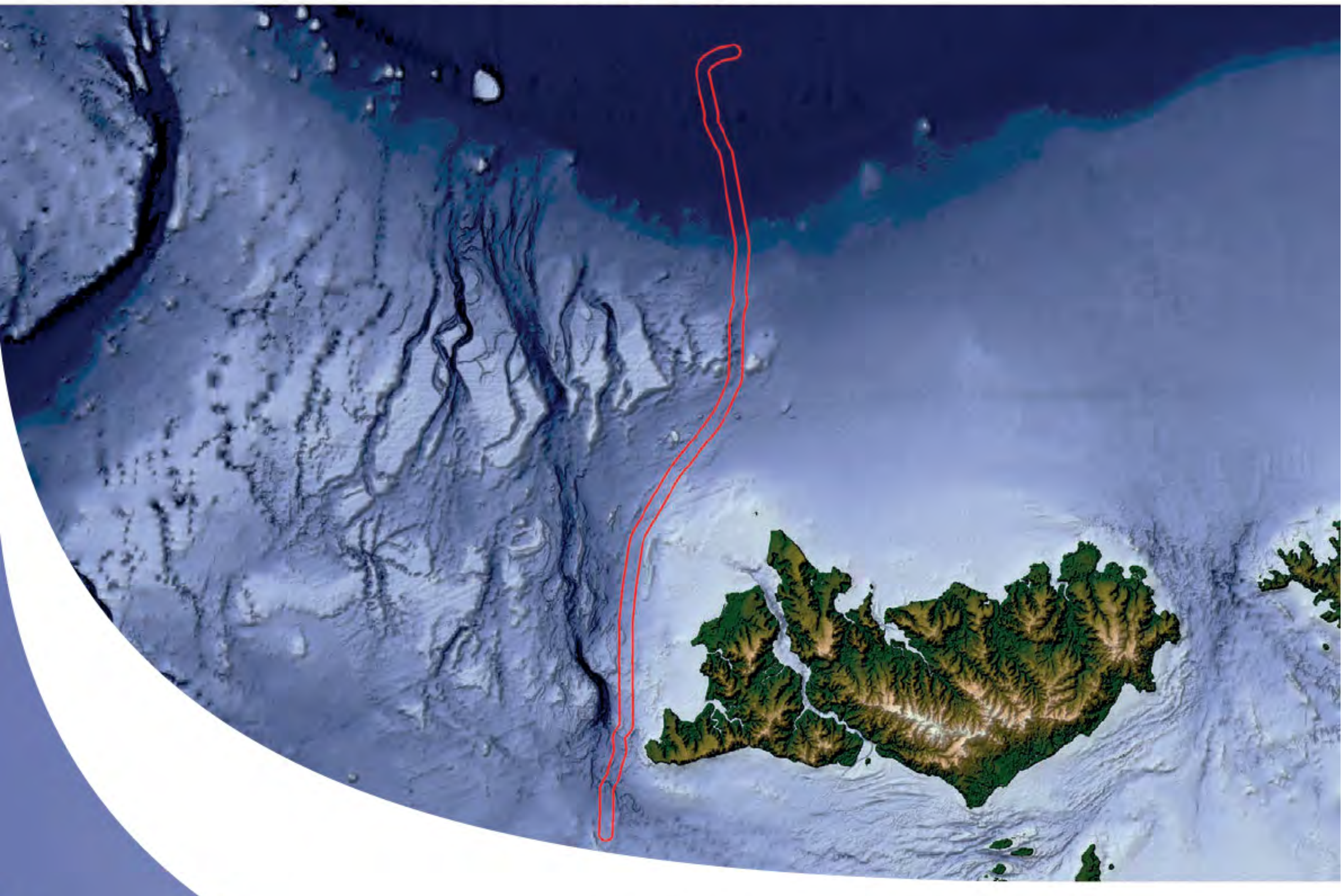
Barossa Gas Export Pipeline

Submerged Palaeolandscapes Archaeological Assessment

Technical Report



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Executive Summary

Wessex Archaeology Ltd and our subcontractor Extent Heritage were commissioned by Santos Australia Ltd, in response to NOPSEMA Direction 1898, to undertake a targeted scientific archaeological assessment of the proposed route of the Barossa GEP. This commission focusses upon the submerged and buried landforms of the seafloor that may have potential to retain Aboriginal cultural heritage dating to periods of lower sea level – the submerged palaeolandscape. The assessment comprises the following pieces of research:

- A palaeogeographic assessment of the offshore study area encompassing the proposed Barossa GEP comprising an assessment of marine geophysical and geotechnical data. This has been contextualised by;
- Ethnohistorical review of Aboriginal communities within the terrestrial study area (adjacent to the proposed Barossa GEP);
- Archaeological assessment of known terrestrial sites within the terrestrial study area; and,
- Creation of a terrestrial predictive model of archaeological sensitivity and assessment and critique of this model for use with submerged palaeolandscapes.

The palaeogeographic assessment identified a total of 60 features interpreted as being deposited during periods of known human occupation of Australia, which have been identified as of high archaeological potential by the supporting ethnohistorical and archaeological assessments, and terrestrial predictive modelling. These include:

- complex systems of palaeochannels,
- former shorelines, and
- dune systems.

A total of 103 features were assigned medium archaeological potential, partly due to the uncertainty of their formation and/or fill. Further geoarchaeological work would aid in refining the interpretation of these features.

The review of geotechnical data identified six distinct lithological units, of which five were assessed as of medium archaeological potential: alluvium, non-marine sand, carbonate sands and gravels, marine to shallow marine sands, and fluvial gravel.

No deposits of high archaeological potential were identified; these tend to comprise fine-grained, bedded, organic-rich sediments (for example, coastal peats and estuarine silts and various palaeo-channel fills). Without scientific dating and palaeoenvironmental analysis there remain significant uncertainties regarding the depositional environments and chronological development of these sedimentary layers.

The ethnohistorical review indicated that Aboriginal communities within the terrestrial study area occupied permanent and semi-permanent camps on floodplains and along the coastline. Settlements were often located close to fresh water sources including rivers, creeks, lakes, and

swamps. However, in some cases, hills and other elevated areas were occupied seasonally. It is thought that people moved seasonally between lowland settlement areas, the coastline, rivers, and elevated areas to exploit different resources and it is likely that this will be reflected in the coastal and riverine distribution of shellfish scatters, middens, and hearths.

The archaeological assessment of known terrestrial sites indicates continuous occupation of the terrestrial study area, and the use of coastal resources throughout the Late Pleistocene (c.50,000 – 11,700 years ago) and Holocene (< 11,700 years ago) periods. This, coupled with the centrality of sea realms to the worldviews, subsistence, and technologies of some contemporary, coastal Aboriginal communities (e.g., Bradley 2010; Keen 2004; McNiven 2004, Sharp 2002) suggests that rising seas inundated many early places occupied and used by early Aboriginal communities (Morrison et al 2023).

Several trends in archaeological patterning were identified within the terrestrial study area, key examples with relevance to the palaeogeographic assessment comprise:

- Proximity to fresh water (river and creek systems, estuaries, swamps, and floodplains) appears to concentrate settlement activities during both the Pleistocene and Holocene (Allen and O'Connell 2003). Earth mounds of Holocene origin are consistently located near stream systems, lakes, and swamps.
- Stone arrangements may be preserved in marine environments, however fish traps in the Northern Territory mainly used organic materials and are much less likely to survive.
- Shell mounds were often positioned on ancient beach ridges, beach slopes or raised rocky knolls, and have been found between 100m and a few kilometres from the present-day coastline.
- Earth mounds can be divided into two distinct types, coastal/estuarine and freshwater.
- Shell mounds, earth mounds, and middens usually occur on the coastal fringe.

The terrestrial predictive model identified the following landforms, with relevance to the palaeogeographic assessment, to be of high archaeological sensitivity:

- Escarpments and ridgelines, where there is potential for caves and rock overhangs.
- Areas of land near higher order drainage lines, representing places where there was, or is, reliable fresh water, and where associated food and fibre resources were plentiful.
- Areas close to current and former coastlines, where there was, or is a greater diversity and richness of food, fibre, and water resources. They have increased potential for shell middens, shell mounds, and occupation deposits.
- Areas close to current and former wetlands, both freshwater and saline. These resource rich areas also have an increased potential for earth mounds.
- Stable dunes often provide good environments for the preservation of archaeological material, such as ancestral remains.

Report Authors

Complex archaeological research, such as that on submerged palaeolandscapes, is inherently interdisciplinary, and this is reflected in the number and range of specialists involved in the production of this report. No one specialist has made decisions or stated opinions without consultation and collaboration with members of the wider team. The following specialists have contributed to this report.

The following specialists are employed by Wessex Archaeology, Portway House, Old Sarum Park, Salisbury, Wiltshire, SP4 6EB, UK:

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Wessex Archaeology, Extent Heritage and the individual experts who prepared the report:

- are not advocates for the Company (Santos), being the party which is paying for the Contractor's expert report;
- are impartial on matters relevant to their area of expertise; and
- are prepared to change their opinion or make concessions when it is necessary or appropriate to do so, even if doing so would be contrary to any previously held or expressed view.

Acknowledgements

Wessex Archaeology and Extent Heritage acknowledges the Tiwi people, Traditional Custodians of the land and seas of the Tiwi Islands, which are the focus of this research, and we pay our respects to Tiwi Elders past and present. We extend our acknowledgement to the Traditional Custodians of Country throughout Australia and their connections to land, sea, and community. We pay our respect to their Elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

We acknowledge Santos's role in providing all available legacy geophysical and geotechnical data for the offshore study area from the Santos and ConocoPhillips archives and for facilitating the acquisition of additional geophysical data within the offshore study area specifically for this report. Santos provided all the information requested by Wessex Archaeology and Extent Heritage and, to our knowledge, no data or information has been withheld. We also acknowledge the work of the team at Fugro who carried out the 2023 geophysical survey and provided the raw data to Wessex Archaeology.

Barossa Gas Export Pipeline

Archaeological Assessment of Submerged Landscapes: Technical report

1 INTRODUCTION

1.1 Scope of document

1.1.1 In January 2023 NOPSEMA, Australia's Offshore Energy Regulator, issued Direction 1898 under General Direction – s 574 in relation to works associated with the Barossa Gas Export Pipeline. That direction included the following requirements:

Direction 2

The registered holders must undertake and complete an assessment to identify any underwater cultural heritage places along the Barossa pipeline route (Pipeline Route) to which people, in accordance with Indigenous tradition, may have spiritual and cultural connections that may be affected by the future activities covered by the EP (the assessment), as follows:

a) The assessment is to be undertaken by suitably qualified and independent experts with relevant experience and research credentials (experts).

b) In undertaking the assessment, the experts must:

i. obtain information from people and /or organisations who have, in accordance with Indigenous tradition, spiritual and cultural connections to any underwater cultural heritage places along the Pipeline route that may be affected by the activities; and

ii. record and have regard to the information obtained.

c) The assessment must be recorded in a report that is to be provided on completion to:

i. people and/or organisations who provided information under paragraph (b)(i) above; and

ii. NOPSEMA.

Direction 3

Following the completion of the assessment required by Direction 2, if any underwater cultural heritage places along the Pipeline Route to which people, in accordance with Indigenous tradition, may have spiritual and cultural connections are identified that may be affected by future activities covered by the EP, the registered holders must update the EP. This must include relevant content as *required under regulation 13 and regulation 14 of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations), including details and evaluation of impacts and risks (the evaluation) of future activities, including:*

> *a. the methods and results of the evaluation on any identified underwater cultural heritage places along the Pipeline Route to which people, in accordance with Indigenous tradition, may have spiritual and cultural connections identified in undertaking Direction 2;*
>
> *b. details of the control measures (if any) adopted to demonstrate that the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable (ALARP) and be of acceptable levels;*
>
> *c. a description of any other legislative requirements that apply to the activity and a demonstration of how those will be met; and*
>
> *d. how any information obtained from people and / or organisations who provided information under paragraph 2(b)(i) above, has been taken into account in the evaluation, and in determining control measures.*

1.1.2 It is within the context of this Direction that Wessex Archaeology and our subcontractor Extent Heritage have worked collaboratively to produce this archaeological assessment relating to the potential for archaeological remains in the shallow water environment impact area of the Barossa GEP project (Figure 1).

1.1.3 This report, and the associated research underpinning it, is limited to a scientific archaeological assessment that identifies the preserved remnants of submerged buried landforms and areas of sea floor that may have potential to retain Aboriginal cultural heritage deposited during periods of lower sea level – the submerged palaeolandscape.

1.1.4 This report specifically does not include any consideration of cultural, social or spiritual values to the Traditional Owners and Knowledge Holders who speak for Country. We understand this is a separate scope of work being undertaken by Santos' consulting anthropologists.

1.1.5 This report identifies, illustrates, and discusses characteristics and features of the submerged palaeolandscape as identified in the marine geophysical and geotechnical data. We are happy for our report to be provided to Tiwi Island Traditional Owners and their anthropologists, which they may use to assist in identifying any cultural values that may be associated with the submerged palaeolandscape.

1.1.6 The impact and effects of proposed works on the submerged palaeolandscape, along with appropriate mitigation strategies are presented in a second report: Barossa GEP Archaeological Assessment of Submerged Palaeolandscapes – Recommendations.

1.2 Project background

1.2.1 Wessex Archaeology, and our subcontractor Extent Heritage, were requested to act as independent experts by Santos Limited (Ltd) to assess the potential for submerged palaeolandscapes that could retain remains of Aboriginal cultural heritage deposited during periods of lower sea level, which may be impacted by the construction of the proposed Barossa gas export pipeline (GEP).

1.2.2 The proposed pipeline is located on the north-western Australian continental shelf and slope in the Northern Territory, to the west of the Tiwi Islands. The proposed GEP is approximately 260 km long and runs south from the Barossa gas field to a tie-in point into the existing Bayu-Undan to Darwin pipeline.

1.3 Archaeological context

1.3.1 Sea levels have changed dramatically over time (Figure 2), and during the last glacial maximum 20,000 years ago they were much lower than they are today. Large areas of what is now seabed were once habitable lands, and as sea-levels rose, these landscapes were inundated and became submerged (Figure 3). These cycles of marine transgression and regression have shaped the Australian coastline, its landforms and resources that we know today.

1.3.2 These changes in landscape/seascape are familiar to the Aboriginal and Torres Strait Islander peoples of Australia who maintain strong connections to Country that was inundated by rising sea levels after the last Ice Age. However, the scientific study of submerged coastal and terrestrial landscapes around the Australian coast is at a relatively early stage in comparison to parts of Europe and the USA. This lack of exploration of the offshore environment is despite Nic Flemming's early (1982) pioneering work at Cootamundra Shoals (to the west of the Barossa GEP) and a long held understanding of the potential for archaeological remains on the Australian Continental shelf (Nutley 2005; Ward, Veth & Manne 2016). Research on underwater aboriginal sites has been carried out at Lake Jasper, Western Australia (Dortch 1984, 1990), and within embayments such as Port Hacking, NSW (Nutley, Coroneos & Wheeler 2016) or Port Phillip Bay, Victoria (Holdgate 1981, 2011; Steyne 2007, 2008, 2009).

1.3.3 The relative lack of exploration of submerged palaeolandscapes offshore in Australia is due in part to comparatively low levels of offshore development that has required archaeological assessments, and limited engagement by the academic community, or at least the funders of academic research, until very recently. Despite the lack of a specific heritage management framework for submerged terrestrial archaeology in Australia, heritage managers have made requirements for the assessment of submerged landscapes for a few nearshore development projects such as the Port Phillip Channel Deepening project, Victoria (Rhodes 2003), and the Beaches Link (Cosmos Archaeology 2020a) and Western Harbour Tunnel projects in NSW (Cosmos Archaeology 2020b).

1.3.4 Recent academic research projects such as the Deep History of Sea Country Australian Research Council[1] project and European Research Council funded ACROSS[2] project focused on submerged terrestrial archaeology/palaeolandscapes in the north and north-west of Australia indicate increasing interest in the submerged palaeolandscapes of the Australian Continental shelf. At present, however, our scientific understanding of the distribution, chronology, preservation, and archaeological potential of submerged landscapes offshore, as a complement to Aboriginal peoples' understanding of their cultural significance, remains very limited.

1.4 Report Structure

1.4.1 This report presents research carried out by an interdisciplinary team of specialists to assess the potential for the survival of topographic features and geomorphology associated with formerly terrestrial palaeolandscapes now underwater and of sediments or features within these submerged palaeolandscapes that might preserve archaeological material associated with the early human occupation of the area.

1.4.2 The report is written with a broad readership in mind; however, this is a technical report and as such some specific language has been used. To aid comprehension a glossary of terms is included in Appendix I.

1.4.3 This research is composed of the following pieces of inter-related work:

- an assessment of ethnohistorical material and archaeological remains in the adjacent terrestrial region,
- a predictive model of what landscape features might retain archaeological material culture,
- an assessment of geophysical data, and a palaeogeographical assessment of the submerged palaeolandscape of the proposed Barossa GEP.

1.4.4 The results of this research are presented in the following sections:

- **Environmental context** section that provides an overview of the key landscape features and formation history of the terrestrial study area, to give a general view of the environmental factors that would have influenced the formation of the archaeological record.
- **Aboriginal ethnohistorical review** of primary sources of documented information relating to Aboriginal use of the terrestrial study area, to glean information about where and how Aboriginal groups were utilising certain landforms. This section also provides information about the types of cultural heritage that might be present in

[1] View the project website at: https://deephistoryofseacountry.com/
[2] View the project website at: https://www.across.soton.ac.uk

certain parts of the landscape. The ethnohistoric research informs the 'terrestrial analogue' predictive model that in-turn informs the palaeogeographic assessment.

- **Desk-top terrestrial Aboriginal archaeology literature review** provides an overview of research on Aboriginal archaeology previously completed in the study area. Given the lack of accessible archaeological site data within the study area, this review is based on an analysis of published peer-reviewed archaeological literature relevant to the terrestrial study area. The literature review of terrestrial Aboriginal archaeological research informs the 'terrestrial analogue' predictive model that in-turn informs the palaeogeographic assessment.

- **Aboriginal heritage predictive model**. This section draws on the results of the ethnohistorical and Aboriginal archaeological literature reviews, along with the environmental context data. The analysis is GIS based and creates a predictive model of archaeologically sensitive landforms across the terrestrial study area. This predictive model serves as a 'terrestrial analogue' of the types of landforms on the submerged palaeolandscape that are likely to have potential to retain archaeological deposits.

- The **palaeogeographic assessment**, presents the results of the desk-based study of the submerged palaeolandscape, which included analysis and interpretation of geophysical and geotechnical data, along with research on sea-level change and local quaternary geology and geomorphology. Work included the identification and mapping of geomorphological features within geophysical data indicative of the submerged palaeolandscape, which have the potential to retain cultural deposits associated with past Aboriginal use and occupation. The palaeogeographic assessment consists of an assessment of legacy geophysical survey data acquired by Fugro Survey Pty Ltd (Fugro) in 2015 and 2017, DOF Subsea Australia Pty Ltd (DOF) in 2018 and EGS Survey Pty Ltd (EGS) in 2021; opensource bathymetry data downloaded from Product catalogue - Geoscience Australia (ga.gov.au) [Accessed 28 February 2023]; and geotechnical data acquired by DOF in 2018. The geophysical data used for this assessment comprises sub-bottom profiler (SBP), sidescan sonar (SSS), multibeam echosounder (MBES) and bathymetry data sets derived from other data sources. After an initial audit of the legacy geophysical data sets, it was noted that there was not a continuous SBP data set deemed of sufficient quality along the entirety of the proposed GEP route. As such, a further SBP survey was conducted by Fugro in March 2023.The data acquired during this survey was also assessed as part of this report.

1.5 Limitations and Assumptions

1.5.1 The study was subject to the following limitations:

Ethnohistoric and Terrestrial Archaeological Assessment

1.5.2 **Heritage Branch NT Data.** Extent Heritage requested site location and site type data across the terrestrial study area from Heritage Branch, NT on 16 February 2023. Heritage Branch replied on 1 March 2023 and declined to provide access to that data because of concerns about data sovereignty, ownership, permissions, and confidentiality. Extent Heritage replied on 1 March 2023 offering to sign a confidentiality deed or a data license agreement to manage those concerns identified by Heritage Branch, however no further response from Heritage Branch has been forthcoming. As a result, this report includes no Heritage Branch data regarding site location patterning and this is a significant limitation given our preferred approach to model development would explore patterns in site location and site type data available in site databases managed by state and territory heritage agencies.

1.5.3 **Aboriginal Areas Protection Authority Data**. Extent Heritage requested site location and site type data across the terrestrial study area from the Aboriginal Areas Protection Authority (AAPA) on 16 February 2023. AAPA replied on 17 February 2023 to advise that they could only provide site points with no other information, and noted there is a fee per parcel of land. For our terrestrial study area this would entail a total fee in excess of $1 million. Given the cost involved and the fact that only simple point data is offered, these data records were not requested and therefore were not included in our research work.

1.5.4 **Tiwi Land Council and Northern Land Council**. Both the Tiwi Land Council and the Northern Land Council were contacted by Extent Heritage to request any relevant site data or reports they may have that could assist with our research. No replies were forthcoming and therefore no data or reports that may be held by the Land Councils was available for our research.

1.5.5 **Aboriginal Traditional Owner Engagement**. The scope of works for this project specifically excluded engagement with Aboriginal Traditional Owners. We understand that this report will be passed on to Traditional Owner groups, and that discussions and consultations with them regarding the cultural values of Sea Country is being carried out by other consultants. Our work is specifically limited to an archaeological assessment of the study area. Our report does not include any identification, research or assessment of potential social, cultural or intangible values of Sea Country or identification of any places of importance to the Traditional Owners. Our scope of work was specifically limited to an archaeological assessment based on available archaeological and ethnohistorical records that provide evidence about Aboriginal occupation and use patterns across the terrestrial study area.

Palaeogeographic and Geoarchaeological Assessment

1.5.6 Data used to compile this report includes secondary information derived from a variety of sources, only some of which have been directly examined for the purposes of this study. The assumption is made that this data, as well as that derived from other secondary sources, is reasonably accurate.

1.5.7 There are a number of limitations and caveats that need to be considered when using global sea-level reconstructions. The first is typically associated with changes in the level of the land relative to the sea (relative sea level) that are particularly pronounced in areas that have been directly overlain by ice during a glacial period, which is not the case for north Australia, which is relatively tectonically stable (Ishiwa *et al.* 2016). This means land levels have not changed considerably and the global sea-level curve is comparable to a local relative sea-level curve. Other considerations include error margins which can be of the order of ± 20 m (Shakun *et al.,* 2015). These errors will define the precision of any palaeogeographic models based on sea-level data.

1.5.8 The bathymetric data underpinning the submerged palaeolandscape mapping undertaken here is based on a 30 m resolution grid that is publicly available. It is acknowledged that higher resolution data may be available within the submerged study area, but which is not obtainable via public data portals, or was acquired for commercial purposes and is therefore not publicly available.

1.5.9 Identification of palaeolandscape features is largely dependent on the type and resolution of data used. The open-source bathymetry data is gridded to 30 m, but actual resolution is highly variable. At the highest resolution, only features that have a seabed expression that are greater than 30 m in size can be identified in the open-source bathymetry data. Away from the areas of highest resolution, it is difficult to identify palaeolandscape features in the open-source bathymetry data. It is highly likely that additional palaeolandscape features are present across the submerged study area, but further higher resolution data acquisition and investigation would be required to locate and map these.

1.5.10 There was a limited amount of geophysical data within the 2 km study area. Although numerous geophysical surveys have been undertaken ahead of planned construction of the GEP, it should be noted that some of these surveys were undertaken along previous iterations of the proposed route. As such, the 2023 Boomer data were the only SBP data to cover the entire route which was considered suitable for archaeological assessment. The other SBP data sets used as part of this investigation allowed for some features to be identified across multiple lines; however, the distance between lines often varied between overlapping with the 2023 data and diverging >500 m from the 2023 data. As such, it is difficult to accurately trace features across multiple lines, or confirm the interpretation from one line to another in some areas. This results in uncertainty in the interpretation of some features, particularly where their form or extents are harder to discern. It also means that there is limited SBP coverage throughout the 2km study area, which means it is likely that there may be further features identified within the study area which are located outside of the SBP data coverage. It is also difficult to correlate stratigraphic units over a wide area with limited SBP data coverage.

1.5.11 Furthermore, differences in equipment specifications resulted in the different datasets having varying data resolution. This means that the same feature may appear different from one data set to the next. This again meant that it could be difficult to confidently identify the same feature across multiple lines.

1.5.12 There were several limitations with regards to the geotechnical data. With exception to the one borehole sample acquired along the route, the penetration of the geotechnical cores was relatively shallow. This meant that the majority of the features identified in the SBP data were beyond the penetration of the geotechnical cores, and therefore the fill of these features could not be verified with the geotechnical logs. Furthermore, although radiocarbon dating was undertaken on cores acquired in the infield data, the results of this were considered inconclusive (Fugro, 2018c, Arup, 2019). This means it is not possible to verify the ages of the features identified during this investigation.

1.5.13 Most of the geotechnical investigations were undertaken as *in-situ* CPTs rather than recovering physical sediment samples; as a result, the interpretation is based on inferences from their physical properties rather than visual inspection. Although this is suitable for engineering purposes, it is less suitable for geoarchaeological assessment. It therefore remains possible that material of palaeoenvironmental interest, such as organic matter, has not been identified within the CPT logs.

1.5.14 Due to differences in the penetration between the SBP data and the geotechnical logs, it is not always possible to definitively correlate the lithological units identified in the geotechnical logs with the features identified in the SBP data. Similarities in the depositional environment of some of the features, as well as the limitations in the geotechnical logs discussed above, has resulted in the same lithological unit being assigned to different stratigraphic units. Furthermore, due to the resolution on the SBP data, it is possible that there may be thin sediment layers identified in the geotechnical logs which are not resolvable in the SBP data.

1.5.15 The limited number of SBP lines, as well as the lack of accurate dating of geotechnical cores, means there is some uncertainty around the interpretation of some of the features, as well as their archaeological potential. Further geophysical and geotechnical work would aid refining the interpretation of geophysical data, which in turn would help to determine the archaeological potential of the area more accurately. It is possible that further investigations might result in the removal, or addition of further features. However, regardless of the uncertainties surrounding some of the interpretation, it is clear that there are a number of terrestrial features present along the proposed GEP route which will need to be considered ahead of the proposed GEP construction.

1.6 Co-ordinate system

1.6.1 The survey data were acquired in Geocentric Datum of Australia 1994 (GDA94) Map Grid of Australia Zone 52 (MGA52) and the results are presented in the same coordinate system.

2 LEGISLATION, GUIDANCE, AND POLICY

2.1 Introduction

2.1.1 The Barossa GEP lies entirely within Commonwealth Waters, and as such Northern Territory legislation relating to cultural heritage does not apply.

2.1.2 The legislative requirement for this piece of archaeological research has come from the NOPSEMA Direction 1898 detailed in Section 1.1.

2.1.3 The work presented in this report conforms with international best practice as laid out in the following relevant Australian legislation, international conventions, and industry guidance that relates specifically to the investigation, protection, and management of underwater cultural heritage.

2.2 Commonwealth Underwater Cultural Heritage Act (2018)

2.2.1 In Australia, underwater cultural heritage is protected under *the Underwater Cultural Heritage Act 2018* (UCH Act). Implementation of the UCH Act is managed by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) in collaboration with State and Territory governments.

2.2.2 The UCH Act replaced the *Historic Shipwrecks Act 1976* and, whilst continuing to protect Australia's shipwrecks, the Act has broadened protection to sunken aircraft and other types of underwater cultural heritage including Australia's First Nations underwater cultural heritage in Commonwealth waters.

2.2.3 Underwater cultural heritage is defined by the Act to mean 'any trace of human existence' that has a cultural, historical or archaeological character and is located under water. 'Trace of human existence' is stated to include:

- sites, structures, buildings, artefacts and human and animal remains, together with their archaeological and natural context; and
- vessels, aircraft and other vehicles or any part thereof, together with their archaeological and natural context; and
- articles associated with vessels, aircraft or other vehicles, together with their archaeological and natural context.

2.2.4 Despite this expansion, which facilitates protection of First Nations underwater cultural heritage, concerns have been raised that the UCH Act does not adequately protect the Indigenous cultural heritage of submerged landscapes.

2.2.5 The UCH Act aims to bring Australian legislation in line with the UNESCO Convention on the Protection of the Underwater Cultural Heritage.

2.3 UNESCO Convention on the Protection of the Underwater Cultural Heritage (2001)

2.3.1 The UNESCO Convention on the Protection of the Underwater Cultural Heritage[3] is the primary piece of international legislation guiding the protection and management of underwater cultural heritage. The convention protects all underwater cultural heritage greater than 100 years old, defined as: 'all traces of human existence having a cultural, historical or archaeological character which have been partially or totally under water, periodically or continuously, for at least 100 years' such as:

- sites, structures, buildings, artefacts and human remains, together with their archaeological and natural context;
- vessels, aircraft, other vehicles or any part thereof, their cargo or other contents, together with their archaeological and natural context; and
- objects of prehistoric character.

2.3.2 Australia has been working towards ratification of this convention for over a decade, and the convention represents international best practice with regards to the protection and management of all underwater cultural heritage.

2.4 Marine Industry Guidance

2.4.1 The Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) are currently consulting on their Draft guidelines to protect underwater cultural heritage (Consultation hub | Draft guidelines to protect underwater cultural heritage - Climate Change (dcceew.gov.au). This document, whilst under consideration should be seen as the best practice expectations for archaeological work in the near and offshore zone.

2.4.2 In the absence of agreed guidelines in Australia for the investigation of underwater cultural heritage, the equivalent relevant offshore industry guidelines that Wessex Archaeology work to in the UK are:

- Historic England Guidance Note: Marine Geophysics Data Acquisition, Processing and Interpretation (2013)
- JNAPC published a Code of Practice for Seabed Developers (2006)

[3] https://en.unesco.org/underwater-heritage/2001

3 METHODOLOGY

3.1 Study Area(s)

Terrestrial study area

3.1.1 The terrestrial study area covers the closest land to the proposed pipeline. This area includes landscape and environmental characteristics that are likely to have existed on areas of the submerged palaeolandscape that the proposed Barossa GEP would traverse.

3.1.2 A terrestrial study area has been defined for this report to inform the desktop assessment and terrestrial predictive model (Figure 4), which in turn provides a terrestrial analogue that assists with the identification of submerged palaeolandscape features that have a higher potential to retain Aboriginal cultural deposits. This terrestrial study area is designed to capture a broad range of landforms and environmental contexts: a representative sample size is necessary for the construction of a robust predictive model. Given the limited archaeological data that is available across the Northern Territory, a large study region has been selected to capture broad-scale archaeological patterning in a dynamic environment. This includes major river catchments (the Daly, Katherine, Roper, Glyde rivers; the Alligator Rivers region;) and prominent landscape features (Arnhem Land plateau and escarpment; Kakadu wetlands; coastal floodplains) which are likely to have been major drivers of landscape use by Aboriginal and Torres Strait Islander groups over time. These broader landscape features are comprised of a range of landforms: freshwater wetlands; brackish swamps; estuarine and fluvial floodplains; chenier ridges and plains; coastal plains; uplands; meandering watercourses; deeply incised valleys; escarpments (Figure 5). These landforms have evolved over time in response to climatic variation.

3.1.3 The terrestrial study area extends across approximately 39,368,031.5 hectares (ha), encompassing Country under the Tiwi Land Council, Anidilyakwa Land Council, and the East Arnhem, West Arnhem, Darwin/Daly/Wagait, Katherine and Ngukurr regions of the Northern Land Council. The terrestrial study area is subject to two legislative frameworks: the Heritage Act 2011 (NT), administered by the Heritage Branch, NT and the Sacred Sites Act 1989 (NT), administered by the Aboriginal Areas Protection Authority (AAPA).

3.1.4 The southern extent of the terrestrial study area follows the sub-catchment boundaries of the Victoria, Katherine and Roper rivers. The northern, eastern and western boundaries are delineated by the present-day coastline of the Australian continent. Offshore islands have been included within the terrestrial study area as these were accessible from mainland Australia during periods when sea levels were lower than today. Prior to the inundation of the Sahul land bridge (14,500 – 8,000 years ago Ka), these offshore islands would have formed areas of high relief across the Sahul shelf, which connected the present-day Australian mainland to Papua New Guinea.

Offshore study area

3.1.5 The palaeogeographic study area is defined as a 2 km buffer around the proposed GEP route (Shapefile 'GEP rev5', as provided by Santos Ltd 13 January 2023). It should be noted that SBP and MBES data outside of this area were assessed in order to provide a wider geological context; however, only features identified within the study area are included in this report at this time.

3.2 Ethnohistorical Review

3.2.1 The ethnohistorical review is a critical literature review of primary and secondary historical source material that records information about First Nations peoples from the period of early contact with European colonists. These records are written by white explorers, settlers, and colonists and as such are highly subjective, and reflect historic racist and cultural biases. The records can, however, provide information about settlement patterns and subsistence practices from this period. Whilst drawing parallels across large geographical areas and long periods of time is highly problematic, ethnohistorical information can prove to be useful in trying to understand ancient communities, when combined with other sources of information, including community histories.

3.2.2 There are very few early, and reliable, ethnohistorical resources relating to the study area that were easily available online via library databases. Those that were available date largely to the early to mid-twentieth century or focused on cultural that are outside the scope of this research.

3.2.3 Source material assessed for this report is primarily peer reviewed publications referred to in the text and listed in the bibliography. Whilst many of these publications referred to primary sources, no relevant, digital or publicly available primary sources were identified.

3.3 Terrestrial Archaeological Assessment

3.3.1 Ordinarily, a terrestrial archaeological assessment would include a review of information within heritage databases held by relevant government agencies and of cultural heritage sites recorded by the relevant First Nations communities. As detailed in Section 1.5, this cultural heritage data could not be obtained. As a result, this terrestrial archaeological assessment is limited to a critical literature review, largely of peer reviewed published research. Data sources are referenced within the text where appropriate and listed in the bibliography.

3.4 Archaeological Predictive Model

3.4.1 The archaeological predictive model builds on information gathered through the ethnohistorical and terrestrial archaeological literature reviews. It uses a wide range of publicly available data to understand the environmental context including:

- Aerial imagery:
  - ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN
- Elevation data:
  - Geoscience Australia
- Topographic shapefiles:
  - OpenStreetMap

- Core mapping/sensitivity model shapefiles:
  - Northern Territory Government Open Data Portal

3.4.2 The full methodology for the creation of the predictive model is explained in Section 6.

3.5 Palaeogeographical Assessment – Marine Geophysical Data Assessment

Geophysics - data sources

3.5.1 A number of data sources were consulted during this assessment, including the following provided by Santos:

- Geophysical survey datasets acquired by Fugro in 2015, 2017 and 2023, DOF in 2018 and EGS in 2021;
- Client supplied survey reports (Fugro 2016a, 2016b, 2018a, 2018b, 2018c, 2023, DOF 2018a, 2018b, EGS 2021).
- Client supplied heritage reports from the proposed GEP (Cosmos Archaeology 2022 and O'Leary *et al.* n.d.);

3.5.2 Additional publicly available data sets were consulted, including:

- Geographical Information System (GIS) resources, including shapefiles and geoTIFFs;
- Peer reviewed academic papers and grey-literature reports, and;
- Published maps and charts.

Geophysics - technical specifications

3.5.3 A number of different geophysical data sets have been acquired over the current proposed GEP, as well as previously proposed and alternative route locations. The dates of these surveys are as follows:

- Fugro between 4 and 18 November 2015;
- Fugro 17 July and 27 August 2017;
- DOF 28 May 2018;
- EGS between 11 and 14 November 2021; and
- Fugro between 10 and 13 March 2023

3.5.4 Further details on the equipment used is in Table 1.

Table 1: Summary of survey equipment

Survey Company	Survey Vessel	Data Type	Equipment	Data Format
Fugro 2015	RV *Solander*	SBP	Surface-towed Applied Acoustics Boomer Power = 100 J/200 J/300 J Pulse Rate = variable (5 pps/3 pps/2 pps)	*.sgy*
		SBP	EdgeTech X-Star Chirp Frequency = 1 kHz/6 kHz Pulse rate = 6 pps	*.sgy*
		SBP	Applied Acoustics Surface-tow Sparker Power = 500 J Pulse Rate = variable (2 pps/1 pps)	*.sgy*
		SSS	Edgetech 4200 FS (100 / 400 kHz, 100 m range)	*.xtf*
		MBES	R2Sonic 2024	*.xyz*
		Positioning	StarPack G2-AUSAT DGNSS	N/A
Fugro 2017	MV *Lauri J.*	SBP	Surface-towed Applied Acoustics Boomer Power = 200 J Pulse Rate = variable (2 pps)	*.sgy*
		SBP	EdgeTech X-Star SB-0512 Chirp Frequency = 1 kHz/6 kHz Pulse rate = 6 pps	*.sgy*
		SBP	Applied Acoustics Surface-tow Sparker Power = 500 J Pulse Rate = variable (1 pps)	*.sgy*
		SSS	Edgetech 4200 FS (100 / 400 kHz, 100 m range)	*.xtf*
		MBES	Kongsberg EM2040	*.xyz*
		Positioning	Fugro StarPack DGNSS	N/A
DOF 2018	*Skandi Hercules*	SBP	Combined Edgetech 2000 DSS Chirp SSS	*.sgy*
		SBP	Applied Acoustics Surface-tow Sparker Power = 1750 J Pulse Rate = variable (1 pps)	*.sgy*
		SSS	Combined Edgetech 2000 DSS Chirp SSS (100 / 400 kHz, 75m range)	*.xtf*
		MBES	R2Sonic 2024	*.xyz*
		Positioning	StarPack Starfix G2	N/A
EGS 2021	MV *Lauri J*	SSS	Edgetech 4200 (100 / 400 kHz, 75m range)	*.xtf*
		MBES	Kongsberg EM2040-07	*.xyz*
		Positioning	MarineSTAR G4 PPP GNSS	N/A
Fugro 2023	MV *Bhagwan K*	SBP	Surface-towed Applied Acoustics Boomer	*.sgy*
		Positioning	Fugro StarPack DGNSS	N/A

3.5.5 As well as the data acquired above, an open source digital elevation model (DEM), downloaded from Product catalogue - Geoscience Australia (ga.gov.au) [Accessed 28 February 2023], was also used as part of this assessment. This contained bathymetric data for the Northern Territory derived from shallow- and deep-water MBES surveys, airborne

LiDAR bathymetry, and satellite derived bathymetry. This was provided as a raster grid file at a 30 m resolution.

Geophysics – data processing

3.5.6 A number of datasets were assessed over the study area, each dataset was processed separately using the following software (Table 2).

Table 2: Software used for geophysical assessment.

Dataset	Processing Software	Interpretation and rationalisation
SBP	CodaOctopus Survey Engine v8.1	ArcMap v10.8
MBES	QPS Fledermaus v7.8.12	
SSS	CodaOctopus Survey Engine v8.1	

3.5.7 The SBP and bathymetry data were used as the primary datasets for the palaeographic assessment.

3.5.8 The SBP data were processed using CodaOctopus Survey Engine Seismic+ software. This software allows the data to be visualised with user selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data by identifying and selecting sedimentary boundaries and shallow geological features that might be of archaeological interest.

3.5.9 The SBP data were interpreted with a two-way travel time (TWTT) along the z-axis. In order to convert from TWTT to depth, the velocity of the seismic waves was estimated to be 1,600 ms^{-1}. This is a standard estimate for shallow, unconsolidated sediments.

3.5.10 The SBP data can also be used to identify small reflectors, which may indicate buried material such as a wreck site covered by sediment. The position and dimensions of any such objects are noted in a gazetteer, and an image acquired of each anomaly for future reference. It should be noted that anomalies of this type are rare, as the sensors must pass directly over such an object in order to detect an anomaly.

3.5.11 For the SBP assessment, a majority of the 2015 Fugro Boomer, all the 2017 Fugro Boomer and Sparker data, and all the 2023 Fugro Boomer data were assessed (Figure 6). Only a limited number of 2018 DOF Sparker lines were assessed. This is due to the fact the 2018 DOF survey data were acquired in a similar location to the 2023 Fugro Boomer data, which were considered to be more suitable for palaeogeographic assessment. As such, the 2018 DOF Sparker data was only assessed where it significantly deviated in position from the 2023 Fugro Boomer data. Although only features identified within the 2 km study area are reported on as part of this assessment, a number of SBP lines from outside of the study area were also assessed in order to better understand the wider geological context.

3.5.12 The 2021 EGS data and the 2018 DOF MBES data were also assessed in order to identify whether there were any features of likely anthropogenic origin, such as shell middens or shipwrecks, identifiable on the seabed. The 2018 DOF data were gridded at 2 m and the 2021 EGS data were gridded at 1 m, and both were analysed using QPS Fledermaus software, which enables a 3-D visualisation of the acquired data and geo-picking of seabed anomalies. The MBES data were also used in the palaeogeographic assessment.

3.5.13 The open-source 30 m Northern Territory DEM and the 2017 Fugro MBES were the bathymetry data sets used for the palaeogeographic assessment. The 2018 Fugro MBES data were gridded at 2 m and exported as a floating points geotiff. These data sets were assessed using QGIS. Merged DEMs were created and displayed as elevation with hillshade overlay. Derivatives of the DEM were also created and used in interpretation. Slope angle maps aided interpretation of steep-sided features, and discriminating channel features. Aspect maps were also created, but due to artefacts in the data, did not provide much additional information.

3.5.14 To model the regional palaeogeography, the DEMs created from the open-source bathymetry data were used, combined with the RSL data from Brooke *et al.* (2017). Ideally, the DEM should be corrected for the appropriate point in time by stripping off more recent sediment, or adding back in eroded stratigraphy, to create a PalaeoDEM. The open-source bathymetry data is used as a proxy for PalaeoDEM at all time scales here, as it is not possible to recreate a PalaeoDEM without more extensive SBP data. It is assumed that any erosion and deposition between time steps is minor, and therefore below the resolution of the regional palaeogeographic reconstruction modelled here.

3.5.15 The 2021 EGS and 2018 DOF high frequency *.xtf* SSS data files were processed using CodaOctopus Survey Engine Sidescan+ software. This allowed the data to be replayed with various gain settings in order to optimise the quality of the images. The data were interpreted for any objects of possible anthropogenic origin. This involves creating a database of anomalies within Coda by tagging individual features of possible archaeological potential, recording their positions and dimensions, and acquiring an image of each anomaly for future reference. These were then cross-referenced against the features identified in the Cosmos Archaeology report (2022) to ensure nothing additional had been identified during the raw data assessment.

3.5.16 The form, size and/or extent of an anomaly is a guide to its potential to be an anthropogenic feature and therefore of archaeological interest. A single small but prominent anomaly may be part of a much more extensive feature that is largely buried. Similarly, a scatter of minor anomalies may be unrelated individual features, define the edges of a buried but intact feature, or may be all that remains of a once large feature as a result of past impacts from, for example, dredging or fishing. Assessment is made of such groups of anomalies during data interpretation to determine which of these alternatives is the most likely.

Geophysics – data quality

3.5.17 Once processed, the geophysical data sets were individually assessed for quality and their suitability for archaeological purposes, and rated using the following criteria (Table 3).

Table 3: Criteria for assigning data quality rating.

Data quality	Description
Good	Data which are clear and unaffected or only slightly affected by weather conditions, sea state, background noise or data artefacts. Seabed datasets are suitable for the interpretation of upstanding and partially buried wrecks, debris fields, and small individual anomalies. The structure of wrecks is clear, allowing assessments on wreck condition to be made. Subtle reflectors are clear within SBP data. These data provide the highest probability that anomalies of archaeological potential will be identified.
Average	Data which are moderately affected by weather conditions, sea state and noise. Seabed datasets are suitable for the identification of upstanding and partially buried wrecks, the larger elements of debris fields and dispersed sites, and larger individual anomalies. Dispersed and/or partially buried wrecks may be difficult to identify. Interpretation of continuous reflectors in SBP data is problematic. These data are not considered to be detrimentally affected to a significant degree.
Below Average	Data which are affected by weather conditions, sea state and noise to a significant degree. Seabed datasets are suitable for the identification of relatively intact, upstanding wrecks and large individual anomalies. Dispersed and/or partially buried wrecks, or small isolated anomalies may not be clearly resolved. Small palaeogeographic features, or internal structure may not be resolved in SBP data.
Variable	This category contains datasets where the individual lines range in quality. Confidence of interpretation is subsequently likely to vary within the study area.

3.5.18 The quality of the 2023 and 2017 Fugro SBP data has been rated as ‘Good’ using the above criteria. Some of the 2023 Boomer files are seen to be affected lightly by the weather, particularly in the southernmost section of the route, although this did not affect the data to a significant degree. Both Boomer data sets struggled to acquire penetration in the deeper water due to the water depth; however, horizons were still identifiable in the 2023 Boomer data and the 2017 Sparker data. This loss of penetration occurred beyond the 125 m bathymetry contour, which is considered to be the Last Glacial Maximum (LGM) low stand and is not thought to have been subaerially exposed, meaning the likelihood of terrestrial features beyond this point is low. As such the data are considered suitable for archaeological interpretation.

3.5.19 The 2018 DOF Sparker data is considered ‘Variable’ using the above criteria. In general, the data quality was average, and it was possible to trace horizons along the lines. In some areas the selected record length meant that there was limited data visible in the *.segy* files; however, due to the acquisition of the 2023 Boomer data, this is not considered an issue.

3.5.20 The 2015 Fugro Boomer data is considered ‘Average’ using the above criteria. Some lines were seen to be affected by the weather and the resolution is seen to be lower compared to the 2017 and 2023 data sets. The seabed pulse is also seen to obscure reflectors in the very upper levels of the data. However, it was still possible to identify and trace horizons along the lines and, as such, the data are considered suitable for archaeological interpretation.

3.5.21 The 2021 EGS data were rated as ‘Good’ using the above criteria. The data quality and resolution was found to be of a good standard and suitable for archaeological assessment of objects and debris over 1 m in size.

3.5.22 The 2018 DOF data were rated as 'Variable' using the above criteria. There was a range in quality over the dataset and therefore the confidence of interpretation varies within the study area for this dataset. In general, it is suitable for archaeological assessment of objects and debris over 2 m in size, however in some areas this is reduced to 5 m in size.

3.5.23 The 2017 Fugro data were rated ‘Good’ and of sufficient quality and resolution to assess palaeolandscape features.

3.5.24 The open-source bathymetry is of ‘Variable’ quality and resolution, which can make interpretation of palaeolandscape features difficult, especially where the actual resolution is lower than the data gridding size of 30 m.

3.5.25 The 2018 DOF and 2021 EGS SSS data have been rated as ‘Variable’. A majority of the lines were of a good quality with targets clearly identifiable; however, a number of lines were affected by cable snatching, likely due to poor weather, and the thermocline within the water column. These lines were only partially affected by these issues, which were represented in the data as striping or positions of data dropout, with targets still clearly identifiable. The altitude of the SSS fish was also quite high in some lines of the 2018 DOF data, resulting in a wide nadir, which coincided with sections of significant data striping. While features were not always clearly identifiable in these lines, they represented less than 4% of the total number of lines and the overlap with the 2021 EGS data mean this is not considered an issue. Generally both SSS data sets were acquired as a single line along the proposed GEP route. As such, there may be some areas without SSS covering the nadir, although this is likely to be covered by the data overlap between the two data sets along the of the route.

Geophysics - anomaly grouping and discrimination

3.5.26 The previous section describes the initial interpretation of all available geophysical datasets that were conducted independently of one another. This inevitably leads to the possibility of any one object being identified in different datasets and therefore overstating the number of archaeological features in the exploration area.

3.5.27 To address this fact, the anomalies were grouped together; allowing one ID number to be assigned to a single feature for which there may be, for example, a SBP feature identified on adjacent Sparker and Boomer lines. Where the same feature was identified on adjacent lines, and within 500 m of each other, they were grouped together. Where there was a distance greater than 500 m between SBP lines, the features were retained as separate features, but their possible association noted in the gazetteer (Appendix II).

3.5.28 Once all the geophysical anomalies and desk-based information have been grouped, a discrimination flag is added to the record to identify those features that are thought to be of archaeological potential. A feature has archaeological potential if it could preserve palaeoenvironmental or archaeological data about how people lived in the area in the past. These flags are ascribed as follows (Table 4).

Table 4: Criteria discriminating relevance of identified features to proposed scheme.

Overview classification	Discrimination	Criteria	Data type
Archaeological	P1	Feature of probable archaeological potential, either because of its palaeogeography or likelihood for producing palaeoenvironmental material	SBP, MBES
Archaeological	P2	Feature of possible archaeological potential	SBP, MBES
Non-impact	O1	Outside horizontal footprint of study area	MBES, SSS, Mag., SBP

3.5.29 The distance from any proposed development or potential impact is not taken into consideration when designating the archaeological potential.

3.5.30 Overlying sediment or depth of the feature below seabed does not generally impact the archaeological potential of an identified feature. Overlying sediment does, however, have the potential to preserve underlying features and sediments, and therefore a buried feature is generally considered to have a higher likelihood of preserving intact sediments than those exposed on the seabed surface. Recent work at Flying Foam Passage, off Murujuga in northwestern Western Australia (Benjamin 2023) however, illustrates that this is not always the case.

3.5.31 The grouping and discrimination of information within this report is based on all currently available information and is not definitive. It allows for all features of potential archaeological interest to be highlighted, while retaining all the information produced during the course of the geophysical interpretation and desk-based assessment for further evaluation, should more information become available.

3.5.32 Any anomalies located outside of the defined study areas identified during this geophysical assessment, are deemed beyond the scope of the current assessment and are subsequently not included in this report.

3.6 Palaeogeographical Assessment – Geotechnical Data Assessment

3.6.1 The geotechnical data were also reviewed as part of this assessment, including provisional logs acquired by Geoquip MarineOperatons AG (Geoquip), and interpretation of the results by Arup Pty Ltd (Arup 2019), both of which were provided to Wessex Archaeology by Santos.

3.6.2 The geotechnical data acquired (Figure 7) by Geoequip from 23 June to 28 August 2018 (Geoequip 2018) using the vessel MS *Skandi Hercules*, comprised:

- 26 no. Box core locations
- 11 no. Vibrocore locations
- 11 no. Piston core locations

- 52 no. 3m CPTU test locations
- 1 no. continuous sampling borehole at the Tie-in location
- 2 no. continuous CPTU boreholes at the Tie-in location

3.6.3 To frame geoarchaeological investigations of this nature, Wessex Archaeology has developed a five-stage approach, encompassing different levels of investigation appropriate to the results obtained, accompanied by formal reporting of the results. The stages are summarised below (Table 5).

3.6.4 This assessment presents the results of a Stage 1 review of geotechnical logs, with recommendations made for any further geoarchaeological works, if deemed necessary.

Table 5: Staged approach to geoarchaeological investigations

Stage	Description
Stage 1: Geoarchaeological review	Desk-based review of geotechnical and geological data. Establish likely presence/ absence/ distribution of archaeologically relevant deposits. Identify deposits or samples for Stage 2 works.
Stage 2: Geoarchaeological recording/monitoring	Target deposits or samples identified in Stage 1. Describe the sequences recovered and undertake deposit modelling (if suitable). Interpret depositional environment (if possible). Identify if suitable deposits are present for Stage 3 works.
Stage 3: Palaeoenvironmental assessment	Sub-sample deposits of archaeological interest for palaeoenvironmental assessment (e.g. pollen, plant macrofossils, foraminifera, ostracod and diatoms) and associated scientific dating. Provide an outline interpretation of the archaeological and palaeoenvironmental context. Any recommendations for Stage 4 works will depend on the potential for further analysis and the project research objectives.
Stage 4: Palaeoenvironmental analysis	Full analysis of samples and additional scientific dating as specified in Stage 3, together with a detailed synthesis of the results, in their local, regional or wider archaeological and palaeoenvironmental context. Publication would usually follow from a Stage 4 report.
Stage 5: Publication	Publication of the results of Stage 1-4 works for submission in a peer reviewed journal, book or monograph, depending on the archaeological significance of the work. The scope and location of the final publication will be agreed in consultation with the client and regulatory bodies where appropriate.

3.6.5 A combined total of 77 vibrocore, Cone Penetration Test (CPT), piston core, and borehole logs were acquired during geotechnical investigations undertaken across the Barossa GEP in 2018 (Geoquip 2018). The geotechnical logs were provided to Wessex Archaeology by DOF Subsea for a Stage 1 geoarchaeological review, in order to identify deposits of potential archaeological interest. Interpretations were made regarding the likely erosional and depositional environment, and formation processes of the recovered sediments. Sub-bottom profiler and bathymetric data in the vicinity of each core location was also considered during the interpretation process.

3.6.6 The vibrocore and CPT logs were drilled to a maximum depth of 4.52 metres below seabed (mbsb) using a high-performance corer. A single borehole located in the continental inner shelf was drilled to a maximum depth of 31.56 mbsb. Cores were assessed as being either a high, medium or low archaeological potential.

4 ENVIRONMENTAL CONTEXT

4.1 Overview

4.1.1 This section provides an overview of the geological and environmental context of the offshore and terrestrial study areas. It outlines current understanding of the formation of the local geology and how the contemporary landscape of the study area formed and has changed over time. Landscape and geomorphology are constantly evolving, and these changes shape both where people would have lived and also how archaeological material would have been deposited, preserved, and then impacted over time.

4.1.2 The following overview is based on a range of secondary sources, including academic papers, monographs, geological information, and for the offshore region, previous work undertaken by Fugro, DOF and Arup over the Barossa GEP. This serves as a baseline for the archaeological patterning and palaeogeographic assessment. It also aids in producing a stratigraphy for the offshore study area, assigning archaeological potential to identified units, and informing future sampling strategies.

4.2 Sea level change and the Quaternary geology of the offshore study area

Sea level change

4.2.1 Over the Quaternary period (the last 2.6 million years), which includes the Pleistocene and Holocene epochs, cyclic changes in climate between glacial (cold) and interglacial (warm) periods mean global sea levels have fluctuated, and areas of shallow seas were once sub-aerially exposed and potentially inhabited. Over a single glacial-interglacial cycle, sea levels fall to a maximum of 120-125 m below the present-day sea level over a period of ~100,000 years, and then subsequently rise as ice sheets melt over a relatively short time period (20,000 years) (Lambeck *et al.*, 2014).

4.2.2 Along the east coast of Australia, postglacial sea level reached up to 1.5 m higher than today between 8,000 BP and 7,000 BP (Dougherty *et al.*, 2019), before falling to the present-day level after 1,500 BP. Sea-level data from the South Alligator River (Woodroffe *et al*., 1985, 1986, 1987) and Darwin (Nott, 1996) show sea level to have reached present day levels around 7,500 BP, and remained at similar elevations since. Therefore, any palaeolandscapes in the offshore study area are expected to date to before 7,500 BP.

4.2.3 Our understanding of past sea-level trends comes from sea-level indicator data and mathematical models, and there are a series of global (eustatic) sea-level reconstructions that can be used to help determine which parts of the seabed were exposed at different time periods, and for how long. For this study, the sea-level curve of Lambeck *et al.* (2014), resampled in Brooke *et al.* (2017), is used as this is a robust model that included data points from the Australian/South Pacific Region, and gives a similar sea-level change curve to that presented by Lewis *et al*. (2013), summarising measured relative sea-level changes from around Australia. This sea-level reconstruction covers the time from 125,000 years to the present day (Figure 2), which is the last glacial-interglacial cycle and covers the period of know inhabitation of the study area. However, Relative Sea Level (RSL) changes at specific locations are controlled by a mixture of near- and far-field sources, including local effects such as isostacy induced by sedimentation and tectonic effects such as subsidence or uplift, and far-field effects such as ocean geoid deformation, ocean siphoning, continental levering, and thermal expansion (Shennan *et al.*, 2015). The actual timing and magnitude of sea-level changes may therefore vary from the curve presented by Brooke *et al.* (2017) by a few metres.

4.2.4 An assessment of sea-level data undertaken by Brooke *et al.* (2017) has shown that the sea level around the Australian continental shelf has fluctuated throughout the Late Quaternary (from c.128,000 – c. 12,000 BP), with sea level most frequently between 30-40 m, 70-80 m and 80-90 m below present levels. During the LGM, relative sea-level data show the sea level to have dropped to approximately -123 m around 22,000 to 19,000 BP (Ishiwa *et al.*, 2019). These depths may represent the positions of former stable coastlines (Figure 3).

Transgressive and climatic impacts on landform preservation

4.2.5 There is potential for marine transgression, weather events such as storms and cyclones, and wave events such as tsunami, to have impacted preservation of palaeolandscape features of archaeological interest during and since the subaerial exposure of the continental shelf. These events may damage, rework, or erode palaeolandscape features, depending on the intensity of the event and the lithology of the landform.

4.2.6 Marine transgression may erode or entirely remove palaeolandscape features through extensive wave or tidal ravinement. Extensive erosion due to marine transgression only tends to occur when the rate of relative sea-level rise compared to the slope angle of the transgressed land surface is low, for example with a low rate of relative sea-level rise and a high slope angle. When marine transgression is rapid, with a high rate of relative sea-level rise and a low slope angle, landforms can be preserved without significant reworking. The terms qualifying the rate of transgression, slow and rapid, are relative and not quantitative, but a period of postglacial sea-level rise such as that which occurred between c. 21,000 BP and c. 8,000 BP (generally above 5 mm/yr) inundating a low slope angle continental shelf such as is observed in the study area (generally below 0.2°) can be considered rapid. Throughout the Australian continental shelf, palaeolandscape features from different ages and depths are often well preserved (Brooke et al., 2017), including areas preserving palaeolandscapes that contain lithic artifacts (Benjamin et al., 2023).

4.2.7 The high-resolution rate of sea-level rise that affects marine transgression at any specific location is almost impossible to establish without targeted dating of submerged palaeolandscape sediments. However, it is broadly understood that the post-glacial sea-level rise was at some times and in some places, at a rate that was observable within a human lifetime. The vast quantity of coastal land that would have been lost to inundation would have required relocation of entire communities and thousands of years of communities renegotiating land boundaries (Nunn and Reid 2016). The long-lasting impact of this is recorded orally by at least 21 different Aboriginal communities from around the coastline of the Australian continent, including the Tiwi Islands (Nunn and Reid 2016). Flood (2006) suggests that in areas that were gently sloping, such as the northern plains of Australia, that around 5 km of land was flooded annually.

4.2.8 The impact of storms and tsunami waves on preservation of palaeolandscape features depends on wave climate, local topography, and lithology of the palaeolandscape feature.

Storm and tsunami waves can actually enhance preservation of palaeolandscape features by depositing capping, protective sands (e.g. Emery et al., 2019, Swindles et al., 2018), and in Australia, storm surges caused by tropical cyclones have been shown to cause minor localised reworking of coastal landforms, but also leading to aggradation of sediments (May et al., 2017), which may enhance their preservation during later marine transgression by making the larger landform more difficult to erode.

Quaternary geology of the offshore study area

4.2.9 The proposed GEP is located within the Bonaparte Basin on Australia's north-west continental shelf. The GEP runs across the eastern edge of the Van Diemen Rise, a regional bank feature on the Darwin Shelf that comprises a series of carbonate banks, which are crossed with a series of sinuous channel features. These are thought to have formed during subaerial exposure during periods of lower sea level and to represent a drowned estuarine valley or river floodplain (Lavering, 1993, Anderson *et al.*, 2011).

4.2.10 The recent geological history of the wider area of the Bonaparte Basin, including the study area, is directly linked to the Pleistocene (2.5 million – 10,000 years ago) glacial/interglacial cycles, which resulted in large areas of the Australian continental shelf being periodically exposed as a terrestrial environment. This is represented in the geological record, with distinct terrestrial landscape features being present, interspersed with deposits of marine and clastic sediments. Due to this fluctuating glacial cycle and the associated sea-level changes, the archaeological record is likely to be phased between periods of occupation and long periods of hiatus when high sea levels restricted access to some of the areas on the continental shelf. These changes in relative sea level are recorded as Marine Isotope Stages (MIS).

4.2.11 The geology of the offshore study area is Cretaceous to Neogene strata, overlain with a mixed, variably cemented carbonate-silliciclastic sedimentary sequence that accumulated during the late Pliocene and Quaternary (Bouget *et al.*, 2013; Fugro 2016a, 2018a; Geoscience Australia, 2022). These are in turn intersected and overlain by fluvial, alluvial, and clastic sediments deposited during the Late Pleistocene and Holocene. Clastic sediments, found within the 50 m contour, are thought to derived from wet-season input from surrounding rivers (Lavering, 1993). In some areas, the carbonate unit is expected to be present at the seabed. Seabed sediments are expected to comprise calcareous sand (Lavering, 1993).

4.2.12 These Late Pleistocene and Holocene sediments were deposited in a range of environments, from terrestrial to marine, and it is the terrestrial sediments, deposited during periods of low relative sea level, that are of the highest archaeological potential. At present, only one potential submerged *in situ* archaeological site has been identified around the Australian coast (Benjamin *et al.,* 2020, Leach et al 2021, Wiseman et al 2021), although further hydrodynamic modelling has suggested that the finds may in fact be reworked and in a secondary context (Ward *et al,.* 2022). Terrestrial archaeological evidence, as discussed in Sections 5 and 6, demonstrates that intersections between water and land would have served as desirable places for people to interact with and occupy, due to the availability of resources and opportunity for movement (Wiseman *et al.,* 2021). Furthermore, evidence globally has demonstrated a correlation between palaeochannels and associated floodplains/terraces within submerged terrestrial landscapes and the presence of archaeological finds (Tizzard *et al.*, 2014; Wessex Archaeology, 2013a; 2013b).

4.2.13 During the Last Glacial Maximum (c. 29,000-21,000 years ago), sea level was at its minimum, at ~125 m below the present-day sea level. The area of the offshore study area that are shallower than -125 m below present-day sea level is thought to have been dry land, forming a landscape that would have included river, wetland, and coastal environments. Rapid sea-level rise over the subsequent 21,000 years flooded the currently submerged offshore study area. Given the rapid rate of sea-level rise, there is potential for preservation of some archaeological sites exposed at the seabed, and the greatest potential for survival would be in sheltered protected environments, such as embayments or estuaries in the palaeoshoreline, or where sediment has buried the former landscape.

4.2.14 The relative periods of lower sea level, and their associated archaeological potential, are discussed further below:

<u>MIS 4 (c. 71,000-57,000 years ago)</u>

4.2.15 Western scientific discourse estimates that the first humans arrived on the Sahul continent around 65,000 BP (Morrison et al 2023). At this time, sea level was around 98 m below present. The Sahul Banks and Van Diemen Rise areas, including the large band of carbonate platforms west of the proposed pipeline route, were subaerially exposed at this time. During MIS 4, sea level was relatively stable between -95 m and -100 m until c. 62,000, when a period of rapid sea level rise occurred up to -68 m at c. 60,000 BP. During MIS 4, the entire pipeline route was exposed subaerially south of KP 74, which was the approximate location of the coastline at this time.

4.2.16 The areas of the Sahul Banks and Van Dieman Rise have been the focus of archaeological interest since the 1980s (Flemming 1986) as one of the likely arrival points of the first Australians, known as the ‘southern route’, which is thought to have taken place during this period of low sea level (Bird et al 2019, Kuijjer et al 2022). Arrival on the Sahul continent at this time would have included a sea crossing (Balme 2013), and the presence of archaeological sites in northern Australia dating to this period (Clarkson et al 2017) represents the earliest known open sea crossing by humans (Bird et al 2019). As such, any archaeological remains identified within the submerged palaeolandscape of the offshore study area dating to this period are likely to be of national and international significance.

<u>MIS 3 (c. 57,000-29,000 years ago)</u>

4.2.17 At the beginning of MIS 3, sea level was around 68 m below present. Between c. 60,000 BP and the onset of the Last Glacial Maximum at c. 29,000 BP, sea level fluctuated between -68 m and -88 m, but generally dropped from around -70 m between 60,000 and 50,000 BP to around -80 m between 50,000 and 30,000 BP. During MIS 3, the Sahul Banks became largely submerged, but Van Diemen Rise remained largely subaerially exposed. The relatively flat shelf areas north and south of the Tiwi Islands remained subaerially exposed. At the shallowest sea level during MIS 3, -68 m, the area of the GEP route was largely subaerially exposed, although located close to the coastline position at this time.

4.2.18 At the southern end of the route, between KPs 256 and 240, sea level inundated a palaeovalley located in this region. The coastline at the northern section of the pipeline route was located at approximately KP 120 at this time. Throughout the rest of MIS 3, the landscape along the pipeline route south of KP 107 would likely have been exposed subaerially.

4.2.19 As discussed above, archaeological evidence indicates that Australian continent was occupied by 50,000 years ago, with archaeological sites indicating continuous occupation of the terrestrial study area, specifically the Arnhem Land plateau, from this period (David et al 2019). Archaeological sites dating to this period on land (see Section 6) demonstrate the presence of people within the region, which suggests that there is the potential for archaeological material to survive within the submerged palaeolandscape from this period. Any archaeological remains identified within the submerged palaeolandscape of the offshore study area dating to this period are likely to be of national and international significance.

Last Glacial Maximum (LGM) (c. 29-21,000 BP; MIS 2)

4.2.20 Sea level dropped rapidly at the onset of the global LGM, from ~-80 m at c. 30,000 years ago to a minimum of around -125 m at c. 29,000 years ago. Sea level was stable at around -125 m below current levels, throughout the LGM. At this time, the whole of the Australian continental shelf shallower than -125 m was subaerially exposed. The extensive Sahul Banks and Van Diemen Rise were separated by a narrow inlet, which opened southwards into a large embayment, the Malita Inlet and Basin. Extensive river networks would have drained through the exposed palaeolandscape. The area underneath the entire pipeline route south of KP 50 was subaerially exposed.

4.2.21 Evidence suggests that during the LGM, the exposed area would have been subject to dry, arid conditions with much of the region being open grassland with some eucalyptus woodlands close to the coastline and mangrove forests in tidally influenced estuaries (Lavering, 1993; Nicholas *et al.,* 2015).

4.2.22 As discussed above, and in more detail below in Section 6, archaeological evidence from within the terrestrial study area demonstrates the continued presence of people throughout this period, suggesting that there is potential for archaeological material to also survive within the submerged palaeolandscape from this period. Any archaeological remains identified within the submerged palaeolandscape of the offshore study area dating to this period are likely to be of national and international significance.

Post-Last Glacial Maximum and Holocene (c. 21,000 years ago - present; MIS 2 – 1)

4.2.23 Rapid postglacial sea-level rise began at c. 21,000 years ago. Although the sea level curve of Brooke *et al.* (2017) is too coarse to include a mid-Holocene highstand, evidence of sea level above the present level is seen around the coast of Australia (Lessa & Masselink, 2006; Lewis *et al*., 2013) Dougherty *et al.*, 2019). Sea level is thought to have reached this highstand c. 8,000 years ago. Assuming this is also the case for the region around the study area, then sea level went from -125 m to 0 m in approximately 13,000 years.

4.2.24 At c. 14,000 years ago, sea level was at around -80 m, with similar subaerial exposure to that seen during MIS 3. By c. 12,000 years ago, sea level was at around -60 m, with Sahul Banks having become almost entirely submerged. The platforms of Van Diemen Rise were a series of islands at this time. The shelf surrounding the Tiwi Islands was gradually flooded, with inundation occurring within valleys first.

4.2.25 By c. 10,000 years ago, sea level had reached -30 m. At this time, a few small islands remained in the Van Diemen Rise area. The Tiwi Islands were still connected to the mainland around this time, but would have become separated soon afterwards. By this time, the landscape along the pipeline route was entirely submerged.

4.2.26 At sites elsewhere in Australia, sea level reached present day levels at c. 8,000 BP, followed by a highstand of around 1.5 m above present sea levels. This final phase of inundation flooded the remaining exposed palaeolandscape and the coastline achieved something similar to that of today.

4.2.27 After Holocene marine transgression, the archaeological potential of the continental shelf, including the offshore study area, becomes maritime history, which has already been assessed and reported on by Cosmos Archaeology (2022).

4.3 Quaternary geology of the terrestrial study area

4.3.1 The terrestrial study area lies within the Northern Australian Craton (NAC). This is intensely deformed and metamorphosed Precambrian rock (4000-541 Ma) overlain by mildly deformed sediments of the McArthur and Victoria basins, dating to the late Paleoproterozoic to Neoproterozoic (2050-541 Ma) (Pegum 1997). The NAC holds some of the most ancient rock outcrops in Australia.

4.3.2 Prominent landscape features within the terrestrial study area include the Arnhem Land plateau and associated escarpment in the west, which rises 300m above the surrounding landscape at its highest point. The plateau holds the catchment areas of some of the major river systems in the region (Alligator Rivers, Daly and Adelaide Rivers, Magela Creek), which transition to coastal lowlands and floodplains dissected by watercourses, such as those found in Kakadu National Park, in the east.

4.3.3 Some of the oldest rock within the terrestrial study area outcrops as the Kombolgie Formation and underlying Koolpinyah erosional surface, both of which are Precambrian in age. These ancient sandstones form part of the most prominent geomorphological features in the landscape: the Arnhem Land plateau (Kombolgie Formation) in the west, and the lowlands and floodplains that lie to the east (Koolpinyah surface). An overview of how these underlying geologies inform the present-day geomorphology of the terrestrial study area is presented below.

Arnhem Land Plateau

4.3.4 The Kombolgie Formation is some of the oldest rock within the terrestrial study area, and outcrops as the Arnhem Land plateau. The bioturbated sandstone bed of the Kombolgie Formation was laid down during the Paleoproterozoic Era (2500-1600 Million years ago). It comprises relatively undeformed siliclastic, medium- to coarse-grained sandstone that can be up to 2km thick. This quartz-rich sandstone is more resistant to weathering than other lithologies within the landscape: as such, the Kombolgie Formation forms areas of high relief within the study area.

4.3.5 The plateau is an exhumed, tabular upland. It is slow to respond to weathering and erosion, injecting low yields of sandy sediments into the surrounding landscape. The plateau is characterised by deeply incised drainage channels which trace the joints and faults of the ancient Kombolgie Formation. Sandstone and limestone outliers form isolated massifs (Notts 2007). The Arnhem Land plateau contains the upper catchment areas of most major river systems in the study area. These exit the plateau either as waterfalls (e.g. Jim Jim, Magela Falls), or via deeply-incised palaeochannels (Notts 2007; Woodroffe et al. 1986; Hiscock 1999).

Arnhem Land Escarpment

4.3.6 The Arnhem Land Escarpment marks the edge of the Arnhem Land Plateau, ranging from 30-300m in height. The scarp is formed of Kombolgie Formation sandstones of the plateau, and unconformably overlies a weaker underlying geology. As these underlying rocks erode the base of the scarp, large sandstone boulders collapse and the scarp retreats. The watercourses that traverse the plateau outlet at the escarpment via two processes: watercourses that follow the deeply incised gorges formed from the joints and faults of the plateau, or via waterfalls (e.g. Jim Jim, Magela Falls). Erosion of the Kombolgie sandstones of the escarpment has led to the development of sand fans, which began accumulating at 230-200,000 and 120-100,000 years ago during interglacial periods. These footslope deposits contain some of the oldest evidence of Aboriginal occupation in the study area (dating to between 60-50,000 years ago) (Nott 2007).

Lowlands

4.3.7 The Koolpinyah erosional surface forms the rolling, dissected lowlands that lie between the Arnhem Land Escarpment and the eastern floodplains. It is comprised of fine to coarse sedimentary deposits overlying Lower Cretaceous rocks in the north-west, and Lower Proterozoic rocks elsewhere across the terrestrial study area (Story et al. 1969). This is an exhumed Proterozoic surface which underlies the Kombolgie Formation of the Arnhem Land Plateau (Nott 2003). The Koolpinyah surface has a complex, polygenetic history. It is an ancient landscape derived from sandy alluvial deposits, wetlands, floodplains, river terraces and palaeochannels (Williams 1969; Nott 2003). These sandstones are more subject to weathering than the more heavily concreted, overlying Kombolgie Formation (Woodroffe et al.1986), but nonetheless are stable in areas where they are found to be outcropping. The Koolpinyah surface has undergone laterization, forming highly oxidised parent rocks and associated regolith. This process of in situ laterization of ancient sandstone accounts for the rich red dirt that is distinctive across the terrestrial study area, and the northern parts of the Australian continent more generally.

4.3.8 The surface itself is polygenetic, being derived from a range of sediments deposited in marine and alluvial contexts. The present-day Koolpinyah surface is defined by Pleistocene River terraces and palaeochannels of clays, silts and sands abutting sandy channels that have formed at the foot of the Arnhem Land Escarpment. Many of these are inundated during the wet season (Nott 2007, Story 1969).

Darwin Region

4.3.9 In contrast to Arnhem Land, the Darwin region is a low relief landscape. There are two distinct landscapes: undulating lowlands in the south, with the northern extent dominated by broad tidal flats (Pietsch and Stuart-Smith 1987). This shoreline is low-energy, with progradation occurring through ongoing marine and terrestrial sediment deposition (Bourke 2000).

4.3.10 These geomorphological features are the result of broad-scale weathering and sediment transport over time. The ancient underlying geological formations dictate areas of high and low relief across the landscape. The evolution of these features is directly relevant to an analysis of the archaeological sensitivity of landforms within the terrestrial study area. Fundamentally, Country is central to the lifeways of Aboriginal and Torres Strait Islander people. As a result, archaeological patterning within the landscape is informed by the key geological and geomorphological formations outlined above.

Regolith and soils

4.3.11 The terrestrial study area is characterised by deeply weathered laterites formed from parent Cretaceous sediments which were laid down during marine transgressions. Laterites are particular to the terrestrial study area, forming as a result of the tropical monsoon climate across the terrestrial study area. Intense and prolonged in situ chemical weathering of parent rock in a hot climate, with cycles of aridity and inundation of iron-rich soils, breaks down soluble minerals within the parent rock. New, stable minerals form in their place. Due to the iron-rich environment across the Top End, ferruginisation leads to the formation of laterites (Mao and Retallack 2019).

4.3.12 During the Quaternary period, several phases of alluvium were deposited on the lowlands and plains that lie west of the escarpment (e.g. the Alligator Rivers region) and within the major palaeochannels of the Arnhem Land plateau. Broad estuarine and marine clay deposits were laid down in the lower reaches of palaeochannels and along the coastline, with limited evidence of aeolian activity (Nott 2003; 2007; Woodroffe et al. 1986).

4.3.13 Older alluvial deposits are comprised of 3km-wide sand sheets and levees that can reach 1km width. These sandy deposits were derived from the Arnhem Land plateau, with occasional lateritic and quartz gravel in areas where the parent source was the Kombolgie volcanic member, or Lower Proterozoic rocks exposed at the base of the escarpment (Nott 2003). Younger alluvium is comprised of fine sand and silt levees and clayey back-plains, and medium-grained sand sheets derived from local rock (Nott 2007).

4.4 Climate, hydrology, and vegetation

4.4.1 The terrestrial study area is subject to tropical monsoonal climate patterns, with a dry season from April to November, and wet season from December to March. The majority of the 1624mm rainfall is delivered during the peak of the wet season, but rainfall can vary in terms of volume and spatial distribution. Temperatures vary from 24-24°C in the wet season, and 17-32°C in the dry season. Tropical cyclones occur periodically during the wet season. Winds prevail east to northwest in the wet season, easterly during the dry. Present-day major river systems form their headwaters in the south of the study area or atop the Arnhem Land Escarpment, draining northward into the Joseph-Bonaparte, Beagle and Van Diemen gulfs and the Arafura Sea (Figure 8). Figure 9 shows the present-day vegetation distribution across the terrestrial study area. Today, it is dominated by woodland. Mangrove forests are sparse and confined to the coastal margins of the terrestrial study area (Figure 10), with grasses and sedges confined to the lowlands and floodplains. There has been significant variation in vegetation over time, in response to the broad-scale climatic variation and hydrological evolution that has occurred across the terrestrial study area.

4.4.2 The terrestrial study area has undergone a series of climatic variations over time. Climate is a key driver of hydrological and vegetation changes across the landscape. As such, the terrestrial study area's hydrology and vegetation have passed through distinct phases in line with key climatic shifts, particularly in reference to waterway evolution over time. Sub-regional models can provide analogues for broad-scale climatic variation across a large area. A case study relevant to the terrestrial study area is outlined below.

Alligator Rivers case study

4.4.3 In a 1986 study, Woodroffe et al. drilled sedimentary cores from across the South Alligator River system in order to determine a model of tidal river and deltaic plains evolution. This model outlines processes that have influenced landscape evolution across macrotidal river systems of the study area. As such, the three distinct phases of the South Alligator River model are considered to be analogous to the development of macrotidal river systems and associated low-lying floodplains across the study area (Woodroffe et al. 1986; Hiscock 1999). Three distinct phases were identified, based on the Woodroffe et al. (1986) study and adapted by Hiscock (1999), outlined below:

<u>Transgressive Phase (8000-7000 BP)</u>

4.4.4 The final episode of Holocene marine transgression into the South Alligator River valley commenced approximately 8500-8000 BP, when sea levels reached approximately 10-12m below present-day levels. The South Alligator River palaeochannel was likely inundated as a marine embayment for approximately 1000 years, during which time the palaeochannel was infilled with marine sediments. Mangrove forests began to develop along the coastal fringes, bordered by eucalypt woodland (Hiscock 1999).

<u>Big Swamp Phase (6800-5300 BP)</u>

4.4.5 Holocene marine transgression ceased at approximately 6500-6000 BP, allowing for sediments to be deposited on coastal and estuarine plains that were previously inundated. The shoaling of estuarine systems led to the establishment of extensive mangrove belts 5-12km across and over 100km in length, across the floodplains. These mangrove stands contained freshwater lagoons, but the 'big swamp' was prominent during this time. Sediment deposition was rapid, maintaining the shallow tidal conditions favourable for mangrove communities. Analysis of pollen samples within the sediment cores taken by Woodroffe et al. (1986) infer that these 'big swamp' mangrove forests were dominated by Rhizophora species. The wide-scale establishment of salt-tolerant Rhizophora stands suggests that tidal inundation occurred broadly across these coastal floodplains. By 5300 BP, Rhizophora had become less dominant, as vegetation shifted to freshwater species (Hiscock 1999). This was likely driven by changes in the depositional environment: coastal progradation led to a shift in floodplain gradient, limiting tidal inundation. The coastline between the South and East Alligator rivers was characterised by sandy, silty beaches with low backdune systems. Sediments were maintained within the South Alligator River rather than being discharged to the coast, limiting progradation at this time. Middens associated with rock shelters along the East Alligator River also date to the Big Swamp Phase.

Sinuous River Phase (4000-2500 BP)

4.4.6 The 'big swamp' mangroves gave over to were replaced by grasses and sedges by approximately 4000 BP, as the floodplains area transitioned from tidal flats and estuaries to freshwater floodplain clays. Palaeochannels identified across the floodplains indicate that the South Alligator River had been infilled by sediment and transitioned to a sinuous, meandering river. Coastal progradation increased during this phase, as the low-energy meandering river deposited terrestrial sediments downstream, and tidal inundation continued to deposit marine sediments. From 3000 BP, middens overlying freshwater floodplain sediments become frequent common, often associated with the banks of palaeochannels and occasionally levee banks.

Cuspate River Phase (2500 BP – present)

4.4.7 The present-day South Alligator River is characterised by cuspate bends, which are shallow channels with point-bar and mid-channel shoals. Remnant mangrove stands were established on these shoals and river bends with deep sedimentary profiles. The subsequent erosion of 'big swamp' deposits allowed for tidal inflow to penetrate further upstream than was possible during the Sinuous River Phase. However, overall, the Cuspate River phase is marked by a continuation of the coastal progradation that was initiated during the Sinuous River phase, which limited the amount of tidal flooding, allowing the further development of the freshwater swamps and floodplains that characterise the study area west of the Arnhem Land Plateau to the present day.

4.4.8 Magela Creek and the Daly River have both undergone similar processes, albeit on differing scales (Clark et al.1992a; Hiscock 1999; Woodroffe et al. 1986). This suggests that the above cycle applies to macrotidal river systems across the study area: a deeply-incised palaeochannel undergoes marine transgression and infilled with marine sediments; brackish and saline swamps develop via tidal inundation of coastal lowlands and floodplains; sediment transport from marine and terrestrial sources leads to further infilling of the river channel, and a sinuous meandering river develops; coastal progradation increases via marine and terrestrial sediment deposition, and swamps/wetlands transition to a freshwater phase; sediments accumulate in the meandering bends and a cuspate river channel forms with some shoaling in river bends and mid-stream.

5 ETHNOHISTORICAL REVIEW

5.1 Overview

5.1.1 Ethnohistorical information, including accounts from the period of first contact with European colonists, offers insight into settlement and subsistence activities around this time. The nature of this record is fragmentary, subjective, reflects historic cultural biases, and therefore drawing parallels across such large geographical areas and long periods of time is problematic. Ethnohistorical information should always, therefore, be read in tandem with other forms of evidence, as well as community histories.

5.1.2 Due to the large geographical area and varying cultural practices and traditions of the First Nations groups living within the area, this section focuses specifically on First Nations people's activities that are directly relevant to the development of a terrestrial predictive model, namely population distributions and movements, and subsistence practices.

5.2 Territory, language, and social structure

5.2.1 The terrestrial study area spans 39,368,031.5 hectares (ha), encompassing a range of territories. Arnhem Land alone, comprising the eastern part of the study area, is home to approximately 126 Aboriginal groups, and is the most linguistically diverse part of Australia. The territories of these groups cover both land and sea country, with each covering approximately 235 square kilometres (Davis et al. 1992). There are currently 13 language groups within the study area, which would have numbered in the hundreds prior to colonisation. These language groups are exceptionally diverse, particularly within Arnhem Land, in the east of the terrestrial study area.

5.2.2 The First Nations people of the study area live in varied environments, from inland forest, mangrove, and riverine and coastal ecosystems, and had varying relationships with bodies of water and the sea. Some groups, such as Yolŋu of north-eastern Arnhem Land have extensive knowledge of maritime navigation and habitually traversed the open seas, whilst others are stayed closer to the coast (Fredericksen 2002; Davis et al.1992; Sharp 2002). The claimed Country for many groups of the coastal parts of the study area extend across both land and sea Country, and for many there is no boundary (Sharp 2002). For many of the 'Saltwater' people of northern Australia the sea is imbued with spiritual meaning, with energy and sentience, whilst the sea is the home of ancestors or ancestral beings for other groups, such as the people of Goulburn Island, who identify submerged islands as 'inhabited by the spirits of the dead' (Sharp 2002; McNiven 2003: 333).

A broad overview of territories and social structures within the terrestrial study area is given below, but it should be noted that this is not a comprehensive appraisal.

Territory and language

<u>Tiwi</u>

5.2.3 There are very few early, and reliable ethnohistorical resources relating specifically to the Tiwi, with most sources dating to the early to mid-twentieth century (Farram 2022, Morris 2000, 2001a, 2001b, Hart and Pilling 1979, Pilling 1962, Stehlik 2011) and focusing on cultural values (Sharp 2002, Venbrux 2011) or other aspects that are not within the scope of this research. These, and other ethnographic sources identified, such as those on the eHRAF World Cultures database, did not provide useful information regarding Aboriginal use of the study area or potential associated material culture.

5.2.4 The Tiwi Islands lie approximately 80km north of Darwin, comprising Bathurst and Melville Islands, with a total land mass of 7870 km2 (Davis et al.1992). Present-day populations are approximately 2,400 across both islands with over 85% of residents identifying as Australian Aboriginal (ABS 2021).

5.2.5 In the 19th and early 20th centuries, the islands were occupied by patrilineal bands of approximately 100 to 300 people (Fredericksen 2002, 291). Territories on the Tiwi Islands are significantly larger than those on the mainland, averaging 1263 km^2. These territories comprise seven ‘countries’ (Fredericksen 2002, 291). At the time of invasion, Tiwi clans are thought to have been patrilineal, but from the 1930s they transitioned to a matrilineal social structure, before partially shifting back to a patrilineal social unit (Fredericksen 2002, 291).

5.2.6 Tiwi largely exploited terrestrial environments. Canoes were used to move through in-shore and estuarine environments, and to travel to near-shore satellite islands (Davis 1992), although Tiwi reportedly made annual trips to the mainland, a journey of around 40 miles, in the early 20th century (Stehlik 1986).

The divide between the western concepts of the sea as empty and disconnected from the land is highlighted by observations made in 1959 by anthropologists Hart and Pilling who described Tiwi as surrounded by ‘the emptiness of a great sea’ (Sharp 2002: 208).

Larrakia

5.2.7 Larrakia country lies in the Darwin region (Bourke 2000). Their population was estimated to be 500 at the time of invasion, though this was possibly much higher previously as the group was severely impacted by an outbreak of smallpox (Foelsche 1882). Larrakia were allied and intermarried with Wulnar, whose Country lies west of Adelaide River (Bourke 2000). At the time of invasion, it is estimated that groups inhabiting the coastal plains of the Adelaide and Mary Rivers numbered up to 1500 people (Bourke 2000; Ritchie 1998).

5.2.8 European invasion of Larrakia country began in the late 19th century. As such, there is limited information on pre-invasion cultural practices (Bourke 2000). Around this time, the Macassan peoples travelled from Sulawesi and began interacting with groups within the study area which has further influenced the record of social structures, language and cultural practices as recorded within the literature (Bourke 2000).

5.2.9 The Larrakia were described in 1936 by the Acting Chief Protector, W. B.Kirkland, as ‘naturally salt-water people’, describing their close connection with the sea. Eylmann (1994) notes that Larrakia would spend days on the open sea using bark canoes, along 30km of coastline and the Adelaide River (Hordern 1989). The Larrakia have been dispossessed of their country more than many groups in the study area, being pushed to the edges of their country as the city of Darwin expanded (Sharp 2002). Despite this, the Larrakia have retained close connection to the islands and coasts of their country.

Kakadu

5.2.10 After visiting the Kakadu region in 1912, Baldwin Spencer reported that:

> *'the Kakadu is one of a group, or nation, of tribes inhabiting an unknown extent of country, including that drained by the Alligator River, the Coburg Peninsula, and the coastal district, at all events as far west as Finke Bay.' (Spencer 1912, 1).*

5.2.11 Prior to invasion, there were more than twenty groups living in present-day Kakadu National Park. The Park ranges from the West to East Alligator Rivers and south to the Mary and Katherine rivers. In the aftermath of Spencer's touring across the region, Kakadu population decreased (Spencer 1912). This is likely a result of fever, influenza, venereal disease and infection that were introduced to the Kakadu population post-invasion.

5.2.12 Six language groups remained in the East Alligator River region in the 1970s (Welch 2008). In Kakadu, clans (gunmogurrgurr) overlap in territory and contain members from different language groups. Gunmogurrgurr is defined by shared territory and the inheritance of the group leader (Welch 2008 in Spencer 1912).

Social structure

5.2.13 Amongst the groups within the terrestrial study area, Tiwi and Yolŋu appear to have retained pre-invasion structures of territoriality. Cultural practices on these countries appear to have resisted the influence of European invasion more so than other parts of the study area (Davis et al. 1992). It is notable that Tiwi and Yolŋu social organisation is distinct from that of most other groups within the study area (Foelsche 1888).

5.2.14 Foelsche (1888) notes that tribes of Kakadu nation (Coburg Peninsula and Alligator Rivers region); Larrakia (Darwin region) and Tiwi Islands demonstrated local organisation, which determined marriage structures. This is in contrast to the distinct 'class' organisation found amongst other mainland groups in the terrestrial study area. He suggests that intermarrying groups amongst the Iwaidji and others may be remnants of pre-invasion 'class' structures. These 'class' structures comprised two moieties divided into two or our classes or sub-classes: some, but not all, had distinct names. These class structures defined marriage practices and were both matrilineal and patrilineal.

5.3 Settlement and subsistence patterns

5.3.1 Ludwig Leichardt travelled across the escarpment to the head of the South Alligator River and port Essington in 1844 and 1845 (Leichardt 1847). While doing so he made numerous invaluable observations about human activities in the region. In 1845, he recorded a range of subsistence activities including shellfish gathering along the South Alligator River and coastal margins and associated debris including freshwater mussels discarded on the banks of this river (Leichardt 1847, 488), and low mounds of marine shell along the coast (Leichardt 1847, 504-5).

5.3.2 Spencer (1928), Basedow (1907) and Foelsche (1882) provide useful accounts of resource gathering activities in the region, recording regular use of swamps and lagoons to catch fish, geese, ducks, turtles, crocodiles and gather eggs, shellfish and the roots of water lilies and rushes. Wallabies, kangaroos and flying foxes were hunted in eucalypt forests and grasslands. Resources were harvested seasonally and in ways left behind material traces, a scenario discussed by Meehan with reference to the process of gathering, eating and discarding of shellfish in the Blythe River estuary (Meehan 1982, 114-120). These sites included a series of features including ephemeral shell scatters at ‘dinnertime camps’ and much larger middens, alongside a variety of other cultural features, at ‘home bases’.

5.3.3 Reconstructing pre-invasion settlement practices and population numbers is difficult, although early accounts suggest population numbers in the terrestrial study area were large. Leichardt, for example, records crowds of up to 200 people within settlements of numerous huts, paths and fireplaces (Leichardt 1847). Leichardt’s account identifies a striking paucity of people/ camps on the plateau, in direct contrast to plains on the South Alligator River and mouth of the Coburg Peninsula that contained up to 200 people, numerous oven-shaped huts, fireplaces and paths (Leichardt 1847, 526). These fragmentary records suggest year-round occupation of the plains, with seasonal shifts as people alternated between wet season huts and unsheltered camps at the start of the dry season (e.g., Leichardt 1847, 527). This is comparable to accounts of the Tiwi Islands, where wet season camps near the sea were abandoned during the dry season in favour of camps on sandy banks, amongst the mangroves, or near swamps (Campbell 1834).

5.3.4 Leichardt (1847, 506) reported a conflict between the desire to live near food or water. The latter was often prioritised, however, an instance was recorded in which a hill camp was established with water taken up to camp in ‘Koolimans’ (Leichardt 1847, 506). Baldwin Spencer provides a similar account of a dry season in which Oenpelli communities, near the East Alligator River, claimed a hill each night to escape the mosquitoes with ‘the women carrying their piccaninies and pith containing water and stores with roots, dams, and other food’ (Spencer 1914, 31-2).

5.3.5 Betty Meehan’s seminal study of the Gidjingali / Anbarra people of Arnhem Land provides insight into patterned disposal of shellfish, divided into ‘dinnertime camps’, ‘home bases’, and ‘processing sites’ (Meehan 1982:112-118). Dinnertime camps were ‘often situated beneath the shade of a tree on or close to beaches around the river mouth. Normally they are adjacent to shell beads into a supply of fresh water, though the latter is not always the best quality because these wells are not cleaned out regularly like those associated with home bases’ (ibid: 112). These may be single use events or visited repeatedly and usually consisted of one or two holes and discrete piles of shellfish and other debris (ibid: 114). These were described as repeatedly used sites, often containing midden quantities of shellfish, formed by scraping debris into piles away from the living areas. These sites also contained a complex of features including multiple hearths around which may be a scattering of debris. Processing sites consisted of the remains of single species in the immediate vicinity from shellfish beds from which they were collected. No clear locations were provided for home bases or processing sites, however, Meehan confirmed that all these site types that occurred ‘within a few kilometres of the Blythe River’ (1982: 118).

5.3.6 Many studies of this region emphasise the spiritual lives of its communities (e.g., Berndt and Berndt 1970; Thomson 1949; Morris 2001). A wide variety of sites were used for ceremony, and natural places modified by humans were also imbued with mythological significance. Some sites were avoided entirely as these were considered 'dangerous' places in the cultural landscape (e.g. Christian and Aldrick 1977, 54-56). Identifying these kinds of sites is not straightforward, and ceremony grounds and associated stone arrangements are found in a variety of different environments (Christian and Aldrick 1977, 54-56).

5.4 Ethnohistory conclusions

5.4.1 Ethnohistorical accounts suggest that communities within the terrestrial study area occupied permanent and semi-permanent camps on floodplains and along the coastline. Settlements were often located close to fresh water sources including rivers, creeks, lakes, and swamps. This was not always the case, however, and hills and other elevated areas were occupied seasonally. People likely moved seasonally between lowland settlement areas, the coastline, rivers, and elevated areas to exploit different resources and this will likely be reflected in the coastal and riverine distribution of shellfish scatters, middens, and hearths.

6 TERRESTRIAL ARCHAEOLOGICAL REVIEW

6.1 Review of archaeological work in the study area

6.1.1 This section presents an overview of major pieces of archaeological research undertaken in the terrestrial study area.

6.1.2 Published archaeological research within the terrestrial study area spans over seventy years (see Table 6 for examples) however, has largely focused on the Arnhem Land Escarpment (e.g. Allen and Barton 1989; Jones 1985; Schrire 1982) and flood plains (e.g. Brockwell 1992; Bourke 2000; Clark and Guppy 1988; Woodroffe et al. 1988).

Table 6: Overview of published archaeological research within the terrestrial study area.

Year/s	Researcher/s	Main excavation sites
1948	C Mountford, F Setzler et al	Groote Eylandt, Milingimbi, Injalak Hill
1964-66	C. White (Schrire)	Paribari, Nawamoyn, Jimeri I, Jimeri II, Malangangerr
1972-73	H. Allen, J. Kamminga	Ngarradj Warde Djobkeng, Malakunanja II, Daberr, Nauwalabila, Balawuru, Nangalawurr and Nawulandja
1977	H. Allen	Ngarradj Warde Djobkeng
1981-1987	R. Jones, B. Meehan, J. Allen, I. Johnston, S. Brockwell	Anbangbang I and II, Djuwarr, Spirit Cave, Yiboiog, Blue painting site, Ki'na, Nauwalabila I, Kumunkuwi, Kun-kundurnku
1987	C. Woodroffe, J. Chappell	A-P
1988	R. Jones, M. Smith, R. Roberts	Malakunanja II, Malangangerr
1991-93	P. Hiscock	N/A
2000-2002	P. Faulkner	141 sites (16 excavated) in Blue Mud Bay
2000-	P. Bourke	Coastal sites all
2007+	S. Brockwell, J Stevenson et al.	Flood plain sites
2008-11	D. Shine, D Wright	Bindjarran (East Alligator River Ranger Station) - PhD
2012+	C. Clarkson, B. Marwick, L. Wallis, M. Smith, R. Fullagar,	Malakunanja II (Madjedbebe)

6.1.3 The earliest research in the terrestrial study area with a strong archaeological focus occurred during the 1948 National Geographic Society expedition to Arnhem Land. This involved Australian and American scientists who completed detailed rock art recording (e.g. Charles Mountford) and conducted numerous rock-shelter excavations (Frederick McCarthy, see May 2009). The results of this study initiated many decades of further archaeological research, notable amongst which was doctoral research by Carmel White (now Schrire). This resulted in excavation of what were then the earliest known ground-edge stone axes in the world and evidence for rock-shelter settlement activity spanning Pleistocene and Holocene periods (e.g. Schrire [White] 1982). Rhys Jones (1985) led another significant project in this area, excavating (amongst other sites) 50,000 year old cultural deposits at Malakunanja II, now called Madjedbebe) and Nawamoyn. Excavation slowed over the next 30 years, followed by a substantial increase in archaeological fieldwork after 2008. This included field teams in the Wellington Range of north-west Arnhem Land, the Red Lily area near the East Alligator River and the Jabiluka Leasehold area surrounded by Kakadu National Park, and Jawoyn Country in the southern half of the western Arnhem Land plateau (e.g., David et al. 2017).

6.1.4 Research has also been conducted in coastal and estuarine regions within the terrestrial study area. The majority of excavations have focused on large shell (Anadara) mounds and middens, such as those in the immediate vicinity of Darwin harbour (Bourke 2004; Brockwell et al. 2020; Hiscock 2007). Two of the largest such studies were completed by Patricia Bourke (2000), focusing on shell and earth mounds, also Pat Faulkner in Blue Mud Bay, north-eastern Arnhem Land. The latter recorded over 140 sites and included 16 excavations (see below; Faulkner and Clark 2004).

6.1.5 There are obvious limitations when using the results of previous, terrestrial archaeological research to inform predictive modelling of submerged cultural heritage in the study area. The first is that settlement practices surviving on predominately late Holocene coastlines and hinterland interior may differ substantially from those occurring along the flooded, early Holocene coastal fringe. Additionally, preservation issues and sampling bias are likely to skew results towards particular site forms (e.g., rock shelters) and robust cultural materials (e.g., lithic artefacts). Finally, it is acknowledged that predictive models have limitations when applied to the terrestrial study area due to the small sample size of published archaeological projects occurring in this region that were available to the authors of this report.

6.2 Settlement patterns

6.2.1 The settlement patterns of the Northern Arnhem Land coastal margins fit within those broadly observed for the East Alligator River region, in which coastal resources were utilised throughout the Late Pleistocene and Holocene (Hiscock 1999). This can be summarised as follows:

Early phase (50,000 – 9,000 years ago)

6.2.2 At the start of this period, sea level was approximately 120-140 metres lower than it is today, during which time the coastline in the study area would have been over 100 km away from its current position and the Alligator Rivers and floodplains were yet to develop. The climate was drier and cooler than it is today, although seasonal wet and dry climates were already in place. The Late Pleistocene period appears to have been associated with broad river valleys with eucalypt woodland.

6.2.3 Archaeological research in the Alligator Rivers' region suggests that people have been living in limestone rock shelters along the edge of and on Arnhem Land escarpment and outliers from at least 50,000 years (Brockwell and Tacon 1995, 681; David et al. 2013; Schrire 1982; Jones 1985; Roberts et al. 1990; 1993; 1998). Rock shelters continued to be occupied during the subsequent 40,000 years, including the Last Glacial Maximum (between 25,000-18,000 years ago), when many areas of Australia were experiencing abandonment as people moved to refugia (e.g. Hiscock 2007, 60). In western Arnhem Land sites occupied during and after this period include Ngarradj and Malakunanja II (Madjedbebe), Nauwalabilla, Nawulandja (Allen 1989; Clarkson et al. 2015). In the Wellington Range region of north-western Arnhem Land rock shelters also appear to be targeted during the past 25,000 years, suggesting similar use of such sites as refuges (e.g., Wesley et al. 2018).

6.2.4 Many of the cultural sites dating to this period are likely to have been located on the vast expanse of now submerged land . While there is limited archaeological evidence dating to this period, in addition to the ‘deep time’ limestone rockshelters on the Arhnem Land escarpment, there is also evidence from the Vanderlin Islands within the study area, and the Whitsunday Islands, Queensland (Barker 2004; Sim and Wallis 20072008). This lack of evidence may be a reflection of a bias in archaeological investigations or differential preservation of material culture.

Middle phase (9000-4000 years ago)

6.2.5 This phase is characterised by major environmental change (Woodroffe et al. 1988). By 7000 years ago temperatures had risen and sea level had reached approximately 4 - 6 metres below current levels. By 6000 years ago islands were separated from the mainland by rising seas and the Kakadu plains flooded. Pollen and seed records suggest that vegetation changed from woodland and open forest to grasslands and large mangrove swamps (Woodroffe et al. 1988). These habitats offered opportunities for new plants, animals, and shellfish.

6.2.6 The archaeological record suggests that environmental change was accompanied by settlement change as people moved down from the escarpment, settling in rock-shelters along the edges of vast swamps and floodplains (e.g., Pari Bari and Jimeri) and outlier sites (e.g. Anbangbang I, Nangalwurr and Bindjarran) (Allen 1989; Jones 1985; Shine et al. 2015). The movement of the coastline inland with rising seas is reflected by the presence of saltwater shellfish at outlier rock-shelters including Nawamoyn (dating to 8182-7679 calibrated years ago), Malangangerr (at 7231-6490 cal. years ago), Malakunanja (at 7463-7013 cal years ago) and Madjedbebe (at 7679-6664 cal years ago) (Kamminga and Allen 1973; Schrire 1982; Allen and Barton 1989). At Nawamoyn and Ngarradj shellfish dominate the archaeological assemblage soon after establishment of the mangroves, approximately 7000 years ago (Brockwell et al. 2011: 5).

6.2.7 Freshwater species (e.g., turtle, fish, swamp birds, mussels and plants) are also present in the archaeological record showing that Bininj were exploiting freshwater lagoons during this time. The change in subsistence to include freshwater species is marked by a change in stone tools, from large flakes and cores to small projectile points, scrapers and edge-ground axes (Schrire 1982: 239).

6.2.8 There is little archaeological evidence for cultural activity on the coastal margins or offshore islands in this period, which could be a reflection of the rapidly changing environment as the coastline rapidly rose and people sought stable environments. The majority of Northern Australia’s offshore islands support the suggestion of a hiatus in human habitation until approximately 4000 years ago (e.g., Sim and Wallis 2008). Morrison et al (2023) discuss the potential mechanisms and reasons behind the abandonment of many coastal islands during this period, with exceptions in the Torres Strait (Wright et al. 2013) and Whitsunday Islands (Barker 2004) where there was persistence of island rich seascapes (Morrison et al 2023).

Late phase (4000-present)

6.2.9 After 4000 years ago, there was a gradual transition in the lowlands from saltwater estuaries and swamps to freshwater floodplains. During the subsequent 2500 years, the mangroves retreated and were replaced by grasses and sedge. The rich freshwater Kakadu wetlands of today and coastal beaches date to the past 3000 years (Allen 1989, 99). This period is characterised in the study area by three key site types: shell mounds and middens, earth mounds, and stone fish-traps.

6.2.10 Over the last 3000 years, the quantity and size of open archaeological sites (artefact scatters and shell mounds) on the flood plains (e.g., Yiboig, Spirit Cave) and coast increased, suggesting a shift in subsistence activities as the resource rich saltwater/freshwater wetlands formed. Sites include large shell middens (from 5700 BP; Hiscock and Mowat 1993) and Anadara shell mounds (after 3000 years ago). Such sites are found across the northern coastline of Australia from Kimberley to Cape York (Bailey 1991; Mitchell 1993).

6.2.11 Earth mounds, long argued by anthropologists to provide dry foundations for habitation sites, are found across northern Australia on the coastal plains that formed during this period. These features are recorded at Milingimbi, Arafura Swamp and the Blyth River in Arnhem Land, Kakadu, the Mary and Adelaide Rivers, Darwin Harbour and Reynolds River (Brockwell 2006).

6.2.12 Stone fish-traps are ubiquitous across Australia, and found across the offshore northern Australian islands, although more commonly in northeastern Australia rather than within the study area. The majority are likely to date within the last 4000 years (Rowland and Ulm 2011, 42). According to Hiscock (1999; see also Jones 1985, 292), the increasing use of fish-traps coincides with the abandonment of rock-shelters, swamps, and grassy plains as people begin to intensively settle and exploit coastal floodplains and beaches. The increase in the number of archaeological sites found that date to this period may reflect the stabilisation of the coastline and coastal ecosystems after inundation.

6.2.13 The last 2000 years, likely marks a phase of further intensification of activity on coastal floodplains in the form of shell and earth mounds, along with artefact scatters and quarries (Allen 1989; Brockwell 2006; Hiscock and Mowat 1993; Faulkner and Clarke 2004; Hiscock and Faulkner 2006). Several such sites have been recorded in the study area including around Darwin Harbour (Bourke 2000; 2002; Burns 1994; 1999; Hiscock 1997; Hiscock and Hughes 2001) and the Cobourg Peninsula (Mitchell 1993; 1994). These sites are frequently located at economically rich areas; at the junction between hinterland and mangroves on low hill slopes, laterite platforms and salt flats (Bourke 2000:73; Bourke 2002:37; Burns 1999:59, 62-64). Further reductions in rock shelter activity have been noted during this period, including at Malangangerr, Nawamoyn, Ngarradj, Malakunanja II and possibly Paribari (Allen 1989, 113). The only recorded shelters occupied during this period were close to stable freshwater lagoons or rivers (e.g., Nawulandja and Anbangbang).

6.3 Implications for predictive modelling

6.3.1 The occupation record of coastal areas (including some islands) within the terrestrial study is continuous throughout the Holocene. This, coupled with the centrality of sea realms to the worldviews, subsistence, and technologies of some contemporary, coastal Aboriginal communities (e.g., Bradley 2010; Keen 2004; McNiven 2004, Sharp 2002) suggests that rising seas flooded many coastal sites (Morrison et al 2023). Oral histories may preserve the histories of some sites (Nunn and Reid 2016), as was recently claimed after the discovery of a submerged rock-shelter at the north end of the Marchinbar Islands (McCarthy et al. 2022, 72).

6.3.2 As noted by McCarthy et al (2022, 74) 'The regional character of archaeological material culture from the Northern Territory has a significant bearing on the search for submerged sites'. The following trends, in particular, are worth noting in reference to the archaeological sensitivity of the terrestrial study area.

- Limestone caves and overhangs are strongly associated with occupation activity in the Northern Territory and offer an attractive target for research. Sampling bias partially explains this Pleistocene to Holocene phenomenon, however, as noted above there is considerable evidence to suggest these sites were targeted during glacial periods. Should we expand our sample size to include Pleistocene sites in adjoining Papua New Guinea and elsewhere in Australia, the archaeological record might indicate the importance of other landforms, including terraces and caves.

- Proximity to fresh water (river and creek systems, estuaries, swamps and floodplains) appears to be a focus of settlement activities in both the Pleistocene and Holocene periods (Allen and O'Connell 2003). Holocene earth mounds consistently located near stream systems, lakes and swamps.

- Within the terrestrial study area, raw material quarries typically constitute quartz, quartzite, silcrete, fine-medium grained sandstones, mudstone, and a wide range of volcanic stone.

- Stone arrangements and some fish traps may be preserved in maritime environments. Historical records suggest, however, that fish traps in the Northern Territory (as opposed to Queensland) mainly used organic materials. Base stones were used in the Crocodile Islands (McCarthy et al. 2022, 75).

- Shell mounds were often positioned on ancient cheniers, beach slopes or raised rocky knolls and are located anywhere between 100m from the present day coastline to a few kilometres away (Bailey 1977; 1999; Woodroffe et al 1988; Hiscock and Mowat 1993; Faulkner and Clarke 2004; Hiscock and Fulkner 2006). Meehan (1982, 2) suggests shell mounds are unlikely to be found offshore. As noted by McCarthy et al (2022, 75), however, researchers outside this country have identified shell middens that have partially survived inundation.

- Earth mounds can be divided into two distinct types, coastal/estuarine and freshwater.

- Shell mounds, earth mounds and middens usually occur on the coastal fringe, at the junction of a number of resource zones and between the hinterland and the sea, on low hill slopes, laterite platforms and salt flats.

6.3.3 It is also worth reiterating recommendations provided elsewhere:

“Darwin and Bynoe Harbours provide varied and partially sheltered environments with maximum availability of facilities to support fieldwork. Shorelines in Darwin Harbour are generally prograding, while Bynoe Harbour shows a more attractive mix of prograding and retrograding coasts. More remote areas attractive for prospection include the Tiwi Islands, the Wessel Islands, the Gulf of Carpentaria, Groote Eylandt and the Sir Edward Pellew Islands, where the focused energy of currents and tides may provide windows of opportunity through erosion of sediments.” (McCarthy et al. 2022, 74).

7 ARCHAEOLOGICAL PREDICTIVE MODEL

7.1.1 Use of a terrestrial analogue, or model, reflects international best practice for submerged palaeolandscape research (English Heritage 2013, BOEM 2020, Veth 2020), and is common practise for terrestrial Aboriginal archaeological research in Australia.

7.2 Sensitivity modelling

7.2.1 This section presents a predictive model of archaeological sensitivity within the terrestrial study area, based on the research presented in Sections 4 and 5 above.

7.2.2 Table 7 outlines the landforms and landscape characteristics that our desktop research indicates as likely to be associated with an elevated level of archaeological sensitivity, whilst Table 8 illustrates the relationship between the sensitivity values and levels of sensitivity.

Table 7: Landscape attributes contributing to the sensitivity model.

Attribute	Dataset	Sensitivity Adjustment
Coastal Dune	250k Mapped	3.0
Perennial Stream of Strahler Order 4 or Higher	Mapped	3.0
Non-perennial Stream of Strahler Order 4 or Higher	Mapped	2.0
Wetland	30m DEM Derived TWI	3.0
Cave and Overhang Forming Potential and Stone Resource Potential	250k Mapped and 30m DEM Derived Slope	3.0
Ridgeline	30m DEM Derived	3.0
500m from Coastline	Calculated	1.5
1km from Coastline	Calculated	1.0
5km from Coastline	Calculated	0.5

Table 8: Sensitivity scores and values

Sensitivity	Adjusted Sensitivity Values
Low	0.5-1.0
Medium	1.5-2.5
High	3.0-4.0
Very High	4.5-8.5

7.2.3 In particular, the following key landscape characteristics and traits were identified as a result of the desktop research:

Escarpments and ridgelines, where there is potential for caves and rock overhangs

7.2.4 Escarpments and outcrops on limestone and sandstone lithology are particularly conducive to formation of caves and rock overhangs that may have been utilised as shelters, especially during the Pleistocene. Rock shelters have the potential to retain deep well-preserved profiles containing stratified archaeological deposits that may extend into deep time Pleistocene occupation.

7.2.5 Current research indicates large shelters and caves were the focus of occupation during the Pleistocene because they offered 'refugia' during these periods of climatic extreme. It is likely that rockshelters were the primary focus of occupation on areas of the submerged landscape that were occupied btw 60ka and 9ka. Of interest here might also be periods of relative sea level stability where coastal cliffs might have formed on limestone or sandstone parent materials.

Areas of land in close proximity to higher order drainage lines

7.2.6 There is likely to be a higher frequency and density of archaeological deposits in areas where reliable fresh water is available or was available in the past, and where associated food and fibre resources were also more plentiful.

7.2.7 After 4ka there was a transition in the lowlands from saltwater estuaries and swamps to freshwater floodplains. During this period the mangroves retreated and were replaced by grass and sedge lands. The freshwater Kakadu wetlands and coastal beaches all date within the last 3,000 years and took final form as the mid Holocene high stand retreated and stabilised at current sea level.

Areas within close proximity to coastline

7.2.8 There is likely to be a higher density and frequency of archaeological deposits in areas that are located in close proximity to the current coast and former coastlines. In particular, there is an elevated potential for shell middens and shell mounds, and an elevated potential for occupation deposits in resource intersection zones where there is a greater diversity and richness of food, fibre and water resources.

Wetlands

7.2.9 There is likely to be a higher density and frequency of archaeological deposits in close proximity to current and former wetlands (both freshwater and saline wetlands). These resource rich environments are an important source of food, fibre and water resources and there is an elevated potential for the presence of earth mounds in close proximity to water bodies and watercourses in hinterland areas.

7.2.10 Current research indicates a shift during the period 9ka – 4ka from the escarpment country down onto lowlands to exploit the resources of swamps, floodplains and estuaries. Pollen evidence indicates environmental shifts during this period from woodland and open forest, to grasslands and swamps. This is particularly the case around 6ka when seas separated Tiwi Islands from the mainland and flooded the Kakadu Plains.

Dunes

7.2.11 Stable dunes are likely to retain a higher density and frequency of archaeological deposits and provide deep profiles with greater preservation potential. There is also potential for burial of ancestral remains within dune systems.

7.3 Data management and limitations

7.3.1 The sensitivity modelling presented in this section utilises general archaeological patterns that have emerged from the desktop review. However, the lack of access permitted to site spatial data for archaeological sites in the region limits the robustness of the model.

7.3.2 Instead, the model uses existing and derived topographic and environmental datasets to identify areas assessed as having relatively higher archaeological sensitivity than other areas within the terrestrial study area.

7.3.3 The sensitivity model was created by adding sensitivity adjustment scores for each topographic or environmental feature on the landscape. Adjustment scores were assigned based on the significance assessment from the above desktop review. Where two or more environmental or topographic features overlap, their sensitivity adjustment scores were added together to form the final model output. Where possible, the model has been ground-truthed for accuracy by aerial imagery review, however, the resolution of the input data is the limiting factor for the spatial fidelity of the final model.

7.4 Hydrology and wetland modelling

7.4.1 Archaeological place patterning is significantly driven by proximity to fresh water, according to the above desktop review. Spatial data exists for watercourses within the study area (Figure 8), however there is no environmental dataset available relating to wetland areas.

7.4.2 Wetland areas were modelled using the Topographic Wetness Index (TWI) derived from the 30m resolution digital elevation model. TWI is an algorithm that calculates a value for each cell based on the following formula:

$$TWI = \ln((\text{upslope contribution} + 1 \times 30) \div (\tan(\text{slope})))$$

7.4.3 Upslope contribution was derived using the SAGA Flow Accumulation tool in QGIS. Slope was derived from the 30m DEM, corrected to contain no zero values and converted to radians. Thus, the TWI is the natural logarithm of the upslope contribution (corrected for cell size, in this case 30m) divided by the tangent of the cell's slope.

7.4.4 This provides a model of locations within the study area where water is likely to collect and be stored, which approximates wetland areas (Figure 11). This does not indicate that areas with high TWI are perennial wetlands but shows where wetland areas may occur in the wet season. Only areas with TWI of 14 or higher were used to identify areas of potential wetland (Figure 12).

7.5 Caves and overhangs on escarpments and ridgelines

7.5.1 The desktop review identified ridgelines and escarpments as areas of potential sensitivity that may contain caves, and overhangs that may have been utilised as rockshelters for occupation, art and other cultural activities. Accordingly, areas containing these landforms were extracted from the DEM analysis and published geological mapping.

7.5.2 Ridgelines (Figure 13) were identified using the Topographic Wetness Index where the TWI was less than 3; in other words, areas at the highest elevations between drainages which have little to no upslope contribution. Linear formations derived by TWI were classed as ridgelines and given a 20m buffer to account for input data variation.

7.5.3 1:250k geological mapping (Figure 14) was examined to identify geologies that are prone to cave and overhang formation and have the potential to contain stone resources, summarised in Table 9. However, the mapped bedrock geology does not account for landforms where caves, overhangs or stone exposures are likely to occur. In order to identify these areas, slopes of higher than 20 degrees were derived from the DEM (Figure 15). Then, areas where high slope coincide with the appropriate geology were extracted and mapped as areas of cave forming and stone resource extraction potential (Figure 16).

Table 9: Geological classes informing cave- and overhang-forming, and stone resource potential areas.

Lithological Description
Conglomerate, sandstone, mudstone, diamictite
Dolostone, limestone, sandstone
Dolostone, sandstone
Dolostone, shale, sandstone
Gneiss, schist, calc-silicate, para-amphibolite, metabasite
Granite
Granite, gneiss, schist
Granite/gneiss
Greywacke, shale, siltstone, sandstone
Greywacke, shale, siltstone, tuff, phyllite, chert, carbonaceous shale, BIF, dolostone
Limestone, shale
Sandstone, conglomerate
Sandstone, conglomerate, greywacke
Sandstone, conglomerate, mudstone
Sandstone, dolostone, magnesite
Sandstone, greywacke, shale
Sandstone, limestone, shale, coal, diamictite
Sandstone, shale
Sandstone, shale, dolostone
Siltstone, shale, sandstone

7.6 Predictive sensitivity model output

7.6.1 The sensitivity model incorporates environmental and topographic landscape elements that have been identified as having a greater likelihood of archaeological activity. The model itself does not indicate that all areas of high sensitivity are archaeological sites, but indicates areas within the landscape where archaeological sites are more likely to be found.

7.6.2 Figure 17 shows the predictive sensitivity model for the entirety of the study area and Figure 18 shows the north-western portion of the study area that is in immediate proximity to the Barossa GEP study area. Areas of darker red correspond to areas of higher sensitivity.

7.7 Transferability of terrestrial model to submerged landscapes

7.7.1 Predictive modelling of archaeologically sensitive landscapes and landforms is common prior to land-based research projects in Australia, and the modelling work is commonly followed by ground truthing of these models via archaeological survey and excavation. In comparison to datasets available for terrestrial modelling, comparable datasets in marine contexts are considerably less well developed, and are currently entirely absent in marine environments in Australia. With limited research on the submerged palaeolandscapes of Australia, the application of terrestrial predictive models as analogues for submerged palaeolandscapes has proved promising as a precursor to investigating the archaeology of submerged palaeolandscapes (Veth et al 2020). While there are inherent sampling and research biases associated with data used to develop archaeological predictive models (for example, see discussion in Verhagen et al 2010), especially when applying them to deep time landscapes, they do offer a best practice approach to the initial identification and appraisal of landforms and features that are likely to have a greater level of archaeological sensitivity.

7.7.2 It is possible to identify a vast range of geomorphological features within bathymetric and sub-bottom data. A comprehensive list of seabed geomorphological features is detailed fully in Dove *et al.* (2020) and Nanson *et al.* (2023). Of particular interest to the archaeological examination of submerged palaeolandscapes are the following features:

Feature type	Description
Channel	Channel cuts and associated infill deposits. May indicate extensions of present-day terrestrial systems or now unconnected channels. May include both fluvial and estuarine environments. Can be described as filled, underfilled, or unfilled, simple (one phase of fill) or complex (multiple phases of fill). Archaeological potential for *in situ* and secondary context artefacts. Infill deposits may also be of palaeoenvironmental interest.
Cut and fill	As per channel features. Cut and fill is used as a descriptor when the feature of interest cannot be traced over a significant distance. Generally used for isolated feature Can be described as simple (one phase of fill) or complex (multiple phases of infill).
Infilled depression	Small isolated infilled features, generally infills of previous topographic depressions. May include remnant features formed by erosion or be associated with inter-tidal deposits. Potential for *in situ* and secondary context artefacts. Infill deposits may also be of palaeoenvironmental interest.
Gravel terrace / Bank	Features associated with the edge of channels/cut and fills, or within channel features. Archaeological potential of in situ and secondary context artefacts
Palaeoshoreline / strandplain	Features associated with ancient coastlines, such as beach deposits, dune formations, cliff/escarpments. Archaeological potential for remains of shell middens, fish traps, along with *in situ* and secondary context artefacts.
Dune systems	Ridges associated with coastal systems have features that indicate a degree of reworking since their deposition, likely to have occurred during marine transgression. Dunes of coastal, rather than seabed origin have different orientations, usually being unrelated to seabed topography, and subparallel to the palaeoshoreline. Archaeological potential for remains of shell middens, burials, along with *in situ* and secondary context artefacts.

Escarpment / cliff features	Outcrops of bedrock platforms. Depending on the geology, potential for cave/shelters and for associated *in situ* deposits.
Fine-grained deposit	Deposits of fine grained material, often identified through parallel bedding/laminations in the data. Can preserve organic material and of potential palaeoenvironmental interest.
Coarse-grained deposit	Deposits of coarse grained material, often identified through acoustically chaotic areas within the data. Can represent deposits such as channel lag gravels and reworked/redeposited terrace material. Archaeological potential for secondary context artefacts
Erosion surface	Generally broad scale, regional features associated with erosion during transgression and regression, or during periods of significant subaerial exposure. May include ravinement surfaces (transgressive erosion surface resulting from nearshore marine and shoreline erosion associated with a sea-level rise), or indicate past land surfaces.
High amplitude reflector	Strong, usually relatively flat/horizontal reflector. Often indicative of sediments containing a high percentage of organic material, or peat. Indicator of former terrestrial land surface. Potential for in situ and secondary context artefacts, and deposits are often of palaeoenvironmental interest. Generally associated with other terrestrial features such as channels, cut and fills or erosion surfaces.
Acoustic blanking	Areas of data masked by features within the sediment. Generally indicative of shallow gas, but can occasionally be caused by coarse grained deposits. Shallow gas may indicate the presence of organic matter/peat at a particular layer caused by microbial activity. Shallow gas can also be sourced from depth migrating to the surface along migration pathways. Discrimination is made during the assessment and only shallow gas thought to be associated with the presence of organic matter is recorded. Generally associated with channel infills, cut and fill features and erosion surfaces.

7.7.3 The features listed above provide the geophysicist with a range of features that, if seen within the data, may be of archaeological potential. There are many site types, such as culturally modified trees, pigment art sites, and burials within mobile sand dunes that are unlikely to have survived the process of inundation, (although sand dunes were identified within the offshore study area Figures 25 and 26). The potential survival of site types such as stone artefact deposits and shell middens will also be heavily dependent on localised preservation conditions and the specific processes of inundation during particular periods of sea level rise and how that applied on different terrain and lithologies.

7.7.4 The angle of slope, wave fetch, speed of inundation, site context (for instance, deep stratified deposits within a rockshelter site on limestone lithology compared with surface artefact scatter on an exposed rock outcrop surface) and site density (for instance, dense shell forming a lime-rich cemented deposit compared with a sparse artefact scatter within loose sandy loam topsoils) will all be important factors in the potential for the survival and integrity of any submerged Aboriginal cultural deposits on the submerged landscape (Nutley. 2005; O'Leary *et al.*, 2023).

7.7.5 Investigations globally have repeatedly shown that palaeolandscape features, such as those listed in this report, are both identifiable within SBP and MBES data, and have also been found to contain archaeological and/or palaeoenvironmental material. The following suggestions were made with regards to potentially identifiable submerged geological features that are likely to have a higher potential for the survival of submerged Aboriginal archaeological deposits:

- **Land 200m either side of palaeochannels** that would have been present as creeks or rivers during the last 70,000 years. Palaeochannels can be over 1km wide and often represent the complexity and dynamic nature of seasonal waterways that may have included multiple braided channels, areas of stagnant water, and/or abandoned channels. Palaeochannels have proven to be highly productive with regards to the preservation of archaeological and palaeoenvironmental remains and are of particularly high archaeological potential.

- **Submerged land 200m from the perimeter of open/closed depressions**. Wetlands and water bodies will present as depressions within the submerged landscape.

- **Escarpments or ridgelines with slope length and slope class (gradient) conducive to form caves and overhangs**. Sandstone and limestone lithology is particularly sensitive.

- **Land within 500m of former shorelines**, particularly shorelines that were relatively stable over longer periods of time during relative sea level stability. This includes former standplains, coastal wetlands, and dune fields.

- **Dense shell mounds** are commonly found along the coast. They are of sufficient size that they could show up in marine geophysical data. Dense shell mounds may be the sort of feature that could survive inundation and there is some recent evidence that this is in fact the case (McCarthy et al 2022: 75). There is a potential that a combination of sea water admixed to the lime rich shell mound matrix may have effect of bonding and cementing the structure together. If this is correct, these features could well have survived inundation and be readily identifiable on the submerged landscape. Shell mounds are often found on ancient cheniers, beach slopes or raised rocky knolls, anywhere between 100m of current coastlines to a few kilometres inland.

- **Clay earth mounds** are a common site type found on recently formed coastal plains across northern Australia. Anthropologists suggest they were primary made to form dry platforms for habitation. These large, compacted features are durable and might have survived inundation in certain settings. Similar to the shell mounds, these are the sort of discrete feature that could potentially be detected with high resolution marine geophysical data.

- **Former islands** in the form of submerged high points on the sea floor may have been a past focus of offshore occupation and use.

- **Stone arrangements and fish traps** may be present but are likely to be fragile site types that have only survived in exceptional circumstances. This is considered particularly likely to be the case in the Northern Territory, where fish traps are mainly comprised of organic materials (McCarthy et al 2022: 75).

8 PALAEOGEOGRAPHIC ASSESSMENT

8.1 Overview

8.1.1 Palaeogeographic assessments are typically undertaken with reference to geological time periods that reflect major climate sea-level and/or environmental changes. This report uses the Marine Isotope Stage (MIS) record to distinguish between different climatic periods, which are deduced from marine palaeoclimatic records and reflect alternating warm (interglacial and interstadial) and cold (glacial and stadial) periods throughout the Quaternary.

8.2 Marine geophysical assessment

Sub-bottom profiler assessment

8.2.1 A number of palaeogeographic features of archaeological potential have been identified within the offshore study area. These features are discussed below, individually described in gazetteer format in Appendix II, and their distribution is illustrated in Figures 19a-j.

8.2.2 The identified geology within the study area has been divided into 7 phases, as described below in Table 10. This is based on both the SBP interpretation and the geotechnical log review (Section 8.3). Due to the limitations discussed in Section 1.5, it was not always possible to correlate the features identified in the SBP data with the lithological units identified in the geotechnical logs. As such, although only 6 lithological units were identified in the geotechnical logs, seven units were identified in the SBP data based on their stratigraphic position.:

Table 10: Shallow stratigraphy of the study area.

Unit	Unit name	Geophysical Characteristics [(1)]	Interpreted Sediment Type [(2)]	Lithological unit [(3)]	Possible Age	Archaeological Potential
7	Post-transgression sediments	Generally observed as a veneer or thickening into large sand wave and bank features. Boundary between surficial sediments and underlying units not always discernible	Gravelly sand with shell fragments, sand waves and ripples indicate sediment is mobile	Seabed sediments	(Holocene, MIS 1)	Considered of low potential in itself, but possibly contains re-worked artefacts and can cover wreck sites and other cultural heritage
6	Upper Channel	Small shallow infilled channels with either seismically transparent fill, or fill characterised by sub-parallel internal reflectors. Can have chaotic basal reflectors which cause acoustic blanking which may indicate biogenic gas or gravelly deposits	Fluvial, estuarine and terrestrial	Alluvium/non-marine sands	Holocene Sediments (Pre-transgression) (MIS 2 to 1)	Potential to contain *in situ* and derived archaeological material, and palaeoenvironmental material
5	Fine grained deposits	Generally a broad unit which can be acoustically quiet or characterised as having numerous horizonal reflectors	Inner shelf deposits. May represent recently deposited clastic sediments from the numerous rivers in the region or sediments deposited in floodplain/estuarine/lacustrine conditions prior to the marine transgression	Alluvium/non-marine sands	Holocene Sediments (Pre-transgression) (MIS 2 to 1)	Potential to contain *in situ* and derived archaeological material, and palaeoenvironmental material. However, as a broad, blanket deposit, it is considered of lower archaeological potential compared to Units 3,4 and 6
4	Channel Complex Deposits	Generally identified as multi-phase channel features with either acoustically quiet fill or with faint, parallel reflectors	Fluvial/terrestrial sediments.	Alluvium/non-marine sands	Pleistocene/early Holocene	Potential to contain *in situ* and derived archaeological material, and palaeoenvironmental material

Unit	Unit name	Geophysical Characteristics [1]	Interpreted Sediment Type [2]	Lithological unit [3]	Possible Age	Archaeological Potential
3	Lower channel	Small shallow infilled channels with either seismically transparent fill, or fill characterised by sub-parallel internal reflectors. Can have chaotic basal reflectors which cause acoustic blanking which may indicate biogenic gas or gravelly deposits	Fluvial, estuarine and terrestrial	Alluvium/non-marine sands/fluvial gravel	Pleistocene/early Holocene	Potential to contain *in situ* and derived archaeological material, and palaeoenvironmental material
2	Possible contourites	Identified as possible erosional features with complex fill of numerous dipping and onlapping reflectors, which are chaotic in some areas	Infill material of silts with interbedded fine sand with complex and variable bedding	Contourite drift	Uncertain. Possible Pleistocene deposits	Deposited in a marine environment and therefore considered of low archaeological potential, although there is some potential to contain derived archaeological material
1	Variably cemented sediments	Generally identified as a unit comprising numerous horizontal reflectors, of varying regularity and amplitude. Some localised evidence of faulting	Complex layered carbonate and siliclastic sediments with highly variable cementation. Includes carbonate bank and terrace systems. Can include aeolianite, calcarenite or calcirudite rich deposits	Carbonate sands and gravels	> MIS 5[4]	Considered of low archaeological potential in itself, although its upper surface may have served as a terrestrial land surface used during human occupation, particularly at bathymetric highs

[1] Based on geophysical data
[2] Based on geophysical characteristics, and survey reports (Fugro 2015a, 2018a; DOF 2018)
[3] Based on the geoarchaological interpretation of the geotechnical logs (Geoquip 2018)
[4] Based on Clarke and Ringis 2000

8.2.3 The oldest geological unit identified within the offshore study area is the variably cemented sediments (Unit 1). In the geophysical data it is characterised as having horizontal reflectors, of varying regularity and amplitude. In some areas, small, localised faulting is observed which may be related to tectonic activity during the early Pleistocene (Bourget *et al.,* 2013), although this is not certain. This is interpreted as being a mixed carbonate-silliciclastic sedimentary sequence that accumulated during the late Pliocene and Quaternary (around 3.5 Ma BP onwards) (Bourget *et al.,* 2013, George and Cauquil 2010). Bourget *et al.* (2013) identified two distinct periods: The first is a period of active carbonate platform aggradation during the late Pliocene and early Quaternary, followed by a phase of infilling of clastic and mixed sediments. Unit 1 is thought to be present across the entire GEP route, either directly at the seabed or beneath a veneer of Holocene sediments (Unit 7) throughout much of the central section of the route; or incised by Pleistocene or Holocene channels (Units 3, 4 and 6); or beneath a unit of fine-grained deposits of varying thickness (Unit 5) (Figure 20).

8.2.4 Unit 1 is thought to have been deposited over a significant time period from the Pliocene to the Quaternary (Bourget *et al.,* 2013). It should be noted that the sediment input is thought to have varied during this time; however, it is not always clear within the SBP data the boundary between the different sediment inputs. Clarke and Ringis (2000) suggest that the Pleistocene sandy carbonate deposits are likely to have been deposited before and during the 120,000 BP highstand (MIS 5). As a broad, blanket deposit with a variable depositional environment, the unit is considered of low archaeological potential and has been grouped as one; however, it should be noted that its upper surface is likely to have formed a terrestrial landscape that may have been used or occupied by humans.

8.2.5 In areas deeper than 125 m, a number of channel-like features have been identified in the SBP data. These are seen to have distinct basal reflector and complex fill with numerous lenses of dipping reflectors. Although channel-like in appearance, these are identified beyond the 125 m contour, suggesting the area has not been sub-aerially exposed and are therefore unlikely to be fluvial channel features. As such, these features have been interpreted as possible contourite channels (Unit 2) which are known to occur around the Australian coast (Eberli and Betzler, 2019), although this is not certain. The age of these features is uncertain, although radiocarbon dating of the sediments in 2018 suggest the fill of these features is beyond the carbon-14 dating range (Fugro, 2018c), which is approximately 50,000 BP (Reimer *et al.*, 2020; Davies, 2022). Given the depth these features are identified, they are not considered to be of archaeological or palaeoenvironmental interest and will therefore not be discussed further.

8.2.6 Cutting into the surface of Unit 1 are a number of possible channel features (for full list see Appendix II). These vary in size and form with some characterised by acoustically quiet fill and others with numerous parallel draped reflectors. The age of these features is uncertain, particularly where they are identified either at seabed level or beneath modern seabed sediments (Unit 7), cutting into Unit 1. However, in some areas, more than one phase of channelling is identified, separated by a unit of sediment (possibly Unit 5). In these cases, a different stratigraphic unit has been assigned to each of the channels depending on their position in relation to each other. Channels **7096**, **7098**, **7112**, **7114**, **7127**, **7149** and possibly **7151** (although this is less certain), are attributed to Unit 3 based on their position below later phases of channelling. Channels **7097**, **7113**, **7126**, **7148** and **7151** are attributed to Unit 6 (Figure 21). The stratigraphic units of the remaining channel features are uncertain.

8.2.7 Research by Fogg *et al* (2020) suggests that the MIS 4 and MIS 2 lowstands are identifiable in seismic data by being characterised by incised channels, with MIS 3 deposits being more planar. It is therefore possible that channels **7096**, **7098**, **7112**, **7114**, **7127**, **7149** and possibly **7151** could be attributed to MIS 4 and channels **7097**, **7113**, **7126**, **7148** and **7151** attributed to MIS 2; however, it would not be possible to confirm this without the dating of sediments and as such, at present the date of the features identified during this investigation is considered uncertain.

8.2.8 Regardless of the uncertainty around their age, these features are likely to have been formed during the periods of low sea level, when the area would have been exposed as a terrestrial landscape. As such, the sediments associated with these features are deemed to be of high archaeological potential. This is due to the fact they could contain *in situ* or derived cultural artefacts and preserved palaeoenvironmental material. It is possible that some of these features may have formed during a lowstand prior to the earliest occupation of Australia; however, this can not be confirmed either way without dating evidence, as such all channel features identified here are considered to be of high archaeological potential.

8.2.9 A number of features identified in the SBP data are seen to correspond with features identified in the MBES data (**7004-7007**, **7010**, **7013-7014**, **7086-7088**, **7091-7092**, **7099**, **7114**, **7119**, **7135** and **7145-7046**). It is possible that these represent the bottom of the channel features identified in the bathymetry data which have been partially infilled with seabed sediments, although they may also represent earlier phases of channelling which have been reactivated at a later data. Due to differences in form and extents of these features between the two data sets, they have not been definitively grouped together at this time and, as such, are listed and reported separately within this report and the gazetteer (Appendix II). However, the corresponding features are described within the gazetteer and their likely association should be noted.

8.2.10 Acoustic blanking, thought to be indicative of gas, was identified at the base of three features (**7115, 7126,** and **7135**). It is possible that this gas is caused by the microbial breakdown of organic matter within the features, which suggests that these features are more likely to contain preserved material of palaeoenvironmental interest. Although it may also be caused by an accumulation of coarse gravelly material.

8.2.11 Two areas of possible channel complexes were identified along the proposed GEP route (**7095** and **7099**). These were identified in the data as broad areas comprising numerous cross-cutting cut and fill features. The features generally have a relatively clear basal reflectors and acoustically transparent/unstructured fill (although the characteristics of these features can vary). Bourget *et al.* (2013) discusses periods of channelisation and a ‘stacked’ seismic signature being identified below the mid-Quaternary unconformity (MQU), which marks the point the sedimentation transitions from carbonate-dominated to clastic input. The exact date of the MQU is uncertain, but Bourget *et al.* (2013) hypothesises that it is pre-MIS 12, which would put it before the earliest known occupation of Australia. However, there was no definitive evidence of the MQU identified in the SBP data, possibly due to the limited seismic penetration, although it may be due to fact the work of Bourget *et al.* 2013 was undertaken closer to the Malita intrashelf basin, which is deeper than the majority of the study area. As such, the age of these possible channel complexes is considered unknown and their archaeological potential is considered high, based on the fact they may represent terrestrial features from periods of human occupation.

8.2.12 A number of cut and fills (for full list see Appendix II) were identified within the proposed GEP route. These features are thought to be of a similar age as the channels described above. However, as their form is less distinct in the SBP data, they are interpreted as cut and fill features rather than possible channels. It is possible that they are the remnants of eroded palaeochannel systems but, as their nature is less certain, they are considered of lower archaeological potential. Cut and fill **7083** is identified beneath an upper unit characterised by some horizontal reflectors, which may be Unit 5 sediments, suggesting the fill may be comprised of Unit 3 sediments.

8.2.13 A number of infilled depressions were also identified throughout the proposed GEP route (**7007, 7010, 7011, 7012 ,7018** and **7161**), generally identified as infilling the surface of the variably cemented unit (Unit 1). It should be noted that other similar, but smaller and less distinct, features are identified along the route; however, these are less clearly discernible and as such only the larger or most distinct features have been mapped. These infilled depressions are present in patches along the route. It is possible that these features are infilled by modern marine sediments (Unit 7), however they may be infilled by pre-transgression Holocene sediments or re-worked sediments which may have some archaeological and palaeoenvironmental potential. As such, they have been mapped here and retained as a precaution.

8.2.14 A broad unit of interpreted fine-grained deposits, possibly alluvium (Unit 5), has been identified in some areas along the proposed GEP route. These are most distinct between KP 194 – 199 and KP 251 – 262. Generally, these are seen to be acoustically quiet with some parallel reflectors, indicating sediments that may have been deposited in a low-energy environment. It is possible that these may represent sediments deposited in an estuarine or lacustrine environment, or possibly flood plain deposits, although this is uncertain. The age of these deposits is also uncertain. Between KP 194 -199 the deposits are seen to overlie one phase of channelling, and be cut into by a later phase, suggesting they may be early Holocene in age or older. This deposit was characterised by numerous distinct, horizontal reflectors, whereas the unit identified between KP 251 – 262 is more acoustically quiet with only faint, occasional horizontal reflectors, suggesting the depositional environment may be different and the units may be different ages.

8.2.15 It is possible the sediments deposited between KP 251 – 262 were deposited after the LGM, when a partially isolated, marine-influenced lake is thought to have been present in the central basin (Nicholas *et al.* 2015), or they may be more recently deposited clastic sediments deposited by wet-season river input (DOF 2018, Arup 2019), although it is noted in Nicholas *et al* (2015) that some areas of the Bonaparte basin suggest very low sedimentation rates.

8.2.16 As blanket deposits of uncertain age and origin, these fine-grained deposits have not been mapped or reported in in the gazetteer at this age; however, it should be noted that where the terrestrial and alluvial sediments are present, there is the possibility of derived or *in situ* artefacts and preserved palaeoenvironmental material. A number of smaller, shallower deposits were identified below the seabed along the route which may represent fine-grained deposits similar to those discussed above, although they may also represent modern marine sediments deposited within depressions on the underlying units. It should be noted that the geoarchaeological assessment (Section 8.3) suggests that the alluvial deposits are much more extensive than those identified in the geophysical data.

8.2.17 Unit 7 is expected to be present across the offshore study area either as a thin veneer or thickening out into sand waves in a few isolated areas. Due to its age and depositional environment, Unit 7 is not considered of archaeological potential in itself. However, in areas of mobile seabed sediment, Unit 7 has the potential to periodically bury seabed archaeological features such as shipwreck sites, or help preserve palaeolandsurfaces.

8.2.18 Any features identified outside of the 2 km study area are considered beyond the scope of the current project and are subsequently not included in this report.

Bathymetry palaeolandscapes assessment

8.2.19 Two different resolutions of bathymetry data were used to interpret palaeolandscape features on the seabed. Regional topography data from Geoscience Australia is gridded to 30 m, with the actual resolution varying. In some areas of the study area, bathymetry resolution is at 30 m, with a coarser resolution outside these areas. In areas of poorer resolution, interpreting palaeolandscape features is difficult. In these areas, the 2018 Fugro 2 m resolution dataset was used, which gives much higher resolution over a small area.

8.2.20 Seabed geomorphological features were classified following the Seabed Geomorphology Classification Scheme set out by Dove *et al.* (2020). Three types of seabed features were interpreted as palaeolandscape geomorphology. These features are channels, escarpments, and ridges. A further two types of seabed geomorphological features, sediment waves and a moat, were interpreted to provide stratigraphic context to other observed seabed features. These features are described and interpreted below.

<u>Channels</u>

8.2.21 Many channels were identified in both the regional and high-resolution bathymetry (for full list, see Appendix II). These channels vary in width, depth, and sinuosity. At the southern end of the proposed GEP route, a complicated network of channels is observed at the base of a broad, shallow valley between KPs 230 and 262 (Figure 22 and 23). This valley is approximately 40 km wide and is approximately 25 m deep. The valley is oriented approximately south-east to north-west where it crosses the pipeline route, but then turns south to north and eventually becomes a large, deep canyon feature approximately 5 km west of KP 222.

8.2.22 Within the broad valley, the channels are highly sinuous, interconnected, between 2 m and 10 m deep, and up to 1 km wide. Given their broader palaeogeographic context within the valley, these channels have been interpreted as palaeochannels of a river network. The bathymetry data shows the river network to have many meanders, channel segments, isolated billabongs, and anabranches. This complicated geomorphological assemblage implies a highly dynamic fluvial environment, with anastomosing and meandering rivers, channel avulsion events, abandoned channels and billabongs. Interfluves between these channels are generally flat, which may indicate the presence of overbank sediments deposited during flooding events.

8.2.23 Further channels have been identified outside of the broad palaeovalley, north of KP 230. Generally, these channels are isolated and not part of a network visible within the study area. These channels can be traced outside of the study area to join the large canyon feature west of the pipeline route. The channels are narrower, generally <500 m. These channels are also generally less sinuous that those encountered within the broad valley. Tributary channels are observed associated with the main channels, implying a general palaeoflow from west to east. Around KP 195, a large channel becomes uninterpretable, possibly due to burial by seabed sediments. It is possible that this is seen to continue in the SBP data as complex channel **7099**.

8.2.24 North of KP 173, there are no palaeochannels visible until KP 87. Here, a 15 m deep, 250 m wide palaeochannel network is observed (Figure 24), the deepest part of the main channel (the thalweg) is sinuous and broadly runs from south-east to north-west. The main thalweg is deeply incised. Smaller, shallower tributaries and abandoned incised meander loops are also present.

8.2.25 The channels described are all interpreted as palaeochannels of past fluvial networks based on their palaeogeographic context. An alternative interpretation, that the channels are submarine in origin, is considered unlikely due to their relatively shallow depth and complicated, anastomosing morphology. Generally, submarine channels are less sinuous, more deeply incised, and comprise a single thalweg. Submarine channels are also generally encountered where submarine slope angles are higher, for example on the continental slope, and therefore below a depth that was exposed during the LGM.

Ridges

8.2.26 Ridge features are observed throughout the study area generally north of KP 196. These ridges differ in morphology, although ridges with similar morphologies are found in clusters.

8.2.27 The first ridge cluster is encountered between KPs 196 and 192. These ridges are straight, broad, and flat topped, being 1-2 km long, up to 200 m wide, 3 m high, and have multiple crests. The long axes of these ridges are oriented NNE-SSW. The ridges are asymmetrical, being steeper on their north to north-western flanks. These ridges are interpreted as potential offshore bars, coastal barriers, or beach ridges on a strandplain.

8.2.28 Between KPs 170 and 148, a series of ridges are observed (Figure 25), with two distinct morphologies, one with generally straight crests with a curvilinear end, and one with generally sigmoidal (S shaped) to sinuous crests. The straight and curvilinear ridges are observed between KP 157 and 156. A series of smaller curvilinear ridges, up to 1 m high, branch off from a main linear ridge with a recurved end, oriented broadly SW-NE, with the recurved tip at the north-eastern end. This ridge is up to 4 m high. The curvilinear branches are on the south-eastern side of the main ridge. This group of ridges is tentatively interpreted to be a relict coastal barrier with recurved ends, implying a progradation of the coastal barrier towards the north-east.

8.2.29 The ridges with sigmoidal to sinuous crests are generally between 200 and 400 m long, and up to 3 m high, although generally around 1 m high. These ridges are also generally oriented south-west to north-east. The ridges are asymmetrical, being steeper on the south-eastern side. The ridge crests are undulating. These ridges are located on a gentle slope that dips towards the north-west. At the north-western edge of this slope, outside of the study area, is a 20 km long, 15 m high arcuate (curvilinear) ridge, oriented south-west to north-east. This large ridge is not covered by high resolution data. North-west of this large ridge, the bathymetry deepens. This large ridge is tentatively interpreted as a large barrier, with a back barrier and strandplain on the landward, south-eastern side of it. The gentle slope with the sinuous to sigmoidal ridges is interpreted to be a strandplain with parabolic and transverse aeolian (wind-blown) dunes superimposed upon it (Figure 26), formed at a time when sea level was around -60 m (approximately c. 12,000 years ago). Rapid marine transgression has preserved these coastal features, as is observed elsewhere around the coast of Australia (Brooke *et al.*, 2017).

8.2.30 The interpretation of these ridges as coastal features is difficult due to the narrow strip of high-resolution bathymetry data available. An alternative interpretation is that these ridges are submarine in origin. However, this is considered unlikely, as the ridges are different in morphology to seabed sediment dunes and waves seen elsewhere, such as a large area of seabed bedforms observed 5 km east of KP 179. These bedforms have a distinctive, smooth morphology, whereas the ridges interpreted as coastal features are more undulating, implying a degree of reworking since their deposition, likely to have occurred during marine transgression. The orientation of seabed bedforms is different, with orientation of long axes of bedforms being east to west and north-west to south-east, not related to seabed topography, whereas the ridges interpreted as coastal features are all subparallel to the palaeoshoreline.

<u>Escarpments</u>

8.2.31 The final seabed feature interpreted as a palaeolandscape feature is an escarpment located at KP 228. This escarpment is formed of a flat-topped promontory with steep flanks close to a palaeochannel. This feature is interpreted as a promontory of bedrock incised into by fluvial downcutting, leaving a cliff band up to 10 m high. Although this is the only instance of a bedrock platform flanked by cliffs seen in the study area, larger examples can be seen on the regional bathymetry data, such as the bedrock plateau 7 km directly south of KP 262.

<u>Seabed features not related to palaeolandscapes</u>

8.2.32 Two seabed geomorphological features, seabed sediment waves and moats, were also examined to provide stratigraphic and palaeogeographic context to the features interpreted as palaeolandscape features. Seabed sediment waves are encountered at KP 254 and 253, between KPs 231 and 228, and a large feature at KP 190-179. These seabed sediment waves partially bury palaeochannels in places, which implies the palaeochannels formed prior to the latest marine transgression.

8.2.33 At KP 40, a large channel-form feature is present, striking approximately east-west. This feature is between -140 and -150 m below present sea level, so is not likely to have been exposed subaerially since the first arrival of humans in Australia. The channel-form is consistently shallower on its southern bank than its northern bank and contains a ridge within. This feature is morphologically distinct from terrestrial landforms and is interpreted as a feature resulting from currents at the seabed, and is known as a contourite moat, and is not related to palaeochannels observed elsewhere along the pipeline route.

Marine geophysical assessment summary

8.2.34 The palaeogeographic features identified in the geophysical data can be broadly divided into two main palaeolandscape characters. In the south, the broad palaeovalley dominates with the complicated, anastomosing river network at its base, separated by interfluves of overbank deposits. This palaeolandscape was probably exposed subaerially between c. 50,000 and c. 14,000 years ago, giving approximately 36,000 years when it was a terrestrial landscape. To the north, the area interpreted as strandplain with coastal ridges, dunes, and a potential large barrier, was a coastal landscape. It is possible this palaeolandscape also had more complex environmental features of archaeological interest such as mangroves, back barrier swamps, and chenier plains, although these features have not been identified within the small amount of high-resolution bathymetry available.

8.2.35 Outside of these two distinct palaeolandscapes, when subaerially exposed during periods of low sea level, the study area was likely to have been largely terrestrial with broadly-spaced river channels. A lack of well-developed palaeochannel networks could be indicative of either the nature of the underlying geology not supporting the incision of bedrock channels, or of limited drainage within a very flat floodplain with low energy fluvial features. This could be indicative of an arid environment, or of an environment and geology that required a very long period of time for such features to form.

8.2.36 A number of possible features of terrestrial origin were also identified in the SBP data. The age of these features is currently uncertain; however, they are identified as features thought to have formed during periods of low sea level during the period of known human occupation of Australia. As such, there is the possibility that some of the features identified could contain *in situ* or derived archaeological material, as well as preserved palaeoenvironmental material.

8.2.37 The MBES data and the SSS data were used to identify whether there were any large objects on the seabed that have the potential to represent submerged features of archaeological potential, for example earth mounds or shell middens, as suggested by the terrestrial predictive modelling (Section 7). No such features have been located underwater in Australia, although shell middens have been preserved underwater elsewhere (Benjamin et al 2018). No additional features of archaeological potential were identified during the assessment beyond those features reported by Cosmos Archaeology (2022). However, at present, the reflective properties of features such as shell middens and earth mounds is unknown, and due to their size and shape it is likely that they would be difficult to differentiate from natural features (Astrup *et al.* 2019). As such, the possibility remains that there are features of archaeological potential such as earth mounds and shell middens on the seabed that have not been identified in the geophysical data at this time.

8.3 Geoarchaeological assessment

Introduction

8.3.1 A total of 77 vibrocore, CPT, piston core and borehole logs were reviewed for this assessment (Appendix III and Figure 7), with the aim of identifying deposits of potential geoarchaeological and archaeological interest, with recommendations for further geoarchaeological work if necessary. Outline descriptions based on geotechnical logs are presented in Appendix IV, accompanied by an initial interpretation of the deposits.

Fluvial gravel

8.3.2 In a single borehole recovered from the Barossa export pipeline route (EP-46-BH), a medium dense to dense, fine to coarse gravel was recorded stratigraphically overlying hard clay bedrock between 19.00 and 20.50 mbsb. The overlying deposit is clayey silt, with few pockets of gravel interpreted as reworked alluvium. Unlike the gravel unit interpreted as calcirudite between 10.25 and 17.50 mbsb, the lower gravel deposit does not contain carbonate. Although the clast lithology for this deposit is unknown, it underlies reworked alluvial sediments and therefore may have been laid down by high-energy fluvial processes, with a subsequent return to lower-energy floodplain deposition. The borehole is located within an extensive channel network, identified within the bathymetric data. Combined with its recorded depth, this suggests that this unit may represent older fluvial deposition dating prior to the Last Glacial Maximum, however, without secure luminescence dates the depositional age of this unit is uncertain. It is possible that the fluvial gravel and its surface dates to periods of early human occupation in the area, and is therefore assigned moderate archaeological potential.

Carbonate sands and gravels

8.3.3 In 25 cores, medium to very dense sands with occasional seams of clay are recorded between seabed and 4.23 mbsb. This deposit is interpreted as partially cemented sand, likely deposited in a shallow marine to coastal environment and subsequently exposed to semi-arid climatic conditions. The exposure of these sands resulted in the precipitation of carbonate material out of solution and thus to the development of variably cemented sediments (Short 2014).

8.3.4 These partially cemented sands vary stratigraphically, with deposits situated both below and between soft silty clays, below carbonate gravel (EP-42-CPT) and outcropping at seabed. Despite the absence of secure dates for the carbonate-rich deposits, it is clear based on stratigraphy that units of various ages are preserved.

8.3.5 Localised, occasionally clayey and sandy carbonate gravel was recorded in six cores predominantly between seabed and 3.0 mbsb. An exception was observed in EP-46-BH, with interbedded carbonate gravel and very stiff calcareous clay recorded between 10.25 and 17.50 mbsb. Given the high carbonate content documented within these gravels, combined with the recovery of frequent coral in EP-09-PC, this gravel unit has been interpreted as gravel calcirudite; an erosional surface largely comprised of gravel-sized carbonate particles and exposed during former lowstands.

8.3.6 Stratigraphically, this deposit is typically recorded at seabed (EP-42-CPT, EP-42-PC, EP-49-CPTA and EP-49-VC), however in one instance (EP-09-PC) is recorded below carbonate-rich seabed sediments. The interbedded carbonate gravel and stiff clay in EP-46-BH is stratigraphically constrained by silts and clays interpreted as alluvium. This suggests that this deposit likely represents a palaeolandsurface, exposed during a pre-Last Glacial Maximum Pleistocene lowstand. However, in the absence of luminescence dates an absolute age cannot be determined.

8.3.7 In a single core (EP-16-CPT), dense to very dense sand with occasional shell fragments was recorded between 2.10 and 3.15 mbsb. The high density of these sands is characteristic of partially cemented carbonate sands, however the presence of shell in this deposit is unique and is indicative of deposition in a marine, or possibly a shallow marine environment. Stratigraphically, this deposit underlies very soft clay between 1.40 and 2.10 mbsb, and a dense sand unit between seabed and 1.40 mbsb, interpreted as alluvium and partially cemented sands, respectively. Despite the lack of chronological control, the stratigraphic positioning supports the interpretation that this deposit represents a former seabed surface exposed in a lowstand prior to the Last Glacial Maximum.

8.3.8 Based on available bathymetric data, EP-16-CPT is identified as within a palaeochannel located between two carbonate platforms and thus, these cemented carbonate sand deposits may be associated with sediments eroded from the adjacent plateaus. The archaeological potential of this unique deposit is considered moderate as, although deposited in marine conditions, it likely formed an erosive platform during the subsequent lowstand.

8.3.9 Collectively, the partially cemented carbonate rich sands and calcirudite may represent either exposed palaeolandsurfaces or shallow marine deposits which have been subject to carbonate precipitation. Landsurfaces exposed during periods of lower sea level would have formed key areas for human occupation and migration, and as such their archaeological potential is considered as moderate. Although no organic remains were identified within these deposits, possibly attributed to the focus on CPT logs which predominantly detect overall lithology as opposed to detailed sedimentological features, the abundance of sand highlights the potential for luminescence dating and palaeoenvironmental (i.e. microfossil assessment).

Contourite drift

8.3.10 Very soft to firm interbedded calcareous sand, silt and clay was recorded in seven cores between seabed and 3.61 mbsb. These deposits are predominantly exposed at seabed, however are occasionally overlain by seabed sediments. Based on both interpreted bathymetric and SBP data, these deposits are typically associated with submerged, channel-levee systems formed through the action of bottom currents controlled by thermohaline and wind-driven circulation patterns. The deposits associated with these features are referred to as contourite drift deposits and are primarily comprised of fine-grained and structureless muds and silts (Rebesco and Camerlenghi 2008). Thus, these fine-grained sediments are interpreted as contourite drift deposits.

8.3.11 Interbedded silt and sand with few partings of clay was also recorded in EP-06-CPT. This core is not associated with the contourite features identified in the wider Outer Shelf, however these deposits are interpreted as being attributed to the distal deposition of terrigenous sediments, most likely laid down in a shallow marine setting during the Late Pleistocene.

8.3.12 Given these deposits are situated below -125 mbsb, they were likely submerged during the Last Glacial Maximum (LGM) and therefore, features of archaeological interest are not expected. These deposits are therefore collectively assigned a low archaeological status.

Non-marine sand

8.3.13 Loose to medium dense, occasionally silty sand was recorded in six cores (EP-13-CPT, EP-14-CPT, EP-15-CPT, EP-34-CPT, EP-48-CPT and EP-50-PC) between 0.80 and 4.18 mbsb. This deposit is different from seabed sediments both stratigraphically and lithologically, as there is an absence of shell, and is not recorded at seabed. The depositional history of this deposit is difficult to determine based on the geotechnical logs, and therefore associated sediments are collectively interpreted as non-marine sand.

8.3.14 The non-marine sand recorded in EP-13-CPT stratigraphically underlies <0.80 m of silty clay interpreted as alluvium and overlies very dense sand interpreted as partially cemented sands. Although the increasing density of this unit may suggest periodic exposure and partial cementation, when considering the wider submerged landscape, this deposit is possibly fluviatile in origin and associated with the overlying alluvium.

8.3.15 In EP-14-CPT, EP-48-CPT, and EP-50-PC, non-marine sand is recorded as underlying alluvial silts and clays. These units, if associated with alluvium, may also represent fine-grained fluvial or possibly floodplain deposition. In addition, a carbonate sand with occasional pockets of gravel and clay was recorded in EP-50-PC. Although initially interpreted as non-marine sand, the pockets of clay and gravel may suggest reworking of fluvial deposits.

8.3.16 A thin (<0.75 m) unit of very loose sand was recorded between 2.25 and 3.0 mbsb in EP-15-CPT and is stratigraphically constrained by two distinct units of soft alluvial clay. Considering this core is located on the margin of an extensive palaeochannel, the non-marine sand is also interpreted as representing deposition in a lower energy fluvial, or possibly floodplain environment. A second medium dense sand deposit is recorded underlying the alluvium in EP-15-CPT between 3.80 and 4.18 mbsb and is tentatively interpreted as representing either partially cemented sands or deposition in a fluvial environment.

8.3.17 Uncertainty around the depositional history and relative age of the non-marine sands highlights the requirement for further palaeoenvironmental assessment and scientific dating. Non-marine sands associated with fluvial deposition are considered moderate archaeological potential. Those interpreted as partially cemented carbonate sands are additionally considered as moderate potential.

Alluvium

8.3.18 Very soft, occasionally gravelly, clay and silt were recorded in 50 cores between seabed and 4.52 mbsb. These soft muds are collectively interpreted as representing alluvial deposition, likely within a floodplain, or possibly estuarine environment.

8.3.19 In EP-46-BH, two distinct units of stiff silty clay with pockets of shell fragments and very hard clayey silt with occasional pockets of gravel are recorded between 0.60 and 10.25 mbsb and 17.50 and 19.0 mbsb, respectively. The uppermost alluvial deposit is situated below seabed sediments, whereas the lower alluvium stratigraphically overlies fluvial gravel, and is overlain by calcirudite. The latter alluvial unit is dense and, based on stratigraphy, is likely to have been deposited prior to the last highstand. However, in the absence of secure dates, the depositional age is uncertain. Alternatively, in some instances alluvial deposits are recorded as underlying partially cemented sands. Based on stratigraphy, these alluvial deposits are suggested to pre-date the most recent period of exposure during the LGM.

8.3.20 Based on the bathymetric data interpretation above, an extensive braided channel system has been identified across the Van Diemen Rise and Inner Shelf Continental areas (Figure 22 and 23). Collectively, the alluvial deposits are likely associated with fine-grained fluvial deposition of this palaeochannel network. However, calcareous clays with shell fragments are also recorded, and may represent estuarine deposits associated with increasing marine conditions as sea-levels rose during interstadials and/or interglacial periods.

8.3.21 A stiff to very hard clay was recorded in two locations (EP-39-CPT and EP-40-CPT) overlying variably cemented sands identified through interpreted SBP data. Although not clearly visible within the SBP geophysical data, this deposit most likely forms a veneer overlying the cemented sediments. The lithology and location of this deposit within an extensive palaeochannel network in the Inner Shelf suggests that the stiff clays were deposited in a low-energy alluvial environment associated with a channel system.

8.3.22 Stiff to very hard clays interpreted as alluvial in origin were also recorded in EP-46-BH between 20.50 and 31.56 mbsb. Stratigraphically, this deposit is situated below fluvial gravels which differs from the stiff clays recorded near seabed in EP-39-CPT and EP-40-CPT. The stratigraphic position of this deposit beneath fluvial and calcirudite gravels suggests that deposition occurred during a Pleistocene lowstand prior to the Last Glacial Maximum. However, an absolute age cannot be determined without secure dates.

8.3.23 Minerogenic alluvium is assigned medium potential status given its potential to preserve geoarchaeological material (i.e. inorganic microfossils) suitable for palaeoenvironmental assessment. These alluvial deposits are often associated with palaeochannel margins and are considered to be key hotspots for past human activity. Globally, they have been found to be associated with archaeological remains, including, for example, Palaeolithic and Mesolithic archaeology associated with submerged deposits of the North Sea region of the UK (Verhart 2004; Tizzard et al. 2015).

Seabed sediments

8.3.24 Loose silty sands with frequent whole and fragments of shell are recorded in 22 cores, between seabed and 1.60 mbsb. These deposits are occasionally rich in carbonate and, combined with the shell content, are interpreted to represent shallow marine to marine sands.

8.3.25 This deposit is typically a veneer overlying carbonate or alluvial sediments, although it is relatively thick (1.60 m) in EP-01-CPT and thus could possibly form part of the contourite drift underlying the loose sands. Nonetheless, the depositional history is difficult to determine from the geotechnical logs alone. Seams of cemented sands have also been recorded at the lower boundary of seabed sediments in EP-18-VC. The lithology of the underlying deposits are unknown, however the identification of cemented sands demonstrates the occurrence of carbonate precipitation.

8.3.26 In EP-01-VC, carbonate sands with few pockets of clay and fine gravel are recorded between seabed and 1.0 mbsb. The heterogeneous nature of this deposit most likely represents reworking of shallow marine sands.

8.3.27 Although there is potential for these deposits to contain reworked archaeology or bury palaeolandscape features, their archaeological potential is considered to be low.

8.4 Palaeogeographic assessment conclusions

Palaeogeographic features

8.4.1 Using the terrestrial predictive model in Section 6, the assessment of geophysical data within the study area resulted in a total of 163 features of palaeogeographic interest and archaeological potential. These are summarised as follows:

- a total of 60 features assigned an P1 archaeological rating;
- a total of 103 features were assigned an P2 archaeological rating.

8.4.2 As terrestrial features interpreted as being deposited during periods of known human occupation of Australia, those features given a P1 archaeological rating are considered of high archaeological potential. Those features with a P2 rating are considered of medium archaeological potential, partly due to the uncertainty of the formation and fill of these features. Further geoarchaeological work would aid in refining the interpretation of these features, and therefore help determine the archaeological potential of the area.

Geoarchaeological assessment

8.4.3 Based on the results of this review of geotechnical data, seven distinct lithological units were identified and their archaeological significance assessed. These have been incorporated with the SBP interpretation results to create a proposed shallow stratigraphy of the study area (Table 10).

8.4.4 A total of five lithological units were assigned medium potential archaeological potential, comprised of alluvium, non-marine sand, carbonate sands and gravels, marine to shallow marine sands and fluvial gravel.

8.4.5 No high potential deposits, which might ordinarily include organic material and peats, were identified during this review.

8.4.6 Given the uncertainties regarding the depositional history of each unit, additional geoarchaeological assessment, including scientific dating, is required to refine understanding of both the depositional processes and ages of these deposits.

9 NON-PALAEOLANDSCAPE SEABED FEATURES ASSESSMENT

9.1.1 The MBES data and the SSS data were used to identify whether there were any features of archaeological potential on the seabed. Although an archaeological assessment of the seabed features has already been undertaken by Cosmos Archaeology (2022), this was done using the SSS mosaics rather than the raw SSS data. As such, an assessment of the raw SSS data, as well as the MBES data, was undertaken in order both to verify the findings by Cosmos Archaeology (2022) and to identify whether there were any indications of large objects on the seabed of archaeological potential. No additional features of archaeological potential were identified during the assessment beyond those features reported on by Cosmos Archaeology (2022).

10 DISCUSSION

10.1.1 The contextual ethnohistoric and archaeological research identified archaeological evidence for the presence of Aboriginal communities within the terrestrial study area from around 50,000 years ago. It is thought that the arrival of the first peoples on the continent occurred sometime in MIS 4 (c. 71,000-57,000 years ago) when sea levels were around 100 m lower than today. This lower sea level would have exposed vast areas of the Australian continental shelf, including most of the proposed route of the Barossa GEP. It is this previously terrestrial landscape that has been investigated within the palaeogeographic assessment.

10.1.2 The level of detail achieved within the investigation of the submerged palaeolandscape was limited due to a lack of available regional contextual information, such as that pertaining to the Quaternary geology and geomorphology of the Bonaparte Basin. This was compounded by limited coverage of the sub-bottom profiler data, which resulted in an inability to follow identified buried features across the landscape, and by the quality of the geotechnical logs provided to Wessex Archaeology, which lacked the sediment description details required for archaeological interpretation. The differences in penetration between the geotechnical and geophysical data resulted in difficulties correlating sediments between the two datasets.

10.1.3 The result of this is that although a number of features were identified representing the submerged palaeolandscape, including palaeochannel and fill complexes, no sediments of high archaeological potential could be definitively identified using the geotechnical logs.

This interpretation of the archaeological potential of sediments is based on limited geotechnical information combined with experience working in the Northern Hemisphere. Detailed geoarchaeological assessment of stratigraphy related to palaeoenvironments is at an early stage offshore in Australia, and it is possible that the different environment, climate, and geochemistry of the Northern Territory has resulted in different sediment preservation. For example, it is possible that the extensive alluvial sediments identified within the geotechnical assessment have a high potential for containing archaeological material, however correlating alluvium in the geotechnical logs with the sub-bottom profile data was difficult due to limited data coverage and sub-bottom profiler resolution. Furthermore, the acoustic blanking identified within some palaeochannel features could also be indicative of organic remains, which would be of high archaeological potential, however, the limited penetration of geotechnical samples meant this layer was not recorded or described in the geotechnical logs.

10.1.4 In conclusion, this research has provided some of the first images and interpretations of the submerged palaeolandscape of the Bonaparte Basin. The palaeolandscape west of the Tiwi Islands ago was a complex system of river channels at the time of the arrival of the first people on the Australian continent over 50,000 years ago. Ethnohistorical and archaeological research has demonstrated this environment would have been an attractive location for people to live due to the availability of fresh water and plentiful, diverse food resources. Noting the limitations of the interpretations outlined in Section 1.5, and our limited understanding of the survival and archaeological potential of deposits within Australian offshore submerged palaeolandscapes, it is possible that there is potential for significant archaeological and palaeoenvironmental remains to survive within the deposits identified. Any surviving archaeological material within the submerged palaeolandscape would be of national and international significance.

10.1.5 A second report details our recommendations following on from the research detailed in this report.

BIBLIOGRAPHY

Allen, J. and O'Connell, J. 2003. 'The long and the short of it: Archaeological approaches to determining when humans colonised Australia and New Guinea.' *Australian Archaeology*, 57(1): 5-19

Allen, H and Barton, G. 1989. *Ngarradj Warde Djobkeng: White cockatoo dreaming and the prehistory of Kakadu*. Sydney: University of Sydney.

Allen, H. 1977. *Archaeology of the East alligator River Region, Western Arnhem Land*. Revised version of a seminar given to Department of Anthropology, University of Auckland. Unpublished manuscript. Canberra: Australian Institute of Aboriginal Studies.

Allen, H. 1989. 'Late Pleistocene and Holocene settlement patterns and environment, Kakadu Northern Territory, Australia'. *Bulletin of the Indo-Pacific Association*, 9: 92-117.

Anderson T J, Nichol S, Radke L Heap A D, Battershill C, Hughes M, Siwabessy P J, Barrie V, Alvarezde Glasby B, Tran M, Daniell J & Shipboard Party, 2011. *Seabed Environments of the Eastern Joseph Bonaparte Gulf, Northern Australia: GA0325/Sol5117 - Post-Survey Report.* Geoscience Australia, Record2011/08,59pp.

Arup, 2019. *Barossa Project Gas Export Pipeline and Flowlines Geotechnical Interpretive Report*, unpubl report, Document ref. 262132-PFL-REP-002 Rev 3

Astrup P M, Skriver C, Benjamin J, Stankiewicz F, Ward I, McCarthy J, Ross P, Baggaley P, Ulm S, Bailey G., 2019. 'Underwater Shell Middens: Excavation and Remote Sensing of a Submerged Mesolithic site at Hjarnø, Denmark.', *The Journal of Island and Coastal Archaeology*, DOI: 10.1080/15564894.2019.1584135

Australian Bureau of Statistics 2021 *Tiwi Islands 2021 Census All person QuickStats.* https://abs.gov.au/census/find-census-data/quickstats/2021/702031060 [Accessed 02/05/2023]

Bailey, G. 1977. 'Shell Mounds, shell middens and raised beaches in the Cape York Peninsula.' *Mankind*, 11: 132-143.

Bailey, G. 1991. 'Hen's eggs and cockle shells: Weipa shell mounds reconsidered.' *Archaeology in Oceania*, 26(1): 21-23.

Bailey, G. 1999. 'Shell mounds and coastal archaeology in northern Queensland.' In J. Hall and I.J. McNiven (eds), *Australian Coastal Archaeology*, pp. 105-112. Canberra: Archaeology and Natural History Publications.

Balme, J. 2013. Of boats and string: The maritime colonisation of Australia. *Quaternary International.* 285: 68-75. https://doi.org/10.1016/j.quaint.2011.02.029

Barker, B. 2017. *The sea people: late Holocene maritime specialisation in the Whitsunday Islands, central Queensland.* Canberra: Pandanus Books in association with the Centre for

Archaeological Research and the Dept. of Archaeology and Natural History, The Australian National University.

Basedow, H. 1907. *Anthropological notes on the western coastal tribes of the Northern Territory of South Australia.* Adelaide: Royal Society of South Australia.

Benjamin, J., O'Leary, M., Ward, I., Hacker, J., Ulm, S., Veth, P., Holst, M., McDonald, J., Ross, P. J. and Bailey, G. 2018 'Underwater archaeology and submerged landscapes in western Australia,' *Antiquity*. Cambridge University Press, 92(363), p. e10. doi:10.15184/aqy.2018.103.

Benjamin J., O'Leary M, McDonald J, Wiseman C, McCarthy J, Beckett E, Morrison P, Stankiewicz F, Leach J, Hacker J, Baggaley P, Jerbić K, Fowler M, Fairwather J, Jeffries P, Ulm S, Bailey G., 2020. 'Aboriginal Artefacts on the Continental Shelf Reveal Ancient Drowned Cultural Landscapes in Northwest Australia.' *PLOS ONE* 15 (7): e0233912. doi:10.1371/journal.pone.0233912.

Benjamin, J., O'Leary, M., McCarthy, J., Reynen, W., Wiseman, C., Leach, J., Bobeldyk, S., Buchler, J., Kermeen, P., Langley, M., Black, A., Yoshida, H., Parnum, I., Stevens, A., Ulm, S., McDonald, J., Veth, P., Bailey, G., 2023. Stone artefacts on the seabed at a submerged freshwater spring confirm a drowned cultural landscape in Murujuga, Western Australia. Quat. Sci. Rev. 313, 108190. https://doi.org/10.1016/j.quascirev.2023.108190

Berndt, R.M. and Berndt, C.H. 1970. *Man, land & myth in North Australia: the Gunwinggu people.* Lansing: Michigan State University Press.

Bird, M.I., Condie, S.A., O'Connor, S. Reepmeyer, C., Ulm, S., Zega, M., Saltré, F. and Bradshaw, C. 2019. 'Early human settlement of Sahul was not an accident.' *Science Reports* 9, 8220. https://doi.org/10.1038/s41598-019-42946-9

BOEM, 2020. Guidelines for Providing Archaeological and Historic Property Information Pursuant to 30 CFR Part 585. https://www.boem.gov/sites/default/files/documents/about-boem/Archaeology%20and%20Historic%20Property%20Guidelines.pdf

Bourget J, Nanson R, Ainsworth R B, Courgeon S, Jorry S J, Al-anzi H, 2013. *Seismic Stratigraphy of a Plio-quaternary Intra-shelf Basin (Bonaparte Shelf, NW Australia)*, West Australian Basins Symposium Perth, WA, 18–21 August 2013

Bourke, P.M. 2000. *Late Holocene Indigenous Economies of the Tropical Australian Coast: An Archaeological Study of the Darwin Region.* Unpublished PhD thesis, Department of Anthropology, Northern Territory University, Darwin.

Bourke, P.M. 2002. 'Shell mounds and stone axes: Prehistoric resource procurement strategies at Hope Inlet, Northern Australia.' *Bulletin of the Indo-Pacific Prehistory Association, Indo-Pacific Prehistory,* 22: 35-44.

Bourke, P.M. 2004. 'Three Aboriginal Shell mounds at Hope Inlet: Evidence for coastal, not maritime late Holocene economies on the Beagle Gulf mainland, northern Australia.' *Australian Archaeology*, 59: 10-22.

Brockwell, S.C.J. 1992. *The Archaeology of the Kakadu Wetlands*. Canberra: Australian National University.

Brockwell, S. 2006. 'Earth Mounds in Northern Australia: A Review.' *Australian Archaeology*, 63(1): 47-56.

Brockwell, S., Faulkner, P., Bourke, P., Clarke, A., Crassweller, C., Guse, D., Meehan, B. and Sim, R., 2009. 'Radiocarbon dates from the Top End: A cultural chronology for the Northern Territory coastal plains.' *Australian Aboriginal Studies*, (1), pp.54-76.

Brockwell, S., Bourke, P., Clarke, A., Crassweller, C., Faulkner, P., Meehan, B., O'Connor, S., Sim, R. and Wesley, D., 2011. 'Holocene settlement of the northern coastal plains, Northern Territory, Australia.' *Beagle: Records of the Museums and Art Galleries of the Northern Territory*, 27: 1-22.

Brockwell, S., Brockwell, K.A.S. and Aplin, K., 2020. 'Fauna on the floodplains: late Holocene culture and landscape on the sub-coastal plains of northern Australia.' *Records of the Australian Museum*, 72(5): 225-236.

Brooke B P, Nichol, S L, Huang, Z, Beaman, R J, 2017. 'Palaeoshorelines on the Australian continental shelf: Morphology, sea-level relationship and applications to environmental management and archaeology.' *Continental Shelf Research* Vol.134, 26-38.

Burns, T. 1994. *Mound over Matter: Origins of Shell and Earth Mounds of Northern Australia: An Evaluation of Mounds on Channel Island and Middle Arm Mainland, Darwin Harbour*. Unpublished BA thesis, Department of Anthropology, Northern Territory University, Darwin.

Burns, T. 1999. 'Subsistence and settlement patterns in the Darwin coastal region during the late Holocene period; A preliminary report of archaeological research.' *Australian Aboriginal Studies*, 1: 59-69.

Campbell, J. 1834. 'Geographical memoir of Melville Island and Port Essington, on the Cobourg Peninsula, Northern Australia; with some observations on the settlements which have been established on the north coast of New Holland.', *Journal of the Royal Geographical Society of London*, 4: 129-181.

Christian C. S. & Aldrick J. M. 1977. *Alligator Rivers Study. A Review Report of the Alligator Rivers Region Environmental Fact-Finding Study*. Australian Government Publishing Service, Canberra.

Clarke, A F. 1994. *Winds of Change: an archaeology of contact in the Groote Eyelandt archipelago, Northern Australia*. PhD diss., Australian National University.

Clark, A.R. and Walker, B.F., 1977. 'A proposed scheme for the classification and nomemclature for use in the engineering description on Middle Eastern sedimentary rocks.' *Geotechnique*, *27*(1), pp.93-99.

Clark, R L and Guppy, G C. 1988. 'A transition from mangrove forest to freshwater wetland in the monsoon tropics of Australia'. *Journal of Biogeography*, 15: 665-684.

Clark, R L, T J East, J Guppy, A Johnston, F Leaney, P McBride, R J Wasson. 1992a. 'Late Quaternary stratigraphy of the Magela Plain'. In R J Wasson (Ed.) *Modern Sedimentation and Late Quaternary Evolution of the Magela Creek Plain. Darwin, Australia*: 28-80. Supervising Scientist for the Alligator Rivers Region, Research Report 6.

Clark, R L, T J East, J Guppy, A Johnston, F Leaney, P McBride, R J Wasson. 1992b. 'Late Quaternary stratigraphy of the Magela Plain'. In R J Wasson (ed.) *Modern Sedimentation and Late Quaternary Evolution of the Magela Creek Plain. Darwin, Australia*: 81-157. Supervising Scientist for the Alligator Rivers Region, Research Report 6.

Clarke J D A, Ringis J., 2000. 'Late Quaternary stratigraphy and sedimentology of the inner part of southwest Joseph Bonaparte Gulf.', *Australian Journal of Earth Sciences* 47(4):715 – 732, DOI:10.1046/j.1440-0952.2000.00804.x

Clarkson, C., Smith, M., Marwick, B., Fullagar, R., Wallis, L.A., Faulkner, P., Manne, T., Hayes, E., Roberts, R.G., Jacobs, Z. and Carah, X., 2015. 'The archaeology, chronology and stratigraphy of Madjedbebe (Malakunanja II): A site in northern Australia with early occupation.' *Journal of Human Evolution*, 83: 46-64.

Clarkson, C., Jacobs, Z., Marwick, B., Fullagar, R., Wallis, L., Smith, M., Roberts, R. G., Hayes, E., Lowe, K., Carah, X., Florin, S. A., McNeil, J., Cox, D., Arnold, L. J., Hua, Q., Huntley, J., Brand, H. E. A., Manne, T., Fairbairn, A., … Pardoe, C. 2017. Human occupation of northern Australia by 65,000 years ago. *Nature*, *547*(7663), 306–310. https://doi.org/10.1038/nature22968

Cosmos Archaeology, 2020a, Annexure E. Potential submerged sites assessment In: Jacobs Group (Australia) Pty Ltd. *Beaches Link and Gore Hill Freeway Connection EIS. Appendix L.* Available online: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8862%2120201204T024117.567%20GMT [Accessed 09/05/2023]

Cosmos Archaeology, 2020b, Annexure E. Potential submerged sites assessment In: Jacobs Group (Australia) Pty Ltd. *Western Harbour Tunnel and Warringah Freeway Upgrade EIS. Appendix L.* Available online: https://media.caapp.com.au/pdf/v0v938/d2cf1495-f8c3-4978-adf7-7cfee490ef21/Appendix%20L.pdf [Accessed 09/05/2023]

Cosmos Archaeology, 2022, *Santos (Barossa) Gas Export Pipeline, Original Barossa GEP Stage (Timor Sea and Tiwi Islands), Maritime Heritage Assessment*, ref. J21/22 V5

David, B., P. Tacon, R. Gunn, J Delannoy and J.M Geneste. 2017. The Archaeology of western Arnhem Land's rock art. In B. David, P. Tacon et al (Eds.). *The Archaeology of Rock Art in Western Arnhem Land, Australia,* pp. 1-20. Canberra, ANU Press

David, B, B Barker, F Petchey, J Delannoy, J Geneste, C Rowe, M. Eccleston, L Lamb, R Wear. 2013. 'A 28,000 year old excavated painted rock from Nawarla Gabarnmang, northern Australia'. *Journal of Archaeological Science* 40: 2493-2501.

David, B., Delannoy, J. J., Mialanes, J., Clarkson, C., Petchey, F., Geneste, J. M., Manne, T., Bird, M. I., Barker, B., Richards, T., Chalmin, E., & Castets, G. 2019. 45,610–52,160 years of site and landscape occupation at Nawarla Gabarnmang, Arnhem Land plateau (northern Australia). *Quaternary Science Reviews*, *215*, 64–85. https://doi.org/10.1016/j.quascirev.2019.04.027

Davies, B. J. 2022. '4.13 – Cryospheric Geomorphology: Dating Glacial Landforms II: Radiometric Techniques.', *Treatise on Geomorphology* (Second Edition), Volume 4, 2022, Pages 249-280, https://doi.org/10.1016/B978-0-12-818234-5.00040-7

Davis, S L and Prescott, J R V. 1992. *Aboriginal Frontiers and Boundaries in Australia*. Melbourne: Melbourne University Publishing.

DOF, 2018a. *Geophysical Survey Report – Export Pipeline Route Skandi Hercules*, unpubl report, Document ref. 1002707-SV-CL-403-0007 Rev02

DOF, 2018b. *Barossa Project, Geophysical Survey Operations Report*, unpubl report, Document ref. 1002707-SV-CL-403-0001

Dortch C. 1997. Prehistory down under: archaeological investigations of submerged Aboriginal sites at Lake Jasper, Western Australia. *World Archaeology.* 29: 15-35

Dortch C. E., Henderson G., May S. R. 1990. Prehistoric Human Sites Submerged in Lake Jasper, South-Western Australia. *Bulletin of the Australian Institute of Maritime Archaeology* 14: 43-52

Dougherty A, Thomas A, Fogwill C, Hogg A, Palmer J, Rainsley E, Williams A, Ulm S, Rodgers K, Jones B, Turney C., 2019. 'Redating the earliest evidence of the mid-Holocene relative sea-level highstand in Australia and implications for global sea-level rise.' *PLOS ONE* 14, 7.

Dove, Dayton, Nanson, Rachel, Bjarnadóttir, Lilja R., Guinan, Janine, Gafeira, Joana, Post, Alix, Dolan, Margaret F.J., Stewart, Heather, Arosio, Riccardo, Scott, Gill, 2020. A two-part seabed geomorphology classification scheme (v.2); Part 1: morphology features glossary. *Zenodo*. https://doi.org/10.5281/ZENODO.4075248

Eberli G.P., Betzler C, 2019. 'Characteristics of modern carbonate contourite drifts.' *The Journal of the International Association of Sedimentologists* 66, 1163–1191, doi: 10.1111/sed.12584

EGS 2021 *GEP Pre-Installation Survey Report, Allseas, Santos Barossa Pipeline Early Prelay Survey*, unpubl report, Document ref. AU031521-RPT-010

Emery, A.R., Hodgson, D.M., Barlow, N.L.M., Carrivick, J.L., Cotterill, C.J., Mellett, C.L., Booth, A.D., 2019. Topographic and hydrodynamic controls on barrier retreat and preservation:

An example from Dogger Bank, North Sea. Mar. Geol. 416, 105981. https://doi.org/10.1016/j.margeo.2019.105981

English Heritage, 2013. Marine Geophysics Data Acquisition, Processing and Interpretation, Guidance Notes. https://historicengland.org.uk/images-books/publications/marine-geophysics-data-acquisition-processing-interpretation/mgdapai-guidance-notes/

Eylmann, E., 1914. 'Die Vogelwelt des südöstlichen Teiles vom Staate Südaustralien'. *Journal für Ornithologie* 62: 226–258.

Farram, S. 2022. The Tiwi of Melville Island, the Portuguese of Timor, and Slavery, *Bijdragen tot de taal-, land- en volkenkunde / Journal of the Humanities and Social Sciences of Southeast Asia*, 178(1), 5-37. doi: https://doi.org/10.1163/22134379-bja10035

Faulkner, P. and Clarke, A. 2004. 'Late-Holocene occupation and coastal economy in Blue Mud Bay, northeast Arnhem Land: Preliminary archaeological findings.' *Australian Archaeology*, 59(1): 23-30.

Flemming N. C. 1982. The Sirius Expedition, Cootamundra Shoals Survey 1982. Expedition Report (4 volumes). Sydney Australian National Maritime Museum

Flood, J. 2006. The Original Australians: Story of the Aboriginal People. Crows Nest: Allen and Unwin.

Foelsche, P. 1881-1888. 'Notes on the Aborigines of North Australia'. *Transactions and Proceedings and Report of the Royal Society of South Australia*, vol. 5: 1-18.

Fogg A, Dix J, Farr, H. 2020. 'Late Pleistocene Palaeo Environment Reconstruction from 3D Seismic data, NW Australia.' The ACROSS project- Australasian Research: Origins of Seafaring to Sahul, *ESS Open Archive*. January 06, 2020, DOI: 10.1002/essoar.10501584.1

Fredericksen, C. 2002. 'Caring for history: Tiwi and archaeological narratives of Fort Dundas/Punata, Melville Island, Australia.' *World Archaeology* 34.2: 288-302.

Fugro, 2016a. *Barossa Field Development – Infield and Pipeline Routing Interim Geophysical Survey, 4 – 18 November 2015, Volume 1A – Survey Results*, unpubl report, Fugro Document No. GP1531

Fugro, 2016b. *Barossa Field Development – Infield and Pipeline Routing Interim Geophysical Survey, 4 – 18 November 2015, Volume 2 – Survey Operations*, unpubl report, Fugro Document No. GP1531

Fugro, 2018a. *Barossa Project – Bathymetry, Geophysical and Environmental Survey Services, Survey Period: 17 July – 27 August 2017, Volume 1A – Survey Results*, unpubl report, Fugro Document No. FRPT GP1577

Fugro, 2018b. *Barossa Project – Bathymetry, Geophysical and Environmental Survey Services, Survey Period: 17 July – 27 August 2017, Volume 2 – Survey Operations*, unpubl report, Fugro Document No. FRPT GP1577

Fugro, 2018c. *Barossa Pre-FEED Follow-on -Geoscience support for PSHA Barossa Development, Lease NT/RL5 Timor Sea, Australia*, Fugro Document No. AGR-1878(0)

Fugro, 2023. *Operations Report – Sub-Bottom Profiler Survey (Work Package 10), Barossa Pipeline to Shore Project – Geophysical and Geotechnical Survey* | Work Package 10 Darwin, Fugro Document No. 190530-52-REP-023 Rev A | 28 April 2023

George T and Cauquil, E. 2010. Site investigation within the Bonaparte Basin, Preview, 2010:148, 41-44, DOI: 10.1071/PVv2010n148p41

Geoscience Australia, 2022. Regional Geology of the Bonaparte Basin, Regional-Geology-of-the-Bonaparte-Basin_2022_FIN.docx (live.com) [Accessed 27/04/2023]

Geoquip, 2018, *Geotechnical Site Investigation, Barossa Development Project, Export Pipeline Investigations, Field Geotechnical Report*, unpubl report, Document ref. MOP18-G-003-FLD-01

Hart, C. W. M., and Pilling, A. R. 1979. *The Tiwi of North Australia: Fieldwork Edition.* New York: Holt, Rinehart and Winston.

Hiatt, E E, T Kurtis Kyser, P A Polito, J Marlatt, P Pufahl. 2021. 'The Paleoproterozoic Kombolgie Subgroup (.8 Ga), McArthur Basin, Australia: Sequence stratigraphy, basin evolution and unfonformity-related uranium deposits following the Great Oxidation Event'. *The Canadian Mineralogist* 59, no. 5: 1049-1083.

Hiscock, P. 1997. Archaeological evidence for environmental change in Darwin Harbour. In J. Hanley et al. (Eds.), *The marine flora and fauna of Darwin Harbour, Northern Territory*. pp. 445-449. Museum and Art Galleries of the Northern Territory, Darwin.

Hiscock, P. 1999. Holocene coastal occupation of western Arnhem land. In J. Hall and I.J McNiven (Eds.), *Australian Coastal Archaeology*, pp. 91-103, Research Papers in Archaeology and Natural History 31. Canberra: Archaeology and Natural History Publications, Research School of Pacific an Asian Studies, Australian National University.

Hiscock, P. 2007. *Archaeology of ancient Australia*. London and New York: Routledge.

Hiscock, P. and Faulkner, P., 2006. 'Dating the dreaming? Creation of myths and rituals for mounds along the northern Australian coastline.' *Cambridge Archaeological Journal*, 16(2): 209-222.

Hiscock, P. and Hughes, P., 2001. 'Prehistoric and World War II use of shell mounds in Darwin Harbour.' *Australian Archaeology*, 52(1), pp.41-45.

Hiscock, P. and Mowat, F. 1993. 'Midden variability in the coastal portion of the Kakadu region.' *Australian Archaeology*, 37(1): 18-24.

Hiscock, P, Mowat, F, and D Guse. 1992. 'Settlement patterns in the Kakadu wetlands: initial data on site size and shape'. *Australian Aboriginal Studies*, 2: 84-89

Hiscock, P. 1999. 'Holocene coastal occupation of western Arnhem Land' In J. H. Hall and I. J. McNiven (Eds) *Australian Coastal Archaeology*, pp. 91-103. Canberra, Australia: ANH Publications, Department of Archaeology and Natural History, RSPAS, The Australian National University.

Holdgate, G. R., Thompson, B. R., & Guerin, B. 1981. Late Pleistocene Channels in Port Phillip. *Proceedings of the Royal Society of Victoria*., 92, 119–130.

Holdgate, G. R., Wagstaff, B., & Gallagher, S. J. 2011. Did Port Phillip Bay nearly dry up between ~2800 and 1000 cal. yr BP? Bay floor channelling evidence, seismic and core dating. *Australian Journal of Earth Sciences*, *58*(2), 157–175. https://doi.org/10.1080/08120099.2011.546429

Hope, G, P J Hughes, J Russell-Smith. 1985. 'Geomorphological fieldwork and the evolution of the landscape of Kakadu National Park. In R. Jones (Ed.) *Archaeological Research in Kakadu National Park*, pp. 165-228. Canberra: Australian National Parks and Wildlife Service. Special Publication 13.

Hordern, M. 1989. *Mariners are warned! John Lort Stokes and H.M.S. Beagle in Australia 1837-1843*. Melbourne: Melbourne University Press.

Ishiwa T, Yokoyama Y, Miyairi Y, Ikehara M, Obrochta S., 2016, Sedimentary environmental change induced from late Quaternary sea-level change in the Bonaparte Gulf, northwestern Australia, *Geoscience Letters*, DOI 10.1186/s40562-016-0065-0

Ishiwa, T., Yokoyama, Y., Okuno, J., Obrochta, S., Uehara, K., Ikehara, M., and Miyairi, Y.: A sea-level plateau preceding the Marine Isotope Stage 2 minima revealed by Australian sediments, Scientific reports, 9, 6449, https://doi.org/10.1038/s41598-019-42573-4, 2019.

Jones, R. 1985 (Ed). *Archaeological Research in the Kakadu National Park 1981 – 1984*. Canberra: Australian National University.

Kamminga, J. and H. Allen. 1973. *Report of the Archaeological Survey: Alligator Rivers Environmental Fact-Finding Study*. Darwin: Government Printer.

Keen, I. 2004. *Aboriginal economy and society: Australia at the threshold of colonisation*. Oxford: Oxford University Press.

Kuijjer, K., Haigh, I., Marsh, R., Farr, H. 2022. Changing Tidal Dynamics and the Role of the Marine Environment in the Maritime Migration to Sahul. *PalaeoAnthropology* 2022.1: 134–148. https://doi.org/10.48738/2022.iss1.105

Lambeck K, Rouby H, Purcell A, Sun Y and Sambridge M., 2014. Sea level and global ice volumes from the Last Glacial Maximum to the Holocene. *PNAS* 111: 43 15296-15303.

Lavering, I. H. 1993. Quaternary and modern environments of the Van Diemen Rise, Timor Sea, and potential effects of additional petroleum exploration activity, *BMR Journal of Australian Geology & Geophysics*, 13: 281 - 292

Leach, J., C. Wiseman, M. O'Leary, J. McDonald, J. McCarthy, P. Morrison, P. Jeffries, J. Hacker, S. Ulm, G. Bailey & J. Benjamin. 2021. The integrated cultural landscape of North Gidley Island: Coastal, intertidal and nearshore archaeology in Murujuga (Dampier Archipelago), Western Australia, *Australian Archaeology*, 87:3, 251-267, DOI: 10.1080/03122417.2021.1949085

Leichardt, L. 1847. *Journal of an Overland Expedition in Australia from Moreton Bay to Port Essington, A distance of upwards of 3000 miles during the years 1844-1845*. London: T & W Boone.

Lessa, G., Masselink, G., 2006. 'Evidence of a Mid-Holocene Sea Level Highstand from the Sedimentary Record of a Macrotidal Barrier and Paleoestuary System in Northwestern Australia.' *J. Coast. Res.* 221, 100–112. https://doi.org/10.2112/05A-0009.1

Lewis, S. E., Sloss, C. R., Murray-Wallace, C. V., Woodroffe, C. D., and Smithers, S. G.: Post-glacial sea-level changes around the Australian margin: a review, Quaternary Science Reviews, 74, 115– 138, https://doi.org/10.1016/j.quascirev.2012.09.006, linking Southern Hemisphere records and past circulation patterns: the AUS-INTIMATE project, 2013

Mao, X and Retallack, G. 2019. 'Late Miocene drying of central Australia'. Palaeogeography, Palaeoclimatology, *Palaeoecology* 514: 292-304.

May, S.K. 2009. *Collecting cultures: myth, politics, and collaboration in the 1948 Arnhem Land expedition*. Maryland: Rowman Altamira.

May, S.M., Brill, D., Leopold, M., Callow, J.N., Engel, M., Scheffers, A., Opitz, S., Norpoth, M., Brückner, H., 2017. Chronostratigraphy and geomorphology of washover fans in the Exmouth Gulf (NW Australia) – A record of tropical cyclone activity during the late Holocene. Quat. Sci. Rev. 169, 65–84. https://doi.org/10.1016/j.quascirev.2017.05.023

McCarthy, J, C Wiseman, K Woo, D Steinberg, M O'Leary, D Wesley, L M. Brady, S Ulm & Benjamin, J., 2022. 'Beneath the Top End: A regional assessment of submerged archaeological potential in the Northern Territory, Australia.', *Australian Archaeology*, 88:1, 65-83

McNiven, I. 2003. 'Saltwater People: spiritscapes, maritime rituals and the archaeology of Australian indigenous seascapes.' *World Archaeology.* 35(3): 329-349. doi:10.1080/0043824042000185757

Meehan, B, Brockwell, J, Allen H and Jones, R. 1985. 'The Wetland Sites'. In Jones, R. *Archaeological Research in the Kakadu National Park 1981 – 1984*. Canberra: Australian National University: 103-53.

Meehan, B. 1982. *Shell Bed to Shell Midden.* Australian Institute of Aboriginal Studies, Canberra.

Mitchell, S. 1993. Shell Mound Formation in Nothern Australia: A case study from Croker Island, Northwestern Arnhem Land. *The Beagle: Records of the Northern Territory Museum of Arts and Sciences*, 10(1): 179-192.

Mitchell, S. 1994 Stone exchange network in north-western Arnhem Land: Evidence for recent chronological change. In M. Sullivan, S. Brockwell and A. Webb (Eds.) *Archaeology in the North,* pp. 188-200. Darwin: North Australian Research Unit, Australian National University.

Morris, J. 2000. Memories of the Buffalo shooters: Joe Cooper and the Tiwi (1895-1936).*Aboriginal History.* Vol24: 141-151.

Morris, J. 2001a. *The Tiwi: From Isolation to Cultural Change*. Darwin: Northern Territory University Press.

Morris, J. 2001b. The Tiwi and the British: an ill-fated outpost. *Aboriginal History.* Vol 25: 243-261.

Morrison, P., O'Leary, M., McDonald, J. 2023. The evolution of Australian island geographies and the emergence and persistence of Indigenous maritime cultures. *Quaternary Science Reviews.* 308. https://doi.org/10.1016/j.quascirev.2023.108071

Mory, A.J., 1988. Regional geology of the offshore Bonaparte Basin. In *The North West shelf, Australia. Symposium* (pp. 287-309)

Nanson, Rachel, Arosio, Riccardo, Gafeira, Joana, McNeil, Mardi, Dove, Dayton, Bjarnadóttir, Lilja, Dolan, Margaret, Guinan, Janine, Post, Alix, Webb, John, Nichol, Scott, 2023. A two-part seabed geomorphology classification scheme; Part 2: Geomorphology classification framework and glossary (Version 1.0). *Zenodo*. https://zenodo.org/record/7804019

Nicholas W A, Carroll A, Picard K, Radke L, Siwabessy J, Chen J, Howard F J F, Dulfer H, Tran M, Consoli C, Przeslawski R, Li J, Jones L. E. A., 2015. 'Seabed environments, shallow sub-surface geology and connectivity, Petrel Sub-basin, Bonaparte Basin, Timor Sea, Interpretative report from marine survey GA0335/SOL5463', Geoscience Australia, Canberra. http://dx.doi.org/10.11636/Record.2015.024

Nott, J., 1996. Late Pleistocene and Holocene Sea-Level Highstands in Northern Australia, Journal of Coastal Research, 12, 907–910, URL http://www.jstor.org/stable/4298541

Nott, JF. 2003. 'The urban geology of Darwin, Australia.' *Quaternary International* 103.1: 83-90.

Nott, J. 2007. 'Long term landscape evolution in the Darwin region and its implications for the origin of landsurfaces in the north of the Northern Territory'. *Australian Journal of Earth Sciences* 41:407-415.

Nunn, P.D., Reid, N.J., 2016. Aboriginal Memories of Inundation of the Australian Coast Dating from More than 7000 Years Ago. Aust. Geogr. 47, 11–47. https://doi.org/10.1080/00049182.2015.1077539

Nutley, D.M. 2005. *Surviving Inundation An examination of environmental factors influencing the survival of inundated Indigenous sites in Australia within defined hydrodynamic and geological settings*. Unpublished Masters thesis, Flinders University, Adelaide.

Nutley, D. M., Coroneos, C., & Wheeler, J. (2016). Potential submerged aboriginal archaeological sites in South West Arm, Port Hacking, New South Wales, Australia. *Geological Society Special Publication*, *411*(1), 265–285. https://doi.org/10.1144/SP411.3

O'Leary M, Benjamin J, Wesley D, Bailey G, Kearney A, n.d., Knowing Sea Country: submerged archaeological potential along the Santos Barossa pipeline route. Unpublished report.

Pegum, D M. 1997. *An Introduction to the Petroleum Geology of the Northern Territory of Australia*. Northern Territory, Australia: Northern Territory Geological Survey.

Pietsch, B A and Stuart-Smith, P G. 1987. *Darwin SD52-4, 1:250 000 Geological Map Series, Explanatory Notes* Darwin, Australia: Government Printer of the Northern Territory.

Pilling, A. 1962. A Historical versus a non-historical approach to social change and continuity among the Tiwi. *Oceania.* Vol 32.4: 321-326. https://doi-org.manchester.idm.oclc.org/10.1002/j.1834-4461.1962.tb01785.x

Rebesco, M. and Camerlenghi, A. (eds)., 2008. *Contourites*. Elsevier.

Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kromer, B., Manning, S.W., Muscheler, R., Palmer, J.G., Pearson, C., Van Der Plicht, J., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S.M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A., Talamo, S., 2020. The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP). *Radiocarbon* 62, 725–757. https://doi.org/10.1017/RDC.2020.41

Rhodes, D. 2003. *Victorian Channel Deepening Project EES: Aboriginal Cultural Heritage, Existing Conditions Report*. Unpublished report prepared for Parsons Brinkerhoff and POMC by Terraculture Pty Ltd.

Roberts, R.G., Jones, R., Smith, M.A. 1990. 'Early dates at Malakunanja II: A reply to Bowdler.' *Australian Archaeology*, 3: 194-197.

Roberts. R.G., Jones, R. and Smith, M.A. 1993. 'Optical dating at Deaf Adder Gorge, Northern Territory, indicates human occupation between 53,000 and 60,000 years ago.' *Australian Archaeology*, 37: 58-59.

Roberts R.G., Yoshida, H., Galbraith, R., Laslett, G., Jones, R. and Smith, N. 1998. 'Single-aliquot and single grained dating confirm thermoluminesence age estimates at Malakununja II rock shelter in Northern Australia.' *Ancient TL*, 16: 19-24.

Rowland, M.J. and Ulm, S. 2011. 'Indigenous fish traps and weirs of Queensland.' *Queensland Archaeological Research*, 14: 1-58.

Schrire, C. 1982. *The Alligator Rivers: Prehistory and Ecology in Western Arnhem Land*. Canberra: Dept. of Prehistory, Research School of Pacific Studies, Australian National University

Shakun J D, Lea D W, Lisiecki L E, Raymo M. E., 2015. 'An 800-kyr record of global surface δ18O and implications for ice volume temperature coupling.' *Earth and Planetary Science Letters* 426 58-68.

Sharp, N. 2002. *Saltwater People: The Waves of Memory.* Allen and Unwin: Crows Nest, NSW

Shennan, I., Long, A.J., Horton, B.P. (Eds.), 2015. *Handbook of Sea-Level Research*, 1st ed. Wiley. https://doi.org/10.1002/9781118452547

Shine, D, M Marshall, D Wright, T Denham, P Hiscock, G Jacobsen and S-P Stephens. 2015. 'The archaeology of Bindjarran rockshelter in Manilikarr Country, Kakadu national Park, Northern Territory'. *Australian Archaeology Association* 80: 104-111.

Shine, D, Wright, D, T Denham, K Aplin, P Hiscock, K Parker and R Walton. 2013. 'Birriwilk, a mid-Holocene site in Manikilarr Country, Western Arnhem Land, NT'. *Australian Archaeology Association* 76: 69-78.

Short, A.D., 2014. 'Australia's temperate carbonate coast: sources, depositional environments and implications.' *Geological Society, London, Special Publications*, *388*(1), pp.389-405

Sim, R. and Wallis, L. 2008. 'Northern Australian offshore island use during the Holocene: the archaeology of Vanderlin island, Sir Edward Pellew Group, Gulf of Carpentaria.' *Australian Archaeology*, 67(1): 95-106.

Spencer, B. 1912. Kakadu People. In: D Welch (Ed.). Northern Territory, Australia. *Australian Aboriginal Culture Series No. 3.*

Spencer, B. 1914. *Native Tribes of the Northern Territory of Australia*. London: Macmillan and Co..

Spencer, B. 1928. *Wanderings in Wild Australia. vol. 2*. London: Macmillan.

Stehlik, B. 1986. 'Hermann Klaatsch and the Tiwi, 1906.' *Aboriginal History*. Vol 10:1/2 pp 59-76. https://www.jstor.org/stable/24054593 [Accessed 09/05/2023]

Steyne, H. 2007 'Investigating the possibility of surviving submerged landscapes in Port Phillip Bay, Victoria, Australia'. *Newsletter for the Australasian Institute for Maritime Archaeology* 26 (4): 10-11. PDF file.

Steyne, H. 2008 'Submerged Prehistoric Landscapes of Port Phillip Bay, Victoria, Australia - Halfway point update'. *Newsletter for the Australasian Institute for Maritime Archaeology* 27 (2): 15-17. PDF file.

Steyne, H. 2009 'Submerged Prehistoric Landscapes of Port Phillip Bay'. *Newsletter for the Australasian Institute for Maritime Archaeology* 28 (3): 1, 11-14. PDF file.

Story, R, M A J Williams, A D L Hooper, R E O'Ferrall, J R McAlpine. 1969. Lands of the Adelaide-Alligator Area, Northern Territory. Melbourne, Australia: Commonwealth Scientific and Industrial Research Organisation, Australia. *Land Research Series No. 25.*

Swindles, G.T., Galloway, J.M., Macumber, A.L., Croudace, I.W., Emery, A.R., Woulds, C., Bateman, M.D., Parry, L., Jones, J.M., Selby, K., Rushby, G.T., Baird, A.J., Woodroffe, S.A., Barlow, N.L.M., 2018. Sedimentary records of coastal storm surges: Evidence of the 1953 North Sea event. Mar. Geol. 403, 262–270. https://doi.org/10.1016/j.margeo.2018.06.013

Tacon, P and Brockwell, S. 1995. 'Arnhem Land prehistory in landscape, stone and paint'. *Antiquity* 69: 676-695.

Thomson 1949 Thomson, D. F. 1949. *Economic Structure and the Ceremonial Exchange Cycle in Arnhem Land.* Melbourne: Macmillan.

Tizzard, L, Bicket, A R, Benjamin, J, and De Loecker, D., 2014. 'A Middle Palaeolithic Site in the Southern North Sea: Investigating the Archaeology and Palaeogeography of Area 240.' *Journal of Quaternary Science* 29, 698–710

Tizzard, L., Bicket, A. and De Loecker, D. 2015. *Seabed Prehistory: Investigating the Palaeogeography and Early Middle Palaeolithic Archaeology in the Southern North Sea*, Wessex Archaeology Monograph 35. Internal reference 70757.

Twidale, C R. 1990. 'The origin and implications of some erosional landforms'. *The Journal of Geology* 98, no. 3: 343-364.

Venbrux, E. 2017. How the Tiwi Construct the Deceased's Postself in Mortuary Ritual, *Anthropological Forum*, 27:1, 49-62, DOI: 10.1080/00664677.2017.1287055

Verhart, L.B.M. 2004. The implications of prehistoric finds on and off the Dutch coast. In: N.C. Flemming (ed.) *Submarine prehistoric archaeology of the North Sea*. Research priorities and collaboration with Industry, York (CBA Research Report 141), 57–61. York, Council for British Archaeology.

Veth, P, J McDonald, I Ward, M O'Leary, E Beckett, J Benjamin, S Ulm, J Hacker, P.J. Ross and Bailey, G., 2020. 'A Strategy for Assessing Continuity in Terrestrial and Maritime Landscapes from Murujuga (Dampier Archipelago), North West Shelf, Australia.', *The Journal of Island and Coastal Archaeology*, 15:4, 477-503

Woodroffe, C., Chappell, J. M. A., Thom, B. G., and Wallensky, E., 1986. Geomorphological dynamics and evolution of the South Alligator tidal river and plains, Northern Territory, vol. 3 of Mangrove Monograph, Australian National University North Australia Research Unit, URL http://hdl.handle.net/1885/8957

Woodroffe, C. D., Thom, B. G., and Chappell, J., 1985. Development of widespread mangrove swamps inmid-Holocene times in northern Australia, Nature, 317, 711–713, https://doi.org/10.1038/317711a0

Woodroffe, C. D., Thom, B., Chappell, J., Wallensky, E., and Grindrod, J.., 1987. Relative sea level in the South Alligator River region, north Australia, during the Holocene, Search, 18, 198–200.

Ward, I., Bastos, A., Carabias, D., Cawthra, H., Farr, H., Green, A., and Sturt, F. 2022. Submerged Palaeolandscapes of the Southern Hemisphere (SPLOSH) – What is emerging from the Southern Hemisphere, *World Archaeology*, 54:1, 6-28, DOI:10.1080/00438243.2022.2077822

Ward I, Larcombe P, Ross P J, Fandry, C. 2022. 'Applying geoarchaeological principles to marine archaeology: A reappraisal of the "first marine" and "in situ" lithic scatters in the Dampier Archipelago, NW Australia.', *Geoarchaeology* published by Wiley Periodicals LLC, https://doi.org/10.1002/gea.21917

Ward, I., Veth, P., & Manne, T. (2016). To the islands born: The research potential of submerged landscapes and human habitation sites from the islands of NW Australia. *Geological Society Special Publication*, *411*(1), 251–263. https://doi.org/10.1144/SP411.4

Welch, D. 2008. 'Introduction' in Spencer, B. 1912. D. Welch (Ed.). *Kakadu People*. Northern Territory, Australia. *Australian Aboriginal Culture Series No. 3*.

Wesley, D., Litster, M., O'Connor, S., Grono, E., Theys, J., Higgins, A., Jones, T., May, S.K. and Taçon, P. 2018. 'The archaeology of Maliwawa: 25,000 years of occupation in the Wellington Range, Arnhem Land.' *Australian Archaeology*, 84(2): 108-128.

Wessex Archaeology, 2013a. *Audit of Current State of Knowledge of Submerged Palaeolandscapes and Sites.* Salisbury, unpubl report, ref: 84570.01

Wessex Archaeology, 2013b. *Palaeo-Yare Catchment Assessment*. Salisbury, unpubl report, ref: 83740.04

Wiseman, C., O'Leary, M., Hacker, J., Stankiewicz, F., McCarthy, J., Beckett, E., Leach, J., Baggaley, P., Collns, C., Ulm, S., McDonald, J., Benjamin, J. 2021. 'A multi-scalar approach to marine survey and underwater archaeological site prospection in Murujuga, Western Australia.' *Quaternary International,* 584: 152-170.

Williams, MAJ. 1969. 'Geomorphology of the Adelaide-Alligator area.' In Story, R.. Williams. MAJ, Hooper, ADL, O'Ferral, RE, & McAlpine, JR. (eds), *Lands of the Adelaide-Alligator Area, Northern Territory*, 71–94. CSIRO Land Research Series No. 25. CSIRO, Melbourne.

Woodroffe, C D, Chappell, J and Thom, B. G. 1988. 'Middens in the context of estuarine development, South Alligator River, Northern Territory'. *Archaeology in Oceania*, 23: 95-103.

Woodroffe, C D, J M A Chappell, B G Thom, E. Wallensky. 1986. *Geomorphological dynamics and evolution of the South Alligator Tidal River and plains, Northern Territory*. Northern Territory, Australia: Australian National University North Australia Research Unit. Mangrove Monograph No. 3.

Wright, D., Hiscock, P. and Aplin, K. 2013. 'Re-excavation of Dabangay, a mid-Holocene settlement site on Mabuyag in western Torres Strait.' *Queensland Archaeological Research*, 16: 15-32.

APPENDICES

Appendix I: Glossary

Alluvium sediments transported by water in a non-marine environment. Any water-borne sediment is technically alluvium, but the common usage is for fine-grained floodplain deposits of streams or rivers.

Bathymetry/Bathymetric the measurement of depth of water in oceans, seas. When we talk of bathymetry in geophysics, we mean the variations in seawater depths, therefore the undulations in the seabed.

Bioturbation the disturbance and physical alteration of sedimentary deposits by living organisms including fauna or plant roots.

BP years before present.

Borehole a hole drilled into the ground for the purpose of extracting a sediment core for geotechnical evaluation.

Buried soil a soil that has developed on a former land surface that has subsequently been buried or inundated.

Cal. BP years before present, based on the calibrated radiocarbon age scale.

Calcirudite A form of limestone that has larger than normal grains.

Chenier stabilized wave-built ridges of sand (or occasionally shell or gravel) formed on an alluvial plain of silt, clay, or peat.

Clay mineral particles smaller than 0.002mm.

Colluvium soil or sediment material that accumulates at the bottom of a slope. Colluvium can be several metres deep, and is usually poorly sorted with either weak, or no stratification. Head is a type of colluvium (see Head).

Cone Penetration Test (CPTU) a in situ penetration test method used to determine the geotechnical properties of soils with depth.

Continental Shelf a relatively shallow submerged terrace of continental crust forming the edge of a continental landmass.

Cretaceous a geological period preceding the Palaeogene extending from 145 to 66 million years ago.

Dry valley a valley with no stream in it.

Fluvial of or in a river.

Geomorphology (the study of) the origin and evolution of topographic and bathymetric features created by physical, chemical or biological processes operating at or near Earth's surface.

Holocene the present warm period (interglacial) that began c. 11,700 years ago following the last glacial period.

Horizons a bedded surface where there is a marked change in the lithology within a sedimentary sequence.

Kombolgie Formation a quartz sand-stone-conglomerate-basalt unit forming the basal part of the Paleoproterozoic Katherine River Group. It is the oldest component of the northwest McArthur Basin.

Koolpinyah surface a dissected, lateritised land surface comprised of a series of gently undulating lowland plains from Darwin to the Arnhem land escarpment. The plains are recent and still actively forming.

Kya thousands of years ago

Interfluves a region between the valleys of adjacent watercourses

Interstadial short warm phase within a glacial (cold) period

Late Devensian the final phase of the last ice age, spanning the period c. 26-11.7 thousand years, including the maximum phase of ice advance during the Last Glacial Maximum (c. 22 thousand years ago)

Laterite is both a soil and a rock type rich in iron and aluminium and is commonly considered to have formed in hot and wet tropical areas. Nearly all laterites are of rusty-red coloration, because of high iron oxide content. They develop by intensive and prolonged weathering of the underlying parent rock, usually when there are conditions of high temperatures and heavy rainfall with alternate wet and dry periods.

Laterization a prolonged process of chemical weathering that produces a wide variety in the thickness, grade, chemistry and ore minerology of the resulting soils, common in the tropical regions.

Last Glacial Maximum the maximum phase of ice advance c. 22,000 years ago.

Lithology the physical classification of rocks, including grain size, texture, structure and colour.

Luminescence dating an absolute radiometric method of determining the age of sediments based on the time elapsed since last exposure to light.

Marine Isotope Stage (MIS) alternating warm (interglacial) and cold (glacial) periods in the earth's climate visible in oxygen isotope data from ocean core samples. Working backwards from the present, odd numbers generally reflect interglacial periods (for example the present MIS 1) and even numbers glacial periods (e.g. MIS 2, the last glacial period).

Marine regression a geological process occurring when areas of submerged seafloor are exposed above the sea level.

Marine transgression a geologic event during which sea level rises relative to the land and the shoreline moves toward higher ground.

mbsb – metres below seabed.

Minerogenic comprised entirely of mineral particles (for example, clay, silt, sand or gravel) with no organic matter (plant or animal remains).

Multibeam echosounders (MBES) an acoustic sensor which uses sound to measure the water depth to the seabed by emitting a sound wave into the water column and listening for the received response. The time it takes for the sound to return to the sensor is used to calculate the depth to the seabed. The data is collected along linear survey lines; when the surveys lines are run adjacent to one another with some overlap, a complete model of the seabed topography can be calculated at a resolution of centimetres.

Mya millions of years ago.

Neoproterozoic the last geological era of the Precambrian eon spanning a period of between 1 billion and 538.8 million years.

Organic matter all dead plant and animal matter in soils and sediments. Sediments described as ‘organic’ or ‘organic-rich’ include such material.

Paleoproterozoic the longest era of Earth’s geological history extending from 2,500 to 1,600 million years.

Peat deposit comprising mainly decayed or partially decayed plant material.

Piston core an oceanographic corer with a piston mechanism which creates suction to extract a sediment core.

Pleistocene the geological period beginning c. 2.6 million years ago and characterised by interglacial (warm) – glacial (cold) cycles, ending at the end of the Last Ice Age (Younger Dryas) around 11,700 years ago. The Late Pleistocene, c. 129,000 – 11,000 years ago saw migrations of early humans from Africa, including archaeological evidence for the earliest people in Australia c.60-50,000 BP.

Precambrian the earliest geological Eon spanning from the formation of Earth c. 4.6 billion years ago to the beginning of the Cambrian Period c. 538.8 million years ago.

Prograding when the rate of sedimentary deposition exceeds the rate of accommodation.

Quaternary the current geological period beginning c. 2.6 million years ago and characterised by interglacial (warm) – glacial (cold) cycles. The Pleistocene and Holocene are geological epochs of the Quaternary Period.

Ravinement a process of erosion that occurs due to waves or tides during marine transgression (inundation). This process can result in the reworking of landforms and the formation of a ravinement surface.

Reflectors a subsurface contrast, such as a boundary between types of sediment, that reflects sound waves. These reflections are what is visible in the marine geophysical data.

River terrace deposits sediments deposited in high energy river channels, typically sands and gravels. Can form multiple terraces associated with successive phases of aggradation and incision related to multiple glacial and interglacial cycles

Sand mineral particles of 2mm to 0.063mm.

Sediment a collection of rock, mineral and/or organic particles that has been moved from their original source and redeposited elsewhere by natural or human processes.

Sidescan sonar an acoustic sensor that uses sound to create a "picture" of the seabed by emitting a sound wave into the water column and listening for the received response. When the sound hits the seabed it returns some of the acoustic energy; the strength of the returned energy can provide clues as to the composition of the seabed sediments, as well as the material of the objects on the seabed. Hard materials such as rock or metal will reflect more of the sound and will therefore give a stronger response in the sidescan sonar data. Softer materials, such as waterlogged wood, absorb some of the energy, resulting in a weaker return. When survey lines are run adjacent to each other, with a wide enough range to overlap, SSS data can be 'mosaiced' to create an image of the seafloor.

Sigmoidal 'S' shaped.

Siliclastic/siliciclastic a group of sedimentary rocks consisting of fragments of minerals and rocks derived from pre-existing rocks.

Silt mineral particles of 0.063mm to 0.002mm.

Soil loose material at the earth's surface undergoing weathering and horizon formation owing to hydration, redox processes and the accumulation of organic matter from organisms that live within it.

Sorting measure of the degree to which the particles in a sediment are concentrated in one size grouping.

Strandplain a broad belt of sand along a shoreline.

Stream valley a valley drained by a river or stream.

Subaerial existing, occurring, or formed in the open air or on the earth's surface, not under water or underground.

Sub-bottom profilers an acoustic sensor used to create a 2D image of the sediment and rock below the seabed. They emit sound waves which penetrate the seabed. When the sound wave hits a change in sediment or rock properties, some of it is reflected. The time it takes the reflected sound waves to return to the receiver is recorded, and this information is used to create a two-dimensional seismic profile. By collecting sub-bottom profiler data along a survey line, you can identify changes in the shape of different sediment and rock bodies and can identify features such as buried river channels.

Superficial deposits geological deposits typically of Quaternary age (less than 2.6 million years old) overlying the solid bedrock geology.

Terrigenous in a marine context meaning of terrestrial origin.

Thalweg a line connecting the lowest points of successive cross-sections along the course of a valley or river.

Vibrocoring a geotechnical sampling technique which uses vibration to insert a cylinder up to 6 m long into the seabed to recover a continuous sequence of intact relatively undisturbed unconsolidated sediments from features below the seabed. This technique is not suitable for acquiring samples of rock and its success depends on the nature of the deposit. It is most successful in cohesive (muds and organic) sediments but can recover sequences of sand and gravel.

Appendix II: Palaeogeographic features of archaeological potential.

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7000	Ridge	P2	-	-	A potential coastal ridge identified in the MBES data as a linear ridge, orientated approximately WSW - ENE, on shallow slope. May represent an offshore bar or beach ridge.	66	MBES (2018 Fugro)
7001	Ridge	P2	-	-	Linear ridge on shallow slope. Potential offshore bar, barrier, or beach ridge.	66	MBES (2018 Fugro)
7002	Ridge	P2	-	-	Linear ridge on shallow slope. Potential offshore bar, barrier, or beach ridge.	66	MBES (2018 Fugro)
7003	Channel	P1	-	-	A possible palaeochannel identified as a deeply incised channel segment. Corresponds with features **7004** and **7005** identified in the SBP data, suggesting some infilling of sediments at the base.	87	MBES (2018 Fugro)
7004	Channel	P1	4.8	15.9	A channel identified in the SBP data, possibly cutting into the interpreted Unit 1, beneath a thin layer of possible marine sands. Feature has a poorly defined basal reflector and acoustically quiet fill which appears acoustically similar to overlying sediment. Feature is seen to correspond with the base of with a larger channel feature identified in the MBES data (**7003**). May represent the base of channel **7003** infilled with modern sediments, or possibly an older phase of channelling.	86-87	Boomer (2015, 2023 Fugro)
7005	Channel	P1	0.5	8.8	A possible channel identified in the SBP data interpreted as cutting into the interpreted Unit 1, beneath a thin layer of possible marine sands. Feature has a distinct basal reflector and acoustically quiet fill which appears acoustically similar to overlying sediment. Feature is seen to correspond with the base of with a larger channel feature identified in the MBES data (**7003**). May represent the base of channel **7003** infilled with modern sediments, or possibly an older phase of channelling.	86-87	Boomer (2018, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7006	Channel	P1	0.9	11.2	A channel identified in the SBP data interpreted as cutting into Unit 1. Feature is identified beneath a thin layer of possible marine sands and has a distinct basal reflector, which has two troughs. Unit fill is generally acoustically quiet with occasional draping reflectors. Feature is seen to correspond with a larger channel feature identified in the MBES data (**7003**). May represent the base of channel **7003** infilled with modern sediments, or possibly an older phase of channelling. EP-12-VC and EP-12_CPT suggest infill material of alluvium.	87	Boomer (2018, 2023 Fugro)
7007	Infilled depression	P2	0.5	3.7	Sediment infilling base of a depression identified on the MBES data. In the SBP data, the feature is seen to have a faint, poorly defined basal reflector overlain by acoustically quiet fill. Feature is seen to correspond with a larger channel feature identified in the MBES data (**7003**). Similarly positioned to features **7004-06**, hut less convincing in form and therefore interpreted as an infilled depression and considered of lower archaeological potential. May represent the base of channel **7003** infilled with modern sediments.	88	Boomer (2018, 2023 Fugro)
7008	Cut and fill	P2	1.3	12.2	A possible multiphase cut and fill identified cutting into an acoustically unstructured unit, possibly Unit 1. Feature has a distinct basal reflector and at least two phases of fill which is generally acoustically quiet. Possibly identified beneath an upper unit of sediment which is acoustically similar to the second phase of fill. Close to another similar feature (**7009**). Possible remnant fluvial feature.	92	Boomer (2018, 2023 Fugro)
7009	Cut and fill	P2	1.4	8.6	A possible multiphase cut and fill identified cutting into an acoustically unstructured unit, possibly Unit 1. Feature has a distinct basal reflector and at least two phases of fill which is generally acoustically quiet, although the lower fill appears to be characterised by faint, dipping reflectors. Possibly identified beneath an upper unit of sediment which is acoustically similar to the second phase of fill. Close to another similar feature (**7008**). Possible remnant fluvial feature.	93	Boomer (2018, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7010	Infilled depression	P2	0.9	4.6	Possible infilled depression identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill. Identified in the base of a depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Likely continues further to the west as infilled depression **7011**; however, due to the distance between the lines, the features have not been grouped together.	103	Boomer (2018, 2023 Fugro)
7011	Infilled depression	P2	1.3	4.9	Possible channel identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill, although this is partially obscured by the seabed pulse. May represent an infilled depression or the cut of an underfilled channel feature or a partially filled with marine sediments. Likely continues further to the east as infilled depression **7010**; however, due to the distance between the lines, the features have not been grouped together.	103	Boomer (2015 Fugro)
7012	Infilled depression	P2	0.8	6.4	Possible infilled depression identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression infilled with sand or the cut of an underfilled channel feature, partially filled with marine sediments.	110	Boomer (2018, 2023 Fugro)
7013	Cut and fill	P2	1.8	13.6	Possible cut and fill identified below a thin unit of possible marine sediment. Feature has a distinct basal reflector and possibly multiple phases of fill, the lower of which is acoustically unstructured and the upper of which is acoustically quiet, although this may represent marine sediments infilling an underfilled feature. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Close to, and similar in for to **7014**.	112	Boomer (2018, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7014	Cut and fill	P2	2.1	9.4	Possible cut and fill identified below a thin unit of possible marine sediment. Feature has a distinct basal reflector and possibly multiple phases of fill, the lower of which is unstructured and the upper of which is acoustically quiet, although this may represent marine sediments infilling an underfilled feature. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Close to, and similar in for to **7013**.	112-113	Boomer (2018, 2023 Fugro), Sparker (2018 DOF)
7015	Channel	P1	3.9	14.3	A possible channel identified below an upper unit of sediment, cutting into the interpreted Unit 1. Feature has a relatively distinct basal reflector and fill characterised by numerous horizontal reflectors indicating layered fill which may have been deposited in a low-energy environment.	118	Boomer (2018, 2023 Fugro)
7016	Complex channel	P1	1.3	16.4	Possible complex channel identified below a veneer of sediment, cutting into the interpreted Unit 1. Feature appears to have multiples phases of acoustically chaotic fill, with a faint basal reflector which shows several troughs. Possible remnant fluvial feature. EP-21-CPT suggests alluvium overlying dense sand.	133 - 134	Boomer (2018, 2023 Fugro)
7017	Cut and fill	P2	1	5	A small cut and fill identified BSB/below veneer of seabed sediment. Feature has a distinct basal reflector and acoustically quiet fill. Possible infilled depression of the remnants of a relict fluvial feature.	135	Boomer (2018 Fugro)
7018	Infilled depression	P2	1	4.5	An infilled depression with a distinct basal reflector and acoustically quiet fill. Identified BSB or beneath a veneer of sediment. Possibly an infilled depression infilled with sand or may be remnants of a fluvial feature.	143	Boomer (2023 Fugro)
7019	Ridge	P2	-	-	Potential beach ridge segment	144	MBES (Opensource)
7020	Complex cut and fill	P2	0.3	10	Possible channel identified BSB/below a veneer or seabed sediments, cutting into the top of the interpreted Unit 1. Feature has a poorly defined basal reflector and possibly multiple phases of fill with a lower chaotic fill and upper fill characterised by numerous dipping horizons.	145	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7021	Complex cut and fill	P2	0.4	9.1	A complex unit identified BSB with numerous cuts, fills and cross-cutting reflectors. Feature may represent a broad, shallow channel complex or may be an area of reworked sediments. Origin uncertain but, as it has the potential to be a fluvial feature, it has been retained as a precaution.	148	Boomer (2023 Fugro)
7022	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	149	MBES (2018 Fugro)
7023	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	149	MBES (2018 Fugro)
7024	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	149	MBES (2018 Fugro)
7025	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	150	MBES (2018 Fugro)
7026	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	150	MBES (2018 Fugro)
7027	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	150	MBES (2018 Fugro)
7028	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	150	MBES (2018 Fugro)
7029	Cut and fill	P2	0.8	8.9	Small cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill characterised by dipping reflectors. May represent remnants of a fluvial feature.	151-152	Boomer (2023 Fugro)
7030	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	151	MBES (2018 Fugro)
7031	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	152	MBES (2018 Fugro)
7032	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	152	MBES (2018 Fugro)
7033	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	152	MBES (2018 Fugro)
7034	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	152	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7035	Cut and fill	P2	1.1	5	A possible cut and fill identified below a veneer of seabed sediment. Feature has a distinct basal reflector and acoustically unstructured fill. May represent a shallow channel or possibly an infilled depression at the top of the interpreted Unit 1.	153	Boomer (2023 Fugro)
7036	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	153	MBES (2018 Fugro)
7037	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7038	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7039	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7040	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7041	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7042	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7043	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7044	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7045	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7046	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7047	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7048	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7049	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7050	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7051	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7052	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7053	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7054	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7055	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7056	Ridge	P2	-	-	Possible dune ridge or beach ridge with cuspate end, ~1 km long	157	MBES (2018 Fugro)
7057	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7058	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7059	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7060	Ridge	P2	-	-	Possible cuspate beach ridge	157	MBES (2018 Fugro)
7061	Ridge	P2	-	-	Possible cuspate beach ridge	157	MBES (2018 Fugro)
7062	Ridge	P2	-	-	Possible cuspate beach ridge	157	MBES (2018 Fugro)
7063	Ridge	P2	-	-	Possible cuspate beach ridge	157	MBES (2018 Fugro)
7064	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	157	MBES (2018 Fugro)
7065	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	158	MBES (2018 Fugro)
7066	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	161	MBES (2018 Fugro)
7067	Cut and fill	P2	0.8	4.8	A small possible cut and fill identified BSB/below a veneer of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature appears faint and poorly defined. May be a small, infilled depression or remnants of a fluvial feature.	162	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7068	Complex cut and fill	P2	1.4	12	A possible complex cut and fill identified below a veneer of sediment cutting into the interpreted Unit 1. Feature has a distinct basal reflector and multiple phases of cutting and fill which is generally acoustically unstructured. May represent relict fluvial feature	164-166	Boomer (2023 Fugro)
7069	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	164	MBES (2018 Fugro)
7070	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	165	MBES (2018 Fugro)
7071	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	165	MBES (2018 Fugro)
7072	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	167	MBES (2018 Fugro)
7073	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	167	MBES (2018 Fugro)
7074	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	168	MBES (2018 Fugro)
7075	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	168	MBES (2018 Fugro)
7076	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	168	MBES (2018 Fugro)
7077	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	168	MBES (2018 Fugro)
7078	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	169	MBES (2018 Fugro)
7079	Complex cut and fill	P2	1.6	16.8	A distinct cut and fill identified below a veneer of seabed sediment cutting into a layered unit which may be part of the interpreted Unit 1. May be seen to continue to the north-west outside of the development area, although due to the distance between lines they have not definitively been grouped together. Feature has a faint basal reflector and multiple phases of acoustically quiet fill. Possible remnants of a fluvial feature.	168-169	Boomer (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7080	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	170	MBES (2018 Fugro)
7081	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	170	MBES (2018 Fugro)
7082	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	170	MBES (2018 Fugro)
7083	Cut and fill	P2	5.4	29.4	A broad cut and fill with a faint basal reflector identified below an upper layer of sediments characterised by numerous, faint horizontal reflectors (possibly Unit 4), cutting into the interpreted Unit 1. Unit fill is generally acoustically unstructured, possibly with multiple phases of cut and fill. Possible remnants of a fluvial feature.	16-170	Boomer (2023 Fugro)
7084	Channel	P1	-	-	Channel segment	173	MBES (2018 Fugro)
7085	Cut and fill	P2	2.4	9.9	A broad cut and fill identified below a thin, upper layer of sediments, cutting into the interpreted Unit 1. Unit fill is generally acoustically unstructured, possibly with multiple phases of cutting and filling. Possible remnants of a fluvial feature. May form part of a larger feature with **7086** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together	171	Boomer (2023 Fugro)
7086	Channel	P1	1.2	23.5	A possible channel identified BSB/below a veneer of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1 (Unit 1). Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together	171	Boomer (2015, 2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7087	Channel	P1	1.5	13.5	A possible channel identified BSB/below a veneer of sediment, cutting into a Unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments, or may be part of the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085 -7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together	171	Boomer (2015, 2018 Fugro)
7088	Cut and fill	P2	2.5	18	A possible cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and generally acoustically unstructured fill, of which there is possibly more than one phase. Identified along the northern edge of a bathymetric high seen in the 2018 Fugro MBES data. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together. Feature appears less convincing compared to others in the area and, as such as been classified as a cut and fill and is considered of lower archaeological potential.	171-172	Sparker (2018 Fugro)
7089	Cut and fill	P2	2	10.1	A possible cut and fill identified a thin unit of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature has a faint basal reflector and acoustically unstructured fill. May be a remnant fluvial feature or may represent overbank deposits related to channel feature **7084**. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together.	172	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7090	Channel	P1	3.1	25.3	A possible channel identified a thin unit of sediment, cutting into a unit characterised by numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature has a faint basal reflector and fill characterised by numerous draping reflectors. Possible channel. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together.	172	Boomer (2023 Fugro)
7091	Channel	P1			A possible cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and generally acoustically unstructured fill, of which there is possibly more than one phase. Identified along the northern edge of a bathymetric high seen in the 2018 Fugro MBES data. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (6586) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085 - 7092;** however, due to the distance between the SBP lines, these have not definitively been grouped together.	173	Sparker (2018 Fugro)
7092	Complex channel	P1	3.5	16.1	A possible complex channel identified below a shallow Unit of sediment, cutting into a Unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments, or may be part of the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085 -7092**; however, due to the distinct between the SBP lines, these have not definitively been grouped together	173	Boomer (2023 Fugro)
7093	Cut and fill	P2	1.3	21.2	A possible cut and fill identified beneath a veneer of marine sediment, cutting into the interpreted Unit 1. Feature has a poorly defined basal	174-175	Boomer (2015 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
					reflector and a acoustically quiet fill. Possibly represents a remnant fluvial feature.		
7094	Complex cut and fill	P2	4.6	22.4	A broad, complex feature identified beneath a thin Unit of sediment, cutting into the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively well defined basal reflector and acoustically transparent/unstructured fill (although the characteristics of these features can vary). Possible remnant of a complex fluvial feature, although may be internal reflectors within Unit 1. EP-28-CPTA suggests Alluvium between 0-0.7 m, overlying dense sand, which may suggest internal reflectors within Unit 1, although this is not definite.	178-181	Boomer (2018, 2023 Fugro)
7095	Channel complex	P1	0.6	25.3	A possible broad channel complex identified beneath a thin unit of sediment, cutting into the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively well defined basal reflector and acoustically transparent/unstructured fill, although some fill is characterised by numerous dipping horizons.	183	Boomer (2018, 2023 Fugro)
7096	Channel	P1	6.8	23.8	A possible channel with a distinct basal reflector and acoustically quiet fill. Feature is identified below an upper unit of sediment (possible Unit 5) which is seen to be cut into by channel feature **7097**, suggesting a different depositional phase between this phase of channelling and that associated with **7097**. Identified cutting into the interpreted Unit 1. May form part of a larger feature with **7098**, however this has been truncated by **7097** and therefore it is not possible to tell.	187	Boomer (2018, 2023 Fugro)
7097	Channel	P1	8.8	119	A channel feature identified below a unit of marine sands, cutting through a lower unit characterised with numerous sub-horizontal reflectors indicating fine-drained deposits (possible Unit 5), and cutting through into lower channels **7096** and **7098**. Feature has a distinct basal reflector and acoustically unstructured/quiet fill.	188	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7098	Channel	P1	8.5	24.4	A possible channel with a distinct basal reflector and acoustically quiet fill. Feature is identified below an upper unit of sediment (possible Unit 5) which is seen to be cut into by channel feature **7097**, suggesting a different depositional phase between this phase of channelling and that associated with **7097**. Identified cutting into the interpreted Unit 1. May form part of a larger feature with **7096**, however this has been truncated by **7097** and therefore it is not possible to tell.	189	Boomer (2018, 2023 Fugro)
7099	Channel complex	P1	3.5	30.1	A broad channel complex identified beneath a unit of sediment, cutting into the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively clear, although occasionally hard to define basal reflectors, and acoustically transparent/unstructured fill (although the characteristics of these features can vary). May be related to nearby palaeochannel **7108** identified on the MBES data, and may form part of a larger feature with **7101** and **7105**.	191-193	Boomer (2018, 2023 Fugro) Sparker (2018 Fugro)
7100	Ridge	P2	-	-	Possible beach ridge	193	MBES (2018 Fugro)
7101	Cut and fill	P2	4.6	15.3	A possible cut and fill identified beneath an upper unit of sediment, interpreted as cutting into a unit with numerous reflectors; possible part of the interpreted Unit 1 although may be part of a larger channel complex (Unit 4). Feature has a distinct basal reflector and acoustically quiet fill. May form part of a larger feature with **7099** and **7105**. May be a remnant fluvial feature.	192-193	Boomer (2018 Fugro)
7102	Ridge	P2	-	-	Possible beach ridge	193	MBES (2018 Fugro)
7103	Ridge	P2	-	-	Possible beach ridge	193	MBES (2018 Fugro)
7104	Ridge	P2	-	-	Possible beach ridge	193	MBES (2018 Fugro)
7105	Cut and fill	P2	6.5	22.6	A possible cut and fill identified beneath an upper unit of sediment, interpreted as cutting into a unit with numerous reflectors; possibly part of the interpreted Unit 1 although may be part of a larger channel complex (Unit 4). Feature has a distinct basal reflector and acoustically quiet fill. May form part of a larger feature with **7099** and **7101**. May be a remnant fluvial feature.	193	Boomer (2018 Fugro) Sparker (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7106	Ridge	P2	-	-	Possible beach ridge	194	MBES (2018 Fugro)
7107	Ridge	P2	-	-	Possible beach ridge	194	MBES (2018 Fugro)
7108	Channel	P1	-	-	Large, wide (~1 km) channel that becomes hard to track northwards in data. May continue as buried channel complex **7099**, identified in the SBP data, although this is not definite.	202-197	MBES (2018 Fugro and Opensource)
7109	Ridge	P2	-	-	Possible beach ridge	195	MBES (2018 Fugro)
7110	Ridge	P2	-	-	Possible beach ridge	195	MBES (2018 Fugro)
7111	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	195	MBES (2018 Fugro)
7112	Channel	P1	11.2	24.6	A possible lower cut of a channel identified below an upper unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment (Unit 5). May be estuarine or lacustrine sediments. Feature has a distinct basal reflector and acoustically unstructured fill. Possible earlier phase of channelling.	195	Boomer (2023 Fugro)
7113	Channel	P1	0.8	10	An upper channel identified BSB/below a veneer of sediment, cutting through a unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment, possibly estuarine or lacustrine sediments (Unit 5). Feature has a distinct basal reflector and acoustically quiet fill. Possible later fluvial feature.	169	Boomer (2023 Fugro)
7114	Channel	P1	6.5	22.7	A possible lower cut of a channel identified below an upper unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment (Unit 5). May be estuarine or lacustrine sediments. Feature has a distinct basal reflector and acoustically unstructured fill. Feature raises into a bank in the centre, possibly just a high point within the channel base. Feature corresponds with the edge of channel **7108** identified in the MBES data. This may represent a previous generation of channelling, although this is not certain.	197	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7115	Channel	P1	2	19.6	A possible channel identified below a thin unit of sediment. Feature has a faint, poorly defined basal reflector with acoustically quiet fill with occasional horizontal reflectors. At the base of the feature, an acoustically chaotic feature can be seen which appears to cause acoustic blanking of lower horizons. It is possible that this may be caused by biogenic gas caused by the microbial breakdown of organic matter, although it may also be caused by gravelly sediments at the base of the channel feature.	199	Boomer (2018 Fugro) Sparker (2018 Fugro)
7116	Channel	P1	-	-	Channel segment with tributaries	206	MBES (2018 Fugro)
7117	Channel	P1	-	-	Palaeochannel, possibly becoming estuarine.	211	MBES (2018 Fugro and opensource)
7118	Channel	P1	-	-	Channel segment with tributaries	209	MBES (2018 Fugro and opensource)
7119	Channel	P1	0.9	8	A possible channel identified within a feature identified in the MBES data (**7117**). Feature has a relatively distinct basal reflector and chaotic fill, possible with more than one phase of cutting and filling. May represent an earlier phase of channelling which has been truncated by a later phase, or may be the partially filled base of **7117**.	211	Boomer (2018, 2023 Fugro) Sparker (2018 Fugro)
7120	Channel	P1	-	-	Tributary segment	212	MBES (2018 Fugro)
7121	Channel	P1	-	-	Tributary segment	212	MBES (2018 Fugro)
7122	Channel	P1	-	-	Narrow palaeochannel segment	214	MBES (2018 Fugro and opensource)
7123	Channel	P1	-	-	Blind channel segment - buried or eroded	217	MBES (2018 Fugro)
7124	Channel	P1	-	-	Blind channel segment - buried or eroded	217	MBES (2018 Fugro)
7125	Channel	P1	-	-	Small channel segment	217	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7126	Channel	P1	0.4	47.2	A possible channel feature identified below a veneer/thin unit of sediment, cutting into a unit characterised by numerous horizontal reflectors which display evidence of faulting indicating Unit 1. Feature has a distinct, occasionally chaotic basal reflector which shoals and deepens throughout the feature and is seen to cause some acoustic blanking of the horizons below. This may indicate shallow gas caused by the microbial breakdown of organic matter, although it may also indicate gravelly sediments at the base of the feature. Unit fill is generally characterised by draping reflectors, although it is seen to be acoustically quiet in some areas. Possibly multiple phases of cut and fill. EP-34-CPT suggests the fill includes non-marine sand.	217 - 222	Boomer (2018, 2023 Fugro)
7127	Cut and fill	P2	1.7	14	A possible lower phase of channelling identified below Channel feature **7126**, cutting into the interpreted Unit 1. Feature has a faint basal reflector and acoustically quiet fill. May represent an earlier phase of channelling.	219-220	Boomer (2018 Fugro)
7128	Channel	P1	1	9.6	A possible channel identified BSB/below a veneer or marine sediment, cutting into the interpreted Unit 1. Feature has generally acoustically quiet fill with occasional higher amplitude horizontal reflectors. Possibly related to channel **7129** identified in the MBES data.	223	Boomer (2018 Fugro)
7129	Channel	P1	-	-	Main large river network draining into canyon	224	MBES (2018 Fugro and opensource)
7130	Channel	P1	1	8.4	Possible channel identified BSB/below a veneer of sediment. Feature has a faint, poorly defined basal reflector and acoustically chaotic fill. Feature appears to be cutting into a unit characterised by numerous horizontal reflectors interpreted as being part of Unit 1. Possibly a continuation of **7131** or part of **7129** identified on the MBES data.	225	Boomer (2023 Fugro)
7131	Channel	P1	-	-	Partially buried palaeochannel	228	MBES (2018 Fugro)
7132	Channel	P1	1.6	8.3	Possible channel identified SBSB/below a veneer of sediment. Feature has a faint basal reflector and acoustically quiet fill. Feature appears to be cutting into a unit characterised by numerous horizontal reflectors	226	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
					interpreted as being part of Unit 1. Possibly related to nearby feature **7131** identified in the MBES data.		
7133	Escarpment	P1	-	-	Cliff band and promontory, up to 10 m relief	228	MBES (2018 Fugro)
7134	Channel	P1	-	-	Palaeochannels largely covered by marine sediments and difficult to interpret from bathymetry	230	MBES (2018 Fugro)
7135	Cut and fill	P2	0.7	5.3	A small cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a distinct basal reflector and acoustically chaotic fill. Feature appears particularly chaotic at the base and is possibly causing some slight acoustic blanking of lower horizons. This may be dure to shallow gas although may be more likely due to gravelly sediments at the base of the feature. Identified below a channel feature identified in the MBES data (**7134**) and may represent an earlier phase of channelling or the base of the feature, partially infilled with sediment.	230	Boomer (2023 Fugro)
7136	Channel	P1	-	-	Palaeochannel largely covered by marine sediments/sediment waves	231	MBES (2018 Fugro and opensource)
7137	Channel	P1	-	-	Steep-sided channels with plateaux interfluves joining into main anabranching river network	235	MBES (2018 Fugro and opensource)
7138	Channel	P1	-	-	Channel segment	237	MBES (2018 Fugro)
7139	Channel	P1	-	-	Large anabranching river complex	242	MBES (Opensource)
7140	Channel	P1	-	-	Channel segment with tributaries	239	MBES (2018 Fugro)
7141	Channel	P1	-	-	Channel segment	241	MBES (Opensource)
7142	Channel	P1	-	-	Channel segment	244	MBES (Opensource)
7143	Channel	P1	-	-	Channel segment with tributaries	245	MBES (2018 Fugro)
7144	Channel	P1	-	-	Main meandering river channel	246	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7145	Channel	P1	2	20	A possible channel segment identified below a Unit of sediment, interpreted as cutting into the interpreted Unit 1. In the 2023 boomer data, the feature is seen to have a faint, poorly defined basal reflector, although this is clearer in the 2015 data, with acoustically chaotic fill. Identified below a channel feature identified in the MBES data (**7144**) and may represent an earlier phase of channelling or the base of the feature, partially infilled with sediment.	246	Boomer (2015, 2023 Fugro)
7146	Cut and fill	P2	0.7	6.6	A possible channel segment identified BSB/below a veneer of sediment, interpreted as cutting into the interpreted Unit 1. The feature has a faint, poorly defined basal reflector with acoustically unstructured fill. Identified below a channel feature identified in the MBES data (**7144**) and may represent an earlier phase of channelling or the base of the feature, partially infilled with sediment. May be a continuation of **7145**; however, due to the distance between lines, the features have not been grouped at this time.	246-247	Boomer (2018 Fugro)
7147	Channel	P1	-	-	Meandering channel complex segment	247	MBES (2018 Fugro)
7148	Cut and fill	P2	1.4	11.6	A cut and fill identified below a veneer of sediment. Feature has a faint but distinct basal reflector with acoustically chaotic fill. Cutting into an interpreted lower phase of channelling (**7149**).	249	Boomer (2015, 2023 Fugro)
7149	Cut and fill	P2	6.8	23.8	A cut and fill identified below an upper Unit of sediment, being cut into by a later phase of cut and fill (**7148**). Feature has a faint but distinct basal reflector with fill characterised by numerous horizontal reflectors, indicating layered fill which may have been deposited in a low-energy environment (possibly a unit of estuarine/lacustrine sediments (Unit 5)).	249	Boomer (2018, 2023 Fugro)
7150	Channel	P1	-	-	Small channel segment seen within larger anabranching river network	250	MBES (2018 Fugro)
7151	Cut and fill	P2	0.8	11	A possible channel identified below a veneer of sediment, with a faint basal reflector and acoustically unstructured fill. In the 2015 Boomer data it appears to be cutting into an acoustically quiet unit (possibly Unit 5) above the interpreted Unit 1, although this is less clear in the 2023 Boomer data. Possible remnant fluvial feature.	250-251	Boomer (2015, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7152	Cut and fill	P2	3.5	27.2	A possible cut and fill identified beneath an acoustically quiet unit (possible Unit 5 although this is not certain) which is thinner in the west, thickening towards the east. Feature has a faint basal reflector and acoustically unstructured fill. Possible remnant fluvial feature from an earlier phase of channelling	251	Boomer (2015, 2023 Fugro)
7153	Channel	P1	-	-	Anabranching channel segments	254-252	MBES (2018 Fugro)
7154	Cut and fill	P2	9	19.1	A possible cut and fill feature identified beneath an upper unit of acoustically quiet sediment with a chaotic base, possibly indicating gravels, cutting into the interpreted Unit 1. Feature has a distinct, undulating basal reflector and fill characterised by faint, draping reflectors. Possible remnant fluvial feature or infilled depression	253	Boomer (2023 Fugro)
7155	Channel	P1	-	-	Small segment of palaeochannel seen on MBES	255-254	MBES (2018 Fugro)
7156	Channel	P1	-	-	Small segment of palaeochannel seen on MBES	255	MBES (2018 Fugro)
7157	Channel	P1			Large, wide (~1.5 km) palaeochannel segment showing anabranching	256	MBES (2018 Fugro)
7158	Complex channel	P1	18.5	37.9	A possible cut and fill identified beneath an upper unit characterised by numerous faint horizontal reflectors (possible Unit 5 but this is uncertain), possibly indicating fine-grained deposits, cutting into the interpreted Unit 1. Feature has a distinct basal reflector and acoustically unstructured fill, possibly multiple phases of cutting and filling. Identified close to similar feature **7159**, but separated by a distinct banked feature which may represent a high point between channel cuts, or possibly a calcarenite surface, although this is uncertain.	256-257	Boomer (2023 Fugro)
7159	Complex channel	P1	15.8	45.2	A complex cut and fill feature identified beneath an upper unit characterised by numerous faint horizontal reflectors (possible Unit 5 but this is uncertain), possibly indicating fine-grained deposits, cutting into the top of the interpreted Unit 1. Feature has a faint, poorly defined basal reflector and numerous phases of cutting and filling, with fill generally appearing acoustically unstructured, although it appears more chaotic in its later phase of fill. Identified close to similar feature **7158**, but separated by a distinct banked feature which may represent a high	2257	Boomer (2015, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
					point between channel cuts, or possibly a calcarenite surface, although this is uncertain. Possible channel complex		
7160	Channel	P1	-	-	Large, wide (~1 km) braided river channel with undulating thalweg	259	MBES (2018 Fugro)
7161	Infilled depression	P2	6.1	31.8	A possible infilled depression identified below an upper unit of acoustically quiet sediment, infilling a depression at the top of the interpreted Unit 1. Fill is characterised by numerous faint, draping reflectors, indicating fine-grained deposits deposited in a low-energy environment. Fill is not clearly different to overlying sediment, although the draping reflectors appear slightly more distinct. Feature has a distinct basal reflector which appears acoustically chaotic where it shoals in the centre.	258-259	Boomer (2015, 2023 Fugro)
7162	Channel	P1	-	-	Small segment of palaeochannel seen on MBES	262	MBES (2018 Fugro)

Appendix III: Geotechnical logs assessed.

ID	Easting (m)	Northing (m)	Elevation (m OD)
EP-01-CPT	629169	8905998	-228.29
EP-01-VC	629178	8906005	-228.29
EP-02-BC	631292	8896265	-192.95
EP-03-CPT	634130	8886732	-156.45
EP-04-CPT	636308	8881906	-147.09
EP-05-CPT	636328	8881808	-139.52
EP-06-CPT	637085	8877633	-131.63
EP-07-CPT	638809	8867962	-121.34
EP-08-VC	640146	8860390	-115.74
EP-09-CPT	640854	8847472	-95.06
EP-09-BC	640846	8847475	-95.06
EP-09-PC	640847	8847469	-95.06
EP-10-CPT	640521	8843266	-87.13
EP-11-BC	640581	8836312	-79.98
EP-11-CPT	640586	8836314	-79.98
EP-11-CPTA	640586	8836310	-79.98
EP-12-CPT	640360	8835338	-85.1
EP-12-VC	640359	8835333	-85.1
EP-13-CPT	640162	8834615	-75.76
EP-13-BC	640163	8834606	-75.76
EP-14-CPT	639833	8833409	-73.28
EP-15-CPT	639344	8827439	-85.67
EP-15-BC	639339	8827452	-85.67
EP-16-CPT	639344	8819740	-79.27
EP-17-CPT	639234	8817440	-76.08
EP-17-CPTA	639235	8817437	-76.08
EP-17-BC	639230	8817456	-76.08
EP-18-CPT	639153	8813541	-75.69
EP-18-VC	639151	8813535	-75.69
EP-19-CPT	637532	8808736	-71.71
EP-19-CPTA	637532	8808740	-71.71
EP-19-BC	637526	8808726	-71.71
EP-20-CPT	633083	8799791	-65.98

ID	Easting (m)	Northing (m)	Elevation (m OD)
EP-20-CPTA	633084	8799795	-65.98
EP-20-PC	633071	8799781	-65.98
EP-21-CPT	627002	8791860	-57.68
EP-21-BC	626992	8791863	-57.68
EP-22-CPTA	620769	8784044	-48.42
EP-23-CPT	614762	8774065	-54.46
EP-23-BC	614763	8774057	-54.46
EP-24-CPT	613104	8771158	-53.67
EP-25-CPT	610617	8766819	-53.19
EP-26-CPT	608379	8762363	-55.68
EP-27-BC	607703	8758420	-57.6
EP-27-PC	607696	8758417	-57.6
EP-28-CPTA	606829	8752479	-55.19
EP-29-CPTA	605680	8743059	-49.41
EP-29-BC	605677	8743048	-49.41
EP-29-PC	605683	8743073	-49.41
EP-31-CPT	605124	8727588	-41.54
EP-32-CPT	605131	8722587	-37.9
EP-32-BC	605125	8722572	-37.9
EP-33-CPT	605136	8718087	-34.84
EP-34-CPT	605143	8712588	-42.28
EP-35-CPT	605148	8707587	-45.61
EP-36-CPT	604903	8704119	-46.85
EP-37-CPT	603132	8701612	-53.36
EP-39-CPT	603167	8698248	-68.75
EP-40-CPT	602248	8693385	-69.64
EP-41-CPT	600119	8687268	-72.18
EP-41-BC	600117	8687264	-72.18
EP-42-CPT	599695	8686650	-74.68
EP-42-PC	600117	8687273	-74.68
EP-43-CPTA	599055	8684024	-71.89
EP-43-CPTA	599055	8684024	-71.89
EP-44-CPT	598948	8679021	-69.08
EP-44-PC	598938	8679027	-69.08
EP-45-BC	598863	8675622	-58.65
EP-46-BH	598803	8670570	-53.73

ID	Easting (m)	Northing (m)	Elevation (m OD)
EP-46-BC	598815	8670577	-53.73
EP-48-CPT	629907	8791047	-53.97
EP-49-CPTA	624915	8779547	-35.16
EP-49-VC	624922	8779551	-35.16
EP-50-PC	620219	8771348	-26.57
EP-51-CPTA	620223	8771358	-34.54
EP-52-CPT	616046	8765883	-34.7
EP-53-CPT	612697	8761895	-42.05
EP-54-CPT	610247	8758596	-52.24

Appendix IV: Review of geotechnical logs.

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Arch'l Potential
EP-01-CPT	0	1.6	Loose silty sand	Seabed sediments	Low
EP-01-CPT	1.6	3.23	Very soft silt	Contourite drift	Low
EP-01-VC	0	1	Grey silty fine siliceous carbonate sand with some pockets of clay and few pockets of fine gravel	Seabed sediments	Low
EP-01-VC	1	2	Very soft dark greenish grey clayey calcareous silt	Contourite drift	Low
EP-01-VC	2	3.61	Very soft dark greenish grey sandy calcareous silt with some pockets of clay	Contourite drift	Low
EP-02-BC	0	0.13	Dark greyish olive fine sand with coarse sand with shell fragments	Seabed sediments	Low
EP-02-BC	0.13	0.52	Dark greenish grey silty sand with coarse shell fragments, abundant bivalves, worm tubes and gastropods	Seabed sediments	Low
EP-03-CPT	0	0.7	Loose silty sand	Seabed sediments	Low
EP-03-CPT	0.7	2.1	Very soft clay with few partings of sand	Contourite drift	Low
EP-04-CPT	0	0.1	Loose silty sand	Seabed sediments	Low
EP-04-CPT	0.1	0.45	Very soft clay	Contourite drift	Low
EP-04-CPT	0.45	1	Soft clay	Contourite drift	Low
EP-04-CPT	1	2.5	Soft to firm clay	Contourite drift	Low
EP-04-CPT	2.5	3.36	Firm clay	Contourite drift	Low
EP-05-CPT	0	0.6	Loose silty sand	Seabed sediments	Low
EP-05-CPT	0.6	0.9	Very loose sandy silt	Contourite drift	Low
EP-05-CPT	0.9	1.2	Very loose silty sand	Contourite drift	Low
EP-05-CPT	1.2	3.27	Soft clay	Contourite drift	Low
EP-06-CPT	0	1	Loose to medium dense sand	Seabed sediments	Low
EP-06-CPT	1	1.75	Very loose sandy silt with some partings of clay	Terrigenous sediments	Low
EP-06-CPT	1.75	3.28	Loose to medium dense sand with few partings of clay	Terrigenous sediments	Low
EP-07-CPT	0	0.7	Greenish grey silty siliceous carbonate sand with few shell fragments	Seabed sediments	Low
EP-07-CPT	0.7	3.33	Very loose to loose silty sand with seams of clay	Alluvium	Moderate
EP-08-VC	0	0.4	Void	N/A	N/A
EP-08-VC	0.4	0.89	Greenish grey sandy silt with shell fragments (bivalves and gastropods)	Alluvium	Moderate
EP-09-CPT	0	1.7	Very soft silty clay with few pockets of sand and shell fragments	Alluvium	Moderate
EP-09-CPT	1.7	2	Very dense sand	Partially cemented sands	Moderate
EP-09-CPT	2	3.97	Interbedded loose silty sand and soft clay	Alluvium	Moderate

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Arch'l Potential
EP-09-BC	0	0.5	Very soft greenish grey silty clay with few pockets of sand and shell fragments	Alluvium	Moderate
EP-09-PC	0	1	Greenish grey silty siliceous carbonate sand with some pockets of shell fragments	Seabed sediments	Low
EP-09-PC	1	2.5	Gravel with mostly coral and some pockets of silt and sand	Gravel calcirudite	Moderate
EP-10-CPT	0	1.9	Very soft clay	Alluvium	Moderate
EP-10-CPT	1.9	3.7	Very loose silty sand with seams of clay	Alluvium	Moderate
EP-10-CPT	3.7	4.16	Medium dense to dense sand	Partially cemented sands	Moderate
EP-11-BC	0	0.5	Very soft greenish grey silty clay with few pockets of sand and shell fragments	Alluvium	Moderate
EP-11-CPT	0	2.6	Very soft clay	Alluvium	Moderate
EP-11-CPT	2.6	4.23	Loose to medium dense silty sand with seams of clay	Alluvium	Moderate
EP-11-CPTA	0	2.55	Very soft clay	Alluvium	Moderate
EP-11-CPTA	2.55	3.5	Loose to medium dense silty sand with seams of clay	Alluvium	Moderate
EP-11-CPTA	3.5	3.8	Loose to dense sand	Partially cemented sands	Moderate
EP-12-CPT	0	4.19	Very soft silty clay with few pockets of sand	Alluvium	Moderate
EP-12-VC	0	3.3	Very soft greenish grey silty clay with few pockets of sand	Alluvium	Moderate
EP-13-CPT	0	0.8	Very soft silty clay	Alluvium	Moderate
EP-13-CPT	0.8	1.1	Loose to medium dense silty sand	Non-marine sand	Moderate
EP-13-CPT	1.1	1.73	Dense to very dense sand with seams of clay	Partially cemented sands	Moderate
EP-13-BC	0	0.45	Very soft greenish grey silty clay with some pockets of sand and fine gravel	Alluvium	Moderate
EP-14-CPT	0	0.85	Soft to firm silty clay	Alluvium	Moderate
EP-14-CPT	0.85	2.5	Loose to medium dense silty sand with seams of clay	Alluvium	Moderate
EP-14-CPT	2.5	3.6	Firm clay with seams of sand	Alluvium	Moderate
EP-14-CPT	3.6	3.75	Medium dense sand	Non-marine sand	Moderate
EP-15-CPT	0	2.25	Very soft to soft clay with few partings of sand and shell fragments	Alluvium	Moderate
EP-15-CPT	2.25	3	Very loose to loose sand	Non-marine sand	Moderate
EP-15-CPT	3	3.8	Soft clay	Alluvium	Moderate
EP-15-CPT	3.8	4.18	Medium dense sand	Non-marine sand	Moderate
EP-15-BC	0	0.5	Very soft greenish grey silty calcareous clay with some pockets of shell fragments	Alluvium	Moderate
EP-16-CPT	0	1.4	Medium dense to dense sand	Partially cemented sands	Moderate

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Arch'l Potential
EP-16-CPT	1.4	2.1	Very soft to soft clay with parting of sand	Alluvium	Moderate
EP-16-CPT	2.1	3.15	Dense to very dense sand with some shell fragments	Marine to shallow marine	Moderate
EP-17-CPT	0	0.7	Very soft clay	Alluvium	Moderate
EP-17-CPT	0.7	2.2	Very dense sand with seams of gravel	Partially cemented sands	Moderate
EP-17-CPT	2.2	3.82	Dense to very dense sand with seams of silt and gravel	Partially cemented sands	Moderate
EP-17-CPTA	0	0.85	Very soft clay	Alluvium	Moderate
EP-17-CPTA	0.85	2.81	Very dense sand	Partially cemented sands	Moderate
EP-17-BC	0	0.5	Very soft greenish grey silty calcareous clay with few partings of sand and pockets of shell fragments	Alluvium	Moderate
EP-18-VC	0	0.7	Greenish grey silty carbonate sand with gravel and some shell fragments and seams of cemented sand at bottom	Seabed sediments	Low
EP-19-CPT	0	1.3	Very soft silty clay with some pockets of sand and shell fragments	Alluvium	Moderate
EP-19-CPT	1.3	2.2	Loose to medium dense sand with few partings of clay	Partially cemented sands	Moderate
EP-19-CPT	2.2	3.85	Very dense sand	Partially cemented sands	Moderate
EP-19-CPT	3.85	4.12	Dense sand	Partially cemented sands	Moderate
EP-19-CPTA	0	1.15	Very soft clay	Alluvium	Moderate
EP-19-CPTA	1.15	3.57	Very dense sand with few partings of clay	Partially cemented sands	Moderate
EP-19-BC	0	0.65	Very soft greenish grey silty clay with some pockets of sand and shell fragments	Alluvium	Moderate
EP-20-CPT	0	1.55	Very soft silty sandy calcareous clay with some pockets of sand and shell fragments	Alluvium	Moderate
EP-20-CPT	1.55	4.23	Very dense sand with pockets of gravel	Partially cemented sands	Moderate
EP-20-CPTA	0	1.55	Very soft clay	Alluvium	Moderate
EP-20-CPTA	1.55	3.27	Very dense sand with some pockets of gravel	Partially cemented sands	Moderate
EP-20-PC	0	1.4	Very soft greenish grey silty sandy calcareous clay with some pockets of sand and shell fragments	Alluvium	Moderate
EP-21-CPT	0	0.75	Very soft clay	Alluvium	Moderate
EP-21-CPT	0.75	1.2	Very soft to soft clay	Alluvium	Moderate
EP-21-CPT	1.2	1.9	Loose sand with few seams of clay	Partially cemented sands	Moderate
EP-21-CPT	1.9	3.3	Very dense sand	Partially cemented sands	Moderate

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Arch'l Potential
EP-21-CPT	3.3	3.88	Medium dense sand with seams of clay	Partially cemented sands	Moderate
EP-21-BC	0	0.5	Very soft greenish grey silty sandy calcareous clay with some whole and fragmented shell	Alluvium	Moderate
EP-22-CPTA	0	0.15	Very soft clayey silt	Alluvium	Moderate
EP-22-CPTA	0.15	0.7	Dense to very dense sand	Partially cemented sands	Moderate
EP-22-CPTA	0.7	2	Medium dense sand	Partially cemented sands	Moderate
EP-22-CPTA	2	3.27	Medium dense sand with seams of clay	Partially cemented sands	Moderate
EP-23-CPT	0	0.6	Very soft clay	Alluvium	Moderate
EP-23-CPT	0.6	1.3	Very loose to loose sandy silt with seams of clay	Alluvium	Moderate
EP-23-CPT	1.3	3.36	Very dense sand with few seams of clay	Partially cemented sands	Moderate
EP-23-BC	0	0.3	Very soft greenish grey silty siliceous carbonate clay with some pockets of gravel	Alluvium	Moderate
EP-24-CPT	0	1.8	Very dense sand with few seams of clay	Partially cemented sands	Moderate
EP-24-CPT	1.8	3.47	Dense sand with few seams of clay	Partially cemented sands	Moderate
EP-25-CPT	0	0.6	Medium dense to dense sand with some seams of clay	Partially cemented sands	Moderate
EP-25-CPT	0.6	2.73	Very dense sand	Partially cemented sands	Moderate
EP-26-CPT	0	0.45	Loose to medium dense silty sand with few seams of clay	Partially cemented sands	Moderate
EP-26-CPT	0.45	1.85	Dense to very dense silty sand with few seams of clay	Partially cemented sands	Moderate
EP-27-BC	0	0.5	Very soft greenish grey gravelly clay with some pockets of sand and shell fragments	Alluvium	Moderate
EP-27-PC	0	0.4	Greenish grey silty siliceous carbonate sand with some pockets of shell fragments	Seabed sediments	Low
EP-27-PC	0.4	2.2	Very soft greenish grey gravelly calcareous clay	Alluvium	Moderate
EP-28-CPTA	0	0.2	Loose sand	Seabed sediments	Low
EP-28-CPTA	0.2	0.7	Very soft to soft clay	Alluvium	Moderate
EP-28-CPTA	0.7	1.35	Medium dense sand with seams of clay	Partially cemented sands	Moderate
EP-28-CPTA	1.35	3.38	Dense to very dense sand	Partially cemented sands	Moderate
EP-29-CPTA	0	2.6	Very soft to soft clay	Alluvium	Moderate
EP-29-CPTA	2.6	3.57	Soft to firm silty clay with few pockets of sand	Alluvium	Moderate
EP-29-BC	0	0.5	Greenish grey gravelly clay with some shell fragments	Alluvium	Moderate

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Arch'l Potential
EP-29-PC	0	2	Very soft greenish grey gravelly calcareous clay with some shell fragments	Alluvium	Moderate
EP-31-CPT	0	0.2	Very soft silt	Alluvium	Moderate
EP-31-CPT	0.2	0.95	Loose to medium dense sand with gravel	Partially cemented sands	Moderate
EP-31-CPT	0.95	2.1	Medium dense to dense sand	Partially cemented sands	Moderate
EP-31-CPT	2.1	2.92	Very dense sand with occasional seams of clay	Partially cemented sands	Moderate
EP-32-CPT	0	0.3	Loose silty sand	Seabed sediments	Low
EP-32-CPT	0.3	3.24	Dense to very dense sand	Partially cemented sands	Moderate
EP-32-BC	0	0.3	Light greenish grey clayey silty siliceous carbonate sand with some whole and fragmented shell	Alluvium	Moderate
EP-33-CPT	0	0.4	Very dense sand	Partially cemented sands	Moderate
EP-33-CPT	0.4	1.46	Medium dense to dense silty sand	Partially cemented sands	Moderate
EP-34-CPT	0	3.1	Very soft to soft clay	Alluvium	Moderate
EP-34-CPT	3.1	3.4	Medium dense sand	Non-marine sand	Moderate
EP-35-CPT	0	0.5	Loose silty sand	Seabed sediments	Low
EP-35-CPT	0.5	3.28	Medium dense to dense silty sand	Partially cemented sands	Moderate
EP-36-CPT	0	0.32	Dense silty sand	Partially cemented sands	Moderate
EP-37-CPT	0	1	Very dense sand	Partially cemented sands	Moderate
EP-37-CPT	1	1.41	Very dense sand with seams of clay	Partially cemented sands	Moderate
EP-39-CPT	0	0.1	Very loose sand	Seabed sediments	Low
EP-39-CPT	0.1	0.45	Soft to firm clay	Alluvium	Moderate
EP-39-CPT	0.45	2.2	Stiff to very stiff clay	Alluvium	Low
EP-39-CPT	2.2	3.57	Very stiff to hard clay	Alluvium	Low
EP-40-CPT	0	0.4	Loose to medium dense sand	Seabed sediments	Low
EP-40-CPT	0.4	1	Firm to stiff clay	Alluvium	Low
EP-41-CPT	0	0.9	Very soft clay	Alluvium	Moderate
EP-41-CPT	0.9	1.7	Firm clay with seams of sand	Alluvium	Moderate
EP-41-CPT	1.7	3.48	Soft to firm clay	Alluvium	Moderate
EP-41-BC	0	0.5	Very soft greenish grey silty carbonate clay with some pockets of sand and whole and fragmented shell	Alluvium	Moderate
EP-41-BC	0.5	1.5	Greenish grey gravelly calcareous clay with some pockets of sand and shell fragments	Alluvium	Moderate

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Arch'l Potential
EP-42-CPT	0	1.6	Dense carbonate gravel	Gravel calcirudite	Moderate
EP-42-CPT	1.6	3.36	Medium dense sand	Partially cemented sands	Moderate
EP-42-PC	0	1	Greenish grey carbonate gravel with pockets of sand and few shell fragments	Gravel calcirudite	Moderate
EP-43-CPTA	0	0.6	Loose silty sand	Seabed sediments	Low
EP-43-CPTA	0.6	1.4	Interbedded stiff clay and medium dense to dense silty sand	Alluvium	Moderate
EP-44-CPT	0	2.1	Firm to stiff clay with seams of sand	Alluvium	Moderate
EP-44-CPT	2.1	3.22	Stiff clay	Alluvium	Moderate
EP-44-PC	0	0.3	Greenish grey siliceous carbonate sand with some whole and fragmented shell	Seabed sediments	Low
EP-44-PC	0.3	1.5	Firm to stiff light greenish grey carbonate clay with few pockets of silt	Alluvium	Moderate
EP-45-BC	0	0.3	Greenish grey silty siliceous carbonate sand with some whole and fragmented shell	Seabed sediments	Low
EP-45-BC	0.3	0.5	Greenish grey silty siliceous carbonate sand with some pockets of clay and few shell fragments	Seabed sediments	Low
EP-45-PC	0	0.3	Greenish grey siliceous carbonate sand with some whole and fragmented shell	Seabed sediments	Low
EP-45-PC	0.3	1.3	Stiff light greenish grey carbonate clay with few pockets of silt	Alluvium	Moderate
EP-46-BH	0	0.6	Loose to medium dense light yellowish brown siliceous carbonate sand with gravel, few pockets of clay and whole and fragmented shell	Seabed sediments	Low
EP-46-BH	0.6	10.25	Stiff to very stiff greenish grey silty calcareous clay with few pockets of shell fragments	Alluvium	Moderate
EP-46-BH	10.25	17.5	Interbedded loose to medium dense light grey clayey fine to coarse carbonate gravel and very stiff light yellowish brown gravelly calcareous clay	Gravel calcirudite	Moderate
EP-46-BH	17.5	19	Very hard clayey silt with few pockets of gravel	Alluvium	Moderate
EP-46-BH	19	20.5	Medium dense to dense grey fine to coarse gravel	Fluvial gravel	Moderate
EP-46-BH	20.5	23.5	Very hard light greenish grey silty clay with few pockets of weakly cemented silt	Alluvium	Low
EP-46-BH	23.5	25.5	Loose to medium dense light grey sandy silt with few pockets of clay	Alluvium	Low
EP-46-BH	2.5	31.56	Very hard light grey clayey silt with pockets of sand and weakly cemented silt	Alluvium	Low
EP-46-BC	0	0.45	Light yellowish brown siliceous carbonate sand with gravel, whole and fragmented shell and few pockets of clay	Seabed sediments	Low
EP-48-CPT	0	1.4	Very soft clay with gravel	Alluvium	Moderate
EP-48-CPT	1.4	3.7	Medium dense silty sand with seams of silt	Non-marine sand	Moderate
EP-49-CPTA	0	3	Medium dense gravel	Gravel calcirudite	Moderate
EP-49-VC	0	2	Olive carbonate gravel with some pockets of clay	Gravel calcirudite	Moderate

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Arch'l Potential
EP-49-VC	2	3	Olive yellow clayey carbonate gravel	Gravel calcirudite	Moderate
EP-50-PC	0	2.5	Very soft greenish grey silty calcareous clay with few pockets of sand	Alluvium	Moderate
EP-50-PC	2.5	3.2	Light bluish grey silty carbonate sand with some pockets of gravel and clay	Non-marine sand	Moderate
EP-51-CPTA	0	0.6	Very soft clay with some pockets of sand	Alluvium	Moderate
EP-51-CPTA	0.6	3.92	Soft silty clay with few partings of sand	Alluvium	Moderate
EP-52-CPT	0	0.5	Loose silty sand	Seabed sediments	Low
EP-52-CPT	0.5	2.2	Medium dense to dense sand	Partially cemented sands	Moderate
EP-52-CPT	2.2	3.43	Dense to very dense sand with some clay pockets	Partially cemented sands	Moderate
EP-53-CPT	0	1.7	Very soft clay with few seams of sand	Alluvium	Moderate
EP-53-CPT	1.7	2.9	Medium dense to dense sand	Partially cemented sands	Moderate
EP-53-CPT	2.9	3.9	Very dense sand	Partially cemented sands	Moderate
EP-53-CPT	3.9	4.52	Interbedded stiff clay and dense sand	Alluvium	Moderate
EP-54-CPT	0	0.45	Very soft clay	Alluvium	Moderate
EP-54-CPT	0.45	2.95	Medium dense to dense sand	Partially cemented sands	Moderate

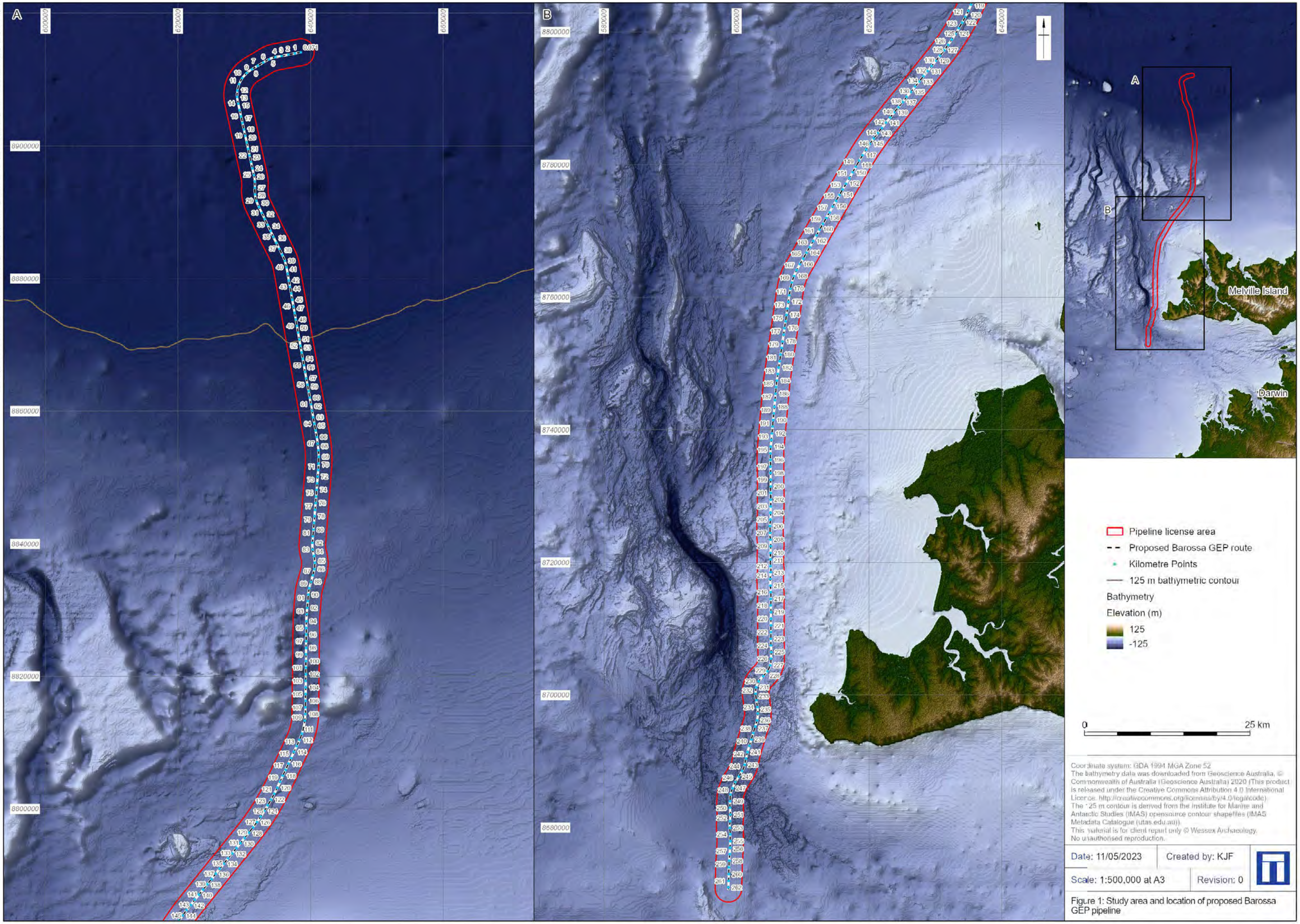
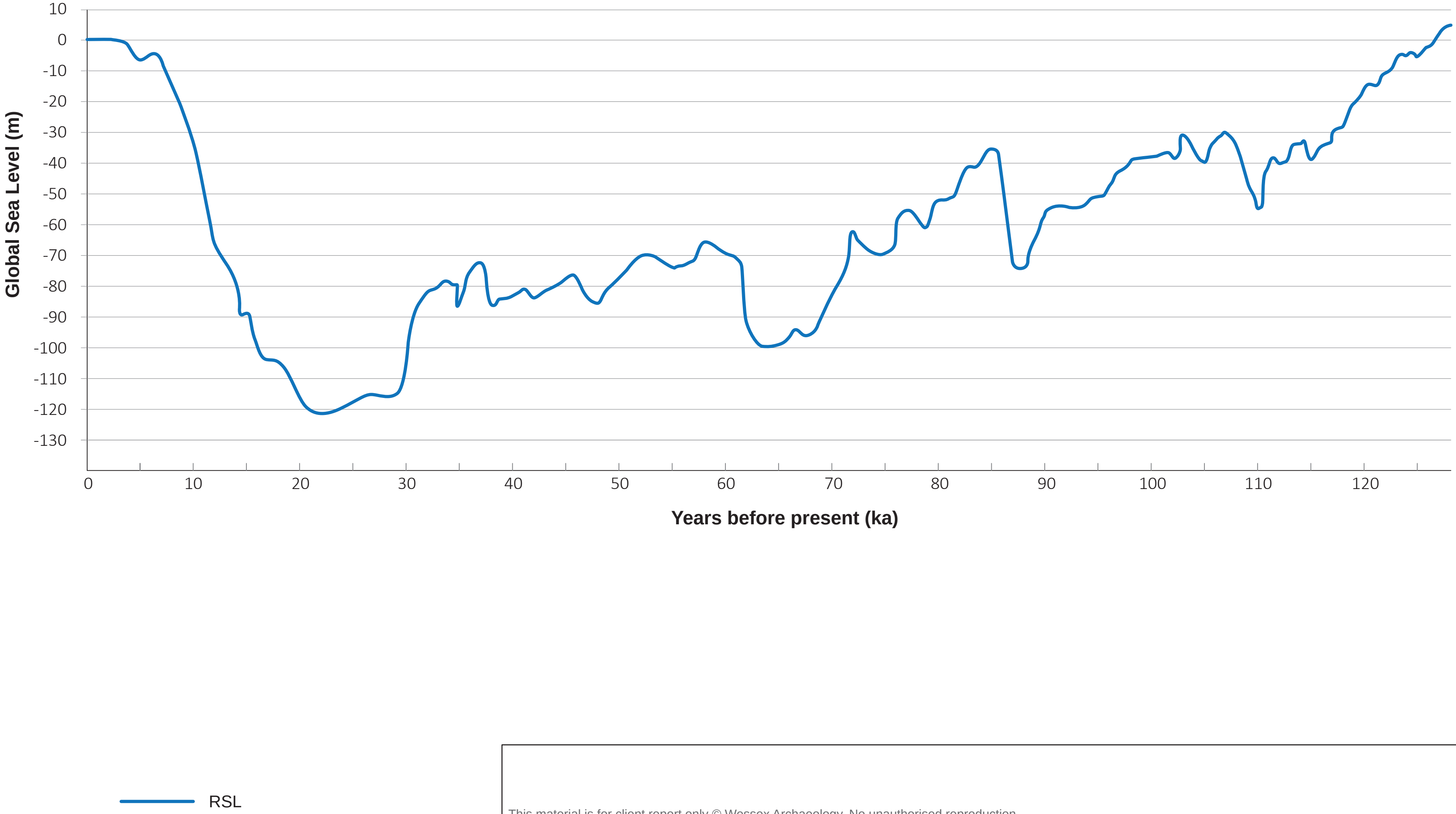
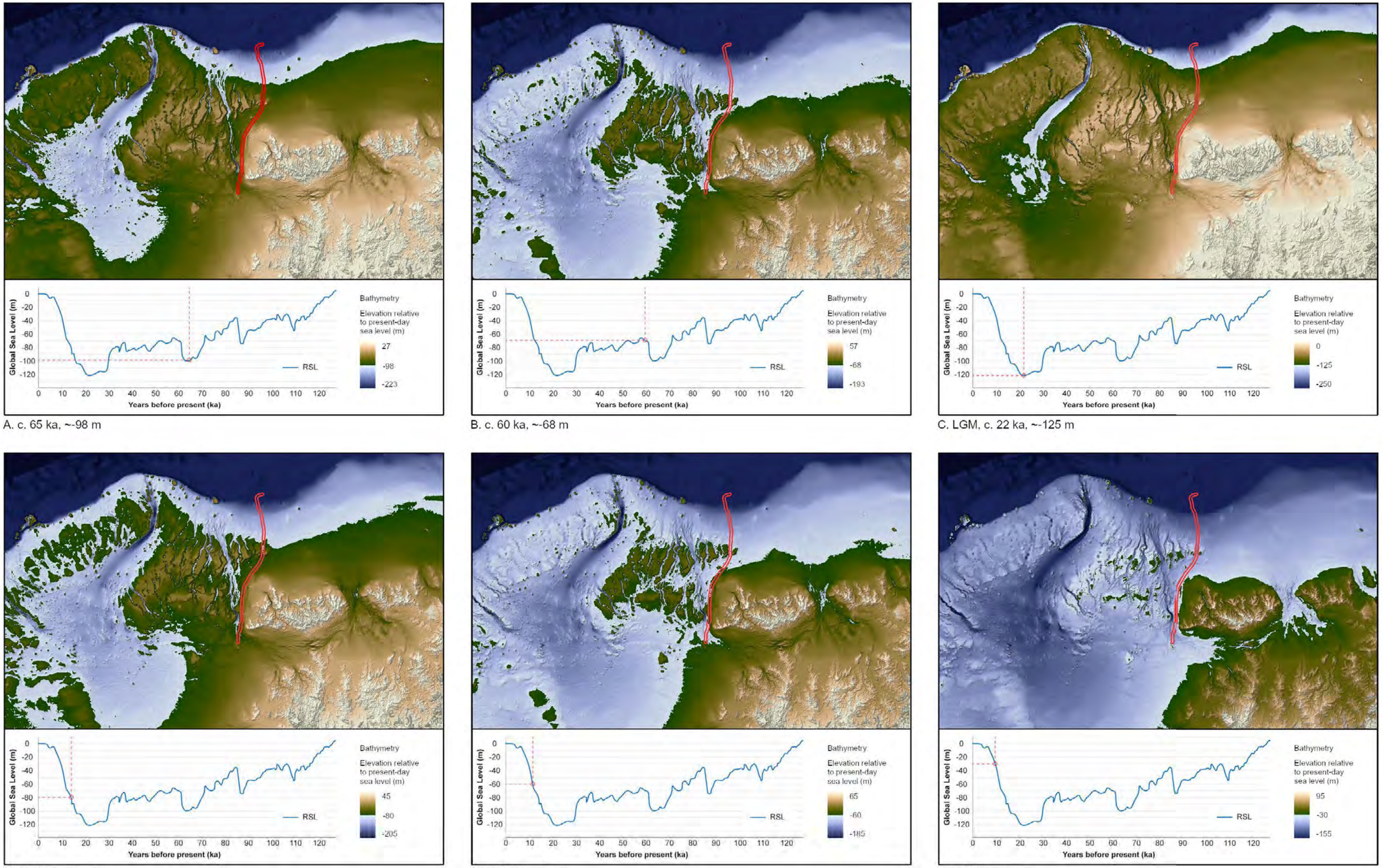


Figure 1: Study area and location of proposed Barossa GEP pipeline



Date: 19/04/2023	Created by: KJF	Revision: 0	Scale: NTS at A4

Figure 2: Sea-level history over the last 120,000 years. Modified after Brooke et al. (2017)



A. c. 65 ka, ~-98 m

B. c. 60 ka, ~-68 m

C. LGM, c. 22 ka, ~-125 m

D. c. 14 ka, ~-80 m

E. c. 12 ka, ~-60 m

F. c. 10 ka, ~-30 m

Pipeline license area

0 250 km

Coordinate system: GDA 1994 MGA Zone 52
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Figure 3: Regional palaeogeographic/sea level reconstructions, with sea level curves (modified after Brooke et al. (2017)) overlain

Coordinate system: GDA 1994 MGA Zone 53
Aerial imagery: ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, © OpenStreetMap contributors https://www.openstreetmap.org/ copyright. © Northern Territory Government Open Data Portal: Strahler stream orders over the Northern Territory, topographic scale data 250k.

Date: 16/05/2023	Created by: AM/KJF	Revision: 0	Scale: 1:2,500,000 at A3

Figure 4: Terrestrial study area

EXTENT HERITAGE ADVISORS

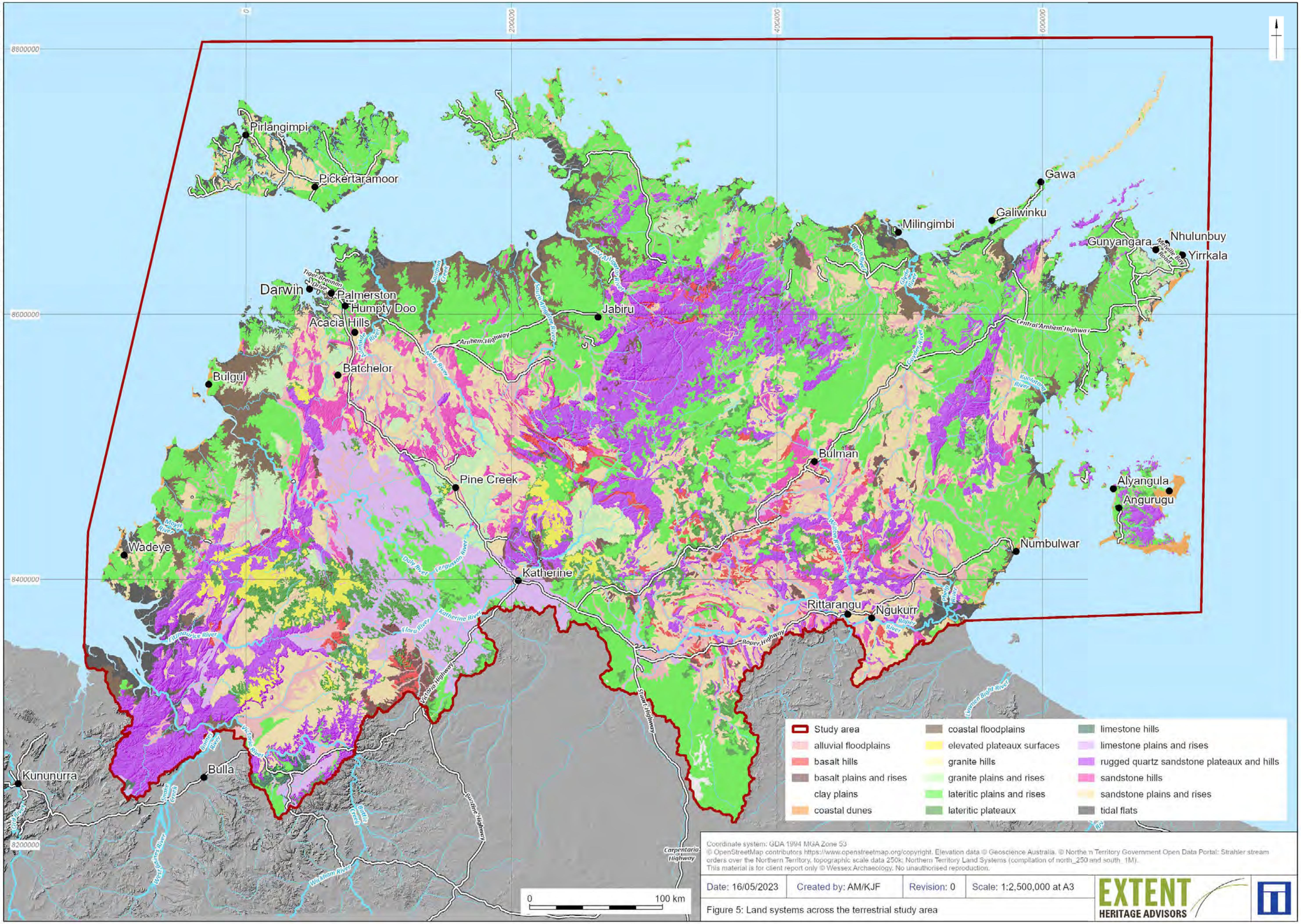


Figure 5: Land systems across the terrestrial study area

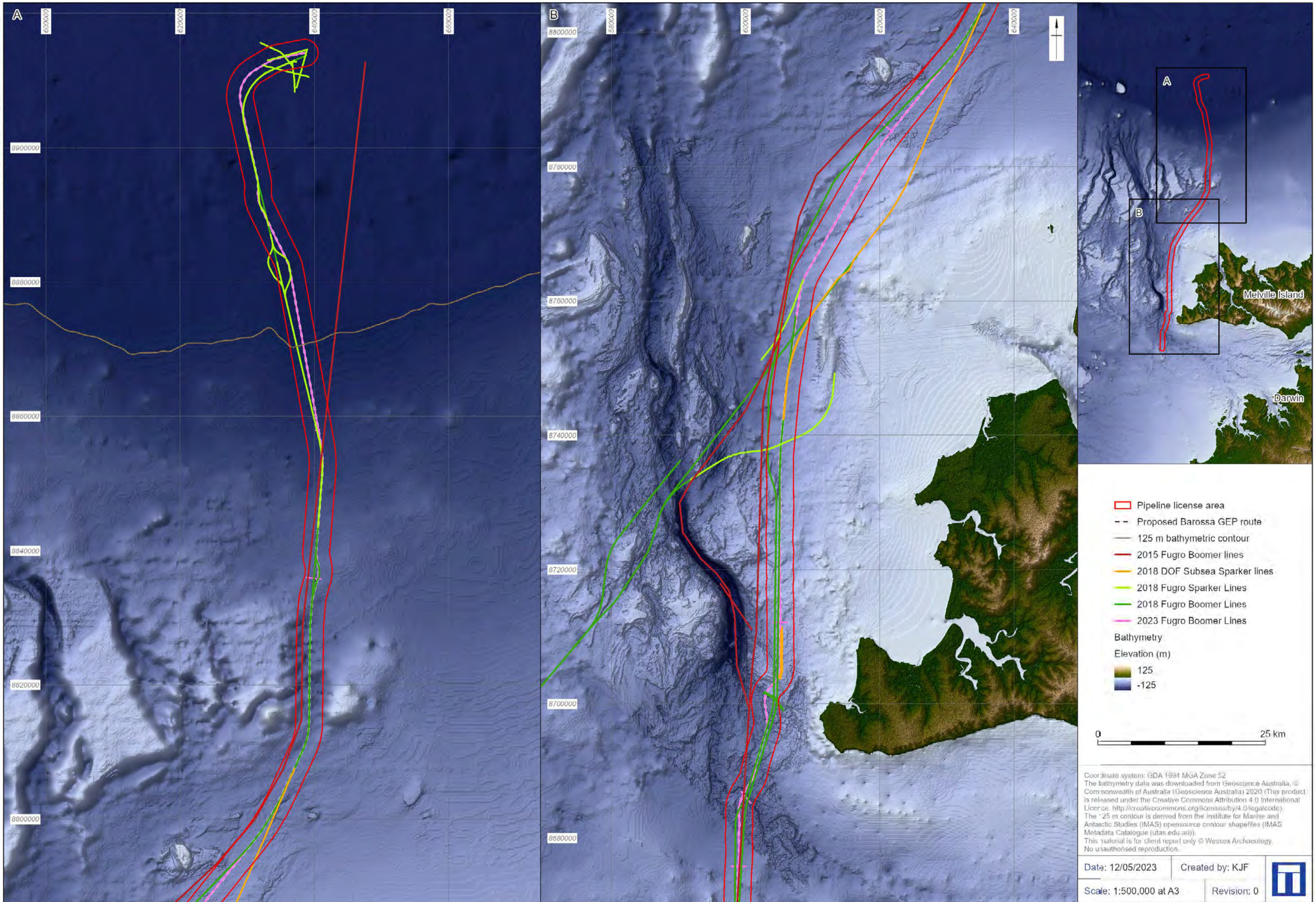
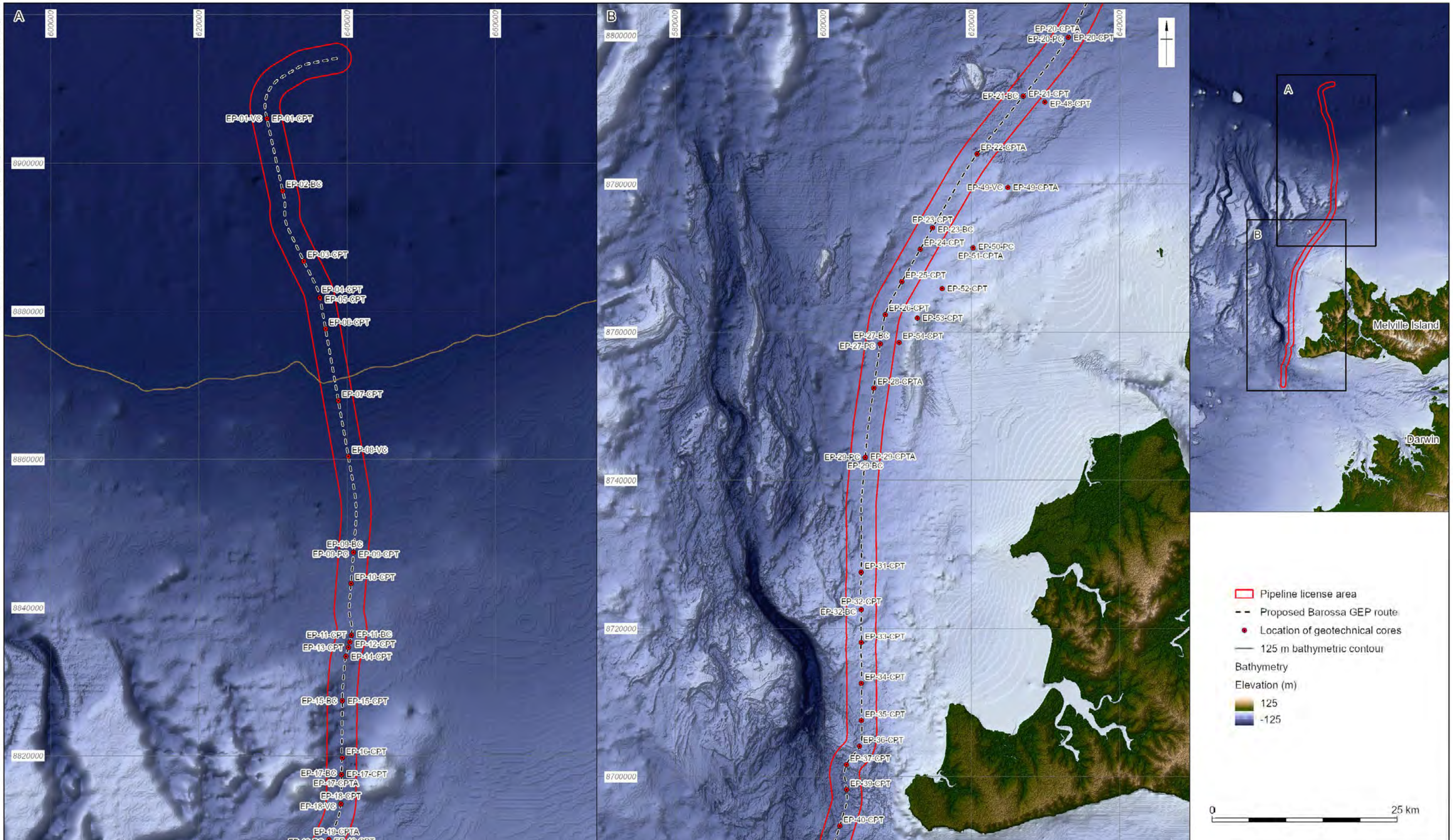


Figure 6: Sub-bottom profiler lines used for palaeogeographic interpretation



Coordinate system: GDA 1994 MGA Zone 52
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The 125 m contour is derived from the Institute for Marine and Antarctic Studies (IMAS) opensource contour shapefiles (IMAS Metadata Catalogue (utas.edu.au)).

Date: 17/05/2023 | Created by: KJF
Scale: 1:500,000 at A3 | Revision: 0

Figure 7: Location of geotechnical cores

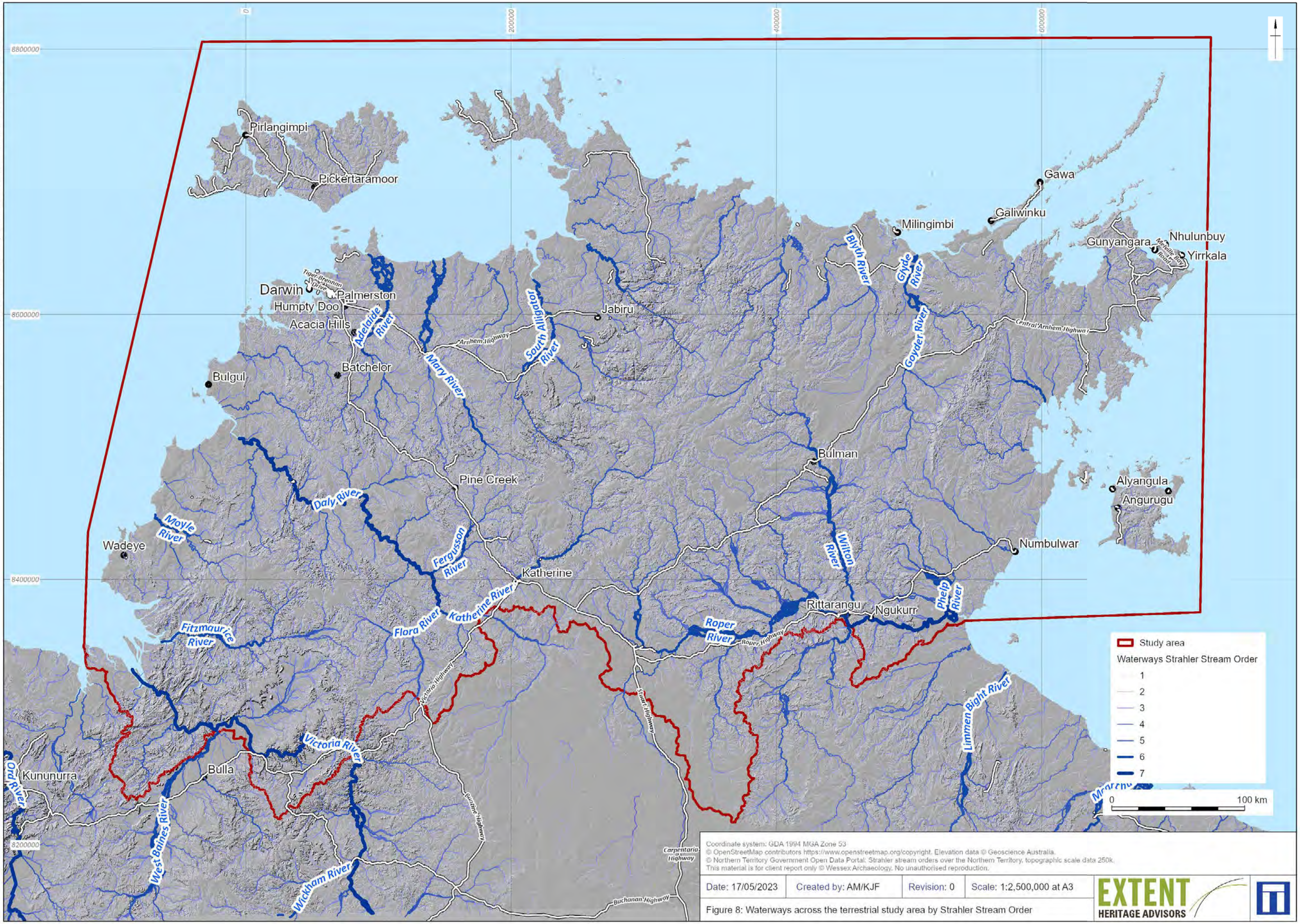
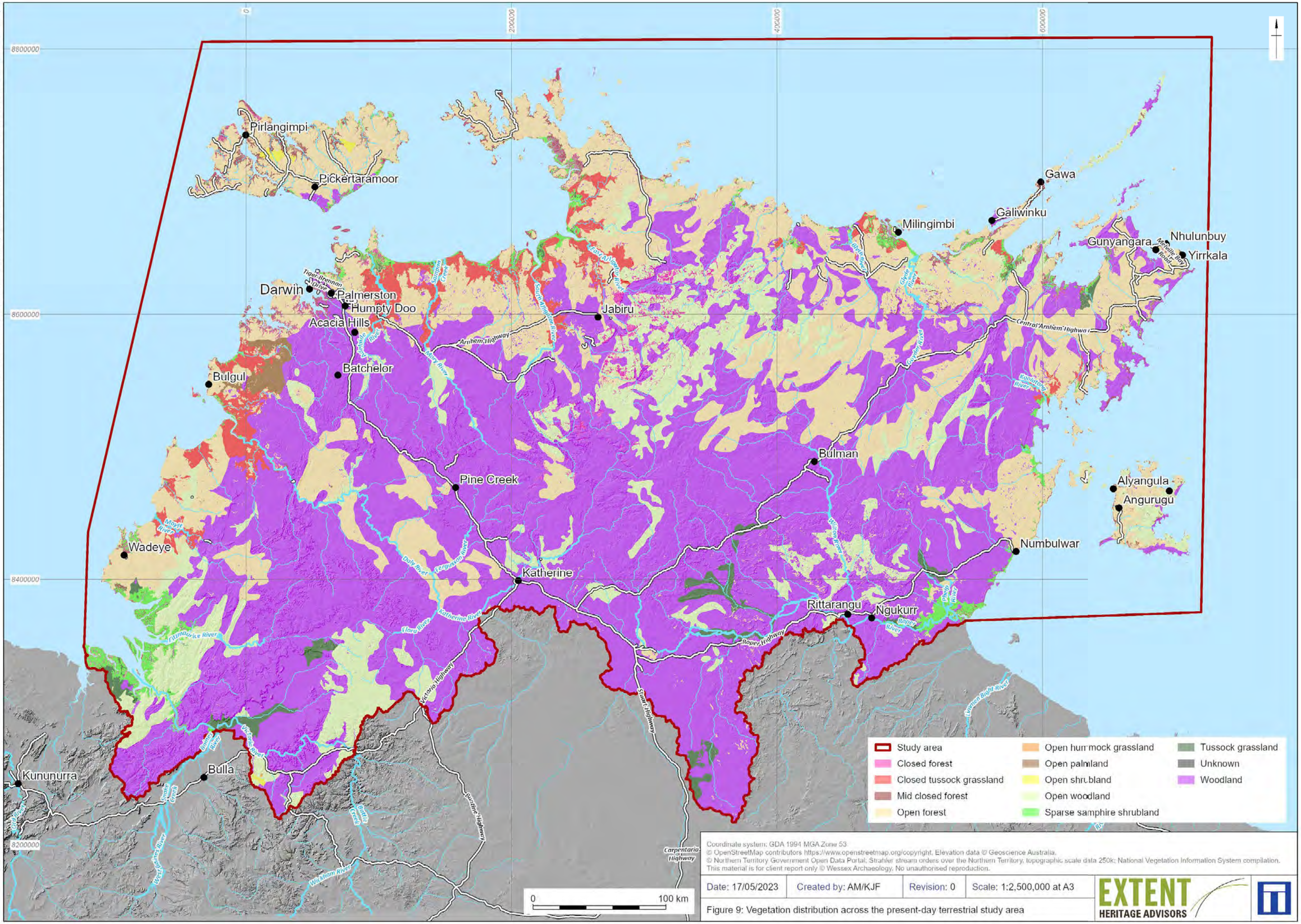


Figure 8: Waterways across the terrestrial study area by Strahler Stream Order



Coordinate system: GDA 1994 MGA Zone 53

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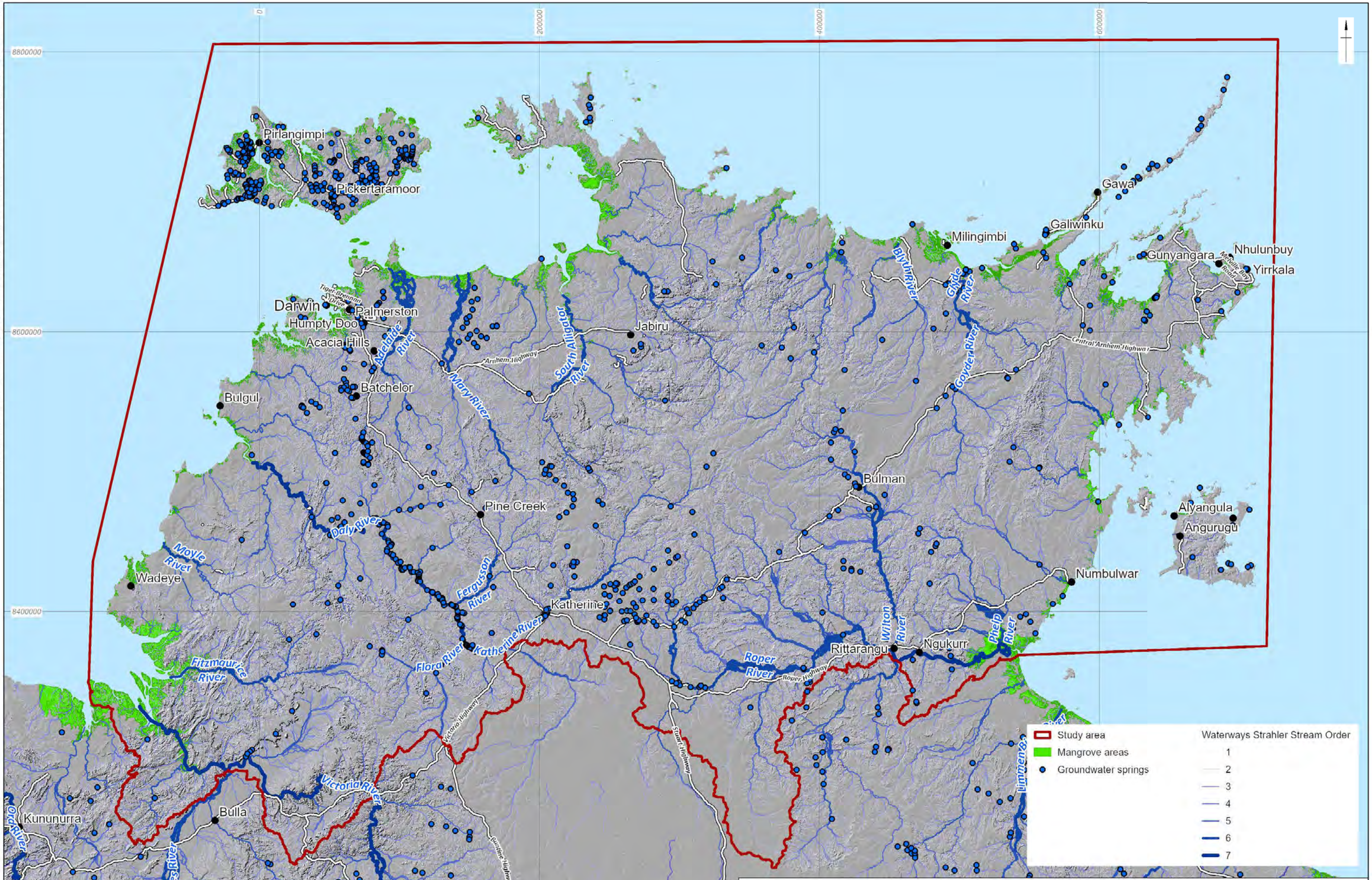
Figure 9: Vegetation distribution across the present-day terrestrial study area



Coordinate system: GDA 1994 MGA Zone 53.
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Figure 10: Present day distribution of mangrove forests within terrestrial study area with waterways and ground springs

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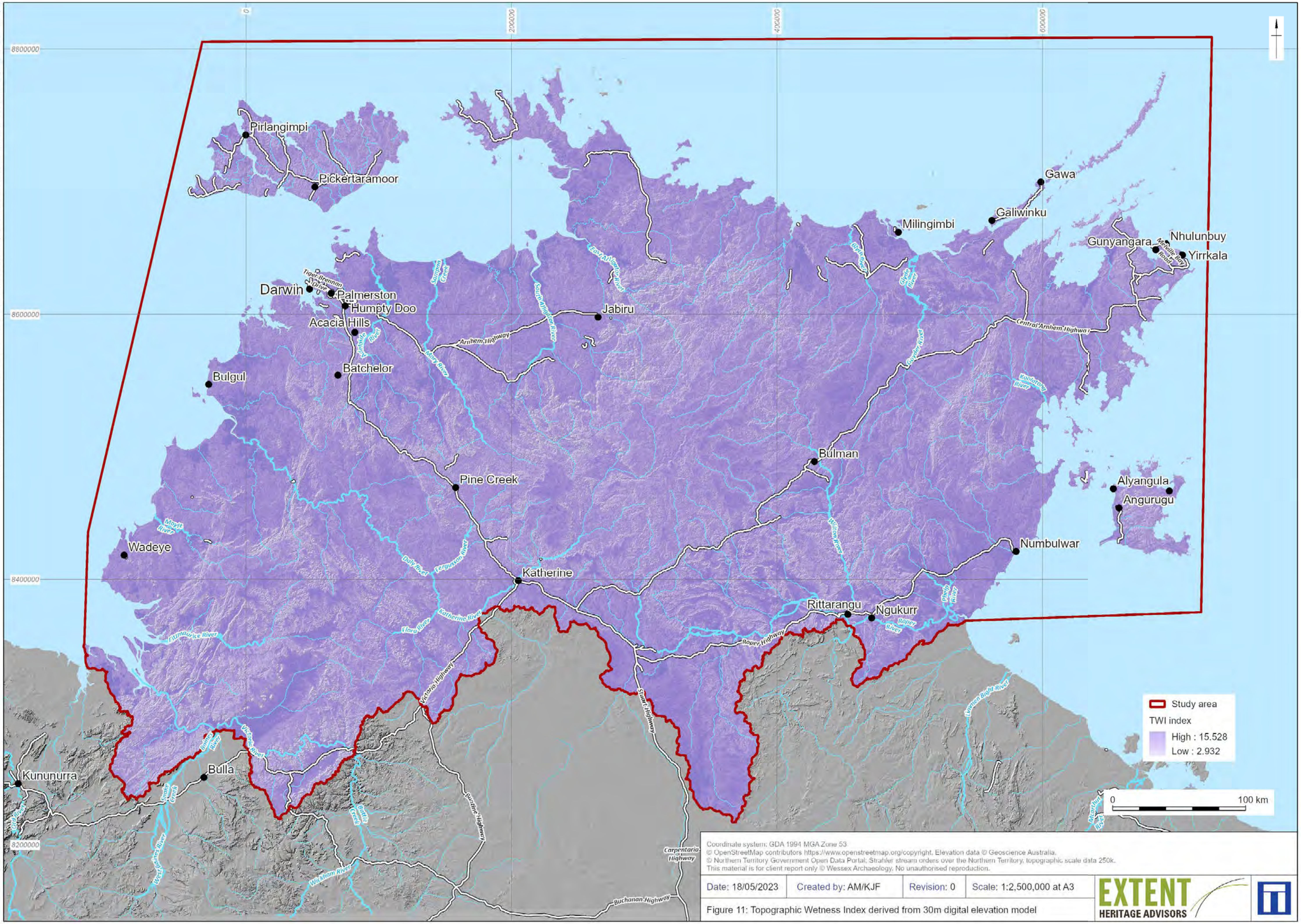
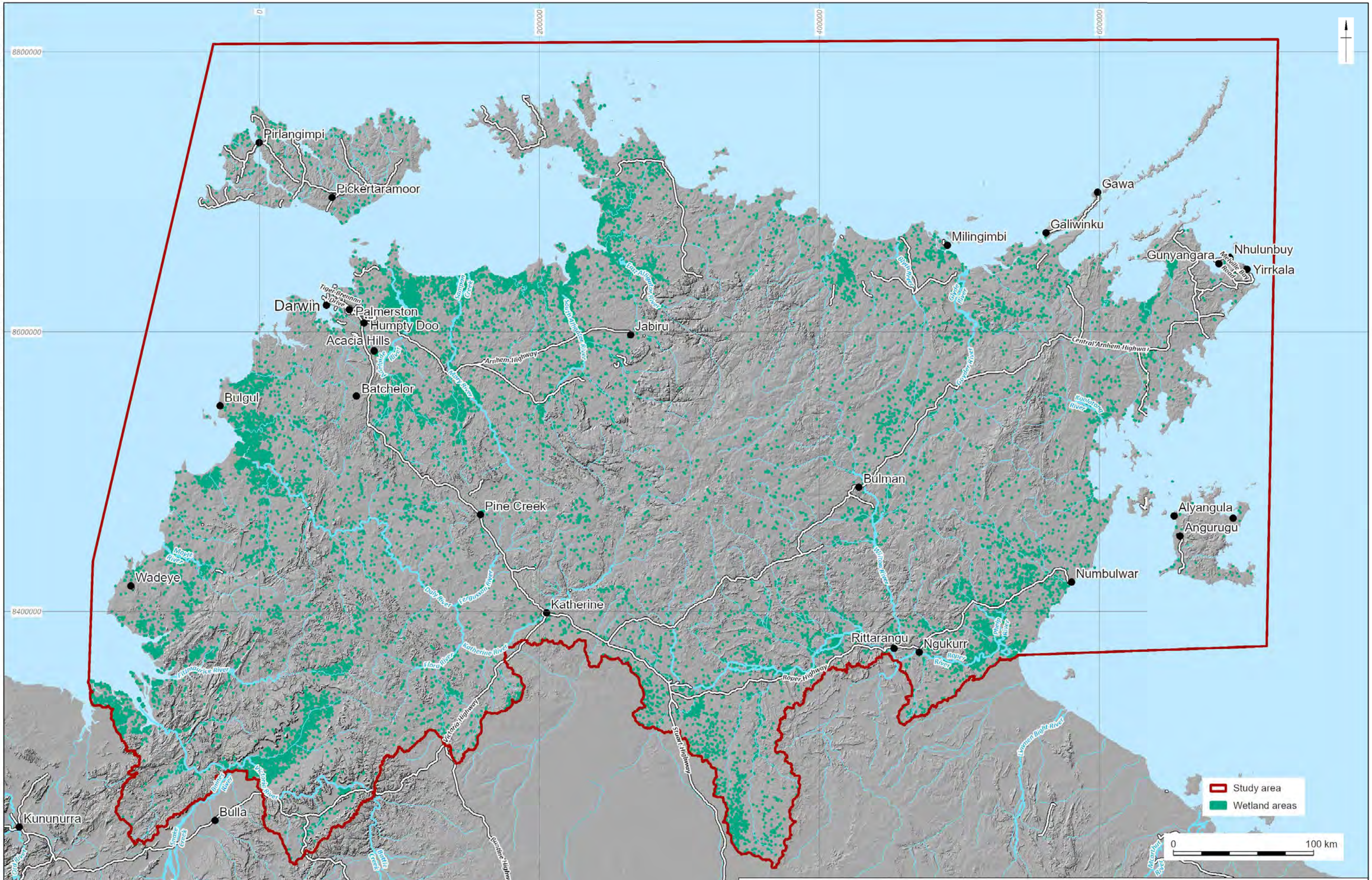


Figure 11: Topographic Wetness Index derived from 30m digital elevation model



Coordinate system: GDA 1994 MGA Zone 53.
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Figure 12: Areas with Topographic Wetness Index of 14 or higher

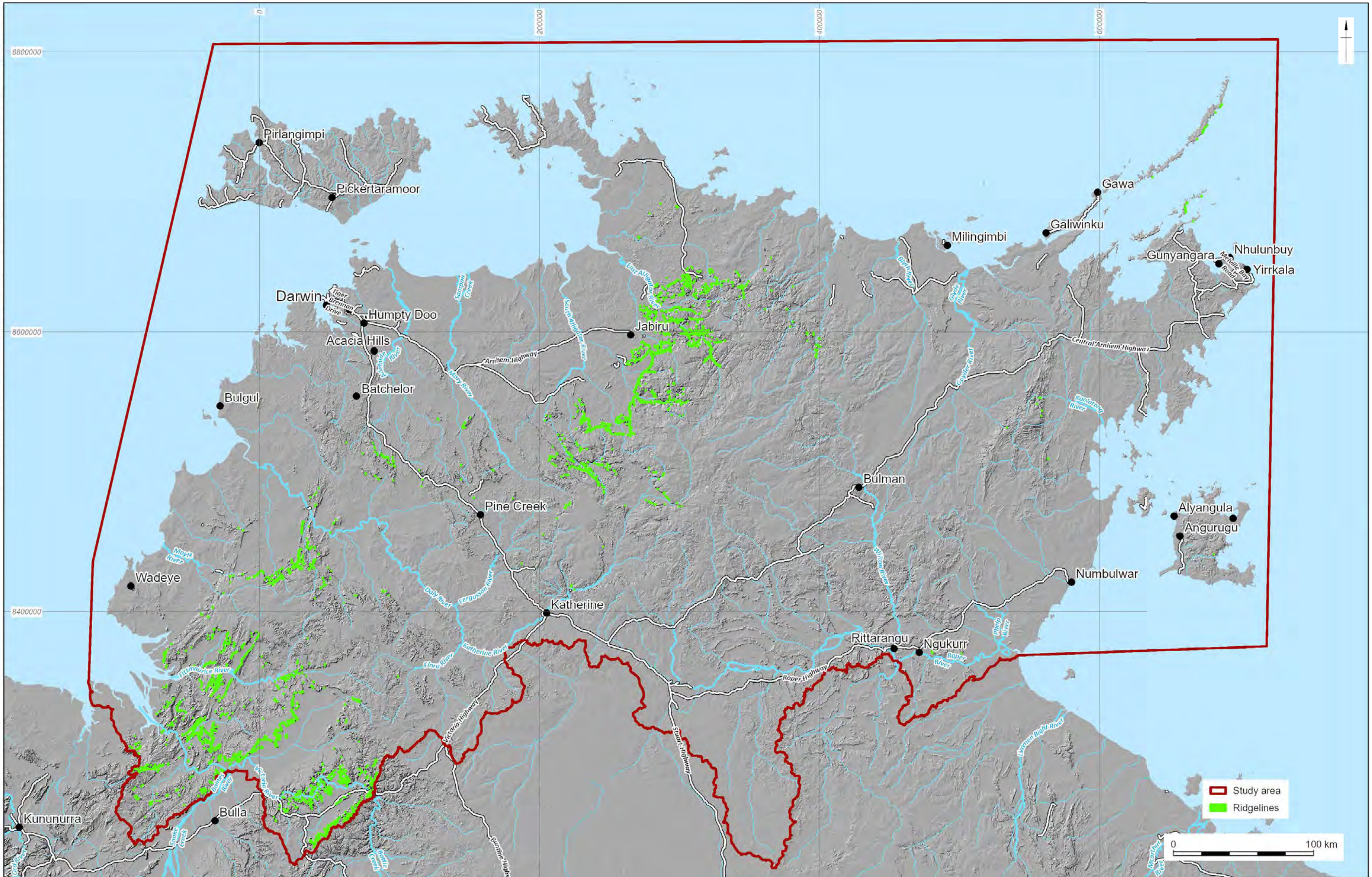

Figure 13: Prominent ridgelines derived from Topographic Wetness Index

Coordinate system: GDA 1994 MGA Zone 53.
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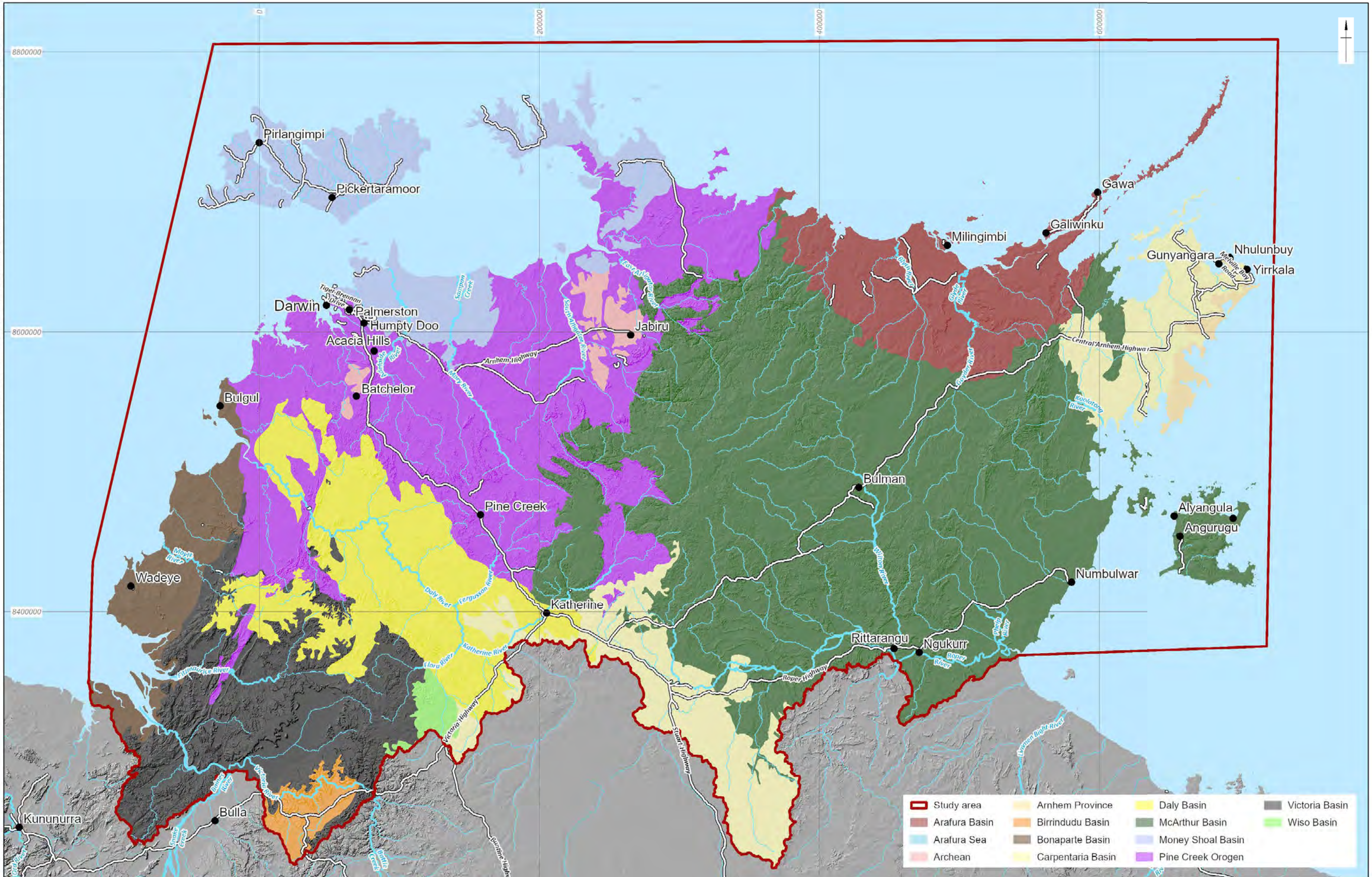

Coordinate system: GDA 1994 MGA Zone 53.
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Figure 14: Geological classes within the study area

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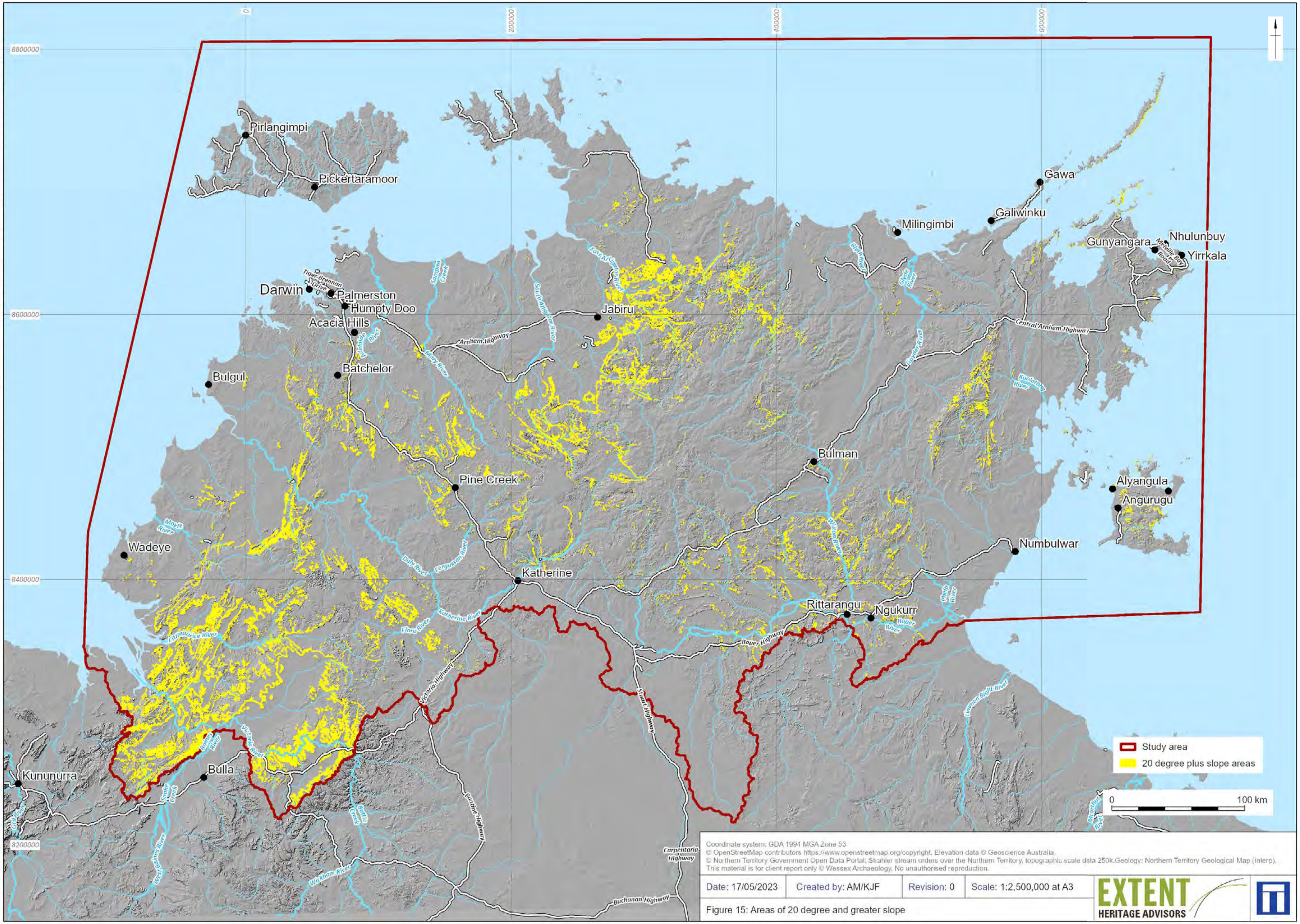


Figure 15: Areas of 20 degree and greater slope

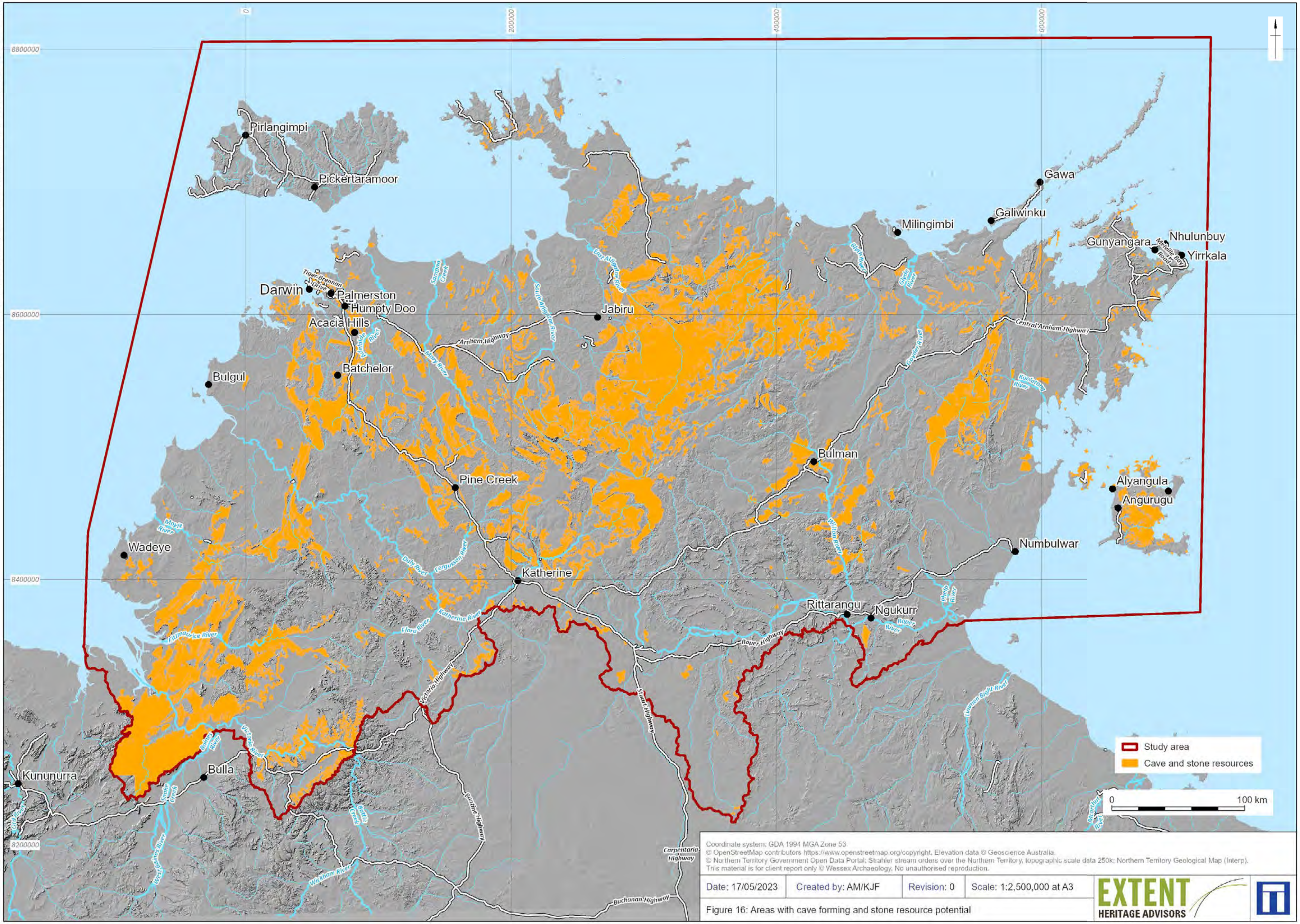
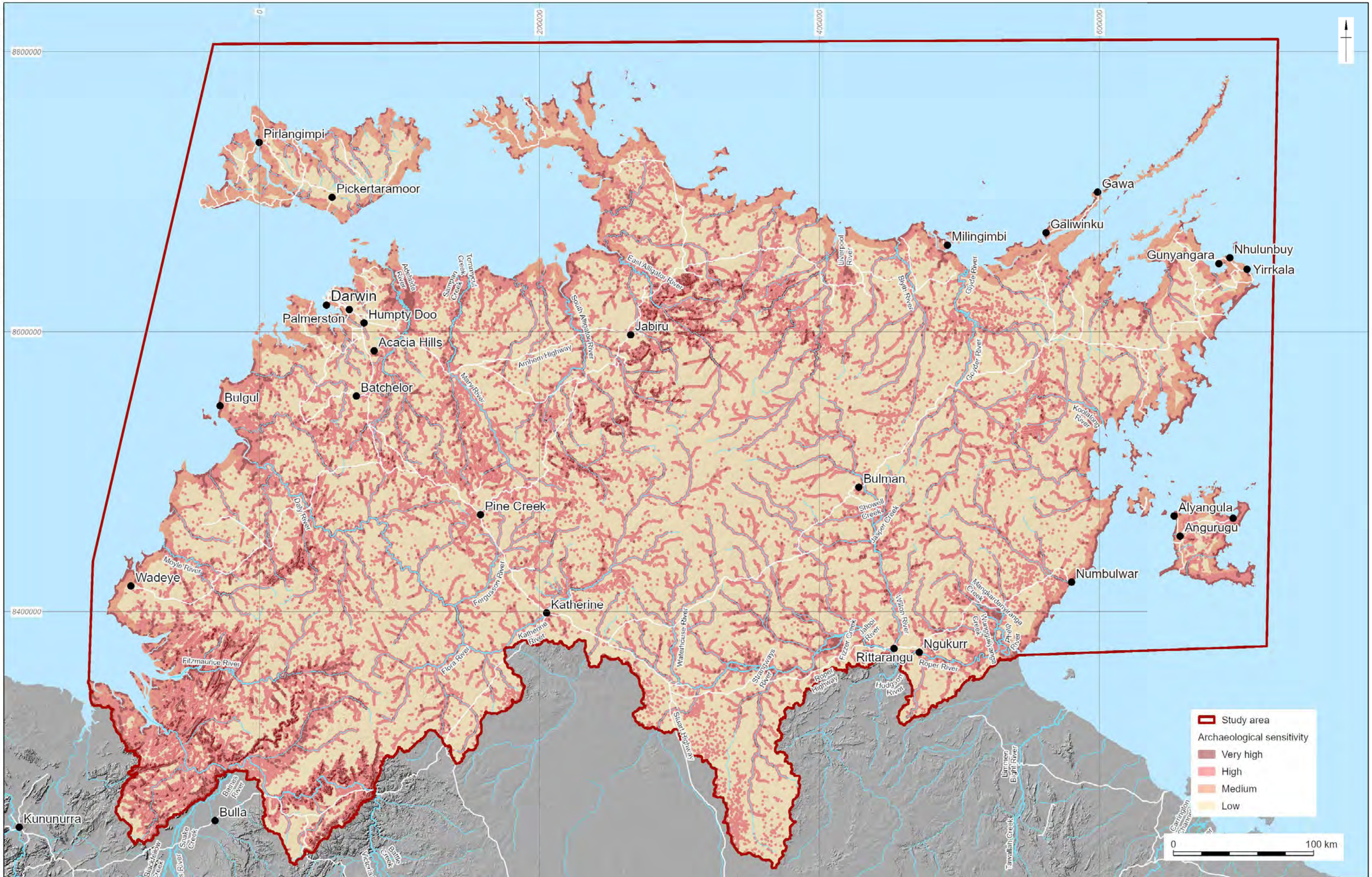


Figure 16: Areas with cave forming and stone resource potential



Date: 17/05/2023 | Created by: AM/KJF | Revision: 0 | Scale: 1:2,500,000 at A3

Figure 17: Archaeological sensitivity model within the terrestrial study area

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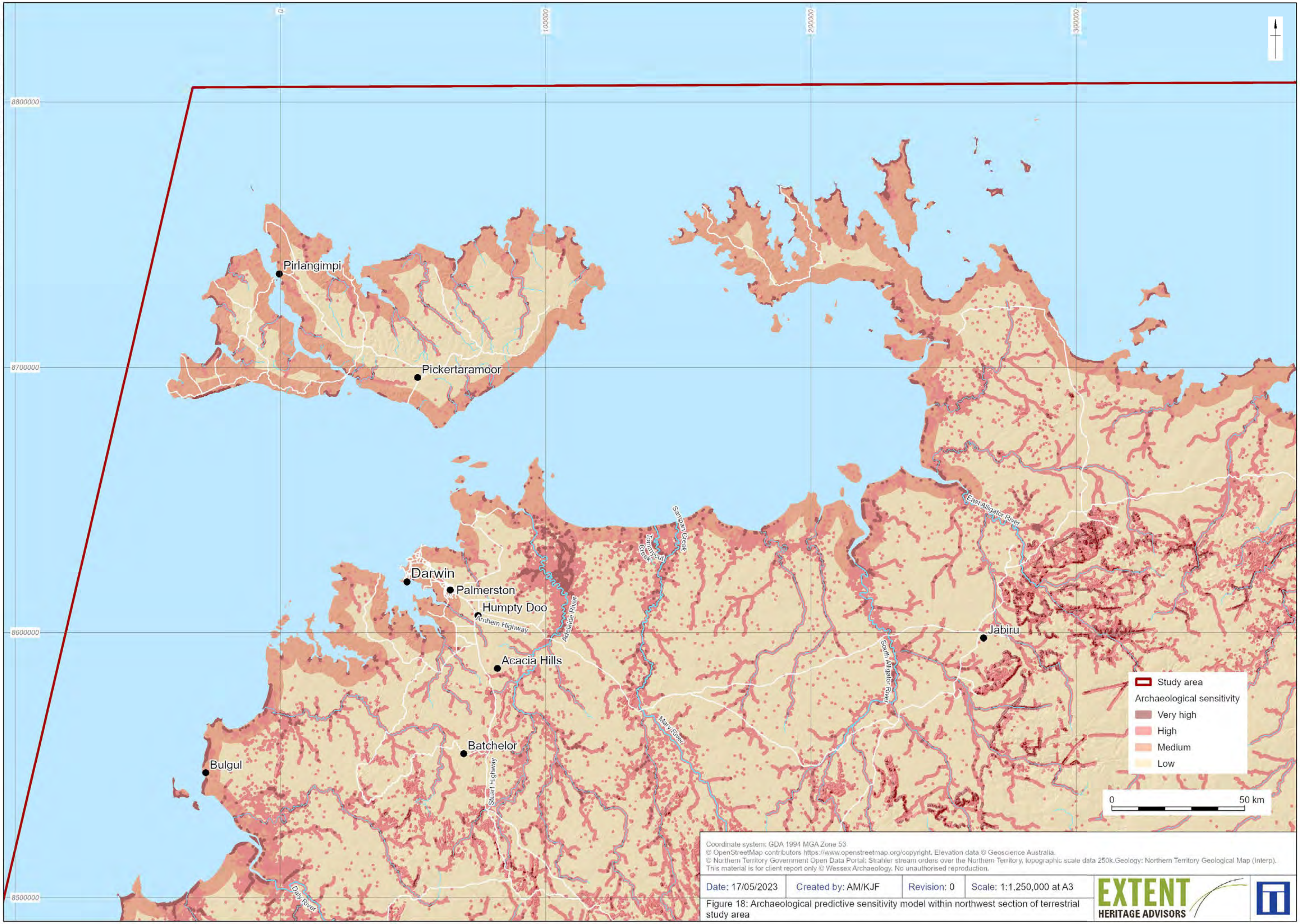

Coordinate system: GDA 1994 MGA Zone 53

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Figure 18: Archaeological predictive sensitivity model within northwest section of terrestrial study area

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Coordinate system: GDA 1994 MGA Zone 52

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Figure 19a: Palaeogeographic features of interest along the proposed route

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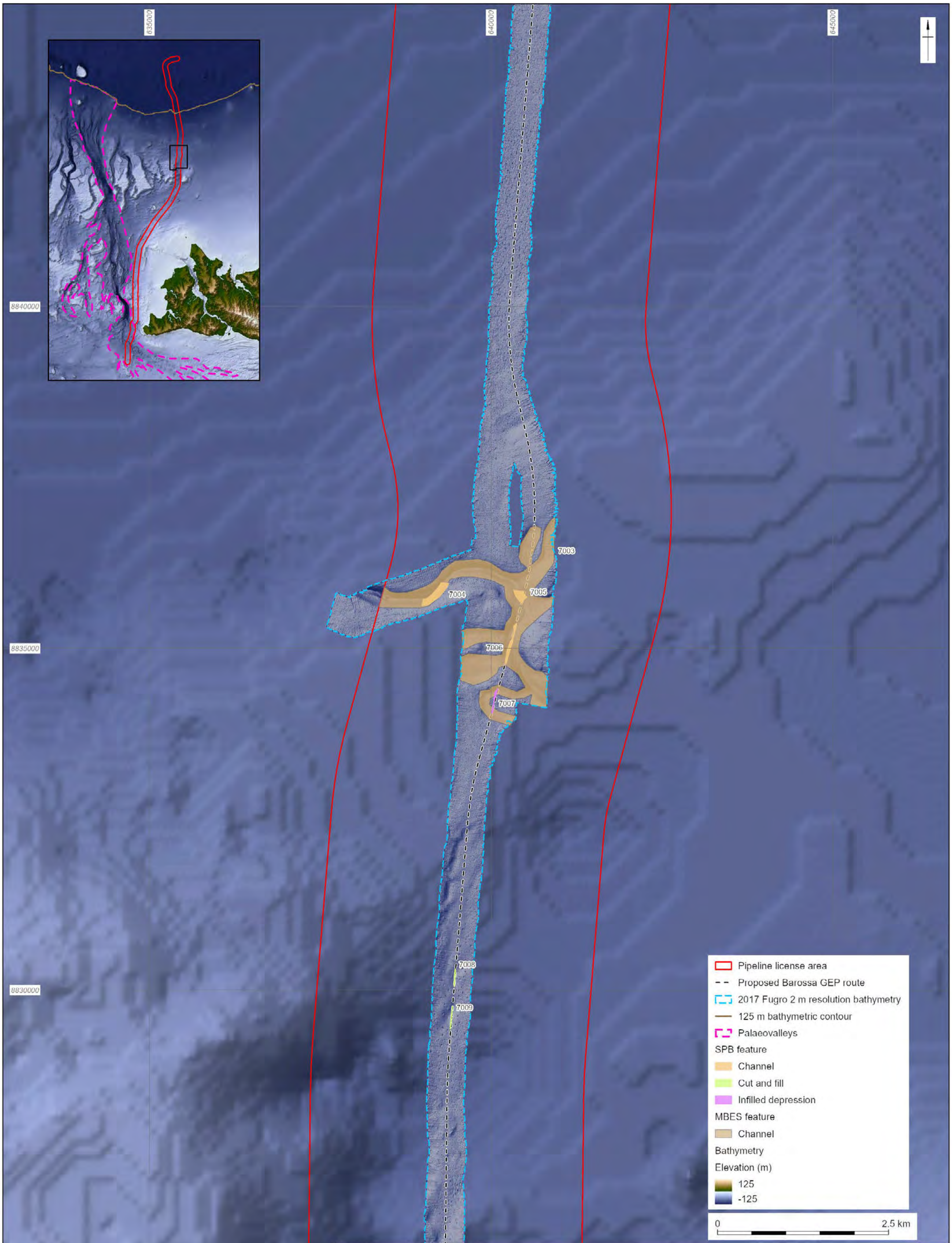

Coordinate system: GDA 1994 MGA Zone 52
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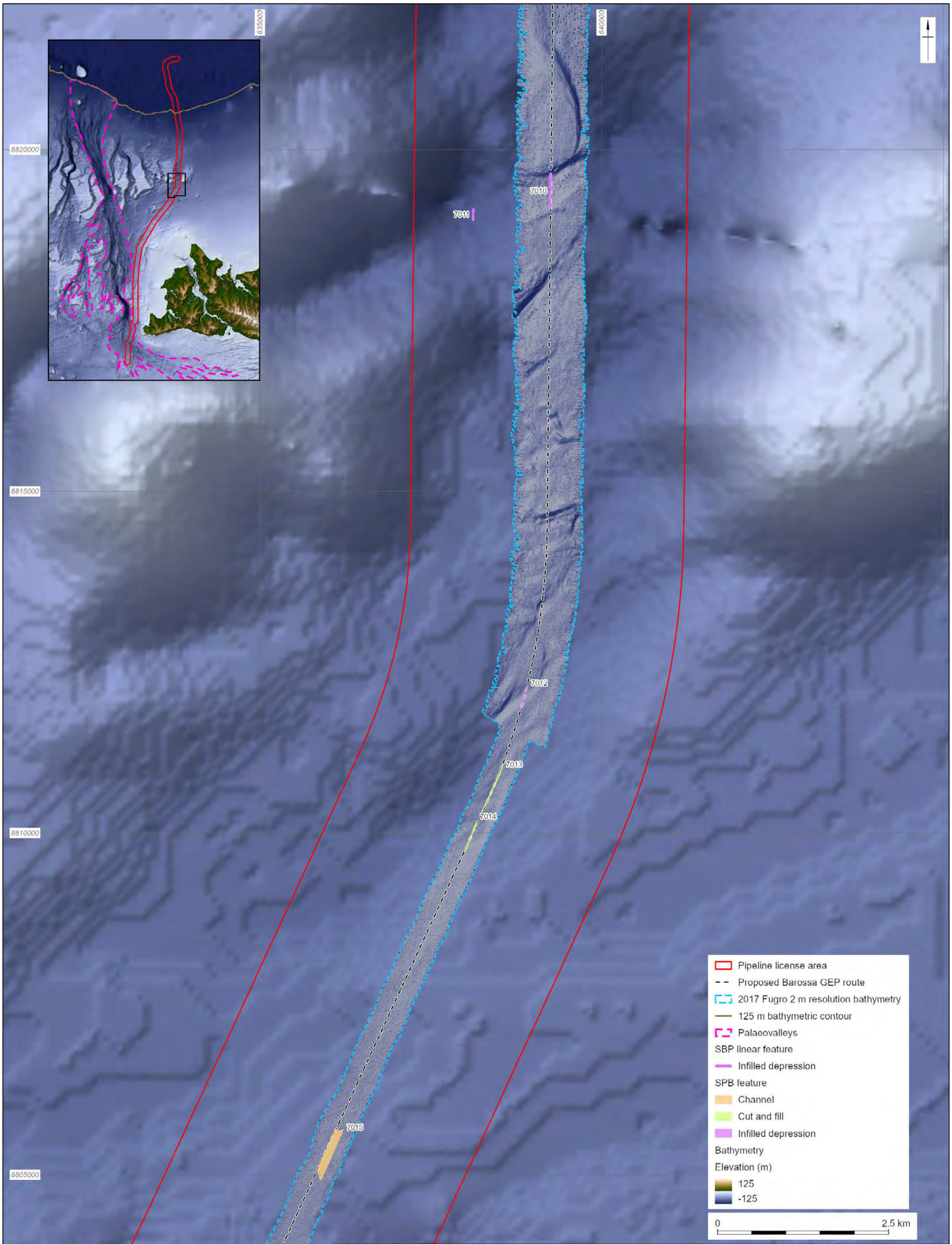
Figure 19b: Palaeogeographic features of interest along the proposed route



Coordinate system: GDA 1994 MGA Zone 52
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Figure 19c: Palaeogeographic features of interest along the proposed route

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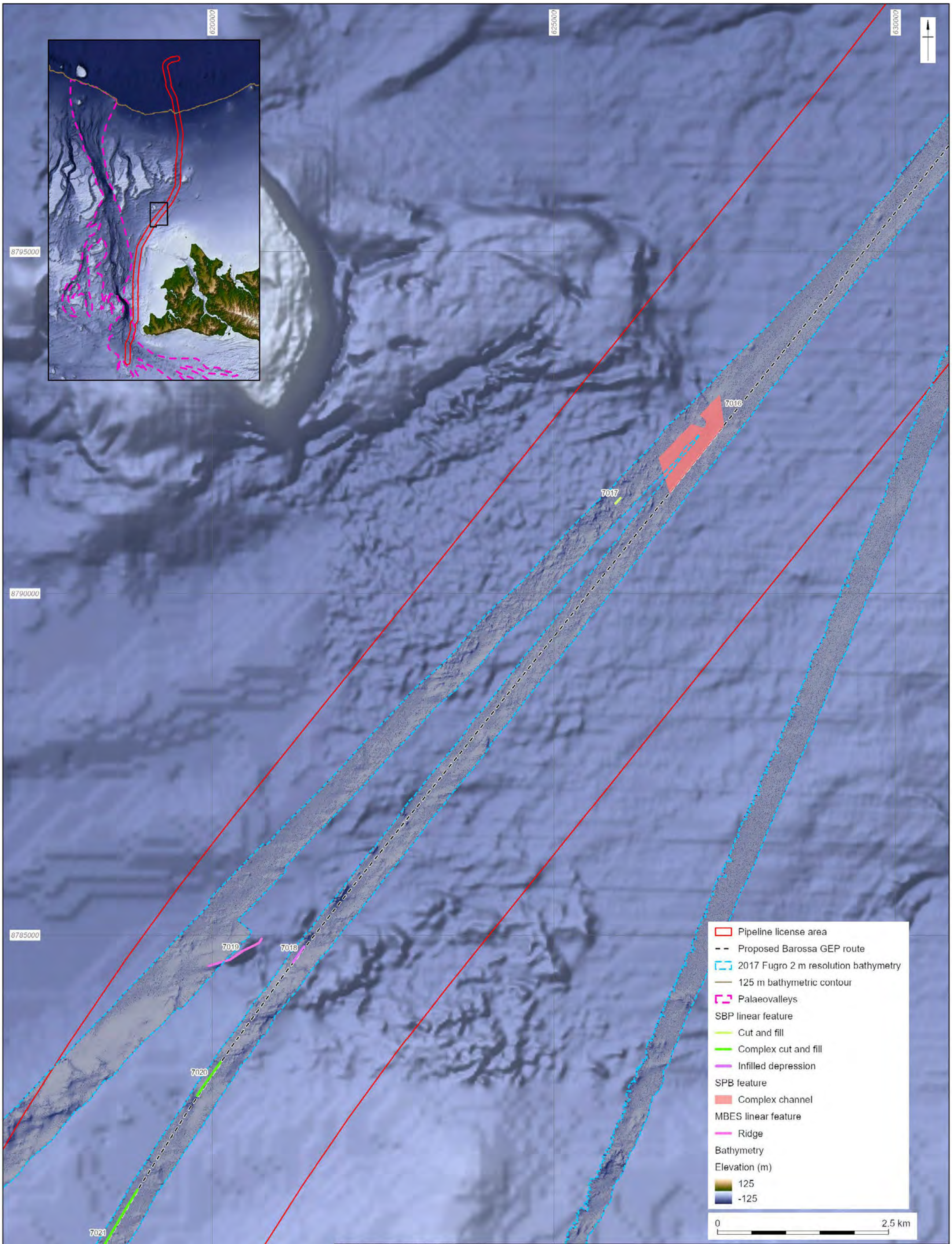

Coordinate system: GDA 1994 MGA Zone 52
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Figure 19d: Palaeogeographic features of interest along the proposed route

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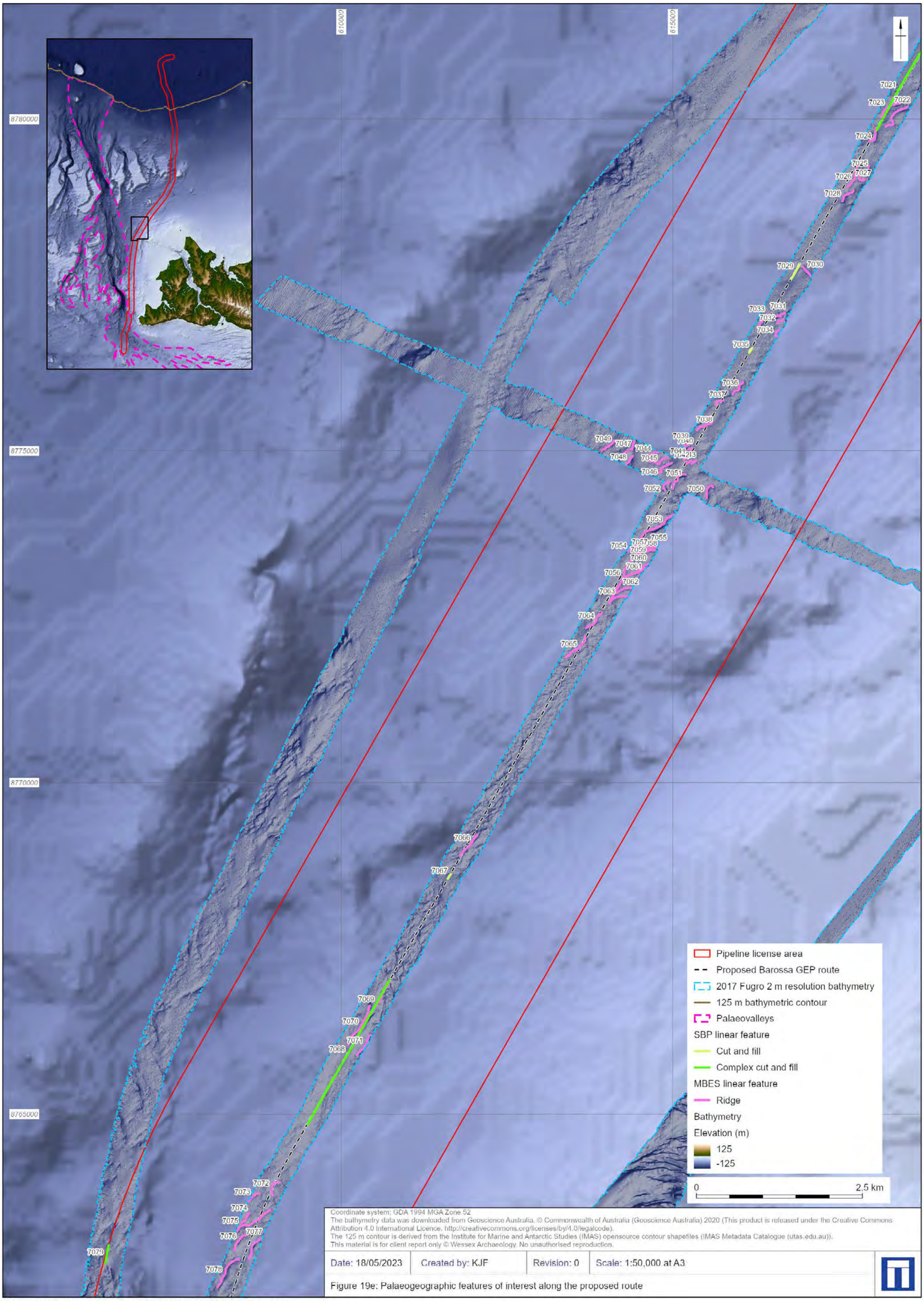

Coordinate system: GDA 1994 MGA Zone 52
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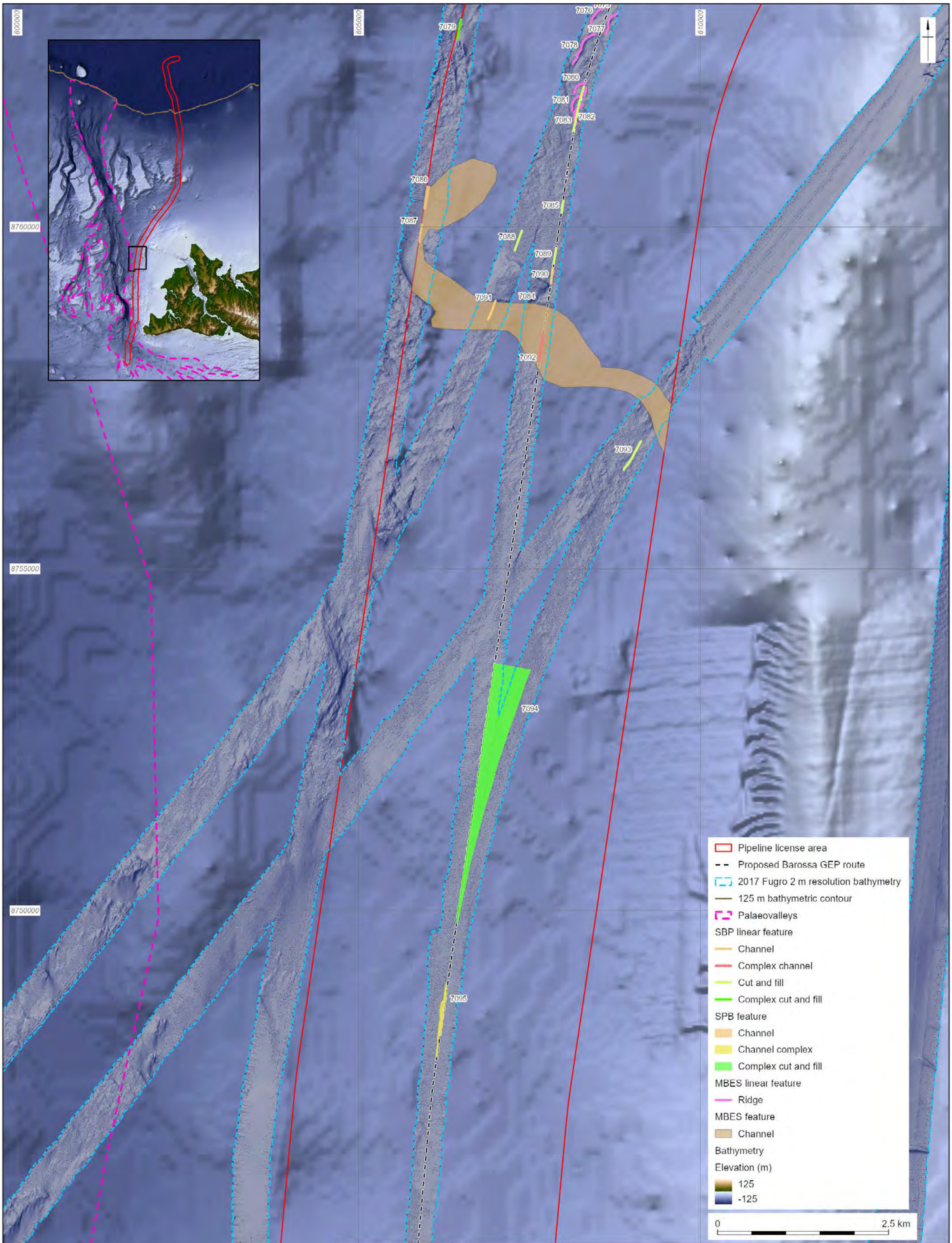
The 125 m contour is derived from the Institute for Marine and Antarctic Studies (IMAS) opensource contour shapefiles (IMAS Metadata Catalogue (utas.edu.au)).

Date: 18/05/2023	Created by: KJF	Revision: 0	Scale: 1:50,000 at A3

Figure 19e: Palaeogeographic features of interest along the proposed route



Coordinate system: GDA 1994 MGA Zone 52
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Figure 19f: Palaeogeographic features of interest along the proposed route

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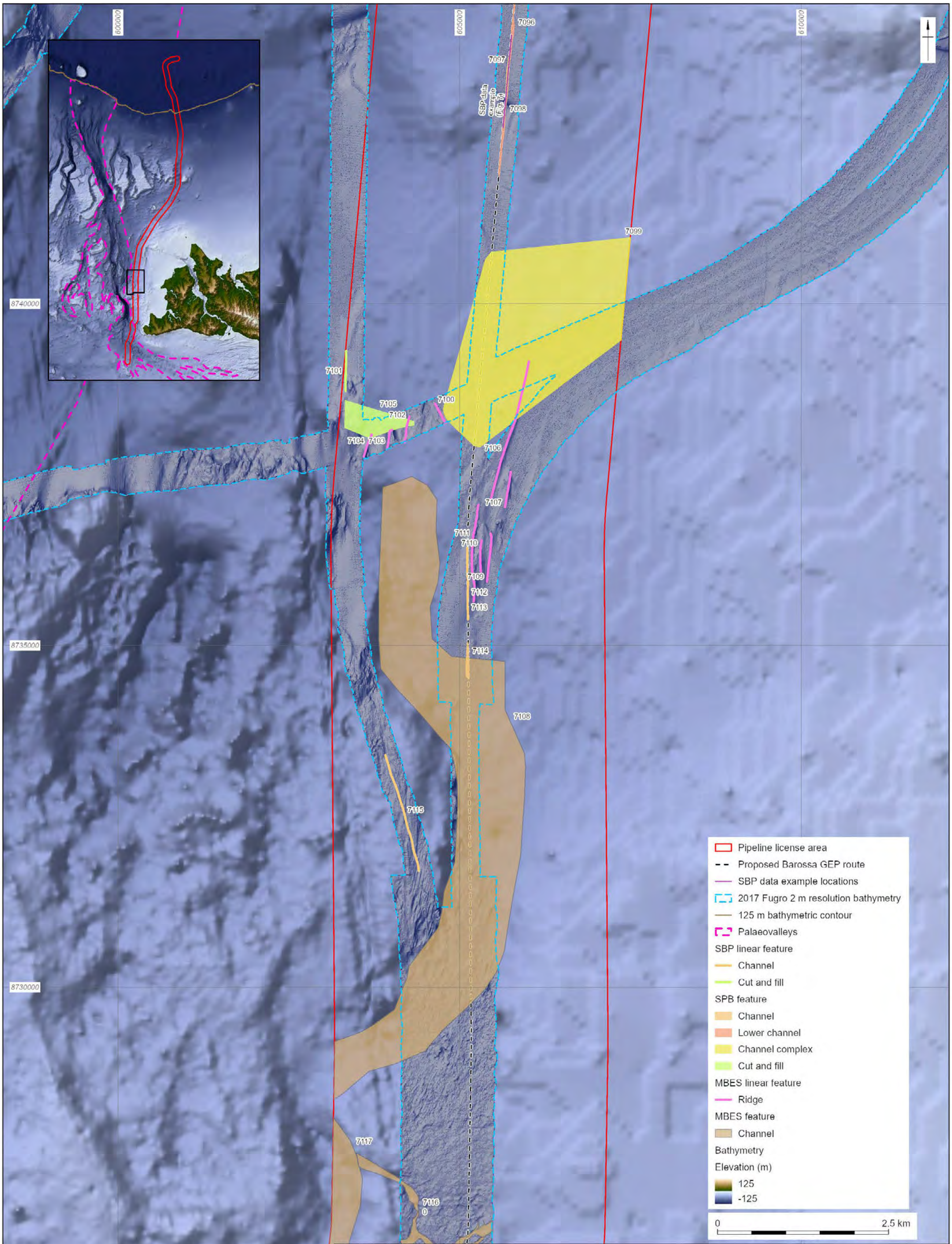

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Figure 19g: Palaeogeographic features of interest along the proposed route

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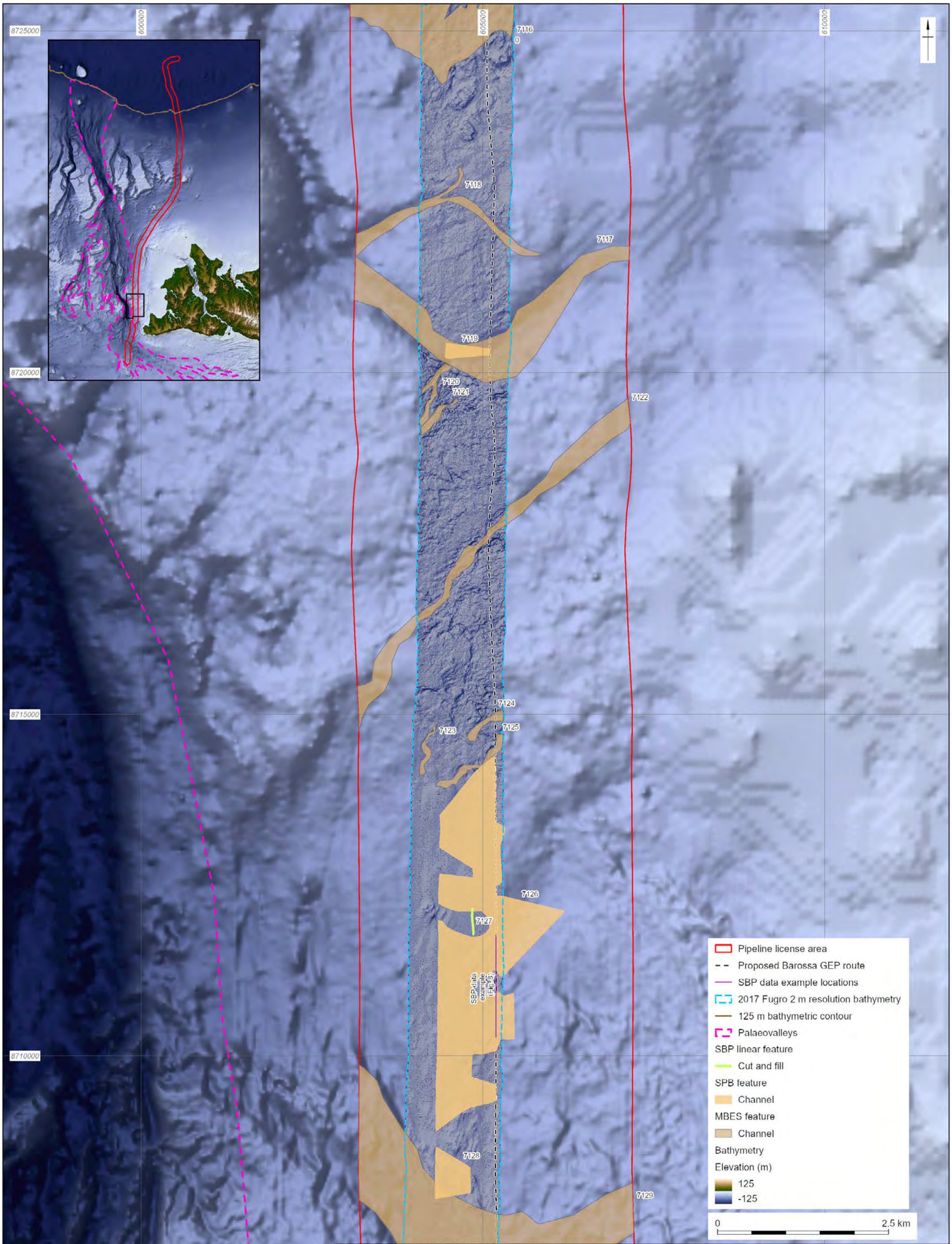

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Figure 19h: Palaeogeographic features of interest along the proposed route

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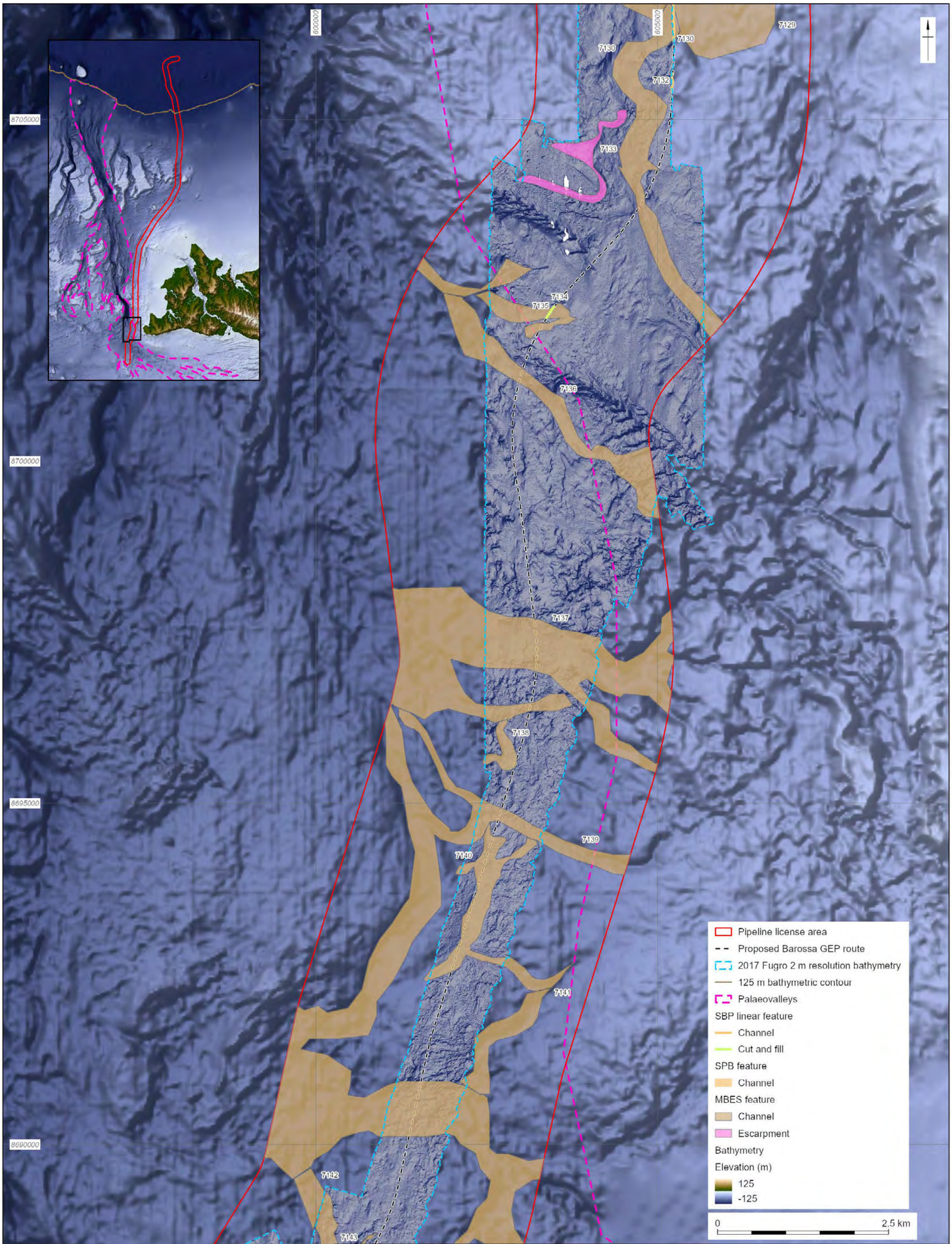

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The 125 m contour is derived from the Institute for Marine and Antarctic Studies (IMAS) opensource contour shapefiles (IMAS Metadata Catalogue (utas.edu.au)).

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Figure 19i: Palaeogeographic features of interest along the proposed route

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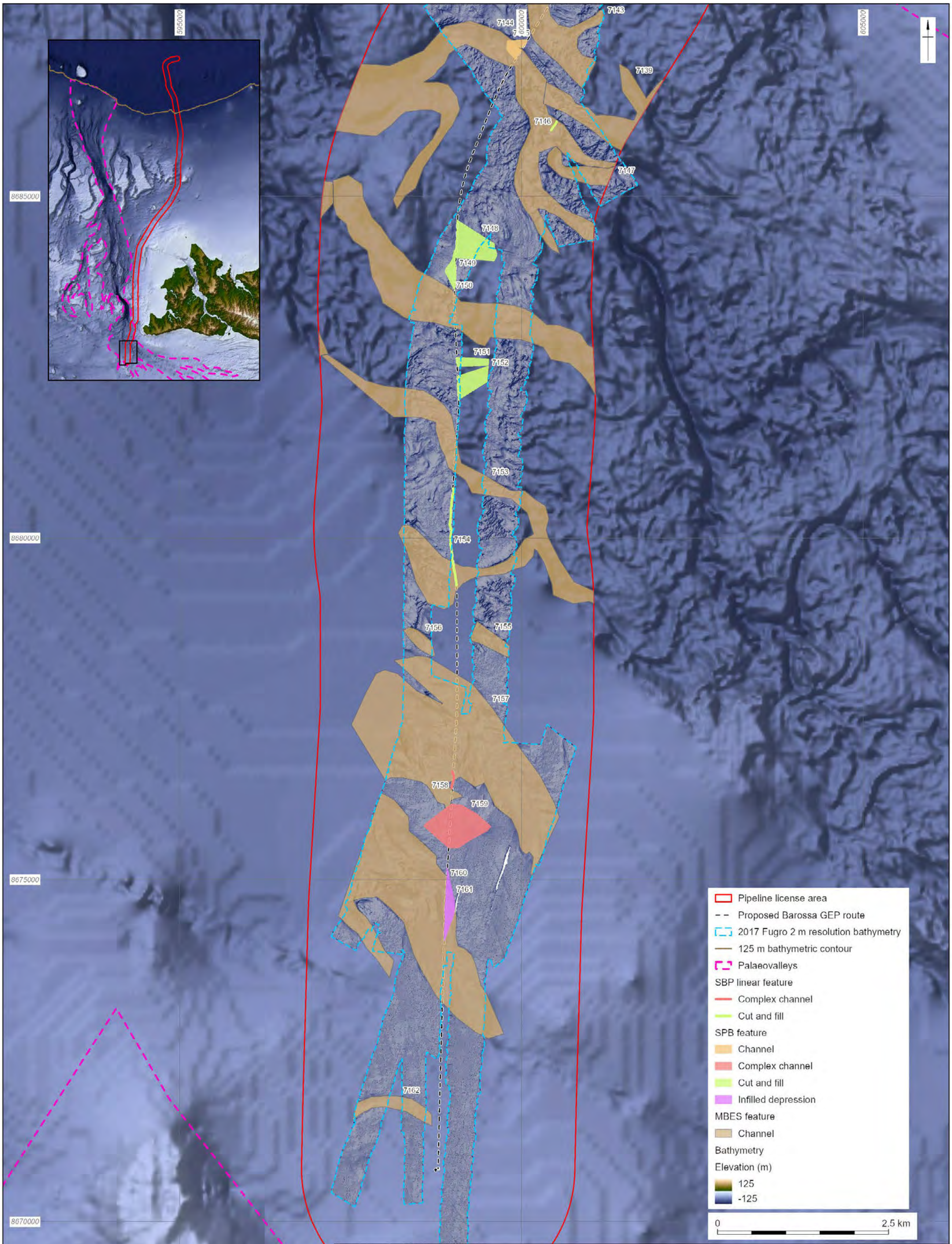

Coordinate system: GDA 1994 MGA Zone 52
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Figure 19j: Palaeogeographic features of interest along the proposed route

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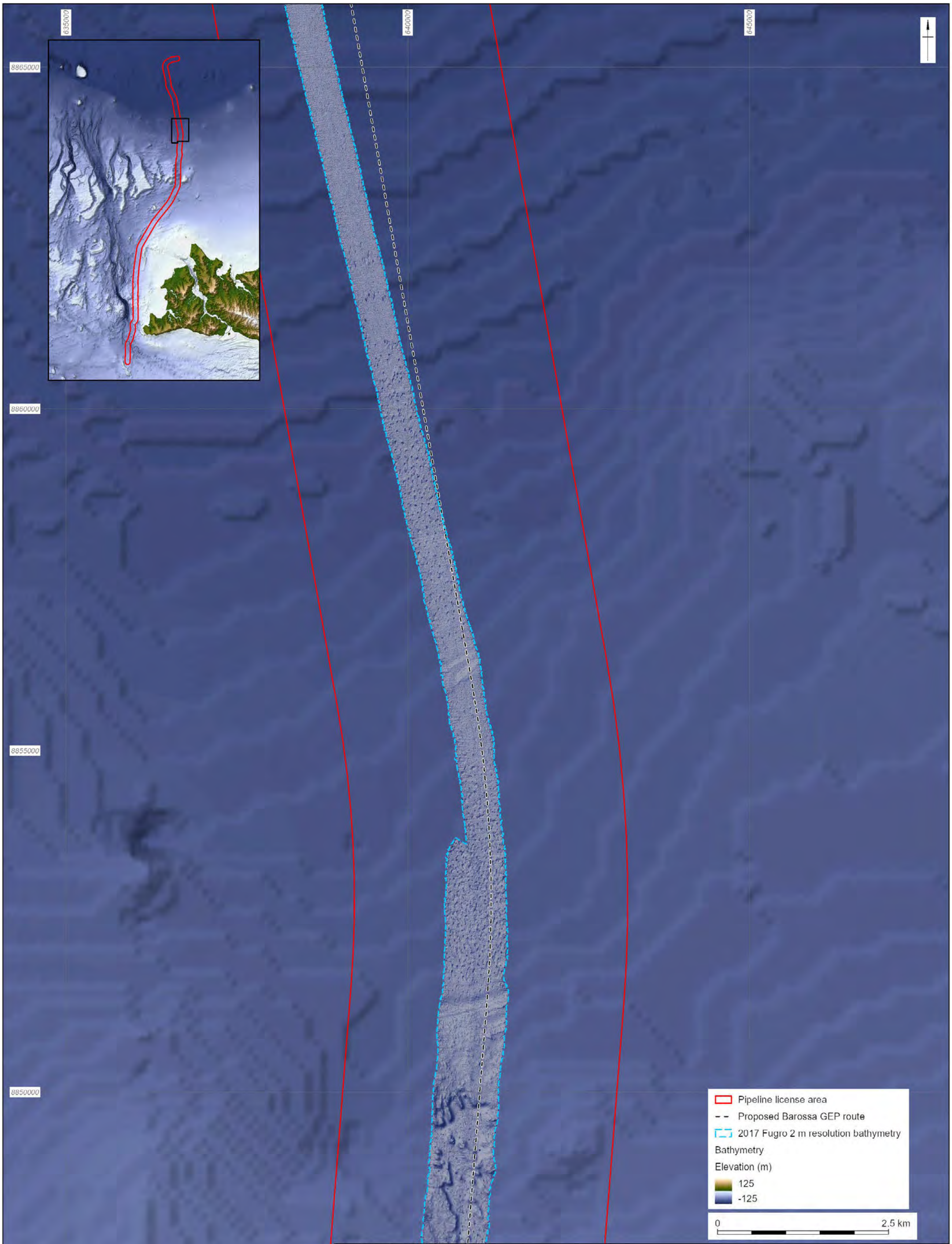

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Figure 19k: Palaeogeographic features of interest along the proposed route (Interpretation removed)

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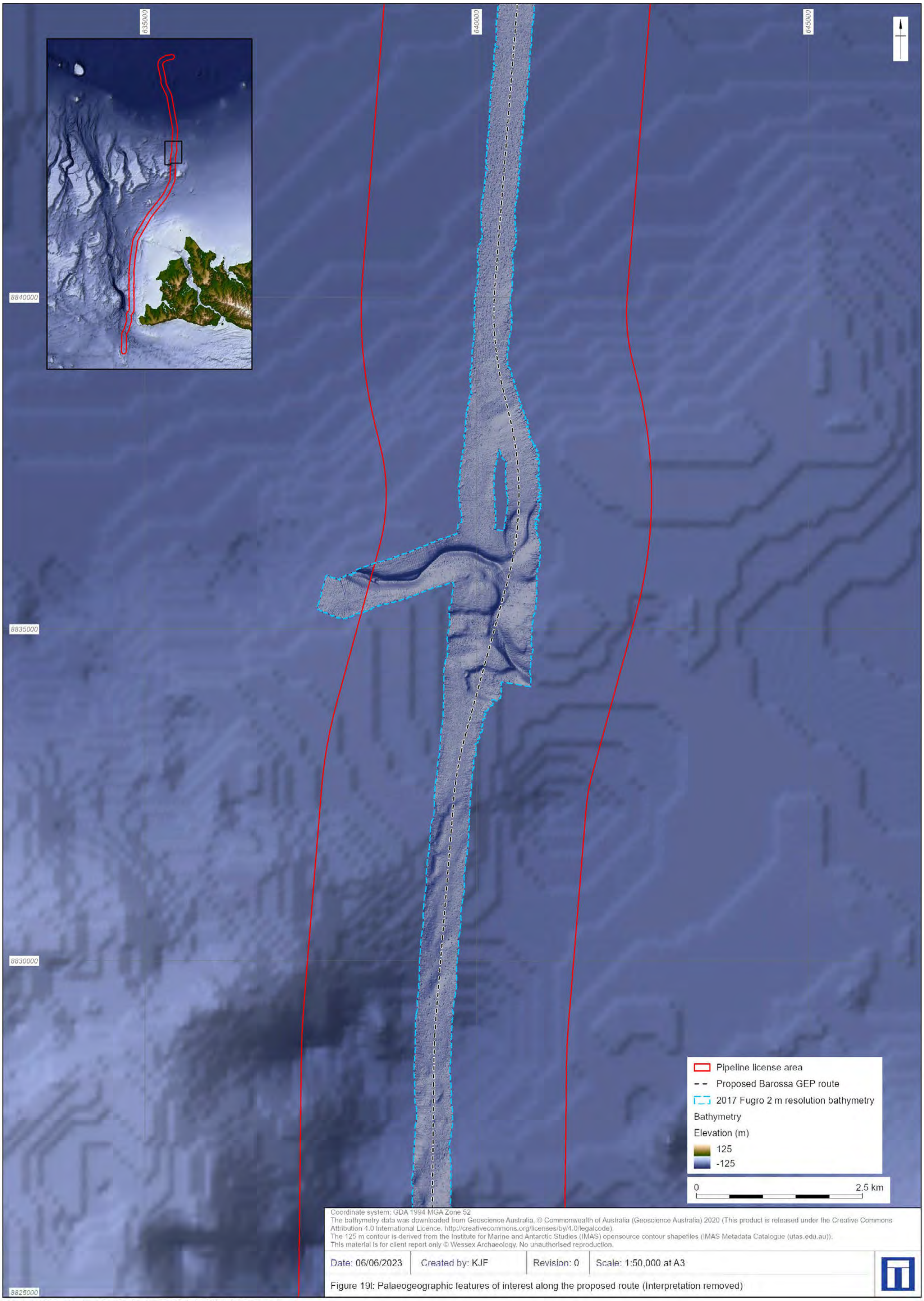
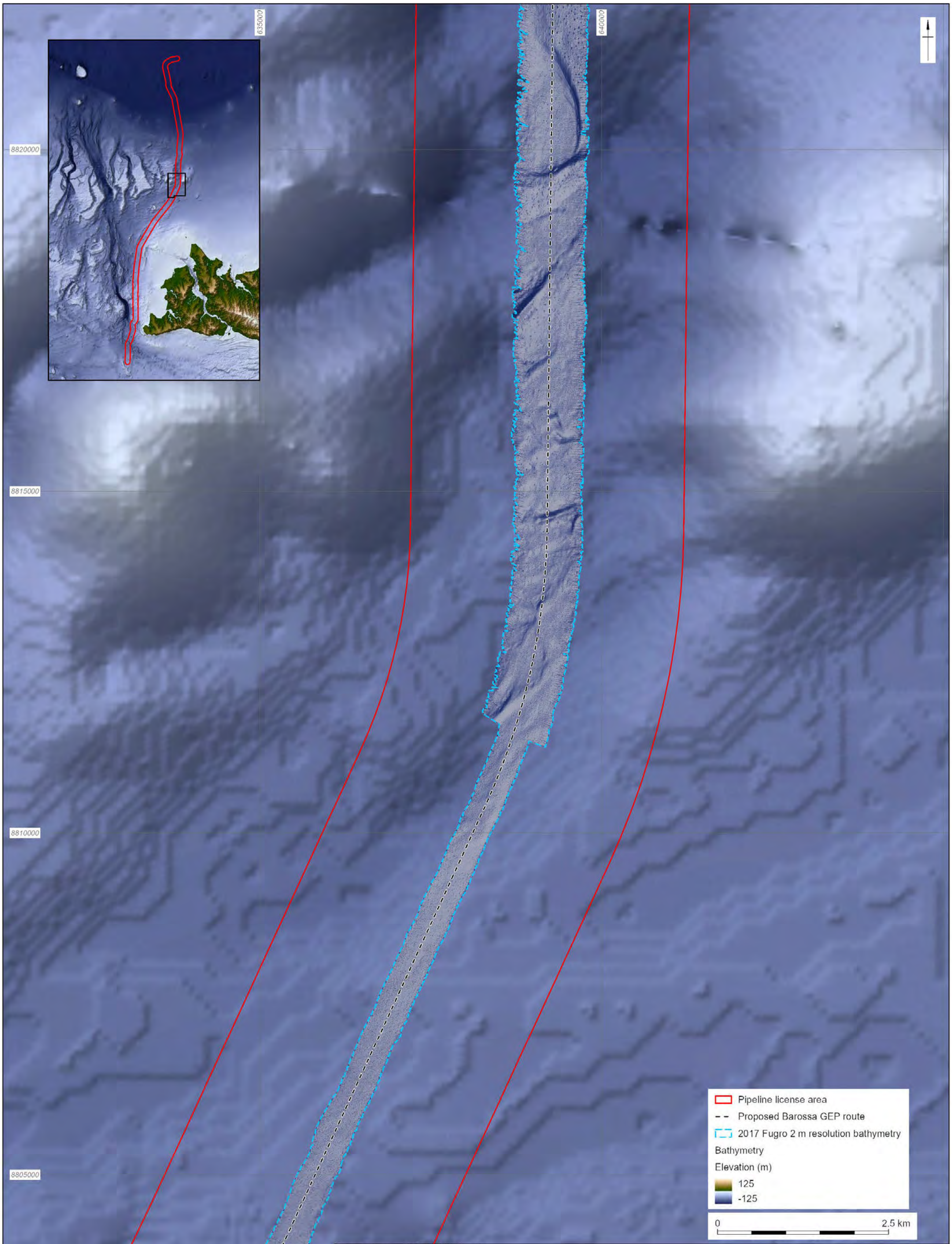


Coordinate system: GDA 1994 MGA Zone 52
The bathymetry data was downloaded from Geoscience Australia.
The 125 m contour is derived from the Institute for Marine and Antarctic Studies (IMAS) opensource contour shapefiles (IMAS Metadata Catalogue (utas.edu.au)).

Date: 06/06/2023 | Created by: KJF | Revision: 0 | Scale: 1:50,000 at A3

Figure 19l: Palaeogeographic features of interest along the proposed route (Interpretation removed)



Coordinate system: GDA 1994 MGA Zone 52
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Figure 19m: Palaeogeographic features of interest along the proposed route (Interpretation removed)

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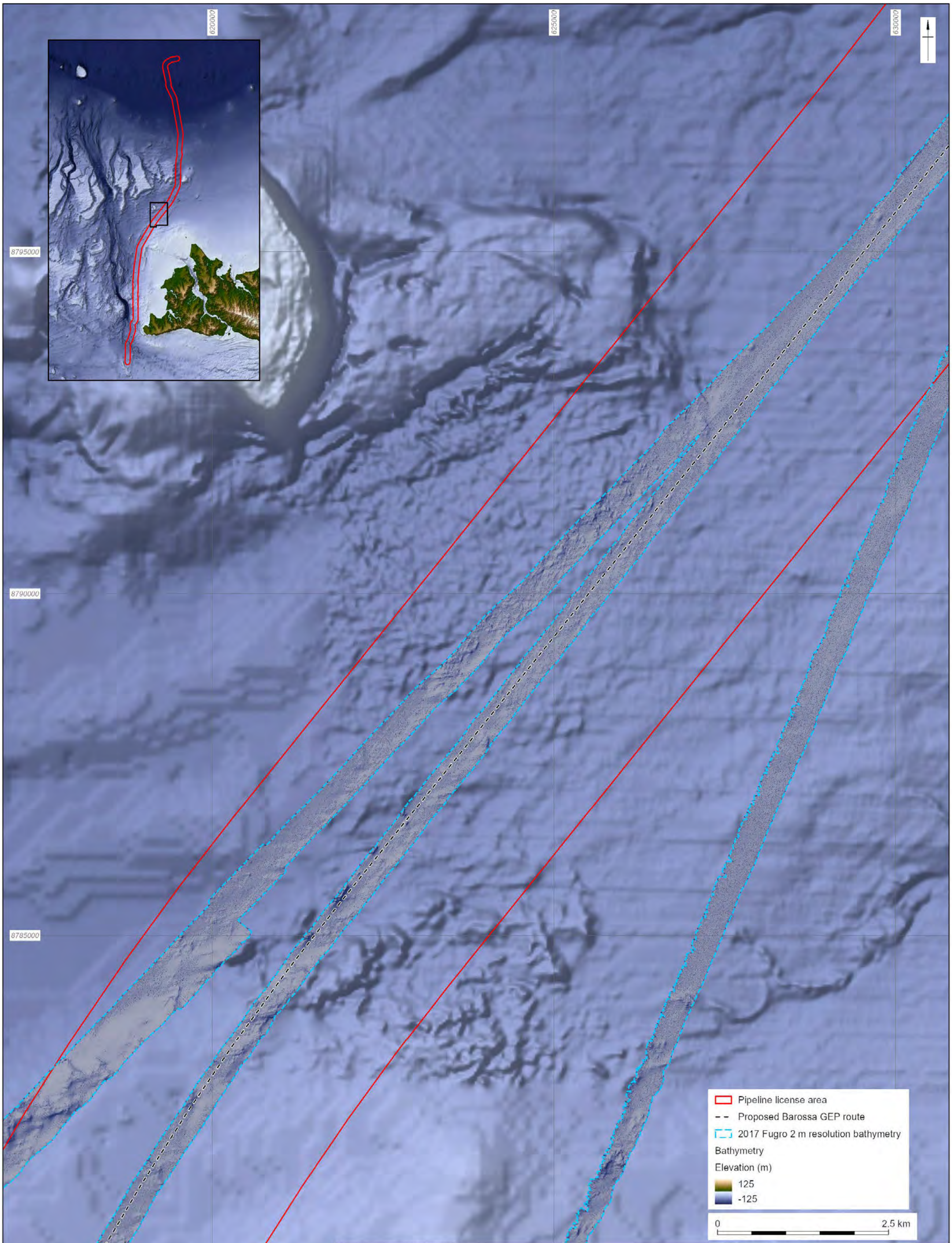

Coordinate system: GDA 1994 MGA Zone 52
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Figure 19n: Palaeogeographic features of interest along the proposed route (Interpretation removed)

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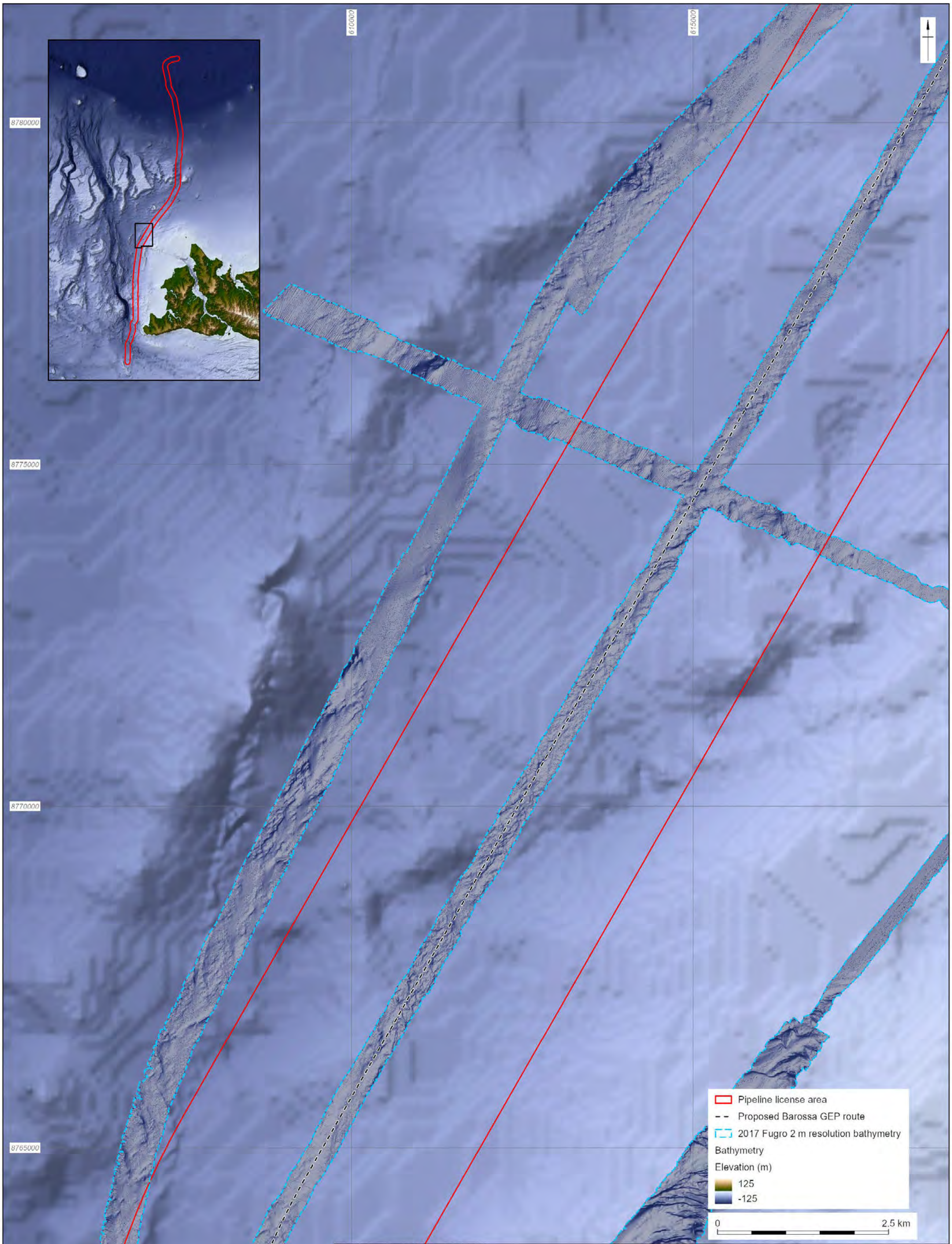

Coordinate system: GDA 1994 MGA Zone 52
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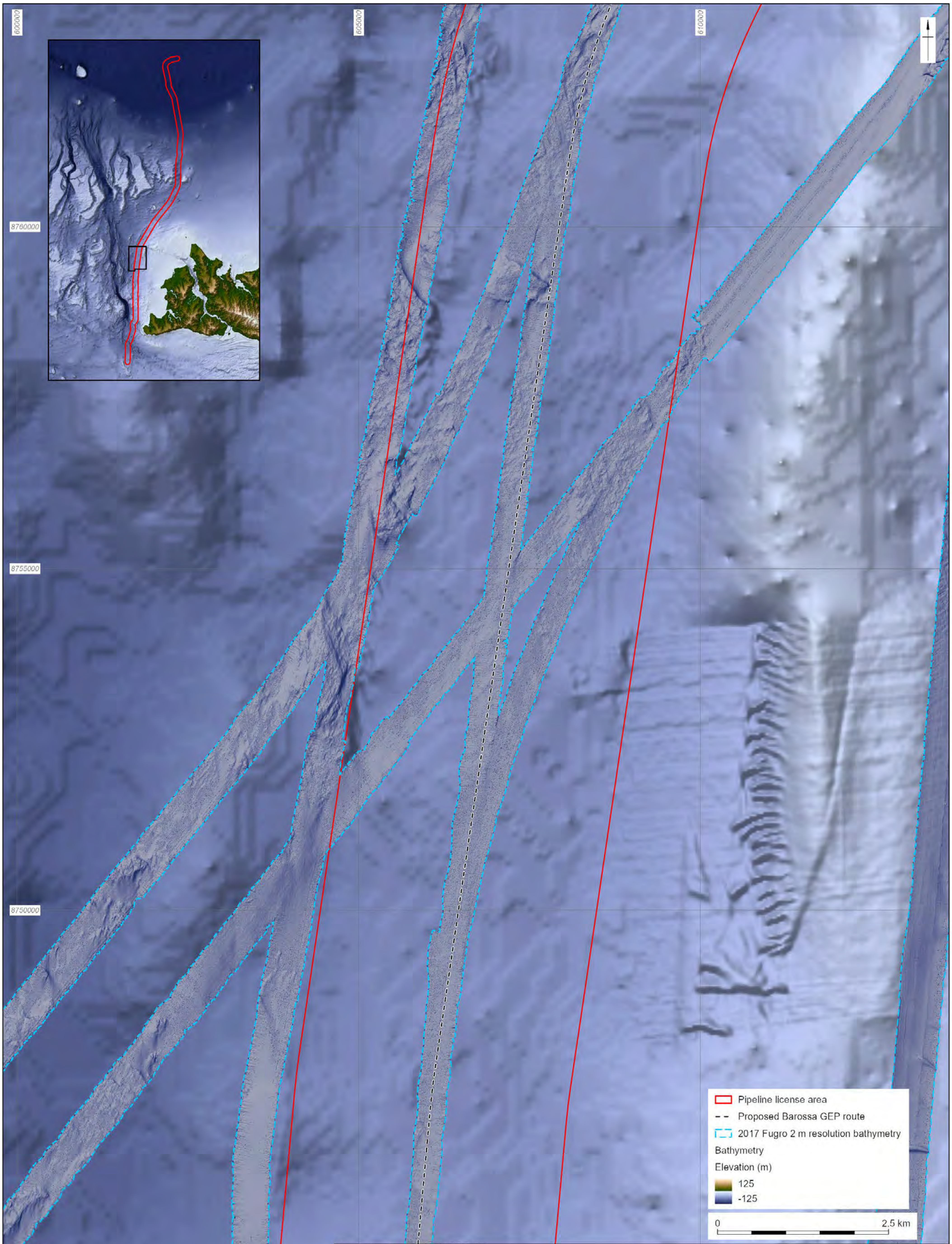
Figure 19o: Palaeogeographic features of interest along the proposed route (Interpretation removed)



Coordinate system: GDA 1994 MGA Zone 52

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The 125 m contour is derived from the Institute for Marine and Antarctic Studies (IMAS) opensource contour shapefiles (IMAS Metadata Catalogue (utas.edu.au)).

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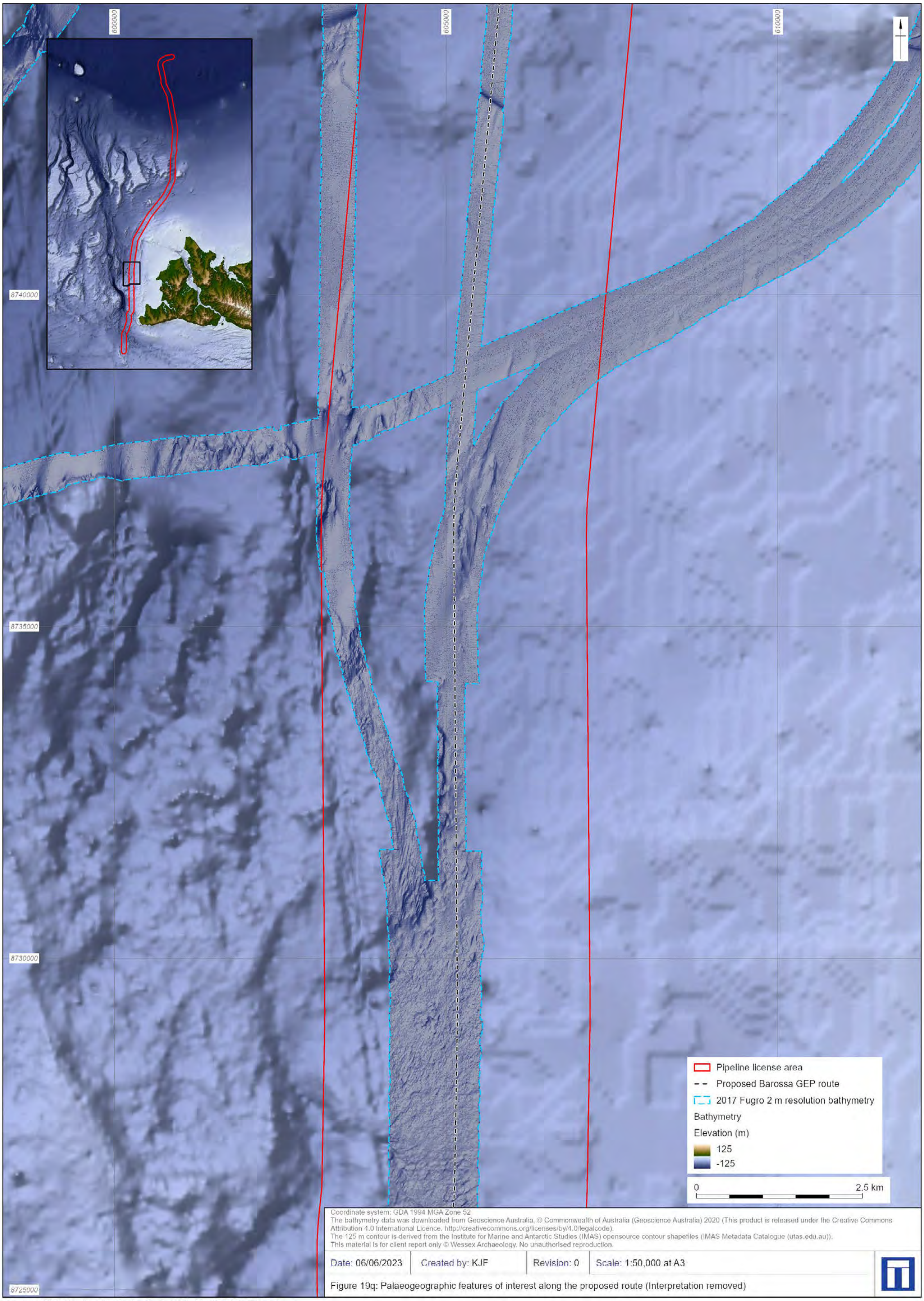
Figure 19p: Palaeogeographic features of interest along the proposed route (Interpretation removed)

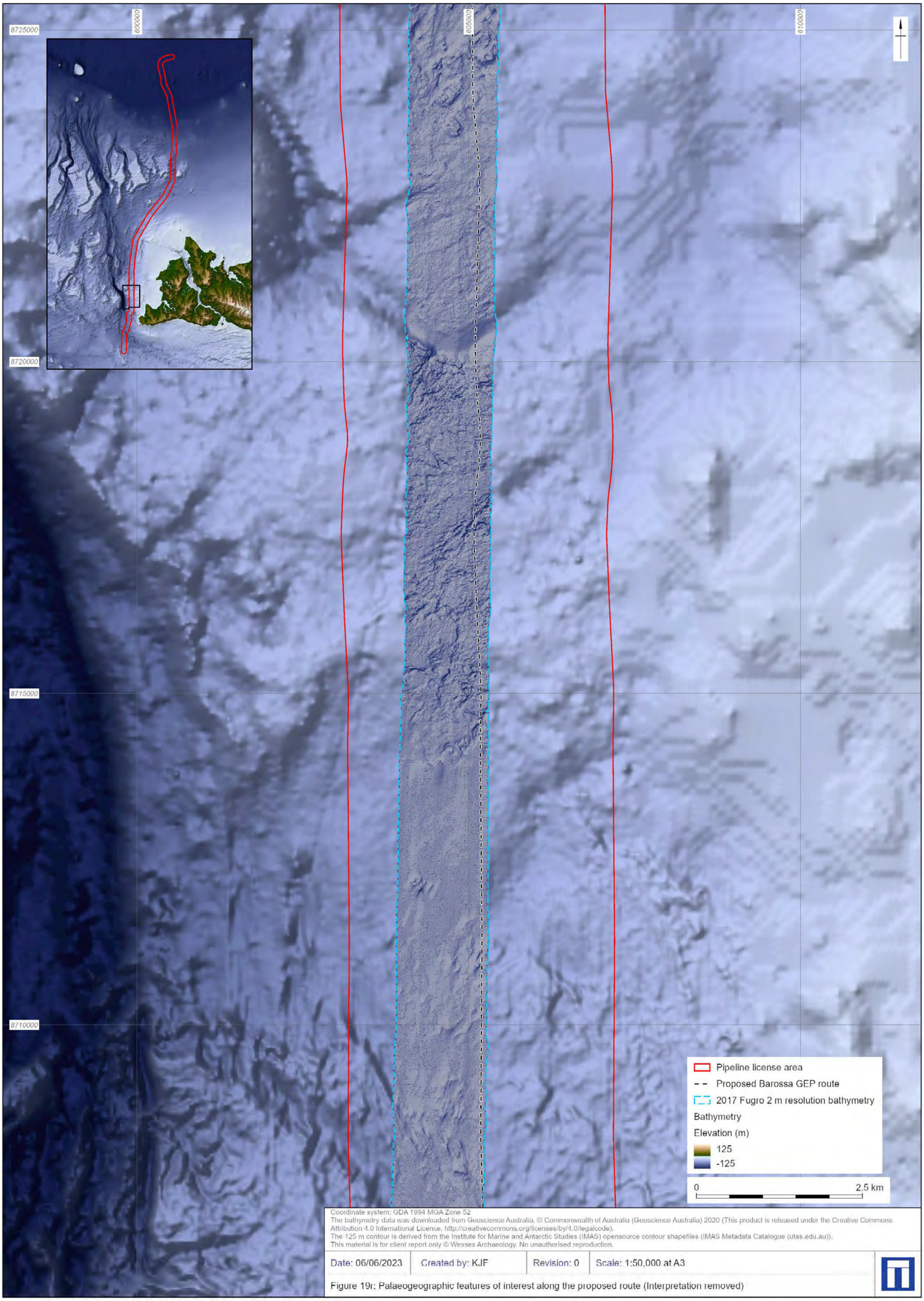


Coordinate system: GDA 1994 MGA Zone 52

The 125 m contour is derived from the Institute for Marine and Antarctic Studies (IMAS) opensource contour shapefiles (IMAS Metadata Catalogue (utas.edu.au)).

Date: 06/06/2023	Created by: KJF	Revision: 0	Scale: 1:50,000 at A3

Figure 19q: Palaeogeographic features of interest along the proposed route (Interpretation removed)



Coordinate system: GDA 1994 MGA Zone 52
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Figure 19r: Palaeogeographic features of interest along the proposed route (Interpretation removed)

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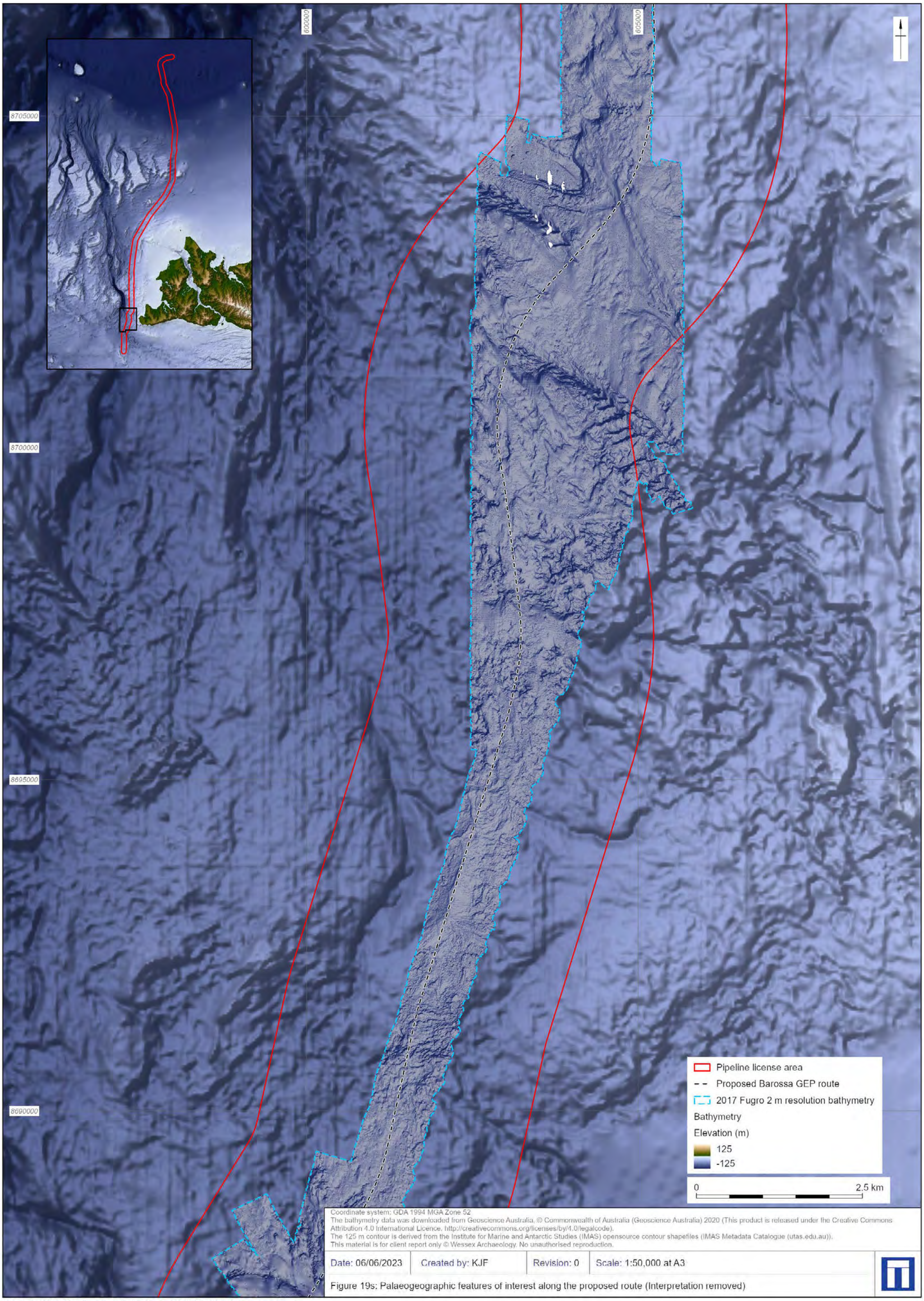

Coordinate system: GDA 1994 MGA Zone 52

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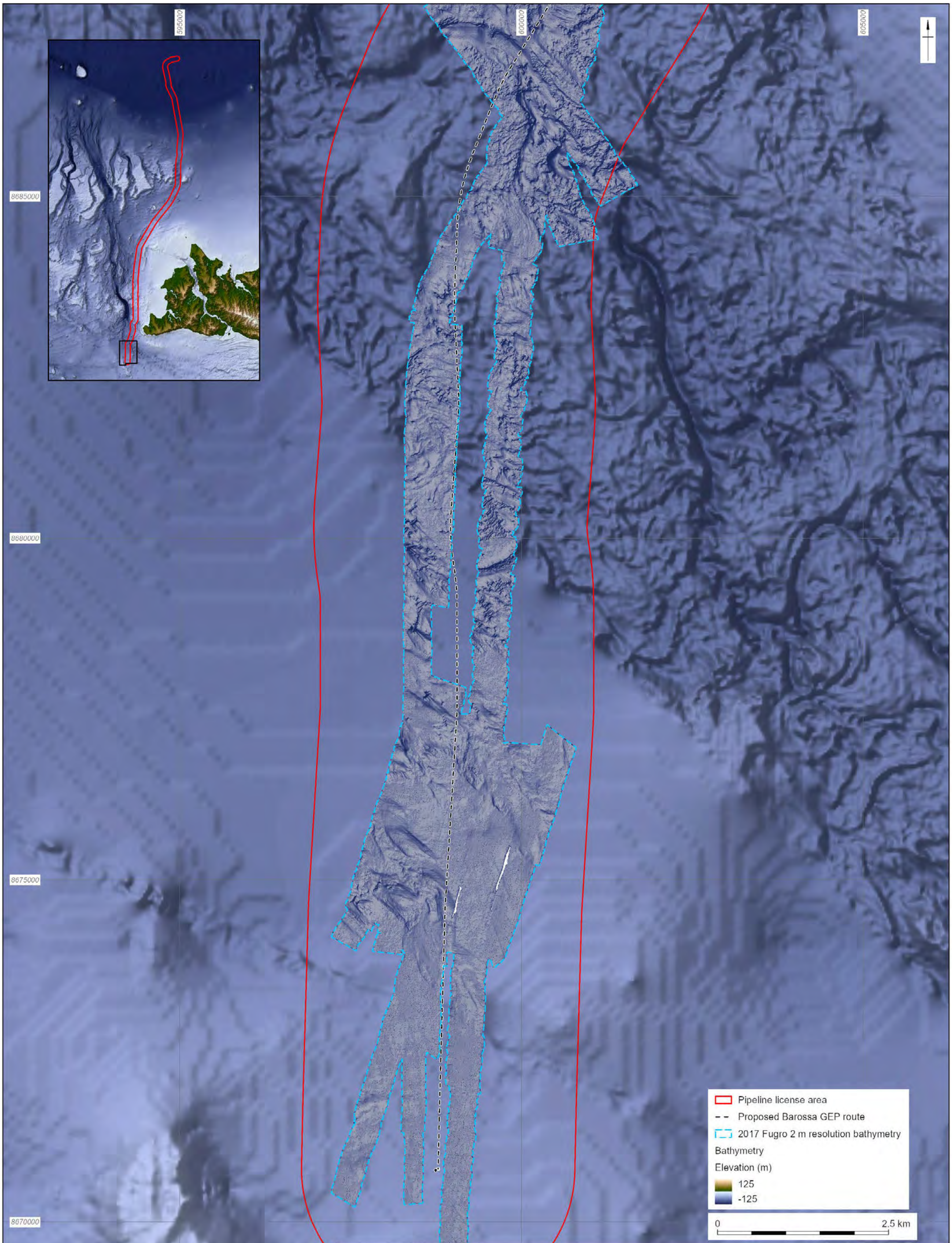
Figure 19s: Palaeogeographic features of interest along the proposed route (Interpretation removed)



Coordinate system: GDA 1994 MGA Zone 52
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Figure 19t: Palaeogeographic features of interest along the proposed route (Interpretation removed)

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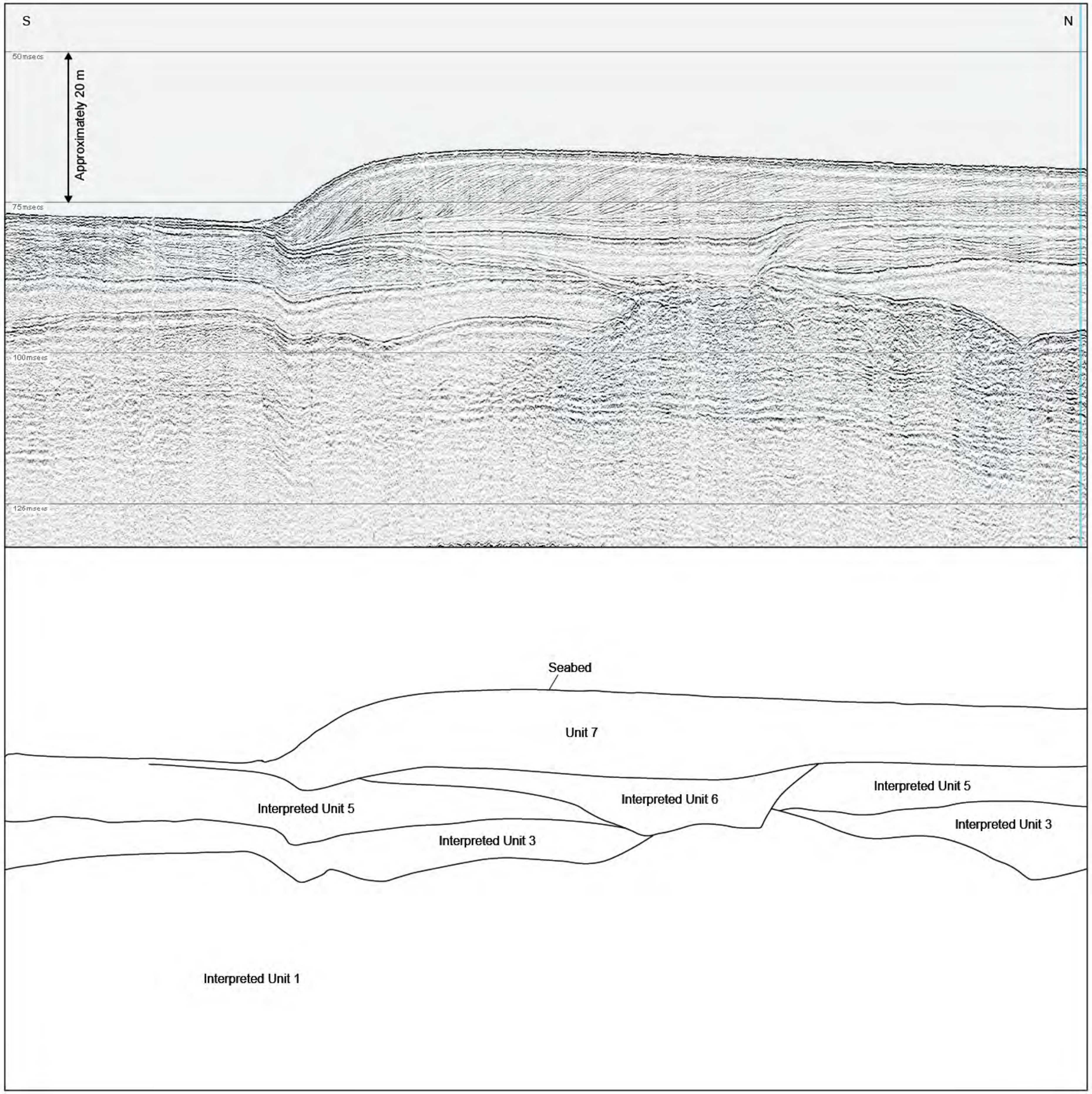

Pipeline license area
Proposed Barossa GEP route
2018 Fugro 2 m resolution bathymetry
SBP data example locations
SBP data
Channel
Lower channel
Elevation (m)
125
-125

Coordinate system: GDA 1994 MGA Zone 52
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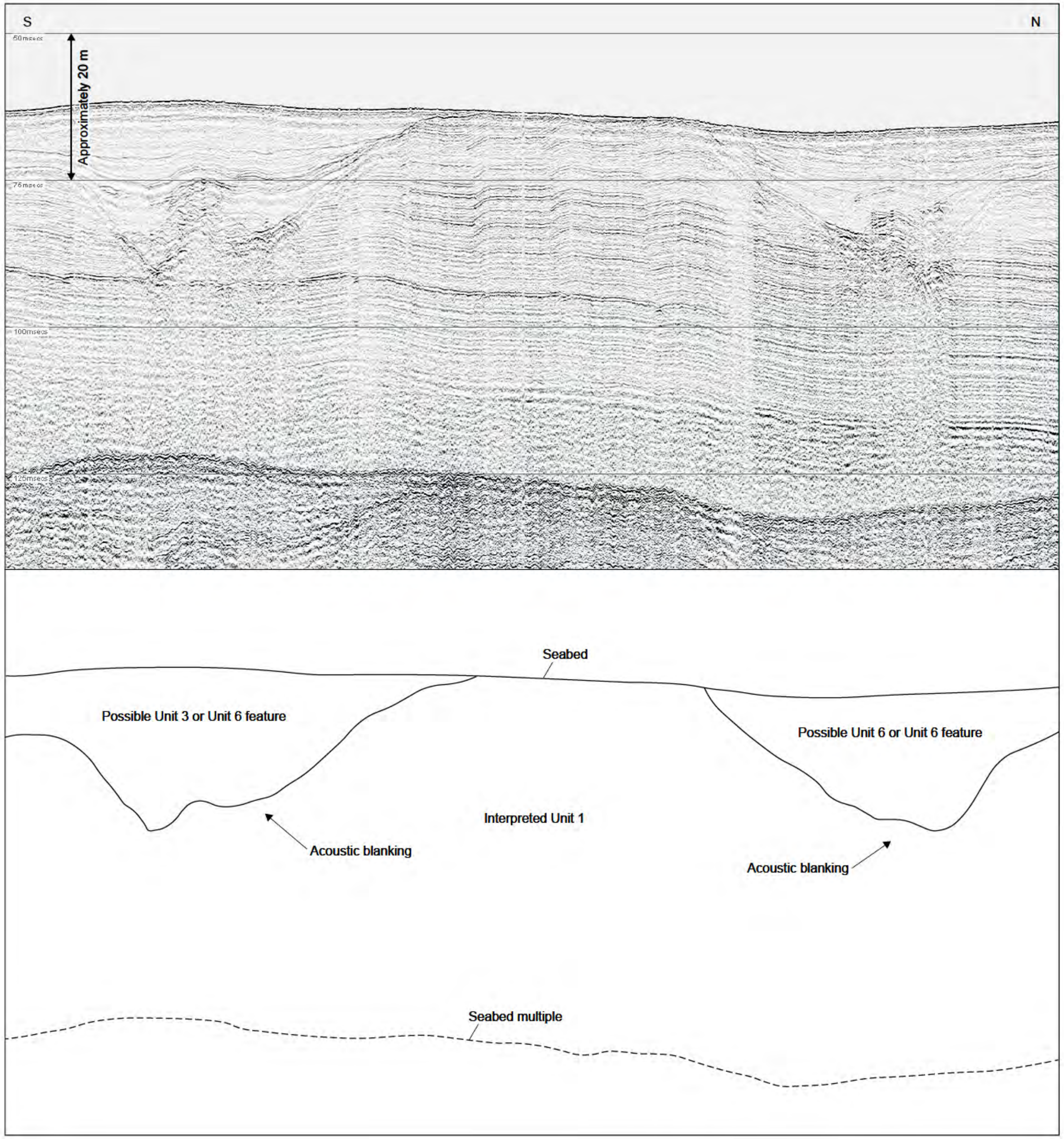
Created by: KJF	Date: 02/05/2023
Scale: 1:25,000 at A3	Revision: 0

Figure 20: SBP data example – 7096 – 7098



Pipeline license area
Proposed Barossa GEP route
2018 Fugro 2 m resolution bathymetry
SBP data example locations
SBP data
Cut and fill
Channel
Elevation (m)
125
-125

Coordinate system: GDA 1994 MGA Zone 52
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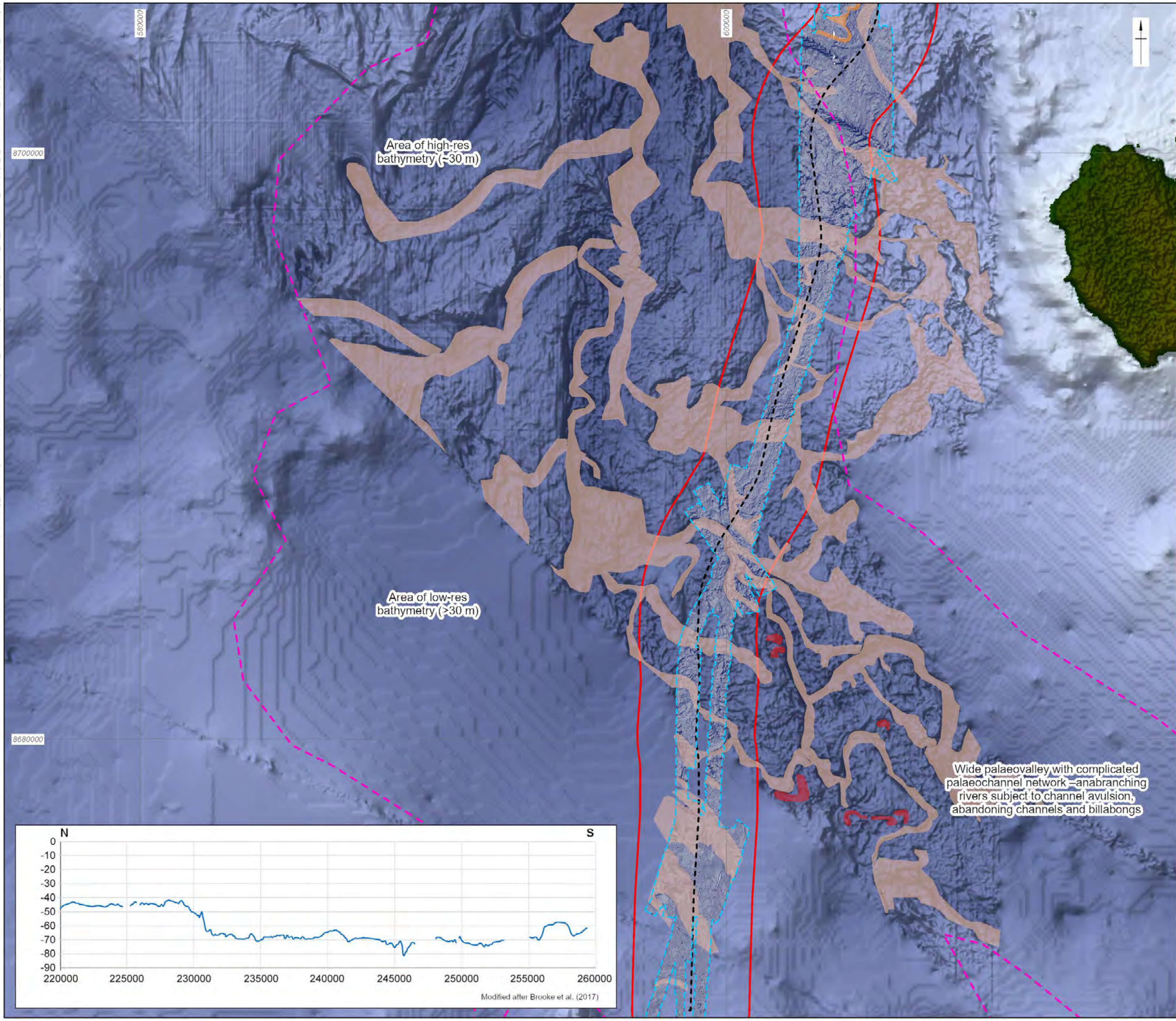
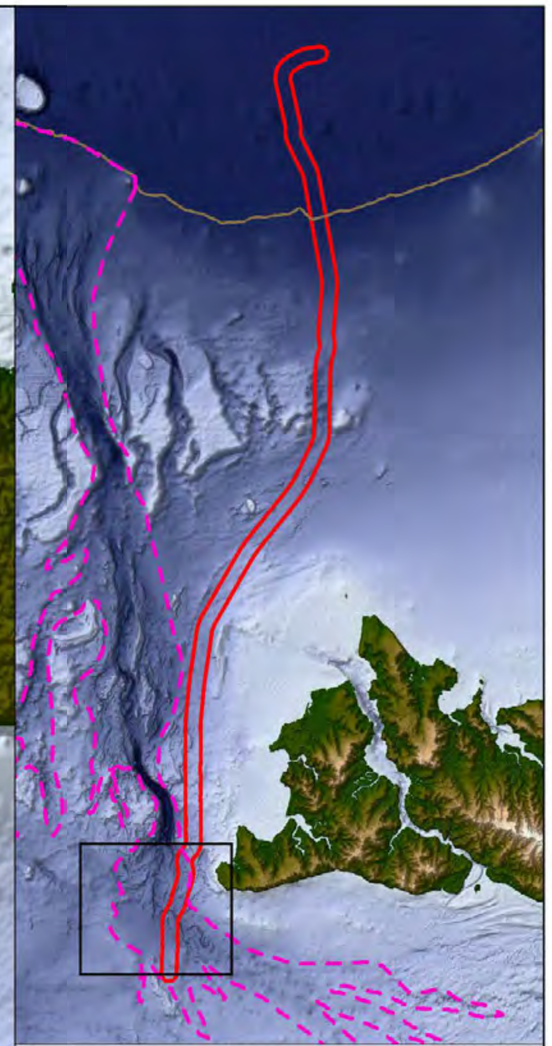
Created by: KJF	Date: 02/05/2023
Scale: Inset 1:25,000 at A3	Revision: 0

Figure 21: SBP data example – 7126





Pipeline license area
Proposed Barossa GEP route
2018 Fugro 2 m resolution bathymetry
125 m bathymetric contour
Palaeovalleys
Palaeochannels
Billabongs
Cliffs
Bathymetry
Elevation (m)
125
-125

0 5 km

Coordinate system: GDA 1994 MGA Zone 52
The bathymetry data was downloaded from Geoscience Australia, © Commonwealth of Australia (Geoscience Australia) 2020 (This product is released under the Creative Commons Attribution 4.0 International Licence. http://creativecommons.org/licenses/by/4.0/legalcode)
The 125 m contour is derived from the Institute for Marine and Antarctic Studies (IMAS) opensource contour shapefiles (IMAS Metadata Catalogue (utas.edu.au)).

Date: 17/05/2023	Created by: KJF
Scale: 1:125,000 at A3	Revision: 0

Figure 22: MBES: 30 m/2 m data showing main palaeovalley and palaeochannel networks at broad scale

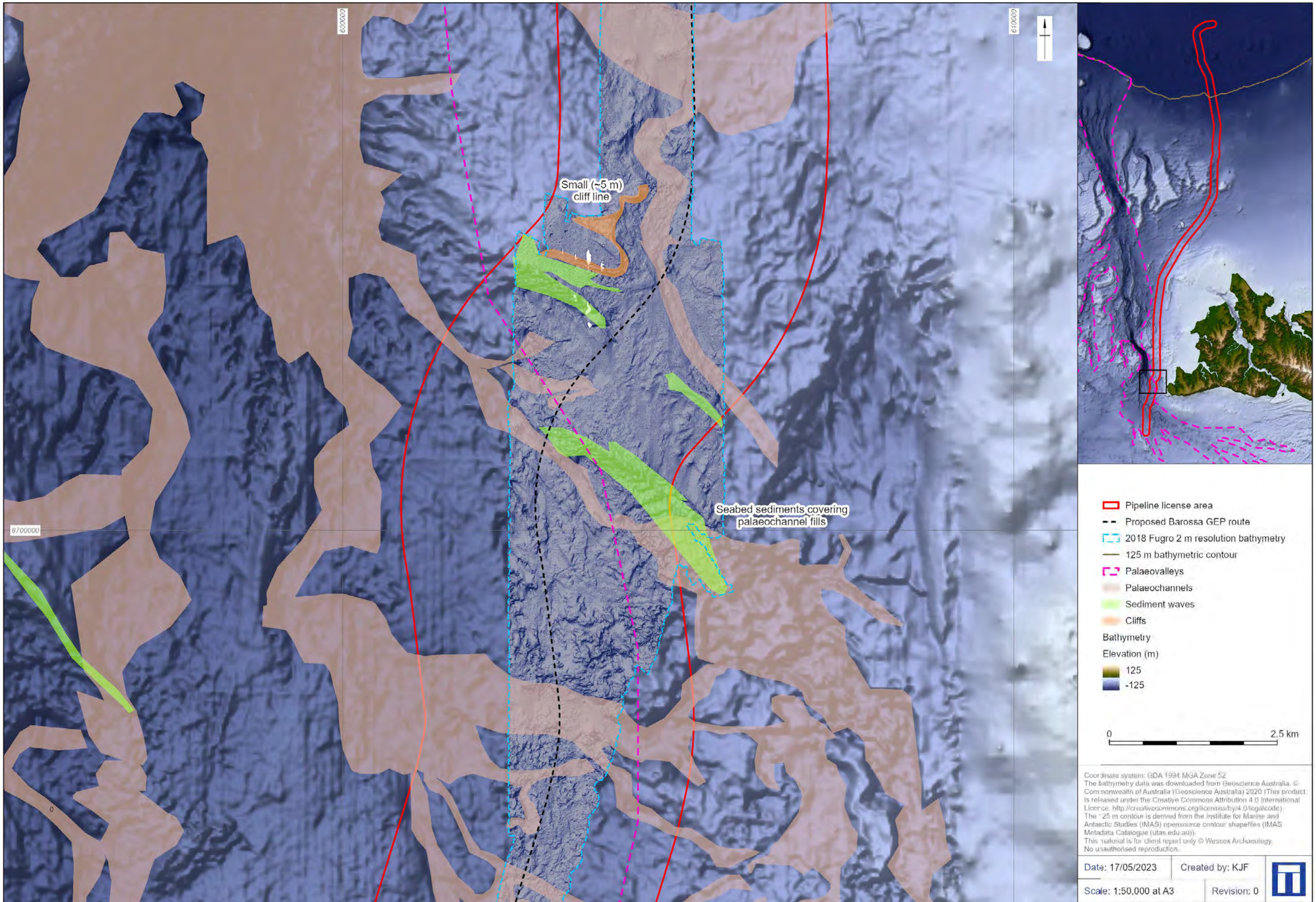
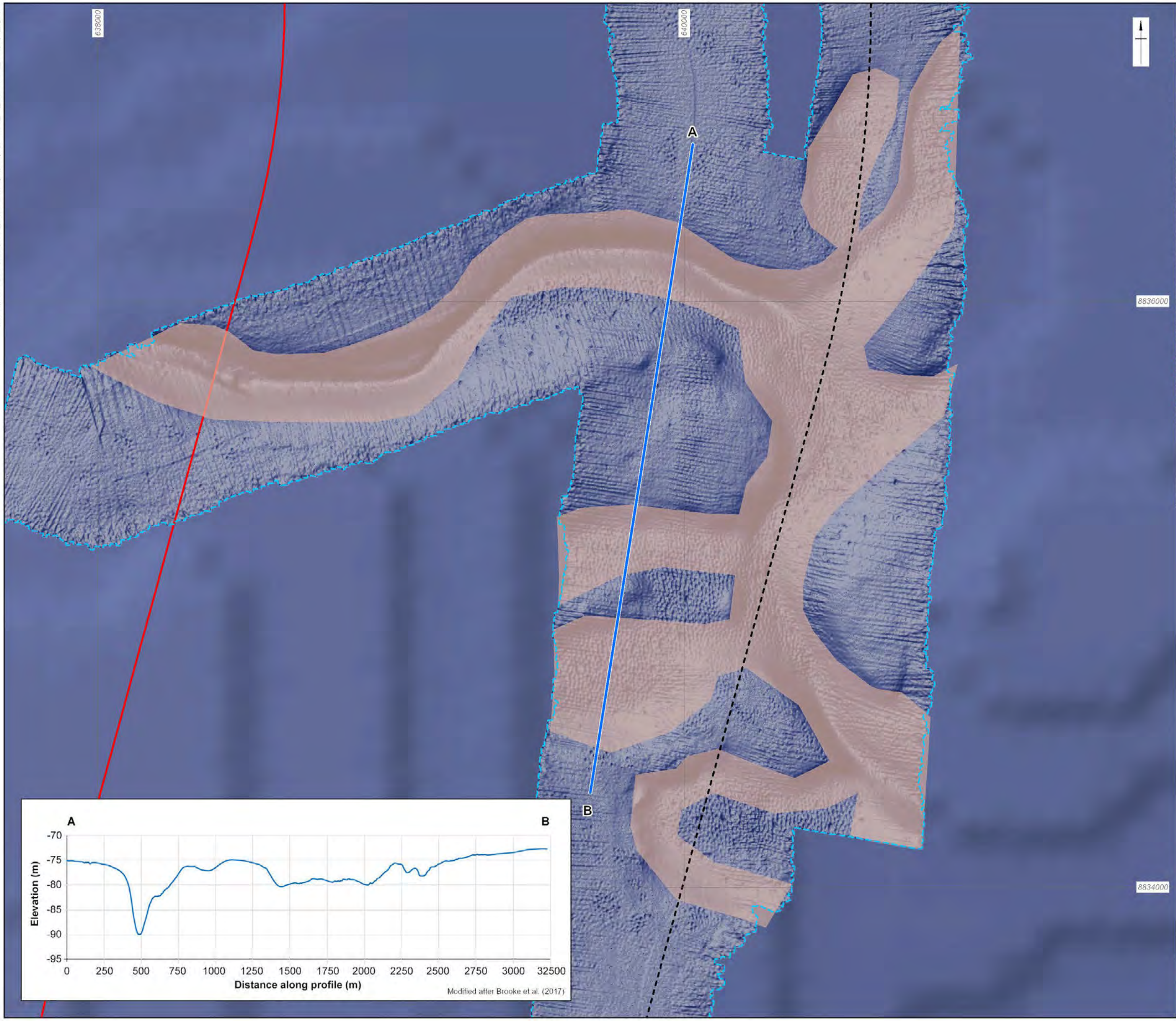
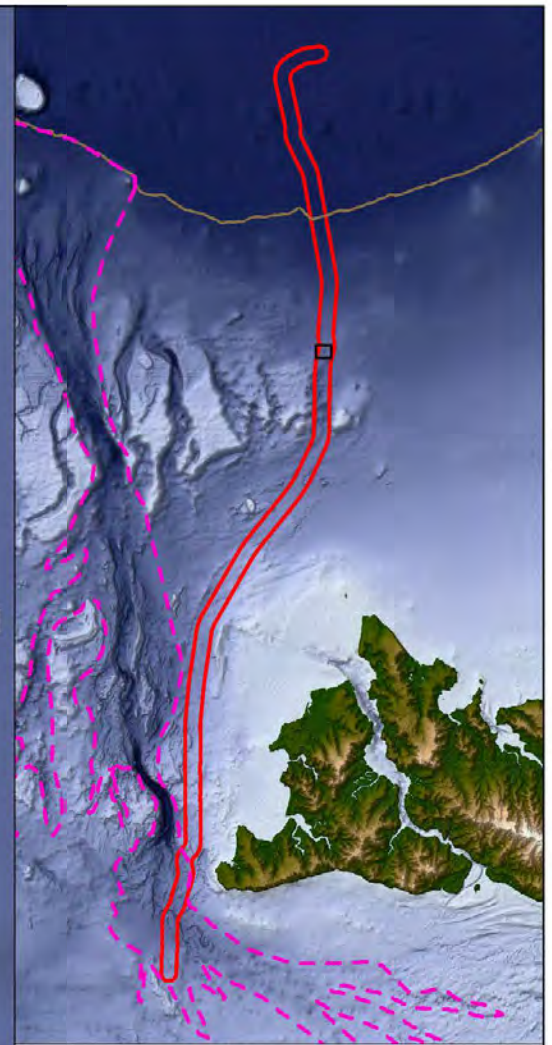


Figure 23: MBES: 30 m/2 m data showing cliff line and seabed sediment cover close-up

W:\Projects\275911\Graphics_Office\Rep figs\Geophys\2023_04_19\275911_Geophys_figures





Pipeline license area
Proposed Barossa GEP route
2018 Fugro 2 m resolution bathymetry
125 m bathymetric contour
Palaeovalleys
Palaeochannels
Bathymetry
Elevation (m)
125
-125

0 500 m

Coordinate system: GDA 1994 MGA Zone 52
The bathymetry data was downloaded from Geoscience Australia, © Commonwealth of Australia (Geoscience Australia) 2020 (This product is released under the Creative Commons Attribution 4.0 International Licence. http://creativecommons.org/licenses/by/4.0/legalcode)
The 125 m contour is derived from the Institute for Marine and Antarctic Studies (IMAS) opensource contour shapefiles (IMAS Metadata Catalogue (utas.edu.au)).

Date: 17/05/2023 | Created by: KJF
Scale: 1:12,500 at A3 | Revision: 0

Figure 24: MBES: 2 m data showing deep, narrow palaeochannel

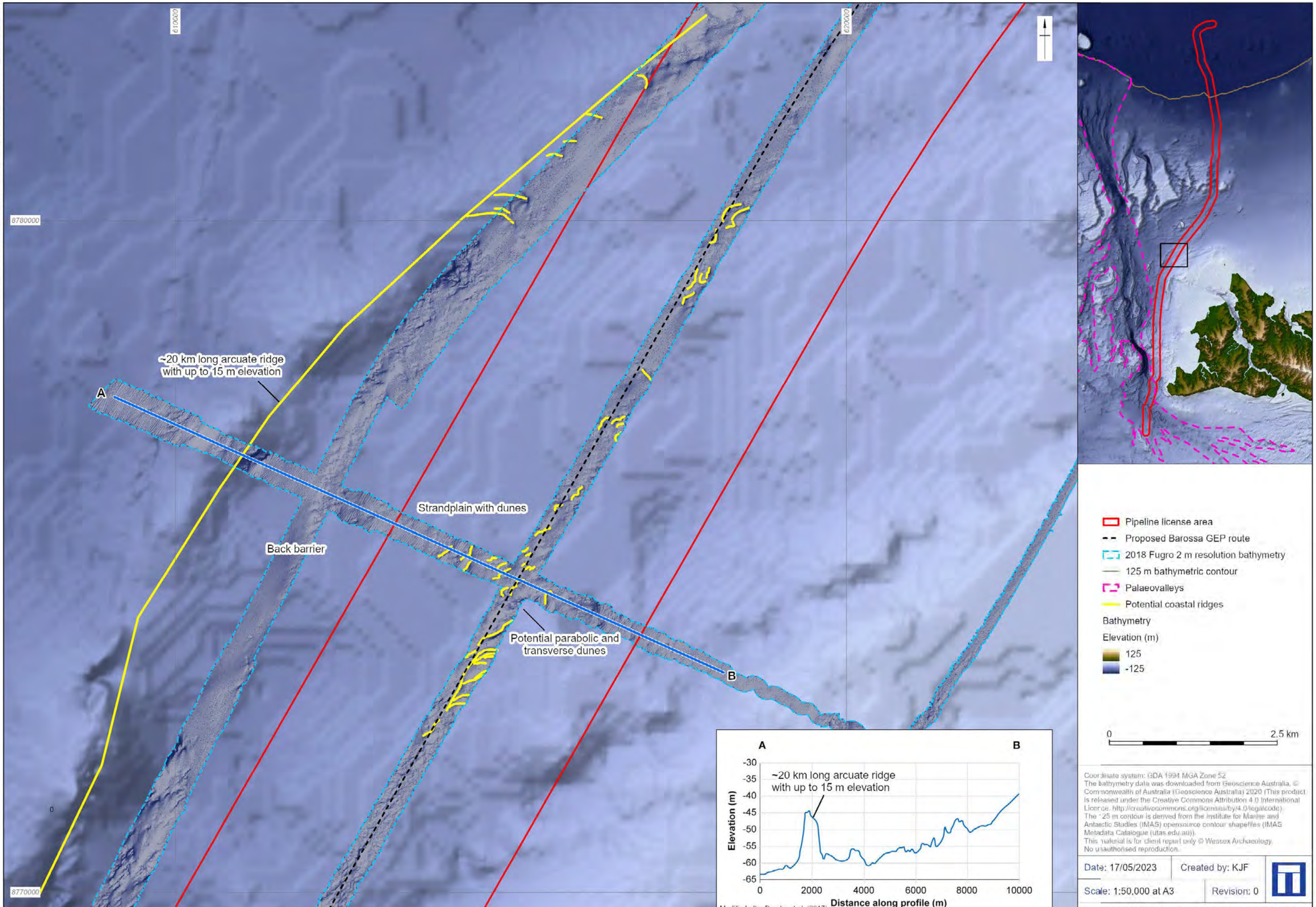


Figure 25: MBES: 30 m/2 m data showing arcuate ridge and dune-forms in broad scale

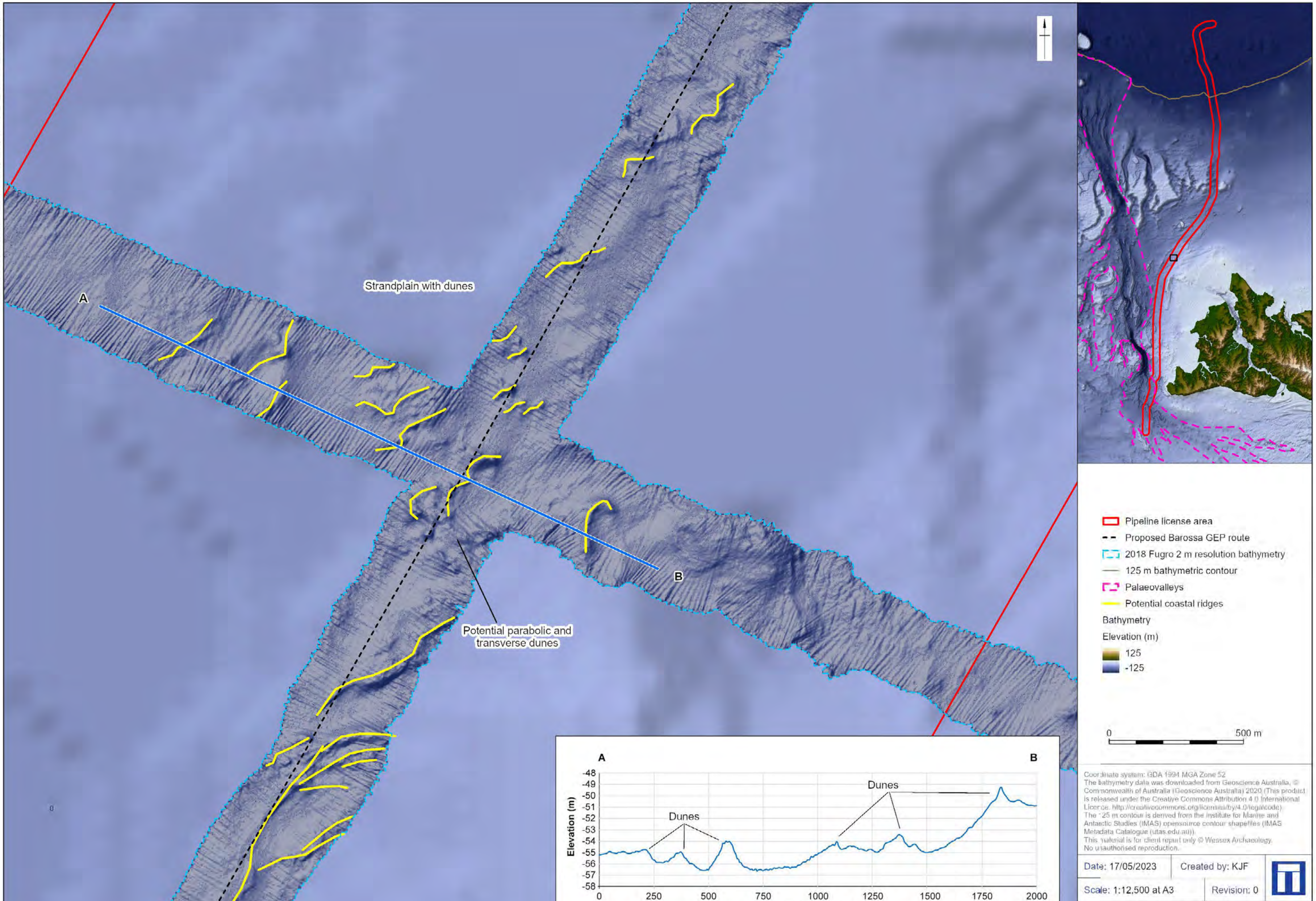
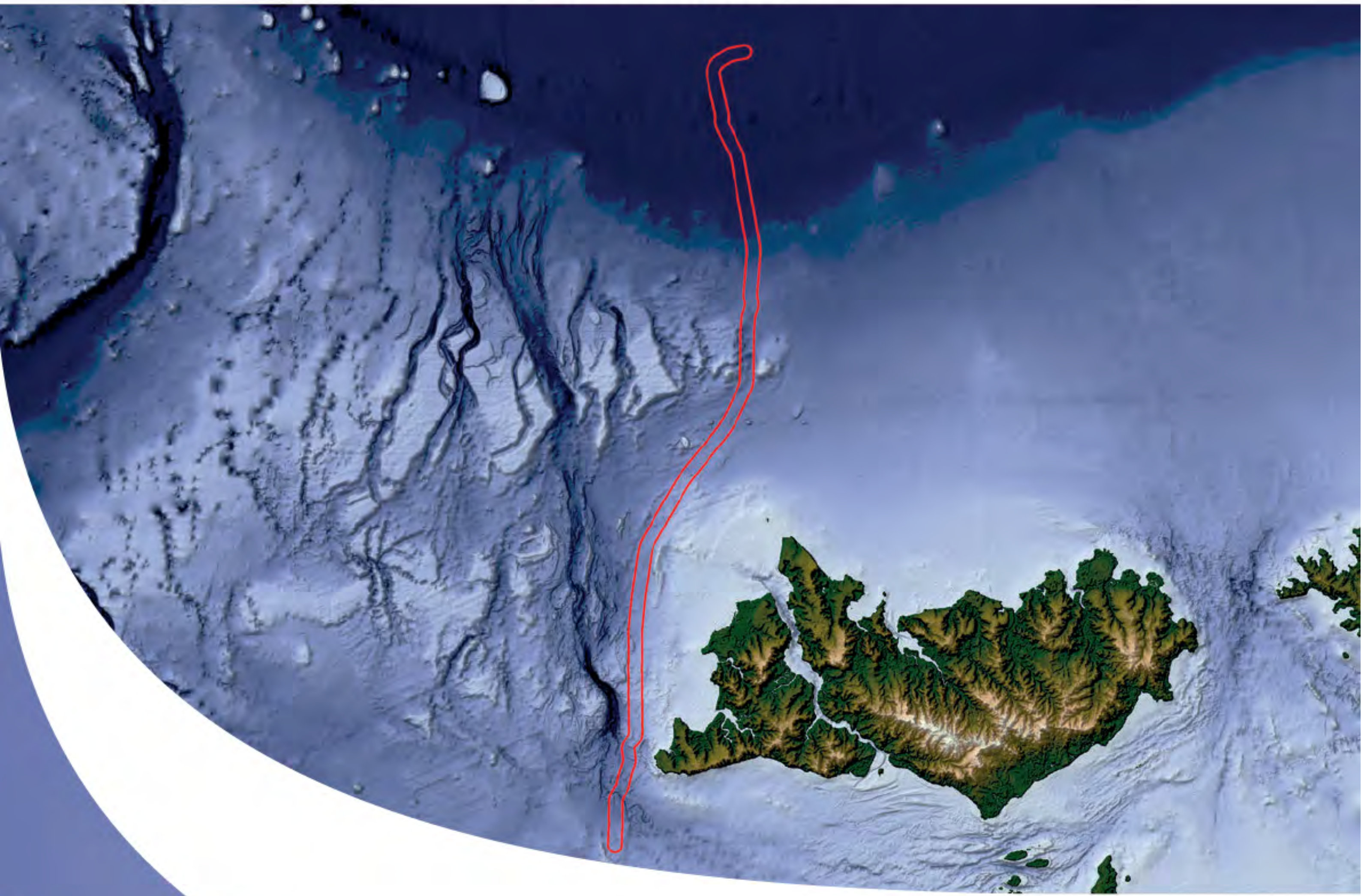


Figure 26: MBES: 2 m data showing dune-forms close up

Barossa Gas Export Pipeline

Submerged Palaeolandscapes Archaeological Assessment

Recommendations



Ref: 275911.2
July 2023

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Contents

Executive Summary

Wessex Archaeology Ltd and our subcontractor Extent Heritage were commissioned by Santos Australia Ltd, in response to NOPSEMA Direction 1898, to undertake a targeted scientific archaeological assessment of the proposed route of the Barossa GEP. This commission focusses upon the submerged and buried landforms of the seafloor that may have potential to retain Aboriginal cultural heritage dating to periods of lower sea level – the submerged palaeolandscape.

This report presents our recommendations, which arise from the results of our palaeogeographic assessment of the offshore study area, detailed in **REPORT 1**. This assessment, using available marine geophysical and geotechnical data, was contextualised by;

- Ethnohistorical review of Aboriginal communities within the terrestrial study area (adjacent to the proposed Barossa GEP);
- Archaeological assessment of known terrestrial sites within the terrestrial study area; and,
- Creation of a terrestrial predictive model of archaeological sensitivity and assessment and critique of this model for use with submerged palaeolandscapes.

In summary, the paleogeographic assessment identified 60 features of ‘high’ archaeological potential, thought to have formed during periods of low sea level when the offshore study area was dry land and during the period of human occupation of Australia. These included complex systems of palaeo-channels, former shorelines, and coastal dune systems. A further 103 features were assigned ‘medium’ archaeological potential, largely due to the uncertainty of their date of formation and/or their fill. In addition to palaeogeographic features, five distinct lithological units were assessed to be of medium archaeological potential. No deposits of high archaeological potential (such as organic-rich deposits) were identified from the data available.

The recommendations made in this report are focused on refining scientific understanding of the features and sediments identified within the palaeogeographic assessment, to more comprehensively understand their nature, date, extent, and therefore refine their archaeological potential.

The recommendations are centred around proactive consultation with the archaeological contractor ahead of or as part of future survey design, to include advice on the type, number and location of geotechnical samples (in order to ensure appropriate material is collected for archaeological purposes), the outlining of specific geophysical survey methodologies which may be beneficial, and ensuring the availability of future log data and samples.

No Archaeological Exclusion Zones (AEZ) have been recommended. We do recommend that a Protocol for Archaeological Discoveries is established prior to groundwork operations, in order that any archaeological material encountered during works is recorded by appropriate specialists, and to allow appropriate additional mitigation measures to be defined and put in place as required.

Report Authors

Complex archaeological research, such as that on submerged palaeolandscapes, is inherently interdisciplinary, and this is reflected in the number and range of specialists involved in the production of this report. No one specialist has made decisions or stated opinions without consultation and collaboration with members of the wider team. The following specialists have contributed to this report.

The following specialists are employed by Wessex Archaeology, Portway House, Old Sarum Park, Salisbury, Wiltshire, SP4 6EB, UK:

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Wessex Archaeology, Extent Heritage and the individual experts who prepared the report:

- are not advocates for the Company (Santos), being the party which is paying for the Contractor's expert report;
- are impartial on matters relevant to their area of expertise; and
- are prepared to change their opinion or make concessions when it is necessary or appropriate to do so, even if doing so would be contrary to any previously held or expressed view.

Acknowledgements

Wessex Archaeology and Extent Heritage acknowledges the Tiwi people, Traditional Custodians of the land and seas of the Tiwi Islands, which are the focus of this research, and we pay our respects to Tiwi Elders past and present. We extend our acknowledgement to the Traditional Custodians of Country throughout Australia and their connections to land, sea, and community. We pay our respect to their Elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

We acknowledge Santos's role in providing all available legacy geophysical and geotechnical data for the offshore study area from the Santos and ConocoPhillips archives and for facilitating the acquisition of additional geophysical data within the offshore study area specifically for this report. Santos provided all the information requested by Wessex Archaeology and Extent Heritage and, to our knowledge, no data or information has been withheld. We also acknowledge the work of the team at Fugro who carried out the 2023 geophysical survey and provided the raw data to Wessex Archaeology.

Barossa Gas Export Pipeline

Archaeological Assessment of Submerged Palaeolandscapes: Recommendations

1 INTRODUCTION

1.1 Project background

1.1.1 In January 2023 NOPSEMA, Australia's Offshore Energy Regulator, issued Direction 1898 under General Direction – s 574 in relation to works associated with the Barossa Gas Export Pipeline. That direction included the following requirements:

Direction 2

The registered holders must undertake and complete an assessment to identify any underwater cultural heritage places along the Barossa pipeline route (Pipeline Route) to which people, in accordance with Indigenous tradition, may have spiritual and cultural connections that may be affected by the future activities covered by the EP (the assessment), as follows:

a) The assessment is to be undertaken by suitably qualified and independent experts with relevant experience and research credentials (experts).

b) In undertaking the assessment, the experts must:

i. obtain information from people and /or organisations who have, in accordance with Indigenous tradition, spiritual and cultural connections to any underwater cultural heritage places along the Pipeline route that may be affected by the activities; and

ii. record and have regard to the information obtained.

c) The assessment must be recorded in a report that is to be provided on completion to:

i. people and/or organisations who provided information under paragraph (b)(i) above; and

ii. NOPSEMA.

Direction 3

Following the completion of the assessment required by Direction 2, if any underwater cultural heritage places along the Pipeline Route to which people, in accordance with Indigenous tradition, may have spiritual and cultural connections are identified that may be affected by future activities covered by the EP, the *registered holders must update the EP. This must include relevant content as required under regulation 13 and regulation 14 of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations), including details and evaluation of impacts and risks (the evaluation) of future activities, including:*

a. the methods and results of the evaluation on any identified underwater cultural heritage places along the Pipeline Route to which people, in accordance with Indigenous tradition, may have spiritual and cultural connections identified in undertaking Direction 2;

b. details of the control measures (if any) adopted to demonstrate that the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable (ALARP) and be of acceptable levels;

c. a description of any other legislative requirements that apply to the activity and a demonstration of how those will be met; and

d. how any information obtained from people and / or organisations who provided information under paragraph 2(b)(i) above, has been taken into account in the evaluation, and in determining control measures.

1.1.2 It is within the context of this Direction that Wessex Archaeology and our subcontractor Extent Heritage were requested to act as independent experts by Santos Limited (Ltd) to assess the potential for submerged palaeolandscapes that could retain remains of Aboriginal cultural heritage deposited during periods of lower sea level, which may be impacted by the construction of the proposed Barossa gas export pipeline (GEP).

1.1.3 The proposed pipeline is located on the north-western Australian continental shelf and slope in the Northern Territory, to the west of the Tiwi Islands. The proposed GEP is approximately 260 km long and runs south from the Barossa gas field to a tie-in point into the existing Bayu-Undan to Darwin pipeline. The offshore study area is defined as a 2 km buffer around the proposed GEP route (as provided by Santos Ltd 13 January 2023).

1.2 Scope of document

1.2.1 Wessex Archaeology and our subcontractor Extent Heritage have worked collaboratively to produce two reports; Report 1: The archaeological assessment relating to the potential for archaeological remains in the shallow water environment impact area of the Barossa GEP project and Report 2: Recommendations.

1.2.2 The aim of this report, Report 2, is to present recommendations for archaeological mitigation and further work associated with the scientific archaeological interpretation of the submerged palaeolandscape as presented in Report 1.

2 ARCHAEOLOGICAL BASELINE SUMMARY

2.1 Context

2.1.1 Sea levels have changed dramatically over the last 100,000 years and, as a result, large areas of what is now seabed were once habitable lands. As sea levels rose, these landscapes were inundated and gradually became submerged.

2.1.2 Western scientific discourse estimates that the first humans arrived on the Sahul continent sometime between 70-65,000 year ago (Morrison *et al.* 2023). At this time, sea level was around between -100 m and -68 m lower than at present, and the Sahul Banks and Van Diemen Rise areas were dry land. The wider Bonaparte Basin has been the focus of archaeological interest since the 1980s (Flemming 1982) when it was identified as one of the likely arrival points of the first Australians, via what is known as the 'southern route' (Bird *et al.* 2019, Kuijjer *et al.* 2022). Arrival on the Sahul continent at this time would have included a sea crossing (Balme 2013), and the presence of archaeological sites in northern Australia dating to around 65-50,000 years ago (Clarkson *et al.* 2017) represents the earliest known open sea crossing by humans (Bird *et al.* 2019).

2.1.3 These changes in landscape/seascape are familiar to the Aboriginal and Torres Strait Islander peoples of Australia who maintain strong connections to Country that was inundated by rising sea levels after the last Ice Age. However, the scientific study of submerged coastal and terrestrial landscapes around the Australian coast is at a relatively early stage in comparison to parts of Europe and the USA. As such, our scientific understanding of the distribution, chronology, preservation, and archaeological potential of submerged landscapes offshore, as a complement to Aboriginal peoples' understanding of their cultural significance, remains very limited.

2.1.4 As one of the possible locations for first landings in Sahul, and one of the first extensive offshore submerged palaeolandscapes to be investigated in Australia, the submerged palaeolandscape of the offshore study area is of scientific interest to the archaeological community nationally and internationally. Any deposits within this landscape that have the potential to contain archaeological remains – either anthropogenic or palaeo-environmental – will be of national and international significance.

2.2 Identified palaeogeographic features.

2.2.1 The assessment of the geophysical data within the study area resulted in a total of 163 palaeogeographic features of archaeological potential. These are summarised as follows:

- a total of 60 features were assigned high archaeological potential.
- a total of 103 features were assigned medium archaeological potential.

2.2.2 The 60 features identified as of high archaeological potential are terrestrial features interpreted as being formed between MIS 4 (c. 70,000 – 57,000 years ago when it is thought the first humans arrived in Australia) and final inundation around 8,000 years ago.

2.2.3 The 103 features of medium archaeological potential are identified as possible terrestrial features but have been assessed as medium potential due to uncertainty about the age of formation and the nature of their fill.

2.2.4 The distance from the proposed development or potential impact is not taken into consideration when designating the archaeological potential. The palaeogeographic features mentioned above represent all the features identified within the offshore study area considered to be of potential archaeological or palaeoenvironmental interest, which includes those which are likely to be too far away, or too deep, to be physically impacted by the proposed development.

2.2.5 No lithological units of high archaeological potential were identified in the assessment of geotechnical logs. In the Northern Hemisphere, where the vast majority of submerged landscape research has taken place, sediments identified as high archaeological potential generally comprise fine-grained, bedded, organic-rich sediments such as coastal peats, estuarine silts, and mixed palaeo-channel fills. These deposits in the Northern Hemisphere have preserved a wide variety of *in situ* material culture, including organic material such as wooden, bone/antler, and fabric artefacts, along with a rich palaeo-environmental remains and stone tools. Nicholas *et al.* (2015) identified organic rich sediments from core samples within the Bonaparte Basin, west of the offshore study area, containing wood and mangrove plant matter dated to c.16,000 years ago (ibid: 40) demonstrating the potential for these kinds of sediments to survive within the region of the Barossa GEP.

2.2.6 A total of five lithological units were assigned medium archaeological potential: alluvium, non-marine sand, carbonate sands and gravels, marine to shallow marine sands and fluvial gravel. These units are thought to have been deposited during periods of low sea level and likely human occupation of the offshore study area. Unlike the high potential, organic rich deposits, these deposits are less likely to preserve such a wide range of material types *in situ* but have the potential to contain material culture such as stone tools, shell middens/mounds, and stone structures. These deposits have been assigned medium archaeological potential due to uncertainties around their age of formation.

2.2.7 It should be noted that the designation of archaeological potential is based on limited geotechnical information, combined with experience of working in the Northern Hemisphere. Detailed geoarchaeological assessment of stratigraphy related to palaeoenvironments is at an early stage offshore Australia, and it is possible that the different environment, climate, and geochemistry of the Northern Territory has resulted in different sediment preservation and, as such, the lithological units may have different potential in an Australian context.

3 POTENTIAL IMPACTS

3.1 Impact Assessment

3.1.1 Santos have provided the following information regarding the potential impacts associated with the Barossa GEP:

- The pipeline is around 65 centimetres in diameter.
- No installation activities are being performed that actively remove sediment or material from the seabed during the installation of the Pipeline (i.e. no trenching or dredging).
- Seabed disturbance is limited to local effects where structures contact the seabed such as deployment of concrete mattresses, terminal foundations, the pipeline itself and post-installed grout bags, all of which are deployed to the seabed in a controlled manner resulting in minimal disturbance of sediment.
- Based on the information provided by Santos in their draft scope of work document (dated January 2023), seabed disturbance is estimated to be:

Subsea Infrastructure	Seabed Footprint
Installation of supporting structures	0.3 ha
Gas export pipeline installation	21.6 ha
Span rectification and stabilisation works	0.6 ha
Contingency of 5%	1.1 ha
Estimated footprint	**23.6 ha**

- This equates to a footprint of 0.08 hectares per kilometre of pipeline laid.
- In areas of soft sediment, the pipeline and associated structures are expected to sink or become partially buried. There may also be sediment accumulation in some areas around the pipeline; this is expected to be highly localised and of low relief (i.e. no higher than the diameter of the pipeline) and will assist in stabilisation of the pipeline.
- While the pipeline may cause localised scouring, the design of the pipeline and associated structures is intended to prevent this occurring due to the risk it may pose to structural integrity of the pipeline.
- All vessels will be dynamically positioned rather than anchored, thus avoiding impacts to the seabed.

3.1.2 Direct impacts to archaeologically significant features and deposits resulting from the construction, operation and maintenance phases of the Barossa GEP may be caused by activities that involve direct contact with the seabed or the removal of seabed sediments.

The primary impacts will be the physical placement and removal of infrastructure on the seabed, and any localised repair and maintenance works.

3.1.3 In order to estimate potential direct physical impacts to features identified along the proposed route, a value of less than 0.7 m below seabed (BSB) was chosen for the purposes of discussion. This is based on a scenario of the pipeline embedding to its full diameter; however, settling depths may vary and the value of 0.7 m BSB is used solely for the purposes of illustrating potential physical impacts as provided by Santos in section 3.1.1.

3.1.4 All palaeogeographic features of archaeological potential within the study area are individually described in gazetteer format in Appendix I, with any features which directly intersect the proposed development and are either directly at the seabed or within 0.7 m BSB, colour coded in blue.

3.1.5 It should be noted that the highlighted features represent those which are considered likely to be directly physically impacted by the development. The actual settling depth of the pipeline may vary along the route and therefore the resultant zone of direct physical impacts may differ from the 0.7 m BSB scenario illustrated.

3.1.6 Furthermore, the features highlighted do not take into consideration indirect physical impacts. Indirect impacts to archaeological significant features and deposits resulting from the construction, operation and maintenance phases of the Barossa GEP are most likely to be caused by changes to hydrodynamic and sedimentary patterns caused by the placement of infrastructure on the seabed.

4 RECOMMENDATIONS FOR MITIGATION

4.1 Context

4.1.1 The extent of the direct physical impact of the pipeline on the seabed across the entire submerged palaeolandscape of the Bonaparte Basin is reported to be localised to the construction and operation & maintenance footprint. Indirect physical impacts may develop in areas where changes to seabed hydrodynamics and sediment patterns occur. The landscape and any potential archaeological remains – palaeo-environmental, dateable deposits, and/or anthropogenic remains – are of high scientific archaeological significance, and of national and international interest.

4.1.2 The following mitigation measures are recommended, as with our interpretations, within the context of western scientific, archaeological praxis and approach to the assessment of cultural heritage value, significance, and archaeological potential of palaeogeographic features and deposits identified.

4.1.3 Our recommendations for mitigation do not account for any cultural significance or values that Tiwi may have in relation to places or features within Sea Country, and we recognise that Tiwi may have additional, varying, or conflicting values and priorities to those identified within this report.

4.1.4 As identified within Report 1, there were several caveats and limitations associated with the interpretation of the geotechnical and geophysical data, associated with the nature and extent of the data provided, which resulted in uncertainties about the depositional history of the identified lithological units.

4.1.5 The primary nature of the recommendations made here are associated with refining our scientific understanding of the features and sediments identified within the palaeogeographic assessment to more comprehensively understand their nature, date, extent, and therefore archaeological potential.

4.2 Recommendations

4.2.1 We recommend that:

- any future geotechnical logs from within the offshore study area be made available for geoarchaeological assessment.

4.2.2 We recommend that if additional geotechnical samples are acquired from the offshore study area:

- the archaeological contractor be consulted to advise on the location of potential geotechnical samples to be acquired for archaeological purposes.
- a representative selection of targeted core samples are taken for palaeo-environmental analysis and scientific dating in order to develop a chronostratigraphic framework.

- the archaeological contractor be consulted specifically with regard to any geotechnical samples taken for scientific dating purposes to ensure that they are not contaminated.

- core samples should be taken from those features showing evidence of causing acoustic blanking (**7115**, **7126** and **7135**).

- the units identified as of archaeological potential should be targeted for core sampling.

- any geotechnical samples acquired found to contain material of archaeological potential, particularly those within the interpreted Pleistocene/early Holocene features, be made available for geoarchaeological assessment and dating.

4.2.3 We recommend that if additional geophysical surveys are carried out over the offshore study area, that:

- 3D ultra-high resolution seismic (UHRS) data are acquired. This would allow for palaeogeographic features be identified across multiple lines and for a 3D surface model to be created.

- An alternative to 3D UHRS would be the acquisition of adjacent SBP wing lines along the route that would allow features to be tracked across multiple lines, which would aid in refining the interpretation.

4.2.4 We recommend that a Protocol for Archaeological Discoveries is established prior to groundwork operations and that any objects of possible anthropogenic origin recovered or encountered are reported using the Protocol, as per the recommendations by Cosmos Archaeology (2022). This process ensures that any archaeological material encountered is recorded by appropriate specialists and appropriate mitigation measures are enacted.

4.2.5 Based on the current level of understanding of the submerged palaeolandscape within the offshore study area, we do not recommend the establishment of any Archaeological Exclusion Zones (AEZ) at this time.

REFERENCES

Bibliography

Balme, J. 2013. Of boats and string: The maritime colonisation of Australia. *Quaternary International.* 285: 68-75. https://doi.org/10.1016/j.quaint.2011.02.029

Bird, M.I., Condie, S.A., O'Connor, S. Reepmeyer, C., Ulm, S., Zega, M., Saltré, F. and Bradshaw, C. 2019. 'Early human settlement of Sahul was not an accident.' *Science Reports* 9, 8220. https://doi.org/10.1038/s41598-019-42946-9

Clarkson, C., Jacobs, Z., Marwick, B., Fullagar, R., Wallis, L., Smith, M., Roberts, R. G., Hayes, E., Lowe, K., Carah, X., Florin, S. A., McNeil, J., Cox, D., Arnold, L. J., Hua, Q., Huntley, J., Brand, H. E. A., Manne, T., Fairbairn, A., Pardoe, C. 2017. Human occupation of northern Australia by 65,000 years ago. *Nature*, *547*(7663), 306–310. https://doi.org/10.1038/nature22968

Cosmos Archaeology, 2022, *Santos (Barossa) Gas Export Pipeline, Original Barossa GEP Stage (Timor Sea and Tiwi Islands), Maritime Heritage Assessment*, ref. J21/22 V5

Flemming N. C. 1982. The Sirius Expedition, Cootamundra Shoals Survey 1982. Expedition Report (4 volumes). Sydney Australian National Maritime Museum

Kuijjer, K., Haigh, I., Marsh, R., Farr, H. 2022. Changing Tidal Dynamics and the Role of the Marine Environment in the Maritime Migration to Sahul. *PalaeoAnthropology* 2022.1: 134–148. https://doi.org/10.48738/2022.iss1.105

Morrison, P., O'Leary, M., McDonald, J. 2023. The evolution of Australian island geographies and the emergence and persistence of Indigenous maritime cultures. *Quaternary Science Reviews.* 308. https://doi.org/10.1016/j.quascirev.2023.108071

Nicholas, W.A., Carroll, A.G., Picard, K., Radke, L.C., Siwabessy, P.J.W., Chen, J., Howard, F.J.F., Dulfer, H., Tran, M., Consoli, C., Przeslawski, R., Li, J. 2015. *Seabed environments, shallow sub-surface geology and connectivity, Petrel Sub-basin, Bonaparte Basin, Timor Sea: Interpretative report from marine survey* GA0335/SOL5463. Record 2015/024. Geoscience Australia, Canberra. http://dx.doi.org/10.11636/Record.2015.024

Appendix I: Palaeogeographic features of archaeological potential.

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7000	Ridge	P2	-	-	A potential coastal ridge identified in the MBES data as a linear ridge, orientated approximately WSW - ENE, on shallow slope. May represent an offshore bar or beach ridge.	66	MBES (2018 Fugro)
7001	Ridge	P2	-	-	Linear ridge on shallow slope. Potential offshore bar, barrier, or beach ridge.	66	MBES (2018 Fugro)
7002	Ridge	P2	-	-	Linear ridge on shallow slope. Potential offshore bar, barrier, or beach ridge.	66	MBES (2018 Fugro)
7003	Channel	P1	-	-	A possible palaeochannel identified as a deeply incised channel segment. Corresponds with features **7004** and **7005** identified in the SBP data, suggesting some infilling of sediments at the base.	87	MBES (2018 Fugro)
7004	Channel	P1	4.8	15.9	A channel identified in the SBP data, possibly cutting into the interpreted Unit 1, beneath a thin layer of possible marine sands. Feature has a poorly defined basal reflector and acoustically quiet fill which appears acoustically similar to overlying sediment. Feature is seen to correspond with the base of with a larger channel feature identified in the MBES data (**7003**). May represent the base of channel **7003** infilled with modern sediments, or possibly an older phase of channelling.	86-87	Boomer (2015, 2023 Fugro)
7005	Channel	P1	0.5	8.8	A possible channel identified in the SBP data interpreted as cutting into the interpreted Unit 1, beneath a thin layer of possible marine sands. Feature has a distinct basal reflector and acoustically quiet fill which appears acoustically similar to overlying sediment. Feature is seen to correspond with the base of with a larger channel feature identified in the MBES data (**7003**). May represent the base of channel **7003** infilled with modern sediments, or possibly an older phase of channelling.	86-87	Boomer (2018, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7006	Channel	P1	0.9	11.2	A channel identified in the SBP data interpreted as cutting into Unit 1. Feature is identified beneath a thin layer of possible marine sands and has a distinct basal reflector, which has two troughs. Unit fill is generally acoustically quiet with occasional draping reflectors. Feature is seen to correspond with a larger channel feature identified in the MBES data (**7003**). May represent the base of channel **7003** infilled with modern sediments, or possibly an older phase of channelling. EP-12-VC and EP-12_CPT suggest infill material of alluvium.	87	Boomer (2018, 2023 Fugro)
7007	Infilled depression	P2	0.5	3.7	Sediment infilling base of a depression identified on the MBES data. In the SBP data, the feature is seen to have a faint, poorly defined basal reflector overlain by acoustically quiet fill. Feature is seen to correspond with a larger channel feature identified in the MBES data (**7003**). Similarly positioned to features **7004-06**, but less convincing in form and therefore interpreted as an infilled depression and considered of lower archaeological potential. May represent the base of channel **7003** infilled with modern sediments.	88	Boomer (2018, 2023 Fugro)
7008	Cut and fill	P2	1.3	12.2	A possible multiphase cut and fill identified cutting into an acoustically unstructured unit, possibly Unit 1. Feature has a distinct basal reflector and at least two phases of fill which is generally acoustically quiet. Possibly identified beneath an upper unit of sediment which is acoustically similar to the second phase of fill. Close to another similar feature (**7009**). Possible remnant fluvial feature.	92	Boomer (2018, 2023 Fugro)
7009	Cut and fill	P2	1.4	8.6	A possible multiphase cut and fill identified cutting into an acoustically unstructured unit, possibly Unit 1. Feature has a distinct basal reflector and at least two phases of fill which is generally acoustically quiet, although the lower fill appears to be characterised by faint, dipping reflectors. Possibly identified beneath an upper unit of sediment which is acoustically similar to the second phase of fill. Close to another similar feature (**7008**). Possible remnant fluvial feature.	93	Boomer (2018, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7010	Infilled depression	P2	0.9	4.6	Possible infilled depression identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill. Identified in the base of a depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Likely continues further to the west as infilled depression **7011**; however, due to the distance between the lines, the features have not been grouped together.	103	Boomer (2018, 2023 Fugro)
7011	Infilled depression	P2	1.3	4.9	Possible channel identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill, although this is partially obscured by the seabed pulse. May represent an infilled depression or the cut of an underfilled channel feature or a partially filled with marine sediments. Likely continues further to the east as infilled depression **7010**; however, due to the distance between the lines, the features have not been grouped together.	103	Boomer (2015 Fugro)
7012	Infilled depression	P2	0.8	6.4	Possible infilled depression identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression infilled with sand or the cut of an underfilled channel feature, partially filled with marine sediments.	110	Boomer (2018, 2023 Fugro)
7013	Cut and fill	P2	1.8	13.6	Possible cut and fill identified below a thin unit of possible marine sediment. Feature has a distinct basal reflector and possibly multiple phases of fill, the lower of which is acoustically unstructured and the upper of which is acoustically quiet, although this may represent marine sediments infilling an underfilled feature. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Close to, and similar in for to **7014**.	112	Boomer (2018, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7014	Cut and fill	P2	2.1	9.4	Possible cut and fill identified below a thin unit of possible marine sediment. Feature has a distinct basal reflector and possibly multiple phases of fill, the lower of which is unstructured and the upper of which is acoustically quiet, although this may represent marine sediments infilling an underfilled feature. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Close to, and similar in for to **7013**.	112-113	Boomer (2018, 2023 Fugro), Sparker (2018 DOF)
7015	Channel	P1	3.9	14.3	A possible channel identified below an upper unit of sediment, cutting into the interpreted Unit 1. Feature has a relatively distinct basal reflector and fill characterised by numerous horizontal reflectors indicating layered fill which may have been deposited in a low-energy environment.	118	Boomer (2018, 2023 Fugro)
7016	Complex channel	P1	1.3	16.4	Possible complex channel identified below a veneer of sediment, cutting into the interpreted Unit 1. Feature appears to have multiples phases of acoustically chaotic fill, with a faint basal reflector which shows several troughs. Possible remnant fluvial feature. EP-21-CPT suggests alluvium overlying dense sand.	133 - 134	Boomer (2018, 2023 Fugro)
7017	Cut and fill	P2	1	5	A small cut and fill identified BSB/below veneer of seabed sediment. Feature has a distinct basal reflector and acoustically quiet fill. Possible infilled depression of the remnants of a relict fluvial feature.	135	Boomer (2018 Fugro)
7018	Infilled depression	P2	1	4.5	An infilled depression with a distinct basal reflector and acoustically quiet fill. Identified BSB or beneath a veneer of sediment. Possibly an infilled depression infilled with sand or may be remnants of a fluvial feature.	143	Boomer (2023 Fugro)
7019	Ridge	P2	-	-	Potential beach ridge segment	144	MBES (Opensource)
7020	Complex cut and fill	P2	0.3	10	Possible channel identified BSB/below a veneer or seabed sediments, cutting into the top of the interpreted Unit 1. Feature has a poorly defined basal reflector and possibly multiple phases of fill with a lower chaotic fill and upper fill characterised by numerous dipping horizons.	145	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7021	Complex cut and fill	P2	0.4	9.1	A complex unit identified BSB with numerous cuts, fills and cross-cutting reflectors. Feature may represent a broad, shallow channel complex or may be an area of reworked sediments. Origin uncertain but, as it has the potential to be a fluvial feature, it has been retained as a precaution.	148	Boomer (2023 Fugro)
7022	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	149	MBES (2018 Fugro)
7023	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	149	MBES (2018 Fugro)
7024	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	149	MBES (2018 Fugro)
7025	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	150	MBES (2018 Fugro)
7026	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	150	MBES (2018 Fugro)
7027	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	150	MBES (2018 Fugro)
7028	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	150	MBES (2018 Fugro)
7029	Cut and fill	P2	0.8	8.9	Small cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill characterised by dipping reflectors. May represent remnants of a fluvial feature.	151-152	Boomer (2023 Fugro)
7030	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	151	MBES (2018 Fugro)
7031	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	152	MBES (2018 Fugro)
7032	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	152	MBES (2018 Fugro)
7033	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	152	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7034	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	152	MBES (2018 Fugro)
7035	Cut and fill	P2	1.1	5	A possible cut and fill identified below a veneer of seabed sediment. Feature has a distinct basal reflector and acoustically unstructured fill. May represent a shallow channel or possibly an infilled depression at the top of the interpreted Unit 1.	153	Boomer (2023 Fugro)
7036	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	153	MBES (2018 Fugro)
7037	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7038	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7039	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7040	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7041	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7042	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7043	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	154	MBES (2018 Fugro)
7044	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7045	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7046	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7047	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7048	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7049	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7050	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7051	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7052	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	155	MBES (2018 Fugro)
7053	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7054	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7055	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7056	Ridge	P2	-	-	Possible dune ridge or beach ridge with cuspate end, ~1 km long	157	MBES (2018 Fugro)
7057	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7058	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7059	Ridge	P2	-	-	Possible cuspate beach ridge	156	MBES (2018 Fugro)
7060	Ridge	P2	-	-	Possible cuspate beach ridge	157	MBES (2018 Fugro)
7061	Ridge	P2	-	-	Possible cuspate beach ridge	157	MBES (2018 Fugro)
7062	Ridge	P2	-	-	Possible cuspate beach ridge	157	MBES (2018 Fugro)
7063	Ridge	P2	-	-	Possible cuspate beach ridge	157	MBES (2018 Fugro)
7064	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	157	MBES (2018 Fugro)
7065	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	158	MBES (2018 Fugro)
7066	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	161	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7067	Cut and fill	P2	0.8	4.8	A small possible cut and fill identified BSB/below a veneer of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature appears faint and poorly defined. May be a small, infilled depression or remnants of a fluvial feature.	162	Boomer (2023 Fugro)
7068	Complex cut and fill	P2	1.4	12	A possible complex cut and fill identified below a veneer of sediment cutting into the interpreted Unit 1. Feature has a distinct basal reflector and multiple phases of cutting and fill which is generally acoustically unstructured. May represent relict fluvial feature	164-166	Boomer (2023 Fugro)
7069	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	164	MBES (2018 Fugro)
7070	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	165	MBES (2018 Fugro)
7071	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	165	MBES (2018 Fugro)
7072	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	167	MBES (2018 Fugro)
7073	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	167	MBES (2018 Fugro)
7074	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	168	MBES (2018 Fugro)
7075	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	168	MBES (2018 Fugro)
7076	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	168	MBES (2018 Fugro)
7077	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	168	MBES (2018 Fugro)
7078	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	169	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7079	Complex cut and fill	P2	1.6	16.8	A distinct cut and fill identified below a veneer of seabed sediment cutting into a layered unit which may be part of the interpreted Unit 1. May be seen to continue to the north-west outside of the development area, although due to the distance between lines they have not definitively been grouped together. Feature has a faint basal reflector and multiple phases of acoustically quiet fill. Possible remnants of a fluvial feature.	168-169	Boomer (2018 Fugro)
7080	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	170	MBES (2018 Fugro)
7081	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	170	MBES (2018 Fugro)
7082	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	170	MBES (2018 Fugro)
7083	Cut and fill	P2	5.4	29.4	A broad cut and fill with a faint basal reflector identified below an upper layer of sediments characterised by numerous, faint horizontal reflectors (possibly Unit 4), cutting into the interpreted Unit 1. Unit fill is generally acoustically unstructured, possibly with multiple phases of cut and fill. Possible remnants of a fluvial feature.	16-170	Boomer (2023 Fugro)
7084	Channel	P1	-	-	Channel segment	173	MBES (2018 Fugro)
7085	Cut and fill	P2	2.4	9.9	A broad cut and fill identified below a thin, upper layer of sediments, cutting into the interpreted Unit 1. Unit fill is generally acoustically unstructured, possibly with multiple phases of cutting and filling. Possible remnants of a fluvial feature. May form part of a larger feature with **7086 -7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together	171	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7086	Channel	P1	1.2	23.5	A possible channel identified BSB/below a veneer of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1 (Unit 1). Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together	171	Boomer (2015, 2018 Fugro)
7087	Channel	P1	1.5	13.5	A possible channel identified BSB/below a veneer of sediment, cutting into a Unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments, or may be part of the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085 -7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together	171	Boomer (2015, 2018 Fugro)
7088	Cut and fill	P2	2.5	18	A possible cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and generally acoustically unstructured fill, of which there is possibly more than one phase. Identified along the northern edge of a bathymetric high seen in the 2018 Fugro MBES data. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together. Feature appears less convincing compared to others in the area and, as such as been classified as a cut and fill and is considered of lower archaeological potential.	171-172	Sparker (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7089	Cut and fill	P2	2	10.1	A possible cut and fill identified a thin unit of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature has a faint basal reflector and acoustically unstructured fill. May be a remnant fluvial feature or may represent overbank deposits related to channel feature **7084**. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together.	172	Boomer (2023 Fugro)
7090	Channel	P1	3.1	25.3	A possible channel identified a thin unit of sediment, cutting into a unit characterised by numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature has a faint basal reflector and fill characterised by numerous draping reflectors. Possible channel. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together.	172	Boomer (2023 Fugro)
7091	Channel	P1	2.8	12.8	A possible cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and generally acoustically unstructured fill, of which there is possibly more than one phase. Identified along the northern edge of a bathymetric high seen in the 2018 Fugro MBES data. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (6586) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085 - 7092;** however, due to the distance between the SBP lines, these have not definitively been grouped together.	173	Sparker (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7092	Complex channel	P1	3.5	16.1	A possible complex channel identified below a shallow Unit of sediment, cutting into a Unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments, or may be part of the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085 -7092**; however, due to the distinct between the SBP lines, these have not definitively been grouped together	173	Boomer (2023 Fugro)
7093	Cut and fill	P2	1.3	21.2	A possible cut and fill identified beneath a veneer of marine sediment, cutting into the interpreted Unit 1. Feature has a poorly defined basal reflector and a acoustically quiet fill. Possibly represents a remnant fluvial feature.	174-175	Boomer (2015 Fugro)
7094	Complex cut and fill	P2	4.6	22.4	A broad, complex feature identified beneath a thin Unit of sediment, cutting into the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively well defined basal reflector and acoustically transparent/unstructured fill (although the characteristics of these features can vary). Possible remnant of a complex fluvial feature, although may be internal reflectors within Unit 1. EP-28-CPTA suggests Alluvium between 0-0.7 m, overlying dense sand, which may suggest internal reflectors within Unit 1, although this is not definite.	178-181	Boomer (2018, 2023 Fugro)
7095	Channel complex	P1	0.6	25.3	A possible broad channel complex identified beneath a thin unit of sediment, cutting into the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively well defined basal reflector and acoustically transparent/unstructured fill, although some fill is characterised by numerous dipping horizons.	183	Boomer (2018, 2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7096	Channel	P1	6.8	23.8	A possible channel with a distinct basal reflector and acoustically quiet fill. Feature is identified below an upper unit of sediment (possible Unit 5) which is seen to be cut into by channel feature **7097**, suggesting a different depositional phase between this phase of channelling and that associated with **7097**. Identified cutting into the interpreted Unit 1. May form part of a larger feature with **7098**, however this has been truncated by **7097** and therefore it is not possible to tell.	187	Boomer (2018, 2023 Fugro)
7097	Channel	P1	8.8	119	A channel feature identified below a unit of marine sands, cutting through a lower unit characterised with numerous sub-horizontal reflectors indicating fine-drained deposits (possible Unit 5), and cutting through into lower channels **7096** and **7098**. Feature has a distinct basal reflector and acoustically unstructured/quiet fill.	188	Boomer (2023 Fugro)
7098	Channel	P1	8.5	24.4	A possible channel with a distinct basal reflector and acoustically quiet fill. Feature is identified below an upper unit of sediment (possible Unit 5) which is seen to be cut into by channel feature **7097**, suggesting a different depositional phase between this phase of channelling and that associated with **7097**. Identified cutting into the interpreted Unit 1. May form part of a larger feature with **7096**, however this has been truncated by **7097** and therefore it is not possible to tell.	189	Boomer (2018, 2023 Fugro)
7099	Channel complex	P1	3.5	30.1	A broad channel complex identified beneath a unit of sediment, cutting into the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively clear, although occasionally hard to define basal reflectors, and acoustically transparent/unstructured fill (although the characteristics of these features can vary). May be related to nearby palaeochannel **7108** identified on the MBES data, and may form part of a larger feature with **7101** and **7105**.	191-193	Boomer (2018, 2023 Fugro) Sparker (2018 Fugro)
7100	Ridge	P2	-	-	Possible beach ridge	193	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7101	Cut and fill	P2	4.6	15.3	A possible cut and fill identified beneath an upper unit of sediment, interpreted as cutting into a unit with numerous reflectors; possible part of the interpreted Unit 1 although may be part of a larger channel complex (Unit 4). Feature has a distinct basal reflector and acoustically quiet fill. May form part of a larger feature with **7099** and **7105**. May be a remnant fluvial feature.	192-193	Boomer (2018 Fugro)
7102	Ridge	P2	-	-	Possible beach ridge	193	MBES (2018 Fugro)
7103	Ridge	P2	-	-	Possible beach ridge	193	MBES (2018 Fugro)
7104	Ridge	P2	-	-	Possible beach ridge	193	MBES (2018 Fugro)
7105	Cut and fill	P2	6.5	22.6	A possible cut and fill identified beneath an upper unit of sediment, interpreted as cutting into a unit with numerous reflectors; possibly part of the interpreted Unit 1 although may be part of a larger channel complex (Unit 4). Feature has a distinct basal reflector and acoustically quiet fill. May form part of a larger feature with **7099** and **7101**. May be a remnant fluvial feature.	193	Boomer (2018 Fugro) Sparker (2018 Fugro)
7106	Ridge	P2	-	-	Possible beach ridge	194	MBES (2018 Fugro)
7107	Ridge	P2	-	-	Possible beach ridge	194	MBES (2018 Fugro)
7108	Channel	P1	-	-	Large, wide (~1 km) channel that becomes hard to track northwards in data. May continue as buried channel complex **7099**, identified in the SBP data, although this is not definite.	202-197	MBES (2018 Fugro and Opensource)
7109	Ridge	P2	-	-	Possible beach ridge	195	MBES (2018 Fugro)
7110	Ridge	P2	-	-	Possible beach ridge	195	MBES (2018 Fugro)
7111	Ridge	P2	-	-	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	195	MBES (2018 Fugro)
7112	Channel	P1	11.2	24.6	A possible lower cut of a channel identified below an upper unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment (Unit 5). May be estuarine or lacustrine sediments. Feature has a distinct basal reflector and acoustically unstructured fill. Possible earlier phase of channelling.	195	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7113	Channel	P1	0.8	10	An upper channel identified BSB/below a veneer of sediment, cutting through a unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment, possibly estuarine or lacustrine sediments (Unit 5). Feature has a distinct basal reflector and acoustically quiet fill. Possible later fluvial feature.	169	Boomer (2023 Fugro)
7114	Channel	P1	6.5	22.7	A possible lower cut of a channel identified below an upper unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment (Unit 5). May be estuarine or lacustrine sediments. Feature has a distinct basal reflector and acoustically unstructured fill. Feature raises into a bank in the centre, possibly just a high point within the channel base. Feature corresponds with the edge of channel **7108** identified in the MBES data. This may represent a previous generation of channelling, although this is not certain.	197	Boomer (2023 Fugro)
7115	Channel	P1	2	19.6	A possible channel identified below a thin unit of sediment. Feature has a faint, poorly defined basal reflector with acoustically quiet fill with occasional horizontal reflectors. At the base of the feature, an acoustically chaotic feature can be seen which appears to cause acoustic blanking of lower horizons. It is possible that this may be caused by biogenic gas caused by the microbial breakdown of organic matter, although it may also be caused by gravelly sediments at the base of the channel feature.		Boomer (2018 Fugro) Sparker (2018 Fugro)
7116	Channel	P1	-	-	Channel segment with tributaries	206	MBES (2018 Fugro)
7117	Channel	P1	-	-	Palaeochannel, possibly becoming estuarine.	211	MBES (2018 Fugro and opensource)
7118	Channel	P1	-	-	Channel segment with tributaries	209	MBES (2018 Fugro and opensource)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7119	Channel	P1	0.9	8	A possible channel identified within a feature identified in the MBES data (**7117**). Feature has a relatively distinct basal reflector and chaotic fill, possible with more than one phase of cutting and filling. May represent an earlier phase of channelling which has been truncated by a later phase, or may be the partially filled base of **7117**.	211	Boomer (2018, 2023 Fugro) Sparker (2018 Fugro)
7120	Channel	P1	-	-	Tributary segment	212	MBES (2018 Fugro)
7121	Channel	P1	-	-	Tributary segment	212	MBES (2018 Fugro)
7122	Channel	P1	-	-	Narrow palaeochannel segment	214	MBES (2018 Fugro and opensource)
7123	Channel	P1	-	-	Blind channel segment - buried or eroded	217	MBES (2018 Fugro)
7124	Channel	P1	-	-	Blind channel segment - buried or eroded	217	MBES (2018 Fugro)
7125	Channel	P1	-	-	Small channel segment	217	MBES (2018 Fugro)
7126	Channel	P1	0.4	47.2	A possible channel feature identified below a veneer/thin unit of sediment, cutting into a unit characterised by numerous horizontal reflectors which display evidence of faulting indicating Unit 1. Feature has a distinct, occasionally chaotic basal reflector which shoals and deepens throughout the feature and is seen to cause some acoustic blanking of the horizons below. This may indicate shallow gas caused by the microbial breakdown of organic matter, although it may also indicate gravelly sediments at the base of the feature. Unit fill is generally characterised by draping reflectors, although it is seen to be acoustically quiet in some areas. Possibly multiple phases of cut and fill. EP-34-CPT suggests the fill includes non-marine sand.	217 - 222	Boomer (2018, 2023 Fugro)
7127	Cut and fill	P2	1.7	14	A possible lower phase of channelling identified below Channel feature **7126**, cutting into the interpreted Unit 1. Feature has a faint basal reflector and acoustically quiet fill. May represent an earlier phase of channelling.	219-220	Boomer (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7128	Channel	P1	1	9.6	A possible channel identified BSB/below a veneer or marine sediment, cutting into the interpreted Unit 1. Feature has generally acoustically quiet fill with occasional higher amplitude horizontal reflectors. Possibly related to channel **7129** identified in the MBES data.	223	Boomer (2018 Fugro)
7129	Channel	P1	-	-	Main large river network draining into canyon	224	MBES (2018 Fugro and opensource)
7130	Channel	P1	1	8.4	Possible channel identified BSB/below a veneer of sediment. Feature has a faint, poorly defined basal reflector and acoustically chaotic fill. Feature appears to be cutting into a unit characterised by numerous horizontal reflectors interpreted as being part of Unit 1. Possibly a continuation of **7131** or part of **7129** identified on the MBES data.	225	Boomer (2023 Fugro)
7131	Channel	P1	-	-	Partially buried palaeochannel	228	MBES (2018 Fugro)
7132	Channel	P1	1.6	8.3	Possible channel identified SBSB/below a veneer of sediment. Feature has a faint basal reflector and acoustically quiet fill. Feature appears to be cutting into a unit characterised by numerous horizontal reflectors interpreted as being part of Unit 1. Possibly related to nearby feature **7131** identified in the MBES data.	226	Boomer (2023 Fugro)
7133	Escarpment	P1	-	-	Cliff band and promontory, up to 10 m relief	228	MBES (2018 Fugro)
7134	Channel	P1	-	-	Palaeochannels largely covered by marine sediments and difficult to interpret from bathymetry	230	MBES (2018 Fugro)
7135	Cut and fill	P2	0.7	5.3	A small cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a distinct basal reflector and acoustically chaotic fill. Feature appears particularly chaotic at the base and is possibly causing some slight acoustic blanking of lower horizons. This may be dure to shallow gas although may be more likely due to gravelly sediments at the base of the feature. Identified below a channel feature identified in the MBES data (**7134**) and may represent an earlier phase of channelling or the base of the feature, partially infilled with sediment.	230	Boomer (2023 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7136	Channel	P1	-	-	Palaeochannel largely covered by marine sediments/sediment waves	231	MBES (2018 Fugro and opensource)
7137	Channel	P1	-	-	Steep-sided channels with plateaux interfluves joining into main anabranching river network	235	MBES (2018 Fugro and opensource)
7138	Channel	P1	-	-	Channel segment	237	MBES (2018 Fugro)
7139	Channel	P1	-	-	Large anabranching river complex	242	MBES (Opensource)
7140	Channel	P1	-	-	Channel segment with tributaries	239	MBES (2018 Fugro)
7141	Channel	P1	-	-	Channel segment	241	MBES (Opensource)
7142	Channel	P1	-	-	Channel segment	244	MBES (Opensource)
7143	Channel	P1	-	-	Channel segment with tributaries	245	MBES (2018 Fugro)
7144	Channel	P1	-	-	Main meandering river channel	246	MBES (2018 Fugro)
7145	Channel	P1	2	20	A possible channel segment identified below a Unit of sediment, interpreted as cutting into the interpreted Unit 1. In the 2023 boomer data, the feature is seen to have a faint, poorly defined basal reflector, although this is clearer in the 2015 data, with acoustically chaotic fill. Identified below a channel feature identified in the MBES data (**7144**) and may represent an earlier phase of channelling or the base of the feature, partially infilled with sediment.	246	Boomer (2015, 2023 Fugro)
7146	Cut and fill	P2	0.7	6.6	A possible channel segment identified BSB/below a veneer of sediment, interpreted as cutting into the interpreted Unit 1. The feature has a faint, poorly defined basal reflector with acoustically unstructured fill. Identified below a channel feature identified in the MBES data (**7144**) and may represent an earlier phase of channelling or the base of the feature, partially infilled with sediment. May be a continuation of **7145**; however, due to the distance between lines, the features have not been grouped at this time.	246-247	Boomer (2018 Fugro)
7147	Channel	P1	-	-	Meandering channel complex segment	247	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7148	Cut and fill	P2	1.4	11.6	A cut and fill identified below a veneer of sediment. Feature has a faint but distinct basal reflector with acoustically chaotic fill. Cutting into an interpreted lower phase of channelling (**7149**).	249	Boomer (2015, 2023 Fugro)
7149	Cut and fill	P2	6.8	23.8	A cut and fill identified below an upper Unit of sediment, being cut into by a later phase of cut and fill (**7148**). Feature has a faint but distinct basal reflector with fill characterised by numerous horizontal reflectors, indicating layered fill which may have been deposited in a low-energy environment (possibly a unit of estuarine/lacustrine sediments (Unit 5)).	249	Boomer (2018, 2023 Fugro)
7150	Channel	P1	-	-	Small channel segment seen within larger anabranching river network	250	MBES (2018 Fugro)
7151	Cut and fill	P2	0.8	11	A possible channel identified below a veneer of sediment, with a faint basal reflector and acoustically unstructured fill. In the 2015 Boomer data it appears to be cutting into an acoustically quiet unit (possibly Unit 5) above the interpreted Unit 1, although this is less clear in the 2023 Boomer data. Possible remnant fluvial feature.	250-251	Boomer (2015, 2023 Fugro)
7152	Cut and fill	P2	3.5	27.2	A possible cut and fill identified beneath an acoustically quiet unit (possible Unit 5 although this is not certain) which is thinner in the west, thickening towards the east. Feature has a faint basal reflector and acoustically unstructured fill. Possible remnant fluvial feature from an earlier phase of channelling	251	Boomer (2015, 2023 Fugro)
7153	Channel	P1	-	-	Anabranching channel segments	254-252	MBES (2018 Fugro)
7154	Cut and fill	P2	9	19.1	A possible cut and fill feature identified beneath an upper unit of acoustically quiet sediment with a chaotic base, possibly indicating gravels, cutting into the interpreted Unit 1. Feature has a distinct, undulating basal reflector and fill characterised by faint, draping reflectors. Possible remnant fluvial feature or infilled depression	253	Boomer (2023 Fugro)
7155	Channel	P1	-	-	Small segment of palaeochannel seen on MBES	255-254	MBES (2018 Fugro)
7156	Channel	P1	-	-	Small segment of palaeochannel seen on MBES	255	MBES (2018 Fugro)
7157	Channel	P1			Large, wide (~1.5 km) palaeochannel segment showing anabranching	256	MBES (2018 Fugro)

ID	Classification	Archaeological Discrimination	Depth Range (mBSB)		Description	KP	Data Source
			From	To			
7158	Complex channel	P1	18.5	37.9	A possible cut and fill identified beneath an upper unit characterised by numerous faint horizontal reflectors (possible Unit 5 but this is uncertain), possibly indicating fine-grained deposits, cutting into the interpreted Unit 1. Feature has a distinct basal reflector and acoustically unstructured fill, possibly multiple phases of cutting and filling. Identified close to similar feature **7159**, but separated by a distinct banked feature which may represent a high point between channel cuts, or possibly a calcarenite surface, although this is uncertain.	256-257	Boomer (2023 Fugro)
7159	Complex channel	P1	15.8	45.2	A complex cut and fill feature identified beneath an upper unit characterised by numerous faint horizontal reflectors (possible Unit 5 but this is uncertain), possibly indicating fine-grained deposits, cutting into the top of the interpreted Unit 1. Feature has a faint, poorly defined basal reflector and numerous phases of cutting and filling, with fill generally appearing acoustically unstructured, although it appears more chaotic in its later phase of fill. Identified close to similar feature **7158**, but separated by a distinct banked feature which may represent a high point between channel cuts, or possibly a calcarenite surface, although this is uncertain. Possible channel complex	2257	Boomer (2015, 2023 Fugro)
7160	Channel	P1	-	-	Large, wide (~1 km) braided river channel with undulating thalweg	259	MBES (2018 Fugro)
7161	Infilled depression	P2	6.1	31.8	A possible infilled depression identified below an upper unit of acoustically quiet sediment, infilling a depression at the top of the interpreted Unit 1. Fill is characterised by numerous faint, draping reflectors, indicating fine-grained deposits deposited in a low-energy environment. Fill is not clearly different to overlying sediment, although the draping reflectors appear slightly more distinct. Feature has a distinct basal reflector which appears acoustically chaotic where it shoals in the centre.	258-259	Boomer (2015, 2023 Fugro)
7162	Channel	P1	-	-	Small segment of palaeochannel seen on MBES	262	MBES (2018 Fugro)

Barossa Field Seafloor
Late Pleistocene/Holocene
Depositional Environment

Henry W. Posamentier PhD

July 11, 2023

Background

1. I have been requested by Quinn Emanuel Urquhart & Sullivan on behalf of Santos Ltd to prepare a report on the Late Pleistocene and Holocene depositional and erosional history of the Arafura Sea with emphasis along the pipeline corridor.

2. I have prepared this report as an independent expert and have done so in accordance with the Federal Court of Australia's Expert Witness Code of Conduct (**Appendices 1 and 2**).

3. In preparing my report I have made all the enquiries which I believe are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which I regard as relevant have, to my knowledge, been withheld.

4. I have attached my Curriculum Vitae to this report (**Appendix 3**).

Summary

5. This report evaluates and describes the evolution of the seafloor from 18,000 years ago until the present, between the Barossa Field and the Bayu-Undan pipeline, with emphasis on the pipeline corridor. The current bathymetry of the pipeline corridor ranges from 50m to 310m as it traverses the continental shelf and slope. For approximately 180km of the 240km length of the pipeline corridor, the surface across which the pipeline traverses comprises a continental shelf setting. This surface was subaerially exposed during the lowest sea-level position, which occurred approximately 18,000 years ago (i.e., late Pleistocene), meaning that this was a land surface when the sea was at its lowest level. Subsequently, during the sea-level rise that followed, this surface was flooded, causing the shoreline to move landward. The land surface, including any landforms (e.g., river channels, flood plains), that was previously exposed during the Late Pleistocene would therefore now be covered with sea water. In the process of sea-level rise, the new seafloor was subjected to erosive processes such as wave action and tidal currents. As a result, a significant amount – potentially 5-10m of sediment – can be stripped from the seafloor across the area. In places, this eroded material can then be re-deposited as a blanket or as channel fill seaward of the shoreline. Consequently, any artifacts that may have been left on the original 18,000-year surface would likely have been removed. Moreover, such artifacts, even after having been removed, likely would have been buried by post-flooding sedimentation. Key takeaways and conclusions are summarized below.

Key takeaways and conclusions

- The modern seafloor along the pipeline route was subaerially exposed at lowstand time (~18,000 Years Before Present – YBP).
- The rate of sea-level rise was relatively slow from 18,000 to 12,000 YBP and accelerated between 12,000 and 10,000 YBP before slowing significantly between 10,000 and 8,000 YBP. The rate of transgression (i.e., flooding) when the rate of sea-level rise was highest from 12,000 YBP to 10,000 YBP at ~18m/year. That is, the shoreline was moving landward at this rate.
- The lowstand land surface along the pipeline route likely was subjected to multiple erosional and depositional processes between ~18,000 YBP and the present:
    - Erosion by wave action associated with tropical cyclones.
    - Erosion by strong tidal currents.
    - Erosion by shoreface-related waves.
    - Sedimentation onto the flooded seafloor.
        - Re-distribution of eroded sediments.
        - Deposition of modern river-sourced sediments.
        - Deposition of carbonate platform and patch reef deposits.

- Because of erosion and sedimentation, the topography of the modern seafloor likely has been modified to varying degrees from its earlier lowstand exposed character. This is because lowstand surfaces were exposed to the multiple geological processes described above.
- Any objects (i.e., archeological artifacts) that may have been present on the land surface of 18,000 YBP would have been eroded by waves or tidal currents during transgression and likely not preserved in this open ocean setting. Subsequently, during the time of transgression (i.e., shelf flooding) and later, when sea-level was at its highstand position (i.e., the interval between 8,000 YBP and the present), this erosional surface was layered over by carbonates (i.e., corals, sponges, etc.) and thin fine-grained sediments (from sediment plumes), as well as coarse-grained sediments from re-deposition of tidal-current eroded sediments.

Introduction

6. A proposed pipeline corridor connecting Barossa Field production to existing infrastructure to the south traverses approximately 240km of seafloor. Currently, that seafloor along the pipeline route/pathway comprises approximately 180km of continental shelf and 60km of continental slope (**Fig. 1**). Extensive site survey work along the proposed pipeline corridor was done by Fugro Survey PTY LTD. This included the acquisition of numerous high-resolution seismic profiles, collection of seafloor sediment samples, as well as acquisition of sidescan sonar bathymetric images. The focus of the present study is to evaluate the seafloor surface and subsurface to better understand its evolution, and specifically to determine the extent to which that exposed surface was modified through erosion and later by sedimentation subsequent to sea-level flooding that occurred between 18,000 and 8,000 years ago. In the context of this report, the term "flooding" means the encroachment of the sea across a previously subaerially exposed land surface. The data examined included the aforementioned data acquired by Fugro Survey PTY LTD as well as the 3D seismic survey over the Barossa Field, integrated with publicly-available bathymetric surveys and maps.

7. **Figure 1** illustrates the regional physiographic setting (i.e., seafloor bathymetry). The Barossa Field lies north of Bathurst and Melville Islands and is situated in 210-275m of water. The modern-day shelf edge is located at about the -120m water-depth isobath, approximately 60km south of Barossa Field. Numerous currently-active, small carbonate buildups can be observed along this modern-day shelf edge. Landward of the shelf edge, there exist large relict (i.e., no longer active) carbonate platforms characterized by numerous tide-related channels cutting across it (**Fig. 2**). In the middle of the continental shelf there is a broad shallow basin referred to as the Malita Intra Shelf Basin (i.e., Malita ISB) connected to the deeper ocean (i.e., that part of the seaway which is deeper than 120m) by a narrow valley (i.e., the Malita Valley).

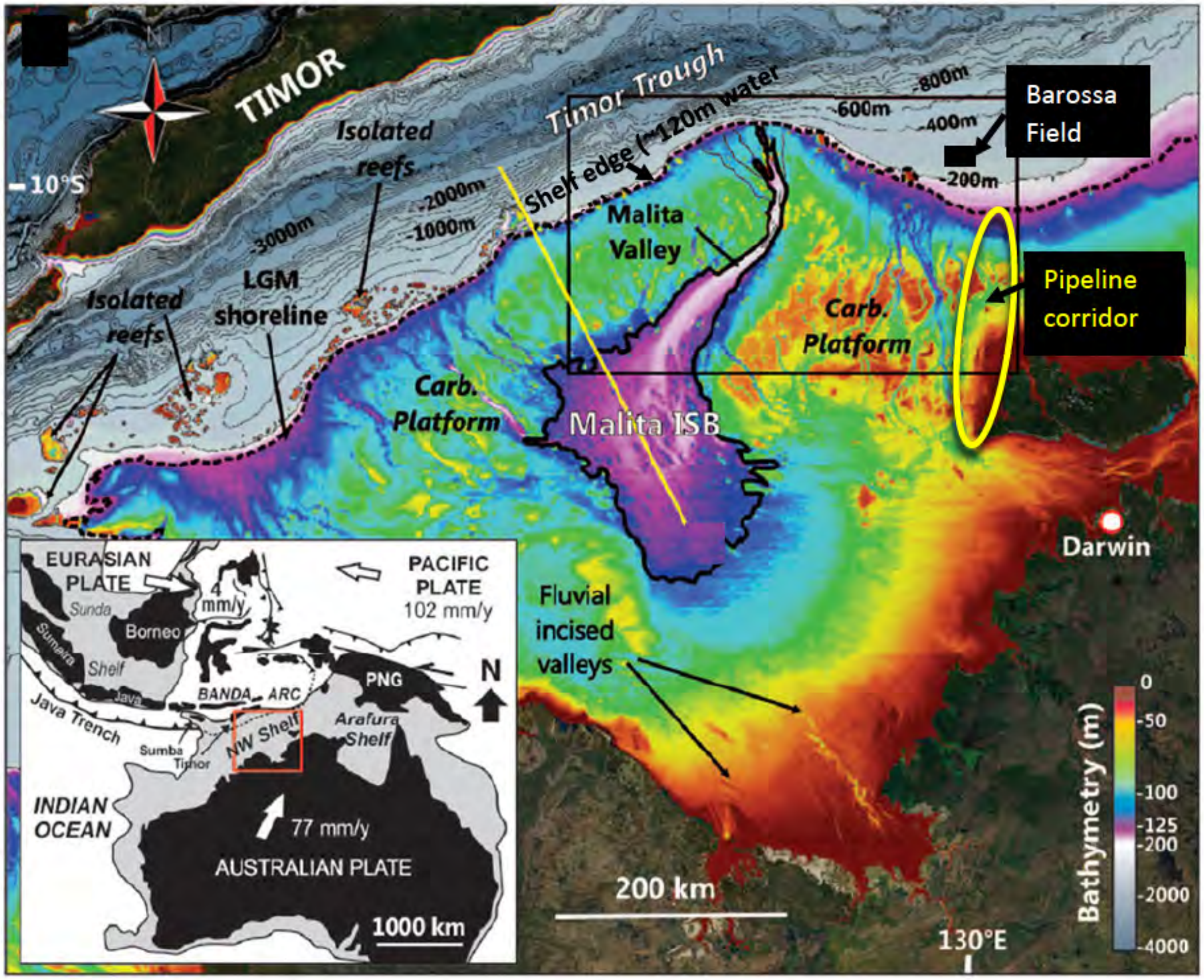


Figure 1. Physiography of the Arafura Sea. Key features include the shelf edge (located just south of Barossa Field), the Malita intra-shelf basin with associated Malita Valley, broad carbonate platforms on the outer shelf flanking the Malita Valley, and small isolated reefs (i.e., carbonate buildups that lie at or just seaward of the shelf edge; from Bourget et al., 2014). The general pipeline corridor is indicated by a yellow oval.

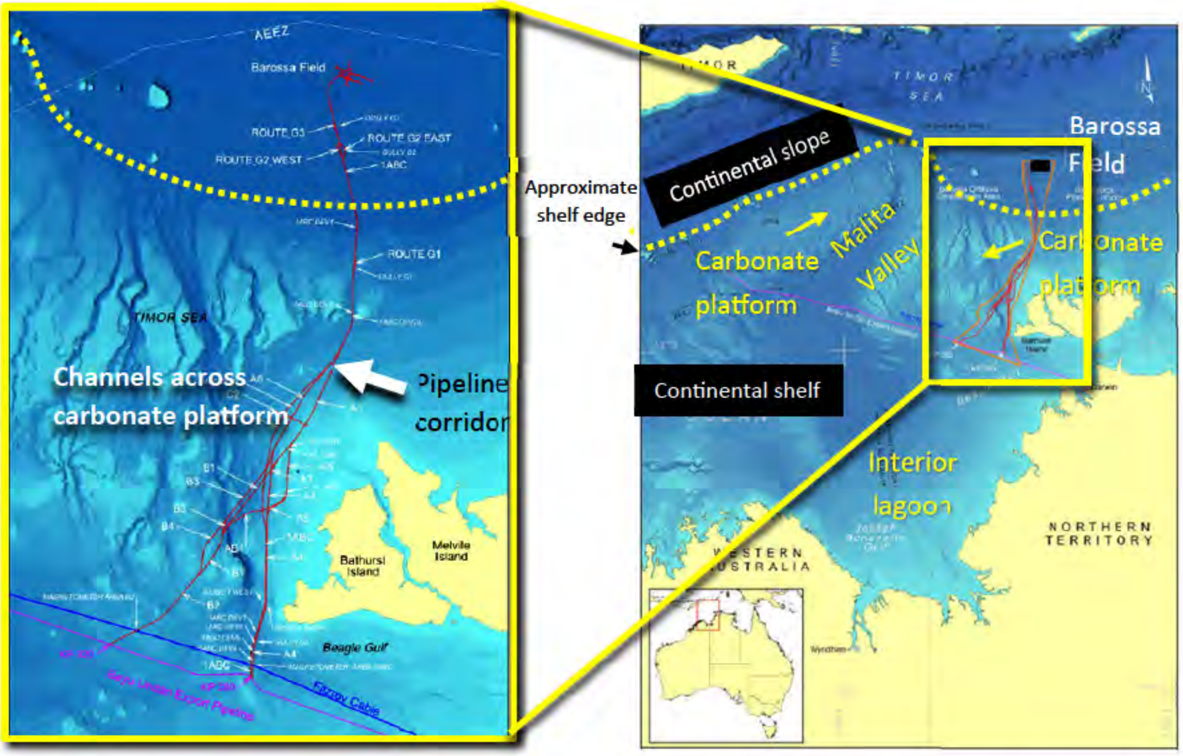
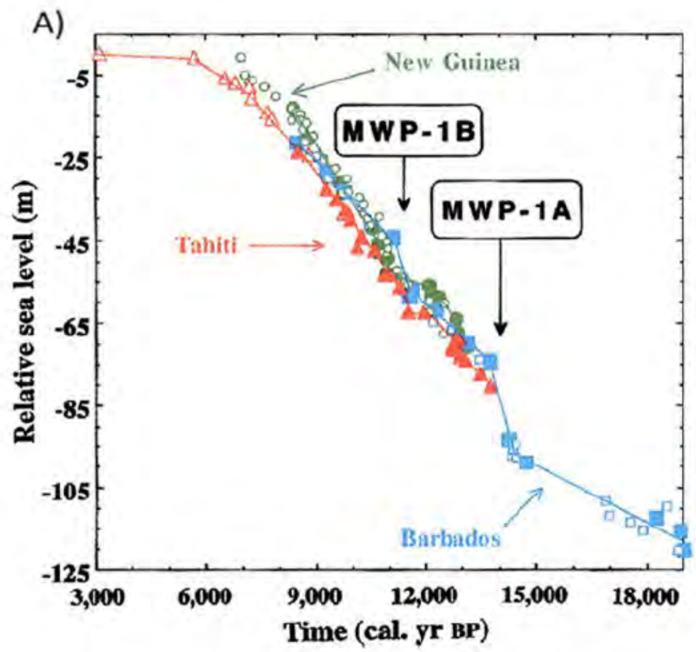


Figure 2. Detail of continental shelf landward of the Barossa Field, showing the pipeline corridor location as well as channels associated with a broad inactive carbonate platform west of the pipeline corridor.

Sea-level history

8. The history of sea-level change from the late Pleistocene until the present is well known (**Fig. 3A**). Based on biostratigraphic, seismic stratigraphic, and outcrop-based observations, the long-term history of global sea-level change has been established (Vail et al., 1977; Haq, et al., 1987). More recently, Lambeck et al. (2014) have published a more detailed sea-level history based on the study of fluctuating glacial ice volumes and the position of ancient shorelines.

9. At various times in the past, global sea level was significantly lower than today. These times of low sea level corresponded to times of active continental glaciation across North America, Scandinavia, Siberia, and Antarctica. These massive amounts of ice accumulated on land, resulting in a net sea-level fall. As the ice melted and water was returned to the oceans, sea level gradually rose worldwide. At approximately 20,000-18,000 years ago sea level stood approximately 120m lower than today. From 18,000 until approximately 12,000 years ago sea level rose slowly before accelerating between 12,000 and 10,000 years ago and then slowing down between 10,000 and 8,000 years ago. Finally, sea level reached today's position approximately 8,000 years ago (**Fig. 3B**).


A)
New Guinea
MWP-1B
MWP-1A
Tahiti
Barbados
Relative sea level (m)
-5
-25
-45
-65
-85
-105
-125
3,000
6,000
9,000
12,000
15,000
18,000
Time (cal. yr BP)

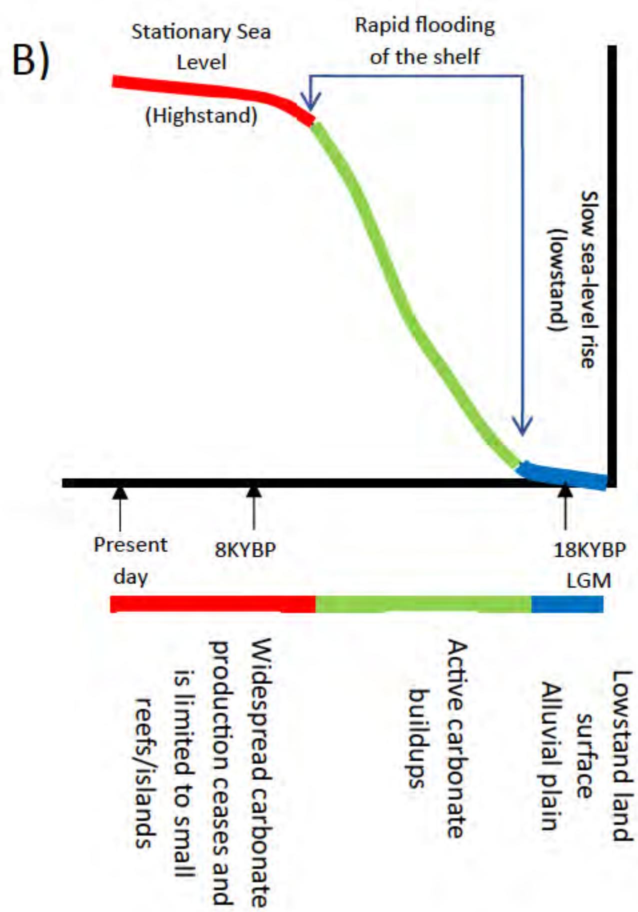

B)
Stationary Sea Level
(Highstand)
Rapid flooding of the shelf
Slow sea-level rise (lowstand)
Present day
8KYBP
18KYBP
LGM
Widespread carbonate production ceases and is limited to small reefs/islands
Active carbonate buildups
Lowstand land surface
Alluvial plain

Figure 3. A) Sea level position during the late Pleistocene, from the last glacial maximum (**LGM**) to the present (Bard et al., 1996). This sea-level curve was generated from several regional sites (e.g., Tahiti, New Guinea, and Barbados) and then summed together to yield a globally-relevant sea-level curve. **B)** Schematic diagram of sea-level change with associated landform development.

Shoreline location from 18,000 years ago to the present

10. At 18,000 years ago (i.e., Late Pleistocene) sea level stood at 120m lower than today so that much of what today constitutes a submerged continental shelf was at that time subaerially exposed. Thus, the 18,000 year shoreline lay well seaward of today's modern shoreline, i.e., with the shoreline located approximately at the -120m contour line, with associated alluvial environments comprising numerous river channels and associated floodplain deposits characterizing much of the terrain (i.e., up to the lowstand shoreline) across what is now submerged seafloor. This lowstand shoreline was located approximately 60km south of the center of the Barossa Field.

11. Between 18,000 and 12,000 years ago the shoreline shifted gradually landward in response to slowly rising sea level. With accelerated sea-level rise between 12,000 and 10,000 years ago, the shoreline shifted rapidly landward, flooding the shelf with seawater, a process referred to as shoreline transgression. The rate of flooding of the shelf was approximately 18m per year. Sea-level rise slowed approximately 10,000 years ago, reaching modern day sea level approximately 8,000 years ago. In response, during that time the rate of transgression decreased significantly. Shoreline transgression resulted in a landward shift of the shoreline by approximately 150km to 200km (**Fig. 4**). **Figure 5** illustrates the progressive landward shift of the shoreline between 18,000 years ago and the present. This shoreline migration is illustrated schematically in **Figure 6**.

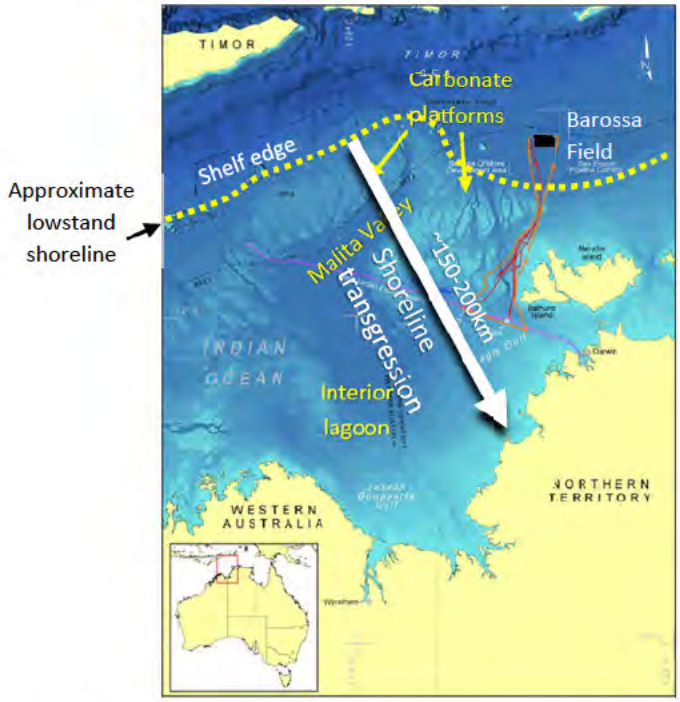
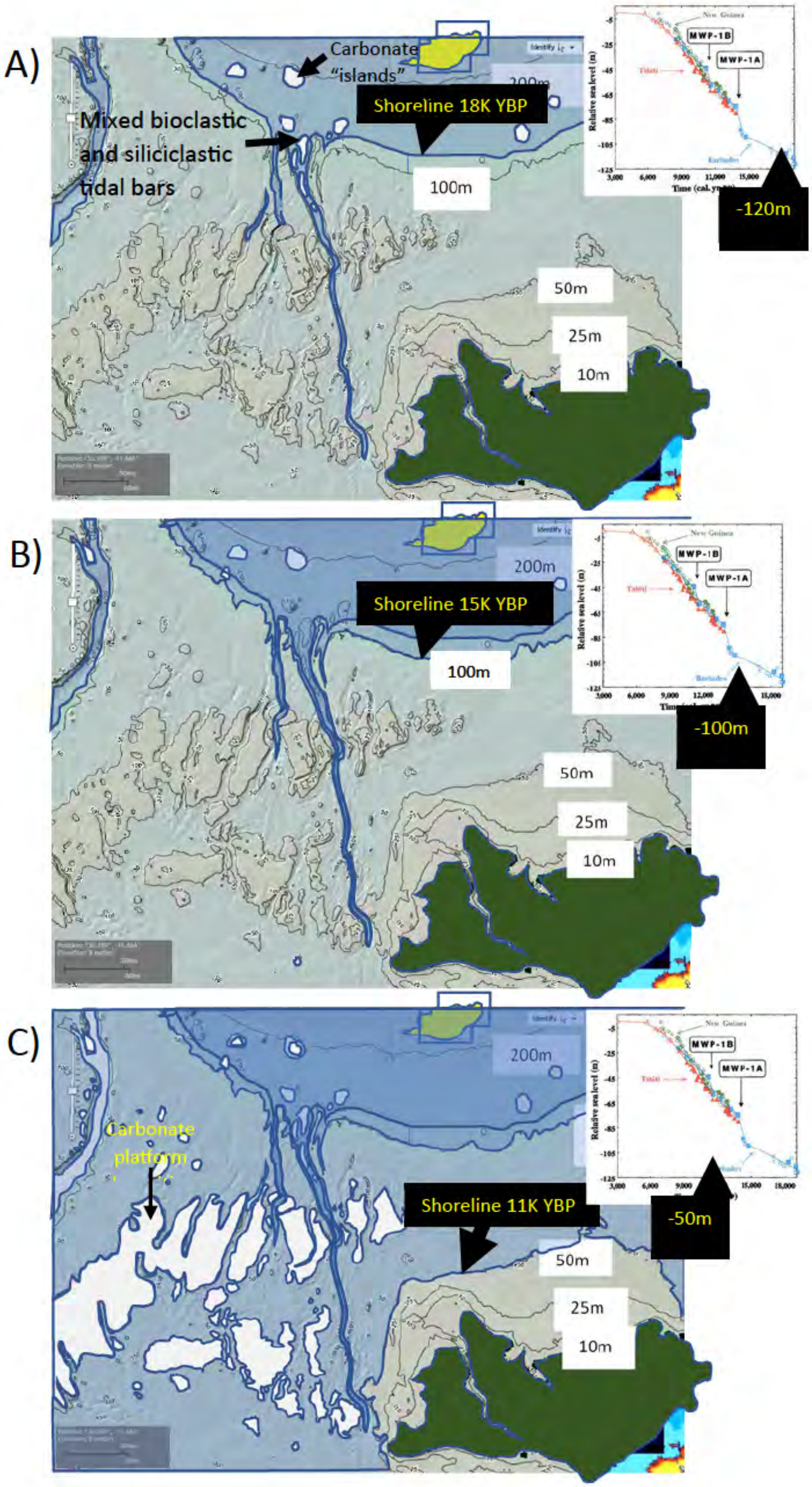
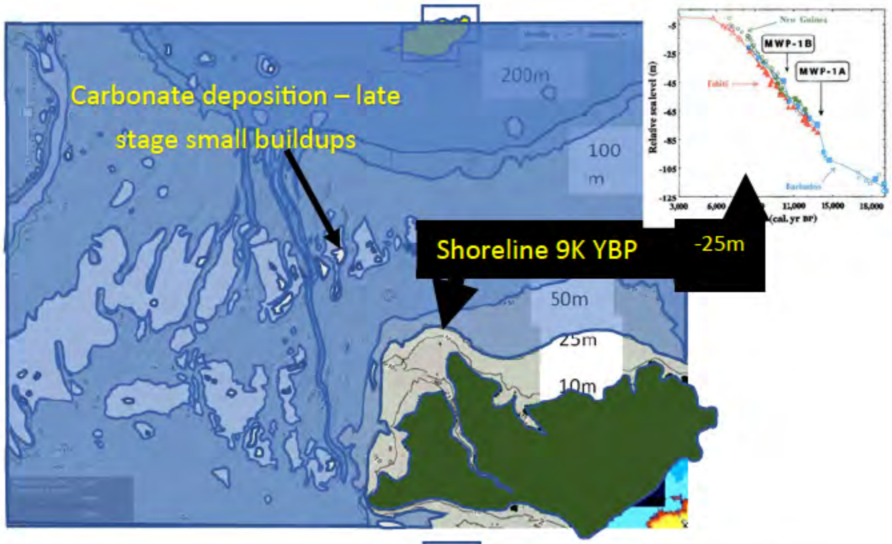


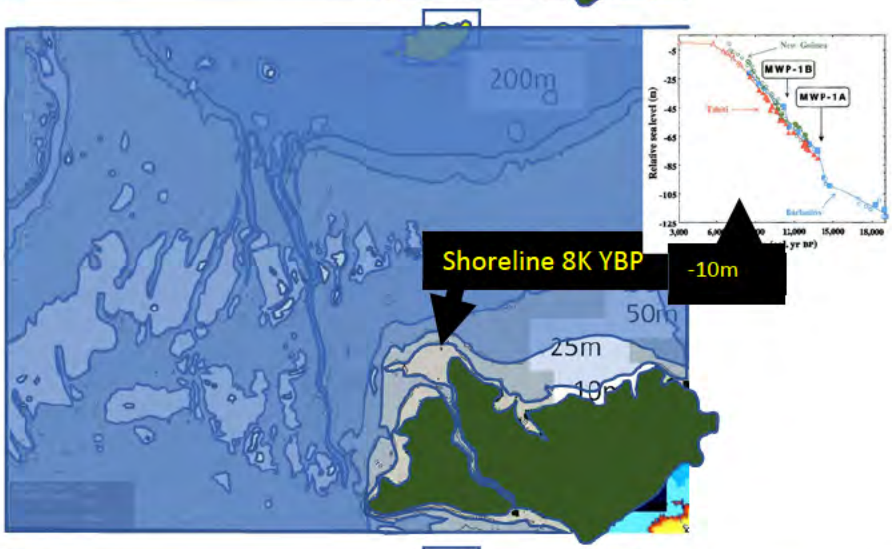
Figure 4. Continental shelf edge in the Arafura Sea. The distance of shoreline landward migration during the Pleistocene sea-level rise after the LGM is shown by the white arrow.


A)
Carbonate "islands"
Mixed bioclastic and siliciclastic tidal bars
Shoreline 18K YBP
200m
100m
50m
25m
10m
-120m
MWP-1B
MWP-1A
B)
Shoreline 15K YBP
200m
100m
50m
25m
10m
-100m
MWP-1B
MWP-1A
C)
Carbonate platform
Shoreline 11K YBP
200m
50m
25m
10m
-50m
MWP-1B
MWP-1A

D)


Carbonate deposition – late stage small buildups
200m
100 m
Shoreline 9K YBP
-25m
50m
25m
10m
New Guinea
MWP-1B
MWP-1A
Tahiti
Barbados
Relative sea level (m)

E)


200m
Shoreline 8K YBP
-10m
50m
25m
New Guinea
MWP-1B
MWP-1A
Tahiti
Barbados
Relative sea level (m)

F)

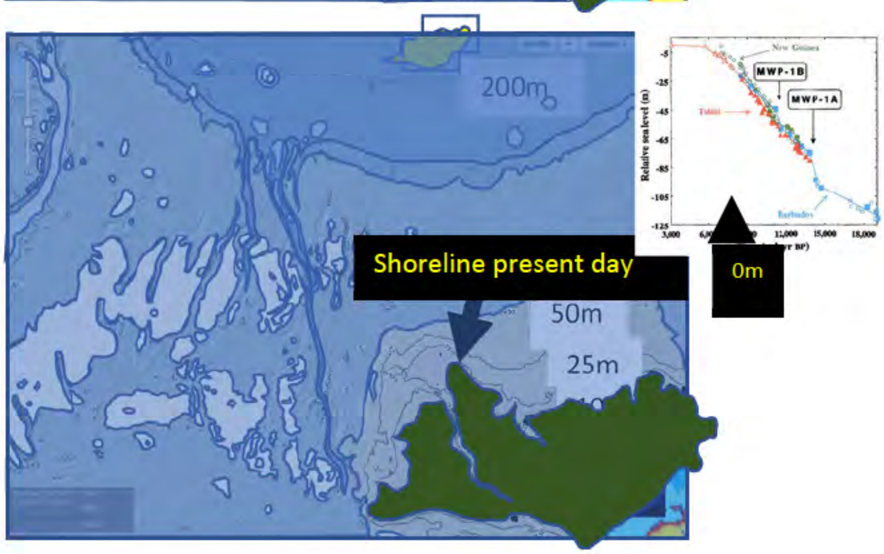

200m
Shoreline present day
0m
50m
25m
New Guinea
MWP-1B
MWP-1A
Tahiti
Barbados
Relative sea level (m)

Figure 5. Bathymetric maps showing progressive landward shoreline migration (i.e., transgression) from 18,000 years ago (the LGM) to the present. The same bathymetric map with contours has been used as a base map with shoreline location superimposed to illustrate the gradual flooding of the shelf (**A through F**).

12. **Figure 5A** illustrates in map view the approximate shoreline position at 18,000 years before the present based on sea level being 120m lower than that of today. Thus, the -120m contour line represents the position of the shoreline at that time. Numerous channels across the shelf landward of the shoreline likely were active and occupied by river systems. Thus, landward of the shoreline, the shelf would have been subaerially exposed and the site of an alluvial plain. We know from modern studies of alluvial plains that these landscapes are dynamic and continuously evolving (e.g., Slingerland and Smith, 2004). Rivers periodically experience flood conditions and river paths can change from time to time through a process called avulsion, wherein flooding rivers escape their banks and find new pathways. Outside of the river channels, floodplain sedimentation by overbanking river flows can result in deposition of fine-grained clays and silts as well as coarser-grained crevasse splay deposits (i.e., deposition associated with gaps in river levees that allow flows to pass from the channel to the floodplain) there.

13. **Figure 5B** shows that as sea level rose after the LGM the shoreline moved progressively landward – a process referred to as transgression. Approximately 15,000 years before present, sea level stood approximately 100m lower than today. The shoreline location would have been at the -100m contour line and most of the shelf would still have constituted an alluvial plain.

14. **Figure 5C** illustrates the landscape associated with continued and accelerated sea-level rise that characterized the period between 15,000 and 11,000 years ago. At this time sea level stood 50m lower than today and the shoreline was located at the -50m contour line. At this time, much of the shelf was flooded and the formerly exposed alluvial plain was now inundated to a depth of 50-100m. At the same time, mainland Australian river systems would gradually have been flooded resulting in an estuarine environment (i.e., “drowned” river valleys) along the lower reaches of these rivers. This flooding by the ocean of these lower reaches of the river would have effectively trapped much of the river-transported sediments within estuaries (see discussion below). As a result, little river-sourced sediment load would have reached the open shelf and, because of the relatively sediment-free water column as well as the shallow water depths over the shelf, carbonate-producing organisms such as corals and sponges would have thrived, producing broad carbonate banks (Przeslawski et al., 2011). One common feature of broad carbonate banks is tidal channels (see discussion below). These channels form as a result of tide-related alternating flooding and exposure of the carbonate bank where flows would have been repeatedly directed landward and seaward respectively.

It is worth noting that these carbonate deposits, were they to have been later subaerially exposed by a significant sea level fall, would have seen the development of caves associated with carbonate (i.e., limestone) dissolution. Carbonate dissolution would have been facilitated by the downward passage of groundwater through joints and fractures. However, as shown by the sea level curve since the time of the LGM (**Fig. 3**), no such sea-level fall that would have resulted in subaerial exposure of the carbonate banks occurred during this time. Hence, it is unlikely that significant caves would have formed within the transgressed shelf since the LGM.

15. **Figure 5D** shows that at 9,000 years before present, sea level stood approximately 25m lower than that of today. By this time, the rate of sea-level rise had slowed. It is likely that at this time river-sourced suspended sediments, rather than being trapped within estuaries, would have emerged from the river mouths and extended across the shelf. This "dirtying up" of the water column would have had a detrimental effect on carbonate growth, causing much of the carbonate bank to become inactive. The only location where carbonate production would have continued would have been along the shelf edge, which is a site characterized by currents moving upslope carrying abundant nutrients sourced from the continental slope (a process referred to as upwelling). This would have resulted in a chain of small patch reefs all along the shelf edge (**Fig. 1**).

16. **Figure 5E** illustrates that minimal sea-level rise between 9,000 and 8,000 years ago would have resulted in a sea-level position approximately 10m lower than that of today resulting in a shoreline at approximately the -10m contour line. Conditions similar to that of today (**Fig. 5F**), with a largely drowned shelf and minimal carbonate production. Would have characterized the shelf at that time. Channels that crossed the carbonate platform as tidal channels when the platforms were active, remain as relict (i.e., no longer active) channels across the submerged shelf, and continued to funnel shelf currents back and forth across the area as tides rose and fell.

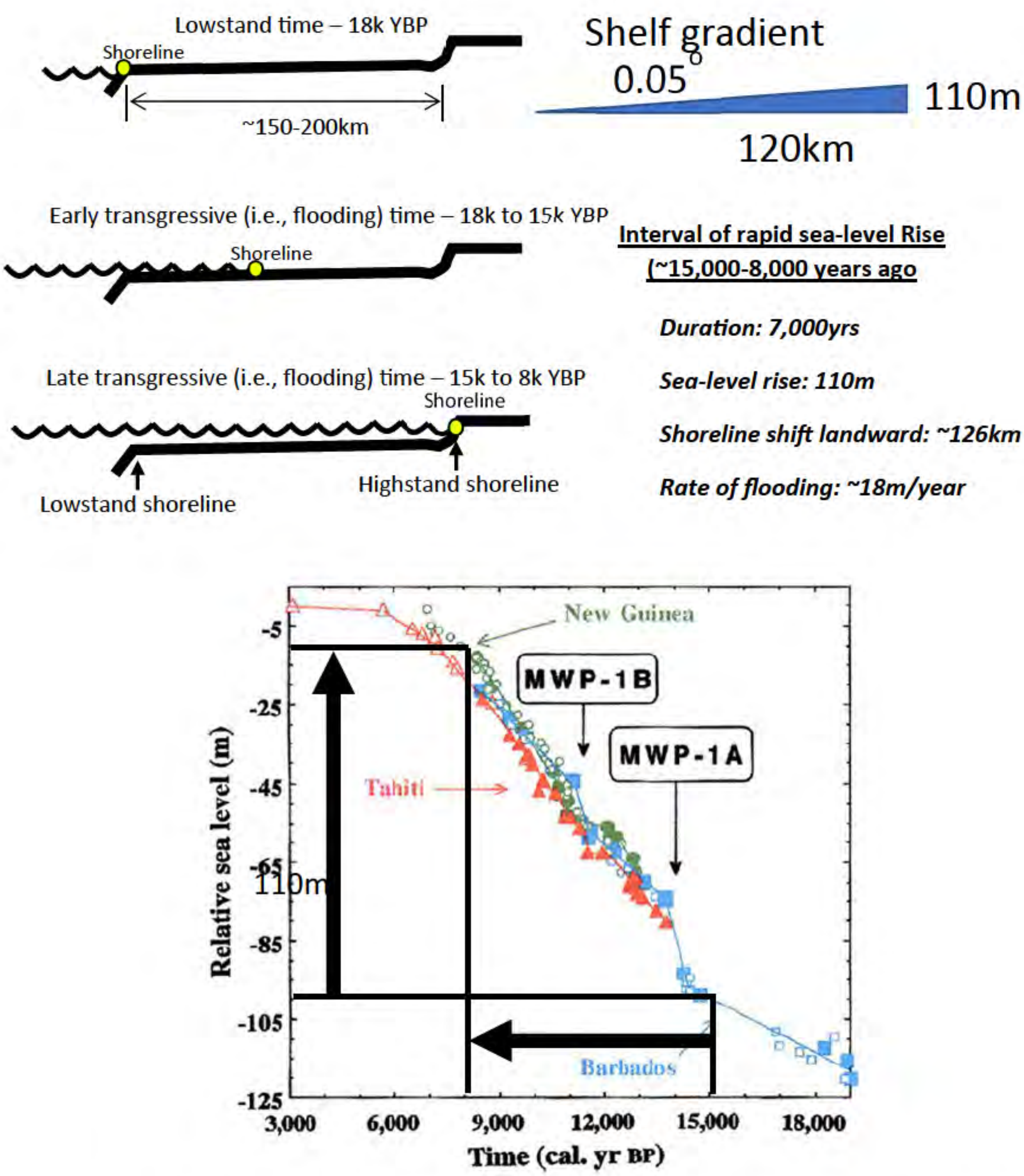


Figure 6. Schematic depiction of landward shoreline migration (i.e., transgression). Note that because of the very shallow gradient of the shelf, transgression would have been very rapid during those times of rapid sea-level rise – at approximately 18m per year. Note that the shelf gradient measured from the shelf edge (-120m water depth) to the nearest landfall, on Bathurst Island (0m), constitutes an average gradient across the shelf. The local gradient along the pipeline route can be variable, given the irregularities of local topography, but overall will be approximately 0.05 degrees or less. (Sea-level curve from Bard et al., 1996).

17. The rate at which the shoreline migrates landward in response to sea-level rise is largely dependent upon the gradient across which flooding occurs. The gentler the gradient, the more rapid will be this shoreline transgression. I have assumed a general gradient here of 0.05 degrees, a gradient that constitutes a reasonable approximation for the overall shelf gradient and is within the range of gradients measured by Posamentier and Allen (1999). The gradient of 0.05 degrees is based upon measuring the water depth change from the LGM shoreline location (i.e., the shelf edge) to the modern shoreline – i.e., 120m – over a distance of 150-200km. Once these two dimensions are known – i.e., the vertical relief and horizontal distance – calculating the inverse tangent allows for the determination of the slope. With this shelf gradient, coupled with the rate of sea-level rise, the rate of flooding of the LGM surface can be calculated to be at least 18m per year, which constitutes a high rate of shoreline transgression compared with more common shoreline transgression rates of less than 5m per year, where transgression is currently occurring.

Agents of erosion and deposition during the evolution of the shelf surface from 18,000 years ago to the present

18. The continental shelf surface was subaerially exposed 18,000 years ago. Consequently, much of the pipeline corridor was a land surface at that time. The depositional environment at this time was characterized by cooler temperatures and higher rainfall meaning that the landscape was one of more lush vegetation than today. This land surface can be described as a coastal plain or alluvial plain with numerous rivers sourced from the Australian mainland. Subsequently, in response to sea-level rise after 18,000 years ago, the shoreline gradually migrated landward. As this landward shift was occurring, the shelf was progressively flooded and as this flooding was occurring, that surface was impacted by a variety of geologic processes, notably erosion as well as later deposition (see discussion below). **Figure 7** schematically illustrates the evolution of the shelf from lowstand time (18,000 years ago) to the present.

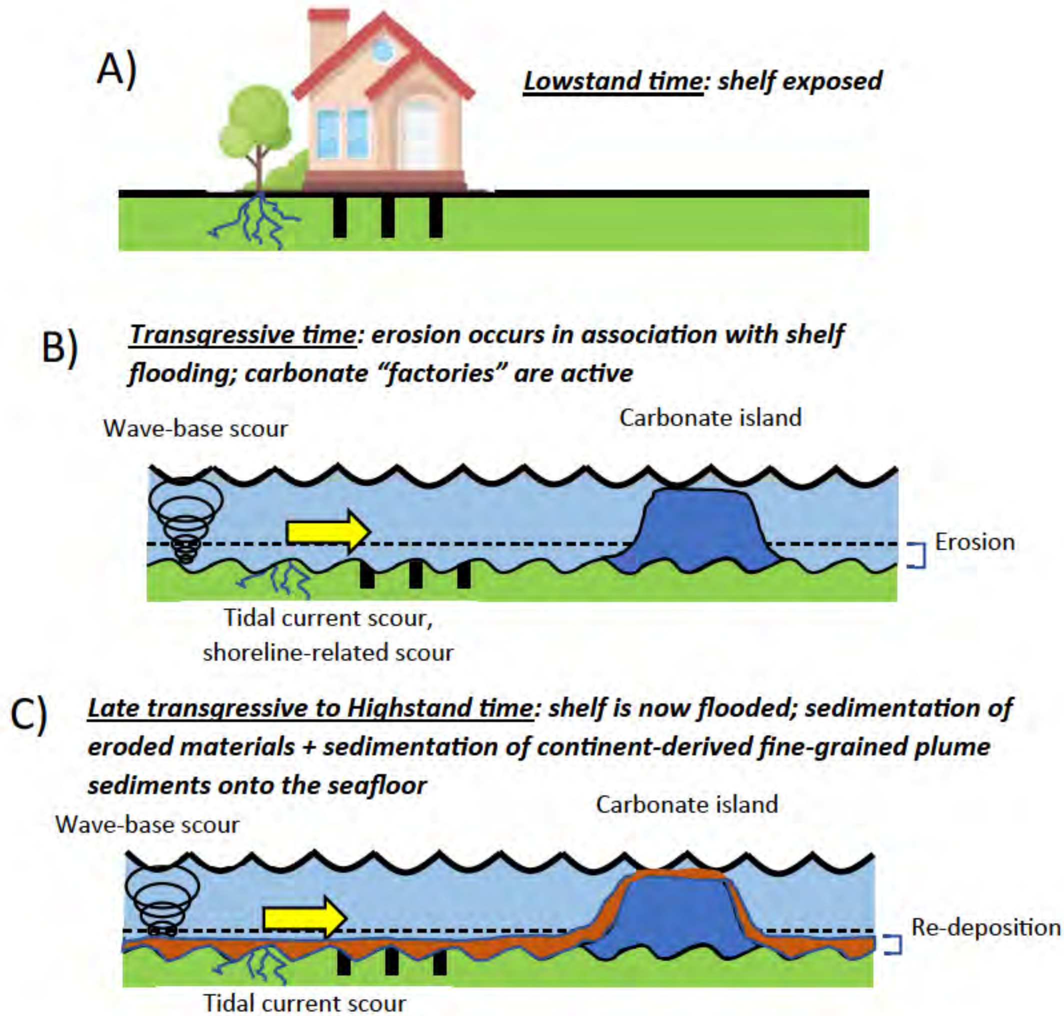


Figure 7. Schematic depiction of the evolution of the 18,000-year lowstand surface. **A)** Lowstand time when the shelf was fully exposed. **B)** Transgressive time when the shoreline was migrating rapidly landward and wave and tidal current erosion were occurring. Carbonate buildups were active during this time. **C)** Late transgressive to highstand time when re-deposition of wave-eroded sediments and plume-derived sediments blanketed the area. Carbonate production ceased at this time.

– Wave erosion at the shoreline and re-deposition of eroded sediments

19. The first erosional agent to impact the land surface was the waves that break at the shoreline. As the shoreline moves landward this zone of shoreface erosion passes over the land surface removing as much as 5-10m off the top of the previously exposed land surface. The factors that control the amount of erosion will be discussed below. The eroded material is subsequently re-deposited seaward of the shoreline onto the submerged LGM land surface (i.e., the continental shelf). **Figure 8** illustrates schematically

the erosion that accompanies this shoreline transgression. **Figure 10** shows two examples of erosion associated with a transgressing shoreline. Note that the coastal plain channel shown in **Figure 10A** ends abruptly at the shoreline. This shoreline is known to be in the process of landward migration. The fact that the channel is not observed seaward of the shoreline confirms that the erosion associated with waves striking the shoreface was sufficient to erode the previous land surface and strip off the overlying several meters of sediment. **Figure 10B** illustrates a shoreline that is currently migrating landward (i.e., transgressing). Seaward of the shoreline, the surface partially exposed in the surf zone shows evidence of vegetation that comprises the roots of plants that formerly populated the delta plain. Continued wave activity at the shoreline will eventually completely remove the vegetation as well as the uppermost few meters of the delta plain. The amount of section that will eventually be eroded off is commonly in the order of 5-10 meters. This eroded sediment ultimately is deposited seaward of the shoreline as shown in **Figure 8**.

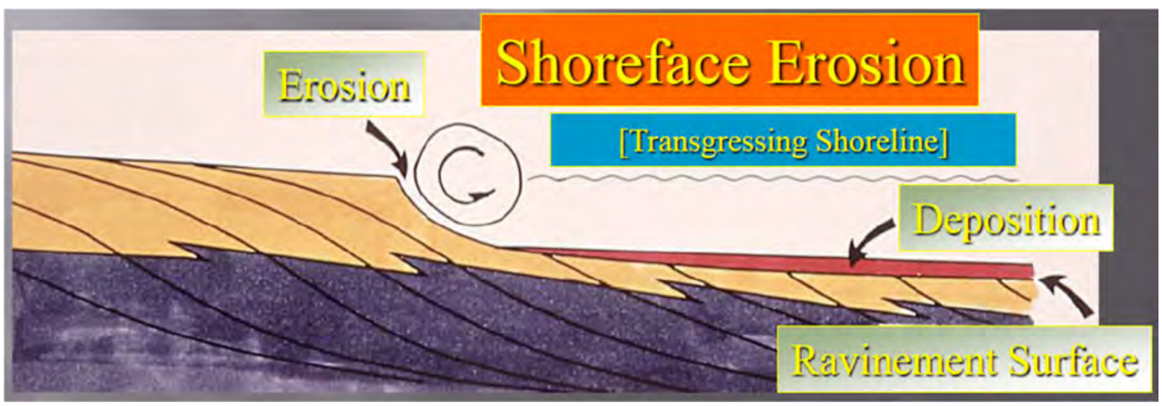


Figure 8. Schematic depiction of erosion that occurs at the shoreface through waves breaking at the shoreline. Note that the surface that is being transgressed can lose up to 5-10m off the top of the previously subaerial land surface. The material that is eroded then gets redeposited onto the shelf seaward of the shoreline.

20. Another depiction of shoreline transgression and associated erosion is illustrated in **Figure 9**, where erosion has removed a portion of the coastal plain/alluvial plain deposits. These eroded materials, which would also have included potential artifacts left behind on the original land surface, would have been re-deposited seaward of the shoreline above the erosional surface as discussed above. This erosional surface is referred to as a ravinement surface.

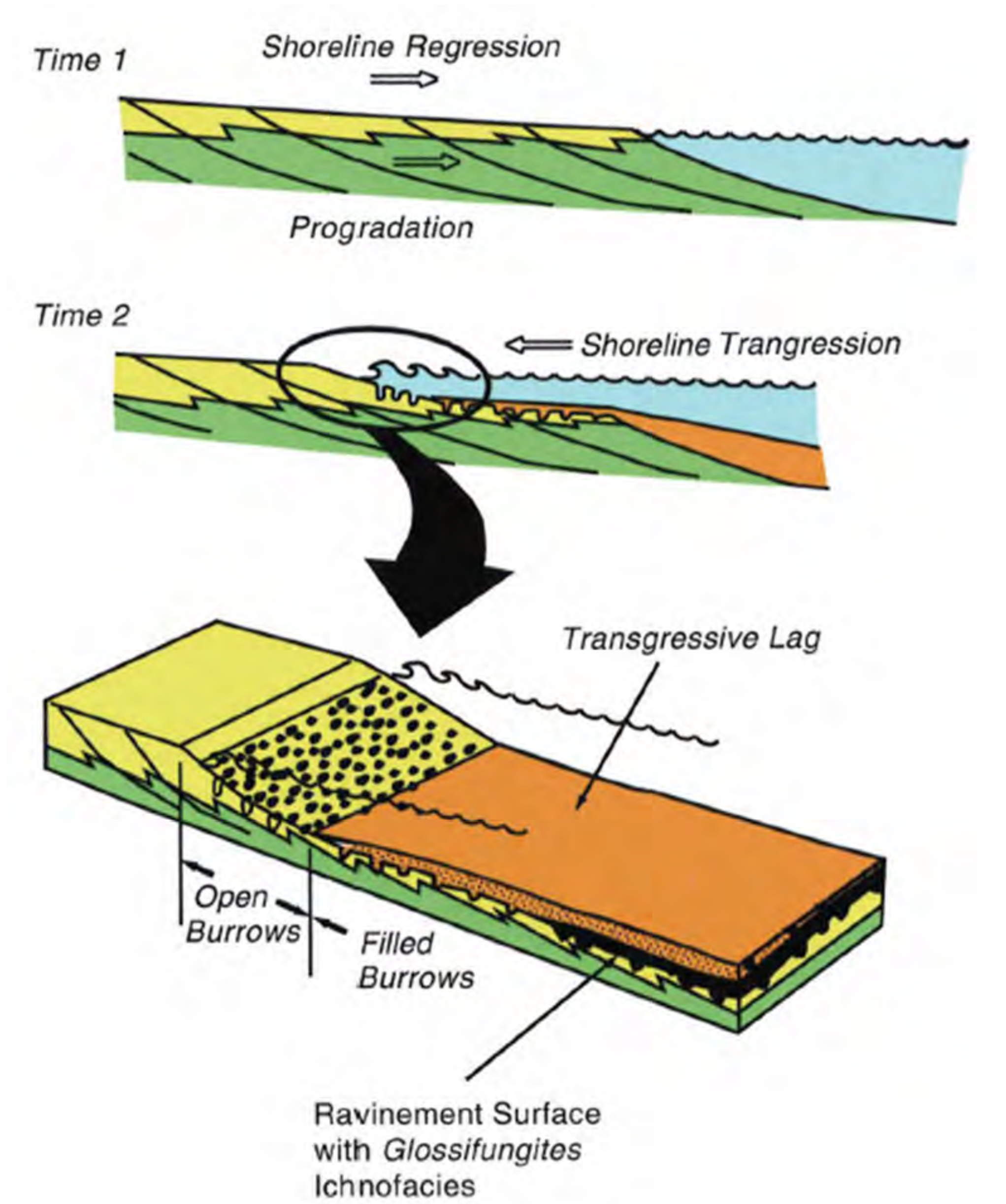


Figure 9. Time 1 indicates a shoreline at a time of sea level stability. Subsequent sea-level rise (**Time 2**) is associated with shoreline transgression (i.e., flooding) with associated erosion. The eroded materials are re-deposited seaward of the shoreline atop the previously eroded surface. This erosional surface is referred to as a ravinement surface (Posamentier and Allen, 1999).

Figure 10. Transgressing shoreline characterized by erosion of previously subaerial surface. **A)** Aerial view of a coastal plain channel that is being eroded by the transgressing shoreline (sourced from Google Earth; image of the Mississippi Delta shoreline). Note that the channel, which earlier had extended farther seaward, now ends abruptly at the eroding transgressing shoreline. As transgression continues, less and less of the channel will be preserved, because erosion shears off up to ~5-10m of the coastal plain section. **B)** Closeup view of the transgressing shoreline. Note that coastal plain vegetation currently can be observed seaward of the shoreline. Eventually, as shoreface erosion continues, even this last vestige of the coastal plain environment will be removed (image by the author).

21. The actual amount of erosion associated with wave activity at the shoreline would depend on several factors:

22. **1) The degree to which the former land surface is cemented prior to shoreline transgression.** In general, a carbonate substrate would have cemented quickly (i.e., over

years) prior to transgression and therefore would have been more difficult to erode. In my experience, rapid cementation of carbonate substrates is common and would mitigate the amount of section eroded during transgression. Consequently, the amount of erosion that would have occurred when a carbonate platform is transgressed would be significantly less than the amount of erosion that would have occurred when a sandy siliciclastic-rich coastal plain is transgressed. The LGM land surface would have been primarily a largely uncemented alluvial plain (i.e., a river system characterized by rivers and associated flood plain deposits). Where transgression occurred across the carbonate platform, significantly less erosion likely would have occurred. In either case any archeological artifacts that may have been present on that surface would have been swept away during the time of transgression and transported elsewhere.

23. **2) The intensity of wave energy at the shoreline.** In general, those coasts that have the highest wave energy are those that face a broad open seaway and those located in temperate latitudes where storms are a common phenomenon. The present study area, which lies approximately 11 degrees south of the equator is commonly not impacted by these regularly-occurring, front-related storms. However, this area does experience occasional tropical cyclones (**Fig. 11**). Also, with Timor Leste and the Indonesian archipelago lying approximately 170km to the north, there is no exposure to a broad ocean. This results in a seaway that has limited extent and therefore limited fetch (i.e., the distance between landmasses across which winds blow and ultimately form waves) and lower daily wave energy. Consequently, these two factors suggest that wave energy at the shoreline, though present, would not be extreme. Hence the general proposed limitation of up to 5-10m of erosion.

24. **3) The rate of transgression, or the amount of time that wave-related shoreline erosional processes could act upon the shoreline at one location.** With rapid transgression the erosional processes would quickly move across a previously exposed land surface tending to limit the amount of erosion that occurs. Relative to the previously discussed factors controlling the amount of shoreline erosion, this factor would have the least significance because most wave-related erosion would have occurred in association with tropical cyclones, a phenomenon that acts on time scales orders of magnitude shorter than shoreline transgression.

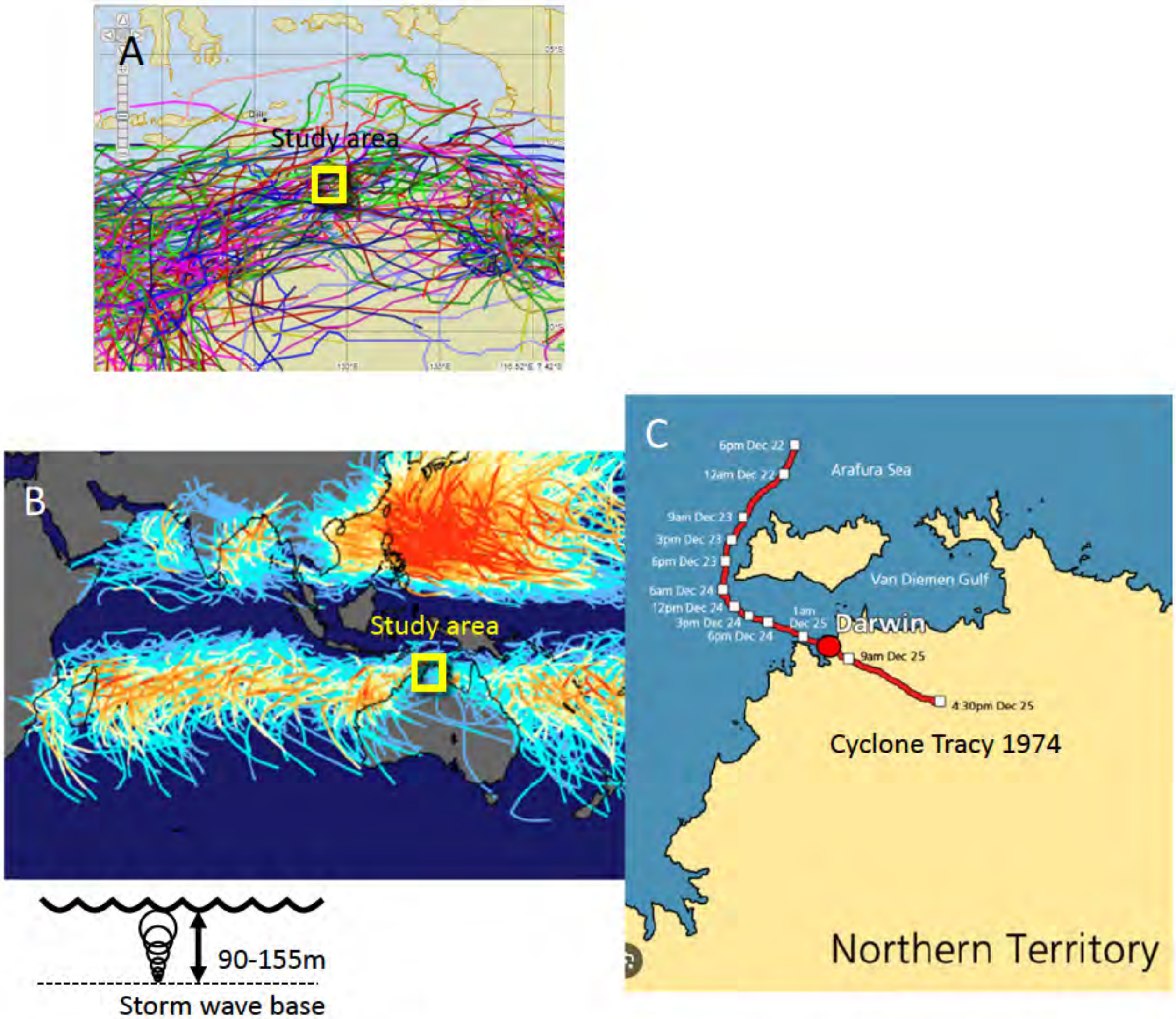


Figure 11. A) Tropical cyclone storm tracks from 1969-2022. The source is from the Australian Government Bureau of Meteorology (http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/history/tracks/). **B)** Another map of tropical cyclone storm tracks from 1851-2006. Note that the study area clearly is impacted by tropical cyclones from time to time (https://ftp.comet.ucar.edu/memory-stick/tropical/textbook_2nd_edition/print_8.htm). **C)** Storm track of Tropical Cyclone Tracy, 1974, which tracks right along the proposed pipeline pathway.

25. In summary, the land surface that was subjected to this wave energy erosion along the shoreline would be eroded, and the sediments lifted off that surface would be transported seaward and subsequently be deposited offshore – where the shore-associated wave energy is not a factor – in the form of a blanket on top of the eroded seafloor (**Fig. 8**). Along with sediments subjected to wave erosion, objects (e.g., archeological artifacts) such as stone tools, wooden objects, and other articles that may have been used by early

humans would either be lifted off the LGM land surface and incorporated into the overall eroded and ultimately re-deposited sediments, or winnowed and left behind upon that surface (see discussion below) and likely later buried. It is unlikely that such artifacts left on this surface would have been preserved *in situ* in their original setting or, in the least, the surroundings of these artifacts would have changed.

26. As an analog, Barras and Johnson (2006) document the coastline erosion that occurred as a result of Hurricanes Katrina and Rita in the Gulf of Mexico, where over one hundred square miles of land was lost. They go on to say that "storm-induced waves and currents erode the muddy wetlands soil (i.e., coastal/delta plain), causing these fragile coastlines to erode."

– Wave erosion in the open ocean during storm events

27. Once a land surface is transgressed by the shoreline, an event that occurred in this area between 18,000 and 8,000 years ago, that surface would comprise the "new" seafloor submerged by tens of meters of sea water. When tropical cyclones pass through this area, large open-ocean waves would be common.

28. The oscillatory motion of storm waves in the Arafura Sea can reach depths of up to 155m (**Fig. 11**) as stated by Fugro Survey PTY LTD (2017) and up to 90m according to the National Oceanic and Atmospheric Administration (**NOAA**) (2023). From my experience working in such settings, I have formed the view that these water depths, likely skewing towards the higher number (i.e., 155m), are reasonable estimates. With the current water depth of the shelf across which the pipeline corridor traverses (i.e., from the 18,000-year shoreline landward to the Tiwi Islands and the Australian mainland) being significantly less than 120m, the seafloor would therefore have lain above storm wave depth and be impacted by waves that occur during tropical cyclones. This oscillatory motion of the water column can be erosive and can be capable of further eroding the substrate (i.e., those deposits immediately below the seafloor). As storms wane, that sediment that has been eroded and placed into suspension in the water column during the storm is subsequently deposited upon this eroded substrate in the form of a depositional blanket.

– Tidal current erosion and re-deposition

29. Strong tidal currents are known to occur in this area, as stated by Fugro Survey PTY LTD (2017). Evidence for strong current activity on the open shelf – i.e., across the previously exposed, and now submerged, lowstand land surface – include the presence of 1) sand-sized (i.e., 0.063-2mm) to granule-sized (i.e., 2-4mm diameter) particles at the seafloor, 2) sedimentary bedforms whose asymmetry and lithology (specifically, the clast grain size) indicates that flows were strong and predominantly in one direction, that is, associated with unidirectional currents, 3) numerous channels on the seafloor, characterized by cut and fill processes (i.e., erosion and deposition), and 4) absence of accumulated sediments across the tops of bathymetric highs indicating that these highs

tend to be swept of sediments by shelf current activity (based upon observations of high-resolution seismic profiles from Fugro Survey PTY LTD, 2017 – see discussion below). The strongest currents would be observed within the channels where flows would have been focused, relative to areas across bathymetric highs outside the channels where flows would be more diffuse.

30. In general, tidal currents are caused by twice a day high/low tides. Between high and low tides, sea level can rise and fall between 1-4m in this area (Fugro Survey PTY LTD, 2017). Each time sea level rises, sea water tends to flow landward. The reverse happens when sea level falls when flow reverses and is directed seaward. These tidal currents can move at velocities capable of transporting sand and granule-sized particles as evidenced by sea-floor grab samples containing sand and shell debris (**Fig. 12**; Fugro Survey PTY LTD, 2018).

Job No.: MGP133914	Date: 12 December 2018	Time: 15:25	Sample: GS2_KP 18.3
Project: Melville Island to Barossa MRS		Time Zone: UTC +9.5	Client: Vocus Communications
Vessel: MV Bhagwan K	Geophysicist: Jerome GASNIER		Water Depth [m]: 30.0
Horizontal Datum: WGS84	Grid: WGS84		Projection: UTM Zone 52 S
Easting [m]: 643 498	Northing [m]: 8 752 268	Recovery [l]: 3.0	Sampler Capacity [l]: 12.0

Description
Very coarse, reddish, light brown SAND with shell debris

Figure 12. Seafloor grab sample from the pipeline corridor containing sand and shell debris (Fugro Survey PTY LTD, 2018).

31. Sedimentary bedforms observed on the modern seafloor in the form of sand waves are imaged by sidescan sonar (**Fig. 13**). Based on their morphology and areal distribution (i.e., closely-spaced dunes of short – less than 3km – length) these sand waves formed sub-aqueously rather than subaerially. These sediment waves are asymmetric, with one flank characterized by a gentle slope and one characterized by a significantly steeper slope, as illustrated in **Figure 14**. The gentle flank comprises the up-current facing surface, whereas the steep (i.e., avalanche) slope comprises the down-current surface. Sediments

travel as bedload (i.e., that part of the transported sediment load that is transported by bouncing or saltating across the seafloor) along the gentle flank and then avalanche down the steep flank. Clusters of these sediment waves are observed along the pipeline corridor, most of which point to strong currents directed in a landward direction. **Figure 15** illustrates in cross section a likely sand wave characterized by accretion (i.e., growth) towards the south.

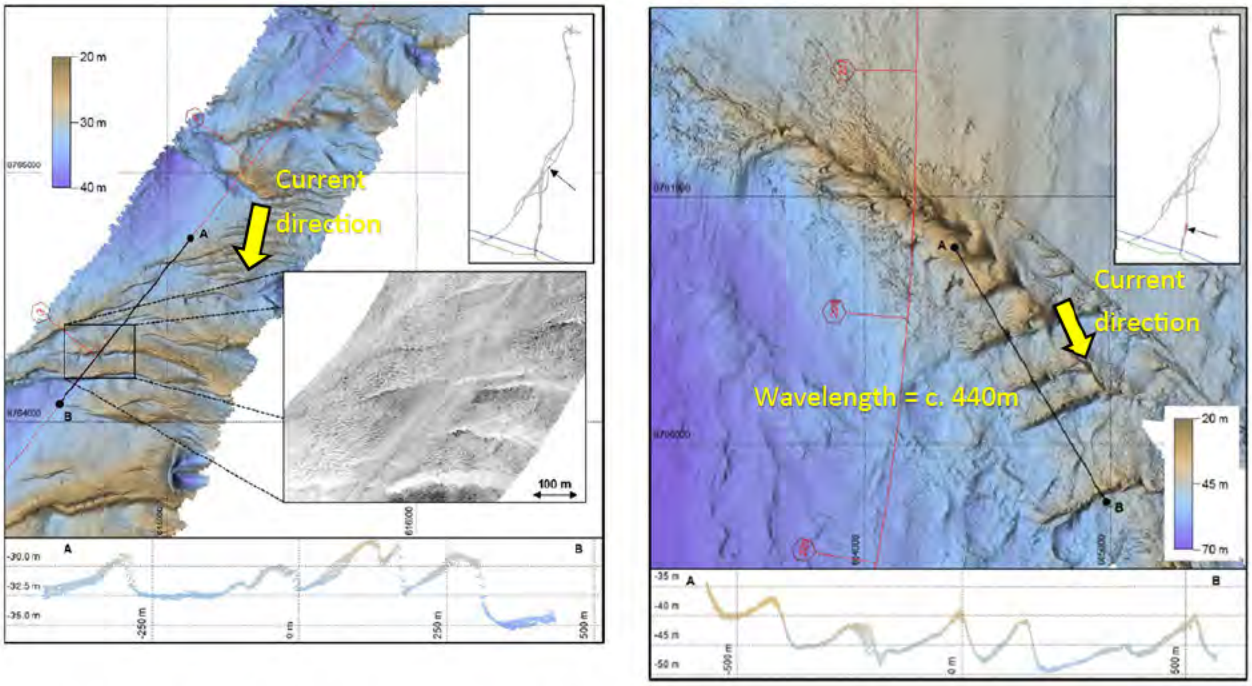


Figure 13. Sidescan sonar imagery from along the pipeline corridor illustrating the presence of sand waves. Note the asymmetry of these bedforms with gentle slopes facing north and steep slopes facing south, indicating a flow direction from north to south (Fugro Survey PTY LTD, 2017).

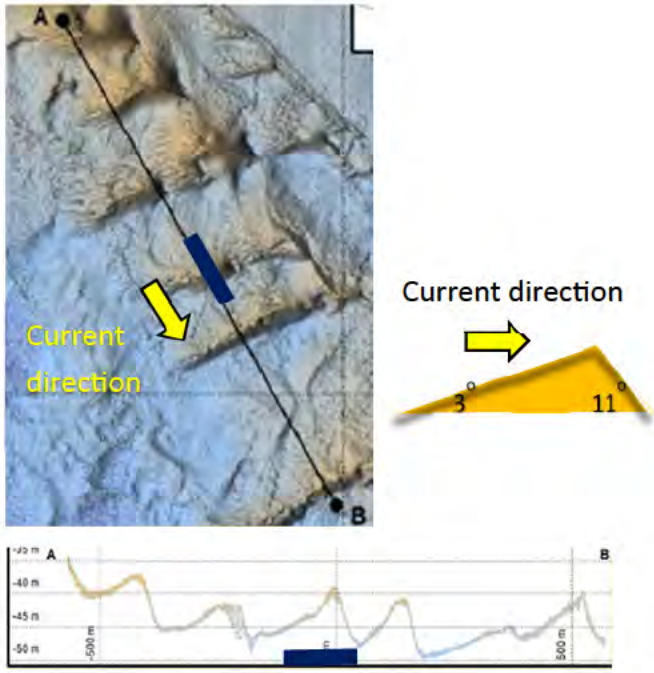


Figure 14. Closeup of sand waves and bottom profile. Note that the up-current flank is characterized by a significantly lower slope angle (i.e., 3°) than the down-current flank (i.e., 11°), indicating flow direction from north to south (Fugro Survey PTY LTD, 2017).

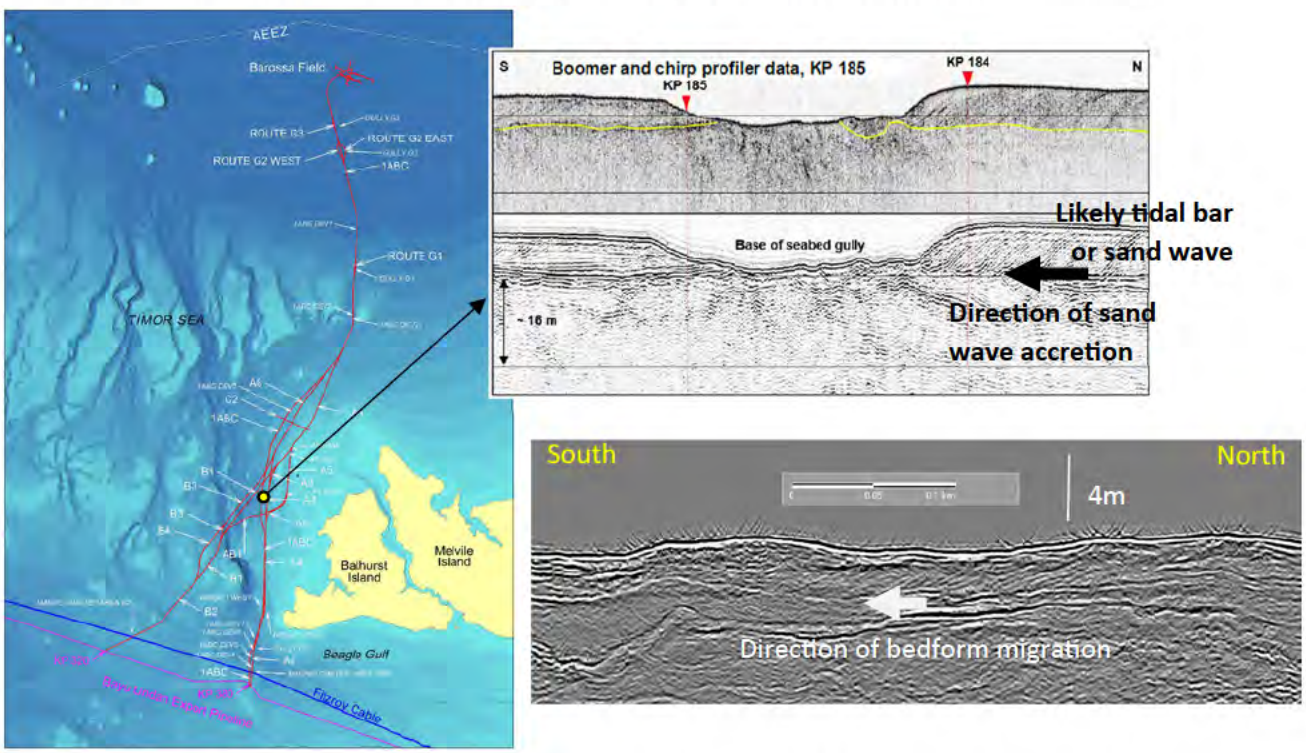


Figure 15. High resolution seismic sections illustrating sand wave accretion towards the south associated with tidal currents flowing from north to south (Fugro Survey PTY LTD, 2017).

32. In addition to sand waves, another sedimentary bedform indicative of strong tidal currents are sediment trails associated with submerged positive bathymetric features such as mounds or hills as illustrated in **Figure 16**. These sediment trails form on the lee (i.e., the down-current side) of submerged positive features on the seafloor, where sediments accumulate behind the protection of these features. Again, the indications are that strong bottom currents directed landward (i.e., from north to south) are present and are inferred to be related to tidal processes.

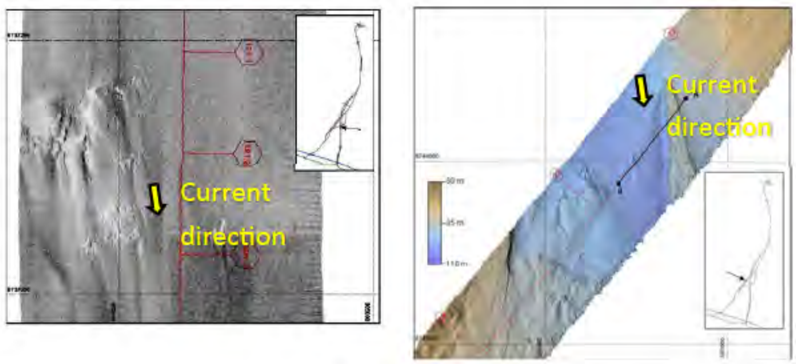


Figure 16. Sidescan sonar images of the seafloor along the pipeline corridor illustrating the presence of sediment trails as a shadow behind seafloor mounds (Fugro Survey PTY LTD, 2017).

33. The sediments that comprise the sediment waves and sediment trails are likely those deposits that had been eroded by shoreline waves, open ocean waves related to tropical cyclones, and tidal currents, and are subsequently re-distributed.

34. It is important to note that in this area, carbonate platforms with associated small patch reefs and tidal channels (see discussion below) are common and 1100km-long beach ridges, such as found farther south along the western Australian margin near Balla Balla (Lebrec, et al., 2023) are not present in the vicinity of the pipeline corridor. This is likely because farther south, the coastline of Australia was greatly affected by repeated and frequent extra-tropical cyclones such as those that travel along polar or Antarctic fronts. In contrast the Arafura Sea lies far enough north so that these extra-tropical cyclones do not reach this area. Consequently, the wave intensity, with the exception of infrequent tropical cyclones, is relatively benign there and significant beach ridges do not form. Rather, the pipeline corridor area is characterized by carbonate buildups in the form of platforms and small patch reefs. Also mitigating the wave intensity is the fact that the fetch across the shelf in the Barossa Field area is significantly less – the distance from the Australian mainland and Timor Leste to the north – than that in the western Australia area where the closest land mass is the Indian sub-continent many thousands of kilometers away.

– Tidal current channels

35. Numerous channels associated with a broad carbonate platform are observed immediately to the west of the proposed pipeline corridor (**Fig. 17**). These channels are observed to end on either side of the platform (**Fig. 4**). It is likely that these are tide-related channels that form in response to rises and falls of sea level associated with daily tides. Each time the tide goes up the platform tends to be flooded so that during that time sea water flows across the platform. When this occurs, channels that focus these tidal flows naturally form and are referred to as tidal channels. The opposite occurs when the tide goes down, at which time water tends to flow off the platform, again naturally promoting the formation of channels. The tide-related currents thus reverse themselves in response to tidal rise and fall and tend to occupy the same channels, albeit with reversed flow.

36. The largest observed channel lies near the eastern margin of the platform and is crossed by the southwestern side of the pipeline corridor. The northern mouth of the channel contains numerous bar forms or linear deposits, referred to as tidal bars (**Fig. 18**). These tidal bars comprise accumulated sediments that commonly are observed at estuary or tidal channel mouths and comprise continent-derived siliciclastic (if available) or carbonate grains (i.e., animal skeletal debris and other carbonate clasts) and is further evidence for the presence of currents through these channels. **Figure 19** illustrates an analog for the carbonate platform and associated tidal channels observed in Miocene deposits offshore northeast of Madura Island, Indonesia. Note that the channels crosscut the platform and end at the platform margin. In general, tidal currents are likely to impact the entire area of the Arafura Sea, however they would be strongest where focused through channels. As a consequence of this focused and locally high-velocity flow, these channels have not completely filled in with sediment and remain as channels on the modern seafloor.

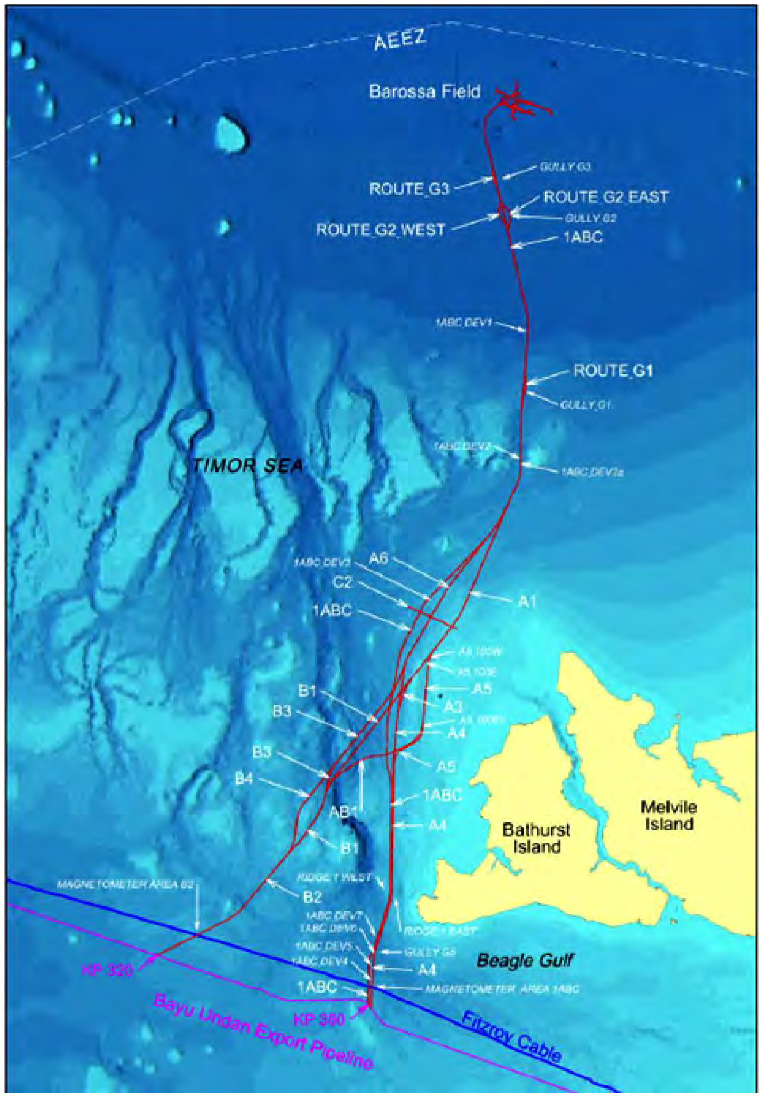


Figure 17. Present-day bathymetry map of the Arafura Sea shelf illustrating the presence of numerous channels cutting across the submerged shelf. These channels likely were of tidal origin and most active when the carbonate shelf was emergent and active during the transgression of the shelf.

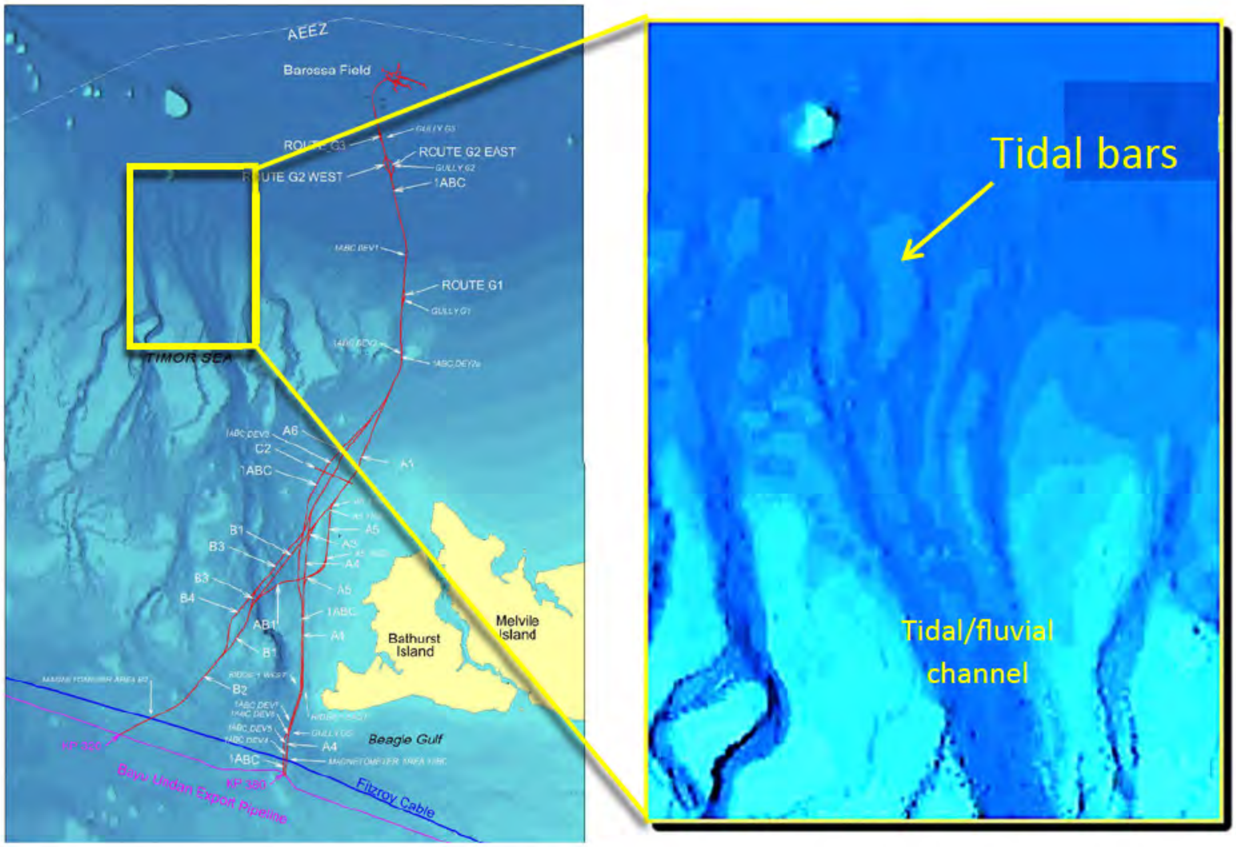


Figure 18. Detail from **Figure 17** illustrating the presence of tidal channel mouth bars associated with the largest of the channels across the carbonate platform.

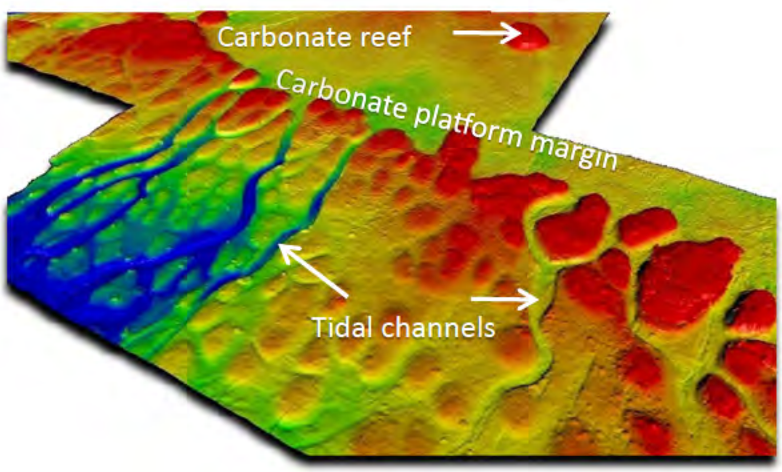


Figure 19. Analog example of tidal channels cutting across a carbonate platform from 3D seismic data offshore northeast of Madura Island, Indonesia (Posamentier et al., 2010).

37. The largest of these channels (i.e., the one shown in **Figure 18**) may be of mixed origin, possibly having been a fluvial (i.e., river) channel connected to the Australian mainland when sea level was lower (e.g., during the LGM), and then occupied by tidal currents after the shelf was flooded. The present-day relief of these submerged channels is up to 35m from platform top to channel floor (**Fig. 20**). Note the bald bathymetric high (i.e., a topographically high landform that is devoid of sediment cover) on the western flank of this channel (**Fig. 20**). This supports the inference that any sediments eroded from the platform top as well as sediments sourced from siliciclastic plumes (see discussion below) would not be preserved there, but rather be swept into nearby bathymetric low locations by tidal currents.

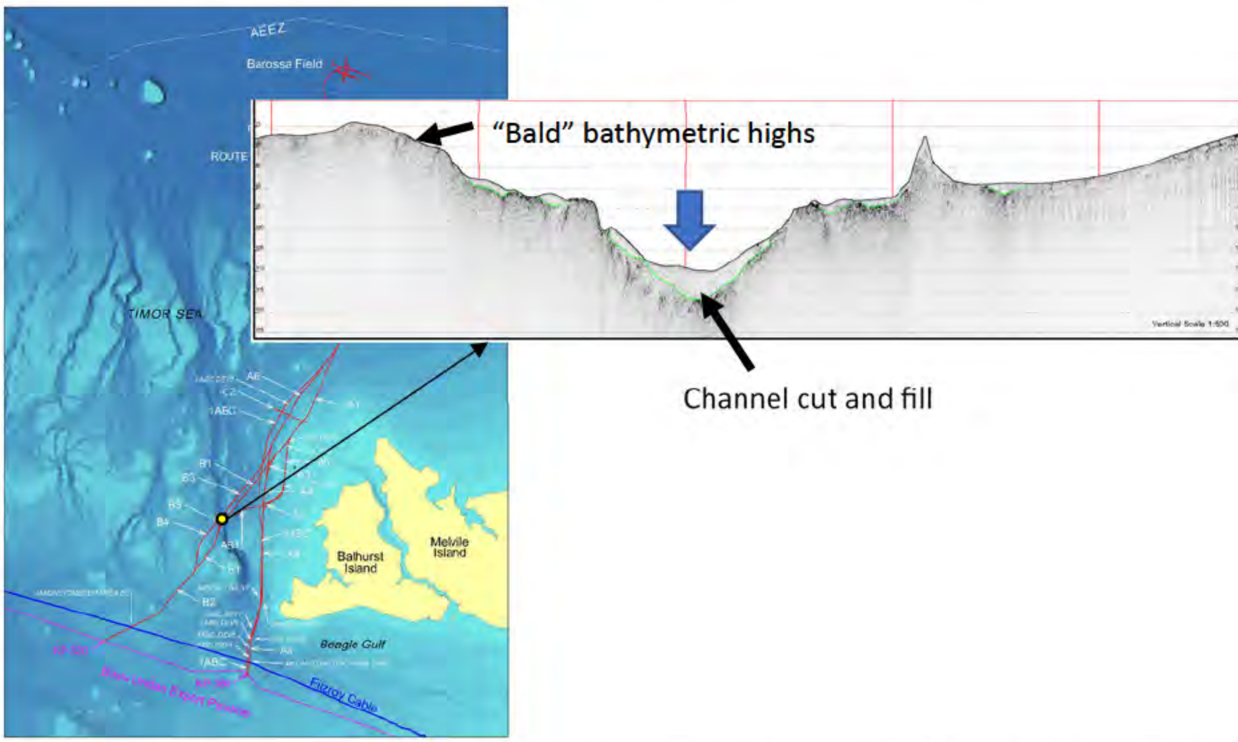


Figure 20. High resolution seismic section across a deeply incised tidal channel. The profile indicates the presence of fill deposits within the channel and bald bathymetric highs on the channel flanks (Fugro Survey PTY LTD, 2017).

38. The platform channels are dynamic landforms. That is, at times they are characterized by erosion – this occurs during intervals when tidal flow velocity is high – and at times they are characterized by sedimentation – this occurs when tidal currents wane. The result is repeated cutting and filling, a process that does not lend itself preservation of originally-deposited material *in situ*.

– Sediment plumes

39. Sediments carried by river systems are transported primarily as bedload and suspended load. The coarsest sediments tend to be transported along the bed, bouncing (or saltating) along a channel floor as they travel towards the river mouths. The suspended load comprises those sediments that are suspended in the water column because they are light enough to be brought into suspension by the turbulence of river flow. These fine-grained sediments (i.e., silt and clay sized particles) are ultimately deposited where river flow velocity wanes sufficiently to allow them to settle out onto the riverbed or onto the shelf where the river flow emerges from the river mouth and slowly traverses the seafloor. Across the shelf, those suspended sediments spread out in the open ocean within the upper part of the water column as they drift slowly seaward, forming plumes seaward of the river mouths. These sediments slowly settle out of suspension and are deposited onto the seafloor as a blanket or drape deposit. However, such drape or blanketing deposits will not be observed ubiquitously in that they will not be able to accumulate in those areas impacted by strong tidal currents, but rather be deposited in those areas where tidal currents are characterized by lower flow velocity such as bathymetrically low areas.

40. The sediments transported and redeposited in this way tend to be rich in siliciclastic sediments brought from the Australian mainland to the river mouths. **Figure 21** illustrates an analog example of a sediment plume in the Mediterranean Sea, related to the Tiber River, Italy, when it was at flood stage. These sediments commonly comprise siliciclastic silt or clay sized particles sourced from the Italian mainland. Eventually, these sediments will fall out of suspension and onto the underlying seafloor.

Figure 21. Satellite image of a sediment plume across the nearshore Mediterranean Sea surface associated with suspended sediments brought in by the Tiber River (https://www.esa.int/ESA_Multimedia/Images/2019/02/Sediment_plume_at_sea).

41. In summary, the agents of erosion can have a significant effect on the LGM land surface. Along with sediments eroded off the top of this surface, objects (e.g., archeological artifacts) would also have been removed. LGM landforms such as hills and fluvial channels with associated floodplains would have seen their uppermost sections removed. Where flooding occurred across a carbonate substrate such as a carbonate platform less erosion likely would have occurred because of the tendency for these deposits to have been cemented shortly after deposition. Nonetheless, any objects left upon this surface likely would have been removed.

– *Winnowing of the seafloor*

42. Winnowing is the process by which fine-grained sediments are preferentially separated and removed from coarser sediments by flowing water. In the case of flooded landforms, waves and currents can selectively erode fine-grained sediments from the flooded surface and leave behind coarser sediments and objects (that could include archeological artifacts), which would have been too heavy to have been eroded and transferred elsewhere. Where winnowing is most likely to occur would be on flooded bathymetric high areas such as flooded carbonate platforms that would be impacted by storm waves and within channels that would be impacted by tidal currents. In both instances however, the periodic nature of these processes (i.e., episodic tropical cyclones and fluctuating tidal currents) means that with each high energy event (i.e., storm or tidal current) there is a period referred to as a waxing phase when the energy level increases

and increased erosion occurs followed by a period referred to as a waning phase when the energy level decreases and re-deposition occurs. Consequently, winnowing commonly occurs early in one of these events (i.e., the waxing phase) and is followed by re-sedimentation late in one of these events (i.e., the waning phase).

43. Of particular interest is what one would expect along the pipeline pathway. As shown in **Figure 22**, the pipeline path, located to the east of the carbonate platform, traverses few if any channels or paleo-topographic highs. Because of this, winnowing would not likely have impacted the terrain underlying the pipeline pathway where such features are absent. Moreover, as discussed above, the presence of extensive sediment trails and sand waves in the pipeline corridor indicates that 8,000 years ago, after flooding of the shelf since, sedimentation rather than winnowing became the dominant process along this corridor.

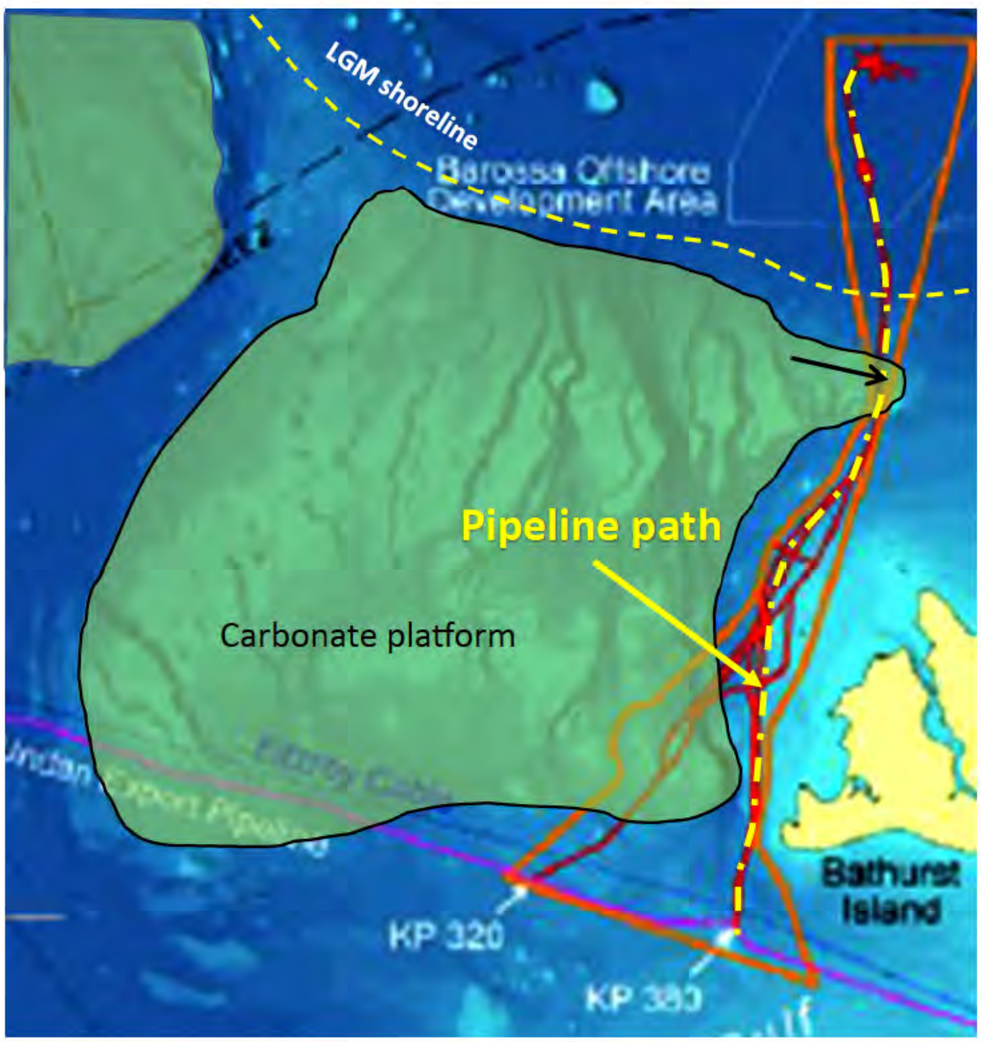


Figure 22. Detail of pipeline corridor. Note that the pipeline traverses only a very small portion of the carbonate platform (note black arrow). Most of the pipeline traverse passes over continental slope and shelf terrain, with the shelf being the site of the LGM land surface. With the exception of the eastern-most margin of the carbonate platform, this surface likely was characterized by alluvial deposition.

Analog for deposition during lowstand and rapidly rising sea-level intervals

44. Data from a 3D seismic survey across the Barossa Field in the Arafura Sea generally provides an analog for the evolution of depositional systems forming under the influence of changing sea level in that area. Imagery both in section and in map view acquired from this seismic survey illustrates the evolution of landforms – the section or vertical view images provide insights with respect to stratigraphy (i.e., the study of the layering of the deposits and their architectural characteristics), whereas the map views provide insights with respect to the paleo-geomorphology (i.e., the study of ancient landforms). 3D seismic surveys constitute a geophysical tool that yields three-dimensional images of the subsurface. These data sets are acquired by oil and gas exploration companies as a means of assessing subsurface geology and mitigating risk related to the presence of various lithologies. The resulting data can be characterized as a cube of subsurface information, which can be sliced much like a CAT scan to reveal stratigraphic architecture when sliced vertically and ancient landforms when sliced horizontally.

45. Although the field area, and therefore the Barossa Field 3D seismic survey, lies seaward of the 18,000-year shoreline, which formed during the LGM, deeper in the 3D section the data reveals that earlier Pleistocene sea-level lowstands were associated with shorelines that lay to the north of the Barossa Field. Thus, during these earlier sea-level lowstands, at least pre-dating 100,000 years before the present, the Barossa Field area was characterized by numerous fluvial channels crossing a broad alluvial plain. Consequently, the paleo landscapes, where fluvial systems can be observed at pre-LGM depths below the Barossa Field, can serve as a useful analog for the landscapes along the pipeline corridor that characterized the LGM.

46. **Figure 23** illustrates a time slice (i.e., **Slice 1**) through the 3D seismic volume at the level of these fluvial systems. Note the abundance of numerous small meandering channel systems typical of alluvial systems, all flowing northwards away from the Australian mainland ultimately feeding a shoreline that lay to the north of this 3D seismic dataset. Overlying these deposits, the seismic section is characterized by a continuous seismic reflection (**Fig. 23**) indicating the presence of a continuous lithology that could be interpreted as either carbonate platform deposits or possibly siliciclastic plume deposits. With either interpretation, these deposits represent a cessation of fluvial deposition, which corresponds to sedimentation at the time the shelf (and the associated alluvial

system) had been flooded. Directly overlying these deposits, small carbonate buildups are observed (**Slice 2** of **Fig. 23**). These buildups, which were small islands at the time during which they were active, have an elliptical shape, with their long axes oriented approximately north-south. This shape asymmetry is likely due to the presence of active north-south tidal currents, similar to the tidal currents that currently characterize the modern seafloor. If there were no tidal currents active, then the buildups would have been circular in shape. With active currents, carbonate growth tends to align itself with the direction of current flow, resulting in oval or elliptical shape.

47. Subsequent to the deposition of these carbonate buildups, fluvial channels can be observed to weave their way between these islands, again heading for a shoreline that lay seaward of the Barossa Field area. This apparent relationship of carbonate islands and alluvial plains suggests that after deposition of carbonate buildups, which produced islands in a shallow shelf setting, sea level must have fallen, resulting in termination of carbonate buildup activity and subaerially exposing the seafloor, leaving the carbonate buildups as isolated hills towering over an adjacent alluvial plain. Subsequently, as shown on the seismic section (**Fig. 23**), the alluvial system as well as the carbonate buildups were overlain by a relatively thin but continuous deposit. These late-stage deposits correspond to sedimentation by plumes as well as tidally reworked sediments in the form of a drape/blanket deposit across the entire area, the timing of which likely corresponds to highstand deposition at least in part of Holocene age when the shoreline lay landward of this location.

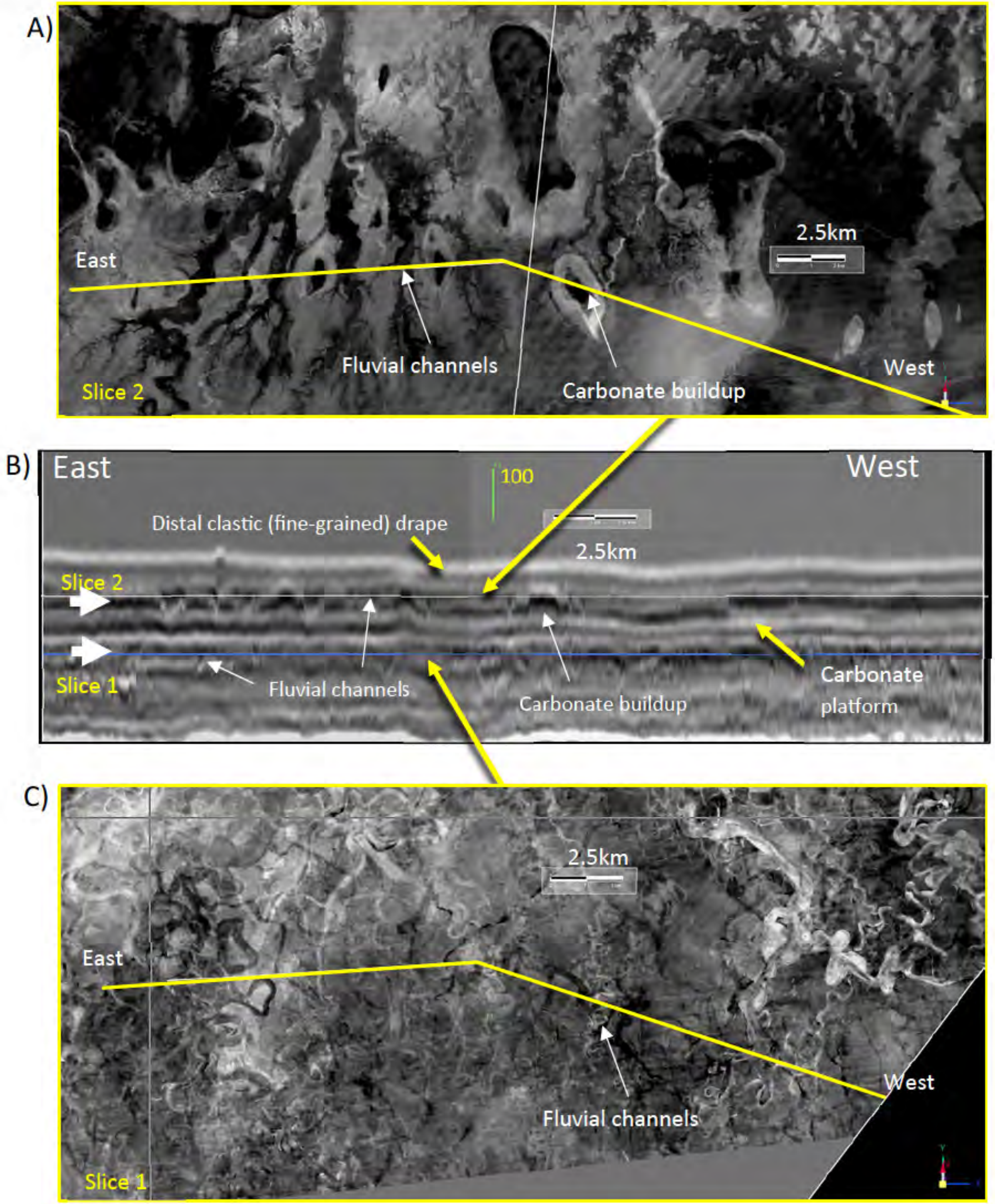
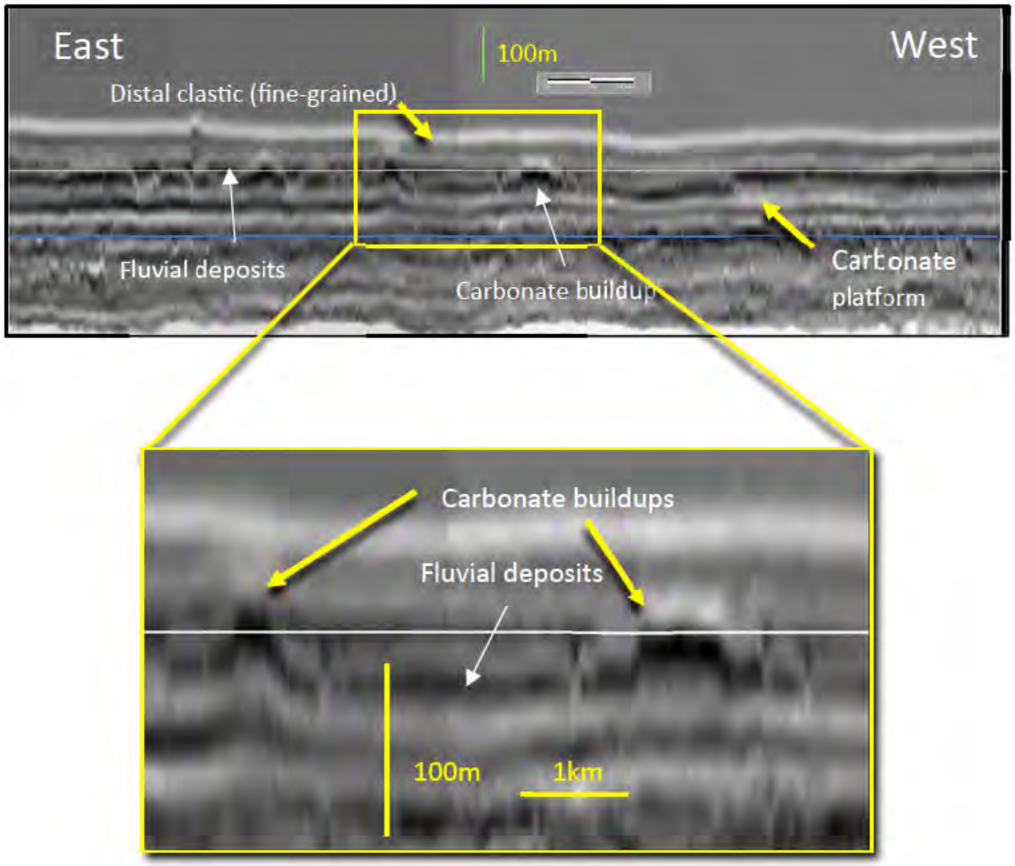
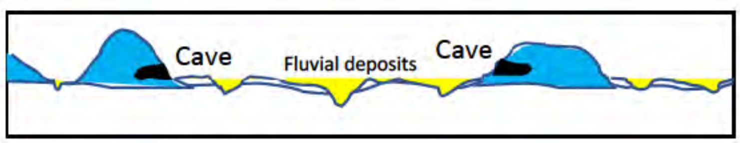


Figure 23. Seismic images from the Barossa Field 3D seismic survey illustrating pre-LGM landforms, possibly dating to pre-100,000 YBP. Precise dating of these landforms is not possible because of absence of age-dating information. In any case, these features certainly predate the LGM in age. Seismic section **B)** shows the level of two time slices from the 3D seismic volume over the Barossa Field, with **Slice 1** being older and **Slice 2**,

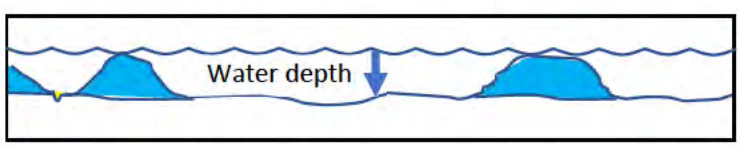
higher up in the section, being younger. **Slice 1** shown in **C)** is a horizontal slice through the data oriented parallel to the paleo-surface and illustrates the presence of a subaerial alluvial plain characterized by numerous meandering river channels. **Slice 2** shown in **A)** is a horizontal slice through the data higher up in the section and is characterized by numerous small-scale carbonate buildups, with fluvial channels weaving their way around these positive features. In the section view shown in **B)**, fluvial deposits shown on **Slice 1** can be observed to be overlain by a through-going seismic reflection likely indicative of a widespread uniform deposit that could be either a carbonate platform or a fine-grained siliciclastic drape/blanket deposit. These deposits are then overlain by the small carbonate buildups and later fluvial deposits shown on **Slice 2** that occupy the lows between the buildups during a later lowstand of sea level.

48. **Figure 24** illustrates a close-up detail of the stratigraphic (i.e., section view) expression of small carbonate buildups with fluvial deposits observed within the topographic lows between the buildups. While the carbonate buildups were active, this shelf area was characterized by water depths of approximately 25m, based upon their relief as measured directly from the seismic section. Subsequent to carbonate deposition, sea level fell and the seafloor, which had been at this water depth, would then have been subaerially exposed and the site of fluvial deposition. During this time of sea-level lowstand, it is possible that caves could have formed within these carbonate deposits (pre-LGM). This scenario of highstand of sea level followed by a fall and possible cave formation did not play out with respect to the post-LGM period, inasmuch as there was no significant fall of sea level once the post 18,000 year sea-level lowstand had passed (**Fig. 3A**).





Time 2: Fluvial deposition during



Time 1: Carbonate deposition during

Figure 24. Detail of carbonate and fluvial stratigraphic relationship. During sea-level highstand carbonate buildups can occur. During subsequent lowstand the buildups would be subaerially exposed with the possibility of cave formation. Whereas this is the likely scenario in the area of the Barossa Field during pre-LGM lowstand time, this scenario would not have been the case along the pipeline pathway because after the LGM there were no significant sea-level falls.

Discussion

49. The pipeline corridor lies on the eastern flank of a broad carbonate platform (**Fig. 1**). The pipeline path highlighted in yellow, passes to the west of Bathurst Island (**Fig. 22**). Starting at Barossa Field, the pipeline first passes across approximately 60km of continental slope. This part of the pipeline traverse would have been submerged below sea level even during the LGM, as it lies below the modern 120m water depth. As such, this surface would not have experienced significant post-LGM erosion. Rather, it would have been the site of slow deposition of fine-grained sediments associated with fine-grained suspended plume sediments slowly falling out of the water column, draping or blanketing the seafloor.

50. Landward of the modern 120m water depth contour line – i.e., the LGM shoreline – the pipeline would traverse what is now a submerged shelf, but 18,000 years ago it would have been an alluvial plain. Also, on that surface, carbonate deposits may have been present as the pipeline passes over the eastern fringe of a carbonate platform. The platform margins are inferred based on the bathymetric map (**Fig. 24**) where the platform is characterized by shallower water and crosscut by numerous channels of tidal origin. The shelf edge, likewise, is identified based on the modern water depth contour of -120m. Commonly, also, platform margins are associated with small patch reefs that fringe and lie just seaward of the platform margin. It is not clear from the available data whether these carbonates were present prior to post-LGM flooding and forced river systems to go around or through the platform area or were deposited only during the post-LGM sea-level rise. The data required for confirmation of this hypothesis would be additional seismic profiles coupled with age-dates for the section along the pipeline route. In any case, only a small part of the pipeline passes over the carbonate platform clearly imaged on the bathymetric maps of the modern seafloor (**Fig. 2**).

51. The gap between the carbonate platform and Bathurst Island is one of low relief in the absence of channels or hills, as indicated by the bathymetric map (**Fig. 24**). We do know that there were active tidal currents in this area as evidenced by the presence of sand waves and sediment trails. And as noted above, these sedimentary features all indicate a predominant flow landward south – i.e., landward-directed flood tides.

52. The amount of erosion associated with agents of erosion that acted on the LGM surface – including shoreline and open ocean storm waves as well as tidal currents – would range from a minimum of less than a meter where cementation of the substrate has occurred (i.e., within carbonate deposits) up to 5-10m where unconsolidated alluvial deposition had occurred.

53. Any objects (e.g., archeological artifacts) left behind on the LGM surface likely would have been significantly impacted first by erosion and removal and later by sedimentation over the top of the LGM surface. Consequently, based on available evidence, few if any of

these artifacts would have been preserved in this area. Generally, the best location for artifact preservation to have occurred would be within the sheltered confines of caves or overhangs that could offer partial protection, and which would likely have survived transgressive erosion. However, because there were no sea-level falls after 18,000 years ago – an essential requirement for cave formation – no caves likely would be present here.

54. If we broaden our evaluation of the land surface to include those surfaces and landforms prior to 18,000 years ago, we can see that there likely were numerous sea-level rises and falls that impacted the evolution of this landscape. That is, there were likely several episodes of carbonate buildup activity followed by sea-level fall, which could have resulted in cave formation. Having said this, when we examine the substrate in the vicinity of the pipeline pathway, we observe that there appear to be no such precursor carbonate buildups in that area. Hence, it is likely that in this area no caves, which would have potentially sheltered any artifacts, would be present. Likewise, the area of the pipeline pathway is devoid of significant landforms such as channels or hills and caves; it is essentially featureless, as it lies between the carbonate platform and Bathurst Island.

Summary and conclusions

55. The modern seafloor and substrate that underlies the proposed pipeline corridor was repeatedly flooded by the sea and then exposed subaerially. This cycle likely was repeated multiple times during the Pleistocene Epoch, which was characterized by alternating periods of glacially-related sea-level highstands and lowstands. With respect to the modern seafloor, of primary interest would be the conditions related to the period of time from the last glacial maximum at 18,000 years ago to the present. This time interval includes the last part of the Pleistocene Epoch, which ended approximately 10,000 years ago, and the subsequent Holocene Epoch. During this time sea level rose from approximately 120m lower than today to the position where it is now.

56. When sea level was 120m lower than today, the shoreline lay considerably farther seaward, located approximately 60km south of Barossa Field (**Fig. 4**). If there were habitations present at that time, they would be associated with artifacts left behind on alluvial plains that existed at that time. Subsequent flooding that occurred after the last glacial maximum (i.e., 18,000 years ago) was associated with erosion of this alluvial substrate as well as later sedimentation above the eroded surface. Widespread erosion would have been associated with wave action at the shoreline as well as tropical cyclone related wave action in the open ocean, in addition to erosion by tidal currents. Consequently, the original 18,000 year land surface with associated possible artifacts likely would have been eroded and removed, before being covered up by sediments later during the time of sea-level rise and shelf flooding.

References

3D Seismic Reflection Survey for Barossa Field, 2016.

Bard, E., Hamelin, B., Arnold, M., Montaggioni, L., Cabloch, g., Faure, G., and Rougerie, F., 1996, Deglacial sea-level record from Tahiti corals and the timing of global meltwater discharge; Nature v. 382, p. 241-244

Barras, J. and J.B. Johnston, 2006. USGS reports latest land-water changes for southeastern Louisiana, USGS Fact Sheet; https://doi.org/10.3133/fs20063030.

Bourget, J., Ainsworth, R.B., and Nanson, R., 2014, Origin of mixed carbonate and siliciclastic sequences at the margin of a "giant" platform during the Quaternary (Bonaparte Basin, NW Australia); *in* Verwer, K., Playton, T.E., and Harris, P.M., eds., SEPM Special Publication 105, Deposits, Architecture, and Controls on Carbonate Margin, Slope, and Basinal Settings, p. 157-177.

Bourget, J., Ainsworth, R.B., and Thompson, S., 2014, Seismic stratigraphy and geomorphology of a tide or wave dominated shelf-edge delta (NW Australia): Process-based classification from 3D seismic attributes and implications for the prediction of deep-water sands; Marine and Petroleum Geology, v. 57, p. 359-384.

Fugro Survey PTY LTD, 2015, Barossa Field development – infield and pipeline routing interim geophysical survey, Volume 1G – Drawings – Export pipeline alternate route and export pipeline additional route; Fugro Document No. GP1531, 19p.

Fugro Survey PTY LTD, 2017, Barossa Project – Bathymetry, geophysical and environmental survey services, Volume 1A – Results Report; Fugro Document No. FRPT GP1577, 84p.

Fugro Survey PTY LTD, 2018, Melville Island to Barossa marine route survey, Volume 1 – Results; Fugro Document No. 127171-52-REP-003, 53p.

Haq, B.U., Hardenbol, J., and Vail., 1987, Chronology of Fluctuating Sea Levels since the Triassic. Science, 235, 1156-1167.

Lambeck, L., Rouby, H., Purcell, A., Sambridge, M., and Sun, Y., Sea level and global ice volumes from the Last Glacial Maximum to the Holocene; Proceedings of the National Academy of Sciences (PNAS), v. 111, No. 43, p. 15296-15303.

Lebrec, U., Riera, R., O'Leary, M., Webster, J.M., Yokoyama, Y., Gliganic, L.A., Lang, S.C., and Paumard, V., 2023, Drilling 1100-km-long seafloor ridges reveals how paleoshrelines control carbonate shelf morphologies (North West Shelf, Australia); Quaternary Science Reviews, v. 312, p. 108-164.

Posamentier, H.W., and Allen, G.P., 1999, Siliciclastic Sequence Stratigraphy: Concepts and Applications: Concepts in Sedimentology and Paleontology, v. 9, SEPM (Society for Sedimentary Geology), Tulsa, OK, 210 p.

Posamentier, H.W., Laurin, P., Warmath, A., Purnama, M., and Drajat, D., 2011, Seismic Stratigraphy and Geomorphology of Oligocene to Miocene Carbonate Buildups, Offshore Madura, Indonesia; *in* Morgan, W.A., George, A.D., Harris, P.M., Kupecz, J.A., Sarg, J.F., eds., SEPM Special Publication 95, Cenozoic Carbonate Systems of Australasia, p. 104-121.

Przeslawski, R,. Daniell, J., Anderson, T., Barrie, J.V., Heap, A., Hughes, M., Li, J., Potter, A., Radke, L., Siwabessy, J., Tran, M., Whiteway, T., and Nichol, S., 2011. Seabed Habitats and Hazards of the Joseph Bonaparte Gulf and Timor Sea, Northern Australia; Geoscience Australia, Record 2011/40.

National Oceanic and Atmospheric Administration (NOAA), 2023, How do hurricanes impact the deep ocean? URL: How do hurricanes impact the deep ocean? : Ocean Exploration Facts: NOAA Office of Ocean Exploration and Research.

Sediment plumes in the Mediterranean Sea;
https://www.esa.int/ESA_Multimedia/Images/2019/02/Sediment_plume_at_sea

Slingerland, R. and Smith, N. D., 2004, River avulsions and their deposits, Annu. Rev. Earth Pl. Sc., v. 32, p. 257–285.

Vail, P.R., Mitchum Jr., R.M., Thompson III, S., 1977, Seismic Stratigraphy and Global Changes of Sea Level: Part 3. Relative Changes of Sea Level from Coastal Onlap: Section 2. Application of Seismic Reflection Configuration to Stratigraphic Interpretation; *in* Seismic Stratigraphy: Applications to Hydrocarbon Exploration, Payton, C.E., ed., AAPG Memoir 26, p. 63-81.

Appendices

Appendix 1. Harmonized Expert Witness Code of Conduct

Appendix 2. Expert Evidence Practice Note

Appendix 3. Henry W. Posamentier Curriculum Vitae

Appendix 1.

Annexure A

HARMONISED EXPERT WITNESS CODE OF CONDUCT[2]

APPLICATION OF CODE

1. This Code of Conduct applies to any expert witness engaged or appointed:

   (a) to provide an expert's report for use as evidence in proceedings or proposed proceedings; or

   (b) to give opinion evidence in proceedings or proposed proceedings.

GENERAL DUTIES TO THE COURT

2. An expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

CONTENT OF REPORT

3. Every report prepared by an expert witness for use in Court shall clearly state the opinion or opinions of the expert and shall state, specify or provide:

   (a) the name and address of the expert;

   (b) an acknowledgment that the expert has read this code and agrees to be bound by it;

   (c) the qualifications of the expert to prepare the report;

   (d) the assumptions and material facts on which each opinion expressed in the report is based [a letter of instructions may be annexed];

   (e) the reasons for and any literature or other materials utilised in support of such opinion;

   (f) (if applicable) that a particular question, issue or matter falls outside the expert's field of expertise;

   (g) any examinations, tests or other investigations on which the expert has relied, identifying the person who carried them out and that person's qualifications;

   (h) the extent to which any opinion which the expert has expressed involves the acceptance of another person's opinion, the identification of that other person and the opinion expressed by that other person;

   (i) a declaration that the expert has made all the inquiries which the expert believes are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which the expert regards as relevant have, to the

[2] Approved by the Council of Chief Justices' Rules Harmonisation Committee

knowledge of the expert, been withheld from the Court;

(j) any qualifications on an opinion expressed in the report without which the report is or may be incomplete or inaccurate;

(k) whether any opinion expressed in the report is not a concluded opinion because of insufficient research or insufficient data or for any other reason; and

(l) where the report is lengthy or complex, a brief summary of the report at the beginning of the report.

SUPPLEMENTARY REPORT FOLLOWING CHANGE OF OPINION

4. Where an expert witness has provided to a party (or that party's legal representative) a report for use in Court, and the expert thereafter changes his or her opinion on a material matter, the expert shall forthwith provide to the party (or that party's legal representative) a supplementary report which shall state, specify or provide the information referred to in paragraphs (a), (d), (e), (g), (h), (i), (j), (k) and (l) of clause 3 of this code and, if applicable, paragraph (f) of that clause.

5. In any subsequent report (whether prepared in accordance with clause 4 or not) the expert may refer to material contained in the earlier report without repeating it.

DUTY TO COMPLY WITH THE COURT'S DIRECTIONS

6. If directed to do so by the Court, an expert witness shall:

   (a) confer with any other expert witness;

   (b) provide the Court with a joint-report specifying (as the case requires) matters agreed and matters not agreed and the reasons for the experts not agreeing; and

   (c) abide in a timely way by any direction of the Court.

CONFERENCE OF EXPERTS

7. Each expert witness shall:

   (a) exercise his or her independent judgment in relation to every conference in which the expert participates pursuant to a direction of the Court and in relation to each report thereafter provided, and shall not act on any instruction or request to withhold or avoid agreement; and

   (b) endeavour to reach agreement with the other expert witness (or witnesses) on any issue in dispute between them, or failing agreement, endeavour to identify and clarify the basis of disagreement on the issues which are in dispute.

Appendix 2.

FEDERAL COURT OF AUSTRALIA

EXPERT EVIDENCE PRACTICE NOTE (GPN-EXPT)

General Practice Note

1. INTRODUCTION

1.1 This practice note, including the *Harmonised Expert Witness Code of Conduct* (**"Code"**) (see Annexure A) and the *Concurrent Expert Evidence Guidelines* (**"Concurrent Evidence Guidelines"**) (see Annexure B), applies to any proceeding involving the use of expert evidence and must be read together with:

(a) the Central Practice Note (CPN-1), which sets out the fundamental principles concerning the National Court Framework (**"NCF"**) of the Federal Court and key principles of case management procedure;

(b) the Federal Court of Australia Act 1976 (Cth) (**"Federal Court Act"**);

(c) the *Evidence Act 1995* (Cth) (**"Evidence Act"**), including Part 3.3 of the Evidence Act;

(d) Part 23 of the *Federal Court Rules 2011* (Cth) (**"Federal Court Rules"**); and

(e) where applicable, the Survey Evidence Practice Note (GPN-SURV).

1.2 This practice note takes effect from the date it is issued and, to the extent practicable, applies to proceedings whether filed before, or after, the date of issuing.

2. APPROACH TO EXPERT EVIDENCE

2.1 An expert witness may be retained to give opinion evidence in the proceeding, or, in certain circumstances, to express an opinion that may be relied upon in alternative dispute resolution procedures such as mediation or a conference of experts. In some circumstances an expert may be appointed as an independent adviser to the Court.

2.2 The purpose of the use of expert evidence in proceedings, often in relation to complex subject matter, is for the Court to receive the benefit of the objective and impartial assessment of an issue from a witness with specialised knowledge (based on training, study or experience - see generally s 79 of the Evidence Act).

2.3 However, the use or admissibility of expert evidence remains subject to the overriding requirements that:

(a) to be admissible in a proceeding, any such evidence must be relevant (s 56 of the Evidence Act); and

(b) even if relevant, any such evidence, may be refused to be admitted by the Court if its probative value is outweighed by other considerations such as the evidence

being unfairly prejudicial, misleading or will result in an undue waste of time (s 135 of the Evidence Act).

2.4 An expert witness' opinion evidence may have little or no value unless the assumptions adopted by the expert (ie. the facts or grounds relied upon) and his or her reasoning are expressly stated in any written report or oral evidence given.

2.5 The Court will ensure that, in the interests of justice, parties are given a reasonable opportunity to adduce and test relevant expert opinion evidence. However, the Court expects parties and any legal representatives acting on their behalf, when dealing with expert witnesses and expert evidence, to at all times comply with their duties associated with the overarching purpose in the Federal Court Act (see ss 37M and 37N).

3. INTERACTION WITH EXPERT WITNESSES

3.1 Parties and their legal representatives should never view an expert witness retained (or partly retained) by them as that party's advocate or "hired gun". Equally, they should never attempt to pressure or influence an expert into conforming his or her views with the party's interests.

3.2 A party or legal representative should be cautious not to have inappropriate communications when retaining or instructing an independent expert, or assisting an independent expert in the preparation of his or her evidence. However, it is important to note that there is no principle of law or practice and there is nothing in this practice note that obliges a party to embark on the costly task of engaging a "consulting expert" in order to avoid "contamination" of the expert who will give evidence. Indeed the Court would generally discourage such costly duplication.

3.3 Any witness retained by a party for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based in the specialised knowledge of the witness[1] should, at the earliest opportunity, be provided with:

(a) a copy of this practice note, including the Code (see Annexure A); and

(b) all relevant information (whether helpful or harmful to that party's case) so as to enable the expert to prepare a report of a truly independent nature.

3.4 Any questions or assumptions provided to an expert should be provided in an unbiased manner and in such a way that the expert is not confined to addressing selective, irrelevant or immaterial issues.

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[1] Such a witness includes a "Court expert" as defined in r 23.01 of the Federal Court Rules. For the definition of "expert", "expert evidence" and "expert report" see the Dictionary, in Schedule 1 of the Federal Court Rules.

4. ROLE AND DUTIES OF THE EXPERT WITNESS

4.1 The role of the expert witness is to provide relevant and impartial evidence in his or her area of expertise. An expert should never mislead the Court or become an advocate for the cause of the party that has retained the expert.

4.2 It should be emphasised that there is nothing inherently wrong with experts disagreeing or failing to reach the same conclusion. The Court will, with the assistance of the evidence of the experts, reach its own conclusion.

4.3 However, experts should willingly be prepared to change their opinion or make concessions when it is necessary or appropriate to do so, even if doing so would be contrary to any previously held or expressed view of that expert.

Harmonised Expert Witness Code of Conduct

4.4 Every expert witness giving evidence in this Court must read the *Harmonised Expert Witness Code of Conduct* (attached in Annexure A) and agree to be bound by it.

4.5 The Code is not intended to address all aspects of an expert witness' duties, but is intended to facilitate the admission of opinion evidence, and to assist experts to understand in general terms what the Court expects of them. Additionally, it is expected that compliance with the Code will assist individual expert witnesses to avoid criticism (rightly or wrongly) that they lack objectivity or are partisan.

5. CONTENTS OF AN EXPERT'S REPORT AND RELATED MATERIAL

5.1 The contents of an expert's report must conform with the requirements set out in the Code (including clauses 3 to 5 of the Code).

5.2 In addition, the contents of such a report must also comply with r 23.13 of the Federal Court Rules. Given that the requirements of that rule significantly overlap with the requirements in the Code, an expert, unless otherwise directed by the Court, will be taken to have complied with the requirements of r 23.13 if that expert has complied with the requirements in the Code and has complied with the additional following requirements. The expert shall:

(a) acknowledge in the report that:

(i) the expert has read and complied with this practice note and agrees to be bound by it; and

(ii) the expert's opinions are based wholly or substantially on specialised knowledge arising from the expert's training, study or experience;

(b) identify in the report the questions that the expert was asked to address;

(c) sign the report and attach or exhibit to it copies of:

(i) documents that record any instructions given to the expert; and

(ii) documents and other materials that the expert has been instructed to consider.

5.3 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the other parties at the same time as the expert's report.

6. CASE MANAGEMENT CONSIDERATIONS

6.1 Parties intending to rely on expert evidence at trial are expected to consider between them and inform the Court at the earliest opportunity of their views on the following:

(a) whether a party should adduce evidence from more than one expert in any single discipline;

(b) whether a common expert is appropriate for all or any part of the evidence;

(c) the nature and extent of expert reports, including any in reply;

(d) the identity of each expert witness that a party intends to call, their area(s) of expertise and availability during the proposed hearing;

(e) the issues that it is proposed each expert will address;

(f) the arrangements for a conference of experts to prepare a joint-report (see Part 7 of this practice note);

(g) whether the evidence is to be given concurrently and, if so, how (see Part 8 of this practice note); and

(h) whether any of the evidence in chief can be given orally.

6.2 It will often be desirable, before any expert is retained, for the parties to attempt to agree on the question or questions proposed to be the subject of expert evidence as well as the relevant facts and assumptions. The Court may make orders to that effect where it considers it appropriate to do so.

7. CONFERENCE OF EXPERTS AND JOINT-REPORT

7.1 Parties, their legal representatives and experts should be familiar with aspects of the Code relating to conferences of experts and joint-reports (see clauses 6 and 7 of the Code attached in Annexure A).

7.2 In order to facilitate the proper understanding of issues arising in expert evidence and to manage expert evidence in accordance with the overarching purpose, the Court may require experts who are to give evidence or who have produced reports to meet for the purpose of identifying and addressing the issues not agreed between them with a view to reaching agreement where this is possible ("**conference of experts**"). In an appropriate case, the Court may appoint a registrar of the Court or some other suitably qualified person ("**Conference Facilitator**") to act as a facilitator at the conference of experts.

7.3 It is expected that where expert evidence may be relied on in any proceeding, at the earliest opportunity, parties will discuss and then inform the Court whether a conference of experts and/or a joint-report by the experts may be desirable to assist with or simplify the giving of expert evidence in the proceeding. The parties should discuss the necessary arrangements for any conference and/or joint-report. The arrangements discussed between the parties should address:

(a) who should prepare any joint-report;

(b) whether a list of issues is needed to assist the experts in the conference and, if so, whether the Court, the parties o r the experts should assist in preparing such a list;

(c) the agenda for the conference of experts; and

(d) arrangements for the provision, to the parties and the Court, of any joint-report or any other report as to the outcomes of the conference ("**conference report**").

Conference of Experts

7.4 The purpose of the conference of experts is for the experts to have a comprehensive discussion of issues relating to their field of expertise, with a view to identifying matters and issues in a proceeding about which the experts agree, partly agree or disagree and why. For this reason the conference is attended only by the experts and any Conference Facilitator. Unless the Court orders otherwise, the parties' lawyers will not attend the conference but will be provided with a copy of any conference report.

7.5 The Court may order that a conference of experts occur in a variety of circumstances, depending on the views of the judge and the parties and the needs of the case, including:

(a) while a case is in mediation. When this occurs the Court may also order that the outcome of the conference or any document disclosing or summarising the experts' opinions be confidential to the parties while the mediation is occurring;

(b) before the experts have reached a final opinion on a relevant question or the facts involved in a case. When this occurs the Court may order that the parties exchange draft expert reports and that a conference report be prepared for the use of the experts in finalising their reports;

(c) after the experts' reports have been provided to the Court but before the hearing of the experts' evidence. When this occurs the Court may also order that a conference report be prepared (jointly or otherwise) to ensure the efficient hearing of the experts' evidence.

7.6 Subject to any other order or direction of the Court, the parties and their lawyers must not involve themselves in the conference of experts process. In particular, they must not seek to encourage an expert not to agree with another expert or otherwise seek to influence the outcome of the conference of experts. The experts should raise any queries they may have in relation to the process with the Conference Facilitator (if one has been appointed) or in

accordance with a protocol agreed between the lawyers prior to the conference of experts taking place (if no Conference Facilitator has been appointed).

7.7 Any list of issues prepared for the consideration of the experts as part of the conference of experts process should be prepared using non-tendentious language.

7.8 The timing and location of the conference of experts will be decided by the judge or a registrar who will take into account the location and availability of the experts and the Court's case management timetable. The conference may take place at the Court and will usually be conducted in-person. However, if not considered a hindrance to the process, the conference may also be conducted with the assistance of visual or audio technology (such as via the internet, video link and/or by telephone).

7.9 Experts should prepare for a conference of experts by ensuring that they are familiar with all of the material upon which they base their opinions. Where expert reports in draft or final form have been exchanged prior to the conference, experts should attend the conference familiar with the reports of the other experts. Prior to the conference, experts should also consider where they believe the differences of opinion lie between them and what processes and discussions may assist to identify and refine those areas of difference.

Joint-report

7.10 At the conclusion of the conference of experts, unless the Court considers it unnecessary to do so, it is expected that the experts will have narrowed the issues in respect of which they agree, partly agree or disagree in a joint-report. The joint-report should be clear, plain and concise and should summarise the views of the experts on the identified issues, including a succinct explanation for any differences of opinion, and otherwise be structured in the manner requested by the judge or registrar.

7.11 In some cases (and most particularly in some native title cases), depending on the nature, volume and complexity of the expert evidence a judge may direct a registrar to draft part, or all, of a conference report. If so, the registrar will usually provide the draft conference report to the relevant experts and seek their confirmation that the conference report accurately reflects the opinions of the experts expressed at the conference. Once that confirmation has been received the registrar will finalise the conference report and provide it to the intended recipient(s).

8. CONCURRENT EXPERT EVIDENCE

8.1 The Court may determine that it is appropriate, depending on the nature of the expert evidence and the proceeding generally, for experts to give some or all of their evidence concurrently at the final (or other) hearing.

8.2 Parties should familiarise themselves with the *Concurrent Expert Evidence Guidelines* (attached in Annexure B). The Concurrent Evidence Guidelines are not intended to be exhaustive but indicate the circumstances when the Court might consider it appropriate for

concurrent expert evidence to take place, outline how that process may be undertaken, and assist experts to understand in general terms what the Court expects of them.

8.3 If an order is made for concurrent expert evidence to be given at a hearing, any expert to give such evidence should be provided with the Concurrent Evidence Guidelines well in advance of the hearing and should be familiar with those guidelines before giving evidence.

9. FURTHER PRACTICE INFORMATION AND RESOURCES

9.1 Further information regarding Expert Evidence and Expert Witnesses is available on the Court's website.

9.2 Further information to assist litigants, including a range of helpful guides, is also available on the Court's website. This information may be particularly helpful for litigants who are representing themselves.

J L B ALLSOP
Chief Justice
25 October 2016

Appendix 3.

Henry W. Posamentier, Ph.D.

[redacted]

EDUCATION:

B.Sc. 1970-Geology, City College of New York
M.A. 1973-Geology, Syracuse University
Ph.D. 1975-Geology, Syracuse University

EMPLOYMENT HISTORY:

2019-present

Adjunct professor of geology – University of Western Australia

2014-present

Geological and geophysical consultant

Worldwide consultant to petroleum exploration and development companies advising on exploration and development strategies and risks, with respect to depositional settings worldwide, which range from fluvial to shallow marine to deep marine, and from clastics to carbonates. Activities include consulting, mentoring/teaching, short courses (sequence stratigraphy, seismic stratigraphy and seismic geomorphology). Companies consulted for include: Chevron worldwide, Woodside Petroleum, OMV, Shell, PTTEP, Petronas, YPF, Cairn Energy, Posco International, African Petroleum, Suncor, Pluspetrol, and Maersk Petroleum.

2011-2014

Sr. Advisor

Chevron Energy Technology Company – Global advisor to New Ventures Group; Responsible for technical excellence in integrated geology and geophysics (seismic stratigraphy and seismic geomorphology) within Chevron and liaison with external geological organizations (Academia, Industry, Government).

2007-2011

Sr. Consultant Geologist

Chevron Energy Technology Company – Global advisor to New Ventures Group; Responsible for technical excellence in integrated geology and geophysics within Chevron and liaison with external geological organizations (Academia, Industry, Government).

2006-2007

Distinguished Advisor

Anadarko Petroleum Corporation – Highest technical position within the company. Responsible for technical excellence in geology throughout the corporation and liaison with external geological activities (Academia, Industry, Government).

2004-2006

Chief Geologist

Anadarko Petroleum Corporation – reporting to the executive vice president of APC. Responsible for technical excellence in geology throughout the corporation.

2002-2004

General Manager of Geoscience and Technology

Anadarko Canada Corporation – General Manager of Geoscience Technology for Anadarko Canada reporting to the president of ACC. Managers of geology, geophysics, and petrophysics comprise my direct reports.

2001-2002

Manager of Geology

Anadarko Canada Corporation – Charged with managing and enhancing geological technical excellence for exploration and production staff.

2000-2001

Senior Technology Advisor

Veritas exploration Services Inc. – Applied research involving the extraction of stratigraphic insights using 3D seismic data. Specialization in deep-water depositional systems. Conducted seismic visualization as well as applied sequence stratigraphy workshops.

1997-2000

Senior Exploration Advisor

ARCO Indonesia Inc. – Exploration using *Clastic Facies, 3D Seismic* and *Sequence Stratigraphy*. Mapped the prolific Talang Akar and Upper Cibulakan formations in offshore northwest Java, and the Mesozoic and Tertiary sections in eastern Indonesia. As a result, most recently I identified two new play types that are currently the focus of our exploration effort in this basin. Follow-up prospects have been generated and will be tested later this year or early next to evaluate these play types.

Participated in the evaluation of several farm-in opportunities on behalf of ARCO Indonesia; mentored junior and senior geologists and geophysicists. Participated in technical workshops on ARCO interests offshore Malaysia, offshore West Africa, the Black Sea, Far East Russia (Sakhalin), the Philippines, the Alaska North Slope, and the East China Sea. Worked extensively with 3D seismic and borehole data to develop techniques and principles for extracting stratigraphic/depositional systems information.

1991-1997

Research and Senior Exploration Advisor

ARCO Exploration and Production Technology - Exploration employing *Sequence Stratigraphy, Seismic Stratigraphy and Clastic Facies;* helped establish an exploration program on Sakhalin Island with a well to be drilled next year; proposed a depositional model that has been incorporated into a development scheme for ARCO's Alaskan North Slope Alpine Field (300 MMBO recoverable); proposed a depositional model to optimize the development drilling of ARCO's Alaskan North Slope Tabasco Field. Participated in numerous workshops both in the USA as well as internationally and mentored junior and senior geologists and geophysicists.

1987-1991

Technical Excellence Group - Esso Resources Canada Ltd. Exploration and field development using sequence and seismic stratigraphy in the Western Canada Sedimentary Basin; Viking and Cardium formations as well as other intervals. Numerous successful wells were drilled. The application of detailed sequence stratigraphic concepts at the field level led to the identification of previously overlooked, independently pressured oil zones that were subsequently exploited and produced. Mentoring junior and senior geologists and geophysicists.

1981-1987

Group Leader and Research Specialist- Clastic Facies Seismic Stratigraphy - Exxon Production Research Company, Houston. With others, developed the exploration concepts and ideas that led to the introduction of sequence stratigraphy as an exploration and production tool.

<u>1979-1981</u>

Senior Research Geologist - Exxon Production Research Company - Exploration using seismic stratigraphy. Worked closely with Dr. Peter Vail, whose pioneering geophysics led to the widely accepted concepts of seismic stratigraphy.

<u>1974-1979</u>

Assistant Professor - Geology, Department of Geosciences, Rider College, NJ – Taught introductory geology, geomorphology, glacial geology, conservation of natural resources, photogeology, stratigraphy and sedimentation.

Industry activities – basins analyzed/stratigraphic studies

Alberta basin (Canada)
Neuquen basin (Argentina)
Malvinas basin (Argentina)
Santos basin (Brazil)
Campos basin (Brazil)
North Sea (UK)
Viking graben (Norway)
Norwegian Sea (Norway)
Orphan basin, Newfoundland (Canada)
Scotian shelf (Canada)
Jeanne d'Arc Basin (Canada)
North slope, Alaska (USA)
US Western Interior basins
Cook Inlet (Alaska)
Barents Sea (Norway)
Sakhalin Island (Russia)
Black Sea (Russia)
Black Sea (Turkey)
Lake Maracaibo (Venezuela)
Carnarvon basin (Australia)
Gulf of Thailand (Thailand/Malaysia)
Offshore Sarawak/Sabah (Malaysia)
Offshore NW Java (Indonesia)
Onshore Sumatra
South China Sea (China/Vietnam)
Bay of Bengal (Myanmar/India)
Kuwait onshore

Bangladesh
Makassar Strait (Indonesia)
Java Sea, offshore Bali (Indonesia)

Stratigraphic studies included clastics (from deep water to shallow water to non-marine) and carbonates. Common objectives were to predict lithologies and establish stratigraphic framework with the ultimate objective being the mitigation of risk with respect to exploration and field development. These studies commonly focused on the identification of exploration opportunities.

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APPLIED RESEARCH INTERESTS:

I have published widely in siliciclastic sequence stratigraphy ranging from development of the basic concepts to application of this approach, from continental to deep-sea environments. More recently I have been involved in the development of the discipline of seismic geomorphology and in particular its application to petroleum exploration and development. My current research involves the integration of seismic and sequence stratigraphy, and seismic geomorphology for the development of geologic models and the prediction of the presence of reservoir, source, and seal facies using 3D seismic data. In addition to teaching courses in sequence stratigraphy and general clastic depositional systems ranging from deep-marine to fluvial, I have also been active in teaching courses in 3D seismic visualization.

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PROFESSIONAL RECOGNITION, CITATIONS, AWARDS:

2022	Townsend Harris Medal for distinguished alumni, City College of New York
2014	Winchell Distinguished Alumni Award from the Department of Earth Sciences at Syracuse University
2012	Robert Berg Award for Outstanding Petroleum Research (AAPG)
2010	William Smith Medal for contributions to applied and economic aspects of geology (Royal Geological Society, London)
2009	A.I. Levorsen Memorial Award for Best Paper at the Pacific Section, AAPG
2008	SEPM Pettijohn Medal for Excellence in Sedimentology
2007	Best Luncheon presentation – CSEG 2006
2006	AAPG Distinguished Lecturer to Europe
2004	Link award for best CSPG Luncheon presentation
2001	Matson Award for best paper, AAPG Annual Meeting (Denver)
2000	Best Oral Presentation SEPM/AAPG Annual Meeting (New Orleans)
1998-1999	AAPG International Distinguished Lecturer to the Middle East

1997	Elected Councilor for Sedimentology, SEPM
1996-1997	AAPG International Distinguished Lecturer to the Former Soviet Union
1996	Elected to Russian Academy of Natural Science
1996	Elected to International Academy (Russia) of Science and Nature and Society
1992-1993	AAPG Distinguished Lecturer (USA)
1990	Best Oral Presentation, Energy and Minerals Division, AAPG Annual Convention (San Francisco)
1990	Honorable mention award for Best Poster Presentation at AAPG Annual Convention (San Francisco)
1971-1972	Fulbright-Hays Fellowship to Austria

COURSES TAUGHT (IN-HOUSE AND EXTERNAL):

Introduction to Sequence Stratigraphy - Exxon Production Research Co., ARCO Exploration and Production Technology, Esso Resources Canada, Esso UK, ARCO British Ltd., ARCO Oil and Gas Co., Houston Geological Society, University of Copenhagen, Bureau of Economic Geology (Austin), Petronas, Woodside Petroleum, Polish National Oil Company

Advanced Seminar in Sequence Stratigraphy - Exxon Production Research Co., ARCO Exploration and Production Technology

Advanced Clastic Facies - ARCO Exploration and Production Technology, Esso Resources Canada, Ltd.

Applied Sequence Stratigraphy Workshop - ARCO Oil and Gas Co., ARCO Exploration and Production Technology, Esso Germany (BEB), Esso UK, Esso France, ARCO Indonesia, Esso Resources Canada, Inc.; Indonesian Petroleum Association

Second High-Resolution Sequence Stratigraphy Conference, Pyrenees, Spain - Organized conference with Emiliano Mutti.

Sequence Stratigraphy Field Seminar - ARCO Exploration and Production, Technology, Exxon Production Research Co., Esso Resources Canada, Ltd.

Sequence Stratigraphy Applied to Well Logs and Core - University of Calgary, ARCO Exploration and Production Technology, Esso Resources Canada, Ltd.

Sequence Stratigraphy - Concepts and Application – AAPG/CSPG/IPA Short Course taught many times during past 10 years

Sequence Stratigraphy Short Course, Universidad Rio do Sul, Porto Alegre, Brazil - Taught short course on behalf of AIOGC.

Principles of Seismic Stratigraphy - Exxon Production Research Co., ARCO Exploration and Production Technology, Esso Resources Canada, Ltd.

Seismic Stratigraphy Workshop - ARCO Exploration and Production Technology, Exxon Production Research Co., Esso Resources Canada

Applied Seismic Stratigraphy - ARCO Exploration and Production Technology, Exxon Production Research Co.

3D Seismic Visualization – Nautilus Training Consortium, Anadarko Petroleum Corporation, CSPG

Seismic Geomorphology and Seismic Stratigraphy – AAPG Short Course

Seismic Geomorphology and Seismic Stratigraphy – Concepts and Applications Chevron in-house

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CONFERENCES ORGANIZED AND CONVENED:

Facies Associations in a Sequence Stratigraphic Framework, Symposium, 13th International Sedimentological Congress, Nottingham, England, 1990

1991 NUNA Conference on High-Resolution Sequence Stratigraphy, Research Conference, Banff, Alberta, Canada (Co-chair with D.A. Leckie)

Variations in Siliciclastic Depositional Systems within a Sequence Stratigraphic Framework, Symposium, 1991 AAPG Annual Convention, Dallas, Texas

Fluvial Response to Base Level Changes: Eustatics vs. Tectonics, Symposium, 1991 GSA Annual Meeting

SEPM Sequence Stratigraphy Research Group Meeting (at AAPG Annual Convention) 1992-1994

SEPM Deep Water Turbidites Research Group Meeting (at AAPG Annual Convention) 1992-1994

Co-chairman of Working Group 1 (Sequence Stratigraphy and Sea-Level Fluctuations in the Cretaceous) 1992-1996

1994 High Resolution Sequence Stratigraphy Research Conference; Tremp, Spain (Co-chair with E. Mutti)

Stratal Architecture, Relative Sea Level and Exploration/Exploitation Significance; SEPM Research Symposium, AAPG Annual Convention, Houston, Texas, 1995

Deep-Water Sedimentary Systems of Arctic and North Atlantic Margins, Geological Society of Norway; Stavanger, Norway, 2004

Seismic Geomorphology; the Use of 3D Seismic Data in the Analysis of Seascapes and Landscapes and How They Form; Royal Geological Society/SEPM, Houston Texas, 2005

Mass Transport Deposits dedicated session; AAPG 2006

Interpretation Visualization in the Petroleum Industry – AAPG Hedberg Conference 2014

INVITED LECTURES:

University of Alberta
University of Calgary
Dalhousie University
University of Saskatchewan
Alberta Research Council
Alberta Geological Society
Colorado School of Mines
Colorado State University
Stanford University
US Geological Survey, Menlo Park
University of Texas at Austin
Bureau of Economic Geology, Austin
McMaster University
Rutgers University
Lamont-Doherty Geological Observatory
University of Wyoming
University of Indiana
University of Copenhagen
Houston Geological Society
West Texas Geological Society
North Texas Geological Society
Dallas Geological Society
Portland State Geological Society
Montana Geological Society
Yuzhno Sakhalinsk, Sakhalin, Russia
Okha, Sakhalin, Russia
Hebrew University, Israel
Aramco Geological Society
Geological Society of Oman
Turkish Geological Society
Azerbeijan Geological Society
Egyptian Geological Society
ITB University, Bandung, Indonesia
Abu Dhabi Geological Society
Malaysian Geological Society
Montana College of Mineral Science and Technology
Myanmar Geoscience Society
Wyoming Geological Association
US Geological Survey, Denver
Saskatchewan Geological Society
Institute of Sedimentology and Petroleum Geology, Calgary
University of Wisconsin
Syracuse University
City College of New York
Ohio State University
Ball State University
University of Pittsburgh
Ottawa University
Indonesia Petroleum Association
University of Liverpool
Universidade Federaldo Rio Grande do Sul, Brazil
Petrobras, Brazil
Vietnam Petroleum Institute
University of Utrecht
Almaty, Kazakstan
Moscow, Russia
St. Petersburg, Russia
China National Offshore Oil Company, Beijing, China

University of Gadja Mada, Yogyakarta,
Indonesia
ONGC India, Chennai
ONGC India, Mumbai
ChevronTexaco Technology Forum
Tulsa Geological Society
New Orleans Geological Society
SEPM Annual Meeting Luncheon
Presentation
Robert Sheriff Distinguished Lecture;
Houston
Kansas University
Tudor Lecture – Indiana University
Southwest AAPG Luncheon (Ft. Worth and Abilene)
University of Oklahoma

BOOKS EDITED:

SEPM Special Publication 42: Sea Level Change - an Integrated Approach, 1988
NUNA Conference on High Resolution Sequence Stratigraphy, Proceedings Volume, 1991
IAS Special Publication 18: Sequence Stratigraphy and Facies Associations, 1993
AAPG Memoir 58: Siliciclastic Sequence Stratigraphy: Recent Developments and Applications, 1993
Second High Resolution Sequence Stratigraphy Proceedings Volume, 1994
SEPM Special Publication 76, Tropical Deltas of Southeast Asia, 2003
SEPM Special Publication 84, Facies Models Revisited, 2006
Geological Society, London, Special Publication 277, Seismic geomorphology: applications to hydrocarbon exploration and production, 2007
SEPM Special Publication 93, Mass Transport Deposits 2011

PATENTS:

Patent nos. AU2012212530B2, US9063246B2, 8861309B2 – Exploitation of self-consistency and differences between volume images and interpreted spatial/volumetric context; Granted 2015-07-09 (Australia), Granted 2015-06-23 (USA)

Patent nos. AU2012212520A, US8972195B2, US8838391B2, US9121968B2 – Extracting geologic information from multiple offset stacks and/or angle stacks; Granted 2015-03-03 (USA)

Patent no. US8355898B2, System and method for modeling flow events responsible for the formation of a geological reservoir; Granted 2013-01-15 (USA)

Patent no. EP2748644B1, US8843353B2, Hybrid deterministic-geostatistical earth model; Granted 2017-09-20 (EU)

PUBLICATIONS:

Posamentier, H. W., 1974: Late-, post-, and neo-glaciation in the Schobergruppe, East Tyrol, Austria; Geological Society of America, Abstracts with Programs, v. 5, n. 1, p. 64.

Posamentier, H. W., 1975: Determination of past glacier behavior based on dendrochronology and dendroclimatology; Geological Society of America, Abstracts with Programs, v. 7, n. 1, p. 108.

POSAMENTIER, H. W., 1977: A new climatic model for glacier behavior of the Austrian Alps; Journal of Glaciology, v. 18, p. 57-65.

POSAMENTIER, H. W., 1977: Dendroglaciology as an aid in determining alpine glaciation chronology: an evaluation; Seventh Biennial Meeting, Northeast North American Branch, International Glaciological Society, 11-13 February, 1977 (abstract).

POSAMENTIER, H. W., 1977: Application of dendroglaciology in the Hohen Tauern, Austria; Dendrochronology Symposium, Tenth International INQUA Congress, Birmingham, England, August 19, 1977, Abstracts, p. 367.

POSAMENTIER, H. W., and NICOLICH, M., 1977: Time series transfer modeling of temperature and glacier snout behavior; Geological Society of America, Abstracts with Programs, v. 9, p. 1114.

POSAMENTIER, H. W., 1978: Thoughts on ogive formation; Journal of Glaciology, v. 20, p. 218-220.

NICOLICH, M., and POSAMENTIER, H. W., 1978: Box-Jenkins transfer modeling of glacier activity and temperature, some recent advances; Annual Meeting of the American Statistical Association, 1978 (abstract).

POSAMENTIER, H. W., 1979: Climate vs. glacier behavior in the Austrian Alps: reply to comments by M. Kuhn; Journal of Glaciology, v. 21, p. 275-277.

NICOLICH, M., and POSAMENTIER, H. W., 1979: Time series transfer modeling of temperature and glacier snout behavior; Journal of the International Association of Mathematical Geology.

POSAMENTIER, H. W., and VAIL, P. R., 1985: Eustatic controls on depositional stratal patterns; Soc. Econ. Paleont. Mineral. Research Conference No. 6, Sea Level Changes - An Integrated Approach, October 20-23, 1985 (Abstract and Poster).

POSAMENTIER, H. W., and VAIL, P. R., 1986: Clastic depositional stratal patterns on passive shelf margins; Soc. Econ. Paleont. Research Conference #7, Shelf Sedimentation, Shelf Sequences and Related Hydrocarbon Accumulation, Corpus Christi, TX, December 7-10, 1986, p. 28.

POSAMENTIER, H. W., and VAIL, P. R., 1986: Stratigraphic response to fluctuations of eustatic sea level; Geol. Soc. Amer. Annual Meeting, November 10-13, 1986 (Abstract).

POSAMENTIER, H. W., 1987: Submarine fans and sea-level change in a sequence stratigraphic framework; Soc. Econ. Paleont. Mineral. Midyear Meeting, Austin TX, August 20-23, 1987.

POSAMENTIER, H. W., ERSKINE, R.D., MITCHUM, R.M., Jr., and VAIL, P. R., 1987: Submarine fans in a sequence stratigraphic framework; Am. Assoc. Pet. Geol. Annual Meeting, Los Angeles, CA, June 7-10, 1987 (Abstract).

VAN WAGONER, J.C., MITCHUM, R.M., POSAMENTIER, H.W., and VAIL, P.R., 1987: An overview of the fundamentals of sequence stratigraphy and key definitions, *in* Balley, B., ed., Seismic Stratigraphy Atlas.

POSAMENTIER, H. W., 1988: Submarine fans: recognition and occurrence within a sequence stratigraphic framework, *in* James, D.P., and Leckie, D.A., eds., Sequences, Stratigraphy, Sedimentology: Surface and Subsurface; Can. Soc. Pet. Geol. Mem 15, p. 582 (Abstract).

POSAMENTIER, H. W., 1988: Fluvial deposition within a sequence stratigraphic framework, *in* James, D.P., and Leckie, D.A., eds., Sequences, Stratigraphy, Sedimentology: Surface and Subsurface; Can. Soc. Pet. Geol. Mem 15, p. 582-583 (Abstract).

POSAMENTIER, H. W., JERVEY, M. T., and VAIL, P. R., 1988: Eustatic controls on clastic deposition I - conceptual framework, *in* C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner, eds., Sea level change - an integrated approach; Soc. Econ. Paleont. Mineral. Spec. Publ. 42, p. 110-124.

POSAMENTIER, H. W. and VAIL, P. R., 1988: Sequence stratigraphy: sequences and systems tract development, *in* James, D.P., and Leckie, D.A., eds., Sequences, Stratigraphy, Sedimentology: Surface and Subsurface; Can. Soc. Pet. Geol. Mem 15, p. 582-583 (Abstract).

POSAMENTIER, H. W., and VAIL, P. R., 1988: Eustatic controls on clastic deposition II - sequence and systems tract models, *in* C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner, eds., Sea level change - an integrated approach; Soc. Econ. Paleont. Mineral. Spec. Publ. 42, p. 125-154.

VAN WAGONER, J.C., POSAMENTIER, H. W., MITCHUM, R. M., Jr., VAIL, P.R., SARG, J.F., LOUTIT, T.S., and HARDENBOL, J., 1988: An overview of the fundamentals of sequence stratigraphy and key definitions, *in* C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner, eds., Sea level change - an integrated approach; Soc. Econ. Paleont. Mineral. Spec. Publ. 42, p. 39-45.

WILGUS, C.K., HASTINGS, B.S., KENDALL, C.G.St.C., POSAMENTIER, H.W., ROSS, C.A., and VAN WAGONER, J.C., 1988: Sea level change - an integrated approach; Soc. Econ. Paleont. Mineral. Spec. Publ. 42, 407 p.

POSAMENTIER, H.W., 1989: Sequence stratigraphy and the utility of stratigraphic models; 28th International Congress, July 9-19, 1989, v. 2, p. 627-628.

POSAMENTIER, H.W. and CHAMBERLAIN, C.J., 1989: Viking lowstand beach deposition at Joarcam Field, Alberta; Can. Soc. Expl. Geophys./Can. Soc. Expl. Geol. Annual Convention - Exploration Update, June 11-15, 1989 p. 96-97 (Abstract).

POSAMENTIER, H.W., JAMES, D.P., and ALLEN, G.P., 1989: Aspects of sequence stratigraphy: recent and ancient examples of forced regressions; British Sedimentologic Research Group, Annual Meeting, London, England, December, 1989, (Abstract)

POSAMENTIER, H.W., LECKIE, D.A., and ALLEN, G.P., 1989: Stratigraphic response to relative sea level Change I: conceptual considerations; Am. Geophys. Union, Chapman Conference on Long-Term Sea Level Changes, Snowbird, Utah, April 17-20, 1989 (Abstract).

ALLEN, G.P., POSAMENTIER, H.W., and LECKIE, D.A., 1989: Stratigraphic Response to Relative Sea Level Change II: Development of a Depositional Sequence During the Pleistocene/Holocene; Am. Geophys. Union, Chapman Conference on Long-Term Sea Level Changes, Snowbird, Utah, April 17-20, 1989 (Abstract).

LECKIE, D.A., POSAMENTIER, H.W., and ALLEN, G.P., 1989: Stratigraphic Response to Relative Sea Level Change III: Development of a Depositional Sequence During the Albian; Am. Geophys. Union, Chapman Conference on Long-Term Sea Level Changes, Snowbird, Utah, April 17-20, 1989 (Abstract)

BERGER, Z. and POSAMENTIER, H.W., 1990, The contribution of an integrated analysis of satellite imagery, gravity, and magnetic data to the recognition of structural/stratigraphic traps in the Alberta Basin, Canada; Am. Assoc. Pet. Geol., Annual Meeting, San Francisco, CA, June 3-6, 1990 (Abstract).

BHATTACHARYA, J., and POSAMENTIER, H.W., 1990: Applications of sequence stratigraphy in the Alberta foreland basin: examples from the Upper Cretaceous; Can. Soc. Expl. Geol. Annual Convention - Basin Perspectives, May 27-30, 1990 p. 29 (Abstract).

POSAMENTIER, H.W., JAMES, D.P., and ALLEN, G.P., 1990: Aspects of sequence stratigraphy: recent and ancient examples of forced regressions; Am. Assoc. Pet. Geol., Annual Meeting, San Francisco, CA, June 3-6, 1990 (Abstract).

POSAMENTIER, H.W. and CHAMBERLAIN, C.J., 1990: Joarcam Field, Alberta: a lowstand shoreline in a sequence stratigraphic framework; 13th International Sedimentological Congress, Nottingham, England, August 26-31, 1990, (Abstract), p. 433.

TESSON, M., GENSOUS, B., ALLEN, G.P., POSAMENTIER, H.W., and RAVENNE, C., 1990: Lowstand wedge deposits: comparison of examples from the quaternary Rhone shelf and the Cretaceous Viking Formation (Alberta); Am. Assoc. Pet. Geol., Annual Meeting, San Francisco, CA, June 3-6, 1990 (Abstract).

POSAMENTIER, H.W. and ERSKINE, R.D., 1991: Seismic expression and recognition criteria of ancient submarine fans, *in* Weimer, P. and Link, M., eds., Seismic facies and sedimentary processes of submarine fans and turbidite systems, Springer-Verlag, p. 197-222.

POSAMENTIER, H.W., ERSKINE, R.D., and MITCHUM, R. M., Jr., 1991: Models for submarine fan deposition within a sequence stratigraphic frameworks, *in* Weimer, P. and Link, M., eds., Seismic facies and sedimentary processes of submarine fans and turbidite systems, Springer-Verlag, p. 127-136.

ALLEN, G.P., and POSAMENTIER, H.W., 1991: Facies and stratal patterns in incised valley complexes: examples from the recent Gironde Estuary (France) and the Cretaceous Viking Formation (Canada); Am. Assoc. Pet. Geol., Annual Meeting, Dallas, Texas, April 7-10, 1991, Abstracts with Programs, p. 70.

POSAMENTIER, H.W., and JAMES, D.P., 1991: Variations of the sequence stratigraphic model: past concepts, present understandings, and future directions; Am. Assoc. Pet. Geol., Annual Meeting, Dallas, Texas, April 7-10, 1991, Abstracts with Programs, p. 191.

POSAMENTIER, H.W., 1991: The significance and recognition of erosional surfaces in a sequence stratigraphic framework: SEPM First Annual Theme Meeting; Continental Margins; Sedimentation, Tectonics, Eustasy, Climate, Portland, Oregon, August 15-18, 1991, Abstracts with Program, p. 27.

POSAMENTIER, H.W., 1991: The application of sequence stratigraphy to prediction of aquifer occurrence and permeability distribution; GSA Annual Meeting, San Diego, California, October 21-24, 1991, Abstracts with Programs.

POSAMENTIER, H.W., and GOODMAN, D.K., 1991: Biostratigraphy in a sequence stratigraphic framework; 24th Annual Meeting of the American Association of Stratigraphic Palynologists, October 20-23, 1991, San Diego, CA, Program and Abstracts.

POSAMENTIER, H.W., and ALLEN, G.P., 1991, The effects of base level control on sedimentation patterns in the fluvial/coastal environment; GSA Annual Meeting, San Diego, California, October 21-24, 1991, Abstracts with Programs.

POSAMENTIER, H.W., ALLEN, G.P., and JAMES, D.P., 1992, High resolution sequence stratigraphy - the East Coulee Delta, Alberta; Jour. Sed. Pet., v. 62, p. 310-317.

POSAMENTIER, H.W., ALLEN, G.P., JAMES, D.P., and TESSON, M., 1992: Forced regressions in a sequence stratigraphic framework: concepts, examples, and exploration significance; Am. Assoc. Pet. Geol. Bull., v. 76, p. 1687-1709.

POSAMENTIER, H.W., and ALLEN, G.P., 1992: High-resolution sequence stratigraphy; concepts and applications; Applied Sequence Stratigraphy Symposium, Golden, CO, Rocky Mountain Association of Geologists, March 25-27, 1992.

POSAMENTIER, H.W., and ALLEN, G.P., 1992: Siliciclastic sequence stratigraphic development in foreland ramp-type basins, with examples from the Viking Formation in south-central Alberta, Canada; Am. Assoc. Pet. Geol., Annual Meeting, Calgary, Alberta, June 21-24, 1992, Abstracts with Programs.

ALLEN, G.P., and POSAMENTIER, H.W., 1992: On the origin and subsequent transgressive modification of incised valleys; Am. Assoc. Pet. Geol., Annual Meeting, Calgary, Alberta, June 21-24, 1992, Abstracts with Programs.

POSAMENTIER, H.W., 1992: Conceptual problems in sequence stratigraphy; SEG Annual Meeting, New Orleans, LA, October 29, 1992.

POSAMENTIER, H.W., 1993: Stratigraphy, *in* McGraw-Hill Yearbook of Science and Technology, McGraw-Hill, New York, p. 385-389.

ALLEN, G.P., and POSAMENTIER, H.W., 1993: Sequence stratigraphy and facies model of an incised valley fill: the Gironde estuary, France; Journal of Sedimentary Petrology, v. 63, p. 378-391.

NORMARK, W.R., POSAMENTIER, H.W., and MUTTI, E., 1993: Turbidite systems: state of the art and future directions; Reviews of Geophysics, v. 31, p. 91-116.

POSAMENTIER, H.W., and JAMES, D.P., 1993: An overview of sequence stratigraphic concepts: uses and abuses, *in* H.W. Posamentier, C.P. Summerhayes, B.U. Haq, and G.P. Allen, eds., Sequence stratigraphy and facies associations: International Assoc. Sed., Special Publication 18, p. 3-18.

POSAMENTIER, H.W., SUMMERHAYES, C.P., HAQ, B.U., and ALLEN, G.P., eds., 1993: Sequence Stratigraphy and Facies Associations; International Assoc. Sed., Special Publication 18, 656 p.

POSAMENTIER, H.W., and CHAMBERLAIN, C.J., 1993: Sequence Stratigraphic Analysis of Viking Formation Lowstand Beach Deposition at Joarcam Field, Alberta, Canada, *in* H.W. Posamentier, C.P. Summerhayes, B.U. Haq, and G.P. Allen, eds., International Assoc. Sed., Special Publication 18, p. 469-485.

POSAMENTIER, H.W., and ALLEN, G.P., 1993: The "healing phase" - a commonly overlooked component of the transgressive systems tract; (abstract) AAPG Annual Convention, New Orleans, LA, April 25-28, 1993, Programs with Abstracts, p. 167.

POSAMENTIER, H.W., and ALLEN, G.P., 1993: Variability of the sequence stratigraphic model: effects of local basin factors; European Union of Geosciences VII, Strasbourg, France, April 4-8, 1993, Abstract Supplement No. 1, Terra nova, v. 5, p. 12.

POSAMENTIER, H.W., and ALLEN, G.P., 1993: Recent advances in sequence stratigraphy: the lowstand and transgressive systems tract; AAPG International Conference and Exhibition, the Hague, Netherlands, October 17-20, 1993.

Posamentier, H.W., and Weimer, P., 1993: Siliciclastic sequence stratigraphy and petroleum geology - where to from here?; AAPG Bulletin, v. 77, p. 731-742.

Posamentier, H.W., and Allen, G.P., 1993: Siliciclastic sequence stratigraphic patterns in foreland ramp-type basins; Geology, v. 21, p. 455-458.

Posamentier, H.W., and Allen, G.P., 1993: Variability of the sequence stratigraphic model: effects of local basin factors; Sedimentary Geology, v. 86, p. 91-109.

Posamentier, H.W., and Allen, G.P., 1993: Geological controls on fluvial aggradation and incision and their significance within a sequence stratigraphic framework; 5th International Conference on Fluvial Sedimentology, Brisbane, Australia, Conference Proceedings, p. 108.

Weimer, P. and Posamentier, H.W., eds., 1993: Siliciclastic sequence stratigraphy: recent developments and applications; AAPG Memoir 58, 492 p.

Weimer, P. and Posamentier, H.W., 1993: Recent advances and applications of siliciclastic sequence stratigraphy, *in* P.W. Weimer and H.W. Posamentier, eds., Siliciclastic sequence stratigraphy: recent developments and applications; AAPG Memoir 58, p. 3-12.

Allen, G.P. and Posamentier, H.W., 1994: Sequence Stratigraphy and Facies Model of an Incised Valley Fill: The Gironde Estuary, France - Reply to Discussion by Martinsen and Helland-Hansen; Journal of Sedimentary Petrology, vB64, p. 81-84.

Bhattacharya, J.P., and Posamentier, H.W., 1994: Sequence stratigraphic and allostratigraphic applications in the Alberta foreland basin; *in* Mossop, G.D., and Shetsen, I., eds., Geological Atlas of the Western Canada Sedimentary Basin, Canadian Society of Petroleum Geologists/Alberta Research Council, p. 407-412.

Schafer, D.B., and Posamentier, H.W., 1994: Development Drilling and Assessment in a 30-year Old Oil Field: New Opportunities Through the Integration of Depositional System and Sequence Stratigraphic Analyses with Cumulative Production Histories; AAPG Annual Meeting, Denver, CO, June 12-15, 1993.

Schafer, D.B., and Posamentier, H.W., 1994: The Role of Conventional Core Analysis in Evaluation of Perforation Strategy; Grand Isle 43 Field, Gulf of Mexico; AAPG Annual Meeting, Denver, CO, June 12-15, 1993.

Wilson, G., and Posamentier, H.W., 1994: High-Resolution Stratigraphic Framework for the Kuparuk River Formation “A” Sandstone, Kuparuk River Unit, Alaska; AAPG Annual Meeting, Denver, CO, June 12-15, 1993.

Posamentier, H.W., and Allen, G.P., 1994: The role of tectonics and eustasy in the development of stratal architecture in foreland basins; AAPG Annual Meeting, Denver, CO, June 12-15, 1993.

Allen, G.P., and Posamentier, H.W., 1994: Transgressive facies and sequence architecture in mixed tide- and wave-dominated incised valleys: example from the Gironde Estuary, France, *in* R.

Dalrymple, B. Zaitlin, and R. Boyd, eds., Incised valley systenms: origin and sedimentary sequences: SEPM Special Publication 51, p. 225-240.

Posamentier, H.W., and Mutti, E., eds., 1994, Second High Resolution Sequence Stratigraphy Conference Proceedings, Tremp, Spain, June 20-27, 1994, 221 p.

Posamentier, H.W., and Allen, G.P., 1994: Silicicalstic sequence stratigraphy - concepts and applications; AAPG Course Notes, 89 p.

POSAMENTIER, H.W., MORRIS, W.R., BHATTACHARYA, J.P., KUPECZ, J.A., LOOMIS, K.B., LOPEZ-BLANCO, M., WU, C., KENDALL, B.A., LANDIS, C.R., SPEAR, D.B., and THOMPSON, P.R., 1995: Cretaceous Panther Tongue Sandstone Outcrop Case Study I: Regional sequence stratigraphic analysis; AAPG Annual Meeting, Houston, Texas, March 5-8, 1995.

MORRIS, W.R., POSAMENTIER, H.W., LOOMIS, K.B., BHATTACHARYA, J.P., KUPECZ, J.A., WU, C., LOPEZ-BLANCO, M., THOMPSON, P.R., SPEAR, D.B., LANDIS, C.R., and KENDALL, B.A., 1995: Cretaceous Panther Tongue Sandstone Outcrop Case Study II: Evolution of delta type within a forced regression; AAPG Annual Meeting, Houston, Texas, March 5-8, 1995.

KOLLA, V., POSAMENTIER, H.W., and EICHENSEER, H., 1995: Stranded parasequences and the forced regressive wedge systems tract: deposition during base level fall - a discussion: Sedimentary Geology, v. 95, p. 139-145.

POSAMENTIER, H.W., and ALLEN, G.P., 1995: Some new developments in sequence stratigraphy and variations on the General Sequence Model; International Symposium on Sequence Stratigraphy in South East Asia, Jakarta, Indonesia, May 12-20, 1995 (extended abstract).

ALLEN, G.P., and POSAMENTIER, H.W., 1995: Recent examples of sequence stratigraphic patterns: a key to the past; International Symposium on Sequence Stratigraphy in South East Asia, Jakarta, Indonesia, May 12-20, 1995 (extended abstract).

POSAMENTIER, H.W., 1995: Controls on forced regression stratal architecture, in: Hunt, D., Gawthorpe, R., and Docherty, M., Conveners, Sedimentary Responses to Forced Regression: Recognition, Interpretation and Reservoir Potential, 7 and 8, September, 1995, London, UK, p. 6-8.

POSAMENTIER, H.W., 1996: Sequence stratigraphy and its role in sedimentary basin fill analysis: 125 Anniversary Meeting of the Geological Society of Sweden, October 16-18, 1996, Geologiska Foreningen I Stockholm (GFF), v. 118, p. A4.

POSAMENTIER, H.W., 1996: Imaging elements of depositional systems with 3-D seismic data: principles and applications: Pacht, J., ed., Proceedings GCSEPM Research Conference, Houston, TX., p. 312-324.

POSAMENTIER, H.W., and MORRIS, W.R., 1996: Forced regressions revisited; stratal architecture of and recognition criteria for forced regressive deposits; AAPG Annual Meeting, San Diego, CA, April 1996

POSAMENTIER, H.W., and MORRIS, W.R., 1997: Stratigraphy of Deep-Water Turbidites; a Dynamic Geomorphological Approach: Proceedings, Tectonics, Stratigraphy, and Petroleum Systems of Borneo, University Brunei Darussalam, June 22-25, 1997, p. 86.

POSAMENTIER, H.W., and MORRIS, W.R., 1997: Stratigraphy of deep-water systems; Part I, process geomorphological classification: AAPG Annual Meeting, Dallas, Texas, April, 1997, p. 236.

MORRIS, W.R., and POSAMENTIER, H.W., 1997: Stratigraphy of deep-water systems; Part II, application of a process geomorphological classification: AAPG Annual Meeting, Dallas, Texas, April, 1997, p. 190.

LIU, X., H. POSAMENTIER, and J. BHATTACHARYA, 1998, 3-D seismic expression of fluvial to deltaic deposits-an example from the Gulf of Mexico: AAPG 1998 Annual Convention Abstract, May 17-28, p. 407.

POSAMENTIER, H.W., W. SUYENAGA, D. RUFAIDA, R. MEYRICK, and S.G. PEMBERTON, 1998, Stratigraphic analysis of the Main Member of the Upper Cibulakan Formation at E Field, offshore Northwest Java, Indonesia: Proceedings of the 26th Indonesia Petroleum Association, p. 129-153**.**

TESSON, M., H.W. POSAMENTIER, and B. GENSOUS, 1998, Stratigraphic Organization of Late Pleistocene Deposits of the Western Part of the Golfe du Lion Shelf, Western Mediterranean Sea, Using High Resolution Seismic and Core Data: AAPG International Conference, Rio de Janeiro, Brazil (Abstract).

POSAMENTIER, H.W., 1998, Modifications of the Sequence Stratigraphic Model with Emphasis on Passive Margins: AAPG International Conference, Rio de Janeiro, Brazil (Abstract).

POSAMENTIER, H.W., 1999, 3D Seismic Visualization of Shelf Ridges: Case study from Offshore Northwest Java: Proceedings of the 27th Indonesia Petroleum Association, p. XX-XX.

BASDEN, W.A., H.W. POSAMENTIER, and R.A. NOBLE, 1999, Structural history of the Terang and Sirasun Fields and the impact upon timing of charge and reservoir performance, Kangean PSC, East Java Sea, Indonesia: Proceedings of the 27th Indonesia Petroleum Association, p. XX-XX.

TESSON, M., H.W. POSAMENTIER, and B. GENSOUS, 2000, Stratigraphic Organization of Late Pleistocene Deposits of the Western Part of the Golfe du Lion Shelf (Languedoc Shelf), Western Mediterranean Sea, Using High Resolution Seismic and Core Data: AAPG Bulletin, v. 84, p. 119-150.

POSAMENTIER, H.W., and W.R. MORRIS, 2000, Aspects of the stratal architecture of forced regressions, *in* R. Gawthorpe and D. Hunt, eds., Forced Regression: Geological Society of London, Special Publication 172, pp. 19-46.

POSAMENTIER, H.W., and G.P. ALLEN, 1999, Siliciclastic Sequence Stratigraphy: Concepts and Applications: Concepts in Sedimentology and Paleontology, v. 9, SEPM (Society for Sedimentary Geology), Tulsa, OK, 210 p.

POSAMENTIER, H.W., 2000, Seismic and lithologic expression of Miocene shelf ridges on the South Java Sea Shelf: AAPG Annual Meeting, New Orleans, April 16-19, 2000, p. A118 (abstract).

POSAMENTIER, H.W., 2000, Seismic stratigraphy into the next millenium; a focus on 3D seismic data: New Orleans, April 16-19, 2000, p. A118 (abstract).

POSAMENTIER, H.W., 2000, Case studies of lowstand alluvial bypass systems: incised vs. unincised: New Orleans, April 16-19, 2000, p. A118 (abstract).

MORRIS, W.R., R.C. HANNON, K.P. HELMOLD, D.G. KNOCK, and H.W. POSAMENTIER, 2000, Jurassic Alpine sandstone, North Slope, Alaska: an example of shoreface deposition within a punctuated transgressive succession: New Orleans, April 16-19, 2000, p. A102 (abstract).

KONKLER, J.L., D.S. HASTINGS, D.H. MCGIMSEY, and H.W. POSAMENTIER, 2000, Tabasco sands, North Slope Alaska: an incised valley mapped with 3D seismic data: New Orleans, April 16-19, 2000, p. A80 (abstract).

POSAMENTIER, H.W., 2000, Incised valleys and fluvial systems; insights from 3D seismic data: GeoCanada 2000, May 29-June 2, 2000, Extended Abstracts.

POSAMENTIER, H.W., 2000, Deep-Water depositional systems – ultra-deep Makassar Strait, Indonesia; GCSSEPM Research Conference, Houston, TX, December 4-6, 2000, Proceedings Volume, p. 806-816.

POSAMENTIER, H.W., 2000, Mid-Shelf Lowstand and Transgressive Systems Tract Deposits of Southeast Asia: Examples from offshore Java and Malaysia; AAPG International Conference and Exhibition, October 15-18, 2000 (Abstract).

POSAMENTIER, H.W., and BASDEN, W.A., 2000, Depositional systems at the continental margin: 3D seismic case study from offshore Northeast Java; AAPG International Conference and Exhibition, October 15-18, 2000 (Abstract).

POSAMENTIER, H.W., 2001, Lowstand alluvial bypass systems: incised vs. unincised: AAPG Bulletin, v. 85, p. 1771-1793.

POSAMENTIER, H.W., 2001, On the role of flow stripping and the deposition of channel levees and frontal splays in deep-water systems; evidence from 3-D seismic data; AAPG International Conference, Denver, CO, June 3-6, 2001 (Extended Abstract).

POSAMENTIER, H.W., 2001, Seismic Geomorphology and depositional systems of deep-water environments; observations from offshore Nigeria, Gulf of Mexico, and Indonesia; AAPG International Conference, Denver, CO, June 3-6, 2001 (Extended Abstract).

POSAMENTIER, H.W., 2001, Mid-Shelf Lowstand and Transgressive Systems Tract Deposits of Southeast Asia: Examples from Offshore Java and Malaysia; AAPG International Conference, Denver, CO, June 3-6, 2001 (Extended Abstract), p. A-160.

POSAMENTIER, H.W., 2001, In over our heads? Braving the world of deep-water exploration: challenges, technologies, and current understanding; Geological Association of Canada and Mineralogical Association of Canada Joint Annual Meeting, St. Johns, Newfoundland, p. 121.

HARPER, J.D., POSAMENTIER, H.W., WILLIAMS, S.H., SOLIMAN, O., and ZAITLIN, B., 2001, Stratigraphic Partitioning of Reservoirs: The Evolution of Reservoir from Deposition to Diagenesis; CSPG Annual Convention, 2001, p.152-153.

POSAMENTIER, H.W., 2002, Ancient shelf ridges – a potentially significant component of the transgressive systems tract: case study from offshore northwest Java: AAPG Bulletin, v. 86, p. 75-106.

KOLLA, V., POSAMENTIER, H.W., and IMRAN, J., 2002, Deepwater sinuous channels and reservoir architecture; AAPG Annual Meeting, p. A-95-96.

NORMARK, W.R., PIPER, D.J.W., POSAMENTIER, H.W., PIRMEZ, C., and MIGEON, S., 2002, Variability in form and growth of sediment waves on turbidite channel levees; Marine Geology, v. 192, p. 23-58.

POSAMENTIER, H.W., 2002, Sequence stratigraphy past, present and future, and the role of 3-D seismic data; in J.M. Armentrout and N.C. Rosen, eds., Sequence Stratigraphic Models for Exploration and Production: Evolving Methodology, Emerging Models, and Application Histories, 22nd Annual GCSSEPM Foundation Bob F. Perkins Research Conference, p. 37-54.

POSAMENTIER, H.W., 2002, Seismic geomorphology and seismic stratigraphy of deep-water depositional elements; AAPG Annual Meeting, p. A-95-96.

POSAMENTIER, H.W., 2002, 3D seismic geomorphology and stratigraphy of deep-water debris flow deposits; AAPG Annual Meeting, p. A-142.

POSAMENTIER, H.W., and KOLLA, V., 2002, Anatomy and evolution of deep-water channels: case studies from Nigeria and the Gulf of Mexico; AAPG Annual Meeting, p. A-142.

POSAMENTIER, H.W., 2002, Sequence stratigraphy past, present and future; the challenge of integrating 3D seismic data; CSPG Annual Meeting, p. 282.

POSAMENTIER, H.W., and WALKER, R.G., 2002, Turbidite facies Models; integrating subsurface and outcrop; CSPG Annual Meeting, p. 283.

POSAMENTIER, H.W., BYRNE, C., COLLAZOS, J.P., HARALDSON-RADFORD, N., JOHNSON, C., KRENTZ, D., MCLAUGHLIN, R., MILLER, M., MITCHELMORE, M., and SCHOOMAKER, M., 2002, Analysis of depositional systems based on seismic geomorphology and stratigraphy integrated with borehole data: case studies from the western Canadian sedimentary basin; AAPG Annual Meeting, p. A-143.

KOLLA, V., POSAMENTIER, H.W., WINKER, C.D., BOURGES, P., 2002, Deepwater Lobe- and Sheet-form Depositional Elements in Open Ocean and Intra-slope Basin Settings; AAPG Annual Meeting, Houston, Texas, March 1-13, 2002.

POSAMENTIER, H.W., 2003, Depositional elements associated with a basin floor channel-levee system: case study from the Gulf of Mexico; Marine and Petroleum Geology, v. 20, p. 677-690.

POSAMENTIER, H.W., 2003, A linked shelf-edge delta and slope-channel turbidite system: 3D seismic case study from the eastern Gulf of Mexico; in H.H. Roberts, N.C. Rosen, R.H. Fillon, J.B. Anderson, eds., Shelf Margin Deltas and Linked Down Slope Petroleum Systems: Global Signfiicance and Future Exploration Potential, 23rd Annual GCSSEPM Foundation Bob F. Perkins Research Conference, p. 115-134.

POSAMENTIER, H.W., 2003, Seismic geomorphology – new tricks for an old dog; CSPG Reservoir, v. 30, p. 19-30.

KOLLA, V., POSAMENTIER, H.W., and BOURGES, P., 2003, Lobe- and sheet-form depositional elements and channel avulsions and occurrence in deepwater settings – allocyclic versus autocyclic controls; AAPG Annual Meeting, p. A-95.

POSAMENTIER, H.W., 2003, Seismic geomorphology and stratigraphy of submarine canyons – insights regarding genesis, evolution, and fill, based on 3-D seismic data; AAPG Annual Meeting, p. A-140.

POSAMENTIER, H.W., and KOLLA, V., 2003, Anatomy of a deep-water channel avulsion – example from the basin floor of the DeSoto Canyon area, Gulf of Mexico; AAPG Annual Meeting, p. A-140.

POSAMENTIER, H.W., 2003, Seismic geomorphologic and seismic stratigraphic analyses using 3-D seismic visualization techniques: examples from the Gulf of Mexico and the western Canadian sedimentary basin; AAPG International Meeting, Cairo, Egypt, p. A-140.

POSAMENTIER, H.W., and KOLLA, V., 2003, Seismic geomorphology and stratigraphy of depositional elements in deep-water settings; Journal of Sedimentary Research, v. 73, p. 367-388.

POSAMENTIER, H.W., 2003, Application of 3D seismic visualization techniques for seismic stratigraphy, seismic geomorphology, and depositional systems analysis: examples from fluvial to deep-marine depositional environments; 6^{th} Petroleum Geology Conference; North West Europe and Global Perspectives, London, UK., p. 130.

POSAMENTIER, H.W., 2004, Seismic geomorphology – Imaging elements of depositional systems from shelf to deep basin using 3D seismic data: implications for exploration and development; in Davies, R.J., Cartwright, J.A., Stewart, S.A., Lappin, M., and Underhill, J.R. (eds.), 3D seismic technology: applications to the exploration of sedimentary basins, Geological Society of London, Memoirs 29, p. 11-124.

POSAMENTIER, H.W., 2004, Seismic geomorphology – imaging elements of depositional systems from shelf to deep basin using 3D seismic data: implications for exploration and development: in R. Ray and W. Pearson, eds., 3D Seismic Symposium; a one day conference highlighting 3-D Seismic Case Histories, February 27, 2004, Denver, CO, Abstract with Programs (keynote address).

POSAMENTIER, H.W., 2004, 3-D yields Strat, Geologic Insights; AAPG Explorer, February 2004, p. 26-27.

POSAMENTIER, H.W., 2004, Application of 3D seismic visualization techniques for seismic stratigraphy, seismic geomorphology and depositional systems analysis; in R. Davies, ed., 3D Seismic Visualization, Geological Society of London Publication (in press).

POSAMENTIER, H.W., GISH, D., BURTON, J., 2004, Cretaceous (Brookian) deep-water deposits of the Alaskan north slope: evidence from 3D seismic data; CSPG Annual Conference.

POSAMENTIER, H.W., 2004, Stratigraphy and geomorphology of deep-water mass transport complexes based on 3D seismic data; Offshore Technology Conference, Houston TX. (Extended Abstract – keynote address).

MINKEN, J., SLATT, R., and POSAMENTIER, H.W., 2004, Erosional Remnants in Deep-Water Channel Systems: Outcrop and Subsurface Characterization; AAPG Annual Conference, Dallas, TX (Abstract), p. A97-98.

KOLLA, V., POSAMENTIER, H.W., FACHMI, M., and WOOD, L.J., 2004, Modes of the Evolution of Deep-water and Fluvial Meander Channels; AAPG Annual Conference, Dallas, TX (Abstract), p. A77.

POSAMENTIER, H.W., 2004, The Stratigraphy and Evolution of the Mississippi Canyon, Gulf of Mexico; AAPG Annual Conference, Dallas, TX (Abstract), p. A113.

POSAMENTIER, H.W., and WALKER, R.G., 2004, Turbidite facies models; AAPG Annual Conference, Dallas, TX (Abstract – keynote address), p. A113..

POSAMENTIER, H.W., 2004, Sequence stratigraphy of deep-water deposits based on integration of seismic stratigraphy and seismic geomorphology using 3D seismic data; International Geological Congress, Florence Italy (extended abstract – keynote address).

POSAMENTIER, H.W., 2004, Application of 3D seismic visualization techniques for seismic stratigraphy, seismic geomorphology and depositional systems analysis: examples from fluvial to deep-marine depositional environments; Petroleum Geology: Northwest Europe Global Perspectives [6TH Geological Society of London Petroleum Geology (London, England, 10/6-9/2003) Proceedings] v.2, pp.1565-1576.

DAVIES, R.J., and POSAMENTIER, H.W., 2005, Geologic processes in sedimentary basins inferred from three-dimensional seismic imaging: GSA Today, v. 15, p. 4-9.

POSAMENTIER, H.W., and LAURIN, P., 2005, Seismic geomorphology of Oligocene to Miocene carbonate buildups offshore Madura, Indonesia: SEG Annual meeting Proceedings, p. 1-3.

POSAMENTIER, H.W., 2005, Stratigraphy and geomorphology of deep-water mass transport complexes based on 3D seismic data: SEG Annual meeting Proceedings, p. 1-4.

KOLLA, V., POSAMENTIER, H.W., FACHMI, M., and WOOD, L.J., 2005, Similarities and dissimilarities, and modes of the evolution of deep-water and fluvial meander channels: Seismic Geomorphology – Applications to Hydrocarbon Exploration and Production Proceedings, Houston TX, 10-11 February, 2005. (Abstract).

POSAMENTIER, H.W., Seismic geomorphology in exploration and development: Seismic Geomorphology – Applications to Hydrocarbon Exploration and Production Proceedings, Houston TX, 10-11 February, 2005. (Abstract).

POSAMENTIER, H.W., and LAURIN, P., 2005, Seismic Geomorphology of Oligocene to Miocene carbonate buildups offshore Madura, Indonesia: 3D seismic visualization techniques and workflows: AAPG Annual meeting Proceedings, (Abstract).

POSAMENTIER, H.W., and WOOD, L.J., 2005, Seismic geomorphology in exploration and development; workflows and applications: AAPG Annual meeting Proceedings, (Abstract).

POSAMENTIER, H.W., 2005, Analysis of Deep-Water Mass Transport Complexes Based on 3D Seismic Data: 2nd. International Conference on Submarine Mass Movements and Their Consequences 2005, 5-7 September, Oslo, Norway, Proceedings (Abstract).

POSAMENTIER, H.W., and MARTINSEN, O., 2006, The character and genesis of mass transport complexes I: geomorphology and process sedimentology from 3D seismic data: AAPG Annual meeting Proceedings, (Abstract), p. 87.

MARTINSEN, O., and POSAMENTIER, H.W., 2006, The character and genesis of mass transport complexes II: processes, classification and insights from outcrops: AAPG Annual meeting Proceedings, (Abstract), p. 69-70.

MARTINSEN, O., and POSAMENTIER, H.W., 2006, Application of the sequence stratigraphic approach: models versus first principles: AAPG Annual meeting Proceedings, (Abstract), p. 69.

POSAMENTIER, H.W. and WALKER, R.G., 2006, Deep-water turbidites and submarine fans: SEPM Special Publication 84, p. 399-520.

POSAMENTIER, H.W., and WALKER, R.G., 2006, (eds.) Facies Models Revisited; SEPM Special Publication 84, 527 p.

POSAMENTIER, H.W., and WICKENS, deV., 2006, Processes Associated with Meandering Channel Migration in Deepwater Systems Based on 3-D Seismic and Outcrop Data; AAPG International Conference and Exhibition, Perth, West Australia 5-8, November 2006.

POSAMENTIER, H.W., DAVIES, R.J., CARTWRIGHT, J.A., and WOOD, L.J., 2007, Seismic geomorphology – and overview: *in:* Davies, R.J., Posamentier, H.W., Wood, L.J., and Cartwright, J.A., (eds.), Seismic geomorphology: applications to hydrocarbon exploration and production: Geological Society, London, Special Publications, 277, p. 1-14.

POSAMENTIER, H.W., 2007, Lithology prediction through integrated seismic geomorphologic and seismic stratigraphic analyses: concepts, workflows, and applications to petroleum exploration and development; AAPG-SEG International Conference, Tyumen, Siberia, Russia, December 2007.

KOLLA, V., POSAMENTIER, H.W., and WOOD, L.J., 2007, Deep-water and fluvial sinuous channels – Characteristics, similarities and dissimilarities, and modes of formation; Marine and Petroleum Geology, v. 24, p. 388-405.

POSAMENTIER, H.W., 2007, Confined flow in deep-water settings from slope to basin floor: contrasting architecture and morphologies between deposits associated with fully- and partially-contained channelized flow; Annual AAPG Convention, Long Beach, CA, April 1-4, 2007.

ARMITAGE, D.A., DUNBAR, T.P., and POSAMENTIER, H.W., 2007, An innovative method of quantifying channel distribution in a frontal splay environment using shallow seismic-reflection data; Annual AAPG Convention, Long Beach, CA, April 1-4, 2007.

POSAMENTIER, H.W., 2008, Using 3D Seismic Data for Visualization of Depositional Systems—Integrating Seismic Stratigraphy and Seismic Geomorphology; Gulf Coast Association of Geological Societies Transactions, Vol. 58, p. 729.

SULLIVAN, M.D., PYRCZ, M.J., POSAMENTIER, H.W., McHARGUE, T., FILDANI, A., DRINKWATER, N., and CLARK, J., 2008, Recent advances in deepwater slope valley depositional models: implications of channel fill percent and stacking patterns from reservoir architecture and producibility; AAPG International Conference, Cape Town, South Africa, October 26-29, 2008.

POSAMENTIER, H.W., 2008, Seismic stratigraphic and seismic geomorphologic expression of mass transport deposits and sediment waves – examples from slope and basin floor settings; AAPG International Conference, Cape Town, South Africa, October 26-29, 2008.

POSAMENTIER, H.W., 2008, Seismic stratigraphy and seismic geomorphology of a slope environment – offshore Angola, West Africa; AAPG International Conference, Cape Town, South Africa, October 26-29, 2008.

PYRCZ, M.J., SULLIVAN, M.D., McHARGUE, T., DRINKWATER, N., CLARK, J., FILDANI, A., POSAMENTIER, H.W., 2008, A showcase of reservoir models generated by event-based geostatistical modeling; AAPG International Conference, Cape Town, South Africa, October 26-29, 2008.

POSAMENTIER, H.W., 2008, Seismic stratigraphy, seismic geomorphology, and process sedimentology of mass transport and other non-turbiditic deposits in deep-water environments; GSA Abstracts with Programs, v.40, no.6, pp.537-538.

McHARGUE, T., CLARK, J., DRINKWATER, N., FILDANI, A., POSAMENTIER, H.W., PYRCZ, M.J., and SULLIVAN, M.D., 2008, A predictive model for turbidite channel element dimensions and fill characteristics relative to equilibrium gradient; Annual AAPG Convention, San Antonio, TX, April 20-23, 2008.

FILDANI, A., ROMANS, B., POSAMENTIER, H.W., McHARGUE, T., PAULL, C., MAIER, K., CLARK, J., and SULLIVAN, M.D., Architecture and depositional response of deep-marine systems from 3D high resolution seismic data; AGU Fall Meeting, San Francisco, CA, December 15-19, 2008.

CATUNEANU, O., and POSAMENTIER, H.W., 2008, Stratal stacking patterns and key bounding surfaces: the basis for a standard system for sequence stratigraphic analysis; 33RD International Geological Congress [IGC], Oslo, Norway, August 6-14, 2008, Proceedings.

POSAMENTIER, H.W., 2009, Using 3D Seismic Data to Predict Lithology in the Subsurface: Applications of Seismic Geomorphology and Seismic Stratigraphy from Deep Water to Shelf; Houston Geological Society Bulletin, Volume 52, No. 4, p. 21.

POSAMENTIER, H.W., REIJENSTEIN, H.M., and BHATTACHARYA, J.P., 2009, Seismic Geomorphology of High-Sinuosity Fluvial Systems Integrating 2D and 3D Seismic
Data; AAPG Hedberg Conference, April 29-May 2, 2009, Jakarta, Indonesia.

McHARGUE, T., PYRCZ, M.J., SULLIVAN, M.D., CLARK, J., LEVY, M., FILDANI, A., POSAMENTIER, H.W., ROMANS, B., and COVAULT, J.A., 2010, Predicting reservoir architecture of turbidite channel complexes: a general model adaptable to specific situations; 106th Annual GSA Cordilleran Section and 85th Annual AAPG Pacific Section Joint Meeting, Anaheim, CA, May 27-29, 2010, Proceedings.

POSAMENTIER, H.W., LAURIN, P., WARMATH, A., PURNAMA, M., and DRAJAT, D., 2010, Seismic Stratigraphy and Geomorphology of Oligocene to Miocene Carbonate Buildups, Offshore Madura, Indonesia; in Morgan, W.A., George, A.D., Harris, P.M., Kupecz, J.A., and Sarg, J.F., Cenozoic Carbonate Systems of Australasia, SEPM Special Publication 95, p. 104-121.

POSAMENTIER, H.W., and MARTINSEN, O.J., 2011, Mass-Transport Deposits in Deepwater Settings; SEPM Special Publication 95, C. Shipp, P. Weimer, and H.W. Posamentier, eds., p. 216-255.

REIJENSTEIN, H.M., POSAMENTIER, H.W., and BHATTACHARYA, J.P., 2011, Seismic geomorphology and high-resolution seismic stratigraphy of inner-shelf fluvial, estuarine, deltaic, and marine sequences, Gulf of Thailand; AAPG Bulletin, v. 95, no. 11 (November 2011), p. 1959–1990.

McHARGUE, T., PYRCZ, M.J., SULLIVAN, M.D., CLARK, J.D., FILDANI, A., ROMANS, B.W., COVAULT, J.A., LEVY, M., POSAMENTIER, H.W., DRINKWATER, N.J., 2011, Architecture of turbidite channel systems on the continental slope: Patterns and predictions; Marine and Petroleum Geology, v. 28 no. 3, p. 728-743.

POSAMENTIER, H.W., MARTINSEN, O.J., and PAOLA, C., Source to sink – why it matters; AAPG Annual Conference, Houston, TX, April 10-13, 2011.

PAYENBERG, T., WILLIS, B., BRACKEN, B., POSAMENTIER, H.W., PYRCZ, M, PUSCA, V., and SULLIVAN, M.D., 2011, Revisiting the subsurface classification of fluvial sandbodies; AAPG Annual Conference, Houston, TX, April 10-13, 2011.

POSAMENTIER, H.W., BALE, K., DECKER, S.M., and JOWITT, R., Seismic stratigraphic and seismic geomorphologic study of mass transport and sediment wave deposition, offshore eastern Canada; AAPG Annual Conference, Houston, TX, April 10-13, 2011.

POSAMENTIER, H.W., BACHTEL, S., GERBER, T.P., LOMASK, J., Seismic geomorphology of a Tertiary-aged isolated carbonate platform system, Browse Basin, northwest shelf of Australia: the spatial and temporal evolution of carbonate platform environments I – the lower section; AAPG Annual Conference, Houston, TX, April 10-13, 2011.

BACHTEL, S., POSAMENTIER, H.W., and GERBER, T.P., Seismic geomorphology of a Tertiary-aged isolated carbonate platform system, Browse Basin, northwest shelf of Australia: the spatial and temporal evolution of carbonate platform environments I – the upper section; AAPG Annual Conference, Houston, TX, April 10-13, 2011.

WILD, R., and POSAMENTIER, H.W., 2012, Seismic Stratigraphy and Geomorphology of a Syn- to Post-Rift Depositional Succession, Qiongdongnan Basin, South China Sea; AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012.

ISKAKOV, E., JENKINS, S., KABDESHEVA, Z., and POSAMENTIER, H.W., 2012, Integrated Seismic Characterization and Reservoir Modeling of Neocomian Fluvial System for Water Injection: Tengiz Oil Field, Republic of Kazakhstan; AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012.

BACHTEL., S.L., POSAMENTIER, H.W., PLAYTON, T.E., JENKINS, S., ISKAKOV, E., KATRENOV, Z., and HARRIS, P., 2012, Seismic Geomorphology of Microbial-Dominated Margin and Slope Environments around an Isolated Platform, Tengiz Field, Kazakhstan; AAPG Hedberg Conference, Microbial Carbonate Reservoir Characterization, June 4-8, 2012 – Houston, TX.

TUSSUPBAYEV, I., ISKAKOV, E., JENKINS, S.D., and POSAMENTIER, H.W., 2012, Seismic imaging and characterization of an isolated carbonate buildup: Tengiz Field; EAGE KAZGEO Conference, October 29-31, 2012, Almaty, Kazakhstan, paper no. D008.

KALZHEKOV, N., POSAMENTIER, H.W., PLAYTON, T.E., JENKINS, S., ISKAKOV, E., KATRENOV, Z., HARRIS, P., and TLEPBERGENOV, M., 2012, Seismic geomorphology of microbial-dominated margin and slope environments around an isolated platform, Tengiz Field; EAGE KAZGEO Conference, October 29-31, 2012, Almaty, Kazakhstan, paper no. c005.

POSAMENTIER, H.W., 2012, On the evolution of submarine canyons: a case study from the Taranaki Basin, New Zealand; AAPG Annual Conference, Long Beach, CA., April 22-25, 2012.

POSAMENTIER, H.W., BACHTEL, S.L., PLAYTON, T.E., KENTER, J., JENKINS, S., ISKAKOV, E., KATRENOV, Z., JAZBAYEV, K., and HARRIS, P., 2012, Seismic stratigraphy and geomorphology of the Tengiz isolated carbonate buildup: utilization of datumed slices to understand platform margin and slope complexity; AAPG Annual Conference, Long Beach, CA., April 22-25, 2012.

JENKINS, S., ISKAKOV, E., KATRENOV, Z., JAZBAYEV, K., POSAMENTIER, H.W., BACHTEL., S.L., STEFANI, J., NARR, W,, FLODIN, E., 2012, Seismic imaging and characterization of an isolated carbonate buildup: Tengiz Field, Republic of Kazakhstan; AAPG Annual Conference, Long Beach, CA., April 22-25, 2012.

POSAMENTIER, H.W., Turbidite stratigraphic architecture – hierarchy development associated with allocyclic factors; AAPG Annual Conference, Houston TX, April 6-9, 2014.

POSAMENTIER, H.W., AYDEMIR, V., SIPAHIOGLU, Ö, Korucu, Ö., ROE, S., ABRIEL, W., NANTAIS, P., WELCH, R., and SAUVE, J., 2014, Seismic stratigraphic and seismic geomorphologic analysis of deep-water deposits of the Turkish Black Sea; AAPG Annual Conference, Houston TX, April 6-9, 2014.

POSAMENTIER, H.W., and LANG, S.C., 2014, Neocomian-Cenomanian fluvial, estuarine, and shoreface siliciclastic and carbonate facies of western Kazakhstan – insights from integrated seismic stratigraphic and geomorphologic analyses; AAPG Annual Conference, Houston TX, April 6-9, 2014.

POSAMENTIER, H.W., AYDEMIR, V., SIPAHIOGLU, Ö, KORUCU, Ö., ROE, S., ABRIEL, W., NANTAIS, P., WELCH, R., 2014, Volcanic deposits in the Black Sea – seismic recognition criteria for differentiating volcanics from carbonates; AAPG Annual Conference, Houston TX, April 6-9, 2014.

POSAMENTIER, H.W., MADOF, A., REIJENSTEIN, H., LANG, S.C., LOGAN, Jr., J.,, and PURDY, R.K., 2014, Fluvial Systems in the Gulf of Thailand – Stratigraphic Implications for Exploration and development; AAPG Annual Conference, Houston TX, April 6-9, 2014.

POSAMENTIER, H.W., LANG, S.C., MADOF, A., EHMAN, K.D., CAMPBELL, E., BUNTING, I., 2016, Integration of Seismic Stratigraphy and Seismic Geomorphology for Prediction of Lithology; Applications and Workflows; GEO 2016, Bahrain

POSAMENTIER, H.W., CLARK T., FARINGTON J., 2017, Seismic Stratigraphy and Seismic Geomorphology of Deep-water Slope deposits: Processes and Products; AAPG Annual Conference, Houston TX, April 2-5, 2014.

POSAMENTIER, H.W., EHMAN, K.D., POWELL, A., LANG, S.C., PAUMARD, V., BOURGET, J., 2017, Deep-water turbidites in not-so-deep basins; AAPG Annual Conference, Houston TX, April 2-5, 2014.

PAUMARD, V., BOURGET, J., PAYENBERG, T., AINSWORTH, B., LANG, S., POSAMENTIER, H.W., GEORGE, A., 2017, Stratigraphic evolution of the Barrow Group (Northern Canarvon Basin, North West Shelf, Australia): Controls on the architecture of a shelf-margin during a syn-rift to post-rift transition; AAPG Annual Conference, Houston TX, April 2-5, 2014.

PAUMARD, V., BOURGET, J., GEORGE, A., PAYENBERG, T., AINSWORTH, B., LANG, S.C., PEYROT, D., POSAMENTIER, H.W., 2018, Controls on shelf-margin architecture and sediment partitioning during a syn-rift to post-rift transition: Insights from the Barrow Group (Northern Carnarvon Basin, North West Shelf, Australia); Earth-Science Reviews (in press).

NIKISHIN, A. M., STARTSEVA, K., VERZHBITSKY, V.E., CLOETINGH, S., MALYSHEV, N.A., PETROV, E.I., POSAMENTIER, H.W., FREIMAN, S.I., LINEVA, M.D., ZHUKOVA, N.N., 2019, The Sedimentary Basins of the East Siberian Sea and the Chukchi Sea and the Adjacent Area of the Amerasian Basin: Seismic Stratigraphy and the Stages of Geological History; Geotectonics, 2019, Vol. 53, No. 6, pp. 635–657.

NIKISHIN, A. M., PETROV, E.I., CLOETINGH, S., FREIMAN, S.I., MALYSHEV, N.A., MOROZOV, A.F., POSAMENTIER, H.W., VERZHBITSKY, V.E., ZHUKOV, N.N., STARTSEVA, K., 2019, Geological structure and history of the Arctic Ocean based on new geophysical data: implications for paleoenvironment and paleoclimate. Part 2. Mesozoic to Cenozoic geological evolution; Earth Science Reviews (in press).

XIAOXIA, E., YU, J., COYLE, S.B., POSAMENTIER, H.W., ROYLE, A., ZHANG, Z., 2019, Meet West Africa deep exploration challenge with geomorphology and targeted AVO inversion; SEG Interpretation (in press).

REIJENSTEIN, H.M., POSAMENTIER, H.W., BANDE, A., LOZANO, F.A., DOMINGUEZ, R.F., WILSON, R., CATUNEANU, O., GALEAZZI, S., 2020, Seismic geomorphology, depositional elements, and clinoform sedimentary processes: impact on unconventional reservoir prediction, in Minisini, D., Fantin, M., Lanusse, I., and Leanza, H., eds., Integrated geology of unconventionals: the case of the Vaca Muerta play, Argentina: AAPG Memoir 121, 29pp.

PAUMARD, V., BOURGET, J., PAYENBERG, T., GEORGE, A., AINSWORTH, B., LANG, S., and POSAMENTIER, H.W., 2020, Controls on deep-water sand delivery beyond the shelf edge: accommodation, sediment supply, and deltaic process regime; Journal of Sedimentary Research, v. 90, p. 104-130.

PAUMARD, V., LANG, S., POSAMENTIER, H.W., and WILSON, M.E.J., 2020, On the value of seismic stratigraphy and seismic geomorphology – Comments on “development patterns of an isolated oligo-mesophotic carbonate buildup, early Miocene, Yadana field, offshore Myanmar” by Teillet et al. (2020), Marine and Petroleum Geology, v.122, pp. 1-5.

DOMINGUEZ, R.F., CATUNEANU, O., REIJENSTEIN, H.M., NOTTA, R., and POSAMENTIER, H.W., 2020, Sequence stratigraphy and the three-dimensional distribution of organic-rich units, *in* Minisini, D., Fantin, M., Noguera, and I.L., Leanza, H.a., eds., Integrated geology of unconventionals: the case of the Vaca Muerta play, Argentina: AAPG Memoir 121, p. 163-200.

REIJENSTEIN, H.M., POSAMENTIER, H.W., BANDE, A., LOZANO, F.A., DOMINGUEZ, R.F., WILSON, R., CATUNEANU, O., and GALEAZZI, S., 2020, Seismic geomorphology, depositional elements, and clinoform sedimentary processes: impact on unconventional reservoir prediction, *in* Minisini, D., Fantin, M., Noguera, and I.L., Leanza, H.a., eds., Integrated geology of unconventionals: the case of the Vaca Muerta play, Argentina: AAPG Memoir 121, p. 237-266.

NIKISHIN A.M., PETROV, E.I., CLOETINGH, S., KORNIYCHUK, A.V., MOROZOV, A.F., PETROV, O.V., POSELOV, V.A., BEZIAZYKOV, A.V., SKOLOTNEV, S.G., MALYSHEV, N.A., VERZHBITSKY, V.E., POSAMENTIER, H.W., FREIMAN, S.I., RODINA, E.A., STARTSEVA, K., and ZHUKOV, N.N., 2021, Arctic Ocean Mega Project: Paper 1 - Data collection, Earth Science Reviews, v. 217, p. 1-24.

NIKISHIN A.M., PETROV, E.I., CLOETINGH, S., MALYSHEV, N.A., MOROZOV, A.F., POSAMENTIER, H.W., VERZHBITSKY, V.E., FREIMAN, S.I., STARTSEVA, K., RODINA, E.A., and ZHUKOV, N.N., 2021, Arctic Ocean Mega Project: Paper 2 **–** Arctic stratigraphy and regional tectonic structure, Earth Science Reviews, v. 217, p xx-xx.

POSAMENTIER, H.W., PAUMARD, V., and LANG, S.C., (2022), Principles of seismic stratigraphy and seismic geomorphology I: Extracting geologic insights from seismic data, Earth Science Reviews, v. 228, https://doi.org/10.1016/j.earscirev.2022.103963.

POSAMENTIER, H.W., PAUMARD, V., and LANG, S.C., (submitted), Principles of seismic stratigraphy and seismic geomorphology II: Recognition of geologic patterns and interpretation of depositional environments, Earth Science Reviews.

Comments on the Barossa Gas Export Pipeline Underwater Cultural Heritage Assessment Report

Henry W. Posamentier PhD

August 21, 2023

Background

1. I have been requested by Quinn Emanuel Urquhart & Sullivan on behalf of Santos Ltd to prepare a report responding to the report of Professor Mick O'Leary (July 2023), focusing on the cultural history of the Arafura Sea along the pipeline corridor.

2. I have prepared this report as an independent expert and have done so in accordance with the Federal Court of Australia's Expert Witness Code of Conduct (**Appendices 1 and 2**).

3. In preparing my Report I have made all the enquiries which I believe are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which I regard as relevant have, to my knowledge, been withheld.

Introduction

4. The following discussion addresses observations and interpretations of paleo-landforms by Associate Professor Mick O'Leary (O'Leary) in the vicinity of the Barossa Field pipeline. I have reviewed the features identified and herein explain my insights regarding how I would interpret them. The data upon which my analysis is based comprises the data acquired by Fugro Survey PTY LTD (2017) and Conoco Phillips Australia PTY LTD (2018) during multiple field seasons and includes high-resolution seismic boomer profiles and multi-beam (i.e., MBES) and sidescan sonar imagery, as well as a 3D multi-channel seismic volume over the Barossa Field.

5. I do not comment on the archeological significance of these features (i.e., P1 vs. P2). My analysis is focused on identifying Last Glacial Maximum (LGM) and later landforms (i.e., post-LGM) and on the evolution of the paleolandscape from subaerial at LGM time to subaqueous subsequent to post-LGM flooding, and associated erosion and deposition. Of particular emphasis is the genesis and preservation potential of the features associated with the LGM surface.

6. For the parts of O'Leary's report that I am responding to, I have done so using the headings and section numbers of his report. Where relevant I have included section references to his report.

7. My interpretations and conclusions are based on existing available data combined with knowledge of the area integrated with geologic first principles (i.e., the basic principles upon which the study of landforms are based).

8. My position in my report dated July 11, 2023 (Report), is that because of erosion and sedimentation, the topography of the modern seafloor likely has been modified to varying degrees from its earlier LGM exposed character. This is because subsequent to flooding of the landscape between LGM time and the present, the LGM surface was exposed to multiple geological processes of both erosion and sedimentation.

General comments on the O'Leary report

9. O'Leary references a sea-level lowering of up to 130m (O'Leary section 1.4, "The study area"), whereas in my Report, I reference a sea-level lowering of 125m. This difference is not significant in light of the fact that precise determination of local sea-level variations through time is not readily apparent. That is, local factors relating to local subsidence contribution to sea-level change cannot be easily determined. In any case, this 5m discrepancy is not significant with respect to landform evolution from LGM time to the present.

10. In general, the discussion of paleolandscapes in the O'Leary report focuses on the interplay between the lay of the land and its association with the cultural heritage. In my opinion, there are several issues that were not addressed in the report. These include:

    1) Preservation potential of aspects of the paleolandscape subsequent to post-LGM flooding of this area. In light of the possible erosion and modification of the original land surface by wave and tidal processes, coupled with sedimentation across the top of this potentially eroded surface, the original LGM landscape could have been significantly altered during transgression.

2) The presence of carbonate platforms with associated landforms (e.g., reefs, etc.) common to this type of environment.

3) The detailed reconstruction of the paleolandscape by O'Leary, based on bathymetry maps of the modern seafloor, does not take into consideration the post-flooding modifications that may have significantly altered the original landscape.

11. The LGM surface constituted a landscape of rivers and associated alluvial plains between today's Bathurst Island and the paleoshoreline, which today lies at a water depth of approximately 125-130m below mean sea level (bmsl). I have concerns about some of the paleolandscape reconstructions and associated LGM landforms and disagree with some of the details of O'Leary's interpretations. Specifically, O'Leary interprets a linear depression near the southern part of the pipeline corridor as a deep lake. In my opinion, this feature was not a lake at LGM time, but rather it was a tidal-current eroded scour, which formed during the post-LGM transgression (see discussion below).

Erosion and sedimentation

12. As discussed in my Report, the LGM surface constituted a paleolandscape that comprised multiple river channels flowing across a coastal plain towards a shoreline to the north. With the advent of sea-level rise after LGM time of approximately 18,000 yBP (years before present), the paleolandscape gradually was inundated, as the shoreline transgressed and migrated landward across the coastal plain. The process of wave action at the shoreline is associated with erosion and in the course of time, as the shoreline migrated across the pre-existing coastal plain the LGM surface would have been "beheaded" to a certain degree. The precise amount of section removed is difficult to establish in the absence of cores and other data. However, even with such data, estimation of the amount of section removed would remain difficult, if not impossible. The amount of erosion would vary dependent upon multiple factors including: 1) the wave energy at the shoreline, 2) the degree of cementation of the substrate, 3) the energy of tidal currents across the inundated shelf, and 4) the rate of shoreline transgression. It is widely accepted that "transgressions are commonly fully erosional in nature, thus reducing the preservation potential of their sedimentary sequences" (Kraft, 1971; Hein et al., 2014).

13. At the latitude of the study area, the Australian coast would have been subjected to tropical cyclones that would have been associated with high shoreline wave energy from time to time. Short periods of intense wave energy likely would have been responsible for removing an uncertain amount of section. The entire LGM surface from the modern shoreline all the way to the 18,000 yBP would have been subjected to this erosional process. The eroded materials subsequently would have been re-deposited seaward of the shoreline over the top of the eroded paleolandscape. In addition, open-sea waves during such storms would have impacted the inundated LGM surface, potentially further eroding that surface, and in the least would have re-distributed some of the sediments deposited subsequent to flooding. Another erosional process that would have acted upon these transgressive deposits are tidal currents across the flooded shelf. The evidence for this includes the presence of migrating subaqueous dunes (i.e., bedforms created at the seafloor), sediment trails, and shelf current-related erosional scour on the modern seafloor. These transgressive deposits, which date back to the late Pleistocene and Holocene, can be observed on both high-resolution multibeam bathymetry maps as well as high-resolution seismic data acquired by Fugro Survey PTY LTD (2017).

14. The modern-day seafloor has been subjected to currents, likely tidal in origin, sweeping across the shelf. The evidence for this is again the presence of subaqueous dunes that show a landward direction of migration – this suggests that the shelf is affected by shelf currents that likely are tidal in nature. Additional evidence of tidal currents include sediment trails in the lee of basin floor positive features, and asymmetric hollows (i.e., closed on one end and open on the other), each suggesting currents generally from the north towards the south. These dunes have been imaged with multibeam surveys along the pipeline corridor (Fugro Survey PTY LTD, 2017). O'Leary acknowledges the presence of tidal currents in today's Clarence and Dunda Straits (O'Leary section 5.0 Phase 6) but does not acknowledge the role of tidal currents across the shelf west of Bathurst and their role in re-shaping the LGM landscape during transgressive time (i.e., between 12,000 yBP and the present).

15. As a consequence of both erosion of the LGM surface and deposition of sediments atop this eroded surface, the landscape upon which human habitation occurred would have been altered to some degree. Much of the LGM surface was likely underlain by unlithified coastal plain deposits (i.e., floodplain and channel deposits) rather than bedrock and therefore would have been readily erodible by post-transgression processes. Fugro Survey PTY LTD (2017) describe a widespread veneer of unlithified silts and sands as well as numerous buried channels over much of the pipeline corridor (e.g., my Report, **Fig. 15**). Although no age dates for these deposits are available, a reasonable inference is that these are Pleistocene to Holocene in age because of their stratigraphic position at the top of the section as well as their unlithified character (**Fig. 1**).

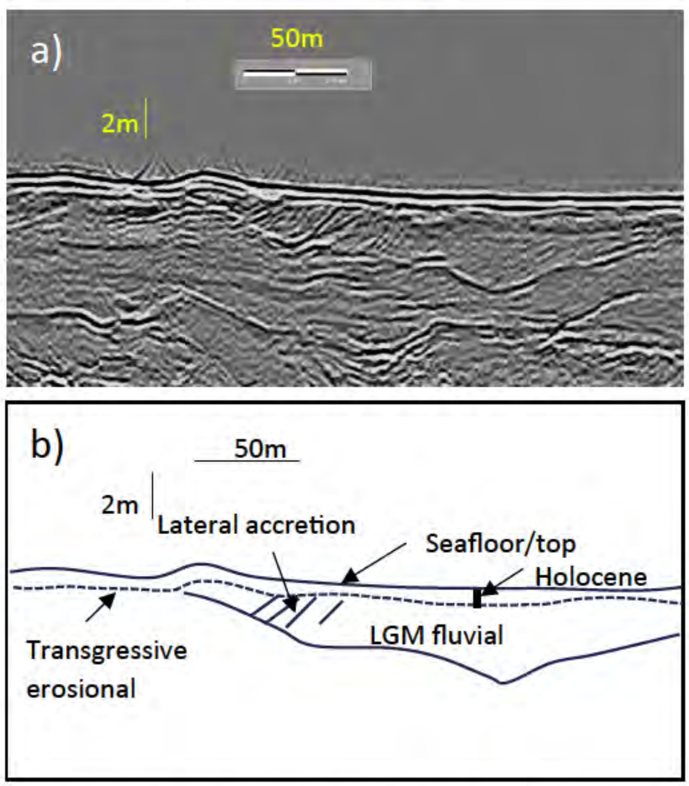

Figure 1. Seismic profile GEP_7_BMR_101_FINAL (Fugro Survey PTY LTD, 2017) illustrating fluvial deposits overlain by a thin (i.e., less than 2m) veneer of Holocene drape deposits.

16. The modern seafloor thus represents a modified version of the LGM surface. Any archaeological objects originally left behind upon the LGM surface likely would have been moved from its original location and buried as well.

Interpretation of modern seafloor bathymetry with respect to paleolandscape reconstruction

O'Leary section 2.4 Submerged terrestrial landscape reconstructions

17. O'Leary has used bathymetric maps to reconstruct the paleo-LGM landscape (see O'Leary section 2.4). The caveat, when using the modern seafloor to infer the presence of paleolandforms, is that this approach does not take into account two factors: 1) post LGM erosion (see discussion above) and 2) post LGM re-deposition of eroded materials as well as river-plume related hemipelagic deposition. These two factors can be responsible for significantly modifying LGM landforms, and along with it removing and transporting archaeological objects, before likely later burial by transgression-related processes. Consequently, inferring age and morphology of paleolandforms using bathymetric maps should be done with caution, making certain that analyses take into consideration processes of erosion and deposition, which may have altered these ancient landscapes. Any archaeological objects left upon these paleolandscapes would also have been affected by these processes.

18. O'Leary also notes that the bathymetric data quality is poor (aside from the narrow swath of Multibeam Echo Sounder – MBES – data along the pipeline corridor), which further undermines the utility of the bathymetric data with respect to precise identification of landforms (see O'Leary sections 2.4, 6.2.5).

Lake and river to the west of Bathurst Island [See O'Leary sections 5.0, 6.2.3, 6.2.5, 8.0]

19. As I have noted in my Report, and also described by O'Leary, there appears to be a significant channel just to the west of the proposed pipeline corridor as revealed on bathymetric maps of this area. This channel figures prominently in the O'Leary report. When modern bathymetric data are examined in detail one can observe that the apparent channel fairway is not a continuous fairway of uniform depth, but rather consists of a series or chain of linear depressions that line up to define a long linear fairway. That is, there is no single uninterrupted channel from the LGM paleo-shoreline (i.e., the 125m isobath – the subsea contour line that corresponds to a modern-day water depth of 125m) southward to where the pipeline corridor ends. Rather, the channel on the modern seafloor consists of a segmented chain of linear depressions (**Fig. 2**), one of which O'Leary has interpreted as a deep lake (O'Leary section 6.2). In my opinion, there are two alternative interpretations to explain these depressions: 1) the original channel that extended across the shelf was only partially infilled, leaving segments that were unfilled appearing as linear disconnected depressions, or 2) the linear depressions represent segments of the river channel that were erosionally scoured by tidal currents during transgression. In neither case were these channels lakes during LGM time (see discussion below).

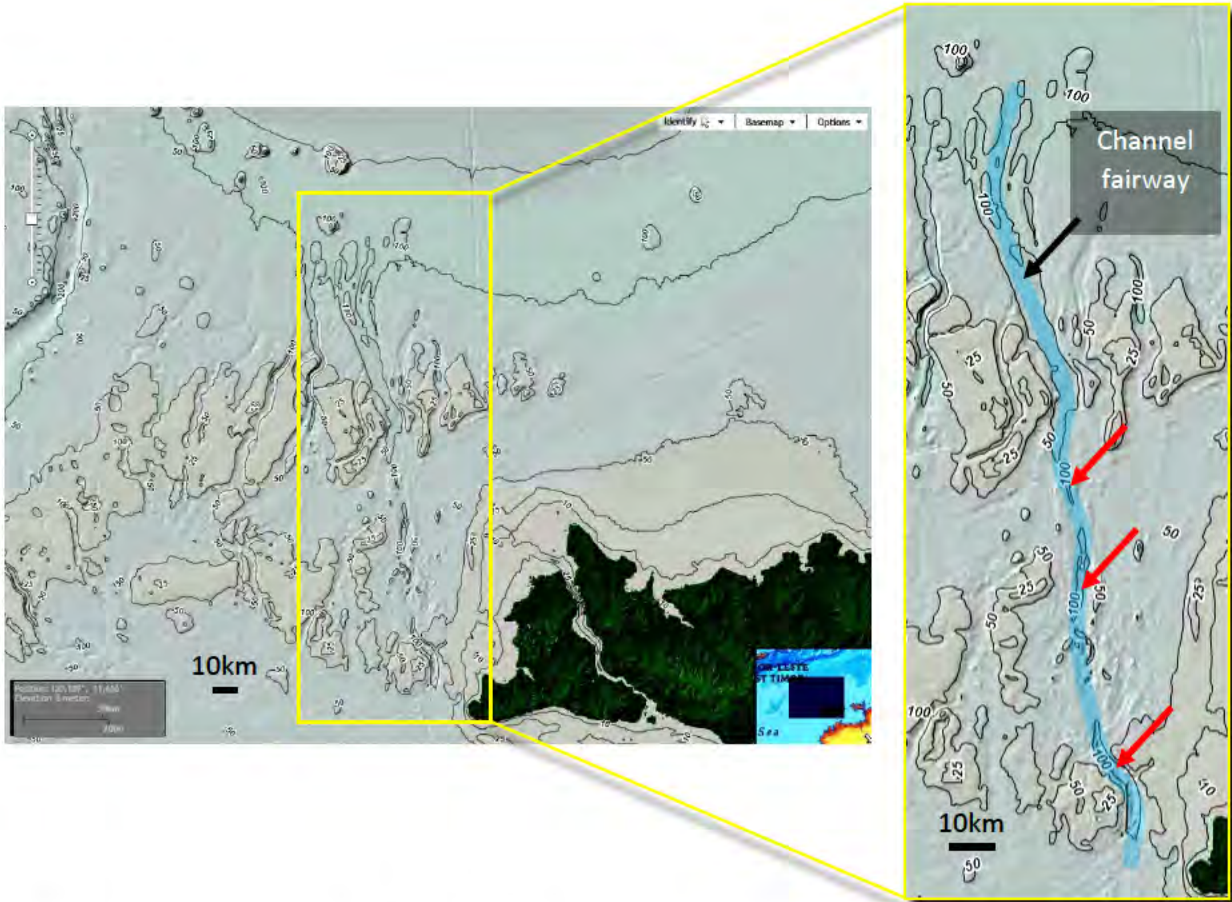

Figure 2. Channel fairway (black arrow) extending from the LGM shoreline to the southern terminus of the pipeline corridor. The bathymetric expression of the channel fairway comprises a chain of isolated linear depressions (red arrows), defined by the 100m isobath.

20. Of particular interest with respect to the inferred channel is the linear depression observed on the bathymetric map near the southern terminus of the pipeline corridor (**Fig. 3**). This depression has been interpreted by O'Leary as a long (25km) and "very deep" LGM lake (O'Leary section 5.0 Phase 4). In my opinion, this feature has a significantly more complex origin and likely was not a lake during LGM time. An assessment of how lakes form yields insights that bear on the likelihood of this feature having been a lake at LGM time.

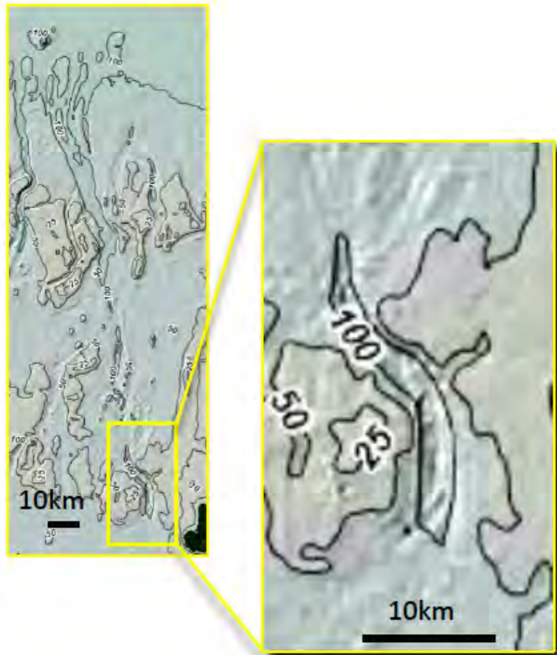

Figure 3. Linear depression near the southern terminus of the pipeline corridor. Current water depth across this depression is greater than 100m. This depression lies between the gentle slope (i.e., the contours are widely spaced) of Bathurst Island on the east and what appears to be a possible submerged carbonate island (i.e., small platform) to the west.

21. In general, lakes in coastal plain settings form naturally where there is significant local subsidence. Where local subsidence occurs that is greater than the rate at which fluvial deposits keep up with that subsidence, a lake will form. This happens in tectonically active settings such as rift valleys. Rift valleys represent the earliest phase of continental break-up and are characterized by accelerated subsidence that varies along the length of the rift valley. In such settings, as illustrated in **Figure 4**, the earliest phase of rifting commonly is associated with a string of lakes, where the lakes form in those parts of the rift where subsidence is high. Rivers entering into these lakes deposit sediments onto the lake margin and lake floor. Eventually, if rift-related subsidence stops, the lake will gradually infill with sediment and the lake will cease to exist.

Figure 4. Great Rift Valley, East Africa. Arrows indicate the presence of linear lakes with the Rift Valley. These lakes form where subsidence rate exceeds sedimentation rate, and form a string of unfilled depressions within this rift or pull-apart tectonic setting. (Google Earth, 2023)

22. Based on regional tectonics, this area of the seafloor underlying the Arafura Sea is not (and was not during the Pleistocene) an area of active rifting; hence, this mechanism of lake formation does not come into play here. More regional subsidence, if it were to have occurred here would have resulted in multiple lakes to the west, and, in general a broad lowland area. However, this is not the case (i.e., there are no significant linear depressions in that area). Moreover, the bathymetry of the flanks of this linear depression identified by O'Leary is characterized by immediately adjacent highland areas, the antithesis of what would characterize an area of broad subsidence. The broad shelf embayment that

lies approximately 200km to the west, referred to as the Malita Intra-Shelf Basin (Bourget et al., 2013), is the more likely geomorphologic response to regional subsidence (**Fig. 5**).

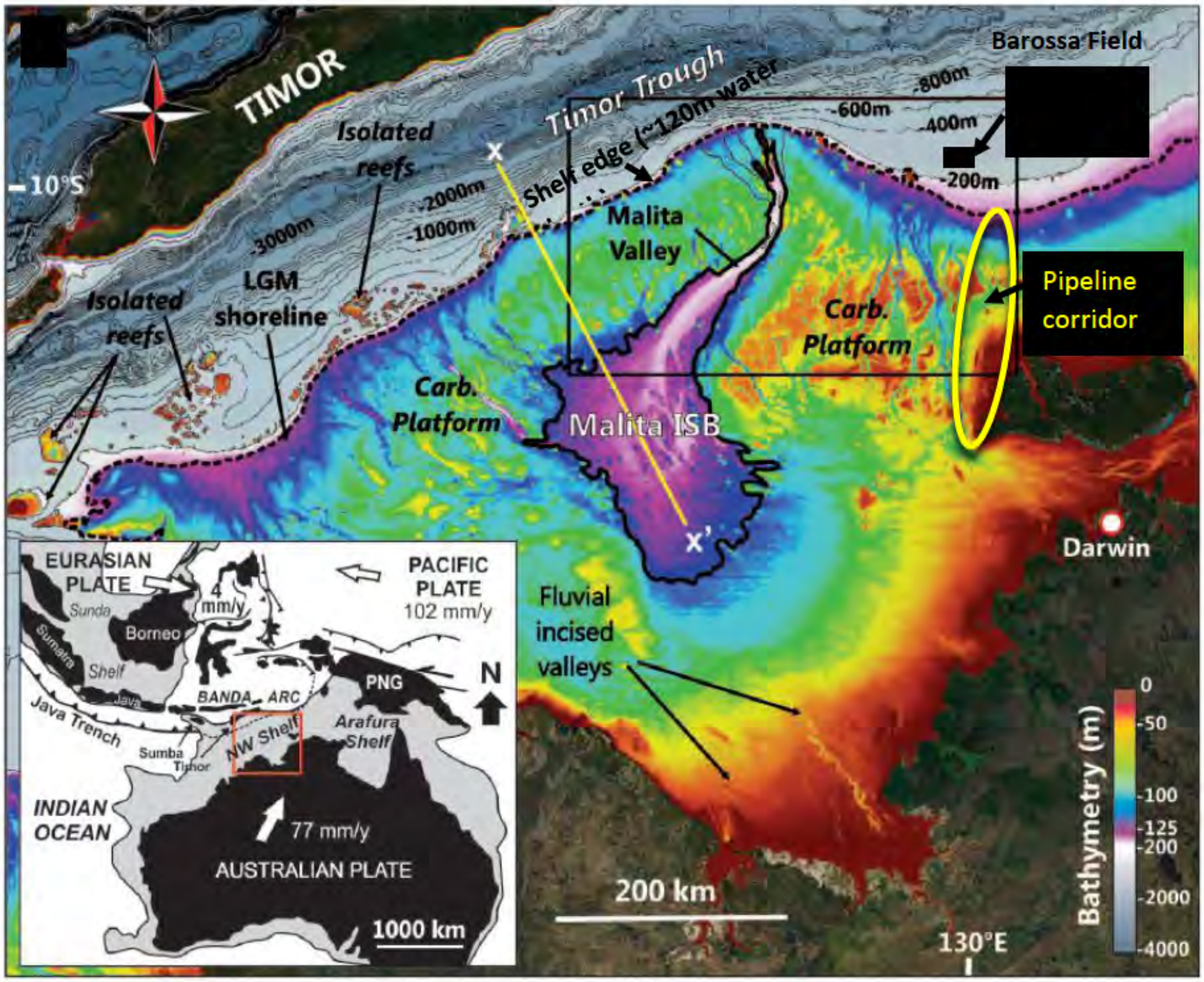

Figure 5. Physiography of the Arafura Sea. Key features include the shelf edge (located just south of Barossa Field), the Malita intra-shelf basin with associated Malita Valley, broad carbonate platforms on the outer shelf flanking the Malita Valley, and small isolated reefs (i.e., carbonate buildups that lie at or just seaward of the shelf edge; from Bourget et al., 2013). The general pipeline corridor is indicated by a yellow oval.

23. Ruling out subsidence as a driver for creating this linear depression, other alternative modes of formation can be considered. The fact that this depression does not lie out in an open shelf setting, but rather lies between two highland areas (which may represent paleo islands) suggests a genetic relationship with these highland areas. In my opinion, this linear depression has a complex history that is the result of an original LGM fluvial channel that was later enhanced by focused tidal scour during subsequent transgression (i.e., post-LGM time) (**Fig. 6**).

24. **Figure 7** schematically illustrates the proposed evolution of this feature. At **Time 1** – LGM time – a fluvial fairway was established just to the west of what is now Bathurst Island and what was then the Australian mainland. Flow was to the north, with the river emptying into the lowstand sea at what is

now the 125m isobath. As is the case with most fluvial systems, this river was likely characterized by a relatively smooth equilibrium longitudinal profile (i.e., the profile down the axis of the river) (Mackin, 1948), without significant depressions along the way. Thus, no lakes likely were present at LGM time (**Fig. 8**). With the onset of sea-level rise after the LGM, the shelf and the fluvial fairway were gradually flooded. As illustrated in **Figure 6**, the shelf was then the site of active carbonate growth characterized by a number of islands comprising carbonate buildups (e.g., patch reefs and platforms). The fluvial channel was likely still present, albeit flooded at this time and no longer an active system.

25. At **Time 2** (**Fig. 7**), approximately 10-12,000 yBP, active shelf currents, probably tidal in origin, were present on the submerged shelf. Wherever these currents encountered a constriction such as a flooded fluvial channel on the seafloor tidal current velocity would be increased. This increased flow velocity would have resulted in deepening and erosion of the channel deposits. In this way, much of the LGM fluvial deposits would have been removed and replaced with transgressive deposits. Consequently, archaeological objects that may have been left on the alluvial plain within the original channel would have suffered the same fate as the fluvial deposits – that is, they would have been eroded, removed from the channel, and ultimately re-distributed elsewhere as transgressive deposits.

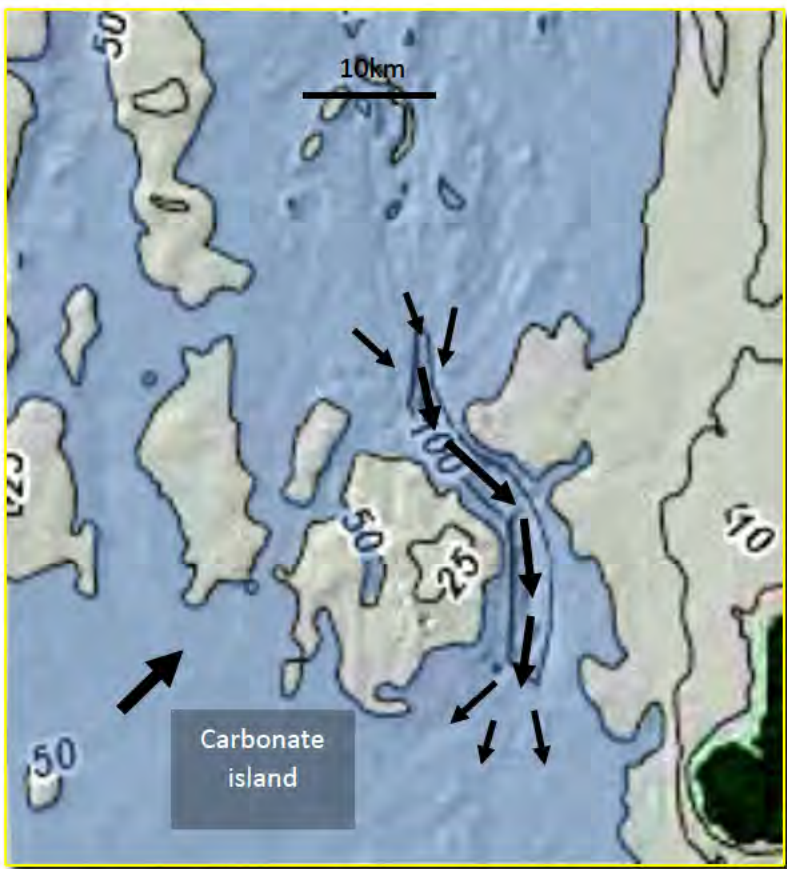

Figure 6. Bathymetric map showing partial inundation of the shelf. At this time (~10-12,000yBP) carbonate islands were likely present just to the west of the linear depression. The paleo fluvial channel fairway was flooded and the gap between the carbonate island and Bathurst Island where the fluvial channel had been, was then the site of a tidal channel. Black arrows indicate enhanced tidal currents focusing through a narrow highland gap. Where flows are constricted, as

they would have been between the flanking highland areas, the flow velocity would have increased and erosively scoured and deepened the channel, thus producing a linear depression as observed on the bathymetric map. As a consequence of this erosion, much of the original LGM fluvial fill would have been removed and only later tide-related sediments would be encountered within the linear depression.

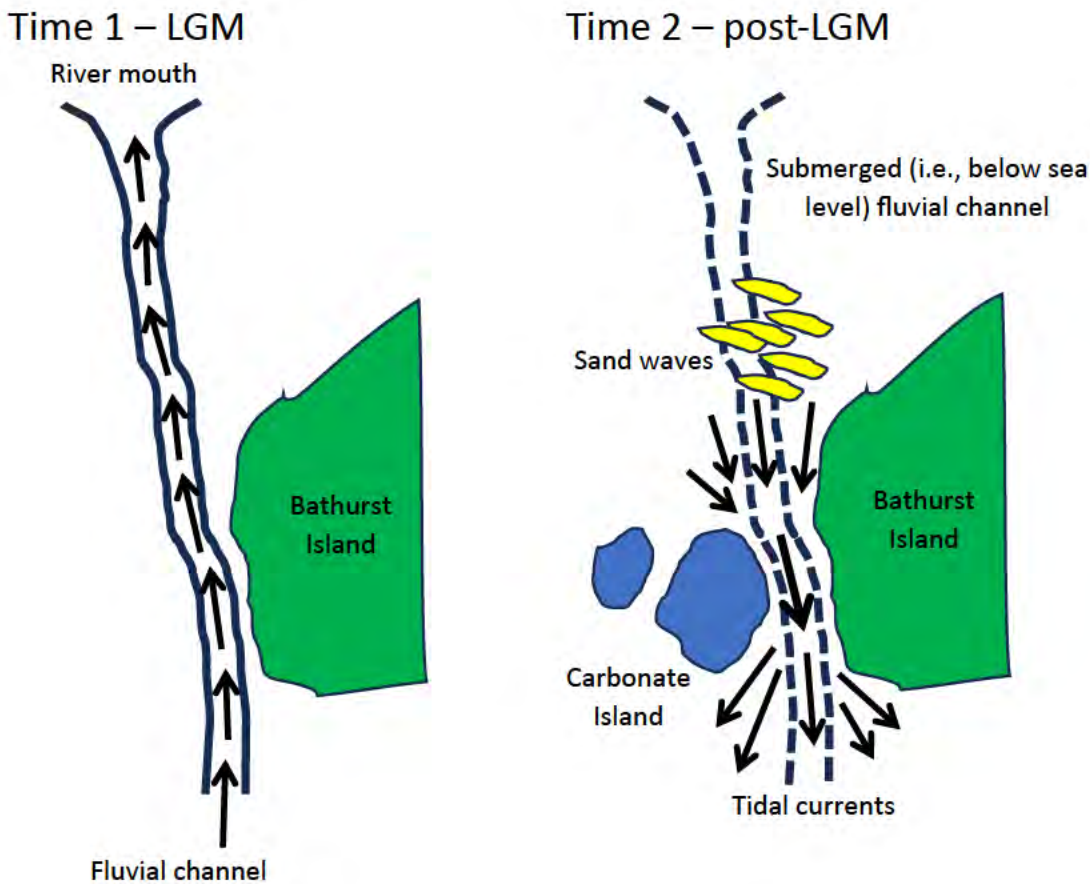

Figure 7. Schematic evolution of linear depression just west of the proposed Barossa pipeline. **Time 1**: fluvial channel during LGM time, just west of Bathurst Island highland. There may or may not have been carbonate islands to the west of this channel fairway. River flow was to the north and emptied into the lowstand sea at the LGM shoreline. **Time 2**: post-LGM transgression (~10-12,000 yBP). The shelf was partially flooded and the fluvial channel was then submerged (i.e., the fluvial system was no longer active). Tidal current focusing would have resulted in deepening of the channel (i.e., erosion of LGM fluvial deposits). Elsewhere, transgressive deposits in the form of migrating sediment waves could have infilled the fluvial channel so that in places, no channel expression would be observed at the seafloor.

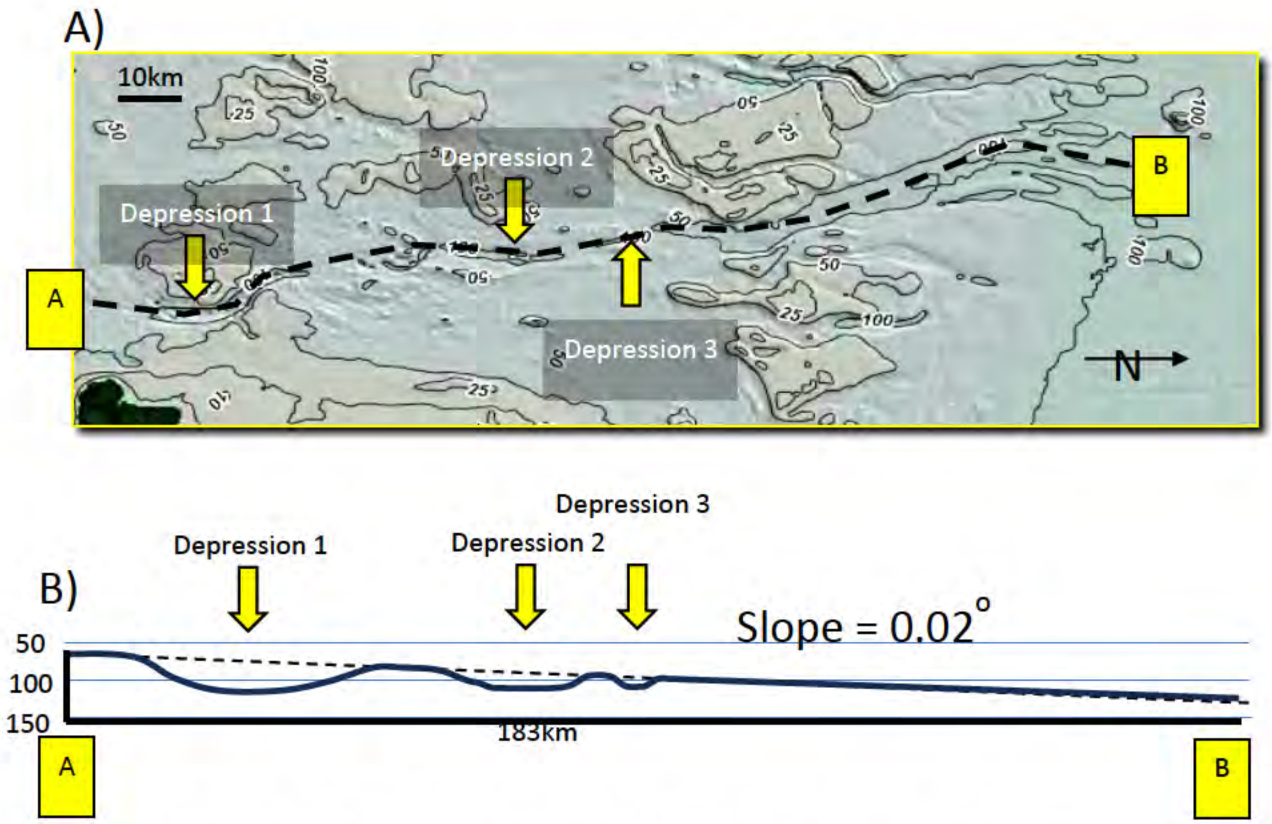

Figure 9. Longitudinal profile along the axis of fluvial fairway just west of the pipeline corridor. A) modern seafloor bathymetry with fluvial fairway axis shown with dashed line. B) Longitudinal profile along the channel axis. The original gradient that likely characterized the fluvial fairway at LGM time is shown as a dashed line that is characterized by uniform dip (from landward to seaward) sloping at approximately 0.02°. The modern-day profile is punctuated by several local depressions that likely formed post LGM time in response to tidal current erosion along the channel fairway.

26. The linear depression has been described by O'Leary as having been a lake over 200m deep at LGM time. Currently this linear depression lies at a water depth of somewhat greater than 100m (the last closing contour associated with this depression is 100m, as observed on bathymetry maps, see **Fig. 9**). When factoring the lowered sea level during LGM time of 125m, the water depth of this depression during LGM time would have to have been significantly less than that amount. This, coupled with the likely erosional scour (which would have resulted in deepening of this linear depression) that occurred during transgressive time, as well as the absence of local subsidence required for lake formation, argues strongly against this having been a lake at LGM time.

27. The continuation of the LGM fluvial fairway to the north of this linear depression is expressed as a subtle linear bathymetric low that would correspond to a fluvial channel belt (**Fig. 3**). Additional bathymetric lows of similar depth as the putative lake referred to by O'Leary punctuate this fairway. There are two likely explanations for the lack of continuity of channel depth (as observed on the

modern seafloor) along the length of the fairway: 1) post-LGM tidal scour along the LGM channel fairway as discussed above, and 2) post-LGM sedimentation (i.e., by sediment waves and fine-grained plume deposits) infilling of parts of the LGM channel fairway (**Fig. 8**).

28. The O'Leary report also fails to mention the presence and role of carbonates in this area. An extensive carbonate platform across the modern Bonaparte continental shelf has been documented by Anderson et al. (2011) (**Fig. 6**). Enhanced carbonate activity during times of transgression are well documented (e.g., Saller, 2011). The elevated area to the west of the linear depression is likely a carbonate island, which is a part of this carbonate platform complex. Carbonates would have been deposited during the time of transgression associated with sea-level rise that followed the LGM lowstand. Whether there were precursor pre-LGM carbonate buildups that were associated with earlier times of shelf flooding is not clear given the currently available data. The degree to which carbonate buildups may or may not have been present prior to post-LGM transgression onto which the post-LGM carbonate factories nucleated, does not impact the post-LGM seascape with respect to possible tidal currents across the area inasmuch as the presence of a raised platform just to the west of the LGM channel fairway is clearly present irrespective of its genesis (i.e., it is unclear whether the carbonates nucleated on a pre-existing carbonate buildup or if they simply built off the LGM seafloor during flooding of the shelf after 12,000 yBP).

Crocodile Man Songline

29. O'Leary refers to the Crocodile Man Songline and describes his migration westward towards what O'Leary refers to as the "embayment" (O'Leary section 6.2.1). According to O'Leary's **Figure 5**, had the Crocodile Man migrated when sea level was less than ~55m lower than today (i.e., during post-LGM Phase 5), he would have reached the shoreline well before reaching the "embayment". If the Crocodile Man had migrated westward when sea level was lower, then he could have reached the embayment.

30. The key issue, however, is whether or not the linear depression observed on the bathymetric map was or was not a standing body of water (i.e., a lake or embayment). O'Leary infers that this modern-day seafloor depression was a lake at LGM time (O'Leary section 6.2.1). As I have discussed, in my opinion my explanation is more supportable, which is that this depression did not exist at LGM time, but rather formed as a result of deepening and scour related to tidal current erosion during post-LGM.

31. O'Leary suggests that the depth of the "embayment" was over 200m in places (O'Leary section 6.2.1). Analysis of the bathymetric map does not justify this assertion, in my opinion. As illustrated in **Figure 9**, the relief of this depression, which should be measured from the floodplain surface to the north or south down to the deepest part of the depression, is at most approximately 75m – see north-south line a-b, **Figure 9**. If one were to measure the *relief* where the depression passes between two highland areas to the east and west, the *relief* is approximately 175m. However, that measured relief from highland to depression floor is not the "embayment" depth, which is more appropriately measured from the floodplain to the depression floor.

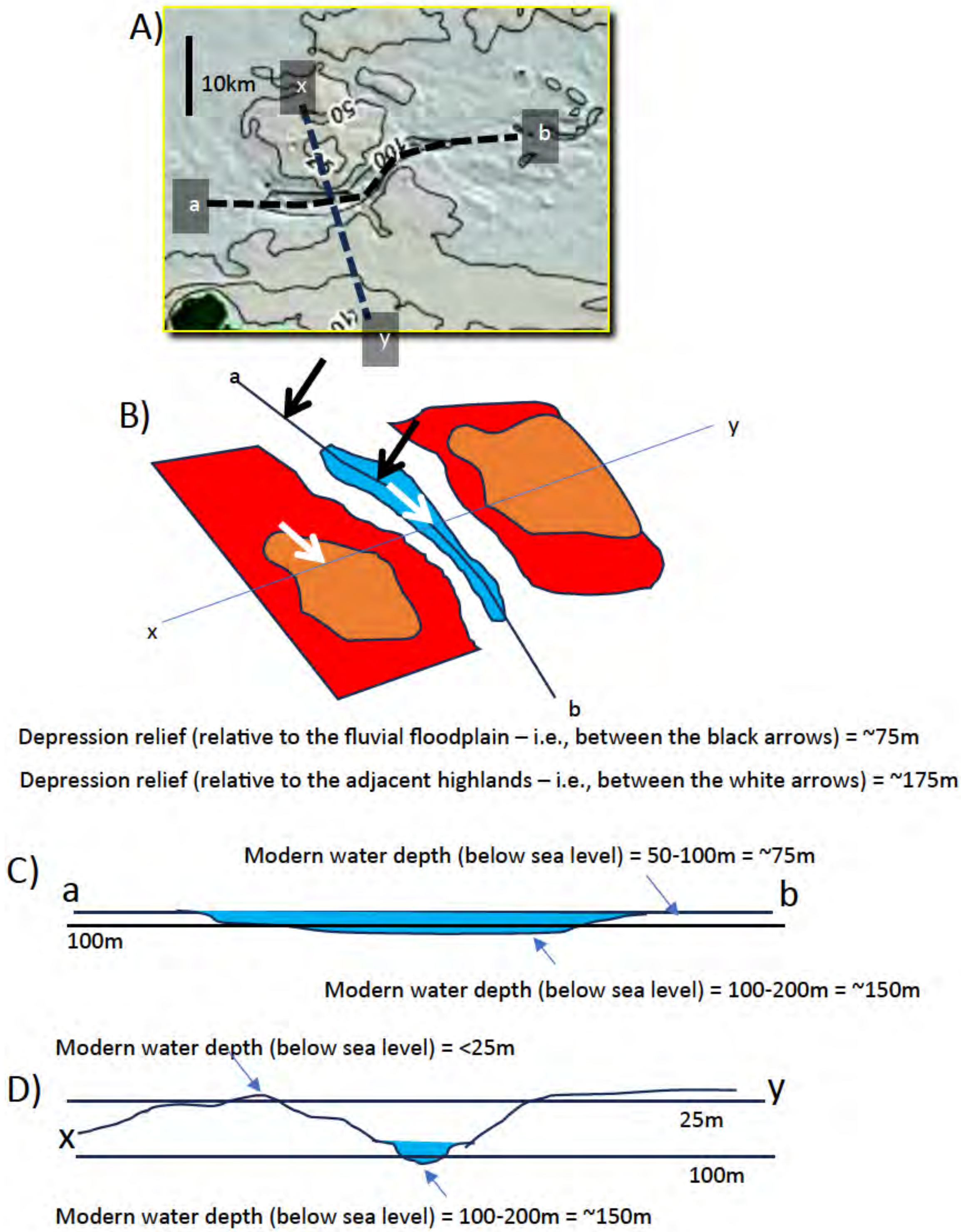

Figure 9. A) Bathymetric map detail showing linear depression within the fluvial fairway. B) schematic perspective view of linear depression flanked by highland areas to the left and right (i.e., west and east), and fluvial fairway to the top and bottom (i.e., north and south). C) and D) illustrate cross profiles as shown on the bathymetric map (A).

Waterfall at headwaters of the embayment [O'Leary section 5.0]

32. In my opinion, the AI-generated image of a waterfall (O'Leary **Figure 5**) at the headwaters of the embayment is not a supportable interpretation, because it appears to be based upon questionable assumptions. For such a waterfall to form several conditions would need to be satisfied. Firstly, the overarching assumption is that there existed a deep embayment – i.e., a deep lake – which, as I have explained above, is questionable, given that in the absence of local subsidence in the region, lakes would not be a common landform. Rather, this linear depression likely formed as a result of erosive tidal currents primarily after shelf flooding post-LGM time as discussed above. Consequently, in the absence of an LGM lake, tributary rivers to the main fluvial fairway likely would not be associated with waterfalls upon joining the fluvial fairway. Moreover, the image suggests the presence of a lithified "caprock" (i.e., a layer of resistant bedrock that results in a precipitous cliff), which is highly speculative. Commonly, channels tributive to incised valleys would be characterized by incision as well, and not have associated waterfalls (**Fig. 10**). Waterfalls commonly are associated with conditions such as the presence of a resistive caprock (compare with **Fig. 10**), which is not readily apparent here.

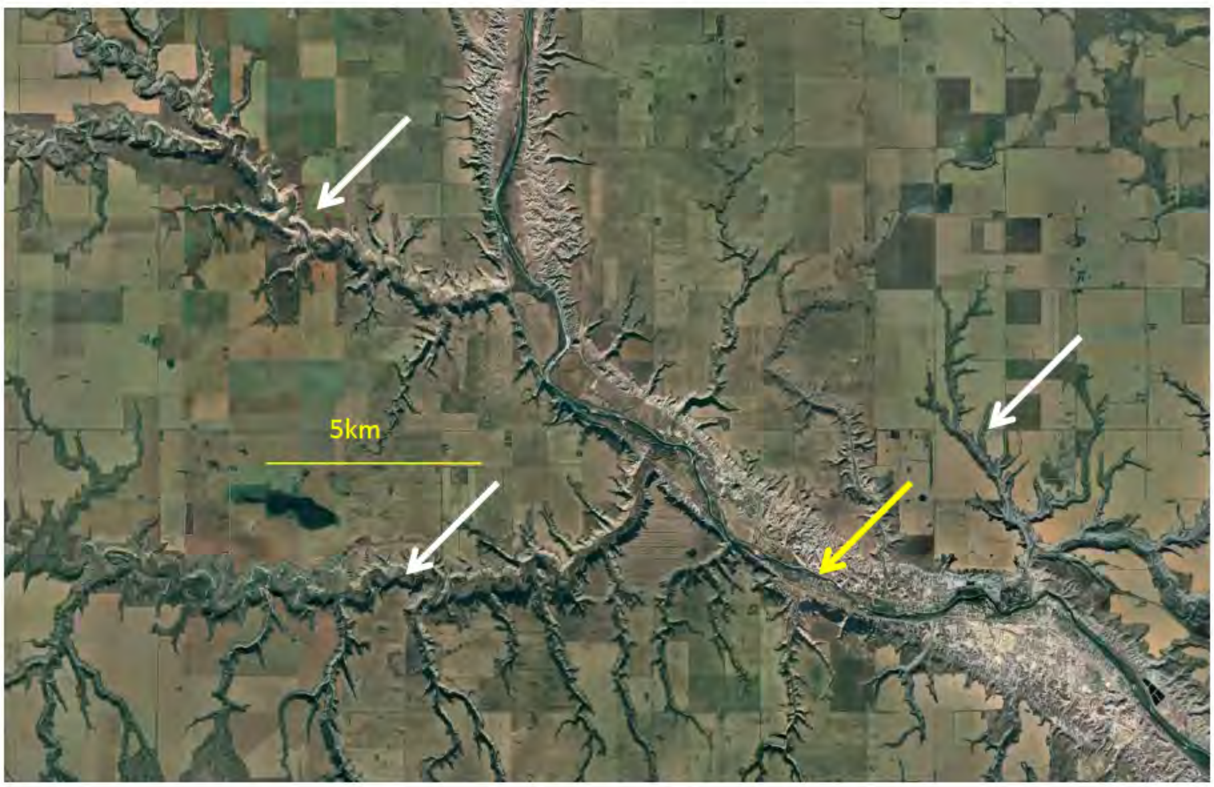

Figure 10. Deeply incised valley (yellow arrow) along the Red Deer River, Alberta, Canada, with associated tributary valleys (white arrows). Note the absence of waterfalls associated with these lateral tributaries. The substrate here is Cretaceous bedrock. (Google Earth, 2023)

Figure 11. Niagara Falls illustrating conditions that would give rise to waterfalls. These include the presence of a deep erosional embayment such as the Niagara gorge down-river from the falls, plus the presence of a resistant caprock (i.e., Lockport Dolomite formation). It is likely that neither of these criteria was present in association with the fluvial fairway in the study area. (Google Earth, 2023)

33. O'Leary states that "the channel can be seen terminating against a 2km long cliff edge" resulting in "waterfalls or cascades of at least 10m and up to 25m high along this southern end of the lake." This can be described as a "hanging valley" (i.e., a tributary valley or channel whose terminus "hangs" above the valley into which the tributary is flowing, producing waterfalls), which is common in situations where a main valley has been eroded deeply and a tributary valley has not cut down to join this main valley. O'Leary does not explain what erosional mechanism would have resulted in the requisite erosional scour. In my opinion, the likely mechanism that would have produced this linear depression, i.e., post-transgression subaqueous tidal current scour, would readily explain the apparent hanging valley relationship with the main channel and its tributary. Inasmuch as this hanging valley relationship would have formed subaqueously, there would have been no waterfall as depicted in O'Leary's **Figure 5**.

Burial grounds [O'Leary sections 6.2.4]

34. The burial grounds to which O'Leary refers are inferred from the presence of subtle ridges observed on the bathymetric maps of the modern seafloor. This interpretation appears to be based on two assumptions: 1) that the bathymetric maps are of sufficient resolution to allow for precise recognition and subsequent interpretation of these features, and 2) that the features on the modern seafloor are features that existed at LGM time and are not the product of processes that were active at post-LGM time – i.e., that these features are not the product of such processes as tidal currents and storm-driven currents. In my opinion these assumptions are not able to be justified. O'Leary repeatedly alludes to the poor quality of the bathymetric data while also not taking into account post-LGM processes that could well have been responsible for the formation of these features.

35. **Figure 12** shows an MBES image over one of the interpreted burial grounds in the form of a northwest-southeast trending ridge. Sand waves and sediment trails indicate the presence of strong post-LGM

shelf currents. However, the origin of the observed ridge is unclear. Although I cannot rule out a burial ground origin, the sharp, almost knife-edge crest of this feature suggests otherwise inasmuch as a burial mound likely would be characterized by a smooth or rounded top.

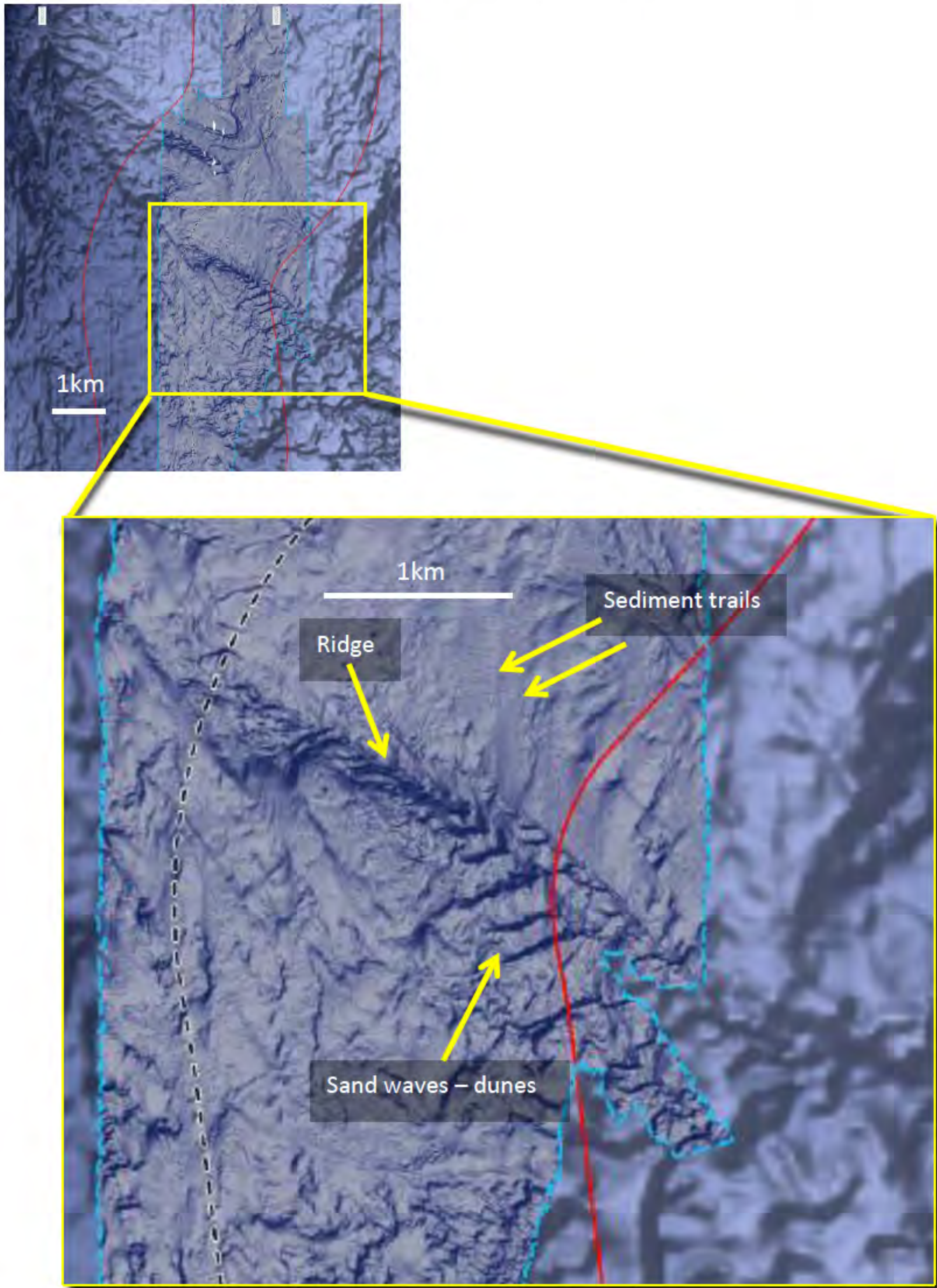

Figure 12. MBES image of seafloor (Fugro Survey PTY LTD, 2017) interpreted by O'Leary as possible burial grounds. The presence of sediment trails and sand waves support the inference

of strong post-LGM shelf currents directed towards the south-southeast. From a morphological perspective the northwest-southeast trending ridge is of uncertain origin.

Conclusions

36. In my opinion, the O'Leary report fails to take into account post-LGM processes that may have had significant impact on the preservation of the LGM associated landforms. These processes include erosion by waves (both at the shoreline as well as in the open sea) and tidal currents, in addition to deposition of transgressive deposits such as sand-prone sediment waves and river-plume sedimentation. In particular, because it is an important aspect of the O'Leary report, the origin of the linear depression near the southern terminus of the pipeline corridor is that it was not a lake as suggested by O'Leary, but rather a tidal-current channel that formed and likely eroded any precursor fluvial deposits (i.e., the fluvial channel fill and associated floodplain) after the shelf was flooded post-LGM time. A tidal channel would have been created subsea, after marine flooding had inundated the paleolandscape post-LGM.

37. In addition to the lack of consideration of post-LGM modification of the LGM landscape, the role of carbonates, which also likely formed post-LGM time, was not considered. These carbonates, in the form of islands that formed after the shelf flooded, impacted the tidal current effect on the paleolandscape, tending to significantly enhance these currents wherever a bathymetric restriction (e.g., a gap between islands) was present.

38. Given my interpretation – i.e., tidal channel rather than lake – the LGM landscape would have been substantially modified by erosion. The erosion of the LGM landscape, including the fluvial channel as well as the adjacent interfluve floodplain areas, coupled with deposition over the top of this eroded landscape during post-LGM time would make encountering any archaeological objects *in situ* on today's seafloor, unlikely. The land that was subaerial during LGM time was, in my opinion, significantly modified post-LGM in light of the processes described above.

39. As a consequence of integrating considerations of erosion and sedimentation that would have occurred post-LGM transgression, O'Leary's discussion of the Crocodile Man Songline as well as discussion of the burial grounds is called into question. Modification of the LGM landscape by post transgressive processes would have impacted how the modern seafloor, as observed on bathymetric maps, should be applied to his analyses.

References

i. Anderson, T.J., Nichol, S., Radke, L., Heap, A.P., Battershill, C., Hughes, M., Siwabessy, P.J., Barrie, V., Alvarez de Galsby, B., Tran, M., Daniell, J., Shipboard Party, 2011, Seabed environments of the eastern Joseph Bonaparte Gulf, Northern Australia, GA0325/Sol5117, Post-Survey Report; Geoscience Australia, 61p.

ii. Belknap, D.F., and Kraft J.C., 1985, Influence of antecedent geology on stratigraphic preservation potential and evolution of Delaware's barrier systems: Marine Geology, v. 63, p. 235–262, doi:10.1016/0025-3227(85)90085-4.

iii. Bourget, J., Ainsworth, R.B., and Nanson, R., 2013, Origin of mixed carbonate and siliciclastic sequences at the margin of a "giant" platform during the Quaternary (Bonaparte Basin, NW Australia); in Verwer, K., Playton, T.E., and Harris, P.M., eds., SEPM Special Publication 105, Deposits, Architecture, and Controls on Carbonate Margin, Slope, and Basinal Settings, p. 157-177.Conoco Phillips Australia PTY LTD, 2018, Barossa Project, Geophysical survey report – Export pipeline route, Skandi Hercules; DOF Subsea Doc. # 1002707-SV-CL-403-0007.

iv. Fugro Survey PTY LTD, 2017, Barossa Project – Bathymetry, geophysical and environmental survey services; Fugro Document No. FRPT GP1577, 59pp.

v. Hein, C.J., FitzGerald, D.M., de Menezes, J.T., Cleary, W.J., Klein, A.H.F., and Albernaz, M.B., 2014, Coastal response to late-stage transgression and sea-level highstand; Geological Society of America Bulletin, v. 126, p. 459–480.

vi. Kraft J.C., 1971, Sedimentary facies patterns and geologic history of a Holocene marine transgression: Geological Society of America Bulletin, v. 82, p. 2131–2158, doi:10.1130/0016-7606()82[2131:SFPAGH]2.0.CO;2.

vii. Mackin, J.H., 1948, Concept of the graded river; Geological Society of America Bulletin, v. 59, p. 463–512.

viii. Saller, A.H., Reksalegora, S.W., and Bassant, P., 2011, Sequence Stratigraphy and Growth of Shelfal Carbonates in a Deltaic Province, Kutai Basin, Offshore East Kalimantan, Indonesia, *in* W.A. Morgan, A.D. George, P.M. Harris, J.A. Kupecz, and J.F. Sarg, eds., Cenozoic Carbonate Systems of Australasia: Society for Sedimentary Geology Special Publication 96, p. 147-174.

Appendices

Appendix 1. Harmonized Expert Witness Code of Conduct

Appendix 2. Expert Evidence Practice Note

Appendix 1.

Annexure A

HARMONISED EXPERT WITNESS CODE OF CONDUCT[2]

APPLICATION OF CODE

1. This Code of Conduct applies to any expert witness engaged or appointed:

   (a) to provide an expert's report for use as evidence in proceedings or proposed proceedings; or

   (b) to give opinion evidence in proceedings or proposed proceedings.

GENERAL DUTIES TO THE COURT

2. An expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

CONTENT OF REPORT

3. Every report prepared by an expert witness for use in Court shall clearly state the opinion or opinions of the expert and shall state, specify or provide:

   (a) the name and address of the expert;

   (b) an acknowledgment that the expert has read this code and agrees to be bound by it;

   (c) the qualifications of the expert to prepare the report;

   (d) the assumptions and material facts on which each opinion expressed in the report is based [a letter of instructions may be annexed];

   (e) the reasons for and any literature or other materials utilised in support of such opinion;

   (f) (if applicable) that a particular question, issue or matter falls outside the expert's field of expertise;

   (g) any examinations, tests or other investigations on which the expert has relied, identifying the person who carried them out and that person's qualifications;

   (h) the extent to which any opinion which the expert has expressed involves the acceptance of another person's opinion, the identification of that other person and the opinion expressed by that other person;

   (i) a declaration that the expert has made all the inquiries which the expert believes are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which the expert regards as relevant have, to the

[2] Approved by the Council of Chief Justices' Rules Harmonisation Committee

knowledge of the expert, been withheld from the Court;

(j) any qualifications on an opinion expressed in the report without which the report is or may be incomplete or inaccurate;

(k) whether any opinion expressed in the report is not a concluded opinion because of insufficient research or insufficient data or for any other reason; and

(l) where the report is lengthy or complex, a brief summary of the report at the beginning of the report.

SUPPLEMENTARY REPORT FOLLOWING CHANGE OF OPINION

4. Where an expert witness has provided to a party (or that party's legal representative) a report for use in Court, and the expert thereafter changes his or her opinion on a material matter, the expert shall forthwith provide to the party (or that party's legal representative) a supplementary report which shall state, specify or provide the information referred to in paragraphs (a), (d), (e), (g), (h), (i), (j), (k) and (l) of clause 3 of this code and, if applicable, paragraph (f) of that clause.

5. In any subsequent report (whether prepared in accordance with clause 4 or not) the expert may refer to material contained in the earlier report without repeating it.

DUTY TO COMPLY WITH THE COURT'S DIRECTIONS

6. If directed to do so by the Court, an expert witness shall:

   (a) confer with any other expert witness;

   (b) provide the Court with a joint-report specifying (as the case requires) matters agreed and matters not agreed and the reasons for the experts not agreeing; and

   (c) abide in a timely way by any direction of the Court.

CONFERENCE OF EXPERTS

7. Each expert witness shall:

   (a) exercise his or her independent judgment in relation to every conference in which the expert participates pursuant to a direction of the Court and in relation to each report thereafter provided, and shall not act on any instruction or request to withhold or avoid agreement; and

   (b) endeavour to reach agreement with the other expert witness (or witnesses) on any issue in dispute between them, or failing agreement, endeavour to identify and clarify the basis of disagreement on the issues which are in dispute.

Appendix 2.

FEDERAL COURT OF AUSTRALIA

EXPERT EVIDENCE PRACTICE NOTE (GPN-EXPT)

General Practice Note

1. INTRODUCTION

1.1 This practice note, including the *Harmonised Expert Witness Code of Conduct* ("**Code**") (see Annexure A) and the *Concurrent Expert Evidence Guidelines* ("**Concurrent Evidence Guidelines**") (see Annexure B), applies to any proceeding involving the use of expert evidence and must be read together with:

(a) the Central Practice Note (CPN-1), which sets out the fundamental principles concerning the National Court Framework ("**NCF**") of the Federal Court and key principles of case management procedure;

(b) the Federal Court of Australia Act 1976 (Cth) ("**Federal Court Act**");

(c) the *Evidence Act 1995* (Cth) ("**Evidence Act**"), including Part 3.3 of the Evidence Act;

(d) Part 23 of the *Federal Court Rules 2011* (Cth) ("**Federal Court Rules**"); and

(e) where applicable, the Survey Evidence Practice Note (GPN-SURV).

1.2 This practice note takes effect from the date it is issued and, to the extent practicable, applies to proceedings whether filed before, or after, the date of issuing.

2. APPROACH TO EXPERT EVIDENCE

2.1 An expert witness may be retained to give opinion evidence in the proceeding, or, in certain circumstances, to express an opinion that may be relied upon in alternative dispute resolution procedures such as mediation or a conference of experts. In some circumstances an expert may be appointed as an independent adviser to the Court.

2.2 The purpose of the use of expert evidence in proceedings, often in relation to complex subject matter, is for the Court to receive the benefit of the objective and impartial assessment of an issue from a witness with specialised knowledge (based on training, study or experience - see generally s 79 of the Evidence Act).

2.3 However, the use or admissibility of expert evidence remains subject to the overriding requirements that:

(a) to be admissible in a proceeding, any such evidence must be relevant (s 56 of the Evidence Act); and

(b) even if relevant, any such evidence, may be refused to be admitted by the Court if its probative value is outweighed by other considerations such as the evidence

being unfairly prejudicial, misleading or will result in an undue waste of time (s 135 of the Evidence Act).

2.4 An expert witness' opinion evidence may have little or no value unless the assumptions adopted by the expert (ie. the facts or grounds relied upon) and his or her reasoning are expressly stated in any written report or oral evidence given.

2.5 The Court will ensure that, in the interests of justice, parties are given a reasonable opportunity to adduce and test relevant expert opinion evidence. However, the Court expects parties and any legal representatives acting on their behalf, when dealing with expert witnesses and expert evidence, to at all times comply with their duties associated with the overarching purpose in the Federal Court Act (see ss 37M and 37N).

3. INTERACTION WITH EXPERT WITNESSES

3.1 Parties and their legal representatives should never view an expert witness retained (or partly retained) by them as that party's advocate or "hired gun". Equally, they should never attempt to pressure or influence an expert into conforming his or her views with the party's interests.

3.2 A party or legal representative should be cautious not to have inappropriate communications when retaining or instructing an independent expert, or assisting an independent expert in the preparation of his or her evidence. However, it is important to note that there is no principle of law or practice and there is nothing in this practice note that obliges a party to embark on the costly task of engaging a "consulting expert" in order to avoid "contamination" of the expert who will give evidence. Indeed the Court would generally discourage such costly duplication.

3.3 Any witness retained by a party for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based in the specialised knowledge of the witness[1] should, at the earliest opportunity, be provided with:

(a) a copy of this practice note, including the Code (see Annexure A); and

(b) all relevant information (whether helpful or harmful to that party's case) so as to enable the expert to prepare a report of a truly independent nature.

3.4 Any questions or assumptions provided to an expert should be provided in an unbiased manner and in such a way that the expert is not confined to addressing selective, irrelevant or immaterial issues.

[1] Such a witness includes a "Court expert" as defined in r 23.01 of the Federal Court Rules. For the definition of "expert", "expert evidence" and "expert report" see the Dictionary, in Schedule 1 of the Federal Court Rules.

4. ROLE AND DUTIES OF THE EXPERT WITNESS

4.1 The role of the expert witness is to provide relevant and impartial evidence in his or her area of expertise. An expert should never mislead the Court or become an advocate for the cause of the party that has retained the expert.

4.2 It should be emphasised that there is nothing inherently wrong with experts disagreeing or failing to reach the same conclusion. The Court will, with the assistance of the evidence of the experts, reach its own conclusion.

4.3 However, experts should willingly be prepared to change their opinion or make concessions when it is necessary or appropriate to do so, even if doing so would be contrary to any previously held or expressed view of that expert.

Harmonised Expert Witness Code of Conduct

4.4 Every expert witness giving evidence in this Court must read the *Harmonised Expert Witness Code of Conduct* (attached in Annexure A) and agree to be bound by it.

4.5 The Code is not intended to address all aspects of an expert witness' duties, but is intended to facilitate the admission of opinion evidence, and to assist experts to understand in general terms what the Court expects of them. Additionally, it is expected that compliance with the Code will assist individual expert witnesses to avoid criticism (rightly or wrongly) that they lack objectivity or are partisan.

5. CONTENTS OF AN EXPERT'S REPORT AND RELATED MATERIAL

5.1 The contents of an expert's report must conform with the requirements set out in the Code (including clauses 3 to 5 of the Code).

5.2 In addition, the contents of such a report must also comply with r 23.13 of the Federal Court Rules. Given that the requirements of that rule significantly overlap with the requirements in the Code, an expert, unless otherwise directed by the Court, will be taken to have complied with the requirements of r 23.13 if that expert has complied with the requirements in the Code and has complied with the additional following requirements. The expert shall:

(a) acknowledge in the report that:

(i) the expert has read and complied with this practice note and agrees to be bound by it; and

(ii) the expert's opinions are based wholly or substantially on specialised knowledge arising from the expert's training, study or experience;

(b) identify in the report the questions that the expert was asked to address;

(c) sign the report and attach or exhibit to it copies of:

(i) documents that record any instructions given to the expert; and

(ii) documents and other materials that the expert has been instructed to consider.

5.3 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the other parties at the same time as the expert's report.

6. CASE MANAGEMENT CONSIDERATIONS

6.1 Parties intending to rely on expert evidence at trial are expected to consider between them and inform the Court at the earliest opportunity of their views on the following:

(a) whether a party should adduce evidence from more than one expert in any single discipline;

(b) whether a common expert is appropriate for all or any part of the evidence;

(c) the nature and extent of expert reports, including any in reply;

(d) the identity of each expert witness that a party intends to call, their area(s) of expertise and availability during the proposed hearing;

(e) the issues that it is proposed each expert will address;

(f) the arrangements for a conference of experts to prepare a joint-report (see Part 7 of this practice note);

(g) whether the evidence is to be given concurrently and, if so, how (see Part 8 of this practice note); and

(h) whether any of the evidence in chief can be given orally.

6.2 It will often be desirable, before any expert is retained, for the parties to attempt to agree on the question or questions proposed to be the subject of expert evidence as well as the relevant facts and assumptions. The Court may make orders to that effect where it considers it appropriate to do so.

7. CONFERENCE OF EXPERTS AND JOINT-REPORT

7.1 Parties, their legal representatives and experts should be familiar with aspects of the Code relating to conferences of experts and joint-reports (see clauses 6 and 7 of the Code attached in Annexure A).

7.2 In order to facilitate the proper understanding of issues arising in expert evidence and to manage expert evidence in accordance with the overarching purpose, the Court may require experts who are to give evidence or who have produced reports to meet for the purpose of identifying and addressing the issues not agreed between them with a view to reaching agreement where this is possible ("**conference of experts**"). In an appropriate case, the Court may appoint a registrar of the Court or some other suitably qualified person ("**Conference Facilitator**") to act as a facilitator at the conference of experts.

7.3 It is expected that where expert evidence may be relied on in any proceeding, at the earliest opportunity, parties will discuss and then inform the Court whether a conference of experts and/or a joint-report by the experts may be desirable to assist with or simplify the giving of expert evidence in the proceeding. The parties should discuss the necessary arrangements for any conference and/or joint-report. The arrangements discussed between the parties should address:

(a) who should prepare any joint-report;

(b) whether a list of issues is needed to assist the experts in the conference and, if so, whether the Court, the parties o r the experts should assist in preparing such a list;

(c) the agenda for the conference of experts; and

(d) arrangements for the provision, to the parties and the Court, of any joint-report or any other report as to the outcomes of the conference ("**conference report**").

Conference of Experts

7.4 The purpose of the conference of experts is for the experts to have a comprehensive discussion of issues relating to their field of expertise, with a view to identifying matters and issues in a proceeding about which the experts agree, partly agree or disagree and why. For this reason the conference is attended only by the experts and any Conference Facilitator. Unless the Court orders otherwise, the parties' lawyers will not attend the conference but will be provided with a copy of any conference report.

7.5 The Court may order that a conference of experts occur in a variety of circumstances, depending on the views of the judge and the parties and the needs of the case, including:

(a) while a case is in mediation. When this occurs the Court may also order that the outcome of the conference or any document disclosing or summarising the experts' opinions be confidential to the parties while the mediation is occurring;

(b) before the experts have reached a final opinion on a relevant question or the facts involved in a case. When this occurs the Court may order that the parties exchange draft expert reports and that a conference report be prepared for the use of the experts in finalising their reports;

(c) after the experts' reports have been provided to the Court but before the hearing of the experts' evidence. When this occurs the Court may also order that a conference report be prepared (jointly or otherwise) to ensure the efficient hearing of the experts' evidence.

7.6 Subject to any other order or direction of the Court, the parties and their lawyers must not involve themselves in the conference of experts process. In particular, they must not seek to encourage an expert not to agree with another expert or otherwise seek to influence the outcome of the conference of experts. The experts should raise any queries they may have in relation to the process with the Conference Facilitator (if one has been appointed) or in

accordance with a protocol agreed between the lawyers prior to the conference of experts taking place (if no Conference Facilitator has been appointed).

7.7 Any list of issues prepared for the consideration of the experts as part of the conference of experts process should be prepared using non-tendentious language.

7.8 The timing and location of the conference of experts will be decided by the judge or a registrar who will take into account the location and availability of the experts and the Court's case management timetable. The conference may take place at the Court and will usually be conducted in-person. However, if not considered a hindrance to the process, the conference may also be conducted with the assistance of visual or audio technology (such as via the internet, video link and/or by telephone).

7.9 Experts should prepare for a conference of experts by ensuring that they are familiar with all of the material upon which they base their opinions. Where expert reports in draft or final form have been exchanged prior to the conference, experts should attend the conference familiar with the reports of the other experts. Prior to the conference, experts should also consider where they believe the differences of opinion lie between them and what processes and discussions may assist to identify and refine those areas of difference.

Joint-report

7.10 At the conclusion of the conference of experts, unless the Court considers it unnecessary to do so, it is expected that the experts will have narrowed the issues in respect of which they agree, partly agree or disagree in a joint-report. The joint-report should be clear, plain and concise and should summarise the views of the experts on the identified issues, including a succinct explanation for any differences of opinion, and otherwise be structured in the manner requested by the judge or registrar.

7.11 In some cases (and most particularly in some native title cases), depending on the nature, volume and complexity of the expert evidence a judge may direct a registrar to draft part, or all, of a conference report. If so, the registrar will usually provide the draft conference report to the relevant experts and seek their confirmation that the conference report accurately reflects the opinions of the experts expressed at the conference. Once that confirmation has been received the registrar will finalise the conference report and provide it to the intended recipient(s).

8. CONCURRENT EXPERT EVIDENCE

8.1 The Court may determine that it is appropriate, depending on the nature of the expert evidence and the proceeding generally, for experts to give some or all of their evidence concurrently at the final (or other) hearing.

8.2 Parties should familiarise themselves with the *Concurrent Expert Evidence Guidelines* (attached in Annexure B). The Concurrent Evidence Guidelines are not intended to be exhaustive but indicate the circumstances when the Court might consider it appropriate for

concurrent expert evidence to take place, outline how that process may be undertaken, and assist experts to understand in general terms what the Court expects of them.

8.3 If an order is made for concurrent expert evidence to be given at a hearing, any expert to give such evidence should be provided with the Concurrent Evidence Guidelines well in advance of the hearing and should be familiar with those guidelines before giving evidence.

9. FURTHER PRACTICE INFORMATION AND RESOURCES

9.1 Further information regarding Expert Evidence and Expert Witnesses is available on the Court's website.

9.2 Further information to assist litigants, including a range of helpful guides, is also available on the Court's website. This information may be particularly helpful for litigants who are representing themselves.

J L B ALLSOP
Chief Justice
25 October 2016

Schedule of my Analysis of the Features Identified in Wessex Archaeology LTD Report

Henry W. Posamentier PhD

September 8, 2023

Background

1. I have been requested by Quinn Emanuel Urquhart & Sullivan on behalf of Santos Ltd to prepare a report responding to the report of Wessex Archaeology LTD (July 2023), focusing on the Late Pleistocene and Holocene depositional and erosional history of the Arafura Sea along the pipeline corridor.

2. I have prepared this report as an independent expert and have done so in accordance with the Federal Court of Australia's Expert Witness Code of Conduct (**Appendices 1 and 2**).

3. In preparing my report I have made all the enquiries which I believe are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which I regard as relevant have, to my knowledge, been withheld.

Schedule of my analysis of features in Wessex Report

In the below schedule, I reproduce columns 1, 2, and 5, of the Wessex Report and provide my analysis of these features in the last two columns. References to MBES data in the below schedule are from Fugro Survey LTD Multibeam Echosounder (2018). References to SBP data in the below schedule are from Fugro Survey LTD (2018, 2023) Sub-Bottom Profiles. MBES data indicate the morphology of the modern seafloor and provide insight to the geomorphology (i.e., map-view images). In contrast, seismic profiles (e.g., SBP data) provide insight to the stratigraphy of what lies below the seafloor.

Any reference to figures are to figures in the Wessex Report.

	ID in the Wessex Report (Appendix II)	**Classification in the Wessex Report (Appendix II)**	**Description in the Wessex Report (Appendix II)**	**My opinion on the features in the Wessex Report (including any alternative views)**	**My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features**
1.	7000	Ridge	A potential coastal ridge identified in the MBES data as a linear ridge, orientated approximately WSW-ENE, on shallow slope. May represent an offshore bar or beach ridge. Linear ridge on shallow slope.	These are more likely isolated subaqueous sediment waves formed post LGM. Offshore bars, barriers, or beach ridges tend to be either straight or subtly curvilinear over tens of kilometers. The fact that one of these features terminates within the swath of the MBES data makes a long linear barrier/beach a less likely interpretation because beach ridges tend to be part of a laterally extensive strand plain.	These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant. Further, the area that comprises the vicinity of the pipeline route was subjected to a number of geologic processes (referred to in the rest of this schedule as "**Row 1 Transgressive Processes**"): • The area was transgressed and initially subjected to erosional forces such as shoreface and storm wave erosion and tidal currents, after the LGM, and then later overlain and mantled (i.e., blanketed) by sediments.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
					• Erosion, sedimentation, and carbonate growth, which characterizes post-LGM time, would likely have modified to varying degrees the original LGM topography (i.e., the landforms) from its earlier subaerially exposed character. • It is unlikely that any archaeological object would have remained *in situ* taking into account post-LGM processes that affected the seafloor at that time.
2.	7001	Ridge	Linear ridge on shallow slope. Potential offshore bar, barrier, or beach ridge.	These are more likely isolated subaqueous sediment waves, formed post LGM. Offshore bars, barriers, or beach ridges tend to be either straight or subtly curvilinear over tens of kilometers. The fact that one of these features terminates within the swath makes a long linear barrier/beach a less likely interpretation because beach ridges tend to be part of a laterally extensive strand plain.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
3.	7002	Ridge	Linear ridge on shallow slope. Potential offshore bar, barrier, or beach ridge.	These are more likely isolated subaqueous sediment waves formed post LGM. Offshore bars, barriers, or beach ridges tend to be either straight or subtly curvilinear over tens of kilometers. The fact that one of these features terminates within the swath makes a long linear barrier/beach a less likely interpretation because beach ridges tend to be part of a laterally extensive strand plain.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
4.	7003	Channel	A possible palaeochannel identified as a deeply incised channel segment. Corresponds with features 7004 and 7005 identified in the SBP data, suggesting some infilling of sediments at the base.	The MBES data suggest that this feature could be a tributary channel to the larger channel identified as feature 7004.	**Same as Row 1 Transgressive Processes**.
5.	7004	Channel	A channel identified in the SBP data, possibly cutting into the interpreted Unit 1, beneath a thin layer of possible marine sands. Feature has a poorly defined basal reflector and acoustically quiet fill which appears acoustically similar to overlying sediment. Feature is seen to correspond with the base of a larger channel feature identified in the MBES data. May represent the base of channel 7003 infilled with modern sediments, or possibly an older phase of channeling.	I have high confidence in interpreting feature 7004 as an incised channel as has Wessex. It is unclear, however, to what system this channel is connected as a tributary, given the limited areal extent of the MBES data. This feature likely was a landform that existed as a coastal plain channel during LGM time based on its presence on the modern (i.e., post-LGM) seafloor.	**Same as Row 1 Transgressive Processes**. Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface. Moreover, their interpretation of modern (i.e., post-LGM) infill of this channel further supports the interpretation of active post-LGM processes that, in my opinion, altered the LGM landscape.
6.	7005	Channel	A possible channel identified in the SBP data interpreted as cutting into Unit 1, b beneath a thin layer of possible marine sands. Feature has a distinct basal reflector and acoustically quiet fill which appears acoustically similar to overlying sediment. Feature is seen to correspond with the base of a larger channel feature identified in the MBES data. May represent the base of channel 7003 infilled with modern sediments, or possibly an older phase of channeling.	These features, in my opinion, are more likely to be part of a rugose seafloor that had developed over time in response to a variety of subaerial and/or subaqueous geologic processes of erosion and sedimentation common in this area.	**Same as Row 1 Transgressive Processes**. Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface. Moreover, their interpretation of modern (i.e., post-LGM) infill of this channel further supports the interpretation of active post-LGM processes that, in my opinion, altered the LGM landscape.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
7.	7006	Channel	A channel identified in the SBP data interpreted as cutting into Unit 1. Feature is identified beneath a thin layer of possible marine sands and has a distinct basal reflector, which has two troughs. Unit fill is generally acoustically quiet with occasional draping reflectors. Feature is seen to correspond with a larger channel feature identified in the MBES data (7003). May represent the base of channel 7003 infilled with modern sediments, or possibly an older phase of channeling. EP-12-VC and EP-12_CPT suggest infill material of alluvium.	This could be a tributary to the main channel feature (7004), however, the base of this feature (i.e., the axis of the possible channel) is higher than the base of the main channel (7004), suggesting that this feature might not be related to the main channel.	**Same as Row 1 Transgressive Processes**. Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface. Moreover, their interpretation of modern (i.e., post-LGM) infill of this channel further supports the interpretation of active post-LGM processes that, in my opinion, altered the LGM landscape.
8.	7007	Infilled depression	Sediment infilling base of a depression identified on the MBES data. In the SBP data, the feature is seen to have a faint, poorly defined basal reflector overlain by acoustically quiet fill. Feature is seen to correspond with a larger channel feature identified in the MBES data (7003). Similarly positioned to features 7004-7006, but less convincing in form and therefore interpreted as an infilled depression and considered of lower archaeological potential. May represent	This feature has been mapped as a channel (Wessex Fig. 1b) but interpreted as an infilled depression or hollow. The arcuate map pattern suggests a possible incised channel meander loop. Alternatively, this feature could also be interpreted as an erosional scour related to seafloor bottom currents.	**Same as Row 1 Transgressive Processes**. This is also supported by Wessex's interpretation of modern (i.e., post-LGM) infill of this channel further supports the interpretation of active post-LGM processes that, in my opinion, altered the LGM landscape.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
			the base of channel 7003 infilled with modern sediments.		
9.	7008	Cut and fill	A possible multiphase cut and fill identified cutting into an acoustically unstructured unit, possibly Unit 1. Feature has a distinct basal reflector and at least two phases of fill which is generally acoustically quiet, although the lower fill appears to be characterised by faint, dipping reflectors. Possibly identified beneath an upper unit of sediment which is acoustically similar to the second phase of fill. Close to another similar feature (7008). Possible remnant fluvial feature.	This feature in the MBES data is expressed as a subtle NNE-SSW trending short linear depression. Whether these represent infilled channels or linear scours related to post-transgression bottom currents is uncertain. The map pattern observed on the MBES data is not consistent with a channel (or, more generically cut and fill) interpretation. I would favor an interpretation of post-transgression scour and infill by modern (i.e., post-LGM) seafloor sediments. Given the similar orientation of features 7008 and 7009, as well as the unidentified similar features to the north, in my opinion this would suggest a possible origin of these features as being the result of seafloor erosion associated with shelf currents (possibly of tidal origin). I make this interpretation based on the observation elsewhere in the study area of the presence of sand waves documenting strong shelf current activity on the modern (i.e., post-LGM) seafloor. There are subtle pockmarks that also characterize the area in **Figures 19b and 19l**. These pockmarks are small (i.e., less than 20m diameter) and constitute a	**Same as Row 1 Transgressive Processes.** Any archaeological objects (dating back to the time that the LGM surface was subaerial) would likely now be buried beneath the transgressive infill. Moreover, if the correct interpretation of these features is post-flooding scour and fill (i.e., this feature formed *after* transgression when the land was subaqueous), this would suggest that the feature was not part of the LGM landscape (i.e., it was part of the post-LGM seascape) and archaeological objects would not have been present.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
				landform that likely is associated with gas escape from below. Pockmarks develop when organic matter such as plants is buried with sediments and bacteria consume the organic material during which time they emit gas. That gas percolates through the overlying section forming depressions (i.e., holes) or pockmarks on the surface. These features likely formed when the surface was below sea level after transgression had occurred.	
10.	7009	Cut and fill	A possible multiphase cut and fill identified cutting into an acoustically unstructured unit, possibly Unit 1. Feature has a distinct basal reflector and at least two phases of fill which is generally acoustically quiet, although the lower fill appears to be characterised by faint, dipping reflectors. Possibly identified beneath an upper unit of sediment which is acoustically similar to the second phase of fill. Close to another similar feature (7008). Possible remnant fluvial feature.	This feature in the MBES data is expressed as a subtle NNE-SSW trending short linear en échelon depressions. Whether these represent infilled channels or linear scours related to post-transgression bottom currents is uncertain. The map pattern observed on the MBES data is not consistent with a channel (or, more generically cut and fill) interpretation. I would favor an interpretation of post-transgression scour and infill by modern (i.e., post-LGM) seafloor sediments. As discussed above (**Row 9**), given the similar orientation of features 7008 and 7009, as well as the unidentified similar features to the north, in my opinion this would suggest a possible origin of these features as being the result of seafloor erosion associated with shelf currents (possibly of tidal origin).	**Same as Row 1 Transgressive Processes.**

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
11.	7010	Infilled depression	Possible infilled depression identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill. Identified in the base of a depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Likely continues further to the west as infilled depression 7011; however, due to the distance between the lines, the features have not been grouped together.	A broad depression can be observed on the MBES data. Based on the broad and shallow aspects of this feature, I would interpret this as a broad erosional scour associated with bottom currents post-transgression and then possibly partially infilled by modern (i.e., post-LGM) seafloor sediments. It seems more likely to me that this is an erosional feature that was formed post-LGM flooding by active shelf currents (possibly tidal) given what we know about post transgression shelf current activity in this area. Further examples of this are shown in Wessex **Figures 19j** and **19t**, where scour features are better expressed. If Wessex is correct in its interpretation, then these features would have been present at LGM time. However, based upon the observation of extensive sand wave fields in this area, it is clear that shelf currents were active. Thus, in the least, these possible LGM depressions would have been buried by transgressive sedimentation. I favor a subaqueous origin for this feature over an interpretation of this feature having somehow formed during the time	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment. . According to Wessex, archeological objects would have been present on this surface. However, if the alternative interpretation of a post-transgression origin is correct, an alternative that I would prefer, then such objects that might have been present on the LGM surface likely would have been removed by post-transgressive erosion and subsequently buried.

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				that this area was subaerial (i.e., during LGM time) because if these features did pre-date transgression, then one would have to hypothesize that such features somehow were not modified by post-transgressive erosion, nor were they significantly buried and obscured by subsequent sedimentation. This seems unlikely given the presence of active shelf currents (which I infer based on the extensive presence of sand waves on the modern (i.e., post-LGM) seafloor) strongly suggesting that post-transgression erosional scour, capable of producing such landforms, would constitute a preferred interpretation for these features.	
12.	7011	Infilled depression	Possible channel identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill, although this is partially obscured by the seabed pulse. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Likely continues further to the east as infilled depression 7010; however, due to the distance between the lines, the features have not been grouped together.	There is no seabed expression of this feature. Outside of the MBES data (where this feature is located) resolution is too low to make a definitive interpretation. Given the proximity to features that I have previously interpreted as erosional scour (see **Row 11**), I favor a partially infilled seabed scour similar to that which I have interpreted for feature 7010.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment. Moreover, their interpretation of marine infill of this channel (Wessex's reference to *marine* sediments implies sedimentation after the LGM surface was flooded) further supports the interpretation of active post-

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
					LGM processes that, in my opinion, altered the LGM landscape.
13.	7012	Infilled depression	Possible infilled depression identified BSB/below a veneer of marine sediment. Feature has a distinct basal reflector and acoustically quiet fill. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression infilled with sand or the cut of an underfilled channel feature, partially filled with marine sediments.	A narrow depression can be observed on the MBES data. I interpret this as an erosional scour associated with bottom currents post-transgression and then partially infilled by modern (i.e., post-LGM) seafloor sediments. Note that the NNE-SSW orientation of this feature is the same as that observed for feature 7010, and interpreted the same way.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment. This feature does not have a definitive channel-form seafloor expression, suggesting that in the least, any LGM landform has been buried by post-LGM depositional processes. Moreover, the Wessex interpretation of modern (i.e., post-LGM) infill of this channel further supports the interpretation of active post-LGM processes that, in my opinion, altered the LGM landscape.
14.	7013	Cut and fill	Possible cut and fill identified below a thin unit of possible marine sediment. Feature has a distinct basal reflector and possible multiple phases of fill, the lower of which is acoustically unstructured and the upper of which is acoustically quiet, although this may represent marine sediments infilling an underfilled	Both features 7013 and 7014 have minimal seafloor expression as observed on the MBES data. Their NNE-SSW orientation is the same as for features 7010 and 7012 and I interpret these features the same way. That is, the features were formed by post-transgression bottom current scour.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.

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			feature. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Close to, and similar to 7014.	Subsequent infilling by modern (i.e., post-LGM) marine sediments is likely.	This feature does not have a definitive channel-form seafloor expression, suggesting that in the least, any LGM landform has been buried by post-LGM depositional processes. Moreover, the Wessex interpretation of modern (i.e., post-LGM) infill of this channel further supports the interpretation of active post-LGM processes that, in my opinion, altered the LGM landscape. If Wessex is correct in their cut and fill interpretation, then the nearly-smooth seafloor over these features strongly suggests that post-transgression depositional processes have buried these channels. Alternatively, if these features are interpreted as post-transgressive scour and fill, then these features would not have been part of the LGM landscape and hence would not be associated with the preservation of archaeological objects on the modern seafloor.
15.	7014	Cut and fill	Possible cut and fill identified below a thin unit of possible marine sediment. Feature has a distinct basal reflector and possible multiple phases of fill, the lower of which is unstructured and the upper of which is acoustically quiet, although this may represent marine sediments	Both features 7013 and 7014 have minimal seafloor expression as observed on the MBES data. Their NNE-SSW orientation is the same as for features 7010 and 7012 and I interpret these features the same way. That is, the features were formed by post-	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
			infilling an underfilled feature. Identified in the base of a broad depression identified in the 2018 Fugro MBES data. May represent an infilled depression or the cut of an underfilled channel feature, partially filled with marine sediments. Close to, and similar to 7014.	transgression bottom current scour. Subsequent infilling by modern (i.e., post-LGM) marine sediments is likely.	Moreover, their interpretation of modern (i.e., post-LGM) infill of this channel further supports the interpretation of active post-LGM processes that, in my opinion, altered the LGM landscape.
16.	7015	Channel	A possible channel identified below an upper unit of sediment, cutting into the interpreted Unit 1. Feature has a relatively distinct basal reflector and fill characterised by numerous horizontal reflectors indicating layered fill which may have been deposited in a low-energy environment.	A channel can be observed on the seismic profile here. It is filled with a reflection-free seismic pattern. Note that this channel, though lying just below the seafloor, has no seafloor expression, suggesting that it has been completely infilled. The reflection free pattern suggests a uniform lithologic fill, likely mud-rich. The absence of such classical indicators of fluvial processes such as lateral accretion surfaces is consistent with a mud-rich tidal channel origin. The presence on the seismic profile of what appear to be multiple channels may, in fact, be a single channel coming in and out of the plane of section, crossing the seismic profile multiple times. The orientation of the profile is sub-parallel to the likely channel direction, which results in multiple channel crossings as the channel axis repeatedly cuts across the seismic profile. A more definitive section view would have been afforded by a profile that would have	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
				been oriented transverse to the channel trend. The significance of fluvial vs. tidal channel origin is that the tidal channels would have been active post-LGM time with currents reversing on a twice-daily basis.	
17.	7016	Channel complex	Possible complex channel identified below a veneer of sediment, cutting into the interpreted Unit 1. Feature appears to have multiple phases of acoustically chaotic fill, with a faint basal reflector which shows several troughs. Possible remnant fluvial feature. EP-21-CPT suggest alluvium overlying dense sand.	The veneer of sediment referred to here (as well as in other areas) suggest active sedimentation during post-LGM transgressive time over a broad area. This is consistent with the inference of active bottom currents during this time. The MBES data is featureless, suggesting a "healing" of any seafloor relief during post-LGM time. The presence of apparently sharp interfluves (interfluves are defined as land surfaces between adjacent channels) suggests that rather than multiple channels crossing the profile, a more likely interpretation is that this is the result of a single channel cutting into and out of the plane of section. The fill of these scours/channels is reflection free (compare with feature 7015). Likely the fill is either mud-rich estuarine deposits or mud-rich infill associated with open-marine (i.e., open ocean water setting in	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment. The implication of a LGM fluvial interpretation vs. a post-LGM tidal-current interpretation is that with a post-LGM interpretation, archaeological objects likely would either not have been present within these channels or in the least would have been buried by sedimentation during post-LGM flooding. In addition, tidal channels would not commonly be associated with floodplains where habitations could be found. Consequently, the likelihood of archaeological objects preserved here is low.

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				contrast with restricted bay) transgressive infill. Channel fills that are exclusively mud rich are far more common in marine tidal-current channels than in fluvial channels. Therefore, where such mud-rich channels are observed, a marine origin (i.e., post-LGM) can be inferred.	
18.	7017	Cut and fill	A small cut and fill identified BSB/below veneer of seabed sediment. Feature has a distinct basal reflector and acoustically quiet fill. Possible infilled depression of the remnants of a relict alluvial feature.	This feature has no seafloor expression as observed on the MBES data. The buried channels observed here seem to have filled completely so that the seafloor has been healed. The reflection-free fill suggests uniform lithology, likely mud-rich (refer to discussion in **Row 17**).	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.
19.	7018	Infilled depression	An infilled depression with a distinct basal reflector and acoustically quiet fill. Identified BSB or beneath a veneer of sediment. Possibly an infilled depression infilled with sand or may be remnants of a fluvial feature.	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour).	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment. In my opinion, this feature formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the

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				There is no clear indication of fluvial processes at work here inasmuch as the fill of these scours is reflection free and no lateral accretion surfaces are observed here, which are indicative of fluvial processes. This suggests that there is no evidence for the presence of a floodplain environment where human habitation, associated with archaeological objects, would have existed. In any event, whether archaeological objects would have been preserved here is very much dependent upon whether the interpreted ridges are thought to have been subaerially formed – i.e., on a coastal plain landward of the shoreline – or subaqueously formed – i.e., by shelf currents. In light of the poor preservation potential of subaerial dune fields coupled with the observation of sand waves on the modern (i.e., post-LGM) seafloor, I would strongly favor the latter interpretation. Hence, the presence of archaeological artifacts associated with these ridges, would, in my opinion, not be likely, given the post-transgressive origin of these landforms.	issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
20.	7019	Ridge	Potential beach ridge segment.	Beach ridges commonly have long linear extent. This feature described by Wessex does not. More likely, this feature is a	**Same as Row 1 Transgressive Processes.**

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				post-LGM subaqueously formed sand wave.	These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
21.	7020	Complex cut and fill	Possible channel identified BSB/below a veneer of seabed sediments cutting into the top of the interpreted Unit 1. Feature has a poorly defined basal reflector and possibly multiple phases of fill with a lower chaotic fill and upper fill characterised by numerous dipping horizons.	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour).	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.
22.	7021	Complex cut and fill	A complex unit identified BSB with numerous cuts, fills and cross-cutting reflectors. Feature may represent a broad, shallow channel complex or may be an area of reworked sediments. Origin uncertain but, as it has the potential to be a fluvial feature, it has been retained as a precaution.	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour).	**Same as Row 1 Transgressive Processes.** This is also supported by Wessex's opinion that this feature may be an area of reworked sediments, presumably post-LGM.

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				There is no clear indication of fluvial processes at work here inasmuch as the fill of these scours is reflection free and no lateral accretion surfaces are observed here, which are indicative of fluvial processes. This suggests that there is no evidence for the presence of a floodplain environment where human habitation, associated with archaeological objects, would have existed.	
23.	7022	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Shoreface and beach ridges would have a much more regularly spaced parallel pattern than what is observed here. Only in rare instances have transgressed aeolian dunes been preserved subsequent to marine flooding and associated erosion. Moreover, my observations suggest that there are few, if any, aeolian dunes on the modern (i.e., post-LGM) coastal plain of northern Australia, the depositional analog for this area, strongly suggesting that the LGM surface similarly would have been devoid of such features.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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				Whether archaeological objects would have been preserved here is very much dependent upon whether the interpreted ridges are thought to have been subaerially formed – i.e., on a coastal plain landward of the shoreline – or subaqueously formed – i.e., by shelf currents. In light of the poor preservation potential of subaerial dune fields coupled with the observation of sand waves on the modern (i.e., post-LGM) seafloor, I would strongly favor the latter interpretation.	
24.	7023	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline (see further discussion in **Row 23**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
25.	7024	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline (see further discussion in **Row 23**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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26.	7025	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline (see further discussion in **Row 23**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
27.	7026	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline (see further discussion in **Row 23**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
28.	7027	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline (see further discussion in **Row 23**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
29.	7028	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no

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				LGM time, seaward of the shoreline (see further discussion in **Row 23**).	habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
30.	7029	Cut and fill	Small cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill characterised by dipping reflectors. May represent remnants of a fluvial feature.	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour). There is no clear indication of fluvial processes at work here inasmuch as the fill of these scours is reflection free and no lateral accretion surfaces are observed here, which are indicative of fluvial processes. This suggests that there is no evidence for the presence of a floodplain environment where human habitation, associated with archaeological objects, would have existed.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.
31.	7030	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	This feature is of very limited areal extent, a pattern not consistent with beach ridges or shoreline trends in general. Alternatively, an interpretation of these features as back-barrier, coastal plain	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have

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				aeolian dunes would not be consistent with what is observed on the modern (i.e., post-LGM) northern Australia coastal plain, where such landforms are not observed. Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation. In any event, the seismic profile data are equivocal – ridges or narrow landform elements that stand proud of the adjacent seafloor are apparent, but internal architecture is obscured; the limited number of seismic profiles are not in the ideal location and the orientation relative to the landform as well as the quality of the seismic data are insufficient to afford a definitive interpretation.	occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
32.	7031	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW,	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological

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				consistent with subaqueous sand wave formation (see discussion in **Row 31**).	objects on the modern seafloor is irrelevant.
33.	7032	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
34.	7033	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
35.	7034	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
36.	7035	Cut and Fill	A possible cut and fill identified below a veneer of seabed sediment. Feature has a distinct basal reflector and acoustically	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting	**Same as Row 1 Transgressive Processes.**

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			unstructured fill. May represent a shallow channel or possibly an infilled depression at the top of the interpreted Unit 1.	effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour). There is no clear indication of fluvial processes at work here inasmuch as the fill of these scours is reflection free and no lateral accretion surfaces are observed here, which are indicative of fluvial processes. This suggests that there is no evidence for the presence of a floodplain environment where human habitation, associated with archaeological objects, would have existed.	Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.
37.	7036	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
38.	7037	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no

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				LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
39.	7038	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
40.	7039	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
41.	7040	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
42.	7041	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
43.	7042	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
44.	7043	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
45.	7044	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have

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				that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
46.	7045	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
47.	7046	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
48.	7047	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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49.	7048	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
50.	7049	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
51.	7050	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
52.	7051	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have

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				that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
53.	7052	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation (see discussion in **Row 31**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
54.	7053	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
55.	7054	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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56.	7055	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
57.	7056	Ridge	Possible dune ridge or beach ridge with cuspate end, ~1 km long	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
58.	7057	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
59.	7058	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have

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				MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
60.	7059	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
61.	7060	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
62.	7061	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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63.	7062	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
64.	7063	Ridge	Possible cuspate beach ridge	I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Beach ridges tend to be long and linear (i.e., >10km), which these are not, as evidenced by the MBES data. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
65.	7064	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
66.	7065	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have

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				these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
67.	7066	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as likely subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
68.	7067	Cut and fill	A small possible cut and fill identified BSB/below a veneer of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature appears faint and poorly defined. May be a small, infilled depression or remnants of a fluvial feature.	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour). There is no clear indication of fluvial processes at work here. The absence of such classical indicators of fluvial processes such as lateral accretion surfaces is consistent with a mud-rich tidal channel origin, most likely marine/subaqueous in origin, lacking an associated floodplain environment. The significance of fluvial vs. tidal channel	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.

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				origin is that the tidal channels would have been active post-LGM time with currents reversing on a twice-daily basis.	
69.	7068	Complex cut and fill	A possible complex cut and fill identified below a veneer of sediment cutting into the interpreted Unit 1. Feature has a distinct basal reflector and multiple phases of cutting and fill which is generally acoustically unstructured. May represent relict fluvial feature	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour). There is no clear indication of fluvial processes at work here. The absence of such classical indicators of fluvial processes such as lateral accretion surfaces is consistent with a mud-rich tidal channel origin, most likely marine/subaqueous in origin, lacking an associated floodplain environment. The significance of fluvial vs. tidal channel origin is that the tidal channels would have been active post-LGM time with currents reversing on a twice-daily basis.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.
70.	7069	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW,	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological

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				consistent with subaqueous sand wave formation.	objects on the modern seafloor is irrelevant.
71.	7070	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects is irrelevant.
72.	7071	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
73.	7072	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
74.	7073	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no

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				LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
75.	7074	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects is irrelevant.
76.	7075	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
77.	7076	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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78.	7077	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
79.	7078	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
80.	7079	Complex cut and fill	A distinct cut and fill identified below a veneer of seabed sediment cutting into a layered unit which may be part of the interpreted Unit 1. May be seen to continue to the north-west outside of the development area, although due to the distance between lines they have not definitively been grouped together. Feature has a faint basal reflector and multiple phases of acoustically quiet fill. Possible remnants of a fluvial feature.	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments up to 5m. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour). There is no clear indication of fluvial processes at work here.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.

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81.	7080	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
82.	7081	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects is irrelevant.
83.	7082	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
84.	7083	Cut and fill	A broad cut and fill with a faint basal reflector identified below an upper layer of sediments characterised by numerous, faint horizontal reflectors (possibly Unit 4), cutting into the interpreted Unit 1. Unit fill is generally	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
			acoustically unstructured, possibly with multiple phases of cut and fill. Possible remnants of a fluvial feature.	of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour). There is no clear indication of fluvial processes at work here.	geologic processes were responsible for burying the LGM surface.
85.	7084	Channel	Channel segment	The MBES data suggest irregular seafloor relief, but no indication of channel morphology. I interpret this irregularity as modern (i.e., post-LGM) sand waves or other landforms formed by subaqueous bottom currents.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
86.	7085	Cut and fill	A broad cut and fill identified below a thin, upper layer of sediments, cutting into the interpreted Unit 1. Unit fill is generally acoustically unstructured, possibly with multiple phases of cutting and filling. Possible remnants of a fluvial feature. May form part of a larger feature with **7086** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour). There is no clear indication of fluvial processes at work here.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.
87.	7086	Channel	A possible channel identified BSB/below a veneer of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine	Both the MBES data as well as the seismic profile document the featurelessness of the sea floor in this area, suggesting effective "healing" of seafloor irregularities by sedimentation during	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive

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			sediments (Unit 5), or may be part of the interpreted Unit 1 (Unit 1). Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together	post-LGM flooding and subsequent burial of any LGM paleolandscape by marine sediments up to 5m. At the modern (i.e., post-LGM) seafloor, as observed with the MBES data, there appears to be a slight depression, likely related to subaqueous bottom current scour. In places there is buried scour and fill (possibly associated with channels or with tidal current/bottom current scour). There is no clear indication of fluvial processes at work here.	geologic processes were responsible for burying the LGM surface. These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
88.	7087	Channel	A possible channel identified BSB/below a veneer of sediment, cutting into a Unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments, or may be part of the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085 -7092**; however, due to the	The MBES data suggest a possible channel. The seismic facies associated with this feature suggests a complex fill history, but the precise origin of the channel formation – i.e., fluvial vs. tidal current scour – cannot be determined. Likewise, as pointed out by Wessex, because of the spacing of SBP lines a map pattern cannot be reliably established. This means that there is uncertainty with respect to the type of channel present (e.g., meandering vs. braided, tidal vs. fluvial).	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m.

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			distance between the SBP lines, these have not definitively been grouped together		
89.	7088	Cut and fill	A possible cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and generally acoustically unstructured fill, of which there is possibly more than one phase. Identified along the northern edge of a bathymetric high seen in the 2018 Fugro MBES data. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together. Feature appears less convincing compared to others in the area and, as such as been classified as a cut and fill and is considered of lower archaeological potential.	The MBES data suggest a featureless seafloor here, consistent with a blanketing of the seafloor with sediment during post-LGM time. As pointed out by Wessex, because of the spacing of SBP lines a map pattern cannot be reliably established. This means that there is uncertainty with respect to the type of channel present (e.g., meandering vs. braided, tidal vs. fluvial).	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.
90.	7089	Cut and fill	A possible cut and fill identified a thin unit of sediment, cutting into a unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature has a faint basal reflector and acoustically unstructured fill. May be a remnant fluvial feature or may represent overbank deposits related to channel feature **7084**. May form part of a larger	The MBES data suggest a featureless seafloor here, consistent with a blanketing of the seafloor during post-LGM time. Some minor scour likely occurred during post-LGM time, but the precise origin of these scours is unclear (i.e., whether the scour was related to tidal currents or storm-associated erosion). As pointed out by Wessex, because of the spacing of SBP lines a map pattern cannot be reliably established. This means that there is uncertainty with respect to the type of	**Same as Row 1 Transgressive Processes.**

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			feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together.	channel present (e.g., meandering vs. braided, tidal vs. fluvial).	
91.	7090	Channel	A possible channel identified a thin unit of sediment, cutting into a unit characterised by numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments (Unit 5), or may be part of the interpreted Unit 1. Feature has a faint basal reflector and fill characterised by numerous draping reflectors. Possible channel. May form part of a larger feature with **7085** -**7092**; however, due to the distance between the SBP lines, these have not definitively been grouped together.	The MBES data suggest a featureless seafloor here with minor irregularities, consistent with a blanketing of the seafloor during post-LGM time. Some minor scour likely occurred during post-LGM time, but the precise origin of these scours is unclear. As pointed out by Wessex, because of the spacing of SBP lines a map pattern cannot be reliably established. This means that there is uncertainty with respect to the type of channel present (e.g., meandering vs. braided, tidal vs. fluvial).	**Same as Row 1 Transgressive Processes.**
92.	7091	Channel	A possible cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a faint basal reflector and generally acoustically unstructured fill, of which there is possibly more than one phase. Identified along the northern edge of a bathymetric high seen in the 2018 Fugro MBES data. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (6586) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger	MBES data and SBP lines suggest the presence of channels buried below a featureless seafloor. Several of the buried channels are characterized by a reflection free seismic pattern suggesting homogeneous fill, likely mud-rich. Channel fills that are exclusively mud rich are far more common in marine tidal-current channels than in fluvial channels. Therefore, where such mud-rich channels are observed, a marine origin (i.e., post-LGM) can be inferred.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment. The implication of a LGM fluvial interpretation vs. a post-LGM tidal-current interpretation is that with a post-LGM interpretation, archaeological objects likely would either not have been present within

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			feature with **7085 – 7092;** however, due to the distance between the SBP lines, these have not definitively been grouped together.	I interpret these channels as tidal current related rather than fluvial. As pointed out by Wessex, because of the spacing of SBP lines, a map pattern cannot be reliably established. This means that there is uncertainty with respect to the type of channel present (e.g., meandering vs. braided, tidal vs. fluvial).	these channels or in the least would have been buried by sedimentation during post-LGM flooding. In addition, tidal channels would not commonly be associated with floodplains where habitations could be found. Consequently, the likelihood of archaeological objects preserved here is low.
93.	7092	Channel complex	A possible complex channel identified below a shallow Unit of sediment, cutting into a Unit characterised with numerous sub-horizontal reflectors which may represent estuarine or lacustrine sediments, or may be part of the interpreted Unit 1. Feature has a faint basal reflector and multiple phases of fill which are generally acoustically unstructured, occasionally chaotic. Feature corresponds with an underfilled palaeochannel identified on the 2018 Fugro MBES data (**7084**) and may represent the partially filled base of this feature, or an earlier phase of cut and fill. May form part of a larger feature with **7085 -7092**; however, due to the distinct between the SBP lines, these have not definitively been grouped together	MBES data and SBP lines suggest the presence of channels buried below a featureless seafloor. Several of the buried channels are characterized by a reflection free seismic pattern suggesting homogeneous fill, likely mud-rich. Channel fills that are exclusively mud rich are far more common in marine tidal-current channels than in fluvial channels. Therefore, where such mud-rich channels are observed, a marine origin (i.e., post-LGM) can be inferred. I interpret these channels as tidal current related rather than fluvial. As pointed out by Wessex, because of the spacing of SBP lines, a map pattern cannot be reliably established. This means that there is uncertainty with respect to the type of channel present (e.g., meandering vs. braided, tidal vs. fluvial).	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface. The implication of a LGM fluvial interpretation vs. a post-LGM tidal-current interpretation is that with a post-LGM interpretation, archaeological objects likely would either not have been present within these channels or in the least would have been buried by sedimentation during post-LGM flooding. In addition, tidal channels would not commonly be associated with floodplains where habitations could be found. Consequently, the likelihood of archaeological objects preserved here is low.
94.	7093	Cut and fill	A possible cut and fill identified beneath a veneer of marine sediment, cutting into the interpreted Unit 1. Feature has	The MBES data indicate a featureless seafloor, suggesting that post-LGM sedimentation resulted in a blanketing of	**Same as Row 1 Transgressive Processes.**

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			a poorly defined basal reflector and a acoustically quiet fill. Possibly represents a remnant fluvial feature.	the area by up to 5m of recent marine sediments.	Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.
95.	7094	Complex cut and fill	A broad, complex feature identified beneath a thin Unit of sediment, cutting into the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively well defined basal reflector and acoustically transparent/unstructured fill (although the characteristics of these features can vary). Possible remnant of a complex fluvial feature, although may be internal reflectors within Unit 1. EP-28-CPTA suggests Alluvium between 0-0.7 m, overlying dense sand, which may suggest internal reflectors within Unit 1, although this is not definite.	The MBES data indicate a featureless seafloor, suggesting that post-LGM sedimentation resulted in a blanketing of the area by recent marine sediments of up to 5m. Channels of uncertain origin (i.e., tidal vs. fluvial) are present here.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.
96.	7095	Channel complex	A possible broad channel complex identified beneath a thin unit of sediment, cutting into the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively well defined basal reflector and acoustically transparent/unstructured fill, although some fill is characterised by numerous dipping horizons.	The MBES data indicate a featureless seafloor, suggesting that post-LGM sedimentation resulted in a blanketing of the area by recent marine sediments of up to 5m. Buried channels of uncertain origin (i.e., tidal vs. fluvial) are present here. The acoustically transparent seismic pattern suggest a homogeneous, likely mud-rich fill, possibly of tidal current origin.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands up to 5m is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.

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97.	7096	Channel	A possible channel with a distinct basal reflector and acoustically quiet fill. Feature is identified below an upper unit of sediment (possible Unit 5) which is seen to be cut into by channel feature **7097**, suggesting a different depositional phase between this phase of channelling and that associated with **7097**. Identified cutting into the interpreted Unit 1. May form part of a larger feature with **7098**, however this has been truncated by **7097** and therefore it is not possible to tell.	The MBES data indicate a featureless seafloor, suggesting that post-LGM sedimentation resulted in a blanketing of the area by recent marine sediments. A channel of uncertain origin (i.e., tidal vs. fluvial) is present here. The fill of this channel again appears to be reflection free, with no apparent lateral accretion to help interpret this as fluvial channels. Hence, I would prefer a tidal channel origin interpretation. I would interpret the fill as either estuarine (i.e., within the confines of a drowned river valley) or transgressive (i.e., in the sense of shelf currents sweeping sea floor sediments into an unfilled channel and filling it) sediment fill. Again, there is no evidence for the presence of channels expressed at the modern seafloor, suggesting that post-transgressive sedimentation was effective at "healing" seafloor irregularities such as channels by either of the two mechanisms discussed above.	**Same as Row 1 Transgressive Processes.**
98.	7097	Channel	A channel feature identified below a unit of marine sands, cutting through a lower unit characterised with numerous sub-horizontal reflectors indicating fine-drained deposits (possible Unit 5), and cutting through into lower channels **7096** and **7098**. Feature has a distinct	The MBES data indicate a featureless seafloor, suggesting that post-LGM sedimentation resulted in a blanketing of the area by recent marine sediments by up to 5m. Buried channels of uncertain origin (i.e., tidal vs. fluvial) are present here.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.

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			basal reflector and acoustically unstructured/quiet fill.		
99.	7098	Channel	A possible channel with a distinct basal reflector and acoustically quiet fill. Feature is identified below an upper unit of sediment (possible Unit 5) which is seen to be cut into by channel feature **7097**, suggesting a different depositional phase between this phase of channelling and that associated with **7097**. Identified cutting into the interpreted Unit 1. May form part of a larger feature with **7096**, however this has been truncated by **7097** and therefore it is not possible to tell.	The MBES data indicate an asymmetric landform characterized by a NW-SE trending lineament. Channels always have two sides, which is in contrast with the one-sided feature present here. Consequently, I would interpret this feature as a NW-SE trending sediment wave. The lineament itself would correspond to the down-current or leading edge of the sediment wave. In addition, Wessex's interpretation of a channel (i.e., feature 7097) cutting this feature is inconsistent with the fact that this lineament (i.e., feature 7098) is fully preserved and clearly observed on the seafloor, whereas the interpreted channel has no seafloor expression. The presence of feature 7098 on the modern seafloor suggests that this landform postdates transgression of the LGM landscape and is likely currently active. If the channel were to have post-dated feature 7097, as suggested by Wessex, then the interpreted channel (i.e., feature 7097) would clearly be observed to be cutting feature 7098, which it does not, according to the MBES data.	**Same as Row 1 Transgressive Processes.**
100.	7099	Channel complex	A broad channel complex identified beneath a unit of sediment, cutting into	The MBES data Indicate a featureless seafloor, suggesting that post-LGM	**Same as Row 1 Transgressive Processes.**

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			the interpreted Unit 1. Characterised by numerous cross-cutting cut and fill features, that generally have a relatively clear, although occasionally hard to define basal reflectors, and acoustically transparent/unstructured fill (although the characteristics of these features can vary). May be related to nearby palaeochannel **7108** identified on the MBES data, and may form part of a larger feature with **7101** and **7105**.	sedimentation resulted in a blanketing of the area by recent marine sediments. Buried channels of uncertain origin (i.e., tidal vs. fluvial) are present here. The acoustically transparent fill suggests homogeneous lithology, likely mud-rich. Channel fills that are exclusively mud rich are far more common in marine tidal-current channels than in fluvial channels. Therefore, where such mud-rich channels are observed, a marine origin (i.e., post-LGM) can be inferred.	The implication of a LGM fluvial interpretation vs. a post-LGM tidal-current interpretation is that with a post-LGM interpretation, archaeological objects likely would either not have been present within these channels or in the least would have been buried by sedimentation during post-LGM flooding. In addition, tidal channels would not commonly be associated with floodplains where habitations could be found. Consequently, the likelihood of archaeological objects preserved on the modern seafloor is low.
101.	7100	Ridge	Possible beach ridge	The MBES data suggest a seafloor with NNE-SSW ridge segments. The proliferation of these ridges present on the modern (i.e., post-LGM) seafloor suggests a post-LGM origin related to subaqueous bottom currents. In particular, this feature likely comprises sediment trails rather than strandplain subaerial dunes. Such features would have formed subaqueously on the lee side of a seafloor "bump" (i.e., a raised or elevated sub-sea mound) and would have been formed subsequent to post-LGM flooding of the shelf. In any case, a north-south orientation of these short lineaments is inconsistent with a putative shoreline trend (i.e., the shorelines would	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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				have had a more east-west orientation, which would be orthogonal to the more north-south trend observed here).	
102.	7101	Cut and fill	A possible cut and fill identified beneath an upper unit of sediment, interpreted as cutting into a unit with numerous reflectors; possible part of the interpreted Unit 1 although may be part of a larger channel complex (Unit 4). Feature has a distinct basal reflector and acoustically quiet fill. May form part of a larger feature with **7099** and **7105**. May be a remnant fluvial feature.	The MBES data suggest a seafloor with a N-S ridge rather than a channel is present here. No apparent channel on the modern (i.e., post-LGM) seafloor suggests that any channels present here are buried by up to 5m and are of uncertain origin (i.e., tidal vs. fluvial).	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.
103.	7102	Ridge	Possible beach ridge	The MBES data suggest a seafloor with NNE-SSW ridge segments. However, the orientation of these short lineaments is inconsistent with a putative shoreline trend, which is necessary to form a beach ridge. The shorelines would have had a more east-west orientation, which would be orthogonal to the more NNE-SSW trend observed here. The proliferation of these ridges present on the modern (i.e., post-LGM) seafloor suggests a post-LGM origin related to subaqueous bottom currents.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
104.	7103	Ridge	Possible beach ridge	The MBES data suggest a seafloor with NNE-SSW ridge segments. However, the orientation of these short lineaments is inconsistent with a putative shoreline trend, which is necessary to form a beach	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have

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				ridge. The shorelines would have had a more east-west orientation, which would be orthogonal to the more NNE-SSW trend observed here. The proliferation of these ridges present on the modern (i.e., post-LGM) seafloor suggests a post-LGM origin related to subaqueous bottom currents.	occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
105.	7104	Ridge	Possible beach ridge	The MBES data suggest a seafloor with NNE-SSW ridge segments. However, the orientation of these short lineaments is inconsistent with a putative shoreline trend, which is necessary to form a beach ridge. The shorelines would have had a more east-west orientation, which would be orthogonal to the more NNE-SSW trend observed here. The proliferation of these ridges present on the modern (i.e., post-LGM) seafloor suggests a post-LGM origin related to subaqueous bottom currents.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
106.	7105	Cut and fill	A possible cut and fill identified beneath an upper unit of sediment, interpreted as cutting into a unit with numerous reflectors; possibly part of the interpreted Unit 1 although may be part of a larger channel complex (Unit 4). Feature has a distinct basal reflector and acoustically quiet fill. May form part of a	The MBES data suggest a seafloor with a N-S ridge rather than a channel is present here. No apparent channel on the modern (i.e., post-LGM) seafloor suggests that any channels present here are buried by up to 5m and are of uncertain origin (i.e., tidal vs. fluvial).	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.

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			larger feature with **7099** and **7101**. May be a remnant fluvial feature.		
107.	7106	Ridge	Possible beach ridge	The MBES data suggest a seafloor with a NNE-SSW ridge segment. The limited length of this lineament (i.e., ~3km) as well as the orientation of this lineament, is inconsistent with a putative shoreline trend, which is necessary to form a beach ridge. The shorelines would have had a more east-west orientation, which would be orthogonal to the more NNE-SSW trend observed here, and moreover would likely have extended well in excess of 3km. The proliferation of these ridges present on the modern (i.e., post-LGM) seafloor suggests a post-LGM origin related to subaqueous bottom currents.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
108.	7107	Ridge	Possible beach ridge	The MBES data suggest a seafloor with numerous NNE-SSW ridge segments. The limited length of these lineaments (i.e., ~3km) as well as their orientation, is inconsistent with a putative shoreline trend, which is necessary to form a beach ridge. The shorelines would have had a more east-west orientation, which would be orthogonal to the more NNE-SSW trend observed here as well as be characterized by a significantly greater length. The proliferation of these ridges present on the modern (i.e., post-LGM) seafloor	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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				suggests a post-LGM origin related to subaqueous bottom currents.	
109.	7108	Channel	Large, wide (~1 km) channel that becomes hard to track northwards in data. May continue as buried channel complex **7099**, identified in the SBP data, although this is not definite.	I observe no channel on the MBES data across the modern (i.e., post-LGM) seafloor. The seafloor is featureless here. If there was a channel here, it would have been completely infilled during post-LGM time.	**Same as Row 1 Transgressive Processes.**
110.	7109	Ridge	Possible beach ridge	The MBES data suggest a seafloor with numerous NNE-SSW ridge segments. The limited length of these lineaments (i.e., ~3km) as well as their orientation, is inconsistent with a putative shoreline trend, which is necessary to form a beach ridge. The shorelines would have had a more east-west orientation, which would be orthogonal to the more NNE-SSW trend observed here as well as be characterized by a significantly greater length. The proliferation of these ridges present on the modern (i.e., post-LGM) seafloor suggests a post-LGM origin related to subaqueous bottom currents.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
111.	7110	Ridge	Possible beach ridge	The MBES data suggest a seafloor with numerous NNE-SSW ridge segments. The limited length of these lineaments (i.e., ~3km) as well as their orientation, is inconsistent with a putative shoreline trend, which is necessary to form a beach ridge. The shorelines would have had a more east-west orientation, which would	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological

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				be orthogonal to the more NNE-SSW trend observed here as well as be characterized by a significantly greater length. The proliferation of these ridges present on the modern (i.e., post-LGM) seafloor suggests a post-LGM origin related to subaqueous bottom currents.	objects on the modern seafloor is irrelevant.
112.	7111	Ridge	Potential parabolic or transverse dune formed on strandplain behind coastal barrier	Given the poor preservation potential of subaerial dunes subsequent to transgression, I interpret these features as possible subaqueous dunes formed post-LGM time, seaward of the shoreline. Note that these ridge segments all align NE-SW, consistent with subaqueous sand wave formation.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
113.	7112	Channel	A possible lower cut of a channel identified below an upper unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment (Unit 5). May be estuarine or lacustrine sediments. Feature has a distinct basal reflector and acoustically unstructured fill. Possible earlier phase of channelling	The MBES data suggest a number of tidal scours of limited length (i.e., less than 3km) characterize the modern (i.e., post-LGM) seafloor (see discussion of features 7109, 7110, and 7111). The buried channels imaged on SBP data are of uncertain origin (i.e., fluvial vs. tidal).	**Same as Row 1 Transgressive Processes.** These tidal scours formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
114.	7113	Channel	An upper channel identified BSB/below a veneer of sediment, cutting through a unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment, possibly estuarine or	The MBES data suggest a slightly irregular seafloor, characterized by minor relief likely associated with formation of seafloor sediments into short ridges or sand waves (oriented N-S) in response to	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for

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			lacustrine sediments (Unit 5). Feature has a distinct basal reflector and acoustically quiet fill. Possible later fluvial feature.	post-LGM subaqueous tide-related bottom currents.	burying the LGM surface by up to 5m of sediment. These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
115.	7114	Channel	A possible lower cut of a channel identified below an upper unit characterised by numerous horizontal reflectors indicating sediments deposited in a low-energy environment (Unit 5). May be estuarine or lacustrine sediments. Feature has a distinct basal reflector and acoustically unstructured fill. Feature raises into a bank in the centre, possibly just a high point within the channel base. Feature corresponds with the edge of channel **7108** identified in the MBES data. This may represent a previous generation of channelling, although this is not certain.	The MBES data suggest a slightly irregular seafloor, characterized by minor relief likely associated with formation of seafloor sediments into short ridges or sand waves (oriented N-S) in response to post-LGM subaqueous tide-related bottom currents.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
116.	7115	Channel	A possible channel identified below a thin unit of sediment. Feature has a faint, poorly defined basal reflector with acoustically quiet fill with occasional horizontal reflectors. At the base of the feature, an acoustically chaotic feature can be seen which appears to cause	The MBES data indicate a seafloor characterized by numerous linear (N-S) grooves, suggesting modification of the seafloor during post-LGM time likely by subaqueous bottom currents. Any channel-like features observed on SBP data would likely have been buried by the	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.

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			acoustic blanking of lower horizons. It is possible that this may be caused by biogenic gas caused by the microbial breakdown of organic matter, although it may also be caused by gravelly sediments at the base of the channel feature.	post-LGM sediments (i.e., sediment waves). The buried channel-like features are of uncertain origin – i.e., tidal currents vs. fluvial processes – and age.	These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
117.	7116	Channel	Channel segment with tributaries	I observe no channel on the MBES data across the modern (i.e., post-LGM) seafloor. The seafloor is featureless here. If there was a channel here, it would have been completely infilled during post-LGM time.	**Same as Row 1 Transgressive Processes.**
118.	7117	Channel	Palaeochannel, possibly becoming estuarine.	I observe no channel on the MBES data across the modern (i.e., post-LGM) seafloor. The seafloor is featureless here. If there was a channel here, it would have been completely infilled during post-LGM time.	**Same as Row 1 Transgressive Processes.**
119.	7118	Channel	Channel segment with tributaries	Likely upstream limit of a tributary channel to a larger channel to the west of this area, as imaged by the MBES data.	**Same as Row 1 Transgressive Processes.**
120.	7119	Channel	A possible channel identified within a feature identified in the MBES data (**7117**). Feature has a relatively distinct basal reflector and chaotic fill, possible with more than one phase of cutting and filling. May represent an earlier phase of channelling which has been truncated by a later phase, or may be the partially filled base of **7117**.	Likely tributary channel able to be observed on the MBES data. Buried channels of uncertain origin (i.e., fluvial vs. tidal channel) are present here. The channel is present on the modern seafloor, having not been infilled, suggesting that shelf currents have been actively scouring and precluding post-LGM	**Same as Row 1 Transgressive Processes.**

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				sedimentation there, thus impeding preservation of archaeological objects.	
121.	7120	Channel	Tributary segment	Channel not apparent on the MBES data.	**Same as Row 1 Transgressive Processes.**
122.	7121	Channel	Tributary segment	Channel not apparent on MBES data	**Same as Row 1 Transgressive Processes.**
123.	7122	Channel	Narrow palaeochannel segment	Channel not apparent on MBES data	**Same as Row 1 Transgressive Processes.**
124.	7123	Channel	Blind channel segment - buried or eroded	Channel not apparent on MBES data	**Same as Row 1 Transgressive Processes.**
125.	7124	Channel	Blind channel segment - buried or eroded	Channel not apparent on MBES data	**Same as Row 1 Transgressive Processes.**
126.	7125	Channel	Small channel segment	Channel not apparent on MBES data	**Same as Row 1 Transgressive Processes.**
127.	7126	Channel	A possible channel feature identified below a veneer/thin unit of sediment, cutting into a unit characterised by numerous horizontal reflectors which display evidence of faulting indicating Unit 1. Feature has a distinct, occasionally chaotic basal reflector which shoals and deepens throughout the feature and is seen to cause some acoustic blanking of the horizons below. This may indicate shallow gas caused by the microbial breakdown of organic matter, although it may also indicate gravelly sediments at the base of the feature. Unit fill is generally characterised by draping reflectors, although it is seen to be acoustically quiet in some areas. Possibly multiple	MBES data indicates the presence of numerous NNE-SSW trending subtle ridges. I interpret these ridges to be produced by subaqueous bottom currents during post-LGM time. Bottom samples (e.g., EP-34-CPT as referenced by Wessex) cannot ascribe a mode of origin based exclusively on sediment grain size as Wessex have suggested. This is because grain size alone is not diagnostic of a particular depositional environment. The map pattern identified as **7126** does not "look" like a channel or channel belt pattern (i.e., it has an amorphous map pattern). I have low confidence in Wessex's interpretation in this instance. Even if channels are identified on seismic profiles, their lack of expression on the	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment. These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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			phases of cut and fill. EP-34-CPT suggests the fill includes non-marine sand.	modern sea floor suggests that post-transgressive processes likely have sufficiently altered (i.e., buried) the LGM landscape so as to make the channels undetectable on the modern seafloor.	
128.	7127	Cut and fill	A possible lower phase of channelling identified below Channel feature **7126**, cutting into the interpreted Unit 1. Feature has a faint basal reflector and acoustically quiet fill. May represent an earlier phase of channelling.	MBES data indicates the presence of numerous NNE-SSW trending subtle ridges just west of this feature. I interpret these ridges to be produced by subaqueous bottom currents during post-LGM time as above (see discussion of features **7109** and **7110**). Buried channels as imaged on SBP data are of uncertain origin (i.e., fluvial vs. tidal channels), however, based on acoustically quiet fill (i.e., homogeneous lithology), the fill likely is not fluvial but is rather tidal current in origin.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
129.	7128	Channel	A possible channel identified BSB/below a veneer or marine sediment, cutting into the interpreted Unit 1. Feature has generally acoustically quiet fill with occasional higher amplitude horizontal reflectors. Possibly related to channel **7129** identified in the MBES data.	MBES data indicates the presence of numerous NNE-SSW trending subtle ridges just west of this feature. I interpret these ridges to be produced by subaqueous bottom currents during post-LGM time as above (see discussion of features **7109** and **7110**). Buried channels as imaged on SBP data are of uncertain origin (i.e., fluvial vs. tidal channels), however, based on acoustically quiet fill (i.e., homogeneous lithology), the fill likely is not fluvial but is rather tidal current in origin.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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130.	7129	Channel	Main large river network draining into canyon	Likely fluvial channel related to the larger channel to the west. I interpret the larger channel (referred to by Wessex as a "canyon") as having originally been a fluvial channel later (i.e., post-LGM) strongly modified (i.e., eroded and deepened) by tidal current processes. This channel appears to be a buried channel without significant internal architecture. It is infilled with reflection-free deposits as observed on SBP data. I interpret the fill as homogenous, mud-rich sediments of tidal-process origin (refer to discussion of feature **7016**). In any case, complete infill of the channel, so that there is minimal seafloor expression, suggests post-LGM processes. In my opinion these processes would have significantly modified the LGM landscape and buried any archaeological artifacts.	**Same as Row 1 Transgressive Processes.**
131.	7130	Channel	Possible channel identified BSB/below a veneer of sediment. Feature has a faint, poorly defined basal reflector and acoustically chaotic fill. Feature appears to be cutting into a unit characterised by numerous horizontal reflectors interpreted as being part of Unit 1. Possibly a continuation of **7131** or part of **7129** identified on the MBES data.	I observe no channel on the MBES data across the modern (i.e., post-LGM) seafloor. Rather, the data show an irregular seafloor more likely related to scour and fill by post-LGM subaqueous bottom currents rather than fluvial processes.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.

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					These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
132.	7131	Channel	Partially buried palaeochannel	I observe no channel on the MBES data across the modern (i.e., post-LGM) seafloor. Rather, the data show an irregular seafloor more likely related to scour and fill by post-LGM subaqueous bottom currents rather than fluvial processes.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
133.	7132	Channel	Possible channel identified SBSB/below a veneer of sediment. Feature has a faint basal reflector and acoustically quiet fill. Feature appears to be cutting into a unit characterised by numerous horizontal reflectors interpreted as being part of Unit 1. Possibly related to nearby feature 7131 identified in the MBES data.	I observe no channel on the MBES data across the modern (i.e., post-LGM) seafloor. Rather, the data show an irregular seafloor more likely related to scour and fill by post-LGM subaqueous bottom currents rather than fluvial processes.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment. These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological

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					objects on the modern seafloor is irrelevant.
134.	7133	Escarpment	Cliff band and promontory, up to 10 m relief	An escarpment is present here based on the MBES data. It is unclear whether this is an asymmetric dune/sediment wave, which would be post-LGM in origin, or a feature of the subaerial LGM paleo landscape. Alternatively, this feature could be an erosional remnant associated with seafloor scour by shelf currents.	**Same as Row 1 Transgressive Processes.**
135.	7134	Channel	Palaeochannels largely covered by marine sediments and difficult to interpret from bathymetry	I observe no channel on the MBES data across the modern (i.e., post-LGM) seafloor. Rather, the data show an irregular seafloor more likely related to scour and fill by post-LGM subaqueous bottom currents rather than fluvial processes.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
136.	7135	Cut and fill	A small cut and fill identified BSB/below a veneer of sediment, cutting into the interpreted Unit 1. Feature has a distinct basal reflector and acoustically chaotic fill. Feature appears particularly chaotic at the base and is possibly causing some slight acoustic blanking of lower horizons. This may be dure to shallow gas although may be more likely due to gravelly sediments at the base of the feature. Identified below a channel feature identified in the MBES data (**7134**) and may represent an earlier	I observe no channel (i.e., no cut and fill) on the MBES data across the modern (i.e., post-LGM) seafloor. Rather, the data show an irregular seafloor more likely related to scour and fill by post-LGM subaqueous bottom currents rather than fluvial processes.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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			phase of channelling or the base of the feature, partially infilled with sediment.		
137.	7136	Channel	Palaeochannel largely covered by marine sediments/sediment waves	Sediment waves are clearly present as observed on MBES data. Buried channels of uncertain origin (i.e., fluvial vs. tidal channel) are present as well.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface. These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
138.	7137	Channel	Steep-sided channels with plateaux interfluves joining into main anabranching river network	MBES data do not support the presence of channels at the seafloor. The irregularity of the seafloor likely is the result of erosion and redeposition of sediments during post-LGM time. Anabranching is a landform that is identifiable only in map view; in this instance, the MBES data do not support that interpretation.	**Same as Row 1 Transgressive Processes.**
139.	7138	Channel	Channel segment	I observe no channel on the MBES data across the modern (i.e., post-LGM) seafloor. Rather, the data show an irregular seafloor more likely related to scour and fill by post-LGM subaqueous bottom currents rather than fluvial processes.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological

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					objects on the modern seafloor is irrelevant.
140.	7139	Channel	Large anabranching river complex	MBES data supports the presence of a channel at the seafloor. However, anabranching cannot be observed here.	**Same as Row 1 Transgressive Processes.**
141.	7140	Channel	Channel segment with tributaries	It is unclear which feature Wessex has designated as feature 7140. I do not see channel segments on the MBES data in the vicinity of their label. There is one apparent channel to the southwest of their label.	**Same as Row 1 Transgressive Processes.**
142.	7141	Channel	Channel segment	A likely channel can be observed on the MBES data.	**Same as Row 1 Transgressive Processes.**
143.	7142	Channel	Channel segment	I do not see a channel on the MBES data. Rather, the seafloor is characterized by an irregular morphology, likely influenced by post-LGM subaqueous bottom currents.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
144.	7143	Channel	Channel segment with tributaries	I do not see a channel on the MBES data. Rather, the seafloor is characterized by an irregular morphology, likely influenced by post-LGM subaqueous bottom currents.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

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145.	7144	Channel	Main meandering river channel	There is a channel apparent on the MBES data, likely fluvial in origin based on the presence of a meander pattern, which is more common in fluvial channels than in large tidal channels.	**Same as Row 1 Transgressive Processes.**
146.	7145	Channel	A possible channel segment identified below a Unit of sediment, interpreted as cutting into the interpreted Unit 1. In the 2023 boomer data, the feature is seen to have a faint, poorly defined basal reflector, although this is clearer in the 2015 data, with acoustically chaotic fill. Identified below a channel feature identified in the MBES data (**7144**) and may represent an earlier phase of channelling or the base of the feature, partially infilled with sediment.	This interpreted channel has no apparent seafloor expression, likely because it is older (i.e., pre-LGM) and subsequently buried post-LGM.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.
147.	7146	Cut and fill	A possible channel segment identified BSB/below a veneer of sediment, interpreted as cutting into the interpreted Unit 1. The feature has a faint, poorly defined basal reflector with acoustically unstructured fill. Identified below a channel feature identified in the MBES data (**7144**) and may represent an earlier phase of channelling or the base of the feature, partially infilled with sediment. May be a continuation of **7145**; however, due to the distance between lines, the features have not been grouped at this time.	This interpreted channel has no apparent seafloor expression, likely because it is older (i.e., pre-LGM) and subsequently buried and of uncertain age. The fill of the channels identified here is characterized by a reflection-free character, suggesting homogenous fill, inconsistent with fluvial processes (i.e., these channels lack evidence for lateral accretion). Rather than interpreting these as fluvial features as Wessex have done, I would interpret these features as tidal channels. Tidal channels are far more likely to fill with deposits that are	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.

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				homogeneous and therefore reflection free. Though I cannot rule out the possibility that these features may have originated as fluvial channels and could have been modified by later tidally-associated erosion (i.e., post-LGM), there is nonetheless no evidence for fluvial origins preserved here.	
148.	7147	Channel	Meandering channel complex segment	Likely channel present on the seafloor based on MBES data.	**Same as Row 1 Transgressive Processes.**
149.	7148	Cut and fill	A cut and fill identified below a veneer of sediment. Feature has a faint but distinct basal reflector with acoustically chaotic fill. Cutting into an interpreted lower phase of channelling (**7149**).	No apparent expression of a channel (i.e., cut and fill) on the modern (i.e., post-LGM) seafloor as observed on the MBES data. Older buried channels of uncertain origin (i.e., tidal vs. fluvial channel) and age are present.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.
150.	7149	Cut and fill	A cut and fill identified below an upper Unit of sediment, being cut into by a later phase of cut and fill (**7148**). Feature has a faint but distinct basal reflector with fill characterised by numerous horizontal reflectors, indicating layered fill which may have been deposited in a low-energy environment (possibly a unit of estuarine/lacustrine sediments (Unit 5)).	No apparent expression of a channel (i.e., cut and fill) on the modern (i.e., post-LGM) seafloor as observed on the MBES data. Older buried channels of uncertain origin (i.e., fluvial vs. tidal channel) and age are present.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.
151.	7150	Channel	Small channel segment seen within larger anabranching river network	There is no evidence for a channel on the MBES data. No anabranching is observed here.	**Same as Row 1 Transgressive Processes.**

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152.	7151	Cut and fill	A possible channel identified below a veneer of sediment, with a faint basal reflector and acoustically unstructured fill. In the 2015 Boomer data it appears to be cutting into an acoustically quiet unit (possibly Unit 5) above the interpreted Unit 1, although this is less clear in the 2023 Boomer data. Possible remnant fluvial feature.	There is no apparent channel on the MBES data. Buried channels of uncertain origin (i.e., fluvial vs. tidal channel) and age are present on the SBP data.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface by up to 5m of sediment.
153.	7152	Cut and fill	A possible cut and fill identified beneath an acoustically quiet unit (possible Unit 5 although this is not certain) which is thinner in the west, thickening towards the east. Feature has a faint basal reflector and acoustically unstructured fill. Possible remnant fluvial feature from an earlier phase of channelling	No channel is apparent on the MBES data. Buried channels of uncertain origin (i.e., fluvial vs. tidal channel) and age are present.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface.
154.	7153	Channel	Anabranching channel segments	No channels are apparent on the MBES data.	**Same as Row 1 Transgressive Processes.**
155.	7154	Cut and fill	A possible cut and fill feature identified beneath an upper unit of acoustically quiet sediment with a chaotic base, possibly indicating gravels, cutting into the interpreted Unit 1. Feature has a distinct, undulating basal reflector and fill characterised by faint, draping reflectors. Possible remnant fluvial feature or infilled depression	No clear channel morphology is observed on the MBES data. I interpret the irregularity of the seafloor as scour and fill, which I infer to be the result of post-LGM subaqueous bottom current scour. Buried channels can be observed on the SBP data, however their lack of seafloor expression suggests infilling and "healing" of the seafloor during post-LGM time.	**Same as Row 1 Transgressive Processes.** Wessex's observation of the presence of a thin layer of marine sands is consistent with the inference that post-LGM transgressive geologic processes were responsible for burying the LGM surface. These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
					objects on the modern seafloor is irrelevant.
156.	7155	Channel	Small segment of palaeochannel seen on MBES	No clear channel morphology is observed on the MBES data. I interpret the irregularity of the seafloor as scour and fill, which I infer to be the result of post-LGM subaqueous bottom current scour. This feature likely is the marine equivalent of a "deflation hollow" that formed by tidal current scour after the shelf was flooded post-LGM. In non-marine settings wind erosion can produce hollowed out depressions, hence the term "hollows". In subaqueous settings bottom currents can produce similar erosion-related depressions. Its asymmetry – i.e., closed depression to the northwest and open towards the southeast – suggests flow direction from NW to SE.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
157.	7156	Channel	Small segment of palaeochannel seen on MBES	No clear channel morphology is observed on the MBES data. I interpret the irregularity of the seafloor as scour and fill, which I infer to be the result of post-LGM subaqueous bottom current scour. This feature likely is the marine equivalent of a "deflation hollow" that formed by tidal current scour after the shelf was flooded post-LGM. In non-marine settings wind erosion can produce hollowed out depressions, hence the term "hollows". In	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
				subaqueous settings bottom currents can produce similar erosion-related depressions. Its asymmetry – i.e., closed depression to the northwest and open towards the southeast – suggests flow direction from NW to SE.	
158.	7157	Channel	Large, wide (~1.5 km) palaeochannel segment showing anabranching	No clear channel morphology is observed on the MBES data. I interpret the irregularity of the seafloor as scour and fill, which I infer to be the result of post-LGM subaqueous bottom current scour. This feature likely is the marine equivalent of a "deflation hollow" that formed by tidal current scour after the shelf was flooded post-LGM. In non-marine settings wind erosion can produce hollowed out depressions, hence the term "hollows". In subaqueous settings bottom currents can produce similar erosion-related depressions. Its asymmetry – i.e., closed depression to the northwest and open towards the southeast – suggests flow direction from NW to SE.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
159.	7158	Complex channel	A possible cut and fill identified beneath an upper unit characterised by numerous faint horizontal reflectors (possible Unit 5 but this is uncertain), possibly indicating fine-grained deposits, cutting into the interpreted Unit 1. Feature has a distinct basal reflector and acoustically unstructured fill, possibly	No clear channel morphology is observed on the MBES data. I interpret the irregularity of the seafloor as scour and fill, which I infer to be the result of post-LGM subaqueous bottom current scour. Buried channels can be observed on the SBP data, however their lack of seafloor	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
			multiple phases of cutting and filling. Identified close to similar feature **7159**, but separated by a distinct banked feature which may represent a high point between channel cuts, or possibly a calcarenite surface, although this is uncertain.	expression suggests infilling and "healing" of the seafloor during post-LGM time.	objects on the modern seafloor is irrelevant.
160.	7159	Complex channel	A complex cut and fill feature identified beneath an upper unit characterised by numerous faint horizontal reflectors (possible Unit 5 but this is uncertain), possibly indicating fine-grained deposits, cutting into the top of the interpreted Unit 1. Feature has a faint, poorly defined basal reflector and numerous phases of cutting and filling, with fill generally appearing acoustically unstructured, although it appears more chaotic in its later phase of fill. Identified close to similar feature **7158**, but separated by a distinct banked feature which may represent a high point between channel cuts, or possibly a calcarenite surface, although this is uncertain. Possible channel complex	No clear channel morphology is observed on the MBES data. I interpret the irregularity of the seafloor as scour and fill, which I infer to be the result of post-LGM subaqueous bottom current scour. Buried channels of uncertain age and origin (i.e., fluvial vs. tidal channel) may be present.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
161.	7160	Channel	Large, wide (~1 km) braided river channel with undulating thalweg	I interpret the patterns observed on the MBES data as bottom current related scour and fill rather than a braided channel system (see above discussion of features **7155**, **7156**, and **7157**).	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological

	ID in the Wessex Report (Appendix II)	Classification in the Wessex Report (Appendix II)	Description in the Wessex Report (Appendix II)	My opinion on the features in the Wessex Report (including any alternative views)	My opinion on the preservation potential of archaeological objects *in situ* on the modern (i.e., post-LGM) seafloor with respect to my interpretation of the features
					objects on the modern seafloor is irrelevant.
162.	7161	Infilled depression	A possible infilled depression identified below an upper unit of acoustically quiet sediment, infilling a depression at the top of the interpreted Unit 1. Fill is characterised by numerous faint, draping reflectors, indicating fine-grained deposits deposited in a low-energy environment. Fill is not clearly different to overlying sediment, although the draping reflectors appear slightly more distinct. Feature has a distinct basal reflector which appears acoustically chaotic where it shoals in the centre.	I do not see a depression on the MBES data. Rather I see a complex cluster of scour and fill features (see above discussion of features **7155**, **7156**, and **7157**). Based on their presence on the seafloor, I infer that the process of scour and fill occurred post-LGM time and was related to subaqueous bottom currents, likely tidal in origin.	**Same as Row 1 Transgressive Processes.** These features formed subaqueously after flooding of the LGM surface, so no habitation of this surface would have occurred, and consequently the issue of preservation potential of archaeological objects on the modern seafloor is irrelevant.
163.	7162	Channel	Small segment of palaeochannel seen on MBES	The feature identified on the MBES data could be a channel segment present on the seafloor, however, the limited coverage by high-resolution MBES data makes this interpretation tenuous.	**Same as Row 1 Transgressive Processes.**

Appendix 1.

Annexure A

HARMONISED EXPERT WITNESS CODE OF CONDUCT[2]

APPLICATION OF CODE

1. This Code of Conduct applies to any expert witness engaged or appointed:

   (a) to provide an expert's report for use as evidence in proceedings or proposed proceedings; or

   (b) to give opinion evidence in proceedings or proposed proceedings.

GENERAL DUTIES TO THE COURT

2. An expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

CONTENT OF REPORT

3. Every report prepared by an expert witness for use in Court shall clearly state the opinion or opinions of the expert and shall state, specify or provide:

   (a) the name and address of the expert;

   (b) an acknowledgment that the expert has read this code and agrees to be bound by it;

   (c) the qualifications of the expert to prepare the report;

   (d) the assumptions and material facts on which each opinion expressed in the report is based [a letter of instructions may be annexed];

   (e) the reasons for and any literature or other materials utilised in support of such opinion;

   (f) (if applicable) that a particular question, issue or matter falls outside the expert's field of expertise;

   (g) any examinations, tests or other investigations on which the expert has relied, identifying the person who carried them out and that person's qualifications;

   (h) the extent to which any opinion which the expert has expressed involves the acceptance of another person's opinion, the identification of that other person and the opinion expressed by that other person;

   (i) a declaration that the expert has made all the inquiries which the expert believes are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which the expert regards as relevant have, to the

knowledge of the expert, been withheld from the Court;

(j) any qualifications on an opinion expressed in the report without which the report is or may be incomplete or inaccurate;

(k) whether any opinion expressed in the report is not a concluded opinion because of insufficient research or insufficient data or for any other reason; and

(l) where the report is lengthy or complex, a brief summary of the report at the beginning of the report.

SUPPLEMENTARY REPORT FOLLOWING CHANGE OF OPINION

4. Where an expert witness has provided to a party (or that party's legal representative) a report for use in Court, and the expert thereafter changes his or her opinion on a material matter, the expert shall forthwith provide to the party (or that party's legal representative) a supplementary report which shall state, specify or provide the information referred to in paragraphs (a), (d), (e), (g), (h), (i), (j), (k) and (l) of clause 3 of this code and, if applicable, paragraph (f) of that clause.

5. In any subsequent report (whether prepared in accordance with clause 4 or not) the expert may refer to material contained in the earlier report without repeating it.

DUTY TO COMPLY WITH THE COURT'S DIRECTIONS

6. If directed to do so by the Court, an expert witness shall:

(a) confer with any other expert witness;

(b) provide the Court with a joint-report specifying (as the case requires) matters agreed and matters not agreed and the reasons for the experts not agreeing; and

(c) abide in a timely way by any direction of the Court.

CONFERENCE OF EXPERTS

7. Each expert witness shall:

(a) exercise his or her independent judgment in relation to every conference in which the expert participates pursuant to a direction of the Court and in relation to each report thereafter provided, and shall not act on any instruction or request to withhold or avoid agreement; and

(b) endeavour to reach agreement with the other expert witness (or witnesses) on any issue in dispute between them, or failing agreement, endeavour to identify and clarify the basis of disagreement on the issues which are in dispute.

Appendix 2.

FEDERAL COURT
OF AUSTRALIA

EXPERT EVIDENCE PRACTICE NOTE (GPN-EXPT)

General Practice Note

1. INTRODUCTION

1.1 This practice note, including the *Harmonised Expert Witness Code of Conduct* (**"Code"**) (see Annexure A) and the *Concurrent Expert Evidence Guidelines* (**"Concurrent Evidence Guidelines"**) (see Annexure B), applies to any proceeding involving the use of expert evidence and must be read together with:

(a) the Central Practice Note (CPN-1), which sets out the fundamental principles concerning the National Court Framework (**"NCF"**) of the Federal Court and key principles of case management procedure;

(b) the Federal Court of Australia Act 1976 (Cth) (**"Federal Court Act"**);

(c) the *Evidence Act 1995* (Cth) (**"Evidence Act"**), including Part 3.3 of the Evidence Act;

(d) Part 23 of the *Federal Court Rules 2011* (Cth) (**"Federal Court Rules"**); and

(e) where applicable, the Survey Evidence Practice Note (GPN-SURV).

1.2 This practice note takes effect from the date it is issued and, to the extent practicable, applies to proceedings whether filed before, or after, the date of issuing.

2. APPROACH TO EXPERT EVIDENCE

2.1 An expert witness may be retained to give opinion evidence in the proceeding, or, in certain circumstances, to express an opinion that may be relied upon in alternative dispute resolution procedures such as mediation or a conference of experts. In some circumstances an expert may be appointed as an independent adviser to the Court.

2.2 The purpose of the use of expert evidence in proceedings, often in relation to complex subject matter, is for the Court to receive the benefit of the objective and impartial assessment of an issue from a witness with specialised knowledge (based on training, study or experience - see generally s 79 of the Evidence Act).

2.3 However, the use or admissibility of expert evidence remains subject to the overriding requirements that:

being unfairly prejudicial, misleading or will result in an undue waste of time (s 135 of the Evidence Act).

2.4 An expert witness' opinion evidence may have little or no value unless the assumptions adopted by the expert (ie. the facts or grounds relied upon) and his or her reasoning are expressly stated in any written report or oral evidence given.

2.5 The Court will ensure that, in the interests of justice, parties are given a reasonable opportunity to adduce and test relevant expert opinion evidence. However, the Court expects parties and any legal representatives acting on their behalf, when dealing with expert witnesses and expert evidence, to at all times comply with their duties associated with the overarching purpose in the Federal Court Act (see ss 37M and 37N).

3. INTERACTION WITH EXPERT WITNESSES

3.1 Parties and their legal representatives should never view an expert witness retained (or partly retained) by them as that party's advocate or "hired gun". Equally, they should never attempt to pressure or influence an expert into conforming his or her views with the party's interests.

3.2 A party or legal representative should be cautious not to have inappropriate communications when retaining or instructing an independent expert, or assisting an independent expert in the preparation of his or her evidence. However, it is important to note that there is no principle of law or practice and there is nothing in this practice note that obliges a party to embark on the costly task of engaging a "consulting expert" in order to avoid "contamination" of the expert who will give evidence. Indeed the Court would generally discourage such costly duplication.

3.3 Any witness retained by a party for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based in the specialised knowledge of the witness[1] should, at the earliest opportunity, be provided with:

(a) a copy of this practice note, including the Code (see Annexure A); and

(b) all relevant information (whether helpful or harmful to that party's case) so as to enable the expert to prepare a report of a truly independent nature.

3.4 Any questions or assumptions provided to an expert should be provided in an unbiased manner and in such a way that the expert is not confined to addressing selective, irrelevant or immaterial issues.

[1] Such a witness includes a "Court expert" as defined in r 23.01 of the Federal Court Rules. For the definition of

4. ROLE AND DUTIES OF THE EXPERT WITNESS

4.1 The role of the expert witness is to provide relevant and impartial evidence in his or her area of expertise. An expert should never mislead the Court or become an advocate for the cause of the party that has retained the expert.

4.2 It should be emphasised that there is nothing inherently wrong with experts disagreeing or failing to reach the same conclusion. The Court will, with the assistance of the evidence of the experts, reach its own conclusion.

4.3 However, experts should willingly be prepared to change their opinion or make concessions when it is necessary or appropriate to do so, even if doing so would be contrary to any previously held or expressed view of that expert.

Harmonised Expert Witness Code of Conduct

4.4 Every expert witness giving evidence in this Court must read the *Harmonised Expert Witness Code of Conduct* (attached in Annexure A) and agree to be bound by it.

4.5 The Code is not intended to address all aspects of an expert witness' duties, but is intended to facilitate the admission of opinion evidence, and to assist experts to understand in general terms what the Court expects of them. Additionally, it is expected that compliance with the Code will assist individual expert witnesses to avoid criticism (rightly or wrongly) that they lack objectivity or are partisan.

5. CONTENTS OF AN EXPERT'S REPORT AND RELATED MATERIAL

5.1 The contents of an expert's report must conform with the requirements set out in the Code (including clauses 3 to 5 of the Code).

5.2 In addition, the contents of such a report must also comply with r 23.13 of the Federal Court Rules. Given that the requirements of that rule significantly overlap with the requirements in the Code, an expert, unless otherwise directed by the Court, will be taken to have complied with the requirements of r 23.13 if that expert has complied with the requirements in the Code and has complied with the additional following requirements. The expert shall:

(a) acknowledge in the report that:

(i) the expert has read and complied with this practice note and agrees to be bound by it; and

(ii) the expert's opinions are based wholly or substantially on specialised knowledge arising from the expert's training, study or experience;

(b) identify in the report the questions that the expert was asked to address;

(c) sign the report and attach or exhibit to it copies of:

(ii) documents and other materials that the expert has been instructed to consider.

5.3 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the other parties at the same time as the expert's report.

6. CASE MANAGEMENT CONSIDERATIONS

6.1 Parties intending to rely on expert evidence at trial are expected to consider between them and inform the Court at the earliest opportunity of their views on the following:

(a) whether a party should adduce evidence from more than one expert in any single discipline;

(b) whether a common expert is appropriate for all or any part of the evidence;

(c) the nature and extent of expert reports, including any in reply;

(d) the identity of each expert witness that a party intends to call, their area(s) of expertise and availability during the proposed hearing;

(e) the issues that it is proposed each expert will address;

(f) the arrangements for a conference of experts to prepare a joint-report (see Part 7 of this practice note);

(g) whether the evidence is to be given concurrently and, if so, how (see Part 8 of this practice note); and

(h) whether any of the evidence in chief can be given orally.

6.2 It will often be desirable, before any expert is retained, for the parties to attempt to agree on the question or questions proposed to be the subject of expert evidence as well as the relevant facts and assumptions. The Court may make orders to that effect where it considers it appropriate to do so.

7. CONFERENCE OF EXPERTS AND JOINT-REPORT

7.1 Parties, their legal representatives and experts should be familiar with aspects of the Code relating to conferences of experts and joint-reports (see clauses 6 and 7 of the Code attached in Annexure A).

7.2 In order to facilitate the proper understanding of issues arising in expert evidence and to manage expert evidence in accordance with the overarching purpose, the Court may require experts who are to give evidence or who have produced reports to meet for the purpose of identifying and addressing the issues not agreed between them with a view to

7.3 It is expected that where expert evidence may be relied on in any proceeding, at the earliest opportunity, parties will discuss and then inform the Court whether a conference of experts and/or a joint-report by the experts may be desirable to assist with or simplify the giving of expert evidence in the proceeding. The parties should discuss the necessary arrangements for any conference and/or joint-report. The arrangements discussed between the parties should address:

(a) who should prepare any joint-report;

(b) whether a list of issues is needed to assist the experts in the conference and, if so, whether the Court, the parties o r the experts should assist in preparing such a list;

(c) the agenda for the conference of experts; and

(d) arrangements for the provision, to the parties and the Court, of any joint-report or any other report as to the outcomes of the conference ("**conference report**").

Conference of Experts

7.4 The purpose of the conference of experts is for the experts to have a comprehensive discussion of issues relating to their field of expertise, with a view to identifying matters and issues in a proceeding about which the experts agree, partly agree or disagree and why. For this reason the conference is attended only by the experts and any Conference Facilitator. Unless the Court orders otherwise, the parties' lawyers will not attend the conference but will be provided with a copy of any conference report.

7.5 The Court may order that a conference of experts occur in a variety of circumstances, depending on the views of the judge and the parties and the needs of the case, including:

(a) while a case is in mediation. When this occurs the Court may also order that the outcome of the conference or any document disclosing or summarising the experts' opinions be confidential to the parties while the mediation is occurring;

(b) before the experts have reached a final opinion on a relevant question or the facts involved in a case. When this occurs the Court may order that the parties exchange draft expert reports and that a conference report be prepared for the use of the experts in finalising their reports;

(c) after the experts' reports have been provided to the Court but before the hearing of the experts' evidence. When this occurs the Court may also order that a conference report be prepared (jointly or otherwise) to ensure the efficient hearing of the experts' evidence.

7.6 Subject to any other order or direction of the Court, the parties and their lawyers must not involve themselves in the conference of experts process. In particular, they must not seek to encourage an expert not to agree with another expert or otherwise seek to influence the outcome of the conference of experts. The experts should raise any queries they may have

accordance with a protocol agreed between the lawyers prior to the conference of experts taking place (if no Conference Facilitator has been appointed).

7.7 Any list of issues prepared for the consideration of the experts as part of the conference of experts process should be prepared using non-tendentious language.

7.8 The timing and location of the conference of experts will be decided by the judge or a registrar who will take into account the location and availability of the experts and the Court's case management timetable. The conference may take place at the Court and will usually be conducted in-person. However, if not considered a hindrance to the process, the conference may also be conducted with the assistance of visual or audio technology (such as via the internet, video link and/or by telephone).

7.9 Experts should prepare for a conference of experts by ensuring that they are familiar with all of the material upon which they base their opinions. Where expert reports in draft or final form have been exchanged prior to the conference, experts should attend the conference familiar with the reports of the other experts. Prior to the conference, experts should also consider where they believe the differences of opinion lie between them and what processes and discussions may assist to identify and refine those areas of difference.

Joint-report

7.10 At the conclusion of the conference of experts, unless the Court considers it unnecessary to do so, it is expected that the experts will have narrowed the issues in respect of which they agree, partly agree or disagree in a joint-report. The joint-report should be clear, plain and concise and should summarise the views of the experts on the identified issues, including a succinct explanation for any differences of opinion, and otherwise be structured in the manner requested by the judge or registrar.

7.11 In some cases (and most particularly in some native title cases), depending on the nature, volume and complexity of the expert evidence a judge may direct a registrar to draft part, or all, of a conference report. If so, the registrar will usually provide the draft conference report to the relevant experts and seek their confirmation that the conference report accurately reflects the opinions of the experts expressed at the conference. Once that confirmation has been received the registrar will finalise the conference report and provide it to the intended recipient(s).

8. CONCURRENT EXPERT EVIDENCE

8.1 The Court may determine that it is appropriate, depending on the nature of the expert evidence and the proceeding generally, for experts to give some or all of their evidence concurrently at the final (or other) hearing.

8.2 Parties should familiarise themselves with the *Concurrent Expert Evidence Guidelines* (attached in Annexure B). The Concurrent Evidence Guidelines are not intended to be

concurrent expert evidence to take place, outline how that process may be undertaken, and assist experts to understand in general terms what the Court expects of them.

8.3 If an order is made for concurrent expert evidence to be given at a hearing, any expert to give such evidence should be provided with the Concurrent Evidence Guidelines well in advance of the hearing and should be familiar with those guidelines before giving evidence.

9. FURTHER PRACTICE INFORMATION AND RESOURCES

9.1 Further information regarding Expert Evidence and Expert Witnesses is available on the Court's website.

9.2 Further information to assist litigants, including a range of helpful guides, is also available on the Court's website. This information may be particularly helpful for litigants who are representing themselves.

J L B ALLSOP
Chief Justice
25 October 2016