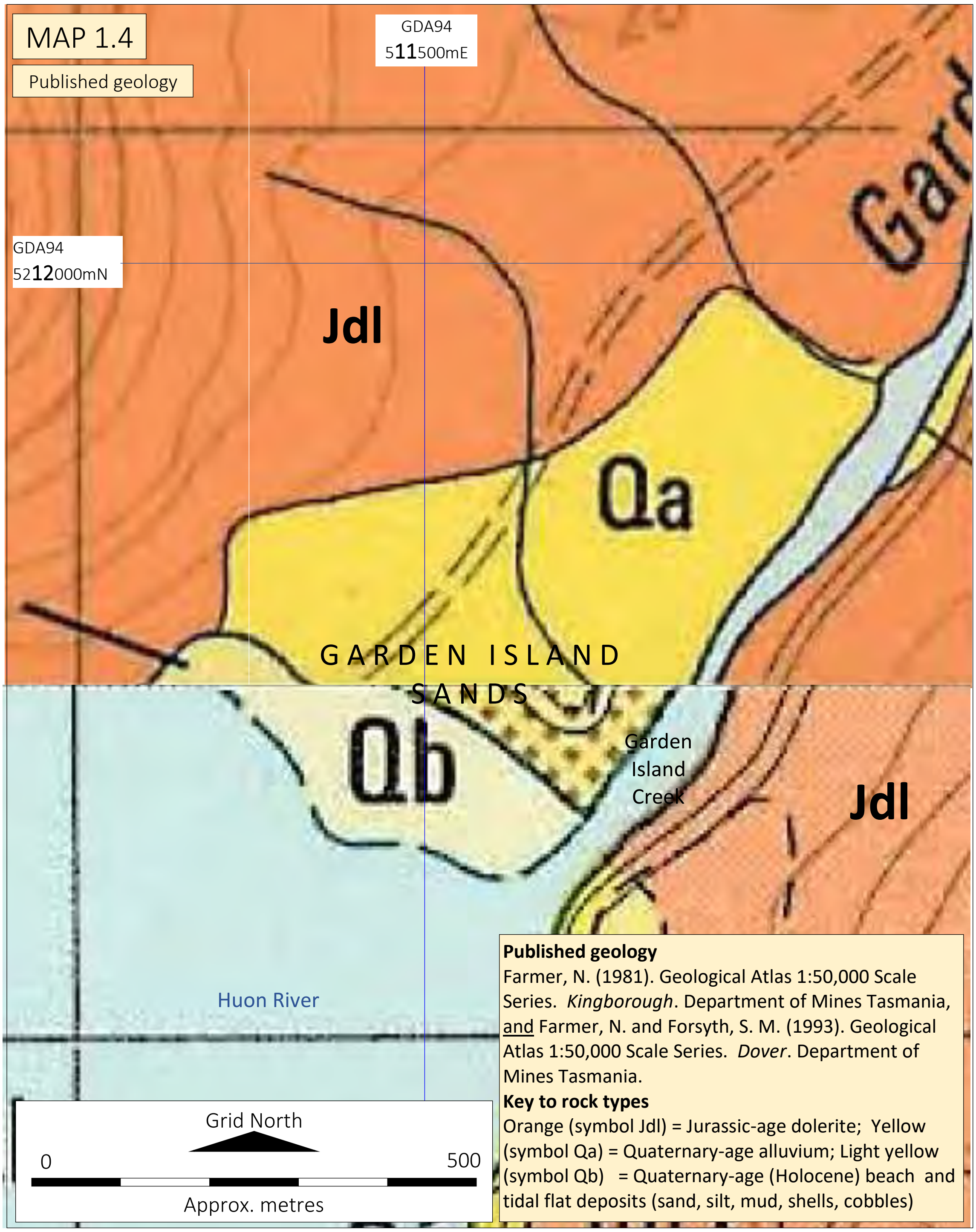
Source: www.thelsit.tas.gov.au

Map 1.1 Location, cadastre and landslide hazard bands
Map 1.2 Aerial imagery
Map 1.3 Hillshading
Map 1.4 Published geology


MAP 1.1
Location, cadastre and landslide hazard bands
Contour interval 5m
GDA94
511500mE
GDA94
5212000mN
Lowes Road
GARDEN ISLAND SANDS
SUNSET DRIVE
Garden Island Creek
Channel Highway
CHANNEL HIGHWAY
Huon River
Landslide Planning Map - Hazard Bands 20131022
Low
Medium
Medium to Active
High
Grid North
0
500
Approx. metres


MAP 1.2
Aerial imagery
GDA94
511500mE
GDA94
5212000mN
Lowes
Road
GARDEN ISLAND
SANDS
Garden
Island
Creek
Channel
Highway
Huon River
Grid North
0
500
Approx. metres


MAP 1.3
Hillshading
GDA94
511500mE
GDA94
5212000mN
Lowes
Road
GARDEN ISLAND
SANDS
Garden
Island
Creek
Channel
Highway
Huon River
Grid North
0
500
Approx. metres



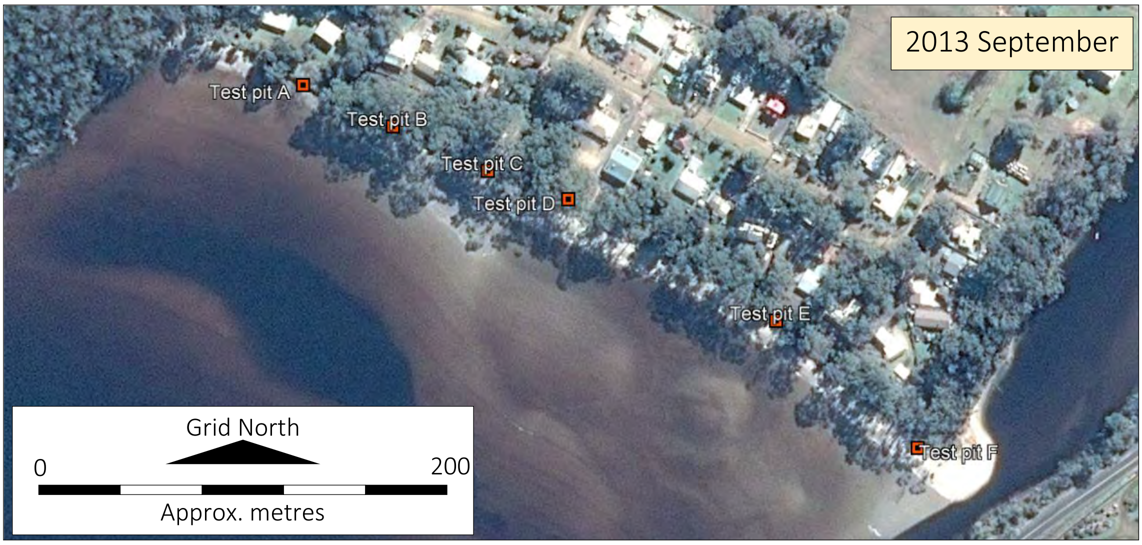
Published geology
Farmer, N. (1981). Geological Atlas 1:50,000 Scale Series. *Kingborough*. Department of Mines Tasmania, and Farmer, N. and Forsyth, S. M. (1993). Geological Atlas 1:50,000 Scale Series. *Dover*. Department of Mines Tasmania.
Key to rock types
Orange (symbol Jdl) = Jurassic-age dolerite; Yellow (symbol Qa) = Quaternary-age alluvium; Light yellow (symbol Qb) = Quaternary-age (Holocene) beach and tidal flat deposits (sand, silt, mud, shells, cobbles)

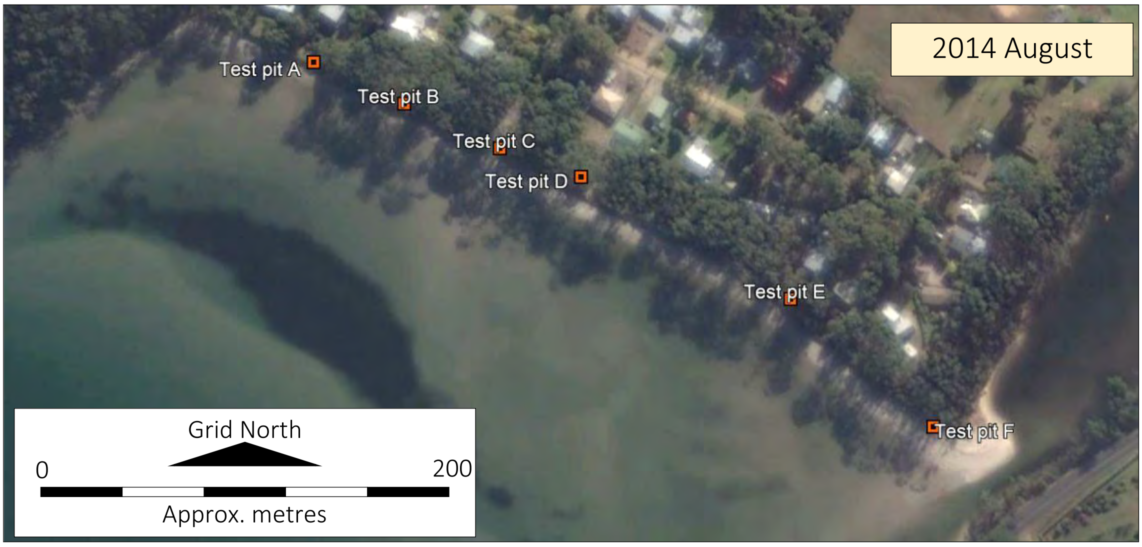
Attachment 2

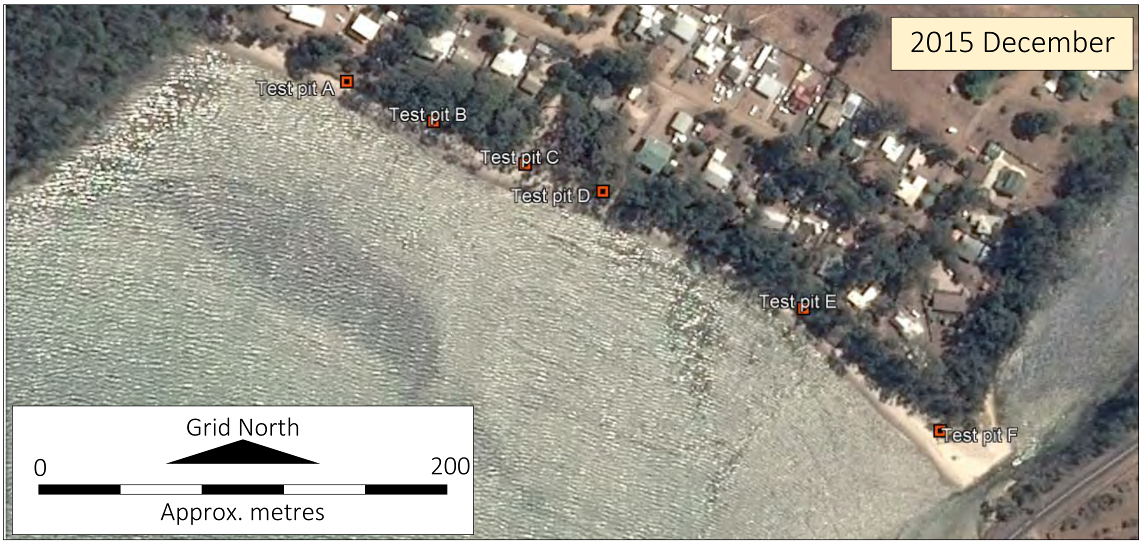
(4 pages including this page)

Historical satellite imagery 2013 – 2022

Source: Google Earth


2013 September
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
Grid North
0
200
Approx. metres


2014 August
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
Grid North
0
200
Approx. metres


2015 December
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
Grid North
0
200
Approx. metres


2016 January
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
Grid North
0
200
Approx. metres


2017 November
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
Grid North
0
200
Approx. metres


2018 September
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
Grid North
0
200
Approx. metres


2019 April
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
Grid North
0
200
Approx. metres

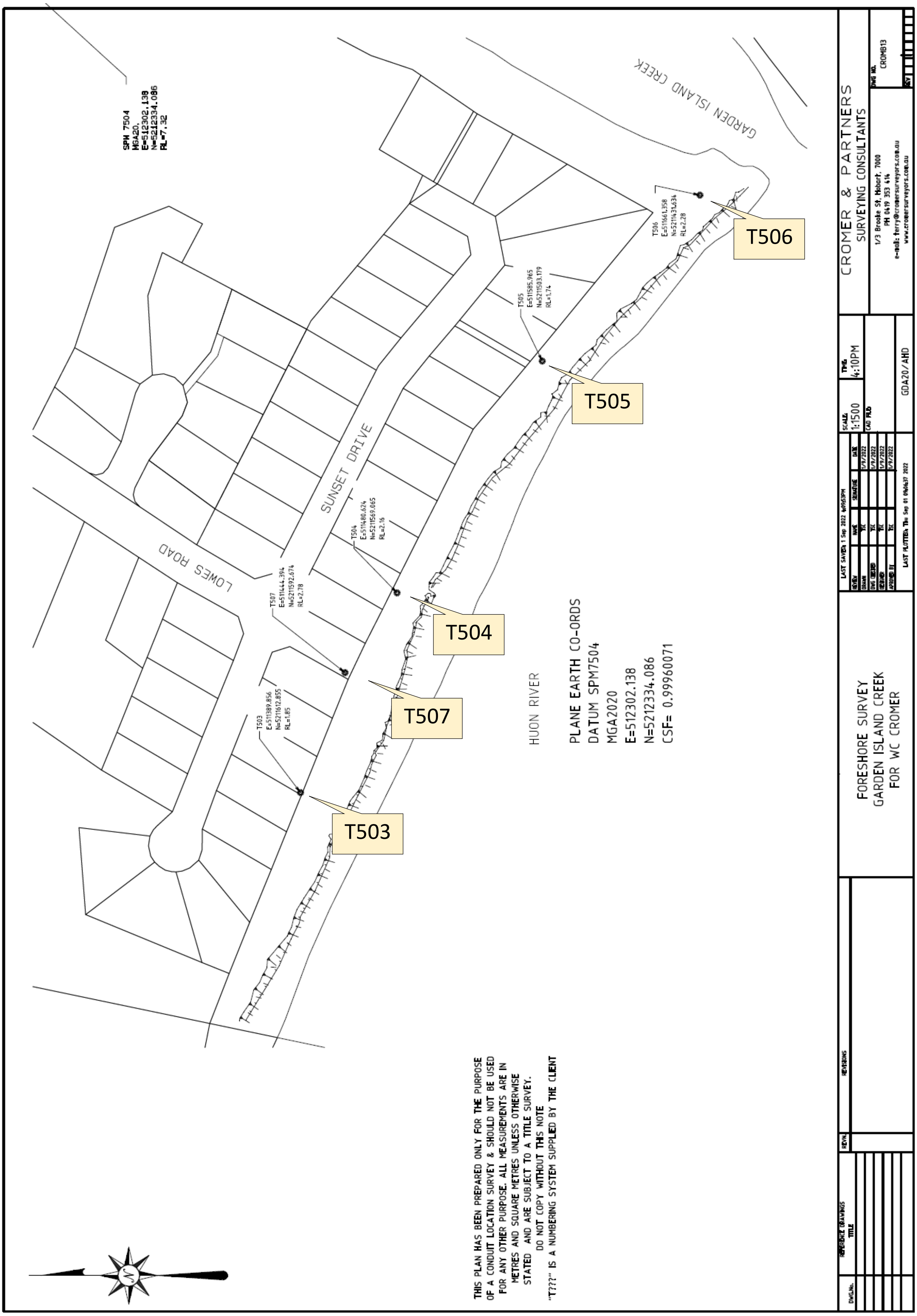

2021 January
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
Grid North
0
200
Approx. metres


2022 March
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F

Attachment 3

(8 pages including this page)

TASMARC markers T503— T507 established August 2022
Surveyed by Elliott Cromer 12 August 2022


T506
T505
T504
T507
T503
SUNSET DRIVE
LOWES ROAD
GARDEN ISLAND CREEK
HUON RIVER
SPM 7504
MGA20
E=512302.138
N=5212334.086
RL=7.32
PLANE EARTH CO-ORDS
DATUM SPM7504
MGA2020
E=512302.138
N=5212334.086
CSF= 0.99960071
THIS PLAN HAS BEEN PREPARED ONLY FOR THE PURPOSE OF A CONDUIT LOCATION SURVEY & SHOULD NOT BE USED FOR ANY OTHER PURPOSE. ALL MEASUREMENTS ARE IN METRES AND SQUARE METRES UNLESS OTHERWISE STATED AND ARE SUBJECT TO A TITLE SURVEY.
DO NOT COPY WITHOUT THIS NOTE
"T???" IS A NUMBERING SYSTEM SUPPLIED BY THE CLIENT
CROMER & PARTNERS
SURVEYING CONSULTANTS
SCALE 1:1500
GDA20/AHD
FORESHORE SURVEY
GARDEN ISLAND CREEK
FOR WC CROMER


GDA94
511500mE
GDA94
5211500mN
Test pit A
Test pit B
Test pit C
Test pit D
Test pit E
Test pit F
T503
T507
T504
T505
T506
Grid North
0
200
Approx. metres

T503


T507
T507
T503
Test pit B
T507
Test pit C


T507
t pit C
T504
Test pit D
T504
T504
T504

T505

T506

Attachment 4

(17 pages including this page)

Site and test pit photos

The scale in the photos is graduated in red- and black-numbered segments each one metre long.
The black numbers are decimetres.


Test pit A
GDA94
511335mE; 5211611mN
Test pit A
Test pit B
Test pit C
KUBOTA
U17-3


GARDEN ISLAND SANDS 4 OCT 22 PIT A
Layer 1
Layer 2

Test pit B
GDA94
511370mE; 5211587mN
On T503 beach profile


GARDEN
ISLAND
SANDS
4 OCT 22
PIT
B
Layer 1
Layer 2


GARDEN
ISLAND
SANDS
4 OCT 22
PIT
B

Test pit C
GDA94
511432mE; 5211568mN
On T507 beach profile


GARDEN ISLAND SANDS
4 OCT 22
PIT C
Layer 1
Layer 2

Test pit D
GDA94
511474mE; 5211554mN
On T504 beach profile


GARDEN
ISLAND
SANDS
4 OCT 22
PIT
D
Layer 1
Layer 2

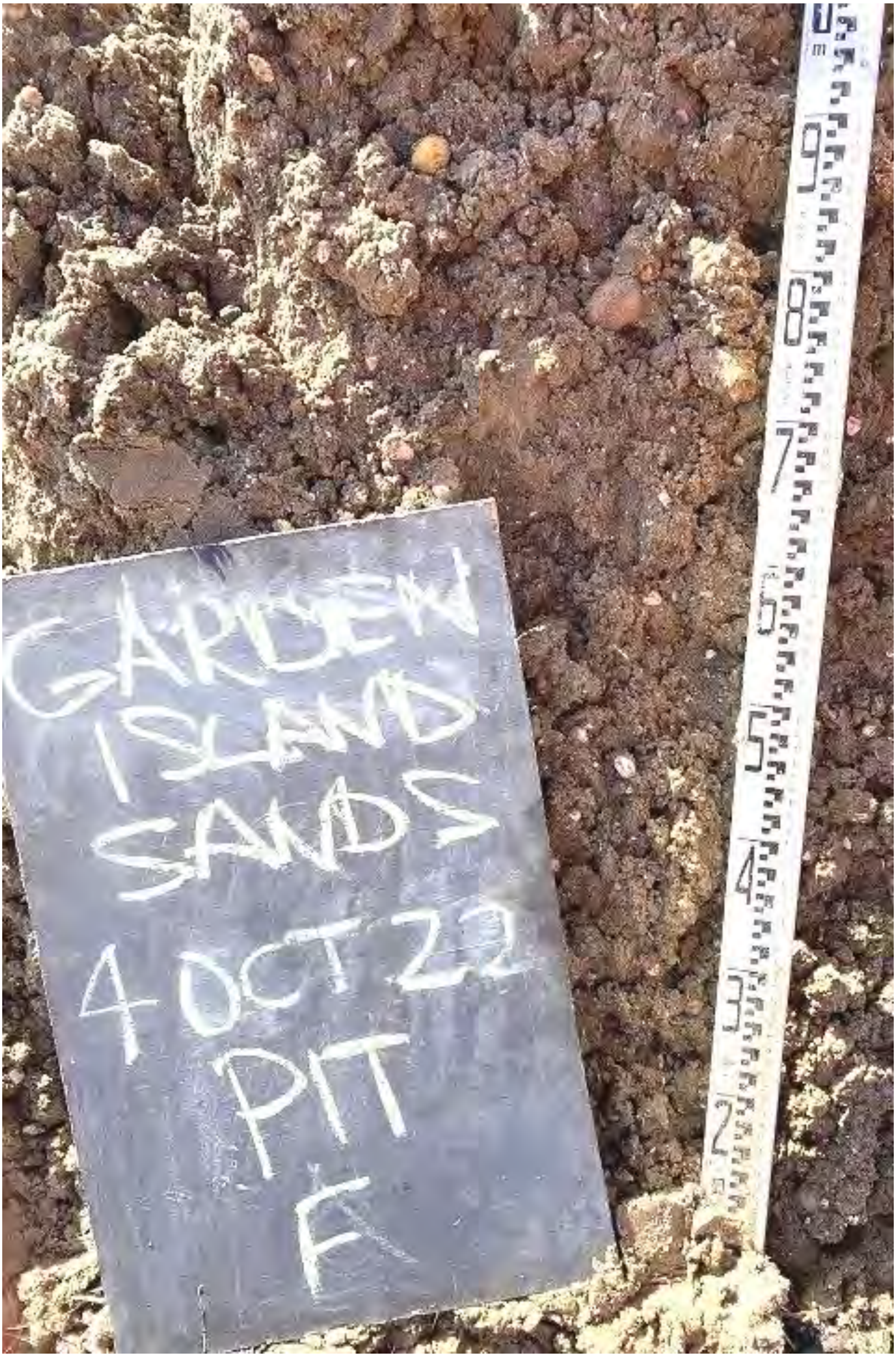

SANDS
4 OCT 22
PIT
D

Test pit E
GDA94
511575mE; 5211490mN
On T505 beach profile


Layer 1
Layer 2


Test pit F
GDA94
511651mE; 5211422mN
On T506 beach profile
Test pit D
Test pit E
Test pit F
KUBOTA


GARDEN
ISLAND
SANDS
4 OCT 22
PIT
F
Layer 1
Layer 2


GARDEN
ISLAND
SANDS
4 OCT 22
PIT
F

Environmental Consulting Options Tasmania

NATURAL VALUES ASSESSMENT OF LPI JYK07, GARDEN ISLAND SANDS, TASMANIA, TO INFORM THE GARDEN ISLAND CREEK EROSION AND FLOOD DISASTER REDUCTION PROJECT

Environmental Consulting Options Tasmania (ECO*tas*) for Friends of Garden Island Creek

30 August 2022

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CITATION

This report can be cited as:

ECO*tas* (2022). *Natural Values Assessment of LPI JYK07, Garden Island Sands, Tasmania to Inform the Garden Island Creek Erosion and Flood Disaster Reduction Project.* Report by Environmental Consulting Options Tasmania (ECO*tas*) for Friends of Garden Island Creek, 30 August 2022.

AUTHORSHIP

Field assessment: Mark Wapstra

Report production: Mark Wapstra

Habitat and vegetation mapping: Mark Wapstra

Base data for mapping: LISTmap

Digital and aerial photography: Mark Wapstra, GoogleEarth, LISTmap

DISCLAIMER

Except where otherwise stated, the opinions and interpretations of legislation and policy expressed in this report are made by the author and do not necessarily reflect those of the relevant agency. The client should confirm management prescriptions with the relevant agency before acting on the content of this report. This report and associated documents do not constitute legal advice.

Note that any reference to the Department of Primary Industries, Parks, Water & Environment (DPIPWE) now refers to the Department of Natural Resources and Environment Tasmania.

ACKNOWLEDGEMENTS

Kelsie Fractal (Friends of Garden Island Creek) provided background information.

COVER ILLUSTRATION

View of old jetty site at end of informal parking area at the end of Lowe Street.

Please note: the blank pages in this document are deliberate to facilitate double-sided printing.

CONTENTS

SUMMARY

General

Friends of Garden Island Creek engaged Environmental Consulting Options Tasmania (ECO*tas*) to undertake a natural values assessment of LPI JYK07, Garden Island Creek, Tasmania, primarily to ensure that the requirements of the identified natural values are appropriately considered during any further project planning (Garden Island Creek Erosion and Flood Disaster Reduction Project) under local, State and Commonwealth government approval protocols.

Site assessment

A natural values assessment of the study area was undertaken by Mark Wapstra (ECO*tas*) on 22 Aug. 2022.

Summary of key findings

Threatened flora

- No plant species listed as threatened on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) and/or the Tasmanian *Threatened Species Protection Act 1995* (TSPA) were detected, or are known from database information, from the study area.

Threatened fauna

- No fauna species listed as threatened on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) and/or the Tasmanian *Threatened Species Protection Act 1995* (TSPA) were detected, or are known from database information, from the study area.

Vegetation types

- The study area supports the following TASVEG mapping units:
  – urban areas (TASVEG code: FUR);
  – marram grassland (TASVEG code: FMG);
  – sand, mud (TASVEG code: OSM);
  – water, sea (TASVEG code: OAQ); and
  – *Eucalyptus viminalis – Eucalyptus globulus* coastal forest and woodland (TASVEG code: DVC).
- DVC is equivalent to a threatened vegetation community (with the same name) listed on Schedule 3A of the Tasmanian *Nature Conservation Act 2002* but does not equate to a threatened ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.
- As a vegetation type, DVC is classified as a moderate priority biodiversity value under Table E10.1 of the Biodiversity Code of the *Huon Valley Interim Planning Scheme 2015* (and will

qualify as priority vegetation under the incoming *Tasmanian Planning Scheme – Huon Valley*).

Weeds

- Four plant species classified as declared weeds within the meaning of the Tasmanian *Weed Management Act 1999* (*Biosecurity Act 2019*) and several others considered to be environmental weeds (author opinion) were detected from the study area.

Plant disease

- No evidence of *Phytophthora cinnamomi* (PC, rootrot) was recorded within the study area.
- No evidence of myrtle wilt was recorded from within the study area.
- No evidence of myrtle rust was recorded from within the study area.
- Several trees showed symptoms of "ginger tree syndrome".

Animal disease (chytrid)

- The study area does not support habitat types strongly associated with amphibian species.

Recommendations

The recommendations provided below are a summary of those provided in relation to each of the natural features described in the main report. The main text of the report provides the relevant context for the recommendations.

Vegetation types

In general terms, minimising the extent of "clearance and conversion" and/or "disturbance" to native vegetation is recommended.

Threatened flora

Not applicable – no threatened flora present.

Threatened fauna

Apart from the generic recommendation to minimise the extent of "clearance and conversion" and/or "disturbance" to native vegetation, it is also recommended that the extent of loss of individual eucalypts and disturbance to understorey is minimised.

Weed and disease management

Irrespective of the scale of works, any vegetation debris and topsoil created during works should be considered "contaminated" with weed propagules and treated accordingly. I usually suggest burial and/or burning on-site (subject to any municipal and other regulations) if this this can be practically achieved during works. Off-site transport will need to be subject to any provisions of the weed legislation, council regulations and material disposed of at a facility registered to take declared weeds.

In the longer-term, mobilisation of volunteers in conjunction with the appropriate land managers may facilitate an ongoing program of weed management. Some species are highly localised and could be treated (probably to the point of elimination) immediately (e.g. remove the two specimens of coast wirilda; cut and paste the localised occurrences of english broom, tree lucerne and trailing daisy; grub out the jonquills). Other species are more challenging such as canary broom that is becoming locally abundant, although generally still easily hand-pulled. The current assessment resulted in all detected occurrences of boneseed being uprooted but other/new specimens will be present such that a "watching brief" will be needed. The management of the macrocarpa pine may require further consideration as it may provide a soil stabilisation function – ideally, in the longer-term the tree will be removed and replaced with white gum.

As part of the proposed works (or future activities), creation and erection of an interpretive sign displaying "weeds to watch" for in the reserve is recommended to alert reserve users to such species and allow for ad hoc control to be undertaken.

<u>Broader interpretive ideas</u>

Creation and erection of an interpretive sign that explains the conservation significance of the vegetation type present within the reserve and displays some of the key flora and fauna elements is recommended to alert reserve users to the importance of the reserve and the need for cooperative and long-term active management to maintain such values.

<u>Longer-term management</u>

The understorey is variably dense and in the absence of disturbance, this may become denser and eventually reduce species diversity (e.g. herbs). Use of small-scale and low intensity fire (e.g. cultural burning practices) and/or slashing may be beneficial. It is recognised that this will need coordination between different parties to take account of varius management issues. Such disturbance may encourage weeds and so should not be undertaken in isolation of active and ongoing weed management.

<u>Legislative and policy implications</u>

A permit under Section 51 of the Tasmanian *Threatened Species Protection Act 1995* (TSPA) should not be required.

A formal referral to the relevant Commonwealth agency under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) should not be required.

Until a specific project outline is presented, it is not known how some legislative instruments will interact. It is recommended that advice be sought from officers within the relevant agency as part of project planning.

INTRODUCTION

Purpose

Friends of Garden Island Creek engaged Environmental Consulting Options Tasmania (ECO*tas*) to undertake a natural values assessment of LPI JYK07, Garden Island Creek, Tasmania, primarily to ensure that the requirements of the identified natural values are appropriately considered during any further project planning (Garden Island Creek Erosion and Flood Disaster Reduction Project) under local, State and Commonwealth government approval protocols.

Scope

This report relates to:

- flora and fauna species of conservation significance, including a discussion of listed threatened species (under the Tasmanian *Threatened Species Protection Act 1995* and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*) potentially present, and other species of conservation significance/interest;
- vegetation types (forest and non-forest, native and exotic) present, including a discussion of the distribution, condition, extent, composition and conservation significance of each community;
- plant and animal disease management issues;
- weed management issues; and
- a discussion of some of the policy and legislative implications of the identified natural values.

This report follows the government-produced *Guidelines for Natural Values Surveys – Terrestrial Development Proposals* (DPIPWE 2015) in anticipation that the report (or extracts of it) may be required as part of various approval processes.

The report format should also be applicable to other assessment protocols as required by the relevant Commonwealth agency (for any referral/approval that may be required under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*), which is unlikely to be required in this case.

More specifically, this assessment and report have been prepared to address specific provisions of the *Huon Valley Interim Planning Scheme 2015*, with particular reference to the natural values/biodiversity provisions of the Environmental Management zone and Biodiversity Code.

Limitations

The natural values assessment was undertaken on 22 Aug. 2022. Many plant species have ephemeral or seasonal growth or flowering habits, or patchy distributions (at varying scales), and it is possible that some species were not recorded for this reason. However, every effort was made to sample the range of habitats present in the survey area to maximise the opportunity of recording most species present (particularly those of conservation significance). Late spring and into summer is usually regarded as the most suitable period to undertake most botanical assessments. While some species have more restricted flowering periods, a discussion of the potential for the site to support these is presented. In this case, I believe that the survey was appropriately timed to detect the species with a highest priority for conservation management in this part of the State, particularly with respect to the long-undisturbed nature of much of the study area.

The survey was also limited to vascular species: species of mosses, lichens and liverworts were not recorded. However, a consideration is made of threatened species (vascular and non-vascular) likely to be present (based on habitat information and database records) and reasons presented for their apparent absence.

Surveys for threatened fauna were largely limited to an examination of "potential habitat" (i.e. comparison of on-site habitat features to habitat descriptions for threatened fauna), and detection of tracks, scats and other signs.

Permit

Any plant material was collected under DNRET permit TFL 22382 (in the name of Mark Wapstra). Relevant data will be entered into DNRET's *Natural Values Atlas* database by the author. Some plant material may be lodged at the Tasmanian Herbarium by the author.

No vertebrate or invertebrate material was collected. A permit is not required to undertake the type of habitat-level assessment described herein.

PROJECT OVERVIEW

The key activities of this planning project will engage experts to collate the information required to:

- assess the causes of erosion and flooding;
- present mitigation options to the community; and
- develop a management plan.

In addition, the project will:

- train the community to monitor erosion;
- develop a framework to assist other communities experiencing similar erosion issues by providing information about the process, identifying suitable consultants, providing cost estimates, and navigating council and crown processes; and
- build resilience in the local community through providing information that builds understanding of future mitigation options and their implementation, to protect properties and the beach.

In the short term, the community seeks to:

- understand the coastal processes causing erosion at Garden Island Sands;
- develop a management plan to direct future efforts to mitigate erosion and care for the natural values of the area; and
- install a permanent structure to provide beach access that is in line with erosion mitigation measures.

The present natural values assessment was commissioned to provide background information on the project site and its wider context, to facilitate any formal planning requirements through the Huon Valley Council and/or Parks & Wildlife Service (Department of Natural Resources and Environment Tasmania) and to facilitate incorporation of natural values into longer-term planning.

STUDY AREA

Overview – cadastral details

The study area was considered to be the Crown land title of LPI JYK07 (potential PID 2580416) under the jurisdiction of NRE Tas (Property Services), located between the foreshore and Sunset Drive, Garden Island Sands (Figures 1-3). For the purposes of assessment, the study area was defined by the private titles to the northeast (most of which are fenced), Garden Island Creek to the southeast, the high tide mark along the foreshore, and a minor creek to the northwest below the steeper slopes of Echo Sugarloaf (part of the Echo Sugarloaf State Reserve).

LISTmap data indicates a computed area of 22,239.797 m^2 (i.e. ca. 2.2 ha).

Land tenure and other categorisations of the study area are as follows:

- Public Reserve pursuant to the *Crown Lands Act 1976*, this reserve extending along the western shore of Garden Island Creek (Figure 6), the latter area not forming part of the present study area;
- Informal Reserve on Other Public Land (Figure 7), with minor discrepancies between the definition of this and the Public Reserve, one seemingly defined by the high water mark, the other by cadastral boundaries;
- South East Bioregion, according to the IBRA 7 bioregions used by most government agencies.

At present, the study area is zoned as Environmental Management pursuant to the *Huon Valley Interim Planning Scheme 2015* (Figure 4), and partly subject to the Biodiversity Protection Area and Waterway and Coastal Protection Areas overlays (Figure 5). Note that other overlays are present but are not considered as part of the present assessment.

Note that as this project is likely to extend into the period when the *Tasmanian Planning Scheme* will become applicable in this municipality, it is useful to examine the proposed zoning and overlays pursuant to the *Huon Valley Local Provisions Schedule* (accessed via the *Tasmanian Planning Scheme* Consultation portal at: https://planning.discovercommunities.com.au/connect/analyst/mobile/#/main?mapcfg=huonvalley). The reserved title is intended to remain zoned as Environmental Management with no change to the aforementioned overlays (except that the Biodiversity Protection Area will be renamed the Priority Vegetation Area overlay).

Other site features

The study area is topographically simple comprising flat terrain a metre or so above a variable width sandy beach with a steep front subject to ongoing coastal erosion (Plates 1-6). There are no marked drainage features present within the actual study area, although Garden Island Creek forms the southeastern boundary (Plates 7 & 8) and an unmarked but seemingly permanent creek forms the northwestern boundary (Plates 9 & 10). The study area supports mainly native forest dominated by *Eucalyptus viminalis* (white gum) with a variably dense understorey (Plates 11 & 12), with some areas impacted by local activities resulting in canopy and understorey modification to the point of local areas being classified as some form of modified land (Plates 13 & 14). The shifting sandspit at the mouth of Garden Island Creek is locally dominated by *Ammophila arenaria* (marram grass) – Plates 15 & 16. Lowes Road extends from the crossroad with Sunset Drive to extend between 14 & 16 Sunset Drive to access an informal car parking and turning circle at the site of the old jetty (Plates 17 & 18). There is also a narrow walkway between 30 & 32 Sunset Drive that provides access to the reserve.

The geology of the study area is important to consider because it can have a strong influence on the classification of vegetation and the potential occurrence of threatened flora (and to a lesser extent, threatened fauna). In this case, the 1:250,000 scale geological mapping (Figure 8) indicates the study area and surrounds are underlain by Quaternary-age "sand gravel and mud of alluvial, lacustrine and littoral origin" (geocode: Qh), which was confirmed informally by site assessment by reference to the deep white sands (see various plates).

LISTmap's Fire History layer (Figure 9) indicates that part of the study area was affected by the "Garden Is Creek" bushfire (Incident Number 1703, 1982) but there was limited to no evidence of this event with no obvious fire scars, scorch marks or burnt logs.

Plates 1-6. Examples of active coastal erosion along face of study area


Plates 7 & 8. Mouth of Garden Island Creek at southeast end of study area


Plates 9 & 10. Small unmarked and un-named creek at northwest end of study area


Plates 11 & 12. Examples of *Eucalyptus viminalis*-dominated forest that dominates the study area


Plates 13 & 14. Examples of modified parts of study area where the *Eucalyptus viminalis* canopy has been removed and the understorey substantially modified


Plates 15 & 16. Patch of marram grass at mouth of Garden Island Creek


Plates 17 & 18. Informal parking area and turning circle at end of Lowes Road

Figure 1. General location of study area

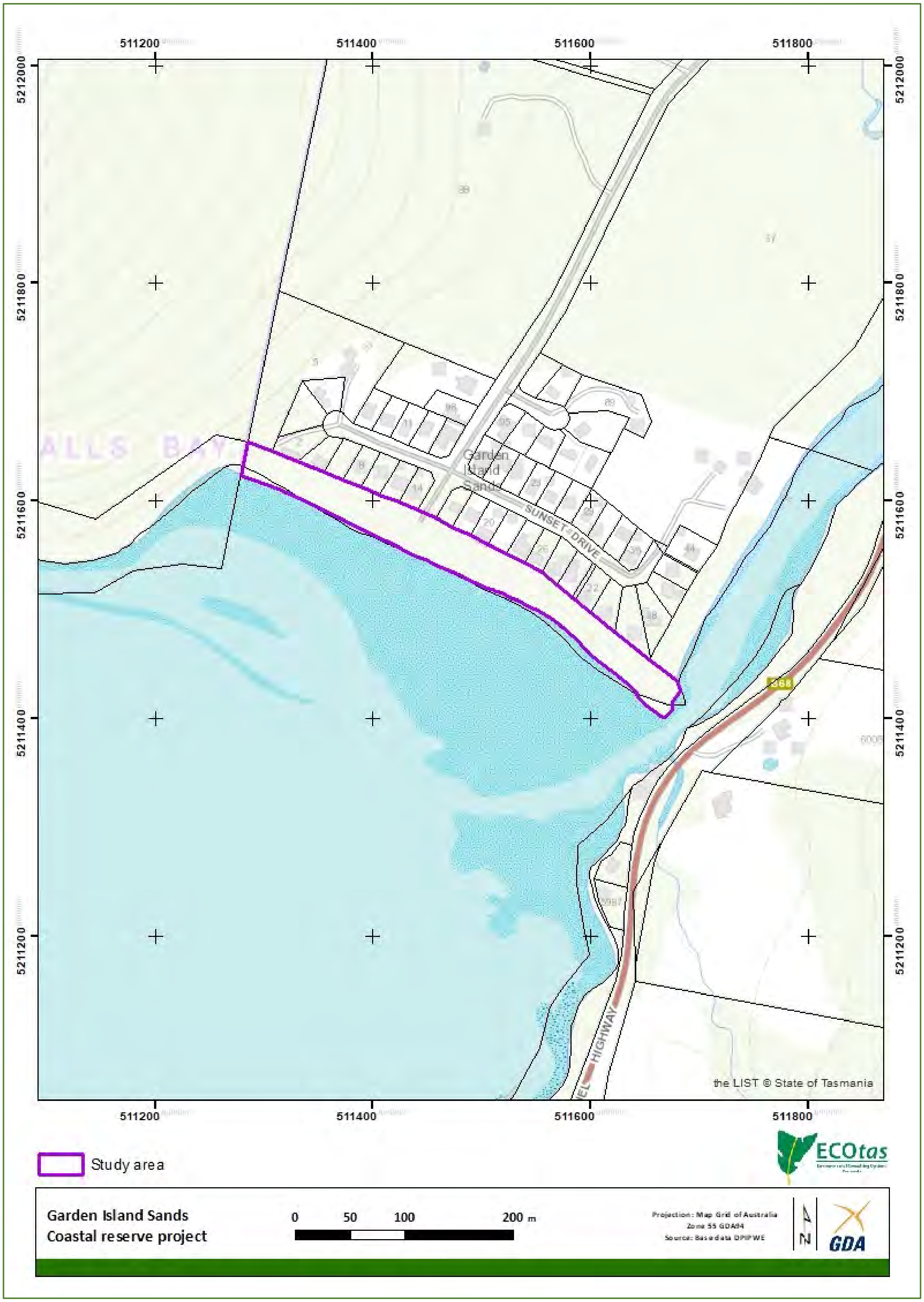

Figure 2. Detailed location of study area showing general topographic and cadastral features

Figure 3. Detailed location of study area showing recent aerial imagery

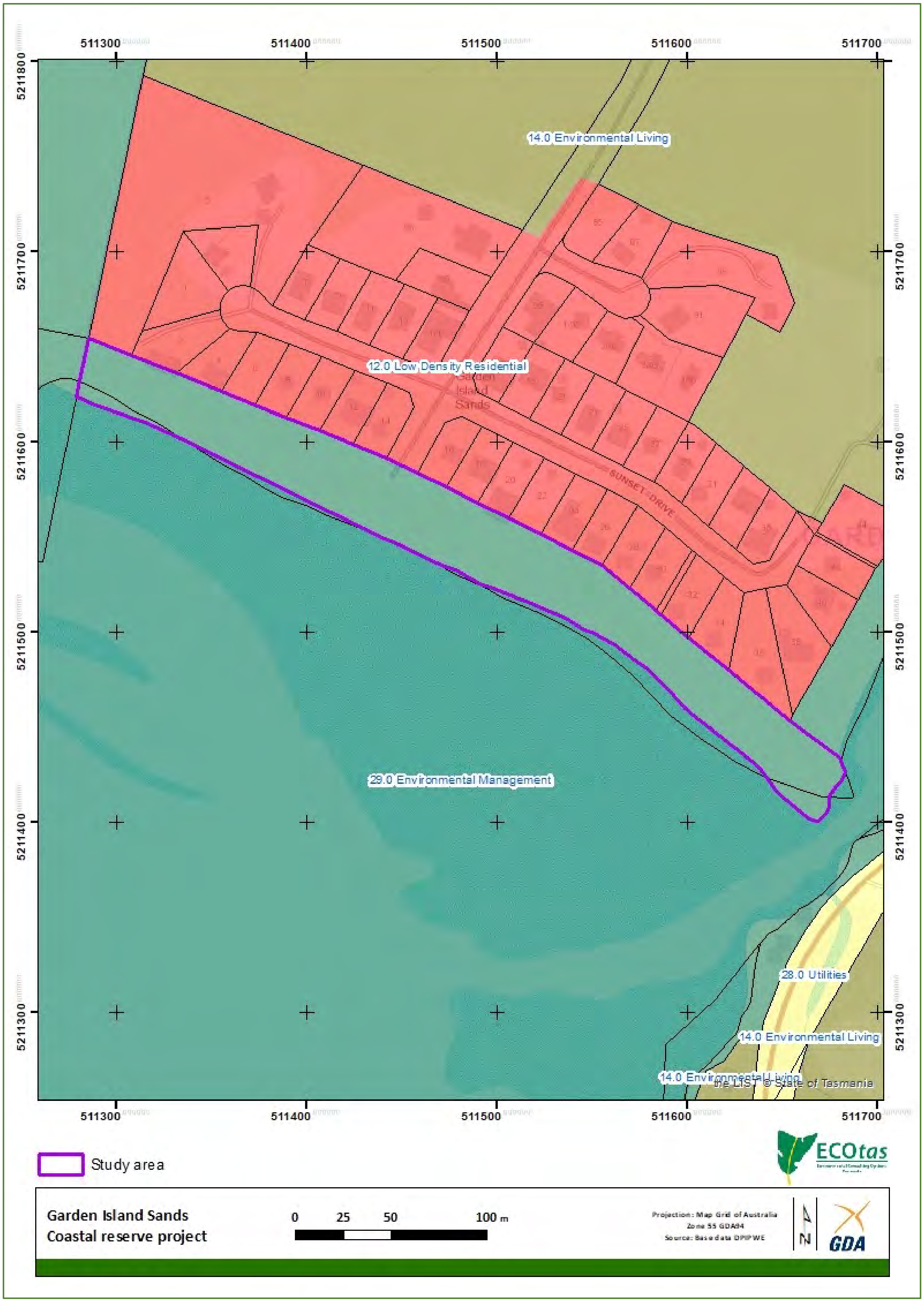

Figure 4. Zoning of study area and surrounds pursuant to the *Huon Valley Interim Planning Scheme 2015*

Figure 5. Extent of Biodiversity Protection Area (green stippling – part of area) and Waterway and Coastal Protection Areas (blue stippling – along coastal fringe) overlays within study area and surrounds pursuant to the *Huon Valley Interim Planning Scheme 2015*

Figure 6. Land tenure of study area and surrounds

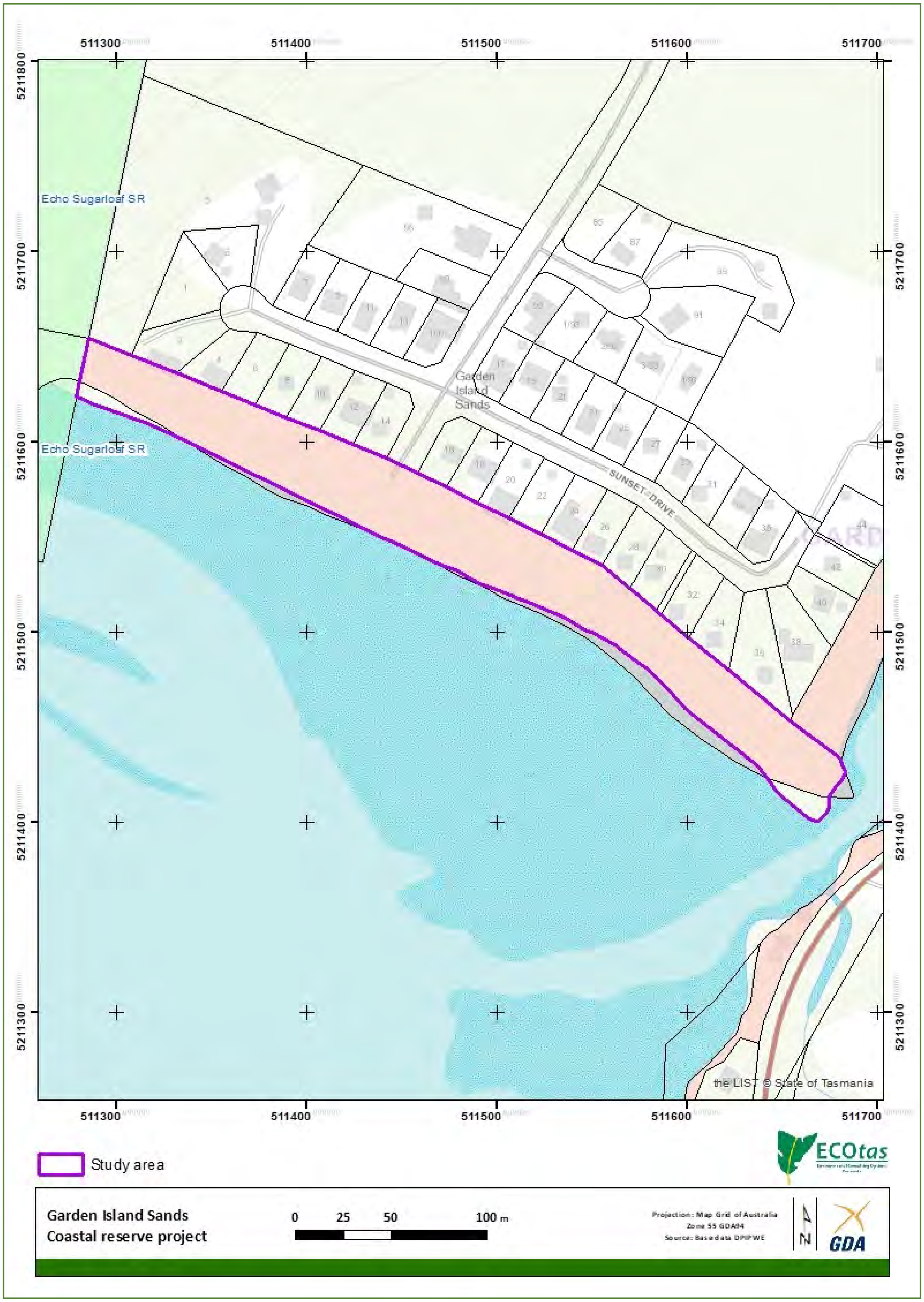

Figure 7. Locatioon of informal reserve relative to cadastral boundaries

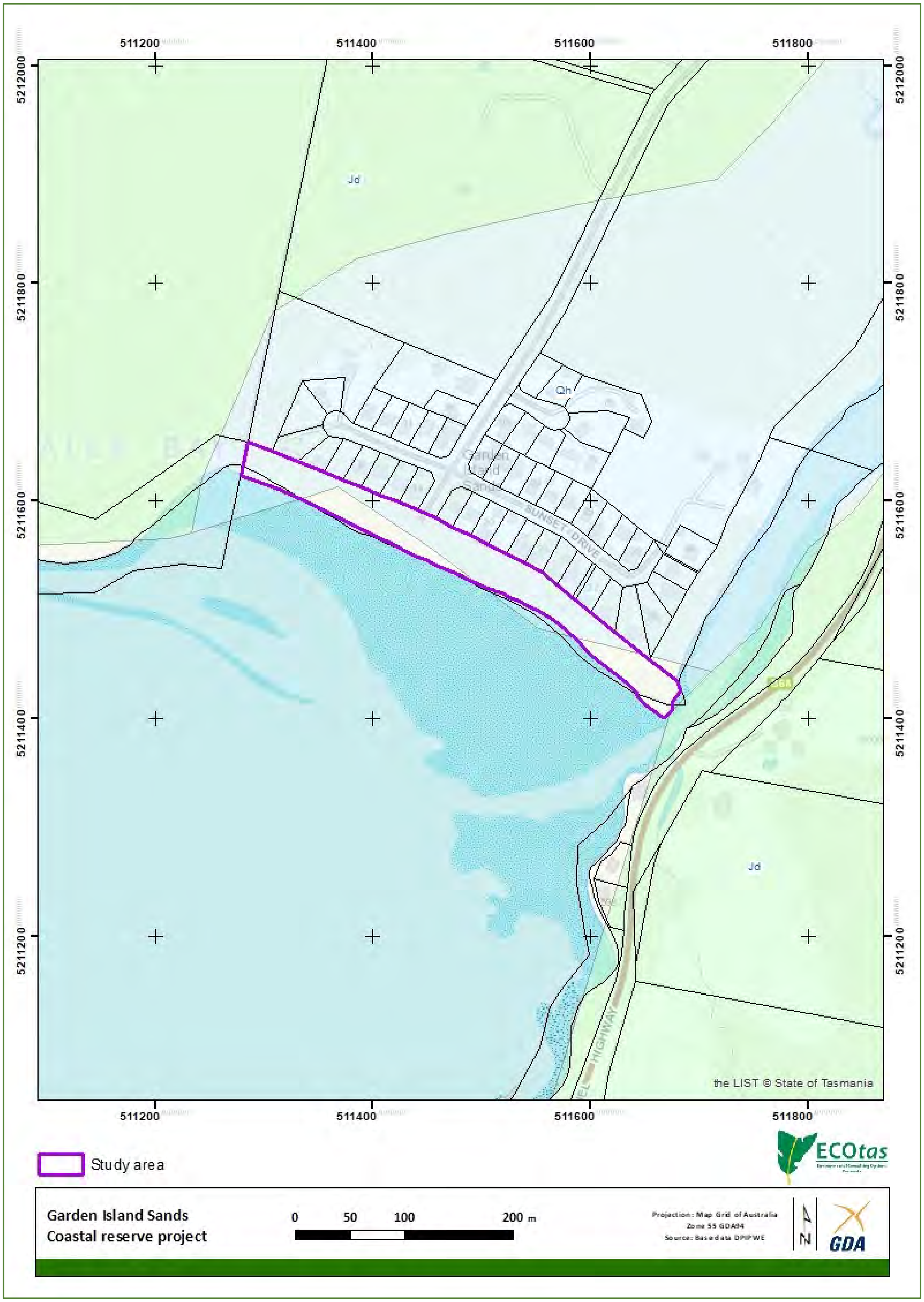

Figure 8. Geology (1:250,000 scale) of the study area and surrounds (refer to text for code)

Figure 9. Fire history of study area and surrounds

METHODS

Nomenclature

All grid references in this report are in GDA94, except where otherwise stated.

Vascular species nomenclature follows de Salas & Baker (2022) for scientific names and Wapstra et al. (2005+) for common names. Fauna species scientific and common names follow the listings in the cited *Natural Values Atlas* report (DNRET 2022a).

Vegetation classification follows TASVEG 4.0, as described in *From Forest to Fjaeldmark: Descriptions of Tasmania's Vegetation (*Kitchener & Harris 2013+).

Preliminary investigation

Available sources of previous reports, threatened flora records, vegetation mapping and other potential environmental values were interrogated. These sources include:

- Tasmanian Department of Natural Resources and Environment Tasmania's *Natural Values Atlas* records for threatened flora and fauna (GIS coverage maintained by the author current as at date of report);
- Tasmanian Department Natural Resources and Environment Tasmania's *Natural Values Atlas* report ECOtas_GardenIslandSands for a polygon defining the study area (centred on 511483mE 5211543mN), buffered by 5 km, dated 21 Aug. 2022 (DNRET 2022a) – Appendix E;
- Forest Practices Authority's *Biodiversity Values Database* report, specifically the species' information for grid reference centroid 511483mE 5211543mN (i.e. a point defining the centre of the NVA report), buffered by 5 km and 2 km for threatened fauna and flora records, respectively, hyperlinked species' profiles and predicted range boundary maps, dated 21 Aug. 2022 (FPA 2022) – Appendix F;
- Commonwealth *Protected Matters Report* for a polygon defining the study area, buffered by 5 km, dated 21 Aug. 2022 (CofA 2022) – Appendix G;
- *Priority Vegetation Report* (Appendix H);
- the TASVEG 3.0, 4.0 & Live vegetation coverages (as available through GIS coverage and via LISTmap);
- GoogleEarth, World Imagery (via ArcGIS) and LISTmap aerial orthoimagery; and
- other sources listed in tables and text as indicated.

Field assessment

The natural values assessment was undertaken on 22 Aug. 2022.

Cadastral data uploaded to the iGIS application guided the in-field assessment, although the boundaries of the study area are well-defined by the foreshore, adjacent creeks and fenced private titles. Hand-held GPS (Garmin Oregon 600) was used to waypoint any natural values features.

Assessment was not limited in any significant manner with access from Lowes Road (main car park area), Sunset Drive (pedestrian access) and generally easily-traversed vegetation.

Vegetation classification

Vegetation was classified by waypointing vegetation transitions for later comparison to aerial imagery. The structure and composition of the vegetation types was described using a nominal 30 m radius plot at a representative site within the vegetation types, and compiling "running" species lists for the balance of the study area.

Threatened flora

With reference to the threatened flora, the survey included consideration of the most likely habitats for such species. Further methods are not provided as no such species were detected.

Threatened fauna

Surveys for threatened fauna were largely limited to an examination of "potential habitat" (i.e. comparison of on-site habitat features to habitat descriptions for threatened fauna), and detection of tracks, scats and other signs.

Weed and hygiene issues

The study area was assessed with respect to plant species classified as declared weeds under the Tasmanian *Weed Management Act 1999* (*Biosecurity Act 2019*), Weeds of National Significance (WoNS) or "environmental weeds" (author opinion and as included in *A Guide to Environmental and Agricultural Weeds of Southern Tasmania*, NRM South 2017).

The site was assessed with respect to potential impacts of plant and animal pathogens, by reference to habitat types and field symptoms.

FINDINGS

Vegetation types

Comments on TASVEG mapping

This section, which comments on the existing TASVEG mapping for the study area, is included to highlight the differences between existing mapping and the more recent mapping from the present study to ensure that any parties assessing land use proposals (via this report) do not rely on existing mapping. Note that TASVEG mapping, which was mainly a desktop mapping exercise based on aerial photography, is often substantially different to ground-truthed vegetation mapping, especially at a local scale. An examination of existing vegetation mapping is usually a useful pre-assessment exercise to gain an understanding of the range of habitat types likely to be present and the level of previous botanical surveys.

There are three relevant versions of TASVEG that can be considered as part of this review. TASVEG Live is the most up-to-date version, available online via LISTmap. It is generally very similar to TASVEG 4.0, especially at a local lot-level scale, but can include localised and/or project-based updates that can be informative. TASVEG 3.0, the immediately preceding version of the vegetation mapping layer, is in theory superseded by TASVEG 4.0. However, examination of this layer can be useful because it was the primary source of information that was included in the Regional Ecosystem Model that guided the priority vegetation area overlay of the *Tasmanian Planning Scheme* in several municipalities, including Huon Valley.

In the case of the present study area, TASVEG 3.0 & 4.0 are identical (Figure 10) but TASVEG Live is marginally different (Figure 11), with the study area and surrounds as:

- *Eucalyptus globulus* dry forest and woodland (TASVEG code: DGL)

  TASVEG 3.0 & 4.0 map a small area of DGL in the far west of the study area, this a minor extension of a much larger polygon of DGL that covers much of the adjacent slopes of Echo Sugarloaf.

- *Eucalyptus viminalis – Eucalyptus globulus* coastal forest and woodland (TASVEG code: DVC)

  DVC is mapped across most of the study area, with TASVEG Live clearly attempting to correct the extent of DVC to take account of the coastline (rather than mapping forest across the beach and into the sea) and the adjacent residential area (rather than mapping forest across suburban yards).

- urban areas (TASVEG code: FUR)

  FUR is mapped across parts of the study area, mainly apparently because of the version of aerial imagery applied that implies some of the suburban yards have encroached into the reserve (this does not actually appear to be the case). The extent of FUR takes account of some historical modification of the coastal forest in front of 2, 4, 6 & 8 Sunset Drive.

The differences between TASVEG 3.0/4/0 and Live are considered inconsequential but TASVEG Live is considered marginally more accurate.

Vegetation types recorded as part of the present study

The vegetation types have been classified according to TASVEG mapping units, as described in *From Forest to Fjaeldmark: Descriptions of Tasmania's Vegetation* (Kitchener & Harris 2013+). Table 1 provides information on the vegetation types identified from the study area (Figure 11). Refer to Appendix A for a more detailed description of the native vegetation mapping unit identified from the study area.

Conservation significance of identified vegetation types

DVC equates to a native vegetation community (with the same name) listed as threatened under Schedule 3A of the Tasmanian *Nature Conservation Act 2002* but does not equate to a threatened ecological community listed on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. As a native vegetation community, DVC qualifies as a moderate priority biodiversity value under Table E10.1 of the Biodiversity Code of the *Huon Valley Interim Planning Scheme 2015* (and will qualify as "priority vegetation" under the Natural Assets Code of the incoming *Tasmanian Planning Scheme – Huon Valley*).

Table 1. Vegetation mapping units present in the study area

[conservation status: NCA – as per Schedule 3A of the Tasmanian *Nature Conservation Act 2002*, using units described by Kitchener & Harris (2013+), relating to TASVEG mapping units (DNRET 2022b); EPBCA – as per the listing of ecological communities on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, relating to communities as described under that Act, but with equivalencies to TASVEG units]

TASVEG equivalent (Kitchener & Harris 2013+)	Conservation priority TASVEG *EPBCA*	Comments
Dry eucalypt forest and woodland		
Eucalyptus viminalis – *Eucalyptus globulus* coastal forest and woodland (DVC)	threatened *not threatened*	DVC occupies most of the study area (apart from areas now mapped as FUR, FMG, OSM & OAQ). The canopy is of variable height and density, wholly dominated by *Eucalyptus viminalis* (white gum), mostly in excellent health, over a variably dense shrubby understorey, in turn over a grass-graminoid layer with local herbs. DVC is in variable condition with the main impacts being localised historical (and ongoing) informal modification in front of some houses and invasion by woody and herbaceous weeds. Coastal erosion is gradually resulting in the loss of DVC, specifically several large white gums.
Modified land		
urban areas (FUR)	not threatened *not threatened*	FUR is mapped across the entrance to the reserve i.e. the access and informal parking areas (now much "tighter" than previous versions of TASVEG). FUR is also mapped for a small area in front of 2 & 5 Sunset Drive where historical modification has resulted in the loss of the canopy and shifting of the understorey from native to exotic grass and herbs (again, the area of FUR is much "tighter" than previous versions of TASVEG).
marram grassland (FMG)	not threatened *not threatened*	The far southeastern part of the reserve at the mouth of Garden Island Creek was once shifting beach/river sand but is now locally dominated by *Ammophila arenaria* (marram grass), possibly a result of an historical attempt at stabilisation with this exotic grass species (it is a pity that locally native species such as *Poa poiformis*, *Austrostipa stipoides*, *Austrofestuca littoralis* and *Spinifex sericeus* were not used)
Other natural environments		
sand, mud (OSM)	not threatened *not threatened*	OSM is mapped across the narrow sandy beach between the forest and the sea. The precise limit of OSM & OAQ (and FRG & DVC) is subject to geographic and temporal variation with continued coastal erosion (and also depends on which version of an aerial image is used).
water, sea (OAQ)	not threatened *not threatened*	Aerial imagery suggests that part of the reserve is usually subject to higher tidal coverage – see also notes under OSM.

Figure 10. Study area and surrounds showing existing TASVEG 3.0 & 4.0 vegetation mapping (see text for codes)

Figure 11. Study area and surrounds showing existing TASVEG 4.0 (yellow polygons and labels) and TASVEG Live (purple polygons and labels) vegetation mapping (see text for codes)

Figure 12a. Revised vegetation mapping: overview (see text for codes)

Figure 12b. Revised vegetation and weed mapping: western section (see text for codes)

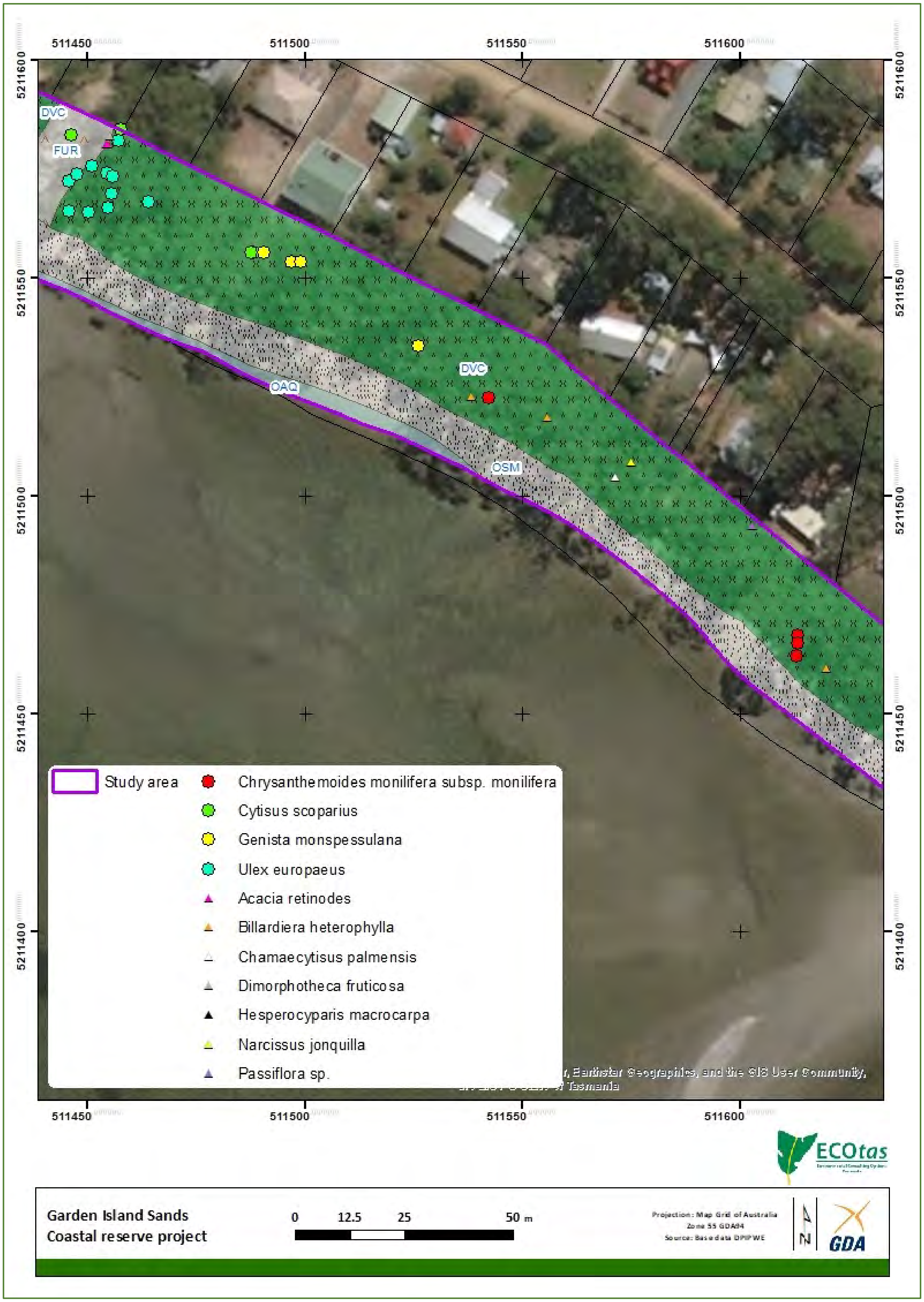

Figure 12c. Revised vegetation and weed mapping: central section (see text for codes)

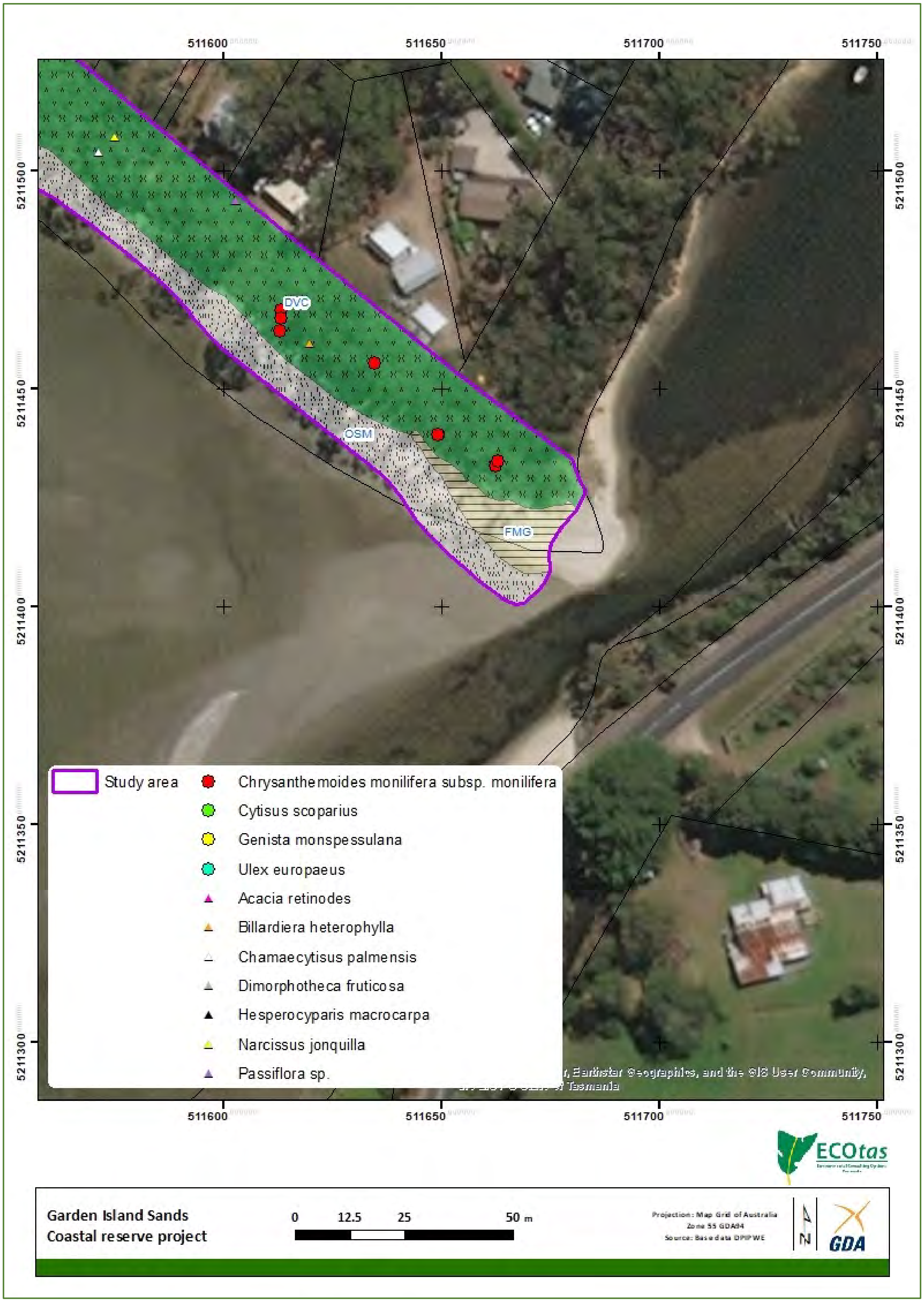

Figure 12d. Revised vegetation and weed mapping: eastern section (see text for codes)

Plant species

General information

A total of 80 vascular plant species were recorded from the study area (Appendix B), comprising 56 dicotyledons (including 1 endemic and 19 naturalised species), 22 monocotyledons (including 1 endemic and 2 naturalised species), 1 gymnosperm (introduced) and 1 pteridophyte (native). The relatively high proportion (33%) of naturalised species is notable.

Additional surveys at different times of the year may detect additional short-lived herbs and grasses but a follow-up survey is not considered warranted because of the low likelihood of species with a high priority for conservation management being present and the very small footprint of the proposed development.

Threatened flora species

No flora species listed as threatened on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) and/or the Tasmanian *Threatened Species Protection Act 1995* (TSPA) are known from database information (Figure 13), or were detected as a consequence of the field survey, from the study area.

I am comfortable that the survey, conducted in late August, was acceptable to detect the most likely species that could potentially be present in this part of the State, especially noting the now long-unburnt status of the understorey practically precluding spring-flowering annuals that require an open understorey, except at a highly local level.

Figure 13 indicates threatened flora species near to the study area and Table C1 (Appendix C) provides a listing of threatened flora from within 5,000 m of the study area (nominal buffer width usually used to discuss the potential of a particular study area to support various species listed in databases), with comments on whether potential habitat is present for the species, and possible reasons why a species was not recorded.

Threatened fauna

No fauna species listed as threatened on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) and/or the Tasmanian *Threatened Species Protection Act 1995* (TSPA) are known from database information (Figure 14), or were detected as a consequence of the field survey, from the study area.

Figure 14 indicates threatened fauna species near to the study area and Table C1 (Appendix C) provides a listing of threatened fauna from within 5,000 m of the study area (nominal buffer width usually used to discuss the potential of a particular study area to support various species listed in databases), with comments on whether potential habitat is present for the species, and possible reasons why a species was not recorded.

While there is potential habitat present for several species (e.g. Tasmanian devil, spotted-tailed quoll, eastern quoll, eastern barred bandicoot, masked owl, forty-spotted pardalote, wedge-tailed eagle, white-bellied sea-eagle), small-scale works that do not result in the loss of individual trees or substantial modification to the understorey (or indeed results in the improvement of habitat) should not have a measurable deleterious impact on such species at any reasonable scale.(see Appendix D for more details on a species-by-species basis).

Figure 13a. Distribution of threatened flora close to the study area (overview)

Figure 13b. Distribution of threatened flora close to the study area (detail)

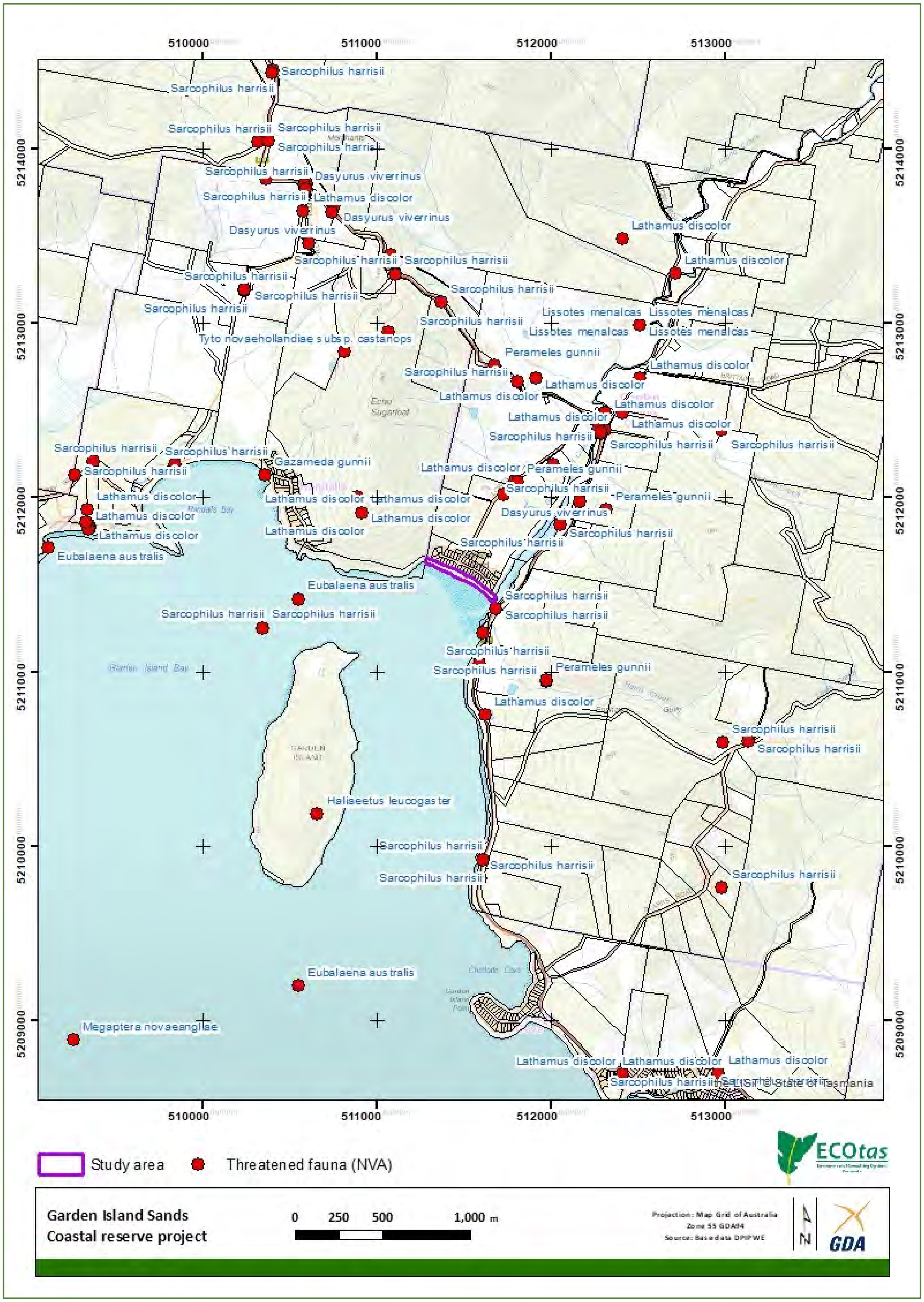

Figure 14a. Distribution of threatened fauna close to the study area (overview)

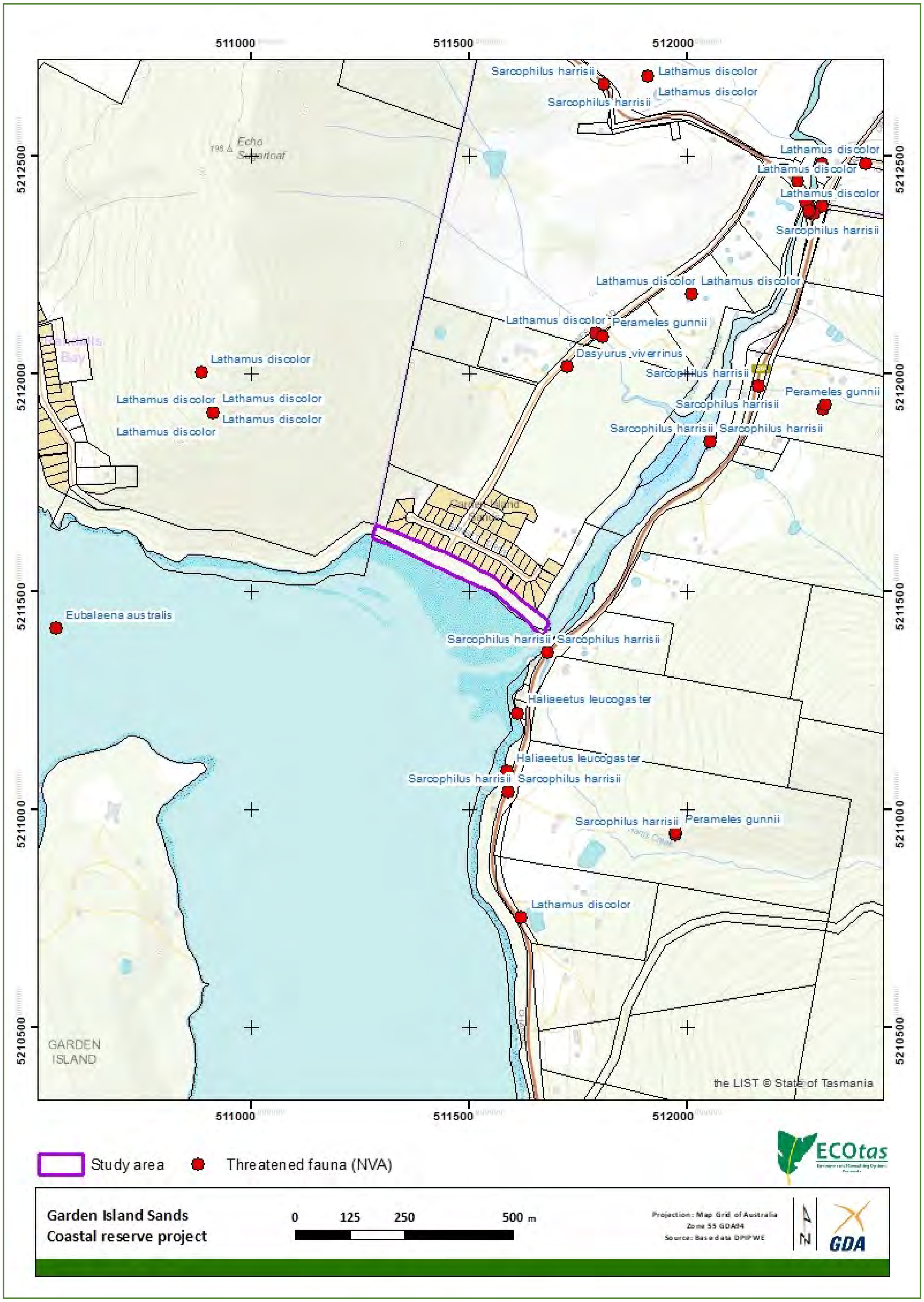

Figure 14b. Distribution of threatened fauna close to the study area (detail)

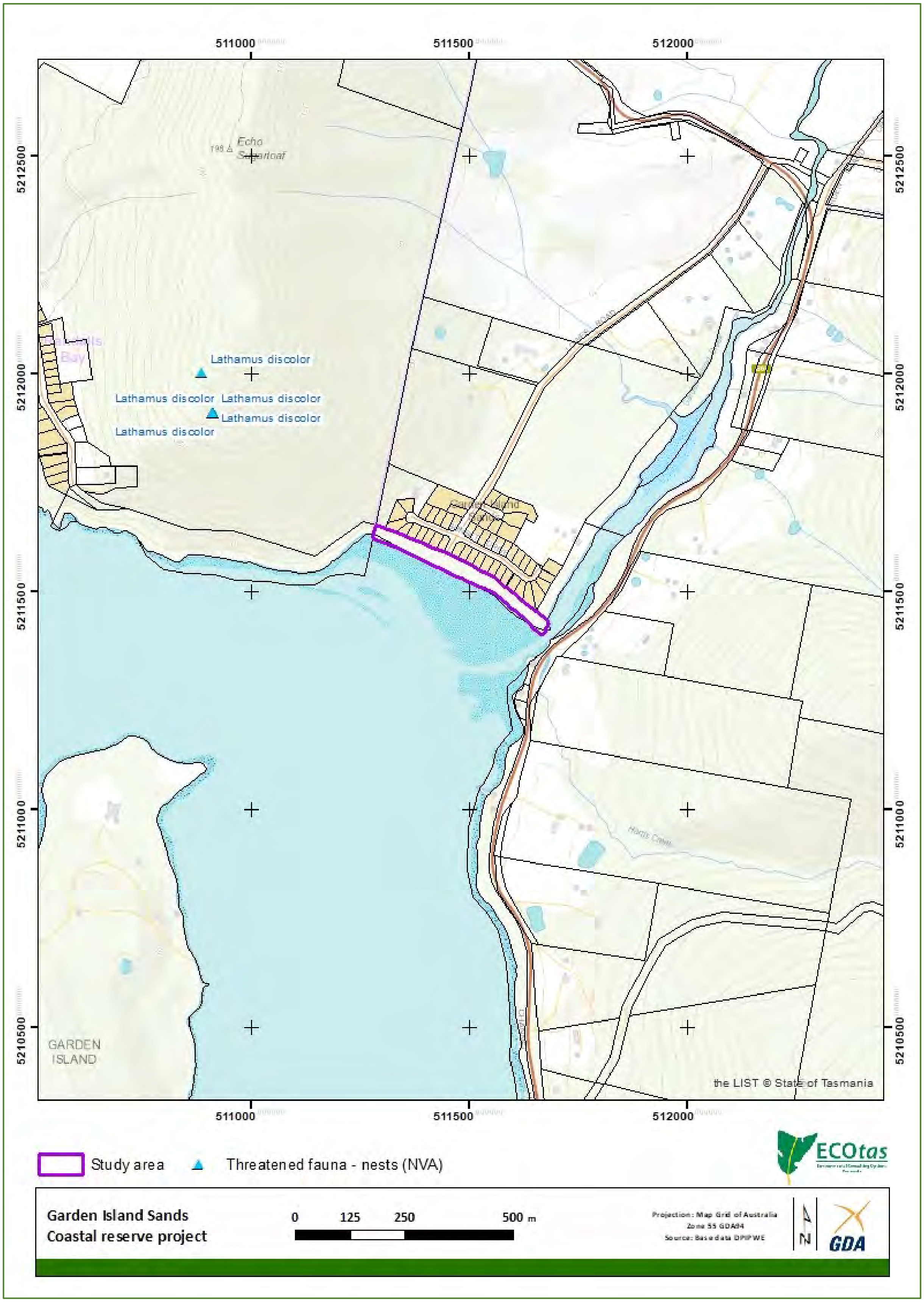

Figure 14c. Distribution of threatened fauna (nest sites only) close to the study area (detail)

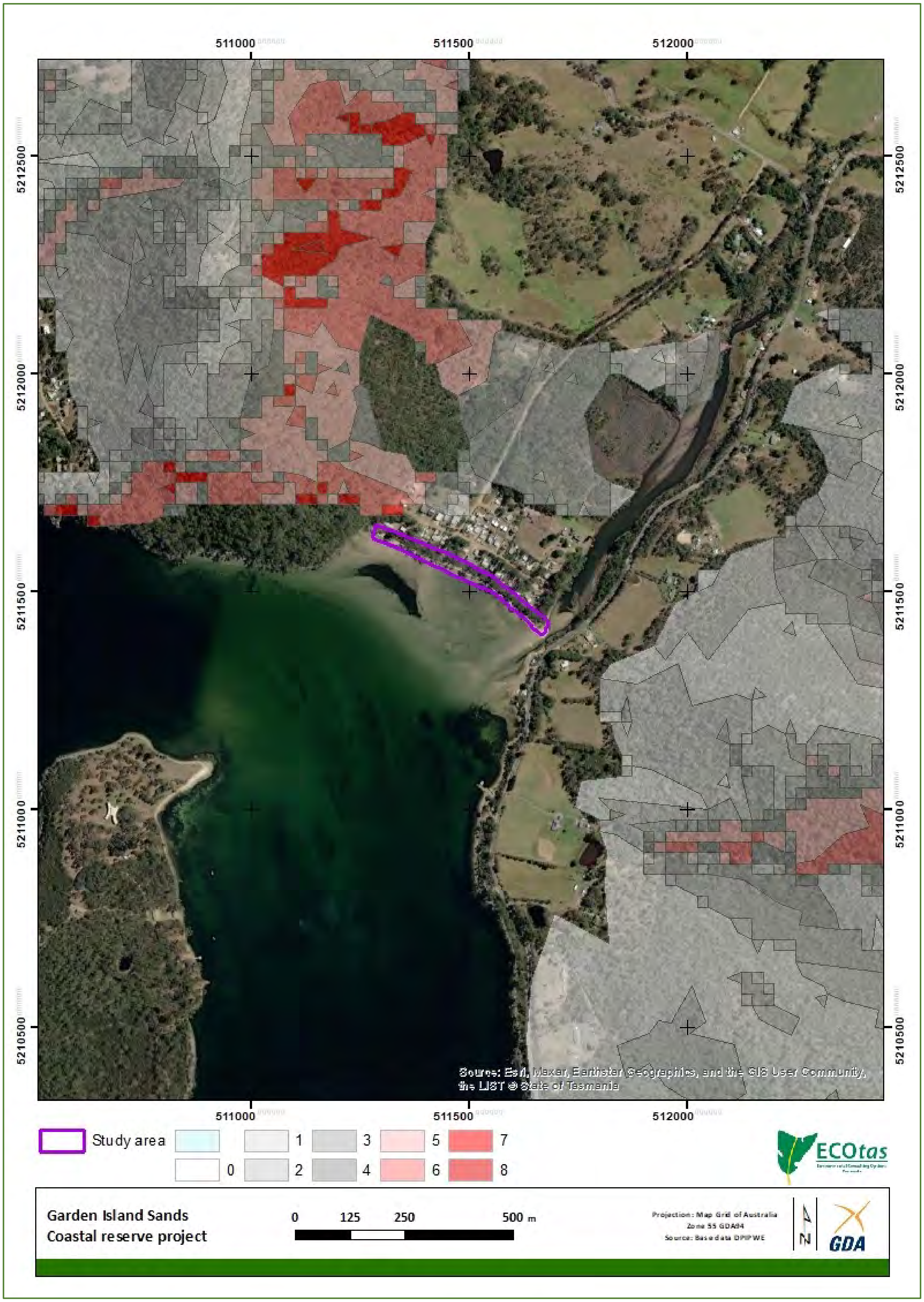

Figure 14d. Modelled potential eagle nesting habitat within vicinity of study area

Other natural values

Weed species

Four plant species classified as declared weeds within the meaning of the Tasmanian *Weed Management Act 1999* (*Biosecurity Act 2019*) were recorded from the study area, as follows (see also Figures 12b-d & 15; Plates 19-34):

- *Ulex europaeus* (gorse)

  Gorse occurs as two main patches: one in and around the parking area (mainly one large patch on the immediate foreshore) and another around historically disturbed parts of the foredune further west.

- *Cytisus scoparius* (english broom)

  English broom is localised to scattered plants on the foredune east of the car park, in the light bush just east of the car park and in the "island" of forest within the car park.

- *Genista monspessulana* (canary broom)

  Canary broom is locally abundant both east and west of the car park, where is colonises sites with modified understorey.

- *Chrysanthemoides monilifera* subsp. *monilifera* (boneseed)

  Boneseed is scattered in the eastern portion of the study area. All occurrences were hand-pulled (easily achieved in this very loose sandy soil).

Several other plant species considered to be environmental weeds (author opinion) were recorded from the study area, as follows (see also Figures 12b-d & 15; Plates 19-34):

- *Acacia retinodes* (coast wirilda)

  Two plants just coming into flower are located on the immediate eastern edge of the car park.

- *Billardiera heterophylla* (bluebell creeper)

  Three scattered but highly localised occurrences in eastern section of study area.

- *Chamaecytisus palmensis* (tree lucerne)

  Single small (but flowering) plant in middle of eastern portion of study area.

- *Dimorphotheca fruticosa* (trailing daisy)

  Single patch at immediate eastern edge of car park.

- *Hesperocyparis macrocarpa* (macrocarpa pine)

  One very old tree in middle part of western section of study area, where its foliage drop is creating a "dead zone" almost devoid of native species such that a small area could almost have been excised from the DVC mapping.

- *Narcissus jonquilla* (jonquill)

  Two small clumps, one under the macrocarpa pine, another in the eastern area near the tree lucerne.

- *Passiflora* sp. (passionfruit)

  Small patch starting to extend in from fenceline planting (species unknown as not in flower or fruit).

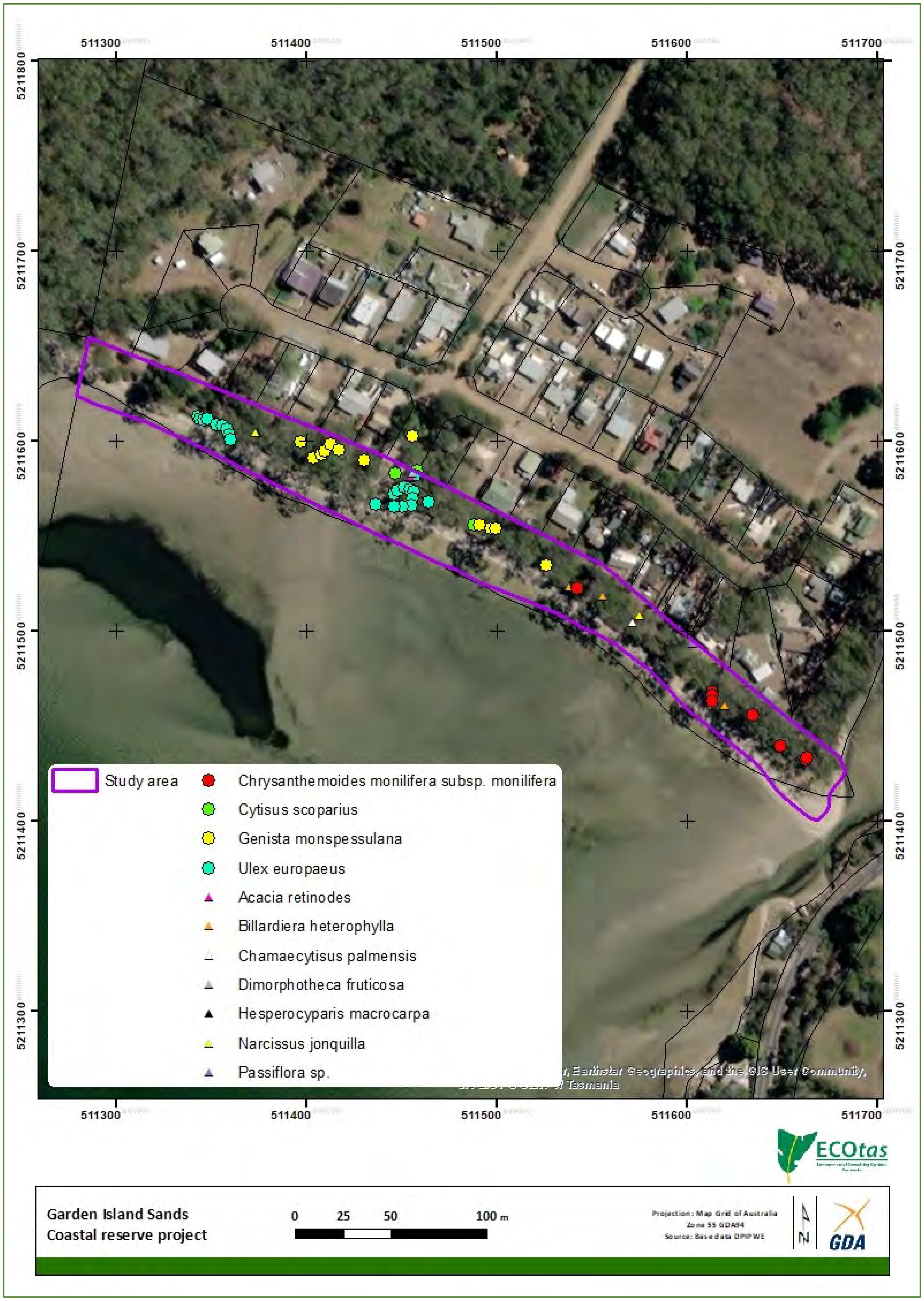

Figure 15. Overall distribution of declared and environmental weeds within study area (refer to Figures 12b-d for details)


Plates 19 & 20. Main patch of *Ulex europaeus* at end of car park


Plates 21 & 22. Smaller patch of *Ulex europaeus* in western section of study area


Plate 23. (LHS) Single specimen of *Cytisus scoparius* in "island" of car park

Plate 24. (RHS) Specimen of *Cytisus scoparius* fallen from eroding bank with other specimens on bank above


Plate 25. (LHS) Mature flowering and fruiting specimen of *Genista monspessulana*

Plate 26. (RHS) Maturing post-seedling specimens of *Genista monspessulana*, at this stage still easily hand-pulled without the need for herbicide


Plate 27. (LHS) Two specimens of *Acacia retinodes* at eastern edge of car park

Plate 28. (RHS) Small patch of *Billardiera heterophylla* growig over bracken and sagg


Plate 29. (LHS) Single flowering specimen of *Chamaecytisus scoparius*

Plate 30. (RHS) Small patch of *Dimorphotheca fruticosa*


Plates 31 & 32. Flowering specimens of *Narcissus jonquilla*


Plate 33. (LHS). *Passiflora* sp. creeping in from adjacent title
Plate 34. (RHS) Mature *Hesperocyparis macrocarpa*

Any works have the potential to exacerbate any weed issues by mobilising soil-stored seed and providing fresh bare ground ideal for seedling establishment. Given the existing access and weed occurrences along both the access and car park area, however, there is a low likelihood of such works introducing novel species to the site.

Several planning manuals provide guidance on appropriate management actions, which can be referred to develop site-specific prescriptions for any proposed works in the study area. These manuals include:

- Allan, K. & Gartenstein, S. (2010). *Keeping It Clean: A Tasmanian Field Hygiene Manual to Prevent the Spread of Freshwater Pests and Pathogens*. NRM South, Hobart;
- Rudman, T. (2005). *Interim* Phytophthora cinnamomi *Management Guidelines*. Nature Conservation Report 05/7, Biodiversity Conservation Branch, Department of Primary Industries, Water & Environment, Hobart;
- Rudman, T., Tucker, D. & French, D. (2004). *Washdown Procedures for Weed and Disease Control*. Edition 1. Department of Primary Industries, Water & Environment, Hobart; and
- DPIPWE (2015). *Weed and Disease Planning and Hygiene Guidelines – Preventing the Spread of Weeds and Diseases in Tasmania*. Department of Primary Industries, Parks, Water & Environment, Hobart.

The information on weeds has been provided to inform future management. Any works on the immediate dune front, especially in the car park area (where there is gorse, english broom and other species present), should consider treatment of weeds prior to on-ground works.

Irrespective of the scale of works, any vegetation debris and topsoil created during works should be considered "contaminated" with weed propagules and treated accordingly. I usually suggest burial and/or burning on-site (subject to any municipal and other regulations) if this this can be practically achieved during works. Off-site transport will need to be subject to any provisions of the weed legislation, council regulations and material disposed of at a facility registered to take declared weeds.

In the longer-term, mobilisation of volunteers in conjunction with the appropriate land managers may facilitate an ongoing program of weed management. Some species are highly localised and could be treated (probably to the point of elimination) immediately (e.g. remove the two specimens of coast wirilda; cut and paste the localised occurrences of english broom, tree lucerne and trailing daisy; grub out the jonquills). Other species are more challenging such as canary broom that is becoming locally abundant, although generally still easily hand-pulled. The current assessment resulted in all detected occurrences of boneseed being uprooted but other/new specimens will be present such that a "watching brief" will be needed. The management of the macrocarpa pine may require further consideration as it may provide a soil stabilisation function – ideally, in the longer-term the tree will be removed and replaced with white gum.

As part of the proposed works (or future activities), creation and erection of an interpretive sign displaying "weeds to watch" for in the reserve is recommended to alert reserve users to such species and allow for ad hoc control to be undertaken.

Rootrot pathogen, *Phytophthora cinnamomi*

Phytophthora cinnamomi (PC) is widespread in lowland areas of Tasmania, across all land tenures. However, disease will not develop when soils are too cold or too dry. For these reasons, PC is not a threat to susceptible plant species that grow at altitudes higher than about 700 m or where annual rainfall is less than about 600 mm (e.g. Midlands and Derwent Valley). Furthermore, disease is unlikely to develop beneath a dense canopy of vegetation because shading cools the soils to below the optimum temperature for the pathogen. A continuous canopy of vegetation taller than about 2 m is sufficient to suppress disease. Hence PC is not considered a threat to susceptible plant species growing in wet sclerophyll forests, rainforests (except disturbed rainforests on infertile soils) and scrub e.g. teatree scrub (Rudman 2005; FPA 2009).

The vegetation type identified from the study area is not usually recognised as being particularly susceptible to PC. Site assessment did not record any field symptoms (dead and/or dying susceptible plant species) from the study area itself. Special management should not be required in relation to PC, provided that the existing Lowes Road and existing access are used.

Myrtle wilt

Myrtle wilt, caused by a wind-borne fungus (*Chalara australis*), occurs naturally in rainforest where myrtle beech (*Nothofagus cunninghamii*) is present. The fungus enters wounds in the tree, usually caused by damage from wood-boring insects, wind damage and forest clearing. The incidence of myrtle wilt often increases forest clearing events such as windthrow and wildfire. The study area does not support *Nothofagus cunninghamii*, such that special management is not required.

Myrtle rust

Myrtle rust is a disease limited to plants in the Myrtaceae family. This plant disease is a member of the guava rust complex caused by *Austropuccinia psidii*, a known significant pathogen of Myrtaceae plants outside Australia. Infestations are currently limited to NSW, Victoria, Queensland and Tasmania (DPIPWE 2015).

No evidence of myrtle rust was noted (limited possible indicator species present). The longer-term management issue for the site is to ensure that any ornamental plantings source plants from a reputable nursery free from the pathogen (such businesses are already subject to strict biosecurity conditions).

Chytrid fungus and other freshwater pathogens

Native freshwater species and habitat are under threat from freshwater pests and pathogens including *Batrachochytrium dendrobatidis* (chytrid frog disease), *Mucor amphibiorum* (platypus mucor disease) and the freshwater algal pest *Didymosphenia geminata* (didymo) (Allan & Gartenstein 2010). Freshwater pests and pathogens are spread to new areas when contaminated water, mud, gravel, soil and plant material or infected animals are moved between sites. Contaminated materials and animals are commonly transported on boots, equipment, vehicles tyres and during road construction and maintenance activities. Once a pest pathogen is present in a water system it is usually impossible to eradicate. The manual *Keeping it Clean – A Tasmanian Field Hygiene Manual to Prevent the Spread of Freshwater Pests and Pathogens* (Allan & Gartenstein 2010) provides information on how to prevent the spread of freshwater pests and pathogens in Tasmanian waterways wetlands, swamps and boggy areas.

The study area does not support habitat of amphibian species, except in a general sense. Special management should not be warranted for any particular works that are outside such habitats.

"Ginger tree syndrome"

"Ginger tree syndrome" occurs in *Eucalyptus viminalis* trees when they become distressed (Mitchell 2015). A significant heat wave in 2013 appears to have caused Statewide loss of white gum, concentrated, but not restricted to the north. *Eucalyptus viminalis* appears to be particularly susceptible to short-term heat stress as it has a reduced ability to close off stomata, resulting in water stress and hence shrinkage of the bark and trunk leading to the production of kino (this leads to the orange discoloration giving the condition its name). Trees will often suffer crown dieback and there is the potential for the whole tree to die. Reversing this impact is not necessarily possible, instead the identification of this issue allows these sites to be monitored to determine the degree of tree loss and recovery that occurs and whether any management intervention is required.

Several individuals of *Eucalyptus viminalis* within the study area appear to be suffering "ginger tree syndrome" (Figure 16, Plates 35 & 36). At some point, these trees may become "unsafe" and require removal. It may be prudent to monitor any further development of "ginger tree syndrome" and manage trees accordingly, including consideration of supplementary planting to offset any loss.

Plate 35. (LHS) Two trees with symptoms of "ginger tree syndrome" near the mature macrocarpa pine (one each side of apparently healthy tree in middle)

Plate 36. (RHS) View of the single tree showing symptoms of "ginger tree syndrome" in eastern part of study area

Restoration/rehabilitation plantings

As part of coastal erosion prevention works, it is presumed that some form of replanting of native plant species will be warranted for areas of bare ground. Ideally, any such plants should be species that are locally indigenous. Appendix B provides a list of all native plant species recorded from the wider study area. Those considered suitable for restoration/rehabilitation plantings are highlighted (including all life forms). Ideally, any plantings will utilise locally sourced cuttings or seeds (although this is probably not overly critical).

Some species that are not recommended for use include any that are not native to Tasmania or not native to the wider area (but are often used in coastal rehabilitation projects). The former includes *Ammophila arenaria* (marram grass), which can become invasive – it has already self-created a patch that is mappable as an area of marram grassland (TASVEG code: FMG) in its own right. The latter includes popular species such as *Correa alba* (white correa), which is not locally indigenous. *Acacia longifolia* subsp. *sophorae* (coast wattle) is also not recommended as it can become locally dominant without active management. Species such as *Carpobrotus rossii* (pigface) appear to have already been used to attempt to stabilise the foreshore bank, and while it may not be locally indigenous, it does occur in the wider area and continued use of this good stabilisation species is not discouraged.

Figure 16. Location of trees showing symptoms of "ginger tree syndrome"

Additional "Matters of National Environmental Significance" – Threatened Ecological Communities

CofA (2022) indicates that the following threatened ecological communities listed on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) are likely to, or may, occur within the area:

- Giant Kelp Marine Forests of South East Australia [Endangered];
- Subtropical and Temperate Coastal Saltmarsh [Vulnerable];
- Tasmanian Forests and Woodlands dominated by Black Gum or Brookers Gum *(Eucalyptus ovata / E. brookeriana*) [Critically Endangered]; and
- Tasmanian White Gum (*Eucalyptus viminalis*) Wet Forest [Critically Endangered].

Existing vegetation mapping (Figures 10 & 11) and revised vegetation mapping (Figure 12) indicates that no such threatened ecological communities occur within or adjacent to the study area. There are no implications under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* in relation to vegetation types.

DISCUSSION

Summary of key findings

Threatened flora

- No plant species listed as threatened on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) and/or the Tasmanian *Threatened Species Protection Act 1995* (TSPA) were detected, or are known from database information, from the study area.

Threatened fauna

- No fauna species listed as threatened on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) and/or the Tasmanian *Threatened Species Protection Act 1995* (TSPA) were detected, or are known from database information, from the study area.

Vegetation types

- The study area supports the following TASVEG mapping units:
  - urban areas (TASVEG code: FUR);
  - marram grassland (TASVEG code: FMG);
  - sand, mud (TASVEG code: OSM);
  - water, sea (TASVEG code: OAQ); and
  - *Eucalyptus viminalis – Eucalyptus globulus* coastal forest and woodland (TASVEG code: DVC).
- DVC is equivalent to a threatened vegetation community (with the same name) listed on Schedule 3A of the Tasmanian *Nature Conservation Act 2002* but does not equate to a threatened ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

- As a vegetation type, DVC is classified as a moderate priority biodiversity value under Table E10.1 of the Biodiversity Code of the *Huon Valley Interim Planning Scheme 2015* (and will qualify as priority vegetation under the incoming *Tasmanian Planning Scheme – Huon Valley*).

Weeds

- Four plant species classified as declared weeds within the meaning of the Tasmanian *Weed Management Act 1999* (*Biosecurity Act 2019*) and several others considered to be environmental weeds (author opinion) were detected from the study area.

Plant disease

- No evidence of *Phytophthora cinnamomi* (PC, rootrot) was recorded within the study area.
- No evidence of myrtle wilt was recorded from within the study area.
- No evidence of myrtle rust was recorded from within the study area.
- Several trees showed symptoms of "ginger tree syndrome".

Animal disease (chytrid)

- The study area does not support habitat types strongly associated with amphibian species.

Legislative and policy implications

Some commentary is provided below with respect to the key threatened species, vegetation management and other relevant legislation. Note that there may be other relevant policy instruments in addition to those discussed. The following information does not constitute legal advice and it is recommended that independent advice is sought from the relevant agency/authority.

Tasmanian *Threatened Species Protection Act 1995*

Threatened flora and fauna on this Act are managed under Section 51, as follows:

51. Offences relating to listed taxa

(1) Subject to subsections (2) and (3), a person must not knowingly, without a permit –

(a) take, keep, trade in or process any specimen of a listed taxon of flora or fauna; or

(b) disturb any specimen of a listed taxon of flora or fauna found on land subject to an interim protection order; or

(c) disturb any specimen of a listed taxon of flora or fauna contrary to a land management agreement; or

(d) disturb any specimen of a listed taxon of flora or fauna that is subject to a conservation covenant entered into under Part 5 of the *Nature Conservation Act 2002*; or

(e) abandon or release any specimen of a listed taxon of flora or fauna into the wild.

(2) A person may take, keep or process, without a permit, a specimen of a listed taxon of flora in a domestic garden.

(3) A person acting in accordance with a certified forest practices plan or a public authority management agreement may take, without a permit, a specimen of a listed taxon of flora or fauna, unless the Secretary, by notice in writing, requires the person to obtain a permit.

(4) A person undertaking dam works in accordance with a Division 3 permit issued under the *Water Management Act 1999* may take, without a permit, a specimen of a listed taxon of flora or fauna.

The simplest interpretation of this is that any activity that results in a specimen (i.e. individual) of listed flora or fauna being "knowingly taken" would require a permit to be issued through Conservation Assessments (Department of Natural Resources and Environment Tasmania), through a formal application process. Note that the Act does not make reference to "potential habitat" such that activities that result in loss of/disturbance to potential habitat (but not known sites) – which mainly refers to threatened fauna – would not require a permit.

No known sites of threatened flora or fauna will be impacted by any proposed development so a permit should be not required under this Act.

Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* an action will require approval from the minister if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance.

Matters of national environmental significance considered under the EPBCA include:

- listed threatened species and communities
- listed migratory species;
- Ramsar wetlands of international importance;
- Commonwealth marine environment;
- world heritage properties;
- national heritage places;
- the Great Barrier Reef Marine Park;
- nuclear actions; and
- a water resource, in relation to coal seam gas development and large coal mining development.

The relevant Commonwealth agency provides a policy statement titled *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* (CofA 2013, herein the *Guidelines*), which provides overarching guidance on determining whether an action is likely to have a significant impact on a matter protected under the EPBCA.

The *Guidelines* define a significant impact as:

> *"...an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts"*

and note that:

> *"...all of these factors [need to be considered] when determining whether an action is likely to have a significant impact on matters of national environmental significance".*

The *Guidelines* provide advice on when a significant impact may be likely:

> *"To be 'likely', it is not necessary for a significant impact to have a greater than 50% chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility.*
>
> *If there is scientific uncertainty about the impacts of your action and potential impacts are serious or irreversible, the precautionary principle is applicable. Accordingly, a lack of scientific certainty about the potential impacts of an action will not itself justify a decision that the action is not likely to have a significant impact on the environment".*

The *Guidelines* provide a set of Significant Impact Criteria, which are "intended to assist…in determining whether the impacts of [the] proposed action on any matter of national environmental significance are likely to be significant impacts". It is noted that the criteria are "intended to provide general guidance on the types of actions that will require approval and the types of actions that will not require approval…[and]…not intended to be exhaustive or definitive".

Listed ecological communities

The study area does not support any such communities.

Threatened flora

The study area does not support populations of EPBCA-listed flora, nor significant potential habitat of such species.

Threatened fauna

The study area may support populations of threatened fauna listed on the Act, although no specific evidence of such species was recorded.

The *Guidelines* consider a "significant impact" to comprise loss that is likely to lead to a long-term decrease in the size of an important population of a species; reduce the area of occupancy of an important population; fragment an existing important population into two or more populations (unlikely); adversely affect habitat critical to the survival of a species; disrupt the breeding cycle of an important population; modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat; introduce disease that may cause the species to decline; or interfere substantially with the recovery of the species.

It is highly unlikely that small-scale works with the purpose of controlling coastal erosion and minimising the continued loss of native vegetation will trigger a need for a referral under the Act.

<u>Tasmanian *Forest Practices Act 1985* and associated *Forest Practices Regulations 2017*</u>

The *Regulations* provide the following relevant circumstances in which a Forest Practices Plan (FPP) is not required.

> 4. Circumstances in which forest practices plan, &c., not required
>
> For the purpose of section 17(6) of the Act, the following circumstances are prescribed:
>
> (a) the harvesting of timber or the clearing of trees, with the consent of the owner of the land, if the land is not vulnerable land and –

(i) the volume of timber harvested or trees cleared is less than 100 tonnes for each area of applicable land per year; or

(ii) the total area of land on which the harvesting or clearing occurs is less than one hectare for each area of applicable land per year –

whichever is the lesser;

(j) the harvesting of timber or the clearing of trees on any land, or the clearance and conversion of a threatened native vegetation community on any land, for the purpose of enabling –

(i) the construction of a building within the meaning of the *Land Use Planning and Approvals Act 1993* or of a group of such buildings; or

(ii) the carrying out of any associated development –

if the construction of the buildings or carrying out of the associated development is authorised by a permit issued under that Act.

Note that the whole study area may qualify as "vulnerable land", which is defined as follows:

vulnerable land means land that –

(a) is within a streamside reserve or a machinery exclusion zone within the meaning of the *Forest Practices Code*; or

(b) has a slope of more than the landslide threshold slope angles within the meaning of the *Forest Practices Code*; or

(c) is within the High or Very High Soil Erodibility Class within the meaning of the *Forest Practices Code*; or

(d) consists of, or contains, a threatened native vegetation community; or

(e) is inhabited by a threatened species within the meaning of the *Threatened Species Protection Act 1995*; or

(f) contains vulnerable karst soil within the meaning of the *Forest Practices Code*; or

(g) contains an area of trees reserved from the harvesting of timber or the clearing of trees under a forest practices plan where the period specified in the plan has expired.

Until a specific project proposal is presented, the interaction of the *Forest Practices Regulations 2017* with the requirements under the *Land Use Planning and Approvals Act 1993* (local planning scheme applicable at the time) and any requirements of the Department of Natural Resources and Environment Tasmania under legislation within their administrative jurisdiction is difficult to provide interpretation on. It is recommended that advice be sought from officers within the relevant agency as part of project planning.

Tasmanian *Nature Conservation Act 2002*

Schedule 3A of the Act lists vegetation types classified as threatened within Tasmania. The study area supports *Eucalyptus viminalis – Eucalyptus globulus* coastal forest and woodland, which is equates to a native vegetation community (with the same name) that is so listed. While the Tasmanian Department of Natural Resources and Environment Tasmania has administrative responsibility for the Act, actual regulation of impacts on threatened vegetation types is usually through either the Tasmanian *Forest Practices Regulations 2017* or the Tasmanian *Land Use Planning and Approvals Act 1993* (local planning scheme applicable at the time), although there may be other legislative instruments under the administrative jurisdiction of the Tasmanian Department of Natural Resources and Environment Tasmania that are applicable. Further advice may be required from officers within the relevant agency as part of project planning.

Tasmanian *Weed Management Act 1999* (*Biosecurity Act 2019*)

Four plant species classified as declared weeds within the meaning of the Tasmanian *Weed Management Act 1999* (*Biosecurity Act 2019*) were detected from the study area, such that the Act may have direct application.

Tasmanian *Land Use Planning and Approvals Act 1993*

Until a specific project proposal is presented, the application of provisions of the applicable planning scheme is difficult to determine. Further advice on this may be needed from officers of Huon Valley Council.

Recommendations

The recommendations provided below are a summary of those provided in relation to each of the natural features described in the main report. The main text of the report provides the relevant context for the recommendations.

Vegetation types

In general terms, minimising the extent of "clearance and conversion" and/or "disturbance" to native vegetation is recommended.

Threatened flora

Not applicable – no threatened flora present.

Threatened fauna

Apart from the generic recommendation to minimise the extent of "clearance and conversion" and/or "disturbance" to native vegetation, it is also recommended that the extent of loss of individual eucalypts and disturbance to understorey is minimised.

Weed and disease management

Irrespective of the scale of works, any vegetation debris and topsoil created during works should be considered "contaminated" with weed propagules and treated accordingly. I usually suggest burial and/or burning on-site (subject to any municipal and other regulations) if this this can be practically achieved during works. Off-site transport will need to be subject to any provisions of the weed legislation, council regulations and material disposed of at a facility registered to take declared weeds.

In the longer-term, mobilisation of volunteers in conjunction with the appropriate land managers may facilitate an ongoing program of weed management. Some species are highly localised and could be treated (probably to the point of elimination) immediately (e.g. remove the two specimens of coast wirilda; cut and paste the localised occurrences of english broom, tree lucerne and trailing daisy; grub out the jonquills). Other species are more challenging such as canary broom that is becoming locally abundant, although generally still easily hand-pulled. The current assessment resulted in all detected occurrences of boneseed being uprooted but other/new specimens will be present such that a "watching brief" will be needed. The management of the macrocarpa pine may require further consideration as it may provide a soil stabilisation function – ideally, in the longer-term the tree will be removed and replaced with white gum.

As part of the proposed works (or future activities), creation and erection of an interpretive sign displaying "weeds to watch" for in the reserve is recommended to alert reserve users to such species and allow for ad hoc control to be undertaken.

Broader interpretive ideas

Creation and erection of an interpretive sign that explains the conservation significance of the vegetation type present within the reserve and displays some of the key flora and fauna elements is recommended to alert reserve users to the importance of the reserve and the need for cooperative and long-term active management to maintain such values.

Longer-term management

The understorey is variably dense and in the absence of disturbance, this may become denser and eventually reduce species diversity (e.g. herbs). Use of small-scale and low intensity fire (e.g. cultural burning practices) and/or slashing may be beneficial. It is recognised that this will need coordination between different parties to take account of varius management issues. Such disturbance may encourage weeds and so should not be undertaken in isolation of active and ongoing weed management.

Legislative and policy implications

A permit under Section 51 of the Tasmanian *Threatened Species Protection Act 1995* (TSPA) should not be required.

A formal referral to the relevant Commonwealth agency under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA) should not be required.

Until a specific project outline is presented, it is not known how some legislative instruments will interact. It is recommended that advice be sought from officers within the relevant agency as part of project planning.

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APPENDIX A. Vegetation community structure and composition

The table below provides basic information on the structure and composition of the native vegetation mapping unit identified from the study area.

Eucalyptus viminalis – Eucalyptus globulus coastal forest and woodland (TASVEG code: DVC)

DVC occupies most of the study area (apart from areas now mapped as FUR, FMG, OSM & OAQ). The canopy is of variable height and density, wholly dominated by *Eucalyptus viminalis* (white gum), mostly in excellent health, over a variably dense shrubby understorey, in turn over a grass-graminoid layer with local herbs.

DVC is in variable condition with the main impacts being localised historical (and ongoing) informal modification in front of some houses and invasion by woody and herbaceous weeds. Coastal erosion is gradually resulting in the loss of DVC, specifically several large white gums.

View east along foreshore showing eroding DVC

Stratum	Height (m) Cover (%)	Species (underline = dominant, parentheses = sparse; + = present only)
Trees	30 m 30%	*Eucalyptus viminalis* [weeds: *Hesperocyparis macrocarpa*]
Tall shrubs	4-6 m 20%	*Banksia marginata, (Exocarpos cupressiformis)*
Medium shrubs	<2 m 10-40%	<u>*Leucopogon parviflorus*</u>, *Acacia melanoxylon, Eucalyptus viminalis, Daviesia ulicifolia, Pultenaea juniperina, (Exocarpos syrticola), Exocarpos strictus, (Leptomeria drupacea)* [weeds: *Ulex europaeus, Genista monspessulana, Cytisus scoparius, Chrysanthemoides monilifera*]
Low shrubs	<0.25 m <1%	*Styphelia humifusa*
Graminoids	20%	<u>*Lomandra longifolia*</u>, *Dianella tasmanica*
Grasses	50%	*Poa spp, Austrostipa stuposa, Deyeuxia quadriseta* [weeds: *Dactylis glomerata, Holcus lanatus, Ehrharta erecta, Ammophila arenaria*]
Ground ferns	variable	*Pteridium esculentum*
Herbs	localised	*Dichondra repens, Lagenophora stipitata, Acaena novae-zelandiae, Coronidium scorpioides, Pterostylis nutans, Viola hederacea*
Climbers	+	*Comesperma volubile* [weeds: *Passiflora* sp., *Billardiera heterophylla*]

APPENDIX B. Vascular plant species recorded from study area

Botanical nomenclature follows *A Census of the Vascular Plants of Tasmania* (de Salas & Baker 2022), with family placement updated to reflect the nomenclatural changes recognised in the *Flora of Tasmania Online* (de Salas 2022+) and APG (2016); common nomenclature follows *The Little Book of Common Names of Tasmanian Plants* (Wapstra et al. 2005+, updated online at www.dpipwe.tas.gov.au).

e = endemic to Tasmania; i = introduced/naturalised to Tasmania

DW = declared weed pursuant to the Tasmanian *Weed Management Act 1999* (*Biosecurity Act 2019*); EW = environmental weed (author opinion)

= species potentially suitable for restoration/rehabilitation plantings

Table B1. Summary of vascular species recorded from the study area

	ORDER			
STATUS	DICOTYLEDONAE	MONOCOTYLEDONAE	GYMNOSPERMAE	PTERIDOPHYTA
	36	14	-	1
e	1	1	-	-
i	19	7	1	
Sum	56	22	1	1
TOTAL	80			

	DICOTYLEDONAE		
	AIZOACEAE		
	Carpobrotus rossii	native pigface	#
	ASTERACEAE		
	Cassinia aculeata subsp. *aculeata*	common dollybush	
i	*Chrysanthemoides monilifera* subsp. *monilifera*	boneseed	DW
i	*Cirsium vulgare*	spear thistle	
	Coronidium scorpioides	curling everlasting	
i	*Dimorphotheca fruticosa*	trailing daisy	
i	*Hypochaeris radicata*	rough catsear	
	Lagenophora stipitata	blue bottledaisy	
e	*Olearia phlogopappa* subsp. *phlogopappa*	coast dusty daisybush	#
	Olearia ramulosa	twiggy daisybush	
	Senecio glomeratus subsp. *glomeratus*	shortfruit purple fireweed	
	Senecio linearifolius var. *linearifolius*	common fireweed groundsel	
	Senecio minimus	shrubby fireweed	
i	*Sonchus oleraceus*	common sowthistle	
	BRASSICACEAE		
i	*Cardamine hirsuta*	hairy bittercress	
	CASUARINACEAE		
	Allocasuarina verticillata	drooping sheoak	
	ERICACEAE		
	Leucopogon parviflorus	coast beardheath	#
	Styphelia humifusa	native cranberry	#
	EUPHORBIACEAE		
i	*Euphorbia peplus*	petty spurge	
	Poranthera microphylla	small poranthera	
	FABACEAE		
	Acacia dealbata subsp. *dealbata*	silver wattle	
	Acacia longifolia subsp. *sophorae*	coast wattle	
	Acacia melanoxylon	blackwood	#
i	*Acacia retinodes*	hills wirilda	EW
	Acacia verticillata subsp. *verticillata*	prickly moses	#
i	*Chamaecytisus palmensis*	tree lucerne	EW
i	*Cytisus scoparius*	english broom	DW

	Daviesia sejugata	leafy spiky bitterpea	#
	Daviesia ulicifolia subsp. *ulicifolia*	yellow spiky bitterpea	#
i	*Genista monspessulana*	montpellier broom	DW
	Pultenaea juniperina	prickly beauty	#
i	*Ulex europaeus*	gorse	DW
i	*Vicia sativa* subsp. *nigra*	narrowleaf vetch	
	GENTIANACEAE		
i	*Centaurium erythraea*	common centaury	
	GERANIACEAE		
	Geranium solanderi	southern cranesbill	
	MYRTACEAE		
	Eucalyptus viminalis subsp. *viminalis*	white gum	#
	OXALIDACEAE		
i	*Oxalis corniculata* subsp. *corniculata*	yellow woodsorrel	
i	*Oxalis latifolia*	largeleaf woodsorrel	
	Oxalis perennans	grassland woodsorrel	
	PASSIFLORACEAE		
i	*Passiflora* sp.	passionfruit	EW
	PITTOSPORACEAE		
i	*Billardiera heterophylla*	bluebell creeper	EW
	Bursaria spinosa subsp. *spinosa*	prickly box	#
	POLYGALACEAE		
	Comesperma volubile	blue lovecreeper	
	POLYGONACEAE		
i	*Acetosella vulgaris*	sheep sorrel	
	PROTEACEAE		
	Banksia marginata	silver banksia	#
	ROSACEAE		
	Acaena pallida	dune buzzy	
	Acaena novae-zelandiae	common buzzy	
	RUBIACEAE		
	Galium australe	coast bedstraw	
	SANTALACEAE		
	Exocarpos cupressiformis	common native-cherry	
	Exocarpos strictus	pearly native-cherry	
	Exocarpos syrticola	coast native-cherry	
	Leptomeria drupacea	erect currantbush	
	SAPINDACEAE		
	Dodonaea viscosa subsp. *spatulata*	broadleaf hopbush	#
	SOLANACEAE		
	Solanum laciniatum	kangaroo apple	
	STYLIDIACEAE		
	Stylidium graminifolium	narrowleaf triggerplant	
	VIOLACEAE		
	Viola hederacea subsp. *hederacea*	ivyleaf violet	
	GYMNOSPERMAE		
	CUPRESSACEAE		
i	*Hesperocyparis macrocarpa*	monterey cypress	
	MONOCOTYLEDONAE		
	AMARYLLIDACEAE		
	Dianella tasmanica	forest flaxlily	#
i	*Narcissus jonquilla*	jonquill	EW
	ASPARAGACEAE		
	Lomandra longifolia	sagg	#
	CYPERACEAE		
	Ficinia nodosa	knobby clubsedge	
	JUNCACEAE		
	Juncus pallidus	pale rush	
	Luzula flaccida	pale woodrush	
	ORCHIDACEAE		
	Acianthus pusillus	small mosquito-orchid	
e	*Chiloglottis triceratops*	threehorned bird-orchid	
	Corybas incurvus	slaty helmet-orchid	
	Pterostylis nutans	nodding greenhood	
	POACEAE		
i	*Agrostis capillaris*	browntop bent	
i	*Aira caryophyllea* subsp. *caryophyllea*	silvery hairgrass	

i	*Ammophila arenaria* subsp. *arenaria*	marram grass	EW
	Austrostipa stuposa	corkscrew speargrass	
i	*Dactylis glomerata*	cocksfoot	
	Deyeuxia quadriseta	reed bentgrass	
i	*Ehrharta erecta* var. *erecta*	panic veldtgrass	
i	*Holcus lanatus*	yorkshire fog	
	Poa hookeri	hookers tussockgrass	
	Poa labillardierei var. *labillardierei*	silver tussockgrass	#
	Poa poiformis var. *poiformis*	coastal tussockgrass	#
	Rytidosperma penicillatum	slender wallabygrass	
	PTERIDOPHYTA		
	DENNSTAEDTIACEAE		
	Pteridium esculentum subsp. *esculentum*	bracken	

APPENDIX C. Analysis of database records of threatened flora

Table C1 provides a listing of threatened flora from within 5,000 m of the study area (nominal buffer width usually used to discuss the potential of a particular study area to support various species listed in databases), with comments on whether potential habitat is present for the species, and possible reasons why a species was not recorded.

Table C1. Threatened flora records from within 5,000 m of boundary of the study area

Species listed below are listed as rare (r), vulnerable (v), endangered (e), or extinct (x) on the Tasmanian *Threatened Species Protection Act 1995* (TSPA); vulnerable (VU), endangered (EN), critically endangered (CR) or extinct (EX) on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA). Information below is sourced from DNRET's *Natural Values Atlas* (DNRET 2022a) and other sources where indicated. Habitat descriptions are taken from FPA (2016), FPA (2017) and TSS (2003+), except where otherwise indicated. Species marked with # are listed in CofA (2022).

Scientific name Common name	Status TSPA EPBCA	Tasmanian habitat description (and distribution)	Comments on study area and database records
Caladenia caudata tailed spider-orchid	v VU # only	*Caladenia caudata* has highly variable habitat, which includes the central north: *Eucalyptus obliqua* heathy forest on low undulating hills; the northeast: *E. globulus* grassy/heathy coastal forest, *E. amygdalina* heathy woodland and forest, *Allocasuarina* woodland; and the southeast: *E. amygdalina* forest and woodland on sandstone, coastal *E. viminalis* forest on deep sands. Substrates vary from dolerite to sandstone to granite, with soils ranging from deep windblown sands, sands derived from sandstone and well-developed clay loams developed from dolerite. A high degree of insolation is typical of many sites.	Potential habitat absent (wholly atypical of all known sites in Tasmania).
Epacris virgata Kettering pretty heath	v - # only	*Epacris virgata* (Kettering) occurs among foothills in southeastern Tasmania in dry sclerophyll forest on hilly terrain at elevations of 10-300 m a.s.l., mainly on dolerite, though sometimes close to the geological boundary of dolerite and Permian mudstone. It is generally associated with grassy/heathy *Eucalyptus ovata* woodland/forest, but is also occasionally found in grassy/heathy *E. pulchella* woodland/forest.	Potential habitat absent (site is not on dolerite).
Lepidium hyssopifolium soft peppercress	e EN # only	The native habitat of *Lepidium hyssopifolium* is the growth suppression zone beneath large trees in grassy woodlands and grasslands (e.g. over-mature black wattles and isolated eucalypts in rough pasture). *Lepidium hyssopifolium* is now found primarily under large exotic trees on roadsides and home yards on farms. It occurs in the eastern part of Tasmania between sea-level to 500 m a.s.l. in dry, warm and fertile areas on flat ground on weakly acid to alkaline soils derived from a range of rock types.	Potential habitat marginally present. This distinctive perennial herb was not detected (no seasonal constraint on detection and/or identification).

Scientific name Common name	Status TSPA EPBCA	Tasmanian habitat description (and distribution)	Comments on study area and database records
Ozothamnus floribundus flowery everlastingbush	e -	*Ozothamnus floribundus* is endemic to southeastern Tasmania, known only from Merchants Hill near Randalls Bay south of Cygnet. It occurs at an elevation of 125 to 140 m a.s.l. in shrubby/heathy *Eucalyptus obliqua* dry sclerophyll forest on substrate variously described as sandstone or mudstone with some dolerite influence.	Potential habitat absent (site is on coastal sands).
Prasophyllum apoxychilum tapered leek-orchid	v EN #	*Prasophyllum apoxychilum* is restricted to eastern and northeastern Tasmania where it occurs in coastal heathland or grassy and scrubby open eucalypt forest on sandy and clay loams, often among rocks. It occurs at a range of elevations and seems to be strongly associated with dolerite in the east and southeast of its range.	Potential habitat absent (wholly atypical of all known sites in Tasmania). Records in southeast Tasmania are taxonomically difficult to place within the broader *Prasophyllum truncatum* species-complex and I suspect several of the database records of *Prasophyllum apoxychilum* may be a better match for the non-listed *Prasophyllum truncatum*, including the one from nearby Randalls Bay.
Thelymitra jonesii skyblue sun-orchid	e EN # only	*Thelymitra jonesii* occurs in moist coastal heath on sandy to peaty soils and in *Eucalyptus obliqua* forest in deep loam soil over dolerite.	Potential habitat absent (atypical of all known sites).
Xerochrysum palustre swamp everlasting	v VU # only	*Xerochrysum palustre* has a scattered distribution with populations in the northeast, east coast, Central Highlands and Midlands, all below about 700 m elevation. It occurs in wetlands, grassy to sedgy wet heathlands and extends to associated heathy *Eucalyptus ovata* woodlands.	Potential habitat absent (no wetlands or swampy habitats present).

APPENDIX D. Analysis of database records of threatened fauna

Table D1 provides a listing of threatened fauna from within 5,000 m of the study area (nominal buffer width usually used to discuss the potential of a particular study area to support various species listed in databases), with comments on whether potential habitat is present for the species, and possible reasons why a species was not recorded.

Table D1. Threatened fauna records from 5,000 m of boundary of the study area

Species listed below are listed as rare (r), vulnerable (v), endangered (e), or extinct (x) on the Tasmanian *Threatened Species Protection Act 1995* (TSPA); vulnerable (VU), endangered (EN), critically endangered (CR) or extinct (EX) on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA). Information below is sourced from the DNRET's *Natural Values Atlas* (DNRET 2022a), Bryant & Jackson (1999), McNab (2018) and FPA (2022); most marine, wholly pelagic and littoral species such as marine mammals, fish and offshore seabirds are excluded (except as indicated below). Species marked with # are listed in CofA (2022).

Scientific name Common name	Status TSPA EPBCA	Tasmanian habitat description (and distribution)	Comments on project area and database records
Accipiter novaehollandiae grey goshawk	e -	Potential habitat is native forest with mature elements below 600 m altitude, particularly along watercourses. Significant habitat for the grey goshawk may be summarised as areas of wet forest, rainforest and damp forest patches in dry forest, with a relatively closed mature canopy, low stem density, and open understorey in close proximity to foraging habitat and a freshwater body.	Potential habitat absent, except in a very general sense. The species may very occasionally utilise the greater study area as part of a home range and for foraging but small-scale works should not have a significant impact on this aspect of the life history of the species.
Antipodia chaostola tax. *leucophaea* chaostola skipper	e EN #	Potential habitat is dry forest and woodland supporting *Gahnia radula* (usually on sandstone and other sedimentary rock types) or *Gahnia microstachya* (usually on granite-based substrates).	Potential habitat absent, as both species of *Gahnia* are not present.
Apus pacificus fork-tailed swift	- - # only	Seasonal migrant (December through March) with habitat open skies over any habitat, more commonly associated with forested hills and mountains (McNab 2018).	Potential habitat widespread but this is a species that flies at high altitude, very fast and highly mobile, feeding on the wing and virtually never perches (McNab 2018). This species should not require further consideration.
Aquila audax subsp. *fleayi* wedge-tailed eagle	e EN #	Potential nesting habitat is tall eucalypt trees in large tracts (usually more than 10 ha) of eucalypt or mixed forest. Nest trees are usually amongst the largest in a locality. They are generally in sheltered positions on leeward slopes, between the lower and mid sections of a slope and with the top of the tree usually lower than the ground level of the top of the ridge, although in some parts of the State topographic shelter is not always a significant factor (e.g. parts of the northwest and Central Highlands).	Potential nesting habitat absent (open forest) from the study area. No known nests within 1,000 m of study area The adjacent slopes of Echo Sugarloaf are mapped as potential nesting habitat, although the most likely such habitat (midslopes) is several hundred metres from the end of Lowes Road. Given that there is an existing suburb (Garden Island Sands) adjacent to the study area and that there has been access and use of the study area for decades, targeted surveys of nearby potential nesting habitat is not considered warranted. This is because any works that would be undertaken

Scientific name Common name	Status TSPA EPBCA	Tasmanian habitat description (and distribution)	Comments on project area and database records
			along the beach front would be little more than incidental activity to nesting birds (should they be present on the adjacent slopes). The species may utilise the greater study area as part of a home range and for foraging but small-scale works should not have a significant impact on this aspect of the life history of the species.
Botaurus poiciloptilus Australasian bittern	- EN # only	Potential habitat is comprised of wetlands with tall dense vegetation, where it forages in still, shallow water up to 0.3 m deep, often at the edges of pools or waterways, or from platforms or mats of vegetation over deep water. It favours permanent and seasonal freshwater habitats, particularly those dominated by sedges, rushes and reeds or cutting grass growing over a muddy or peaty substrate (TSSC 2011).	Potential habitat absent. Wetlands are absent.
Brachionichthys hirsutus spotted handfish	e CR #	The species is found in coastal waters in soft sediment benthic environments from coarse to fine sand and shell grit to silt, with a depth distribution between 0-60 m.	Provided that works do not directly impact on the marine habitat, this species should not require further consideration.
Bubulcus coromandus [syn. *B. ibis*, *Ardea ibis*] cattle egret	- - # only	Seasonal migrant (April through October) with habitat agricultural lands, crops, dams, pastures, particularly those with cattle, mudflats and wetlands (McNab 2018).	Potential habitat absent, except in the most general of senses. This species should not require further consideration.
Ceyx azureus subsp. *diemenensis* [syn. *Alcedo azurea* subsp. *diemenensis*] Tasmanian azure kingfisher	e EN #	Potential foraging habitat is primarily freshwater (occasionally estuarine) waterbodies such as large rivers and streams with well-developed overhanging vegetation suitable for perching and water deep enough for dive-feeding. Potential breeding habitat is usually steep banks of large rivers (a breeding site is a hole (burrow) drilled in the bank).	Potential habitat absent. No permanent waterbodies or drainage features present, noting that the western watercourse is too small and Garden Island Creek is tidal and lacks perches for foraging (no works are proposed to stream beds or banks).
Dasyurus maculatus subsp. *maculatus* spotted-tailed quoll	r VU #	Potential habitat is coastal scrub, riparian areas, rainforest, wet forest, damp forest, dry forest and blackwood swamp forest (mature and regrowth), particularly where structurally complex and steep rocky areas are present, and includes remnant patches in cleared agricultural land.	Potential habitat present, although no direct evidence (e.g. scats, dens, prints, etc.) was observed. Small-scale works that includes retaining the overstorey and understorey should not have a significant impact on this species at any reasonable scale.
Dasyurus viverrinus eastern quoll	- EN #	Potential habitat is a variety of habitats including rainforest, heathland, alpine areas and scrub. However, it seems to prefer dry forest/native grassland mosaics which are bounded by agricultural land.	See under spotted-tailed quoll.
Gallinago hardwickii Lathams snipe	- - # only	Seasonal migrant that prefers brackish, fresh and saline habitats including lagoons, lakes, marshes, swamps, wet grasslands and paddocks and wetlands with tussockgrasses (McNab 2018).	Potential habitat absent, except in the most general of senses. This species should not require further consideration.

Scientific name Common name	Status TSPA EPBCA	Tasmanian habitat description (and distribution)	Comments on project area and database records
Gazameda gunnii Gunn's screw shell	v -	This species lives subtidally and offshore on sand (Grove 2018).	Potential habitat absent (species does not usually occur in shallow sandy bays).
Haliaeetus leucogaster white-bellied sea-eagle	v -	Potential habitat comprises potential nesting habitat and potential foraging habitat. Potential foraging habitat is any large waterbody (including sea coasts, estuaries, wide rivers, lakes, impoundments and even large farm dams) supporting prey items (fish). Potential nesting habitat is tall eucalypt trees in large tracts (usually more than 10 ha) of eucalypt or mixed forest within 5 km of the coast (nearest coast including shores, bays, inlets and peninsulas), large rivers (class 1), lakes or complexes of large farm dams.	See also comments under wedge-tailed eagle. The species may utilise the greater study area as part of a home range and for foraging (although this would be mainly over open water) but small-scale works should not have a significant impact on this aspect of the life history of the species.
Hirundapus caudacutus white-throated needletail	- VU #	Seasonal migrant (December through March) with habitat open skies over any habitat, more commonly associated with forested hills and mountains (McNab 2018).	Potential habitat widespread but this is a species that flies at high altitude, very fast and highly mobile, feeding on the wing and virtually never perches (McNab 2018). This species should not require further consideration.
Lathamus discolor swift parrot	e CR #	Potential foraging habitat comprises *E. globulus* or *E. ovata* trees that are old enough to flower. Potential nesting habitat is considered to comprise eucalypt forests that contain hollow-bearing trees.	Potential habitat absent because *Eucalyptus ovata* (black gum) and *Eucalyptus globulus* (blue gum) are not present and hollow-bearing trees are also absent (and the site is atypical of nesting sites that tend to be on ridgelines and upper slopes in hollow-rich forest e.g. Echo Sugarloaf).
Lissotes menalcas Mt Mangana stag beetle	v -	Potential habitat is any eucalypt forest that contains rotting logs (often numerous, and usually greater than about 40 cm diameter at mid-log length) below about 650 m a.s.l. (generally moist habitats that have not been subject to high intensity or frequent fires in about the last 20 years). The species has a patchy distribution within areas of potential habitat. Some rainforest will support the species, although in low densities as the species has an apparent preference for eucalypt logs. In terms of using mapping layers, potential habitat is all areas mapped as 'wet forest' under TASVEG or another forest type that is within 50 m of a freshwater source (e.g. stream or wetland) and either high, medium or low mature habitat availability OR PI-type mature crown density class 'a', 'b', 'c', 'd' and 'f'.	Potential habitat absent. Site is dry woodland and forest with limited coarse woody debris and on deep sands.
Litoria raniformis green and golden frog	v VU #	Potential habitat is permanent and temporary waterbodies, usually with vegetation in or around them, including features such as natural lagoons, permanently or seasonally inundated swamps and wetlands, farm dams,	Potential habitat absent. No permanent waterbodies or drainage features present within the study area (adjacent watercourses are atypical because of their size/rockiness or salinity).

Scientific name Common name	Status TSPA EPBCA	Tasmanian habitat description (and distribution)	Comments on project area and database records
		irrigation channels, artificial water-holding sites such as old quarries, slow-flowing stretches of streams and rivers and drainage features.	
Myiagra cyanoleuca satin flycatcher	- - # only	Seasonal migrant (November through march) with habitat scrub, wet and dry sclerophyll forests, woodlands and creeklines (McNab 2018).	Potential habitat present. Small-scale works should not have a significant impact on this species, particularly as the intent is to retain native vegetation (including individual trees). This species should not require further consideration.
Neophema chrysostoma blue-winged parrot	- - # only	Seasonal migrant (October through April) with habitat agricultural lands, crops, dams, paddocks, coastal scrub, open grassy woodlands, heathland and saltmarshes (McNab 2018).	See under satin flycatcher.
Pardalotus quadragintus forty-spotted pardalote	e EN #	Potential habitat is any forest and woodland supporting *E. viminalis* (white gum) where the canopy cover of *E. viminalis* is greater than or equal to 10% or where *E. viminalis* occurs as a localised canopy dominant or co-dominant in patches exceeding 0.25 ha.	Potential habitat present, although there are limited reported nesting and/or foraging locations outside the specifically recorded sites. That said, the site is coastal and dominated by white gum, superficially ideal for the species. Small-scale works that includes retaining the overstorey and understorey should not have a significant impact on this species at any reasonable scale. In the longer-term, there may be opportunities to enhance habitat by planting further *Eucalyptus viminalis* in some natural and artificial canopy gaps.
Parvulastra vivipara Tasmanian live-bearing seastar	v VU # only	The species lives in rocky areas in the upper intertidal zone, usually under rocks or in crevices. They appear to have a water depth limit, being found from just below the high water mark to a depth of approximately 1.2 m at high water. The species prefers gently sloping, sheltered shores, characterised by rocks often no more than 20-30 cm high. Some small colonies seem to be habitat specific, with some preferring dolerite and others sandstone.	Potential habitat absent (beach is wholly sandy).
Perameles gunnii subsp. *gunnii* eastern barred bandicoot	- VU #	Potential habitat is open vegetation types including woodlands and open forests with a grassy understorey, native and exotic grasslands, particularly in landscapes with a mosaic of agricultural land and remnant bushland. Significant habitat is dense tussock grass-sagg-sedge swards, piles of coarse woody debris and denser patches of low shrubs (especially those that are densely branched close to the ground providing shelter) within the core range of the species.	See under spotted-tailed quoll.

Scientific name Common name	Status TSPA EPBCA	Tasmanian habitat description (and distribution)	Comments on project area and database records
Prototroctes maraena Australian grayling	v VU #	Potential habitat is all streams and rivers in their lower to middle reaches. Areas above permanent barriers (e.g. Prosser River dam, weirs) that prevent fish migration, are not potential habitat.	Garden Island Creek could provide potential habitat but no works are proposed within or adjacent to this such that the species should not require further consideration.
Pseudemoia pagenstecheri tussock skink	v -	Potential habitat comprises native grasslands dominated by tussock-forming grasses.	Potential habitat absent. Native grassland is absent.
Sarcophilus harrisii Tasmanian devil	e EN #	Potential habitat is all terrestrial native habitats, forestry plantations and pasture. Devils require shelter (e.g. dense vegetation, hollow logs, burrows or caves) and hunting habitat (open understorey mixed with patches of dense vegetation) within their home range (4-27 km^2). Potential denning habitat is areas of burrowable, well-drained soil, log piles or sheltered overhangs such as cliffs, rocky outcrops, knolls, caves and earth banks, free from risk of inundation and with at least one entrance through which a devil could pass.	See under spotted-tailed quoll.
Thinornis rubricollis hooded plover	- VU	Potential nesting habitat is the dry sand above the high tide mark on larger beaches.	The narrow wave-washed beach with steep eroding "dune" is effectively unsuitable for the species (in terms of nesting). Works that ultimately stabilise the "dune" and control coastal erosion may be beneficial in the longer-term.
Tyto novaehollandiae subsp. *castanops* masked owl	e VU #	Potential habitat is all areas with trees with large hollows (≥15 cm entrance diameter). Remnants and paddock trees (in any dry or wet forest type) in agricultural areas may constitute potential habitat. Significant habitat is native dry forest with trees over 100 cm dbh with large hollows (≥15 cm entrance diameter).	Potential nesting habitat absent. Large trees with large hollows are absent from the study area. The species may utilise the greater study area as part of a home range and for foraging but small-scale works should not have a significant impact on this aspect of the life history of the species.

APPENDIX E. **DNRET's** *Natural Values Atlas* report for the study area

Appended as pdf file.

APPENDIX F**. Forest Practices Authority's** *Biodiversity Values Atlas* report for the study area

Appended as pdf file.

APPENDIX G**. CofA's** *Protected Matters* report for the study area

Appended as pdf file.

APPENDIX H. *Priority Vegetation Report*

Appended as pdf file.

ATTACHMENTS

- .shp file of revised vegetation mapping
- .shp file of point locations of weeds
- .shp file of point location of tree with "ginger tree syndrome"

ABORIGINAL HERITAGE ASSESSMENT REPORT

GARDEN ISLAND SANDS

February 2023

Prepared for Friends of Garden Island Creek

Version: 1.0

Dr. Silas Piotrowski	Consultant Archaeologist
Stephen Stanton	Aboriginal Heritage Officer

REVIEW HISTORY

Version 10number	Reason for review	Report status	Prepared by	Reviewed by	Authorised by	Issued date
1.o	First review	Draft	S. Piotrowski	B. Paton-Clarke		27 February 2023
1.1		Final	S. Piotrowski		B. Paton-Clarke	31 March 2023

EXECUTIVE SUMMARY

PROJECT BACKGROUND

Garden Islands Sands is the name given to an approximately 450m long stretch of beach at the mouth of Garden Island Creek, and directly adjacent to Garden Island, where the Huon River enters D'Entrecasteaux Channel in southern Tasmania.

As part of a Preparing Australian Communities – Local Stream Program grant, The Friends of Garden Island Creek (FOGIC) community organisation commissioned a report on erosion of the beach at Garden Island Sands. The report is to include a number of specialist investigations, including geomorphic (Sharples 2023) and geotechnical (Cromer 2023) surveys, and the Aboriginal Heritage assessment. The findings of the report will inform the selection of the erosion mitigation measures implemented at the beach, which are to be funded through subsequent grant applications. Contingent on these findings, such measures may include:

a) installing a new access way at the end of Lowes Road, consisting of a sand ladder replacing a concrete boat ramp that has since been removed.

b) erosion mitigation measures along the length of the beach, possibly in the form of a sloping sand bag wall or other hard structure.

Silas Piotrowski (Consulting Archaeologist) was engaged by FOGIC ('the Proponent'), and in accordance with *Aboriginal Heritage Standards and Procedures* issued by Aboriginal Heritage Tasmania (AHT) Stephen Stanton (Aboriginal Heritage Officer/Consultant) was engaged to carry out Aboriginal community consultation for the assessment.

An area within which all proposed erosion mitigation works would take place was designated the Project Investigation Area. This was refined during the field assessment to the face of the eroded foredune.

DESKTOP RESULTS

A search of the Aboriginal Heritage Register (AHR) indicated a large number of artefact scatters and living areas (shell middens) on the coast line in the surrounding area, however none were recorded closer than 1Km from Garden Island Sands. One isolated artefact (9254) was recorded on Garden Island itself, and the closest site is a living area (shell midden) (1742) slightly over 1Km west of Garden Island Sands.

FIELD SURVEY RESULTS

No previously unrecorded Aboriginal heritage sites were identified in the Project Investigation Area.

IMPACT ASSESSMENT

Due to the extent of erosion, any proposed works on the present cutting are unlikely to disturb any in-situ Aboriginal heritage material.

MANAGEMENT RECOMMENDATIONS

The consultants recommend that:

1. Copies of the final report should be forwarded to South East Tasmania Aboriginal Corporation (SETAC).
2. Although low, there is some possibility of sub-surface material throughout the Project Investigation Area, given its location close to the shore line. An Unanticipated Discovery Plan (UDP) should be followed during any future erosion mitigation works.
3. The Proponent make contact with SETAC to discuss the remediation techniques that may be applied, and the planting of native species be adopted during the remediation process.

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LIST OF FIGURES AND TABLES

All coordinates are GDA94, MGA zone 55. Accuracy for handheld GPS device is assumed to be within $^{+}/_{-}$ 5

INTRODUCTION

This is the report of an Aboriginal heritage assessment of Garden Islands Sands in southern Tasmania. Garden Islands Sands is the name given to an approximately 450m long stretch of beach at the mouth of Garden Island Creek, and directly adjacent to Garden Island, where the Huon River enters D'Entrecasteaux Channel in southern Tasmania (Figure 2).

Aboriginal community consultation was undertaken with South East Tasmania Aboriginal Corporation (SETAC) at the commencement of the assessment, at the completion of fieldwork, as it progressed and during compilation of the report. This consultation will be ongoing until the final report is completed.

Figure 1: Map of the Huon and D'Entrecasteaux area with Garden Island Sands marked.

RELEVANT POLICY, LEGISLATION AND GUIDELINES

ABORIGINAL HERITAGE ACT (TAS) 1975

The *Aboriginal Heritage Act 1975* ('the Act', formerly *Aboriginal Relics Act 1975*) is the primary piece of legislation relating to the protection of Aboriginal cultural heritage in Tasmania. Section 2(3) of the Act outlines the cultural heritage to which it relates (i.e. 'relics'):

(a) any artefact, painting, carving, engraving, arrangement of stones, midden, or other object, made or created by any of the original inhabitants of Australia or the descendants of any such inhabitants, which is of significance to the Aboriginal people of Tasmania; or

(b) any object, site, or place that bears signs of the activities of any such original inhabitants or their descendants, which is of significance to the Aboriginal people of Tasmania; or

(c) the remains of the body of such an original inhabitant or of a descendant of such an inhabitant that are not interred in–

(i) any land that is or has been held, set aside, reserved, or used for the purposes of a burial-ground or cemetery pursuant to any Act, deed, or other instrument; or

(ii) a marked grave in any other land.

Section 2 (8) of the Act defines significance (of a relic) as being in accordance with -

(a) the archaeological or scientific history of Aboriginal people; or

(b) the anthropological history of Aboriginal people; or

(c) the contemporary history of Aboriginal people; or

(d) Aboriginal tradition.

Section 14(a) makes it an offence to 'destroy, damage, deface, conceal, or otherwise interfere with a relic'.

The penalty for offences under section 14 is:

for 'a body corporate, other than a small business entity, a fine not exceeding 10 000 penalty units' and

for 'an individual or a small business entity, a fine not exceeding 5 000 penalty units'. Where the individual or body corporate is deemed to have acted in a reckless or negligent manner, the penalties are 2 000 and 1 000 units respectively.

In the case of human remains being discovered during the course of Aboriginal heritage assessments, the *Coroners Act 1995* dictates the process which allows the coroner to determine whether the remains are of Aboriginal origin. In this case, section 23 of that Act dictates that 'the coroner must refer the matter to an Aboriginal organisation approved by the Attorney-General', and that the remains then fall under the protection of the *Aboriginal Heritage Act 1975.*

PROJECT ACTIVITY DESCRIPTION

As part of a Preparing Australian Communities – Local Stream Program grant, The Friends of Garden Island Creek (FOGIC) community organisation commissioned a report on erosion of the beach at Garden Island Sands. The report is to include a number of specialist investigations, including geomorphic (Sharples 2023) and geotechnical (Cromer 2023) surveys, and the Aboriginal Heritage assessment. The findings of the report will inform the selection of the erosion mitigation measures implemented at the beach, which are to be funded through subsequent grant applications. Contingent on these findings, such measures may include:

a) installing a new access way at the end of Lowes Road, consisting of a sand ladder replacing a concrete boat ramp that has since been removed.

b) erosion mitigation measures along the length of the beach, possibly in the form of a sloping sand bag wall or other hard structure.

Silas Piotrowski (Consulting Archaeologist) was engaged by FOGIC ('the Proponent'), and in accordance with *Aboriginal Heritage Standards and Procedures* issued by Aboriginal Heritage Tasmania (AHT) Stephen Stanton (Aboriginal Heritage Officer/Consultant) was engaged to carry out Aboriginal community consultation for the assessment.

A polygon within which all proposed erosion mitigation works would take place was designated the Project Investigation Area (PIA) (Figure 4).

Figure 5: The Project Investigation Area marked in red.

BACKGROUND INFORMATION

LAND USE HISTORY

The land at Garden Island Sands is a relatively undeveloped parcel of waterfront similar to the nearby Randalls and Eggs and Bacon bays at the mouth of the Huon River. As with these other bays, small communities of shacks have been constructed. At Garden Island Sands there are around 50 structures, mainly running parallel to the beach accessed by Sunset Drive. These are separated from the beach by a thin (approx. 20m) strip of remnant native vegetation (Figure 6).


Figure 9: Strip of native vegetation between the foredune and shacks.

ENVIRONMENTAL CONTEXT

The strip of native vegetation is defined according to the TASVEG classificiation system as (DVC) Eucalyptus viminalis - Eucalyptus globulus coastal forest and woodland, with a small section of (FUR) Urban areas at the western end of the beach, and (DGL) Eucalyptus globulus dry forest and woodland on the low adjacent headland. The (DVC) area, although impacted by encroaching erosion from the beach, and felling of trees, appears to be in a generally healthy condition.

CULTURAL CONTEXT

The Huon catchment and this area where it enters the channel are known to be traditionally the land of the Mellurkerdee band of the South East nation (Ryan 2003). The area has high Aboriginal cultural significance and is the location of numerous Aboriginal sites and special places. As the local Aboriginal community organisation, SETAC has been involved in the management and active maintenance of these places for many years. They provide strong links to the area for today's Aboriginal community and strengthen cultural identity. Site types include extensive stone quarries, living areas (shell middens), stone artefact scatters and special places such as Garden Island, all of which have strong cultural connections.

ENVIRONMENT

Table 1 Environmental profile of the Project Investigation Area.

Geology / Geomorphology	Vegetation	Cultural Landscape
Upper Pleistocene Sand gravel and mud of alluvial, lacustrine and littoral origin, (i.e. the course of Garden Island creek), surrounded and underlaid by Tasmanian Dolerite (Mineral Resources Tasmania Geological Polygons 250k, confirmed by Sharples 2023).	Coastal forest with some large *Eucalyptus* spp. remnants, dense understory including *Bankisa* spp.	Frequent expressions of shell (midden) material and artefact scatters indicating living areas along coastline and islands.

PREVIOUS ABORIGINAL HERITAGE INVESTIGATIONS

A search of the AHR indicated that a number of heritage assessments have been carried out in the surrounding area, but only one appears to have covered the PIA.

Long and Fresløv 2001

This report identified as an 'Archaeological Impact Assessment' was commissioned and conducted by the Crown Land Services division of the then Department of Primary Industries and Water over pre-existing shack sites in southern Tasmania. The aim of the assessment was to identify whether the shacks and associated activities, as well as the future installation of wastewater infrastructure would impact on Aboriginal heritage. Field assessment covered 15 locations from Surges Bay (north-west of Garden Island) south as far as Recherché Bay, and including Garden Island Creek.

The report noted that:

All shacks at Garden Island Creek are situated on archaeologically sensitive landforms, which are closely associated with Aboriginal archaeological site distribution in south east Tasmania. All shack locations have potential to contain cultural material, though ground surface visibility did not allow for the authentication of an Aboriginal site. (Long and Fresløv 2001:17).

Stanton 2003

This assessment of Garden Island itself was conducted for a proposed subdivision that evidently did not proceed. As Stanton (2003:4) noted, the closest recorded site at that time was a shell midden (TASI/AH1742) at the south eastern corner of Randall's Bay, which appears to have remained the case since. Stanton identified an isolated stone artefact (TASI/AH 9254) consistent with the patterning of recorded sites in the area.

PREVIOUSLY RECORDED ABORIGINAL HERITAGE SITES

There were no previously recorded sites in the Project Investigation Area.

STATEMENT ON SITE PREDICTION

Brown's (1986) South East Regional Study, incorporating Garden Island, notes the richness of sites along the coasts and estuaries of the region. Brown's modelling suggested that middens may occur more frequently close to coastal lagoons and fresh water, and where the shore profile on rocky headlands is less steep.

Garden Island Sands fits these criteria to a degree. The adjacent dolerite headland is steep where it meets the western end of the beach, however a walking track currently provides reasonable access, and there is a coastal lagoon some distance upstream of Garden Island Creek. The southerly aspect of this section of the bay reduces its site potential to some degree.

As the AHR search indicates, isolated artefacts and scatters, and living areas (shell middens) have been recorded in some abundance in the undisturbed coastal fringes of the Huon River estuary, in either direction from the beach.

Therefore, given its coastal context, it can be reasonably predicted that cultural material could still be present in the Project Investigation Area in an undisturbed state.

RESEARCH DESIGN AND FIELD METHODS

The aim of the field assessment was to determine whether erosion mitigation works in the Project Investigation Area would impact any Aboriginal heritage.

Field methods employed for the assessment involved the undertaking of pedestrian transects of the beach and the exposed cutting where mitigation works are to take place. Given the narrow width of the PIA, informal transects following the eroded bank were employed (Figure 8). Vegetation cover inland from the

Figure 13: Aerial photo showing the PIA (red) and informal transects (yellow) following the extent of the eroded foredune.

bank precluded access and visibility. Being that mitigation works will not take place in this area, this portion of the PIA was not assessed.

EFFECTIVE SURVEY COVERAGE

The entirety of the eroded foredune was visually assessed. Visibility was unobstructed in some areas (Figure 10), whereas other sections were covered by previous mitigation works (Figure 12), or vegetation (Figure 13). The heavily vegetated sections of the PIA inland from the foredune were only accessed where possible.

Figure 17: Example of recent, active erosion on the foredune.

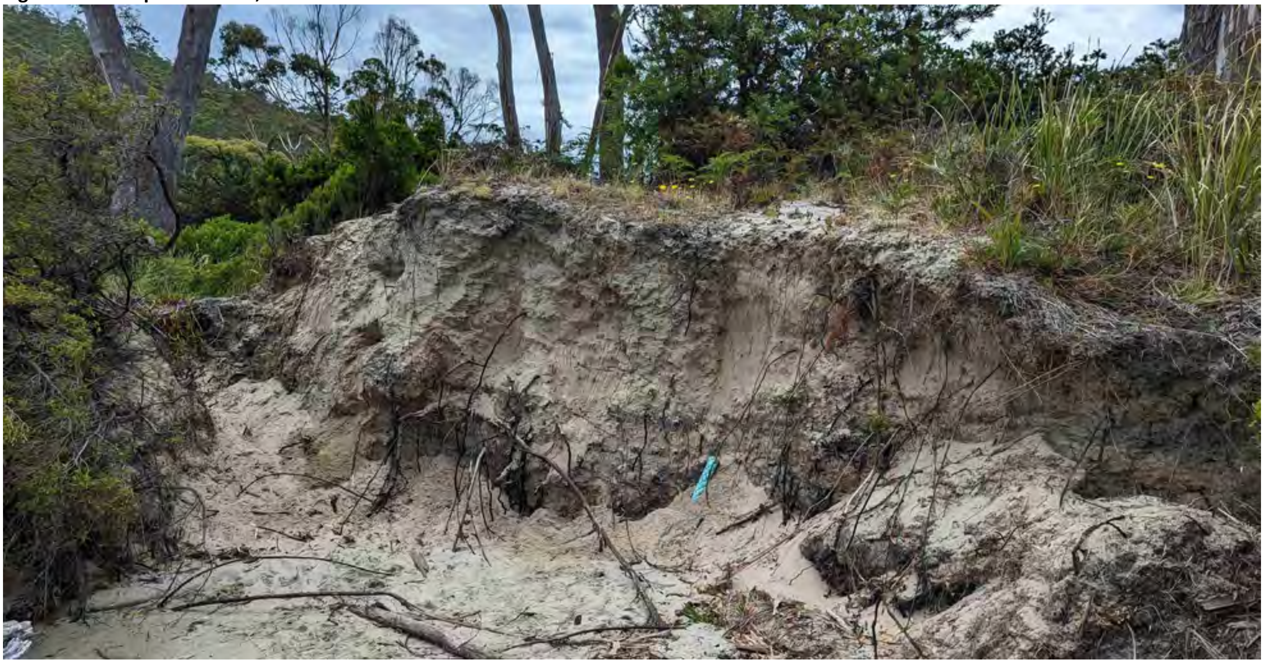

Figure 18: Example of recent, active erosion on the foredune.

Figure 21: Example of previous erosion mitigation measures.

Figure 25: Native vegetation cover at the western end of the beach.

RESULTS

No previously unrecorded Aboriginal heritage sites were identified in the Project Investigation Area.

INTERPRETATION AND DISCUSSION

Although the statement on site prediction provided above holds true for a desktop assessment, the field assessment indicated a very low likelihood of identifying in-situ Aboriginal heritage. This is primarily due to the extent of the relatively recent erosion of the foredune.

As the geomorphological investigation notes, although the present foredune was likely deposited over the last 6000-7000 years (Sharples 2023:12), aerial photography indicates it remained stable from at least 1948 until 2000, when erosion accelerated rapidly, most likely due to Global Mean Sea-Level Rise (GMSLR) (Sharples 2023:53). Erosion is currently active and in some places the scarp is up to 10m inland from the mean shoreline in 1948 (Sharples 2023:35-47).

With the dwelling and road construction behind the foredune, only the vegetated strip between the two retains potential for undisturbed Aboriginal heritage, but visibility here was effectively nil.

ABORIGINAL COMMUNITY CONSULTATION

Table 2 Aboriginal Community Consultation carried out.

Date	Contact	Organisation	Method	Action/Response	Comment
28.1.23	CEO Jaime Currie	SETAC	Email	Provided an introduction to the project together with a map of the investigation area. Outlined the results of survey. Offered to meet and discuss the project and committed to providing a copy of the draft report for comments as the project progresses.	
14.3.23	Jaime Currie	SETAC	Email	Provided a copy of the draft report for consideration by SETAC's Board and/or Cultural Heritage Committee	
16.3.23	Jaime Currie	SETAC	Phone call	Follow up re draft and offered to meet and discuss.	
24.3.23	Jaime Currie	SETAC	Phone call	Further follow up re meeting	
30.3.23	Deb Cowen (Cultural Committee Member) and James Shaw	SETAC	Meeting	Discussed project, our findings and recommendations	**SETAC support the project and requested an additional recommendation that there be follow up between the project proponents (FOGIC) and SETAC**

	(Cultural Committee Member & Land Management Team Leader)				**re techniques to be applied and any plantings of native species to be adopted during the remediation process.**

STATEMENT OF LANDSCAPE SIGNIFICANCE

Although no Aboriginal heritage in the form or artefacts or cultural sites was identified, the areas of undeveloped landscape are significant in terms of Aboriginal history and tradition as outlined in the *Aboriginal Heritage Act 1975*.

These further statements of significance have been prepared in reference to the *Australia ICOMOS Burra Charter 2013*, and associated *Practice note for Understanding and assessing cultural significance* and *Practice note for Indigenous Cultural Heritage Management*.

AESTHETIC SIGNIFICANCE

The area's positioning relative to the coastline, and the presence of remnant native species, including some established examples renders some aesthetic value in both historic and modern contexts.

SCIENTIFIC SIGNIFICANCE

Sullivan & Bowdler (1984) provide a framework for gauging the potential for a site to yield scientific information on a scale between low, medium and high, based on its integrity, structure, content, and representativeness. The landscape here is assessed as below on the same scale:

Integrity: **Low**. The landscape has been extensively cleared and levelled, and recent erosion has impacted on the seaward side of the PIA.

Structure: **Low**. Cultural material would reasonably be expected to be densest closest to the waterline, which has now receded up to 10m from it's earlier extents.

Content: **Low**. Although numerous, the recorded heritage in the surround area is comprised of small scatters and isolated artefacts.

Representativeness: **Low**. Despite pocked of remnant, and in some places, established native vegetation, the area has been highly modified.

Overall, the significance of the landscape within the PIA is ranked as **Low**.

SOCIAL AND SPIRITUAL SIGNIFICANCE (ABORIGINAL CULTURAL SIGNIFICANCE)

The following statement has been developed after consultation with SETAC.

All Aboriginal heritage sites have cultural significance and provide evidence of the largely undocumented Aboriginal history of Tasmania. For Aboriginal people, heritage sites including artefacts and a range of other site types have Aboriginal cultural significance as a tangible link to ancestors and traditional ways of living.

While Aboriginal heritage provides strong links to our past, it is important to note that it is not limited to physical evidence of the past but also includes intangible aspects of culture. Physical and spiritual connections to land and all things contained within the various landscapes which make up the land mass of lutruwita (Tasmania) continue to be an essential aspect of Aboriginal culture and identity. They help to reaffirm connections with country.

The social and spiritual significance of individual Aboriginal sites and the significance of intangible Aboriginal values (i.e. values that are not fabric-based, such as stories and feelings) can only be attributed by the Aboriginal community. The following general statement of Aboriginal cultural significance is provided by consultant Aboriginal Heritage Officer/Consultant, Stephen Stanton.

Physical evidence of past occupation in the Huon River area includes artefacts and shell middens (living places). Non-physical aspects of culture may include knowledge and practices (e.g. stories, songs, or dances) which form strong interconnections between people and specific places. Various resources – plant, animal and marine are also integral elements of the Aboriginal landscape in the Huon estuary.

While much of the landscape of the Project Investigation Area has been highly modified by European practices which can alter, displace or destroy Aboriginal heritage, there remains some potential for Aboriginal sites to be present.

There is a strong Aboriginal cultural connection with land surrounding the Project Investigation Area and all country that forms part of the entire land mass of *lutruwita* (Tasmania). This affinity with land has continued since it comprised the various territories of Tasmanian Aborigines, and in this instance, the tribal lands of the South East People.

The land comprising the Project Investigation Area is an integral part of a larger story that has been progressing for many thousands of years. The Aboriginal values of the South East comprise more than specific sites or places – it is a complex landscape inter-woven with over 40,000 years of stories, traditions, beliefs and values.

As a general principle, any development upon, or other disturbance of land, is contrary to Aboriginal beliefs regarding the land, its values, and its inherent cultural significance. This applies to all land irrespective of its current tenure, the degree of landscape modification or the levels of disturbance.

MANAGEMENT RECOMMENDATIONS

The consultants recommend that:

1. Copies of the final report should be forwarded to South East Tasmania Aboriginal Corporation (SETAC).
2. Although low, there is some possibility of sub-surface material throughout the Project Investigation Area, given its location close to the shore line. An Unanticipated Discovery Plan (UDP) should be followed during any future erosion mitigation works.
3. The Proponent make contact with SETAC to discuss the remediation techniques that may be applied, and the planting of native species be adopted during the remediation process.

REFERENCES

Brown, S. 1986. *Aboriginal Archaeological Resources in South East Tasmania. An Overview of the Nature and Management of Aboriginal Sites.* Occasional paper No. 12. National Parks and Wildlife Service Tasmania.

Stanton, S. 2003. *Aboriginal Cultural Heritage Assessment:- Proposed Subdivision on Garden Island, in Southern Tasmania.* Report prepared for Griggs, Leary & Co. Pty Ltd Hobart.

Sullivan, S. and Bowdler, S. (eds) 1984. *Site surveys and significance assessment in Australian archaeology*. Dept. of Prehistory, Research School of Pacific Studies, Australian National University, Canberra.

Ryan, L. 2012. *Tasmanian Aborigines a history since 1803*. Allen and Unwin:Sydney.

APPENDICES

ABORIGINAL HERITAGE REGISTER SEARCH RESULTS

Aboriginal Heritage Tasmania
Natural and Cultural Heritage Division
Department of Primary Industries, Parks, Water and Environment
Level 8, 59 Liverpool Street, Hobart
GPO Box 44, Hobart, TAS, 7001

p 03 6165 3152
e aboriginal@heritage.tas.gov.au

www.aboriginalheritage.tas.gov.au
www.dpipwe.tas.gov.au

Legend:
- AH Item
- AH Instrument

N
GDA94 - Zone 55
1:53K

Garden Island Sands Erosion Works

Silas Piotrowski
Created on 09/12/2022
Created by Billy Paton-Clarke

This map is intended for use by the nominated recipient, for research purposes only. The map cannot be used for any other purposes without written permission from AHT. Information about Aboriginal heritage sites and instruments issued by AHT is confidential and is not for public dissemination.

UNANTICIPATED DISCOVERY PLAN (UDP)

For the management of unanticipated discoveries of Aboriginal relics in accordance with the *Aboriginal Heritage Act 1975* and the *Coroners Act 199*5. The Unanticipated Discovery Plan is in two sections.

Discovery of Aboriginal Relics other than Skeletal Material

Step 1:

Any person who believes they have uncovered Aboriginal relics should notify all employees or contractors working in the immediate area that all earth disturbance works must cease immediately.

Step 2:

A temporary 'no-go' or buffer zone of at least 10m x 10m should be implemented to protect the suspected Aboriginal relics. No unauthorised entry or works will be allowed within this 'no-go' zone until the suspected Aboriginal relics have been assessed by a consulting archaeologist, Aboriginal Heritage Officer or Aboriginal Heritage Tasmania staff member.

Step 3:

Contact Aboriginal Heritage Tasmania on 1300 487 045 as soon as possible and inform them of the discovery. Documentation of the and should be emailed to aboriginal@heritage.tas.gov.au as soon as possible. Aboriginal Heritage Tasmania will then provide further advice in accordance with the *Aboriginal Heritage Act 1975*.

Discovery of Skeletal Material

Step 1:

Call the Police immediately. Under no circumstances should the suspected skeletal material be touched or disturbed. The area should be managed as a crime scene. It is a criminal offence to interfere with a crime scene.

Step 2:

Any person who believes they have uncovered skeletal material should notify all employees or contractors working in the immediate area that all earth disturbance works cease immediately.

Step 3:

A temporary 'no-go' or buffer zone of at least 50m x 50m should be implemented to protect the suspected skeletal material. No unauthorised entry or works will be allowed within this 'no-go' zone until the suspected skeletal remains have been assessed by the Police and/or Coroner.

Step 4:

If it is suspected that the skeletal material is Aboriginal, Aboriginal Heritage Tasmania should be notified.

Step 5:

Should the skeletal material be determined to be Aboriginal, the Coroner will contact the Aboriginal organisation approved by the Attorney-General, as per the *Coroners Act 1995*.

Guide to Aboriginal site types

Stone Artefact Scatters

A stone artefact is any stone or rock fractured or modified by Aboriginal people to produce cutting, scraping or grinding implements. Stone artefacts are indicative of past Aboriginal living spaces, trade and movement throughout Tasmania. Aboriginal people used hornfels, chalcedony, spongelite, quartzite, chert and silcrete depending on stone quality and availability. Stone artefacts are typically recorded as being 'isolated' (single stone artefact) or as an 'artefact scatter' (multiple stone artefacts).

Shell Middens

Middens are distinct concentrations of discarded shell that have accumulated as a result of past Aboriginal camping and food processing activities. These sites are usually found near waterways and coastal areas, and range in size from large mounds to small scatters. Tasmanian Aboriginal middens commonly contain fragments of mature edible shellfish such as abalone, oyster, mussel, warrener and limpet, however they can also contain stone tools, animal bone and charcoal.

Rockshelters

An occupied rockshelter is a cave or overhang that contains evidence of past Aboriginal use and occupation, such as stone tools, middens and hearths, and in some cases, rock markings. Rockshelters are usually found in geological formations that are naturally prone to weathering, such as limestone, dolerite and sandstone

Quarries

An Aboriginal quarry is a place where stone or ochre has been extracted from a natural source by Aboriginal people. Quarries can be recognised by evidence of human manipulation such as battering of an outcrop, stone fracturing debris or ochre pits left behind from processing the raw material. Stone and ochre quarries can vary in terms of size, quality and the frequency of use.

Rock Markings

Rock marking is the term used in Tasmania to denote markings on rocks which are the result of Aboriginal practices. Rock markings come in two forms; engraving and painting. Engravings are made by removing the surface of a rock through pecking, abrading or grinding, whilst paintings are made by adding pigment or ochre to the surface of a rock.

Burials

Aboriginal burial sites are highly sensitive and may be found in a variety of places, including sand dunes, shell middens and rock shelters. Despite few records of pre-contact practices, cremation appears to have been more common than burial. Family members carried bones or ashes of recently deceased relatives. The Aboriginal community has fought long campaigns for the return of the remains of ancestral Aboriginal people.

GLOSSARY / LIST OF ABBREVIATIONS

AHO	Aboriginal Heritage Officer
AHT	Aboriginal Heritage Tasmania
AHR	Aboriginal Heritage Register
GPS	Global Positioning System
PIA	Project Investigation Area
SETAC	South East Tasmania Aboriginal Corporation
UDP	Unanticipated Discovery Plan