BUCHAN VALLEY AND GIPPSLAND LAKES
CULTURAL MAPPING PROJECT

3 GIPPSLAND LAKES REGION PREDICTIVE MODELLING

JESSIE BIRKETT-REES
BRUNO DAVID
BRENT SUTTIE

GUNAIKURNAI LAND AND WATERS
ABORIGINAL CORPORATION

www.gunaikurnai.org

GUNAIKURNAI LAND & WATERS
Gunaikurnai Land and Waters Aboriginal Corporation
AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for
Australian Biodiversity
and Heritage
MONASH University

Acknowledgements

We thank and acknowledge the Gunaikurnai Land and Waters Aboriginal Corporation. Thank you also to Matt Holland for assistance with project co-ordination, the project co-ordinators Russell Mullet and Joanna Fresløv and the Monash Indigenous Studies Centre at Monash University for logistical support.

Project co-ordinators and authors

Gunaikurnai Land and Waters Aboriginal Corporation Project Co-ordinator:
Russell Mullett

Gunaikurnai Land and Waters Aboriginal Corporation Project Co-ordinator:
Joanna Fresløv

Dr Jessie Birkett-Rees, Monash University

Professor Bruno David, Monash University
Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage

Brent Suttie, Memorial University of Newfoundland, Canada

1 October 2020

Cover Illustration
From the Cottages to the Red Bluff. Flora Gregson, 22 March 1877.

Design and desktop publising: Pauline Heaney, Lettuce Create.

Cultural warning

This report contains information on the location and characteristics of Ancestral places and objects in the Gippsland Lakes region, within GunaiKurnai lands and waters.

Information on places and objects was sourced from the Victorian Aboriginal Heritage Register (VAHR), with permission from the GunaiKurnai Land and Waters Aboriginal Corporation and under the terms of the Memorandum of Understanding (MoU) between the GunaiKurnai Land and Waters Aboriginal Corporation and Monash University. This information relates to confidential GunaiKu nai cultural heritage.

The places and objects listed in the VAHR include the locations of Ancestral Remains and the Boomerang Point Massacre site. In the interests of producing a report that addresses the diversity of GunaiKurnai places within the Gippsland Lakes region, these sensitive sites are included in this study.

Mia mia opposite Laughton's Hotel, Lakes Entrance. Daniel Long, 1856.

Sand Hummocks between Reeves River and the sea. Flora Gregson, 28 March 1877.

Contents

The Proposed New Entrance to Lakes. Daniel Long, 1883.

'Bifurcated waterway with wooded land on both sides and an island in centre, a paddle steamer on the water, other craft at jetty on island.'

Introduction

This report accompanies digital information layers delivered as Component 3 of the multi-stage 'Buchan Valley and Gippsland Lakes Cultural Mapping Project', a partnership research project between the GunaiKurnai Land and Waters Aboriginal Corporation, and the Monash Indigenous Studies Centre (Monash University). The aims of the report are to present a predictive model of archaeological site locations for the Gippsland Lakes. In this study, an 'archaeological site' is defined as a place with p ysical artefacts or where a place has demonstrably been physically modified y people; other places may be known through oral traditions held by community members or recorded in historical records, and are discussed as 'oral tradition sites'. A given place can be an archaeological site (if it has material evidence of past use), oral tradition site (if it is known through oral traditions or historical records), or both.

A key purpose of the predictive model is to help inform where across the Gippsland Lakes study area archaeological sites are likely to occur, and where priority areas of risk to archaeological sites are likely to be in light of changing environmental conditions and human use (oral tradition sites do not feature prominently in this report, because such sites have not been listed in the VAHR, which is the source of much of the information for this report). The predictive model uses pre-existing information, including the location and characteristics of registered archaeological sites sourced from the VAHR, together with existing information about the Gippsland Lakes environment available through Parks Victoria, the Department of Environment, Land, Water and Planning (DELWP), and the Victorian Government digital data repository (https://www.data.vic.gov.au/). The predictive model produced therefore reflect the pattern of distribution of currently known archaeological sites around the Gippsland Lakes study area, as registered in accessible databases. The patterns we have highlighted in this report could change as new areas are field-su veyed, new sites are discovered, and new environmental zones identified

Aboriginal people camped at Lakes Entrance, Gippsland. Flora Gregson, 1871.

This report gives details of the information used to construct the predictive model, how it may be used, and the ability for it to be updated through field testing and application The predictive model is presented through a Geographic Information System (GIS). A GIS is a collection of different, thematic layers of information that are related to each other by where they occur in the landscape. In this instance, each layer of information extends across the same spatial area of the Gippsland Lakes. Each layer contains a different set of information about the landscape. The layers and functionality were built using ESRI ArcMap 10.7.1. The results of this work are presented as a package of digital layers for use in ArcMap 10.7.1, with key layers extracted for use in Google Earth, for ease of access.

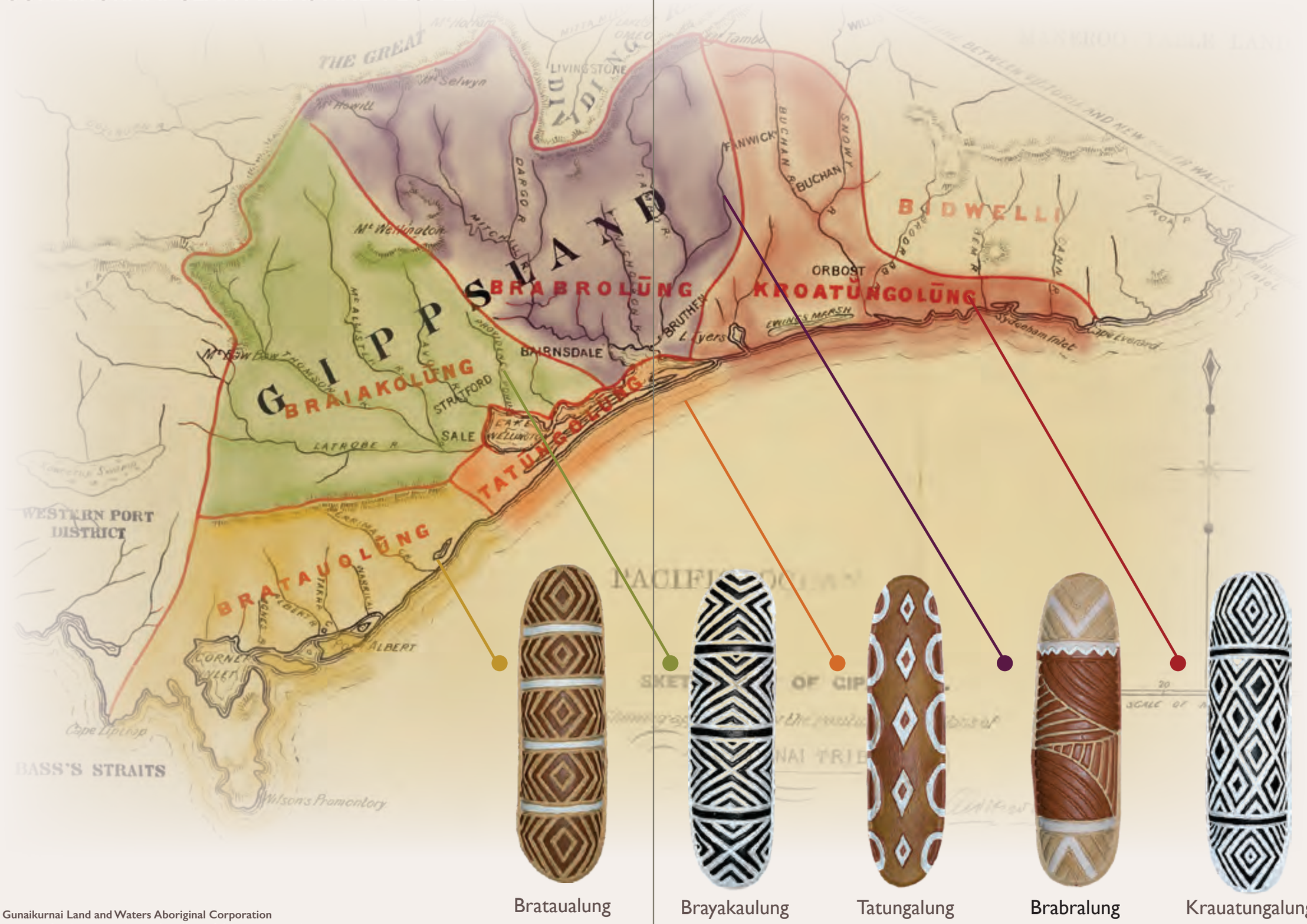
The layers of information that make up the predictive model are arranged under four subheadings in the GIS: 'ArchaeologicalResources', 'ModelLayers', 'BaseMaps' and 'AdditionalData'. The 'ArchaeologicalResources' layer represents the location of all the archaeological sites in the current VAHR records for the Gippsland Lakes study area. 'ModelLayers' consists of the results of our predictive modelling, in the form of several new layers of information.

These layers show the areas of the Gippsland Lakes in which archaeological sites are most likely to be located and the areas which may be at risk under changing environmental conditions. The 'BaseMaps' and 'AdditionalData' layers contain information that was either used to produce the predictive model, or that are deemed potentially useful for future research. These include information about topographic elevation, land characteristics (geology and geomorphology), the locations of water (hydrology), plants (vegetation), animals (fauna), and current land use (planning). Details on each of these categories of information are provided below and in Appendix 1.

Opportunities for further research

The information and predictive model presented in this report are based on current (2020) understandings of the characteristics and location of archaeological sites. The predictive model is tailored to the Gippsland Lakes study area but is only as accurate as the available information allows it to be. Field-testing of the predictive model has not been undertaken as it was not part of our brief, but such field-testing is strong y recommended, especially given the varied quality and patchiness of the available information (both site characteristics and site locations, and environmental information). Field-testing is important to adjust and refin the predictive model and to improve its usability and accuracy as more field details becom available. Ideally, field-testing ought not assume in advance where sites will be istributed. It will be most effective if designed to be systematic and random, covering as many different landscape zones (and their interfaces) as possible across the region. In order to ensure that the results of field-testing are in fact representati e of what is present or absent in the landscape, field-testing needs to be conducted in a manner that results i a statistically valid and representative sample of the landscape. We cannot draw the most reliable conclusions from results that do not provide a statistically valid and representative sample.

GUNAIKURNAI CLAN AREAS AND PEOPLE

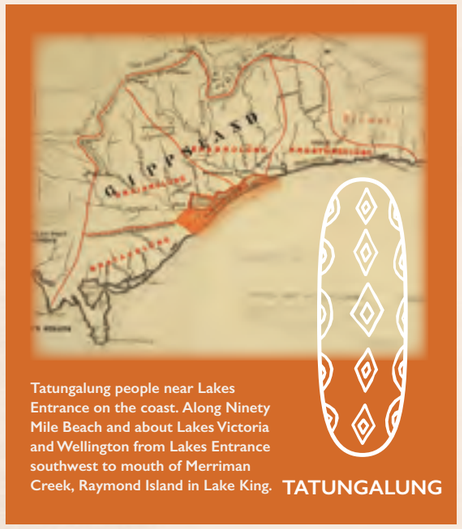


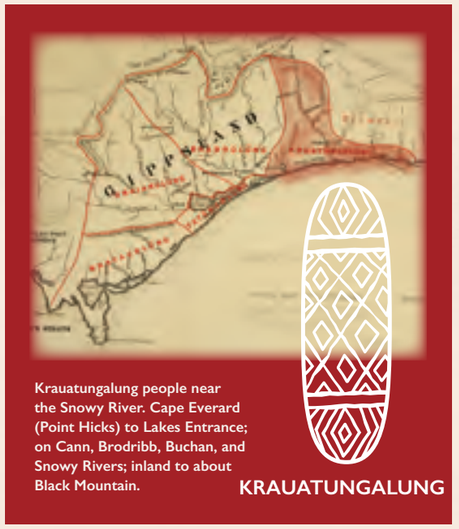
Gunaikurnai Land and Waters Aboriginal Corporation respects that interpretation and spelling of these names varies.

Background

Gippsland Lakes region

The study area is located in GunaiKurnai Country, principally within the territories of the Tatungalung and Krauatungalung clans, bordered by the Brayakaulung and Brabralung clan areas.





The lake waters are a GunaiKurnai 'cultural centre', where spiritual totems and Ancestral stories are found. The environmental diversity of the lakes has long provided abundant food resources and raw materials for GunaiKurnai. The lands and waters of the lakes and associated wetlands comprise traditional hunting, fishing camping and gathering places of the Old People, who favoured the use of traditional bark canoes for transport across the lakes and along the rivers. They are also important story places that relate to all aspects of GuaniKurnai life and world views, both past and present. Major base camp locations can be found along the dunes between the lakes and the sea, with many shell accumulations still evident as archaeological sites.

The Gippsland Lakes consist of four large, shallow coastal lakes. They are known as Lake Wellington (GunaiKurnai name: Murla), Lake Victoria (Toonallook), Lake King (Ngarrang) and Lake Reeve (Walmunyeera) (Clark and Heydon 2002). These lakes are fed by fi e major river systems fl wing from the Latrobe Valley and Victorian highlands: the Latrobe-Macalister-Thompson and the Avon-Perry river systems that fl w into Lake Wellington; and the Mitchell, Nicholson and Tambo Rivers that fl w into Lake King. The lakes and rivers are associated with many wetlands and lagoons, notably the brackish Lake Coleman, the Dowd Morass and Macleod Morass, and the saline Lake Reeve wetlands.

The Entrance to the Gipps Land Lakes. C. Winter (engraver), 1867. From a sketch by W. H. Jarrett.

'Viewed from the high ground at Jemmy's Point looking south-west;
includes the River Reeves; Doughboy, Flanagan and Bull islands; Lake Reeves.'

Ramsar Wetlands

The Gippsland Lakes area is a listed Ramsar Wetland (Australian site number 21: http://www.environment.gov.au/water/wetlands/publications/gippsland-lakes-ramsar-site-ecd; Australian Wetlands Database 2019). The Convention on Wetlands of International Importance is an international treaty that recognises and lists outstanding wetlands around the world, the designated list of notable wetlands to be protected being generally known as the 'Ramsar Wetlands' (after the town of Ramsar in Iran, where the treaty was signed in 1971). The nine potential criteria for listing are all based on 'biodiversity and uniqueness of their ecology, botany, zoology, limnology or hydrology' (http://www.environment.gov.au/water/wetlands/ramsar/criteria-identifying-wetlands), rather than on Indigenous cultural values. The Gippsland Lakes were listed as a Ramsar Wetland on 15 December 1982, under the following criteria:

> **'Criterion 1:** A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region'.
>
> **'Criterion 2:** A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities'.
>
> **'Criterion 5:** A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds'.
>
> **'Criterion 6:** A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird'.
>
> **'Criterion 8:** A wetland should be considered internationally important if it is an important source of food for fishes spawning ground, nursery and/or migration path on which fish stocks either within the wetland or elsewhere, depend'.

The Gippsland Lakes include a wide range of cultural, terrestrial, fluvial (iver), palustrine (inland wetlands with plants that grow above water but whose roots lie below water), lacustrine (lake), marine and coastal processes.

Scene at the 'Works'. Flora Gregson, 15 February 1878.

The 90 Mile Beach. Flora Gregson, c. 1870.

The Geographic History of the Lakes

Although this study addresses the Gippsland Lakes region only, it is necessarily also informed by the broader geographic region and history of the Gippsland Lakes.

The characteristics of the lakes are closely associated with the development of Ninety Mile Beach (Boon et al. 2015) and with a relict, inland coastal sand barrier and an active, seaward sand barrier that separates the sea from the lakes (Bird 1965, 2010). The area has always been dynamic (see 'Land (Geology and Geomorphology)' page 20), but conditions changed substantially when a permanent passage between the lakes and the seas was created at Lakes Entrance in 1889.

The Gippsland Lakes had been an intermittently closed and open expanse of lagoons, separated from the Tasman Sea by a series of low barrier dunes. Freshwater from the rivers collected in the lakes and wetlands until higher water levels broke through the sand dunes causing a temporary opening to the sea. Sand transport along Ninety Mile Beach would eventually close this connection between the sea and the lakes, allowing the lakes to gradually return to freshwater conditions. The cycle of intermittent opening and closing was dramatically and permanently altered with the establishment of an artificial ent ance to the lakes. Changes to the landscape surrounding the lakes, including clearing of land and development of infrastructure, have resulted in changes to the rivers and to the shorelines of the lakes. The lakes environment we see today is not what it was like prior to 1889. However, it is possible to reconstruct elements of the past landscape and to make reasonable projections of its future based on present-day observations.

The Red Bluff. The end of the '90 Mile Beach'. Flora Gregson, c. 1870.

GIPPSLAND LAKES BEFORE THE PERMANENT ENTRANCE, 1885.

1885 map, from before the permanent entrance, but annotated with 'Proposed New Entrance'.
Gipps Land Lakes: showing the routes of steamers Tanjil and Bairnsdale. Lakes Navigation Company.

'NATURAL ENTRANCE' TO THE LAKES.

'Elevated view over trees and scrub towards waterways opening to the sea'.
Photographer unknown. Compiled by James Blundell.

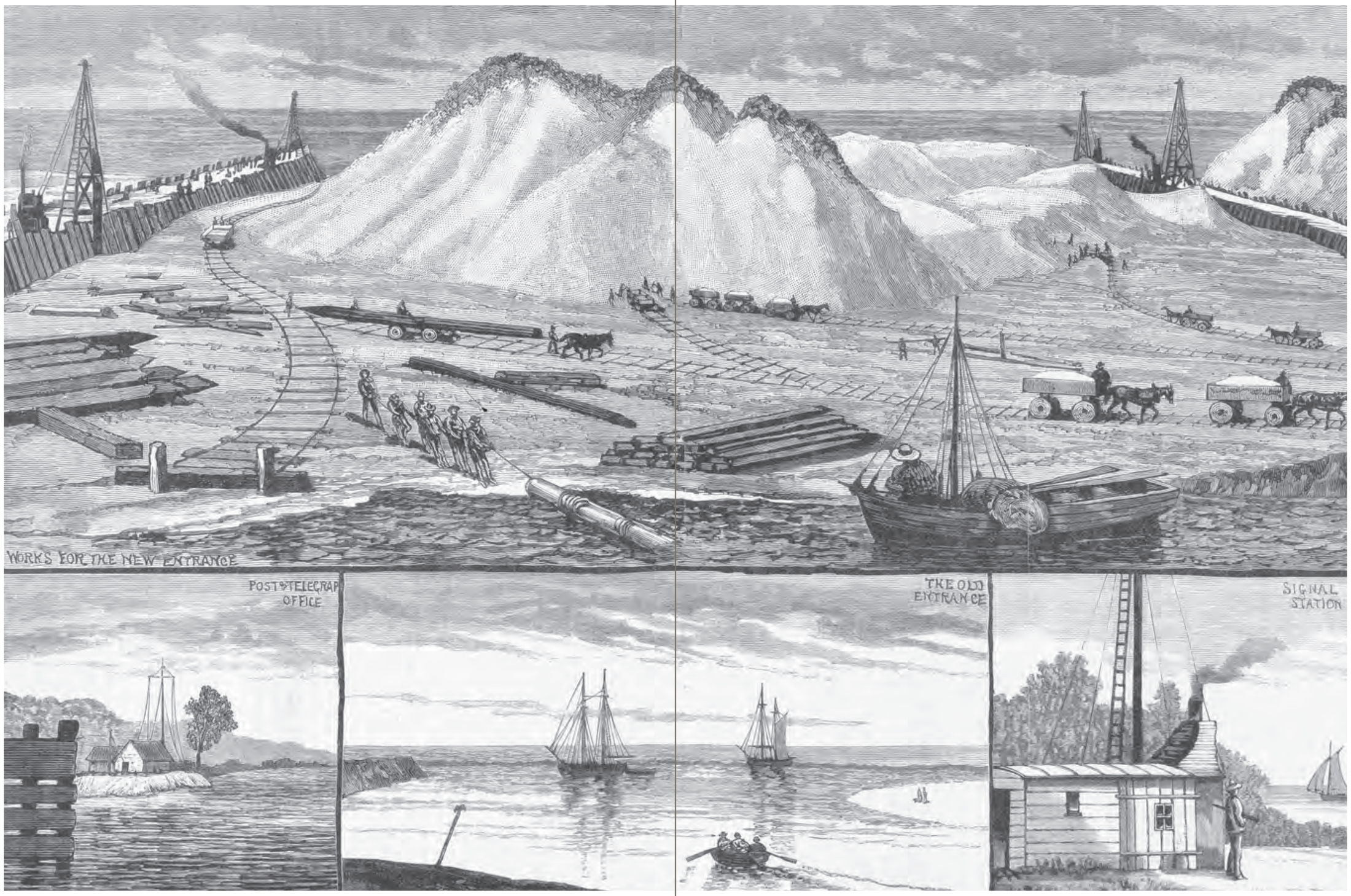
AFTER THE PERMANENT ENTRANCE TO THE SEA, 1940s.

Map produced in the 1940s after the permanent entrance was established.
Gippsland Lakes: showing routes of steamers. Victorian Railways.

GOVERNMENT WORKS AT ENTRANCE, 1887.

Government Works at new Lakes Entrance, Gippsland.
Photographer unknown. Compiled by James Blundell.

GOVERNMENT WORKS AT LAKES ENTRANCE, 17 DECEMBER 1884.



Works at the New Entrance, Gipps Land Lakes. Published by Alfred Martin Ebsworth, 17 December 1884.

Archaeological Predictive Models

Landscape modelling has been used in archaeological research and environmental management for decades, but has become steadily more sophisticated with the introduction of increasingly powerful Geographic Information Systems (GIS). Recent research (Deur and Butler 2016; Verhagen 2018; Wachtel et al. 2018) highlights two ways that predictive models have been used in archaeological research and heritage management. First, predictive models have been constructed where some archaeological sites are known from a relatively large region, and for which predictions are sought on where yet unknown sites are likely to occur within that broader region. Second, predictive models have proved useful where most of the archaeological sites in an area have been known, and where that knowledge can be used to predict the pattern of site distributions in similar, adjacent regions where sites have not yet been (or not yet been sufficient y) recorded. Both these uses of GIS for site prediction can be used for the Gippsland Lakes, where archaeological surveys have been undertaken in some but not in other areas over the past century, resulting in an extensive but uneven record of documented archaeological sites.

This project has constructed a data-driven archaeological predictive model. This means that pre-existing information on archaeological sites and known environmental characteristics were analysed to identify areas where archaeological sites are most likely to be located. We have also analysed existing information to identify areas that may be affected by changing environmental conditions. Through this information, we can then consider whether areas that contain archaeological sites might also be areas at risk. Our analyses of the available sites and their environments have produced new GIS layers of information that can be organised into themes, each created by finding patte ns from the existing information. These new patterns and GIS layers are the 'results' of the predictive modelling (see 'Analysis: Model Layers', below), and can be used to predict the characteristics of areas where archaeological sites are likely to be.

The areas in which archaeological sites are most likely to be located are highlighted in the GIS layer 'ElevatedPotential'. This layer shows areas that have a higher (elevated) likelihood (potential) of being the locations of archaeological sites. The locations of shorelines in the past are shown in the layer 'Paleoshorelines', highlighting areas that may have been particularly attractive to people at times when water levels in the lakes were higher than they are today. We have also created a GIS layer that simulates what the study area would look like with higher water levels in the lakes ('InundationModel'). This enables us to visualise which parts of the land were above water in the past, and which areas of land may be affected if current water levels rise. To further investigate potential changes to the Gippsland Lakes area in light of changing environmental conditions and human use, we have produced a GIS layer that identifies areas most at isk of shoreline erosion ('CoastalErosionThreat'). This modelling helps identify priority areas of risk to archaeological sites, based on projected levels of erosion at successive dates into the future (Baby 2020, 46; Victorian Coastal Council 2008). These GIS layers each expand on pre-existing information and allow us to examine the characteristics of locations that contain archaeological sites in greater detail.

Note on sources of information

We have used the sum of available information on archaeological sites, their locations, and the characteristics of the Gippsland Lakes environment. However, none of the information we have used had been expressly collected with archaeological predictive modelling in mind. With careful assessment, this diverse information can be used to inform on the landscape settings of archaeological sites, and on how these have changed or are likely to change through time. The GIS layers of information used to construct the predictive model are outlined below. Where possible, web links are provided to their metadata (which contain details such as who gathered the information, when and how it was gathered etc.) in Appendix 1. These information layers have been evaluated, processed and refined y the predictive model project team (Cambrian Environmental and Monash University). Where possible, we have removed inconsistencies and errors in the original data.

The boundary of the Gippsland Lakes study area was provided by Parks Victoria. This boundary does not bear any particular relationship to the physical or cultural landscape of the Gippsland Lakes region, but was rather defined or the purposes of delimiting this project's geographical scope **(Figure 1)**. Establishing boundaries for data analysis is a necessary but challenging process. The predictive model presented here relates only to the area within the project boundary, which represents only part of GunaiKurnai Country and of the broader Gippsland Lakes geographic area. The patterns identified in the predicti e model may differ if we were to examine the Gippsland Lakes within natural catchment boundaries, or GunaiKurnai cultural (e.g. land use) boundaries, for example.

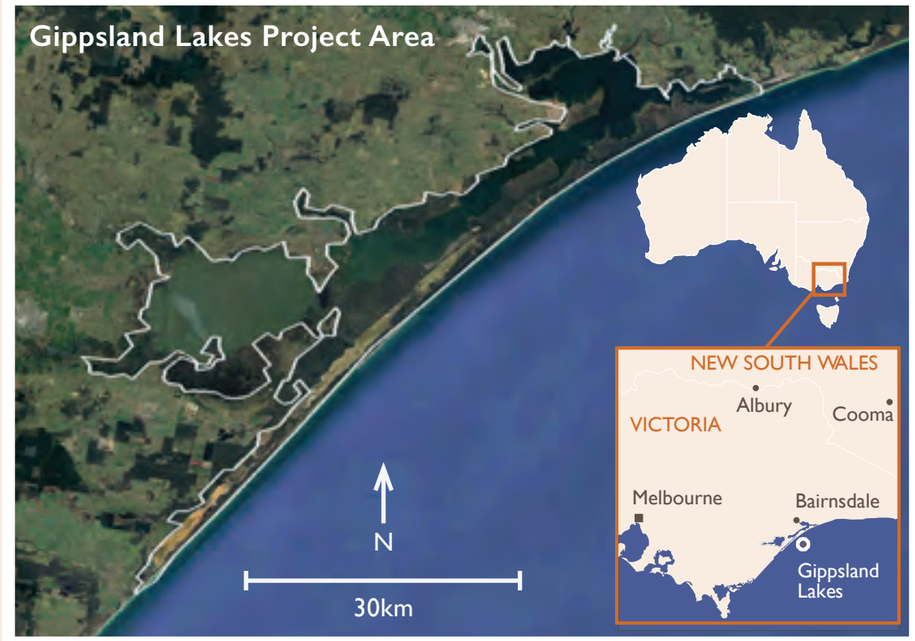


Figure 1. Area covered by the predictive model.

View of Sperm Whale Head jetty. Joanna Fresløv.

View north from Artefact Scatter at Sperm Whale Head. Joanna Fresløv.

An archaeological predictive model already exists for the State of Victoria, though it is broad in scope. The *Aboriginal Heritage Act* 2006 and the *Aboriginal Heritage Regulations* 2016 identify parts of the landscape deemed by Aboriginal Victoria to be more likely to contain archaeological sites. These areas of 'cultural heritage sensitivity' are presented in the Aboriginal Cultural Heritage Register Information System (ACHRIS: **https://achris.vic.gov.au/#/onlinemap**), with these parts of the landscape being given preference in cultural heritage management (CHM) assessments. Archaeological sites located during CHM assessments are registered in the VAHR. Given that the information in VAHR records was gathered using the parameters set out in the *Aboriginal Heritage Act* and the *Aboriginal Heritage Regulations,* the existing VAHR record is inherently biased toward areas that are considered to have 'cultural heritage sensitivity' under the Act and Regulations. For this report, not undertaken under the terms of a CHM assessment, we have worked to refine these broad designations and to pr vide a more nuanced analysis of the Gippsland Lakes landscape.

Information about the archaeological sites in the study area was sourced from the VAHR. We understand that the VAHR does not view archaeological sites in the same way as a GunaiKurnai person might. The VAHR information consists of an eight-digit number for each registered archaeological site, geographic coordinates identifying the location of each site, and a site category assigned according to the categories defined in the VAHR. Additional, qualitative information is provided on a 'site card', which is the record produced by the person recording the site for the purposes of registration. We have checked the site card of each registered archaeological site within the Gippsland Lakes study area as part of this project. The amount of detail provided on these site cards is not uniform; the main differences appear to relate to the year in which a given site card was produced and the person recording the information. Information is often more consistently entered on more recent cards, although there are notable exceptions, such as a thorough 1971 survey of culturally modified trees (.g. VAHR site code 8321-0011). The implication of the varied quality of detail provided in the site cards is that we cannot 'filter the information equally, across all of the records, to improve the categorisation of archaeological sites. Given the nature of the available data, we therefore use the VAHR categories to investigate different types of archaeological sites in the Gippsland Lakes study area.

The VAHR classifies sites into 11 types 'Aboriginal Historical Place', 'Aboriginal Object Collection' 'Aboriginal Intangible Place or Consultation', 'Artefact Scatter', 'Earth Feature', 'Ancestral Remains', 'Quarry', 'Rock Art, 'Scarred Tree', 'Shell Midden' and 'Stone Feature'. The terms used in the VAHR categories, and the ways in which archaeological sites are grouped or divided, are not uniformly agreed on by all its users. This is the way the existing information about archaeological sites is presented in the VAHR records and therefore these categories are used in our research.

The definition of each VAHR site type has also changed over time. For instance, prior to 2012, an archaeological site with stone artefacts could be registered as an 'Artefact Scatter' or as an 'Isolated Artefact'. In 2012, the Office of Aboriginal Affairs Victoria introduced a new system for describing and registering areas where fewer than 10 stone artefacts were found within an area of 100 m^2 as 'Low Density Artefact Distributions' (LDAD) (Spry 2016). This change in definition is pro lematic for many reasons. In relation to the predictive model, it means that sites recorded before and after 2012 are spread into two or more site types, not because the sites are necessarily different in their characteristics, but simply because they were recorded in different ways. Although we have separated Artefact Scatters and LDADs in the predictive model, this choice was necessary given the nature of the information at our disposal, rather than being based on the qualitative characteristics of these sites. If preferred, however, the two separate categories can be grouped when using our results (note, however, that a problem will persist, because one LDAD may actually be made up of many single stone artefact locations, without the precise location details of each having been recorded).

Mr. Carpenter's, North Arm, Lakes Entrance. Flora Gregson, 1913.

The Works from Mr. Carpenter's, North Arm. Flora Gregson, 11 April 1877.

Information used to prepare the predictive model

Archaeological sites

A total of 646 archaeological sites are registered in the VAHR for the study area, as at July 2020 (**Figure 2**). Artefact Scatters make up nearly half (48%) the sites and, if we group Artefact Scatters and LDADs, archaeological sites consisting of stone artefacts make up 74% of the known sites in the study area. Of the nine sites with Ancestral Remains identifie in the area, one is a reinterment undertaken by GunaiKurnai Land and Waters Aboriginal Corporation staff in 2018. There are no recorded Quarries, Stone Features or Rock Art locations within the study area, and the category Earth Feature consists exclusively of 'Soil Deposit' (i.e. no 'Hearths', 'Mounds' or 'Rings').

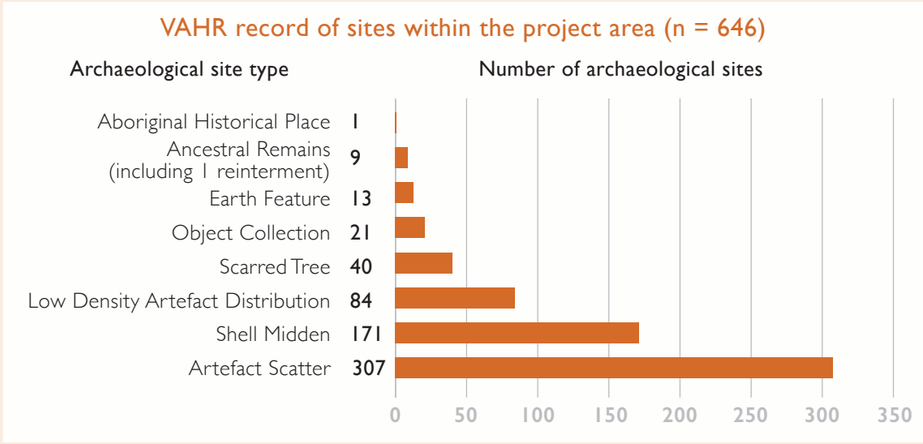


Figure 2. Number of sites registered, by site type in the VAHR for the Gippsland Lakes study area.

Artefact Scatter at Sperm Whale Head. Joanna Fresløv.

Artefact Scatter

'Artefact Scatters' are concentrations of stone artefacts seen on the ground surface. They were produced by the activities of the Old People during camping, tool production and other activities in the course of daily life around the Gippsland Lakes. For an archaeological site to be recorded as an Artefact Scatter, stone artefacts must be present, but other kinds of artefacts such as food remains (e.g. animal bone, shell), charcoal or ochre may also occur. Although Artefact Scatters are numerous, no two sites are identical. Such sites can also provide information about interactions between disparate groups across the landscape (e.g. Through the presence of imported stone and materials that may have been traded in) and cultural changes over time (e.g. Through changes in types of artefacts or in the technologies employed to make them). An Artefact Scatter can be the result of a single event or activity, or it can indicate places that people returned to over long periods of time.

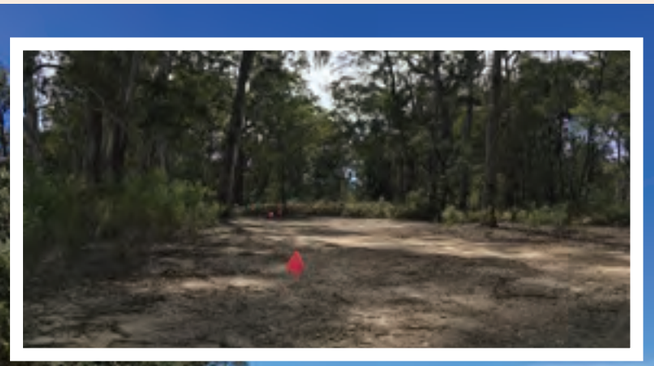
Artefact Scatters are found in many areas of the Gippsland Lakes study area. They appear to be particularly common near the margins of bodies of water, although this may reflec a recorder bias because the sites close to water listed in the VAHR tend to have lower vegetation and can thus be more easily seen and recorded (see 'Plants (Vegetation)', below). Of the known Artefact Scatters in the modelled area, 70% are located within 100 m of water.

Artefact Scatter before excavation at North Arm. Joanna Fresløv.

Artefacts from North Arm site. Joanna Fresløv.

Low Density Artefact Scatter (LDAD)

This type of Artefact Scatter fi st began to be used in the VAHR in 2012, in order 'to facilitate a streamlined recording process for lower densities of artefacts' (Aboriginal Victoria 2013). It therefore only represents more recently registered Artefact Scatters with low densities of stone artefacts. LDADs are difficult to ana yse, because in reality they could be single artefacts or very large sites with hundreds or even thousands of sparsely distributed artefacts spread across a large area (i.e. They could represent many different kinds of artefact scatters all under the one term). LDADs appear to be located near other LDADs in the study area, but this is as likely to represent the locations of archaeological assessments (after 2012) as it is to represent an actual pattern in the distribution of archaeological sites across the landscape. There are 84 LDADs in the Gippsland Lakes study area, but these were all recorded during just nine field su veys. Even so, LDADs are widely distributed within the study area and, as is the case for Artefact Scatters, appear to be most common along the margins of watercourses and lagoons. On the western side of the study area, one LDAD is associated with the southern foreshore of Lake Wellington (VAHR site code 8321-0471); another is associated with the Salt Lake Backwater Morass (VAHR site code 8321-0470). In the far east of the study area, there is an LDAD on the shore of the Nyerimilang Park Gippsland Lakes Reserve (VAHR site code 8422-0688) and another on the shores of Eagle Point Bay (8422-0651). The majority of LDADs are located on Raymond Island, with three occurring around the island's coastline. Such low numbers of recorded sites make it difficult to accu ately predict where other LDADs are likely to occur, although a pattern is beginning to emerge.



Low Density Artefact Scatter at Lake Tyers. Joanna Fresløv.

Artefact Scatter location at Lake Tyers. Joanna Fresløv.

Culturally modified tree ('Sca red Tree')

'Scarred Trees' are trees with sections of bark deliberately removed by the Old People, for the creation of shields, shelters, tools, containers, and bark canoes for transport across the lakes and along the rivers. The scars on the trees can vary in size, in keeping with the multiple purposes for which the bark was removed, but they are typically regular in shape and often have parallel sides and pointed or rounded ends. Scarred Trees are mature trees most frequently located along rivers and lakes. Some Scarred Trees have also been carved, containing designs cut into the wood. Two of the Scarred Trees (8321-0028 and 8321-0029) within the Gippsland Lakes study area have their scars thus incised.

Scarred Trees at Lake Tyers. Joanna Fresløv.

Throughout the study area, Scarred Trees are found in the immediate proximity of waterways. Of the 40 Scarred Trees recorded, 35 (87%) are recorded as 'Red Gums', with one (3%) additional tree recorded as simply 'Gum' and four (10%) without their taxa recorded. The majority of Scarred Trees (23, 57%) were in good health when they were registered in the VAHR, with only four (10%) recorded as being in poor health **(Figure 3)**. One tree had no condition recorded. The remaining trees were dead, with six (15%) of these noted to be still standing.

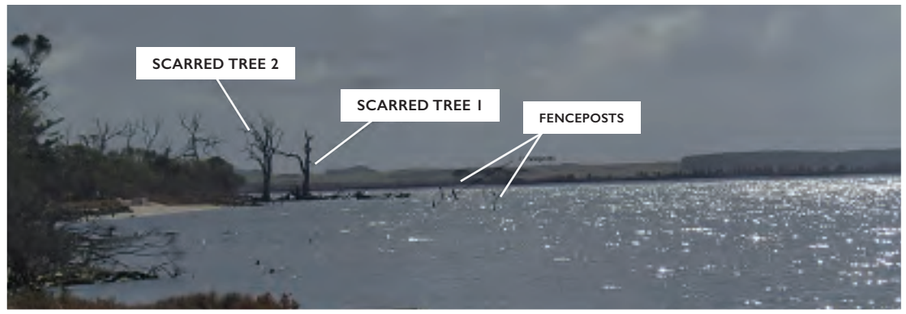
Of the dead trees, several had evidently already been affected by changing environmental conditions around the lake shores and wetland margins. For instance, the Tatungalung Scarred Tree complex (VAHR site code 8321-0472), on the western shore of Lake Victoria at Hollands Landing, includes two dead Red Gums (see photo below). These trees once stood on land near the lake but erosion of the lake shoreline has caused the waterline to move further inland. The trees are now located in the water, between three and 10 metres from the current shore. Nearby is a third Red Gum (VAHR site code 8321-0473), in May 2018 also recorded as dead and standing in water.

Scarred Trees are highly distinctive and visible archaeological sites. Even so, we are able to indicate meaningful patterns in their distribution across the landscape, which may facilitate the identification of more Sca red Trees in areas that have not yet been surveyed. Examination of the types of vegetation present around the lakes, using the information in GIS layers 'NV1750_EVC' and 'NV2005_EVCBCS', reveals a close association between particular types of vegetation and the location of known Scarred Trees.

The State of Victoria uses Ecological Vegetation Classes (EVCs) to classify vegetation into primary classes and subclasses. Based on the locations of known Scarred Trees, four vegetation subclasses in GIS layer 'NV2005_EVCBCS' are particularly relevant. These are:

- '8.1 Riparian Scrubs or Swampy Scrubs and Woodlands',
- '12.1 Plains Grasslands and Chenopod Shrublands',
- '13.1 Plains Grassy Woodlands/Forests', and
- '14.2 Riverine Grassy Woodlands/Forests'.

Over half of the known Scarred Trees (26, 65%) are located within areas with these types of vegetation. If we examine the area immediately adjacent to these EVC areas, we find that 88 (35) of known Scarred Trees are within 20 m of these areas, and 90% (36) are within 50 m (**Figure 4**). The EVC vegetation maps were created for the whole State of Victoria at scales of 1:100,000 and 1:25,000; at these scales of mapping, a distance of 20 m from a mapped boundary is within margins of error, so it is possible that these nearby trees are even closer to the above-listed vegetation sub-classes than the vegetation distributions show.



Aboriginal Scarred Trees on the northwest shore of Lake Victoria (VAHR site code 8321-0472). (photo by Kate Morton, Aboriginal Victoria, 5 September 2017).

Figure 3. Health of Scarred Trees recorded in the Gippsland Lakes study area, at the time they were registered in the VAHR.

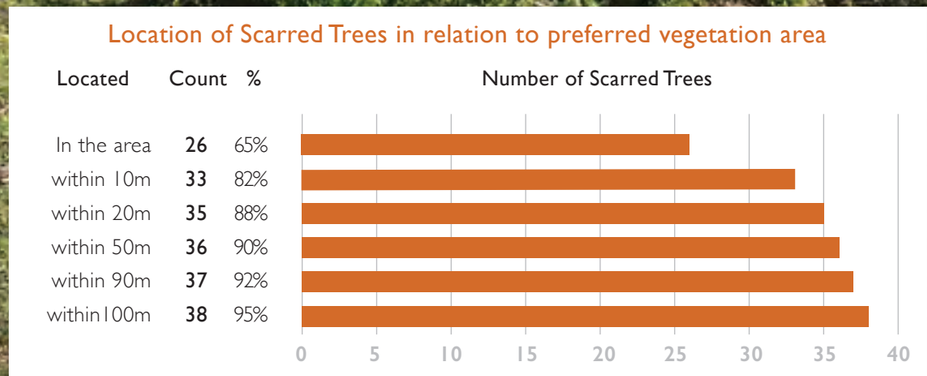


Figure 4. Location of Scarred Trees in relation to the preferred vegetation EVC subclasses 8.1, 12.1, 13.1 and 14.2

Scarred Trees at Lake Tyers. Joanna Fresløv.

Shell Midden

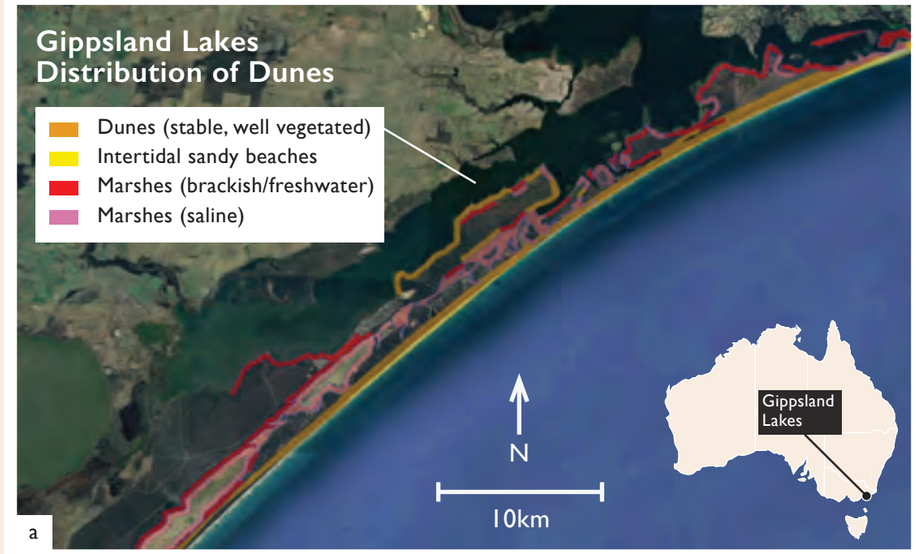
'Shell Middens' contain the remains of shellfish ha vested by the Old People. These shell accumulations are called 'middens' in the VAHR records, a site type we therefore use in the GIS layers. Shell deposits occur in a range of locations: they can be found as layers of shell exposed in dunes and river banks, or as shell scatters exposed on eroded surfaces. In addition to shell, which is typically the most common kind of item found in Shell Middens, such sites may also contain fish bone or the bones of marine (e.g. seal) or terrestrial (e.g. kangaroo) mammals. Hearth stones and charcoal from fireplaces m y also be found in, or in association with, Shell Middens.

Shell Middens are the second-most common site type in the study area. Of the 171 Shell Middens, only 16 (9%) are located in areas near the lakes and lagoons, inland from the coast. The remaining 155 (91%) occur in the outer barrier dune (Bird 1965) between the lakes and Ninety Mile Beach. Within this area, Shell Middens are closely associated with specific types of coastal habitat (soil an vegetation). The GIS layer 'LCC_COASTAL_CLASSIFICATION' shows the locations of several types of coastal habitat: dunes, intertidal beaches, freshwater marshes and salt marshes. Most of the recorded Shell Middens (140 of 155, 90%) are found in 'Dunes (stable, well vegetated)' (**Figure 5a,b**).

Investigation of the GIS's geological layers also reveals a close association between Shell Middens and sand dunes. The layer 'SG_GEOLOGICAL_UNIT_250K_lakes' lists Victoria's surface geology in the study area. When using this GIS layer, we find that Shell Middens ar particularly found in areas identified as 'Qd1 ('inland dune deposits')', 'Qd2 ('dune deposits')' and 'Qdl1 ('coastal dune deposits')'. These geological landforms only partly overlap with the dunes recorded in the GIS layer 'LCC_COASTAL_CLASSIFICATION', and therefore represent a different category of useful information.

Shell Midden and Ancestral Remains at Paradise Beach. Joanna Fresløv.
Note that the ancestral remains are not shown on this photo.

We used the GIS layer 'SG_GEOLOGICAL_UNIT_250K_lakes' to create a new GIS layer that contains only areas identified as dune deposits (l yer 'Qd1_Qd2_Qd3_Qdi_Qdl1_DuneDeposits'). We found that 157 (92%) of all Shell Middens are associated with the dunes in this GIS layer. Returning to the surface geology layer 'SG_GEOLOGICAL_UNIT_250K', we found that 13 (8%) Shell Middens are found in 'coastal lagoon deposits' (which we also provide as a layer in the GIS: 'QG_Qm1_CoastalLagoonDeposits').



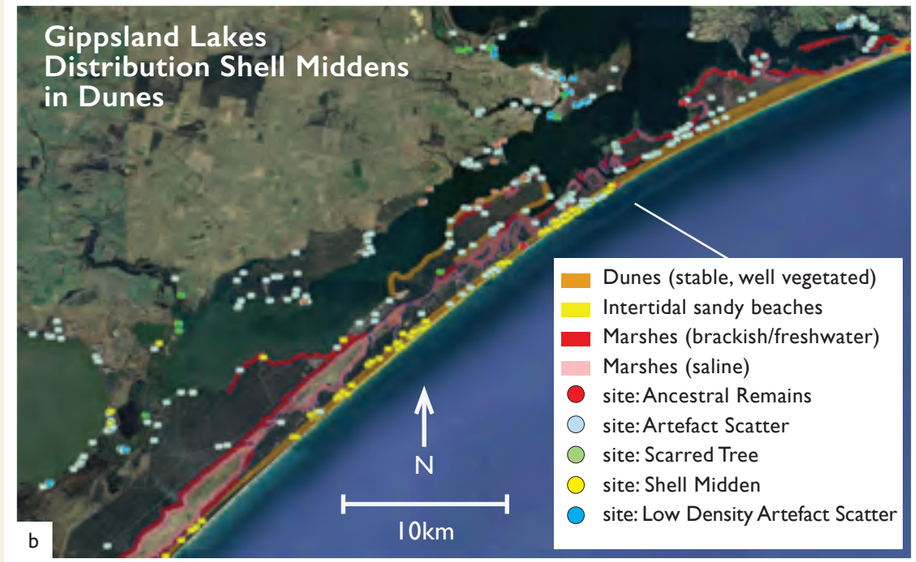


Figure 5a Distribution of dunes, intertidal sandy beaches and marshes in GIS layer 'LCC_COASTAL_CLASSIFICATION_Lakes', and **5b** Recorded archaeological sites; Shell Middens are in clear association with areas classified as 'Dunes (stable, well vegetated)'.

Ancestral Remains

There are eight sites classified as 'Ancestral Remains' in the Gippsland Lakes study area. Six of these are found in dune deposits in the GIS's surface geological layer called 'Qd1_Qd2_Qd3_Qdi_Qdl1_DuneDeposits'. These are sites where human burials occur. They are located in dunes along Ninety Mile Beach and the outer barrier of Lake Reeve. The GIS layer also includes the most inland site in the study region, Marley Point on Lake Wellington (VAHR site code 8321-0151). The other two sites, both on the Boole Poole Peninsula, are associated with coastal lagoon deposits (GIS layer 'QG_Qm1_CoastalLagoonDeposits') and freshwater marshes (in GIS layer 'LCC_COASTAL_CLASSIFICATION').

Shell Midden and Ancestral Remains at Lake Tyers. Joanna Fresløv.
Note that the ancestral remains are not shown on this photo.

Earth Feature

The 13 'Earth Feature' archaeological sites are all located on the boundary of wetlands and lakes/lagoons. Earth Features have mainly been recorded from the shores of the Lakes National Park (Sperm Whale Head) and Banksia Peninsula and their immediate coastlines. Some of these sites (e.g., VAHR site codes 8422-0317, 8422-0318) are registered as exposures of possible Pleistocene dunes.

Ochre source at Lake Tyers. Joanna Fresløv.

Shell Midden and Ancestral Remains at Lake Tyers. Joanna Fresløv.
Note that the ancestral remains are not shown on this photo.

Topographic Elevation Layer

The GIS's topographic elevation layer ('LakesElevationData') was produced using LiDAR results collected by the East Gippsland Catchment Management Authority. LiDAR uses laser light to densely sample landscape surfaces, producing a very accurate measurement of topography. In the GIS layer 'LakesElevationData', we have used the LiDAR measurements to show the topography of the Gippsland Lakes. The highest point in the study region is near Kalimna (44 m above sea level), with small rises up to 33 m in the Lakes National Park and up to 29 m near the Mitchell River estuary. The low elevation of much of the study region means that areas that are even slightly higher above sea level offer vantage points. However, there are not many recorded archaeological sites in these few higher areas; if the site records are representative of site distributions across the study region as a whole, then the highest topographic levels do not appear to have been a significant site dete minant factor for site location.

The steepness of slopes is often a factor in the location of archaeological sites in Australia and elsewhere in the world, but much of the study region is fairly low-lying, and steep slopes are rare in this mainly low-lying coastal landscape. Here the slope of the land therefore does not prove useful to predicting likely site locations. Nevertheless, the topographic levels presented in the GIS layer 'LakesElevationData' proved to be very useful for the creation of two other GIS layers called 'InundationModel' and 'CoastalErosionThreat', described below under the heading 'Analysis: Model Layers'.

Three GIS layers are most relevant to elevation (height above sea level) and topography:
- 'LakesElevationData'
- 'ElevationData'
- 'EL_CONTOUR_Lake'

Land (Geology and Geomorphology)

There have now been many studies of the rock types and landforms of Gippsland (Birch 2003; Hocking 1976; VandenBerg et al. 2000). Geomorphological histories (the study of sediments and how landforms formed) help us understand how the present-day landscape of the study region was formed and what it may have looked like in the past. The lakes developed during the Late Pleistocene and Holocene geological periods that together span the past 129,000 years. In the Pleistocene, when sea levels were higher than they are today, Lakes Wellington, Victoria and King were part of a bay extending inland from the current coastline, with ocean waves breaking against sea cliffs. The lakes now exist within the area of this former bay, bordered by the former sea cliffs (known as the 'marginal bluff', **Figure 6**).

The development of the Gippsland Lakes area is closely connected to rising and falling sea levels during the Pleistocene and Holocene; these changes are visible in the geology and geomorphology of the study area. As global sea levels gradually fell during the course of the Late Pleistocene, sandy barriers built up across the mouth of what was then the 'Gippsland Lakes bay' (Bird 1978; Riedel et al 2003) (**Figure 7**). These sandy barriers formed during two phases, fi st between 72,000–50,000 years ago; and again between 48,000–40,000 years ago (Bryant and Price 2013), in the process creating a beach and lagoon system behind it. A third sandy barrier formed more recently, from the start of the Holocene (around 11,000 years ago) to present, creating Ninety Mile Beach (Boon et al. 2015; Timms 2012). Sea levels rose between 11,000–8,000 years ago, reaching a high point around 6,000 years ago (Sloss et al. 2007).

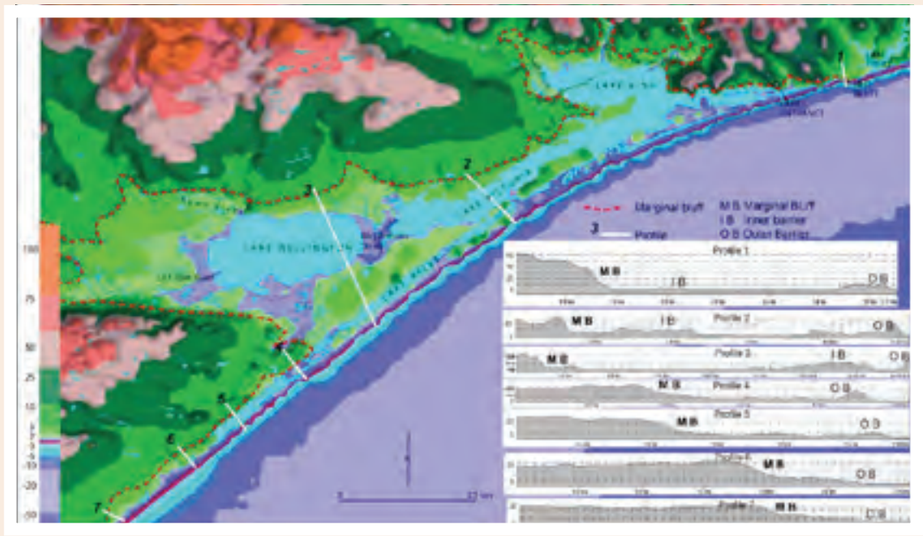


Figure 6. The dotted red line ('marginal bluff') marks the extent of the former coastline from the time when the sea was further inland. The white lines between the coastline and the marginal bluff refer to the elevation profiles sh wn in the lower right of the figur (after Boon et al. 2015, figure 7)

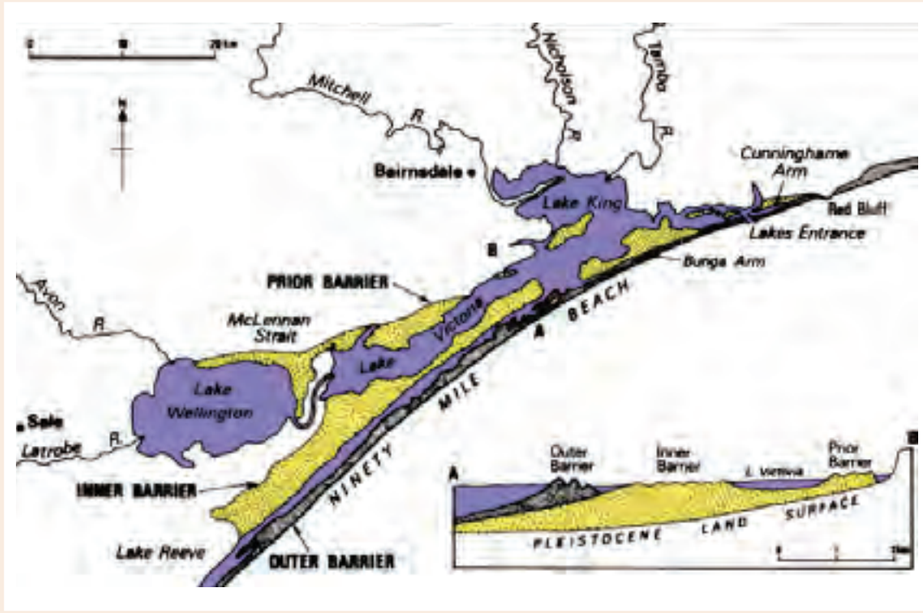


Figure 7. Late Pleistocene dune barriers (yellow with black stippling). The 'prior barrier' formed before the lakes existed and before the 'inner barrier' was the coastline. The 'outer barrier' is the most recent formation. It built up during Holocene times to form Ninety Mile Beach (Bird 2010, figure 21.6.9.2)

Since then, sea levels have remained relatively constant, although a very gradual rise of around 3 mm per year has been observed in recent decades (Gehrels and Woodworth 2013).

The most recent sandy barrier (Ninety Mile Beach) was opened in 1889 to build a permanent channel from the sea to the lakes. The creation of a permanent channel disrupted the movement of sand along the beach and has resulted in tidal deltas that require dredging of the lakes' entrance. Sand and other sediment has also built up in Cunninghame Arm, which was previously a natural, temporary channel between the lakes and the sea. The shorelines of the lakes and the vegetation growing beside the lakes has also changed since the permanent channel between the lakes and the sea was created. Eric Bird has written the most comprehensive studies of the geomorphology of the Gippsland Lakes, in which he investigated the changing characteristics of water, sediment and vegetation (Bird 1965, 1966, 1978) and shorelines of the lakes (Bird 1983; Bird and Rosengren 1971; Bird and Lennon 1989). Bird (1961) showed that there was an association between the erosion of lake shoreline and the decline of reeds (*Phragmites australis*), as the reeds had protected the lake shoreline from erosion. At the time of Bird's study, the reedbed vegetation was dying as a consequence of increased salinity, which was in turn caused by the opening of the artificial ent ance to the lakes (Bird 1983; CSIRO 2001; Riedel et al. 2003). Changes to lake shorelines and their vegetation communities can help better understand how the broader Gippsland Lakes land and waterscapes are transforming through time. Riedel et al. (2003) have thus reported on coastal erosion around the lakes, and Charteris et al. (2009) have examined threats of climate change along the Gippsland coast. The erosion of lake shorelines, and rising sea levels, have the potential to expose and damage archaeological sites within those landforms.

Rivers, floodplains and deltas extend into the la es, also influencing the shorelines of th lakes and the wetlands. Old river channels and terraces have been noted above; such features may have been used by the Old People, such as for travel along the rivers connecting with the lakes. River fl ws have changed as a result of changing land use in the twentieth century, including through the construction of dams, irrigation diversion channels, artificial le ees and clearing of the river channels. This has reduced the amount of freshwater fl wing into the lakes, and changed the annual flood patte ns. Land clearance and destabilisation of river banks have also resulted in increased sediment loads carried by rivers and streams into the lakes.

We used information from several GIS layers to understand the geology and geomorphology of the Gippsland Lakes, including the 1:250,000 scale map produced by the Geological Survey of Victoria (GIS layer 'SG_GEOLOGICAL_UNIT_250K'). We then analysed the distribution of archaeological sites (e.g. Ancestral Remains, Artefact Scatters and Shell Middens) across this GIS layer, to see where sites are found relative to the geology (e.g. dunes and coastal lagoons) of the study region. The GIS layer showing information on coastal habitats (layer 'LCC_COASTAL_CLASSIFICICATION') has also provided useful information on what kinds of sites have been found among the dunes and coastal marshlands. The majority of sites in this coastal area are Shell Middens and Artefact Scatters in 'Dunes (stable, well-vegetated)' (**Figure 8**). Archaeological sites are found in areas of freshwater marsh throughout the study area.

In the GIS, we have included information (layers) on marshes and wetlands. The information contained in these GIS layers was also useful for our investigation of potential relationships between the distributions of different vegetation communities and the distribution of archaeological sites. We found that areas of 'coastal marshes' identified in the GIS l yer 'LCC_COASTAL_CLASSIFICATION' are related to the location of known archaeological sites.

The GIS layers 'NV1750' and 'WETLAND_PRE_EUROPEAN' show the distribution of Ecological Vegetation Classes (EVCs) for periods prior to European settlement, indicating where early and current wetlands are located. Many of the known archaeological sites are found in these wetland locations.

The GIS layers that are relevant to the geology and geomorphology are:
- Geological units: 'SG_GEOLOGICAL_UNIT_250K_lakes'
- Dune deposits: 'Qd1_Qd2_Qd3_Qdi_Qdl1_DuneDeposits'
- Coastal lagoon deposits: 'Qm1_CoastalLagoonDeposits'
- Coastal habitat classification 'LCC_COASTAL_CLASSIFICATION_Lakes'
- Geological basins: 'GEOL_BASINS'
- Ramsar Wetland registration: 'RAMSAR25_lakes'
- Present-day wetlands: 'WETLAND_CURRENT_Lakes'
- Wetlands from c. 1750 CE and present-day wetlands: 'WETLAND_PRE_EUROPEAN_Clip'

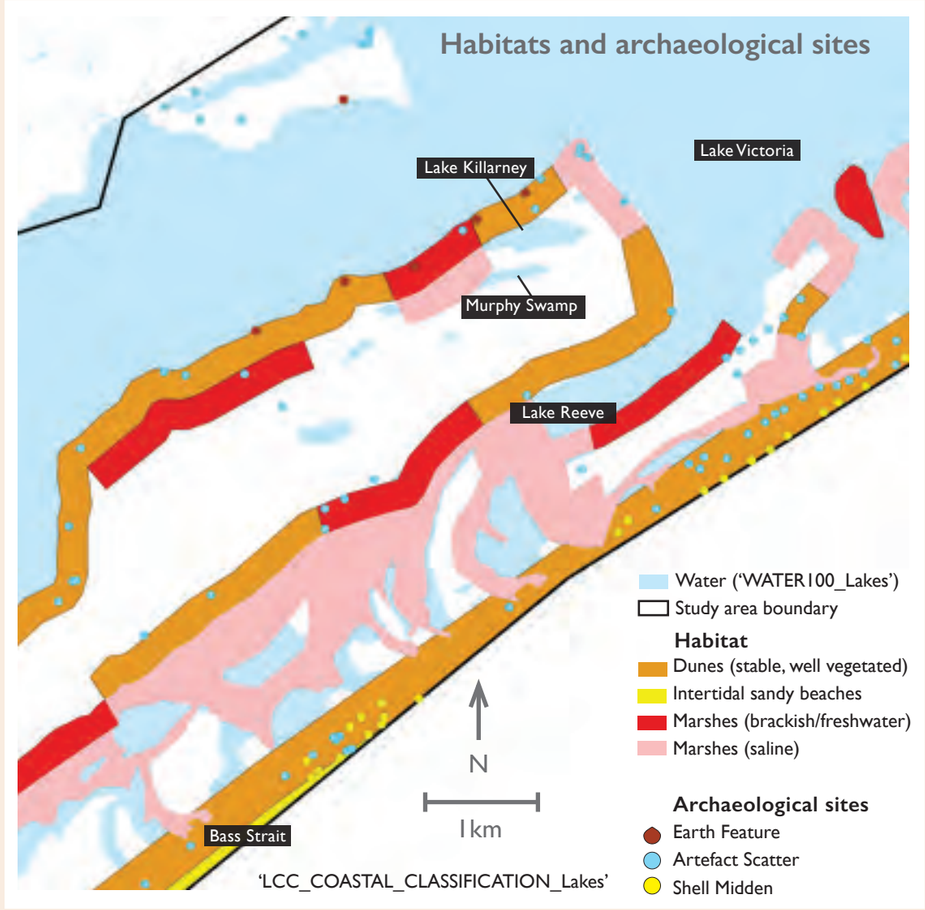


Figure 8. Habitats from the GIS layer 'LCC_COASTAL_CLASSIFICATION_Lakes' and recorded archaeological sites. The GIS layer 'LCC_COASTAL_CLASSIFICATION_Lakes' covers Ninety Mile Beach, the outer barrier dune and parts of the southern shore of Lake Victoria, as shown here in the Lakes National Park area.

The Lakes Entrance. Flora Gregson, 1 January 1878.

Water (Hydrology)

Today water fl ws between rivers and streams, floodplains and deltas and the la es and, by extension, to the Tasman Sea. Depth (bathymetric) information relating to the lakes has been used in this project to investigate how water fl ws inside the lakes today and on how shorelines would change with changing water levels. Water fl w and storage are relevant to ongoing changes in the landscape. Information on the physical properties of the lakes, rivers and floodplains is thus useful for understanding site locations in the past, and for their preservation into the future.

Of all the sites recorded in the VAHR, 63% are within 100 m of a lake, river or stream. This tendency for archaeological sites to be located close to waterways is even more pronounced among particular types of sites: 75% of Ancestral Remains and 85% of Scarred Trees are located within 100 m of a lake, river or stream. This proximity to water helps define area where archaeological sites are more likely to be located. This is relevant when considering potential risks to archaeological sites posed by changing shorelines.

The GIS layers that feature information on water are:

- Bathymetric information: 'JonesBay_Bathymetry; WellingtonBay_Bathymetry'; 'BATHYMETRY_GIPPSLAND_LAKES'
- Water bodies: 'WATER100_Lakes'
- Classification of waterbodies 'HY_WATER_AREA_POLYGON_Lakes'
- Rivers: 'MODIFIED_RIVERS'
- Watercourses: 'HY_WATERCOURSE_LakesArea'
- Watercourse and water body names: 'GEO_AREA_HYDRO_LABEL'
- Non-natural water storage: 'FARMS_DAMS DETAIL'
- Flood-prone areas: 'FLOODWAY'
- 'Gippsland_2013_50m_2_600dpi'

Plants (Vegetation)

The diversity of vegetation communities within the study region is internationally recognised (Ramsar Convention). The type of vegetation present in each habitat is influenced y distance from freshwater and from the coast, and by sediment type (e.g. sand, silt, clay; see GIS layer 'SG_GEOLOGICAL_UNIT_250K_Lakes' under the column 'Litholgy'). The GIS layers on vegetation list vegetation in terms of EVCs and bioregions (Victorian Government Department of Sustainability and Environment November 2007). In the GIS layers 'NV2005_EVCBCS' and 'NV1750_EVC' , 16 EVC classes and 18 subclasses are found within the Gippsland Lakes study area. No vegetation is recorded for the lakes themselves (EVC 99, 'fresh water'). Near the lakes, heathlands (EVC 16) cover the largest area of the region, extending across the Gippsland Coastal Park and The Lakes National Park. Areas of swamp scrub (EVC 8) are found around Lake Wellington, as are areas of deep, freshwater marsh (EVC 18). The coast is, unsurprisingly, covered by coastal dune scrub (EVC 1), with woodlands (EVC 15) occurring behind the barrier dune and also on Raymond Island. Stands of plains grassy woodlands (EVC 13) are also found on Raymond Island. They are associated with the locations of archaeological sites on the western shore of Lake Wellington.

We have compared the distribution of vegetation communities (GIS layers 'NV2005_EVCBCS_lakes', 'NV1750_EVC_lakes', 'GIPPS_LAKES_COASTAL_TYPES_Lakes') with land use patterns (see 'Planning' on page 47). This comparison shows that there are some inconsistencies in

the available information, with land that is shown to be covered by vegetation in one layer shown to have been cleared in another. The information about vegetation has proven useful to determining the location of archaeological sites; it would be potentially useful to refine th current records of vegetation communities present in the study area, through survey of this area, in order to provide more accurate information. This information could help to more accurately determine areas where archaeological sites are likely to be found.

The GIS layer 'SVEG100' ('structural vegetation') includes areas identified with stands o 20–50% Forest Red Gum, particularly in the north of the study area near the Mitchell River, Nicholson River and Slaughterhouse Creek. Given that 87% of recorded Scarred Trees are 'Red Gum', the Forest Red Gum stands in the areas listed above may be worth surveying for further Scarred Trees. However, no other site type is preferentially distributed in Red Gum stands (according to the known sites on the VAHR), so these areas have not been included in the layer 'ElevatedPotential', which shows overall areas where archaeological sites are more likely to be located. As previously noted, GIS layers 'NV1750_EVC' and 'NV2005_EVCBCS' reveal a close association between particular classes of vegetation and the presence of known Scarred Trees (**Figure 9**). Unsurveyed areas with these vegetation communities therefore potentially contain more Scarred Trees.

The GIS layers that are relevant to vegetation are:
- Modelled 1750s vegetation: 'NV1750_EVC_lakes'
- Modern vegetation: 'NV2005_EVCBCS_Lakes'
- Coastal vegetation: 'GIPPS_LAKES_COASTAL_TYPES_Lakes'
- Intertidal zone: 'VIC_INTERTIDAL_EVC_MAPPING_Lakes'
- Tree density: 'TREE_DENSITY_Lakes'
- Structural vegetation: 'SVEG100_Lakes'

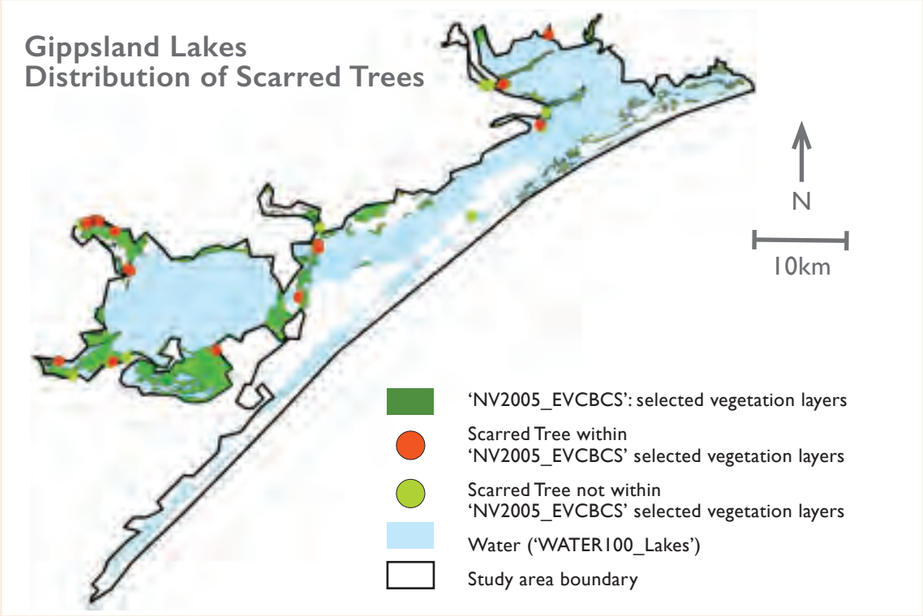


Figure 9. Distribution of Scarred Trees superimposed on selected EVC vegetation types, where most Scarred Trees are found (see GIS layer 'NV2005_EVCBCS').

Animals (Fauna)

We have included a GIS layer ('VBA_FAUNA_GRID_1M') that shows observations of animal species diversity. The rich biodiversity of the Gippsland Lakes is a popular attraction today, and would have affected site location strategies and economic choices in the past. The GIS layers showing the range of animal species observed in the study region (primarily fish and bird species) are included in the interest of complete ess and possible use in future research. Although the taxa observed today may not mirror those found in the archaeological record, this information has potential use for interpreting site locations or landscape change over time.

The GIS layer showing the distribution of fauna is:
- Faunal observations: 'VBA_FAUNA_GRID_1M'

Planning

Information about current administrative practices and infrastructure in the study region is included to support potential future field su veys, including field-testing of patte ns revealed in this report. The GIS layers on 'planning' include access roads, townships and property boundaries, planning zones, and local administrative boundaries. This information can also be used to investigate risks to archaeological sites resulting from the use of existing infrastructure or from future developments. For instance, proximity to roads may heighten the danger of disturbance to archaeological sites. It may also be the case that more sites are recorded and registered at short distances from roads, simply because ease of access has meant a greater chance of site discovery. These types of questions can be investigated through the use of information about present-day planning and infrastructure.

The GIS layers on bushfire histo y ('FIRE_HISTORY_Lakes, BUSHFIRE_PRONE_AREA, LF_DISTRICT') and agricultural clearance ('AGCLEAR100_Lakes') can also provide information useful for archaeological site risk assessments, and to assist archaeological survey teams select areas for investigation.

The GIS layers that show current land use and planning are:
- 'GunaiKurnai Land and Waters Aboriginal Corporation RAP area'
- Roads and tracks: 'TR_ROAD'
- Urban areas: 'TownshipsLakes'
- Cadastral information: 'Property'
- Landscape disturbance: 'DISTURB100_Lakes'
- Historical land clearance: 'AGCLEAR100_Lakes'
- Recent fire histo y: 'FIRE_HISTORY_Lakes, BUSHFIRE_PRONE_AREA, LF_DISTRICT'
- Planning overlays: 'PLAN_OVERLAY, PLAN_ZONE, PLM25'
- Local administrative areas: 'WARD_2017, PARISH_POLYGON_Lakes'
- Resource licences: 'MINTEN'
- Recent heritage sites: 'HERITAGE_INVENTORY_Lakes'
- Regional Australian boundaries: 'FR_FRAMEWORK_AREA_LINE'

Spearing Fish by Torch-light. Flora Gregson, 11 April 1877.

Analysis: Model Layers

Here we outline six new GIS layers created for this project and found in the GIS under the heading 'ModelLayers'.

GIS layer 'ElevatedPotential'

This GIS layer shows the areas where archaeological sites are most likely to be located (**Figure 15**). It was produced from the analyses presented in the 'Results contributing to the GIS layer 'ElevatedPotential'' section (page 53).

GIS layer 'HighPotentialWater'

The GIS layer 'HighPotentialWater' displays a boundary of 100 m inland from the recorded shorelines of lakes and rivers. This zone adjacent to shorelines covers the area where most of the known archaeological sites in all categories are located. This suggests that there is probably a strong sampling bias in the way sites have been recorded so far (i.e. that areas close to water have been preferentially targeted for site surveys), and the degree to which water has affected site location in the past cannot be accurately assessed with the available site survey data. Potential sampling biases may be due to three important factors: 1) the current Regulations, which preference for assessment areas that are close to named waterways; 2) the visibility of surface archaeological materials, which is greater on exposed shorelines than in vegetated areas further inland; 3) accessibility, which again relates to vegetation cover and the greater difficulty of accessing areas of etland or marshes for archaeological survey and testing. These factors relate to archaeological surveys and testing strategies undertaken to date, so the site distributions revealed by these surveys may not accurately represent actual site location patterns for the landscape as a whole. This possible bias remains to be investigated through systematic field testing Field surveys away from shorelines may provide valuable information on this.

GIS layer 'ArchaeologicalSitesLakes_Buf2'

The GIS layer 'ArchaeologicalSitesLakes_Buf2' represents a 100 m-wide buffer placed around each recorded archaeological site location. Archaeological sites are recorded as points in the VAHR records. This GIS layer expands the recorded point location of a site to a circle of 200 metres diameter (100 m on each side). It is intended to: 1) take into account minor inaccuracies in the spatial recordings in the VAHR records; and 2) capture the *area* of the majority of the archaeological sites, to ensure that they are represented to have a spatial extent rather than a simple point location. The variable spatial accuracy of the VAHR records is an issue which needs to be addressed elsewhere. Creating a buffer zone around archaeological site locations ensures that we reliably identify *areas* for analysis in which archaeological sites are actually located.

GIS layer 'Paleoshorelines'

The GIS layer 'Paleoshorelines' shows where shorelines were in the past. It uses the topographic elevation GIS layer ('LakesElevationData') to show the locations of former shorelines. These old shorelines may have elevations up to 23–25 m above the present-day sea level. We have chosen to highlight the toe (the base) of these shorelines, at a height of 6–9 m above present-day sea level. We know that the water levels of the lakes and of the sea rose and fell over time, creating many past landforms. Ancient shorelines are of interest in relation to past occupation sites and for how they can help better understand how areas were occupied or otherwise used during periods when lake and sea levels changed. Historical records and oral histories (see e.g. Stevens 2020) indicate that the Old People used the full extent of the lakes but favoured shorelines for some activities, including food procurement and processing, and as arrival and departure points for travel across water-ways. The identification of ormer shorelines may assist in determining the locations of former activities (today represented as archaeological sites).

GIS layer 'InundationModel'

The GIS layer 'InundationModel' uses the topographic elevation layer 'LakesElevationData', and waterbody and watercourse layers 'HY_WATER_AREA_POLYGON_Lakes' and 'HY_WATERCOURSE_LakesArea' to identify areas that would have been flooded (or m y again be flooded) du ing periods of higher sea levels. **Figure 10** shows this GIS layer in the vicinity of Lake Victoria, Lake King and Raymond Island. The solid blue area in **Figure 10** shows the current level of the lakes; different colours are used to highlight areas that would gradually have become land as the higher water levels in the past fell (four water level ranges are shown: 6–9 m, 5–6 m, 2–5 m and 0–2 m above current sea level). These ranges do not represent any particular period of time; they have been selected simply to show how this layer of information may be used and manipulated. For instance, Raymond Island would have been completely underwater when water levels were 5–6 m higher than they are today. The GIS layer 'InundationModel' simulates flooding and d aining of the lakes. It has been modelled to show changes in water levels as a uniform process across the area. The water levels currently shown can be adjusted by the user of this report, enabling any scenario of interest to be shown, whether this be in relation to past or future water levels.

GIS layer 'Coastal Erosion Threats'

The GIS layer 'CoastalErosionThreats' is based on information about water, topography and recently published research on coastal erosion (Baby 2020). This layer maps areas that would be impacted by projected shoreline erosion. The projected impacts are based on an estimated sea level rise of 0.2 m by 2030, of between 0.2 and 0.7 m by 2070, and of up to 1.1 m by 2100 (Baby 2020, 46; Victorian Coastal Council 2008). We have displayed in the GIS layer (and shown in **Figure 11**) the impacted shorelines by time periods, showing in red the areas that are at most immediate risk. When reading this map, it is important to note that the extent of some areas at immediate risk are also overlayed by areas deemed to be at risk in later years (areas shown in orange and yellow). This is because many areas at immediate risk will continue to be affected as time goes on.

Figure 11 again shows an area near Raymond Island where risks to archaeological sites are high through shoreline erosion. In this figure e have also displayed the depths of the lakes (from the GIS layer 'BATHYMETRY_GIPPSLAND_LAKES'), because the varying depths help interpret projected threats to shoreline features.

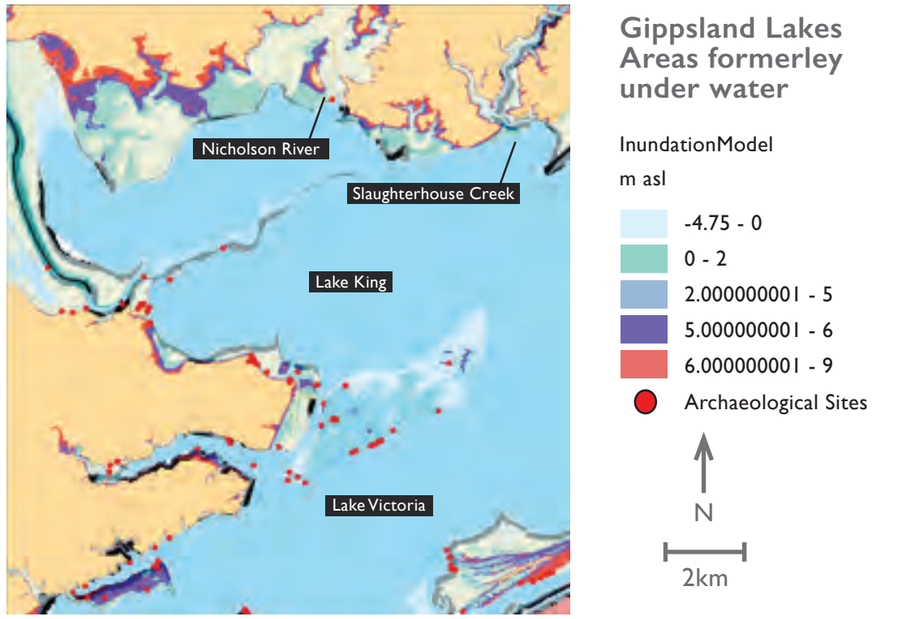


Figure 10. Areas of Lake King, Lake Victoria and Raymond Island that were formerly submerged under water. A graded colour scale is used to indicate different water levels.

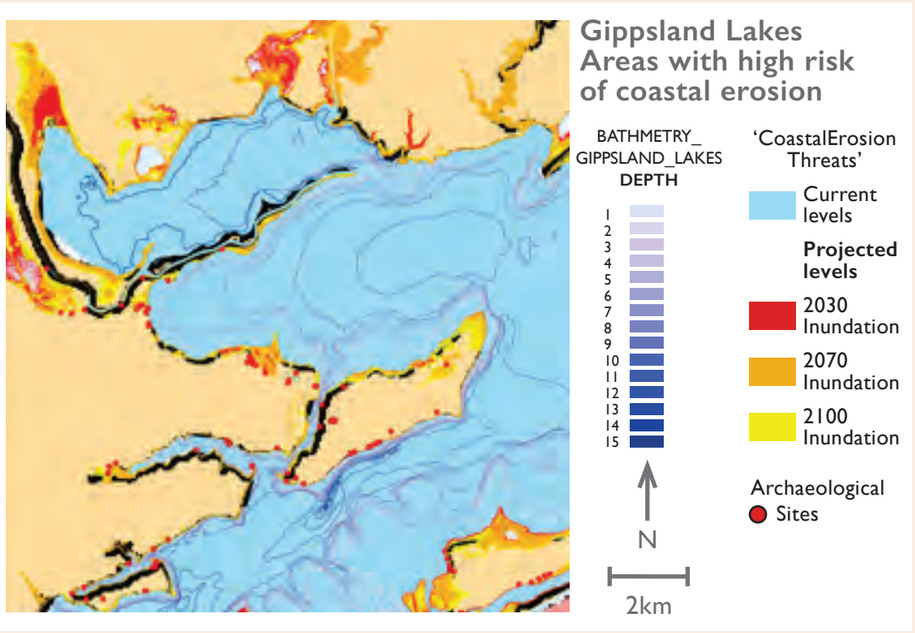


Figure 11. Areas of Lake King, Lake Victoria and Raymond Island with high risks of coastal erosion. The colour scale is graded according to time; the inundation levels are based on recent projections of regional coastal erosion rates (Baby 2020).

Results contributing to the GIS layer 'ElevatedPotential'

The GIS layer 'ElevatedPotential' is based on analyses of the data contained in all the contributing GIS layers. It shows the areas where archaeological sites are most likely to be located. The analyses resulted in this aggregate layer, constructed from several tests that revealed associations between known archaeological sites and environmental variables. Here we outline some of the most important findings used to create the GIS l yer 'ElevatedPotential'.

Associations between archaeological site locations and water

Archaeological sites tend to be found near lakes and rivers across the study region. Whether this pattern is due to sampling bias or actual site distribution patterns is uncertain (see page 50) for discussion of this point). Site distributions around waterbodies (lakes) and watercourses (rivers) and their 100 m buffer zones (GIS layer 'HighPotentialWater') were combined with the 100 m buffer zones placed around individual sites (GIS layer 'ArchaeologicalSitesLakes_Buf2') in order to further analyse the distribution of sites relative to lakes and rivers. Of the 646 known archaeological sites, 407 (63%) were located within 100 m of lakes or rivers (Figure 12). Perhaps surprisingly, the underrepresentation of Shell Middens highlights the fact that few Shell Middens are found very close to fresh or brackish water in lakes or rivers. Further analysis indicates that most of the Shell Middens are closer to the sea than to the lakes.

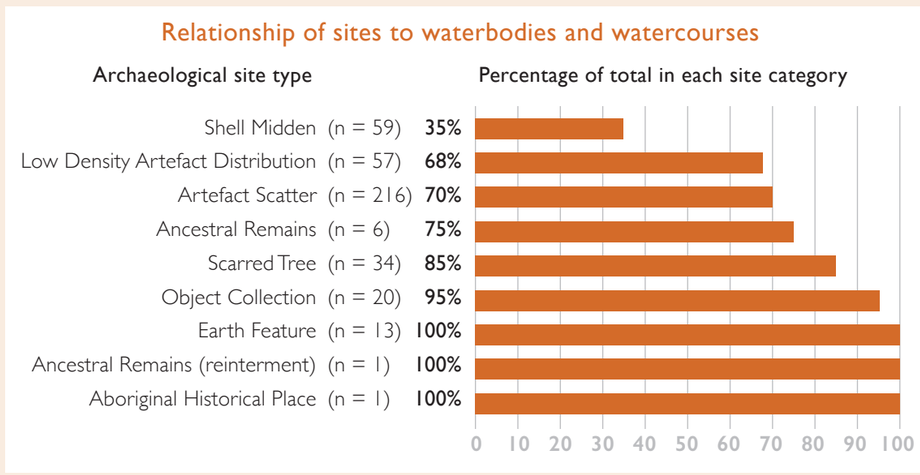


Figure 12. Chart showing the percentage of each type of archaeological site found in close proximity (100 m) to lakes, rivers and streams.

Associations between archaeological site locations and sandy sediments

Analyses of geological and geomorphological GIS layers (e.g. 'LCC_COASTAL_CLASSIFICATION_Lakes', 'GEOL250_Polygon' and 'Qd1_Qd2_Qd3_Qdi_Qdl1_DuneDeposits') show that many archaeological sites are found on sandy sediments, variously identified in the a orementioned layers as 'inland dune deposits', 'dune deposits', 'coastal dune deposits' and 'Dunes (stable, well vegetated)'. We have not included areas identified as 'intertidal sandy beach' because only two archaeological sites were associated with this classification Layers identified as either 'inland dune deposits', 'dune deposits' or 'coastal dune deposits' collectively contain 60% (388) of the known archaeological sites. In particular, most Shell Middens (92%) and Ancestral Remains (75%) are found on or in these types of sandy sediments. Further analysis indicates that 89% (152) of Shell Middens are located in areas classified as 'coastal dune deposits'. The relationship between site locations and sandy sediments in GIS layer 'Qd1_Qd2_Qd3_Qdi_Qdl1_DuneDeposits' is shown in Figure 13.

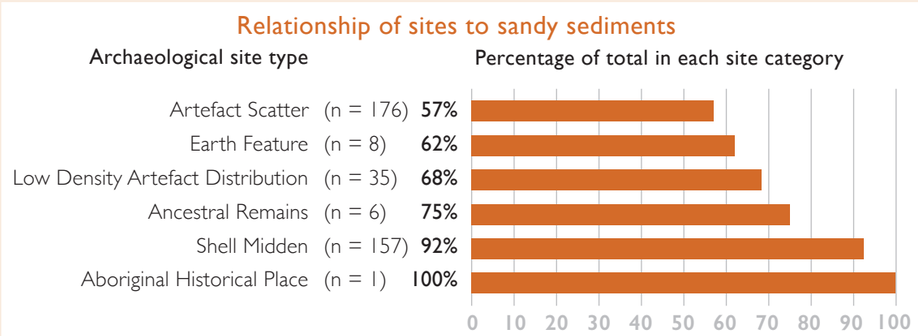


Figure 13. Percentage of each archaeological site type found on or in sandy sediments (geological units Qd1, Qd2, Qd3, Qdi, Qdl1).

Associations between archaeological sites and wetlands

Archaeological sites are often associated with wetlands and their margins. Analyses of several wetland layers resulted in a composite layer of coastal marshlands. It was created from the GIS layers 'LCC_COASTAL_CLASSIFICATION_Lakes' and 'WETLAND_PRE_EUROPEAN'. The results indicate that Ancestral Remains and Artefact Scatters are often found near wetlands (Figure 14).

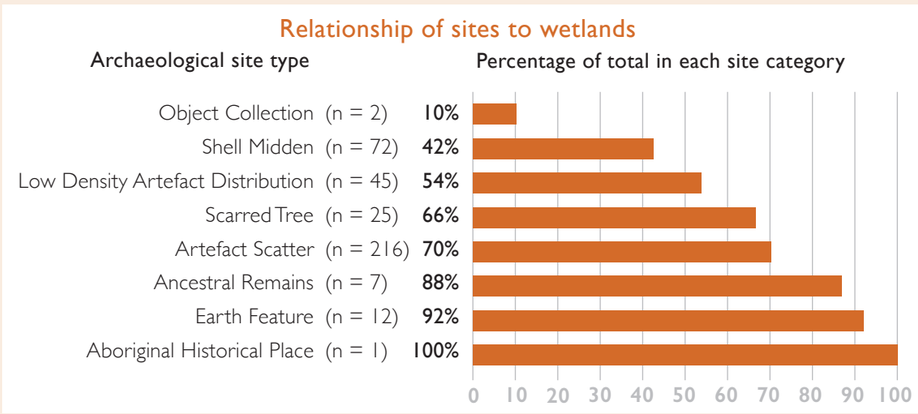


Figure 14. Percentage of each type of archaeological site found within a selected area of costal marshes and wetlands.

Risk assessment of archaeological site locations: coastal erosion

The GIS layer 'CoastalErosionThreat', described above, shows where potential risks to archaeological sites near shorelines are greatest. Using the 'CoastalErosionThreat' GIS layer together with the location of archaeological sites (the 'ArchaeologicalSitesLakes_Buf2' GIS layer), we can simulate how many sites can be expected to be impacted by costal erosion by 2030. The results reveal that 38% (247) of the known archaeological sites are likely to be impacted. Figure 15 shows the percentage of each site type that is likely to be impacted by coastal erosion within the next decade.

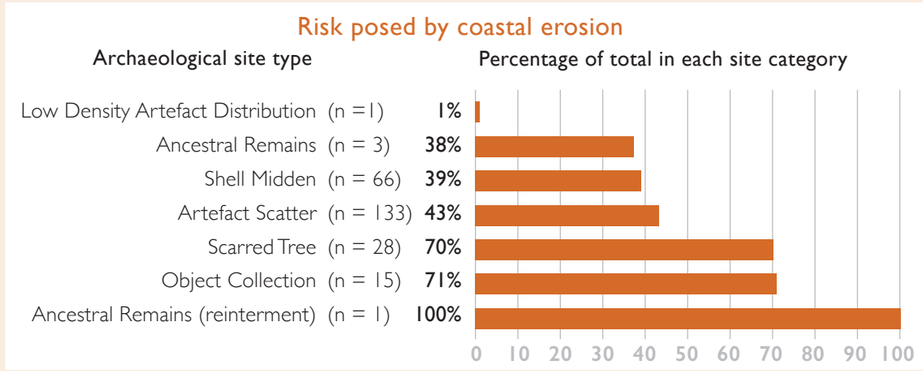


Figure 15. Percentage of known archaeological sites that is likely to be affected by projected coastal erosion by 2030.

Validation of the Predictive Model's GIS Layer 'ElevatedPotential'

The ACHRIS 'cultural heritage sensitivity' GIS layer is the current standard used to identify areas more likely to contain archaeological sites across the State of Victoria. This ACHRIS GIS layer identifies the entire area of the Gippsland La es as uniformly archaeologically 'sensitive'. However, the purpose of our study is to refine cu rent understandings of the distribution of archaeological sites across the landscape. Our GIS layer 'ElevatedPotential' shows where archaeological sites are most likely to be found, based on the VAHR site locations (see above for discussions of limitations).

ACHRIS identifies the entire study area as an area of heightened archaeological potential (in the sense that the study area is not internally differentiated, and therefore all archaeological sites are found within a single undifferentiated area). Our GIS layer 'ElevatedPotential' covers 12% of the study region and captures 97% (625) of the known site locations. This is a substantial reduction in area, and effectively means that archaeological sites are eight times more likely to be found in the area designated by the GIS layer 'ElevatedPotential' than elsewhere (see Figures 16–18). However, the caveat needs to be kept in mind that these patterns were generated from potentially biased data, so they need to be field-tested as explained above.

Our results also indicate that the areas identified in the GIS ayer 'Paleoshorelines' are likely to have a moderate potential of containing archaeological sites. Given the significance o shorelines for the way landscapes were occupied or otherwise used in the historical and archaeological records, past shorelines are also likely to contain archaeological sites and are

thus worthy of further investigation. The 'Paleoshorelines' GIS layer was developed using LiDAR results; examination of the LiDAR results also clearly indicates the presence of further dunes or shorelines in the area of Lake Wellington and Morely Swamp (Figure 19). Refinemen of key details through more detailed mapping, such as the location of dune deposits, would enhance the accuracy of our modelling and its efficienc . The area shown in Figure 19 is currently only partially covered by the 'ElevatedPotential' GIS layer due to the boundaries of the study area. Figure 19 also indicates the locations of areas identified as 'dune deposits' in GIS layer 'Qd1_Qd2_Qd3_Qdi_Qdl1_DuneDeposits', but located outside the current boundaries of the study area. Dune deposits have been shown to be very likely to be the location of archaeological sites and therefore these dune deposits immediately adjacent to the study area boundary are also likely to be the location of archaeological sites.

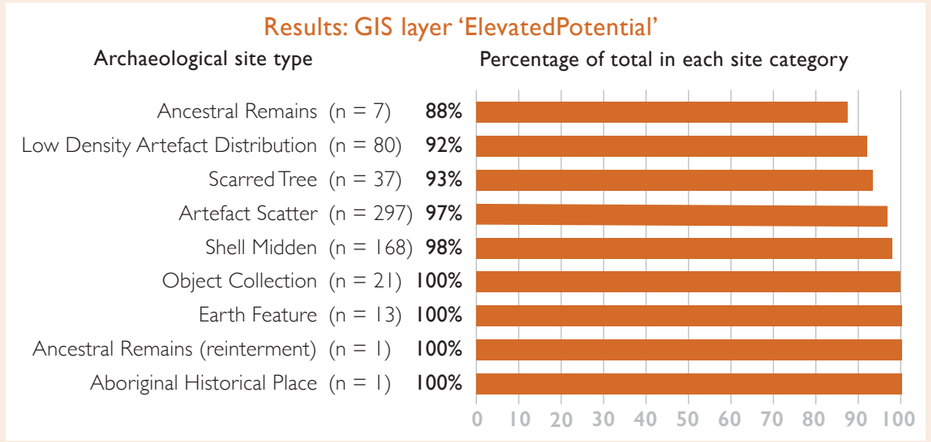


Figure 16. Percentage of known archaeological sites found within the areas identified in th GIS layer 'ElevatedPotential'.

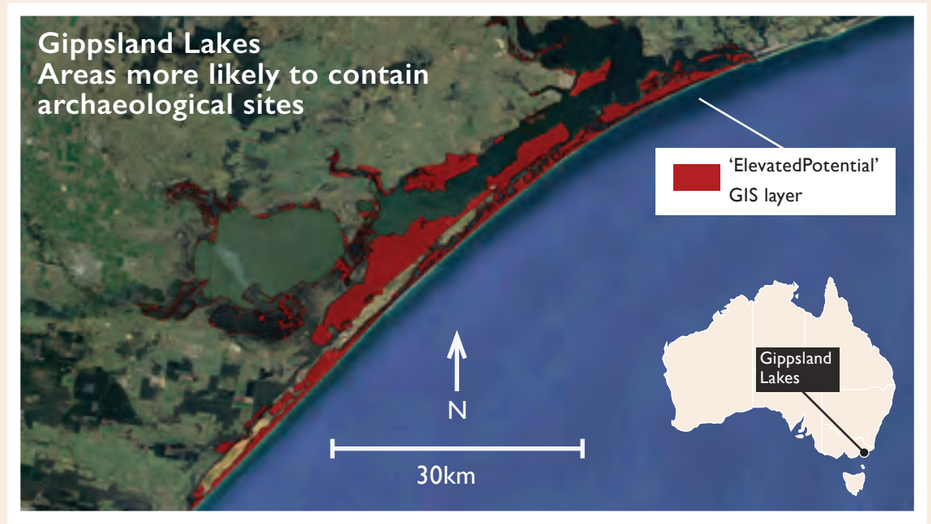


Figure 17. Areas that are more likely to contain archaeological sites (in red), as predicted by the 'ElevatedPotential' GIS layer.

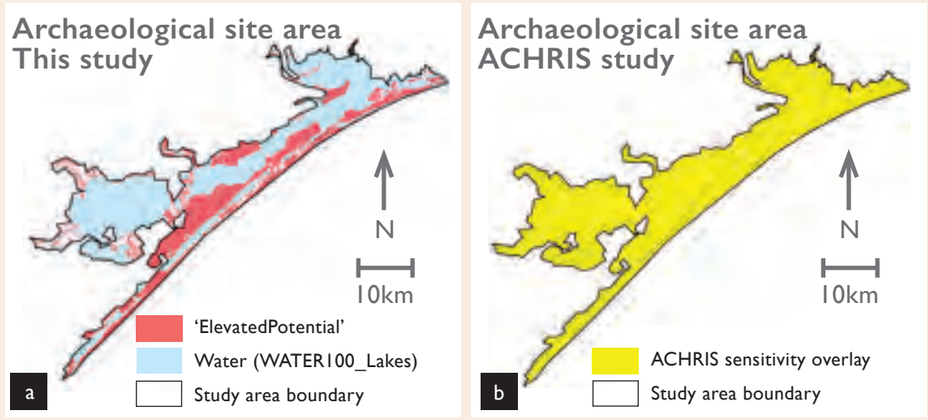


Figure 18. Comparison between the areas identified as more li ely to contain archaeological sites: **18a** from this report (shown in pink). **18b** from ACHRIS (shown in yellow).

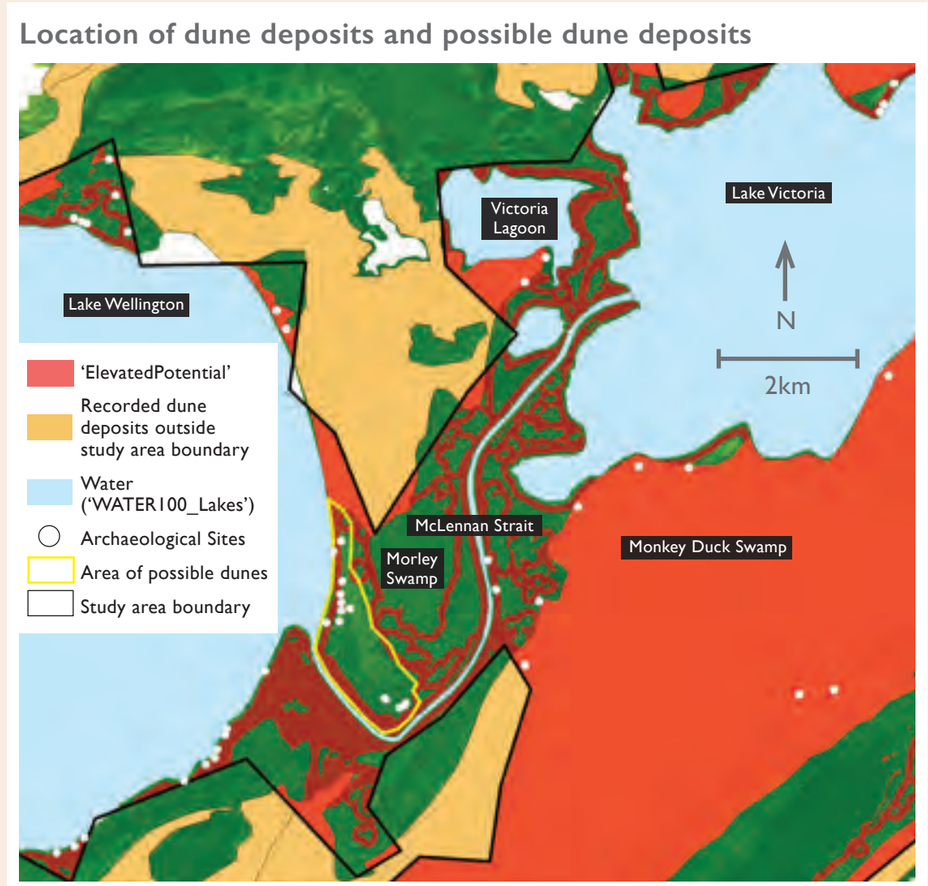


Figure 19. Location of possible dune deposits in the study area (within the area marked with by the yellow line) and locations of known dune deposits (beige areas) bordering the study area boundary.

Reeves River and Entrance. Flora Gregson, 21 January 1878.

References

Aboriginal Victoria
2013. *Recording Low Density Artefact Distributions (LDAD) in ACHRIS.* Victorian Government Department of Premier and Cabinet, Melbourne.
https://www.aboriginalvictoria.vic.gov.au/sites/default/files/2019-09/Low-Density-Artefact-Distributions-Updated-Recording-Guidelines_20_June_2014.pdf

Australian Government Department of Agriculture, Water and Environment
2019 *Australian Wetlands Database: Gippsland lakes.* Australian Government Department of Agriculture, Water and Environment.
http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=21# (accessed 3//5/ 20).

Baby, S.
2020. Spatial decision support system for coastal flood management in Victoria, Australia. Unpublished PhD thesis, RMIT University, Melbourne.

Birch, W. D.
2003. *Geology of Victoria.* Special Publication no.23. Geology Society of Australia, Sydney.

Bird, E. C. F.
2010. The Gippsland Lakes, in E. C. F. (ed.) Encyclopedia of the World's Coastal Landforms. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-8639-7_241

Bird, E. C. F.
1983. Shoreline changes in the Gippsland Lakes 1957-1983. *Proceedings of the Royal Society of Victoria,* 95 (4), 227-235.

Bird, E. C. F.
1978. ***T**he geomorphology of the Gippsland Lakes region.* Ministry for Conservation, Environmental Studies Series 186, Melbourne.

Bird E. C. F.
1966. The impact of man on the Gippsland Lakes, Australia. In S. R. Eyre and G. Jones (eds.), *Geography as human ecology: Methodology by example.* Edward Arnold, London, 55–73.

Bird E. C. F.
1965. *A geomorphological study of the Gippsland Lakes.* Australian National University, Canberra.

Bird E. C. F.
1961. Reed growth in the Gippsland Lakes, ***Victorian Naturalist*** 77, 262–268.

Bird, E. C. F. and J. Lennon
1989. *Making an entrance: the story of the artificial entrance to the Gippsland Lakes.* Geostudies Australia, Bairnsdale.

Bird, E. C. F. and N. J. Rosengren
1971. The disappearing Mitchell delta. *Proceedings of the Royal Society of Victoria* 84, 153–8.

Boon, P. I., P. Cook and R. Woodland
2016. The Gippsland Lakes: management challenges posed by long-term environmental change. *Marine and Freshwater Research,* 67 (6), 721–737.

Boon, P. I., N. Rosengren, D. Frood, A. Oates and J. Reside
2015. *Shoreline Geomorphology and Fringing Vegetation of the Gippsland Lakes.* Report to Gippsland Lakes Ministerial Advisory Committee, Bairnsdale.

Bryant, E. and D. Price,
2013. Late Pleistocene marine chronology of the Gippsland Lakes region, Australia. *Physical Geography,* 18 (4), 318–334. https://doi.org/10.1080/02723646.1997.10642622

Charteris, A., E. Sjerp, A. McGowan, E. Lawry and D. Malcolm
2009. Geomorphological Threats of Climate Change on the Gippsland coast. In *Coasts and Ports 2009: A dynamic environment.* Engineers Australia, Wellington, 1–6.

Clark, I. D. and T. Hayden
2002. *Dictionary of Aboriginal Placenames of Victoria.* Victorian Aboriginal Corporation for Languages, Melbourne.

Conn, B. J.
1993. Natural regions and vegetation of Victoria. In D.B. Foreman and N.G. Walsh eds, *Flora in Victoria,* volume 1. Inkata Press, Melbourne, 79–158.

CSIRO
2001. *Gippsland Lakes environmental study: assessing options for improving water quality and ecological functioning.* Prepared for the Gippsland Coastal Board. https://publications.csiro.au/rpr/pub?list=BRO&pid=procite:735cbacb-1df8-4351-b102-bae2fbf9d025.

Department of Sustainability, Environment, Water, Population and Communities
2010. *Gippsland Lakes Ramsar site Ecological Character Description.* Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Deur, D. and V. L. Butler.
2016. Incorporating Archaeology Into Local Government Historic Preservation and Planning: A Review of Current Practice. *Journal of the American Planning Association,* 82 (2), 189-203.

Hocking, J. B.
1976. Definition and revision of the Tertiary stratigraphic units, onshore Gippsland Basin. *Geological Survey of Victoria Report* 1976/1.

Riedel, P., E. Sierp and E. C. F. Bird
2003. Response to Coastal Erosion around the East Gippsland Lakes, Victoria, Australia. In P. S. Kench and T. M. Hume (eds), *Coasts and Ports 2003 Australasian Conference,* Barton, ACT, Australia.

Sloss C. R., C.V. Murray-Wallace and B. G. Jones
2007. Holocene sea-level change on the southeast coast of Australia: a review. *Holocene* 17: 999–1014.

Spry, C.
2016. Evaluating the recording system for high- and low-density stone artefact occurrences in Victoria, Australia: A stone artefact analysis perspective. *Excavations, Surveys and Heritage Management in Victoria* 4, 43-51.

Stevens, L.
2020. Buchan Valley and Gippsland Lakes Cultural Mapping Project 1: The Historical Records. Unpublished Report to GunaiKurnai Land and Waters Aboriginal Corporation and Parks Victoria, Kalimna West.

VandenBerg. A. H. M., C. E. Willman, S. Maher, B. A. Simons, R. A. Cayley, D. H. Taylor, V. J. Morand, D. H. Moore and A. Radojkovic
2000. The Tasman Fold Belt System in Victoria. *Geological Survey of Victoria, Special Publication.* Geological Survey of Victoria, Deptartment of Natural Resources and Environment, Melbourne.

Verhagen, P.
2018. Predictive Modeling. *The Encyclopedia of Archaeological Sciences,* 1-3.

Victorian Coastal Council
2008. *Victorian Coastal Strategy 2008.* Victorian Coastal Council, Melbourne, http://www.vcc.vic.gov.au/2008vcs/VCCCoastalStrategyfinal.pdf

Victorian Government Department of Sustainability and Environment
2007. *EVC/Bioregion Benchmark for Vegetation Quality Assessment, East Gippsland Lowlands bioregion.* Victorian Government Department of Sustainability and Environment, Melbourne.

Wachtel, I., R. Zidon, S. Garti and G. Shelach-Lavi,
2018. Predictive modelling for archaeological site locations: Comparing logistical regression and maximal entropy in north Israel and north-east China. *Journal of Archaeological Science* 92, 28-36.

Appendix 1:
Names and Descriptions of Information Layers in the GIS

Topographic Elevation Data

'LakesElevationData'

Topographic elevation data have been processed from LiDAR gathered across the study area. The area for which LiDAR results are available does not cover the area submerged beneath the present-day surface of the lakes. Elevations extend to 70 m above sea level.

'EL_CONTOUR_lake'

This GIS layer has been extracted from 'EL_CONTOUR', which is part of 'Vicmap Elevation 10–20 Contours & Relief' and a subset of 'Vicmap Elevation' (see data.vic.gov.au). The GIS layer 'EL_CONTOUR' was created by Land Use Victoria and the Department of Environment, Land, Water and Planning (DELWP). It was last updated in 2019. This GIS layer depicts topographical relief features represented by lines. Data have been derived from Land Victoria's State Digital Map Base topographic data. The GIS layer 'EL_CONTOUR_lake' has been extracted to cover only the Gippsland Lakes study area and information is presented at 10 m intervals. This scale is not particularly useful for the low-lying Gippsland Lakes region. LiDAR data presented in the 'LakesElevationData' GIS layer provided much-needed detail. The GIS layer 'EL_CONTOUR_lake' is included for comparison.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002504&publicId=guest&extractionProviderId=1

'ElevationData'

This GIS layer provides a series of spot heights taken across the land and water of the Gippsland Lakes.

Land (Geology and Geomorphology)

Geological units: 'SG_GEOLOGICAL_UNIT_250K_lakes'

The GIS layer 'SG_GEOLOGICAL_UNIT_lakes' has been extracted from the Victoria-wide layer 'GEOL250_POLYGON' to cover only the Gippsland Lakes study area. This GIS layer lists geological units, was collected by the Geological Survey of Victoria and is presented at a scale of 1: 250,000.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003378&publicId=guest&extractionProviderId=1

Dune deposits: 'Qd1_Qd2_Qd3_Qdi_Qdl1_DuneDeposits'

This GIS layer has been extracted from the state-wide 'GEOL250_POLYGON'. We have created the GIS layer 'Qd1_Qd2_Qd3_Qdi_Qdl1_DuneDeposits' to contain only the geological units identified as dune deposits (see discussion ab ve). These are relevant because of their relationships to the locations of archaeological sites in the Gippsland Lakes. Shell Middens and Ancestral Remains are particularly likely to be located in areas identified in this GIS l yer.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003378&publicId=guest&extractionProviderId=1

Coastal Lagoon deposits: 'QG_Qm1_CoastalLagoonDeposits'

This GIS layer has been extracted from the state-wide 'GEOL250_POLYGON'. We have created the GIS layer 'QG_Qm1_CoastalLagoonDeposits' to contain only geological units identified as 'coastal lagoon deposits'. These are relevant because 30% of all sites (191 of 646) are within 100 m of coastal lagoon deposits. Artefact Scatters are very frequently on the margins of coastal lagoon deposits in the Gippsland Lakes region.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003378&publicId=guest&extractionProviderId=1

Coastal habitat classification 'LCC_COASTAL_CLASSIFICATION_Lakes'

This GIS layer has been extracted from a separate GIS layer called 'LCC_COASTAL_CLASSIFICATION', created by the Marine Pollution program in the Department of Transport in 2018. 'LCC_COASTAL_CLASSIFICATION' identifies shoreline types and habitats in the coasta and shallow subtidal region. 'LCC_COASTAL_CLASSIFICATION_Lakes' is extracted to cover only the Gippsland Lakes and is only available for the coastal barrier area between the lakes and the sea, and for part of the southern shoreline of Lake Victoria. This limited coverage is because the original GIS layer 'LCC_COASTAL_CLASSIFICATION' is limited to coastal areas. The GIS layer classifies sections of this coastal habitat into 'Dunes (stable, well-vegetated)', 'intertidal sandy beaches', 'brackish marshes', 'freshwater marshes' and 'saline marshes'. Shell Middens and Artefact Scatters are frequently located within the coastal area identified as 'Dunes (stable, well-vegetated)' (**Figure 5**), but the areas of marsh are also the location of many archaeological sites.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004108&publicId=guest&extractionProviderId=1

Geological basis: 'GEOL_BASINS'

This GIS layer shows the boundaries of the Gippsland geological basin.

Ramsar Wetland registration: 'RAMSAR25_lakes'

The Gippsland Lakes are designated under the Ramsar Convention of Wetlands of International Importance, to which Australia is a signatory. This GIS layer is included as another measure of the recognised ecological significance of th area. The GIS layer 'RAMSAR25' was completed in 2019 by the Water and Catchments Group of DELWP, Victoria. It integrates improvements in accuracy from the previous Ramsar wetland layer. The GIS layer 'RAMSAR25_lakes' has been extracted to cover only the Gippsland Lakes study area.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004218&publicId=guest&extractionProviderId=1

Present-day wetlands: 'WETLAND_CURRENT_Lakes'

GIS layer 'WETLAND_CURRENT_Lakes' has been extracted from the layer 'WETLAND_CURRENT'. 'WETLAND_CURRENT' was created by the Water Group of DELWP, Victoria, and it was last updated in 2017. It displays present-day wetland data derived from a GIS layer known as 'WETLAND_1994' (Victoria's fi st wetland geospatial inventory) and local wetland datasets. Creation of the GIS layer 'WETLAND_CURRENT' was undertaken using interpretation of aerial photographs (dated 2007–2011) supplemented with existing geospatial datasets that informed the identification of etland boundaries (e.g. vegetation mapping, topography). Wetlands were classified according to a revised classificati framework with primary categories based on wetland system type, salinity regime, water regime, water source, dominant vegetation and wetland origin. The GIS layer 'WETLAND_CURRENT_Lakes' has been extracted to cover only the Gippsland Lakes study area. The layer can be queried according to a range of recorded data, including wetland type (stored in the attribute table information field 'WETLAND_TYPE', e.g. 'coastal saltmarsh', 'temporary saline swamp'), 'palustrine system' or 'lacustrine system' (found in formation field 'AQ_SYS'), salinity regime (field 'SAL_REG'), water regime (field 'WTRREG', e.g. 'permanent', 'supratidal', 'periodically inundated') and whether these are naturally occurring or artificial etlands.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004912&publicId=guest&extractionProviderId=1

Wetlands from c. 1750 CE and present-day wetlands: 'WETLAND_PRE_EUROPEAN_Clip'

The GIS layer 'WETLAND_PRE_EUROPEAN_Clip' represents areas of wetland considered to have been present prior to European settlement. This layer is extracted from the state-wide layer 'WETLAND_PRE_EUROPEAN', created by the Water Division of DELWP, Victoria, and was completed in 2018. The information in this GIS layer can be filtered y classifications base on salinity and permanence (information field 'CORR_CLASS', e.g. 'semi-permanent saline', 'shallow freshwater marsh', 'permanent saline') and on occurrence (field 'OCCURRENCE': 'pre-European and current', or 'pre-European only'). Seven areas within the Gippsland Lakes study area are identified as 'pre-European only', the largest being the southern section of Lake Victoria.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004910&publicId=guest&extractionProviderId=1

Water (Hydrology)

Bathymetric data: 'JonesBay_Bathymetry'; 'WellingtonBay_Bathymetry'; 'BATHYMETRY_GIPPSLAND_LAKES'

These GIS layers collectively represent the current bathymetric data for the study area. The layer 'BATHYMETRY_GIPPSLAND_LAKES' covers the Gippsland Lakes study area and was created by Fisheries Victoria and DELWP, Victoria. The data for Jones Bay, located beyond the silt jetties in Lake King, and the data for Lake Wellington, were digitised for the project using information provided in sailing charts. These layers are included to inform researchers on near-shore areas, which may be useful or relevant to analyses of archaeological site location. Bathymetric data can also be used to investigate aspects of the changing form of the lake beds and channels.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004014&publicId=guest&extractionProviderId=1

Water bodies: 'WATER100_Lakes'

The GIS layer 'WATER100_Lakes' describes named water bodies and islands within the Gippsland Lakes region. These can be filtered y feature type (field LANDTYPE 'river', 'island', 'lake', 'lagoon', 'swamp') and by category (field WETCAT: 'semi-permanent saline', 'permanent open freshwater', 'deep freshwater marsh', etc.).

Classification of waterbodies: 'HY_WATER_AREA_POLYGON_Lakes'

This GIS layer 'HY_WATER_AREA_POLYGON_Lakes' was extracted from the layer 'HY_WATER_AREA_POLYGON' that was created by Land Use Victoria in DELWP. This GIS layer is current to July 2020, and simply distinguishes different areas of water within the Gippsland Lakes region. Within the study area the only classifications present are watercourses ('watercourse_area_river'), lakes ('wb_lake') and salt lakes ('wb_lake_salt'). It is worth noting that this GIS layer does not accurately represent wetland areas; wetlands are more effectively investigated using the layers 'WETLAND_CURRENT_Lakes' or 'WETLAND_PRE_EUROPEAN_Clip', outlined on page 65.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002491&publicId=guest&extractionProviderId=1

Rivers: 'MODIFIED_RIVER'S

The GIS layer 'MODIFIED_RIVERS' represents 'modified' and 'unmodified' waterways for all of Victoria. These waterways have been classified as either 'perennial' or 'non-perennial' (i.e. ephemeral). In the Gippsland Lakes study area, this GIS layer represents the five major rivers flowing into the lakes: the Latrobe River, the Avon River, the Michell River, the Nicholson River and the Tambo River.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803005031&publicId=guest&extractionProviderId=1

Watercourses: 'HY_WATERCOURSE_LakesArea'

This has been extracted from the state-wide GIS layer 'HY_WATERCOURSE'; 'HY_WATERCOURSE_LakesArea' covers only the Gippsland Lakes study area. This layer was created by Land Use Victoria in DELWP and was last updated in 2020. The layer is available at a scale of 1:25,000 and shows the creeks, streams and rivers flowing into and through the Gippsland Lakes. These also include channels, connectors and drainages.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002490&publicId=guest&extractionProviderId=1

Watercourse and waterbody names: 'GEO_AREA_HYDRO_LABEL'

This GIS layer simply provides common names for watercourses and water bodies within Victoria.

Non-natural water storage: 'FARM_DAMS_DETAIL'

These are non-natural water storages, primarily farm dams, in Victoria. The GIS layer was produced from a combination of satellite and aerial imagery and is current to 2019. This layer was filtered out of our analyses of waterbodies, given that these represent modern water storages.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803005037&publicId=guest&extractionProviderId=1

Flood-prone areas: 'FLOODWAY'

This GIS layer shows areas subject to flooding, based on legally defined or otherwise delineated floodways. Given that these areas are typically low-lying land close to rivers or water bodies, much of the Gippsland Lakes study area is included within this layer. Even so, this GIS layer is included as it may prove useful to risk assessments.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004311&publicId=guest&extractionProviderId=1

'Gippsland_2013_50m_2_600dpi'

This georeferenced image is sourced from Geosciences Australia's interactive map of marine bathymetry. The image shows the near-shore and deep-water marine features off the coast of East Gippsland. This information could inform understandings of the Gippsland Lakes environment and the long-term landscape history of the area. The data have been downloaded and saved as a geotiff.

http://maps.ga.gov.au/interactive-maps/#/theme/marine/map/marinebathymetry

Plants (Vegetation)

Modelled 1750s vegetation: 'NV1750_EVC_lakes'

The GIS layer 'NV1750_EVC_lakes' has been extracted from the state-wide GIS layer 'NV1750_EVC'. It represents the proposed extent of native vegetation c.1750 CE and expresses vegetation communities using the Victorian standard Ecological Vegetation Classes (EVCs). EVC names, classes and subclasses are available in the data. The data are modelled at scales ranging from 1: 25,000 to 1: 100,000 and were last updated in 2018. This is the master EVC dataset from which 'NV1750_EVCBCS' and 'NV2005_EVCBCS' are also derived.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003494&publicId=guest&extractionProviderId=1

Modern vegetation: 'NV2005_EVCBCS_Lakes'

This GIS layer represents modern (2005) Ecological Vegetation Classes with Biodiversity Conservation Status (BCS) and was last updated in 2018. These state-wide data have been clipped to cover only the Gippsland Lakes project area. The information is derived from a combination of GIS layers on the Victorian bioregions ('VBIOREG100'), pre-1750 EVCs ('NV1750_EVC') and the current version of Native Vegetation Extent ('NV2005_EXTENT'). Bioregional conservation status and geographic occurrence are applied to unique Bioregion-EVC units.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003495&publicId=guest&extractionProviderId=1

Coastal vegetation: 'GIPPS_LAKES_COASTAL_TYPES_lakes'

This GIS layer represents coastal vegetation types present within the Gippsland Lakes study area. These include 'coastal scrub', 'estuary', 'intertidal sand flat', 'lagoon', 'salt marsh', 'sand beach', 'sand dunes', 'steep shoreline', and 'subtidal sandy substrate' (under field SHORETYPE). Areas which are 'unclassified' are also represented.

Intertidal zones: 'VIC_INTERTIDAL_EVC_MAPPING_Lakes'

This GIS layer provides Ecological Vegetation Classes for the intertidal regions of the Gippsland Lakes study area. This information can be filtered by region (field SECTOR: 'Lakes Victoria and King'; 'Lake Reeve'; 'Lake Wellington') and also by type of vegetation.

Tree density: 'TREE_DENSITY_Lakes'

The GIS layer 'TREE_DENSITY_Lakes' has been extracted from 'VMVEG_TREE_DENSITY' created by Land Use Victoria in DELWP and last updated in 2019. Tree density has been classified as either 'Scattered', 'Medium' or 'Dense'. The majority of the land around the lakes is classified as densely treed. This GIS layer has numerous potential uses, but the way the information is currently classified is not refined enough to add meaningful information to the predictive model. However, based on the current form of this layer, there does not seem to be a correlation between the classifications of density in this GIS layer and the location of Scarred Trees.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003127&publicId=guest&extractionProviderId=1

Structural vegetation: 'SVEG100_Lakes'

This is a structural vegetation GIS layer extracted from the state-wide layer 'SVEG100'. 'SVEG100' was created by the group Forest, Fires and Regions in DELWP and was last updated in 2018. The GIS layer 'SVEG100_Lakes' indicates stands of '20–50% Forest Red Gum', particularly in the north of the study area, near the Mitchell River, Nicholson River and Slaughterhouse Creek. Given the analysis of Scarred Trees (87% of which are 'Red Gum'), these locations may be relevant for research purposes. These have not been included in the GIS layer 'ElevatedPotential' but might be considered of moderate potential.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002171&publicId=guest&extractionProviderId=1

Animals (Fauna)

Fauna observations: 'VBA_FAUNA_GRID_1M'

This GIS layer was created by the Biodiversity and Ecosystem Services and DELWP. It was last updated in 2018. The layer presents the fauna records from the Victorian Biodiversity Atlas (VBA) against a standard grid of 1° longitude/latitude (GDA94). Any VBA taxa record with its centre in a cell is counted as a record for that cell. The number of times a taxon has been recorded in a cell is collated in the field 'RECORDS' within the attribute table for GIS layer 'VBA_FAUNA_GRID_1M'. The first and last dates that a taxon has been recorded in a cell are also provided. This GIS layer therefore contains interesting data on the current diversity of species in the Gippsland Lakes study area. Also included are GIS layers listing estuary fish species and habitat, coastal bird habitat, and shorebird sites within the lakes.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803005208&publicId=guest&extractionProviderId=1

Planning

GunaiKurnai Land and Waters Aboriginal Corporation area

The extent of the GunaiKurnai Registered Aboriginal Party (RAP) area (2020) is included simply to indicate the position of the Gippsland Lakes study area within this extensive area. The boundaries of the RAP area were sourced from ACHRIS in 2020.

Roads and tracks: 'TR_ROAD'

The GIS layer 'TR_ROAD' was created by Land Use Victoria and DELWP and was last updated in July 2020. The layer shows the road networks within the study area and is included together with other layers of information relating to modern infrastructure. 'TR_ROADS' provides information on access to locations in the Gippsland Lakes study area and also offers the capacity to contribute to potential assessments of risk to archaeological site locations (e.g. proximity to modern roads as a potential factor in site disturbance) or potential analyses of factors contributing to VAHR site registrations (e.g. correlation between the locations of currently registered sites and modern roads).

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002595&publicId=guest&extractionProviderId=1

Urban areas: 'TownshipsLakes'

This GIS layer is extracted from the state-wide GIS layer 'TOWNSHIP_POLYGON', which is a subset of the 'VICMAP_ADMIN' layers created by Land Use Victoria and DELWP. The 'VICMAP_ADMIN' GIS layers include a range of information relating to modern locality boundaries and were last updated in July, 2020. 'TownshipsLakes' shows the boundaries of present-day towns within the Gippsland Lakes study area. These consist of Bairnsdale, Goon Nure, Kalimna, Metung, Nuntin, Nungurner, Paynesville, Raymond Island, Seacombe and Seaspray.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002529&publicId=guest&extractionProviderId=1

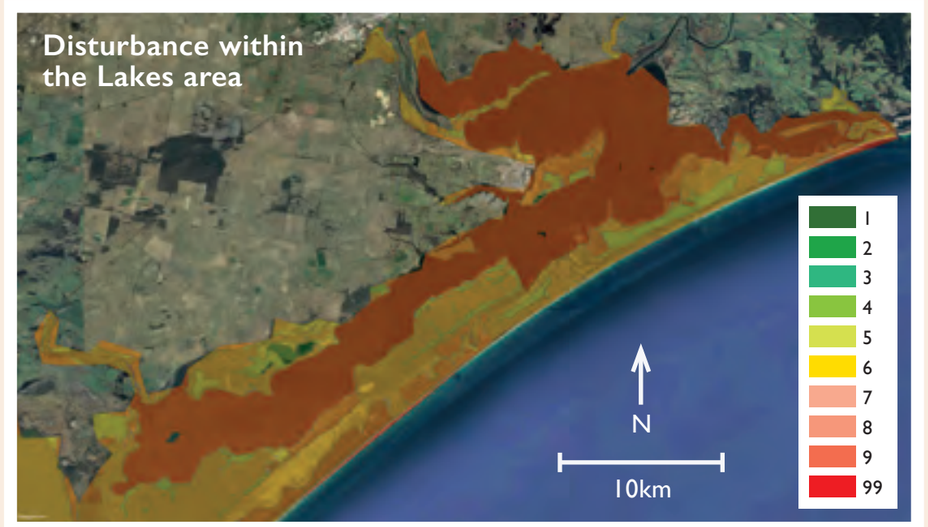
Cadastral data: 'Property'

Modern property parcels and postcodes are found in the GIS layer 'Property'. This layer is derived from the 'VICMAP_PROPERTY' GIS layer that was created by Land Use Victoria and DELWP, last updated in May 2020. Vicmap Property is the cadastral map base of Victoria, providing information about land parcels and property details. The information in the 'VICMAP_PROPERTY' layer is captured at various scales ranging from metre-scale accuracy down to 1:25,000. The GIS layer 'Property' is potentially useful for sourcing information on current land tenure and access.

http://services.land.vic.gov.au/SpatialDatamart/dataSearchViewMetadata.html?anzlicId=ANZVI0803002683&extractionProviderId=1

Landscape disturbance: 'DISTURB100_Lakes'

This GIS layer is sourced from DELWP as part of their information layers on 'Land History'. The GIS layer 'DISTURB100_Lakes' indicates areas of the landscape that have undergone 'disturbance', using a scale of 1 (least disturbed) to 99 (most disturbed). In the Gippsland Lakes study area, the entrance to the lakes is identified as most high y disturbed; areas of the Blond Bay Wildlife Reserve and Raymond Island as least disturbed. An extracted image of this GIS layer is shown below.



GIS layer 'DISTURB100_Lakes', 1 = least disturbed, 99 = most disturbed.

'AGCLEAR100_Lakes'

This GIS layer is sourced from DELWP as part of their information layers on 'Land History'. Areas of land that have been cleared of vegetation for agricultural use are indicated in this GIS layer. Within the Gippsland Lakes study area, eight areas are identified as h ving been cleared between 1891 and 1913. The information in this GIS layer also includes the duration of the clearance. The eight areas identified as h ving been subject to clearance do not intersect with multiple sites.

Recent fire histo y: 'FIRE_HISTORY_lakes'

The GIS layer 'FIRE_HISTORY_lakes' is extracted from the state-wide GIS layer 'FIRE_HISTORY' that was created by Land, Fire and Regions and DELWP. The layer includes information relating to fires in the Gippsland La es study area between 1978 and 2017. The fires are thos primarily on public land and these include bushfires and DE WP planned burns. Since 2006, information about fire se erity has been included and since 2009 CFA data on fires occu ring on private land has also been included. The dataset is current (2020) and is included as supporting information, due to its potential relevance to risk assessments of archaeological sites.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004741&publicId=guest&extractionProviderId=1

'BUSHFIRE_PRONE_AREA'

This GIS layer, created by the Planning program and DELWP, indicates areas deemed to have heightend risks of bushfires It was last updated in May 2020.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004569&publicId=guest&extractionProviderId=1

Fire district: 'LF_DISTRICT'

This GIS layer, created by Forest, Fire and Regions and DELWP, provides details on the DELWP Land and Fire district boundaries for the region. It was last updated in May 2020.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803005279&publicId=guest&extractionProviderId=1

Planning overlays: 'PLAN_OVERLAY'

This GIS layer was created by Planning and DELWP and was last updated in July 2020. The GIS layer provides information on existing planning overlays, including erosion risks, inundation risks, significant landscapes or areas of protected egetation.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI080300291 0&publicId=guest&extractionProviderId=1

'PLAN_ZONE'

This GIS layer represents land use zones, such as 'residential', 'industrial', 'farming' and 'public parks'. The layer was created by Planning and DELWP and it was last updated in July 2020.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002909&publicId=guest&extractionProviderId=1

'PLM25'

This GIS layer refers to public land management and includes state forests, parks, reserves and coastal and marine areas to 5.5 km (3 miles) from the high watermark. The GIS layer, which was created by DELWP under their Land Management Policy program, is presented at a scale of 1: 25,000, and is current to April 2020.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003978&publicId=guest&extractionProviderId=1

Local administrative areas: 'WARD_2017'

The GIS layer 'WARD_2017' contains ward boundaries for Local Government Areas in Victoria. The study area is in the East Gippsland and Wellington Local Government Areas. This GIS layer is part of the 'VICMAP_ADMIN' information layers, referred to above.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803005786&publicId=guest&extractionProviderId=1

'PARISH_POLYGON_Lakes'

The boundaries of the 18 parishes of the Gippsland Lakes are included in this GIS layer. It is part of the 'VICMAP_ADMIN' GIS layers, referred to above.

https://discover.data.vic.gov.au/dataset/vicmap-admin

Resource licences: 'MINTEN'

This GIS layer was created by Earth Resources Regulation and the Department of Jobs, Precincts and Regions, Victoria. The GIS layer 'MINTEN' displays mineral tenements within Victoria. This is an amalgamated layer comprising current and expired licences and was last updated in 2020. There are eight current licenses shown within the Gippsland Lakes study area. Each of these is a licence for extraction of sand and gravel.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803002840&publicId=guest&extractionProviderId=1

Recent heritage sites: 'HERITAGE_INVENTORY_lakes'

The heritage inventory provides a listing of all known historical, non-Indigenous archaeological sites in Victoria and exists under the Heritage Act. It was produced by Heritage Victoria and was last updated in August, 2020. There are five registered heritage site locations within the study area. Within site H8422-0001 (the New Works Site) is VAHR site 8422-0083.

http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803004875&publicId=guest&extractionProviderId=1

Regional Australian boundaries: 'FR_FRAMEWORK_AREA_LINE'

This is simply an outline of the east coast of Australia, including Tasmania, Victoria and parts of New South Wales and South Australia.

Flora Gregson, 1878. Reeves River and Entrance.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1720992

Sources of Images

Cover: **From the Cottages to the Red Bluff.** Flora Gregson, 22 March 1877.
http://search.slv.vic.gov.au/permalink/f/1o9hq1f/SLV_VOYAGER1721001

Page 3: **Mia mia opposite Laughton's Hotel, Lakes Entrance.** Daniel Long, 1856.
http://search.slv.vic.gov.au/permalink/f/cjahgv/SLV_VOYAGER1792224

Page 4: **Sand Hummocks between Reeves River and the sea.** Flora Gregson, 28 March 1877.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1720997

Page 8: **The Proposed New Entrance to Lakes**. Daniel Long, 1883.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1792236

Page 10: **Aboriginal people camped at Lakes Entrance, Gippsland.** Flora Gregson, 1871.
http://search.slv.vic.gov.au/permalink/f/1o9hq1f/SLV_VOYAGER1720956

Page 12: **Sketch Map of Gippsland.** Fison, Lorimer, 1832-1907; Howitt, A. W. (Alfred William), 1830-1908
https://commons.wikimedia.org/wiki/File:Sketch_Map_of_Gippsland_-_Showing_approximately_the_Positions_of_the_Clans_of_the_Kurnai_Tribe.jpg

Page 14: **The Entrance to the Gipps Land Lakes.** C. Winter (engraver), 1867. From a sketch by W. H. Jarrett.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1688945

Page 17: **Scene at the 'Works'.** Flora Gregson, 15 February 1878.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1720984

Page 18: **The 90 Mile Beach.** Flora Gregson, c. 1870.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1721008

Page 19: **The Red Bluff. The end of the '90 Mile Beach'.** Flora Gregson, c. 1870.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1721004

Page 20: **1885 map, from before the permanent entrance, but annotated with 'Proposed New Entrance'.** Lakes Navigation Company.
http://handle.slv.vic.gov.au/10381/400946

Page 20: **Map produced in the 1940s after the permanent entrance was established. Gippsland Lakes: showing routes of steamers.** Victorian Railways.
http://handle.slv.vic.gov.au/10381/287351

Page 21: **'Elevated view over trees and scrub towards waterways opening to the sea'.** Photographer unknown. Compiled by James Blundell.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER2593021

Page 21: **Government Works at new Lakes Entrance, Gippsland.** Compiled by James Blundell.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER2593022

Page 22: **Works at the New Entrance, Gipps Land Lakes.** Alfred Martin Ebsworth, 17 December 1884.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1777158

Page 28: **The Works from Mr. Carpenter's, North Arm**. Flora Gregson, 11 April 1877.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1721086

Page 29: **Mr. Carpenter's, North Arm, Lakes Entrance.** Flora Gregson, 1913.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1721151

Page 48: **Spearing Fish by Torch-light.** Flora Gregson, 11 April 1877.
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1720948

Page 58: **Reeves River and Entrance. Flora Gregson, 21 January1878.**
http://search.slv.vic.gov.au/permalink/f/1cl35st/SLV_VOYAGER1720992

GUNAIKURNAI LAND AND WATERS ABORIGINALCORPORATION
Forestec, 27 Scriveners Road, Kalimna West, Victoria, 3909
Phone: 03 5152 5100 Fax: 03 5152 1666
Email: **reception@glawac.com.au** Web: **www.gunaikurnai.org**

Gunaikurnai Land and Waters Aboriginal Corporation