REPORT ON ABORIGINAL ARCHAEOLOGICAL INVESTIGATIONS AT THE ROE 8 REHABILITATION MANAGEMENT AREA, LAKE WALLIABUP (BIBRA LAKE) AND LAKE COOLBELLUP (NORTH LAKE)

September 2022

archae-aus

1/107 Stirling Highway North Fremantle Western Australia 6159 PO Box 742 Fremantle Western Australia 6959 ABN 92 074 791 156

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Archae-aus Pty Ltd

1/107 Stirling Highway
North Fremantle WA 6159
PO Box 742
Fremantle WA 6959

T: 08 9433 1127
E: office@archae-aus.com.au

http://www.archae-aus.com.au

Project Manager: Fiona Hook
Email: fiona@archae-aus.com.au

Front Cover (Left): Joe Dortch explains the excavation of Square 1 to Noongar Elders

Front Cover (Right): Student volunteers excavating a shovel test pit

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Warning

Please be aware that this report contains images of deceased persons and the use of their names, which in some Aboriginal communities may cause sadness, distress or offence.

Disclaimer

The authors are not accountable for omissions and inconsistencies that may result from information which may come to light in the future but was not forthcoming at the time of this research.

Report Format

The report is divided into four sections: Section 1 Introduction; Section 2 Background; Section 3 Methods; Section 4 – Results; Section 5 Discussion and Recommendations.

The report follows the Department of Planning, Lands and Heritage's Guidelines for preparing Aboriginal Heritage Reports[1].

Spatial Information

All spatial information contained in this report uses the Geocentric Datum of Australia 1994 (GDA94), Zone 50 unless otherwise specified. All spatial information obtained during fieldwork was taken using a handheld Garmin GPS with a purported accuracy of ±3 m. Where we report spatial information collected in the field, we have opted for a slightly wider degree of accuracy of ±5 m.

Authorship

This report was written by Dr Caroline Bird (PhD Archaeology, UWA) and edited by Fiona Hook.

The GIS data and maps were drafted by Caroline Bird.

Artefact cataloguing and analysis was carried out by Caroline Bird

[1] https://www.dplh.wa.gov.au/information-and-services/aboriginal-heritage/aboriginal-site-preservation

EXECUTIVE SUMMARY

This document details the results of a shovel test pitting program and archaeological excavations in the Roe 8 Management area between Lake Walliabup (Bibra Lake) and Lake Coolbellup (North Lake).

The fieldwork was conducted by Archae-aus 14-18 December 2020, with the involvement of Noongar elders and the assistance of student volunteers from Notre Dame University and the University of Western Australia.

1) Appropriate Aboriginal research and engagement to understand the Aboriginal heritage significance of the site, including (but not limited to) exploration of the following elements:
    - Aboriginal burial site(s);
    - Corroboree/ meeting place / camp site.
2) A draft community engagement plan demonstrating culturally appropriate engagement to be submitted to the City for approval at commencement of the project for the above.
3) A completed and detailed synthesis of all previous studies, research and analysis that has been performed on the site or surrounding the site relating to any aspect of Aboriginal heritage, including assessment and recording of finds in WA Museum lodged by Sylvia Hallam (Swan Coastal Plain Archaeological Project 1973) and others.
4) An on-ground assessment of possible artefacts including sub-surface excavations such as shovel test pits and open excavations.

The program of shovel test-pitting and excavation within DPLH 3709 was authorised by permit no. 605 issued under Section 16 of the Aboriginal Heritage Act 1972. The community plan was prepared prior to the section 16 permit application.

The fieldwork was conducted 14th to 18th December 2020.

Twenty-seven shovel test pits were excavated. One pit (T1-150) was abandoned at 16 cm when a possible fragment of asbestos was found. The other pits were excavated to an average depth of 80 cm. Of these, seventeen had cultural material in the form of Aboriginal artefacts. Eight of these pits also had historic cultural items.

Two locations were selected for systematic excavation based on the results of the STP program. Square 1 was located south of Hope Road within the footprint of 4107 and adjacent to STP T2-75. Square 2 was located north of Hope Road adjacent to STP T6-55

Square 1 is a 1 x 1 m test pit:

- It was excavated to a depth of 1.07 m. At this point, one side of the test pit became unstable and partially collapsed. A 50 x 50 cm sondage was excavated in the north-west corner to a final depth of 1.55 m.
- Charcoal was sparse and mainly occurred in the upper levels.
- Two in situ samples, from EU4 and EU6, were sent to Waikato Dating Laboratory in New Zealand. The determinations are in sequence, but the calibrated ranges overlap and fall mainly within the historic period. There was insufficient charcoal from the lower excavation units for dating.
- Three OSL samples were taken. The results showed a consistent depositional sequence extending back about 10,000 years associated with cultural material.

- Cultural material was relatively sparse in Square 1. European historic glass (12 fragments) and road metal (2 fragments) occurred throughout the upper part of the excavation (EU1-6).
- Stone artefacts appear first in EU4 and continue through most EUs until EU15 (about 1 m below surface). About 69% of the artefacts are quartz and these occur throughout. Fossiliferous chert artefacts appear at EU9, with a noticeable concentration in EU12. OSL dating shows that this concentration dates to about 8000 to 9000 years ago. There are trace amounts of dolerite and quartzite.

Square 2 is a 1 x 1 m test pit:

- It was excavated to a final depth of 1.02 m. At 71 cm, time constraints and the reduction quantity of cultural material, meant that the test pit was completed by excavating a 50 x 50 m sondage in the south-west corner of the square.
- Compared to Square 1, charcoal was far more abundant in Square 2 and continued to greater depth. Four in situ samples, from EU4, EU6, EU8 and EU10 were sent to Waikato Dating Laboratory in New Zealand. EU4 and EU6 are inverted and both are relatively recent falling within the last thousand years. The other two determinations are in sequence. The sample from EU8 is immediately below the concentration of cultural material in EU7 and thus provides a maximum age for those artefacts of about 2500 years. The sample from EU10 was the lowest in situ charcoal and gave a calibrated age of about 4500 years ago. There were trace amounts of both charcoal and artefacts below this sample and it is possible that older occupation could be identified as the excavation was terminated due to lack of time.
- Square 2 was much richer than Square 1 in terms of quantity of cultural material. There were no pieces of glass or ceramic or other material of European origin and stone artefacts appeared in EU2 immediately after removal of the surface vegetation as EU1. Ninety-five artefacts were recovered from Square 2. Most were quartz with one fragment each of chert and dolerite. Artefacts occurred throughout the sequence to EU13, but there was a noticeable concentration in EU7.

The results of the STP program and the excavations show that the ancestors of the Whadjuk Noongar left the traces of their activities much more widely through the area between the Lakes Walliabup and Coolbellup than the limited surface traces would suggest. Noongar traditions attest to the spiritual significance of this wetlands system as well as the economic importance of the rich plant and animal resources of this area. Historical sources confirm the importance of the area as a meeting place and a waypoint for those travelling along the wetland corridor between the Swan and Canning Rivers and the Pinjarra area. The quantity of sub-surface artefacts discovered during this project indicates that the whole of the higher ground around the lakes would have been favoured for camping. The whole wetland complex is best considered as a single cultural landscape with a high probability of encountering cultural material anywhere in it. On the basis of the density of artefacts found in the STPs we estimate there could be more than 20 million artefacts in the high potential archaeological area around the lakes.

The dating evidence obtained from this project confirms that the Whadjuk Noongar ancestors have used this landscape for at least 10,000 years.

This project has successfully shown that a rich tangible record of cultural material relating to the lives of the ancestors of the Whadjuk Noongar survives under the surface of the ground in this wetland complex complementing the spiritual and cultural importance ascribed to the lakes by Noongar tradition. This record survives because much of the area is public open space with relatively little impact on the sub-surface material. Elsewhere in the Perth Metropolitan Area, wetlands have been drained and filled in for industry and housing. Thus, the Walliabup and Coolbellup wetlands have high significance in terms of both tangible and intangible values. This importance has been recognised since 1988 when the first recommendation was made for an integrated cultural heritage management plan to care for this cultural landscape, but never implemented.

It is recommended based on the results of this work and at the instruction of the Noongar elders consulted on 19 September 2022 that:

- This report be released to the public.
- Lake Walliabup (Bibra Lake) and Lake Coolbellup (North Lake) is recognised as a Noongar Cultural Landscape and one heritage site that is of great importance and significance.
- A Heritage Information Submission Form (HISF) that contains information on all the cultural values collected so far is submitted to the DPLH for one heritage place. The HISF Form shall use the existing site North Lake and Bibra Lake (DPLH ID 3709) but enlarges its boundary to encompass the proven potential for sub-surface cultural material of the areas surrounding the two lakes and thus expands the range of values.
- That the artefacts collected during the excavations and shovel test pitting are to be put on display at the City of Cockburn Aboriginal Cultural and Visitors centre.
- That an integrated cultural heritage management plan be developed for the Lake Walliabup (Bibra Lake) and Lake Coolbellup (North Lake) area. This management plan should be codesigned with the Noongar elders consulted.
- With further consultation and under guidance from the integrated cultural heritage management plan:
    - additional archaeological excavation and shovel test pitting work occurs around the two lakes to further research and understand this significant Noongar history.
    - Stories are collected from the Elders about this place.
    - Results of this work is used in interpretation for the public and in community engagement.

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SECTION ONE – INTRODUCTION

PROJECT BACKGROUND

The Rehabilitating Roe 8 Rehabilitation Management Plan (Emerge 2018) was developed in 2018 and included considerable community consultation. The Rehabilitation Management Plan (the plan) was adopted by the State government in July 2018 and works commenced shortly thereafter on rehabilitating the ecosystems within the alignment. The plan details both the rehabilitation activities linked with rehabilitating the damage to vegetation caused by clearing for the proposed Roe 8 highway extension and also the community engagement elements required to assist with repairing community trust and connectedness with this space.

A key element of this project is the identified indigenous cultural heritage values of the site. The Aboriginal heritage values of the project area have been noted in previous studies and through identification and listing of two sites (3709 and 4107). The Roe 8 road reserve within Bibra Lake intersects Lakes Coolbellup and Walliabup. Within this area one registered site 3709 and other heritage place 4107 occur. Registered Site 4107, which falls within the Roe 8 alignment, was deregistered prior to commencement of clearing works. The proposed rehabilitation works will be addressed over a number of years within eight Management Areas. Three of these Areas (Hope Road North, Turtle Corner and North Lake Road East) are of particular concern due to their proximity to the lakes and intersection with known heritage sites (Figure 2).

The Coolbellup and Walliabup Lakes area is of ongoing cultural importance to the Whadjuk Noongar Traditional Owners. This connection has been documented in previous heritage assessments of archaeological and ethnographic values (Australian Interaction Consultants, 2005b; Yates, 2005; Harris, 2010; Quartermaine, 2010; Gifford *et al.*, 2011; Hook and Dortch, 2017). Some excavations in 2017 (Hook and Dortch 2017) around the northern portion of Bibra Lake revealed a range of significant artefacts. Given the proximity of rehabilitation works to the area of Bibra Lake that yielded artefacts it is reasonable to assume that other as yet undiscovered artefacts may be within the area identified for rehabilitation. As part of the Rehabilitating Roe 8 project rehabilitation works will over time be conducted in areas within these two sites. Given this, Aboriginal heritage values within the site may be impacted on.

In order to guide the management of the heritage landscape during rehabilitation works, City of Cockburn commissioned a Cultural Heritage Management Plan (CHMP) (Archae-aus Pty. Ltd., 2019). The CHMP defined areas of high archaeological potential in the form of sub-surface cultural material. The CHMNP recommended that an investigation of the sub-surface potential occur to help guide any rehabilitation works.

SCOPE OF WORKS

Archae-aus was engaged by the City of Cockburn under the Rehabilitating Roe 8 Programme to investigate the Aboriginal cultural heritage significance of the Roe 8 management areas intersecting Aboriginal Registered Site North Lake and Bibra Lake (DPLH ID 3709) and Other Heritage Place Bibra Lake North (DPLH ID 4107). This scope of work fits within the Rehabilitating Roe 8 project, in accordance with the Cultural Heritage Management Plan (Archae-aus Pty. Ltd., 2019). The scope includes:

1) Appropriate Aboriginal research and engagement to understand the Aboriginal heritage significance of the site, including (but not limited to) exploration of the following elements:
    - Aboriginal burial site(s);
    - Corroboree/ meeting place / camp site.
2) A draft community engagement plan demonstrating culturally appropriate engagement to be submitted to the City for approval at commencement of the project for the above.
3) A completed and detailed synthesis of all previous studies, research and analysis that has been performed on the site or surrounding the site relating to any aspect of Aboriginal heritage, including

assessment and recording of finds in WA Museum lodged by Sylvia Hallam (Swan Coastal Plain Archaeological Project 1973) and others.

4) An on-ground assessment of possible artefacts including sub-surface excavations such as shovel test pits and open excavations.

The program of shovel test-pitting and excavation within DPLH 3709 was authorised by permit no. 605 issued under Section 16 of the *Aboriginal Heritage Act* 1972.

PERSONNEL

The fieldwork was conducted 14th to 18th December 2020. The following people participated in the fieldwork:

Archae-aus

Fiona Hook	Caroline Bird	Joe Dortch (Dortch Cuthbert)
Tessa Woods	Emily Martin	Michael Bonner

Whadjuk Noongar Community Representatives

Neville Collard	Sam Dinah (dec.)	Gary Garlett
Connie Collard	Betty Garlett	Robyn Maher
Freda Ogilvie	Dawn Smith	Alice Warrell (dec.)
Marlene Warrell	Kay Walley	Marie Taylor

Student Volunteers (University of Western Australia and Notre Dame University)

Stewart Wallace	Caitlin Cleverly	Ayesha Limb
Anja Becker	Alana McNee	Marcel Teschendorff
Janet Osborne	Samantha Woods	
Hazel Dortch	Briar Castle	

Figure 1. Traditional Owners, archaeologists and student volunteers sharing stories over lunch

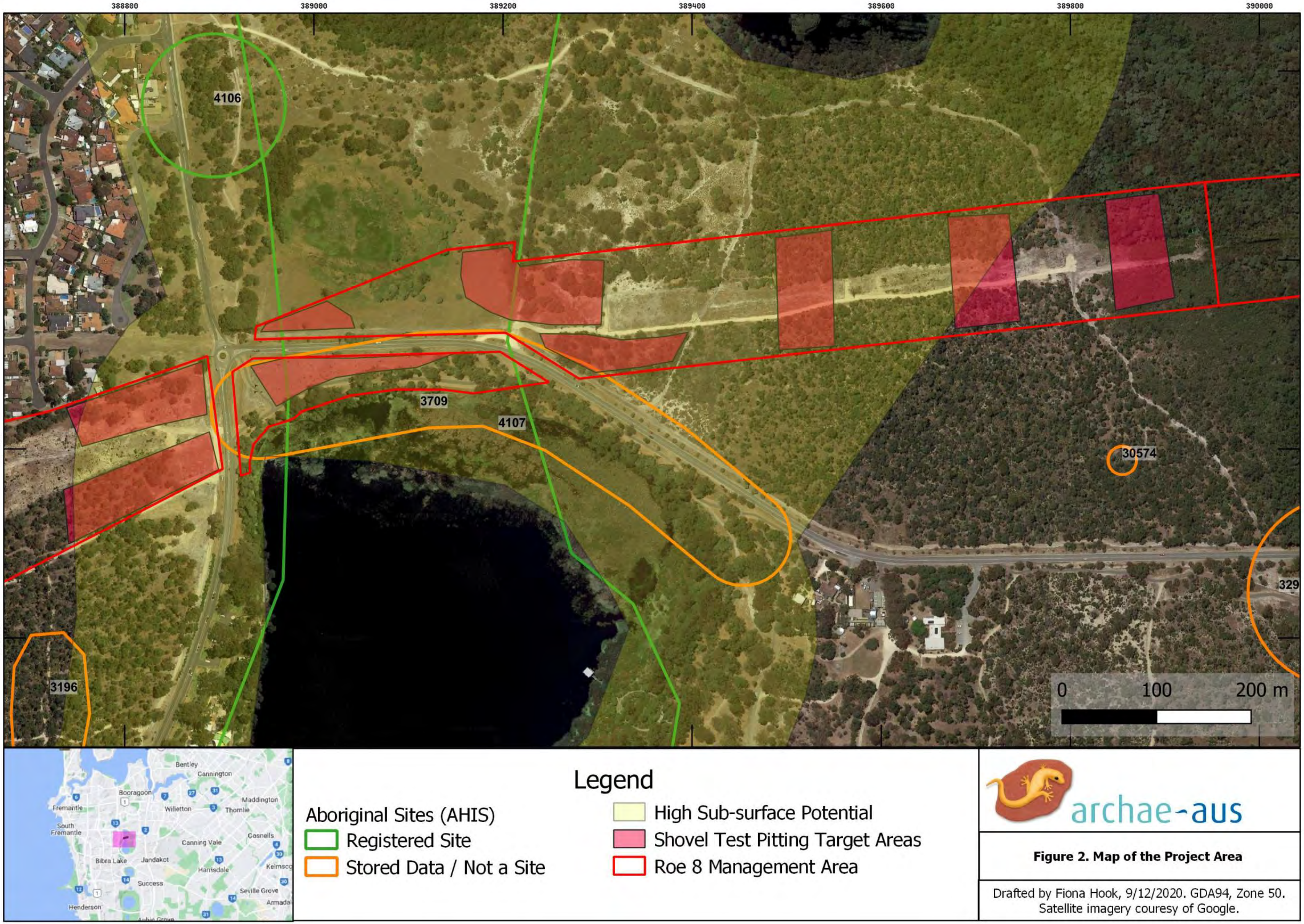

Figure 2. Map of the Project Area

Drafted by Fiona Hook, 9/12/2020. GDA94, Zone 50. Satellite imagery couresy of Google.

SECTION TWO – BACKGROUND

ENVIRONMENT

The Project Area is within the Swan Coastal Plain, spanning two undulating dune systems: the Spearwood and Bassendean Sands (Emerge Associates, 2018). Within these sand dunes, Lake Coolbellup and Lake Walliabup (including the short stretch between them) are classified as wetlands containing black sands and peaty soils, as per the Herdsman complex (described by Churchward and McArthur 1980, see Emerge Associates 2018). Archaeological test excavations in 2017 showed that the darker surface sands overlie white-grey sands (Hook and Dortch, 2017). This pattern had also been noted during the excavation at 3294 (North Lake North) in 1975 (Pearce, 1979).

Cycles of clearing and revegetation (prior to and including the Roe 8 project) have modified the topography and native vegetation. Ecological reports, however, provide reviews of the Project Area in recent years. The lakesides and connecting wetlands support water-adapted vegetation such as sedge-like grasses and paperbark trees. These transition into shrub and moderate density woodlands, including grass trees and a range of upper storey species in the surrounding dunes landforms (Emerge Associates, 2018). As is typical for the wider area, the dominant species include *Banksia* spp., *Eucalyptus* spp., *Acacia* spp., *Melaleuca* spp. (paperbark) and *Allocasuarina* spp. Some of these plants are traditional Aboriginal foods and medicine sources (Gifford *et al.*, 2011). Clearings in the woodlands carry an understorey of shrubs and grasses. Archaeological materials have been found on the low rise that separates Lake Coolbellup and Lake Walliabup.

REGIONAL CULTURAL BACKGROUND

The South-west of Western Australia forms a distinct biogeographic and cultural region, bounded by the Indian Ocean to the west, the Southern Ocean to the south and inland by the arid zone. It has a Mediterranean climate and a high level of biodiversity. Noongar boodja, or country, corresponds roughly to this biogeographic region. Noongar people today are descendants of a number of groups living in the region, who shared a similar culture and spoke dialects of a single language. These groups had core territories, but maintained strong relationships with neighbouring groups, with whom they traded and interacted.

The descendants of the people whose main territory is now the Perth Metropolitan Area are the Whadjuk Noongar. The memories and stories of the Whadjuk Noongar attest to the long-term occupation of the region by Aboriginal people. Archaeological evidence documents this occupation and resilient adaptation to changing environments through time through analysing the characteristics of the cultural materials that survive from older time periods and their distribution in time and space.

The Rehabilitating Roe 8 project is within what was the estate of Midgegooroo. Both Midgegooroo and his son Yagan became prominent leaders of Noongar resistance to European settlement (Lyon, 1833; Green, 1984).

The Swan and Canning Rivers and their tributaries, as well as the numerous springs and lakes throughout the area, provided a rich economic base for Aboriginal people. The waterways are also central to Whadjuk Noongar spiritual beliefs because of the water spirit, Waugal, that formed them. It is believed that the Waugal still inhabits the river and subterranean waters, allowing the water to flow (McDonald Hales and Associates, 2002: 42-42).

Lake Walliabup (Bibra Lake) and Lake Coolbellup (North Lake) are part of a chain of lakes that follow the waterway system now known as the Beeliar wetlands, and part of the Beeliar Regional Park. Waugal beliefs remain central to Noongar cultural identity and ethnographic evidence attests to the ongoing importance of the Waugal presence in these wetlands and their connection to other Waugal sites in the Perth area and beyond.

The Beeliar wetlands formed a seasonal route through the area for the Whadjuk Noongar's ancestors (Gifford *et al.*, 2011). The lakes, like other wetlands and rivers, would have been a place where groups of Aboriginal people would gather to spear fish and to collected turtles, reeds and other foods. The wetland chain is also well-known as part of a regular travel route from the Swan River to the Pinjarra area. At the time of European establishment of the Swan River Colony in 1829, the whole region was criss-crossed by a network of 'well-beaten paths', with water sources forming key nodes (Hallam, 1975, p. 66 ff.). Lake Walliabup was an important node in the network, as it was the meeting point for two paths leading to the Mandurah area – one from North Fremantle, and the other from the Causeway via the Canning River (Hammond, 1933).

Dating

Most archaeological investigations in the South-west have focused on the Perth Metropolitan Area and the Swan Coastal Plain, where several sites have established that human occupation in the region can be traced back at least 40,000 years. At this period, lower sea levels meant that the coastal sand plain extended out to the edge of the continental shelf and islands such as Rottnest / Wadjemup, were limestone hills within the plain (Dortch and Dortch, 2019).

The oldest site in the Perth area is Upper Swan (DPLH ID 4299). This large, open artefact scatter site on a terrace of the Swan River was used more than 40,000 years ago. The site comprises numerous artefacts and charcoal patches, indicating a Pleistocene occupation of the area, where groups of people camped, prepared fires for cooking and warmth and used cores and hammer stones to manufacture a variety of stone tools. Other early sites on the Swan Coastal Plain are located at the site of the Fiona Stanley Hospital dating to 35,000 years ago (Dortch, Dortch and Cuthbert, 2009), on an old river terrace in the Helena Valley dated to about 29,000 (Schwede, 1983, 1990) and a site at Minim Cove near the mouth of the Swan River which has been dated to about 10,000 years ago (Clark and Dortch, 1977). Yellabidde Cave on the northern fringe of the south-west has also been dated to 25,500 years ago with occupation continuing through to the recent past (Monks *et al.*, 2016). Further south in the Leeuwin-Naturaliste region, a date of 48,000 years for the first use of Devils Lair has been reported. This date has been questioned, but use of the site certainly goes back about 45,000 years (Allen and O'Connell, 2014; Balme, 2014). Nearby Tunnel Cave was first occupied about 27,000 years ago (Dortch, 1994, 1996).

Land use patterns

Hundreds of surface stone artefact scatters have been recorded across the Perth Metropolitan area (Hallam, 1972, 1975, 1977b; Anderson, 1984; Strawbridge, 1988; Bowdler, Strawbridge and Schwede, 1991). These mark former camping areas and other activities associated with hunting, gathering and fishing, and collecting materials to make shelters and a range of tools and personal equipment. The stone artefacts include finished tools, as well as the flakes and cores that make up the waste from tool-making. Quartz is the most common stone type used for artefacts on the Swan Coastal Plain. Other materials used include dolerite, granite, mylonite, crystal quartz, silcrete and fossiliferous chert. Recent sites often include tools made from glass. There are no natural stone sources occurring on the Swan Coastal Plain. Most stone, therefore, comes from sources in the Darling Range or perhaps even further inland. The exception is Eocene fossiliferous chert. No local sources have been identified for this particular fossiliferous chert and, where sites have been dated, there is no fossiliferous chert in the most recent levels. Sites closer to the present coastline tend to have higher percentages of fossiliferous chert. Therefore, it seems likely that sources of this material were located closer to the edge of the continental shelf and were drowned by rising sea levels by about 6,000 years ago at the end of the last ice age (Glover, 1984). Fossiliferous chert still continued in use, of course, as old artefacts were recovered from sites and reworked. Nevertheless, this means that fossiliferous chert acts as a rough chronological marker for sites on the Swan Coastal Plain, indicating use of particular places going back more than about 5,000 years.

The distribution of these sites suggests a long-term stable pattern of land use particularly focused on the rivers and the resource-rich wetlands and swamps of the coastal plain. Preservation of organic material and charcoal is rare at open surface artefact scatters and few have been dated. Dated open sites on the sandplain at the airport and Fiona Stanley Hospital, as well as Upper Swan and Helena River on the inland edge of the region, indicate long-term continuity of occupation (Dortch and Dortch, 2019). Historical sources confirm the importance of wetland resources in past Aboriginal subsistence patterns (Hallam, 1987, 1991). Many wetlands were also used as Noongar campsites within living memory and continue to be visited to access traditional resources. Noongar people moved to manage seasonal variation in distribution and abundance of food resources. Local abundance of particular resources provided opportunities for large gatherings and there were seasonal movements between the coastal plain and the jarrah and marri forests of the Darling Scarp (Anderson, 1984).

Figure 3. Aboriginal sites in the Bibra Lake-North Lake area

Drafted by Fiona Hook, 9/12/2020. GDA94, Zone 50. Satellite imagery couresy of Google.

ABORIGINAL HERITAGE SITES IN THE BIBRA LAKE-NORTH LAKE AREA

Systematic Investigation of Aboriginal heritage sites in the Walliabup-Coolbellup Lakes area began in the 1970s with reports to the Western Australian Museum of artefact scatters around the lakes by Robert Stranger (Figure 3, Table 3). These sites were subsequently recorded by Sylvia Hallam as part of her large-scale survey of sites in the Perth Metropolitan Area (Hallam, 1972, 1977b, 1977a, 1986). Hallam's project team routinely made collections at surface sites for later laboratory analysis; these collections and associated recording sheets are now held by the Western Australian Museum and form an important archive of cultural material from sites, many of which have now been destroyed or altered by subsequent development.

As well as Bibra Lake North (4107), Hallam documented four other artefact scatters: North Lake North (3294), North Lake East (3295 – name incorrectly recorded on Register as North Lake, Coolbellup), North Lake Southwest (4106), Hope Road Swamp (3296). A fifth site that should be regarded as belonging to this complex is Swamp 81 (4103), an artefact scatter along the western margin of a small swamp to the south-west of Bibra Lake. Hallam interpreted both Bibra Lake North and North Lake North, as well as Swamp 81, as "recurrently occupied campsites", with Bibra Lake North and North Lake North particularly showing a wide range of artefact types and raw materials. North Lake East, North Lake Southwest and Hope Road Swamp had smaller amounts of cultural material and were interpreted as less intensively used campsites.

Lake Bibra: Forrest Road (3196) is poorly documented and does not appear to have been documented by Hallam. It is recorded on AHIS as located to the west of Bibra Lake and is incorrectly categorised as a "Quarry".

Table 3. Registered sites and Other Heritage Places in the Bibra Lake-North Lake area

DPLH ID	Place Name	Site Type	Location	Current status
3294	NORTH LAKE N.	Artefacts / Scatter, Dating: 2300BP, Camp	495 m north of Hope Road North	Registered Site
3295	NORTH LAKE, COOLBELLUP	Artefacts / Scatter	280 m north of Hope Road North	Registered Site
3709	NORTH LAKE AND BIBRA LAKE	Mythological, Camp, Hunting Place	Intersects Hope Road North and Turtle Corner	Registered Site
4106	NORTH LAKE SW	Artefacts / Scatter	165 m north of Hope Road North	Registered Site
3196	LAKE BIBRA: FORREST ROAD	Quarry	80 m south of North Lake Road East	Stored Data / Not a Site
3296	HOPE ROAD SWAMP/BIBRA LAKE.	Artefacts / Scatter, Camp	180 m south of Bibra Drive	Stored Data / Not a Site
4107	BIBRA LAKE NORTH	Artefacts / Scatter	Intersects Turtle Corner, Hope Road North and North Lake Road East	Stored Data / Not a Site
30574	NOON10_SMS_001	Modified Tree	135 m south of Hope Road North	Stored Data / Not a Site

In 1988, Strawbridge prepared a management scheme for sites in the Perth Metropolitan Area (Strawbridge, 1988). This drew heavily on Hallam's work as well as a parallel ethnographic review (O'Connor, Bodney and Little, 1985). Strawbridge's review identified the artefact scatters associated with the Walliabup-Coolbellup Lakes wetland chain, including Bibra Lake North, Swamp 81, North Lake Southwest and North Lake East, as representative archaeological sites that should receive further investigation and be preserved from future development on the grounds of research potential (p. 101-102, p. 110). North Lake North was identified as part of the complex, but was thought to have been destroyed. However, since Pearce's excavation at North

Lake North had demonstrated the presence of sub-surface cultural material and recovered datable material, this lent weight to the value of the sites around Lake Walliabup and Lake Coolbellup. Strawbridge concluded:

> The recorded archaeological sites around this wetland chain are in need of urgent examination in the face of development activities. The current condition of all these sites needs examination dure to the residential development proceeding around them. The establishment of a park/recreation reserve which is being considered by the Department of Conservation and Land Management, would provide some measure of protection for these sites. (Strawbridge, 1988, pp. 101–102)

Strawbridge also identified the importance of the newly-identified ethnographic site North Lake and Bibra Lake (p.113). Thus, by 1988, the importance of wetlands in the Perth metropolitan area had been clearly recognised from both Noongar and archaeological perspectives and the Bibra Lake-North Lake wetland complex had been identified as a prime example requiring active management.

In 2000, all the sites around Bibra Lake and North Lake were revisited as part of the Metropolitan Sites Project. This was an audit with the aim of relocating sites and making an assessment of their current condition, for proposed management as well as capturing GPS readings (Yates Heritage Consultants, 2000). Presumably this was when the current boundary for 4107 was captured since it does not conform to that recorded in the 1970s. The field inspection 3295, 3293, 4103, 3294, 4106 and 4107 noted that there was little surface evidence visible at any of them. The surface collections in the 1970s were considered one explanation, but a combination of poor visibility and landscaping works also contributed. The possibility of sub-surface materials was noted and Yates highlighted the need for a conservation plan for the complex of artefact scatters in the Walliabup-Coolbellup Lakes wetland (2000, p. 5).

The sites in the Walliabup-Coolbellup Lakes area have since been revisited and reviewed in the course of various surveys in relation to development in the area and conservation works, as well as the Roe 8 project (Australian Interaction Consultants, 2005a; Harris, 2010; Quartermaine, 2010; Cecchi, 2011; Gifford *et al.*, 2011). These reported that there was little surviving surface evidence of the sites recorded in the 1970s – variously attributed to landscaping works and the collections made in the 1970s. However, most also agreed that there was a high probability of sub-surface material. The excavation at North Lake North in 1975 had, of course, already demonstrated that there was sub-surface material and that datable material could be recovered (Pearce, 1979). For 4107 (Bibra Lake North), this possibility was only adequately tested for the first time in 2017, following the de-registration of the site to make way for Roe 8 (Hook and Dortch, 2017).

The history of recording and documentation of the registered sites and other heritage places around the lakes provides an insight into changes in how they have appeared at different times over the last half century. These changes reflect events and processes that both reveal and conceal cultural material, including erosion, landscaping, revegetation, as well as construction activities that result in site destruction. These processes can be clearly seen at both North Lake North and Bibra Lake North.

In the 1970s, 3294 (North Lake North) was under threat from the establishment of Farrington Road and associated development and the site was collected and test-pitted by Bob Pearce in 1975 as part of his MA studies (Pearce, 1979). Pearce excavated a 2 x 1 m trench in 10 cm spits, stepped down to 1 x 1 m at about 20 cm below surface and 0.5 x 0.5 m at 60cm below surface. Excavation finished at 80 cm, with the last 10 cm devoid of artefacts. The deposit was sandy throughout, grey at the surface and changing gradually to white. Charcoal only occurred in the upper levels. A charcoal sample from Spit 4 (30-40 cm) yielded a date of 2195±195 bp (SUA-645).

The assemblage from North Lake North is mostly quartz (>90%) with small quantities of chert, mylonite and silcrete. Small chips less than 15 mm long make up about 80% of the artefacts. Formal tools include scrapers, adzes and backed pieces. The distribution of cultural material varies with depth, showing a marked peak in

Spits 2 (10-20 cm) and 3 (20-30 cm). Nearly 50% of the artefacts came from Spit 2. Pearce considered that the site was occupied only within the last 5000 years on the basis of comparison with the sequence from Walyunga and the absence of fossiliferous chert in the excavation, although he did note that the sample size was small from the lowest spits. The single radiocarbon date was consistent with this interpretation. However, Hallam's analysis of the surface assemblage did identify fossiliferous chert and thus she considered the site was very likely to have been used earlier.

The changing boundaries of North Lake North illustrate the complexity of interpreting surface sites in the Perth Metropolitan Area. The original site record shows the site extending along the north shore of North Lake and notes the area of exposed artefacts as 450 m by 50 m and 20-30 m from the waterline of the lake, with an average density of 8/10 m^2. The area to the east of the lake is noted as 'not searched', while scattered artefacts were noted for some distance along the western margin. Hallam notes the site had been destroyed for housing and Strawbridge does not include it in her recommendations for the wetland complex (Hallam, 1986; Strawbridge, 1988). However, Yates' visit during the 2000 audit noted scattered artefacts along the north-west margin of the lake in the public open space between the lake and Progress Drive. No artefacts were seen along the northern lake margin where the original scatter had been recorded, but visibility was poor and a gravel path had been installed. The boundary of the site was apparently expanded to include the area of public open space along part of the western edge of the lake, where scattered artefacts were noted. However, Farrington Road now goes through the area of densest scatter identified when the site was first recorded and the location of the test pit is beneath the road.

A similar history of change can be documented for Bibra Lake North (4107). This site was originally recorded in 1973 as four discrete artefact scatters extending for about 500 metres between Bibra Lake and Hope Road (Figure 4). These scatters were no doubt observed in eroded areas. There is no trace today of the buildings and fence lines noted in the 1970s site recording, except for occasional pieces of glass, ceramic and metal. Since then, a concrete bike path has been installed and the area has been landscaped and revegetated. Consequently, only occasional artefacts are now visible on the surface. Hallam's field notes indicate that she collected from Scatter 2 only and Scatter 3, which was the densest, was left completely undisturbed. Hallam also notes that Robert Stranger had already collected from Scatter 1. Therefore, the conclusion reached by numerous subsequent archaeologists that the reason so few artefacts have been visible on the surface is because the surface collection had destroyed the site is incorrect. Rather, the reason so few artefacts appear on the surface today at Bibra Lake North is more likely to be a result of the demolition of the buildings on the site and more recent landscaping and revegetation activities in the decades since.

The distribution of cultural material around the lakes as it appears on the surface and is currently documented is therefore not a good indicator of the actual distribution of past activities in the area. As Hook and Dortch (2017, p. 10) note, both Noongar tradition and archaeological evidence indicate that camping would have been widespread in elevated areas (>2 m above the current lake level) around the lakes. The patchy distribution of cultural material as recorded by the Site Register is best interpreted as representing limited time-stamped "windows" into a much wider sub-surface distribution of cultural material, which in turn reflects the high importance of these wetlands and their rich resources to Noongar people in the past.

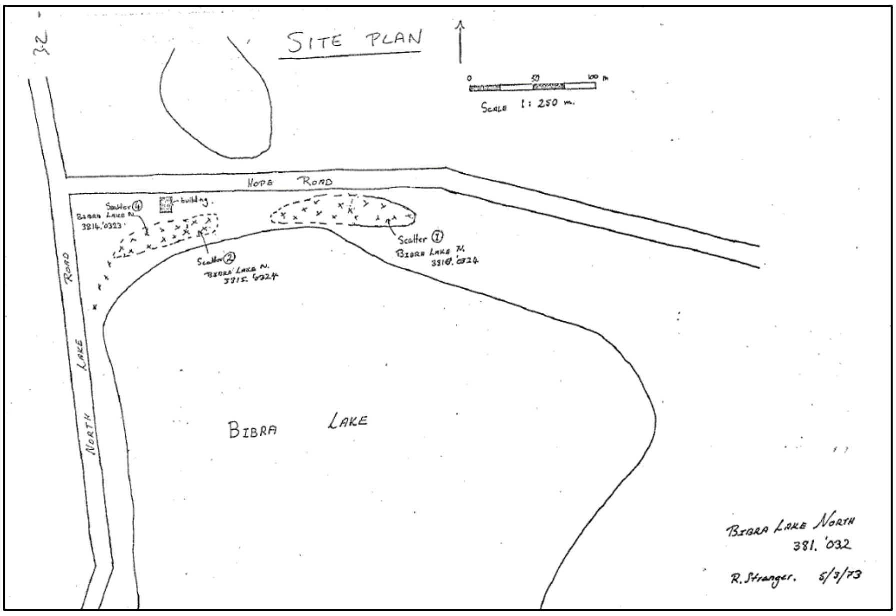

Figure 4. Sketch plan of Bibra Lake North, as originally recorded in 1973 (DPLH Site File)

SECTION THREE – METHODS

The investigation of archaeological potential in the Roe 8 rehabilitation area aimed to identify the extent of cultural material between the two lakes forming Registered ethnographic site 3709 North Lake and Bibra Lake and at Other Heritage Place 4107 Bibra Lake North. The actual distribution of artefacts visible today in the project area results from a range of factors including ground surface visibility, vegetation growth and natural and cultural disturbance processes. This visible distribution is thus not necessarily a reliable guide to the distribution of evidence of past human activity and it is likely that subsurface cultural material exists in the area.

The recorded footprint of 4107 (Bibra Lake North) is roughly based on the presence of artefacts as the site appeared in the 1970s. A sample of artefacts was collected in the 1970s and since then the site has been subjected to a range of processes including demolition of buildings, landscaping and revegetation, installation of reticulation and construction of a cycle path. Consequently, there are few artefacts visible today. However, the shovel test pitting conducted in 2017 showed that subsurface artefacts and charcoal did occur within the footprint of the site at the eastern end and outside the Roe 8 corridor (Hook and Dortch, 2017).

To assess the archaeological potential of the Roe 8 management area a sampling program using shovel test pits (STPs) was used. The results of the shovel pit testing were then used to select two areas for excavation.

SHOVEL TEST PITS

Shovel test pitting is a technique widely used by archaeologists to test for the presence of subsurface cultural material. As the name implies, STPs are small test pits up to 50 x 50 cm, dug by hand, using shovels or hand shovels, to a depth of up to about a metre. A key consideration in the design of shovel-test sampling program is the spacing and layout of STPs. The success of a program in identifying and characterising sites obviously depends on the underlying spacing and density of the targeted cultural materials.

The previous survey in 2017 used a staggered grid system and placed STPs at approximately 25 m intervals. Some STPs had to be moved slightly to take account of vegetation or roots. Six of the 20 STPs had artefacts. The number of artefacts ranged from one to nine. Most artefacts were flakes or angular fragments of quartz. One quartz bipolar core, three chert fragments and two pieces of granite were also found. STPs with artefacts were concentrated towards the eastern end of 4107 on elevated ground close to Hope Road and more than 3 m above the present lake level (Hook and Dortch, 2017).

This survey used a similar strategy based on a staggered grid system to sample areas within and outside the recorded footprint of 4107. Hook and Dortch (2017, p. 10) suggested that their results confirmed previous archaeological investigations and Noongar traditions that camping typically occurred within 80 to 200 m of freshwater sources. The sample program thus targeted areas beyond this distance. As the area covered was considerably larger, STPs were placed at greater intervals. Figure 5 shows the distribution of STPs for both this project and the 2017 program.

Each test pit was initially excavated with shovels. Below c.40 cm depth, hand shovels were used to continue excavation. Any artefacts and charcoal fragments noted in situ were bagged and their depths recorded. Excavation continued until the pit became too deep to excavate (usually between 90 and 100 cm). All excavated material was passed through 6 mm and 3 mm nested sieves. Any artefacts or charcoal found in the sieves were bagged and depths recorded.

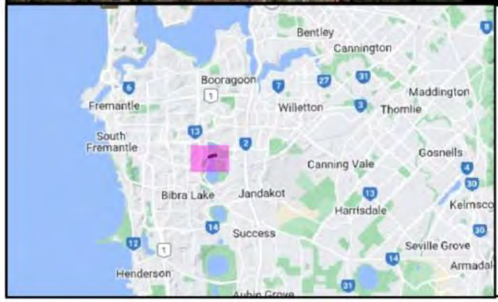

Figure 5. Location of shovel test pits and excavated squares

Drafted by Fiona Hook, 9/12/2020. GDA94, Zone 50. Satellite imagery courtesy of Google.

Figure 6. A Shovel Test Pit, laid out and ready to dig

Figure 7. Digging a Shovel Test Pit

Figure 8. Removing the final layer from a Shovel Test Pit, using a hand shovel

Figure 9. Survey team members sorting through the sieve residue and recording

Figure 10. Sieving the soil from a Shovel Test Pit

Figure 11. A quartz artefact found in the sieve

EXCAVATION

Two 1 x 1 m squares were excavated close to STPs which yielded high numbers of artefacts. Square 1 was on the south side of Hope Road within the original recorded footprint of 4107 and was placed close to STP T2-75. Square 2 was on the north side of Hope Road, and therefore outside the 4107 site boundary, and was placed close to STP T6-55 (Figure 5).

Excavation used standard archaeological techniques and recording methods. Stratigraphy was followed where it existed, otherwise excavation proceeded by arbitrary excavation units, or spits, of about 5 cm. Any cultural items seen during excavation were recorded in situ and bagged separately. The weight and volume of excavated deposit was recorded by bucket (Johnson, 1979). All deposits were passed through a nest of 6 mm and 3 mm sieves. Artefacts, charcoal and any other potentially cultural material recovered from the sieves were all bagged by excavation unit. For each excavation unit, Munsell colour and pH of the deposit were recorded and a bulk soil sample was collected.

In situ charcoal samples were collected from both excavated squares, and charcoal was also recovered from the 6 mm sieve. Sediment samples for dating by OSL were collected from Square 1, where very little charcoal was recovered.

ANALYSIS

In the laboratory, all cultural material was sorted and catalogued. Historic cultural items, such as ceramics and glass, were counted and weighed. All Aboriginal artefacts were classified according to raw material and technological categories, weighed and measured. Some additional technological features were also recorded where relevant. A complete catalogue of cultural material is included here as Appendix Three, together with a summary of the classification used and attributes recorded.

Charcoal samples collected during the excavation were radiocarbon dated by the University of Waikato Radiocarbon Dating Laboratory (see Appendix). Three OSL samples were sent to the University of Wollongong for dating.

The 1970s artefact collections in the Western Australian Museum from 4107 (Bibra Lake North) were also inspected.

Figure 12. Setting up the Square 1 excavation

Figure 13. Elder Neville Collard inspecting quartz and chert artefacts excavated from Square 1

Figure 14. Weighing buckets before sieving

Figure 15. Beginning excavation in Square 2

Figure 16. Square 2: sieving and recording

Figure 17. Measuring soil pH

COMMUNITY ENGAGEMENT

Two community consultation events have occurred with regards to preparing the submission for Section 16 approval under the *Aboriginal Heritage Act 1972* to undertake an archaeological investigation within the Roe 8 corridor within what is known as North Lake Reserve (Property ID 6029987, 50L Roe Highway BIBRA LAKE WA 6163) and the northern portion of Bibra Lake Reserve (Property ID 6029987, also known as 50L Roe Highway BIBRA LAKE WA 6163). These two locations fall into the registered site 3709 (Bibra Lake and North Lake).

18th December 2019 – Community Consultation workshop and site visit

Attendees:

Gladys Yarran	Marlene Warrell	Alice Warrell
Neville Collard	Connie Collard	Sam Dinah
Errol Blurton	Caleb Collard	Betty Garlett
Robyn Maher	Marie Taylor	Narelle Ogilvie
Freda Ogilvie	Geoff Collard	Marissa Verma

Facilitator: Latitude Creative Services –Gina Pickering; Archae-aus – Fiona Hook; City of Cockburn – Linda Metz

Outcomes:

- All meeting participants supported proposed archaeological plan.
- Conditions included Elders being on site during digs and maybe some young Aboriginal people to attend.
- No pay is available for young people, however Elders to be paid for monitoring work.

23rd January 2020 – Consultation session

Attendees:

Marie Taylor	Neville Collard	Gladys Yarran
Marlene Warrall	Rev Sam Dinah	

Facilitator: Latitude Creative Services –Gina Pickering

Outcomes:

- Bibra Lake (Lake Walliabup) and North Lake (Coolbellup Lake) are significant sites for local Noongar people. The site was used for camping, hunting and food collection. It still has traditional uses being practiced today.
- Frustration expressed regarding lack of consultation with regards to deregistration of site 4107.
- Support from all participants for archaeological works to be conducted.

- Conditions: No identified no-go areas. Aboriginal elders and monitors must be present during all works. Other community members are also welcome but have no rights to speak on finds or cultural matters.

12th February 2020 – SWALSC Wadjuk Working Group meeting

The working group provided support for the section 16 application. The WWG stated that would like all artefacts recovered from the excavations reinterred once they have been analysed.

In accordance with the outcomes of community consultation, Whadjuk Noongar Elders were invited to participate in order to monitor the shovel test pitting program and the excavations (Figure 1, Figure 13, Figure 18, Figure 19).

14th to 18th December 2020 – Fieldwork

The following Elders attended the fieldwork and shared their stories with the archaeology team.

Neville Collard	Sam Dinah (dec.)	Gary Garlett
Connie Collard	Betty Garlett	Robyn Maher
Freda Ogilvie	Dawn Smith	Alice Warrell (dec.)
Marlene Warrell	Kay Walley	Marie Taylor

19th September 2022 – Community Consultation workshop

Fiona Hook presented the result of the shovel test pitting and excavation to the Elders. The elders then discussed the recommendations facilitated by Jaye Snowdon and Mitchell Garlett.

Attendees:

Betty Garlett	Marlene Warrell	Narelle Ogalvie
Dawn Smith	Gladys Yarran	Marissa Verma
Freda Ogilvie	Errol Blurton	Marie Taylor
Kay Walley	Geoff Collard	

Facilitator: City of Cockburn – Jaye Snowdon, Mitchell Garlett and Chris

Outcomes:

- The elders provided their permission to release this report to the wider public.
- The elders agreed that a HISF detailing a larger site (as mapped in this report) be submitted to the DPLH.
- The elders agreed that the artefacts recovered during the shovel test pitting and excavation be put on display at the City of Cockburn Aboriginal Cultural and Visitors centre.
- The elders requested that an overarching cultural management plan is developed with the City of Cockburn and DBCA.

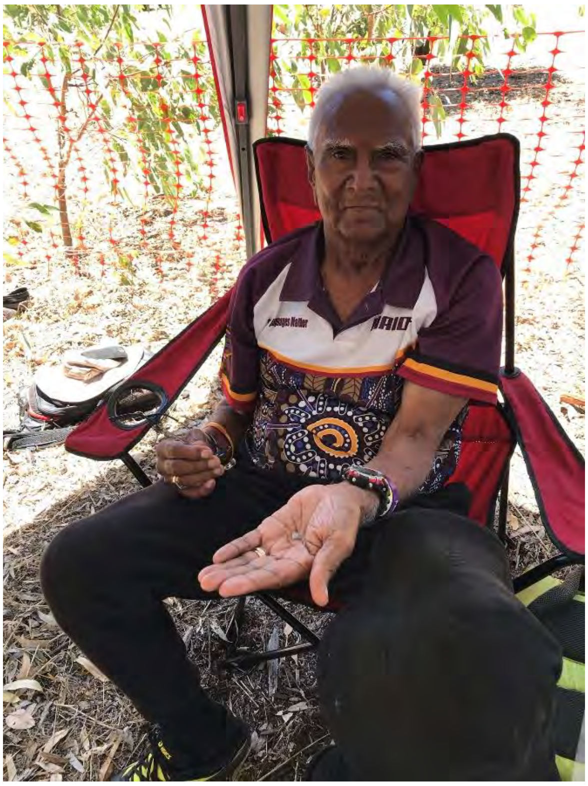	
Figure 18. Sam Dinah (dec.) inspecting a quartz artefact recovered from Square 1	**Figure 19. Whadjuk Noongar Traditional Owners observing excavation in Square 1**

SECTION FOUR – RESULTS

SHOVEL TEST PITS

Twenty-seven shovel test pits were excavated. One pit (T1-150) was abandoned at 16 cm when a possible fragment of asbestos was found. The other pits were excavated to an average depth of 80 cm. Of these, seventeen had cultural material in the form of Aboriginal artefacts. Eight of these pits also had historic cultural items. Table 4 summarises the distribution of test pits with cultural material and their contents.

The success rate for identification of cultural material in this shovel test pit program is high; nearly two thirds (63%) of STPs had cultural material. By comparison 30% of STPs in 2017 had artefacts. Figure 20 shows the distribution of STPs with cultural material. STPs with Aboriginal artefacts occur both within the recorded footprint of DPLH 4107 and outside it. Aboriginal cultural material is distributed along the dune ridge between Lake Walliabup (Bibra Lake) and Horse Paddock Swamp. Historic European cultural items, comprising mostly small fragments of glass and ceramic sherds, occur in STPs at the western end of the project area both north and south of the road. This material is most probably associated with the buildings that existed in this locality until the late 1970s, although some of it might relate to Aboriginal camping in the area in the historic period. A glass fragment with retouch was collected from DPLH 4107 in the 1970s. None of the glass from the STPs, however, showed any evidence that they had been modified for use as tools.

Table 4 Summary of cultural material from shovel test pits

	Quartz		Chert		Silcrete		Glass		Ceramic		Metal		Shell		Total	
STP	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)
T1-50	21	5.89	0	0	1	0	1	0.19	0	0	0	0	0	0	23	6.08
T1-100	12	1.99	0	0	0	0	0	0	0	0	0	0	0	0	12	1.99
T1-150	0	0	0	0	0	0	1	1.9	1	0.07	0	0	0	0	2	1.97
T2-25	2	1.53	0	0	0	0	0	0	0	0	0	0	0	0	2	1.53
T2-75	4	0.34	3	2.38	0	0	0	0	0	0	0	0	0	0	7	2.72
T3-25	4	0.4	0	0	2	0.28	3	7.27	0	0	0	0	0	0	9	7.95
T4-00	10	6.7	0	0	0	0	1	1.87	0	0	0	0	0	0	11	8.57
T4-50	2	0.66	0	0	0	0	5	8.47	1	1.36	0	0	1	0.3	9	10.79
T5-25	0	0	1	4.3	0	0	4	1.23	0	0	1	0.61	0	0	6	6.14
T5-75	1	0.57	0	0	0	0	10	10.99	4	4.47	0	0	0	0	15	16.03
T6-55	1	0.12	0	0	0	0	0	0	0	0	0	0	0	0	1	0.12
T7-75	22	11.51	1	1.78	0	0	0	0	0	0	0	0	0	0	23	13.29
T7-125	1	0.11	0	0	0	0	0	0	0	0	0	0	0	0	1	0.11
T8-00	1	0.05	0	0	0	0	0	0	0	0	0	0	0	0	1	0.05
T8-50	1	0.16	0	0	0	0	0	0	0	0	0	0	0	0	1	0.16
T10-55	1	0.08	0	0	0	0	0	0	0	0	0	0	0	0	1	0.08
W-001	1	0.1	0	0	0	0	8	9.98	3	5.79	0	0	0	0	12	15.87
Total	84	30.21	5	8.46	3	0.28	33	41.9	9	11.69	1	0.61	1	0.3	136	93.45

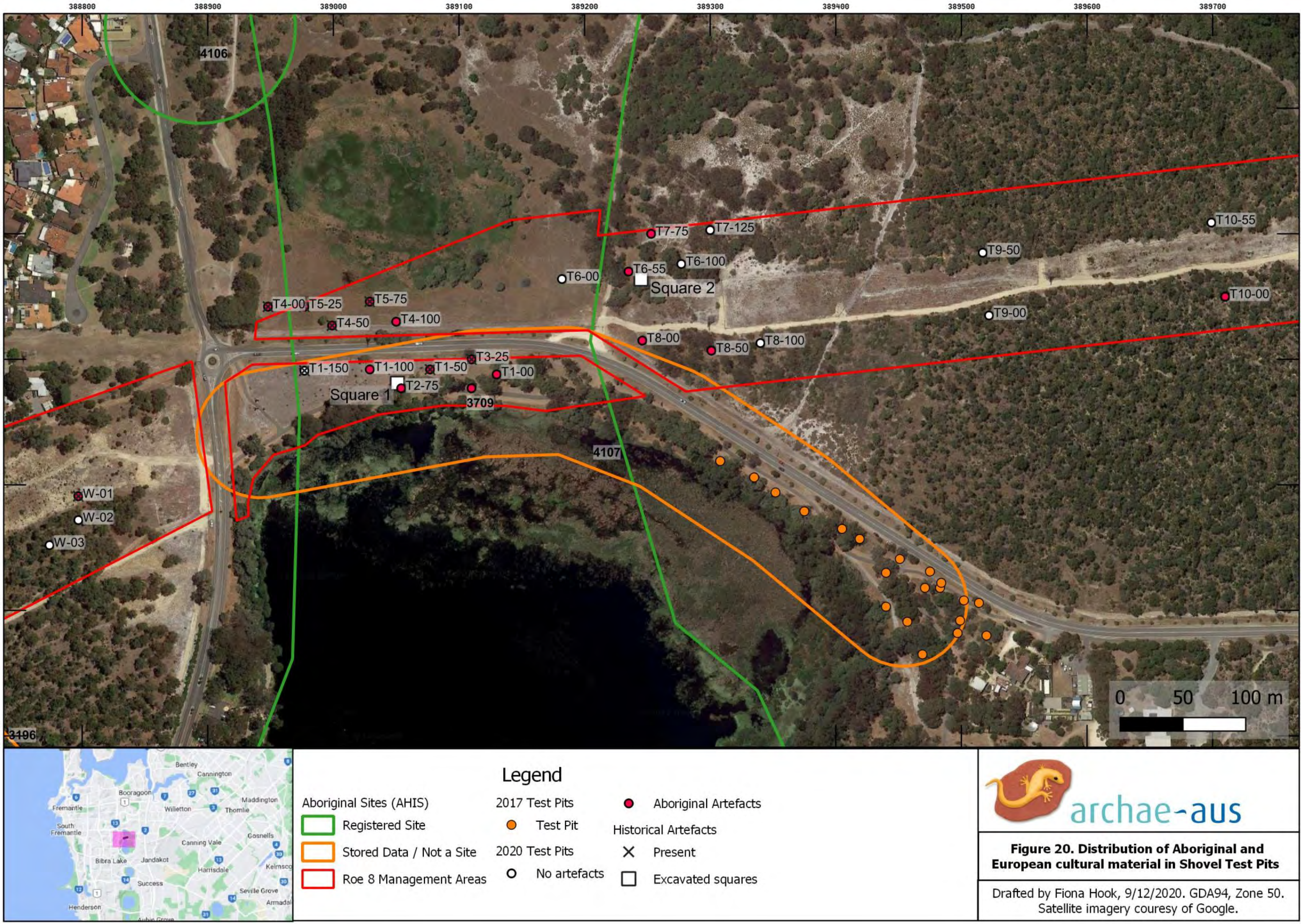

Figure 20. Distribution of Aboriginal and European cultural material in Shovel Test Pits

Drafted by Fiona Hook, 9/12/2020. GDA94, Zone 50. Satellite imagery couresy of Google.

The total number of Aboriginal artefacts in the STPs ranged from 1 to 23, with a mean of 5.75. The 2017 STPs ranged from 1 to 9 with mean of 3.83. Table 5 shows the distribution of Aboriginal artefacts with depth below surface in STPs, while Table 6 shows the distribution of historic cultural items. Aboriginal cultural material is mostly found at greater depths than historic material (Figure 21). T4-00 was the only STP which had glass and ceramic items deeper than 50 cm below surface. This was on the north side of Hope Road close to the intersection with Progress Drive and there had clearly been substantial disturbance from landscaping in this locality.

Table 5 Distribution of Aboriginal cultural items in STPs by depth below surface.

Depth below surface	T1-50	T1-100	T2-25	T2-75	T3-25	T4-00	T4-50	T5-25	T5-75	T6-55	T7-75	T7-125	T8-00	T8-50	T10-55	W-001
0-10	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0
10-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-30	0	0	0	0	0	0	0	0	0	0	16*	0	0	0	1	0
30-40	17	1	2	2	2	0	0	0	0	0	5	0	0	0	0	1
40-50	3	3	0	2	0	3	0	0	0	0	1	0	0	0	0	0
50-60	0	5	0	0	0	7	1	0	0	1	0	0	1	0	0	0
60-70	2	3	0	1*	4	0	0	1*	0	0	1	0	0	0	0	0
70-80	0	0	0	1*	0	0	0	0	0	0	0	0	0	0	0	0
80-90	0	0	0	1*	0	0	0	0	0	0	0	0	0	0	0	0

*fossiliferous chert present

Table 6 Distribution of historic European cultural material in STPs by depth below surface

Depth below surface	T1-50	T1-150	T3-25	T4-00	T4-50	T5-25	T5-75	W-001
0-10	0	0	0	0	4	0	1	0
10-20	0	2	3	0	2	5	3	4
20-30	0	0	0	0	0	0	8	5
30-40	0	0	0	0	1	0	2	2
40-50	1	0	0	0	0	0	0	0
50-60	0	0	0	1	0	0	0	0
60-70	0	0	0	1	0	0	0	0
70-80	0	0	0	1	0	0	0	0
80-90	0	0	0	1	0	0	0	0

Table 7 Summary of artefact types from STPs

	Quartz	Chert	Silcrete	Total
Undiagnostic fragment	59	2	3	64
Flake	22	2	0	24
Core	3	0	0	3
Tool/Retouched	0	1	0	1
Total	**84**	**5**	**3**	**92**

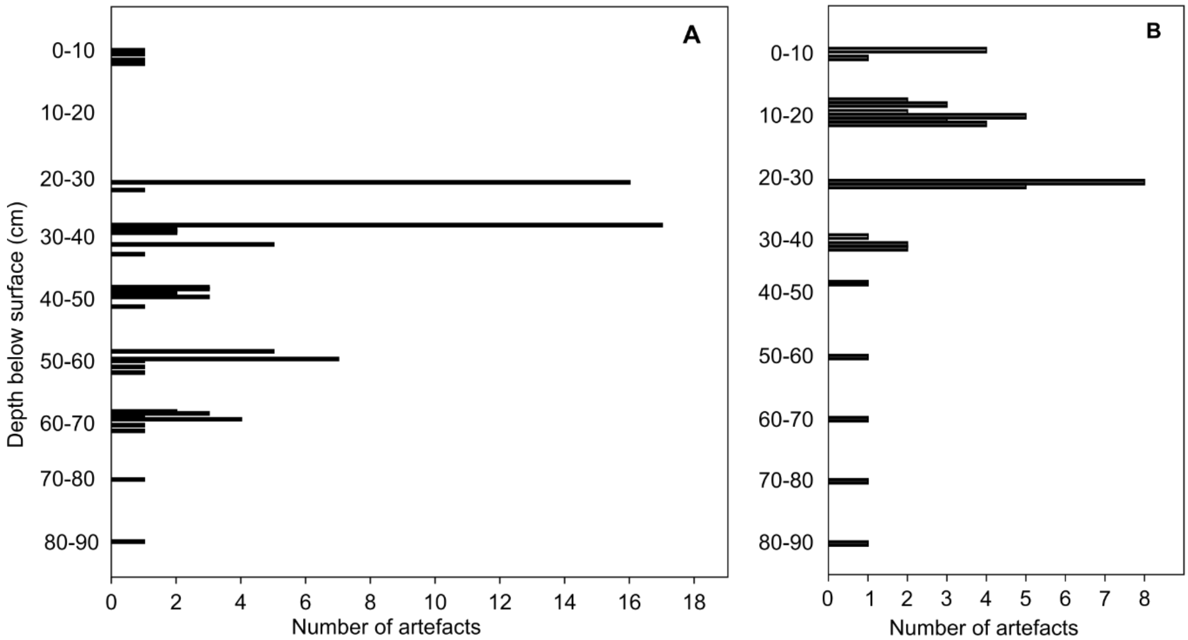

Figure 21. Distribution of cultural material from STPs by depth. A. Aboriginal artefacts. B. Historic European cultural material

Table 7 summarises the artefact types found in the STPs. Most artefacts are quartz, with small quantities of fossiliferous chert and silcrete. Most of the fossiliferous chert artefacts were recovered from lower levels of the STPs (Table 5).

The artefacts are typical of other assemblages found in the Perth Metropolitan area with large quantities of small flakes and fragments resulting from manufacture of flaked stone tools. The artefact with secondary retouch is an adze made from fossiliferous chert, which would have been used for woodworking (Figure 22).

The results of the STP program show that there is a widespread sub-surface distribution of cultural material within the project area that is not confined to the recorded boundary of 4107. It is likely that this pattern would be repeated around both Lake Walliabup and Lake Coolbellup and associated swampy depressions. The whole wetland complex can be regarded as a cultural landscape. The recorded sites should therefore be regarded as small "windows" into this landscape, mostly created by recent disturbance, rather than a reliable guide to the distribution of past activities.

The vertical distribution of cultural material from the STPs suggests that disturbance since 1829 is largely confined to the top 30-50 cm and focuses on areas affected by buildings or roads. Landscaping and installation of services has also had an impact.

Figure 22. Adzes. Quartz adze from Square 2, EU7 (left) and fossiliferous chert adze from STP T7-75 (right)

EXCAVATIONS

Two locations were selected for systematic excavation on the basis of the results of the STP program. Square 1 was located south of Hope Road within the footprint of 4107 and close to STP T2-75. Square 2 was located north of Hope Road adjacent to STP T6-55 (see Figure 5).

Square 1

Square 1 is a 1 x 1 m test pit. It was excavated to a depth of 1.07 m. At this point, one side of the test pit became unstable and partially collapsed. A 50 x 50 cm sondage was excavated in the north-west corner to a final depth of 1.55 m.

The surface was covered by mulch, which was removed as EU1. The remainder of the deposits were sandy and graded in colour from dark grey to white, without a clear stratigraphic break (Figure 23). This relates primarily to the organic content of the deposit, including charcoal, which diminished with depth (Table 8). The northern half of Square 1 had been disturbed by an undocumented reticulation pipe and trench (Figure 25). This feature appeared at about 25 cm below the surface and the base of the trench feature was reached at 48 cm below surface.

Table 8 Square 1: summary of Munsell colour and pH readings

Excavation unit	pH	Munsell Reading	Colour	End depth below surface (cm)
1	-	-	-	4
2	6.5	7.5YR2.5/2	Very Dark Brown	11
3	6.5	7.5YR2.5/1	Black	14
4	6	7.5YR2.5/1	Black	23
5	-	7.5YR2.5/1	Black	27
6	6	7.5YR2.5/1	Black	36
7	6	5YR4/1	Dark Gray	45
8	8.5	10R 5/1	Reddish Gray	52
9	8.5	2.5YR4/1	Dark Reddish Gray	58
10	8.5	2.5YR5/1	Reddish Gray	66
11	8	5YR5/1	Gray	71
12	8	5YR6/1	Gray	79
13	5	5YR6/1	Gray	90
14	7	5YR6/1	Gray	95
15	7	5YR6/1	Gray	103
17	7	5YR6/1	Gray	110
18	6.5	5YR6/1	Gray	132

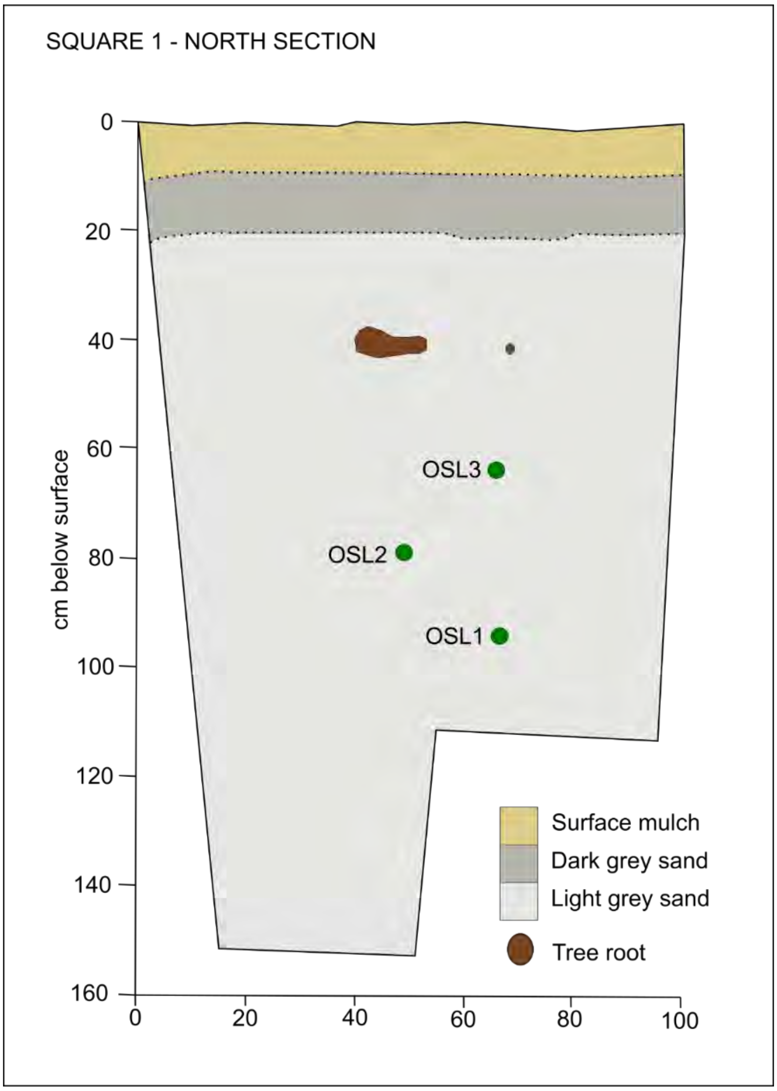

Figure 23. Square 1: North section

Table 9 Radiocarbon determinations from Square 1 and Square 2

Waikato Lab. Code	Date	Error	Median calibrated date	Range 68.3% probability	Range 95.4% Probability	Context	Depth below surface (cm)	Type
52501	210	21	195	279-145	269-...	Square 1 EU6	32	in situ AMS
52502	161	20	105	258-...	288-107	Square 1 EU4	23.5	in situ AMS
52503	706	14	596	654-569	661-564	Square 2 EU4	19	in situ AMS
52504	403	20	446	488-334	495-326	Square 2 EU6	30	in situ AMS
52505	2469	21	2470	2673-2362	2700-2353	Square 2 EU8	43	in situ AMS
52506	4028	20	4473	4515-4419	4568-4360	Square 2 EU10	55.5	in situ AMS

Table 10 OSL determinations from Square 1

CABAH Lab. Code	Sample #	Age (ka)	Water content (%)	Total dose rate (Gy/ka)	Equivalent dose rate	Over-dispersion (%)	D_e age model	Depth below surface (cm)	Context
986	OSL1	10.0±0.8	3±1	0.59±0.04	5.9±0.2	51	FMM-1	94	EU14
987	OSL2	8.7±0.8	3±1	0.54±0.04	4.7±0.3	60	FMM-1	78	EU12
988	OSL3	6.7±0.6	3±1	0.57±0.04	3.8±0.2	73	FMM-1	64	EU10

Dating

Charcoal was sparse and mainly occurred in the upper levels (Figure 24). Two in situ samples, from EU4 and EU6, were sent to Waikato Dating Laboratory in New Zealand (Table 9). The determinations are in sequence, but the calibrated ranges overlap and fall mainly within the historic period. There was insufficient charcoal from the lower excavation units for dating.

Three OSL samples were taken from these levels (Figure 28, Table 10). The results are in sequence. OSL1 from EU14 indicates an age of about 10,000 years for the earliest cultural material in Square 1. OSL2 is associated with the concentration of fossiliferous chert artefacts in EU12. The youngest fossiliferous chert artefact occurs in the spit immediately above OSL3.

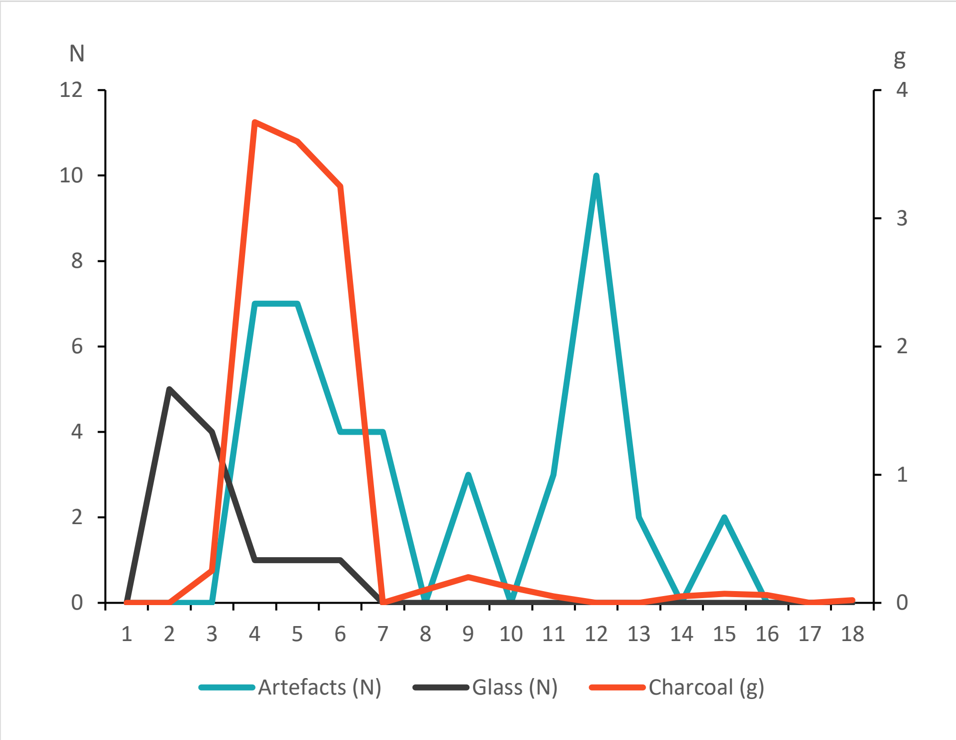

Figure 24 Square 1: distribution of artefacts and charcoal by excavation unit

Figure 25. Square 1 after EU6, showing disturbance from reticulation pipe and trench

Figure 26. Square 1, after EU10

Figure 27. Square 1, after EU 18

Figure 28. Square 1: taking sediment sample for OSL dating

Figure 29. Fossiliferous chert (left) and quartz (right) artefacts from the concentration in Square 1, EU12

Cultural material

Cultural material was relatively sparse in Square 1. European historic glass (12 fragments) and road metal (2 fragments) occurred throughout the upper part of the excavation (EU1-6) (Figure 24).

Stone artefacts appear first in EU4 and continue through most EUs until EU15 (about 1 m below surface) (Figure 24). About 69% of the artefacts are quartz and these occur throughout. Fossiliferous chert artefacts appear at EU9, with a noticeable concentration in EU12 (Figure 29). On the basis of the OSL determinations, this concentration dates to about 8,700 years ago. There are trace amounts of dolerite and quartzite (Table 11).

The artefacts are all flakes or undiagnostic fragments, with two cores. These are all the products of stone tool manufacture. There were no shaped tools. This is not surprising since the number of artefacts from Square 1 is relatively small.

Table 11 Square 1: distribution of Aboriginal artefacts by excavation unit

EU	Quartz	Chert	Dolerite	Quartzite	Total
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	6	0	1	0	7
5	7	0	0	0	7
6	4	0	0	0	4
7	4	0	0	0	4
8	0	0	0	0	0
9	1	1	0	1	3
10	0	0	0	0	0
11	3	0	0	0	3
12	3	7	0	0	10
13	1	1	0	0	2
14	0	0	0	0	0
15	0	1	1	0	2
Total	29	10	2	1	42

Table 12 Square 1: artefact types

Type	Quartz	Chert	Dolerite	Quartzite	Total
Undiagnostic fragment	20	3	2	1	26
Core	2	0	0	0	2
Flake	7	7	0	0	14
Total	29	10	2	1	42

Square 2

Square 2 is a 1 x 1 m test pit. It was excavated to a final depth of 1.02 m. At 71 cm, time constraints and the reduction quantity of cultural material, meant that the test pit was completed by excavating a 50 x 50 m sondage in the south-west corner of the square.

Like Square 1, the deposits were sandy and graded in colour from dark grey to light, without a clear stratigraphic break. Charcoal occurred in much more quantity and at greater depths than in Square 1 and therefore the sands were darker (Figure 30).

Table 13 Square 2: summary of Munsell colour and pH readings

Excavation unit	pH	Munsell Reading	Colour	End depth below surface (cm)
1	6.5	10YR5/1	Gray	5
2	4.5	10YR2/1	Black	11
3	4.5	10YR2/1	Black	15
4	6	10YR2/1	Black	20
5	4.5	10YR3/1	Very Dark Gray	24
6	5.5	10YR4/2	Dark Grayish Brown	28
7	5	10YR3/2	Very Dark Grayish Brown	38
8	5.5	10YR5/2	Grayish Brown	44
9	5.5	10YR4/1	Dark Gray	52
10	-	10YR5/2	Grayish Brown	66
11	6	5YR5/1	Gray	79
12	6	10YR5/1	Gray	88
13	6.5	10YR6/1	Gray	98

Dating

Compared to Square 1, charcoal was far more abundant in Square 2 and continued to greater depth (Figure 30). Four in situ samples, from EU4, EU6, EU8 and EU10 were sent to Waikato Dating Laboratory in New Zealand (Table 9). EU4 and EU6 are inverted and both are relatively recent falling within the last thousand years. The other two determinations are in sequence (Figure 33).

The sample from EU8 is immediately below the concentration of cultural material in EU7 and thus provides a maximum age for those artefacts of about 2500 years. The sample from EU10 was the lowest in situ charcoal and gave a calibrated age of about 4500 years ago. There were trace amounts of both charcoal and artefacts below this sample and it is possible that older occupation could be identified as the excavation was terminated due to lack of time. The trendline of the three lower dates is linear, suggesting a uniform deposition rate for the sands below the disturbance associated with the last two hundred years. Extrapolating the trendline suggests that the deposits at the base of the excavation may date back to beyond 10,000 years into the Pleistocene.

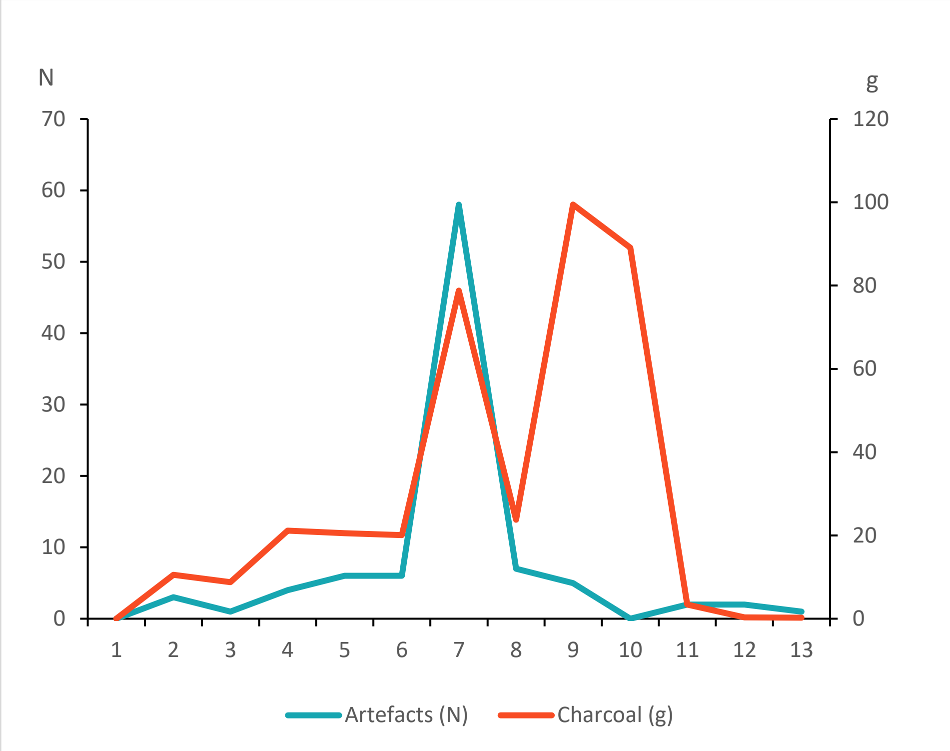

Figure 30 Square 2: distribution of artefacts and charcoal by excavation unit

Figure 31 Square 2, after EU7

Figure 32 Square 2, after EU10

Cultural material

Square 2 was much richer than Square 1 in terms of quantity of cultural material. There were no pieces of glass or ceramic or other material of European origin and stone artefacts appeared in EU2 immediately after removal of the surface vegetation as EU1.

Ninety-five artefacts were recovered from Square 2. Most were quartz with one fragment each of chert and dolerite. Artefacts occurred throughout the sequence to EU13, but there was a noticeable concentration in EU7 (Table 14).

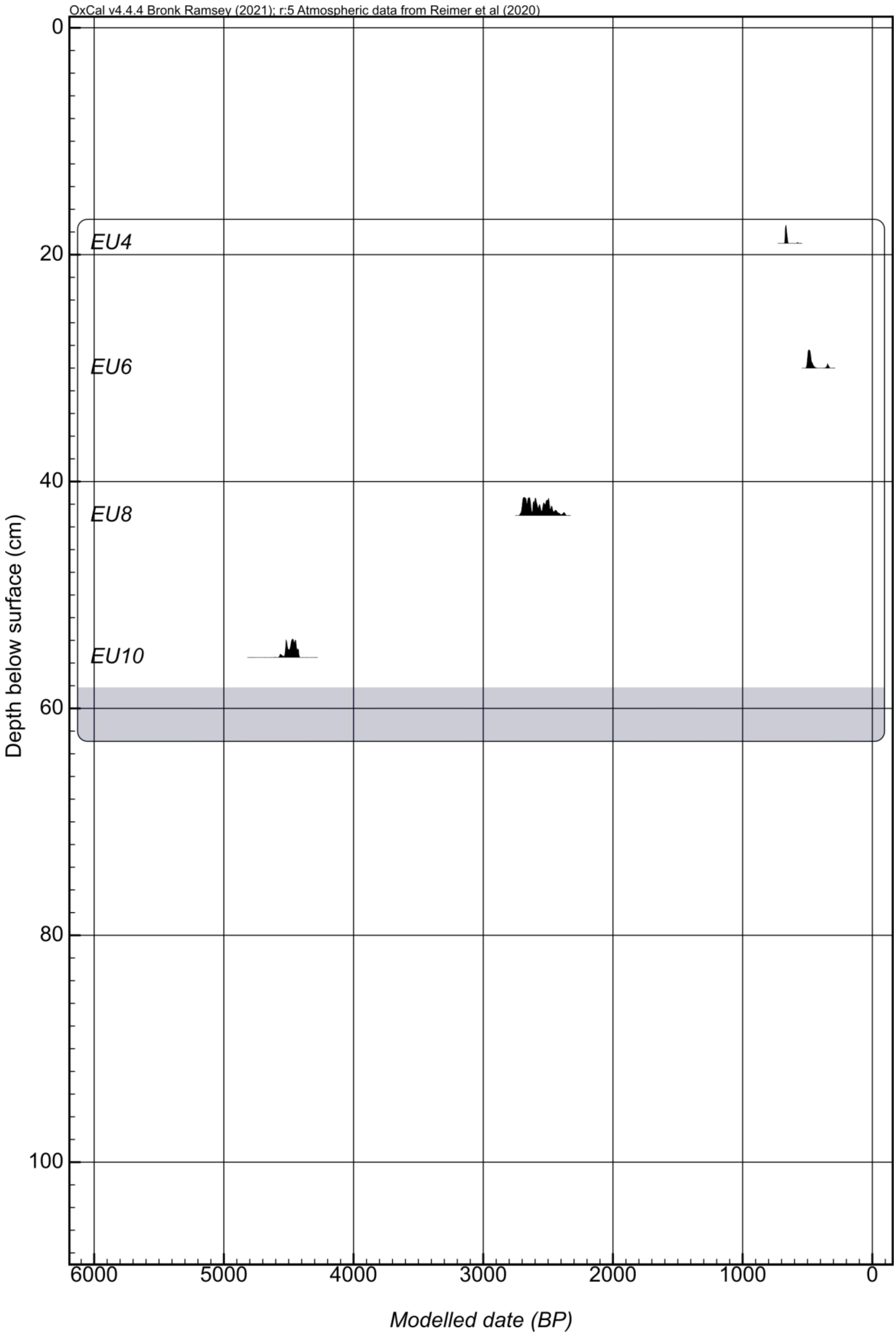

Figure 33 Square 2: distribution of calibrated radiocarbon determinations according to depth below surface

Most artefacts were flakes and fragments resulting from making flaked stone artefacts. There were four quartz bipolar cores, indicating that the flaking techniques used included bipolar flaking on an anvil. The other cores were broken fragments. There were also three retouched artefacts. One of these was an undiagnostic retouched flake. The other two were adzes, which were probably used for woodworking (Figure 22). All three tools came from EU7.

Table 14 Square 2: distribution of artefacts by excavation unit

EU	Chert	Dolerite	Quartz	Total
1	0	0	0	0
2	0	0	3	3
3	0	0	1	1
4	0	0	4	4
5	0	0	6	6
6	0	0	6	6
7	1	1	56	58
8	0	0	7	7
9	0	0	5	5
10	0	0	0	0
11	0	0	2	2
12	0	0	2	2
13	0	0	1	1
Total	**1**	**1**	**93**	**95**

Table 15 Square 2: artefact types

Type	Chert	Dolerite	Quartz	Total
Undiagnostic fragment	1	1	67	69
Core	0	0	7	7
Flake	0	0	16	16
Tool/Retouched	0	0	3	3
Total	**1**	**1**	**93**	**95**

WESTERN AUSTRALIAN MUSEUM COLLECTIONS

The Western Australian Museum holds the surface collections made by Sylvia Hallam and Robert Stranger in the early 1970s from the sites around Lake Walliabup and Lake Coolbellup, as well as the excavated material from North Lake North. The Bibra Lake North collection is 1030 artefacts. Hallam's field notes describe four discrete scatters along the north-west margin of the lake. Scatter 1 was the most easterly and Robert Stranger had already collected from this scatter. Hallam's team collected primarily from Scatter 2 and left Scatter 3 and 4 largely undisturbed. Scatter 3 was the densest, while Scatter 4 was very sparse.

A full reassessment of the collections around Lakes Walliabup and Coolbellup (and indeed elsewhere in the Perth Metropolitan Area) made in the 1970s would be valuable as these collections are an invaluable record of Noongar life and culture in areas now heavily affected by development. However, limited time and constraints on access at the Western Australian Museum meant that a complete reanalysis of these collections could not be completed within the scope of this project. Therefore, only the Bibra Lake North collection was examined during the visit to the museum, with a view to qualitative comparison with the results of the STP program and excavations.

The collection from Bibra Lake North is mostly quartz with a very small number of artefacts of fossiliferous chert, mylonite and an unknown material that is probably silcrete. The Swan Coastal Plain lacks stone sources suitable for stone tool making. Fossiliferous chert is thought to indicate use of the site before about 6000 years ago as the sources for this material are assumed to be somewhere on the continental shelf and were drowned by rising sea levels at the end of the last ice age. Mylonite is a fine-grained volcanic raw material, which comes from quarries in the Darling Scarp. The nearest source of quartz is also the Darling Scarp (Glover, 1984; Dortch and Dortch, 2019). Mylonite is the only one of these materials that was not found in either the STPs or the excavations. A very small amount of dolerite was also found in the excavations, but not in the museum collection. This material also comes from the Darling Scarp.

These small differences between the museum collection and the site are the result of sampling factors. Fossiliferous chert artefacts in Square 1 were mostly found in the lower excavation units, consistent with this material being a feature of older sites in the Perth Metropolitan Area (Figure 29). Occasional finds of this material on the surface result from recent disturbance or exposure of older sediments by erosion.

The artefacts in the museum collection included the full range of debris, flakes and cores from the manufacture of stone artefacts (Figure 34). Several of the cores are bipolar. This technique involves flaking by resting the core on an anvil and is commonly used to flake quartz. Other cores show that percussion flaking was also used (Figure 36). The artefacts from the STPs and excavations showed a similar range of percussion flaking and bipolar technologies (Figure 35).

Retouched material, or formal tools, in the museum collection included backed pieces (Figure 41) and adzes (Figure 38, Figure 42, bottom). No backed artefacts were found in the excavation. All the retouched tools were adzes. These tools would have been hafted on the handle of the spear thrower and used for woodworking. Some of the adzes were worn down in a distinctive pattern to form concave edges. This characteristic “spokeshave” wear pattern results from using the tool to work on spear shafts or digging sticks. Artefacts with this wear pattern came from both the museum collection (Figure 42, bottom) and from the STPs and Square 2 (Figure 22, Figure 40). Woodworking was clearly an important activity in the area.

It was clear on viewing the collection and matching individual artefacts with the original recording sheets that many of the collected artefacts had been wrongly classified. This is not surprising, as our understanding of flaked stone technology has changed over time, particularly with regard to the analysis of quartz artefacts. For example, bipolar technology was poorly understood in the 1970s and bipolar cores were commonly mistaken for retouched tools. This is the case with the Hallam collections where bipolar cores are commonly labelled “fabricators”. The main impact on interpreting the recording sheets is that the sheets over-estimate the number of artefacts that are secondarily retouched.

Figure 34. Quartz artefacts from the 1970s collection at the Western Australian Museum

Figure 35. Quartz artefacts from Square 2, EU 7. A bipolar core made by splitting a quartz pebble on an anvil (left), and a series of quartz flakes

Figure 36. A quartz single platform core from the 1970s collection at the Western Australian Museum

Figure 37. Quartz core (right) and flakes from STP 7-75. The quartz core is very similar to the one in Figure 36.

Figure 38. A quartz adze from the 1970s collection at the Western Australian Museum

Figure 39. Detail of the working edge of the quartz adze in Figure 38.

Figure 40. Quartz adzes from Square 2, EU 7

Figure 41. Backed artefacts from the 1970s collection at Western Australian Museum

Figure 42. Fossiliferous chert flake with edge damage, resulting from use (top) and quartz adze (bottom) from the 1970s collections at the WA Museum

DISCUSSION

The results of the STP program and the excavations show that the ancestors of the Whadjuk Noongar left the traces of their activities much more widely through the area between the Lakes Walliabup and Coolbellup than the limited surface traces would suggest. Noongar traditions attest to the spiritual significance of this wetlands system as well as the economic importance of the rich plant and animal resources of this area. Historical sources confirm the importance of the area as a meeting place and a waypoint for those travelling along the wetland corridor between the Swan and Canning Rivers and the Pinjarra area. The quantity of sub-surface artefacts discovered during this project indicates that the whole of the higher ground around the lakes would have been favoured for camping. The whole wetland complex is best considered as a single cultural landscape with a high probability of encountering cultural material anywhere in it. On the basis of the density of artefacts found in the STPs, we estimate conservatively that there could be more than 20 million sub-surface artefacts in the high potential archaeological area around the lakes. Using a more generous calculation the estimated number of sub-surface artefacts could be 40 million.

The absolute dating evidence from this project confirms that the Whadjuk Noongar ancestors have used this landscape for at least 10,000 years. The OSL results from Square 1 show that cultural material was first deposited about 10,000 years ago, with a noticeable peak in artefacts between 8,000 and 9,000 years ago. While the oldest date for Square 2 is about 4,500 years, artefacts do continue below this level and the deposition rates suggest the base of the excavation was about 10,000 years. Sterile deposits were not reached in Square 2 so it is possible that the Whadjuk Noongar ancestors may have been using this locality for even longer.

Radiocarbon dating has proved difficult to apply in the Perth Metropolitan Area because of poor preservation of organic material suitable for dating. OSL is a technique for dating sediments directly. In this case, the combination of OSL and radiocarbon dating shows clearly a consistent depositional sequence around the lakes spanning at least 10,000 years and associated with cultural material (Figure 43).

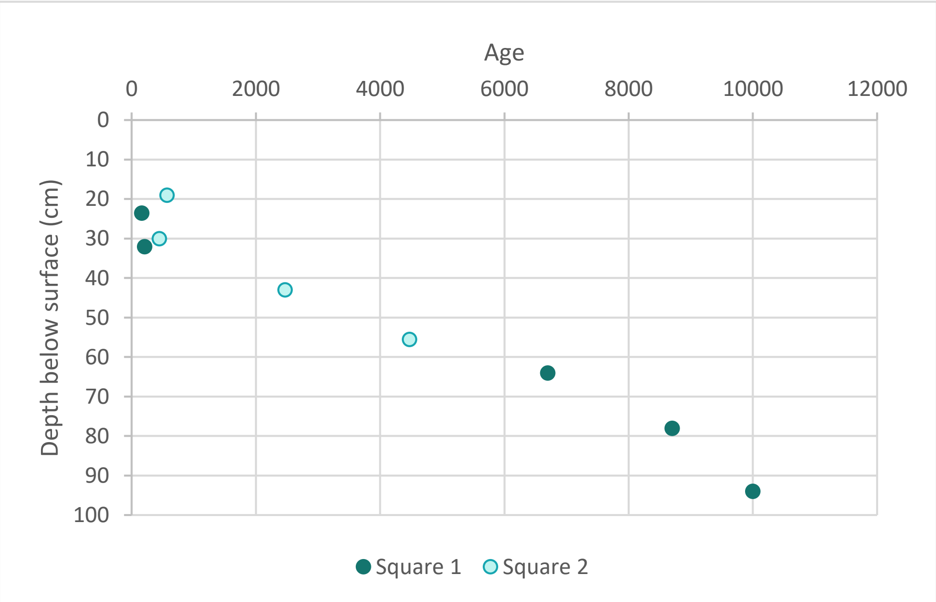

Figure 43. Radiocarbon and OSL determinations from Square 1 and Square 2 plotted against depth below surface

The artefacts recovered are typical of those from sites in the Perth Metropolitan Area. The lack of stone in the Swan Coastal Plain means that the raw materials artefacts are made from show the cultural connections people using Lake Walliabup and Lake Coolbellup would have had. They would have obtained quartz, dolerite and mylonite from inland along the Darling Scarp. The source for fossiliferous chert is not known but is thought to be offshore, submerged by rising sea levels at the end of the last ice age. Thus, the Whadjuk Noongar ancestors must have ranged widely over a broad coastal plain between the Darling Scarp and the coast, which 10,000 years ago was beyond Rottnest / Wadjemup. The dating evidence from Square 1 is consistent with other dated sites on the Swan Coastal Plain, which support the interpretation that Whadjuk Noongar ancestors lost access to fossiliferous chert sources about 5,000 to 6,000 years ago (Glover, 1975; Pearce, 1978)

Many of the artefacts found are cores, flakes and shatter fragments, which are from the making of shaped stone tools. Stone tools were important to the Whadjuk Noongar ancestors because they were used for a very wide range of other activities, including the making of wooden tools. Often these were not simply waste products but, since they had sharp edges, were used opportunistically for cutting tasks. Suitable flakes were carefully shaped into retouched tools. Backed artefacts have one sharp edge and one edge deliberately blunted to form a “back”. These could be used as cutting tools with the blunted back a practical solution to protecting the fingers – rather like a pocket knife today. The blunted back also provided a good surface to attach resin so that the flake could be mounted. A row of backed artefacts could be mounted in a handle to make a taap knife. A taap spear also had a double row of similar flakes mounted to make a barbed spear head. The other main type of tool had a strong edge for scraping wood. Some were used in the hand but others were also usually hafted by being set into the handle of a spear thrower. As the tool became blunt, it would be resharpened and sometimes even taken out of the handle and turned around to use a second edge. This results in a characteristic wear pattern and the adzes archaeologists find have usually been discarded because they are worn out. There were examples of these in both the museum collection and the excavated artefacts. Some have concave working edges, which shows they had been used for scraping wooden shafts, such as spears or digging sticks or handles for kodj axes. They could also have been used for making bone points, mainly used as awls for making kangaroo skin bags and cloaks (Bird and Beeck, 1980).

This project has successfully shown that a rich tangible record of cultural material relating to the lives of the ancestors of the Whadjuk Noongar survives under the surface of the ground in this wetland complex complementing the spiritual and cultural importance ascribed to the lakes by Noongar tradition. This record survives because much of the area is public open space with relatively little impact on the sub-surface material. Elsewhere in the Perth Metropolitan Area, wetlands have been drained and filled in for industry and housing. Thus, the Lake Walliabup and Lake Coolbellup wetlands have high significance in terms of both tangible and intangible values. This importance has been recognised since 1988 when the first recommendation was made for an integrated cultural heritage management plan to care for this cultural landscape, but never implemented.

Although many surface sites have been recorded in the Perth Metropolitan Area, the sub-surface record remains poorly understood. This project has demonstrated that the surface archaeological record is a poor guide to the presence of sub-surface cultural material and that an intact archaeological record of the past cultural landscape can potentially be identified beneath the disturbed surface layer relating to two hundred years since the arrival of Europeans. This has clear implications for planning and management of cultural values elsewhere in the Perth Metropolitan Area as development expands beyond the relatively well-documented area that was surveyed for Aboriginal heritage values in the 1970s and 1980s.

Lake Walliabup and Lake Coolbellup: investigating a Whadjuk Noongar cultural landscape

We can find out about the life of Whadjuk Noongar ancestors through archaeology.

These artefacts are made from a type of chert that is not found in the Perth area today. We think it comes from quarries that are now under the sea, drowned when sea levels rose at the end of the last ice age.

Quartz artefacts from the Darling Scarp show the range of Whadjuk Noongar cultural connections.

New dates from archaeological excavations on the northern shore of Lake Walliabup show Noongar people have lived here for at least 10,000 years.
At a conservative estimate, there could be more than twenty million artefacts in the sandy deposits around the lakes.

Whadjuk Noongar traditional owners identified this mark on a tuart tree as a cultural scar (OHP30574)

Adzes excavated near Lake Walliabup. These were used for woodworking.

Lake Walliabup

Whadjuk Noongar ancestors used adzes to make tools like this taap knife and kodj hatchet.

Some of the rich plant and animal resources found around the wetlands.

Registered Sites
Other Heritage Places

SECTION FIVE – CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The results of the STP program and the excavations clearly show that there is a widespread sub-surface distribution of cultural material within the Roe 8 project area between North Lake and Bibra Lake and more generally associated with the wetland complex. This reflects the cultural importance of the wetland complex as captured by the registered ethnographic site, which also acknowledges the connected nature of the whole landscape.

The distribution of surface artefacts at any given point in time is a result of ground surface visibility and disturbance processes. Consequently, the recorded boundaries of Registered sites and other heritage places must be regarded as capturing an interpretation of the surface distribution at the point of recording. These boundaries are not a reliable guide to the actual distribution of cultural material and must be carefully interpreted in the light of the history of recording, disturbance processes through time, topography and the characteristics and distribution of key landforms, such as wetlands and source-bordering dunes.

The results of the STP program also suggest that disturbance processes in the colonial period generally affect the top 30-50 cm of deposits. Beneath this, there mostly survives a relatively intact archaeological record. Artefacts do however occur in these upper layers. Therefore, for any tree planting and rehabilitation works that will occur in the proposed new site boundary Aboriginal heritage monitoring will need to occur.

The results of the excavations confirmed the presence of intact archaeological evidence of past occupation below the disturbed surface layers. Both the radiocarbon determinations and the presence of European cultural material suggest that nearly two centuries of European settlement and associated agricultural and more recently urban development have affected the upper levels of this landscape, but that evidence of past occupation episodes survive relatively intact at depth.

The dates from the excavations show clearly that Noongar people have used this landscape for at least 10,000 years. This new evidence confirms and extends the results of Pearce's excavation at North Lake North nearly half a century ago, which yielded a date of about 3000 years ago, with cultural material extending below that.

The occurrence of fossiliferous chert is considered a relative chronological marker in the Perth Metropolitan Area, indicating use before about 5000 years ago. The OSL dates and the distribution of fossiliferous chert with depth in Square 1 is consistent with this interpretation. Fossiliferous chert was absent from Square 2, and most of the cultural material in this square occurred above the date of 4500 years ago. However, it is possible that artefacts continued below this as the excavation was terminated due to lack of time.

Further excavation and dating of occupation evidence at Square 2 and other locations around the lakes will allow for a more complete and nuanced understanding of the use of the landscape by the Whadjuk Noongar's ancestors.

RECOMMENDATIONS

It is recommended based on the results of this work and at the instruction of the Noongar elders consulted on 19 September 2022 that:

- This report be released to the public.
- Lake Walliabup (Bibra Lake) and Lake Coolbellup (North Lake) is recognised as a Noongar Cultural Landscape and one heritage site that is of great importance and significance.
- A Heritage Information Submission Form (HISF) that contains information on all the cultural values collected so far is submitted to the DPLH for one heritage place. The HISF Form shall use the existing site North Lake and Bibra Lake (DPLH ID 3709) but enlarges its boundary to encompass the proven potential for sub-surface cultural material of the areas surrounding the two lakes and thus expands the range of values.
- That the artefacts collected during the excavations and shovel test pitting are to be put on display at the City of Cockburn Aboriginal Cultural and Visitors centre.
- That an integrated cultural heritage management plan be developed for the Lake Walliabup (Bibra Lake) and Lake Coolbellup (North Lake) area. This management plan should be codesigned with the Noongar elders consulted.
- With further consultation and under guidance from the integrated cultural heritage management plan:
    - additional archaeological excavation and shovel test pitting work occurs around the two lakes to further research and understand this significant Noongar history.
    - Stories are collected from the Elders about this place.
    - Results of this work is used in interpretation for the public and in community engagement.

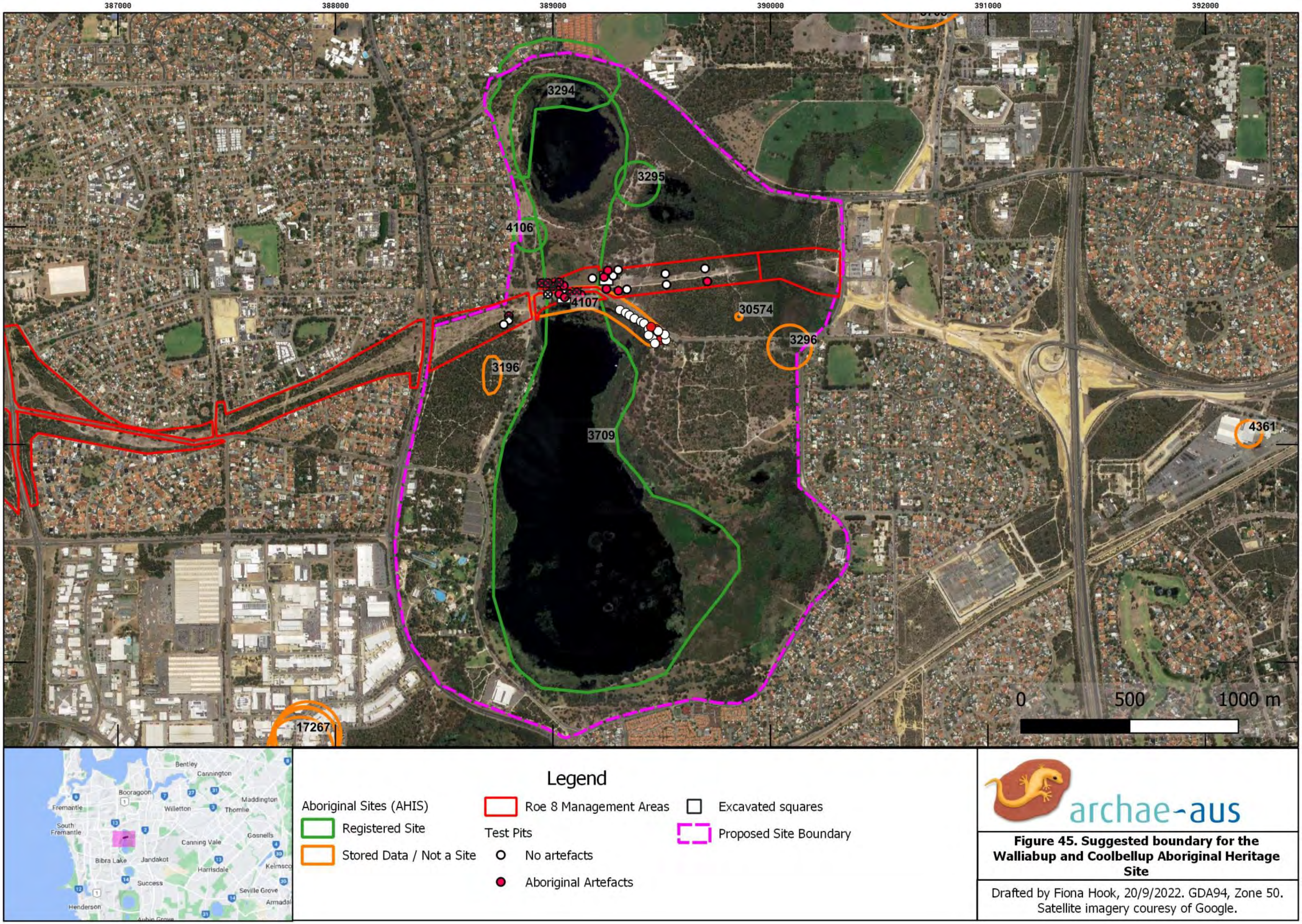

Figure 45. Suggested boundary for the Walliabup and Coolbellup Aboriginal Heritage Site

Drafted by Fiona Hook, 20/9/2022. GDA94, Zone 50. Satellite imagery couresy of Google.

REFERENCES CITED

Allen, J. and O'Connell, J. F. (2014) 'Both half right: updating the evidence for dating first human arrivals in Sahul', *Australian Archaeology*, 79, pp. 86–108.

Anderson, J. (1984) *Between Plateau and Plain. Flexible Responses to varied Environments in Southwestern Australia*, *Occasional Papers in Prehistory*. Canberra: Research School of Pacific Studies, ANU.

Andrefsky, W. (2005) *Lithics: Macroscopic approaches to analysis*. Second. Cambridge: Cambridge University Press.

Archae-aus Pty. Ltd. (2019) *Cultural Heritage Management Plan for the Rehabilitating Roe 8 Project*. North Fremantle.

Australian Interaction Consultants (2005a) *Report on further archaeological and ethnographic consulation of the proposed Phoenix Road Industrial Estate Development at Lot 502 Bibra Lake, Western Australia to accompany s18 application*.

Australian Interaction Consultants (2005b) *Report on further archaeological and ethnographic consultation of the proposed Phoenix Road Industrial Estate Development at Lot 502 Bibra Lake, Western Australia to accompany s18 application. Report prepared by AIC for Landcorp*.

Balme, J. (2014) 'Devils Lair: occupation intensity and land-use', *Australian Archaeology*, 79, pp. 179–186.

Bird, C. and Beeck, C. (1980) 'Bone points and spatulae: salvage ethnography in Southwest Australia', *Archaeology and Physical Anthropology in Oceania*, 15(3), pp. 168–171. doi: 10.1002/j.1834-4453.1980.tb00336.x.

Bowdler, S., Strawbridge, L. and Schwede, M. (1991) 'Archaeological mitigation in the Perth Metropolitan Region', *Australian Archaeology*, 32, pp. 21–25.

Cecchi, J. (2011) *An archaeological survey of Bibra Lake, Perth. Unpublished report prepared for City of Cockburn*.

Clark, J. and Dortch, C. E. (1977) 'A 10,000 year BP radiocarbon date for archaeological finds within a soil of the Spearwood dune system, Mosman Park', *Search*, 8, pp. 36–38.

Dortch, J. (1994) 'Pleistocene radiocarbon dates for hearths at Tunnel Cave, South-western Australia', *Australian Archaeology*, 38, pp. 45–46.

Dortch, J. (1996) 'Late Pleistocene and recent Aboriginal occupation at Tunnel Cave and Witchcliffe Rock Shelter, South-western Australia', *Australian Aboriginal Studies*, 1996(2), pp. 51–60.

Dortch, J. and Dortch, C. (2019) 'Late Quaternary Aboriginal hunter-gatherer occupation of the Greater Swan Region, south-western Australia', *Australian Archaeology*, 85(1), pp. 15–29. doi: 10.1080/03122417.2019.1594556.

Dortch, J., Dortch, C. and Cuthbert, D. (2009) *Report of archaeological excavations and related ethnographic consultations during Stage A Forward Works, Fiona Stanley*.

Emerge Associates (2018) *Rehabilitation Management Plan Roe 8 Cleared Areas*.

Gifford, P. *et al.* (2011) *Aboriginal Cultural Heritage Survey of the Proposed Roe Highway Extension*.

Glover, J. (1975) 'The petrology and probably stratigraphic significance of Aboriginal artifacts from part of south-western Australia', *Journal of the Royal Society of Western Australia*, 58, pp. 75–85.

Glover, J. E. (1984) 'The Geological Sources of Stone for Stone Artefacts in the Perth Basin and Nearby Areas', *Australian Aboriginal Studies*, 1984(1), pp. 17–25.

Green, N. (1984) *Broken spears: Aboriginals and Europeans in the south-west of Australia*. Perth: Focus Education Services.

Hallam, S. J. (1972) 'An archaeological survey of the Perth area, Western Australia, a progress report on art and artefacts, dates and demography', *Australian Institute of Aboriginal Studies Newsletter*, pp. 11–19.

Hallam, S. J. (1975) *Fire and Hearth: a study of Aboriginal usage and European usurpation in south-western Australia*. Canberra: Australian Institute of Aboriginal Studies.

Hallam, S. J. (1977a) 'Recent archaeological research in Western Australia', *Australian Archaeology*, 6, pp. 13–17.

Hallam, S. J. (1977b) 'Topographic archaeology and archaeological evidence', in Wright, R. (ed.) *Stone Tools as Cultural Markers*. Canberra: Australian Institute of Aboriginal Studies, pp. 169–177.

Hallam, S. J. (1986) *Australian Research Grants Scheme: Final report on the project - the Swan Coastal Plain, Western Australia*. Perth: Department of Indigenous Affairs.

Hallam, S. J. (1987) 'Coastal does not equal littoral', *Australian Archaeology*, 25, pp. 10–29.

Hallam, S. J. (1991) 'Aboriginal women as providers : the 1830s on the Swan', *Aboriginal History*, 15(1), pp. 233–242.

Hammond, J. E. (1933) *Winjan's People*. Perth: Imperial Printing.

Harris, J. (2010) *A desktop archaeological survey of the Roe Highway extension within the City of Cockburn, in Perth, Western Australia. Unpublished report prepared by Brad Goode and Associates for South Metro Connect*.

Hawkins, R. and Mosig Way, A. (2020) 'Rethinking the Desirability of Quartz for the Manufacture of Standardized Retouched Flakes: An Example From Weereewaa (Lake George), South-eastern Australia', *Lithic Technology*, 0(0), pp. 1–16. doi: 10.1080/01977261.2020.1768687.

Holdaway, S. and Stern, N. (2004) *A record in stone: The study of Australia's flaked stone artefacts*. Melbourne & Canberra: Museum Victoria & Aboriginal Studies Press.

Hook, F. and Dortch, J. (2017) *Report of the Shovel Test Pitting Survey of DAA 4107 (Bibra Lake North) within Lot 65, between Walliabup and Coolbellup Lakes, City of Cockburn*.

Johnson, I. (1979) *The getting of data: A case study from the recent industries of Australia.*, *Research School of Pacific Studies*. ANU.

Lyon, R. M. (1833) 'A Glance at the manners, and Language of the Aboriginal Inhabitants of Western Australia: With a Short Vocabulary', in Green, N. (ed.) *Perth Gazette and Western Australian Journal*. Perth: Creative Research. Mount Lawley College of Advanced Education.

McDonald Hales and Associates (2002) *A Report on Aboriginal Heritage Investigations of the Proposed Champion Lakes Development, Westfield*. Perth.

Monks, C. *et al.* (2016) 'Pleistocene occupation of Yellabidde Cave in the northern Swan Coastal Plain, southwestern Australia', *Australian Archaeology*, 82(3), pp. 275–279. doi: 10.1080/03122417.2016.1244216.

O'Connor, R., Bodney, C. and Little, L. (1985) *Report on the survey of Aboriginal areas of significance* *in the Perth Metropolitan and Murray River Regions. Unpublished report prepared for the Department of Sites*. Perth.

Pearce, R. (1979) *Analysis of some Western Australian small tool assemblages*. University of Western Australai.

Pearce, R. H. (1978) 'Changes in artefact assemblages during the last 8000 years at Walyunga, Western Australia.', *Journal of the Royal Society of Western Australia.*, 61(1), pp. 1–10.

Quartermaine, G. (2010) *Report on an archaeological investigation for Aboriginal sites – proposed Narma Kularck Bird Walk at Bibra Lake. Unpublished report prepared by Quartermaine Consultants for City of Cockburn.*

Schwede, M. (1983) 'Supertrench- phase 2, a report on excavation results', in Smith, M. (ed.) *Archaeology at ANZAAS*. Perth: Western Australian Museum, pp. 53–62.

Schwede, M. (1990) *Quartz, the Multifaceted Stone: A Regional Prehistory of the Helena River valley on the Swan Coastal Plain of Southwestern Australia*, *Archaeology*. University of Western Australia.

Spry, C. *et al.* (2019) 'Identifying quartz artefacts in archaeology and cultural heritage management: issues, approaches and a new open- access project', *Excavations, Surveys and Heritage Management in Victoria*, 8, pp. 77–83.

Strawbridge, L. (1988) *Aboriginal Sites in the Perth metropolitan area: a management scheme*. Perth: Department of Indidenous Affairs.

Yates, A. (2005) *Metropolitan Sites Project Southern Region. Unpublished report prepared for Aboriginal Affairs Department.*

Yates Heritage Consultants (2000) *Metropolitan Sites Project Southern Region: for Aboriginal Affairs Department*.

APPENDIX ONE: TERMS AND ABBREVIATIONS

Term / Abbreviation	Meaning / Interpretation
Aboriginal archaeological place or assemblage	A place (or group of physical sites) in which evidence of past activity by Aboriginal people is preserved (either prehistoric or historical or contemporary), and which has been, or may be, investigated using the discipline of archaeology and represents a part of the archaeological record.
Aboriginal Site	This term is used only for archaeological and ethnographic sites to which the *AHA* applies by the operation of Section 5.
ACMC	The Aboriginal Cultural Material Committee.
AHA	Abbreviation for *Aboriginal Heritage Act 1972.*
Archaeological site	Is a place (or group of physical sites) in which evidence of human past activity is preserved (either prehistoric or historical or contemporary), and which has been, or may be, investigated using the discipline of archaeology and represents a part of the archaeological record. This term is used to refer to a place regardless of whether it has been assessed under section 5 of the *AHA*.
Artefact	Any object made, affected, used, or modified in some way by humans.
Assessment	Professional opinion based on information that was forthcoming at the time of consideration.
CHMP	Cultural Heritage Management Plan
Cultural material / archaeological material	Any object made, affected, used, or modified in some way by humans.
DPLH	Department of Planning, Lands and Heritage (formerly the Department of Aboriginal Affairs).
GPS unit	Handheld device used as a Global Positioning System.
Heritage survey	Survey and inspection undertaken in order to investigate and document the Aboriginal heritage record of a particular area.
Isolated Artefact	Single or low number of artefacts that are not considered to constitute Aboriginal Sites according to sections 5 and 39 (2) the AHA.
HPA	*Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (the HPA).
LGM	Last Glacial Maximum.
Native Title	Recognition of the traditional rights and interests to land and waters of Aboriginal and Torres Strait Islander people.
NTA	*Native Title Act 1993.*
Object	An artefact - any object made, affected, used, or modified in some way by humans.
OSL	Optically Stimulated Luminescence. A dating technique used mainly on buried sediments which identifies the last time the sediment was exposed to light.
Section 16	In the *Aboriginal Heritage Act 1972*, the section that allows for the archaeological investigation / research of an Aboriginal site.
Section 16 Permit	A document from the DPLH detailing the conditions attached to the permission granted by the Registrar of Aboriginal sites to conduct further investigations at a site.
Section 17 Disturbance	When an Aboriginal site has been damaged by ground disturbance works without Section 18 permission.
Section 18	The section of the *Aboriginal Heritage Act 1972* that details the process for permission to disturb the land on which an Aboriginal site is located.
Section 18 Approval	A letter from the Minister of Aboriginal Affairs providing approval for the disturbance of land on which a site is located.
Section 39(2) Assessment	Process of the ACMC assessing a reported site's significance and interest.
Scope of Works	The nature of the work undertaken as requested by the client or proponent.
STP	Shovel Test Pit. A small test pit up to 50 x 50 cm, excavated by hand to identify the presence of sub-surface cultural material
SWALSC	South-West Aboriginal Land and Sea Council

APPENDIX TWO: LEGISLATION

Western Australia's *Aboriginal Heritage Act* 1972 (the *AHA*) is the main legislative framework for Aboriginal heritage in the State. Important and significant Aboriginal sites and objects are protected under it. The *AHA* protects sites and objects that are significant to living Aboriginal people as well as Aboriginal sites of historical, anthropological, archaeological and ethnographic significance. The *AHA* is currently administered by the Department of Planning, Lands and Heritage (DPLH), formerly the Department of Aboriginal Affairs (DAA).

The primary sections of the *AHA* that need to be considered are section 5 which defines the term 'Aboriginal Site', and section 39 (2) which details what the Aboriginal Cultural Materials Committee (ACMC) should have in regard to considering the importance of objects and places. Section 17 of the *AHA* states that it is an offence to: alter an Aboriginal site in any way, including collecting artefacts; conceal a site or artefact; or excavate, destroy or damage in any way an Aboriginal site or artefact; without the authorisation of the Registrar of Aboriginal Sites under section 16 or the Minister of Aboriginal Affairs under section 18 of the *AHA*.

Aboriginal heritage sites are also protected under the Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (the *HPA*). The *HPA* complements state/territory legislation and is intended to be used only as a 'last resort' where state/territory laws and processes prove ineffective. Under the *HPA* the responsible Minister can make temporary or long-term declarations to protect areas and objects of significance under threat of injury or desecration. The *HPA* also encourages heritage protection through mediated negotiation and agreement between land users, developers and Aboriginal people.

Aboriginal human remains are protected under the *AHA* and the *HPA*. In addition, the discovery of human remains requires that the following people are informed: the State Coroner or local Police under section 17 of the *Coroners Act* 1996; the State Registrar of Aboriginal Sites under section 15 of the *AHA*; and the Federal Minister for Aboriginal Affairs under Section 20 of the *HPA*.

In terms of broader recognition of Aboriginal rights, the *Native Title Act* (*NTA*) recognises the traditional rights and interests to land and waters of Aboriginal and Torres Strait Islander people. Under the *NTA*, native title claimants can make an application to the Federal Court to have their native title recognised by Australian law. The *NTA* was extensively amended in 1998, with further amendments occurring in 2007, 2009 and again in 2017. Under the future act provisions of the *NTA*, native title holders and registered native title claimants are entitled to certain procedural rights, including a right to be notified of the proposed future act, or a right to object to the act, the opportunity to comment, the right to be consulted, the right to negotiate or the same rights as an ordinary title holder (freeholder).

DPLH REGISTER STATUS

The Aboriginal Heritage Inquiry System (AHIS), managed by the DPLH, is the tool through which the public can access information about heritage places and their legal status. There are two broad categories by which the AHIS uses to characterise heritage places: Aboriginal Sites (registered sites) or Other Heritage Places.

A registered Aboriginal Site is a place that fulfils the following definitions for protection under section 5 of the *AHA*:

1) Any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present.
2) Any sacred, ritual or ceremonial site which is of importance and special significance to persons of Aboriginal descent.
3) Any place which, in the opinion of the Aboriginal Cultural Materials Committee (ACMC), is or was associated with Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State.
4) Any place where objects to which the *AHA* applies are traditionally stored, or to which, under the provisions of the *AHA*, such objects have been taken or removed.

The category 'Other Heritage Place' is complex and is not a reliable indicator for the legal status of a heritage place under the *AHA*.

The status of most 'Other Heritage Places' is either 'Lodged' or 'Stored Data'.

- Lodged indicates a potential Aboriginal Site that has been reported but not yet assessed by the ACMC. These places are therefore immediately protected under the *AHA*.
- Stored Data / Not a Site indicates a place that has been assessed by the ACMC, who have decided that the place does not fulfil the above definitions for an Aboriginal Site, protected under the *AHA*.

A small number of 'Other Heritage Places' have 'Contact DAA/DPLH' as their status, indicating that contact needs to be made with the Department of Planning, Lands and Heritage regarding these places, to access further information/advice.

Thus some 'Other Heritage Places' are protected under the *AHA*, while others are not. Consequently, Archae-aus would recommend full and transparent consultation with Traditional Owners about all of their heritage places.

Furthermore, the status of both Aboriginal Sites and Other Heritage Places may change as the information available or assessment procedures change through time. In the last few years, the register status of some places has changed from one of these categories to another. An apparent shift has occurred in the benchmarks used by the ACMC in the assessment of places as Aboriginal Sites under section 5 of the *AHA*. These changes have been most noticeable since 2012, particularly in the outcomes of section 18 applications, despite no change in the *AHA* itself. For example, some Aboriginal Sites have been re-classified as Other Heritage Places, meaning that they are no longer considered to meet the criteria to be registered as Aboriginal Sites and thus may no longer protected under the *AHA*. This process is being challenged by Aboriginal groups in the Supreme Court. One decision by the court in April 2015 determined that the ACMC criteria used for assessing places under 5b was incorrect[1]. The ACMC was instructed to reassess those places assessed by the ACMC under 5b since 2012. This reassessment process has begun, and several places have been placed back onto the register of Registered Sites under the *AHA*. Other challenges under 5a assessments are in train through the Supreme Court.

[1] https://www.dlapiper.com/~/media/Files/Insights/Publications/2015/04/Supreme_court_clarifies_meaning_of_sacred_site_in_WA.pdf

APPENDIX THREE: ARTEFACT CATALOGUE

Artefact analysis

Flaked stone artefacts were all classified according to standard technological categories, with some modifications for quartz artefacts (Holdaway and Stern, 2004; Andrefsky, 2005). The manufacture of flaked stone artefacts by percussion is a reductive process, which preserves all manufacturing stages. As well as finished tools, analysis of the discarded waste products from different manufacturing stages and techniques provides information about the procurement and processing of raw materials. Stone materials used for flaking are usually homogenous silicious rocks, such as chert, with a characteristic pattern of conchoidal fracture. Quartz is an exception, as it is commonly used for making tools but commonly fractures unpredictably along internal flaws and crystal planes. Quartz artefacts can therefore be difficult to classify according to standard categories (Spry *et al.*, 2019; Hawkins and Mosig Way, 2020).

All artefacts were classified into four overall classes: debris, flake, core or Tool.

Class	Type
Debris – piece of flaked stone which lacks diagnostic features of conchoidal fracture. This class is sometimes referred to as "flaked piece" or "shatter".	Undiagnostic fragment – angular fragment that lacks any diagnostic features of conchoidal fracture
	Fragment – thin, flake-like fragment that lacks any diagnostic features of conchoidal fracture
Core – piece of stone that has been struck to remove flakes and shows negative flake scars	Single-platform core – a core that has been struck from a single direction
	Multi-platform core – a core that has been rotated and struck from two or more directions
	Bipolar – a core with characteristic damage at opposing ends, which has been flaked using an anvil.
	Core fragment – undiagnostic fragment of flaked stone with negative flake scars
Flake – flake that has been removed from a core and shows one or more diagnostic features (such as point of force application, bulbar scar, fissures, ripple marks)	Complete flake – flake with platform, termination and intact margin.
	Proximal flake – transversely broken flake with platform.
	Distal flake – transversely broken flake with termination
	Longitudinal split flake (right or left) – broken flake that has split longitudinally along the direction of applied force. It preserves part of the platform and termination and part of the margin.
Tool – flake or fragment with a margin that has been modified by secondary flaking or use	Backed piece – flake or blade with blunted "back" formed by secondary flaking opposite a sharp unmodified edge. Backed pieces come in a variety of shapes.
	Scraper – flake or blade with an edge modified by a continuous length of unifacial secondary retouch.
	Adze – flake or blade with an edge repeatedly modified by steep retouch, often worked down to a characteristic "slug" form.
	Undiagnostic retouched/ utilized – flake or blade with edge damage

A series of attributes were recorded for all flaked stone artefacts. These were:

Lithology – raw material. Most artefacts were quartz; fossiliferous chert, dolerite and silcrete were also present

Dimensions – length, width, thickness, weight. For flakes, length, width and thickness were oriented according to direction of flaking. Otherwise, length was the maximum dimension with width at right angles to length and thickness at the mid-point. Artefacts smaller than 5 mm were not measured.

Cortex – amount and type. Cortex is the natural weathered surface of the original lithic raw material. This may indicate whether the material came from a terrestrial source or from water-worn pebbles or cobbles.

The following attributes were recorded for all flakes, if present:

Platform type, width and thickness

Presence or absence of overhang removal

Termination type

The number of platforms was recorded for cores

The position of retouch was recorded for tools, using the quadrant method (Holdaway and Stern, 2004).

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
1	1	T1-100	1	Flake	Complete flake	Quartz	15.3	9.0	3.5	0.51	6.2	2.8	Plain	Absent			Small area of notched edge damage at distal end - quadrant 3
2	1	T1-100	2	Flake	Complete flake	Quartz	11.2	6.8	1.8	0.15	4.1	2.5	Plain	Absent			
3	1	T1-100	2	Flake	Complete flake	Quartz	6	3	0.5	0	3	0.3	Plain	Absent			
4	1	T1-100	2	Debris	Undiagnostic fragment	Quartz	6.6	2.3	0.7	0							
5	1	T1-100	3a	Debris	Undiagnostic fragment	Quartz	9.6	5.9	3.5	0.24							
6	1	T1-100	3a	Flake	Complete flake	Quartz	7.5	6	0.7	0.03	4.6	0.2	Crushed	Absent			
7	1	T1-100	4a	Debris	Fragment	Quartz	15.6	6.4	3	0.28							
8	1	T1-100	4a	Debris	Fragment	Quartz	4.8	3.2	0.8	0.11							
9	1	T1-100	4a	Debris	Undiagnostic fragment	Quartz	7.2	5.2	2.2	0							
10	1	T1-100	5a	Flake	Longitudinal split flake-right	Quartz	13.8	13.4	3.9	0.67	6.6	2.5	Plain	Absent			
11	1	T1-100	5a	Debris	Fragment	Quartz	7	2.5	1	0							
12	1	T1-100	6a	Debris	Fragment	Quartz	6.1	1.4	0.5	0							
13	1	T1-50	1a	Flake	Longitudinal split flake-right	Quartz	13.4	10.1	2.6	0.45	4.1	3.2	Plain	Absent	Feather		

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
14	1	T1-50	1a	Flake	Complete flake	Quartz	10.3	5.6	3.5	0.17	3.3	0.9	Crushed	Absent	Other		
15	1	T1-50	1a	Flake	Complete flake	Quartz	8.8	5.4	2.5	0.1	3	1.2	Crushed	Absent	Other		
16	1	T1-50	2a	Debris	Fragment	Other	6.3	4.5	0.8	0							Silcrete
17	1	T1-50	2a	Debris	Undiagnostic fragment	Quartz	13.9	13.3	7.5	0.98							
18	1	T1-50	2a	Debris	Fragment	Quartz	6.7	6.1	2.2	0.11							
19	1	T1-50	2a	Debris	Fragment	Quartz	10.5	5.7	2.8	0.17							
20	1	T1-50	2a	Debris	Fragment	Quartz	6.6	3.6	1.2	0							
21	1	T1-50	2a	Debris	Fragment	Quartz	12.2	3.5	2.8	0.1							
22	1	T1-50	2a	Debris	Undiagnostic fragment	Quartz	7.5	3.6	2	0.05							
23	1	T1-50	2a	Debris	Undiagnostic fragment	Quartz	4.9	4.6	3.2	0.08							
24	1	T1-50	2a	Debris	Fragment	Quartz	7	4.9	1.2	0.04							
25	1	T1-50	2a	Debris	Fragment	Quartz	4.4	3.2	1.2	0							
26	1	T1-50	2a	Debris	Fragment	Quartz	6.2	3	1.2	0.02							
27	1	T1-50	2a	Debris	Fragment	Quartz	7.3	3.8	1.4	0.04							
28	1	T1-50	2a	Debris	Fragment	Quartz	6.5	3	1.1	0							
29	1	T1-50	2a	Debris	Fragment	Quartz	11.8	7.5	3.3	0.26							
30	1	T1-50	3a	Debris	Fragment	Quartz	15.9	5.6	3.1	0.29							
31	1	T1-50	3a	Debris	Undiagnostic fragment	Quartz	6.5	3.5	3	0.08							
32	1	T1-50	3a	Flake	Complete flake	Quartz	8.8	6.7	1.6	0.14	5	1	Crushed	Absent	Feather		
33	1	T1-50	3a	Other	Other	Glass				0.19							Amber glass fragment

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
34	1	T1-50	4a	Debris	Undiagnostic fragment	Quartz	22.8	15	7	2.75							Tabular piece
35	1	T1-50	4a	Debris	Undiagnostic fragment	Quartz	5.2	3.5	2.7	0.06							
36	1	T1-150	1	Other	Other	Glass				1.9							Green glass fragment
37	1	T1-150	1	Other	Other	Ceramic				0.07							Ceramic chip
38	1	T2-25	1	Flake	Proximal flake	Quartz	12	14.7	5.5	1.01	7.3	1	Ridge	Absent			Split pebble 100% cortex on dorsal surface
39	1	T2-25	2a	Debris	Undiagnostic fragment	Quartz	15.4	9.4	4.4	0.52							
40	1	T2-75	4	Flake	Complete flake	Quartz	10.8	8.3	1.5	0.19	7.5	1.1	Ridge	Absent	Other		
41	1	T2-75	5	Flake	Distal flake	Quartz	7.8	6.7	1.6	0.1					Hinge		
42	1	T2-75	6	Debris	Fragment	Quartz	7.1	5.3	1.5	0.05							
43	1	T2-75	6	Debris	Fragment	Quartz	4.7	3.2	1.5	0							
44	1	T2-75	8	Debris	Fragment	Chert	26.1	9.4	8	1.32							
45	1	T2-75	9	Flake	Complete flake	Chert	8.6	2.3	2.4	0.25	8.3	2.1	Plain	Absent	Feather		
46	1	T2-75	10	Debris	Fragment	Chert	23	9.3	3.9	0.81							
47	1	T3-25	1	Other	Other	Glass				0.88							green glass
48	1	T3-25	1	Other	Other	Glass				0.18							Brown glass
49	1	T3-25	1	Other	Other	Glass				6.21							Brown glass
50	1	T3-25	3	Flake	Distal flake	Quartz	10.2	8	1.6	0.12					Feather		
51	1	T3-25	4	Debris	Fragment	Quartz	7.6	4	2.3	0.07							
52	1	T3-25	7	Flake	Complete flake	Quartz	12.4	5.7	1.8	0.11	3	1.1	Crushed	Absent	Feather		
53	1	T3-25	7	Debris	Fragment	Quartz	10.1	4.8	2.2	0.1							

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
54	1	T3-25	7	Debris	Undiagnostic fragment	Other	8.5	5.8	4.8	0.22							Silcrete?
55	1	T3-25	7	Debris	Undiagnostic fragment	Other	5.1	4.7	3.4	0.06							Silcrete?
56	1	T4-00	1	Debris	Undiagnostic fragment	Quartz	9.8	3.5	1.4	0.11							
57	1	T4-00	1	Flake	Complete flake	Quartz	19.3	13.2	5	1.3	4.8	2.7	Plain	Absent	Feather		
58	1	T4-00	1	Core	Core fragment	Quartz	17.7	10.7	6.5	0.99							
59	1	T4-00	2	Debris	Undiagnostic fragment	Quartz	16	7.2	4.4	0.66							
60	1	T4-00	3	Debris	Undiagnostic fragment	Quartz	7.7	4.2	1.6	0.04							
61	1	T4-00	3	Debris	Fragment	Quartz	19.5	10.5	5.2	0.93							
62	1	T4-00	4	Other	Other	Glass				1.87							Mauve glass fragment
63	1	T4-00	5	Debris	Undiagnostic fragment	Quartz	13.7	9.9	4.7	0.46							
64	1	T4-00	5	Debris	Undiagnostic fragment	Quartz	10.7	7	3.8	0.28							
65	1	T4-00	5	Debris	Fragment	Quartz	8	4.8	1.3	0.03							
66	1	T4-00	5	Debris	Fragment	Quartz	22.8	16.3	5.7	1.9							
67	1	T4-50	1	Debris	Undiagnostic fragment	Quartz	13.8	9.5	5.1	0.66							
68	1	T4-50	1	Other	Other	Glass				2.32							Green glass fragment
69	1	T4-50	1	Other	Other	Glass				2.2							Colourless glass fragment

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
70	1	T4-50	2	Other	Other	Ceramic				1.36							Ceramic sherd, white glaze
71	1	T4-50	2	Other	Other	Shell				0.3							Shell button
72	2	T4-50	4	Other	Other	Glass				0.25							2 colourless glass fragments
73	1	T4-50	5	Other	Other	Glass				3.7							Very weathered glass fragment
74	1	T4-50	7	Debris	Fragment	Quartz	4.8	4	0.7	0							
75	1	T5-25	1	Other	Other	Glass				0.17							Colourless glass fragment
76	1	T5-25	1	Other	Other	Glass				0.09							Green glass fragment
77	1	T5-25	1	Other	Other	Glass				0.04							Blue glass fragment
78	1	T5-25	2	Other	Other	Glass				0.93							Green glass fragment
79	1	T5-25	2	Other	Other	Metal				0.61							Metal fragment
80	1	T5-25	3	Flake	Distal flake	Chert	16.5	7.7	4.8	4.3					Feather		Secondary flaking on dorsal ridge
81	1	T5-75	1	Other	Other	Glass				2.4							Light green glass rim sherd
82	1	T5-75	1	Debris	Undiagnostic fragment	Quartz	11.6	8.5	5.4	0.57							
83	1	T5-75	2	Other	Other	Glass				0.15							Light green glass flake
84	1	T5-75	2	Other	Other	Glass				5.05							Light green glass fragment
85	1	T5-75	2	Other	Other	Ceramic				0.15							Ceramic glazed fragment

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
86	1	T5-75	3	Other	Other	Ceramic				1.07							Ceramic glazed fragment
87	1	T5-75	3	Other	Other	Ceramic				0.63							clay fragment?
88	5	T5-75	3	Other	Other	Glass				2.35							5xcolourless glass
89	1	T5-75	3	Other	Other	Glass				0.53							Green glass fragment
90	1	T5-75	4	Other	Other	Glass				0.51							Green glass fragment
91	1	T5-75	4	Other	Other	Ceramic				2.62							Ceramic sherd
92	1	T6-55	2	Debris	Fragment	Quartz	7.9	6	2.4	0.12							
93	1	T7-75	2	Debris	Fragment	Quartz	7	5.4	1	0.05							
94	1	T7-75	2	Debris	Fragment	Quartz	6.6	5.1	1	0.04							
95	1	T7-75	2	Debris	Fragment	Quartz	7.5	4.2	2.1	0.07							
96	1	T7-75	2	Debris	Fragment	Quartz	6.3	3.1	0.9	0.03							
97	1	T7-75	2	Debris	Undiagnostic fragment	Quartz	5.5	3.8	1.9	0.04							
98	1	T7-75	2	Debris	Undiagnostic fragment	Quartz	6.6	3.8	1.8	0.04							
99	1	T7-75	2	Debris	Undiagnostic fragment	Quartz	7.4	2.8	0.8	0							
100	1	T7-75	2	Debris	Undiagnostic fragment	Quartz	5.4	3.2	0.4	0							
101	1	T7-75	2	Debris	Undiagnostic fragment	Quartz	5	2.8	2.3	0.04							
102	1	T7-75	2	Debris	Undiagnostic fragment	Quartz	4.3	3.3	1.4	0							
103	1	T7-75	2	Flake	Complete flake	Quartz	19.9	15.7	3	0.96	8.9	1.9	Plain	Absent	Feather		
104	1	T7-75	2	Flake	Complete flake	Quartz	11.3	11.1	2.7	0.37	10.5	4.1	Plain	Absent	Feather		

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
105	1	T7-75	2	Flake	Proximal flake	Quartz	6.6	7	1.1	0.07	4.9	1.8	Plain	Absent	Step		
106	1	T7-75	2	Flake	Complete flake	Quartz	7.9	11.9	3	0.18	7.2	2.6	Plain	Absent	Feather		
107	1	T7-75	2	Core	Single platform core	Quartz	9.2	13	12.4	1.39						1	
108	1	T7-75	2	Tool/Retouched	Other	Chert	21.9	13.3	4.9	1.78	11.3	5.2	Plain	Absent	Other		Adze. Weathered. Retouch quadrants 2 and 4
109	1	T7-75	4	Flake	Complete flake	Quartz	8	5.6	1	0.07	5.4	1.6	Plain	Absent	Feather		Clear quartz
110	1	T7-75	3	Flake	Complete flake	Quartz	30.5	21.4	8.6	4.26	11.3	3.8	Plain	Absent	Feather		
111	1	T7-75	3	Debris	Fragment	Quartz	7.4	6.8	1.2	0.09							
112	1	T7-75	3	Debris	Fragment	Quartz	6.2	4.3	2.1	0.05							
113	1	T7-75	3	Debris	Undiagnostic fragment	Quartz	5.6	3.6	1.9	0.05							
114	1	T7-75	3	Core	Single platform core	Quartz	14.3	18	13.9	3.67						1	Similar to #109
115	1	T7-75	6	Debris	Fragment	Quartz	6.5	5	1.3	0.04							
116	1	T7-125	1	Debris	Fragment	Quartz	10	7.6	1.7	0.11							
117	1	T8-00	4	Debris	Fragment	Quartz	7	4.8	1.2	0.05							
118	1	T8-50	1	Debris	Undiagnostic fragment	Quartz	9.3	7.3	2.6	0.16							
119	1	T10-55	1	Flake	Complete flake	Quartz	8.6	6.8	1.1	0.08	3.5	0.7	Crushed	Absent	Feather		
120	1	W-001	1	Other	Other	Ceramic				1.48							White glazed ceramic

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
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121	1	W-001	1	Other	Other	Ceramic				0.84							White glazed ceramic
122	1	W-001	1	Other	Other	Glass				1.25							Amber glass
123	1	W-001	1	Other	Other	Glass				5.63							colourless glass
124	1	W-001	2	Other	Other	Glass				1.85							colourless glass
125	1	W-001	2	Other	Other	Glass				0.12							colourless glass
126	3	W-001	2	Other	Other	Glass				0.1							3xchips amber glass
127	1	W-001	3	Other	Other	Ceramic				3.47							White glazed rim sherd with blue decorative lines
128	1	W-001	3	Other	Other	Glass				1.03							Light green glass fragment
129	1	W-001	3	Debris	Fragment	Quartz	7.8	5.5	2.4	0.1							
130	1	1	2	Other	Other	Glass				0.91							Glass - colourless
131	1	1	2	Other	Other	Glass				0.31							Glass - colourless
132	1	1	2	Other	Other	Glass				0.25							Glass - colourless
133	1	1	2	Other	Other	Glass				0.37							glass - brown
134	1	1	2	Other	Other	Glass				0.13							glass - brown
135	1	4	2	Other	Other	Glass				0.51							4xgreen glass
136	1	1	3	Other	Other	Glass				0.09							Glass - colourless
137	1	1	3	Other	Other	Glass				0.03							Glass - colourless
138	1	1	3	Other	Other	Glass				0.08							Glass - colourless
139	1	1	3	Other	Other	Glass				0.19							Glass - green
140	1	1	4	Other	Other	Glass				2.24							Glass - green

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
141	1	1	4	Other	Other	Road metal				0.35							Road metal?
142	1	1	4	Debris	Fragment	Dolerite	6.2	5.2	1.7	0.05							Possibly road metal
143	1	1	4	Debris	Undiagnostic fragment	Quartz	11.1	7.8	3.8	0.31							
144	1	1	4	Debris	Undiagnostic fragment	Quartz	13.1	8	5.9	0.57							
145	1	1	4	Debris	Fragment	Quartz	7.5	4.4	1.3	0.05							
146	1	1	4	Debris	Fragment	Quartz	7.3	4	1	0.04							
147	1	1	4	Core	Multi-platform core	Quartz	13.2	12.9	11.9	1.72						2	In situ #2. Similar to #109
148	1	1	4	Flake	Distal flake	Quartz	9.6	8.1	1.2	0.11							In situ #6
149	1	1	5	Other	Other	Road metal				0.2							Road metal?
150	1	1	5	Other	Other	Glass				0.03							Glass - green
151	1	1	5	Debris	Undiagnostic fragment	Quartz	11.1	3.8	2.8	0.14							
152	1	1	5	Debris	Undiagnostic fragment	Quartz	16.3	8	4.5	0.61							
153	1	1	5	Debris	Fragment	Quartz	5.2	4.3	1	0							
154	1	1	5	Debris	Fragment	Quartz	15.4	12.5	3.7	0.86							
155	1	1	5	Debris	Fragment	Quartz	14.4	10.5	3.7	0.58							
156	1	1	5	Flake	Complete flake	Quartz	9.5	8.4	2.5	0.16	5.1	1.7	Plain	Present	Feather		
157	1	1	5	Debris	Undiagnostic fragment	Quartz	5.1	3.5	1.9	0							
158	1	1	6	Other	Other	Glass				0.15							Glass - green
159	1	1	6	Flake	Complete flake	Quartz	6.5	6.1	1.5	0.05	4.1	1.4	Plain	Absent	Feather		

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
160	1	1	6	Debris	Fragment	Quartz	5.9	4	1.9	0.05							
161	1	1	6	Flake	Longitudinal split flake-right	Quartz	14.3	7.4	3.5	0.44	4.3	3	Plain	Absent	Feather		
162	1	1	6	Flake	Longitudinal split flake-right	Quartz	17.1	5.9	4.2	0.35	5.7	4.5	Plain	Absent	Feather		
163	1	1	7	Debris	Fragment	Quartz	6.4	3.6	0.7	0							
164	1	1	7	Debris	Fragment	Quartz	10	6.6	2.6	0.19							
165	1	1	7	Debris	Fragment	Quartz	11.3	6	3.7	0.18							
166	1	1	7	Debris	Fragment	Quartz	6.5	4.2	2	0.08							
167	1	1	9	Debris	Fragment	Quartz	9.9	9	3.5	0.32							
168	1	1	9	Flake	Complete flake	Chert	6.4	7.2	0.8	0.04	4.4	0.7	Gull wing	Absent	Feather		Terrestrial cortec 50% of dorsal surface
169	1	1	9	Debris	Fragment	Other	12.8	10.4	1.2	0.22							Quartzite
170	1	1	11	Core	Core fragment	Quartz	15	11.1	7	1.14							
171	1	1	11	Debris	Fragment	Quartz	10.5	4.4	2.4	0.12							
172	1	1	11	Debris	Fragment	Quartz	11.4	5	5	0.2							
173	1	1	12	Debris	Fragment	Quartz	9.4	3.3	1.1	0							
174	1	1	12	Debris	Fragment	Quartz	16.3	12.2	4.3	0.73							
175	1	1	12	Flake	Fragment	Quartz	12.1	10.4	2.1	0.35	9.8	0.9	Ridge	Absent	Feather		
176	1	1	12	Flake	Complete flake	Chert	21.4	10.7	2.9	0.62	7.9	1.8	Plain	Absent	Feather		
177	1	1	12	Flake	Complete flake	Chert	5.1	5.5	0.7	0	4.5	1.2	Plain	Absent	Feather		
178	1	1	12	Debris	Fragment	Chert	13.3	5.3	2.9	0.14							
179	1	1	12	Flake	Distal flake	Chert	15.2	12.2	3.6	0.43					Feather		
180	1	1	12	Flake	Fragment	Chert	8.3	6.2	0.8	0.05							

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181	1	1	12	Debris	Undiagnostic fragment	Chert	7.3	6.7	6.1	0.11							
182	1	1	12	Debris	Undiagnostic fragment	Chert	11.5	10.2	4.6	0.35							
183	1	1	13	Flake	Complete flake	Quartz	7.3	8.6	1.5	0.1	8.5	1.2	Plain	Absent	Feather		
184	1	1	13	Flake	Complete flake	Chert	12.7	13.7	2.8	0.29			Plain	Absent	Feather		Platform not measured because incomplete
185	1	1	15	Flake	Complete flake	Chert	4.6	5.3	0.8	0	4.2	0.8	Gull wing	Absent	Feather		
186	1	1	15	Debris	Fragment	Dolerite	11.4	8.3	2.6	0.29							
187	1	2	2	Debris	Fragment	Quartz	5.7	4.7	2.1	0.03							
188	1	2	2	Debris	Fragment	Quartz	6.2	3.7	1.6	0							
189	1	2	2	Debris	Fragment	Quartz	4.9	3.6	1.1	0							
190	1	2	3	Debris	Fragment	Quartz	6.4	2.8	1.3	0.02							
191	1	2	4	Debris	Fragment	Quartz	9	5.8	2	0.12							
192	1	2	4	Debris	Fragment	Quartz	6.1	3.9	1	0.02							
193	1	2	4	Debris	Fragment	Quartz	5.6	3.8	2.2	0.05							
194	1	2	4	Debris	Fragment	Quartz	5	4.5	0.6	0							
195	1	2	5	Flake	Bipolar	Quartz	10.2	4	2.9	0.14			Crushed	Absent	Axial		This is a split bipolar piece - classified as a flake but no measurements possible on platform
196	1	2	5	Debris	Fragment	Quartz	6.4	5.8	1.7	0.06							
197	1	2	5	Debris	Proximal flake	Quartz	5.6	7.3	1.2	0.07	5.2	0.8	Crushed	Absent	Step		

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
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198	1	2	5	Debris	Fragment	Quartz	5.4	2.5	0.7	0							
199	1	2	5	Debris	Fragment	Quartz	5.1	3.1	0.9	0							
200	1	2	5	Debris	Fragment	Quartz	5.1	3.1	1	0							
201	1	2	6	Flake	Complete flake	Quartz	8	6.9	2.7	0.13	2.9	1.7	Plain	Absent	Step		Atypical termination
202	1	2	6	Debris	Fragment	Quartz	5.6	3.4	1.1	0.03							
203	1	2	6	Debris	Fragment	Quartz	5.1	3.5	1.2	0							
204	1	2	6	Debris	Fragment	Quartz	5.3	3.5	1	0							
205	1	2	6	Debris	Fragment	Quartz	4.3	2.7	0.6	0							
206	1	2	6	Debris	Fragment	Quartz	6.8	3.6	1.3	0.03							
207	1	2	7	Debris	Fragment	Dolerite	5.7	3.8	0.6	0							
208	1	2	7	Debris	Fragment	Chert	6.8	4.2	1.1	0							
209	1	2	7	Debris	Undiagnostic fragment	Quartz	13	10.5	6.2	0.77							
210	1	2	7	Debris	Undiagnostic fragment	Quartz	12.2	10.3	6	0.53							
211	1	2	7	Debris	Undiagnostic fragment	Quartz	11.4	5	3.8	0.19							
212	1	2	7	Debris	Undiagnostic fragment	Quartz	7.9	6.3	5.4	0.19							
213	1	2	7	Debris	Undiagnostic fragment	Quartz	8.7	3.8	2.7	0.07							
214	1	2	7	Debris	Undiagnostic fragment	Quartz	9.7	5.4	4	0.19							
215	1	2	7	Debris	Undiagnostic fragment	Quartz	11.8	6.8	3.6	0.32							
216	1	2	7	Debris	Fragment	Quartz	11.2	4.3	3.3	0.14							
217	1	2	7	Debris	Fragment	Quartz	11.7	8.1	4.3	0.33							
218	1	2	7	Debris	Fragment	Quartz	7.8	7.7	2.3	0.15							

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
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219	1	2	7	Debris	Fragment	Quartz	8.1	4.1	1.9	0.07							
220	1	2	7	Debris	Fragment	Quartz	8.3	5.5	1.1	0.05							Clear quartz
221	1	2	7	Debris	Fragment	Quartz	7.5	6	1.5	0.08							Clear quartz
222	1	2	7	Debris	Fragment	Quartz	5.3	3.2	0.5	0							Clear quartz
223	1	2	7	Debris	Fragment	Quartz	8.8	5.4	1.6	0.06							
224	1	2	7	Debris	Fragment	Quartz	8.3	6.7	1.7	0.06							
225	1	2	7	Debris	Fragment	Quartz	6.6	4	1.5	0.05							
226	1	2	7	Debris	Fragment	Quartz	7.6	4.3	1.1	0.04							
227	1	2	7	Debris	Fragment	Quartz	6.2	4	1	0.02							
228	1	2	7	Debris	Fragment	Quartz	7.7	3.4	1.9	0.03							
229	1	2	7	Debris	Fragment	Quartz	6.3	4.8	0.8	0.02							
230	1	2	7	Debris	Fragment	Quartz	7.4	5.1	1.2	0.04							
231	1	2	7	Debris	Fragment	Quartz	5.9	3.2	1.4	0.03							
232	1	2	7	Debris	Fragment	Quartz	7.5	4.9	1.4	0.4							
233	1	2	7	Debris	Fragment	Quartz	7.1	2.4	1.4	0.03							
234	1	2	7	Debris	Fragment	Quartz	4.7	2.7	1.7	0							
235	1	2	7	Debris	Fragment	Quartz	5.3	3.6	0.8	0							
236	1	2	7	Debris	Fragment	Quartz	6.4	3.8	1	0.02							
237	1	2	7	Debris	Fragment	Quartz	5.6	4.5	1.2	0.02							
238	1	2	7	Debris	Fragment	Quartz	7	1.6	1.5	0							
239	1	2	7	Debris	Fragment	Quartz	4.5	3.4	1.8	0							
240	1	2	7	Debris	Fragment	Quartz	5.2	3.9	1.9	0.04							
241	1	2	7	Debris	Fragment	Quartz	4.4	3.1	0.4	0							
242	1	2	7	Debris	Fragment	Quartz	4.5	2.9	0.5	0							
243	1	2	7	Debris	Fragment	Quartz	3.6	2.7	0.6	0							
244	1	2	7	Debris	Fragment	Quartz	3.5	2.4	0.4	0							
245	1	2	7	Flake	Complete flake	Quartz	7.2	6.8	1.6	0.09	4.3	0.7	Crushed	Absent	Feather		

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
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246	1	2	7	Flake	Complete flake	Quartz	8.8	4.9	1.1	0.06	2.6	0.8	Plain	Absent	Feather		
247	1	2	7	Flake	Bipolar	Quartz	8.7	5	1.9	0.09	3.5	0.6	Ridge	Absent	Crushed		
248	1	2	7	Flake	Complete flake	Quartz	12.9	14.2	5.1	0.95	7.4	1.8	Faceted	Present	Feather		
249	1	2	7	Flake	Complete flake	Quartz	14.5	9.3	3.4	0.5	3.4	2.9	Plain	Absent	Feather		
250	1	2	7	Flake	Proximal flake	Quartz	11.3	8.9	3.3	0.34	2.7	1.2	Crushed	Absent	Other		Termination splintered
251	1	2	7	Flake	Proximal flake	Quartz	11.7	11.2	3	0.49	4.6	2.8	Plain	Absent	Step		
252	1	2	7	Flake	Complete flake	Quartz	9.9	16.2	3.7	0.58	8.9	4.1	Plain	Absent	Feather		
253	1	2	7	Flake	Complete flake	Quartz	11.4	18.3	4.8	1.24	6.3	2.6	Plain	Absent	Feather		
254	1	2	7	Flake	Complete flake	Quartz	16.8	14	2.4	0.76	7.2	1.6	Gull wing	Absent	Feather		
255	1	2	7	Core	Bipolar	Quartz	23.4	16.2	9.5	3.72						1	Split pebble. 50% cortex on dorsal surface
256	1	2	7	Tool/Retouched	Other	Quartz	19	11.4	3.4	0.7					Feather		Flat adze. Retouch quadrants 2 and 4
257	1	2	7	Tool/Retouched	Other	Quartz	15.7	8.6	3.4	0.54	6.9	2.9	Plain	Absent	Hinge		Concave scraper on flake. Platform has 'double bulb'. Retouch Quadrant 4
258	1	2	7	Core	Core fragment	Quartz	22.9	10.5	10.4	2.03							In situ #4

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
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259	1	2	7	Tool/Retouched	Undiagnostic ret/util.	Quartz	20.1	9.2	2.3	0.47							in situ #5. This artefact is naturally backed and shows edge damage/retouch along the chord. Retouch quadrant 3 and 4
260	1	2	7	Core	Core fragment	Quartz	19.2	12	6.2	1.58							In situ #6. Possible bipolar core fragment.
261	1	2	7	Flake	Complete flake	Quartz	4.3	8	1.2	0.06	3.9	2	Plain	Absent	Feather		In situ #7.
262	1	2	7	Core	Core fragment	Quartz	13.2	7.1	5.9	0.5							In situ #9.
263	1	2	7	Flake	Complete flake	Quartz	10.1	12.7	2.1	0.42	8.9	3.2	Faceted	Absent	Feather		In situ #10.
264	1	2	7	Debris	Fragment	Quartz	14.3	9.9	4.4	0.54							In situ #12.
265	1	2	8	Debris	Fragment	Quartz	20.7	8.8	2.8	0.56							In situ #15.
266	1	2	8	Core	Bipolar	Quartz	15.4	8.4	4.7	0.79							Split core.
267	1	2	8	Debris	Undiagnostic ret/util.	Quartz	8.7	7.5	3.8	0.23							
268	1	2	8	Core	Bipolar	Quartz	12	7.1	3.7	0.32							Very similar to #266. Does not refit.
269	1	2	8	Debris	Fragment	Quartz	8.2	3.6	1.1	0.05							
270	1	2	8	Debris	Fragment	Quartz	5.6	2.4	1	0							
271	1	2	8	Debris	Fragment	Quartz	4.7	2.3	1.7	0							
272	1	2	9	Flake	Complete flake	Quartz	12.8	6.5	2	0.23							Clear quartz

ID and context				Artefact type and Raw material			Dimensions				Flake attributes - platform and termination					Cores only	Supplementary information
ID	Count	Square	Excavation unit	Class	Type	Lithology	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Platform width (mm)	Platform thickness (mm)	Platform type	Overhang removal	Termination type	Core - N of platforms	Comments
273	1	2	9	Flake	Distal flake	Quartz	13.6	9.7	4.4	0.38					Feather		Clear quartz
274	1	2	9	Debris	Fragment	Quartz	12	2.8	1.4	0.06							
275	1	2	9	Debris	Fragment	Quartz	6.3	4	0.8	0.03							
276	1	2	9	Debris	Fragment	Quartz	5.4	3.9	0.8	0							
277	1	2	11	Core	Bipolar	Quartz	12.9	6.8	4.3	0.24							Bipolar core fragment
278	1	2	11	Debris	Fragment	Quartz	6.4	4.6	0.9	0							
279	1	2	12	Debris	Fragment	Quartz	10.2	3.4	1.7	0.06							
280	1	2	12	Debris	Fragment	Quartz	5.1	4.1	2	0.04							

APPENDIX FOUR: RADIOCARBON AND OSL DATING REPORTS

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Private Bag 3105
Hamilton,
New Zealand.
Ph +64 7 838 4278
email c14@waikato.ac.nz

Radiocarbon Dating Laboratory

Thursday, 29 April 2021

Report on Radiocarbon Age Determination for Wk- 52501

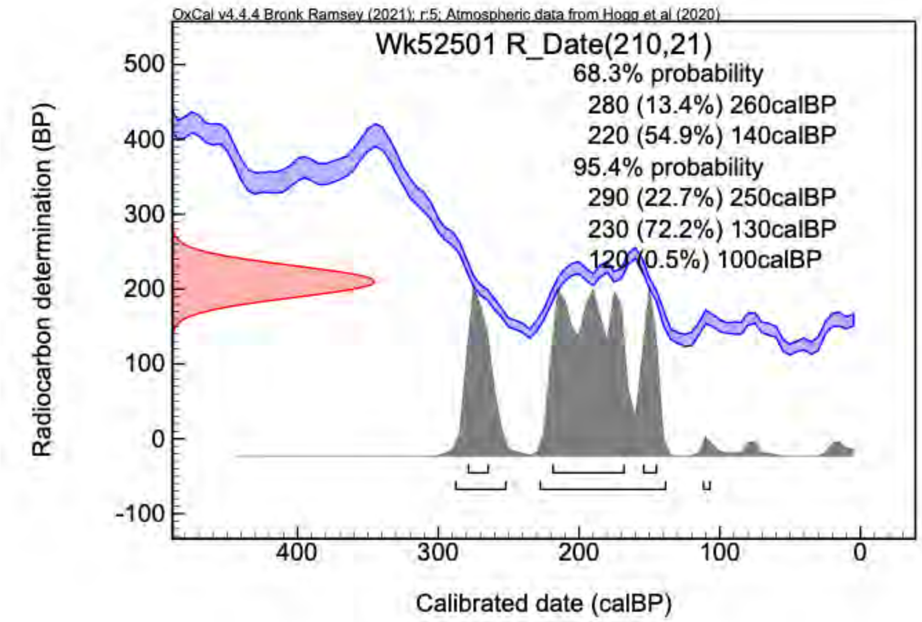
Submitter	F. Hook
Submitter's Code	HopeRd_SQ1_EU6_Bag 5
Site & Location	Hope Road, Australia
Sample Material	Charcoal
Physical Pretreatment	Sample cleaned.
Chemical Pretreatment	Sample washed in hot HCl, rinsed and treated with multiple hot NaOH washes. The NaOH insoluble fraction was treated with hot HCl, filtered, rinsed and dried.

$D^{14}C$	-25.8 ±	2.6 ‰
$F^{14}C\%$	97.4 ±	0.3 %
Result	**210 ± 21 BP**	

(AMS measurement)

Comments

Please note: The Carbon-13 stable isotope value ($\delta^{13}C$) was measured on prepared graphite using the AMS spectrometer. The radiocarbon date has therefore been corrected for isotopic fractionation. However the AMS-measured $\delta^{13}C$ value can differ from the $\delta^{13}C$ of the original material and it is therefore not shown.



- Explanation of the calibrated Oxcal plots can be found at the Oxford Radiocarbon Accelerator Unit's calibration web pages (http://c14.arch.ox.ac.uk/embed.php?File=explanation.php)
- Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation, $\delta^{13}C$, is expressed as ‰ wrt PDB and is measured on sample CO_2.
- $F^{14}C\%$ is also known as *Percent Modern Carbon (pMC).*

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Thursday, 29 April 2021

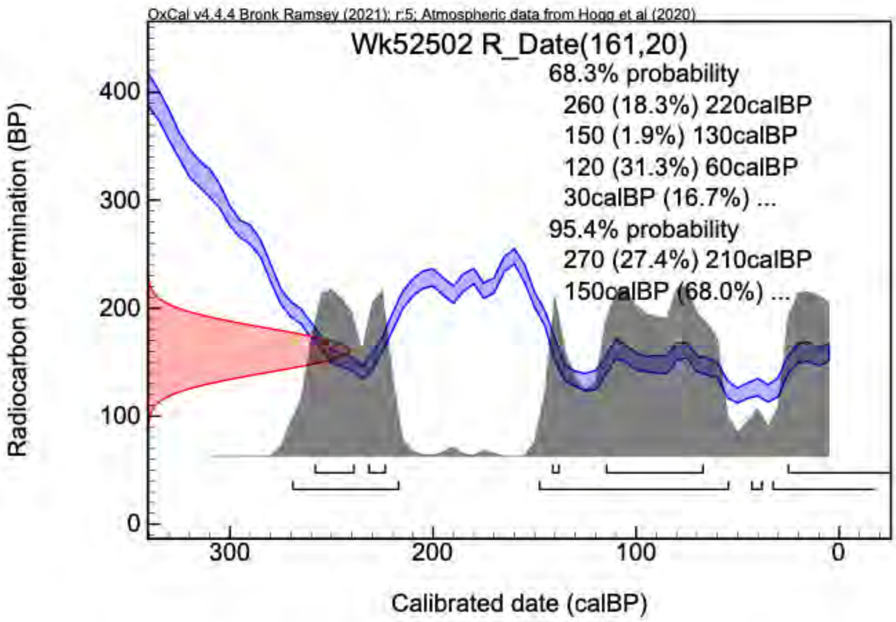
Report on Radiocarbon Age Determination for Wk- 52502

Submitter	F. Hook
Submitter's Code	HopeRd_SQ1_EU4_Bag3
Site & Location	Hope Road, Australia
Sample Material	Charcoal
Physical Pretreatment	Sample cleaned.
Chemical Pretreatment	Sample washed in hot HCl, rinsed and treated with multiple hot NaOH washes. The NaOH insoluble fraction was treated with hot HCl, filtered, rinsed and dried.

$D^{14}C$	-19.9 ± 2.5 ‰
$F^{14}C\%$	98.0 ± 0.2 %
Result	**161 ± 20 BP**

(AMS measurement)

Comments
Please note: The Carbon-13 stable isotope value ($\delta^{13}C$) was measured on prepared graphite using the AMS spectrometer. The radiocarbon date has therefore been corrected for isotopic fractionation. However the AMS-measured $\delta^{13}C$ value can differ from the $\delta^{13}C$ of the original material and it is therefore not shown.



- Explanation of the calibrated Oxcal plots can be found at the Oxford Radiocarbon Accelerator Unit's calibration web pages (http://c14.arch.ox.ac.uk/embed.php?File=explanation.php)
- Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation, $\delta^{13}C$, is expressed as ‰ wrt PDB and is measured on sample CO_2.
- $F^{14}C\%$ is also known as *Percent Modern Carbon (pMC).*

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Radiocarbon Dating Laboratory

Thursday, 29 April 2021

Report on Radiocarbon Age Determination for Wk- 52503

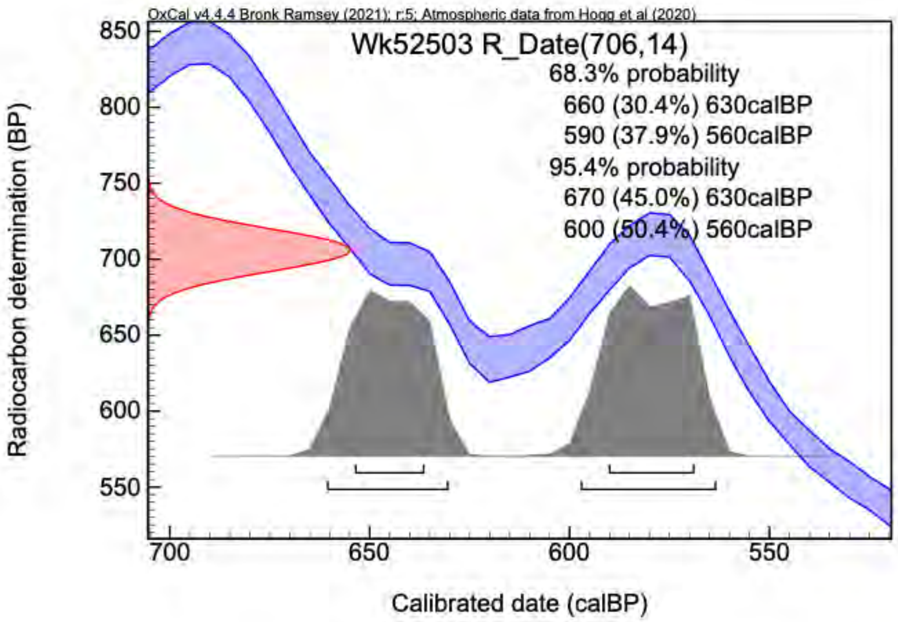
Submitter	F. Hook
Submitter's Code	HopeRd_SQ2_EU4_Bag1
Site & Location	Hope Road, Australia
Sample Material	Charcoal
Physical Pretreatment	Sample cleaned.
Chemical Pretreatment	Sample washed in hot HCl, rinsed and treated with multiple hot NaOH washes. The NaOH insoluble fraction was treated with hot HCl, filtered, rinsed and dried.

$D^{14}C$	-84.1 ±	1.6 ‰
$F^{14}C\%$	91.6 ±	0.2 %
Result	**706 ± 14 BP**	

(AMS measurement)

Comments

Please note: The Carbon-13 stable isotope value ($\delta^{13}C$) was measured on prepared graphite using the AMS spectrometer. The radiocarbon date has therefore been corrected for isotopic fractionation. However the AMS-measured $\delta^{13}C$ value can differ from the $\delta^{13}C$ of the original material and it is therefore not shown.



- Explanation of the calibrated Oxcal plots can be found at the Oxford Radiocarbon Accelerator Unit's calibration web pages (http://c14.arch.ox.ac.uk/embed.php?File=explanation.php)
- Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation, $\delta^{13}C$, is expressed as ‰ wrt PDB and is measured on sample CO_2.
- $F^{14}C\%$ is also known as *Percent Modern Carbon (pMC).*

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Te Whare Wānanga o Waikato

Private Bag 3105
Hamilton,
New Zealand.
Ph +64 7 838 4278
email c14@waikato.ac.nz

Radiocarbon Dating Laboratory

Thursday, 29 April 2021

Report on Radiocarbon Age Determination for Wk- 52504

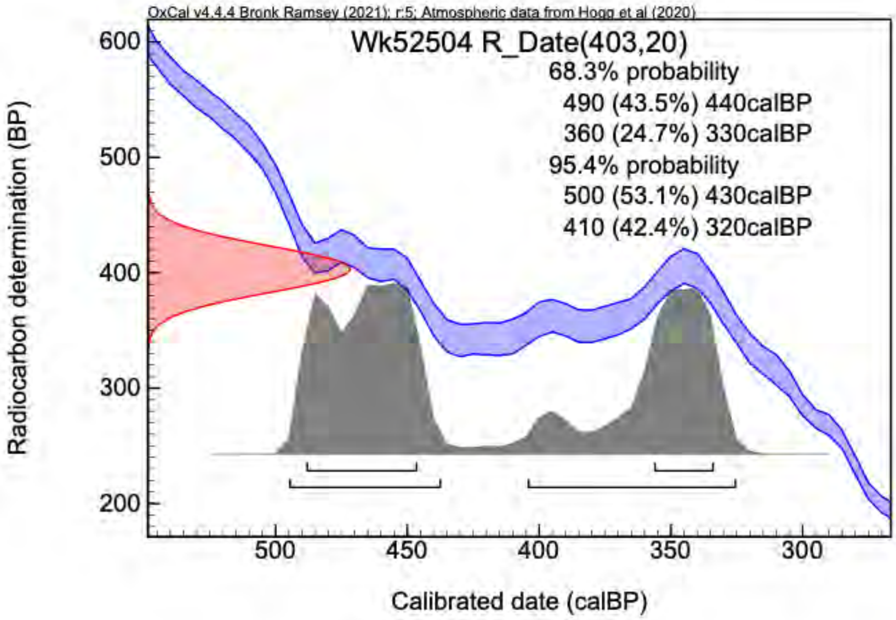
Submitter	F. Hook
Submitter's Code	HopeRd_SQ2_EU6_Bag3
Site & Location	Hope Road, Australia
Sample Material	Charcoal
Physical Pretreatment	Sample cleaned.
Chemical Pretreatment	Sample washed in hot HCl, rinsed and treated with multiple hot NaOH washes. The NaOH insoluble fraction was treated with hot HCl, filtered, rinsed and dried.

$D^{14}C$	-49.0 ±	2.4 ‰
$F^{14}C\%$	95.1 ±	0.2 %
Result	**403 ± 20 BP**	

(AMS measurement)

Comments

Please note: The Carbon-13 stable isotope value ($\delta^{13}C$) was measured on prepared graphite using the AMS spectrometer. The radiocarbon date has therefore been corrected for isotopic fractionation. However the AMS-measured $\delta^{13}C$ value can differ from the $\delta^{13}C$ of the original material and it is therefore not shown.



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- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation, $\delta^{13}C$, is expressed as ‰ wrt PDB and is measured on sample CO_2.
- $F^{14}C\%$ is also known as *Percent Modern Carbon (pMC).*

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Te Whare Wānanga o Waikato

Private Bag 3105
Hamilton,
New Zealand.
Ph +64 7 838 4278
email c14@waikato.ac.nz

Radiocarbon Dating Laboratory

Thursday, 29 April 2021

Report on Radiocarbon Age Determination for Wk- 52505

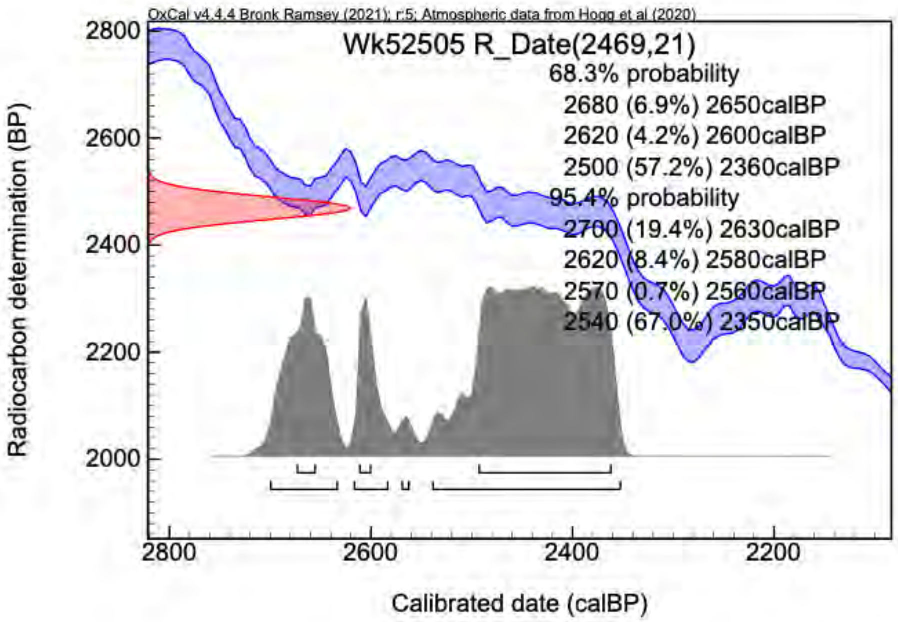
Submitter	F. Hook
Submitter's Code	HopeRd_SQ2_EU8_Bag14
Site & Location	Hope Road, Australia
Sample Material	Charcoal
Physical Pretreatment	Sample cleaned.
Chemical Pretreatment	Sample washed in hot HCl, rinsed and treated with multiple hot NaOH washes. The NaOH insoluble fraction was treated with hot HCl, filtered, rinsed and dried.

$D^{14}C$	-264.6 ± 1.9 ‰
$F\ ^{14}C\%$	73.5 ± 0.2 %
Result	**2469 ± 21 BP**

(AMS measurement)

Comments

Please note: The Carbon-13 stable isotope value ($\delta^{13}C$) was measured on prepared graphite using the AMS spectrometer. The radiocarbon date has therefore been corrected for isotopic fractionation. However the AMS-measured $\delta^{13}C$ value can differ from the $\delta^{13}C$ of the original material and it is therefore not shown.



- Explanation of the calibrated Oxcal plots can be found at the Oxford Radiocarbon Accelerator Unit's calibration web pages (http://c14.arch.ox.ac.uk/embed.php?File=explanation.php)
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- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation, $\delta^{13}C$, is expressed as ‰ wrt PDB and is measured on sample CO_2.
- $F\ ^{14}C\%$ is also known as *Percent Modern Carbon (pMC).*

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Te Whare Wānanga o Waikato

Private Bag 3105
Hamilton,
New Zealand.
Ph +64 7 838 4278
email c14@waikato.ac.nz

Radiocarbon Dating Laboratory

Thursday, 29 April 2021

Report on Radiocarbon Age Determination for Wk- 52506

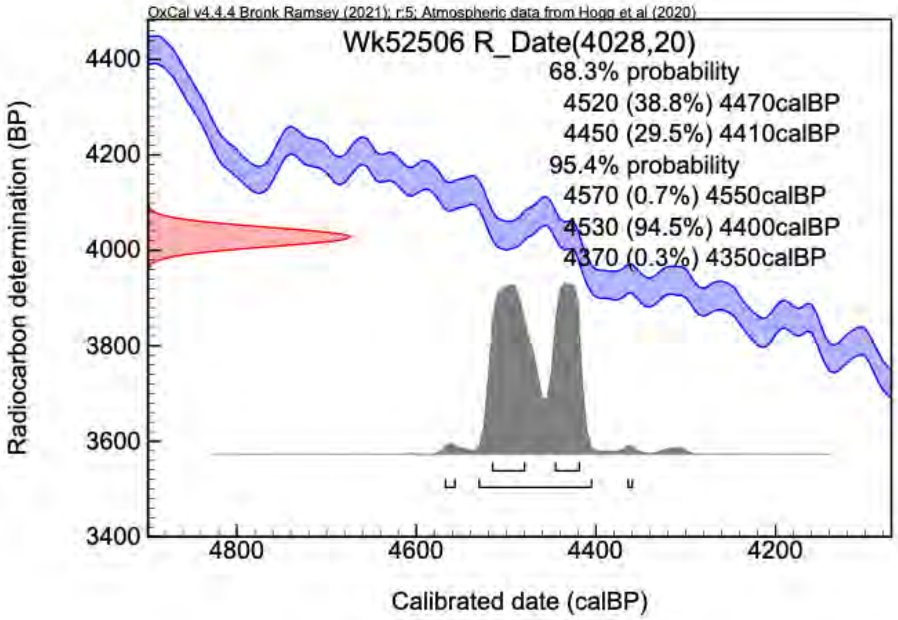
Submitter	F. Hook
Submitter's Code	HopeRd_SQ2_EU10_Bag16
Site & Location	Hope Road, Australia
Sample Material	Charcoal
Physical Pretreatment	Sample cleaned.
Chemical Pretreatment	Sample washed in hot HCl, rinsed and treated with multiple hot NaOH washes. The NaOH insoluble fraction was treated with hot HCl, filtered, rinsed and dried.

$D^{14}C$	-394.4 ± 1.5 ‰
$F^{14}C$%	60.6 ± 0.2 %
Result	**4028 ± 20 BP**

(AMS measurement)

Comments

Please note: The Carbon-13 stable isotope value ($\delta^{13}C$) was measured on prepared graphite using the AMS spectrometer. The radiocarbon date has therefore been corrected for isotopic fractionation. However the AMS-measured $\delta^{13}C$ value can differ from the $\delta^{13}C$ of the original material and it is therefore not shown.



- Explanation of the calibrated Oxcal plots can be found at the Oxford Radiocarbon Accelerator Unit's calibration web pages (http://c14.arch.ox.ac.uk/embed.php?File=explanation.php)
- Result is *Conventional Age or Percent Modern Carbon (pMC)* following Stuiver and Polach, 1977, Radiocarbon 19, 355-363. This is based on the Libby half-life of 5568 yr with correction for isotopic fractionation applied. This age is normally quoted in publications and must include the appropriate error term and Wk number.
- Quoted errors are 1 standard deviation due to counting statistics multiplied by an experimentally determined Laboratory Error Multiplier.
- The isotopic fractionation, $\delta^{13}C$, is expressed as ‰ wrt PDB and is measured on sample CO_2.
- $F^{14}C$% is also known as *Percent Modern Carbon (pMC).*

AUSTRALIAN RESEARCH COUNCIL
Centre of Excellence for Australian Biodiversity and Heritage

OSL dating report for Archae-aus – Fiona Hook

Hope Road, Perth, WA

23 July 2021

Zenobia Jacobs
University of Wollongong

Abstract

Optically stimulated luminescence (OSL) dating was applied to individual grains of quartz extracted from three sediment samples that were collected from a homogeneous sand deposit at Hope Road in Perth, Western Australia. All samples responded well to OSL measurement (i.e., relatively bright OSL signals and decay and dose response curves typical of quartz grains). The equivalent dose (D_e) distributions for all three samples suggest post-depositional mixing. The D_e distributions of each sample consist of 2–3 discrete components, with one dominant component that we interpret to represent the original depositional event. In each sample, the dominant component represents the youngest grains that were then post-depositionally mixed together with grains from an older deposit. Reliable ages could be determined for all samples using the finite mixture modelled D_e value of the dominant component. Minimum D_e values were also calculated as a conservative estimate of D_e and age. Environmental dose rates were estimated from measurements in the laboratory using two different techniques – GM-25-5 beta counting and thick source alpha counting. There is little variation in the beta and gamma dose rate within and between samples. The final age estimates for the three samples are 10.0 ± 0.8 ka for OSL 1 from a depth of 94 cm below surface, 8.7 ± 0.8 ka for OSL 2 from 78 cm below surface and 6.7 ± 0.6 ka for OSL 3 from 64 cm below surface. Deposition of the sand within this 30 cm depth interval, therefore, occurred during the early to mid-Holocene period. The minimum ages as conservative estimates are also consistent with this period of deposition.

Introduction

Three samples were submitted for single-grain OSL dating by Fiona Hook from *Archae-aus*. All OSL dating work was carried out at the University of Wollongong (UOW) luminescence dating laboratory in the Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage (CABAH). Upon arrival at the laboratory, samples were allocated CABAH numbers (Table 1), which are used in this report in tandem with the field codes assigned by the excavators. This report provides a brief summary of the procedures employed and results obtained for the samples.

Sample locations

Three samples were collected from a cleaned profile wall of a single excavation square at Hope Road, Perth, WA. Stainless steel tubes were hammered into the section wall, labelled and sealed. Samples for OSL dating were collected at depths of 64, 78 and 94 cm below surface. Sample field and lab codes, together with mid-point depths of the sample tubes below ground surface are provided in Table 1.

Table 1: *Sample field and lab codes, and depth below surface.*

Field Code	CABAH code	Depth below surface (cm)
Hope Road_SQ1_OSL#1	CABAH-986	94
Hope Road_SQ1_OSL#2	CABAH-987	78
Hope Road_SQ1_OSL#3	CABAH-988	64

Optically stimulated luminescence (OSL) dating

OSL dating provides a means of determining burial ages for sediments and associated artefacts and fossils (Huntley et al., 1985; Aitken, 1998; Duller, 2004; Jacobs and Roberts, 2007; Wintle, 2014; Roberts et al., 2015; Athanassas and Wagner, 2016). The method is based on the time-dependent increase in the number of trapped electrons induced in mineral grains—such as quartz—by low levels of ionising radiation from the decay of natural uranium, thorium and potassium in the surrounding deposits, and from cosmic rays. The time elapsed since the light-sensitive electron traps were emptied can be determined from measurements of the luminescence signals from quartz (optically stimulated luminescence, OSL) from which the equivalent dose (D_e) is estimated, together with determinations of the radioactivity of the sample and the material surrounding it to a distance of ~30 cm (the environmental dose rate). The luminescence 'clock' is reset by just a few seconds (quartz) of exposure to sunlight. The D_e divided by the environmental dose rate gives the burial time of the grains in calendar years ago.

We exploited the inherent benefits of single-grain dating that include the identification and elimination of individual grains that exhibit aberrant luminescence characteristics (Jacobs et al., 2006; Jacobs and Roberts, 2007; Duller, 2008) and the use of D_e distributions to investigate the potential impact that depositional and post-depositional processes, such as sediment mixing or insufficient exposure to sunlight (partial bleaching), may have on age determination.

Sample preparation and analytical facilities

All samples were prepared using routine optical dating procedures (Aitken, 1998). Samples were first treated with HCl acid and H_2O_2 solution to remove carbonates and organic matter, respectively. The remaining sediment was then dried and sieved to obtain a range of sand-sized grain fractions. Grains of 180–212 µm in diameter were used for dating. The quartz grains were separated from heavy minerals in the sample using a sodium polytungstate solution of density 2.70 g/cm^3. The quartz grains were etched using 40% HF acid for 45 min to dissolve any remaining feldspar grains that may be present in the quartz separates, and to remove the alpha-irradiated layer around the surface of each grain. The HF-etched quartz grains were then rinsed in HCl acid to remove any precipitated fluorides and sieved again.

Single-grain OSL measurements of D_e were made for all quartz samples. OSL measurements were made on an automated Risø TL-DA-20 luminescence reader equipped with a focused green (532 nm) laser for single-grain stimulation (Bøtter-Jensen et al., 2003). Luminescence emissions were detected using an Electron Tubes Ltd 9235QA photomultiplier tube. The OSL signals were detected through Hoya U-340 filters. Single-grain measurements were made using aluminium discs drilled with 100 holes, each 300 µm in diameter and 300 µm deep (Bøtter-Jensen et al., 2003). Irradiations were carried out inside each luminescence reader using $^{90}Sr/^{90}Y$ beta sources that have been calibrated using a range of known gamma-irradiated quartz. Spatial variations in beta dose rate to individual grain positions were taken into account for D_e determination (Ballarini et al., 2006).

Equivalent dose (D_e) determination

All single-grain quartz measurements were made using the single-aliquot regenerative-dose (SAR) procedure (Galbraith et al., 1999; Murray and Wintle, 2000). The SAR procedure involves measuring the OSL signals from the natural (burial) dose (L_n) and from a series of regenerative doses (L_x) that adequately bracket the D_e value (given in the laboratory by means of the calibrated $^{90}Sr/^{90}Y$ beta source) (Fig. 1). Grains were preheated at 260°C for 10 s prior to optical stimulation by an intense, green (532 nm) laser beam for 2 s at 125°C. A fixed test dose (~9 Gy, preheated at 160°C for 5 s) was given after each natural and regenerative dose, and the induced OSL signals (T_n and T_x) were used to correct for any sensitivity changes during the SAR sequence. A duplicate regenerative dose was included in the sequence to check on the adequacy of this sensitivity correction, and a 'zero regenerative dose' (0 Gy) measurement cycle was included to monitor the extent of any 'recuperation' induced by the preheat treatment. As a check on possible contamination of the acid-etched quartz grains by other mineral inclusions, we also applied the OSL IR depletion ratio test (Duller, 2003) to each grain at the end of the SAR sequence, using an infrared exposure of 40 s at 50°C.

A total of 1,500 individual quartz grains were measured; 500 per sample. Not every grain that we measure is useful as a chronometer. Most grains have inherent luminescence properties that make them unsuitable and that may give rise to inaccurate estimates of D_e. These unsuitable grains are identified based on known characteristics and the outcomes of tests build into the measurement sequences (e.g., the recycling ratio test, OSL-IR depletion ratio test and recuperation ratio test). A series of quality-assurance criteria (Jacobs et al., 2006; Li et al., 2017) have been developed to objectively identify and reject such grains. Grains were rejected for the following reasons:

1. Initial T_n signal is less than 3σ above the corresponding background count, or the relative error on T_n is >25%.
2. Recuperation ratio (i.e., the ratio of the L_x/T_x values for the 0 Gy and maximum regenerative doses) is >5%.
3. Recycling ratio (i.e., the ratio of L_x/T_x values for the duplicate regenerative doses) is not consistent with unity at 2σ.
4. OSL IR depletion ratio is more than 2σ less than unity (Duller, 2003).
5. L_x/T_x ratios are too scattered to be reliably fitted with a curve, or have a large figure-of-merit (FOM) value with an upper limit of 10%.
6. D_e value is obtained by extrapolation of the fitted DRC, rather than interpolation among the regenerative-dose signals.
7. L_n/T_n ratio is statistically consistent with, or higher than, the saturation level of the corresponding DRC, so that a finite D_e value and error estimate could not be obtained.

Table 2 lists the numbers of individual grains measured, rejected and accepted for D_e determination for each of the samples, and the reasons for grain rejection. By far the most grains (45–53%) are rejected because they simply do not emit light or emit so little light that the counting statistics are too poor to obtain meaningful information (criterion 1). All accepted grains provide reliable estimates of D_e.

Table 2: *Number of individual quartz grains measured, rejected and accepted for each, together with the reasons for grain rejection (see text for reference to numbers).*

Sample	**No. of grains measured**	**Rejection criteria (see footnotes)**							**Sum of grains rejected**	**No. of grains accepted**
		1	**2**	**3**	**4**	**5**	**6**	**7**		
CABAH-986	500	237	4	74	18	33	0	2	368	132
CABAH-987	500	223	3	55	17	50	0	3	350	150
CABAH-988	500	265	3	60	9	28	0	3	368	132

To calculated D_e values from each of the accepted grains, we first estimated L_n, L_x, T_n and T_x values from the first 0.22 s of OSL decay, with the mean count recorded over the last 0.3 s subtracted as background. Sensitivity-corrected (L_x/T_x) dose response curves (DRCs) were then constructed from the L_x and T_x OSL signals, using a general-order kinetic (GOK) function (Guralnik et al., 2015), and the sensitivity-corrected natural OSL signal (L_n/T_n) projected onto the fitted DRC to estimate the D_e value by interpolation (right-hand column in Fig. 1). All data analyses, including curve fitting, D_e determination and error estimations, were achieved using the functions implemented in the R-package 'numOSL' (Peng et al., 2013).

Fig. 1 (left-hand column) shows the natural and regenerative dose OSL decay curves for a representative quartz grain from each of the samples. The OSL decay curves exhibit a range of shapes, but are generally quite reproducible and decay rapidly to instrumental background, with less than ~5% of the initial signal remaining after 0.3 s of optical stimulation. Fig. 1 (right-hand column) shows the corresponding dose response curves for the same representative grains. The majority of dose response curves have very similar shapes and continue to grow far beyond the range of D_e values for samples in this study.

The performance of the single-grain OSL procedure described above, including the rejection criteria, was tested using a dose recovery test (Galbraith et al., 1999) on one sample (OSL 2). The grains were first bleached for two days in natural sunlight and then given a beta dose of 100 s (~12 Gy) that act as a surrogate 'natural' dose. Five hundred grains were measured using the procedure outlined above, using a preheat combination of 260°C for 10 s (PH-1) and 160°C for 5 s (PH-2). The dose recovery ratio (i.e., the ratio of measured dose to given dose) of 0.99 ± 0.01 (n = 188), is consistent with unity at 2σ, demonstrating that the single-grain OSL procedure, including the choice of rejection criteria, can produce reliable estimates of measured dose for the samples measured in this study. The dose recovery results are shown in Fig. 2 where the dose recovery ratios (DR ratios) are presented as a radial plot. The overdispersion (OD) value is 9 ± 1%.

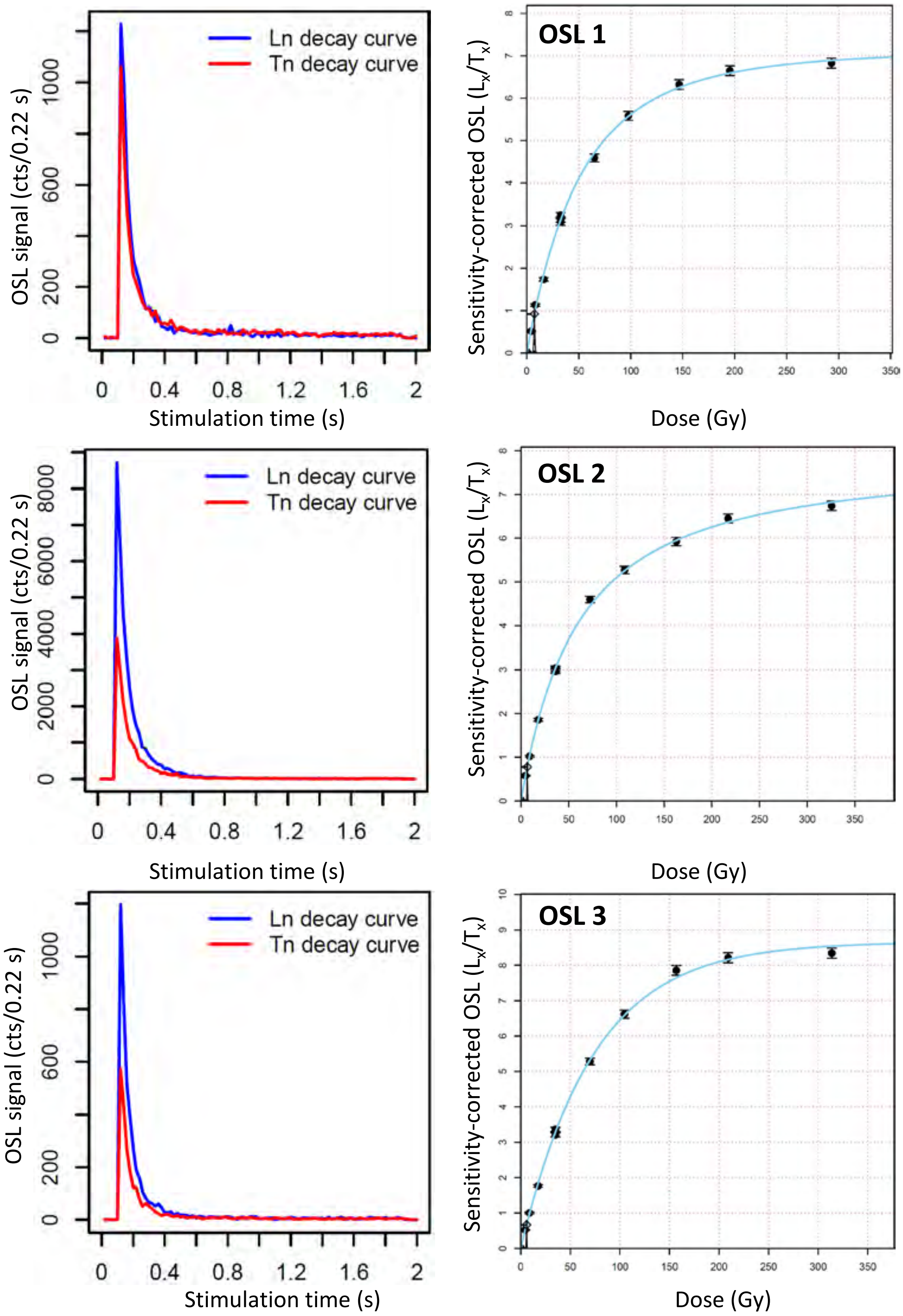


Figure 1: *(left-hand column) Representative OSL decay curves for the natural dose (blue) and test dose (~9 Gy; red) OSL signals for one bright grain from each sample, and (right-hand column) their corresponding full dose response curves.*

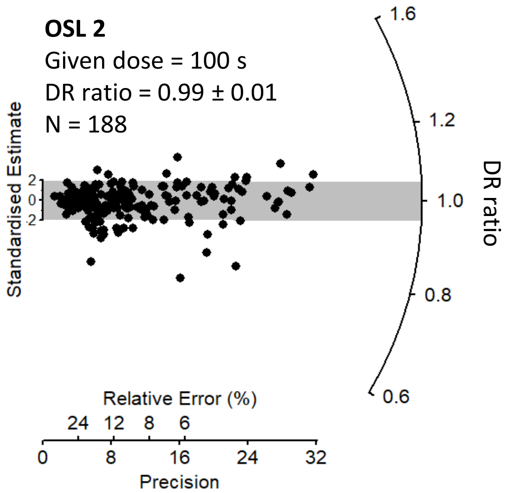


Figure 2: *Measured over given dose ratios (DR ratios) for individual grains from samples OSL 2. All grains consistent with the given dose fall within the grey band that is centred on a value of unity (ratio of 1).*

D_e results

Information about the numbers of grains measured and used for D_e determination are provided in Table 2. The overdispersion (OD) values calculated for the D_e distributions, and the D_e values ± 1σ uncertainties, using a range of different statistical models are presented in Table 3 for each sample.

It is commonplace in single-grain OSL dating for there to be some spread in the data due to natural variability and other complicating factors. To quantify the degree of spread, we routinely calculate the OD values for the D_e distributions of each sample. OD represent the relative standard deviation (i.e., the coefficient of variation) of the D_e distribution after accounting for the various measurement uncertainties (Galbraith et al., 2005; Galbraith and Roberts, 2012). Even for samples that have been well-bleached (zeroed by sunlight) prior to deposition and that remained undisturbed since burial, some degree of OD are present; typical values for such samples range between ~10 and 30%. The OD values for the samples in this study are 90 ± 6% (OSL 1), 114 ± 7% (OSL 2) and 106 ± 7% (OSL3), all much higher than expected for a sample that is well-bleached and undisturbed.

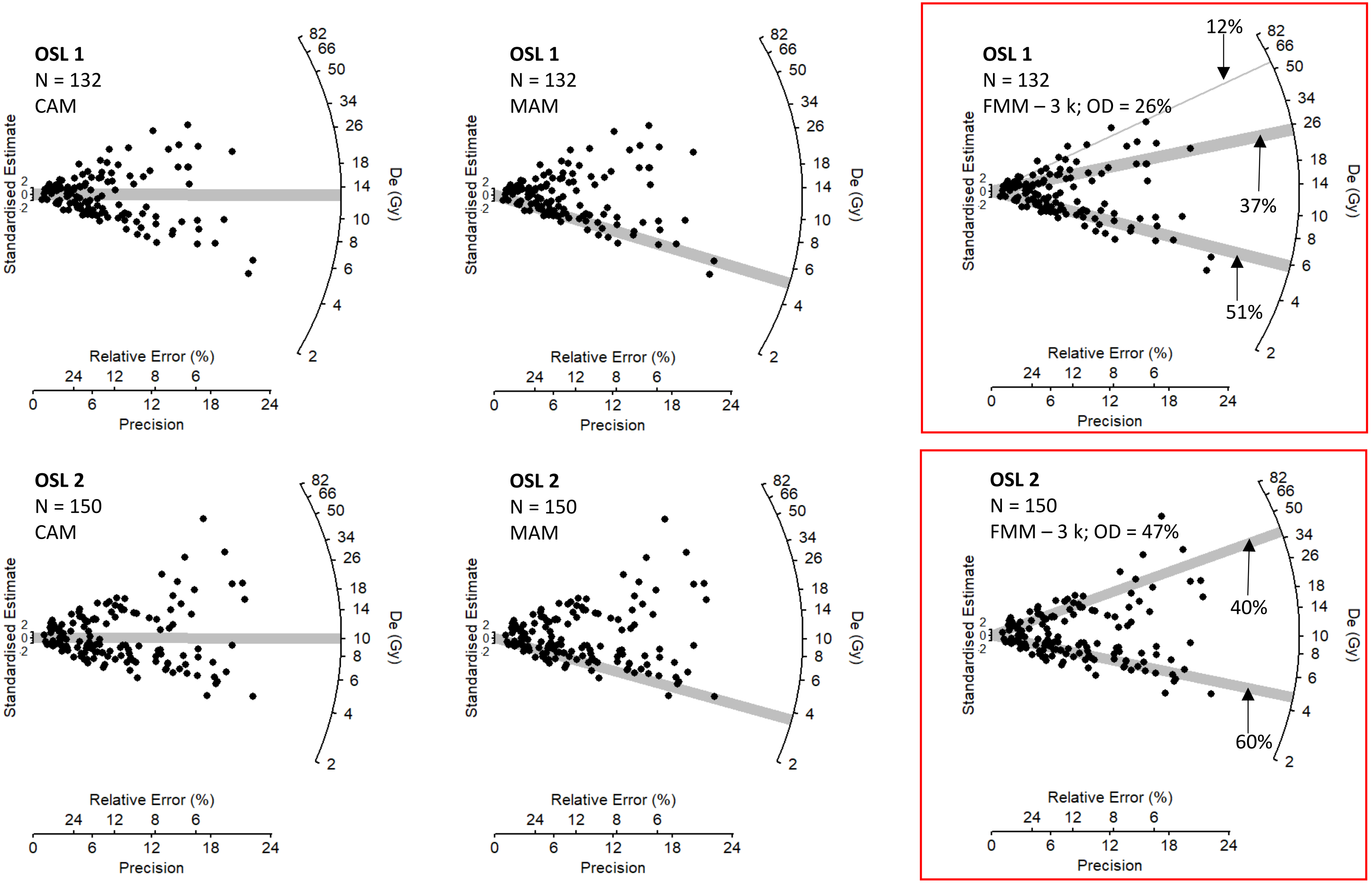
Information about potential reasons for OD can be obtained by looking at the shape and patterns of the D_e distributions for each sample when plotted as radial plots. Radial plots for all samples are presented in Fig. 3. In such plots, each point represents a single grain, for which the D_e can be read by extending a line from the 'standardised estimate' axis on the left-hand side to intersect the radial axis on the right; the point of intersection is the D_e. The uncertainty on this estimate can be read by extending a line vertically from the data point to intersect the horizontal axis running along the bottom of the plot. This axis shows the relative standard error in % (i.e., the standard error, in Gy, divided by the D_e estimate, in Gy, multiplied by 100) and its reciprocal (the 'precision'). In such plots, the most precise estimates fall to the right and the least precise to the left. If the D_e values were consistent with statistical expectation, then 95% of the points should scatter within any chosen band of width ±2 units projecting from the left-hand axis (see grey bands in Figs 2 and 3), and 0% overdispersion will be obtained.

To investigate the D_e distributions further for each of the samples, we calculated the final D_e value using three different statistical models (Table 3)— the central age model (CAM), minimum age model (MAM) and finite mixture model (FMM). We plotted the same D_e distribution for each sample three times in Fig. 3, but the position of the grey bands are different depending on the model used.

The first distribution (left in Fig. 3) has the grey band centred on a ***weighted mean*** D_e value determined using the CAM of Galbraith et al. (1999). The CAM assumes that the D_e values for all grains are centred on some average value of D_e (similar to the median) and the estimated standard error takes account of any D_e overdispersion; hence, the greater the OD, the larger the error. The CAM D_e and OD values are provided in Table 3. This method is preferred when D_e values are randomly and broadly scattered around a central value with few significant younger or older outliers. In other words, the D_e distribution suggests that the grains were well-bleached prior to deposition and remained relatively undisturbed since burial. This is not the case for any of the samples in this study, where the CAM D_e values go through the middle of the distributions and do not capture the majority of the grains.

The second distribution (middle in Fig. 3) has the grey band centred on a ***minimum*** D_e value determined using a 3-parameter minimum age model (MAM) and an estimate of σ_b = 0.2 (Galbraith et al., 1999; Galbraith & Roberts, 2012); the latter is based on the OD values typically obtained for samples that are well-bleached. Also provided in Table 3 is the *p0* values, which is an estimate of the proportion of grains consistent with the minimum D_e value. This method is only preferred where the depositional context suggest that partial bleaching is the most reasonable explanation of the distribution. The mode of deposition of the sand in this study is not known, but it is unlikely to have been partially bleached as this only really occurs in fluvial or marine settings where sand is transported in turbid water and where the UV light spectrum is cut-off. If this model is used for a reason other than partial bleaching, then the D_e value should be indicated with a greater than (>) symbol to indicate it is a minimum D_e value that will result in a minimum age estimate.

The third distribution (right in Fig. 3) has one or more grey bands or lines each centred on a weighted mean value representing a discrete D_e component determined using the finite mixture model (FMM) of Roberts et al. (2000). The optimal number of components (k), and optimal OD for the components are determined statistically using a combination of maximum log likelihood (llik) and Bayes Information Criterion (BIC) functions (see Galbraith & Roberts, 2012). For each sample, the model is run iteratively using combinations of 2–5 components and OD values ranging between 10 and 60%. The optimum combination using llik and BIC are what is used to then determine the weighted mean D_e value for each of the identified components. The D_e values for each component, the proportion of grains associated with the specific component and the OD value used for determination of the D_e values are provided in Table 3. The proportion of grains are also shown in Fig. 3. This model should only be applied to samples that show evidence for discrete/finite D_e components and where the context may suggest that a post-depositional event(s) led to mixing of grains from two or more discrete and finite age components. It should not be applied to D_e distributions that show a broad dose continuum, indicative of continuous mixing through bioturbation and/or soil formation.


OSL 1
N = 132
CAM
OSL 1
N = 132
MAM
OSL 1
N = 132
FMM – 3 k; OD = 26%
12%
37%
51%
OSL 2
N = 150
CAM
OSL 2
N = 150
MAM
OSL 2
N = 150
FMM – 3 k; OD = 47%
40%
60%
Standardised Estimate
Relative Error (%)
24 12 8 6
0 6 12 18 24
Precision
De (Gy)
82 66 50 34 26 18 14 10 8 6 4 2

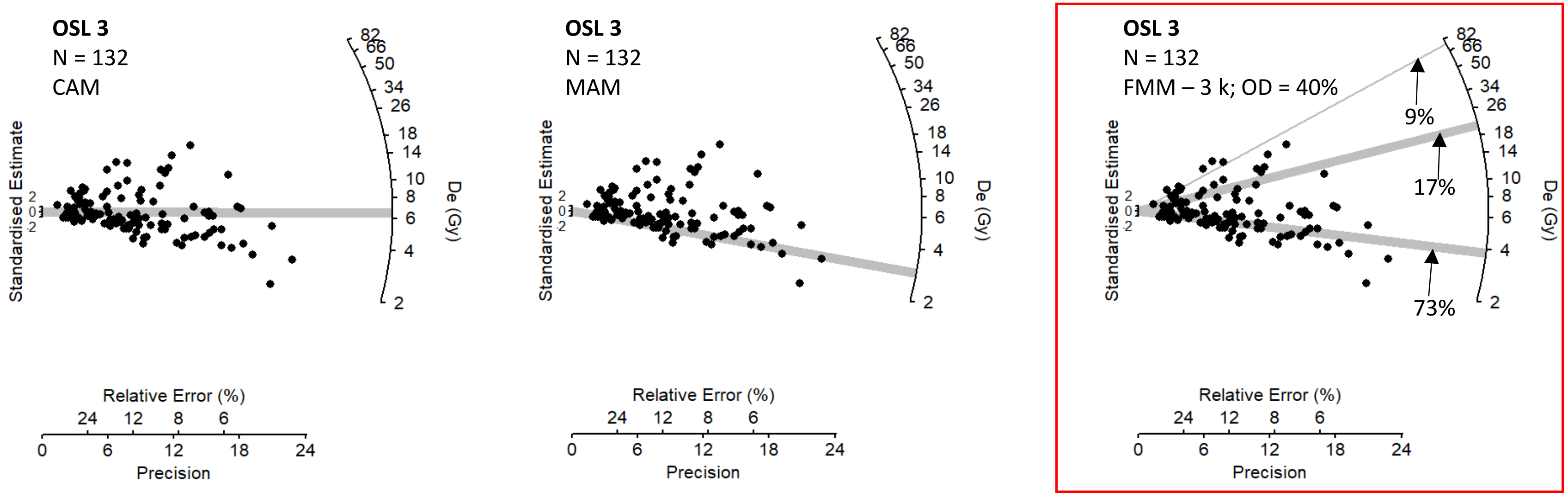


Figure 3: *Radial plots for the three samples measured in this study. The D_e distribution for each samples is displayed three times. On each occasion the grey bad is centred on the D_e value determined using one of three different statistical models. The radial plots on the left have the grey bands centred on the weighted mean D_e value of all grains using the CAM. The radial plots in the middle have their grey bands centred on the minimum age model (MAM) D_e value. The radial plots on the right have their grey bands centred on the weighted mean D_e (CAM) of two or more discrete components determined using the finite mixture model (FMM). Also shown are the proportion of grains that represent each of the components.*

Table 3: Equivalent dose (*D_e*) *and overdispersion (OD) values for each sample using different statistical models. Values in bold are the preferred estimates.*

Sample	CAM (Gy)	OD (%)	FMM-1 (Gy)	FMM-2 (Gy)	FMM-3 (Gy)	OD (%)	MAM (Gy)	*p0*
OSL 1	13.0 ± 1.1	90 ± 6	**5.9 ± 0.2 (51%)**	24.8 ± 1.7 (37%)	55.9 ± 7.4 (12%)	26	5.1 ± 0.3	0.26
OSL 2	10.0. ± 0.9	106 ± 7	**4.7 ± 0.3 (60%)**	37.2 ± 2.8 (40%)	—	47	3.6 ± 0.5	0.24
OSL 3	6.6 ± 0.6	106 ± 7	**3.8 ± 0.2 (73%)**	20.6 ± 3.5 (17%)	75 ± 17 (9%)	40	2.9 ± 0.2	0.39

The final model choice for De determination used in calculation of the age should be based on a visual appraisal of the radial plots and/or on the basis of contextual knowledge. All three samples show D_e distributions that can be best described as showing evidence of post-depositional mixing, with one component containing 51–73% of the grains (Fig. 3). Application of the FMM and use of the D_e value obtained for the component represented by the greatest proportion of grains is considered best for all three samples (right-hand radial plots in Fig. 3). As expected, the MAM D_e values are always lower as it only takes into account the lowest 24–39% (*p0* values in Table 3) of the grains in the D_e distribution of each of the samples. The MAM represent minimum age estimates that can be considered conservative estimates of the sample's last exposure to sunlight. The model interpreted to best constrain the D_e dstirbution of each sample is shown with a red square around the radial plots in Fig. 3 and highlighted in bold in Table 3.

Environmental dose rate determination and results

The total environmental dose rate consists of contributions from beta, gamma and cosmic radiation external to the grains, plus a small alpha dose rate due to the radioactive decay of uranium and thorium inclusions inside sand-sized grains of quartz. To calculate the OSL ages, we have assumed that the present-day radionuclide activities and dose rates have prevailed throughout the period of sample burial.

We estimated the beta dose rates directly by low-level beta counting of dried, homogenised and powdered sediment samples in the laboratory, using a Risø GM-25-5 multi-counter system (Bøtter-Jensen and Mejdahl, 1988). We prepared and measured samples, analysed the resulting data, and calculated the beta dose rates and their uncertainties following the procedures described and tested in Jacobs and Roberts (2015); three sub-samples were measured for each sample. For all samples, allowance was made for the effect of sample moisture content (Nathan and Mauz, 2008), grain size (Brennan, 2003) and HF acid etching (Bell and Zimmerman, 1978) on beta-dose attenuation.

We estimated the gamma dose rates in the laboratory from measurements of uranium, thorium and potassium concentrations for each of the samples using a combination of thick source alpha counting and GM-25-5 beta counting. The U, Th and K values were then converted to gamma dose rates, using the dose rate conversion factors of Guèrin et al. (2011).

The cosmic-ray dose rates were calculated following Prescott and Hutton (1994), and adjusted for water content, and we assumed an effective internal alpha dose rate of 0.03 ± 0.01 Gy/ka.

Current water contents of 0.7–2.3% were measured; a value of 3 ± 1% was used for dose rate determination (Table 4). These values represents the assumed long-term water content (i.e., averaged over the entire period of sample burial) with an uncertainty sufficient to accommodate the likely range of water contents experienced by these deposits; the OSL ages increase by ~1% for each 1% increase in water content.

The environmental dose rate data together with the total dose rates are provided in Table 4.

Table 4: *Dose rate values. Uncertainties are reported at 1σ.*

Sample	Water (%)[a]	External dose rate (Gy/ka)			Total (Gy/ka)
		Beta	Gamma	Cosmic	
OSL1	3 ± 1 (1.3)	0.24 ± 0.02	0.14 ± 0.01	0.18	0.59 ± 0.04
OSL2	3 ± 1 (0.7)	0.20 ± 0.02	0.14 ± 0.01	0.18	0.54 ± 0.04
OSL3	3 ± 1 (2.3)	0.22 ± 0.02	0.14 ± 0.01	0.18	0.57 ± 0.04

[a]Water content in brackets is the content measured in the laboratory

Age estimates

OSL age estimates using the FMM and MAM age models for all samples are summarised in Table 5. Uncertainties on the ages are given at 1σ (the standard error on the mean) and were estimated by combining, in quadrature, all known and estimated sources of random and systematic error. Preferred age estimates for final age determination are shown in bold. The minimum age estimates are a useful conservative estimate of age; sediment could not have been deposited later than this. It is interesting to note that the MAM age for the deepest sample (OSL1) is consistent with the FMM-1 age for the middle sample (OSL2) and its MAM age is in turn consistent with the FMM-1 age of the uppermost sample. This suggests a stratigraphic coherence, but within otherwise post-depositionally mixed sediments. Together these three samples suggest sediment deposition during the early to mid-Holocene.

Table 5: *Age estimates using two different statistical models to determine the best estimate of D_e for age calculation. Uncertainties are provided at 1σ.*

Sample	FMM-1 (ka)	FMM-2 (ka)	FMM-3 (ka)	MAM (ka)
OSL1	**10.0 ± 0.8**	42.2 ± 4.0	94.9 ± 14.1	>8.6 ± 0.8
OSL2	**8.7 ± 0.8**	68.3 ± 6.9	—	>6.6 ± 1.0
OSL3	**6.7 ± 0.6**	36.5 ± 6.7	133 ± 31	>5.2 ± 0.5

References

Aitken, M.J., 1998. An Introduction to Optical Dating. Oxford University Press, Oxford.

Athanassas, C.D., Wagner, G.A., 2016. Geochronology beyond radiocarbon: optically stimulated luminescence dating of palaeoenvironments and archaeological sites. Elements 12, 27–32.

Ballarini, M., Wintle, A.G., Wallinga, J., 2006. Spatial variation of dose rate from beta sources as measured using single grains. Ancient TL 24, 1–8.

Bell, W.T., Zimmerman, D.W., 1978. The effect of HF acid etching on the morphology of quartz inclusions for thermoluminescence dating. Archaeometry 20, 63–65.

Bøtter-Jensen, L., Mejdahl, V., 1988. Assessment of beta-dose-rate using a GM multicounter system. Nuclear Tracks and Radiation Measurements 14, 187–191.

Bøtter-Jensen, L., Andersen, C.E., Duller, G.A.T., Murray, A.S., 2003. Developments in radiation, stimulation and observation facilities in luminescence measurements. Radiation Measurements 37, 535–541.

Brennan, B.J. Beta doses to spherical grains. Radiation Measurements 37, 299–303.

Duller, G.A.T., 2003. Distinguishing quartz and feldspar in single grain luminescence measurements. Radiation Measurements 37, 161–165.

Duller, G.A.T., 2004. Luminescence dating of Quaternary sediments: recent advances. Journal of Quaternary Science 19, 183–192.

Duller, G.A.T., 2008. Single-grain optical dating of Quaternary sediments: why aliquot size matters in luminescence dating. Boreas 37, 589–612.

Galbraith, R.F., Roberts, R.G., 2012. Statistical aspects of equivalent dose and error calculation and display in OSL dating: an overview and some recommendations. Quaternary Geochronology 11, 1–27.

Galbraith, R.F., Roberts, R.G., Laslett, G.M., Yoshida, H., Olley, J.M., 1999. Optical dating of single and multiple grains of quartz from Jinmium rock shelter, northern Australia: Part I, experimental design and statistical models. Archaeometry 41, 339–364.

Galbraith, R.F., Roberts, R.G., Yoshida, H., 2005. Error variation in OSL palaeodose estimates from single aliquots of quartz: a factorial experiment. Radiation Measurements 39, 289–307.

Guerin, G., Mercier, N., Adamiec, G., 2011. Dose-rate conversion factors: update. Ancient TL 29, 5–9.

Guralnik, B., Li, B., Jain, M., Chen, R., Paris, R.B., Murray, A.S., Li, S.-H., Pagonis, V., Valla, P.G., Herman, F., 2015. Radiation-induced growth and isothermal decay of infrared-stimulated luminescence from feldspar. Radiation Measurements 81, 224–231.

Huntley, D.J., Godfreysmith, D.I., Thewalt, M.L.W., 1985. Optical dating of sediments. Nature 313, 105–107.

Jacobs, Z., Roberts, R.G., 2007. Advances in optically stimulated luminescence dating of individual grains of quartz from archeological deposits. Evolutionary Anthropology 16, 210–223.

Jacobs, Z., Roberts, R.G., 2015. An improved single grain OSL chronology for the sedimentary deposits from Diepkloof Rockshelter, Western Cape, South Africa. Journal of Archaeological Science 63, 175–192.

Jacobs, Z., Duller, G.A.T., Wintle, A.G., 2006. Interpretation of single grain D_e distributions and calculation of De. Radiation Measurements 41, 264–277.

Li, B., Jacobs, Z., Roberts R.G., Galbraith, R., Peng, J., 2017. Variability in quartz OSL signals caused by measurement uncertainties: problems and solutions. Quaternary Geochronology 41, 11–25.

Murray, A.S., Wintle, A.G., 2000. Luminescence dating of quartz using an improved single-aliquot regenerative-dose protocol. Radiation Measurements 32, 57–73.

Nathan, R.P., Mauz, B., 2008. On the dose-rate estimate of carbonate-rich sediments for trapped charge dating. Radiation Measurements 43, 14–25.

Peng, J., Dong, Z., Han, F., Long, H., Liu, X., 2013. R package numOSL: numeric routines for optically stimulated luminescence dating. Ancient TL 31, 41–48.

Prescott, J.R., Hutton, J.T., 1994. Cosmic-ray contributions to dose rates for luminescence and ESR dating: large depths and long-term time variations. Radiation Measurements 23, 497–500.

Roberts, R.G., Jacobs, Z., Li, B., Jankowski, N.R., Cunningham, A.C., Rosenfeld, A.B., 2015. Optical dating in archaeology: thirty years in retrospect and grand challenges for the future. Journal of Archaeological Science 56, 41–60.

Wintle, A.G., 2014. Luminescence dating methods. In: Holland, H.D., Turekian, K.K. (Eds), Treatise on Geochemistry (second edition), vol. 14, pp. 17–35. Elsevier, Oxford

Archae-aus Pty Ltd

1/107 Stirling Highway
North Fremantle, WA, 6159

www.archae-aus.com.au
t. 08 9433 1127