Archaeology of Life in an Isolated Land

Bartholomew King

Master of Archaeology and Cultural Heritage Management

Flinders University

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Archaeology and Heritage Management, College of Humanities, Arts and Social Sciences, Flinders University, South Australia

Word Count- 20,794

Abstract

The ability to adapt to new landscapes and environments is an essential aspect of moving into a new land and infrastructure can provide insight into how people adapted, survived and lived in new landscapes. The Pilbara region of Australia was first surveyed for agriculture in 1861, with the first non-Indigenous people taking up pastoral leases in the mid-1860s. Adapting infrastructure and agricultural practices to this new environment required detailed and ongoing landscape learning, which can be determined through interpretation of the remaining standing structures. The aim of this thesis is to assess the surviving infrastructure at one pastoral station to understand landscape learning, environmental adaptation and how architectural decisions influenced human life.

This thesis focuses on the historic precinct of Balmoral Station in the Pilbara region of Western Australia. It presents the case that life was impacted significantly by infrastructure in Australia's isolated north-west. Determining how the infrastructure impacted life requires an understanding of the environment, landscape, isolation, available information, resources and the people who settled in the region to establish pastoral properties.

The leaseholders' adaptations to the climate that impacted the property since 1866 influenced the construction of the current infrastructure that was built in 1952. The use of concrete walls, strong timber framing and hip roofs made the buildings robust. The designs adopted for structures inhabited year round made the buildings comfortable in the extreme summer heat. Architectural adaptation to cyclones and heat made life bearable. Landscape learning and understanding influenced the location for infrastructure. Using the landscape to provide shelter from wind and promote cooling through cross ventilation of buildings also contributed to liveability.

The historic precinct of Balmoral is one of the last surviving remnants of shearing history in the Pilbara. All shearing infrastructure in the Pilbara was abandoned between 1999 and 2000 to make way for cattle, leaving the infrastructure to degrade and be destroyed. Balmoral is thus a rare example of what life was like in the Pilbara and its archaeology is essential to understanding how people adapted and lived in Australia's remote northwest.

Declaration of Candidate

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed

Bartholomew King

November 2021

Acknowledgements

Above all I would like to thank Dr Heather Burke, particularly for the direction, support and patience provided throughout the year. Without her extensive help, subject knowledge and supervision this study would not be what it is today.

I would also like to acknowledge the support and direction provided by Daniel Puletama from the beginning of the project. The assistance from Gary Blinco, in the field, made site recording and interpretation much more efficient and effective than it could otherwise have been.

The understanding and acceptance from my family, Emma Archbold and Murphy Wildman, to allow me the time to conduct this thesis is greatly appreciated.

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1 Introduction

Susan Lawrence's (2003) book *Archaeologies of the British: Explorations of Identity in the United Kingdom and Its Colonies 1600–1945* provides a vast amount of information about the distribution of the European population throughout the colonies in the southern hemisphere. Information surrounding the population who arrived in the Australian colony is limited to the eastern part of the continent, however, and those who continued west are not discussed (Symonds 2003:138). The colony of Swan River was founded in 1829, 22 years earlier than the establishment of the Victorian colony (Ogle 1938:10). Despite this, European historical research into the western colony (now Western Australia) is significantly less than the volume of research conducted in other parts of Australia (Blackman 1988; Connah 1983; Hayes 2007; Lawrence and Davies 2012).

The lack of attention paid to the west is even more evident when considering remote areas such as the Pilbara. Difficulty of access, remoteness and weather have all contributed to limited research into the Pilbara's past, and a lack of focus on historical archaeology, in particular, is lessening the historical importance of this region to understanding Australia's past. A general lack of research into Western Australian architecture has been identified as a result of a lack of income in the colony until the gold rush in the 1890s (Pitt Morrison and White 1981:512). The progression of architecture spurred by the increase of money did not occur in Western Australia as early as it did in the rest of the continent (Pitt Morrison and White 1981:512).

In the Pilbara in particular, weather and other environmental factors are constantly affecting remaining infrastructure, which will eventually result in much of its history being lost. A Local Government Heritage Inventory commissioned by the Shire of Roebourne (now City of Karratha) in 2012 depicts the current status of the infrastructure on pastoral stations across the Pilbara (Eureka Archaeological Research & Consulting (UWA) 2012:64, 81, 183, 206, 269), noting that the shearing infrastructure is severely degraded or destroyed at all pastoral properties except three: Mardie, Balmoral and Karratha. These were some of the first pastoral leases in the Pilbara, but their remaining infrastructure has been noted to be at risk from the ongoing threats of cyclones and mining development.

The Local Government Heritage Inventory report only focussed on the condition of major standing structures and provided a very rudimentary history. The time taken to conduct the Local Government Heritage Inventory was very minimal, given that every pastoral station and historical place in the Pilbara—estimated to be over 16,000km^2—was assessed in the space of one year, including the islands. The assessments therefore only briefly discussed the standing structures at stations and present a very basic summary of each station's history, often relying on unpublished information. Moreover, if a building was not intact, then it was overlooked. There are standing structures at Mardie and Balmoral that were neglected in the reports, but that are still visible in the landscape, including water tank towers, windmills, storage sheds and a generator shed.

There is thus a clear gap in thorough research into current structural condition, land use, contact history and how this links to the history of the Pilbara. This research therefore focuses on the Balmoral station precinct (Figure 1) to attempt to determine how the development of pastoralism in the region affected the infrastructure, including the architecture, on this property and, in turn, how the infrastructure influenced life in the Pilbara in the past. Infrastructure is defined here as all standing structure and, remnants of structures that are sufficient to identify use, layout and materials, plus any services such as water sources or electricity.

This research records in detail all of the surviving infrastructure on Balmoral Station, including its condition, components and changing form. Although the focus is on Balmoral, it also naturally touches on the history of neighbouring Mardie station, since the two were established in tandem and worked separately until they were amalgamated into one property in 1925; they continue to operate today as a combined enterprise known collectively as Mardie (for more information see Chapter 2). The shearing infrastructure at Mardie and Balmoral stations was very similar, but the living infrastructure and their locations in the landscape very different. As two of the only three remaining intact precincts relating to the Pilbara's sheep industry, the remaining infrastructure on Balmoral and Mardie stations thus represent a vanishing way of life that have an uncertain future. This thesis aims to assess and interpret the infrastructure of Balmoral station to answer the question: how can the historical infrastructure and remains of Balmoral station inform us about landscape learning, past land use and station life in the Pilbara?

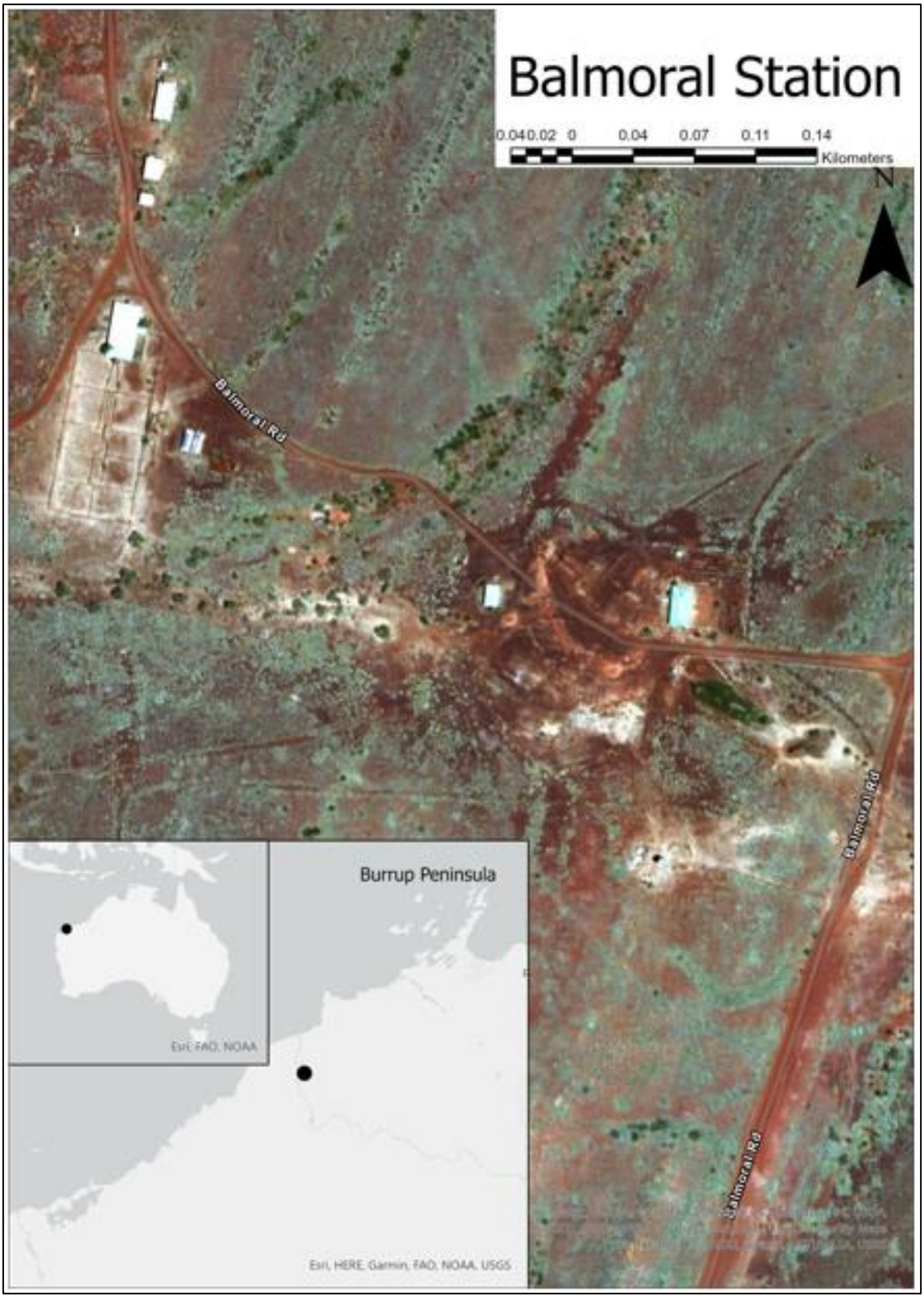

Figure 1: Map of Balmoral Precinct.

A subsidiary question being asked is: what is the current condition of Balmoral's shearing infrastructure? This will provide potential further research options to support the main results of this thesis.

1.1 Significance of this research

Historical archaeological research to determine the nature, degree and scale of landscape learning and environmental adaptation by non-Indigenous people in the Pilbara has not previously been conducted. With so few remaining examples, the opportunity to conduct this research is significantly restricted. Being able to access and assess sites on private property owned by mining companies is often difficult, and all three remaining intact examples of shearing precincts in the Pilbara are owned by mining companies. This study constitutes one of the few studies that has been able to access this infrastructure. This study can contribute to the understanding of architectural reflections of environmental adaptation and determine the benefits that this provides to archaeological knowledge. Understanding adaptations in infrastructure will provide insight into the landscape learning adopted by pastoralists and their interactions with the environment.

North America has been increasing the volume of archaeological assessments conducted on agrarian sites as a result of land clearing since the 1980s (De Cunzo 2001:86; O'Donovan and Wurst 2001:77). The American *Northeast Historical Archaeology* journal had a specific issue in 2001 based around historical archaeology in agriculture, assessing various aspects of farmsteads and agricultural life in northeast North America (Baugher and Klein 2001:1–2). Baugher and Klein argue that agricultural sites are amongst the earliest European inhabited places in the northeast, were home to the majority of the region's population, and provide information on local economic, social and cultural development, because they connect the present to society and culture. Although the material traces of standing structures and pastoral infrastructure was an early focus of historical archaeology research in Australia (e.g. Birmingham and Jeans 1983:9; Connah 1983:9), since the 1990s historical archaeology appears to have focussed on other aspects of pastoral wealth, such as how it was used to reflect and create social and/or class status (e.g. Allison 2014:89; Blackman 1988:28–29; Burke 1999; Hayes 2007; O'Donovan and

Wurst 2001:73; Terry 2013:570). As a result, Australia is yet to adopt a more holistic approach to the archaeology of farming and the range of agrarian practices.

Adapting what has been conducted in the North American context to the Australian landscape may progress the understanding of Australian agricultural and pastoral infrastructure and its impacts on land use. In the Pilbara, especially, the focus of heritage assessments in land clearing projects has been overwhelmingly on Indigenous heritage. Very rarely is the impact to pastoral history considered as a legitimate aspect of the archaeology that requires attention. The work being done in the northeast US can create a precedent for acceptable assessments for such archaeology.

Chapter 2 will outline the history of the Mardie-Balmoral station from arrival in the region of the first pastoralists. This chapter will discuss the first non-Indigenous people who lived on the leases and what information, resources and opportunities were available to them during the 19th century. A detailed assessment of available information relating to influencing factors on pastoral leases and the people who inhabited them is provided in Chapter 3. This chapter outlines the known issues faced by European settlers across Australia and some of the interactions with the Indigenous population in Australia's north-west. The minimal historical archaeological research conducted on the pastoral industry in Australia's north-west is identified as a limiting factor. A review of the historical archaeology conducted in Western Australia up to 2013 supports the view that limited research has been conducted specifically on the pastoral history (Winter 2013:52-53). The architectural and environmental adaptations made to climate and disasters in other parts of the world are also assessed in Chapter 3 to determine links to Pilbara infrastructure. How these adaptations were assessed at Balmoral is outlined in Chapter 4 and the outcomes of this assessment are detailed in Chapter 5. The analyses of these results and their connection to the findings in the literature review are detailed in chapter 6. Chapter 7 presents a summary of the findings to answer the questions this thesis aimed to address.

2 History of Pastoralism in the Pilbara

The Pilbara was settled by Europeans in the 1860s, primarily for the utilisation of the open grasslands as pasture for sheep. Balmoral Station, established in 1866, was a sheep pastoral property that operated independently until it was purchased and amalgamated in 1925 with the pastoral property to the south, Mardie, to form a 225,000 hectare property (Bridge 2004:27). The property continues to be operated under the name Mardie-Balmoral (shortened to Mardie) as a pastoral station. The property underwent a significant change in the years 1999–2000, when sheep were removed from the property for the first time since 1866 and replaced by cattle. This change was the beginning of a property-wide landscape change, with weeds gradually taking over paddocks and rendering them useless, as cattle are more selective in their grazing than sheep. The stock change also rendered all shearing buildings redundant, resulting in them being abandoned.

Both stations were settled by Scottish settlers: Mardie, south of the Fortescue River, by David Simpson and Malcolm McIntosh in 1865 (Sharp 1979:105), and Balmoral, north of the Fortescue River, to Robert Fraser and brothers James and David Stewart (Sharp 1979:105). All of them had previously worked as sheep farmers in Scotland and were recruited to join the Denison Plains Company because of their 'skills as stockmen', arriving in Australia at Nickol Bay (modern Dampier) via Melbourne (McCarthy 1989:130; Sharp 1979:105). Little else is known about these men prior to their arrival in Australia, but their successes in the Pilbara indicate they were competent stockmen (McCarthy 1989:130). Simpson and McIntosh only had 80 ewes at the start of their operation, so entered an agreement with the Stewarts and Fraser to work together until both flocks were of a sufficient size to be profitable and station infrastructure could be built.

The first homesteads and shearing infrastructure at Balmoral and Mardie were built in 1866. The form of the original homesteads is unknown, since the Balmoral structure was replaced by the current homestead in 1952 and the Mardie head station moved from its original location in 1904. The only remaining physical evidence of the original Mardie homestead is the date palms planted next to a creek (Sharp 1979:113). In contrast, the shearing infrastructure at each was built in the locations in which it still stands. When the stations were amalgamated both precincts continued to be utilised, but after 1925 the Balmoral homestead became an outstation for Mardie and was lived in by an overseer (Sharp 1979:113). The first overseer was Frank Venn, the previous station manager at Balmoral.

Following the amalgamation, an assessment of the property size determined the justification for operating and maintaining two separate shearing precincts. The current Mardie property being so large, made a single mustering point for shearing near the Mardie homestead unviable. Mustering over large distances took time, as contract musterers would have been needed to assist. Another justification for maintaining two shearing precincts was the physical barrier of the Fortescue River that separated the two stations. This restricted movement of livestock between paddocks, and crossing the river was uncertain prior to weather-proof bridges being constructed with the highway upgrade in 1974 (Western Australia Department of Main Roads 2021). The catchment for the Fortescue River starts 760 kilometres from Mardie with a 100 kilometre long wetland at its source (Environmental Protection Authority 2013) and is impassable during even minor rain events. As pastoral activities were dependent on being able to access infrastructure, the facilities at Balmoral continued to be used in conjunction with those at Mardie until the transition to cattle in 1999.

Table 1 is a list of the station owners at Balmoral Station since 1866. The family who owned and operated Balmoral for the longest period was the Sharpe family. Benjamin Sharpe purchased the Mardie lease in 1922, then amalgamated his property with Balmoral in 1925. He ran the combined Mardie-Balmoral Station until he handed it to his son, Robert Sharpe, in 1945. Robert operated the station until 1968, when he handed it to his son Benjamin Sharpe, who in turn sold it 11 years later in 1979. This ended the Sharpe family’s 54 year operation of Balmoral and 57 years of Mardie Station.

Table 1: Balmoral Station owners

Year station purchased	Lease Holder
1866	Robert Fraser and James and David Stewart
1886	David Stewart
1910	James Munro
1916	Samuel Peter McKay and H. Green
1924	Frank E. Venn
1925	Karratha and Balmoral Amalgamated
1925	Benjamin Sharpe
1945	Robert Sharpe (Benjamin's son)
1968	Benjamin Sharpe (Robert's son)
1979	Phillip Blackman
1999	David Thompson
2000	*Sheep transition to cattle*
2007	Pastoral Management Pty Ltd

The last lease owner, Pastoral Management Pty Ltd. is a subsidiary business of CITIC Pacific Mining. When it purchased the lease in 2007 it established a temporary mining camp at the Balmoral homestead to house employees. This camp consisted of six temporary demountable buildings housing a total of 24 people. The company operating the camp (ISS) utilised the homestead for linen storage and washing facilities. ISS is a multinational catering and facility management company.

2.1 Station and pearling workers

The dispossession that broad acre grazing has caused to the Indigenous population across Australia has been discussed and recognised (Harrison 2004:109; Irving 1935:6; Paterson 2018:4; Strauch et al. 2000:289). Although the scope and scale of such changes could not be accommodated within the present study, to avoid the topic completely would be disrespectful to the Indigenous people and their input to the region's development since European settlement. Indigenous life in the Pilbara was influenced by European settlement and the subsequent exploitation of Aboriginal people for work (Paterson 2018:5).

Prior to the establishment of pastoral stations in the 1860s the coast between Fitzroy River and Murchison River was utilised for whaling and pearling (Vreeswyk et al. 2004:14). This includes the Fortescue River on Mardie Station (Paterson 2006:4).

While working at Mardie, McIntosh and David Simpson quickly expanded their economic interests and began collecting pearl shell from beaches on Mardie station with the assistance of Indigenous labour, using the profits to further develop Mardie. Simpson is noted as having been particularly cruel to Indigenous people in his employ, taking the law into his own hands, killing and beating Indigenous people who did not follow his authority (Sholl 1865:np). By the 1880s the Stewart and Fraser brothers at Balmoral also had a pearling business (*West Australian* 1886:3). All of these men made profits out of sheep, pearl shell and hiring out the Indigenous people who lived on their leases to other pearlers, while the Stewarts and Fraser also extended their profitability with bush hay. This was part of a wider pattern of exploitation of Indigenous people as cheap labour in the Pilbara (Gregory and Paterson 2015:149).

The importance of Indigenous labour to the pearling industry is well known and acknowledged in the Pilbara, in particular at Cossack (Vreeswyk et al. 2004:14). With many Europeans being unwilling to work in the region and the Indigenous people wanting access to their home country, it was an opportunity for station owners to exploit Indigenous workers (Biskup 1973:19). This resulted in Indigenous labour extending to pearl collection until South East Asian workers began being used as a cheaper labour force from the late 1870s (Paterson and Veth 2020:3). Indigenous people continued to be used as cheap labour on pastoral stations until the 1960s.

Despite the almost sole reliance on Indigenous people in the pastoral industry and partial reliance in the pearling industry, there was still significant discrimination (Nettlebeck 2014:19). The Indigenous workers in the Pilbara, like many parts of Australia, were heavily victimised in the regional legal system, as well as facing discrimination at work (Nettlebeck 2014:19). Many Indigenous station workers were arrested and sentenced without proof of a crime (Nettlebeck 2014: 20). Some Europeans acknowledged the input the Indigenous population had to the region’s success, however. In 1865 Robert Sholl (Chief Magistrate for the Northwest) noted the important role the Indigenous people had in the region’s industry and that the Indigenous population “are surely worthy of the kindest and most favourable consideration” (Sholl 1865:np).

The extent to which Indigenous labour was used in the pastoral industry on Balmoral and Mardie stations is largely unknown, since there are no extant collections of station records. That Balmoral Station did employ Indigenous people is reflected in at least one building constructed specifically for Indigenous workers. How these buildings and the associated work routines impacted the lives of the local Mardahunerra people, however, is difficult to ascertain. The Indigenous people who worked on Balmoral were predominantly Traditional Owners of the land that Mardie and Balmoral was established on, and these people often lived at Balmoral with their families. This differs from the bulk of the European workers, who would often work seasonally and individually, moving between stations throughout the year. The only records of interactions between Indigenous and non-Indigenous station workers at Mardie or Balmoral is David Simpson's previously mentioned cruelty towards Indigenous people.

2.2 Transport and communication networks

During the first half of the 1800s Western Australia had little industry that assisted the economy's growth outside of the south west of the colony. With the 1857 discovery of pearl shell in the Pilbara, however, the pearling industry on the coast soon increased to include specific ports and processing facilities for the industry (Paterson and Wilson 2009:100). In terms of pastoralism, the open plains of the Pilbara were an ideal location to quickly establish large scale leases. The land did not require laborious clearing by hand as did many other farming locations. This made Pilbara pastoral stations a rapid prospect for establishing and boosting the Western Australian colony's economy. The predominantly sheep pastoral industry of Western Australia continued to grow from the 1860s, with many properties reaching their peak flock size and output in the mid-20th century (Ville 2000:3).

The majority of the West Australian population being based in the south of the colony, however, made access to remote Pilbara settlements difficult. The resupply points between Perth and the Pilbara were long distances apart and roads were either poorly maintained or absent (Vreeswyk et al. 2004:14). With road access laborious, difficult and time consuming, the quickest mode of transport for goods, livestock and people to the Pilbara was on ships (Vreeswyk et al. 2004:13). Unlike the east coast, the reef systems along the west coast are minor and do not impede shipping. The utilisation of suitable river inlets as coastal shipping locations for the

Pilbara was the only means of cargo and cattle delivery to stations until stock routes were opened in 1866 (Vreeswyk et al. 2004:13–14).

With such widely spaced supply outposts along the coast of Western Australia, the reliance on pastoral stations for basic resupply on the journey north and south was essential (Vreeswyk et al. 2004:13–14). Many homesteads needed to be close to the coast for their own supplies; this led to the stock routes following the line of homesteads and outposts, tracking closely to the coast. Along with a reliable water source, the proximity to coastal shipping supply lines at river mouths was another factor in homestead placement (Vreeswyk et al. 2004:13–14). Mardie station contains the mouth of the Fortescue River, and during the peak of its sheep operation (1870s to 1940s) had facilities to allow the import and export of goods. This consisted of a 10−15m wood piled jetty landing on the southern bank at the mouth of the Fortescue River (Sharp 1979:114).

The reliance on coastal supply routes continued until the new North West Coastal Highway route was constructed and sealed, with construction being completed in 1974 (Western Australia Department of Main Roads 2021). Prior to this the road north was a single lane dirt track that passed within a few hundred metres of Mardie homestead and within 100m of the Balmoral homestead. During the road upgrades the route changed, moving the highway 20km east of Mardie and 8km east of Balmoral. This isolated the infrastructure at Mardie and Balmoral from the thoroughfare of people travelling north and south.

A technological advancement that reduced the perception of isolation in many parts of Australia in the late 1800s was the telegraph line. The installation of the overland telegraph line increased the ability for people in the Pilbara (and across Australia) to communicate with the colony’s capitals and reached Mardie and Balmoral in 1885 when a post office was established at the Fortescue River mouth (Figure 2)(*Perth Daily News* 1885:6).

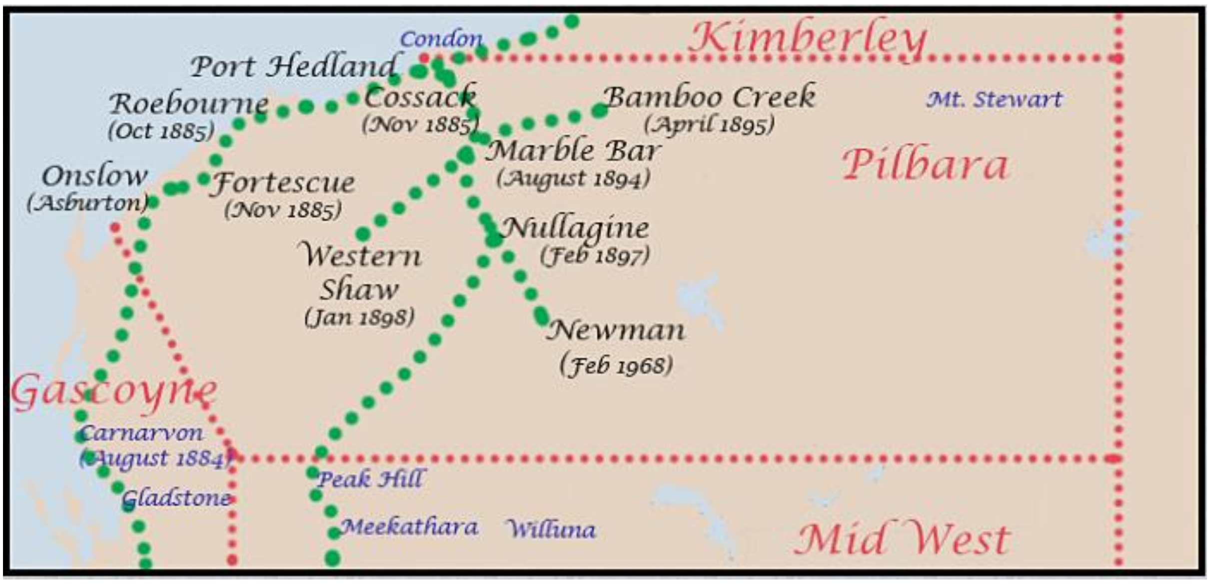

Figure 2: Map of the Pilbara depicting the telegraph line with dates the line reached each location (Map Source: Western Australia: 1869–1900-Telegraph lines in the Pilbara).

2.3 The Pilbara environment

The Pilbara environment is full of extremes. The arid environment is prone to droughts interspersed by extreme rain events from tropical cyclones (Australian Bureau of Meteorology 2021a). The Western Australia Kimberley and Pilbara coast is the most cyclone prone region in Australia. Official reports of cyclones with the Australian Bureau of Meteorology only go back to 1970, but since then 338 cyclones have impacted the west coast of Australia (Australian Bureau of Meteorology 2021b). On average, this means the Pilbara is affected in modern times by five cyclones a year, with two crossing the coast, and one classified as severe (Australian Bureau of Meteorology 2021a). A cyclone becomes 'severe' when average winds reach or exceed 118kph. Each event can cause widespread flooding, even if it does not cross the coast (Australian Bureau of Meteorology 2021a).

It is more difficult to establish the pattern of weather events before 1970, but rainfall data for Mardie station extends back to 1885 (Appendix B – Historic Weather Data) and can be used to surmise the regularity and extent of cyclonic conditions in the region. Table 2 contains a summary of rainfall data broken down into categories of millimetres of rain per year. This demonstrates the years that the region received high rainfall. Given that 200mm was the average amount of rainfall received during a cyclone between 2010 to 2021 (Australian Bureau of Meteorology 2021c), it can be assumed that each year with greater than 200mm of rain historically was caused by a cyclone. Two years showing greater than 800mm of rain indicates impact by at least one severe cyclone causing long term flooding. The rainfall data has been graphed (Figure 3) to demonstrate the variability and shows that, on average, the region was affected by one cyclone a year, interspersed with years of no cyclonic activity.

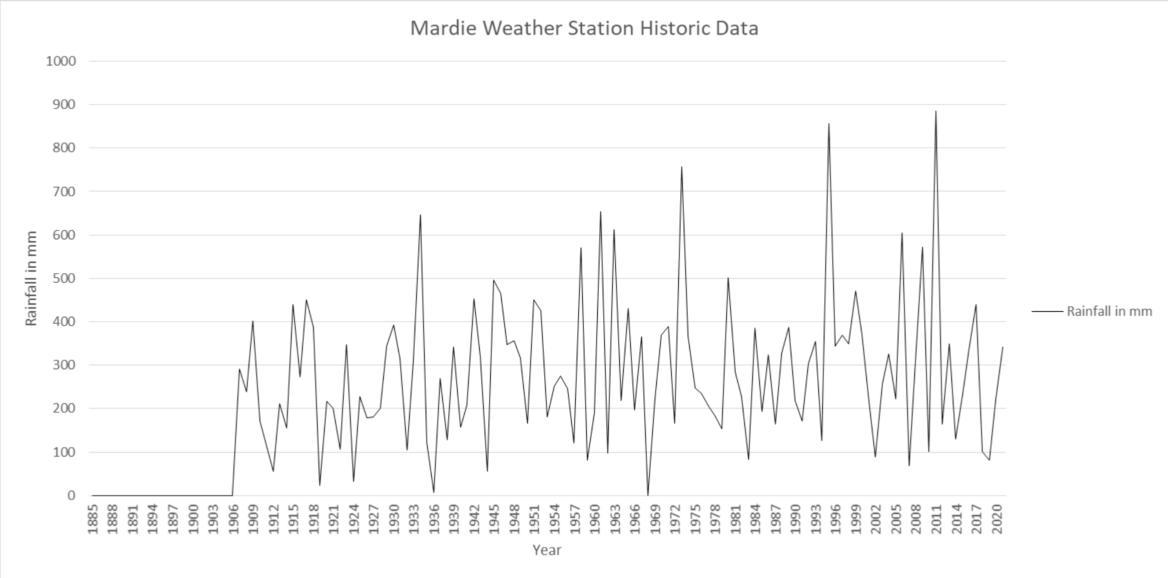

Figure 3: Annual rainfall data between 1885 and 2020

Table 2: Summary of rainfall data broken down into categories of mm per year.

Rainfall per year in mm	**Number of occurrences since 1885**
Years with <100mm	11
Years 100 to 200mm	26
Years 200 to 300mm	26
Years 300 to 400mm	30
Years 400 to 500mm	11
Years 500 to 600mm	3
Years 600 to 700mm	4
Years 700 to 800mm	1
Years >800mm	2

Note: the average evaporation rate in the Pilbara is 9.1mm per day

Various extreme weather events can be identified in the historical records of the Pilbara. In 1894 water rose two feet inside the homestead at Balmoral, destroyed stock yards, damaged the shearing shed and washed away up to 48 kilometres of fences (*West Australian* 1894:7). Rainfall data was not available from the Mardie rain gauge to determine the volume of rain that impacted the area. The most well-known cyclonic event to hit Mardie and Balmoral stations, however, was the cyclone that impacted the Pilbara in early 1945. This cyclone was not formally named, but destroyed or damaged every building in Roebourne and most buildings across the region (Australian Bureau of Meteorology 2019; West Australian 1948:19). Figure 4 to Figure 11 show the significant damage caused to the Balmoral homestead, shearing shed and shearer's kitchen/dining hall, none of which was rebuilt until 1952:

> At Balmoral are the overseer Gordon Raynor and his 21-year-old daughter Joan, and building contractor Bill Bell and his wife, and three builder's labourers. Bell at present is building wool and shearing sheds at Balmoral and soon he will begin building a new homestead for the Raynors. (*West Australian* 1952:3).

As Gordon Raynor was an employee of Mardie, it is presumed that he and his daughter lived at Mardie until Balmoral reconstruction occurred. The cyclone also caused loss of a large number of sheep, affecting profits from the station until the flock could replenish. This could have contributed to the delay in reconstruction, as could a general lack of available resources and labour after World War 2.

There is no information regarding the pre-1952 homestead structure and there are no known historical records that mention relocation of the homestead at Balmoral, therefore the 1952 structure was potentially rebuilt in the same location (Sharp 1979:117). The only indication of the original building's construction is contained in the post-cyclone images, taken after it was destroyed. These show that the building had a timber frame and corrugated iron outer, with possibly two rows of rooms with verandahs front and back. The roof design cannot be seen, as the roof and most walls are missing in the pictures. It is unclear if the original building from the 1860s had the same layout as the current building. No information was available for construction activities at Balmoral prior to 1952, suggesting that the structure destroyed in 1945 was the structure built in the 1860s. Due to the tumultuous weather in the region there are no complete representations of buildings from the 1860s remaining which could be compared. Information available in the Shire of Roebourne Local Government Heritage Inventory, however, indicates that most of the structures captured in this report were built using timber and corrugated iron (Eureka Archaeological Research & Consulting (UWA) 2012).

Figure 4: Balmoral Station dining hall after 1945 cyclone.

Figure 5: Balmoral Station shearers' quarters and dining room after 1945 cyclone. All structures in photograph demolished after cyclone.

Figure 6: Balmoral shearers' quarters after 1945 cyclone.

Figure 7: Balmoral homestead (left) after 1945 cyclone. Generator shed still intact (right).

Figure 8: Balmoral homestead after 1945 cyclone

Figure 9: Balmoral homestead after 1945 cyclone.

Figure 10: Balmoral homestead after 1945 cyclone.

Figure 11: Panoramic photograph of Balmoral homestead indicating the degree of damage and its location in the landscape.

Temperature is another extreme in the Pilbara. Temperature records at Mardie commenced in 1957 and the maximum and minimum temperatures for each month since then are summarised in Appendix B – Historic Weather Data. Summer high temperatures regularly exceeded 50° in 1998 and winters occasionally reached below 3°. The summer months have an average daily maximum temperature over 37°C (Australian Bureau of Meteorology 2021c). Both the temperature and rainfall variations show that life in the Pilbara is significantly influenced by the weather, and that extreme weather in this context was, and is, relatively commonplace.

2.4 General building location, materials and condition

Given the climatic extremes to which the region is exposed, buildings in the Pilbara had to be constructed to take advantage of prevailing winds, natural shade, where the sun rose and where it set. Many of the original buildings in the Pilbara from first settlement by Europeans were constructed using timber, stone or a composite of both. Materials are selected to contribute different attributes to a building, but are also chosen based on availability (Campisi and Saeli 2018:1). Using locally sourced material in construction can reduce costs, increase the reparability of structures and increase efficiency in construction (Morela et al. 2001:1119). The proximity to (and ability to access) materials, budget and labour were limiting factors in the construction techniques used in the Pilbara. This region of Western Australia is sparsely occupied, isolated and contains limited local construction materials. During the 1860s these factors were more prevalent without the colony's ability to produce and manufacture construction products and reliance on imports (Nayton 2011:98).

Access to suitable construction materials like stone and timber close to the Mardie-Balmoral station was difficult, as the region consists of heavily weathered dolerite, banded iron, shales and chert (Semeniuk and Brocx 2019:59). These rock types are difficult to work with and difficult to quarry (Semeniuk and Brocx 2019:60). Along with a lack of suitable material was a lack of demand. The population in the Pilbara did not warrant a full time quarry and stone mason. The lack of readily available stone from local quarries resulted in a need to transport material from other areas of Australia. This resulted in a pattern to the distribution of different construction materials. Stone buildings, for example, were more prevalent in the areas close to ports, to obviate overland transportation costs, since the only method of access to the Pilbara in the early years of European settlement was by boat. Only less essential buildings (outstations) were built cheaply of local stone (Vreeswyk et al. 2004:14).

As a result of the lack of stone quarries the bulk of the buildings in the region were constructed with timber (Eureka Archaeological Research & Consulting (UWA) 2012:183, 230, 269). In Western Australia the greater part of the state north of Perth has limited timber resources that could be utilised for construction (Kealley 1991:291) and during first European settlement in the Pilbara, timber was shipped in from southern timber mills (*West Australian* 1881:6). The south west of Western Australia is potentially the source of timber utilised in construction in the northern parts of the state. The timber from the south western areas of Western Australia are Jarrah (*Eucalyptus marginata)* and Marri (*Corymbia calophylla)* (Craig 2002:1610; Tornlund and Ostlund 2002:86). The only sources of timber on the Mardie and Balmoral stations are limited supplies of River Red Gum (*Eucalyptus camaldulensis),* Weeping Paperbark (*Maleleuca Ieucadendra*) and Ghost Gum (*Corymbia aparrerinja*). These trees only grow along the major watercourses and this hard wood is difficult to mill without specific tools and skilled labour (*West Australian* 1881). If timber was utilised from these sources it would have been limited, as most eucalyptus trees in favourable climate with ample water and minimal fauna impacts can grow 12m to 15m in 15 to 20 years (Levy et al. 2016:3–5). Timber from the creek lines may have been suitable for minor building construction, repairs and renovations, but could not be utilised for regular construction. There are no records of official timber mills in the Pilbara since the 1860s, so any locally sourced timber would have had to be milled manually by someone on the property.

The source of construction materials would have impacted life in the Pilbara, whether locally sourced or transported in. Living in remote locations requires planning and forethought to ensure business and life is sustainable. The Pilbara, even today, contains very few of the facilities and resources that every other state and major centre has access to. An example of this is the lack of agricultural infrastructure north of Geraldton, over 1000km south of Mardie station (Department of Primary Industries and Regional Development 2021). Geraldton contains the closest abattoir, despite the Western Australian regions north of Geraldton containing 230 pastoral stations.

2.5 Summary

A variety of factors have influenced life on Mardie and Balmoral stations since they were established in the mid-1860s. Throughout the history of both stations the lives of the occupants have been impacted by distance, lack of adequate local building resources, difficulties with resupply and extreme weather events. To access the land, local Indigenous people were forced into work, and often exploited in the process. How, when and how well the residents on Mardie and Balmoral stations learnt to adapt to these changing and extreme conditions is something that can be revealed in the archaeology by examining the process of landscape learning evident in the surviving infrastructure on Balmoral Station.

3 Learning to adapt: the historical archaeology of adaptation

3.1 Relationships on pastoral stations

Geoffrey Blainey notes that the mining history of Australia is more accepted than that of the pastoral industry, as it involved a much larger population and often resulted in large central hubs being developed (Blainey 1978:99). Both industries are lauded for involving hard work and the start of the Australian nation. Although both industries involved levels of racism, the pastoral industry was the first to steal land and foster general mistreatment of the Indigenous population over a sustained period (Harrison 2004:122; Murray 2004:204, 208; Paterson 2005:29, 2006:107; Paterson and Veth 2020:3; Paterson and Wilson 2009:100). The pastoral history of Australia is littered with stories of poor labour conditions, racism and massacres inflicted on the Indigenous population by pastoralists and government enforcement agencies (through both the police and the legal system) (Harrison 2004:122; Murray 2004:204, 208; Nettelbeck 2014:29). The reluctance of the Australian population in the past to face these issues is potentially one reason that more detailed research on the pastoral history of the Pilbara has not been conducted.

The isolation of Australia's north-west, the abundance of Indigenous heritage places and mining companies' legal and social requirements to protect, research and invest in Indigenous heritage has combined to limit formal research into the non-Indigenous history of the region. This is despite the fact that the establishment of towns and urban centres created by mining booms has been a major focus of historical archaeological research elsewhere (Lawrence and Davies 2011:147). Alistair Paterson is one of a few archaeologists who have conducted recent published research involving historical archaeology of non-indigenous sites in the Pilbara, focussing on the contact period between Indigenous populations and pastoralists in Australia's North West. His work at Inthanoona Station focussed on the Indigenous view of the arrival of Europeans and the establishment of the pastoral and pearling industries. This article centres itself on the exploitation of the Indigenous population and brings it to the fore. The isolation from the centre of the Swan River colony (subsequently Western Australia) in Perth meant the use of convicts to work on stations was not permitted, resulting in the use of Indigenous labour on all Pilbara properties (Paterson and Wilson 2009:100). Fencing, well digging, track construction, building construction and tending to animals needed (unpaid)

Indigenous workers. This exploitation was justified by allowing the Indigenous people to remain living on the land and providing them with food (Paterson and Wilson 2009:101). Paterson and Wilson's article indicates that the utilisation of Indigenous people for work was supported and enforced by the legal system. Inthanoona was worked utilising mostly indigenous staff until it was bought out in 1912, although supposedly the Indigenous staff continued to be employed by the new landholders (Sharp 1979:117). The removal of Indigenous people from traditional life is reflected in the rock art at Inthanoona. Rock art motifs depict aspects of pastoral life and people wearing introduced European clothing. These images are densely concentrated around the main buildings, indicating that Indigenous workers no longer had their traditional range of movement in the area. All of the information from Paterson and Wilson's article can be extrapolated to other properties of the era in the Pilbara. The utilisation of Indigenous workers was supported by the colony and there was no alternative cheap labour force available.

Similar to Paterson and Wilson (2009), Harrison (2004) used historical archaeology to interpret the relationships between Indigenous people and non-Indigenous pastoralists in the east Kimberley. He used physical evidence, oral histories and historical records to determine the status and progression of the relationship between Indigenous and non-Indigenous people. Harrison focused more on infrastructure layout rather than individual buildings, as the layout contributed more to his focus on relationships between groups. Harrison focused on properties surrounding Halls Creek, including old Lamboo Station, with an emphasis on the progression of understanding of the Indigenous people by the Europeans and vice versa. Harrison discusses the progression of dwelling proximity from the early years of European settlement, when Indigenous and non-Indigenous homes were completely segregated, to the mid-20th century, when they began being constructed closer to each other. This is discussed as being an outcome of acceptance of differences and a greater understanding of Indigenous people's traditional behaviours.

3.2 Architecture and landscape learning

Early trends in historical archaeology during the 1970s and 1980s focussed on understanding how people adapted to the environment, especially the establishment of suitable infrastructure and agriculture. The 1970s−1980s reflected wider changes in the theoretical trends in humanities research with a push toward environmental determinism. This entails the environmental adaptation and landscape learning evident in the archaeology of structures. Environmental adaptation has been investigated in detail by Birmingham and Jeans (1983), who used a fictitious family shipwrecked on an island to posit a model for adaptation to a new environment. Their colonisation model (Figure 12) outlines the progression of colonisation from the exploratory phase to learning phase and finally developmental phase; the exploratory phase is based on first arrival and basic assumptions of the land by the first arrivals. The learning phase is the adaption to the land and determining what works and what does not (Birmingham and Jeans 1983:6). The final developmental stage is the progressive development of a new economy based on the learnings from the new region. Being able to incorporate aspects of their previous home into their new situation, would assist with the colonisation process. Having access to resources on the shipwreck brought from their old country and using them in their new situation reduced the amount of landscape adaptation required, minimising time spent in the exploratory and learning phase of the colonisation model (Birmingham and Jeans 1983:5).

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Figure 12: Flow chart illustrating the process of colonisation from initial contact to the development of a mature economy. (Birmingham and Jeans 1983:6)

Historical archaeology during this period focused on colonisers' adaptation of prior knowledge from their home country and learning the new landscapes and environment. Connah's 1983 article, for example, investigated sheep stations in the New England region of New South Wales to understand 19th century settlements in the region, but also viewed the impacts of environmental adaptation. He identified the continued use of cheaper products from Britain in construction (as opposed to local products) and their use in architecture adapted for the Australian environment (Connah 1983:18; Freeland 1968:117). An example of this is the import of Lysaght steel from Britain into Australia from 1857 until they were able to establish a cost effective Australian based manufacturing facility in 1920 (Lysaght 2021). The use of corrugated iron in Australian architecture after 1860 has since become synonymous with Australian house designs (Freeland 1968:119).

Archaeological assessments of structures from around Australia highlight the progression in building design through the formative years of European settlement in Australia (Allison 2014:98–99; Blackman 1988:27; Connah 1983:18). The progressive architectural changes in major Australian cities from colonial to post-colonial styles were enforced by various building Acts, rather than environmental adaptation (Freeland 1968:84). Hip roofs, verandahs and overhanging roofs were removed (via legislature) as standard urban building features in the colonial period, 1822–1837, in place of more fire resistant and subsequently repetitive and mundane features, which can be seen in the Sydney architecture of the era, for example the terrace cottages of Darlinghurst New South Wales constructed between 1838–1850 (Freeland 1968:85).

Hip roofs, verandahs and other temperature regulating features, however, featured heavily in regional and rural homesteads and inns designed and built after 1838 (Freeland 1968:102). These elements still featured heavily in regional areas until the start of the gold rushes of the 1850s caused labour shortages across Australia (Freeland 1963:112). The colonies adapted to the lack of labour by adopting timber framed, weatherboard and iron roofed construction techniques from the Americans who joined the Australian gold rushes (Freeland 1968:117). These changes occurred across Australia in places where a cheap, quick and reasonably satisfactory building construction took precedence over the social virtues that came with brick construction (Freeland 1968:117).

Connah also attempted to identify the cultural adaptation of people to the Australian environment by transferring prior knowledge into a distinctly Australian approach to agriculture. Connah identified an individual who had been formally trained in a British agricultural college, travelled in America and settled in Australia in the 1860s. This individual adapted what he had learnt at college in Britain and America to improve his pastoral station (Connah 1983:19). He also published letters in the local newspaper with suggestions to other landholders on betterment of pastoral practices. This is a case study of landscape learning, information distribution for adaptation and agricultural practice progression. Throughout his study Connah (1983:19) attempts to highlight the benefits of understanding archaeology, rather than just recording it. He outlines the benefits of using archaeology to understand adaptations, their source and the benefits they provided to the people who made them.

There are also instances of colonisers struggling to adapt in a new environment (Hardesty 2003:89). Hardesty outlines environmental adaptation from a mining perspective using an example of the Nevada based Comstock Lode mining operation in the 1850s. He investigated the idea that the willingness to adapt old technology and develop new technology in the new Nevada mines was based on the potential profits from adaptations, if an adaptation did not return a suitable profit it was rejected. Hardesty's article focuses on economic benefits to adaptation, rather than adaptation for survival in a new environment. The colonisation model in Figure 12 indicates that Hardesty's research from 2003 was focused solely on the transition from the learning phase to the developmental phase.

Compared to the environmental determinism of the 1970s–1980s, much archaeological research in the last 30 years has reflected more post processual elements and an interest in social causes for change and variability. The application of such research to pastoral properties has focussed on the relationship between social status and the progressive renovations and additions to standing structures. In Queensland the Caboonbah Homestead near Somerset Dam was researched in 2013 by Linda Terry in an attempt to determine the social status and class of the original occupying family. Terry (2013) used excavations and found artefacts to determine the status of the family, but unfortunately the homestead building itself could not be assessed as it burned down in 2009. Having standing structures to assess is beneficial, as the construction, materials, features and size can indicate social status as much as functional choices of the construction period. In contrast, Pam Blackman's much earlier 1988 research assessed an 1887 pastoral homestead in Queensland's Lockyer Valley in terms of changes in building style, as it was clear the home additions were not conducted to match the previous style of the home (Blackman 1988:28–29). Blackman provided a detailed analysis of the structure's design, layout and methods adopted for adding the extensions. Both Blackman (1988) and Terry (2013) use their data to discuss the socio-economic standing of the original homeowners and how this influenced their resulting homesteads, but neither considered how the infrastructure impacted the lives of the residents, rather they focus on how the residents impacted (and developed) the infrastructure. Determining the impact that a structure has on the residents has rarely been discussed in the literature.

3.3 Archaeology and the environment

An international focus across many disciplines on climate change over the past decade, however, has brought research interests back into the realm of environmental adaptation, albeit through linking environmental learning with the adaptation of previous knowledge and ongoing landscape learning in the face of new conditions and events. Such research is premised on the idea that humans can use history to understand how adaptation and landscape learning have changed society. Historical research to understand contemporary issues is becoming more prevalent in modern archaeology (Lawrence and Davies 2009:642). The discussion around climate change hinges around mitigation, but the changes have started, and understanding adaptation is once again necessary (Rockman 2011:193–194). Learning from the past and using it to adapt to the future may assist humans in understanding the best approach going forward (Rockman 2011:194).

Paterson and Wilson (2009), Lawrence and Davies (2011) and Blainey (1978) all discuss the issues faced when adapting various forms of industry from Europe to Australian conditions. Lawrence and Davies (2011) discuss the importance of agriculture to survival, then the progression into agriculture as business, which took years to achieve. The slowness of this process can be put down to 'landscape learning' by settlers, who initially attempted to implement practices common in Europe (Paterson and Wilson 2009:100). The 'landscape learning process' is defined as being, "the social response to a lack of knowledge about natural resources in an area and a lack of access to prior knowledge about natural resources" (Rockman 2003:12). First outlined by Rockman in 2003, landscape learning describes the continual learning and adaptation that non-Indigenous people face when living and working in new environments. Rockman (2003) describes the issue of perception versus reality when entering a new environment. She argues that colonisation, behaviours and environmental knowledge are all linked: “New behaviours need to be developed to adapt to a new environment and new environments form new behaviours” (Rockman 2003:3). Rockman outlines various examples from across the world in which environmental resource knowledge and the distribution of this information is essential for survival (Rockman 2003:8).

The landscape learning model can be used to identify environmentally impacted cultural change through locational, limitational and social elements (Rockman 2009:52). Locational elements are the fixed characteristics of natural resources, while limitational elements are the cycles and constraints of the natural environment. Limitational knowledge is gained over time as cyclical changes in the environment are determined. Social elements are the transfer of locational and limitational information amongst and between groups and generations. These elements are also seen in non-Indigenous Australia, although often in slow learning as reflected in gradually changing agricultural practices, and shifts in structure placement and design.

The issues that attempting to farm in the old ways in a new landscape posed for colonists in the early years of colonisation are discussed by Dennis Blanton (2003). Blanton outlines issues faced in North America by colonists who attempted to live similar lives to those they had in their native countries rather than adapt. This ethnocentrism led to high mortality rates in locations that were more than sufficient to support life (Blanton 2003:196). An example of poor landscape understanding and naivety was also visible in the first years of European occupation in the Sydney region of NSW. The European population struggled for food in a landscape that supported a sizeable Indigenous population (Lawrence and Davies 2011:129). In the first years, the colony crops struggled and colonists relied on preserved food rather than adapt their thinking to utilise native foods (Lawrence and Davies 2011:129). It was not until the non-Indigenous population began to understand the newly colonised environment that they were able to adapt agrarian techniques to establish the new crop farming and pastoral industries. Unlike many other colonised nations there was no domestication of native fauna in Australia as a result of introduced farming (Paterson 2018:7). This could either demonstrate the unwillingness to adapt to Australian resources, or the inability of Australian resources to be adapted.

Colonists in Australia needed to understand the landscape and the location of natural resources, which became apparent soon after colonisation (Lawrence and Davies 2012:47). Water, in particular, was a resource that was not as readily available as in most other parts of Europe and the Australian landscape was much drier (Lawrence and Davies 2012:47). Lawrence and Davies' (2012) work in the Victorian goldfields regarding historical European water management and infrastructure describes the importance of water to successful mining operations, including the domestic lives of the miners. Water was not only a key priority when European settlers first established mining operations and agricultural properties, but throughout their operation (Harrison 2004:122). Poor water quality from bores and flooding led to the abandonment of Old Lamboo Station homestead in the Kimberley after it had been inhabited for approximately 70 years (Harrison 2004:122). Depending on the aquifer recharge into a bore, water quality can gradually decline and is often dependant on the rainfall that an area receives. The lack of rainfall in the east of the Australian continent provided challenges to European settlers, who had to engineer waterways to move the limited water where they needed it (Lawrence and Davies 2012:47). Compared to the east coast, the north-west is significantly drier. Potentially due to its isolation, low population or the lack of water, there is no mention in historical archaeological literature regarding the techniques and engineering methods implemented to live in this area of Australia. Water is a valuable resource anywhere, but in a perpetually dry landscape it is the difference between life and death.

Prior knowledge of the environment and climate around Australia was more detailed in some regions compared to others in the early to mid-19th century. Some aspects of the Australian climate were known to colonists, but detailed information regarding weather and climate was lacking. In 1829, for example, when the Colony of Western Australia was first established, 4,000 settlers immigrated after promises of quality farmland drew people west; within 12 months only 1132 remained (Moore 1985:30, 31). The *Colony of Western Australia Manual for Emigrants* described the climate around the Perth region and outlined the benefits of the Western Australia environment for health and agriculture ten years later (Ogle 1839:28, 30, 88). When this manual was released the colony north of Perth had still not been assessed in terms of its suitability for agriculture and the manual was more of an advertisement than a genuine guide for new arrivals, mentioning nothing of the actual environment and climatic conditions expected in Western Australia. The known lack of understanding of the climate outside of the Perth region provides an indication of the limited available landscape knowledge (Young 1985:175). The lack of information about the landscape and environment led to colonists in Western Australia's formative years living a precarious existence as they attempted to adapt European farming methods to the new landscape (Moore 1985:31).

Landscape learning can be separated into quick or slow learning and partial or complete learning. Quick learning happens from one group to another and within a single generation, while slow learning takes generations to develop. An example of quick learning is the building construction adaptation made in 1839 by Commandant Captain John McArthur after he discovered white ants rapidly devastated buildings constructed on low piles in Queensland, which was easily prevented in buildings with taller piles (Freeland 1968:118). Adaptation of tall house piles was widely adopted in Queensland (Coppabella 1926:47). In most instances the landscape learning model shows that a colonising people who adopt quick learning have a better success rate in a new environment (Birmingham and Jeans 1983:6).

Utilising information from previous populations can also minimise the requirement for complete landscape learning and hasten the process (Rockman 2003:12). This is particularly the case if oral and written histories exist that can influence people's perceptions or if previous generations or populations are willing to share their knowledge. In the Australian context landscape learning was quicker when only partial learning was required with assistance given from Indigenous people who already knew the land. Alternatively it was more complicated if Indigenous people were treated as the enemy or did not give this information freely. Landscape learning by the Indigenous population may have also inadvertently reduced the landscape learning required by the colonising population: the traditional use of fire, for example, would have reduced the land clearing requirement for farming (Paterson 2018:8).

The archaeology of disaster and change also factors into landscape learning and Torrence and Grattan argue that environmental factors, especially natural disasters, rapidly accelerated landscape learning and adaptation. Torrence and Grattan (2003) discuss the impact that natural events have had on cultural change through history, ranging from volcanic eruptions to earthquakes. In the 1970s natural disasters were not widely considered in determining cultural adaptation, but are being factored into archaeological research more readily now. Not taking into account adaptation to natural disasters overlooks a major influencing factor in environmental adaptation and why people live the way they do in regularly impacted regions. The archaeology of disaster and change is the adaptation by human societies to significant natural events. These could be landscape wide, like the eruption of Toba around 70,000 B.P. (Ambrose 1998:624), or isolated incidents like cyclones.

Major events require rapid cultural adaptation in order to survive, while isolated events require adaptation to continue living and operating in a region. Not all communities manage natural disasters in the same way, however, and adaptation does not always result. For example, the coastal towns of Papua New Guinea accept natural disasters as a part of life (Davies 2002:30). It is estimated that the north coast of Papua New Guinea is affected by a tsunami every 15–70 years, but despite this, there is no information passed down between generations and no social adaptation (Davies 2002:30). Towns are severely impacted and lives lost almost every time a severe tsunami hits the coast. This lack of overall cultural change is reinforced by Lucille Johnson (2002), who assessed the cultural changes in response to volcanic eruptions and earthquakes on the Shumagin Islands in Alaska. Johnson assessed long term effects of these natural events and noted that the local population had psychologically adapted to live with the impacts and did not see them as reason for physical change (Johnson 2002:196). The people who inhabit these islands continue to rebuild infrastructure destroyed by natural disasters, often in the same location (Johnson 2002:202). There is an argument in this case that the people who remained living in the Shumagin islands had accepted the eruptions and earthquakes as part of their culture. Adapting their culture to psychologically prepare themselves for the impacts of living on the Alaskan islands can be seen as a spiritual embrace of disaster.

Understanding whether, and, if so, how natural disasters affect landscape learning is complicated by the fact that, without sufficient data, changes and adaptations may not be visible in the archaeological record. Visible changes in the archaeological landscape would be sediments washed from other catchments and deposited in a new environment. European arrival changes may be represented in adaptations of architecture, with new structural designs and reinforcements implemented (Freeland 1968:117). Changes could also be seen in relocation of infrastructure as landscape learning develops. Using archaeological records to understand adaptations can demonstrate willingness to learn and adapt. Assessing and understanding the archaeological record can provide information on European adaptation to environment and preparation for natural disasters. Understanding natural disaster impacts on a newly colonised landscape can assist in determining when adaptation may have occurred, especially if this can be revealed in the material record of standing structures. The structures constructed since the arrival of Europeans could provide more archaeological evidence of human adaptation than a subsurface excavation could determine.

3.4 Architecture for disaster

Designing structures to withstand natural disasters is essential for survival and continuity of human activities. This applies to all elements of a structure, including its materials, techniques and forms. The architecture and construction of buildings expected to withstand cyclonic conditions determines how well the building withstands the impacts (Stewart 2003:672). Ankush Agarwal (2007) was appointed by the United Nations Development Program to develop an overview of the impacts of cyclones on house structures and how different architecture handles impacts. Wind pressure differentiation around the building causes specific sections of the house to bear the brunt of the force and if buildings are not built uniformly to distribute force, a seemingly strong structure could fail. Agarwal's and other studies (Meecham 1992; Phong and Duc Tinh 2010) have pointed to more stable architectural elements, such as the hip roof. Although other forms such as gable roofs are easier to build and require less material (Figure 2), the hip roof has consistent sides with no angle that receives more pressure from wind than any other (Figure 2) (Agarwal 2007:9; Meecham 1992:1717). Its form therefore reduces aerodynamic loads and distributes them more evenly (Meecham 1992:1717), making it the most suitable design in high wind/cyclone prone regions (Agarwal 2007; Meecham 1992).

3.5 Conclusion

The towns in the north-west, settled for agricultural purposes, have had limited or no research conducted into their histories or archaeology. The Kimberley region receives consistent seasonal rainfall, while the pastoral properties of Western Australia's Gascoyne, Mid-West and Wheatbelt receive consistent rains and were readily accessible from Perth. The Kimberley region had similar cyclonic conditions to manage, but does not have the extreme heat and uncertainty of rain. The infrastructure of the Pilbara was required to withstand a cyclone, but still be liveable in up to 50 degree Celsius heat. These factors make the Pilbara unique, requiring historical archaeological assessment separately to other Australian regions.

4 Methods

To assess all structures at both precincts and across the Mardie-Balmoral station was beyond the scope of this thesis. Due to access restrictions caused by cyclones in 2021 and heavy rainfall in May, followed by Covid-19 border restrictions, the time available to conduct field work was decreased. Of the two stations, Balmoral was easier to access during and after light rain. Another influencing factor on focussing on Balmoral is the intact nature of the infrastructure. As the Mardie infrastructure is the modern hub for the property, the Balmoral infrastructure was abandoned in the 1990s and subsequently forgotten. This meant that it has not been subject to the addition of modern features over the last 25 years.

4.1 Building selection

To determine which buildings at Balmoral were relevant to the thesis aims, three basic criteria were developed:

- Was the building lived in?
- Was the structure used in everyday life at the station?
- Are there sufficient remains to determine layout and use?

The first criterion considered whether the structure was used for living purposes or to support the business throughout the year. This focussed on buildings used for living in, cooking and as general workshops. Criterion two distinguished between structures that were used year round and those that were only utilised during short periods, such as the shearing sheds. Assessing whether or not there were sufficient structural remains to determine layout and use enabled a focus on those structures with more physical elements. Structures such as the miscellaneous slab at Balmoral Station were not considered unless there was physical evidence indicating the placement of walls or doors that enabled a determination of layout and materials used in construction. The Indigenous house at Balmoral Station also consists of just a slab, but there are sufficient markings and remains on the slab to indicate the locations and width of doors, layout and the thickness of the walls, as well as the construction materials utilised. Infrastructure utilised to supply water to the buildings was also assessed, chiefly consisting of windmills and elevated tanks.

After reviewing each of the buildings at Balmoral against these criteria the following buildings were determined to be suitable for recording:

- Homestead
- Indigenous house
- Workshop
- Supervisor's house
- Dining hall/mess building
- Shearers' quarters.

4.2 Archival research

To assist determination of building age, details about previous use from local archives were reviewed. The best source of local historical information is the City of Karratha (previously Shire of Roebourne) archives. The 2012 Shire of Roebourne Local Government Heritage Inventory included an overview of the Balmoral and Mardie buildings. The website Trove also provided articles and photographs from Mardie and Balmoral, predominantly around the cyclone impacts at the property. The local Karratha library was checked for relevant material, but had little that was not available via online resources. State Library of Western Australia contained valuable information on the West Australian colony and Pilbara history.

4.3 Inconsistent data

There were noted inconsistencies in historical photographic descriptions. Historical photographs taken after the 1945 cyclone depict destroyed buildings, but do not indicate their location in the landscape and show very little background that could indicate where the buildings were constructed. This is most likely due to the photographic technological restrictions of the day. In conjunction with this there are photographs that are labelled as being from the Mardie shearing precinct that are clearly buildings at Balmoral. This mislabelling makes it difficult to trust the written captions of the images.

4.4 GIS for assessment

Being able to see the landscape from above and analyse features from photographs taken at height allows sites to be identified that could not be seen from the ground (Parcak 2009:16). GIS technology is constantly progressing, improving significantly with each new software update. Using GIS for site predictive modelling can uncover potential features in areas that cannot be readily accessed, or areas that have been assessed in the field and thought to contain nothing relevant (Parcak 2009:27; Shennan and Donoghue 1992:226). The application of GIS in archaeology is not new (González-Tennant 2016:24), but appropriate application is essential to a beneficial outcome.

ARC GIS was used for all mapping in this thesis. A comparison between GIS and physical recording was conducted by measuring building perimeters on ARC GIS and conducting a ground truth exercise to determine accuracy. This was done to determine the most time efficient method for measuring building perimeters. GIS was also utilised to determine the orientation of each of building. Predominant wind direction was measured by reviewing the available weather data for the region and plotting a wind rose over a map of the buildings.

Historic aerial photographs were used to identify fence lines, access tracks and to determine links between buildings. Unfortunately, the only aerial photograph that was available was from July 2012, photographed by CITIC Pacific Mining. Any potential paths, tracks or walkways that were identified on aerial photographs were checked in the field to determine if they were actual building links or just cattle tracks. This comparison was also done for fences in the building precincts that would indicate segregation of areas. Any confirmed fences were noted.

4.5 Form of structure

4.5.1 Structure parameters

Each structure at Balmoral was physically measured to determine its dimensions, including: room sizes; size of doors and windows; and size of living areas (if present). The footings and support for the building walls were measured to determine the design aims of the building. Design aims are based on the strength of the building and temperature management inside the building, the size of living areas and rooms, and the building's location in the landscape. This includes the viewshed for each building, which is particularly pertinent for the homestead. Building layouts were then drawn to provide a scaled physical layout. In the instance of the Indigenous house the layout of the building was based on markings on, and material attached to, the concrete pad.

Each building's roof was assessed against the basic features in Figure 13 to determine its design, which was then researched for its strength characteristics, including the internal truss layout (Appendix A – Design Record Sheet.). Each building's location and design were also assessed against ten points to determine their suitability to withstand a cyclonic weather event, listed on the field sheet in Appendix A – Design Record Sheet.

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Figure 13: Roof designs (image from Roof Vents Australia) Note: a shed roof is referred to as a skillion roof in architectural terms.

4.6 Construction materials

Internal and external construction materials for each structure were recorded using the recording sheet in Appendix A – Design Record Sheet.

4.6.1 Timber

Timber identification without sending samples for laboratory testing was conducted by assessing the wood characteristics listed in the field recording sheet in Appendix A – Design Record Sheet. This information was then extrapolated to determine the source of the timber and the type of timber (e.g. hardwood or softwood). Any evidence for how the timber was prepared for use (e.g. hand sawn or steam milled) was also recorded.

4.7 Evidence for reuse.

Material reuse was assessed in the buildings in an attempt to determine the extent of recycling and reuse. Elements of the buildings were visually checked to determine any aspects that varied from surrounding material. Cladding material utilised in the buildings at the Balmoral Precinct was asbestos, so this was not touched and contact avoided. Visual inspections of building features were conducted to determine reuse and colour discrepancies, since these indicators were often the best method for identification of newer material.

4.8 Other associated elements

All additional external features of each building, such as water infrastructure (downpipes, guttering, water tanks), were also recorded. All of the water to the buildings in both the Balmoral and Mardie precincts is fed from nearby bores, which was historically pumped using a windmill. The areas surrounding the bores and inlets to buildings were inspected for evidence of original piping, as the water is currently piped to some buildings using above ground plastic pipe that is a modern addition.

The use of steel pipes in buildings was also assessed. The verandahs of most buildings in the Balmoral precinct are supported by repurposed steel pipes. Each building was visually assessed to see where these pipes were reused. Assessing the standing structures internals provided some detail of the type of pipe utilised historically. Checking the pipes and comparing their gauge to the repurposed pipe for structural support indicated whether the support metal was sourced locally.

4.9 Condition assessment

The condition of the building was assessed against the following parameters (Table 3).

Table 3: Building assessment parameters and criteria.

Building assessment parameter	Criteria
Damage	Including evidence of fire, materials broken or destroyed from human impact (vandalism), or broken material caused by environmental factors like cyclones.
Degradation	Including general wear from a lack of repair. This includes rust, materials that have fallen or moved from their initial locations from natural degradation.
Infestations	Including impact from termites, insects or intrusion into the building from plants.
Loss	Including loss of the building or aspects of the building (footings, structural evidence). This can be caused by any of the above parameters, but cannot be attributed to just one. Can also be the loss of a building from an unknown cause.

Each of these parameters was assessed based on their impact on each section of a building and used to determine an overall condition rating. Table 4 **Error! Reference source not found.**provides an overview of what each parameter was assessed against and the resulting rating.

Table 4: Condition hierarchy

Condition parameter	Assessment parameter	Affects <10% of building	Affects 11–50% of building	Affects 51–90% of building	Affects >90% of building
Damage	Physical alteration of structural material due to specific events. e.g. material still standing, but holes in material caused by vandalism or weather. Material collapsed, elements broken, caused by removal of material, vandalism, cyclonic weather	Good	Adequate	Poor	Very Poor
Degradation	Any process acting naturally on materials, e.g. rust, wear, rot, water intrusion. Caused by natural degradation with no signs of intentional destruction	Good	Adequate	Poor	Very poor
Infestation	Any sustained incursion by insects or animals, e.g. termites, rodents, etc.	Good	Adequate	Poor	Very poor
Loss	Any physical removal or material by humans or cyclonic weather?	Adequate	Poor	Very poor	Building absent

The subjective assessment of the effects of such processes on each structure were as per Table 5.

Table 5: Subjective assessment rating and criteria.

Subjective building rating	Criteria
Good	Building is structurally sound with all main elements still present and is not in danger of falling down.
Adequate	Building is in sound structural integrity, but showing signs of missing elements that may lead to structural decay in the future.
Poor	Building is showing impaired structural integrity, with evidence of some structural elements missing and the remaining elements impaired. Building may fail in extreme conditions without repair.
Very Poor	Building has lost structural integrity, with most major support and structural elements missing. Building in serious danger of completely failing without rapid repair works.
Building absent	The bulk of the building is missing, with only minimal evidence of a structure being previously in place. Some materials still present, but no longer standing or indicative of initial location.

Any structural sections that varied significantly from the average condition were noted, for example when a building was predominantly intact, but had one destroyed section of a wall, window or part of the roof.

5 Results

The Balmoral precinct consists of six standing structures, one of which can only be identified based on remnants of the concrete slab, and two elements of water infrastructure. A map of the precinct can be seen in Figure 14. The six standing structures in the Balmoral precinct are the homestead, shearing shed, workshop, supervisor’s building, dining hall and shearers’ quarters. The structure no longer standing was the house used by Indigenous families who lived and worked in the precinct.

The orientation of all standing structures at Balmoral is north-south. The only building in the group that differs from the north-south orientation is the Indigenous house, which is aligned in an east-west direction. Each of the buildings are connected via a central road that branches off the Balmoral Road to the east of the precinct. Balmoral Road was the historical route of the North-West Coastal Highway.

Each of the buildings contain various items that indicate original use as an operational sheep grazing property, as well as ongoing use since it was abandoned in 1990. The original items are indicative of the building and each room’s use. Some rooms are empty of all material and have no evidence indicating their original use.

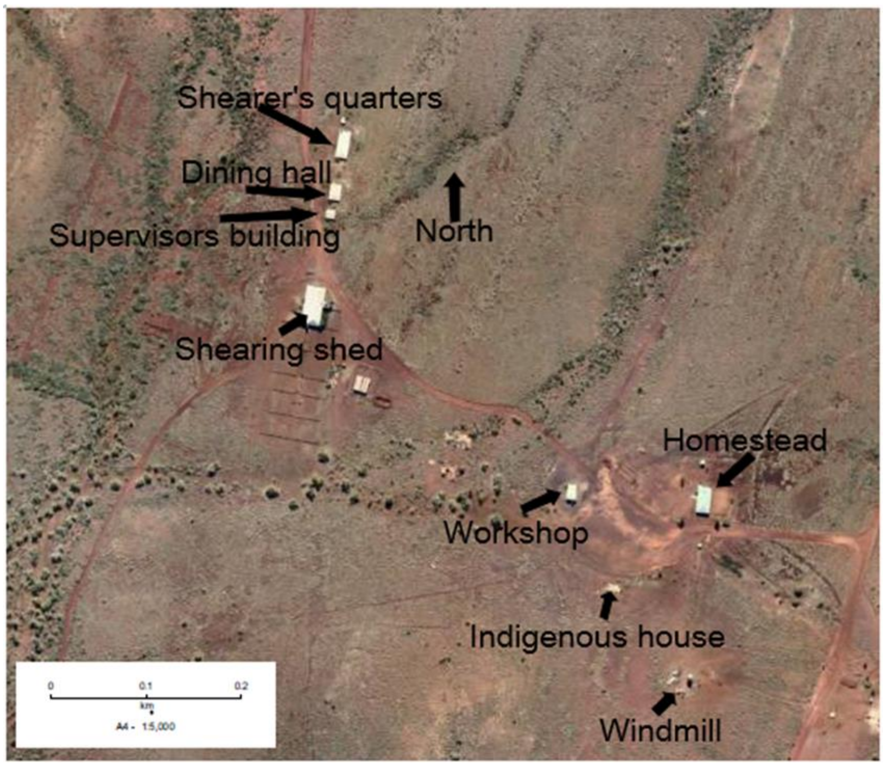

Figure 14: Individual buildings at Balmoral Precinct.

5.1 Standing Structures

5.1.1 Balmoral homestead

Balmoral homestead is an asbestos ('fibro') and timber building situated on a rise above a flood plain to the east, which extends 8km before a slight rise in the landscape where the modern North-West Coastal Highway runs in a north-south direction. The Balmoral homestead is approximately 14m higher than the base of the rise where the flood plain begins. The old Northwest Coastal Highway ran in a north south direction at the base of the rise below the homestead.

The homestead building, built in 1952, has nine rooms in its current form and is assumed to have been built in the same location as the previous iteration (see Chapter 2). On ground assessment also did not identify any concrete, footings, ceramics, glass or building material indicating placement of an earlier homestead in the direct vicinity of the current buildings. This does not eliminate the potential that the homestead was relocated, since the lack of material could potentially be due to ongoing use since 1952. The families who lived at the property could also have cleaned the area of debris, and the subsequent use of the area as a mine camp could have resulted in any material on the ground being moved for safety reasons.

The homestead predominantly contains original construction material consistent with buildings of the 1940s−1950s. The outer skin of the building is weatherboard timber and asbestos, while internally asbestos cladding is used throughout. The asbestos cladding, weatherboard and timber frames are all nailed in place. The internal asbestos sheeting has strips of timber nailed over the joins to hold the adjoining sheets in place. This is presumably to improve the aesthetics of the wall joins without the need for plastering. This building indicates continued use and maintenance until all infrastructure in the precinct ceased being used in 1990.

The Balmoral homestead (Figure 15) has a corrugated iron hip roof (Figure 17), although the internal structures of the roof could not be assessed as it is cladded with asbestos sheeting. The homestead building has a concrete slab that protrudes from the ground a maximum of 40cm on the eastern side of the house. As the building is on a slight slope, the western side of the house has the slab only slightly raised at 20cm. The building has a 40cm high concrete base on each wall, including internally (Figure 16). These bases are made using local dolerite stone as an aggregate, with a smooth render placed over the top (Figure 18).

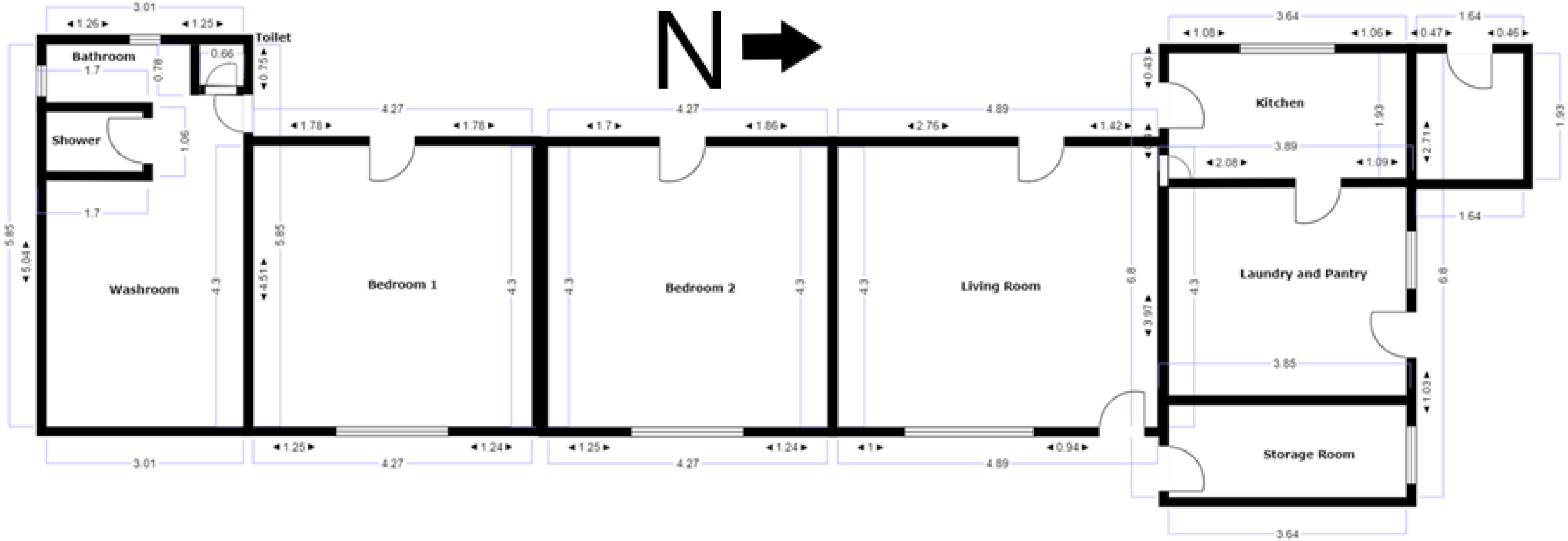

Figure 15: Drawing outline of Balmoral homestead.

The construction material throughout the building is consistent and there is no sign of repairs or renovations to any part of the building. The only material that has been replaced is the glass in the windows of both bedrooms. The glass in every other window is still the original. The only modern additions to the building are lighting and a solar hot water system.

In terms of layout, the remaining fittings and moveable elements allow identification of room function. The room in the south-east of the building was originally an open wash area. The floor is tiled and this area opens into the bathroom. The area was built in with mesh and plywood in 2009–2010 when the area was used as a laundry for the nearby mining camp. Modern poly pipe has been installed on the north wall of the washroom, with fittings for washing machines. This room is 3m wide and 4.27m long. Adjacent to this room on the south western corner is a bathroom, shower and toilet, which has a 1.2m concrete base section to the wall.

The two rooms north of the washroom are bedrooms measuring 4.27m by 4.27m. Both have built in wardrobes. One of the bedrooms was used as storage for the temporary mine camp. This is indicated by the writing on a door stating “ISS Linen Storage”. The next room north is a living area measuring 4.89m by 4.27m. This area is only slightly wider than the bedrooms and the same length. There is no designated dining room in the building, indicating this space could have doubled as a dining area. This room contains various items left behind by the temporary mining camp occupants and other visitors over the years, including witches hats, broken beer bottles and other modern rubbish.

The rooms on the north of the house are a kitchen to the north-west, laundry and kitchen storage in the centre and a general storage room on the north east. The kitchen storage and laundry area has cabinets, sinks and an area for a hot water system. The storage room has shelving on all walls. One of the bedrooms, living room and verandah area are all used by kangaroos in an attempt to cool down during summer. Animals can access the rooms as all doors are open or have had hinges removed.

Figure 16: Height of concrete walls at Balmoral homestead (Photograph: Bart King).

Figure 17: Balmoral homestead roof design (Photograph: Bart King)

Figure 18: Concrete section of walls made up of reinforced concrete and render. (Photograph: Bart King)

5.1.2 Supervisor's house

The supervisor's building (Figure 20: Supervisor's building layout (measurements in metres).) is a three roomed structure erected on a concrete slab that sits 40cm above the ground. A concrete wall base rises a further 65cm above the slab. The two main rooms are 3.9m wide, 4.8m long and 2.5m high. The third room is a wash room/bathroom, which is 3.3m wide, 2.7m long and 2.5m high. The structure has a concrete floored verandah under a skillion roof running almost the full front length of the building onto which all three rooms open. This is 5.1m wide and 2.7m long (Figure 20). This building has asbestos internal cladding on the walls and roof. Externally the walls are corrugated iron above the concrete wall base (Figure 19). The roof is also corrugated iron, with thin steel belt reinforcements on the outside. The supervisor's building is similar to the homestead in that it has a hip roof made from corrugated iron and the internal ceilings are cladded (Figure 19).

There is little within this building that indicates what each room was originally used for, except the bathroom/washroom. The rooms are now full of general rubbish, none of which indicates a specific use. The rooms contain empty 205 litre steel drums, hessian bags and general rubbish and two fridges sitting on the verandah. The building contains evidence of use since 1990, with drill core and drill rig drill bits on and next to the verandah. The windows have original corrugated iron shutters over the glass, which are shut in Figure 19 below. External construction features and design are similar to the dining hall and the shearer's quarters. The lack of cooking facilities and dining area indicates that this building was constructed in conjunction with the dining hall. It appears to have been built as a stand-alone sleeping quarters. Cladding in both the homestead and the supervisors' building appears to be of a similar age. Both appear to be a similar sheet type, but, due to the harmful nature of asbestos, were not assessed any further than superficially.

Figure 19: Balmoral supervisor's building showing hipped roof and window shutters. (Photograph: Bart King)

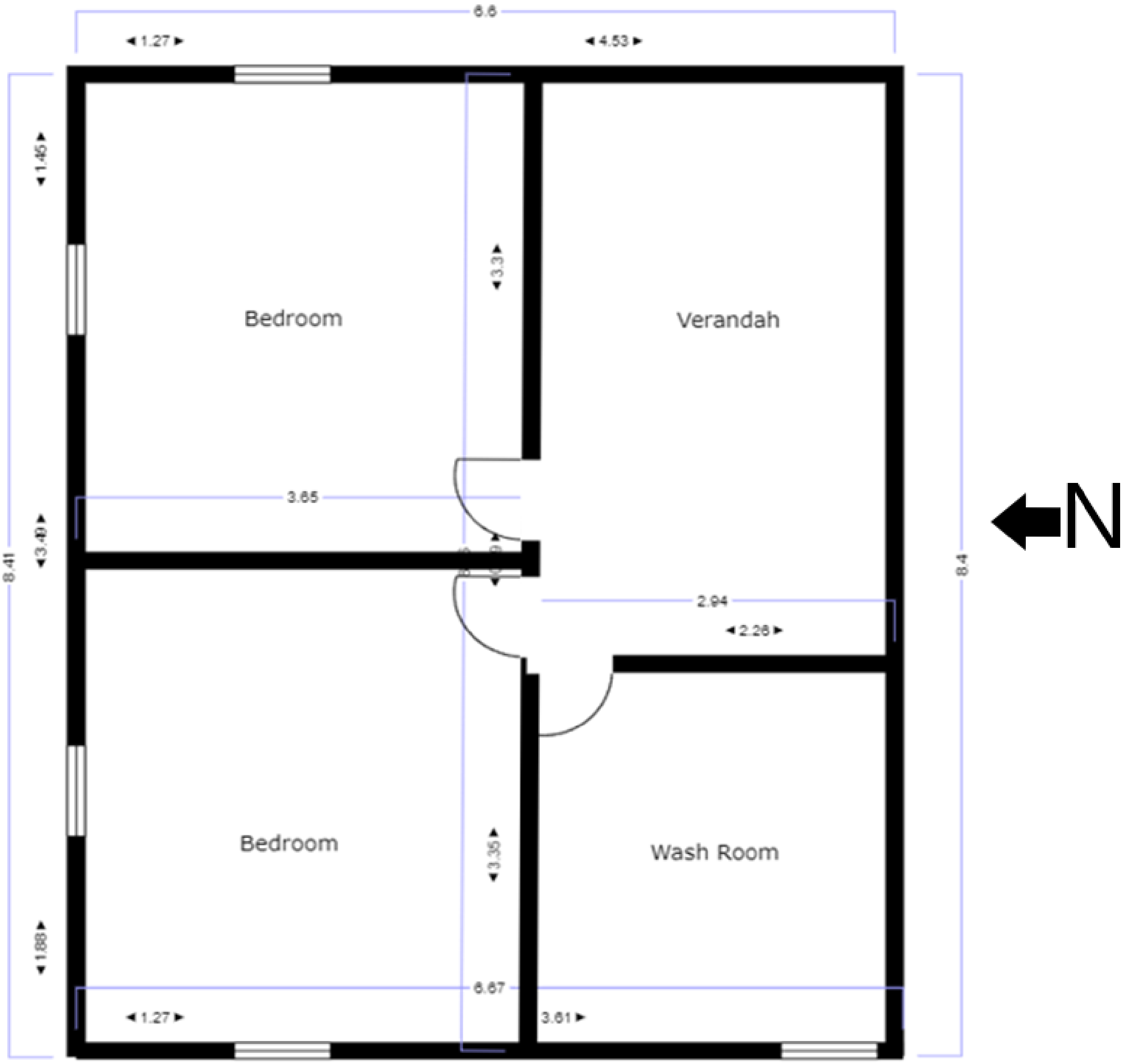

Figure 20: Supervisor's building layout (measurements in metres).

5.1.3 Dining hall

The dining hall consists of five rooms of various sizes and shapes and is built on unlevelled ground (Figure 21). As with the previous two structures, the foundations of this building are concrete, which has also been poured to form the lower portion of the walls. Given the uneven ground surface, the height from ground level of the concrete wall varies around the structure: on the western side of the dining hall the concrete is 1.65m above ground level (Figure 24) and on the eastern side 1.2m (Figure 25). The dining hall has a corrugated iron hip roof. The internal truss layout is a queen post made solely from timber (Figure 25). The roof is 2.5m high on the outside with a skillion roof up to 4.6m in the middle of the building.

The dining hall has little of its original contents, making it difficult to interpret the use of the rooms. In the north-west corner is the kitchen, which is 5.9m wide and 4m long. This room has no cupboards, cabinets or benches. The only indication that this area was the kitchen is a cast iron, wood fired oven in an alcove in the north of the building and sink on the western wall (Figure 22 and Figure 23). The oven has a maker's mark indicating it is a Metters oven, model number 06. Metters Limited was an Australian based oven manufacturer with a factory in Perth (Metters 1936:2). As this oven is built into the recess in the kitchen it can be expected this was installed in 1952 when this building was constructed (*West Australian* 1952:3). Adjacent to the kitchen is a 5.9m wide and 8.5m long dining room (Figure 21). Separating the kitchen and dining room is a wall with a servery (Figure 22).

The dining area has long timber tables with bench seats, but these are in poor condition, showing signs of termites. The three rooms on the eastern side of the building, however, cannot be positively identified to a specific function as they are empty of fittings. They are all unclad, with corrugated iron walls and timber framing on top of the concrete wall base. The rooms are all 3.5m wide and 4.4m long with a skillion roof. These rooms are accessed via the kitchen and dining area (Figure 21). The room adjacent to the kitchen is assumed to have been a pantry, while the other two rooms may have been general storage or accommodation rooms.

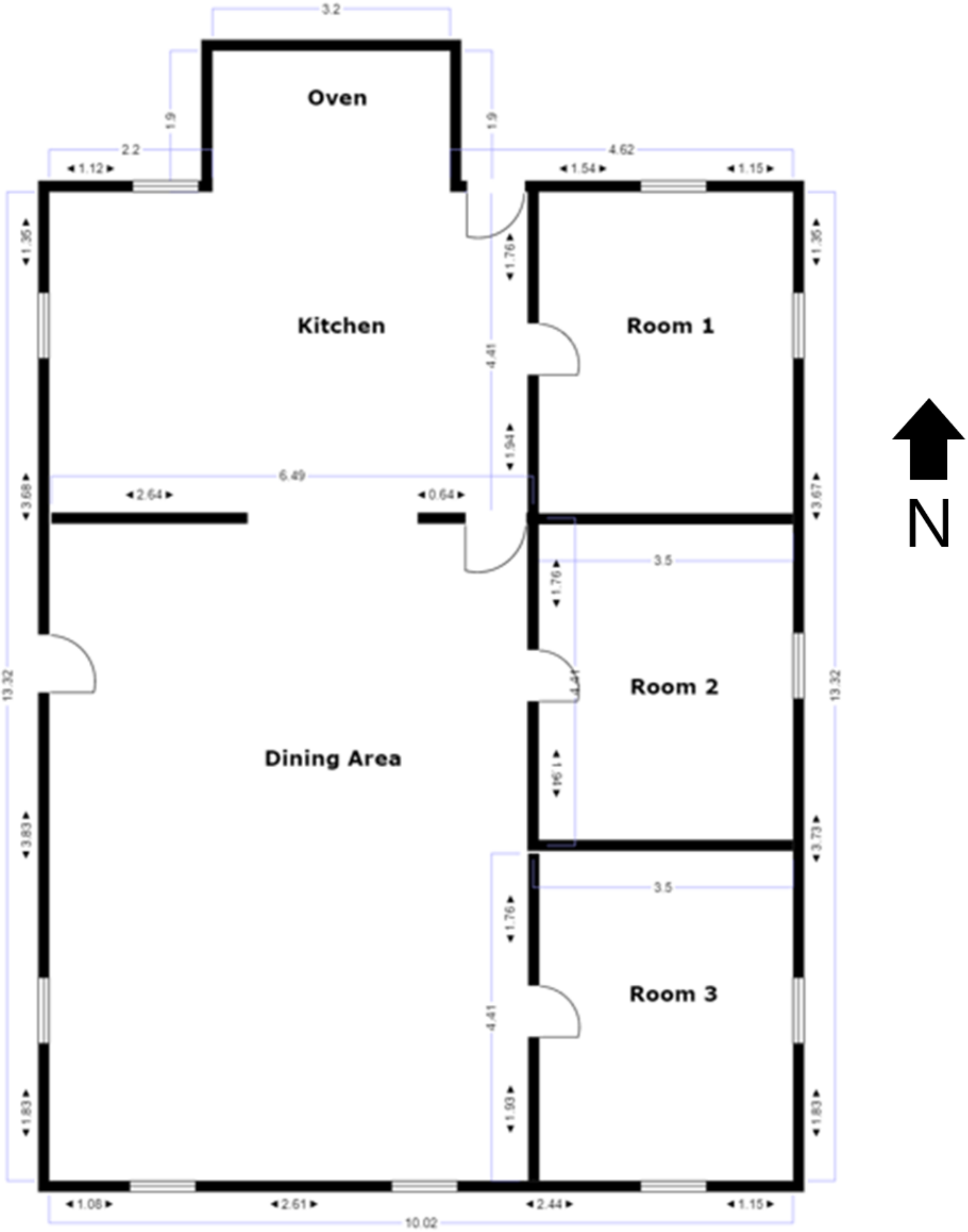

Figure 21: Dining hall building layout (measurements in metres).

Figure 22: Servery in wall and wood fired, cast iron oven. (Photograph: Bart King)

Figure 23: Metters wood fired oven at Balmoral dining hall. (Photograph: Gary Blinco)

Figure 24: Balmoral dining hall western side. 1.6m concrete wall. (Photograph: Bart King)

Figure 25: Balmoral dining hall eastern side. 1.2m concrete wall and roof layout. (Photograph: Bart King)

5.1.4 Shearers' quarters

The Balmoral shearers' quarters consists of ten identically shaped and sized rooms on either side of a central hallway, a washroom in the north-west corner and storage room in the north-east corner (Figure 30). The ten rooms are all 3.35m wide and 3.4m long with a corrugated iron hipped roof with internal trusses in the queen post layout (Figure 28 and Figure 29). The washroom and storage room have identical dimensions at 3.35m wide and 6.7m long. The ceiling is 2.5m high internally on the outside of the rooms and rises to a height of 4.6m in the centre of the building. The rooms have a front and side wall that is 2.5m high, although the front wall does not meet the roof line, as seen in Figure 29. The structure has a concrete wall base around the building, measuring 1.15m from ground level (Figure 26 and Figure 27). Windows have original timber shutters over the glass. Three of the shutters and glass windows have been broken. The doors at the north and south end of the building have rotted and are no longer complete. This structure has no designated living area or outside areas and was used solely as accommodation for workers on the property.

The ten identical rooms line up from the southern end of the building and all open out onto the central hallway (Figure 29 and Figure 30).These were all bedrooms, some of which still contain steel bed frames, but no other furniture. The room in the north-west corner is a shower room with three cubicles and timber benched wash basin on the western wall (Figure 31 and Figure 32). The room on the north-east is suspected to be a storage room. The only identifying factor in this room is some coat hooks on the walls. This space could have been used for saddle or general equipment storage. There are no other rooms or buildings in the precinct that indicate storage for shearers' or stockmen's general equipment. This building has also been utilised by kangaroos in an attempt to cool down during summer, indicated by the droppings and deceased kangaroos.

Figure 26: Balmoral shearers' quarters southern end. (Photograph: Bart King)

Figure 27: Balmoral shearers' quarters northern end. (Photograph: Bart King)

Figure 28: Shearers' quarters roof design (Photograph: Bart King)

Figure 29: Balmoral Shearers' quarter's roof truss layout. (Photograph: Bart King)

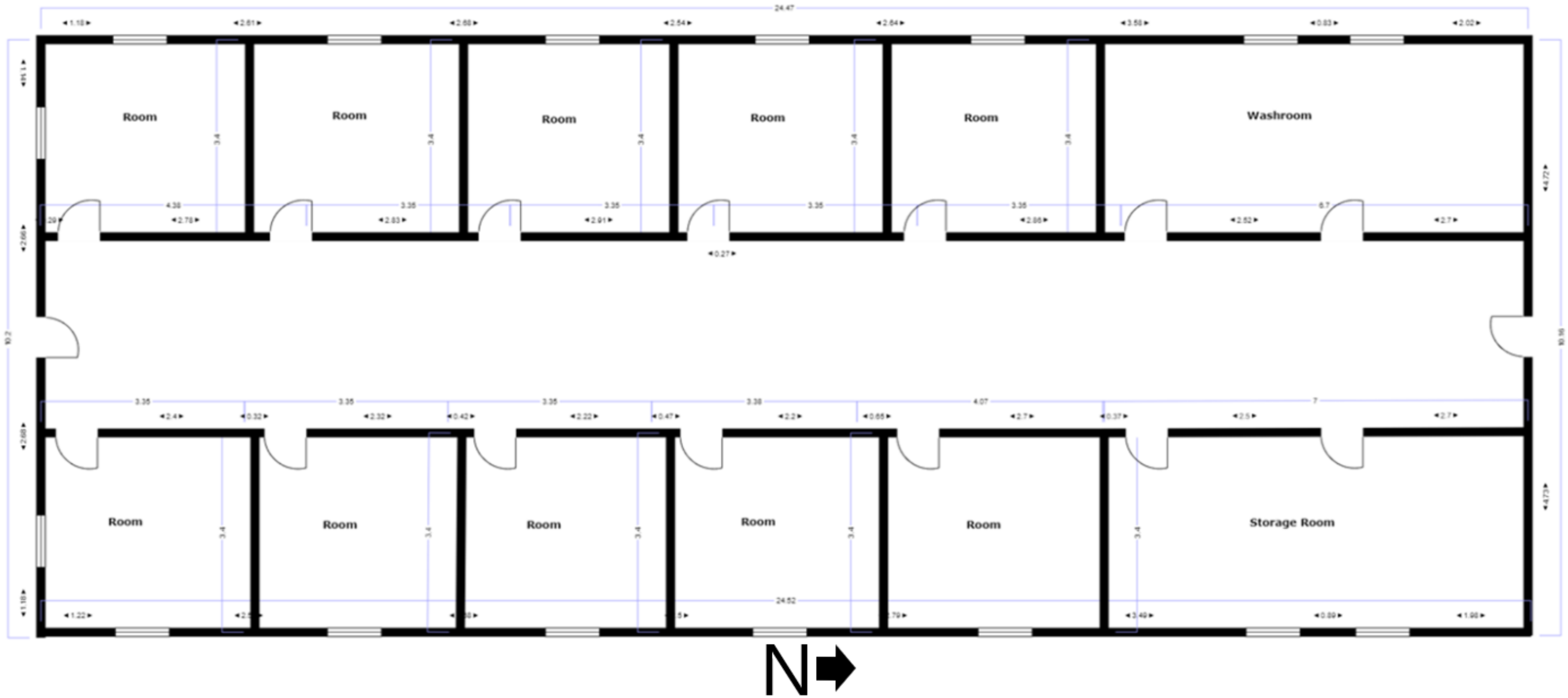

Figure 30: Shearers' quarters building layout (measurements in metres).

Figure 31: Sink in shower room of shearers' quarters (Photograph: Bart King)

Figure 32: Timber in shower room of shearers' quarters. (Photograph: Bart King)

5.1.5 Shearing shed

The shearing shed at Balmoral (Figure 33) is 30m long and 16m wide, with a hip roof design and queen post internal truss layout. The shearing shed has ten shearing bays with stock yards at the southern end of the building. The interior of the building has a large open holding pen in which a number of sheep could be kept prior to being shorn. The north end of the building is the wool cleaning, classing and packing area, with a large open central area with storage bays lining each side. The western side has twelve storage bays and the eastern side nine.

On the eastern side of the building is the engine room and shear sharpening area. This room contains a concrete pedestal that supported the engine that drove the shaft for the shears. The wool cleaning and classing area is all concrete floored, while the rest of the building has a raised timber floor. This is a standard design in shearing sheds, allowing sheep droppings to fall through widely spaced timber slats. The roof and wall supports and frames are all timber, with a corrugated iron outer.

Figure 33: Balmoral shearing shed. (Photograph: Bart King)

5.1.6 Workshop

The workshop at Balmoral was a basic building, similar in design to all other buildings in the precinct. The workshop is a stand-alone building sitting between the shearing shed and the homestead. It consists of concrete half walls below corrugated iron walls with timber framing and supports. The building is a hip roof design with the queen post internal truss layout.

The centre of the building is an open working area with two rooms either side of the work area (Figure 34). These rooms were used for storage and working, most containing work benches, original equipment and modern additions. Original equipment consists of pumps and parts that appear to have been in place for more than ten years. Modern additions are air filters, epoxy resins, tyres, oil drums and drill rig maintenance items (greases, oil filters, and pump parts).

Figure 34: Balmoral precinct workshop building. (Photograph: Bart King)

5.1.7 Indigenous house

The Indigenous house in the precinct is no longer standing. The building was 11m wide, 5.5m long and approximately 2m high. The steel poles on the pad were all 2m long and there is evidence that these poles were once secured in the concrete slab, but have since rusted off at the base. The external and internal walls were all timber framed with corrugated iron on the exterior.

This building was assessed in an attempt to determine use and layout. At the time of the field work the area was covered in grass that required clearing. The slab still had evidence of walls, doors and verandah supports and most features, construction materials and the layout could still be identified. The only element that could not be identified was the roof design, suggesting it was not hipped like the other structures. The slab indicated that most of the building was open verandah living area, with two main internal rooms, similar to the supervisor's house. The only remaining item indicating the position of the cooking area is the oven in the south east corner (Figure 35). The central room on the slab was 6.4m wide and 3.15m long and does not appear to have a front wall made from timber or corrugated iron, and potentially had no wall (Figure 37). The room to the west of the central room was 3.4m wide and 5.5m long with evidence of all walls having been made from timber and corrugated iron.

The concrete slab is scattered with items that were once been used in the building's construction. Corrugated iron sheets that match the corrugation in the outside of the concrete slab and in the concrete around the oven are scattered around the slab. Pieces of timber with signs of termites are on the slab, with nails and fastening bolts scattered throughout (Figure 36).

Figure 35: Oven at Indigenous house (Photograph: Bart King)

Figure 36: Concrete slab of Indigenous house with timber, metal fasteners and corrugated iron. (Photograph: Bart King)

Figure 37 is an estimate of the layout of the Indigenous house. It is unclear whether the walls adjacent to the oven were full walls (depicted as narrow lines), or potentially narrow verandah sections.

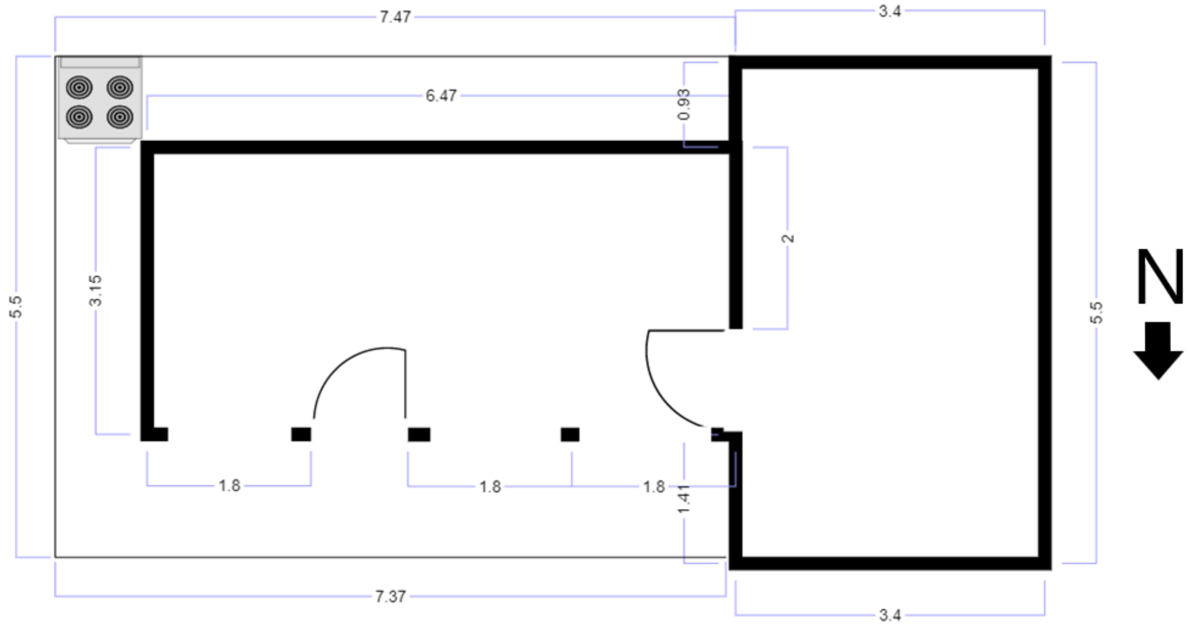

Figure 37: Indigenous house layout (measurements in metres).

5.2 Other features

The water infrastructure across Mardie-Balmoral station has continually been upgraded from steel tanks with concrete bases and windmill driven pumps, to polyethylene tanks with solar powered pumps. There are two bores supplying water to the Balmoral precinct, located 135m south and 195m south east of the homestead. These bores still have the windmills and 15 thousand litre corrugated steel tanks in place, however, they are no longer used. These bores supplied all water to the homestead, Indigenous house, dining hall, supervisor's building and shearers' quarters. The previous tanks were constructed on top of a timber stand, with the base at 3.5 m above ground level (Figure 35). Putting the tank to the south of the homestead above the height of all structures at Balmoral allowed gravity feed to the buildings. The tank to the south-east is lower than the homestead and required a pump to supply water to the buildings.

5.3 Segregated spaces: yards and fences

Analyses of the 2012 map layer in ARC GIS identified land segregation in the form of fencing around two buildings at the Balmoral precinct. The homestead has a stock fence surrounding it that is a modern addition and an older fence line a few metres outside the modern fence; this is marked in Figure 38. On the east side of the building this older fence is five metres beyond the modern fence and the remainder of it is within 1m of the modern fence. The old fence is made up of steel star pickets and timber posts with three strands of wire, giving it a height of 1m. The area inside the original fence was 3,710m^2 with a width of 68.2m and 54.4m. The modern fence is also a three strand wire fence, but is taller compared to the older fence, at 1.5m high. The new fence also has star pickets for intermediate fence posts and 1.5inch galvanised pipe concreted into the ground for corner stays. The taller, newer fence is an adaptation for cattle, while the lower, older fence was used when sheep were the primary stock on the property. Both fences are adjacent to each other and demarcate the same shape of yard around the homestead (Figure 38).

The only other building with its own segregated external space was the Indigenous house. The available map scale (1:1000m), was sufficient to identify a faint outline around the Indigenous house. This yard had an area of 532m^2, with a width of 19m and a length of 28m. The fence was in disrepair on the ground and was not able to be identified as a feature in the long grass at the time of survey. This fence line is marked around the Indigenous house in Figure 38. The fact that only the homestead and Indigenous house had segregated yard areas is presumably due to these buildings being the only structures occupied year round by families.

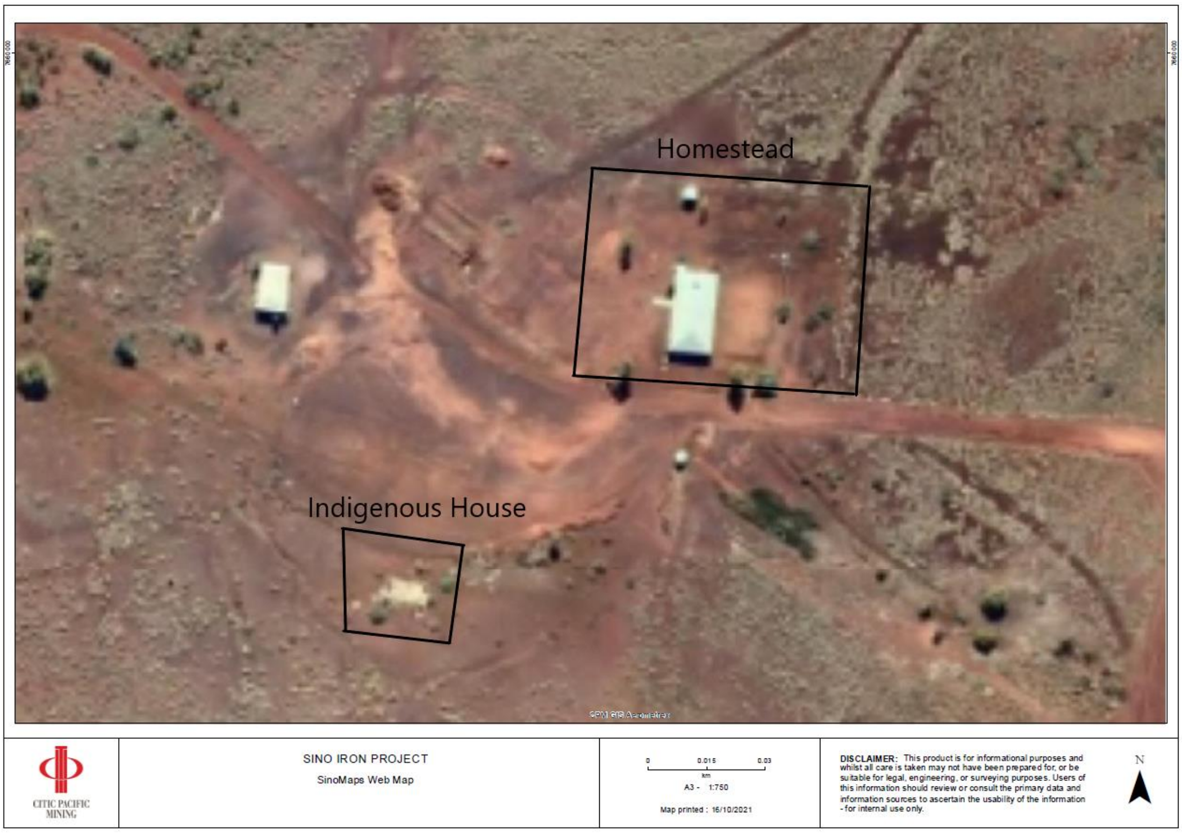

Figure 38: Balmoral homestead and Indigenous house with fence lines denoted with black outlines

5.4 Summary

The cyclone that impacted the Balmoral infrastructure in 1945 was strong enough to destroy or damage all buildings beyond repair. This is evident in the consistent use of materials and construction techniques in the rebuilt structures at Balmoral, as well as historical information. None of the remaining standing structures represent the earlier iteration of the property. The consistent standardised design (hip roof, queen post truss layout, concrete walls) and materials (timber, concrete and Lysaght corrugated iron) support the construction period being from the mid-20th century.

6 Analysing the Buildings at Balmoral

An overall assessment of structures at Balmoral was conducted to record construction materials and the condition of structures. The materials utilised and their condition within each building is recorded in Appendix C – Balmoral Shearing precinct condition assessment. This condition assessment provides an indication of infrastructure degradation since maintenance ceased in 2000. Condition can potentially inform conservation requirements for future assessments, as well as provide insights into the suitability of materials and landscape learning by previous leaseholders. The current structural integrity of the buildings relates most clearly to available architecture and construction techniques in 1952. While the assessment therefore is for mid-20th century construction, the landscape learning aspect considers all influencing factors that led to the features and layout of construction at Balmoral in 1952.

6.1 Building siting and orientation

The location of infrastructure in the landscape can indicate understanding of the local environment by leaseholders at the time the pastoral station was established. The buildings at the Balmoral precinct have been built each side of a crest at the southern end of a hill range. Buildings on the west side have been built in a shallow valley extending north-south, with the land rising to the north. The highest point of the hill is 211 metres north of the homestead and it falls 10 metres in elevation down to the homestead. The hill continues to slope down from the homestead building to the south and east. The ground to the west of the building is flat towards the Indigenous house and the shearing shed. The orientation of five of the six standing structures at Balmoral is north-south (Figure 14).

The Fortescue River is 2.4km south west of the Balmoral precinct, with a tributary that runs south of the Balmoral precinct within 1.1km. This tributary contributes to the flood plain to the east. During a flood event the precinct is cut off from the south, west and east. DuBoulay Creek lies 5.6km to the north of the Balmoral precinct, this also contributes to the flood plain to the east of the buildings. The elevated section of land on which the Balmoral precinct stands is the only suitable section on which to construct buildings without requiring significant earthworks. All other hills in the area have an average gradient of greater than 20% (see Figure 39).

Figure 39: Average slope gradient of hill ranges north of Fortescue River. (Photograph: Bart King)

The selection of infrastructure location at Balmoral was simpler than Mardie. The north side of the Fortescue has a rise in elevation that was useful for building purposes, but the south side of the Fortescue River is predominantly low floodplains. Without proper land surveys it would be difficult to locate high points in the landscape. During severe cyclones the infrastructure at Balmoral would have been cut off from supply, but the infrastructure was safe from flooding due to well-planned building locations. This use of landscape is similar to Karratha station, which utilises a rocky outcrop and rise in the landscape to reduce the wind impacts on the station infrastructure (Eureka Archaeological Research & Consulting (UWA) 2012:185).

The benefits of the Balmoral infrastructure location are also evident in the effects of wind direction and speed. The data from January 2010 to December 2020 have been summarised and placed over a map of the Balmoral precinct as a wind rose (Figure 40). The wind each year is consistent in direction and relative strength, the 11 years of data in the wind rose can be extrapolated to show long term wind speed and direction forces placed on the Balmoral buildings. This shows that strong winds consistently impact the region from south to north-west. The orientation and siting of the Balmoral structures would have ensured that any wind coming from the east, north or west was deflected over the buildings by the natural ground slope. Wind from the south would have been slowed by the shearing shed, supervisor's building and dining hall before impacting the shearers' quarters.

The homestead also has a raised backyard section parallel with the eastern verandah, with signs that it was planted with grass; it would therefore have acted as a natural insulator surrounding the homestead. The raised section also allows wind to push up the slope from the east and continue to flow up and over the building. The shearers' quarters, dining hall and supervisor's buildings are all on the western side of the rise to the homestead building. These structures are surrounded by banded iron rocky outcrops to the north and west and the shearers' quarters has been cut into this rock at the north eastern edge (Figure 27). The natural landscape provides the shearers' quarters, dining hall and supervisor's building with protection from wind, but would also have reduced wind flow and therefore increased the temperature. This could be felt while taking field readings, with a physically noticeable temperature increase between the homestead and the shearers' quarters, dining hall and supervisor's building. The layout of the infrastructure in relation to the natural banded iron hills would have made living in the area during summer difficult without environmental adaptation. The current pastoral practice of mustering during spring and conducting limited activity during summer would have been an adaptation to these conditions and is standard on pastoral leases across the Pilbara.

The only building in the group aligned in an east-west direction is the Indigenous house. The reasoning for this variation is unknown, but can be theorised in an attempt to understand. It is possible that less emphasis was placed on design to withstand cyclones for this building, given that it was built by the lease holders for the Indigenous workers. Less attention to structural integrity in the Indigenous house is also suggested by the fact that this is the only structure in the complex that is no longer standing. While it is possible that Indigenous workers could shelter in the homestead during cyclones, less attention being paid to their everyday accommodation implies a different standard of care for Indigenous people compared to European workers, indicating that working station life was not consistent for all.

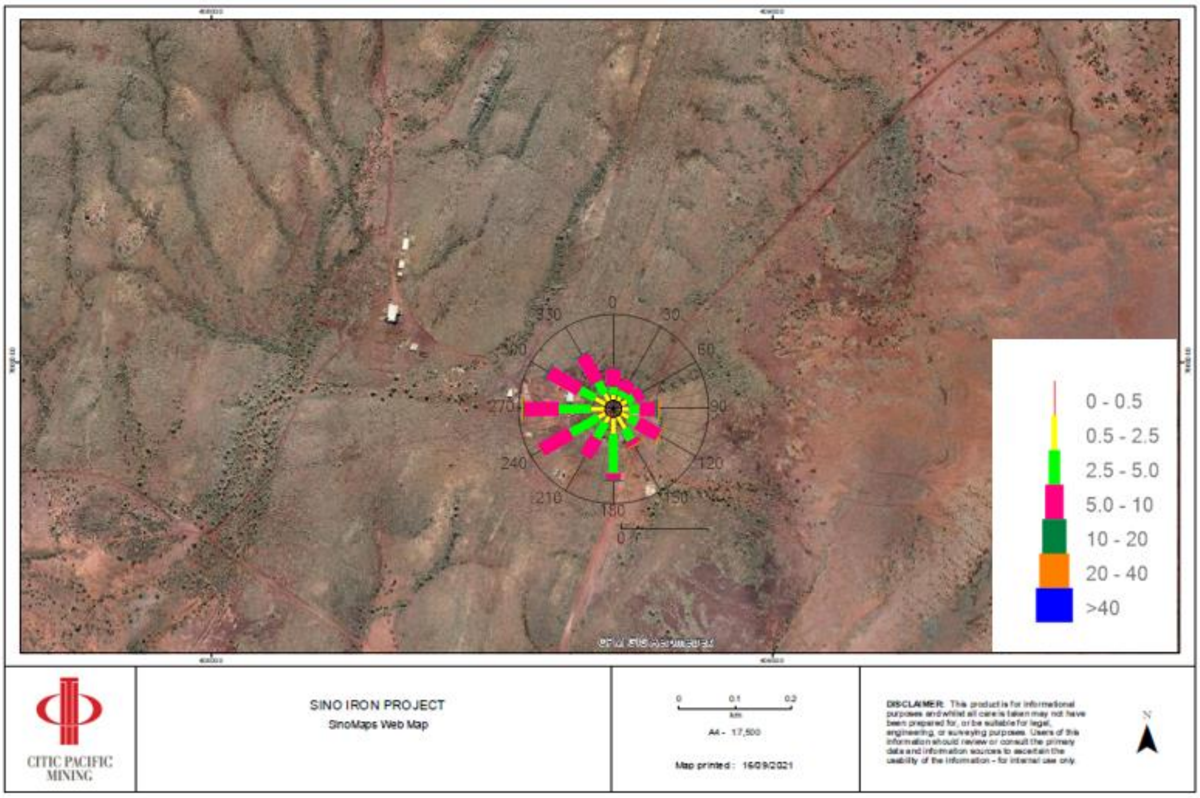

Figure 40: Wind rose over Balmoral Homestead. Colour scale indicates wind speed in metres per second

6.2 Structural integrity

6.2.1 Roof design

All of the standing structures at Balmoral have the same hipped roof design (Figure 41). This was most likely a response to the frequent cyclonic weather that impacts the Pilbara coast. The hip roof design has been proven to distribute force throughout the structure so that no single area recieves more force than another (Agarwal 2007:9; Meecham 1992:1717). This design is also utilised at the Mardie and Karratha station homesteads, but not in their other infrastructure. These properties adopted designs to withstand cyclones in different ways. Mardie uses gable roofs for infrastructure and Karratha curved roofs (Eureka Archaeological Research & Consulting (UWA) 2012:185, 206). The Mardie, Karratha and Balmoral designs have proven to be sound designs as they are all still in place.

Mardie and Karratha stations' infrastructure was significantly damaged during the same 1945 cyclone that destroyed Balmoral infrastructure. The different roof design at Mardie indicates buildings may have only required repair, rather than complete rebuild, it would be expected Mardie and Balmoral would have the same design if a complete rebuild was required. The Karratha station shearing shed was also reconstructed in 1945, but another different design utilised. The different construction indicates the various approaches to limiting impacts from severe cyclones. However, the Karratha infrastructure has been repurposed as stables and continually maintained since the transition to cattle in 2000, making it unclear if structural maintenance has been required.

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Figure 41: Comparison of hip roof vs gable roof (Agarwal 2007:9)

The angle of the roof between 30−45 degrees on all Balmoral structures allows wind to move over the building and minimises pressure build up on any one aspect of the building. The only building that may have varied from the hip roof design was the Indigenous house. As the structure is no longer standing the roof may have been built with less of an emphasis on resilience to cyclonic weather. The confidence that most buildings would remain intact during cyclone season would have influenced the stability of life for the inhabitants. Knowing that the buildings were built and designed well would allow residents to know that there would be minimal disruption to infrastructure during cyclone season.

6.2.2 Construction materials

The source and type of construction materials provides information about the resources available in the region and what had to be transported in. Mardie, Balmoral and Karratha station infrastructure all utilise concrete, timber and corrugated iron, but the construction techniques and designs vary (Eureka Archaeological Research & Consulting (UWA) 2012:185, 206).

All buildings at Balmoral have corrugated iron roofs and all but the homestead building have corrugated iron walls. The product stamp on the inside (Figure 42) indicates all the corrugated iron came from Lysaght, an Australian steel product supplier that continues to operate today. Lysaght commenced manufacture of galvanised corrugated iron in Newcastle NSW in 1921 (Lysaght 2021). The Lysaght product must have been considered quality goods to have been sourced and transported to the Pilbara from Newcastle. Prior to Lysaght commencing manufacture in Australia it was manufactured in Bristol England from 1857 and transported to various British colonies, in particular Australia with the commencement of the gold rushes (Lysaght 2021). Sourcing this material from NSW provides some insight into the limited manufacturing capabilities of Western Australia even in the mid-20th-century.

Figure 42: Manufacturers stamp on corrugated iron at Balmoral. (Photograph: Bart King)

The most notable change to construction methods and materials between the pre-1945 and the post 1952 structures is the addition of concrete to the base of the walls to increase structural strength. All buildings except the shearing shed, workshop and Indigenous house were built with this addition. The solid foundation was consistent in all inhabited structures (accept the Indigenous house), with thick concrete slabs and concrete bases to all of the external walls (Figure 16, Figure 19, Figure 22, Figure 23, Figure 25, Figure 27, Figure 29, Figure 32)*,* indicating they were built to withstand heavy wind. The thick concrete also acts as an insulator, reducing the temperature slightly within these buildings. The concrete wall sections in all buildings prevent wind from getting under the base of the walls, creating pressure differentiation and causing potential structural failure. The use of concrete in the walls appears to be an adaptation from previous cyclones, but shows the slow materialisation of landscape learning. The exposure to almost annual cyclonic weather over the previous 80 years suggests that landholders were likely aware of the limitations of previous buildings. The residents lived with the infrastructure they had, however, as it was suitable during previous cyclones and they may have had a sense of security in the structures. The structures were not able to withstand a direct impact from a severe cyclone, which they may not have been subjected to previously. The reconstructed infrastructure was then adapted to withstand the worst case scenario they had been subjected to.

The concrete in each building at the Balmoral precinct was checked in an attempt to identify material utilised in the construction. Sourcing local water, aggregate and cement would be the most efficient way to create the footings and walls of the buildings. Local business archives were reviewed to attempt to identify the region's cement making capabilities, but failed to identify any registered cement-making businesses in the Pilbara. Buildings with damage to the concrete (Figure 18) showed that river stone was used as an aggregate. This demonstrates that the material was most probably batched onsite. The proximity of the Balmoral precinct to the Fortescue River would make it a suitable source to locate aggregate material. The area surrounding Balmoral also has sandy soils of various grain sizes, making selection and sourcing of suitable material straightforward (McIntyre 2009:22). However, the lack of information regarding local cement production indicates cement was transported in from elsewhere.

Timber was assessed to check weight, grain texture, and colour, all of which indicated a dense hard wood. The lack of termite infestation indicates some resilience in this respect. The oils in the *Melaleuca leucadendra* have been shown to be a natural mosquito repellent and potentially termite resistant (Partho and Palaniappan 2016:266). Without laboratory testing the tree species cannot be guaranteed, but available information indicates the timber used in construction at Balmoral may have been the local Cajeput (*Melaleuca leucadendra)* (Sharp 1979:115). Figure 29 shows the coarse grain of the timber, surface colour and sub surface colour. Figure 29 also shows signs of the coarse cutting along the length of the timbers using a small circular saw, further supporting the assumption that this material was not sourced from a purpose-built timber mill.

All major construction materials, except corrugated iron and cement, were sourced from the property. The materials and their source demonstrates the limitations faced by leaseholders and their resourcefulness adapting to the available material. The planning requirements to ensure sufficient materials were available for fencing, windmills, stock yards and infrastructure would have been vital to continue operation on isolated pastoral properties.

6.3 Comfort at Balmoral

Comfort can be defined as a state of physical and mental ease in the environment. Perception of comfort changes as technology advances, comfort in a building in the Pilbara is determined primarily by a structure's ability to reduce internal heat. If a building can suitably do this, liveability increases. The Balmoral homestead and supervisor's building indicate some basic comfort improvements between 1952 and 2000. Both contain cladding with potential insulation, although the cladding material is asbestos and was not physically inspected during this survey. The supervisor's building has been constructed in the same design as the shearers' quarters and dining hall (which are not cladded). It is unclear when the cladding was added to the buildings (during initial construction or afterward), as asbestos in the Australian construction industry gained popularity in the 1950s and continued to be used until the 1980s (Gray et al. 2016:292). All mining, manufacture, import and use of asbestos products were banned in Australia in 2003 (Gray et al. 2016:292; Olsen et al. 2011:271). Western Australia was one of the last states to ban all asbestos products, but asbestos was very minimally used in construction after the 1980s (Olsen et al. 2011:271). Based on this information it is estimated the cladding would have been added prior to the end of the 1960s, with potential to have been added up to the early 1980s. This addition indicates cladded buildings were utilised year round, while the unclad shearers' quarters and dining hall were only used seasonally.

Another contributing factor to perceptions of comfort is continual environmental adaptation and landscape learning about the local area and other parts of Australia. Designing houses with doors leading directly to external verandah areas allowed cross ventilation and was a common early element of architectural design (Freeland 1968:45). As a temperature management tool the integration of outdoor space surrounding the house into daily activities became a consistent aspect of homesteads across Australia (Conrad 1979:393). Wentworth (1951), for example, mentions the verandah and low roof overhang for temperature management for comfort at Cowlumbla homestead in NSW, which had bedrooms that opened onto the verandah to cool the rooms (Wentworth 1951:19). Similarly, Allison (2014) notes use of the verandah area on the Old Kinchega homestead in country NSW as a place to sit in the afternoon to escape the heat.

This adaptation is evident in the Balmoral homestead, with verandah areas on the western and eastern sides. The homestead's lack of internal halls, combined with its elevated location, would have contributed to air flow through the building, enhancing the comfort of its residents. With bedrooms and dining room opening directly onto the verandah, sleeping and recreational activities would have been cooler than other parts of the homestead. While it is possible that the construction at Balmoral after 1945 was a downgrade from the previous homestead, it was also clearly designed to be the most comfortable building in the precinct, reinforcing the social hierarchy of the property.

Verandahs were utilised in the same way at the supervisor's house, with both rooms and the wash room opening onto one. It is assumed this was also the case with the Indigenous house, based on the assumed layout, since it had no internal halls and the main room opened onto a narrow verandah. The lack of internal doors between rooms in each of these buildings required residents to walk outside from each room to move around and at all three buildings the residents would be exposed to the elements every time a room was exited (Freeland 1968:22).

Contrary to the homestead and supervisor's building at Balmoral, the dining hall and shearers' quarters were built less for comfort and more for longevity. Both have solid concrete footings and concrete half walls adding strength to the structures. The windows on each of the buildings are small, only 1.1m^2, allowing minimal wind flow and ventilation. The windows have sturdy timber shutters on the outside over the glass. These shutters are used during cyclonic weather to reduce the chance of glass breaking from debris and pressure build up. The roof section is well constructed with large timber reinforcements, as can be seen in Figure 29. The walls are simply built, with no internal cladding or insulation.

These buildings are sturdy and have withstood several cyclones since they were abandoned in 2000 with no evidence of damage. The temperature table in Appendix B – Historic Weather Data suggests that uninsulated buildings with poor ventilation would have been difficult to live in during summer months. The basic design of the shearers' quarters demonstrates the conditions that the contracted labour lived in. The lack of evidence of any material changes to this structure over time indicates the building had not been improved since 1952. Due to its basic nature it may have been a similar layout to the shearers' quarters that was destroyed in 1945, but this is impossible to know.

How comfortable a building makes the occupants can be defining in a place as hot as the Pilbara. Without suitable measures to manage summer heat the region could be unbearable, especially as a long term lifestyle. Landscape learning and adaptation is evident in the architectural and material choices made in the homestead and supervisor's building, although the supervisor always lived with a lesser degree of comfort than those at the homestead. The dining hall and shearers' quarters potentially were not built for habitation during the hottest months of the year and, although the features for comfort in both are limited, the strength of these buildings and others at Balmoral have proven to be sufficient by remaining intact.

6.4 Hierarchical relationships between areas

The location of Indigenous homes close to European homes was a trend in Australia's north-west pastoral properties by the 1950s. Most pastoral properties recorded in the Local Government Heritage Inventory had Indigenous houses close to the main homestead (Eureka Archaeological Research & Consulting (UWA) 2012:64, 183, 206, 269). Harrison (2004) discusses the progression in station infrastructure layout in regard to Indigenous houses. Prior to the 1950s the hostility between European settlers and Indigenous people led to housing segregation, but around the 1950s this animosity has decreased and led to the permanent residents of the pastoral properties (Indigenous and European) living closer together (Harrison

2004:127). The infrastructure at Balmoral reflects this change, as it was constructed in 1952 and both homes are relatively close. The location of the Indigenous house and the homestead also indicates that the permanent residents on the property were segregated from temporary contract workers. Paterson's 2009 article at Inthanoona does not distinguish between Indigenous and non-Indigenous homes. Assessing the relationship between Indigenous homes and the European homestead at Inthanoona, given that the complex was established in 1864 and abandoned around 1912, could have supported or opposed Harrison's idea of changing levels of segregation. We do not have historical data to enlighten us to the living conditions for pastoral workers, so archaeology is one way to do this; in the case of Balmoral the layout of the structures helps to understand part of the relationship between owners and workers on this property.

In this respect the design of the Indigenous house varies from all other structures in the Balmoral precinct. Although this was still built on a concrete slab, this structure had no base concrete walls. The remnants of corrugated iron adjacent to the oven at first assessment were suspected to indicate external walls to the main building, but after drawing the house layout it is more likely that they indicate narrow verandahs. This would make the oven an external feature, limiting the direct heating to the structure caused when cooking. The Indigenous house managed comfort differently to the other buildings: having fewer walls meant that wind could pass through and placing the kitchen outside reduced the temperature inside the structure. It is assumed that the Indigenous house, being so compact, required adaptation of the kitchen that was not necessary in other structures. It is possible that the inclusion of a kitchen in the Indigenous house implies that the inhabitants may not have been welcome in the dining hall, or it may simply indicate that the Indigenous house was lived in by families rather than single men, like the supervisor's building. Without historical or oral historical data this is not possible to reconcile at present.

It is part of the hierarchy that the Indigenous house was different in many ways. There were elements of comfort and privacy built into it (fenced yard area and verandahs) that the shearers and supervisor did not have, but also other elements that indicated it was given a lesser status (lack of concrete base to the walls and different orientation). The location of the building in an open flat area, combined with a lack of structural strength and its alternate orientation, made it more susceptible to wind damage. The Indigenous house faced the road that interconnected the buildings and the backyard was a flat area south of the building. The front of the Balmoral homestead also faced the interconnecting road, but the back yard looked out across the plains. The Indigenous house can be seen from the homestead, while the supervisor's building and shearers' quarters cannot. One reason for the visibility of the Indigenous house could be for surveillance, as was the case in European settlements elsewhere with hierarchical racially-based worker populations (Delle 2016:115). In this light, the privacy granted to the various classes of employees can also be seen in the precinct. Workers residing in the supervisor's building and shearers' quarters were allowed greater privacy than those residing in the Indigenous house, who could have been subject to a tighter, albeit casual watch. This is a complex aspect of the relationship between Indigenous and non-Indigenous people that is reflected in the infrastructure.

6.5 Grazing animal transition

The change of grazing stock from sheep to cattle has impacted the shearing infrastructure that had been utilised since Balmoral station was established in the 1860s. The rapid decline of infrastructure was noted across the Pilbara after the majority of sheep stations transitioned to cattle between 1999 and 2000 (Eureka Archaeological Research & Consulting (UWA) 2012:81, 269, 309). This change in land use rendered the shearing infrastructure superfluous and financial investment to manage the facilities became a redundant cost. Sheep stations in the Pilbara required (at a minimum) a homestead, workshops, shearing sheds and adjacent yards, accommodation buildings, kitchen/dining hall and bathroom facilities, while cattle stations only required a homestead, accommodation and dining facilities for seasonal mustering staff. This is a large reduction in infrastructure, reducing need for maintenance and staff. The reduction in buildings is particularly apparent at Mardie station, as it had two separate hubs (Mardie and Balmoral precincts), each with all of the associated shearing infrastructure mentioned above. As sheep were phased out, all infrastructure at Balmoral was abandoned and no longer utilised or maintained. This reduction in cost allowed the lease owners and managers to financially handle impacts from droughts and floods more so than they could with the operational costs from running sheep.

6.6 Shearing Shed Design

The design, layout and construction of the Balmoral Shearing shed are standard and therefore similar to other shearing sheds in Australia (McGarry et al. 1960:190). Built in 1952, this structure conforms to a generic design and layout, consisting of catching pens (Figure 44), shearing floor (Figure 45), engine room (Figure 46), wool bins and wool table area (Figure 47) (Sharp 1979:117). The catching pen floors are removable allowing manure that falls through the timber floor slats to be cleared from under the building. This facility was solely used for shearing, wool cleaning and packing. Any wool classing or further processing was conducted offsite. To the south are holding yards that feed into the catching pen within the building. The shearing floor allowed ten shearers to work simultaneously. The shears were operated by an overhead shaft that was driven by a motor in the engine room. An article written by McGarry et al. (1960) names the main features of a basic shearing shed, all of which are represented at Balmoral. The Old Errowanbang wool shed in NSW is an example of a shearing shed that has been architecturally designed, well-constructed and operated as a shearing and wool processing facility (NSW Government 2021). Another example is the Jondaryan Woolshed in Queensland, which, at its peak in 1892, allowed 88 shearers to work simultaneously (Lennon 2011:21). The scale of this operation and continued use from 1860 to today displays the significance of this building (Lennon 2011:21). In contrast the design, layout and construction of the Balmoral shearing shed is much more modest. The basic nature of this structure indicates the nature of the wool industry in the Pilbara and the carrying capacity of Balmoral: it was not able to support the larger facilities seen in Queensland and NSW. Despite Balmoral's large land area, the climate made it unable to support the flock sizes seen in other states.

Figure 43: Balmoral shearing shed. (Photograph: Bart King)

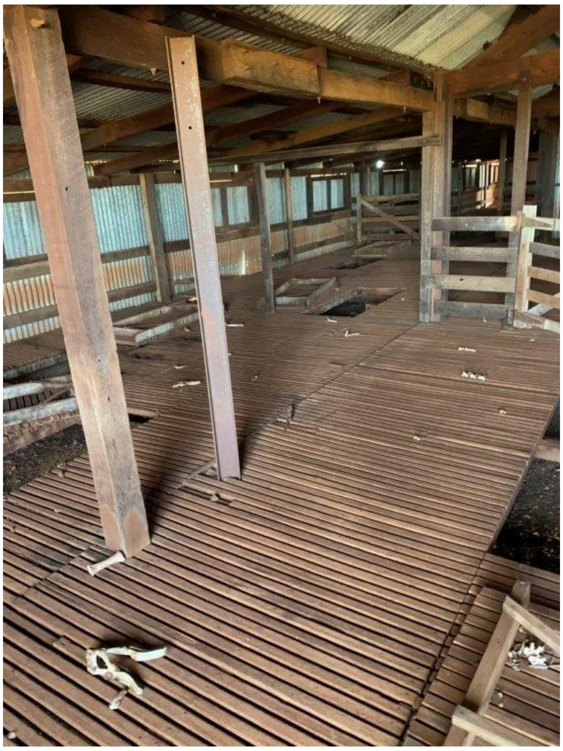

Figure 44: Catching pen area with removable floor panels (photograph: Bart King)

Figure 45: Shearing floor with overhead shaft drive for shears (photograph: Bart King)

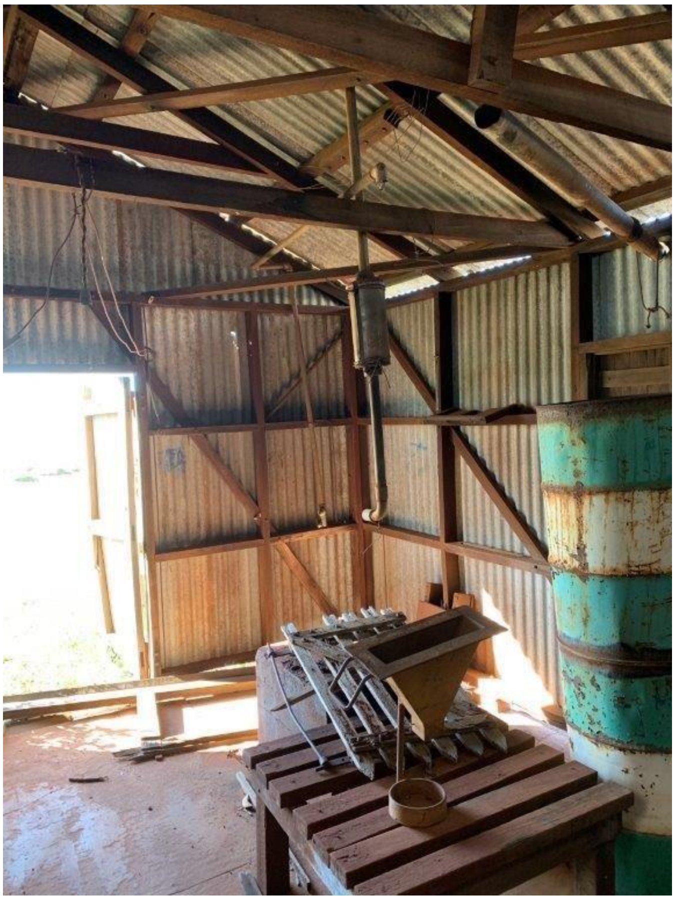

Figure 46: Engine room showing slab that engine was mounted on and exhaust still in place. (Photograph: Bart King)

Figure 47: Wool bin with wool table area in the foreground. (Photograph: Bart King)

6.7 Summary

Pastoral land use has influenced the infrastructure at Balmoral. Each remaining standing structure was a valuable aspect to European land utilisation, and the Indigenous house is a clear example of the perceived class difference between Indigenous and non-Indigenous Australians. The liveability of the infrastructure varied, with the shearers' quarters and dining hall built solely for strength, with very few elements for comfort. The supervisor's building and homestead were built for year round inhabitation, with some measures for comfort. The Indigenous house varies from the other infrastructure in that it was built with minimal comfort elements and limited strength, despite it being inhabited (supposedly) most of the year. The liveability varied between class and emphases put on comfort for year round habitation in all but the Indigenous house.

7 Conclusions: Landscape Learning on Balmoral Station

This study set out to identify what could be determined from the current infrastructure about land use, landscape learning and life of the historic leaseholders in the Pilbara. Assessment of the infrastructure, literature and historical resources pertaining to Balmoral has demonstrated the influencing factors that led to the architectural design adopted in the current structures and its impact on life. The landscape learning and environmental adaptation that is evident can be attributed to exposure to the Pilbara environment and improvements in standard architecture and construction techniques. Photographic and written records demonstrate that the original infrastructure at Balmoral was well placed in the landscape to minimise impacts from climate, but the construction was insufficient to withstand a severe cyclone. The current infrastructure was built to better handle the conditions by adapting to cyclones, previous flooding and extreme heat. Doing this the residents and pastoral activities at Balmoral were better protected from these climatic influences.

All of the infrastructure at Balmoral is of the same construction technique and materials, indicating that all of the buildings were constructed in the same rebuilding effort in 1952. The destruction caused by the 1945 cyclone was enough to warrant a rebuild of all structures. The landscape learning and environmental adaptations are therefore demonstrations of what was available in the mid-20th century. There are no remaining examples of the previous iteration of the Balmoral infrastructure, making a comparison of landscape learning between new and old iterations of the property impossible.

7.1 Link to previous research

The vast majority of previous research assesses landscape learning, environmental adaptation and architecture as separate elements. Very few studies link each of these aspects to determine their overall impact on residents living in particular regions and forms of infrastructure. A focus of historical archaeology in the 1990s and 2000s was on determining the social status of the landholders. Prior to this in the 1970s and 1980s environmental adaptation in new landscapes was a popular topic. More recently the model of landscape learning has shifted focus back towards adaptation, with a focus on the process of learning and how this affected material remains. This research is progressing the assessment to determine the impact that adaptations had on life, rather than just on what adaptations were made. Landscape learning has guided the understanding of environmental adaptation and its importance to assessing infrastructure. A lack of prior research in the Pilbara is potentially due to the low population, land access restrictions and/or the general lack of importance placed on this region. This thesis has shown what can be gained from understanding the impacts to life that infrastructure had in isolated pastoral sites.

The impacts that the arrival of non-Indigenous people had on the Indigenous people has been the focus of research in the Pilbara previously, but studies have not looked into life on agricultural properties beyond Indigenous dispossession (Paterson and Wilson 2009:100). Previous archaeological assessment in the Pilbara focussed predominantly on artefacts and traditional land use and mostly overlooked modern Indigenous involvement in the progressions of the pastoral industry.

7.2 Landscape learning in infrastructure

The landscape learning and environmental adaptation that is displayed in the current infrastructure of Balmoral is an indication of the progression of design and construction required in the Pilbara. Quick learning was required in the Pilbara to establish profitable pastoral stations, potentially with the assistance of a willing Indigenous population. The leaseholders on Mardie and Balmoral were Scottish born and had not spent long in Australia (Melbourne) prior to moving to the Pilbara (refer to Chapter 2). They had little time to learn about the Australian environment or pastoral practices prior to taking up the Mardie and Balmoral leases. The willingness to adapt to the environment quickly indicates why stations like Chinginarra (now part of Mardie Station) lasted one year and Inthanoona 30 years, while others have continued to the present (Paterson and Wilson 2009:99; Sharp 1979:113). The physical distance between pastoralists in the Pilbara caused by the size of the leases would have made the dissemination of landscape learning between properties slow and individual quick learning essential. This is evident in the varying designs, layouts and materials used in infrastructure across the Pilbara as noted in the Local Government Heritage Inventory. An example of this is the construction at Karratha, Balmoral and Mardie stations all being distinctly different, despite them being neighbours (Eureka Archaeological Research & Consulting (UWA) 2012:62, 182, 205).

The slow materialisation of landscape learning in the infrastructure at Balmoral is evident in the 1952 reconstruction. The region was impacted almost every year by cyclonic weather, but it was not until a major cyclone destroyed the infrastructure that changes were made. This may be perceived in the archaeology as a lack of landscape learning, but the lag in implementation of knowledge could also have been due to cost, time, labour and availability of resources to implement the changes. This differs from agricultural or pastoral practices which exhibits material change more quickly, as reflected in the property fences. More enduring features like buildings were less able to be changed, except in minor ways. The changes were implementations of the locational, limitational and social knowledge learnt and transferred between landholders since the station was established. The locational adaptations can be seen in the placement of the structures in the landscape, using the natural features to reduce the wind's direct impact on infrastructure, but also to raise the buildings above the surrounding flood plains. The placement of the homestead also uses its location to assist in cooling the structure via cross ventilation. Limitational knowledge and adaptations often develop over time (Rockman 2009:53). In the case of Balmoral the time taken to learn is unclear because the surviving archaeology only reveals decisions made in and after 1952. The design features prior to 1952 could not be assessed, but those afterwards are clear adaptations from limitational knowledge. Thick concrete walls and slabs, strong hardwood timber reinforcements, hip roofs and a lack of internal halls were all adaptations to severe cyclonic conditions and heat. Finding a balance between heat mitigation and cyclone resistance was essential for structural longevity and liveability in the buildings utilised year round. The understanding of the landscape and implementations made to structures in 1952 are derived from interaction with the environment and socially shared knowledge.

The architectural advancements made throughout Australia since the arrival of Europeans varied around Australia. The adaptations made in the formative years of the colony to manage heat (Freeland 1968:45) were the same as those adopted at Balmoral in 1952. Verandahs, cross ventilation and low roofs were incorporated in the early 19th century and were still seen as the best construction options in 1952.

The leaseholders' adaptations to the climate, reflected in the 1952 construction activities, were a culmination of landscape learning on the property since 1866. The outcome of these learnings influenced the life of the inhabitants from the mid-20th century to the year 2000. The security provided by well-built structures in an uncertain and extreme environment is a contributing factor to the continuity of the lease.

The adaptations made in the construction of infrastructure at Balmoral can be linked to aspects of Birmingham and Jeans' (1983) colonisation model. The move from exploratory to learning phases and into a development phase can be seen in the property's history through the selection of infrastructure location and construction based on available materials (exploratory), establishment of activities and behaviours based on progression of knowledge (learning) and construction of new infrastructure and progression of industry to extract the most from the land (development).

The pace of progression through the colonisation model is dependent on the pace of landscape learning. The influencing factors noted by Meltzer (2003) outline aspects of landscape learning progression. He notes that, even if an Indigenous population is not present or willing to provide information, the evidence of their adaptations can help colonisers. This can be surmised at Balmoral, regardless of the Indigenous population's willingness to provide information, since the signs of their habitation in certain locations could have influenced the colonisers' selection of areas to establish infrastructure. Balmoral being close to permanent waterholes in the Fortescue River could have been influenced by signs of Indigenous habitation in the area. It is unclear whether the non-Indigenous population copied from a distance or learnt directly from the Indigenous population (Meltzer 2003:225). The Mardie infrastructure, on the other hand, may have been an example of the perceptions noted by Blanton (2003) and the unwillingness to listen or learn from an Indigenous population. The need to relocate the Mardie homestead and the evidence of cruelty to the Indigenous population would support the idea that the Mardie landholders were less willing to learn from the Indigenous population. The speed and success of adaptation is noted as being linked to the willingness to learn from what was already available. The location and use of land for infrastructure at Balmoral is potentially an example of quick learning from adaptations made by the Indigenous inhabitants.

The land use changes caused by stock transition away from sheep has led to the abandonment of many historical shearing precincts across the Pilbara. Despite this the information that can be gained from the structures of what life was like in the Pilbara and how the people adapted is essential to the region's history.

7.3 Further research

Understanding the links between historical land use and infrastructure provides a footing for future assessments of other shearing infrastructure in the Pilbara. Further research could include similar assessments on the remaining Pilbara shearing infrastructure, or expanding to assess sites from other regions to establish links between landscape learning, climate and infrastructure.

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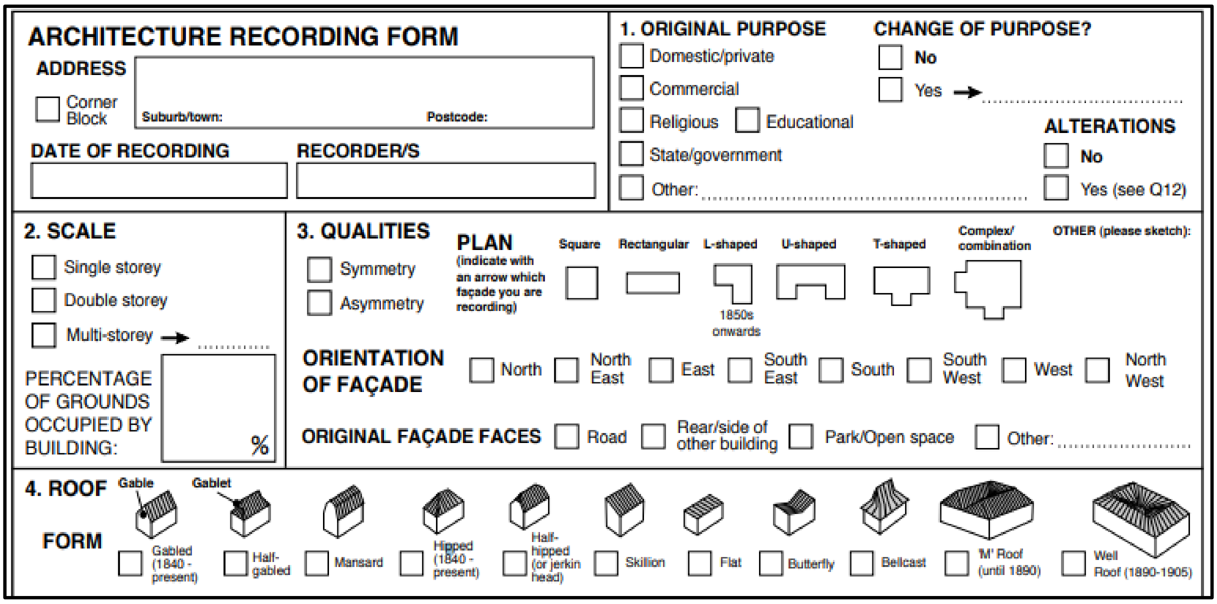
Appendix A – Design Record Sheet.



ARCHITECTURE RECORDING FORM

ADDRESS

☐ Corner Block

Suburb/town: Postcode:

DATE OF RECORDING

RECORDER/S

1. ORIGINAL PURPOSE
☐ Domestic/private
☐ Commercial
☐ Religious ☐ Educational
☐ State/government
☐ Other: ......

CHANGE OF PURPOSE?
☐ No
☐ Yes → ......

ALTERATIONS
☐ No
☐ Yes (see Q12)

2. SCALE
☐ Single storey
☐ Double storey
☐ Multi-storey → ......

PERCENTAGE OF GROUNDS OCCUPIED BY BUILDING: %

3. QUALITIES
☐ Symmetry
☐ Asymmetry

PLAN (indicate with an arrow which façade you are recording)
Square / Rectangular / L-shaped / U-shaped (1850s onwards) / T-shaped / Complex/combination / OTHER (please sketch):

ORIENTATION OF FAÇADE
☐ North ☐ North East ☐ East ☐ South East ☐ South ☐ South West ☐ West ☐ North West

ORIGINAL FAÇADE FACES
☐ Road ☐ Rear/side of other building ☐ Park/Open space ☐ Other: ......

4. ROOF FORM
Gable / Gablet
☐ Gabled (1840 - present) ☐ Half-gabled ☐ Mansard ☐ Hipped (1840 - present) ☐ Half-hipped (or jerkin head) ☐ Skillion ☐ Flat ☐ Butterfly ☐ Bellcast ☐ 'M' Roof (until 1890) ☐ Well Roof (1890-1905)

Design Criteria	Yes	No
Location selected to avoid the full force of the wind or flood		
Building layout a simple regular shape, to avoid concentration of pressure.		
Roof angle at 30° to 45° to prevent it being lifted off by the wind.	Note angle	Note angle
Wide roof overhangs avoided; separate the veranda structure from the house.		
All the foundations, walls, and roof structure are firmly fixed together.		
Reinforce the bracing in the structure; strengthen walls and joints/ junctions to increase stiffness.		
The roof covering is firmly attached to the roof structure to prevent it from lifting.		
If doors & shutters cannot be shut, is there opposing openings to reduce pressure build up.		
Doors and shutters can be closed.		
Trees planted around the house as wind breaks and reduce flow of water, but not too close.		

1. Timber Colour

Has the timber darkened on the outside? (Sand/cut timber to see if underlying wood differs from outer layer.)	
Outer colour:	<u>Red/Brown/grey/other</u>
Internal colour:	<u>Red/Brown/grey/other</u>

2. Assess the wood grain
    a. Softwoods - Have smooth surface with no indentations from grain.
    b. Hardwoods - Have smooth, but bumpy sections where wood grains occur.

Surface smooth?	Yes/No
Grain evident to touch?	Yes/No
How was timber cut?	Wood quarter sawn or plainsawn?

3. Weight/density of the timber (compare to known timber of same volume)

Does timber dent easily? Does timber dent from fingernail?	Yes/No
Dimensions of timber weighed:	
Weight of timber:	

4. Use of the timber

Use of the timber (circle relevant)	(structural, decorative, edging)
Is different timber used for different applications?	
Evidence of different timber?	Yes/No
If yes, where are different timber types evident?	

5. Materials used in construction: (circle all relevant)

Corrugated Iron roof	Timber window frames
Corrugated Iron walls	Timber supports (other than framing)
Corrugated iron doors	Concrete piping
Corrugated iron windo shutters	Concrete walls
Timber framing	Concrete floors
Timber doors	Glass windows
Timber floor	Asbestos cladding
Timber window shutters	Mesh/fly screen
Steel supports	Steel framing
Steel piping	Plastic piping
No cladding	Mesh/fly screen in timber frame door
Other:	

6. Roof truss in building (circle relevant)

NAME	MAX. SPAN (M)	CONFIGURATION
KING POST	5	
QUEEN POST	6	
FINK	9	
FAN	10	
FW	13	
DOUBLE W	13	
TRIPLE W	18	
KING SCISSORS	4	
QUEEN SCISSORS	6	
HOWE SCISSORS	8	
DOUBLE HOWE SCISSORS	12	
TRIPLE HOWE SCISSORS	16	
WARREN SCISSORS	12	
DOUBLE WARREN SCISSORS	16	
MODIFIED SCISSORS	8	
MODIFIED SCISSORS	8	
MODIFIED SCISSORS	12	
MODIFIED SCISSORS	12	
MODIFIED SCISSORS	16	
POLYNESIAN or GAMBREL	8	
POLYNESIAN or GAMBREL	12	
MONO-HALF HOWE COMP	7	
MONO-HALF SCISSORS HOWE TENSION	7	
MONO-HALF SCISSORS WARREN	6	
POLYNESIAN or GAMBREL	12	
POLYNESIAN or GAMBREL	16	
SIMPLE ATTIC FRAME	10	
QUEEN POST ATTIC FRAME	14	
HOWE ATTIC FRAME	14	
VAULTED CEILING	8	
VAULTED CEILING'	8	
VAULTED CEILING'	13	
VAULTED CEILING'	18	
BOWSTRING 5 to 9 PANELS	18	
HOWE GIRDER	8	
DOUBLE HOWE GIRDER	9	
TRIPLE HOWE GIRDER	12	
INVERTED HOWE	8	
INVERTED DOUBLE HOWE	12	
MONO PITCH HIP END 45° CORNER SET	-	
HIP TYPE "S"	10	
HIP TYPE "T" TRUNCATED SYSTEM	-	
HIP TYPE "D" (DUTCH HIP)	-	
HIP TYPE "F"	10	

Appendix B – Historic Weather Data

Table 6: Historic rainfall data for Mardie Station

Year	Rainfall in mm	Year	Rainfall in mm	Year	Rainfall in mm	Year	Rainfall in mm
1885	0	1926	178.4	1967	366.2	2008	309.8
1886	0	1927	181.5	1968	0	2009	572.9
1887	0	1928	201.2	1969	222.5	2010	100.7
1888	0	1929	343.5	1970	368.8	2011	886.2
1889	0	1930	392.3	1971	389.1	2012	163.8
1890	0	1931	314.5	1972	166.8	2013	348.7
1891	0	1932	105.5	1973	757.1	2014	129.9
1892	0	1933	310.9	1974	367	2015	233
1893	0	1934	647.2	1975	248.4	2016	337
1894	0	1935	123.4	1976	234.4	2017	440.6
1895	0	1936	6.4	1977	205.8	2018	100.8
1896	0	1937	269	1978	184.2	2019	80.6
1897	0	1938	128.1	1979	153.2	2020	220.4
1898	0	1939	342.3	1980	501.1	2021	342.9
1899	0	1940	156.8	1981	284.2		
1900	0	1941	208.4	1982	227.8		
1901	0	1942	452.4	1983	83.5		
1902	0	1943	319.5	1984	385.3		
1903	0	1944	55.2	1985	193.3		
1904	0	1945	495.5	1986	324		
1905	0	1946	465.9	1987	164.8		
1906	0	1947	348.3	1988	327.2		
1907	291.5	1948	356.7	1989	387.1		
1908	239.4	1949	316.4	1990	219.5		
1909	402.6	1950	166.9	1991	172.6		
1910	171	1951	450.9	1992	303.6		
1911	118.1	1952	425.1	1993	353.9		
1912	56.6	1953	181.6	1994	125.7		
1913	212.3	1954	252.3	1995	856.6		
1914	155.1	1955	275.6	1996	343		
1915	440	1956	245.6	1997	368.8		
1916	273.7	1957	121.2	1998	349.4		
1917	450.4	1958	571.1	1999	471.4		
1918	387.4	1959	80.5	2000	370.2		
1919	22.4	1960	189.5	2001	215.4		
1920	216.6	1961	654	2002	88		
1921	200.4	1962	98.1	2003	257.6		
1922	105.9	1963	612.6	2004	326		
1923	346.9	1964	218.9	2005	223		
1924	32.2	1965	430.5	2006	605.6		
1925	227.7	1966	197.1	2007	68.8		

Table 7: Annual monthly temperature minimum and maximum temperatures.

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lowest minimum temp	16.1	17.3	13.3	10.0	7.8	3.9	2.9	4.4	6.0	7.6	12.8	14.8	2.9
Highest minimum temp	32.6	32.8	34.0	30.5	26.0	24.0	22.3	23.0	22.2	26.5	29.6	32.2	34.0
Lowest maximum temp	35.0	35.8	35.2	36.3	31.7	27.4	26.8	29.1	32.5	36.0	34.0	36.5	25.4
Highest maximum temp	49.0	50.5	47.2	43.7	40.5	35.4	34.5	39.0	41.0	46.0	47.0	48.8	50.5

Appendix C – Balmoral Shearing precinct condition assessment

Building identification	Materials location	Construction material	Condition	Affect to building	Comment
Homestead	Roof	Corrugated iron	No issues noted.	Affects <10% of building	
		Timber	Degradation. Timber rotting.	Affects 51-90% of building	
	Outer walls	Asbestos Cladding	Minor damage in sections. Mostly good condition.	Affects <10% of building	
		Concrete	Minor degradation in generator room. Predominantly good condition.	Affects <10% of building	Figure 18
		Timber	No issues noted.	Affects <10% of building	Affecting all timber in structure.
		Mesh/fly screen	No issues noted	Affects <10% of building	Modern addition to washroom area.
	Inner Walls	Asbestos Cladding	Infestation.	Affects <10% of building	Wasp nests on all walls. Dead kangaroos in living room.
		Concrete	No issues noted	Affects <10% of building	
		Timber	No issues noted	Affects <10% of building	No sign of rot on exposed internal timber in laundry room.
	Kitchen	Timber	No issues noted	Affects <10% of building	Very dirty area. Otherwise good condition.
Overall building condition				Good	Only issue identified is timber degradation in framing

					of verandah roof sections.
Supervisors building	Roof	Corrugated iron	No issues noted	Affects <10% of building	
		Timber	No issues noted	Affects <10% of building	
	Outer walls	Corrugated iron	No issues noted	Affects <10% of building	
		Concrete	No issues noted	Affects <10% of building	
	Inner walls	Asbestos cladding	No issues noted	Affects <10% of building	Inner roof structure cannot be seen.
		Concrete	No issues noted	Affects <10% of building	
Overall building condition				Good	Building in good condition overall.
Indigenous house	All building	Corrugated iron	Loss	Affects >90% of building.	
		Steel	Loss	Affects >90% of building.	
	Kitchen	Steel (oven)	Degradation	Affects <10% of building	Oven in place and has minor sign of degradation.
Overall building condition				Building absent	Building no longer in place. Oven only part of building still in place.
Dining hall	Roof	Corrugated iron	No issues noted	Affects <10% of building	
		Timber	No issues noted	Affects <10% of building	
	Outer walls	Corrugated iron	No issues noted	Affects <10% of building	
		Concrete	No issues noted	Affects <10% of building	
	Inner walls	Corrugated iron	No issues noted	Affects <10% of building	
		Concrete	No issues noted	Affects <10% of building	

		Timber	No issues noted	Affects <10% of building	Timber is in very good condition.
	Kitchen	Cast iron (stove)	Degradation	Affects <10% of building	Minor surface rust to surface of oven.
		Concrete (walls and sink)	No issues noted	Affects <10% of building	
Overall building condition				Good	Building in good condition overall.
Shearers' quarters	Roof	Corrugated iron	No issues noted	Affects <10% of building	
		Timber	Degradation	Affects <10% of building	Minor rot in timber.
	Outer walls	Corrugated iron	No issues noted	Affects <10% of building	
		Concrete	No issues noted	Affects <10% of building	
	Inner walls	Corrugated iron	No issues noted	Affects <10% of building	
		Timber	Infestation	Affects <10% of building	Minor signs of termites. (Figure 32). Most of the timber in very good condition.
		concrete	No issues noted.	Affects <10% of building	
Overall building condition				Good	Building in good condition overall. Only minor signs of termites in shower room.