Diachronic Observations of the Decay of a Pisé Building at Jugiong (NSW)

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This study describes the remains of a nineteenth century pisé building at Jugiong (NSW), the decay processes that impact on them, and the extent of the decay observed between 1993 and 2015. The aim of this study was to compile a long-term, non-invasive assessment of decay of a rammed earth structure. The initial observations were carried out opportunistically with the primary objective of accumulating imagery of ongoing decay that could be used for teaching purposes. This study is unique inasmuch as it reports on over two decades of unfettered decay. Even though the site was identified as a heritage item in 2009 and included in the Local Environmental Plan in 2011 (Shire of Harden, 2014), no conservation action has occurred so far.

**Pisé as a construction material**

Early European settlement in rural New South Wales (NSW) was constrained by the climate and the availability of building materials. Low status and low-cost building materials dominated, even in established communities, such as Albury in the 1860s (Government of New South Wales, 1862). This was applicable especially to farmers of rural communities of NSW, who could not afford construction made from stone, fired brick or cut timber, either because of sheer cost or because the building materials were not readily available. As such, they commonly resorted to the use of bush timber or to various forms of earth construction. The passive energy characteristics of earth construction (Heathcote, 2011) were particularly welcomed in the Riverina district (Freeman, 2013), where in summer daily maximum temperatures could exceed 40°C. Pug and pine construction, as well as other techniques of half timbering, were favoured among German settlers (Lewis, 2013; Spennemann, in prep), while mud brick (‘adobe’) construction as well as pisé were favoured by settlers of Angle-Celtic ancestry.

_Pisé de terre_ (pisé as shorthand), a technique of French vernacular architecture, is characterised by erecting walls from earth, compacted (‘rammed’) between formwork (see below). The technique was first formally described by François Cointeraux (1791) in his treatise on rural architecture, a work that was to prove very influential throughout Europe and many of its colonies (Cellauro & Richaud, 2006). Given its low-tech and low-cost nature, pisé was soon advocated as suitable building material for rural buildings. Treatises on the matter were published in the early nineteenth century in England (Burn, 1814, pp. 50–55), in the United States of America (Johnson, 1806), as well as, later, also in Germany (e.g. Engel, 1865). The technique remained in use in the early twentieth century (Betts & Miller, 1937; Ellington, 1924; Humphrey & Coffin, 1924; Patty, 1933) and, given its energy efficiency (Heathcote, 2011), has since seen a renaissance among advocates of sustainable architecture (e.g. Webster-Mannison, 2000; Webster-Mannison & McInerney, 1998).

**Pisé in Australia**

Soon after the foundation of the European colony in Australia, pisé was publicised in the local news papers of New South Wales (Anonymous, 1823b, 1823c) and Tasmania (Anonymous, 1823a). The technique was readily taken up by the rural community (e.g. Bathurst: Anonymous, 1827; Launceston: Anonymous, 1830), but belittled by some the more snobbish Sydney correspondents (Anonymous, 1827). The technique was advocated to intending emigrants as a means of erecting a suitable residence in rural areas (Mann, 1849). In the 1860s and 1870s pisé was widely advocated as a suitable construction material for rural communities. The Melbourne newspapers _The Age_ and _The Australasian_ published a number of articles on its use extolling its suitability and
economy (Anonymous, 1863, 1865a, 1865b). Likewise, the *Australian Town and Country Journal*, a Sydney-based weekly newspaper, ran a series of articles on suitable low-cost earth-based construction. Featured among these was wattle and daub (Anonymous, 1893b), adobe (Anonymous, 1893a) and especially pisé (Anonymous, 1870b, 1871, 1873, 1876, 1892, 1904). Other local and regional papers, such as the *Albury Banner*, also advocated the use of pisé to their rural audience (Anonymous, 1897a, 1897b, 1902).

![Fig. 1. The pisé ruins at Jugiong (NSW) as seen from the northeast in September 2005.](image)

**The technique**

*Pisé* describes a technique where wooden parallel forms (‘shutters’) are erected to the desired width of the wall. The semi-dry loam/earth is poured or shovelled in and then compressed (‘rammed’) into the form using posts of heavy timber. While the specific mix depended on the local soil, a favourable mix was 25-30% clay and 70-75% sand and fine gravels (Anonymous 1870; 1871; 1876). The technique of erecting pisé buildings, as employed at the study location of Jugiong (NSW), was described by a correspondent of the *Australian Town and Country Journal* as follows:

> The earth used at Jugiong and Murrumburrah is a gritty coarse earth, into the composite of which decomposed granite largely enters. Clay is recommended in some encyclopaedias, but practical experience in this part of the country has shown that clay does not answer well, as it cracks. It has often struck me in travelling through the immense Riverina country, how well adapted the pisé buildings are to it. Timber is very scarce, and there is no stone available for hundreds of miles. At their foot the station-holders have splendid materials, for there is any quantity of the proper kind of earth for the erection of first-class residences at a ridiculously low price. Pise is quite equal to stone in durability, and while stone would cost 16s per perch where it is to be had easily, the pisé buildings can be put up at about 3s per perch…
Most of the walls in the district I am now describing are not less than two feet in thickness, and this width is strongly recommended. The frames are secured with iron bolts, connecting the two sides; those bolts are from 0.75 to 0.87 inch in thickness, and placed about two feet apart. In order to raise the boxes easily to the next layer, the corner box is on hinges. No foundation but the solid earth is required. These frames or moulds, having been properly fixed on the bare ground, the earth is thrown in and rammed with heavy rammers, shod with the cast-iron box of a dray wheel. When each layer is finished the bolts are unscrewed, and drawn out easily by a handle attached. The frame is then moved further on till the whole length of the wall has been completed. A second layer is then put on, and the whole process is repeated till the walls are completed. In commencing a wall the first frame is placed at one of the extremities, and one end of the frame is closed by planks secured by iron cramps, and at the other part where there is no enclosure the wall of earth is sloped off at an angle of about sixty degrees to facilitate the joining on of the next piece of wall. Care must be taken that the joints are not on the top of one another; on the same principle that guides the masons in stone work they invariably place the second layer of stone to cover the joints of the ones below” (Anonymous, 1872c).

An 1871 advice to the rural community recommends that the frames should be ten feet long and three feet high. Each layer should

“form a bed of an uniform thickness of not more than three or four inches; they then ram it down, reducing it to little less than half of its former thickness. This first bed being compressed, the labourers bring more earth and form another, spread out and beat in the same manner, so on til the whole case is filled, and the frame is ready to be shifted for another a course” (Anonymous, 1871).

The strength of a pisé wall depends on the proportions of clay in relation to sand and fine gravels. Modern pisé construction adds a small percentage of Portland cement to the mix, especially if the building is meant to be double storey and to possess heavy concrete floors (Webster-Mannison, 2000; Webster-Mannison & McInerney, 1998).

Pisé buildings tend to have a rendered surface (both exterior and interior), either in the form of mud plaster, a whitewash or both. Mud plaster is notoriously fragile and susceptible to climatological and physical decay as it comprises clay/loam and very
finely chopped hay and straw, or chaff. Mud plaster is hygroskopically fully compatible with the underlying pisé wall, but just as unstable. Whitewash consists of ground gypsum, water and clay or fine loam and is applied by brush or rag. More durable than mud plaster or whitewash is lime plaster, mixed of lime, sand and water. To make the plaster adhere to the walls, they are often raked or scored diagonally.

The ruins at Jugiong

The township of Jugiong is located at the northern banks of the Murrumbidgee River, some 40km north of Gundagai. The first European settlement occurred in 1825 when Henry O’Brien took up Jugiong station. The village started where the Great Southern Road (Sydney to Melbourne) crossed two smaller creeks. It was first formally mapped in 1839 (Townsend, 1839). The first pub opened in 1845 and the Roman Catholic cemetery was dedicated in 1851 (Larmer, 1851). In April 1852 the town of Jugiong was surveyed (Macy, 1852) and gazetted the year after. Extensive allotment purchases by a squatter on occasion of the first land sales held in 1854 effectively stifled development and thus inhibited the economic growth of the town. Even though a post office opened in 1856 and a watch house was built in 1858, the community only grew very slowly. The Catholic Church was opened in 1860, a police station in 1872 and a denominational school the year after. By the early 1880s Jugiong had been declared and a place for holding Courts of Petty Sessions (1882) and was serviced by a public school (1883) (Aldridge, 1983; Anonymous, 1872a, 1872b, 1872c, 1872d, 1878; Kass, 2009, p. 15ff).

Unlike areas to the southwest, where the Protestant Germans and their building traditions shaped the communities (Spennemann, 2007, 2014; Spennemann & Sutherland, 2008), the residents of the Jugiong area were predominantly of Anglo-Celtic origin. The town had quite a large number of pisé buildings, as a correspondent of the Australian Town and Country Journal attested after a visit to Jugiong in August 1872:

“The erection of pisé buildings has often been advocated in the Town and Country Journal, and in the district which I am now describing, pise will soon be almost the only buildings erected. The inhabitants of the district of Jugiong are fast becoming believers in this class of dwellings. The example was set by a few gentlemen some years ago; and their private residences of pisé work are models of comfort, cheapness, and elegance…

The earth used at Jugiong and Murrumburrah is a gritty coarse earth, into the composite of which decomposed granite largely enters. Clay is recommended in some encyclopaedias, but practical experience in this part of the country has shown that clay does not answer well, as it cracks. It has often struck me in travelling through the immense Riverina country, how well adapted the pisé buildings are to it. Timber is very scarce, and there is no stone available for hundreds of miles. At their foot the station-holders have splendid materials, for there is any quantity of the proper kind of earth for the erection of first-class residences at a ridiculously low price. Pise is quite equal to stone in durability, and while stone would cost 16s per perch where it is to be had easily, the pisé buildings can be put up at about 3s per perch…(Anonymous, 1872c).

Background to the site

The pisé ruins are located next to Riverside Drive, just to the northeast of Jugiong cemetery at the north-eastern outskirts of Jugiong, NSW (Fig. 3). The site is located at 34° 49’ 20.77” S 148° 20’ 50.88” E.

1. Originally the road had been known as the ‘Great Southern Road,’ later formally names ‘Audley Street,’ and then ‘Hume Highway’. Since the completion of the Jugiong By-pass, the road has been named ‘Riverside Drive’, but, confusingly, the official RMS road signs currently installed on the Hume Highway spell the road ‘River Side Drive’.
Fig. 3. Aerial view of Jugiong with places mentioned in the text.
1—Catholic Church; 4—Hume Highway Bypass 7—Cooney’s Hotel;
2—Sheahan’s Hotel; 5—Catholic Cemetery; 8—Great Southern Road /
3—Jugiong Public School 6—Pisé ruins site Old Hume Highway
(Photo taken 14 January 2008, via Land and Property Information, 2008).

Fig. 4. Topography (20m intervals) of the Jugiong site
(Base photo see Fig. 3, mapping SPAN, Charles Sturt University).
The ruins, as observed in 1993, comprised of a long wall on the northern side and three wall segments on the southern side. Both the eastern and western sides were missing and the southern wall, even when accounting for door and window openings, was incomplete (Fig. 1, Fig. 5). Based on 2015 measurements, the original building measured approximately 4.9m in the north–south and 8.5m in the east–west axis (about 16 x 28 feet) with a walling height exceeding 2.1m (7 feet). The pisé walls would have been 0.5m (approximately 20 inches) thick. The extant remains, as measured in April 2015, are shown in Fig. 6.

The building was erected on a soil platform cut into the slope of the hill. This platform measures approximately 16m north-south and 20–25m east-west. The building was set to the back of the platform, originally about 3m (10 feet)\(^1\) from the northern and about 4.5m (originally about 15 feet) from the western edge (adjacent to the cemetery). The southern wall, which would have held a centrally located door, is set about 15m from the (current) edge of the Sydney–Melbourne Road (now Riverside Drive).\(^2\)

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\(^1\) Today, due to slope erosion, this is only between 1.8 and 2.5m wide.

\(^2\) Modern road grading has resulted in an embankment (of about 1.5m height) cut into the slope, cutting off the slightly sloping terrace some 10m from the southern wall.

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Statutory Information

The ruins are listed as a heritage site of local significance in the currently valid Local Environmental Plan (LEP) 2011 for Harden Shire (Shire of Harden, 2014, Schedule 5 item I62). It is included as an example of “pisé wall construction technology…which was highly popular throughout Harden shire from the mid 1860’s to the late 1940’s” (criterion a), as “part of a group of pise town house cottages that once were prolific but now rare” (criterion f) (Shire of Harden, 2009).

Confusion in the listing

The location and land titles of the heritage-listed property are confusing. The LEP lists the historic site as being located on ‘Lot 2, DP 117819’ (Shire of Harden, 2014, Schedule 5 item I62). The actual ruins, however, are in fact located on Lot 3 section 18, DP758547 (Land and Property Information, 2015c) as clearly evidenced when superimposing the 1851 survey map of the Roman Catholic Chapel, Residence and School House Allotments over a modern aerial image (Fig. 7, Fig. 8) (see also Appendix A for a more detailed discussion). The erroneous lot identification in the LEP, coupled with the fact that the associated inventory sheet provides no image or any other specific descriptive information implies that the property cannot be positively identified. From the perspective of legal protection of the heritage asset this may well make the listing unenforceable. In consequence, a review of and subsequent amendment to the Harden Shire LEP will be required.

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1. Intriguingly the heritage item is not included in the Database of Statutory Listed Items maintained by NSW Heritage (2015); it would seem that data from the most recent LEP (Shire of Harden, 2014) have not yet been uploaded.
Fig. 7. Identification of land allotments in the immediate study area, Parish of Jugiong (base map: Land and Property Information, 2015a).

Fig. 8. Superimposition of the 1851 survey map of the Roman Catholic Chapel, Residence and School House Allotments at Jugiong (Larmer, 1851) over an aerial image of the site. (Photo taken 14 January 2008, via Land and Property Information, 2008). The site of the pisé ruins under discussion is indicated by the arrow.
The 1851 map shows an allotment marked “Roman Catholic Burial Ground” (Fig. 8, Fig. 103, Fig. 104). The plan drawing indicates the existence of a hut, of about \( \frac{1}{2} \) of a chain long and \( \frac{1}{3} \) of a chain wide (approximately 10 x 7m). The hut is set on a flat area that has a sloping section to the south. It needs to be stressed that this is not the pisé ruins being discussed, but a different hut, located to the northwest. It would appear that the hut on the map belonged to the original Jugiong Squatting run. When Henry O’Brien took up Jugiong station in 1825 he soon after “erected a shepherd's hut on the rise where the Jugiong cemetery is now situated.” That hut was still in existence in 1845 (Gormly, 1902). Given that every building of Jugiong, bar Sheahan’s Hotel, was destroyed in the 1852 floods (Anonymous, 1852a), it can be surmised that the hut at the cemetery would have perished a year after the mapping.

The next mapping of the area, the 1883 town map includes the area being discussed and places section 18 just to the east of the formal town boundary (Fig. 13) and thus outside of the gazetted part of Jugiong (Carth, 1883). The metalled section of the main road also ends there (ibid). That map also identifies the three church allotments as well as the surrounding properties, but leaves blank the cemetery allotment as well as the allotment which contains the building being discussed. The town map of 1883 shows a number of residential buildings immediately to the west of the church property (Carthy, 1883): a residence near Hume Street and cluster of three buildings, a residence, a store, and an unmarked building to the rear of the store (Fig. 13). All these buildings are on the property listed as first alienated by Thomas Callon, with the ‘residence’ next to the store actually straddling the boundary with the allotment earmarked for the Catholic School. Further to the east of the cemetery, the 1883 map shows “Cooney’s Hotel” (on section 17) facing the Sydney Road (Carthy, 1883). The hut shown of the 1851 plan (Fig. 104) is not represented.
Fig. 10. Aerial image of the site
(Photo taken 14 January 2008, via Land and Property Information, 2008).

Fig. 11. Aerial image of the site. Note the loss of the Robinia pseudoacacia near the road side
Fig. 12. Satellite image of the site. Note the loss of the Robinia pseudoacacia near the road side. (Photo taken in 2015, CNES/ Astrium via Google Maps).

Fig. 13. Section of the town map of 1883 (Carthy, 1883).
Fig. 14. Section of the town map of 1916 hand annotated to 1 July 1963 (Department of Lands, 1963a).

Fig. 15. Section of the town map of 1916, hand annotated to 19 August (Department of Lands, 1963b).
At first sight, the 1883 map would therefore suggest that the building under discussion was erected after that map had been compiled. Overall, the representation of buildings on the 1883 map, however, is rather limited. It would appear that only the more substantial, *i.e.* brick and stone buildings were marked.¹

**History of the Property**

While the heritage inventory sheet is silent on the exact nature of the ruins, the sheet’s author speculates it might have been a residential cottage (Shire of Harden, 2009). There is substantial confusion about the original function of the building, with Jugiong residents interpreting it as a residential cottage (Sheahan, 2015b), a shop (Maskell-Knight, 2015), as the Catholic school (Sharman, 2015), or even as an inn (mentioned to Sharman, 2015 by a non-resident).

Given the devastating flood of 1852, which destroyed every single building of the Jugiong community bar the hotel (which was damaged) (Anonymous, 1852a), the pisé structure under discussion post-dates that event.

Given the small size of the allotment, its distance from the other residential allotments, and its placement on the ‘out-of-town’ side of and proximity to the Roman Catholic cemetery might, at first hand, suggest that the building was associated with denominational use of some kind. Nineteenth century newspapers indeed mention the area, but only refer to the cemetery and the nearby school:

> “The Jugiong [school] is a certified denominational school, under the charge of Mr. Duhigg. The building is a rough substantial one, but the interior is in a wretched state of repair. Below the school is the cemetery, and further along the Sydney road are two public-houses” (Anonymous, 1872a, 1872b).

It appears that the Roman Catholic denominational school was abolished once the Jugiong public school commenced in 1883 (Aldridge, 1983). Little is mentioned about other properties in the immediate study area. An 1878 article mentions that

> “[a] short distance from Mr. Cooney’s [Hotel, ed.] is Mr. Myers’ general store; this gentleman commenced business here some three years ago, and has prospered well, though the seasons have not been of the best. A mile still further is the Jugiong Hotel” (Anonymous, 1878).

This has led some Jugiong residents to assume that the pisé ruins under discussion are identical with Myers’ general store (e.g. Maskell-Knight, 2015). A Myer Myers is on record as having opened a store in Jugiong in November 1875 (Fig. 16) (Anonymous, 1875; Myers, 1875) which he operated as a post office store (from 1879). Myers left Jugiong in February 1890,² having sold the store to Arthur Boggis (Anonymous,

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¹ An exception is a ‘mud house’ on lot 196, but it appears that this building was only included as it constituted an existing improvement of the lot to be sold (as likewise mentioned were fences on two other lots).

² Born ~1843 in the UK, Myer Myers had emigrated as a child to Sydney where his father Harris (born in Poland) opened a draper shop—a business carried on by Myer’s brothers Alfred and Sidney (not the Sidney Myer of the department store chain) (Anonymous, 1886). The Myers soon played a prominent role in the Jugiong community (Anonymous, 1890a, 1890b). To demonstrate his commitment he also invested in proposed enlargement of the town in 1882 (Carthey, 1883) and purchased allotments 248 and 249 on Hume Street (see Department of Lands, 1916). His mother Abigail died 17 Oct 1886 at Jugiong during a visit and was temporarily buried in the Jugiong cemetery (Anonymous, 1886). Myers was appointed post and telegraph master in 1879 (Kass, 2009, p. 16; Public Service Enquiry Commission, 1890, p. 55) and magistrate in September 1887 (Anonymous, 1887). Myers died 1912 at Waverly (NSW Registry of Births, 2015a).
After Boggis died of influenza in November 1891 (Anonymous, 1891a, 1891b) the business was carried on for while by his wife Kate (sandac, 2003). The store was then operated by a J.T. Boughton who is on record as a postmaster for 1894 and mentioned in the press as having a clearing-out auction sale in June 1895 (Anonymous, 1895a). Even though it was suggested it was merely a temporary move, the sale occurred during the height of the 1893-95 depression. There appears to be no further record of the store or of Mr. Boughton in Jugiong.

The oldest resident at Jugiong, now 89-year old Bill Sheahan, recalled in March 2015 that when he was a little boy in the early 1930s, a former store existed to the west of the cemetery and separated from it by a narrow laneway. That store had been known as ‘Williams’ General Store’. The building is described as a three-room cottage with a verandah at the front and back. At the back of that property was a small corrugated iron building which housed a shoe maker (Sheahan, 2015a). That description matches well the buildings shown on the town map of 1883 (Fig. 13). Indeed, a John Williams, store owner in Jugiong, is on record as having purchased property at Jugiong in 1901, and is

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1. Arthur Boggis came from West Wallsend / Minmi (spelled 'Bogg' in Anonymous, 1890b; Boggis, 1889a, 1889b, 1890a, 1890b).

2. On 5 June 1894 J.T. Boughton reported that his post office was too close to the river and was often flooded out. He had been offered a new site near the main road in the centre of town (B.5784, NAA, CRS SP 32/1, Jugiong PO file Part 1, cited in Kass (2009, p. 16). It is unclear whether the post office was relocated.—The recurrent flooding of the Jugiong post office is also mentioned in an 1895 article in the Gundagai Times (Anonymous, 1895b).

3. Williams was the victim of a burglary in 1903 Kass (2009, p. 16). His store was damaged in 1905 and reopened in September 1906 (Anonymous, 1903b). Mr Williams store is also mentioned in a court case in 1923 (Anonymous, 1906). Williams is on record as having served as a trustee of the Jugiong Commons for 1899 and 1901 and as its secretary for 1907, 1909 and 1931 (Anonymous, 1923). In 1916 John Joseph Williams is on record as being a participant in an accident with a motor car on the Gundagai–Coolac Road (Anonymous, 1899, 1901b, 1907, 1909, 1931).
listed in the 1901 Census for NSW as residing in Jugiong. The allotment in question comprised 37 acres 2 roods and 4 perches of the late T. Callan (Anonymous, 1901a). Perusal of the 1883 town map shows that the land allotment with the store (to the west of the cemetery) was originally owned by Thomas Callon (Fig. 13).

As far as the ruins site itself is concerned, Bill Sheahan recalled that Tom Sheehan, a bachelor, lived at the site. The building is described as a small cottage with an iron roof and a modest verandah. Tom Sheehan died in 1936 and, apparently, the


2. Bill Sheahan was adamant that Tom Sheehan was spelled with two ‘e’.

3. Comparatively little is known about the occupant. A Thomas Sheehan, “returned soldier”, is mentioned as a victim of an attempted shooting in Jugiong in 1903 (Anonymous, 1903a, 1903c, 1903d).

Born in Gundagai in 1872, Thomas Sheehan joined the Citizen’s Bushmen Contingent (CBC) to fight in the Boer War (Roe, 2012). He was amongst the drafts for the No. 1 Squadron, CBC sailing from Sydney aboard ‘Ranee’ on 21 March 1901 (Anonymous, 1901c; 1901e, p. 22; depicted on top photo, third row from top, fourth person from left); served as a trooper in the 3rd New South Wales Imperial Bushmen (regimental no. 3163; the regiment had been raised at Klerksdorp, Transvaal, on 4 May 1901); and was invalided to Australia 9 July 1901 (Murray, 1911, p. 163), arrived back in Sydney 12 August 1901 (Anonymous, 1901d).

Sheehan is mentioned as a participant at a horse race (Anonymous, 1915); and as best man at a wedding in 1922 (Anonymous, 1922b).—A Thomas Michael Sheehan is listed in 1927 as the purchaser of allotments 7 & 8, section 8 of Jugiong (Anonymous, 1927).

4. It should be noted that use of the, presumably, single- or double-room building as a residential cottage does not preclude an earlier use of the structure as a school or shop.

5. His death at the age of 90 is mentioned in the newspaper for October 1936 (Anonymous, 1936).—Perusal of the Jugiong Cemetery head stone data (Grieves, 2006) or NSW Births, Death and Marriages...
property was left to decay (Sheahan, 2015b). Given the period, the Great Depression of the mid-1930s, it is quite possible that the building may have served as an abode of itinerant people, temporarily residing at the edge of town while en route from Sydney to Melbourne (or vice versa).

It is unclear whether the building’s roof collapsed or whether it was taken down intentionally. The current owner of the property that contains the ruins noted that, when he purchased the area in approximately 1972, the ruins no longer had a roof (Sharman, 2015). Given the general shortage of building and construction materials after World War II (Archer, 1987, p. 185; Cuffley, 1993, p. 56), it can be assumed that any usable element of the abandoned building, in particular the roofing timbers as well as the roofing iron, would have been salvaged. Thus it can be presumed that from the late 1940s onwards the abandoned building would have been without a roof.

**Observations Methodology**

The observations and assessment of the decay of the property were macroscopic only. The data collection strategy was limited to opportunistic photography over a prolonged period (Table 1). The ruins site was never formally measured before the time this report was written.

**The images**

The ruins were first noted by the author in January 1993 en route from Canberra (ACT) to Albury (NSW), and first visited and photographed on 15 February 1993. From then on they were photographed, to a varied degree of detail, at irregular intervals in 1994, 1996, 1997, 1999, 2000, 2001, 2005, 2007 and 2015. As all images were taken during road trips between Albury and Canberra, the overall quality of the images is mixed, largely governed by the light and weather conditions at the time, as well as the cameras used (Table 1). After the opening of the Jugiong Diversion of the Hume Highway in October 1995 visits to the site necessitated a detour from the main route.

The film-based images were scanned as prints (using a Canon LIDE 110) or as negatives (using an Epson V700). For purposes of interpretation and comparison, some of the images have been post-processed and enhanced (contrast and levels) using HDR Efex Pro 2.0. To remove visual clutter and to emphasise the key elements of the walls, for a number of images the background was removed in Photoshop CS3.

For the purpose of this analysis, a small number of additional images could be sourced on the World-Wide Web which were taken by other photographers in November 2006, June and December 2010 and April 2013 (ausgirl, 2010; Johnston, 2010; snucklepuff, 2013; Spong, 2006a, 2006b, 2006c, 2006d, 2006e, 2006f).

did not yield any reference to a Tom or Thomas Sheehan who died in or near Jugiong. This suggests that he had no relatives (willing to) to purchase a permanent grave marker for him.—The death of a Thomas Sheehan is on record for 1936 in the registration district of Young (NSW Registry of Births, 2015b).
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Table 1. Details of the photo documentation.

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</table>

Weather conditions 1993–2015

No official climatological data have been collected in Jugiong itself. The closest Bureau of Meteorology station is at Gundagai (station 073141) with provides data for the years 1995–2015 (Table 2) (Bureau of Meteorology, 2014). Median annual rainfall over the period was 589mm, but fluctuated from a low of 283.6mm in 2006 to a high of 1,034mm in 2010 (Fig. 18) (Bureau of Meteorology, 1995–2015). The maximum daily rainfall was observed on 4 March 2012 when 78.4mm of rain fell. Twenty-five millimetres or more of rainfall were observed on 86 days (n=7,243).

Table 2. Climatological Data for Gundagai (Bureau of Meteorology, 1995–2015).

<table>
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<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
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<td>17.7</td>
<td>13.9</td>
<td>12.9</td>
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Fig. 18. Annual and median precipitation 1996–2014. Also marked are the years for which photographic evidence exists. Large dots: own images. Small dots: images sourced from the internet.

Fig. 19. Monthly precipitation 1995–2014. Shown are average (thick solid line), standard deviation (thin solid line) and minima and maxima (dashed lines) (Bureau of Meteorology, 1995–2015).
Fig. 20. Monthly variation of daily temperature ranges. Data for 1995–2015 grouped in 10-Day intervals (n=6,602).

Fig. 21. Frequency (in %) of daily temperature ranges (in °C) as observed for 1995–2015 (n=6,602).
The recorded minimum was -5.5°C, documented for 21 July 1997, while the recorded maximum was 44°C, recorded on 7 February 2009. During the observation period (May 1995–March 2015) temperatures reached or exceeded 40°C on 59 days (0.8%, n=7,193). On 498 days (7.5%, n=6,649) minimum temperatures at or below 0°C were reached, with 142 days (2.1%) having temperatures of -2°C or below (Bureau of Meteorology, 1995–2015). From a conservation point of view, it needs to be noted that the summer months not only exhibit higher temperatures, but also greater daily temperature ranges (Fig. 20).

The available wind data are also for Gundagai, which show that at that station, the majority of mornings are calm and the afternoon winds are primarily coming from the west (Fig. 22) (National Climate Centre, 2014a). During the summer months the winds tend to be more easterly. Strong winds are uncommon, but have been recorded historically.¹

![Fig. 22. Rose of wind direction versus wind speed in km/h (10 May 1995 to 30 Sep 2010) 9am and 3pm. Observations for Gundagai (n=5,529) (National Climate Centre, 2014a, 2014b).](image)

Using wind data from other meteorological stations that are not very close to a site is of course fraught with problems as winds experienced at single- and double-storey building height are heavily influenced by the local topography. In the case of the Jugiong ruins, the site is located in the alluvial plain at the bottom of a steeply sloping valley. Since the Murrumbidgee meanders deeply at this location, any funnelling of winds is limited to short distances. At a micro-scale the Murrumbidgee trends east-west near the ruins (Fig. 4). As this is congruent with the primary wind directions (Fig. 22) we can expect greater impact on the western and eastern façades of the structure.

**Assessment of Decay of the Pisé Ruins at Jugiong**

The remainder of this document will discuss the principles of decay that are acting on pisé structures in general as well as those decay agents that impact the site at Jugiong in

¹ For example, a severe windstorm damaging almost every building in Jugiong has been recorded for 1898 (Anonymous, 1898).
Diachronic Observations of the Decay of a Pisé Building at Jugiong (NSW)

particular, including processes that are hidden from view. Based on these a decay model will be presented that can then be compared with the decay that can be documented macroscopically through observation.

**Decay Processes affecting pisé structures**

In the literature, the pattern and mechanics of the decay of earthen structures are well described (see Guillaud, 2012; Hall & Djerbib, 2004, 2006a, 2006b; Mileto, Vegas López-Manzanares, Cristini, & García Soriano, 2012; Parra Saldivar & Baty, 2006; Sebastián & Cultrone, 2010; Silva, Oliveira, Schueremans, Miranda, & Machado, 2014; Tiller & Look, 1978). In principle, the decay processes affecting pisé buildings are physical, chemical and biological. The processes acting upon the pisé ruins at Jugiong are no exception.

*Pisé* work has some resistance against deterioration, and can be built to erect long-lasting houses, provided that the earthwork is not exposed to rain or surface moisture. The agents of decay are predominantly physical, with rainfall and its derivatives causing the bulk of damage. The moment a *pisé* structure has lost its surface finish, it becomes susceptible to decay due to the ingress of water. Since pisé buildings essentially consist of unfired loams or clays, they have a high hygroscopic index, and therefore shrink and swell depending on the moisture content of the ambient air. Because of this they are very vulnerable to rising damp caused by high levels of ground moisture (Fig. 10f). If the clay becomes so wet that it reaches its plasticity limit, walls may bulge under the weight of the roof. Damage to or loss of a roof allows rainfall to enter the unprotected top ends of *pisé* walls (‘falling damp’, Fig. 10b). Decay of the wall can be accelerated at times of prolonged wetness. Its severity depends on the intensity of the rainfall, as well as moisture content of the walling at the time of precipitation. The decay of the exposed wall tops can be exacerbated by vortexes created by winds (Fig. 10a). Since pisé buildings have a high hygroscopic index, they are also subject to penetrating damp caused by wind-driven rain as well as dew (Fig. 10c). Structural cracking of the walling decreases its load-bearing capacity and stiffness. Moreover, such cracks are ready pathways for further moisture ingress deep into the walling, thus aiding and accelerating decay (Fig. 33).

Rainfall wets and softens the ground surrounding the walls (Fig. 10d). Raindrops (or hail pellets) splashing off the ground during heavy down pours can dissolve the render through general wetting and micro-impact of the drops (depending on raindrop velocity) and thus weaken the lower parts of walls (Fig. 10d–e), which may have already been weakened by rising damp (Fig. 10f). If this basal erosion is left unchecked, it eventually undermines the walling, thereby reducing its structural integrity to such an extent that entire walls can topple or collapse.

Flooding of the bottom part of the walling, either through rainfall-induced sheet flooding or through riverine flooding constitutes a significant threat to the integrity and stability of a pisé structure. The degree of impact depends on the duration of the immersion event, as well as the efficacy of any protection measures (sand bagging, boarding) that may occur.

Earth buildings which lack a damp-proof course are subject to ingress by moisture carrying water soluble salts. Depending on the level of ground moisture and the concentrations of the salts therein, this may lead to salt crystallisation in the pore spaces and subsequent efflorescence. Ongoing hydration and dehydration events increase the problem which will bring about a decay of the fabric through micro-erosion as well as spalling, that may, eventually, lead to structural failure (Fig. 10h).
While moisture is a major decay agent, it needs to be noted though, that the binding agent of the walls, the clay, relies on the presence of moisture, and thus pisé buildings should not be allowed to dry out totally. Thus the introduction of a damp proof course would be counterproductive as far as the stability of the structure is concerned. A total drying out of the walls would lead to shrinkage of the clay particles and thus a separation of the sand and fine gravel that act as ‘aggregate.’ Cumulatively this leads to a gradual erosion of the exposed surfaces. In extreme cases this may cause large-scale cleaving of wall segments, especially if structural inequalities exists, for example walls lacking overlapping layers due to poor quality of initial construction work.

On a more micro-scale level, the effect of differential thermal expansion of the components of the pisé should not be underestimated. These include the effects of freeze-thaw action as well as differential thermal expansion between the core and the expose surfaces of the walling. As the pisé earth-mix is unfired, the bonds between the clay particles and the sand and fine gravel aggregate is weak. This can be exacerbated if
the surface of the aggregate particles is rounded and smooth rather than rough and textured. Moreover, the nature of the clay inclusions, for example gypsum, influences its bonding characteristics.

Any pisé structure close to main roads is also subject to impacts caused by vehicular traffic. These are chemical, due to exhaust gases, and mechanical, due to ground vibrations (Fig. 10). Chemical decay derived from weak acids (formed from CO₂ and SO₂ vehicle emissions) will act on the calcium carbonate component of the clays of the site during those days when dew is deposited on the walls (compare to effects of sandstone in urban areas: (Sabbioni & Zappia, 1992; Turkington, Martin, Viles, & Smith, 2003)). We can set aside airborne vibration impact caused by heavy vehicles, as it mainly acts on windows and fittings. Ground-borne vibration from traffic on arterial roads is dependent on the nature of the road surface; the passing vehicle (specifically its weight, type of its suspension, and travelling speed); the underlying soil conditions (composition and moisture content); and the distance of the site from the vibration source (Hajek, Blaney, & Hein, 2006; Hunaidi & Tremblay, 1997). Ground borne vibrations are also more pronounced at higher points of a structure, with double velocity observed at first floor level compared to the foundations (Hunaidi, 2000).

In addition, burrowing animals can weaken the foundations and lower wall sections. Whilst most pisé walls have been erected on a foundation of stones, animals, especially rats and mice (but also rabbits) burrowing in the walls and the foundations for nesting and access purposes are not uncommon (Fig. 10h). Mud wasps are known to add to the decay by removal of clay from wetted wall surfaces. In addition, the nature of the material, combined with wall moisture, makes pisé walls which have lost their render or which exhibit cracks susceptible to colonisation by plants (Fig. 10j). Anthropogenic decay agents, mainly in the form of vandalism (such as pushing over weakened wall segments) also cannot be discounted altogether (Fig. 10k).

For pisé sites in rural areas, the impact of livestock also needs to be considered, especially at abandoned house sites. The impact can be mechanical by livestock (mainly sheep and cattle) using the walls for shade and shelter, as well as surfaces to rub against. This impact can be gradual, leading to the micro decay of surfaces, and catastrophic, by unstable walls being pushed over during rubbing events. Abandoned pisé buildings in dry-land salinity-affected areas face an unexpected additional decay agent—livestock licking the salty walls and thereby wetting and eroding the surfaces.¹

Finally, because of the low tensile strength of adobe and pisé walls, differential settlement of foundations, or changes in the weight distribution of a roof may have severe or even catastrophic implications on the structural integrity of a building during seismic events. These are well described in the literature (see Allen, Sanchez, & Hill, 1991; Green & Watson, 1991; Tolles, Webster, Thiel, Kimbro, & Ginell, 1991). We are not concerned with these effects given that the area is not known for its seismic risk (Burbidge, 2012; Leonard, Burbidge, & Edwards, 2013; Standards Australia, 1979, 2007). It should be noted, however, that the historical record shows that destructive earthquakes have affected the area (Spennemann, 1996, 1998).

Assessment of processes hidden from view

Some decay processes are hidden from view and thus cannot be readily assessed on the basis of pure macroscopic observation (for these see below). These are thermal

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¹ The author is indebted to Jim Sheahan (Jugiong) for this observation.
expansion as part of the diurnal cycle, freeze-thaw action as well as vibrational impact from passing traffic.

**Impact of Thermal Expansion**

The effects of thermal expansion and contraction need to be considered. On a macro-level they effect the walling between its core and the surface. On a micro-level they impact on the bonds between the clay particles and the aggregate.

The temperature data for 1995–2013 show that the average range between the daily maximum and the daily minimum is 10.5°C in winter and 15.8°C in summer. The average thermal expansion is thus of comparatively little concern. Of interest are the larger thermal ranges, especially if they occur on a sustained basis. During the observation period, 5.3% of the recorded days (n=6,602) showed a range of 20°C or more, with 0.2% having a range of 25° or more; the maximum recorded range was 27.3°C (Table 3). It is impossible to accurately quantify any stresses derived from these temperature ranges given the absence of detailed tests of the soil and building fabric and a concomitant understanding of the thermal expansion coefficients of the clays and the fine sands/gravel admixtures.

From a building perspective it needs to be considered that these are temperatures recorded in the shade and not the actual temperatures that act on the illuminated fabric. The author’s own anecdotal observations in Albury (NSW) showed that on days with 40°C ambient air temperature, a white surface registered temperatures in excess of 60°C. Given night temperatures of about 20°C, the daily thermal range for the surfaces was in excess of 40°C. During summer, up to 11.5 peak sun hours (i.e. kWh/m²/day) act on the northern faces of the walls (Fig. 25), while the southern faces are more shaded and thus experience less thermal impact. In addition, during part of the day the northern wall may cast shadows on the northern face of the southern wall segments and thus reduce the thermal impact there.

Obviously, heat exposure and the concomitant thermal expansion of the fabric is attenuated towards the core of the walling. The effects of ongoing thermal expansion and contraction gradually weaken the bonds of the clay particles with the sand and fine gravel aggregate. The developing micro-cracks will lead to particle erosion on the surface which is then exacerbated by wind and rain. Cumulatively, these micro-cracks also contribute to a structural weakness of the walling itself.

A shadow analysis was carried out using Google Sketchup. Shadows for both the southern summer and winter solstices (21 December and 21 June) were simulated, as well as shadows for the autumn equinox (20 March; see Fig. 26–Fig. 27). The analysis showed that the northern face of the northern wall is exposed throughout the year, while the northern face of the southern wall segments is exposed for most of the year, except during the early morning and late afternoon hours in the winter months when the lower sections of that wall are shaded. The southern faces of the walls are always in the shade with the exception of the early morning hours at the height of summer (see hourly simulation for the summer solstice, Fig. 28–Fig. 29). During that time of the day and the season, however, the sun exudes less energy and the impact of that shading can be deemed negligible.

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1. The programming and GIS simulation was carried out by Deanna Duffy (Spatial Analysis Network, Charles Sturt University).
Fig. 24. Path of the sun at the Jugiong site. (Sun path data from SunEarthTools, 2015, aerial image from Land and Property Information 2015, final image by the author).

Fig. 25. Strength the sun at the Jugiong site throughout the year, expressed as incident power measured in peak sun hours per day (kWh/m²/day). (Data from Honsberg & Bowden, 2013).
Fig. 26. Shadow analysis. Ruins site seen from northwest. Shadows for the southern winter solstice (top), equinox (middle) and southern summer solstice (bottom) at 8am (left), noon (middle), and 4pm (right).

Fig. 27. Shadow analysis. Ruins site seen from southeast. Shadows for the southern winter solstice (top), equinox (middle) and southern summer solstice (bottom) at 8am (left), noon (middle), and 4pm (right).
Fig. 28. Shadow analysis. Ruins site seen from northwest. Shadows for the southern summer solstice at hourly intervals.
Fig. 29. Shadow analysis. Ruins site seen from northwest. Shadows for the southern summer solstice at hourly intervals.
Given the shadow analysis, it can be expected that the southern faces of the ruins would be exposed to substantially less thermal expansion than the northern faces (see below).

The solar intensity is less during winter so that the early morning and late afternoon shadow effects have a small, if not negligible, influence on the thermal stress on the surfaces.

**Impact of Freeze-Thaw Action**

Freeze-thaw action is a second process to be considered. Moisture contained in the wall fabric will solidify at the freeze point of 0°C. Given the anomaly of water, the volume occupied by solid water is larger than that of liquid water, thus exerting stresses on the fabric. Any presence of water-soluble salts in the moisture will lower the freezing point.

As noted earlier, that point was reached on 7.5% of all observed days (Bureau of Meteorology, 1995–2015). At no time was the daily maximum temperature below freezing point, which implies that the ice re-liquified every time during the course of the day. Consecutive days of below freezing point imply the refreezing of more or less the same moisture content and thus will create continual stresses. On 271 instances frost was recorded on two consecutive days (n=7,374 days), with 119 instances of frost on three consecutive days and 49 instances of frost measured on five or more consecutive days. These instances relate to residual moisture in the fabric. The effect will of course be greater if, prior to the freezing event, the fabric has been wetted by recent rainfall. The climatological data show that on only two occasions rainfall of more than 5mm occurred on the same day as the frost. There were 8 (25) events where it froze the day after 10mm (5mm) rain fell and 16 (50) events where it froze the two days after 10mm (5mm) rain fell.

On 211 occasions rainfall greater than 5mm was recorded on two consecutive days and on 55 occasions it had rained for 3 days or more. The impact will be exacerbated if heavy rain (25mm or more) falls on an already wetted surface, thereby accelerating erosion. This occurred on 26 occasions, with 6 occasions where such rain fell following two days of rainfall. One particularly significant event occurred between 29 February and 4 March 2012 (Table 4).

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<td>78.4 mm</td>
</tr>
<tr>
<td>5 Mar</td>
<td>2.4 mm</td>
</tr>
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</table>

**Impact of passing vehicular traffic**

Given that the location of the ruins site is only approximately 20–25m\(^1\) from the centre line of the former Hume Highway, the possible impacts caused by vehicular traffic also need to be taken into account.

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\(^1\) Depending on which wall (northern or southern) is considered.
Before the Jugiong Bypass was completed in October 1995 (Roads & Maritime Services, 2013) a total of 10,978 axle pairs went past the site (1994 data, up from 7,610 in 1984)(NSW Roads and Traffic Authority, 1999, 2001; 2004, p. 11). No data exist that break down the vehicular traffic at Jugiong into light and heavy vehicles for the period before the bypass (Bamberry, 2015). Accurate daily count data exist for the Hume Highway at Holbrook for the years 2008 and 2010; these show a vehicle breakdown of 58% (55%) light vehicles, 9% (4%) medium vehicles, and 33% (41%) heavy vehicles (Parsons Brinckerhoff Australia, 2010).\(^1\) Using these proportions, and a ratio of 2.5 axle pairs per heavy vehicle,\(^2\) we arrive at approximately 7,410 vehicles, at least 3,040 of which were trucks.\(^3\) Well over half the trucks run on the Hume Highway at night. With Tarcutta, the half-way point between Sydney and Melbourne and a nightly change-over location, some 85 km (or ~45min drive time) to the south, the majority of trucks would have passed the site between 8pm and midnight.

By comparison, in 2013 the estimated number of vehicle movements on Riverside Drive had dropped to 300 vehicles per day, with only 50 of them being heavy (JL Kilby Pty, 2013, p. 182).

No data exist regarding the air quality in the Jugiong area. It can be assumed that CO\(_2\) and SO\(_2\) concentrations in the air, and the concomitant chemical decay of the wall surfaces (derived from weak acids deposited by dew), would have been higher during the days when the Hume Highway passed directly in front of the site. Given the open, rural landscape and the absence of heavy industry and dense urban traffic, it can be assumed that CO\(_2\) and SO\(_2\) concentrations will be very low and chemical decay can be deemed negligible. Unlike soluble salts that accumulate in pore spaces of building fabric (Spennemann, 1999, 2001) the chemical decay caused by surface-deposited weak aids is immediate and has no residual effects.

While no actual vibration measurement data exist for the Jugiong site, we can draw on published data and assume 0.01 to 0.2 mm/s at the footings of buildings 10-20m away from the roadside edge for smooth-surface highway traffic (Department for Transport, 2007, p. 15-2) and 0.1–2mm/s for construction traffic and traffic on irregular road surfaces (AECOM Australia, 2011; Department for Transport, 2007, p. 15-2). Given the state of the Hume Highway at Jugiong at the time it was operational, and given that the underlying soil is clayey, it is safe to assume that the vibration levels would have been at the higher margins. CalTrans (2004) uses 1.9mm/sec as a standard measure (CalTrans, 2004; Roberts, 2009). Applying the CalTrans value, we arrive at a velocity of ~2.45 mm/s at the top of the walling. The widely recognised German standard on vibrations specifies that structures of particular sensitivity, such as those

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1. Given the general data for the Sydney to Melbourne Transport Corridor (Bureau of Infrastructure, 2014), the volume of vehicles at Gundagai is higher than at Holbrook (as the Gundagai data also include Wagga Wagga and Adelaide-bound traffic via the Sturt Highway), but the proportion of heavy trucks is less at Gundagai.

2. Trucks have 1 axle pair (one axle in front, one in the back); heavy trucks 1.5 axle pairs (1f, 2b); semi-trailers and trucks towing a dog trailer have 2.5 axle pairs (1f, 2b on engine, 2 on trailer); and B-doubles have 4.5 axle pairs (1f, 2b on engine, 3 on each trailer).

3. B-Double operations commenced in 1986 in NSW, with the first B-double operating on the Hume Highway in 1991 (Department for Transport, 2011; Pearson, 2010). Since then the number of B-doubles has increased, which has reduced the total use of rigid trucks. It is possible, therefore, that the percentage of trucks travelling the Hume Highway would have been higher in 1994 than in 2008/10. On the other hand, the overall number of trucks (in relation to passenger cars) has increased since 1994. For the sake of a mere approximation of traffic volume, it is assumed that both factors cancel each other out.
under a preservation order (i.e. heritage listing in Australian terms) should not be exposed to a velocity exceeding 3 mm/s at ground level and 2.5 mm/s at their highest point (Deutsche Norm, 1999).

Thus it seems that the ruins site would have been, and still is, subjected to vibration effects that are just below the DIN threshold. Yet, even where the actual vibration may not be sufficient to generate structural damage by itself, it may be sufficient to exacerbate existing stresses in the building fabric due to differential settling or thermal expansion, the effects of which will manifest themselves in cracking and, in extreme cases, structural failure (Hunaidi, 2000). As mentioned above, at the time the Hume Highway went past the site, the heavy vehicle traffic was not uniformly distributed throughout a 24-hour day but was concentrated during the evening and early night period, when the Sydney–Melbourne and the Melbourne–Sydney long-haul trucks passed through.

Further, long-term, sustained exposure to vibrations, as is the case with ongoing highway traffic, can cause structural fatigue in buildings (Hunaidi, 2000). Even though the level of vibration dropped dramatically since the opening of the Jugiong Bypass, there will have been residual weakening of the structure.

Flooding

While flooding of the township by the Murrumbidgee River is on record, no riverine or sheet-flooding events affected the ruins during the period of observation. Historically, the site would have been flooded in 1925, when the Hume Highway was covered by six feet of water (Anonymous, 1925a), and also in 1950, when the road at Jugiong was five feet under water (Anonymous, 1950).

Decay Model

In light of the topography and the prevailing weather conditions acting on the site, as well as the predicted decay processes hidden from view, the following decay model can be advanced.

The state of the building at the time of abandonment is unclear, but it can be assumed that it would not have been in pristine shape. It can be safely asserted, however, that following the abandonment of the building all maintenance would have

1. Massive and very destructive flooding of the Murrumbidgee is on record for in 1852, which destroyed much of Jugiong (Anonymous, 1852a, 1852b, 1852c, 1852d; Roche, 1925). Substantial flooding occurred in 1853 (Anonymous, 1853), (with evidence of repeated flooding in the past: Anonymous, 1859), 1870 (Anonymous, 1870a), 1891 (Anonymous, 1895b), 1922 (Anonymous, 1922a), 1925 (Anonymous, 1925a, 1925b), 1950 (Anonymous, 1950), 1951 (Anonymous, 1951), 1974 (Anonymous, 1974).—Jugiong Creek feeds into the Murrumbidgee just upstream of the township. In light of this, the downstream flood gauge data for Gundagai (station 410004, data since 2 August 1886) are the most relevant (Office of Water, 2015), as the Jugiong Gauge that operated before World War II is no longer in existence.

When the Murrumbidgee broke its banks in July 1900, John Williams’ store, just to the west of the site, was flooded to a depth of a foot. At Cooney’s Hotel the waters rose 18 inches above the basement (Anonymous, 1900). Ten years earlier, in 1891, a flood had washed away part of that hotel and had inundated the former post office (at Myers’/Boughton’s sore) to a height of ten feet (Anonymous, 1895b). Based on spatial data it appears that the ruins site is at the same elevation as Cooney’s Hotel, which suggests that the building at the time would also have experienced some level of flooding.

In addition, a massive sheet-flooding event, affecting all of Jugiong, is on record for 1945 (Anonymous, 1945).
ceased. Moreover, it can be assumed that during the Great Depression the building may have served as temporary accommodation of itinerant travellers—and that some fittings and ‘sellable’ items may have been removed at that time (if not before). At one point the window glass would have been removed or broken, thereby allowing ingress of moisture. It can be assumed that during the period of post-World War II austerity and building material shortage, the roof (iron and timbers) as well as all other salvageable constriction materials (window and door surrounds etc.) would have been removed.

Fig. 30. Nomenclature of the components of the ruins of a pisé building at Jugiong (NSW). d—former door, w—former window.

From then on, the exposed shell of the building would have been at the mercy of the elements. The tops of the walling would have experienced falling damp, while the faces would have been exposed to penetrating damp and the effects of thermal influences. Given the predominant wind directions, the western and eastern facades would experience greater decay than the north and south facades. This may have been accelerated if the eastern and western walls had window openings.

The southern wall with its two windows and the centrally located door was structurally weaker than the window-less northern wall. Moreover, it is closer to the Hume Highway and will have been exposed to stronger vibrations from vehicular traffic. It can be anticipated, therefore, that the southern wall would exhibit greater decay than the northern wall.

Given the alignment of the building, it can also be expected that the northern faces of the northern and southern wall sections will exhibit a greater level of decay (due to thermal expansion) than the shaded southern sides.

**Observed Processes of Decay**

At the time of the first observation in February 1993, the ruins were comprised of a long northern wall with a north-western corner segment, the south-eastern and south-
western corner blocks and the south-eastern block of the southern wall (Fig. 46). The south-western block had fallen before that time, but remnants could be seen lying on the ground (Fig. 45). As there were no obvious traces of the western and eastern walls, it can be surmised that they had fallen/collapsed quite some time before. This conforms with the decay model. The walling was erected on a foundation of quarried, but not dressed blocks of granite (Fig. 49–Fig. 51).

![Diagram of pisé wall layers](image)

Fig. 31. Influences of construction technique and quality of work on the preservation of pisé walls. Section of the northern face of the now collapsed south-eastern block, as seen on 30 September 2005.

The partially eroded state of the walls demonstrates well the nature of pisé construction. The successive layers of soil that were poured into the form and then padded down can be readily discerned by the zones of compacted and less compacted
soil (Fig. 31). While the observed thickness of the layers\(^1\) ranges from 7 to 12 cm, the majority of layers measured between 10 and 11 cm. The upper 30–40% of the layers are more compacted than the lower parts (Fig. 31). Thus the layers are clearly thicker than the “not more than three to four inches” recommended in 1871, which through ramming were reduced to “little less than half of [their] former thickness” (Anonymous, 1871).

Further, some layers show residual traces of external finishes, both in terms of the formwork (Fig. 31), but also of render (Fig. 70) and whitewash (Fig. 70, Fig. 80). In terms of gradual decay, the more non-compacted part of each soil layer erodes faster than the compacted section. The cause for this is the minor difference in hygroscopic index caused by compaction and also the difference in micro spaces between the clay particle and the sand/fine gravel ‘aggregate’ (Fig. 31).

The matrix appears like alluvial clayey soil. Macroscopically, there is no discernible difference in the soil used for the pisé building and the underlying soils of the hillside. Thus it can be surmised that the volume of soil used for the wall construction was indeed that which had to be excavated in order to create the level terrace on which the building rests.

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\(^1\) As measured in 2015 at the northern wall (both faces) and the northern faces of both the southwestern and the southern wall segments.
differences in the original soil matrix, both vertically (top soil vs. underlying material) and horizontally (i.e. distance to the river).

During the period of observation (1993–2015) the moisture regime of the site underwent a dramatic change. The early images, taken in 1993 and 1994 show the tops of the southern wall sections covered with mosses and grasses (Fig. 44–Fig. 45), and the top of the northern wall covered with grass (Fig. 46). By 2001 the moss had dried up and by 2005 had fully disappeared. It seems that the declining health of the *Robinia pseudoacacia* trees (Fig. 5, Fig. 12) and the concomitant loss of tree canopy (Fig. 100–Fig. 101) reduced the shading of the walls and thus overall moisture regime, both in terms of increased evaporation and reduced continued moistening due to drip effects of the leaves of the canopy.

The established nature of the moss and grass covering encountered in 1993 suggests that the tops of the walls were in fact quite stable and not subjected to excessive micro-erosion. Once the moisture regime had changed, however, such erosion was set to recommence. Comparison of the walling over time, however, shows that the decay at the top was less than the decay observed on the sides, in particular eastern margins. This is well documented for the south-western corner block (Fig. 38) and the south-eastern wall block (Fig. 39).

The walls exhibit vertical cracking than can lead to full-scale cleaving of sections (e.g. Fig. 33). These are caused by a low quality of work at the time of construction, where little care had been taken to ensure that the individual bucket loads of soil overlapped properly before they were tamped down. Differential shrinking of the clay and sand/fine gravel mix and minor structural settlement are the causes, which may well have been exacerbated by ground vibrations (see below). These cracks, which can be quite wide, lead to segmentation and eventual structural failure.

Once the lower section of walling has been sufficiently weakened by rising damp and undermined by splash effects, it can collapse, commonly by toppling over and breaking up as it hits the ground (Fig. 96–Fig. 97). The eastern portion of the south-eastern corner had toppled not long before 1993; some evidence of this was still visible in March 1994 (Fig. 47). Ground moisture had penetrated the fallen walling and it had been colonised by grasses. The same applies to part of the southern wall (Fig. 54). The western wall segment of the south-western corner of the building exhibited minor cleaving by March 1994 (Fig. 54). By September 2005 the cleavage was very pronounced (Fig. 55) and gaping by November 2006 (Fig. 74); this lead to the collapse of the wall segment in mid 2007 (Fig. 56).

The south-western corner block had also undergone slow decay, especially at its eastward wall face. The difference between 1994 and 2015 is dramatic (Fig. 38) and seems to have accelerated in the decade since 2005, compared to the previous decade (compare Fig. 68, Fig. 72 and Fig. 73). A similar observation can be made for the south-eastern wall block, where the decay also occurred primarily on its eastward wall face, with the decay accelerating after 2005 (Fig. 39).

By April 2015 the south-western wall block had developed bowing of the centre (Fig. 62) as well a moderate lean to the south (Fig. 48), suggesting that the walling may topple over in the short– to medium-term future. The wall section also exhibits a crack down the centre line, more developed in the eastern than the western side (Fig. 62–Fig. 63). Eventually one part, presumably the southern face, will cleave off.
Fig. 33. The northern wall (seen from north) in 2015. Note the impending structural failures (middle image) as well as the lack of proper overlay of earth layers during construction. Image merged from seven frames.
Fig. 34. The eastern end of the northern wall (as seen from north) on 2 March 2015.

Fig. 35. Extent of surface erosion of the northern face of the northern wall. Note the exposed line of render on the ground. Photographed on 2 April 2015.
Fig. 36. Extent of surface erosion of the northern face of the south-eastern wall block. Note how far the tape can be inserted. Also note the protruding lower layer. Photographed on 2 April 2015.

Fig. 37. Examples of differential decay. Left: South face of the south-eastern wall block. Right: North face of the south-western corner block. Scale in 1 cm gradation. Photographed on 2 April 2015.
There is a clear pattern of decay that shows that at the time of construction, the eastern and western wall sections were not very well integrated into the northern and southern walls. In 1994 traces of the eastern wall section at the south-eastern corner block could be seen on the ground (Fig. 47). In 2008 or early 2009 the western wall section of the north-western corner collapsed (Fig. 95–Fig. 83) and in mid 2007 the western wall section of the south-western corner (Fig. 55–Fig. 56).

The colonisation of fallen wall sections with vegetation is not immediate. Even though the soil exhibits a suitable level of moisture (due to full ground contact), it is essentially nutrient poor, if not sterile, soil with low carbon content. Not surprisingly, colonisation by plants is impeded. Yet, once the walling has toppled, the close contact with ground and the resulting rising damp means that the formerly discrete walling (Fig. 96–Fig. 97) gradually disintegrates into an amorphous mass that is eventually colonised by weeds and surrounding ground cover vegetation (Fig. 98–Fig. 99). It is then subjected to ongoing erosion processes leading to a gradual levelling of the fallen section (Fig. 99).

While the southern face of the wall sections experienced comparatively little decay, with white-wash quite evident in 1993 and some traces of that wash still extant in 2015, the northern faces have experienced heavy surface erosion. At the base of its northern face, the northern wall exhibits remnants of the former rendered surface (Fig. 35). This allows us to determine that the wall had lost some 9–10cm in thickness at the base, and more towards the top. The northern face of the south-eastern wall block exhibits a general surface loss of 3-4 cm, with the less compressed sections of the layers showing additional erosion of 13cm (Fig. 36).

The decay pattern of the southern face of the northern wall is worth noting (Fig. 83). The central section of the walling shows a smooth and rendered surface, while both
the top and the bottom (with a small exception) show a loss of render and furrowed surface erosion. It would appear that these three zones reflect the form boards, and that compression in the middle level form was better than at either the top or the bottom.

At the time of the first observation in 1993, parts of the south-facing sides of all walling still retained some traces of plaster and whitewash (Fig. 44, Fig. 53, Fig. 68, Fig. 80, Fig. 94). By comparison, the north-facing sides had decayed much more (compare Fig. 87 with Fig. 94). Sometime between 7 and 9 October 1994 part of the residual external plaster of the south-western corner block spalled off (compare Fig. 68 and Fig. 69 with Fig. 70). The straight line at the top suggests that this spalling occurred as a result of human interference. That piece of whitewash then continued to decay over time (Fig. 71, Fig. 72) until by 2015 it had almost disappeared (Fig. 73).

The south-western corner block exhibits a hole near the top approximately 200cm above present ground level (Fig. 79). It can be surmised that the 75mm-diameter hole would have received a beam, either to hold up the roof, or to support the verandah.

**Observed Decay Sequence**

Based on the observations described and discussed above (Fig. 40), the following generalised decay sequence can be proposed. Considering all available evidence, the building was once a one- or two-roomed cottage, presumably with a gabled roof. The building had a centrally located door as well as two window openings on the southern side, facing the road. We can assume that the building had a fireplace with a chimney, but there is no remaining evidence. We can speculate that the windows would have been shaded by a verandah. Ornamental plantings were one or more hawthorn (*Rosa rubiginosa*) bushes to the east and a *Robinia pseudoacacia* at the western end (Fig. 41). The latter formed an ornamental boundary of the three church allotments used as a cemetery (see aerial image Fig. 10).

Once the building had lost its roof, the exposed shell of the structure would also have been at the mercy of the elements. The tops of the walling will have experienced falling damp, while the wall faces would have been exposed to penetrating damp and especially to the effects of thermal influences. The effects of the latter are well attested by the differential extent of decay and surface loss observed on the northern compared with the southern wall faces.

Splash-effects during high rainfall events appear to have a greater impact on the lower wall sections of the southern sides of the walling. It can be surmised that the shaded nature of these sides implies a greater retention of rising damp–induced moisture. A high level of moisture makes earthen walling much more susceptible to the physical impact of raindrops. Eventually the under-cutting destabilises the wall, causing it to topple.

Given the predominant wind directions, the western and eastern facades would experience greater decay than the north and south facades. Among these, the eastern faces of the walling will have decayed at a greater rate as is evidenced by observed differential decay of the remaining wall sections (e.g. Fig. 38).
Fig. 40. Observed Decay Sequence of the ruins of a pisé building at Jugiong (NSW).

Fig. 41. Tentative reconstruction of a pisé building at Jugiong (NSW).
Implications

The structure has been identified as an item of local heritage significance (Shire of Harden, 2014), based on the site being an example of “pisé wall construction technology...which was highly popular throughout Harden shire from the mid 1860’s to the late 1940’s,” and it being “part of a group of pise town house cottages that once were prolific but now rare” (criterion f) (Shire of Harden, 2009).

The long-term, unfettered decay has reduced the integrity of the structure to such an extent that it has to be regarded as being beyond repair. In essence, at the time of writing, approximately only one third of the former walling is still standing, and much of that has severely decayed and is compromised. While the remnant walling remains as an example of pisé wall construction technology, its significance as a “group of pise town house cottages” can no longer be argued because the architectural integrity of the building is heavily compromised. Indeed, it can be posited that even at the time of listing in 2009 the conditions of criterion f, as applied, were no longer fulfilled.

In the absence of photographic information, any reconstruction of the missing two-thirds of the site will be highly speculative. Further, the high costs of reconstruction will far outweigh any significance that may have been ascribed to the site. It would be advisable to expend conservation funds on the preservation of other pisé structures in Harden Shire.

In part, the cultural heritage value of the site rests in the decay which allows the observation of the construction technique. Once a new wall unit has collapsed it would be advantageous to collect two representative soil samples, one from the top and from the base and to compare these with a sample taken from the surrounding soil.

The main cultural heritage management value of the ruins rests in its capacity to allow ongoing monitoring of the unrestricted decay of a pisé building and to serve as an educational site until such time that the structure has collapsed altogether.
Photographic Documentation

Fig. 42. The ruins site as seen from the east on 2 April 2015. Note the levelled area for house site.

Fig. 43. The ruins site as seen from the west on 2 April 2015. Note the levelled area for house site.
Fig. 44. The southern and south-eastern block as seen from the southeast on 15 February 1993. Note the presence of plaster and whitewash as well as the vegetation on top of the walls.

Fig. 45. The southern and south-eastern block as seen from the south in March 1994. Note the extensive presence of plaster and whitewash.
Fig. 46. The ruins as seen from the southeast on 15 February 1993.

Fig. 47. The south-eastern wall and south-eastern corner block as seen from the southeast in March 1994. Note the traces of the collapsed section of the eastern wall section of the south-eastern corner.
Fig. 48. The ruins as seen from the southeast on 2 April 2015. Note the overall lean and the southward bowing of the south-eastern wall block (left front of image).

Fig. 49. The base of the south-western block as seen from the east on 15 February 1993. Note the stone foundation in the window space.

Fig. 50. The base of the south-eastern wall block as seen from the northeast in March. Note the wooden reinforcement.
Fig. 51. The stone foundations of the south-eastern block as seen on 9 October 1994.

Fig. 52. The stone foundations of the collapsed south-western block as seen on 30 September 2005.
Fig. 53. The south-eastern wall and south-eastern corner block as seen from the southeast on 15 February 1993. Note the presence of plaster and whitewash. Background edited out in Photoshop.

Fig. 54. The south-western block as seen from the northeast in March 1994. Note the collapsed section of the south-western wall at left.
Fig. 55. The south-western block as seen from the northeast on 30 September 2005. Note the increased cleavage of the western wall segment.

Fig. 56. The south-western block as seen from the northeast 8 September 2007. Note that the western wall segment has collapsed.
Fig. 57. The south-western block as seen from the northeast 2 April 2015. Note that ongoing gradual decay.

Fig. 58. The south-eastern wall block as seen from the south on 15 February 1993.

Fig. 59. The south-eastern wall block as seen from the south in March 1994.
Fig. 60. The south-eastern wall block as seen from the south on 30 December 2000.

Fig. 61. The south-eastern wall block as seen from the south on 2 April 2015.

Fig. 62. The south-eastern wall block as seen from the east on 2 April 2015.

Fig. 63. The south-eastern wall block as seen from the west on 2 April 2015.
Fig. 64. The south-eastern wall block as seen from the north in March 1994.

Fig. 65. The south-eastern wall block as seen from the north on 30 December 2000.

Fig. 66. The south-eastern wall block as seen from the north on 30 September 2005.

Fig. 67. The south-eastern wall block as seen from the north on 2 April 2015.
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Fig. 68. The south-western corner block as seen from the south in March 1994.

Fig. 69. The south-western corner block as seen from the south on 7 October 1994.

Fig. 70. The south-western corner block as seen from the south on 9 October 1994.

Fig. 71. The south-western corner block as seen from the south on 26 April 2001.
Fig. 72. The south-western corner block as seen from the south on 30 September 2005.

Fig. 73. The south-western corner block as seen from the south on 3 March 2015.

Fig. 74. The south-western corner block as seen from the west on 5 November 2006. (Photo Matthew Spong)

Fig. 75. The south-western corner block as seen from the west on 2 April 2015. Note the remnant of the western wall segment.
Fig. 76. The south-western corner block as seen from the northwest on 2 April 2015. Note the remnant of the western wall segment.

Fig. 77. The south-western corner block as seen from the east on 2 April 2015. Note the remnant of the western wall segment.

Fig. 78. The south-western corner block as seen from the north on 2 April 2015.

Fig. 79. The hole in to the top of the south-western corner block as seen from the north on 2 April 2015.
Fig. 80. The south-eastern corner block as seen from the south on 9 October 1994.

Fig. 81. The south-eastern corner block as seen from the northwest on 7 October 1994.

Fig. 82. The south-eastern corner block as seen from the north on 26 April 2001.
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Fig. 83. The northern wall as seen from the south on 2 April 2015.

Fig. 84. The northern wall as seen from the north on 2 March 2015.

Fig. 85. The northern wall as seen from the east

Fig. 86. The northern wall as seen from the

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on 2 April 2015.

west on 2 April 2015.

Fig. 87. The northern wall as seen from the northwest in March 1994.

Fig. 88. The northern wall as seen from the northwest on 2 March 2015.
Fig. 89. The northern wall as seen from the northeast on 9 October 1994.

Fig. 90. The northern wall as seen from the northeast on 30 September 2005.
Fig. 91. The northern wall as seen from the northeast on 2 April 2015.

Fig. 92. The western corner of the northern wall as seen from the southeast on 15 February 1993. Note the stub of the western wall.

Fig. 93. The western corner of the northern wall as seen from the south in March 1994. Note the deep cleavage. (Image stitched from two frames).
Fig. 94. The northern wall as seen from the southwest on 9 October 1994.

Fig. 95. The northern wall as seen from the southwest on 2 April 2013.
Fig. 96. The collapsed south-eastern block as seen from southeast on 30 September 2005.

Fig. 97. The collapsed south-eastern block as seen from northwest on 30 September 2005.
Fig. 98. The pre-1993 collapsed south block as seen from southeast in October 1996.

Fig. 99. The pre-1993 collapsed south block as seen from south on 30 September 2005.
Fig. 100. The Robinia canopy fully covering the south-western corner block, as seen from the southeast on 30 December 2000.

Fig. 101. The Robinia as seen from the south-west on 2 March 2015.
Appendix A: Sorting out Cadastral Confusion

The location and land titles of the heritage-listed property are confusing. As mentioned, the LEP lists the historic site as being located on ‘Lot 2, DP 117819.’

That allotment, however, is in fact right in the center of the Jugiong Cemetery (Fig. 7). It had initially been reserved for the residence of the Catholic Priest (see also Fig. 104) (mapping by Larmer, 1851). The error may have been caused by a misreading of the cadastral information when examined using the SixViewer Map and Aerial photograph interface of NSW Land and Property Information (2015b). Using that system, it appears that the pisé ruins are located on Lot 2 section 18, DP758547 (Fig. 102). Close examination, however, shows that the geo-referencing of the aerial image with the cadastral map is in error.

It can be assumed that the intent had been to list the ruins location as ‘Lot 2 section 18, DP758547.’ The fact that is listed as being located on ‘Lot 2, DP 117819’ (Shire of Harden, 2014, Schedule 5 item I62) appears to be a mere transcription error in the LEP: the previous item listed in the LEP is the Catholic Cemetery, which is correctly located at ‘Lots 1–3, DP 117819’ (Shire of Harden, 2014, Schedule 5 item 161).

The actual pisé ruins, however, are locate on Lot 3 section 18, DP758547 (Land and Property Information, 2015c) as evidenced when superimposing the 1851 survey map over the modern aerial image.

Perusal of a number of historic maps shows that on 13 October 1851 the area to the west of the pisé building was dedicated as a reserve for the use by the Roman Catholic Church (Larmer, 1851). Set aside where three allotments (from the west): one for the school (½ acre), one for the priest’s residence (½ acre), and one for the chapel (1 acre) (Fig. 104),1 with trustees appointed in 1851.2 Following the conversion to Torrens titles (Department of Lands, 1974), these allotments are, today, respectively identified as Lots 1–3, DP 117819 (Land and Property Information, 2008).

To the east of the allotment for the chapel, the 1851 map shows an allotment marked “Roman Catholic Burial Ground” (Fig. 104). The drawing indicates the existence of a hut, of about ½ length long and 1/3 of a chain wide (approximately 10 x 7m). The hut is set on a flat area which has a sloping section to the south.3

The 1851 map also indicates a number of small rectangles, possibly graves, on that sloping area (Fig. 104, Fig. 105). If these are indeed graves, then there are nine interments in north-south and twelve interments in east-west orientation, making it a total of 21 deceased at Jugiong before 1851.

The 1851 mapping also shows a large fenced-in area that encloses the allotment for the Catholic priest’s residence, the Chapel and the allotment with the hut site. It also encompasses the southern section of Section 18, lot 5, then owned by Thomas Callon. The eastern boundary of Section 18, lots 2 (with the pisé ruins) and lot 5 is a continuous

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1. Dimensions were 1 x 5 chains each for the school and the priest’s residence, and 2 x 5 chains for the chapel,

2. In 1851 the Right Revd William Laniaan, the Very Revd Michal McAllroy and John Philipp Sheahan were appointed as trustees for the site for the Roman Catholic Church, School & Presbyter (annotation ‘Mis 33.5536’ on Larmer, 1851).

3. It would appear that this hut belonged to the original Jugiong Squatting run: when Henry O’Brien took up Jugiong station in 1825 he soon after “erected a shepherd’s hut on the rise where the Jugiong cemetery is now situated.” That hut was still in existence in 1845 (Gormly, 1902).
line bearing N13W. This mapping, then, clearly identifies the Catholic Burial Ground as the allotment to the west of the boundary line to lot 3.

The superimposition of the 1851 survey map over the modern aerial image (Fig. 8) shows that the pisé ruins site is indeed on lot 3, section 18 and thus is not identical with the hut shown on the 1851 map.

The next mapping of the area, the 1883 town map includes the area under discussion and places section 18 just to the east of the formal town boundary (Fig. 13) and thus outside of the gazetted part of Jugiong (Carthy, 1883). The metalled section of the main road also ends there (ibid.). That map also identifies the three church allotments as well as the surrounding properties, but leaves blank that allotment which contains cemetery. On the 1916 town map this allotment is identified as “Parish of Jugiong, Section 18, lot 2” (Fig. 14) (Department of Lands, 1916). A hand-annotated version of the 1916 map shows that lot 2 was reserved from sale on 30 November 1917 (R52532; Department of Lands, 1963a); the stated purpose was the preservation of graves, with trustees for the ‘about one acre’-sized reserve appointed and gazetted on 1 February 1918 (Fig. 15) (Anonymous, 1918; Department of Lands, 1963b).1

Fig. 103. The 1851 survey map of the Roman Catholic Chapel, Residence and School House Allotments at Jugiong (Larmer, 1851).

Fig. 104. Section of the 1851 survey map of the Roman Catholic Chapel, Residence and School House Allotments at Jugiong (Larmer, 1851)
Fig. 105. Section of the 1851 survey map of the Roman Catholic Chapel, Residence and School House Allotments at Jugiong, showing the hut in relation to the (presumed) graves (Larmer, 1851)
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